Madhya Bhotekoshi Jalavidyut Company Limited

Middle Bhotekoshi Hydroelectric Project (102MW)

BIDDING DOCUMENTS

For

Design, Supply, Construction, Testing and Commissioning of Single Circuit 220kV Transmission Line from Middle Bhotekoshi Hydroelectric Project to Barhabise Sub-Station

International Competitive Bidding (ICB)

Single Stage Two Envelope Bidding Procedure

Contract Identification No: MBJCL/MBKHEP-074/75-TL-01

Volume II of III

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PART I BIDDING PROCEDURES

Section I Instructions to Bidders (ITB) Vol I

This section specifies the course of actions to be taken by Bidders in the preparation and submission of their Bids following a Two-Stage bidding procedure. Information is also provided on the submission, opening, and evaluation of bids and on the award of contract.

Section II Bid Data Sheet (BDS) Vol I

This section consists of provisions that are specific to each procurement and supplement the information or requirements included in Section 1 - Instructions to Bidders.

Section III Evaluation and Qualification Criteria (EQC) Vol I

This section contains all the criteria that the Employer shall use to evaluate bids and qualify Bidders. In accordance with ITB 25, ITB 48 and ITB 50, no other factors, methods or criteria shall be used. The Bidder shall provide all the information requested in the forms included in Section IV (Bidding Forms).

Section IV Bidding Forms (BDF) Vol I/III

This Section contains the forms which are to be completed by the Bidder and submitted as part of his Bid.

PART II REQUIREMENTS

Section V Works Requirements (WRQ) Vol I/II

This Section contains the Specification, the Drawings, and supplementary information that describe the plant and services to be procured.

Section VI Preamble to the Bill of Quantities (BOQ) Vol III

This Section contains the price schedules, Bill of Quantities of the plant and services to be procured.

PART III CONDITIONS OF CONTRACT AND CONTRACT FORMS

Section VII General Conditions of Contract (GCC) Vol I

This Section contains the general clauses to be applied in all contracts. These Conditions are subject to the variations and additions set out in Section VIII (Special Conditions of Contract).

Section VIII Special Conditions of Contract (SCC) Vol I

This Section supplements the General Conditions of Contract (GCC). Whenever there is a conflict, the provisions herein shall prevail over those in the GCC. The clause number of the SCC is the corresponding clause number of the GCC.

Section IX Contract Forms (COF) Vol I

This Section contains the Letter of Acceptance, the Contract Agreement and Appendices to the Contract Agreement which, once completed, will form part of the Contract.

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Scope of Supply of Plant & Services and Supplementary Information

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Scope of Supply of Plant & Services and Supplementary Information

1. Scope

1.1 The Scope of Works covers design, manufacture, supply, Installation, Testing and Commissioning of 220 kV Single Circuit Transmission Line and design & construction of all the required civil works for the above stated works, as per Employer's Requirements and as defined in these bidding documents. Total Length of the transmission line is approximately 4 km. ACSR "BISON" conductor shall be run on the transmission line.

The Scope of work covered shall, but not to:

1.1.1 Check Survey on the alignment surveyed by the Employer including route alignment and profiling, tower spotting, optimization of tower locations;

1.1.2 Soil resistivity measurement, geotechnical investigation and detail survey;

1.1.3 Design, Prototype testing, Fabrication and Supply of all types of 220 kV Single Circuit Transmission Line Towers including bolts, nuts and washers, hangers, D-shackles and all types of tower accessories like phase plate, number plate, danger plate, anti-climbing device, bird guards all complete;

1.1.4 Supply of ACSR "BISON" conductor, insulator and hardware with necessary accessories all complete;

1.1.5 Supply of OPGW, associated hardware with necessary accessories all complete;

1.1.6 Design of foundations for different soil conditions for all towers and casting of foundation for tower footings as per approved drawings;

1.1.7 Supply and Installation of Tower Earthing;

1.1.8 Erection of towers including supply and application of zinc rich primer & enamel paint, protection of tower footing, fixing of insulator strings, stringing of conductor, OPGW/Earth wires along with all necessary line accessories all complete;

1.1.9 Testing and Commissioning of the erected transmission lines;

1.1.10 Supply, erection, testing and commissioning of outdoor splice boxes at the intermediate and last dead-end tower, optical approach cable and optical distribution frame (ODF) inside the communication room of control buildings at both sub-station. The testing and commissioning of fiber optic cable include that of OPGW all complete.

1.1.11 Other items not specified above but are required for the successful commissioning of the transmission line, unless specifically excluded in the Specification.

The Contractor shall submit all the reports, calculation and drawings they make for detail design of steel lattice tower, tower foundations, tower spotting, sag calculation 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. The Employer may accept or reject such proposal submitted by the Contractor.

The Contractor shall develop structural drawings, shop drawings and Bill of Materials of all the towers after completing prototype testing of tower. The design and drawings for all type of foundations for the towers and transmission line shall be developed by the Contractor, in sequence, suiting the project requirements.

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 Bill of Quantities of the Bidding documents. However, the work shall be executed as per approved construction drawings and project requirement.

The various item of work is described very briefly in the appropriate Bill of Quantities. The various items of the Bill of Quantities shall be read in conjunction with the corresponding chapters in the Technical Specifications including amendments and, additions, if any. The Bidder's rates shall be

based on the description of activities in the Bill of Quantities as well as necessary operations detailed in these Technical Specifications.

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.

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.

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.

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 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 (if any) etc. shall be made as per the actual quantities supplied according to the Bill of Quantities.

1.2 All the raw materials such as steel, zinc for galvanizing, reinforcement steel and cement for tower foundation, coke and salt for tower earthing etc. bolts, nuts, washers, links, danger plates, phase plates, number plates, Circuit Plates, anti-climbing device, bird guards, etc., required for the supply and construction of 220 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.

1.3 The entire stringing work of conductor and earth wire shall be carried out by tension stringing technique. The Contractor shall indicate in their offer, the sets of tension stringing equipment, he is having in his possession and the sets of stringing equipment he would deploy exclusively for this project which under no circumstance shall be less than the number and capacity requirement indicated in Qualifying Requirements for Bidder.

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.

1.4 Project Information, Location Details, Access and Terminal Points.

Middle Bhotekoshi Hydropower Project is run-off-the river type Hydro Electric Project. It has installed capacity of 102 MW with annual estimated generation of 235 GWH. This Hydropower Project situated at the left bank of Bhotekoshi River, Jambu village, Gati VDC-3 of Sindhupalchowk district in mid region. The project is located about 95 km north-east of Kathmandu. The powerhouse is situated about 4 km upstream from Barhabise Bazaar. The project is going in the stage of construction; it is essential to carry out the detail survey to evacuate the power from the project and connected to the National Grid at the nearest point, i.e. at the proposed Barhabise Hub. A reconnaissance study team was mobilized to access and fix the route suitable for the single circuit 220 kV transmission line. After avoiding settlement and dense forest areas, shortest possible transmission line route on that vicinity have been fixed. The power from MBK HEP shall be evacuated through proposed **Barhabise Sub-station (to be constructed by NEA)**; this is then connected to Kathmandu Hub near **Lapshiphedi** and eventually to INPS. The said Barhabise - Kathmandu 400 kV transmission line project is being developed/constructed by the, **NEA**.

In the integrated national power system (INPS), most of the Hydro Electric plants are situated in the central and western part of Nepal. There are plans to construct much more power plants in the different river basins situated in the central part of the country in the vicinity of Kathmandu valley

as well. Considering location of the hydroelectric projects around Barhabise, in Sindhupalchowk NEA has envisaged development and construction of high voltage substation and transmission line.

After construction of MBHEP the generated power could be transmitted to wards Kathmandu through Barhabise - Kathmandu 400 kV transmission line or towards the southern part of the country and maybe even export of power through Barhabise - Khimti - Dhalkebar 220 kV transmission line and Dhalkebar – Muzaffarpur cross border transmission line thereafter.

At present Nepal is required to manage power deficit by purchasing huge amount of power from India. This project shall also contribute strengthen INPS from Bhotekoshi Basin to the other region of Nepal. Barhabise - Kathmandu or Barhabise - Khimti - Dhalkebar interconnection link is one of the grid lines to serve the above purpose.

The Detail Route Alignment Survey with Tower Spotting study for power evacuation of Middle Bhotekoshi through Barhabise hub was started as per agreement between Sai Om Engineering Consultancy Pvt. Ltd. to carry out detail survey works of 220 kV transmission line from Middle Bhotekoshi HEP switchyard to Proposed Barhabise Sub-station.

The reconnaissance field survey was started immediately after submission of Desk Study Report for the proposed alignment. Incorporating the comments and suggestions on the desk study and detail joint reconnaissance study performed by the engineers and surveyors, the final route for Middle Bhotekoshi-Barhabise 220 kV Transmission Line has been fixed.

The detailed survey work was started with the field visit of the concerning experts and engineers of Middle Bhotekoshi Hydropower Project. Subsequently, the survey team carried out an instrument survey of the selected route, performed visual impact studies and conducted field surveys to record the relevant characteristics present within the transmission line corridor. Using the data collected in the field, the team prepared the requisite plan / profile drawings and carried out the preliminary design of the transmission line.

The 220 kV transmission route alignment starts at the near proposed Middle Bhotekoshi HPP switchyard at Jambu, Khet-Khorang, Gati VDC-3 Sindhupalchowk district and passes through finally at proposed 400/220/132 kV Barhabise Sub-station (NEA) at Betephat-Sano Palati village, Barhabise VDC-6, Sindhupalchowk district. It crosses once under Construction of Upper Chaku 132 kV transmission line and Kali Khola, Hyalme Khola, Chahare Khola, Sirshe Khola, Khakdol Khola, Khamare Khola and Guhe Khola once. Similarly, it crosses major earthen road three times, LT line two four times, 11 kV line four and 33 kV line twice. The route alignment passes through Nepal Army Camp which is lies between chainage 2+364km to 2+462km right part of right of way. Altogether, there are seven angle points among which are two dead-end angle points along the route alignment. The maximum deviation angle is 42º at AP-6. There is one angle point having deviation angle in the range of 0º to10º, three in the range of 10º to 30º. This route passes through fairly dense mix forest about 943m, about 2178m of cultivated, about 99m kharbari and about 667m land including the barren land, khola, kholsi, earthen road and foot track.

2. Details of Transmission Line Routes and Terrain

Detailed survey including route alignment, profiling, tower spotting etc. have been carried out by the Employer and these are not expected to vary substantially. The details collected through detailed survey viz route alignment maps, profiling, tower spotting etc. are enclosed with the bidding documents.

The Contractor shall have to check the tower spotting provided by the Employer 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. Checking of 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 the Specification.

The Bidders may visit the line route to acquaint themselves with terrain conditions and associated details of the proposed transmission lines.

3. Right of Way (RoW) and Clearance of RoW

The Contractor shall be responsible for clearing the Bushes and trees along the Right of way (RoW) and tower foundation area of the Transmission Line. The scope of works shall include the numbering, marking, cutting, felling, transport to stockyard, storing and handling etc. of bushes and trees all complete.

The Contractor shall also be responsible for obtaining any permits or approvals etc. required for the clearing of bushes and trees along the RoW of the Transmission Line from the concerned governmental authorities or Community Forest User Groups (CFUG).

The Employer will use his best efforts to assist in obtaining such permits or approvals etc., nevertheless the Contractor shall be solely responsible therefor.

The Contractor shall inform the Employer in writing of the details regarding the clearing of bushes and trees and shall submit a formal written request for assistance from the Employer for obtaining any permits or approvals regarding such clearance. The Employer will assist the Contractor to obtain necessary permits or approvals. Any fees or other charges related to such activities shall be at the cost of the Contractor.

All cost of clearing along with the charges for obtaining necessary permits or approvals from the concerned governmental authorities or CFUGs are deemed to be included in the item rates of Bill of Quantities. No separate payment shall be made to the Contractor for the clearing of bushes and trees along the RoW of the Transmission line under the scope of this Contract.

4. Contractor Execution Plan

The Contractor shall submit a detailed plan for resources mobilization & execution of various activities under the project scope within one month 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.

5. Contractor's Site Establishment

In general, the Contractor will be responsible for providing under the Contract the site installations required for his personnel or in connection with the construction of the works and the fulfillment of his obligations under the Contract.

6. Site Data

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

Horizontal seismic coefficient is 0.25.

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

Maximum ambient shade temperature	45°C
Minimum ambient shade temperature	0°C
Annual average temperature	32°C
Wind Zone (as per IS: 875)	4
Basic Wind Speed	34.4 m/sec
Maximum	47 m/sec
Rainfall	1,000 mm/annum
Monsoon season	June-August
Relative humidity,	maximum 100 %
	minimum 20 %
Altitude	maximum 1213 from sea level
	minimum 1013 from sea level
Atmospheric pollution	Light
Isokeraunic level (thunderstorm days)	50

Site is geographically remote with hilly terrain. Some of the tower points are accessible by foot trails only.

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

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

Chapter 2
General Technical Specifications

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Chapter 2
General Technical Specifications

1. Foreword

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

2. General Requirement

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.

3. 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.

AASHO	American Association of State Highway Officials
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 of Testing Materials
AWS	American Welding Society
BS	British Standard Institution
CSA	Canadian Standard Association

DIN	Deutsches Institute Für Normung
EEI	Edison Electric Institute
IEC	International Electro Technical Commission
NEMA	National Electric Manufacturers Association
IEEE	Institute of Electrical and Electronics Engineers
IS	Bureau of Indian Standard
ISO	International Organization for Standardization

4. 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.

5. 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. Very 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.

6. Labels, Ratings and Nameplates

6.1 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.

6.2 Labels

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

7. 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.

8. 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. Welders certificates shall be furnished to the Employer, if requested by him.

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.

9. 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 87 micron 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.

10. Maintenance Tools

The Bidder must add to the Bill of Quantities, the 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 issuance of the Completion Certificate.

11. 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.

12. 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.

13. Limits of Installation and Drawings

13.1 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 Bidder.

13.2 Terminal Points

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

13.3 Specification, Bid and Contract Drawings

a. 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 the Employer for bidding purposes are contained at the end of this Volume.

b. Bid Drawings

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

The following drawings must be prepared by the bidders and accompany copy of their Bid:

- 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/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 to 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 bidder 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 Bidding Documents will then form part of the Contract Document and be signed both by the Employer and the Contractor for identification purposes.

c. Contract Drawings and Documents for Approval,

i. General

All designs and drawings submitted with the successful Bid 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:

aa. Survey Drawings, including:
- Route Maps
- Centre-Line Plans and Profiles of line
- Optimized Tower Spotting Drawings
- Soils Survey Map Identifying Foundation type selected for each individual tower.

bb. Tower Drawings consisting of:
- Detailed Design Drawings and calculation for each type of tower and leg extension; tower loading calculations and diagrams.
- 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.

cc. Proposed procedure for applying loads and measuring deflections and other pertinent data during tower tests.

dd. Tower Foundation drawings consisting of design drawings, calculations, volumes and weight of Re-Bar.

ee. Each Type of Insulator string assembly with all fittings.

ff. Line accessories consisting of sleeves, splice, vibration dampers, patch rod, etc.

gg. Detailed Drawings of grounding materials and ground connection consisting of ground electrodes, ground connecting strip, ground connecting bolts and list of ground electrodes for each tower.

hh. 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:

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

bb. Towers

Design drawings and calculation for each type of tower and leg extension:
- 4 copies within 60 days after effective date.

Details drawings for each type of tower and leg extension:
- 4 copies within 60 days after effective date.

Bill of Materials
- 4 copies within 30 days before each shipment.

cc. 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.

dd. Tower Foundations

Design Drawings and Calculation for each type:

- 4 copies within 60 days after the Effective Date.

Details 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:

Details Drawings:

- 4 copies within 60 days after the Effective Date.

List of Ground Electrodes:

- 4 copies within 30 days after complete ground resistance tests.

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

- 4 copies within 90 days after the Effective Date.

ff. Modified approval drawings:

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

gg. 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.

ii. As Built Drawings:

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

jj. Reproducible:

Surveys:

- 2 copies 30 days before the issuance of the Completion 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:

Details drawings

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

Foundation List

- 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.

kk. CD/DVD ROM of Final/As-built Drawings:

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

ll. Test Reports:
Shop Tests and Field Tests:

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

mm. Instruction manuals and lists of operation and maintenance tools:

- 8 sets not later than 30 days before shipment.

ii. Drawings: Titles and Sizes

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

aa. Madhya Bhotekoshi Jalavidyut Company Limited
bb. Madhya Bhotekoshi Hydroelectric Project
cc. Madhya Bhotekoshi-Barhabise 220kV Transmission Line
dd. Title of the Contract
ee. Contract No

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.

A_0	841 x 1189 mm	(33.11 x 46.81 in)
A_1	594 x 841 mm	(23.39 x 33.11 in)
A_2	420 x 594 mm	(16.54 x 23.39 in)
A_3	297 x 420 mm	(11.69 x 16.54 in)
A_4	210 x 297 mm	(8.27 x 11.69 in)

iii. 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/DVD-ROM): CD/DVD-ROM of all final approved drawings/documents shall be submitted.

14. 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.

15. Design Review Meeting

The Contractor will be called upon to attend design review meetings with the Employer, and the Engineer 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.

16. Progress Reports

Before the tenth (10^{th}) 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.

a. General descriptions of the Works performed during the reporting period on each main activity and include notable problems, which were encountered.
b. The percentages of each main work activity completed during the reported month compared with the scheduled program. Appropriate comments shall explain any differences.
c. The total overall percentages of erection work completed with reference to the actual construction program. Appropriate comments shall explain any differences.
d. 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.
e. 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.
f. A list of manpower employed during the reporting period.
g. A list of the Contractor's equipment and materials presently stored at Site.
h. Progress photographs of significant events. The Employer may ask to include specific photographs if deemed necessary.
i. Main items of temporary facilities constructed during the reporting period.
j. A statement detailing the status of progress on the overall program and how to regain any lost time or setbacks, which may have occurred.
k. A list of inoperable, temporary equipment and the estimated date when the repair will be completed.
l. A statement about labor relations and an explanation of an actual or potential problem.
m. A list of accidents at site involving the hospitalization and/or death of any person.
n. A statement concerning effectiveness of the security programme and a list of major thefts.
o. A list of the amount and date of any payments received during the reporting period and the amount of any invoice, which has been submitted but not yet paid.
p. A list of claims submitted during the reporting period including the claimed cost and extension of time.
q. A statement concerning potential problems and recommendations on how they could be solved.

17. Progress Meetings

The Contractor shall be required to attend regular Site Progress Meetings with the Engineer and, at the option of the Employer, 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/Engineer 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 or the Engineer may direct

that representatives of the Contractor's subcontractors attend the Progress Meetings and/or biweekly 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 labor relations and environmental management.

The Engineer 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.

18. Packing

a. 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.
b. 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.
c. All packing shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided.
d. 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.
e. 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.
f. 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.
g. Angle section shall be wire bundled.
h. 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.
i. Bolts, nuts washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.
j. The packing shall be properly done to avoid losses & damages during transit.
k. Each bundle or package shall be appropriately marked.

19. Storage of Material

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

19.1 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.

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.

19.2 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.

19.3 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.

19.4 Structural Steel or Tower Parts

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.

19.5 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.

19.6 Hardware fittings, 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.

Chapter 3
Inspection, Testing and Commissioning

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Chapter 3
Inspection, Testing and Commissioning

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 the Employer/Employer's personnel (including Visa, International air fares, National air fares, transportation by car or train, full board accommodation, insurance cost and per diem allowance) 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 Bill of Quantities except for the prototype testing of towers.

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 and materials supplied under the Contract.

2. Objectives

The objectives of commissioning work, prior to the successful energization of Plant at full voltage and connection to the system, are the following:

a. Confirm the integrity (correctness)of installation.
b. Confirm the integrity of insulation, connections and phasing.
c. Ensure proof of equipment characteristics.
d. Review workmanship.
e. Confirm the correct implementation of the design.
f. Check equipment ratings.
g. Check and measure resistivity of earthing grid and earthing system.
h. Confirm the proper functioning of SCADA system (if applicable).

3. 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. The Contractor shall submit his detailed Quality Assurance / Quality Control procedures for the Employer's comments and approval not later than 30 days after the Commencement Date. The Employer will either approve the quality procedures or require reasonable amendments to be made, and the Contractor shall introduce and implement all such amendments within 14 days and re-submit the documents to the Employer for approval.

Works carried out prior to approval of the Contractor's quality procedures shall require separate approval of individual quality plans for each of such works, with the exception of site establishment temporary works and site surveys.

The Contractor's quality system shall comply with all the requirements of the Contract as well as with the requirements for quality assurance and testing as set out in the Contract. It shall be the responsibility of the Contractor to demonstrate to the Employer that compliance with the specified requirements is achieved.

The Contractor is responsible for measuring the quality of the Work in accordance with the requirements 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.

3.1 Quality Assurance Documents

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

3.2 Inspection and Testing

The provisions of the clauses on Test and Inspection of the GCC, SCC and technical specifications shall be applicable to the supply and erection portions of the Works.

The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where materials and equipment and their component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Supplier's and sub-Supplier's works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

During final inspection of the material, the Employer shall select samples at random from the lot for carrying out acceptance tests.

The Contractor/Supplier shall keep the Employer informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Employer in writing. In the latter case, also the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

The acceptance of any quantity of material shall in no way relieve the Contractor of his responsibility for meeting all the requirements of the Specification and shall not prevent subsequent rejection, if such materials are later found to be defective.

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 if, after the same are inspected at Site following the latter, material is found defective, then the Contractor shall bear the additional cost of this inspection and reinstatement according to the Specification.

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 center. 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.

The Contractor shall organize all shop tests and inspections which shall be witnessed by the Engineer/Employer's Representative in such a manner that the total number of these shall not exceed **60-man days**.

Engineers and technicians nominated by the Employer shall witness selected factory tests as mentioned in the Bidding Document.

The number of Employer's engineer/inspectors for testing of different items equipment and materials at manufacturer's plant shall be as follows, but not limited to:

- Tower with Accessories and Prototype Test — 2 persons, 2 visits
- ACSR Conductors — 2 persons, 1 visit
- OPGW and Earthwire — 2 persons, 1 visit
- Insulators, Hardware and Accessories — 2 persons, 1 visit
- Grounding Materials — 2 persons, 1 visit

The Contractor shall provide the following for each of the Employers' personnel participating in the factory acceptance tests.

- Round-Trip Air Ticket between Kathmandu and the place of testing
- Food and Accommodation
- Inland Travelling Expenses
- Visa and Fee, if applicable
- Per diem allowance of USD 150 per calendar day
- Health Insurance to cover all medical costs that may be required during the stay abroad for factory acceptance test.

3.3 Test Certificates

Within 15 days of the completion of any test, four sets of all principal test records, test certificates, performance curves, tables etc. 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.

In addition, the following references shall be entered in the top right-hand order:

- Employer's Name
- Project Title and Lot / Chapter of Specification
- Plant's Name
- Number of Contractor's reference drawings
- Date

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. Three copies of each volume shall be supplied to the Employer.

4. Guarantees

The Bidders shall state and guarantee the technical particulars listed in the Technical Datasheets 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, IS or ANSI will apply unless stated otherwise.

5. Tests at Manufacturers Works

5.1 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, IS 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 thirty (30) day's prior notice, in writing or by tele-fax, shall be given to the Employer/Employer's Representative 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.

All equipment/material to be supplied shall conform to type tests as per technical specification and shall be subject to acceptance tests, routine tests and tests during manufacture in accordance with the requirements stipulated under respective chapters.

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.

5.2 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.

5.3 Type of Tests

Inspection and testing of the equipment shall include all inspections, test checks, procedures, etc., whether mechanical, hydraulic or electrical, as required to ensure that the equipment supplied meets the requirements of the specifications.

They shall comprise, but not be limited to:

- Chemical analysis of materials
- Destructive tests of towers
- Checks and examinations of welds
- Checks of fits and assemblies
- Dimensional checks
- Inspection of paints and coatings (thickness, porosity and adhesion)
- Various test on composite long rod insulator
- Test of insulator fittings
- Test of conductors and OPGW wire

The technique, equipment and instrumentation to be used for these tests, checks, inspections, examinations, etc. shall be in accordance with the pertinent and internationally accepted standards, rules or codes, in particular those mentioned in the specification.

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

- Type Tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this Specification. These tests shall be carried out on samples prior to commencement of commercial production against the order
- Acceptance Tests shall mean those tests which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot.
- Routine Tests shall mean those tests, which are to be carried out on the material to check requirements which are likely to vary during production.
- Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Contractor to ensure the desired quality of the end product to be supplied by him.

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

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

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

a. Type Tests

Type tests are required to prove the general design of the equipment.

In accordance with the stipulation of specification, the reports for all the type tests as per technical specification of each equipment/material shall be furnished by the Contractor along with the equipment/material design drawings for the Employer's approval. The type tests report/certificate should be for the similar equipment/material of identical model, design and rating, type etc. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on IEC Guide 25/17025 or EN 45001 or by the National accreditation body of the country where laboratory is located) or witnessed by Utility or representative of accredited test lab.

The test reports submitted shall be of the tests conducted within last 10 (ten) years from the last date of Bid submission. In case the test reports are of the test conducted earlier than 10 (ten) years from the last date of Bid submission, the Contractor shall repeat these test(s) at no extra cost to the purchaser.

The Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, then any/all type tests shall be carried out in presence of the Inspector/Employer's representative without any additional cost implication to the Employer.

In case of failure in any type test, the Supplier whose material has failed is either required to modify the design of the material and manufacture fresh sample lot and repeat all the tests successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at his own expenses. In case fresh lot is manufactured for testing then the lot already manufactured shall be rejected. The decision of the Employer in this regard shall be final and binding on the Contractor. Such repeat type tests shall be carried out in presence of the Inspector/Employer's representative and all the expenses for deputation of Inspector/Employer's representative shall be borne by the Contractor.

Further, if on receipt of the Contractor's notice of testing the Employer's representative/Inspector does not find 'materials and facilities' to be ready for testing, the expenses incurred by the Employer for re-deputation shall also be borne by the Contractor.

If type testing is required, the Contractor shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Employer. The Contractor shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Employer.

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

b. Random Sample Tests (Acceptance Tests)

These are tests, which are being carried out on random samples of a lot of equipment, parts or material. Choosing of the samples to be tested, will be done by the Engineer/Employer and the complete lot of equipment, parts etc. shall be presented for this purpose. The number of samples taken will be either at the discretion of the Engineer/Employer, particularly for small lots, or shall conform to the generally accepted rules and standards of statistical testing.

The whole lot of which the samples have been taken shall be considered satisfactorily if none of the samples tested has failed. Should one only of the samples fail, even only in one test, the following shall apply:

- small lots: all pieces shall be fully tested
- large lots: a second set of samples, identical in number to the first one, shall be chosen and tested. If this set will pass all tests satisfactorily, the lot shall be considered to be accepted. If again one or more samples will fail in one or more tests, either the whole lot shall be rejected or all pieces of the lot shall be fully tested individually. The decision of which of the two alternatives to follow shall be with the Engineer/Employer.

Pieces of lots which have been declared non-acceptable and samples which have failed in test must be marked immediately and must not be presented for test again.

6. Contractor's Quality Control System

The Contractor and all of his suppliers or Sub-contractors shall have a fully established and efficient quality control system certified under ISO9001. Should the Engineer/Employer, during his inspections or otherwise, determine that this system is not sufficiently effective, based on:

- formal errors in contradiction to the established procedures
- and/or manufacturing deficiencies
- and/or non-acceptable test results and missing tests

The Engineer/Employer may, at his entire discretion and at the full expense of the Contractor, impose such additional tests and inspections as deemed necessary to assure the quality of manufacturing and performance as stipulated by the terms of the Contract.

7. Responsibilities

To ensure that the test jurisdiction and transfer of responsibilities is regulated by strict safety and handover procedures, the Contractor agrees the interface with the Employer to establish and implement handover procedures consistent with the terms of these Specifications.

The Employer shall retain full jurisdiction over all commissioning activities, which may affect the operation of the existing system. In these circumstances and when so requested, shall provide technical advices and assistances.

The Contractor shall be responsible for technical guidance and assistance in establishing the scope and method of tests, witnessing of the testing, assessment of results, and re-negotiation of the changes in test schedules which may be necessary as a result of other circumstances, such as delays in the delivery, possible equipment failures.

8. Safety Procedures

The Contractor shall share the responsibility for safety procedures with the Employer. The Contractor shall establish and implement a work permit and tagging system and associated safety procedures (subject to the review of the Employer) for all equipment, systems and areas not covered by the Employer's safety procedures.

The Employer will assume responsibility for the establishment and implementation of tagging, safety and work permit procedures for the protection of personnel and equipment, as soon as equipment and systems are connected to or are energized from the existing system.

9. Training of the Employer's Staff

The Contractor shall plan for the Employer's staffs' participation, either continuously or on a regularly recurring basis, in the commissioning work and:

Allow the Employer's staffs to become familiar with the design, operating and maintenance aspects of the transmission lines.

Maintain a continuing assessment with the Engineer/Employer of the precautions required in or possible consequences of, initial energization of the transmission line and equipment, Allow for the above two necessary objectives in the preparation of schedules.

10. Commissioning Staff

The Contractor shall provide commissioning personnel including skilled and unskilled labor as required. Submit a list with names, experience and proposed duration of the stay of key personnel on site, consistent with the construction schedule, along with the commissioning program.

Ensure that only staffs assigned to commissioning fulfills that duty for the duration of the assignment.

Ensure that commissioning staffs have authorization, and the competence, to undertake minor repairs or to make temporary redesigns and to reconnect systems to meet the specified system performance to preclude delays in energization and putting into commercial service of any part of the works.

11. Test Equipment

The Contractor shall ensure that all instruments, tools and other equipment required for testing and commissioning are available on site, ensure that the test equipment is of satisfactory quality and condition and, where necessary, is calibrated by an approved authority or standard.

Make arrangements for the provision of power supplies for testing with necessary vector configuration, voltage and current rating.

12. Testing and Commissioning Program

Prepare a commissioning program for approval by the Employer and for incorporation into the Project master construction program. Allocate adequate time in this program to permit full commissioning of all components.

Carry out all the tests during normal working hours as far as practicable. Tests, which involve existing apparatus and system outages, may be carried out outside normal working hours. Give the Employer sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing program.

Note that no tests listed in the agreed program will be waived except upon the instructions or consent of the Employer in writing.

13. Requirements for Field Tests

The field tests shall be carried out in presence of Engineer/Employer. The field tests shall be carried out by the Contractor after adjustment of all the equipment have been completed.

Expandable and lead wires and other materials required for the field tests shall be arranged by the Contractor. The Contractor shall be responsible for providing all measuring instruments, test equipment and tools required for the tests.

Preparation of the test record sheets and test reports shall be the responsibility of the Contractor and the results of the field tests shall be submitted by the Contractor for Employer's approval.

Submit test procedures, consisting of detailed test methods and samples of the related test record forms, for all equipment to be tested, to the Employer for approval along with the commissioning program. Strictly adhere to these procedures for the commissioning tests.

14. Records

Maintain an up-to-date record of all commissioning activities on site.

Record the results of the tests clearly on forms and formats approved by the Employer and with clear references to the equipment and items tested, so that the record can be used as the basis for maintenance tests, in future. Submit the required number of site test records to the Employer as soon as possible after completion of the tests.

Record the details of the test equipment and instruments used in the test sheets, in those cases where the instrument or equipment characteristics can have a bearing on the test results.

15. "As-Built" Drawings

Keep an ongoing record of all changes on a master set of drawings. Produce and supply a minimum of five complete sets of marked-up "As Constructed/As-Built" drawings before leaving the Site. Correct and re-issue the original drawings as soon as possible as per this specification.

16. Site Tests

The Contractor shall prepare and submit for the Employer/Engineer's approval complete site test procedures and test forms for each test required by the Contract and to be witnessed by the Engineer/Employer. Such approval must have been obtained at least one week before the start of such testing and it is suggested that the corresponding submission be given to the Engineer/Employer at least three weeks earlier. The Contractor shall bear all costs resulting from non-compliance with this requirement. The following tests shall be carried out as a minimum.

16.1 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.

16.2 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.

16.3 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.

16.4 Conductor Joint Tests

In 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.

16.5 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.

16.6 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.

16.7 Tests 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.

16.8 Tests 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. Three copies of the final approved report shall be submitted to the Employer.

17. 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. Bidders 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.

The test voltage shall be applied for five minutes for 220 kV overhead lines and shall be as follows:

Line Voltage	D.C Test Voltage to Earth
220 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.

Chapter 4
Transmission Line Tower

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1. General Description of the Tower

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

1.2 The tower shall be fully galvanized using mild steel or/and high tensile steel sections as specified in clause no. 7. Bolts and nuts with spring washer are to be used for connections.

1.3 The towers shall be of the following types:

220kV Single Circuit SD

2. Classification of Towers

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

Type of Tower	Deviation Limit	Typical Use
SD	0-60°	Angle Tower with Tension Insulator. Also to be used for uplift forces resulting from an uplift span up to 600m under broken wire condition. Dead End with 0 to 15° deviation both on line side and sub-station side (slack span).

Notes

- As the number of tower is less, the employer decided to use only one type of tower which is SD. It causes less investment as only a single Proto-Type Test is required.
- The insulator required will be as per the Deviation Limit in the individual tower i.e. not all type of insulator are tension insulators.

2.2 Towers for Major Crossings

The above SD type towers shall also be used with suitable modifications for very long spans (spans more than that of given in clause no. 3) which can't be crossed by normal tower with extensions as given in clause 2.3 like valley and river crossings etc. These Towers shall be developed by strengthening the above SD type towers as per the site requirement. However, the cost for such strengthening is understood to be included in the tower cost itself in the Bill of Quantities.

The transmission line towers shall be single circuit L-configuration with one peak for the OPGW. However, contractor shall take care of major crossing of 132 kV Line proposed in between AP 3/0 and AP 4/0, if necessary in those crossing special towers shall be designed with double peak one for OPGW and one for Ground Wire in order to reduce the tower height to maintain clearance and same shall be included in the present scope of the contract.

2.3 Extensions

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

2.3.2 The provision for addition of 18/25M body extension to the tower is also kept. For Power Line Crossing or any other obstacle, the tower can be used with 18/25 M extensions depending, upon the merit of the prevailing site condition. The maximum reduced spans shall be mentioned in the tower spotting data. However, this shall, in no case be less than 250 meters. The cost of the additional weight due to 18/25M extension shall also be

understood to be included in the tower cost itself in the Bill of Quantities as described in clause no. 2.2.

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

2.3.4 In situations where difference in leg differential does not suit the standard unequal leg extension provisions on the towers mentioned above, suitable chimney extensions shall be provided to reduce benching/revetment requirement. The cost of additional volumes of foundation due to chimney extensions shall also be understood to be included in the quoted price of the foundation in the Bill of Quantities.

2.3.5 The leg extensions, unequal leg extensions, chimney extensions and / or a combination of these suitable for a tower location shall be selected by the Employer on the basis of techno-economics evaluation.

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

3. Spans

3.1 Design Span or Normal Span

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

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. Wind Span for Broken Wire Condition shall be 210m.

3.3 Weight Span

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

Table 1.1

TOWER TYPE	NORMAL CONDITION		BROKEN WIRE CONDITION	
	MAX. (m)	MIN. (m)	MAX. (m)	MIN. (m)
SD	1000	-600	600	-600

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. The cost for such modified tower shall also be understood to be included in the quoted price of the tower in the Bill of Quantities.

4. Electrical Clearances

4.1 Ground Clearance

The minimum ground clearance from the bottom conductor shall not be less than 7200 mm for 220KV lines at the maximum sag conditions i.e at 80°C and still air.

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

b. Conductor creep shall be compensated by over tensioning the conductor at a suitable temperature, lower than the stringing temperature.

4.2 Power Line Crossing Clearance

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

4.3 Live Metal Clearance

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

Table 1.2

Description	Swing Angle	Live metal Clearance
Suspension String (Single/Double)	NIL	2535 mm
	15°	2360 mm
	30°	2180 mm
	45°	1995 mm
Tension String (Single/Double)	---	2535 mm
Jumper	Nil	2535 mm
	10°	2535 mm
	20°	1995 mm

Note:

In case of pilot insulator strings, the angle of swing of the jumper along with the pilot string shall be considered as 15°.

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

4.3.3 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.

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

4.4 Angle of Shielding

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

4.5 Mid Span Clearance

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

4.6 Clearance Between Phases

The minimum clearances between horizontal conductors shall not be less than 8.4 metre and that between vertical conductors shall be 4.9 metre.

Where obstruction is met requiring special clearance, the clearance shall be approved by the Employer. After the survey and profile is approved, if any factors likely to cause infringement of clearance become apparent the contractor shall inform the Employer immediately.

5. Normal Loading Conditions

5.1 Loads at Conductor and OPGW wire Points

The Contractor shall develop the tower designs based on the loadings of the conductors including OPGW wire for the tower.

5.2 Wind Load 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. Terrain category shall be considered as 2.

b. The angle of incidence of Wind θ (Theta) = 0°.

5.3 Maximum Tension

5.3.1 Maximum tension shall be based on either

a. at 0°C with 36% full wind pressure, or

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

5.3.2 The Contractor shall calculate sag tension calculation for a normal span of 350 meters for the purpose of tower design.

5.3.3 The initial conductor and OPGW wire tension (maximum) at 32°C and without wind shall be 22% of the ultimate tensile strength of the conductor and 20% of the ultimate tensile strength of the OPGW wire.

5.4 Limiting Tensions of Conductor and OPGW wire

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

5.5 Broken Wire Condition

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

6. Design of Towers

6.1 Design Criteria

Towers shall be designed based on spans and clearances as per Clause 3 & 4 and loading conditions as per Clause 5 above.

6.2 Design Temperatures

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

a. Minimum Temperature : 0°C

b. Every day temperature of conductor : 32°C

c. Maximum temperature of

i. Conductor : 80°C

ii. Earthwire exposed to sun : 53°C

6.3 Conductor and Earthwire Configuration

For single circuit towers, the three phases shall be in triangle formation (L configuration). The phase to phase spacing for conductors shall be not less than 4.9 meters vertically for the towers with deviation angle less than 30° and 8.30 meters for the tower with deviation angle greater than 30°. However, the minimum horizontal separation between phase conductors shall be 8.4 meters. The OPGW wire shall be installed at the top of the tower.

The OPGW configuration shall be such that the conductor is to be shielded in all cases within the specified shielding angle.

6.4 Redundant Design

6.4.1 All redundant in the tower are to be triangulated.

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

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

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

6.5 Thickness of Members

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

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

b. For all other members : 4 mm

6.6 Bolts and Nuts

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

Table 1.3

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

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

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

6.7 Slenderness Ratio

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

6.7.2 Slenderness ratio for compression and tension members shall not exceed the values specified therein.

6.7.3 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:

	Value of KL/R
a. For main corner leg members including the corner members of OPGW wire peak and the lower corner members of cross-arms	120
b. For other members having calculated stresses	200
c. For Redundant members	250
d. For members having tensile stress only	375

6.8 Erection Stress

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

6.9 Structural Arrangement of Members in a Tower

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

6.9.2 Internal angle between two members shall not be less than 15°.

6.10 Design Calculation and Drawings

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

a. Along with the Bid:
   - Detailed design calculations and drawings for tower only

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

6.10.2 After successful testing of tower and subsequent approval of design, drawings and bill of materials, the Contractor shall furnish the following in 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.

6.10.3 The Contractor is required to submit four copies of the drawings as mentioned in clause 6.10.2 for Employer's approval. While submitting the designs, structural drawings bill of materials and any other drawing pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing 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.

6.10.4 The design and drawings as covered in clause 6.10.1 (b) above shall be approved / commented by the Employer as the case may be within twenty-eight (28) days of receipt of design / drawings in Employer's office. If the design / drawings are commented by the Employer, the Contractor shall submit revised designs / drawings within fifteen (15) days of date of issue of comments.

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

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

6.10.6 The tower accessories drawings like name plate, danger plate, phase plate, anticlimbing 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.

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

WARNING: THIS IS PROPRIETORY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH ***[Name of Employer]***. UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM ***[Name of Employer]*** IN WRITING.

6.11 Altitude Correction Factors

As the transmission line lie on a high-altitude site, during the design of the tower, altitude correction factor shall also be considered so as to realize the effect of altitude on towers and its design.

7. Materials

7.1 Tower Steel Sections

7.1.1 IS Steel Sections of tested quality of conformity with IS:2062:2011 grade E250 (Designated Yield Strength 250 MPa) and/ or IS: 8500 grade E350 (Designated Yield Strength 350 MPa) are to be used in towers, extensions, stubs and stub setting templates. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards viz BSEN 10025. However, use of steel grade having designated yield strength more than that of EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) is not permitted, unless otherwise indicated in this specification.

7.1.2 Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS: 1079 (Grade-0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS: 2062 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to grade E250 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/ metallurgical properties may also be used in place of plates for packing plates/ packing washers. The chequered plates shall conform to IS: 3502. SAILMA 350HI grade plate can also be accepted in place of HT plates (EN 10025 grade S355 JR/JO / IS 2062:2011 – grade E350, as applicable) provided SAILMA 350HI grade plate meet all the mechanical properties of plate as per EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) / IS 2062: 2011 – grade E350.

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

7.2 Fasteners: Bolts, Nuts and Washers

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

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

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

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

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

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

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

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

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

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

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

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

8. Tower Accessories

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

8.1 Step Bolts and Ladders

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

8.2 Insulator String Attachments

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

8.3 OPGW Wire Clamp Attachments

a. Suspension Clamps
OPGW 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 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.

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

8.5 Danger, Number and Phase plate
Danger plates, Number 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 phase plates.
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 and number plates shall be rounded off to remove sharp edges.
d. The letters of number plates shall be red enameled with white enameled background.

8.6 Aviation Requirements

8.6.1 Aviation requirements viz Span marker, night marker (obstruction light) and painting of towers conforming to IS: 5613 shall be in the scope of Contractor. The cost of it shall be understood to be included in Tower Cost.

9. Tower Fabrication

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

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

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

9.3 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.

9.4 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.

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

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

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

9.8 The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.

9.9 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.

9.10 Drilling and Punching

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

9.10.2 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 0.8mm. i.e. the allowable taper in a punched hole should not exceed 0.8mm on diameter.
c. Holes must be square with the plates or angles and have their walls parallel.

9.10.3 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.

9.11 Erection mark

9.11.1 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.

9.11.2 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"

10. Quantities and Weights

10.1 The quantity of tower (together with required extension) is mentioned in the Schedule of Price.

10.2 The estimated unit weight of each type of galvanized towers, stubs and leg extensions shall be furnished by the bidder. The weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. ungalvanized) weight of steel members of the size indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weights due to holes, notches and bevel cuts etc. but taking into consideration the weight of the D shackles, hangers, strain plates, pack plates, gusset plates 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.

10.3 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.

11. Galvanizing

11.1 Fabricated Tower Parts & Stubs

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

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

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

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

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

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

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

iv. Fluxing:
The rinsed article shall be dipped in a solution of Zinc ammonium chloride. The concentration and temperature of the flux solution shall be standardized by the contractor depending on the article to be galvanized and individual circumstances. These shall form part of plant standard to be formulated and submitted to Purchaser along with Quality Assurance Program. The specific gravity of the flux solution shall be periodically monitored and controlled by adding required quantity of flux crystals to compensate for drag-out losses. Free acid content of the flux solution also shall be periodically checked and when it is more than two (2) grams of free acid per litre of the solution, it shall be neutralized. Alternatively, Ph value should be monitored periodically and maintained between 5 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°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°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.

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

12. Earthing

12.1 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 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.

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

12.3 The provisional quantities for pipe type 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.

12.5 Earthing for River Crossing Towers /Pile foundation
Galvanized earthing strip of flat 50 x 6 mm is to be provided in two legs of tower for each location with proper arrangement of connecting these strips by 16mm bolts shall be provided in the stubs. For pile foundation, the strip has to be taken up to scour level along the concrete of pile

foundations. Only bolted connections are allowed for connecting this strip to achieve desired length. Contractor shall submit the detailed drawing for approval of Employer before installations.

13. Inspection and Tests

13.1 General

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

13.1.1 Mills Tests

The rolled steel angles including stub and fasteners (nuts & bolts) for the towers shall pass the following mill tests in accordance with the requirements of Indian / International Standard for each thickness and each quality.

a. Tensile test,
b. Chemical analysis.
c. Bend test, if applicable, and
d. Impact test, if applicable

Certified copies of mill test reports shall be furnished to the Employer/Engineer as soon as possible after the tests are made. The results of the test shall be in a form that provides means of determining compliance with the applicable specifications for the materials tested. All expenses of such testing shall be in account of the Contractor

13.1.2 Galvanization Test (Zinc Coating Tests)

The rolled steel angles including the stub and fasteners (nuts & bolts) for the towers shall pass the zinc coating test as per Clause 12 of this Chapter. The test shall be carried out with calibrated test equipment. The certified copies of such test reports shall be furnished to the Employer/Engineer as soon as possible after the tests are made. The results of the test shall be in a form that provides means of determining compliance with the applicable specifications for the materials tested. The report shall also include the calibration certificate of the equipment used for measurement. All expenses of such testing shall be in account of the Contractor.

13.2 Inspection

In addition to the provision of GCC and Chapter 3 of Volume II of this Specification, the following shall also apply:

13.2.1 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.

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

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

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

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

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

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

13.2.8 Test on the tower 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 Bill of Quantities.

13.2.9 The Employer reserves the right to waive the requirement for performing any or all tests related to the towers. Should the Employer exercise this right, the applicable unit prices for performing the test will be deducted from the total contract price. The Contractor will not be entitled to any additional compensation by reason of such waiving. However, the Employer will inform the Contractor well in advance about such waiver of tests.

14. Tower Load Tests

14.1 Testing of Tower

A Galvanized tower complete with the longest extension to be used shall be subjected to design and destruction tests by first applying test loads applied in a manner approved by the Employer. The tower shall withstand these tests without showing any sign of failure or permanent distortion in any part. Thereafter the tower shall be subjected to destruction by increasing the loads further in an approved manner till it fails. The tower shall be tested for all the conditions considered for the design of tower. The Contractor shall submit to the Employer, for approval, the detailed programme and proposal for testing the towers showing the methods of carrying out the tests and manner of applying the loads. After the Employer has approved the test procedures and 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 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.

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

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

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

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

14.1.5 The tower to be tested shall be a full-scale prototype galvanized tower and shall be erected vertically on rigid foundation of the stub protruding above ground level as provided in the design/drawing between ground level and concrete level. This portion of the stub shall be

kept un-braced while testing. The tower erected on test bed shall not be out of plumb by more than 1 in 360.

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

14.1.7 The tower is to be tested with strain plate as per approved design / drawings.

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

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

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

14.2 Method of Load Application

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

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

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

14.3 Tower Testing Procedure

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

14.3.1 Bolt Slip Test

In a bolt slip test the test loads shall be gradually applied up to the 50% of design loads under normal condition, kept constant for two (2) minutes at that loads and then released gradually. For measurement of deflection the initial and final readings on the scales (in transverse & longitudinal directions) before application and after the release of Loads respectively shall be taken with the help of theodolite. The difference between readings gives the values of the bolt slip.

14.3.2 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

14.3.3 Observation Periods

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

14.3.4 Recording

The Deflections shall be recorded for the "before-load", "load-on (i.e. intermediate stage)" 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.

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.

14.3.5 Destruction Test

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

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

14.3.6 Modification of Tower Components

Any conspicuous yielding or any failure of any part of the tower under any of the tests specified in this sub-article shall be considered a defect. If a defect develops, the Contractor shall modify his design of the tower and send to the 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.

14.3.7 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.

14.3.8 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 etc.

15. Packing

15.1 Angle section shall be wire bundled.

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

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

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

16. Standards

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

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

S.No.	Indian Standard	Title	International Standard
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(Part 1) Sec 1-1995 Sec 2-1992	Code of Practice for General Building Construction in Steel Sec 2 – 1992 in Overhead Transmission Line Tower: Materials, loads and Permissible Stress Section- 1: Materials and loads Section-2: Permissible stresses.	ASCE 52 IEC 826 BS 8100
4(b)	IS: 802(Part 2) - 1990	Code of Practice for use of structural steel in Overhead Transmission Line: Fabrication, Galvanizing, inspection & Packing	ASCE 52
4(c)	IS: 802(Part 3) - 1990	Code of Practice for use of structural steel in Overload Transmission Line: Tower 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	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	

S.No.	Indian Standard	Title	International Standard
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, 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 & 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 ASTM A90
28	IS: 6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles.	ASTM A90
29	IS: 8500-1992	Specification for Weldable Structural Steel (Medium & High Strength Qualities)	
30	IS: 10238-1989	Step Bolts for Steel Structures	
31	IS: 12427-1988	Bolts for Transmission Line Towers	
32		Indian Electricity Rules.	
33	Publication No. 19(N)/700	Regulation for Electrical Crossing of Railway Tracks	

The standards mentioned above are available from

BIS/IS	Bureau of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi – 110001, INDIA
ISO	International Organization for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12, DK-2900, Heeleprup, DENMARK.
CSA	Canadian Standard Association 178, Rexadale Boulevard, Rexdale (Ontario) Canada, M9W 1R3
DIN	Deutsches Institute Fiir Normung, Burggrafenstrassee 4-10, Post Farh 1107, D-1000 Berlin 30, GERMANY
ASTM	American Society for testing and Material 1916 Race Street, Philadelphia. PA 1903-1187, USA
Indian electricity Rules Regulation for electricity crossing of railway Tracks	Kitab Mahal Baba Kharak Singh Marg New Delhi-110001, INDIA
ASTM	American Society of civil Engineers 345 East 47th Street New York, NY, 10017-2398, USA
IEEE	Institute of Electrical and Electronics Engineers 445 Hoes Lane Piscataway, NJ 0085-1331, USA
IEC	International Electro Technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue De Verembe, Geneva, SWITZERLAND

Chapter 5
Tower Foundation and Civil Works

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1. Foundation

1.1 The foundation shall generally be of open cast type. Reinforced Cement concrete footing shall be used for the towers in conformity with the present-day practices 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.

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

2. Classification 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:

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

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

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

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

2.5 Partially Submerged
To be used at locations where sub-soil water table is met between 0.75 meter and 1.5metre below the ground level.

2.6 Fully Submerged
To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.

2.7 Black Cotton Soil
To be used at locations where soil is clayey type, not necessarily black in color, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is considered submerged in nature.

2.8 Dry Fissured - Rock
To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite, conglomerates or any other soil of similar nature is met at 3.5meters or more below the ground level. Under cut type foundation is to be used for fissured rock locations.

2.9 Wet Fissured - Rock

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met 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.

2.10 Hard Rock

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

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.

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

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

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

2.13 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 affect 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.

2.14 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 9.3.2 of this chapter.

3. Type of Foundations

The contractor shall offer open type of foundation (i.e. slab and chimney) with maximum depth of foundation as 3.0 meters for above classification of foundations depending on economy and feasibility of construction at site.

The Contractor 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 Contractor.

4. Soil Investigation

The contractor shall undertake soil investigation as per Chapter 5 of the Volume II at tower locations as approved by the Employer. The provisional number of soil testing locations is furnished in Schedule of Prices Vol III. Unit rates for the same are to be furnished by the Contractor in appropriate Schedule of Prices Vol III, for adjustment purpose with actual quantities required for soil testing.

5. Loads on Foundation

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

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

a. Max. Tension or uplift along the leg slope.

b. Max. Compression or down-thrust along the leg slope.

c. Max. Horizontal shear or side thrusts.

5.3 Overload Factor for Foundation

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.

6. Stability Analysis

6.1 In addition to the strength design, stability analysis of the foundation shall be done to check the possibility of failure by over-turning, uprooting, sliding and tilting of the foundation.

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

a. Resistance Against Uplift

The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth as per formula 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 5.1.

7. Properties of Concrete

7.1 The cement concrete used for the foundations shall generally be of grade M-20 having 1:1.5:3 nominal volumetric mix ratio with 20mm coarse aggregate for chimney portion and 20mm/40mm

aggregates for pyramid or slab portion. All the properties of concrete regarding its strength under compression, tension, shear, punching and bending etc. as well as workmanship will conform to IS: 456:2002.

7.2 The weight of concrete to be considered for design of foundations is given in table 5.1 given below:

Table 5.1

Type of Concrete	Weight of Concrete kN/m^3 (kg/m^3)	
	Dry Region	In presence of Sub-Soil Water
Plain Concrete	21.96 (2240)	12.16 (1240)
Reinforced Concrete	23.54 (2400)	13.73 (1400)

7.3 The Quantity of minimum cement to be used per unit quantity of consumption for different mix (nominal mix) of concrete should be as follows:

Table 5.2

S.No.	Description	Unit	Quantity of Minimum cement to be used per Unit quantity of work (in kg)
1	1:1.5:3 nominal mix concrete	M^3	400
2	1:2:4 nominal mix concrete	M^3	320
3	1:3:6 nominal mix concrete	M^3	220
4	Random Rubble Masonry with 1:6 cement mortar	M^3	83

In this regard, utilization record is to be maintained at site.

7.4 Alternatively, ready-mix concrete from batching plant as per IS 4925 can also be used with no extra payment and without any recovery. However, cement content shall be as per IS 456. The ready-mix concrete shall conform to IS 4956. The select and use of materials for the ready-mix concrete shall be in accordance with IS 456. The concrete shall be of M20 grade design mix as per IS 456. The transport of concrete and transportation time shall be as per IS 4926.

7.5 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.

c. 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.

D. 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.

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

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

7.8 Reinforcement shall conform to IS: 432-1966 for M.S bars and hard drawn steel wires and to IS: 1138-1966 and IS: 1786-1966 for deformed and cold twisted bars respectively. All reinforcement shall be clean and free from loose mill scales, dust, loose rust, and coats of paint, oil or other coatings, which may destroy or reduce bond. 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.

8. Design of Foundation

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

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

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

8.4 The physical properties of soil under various conditions are furnished in table 5.3 to be considered for the design of foundations. These types of foundations correspond to list of foundations furnished in Schedule of prices VOL III.

8.5 The composite rates quoted in Schedule of prices shall be payable for foundations developed based on above soil properties and classified as clause 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 5.3 are tentative in nature. After soil investigations, if it is found that the foundations listed in Schedule of Prices Vol III 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

8.6 Particulars of the foundations, along with the volumes of concrete, weight of reinforcing bars and excavation volumes are in lump sum basis. No extra payment shall be made if there is change in foundation design. The foundation shall be designed such as to satisfy the following conditions

8.6.1 The thickness of concrete in the chimney portion of the tower footing would be such that it provides minimum cover of not less than 100 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.

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

8.6.3 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.

8.6.4 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.

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

8.6.6 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.

8.6.7 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, almost the same depths of foundations shall be used for different types of foundations.

8.6.8 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.

8.6.9 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.

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

8.6.11 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 5.3

1. Normal Soil		
a. Ultimate Bearing Capacity	**Unit**	**Value**
i. Normal dry soil	kN/m^2 (Kg/m^2)	268 (27,350)
ii. Wet soil due to presence of sub-soil / surface water	kN/m^2 (Kg/m^2)	134 (13,675)
iii. Wet Black Cotton	kN/m^2 (Kg/m^2)	134 (13,675)
b. Weight of Normal Soil	**Unit**	**Value**
i. Dry soil	kN/m^3 (Kg/m^3)	14.12 (1440)
ii. In presence of surface water	kN/m^3 (Kg/m^3)	14.12 (1440)
iii. In presence of sub-soil	kN/m^3 (Kg/m^3)	9.22 (940)
c. Angle of Repose	**Unit**	**Value**
i. Normal dry soil	(°)	25
ii. Wet soil due to presence of sub-soil / surface water	(°)	15
iii. Wet Black Cotton	(°)	0
2. Fissured Rock		
a. Ultimate Bearing Capacity	**Unit**	**Value**
i. Dry fissured rock	kN/m^2 (Kg/m^2)	498 (50,800)
ii. Wet fissured rock	kN/m^2 (Kg/m^2)	498 (50,800)
b. Weight of Fissured Rock	**Unit**	**Value**
i. Dry	kN/m^3 (Kg/m^3)	14.12 (1,440)
ii. In presence of sub-soil water	kN/m^3 (Kg/m^3)	9.22 (940)

c. Angle of Repose	Unit	Value
i. Fissured rock in dry portion	(°)	20
ii. Fissured rock in presence of water	(°)	10
3. Hard Rock		
a. Ultimate Bearing Capacity	kN/m^2 (Kg/m^2)	1,225.83 (125,000)
b. Ultimate Bond between Steel	kN/m^2 (Kg/m^2)	0.147 (15)
4. Sandy Soil		
a. Ultimate Bearing Capacity	kN/m^2 (Kg/m^2)	1,225.83 (125,000)
b. Weight	kN/m^3 (Kg/m^3)	14.12 (1,440)
c. Repose	(°)	20

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.

9. Measurement, Unit Rates and Payment for Foundation

9.1 Measurement

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

9.1.2 The Contractor 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 2 of this Chapter) for each type of tower. Composite price quoted (as described in Clause 8.4 of this Chapter) in respective Price Schedule for each type of foundation must comply with unit rate quoted and guaranteed foundation quantities mentioned.

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.

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.

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 tonnes corrected to third place of decimal, no allowance being made for wastage. No payments will be made for wire required for binding the reinforcement, chairs, bolsters and spacers, as the cost of these is deemed to be included in the unit rate quoted for the item of reinforcement.

9.2 Unit Rate

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.

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.

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

9.3 Payment for Foundation

9.3.1 Normal Foundation

Payment of normal foundations classified under Clause 2 of this Chapter shall be made as described in Clause 8.4 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.

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 Contractor as per Clause 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 undercut foundations) the base pad or actually excavated whichever is less and the unit rate of this item as indicated in the 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 the 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 tonnes 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 9.1.5.

10. Construction of Tower Foundation

10.1 Testing of Soil

10.1.1 The Contractor shall be required to undertake testing of soil for the tower locations in the manner specified under Chapter 6 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.

10.2 Excavation

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.

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.

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.

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.

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.

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.

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 Employer.

10.3 Setting of Stubs

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

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.

10.3.2 Setting of stubs at each location shall be approved by the Employer.

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.

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 the section for stub / leg of last panel shall not change during completion of tower testing.

10.4 Stub Setting Templates / Props

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 up to 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.

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

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.

10.4.4 Generally for a transmission line 1 (one) number of stub setting templates shall be deployed by the Contractor.

However, if the Employer/Employer's Representative 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 props (if permitted) to be supplied, will depend as per actual site condition and completion schedule of line.

10.5 Mixing, Placing and Compacting of Concrete

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.

Alternatively, Ready Mix concrete from batching plant as per IS 4925 can also be used with no extra payment and without any recovery. However, Cement content shall be as per IS 456. The ready-mix concrete shall conform to IS:4926. The selection and use of Materials for the ready-mix concrete shall be in accordance with IS:456. The concrete shall be of M20 grade design mix as per IS:456. The transport of concrete and transportation time shall be as per IS:4926.

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.

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.

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.

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.

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

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.

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.

10.7 Backfilling and Removal of Stub Templates

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.

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 9 of Chapter 6. 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.

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.

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.

10.9 Protection of Tower and Tower Footing

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.

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 uphill / downhill 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.

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 Schedule shall include the required lead and consolidation and leveling of earth after backfilling.

10.9.4 The provisional quantities for protection work of foundations are furnished in Price Schedule of the 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.

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.

10.9.6 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.

10.9.7 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 6
Transmission Line Conductors

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Chapter 6
Transmission Line Conductors

1. General

The scope of work comprises of manufacture, factory test, supply, stringing, testing and commissioning of ACSR "BISON" conductor for about 4 km of 220 kV Single Circuit Transmission Line of Madhya Bhotekoshi Hydroelectric Project from the project's switchyard to Barhabise Sub-station.

2. Technical Description of ACSR Conductor

2.1 Details of Conductor:

2.1.1 The ACSR Conductor shall generally conform to IEC: 61089/ IS: 398 (relevant part)/ ASTM: B-232 except where otherwise specified herein.

2.1.2 Standard Technical Particulars

The Standard Technical Particulars (STP) of the ACSR conductors are enclosed at Annexure-A of this chapter. The values indicated in the STP are minimum and / or maximum values required to be met by the Contractor.

2.2 Workmanship

2.2.1 All the aluminum 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.

2.2.2 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.

2.2.3 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.

2.2.4 The steel strands shall be hot dip galvanized and shall have a minimum zinc coating as indicated in the STP. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand number of dips in Standard Preece test as indicated in STP. 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: 60888.

2.2.5 The steel strands shall be performed and post formed in order to prevent spreading of strands in the event of cutting of complete core. Care shall be taken to avoid, damages to galvanization during pre-forming and post-forming operation.

2.2.6 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.

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

2.2.8 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.

2.3 Joints in Wires

2.3.1 Aluminium Wires

2.3.1.1 During stranding, no aluminum wire welds shall be made for the purpose of achieving the required conductor length.

2.3.1.2 No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

2.3.1.3 Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand as per STP.

2.3.2 Steel Wires

2.3.2.1 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

2.4 Tolerances

The manufacturing tolerances to the extent indicated in the STP shall be permitted in the diameter of individual aluminium and steel strands and lay-ratio of the conductor.

2.5 Materials

2.5.1 Aluminium

2.5.1.1 The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity and copper content as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IEC: 60889.

2.5.2 Steel

2.5.2.1 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 chemical composition indicated in the STP.

2.5.2.2 The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 60888.

2.5.3 Zinc

2.5.3.1 The zinc used for galvanizing shall be electrolytic High-Grade Zinc of purity as indicated in the STP. It shall conform to and satisfy all the requirements of IS:209.

2.6 Standard Length

2.6.1 The standard length of the conductor shall be as indicated in the STP. All lengths outside this limit of tolerance shall be treated as random lengths. Not less than 90% of the total quantity of the conductor shall be supplied in standard lengths.

2.6.2 Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. At any point, the cumulative quantity supplied of such random lengths shall not be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.

2.6.3 The employer reserves the right to place orders for the lengths above the standard length on the same terms and conditions applicable for the standard lengths during the pendency of the Contract.

3. Tests and Standards

3.1 Type Tests

3.1.1 The following tests shall be conducted on a sample/samples of the conductor(s) required under the package from each stranding machine from which the conductor is to be manufactured & supplied:

a. DC resistance test on stranded conductor
b. UTS test on stranded conductor
c. Corona extinction voltage test (dry) *
d. Radio interference voltage test (dry) *

} As per Annexure-B

* applicable for 220 kV or above voltage level only

3.1.2 Type tests specified under Clause 3.1.1 shall not be required to be carried out if contractor has conducted these tests earlier on the same conductor & same bundle configuration (applicable for tests 'c' & 'd') and valid type test certificates are available. The test certificate shall be considered valid if,

i. Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of utility and

ii. Tests conducted on the samples of conductor manufactured from same stranding machine within 3 (three) years prior to the date of commencement of manufacturing for the package. However, the manufacturing of the conductor for the package can be carried till 3 (three) years from the date of type testing.

3.1.3 In case the tests have been conducted earlier than the above stipulated period or carried out on another stranding machine or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the contractor at no extra cost to the employer. Also, in case, manufacturing (scheduled/actual) is beyond the 3 (three) years from the date of type testing, contractor has to repeat the above type tests at no extra cost to the Employer.

3.2 Acceptance Tests

a. Visual and dimensional check on drum
b. Visual check for joints, scratches etc. and length measurement of conductor by rewinding
c. Measurement of diameters of individual 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
i. DC resistance test on Aluminium strands
j. Procedure qualification test on welded joint of Aluminium strands
k. Drum strength test (steel drum)
l. Barrel Batten strength test (wooden drum)

} As per Annexure-B

Note: All the above tests except (j) shall be carried out on Aluminium and steel strands after stranding only.

3.3 Routine Test

a. Check to ensure that the joints are as per Specification

b. Check that there are no cuts, fins etc. on the strands

c. Check that drums are as per Specification

d. All acceptance test as mentioned above to be carried out on aluminium and steel strands of 20% of drums

3.4 Test During Manufacture

a. Chemical analysis of zinc used for galvanizing
b. Chemical analysis of aluminium used for making aluminium strands
c. Chemical analysis of steel used for making steel strands

} As per Annexure-B

3.5 Testing Expenses

3.5.1 In the event of type testing, bidder shall ensure that adequate facilities are available in the laboratories and the tests can be completed in these laboratories within the time schedule.

3.5.2 In case of failure in any type test, the contractor is either required to manufacture fresh sample lot and repeat the entire tests successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at his own expense. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

3.5.3 The entire cost of testing for the type, acceptance, routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price of conductor, except for the expenses of the inspector/employer's representative.

3.5.4 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of inspector/employer's representative shall be to the contractor’s account. Also, if on receipt of the contractor's notice of testing, the employer's representative does not find the test samples or testing facilities/equipment ready for testing, the expenses incurred by the employer for re-deputation shall be to the contractor’s account.

4. Additional Tests

4.1 The employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at contractor’s premises, at site or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the Specifications.

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

5. Sample Batch for Type Testing

5.1 In case the type tests are required to be carried out, the samples for type testing shall be manufactured in accordance with the Standard Manufacturing Quality Plan.

5.2 The contractor shall offer at least three drums for selection of sample required for conducting all the type tests.

5.3 The contractor is required to carry out all the acceptance tests successfully in presence of employer’s representative before sample selection.

6. Test Reports

6.1 In case type tests have been carried out earlier by the contractor and valid type test reports are available as specified in clause 2.1.1 above, the contractor shall submit one copy of the test report along with approval letter issued by utility.

6.2 In case fresh type tests have been carried out under the package, the type test reports shall be furnished in original along with two copies. One copy will be returned duly certified by the employer.

6.3 The commercial production of the conductor can be taken up by the contractor after clearance from the employer.

6.4 Record of routine test reports shall be maintained by the contractor at his works for periodic inspection by the employer's representative.

6.5 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.

7. Inspection

7.1 The employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the contractor's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

7.2 The contractor shall keep the employer informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.

7.3 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the employer in writing. In the latter case, also the conductor shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

7.4 The acceptance of any quantity of material shall in no way absolve the contractor of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

8. Test Facilities

8.1 The following test facilities shall be available at the contractor's works:

a. Various testing and measuring equipment for carrying out specified acceptance tests, routine tests and tests during manufacture inter alia including tensile testing machine, resistance measurement facilities, torsion & wrap testing machine, dimension checking instruments viz. digital vernier and micrometer etc., galvanizing test instruments viz. digital elcometer and standard preece test etc., burette, digital thermometer, barometer etc.

b. Digital milli/micro ohm meter along with standard resistance for calibration of resistance bridges.

c. Spectrometer, if contractor has its own properzi mill

d. 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.

9. Packing

9.1 The conductor shall be supplied in non-returnable, strong, wooden drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement

during transit, storage and subsequent handling and stringing operations in the field. The Contractor shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS:1778 or equivalent, except as otherwise specified hereinafter.

9.2 One standard length shall be wound on each drum. The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.

9.3 The standard drawing of the drum for conductor is enclosed with the specification. The Bidder shall supply the conductor in the drum conforming to the specification drawing.

9.4 All wooden components shall be manufactured out of seasoned soft wood, free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor.

9.5 The flanges shall be of two ply constructions with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75mm. Where a slot is cut in the flange to receive the inner end of the conductor the entrance shall be in line with the periphery of the barrel.

9.6 The wooden battens used for making the barrel of the conductor shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the conductor.

9.7 Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.

9.8 Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.

9.9 The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.

9.10 Before reeling, card board or double corrugated or thick bituminized water-proof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material. After reeling the conductor, the exposed surface of the outer layer of conductor shall be wrapped with water proof thick bituminized bamboo paper to preserve the conductor from dirt, grit and damage during transport and handling.

9.11 A minimum space of 75 mm for conductor shall be provided between the inner surface of the external protective tagging and outer layer of the conductor.

9.12 Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp, edges or allow the battens to be released due to corrosion.

9.13 The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

9.14 A steel collar shall be used to secure all barrel studs. This collar shall be located between the washers and the steel drum and secured to the central steel plate by welding.

9.15 Outside the protective lagging, there shall be minimum of two binders consisting of hoop iron/galvanized steel wire. Each protective lagging shall have two recesses to accommodate the binders.

9.16 The conductor ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.

9.17 As an alternative to wooden drum Bidder may also supply the conductors in non-returnable painted steel drums or wood-Steel hybrid drums. After preparation of steel surface according to IS:9954, synthetic enamel paint shall be applied after application of one coat of primer. Wooden/Steel drum/Wood-Steel hybrid drum will be treated at par for evaluation purpose and accordingly the Bidder should quote in the package.

10. Marking

10.1 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. Barrel diameter at three locations & an arrows marking at the location of the measurement.

j. Number of turns in the outer most layer.

k. Gross weight of drum after putting lagging.

l. Tear weight of the drum without lagging.

m. Net weight of the conductor in the drum.

n. CIP/MICC No

The above should be indicated in the packing list also.

11. Verification of Conductor Length

11.1 The employer reserves the right to verify the length of conductor after unreeling. The quantity for verification shall be between a minimum of five percent (5%) to a maximum of ten percent (10%) in a lot offered for inspection. The actual quantity will be discussed and mutually agreed to by the contractor & employer.

12. Altitude Correction Factors

12.1 As the transmission line lie on a high-altitude site, altitude correction factor shall also be considered during design so as to realize the effect of altitude on conductors.

13. Standards

13.1 The conductor shall conform to the following Standards, which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

13.2 In the event of the supply of conductor conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the contractor and those specified in this document will be provided by the contractor to establish their equivalence.

S. N.	Indian Standard	Title	International Standard
1	IS: 209	Specification for zinc	BS:3436
2	IS: 398 Part-I	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC:61089 BS:215
3	IS: 398 Part-II	Aluminum Conductor Galvanized Steel Reinforced	BS:215 IEC:61089
4	IS: 398 Part-V	Aluminum Conductor Galvanized Steel- Reinforced for Extra High Voltage (400 KV) and above	IEC:61089 BS:215
5	IS: 1778	Reels and Drums for Bare Conductors	BS:1559
6	IS: 1521	Method of Tensile Testing of Steel Wire	ISO 6892
7	IS: 2629	Recommended Practice for Hot Dip Galvanizing of Iron and Steel	
8	IS: 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
9	IS: 4826	Galvanized Coating on Round Steel Wires	IEC: 60888 BS:443
10	IS: 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433 ISO 1460
11	IS: 8263	Method of Radio Interference Tests on High Voltage Insulators	IEC: 60437 NEMA:107 CISPR
12		Zinc Coated steel wires for stranded Conductors	IEC: 60888
13		Hard drawn Aluminium wire for overhead line conductors	IEC: 60889

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonvile Road, N - 19-ND, UK
IEC/CISPR	International Electro Technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de Verembe, Geneva, SWITZERLAND
BIS/IS	Bureau of Indian Standards. Manak Bhavan 9, Bahadur Shah Zafar Marg, New Delhi–110001, INDIA
ISO	International Organization for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12, DK-2900, Heeleprup, DENMARK.
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017, U.S.A.

ANNEXURE – A

Standard Technical Particulars for ACSR Conductors

S.N.	Description	Unit	Standard Technical Particulars Conductors (ACSR BISON)
1	**Construction**		
1.1	Stranding and wire diameter		
a.	Aluminium wire		54 / 3.00 mm
b.	Steel wire		7 / 3.00 mm
1.2	Layers and no. of wire		
a.	Steel core		1
b.	1st Steel Layer		6
c.	1st Aluminium Layer		12
d.	2nd Aluminium Layer		18
e.	3rd Aluminium Layer		24
2	**Raw Materials**		
2.1	Aluminium		
a.	Minimum purity of Aluminium	%	99.50
b.	Maximum copper content	%	0.04
2.2	Steel wires/ rods		
a.	Carbon	%	0.50 to 0.85
b.	Manganese	%	0.50 to 1.10
c.	Phosphorous	%	Not more than 0.035
d.	Sulphur	%	Not more than 0.045
e.	Silicon	%	0.10 to 0.35 (max)
2.3	Zinc		
a.	Minimum purity of Zinc	%	99.95
3	**Aluminium Strands after Stranding**		
3.1	Diameter		
a.	Nominal	mm	3.00
b.	Maximum	mm	3.02
c.	Minimum	mm	2.98
3.2	Minimum Breaking Load of Strand		
a.	Before stranding	kN	1.17
b.	After Stranding	kN	1.11
3.3	Max resistance of 1m length of strand at 20°C	Ω	0.004053
4	**Steel Strand after stranding**		
4.1	Diameter		
a.	Nominal	mm	3.00
b.	Maximum	mm	3.06
c.	Minimum	mm	2.94
4.2	Minimum Breaking Load of Strand		
a.	Before stranding	kN	9.29
b.	After Stranding	kN	8.83

4.3	Galvanizing			
a.	Minimum weight of zinc coating per m^2	gm	240	
b.	Minimum number of dips that the galvanized strand can withstand in the standard preece test	Nos	2 of one minute and 1 of half minute	
c.	Minimum number of twists in gauge length equal 100 times the diameter of wire which the strand can withstand in the torsion test (after stranding)	Nos	16	
5	**Stranded Conductor**			
5.1	Overall diameter	mm	27	
5.2	Sectional area of Aluminium	mm^2	381.5	
5.3	Total Sectional area	mm^2	431	
5.4	Minimum UTS of the Conductor	kN	117.5	
5.5	Lay length of outer steel layer		Max	Min
a.	1^{st} Steel Layer		18	16
b.	1^{st} Aluminium Layer	mm	14	12
c.	2^{nd} Aluminium Layer	mm	13	11
d.	3^{rd} Aluminium Layer	mm	12	10
5.6	DC resistance of the conductor at 20°C	Ω/km	0.0758	
5.7	Standard length of the conductor	m	2200	
5.8	Tolerance on the standard length		±5	
5.9	Direction of lay of outer layer		Right Hand	
5.10	Linear mass of the conductor			
a.	Standard	Kg/km	1444	
b.	Maximum	Kg/km	1416	
c.	Minimum	Kg/km	1473	

ANNEXURE – B

Tests on Conductor

a. DC 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 or digital ohm-metre of sufficient accuracy by placing the clamps initially zero metre and subsequently one metre 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. The resistance corrected at 20^0C shall conform to the requirements indicated in the STP.

b. 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 100% of the UTS of conductor 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 this value shall be recorded.

c. Corona Extinction Voltage

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 m above ground. The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154 kV (rms) line to ground under dry condition. There shall be no evidence of corona on any part of the 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 atmospheric conditions during testing shall be recorded and test results should be corrected for standard atmospheric conditions.

d. Radio Interference Voltage Test

Under the conditions as specified under (b) above, the conductor samples shall have radio interference voltage below 1000 microvolts. This test may be carried out with corona control rings and arcing horns. The test procedure shall be in accordance with IEC-60437.

e. 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.

f. Visual Check for Joints, Scratches etc. and length measurement of conductor by rewinding

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. One drum out of ten drums or part thereof from each lot shall be rewound in the presence of the Employer's representative.

g. Measurement of diameters of individual Steel and Aluminium strands

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

h. 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.

i. Galvanizing Test

The test procedure shall be as specified in IEC 60888. 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 and Elongation Tests on Steel Strands

The test procedures shall be as per clause No. 10.3 of IEC 60888. In torsion test, the number of complete twists before fracture shall not be less than that indicated in the STP. 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 3.5% for a gauge length of 250 mm after stranding.

k. Procedure Qualification test on welded Aluminium

Two Aluminium wire shall be welded as per the standard 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 breaking strength of individual strands.

l. Drum Strength Test of Steel drums

The details regarding Drum strength test will be discussed and mutually agreed to by the contractor & Employer as per the Standard Quality Assurance Plan.

m. Barrel Batten Strength Test of Wooden Drums

The details regarding barrel batten strength test will be discussed and mutually agreed to by the contractor & Employer as per the Standard Quality Assurance Plan.

n. 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.

o. Chemical Analysis of Aluminium

Samples taken from the aluminium ingots/rods shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

p. Chemical Analysis of Steel

Samples taken from the steel rods shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

Chapter 7
Line Insulators

Chapter 7
Line Insulators

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Chapter 7
Line Insulators

1. General

The scope of work comprises of design, manufacture, testing at shop, supply, insurance, handling, storage, erection, testing and commissioning of composite long rod insulators for about 4 km of 220 kV Single Circuit Transmission Line of Madhya Bhotekoshi Hydroelectric Project from the project's switchyard to Barhabise Sub-station.

2. Technical Description of Line Insulator

2.1 Details of Insulator:

2.1.1 The insulators of the strings shall consist of composite long rod insulators for a three phase, 50 Hz, effectively earthed 220 kV AC transmission system application in a very heavily polluted environment. Couplings shall be ball and socket type.

2.1.2 Bidder shall quote such composite insulators which have proven use under foggy/humid operational conditions in polluted industrial environment combined with smoke and dust particles. 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 satisfactorily. 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.

2.1.3 Insulators shall have sheds of the "open aerodynamic profile without any under ribs" with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

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

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 x 2465	7595	1x1	70	70
2.	Single Suspension 'Pilot'	20 x 2465	7595	1x1	70	70
3.	Double Suspension	20 x 2465	7595	2x1	70	2x70
4.	Single Tension	20 x 2610	7595	1x1	120	1x120
5.	Double Tension	20 x 2610	7595	2x1	120	2x120

Note: * The core diameter of composite insulators mentioned at column no 3 is for indicative purpose. The bidder shall offer composite long rod insulators of suitable core diameter to meet specified E&M and torsion strength requirements. For offered core diameter, less than indicated in table above, the bidder shall submit documentary evidence of past supplies & satisfactory operation of the same for minimum period of three years. However, the overall string length shall be within the limits specified in the drawing.

2.2 Ball and Socket Designation

2.2.1 The dimensions of the Ball and Socket shall be of 16 mm (Alt-B) designation for 70 kN & 20mm designation for 120 kN Insulators in accordance with the standard dimensions stated in IEC:60120/IS:2486 (Part-II).

2.3 Dimensional Tolerance of Composite Insulators

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

± (0.04d+1.5) mm when d≤300 mm.

± (0.025d+6) mm when d>300 mm.

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

2.3.2 The tolerance in creepage distance shall be based on design dimensions and their tolerances. However, no negative tolerance shall be applicable to creepage distance specified in clause 2.1.4.

2.4 Interchangeability

2.4.1 The composite long rod insulators inclusive of the ball & socket connection shall be standard design suitable for use with the hardware fittings of any make conforming to relevant IEC standards.

2.5 Corona and RI Performance

2.5.1 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 shall not generate any radio interference beyond specified limit under the operating conditions.

2.6 Maintenance

2.6.1 The 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.

2.6.2 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.

2.7 Materials

2.7.1 Core

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

2.7.2 Housing & Weather sheds

The FRP rod shall be covered by a sheath of a silicone rubber compound of a thickness of minimum 3mm. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique to be followed with detailed procedure and sampling shall be furnished by the Contractor and finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile. The weather sheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection molding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection molding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection molding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A 4.5 according to IEC60587. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

2.7.3 End Fittings

End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron spheroidal graphite or forged steel. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The gap between fitting and sheath shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

2.7.4 Grading Rings

Grading rings shall be used at both ends of each composite insulator unit for reducing 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/ exceeding of permissible electrical stress of material. The insulator contractor shall furnish design calculations using appropriate electric field software showing electric field at surface of housing, inside housing & core and at the interface of housing and metal fittings with the proposed placement and design of corona. Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

The design &supply of grading rings shall be in the scope of the composite insulator contractor.

2.8 Workmanship

2.8.1 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 transmission lines specified and will give continued good service.

2.8.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.

2.8.3 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

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

2.8.5 Weather sheds / Housing shall be uniform in quality. It shall be free from voids and impurities. Weather sheds/Housing shall be clean, sound, smooth and free from gross defects and excessive flashing at parting lines.

2.8.6 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.

2.8.7 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 600 gm/m^2. and shall be in accordance with the requirement of ISO:1461 (E) and shall satisfy the tests mentioned in ISO:1460 (E). 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.

2.8.8 The contractor shall guarantee that there shall not be any failure/ decapping / breaking of insulators on line under normal operating condition. In the event of any failure/ decapping /breaking of insulators during the first ten years of service, Contractor shall supply to the owner free of cost spare insulators equal to 10 times the failed insulator quantity. Further, in case of decapping / Breaking and subsequent line drop, during the first ten years of service, the contractor shall also have to pay Rs 1,00,000/- (Rs one lakh only) per dropped string towards expenditure to be incurred by NEA for this line repair

3. Equipment Marking

3.1 Each composite long rod unit shall be legibly and indelibly marked with the trade mark of the manufacturer, name of NEA and month & year of manufacture. The guaranteed combined mechanical and electrical strength shall be indicated in kilo Newton followed by the word 'kN' to facilitate easy identification and to ensure proper use.

3.2 One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap/end fitting 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	70 kN long rod unit	:	Black
For	120 kN long rod unit	:	Yellow

4. Bid Drawings

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

4.2 The Bidder shall furnish along with the bid the outline drawing of each insulator unit along with grading rings including a cross sectional view of the long rod insulator unit. The drawing shall include but not limited to the following information:

a. Major Dimensions with manufacturing tolerances
b. Minimum Creepage distance with positive tolerance
c. Protected creepage distance
d. Unit mechanical and electrical characteristics
e. Size and weight of ball and socket parts
f. Weight of composite long rod units
g. Materials

4.3 After placement of award, the Contractor shall submit full dimensioned insulator drawings containing all the details as given in Clause No. 3.2 above, in four (4) copies to Owner for approval. After getting approval from Owner, the Contractor shall submit 10 more copies of the same drawing along with a soft copy to the Owner for further distribution and field use at Owner's end.

4.4 After placement of award the Contractor shall also submit fully dimensioned insulator crate drawing for different type of insulators.

5. Tests and Standards

5.1 Type Testis

The required type tests on composite long rod units, components, materials and complete strings are stipulated hereunder.

The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for a similar design. The tests certificate shall be considered valid if:

a. Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of any utility and

b. Tests have been conducted not prior to 5 (five) years from the date of bid opening.

In case, the tests have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Contractor at no extra cost to the Employer.

5.1.1 On the complete composite long rod insulator string with hardware fittings

S.No.	Test	Reference	Strings on which test to be conducted
a	Power frequency voltage withstand test with corona control rings / grading ring and arcing horns under wet condition	IEC: 383-1993 Annex-A	SISP, SI, DT
b	Switching surge voltage withstand test under wet condition	IEC: 383-1993	SISP, SI, DT
c	Impulse voltage withstand test under dry condition	IEC: 383-1993	SISP, SI, DT
d	Corona and RIV test under dry condition	Annex-A	SISP, SI, DT
e	Mechanical Strength Test	Annex-A	SISP, SI, DT
f	Vibration Test	Annex-A	SI, DT
g	Salt-fog pollution withstand test	Annex-A	

SI: Single I Suspension SISP: Single I Suspension Pilot DT: Double Tension

5.1.2 On composite long rod insulator Units

S.No.	Test	Reference
a	Tests 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	Annex-A
e	Brittle fracture resistance test	Annex-A
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	Annex-A
m	Recovery of Hydrophobicity test	Annex-A
n	Torsion test	Annex-A

Hardness test, Accelerated weathering test and flammability test specified under Clause No 5.1.2 above shall be conducted on housing / weather shed of wither 70 kN or 120 kN composite long rod for the same type of material.

5.2 Acceptance Tests:

5.2.1 For Composite Long Rod Insulators

a	Verification of dimensions	IEC: 61109-2008
b	Galvanizing test	IEC: 60383
c	Verification of end fittings	IEC: 61109 -2008
d	Recovery of Hydrophobicity	Annexure-A
e	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IEC: 61109-2008
f	Tests on interfaces and connections of metal fittings	IEC: 61109-2008
g	Silicone content test	Annexure-A
h	Brittle Fracture Resistance Test	Annexure-A
i	Dye Penetration Test	IEC :61109-2008
j	Water Diffusion Test	IEC: 61109-2008

The test 5.2.1 (f) to (j) shall be carried out as acceptance test on any one lot.

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IEC 61109.

5.3 Routine Tests

5.3.1 For Composite Long Rod Insulator Units

a	Visual Examination	As per IEC:61109-2008
b	Mechanical routine test	As per IEC:61109 -2008

5.4 Tests During Manufacture

5.4.1 On all components as applicable

a	Chemical analysis of zinc used for galvanizing	As per Annexure-A
b	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.	As per Annexure-A
c	Chemical analysis hardness tests and magnetic particle inspection for forgings	As per Annexure-A
d	Tracking and erosion test on insulating material	IEC 60587

5.5 Testing Expenses

5.5.1 As mentioned under clause 4.1 above, no type test charges shall be payable to the contractor.

5.5.2 For Type Tests which involves the tests on the complete insulator string with hardware fitting, standard hardware fittings similar to existing insulator strings shall be arranged and used by the insulator contractor at his own cost.

5.5.3 In case of failure in any type test the contractor is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 4.1 of this specifications or to repeat that particular type test at least three times successfully at his own expenses.

5.5.4 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

5.5.5 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

5.5.6 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/Owner's representative shall be deducted from the contract price. Also, if on receipt of the Contractor's notice of testing, the Owner's representative does not find the material or test setup/equipment to be ready for testing, expenses incurred by the Owner for re-deputation shall be deducted from contract price.

5.5.7 The Contractor shall intimate the Owner about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of domestic testing) and at least 6 weeks advance (in case of testing abroad) of the scheduled date of testing during which the Owner will arrange to depute his representative to be present at the time of carrying out the tests.

6. Sample Batch for Type Testing

6.1 The Contractor shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Owner. The Contractor shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Owner.

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

7. Schedule of Testing

7.1 The Bidder has to indicate the schedule of following activities in their bids:

a. Submission of Drawing for approval

b Submission of Quality Assurance Program for approval

c. Offering of material for sample selection for type tests

d. Type testing

8. Additional Tests

8.1 The Owner 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 material complies with the Specifications.

8.2 The Owner 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 centre. In case of evidence of noncompliance, it shall be binding on the part of the Contractor to prove the compliance of the items to the technical specifications by repeat tests or correction of deficiencies or replacement of defective items, all without any extra cost to the Owner.

9. Coordination for Testing

9.1 The Contractor shall have to co-ordinate testing of insulators with hardware fittings to be supplied by other Contractor and shall have to guarantee overall satisfactory performance of the insulators with the hardware fittings.

10. Altitude Correction Factors

10.1 As the transmission line lie on a high-altitude site, during the design of composite long road insulator and its accessories/fittings, altitude correction factor shall also be considered so as to meet the BIL level.

11. Guarantee

11.1 The Contractor of insulators shall guarantee overall satisfactory performance of the insulators.

12. Test Reports

12.1 Copies of type test reports shall be furnished in at least six (6) copies along with one original. One copy shall be returned duly certified by the Owner only after which the commercial production of the concerned material shall start.

12.2 Copies of acceptance test reports shall be furnished in at least six (6) copies. One copy shall be returned duly certified by the Owner, only after which the material shall be dispatched.

12.3 Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Owner's representative.

12.4 Test certificates of test during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Owner.

13. Inspection

13.1 The Owner's representative shall at all times be entitled to have access to the works and all places of manufacture, where insulator, and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Contractor's and sub-Contractor's works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

13.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in clause No.4.12 of the specification. The Owner shall select samples at random from the packed lot for carrying out acceptance tests. The lot should be homogeneous and should contain insulators manufactured in 3-4 consecutive weeks.

13.3 The Contractor shall keep the Owner informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

13.4 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Owner in writing. In the latter case also, the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

13.5 The acceptance of any quantity of material shall be no way relieve the Contractor of his responsibility for meeting all the requirements of the specification and shall not prevent subsequent rejection, if such materials are later found to be defective.

14. Packing and Marking

14.1 All insulators shall be packed in suitable PVC/ plastic tubes/any other suitable packing. The packing shall provide protection against rodent. The Contractor shall furnish detailed design of the packing. For marine transportation, crates shall be palleted.

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

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

14.4 All packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each case/crate shall have all the markings stenciled on it in

14.5 The Contractor shall guarantee the adequacy of the packing and shall be responsible for any loss or damage during transportation, handling, storage and installation due to improper packing. indelible ink.

15. Standards

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

12.2 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 or better 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 equivalence.

S. N.	Indian Standard	Title	International Standard
1	IS: 209-1992	Specification for zinc	BS:3436
2	IS: 406-1991	Method of Chemical Analysis of Slab Zinc	BS:3436
3	IS: 731-1991	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	BS:137-(I&II) IEC:60383
4	IS: 2071 Part (I)-1993 Part (II)-1991 Part (III)-1991	Methods of High Voltage Testing	IEC: 60060-1
5	IS: 2486 Part (I)-1993 Part (II)-1989 Part (III)-1991	Specification for Insulator fittings for Overhead Power Lines with a nominal voltage greater than 1000V General Requirements and Tests Dimensional Requirements Locking Devices	BS: 3288 IEC: 60120 IEC: 60372
6	IS: 2629-1990	Recommended Practice for Hot Dip Galvanization for Iron and Steel	ISO: 1461 (E)
7	IS: 2633-1992	Testing of Uniformity of Coating on Zinc Coated Articles	
8	IS: 6745-1990	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	BS:433-1969 ISO:1460-1973
9	IS: 8263-1990	Methods of RI Test of HV insulators	IEC: 60437 NEMA Publication No: 07/1964/CISPR
10	IS: 8629-1990	Methods for Switching Impulse test on HV insulators	IEC: 60506
11		Thermal Mechanical Performance test and mechanical performance test on string insulator units	IEC: 60575
12		Salt Fog Pollution Voltage Withstand Test	IEC: 60507
13		Composite Insulators for A.C. overhead lines with nominal voltage greater than 1000V – Definitions, Test Methods and Acceptance Criteria	IEC: 61109
14		Selection and Dimensioning of High Voltage Insulators intended for use in polluted conditions: Polymer Insulators for AC Systems	IEC: 60815-3
15		Tests on Insulators of Ceramic Material or Glass or Glass for overhead lines with a nominal voltage greater than 1000V	IEC: 60383
16		Composite String Insulator Units for overhead lines with a nominal voltage above 1000V: Standard strength classes and end fittings	IEC: 61466-1

17		Composite String Insulator Units for overhead lines with a nominal voltage above 1000V: Dimensional and Electrical Characteristics	IEC: 61466-2
18		Electrical Insulating Materials used under severe ambient conditions – Test methods for evaluating resistance to tracking and erosion	IEC: 60587
19		Polymeric Insulators for indoor and outdoor use with nominal voltage greater than 1000V-General Definitions, Tests, methods and Acceptance Criteria.	IEC: 62217

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonvile Road, N - 19-ND, UK
IEC/CISPR	International Electro Technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de Verembe, Geneva, SWITZERLAND
BIS/IS	Bureau of Indian Standards. Manak Bhavan 9, Bahadur Shah Zafar Marg, New Delhi–110001, INDIA
ISO	International Organization for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12, DK-2900, Heeleprup, DENMARK.
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017, U.S.A.
ASTM	American Society for Testing and Materials, 1916 Race St. Philadelphia, PA19103 USA

ANNEXURE – A

1. Tests on Complete Strings with Hardware Fittings

1.1 Corona Extinction Voltage

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154 kV (rms) line to ground under dry condition 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: 60383.

1.2 Radio Interference Voltage 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 1000 micro volts at one MHz when subjected to 50 Hz AC voltage of 154 kV line to ground under dry condition. The test procedure shall be in accordance with IS: 8263 / IEC: 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 each sub-conductor tensioned at 25% of conductor UTS 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. All 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. 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.

1.5 Salt-fog pollution withstand test

This test shall be carried out in accordance with IEC:60507. The salinity level for composite long rod insulators shall be 160Kg/m3 NaCl.

2. Tests on Long Rod Insulator Units

2.1 Brittle Fracture Resistance

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO_3 acid directly in contact with naked FRP rod. The contact length of acid shall not be less

than 40mm and thickness around the core not less than 10mm.The rod shall withstand 80% of SML for 96 hours.

2.2 Recovery of Hydrophobicity Test

a. 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.

b. 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.

c. 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.

d. 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.

2.3 Silicone Content Test

Minimum content of silicone as guaranteed by contractor shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Owner& Contractor in Quality Assurance Programme.

2.4 High Pressure Washing Test

The washing of a complete insulator of each E&M rating is to be carried out at 3800kPa with nozzles of 6mm diameter at a distance of 3m from nozzles to the insulator. The washing shall be carried out for 10minutes. There shall be no damage to the sheath or metal fitting to housing interface. The verification shall be 1-minute wet power frequency withstand test at 460kV rms.

2.5 Torsion Test

Three complete insulators of each E&M rating shall be subjected to a torsional load of 55Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IEC 61109.

3. Tests on All Components (As Applicable)

3.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analyzed as per IS: 209-1979. The purity of zinc shall not be less than 99.95%.

3.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Owner 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 Owner in Quality Assurance Programme.

Chapter 8
Hardware Fittings and Accessories

Chapter 8
Hardware Fittings and Accessories

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Chapter 8
Hardware Fittings and Accessories

1. Hardware Fittings

1.1 General

This chapter details technical particulars of hardware fittings and accessories suitable for ACSR BISON Conductor to be supplied by the Contractor.

The hardware fittings shall be suitable for use with composite long rod insulators having ball and socket fittings. The hardware fittings shall be as per the specification drawings enclosed in the chapter of drawings of the specification. Each hardware fitting shall be supplied complete in all respects and shall include the following hardware parts:

1.1.1 Suitable arcing horn as specified in clause 1.8 hereinafter.

1.1.2 Suitable yoke plates complying with the specifications given hereinafter.

1.1.3 Corona control rings/grading ring with fittings for attachment to line side yoke plate.

1.1.4 Sag adjustment plate for Double / Quad tension hardware fittings and turn buckle for single tension hardware fittings.

1.1.5 Suspension and dead-end assembly to suit conductor size as detailed in clause 1.13, 1.14 and 1.15 hereinafter.

1.1.6 Provisions for attaching balancing weights on the line side yoke plate of single suspension pilot hardware fittings.

1.1.7 Other necessary fittings viz D-shackles eye links, extension links, ball clevis, socket clevis, clevis eye, U clevis and chain link etc. to make the hardware fittings complete.

1.1.8 2.5% extra fasteners.

1.2 Dimensions of Insulator String along with Hardware Fitting

1.2.1 The various limiting dimensions of the insulator strings shall generally be in conformity with the dimensions of the existing hardware fittings. The Contractor shall be required to verify the dimensions of the existing insulator strings and shall ensure that the new fittings are generally conforming to the dimensions of the existing fittings.

1.3 Interchangeability

1.3.1 The hardware for insulator strings with composite/ disc insulators together with ball and socket fittings shall be of standard design, so that these hardware are inter- changeable with each other and suitable for use with insulators of any make conforming to relevant Standards.

1.4 Corona and RI Performance

1.4.1 Sharp edges and scratches on all the hardware fittings shall be avoided. All surfaces must be clean, smooth, without cuts and abrasions or projections. The Contractor must give suitable assurance about the satisfactory corona and radio interference performance of the materials offered by him.

1.5 Maintenance

1.5.1 The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be generally bare hand method & hot stick method.

1.5.2 The line side yoke plate shall have a notch & a working hole of suitable size. The design of corona control rings/grading ring shall be such that it can be easily replaced by employing hot line maintenance technique.

1.6 Designation

1.6.1 Ball and Socket Designation

The dimensions of the ball and socket are furnished in Chapter-6. The designation should be in accordance with the standard dimensions stated in IS:2486-(Part-II)/IEC:60120. The dimensions shall be checked by the appropriate gauge after galvanizing only.

1.7 Security Clips and Split Pins

1.7.1 Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking of the coupling as per IS:2486-(Part-III)/ IEC: 60372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking devices allow, separation of fittings.

1.7.2 The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required to pull the security clip into its unlocked position shall not be less than 50 N (5 kg) or more than 500 N (50 kg).

1.7.3 Split pins shall be used with bolts & nuts.

1.8 Arcing Horn/Intermediate Arcing Horn

1.8.1 The arcing horn/Intermediate Arcing Horn shall be either ball ended rod or tubular type.

1.8.2 The arcing horn shall be provided as shown on the drawing of the hardware fittings, in this specification.

1.8.3 The air gap shall be so adjusted to ensure effective operation under actual field conditions.

1.9 Yoke Plates

1.9.1 The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength as specified in the bid drawings.

1.9.2 The plates shall be either triangular or rectangular in shape as may be necessary. The design of yoke plate shall take into account the most unfavorable loading conditions likely to be experienced as a result of dimensional tolerances for disc insulators as well as components of hardware fittings within the specified range. The plates shall have suitable holes for fixing corona control rings/grading ring/arcing horn. All the corners and edges should be rounded off with a radius of at least 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the contractor. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per relevant clause of IS:800-2007.

1.10 Corona Control Rings/Grading Ring

1.10.1 The Corona control rings/ grading ring shall be provided with hardware fittings. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.

1.10.2 The corona control rings/grading ring shall be made of high strength heat treated aluminium alloy tube of minimum 2.5 mm wall thickness. If mild steel brackets are used then the brackets shall not be welded to the pipe but shall be fixed by means of bolts and nuts on a small aluminium plate attachment welded to the pipe. The welded center of the corona control ring/grading ring shall be grinded before buffing. Alternately, Aluminium tube/flats of suitable dimensions welded to the corona control rings/grading rings may be used for connection to yoke plate.

1.10.3 The Corona control rings/grading ring should have a brushed satin finish and not a bright glossy surface. No blemish should be seen or felt when rubbing a hand over the metal.

1.10.4 The limiting dimensions of corona control ring shall be as per the specification drawings.

1.10.5 Bidder may quote for grading ring with armour grip suspension assembly. The grading ring shall be of open type design with a gap of 125 mm. The open ends shall be suitably terminated. The outside diameter of the tube shall be 60 mm. The ends of grading ring tube shall be sealed with welded aluminium cap duly buffed.

1.11 Sag Adjustment Plate

1.11.1 The sag-adjustment plate to be provided with the quadruple/double tension hardware fitting shall be of three plate type. The sag adjustment plate shall be provided with a

safety locking arrangement. The device shall be of such design that the adjustment is done with ease, speed and safety.

1.11.2 The maximum length of the sag adjustment plate from the connecting part of the rest of the hardware fittings shall be 520mm. The details of the minimum and maximum adjustment possible and the steps of adjustment shall be clearly indicated in the drawing. An adjustment of 150 mm minimum at the interval of 6mm shall be possible with the sag adjustment plate.

1.11.3 Design calculations for deciding the dimensions of sag adjustment plate shall be furnished by Contractor. The hole provided for bolts should satisfy shear edge condition as per relevant clause of IS:800-2007.

1.12 Turn Buckle

1.12.1 The turn buckle is to be provided with single tension hardware fitting. The threads shall be of sufficient strength to remain unaffected under the specified tensile load.

1.12.2 The maximum length of the turn buckle from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing. An adjustment of 150 mm minimum shall be possible with turn buckle.

1.13 Suspension Assembly

1.13.1 The suspension assembly shall be suitable for the specific conductor as given in Chapter-6 of this Specification.

1.13.2 The suspension assembly shall include free center type suspension clamp along with standard preformed armour rods or armour grip suspension clamp; except for Pilot insulator string for which only suitable Envelope type suspension clamp shall be used.

1.13.3 The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.

1.13.4 The suspension clamp along with standard preformed armour rods/armour grip suspension clamp set shall have the slip strength not less than that specified in the Standard Technical Particulars.

1.13.5 The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth without any cuts, grooves, abrasions, projections, ridges or excrescence, which might damage the conductor.

1.13.6 The suspension assembly/clamp shall be designed so that it shall minimize the static & dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs & have required level of Corona/RIV performance.

1.13.7 The magnetic power loss shall not be more than that stipulated in the Standard Technical Particulars.

1.13.8 Free Center Type Suspension Clamp

For the Free Center Suspension Clamp seat shall be smoothly rounded and curved into a bell mouth at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together.

1.13.9 Standard Preformed Armour Rod Set

1.13.9.1 The Preformed Armour Rods Set, suitable for specific Conductor, shall be used to minimize the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localized heating effect due

to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

1.13.9.2 The preformed armour rods set shall have right hand lay and the inside diameter of the helics shall be less than the outside diameter of the conductor to have gentle but permanent grip on the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.

1.13.9.3 The pitch length of the rods shall be determined by the Contractor but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

1.13.9.4 The length of each rod along with permissible tolerances shall be as stipulated in the Standard Technical Particulars. The end of armour rod shall be parrot billed.

1.13.9.5 The number of armour rods in each set shall as stipulated in the Standard Technical Particulars. Each rod shall be marked in the middle with paint for easy application on the line.

1.13.9.6 The armour rod shall not lose their resilience even after five applications.

1.13.9.7 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).

1.13.10 Armour Grip Suspension Clamp

1.13.10.1 The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminium reinforcements and AGS preformed rod set.

1.13.10.2 Elastomer insert shall be resistant to the effects of temperature up to 95oC, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.

1.13.10.3 The AGS preformed rod set shall be as detailed in clause 1.13.10.4 to 1.13.10.7 in general except for the following.

1.13.10.4 The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength as detailed under clause 1.13.4 and shall not introduce unfavorable stress on the conductor under all operating conditions. However, the length of AGS preformed rods shall not be less than that stipulated in the Standard Technical Particulars.

1.14 Envelope Type Suspension Clamp

1.14.1 The seat of the envelope type suspension clamp shall be smoothly rounded & suitably curved at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together. Hexagonal bolts and nuts with split-pins shall be used for attachment of the clamp.

1.15 Dead end Assembly

1.15.1 The dead-end assembly shall be suitable for specific Conductor.

1.15.2 The dead-end assembly shall be compression type with provision for comprising jumper terminal at one end. The angle of jumper terminal to be mounted should be 30° with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I2R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

1.15.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions & shall bear the words ‘COMPRESS FIRST’ suitably inscribed

near the point on each assembly where the compression begins. If the dead-end assembly is designed for intermittent die compressions it shall bear identification marks 'COMPRESSION ZONE' and 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. The letters, number and other markings on the finished clamp shall be distinct and legible. The dimensional tolerances of the cross section of aluminium and steel dead end; for dead end assembly for the specific conductor shall be as stipulated in the Standard Technical Particulars.

1.15.4 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

1.16 Balancing Weights

1.16.1 For holding the single suspension pilot insulator string used for jumper connections from excessive deflection, suitable balancing weights, weighing 200 kg. are to be suspended through the line side yoke plate. It shall consist of four weights, each weighing 50 Kgs. and shall be connected to the yoke plate by means of eye bolt and shackle arrangement. The bottom weight shall be provided with recess to shield the ends of eye bolts. The same shall be suitable for use on specific transmission lines.

1.17 Fasteners: Bolts, Nuts and Washers

1.17.1 All bolts and nuts shall conform to IS:6639. All bolts and nuts shall be galvanized as per IS-1367 - (Part 13)/IS-2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.

1.17.2 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS-:12427. Bolts should be provided with washer face in accordance with IS:1363 Part-1 to ensure proper bearing.

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

1.17.4 Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

1.17.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.

1.17.6 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanized. The thickness of washers shall conform to IS:2016-1967.

1.17.7 The Contractor shall furnish bolt schedules giving thickness of components connected. The nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

1.17.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

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

1.17.10 To ensure effective in-process Quality control it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc., in-house. The manufacturer should also have proper Quality

Assurance system, which should be in line with the requirement of this specification and IS-.14000 services Quality System standard.

1.17.11 Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolt shall be 5.6.

1.18 Materials

1.18.1 The materials of the various components shall be as specified hereunder. The Contractor shall indicate the material proposed to be used for each and every component of hardware fittings stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

1.18.2 The details of materials for different component are listed as in

Table-I

S.No	Name of Item	Material Treatment	Process of Standard	Reference	Remarks
1	Security Clips	Stainless Steel / Phosphorous Bronze	-	AISI 302 or 304-L / IS-1385	
2	Arcing Horn	Mild Steel Rod / Tube Type	Hot dip galvanized	As per IS-226 or IS-2062	
3	Ball Fittings, Socket, all shackles links clevis	Class-IV Steel	Drop forged & normalized hot dip galvanized	As per IS-2004	
4	Yoke Plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
5	Sag Adjustment plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
6(a)	Corona Control Ring / Grading Ring	High Strength Al. Alloy tube (6061 / 6063 / 1100 type or 65032 / 63400 type)	Heat treated hot dip galvanized	ASTM-B429 or as per IS	Mechanical strength of welded joint shall not be < 20 kN
6(b)	Supporting Brackets & Mounting Bolts	High Strength Al. Alloy tube (7061 / 6063 / 65032 / 63400 type) or Mild Steel	Heat treated hot dip galvanized	ASTM-B429 or as per IS-226 or IS-2062	
7(a)	Envelope type Clamp: Clamp Body, Keeper Piece	High Strength Al. Alloy 4600/ LM-6 or 6061/65032 or 6063/63400	Casted or forged & Heat treated	IS:617 or ASTM-B429	
7(b)	Envelope type Clamp: Cotter bolts/ Hangers, Shackles, Brackets	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
7(c)	Envelope type Clamp: U-bolts	Stainless steel or High Strength Al Alloy 6061 / 6063 or 65032 / 63400	Forged & Heat Treated	AISI 302 or 304-L ASTM-B429	
8(a)	Dead End Assembly: Outer Sleeve	EC grade Al of purity not less than 99.50%			
8(b)	Steel Sleeve	Mild Steel	Hot Dip Galvanized	IS-226 / IS-2062	

Note:

Alternate materials conforming to other national standards of other countries also may be offered provide the properties and composition of these are close to the properties and compositions of material specified. Bidder should furnish the details of comparison of material offered viz a viz specified in the bid or else the bids are liable to be rejected.

1.19 Workmanship

1.19.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Contractor shall offer only such equipment as guaranteed by him to be satisfactory and suitable for the rated transmission lines and will give continued good performance.

1.19.2 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and corners to limit corona and radio-interference, best resistance to corrosion and a good finish.

1.19.3 All ferrous parts including fasteners shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing shall he done in accordance with IS:2629-1985/IS-1367(Part 13) and shall satisfy the tests mentioned in IS:2633-1986.

1.19.4 Before ball fittings are galvanized. all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

1.19.5 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash rust, stains, bulky white deposits and blisters. The zinc used for galvanizing shall be Zinc of any grade in IS: 209:1992 ingot (fourth revision) or IS: 13229:1991.

1.19.6 Pin balls shall be checked with the applicable “GO” gauges in at least two directions. one of which shall be across the line of die flashing, and the other 90o to this line. "NO GO" gauges shall not pass in any direction.

1.19.7 Socket ends, before galvanizing, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS:2486/IEC: 120.

The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

1.19.8 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm.

1.19.9 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

1.19.10 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.

1.19.11 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.

1.19.12 All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.

1.19.13 Welding of aluminium shall be by inert gas shielded tungsten arc or inert gas shielded metal arc process. Welds shall be clean, sound, smooth, uniform without overlaps, properly fused and completely sealed. There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions. Porosity shall be minimized

so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.

1.20 Bid Drawings

1.20.1 The Contractor shall furnish full description and illustrations of materials offered.

1.20.2 Fully dimensioned drawings of the complete insulator string hard wares and their component parts showing clearly the following arrangements shall be furnished along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

a. Attachment of the hanger or strain plate.
b. Suspension or dead-end assembly.
c. Arcing horn attachment to the string as specified in clause 1.8 of this technical Specification.
d. Yoke plates
e. Hardware fittings of ball and socket type for inter connecting units to the top and bottom Yoke plates.
f. Corona control rings/grading ring attachment to conductor and other small accessories.
g. Links with suitable fittings.
h. Details of balancing weights and arrangements for their attachment in the single suspension pilot insulator string.

1.20.3 All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm. The drawings shall include:

a. Dimensions and dimensional tolerance.
b. Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.
c. Catalogue No.
d. Marking
e. Weight of assembly
f. Installation instructions
g. Design installation torque for the bolt or cap screw.
h. Withstand torque that may be applied to the bolt or cap screw without failure of component parts.
i. The compression die number with recommended compression pressure.
j. All other relevant terminal details.

1.20.4 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components in four (4) copies to the Employer for approval. After getting approval from the Employer and successful completion of all the type tests, the Contractor shall submit thirty (30) more copies of the same drawings to the Employer for further distribution and field use at Employer's end.

2. Accessories for Conductor

2.1 General

2.1.1 This portion (under clause 2.0) details the technical particulars of the accessories for Conductor.

2.1.2 2.5% extra fasteners and retaining rods shall be provided.

2.2 Mid Span Compression Joint

2.2.1 Mid Span Compression Joint shall be used for joining two lengths of conductor. The joint shall have a resistively less than 75% of the resistivity of equivalent length of conductor. The joint shall not permit slipping off, damage to or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

2.2.2 The joint shall be made of steel and aluminum sleeves for jointing the steel core and aluminum wires respectively. The steel sleeve should not crack or fail during compression. The steel sleeve shall be hot dip galvanized. The aluminum sleeve shall have aluminium of purity not less than 99.5%. The dimensions and dimensional tolerances of mid span compression joint shall be as per Standard Technical Particulars.

2.3 T-Connector

2.3.1 T-Connector of compression type shall be used for jumper connection at transposition tower. It shall be manufactured out of 99.5% pure aluminium and shall be strong enough to withstand normal working loads. The T-connector shall have a resistivity across jumper less than 75% resistivity of equivalent length of conductor. The T-connector shall not permit slipping off, damage to or failure of complete conductor. The welded portions shall be designed for 30 kN axial tensile load. Leg sleeve of T-connector should be kept at an angle of 15 deg. from vertical and horizontal plane of the conductor in order to minimize jumper pull at the welded portion. The dimensions and dimensional tolerances of T-connector shall be as per Standard Technical Particulars.

2.4 Repair Sleeve

2.4.1 Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium and shall have a smooth surface. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The dimensions and dimensional tolerances of repair sleeve shall be as per Standard Technical Particulars.

2.5 Vibration Damper

2.5.1 Vibration dampers of 4R-stockbridge type with four (4) different resonances spread within the specified Aeolian frequency band width corresponding to wind speed of 1 m/s to 7 m/s shall be used at suspension and tension points on each conductor to damp out Aeolian vibration as mentioned hereinafter.

2.5.2 Alternate damping systems or “Dogbone” dampers offering equivalent or better performance also shall be accepted provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.

2.5.3 One damper minimum on each side per Conductor for suspension points and two dampers minimum on each side per conductor for tension points shall be used for ruling design span.

2.5.4 The Bidder may offer damping system involving more number of dampers per ruling design span than the specified. However suitable price compensation shall be considered for evaluation. For the purpose of price compensation 80% of the towers as suspension locations and 20% of the towers as tension locations and all the spans shall be assumed to be ruling design spans.

2.5.5 The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.

2.5.6 The messenger cable shall be made of high strength galvanized steel/stain less steel with a minimum strength of 135 kg/mm^2. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanized in accordance with the recommendations of IS:4826 for heavily coated wires.

2.5.7 The damper mass shall be made of hot dip galvanized mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.

2.5.8 The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

2.5.9 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.

2.5.10 The vibration damper shall be capable of being installed and removed from energized line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.

2.5.11 The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.

2.5.12 The magnetic power loss of vibration damper shall not exceed the limit as stipulated in the Standard Technical Particulars.

2.5.13 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed under Annexure-A, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

S.N.	Description	Technical Particulars
1	Span Length in meters	
i.	Ruling Design Span	As per Chapter 2 of this Specification
ii.	Maximum Span	1100 meters
iii.	Minimum Span	100 meters

2	Configuration	As per Chapter 2 of this Specification
3	Tensile Load in Conductor at temperature of 0°C and still air	As per sag tension calculation
5	Maximum Permissible Dynamic Strain	± 150 micro strains

2.5.14 The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Bidder. Placement charts should be duly supported with relevant technical documents and sample calculations.

2.5.15 The damper placement charts shall include the following:

a. Location of the Dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per conductor per span.

b. Placement distances clearly identifying the extremities between which the distances are to be measured.

c. Placement recommendation depending upon type of suspension clamps (viz Free center type / Armour grip type etc.)

d. The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

2.6 Material and Workmanship

2.6.1 All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for transmission line application of the rated voltage with single/ bundle conductors and will give continued good performance.

2.6.2 The design, manufacturing process and quality control of all the materials shall be such as to achieve requisite factor of safety for maximum working load, highest mobility, elimination of sharp edges and corners, best resistance to corrosion and a good finish.

2.6.3 All ferrous parts shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized as per grade 4 of IS-1573-1970. The bolt threads shall be undercut to take care of increase in diameter due to galvanizing. Galvanizing shall be done in accordance with IS:2629/IS-1367 (Part-13) and satisfy the tests mentioned in IS-2633. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanized materials shall have a minimum overall coating of Zinc equivalent to 600 gm/m^2 and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanizing unless otherwise specified.

2.6.4 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanizing shall be of grade Zn.99.95 as per IS:209.

2.6.5 In case of castings, the same shall be free from all internal defects like shrinkage, inclusion, blow holes. cracks etc.

2.6.6 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localized heating phenomenon is averted.

2.6.7 No equipment shall have sharp ends or edges, abrasions or projections and shall not cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under all service conditions.

2.6.8 Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.

2.6.9 The fasteners shall conform to the requirements of IS:6639. All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

2.7 Compression Markings

2.7.1 Die compression areas shall be clearly marked on each equipment designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' 'suitably inscribed on each equipment where the compression begins. If the equipment is designed for intermittent die compressions, it shall bear the identification marks 'COMPRESSION ZONE' and 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compression and knurling marks showing the end of the zones. The letters, number and other markings on finished equipment shall be distinct and legible.

2.8 Bid Drawings

2.8.1 The Bidder shall furnish detailed dimensioned drawings of the equipment and all component parts. Each drawing shall be identified by a drawing number and Contract number. All drawings shall be neatly arranged. All drafting and lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions and dimensional tolerances shall be mentioned in mm.

2.8.2 The drawings shall include

a. Dimensions and dimensional tolerances

b. Material. fabrication details including any weld details and any specified finishes and coatings. Regarding material, designations and reference of standards are to be indicated.

c. Catalogue No.

d. Marking

e. Weight of assembly

f. Installation instructions

g. Design installation torque for the bolt or cap screw

h. Withstand torque that may be applied to the bolt or cap screw without failure of component parts

i. The compression die number with recommended compression pressure.

j. All other relevant technical details

2.8.3 Placement charts for damper

2.8.4 The above drawings shall be submitted with all the details as stated above along with the bid document. After the placement of award. the Contractor shall again submit the drawings in four copies to the Purchaser for approval. After Purchaser's approval and successful completion of all type tests, 10 (ten) more sets of drawings shall be submitted to Purchaser for further distribution and field use at Purchaser's end.

3. G.S. Earth Wire Accessories

3.1 General

3.1.1 This portion specify the details of the technical particulars of the accessories for Galvanized Steel Earth wire.

3.1.2 2.5% extra fasteners and retaining rods shall be provided.

3.2 Mid Span Compression Joint

3.2.1 Mid Span Compression Joint shall be used for joining two lengths of earth wire. The joint shall be made of mild steel with aluminium encasing. The steel sleeve should not crack or fail during compression. The Brinnel Hardness of steel should not exceed the value as stipulated in the Standard Technical Particulars. The steel sleeve shall be hot dip galvanized. The aluminium sleeve shall have aluminium of purity not less than that stipulated in the Standard Technical Particulars. Filler aluminium sleeve shall also be provided at the both ends. The joints shall not permit slipping off, damage to or failure of the complete earth wire or any part thereof at a load not less than 95% of the ultimate tensile strength of the earth wire. The joint shall have resistivity less than 75% of resistivity of equivalent length of earth wire. The dimensions and the dimensional tolerances of the joint shall be as stipulated in the Standard Technical Particulars

3.3 Vibrations Damper

3.3.1 Vibration dampers of 4R-Stockbridge type with four (4) different frequencies spread within the specified aeolian frequency band-width corresponding to wind speed of 1m/s to 7 m/s shall be used for suspension and tension points on each earth wire in each span to damp out aeolian vibrations as mentioned herein after.

3.3.2 Alternate damping systems or “Dogbone” dampers offering equivalent or better performance also shall be acceptable provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.

3.3.3 One damper minimum on each side per earth wire at suspension points and two dampers on each side per earth wire at tension points shall be used for ruling design span of 400 meters for 400 kV line and design span of 350 meters for 220 kV line.

3.3.4 The Bidder may offer damping system involving more number of dampers per ruling design span than the specified. However suitable price compensation shall be considered for evaluation. For the purpose of price compensation 80% of towers as suspension locations and 20% of the towers as tension locations and all the spans assumed to be ruling design spans.

3.3.5 The clamp of the vibration damper shall be made of aluminium alloy. It shall be capable of supporting the damper during installation and prevent damage or chaffing of the earth wire during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the earth wire without damaging the strands or causing premature fatigue failure of the earth wire under the clamp. The clamp groove shall be in uniform contact with the earth wire over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or materials which could cause damage to the earth wire when the clamp is installed. Clamping bolts shall be provided with self-locking nuts designed to prevent corrosion of the threads or loosening during service.

3.3.6 The messenger cable shall be made of high strength galvanized steel/stainless steel with a minimum strength of 135 Kg/sq.mm. It shall be of preformed and post formed quality in order to prevent subsequent droop of weights and to maintain consistent flexural stiffness of the cable in service. The number of standards in the messenger cable shall be

19. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion.

3.3.7 The damper mass shall be made of hot dip galvanized mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkages, inclusions and blow holes etc. The inside and outside surfaces of the damper masses shall be smooth.

3.3.8 The vibration analysis of the system, with and without damper, dynamic characteristic of the damper as detailed under Annexure-A, shall have to be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows:

S.N.	Description (For 7 / 3.35 mm GS Earthwire)	Technical Particulars
1	Span Length in meters	
i.	Ruling Design Span	350 meters
ii.	Maximum Span	1100 meters
iii.	Minimum Span	100 meters
2	Tensile Load in Conductor at temperature of 0°C and still air	As per sag tension calculation
3	Armour Rods used	Standard preformed armour rods / AGS
4	Maximum Permissible Dynamic Strain	± 150 micro strains

3.3.9 The damper placement chart for spans ranging from 100 m to 1100 m shall be submitted by the Bidder. All the placement charts should be duly supported by relevant technical documents.

3.3.10 The damper placement charts shall include the following:

a. Location of the dampers for various combinations of spans and line tensions clearly indicating number of dampers to be installed per earth wire per span.

b. Placement distances clearly identifying the extremities between which the distances are to be measured.

c. Placement recommendation depending upon type of suspension clamps (viz, free center type/trunion type etc.)

d. The influence of mid span compression joints in the placement of dampers.

3.4 Flexible Copper Bond

3.4.1 The flexible copper bond shall be circular in cross-section of minimum 34 sq.mm equivalent copper area and not less than 500 mm in length. It shall consist of 259 wires of 0.417 mm dia. tinned copper conductor. It shall be laid up as 7 stranded ropes, each of 37 bunched wires. The tinning shall be as per relevant Indian Standard. Two tinned copper connecting lugs shall be press jointed to either ends of the flexible copper cable. One lug shall be suitable for 12 mm, dia. bolt and the other for 16 mm dia bolt. The complete assembly shall also include one 16 mm dia., 40 mm long HRH MS Bolt hot dip galvanized with nut and lock washer.

3.5 Suspension Clamp

3.5.1 Standard anchor shackle/twisted shackle for earth wire suspension clamp shall be supplied for attaching to the hanger plate of tower.

3.5.2 At all suspension towers, suitable suspension clamps shall be used to support the required earth wire. The clamps shall be of either free center type or trunion type and shall provide adequate area of support to the earth wire. The groove of the clamp shall be smooth, finished in a uniform circular or oval shape and shall slope downwards in a

smooth curve to avoid edge support and hence to reduce the intensity of bending moment on earth wire.

3.5.3 There shall be no sharp point in the clamps coming in contact with earth wire. There shall not be any displacement in the configuration of the earth wire strands nor shall the strands be unduly stressed in final assembly during working conditions.

3.5.4 The clamping piece and the clamp body shall be clamped by at least two U-bolts of size not less than 10 mm diameter having one nut and one 3 mm thick lock nut with washer on each of its limbs. Suspension clamps shall be provided with inverted type U-bolts. One limb of the U-bolt shall be long enough to accommodate the lug of the flexible copper bond.

3.5.5 The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pin etc. The total drop of the suspension assembly from the center point of the attachment to the center point of the earth wire shall not exceed 150 mm. The design of the assembly shall be such that the direction of run of the earth wire shall be same as that of the conductor.

3.5.6 The complete assembly shall be guaranteed for slip and breaking strength of values indicated in the Standard Technical Particulars.

3.6 Tension Clamp

3.6.1 At all tension towers suitable compression type tension clamps shall be used to hold the required galvanized steel earth wire. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates.

3.6.2 The clamps shall have adequate area of bearing surface to ensure positive electrical and mechanical contact and shall not permit any slip to the earth wire under working tension and vibration conditions. The angle of jumper terminal to be mounted should be 30 deg. with respect to the vertical line.

3.6.3 The clamps shall be made of mild steel with aluminium encasing. The steel should not crack or fail during compression. The Brinnel hardness of steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanized. The aluminium encasing shall have aluminium of purity not less than 99.5%. Filler aluminium sleeve shall also be provided at the end.

3.6.4 The complete assembly shall be so designed as to avoid undue bending in any part of the clamp and shall not produce any hindrance to the movements of the clamps in horizontal or vertical directions.

3.6.5 The slip strength of the assembly shall not be less than 95% of the ultimate strength of the earth wire.

3.6.6 The clamps shall be complete with all the components including anchor shackle, bolts, nuts, washers, split pin, jumper arrangement etc.

3.7 Material and Workmanship

Same as Clause 2.8 of this chapter

3.8 Compression Marking

Same as Clause 2.9 of this chapter

3.9 Bid Drawings

Same as Clause 2.10 of this chapter

4. Standard Technical Particulars

4.1 The Standard technical particulars to adhered by the contractor / manufacturer are furnished below:

A. Standardized Technical Particulars of Hardware Fittings and Accessories of ACSR BISON conductor for 220Kv Transmission Line

I. Suspension Hardware Fittings for ACSR BISON Conductor					
S.N.	Description	Unit	Particulars / Value		
			Single "I" Suspension Fittings with		Single Suspension Pilot Fitting
			AGS Clamp	Free Centre Clamp	Envelope Clamp
1	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 600 A	Watt	4	4	8
2	Slipping Strength of Suspension Assembly	KN	15-22	15-22	15-22
3	Particulars of Standard / AGS preformed armour rod set for suspension assembly				
	a. No. of rods per set	No	12	12	NA
	b. Direction of Lay		Right hand	Right hand	NA
	c. Overall Length after fitting on Conductor	mm	2080	2540	NA
	d. Diameter of each rod	mm	7.87	7.87	NA
	e. Tolerance in				
	i. Diameter of each rod	± mm	0.10	0.10	NA
	ii. Length of each rod	± mm	25	25	NA
	iii. Difference of Length between the longest & shortest rod in set	± mm	13	13	NA
	f. Type of Aluminum alloy used of manufacture of PA rod set		6061 / 65032	6061/ 65032	NA
4	Particulars of Elastomer (for AGS Clamp only)				
	a. Type of Elastomer		Chloroprene / Neoprene Rubber	NA	NA
	b. Shore Hardness of Elastomer		65 to 85	NA	NA
	c. Temperature range for which elastomer is designed		Up to 95°C	NA	NA
	d. Moulded on insert		Yes	NA	NA
5	Mechanical strength of suspension fitting (excluding suspension clamp)	kN	70	70	70
6	Mechanical strength of suspension clamp	kN	70	70	70
7	Purity of Zinc used for galvanizing	%	99.95	99.95	99.95
8	Minimum number of dips in standard preece test the ferrous parts can withstand	No	a. Fasteners: 4 dips of 1 min b. Spring Washers: 3 dips of 1 min c. All others: 6 dips of 1 min		

II. Tension Hardware Fittings for ACSR BISON Conductor			
S.N.	Description	Unit	Particulars / Value (Double Tension)
1	Mechanical Strength of Tension Fitting (excluding dead end clamp)	kN	2x120
2	Type of Dead End Assembly		Compression
3	Compression Pressure	MT	100
4	Maximum Electrical Resistance of Dead End Assembly as a percentage of equivalent length of Conductor	%	75
5	Slip Strength of Dead End Assembly	kN	95% of UTS of ACSR BISON
6	Purity of Zinc used for galvanizing	%	99.95
7	Minimum number of dips in standard preece test the ferrous parts can withstand	Nos	a. Fasteners: 4 dips of 1 min b. Spring Washers: 3 dips of 1 min c. All others: 6 dips of 1 min

III. Mid Span Compression Joint for ACSR BISON Conductor				
S.N.	Description	Unit	Particulars / Value	
			Aluminum Sleeve	Steel Sleeve
1	Material of Joint		Aluminum of purity 99.5%	Mild Steel (Fe-410, IS: 2062)
2	Range of Hardness of the steel sleeve (Brinnel Hardness)	BHN	From 100 to 200	
3	Weight of Zinc coating for steel sleeve	gm/m^2	610	
4	Dimension of sleeve before compression			
	a. Inside Diameter	mm	To be decide during detailed engineering	
	b. Outside Diameter	mm		
	c. Length	mm	710 ± 5	241 ± 5
5	Dimension of sleeve after compression			
	a. Outside Dimension (corner to corner)	mm	To be decide during detailed engineering	
	b. Outside Dimension (face to face)	mm		
6	Slip Strength	kN	95% of UTS of ACSR BISON	
7	Maximum Resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
8	Minimum corona Extinction Voltage kV (RMS) under dry condition	kV	154	
9	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 154 kV (rms) under dry condition	Micro Volts	1000	

IV. Repair Sleeve for ACSR BISON Conductor			
S.N.	Description	Unit	Particulars / Value
1	Material		Aluminum of minimum purity 99.5%
2	Dimension of Aluminum sleeve before compression		
	a. Inside Diameter	mm	To be decide during detailed engineering
	b. Outside Diameter	mm	
	c. Length	mm	275 ± 5
3	Dimension of Aluminum sleeve after compression		
	a. Outside Dimension (corner to corner)	mm	To be decide during detailed engineering
	b. Outside Dimension (face to face)	mm	
4	Minimum corona Extinction Voltage kV (RMS) under dry condition	kV	154
5	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 154 kV (rms) under dry condition	Micro Volts	1000

V. Vibration Damper for ACSR BISON Conductor			
S.N.	Description	Unit	Particulars / Value
1	Type of Damper		4R – Stock bridge type
2	Materials of components		
	a. Damper masses		Cast Iron / Mild Steel / Zinc Alloy duly hot dip Galvanized
	b. Clamp		Aluminum Alloy 4600
	c. Messenger Cable		High Tensile Strength Galvanized Steel
3	Number of Strands in Stranded Messenger Cable	Nos	19
4	Minimum Ultimate Tensile Strength of Stranded Messenger Cable	Kg/mm^2	135
5	Slip Strength of Stranded Messenger Cable (mass pull off)	kN	5
6	Slipping Strength of Damper Clamp		
	a. Before Fatigue Test	kN	2.5
	b. After Fatigue Test	kN	2
7	Resonance Frequencies Range	Hz	5 to 40
8	Maximum Magnetic Power Loss per vibration damper watts for 600 amps, 50 Hz Alternating Current	Watts	1
9	Minimum Corona Extinction Voltage kV (RMS) under dry condition	kV	154

10	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 154 kV (RMS) under dry condition	Micro Volts	1000
11	Percentage variation in reactance after fatigue test in comparison with that before fatigue test	%	± 40 (Maximum)
12	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	± 40 (Maximum)

5. Test and Standards

5.1 Type Tests

5.1.1 On the complete Insulator String with Hardware Fittings

S.N.	Tests	Ref	Stings on which test to be conducted*
1	Power frequency voltage withstand test with corona control rings / grading ring and arcing horns under wet condition	IEC: 60383	SIS (T), DT (T), SISP
2	Impulse Voltage withstand test under dry condition	IEC: 60383	SIS (T), DT (T), SISP
3	Mechanical Strength Test	As per Annex: A	SIS (T), DT (T), SISP
4	Vibration test	As per Annex: A	SIS (T), DT (T), SISP

5.1.2 On Suspension Hardware Fittings only

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284; Clause 7 and 8
2	Magnetic Power Loss Test for Suspension assembly	Annex: A
3	Clamp slip strength VS Torque Test for Suspension Clamp	IEC: 61284; Clause 11.4.2
4	Vertical Damage Load and Failure Loat Test for Suspension Clamp	IEC: 61284; Clause 11.4.1
5	OZONE Resistance Test on Elastomer	IEC: 61854

5.1.3 On Tension Hardware Fittings only

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284; Clause 7 and 8
2	Heat Cycle Test for Dead End Assembly	IEC: 61284; Clause 13.0
3	Mechanical Damage and Failure Load Test (excluding clamp)	IEC: 61284; Clause 11.5.2
4	Tensile Test for Dead End Clamp	IEC: 61284; Clause 11.5.1

5.1.4 Mid Span Compression Joint for Conductor and Earthwire only

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284; Clause 7 and 8
2	Heat Cycle Test (not applicable to the one for Earthwire)	IEC: 61284;
3	Tensile Test	IEC: 61284; Clause 11.5.1

5.1.5 T-Connector for Conductor

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284; Clause 7 and 8
2	Heat Cycle Test	IEC: 61284;
3	Tensile Test	IEC: 61284; Clause 11.6.1
4	Axial Tensile Load Test on welded portion	Annexure: A

5.1.6 Repair Sleeve for Conductor

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284; Clause 7 and 8
2	Tensile Test	IEC: 61284; Clause 11.6.1

5.1.7 Flexible Copper Bond

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284; Clause 7 and 8
2	Slip Strength Test	Annexure: A

5.1.8 Vibration Damper for Conductor and Earthwire

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61897; Clause 7.1 and 7.2
2	Dynamic characteristics test	Annexure: A
3	Vibration analysis	Annexure: A
4	Clamp slip test	IEC: 61897; Clause 7.5
5	Clamp bolt tightening test	IEC: 61897; Clause 7.7
6	Attachment of weights to messenger cable	IEC: 61897; Clause 7.8
7	Attachment of clamp to messenger cable	IEC: 61897; Clause 7.8
8	Fatigue tests	Annexure: A
9	Magnetic power loss test (N/A to that for Earthwire)	Annexure: A
10	Damper effective evaluation	IEC: 61897; Clause 7.11.3.2

5.1.9 Earthwire Suspension Clamp Assembly

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284
2	Vertical Damage Load and Failure Load Test (Excluding Clamp)	IEC: 61248; Clause 11.4.1 and 11.4.2
3	Clamp Slip Test for Suspension Clamp	IEC: 61248; Clause 11.4.1 and 11.4.2

5.1.10 Earthwire Tension Clamp Assembly

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284
2	Mechanical Damage Load and Failure Load Test (Excluding Clamp)	IEC: 61248; Clause 11.5.1 and 11.5.2
3	Clamp Slip Test for Clamp	IEC: 61248; Clause 11.5.1 and 11.5.2

5.1.11 Type tests specified under Clause 5.1.1 to 5.1.10 shall not be required to be carried out if a valid test certificate is available for a similar design, i.e., tests conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative (s) of any Utility.

In the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / material/manufacturing process change including substitution of components or due to noncompliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Employer/ Employer/ Purchaser

5.2 Acceptance Tests

5.2.1 On both Suspension and Tension Hardware Fittings

S.N.	Tests	Ref
1	Visual Examination & Dimensional and Material Verification	IEC: 61284; Clause 7 & 8
2	Galvanizing / Electroplating Test	Annexure: A
3	Mechanical Damage and Failure Load Test of each component (Excluding corona control rings, grading ring and arcing horn)	IEC: 61248; Clause 11.3.1
4	Mechanical Strength Test of Welded Joint	Annexure: A
5	Mechanical Strength Test for Corona Control Rings / Grading Rings and Arcing Horns	BS: 3288 – (Part-I), Clause 7.3.2
6	Test on Locking Device for Ball and Socket Coupling	IEC: 60372 (2)
7	Chemical Analysis, Hardness Tests, Grain Size, Inclusion Rating and Magnetic Particle Inspection for Forgings / Castings	Annexure: A

5.2.2 On Suspension Hardware Fittings Only

S.N.	Tests	Ref
1	Clamp Slip Test for Suspension Clamp	Annexure: A
2	Shore Hardness Test of Elastomer Cushion for AG Suspension Clamp	Annexure: A
3	Bend Test for Armour Rod Set	IS: 2121 – (Part-I), Clause 7.5, 7.10, 7.11
4	Resilience Test for Armour Rod Set	
5	Conductivity Test for Armour Rod Set	

5.2.3 On Tension Hardware Fittings Only

S.N.	Tests	Ref
1	Tensile Test for Dead End Assembly	IEC: 61284; Clause 11.5.1

5.2.4 Mid Span Compression Joint for Conductor and Earthwire

S.N.	Tests	Ref
1	Visual examination & Dimensional and material Verification	IEC: 61284; Clause 7 & 8
2	Galvanizing Test	Annexure: B
3	Hardness Test	Annexure: B

5.2.5 T-Connector for Conductor

S.N.	Tests	Ref
1	Visual examination & Dimensional and material Verification	IEC: 61284; Clause 7 & 8
2	Tensile Test	IEC: 61284; Clause 11.6.2
3	Axial Tensile Load Test for Welded Portion	Annexure: A

5.2.6 Repair Sleeve for Conductor

S.N.	Tests	Ref
1	Visual examination & Dimensional and material Verification	IEC: 61284; Clause 7 & 8
2	Tensile Test	IEC: 61284; Clause 11.6.1

5.2.7 Flexible Copper Bond

S.N.	Tests	Ref
1	Visual examination & Dimensional and material Verification	IEC: 61284; Clause 7 & 8
2	Slip Strength Test	Annexure: A

5.2.8 Vibration Damper for Conductor and Earthwire

S.N.	Tests	Ref
1	Visual examination & Dimensional and material Verification	IEC: 61897; Clause 7.1 & 7.2
2	Galvanizing Test	IEC: 61897; Clause 7.3
	a. On Damper Masses	
	b. On Messenger Cable	
3	Clamp Slip Test	IEC: 61897; Clause 7.5
4	Clamp Bolt Tightening Test	IEC: 61897; Clause 7.7
5	Attachment of Weights to Messenger Cable	IEC: 61897; Clause 7.8
6	Attachment of Clamp to Messenger cable	IEC: 61897; Clause 7.8
7	Verification of Resonance Frequencies	Annexure: B
8	Strength of Messenger Cable	Annexure: B
9	Dynamic Characteristics Test	Annexure: B

5.2.9 Earthwire Suspension Clamp Assembly

S.N.	Tests	Ref
1	Visual examination & Dimensional and material Verification	IEC: 61284
2	Galvanizing Test	Annexure: A
3	Vertical Damage Load and Failure Load Test (Excluding Clamp)	IEC: 61284; Clause 11.4.1 & 11.4.2
4	Clamp Slip Test for Suspension Clamp	IEC: 61284; Clause 11.4.1 & 11.4.2

5.2.10 Earthwire Tension Clamp Assembly

S.N.	Tests	Ref
1	Visual examination & Dimensional and material Verification	IEC: 61284
2	Galvanizing Test	Annexure: A
3	Mechanical Damage Load and Failure Load Test (Excluding Clamp)	IEC: 61284; Clause 11.5.1 & 11.5.2
4	Clamp Slip Test for Clamp	IEC: 61284; Clause 11.5.1 & 11.5.2

5.3 Routine Tests

5.3.1 For Hardware Fittings

S.N.	Tests	Ref
1	Visual examination	IS: 2486 - (Part - I)
2	Proof Load Test	Annexure: A

5.3.1 For Conductor and Earthwire Accessories

S.N.	Tests	Ref
1	Visual examination and Dimensional Verification	IS: 2121 (Part II); Clause 6.2, 6.3, 6.7

5.4 Tests During Manufacture on all components as applicable

5.4.1 On all components as applicable

S.N.	Tests	Ref
a	Chemical analysis of zinc used for galvanizing	IS: 2486 – (Part- I)
b	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.	As per Annexure-A
c	Chemical analysis hardness tests and magnetic particle inspection for forgings	As per Annexure-A

5.5 Testing Expenses

5.5.1 As indicated in clause 5.1.11 above, no type test charges shall be payable to the contractor.

5.5.2 In case, type testing is required due to non-availability of type test reports, for type test on the complete insulator string, the Contractor has to arrange similar insulators at his own cost.

5.5.3 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities for conducting the tests are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

5.5.4 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

5.5.5 In case of failure in any type test, if repeat type tests are required to be conducted, then, all the expenses for deputation of Inspector/Employer's representative shall be deducted from the contract price. Also, if on receipt of the Contractor's notice of testing, the Employer's representative/Inspector does not find 'plant' to be ready for testing the expenses incurred by the Employer for re-deputation shall be deducted from contract price.

5.5.6 The Contractor shall intimate the Employer about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of Domestic Contractor and at least 6 weeks advance in case of Foreign Contractor) of the scheduled date of testing during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests.

5.6 Sample Batch for Type Testing

5.6.1 The Contractor shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Employer. The Contractor shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Employer.

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

5.7 Schedule of Testing and Additional Tests

5.7.1 The Bidder has to indicate the schedule of following activities in their bids:

a. Submission of Drawing for approval

b Submission of Quality Assurance Program for approval

c. Offering of material for sample selection for type tests

d. Type testing

5.7.2 The Employer reserves the right of having at his own expense any other test(s) of reasonable nature carried out at Contractor's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the specifications.

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

5.8 Test Reports

5.8.1 Copies of type test reports shall be furnished in at least six copies along with one original. One copy shall be returned duly certified by the Employer, only after which the commercial production of the concerned material shall start.

5.8.2 Copies of acceptance test report shall be furnished in at least six copies. One copy shall be returned, duly certified by the Employer, only after which the materials will be dispatched.

5.8.3 Record of routine test report shall be maintained by the Contractor at his works for periodic inspection by the Employer 's representative.

5.8.4 Test certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Employer.

5.9 Inspection

5.9.1 The Employer 's representative shall at all times be entitled to have access to the works and all places of manufacture, where the material and/or its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Contractor's, sub-Contractor's works raw materials, manufacturer's all the material and for conducting necessary tests as detailed herein.

5.9.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in clause 5.11 of this part of the Specification. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

5.9.3 The Contractor shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of material in its various stages so that arrangements could be made for inspection.

5.9.4 Material shall not be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Employer in writing. In the latter case, also the material shall be dispatched only after all tests specified herein have been satisfactorily completed.

5.9.5 The acceptance of any quantity of material shall in no way relieve the Contractor of his responsibility for meeting all the requirements of the Specification, and shall not prevent subsequent rejection, if such material is later found to be defective.

5.10 Packing and Marking

5.10.1 All material shall be packed in strong and weather resistant wooden cases/crates. The gross weight of the packing shall not normally exceed 200 Kg to avoid handling problems.

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

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

5.10.4 Bolts, nuts, washers, cotter pins, security clips and split pins etc. shall be packed duly installed and assembled with the respective parts and suitable measures shall be used to prevent their loss.

5.10.5 Each component of Hardware fittings and accessories shall be legibly and indelibly marked with trade mark of the manufacturer. However, in such type of component / item, which consists of many parts and are being supplied in assembled condition (suspension clamp, vibration damper, spacer/rigid spacer, spacer damper etc.), the complete assembly shall be legibly and indelibly marked on main body/on one of the parts. The symbol ☂ / ↑ along with the word 'TOP' shall be marked on the main body of the spacer damper for installing spacer damper in correct position.

5.10.6 All the packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stenciled on it in indelible ink.

5.11 Standards

5.12.1 The Hardware fittings; conductor and earth wire accessories shall conform to the following Indian/International Standards which shall mean latest revisions, with amendments / changes adopted and published, unless specifically stated otherwise in the Specification.

5.12.2 In the event of the supply of hardware fittings; conductor and earth wire accessories conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

S. N.	Indian Standard	Title	International Standard
1	IS: 209-1992	Specification for zinc	BS: 3436
2	IS: 398-1992	Aluminum Conductor Galvanized Steel- Reinforced for Extra High Voltage (400 KV) and above	IEC: 1089-1991 BS: 215-1970
3	IS: 1573	Electroplated Coating of Zinc on Iron and Steel	
4	IS: 2121 Part (II)	Specification for Conductor and Earthwire Accessories for Overhead Power Lines: Mid-span Joints and Repair Sleeves for Conductors	
5	IS: 2486 Part (I)-1993	Specification for Insulator fittings for Overhead Power Lines with a nominal voltage greater than 1000V: General Requirements and Tests	
6	IS: 2629-1990	Recommended Practice for Hot Dip Galvanization for Iron and Steel	
7	IS: 2633-1992	Testing of Uniformity of Coating on Zinc Coated Articles	
8		Ozone Test on Elastomer	ASTM – D1 171
9		Tests on Insulators of Ceramic Material or Glass for Overhead Lines with a nominal voltage greater than 1000V	IEC: 383-1993
10	IS: 4826	Galvanized Coating on round Steel Wires	ASTM A472-729 BS: 443-1969
11	IS: 6745-1990	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	BS:433-1969 ISO:1460-1973

12	IS: 8263-1990	Methods of RI Test of HV insulators	IEC: 60437 NEMA Publication No: 07/1964/CISPR
13	IS: 6639	Hexagonal Bolts for Steel Structures	ISO / R - 272
14	IS: 9708	Specification for Stock Bridge Vibration Dampers for Overhead Power Lines	

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonvile Road, N - 19-ND, UK
IEC/CISPR	International Electro Technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de Verembe, Geneva, SWITZERLAND
BIS/IS	Bureau of Indian Standards. Manak Bhavan 9, Bahadur Shah Zafar Marg, New Delhi–110001, INDIA
ISO	International Organization for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12, DK-2900, Heeleprup, DENMARK.
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017, U.S.A.
ASTM	American Society for Testing and Materials, 1916 Race St. Philadelphia, PA19103 USA

ANNEXURE – A

1. Tests on Complete Strings with Hardware Fittings

1.1 Corona Extinction Voltage (Dry)

The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than that stipulated in the Standard Technical Particulars. There shall be no evidence of corona on any part of the sample. The test shall be carried out as per IEC: 61284. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC: 60060-1.

1.2 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (1.1) above, the sample shall have a radio interference voltage level below that stipulated in the Standard Technical Particulars. The test procedure shall be in accordance with IEC: 61284.

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 each sub-conductor tensioned at 25% of conductor UTS 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. All 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. 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.

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	$I_n = I_{sys} = 40$ kA	Two of $t_n = 0.2$s and one $t_n = 0.5$s

The acceptance criteria after the completion of test series shall be following:

a. Insulator separation not permitted.

b. Burning / melting of metal components, breaking of insulator sheds and removal of glaze are permitted.

c. The complete insulator string along with its hardware fittings including arcing horn, corona control ring / grading ring shall withstand 80% of UTS.

1.6 Assembly Test

This test shall be carried out to ensure that the cotter pins, bolts, clamps etc., fit freely and properly.

2. Tests on Hardware Fittings

2.1 Magnetic Power Loss Test for Suspension Assembly

The sample shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. This test shall be carried out as per Clause 12.0 of IEC:61284. An alternating current over the range of 400 to 600 Amps, shall be passed through a suitable length of conductor and the power losses shall be measured both with and without the fittings assembled on the conductor. Armour rods shall be applied to the conductor if they are used in service. The reading of the wattmeter with and without five suspension clamps shall be recorded. The test is passed if the average power loss for suspension clamp at given ampere is less than or equal to the value indicated in the Standard Technical Particulars.

2.2 Galvanizing / Electroplating Test

The test shall be carried out as per Clause no. 5.9 of IS:2486-(Part-1) except that both uniformity of zinc coating and standard preece test shall be carried out and the results obtained shall satisfy the requirements of this specification.

2.3 Mechanical Strength Test of Welded Joint

The welded portion of the component shall be subjected to a Load of 2000 kg for one minute. Thereafter, it shall be subjected to die-penetration/ultrasonic test. There shall not be any crack at the welded portion.

2.4 Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly

The shore hardness at various points on the surface of the elastomer cushion shall be measured by a shore hardness meter and the shore hardness number shall be between the values indicated in the Standard Technical Particulars.

2.5 Proof Load Test

Each component shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength which shall be increased at a steady rate to 67% of the UTS specified. The load shall be held for one minute and then removed. After removal of the load the component shall not show any visual deformation.

2.6 Tests for Forging Casting and Fabricated Hardware

The chemical analysis, hardness test, grain size, inclusion rating and magnetic particle inspection for forging, castings and chemical analysis and proof load test for fabricated hardware shall be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as in the Quality Assurance programme.

3. Tests on Conductor and Earthwire Accessories

3.1 T-Connector for Conductor

3.1.1 Axial Tensile Load Test for Welded Portion

Samples taken from the zinc ingot shall be chemically analyzed as per IS: 209-1979. The purity of zinc shall not be less than 99.95%.

3.2 Flexible Copper Bond

3.2.1 Slip Strength Test

On applying a load of 3 kN between the two ends, stranded flexible copper cable shall not come out of the connecting lugs and none of its strands shall be damaged. After the test, the lugs shall be cut open to ascertain that the gripping of cable has not been affected.

3.3 Vibration Damper for Conductor and Earth wire

3.3.1 Damper Characteristics Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for aeolian vibration frequency band ranging from 0.18/d to 1.4/d-where d is the conductor diameter in meters. The damper assembly shall be vibrated vertically with a + 1 mm amplitude up to 15 Hz frequency and beyond 15 Hz at ± 0.5mm to determine following characteristics with the help of suitable recording instruments:

a. Force Vs frequency
b. Phase angle Vs frequency
c. Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the aeolian vibration frequency-band between the lower and upper dangerous frequency, limits determined by the vibration analysis of conductor/earth wire without dampers.

Acceptance criteria for vibration damper.

a. The above dynamic characteristics test on five dampers shall be conducted.
b. The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
c. The above mean reactance response curve should lie within the limits specified for ACSR BISON conductor & 3.35 mm Earthwire
d. The above mean phase angle response curve shall be between 25o to 130o within the frequency range of interest.
e. If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
f. Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

3.3.2 Vibration Analysis

The vibration analysis of the conductor/earthwire shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis:

a. The analysis shall be borne for single conductor/earthwire without armour rods as per the parameters given under clause 2.5.13 and 3.3.8 of this part of the Specification. The tension shall be taken as 25% of RTS of conductor/ earth wire for a span ranging from 100 m to 1100 m.
b. The self-damping factor and flexural stiffness (El) for conductor and earthwire shall be calculated on the basis of experimental results. The details of experimental analysis with these data should be furnished.
c. The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.
d. Examine the aeolian vibration level of the conductor/earthwire with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
e. From vibration analysis of conductor/earthwire without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper

dangerous frequency limits between which the aeolian vibration levels exceed the specified limits shall be determined.

f. From vibration analysis of conductor/earthwire with damper/dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment points and the antinodes on the conductor/earthwire shall be determined. In addition to above damper clamp vibration amplitude and antinode vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment points, clamped span extremities and antinodes shall not exceed the specified limits. The damper vibration amplitude shall not be more than that of the specified fatigue limits.

3.3.3 Fatigue Tests

a. Test Set Up

The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30 m. The conductor/earthwire shall be tensioned at 25% of RTS of conductor/earthwire and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor/earthwire has been tensioned, clamps shall be installed to support the conductor/earthwire at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the conductor/earthwire. There shall be no loose parts, such as suspension clamps, U bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for stepless speed control as well as stepless amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

b. Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ± 25/f mm, where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the, test if resonance shift is observed the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned hereinabove shall be repeated after fatigue test without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from conductor / earthwire and subjected to damper characteristics test. There shall not be any major deterioration in the characteristic of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The conductor/earthwire under clamp shall also be free from any damage.

For the purpose of acceptance, the following criteria shall be applied.

1. There shall not be any resonant frequency shift before and after the test by more than + 20 %.
2. The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than + 20 %.

3.4 Magnetic Power Loss Test for Damper

The sample involving ferrous parts shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. The test should be carried out at various currents ranging from 400 amperes to 800 amperes. The test shall be carried out as per clause 12.0 of IEC: 61284. The average power loss shall be limited to the values indicated in the Standard Technical Particulars.

3.5 Corona Extinction Voltage Test (Dry)

The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than that indicated in the Standard Technical Particulars. There shall be no evidence of corona on any part of the sample. The test shall be carried out as per IEC:61284. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC: 60060-1.

3.6 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (3.7) above, the sample shall have a radio interference voltage level below the value indicated in the Standard Technical Particulars. The test procedure shall be in accordance with IEC: 61284.

3.7 Chemical Analysis Test

Chemical analysis of the material used for manufacture of items shall be conducted to check the conformity of the same with Technical Specification and approved drawing.

4. Tests on All components (As applicable)

4.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analyzed as per IS-209-1979. The purity of zinc shall not be less than 99.95%.

4.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The, sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Purchaser in Quality Assurance Programme.

4.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally recognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Purchaser in Quality Assurance Programme.

ANNEXURE – B

Acceptance Tests

1. Mid Span Compression Joint for Conductor and Earthwire

   1.1 Hardness Test

   The Brinnel hardness at various points on the steel sleeve of conductor core and of the earthwire compression joint and tension clamp shall be measured.

2. T-Connector for Conductor

   2.1 Axial Tensile Load Test for Welded Portion

   Same as clause 3.1 of Annexure - A.

3. Flexible Copper Bond

   3.1 Slip Strength Test

   Same as clause 3.2 of Annexure - A.

4. Vibration Damper for Conductor and Earthwire

   4.1 Verification of Resonance Frequencies

   The damper shall be mounted on a shaker table and vibrate at damper clamp displacement of +/- 0.5 mm to determine the resonance frequencies. The resonance shall be visually identified as the frequency at which damper mass vibrates with maximum displacement on itself. The resonance frequency thus identified shall be compared with the guaranteed value. A tolerance of ± 1 Hz at a frequency lower than 15 Hz and ± 2 Hz at a frequency higher than 15 Hz only shall be allowed.

   4.2 Strength of the Messenger Cable

   The messenger cable shall be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. Alternatively, each strand of message caste may be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. In such a case, the 95% of yield strength of each wire shall be added to get the total strength of the caste. The load shall be not less than the value guaranteed by the Contractor

   4.3 Damper Characteristics Test

   The test will be performed as acceptance test with the procedure mentioned for type test with sampling mentioned below:

   Vibration Damper of Conductor: 1 Sample for 1000 Nos. & below
   3 Samples for lot above 1 000 & up to 5000 nos.
   Addl. 1 sample for every additional 1500 pieces above 5000.

   The acceptance criteria will be as follows:

   a. The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of ranging from 0.18/d to 1.4/d-where d is the conductor diameter in meters. The damper assembly shall be vibrated vertically with a ±1mm amplitude up to 15 Hz frequency and beyond 15 Hz at ± 0.5mm
   b. If all the individual curve for dampers are within the envelope as already mentioned for type test for reactance & phase angle, the lot passes the test.
   c. If individual results do not fall within the envelope, averaging of characteristics shall be done.
      1. Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.
      2. Similar averaging shall be done for phase angle.
      3. Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.
      4. The above curves shall be within the envelope specified.

Chapter 9
Earthwire

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Chapter 9
Earthwire

1. Technical Description of Galvanized Steel Earthwire

1.1 General

1.1.1 The galvanized steel earth wire shall generally conform to the specification of ACSR core wire as mentioned in IS: 398 (Part-II)-1976 except where otherwise specified herein.

1.1.2 The details of the earth wire for 220 kV are tabulated below:

a.	Stranding and wire diameter		: 7/3.35 mm steel
b.	Number of Strands	Steel Core	: 1
		Outer Steel Layer	: 6
c.	Total Sectional Area		: 61.7 mm2

Other technical details are furnished in the Chapter-1 and 2 of this volume.

1.2 Workmanship

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

1.2.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

1.2.3 The steel strands shall be hot dip galvanized and shall have minimum Zinc coating after stranding, as stipulated in Cl. 2.0 of this section of the Specification. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-M.

1.2.4 The steel strands shall be pre-formed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanization during preforming and post forming operation.

1.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

1.3 Joints in Wires

1.3.1 There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

1.4 Tolerances

1.4.1 The manufacturing tolerance to the extent of the limits as stipulated in Clause 2.0, Table 1 of this chapter of the Specification only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire.

1.5 Materials

1.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and the chemical composition shall conform to the requirements as stipulated in Clause 2.0, Table 1 of this chapter of the Specification.

1.5.2 Zinc

The zinc used for galvanizing shall be electrolytic High-Grade Zinc and shall conform to the requirements of IS 209.

1.6 Standard Length

1.6.1 The standard length of the earth wire shall be as stipulated in Clause 2.0, Table 1 with the specified tolerance on standard length.

1.6.2 Random length will- be accepted provided no length is less than 70% of standard length and the total quantity of random lengths is not more than ten (10) percent of the total quantity in each shipment.

2. Standard Technical Particulars

2.1 The standard Technical Particulars to be adhered by the contractor / manufacturer are furnished in Annexure-B of this chapter.

3. Tests and Standards

3.1 Type Tests on Earthwire

3.1.1 The required type tests on earthwire are stipulated hereunder. The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for the same earthwire. The tests certificate shall be considered valid if:

a. Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of any utility and

b. Tests have been conducted not prior to 5 (five) years from the date of bid opening.

In case the tests have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

3.1.2 The following tests are required on samples of earthwire from each manufacturing works:

a. UTS test : As per Annexure - A

b. DC resistance test : As per Annexure - A.

3.2 Acceptance Tests on Earthwire

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

3.3 Routine Tests on Earthwire

a.	Check for correctness of stranding	: As per Annexure - A
b.	Check that there are no cuts, fins etc. on the strands.	: As per Annexure - A
c.	Check that drums are as per Specification.	: As per Annexure - A

3.4 Tests During Manufacture Earthwire

a.	Chemical analysis of zinc used for galvanizing	: As per Annexure - A
b.	Chemical analysis of steel	: As per Annexure - A

3.5 Tests During Manufacture Earthwire

3.5.1 No type test charges shall be payable to the supplier.

3.5.2 Bidders shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that the tests can be completed in these laboratories within the time schedule guaranteed by them.

3.5.3 In case of failure in any type test the Contractor is either required to manufacture fresh sample lot and repeat all the test successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at his own expenses. In case fresh lot is manufactured for testing then the lot already manufactured shall be rejected. The decision of the Purchaser in this regard shall be final and binding on Contractor.

3.5.4 The entire cost of testing for the acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price except for the expenses of the inspector/ Employer's representative.

3.5.5 In case of failure in any type test, repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/ Employer's representative shall be deducted from the contract price. Also, if on receipt of the Contract's notice of testing the Employer's representative/Inspector does not find 'materials and facilities' to be ready for testing, the expenses incurred by the Employer for re-deputation shall be deducted from the contract price.

3.6 Additional Tests

3.6.1 The Owner 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.

3.6.2 The Owner 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 Owner.

3.7 Sample Batch for Type Testing

3.7.1 The Contractor shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from Owner's Quality Assurance Deptt. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Owner.

3.7.2 The Contractor shall offer at least three drums for selection of sample required for conducting all the type test.

3.7.3 The Contractor is required to carry out all the Acceptance tests successfully in presence of Owner's representative before sample selection.

3.8 Test Reports

3.8.1 Copies of type test reports shall be furnished in at least six copies along with one original. One copy will be returned duly certified by the Owner only after which the commercial production of the material shall start.

3.8.2 Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Owner's representative.

3.8.3 Test Certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Owner.

3.9 Material and Workmanship

3.9.1 The Owner 's representative shall at all times be entitled to have access to the works and all places of manufacture, where earth wire shall be manufactured and representative shall have full facilities for unrestricted inspection of the Contractor's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

3.9.2 The Contractor shall keep the Owner informed in advance of the time of starting and of the progress of manufacture of earth wire in its various stages so that arrangements can be made for inspection.

3.9.3 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Owner in writing. In the latter case, also the earth wire shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

3.9.4 The acceptance of any quantity of material shall in no way relieve the Contractor of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

3.10 Test Facilities

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

a. Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer etc.

b. Standard resistance for calibration of resistance bridges.

c. Finished Earth wire shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc., with traverse laying facilities.

3.11 Packing for Earthwire

3.11.1 The Earth wire shall be supplied in non-returnable, strong, wooden drums and provided with lagging of adequate strength, constructed to protect the Earth wire against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Contractor shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS 778-1980, except as otherwise specified hereinafter.

3.11.2 The drums shall be suitable for wheel mounting and for letting off the earth wire under a minimum controlled tension of the order of 5 kN.

3.11.3 The general outline of the drum for Earth wire shall be as per annexed drawing. The Contractor should submit their proposed drum drawings along with the bid.

3.11.4 For Earth wire, two standard lengths shall be wound on each drum.

3.11.5 For Earth wire, each strand shall be individually welded to prevent parting of two lengths at a tension less than 15 kN. The two ends where the first length finishes and the second length starts, shall be clearly marked with adhesive tape and no weld should be present outside these marks. The length between the two marks shall be treated as scrap and will not be taken into account for measurement purposes.

3.11.6 All wooden components shall be manufactured out of seasoned softwood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the earth wire.

3.11.7 The flanges shall be of two ply constructions with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3 mm from that indicated in the figure. There shall be at least 3 nails per plank of ply

with maximum nail spacing of 75 mm. Where a slot is cut in the flange to receive the inner end of the earth wire the entrance shall be in line with the periphery of the barrel.

3.11.8 The wooden battens used for making the barrel of the earth wire shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the earth wire.

3.11.9 Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel studs shaft be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.

3.11.10 Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.

3.11.11 The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.

3.11.12 Before reeling, cardboard or double corrugated or thick bituminous waterproof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material. After reeling the earth wire, the exposed surface of the outer layer of earth wire shall be wrapped with water proof thick bituminous bamboo paper to preserve the earth wire from dirt, grit and damage during transport and handling.

Medium grade craft/crepe/polythene paper shall be used in between the layers.

3.11.13 A minimum space of 50 mm for earth wire shall be provided between the inner surface of the external protective lagging and outer layer of the earth wire.

3.11.14 Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp edges or allow the battens to be released due to corrosion.

3.11.15 The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

3.11.16 Outside the protective lagging there shall be minimum of two binders consisting of hoop iron/galvanized steel wire. Each protective lagging shall have two recesses to accommodate the binders.

3.11.17 The earth wire ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the earth wire layers during transit and handling.

3.12 Marking

3.12.1 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. Number of turns in the outer most layer
l. Distance between outer most layer of Earth wire and the inner surface of lagging

n. Barrel diameter at three locations and an arrow marking at the location of measurement.

3.13 Verification of Earthwire Length

3.13.1 The Owner 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.

3.14 Standards

3.14.1 The earth wire shall conform to the following Indian/ International Standards, which shall mean latest revisions, amendments/changes adopted and published, unless otherwise in the Specification.

3.14.2 In the event of the supply of earth wire conforming to standards other than specified, the Contractor shall confirm in his bid that these standards are equivalent to those specified. In case of award salient features of comparison between the standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

S.N.	Indian Standard	Title	International Standard
1	IS: 209-1992	Specification for zinc	BS: 3436
2	IS: 398-1992	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC: 1089-1991 BS: 215-1970
3	IS: 398-1998 Part - II	Aluminum Conductor Galvanized Steel Reinforced	IEC: 1089-1991 BS: 215-1970
4	IS: 398-1996 Part - IV	Aluminum Alloy Stranded Conductor	IEC: 1089-1991 BS: 3242-1970 ASTM: 8399 M86
5	IS: 398-1996 Part - V	Aluminum Conductor Galvanized Steel-Reinforced for Extra High Voltage (400kV) and above	IEC: 1089-1991 BS: 215-1970
6	IS: 1778-1997	Reels and Drums for Bare Conductors	BS: 1559-1949
7	IS: 1521-1991	Method of Tensile Testing of Steel Wire	ISO 6892-1984
8	IS: 2629-1990	Recommended Practice for Hot Dip Galvanizing of Iron and Steel	
9	IS: 2633-1992	Testing of Uniformity of Coating on Zinc Coated Articles	
10	IS: 4826-1992	Galvanized coating on round steel wires	IEC: 888-1987 BS: 443-1969
11	IS: 6745-1990	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	BS:433-1969 ISO:1460-1973
12	IS: 8263-1990	Methods of RI Test of HV insulators	IEC: 60437 NEMA Publication No: 07/1964/CISPR
13	IS: 9997-1991	Aluminum Alloy Redraw Rods	IEC: 104-1987
14		Zinc coated steel wires for stranded conductors	IEC: 888-1987
15		Hard drawn aluminum wire for overhead line conductors	IEC: 889-1987

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonvile Road, N - 19-ND, UK
IEC/CISPR	International Electro Technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de Verembe, Geneva, SWITZERLAND
BIS/IS	Bureau of Indian Standards. Manak Bhavan 9, Bahadur Shah Zafar Marg, New Delhi–110001, INDIA
ISO	International Organization for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12, DK-2900, Heeleprup, DENMARK.
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017, U.S.A.
ASTM	American Society for Testing and Materials, 1916 Race St. Philadelphia, PA19103 USA

ANNEXURE – A

1. Tests on Earthwire

1.1 UTS Test

Circles perpendicular to the axis of the earth wire shall be marked at two places on a sample of earth wire of minimum 5 m length suitably compressed with dead end clamps at either end. The load shall be increased at a steady rate up to 50% of UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to 100% of UTS and held for one minute. The earth wire sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2 D.C. Resistance Test

On an earthwire 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 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°C. The resistance corrected at 20°C shall conform to the requirements of this Specification.

1.3 Chemical Analysis of Zinc

Samples taken from the zinc ingots shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

1.4 Chemical Analysis of Steel

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

1.5 Visual and Dimensional Check on Drums and its barrel strength test.

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this Specification. The details regarding barrel strength test will be discussed and mutually agreed to by Contractor and Owner in the quality assurance programme.

1.6 Visual Check for Joints, Scratches etc. and Length of Earth wire

Ten percent drums from each lot shall be rewound in the presence of the Owner. The Owner shall visually check for scratches, joints etc. and see that the earth wire generally conforms to the requirements of this Specification. The length of earth wire wound on the drum shall be measured with the help of counter meter during rewinding.

1.7 Dimensional Check

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

1.8 Lay Length Check

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

1.9 Galvanizing Test

The test procedure shall be as specified in IS 4826-1979. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

1.10 Torsion Test

The minimum number of twists which a single steel strand shall withstand during torsion test shall be eighteen for a length equal to 100 times the standard diameter of the strand. In case test sample length is less or more than 100 times the stranded diameter of the strand the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number.

ANNEXURE – B

Standardized Technical Particulars of 7/3.35mm Galvanized Steel Earth wire			
S.N.	Description	Unit	Standard Values
1	Raw Materials		
1.1	Steel wires / rods		
	a. Carbon	%	Not more than 0.55
	b. Manganese	%	0.40 to 0.90
	c. Phosphorous	%	Not more than 0.04
	d. Sulphur	%	Not more than 0.04
	e. Silicon	%	0.15 to 0.35
1.2	Zinc		
	a. Minimum purity of Zinc	%	99.95
2	Steel Strands		
2.1	Diameter		
	a. Nominal	mm	3.35
	b. Maximum	mm	3.40
	c. Minimum	mm	3.30
2.2	Minimum breaking load of strand		
	a. After stranding	KN	8.98
2.3	Galvanizing		
	a. Minimum weight of zinc coating per m^2 after stranding	gm	275
	b. Minimum number of dips that the galvanized strand can withstand in the standard preece test	Nos	3 dips of 1 minute and 1 dip of ½ minute
	c. Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding	Nos	18
3	Stranded Earthwire		
3.1	UTS of Earthwire	KN	61.1 (minimum)
3.2	Lay length of outer steel layer		
	a. Standard	mm	181
	b. Maximum	mm	198
	c. Minimum	mm	165
3.3	Maximum DC resistance of earthwire at 20°C	Ω/km	2.5
3.4	Standard length of earthwire	M	2000
3.5	Tolerance on standard length	%	±5
3.6	Direction of lay for outside layer		Right hand
3.7	Linear mass		
	a. Standard	Kg/km	482
	b. Maximum	Kg/km	496
	c. Minimum	Kg/km	468

Chapter 10
OPGW Cabling and Associated Hardware & Fittings

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Chapter 10

OPGW Cabling and Associated Hardware & Fittings

1. Technical Description of OPGW cabling and associated hardware & fittings

1.1 General

1.1.1 The broad scope of this specification includes the survey, planning, design, engineering, manufacturing, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, splicing, termination, testing, demonstration for acceptance and commissioning and documentation for:

a. OPGW fibre optic cable including all associated hardware, accessories & fittings

b. Fibre Optic approach cable including installation material

c. Fibre Optic Distribution Panels (FODP) & Joint Box

d. Supply of spares

e. All other associated work/items described in the technical specifications

1.1.2 The 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).

1.1.3 The proposed manufacturer of OPGW cable shall meet the following criteria. The plant/equipment must have been type-tested and certified by an international reputable laboratory.

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

1.2 Fibre Optic Cabling

1.2.1 In this chapter of the technical specification, the functional & technical specifications of OPGW cable, associated hardware & fittings for the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable is mentioned. Bidders shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

1.2.2 All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guarantee design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

1.3 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristics:

1.3.1 Physical Characteristic

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1.

1.3.2 Attenuation

The attenuation coefficient for wavelengths between 1525nm and 1575nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km.

The attenuation coefficient between 1285nm and 1330nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB.

The fibre attenuation characteristics specified in table 1 shall be “guaranteed” fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550 nm: 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Maximum attenuation @ 1310 nm: 0.35 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Table 1: DWSM Optic Fibre Characteristics

Fibre Description	Dual-Window Single-Mode
Mode Field Diameter	8.6 to 9.5 µm (± 0.6 µm)
Cladding Diameter	125.0 µm ± 1 µm
Mode Field Concentricity Error	≤ 0.6 µm
Cladding Non-Circularity	≤ 1%
Cable Cut-off Wavelength λ_{cc}	≤ 1260 nm
1550 nm Loss Performance	As per G.652 D
Proof Test Level	≥ 0.69 GPA
Attenuation Coefficient	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Chromatic Dispersion; Maximum	18 PS / (nm x km) @ 1550 nm 3.5 PS / (nm x km) 1288-1339 nm 5.3 PS / (nm x km) 1271-1360 nm
Zero Dispersion Wavelength	1300 to 1324 nm
Zero Dispersion Slope	0.092 PS / (nm^2 x km) maximum
Polarization Mode Dispersion Coefficient	≤ 0.2 PS / $km^{½}$
Temperature Dependence	Induced Attenuation ≤ 0.05 dB (-60°C to +85°C)
Bend Performance	@ 1310 nm (75 ± 2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB/km @ 1550 nm (75 ± 2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.10 dB/km @ 1550 nm (32 ± 0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB/km

1.4 Fibre Optic Cable Construction

1.4.1 The OPGW (Optical Ground Wire) cable is proposed to be installed on the new transmission lines along with transmission line construction. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the transmission lines. The Tower span details shall be collected by the contractor during survey. To meet the overall requirement of the transmission line(s), the contractor may offer more than one design without any additional cost to Employer, in case single design is not meeting the requirement. OPGW cable to be designed to meet transmission line sag-tension parameters and other details to be provided by Transmission Line contractor. Any other details, as required for cable design etc. shall be collected by the Contractor during survey.

1.4.2 Optical Fibre Cable Link Lengths

The estimated optical fibre link lengths are provided in Appendices as transmission line route length. However, the Contractor shall supply the OPGW cable as required based on the tower schedule. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

1.4.3 Optical Fiber Identification

All optical fibres shall be individually coated. Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres is included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

1.4.4 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 filled with a water-blocking gel.

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.

1.4.5 Optical Fibre Strain & Sag-Tension chart

The OPGW cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions of transmission lines. Zero fibre strain condition shall apply even after a 25-year cable creep.

For the purpose of this specification, the following definitions shall apply:

- *Maximum Working Tension (MWT)* is defined as the maximum cable tension at which there is no fibre strain.
- The *no fibre strain* condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry
- The *Cable strain margin* is defined as the maximum cable strain at which there is no fibre strain.
- The *cable Maximum Allowable Tension (MAT)* is defined as the maximum tension experienced by the Cable under the worst-case loading condition.
- The cable *max strain* is defined as the maximum strain experienced by the Cable under the worst-case loading condition.
- The cable *Every Day Tension (EDT)* is defined as the maximum cable tension on any span under normal conditions.
- The *Ultimate / Rated Tensile Strength (UTS/ RTS/ breaking strength)* is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.
- The 25-year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25-year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions as per tower design of the transmission line.

The size of OPGW shall be selected such that max. tension and sag at specified temperature and wind condition remains within the limits of transmission line tower design.

1.4.6 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

1.4.6.1 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

1.4.6.2 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

1.4.7 Marking, Packaging and Shipping

1.4.7.1 This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

a. Drum Markings

Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Employer’s destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.

b. Cable Drums

All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling

during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

1.4.7.2 The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

1.4.7.3 There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the Employer.

1.5 Optical Ground Wire (OPGW)

1.5.1 General

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

1.5.2 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials for stranded wires and tubes are not allowed. Central fibre optic unit may be of aluminium / aluminium alloy tube. There shall be no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc. with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

1.5.3 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 2 OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

1.5.4 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

1.5.5 Electrical and Mechanical Requirements

Table 2 provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. OPGW installation sag & tension charts shall be as per transmission line requirement. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this chapter shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

Table 2: OPGW Electrical and Mechanical Requirements

1	Everyday Tension	≤ 20% of UTS of OPGW
2	DC Resistance at 20°C	< 1.0 Ω / km or Employer provided values
3	Short Circuit Current	≥ 6.32 kA for 1.0 Second or Employer provided Values

Bidder may offer separate design for each short circuit rating however OPGW design with higher short circuit level shall be acceptable.

1.3.5 Operating conditions

Since OPGW shall be located at the top of the transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

1.6 Installation Hardware

1.6.1 The scope of supply includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation minimum@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to Employer.

1.6.2 The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc. shall be marked on the drawings.

1.6.3 The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

a. Suspension Assemblies

Preformed armour grip suspension clamps and aluminium alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a

vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

b. Dead End Clamp Assemblies
All dead-end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

c. Clamp Assembly Earthing Wire
Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead-end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

d. Structure Attachment Clamp Assemblies
Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.

e. Vibration Dampers
Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 350 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminum alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanized steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanized in accordance with the recommendations of IS: 4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanized mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses shall be smooth.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation.

The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

Table 3

S.N.	Description	Technical Particulars
1	Span Length in meters a. Ruling Design Span b. Maximum Span c. Minimum Span	 350 m 1100 m 100 m
2	Configuration	As per Specifications
3	Tensile Load in each	As per Sag-Tension Calculation
4	Armour Rods used	Standard preformed armour rods / AGS
5	Maximum Permissible Dynamic Strain	± 150 micro strains

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Contractor. Placement charts should be duly supported with relevant technical documents and sample calculations.

The damper placement charts shall include the following

a. Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per OPGW cable per span.

b. Placement distances clearly identifying the extremities between which the distances are to be measured.

c. Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)

d. The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

1.7 Fibre Optic Splice Enclosures (Joint Box)

1.7.1 General

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free

environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 meters from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalized after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

1.7.2 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

a. All fibre splices shall be accomplished through fusion splicing.
b. Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
c. All splices and bare fibre shall be neatly installed in covered splice trays.
d. For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.
e. For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

1.8 Fibre Optic Approach Cables

1.8.1 General

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

1.8.2 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

1.8.3 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armoring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

1.8.4 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

1.9 Fibre Optic Distribution Panel

1.9.1 General

Fibre Optic Distribution Panels is required for each location for termination of fibres in a manner consistent with the following:

a. FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

b. FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement

c. All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

1.9.2 Optical Fibre Connectors

Optical fibres shall be connectible with FC-PC type connectors preferably. Alternatively, connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

1.10 Service Loops

1.10.1 For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

a. Outdoor Cable Service Loops
In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

b. Indoor Cable Service Loops
FODPs shall provide at least three (3) metre of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

c. Fibre Units Service Loops
For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

d. Pigtail Service Loops
Connectible pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

e. Fibre Service Loops
At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

1.11 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied for OPGW and associated items.

a. American Society for Testing and Materials ASTM
ASTM – B415 Standard Specification for Hard-Drawn Aluminum – Clad Steel wire

b. Bell Communication Research
GR – 20 Generic Requirements for Optical Fibre and Optical Fibre

c. ITU – T/CCITT Recommendations

G.650	Definitions and test methods for the relevant parameters of single-mode fibres
G.652	Characteristics of a single-mode optical fibre cable

d. IEEE

IEEE - 1138	IEEE Standard Construction of Composite Fibre Optic Ground Wire (OPGW) for Use on Electric Utility Power Lines

e. Telecommunication Industry Association EIA / TIA

EIA / TIA – 455-3	IEEE Standard Construction of Composite Fibre Optic Ground Wire (OPGW) for Use on Electric Utility Power Lines
EIA / TIA – 455-16	Salt Spray (Corrosion) Test for Fibre Optic Components
EIA / TIA - 455-20	Measurement of Change in Optical Transmittance
EIA / TIA – 455-25	Repeated Impact Testing of Fibre Optic Cables and Cable Assemblies
EIA / TIA – 455-32	Fibre Optic Circuit Discontinuities
EIA / TIA – 455-33	Fibre Optic Cable Tensile Loading and Bending Test
EIA / TIA – 455-41	Compressive Loading Resistance of Fibre Optic Cables
EIA / TIA – 455-59	Measurement of Fibre Point Defects Using an OTDR
EIA / TIA – 455-62	Measurement of Optical Fibre Macro-Bend Attenuation
EIA / TIA – 455-78	Spectral Attenuation Cutback Measurement for Single- Mode Optical Fibres
EIA / TIA – 455-80	Measurement of Cut-Off Wavelength of Single-Mode Fibre by Transmitted Power
EIA / TIA – 455-81	Compound Flow (Drip) Test for Filled Fibre Optic Cable
EIA / TIA – 455-82	Fluid Penetration Test for Fluid-Blocked Fibre optic Cable
EIA / TIA – 455-91	Fibre Optic Cable Twist-Bend Test
EIA / TIA – 455-164	Single-Mode Fibre, Measurement of Mode Field Diameter by Far-Field Scanning
EIA / TIA – 455-167	Mode Field Diameter Measurement, Variable Aperture Method in the Far-Field
EIA / TIA – 455-168	Chromatic Dispersion Measurement of Multimode Graded Index and Single-Mode Optical Fibres by Spectral Group Delay Measurement in the Time Domain
EIA / TIA – 455-169	Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Phase-Shift Method
EIA / TIA – 455-170	Cable Cut-off Wavelength of Single-Mode Fibre by Transmitted Power
EIA / TIA – 455-174	Mode Field Diameter Measurement
EIA / TIA – 455-175	Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Differential Phase-Shift Method
EIA / TIA – 455-176	Method of Measuring Optical Fibre Cross-Sectional Geometry by Automated Grey-Scale Analysis
EIA / TIA – 598	Optical Fibre Cable Color Coding

f. International Electrotechnical Commission IEC Standards

IEC-60793-1 series	Optical fibres – Generic & product specifications, measurement methods & test procedures specification
IEC-60794-1-1	Optical fibre cables – Generic specification
IEC-60794-1-2	Optical fibre cables – Basic optical cable test procedure
IEC-60794-3	Optical fibre cables–Duct, buried & aerial cables–sectional specification
IEC-60794-4	Optical fibre cables – Overhead cables

IEC-61089	Round wire concentric lay overhead electrical stranded conductors
IEC-61232	Aluminium-clad steel wires for electrical purposes
IEC-61284	Overhead Lines-Requirements and tests for fittings
IEC-61395	Overhead electrical conductors – Creep test procedures for stranded conductors

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

References

a. CIGRE Guide for Planning of Power Utility Digital Communications Networks
b. CIGRE Optical Fibre Planning Guide for Power Utilities
c. CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities
d. CIGRE Guide to fittings for Optical Cables on Transmission Lines

2. Inspection and Testing Requirement

2.1 General

2.1.1 All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

2.1.2 Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

2.1.3 The entire cost of testing for factory, production tests and other test during manufacture specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

2.1.4 Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

2.1.5 All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

2.1.6 Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

2.1.7 The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.:

2.2 Testing Requirements

2.2.1 Following are the requirements of testing:

a. Type Testing

b. Factory Acceptance Testing

c. Site Acceptance Testing

2.2.2 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

a. All cable & equipment being supplied shall conform to type tests as per technical specification.

b. The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.

c. The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in these specifications carried out at accredited labs and witnessed by third party / customer's representatives.

In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

In case the Type Test is required to be carried out, then following shall be applicable:

d. Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

e. The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

2.2.2.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures, at least three samples shall be offered for selectionThe Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

2.2.2.2 List of Type Tests

The type testing shall be conducted on the following items:

a. Optical fibres
b. OPGW Cable
c. OPGW Cable fittings
d. Vibration Damper
e. Splice Enclosure (Joint Box)
f. Approach Cable

Type Tests for Optical Fibres

The type tests listed below in table 4 shall be conducted on DWSM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent chapter.

Table 4

S.N.	Test Name	Acceptance Criteria	Test Procedure
1	Attenuation	As per Clause 1 of this chapter	IEC 60793 – 1 – 40 or EIA / TIA 455-78A
2	Attenuation Variation with wavelength	As per Clause 1 of this chapter	IEC 60793 – 1 – 40 or EIA / TIA 455-78A
3	Attenuation at Water Peak	As per Clause 1 of this chapter	IEC 60793 – 1 – 40 or EIA / TIA 455-78A

4	Temperature cycling (Temperature dependence of Attenuation	As per Clause 1 of this chapter	IEC 60793 – 1 - 52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation with bending (Bend Performance)	As per Clause 1 of this chapter	IEC 60793 – 1 - 47 Or EIA/TIA 455-62A
6	Mode Field Diameter	As per Clause 1 of this chapter	IEC 60793 – 1 - 45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion	As per Clause 1 of this chapter	IEC 60793 – 1 - 42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter	As per Clause 1 of this chapter	IEC 60793 – 1 - 20 Or EIA/TIA 455-176
9	Point Discontinuities of Attenuation	As per Clause 1 of this chapter	IEC 60793 – 1 - 40 Or EIA/TIA 455-59
10	Core-clad concentricity error	As per Clause 1 of this chapter	IEC 60793 – 1 - 20 Or EIA/TIA 455-176
11	Fibre tensile proof testing	As per Clause 1 of this chapter	IEC 60793 – 1 - 30 Or EIA/TIA 455-31B

Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 5 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 5

S.N.	Test Name	Test Description	Test Procedure
1	Water Ingress Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-4 Method F5 or EIA / TIA 455-82B) Test Duration: 24 Hrs
2	Seepage of Filling compound	IEEE 1138-2009; EIA / TIA 455-81B	Preconditioning period: 72 Hrs Test Duration: 24 Hrs
3	Short Circuit Test	IEEE 1138-2009 Or IEC 60794-4-10 / IEC 60794-1-2 (2003) Method H1	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring & recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test. Initial temperature during the test shall be greater than or equal to ambient field temperature.

4	Aeolian Vibration Test	IEEE 1138-2009 Or IEC 60794-4-10 / IEC 60794-1-2 Method E19	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
5	Galloping Test	IEEE 1138-2009	Test shall be conducted with the tension / suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring
6	Cable Bend Test	Procedure 2 in IEC 60794-1-2 Method E11	The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.
7	Sheave Test	IEEE 1138-2009 Or IEC 60794-1-2 (2003) Method E1B	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The Sheave dia. shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
8	Crush Test	IEEE 1138-2009 Or IEC 60794-1-2 Method E3 / EIA/TIA 455-41B	The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal to 1.3 times the weight of a 400-metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.
9	Impact Test	IEEE 1138-2009 Or IEC 60794-1-2	The impact test shall be carried out in accordance with IEC 60794-1-2 E4. Five separate impacts of 0.1-0.3kgm shall be

		Method E4 / EIA / TIA 455-25B	applied. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.
10	Creep Test	IEEE 1138-2009	As per Aluminium Association Method, the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when the creep shall achieve the strain margin limits shall also be calculated.
11	Fibre Strain Test	IEEE 1138-1994	
12	Strain Margin Test	IEEE 1138-2009	
13	Stress Strain Test	IEEE 1138-2009	
14	Cable Cut-off Wavelength Test	IEEE 1138-1994	
15	Temperature Cycling Test	IEEE 1138-2009 or IEC 60794-1-2 Method F!	
16	Corrosion (Salt Spray) Test	EIA / TIA 455-16A	
17	Tensile Performance Test	IEC 60794-1-2 Method E1 / EIA/TIA 455-33B	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded
18	Lighting Test	IEC 60794-4-10 / IEC 60794-1-2 (2003)	The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.
19	DC Resistance Test	IEC 60228	On a fibre optic cable sample of minimum 1 metre 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 metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.

Type Tests on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

i. Mechanical Strength Test for Suspension/Tension Assembly

Applicable Standards: IEC 61284, 1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16^{o}. This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.

- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

ii. Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder 'zeroed'. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one-minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one-minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.
  - * Definition of no slippage in accordance with IEC 61284, 1997: - Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.
- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.
- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.
- The Armour Rods shall not be displaced from their original lay or damaged**.
  - ** Definition of no damage in accordance with convention expressed in IEC 61284: 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

iii. Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on an 8m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods

and Tension Dead -End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 % of the UTS and the position scale of the recorder is zeroed. The load shall then gradually be increased up to 95 % of the UTS and maintained for one minute. After one-minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

iv. Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kg or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also, the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

v. Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

<u>Type Test on Vibration Damper</u>

The testing standard of vibration damper for OPGW shall be as per applicable international standard i.e. IEC 61897.

i. Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian Vibration frequency band ranging from 0.18/d to 1.4/d – where d is the OPGW cable diameter in meters. The damper assembly shall be vibrated vertically with a ±1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

a. Force Vs Frequency
b. Phase Angle Vs Frequency
c. Power Dissipation Vs Frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

Acceptance criteria for vibration damper:

a. The above dynamic characteristics test on five dampers shall be conducted.
b. The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
c. The above mean reactance response curve should lie within following limits:

   V.D. for OPGW - 0.060 f to 0.357 f kgf/mm*, Where f is frequency in Hz.
d. The above mean phase angle response curve shall be between 25o to 130o within the frequency range of interest.
e. If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
f. Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

ii. Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

a. The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable for a span ranging from 100 m to 1100 m.
b. The self-damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.
c. The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.
d. Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
e. From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.
f. From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment points and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

   The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

iii. Fatigue Tests

a. Test Set Up

   The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 25% of

RTS of fibre optic cable and shall not be equipped with protective armour rods at any point.

Constant tension shall be maintained within the span by means of lever arm arrangement. After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

b. Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ±25/f mm where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

1. There shall not be any resonant frequency shift before and after the test by more than ± 20%
2. The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ± 20%

Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper

Table 6

S.N.	Test Name	Test Procedure
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip test	IEC 61897 Clause 7.5

3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachments of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

i. Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40□C to +65□C with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than ±0.05dB. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

ii. Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55□C ±2□C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than ±0.05dB, and the internal humidity rate measured, less than 2%.

iii. Rain Withstand Test / Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ±0.05dB.

iv. Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ±0.05dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

v. Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

a. 3 torsion cycles of ±180□ shall be exercised on the cable. Each cycle shall be less than one minute.

b. 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

vi. Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

vii. Drop Test

With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 7: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 7: Type Tests for Fibre Optic Approach Cable

S.N.	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration: 24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning: 72 hours, Test duration: 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress Strain Test	(EIA 455-33A)
6	Cable Cut-off Wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) 2 cycles

i. Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

2.3 Factory Acceptance Tests

2.3.1 General

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorized representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general, the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc.

For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

2.3.2 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

2.3.3 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

2.3.4 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above-mentioned IEEE standards unless specified otherwise in the technical specifications.

Table 8

Factory Acceptance Tests for Optical Fibres: Optical Tests

S.N.	Test Name	Acceptance Criteria	Test Procedure
1	Attenuation Coefficient	As per Clause 1 of this chapter	EIA / TIA 455-78A
2	Point Discontinuities of Attenuation		EIA / TIA 455-59
3	Attenuation at Water Peak		EIA / TIA 455-78A
4	Chromatic Dispersion		EIA / TIA 455-168A/169A/175A
5	Core-clad concentricity error		EIA / TIA 455-176
6	Cladding Diameter		EIA / TIA 455-176
7	Fibre tensile proof testing		EIA/TIA 455-31B

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

2.3.5 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 9

Applicable Standard: IEEE 1138 / IEC 60794

S.N.	Factory Acceptance Test
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

2.3.6 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 10. The sampling plan shall be as per relevant standard:

Table 10

S.N.	Factory Acceptance Test on Suspension Assembly
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
5	Galvanising test
S.N.	**Factory Acceptance Test on Tension Assembly**
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings
8	Mechanical strength of each component
9	Galvanising Test
S.N.	**Factory Acceptance Test on Vibration Damper**
10	Galvanizing test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires

14	Attachments of weights to messenger cable
15	Attachments of clamps to messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
S.N.	**Factory Acceptance Test on Structure Mounting Clamp**
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings

2.3.7 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 11:

Table 11

S.N.	Factory Acceptance Test
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings

2.3.8 Factory Acceptance Test on Splice Enclosure (Joint Box) / FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 12

Table 12

S.N.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings

2.3.9 Factory Acceptance Test on other Items

As per technical specification and approved DRS/Documents.

2.4 Site Acceptance Tests

2.4.1 General

The Contractor shall be responsible for the submission of all material & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall

be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

2.4.2 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Table 13) through 15 below:

Table 13

Fibre Optic Cable Pre-Installation Testing

S.N.	Description
1	Physical Inspection of the cable assembly for damage
2	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3	Fibre Optic Cable length measurement using OTDR

Table 14

Fibre Optic Cable Splicing Testing

S.N.	Description
1	Per splice bi-directional average attenuation with OTDR
2	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3	Physical inspection of sealing techniques, weatherproofing, etc.

Table 15

Fibre Optic Cable Commissioning Testing

S.N.	Description
1	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.

3. Installation for OPGW Cabling

3.1 Installation Requirements

3.1.1 General

The OPGW cable shall be installed at the top of the tower in place of earthwire (only one of the earthwire peaks in case of 220kV & above lines, if applicable) for under construction transmission lines as envisaged.

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor.

For OPGW Cable to be installed on new line transmission line, the stringing shall be carried by the Transmission Line Contractor as per the stringing chart/procedure submitted by them and approved by Employer. The Contractor shall install OPGW as per approved stringing procedure.

The Contractor shall follow precautions including proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations etc.

3.1.2 Installation of OPGW cable

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor. In such a case, the jointing of OPGW on suspension tower if required, shall be acceptable subject to its suitability.

3.1.3 Installation Hardware Fittings

All required hardware fittings shall be installed along with OPGW Cable.

3.2 Installation of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition.

Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable.

All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

3.3 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

3.4 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

a. All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

b. Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

3.5 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

3.6 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

a. All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

b. Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to- paint bond.

c. Mechanical construction drawings of the cable raceways shall be submitted for Employer’s information & review.

Chapter 11
Standardized Field Quality Plan

Chapter 11
Standardized Field Quality Plan (SFQP)

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by EMPLOYER	Accepting authority of EMPLOYER
					Agency	Extent		
1.	Preliminary /Detailed Survey	a. Route alignment	Optimization of route length	a. Preliminary survey. b. Topographical map c. Tower spotting data given by Engg	Contractor	100% at Field	100% based on record documents	To be notified by the Owner
		b. Route profiling & tower spotting.	1. Ground clearance. 2. Cold wt. Span 3. Hot wt. Span 4. Sum of Adj. Span (wind span) 5. Angle of Deviation. 6. Suitability of Tower spotting in hilly area	a. Sag template b. Tower Spotting data c. Route alignment	Contractor -do- -do- -do- -do- -do-	100% at Field -do- -do- -do- -do- -do-	100% based on record documents -do- -do- -do- -do- Verification of 100% at Field	
2.	Check Survey	Tower Location & Final Length	1. Alignment 2. Final Length 3. Angel of deviation & pit Marking-	a. Route alignment b. Tower Schedule c. Profile	Contractor -do-	100% at Field -do-	1. All angle towers in plains and 50% in hilly terrains. 2. Final length to be checked on 100% basis based on records / documents 20 % test check at site for physical verification.	
3.	Detailed Soil Investigation	a. Bore log	1. Depth of bore log 2. SPT Test 3. Collection of samples	As per Specification	Contractor	100% at Field	To witness 20% at Field	
		b. Tests on samples	As per tech. Specs.	As per Specification	Contractor (Testing in MBKJCL accepted Lab.	100% by testing lab (Reports to be signed by Testing person & Checking person)	Review of lab test results (All soil reports to have signature of EMPLOYER executive reviewing the report)	To be notified by the Owner based on the guide line issued by EMPLOYER as Annex-6
		c. Special foundations	As per tech. Specs	As per Specification				
4	Revetment	RR Masonry	a. Size of Stone	CPWD Spec.	Contractor	100% physical verification per source	Physical verification on random basis	To be notified by the Owner (MBKJCL)
			b. Water absorption	-Do-	-Do- (Testing in MBKJCL accepted Lab)	1 sample/ source	Review of Lab Test results	-Do-

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by EMPLOYER	Accepting authority of EMPLOYER
					Agency	Extent		
			c. Cement: sand ratio in mortar	As per Specification	Contractor	100%	Physical verification in random.	-Do-
5	Benching	Checking of Reduced Level	Reduced Level	As per approved drawings	Contractor	100%	100% by Site Engineer and 20% by Line In-charge	To be notified by the Owner (MBKJCL)
6.	Tower Foundation	**A) Materials**						
		1. Cement	a. Brand approval	Cement of MBKJCL approved brands may be procured.	Contractor	100%	Any new brand cement proposed by Contractor shall be assessed by MBKJCL.	MBKJCL
			b. Physical tests	As per document at Annexure-I of this FQP	**Contractor** Samples to be taken jointly with Employer and tested at MBKJCL approved lab	**Review of 100% MTC's and one sample for every batch number of manufacturer.**	100% review of lab test results and MTC. Test results shall be sent by the Lab. by E-mail directly to Employer; further, hard copy of test certificate shall also be sent by the Lab directly to Employer by postal Address.	To be notified by the Owner (MBKJCL)
			c. Chemical Tests Chemical composition of Cement	-do-	Contractor	Review of all MTC's	100% review of MTC test results	To be notified by the Owner (MBKJCL)
		2. a**) Reinforcement Steel**	a. Source approval	May be procured either from main producers directly or through the authorized dealers who can produce MTC from main producers with traceability.	Contractor	**100%**	Material shall be supplied from Main Producers / authorized dealers.	To be notified by the Owner (MBKJCL)
			b. Physical and Chemical analysis test	As per annexure-2 of this FQP	Contractor to submit MTC	100% MTC's One sample* / 500MT / Manufacturer shall be jointly sealed by Employer and tested at MBKJCL approved Lab. * **Note: All sizes of 10mm and above shall be taken for testing in every 500MT.**	100% review of MTC. Review of Lab test results. Test results shall be sent by the Lab. by E-mail directly to MBKJCL; further, hard copy of test certificate shall also be sent by the Lab. directly to MBKJCL by postal Address.	To be notified by the Owner (MBKJCL)

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by EMPLOYER	Accepting authority of EMPLOYER
					Agency	Extent		
		2. b. Miscellaneous structural steel.	Source Approval.	**Source with material meeting Specification**	**contractor**	**As proposed by contractor**	**To verify documents.**	To be notified by the Owner (MBKJCL)
		3. Coarse Aggregates	a. Source approval	Source with materials meeting Specification	Contractor	Proposed by the Contractor, indicating the location of the quarry and based on the test results of Joint samples tested at MBKJCL accepted Lab.	To review the proposal based on the documents	To be notified by the Owner (MBKJCL) Once approved, the particular quarry shall be used for all the running contracts under various packages.
			b. Physical tests	As per document at Annexure-3 of this FQP	Contractor	One sample per **1000** cum or part thereof per source for 765KV & above TL and One sample per **500** cum or part thereof per source for 500KV & below TL, Samples to be tested by Contractor in MBKJCL approved lab	100% review of lab test results. Out of these 100% samples, Employer shall witness at TPL, 5 samples selected at random, spread during the overall execution period of contract.	To be notified by the Owner (MBKJCL).
		4. Fine aggregate	a. Source approval	Source with materials meeting Specification	Contractor	Proposed by the Contractor, indicating the location of the quarry and based on the results of Joint samples tested in MBKJCL accepted lab.	To review the proposal based on the documents.	Project In-charge Once approved, the particular quarry shall be used for all the running contracts under various packages.
			b. Physical test	As per Annexure-4 of this FQP	Contractor	One sample per **1000** cum or part thereof per source for 765KV & above TL and One sample per **500** cum or part thereof per source for 500KV & below TL, Samples to be tested by Contractor in MBKJCL approved lab	100% review of lab test results. Out of these 100% samples, MBKJCL shall witness at TPL, 5 samples selected at random, spread during the overall execution period of contract.	To be notified by the Owner (MBKJCL).
		5. Water	a. Cleanliness (Water shall be fresh & clean)	Specification	Contractor	100% visual check at Field	Verification at random	To be notified by the Owner (MBKJCL)

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by EMPLOYER	Accepting authority of EMPLOYER
					Agency	Extent		
			b. PH Value	- do -	Contractor at site with calibrated PH meter or any other approved method	One sample per source	100% review of the test results Ph not less than 6	To be notified by the Owner (MBKJCL)
		B. Foundation Classification	a. Visual observation of soil strata b. Ground water level c. History of water table in adj. Area/surface water d. Soil Investigation wherever required	Specification	Contractor	100% at Field	100% at Field	a. [other than b & c locations below] Recommendation by Site Engineer to be approved by Site in-charge after visiting at least 5% locations b. In case of WBC/SFR/FS / ULE / Raised Chimney based on recommendation by Site In-charge, to be approved by MBKJCL after visiting at least 5% locations. c. For Spl. Fdns. (shallow depth, pile foundation, well foundation etc.) Acceptance by Regional head.
		C. Concrete Works						
		a. Before concreting						
		1. Bottom of excavated earth	Depth of foundation	Construction Drgs.	Contractor	100% at Field	100% check by Employer	To be notified by the Owner (MBKJCL)
		2. P.C.C Grade, thickness & Size	Completeness	IS:456 & approved construction drawings & specification.	Joint Inspection by MBKJCL and CONTRACTOR	For all locations	For all locations	To be notified by the Owner (MBKJCL)
		3. Stub setting	1. Centre Line	Construction Drgs	-do-	-do-	-do-	*_* -do-
			2. Diagonals	-do-	-do-	-do-	-do-	*_* -do-
			3) Level of stubs	-do-	-do-	-do-	-do-	*_* -do-
		4. Reinforcement steel	Placement	Bar bending schedule.	-do-	-do-	-do-	*_* -do- *_* At least 5% locations shall be cross verified by immediate Reporting Officer / Site In-charge, at random with respect to stub setting and reinforcement steel placement.

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by EMPLOYER	Accepting authority of EMPLOYER
					Agency	Extent		
		b. During Concreting						
		1. Workability	Slump test	Range 25 mm to 55 mm refer document at Annexure-5 of this FQP	Contractor	Minimum One per day per location	check at random	To be notified by the Owner (MBKJCL)
		2. Concrete Strength	Cubes Comp Strength	**As per annexure-5 of this FQP**	Contractor Casting of cubes at site. Cubes to be tested for 28 days strength at MBKJCL appd. Lab /MBKJCL Lab/At site (if testing machine installed by contractor is duly calibrated by NABL Lab.) Cubes at **100%** location are to be taken in presence of Employer officials	One sample of 3 cubes in each tower locations if all the legs are cast continuously without interruption. If otherwise, additional 3 cubes to be taken for every subsequent continuous casting case. **Note:** It is to be ensured that in every case 3 samples shall be selected in such a way that one each from start, middle and end of the casting process.	Normally testing shall be carried out at the cube Testing Facility installed by contractor at MBKJCL premises, in the witness of Employer. Alternatively, samples shall be tested at MBKJCL approved Labs/ MBKJCL Lab. In this case, test results shall be sent by the Lab, by E-mail directly to MBKJCL; further, hard copy of Test Certificate shall also be sent by the Lab directly to MBKJCL by Postal Address. Further, Employer to witness testing on 20% samples and also to review 100% test results.	To be notified by the Owner (MBKJCL). Out of testing on 10% samples to be witness at TPL by Employer Site Engineer and at least 5% samples at random, shall be witnessed by Site In-charge. In-case of Site/ MBKJCL Lab, 100% witness by Employer Representative.
		3. Chimney Concrete	Top level of chimney concrete w.r.t GL	Appd. Drgs.	Contractor	100% at Field	100% check by Employer	To be notified by the Owner (MBKJCL)
		c. After Concreting						
		Back filling	**Completeness**	**As per Specification**	**Contractor**	**100%**	**100%**	To be notified by the Owner (MBKJCL)
7.	Pile Foundations	**Refer FQP OF TRANSMISSION LINE PILE FOUNDATION**						
8.	Tower Erection	1. Materials of Tower member/ bolts & nuts /washers/ accessories	Visual checking for 1. Stacking 2. Cleanliness 3. Galvanizing 4. Damages	Appd. Drgs. /BOM	Contractor	100% at stores	100% verification of records	To be notified by the Owner (MBKJCL)

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by EMPLOYER	Accepting authority of EMPLOYER
					Agency	Extent		
8.	Tower Erection	2. Erection of Super-structure	1. Sequence of erection	As per Appd. Drgs. / specification	Contractor	100% at field	Random	To be notified by the Owner (MBKJCL)
			2. Check for completeness		Contractor	100% at field	25% by Site Engr and random by Site Incharge.	
			3. Tightening of nuts & bolts	-do-	-do-	-do-		
			4. Check for verticality	-do-	-do-	-do-		
			5. Tack welding for bolts & nuts	Specification	Contractor	100% at Field		
		3. Tower footing resistance (TFR)	TFR at locations before and after earthing.	Specification	Contractor	100% at Field	20% locations to be verified	To be notified by the Owner (MBKJCL)
9	Earthing	Pipe Type	Salt & charcoal	As per approved drawings	Contractor	100%	Checking of record 100% and physical verification in Random	To be notified by the Owner (MBKJCL)
		Counterpoise Type	Length & Depth of earth electrode.	As per approved drawings	Contractor	100%	---do---	
10	Stringing	1. Materials						
		a. Insulators	1. Visual check for cleanliness /glazing/cracks/and white spots.	Specification	Contractor	100% at Field	100% verification of records & to carry Physical verification random checks 10%	To be notified by the Owner (MBKJCL)
			2. IR Value	Minimum acceptable value 2000 Mega ohm	-do-	Test shall be carried on 100% insulators using 5/10 kV (DC) Megger	100 % by Contractor & record review by Employer & joint witnessing by Employer on 5% insulator	
			3. Traceability (Make/batch No/ Locations where installed)	Packing list/CIP	Contractor	100% at field	100% Review of records	
		b. Conductor	On receipt, 1. Visual check of drum.	Packing list/CIP	Contractor	100% at stores	20% check	To be notified by the Owner (MBKJCL)
			2. Check for seals &Employer signed sticker on outer end	-do-	-do-	-do-	-do-	
			3. Check depth from top of flange to the top of the outer most layer	-do-	-do-	-do-	-do-	
		c. Earth wire	Check for seals at both ends	Packing list/ CIP	Contractor	100% at stores	20% check	-do-

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by EMPLOYER	Accepting authority of EMPLOYER
					Agency	Extent		
		2. Field activity						
		a. Before Stringing	Readiness for stringing	Stringing procedures as per specification	Contractor	Readiness certificate to be submitted by the Contractor	Review of Certificate	To be notified by the Owner
		b. During stringing	(Conductor/Earth-wire)					
			1. Scratch/cut check (Visual)	Appd. Drawings/ Specn.	Contractor	100% at Field	100% verification of record & 20% Field check	To be notified by the Owner
			2. Repair sleeve		-do-	-do-		
			3. Mid span Joints		-do-	-do-		
			4. Guying (in case of towers not designed for one side stringing)	Appd. Guying arrangement/ Specn.	-do-	-do-	100%	
		c. After stringing	Check for,					
			1. Sag/Tension	Stringing Chart / tower Spotting data	-do-	-do-	100% verification of record & 20% field check	To be notified by the Owner
			2. Electrical clearances	As per Appd. Drgs. / specifications	-do-	-do-		
			i. Ground clearance		-do-	-do-		
			ii. Live metal clearance etc.		-do-	-do-		
			3. Jumpering		-do-	-do-		
			4. Copper bond		Contractor	100% at Field		
			5a. Placement of pacer/damper		-do-	-do-	-do-	
			5b. Tightening of bolts & nuts as per manufacturer recommendations.	-do -	-do-	100% with fixed torque wrench.	-do-	
11.	Final Testing a. Pre-commissioning of lines	Readiness of lines for pre-commissioning	1. Completeness of line. 2. Meggar test of line	latest pre-commissioning procedures	Joint inspection by Employer and Contractor	100%	100%	To be notified by the Owner
	b. Commissioning of line	Readiness of lines for commissioning	1. Digital photograph of each tower to ascertain the completeness of tower.	a. Latest pre-commissioning procedures b. Pre-commissioning Report c. MBKJCL clearance	-do-	-do-	-do-	-do-

Annex-1

(Sheet 01 of 02)

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CEMENT

1.	**ORDINARY PORTLAND CEMENT**				
S. No.	**Name of the test**	**Ordinary Portland Cement 33 grade as per IS 269**	**Ordinary Portland Cement 43 grade as per IS 8112**	**Ordinary Portland Cement 53 grade as per IS 12269**	**Remarks**
a.	**Physical tests**				To be conducted in apprd. Lab
i.	Fineness	Specific surface area shall not be less than 225 sq. m. per Kg. or 2250 Cm2/gm.	Specific surface area shall not be less than 225 sq. m. per Kg or 2250 Cm2/gm.	Specific surface area shall not be less than 225 sq. m. per Kg or 2250 Cm2/gm.	Blaine's air permeability method as per IS 4031 (Part-2) / Sieve analysis as per IS 4031 (part-3)
ii.	Compressive strength	72 ± 1 hour: Not less than 16 MPa (16 N/mm^2)	72 ± 1 hour: Not less than 23 MPa (23 N/mm^2)	72 ± 1 hour: Not less than 27Mpa (27 N/mm^2)	As per IS 4031 (Part-6)
		168 ± 2 hour: Not less than 22 MPa (22 N/mm^2)	168 ± 2 hour: Not less than 33Mpa (33 N/mm^2)	168 ± 1 hour: Not less than 37Mpa (37 N/mm^2)	
		672 ± 4 hour: Not less than 33 MPa (33 N/mm^2)	672 ± 4 hour: Not less than 43 MPa (43 N/mm^2)	672 ± 1 hour: Not less than 53 MPa (53 N/mm^2)	
iii.	Initial & Final setting time	Initial setting time: Not less than 30 minutes	Initial setting time: Not less than 30 minutes	Initial setting time: Not less than 30 minutes	As per IS 4031 (Part-5)
		Final setting time: Not more than 600 minutes	Final setting time: Not more than 600 minutes	Final setting time: Not more than 600 minutes	-do-
iv.	Soundness	Unaerated cement shall not have an expansion of more than 10mm when tested by Le Chatlier and 0.8% by Autoclave test.	Unaerated cement shall not have an expansion of more than 10mm when tested by Le Chatlier and 0.8% by Autoclave test	Unaerated cement shall not have an expansion of more than 10mm when tested by Le Chatlier and 0.8% by Autoclave test.	Le Chatlier and Autoclave test as per IS 4031 (Part-3)
b.	**Chemical composition tests**				Review of MTCC only
		a. Ratio of percentage of lime to percentage of silica, alumina & iron oxide 0.66 to 1.02	a. Ratio of percentage of lime to percentage of silica, alumina & iron oxide 0.66 to 1.02	a. Ratio of percentage of lime to percentage of silica, alumina **&** iron oxide 0.80 to 1.02%	
		b. Ratio of percentage of alumina to that of iron oxide Minimum 0.66%	a. Ratio of percentage of alumina to that of iron oxide Minimum 0.66	a. Ratio of percentage of alumina to that of iron oxide Minimum 0.66%	
		c. Insoluble residue, percentage by mass Max. 4.00%	c. Insoluble residue, percentage by mass Max. 2.00%	c. Insoluble residue, percentage by mass Max. 2.00%	

Annex-1
(Sheet 02 of 02)

S. No.	Name of the test	Ordinary Portland Cement 33 grade as per IS 269	Ordinary Portland Cement 43 grade as per IS 8112	Ordinary Portland Cement 53 grade as per IS 12269	Remarks
		d. Magnesia percentage by mass Max. 6%	d. Magnesia percentage by mass Max. 6%	d. Magnesia percentage by mass Max. 6%	
		e. Total sulphur content calculated as sulphuric anhydride (SO3), percentage by mass not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.	e. Total sulphur content calculated as sulfuric anhydride (SO3), percentage by mass not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.	e. Total sulphur content calculated as sulfuric anhydride (SO3), percentage by mass not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.	
		f. Total loss on ignition shall not be more than 5 percent	f. Total loss on ignition shall not be more than 5 percent	f. Total loss on ignition shall not be more than 5 percent	
2.	**PORTLAND POZZOLANA CEMENT AS PER IS 1489/2005**				
a.	**Physical tests**	i. Fineness	Specific surface area shall not be less than 300 sq. m. per Kg. or 3000 Cm^2/gm		To be conducted in MBKJCL approved Lab
		ii. Compressive strength	a. 72 ± 1 hour: Not less than 16 MPa (16 N/mm2) b. 168 ± 2 hour: Not less than 22 MPa (22 N/mm2) c. 672 ± 4 hour: Not less than 33 MPa (33 N/mm2)		
		iii. Initial & Final setting time	Initial setting time: Not less than 30 minutes Final setting time: Not more than 600 minutes		
		iv. Soundness	Un aerated cement shall not have an expansion of more than 10mm Le chatlier test and 0.8% by Autoclave test as per IS 4031 (Part-3)		
b.	**Chemical composition tests**				
		a. Magnesia percentage by mass Max. 6%			Review of MTCC only
		b. Insoluble material, percentage by mass x + 4 (100-x)/100 where x is the declared % of pozzolana in the PPC			-do-
		c. Total sulphur content calculated as sulphuric anhydride (SO3), percentage by mass not more than 3.0			-do-
		Total loss on ignition shall not be more than 5 percent			

Annex-2

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR REINFORCEMENT STEEL AS PER IS 1786-1985 Edition-4.3 (2004-12)

S. No.	Name of the test	Fe 415	Fe 500
3.	**REINFORCEMENT STEEL**		
i.	**Chemical analysis test**		
	a. Carbon	**0.30 Percent Maximum**	**0.30 Percent Maximum**
	b. Sulphur	**0.060 Percent Maximum**	**0.055 Percent Maximum**
	c. Phosphorus	**0.060 Percent Maximum**	**0.055 Percent Maximum**
	d. Sulphur & Phosphorus	**0.11 Percent Maximum**	**0.105 Percent Maximum**
ii.	**Physical tests**		
	a. Tensile Strength Minimum	10% more than actual 0.2% proof stress but not less than 485 N/Sq.mm.	8 % more than actual 0.2% proof stress but not less than 545 N/Sq.mm
	b. 0.2% of proof stress/Yield stress Minimum, N/mm 2	415	500
	c. Elongation percent, Minimum	14.5	12
iii.	**Bend & Rebend tests**	Pass	Pass

Annex-3

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR COARSE AGGREGATES AS PER IS 383

4.	**Coarse Aggregates**										
i.	Physical Tests										
	a. Determination of particles size	a. IS Sieve Designation	**Percentage passing for Single-Sized Aggregate of nominal size**					**Percentage Passing for graded Aggregate of nominal size**			
			40 mm	**20 mm**	**16 mm**	**12.5 mm**	**10 mm**	**40 mm**	**20 mm**	**16 mm**	**12.5 mm**
		63 mm	100	-	-	-	-	-	-	-	-
		40 mm	85 to 100	100	-	-	-	95 to 100	100	-	-
		20 mm	0 to 20	85 to 100	100	-	-	30 to 70	95 to 100	100	100
		16 mm	-	-	85 to 100	100	-	-	-	90-100	-
		12.5 mm	-	-	-	85 to 100	100	-	-	-	90 to 100
		10 mm	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
		4.75 mm	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
		2.36 mm	-	-	-	-	0 to 5	-	-	-	-
	b. Flakiness index		Not to exceed 25%								
	c. Crushing Value		Not to exceed 45%								
	d. Presence of deleterious material		Total presence of deleterious materials not to exceed 5%								
	e. Hardness		Abrasion value not more than 50%, Impact value not more than 45%								
	f. Soundness test (for concrete work subject to frost action)		Not to exceed 12% when tested with sodium Sulphate and 18% when tested with magnesium Sulphate								

Annex-4

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR FINE AGGREGATES AS PER IS 383

5.	**b) Fine aggregates**				
i.	Physical Tests	**IS Sieve Designation**	**Percentage passing for**		
	a. Determination of particle size		**F.A. Zone I**	**F.A. Zone II**	**F.A. Zone III**
		10 mm	100	100	100
		4.75 mm	90-100	90-100	90-100
		2.36 mm	60-95	75-100	85-100
		1.18 mm	30-70	55-90	75-100
		600 microns	15-34	35-59	60-79
		300 microns	5 to 20	8 to 30	12 to 40
		150 microns	0-10	0-10	**0-10**
	b. Silt content		Not to exceed 8%	Not to exceed 8%	Not to exceed 8%
	c. Presence of deleterious material	Total presence of deleterious materials shall not exceed 5%			
	d. Soundness Applicable to concrete work subject to frost action	12% when tested with sodium Sulphate and 15% when tested with magnesium Sulphate			

Annex-5

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CONCRETE WORK

1.	**Concrete**	a. Workability	Slump shall be recorded by slump cone method and it shall between 25-55 mm.
		b. Compressive strength	**For nominal (volumetric) concrete mixes compressive strength for 1:1.5:3 (Cement: Fine aggregates: Coarse aggregates) concrete 28 days strength shall be min 265Kg/cm^2 and for 1:2:4 (Cement: Fine Aggregate: Coarse Aggregate) nominal mix concrete 28 days strength shall be min 210Kg/cm^2.**

Notes:

1. ACCEPTANCE CRITERIA BASED ON 28 DAYS COMPRESSIVE STRENGTHS FOR NOMINAL MIX CONCRETE:
   a. On the basis of mandatory lab test result, in case of actual average compressive strength being less than specified strength but up to 70% of specified strength, concrete may be accepted and the rate payable shall be in the same proportion as the actual average compressive strength bears to specified compressive strength.
   However, in case cube strength of any one leg of any location is found to be between 70% to 100% of specified value, all four legs of the respective location shall be analyzed. Root cause analysis has to be carried out with NDT method to verify the quality and strength of the foundations. If the results are not acceptable penalty such as re-doing of complete foundation/legs, cost towards supervision charges shall be levied from the contractor towards the sub-standard work, with the approval of Project Manager.
   b. If the actual average strength of accepted sample is less than 70% of specified strength, the Site -in-charge shall reject the defective portion of work represent by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall be taken at the risk and cost of contractor. If, however, the Engineer-in-charge / Project In-charge so desires, he may order additional tests to be carried out to ascertain if the structure can be retained/rectified. All the charges in connection with these additional tests shall be borne by the Contractor.
2. 53 Grade cements shall be used after obtaining specific approval of the Engineer in charge.
3. Portland slag cement conforming to IS:455 may be used as per Technical Specification.

General Notes:

1. This standard Field Quality Plan is not to limit the supervisory checks which are otherwise required to be carried out during execution of work as per drawings/Technical specifications etc.
2. Contractor shall be responsible for implementing/documenting the SFQP. Documents shall be handed over by the contractor to Employer after the completion of the work.
3. Acceptance criteria and permissible limits for tests are indicated in the Annexures. However, for further details/tests specification and relevant Indian standards shall be referred.
4. Tests as mentioned in this FQP shall generally be followed.

Chapter 12
Technical Data Sheet

Chapter 12
Technical Data Sheet

Table of Contents

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As a representative for	**Address**	**Date**	**Signature**

Chapter 12
Technical Data Sheet

A. Supply of Conductors, Earthwire and Hardware / Fittings for Conductors

I. Guaranteed Technical Particulars for Conductors (BISON)

S.No.	Description	Unit	Tender Data
1	Manufacturer		
2	Country of origin		
3	Applicable Standard		
4	Years of Manufacturing Experience	Years	
5	ISO Certificate Submitted?	Yes/No	
6	Manufacturer Sales Record Submitted?	Yes/No	
7	Composition of Conductor		
	a. Aluminium		
	Strands	Nos	
	Layer	Nos	
	Strand Diameter	mm	
	Diameter of complete conductor	mm	
	b. Steel Core		
	Strands	Nos	
	Strand Diameter	mm	
	Diameter of Steel Core	mm	
8	Cross-section of Aluminium	mm^2	
9	Cross-section of Steel Core	mm^2	
10	Total Cross-section	mm^2	
11	Nominal copper equivalent area	mm^2	
12	Ultimate breaking strength of stranded conductor	kN	
13	Ultimate breaking strength of steel core	kN	
14	DC resistance of conductor per km at 20°C	Ω	
15	Weight per km of conductor	kg	

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As a representative for	**Address**	**Date**	**Signature**

16	Modulus of Elasticity		
	a. Initial	N/mm^2	
	b. Final	N/mm^2	
17	Coefficient of Expansion per °C		
18	Whether Steel core greased?	Yes/No	
19	Whether steel strands are galvanized?	Yes/No	
20	Galvanizing		
	a. Standard to which galvanizing is tested		
	b. Weight of zinc coat	g/m^2	
21	Whether sample submitted?	Yes/No	
22	Packing		
	a. Type of Drum		
	b. Materials of Drum		
	c. Dimension of Drum		
	Diameter of Drum Core	mm	
	Total diameter of drum	mm	
	Total width of drum	mm	
	Dimension of wooden materials used	mm	
	d. Length of Conductor per drum	m	
	e. Net weight per drum	kg	
	f. Gross weight per drum	kg	
	g. Materials used for termite proofing of drums		
	h. Whether drawings are submitted	Yes/No	
23	Whether all tests in relevant standard specification will be carried out and test reports submitted?	Yes/No	
24	Permanent elongation factor due to creep	m/m	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

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As a representative for	**Address**	**Date**	**Signature**

II. Guaranteed Technical Particulars for Earthwire

S.No	Description	Unit	Tender Data
	Optical Fibre Ground Wire (OPGW)		
1	Manufacturer		
2	Country of origin		
3	Applicable Standard		
4	Years of Manufacturing Experience	Years	
5	ISO Certificate Submitted?	Yes/No	
6	Manufacturer Sales Record Submitted?	Yes/No	
7	Outer wire diameter	mm	
8	Weight per km	kg	
9	Minimum static bend diameter	mm	
10	Calculating ultimate strength	kN	
11	Composition		
	a. Tension wires		
	Type	Material	
	Stranding	No x mm	
	Layers	No	
	b. Fibre Tube		
	Type	Material	
	Dimension	mm	
12	Thermal Elongation Coefficient	10^{-6}/K	
13	Maximum permissible stress	N/mm^2	
14	Mean permissible stress (E_i, E_p)	N/mm^2	
15	Modulus of Elasticity	N/mm^2	
16	DC resistance at 20°C	Ω/m	
17	Delivery length per drum	km	
18	Short time current (1 Sec)	kA	
	Optical Fibre Cable		
19	Coating Diameter	µm	
20	Coating concentricity error	µm	
21	Coating non-circularity	%	
22	Finished cable attenuation	dB/km	
23	Number of fibres	No	

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As a representative for	**Address**	**Date**	**Signature**

24	Normal Temperature range	°C	
25	Maximum temperature < 1.0 Second	°C	
26	Lifetime expected	years	
27	Packing		
	a. Type of Drum		
	b. Materials of Drum		
	c. Dimension of Drum		
	Diameter of Drum Core	mm	
	Total diameter of drum	mm	
	Total width of drum	mm	
	Dimension of wooden materials used	mm	
	d. Length of Conductor per drum	m	
	e. Net weight per drum	kg	
	f. Gross weight per drum	kg	
	g. Materials used for termite proofing of drums		
	h. Whether drawings are submitted	Yes/No	
23	Whether all tests in relevant standard specification will be carried out and test reports submitted?	Yes/No	
	Galvanized Steel Wire (GSW)		
1	Manufacturer		
2	Country of origin		
3	Applicable Standard		
4	Years of Manufacturing Experience	Years	
5	ISO Certificate Submitted?	Yes/No	
6	Manufacturer Sales Record Submitted?	Yes/No	
7	Outer wire diameter	mm	
8	Weight per km	kg	
9	Minimum static bend diameter	mm	
10	Calculating ultimate strength	kN	
11	Composition		
	a. Wires Type	Material	
	b. Stranding	No x mm	
	c. Layers	No	

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

12	Galvanizing		
	a. Zinc coating	g/m^2	
	b. Preece test dips (minimum)	No	
13	Thermal Elongation Coefficient	$10^{-6}/K$	
14	Maximum permissible stress	N/mm^2	
15	Mean permissible stress (E_i, E_p)	N/mm^2	
16	Modulus of Elasticity	N/mm^2	
17	DC resistance at 20°C	Ω/m	
18	Delivery length per drum	km	
19	Short time current (1 Sec)	kA	
20	Packing		
	a. Type of Drum		
	b. Materials of Drum		
	c. Dimension of Drum		
	Diameter of Drum Core	mm	
	Total diameter of drum	mm	
	Total width of drum	mm	
	Dimension of wooden materials used	mm	
	d. Length of Conductor per drum	m	
	e. Net weight per drum	kg	
	f. Gross weight per drum	kg	
	g. Materials used for termite proofing of drums		
	h. Whether drawings are submitted	Yes/No	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

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As a representative for	**Address**	**Date**	**Signature**

III. Guaranteed Technical Particulars for Hardware and Fittings for Conductors

S.No.	Description	Unit	Tender Data
1	**Tension Clamp**		
	a. Maker's Name		
	b. Type of Clamp		
	c. Breaking strength	N	
	d. Slipping strength	N	
	e. Whether dimensional drawing submitted?	Yes/No	
2	**Suspension Clamp**		
	a. Maker's Name		
	b. Type of Clamp		
	c. Breaking strength	N	
	d. Slipping strength	N	
	e. Whether dimensional drawing submitted?	Yes/No	
3	**Tension Joint**		
	a. Maker's Name		
	b. Type (single or two piece)		
	c. Tensile strength	N	
	d. Slipping strength	N	
	e. Whether dimensional drawing submitted?	Yes/No	
4	**Repair Sleeve**		
	a. Maker's Name		
	b. Type		
	c. Slipping strength	N	
	d. Dimension	N	
	e. Whether dimensional drawing submitted?	Yes/No	
5	**Vibration Damper**		
	a. Maker's Name		

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As a representative for	**Address**	**Date**	**Signature**

	b. Type		
	c. Weight	N	
	d. Type of attachment to conductor	N	
	e. Whether dimensional drawing submitted?	Yes/No	
6	Whether all details of arcing horns and all other fittings and hardware are submitted with the Bid	Yes/No	
7	Whether all fittings are suitable and complete in all respects?	Yes/No	
8	Whether all fittings are galvanized?	years	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

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As a representative for	**Address**	**Date**	**Signature**

IV. Guaranteed Technical Particulars for Hardware and Fittings for Earthwire

S.No.	Description	Unit	Tender Data	
			OPGW	GSW
1	**Tension Clamp**			
	a. Maker's Name			
	b. Type of Clamp			
	c. Material			
	d. Tensile strength	N		
	e. Slipping strength	N		
	f. Whether dimensional drawing submitted?	Yes/No		
2	**Suspension Clamp**			
	a. Maker's Name			
	b. Type of Clamp			
	c. Breaking strength	N		
	d. Slipping strength	N		
	e. Whether dimensional drawing submitted?	Yes/No		
3	**Tension Joint**			
	a. Maker's Name			
	b. Type			
	c. Tensile strength	N		
	d. Slipping strength	N		
	e. Whether dimensional drawing submitted?	Yes/No		
4	**Repair Sleeve**			
	a. Maker's Name			
	b. Type			
	c. Slipping strength	N		
	d. Dimension	N		
	e. Whether dimensional drawing submitted?	Yes/No		

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As a representative for	**Address**	**Date**	**Signature**

5	**Vibration Damper**			
	a. Maker's Name			
	b. Type			
	c. Weight	N		
	d. Type of attachment to wire	N		
	e. Whether dimensional drawing submitted?	Yes/No		
6	Details of shackles and all other fittings and hardware to be submitted with the bid.	Yes/No		

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

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As a representative for	**Address**	**Date**	**Signature**

B. Supply of Insulators and Hardware / Fitting for Insulator Strings

I. Guaranteed Technical Particulars for Composite Long Rod Insulators

S.No.	Description	Unit	Tender Data	
			Tension	Suspension
1	Manufacturer			
2	Country of origin			
3	Applicable Standard			
4	Years of Manufacturing Experience	Years		
5	ISO Certificate Submitted?	Yes/No		
6	Manufacturer Sales Record Submitted?	Yes/No		
7	Composite Material			
	a. Core Material			
	b. Housing Material			
	c. Weather shed material			
	d. End fitting			
	e. Grading Ring			
8	Long Rod Diameter			
	a. Diameter of core	mm		
	b. Diameter of weather sheds	mm		
9	Overall length of Insulator including fittings	mm		
10	Weight of Insulator including fittings	kg		
11	Breaking strength of complete set			
	a. Set with single insulator string	kN		
	b. Set with double insulator string	kN		
12	Creepage Distance	mm		
13	Dry arcing distance	mm		
14	Gap between arcing horns (if applicable)	mm		
15	Highest System Voltage	kV		

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As a representative for	**Address**	**Date**	**Signature**

16	System frequency	Hz		
17	Power frequency (50Hz) withstand voltage			
	a. Dry, one minute	kV		
	b. Wet, one minute	kV		
18	Dry lighting impulse withstand voltage			
	a. 1.2/50 µs positive wave	kV		
	b. 1.2/50 µs negative wave	kV		
19	Wet switching surge impulse voltage			
	a. Positive wave (peak)	kV		
	b. Negative wave (peak)	kV		
20	Dry impulse withstand voltage			
	a. Positive wave (peak)	kV		
	b. Negative wave (peak)	kV		
21	Wet impulse flashover of complete set			
	a. Positive wave (peak)	kV		
	b. Negative wave (peak)	kV		
22	Minimum corona extinction voltage under dry condition	kV (rms)		
23	Accelerated Aging test report submitted?	Yes/No		
24	List of type test report submitted?	Yes/No		
25	Type test report submitted?	Yes/No		
26	Dimensioned GA Drawing submitted?	Yes/No		
27	Manufacturer's Catalogue submitted?	Yes/No		

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

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As a representative for	**Address**	**Date**	**Signature**

C. Design, Tower Supply and Construction of 220kV Transmission Line

I. Assumed Maximum Working Conditions

S.no.	Description	Unit	Guarantee
1	Minimum temperature of conductors and earthwire	°C	
2	Maximum temperature of conductors and earthwire	°C	
3	Everyday temperature of conductors and earthwire	°C	
4	Wind pressure per square meter on projected area of conductors, earthwire and insulator		
	a. All loading cases except erection	N/m^1	
	b. Loading cases erection	N/m^1	
5	Wind pressure per square meter on projected area of members of one face of towers		
	a. All loading cases except erection	N/m^1	
	b. Loading cases erection	N/m^1	
6	Mass of Insulator string		
	a. Single suspension string	kg	
	b. Double suspension string	kg	
	c. Single tension string	kg	
	d. Double tension string	kg	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

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As a representative for	**Address**	**Date**	**Signature**

II. Minimum Factors of Safety as Assumed Maximum Simultaneous Working Loads

S.no.	Description	Unit	Guarantee
1	Steel Towers, based on elastic limit of tensioning members and on crippling strength of compression members		
	a. Worst normal working condition		
	b. Exceptional condition (unbalanced load/broken wire)		
	c. Construction and maintenance conditions		
2	Foundations against overturning and uprooting		
	a. Worst normal working condition		
	b. Exceptional condition (unbalanced load/broken wire)		
	c. Construction and maintenance conditions		
3	Insulators and fittings		
	a. Everyday working condition		
	b. Worst normal working condition		
	c. Exceptional condition		
	All fittings shall at least have the same ultimate strength as that of the insulators		
4	Conductors and Earthwire		
	a. Ultimate Loads under maximum wind at minimum temperature, referred to UTS		

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

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As a representative for	**Address**	**Date**	**Signature**

III. Line Conductor

S.no.	Description	Unit	Guarantee
1	Code Name		
2	Applicable Standard		
3	Material of Conductors		
4	Number of and diameter of wire		
	a. Aluminium		
5	Minimum stress of steel at 1% elongation	N/mm^2	
6	Overall diameter of conductor	mm	
7	Mass of conductor per km	kg/km	
8	Stringing tension of conductor in still air at +32°C, basis for sag calculations, initial tension	N	
9	Final tension of conductor in still air at +32°C not to exceed	N	
10	Final tension of conductor in still air at +0°C not to exceed	N	
11	Maximum working tension of downlead conductor	N	
12	Maximum working tension of conductor		
	a. At erection at 32°C in still air	N	
	b. At full wind at 32°C	N	
	c. Zero wind and 0°C	N	
13	Rated breaking strength of conductor	N	
14	Assumed equivalent modulus of elasticity of conductor		
	a. Initial	MPa	
	b. Final	MPa	
15	Assumed equivalent coefficient of linear expansion of conductor	per °C	
16	Permanent elongation due to creepage	m/m	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

IV. Earthwire: Optical Fibre Ground Wire (OPGW)

S.no.	Description	Unit	Guarantee
1	Applicable Standard		
2	Material of Conductors		
3	Cross-section	mm^2	
4	Number of and diameter of wire	No/mm	
5	Overall diameter of wire	mm	
6	Mass of wire per km	kg/km	
7	Final tension of conductor in still air at +32°C not to exceed	N	
8	Final tension of conductor in still air at +0°C not to exceed	N	
9	Maximum working tension of downlead wire	N	
10	Maximum working tension of wire		
	a. At erection at 32°C in still air	N	
	b. At full wind at 32°C	N	
	c. Zero wind and 0°C	N	
13	Rated breaking strength of wire		
14	Assumed equivalent modulus of elasticity of wire		
	a. Initial	MPa	
	b. Final	MPa	
15	Assumed equivalent coefficient of linear expansion of wire	per °C	
16	Permanent elongation due to creepage	m/m	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

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V. Earthwire: Galvanized Steel Earthwire (GSW)

S.no.	Description	Unit	Guarantee
1	Applicable Standard		
2	Material of Conductors		
3	Cross-section	mm^2	
4	Number of and diameter of wire	No/mm	
5	Overall diameter of wire	mm	
6	Mass of wire per km	kg/km	
7	Final tension of conductor in still air at +32°C not to exceed	N	
8	Final tension of conductor in still air at +0°C not to exceed	N	
9	Maximum working tension of downlead wire	N	
10	Maximum working tension of wire		
	a. At erection at 32°C in still air	N	
	b. At full wind at 32°C	N	
	c. Zero wind and 0°C	N	
13	Rated breaking strength of wire		
14	Assumed equivalent modulus of elasticity of wire		
	a. Initial	MPa	
	b. Final	MPa	
15	Assumed equivalent coefficient of linear expansion of wire	per °C	
16	Permanent elongation due to creepage	m/m	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

VI. Lattice Steel Tower Design Particular

S.no.	Description	Unit	Guarantee
1	Manufacturer		
2	Country of origin		
3	Applicable Standard		
4	Years of Manufacturing Experience	Years	
5	ISO Certificate Submitted?	Yes/No	
6	Manufacturer Sales Record Submitted?	Yes/No	
7	Maximum working tension of conductors for purposes of tower design and application		
	a. Line Conductor	N	
	b. Earthwire: OPGW	N	
	C. Earthwire: GSW	N	
	d. Downlead Line Conductor	N	
	e. Downlead Earthwire: OPGW	N	
	f. Downlead Earthwire: GSW	N	
8	Maximum working uplift per phase for tension tower design	N	
9	Maximum working uplift per earthwire for tension tower design	N	
10	Overall length of suspension insulator rod from point of suspension to bottom of phase conductor clamp.	mm	
11	Overall length of tension insulator rod measured from point of attachment on crossarm to point where jumper loop parabola leaves conductor.	mm	
12	Minimum clearance from live metal and earthed tower steel work.		
	a. By still air and up to 20° swing	mm	
	b. By maximum wind load, 55° swingout	mm	
13	Insulator suspension set, allowable swingout angle by maximum wind load	degree	
14	Jumper Loop, allowable maximum swing out angle by maximum wind load	degree	
15	Earthwire maximum protected angle from vertical at the tower attachment.	Degree	

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

16	Basic Span Length	m	
17	Minimum Ground Clearance of phase conductor assuming temperature of 85° C	m	
18	Final Sag of phase conductor in still air at 85° C and standard span	m	
19	Vertical Distance between Underside of Supporting Crossarm and point about which live metal is connected.	mm	
20	Height above ground of underside of bottom cross arms	m	
21	Vertical Distance between top and bottom phase conductor crossarm	m	
22	Height of Structure above ground	m	
23	Horizontal spacing between center line of structure and conductors		
	a. Upper	m	
	b. Lower	m	
24	Minimum vertical spacing between upper and lower conductors	m	
25	Final sag of conductor at everyday temperature in still air for basic span		
	a. Phase Conductor	m	
	b. OPGW	m	
26	Width of structure attachment of lower cross arm	m	
27	Overall dimension of support base at ground level		
	a. Transverse	m	
	b. Longitudinal	m	
28	Quality of Steel in Structures		
	a. Applicable Standards		
	Mild Steel		
	High Tensile Steel		
	b. Maximum yield stress		
	Mild Steel	N/mm^2	
	High Tensile Steel	N/mm^2	
	c. Maximum Elongation of Breaking		
	Mild Steel	%	

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

	High Tensile Steel	%	
29	Quality of Steel Bolts and Nuts		
	a. Applicable Standards		
	b. Maximum yield stress		
	c. Maximum breaking stress		
30	Minimum ratios of slenderness assumed in design		
	a. Compression members		
	Main members, leg members, cross-arms		
	Stressed bracings		
	Unstressed bracings, redundant		
	b. Tension members		
31	Minimum thickness of members		
	a. Legs and main compression members in cross-arm and shield wire peak (open/closed section)	mm	
	b. Other members (open/closed section)	mm	
	c. Redundant members (open/closed section)	mm	
	d. Gusset Plates	mm	
32	Minimum Bolt Diameter	mm	
33	Minimum thickness of members for which holes drilled	mm	
34	Maximum thickness of members for which holes punched	mm	
35	Minimum zinc coating		
	a. For Members	g/m^2	
	b. For Bolts and Nuts	g/m^2	
36	Whether markings stamped before galvanizing?	Yes/No	
37	Minimum Guaranteed Weight		
	a. Stub (Set of 4)	Kg	
	b. Basic tower	Kg	
	c. - 4.5 M extension	Kg	
	d. - 3.0 M extension	Kg	

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

	e. - 1.5 M extension	Kg	
	f. ± 0 M extension	kg	
	g. + 1.5 M extension	kg	
	h. + 3.0 M extension	kg	
	i. + 4.5 M extension	kg	
	j. + 6.0 M extension	kg	
	k. + 7.5 M extension	kg	
	l. + 9.0 M extension	kg	
	m. + 18.0 M extension	kg	
38	Maximum Transverse overturning moment at ground level of standard height tower	kNm	
39	Ultimate uplift load per tower (approximate)	kg	
40	Ultimate uplift load per tower; broken wire condition (approximate)	kg	
41	Ultimate compression load per tower; normal condition (approximate)	kg	
42	Ultimate transverse load per leg; (approximate)	kg	
43	Ultimate longitudinal load per leg; (approximate)	kg	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

VII. Foundation Design Particular (Concrete)

S.no.	Description	Unit	Guarantee
1	Maximum ultimate stresses allowable in concrete for foundation design		
	a. Tensile stress due to bending	kN/m^2	
	b. Bond stress, galvanized steel / concrete	kN/m^2	
	c. Bearing stress	kN/m^2	
	d. Punching shear stress	kN/m^2	
	e. 28-day strength of concrete	kN/m^2	
2	Maximum angle between base and side of a pyramidal part of concrete foundation	degree	
3	Minimum proportion of stub load to be allowed for in design of stub flats	%	

Note

Schedule of guaranteed technical particulars shall be filled in and completed in every respect and submitted with the tender.

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

D. Miscellaneous Materials, Hardware and Fittings

I. General Particulars and Guarantees, Grounding Materials

S.no.	Description	Unit	Guarantee
1	Counterpoise Cable		
	a. Appropriate Standard		
	b. Material of Counterpoise Cable		
	c. Number & diameter of wires	Nos/mm	
	d. Overall diameter	mm	
	e. Weight	kg/km	
	f. Length per drum	m	
	g. Gross weight per drum	kg	
2	Clamp or lug including bolt for connection to tower steel		
	a. Maker's name		
	b. Type		
	c. Hole in diameter for attachment	mm	
	d. Suitable for conductor diameter	mm	
	e. Whether dimensional drawing submitted		
3	Counterpoise compression joint		
	a. Maker's name		
	b. Type		
	c. Whether dimensional drawing submitted		
4	Parallel groove clamps for counterpoise Tee joints		
	a. Maker's name		
	b. Type		
	c. Whether dimensional drawing submitted		
5	Single to twin connector		
	a. Maker's name		
	b. Type		

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

	c. Whether dimensional drawing submitted		
6	Earthing Rods		
	a. Maker's name		
	b. Type		
	c. Material		
	d. Diameter	mm	
	e. Length	mm	
	f. Whether dimensional drawing submitted		
7	Clamp for connecting counterpoise to earthing rods		
	a. Maker's name		
	b. Type		
	c. Material		
	d. Is the clamp suitable to the proposed earthing rod		
	c. Whether dimensional drawing submitted		

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

II. General Particulars and Guarantees, Flexible Copper Bond

S.no.	Description	Unit	Guarantee
1	Name and address of manufacturer		
2	Drawing enclosed	Yes/No	
3	Stranding		
4	Cross sectional area	mm^2	
5	Minimum copper equivalent area	mm^2	
6	Length of copper cable	mm	
7	Material of lugs		
8	Bolt size		
	a. Diameter	mm	
	b. Length	mm	
9	Resistance	Ω	
10	Total weight of flexible copper bond	kg	

Note

Tolerance, wherever applicable, shall also be specified.

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

III. General Particulars and Guarantees, Vibration Dampers for ACSR BISON Conductors

S.no.	Description	Unit	Guarantee	
1	Name and address of manufacturer			
2	Drawing enclosed			
	a. Design Drawing	Yes/No		
	b. Placement Chart	Yes/No		
3	Suitable for conductor size	mm		
4	Total weight of one damper	kg		
			Right	**Left**
5	Diameter of each damper mass	mm		
6	Length of each damper mass	mm		
7	Weight of each damper mass	kg		
8	Material of damper masses			
9	Material of clamp			
10	Material of the stranded messenger cable			
11	Number of strands in stranded messenger cable			
12	Lay ratio of stranded messenger cable			
13	Minimum ultimate tensile strength of stranded messenger cable	kg/mm^2		
14	Slip strength of stranded messenger cable (mass pull off)	kN		
15	Resonance frequencies		**Right**	**Left**
	a. First frequency	Hz		
	b. Second frequency	Hz		
16	Designed clamping torque	kg.m		
17	Slipping strength of damper clamp			
	a. Before fatigue test	kN		
	b. After fatigue	kN		
18	Magnetic power loss per vibration damper watts for 600A, 50Hz alternating current	Watts		
19	Minimum corona Extinction voltage kV (RMS) under dry condition	kV		
20	Radio interference voltage at 1MHz for phase to earth voltage of 154 kV (RMS) microvolts under dry condition	mV		
21	Percentage variation in reactance after fatigue test in comparison with that before fatigue test	%		
22	percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%		

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

IV.	General Particulars and Guarantees, Vibration Dampers for Optical			
S.no.	**Description**	**Unit**	**Guarantee**	
1	Name and address of manufacturer			
2	Drawing enclosed			
	a. Design Drawing	Yes/No		
	b. Placement Chart	Yes/No		
3	Suitable for conductor size	mm		
4	Total weight of one damper	kg		
			Right	**Left**
5	Diameter of each damper mass	mm		
6	Length of each damper mass	mm		
7	Weight of each damper mass	kg		
8	Material of damper masses			
9	Material of clamp			
10	Material of the stranded messenger cable			
11	Number of strands in stranded messenger cable			
12	Lay ratio of stranded messenger cable			
13	Minimum ultimate tensile strength of stranded messenger cable	kg/mm^2		
14	Slip strength of stranded messenger cable (mass pull off)	kN		
15	Resonance frequencies		**Right**	**Left**
	a. First frequency	Hz		
	b. Second frequency	Hz		
16	Designed clamping torque	kg.m		
17	Slipping strength of damper clamp			
	a. Before fatigue test	kN		
	b. After fatigue	kN		
18	Magnetic power loss per vibration damper watts for 600A, 50Hz alternating current	Watts		
19	Minimum corona Extinction voltage kV (RMS) under dry condition	kV		
20	Radio interference voltage at 1MHz for phase to earth voltage of 154 kV (RMS) microvolts under dry condition	mV		

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

E. Method Statement for Erection of Towers and Stringing of Conductors

S.no.	Description	Unit	Guarantee
1	Erection Method to be adopted at site		
2	Method of statement for Erection of Tower Submitted	Yes/No	
3	Stringing Method to be adopted at site		
4	Method of statement for Stringing submitted	Yes/No	

.....	.....	.....	.....
As a representative for	**Address**	**Date**	**Signature**

Chapter 13
Drawings

Chapter 13
Drawings

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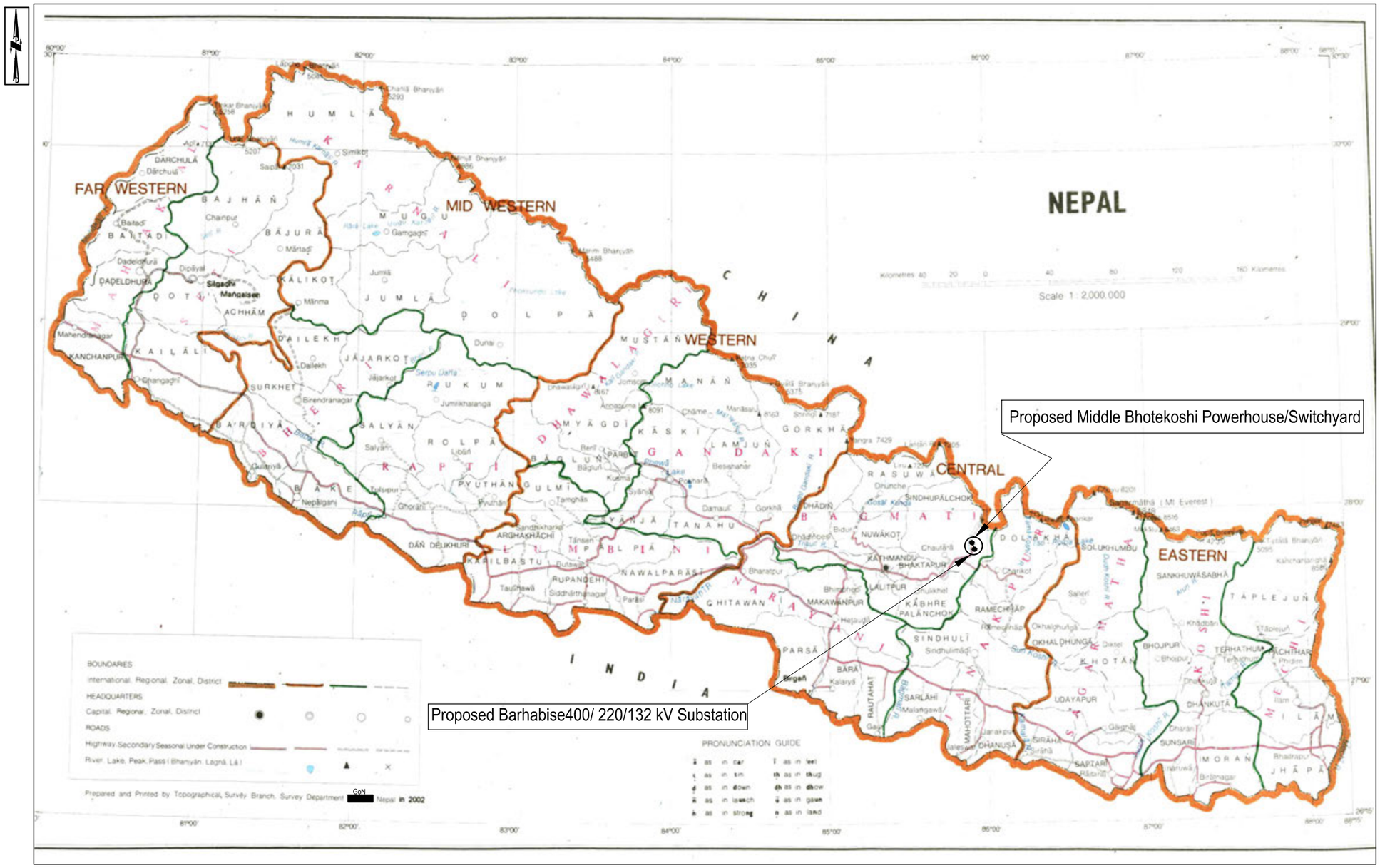
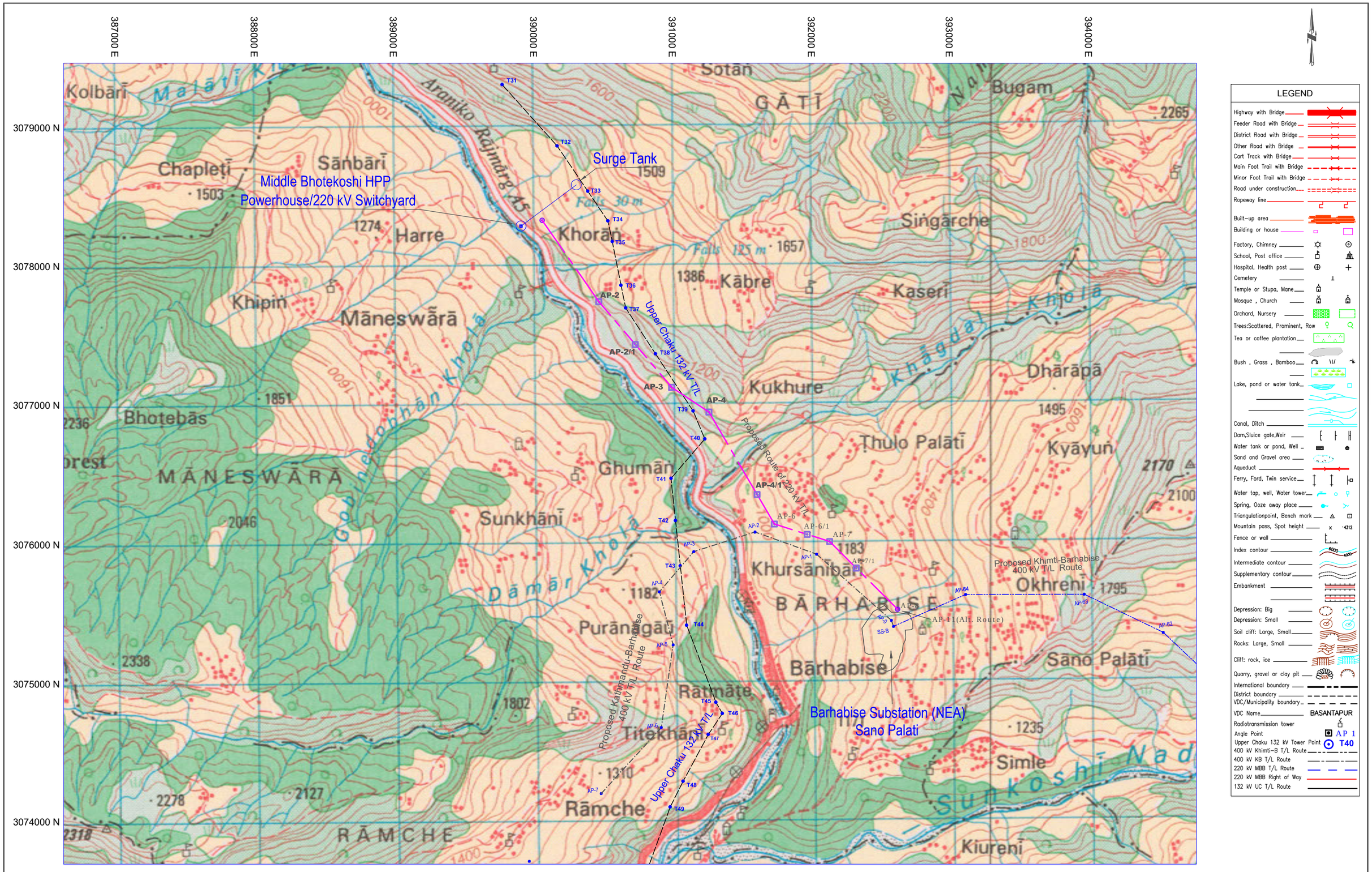


Client :- Madhya Bhotekoshi Jalavidyut Company Limited, Maharajgang, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220kV Transmission Line Project Sindhupalanchok, Bagamati Zone, Nepal	Title Project Location Map	Not in Scale	Figure No. MBK TL-01	Sheet No.
				Revision Date : May, 2016	



LEGEND

- Highway with Bridge
- Feeder Road with Bridge
- District Road with Bridge
- Other Road with Bridge
- Cart Track with Bridge
- Main Foot Trail with Bridge
- Minor Foot Trail with Bridge
- Road under construction
- Ropeway line
- Built-up area
- Building or house
- Factory, Chimney
- School, Post office
- Hospital, Health post
- Cemetery
- Temple or Stupa, Mane
- Mosque , Church
- Orchard, Nursery
- Trees:Scattered, Prominent, Row
- Tea or coffee plantation
- Bush , Grass , Bamboo
- Lake, pond or water tank
- Canal, Ditch
- Dam,Sluice gate,Weir
- Water tank or pond, Well
- Sand and Gravel area
- Aqueduct
- Ferry, Ford, Twin service
- Water tap, well, Water tower
- Spring, Ooze away place
- Triangulationpoint, Bench mark
- Mountain pass, Spot height (x 4312)
- Fence or wall
- Index contour (6000, 4000)
- Intermediate contour
- Supplementary contour
- Embankment
- Depression: Big
- Depression: Small
- Soil cliff: Large, Small
- Rocks: Large, Small
- Cliff: rock, ice
- Quarry, gravel or clay pit
- International boundary
- District boundary
- VDC/Municipality boundary
- VDC Name: BASANTAPUR
- Radiotransmission tower
- Angle Point: AP 1
- Upper Chaku 132 kV Tower Point: T40
- 400 kV Khimti-B T/L Route
- 400 kV KB T/L Route
- 220 kV MBB T/L Route
- 220 kV MBB Right of Way
- 132 kV UC T/L Route

Client :-

Madhya Bhotekoshi Jalavidyut Company Limited

Maharajgunj, Kathmandu , Nepal

Middle Bhotekoshi Hydropower Project

Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project

Sidhupalanchok, Bagamati Zone, Nepal

Route Alignment Plan

0 250 500 750m

Scale : 1:25,000

Major Contour Interval 200 meters

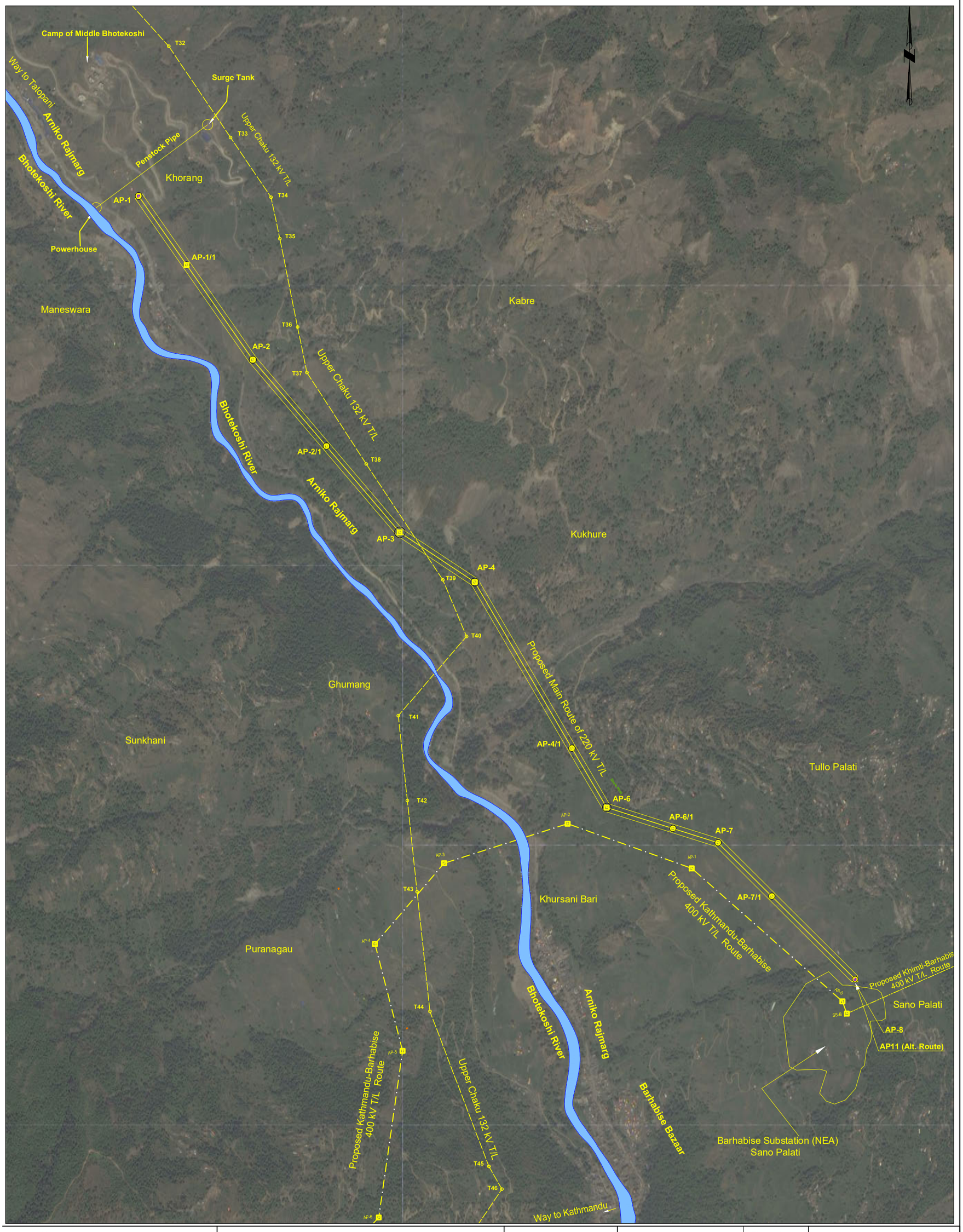
Minor Contour Interval 40 meter

Figure No. MBK TL-02

Sheet No.

Revision

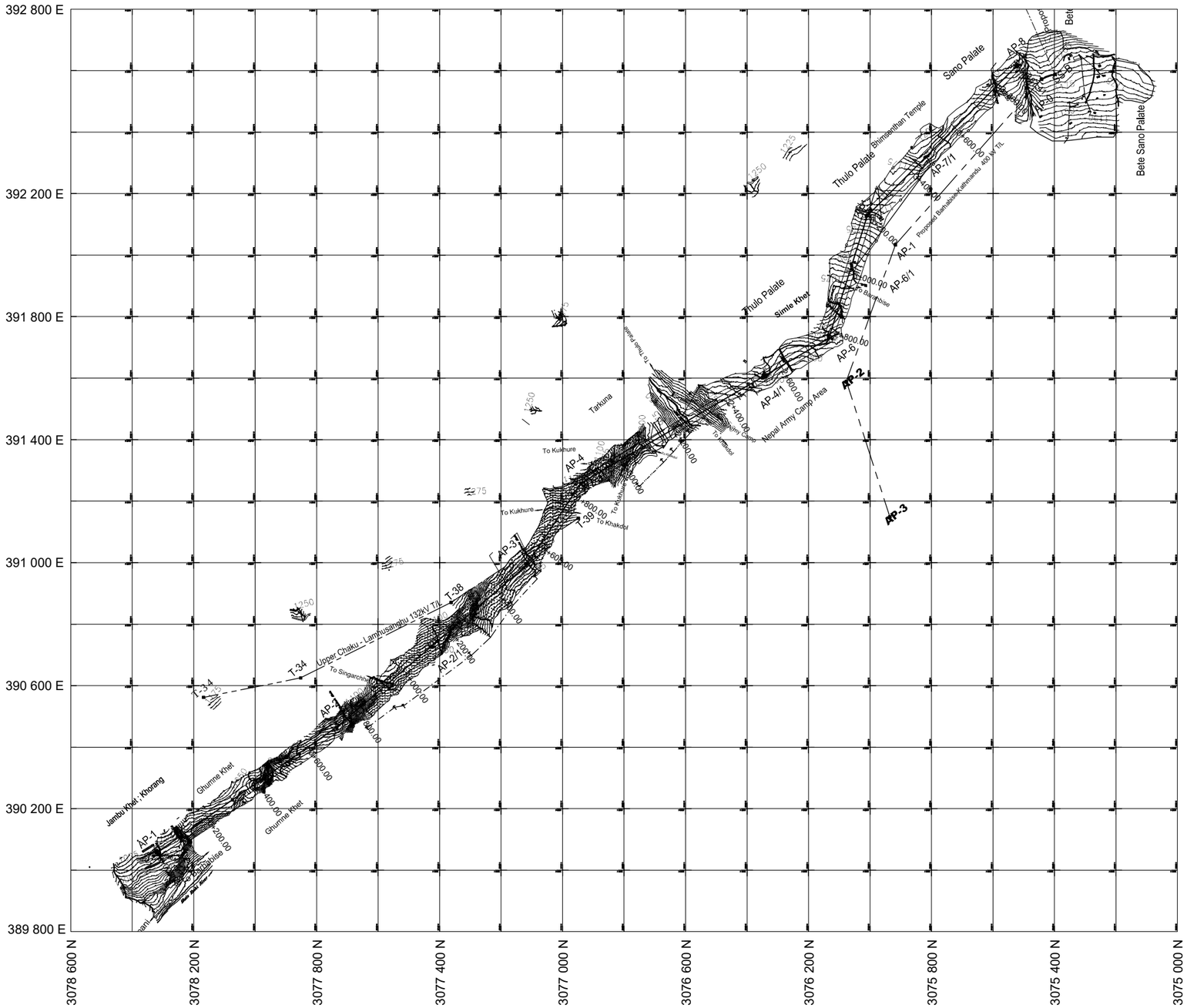
Date : May, 2016



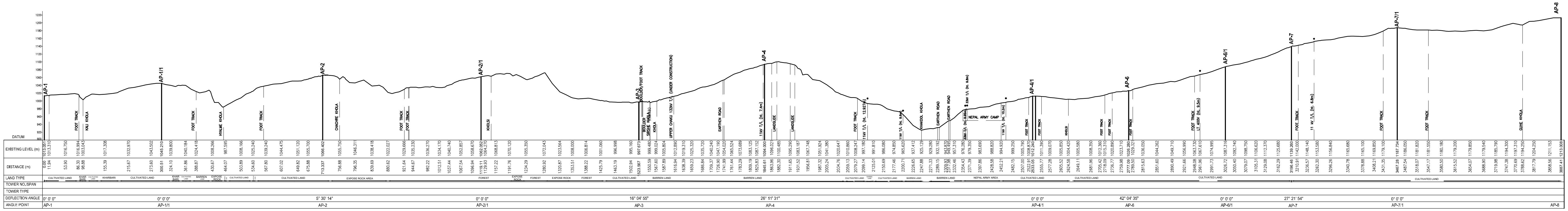
Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Route Alignment Plan of Google Earth Imagery	0 120 240 360m Scale : 1:12,000	Figure No. MBK TL-03 Revision	Sheet No.

LEGEND:

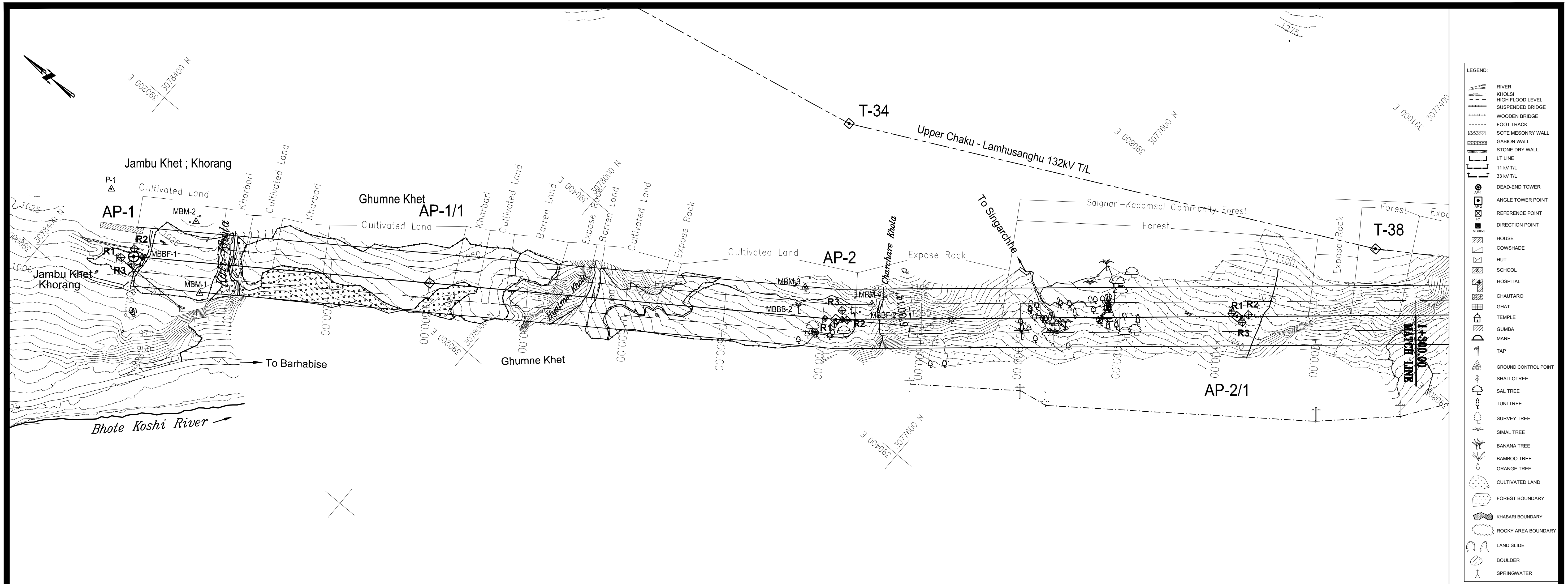
- RIVER
- KHOLSI
- HIGH FLOOD LEVEL
- SUSPENDED BRIDGE
- WOODEN BRIDGE
- FOOT TRACK
- SOTE MESONRY WALL
- GABION WALL
- STONE DRY WALL
- LT LINE
- 11 kV T/L
- 33 kV T/L
- DEAD-END TOWER (AP-1)
- ANGLE TOWER POINT (AP-2)
- REFERENCE POINT (R1)
- DIRECTION POINT (MBBS-2)
- HOUSE
- COWSHADE
- HUT
- SCHOOL
- HOSPITAL
- CHAUTARO
- GHAT
- TEMPLE
- GUMBA
- MANE
- TAP
- GROUND CONTROL POINT (MBK-1)
- SHALLOTREE
- SAL TREE
- TUNI TREE
- SURVEY TREE
- SIMAL TREE
- BANANA TREE
- BAMBOO TREE
- ORANGE TREE
- CULTIVATED LAND
- FOREST BOUNDARY
- KHABARI BOUNDARY
- ROCKY AREA BOUNDARY
- LAND SLIDE
- BOULDER
- SPRINGWATER

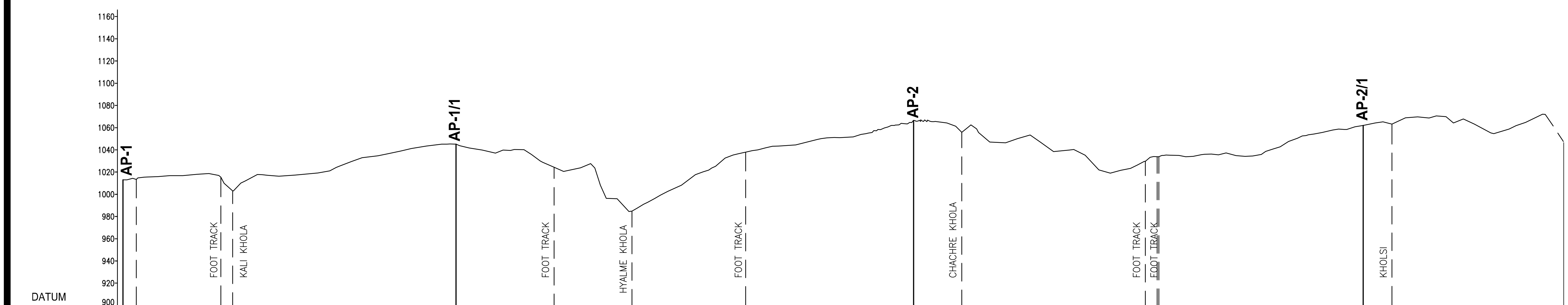


Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Plan of 220 kV Transmission Line Route	0 150 300 450m Scale : 1:15,000 Major Contour Interval 5 meters	Figure No. MBK TL-04 Revision Date : May, 2016	Sheet No.



Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Profile of 220 kV Transmission Line Route	0 100 200 300m Scale : 1:10,000	Figure No. MBK TL-05	Sheet No.
				Revision	
				Date :	May, 2016





DISTANCE (m)	EXISTING LEVEL (m)
0.00	**1013.051**
11.94	1013.310
53.90	1016.750
86.30	1016.994
98.88	1003.043
155.39	1017.308
215.67	1032.970
273.60	1043.502
300.51	**1045.210**
324.10	1039.800
361.86	1040.184
388.87	1024.418
430.67	1008.266
464.07	987.595
503.89	1008.166
534.60	1025.240
567.80	1039.240
607.02	1044.475
649.82	1051.120
675.88	1055.700
713.337	**1066.402**
756.88	1055.750
796.35	1046.311
839.69	1038.418
880.62	1022.027
921.64	1029.666
944.67	1035.230
982.22	1036.270
1012.51	1034.170
1037.44	1040.740
1067.54	1052.857
1096.94	1058.670
1119.11	**1062.052**
1157.22	1068.813
1191.76	1070.120
1234.29	1055.350
1280.92	1072.043

LAND TYPE: CULTIVATED LAND – KHAR BARI – CULTIVATED LAND – KHARBARI – CULTIVATED LAND – KHAR BARI – CULTIVATED LAND – BARREN LAND – EXPOSE ROCK – BARREN LAND – CULTIVATED LAND – EXPOSE ROCK – CULTIVATED LAND – EXPOSE ROCK AREA – FOREST – EXPOSE ROCK – FOREST

TOWER NO./SPAN:

TOWER TYPE:

DEFLECTION ANGLE	ANGLE POINT
0° 0' 0"	AP-1
0° 0' 0"	AP-1/1
5° 30' 14"	AP-2
0° 0' 0"	AP-2/1

Client :-
Madhya Bhotekoshi Jalavidyut Company Limited
Maharajgunj, Kathmandu , Nepal

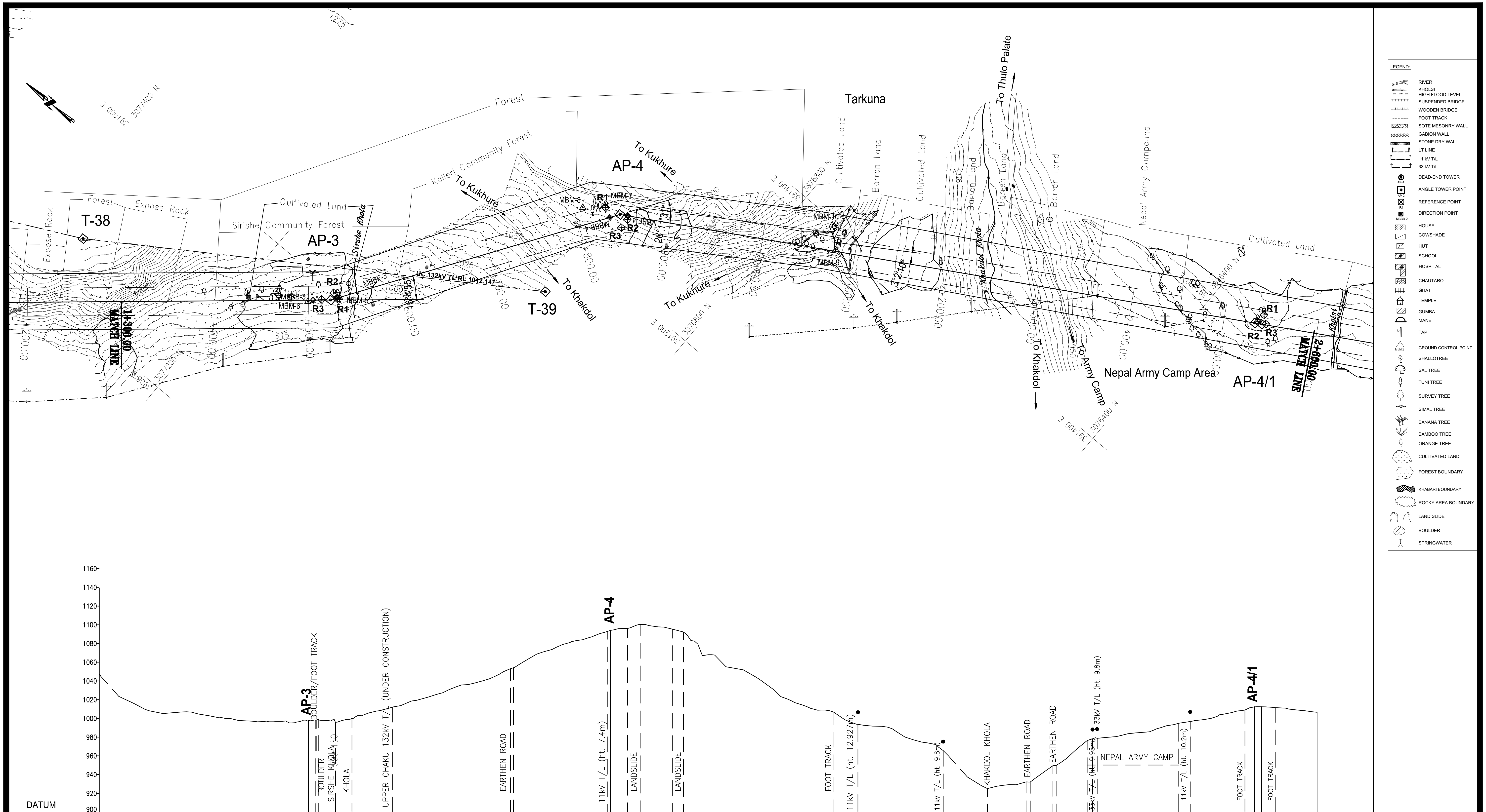
Middle Bhotekoshi Hydropower Project
Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project
Sidhupalanchok, Bagamati Zone, Nepal

Plan & Profile of Route Alignment

0 40 80 120m
Scale : 1:4000
Major Contour Interval 5 meters
Minor Contour Interval 1 meter

Figure No.	Sheet No.
MBK TL-06	1/3

Revision
Date : May, 2016



DISTANCE (m)	EXISTING LEVEL (m)
1320.87	1023.564
1353.51	1008.000
1388.22	1006.814
1425.79	1001.060
1463.19	996.998
1502.94	995.160
1523.567	**997.673**
1550.59	999.480
1567.60	999.024
1587.89	1005.804
1616.94	1012.890
1638.39	1019.310
1659.23	1025.320
1686.84	1035.720
1709.37	1040.240
1726.90	1047.190
1741.99	1054.020
1761.44	1065.524
1783.29	1073.689
1809.19	1083.125
1825.83	1087.152
1845.61	**1094.000**
1863.96	1096.021
1882.30	1100.485
1911.65	1095.290
1931.52	1083.187
1956.81	1067.748
1987.32	1051.924
2005.24	1041.380
2034.76	1020.647
2059.13	1010.860
2079.27	1008.247
2099.14	997.180
2125.01	991.810
2150.69	986.080
2177.46	974.850
2200.71	965.620
2226.65	937.412
2247.88	925.129
2271.33	929.280
2289.15	932.192
2309.93	943.870
2317.98	949.495
2332.46	957.310
2354.43	976.280
2371.39	979.350
2397.86	983.690
2428.58	988.820
2452.21	994.920
2482.15	999.250
2507.00	1005.790
2522.91	1008.870
2533.05	**1012.24**
2555.77	1011.390
2577.28	1009.070

LAND TYPE: EXPOSE ROCK – FOREST – CULTIVATED LAND – BARREN LAND – BARREN LAND – CULTIVATED LAND – BARREN LAND – CULTIVATED LAND – BARREN LAND – BARREN LAND – NEPAL ARMY AREA – CULTIVATED LAND

TOWER NO./SPAN

TOWER TYPE

DEFLECTION ANGLE	16° 04' 55"	26° 11' 31"	0° 0' 0"
ANGLE POINT	AP-3	AP-4	AP-4/1

Client :-

Madhya Bhotekoshi Jalavidyut Company Limited

Maharajgunj, Kathmandu , Nepal

Middle Bhotekoshi Hydropower Project

Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project

Sidhupalanchok, Bagamati Zone, Nepal

Plan & Profile of Route Alignment

0 40 80 120m

Scale : 1:4000

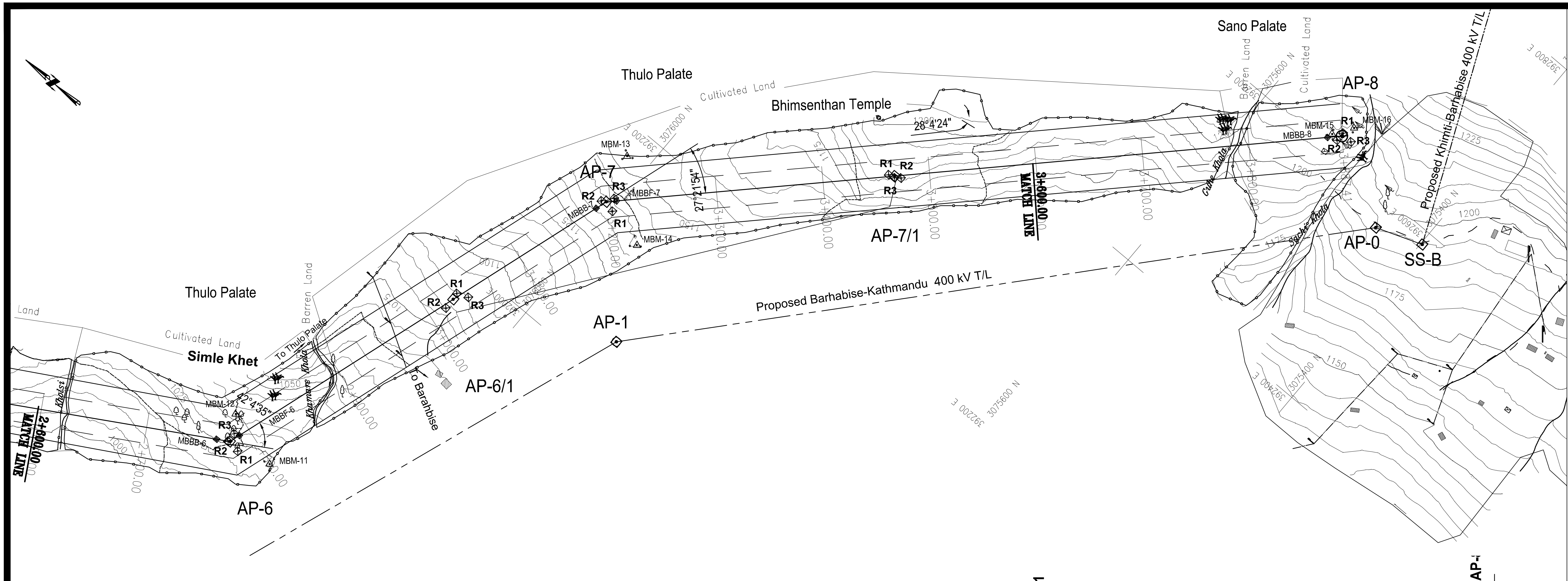
Major Contour Interval 5 meters

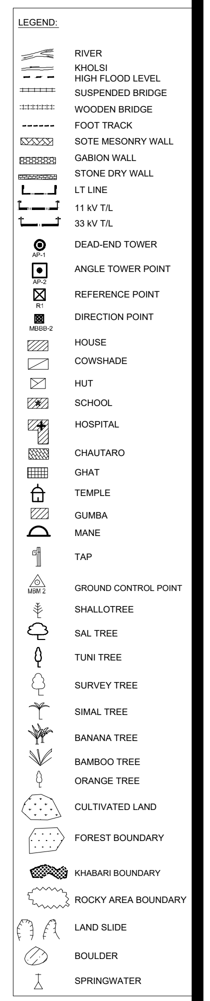
Minor Contour Interval 1 meter

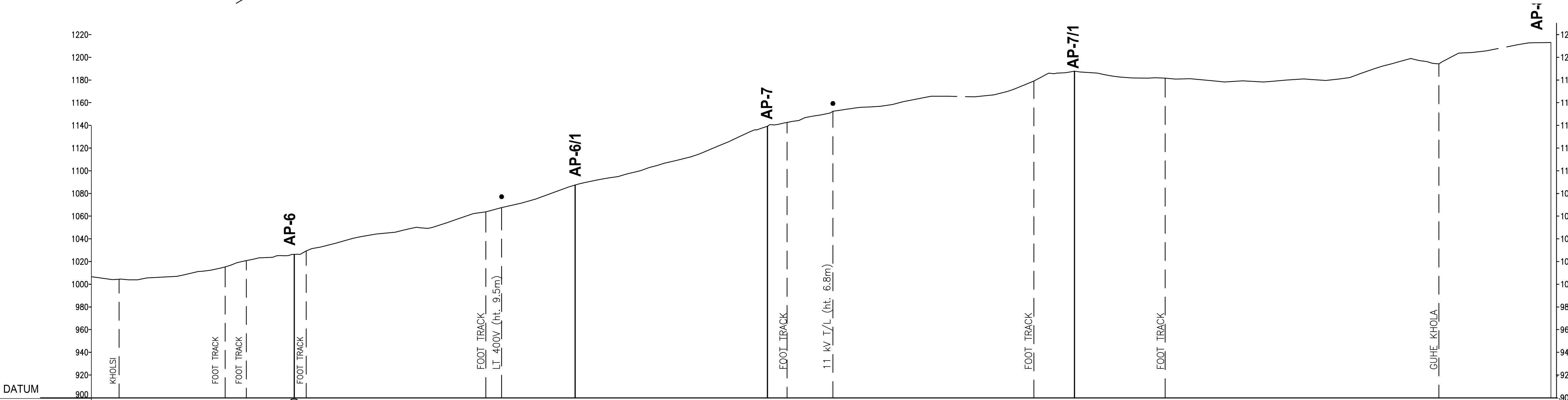
Figure No.	Sheet No.
MBK TL-07	2/3

Revision

Date : May, 2016





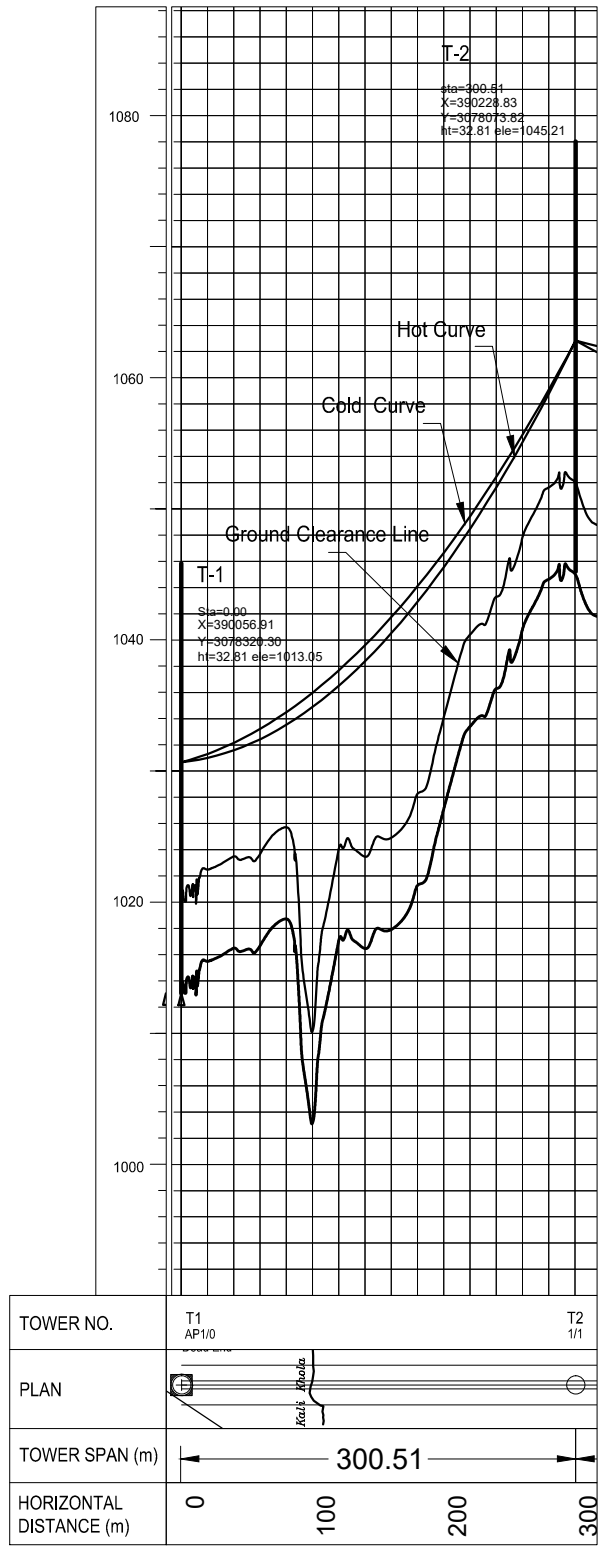


DISTANCE (m)	EXISTING LEVEL (m)
2605.52	1005.850
2624.58	1004.420
2649.11	1005.580
2681.96	1008.350
2705.42	1012.360
2718.09	1015.310
2736.77	1020.890
2759.98	1023.710
2778.987	**1026.320**
2789.50	1029.321
2815.63	1036.050
2851.60	1044.262
2890.49	1049.710
2921.66	1056.990
2948.08	1063.730
2961.96	1067.610
2991.73	1074.995
3026.72	**1087.316**
3050.40	1092.740
3079.07	1098.750
3105.31	1106.620
3129.08	1112.370
3162.29	1125.680
3196.46	**1139.260**
3210.91	1142.000
3236.57	1148.140
3262.30	1153.580
3296.26	1156.840
3340.78	1165.680
3378.88	1165.100
3408.21	1169.850
3431.35	1179.100
3467.29	**1187.734**
3487.54	1186.050
3518.07	1181.820
3547.17	1181.550
3580.50	1180.180
3615.52	1179.200
3654.07	1179.850
3688.90	1179.540
3719.98	1185.790
3747.38	1194.300
3770.69	1197.310
3788.62	1194.250
3817.79	1204.250
3858.56	1211.153
3887.41	**1213.008**

LAND TYPE	CULTIVATED LAND	CULTIVATED LAND		CULTIVATED LAND	
TOWER NO./SPAN					
TOWER TYPE					
DEFLECTION ANGLE	42° 04' 35"	0° 0' 0"	27° 21' 54"	0° 0' 0"	
ANGLE POINT	AP-6	AP-6/1	AP-7	AP-7/1	AP-8

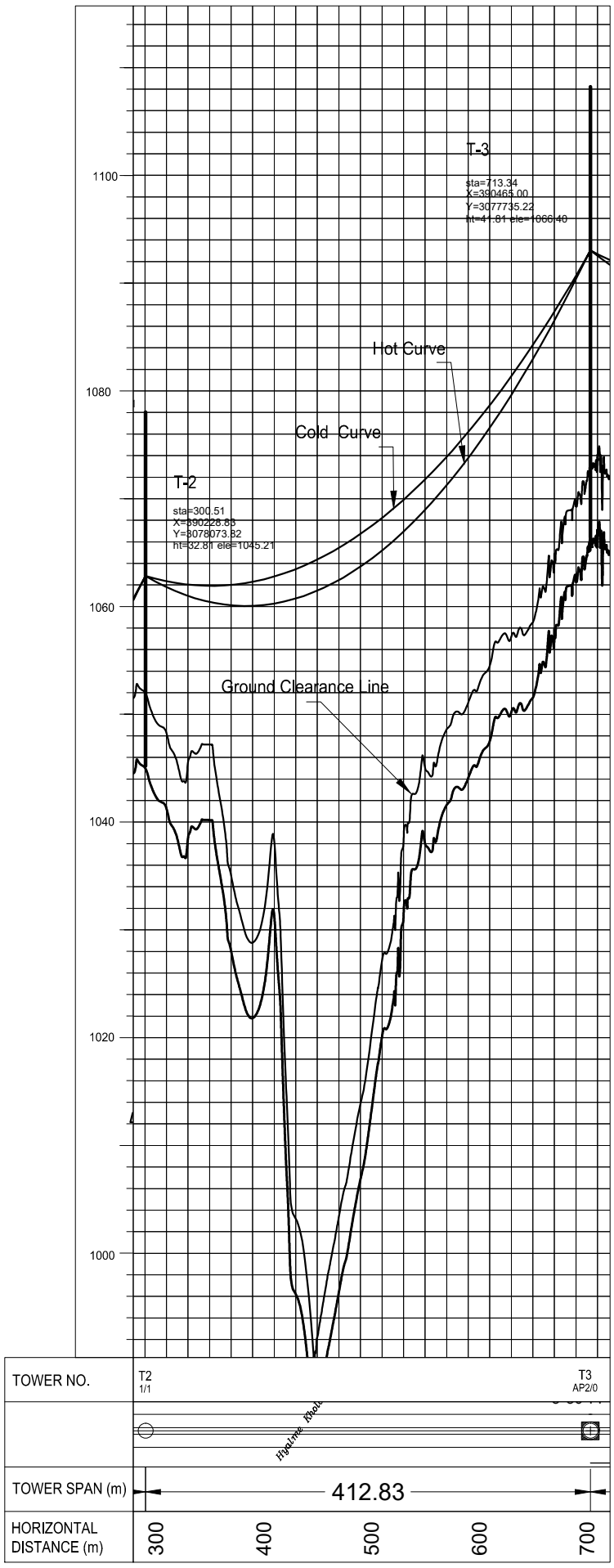
AP-4/1

Client :- Madhya Bhotekoshi Jalavidyut Company Limited, Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Plan & Profile of Route Alignment	0 40 80 120m Scale : 1:4000 Major Contour Interval 5 meters Minor Contour Interval 1 meter	Figure No.: MBK TL-08 Sheet No.: 3/3 Revision May, 2016



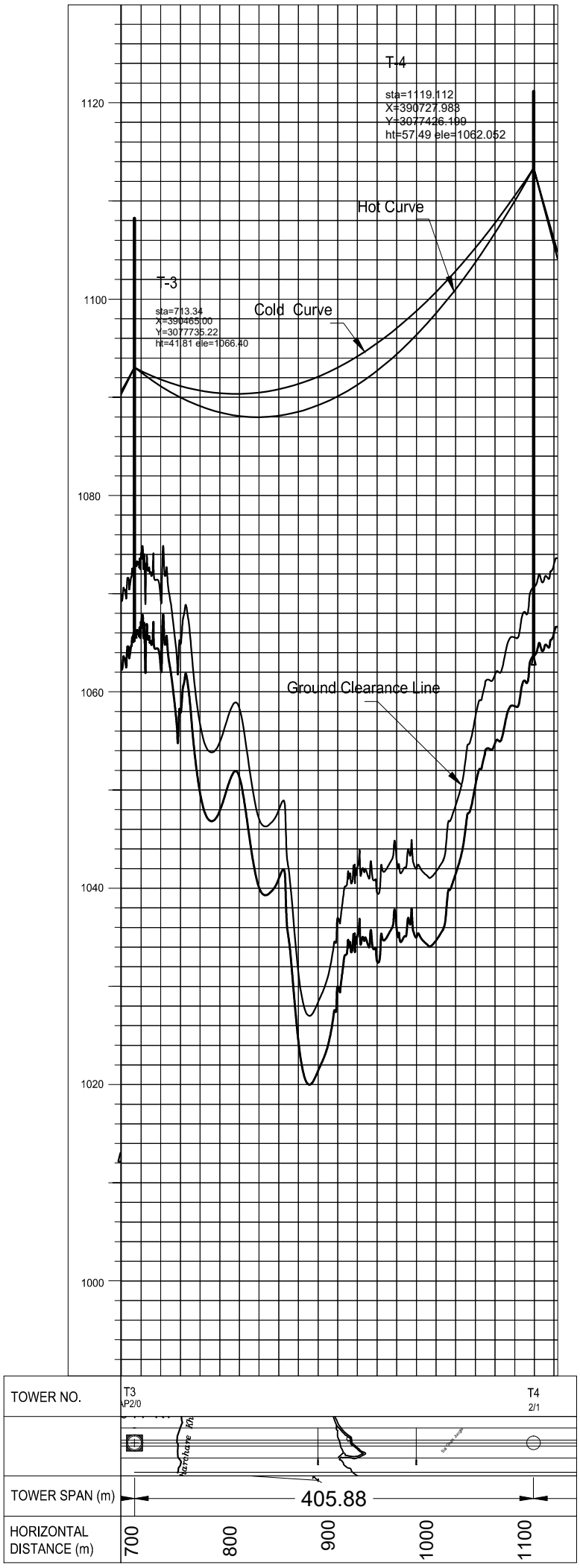
PLS-CADD Drawing

Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-9 Sheet No. 1/11 Revision Date : March, 2016	Scale 0 40 80 120m H=1:4000 V=1:400



Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-10 Revision Date : March, 2016	Sheet No. 2/11

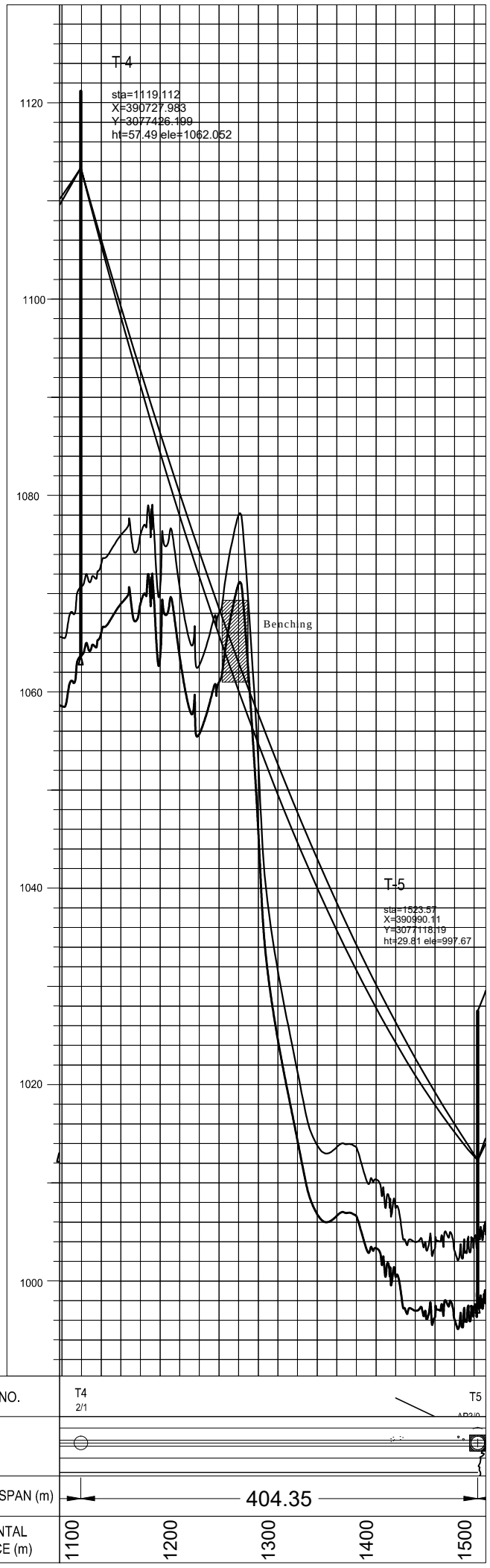
Scale
0 40 80 120m
H=1:4000
V=1:400



PLS-CADD Drawing

Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-11 Revision Date : March, 2016	Sheet No. 3/11

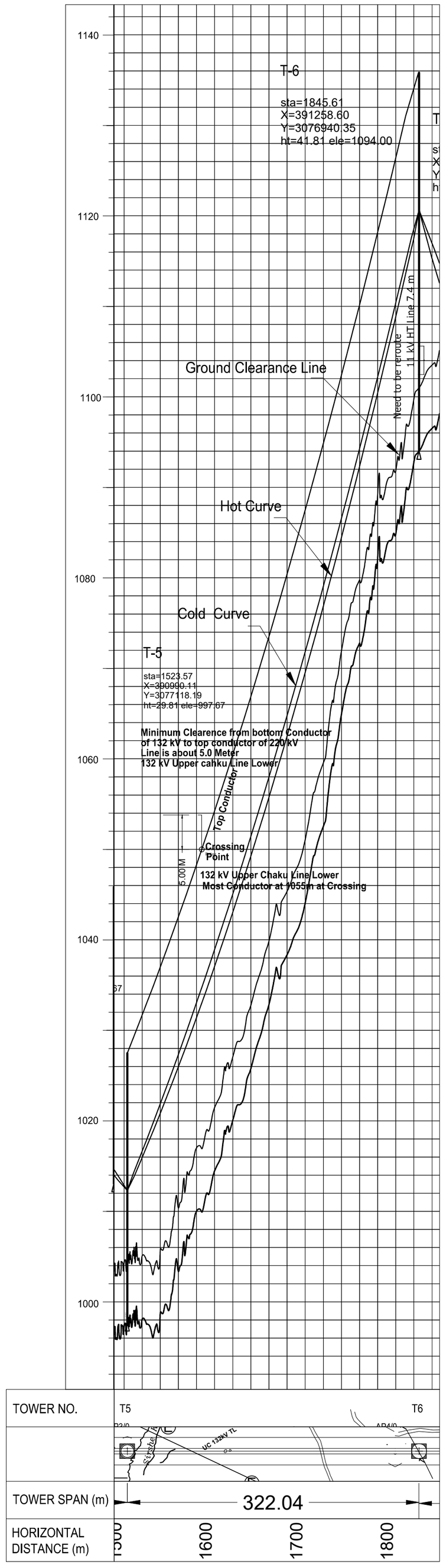
Scale
0 40 80 120m
H=1:4000
V=1:400



PLS-CADD Drawing

Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-12 Revision Date : March, 2016	Sheet No. 4/11

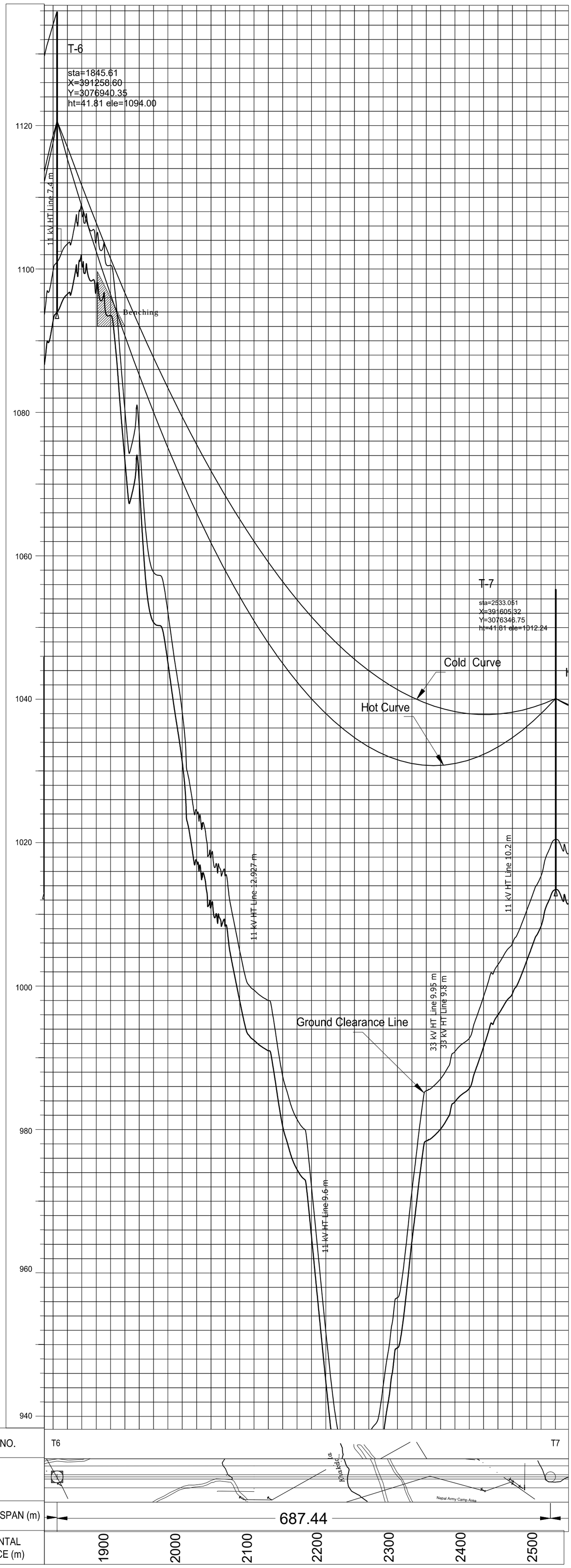
Scale
0 40 80 120m
H=1:4000
V=1:400



PLS-CADD Drawing

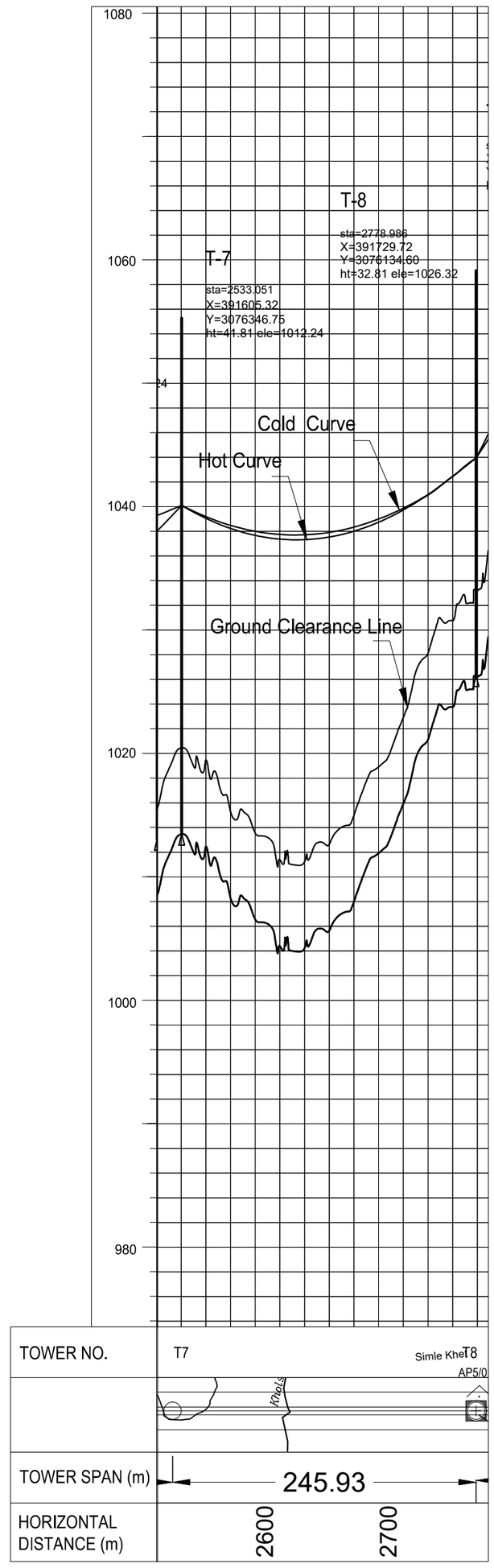
Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-13 Revision Date : March, 2016	Sheet No. 5/11

Scale
0 40 80 120m
H=1:4000
V=1:400



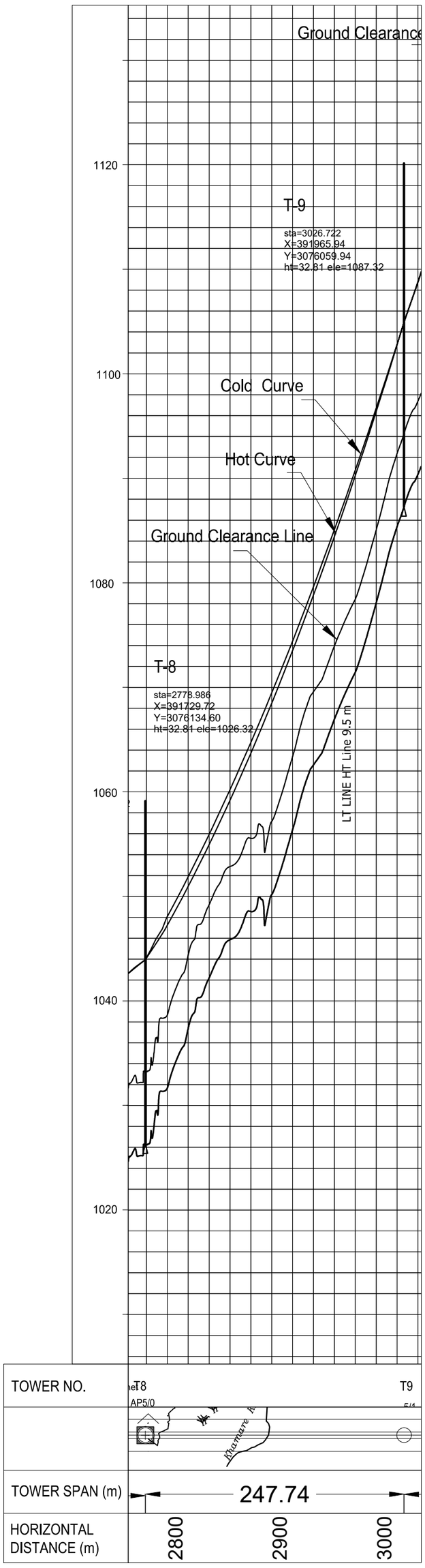
PLS-CADD Drawing

Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-14 Sheet No. 6/11 Revision Date : March, 2016	Scale 0 40 80 120m H=1:4000 V=1:400



PLS-CADD Drawing

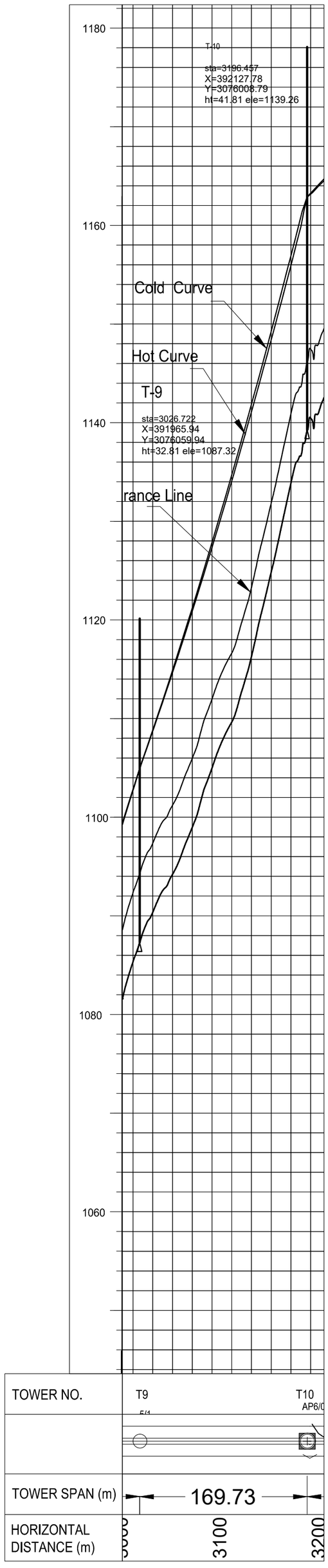
Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-15 Sheet No. 7/11 Revision Date : March, 2016	Scale 0 40 80 120m H=1:4000 V=1:400



PLS-CADD Drawing

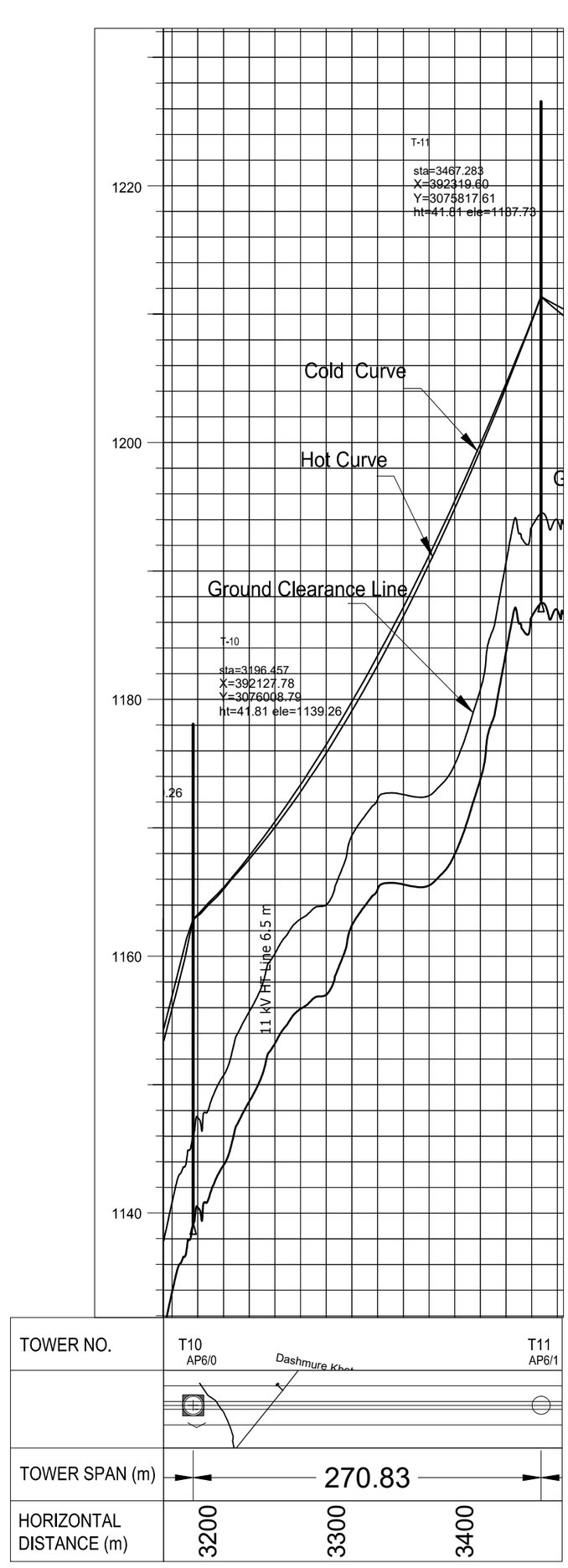
Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-16 Revision Date : March, 2016	Sheet No. 8/11

Scale
0 40 80 120m
H=1:4000
V=1:400



PLS-CADD Drawing

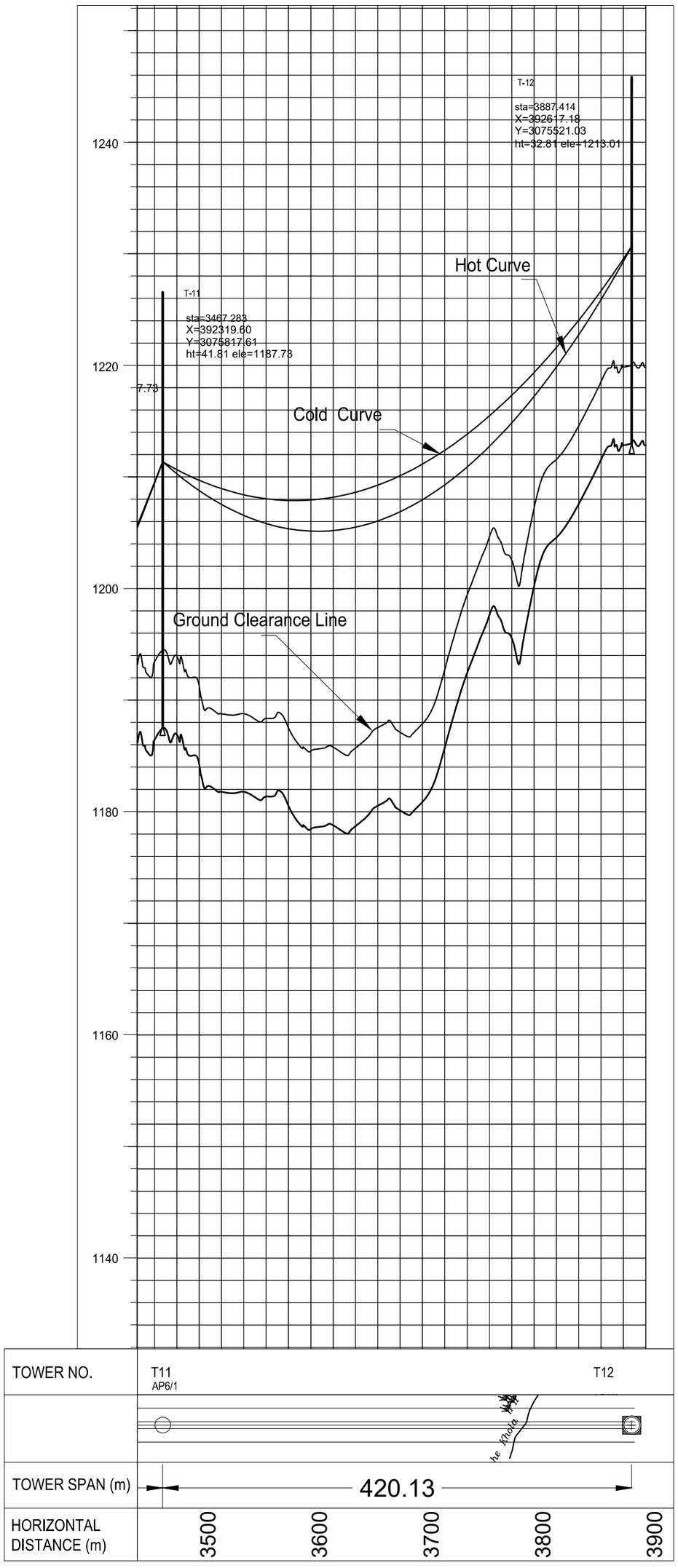
Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-17 Sheet No. 9/11 Revision Date : March, 2016	Scale 0 40 80 120m H=1:4000 V=1:400



PLS-CADD Drawing

Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-18 Revision Date : March, 2016	Sheet No. 10/11

Scale
0 40 80 120m
H=1:4000
V=1:400

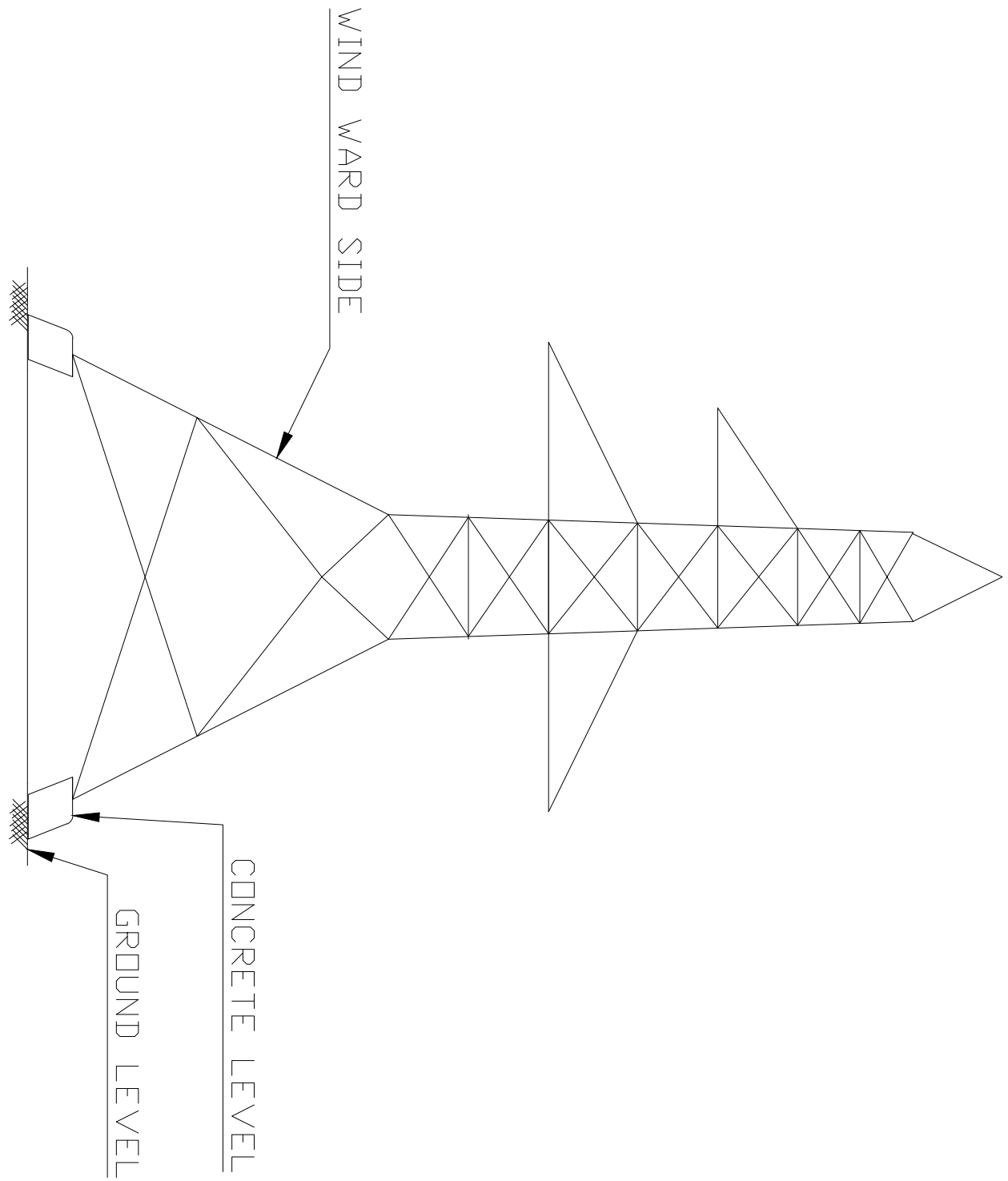


PLS-CADD Drawing

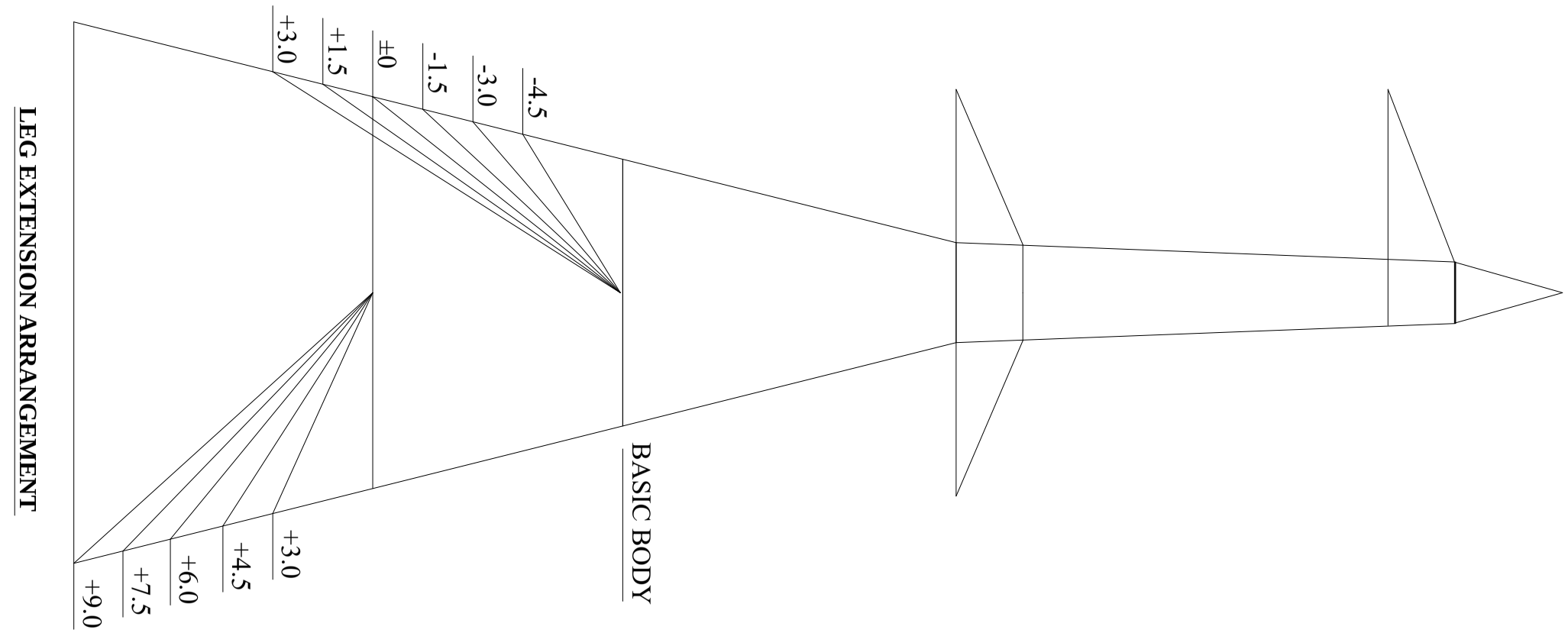
Client :- Madhya Bhotekoshi Jalavidyut Company Limited Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project Sidhupalanchok, Bagamati Zone, Nepal	Title Route Alignment Plan	Figure No. MBK TL-19 Revision Date : March, 2016	Sheet No. 11/11

Scale
0 40 80 120m
H=1:4000
V=1:400

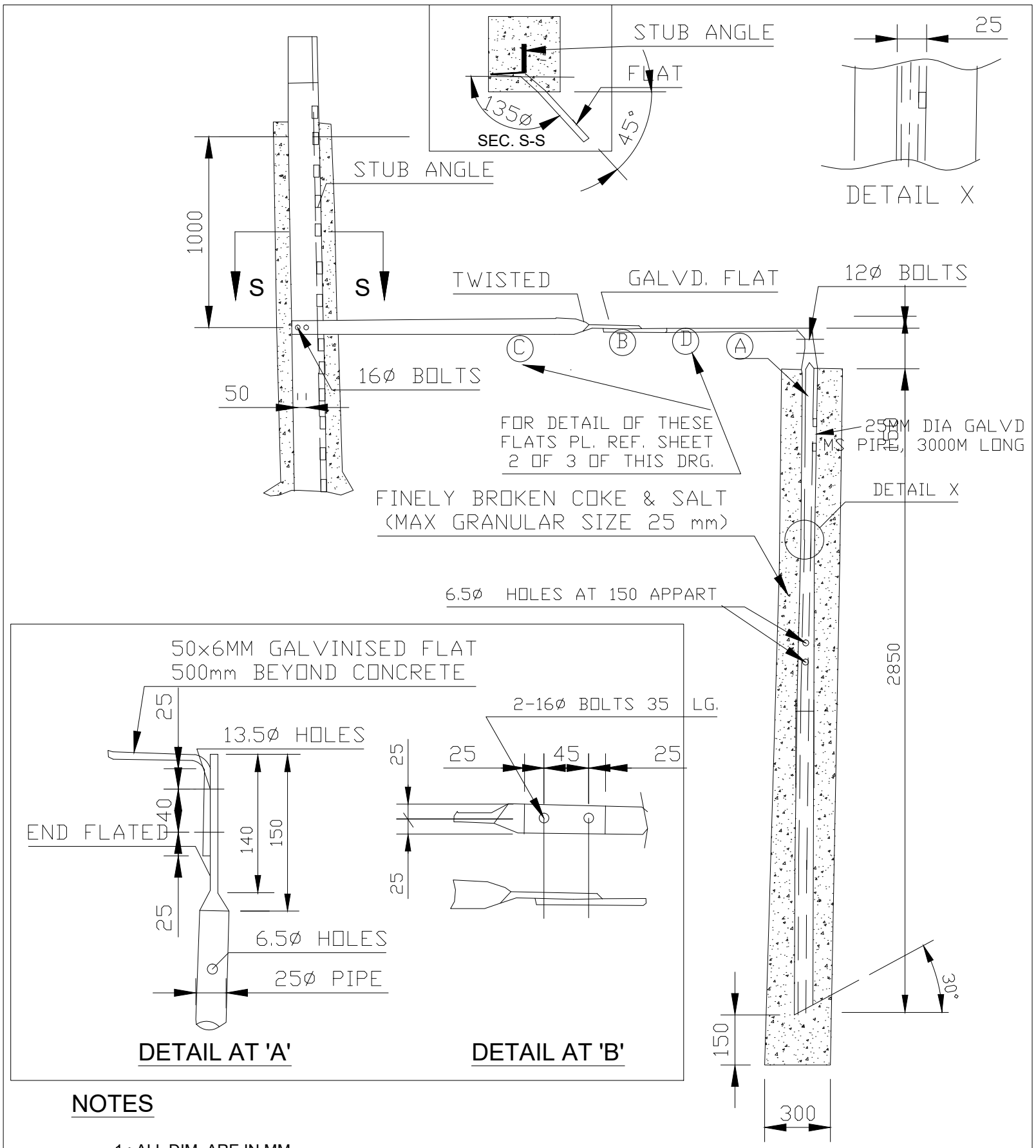
TYPICAL SINGLE CIRCUIT TOWER



Client :-	Middle Bhotekoshi Hydropower Project	D				Designed by		Title	Figure No. MBK TL-20 / Sheet No.
Madhya Bhotekoshi Jalavidyut Company Limited		C				Drawn by		220 kV Transmission System	
	Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project	B				Checked by		Not in Scale	
Maharajgunj, Kathmandu , Nepal	Sidhupalanchok, Bagamati Zone, Nepal	A				Approved by			Revision / Date : May, 2016
		REV.	DATE	DESCRIPTION REVISION	APPROVED BY				



Client :- Madhya Bhotekoshi Jalavidyut Company Limited, Maharajgunj, Kathmandu , Nepal	Middle Bhotekoshi Hydropower Project; Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project; Sidhupalanchok, Bagamati Zone, Nepal	D				Designed by		Title: Leg Extension Arrangement	Not in Scale	Figure No. MBB TL-35; Sheet No.
		C				Drawn by				
		B				Checked by				Revision
		A				Approved by				Date : May, 2016
		REV.	DATE	DESCRIPTION REVISION	APPROVED BY					



NOTES

1 : ALL DIM. ARE IN MM

2 : STRIP IS TO BE PROVIDED ON ONE LEG OF EACH TOWER

3 : STRIP WITH PIPE EARTH ARRANGMENT IS TO BE PROVIDED ON ONLY ONE LEG FOR THE LOCATION WHERE TOWER FOOTING RESISTANCE IS MORE THAN 10 OHMS

4 : 17.5 MM Ø HOLES SUITABLE FOR 16MM BOLTS FOR EARTHING DEVICES

5 : FOR COUNTER POISE EARTHING STRIP 'C' SHALL BE CONNECTED WITH COUNTER POISE WIRE THROUGH 'A' LUG

Sheet No.

Figure No. MBK TL - 22

Revision

Date : May, 2016

Not in Scale

Title

Details of Oioe Type Earthing

REV.	DATE	DESCRIPTION REVISION	APPROVED BY
C			
B			
A			

Designed by | Drawn by | Checked by | Approved by

Middle Bhotekoshi Hydropower Project

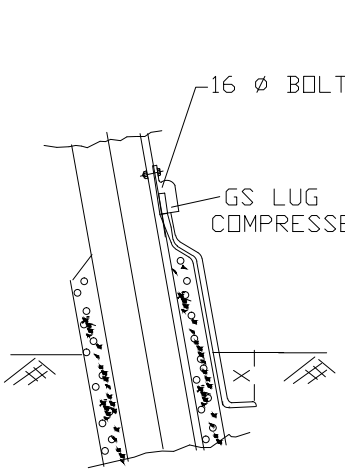
Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project

Sidhupalanchok, Bagamati Zone, Nepal

Client :-

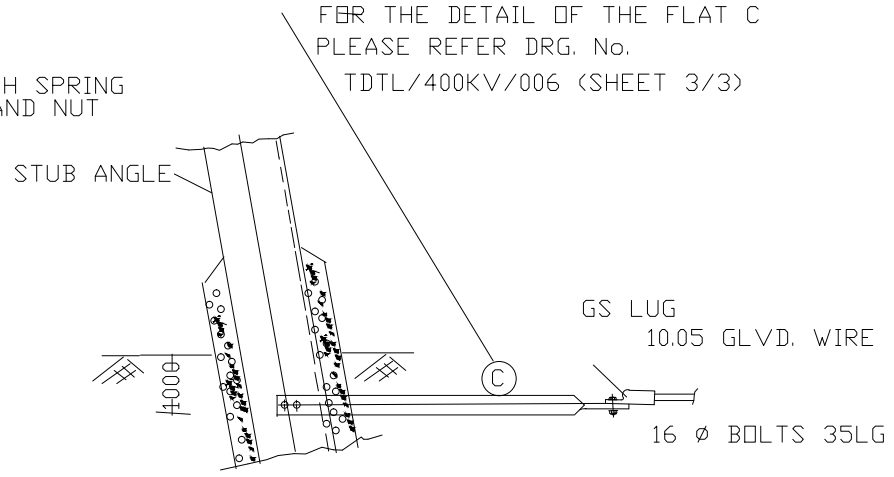
Madhya Bhotekoshi Jalavidyut Company Limited

Maharajgunj, Kathmandu , Nepal

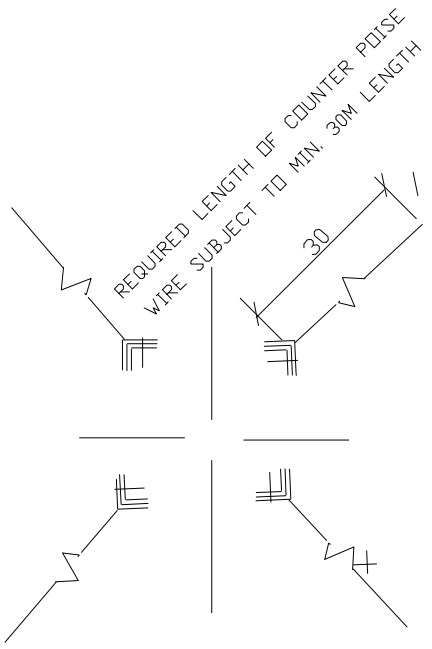


X IS NOT LESS THAN 1000MM

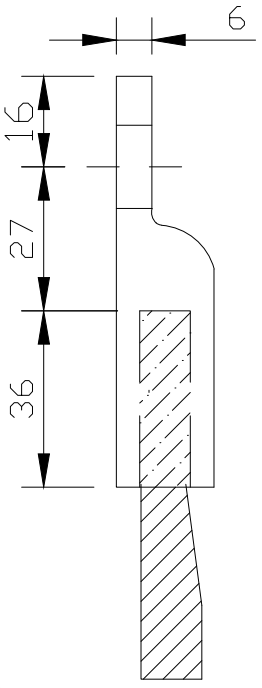
LUG FITTING (TYPICAL) FOR THREE LEGS

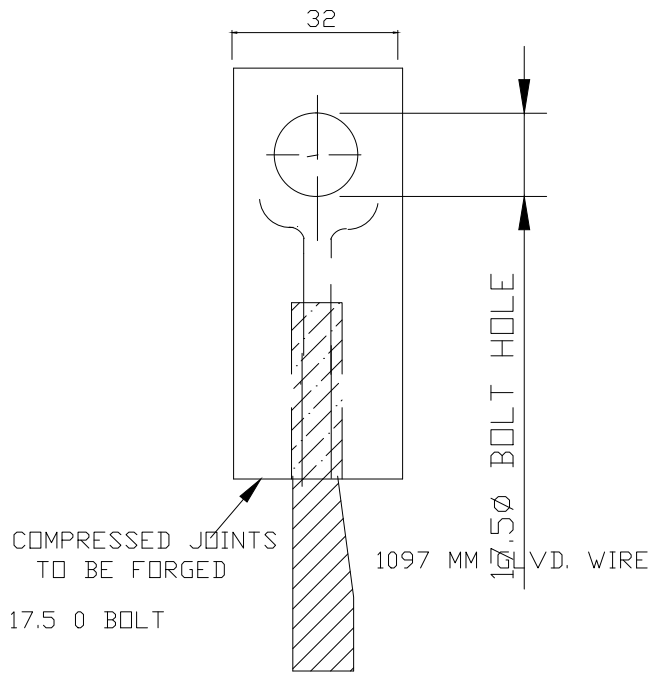


LUG FITTING ON FOURTH LEG



BASE OF TOWER





DETAIL OF LUG

LIST OF BOLTS & NUTS/TOWER

S. No	SIZE	QTY.
1	M16 X 45LG	3
2	M16 X 35LG	1
3	3.5 THK.SPG WASHER	4

NOTES

1 : ALL DIM. ARE IN MM
2 : 10.97mm GALVINISED WIRE WITH G.S LUG FORGED AT ONE END
OTHER END FREE FOR A REQUIRED LENGTH OF COUNTERPOISE WIRE
3 : FOUR G.S. LUG WILL BE REQUIRED PER TOWER . THREE LUGS WILL BE CONNECTED ON 3 LEGS & FOURTH LUG WILL BE CONNECTED WITH FLAT TYPE 'C' PROVIDED FOR PIPE TYPE EARTHING .
4 : 10.97 MM WIRE SHALL BE OUTSIDE COPPING .
5 : ONE SET COMPRISING OF FOUR NUMBERS OF REQUIRED LENGTH OF COUNTERPOISE WIRE

Figure No. MBK TL- 23 | Sheet No.
Revision
Date : May, 2016
Not in Scale

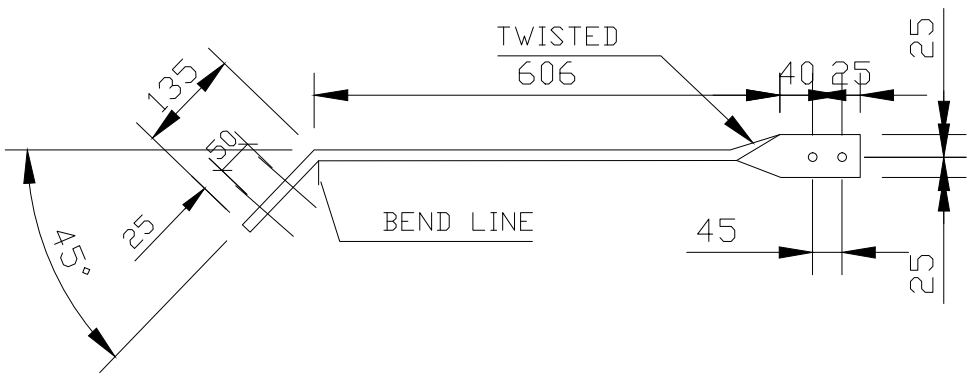
Title: Counterpoise Earthing Arrangement

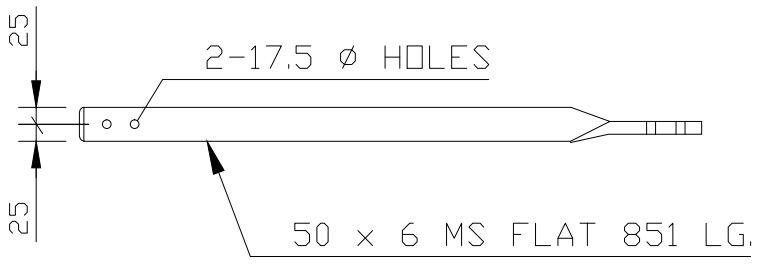
REV.	DATE	DESCRIPTION REVISION	APPROVED BY
A			
B			
C			

Designed by | Drawn by | Checked by | Approved by

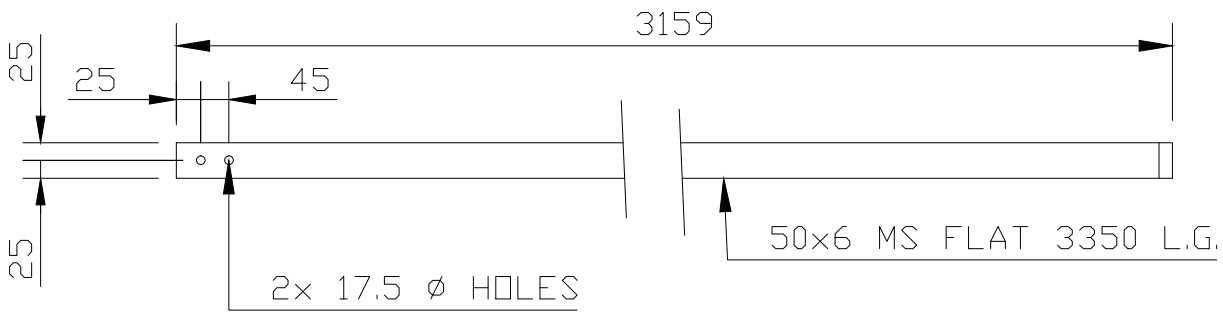
Middle Bhotekoshi Hydropower Project
Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project
Sidhupalanchok, Bagamati Zone, Nepal

Client :-
Madhya Bhotekoshi Jalavidyut Company Limited
Maharajgunj, Kathmandu , Nepal

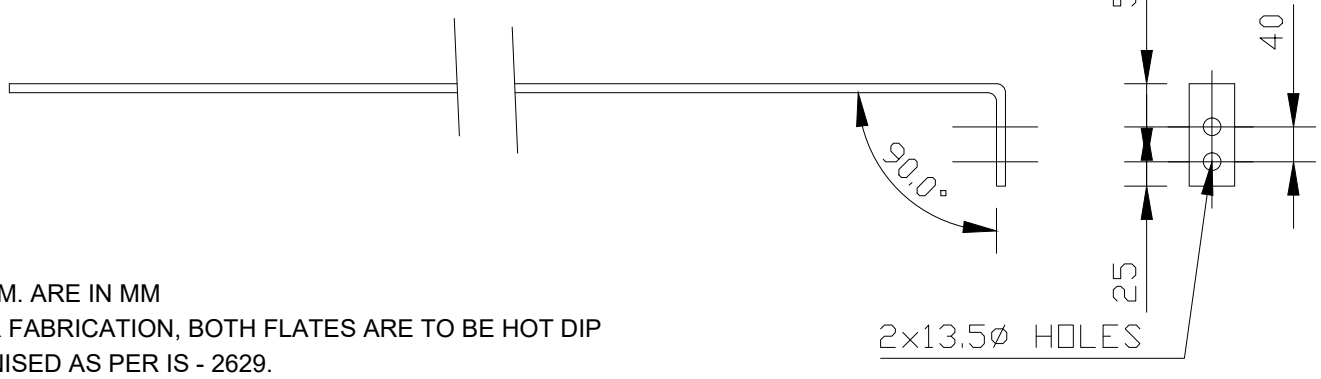




DETAIL OF FLAT TYPE `C'



DETAIL OF FLAT TYPE `D'



NOTES

1 : ALL DIM. ARE IN MM
2 : AFTER FABRICATION, BOTH FLATES ARE TO BE HOT DIP GALVINISED AS PER IS - 2629.
3 : `FLAT TYPE `C' IS TO BE PROVIDED ON ONE LEG OF EACH TOWER
4 : FLAT TYPE `D' IS TO BE PROVIDED WITH PIPE EARTH ARRANGEMENT AND TO BE CONNECTED WITH FLAT `C' FOR THE LOCATION WHERE TOWER FOOTING RESISTANCE IS MORE THAN 10 OHMS

LIST OF BOLTS & NUTS WITH SP. WASHER			
S.NO.	SIZE	QTY.	REMARKS
1	M 16Ø x 45 LG.	2	PER TOWER
2	M 16Ø x 35 LG.	2	PER PIPE TYPE EARTHING
3	M 12Ø x 30 LG.	2	PER PIPE TYPE EARTHING

Not in Scale

Figure No. MBK TL- 24

Sheet No.

Revision

Date : May, 2016

Title

Details For Flats For Earthing

REV.	DATE	DESCRIPTION REVISION	APPROVED BY
C			
B			
A			

Designed by | Drawn by | Checked by | Approved by

Middle Bhotekoshi Hydropower Project

Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project

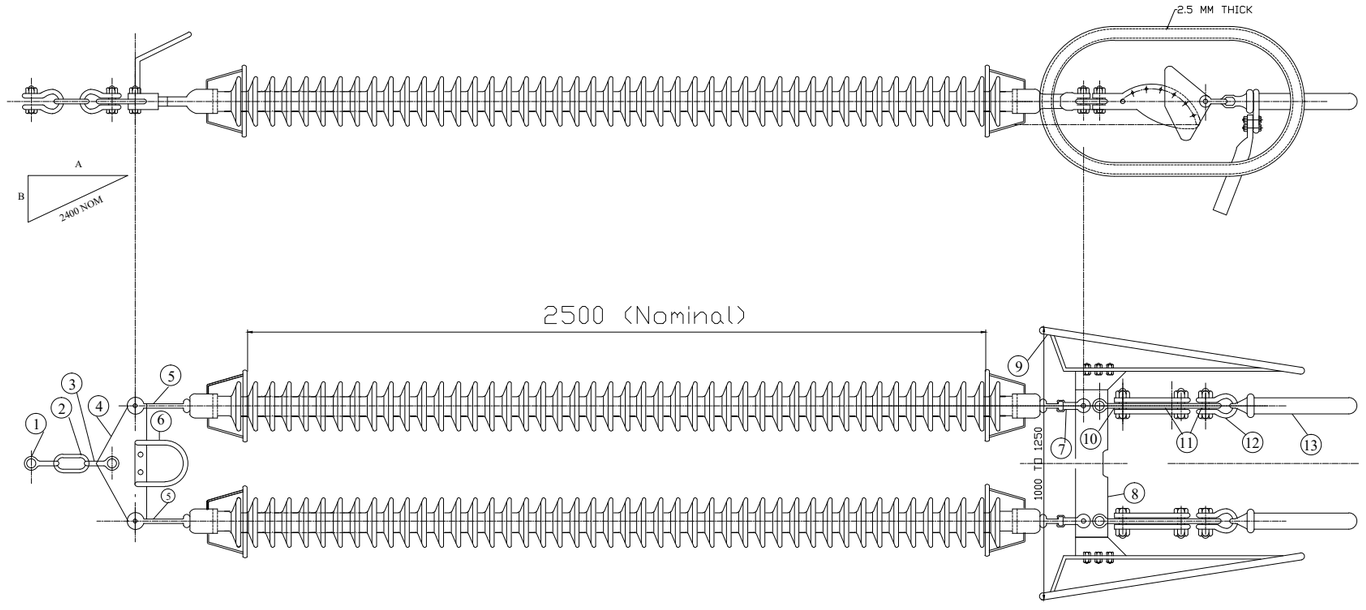
Sidhupalanchok, Bagamati Zone, Nepal

Client :-

Madhya Bhotekoshi Jalavidyut Company Limited

Maharajgunj, Kathmandu , Nepal

S.NO.	DESCRIPTION	QTY.	MATERIAL	MIN. ULTIMATE TENSILE STRENGTH
1	ANCHOR SHACKLE	1	FORGED STEEL	240KN
2	CHAIN LINK	1	FORGED STEEL	240KN
3	ANCHOR SHACKLE	1	FORGED STEEL	240KN
4	YOKE PLATE	1	MILD STEEL	240KN
5	BALL CLEVIS	2	FORGED STEEL	120KN
6	ARCING HORN	1	MILD STEEL	N.A.
7	SOCKET CLEVIS	2	FORGED STEEL	120KN
8	YOKE PLATE	1	MILD STEEL	240KN
9	CORONA CONTROL RING/ GRADING RING	1SET	AL ALLOY PIPE	N.A.
10	CLEVIS EYE	2	FORGED STEEL	120KN
11	SAG ADJUSTING PLATE	2	MILD STEEL	120KN
12	ANCHOR SHACKLE	2	FORGED STEEL	120KN
13	TENSION CLAMP	2	E.C. GRADE AL. & M.S.	114.8 KN SLIP STRENGTH



NOTES:-

1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. BALL& SOCKET SIZE OF 20MM. DESIGNATION AS PER IS
4. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
5. ALL DIMENSIONS ARE IN MM.

Client :-

Madhya Bhotekoshi Jalavidyut Company Limited

Maharajgunj, Kathmandu , Nepal

Middle Bhotekoshi Hydropower Project

Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project

Sidhupalanchok, Bagamati Zone, Nepal

REV.	DATE	DESCRIPTION REVISION	APPROVED BY
C			
B			
A			

Designed by

Drawn by

Checked by

Approved by

Title

Out Line Diagram of Composite Long Rod Double Tension Insulator String

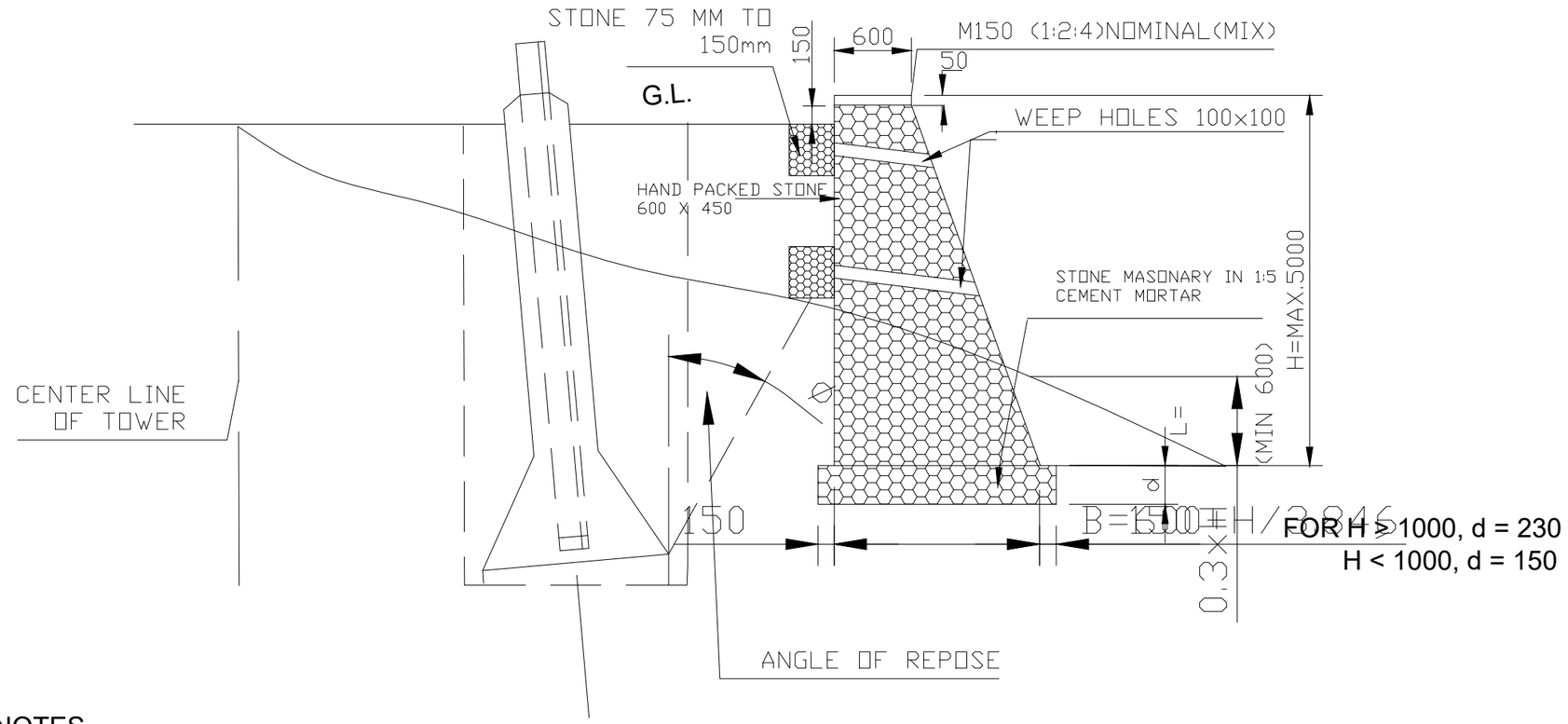
Not in Scale

Figure No. MBK TL- 25

Sheet No.

Revision

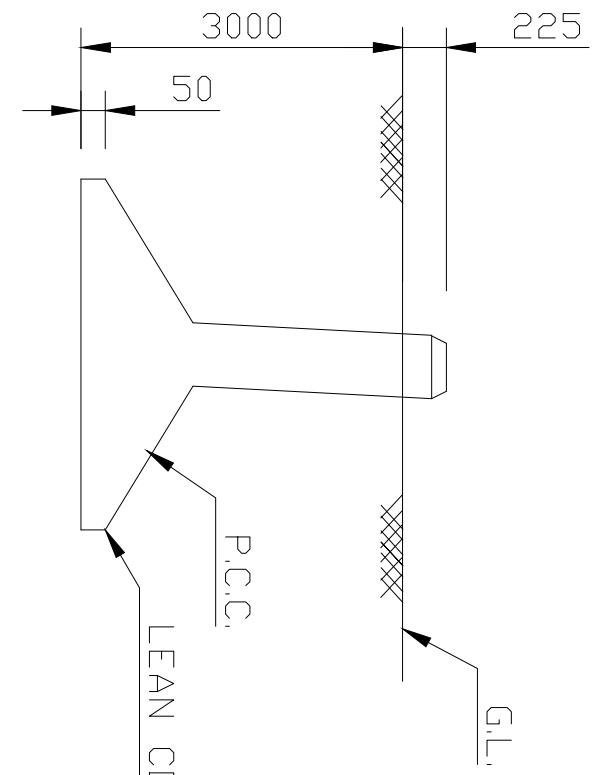
Date : May, 2016



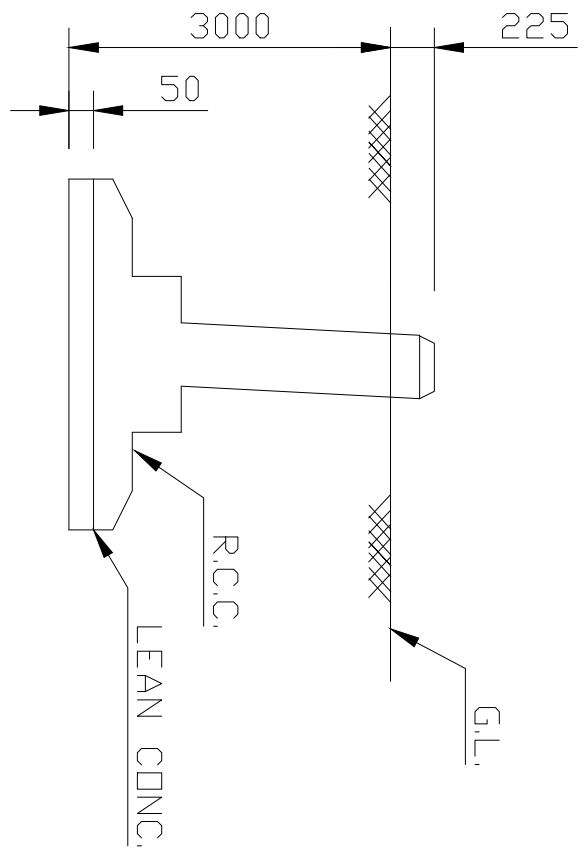
NOTES

1 : ALL DIM. ARE IN MM UNLESS OTHERWISE SPECIFIED.
2 : WEEP HOLES SHOULD BE OF SIZE 100mm x 100mm OR 150mm x 150mm INCASE OF LARGE SIZE REVETMENT.
3 : WEEP HOLES SHOULD BE 2.5Mt C-C APART HORIZONTAL
4 : CENTER OF TOP MOST WEEP HOLES TO BE NOT LESS THAN 300 mm BELOW TOP
5 : THE MIN. DEPTH OF REVETMENT WALL BELOW G.L. WILL BE 600mm
6 : DIM. 'B' ARE VALID ONLY FOR 'H' NOT EXCEEDING 5.00 METER
7 : SIZE OF STONE FOR MASONARY WORK. 300 x 150 x 150 & BELOW
8 : THE MASONRY WORK SHOULD BE CARRIED OUT IN 1:5 CEMENT MORTAR
9 : SIZE OF STONE PACKING AT WEEP HOLE 75 mm TO 150mm

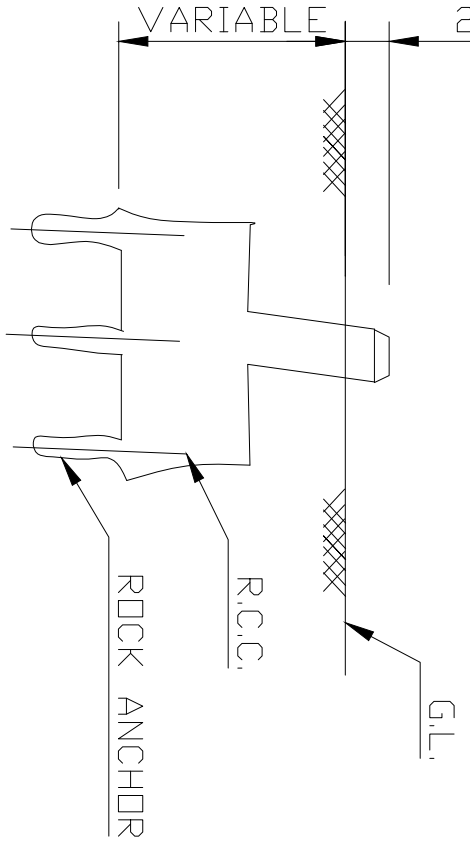
Client :-	Middle Bhotekoshi Hydropower Project					Designed by		Title		
Madhya Bhotekoshi Jalavidyut Company Limited		C				Drawn by		Protection of Tower Footing/Up Hill Slope	Not in Scale	Figure No. MBK TL- 26 / Sheet No.
	Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project	B				Checked by				Revision
Maharajgunj, Kathmandu , Nepal	Sidhupalanchok, Bagamati Zone, Nepal	A				Approved by				Date : May, 2016
		REV.	DATE	DESCRIPTION REVISION	APPROVED BY					



TYP. FOUNDATION SHAPE FOR P.C.C. TYPE



TYP. FOUNDATION SHAPE FOR R.C.C. TYPE



TYP. FOUNDATION SHAPE FOR HARD ROCK

Middle Bhotekoshi Hydropower Project					Designed by	Title	Figure No. / Sheet No.
Middle Bhotekoshi-Barhabise 220 kV Transmission Line Project	C				Drawn by	Tentative Shap of Tower Footings	MBK TL- 27
Sidhupalanchok, Bagamati Zone, Nepal	B				Checked by	Not in Scale	Revision
	A				Approved by		Date : May, 2016
	REV.	DATE	DESCRIPTION REVISION	APPROVED BY			

Annex

Tower Schedule

S.N.	Tower No.	Structure Number	Station (m)	WGS Coordinates		Elevation (m)	Ahead Span (m)	Remarks	Plan Comment
				X Easting (m)	Y Northing (m)				
1	T-1	AP 1/0	0	390056.915	3078320.3	1013.051	300.509		
2	T-2	1/1	300.509	390228.829	3078073.82	1045.214	412.828		
3	T-3	AP 2/0	713.337	390464.997	3077735.22	1066.402	430.77		
4	T-4	2/1	1119.112	390727.983	3077426.2	1062.052	404.353	Strengthening	
5	T-5	AP 3/0	1523.566	390990.112	3077118.19	997.673	322.041	Strengthening	132 kV Chaku Crossing
6	T-6	AP 4/0	1845.608	391258.597	3076940.35	1094.000	694.843	Strengthening	132 kV Chaku Crossing & 11 kV Crossing
7	T-7	4/1	2533.051	391605.32	3076346.75	1012.24	238.533		
8	T-8	AP 6/0	2778.984	391729.715	3076134.6	1026.32	247.737		
9	T-9	6/1	3026.721	391965.935	3076059.94	1087.316	169.735		
10	T-10	AP7/0	3196.456	392127.78	3076008.79	1139.26	270.826		
11	T-11	7/1	3467.282	392319.604	3075817.61	1187.734	420.131		
12	T-12	AP8/0	3887.413	392617.18	3075521.03	1213.008	0		