RASUWAGADHI HYDROPOWER COMPANY LIMITED

Rasuwagadhi Hydroelectric Project

TENDER NO: RHGPCL/RGHEP/073/74/TL-01

TENDER DOCUMENT

FOR

DESIGN, SUPPLY, CONSTRUCTION, TESTING AND COMMISSIONING OF 132kV D/C TRANSMISSION LINE FROM RASUWAGADHI HYDROELECTRIC PROJECT TO CHILIME HUB

VOLUME II: EMPLOYERS REQUIREMENT

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PART A

SCOPE OF WORK AND GENERAL TECHNICAL SPECIFICATION OF TRANSMISSION LINE

SCOPE OF WORK & GENERAL TECHNICAL SPECIFICATIONS

1.1 Scope

1.1.1 The Scope of Works covers design manufacture, supply, installation, testing and commissioning of 132 kV D/C (double circuits strung) Transmission Line and design and construction of all the required civil works for the above stated works, as per Employer's Requirement and as defined in these bidding documents. Total length of Rasuwagadhi HEP to Chilime Hub 132 kV D/C Transmission Line is approx. 10.5 km with ACSR 'BEAR' conductor.

The scope of work covered shall be:

- Detail survey & check survey on the alignment surveyed by the Employer including route alignment and profiling, tower spotting, optimization of tower locations;
- Soil resistivity measurement, geotechnical investigation and check survey;
- Design, proto type testing, fabrication and supply of all type 132 kV double circuits 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 all complete;
- Supply of conductor, insulator, OPGW, earth wire, hardware fittings, and conductor, OPGW & earth wire accessories all complete;
- Design of foundations for different soil conditions for different type of towers, classification of foundation for different type of towers and casting of foundation for tower footings as per approved drawings;
- Erection of towers including supply and application of zinc rich primer & enamel paint, protection of tower footing, tower earthing, fixing of insulator strings, stringing of conductors, OPGW and earth wires along with all necessary line accessories;
- Testing and commissioning of erected transmission line;
- Testing and commissioning of fiber optic conductor including that of OPGW all complete;
- Other items not specified above but are required for the successful commissioning of the transmission line, unless specifically excluded in the specification and mentioned.

The contractor shall submit with all the reports, calculations and drawings they make for detail design of double circuit steel lattice tower, tower foundations, tower spotting, sag calculations etc. to the employer after completion of detail design part.

The contractor shall present valid and genuine proposals to change the location or alignment of tower as studied by the Employer. Employer may accept or reject such proposal submitted by the contractor.

1.1.2 Contractor shall develop structural drawings, shop drawings & Bill of Materials of all 132 kV Double circuit towers after completing proto testing of towers. The design and

drawings for all type of foundations for the towers and 132 kV line shall be developed by the Contractor, in sequence, suiting the project requirements.

(a) The provisional quantities of fabricated & galvanized steel towers as per specifications requirement, foundation type and their numbers, quantity of various line materials and other items are given in appropriate Bid Price Schedule 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 engineering, supply and installation of plant equipment and material with skilled and unskilled labor etc. essential for satisfactory completion of various works.

(e) The Contractor shall be responsible for completion of Works with the guaranteed performance as to the international standard, specification and Employer's requirement without any problem to the Employer.

(f) Failure to perform the required quality and pass through test for completion, the Contractor is entitled to liquidate damage as specified in other sections of the Contract.

Measurements for payment of major items like detail survey, check survey, soil investigation, tower foundations, steel towers, conductors, OPGW/Ground wire, insulators and accessories, grounding of the towers etc. shall be in Quantity basis. Measurements for payment of other items such as spare part, tower testing, training etc. shall be made as per the actual quantities supplied according to the Bid Price Schedule.

1.1.3 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, links, danger plates, phase plates, number plates. Circuit Plates, anti-climbing device, bird guards, etc., required for the supply and construction 132 kV Transmission Line works shall be included in the Contractor's scope of supply. Bidder shall clearly indicate in the offer, the sources from where they propose to procure the raw materials and the components.

1.1.4 The 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.

In the hilly/mountainous terrain or in thick forest areas, where mobilization of tensioner & puller equipment is not possible, 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/earth wire and the conductor/earth wire is installed at the prescribed sag-tension as per the approved stringing charts.

1.1.5 Location Details and Terminal Points
The 132 D/C transmission line shall emanate from switchyard of Rasuwagadhi Hydroelectric Power Station switchyard and shall terminate in proposed Chilime Hub Substation. The transmission line shall be passing through cultivated lands, barren lands, forest, hilly and rocky mountainous areas.

1.1.6 The Contractor shall have to construct the above 132 kV transmission line completely up to gantries on the either end. Stringing shall also be carried out from switchyard gantry to the proposed Chilime Hub substation gantry.

1.2 General

The whole of the works shall be designed to ensure satisfactory operation. All reasonable precautions shall be taken in the design of equipment and of the works, to ensure the safety of personnel concerned with the operation and maintenance of the works, and of the public.

All workmanship shall be of the highest class throughout and the design dimensions and materials of all parts shall be such that the stresses to which they are subjected shall not render them liable to distortion or damage under the most severe conditions encountered in service.

The detailed design shall be such as to facilitate inspection, cleaning and repairs and simplicity of operation and maintenance. All apparatus shall be designed to ensure satisfactory operation under the atmospheric conditions prevailing in the areas where the line is to be built and under such variations of load and voltage as may occur under the working conditions of the system. The design of all line supports, conductors, insulators and fittings shall be such as to minimize the risk of damage in service of any part of the lines. No welding, plugging or filling of defective parts shall be carried out without the prior sanction in writing of the Employer.

Anything mentioned in the Specifications and not shown on the drawings or shown on the drawings and not mentioned in the Specifications shall have the effect as if shown or mentioned in both. In case of difference between drawings

and Specifications, the Specifications shall prevail. In case of difference between scaled dimensions and figures on drawings, the figures shall prevail.

Corresponding parts of equipment liable to renewal shall be interchangeable and the Contractor will be required to demonstrate this feature to the Employer's satisfaction.

Locally available goods, construction materials including fuel, lubricating oil, cement, timber, iron and steel goods, etc. shall be procured locally and tax-reimbursement for such items shall not be provided.

Field Works shall be scheduled as per work-site availability without the Employer having to incur additional cost.

1.3 Current Ratings

Every current carrying part of the equipment including conductors, connections and joints shall be capable of carrying their rated current continuously under the site conditions as specified.

1.4 Labels, Ratings and Nameplates

1.4.1. General

All labels, circuit name and rating plates shall be inscribed in both vernacular and the English language. The material used and inscription size of all lettering shall be to the approval of the Employer.

Labels using adhesive backed plastic materials will not be permitted.

1.4.2 Labels

All equipment and apparatus there on shall be clearly labeled in an approved manner.

1.5 Castings

All castings shall be as free from blowholes, flaws and cracks as is practicable. No welding, filling or plugging of defective parts shall be done without the sanction of the Employer and then only with his approval in writing.

1.6 Welding

In all cases where fabrication welds are liable to be highly stressed, such as may be the case in parts subjected to reversals of stresses in operation, the Contractor is to

supply the Employer with a general arrangement drawing of the fabrication and, at a later date but before fabrication commences, a detailed drawing of all proposed weld preparations on the fabrication.

Before such welding commences the Contractor is to satisfy the Employer that the welders or welding operators are qualified in accordance with the requirements of the appropriate section of BS 2654 or such other standard as may be approved.

After examining the general arrangement and welding detail drawings, the Employer will inform the Contractor of the stages at which inspection will be required. It will be the Contractor's responsibility to notify Employer when one or more of the inspection stages will be reached and no further work is to be carried out until, the specified stage has passed the Employer's inspection.

In addition to the above, the Employer or his representative reserves the right to visit the Contractor's Works at any reasonable time during fabrication of the items of plant and to familiarize him with the progress made and the quality of work to date.

In the event of the Contractor wishing to alter any part of the weld preparation, he shall first submit to the Employer a copy of the revised drawing showing the amended preparation in detail and then await confirmation of acceptance or non-acceptance.

All welding equipment, such as aggregates, transformers, cables, electrode-holders, electrodes, etc. for welding of parts and components of the equipment at the Site shall be supplied in a sufficient amount and at dates so as to warrant an un-interrupted and most expeditious progress of the welding and erection work.

The same shall apply to all pre-heating equipment, heat-sheathing, stress-relieving equipment, etc.

All such welding equipment and related material shall be of reputable make, rugged construction and of capacities to suit the purpose they are intended for.

1.7 Galvanizing

All iron and steel used in the construction of the Contract Works shall be galvanized after all sawing, shearing, drilling, punching, filling, bending and machining is completed. The zinc coating shall be uniform, clean, smooth and as free from spangle as possible. Galvanizing shall be applied by the hot dip process and, for all parts other than steel wires; shall consist of a coating of at least 610 grams of zinc per square meter of surface and be not less than 0.086 mm in thickness, and shall withstand the tests set out in ISO/R1459, 1460 and 1461 or such other standards as may be approved. Steel tower materials shall be treated with Sodium Dichromate solution after galvanizing and before shipment.

All steel wires shall be galvanized by an approved process before stranding. The zinc shall be smooth, clean, of uniform thickness, and free from defects and shall withstand the tests set out in IEC Publication 209 or such other standard as may be approved.

The preparation for galvanizing and the galvanizing itself shall not distort or adversely affect the mechanical properties of the material. After galvanizing, holes shall be free from nodules of spelter.

If any galvanized part is found to be imperfect, it shall be replaced. The whole of the expense involved in the replacement of the imperfect part shall be borne by the Contractor.

If in the opinion of the Employer, the extent of damage found on site to a galvanized part appears capable of repair, the Contractor may, after receiving such agreement in writing attempt to such repair by approved methods. The agreement to attempt repair shall not bind the Employer to accept the repaired part when this is re-offered for inspection. The Contractor has the responsibility to take care and protect properly all material on the shipment overseas.

1.8 Maintenance Tools

The Tenderer must add to the Price Schedule of Maintenance Tools along with the relevant rates and prices for any special items, in sufficient number, that may be required for maintenance of material supplied under this Contract. Line erection tackle need not be included.

Each maintenance tools and appliance is to be clearly marked with its size and/or purpose and is not to be used for erection purposes by the Contractor.

The tools and equipment with the appropriate boxes are to be handed over to the Employer at the Employer's stores depot at the time of arrival at site and not later than the Operational Acceptance Certificate.

1.9 Spare Material

Any spare material ordered by the Employer must be delivered directly into such stores as may be nominated by the Employer and delivery will not be deemed to be complete until packaged material has been opened by the Contractor, the contents checked by a Representative, or assembled into units at the Employer's option. Schedules of spare materials in triplicate shall be arranged for the easy identification and checking of material and presented to the Employer at the hand over. Prior to the handing over date for Contract spares, the Contractor shall be responsible for all security arrangements and the safe custody of the spare materials, unless they have already been delivered and accepted by the Employer at the latter stores. The Contractor shall obtain a receipt for all material handed over to the Employer.

1.10 Bolts and Nuts

Members of lattice steel structures shall be secured by means of bolts and nuts with approved spring washers conforming to ASA B27.1. All bolts and nuts shall conform to ASTM A394 or BS 916. Nuts and heads of all bolts shall be of the hexagonal type. Nuts (except lock nuts) shall be full bearing on one side.

Minimum size of bolts for all structural connections shall be 16 mm diameter.

All bolts and screwed rods shall be galvanized including the threaded portions. All nuts shall be galvanized with the exception of the threads, which shall be oiled. The nuts of all bolts attaching insulator set droppers, U bolts and earth conductor clamps to the structures shall be locked in an approved manner. The screwed thread of any bolts or studs shall not form part of a shearing plane between members. When in position, all bolts or screwed rods shall project through the corresponding nuts for at least a full turn but such projection shall not exceed 10 mm.

Where for any type of support high tensile steel bolts are employed, then bolts for this type are to be used for all connection for every type of support on that line in order to avoid the use of mild steel bolts in error where high tensile type should be employed.

Nuts shall be finger tight on the bolt and will be rejected if they are, in the opinion of the Employer, considered to have an excessively loose or tight fit. Bolts with threads re-tied after galvanizing will be rejected.

The Contractor shall request his Supplier to select two samples of each type of bolt and nut to be used in the Contract and send these two samples to the Employer at his Head Office for approval within one month of the date of issuing the sub-order. The Employer will then reject bolt consignments, which fall in any respect below the standard of samples submitted and approved.

1.11. LIMITS OF INSTALLATIONS AND DRAWINGS

1.11.1 Introduction

This section defines the terminal points for the overhead line to be supplied under this contract. All equipment within these terminal points shall be supplied by the Tenderer.

1.11.2 Terminal Points

The overhead lines shall terminate in slack spans, onto existing line-towers and substation gantry structures supplied by others. But the responsibility for installing the slack spans shall be with the line contractor.

Provision of jumpers from the slack span of sufficient length (min.6m) to terminate on the appropriate line/substation equipment shall be included under this contract together with clamps to connect the jumpers to the slack span. The connection of

the jumpers to the electrical equipment together with the necessary clamps will be the responsibility of others.

1.11.3 Specification Tender and Contract Drawings

1.11.3.1 Specification drawings

The drawings issued by the Employer with the specification and forming part of the documents for tendering purposes are intended to be descriptive of the character of the works and used in conjunction with the requirements of the specification and shall in no way limit the responsibility of the contractor to supply all plant, equipment and materials etc. to fulfill the requirements of the contract works covered by this specification. The Contractor shall investigate the Site and design accordingly without any additional cost to the Employer. Any omission from both drawing and the specification or any express reference to any detail or work necessary and obviously intended shall not relieve the Contractor of his responsibility to include that detail of work in his supply and price.

The specification drawings issued by Employer for tendering purposes are contained at the end of this Volume.

1.11.3.2 Tender drawings

Typical drawings are to be submitted with the Tender showing all essential details of construction of the various items of supply.

The following drawings must be prepared by Tenderers and accompany copy of their tender:

- Outline and general arrangements for all basic types of lattice steel structure with tower loading diagrams and loading calculations for normal and broken wire conditions.
- Details of types of foundations with volume of earthwork concrete and rebar.
- Conductor tension clamps and jumper terminals.
- Earth tension clamps and jumper terminals.
- Conductor non-tension joints.
- Suspension Insulator strings and clamps with all fittings.
- Tension Insulator strings and clamps with all fittings.
- Vibration dampers.
- Arcing horn
- Conductor final tension charts.
- Drawings and/or other data indicating the method of stringing to be adopted.
- Drawing and/or details of Tools and Equipment.

Drawings need have leading dimensions only. Structure and drawings should have provisional dimensions of principal members and shall indicate the necessary clearance dimensions for structures for still air and maximum swing of insulator strings and jumpers called for in this specification. The conductor tension charts are

to show final sags and tensions for a range of equivalent spans between those approximately 50 percent higher and lower than the basic span given, in still air at maximum, every day and minimum temperature and the tension at minimum temperature at full wind.

The successful Tenderer will be required, at the time of letting of the Contract, to supply additional copies of the above drawings as may be selected by the Employer. These drawings, together with such drawings originally issued with the Tender Documents will then form part of the Contract Document and be signed both by the Employer and the Contractor for identification purposes.

1.11.3.3 Contract Drawings and Documents for Approval

1.11.3.3.1 General

All designs and drawings submitted with the successful Tender shall be considered preliminary only and not to be considered as approved. Prior to commencement of the work, the Contractor shall submit drawings and data to the Engineer for approval. Should the Engineer direct that modifications be made in order to satisfy the requirements of the Specifications, the Contractor shall submit revised drawings for approval. Alteration in the Contract price shall not be allowed by reason of the drawing modifications.

The Contractor shall submit the following drawings and data to the Engineer for approval:

(a) Survey drawings, including:

1 Route maps.
2 Centre-line plans and profiles of each line
3 Optimized tower spotting drawings.
4 Soils survey map identifying foundation type selected for each individual tower.

(b) Tower drawings consisting of:

1 Detailed design drawings and calculations for each type of tower and leg extension; tower loading calculations and diagrams.

2 Detailed design drawings including tower framing, size and length of each member; spacing holes in each member; number, size and lengths of bolts and fillers at each joint, detail of bolts, nuts, locknuts, fillers, washers and spring washers, and detail showing attachments of insulator assemblies and overhead ground wire assemblies and tower signs.

(c) Proposed procedure for applying loads and measuring deflections and other pertinent data during tower tests.

(d) Tower foundation drawings consisting of design drawings, calculations, volumes and weight of re-bar.

(e) Each type of insulator string assembly with all fittings.

(f) Line accessories consisting of sleeves, splices, vibration dampers, patch rod, etc.

(g) Detailed drawings of grounding materials and ground connection consisting of ground electrodes, ground connecting strip, ground connecting bolts, counterpoise and list of ground electrodes for each tower.

(h) Initial sag and tension tables for conductors and overhead ground wire including details of calculations necessary for stringing

Approval of the Contractor's drawings shall not in any way relieve the Contractor of any part of his obligation to meet all the requirements of the Contract or of the responsibility for the correction of the drawings.

The drawings and data for approval shall be submitted in the following manner and designated deadlines:

I. Survey:

- Survey maps with tower spotting and other details of each sector within 30 days after completion of survey of each sector.

II. Towers

Design drawings and calculation for each type of tower and leg extension:

- 4 copies within 60 days after Effective Date.

Detail drawings for each type and leg extension:

- 4 copies within 60 days after Effective Date.

Bills of materials

- 4 Copies within 30 days before each shipment.

III. Test procedures:

Towers:

- 4 copies not less than 60 days before date fixed for test.

Insulators, hardware and fittings:

- 4 copies within 60 days before date fixed for test.

Sub-soil tests:

- 4 copies within 30 days before date fixed for test.

Ground electrical resistance:

- 4 copies within 30 days before date fixed for test.

Piles:

- 4 copies within 60 days before date fixed for test.

IV. Tower foundations

Design drawings and calculation for each type:

- 4 copies within 60 days after the Effective Date

Detail drawings for each type:

- 4 copies within 90 days after Effective Date.

Foundation list:

- 4 copies within 30 days after completion sub soil tests and foundation design.

Tower grounding:

Detail drawings:

- 4 copies within 60 days after the Effective Date.

List of ground electrodes:

- 4 copies within 30 days after complete ground resistance tests

Drawings and/or catalogues of insulators, hardware and fittings:

- 4 copies within 90 days after the Effective Date.

V. Modified approval drawings

- 4 copies within 30 days after receipt of returned drawings and data for correction.

VI. Final drawings

Prints of design drawings and calculation for all surveys, towers and tower foundations:

- 5 copies of each within 30 days after receipt of approved drawings.

VII. As Built Drawings

-5 copies of all drawings and list of materials, tower schedules, etc. 30 days before the issuance of the Operational Acceptance Certificate.

VIII. Reproducible

Surveys:
-2 copies 30 days before the issuance of the Operational Acceptance Certificate.

Towers
Details drawings for all towers:
- 2 copies within 30 days after receipt of approved drawings.

Bills of materials and tower schedules
- 2 copies within 30 days after receipt of approved drawings.

Tower foundations
Detail drawings:
- 2 copies within 30 days after receipt of approved drawings.

Foundation list:
- 2 copies within 30 days after receipt of approved drawings.

Tower drawings:
Detail drawings:
- 2 copies within 30 days after receipt of approved drawings.

List of ground electrodes:
- 2 copies within 30 days after receipt of approved drawings.

Insulators, hardware and fittings:
- 2 copies within 30 days after receipt of approved drawings.

Other materials:
- 2 copies within 30 days after receipt of approved drawings.

IX. CD ROM of final/as-built drawings

- 2 each within 30 days before the issuance of the Operational Acceptance Certificate.

X. Test reports

Shop tests and field tests:

- 5 copies immediately, but not later than 15 days after completion of tests.

XI. Instruction manuals and lists of operation and maintenance tools

- 8 sets not later than 30 days before shipment.

1.11.3.2 Drawings: Titles and Sizes

The title of Contractor's drawing shall also include the followings:

a) Rasuwagadhi Hydropower Company Limited.
b) Name of the Project:
c) Contract No.
d) Name of the Transmission Line Section (if applicable)
e) Description of Transmission Line Section (if applicable)

the signature of the Contractor's engineer and the date shall appear in the bottom right-hand corner of each drawing. The Contractor shall use any one of the following sizes for the preparation of drawings.

AO	841 x 1189 mm	(33.11 x 46.81 in)
A1	594 x 841 mm	(33.39 x 33.11 in)
A2	420 x 594 mm	(16.54 x 23.39 in)
A3	297 x 420 mm	(11.69 x 16.54 in)
A4	210 x 297 mm	(8.27 x 11.69 in)

1.11.3.3 Employer approval

Unless specified differently elsewhere, each review period of the Contractor's Document shall not exceed **thirty-five (35) days**, calculated from the date on which the Engineer/Employer receives the Contractor's Document and the Contractor's notice at his office.

The Employer or its designated Engineer will, within the review period, give notice to the Contractor about the status of the documents/drawings submitted for approval, marked either as "APPROVED", "APPROVED EXCEPT AS NOTED", or RETURNED FOR CORRECTION".

The notations "APPROVED" or "APPROVED EXCEPT AS NOTED" will authorize the contractor to proceed with the manufacturing drawings, subject to the corrections, if any, indicated thereon. The notation "RETURNED FOR CORRECTION" shall require the Contractor to make the necessary revisions on

the drawings and submit for approval within **twenty-eight (28)** days in the same manner as before.

Approval of the Contractor's documents/drawings shall not in any way relieve the Contractor of any part of his obligation to meet all the requirements of the Contract or of the responsibility for the correction of the drawings.

Reproducible (CD-ROM): CD-ROM of all final approved drawings shall be submitted.

1.12 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.

1.13 Design Review Meeting

The Contractor will be called upon to attend design review meetings with the Employer, during the period of Contract.

The Contractor shall attend such meetings at his own cost at the 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.

1.14 Progress Reports

Before the tenth (10th) day of each calendar month the Contractor shall submit copies of the monthly progress reports in a format acceptable to the Employer/Engineer, detailing the progress of the work during the preceding month. The document shall report on the status of the work during the whole duration of the contract, starting from the commencement date. The report shall contain, but not be limited to, the following information:

- General descriptions of the Works performed during the reporting period on each main activity and include notable problems, which were encountered.
- The percentages of each main work activity completed during the reported month compared with the scheduled program. Appropriate comments shall explain any differences.
- The total overall percentages of erection work completed with reference to the actual construction program. Appropriate comments shall explain any differences.
- A list of all activities of scheduled and actual progress during the reporting period including actual starting dates compared with scheduled

starting dates and actual completion dates compared with scheduled completion dates for each activity. Appropriate remarks shall explain any differences.

- A list of activities scheduled to be started within the next period of 90 day, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the actual construction programme, an explanation shall be given.
- A list of local manpower (by trade classification) employed during the reporting period.
- A list of expatriate personnel (by position) employed during the reporting period.
- A list of the Contractor's equipment and materials presently stored at Site. A list of equipment and materials which arrived at the port of entry and is in the process of being cleared through customs shall also be included.
- Progress photographs of significant events. The Employer may ask to include specific photographs if deemed necessary.
- Main items of temporary facilities constructed during the reporting period.
- A statement detailing the status of progress on the overall program and how to regain any lost time or setbacks, which may have occurred.
- A list of inoperable, temporary equipment and the estimated date when the repair will be completed.
- A statement about labor relations and an explanation of an actual or potential problem.
- A list of accidents at site involving the hospitalization and/or death of any person.
- A statement concerning effectiveness of the security programme and a list of major thefts.
- A list of the amount and date of any payments received during the reporting period and the amount of any monthly invoice, which has been submitted but not yet paid.
- A statement concerning potential problems and recommendations on how they could be solved.

1.15 Progress Meetings

The Contractor shall be required to attend regular Site Progress Meetings with the Employer where the progress of the Works will be reviewed. Such meetings shall normally be held monthly after submission of the draft monthly progress report specified in the Contract, however depending upon the requirements, progress meetings shall be held biweekly or monthly. The Contractor shall present the specified draft biweekly and monthly progress report to the Employer before the meeting at a time to be agreed for circulation to participants by the Employer.

The Contractor shall be represented at all meetings by a responsible representative who has the power to commit the Contractor in all matters

concerning the Contract. The Employer may direct that representatives of the Contractor's subcontractors attend the Progress Meetings and/or weekly and/or other meetings.

The Progress Meeting agenda will include approval of the minutes of previous meetings, a report on progress of design, manufacture, transportation, installation, commissioning and training in relation to the programme, matters arising from any difficulties encountered in the Works and specific items on safety and accidents, community and labour relations and environmental management.

The Employer will chair the meeting and the Contractor shall record points of decision, action, agreement (or not), and will draft Minutes which will be presented to the meeting participants within 3 days after the meeting. If no comments have been submitted by the Employer prior to next progress meeting in writing, the Minutes shall be deemed to have been accepted by the Employer and to be a true record of the declarations, instructions and decisions taken during the meeting.

The Contractor will be required to attend other meetings from time to time on other subjects.

1.16 Site Data

All plant and equipment supplied under the contract shall be entirely suitable for the climatic conditions prevailing at site.

Between June and August low-lying areas are subject to flooding.
Horizontal seismic coefficient is 0.2

Atmospheric pollution is low and special insulator design or washing is not required.

Maximum ambient shade temperature	45 degree C
Minimum ambient shade temperature	0 degree C
Annual average temperature	32 degree C
Wind Zone (as per IS: 875)	4
Basic Wind Speed	47 m/sec
Rainfall	1,000 mm/annum
Monsoon season	June-August
Relative humidity,	maximum 100 % minimum 20 %
Altitude	maximum 2301.63 MSAL minimum 1634.21 MSAL
Ice & snow thickness	0 mm
Atmospheric pollution	Light
Isokeraunic level (thunderstorm days)	50

The information in this Clause is given solely for the general assistance of Tenderers and no responsibility for it will be accepted or will any claim based on this Clause be considered.

The Tenderer is advised to survey the sites covered under this Contract to acquaint himself with site conditions.

1.17 Applicable Standard

All equipment, materials, fabrication and tests under these specifications shall conform to the latest applicable standards, manuals and standards contained in the following list or to standards, manuals and specifications approved as equal by the Employer. Any details not specifically covered by these standards and specifications shall be subject to approval of the Employer. In the event of contradictory requirements between the standards and these specification requirements, the terms of the specifications shall apply.

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standard Institute, Inc.
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
BS	British Standard Institution
EEI	Edison Electric Institute
IEC	International Electro technical Commission
NEMA	National Electric Manufacturers Association
AASHO	American Association of State Highway Officials
IEEE	Insttitute of Electrical and Electronics Engineers
IS	Bureau of Indian Standard
ISO	International Organization for Standardization
CSA	Canadian Standard Association
DIN	Deutsches Institute Für Normung

1.18 Design

In complying with the requirements of the Technical Specifications both with respect to arrangements and details, design shall conform to the best current engineering practice. Every component shall be of the manufacturers standard design, provided that this design is in general accordance with the equipment/material specifications and it shall use components proven to be satisfactory by previous experience.

The design shall duly consider the requirements of easy operation, maintenance and replacement of worn parts as well as a long life or service under the prevailing site conditions.

All equipment/material, including its accessories and auxiliaries, shall be built and installed to facilitate inspection, cleaning, maintenance and replacement work. Identical parts must be fully interchangeable between themselves and with the spare parts. Except in cases where for functional reasons, or due to a specific design, a special arrangement of the equipment is necessary, the inspection, maintenance and replacement of the part of the equipment shall, as far as practicable, not entail a preceding dismantling of other permanently installed equipment.

The design, dimensions and materials of all parts shall be such that they will not suffer damage even after prolonged service as a result of stresses under the most severe service conditions. The material used in the construction of the equipment shall be of the highest quality and selected particularly to meet the duties required of them. The equipment shall be designed and constructed to minimize corrosion. Water must not collect at any point. Workmanship and general finish shall be of the highest class throughout. Surface protection must be corrosion proof under subtropical climate conditions.

The equipment shall also be designed to prevent, where practical and/or required, the ingress of all vermin, accidental contact with live parts and minimize the ingress of dust and dirt. Specific requirements concerning dust proofing, if any, are specified elsewhere in this document. The ambient conditions on the Site have to be taken strictly into consideration.

The development of condensation water in electrical equipment must be avoided even under the most adverse conditions.

In the overall and detailed design of the equipment and in installing the equipment, utmost attention shall be given to fire and fire-propagation protection, safety of the operating and maintenance staff and protection of the environment.
In designing the works under the Contract, and in case of different facilities at different locations being engaged in the process, the Contractor shall take utmost care of full coordination in every respect.

1.19 Packaging

- All the materials manufactured at the manufacturer's works shall be labeled “RGHPCL132kV/DC” before the inspection is being carried out.
- 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.
- 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.
- 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.

- 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.
- 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.
- Angle section shall be wire bundled.
- Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tested and bolted together in multiples or securely wired through holes.
- Bolts, nuts washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.
- The packing shall be properly done to avoid losses & damages during transit. Each bundle or package shall be appropriately marked.

1.20 Storage of Materials

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

1.20.1 Cement Storage

Cement received at site should be stored in a building or shed which is dry, leak proof and moisture proof. The building should have minimum numbers of windows. Cement bags stored and stacked off the floor on wooden planks in such a way so as to keep about 150 mm to 200 mm clearance from the ground. The floor may be of lean cement concrete or two layers of dry bricks laid on well consolidated earth. A minimum space of 600 mm shall be kept around and between the exterior walls and the stacks. In stacks, bags shall be kept close together to reduce air circulation. The height of the stack shall not be more than 12 bags and the width of the stack shall not be more than four bags or 3 meters.

For extra safety during monsoon, or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a waterproofing membrane such as polyethylene etc. Different type and make of cement shall be stacked and stored separately.

1.20.2 Aggregates

Aggregates shall be stored at site on a hard dry and level patch of ground. If such a surface is not available, a platform of planks or old corrugated iron sheets, or floor bricks or a thin layer of lean concrete shall be made so as to prevent contamination with clay, dust, vegetable and other foreign matter. The stacks of fine and coarse aggregates shall be kept in separate stock piles sufficiently removed from each other

to prevent the material at the edges of the piles from getting intermixed. Fine aggregate shall be stacked in a place where loss due to the effect of wind is minimum.

1.20.3 Reinforcement Steel

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

1.20.4 Structural Steel or Tower Plate

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

1.20.5 Conductor and Earthwire Drums

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

1.20.6 Hardware fitting, Accessories and Insulators

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

1.21 Contractor's Execution Plan

The Contractor shall submit a detailed plan for resources mobilization & execution of various activities under the project scope within two months after the award of the contract to be approved by Employer.

The detail should also cover the locations and size of stores to be established by the contractor.

The Contractor shall deploy a Project Manager at site who shall not be changed without the consent from the Employer, once deployed. The work at site shall be carried out after permission from the Employer and with proper consent of the Land, Employers and forest officials.

VOLUME: II

SECTION: VI

PART B

PARTICULAR TECHNICAL SPECIFICATION OF TRANSMISSION LINE

CHAPTER 1

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:

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

1.1.2 The towers shall be self-supporting, square base, hot dip galvanized, latticed steel type & designed to carry the line conductors with necessary insulators, OPGW & earth wire and all fittings under all loading conditions. Outline diagram of double circuits 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 132 kV double transmission line are classified as given below:

Type of Tower	Deviation Limit	Typical Use
For Double circuit towers:		
DA	0 – 2 deg.	To be used as tangent / suspension Tower with Suspension insulator string
DB	2 - 15 deg.	a) Angle tower with tension insulator string. b) Also to be used for uplift force resulting from an Up-lift span up to 400m under broken wire Conditions. c) Also to be used for Anti Cascading Condition.
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 550m under broken wire condition. c) Also to be used for Anti Cascading Condition.
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.

Notes:

i) All above towers shall be designed for double circuit strung condition and also considering that all conductors, OPGW and earth wire on the top of both circuits shall be placed on both sides of the tower.
ii) All above towers can also be used for longer span with smaller angle of deviations without infringement of ground clearance.

1.2.2 Extensions

1.2.2.1 The Double Circuit towers shall be designed so as to be suitable for adding -4.5M, –3M, -1.5M, 0M, 1.5M, 3M, 4.5M, 6M, 7.5M and 9M body extensions / leg extensions 132 kV line 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.

1.2.2.2 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 220 meters for 132 kV line.

1.2.2.3 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.

1.2.2.4 All above body and leg extension/reduction provisions to towers shall be treated as part of normal (basic) tower only.

1.3 Spans

1.3.1 Design Span or Normal Span

The Design Span or Normal Ruling Span of the line is 330m for 132 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 points 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 1.1a
(For 132 kV Line)

Tower Type	Normal Condition		Broken Wire Condition	
	Max. (m)	Min. (m)	Max. (m)	Min. (m)
DA	420	-	250	-
DB, DC700	420	-	-	
DD	700	-	420	-

Design Span for 132 kV Line

Tower Type	Ruling Span, m	Wind Span, m	Weight Span, m

DA	330	350	700
DB & DC	330	550	1000
DD/DDE	330	550	1000

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 7000 mm for 132 kV line at the maximum sag conditions i.e. at 80°C and still air.

a) An allowance of 150mm for 132 kV line shall be provided to account for errors in stringing.

b) Conductor creep shall be compensated by over tensioning the conductor at a temperature of 20°C, lower than the stringing temperature for ACSR single "Bear" for 132 kV D/C transmission line.

1.4.2 Power Line Crossing

Minimum clearance between power lines to power line crossing should be 3500 mm for 132 kV transmission line.

1.4.3 Live Metal Clearance

The minimum live metal clearance to be provided between the live parts and steel work of superstructure for 132 kV transmission lines shall be as given in Table 1.2

Table 1.2

Description	Swing Angle	Live Metal Clearance in mm
		2000 m EL
		132 kV
	NIL	
Suspension String (Single / Double)	15 Degree	1530
	30 Degree	1370
	45 Degree	1220
	60 Degree	1070
Tension String (Single / Double)	--	
Jumper	NIL	
	10 Degree	1530
	20 Degree	1070
	30 Degree	1070

NOTE: IN CASE OF PILOT INSULATOR STRINGS, THE ANGLE OF SWING OF THE JUMPER

ALONGWITH THE PILOT STRING SHALL BE CONSIDERED AS 15 DEG.

1.4.4 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.

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

1.4.6 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.

1.4.7 Conductor and OPGW clearance

For all supports the clearances from conductors, arc horns jumper loops and all live metal to the structure or earthen steel work shall not be less than those specified in Schedule A.2. Where uplift conditions occur at tension tower positions detail should be provided to show that the above requirements are not infringed.

The length of angle structure cross-arm shall be such as to ensure that the distances between conductors from straight line structures are maintained in a plain normal conductor.

The phase distance: the minimum distance between testing point at insulators shall set as per standard practice at IEC or any other standards. Allowance shall be made for increasing or decreasing the length and varying the arrangement of all terminal tower cross arms to enable span connections to be made in any desire phase sequence.

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/earth wire and outer power conductor in still air at tower supports, to the vertical line through the centre line of the OPGW/earth wire. 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/earth wire clamp equal to 150 mm should be considered while calculating the minimum angle of protection.

1.4.9 Clearance between phases

The clearance between the line conductors and ground in still air under the maximum specified temperature and final tension shall not be less than the figure stated Schedule A.2. An additional clearance of 0.5 m is required to allow for long term conductor creep, which shall be included in the calculation of tower heights.

Where obstruction of other types is met requiring special clearance the clearance shall be approved by the Employer. If after the survey and profile is approved any factors

likely to cause infringement of clearance become apparent the contractor shall inform the Employer immediately.

The sag of the earth wire for the basic span at the highest temperature still air shall be 80 percent of the phase conductors. The distance between conductors belonging to different circuits shall be 1.20 times the distance belonging to the same circuit. However, the distance shall not be smaller than 3.0 m.

1.4.10 Erection loads

Bidders shall fully consider the loading conditions for the towers and provide adequate margins of strength in the designs for unbalanced erection loadings. The Bidder shall indicate on Tender drawings to which points on the towers to be proposed to use back stays when stringing conductors and shall state what factors of safety are obtained under these conditions.

1.4.11 Design

The design of all supports, conductors, insulators and fittings shall be such as to minimize the risk of damage or deterioration in service of any part of the transmission lines due to vibration.

The calculation procedures applied for support and foundation design shall be showed by Bidder.

1.4.12 Mid Span Clearance

The minimum vertical mid span clearance between the earth wire and the nearest power conductor shall not be less than 6.1 meters for 132 kV, which shall mean the vertical clearance between earth wire and the nearest conductor under all temperatures and still air condition in the normal ruling span. Further, the tensions of the OPGW/earth wire and power conductor shall be so co-ordinated that the sag of OPGW/earth wire shall be at least 10% less than that of power conductors under all temperature loading conditions.

1.5 Loading Conditions

1.5.1 The conductors, insulators, accessories and towers shall withstand the following load combinations:

1. Minimum temperature

   This combination includes:
   - the weight or structures, conductors and accessories
   - the conductor loads in min. temperature condition

2. Maximum wind

   This combination includes:
   - the weight of structures, conductors and accessories
   - the conductor loads in max. wind conditions
   - the wind load on the structure, conductors and accessories

3. Broken wire

   This combination includes:

- the weight of the structures, conductors and accessories
- The load due to breakage of one conductor or earth wire tension reduced to 60 % of the max. Working tension
- Other loads as in normal condition at EDS temperature

4. Conductor stringing

This combination includes:

- the weight of the structures, conductors and accessories
- the loads due to stringing of the conductors in the stringing conditions

Loading diagrams for each condition

1.6 Normal Loading Conditions

1.6.1 Loads at Conductor, OPGW and Earth wire Points

The Contractor shall develop the tower designs based on the loadings of the conductors on both circuits including OPGW and Earth wire.

1.6.2 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 category shall be considered as 2.

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

1.6.3 Maximum Tension

1.6.3.1 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.

1.6.3.2 The initial conductor and OPGW and earth wire 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/earth wire.

1.6.4 Limiting Tensions of Conductor & OPGW/Earth wire

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

1.6.5 Broken Wire Condition

1.6.5.1 Suspension Tower Type DA

Any one phase or OPGW/earth wire broken; whichever is more stringent for a particular member.

1.6.5.2 Tension Tower Type DB and DC

Breakage of any two phases on the same side and on the same span or breakage of any one phase and one OPGW and one earth wire on the same side and same span whichever combination is stringent for a particular member.

1.6.5.3 Tower Type DD/DDE

Breakage of all the three phases on the same side and on the same span or breakage of two phases and one OPGW/earth wire on the same side and on the same span, whichever combination is more stringent for a particular member.

1.7 Design of Towers

1.7.1 Design Criteria

Towers shall be designed based on spans and clearances as per Clause 3.3 & 3.4 and loading conditions as per Clause 3.5 above.

1.7.2 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) Earth wire exposed to sun	:	53 deg. C

1.7.3 Conductor and OPGW/Earth wire 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 3.5m for 132 kV vertically for DA, DB and DC and DD/DDE towers. However, the minimum horizontal separation between phase conductors of two circuits shall be 7 meters for 132 kV. In double circuit suspension towers single suspension vertical (I-type) insulator strings shall be used.

1.7.4 Redundant Design

1.7.4.1 All redundant in the tower are to be triangulated.

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).

1.7.4.1.1 All redundant shall be designed individually for 2.5% of maximum axial load of connecting members (i.e. leg members, bracing members etc.). The Contractor has to furnish the calculations for the same.

1.7.4.1.2 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.

1.7.5 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 : 6 mm earth wire peak and main cross arm

b) For all other members : 4 mm

1.7.6 Bolts and Nuts

1.7.6.1 The minimum bolt spacing and rolled edge distance and sheared edge distance from the centers of bolt holes to be maintained for 132 kV transmission line are given in Table 1.3a.

TABLE 1.3a

Diameter of Bolt (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 45 mm

1.7.6.2 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.

1.7.7 Slenderness Ratio

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

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

1.7.7.3 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:

Slenderness ratios for members for 132 kV line shall be limited as follows:

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

1.7.8 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**.**

1.7.9 Structural Arrangement of Members in a Tower

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

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

Design Calculation and Drawings

1.7.10 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 DC type towers for 132 kV double circuits line.

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.

1.7.10.1 After successful testing of tower and subsequent approval of design, drawings and bill of materials, the Contractor shall furnish the following in four (4) 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.

1.7.10.2 The Contractor is required to submit four copies of the drawings as mentioned in clause 3.7.10.1 for Employer 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 Employer's 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.

1.7.10.3 The design and drawings as covered in clause 3.7.10.1 (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 Employer's 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.

1.7.10.4 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.

1.7.10.5 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.

1.7.10.6 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 EMPLOYER UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM EMPLOYER IN WRITING.

1.8 Materials

1.8.1 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 plates are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS: 2062 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 Employer before any substitution.

1.8.2 Fasteners: Bolts, Nuts and Washers

1.8.2.1 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 galvanized as per IS: 1367 (Part-13) / IS: 2629.

1.8.2.2 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).

1.8.2.3 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.

1.8.2.4 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.

1.8.2.5 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.

1.8.2.6 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.

1.8.2.7 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.

1.8.2.8 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.

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

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

1.8.2.11 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.

1.9 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.

1.9.1 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 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.

1.9.2 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 140 KN for 132 kV double suspension string suspension towers. The design and supply of hanger, D-shackles, strain plates etc. are also in the scope of Contractor.

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

1.9.3 OPGW/Earth wire Clamp Attachments

a) Suspension Clamps

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

b) Tension Clamps

OPGW/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 approval for details of the attachments before the mass fabrication.

1.9.4 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.

1.9.5 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.

1.10 Tower Fabrication

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

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

1.10.1.1 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.

1.10.1.2 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.

1.10.1.2 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.

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

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

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

1.10.5 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.

1.10.6 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.

1.10.7 Drilling and Punching

1.10.7.1 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.

1.10.7.2 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.

1.10.7.3 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.

1.10.8 Erection mark

1.10.8.1 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.

1.10.8.2 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"

1.11 Quantities and weights

1.11.1 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.

1.11.2 The estimated unit weight of each type of galvanized towers, stubs and leg extensions shall be furnished by the bidder. The weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. un-galvanized) weight of steel members of the size indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weights due to holes, notches and bevel cuts etc. but taking into consideration the weight of the anti-climbing 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.

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

1.12 Galvanizing

1.12.1 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 Employer along with Quality Assurance Program.

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

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

1.12.2. 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.

1.13 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 Code of practice for Earthing.

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

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

1.13.2 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.

1.13.3 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.

1.14 Inspection and Tests

1.14.1 General

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

1.14.2 Inspection

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

1.14.2.1
a) The Contractor shall keep the Employer informed in advance about the time of starting and of the progress of manufacture and fabrication of various 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.

1.14.2.2 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.

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

1.14.2.4 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 Employer or his authorized representative considers that the defects can be rectified.

1.14.2.5 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.

1.14.2.6 All gauges and templates necessary to satisfy the Employer shall be supplied by the Contractor.

1.14.2.7 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.

1.15 Tower Load Tests

1.15.1 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 program 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 programs the Contractors will intimate the Employer about carrying out the tests at least 30 days in advance of the scheduled date of tests during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests. 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 Engineer/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.

1.15.1.1 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.

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

1.15.1.3 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.

1.15.1.4 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 for 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.

1.15.1.5 Each type of suspension tower to be tested (132 kV D/C) shall be a full scale prototype galvanized tower and shall be erected vertically on rigid foundation of the stub protruding above ground level as provided in the design/drawing between ground level and concrete level. This portion of the stub shall be kept un-braced while testing. The tower erected on test bed shall not be out of plumb by more than 1 in 360.

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

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

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

1.15.1.9 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.

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

1.15.2 Method of Load Application

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

1.15.2.2 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.

1.15.2.3 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.

1.15.3 Tower Testing Procedure

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

1.15.3.1 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.

1.15.3.2 Normal Broken Wire Load Tests

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

25 percent,

50 percent,

75 per cent,

90 percent,

95 percent and

100 percent

1.15.3.3 Observation Periods

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

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

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

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

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

1.15.3.4 Recording

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

1.15.3.5 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.

1.16 Packing

1.16.1 Angle section shall be wire bundled.

1.16.2 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.

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

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

1.17 Standards

1.17.1 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) or equivalent 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.

1.17.2 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 Towers	Bolts for Transmission Line	

CHAPTER 2

LINE CONDUCTORS AND ACCESSORIES

2.1 General

The scope of work comprises of manufacture, factory test, supply, stringing and commissioning of ACSR "Bear" conductor, optical ground wire and along with Composite long rod insulators and line hardware for about 10.5 km Rasuwagadhi Hydroelectric project – Chilime Hub 132 kV transmission line.

The Contractor shall ensure complete supervision by competent technical personnel(s) during installation, testing and commissioning of the whole 132kV Transmission line system in totality under the project. The supervision shall also include the on-site training to the Employer's Representatives(s).

The proposed manufacturers of ACSR conductors, insulators, optical ground wire and hardware, and optical fiber ground wire shall meet the following criteria. The plant/equipment must have been type-tested and certified by an international reputable laboratory.

The manufacturers of conductor, insulators and hardware must meet the qualification requirements as specified in Instructions to Bidders.

2.2 Conductor Specification

All conductors shall be of aluminum conductor steel reinforced (ACSR) construction and shall be manufactured in strict conformity with BS 215 (Part 2)/IS or IEC:1089 except where otherwise specified herein. Bidders must offer conductor and wire from reputed and experienced manufacturers.

The steel core and the first layer of aluminum of ACSR conductors shall be greased. The grease shall be of neutral type and at a temperature of 100-degree centigrade, the grease shall neither flow within nor extrude from the conductor. The grease shall retain its properties as resistance to oxidization and chemical stability at all service temperatures.

The outermost layer of all conductors shall be stranded with right hand lay.

The correct tension must be maintained on the stranding machine when spinning the cable to avoid the possibility of bird caging during stringing. Any conductor not complying this may be rejected at the discretion of the Employer.

The purity of the aluminum shall be the highest commercially available and shall not less than 99.5%, the copper content not exceeding 0.04%. The Contractor shall submit certificates of analysis giving the percentage and nature of any impurities in the metal from which the wires are made. Aluminum wires shall be made to BS 2627 and steel wires to BS 4565.

Precautions shall be taken during the manufacture, storage and erection of steel-cored aluminum conductors to prevent the possibility of contamination by copper or other materials, which may adversely affect the aluminum. The manufacture of steel-cored aluminum conductors shall be carried out in a portion of the factory specially set aside for such purposes. Machinery previously used in the

manufacture of copper or copper-bearing conductors shall not be used for the manufacture of these aluminum or steel wires.

2.2.1 Conductor size

The size and composition of all phase conductors shall be as stated in Schedule A.5, Chapter 8.

2.2.2 Conductor Drum Lengths

Conductors shall be supplied on drums of approved construction and the drums shall be securely battened to protect the conductor. Drum battens shall not be removed until the drum is properly mounted at the drum station on the line and battens shall be immediately refitted to the drum if any surplus conductor is left thereon.

Each drum shall be marked gross weight, net weight, the length and size of the conductor and, in addition, the conductor manufacturing batch number shall be inscribed on the drum. Empty drums shall become the property of the Employer and be returned by the Contractor to the Employer's stores designated by the Employer. The maximum length of conductor shall not exceed 2 km per drum.

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.

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

2.2.3 Workmanship

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

Precautions shall be taken during the manufacture, storage and erection of steel-cored aluminum conductors to prevent the possibility of contamination by copper or other materials, which may adversely affect the aluminum. The manufacture of steel-cored aluminum conductors shall be carried out in a portion of the factory specially set aside for such purposes. Machinery previously used in the manufacture of copper or copper-bearing conductors shall not be used for the manufacture of these aluminum or steel wires.

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.

The steel strands shall be hot dip galvanized and shall have a minimum zinc coating of 260 grams/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/ BS 4565.

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.

The steel core and the first layer of aluminum of ACSR conductors shall be greased. The grease shall be of neutral type and at a temperature of 100-degree centigrade, the grease shall neither flow within nor extrude from the conductor. The grease shall retain its properties as resistance to oxidization and chemical stability at all service temperatures.

The outermost layer of all conductors shall be stranded with right hand lay.

The correct tension must be maintained on the stranding machine when spinning the cable to avoid the possibility of bird caging during stringing. Any conductor not complying this may be rejected at the discretion of the Employer.

2.2.4 Joints in wires

2.2.4.1 Aluminium wires

Joints in aluminium wires shall be as per relevant International Standard.

2.2.4.2 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.

2.2.5 Materials

2.2.5.1 Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%. They shall have the same properties and characteristics as prescribed in IEC: 889/ BS 2627.

2.2.5.2 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 properties and characteristics as prescribed for regular strength steel wire in IEC: 888/ BS 4565.

2.2.5.3 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 or equivalent.
The Contractor shall submit certificates of analysis giving the percentage and nature of any impurities in the metal from which the wires are made.

2.2.6 Tests

2.2.6.1 Type Tests

In accordance with the stipulation of specification, the following type tests reports of the earth wire shall be submitted for approval.

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 or equivalent

2.2.6.2 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 strands	
d)	Check for lay-ratios of various layers	
e)	Galvanizing test on steel strands	
f)	Torsion and Elongation tests on steel strands	
g)	Breaking load test on steel and Aluminium strands	
h)	Wrap test on steel & Aluminium strands	IEC: 888 & 889
i)	DC resistance test on Aluminium strands	IEC: 889
j)	Procedure qualification test on welded joint of Aluminium strands	Annexure-A
k)	Drum marking check	

Note: All the above tests except (a,b and k) shall be carried out on aluminium and steel strands after stranding only.

2.2.6.3 Routine Tests

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

2.2.6.4 Tests during Manufacture

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

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 the conductor.

2.2.7 Additional Tests

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 him that the materials comply with the Specifications.

The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test centre. In case of evidence of non compliance, it shall be binding on the part of Supplier to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items all without any extra cost to the Employer.

2.2.8 Test Reports

- Copies of type test reports shall be furnished in at least two copies for employer approval.
- Copies of acceptance test reports shall be furnished in at least four (4) copies. One copy shall be returned duly certified by the Employer, only after which the material shall be dispatched.
- Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.
- Test Certificates of tests during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Employer.

2.2.9 Test Facilities

The following additional test facilities shall be available at the Supplier's works:

- Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer etc.
- Standard resistance for calibration of resistance bridges.

- 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.

2.2.10 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.

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

k) Number of turns in the outer most layer.

l) Gross weight of drum after putting lagging.

m) Tear weight of the drum without lagging.

n) Net weight of the conductor in the drum.

o) Material Inspection & Clearance certificate No.

The above should be indicated in the packing list also.

2.2.11 Verification of Conductor Length

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

2.3 Earth-wire/OPGW

Shield wires are to be made electrically continuous at each suspension and tension towers by bolted jumpers or other approved means and are to be bonded to the tower steelwork by an approved removable link on all supporting structures.

Bidders must offer E.H.S earth-wire with in closed optic fibers from reputed and experienced manufacturers. The optic fibers, properly surrounded by steel wire around, shall form the optical ground wire (OPGW) system.

The technical characteristics of the earth wire are stated in Schedules A.6 and A.7 of Chapter 8.

2.4 Creep of ACSR-conductors

When stringing ACSR-conductors, the creep shall be taken into account. A suitable method is stringing the conductor to a higher tension. This is expressed as a temperature difference corresponding to the estimated creep.

Unless more reliable data is available, the temperature difference for Bear-conductor of 20°C may be used.

2.5 Conductor and Earth-wire Accessories and Hardware-Fittings

Bidders must offer conductor and earth wire accessories and hardware-fittings from reputed and experienced manufacturers.

2.5.1 String Metal Work-Galvanizing

All ferrous metal, forming a component part of insulator units and used in the fabrication of accessories, shall be galvanized.

2.5.2 Shackles

Shackles shall be of malleable iron to BS 3288 and supplied with shackle pin, washer and retaining split-pin and shall be of such dimensions as to ensure the factors of safety specified in Schedule A.3 of Chapter 8 are maintained.

2.5.3 Arcing Horns

The design of all insulator sets shall be such that the line and earth end fittings shall be suitable for mounting of arcing horns. Arcing horns shall be provided in accordance with the drawings attached.

Tension string arcing horns shall provide a single arc path above the upper surface of the insulator string. The design of arcing horns shall be such as to prevent cascading of the arc over the line and insulator units in the events of flashover. The life and general shape of the arcing horns shall be such as to give a maximum value of impulse flash over voltage, consistence to the above requirements. Insulator strings and arc fittings shall be subjected to such tests as the Employer/Employer's representative may require proving compliance with the requirements without extra cost to the Employer.

2.5.4 Conductor-End Metal Work

All conductor-end metalwork such as socket-tongue adapters, yoke plates, conductor clamps, socket clevises, tension clamps etc., shall be of approved design and shall comply with the requirements of this specification.

2.5.5 Joints

Conductor joints and clamps shall be designed in accordance with BS 3288. The electrical conductivity and current carrying capacity of each joint or complete clamp assembly shall not be less than the equivalent length of conductor.

Tension joints shall be of approved design and shall be made so as not to permit slipping of or cause damage to or failure of the complete line conductor or any part thereof, at a load less than 95% of the ultimate strength of the conductor with which they are to be used.
Tension joints shall be of the tubular compression type, requiring only one set of dies. All aluminum compression joints shall be of at least 99.5% pure aluminum.

Tension joint sleeves shall be supplied complete with grease. Dies shall be plainly marked with size and type and only those approved by the Employer/Employer's representative shall be used with each individual joint or conductor. The Employer/Employer's representative shall approve the make and type of hydraulic jointing compressor.

The design of joint and clamps and any special tools to be used in their assembly shall be such that it reduces the possibilities of faulty assembly or erection to a minimum.

Non-ferrous alloys shall be such as to withstand atmospheric conditions without painting or other protection. The Contractor shall submit certificates of analysis for the various parts.

2.5.6 Suspension Clamps

Suspension clamps shall be of aluminum alloy and free to pivot in the vertical plane containing the conductor and shall permit the complete conductor to slip before failure of the latter occurs. The outermost point of clamping pressure shall be not less than two conductor diameters inside the outermost point of contact between the conductor and its supporting groove (the conductor being assumed to be horizontal).

The supporting groove beyond the latter point shall be curved in the vertical to a minimum radius of 150mm and for a sufficient distance to allow for the conductor leaving the clamp at the maximum inclination to be obtained in service. The mouth of the supporting groove shall be slightly flared in plan. The grooves in the clamping piece or pieces shall be bell-mouths at each end and all conductor grooves and bell-mouths shall, after galvanizing, be smooth and free from waves, ridges or other irregularities.

2.5.7 Tension Clamps

Tension dead-end clamps shall be of aluminum alloy compression type and shall be equipped with an integral jumper lug. This lug shall have at least four boltholes for connection of the non-tension compression jumper end.

The mechanical efficiency of any tension clamp shall not be affected by method of erection involving the use of "come- along" or similar erection clamps before, during or after assembly and erection of the tension clamp itself.

2.5.8 Vibration Dampers

Each conductor including the earth wire shall be fitted with vibration dampers. Dampers for OPGW shall be provided with armor rods.
The dampers shall be of an approved type, shall have conductor clamps of aluminum alloy, and shall be attached to the conductors in such a manner that it will prevent damage to the conductors and to individual strands thereof.

Copies of typical Vibration Recorder Tests carried out by the damper manufacturer shall provide evidence of the adequacy of the dampers.

The manufacturer shall calculate the number of dampers per span, the position and the maximum span length for each damper size. The calculation shall be based on the following data:

a) Conductor and conductor arrangement, armor rods
b) Equivalent span lengths
c) Conductor height above ground

The calculations shall be made for the following three terrain conditions, if not indicated otherwise or instructed by the Employer:

a) Hilly terrain, with trees and obstructions
b) Flat terrain, no trees, and no obstructions
c) Undulating, relatively open country with some trees

Number of dampers per span to be installed is tentatively decided for both conductors and ground wires as follow;

Span up to 300 m	2 nos. per span
Span from 300 to 600m	4 nos. per span
Span exceeding 600m	6 nos. per span

The contractor shall submit their proposed number of dampers and a fixing spacing of dampers to the Employer's Representative for approval.

2.5.9 Armor Rod

Armor rod shall be of the preformed type and shall be made of a material compatible to that of the conductor. Rod shall be shaped in such a way that they will grip the conductor and shield wire tightly. The rod shall be capable of being installed by hand without the use of special tools. The manufacturer of vibration dampers shall determine the length of the rod.

2.5.10 Corona and Radio Interference

The design of all conductor fittings, vibration dampers etc., shall avoid sharp corners or projections, which would produce high electrical stress in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surfaces and to maintain good electrical contact under service conditions.

Particular care should be taken during manufacture of conductors and fittings and during subsequent handling to ensure smooth surfaces free from abrasion.

Radio interference noise of insulator and conductor fittings shall be within the limits of IEC or BS recommendations.

2.5.11 Tests on complete strings and Hardware-Fittings

a) Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 105 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.

b) RIV Test (Dry)

Under the conditions as specified under (1.a) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 500 micro volts at one MHz when subjected to 50 Hz, AC voltage of 105 kV line to ground under dry condition. The test procedure shall be in accordance with IS: 8263 /IEC: 60437.

c) 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.

d) Vibration Test

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 meters. In the case of suspension string a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and two sub-conductors (each tensioned at 31 KN shall be secured with clamps. The system shall be suitable to maintain constant tension on each Sub-Conductor throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point, nearest to the string, shall be measured and the same shall not be less than 1000/f1.8 where f is the frequency of vibration in cycles/sec. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test the insulators shall be examined for looseness of pins and cap or any crack in the cement. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and insulators after the vibration test. The insulators shall be subjected to the Mechanical performance test followed by mechanical strength test as per relevant standards.

e) 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.

2.6 Payment for Conductors and Accessories

Payment for the supply and delivery for the contract item, conductors, earth-wire and accessories; 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 conductor and accessories fabrication, delivery etc.

2.7 Optical Ground Wire (OPGW)

2.7.1 General

The scope of work comprise of supply, installation, testing and commissioning of optical ground wire (OPGW), including necessary accessories for fiber termination and splicing, for 10 km Rasuwagadhi-Chilime Hub 132 kV transmission line.

Bidders shall offer the OPGW and their accessories from the reputed manufacturer. The contractor shall ensure complete supervision by competent technical personnel(s) of the OPGW manufacturer during installation, testing and commissioning of the whole OPGW system in totality under the project. The supervision shall also include the on-site training to the Employer's Representative(s).

The manufacturers of OPGW wire must meet the qualification requirements as specified in the Instruction to Bidders.

2.7.2 Technical Requirements

The optical fiber ground wire (OPGW) shall be of approximate cross section 60 mm^2. Aluminum clad steel or/and aluminum alloy wires shall form the stranding part of earth wire. The ground wire of the 132kV 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 makeup 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.

2.7.3 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 Schedule A.7 of Chapter 8.

2.7.3.1 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 ± 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.

2.7.3.2 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.

2.7.3.3 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.

2.7.3.4 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 24 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.

2.7.3.5 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.

2.7.3.6 Testing of Fiber optic cable

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.

2.7.3.7 Maintenance

To maintain the cable the Contractor shall propose suitable equipment and necessary training for the Employer personnel to execute the work.

2.7.3.8 Joints

Number of joints shall be kept to a minimum. Approved equipment and methods must be used to test the cable from both ends. Joints shall be planned to be closed to the road with easy access.

2.7.3.9Particular Requirement for OPGW 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 24 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 24 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.

2.7.3.10 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.

2.7.3.11 Tests

The following tests shall be conducted once on sample/samples of OPGW for every 50km of production from the manufacturing facility.

- Structure and dimension test
- Transmission characteristics test
- Characteristics test of ACS
- UTS test

2.8 Galvanized Steel Earth wire

2.8.1 General

The scope of work comprises of manufacture, factory test, supply, stringing, testing and commissioning of Galvanized Steel Earth wire for about 10 km of 132 kV Transmission line.

The Galvanized Steel Earth wire shall be run from switchyard of Rasuwagadhi Hydroelectric Project to the Chilime Hub Gantry.

The Contractor shall ensure complete supervision by competent technical personnel(s) during installation, testing and commissioning of the whole Earth Wire system in totality under the project. The supervision shall also include the on-site training to the Employer's Representative(s).

The proposed manufacturer of Galvanized Steel Earth wire shall meet the following criteria. The plant/equipment must have been type-tested and certified by an international reputable laboratory.

The manufacturers of Galvanized steel Earth wire must meet the qualification requirements as specified in Instructions to Bidders.

2.8.2 Details of Earthwire

The Bidders must offer E.H.S Galvanized earth-wire from reputed and experienced manufacturers. Shield wires are to be made electrically continuous at each suspension and tension towers by bolted jumpers or other approved means and are to be bonded to the tower steelwork by an approved removable link on all supporting structures.

The technical characteristics of the earth wire are stated in Schedules A.6 of Chapter 8.

2.8.3 Workmanship

- 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.
- The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.
- 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 A363 (IEC 209).
- 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 pre-forming and post-forming operation.
- To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

2.8.4 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.

2.8.5 Materials

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

2.8.6 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 or equivalent.

The Contractor shall submit certificates of analysis giving the percentage and nature of any impurities in the metal from which the wires are made.

2.8.7 Standard lengths

The standard length of the earth wire shall be 2000 meters. The tolerance on length shall be ± 5% on the standard length.

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.

2.8.9 Tests and Standards

2.8.9.1 Type Tests

In accordance with the stipulation of specification, the following type tests reports of the earth wire shall be submitted for approval.

a)	UTS test	Annexure - B
b)	DC resistance test	

2.8.9.2 Acceptance Tests

a)	Visual and dimensional check on drum	Annexure - B
b)	Visual check for joints, scratches etc. and lengths of earth wire	
c)	Dimensional check	
d)	Lay length check	
e)	Galvanizing test	
f)	Torsion test	
g)	Elongation test	IS: 398 (Part-II) or equivalent
h)	Wrap test	
i)	DC resistance test	
j)	Breaking load test	IS: 398 (Part-II) or equivalent
k)	Chemical Analysis of steel	Annexure- B

2.8.9.3 Routine Tests

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.

d) All acceptance test as mentioned above to be carried out on each coil

2.8.9.3 Tests during Manufacturing

a)	Chemical analysis of zinc used for galvanizing	Annexure - B
b)	Chemical analysis of steel	

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 earth wire.

2.8.9.4 Additional Tests

i. 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.
ii. 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.

2.8.9.5 Test Reports

i. Copies of type test reports shall be furnished in at least three copies along with one original. One copy will be returned duly certified by the Employer only after which the commercial production of the material shall start.
ii. Copies of acceptance test reports shall be furnished in at least four (4) copies. One copy shall be returned duly certified by the Employer, only after which the material shall be dispatched.
iii. Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.
iv. 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.

2.8.9.10 Test facilities

The following additional test facilities shall be available at the Contractor's works:

i. Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer etc.
ii. Standard resistance for calibration of resistance bridges.
iii. 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.

2.8.9.11 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

2.8.9.12 Verification of Earthwire Length

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

ANNEXURE A

1) Tests on Conductor

a) UTS Test on Stranded Conductor

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

b) Corona Extinction Voltage Test

The samples of a bundle of two conductor of 5 m length shall be strung with spacing of 450 mm between them at a height not exceeding 7.5 m above ground. The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 105 kV (rms) line to ground under dry condition. There shall be no evidence of corona on any part of the samples. The test should be conducted without corona control rings. However, small corona control rings may be used to prevent corona in the end fittings. The voltage should be corrected for standard atmospheric conditions.

c) Radio Interference Voltage Test

Under the conditions as specified under (b) above, the conductor samples shall have radio interference voltage level below 500 micro volts at one MHz when subjected to 50 Hz AC voltage of 105 kV line to ground under dry conditions. This test may carry out with corona control rings and arcing horns.

d) D.C. Resistance Test on Stranded Conductor

On a conductor sample of minimum 5m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially 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 20^0C as per IS: 398-(Part-IV)-1982 or equivalent. The resistance corrected at 20^0C shall conform to the requirements of this Specification.

e) Chemical Analysis of Aluminium and Steel

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

f) Visual and Dimensional Check on Drums

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

g) Visual Check for Joints, Scratches etc.

Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of

this Specification. Ten percent (10%) drums from each lot shall be rewound in the presence of the Employer's representative.

h) Dimensional Check on Steel and Aluminium Strands

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

i) Check for Lay-ratios of Various Layers

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

j) Procedure Qualification test on welded Aluminium strands

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

k) 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.

l) Galvanizing Test

The test procedure shall be as specified in IEC: 888. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

m) Torsion and Elongation Tests on Steel Strands

The test procedures shall be as per clause No. 10.3 of IEC: 888. In torsion test, the number of complete twists before fracture shall not be less than 16 on a length equal to 100 times the standard diameter of the strand. In case test sample length is less or more than 100 times the stranded diameter of the strand, the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation of the strand shall not be less than 4% for a gauge length of 250 mm.

n) Check on Barrel Batten strength of Drums

The details regarding barrel batten strength test will be discussed and mutually agreed to by the Contractor & Employer.

Annexure-B

1. TESTS ON EARTH WIRE

a) 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.

b) D.C. Resistance Test

On an earth wire sample of minimum 5m length two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge/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.

c) 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.

d) 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.

e) 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.

f) 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.

g) Dimensional Check

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

h) Lay Length Check

The lay length shall be checked to ensure that they conform to the requirements of this Specification.

i) 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.

j) 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.

CHAPTER 3

TOWER FOUNDATION AND CIVIL WORKS

3.1 Foundations

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

3.2 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:

3.2.1 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

3.2.2 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

3.2.3 Fully Submerged Foundation

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

3.2.4 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.

3.2.5 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.

3.2.6 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.

3.2.7 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.

3.2.8 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 of 3.9.3.2.

3.3 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.

3.4 Soil Investigation

The Contractor shall undertake soil investigation as per CHAPTER 4 of the specification 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.

3.5 Loads on Foundations

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 thrusts.

3.5.1 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.

3.6 Stability Analysis

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.

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

B) RESISTANCE AGAINST DOWN THRUST

The down-thrust loads combined with the additional weight of concrete above earth

will be resisted by bearing strength of the soil assumed to be acting on the total area of the bottom of the footings.

C) RESISTANCE AGAINST SIDE-THRUST

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

The chimney shaft shall be reinforced for the combined action of axial force, tension and compression and the associated maximum bending moment. In these calculations, the tensile strength of concrete shall be ignored. Similarly, since stub angle is embedded 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 3.1.

3.7 Properties of Concrete

The cement concrete used for the foundations shall be of grade M-20 corresponding to 1:1.5:3 nominal mix ratios 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.

3.7.1 The weight of concrete to be considered for design of foundations is given in TABLE 3.1.

TABLE 3.1

TYPE OF CONCRETE	WEIGHT OF CONCRETE kN / m^3(kg/m^3)	
	DRY REGION	IN PRESENCE SUB-SOIL WATER
Plain Concrete	21.96 (2240)	12.16 (1240)
Reinforced Concrete	23.54 (2400)	13.73 (1400)

3.7.2

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 the Employer reserves the right to direct the Contractor to conduct tests for each batch/lot of cement used by the Contractor and the 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.

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

3.7.4 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.

3.7.5 Reinforcement shall conform to IS: 432-1966 for M.S bars and hard drawn steel wiresand 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.
The Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out intent of drawings and specifications.

3.8 Design of Foundations

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

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

3.8.3 The physical properties of soil under various conditions are furnished in TABLE 3.2 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 3.2 of this Chapter. 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 3.2 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.

3.8.4 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:

3.8.5 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.

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

3.8.7 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.

3.8.8 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.

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

3.8.10 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.

3.8.11 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.

3.8.12 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.

3.8.13 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.

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

3.8.15 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 3.2
PROPERTIES OF EARTH

1. Normal Soil		
PROPERTIES OF SOIL	ULTIMATE BEARING CAPACITY kN/m^2 (kg/m^2.)	ANGLE OF REPOSE DEGREE
a) Normal Dry Soil	268 (27350)	25
b) Wet Soil Due to Presence of Subsoil/Surface Water	134 (13675)	15
c) Sandy Soil	268 (27350)	15
2. Weight of Earth for Normal Soil		
PROPERTIES OF SOIL	UNIT	VALUE
a) Dry	kN/m^3 (kg/m^3.)	14.12 (1440)
b)In presence of Surface Water	kN/m^3 (kg/m^3.)	14.12 (1440)
c)In presence of Subsoil Water	kN/m^3 (kg/m^3.)	9.22 (940)
3.Fissured Rock		
PROPERTIES OF SOIL	ULTIMATE BEARING CAPACITY kN/m^2 (kg/m^2.)	ANGLE OF REPOSE DEGREE
a) Dry	498 (50800)	20
b) In presence of Subsoil Water	498 (50800)	10
4. Weight of Earth for Fissured Rock		
PROPERTIES OF SOIL	UNIT	VALUE
a) Dry	kN/m^3 (kg/m^3.)	14.12 (1440)
b) In presence of Subsoil Water	kN/m^3 (kg/m^3.)	9.22 (940)
5. Hard Rock		
PROPERTIES OF SOIL	ULTIMATE BEARING CAPACITY kN/m^2 (kg/m2.)	ULTIMATE BOND BETWEEN STEEL AND CONCRETE kN/m^2 (kg/m^2.)
Hard Rock	1225.83 (125000)	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.

3.9 Measurement, Unit Rates and Payment for Foundation

3.9.1 Measurement

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

3.9.1.2 The Bidder has to provide in the Bid the guaranteed foundation quantities (i.e. Excavation volume, Concrete volumes and Weight of Reinforcements) and unit rates for excavation, concreting and reinforcement for each type of foundation (as classified in Clause 3.2 of this Chapter) for each type of tower. Composite price quoted (as described in clause 3.8.3 of this Chapter) in respective Schedule for each type of foundation must comply with unit rate quoted and guaranteed foundation quantities mentioned.

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

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

3.9.1.5 The steel required for reinforcement of foundation shall be provided by the Contractor. Measurement will be based on the calculated weights of actually used in tones 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.

3.9.2 Unit Rate

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

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

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

3.9.3 Payment for Foundation

3.9.3.1 Normal Foundations

Payment of normal foundations classified under Clause 3.2 of this Chapter shall be made as described in Clause 3.8.3 of this Chapter. 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.

3.9.3.2 Special Foundations

Unit rates for the payment purpose for special foundations (excavation, concreting and reinforcement) shall be based on the unit rates quoted by the Bidder as per Clause 3.9.1.2 for the same soil type.

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

b) 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.

c) 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 or 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 3.9.1.5.

3.10 Construction of Tower Foundation

3.10.1 Testing of Soil

The Contractor shall be required to undertake testing of soil for the tower locations in the manner specified under Chapter 4 of this Specification and shall submit his report

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

3.10.2 Excavation

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

3.10.2.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out excavation as per drawings without any side clearance. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, using timbering, shoring, shuttering, dewatering etc. as approved by the Employer. The 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 the Contractor before placing concrete.

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

a) Dry Soil
Soil removable either manually, means of a spade and shovel or mechanically by proclaims, 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.

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

3.10.2.5 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated. Shoring and timbering / shuttering as approved by 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.

3.10.2.6 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, if permitted by the Employer, shall be done with utmost care to 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.

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

3.10.3 Setting of Stubs

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

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

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

3.10.3.3 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 the Employer.

3.10.3.4 As per the schedule testing of all towers must be completed before the start of casting foundations. However, for any reason if the testing of tower gets delayed the 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 the 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.

3.10.4 Stub Setting Templates / Props

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

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

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

3.10.4.4 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	1
ii) For each type of DB, DC, DD/DDES, DF and FD/FDES type	1

However, if the 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 the Employer.

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

3.10.5 Mixing, Placing and Compacting of Concrete

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

3.10.5.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in Color 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.

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

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

3.10.5.5 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for 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.

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

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

3.10.6 Curing

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

3.10.7 Backfilling and Removal of Stub Templates

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

3.10.7.2 The backfilling materials shall be clean and free from organic or other foreign materials. A clay type soil with a grain size distribution of 50% or more passing the number 200 sieve as well as a black cotton soil is unacceptable for backfilling. The earth shall be deposited in maximum 200mm layers, leveled, wetted if necessary and compacted properly before another layer is deposited. The moisture content for compaction shall

be based on the Proctor compaction test results given in the Geo-technical Report, Clause 4.9 of Chapter 4. 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.

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

3.10.8 Benching

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

3.10.9 Protection of Tower and Tower Footing

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

3.10.9.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in small water streams (Nalas), river bank / bed, undulated terrain, protection of up hill / down hill slopes required for protection of tower etc., including suitable revetment or 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). The 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.

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

3.10.9.4 The provisional quantities for protection work of foundations are furnished in Price

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

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

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

3.10.9.6 For some of the locations in small water streams (Nalas), river bed or undulated terrain etc., boulders of minimum. 150mm size bounded and packed in 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.

CHAPTER 4

PRELIMINARY WORK

4.1 Detailed Survey and Optimization of Tower Location

4.1.1 Detailed survey along the route alignment has been carried out and profile has been plotted by the Employer. Details of angle of deviation and section lengths along with route alignment shall be given by the Employer. The Contractor shall have to do tower spotting on already prepared and/or to be 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 this Specification. The Provisional quantity for check survey has been indicated in Price Schedule. The 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.

4.1.2 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 the 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.

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

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

4.1.5 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.

4.2 Detailed Survey

Following activities shall be part of Detailed Survey work:

4.2.1 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 RGHEP 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.

4.2.2 Profile Plotting & Tower Spotting

From the field book entries, the route plan with enroute details and level profile shall be plotted and prepared to scale of 1:2000 horizontal & 1:200 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.

4.3 Spotting of Tower Location

4.3.1 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.

4.3.2 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/DDES 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 7.0m for 132 kV 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 Enroute

All topographical details, permanent features, such as trees, building etc. 30m for 132 kV on either side of the alignment shall be detailed on the profile drawing.

4.4 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.

4.4.1 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. The Contractor may please note that the Employer shall not pay any compensation for any loss or damage to the properties or for tree cutting due to the Contractor's work.

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

4.4.3 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 40 m belt should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.

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

4.5 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.

4.6 Check Survey for Tower Location

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

4.6.2 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.

4.6.3 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 the 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.

4.6.4 Land Parcel Nos. (Map indicating owners of the land) along the final route

alignment shall be provided to the Contractor by the Employer on which the Contractor shall mark the tower locations showing its boundary covering all four foundation pads and submit the details of affected Land Parcel Nos. along with their areas for all tower locations to the Employer after the approval of check survey.

4.7 Environmental Conditions

4.7.1 Forest

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

4.7.2 General Climatic Conditions

Climatic conditions shall be as indicated in this Specification.

4.8 Statutory Regulations and Standards

4.8.1 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.

4.8.2 Reference Standard

4.8.2.1 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.

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

4.9 Geotechnical Investigations

4.9.1 General

4.9.1.1 The 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 Employer. The range of load intensities from the various structures is expected to be between 100 KN/sq. m and 500 KN/sq.m.

4.9.1.2 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.

4.10 Scope

4.10.1 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. However, during actual execution of work, the quantities shall be decided by the Employer, 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 is to be done in every location for foundation classification up to foundation depth and furnish bore log data including the depth of ground water table. No separate payment for trial pit shall be done. Based on the soil parameters, the Contractor has to recommend the type of foundation suitable for each locations and same shall be got approved by the Employer.

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

4.10.3 The 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 the Employer. The 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. The 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. The Contractor shall arrange to collect the data regarding change of course of rivers, major natural streams and nalas, etc., encountered along the transmission line route from the best available sources and

shall furnish complete hydrological details including maximum velocity, discharge, highest flood level (H.F.L) & scour depth etc. of the concerned rivers, major streams and nalas (canals).

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

4.10.5 Whenever the Contractor is unable to extract undisturbed samples, it shall immediately inform the Employer. Payment for boring charges shall be subject to the 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 the Contractor in such cases shall ensure that specified numbers of vane shear tests are performed and the results correlated with other soil parameters.

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

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

4.10.8 After reviewing the Contractor's geotechnical investigation draft report, the Employer may call the Contractor & his geotechnical engineer for discussions to be held at the 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 the 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.

4.10.9 The Contractor shall carry out all work expressed and implied in Clause 4.10 of this Chapter in accordance with requirements of the Specification and satisfaction of the Employer.

4.11 General Requirements

4.11.1 Wherever possible, the 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.

4.11.2 The 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.

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

4.11.4 The water level in neighboring streams and watercourses shall be noted. The 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.

4.11.5 It is essential that equipment and instruments be properly calibrated at the commencement of the work. If the Employer so desires, the 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, the Contractor shall arrange for the same.

4.12 Codes and Standards for Geotechnical Investigations and Foundation Design

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, with prior approval of the Employer.

4.12.1 All geotechnical investigation and foundation design work shall be carried out in accordance with the following Indian Standards, Codes and Manual:

Indian Standards (IS)	Title	International and Internationally Recognized Standard/Code
IS: 1080-1990	Codes of Practice for Design and Construction of Simple Spread Foundations	
IS: 1498-1992	Classification and	ASTM D 2487/

	Identification of Soils for General Engineering purposes.	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	ASTM D 2938

	Unconfined Compressive Strength of Rock Materials.	
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- (Part-II)-1991	Description of Discontinuities in Rock Mass-Core Recovery and Rock Quality.	
	CBIP Manual on Transmission Line Towers, Chapter – 10 Foundations	

4.13 Field Investigation for Soils

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

4.13.1 Boring

Boreholes are required for detailed soil investigations.

4.13.1.1 General Requirements

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

b) All boreholes shall be minimum 7m deep for normal open cast type foundations. If the strata with Standard Penetration Test – N value measured greater than 100

with characteristics of rock is met, the borehole shall be advanced by coring at least 3m further, limited to total 7m depth, with prior approval of the Employer.

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, the Contractor shall backfill all boreholes as directed by the Employer.

4.13.1.2 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.

4.13.1.3 Shell and Auger Boring

4.13.1.3.1 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.

4.13.1.3.2 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 4.13.1.2 shall apply for this type of boring also.

4.13.1.4 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.

4.13.2 Standard Penetration Test (SPT)

4.13.2.1 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

4.13.2.2 The spacing between the levels of standard penetration testing and next undisturbed sampling shall not be less than 1.0 m. 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.

4.13.2.3 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.

4.13.2.4 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.

4.13.3 Sampling

4.13.3.1 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 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.

4.13.3.2 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.

4.13.3.3 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

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

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

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.

b) 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.

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.

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.

4.13.4 Ground Water Table

4.13.4.1 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 Employer:

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.

4.13.4.2 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 field 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.

4.13.4.3 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 Employer.

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

Dynamic cone penetration test shall be conducted with bentonite slurry to predict stratification, density, bearing capacity of granular soils, etc. The test shall be conducted by driving a standard size cone attached to the bottom of a string of straight and tightly coupled drill rods to the specified depth or refusal, whichever comes first. Refusal shall be considered when the blow count exceeds 100 for 300mm penetration. The Equipment, accessories required for performing the test, test procedures, field observations and reporting of results shall conform to IS: 4968, Part-II. The driving system shall comprise of a 650 N weight having a free fall of 750mm. The cone shall be 60^0 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 Employer.

4.13.6 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 hammers 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 cohesionless 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).

4.13.7 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 Employer. 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.

4.14 Field Investigation for Rock

4.14.1 Rock Drilling

4.14.1.1 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 Employer. 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.

4.14.1.2 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 Employer, and his decision as to whether a TC or a diamond bit is to be used shall be final and binding on the Contractor.

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

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

b) The depth through which a uniform rate of penetration was maintained, the depth at which marked change in rate of penetration or sudden fail on drill rod

occurs, the depth at which any blockage of drill bit causing core loss, if any, shall be recorded.

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

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

4.14.2 Core Sampling

4.14.2.1 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.

4.14.2.2 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.

4.15 Laboratory Testing

4.15.1 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 the Employer 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 the Contractor to the satisfaction of the Employer 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).

4.15.2 Tests

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

4.15.3 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 Employer;

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 SO3 and SO4), organic matter and any other chemical harmful to the foundation material. The contents shall be indicated as parts per million (PPM) by weight.

4.16 Geotechnical Investigation Report

4.16.1 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, summarised 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 as graphical form, practical and theoretical considerations for the interpretation of test results, supporting calculations for the conclusions drawn, etc.

b) Initially, the Contractor shall submit three copies of the draft report for the Employer's review. After receiving the Employer's comments, if any, the 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 the Employer 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 CHAPTER 3 of this specification.

4.16.2 Data to be furnished

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

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

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

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

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

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

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

g) Results of all laboratory test summarised 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-ϕ values of Mohr circles, the same may be obtained from p-q plots.

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

   i) e vs. log p;

   ii) e vs. p;

   iii) Compression vs log t or Compression vs √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) ϕ (angle of internal friction)
10. Consolidation Test
    a) e0
    b) Pc
    c) Cc
    d) DP
    e) Mv
    f) Cv
11. Shrinkage limit (%)
12. Swell Test
    a) S.Pr
    b) FS
13. Relative Density (%)
14. Remarks

Notations:

I. For type of Sample:
DB - Disturbed bulk soil sample.
DP - Disturbed samples from cutting edge of undisturbed soil sample.
Rm - Remoulded soil sample
UB - Undisturbed block soil sample
US - Undisturbed soil sample by sampler
W - Water sample

II. For Strength Test:
SCPT - Static Cone Penetration Test
UCC - Unconfined Compression Test
VST - Vane Shear Test
Tuu - Unconsolidated Undrained 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)
Φ - Angle of Internal Friction (degrees)
S - Pr. - Swelling Pressure (kPa)
e0 - Initial Void Ratio
Pc - Reconsolidation Pressure (kPa)
Cc - Compression Index
DP - Change in pressure (kPa)
mv - Coefficient of Volume Compressibility (m^2/KN)
Cv - Coefficient of Consolidation (m^2/hr)

IV. For Chemical Test
As per Specifications - Clause 4.16.4 of this Chapter.

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, σc
    - Saturated
    - In situ water content
12. Modulus of Elasticity, Et
13. Poisson's ratio, ν
14. Brazilian tensile strength, σtp
15. Point load strength, σtp
16. Shear strength parameter, c, φ (Triaxial compression)
17. Rock joint parameters
18. Percentage core recovery
19. RQD (Rock Quality Designation)

4.16.3 Recommendations

4.16.3.1 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 4.8 of this CHAPTER and the following.

a) The subsurface material must provide safe bearing capacity and uplift resistance by incorporating appropriate safety factors specified in 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 1.0, 2.0 and 3.0 m

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. The 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 the Contractor considers such investigations necessary.

4.16.4 Hydro-geological Conditions

4.16.4.1 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 Mg^{2+}

e) Content of ammonia salts, mg/l, recalculated in terms of ions NH_4^+

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 SO_4
i) aggregate content of chlorides, sulphates, nitrates, carbonates and other salts mg/l.

4.17 Rates and Measurements

4.17.1 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.

CHAPTER 5

ERECTION, STRINGING AND MISCELLANEOUS WORKS

5.1 Erection of Steel Towers

All towers shall be vertical under the stresses set up by the completed overhead line.

Precautions shall be taken to ensure that no parts of the structures are strained or damaged in any way during erection and drifting shall not be allowed.

Support members, which arrive on Site with slight distortions due to handling in transit, shall be straightened by the Contractor using an approved means and offered to the Employer for inspection and subsequent acceptance or rejection before erection commences.

Suitable ladders shall be used whenever necessary during erection but such ladders and removable step bolts shall be removed when erection is not in progress.

Spanners used during erection shall be well shaped and fit closely on the hexagon to avoid damaging nuts and bolt head.

Reaming or drilling for correction of mismatched holes will not be allowed without the written approval of the Employer.

The Contractor shall ensure that a rigid bolt-checking program is carried out on all supports. On completion of initial assembly of towers, an organized bolt checking team shall check all bolts for tightness from the structure top downwards.

Bolt checking shall be carried out with a torque-wrench within one week from the time the support is erected. Bolt tightening shall be as follows:

Size of Bolt (mm)	Tightening Torque (kg-cm)
16	1000-1200
20	1400-1800

Throughout the course of support erection the Contractor shall ensure that unbraced members are adequately supported by stays or guys or temporary struts prior to being braced.

The bracing of all four sides of the support shall be completed before guys are removed and before any erection of a higher section of the tower is commenced.

The Contractor shall notify the Employer two weeks before the supports are ready for inspection. The inspection and correction of defects if any shall be complete before the start of the stringing operation.

Damaged galvanizing may be repaired on site in accordance with Article 1.7 of General Technical Specification.

All bolts and nuts below the Anticlimbing device shall be properly punched such as to provide safety against opening of the nut-bolts even with a wrench set. The punched area shall immediately be coated with zinc paint.

Payment for the contract item Steel tower erection will be made at the unit price bid "Galvanized steel tower with required extensions and stubs". Therefore in the schedule the unit bid price shall include full compensation for all cost incurred in furnishing all materials, tools, labors etc. for erection work related to this item.

5.2 Conductor {including Ground-wire (OPGW)} Stringing

At least 3 months before conductor stringing commences, the Contractor shall submit to the Employer a detailed account of his proposed stringing procedure which should include details of temporary support stays and compensation for initial stretch and long term creep of the conductors.

Full use shall be made of maximum conductor lengths in order to reduce the number of mid span joints to a minimum.

There shall not be more than one joint per conductor in any one span, and tension joints shall not be less than 15 meters from any conductor clamp. No tension joints shall be used:

a) In section of less than 3 spans between tensions supports.
b) In spans over navigable rivers, buildings, power lines, telecommunication lines, public roads and in any span subject to special way leave conditions or in any adjacent span.

Double suspension / tension insulator-strings shall be used on both sides of towers over rivers, buildings, roads, etc. as approved by the Employer.

Conductor repair sleeves shall not be used without the permission of the Employer.

The conductors, joints and clamps shall be erected using the approved tools and in such a manner that no bird caging, over tensioning of individual wires or layers or other deformation or damage to the conductors occurs. Clamps or other devices used in erection shall be of approved design and shall allow no relative movement of strands or layers of the conductors.

The Contractor shall keep a record of all conductor joints giving the location, the date of assembly and the name of the lineman responsible for the jointing. Where records of joints made by a particular lineman show a repeated performance below that required, the Contractor shall cease to employ the lineman on jointing operations and shall immediately replace him with other qualified personnel.

Phase conductors and ground-wire (OPGW) shall be erected with such sags that at everyday temperature in still air, the final tensions shall provide sufficient factors of safety on the ultimate tensile strength of the conductor. The Contractor shall submit erection and final sag

and tension charts for conductor & ground-wire. These charts shall plot inter-related curves of tensions against equivalent span lengths, and actual span lengths against sags, at temperatures of -5.5 degree C, 32 degree C, and 80 degree C in still air conditions as well as in ice-loaded (9.6mm thickness) condition at -5.5 degree C. They shall also show details of conductor size, conductor breaking load, and conditions of loading.

In calculating the sags and tensions, allowance shall be made for the elasticity and coefficients of expansion of the conductor materials.

The term "final tension" shall mean the tension existing in a line conductor, for any given condition of loading after sufficient period in service to allow for "bedding down" stretch and creep to take place. For purposes of calculating creep-allowance, this shall be taken as ten years from erection.

The "equivalent span" method shall be used, in which the tension in any section length is that which would apply to a single span equal to the square root of the length arrived at by dividing the sum of the cubes of the individual span lengths, in the section considered, by their sum. The calculated tensions at the time of initial erection shall be increased by an approved amount to allow for settling of the conductors, other means may be adopted subject to the approval of the Employer.

At the end of the guarantee period, the specified ground clearance plus the conductor creepage allowance shall not be infringed.

Where required by the Employer, prior to the issue of the Operational Acceptance Certificate, the Contractor shall be responsible for checking that the relative sags of the conductors are within the specified tolerance. Such checks shall be carried out at selected point along the route as required by the Employer. Clearances between conductors and ground and between jumpers and structures shall be checked by the Contractor during erection and before handing over the line.

The Contractor shall provide dynamometers, sighting boards and levels suitably mounted for clamping to support steelworks and other approved apparatus necessary for the proper checking of the work. When required by the Employer, dynamometers shall be tested and if necessary recalibrated at the Contractor's expense.

During the progress of the work, the Contractor shall record on approved schedules the particulars of the sagging of conductors on each section of the route. These schedules shall show the support numbers of the section, individual span lengths, the equivalent span, the design and erection sags, together with the mean actual sag of the phase conductor as well as the temperature, and the dates of the stringing and checking. At the end of the Contract, six sets of these schedules shall be handed to the Employer.

Blocks for running out conductors shall be of approved type and shall be robust and full running. The wheel of the running out block shall have a diameter of not less than 20 times the outside diameter of the conductor and shall be fabricated from aluminum.

The Contractor shall provide as a minimum sufficient running blocks commensurate with stringing the longest section of the project.

Jumper-loops shall be cut to length such that the loop arcs at the points of departure from tension-clamp are naturally tangential to the tension -clamp departure angle.

All conductor, connections and clamps shall be treated with approved jointing grease to prevent galvanic corrosion between dissimilar metals and to inhibit aluminum surface oxidization.

After the line conductors have been finally tensioned to their correct sags, the Contractor shall erect vibration dampers at the recommended distance from the conductor clamps.

Standard tools shall be employed as per the best prevailing engineering practices for conductor & OPGW stringing works.

Payment for the contract item conductor stringing and ground-wire (OPGW) stringing will be made at the unit price bid. Therefore, in the schedule the unit bid price shall include full compensation for all cost incurred in furnishing all materials, equipment and labor related to this item.

CHAPTER 6

PAYMENT FOR WORKS

Payment for Works

Invoicing of materials and erected work shall be submitted separately for the purpose of accounting.

Interim Certificates for site work shall be restricted in scope to the following items:

a) Preliminary work
b) Concrete foundations
c) Steel towers
d) Conductor & OPGW and their associated fittings and insulator set
e) Towers and earthing systems
f) Miscellaneous works

The Contractor shall submit to the Employer for approval a draft blank printed Form of Measurement Certificate, for each line at an early stage in the Contract.

All measurements for the purpose of payments shall be made jointly between representatives of the Contractor and the Employer.

The measurement of conductor and OPGW stringing is to be made along the center line of the transmission lines without allowance for sag or scrap, and will be based on the horizontal distance involved. Measurement for supply part of conductor and OPGW is to be made as per actual length supplied.

The rates in the Price Schedule for the standard towers, foundations and for excavation in any type of ground, concrete etc., shall include all work irrespective of access conditions, slope of the ground, nature of the subsoil and the presence of water.

No extra payments will be made for:

a) Excavation necessary solely for the installation of stub setting templates.
b) Tower erection methods employed
c) Additional costs of access and transport of personnel, materials and erection equipment to the structure or along the route.
d) Pumping out of water and flooding conditions
e) Shuttering, planking and close timbering of excavations.
f) Scaffolding necessary for stringing of conductors over existing overhead line, telecommunication lines, building, waterways, roads, railways, etc.
g) Delays arising from the necessity to switch out and earth existing overhead lines which have to be crossed over or under and
h) Other items specifically mentioned in the document.

Payment for various items as per the Price Schedule shall be as follows:

Schedule for Payment

Item No.	Description	Unit	Basis of Payment
1	Preliminary Work		
1.1	Detailed Survey including Check Survey	km.	based on km of line length (Horizontal distance)
1.2	Detail soil test	location	based on no. of location
1.3	Measurement of Ground electric resistance	location	based on no. of location.
2.	Foundations	nos.	based on no. and type of foundations
3.	Foundation protection Works		
3.1	Stone masonry work	cum	based on measured value
3.2	Gabion wall	cum	based on measured value
3.3	Excavation/Backfill	cum	based on measured value
3.4	P.C.C. Works	cum	based on measured value
3.5	Re-bar	tons	based on measured value
4.1	Galvanized steel tower supply	No	based on no. and type of tower supplied
4.2	Galvanized steel tower erection	No	based on no. and type of tower erected
5.	Tower signs on tower	set/no	based on no. of sets/ no
6.	Tower test	tower	based on no. of tower
7.	Ground material		

7.1	Ground steel rod/angle with ground steel wire (each set means one complete set for one tower footing)	set	based on no. of sets
7.2	Additional galvanized Steel wire	mtrs	based on length of galvanized steel wire
8.	Insulator string and OPGW attachment assemblies	sets	based on no. of sets.
9.	Conductor and accessory		
9.1	ACSR conductor and OPGW	km	based on length of supply
9.2	Stringing of ACSR conductor (single wire) and OPGW	km	based on horizontal distance
9.3	Stock bridge vibration damper with accessories	nos.	based on nos. of pieces

CHAPTER 7

INSPECTION, TESTING AND COMMISSIONING

7.1.1 Scope of Works

The whole of the Works supplied under the Contract shall be subject to inspections and tests by the Employer or their Representatives during manufacture, erection and after completion. The inspections and tests shall include, but not be limited to, the requirements of this section of the Specifications. All cost incurred in providing the observation by Employer's personnel (including Visa, International air fares, National air fares, transportation by car or train, full board accommodation and per diem allowance at the rate of USD 150 per day) shall be borne by the contractor within the scope of this contract. These costs shall not be claimed separately and shall be deemed to be loaded in the individual items of the Schedule of Prices.

The Contractor shall provide all costs, appliances, apparatus, supervision, labor and services necessary to carry out all tests, unless specifically stated otherwise. This shall also apply to tests performed at site or elsewhere.

The Contractor shall furnish the detailed schedule of his commissioning plan at least one month prior to the scheduled date. The schedule shall include the commissioning procedures, testing sequences and details of special testing equipment, tests and commissioning record formats, information about relevant standards etc.

The scope of the commissioning program includes the site testing and putting into successful operation of all the works and equipment's and materials supplied under the Contract

7.1.2 Quality, Assurance, Inspection and Testing

To assure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his subcontractor's premises or at the Site or at any other place of work are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such program shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions and after the award of the Contract. A quality assurance program of the Contractor shall generally cover, but not be limited to the following:

(a) His organization structure for the management and implementation of the proposed quality assurance program.
(b) Documentation control system.
(c) Qualification data for bidder's key personnel.
(d) The procedure for purchases of materials, parts, components, and selection of sub-contractors' services including vendor analysis, source inspection, incoming raw materials inspection, verification of materials purchases.
(e) System for shop manufacturing including process controls and fabrication and assembly controls.
(f) Control of non-conforming items and system for corrective actions,
(g) Control of calibration and testing of measuring and testing equipment.
(h) Inspection and test procedure for manufacture.

(i) System for indication and appraisal of inspection status.
(j) System for quality audits.
(k) System for authorizing release of manufactured products to the Employer.
(l) System for maintenance of records.
(m) System for handling storage and delivery.
(n) A quality plan detailing out the specific quality control procedure adopting for controlling the quality characteristics relevant to each item 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.

- Quality Assurance Documents

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

  The Employer, through his duly authorized representatives, reserves the right to carry out Quality Audit and Quality Surveillance of the systems and the procedures of the Contractor's and the subcontractor's Quality Management and Control Activities.

- Inspection, Testing and Inspection Certificates

  The provisions of the clauses on Test and Inspection of the GCC and SCC shall be applicable to the supply and erection portions of the Works. The Employer shall have the right to re-inspect at his expenses any material though previously inspected and approved by him at the Contractor's works, before and after the same are inspected at Site. **If the material is found defective, then the Contractor shall bear the cost of this inspection and reinstatement according to specification**.

7.2 Guarantees

Tenderers shall state and guarantee the technical particulars listed in the Schedules of Technical Particulars and Guarantees forming a part of the other sections. These guarantees shall be binding and shall not be departed from without the written permission of the Employer. The tolerances permitted in the BS, ISO or ANSI will apply unless stated otherwise.

7.3 Tests at Manufacturers Works

7.3.1 General

Where no specific test is specified, then the various items of materials and equipment shall be tested in accordance with the relevant British, IEC, or American Standards. Where no appropriate standard is available, tests shall be carried out in accordance with the maker's standard practice, which shall be subject to the Employer's approval.

At least fourteen day's prior notice, in writing or by tele-fax, shall be given to the Employer/Engineer of the readiness of the plant for test or inspection and every facility shall be provided by the

Contractor and sub-Contractor (s) to enable the Employer or their Representative to carry out the inspections and witness the tests. This includes progress, test rig and packing inspections also.

Inspection of equipment and materials shall not be carried out unless the Employer has approved copies of the relevant sub-orders, drawings and test procedures.

No equipment shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, or inspection has been waived by the Employer.

Functional electrical and mechanical tests shall be carried out on the completed plant and equipment after assembly in the Works. The extent and method of recording the results shall be agreed by the Engineer/ Employer in sufficient time to enable the tests to be satisfactorily witnessed or to make any changes to the proposed program of tests.

All instruments and apparatus used in the performance of the tests shall be subject to the approval of the Employer and, if required by the Engineer/ Employer, shall be calibrated to an agreed standard at a laboratory of national standing to be nominated by the Contractor and approved by the Employer.

The costs of carrying out such calibration shall be borne by the Contractor in all cases.

The costs of making any test shall be borne by the Contractor. This shall apply to tests performed at the site or elsewhere.

After receiving the prior information about the completion of manufacturing at the factory, the Employer will depute his personnel to the Contractor's factory to witness the fabrication, assembly and testing of any or all parts of major equipment and materials. The number of the Employer's personnel and equipment to be witnessed will be as listed below. The duration of such visits shall be as per inspection/testing requirements.

- Towers with accessories and prototype test	4 persons, 1 visit..... ... 5 Days
- ACSR Conductors	3 persons, 1 visit .....3 Days
- OPGW & Earth wire	3 persons, 1 visit. .....4 Days
- Insulators, Hardware & accessories	3 persons, 1 visit.....4 Days
- Grounding Materials	3 persons, 1 visit.....4 Days

7.3.2 Material tests

Requirements for the testing of castings and forging are detailed elsewhere in the Specification. Representative samples of all plates, bars and pipes etc. which form components of the plant shall be tested as required by the relevant standard or code at the request of the Employer.

7.3.3 Test certificates

Within 15 days of the completion of any test, triplicate sets of all principal test records, test certificates and performance curves shall be supplied to the Employer.

These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer or his Representative. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the contract reference title.

Specified requirements shall be shown on each certificate for comparison with actual test results.

When all equipment has been tested, test certificates from all Works and Site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index. Two copies of each volume shall be supplied to the Engineer and four copies to the Employer.

7.3.4 Type tests

Type tests are required to prove the general design of the equipment. Type test reports of tests performed on similar equipments shall be acceptable. But in case some type tests are required by the Employer these tests prescribed shall be carried out at the Contractor's cost.

7.4 Test

Test on each type of towers to be supplied, shall be made at the manufacturer's plant or at such location as may be mutually agreed. The number of tower test, if required, is given in price schedule.

The Contractor shall give Employer not, less than 30 days advanced notice, in writing or by fax, of the date when towers will be ready for tests. Employer reserves the right to waive the requirement for performing any or all tests. Should Employer exercise this right, the applicable unit prices for performing the test will be deducted from the total contract sum. The Contractor will not be entitled to any additional compensation by reason of such waiving.

Each test shall be performed in accordance with the following requirements:

a. **Tower**: The tower shall be fabricated from approved detail drawings in a manner as close to final production procedures as is practicable. The tower shall be complete in every detail.
b. **Erection**: The tower shall be erected on rigid foundation using the specified tower and bolts and nuts shall be tightened to the specified torque. The vertical axis through the center of gravity of the erected tower shall not be out of gravity of the erected tower and shall not be out of plumb by more than 1 cm for every 500 cm height.
c. **Rigging**: The Contractor shall submit for approval as to compliance with the specifications, diagrams showing the proposed methods of applying loads and measuring deflection.
d. **Loading**: All test loads corresponding to conductor and overhead ground wire loading shall be applied directly to the regular attachment. Details shall be provided for these loads. Test wind loads equivalent to wind loads on the tower shall be applied where convenient and in such a manner that the summations of applied load and overturning moment are as close as possible to the actual behavior as designed. Extra compressible member is not allowed for use of applying wind loads on tower. To ensure application of full-test loads to the tower, friction losses in rigging shall be added to the rigging loads.
e. **Load Programs**: The contractor shall program the tests to most favorably demonstrate that the towers will carry all design loads and conditions specified in the

loading diagrams. Test wind loads on tower shall be the same as applied in design calculation.

f. **Deflection Measurements**: Deflections shall be recorded for the "before-load", "load-on" and "load-off" condition to provide longitudinal and transverse deflections at the tower top center, at the elevation of the middle cross arm (s) and at least one intermediate point of tower body.

g. **Design Load Tests**: The initially applied loads and the increment of loading shall be 25 percent of the loads given in the loading diagrams. Each load increment shall be maintained for not less than two minutes for each assumption except under maximum (full) design loads the period of five minutes shall be maintained and during which time there shall be no slacking off or adjustment of the loads. Should it become necessary to adjust the loading, the two or five minutes period shall start after the loading is stabilized and constant. All test loads shall be removed completely before the loads for testing under different assumptions are applied.

h. **Destruction Tests**: After the successful completion of the load tests, the tower shall be further tested to destruction by increasing the transverse loads under any condition specified by Employer in increments not to exceed five per cent of full design transverse loads. The vertical and/or longitudinal loads (s) are kept constant at their full design values while deflections are being recorded.

i. **Modification of Tower Components**: Any conspicuous yielding or any failure of any part of the tower under any of the tests specified in sub-article shall be considered a defect. If a defect develops, the Contractor shall modify his design of the tower and send to Employer for approval. The modified tower shall then be retested at the Contractor's expense (including the cost of witness, if any) until satisfactory results are obtained.

j. **Material Tests**: Steel materials used for tested towers shall be subject to tension or bend test in accordance with ASTM A370. Tests shall be performed by the Contractor at no additional cost to Employer. The test specimens shall be selected as follows:

    1. Two sets selected from the destructed members of each tested tower.
    2. Two sets selected from the undisturbed members of each tested tower.

k. **Reports**: The Contractor shall furnish four certified copies of full reports of all tower and material tests, the calibration of the dynamometers or gauges, including clear photographs of the test set-ups and nature of all failures, diagrams showing deflection of towers at each interval of loading, details diagrams deflection records.

7.5 Conductors

The conductors shall be tested in accordance with the requirements of the appropriate IEC, ISO or ANSI.

7.6 Routine Test

All equipment shall be subjected to routine tests at the manufacturer's work and shall include but not be limited to the following:

7.6.1 Operational tests

All equipment shall be tested after complete assembly to ensure the correct operation.

7.6.2 Clamps, joints and insulator fittings

Sample parts selected at random by the Employer shall be subjected to such tests as the Employer may direct in order to demonstrate compliance with Specifications and BS 3288 as applicable.

7.6.3 Insulators, fittings and conductor overall tests

A complete mechanical test of insulator string, fittings and section of conductor for suspension and tension sets at each voltage level will be required. The complete units shall withstand load tests including the safety factors specified. Tests other than mechanical tests on the complete unit may be required at the discretion of the Employer.

7.7 Site Tests

7.7.1 Measurement of footing resistance

Before stringing the conductor, the footing resistance of each support shall be measured with an earth resistance-measuring instrument to the approval of the Employer.

7.7.2 Measurement of earth electrode resistance

Where the footing resistance is found to exceed 25 ohms additional earth electrodes are to be installed and the combined earth electrode and footing resistance measured together and recorded using the same test instrument. Additional electrodes are to be installed to obtain a maximum resistance value of 25 ohms.

7.7.3 Measurement of line impedance

Positive and zero sequence impedance measurement tests shall be carried out after final line inspection has been completed. The measurement tests shall be carried out on all new lines covered by this Contract, by the Contractor and at his cost.

7.7.4 Conductor joint tests

In the case of tension clamps, joints and bi-metal terminals the resistance of each part shall be measured by instruments supplied by the Contractor and approved by the Employer. The resistance of such fittings shall not exceed 75% of the electrical resistance of the equivalent length of conductor. The tests shall be carried out in the presence of the Employer. Stringing shall not commence until suitable instruments are on Site, approved by the Employer and ready for use.

7.7.5 Measurement of galvanizing thickness

The Contractor shall have available on Site for the Employer's use an instrument suitable for the accurate checking of galvanizing thickness. The gauge shall be available from the time of arrival of the first consignment of steelwork until the issue of the Operational Acceptance Certificate. The cost of the gauge and other operating expenses are deemed to be included in the Contract Price and the gauge will remain the property of the Employer.

7.7.6 Tests on completion

Acceptance tests shall be carried out on Site by the Contractor on each section of the Works. These tests shall immediately follow the commissioning of each section of the Works.

The lines shall be energized at full working voltage before handing over and the arrangement for this, and such other tests as the Employer shall desire to make on the complete line, shall be assisted by the Contractor who shall provide such labor, transport and other assistance as is required without any extra charge. Apparatus for special tests shall be provided by the Contractor.

The Contractor shall submit to the Employer at least two months before the anticipated commencement of acceptance tests his detailed proposal for carrying out acceptance tests.

7.7.7 Test instrumentation

The method of measuring all quantities and qualities and the measurement tolerances shall be in accordance with the appropriate BS, ISO or ANSI.
The terminal conditions required for establishing whether the guarantees are met shall be measured by precision test equipment to be installed by the Contractor in addition to the permanent measuring equipment where supplied under the contract.

The overall design of the Works shall provide for the installation and use of test equipment so as not to interfere with the plant loading or delay the guarantee completion dates.

All the precision test equipment to be used for carrying out tests shall be calibrated against standard instruments before the tests. and if required by the Employer, also after the tests. Calibration records shall be available for inspection by the Employer or his Representative.

During the design stage of the plant, the contractor shall give details of measurements to be made to substantiate that the performance of the plant meets the requirements of the specification and in particular shall submit for approval a schedule of performance test instrumentation necessary to demonstrate the guarantees.

7.7.8 Test reports

For each of the specified tests the contractor shall agree the test figures with the Employer and shall submit for approval triplicate copies of the test report containing a complete analysis of the test results within one month of the completion of the relevant test. Eight copies of the final approved report shall be submitted to the Employer.

7.8 Commissioning Test

The contractor shall be responsible for checking that total and relative sags of conductors are within the specified tolerances. Such checks shall be carried out at positions along the route selected by the Employer and the contractor shall provide the necessary surveying instruments to enable the checks to be carried out with the line in service without any extra charge.

The commissioning tests are as follows:

(a) Measurement of line parameters

The line insulation resistance shall be measured on each individual section of the lines before the jumper loops are closed and again on the whole lines when they are completed.

The electrical parameters of the lines such as resistance, reactance, susceptance etc. shall be measured in a manner to be approved by the Employer, sufficiently accurately to enable the positive, negative and zero sequence impedance to be determined for the lines.

The lines shall then be energized at the proposed operating voltage from the Employer's system or generating station and the charging current measured and other such tests performed as the Employer may require to make on the completed line.

The contractor shall carry out all these tests in the presence of the Employer, and shall provide all the necessary labor, transportation, apparatus, instruments and other assistance as required, without any extra charge.
(b) High voltage tests

The overhead lines shall be tested with DC voltage applied between each phase and earth by means of a DC high voltage-testing unit and without cleaning of the insulators. Tenderers shall state leakage current expected for such tests, for the different section of lines and taking into consideration and atmospheric conditions. The contractor shall supply the necessary apparatus, instruments and the D.C. high voltage supply and the testing unit including those required for carrying out test and should be shown in the schedules in Volume I.

The test voltage shall be applied for five minutes for 132 kV overhead lines and shall be as follows:

Line Voltage	D.C Test Voltage to Earth
132 kV	187 kV

The electric power necessary for the tests at Site shall be managed by the Contractor. The contractor shall satisfy himself that all connections are good before switching power and shall be responsible for, and make good any damage that may arise because of faulty connections.

All D.C. measuring apparatus, instruments including D.C. high voltage testing unit will be subject to checking and calibration by the Employer before starting the high voltage D.C. current test, catalogues and details to be submitted with offer. Full details and catalogue of the proposed high voltage D.C. testing equipment shall be submitted for approval before shipping the test equipment.

SCHEDULE A.1

SYSTEM AND LINE DATA

Item	Description	Unit	Data
1.	System Data		
1.1	System nominal voltage	kV	132
1.2	System maximum voltage	kV	145
1.3	System nominal frequency	Hz	50
1.4	Line Data		

Construction of 132 kV transmission line with double circuit towers and Double circuit stringing from Rasuwagadhi Hydroelectric Project to the proposed Chilime Hub.

SCHEDULE A.2

TOWER CONFIGURATION

SCHEDULE A.3

FACTORS OF SAFETY

Item	Description	Minimum Factor Of Safety
1.	Conductors and Insulators	
1.1	Conductors based on ultimate Tensile strength	2.5
1.2	Conductors based on ultimate Tensile strength at still air Every-day temperatures	5.0
1.3	Complete insulator strings And fittings on minimum Breaking load of insulator	3.0
1.4	Dead end compression clamps and compression splices based on conductor ultimate tensile Strength	0.95
2.	Ground Wire (OPGW)	
2.1	Earth wire based on earth wire ultimate tensile strength	4.0
2.2	Earth wire at still air everyday Temperature based on earth wire ultimate tensile strength	6.0
2.3	Complete tension assembly at earth wire maximum working tension	4.0
2.4	Complete suspension assembly at maximum vertical load	4.0

SCHEDULE A.4

INSULATOR SETS

Item	Description	Unit	Data
1.	Insulator unit		
1.1	Type of insulator		Composite long Rod
1.2	Composite material		HT-Silicon Rubber

1.3 Dimensions

S. No.	Type of String	*Size of Composite Insulator (Core dia. x Nominal length) (mm)	Minimum Creep age Distance (mm)	No. of individual Units per String (Nos.)	Electro-Mechanical Strength of Insulator Unit (kN)	Mech. Strength of Insulator String along with Hardware Fittings (kN)
1	2	3	4	5	6	7
1.	Single 'I' Suspension	20 x1305	4495	1x1	70	70
2.	Single Suspension 'Pilot'	20 x1305	4495	1x1	70	70
3.	Double Suspension	20 x 1305	4495	2x1	70	2x70
4.	Single Tension	20 x 1450	4495	1x1	120	1x120
5.	Double Tension	20 x 1450	4495	2x1	120	2x120

Note: *The sizes of composite long rod insulators mentioned at column No.3 are indicative only and not mandatory. The bidder can offer composite long rod insulators having different size; however, the overall string length shall be within the limits specified.

1.4	Highest System Voltage	KV	145
1.5	System frequency	HZ	50
1.6	Rated Lightning Impulse Withstand Voltage (dry)	KV max	650
1.7	Creepage distance (mm)	mm	4300
1.8	Rated power frequency withstand Voltage		
	a) Wet	KV	275
	b) Dry	KV	325
1.9	Minimum mechanical failing load:		
	a) Suspension Rod	KN	70
	b) Tension Rod	KN	120

SCHEDULE A.5

LINE CONDUCTOR

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	kg	11,340
1.7	Modulus of elasticity final	kg/ mm^2	8,200
1.8	Coefficient of linear expansion	per ^{0} 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

SCHEDULE A.6

EARTH WIRE

Item	Description	Unit	Data
1.	E.H.S.Galvanized Steel Wire		7/3.35
1.1	Nominal sectional area	mm^2	61.7
1.2	Number and diameter of component Wire	No/mm	7/3.35
1.3	Weight of wire	kg/km	483
1.4	Overall diameter	mm	10.05
1.5	Ultimate breaking strength	kg	7,400
1.6	Modulus of elasticity final	kg/mm^2	19,000
1.7	Coefficient of linear expansion	per ^{O} C	$1.5x10^{-5}$
1.8	Electrical D.C resistance at 20 C	ohm/km	
1.9	Standard unjointed length on reel	m	2,000
1.10	Every day stress	N/mm^2	180
1.11	Standards	ASTM A363 (IEC 209)	

SCHEDULE A.7

OPTICAL GROUND WIRE (OPGW)

A. OPTICAL GROUND WIRE

1. STANDARD

Aluminum alloy wires	IEC 104 type A
Aluminum clad steel wire	IEC 1232
Cable construction	IEC 1089 (where applicable)
Optical Unit	ITU-T (former CCIT) G 652

2. PROPERTIES OF THE OPTICAL FIBRES

Single mode fibers	24
Dimensions and geometry of fiber	according to ITU-T G.652
Fiber attenuation at 1310 nm at 20^0C max.	≤0.4 dB/km
Fiber attenuation at 1550 nm at 20^0 C max.	≤0.3 dB/km
Attenuation deviation at 1310 nm and 1550 nm	0.1 dB/km within -45^0C to 80^0C

OTHER PROPERTIES OF FIBER:

Outer diameter (approx.):	12 mm
Cable weight (approx.):	500 kg/km
Calculated breaking load:	71.4 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 ^{0}C:	5.5 kA
DC resistance at 20 ^{0}C:	Not more than 0.75 ohm /km

SCHEDULE A. 8

MATERIAL FOR TOWER GROUNDING

Item	Description	
1.	Ground rods	
1.1	Galvanized steel angles	50 x 50 x 5mm steel angles 2m long
1.2	Copper weld ground rods 16mmdia.	2m long
2.	Ground wire	
2.1	Galvanized steel wire	38mm^2 (7/2.6mm)
2.2	Copper conductor	38mm^2 (7/2.6mm)
3.	Connection of ground electrode with stub angle	
3.1	For connection of steel rods:	Steel wire as above
3.2	For connection of copper weld rods:	Copper conductor as above

SCHEDULE A.9

TESTS AT MANUFACTURER'S PLANT

The following tests shall be carried out at the manufacturer's premises.

Item	Description	Standards
1.	Rolled Steel Angles and Bolts	
1.1	Tensile strength test and chemical analysis, zinc coating test	Steel mill certificates
1.2	Full scale tower load test to destruction	IEC 652
2.	Insulators The relevant tests are specified under Sub-clause 9.11, Chapter 9, Volume II, Section VI Part B	
3.	Insulator Fittings	
3.1	Routine and sample mechanical tests	BS 3288
3.2	Galvanizing tests	BS 729
4.	Clamps and joints	
4.1	Mechanical and electrical type tests, galvanizing and mechanical routine tests	BS 3288 BS 729 ISO
5.	Dampers	
5.1	Fatigue resistant tests	
5.2	Test of clamp slippage resistance	BS 729
5.3	Galvanizing tests	ISO

6. Line Conductor, Earthwire and OPGW
The relevant tests are specified under Chapter 2, Volume II, Section VI Part B

Employer's representatives will inspect and witness the tests of tower and other materials at manufacturer's plant as listed below.

The number of Employer's inspectors for testing different items of equipment and materials at manufacturer's plant shall be limited as detailed here under.

Item	Description	No of Inspector
1.1	Tower and accessories test and prototype test of double circuit tower	four (4) persons * 5 days
1.2	ACSR Conductor	three (3) persons * 3 days
1.3	OPGW and Earthwire	three (3) persons * 4 days
1.4	Insulators, Hardware & accessories (for Insulator, Conductor & OPGW)	three (3) persons * 4 days
1.5	Grounding Materials	three (3) persons * 4 days

CHAPTER 9

INSULATORS

9.1 General

The scope of work comprise of design, manufacture, testing at shop, supply, insurance, handling, storage, erection, testing and commissioning of composite long rod insulators including necessary hardware fittings and accessories, for 132 kV double circuit Transmission line of Rasuwagadhi Hydroelectric Project.

Bidders shall offer the insulators and their fittings/accessories from the reputed manufacturer. The Contractor shall ensure complete supervision by competent technical personnel(s) of the insulators during their installation, testing and commissioning. The supervision shall also include the on-site training to the Employer's Representative(s).

The proposed manufacturer of composite long rod insulators shall meet the following criteria. The plant/equipment must have been type-tested and certified by an international reputable laboratory.

The manufacturers of composite long rod insulators must also meet the qualification requirements as specified in Instructions to Bidders.

9.2 Details of Composite Long Rod Insulators

The insulators shall be of the composite long rod type; fully type tested and has been in production for at least five years for a three phase, 50 Hz, effectively earthed for 132 kV transmission line systems in a lightly polluted atmosphere.

They must withstand safely all operating stresses even in the presence of Ozone and UV radiation. The composite material shall be of inherent stability. The insulators shall be matched with the accessories to be used.

The insulators shall be of puncture proof type. The insulator shall be made of a core with fiberglass-reinforced resin and sets of different plastic materials. They shall be light weight and high tensile strength. They must withstand safely all operating stresses even in the presence of Ozone and UV radiation.

Bidder shall quote such composite long rod insulators which have proven use under environmental and operational condition likely to be encountered for the subject project. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactory. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in Appendix-C of IEC-61109.

Insulators shall have sheds of the open aerodynamic profile with good self-cleaning properties. Insulator shed profile; spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

The size of composite long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electro-mechanical strength and mechanical strength of insulator string along with hardware fittings shall be as follows:

S. No.	Type of String	*Size of Composite Insulator (Core dia. x Nominal length) (mm)	Minimum Creepage Distance (mm)	No. of individual Units per String (Nos.)	Electro-Mechanical Strength of Insulator Unit (kN)	Mech. Strength of Insulator String along with Hardware Fittings (kN)
1	2	3	4	5	6	7
1.	Single 'I' Suspension	20 x1305	4495	1x1	70	70
2.	Single Suspension 'Pilot'	20 x1305	4495	1x1	70	70
3.	Double Suspension	20 x 1305	4495	2x1	70	2x70
4.	Single Tension	20 x 1450	4495	1x1	120	1x120
5.	Double Tension	20 x 1450	4495	2x1	120	2x120

Note: *The sizes of composite long rod insulators mentioned at column No.3 are indicative only and not mandatory. The bidder can offer composite long rod insulators having different size; however, the overall string length shall be within the limits specified.

9.3 Dimensional Tolerance of Composite Insulators

The tolerances on all dimensions e.g. diameter, length and creepage distance shall be allowed as follows:

$\pm$ (0.04d+1.5) mm when d $\leq$ 300 mm.
$\pm$ (0.025d+6) mm when d > 300 mm.

Where, d being the dimensions in millimeters for diameter, length or creepage distance as the case may be.

However, no negative tolerance shall be applicable to creepage distance.

9.4 Interchangeability

The composite long rod insulators inclusive of the clevis and tongue connection shall be standard design suitable for use with the hardware fittings of any make conforming to relevant IEC standards.

9.5 Corona and R1 Performance

All surfaces shall be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The insulator and metal parts shall be so designed and manufactured that it shall avoid local corona formation and no generate any radio interference beyond specified limit under the operating conditions.

9.6 Maintenance

The composite long rod insulators offered shall be suitable for employment of hot line maintenance technique so that usual hot line operation can be carried out with ease, speed and safety.

All insulators shall be designed to facilitate cleaning and insulators shall have the minimum practical number of sheds and grooves. All grooves shall be so proportioned that any dust deposit can be removed without difficulty either by wiping with a cloth or by remote washing under live line condition.

9.7 Materials

9.6.1 Core

It shall be a glass-fiber reinforced epoxy resin rod of high strength (FRP rod). Glass fibers and resin shall be optimized. It shall be electrical grade, boron free glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

9.6.1 Housing

The FRP rod shall be covered by a seamless sheath of a silicone elastomeric compound or silicone alloy compound of a thickness of 3mm minimum.

It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core. The strength of the bond shall be greater than the tearing strength of the polymer.

9.6.2 Weather sheds

The polymer weather sheds made of silicone electrometric compound or silicon alloy shall be firmly bonded to the sheath, vulcanized to the sheath or molded as part of the sheath and be seamless and free from imperfections. The weather sheds should have silicon content of minimum 30% by weight The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. It shall be capable of high pressure power washing.

9.6.3 End Fittings

End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron spheroid graphite or forged steel. They shall be connected to the rod by means of a controlled compression technique. The gap between fitting and sheath shall be sealed by a flexible silicone elastomeric compound or silicone alloy compound sealant. System of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The sealing must be humidity proof.

9.6.4 Grading Rings

Grading rings shall be used at line end for 132 kV reduce the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting. Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

The price of grading rings shall be considered as including in the price of Composite Long Rod Insulators.

9.8 Workmanship

- All the materials shall be of latest design and conform to the best modern practices adopted in the extra high voltage field. Bidders shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for 132 kV transmission lines and will give continued good service.

- 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.

- 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.

- The core shall be sound and free of cracks and voids that may adversely affect the insulators.

- Weather sheds shall be uniform in quality. They shall be clean, sound, smooth and free from gross defects and excessive flashing at parting lines.

- End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

- All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 600 gm/sq.m and shall be in accordance with the requirement of ISO:1461 (E) or equivalent and shall satisfy the tests mentioned in ISO:1460 (E) or equivalent. The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard Preece test. The galvanizing shall be carried out only after any machining.

9.9 Equipment Marking

- Each composite long rod unit shall be legibly and indelibly marked with the trade mark of the manufacturer, name of RGHEP 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.
- For composite long rod insulators the marking shall be on the metal parts.
- One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap of each composite long rod of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark:

For	120 KN long rod unit	:	Yellow
For	160 KN long rod unit	:	Green
For	70 KN long rod unit	:	Red

9.10 Bid Drawings

a) The Bidder shall furnish full description and illustration of the material offered.

b) The Bidder shall furnish along with the bid the outline drawing (6 copies) of each insulator unit including a cross sectional view of the composite long rod insulator unit. The drawing shall include but not limited to the following information:

(a) Composite long rod diameter with manufacturing tolerances

(b) Minimum Creepage distance with positive tolerance

(c) Protected creepage distance

(d) Eccentricity of the long rod unit

(i) Axial run out

(ii) Radial run out

(e) Unit mechanical and electrical characteristics

(f) Weight of composite long rod units

(g) Materials

(h) Identification mark

(i) Manufacturer's catalogue number

c) After placement of award, the Supplier shall submit full dimensioned insulator drawings containing all the details as given in Clause No. 9.10 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 6 more copies of the same drawing to the Employer for further distribution and field use at Employer's end.

d) After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different type of insulators.

e) After placement of award, the Supplier shall submit full dimensioned manufacturing drawing of composite long rod insulator unit in six (6) copies to the Employer for reference and record.

9.11 Tests and Standards

9.11.1 Type Tests

The following type tests shall be conducted on a suitable number of individual long rod units, components, materials or complete strings:

A. On the complete composite Long Rod Insulator String with Hardware Fittings

(a)	Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition	IEC:383-1993 Annexure -C
(b)	Switching surge voltage withstand test under wet condition	IEC:383-1993
(c)	Impulse voltage withstand test under dry condition	IEC:383-1993

(d)	Corona and RIV test under dry condition	Annexure-C
(e)	Mechanical strength test	Annexure-C
(f)	Vibration test	Annexure-C

B. On Composite Insulator Units

a.	Test on interfaces and connections of metal fittings	IEC: 61109-2008
b.	Assembled core load time test	IEC:61109-2008
c.	Damage limit proof test and test of tightness of interface between end fittings and insulator housing	IEC:61109-2008
d.	High Pressure washing test	As per Annexure C
e.	Brittle fracture resistance test	As per Annexure C
f.	Dye penetration test	IEC:61109-2008
g.	Water diffusion test	IEC:61109-2008
h.	Tracking and erosion test	IEC:61109-2008
i.	Hardness test	IEC:61109-2008
j.	Accelerated weathering test	IEC:61109-2008
k.	Flammability test	IEC:61109-2008
l.	Silicone content test	As per Annexure C
m.	Recovery of Hydrophobicity tests	As per Annexure C
n.	Torsion test	As per Annexure C
o.	Accelerated ageing test of 5000 hrs or Test at multiple stresses of 5000 hrs	IEC 61109 Appendix- C IEC 62217 Annex- B

All the type test given above shall be conducted on Single 'I' suspension and double tension insulator string (2x120 KN EMS) along with hardware fittings and individual units of 70 KN and 120 KN only.

9.11.2 Acceptance Tests:

For Composite Long Rod Insulators:

(a)	Verification of dimensions	IEC: 61109, Clause 7.2
(b)	Galvanizing test	IEC: 60383
(c)	Verification of the specified Mechanical load	IEC: 61109, Clause 7.4
(d)	Recovery of Hydrophobicity	Annexure-C

9.11.3 Routine Tests

a)	Visual Inspection	As per IEC:61109 Clause 8.2 & 8.3
b)	Mechanical routine test)	As per IEC:61109 Clause 8.2 & 8.3

9.11.4 Tests during Manufacture

On all components as applicable

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

b)	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.	As per Annexure-C
c)	Chemical analysis hardness tests and magnetic particle inspection for forgings	As per Annexure-C
d)	Tracking and erosion test on insulating material	IEC60587/IEC:61109-2008

9.12 Sample Batch for Type Testing

The bidder shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Employer. The bidder 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.

Before sample selection for type testing, the bidder shall be required to conduct all the acceptance tests successfully in presence of Employer's representative.

9.13 Schedule of Testing

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.

9.14 Additional Tests

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.

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.

9.15 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.

9.16 Guarantee

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators.

9.17 Test Reports

- Copies of type test reports shall be furnished in at least six (2) copies for the Employer's approval.
- 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.
- Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Employer's representative.
- 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.

9.18 Packing and Marking

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.

The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

Suitable cushioning, protective padding, or dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

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 stenciled on it in indelible ink.

NOTE: During erection of the line, the packing of Composite long rod insulators shall be opened only after transporting the insulator packing cases to tower locations. Packing cases opened during in-store inspection shall be restored before transporting them to tower locations.

9.19 Standards

The insulator strings and its components shall conform to the following Indian/ International Standards which shall mean latest revision, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

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.

S. 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

S. No.	Indian Standard	Title	International Standard
4.	IS:2071 Part (I) – 1993 (Part(II)- 1991 Part(III)-	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 or equivalent	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 the long rod type	IEC : 60433
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-C

1. Tests on Complete Strings with Hardware Fittings

1.1 Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 105 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.

1.2 RIV Test (Dry)

Under the conditions as specified under (1.1) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 500 micro volts at one MHz when subjected to 50 Hz, AC voltage of 105 kV line to ground under dry condition. The test procedure shall be in accordance with IS: 8263 /IEC: 60437.

1.3 Mechanical Strength Test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to, remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.4 Vibration Test

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 meters. In the case of suspension string a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and two sub-conductors (each tensioned at 31 KN shall be secured with clamps. The system shall be suitable to maintain constant tension on each Sub-Conductor throughout the duration of the test. Vibration dampers shall not be used on the test span. 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 Long rod insulators
Temperature cycle test followed by mechanical performance test	100

1.5 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 Composite Long Rod Insulator Units

2.1 Brittle Fracture Resistance Test

Assembled core load time test with container that contains1n-HNO3 concentric acid that is applied at the naked rod. The rod should be held at 80% of SML for the duration of the test.

The rod should not fail within the 96 hour test duration

2.2 Recovery of Hydrophobicity Test

(1) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.

(2) Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1" x 1".Continue treating this area for 2 – 3 minutes, operating the tester at maximum output.

(3) Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.

a. Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

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 or equivalent. 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 Contractor 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 Contractor 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%.

CHAPTER 10: ENVIRONMENTAL REQUIREMENTS

S.N	Environmental Impacts	Mitigation Measure	Individuals responsible	National Standards or Guidelines/ Approved Documents	Timing of Actions	Competent Authority/agency	
A	**Physical Environment**						
A.1.1	Impacts of land instability and erosion	As far as possible, existing trails will be used for transportation of materials to ROW and Tower foundation sites. Incase new trail need opening will utilize the most stable part of the terrain to avoid erosion, gully formation and landslides.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.1.2		Foundation excavation work will be limited to required depth	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.1.3		Side casting of the excavated material is minimized through adequate measures	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.1.4		The excavated material will be safely placed and protected for later backfilling use	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A.15		Surplus excavated materials after backfilling operation at foundation will be managed through landscaping around the foundation site	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A.16		The landforms around the foundation site will be planted with local grass vegetation and bio – engineering techniques will be applied for the protection of landscape after the construction of the foundation.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.1.7		Surface runoff around the foundation site will be drained with adequate drainage to the nearby natural drain.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.1.8		RoW land clearing operation shall not practice clear felling of the vegetations and trees. This will be a trimming operation leaving standing vegetation to a height of maximum 3 m.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.2.1	Impacts on water quality	Establish sufficient pit toilet facilities at the active construction sites and enforce use of these toilets by the construction workers to discourage or prohibit open	Contractor	Approved IEE	Construction Phase	ES/ SE	

S.N	Environmental Impacts	Mitigation Measure	Individuals responsible	National Standards or Guidelines/ Approved Documents	Timing of Actions	Competent Authority/agency	
		defecation.					
A.2.2		Prohibition on the haphazard discharge of construction spoils, or other camp wastes on the water bodies.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.2.3		All the spent oils, mobils and chemicals and the containers as per the instruction of the will be collected and managed engineers.	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A.24		Collect all the solid waste generated at the construction/camp site and segregate the waste according to its characteristics for reuse, recycling, disposal etc. and store in a safe place to be disposed as per the instruction of the engineer safely.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.3.1	Impact on Air Quality	Minimize the earth excavation to the required limits to avoid fugitive dusts generation.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.3.2		Stockpile safely the excavated earth to reduce generation of fugitive dusts.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.3.3		Open burning of any solid waste around camp site and foundation construction site will be prohibited.	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A.34		Restriction on the use of firewood or agriculture residues or animal droppings for cooking in the construction camps.	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A.35		Fuel wood at the camp sites will be replaced by the subsidised kerosene or LPG.	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A.36		Regular sprinkling of water will be done at the foundation construction site to minimize fugitive dust emission.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.4.1	Impacts of Noise pollution	Noise producing construction activities at the tower foundation will be carried out in the day time only.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.4.2		Anthropogenic noises at the camp sites will be minimised through special instruction to the workforce.	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.4.3		Use of generators fitted with noise muffles at the construction and camp sites	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.5.1	Impacts spoil Disposal	Foundation excavation work will be limited to required depth	Contractor	Approved IEE	Construction Phase	ES/ SE	
A.5.2		Side casting of the excavated material is minimized through	Contractor	Approved IEE	Construction Phase	ES/ SE	

S.N	Environmental Impacts	Mitigation Measure	Individuals responsible	National Standards or Guidelines/ Approved Documents	Timing of Actions	Competent Authority/agency	
		adequate measures					
.A.53		The excavated material will be safely placed and protected for later backfilling use	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A.54		Surplus excavated materials after backfilling operation at foundation will be managed through landscaping around the foundation site	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A6.1	Impacts of solid and liquid waste disposal	Establish sufficient pit toilet facilities at the active construction sites and enforce use of these toilets by the construction workers to discourage or prohibit open defecation.	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A6.2		Collect all the solid waste generated at the construction/camp site and segregate the waste according to its characteristics for reuse, recycling, disposal etc. and store in a safe place to be disposed as per the instruction of the engineer safely	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A6.3		The House keeper and user of the hazardous materials will be properly trained to care against the spilling, and related contamination of the material with the soil, water etc.	Contractor	Approved IEE	Construction Phase	ES/ SE	
.A6.4		Spent oils, lubricants and other chemicals generated will be safely collected in drums and disposed as per the advice of the engineers.	Contractor	Approved IEE	Construction Phase	ES/ SE	
B	**Biological Environment**						
B1.1.	Impacts on forest vegetation specifically of Protected, Rare and Endangered	Avoid clear felling of vegetation	Contractor	Approved IEE	Construction Phase	ES/ SE	
B1..2		Limit felling operation to trimming to a safe height (maximum of 3 m from the ground).	Contractor	Approved IEE	Construction Phase	ES/ SE	
B1..3		Alternative fuel will be provided at the camps to avoid the use of local firewood for cooking and space heating.	Contractor	Approved IEE	Construction Phase	ES/ SE	

S.N	Environmental Impacts	Mitigation Measure	Individuals responsible	National Standards or Guidelines/ Approved Documents	Timing of Actions	Competent Authority/agency	
B1..4	species	Instruct the workforce not to damage the vegetation of the project area. Damage to the standing vegetation other than specified will be an act of offense.	Contractor	Approved IEE	Construction Phase	ES/ SE	
B.2.1	Impacts on wildlife habitats specifically of Protected, Rare and Endangered species	Avoid clear felling of vegetation	Contractor	Approved IEE	Construction Phase	ES/ SE	
B.2.2		Limit felling operation to trimming to a safe height (maximum of 3 m from the ground) such that the habitat will be maintained.	Contractor	Approved IEE	Construction Phase	ES/ SE	
B.2.3		Limit construction activities only in day time	Contractor	Approved IEE	Construction Phase	ES/ SE	
B.2.4		Instruct the workforce not to hunt or damage wildlife of the project site. Hunting and damage to wildlife will be an act of offense and punishable	Contractor	Approved IEE	Construction Phase	ES/ SE	
B.2.5		Prohibit use of the wildlife meat by the construction workforce.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C	**Socio-Economic Environment and Cultural**						
C1.1.	Impacts to the electricity lines, foot trails	Prior notification to the local community will be served a week before the closer of the foot trail for public use	Contractor	Approved IEE	Construction Phase	ES/ SE	
C1.2.		Stringing operation over the foot trails will be completed within a day	Contractor	Approved IEE	Construction Phase	ES/ SE	
C1.3.		Alternative route will be suggested for use on the day of the foot trail closer.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.2.1	Impacts to Local Infrastructure Services	Discourage outside workforce and encourage local employment in the project area.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.2.2		Establish sanitation facilities (waste and toilets) in construction sites and camps.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.2.3		Use water sources other than the water sources used by the communities for the construction works and camps.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.2.4		Establish first aid clinics within the camps	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.3.1	Impacts of Loss of agricultural crops	season The stringing of cables will be carried out in the dry as far as possible. If any loss or damage of the standing crops occured, such crops will be compensated as per the norms of District Agriculture office	Contractor	Approved IEE	Construction Phase	ES/ SE	

S.N	Environmental Impacts	Mitigation Measure	Individuals responsible	National Standards or Guidelines/ Approved Documents	Timing of Actions	Competent Authority/agency	
C.3.2		The construction workforce will be instructed not to damage the standing crops other than required	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.3.3		Prior information to the crop owners with regard to the potential crop damage and ensure compensation of the lost crops as per the norms of District Agriculture Office in the event of such loss	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.4.1	Impacts on Community Forest Resources	Only required trees will be cleared to the required height after careful pegging and numbering of the trees	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.5.1	Impacts on Occupational health safety	Regular instruction to the construction workers on the health and safety issues in the related construction works.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.5.2		The construction workforce will be provided with protective equipments such asboots and gloves, helmets and masks to all the construction workers.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.5.3		Provision of first aid kits in the construction sites with instruction of use	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.5.4		Health and safety plans will be prepared and operationalised for the entire period of construction to safeguard the health safety of the construction workforce with provisions of and .rescue in case of accidents	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.6.1	Impacts on Community Health and Hygiene	Fencing of high risk construction sites to prevent accidents with sign boards.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.6.2		Sanitary conditions of the camps such as toilets, water supply, solid and liquid wastes will be managed by .launching special sanitary programs	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.7.1	Impacts on gender, indigenous, tribal and vulnerable groups	Discrimination on Gender, indigenous, tribal and vulnerable is prohibited and priority to these groups in the construction work employment will be given in equal salary payments as to the other working members with similar work nature.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.7.2		Discourage usage of offending language at work place.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.7.3		All the construction workforce will be instructed to give respect to the female membersincluding the indigenous,	Contractor	Approved IEE	Construction Phase	ES/ SE	

S.N	Environmental Impacts	Mitigation Measure	Individuals responsible	National Standards or Guidelines/ Approved Documents	Timing of Actions	Competent Authority/agency	
		tribal and vulnerable groups of the society.					
C. 7.4		The local culture, tradition and language will be respected.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.8.1	Impacts on law and order situation	Provide maximum job opportunities to local people.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.8.2		Instruct outside workers to respect the local people, culture and traditions and not to indulge in conflict with the local community members.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.8.3		ordination with regional security authorities will be -Co established to increase the numbers of security personnel in the project sites.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C8..4		Terminate employees who disregard security and safety of communities.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.9.1	Aesthetic Impacts of Stockpiling of the Construction Materials and Spoil disposal	Excavated materials will be placed in safe and sound areas to minimize runoff and wind erosion	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.9.2		The spoil materials will be used for backfilling and landscaping of the tower foundation sites	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.9.3		Construction and camp waste shall be collected, segregated and managed as per the 4R principle.	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.10.1	Impacts to local religious sites, tradition and culture	Instruct and supervise the construction workers that the local culture and traditions are respected	Contractor	Approved IEE	Construction Phase	ES/ SE	
C.10.2		Instruct and supervise the construction workforce that the local people including children and women are respected	Contractor	Approved IEE	Construction Phase	ES/ SE	

RASUWAGADHI HYDROPOWER COMPANY LIMITED
RASUWAGADHI HYDROELECTRIC PROJECT (111MW)
RGHEP - Chilime Hub 132 kV Transmission Line Project

MANDATORY

ITEM: OPGW GROUNDWIRE AND ACCESSORIES

S. No.	Description	Unit	Optical ground wire
1	Manufacturer		
2	Country of origin Standard		
3	ISO Certificate submitted	yes/no	
4	Manufacturer sales record submitted	yes/no	
5	Code word		
6	EHS galvanized steel wires: Number of wires and diameter	nos/mm	
	Lay-outer layer	mm	
	Steel quality (grade)		
	Nominal cross sectional area	mm^2	
	Weight	kg/m	
7	Overall diameter of OPGW	mm	
8	Ultimate tensile strength of OPGW	kg	
9	Tension of OPGW in still air at every day temperature	kg	
10	Maximum working tension of OPGW	kg	
11	Equivalent modulus of elasticity of OPGW	kg/m^2	
12	Equivalent coefficient of linear expansion of complete optical	per ^0C	
13	Standard length of OPGW on each drum	km	
14	Maximum weight of OPGW and drum	kg	
15	Vibration dampers: Type		
	Weight	kg	
	Distance from clamp mouth to attachment point: a. 1st damper	mm	
	b. 2nd damper (if required)	mm	
16	Optical Groundwire Optical Fibre Type	Mode	
	Nos. of optical fibre	nos	
	Lay of outmost layer		
	Cross sectional area	mm^2	
	Fibre diameter a. Mode field diameter	µm	
	b. Cladding diameter	µm	
	Standard a.Single mode fibre		
	b.Optical fibre cable		
	c.Stranding part		
17	Optical attenuation at wave length:		
	1310 mm	dB/km	
	1550 mm	dB/km	
18	Short circuit carrying capacity	kA x sec	
19	Other properties		
20	OPGW manufacturing process		
21	Optical fibre termination and splicing:		
	Line termination unit		
	Outdoor splicing box		
22	OPGW fittings and accessories		
	Suspension assembly		
	Tension assembly		
23	List of recommended spares		

Signed .....
As Representative for .....
Address .....

Date : .....

RASUWAGADHI HYDROPOWER COMPANY LIMITED
RASUWAGADHI HYDROELECTRIC PROJECT (111MW)
RGHEP - Chilime Hub 132 kV Transmission Line Project

MANDATORY

ITEM : CONDUCTOR AND EARTHWIRE PARTICULARS

S. No.	Description	Unit	ACSR BEAR CONDUCTOR
1	Manufacturer		
2	Country of origin		
3	Standard		
4	Code word		
5	Aluminium Wires :		
	No. of and diameter	no/mm	
	Lay inner layer	mm	
	Lay middle layer	mm	
	Lay outer layer	mm	
6	Steel Wires :		
	No. & diameter	no/mm	
	Lay outer layer	mm	
	Steel quality (Grade)		
7	Overall diameter of conductor	mm	
8	Maximum DC resistance of conductor at 20 ^{O}C	ohms/km	
9	Maximum AC resistance of conductor at 20 ^{O}C	ohms/km	
10	Ultimate tensile strength of conductor	kg	
11	Tension of conductor in still air at every day temperature	kg	
12	Maximum working tension of conductor	kg	
13	Equivalent modulus of elasticity of complete conductor	kg/m^2	
14	Conductor weight with grease	kg/m	
15	Equivalent coefficient of linear expansion of complete conductor	10 $^{-6}$per ^{O} C	
16	Standard length of conductor on drum	m	
17	Maximum weight of conductor and drum	kg	
18	Vibration dampers ;		
	Type		
	Weight	kg	
	Distance from clamp mouth to attachment point :		
	a. 1st damper	mm	
	b. 2nd damper (if required)	mm	
19	Conductor grease :		
	Type		
	Density	kg/m^3	
	Weight of grease per kilometer	kg	
17	Aluminum wires before stranding :		
	Minimum breaking load	kg	
	Tensile breaking stress	kg/m^2	
	Cross sectional area	mm^2	
18	Steel wires before stranding :		
	Minimum tensile strength Minimum stress of 1 % elongation	kg/m^2 kg/m^2	
	Elongation in 200 mm length of breaking	%	
	Yield stress/breaking strength	%	
19	Conductor manufacturing process		
20	Joint compressors :		
	Type of compressor		
	Dies to be supplied		
	List of recommended spares		

Signed .....
As Representative for .....

Address .....
Date : .....

RASUWAGADHI HYDROPOWER COMPANY LIMITED
RASUWAGADHI HYDROELECTRIC PROJECT (111MW)
RGHEP-Chilime Hub 132 kV Transmission line project

MANDATORY

ITEM : 132 kV STRUCTURE DESIGN PARTICULARS (STEEL TOWERS)

S. no.	Description	DOUBLE CIRCUIT				
		DA	DB	DC	DF	DD/DDES
1	Manufacturer					
2	Country of origin					
3	Overall length of suspension insulator rod from point of suspension to bottom of phase conductor clamp (mm).					
4	Overall length of tension insulator rod measured from point of attachment on crossarm to point where jumper loop parabola leaves conductor (mm).					
5	Shield angle of the earthwire					
6	Jumper Drop (mm).					
7	Minimum Guaranteed Weight (kg) a. Stub (per leg)					
	b. Basic tower					
	c. - 4.5 M extension (per leg)					
	d. - 3.0 M extension (per leg)					
	e. - 1.5 M extension (per leg)					
	f. +/- 0 M extension (per leg)					
	g. + 1.5 M extension (per leg)					
	h. + 3.0 M extension (per leg)					
	i. + 4.5 M extension (per leg)					
	j. + 6.0 M extension (per leg)					
	k. + 7.5 M extension (per leg)					
	l. + 9.0 M extension (per leg)					

Signed_____

As Representative for _____ Date _____

Address _____

RASUWAGADHI HYDROPOWER COMPANY LIMITED
RASUWAGADHI HYDROELECTRIC PROJECT (111MW)
RGHEP - Chilime Hub 132 kV Transmission Line Project

MANDATORY

ITEM : COMPOSITE LONG ROD INSULATOR SETS

S.No.	Description	Unit	Data
	Manufacturer		
	Country of origin		
1	Insulator type		
2	Composite material		
3	Highest System Voltage		
4	System Frequency		
5	Rated Lightning Impulse Withstand Voltage (dry)		
6	Rated Power Frequency Withstand Voltage		
	a) Dry		
	b) Wet		
7	Creepage distance as multiplied arcing distance		
8	Minimum mechanical failing load:		
	a) Suspension Rod		
	b) Tension Rod		
9	Factor of safety under maximum loading condition		
	a) Insulator set		
	b) Iron fittings (if any)		
10	Overall length of insulator strings		
11	Insulator hardware:		

Signed .....

As Representative for .....

Address ..... Date : .....