

BIDDING DOCUMENT

Procurement of Plant

TANAHU HYDROPOWER PROJECT

PACKAGE 3:

**DESIGN, SUPPLY, INSTALLATION AND COMMISSIONING OF
220 kV TRANSMISSION LINE PROJECT OF TANAHU
HYDROPOWER PROJECT**

Volume II (Part A)

Employer's Requirements

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SPECIFICATIONS**

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SECTION 1
EMPLOYER'S REQUIREMENTS

TRANSMISSION LINE
SCOPE OF WORKS AND SPECIFICATIONS

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1 General Technical Conditions of Transmission Line

1.1 General

The Government of Nepal has received a loan from the Asian Development Bank (ADB) toward the cost of the Tanahu Hydropower Project, and it intends to apply part of the proceeds of this credit to payments under the contract for Procurement of the 220kV Damauli – Bharatpur Transmission Line.

All works described herein and other works necessary to complete the job for proper coordination and operation, even if not stated, shall be within the scope of the Contractor's work and the cost of such works shall be considered to be included in the bid price.

The Contractor shall provide spare parts and tools for the transmission line as specified in this specification; furnish qualified supervision and construction personnel for the installation, testing, commissioning and remedying defects within warranty period and checking out of the equipment necessary to complete the scope of works as mentioned above and detailed in the Price Schedule. The work shall be performed in close cooperation with the Employer.

The Contractor shall be responsible for coordination of the installation of the transmission line and other related works. The Employer will furnish the information needed to coordinate the work with others.

Locally available goods, construction materials including asphalt, fuel, lubricating oil, cement, timber, iron and steel goods, etc. shall be procured locally.

1.2 Project Scope

This Specification covers the following project scope:

- i. Detailed survey including route alignment, profiling (where ever route change is required), tower spotting, optimization of tower locations, soil resistivity measurement & geotechnical investigation (including special foundation locations viz. pile/well foundation locations, whenever applicable & covered under BPS);
- ii. Check survey;
- iii. Design, Proto type testing, fabrication and supply of all type of 220 kV double circuit and multi circuit transmission line towers including bolts, nuts and washers, step bolts, hangers, D-shackles etc.;
- iv. Supply of all types of tower accessories like phase plate, circuit plate (where ever applicable), number plate, danger plate, anti-climbing device, Bird guard (where ever applicable);
- v. Supply of ACSR Bison Conductor, Insulators, Earth wire, Hardware Fittings, Accessories for ACSR Bison Conductor & Earth wire and OPGW & associated fittings & accessories;
- vi. Design of foundations for different soil conditions for different type of towers, classification of foundation for different type of towers and casting of foundation for tower footings as per approved drawings;
- vii. Supply & Installation of Tower Earthing;
- viii. Erection of towers, tack welding of bolts and nuts including supply and application of zinc rich paint, fixing of insulator strings, stringing of conductors and earth wires/OPGW along with all necessary line accessories;
- ix. Painting of towers & supply and erection of span markers, obstruction lights (wherever applicable) for aviation requirements (as required)

-
- x. Testing and commissioning of the erected transmission lines
 - xi. Other items not specifically mentioned in this Specification but are required for the successful commissioning of the transmission line, unless specifically excluded in the Specification.
 - xii. Contractor shall develop design, structural drawings, shop drawings & Bill of Materials of all 220 kV Double circuit towers and carryout the proto testing of towers. Similarly, the design and drawings for all type of foundations for the towers shall also be developed by the contractor, in sequence, suiting the project requirement.

The provisional quantities of fabricated & galvanised steel towers as per specifications requirement, foundation type and their numbers, quantity of various line materials and other items are given in the appropriate Price Schedule of the bid documents.

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

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 plant equipment, materials, skilled and unskilled labour etc. essential for satisfactory completion of various works.

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

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

The installation & stringing of the ACSR Bison Conductor for the above transmission line shall be carried out by the transmission line contractor. The entire stringing work of conductor and earth wire / OPGW 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. The period of deployment of tension stringing equipment shall be as per actual site requirement. Power line crossing, river crossings, other single span sections where deployment of tension stringing machine is not warranted and in hilly terrain, thick forest or areas with site constraints, where deployment of tension stringing machine is not feasible, manual stringing may be adopted after getting approval of Employer's site engineer.

The Bidder having requisite experience has freedom to use helicopter or to use drone for stringing. The Bidder intending to use helicopter or drone shall furnish detailed description of the procedure, type & number of helicopter or drone & accessories etc., to be deployed for stringing operation. The payment for stringing shall be done as per the unit rates of stringing under the contract irrespective of the methodology adopted for stringing. The Employer intends to minimize the forest clearance at valleys and other possible areas and prefers to use the drone in such situations. No extra payment shall be paid for the use of helicopter or drone. The Contractor himself shall get the approval from respective authority for the use of these technologies but the Employer will provide the necessary recommendation to related authority upon the request from the Contractor.

The Bidder shall quote the unit rates for tower and foundation as per units mentioned in appropriate price schedules. However, payment of these items identified in the schedule of prices shall be made as follows: Tower Supply: On completion of respective complete tower. Tower Erection: On erection of respective complete tower. Tower Foundation: On completion of respective foundation.

This specification also includes the supply of ACSR Bison Conductor, Insulators, Earth wire, hardware fittings, all type of accessories for conductor and earth wire and OPGW and its associated hardware & accessories as detailed in the specification. Contractor shall clearly indicate in their offer,

the sources from where they propose to procure these materials in appropriate Schedule. The technical descriptions of these items are given in relevant section of this Volume of the bidding documents.

Spare Materials

As an option, the Bidder can recommend spare materials and test equipment in the Price Schedule which shall not be considered for evaluation.

1.3 Scope of Work

Preliminary data of the preferred transmission line route has been prepared by the Employer. The proposed route alignment passes through undulating hilly and mountainous landscapes and the variation of the altitude of the terrain ranges from 100 m up to 1200 m above sea level. The Contractor, through detailed survey, will confirm the route alignment and tower locations as provided by the Employer. Modifications to the proposed alignment may be required in order to improve constructability and reduce impact to surrounding communities and environment.

The Contractor will design, procure and construct the double circuit 220kV Damauli - Bharatpur Transmission Line which shall originate at the Tanahu Hydropower Project south east of the town of Damauli, progress 33.4 km in the south east direction, and terminate on a quad circuit tower located in the vicinity of Angle Point (AP) 40, north of the Bharatpur substation. The transmission line shall have two circuits, one optical ground wire (OPGW) and one overhead shield wire (OHSW).

The Contractor will terminate the 220kV Damauli - Bharatpur Transmission Line at the Tanahu Hydropower Project by spanning from a structure in the vicinity of AP1 to AP0 - the location of the gantry structure within the Power Station. The Contractor will coordinate design of the termination span with the Package 2 Contractor who will design, supply and construct the gantry structure.

Under the Contractors scope of work, two Special Towers (DE 0° – 90°) are to be placed between AP1 and AP4 that can be configured to;

- 1) In its initial configuration, and as a part of this project's scope, the two deadends are to span between one another as inline deadends with a 0° line angle.
- 2) At a future date, and not a part of the Contractors scope of work; the Special Towers are to be utilized in an in/ out configuration to span to a proposed future new Damauli substation located north of the project alignment. In such a configuration the line angle will be 60° – 90°.
- 3) The Contractor shall ensure that the placement of the two Special Towers (DE 60° – 90°) be such that there are no topographic obstructions to the placement of the first future tie in structure on the alignment proceeding towards the future new Damauli substation.

Damauli-Bharatpur 220 kV Line (THL Line) will join a quad (four) circuit tower of MCTLP 220 kV transmission line constructed by the Marsyangdi Corridor Transmission Line Project (MCTLP) in the vicinity of AP 39. MCTLP 220 kV transmission line emanated from Markichowk Substation in Tanahun District and shall be terminated at New Bharatpur substation. Four Circuits towers shall carry four circuits of 220 kV transmission lines (2 circuits of MCTLP and 2 Circuits of THL) from AP 34 of MCTLP upto New Bharatpur substation. THL line has to cross two existing 132 kV transmission lines (Damauli Bharatpur 132 kV transmission and Marsyangdi Bharatpur 132 kV transmission line) to meet starting Four-circuit tower. The crossing has to be done from location close to AP39 of THL which may require to be relocated. Relocated Dead End Tower (AP 39-THL) shall be relocated such that two incoming lines i.e. double circuit line coming from this Project and double circuit line coming from MCTLP shall make the equal angle i.e. bisecting angle. After that, the conductors of this Package will be connected to Four-circuit tower of MCTLP. DD type tower to be supplied from this Package to take off to multi-circuit tower shall be less than 150 m from multi-circuit tower.

The Contractors scope of work will be to coordinate the termination of the phase conductors and ground wires of the 220kV Damauli- Bharatpur line onto the MCTLP quad tower. An OPGW splice box, supplied by this Contractor, is to be installed on the quad tower to facilitate OPGW splicing. The quad tower and subsequent structures and spans progressing to the Bharatpur substation will be designed, procured and constructed by MCTLP. The OPGW will occupy the right side earth wire position when seen progressing towards the Bharatpur sub-station.

1.4 General Transmission Line Parameters

Transmission Line length: 33.4 km

Structure type: Galvanized Steel Lattice tower

Foundation type: Design based on Contractor geotechnical analysis

Circuit configuration: Vertical Double Circuit (D/C)

Conductor Type:

- I. Twin bundled ACSR BISON (-for typical span lengths 200 – 400 meters)
- II. Twin bundled ACSR MOOSE (-Dependent on detail design, may be used for span lengths greater than 400 meters)

Conductor maximum operating temperature: 80°C.

Ground wire configuration: Optical fiber Ground Wire (OPGW) Single Mode 24 core for the first circuit and one galvanized 7/3.35 mm steel earth wire for second circuit.

Stringing: Both sides strung

Right Of Way width: 30 meters

Typical Span Length 200 - 400 meters

Transmission Line Crossings include but are not limited to;

Five (5) Major River Crossings

Three (3) Highway Crossings

11kV – 33kV Distribution overhead Crossings

1.4.1 System Operating Electrical Parameters

Rated service voltage: 220 kV

Highest system voltage: 245 kV

Number of phases: 3

Sub conductors: Two (2) subconductors per phase

Frequency: 50 Hz

MVA Rating: 227.4 MVA

Minimum Corona extinction voltage at 50 Hz AC system under dry condition:

154 (Min) kV (rms) phase to earth

Radio interference voltage at one MHz for phase to earth voltage of 154 KV under dry condition:

1000 (Max) Micro Volts

The Contractor, with an appropriate insulation coordination study, shall verify the following values are appropriate:

Impulse voltage withstand level: 1050 kV (peak)

Power frequency withstand voltage (Wet): 460 kV (rms)

1.4.2 Climatic Operating Conditions

All plant and equipment supplied under the contract shall be entirely suitable for the climatic conditions prevailing at site. Between June and August low-lying areas are subject to flooding.

Atmospheric pollution level: Low-Light

Maximum ambient shade temperature: 50 deg. C

Minimum ambient shade temperature: 0 deg. C

Annual average temperature: 32 deg. C

Maximum wind velocity for line design purpose: 34.4 m/sec

Rainfall: 1,000 mm/annum

Monsoon season: June-August

Relative humidity: Maximum: 100 %, Minimum: 20 %

Altitude Maximum: 1200 MSAL (Meters Above Sea level)

Minimum: 100 MSAL

No ice or snow expected

Isokeraunic level (thunderstorm days): 60

1.4.3 Seismic Condition

All structure shall be designed with the seismic factor 0.15g.

The information in this Clause is given solely for the general assistance to Bidders and no responsibility for it will be accepted nor will any claim based on this Clause be considered.

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

- I. The Contractor shall be responsible for surveying, boring, geologic and subsoil conditions for all foundations as specified in Price Schedules, and for the precise location of the towers under this Project.
- II. The Contractor shall be responsible for all the necessary soil tests and measuring the earth resistivity at every tower locations. The Contractor shall perform the design of ground grid of all foundations.
- III. The Contractor shall locate, and record on the construction drawings, all interfacing utility lines or other obstructions. Damage to existing line or equipment shall be avoided. If any such damages occur, the Contractor shall repair and make good such structures at his own expenses.
- IV. Transport Facilities and Transportation to Site

Distribution of the material to the work sites may be affected by road. Any necessary access roads from public highways, over which the Contract works are to be transported, will be the Contractor's responsibility.

1.5 Codes and Standards

1.5.1 Applicable Standards

All equipment, materials, fabrication and tests under these Specifications shall conform to the latest applicable standards, manuals and Specifications contained in the following list or to equivalent applicable standards, manuals and Specifications established and approved in the country of manufacturer, and approved as equal by Employer. Any details not specifically covered by these standards and specifications shall be subjected to approval of the Employer.

Acronym	Organisation
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standard Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
BS	British Standard Institution
IEC	International Electro-technical Commission
IS	Indian Standard
NEMA	National Electric Manufacturers Association
IEEE	Institute of Electrical and Electronics Engineers
JIS	Japanese Industrial Standards
DIN	Deutches Institut fur Normung
ITU-T	International Telecommunication Union
NEA	Nepal Electricity Authority
EIA	Electronic Industries Alliance
TIA	Telecommunications Industry Alliance

Indian Standards may be used instead of applicable American and British Standards.

1.5.2 General Requirements

All plants and equipment supplied under this Contract shall conform to or be of higher quality than the latest applicable standard.

If the Specifications contained in this Contract conflict in any way with any of the reference standards, the Specifications shall take precedence. If there are conflicts between different specified reference standards covering the same material or equipment, the standard, which will provide the highest quality and most suitable application as determined by the Employer, shall prevail.

References to standards or to equipment of a particular manufacturer shall be regarded as followed by the words "or equivalent" except as otherwise noted. The Contractor may propose alternative standards, or equipment that shall be equal to those specified unless the system requires specific equipment, as mentioned in the specification, to ensure compatibility. If the Contractor for any reason proposes alternatives to or deviations from the above standards, or desires to use equipment not covered by the above standards, the Contractor shall state the exact nature of the change, the reason for making the change, and shall submit, for the approval, relevant specifications of the equipment in the original language, and in case that these specifications are written in language other than English, the English version shall be attached and shall govern. The decision of the Employer in the matter of

equality will be final. In spite of whatever stated above, where specific manufacturer have been mentioned, equipment from only those manufacturers shall be supplied/used, and equipment from a collaborated of the same shall not be acceptable.

Notwithstanding the above, if the specification calls for equipment of specific manufacturers, only those manufacturers, which are specified, shall be acceptable to the Employer. Also, manufacturers having collaboration with the specified manufacturers will not be accepted.

1.6 Assistance by the Employer

The Employer will give assistance to the Contractor as much as possible in the following:

- (a) Facilitating access to all locations involved in carrying out the works.
- (b) General guidance to the Contractor for all negotiations with the Authorities in Nepal.

This assistance will be provided without any obligations, legal or otherwise.

1.7 Access to the Line and Right of Way

Right of way and way leave clearance shall be arranged by the Employer in accordance with Contractor Execution Plan. Employer will secure way leave and Right of way in the Forest area. The responsibility of the Employer shall be limited to securing the Right of Way, compensation of land acquisition and permanent structure. All other responsibilities shall be of the Contractor as mentioned in this Specification. Details of the Right Of Way shall be prepared by the Contractor as mentioned in this Specification.

1.8 Contractor Execution Plan

After award of the contract, the contractor shall submit a detailed plan for resources mobilization & execution of various activities under the project. 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 allowed to be changed without the consent from THL, once deployed. The work at site shall be carried out after permission from the Site-in-charge and with proper consent of land owners and forest officials

1.9 Environmental Mitigation Measures

1.9.1 Physical Environment

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

1.9.1.1 Changes in land use and landscape

Construction activities must be planned and approved prior to commencement of work. The construction material will be stored only at the designated areas and the haphazard dumping of any construction spoils or wastes, including water is strictly prohibited. Random discharge of cement slurry, garbage and other solid wastes generated by the construction activities and workforce will be avoided where possible.

1.9.1.2 Disposal of the construction spoils

The excavated material will not be left haphazardly. It must be levelled on the ground. Furthermore, the excess disposal material generated which cannot be levelled on the ground will be carried out to the acquired land for transmission line/substations.

1.9.1.3 Stockpiling of the construction materials

The Contractor must negotiate with the owner of the property for the use of their premises for stockpiling even for short periods.

1.9.1.4 Nuisance to the nearby properties

Although some nuisances may be unavoidable, the Contractor will have to minimize such nuisances. The Contractor will have to work in close-coordination with local community while working in the settlement areas.

1.9.1.5 Impact on the infrastructure

The Contractor shall ensure that there will be no interference with the existing infrastructure including utility facilities during construction.

1.9.1.6 Change in air quality

Though change in water quality is unlikely during construction activity, Sprinkling of water on gravel roadways shall be carried out by the Contractor at least once a day during dry season.

1.10 Socio-economic and Cultural Environment

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

- a. Loss of farmland and other category of land:
Any damage to the farmland by the construction activity will have to be restored and rehabilitated.
- b. Occupational safety and hazard:
The Contractor will provide appropriate training in handling equipment and machinery to the workers and labourers before construction. All workers employed by the Contractor shall be insured against accidents.
- c. Loss of standing crops:
The Contractor shall make compensation for the loss of standing crops due to project activities.
- d. Employment of project affected people:
Priority will be given to the project affected people while hiring workers and labourers during project construction. Nepal being a signatory to the International Convention against Child labour, the Contractor shall not employ child labourers in construction.

1.11 Terminal Points

Tanahu Hydropower Project Gantry Structure

The 220 kV Damauli - Bharatpur Transmission Line shall be started from a gantry structure at the Tanahu Hydropower Project. The gantry structure shall be supplied by others.

The responsibility for installing the termination span conductors including supply of insulator, hardware and overhead shield wire dead-end clamps and jumper cables shall be with this Contractor.

The transmission line Contractor shall also be responsible for supply and installation of OPGW, including dead-end clamps and a junction box. Others (-the Substation Contractor) will carry out installation of optic Fiber cables from the junction box on the gantry structures to the respective communication equipment in the control building.

MCTPL Quad Tower

The MCTPL project will supply and erect a four (quad) circuit tower after AP39. It is in the Contractor's scope to terminate the 220kV Damauli - Bharatpur Transmission Line conductors and ground wires, and supply all termination hardware including splice box for installation on to the quad circuit tower.

1.12 Variation in Quantities of Work

The Quantities listed in the Schedule of Prices represent the estimated quantities for bidding purpose only. The Contractor shall carryout site survey, detail design and shall submit final bill of quantity for approval after completion of detailed survey and design works. The actually required quantity may vary from the quantity as listed in price schedule. The Contractor shall agree to make no claim for anticipated profits or for alleged losses because of any difference between the quantities actually furnished and installed and the estimated quantities as indicated in these Bidding Documents.

1.13 Specification Drawings

The drawings issued by the Employer with the Specification and forming part of the documents for Bidding 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 fulfil the requirements of the Contract works covered by this Specification. Prior to detailed design, the Contractor shall investigate the site, check all drawings and parameters and design accordingly without additional cost to the Employer.

Any omission from both drawing and the Specification or any expressed reference to any detail, or work necessary and obviously intended, shall not relieve the Contractor from his responsibility to include that detail of work in his supply and price.

1.14 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 Bidders and included in the 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 earthworks, concrete and reinforcement steels.
- Conductor tension clamps and jumper terminals.
- Ground wire tension clamps and jumper terminals.
- Insulators.
- Suspension Insulator strings and clamps with all fittings.
- Tension Insulator strings and clamps with all fittings.
- Vibration dampers.
- OPGW, Suspension assembly for OPGW, and Tension assembly for OPGW
- Corona control rings/grading ring attachment to conductor and other small accessories
- 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. Structures and drawings should have provisional dimensions of principal members, and shall indicate the necessary clearance to be maintained 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 temperatures 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 Documents and be signed both by the Employer and the Contractor for identification purposes.

1.15 Contract Drawings and Documents for Approval

1.15.1 General Requirements

Unless otherwise specifically mentioned, the drawings and data pertaining to the Works shall be according to this Sub-Clause.

- i. All drawings shall be prepared in AutoCAD and the Contractor shall submit 3 sets of such electronic drawing files in Compact Disc to the Employer.
- ii. The Contractor shall submit at least 3 No. copies of Construction Drawings for approval and other design documents/programs, etc. to the Employer. The Employer will instruct the detail procedures for submission of each kind of drawings/documents for approval after signing of the Contract.
- iii. The Contractor shall submit the drawings and data to the Employer's Representative for approval in the following manner and in accordance with the designated deadlines.

Table 1.15.1-1 Submittals for Equipment Supply and/or Installation Work

Item	No. of Copies	Deadline and Remarks
Construction Execution Plan	3	Within 30 days from the date of signing of Contract
Principal equipment drawings for approval	5	Within 90 days from the date of signing of Contract
Principal installation drawings for approval	5	Within 120 days from the date of signing of Contract
Revised drawings for approval	5	Within 30 days after receiving drawing for revision
Final drawings with reproducible copies	6(1)	Within 30 days after receiving approval
Auto CAD files of Final Drawings in Compact Disc	3	Within 30 days after receiving approval
Final PLS Cadd Model with PLS Tower M4 structures on Compact Disc	3	Upon completion of detail design and issuance of Final drawings
Schedule of manufacturing and transportation	3	Within 30 days from the date of signing of Contract
Plan for Shop tests	3	Not less than 45 days before testing
Results of shop tests for approval	5	Upon Completion of tests
Records of shop tests	5	Upon approval of results of shop tests

Plan for field-tests	3	Not less than 15 days before testing
Reports for field tests	5	Within 7 days after completion of each test
As-built drawings	5(1)	Within 30 days after completion of Installation work
Auto CAD file of As-built drawings	3	Within 30 days after completion of installation work
Proposed Construction programme	3	45 days before commencement of installation work
Proposed Constructability and Outage programme	3	45 days before commencement of installation work
Instruction manual and drawings with reproducible copies for Installation	5(1)	30 days after shipment of equipment

Table 1.15.1-2 Submittals for Civil Works

Item	No. of Copies	Deadline and Remarks
Detail Construction Schedule & Method	3	Within 30 days from the date of signing of Contract
Drawing for approval (Principal drawing for construction)	5	Within 90 days from the date of signing of Contract
Revised Drawing for approval	5(1)	Within 15 days After receiving drawing for revision
Auto CAD file of approved drawings in Compact Disc	3	Within 15 days after receiving drawing for revision
Reports of Field Tests	4	Within 7 days after completion of each test
As-built drawings	5(1)	Within 30 days after completion of construction works
Auto CAD file of As-built drawings in Compact Disc	3	Within 30 days after completion of construction works

Table 1.15.1-3 Other Submittals

Item	No. of Copies	Deadline and Remarks
Detailed Technical Daily Progress Reports with photographs and billable items as per Estimate Table	3	Daily on commencement of Construction
Monthly Progress Reports with photographs	3	By 10th of following month
Packing list (copy)	5	At each shipment

Invoice (copy)	5	At each shipment
Bill of lading (copy)	5	At each shipment
Certificate of origin (copy)	1	At each shipment

Note: Numbers in parenthesis represent the number of reproducible copies required.

1.15.2 Drawings: Titles and Sizes

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

Tanahu Hydropower Limited

220 kV Transmission Line Project of Tanahu Hydropower Project

Contract No. _____ Item No. _____

Brief Description:

The size of the drawings except otherwise specified in the Specification shall be any one of the Following sizes.

- A0 841mm x 1189mm
- A1 594mm x 841mm
- A2 420mm x 594mm
- A3 297mm x 420mm
- A4 210mm x 297mm

1.15.3 Drawing Requirements

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 Employer's Representative for approval.

Should the Employer's Representative 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 drawings modifications.

The Contractor shall submit the following drawings and data to the Employer's Representative for approval:

1.15.3.1 Survey Drawings

- i. Final route maps.
- ii. Optimized tower-spotting drawings.
- iii. Soils survey map, identifying foundation types selected for each individual tower.

1.15.3.2 Tower Drawings

- i. Detailed design drawings and calculations for each type of tower and leg extension; tower loading calculations and diagrams.
- ii. Detailed design drawings including tower framing, size and length of each member; holes spacing in each member; number, size and lengths of bolts and fillers at each joint; detail

of bolts, nuts, lockouts, fillers, washers and spring washers; and details showing attachments of insulator assemblies, overhead ground wire assemblies and tower signs.

1.15.3.3 Other Drawings

- i. Proposed procedure for applying loads and measuring deflections and other pertinent data during tower tests.
- ii. Tower foundation drawings consisting of design drawings, calculations, volumes and weight of reinforcement steel.
- iii. Each type of glass/porcelain insulator string assembly with all fittings.
- iv. Conductor and Ground wire accessories consisting of sleeves, splices, vibration dampers, patch rod, etc.
- v. Detailed drawings of grounding materials and ground connection consisting of ground electrodes, ground connecting strip, ground connecting bolts, counterpoise and list of ground electrodes for each tower.
- vi. Initial sag and tension tables for conductors and overhead ground wire including details of calculations necessary for stringing.
- vii. OPGW suspension and tension assembly, and accessories.

1.15.3.4 Drawing Submission Deadlines

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

- i. Work Schedule: Complete work schedule within 30 days after signing of contract.
- ii. Survey: Survey maps with tower spotting / sag plotting and other details of each sector, 3 sets within 30 days after completion of survey of each sector.
- iii. Towers: Design drawings and calculation for each type of tower and body extension: 5 copies within 120 days after completion of survey works.

Detail drawings for each type of tower and leg extension:

5 copies within 60 days after approval of design drawing.

Bills of materials:

4 Copies within 30 days before each shipment.

Test procedures:

- iv.
- v. Towers: 4 copies not less than 60 days before the date fixed for test.

Insulators, hardware and fittings:

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

Sub-soil tests:

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

Ground electrical resistance:

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

OPGW tests:

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

- vi. Tower foundations & Grounding:
 - a. Design drawings and calculation for each type: 5 copies within 120 days after completion of survey works.
 - b. Detail drawings for each type: 5 copies within 120 days after completion of survey works.
 - c. Foundation list: 5 copies within 30 days after completion of sub-soil tests and foundation design.
 - d. Tower grounding: 5 copies detail drawings within 60 days after the signing of Contract.

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- e. List of ground electrodes: 5 copies within 30 days after complete ground resistance tests
 - f. Drawings and/or catalogues of insulators, hardware and fittings: 5 copies within 120 days after completion of survey works.
 - g. Detailed drawings of grounding materials and ground connection consisting of ground electrodes, ground connecting strip, ground connecting bolts:
 - h. 5 copies within 120 days after completion of survey works.
 - vii. Modified approval drawings:
 - a. 5 copies within 30 days after receipt of returned drawings and data for correction.
 - viii. Final drawings:
 - a. Prints of design drawings and calculation for all surveys, towers, tower foundations and stringing work:
 - b. 6 copies of each within 30 days after receipt of approved drawings.
 - ix. As-Built Drawings:
 - a. 5 copies (1 reproducible additionally) of all drawings, list of materials and tower schedules after the issuance of the Completion Certificate.
 - x. Electronic Copies (CD's):
 - a. 3 copies of all drawings in AutoCAD format, list of materials and tower schedules in Excel format after the issuance of the Completion Certificate.
 - xi. Test reports:
 - a. Shop tests and field tests:
 - b. 5 copies immediately, but not later than 15 days after completion of tests.
 - xii. Instruction manuals and lists of operation and maintenance tools:
 - a. 5 sets not later than 30 days before Completion Certificate

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.

1.15.4 Employer's Approval

The Employer or the Employer's Representative will approve each drawing within thirty five (35) days after receipt at his office. One print of each of the drawings submitted for approval will be returned by the Employer or the Employer's Representative marked either "APPROVED" or "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 thirty five (35) days in the same manner as before.

Approval of the Contractor's drawings (including cases of un-noticed/unknown deviations) 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 ultimate responsibility of meeting all the requirements of technical specifications shall rest on the Contractor.

All final as-built/approved drawings shall be provided to the Employer in CD ROM.

1.16 Quality Control

1.16.1 General

The Contractor shall provide and maintain a quality control program to ensure compliance with quality standards of the Technical Specifications. Within 30 days from the date of signing of the Contract, the Contractor shall furnish to the Employer three (3) copies of his complete quality control procedures, manual, and a description of the quality control organization.

The Employer will monitor the Contractor's methods, procedures and processes for compliance with the quality control program and the quality standards of these Specifications. Failure of the Contractor to effectively maintain the quality control program throughout all phases of the work will be considered a failure to execute the work with the diligence required by the Contract documents.

1.16.2 Inspection of Transmission Line Works

Items for the Inspection of Transmission Line works and estimated Man-Day for the inspections are listed below, but not limited to:

The days of inspections period may be adjusted after award of Contract.

Table 1.11.2-1 Man-days for Employer and Engineer Inspections

No.	Equipment	No. of Inspectors and No. of Days			
		Shop Inspection ^[1]		Site Inspection ^[2]	
		Inspector s	Days	Inspector s	Days
1	220kV Transmission Line Facility				
1.1	Steel structure and fitting parts assembly	2	7	1	4
1.2	Conductors	2	7	1	2
1.3	Ground wires	2	7	1	2
1.4	Insulator	2	7	1	2
1.5	Associated hardware	2	7	1	2
1.6	Optical Fiber Ground Wire (OPGW)	2	7	1	2
Total man-days		12	42	6	14

Notes:

- Shop Inspections monitor during the material and manufacturing process.
- Site Inspections monitor at delivery to Site.
- The above quantity is for bid purpose only and will be changed subject to actual situation.
- All necessary arrangement for the inspections shall be executed by the Contractor with coordination to the Inspector.
- The days include round trip days to the relevant place for each inspection from the home country of the Inspector.

1.17 Spare Material

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

1.18 Technical Requirements

1.18.1 Galvanizing

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

An approved process shall galvanize all steel wires 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 speller.

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 effect repair by approved methods. The agreement to attempt repair shall not bind the Employer to accept the repaired part when this is re-offered for inspection.

The Contractor has the responsibility to take care and protect properly all material on the shipment overseas.

1.18.2 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 ISO 898-1. Nuts and heads of all bolts shall preferably 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.

Samples of the bolts used to affix lattice tower members should be independently hardness tested by the Contractor to show conformity to ISO 898-1. Results of the bolt hardness test shall be sent to the Employer at his Project Office.

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 with the results of the bolt hardness test at his Project Office for approval within one month of the date of issuing the sub-order. The Employer will then reject bolt consignments, which fall in any respect below the standard of samples submitted and approved.

1.18.3 Castings

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

1.18.4 Welding

In all cases where fabrication welds are liable to be highly stressed, such as may be the case in parts subjected to reversals of stresses in operation, the Contractor is to supply the Employer with a general arrangement drawing of the fabrication and, at a later date but before fabrication commences, a detailed drawing of all proposed weld preparations on the fabrication.

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

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

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

In the event of the Contractor wishing to make an alteration to 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.

1.18.5 Labels, Ratings, and Nameplates

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 subject to the approval of the Employer.

Labels using adhesive backed plastic materials will not be permitted.

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

1.19 Guarantee for Materials and Workmanship

The Contractor shall guarantee that materials incorporated into the Work are unused and the best of their respective kind for the service intended, and that all items will be free from inherent defects in workmanship and material, and that all equipment and its components will operate successfully at all capacities up to and including the maximum specified load without undue noise, heating, straining of parts, wear and vibration and that an ample safety factor is included in every design.

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, cables, 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.

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

The whole of the Works supplied under the Contract shall be subject to inspection and test by the Employer or their Representatives during manufacture, erection and after completion. The inspection and tests shall include, but not be limited to, the requirements of this chapter of the Specifications.

The Contractor shall provide all costs, appliances, apparatus, supervision, labour and services necessary to carry out all tests, unless specifically stated otherwise.

2 Detailed Survey and Preliminary Works

2.1 Survey Work

The Contractor shall be responsible for undertaking a detailed survey of 220kV Damauli - Bharatpur Transmission Line.

Preliminary data of the preferred transmission line route and tower schedule for 220kV Damauli - Bharatpur Transmission Line have been prepared by the Employer in the Route Alignment Survey report. However, this data shall be used for provisional and informational use only.

The Contractor shall visit sites and prepare and optimize the transmission line route, shall identify tower locations, and determine types of towers, all based on results of his detailed survey. The quantities given in the Price Schedule are provisional only and the Contractor shall finalize the quantities after actual site survey.

All important objects and features along the transmission line centerline (railways, highways, roads, canals, rivers, transmission lines, distribution lines, telephone lines etc.) shall be surveyed. The survey works shall be performed by qualified and experienced personnel and supervised by qualified surveyors. Not less than 15 days prior to commencement of work, the Contractor shall submit qualification of surveyors, work program and list of surveying equipment for approval of the Employer.

2.1.1 Route Marking

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

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

2.1.2 Profile Plotting

From the field book entries, the route plan with en-route details and level profile shall be plotted and prepared to scale of 1:2000 horizontal & 1:400 vertical on the paper having grid of 10mm x 10mm as per approved procedure. Reference levels at every 20 meters along the profile are also to be indicated on the profile besides 15 meters Right and Left on either side of the center line of the alignment. Areas along the profile sheet, in the view of the contractor, are not suitable for tower spotting, shall also be clearly marked on the profile plots. If the difference in levels be too high, the chart may be broken up accordingly to requirement. A 10mm overlap shall be shown on each following sheet. The chart shall progress from left to right having width of Sheet 594 mm wide. For 'as built' profile these shall be in A1 size.

2.1.3 Sag Template

All sags used in construction sagging activities will be prepared in a sag table generated from PLS-CADD. Additionally, the Contractor shall prepare a Sag template curve drawing based upon the actual ruling span achieved in the tower spotting and submit the same along with sag and tension calculations for the approval of the Employer. The physical sag template prepared based on the approved sag-template curve drawing shall only be used for checking tower spotting on the profiles.

Two numbers of the approved template, prepared on rigid transparent plastic sheet, shall be provided by the Contractor to the Employer for the purpose of checking the tower spotting and subsequent use in line maintenance. The templates shall be on the same scale as that of the profile.

Tower Spotting

All towers will be spotted in PLS-CADD software with the following requirements:

2.1.3.1 Maximum allowable consecutive Spans

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

2.1.3.2 Extension

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

2.1.3.3 Loading

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

The towers shall be able to withstand all design loads with only one circuit strung on the line (i.e. one side strung, one side vacant).

2.1.3.4 Road Crossings

At all important road crossings, the tower shall be fitted with double suspension or tension insulator strings depending on the type of tower. The overhead clearance at the roads under maximum conductor design temperature and in still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces will not be less than 8.5m.

2.1.3.5 River Crossings

In case of major river crossings, clearance required by navigation authority shall be provided. For non-navigable river, clearance shall be measured with respect to highest anticipated flood level (HFL). Survey made to edge of river bank.

2.1.3.6 Power Line Crossings

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

2.1.3.7 Telecommunication Line Crossings

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

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

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

2.1.3.8 Details Discovered En-route

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

2.1.4 Clearance from Ground, Building, Trees etc.

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

The Contractor shall check the minimum clearance of conductor crossing the existing highways, major waterways, power and telecommunication lines, etc.

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

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

The trees list should contain the following:

- Girth (circumference) measured at a height of 1 meter from ground level.
- Approximate height of the tree with an accuracy of +2 meters.
- Name of the type of the species/tree.
- The bushy and under growth encountered in the 40M belt (20 meters on either side of the alignment) should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.

2.2 Survey Report

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

Information with respect to infrastructure details available en-route, identification and explanation of route constraints, etc shall also be furnished in the Survey report and shall include but not be limited to:

1. Information regarding infrastructural facilities available along the final route alignment like access to roads, railway stations, construction material sources (like quarry points for stone, sand and

availability of construction water), labour, existing transport facilities, fuel availability etc. shall be furnished in the survey report.

2. All observations which the Contractor thinks would be useful to the construction of the transmission line mentioned under the scope of work are to be reported.
3. Suggestions regarding the number of convenient zones (line segments /portions) in which the entire alignment can be divided to enhance constructability are to be given.
4. Suggestions regarding location for setting up stores (laydown) area during line construction in consultation with Employer's representative shall also be provided by the contractor.
5. Working months available during various seasons along the final route alignment, with period, time of sowing & harvesting of different type of crops and the importance attached to the crops particularly in the context of way leave problems and compensation payable shall be stated by the Contractor.
6. Availability of labour of various categories and contractors of civil works shall also be reported.
7. Some portions of the line may require clearance from various authorities. The Contractor shall indicate the portion of the line so affected, the nature of clearance required and the name of concerned organizations such as local bodies, municipalities, Inland navigation, Irrigation Department, Power Utilities and Divisional Forest/wild life Authorities etc. All safety regulation i.e. statutory requirements of Govt. of Nepal shall be complied to by the Contractor during routing/survey/construction of the transmission line through patches of dense forest/wild life.
8. All the requisite data for processing the case for statutory clearances shall be provided along with the report.
9. The Contractor shall also collect & report details pertaining to pollution levels envisaged along the transmission line.
10. Three copies (3) of survey reports shall be furnished by the Contractor to the Employer.

2.2.1 Check Survey for Tower Location

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

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

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

2.2.2 Land Parcels

2.2.2.1 Land Parcel Identification

The Scope of work of "Check Survey" also includes the identification of the land parcels and permanent structures owned by public as well as private individuals on the Right of Way of Transmission Line (ROW is 15m on either side of the entire length of the Route Alignment). The Contractor shall mark the tower locations showing its boundary covering all four foundation pads and submit the details of affected Land Parcel numbers along with their areas for all tower locations to the Employer after the approval of Check Survey. Preliminary information of land plot number and owner names were prepared during the route alignment survey which is included in Route Alignment Survey Report in Supplementary Information section. The Contractor is responsible to verify the details, which should include land plot number, and owners name and addresses as obtained from the records of Land Revenue Office (Maalpot) and Survey Division (Naapi Sakha) of the concerned districts. It will be the responsibility of the Contractor to hire the Land Surveyors (Amin) and other

required manpower, survey instruments & accessories, cadastral maps and collect the required information as mentioned herein above.

2.2.2.2 Tower Footing Land Acquisition

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

2.2.2.3 Re-Identification of Land Plots

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

2.2.2.4 Land Acquisition Process

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

2.2.2.5 Land and Structure Costs

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

2.2.2.6 Loss of Standing Crops

The Employer shall make compensation for the loss of standing crops due to project activities. However the Contractor shall assess the quantity of such losses and forward the Employer with the necessary field measurements to substantiate timely compensation to the owners.

2.2.3 ROW Clearance (Forest)

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

2.2.3.1 Tree Marking Process

The Employer shall forward the report to the Forest Office and shall initiate the process of getting approval for felling of trees. Upon approval on the report from the District Forest Office, Contractor shall initiate the process of marking (which is termed as "TANCHA") of the trees in coordination with the concerned District Forest Office.

2.2.3.2 Forest Clearing

After process of marking (TANCHA) of the trees by the Contractor, the Employer shall clear the forest in the Right of Way.

2.2.3.3 Per Diem Allowances

The per diem allowance of forest technician/guards etc. as deputed by District/Community Forest Office during taking detailed log of the trees shall be paid by the Contractor as of actual man days involved in the works.

2.2.4 Payment

The cost of Detail survey including route alignment, profiling and Check survey including tower spotting works shall be included under the item Survey in the Price Schedule at the respective unit bid price.

2.3 Design Tasks and Deliverables

Design Improvements

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

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 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.

Design Review Meeting

The contractor will be called upon to attend design review meetings with the Employer, and the Project Supervision Consultants of the Employer during the period of Contract. The contractor shall attend such meetings at his own cost at the Corporate Office of the Employer or at mutually agreed venue as and when required. A weekly meeting shall be set up between the Contractor and Employer to review Design and Construction issues.

Design Deliverables

It is expected that the Contractor perform the following tasks and provide a complete Engineering Design Package comprised of but not limited to the following:

- 1) A Google-pro version (i.e. kmz file) of surveyed alignment
- 2) Shall be submitted by the Contractor to the Employer/PSC.
- 3) Field verify phasing, and provide phasing diagram on Plan & Profile Drawings

- 4) Tanahu Hydropower Station gantry structure design loadings to be given to Package 2 Contractor
- 5) Avalanche containment mitigation plan
- 6) Verification that either the topology of the project area does not make the transmission line susceptible to galloping or that the effects of single and double loop galloping is mitigated
- 7) A report summarizing whether conductor blow out will impact vegetation or other obstructions located along the ROW edge and a recommendation whether addition ROW is required in specific areas.
- 8) Proof of aeronautical inquiry to determine design limitations and permits as required based on results
- 9) Foundation Design and Rock Quantity analysis
- 10) PLS-CADD design *.bak file comprised of PLS Tower M4 structure models
- 11) Verify Line Design meets the lightning performance requirements
- 12) Plan and profiles indicating splice locations, key points of interest, and constructability input
- 13) Stake and field review all critical structure locations. Document determination for final structure placement at these locations.
- 14) Vibration Damper placement analysis and table
- 15) Galloping Device placement analysis and table (if deemed to be required)
- 16) Staking Table including location of centroid of structure and tower footings
- 17) Crossing drawings for roads, utility crossings, river/waterway, Rail road, etc.
- 18) Material Order for special and long lead time materials.
- 19) Prepare list of conductor and grounding assemblies
- 20) Prepare Design/Work Location notes as needed for each structure location
- 21) Based on soil resistivity results, pre-design structure grounds
- 22) Determine the location of known utilities within proposed transmission line path
- 23) Verify location and depth of underground facilities in proximity to tower locations

Preliminary Tower Schedule PLS-CADD Model

A functional PLS-CADD model inclusive of PLS Tower Method 4 structure models along with profile sheets, duly spotted, preliminary schedules indicating type of towers, type of foundations, wind span, weight span, and angle of deviation, river / road crossing and other details shall be submitted for the approval of the Employer.

The line design should be accomplished using all 3-D Tower modelling with PLS-Tower in PLS-Cadd Version 12.0 or newer (full version with SAPs) with the survey data obtained during detailed survey and further refine during check survey at all or any tower locations or section thereof as would be required during different stages of the project implementation as per direction of the Employer.

Detailed design for 3-D analysis of Towers includes:

- 1) Modification of electrical clearance diagram.
- 2) Design/modeling of different combination of leg and body extensions
- 3) Wire clearance diagram for gantry take off tower.
- 4) Design of jumpering/ jumper drop for actual span and profile.
- 5) Design of new foundation with respect to different soil parameters and actual/prescribed loading.
- 6) Hill side leg extension (positive and negative) and Truncations proposed.
- 7) Line schedule and Insulator/Jumper swing calculations.

After approval the Contractor shall submit four more sets of the approved reports along with three soft copies on CD of a fully functional PLS-CADD model inclusive of PLS Tower M4 structure models and final profile drawings to the Employer for record purpose. The PLS-CADD model and Method 4 structures must be fully functional and absent of program errors.

2.4 Right-of-Way and Access

2.4.1 Land Schedule

The Contractor shall confirm the land schedule of the given line route prepared by the Employer and shall prepare schedule of land under tower foundation to be permanently acquired and under the right of way to be compensated for private ownership land and same for government owned land.

2.4.2 Routes, Right-of-Way and Access

The Employer shall be responsible for acquisitions for tower footing area and compensations for right of way area.

The necessary right of way for the lines to enable the Contractor to carry out stringing and erection will be obtained by the Employer.

The Contractor will not be reimbursed for waiting time caused by delay in obtaining right of way unless he has established on site in advance of obtaining the right of way on the direct request of the Employer's Representative. Where partial right of way only is granted, the Contractor shall program his work accordingly.

The Contractor shall make all necessary arrangements for the access roads and/or temporary land used with the landowners, before going onto private land; but if any, difficulty arises, the Contractor shall promptly inform the Employer's Representative. Such arrangements shall be at least one month in advance of the desired access date, to allow time to clear any difficulties. The Employer shall be kept informed of all negotiations and successful arrangements.

At any early stage of the Contract, the Contractor shall arrange all proposed points of access and, after the approval of the Employer; the Contractor shall prepare maps for submission to the Employer for the settlement of way leave arrangements. No other access shall be used without the prior consent of the Employer.

It shall be clearly understood by the Contractor that the cost of construction of access roads and delivery of construction material to erection points shall be deemed to be included in the bid price and the Contractor shall have no claim whatsoever to extra payment for construction and maintenance of access as may be required.

2.4.3 Clearing General

Clearing shall include removal and disposal of all trees, bushes, down timber, tree roots, debris, indicated structures and other obstructions from the areas to be occupied by permanent works of the Contract, at tower foundation sites.

The Contractor shall be responsible for prevention of damage to structures and other objects, which are not included in the clearing work. No objects of any kind outside the indicated limits of the work shall be removed or damaged. The Contractor shall protect existing utilities, which are not specifically included in the work.

2.4.4 Notices

Before construction commences, the Contractor shall give to the Employer not less than seven days' notice that support positions have been pegged and are available for inspection.

Before the Contractor commences work, he shall obtain from the Employer way leave schedule giving details of any special requirements of the occupiers or Employer concerned.

When the Contractor is about to carry out erection of the conductors along or across power, telegraph or telephone lines, or public roads, he shall give the requisite notice to the appropriate authorities mentioning the date and time which he proposes to perform the work and shall send a duplicate copy of each notice to the Employer. The Contractor shall construct trestles for such line or road crossings. No separate payment shall be made for such works.

The Contractor shall at all times during the execution of the Works, ensure compliance with all such reasonable requirements of the occupier or Employer as are brought to the Contractor's notice by the Employer.

2.4.5 Damage

The Contractor shall take all reasonable precautions to avoid damage to land, property, roads, crops, fences, walls, gates, etc., and shall ensure that the work is adequately supervised so that unavoidable damage is reduced to the minimum. The Contractor will be liable for all damage arising by or in consequence of the works except unavoidable damage to crops and shall pay compensation or make good at the option of the Employer. The Contractor must clean the site and remove all soil and surplus material after erection. The Contractor shall be responsible for any obstructions to the work from the local people, resulting from such un-cleaned sites.

The Contractor will be responsible for payment necessary for agreed passage over private roads, where the Contractor has made arrangements.

2.4.6 Crossing of obstacles

The Contractor shall make all necessary arrangement and take all necessary precautions where the route crosses buildings, power lines, orchards, gardens or other obstacles or ground, over which erection cannot be carried out in the normal manner.

Where the local authorities or other public undertaking affected deem it necessary to make provision for the protection of their employees or property, or of the public, or for the assistance of traffic to provide flagmen or watchmen, the cost of such provision shall be borne by the Contractor. The provision of special scaffolding for purposes of affecting crossings of the route over roads, railways, rivers, telegraph and telephone lines or other similar obstructions as the Employer and/ or the Contractor may consider necessary, shall be the Contractor's responsibility and all costs of such special crossings shall be borne by the Contractor.

Adequate provision shall be made by the Contractor to prevent the straying or damage to livestock during the execution of the Contract Works and until permanent reinstatement of fences, walls, hedges, gates and the like is completed, the Contractor shall be held responsible for any loss or damage due to failure to comply with the above requirements.

2.4.7 Payment

No separate payment shall be made for clearing, cutting and special scaffolding arrangements and access road. Therefore, the Contractor shall include all the cost to be incurred for such works, in the unit bid for construction of foundation, stringing or tower erection.

2.5 Detail Soil Investigation

2.5.1 Scope

This specification covers all the works required for geotechnical investigation and preparation of a detailed report. The work shall include mobilization of necessary equipment, providing necessary engineering supervisors and technical personnel, skilled and unskilled labour and others as required, to carry out field investigations and tests, laboratory tests and analysis and interpretation of data and results, preparation of a detailed soil report including recommendations and providing technical services as and when called for by the Employer. The investigation method shall be as described herein or any other methods approved by Employer giving the same information as needed to ensure that soil parameters are sufficient for reliable foundation design. The Employer shall approve the location for detail soil investigation.

2.5.2 Codes and standards

All works shall be carried out strictly in accordance with the Technical Specifications, unless otherwise approved by the Employer in writing. Where not specified, the latest-edition of one or more of the following codes of practice or any other applicable code shall be followed.

BS 1377 : Methods of Test for Soils for Civil Engineering Purposes

BS 1924 : Methods of Test for Stabilized Soils

BS 5930 : Code of Practice for Site Investigations

BS 6031 : Code of Practice for Earthworks

CP 2004 : Code of Practice for Foundations

Codes equivalent to these in Indian/ American/ DIN Standards can also be used not limited to the following:

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

Indian Standards (IS)	Title	International and Internationally Recognize Standard/Codes
IS: 4434-1992	Code of Practice for in-situ Vane Shear Test for Soils.	ASTM D 2573/ ASTM D 4648
IS: 4453-1992	Code of Practice for Exploration by Pits, Trenches, Drifts and Shafts.	
IS: 4464-1990	Code of Practice for Presentation of Drilling Information and core description in Foundation Investigation.	
IS: 4968- (Part-II)-1992	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry.	
IS: 5313-1989	Guide for Core Drilling observations.	
IS: 6403-1990	Code Practice for Determination of Allowable Bearing Pressure on Shallow Foundation.	ASTM D 194
IS: 6926-1990	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects.	
IS: 6935-1989	Method of Determination of Water level in a Bore Hole.	
IS: 7422-1990	Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant parts).	
IS: 8009- (Part-I)-1993	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations subjected to symmetrical Vertical Loads).	
IS: 8764-1991	Method of Determination of Point Load Strength Index of Rocks.	
IS: 9143-1991	Method of Determination of Unconfined Compressive Strength of Rock Materials.	ASTM D 2938
IS: 9179-1991	Method of Preparation of Rock Specimen for Laboratory Testing.	ASTM D 4543
IS: 9259-1992	Specification for Liquid Limit Apparatus.	ASTM D 4318
IS: 9640-1992	Specification for Split Spoon Sampler.	ASTM D 1586
IS: 10050-1992	Method of Determination of Slake Durability Index of Rocks.	ASTM D 4644
IS: 11315- (Part-II)-1991	Description of Discontinuities in Rock Mass-Core Recovery and Rock Quality.	

2.5.3 Purpose

The purpose, in brief, of the proposed geotechnical investigation is to ascertain the type of substrata such as soil, rock etc., their characteristics and their suitability for the structures proposed to

be built and, to decide on the choice of the type of foundation to be adopted for the type and magnitude of envisaged loading. All the tests that are considered necessary in the opinion of the Employer for this purpose shall be conducted. Any additional tests/ works, change in the number and type of specified tests, revision in the diameter, depth of bore holes, samples to be collected etc. shall be carried out as directed by the Employer.

2.5.4 Calibration of equipment

The Contractor shall ensure that all the equipment/instruments are properly calibrated, at the start of the work, to reflect actual values. If so demanded by the Employer, the Contractor shall have the instruments tested at an approved laboratory at his cost and the test reports shall be submitted to the Employer. If the Employer desires to witness such tests, the Contractor shall arrange for the same at his own cost.

2.5.5 Field work

2.5.5.1 General

It is essential that personnel on this work of geotechnical investigation and laboratory testing should have the appropriate experience. The entire investigation shall be supervised by a suitably qualified and experienced engineer or engineering geologist. All field and laboratory works shall be executed by experienced technicians.

The Contractor shall have, on site, all required survey instruments as determined by the Employer to carry out the work accurately according to Specification and Drawings. The Contractor shall set out all the specified locations for boreholes and field tests at site. At each location of bore-hole, and other field tests, the Contractor shall establish the ground level prior to commencing of the boring operation. The ground level shall be related to an established benchmark.

2.5.5.2 Method of boring

Boring in soil: In soil strata, boring may be carried out by auger or percussion tools or by method approved by the Employer or Employer's representative. Bentonite slurry or mud circulation process can also be used, if permitted. However, for those boreholes, where water samples are to be collected for chemical analysis, bentonite slurry or mud circulation method shall not be used or shall be restricted as directed by the Employer or Employer's representative. The diameter of the boreholes, unless stated otherwise, shall be such as to permit collection of undisturbed samples of 90mm diameter.

Where necessary, boreholes shall be cased and whenever a borehole is cased, the bottom of the casing shall always be maintained within 150mm of the bottom of the borehole. The casing shall never be in advance of the bottom of borehole during undisturbed sampling or standard penetration tests.

(b) Borehole depth: All the boreholes shall be sunk to a depth of 7m at field or as directed by the Employer's Representative. If rock with core recovery greater than 25% is met at an earlier depth, the boring shall be continued for a further depth of 3 meters or more if directed by the Employer.

(c) Sampling: Sequence of sampling: The general sequence of sampling adopted shall be such as to obtain alternatively undisturbed samples at every 1.5-meter interval and at every significant change of stratum. Undisturbed sample wherever possible, shall be collected at every 3.0 meters interval and at every identifiable change of soil formation. Likewise disturbed samples, as obtained in the standard split spoon, shall be collected by conducting the standard penetration test at every 3.0 meters interval and at the significant change of soil stratum.

(d) Undisturbed sampling in boreholes: Samplers used for collecting undisturbed samples in soils shall meet IS, BS or American Standards requirements and shall be appropriate to the type of soil to be sampled. Undisturbed soil samples collected shall be 90mm in diameter and 450mm in length so as to enable laboratory testing.

The area ratio of samplers shall be within the permissible limit and shall not exceed 25 percent for samples of 90mm diameter. The cutting edge of the cutting shoe of the sample shall be tapered at an angle not exceeding 20 degrees and inside clearance ratio shall generally be limited to 0.5 to 1.5 percent. Samples with lower clearance ratio shall be used in soft strata and these with higher clearance ratio shall be used in stiff strata. The cutting edge or shoe of sampler shall be free from rust, pitting, burring or any other defect. The sampler shall be fitted with ball check valve at the upper end.

For clays other than very soft clays open drive samplers are permissible, whereas in very soft clays and in sandy soils, piston samplers with core catcher device or other approved samplers shall only be used. The use of oil inside the samplers in operation shall be limited to minimum practicable.

Before sampling operation, the Contractor shall clean the bottom of borehole very carefully and every care shall be taken to avoid disturbance of material to be sampled. For sampling, the sampler shall be lowered to the bottom of borehole without impact and pressed into the soil in a single continuous movement at a sufficiently slow rate to permit the check valve to pass the water in the tube with creating excess back pressure. In firm material, and whenever approved by the Employer the sample may be driven into the soil; but the sampler shall never be pushed or driven to its full length. After penetration to the required depth, the sampler shall be free from the soil by being rotated by one full turn and then shall be withdrawn.

The sample shall not be removed from the tube but shall be trimmed back from the ends of the tube and the space filled with molten microcrystalline wax, the tube capped with metal or plastic cap and sealed with adhesive tape.

(e) Undisturbed soil samples from trial pits and other sources: The Contractor may be required to collect undisturbed soil samples from trial pits excavations or other sources. These samples may be core samples or block samples and may be obtained with a special orientation as indicated by the Employer. Core samples shall generally be obtained by jacking a thin walled open drive sampler of around 100mm diameter into the stratum. The sample tubes shall be driven if approved by the Employer or Employer's representative. The sample tubes shall be held steady during jacking/driving and a suitable frame shall be used for guiding inclined samplers.

(f) Disturbed soil samples: The material from the cutting shore of the thin walled sampler and from the split spoon sampler of the standard penetration test can be treated as disturbed sample, but will not be paid for separately. All disturbed samples collected shall be placed without delay in an air-tight jar of not less than 0.4kg nominal size and each sample shall fill the jar as far as possible.

Larger disturbed samples may be required to be collected from trial pits or excavations. Each of such samples should be at least 10 kg. Such samples shall be sealed into heavy-duty polythene bags immediately on collection.

(g) Water samples: The Contractor shall take water samples from boreholes, whenever directed by the Employer, before addition of water to the hole. If this is not possible prior to collection, the water level in the borehole shall be lowered by about 0.5m, water allowed to rise by seepage through walls of borehole and then water sample collected.

No water sample shall be taken when bentonite slurry or mud has been circulated in the borehole. The method of sampling shall be such as to ensure that the sample is not contaminated by rainwater, surface water etc. The quantity of sample to be collected is about 1 litre and shall be stored only in approved airtight, clean container. Water samples should be tested as soon as possible after collection.

(h) Numbering of samples: The Contractor shall assign a reference number to each soil and water sample taken from the borehole.

This number shall be unique for that borehole and shall be in order of depth below ground level.

(i) Labelling of samples: All samples shall be clearly labelled indicating job number, borehole number, sample number, date of sampling, brief description of samples, type of sample, elevation of sample etc. and in case of undisturbed samples, the top and bottom of samples shall also be clearly labelled. Each such label shall be pasted on the container and shall also be included in the container.

(j) Transporting and storing of samples: The Contractor shall store properly all the samples at the site till they are transported to his laboratory for testing. All rock cores and samplers with undisturbed soil samples shall be placed in order of their occurrence in strong wooden boxes suitably partitioned and

provided with hinged wooden covers, so that the samples are not damaged during transit by impact or improper handling. To minimize disturbance during shipment, samplers containing undisturbed soil samples shall be packed with wood dust or similar other resilient material and as directed by the Employer or Employer's representative. The Contractor shall transport all samples to his testing laboratory as quickly as possible and test the samples. Samples shall be transported by air, if the stipulated completion period so warrants. All unused and excess samples after testing should be retained and safely stored by Contractor till three months after the end of submission of the report.

2) Specific observations during boring: The observation to be made by the Contractor during boring shall include, but not be limited to the following:

a) Sequence and thickness of different strata: Visual description of each stratum shall be provided.

b) Ground water table: The depth at which groundwater is struck during boring shall be carefully noted and the depth of water table shall be ascertained subsequently in the complete borehole by daily observing the depth for the next six to seven days. Depth of ground water shall also be observed in wells, if wells exist in the vicinity.

"Loss" or "Make" of drilling fluid: The "Loss" or "Make" of drilling fluid if observed during the boring shall be noted and brought to the attention of the Employer or Employer's representative. Attempts shall be made to detect joints, fissures, artisan conditions etc.

Presence of lime, mica. etc. The soil and rock samples shall be examined for presence of lime, mica etc. and shall be recorded, if any. The Contractors rate for boring shall be deemed to include these and all other relevant observations.

3) Submission of field logs: The Contractor shall submit or mail to the Employer as directed, two copies of the preliminary log of each borehole as soon as the borehole is completed.

4) Standard penetration test (SPT): Unless directed otherwise by the Employer or Employer's representative, the Contractor shall carry out standard penetration test at 1.0 meter intervals and at every noticeable change of soil formation and as per the procedure in BS or ANSI or IS. The finest test shall generally begin at 1.0m depth unless an undisturbed sample is collected at that depth, and further test at 2.0m, 3.0m, 4.0 m, 5.0m, 6.0m, and 7.0m depths shall be done.

For conducting the test, the bottom of borehole shall be cleaned properly and the spoon shall be properly and centrally seated in position in the borehole. The derive weight assembly shall consist of a driving head of 65kg weight with 75cm free fall. It shall be ensured that the energy of falling weight is not reduced by friction between the drive weight and guides or between rope and winch drum. Standard connecting rods shall be used.

The test shall be stopped (When the test is not conducted in weathered/Soft rock) when the total blow count including seating drive reaches 120. The corresponding penetration shall be noted. If the total penetration is more than the seating penetration of 15cm, a breakup of blow count for 15cm seating penetration and for the remaining portion of penetration shall also be given.

5) Excavation of trial pits: The Contractor shall excavate trial pits to the depth of 3.0 meters. Relevant tests specified in these pits shall also be carried out. Whether specified or not, in every trial pit, including those excavated for loading tests, tests by "Pocket Penetrometer" and by "Picket" shall be generously carried out at different depths in different strata. Picket test shall be conducted in non-cohesive strata. In this test a wooden picket of dimensions 5cm x 5cm in cross section, with a sharp point and about 70cm long shall be pushed perpendicular to the surface of soil by a force of about 70kg and the penetration of the picket shall be recorded. The test by pocket penetrometer shall be done in soils with cohesive touch and in weathered rock.

6) Backfilling of boreholes and pits: The Contractor shall backfill the boreholes and pits. The borehole shall be back filled by bentonite/mud-cement grout. The cement and bentonite/mud for the

grout shall be in the ratio 1 to 1 by weight and shall be made into slurry with no more water than is necessary for placing the slurry in the borehole. If there is standing water in the borehole, grout shall be placed by tremie. The pit shall be backfilled with proper ramming using the excavated material.

2.5.6 Geological stability of slope

The majority of the transmission line route pass through steep Himalayan slopes with altitudes from 100 meters to 1200 meters above sea level. All the tower locations uphill or downhill of a slope shall be assessed from an engineering geological point of view to ensure the avoidance of landslide prone areas. The study of both short-term and long-term slope stability at tower locations, using an acceptable software, shall be within the scope of the Contractor or the Contractor's specialized soil investigation and geotechnical firm. The Contractor shall identify such tower locations which may have the risk of slope stability and collect topographical and subsoil data and observe any feature or activity in the vicinity which may have an adverse impact on slope stability. The Contractor shall recommend any other type of foundation or protection measures necessary for long-term stability of slope and protection of tower foundation.

A detailed report of all tower locations in steep slope areas addressing short and long term risk of slope stability and recommended mitigation and protection measures shall be submitted by the Contractor with the Geotechnical Report.

2.5.7 Laboratory tests

- a) General: All the laboratory testing shall be performed by qualified and experienced personnel, familiar with and having access to equipment and facilities for the accurate determination of data necessary for requirements under this specification.
- b) Independent laboratory: The Employer reserves the right to have the samples tested in an independent laboratory. If the Contractor is directed to get the samples tested in an independent laboratory, he shall be paid only the actual cost of such tests.
- c) Program for testing: The Employer or Employer's representative will direct Contractor on samples to be tested and on type of test to be conducted. The Employer or Employer's representative is not bound to furnish this information at the beginning of the investigation itself but shall instruct the Contractor at an appropriate time during the course of the investigation. In case of clayed soil, tri-axial compression test on undisturbed soil samples shall be carried out.
- d) Standards for testing: The Contractor shall test the samples as per the relevant BS, ANSI, IS or directed by the Employer.
- e) Access to the laboratory: The Employer shall have the right of access to Contractor's Laboratory or other Laboratory where tests have been arranged to be carried out during the progress of this investigation.
- f) Submission of test data and results: The Contractor shall submit when demanded by the Employer, preliminary copy of the data and the computed results of the tests he has conducted. However, the final report shall contain all the experimental data and the results.

2.5.8 Geotechnical Report

1. General

The Contractor shall submit his report in two separate volumes;

Volume I shall be the main body of the report containing geological history of the site summarized test data, observations, conclusions and recommendations.

Volume II shall be in the form of appendix and shall contain actual field and laboratory observations, calculations of test results, supporting calculations for the recommendations made etc. Initially, the Contractor shall submit these volumes to the Employer in a draft form.

2. Route plan

A route plan showing location of all boreholes, trial pits, etc. shall be presented in the report.

3. Bore logs

A true cross-section of all boreholes, trial pits showing thickness, position and classification of each soil stratum found between top surface and bottom of the hole shall be submitted. The various tests conducted and recovered from every soil and rock stratum shall be clearly against that stratum.

A record in full of every trial pit or incomplete boring with appropriate explanations shall be reported in the same manner as the completed pits or boreholes.

4. Ground water

All available data on ground water conditions shall be presented separately and shall be identified by borehole number and sampling dates and timing of observations, showing clearly the number of observation made in a particular safe.

5. A detailed report of all tower locations in steep slope areas addressing short and long term risk of slope stability and recommended mitigation and protection measures.

6. Test results

- 1) The recommendations shall be based on observations and test results and shall encompass theoretical as well practical considerations for foundations for the types of structures envisaged. The Contractor shall acquaint himself with the type of structures proposed.
- 2) Recommendations shall include, but not be limited to, the following:
 - a. A brief geological description including that of faults, folds, etc., if any, on the basis of published literature.
 - b. Seismic history including a brief description of previous earthquakes, giving time, period, magnitude, ground acceleration, epicenter, damage done etc.
 - c. Recommended type of foundations and safe/allowable bearing capacities.
 - d. Possibility and extent of scour in riverbeds.
 - e. Recommendation for class of concrete to be used for foundations vis-à-vis deleterious effect of ground water/soil chemicals concrete and steel.
 - f. Earth pressure coefficients that may be adopted.
 - g. Any other relevant information and data.
 - h. Technical services as and when called by the employer.

2.5.9 Payment

Payment for the contract item "Detail Soil Investigation" will be made per location for all type of soil except FR and HR, for Fissured Rock and for Hard rock separately as provided in the unit price bid. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all costs incurred in furnishing all materials, equipment, technical services, labour and other operations related to the scope of work of soil tests, as specified before.

The contractor shall undertake "Detail Soil Investigation" at tower locations as approved by the Employer. The provisional number of soil testing locations is furnished in Schedule of Prices. Unit rates

for the same are to be furnished by the bidder in appropriate Schedules of Price, for adjustment purpose with actual quantities required for soil testing.

2.6 Sounding Test

- a. Testing by means of simple hand operated standard hammer-blown penetrometer or equivalent shall be carried out, at least 1 (one) test at every tower's center peg unless otherwise instructed by the Engineer to investigate soil conditions at the tower location. These tests shall be carried out after finalization of tower spotting. Except for soft and hard rock foundation, the depth of investigation shall be minimum 3 meter below the foundation footing for normal types of foundation, or 9 meter below the ground level for very loose soil, where any special foundation is encountered. The number of tests and / or their depth may differ according to the necessity or direction of the Engineer.

Payment: Payment for the measurement of Sounding Test will be included in the sub-items of the contract item, "Detail Soil Investigation", at the unit price bid.

Therefore, in the Price Schedule the unit bid price shall include full compensation for all cost incurred in furnishing all equipment, technical services, labour and other related to "Sounding Test".

2.7 Measurement of Ground Resistance

The Contractor is required to perform ground resistance test at every support location. Method of measurement, tools and instruments shall be submitted to the Employer's representative for approval.

The measurement of ground resistance shall be performed at every meter depth from ground surface to the specified depth or to maximum depth of sub-soil tests except where ground resistance value of 10 ohms or less is obtained at any adjacent levels, no further measurement is required.

The Contractor may use drilling rod(s) of sub-soil test equipment during performing the sub- soil test as earth electrodes for measuring the ground resistance.

The Contractor shall recommend the type of earth electrodes in accordance with the results of ground resistance obtained. Selection of earth electrode type shall be suitable for each structure and its particular site conditions. The data obtained shall be prepared in an approved form and submitted to the Employer's Representative.

Payment for the measurement of ground resistance will be included in the sub-items of the contract item, "Detail Soil Investigation", at the unit price bid.

Therefore, in the Price Schedule the unit bid price shall include full compensation for all cost incurred in furnishing all equipment, technical services, labour and other related to "Measurement of Ground Resistance".

2.8 Benching

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

Payment for the item "Benching" for different type of soil/rock shall be made per cubic meters as provided in price schedule. Therefore, for the items within "Benching" in the Price Schedule, the unit bid price shall include full compensation for all cost incurred in furnishing all equipment, technical services, labour and other related to "Benching" for different types of soil/rock.

3 Transmission Line Structures

3.1 General

The scope of works comprises of design, manufacture, shop test, supply, erection, field testing and commissioning of self-standing, galvanized latticed steel towers for 220kV Damauli - Bharatpur D/C Transmission Line. The Contractor shall investigate the site and propose a suitable tower types and locations. The conductor type, for all of the line sections to be erected under the project, shall be ACSR "BISON". Ground wires shall be one galvanized steel wire and one optical ground wire (OPGW).

Bidders must offer towers from reputed and experienced manufacturers. The proposed manufacturers of tower shall meet the criteria as specified in the Evaluation and Qualification Criteria, Vol. I, Section 3 of the Bidding Document.

The Bidder must submit evidence (registration date, sales/supply record, ISO Certificate, type-test certificate and other documentary evidence) of the offered manufacturer meeting the specified qualifying requirements.

3.2 Design Conditions

3.2.1 Tower Families

Types of towers for the transmission line under the contract are given in Schedule A.4.

3.2.2 Extensions

All types of tower shall be provided with leg extensions of -4.5 m, -3.0 m, -1.5 m, +/-0 m, +1.5 m+3m, +4.5 m, +6 m, +7.5 m, 9 m. For DA, DD and DE type, additional +18 m and +25 m leg extensions also shall be provided where necessary. The bidder is required to enter the costs of basic body and stub for each type of tower. Also, the cost for leg extension, which will be attached to the basic body, shall also be entered in the appropriate items of Schedule of Prices by the Bidder.

The provision for addition of +18m and +25m, leg extension to tower DA, DD, and DE shall also be kept for Power Line Crossings or any other obstacle, depending upon the merit of the prevailing site condition.

3.2.3 Spans

Design spans for tower design are given in Schedule A4.

The term span shall mean the horizontal distance between centers of the adjacent towers on ground level. The term wind span shall mean half the sum of adjacent horizontal span lengths supported on any one support. The term weight span shall mean the equivalent length of the weight of conductor supported at any one support at maximum temperature in still air.

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

3.2.4 Electrical Clearances

For all supports, the clearances from conductors, arc horns, jumper loops and all live metal to the structure or earthen steel work shall not be less than those specified in Schedule A.3.

Where uplift condition occurs at tension tower positions, details should be provided to show that the above requirements are not infringed.

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

Jumper suspension insulator strings should be used on locations where sufficient clearance of the jumpers is not available with the structure.

The maximum angle of the shade protection of the earth wire to any top conductor shall not be greater than 20 degrees to the vertical at the support and at any point in the span.

The clearance between the line conductors and ground in still air under the maximum specified temperature and final tension shall not be less than the figure stated in Schedule A.3. An additional clearance of 0.5m is required to allow for surveying errors, long-term conductor creep, etc. which shall be included in the calculation of tower heights.

Where obstruction of other types is met requiring special clearance, the Employer shall approve the clearance. If any factors, likely to cause infringement of clearance, become apparent, the Contractor shall inform the Employer immediately. The Contractor shall be responsible for design and supply of any special arrangements necessary for maintaining required clearance without any additional cost of the tower.

The sag of the earth wire, and OPGW cable for the basic ruling span, at the severest condition, shall be approximately 80 percent of the phase conductors operating at the same condition. The contractor shall adjust the sag and tension criteria for the earth wire and OPGW to coordinate this performance target.

3.2.5 Loading Conditions and Tension Criteria

1) Design wind speed: Design wind speed for the project area is 34.4 m/s.

2) Design Temperatures: The following temperature range for the conductors and ground wires shall have been adopted for line design:

a) Minimum Temperature	: 0 °C
b) Every day temperature of conductor	: 32 °C
c) Assumed creep temperature	: 32 °C
d) Max. Temperature of:	
- Conductor	: 80 °C
- OPGW / Ground wire exposed to sun	: 53 °C

3) Conductor and OPGW / Ground wire Configuration

For double circuit towers the three phases shall be in vertical formation. The phase to phase spacing and the horizontal separation between phase conductors of two circuits shall be as per the required standard. The bidder shall provide evidence (relevant pages of the standards) in support of their design.

4) The tower base of all types of towers shall be square (tower base for DA type tower may be an exception).

5) Wind loads: wind loads for tower design shall be used as follows:

a) Wind Pressure on conductor: 740 N/m²

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- b) Wind Pressure on tower: 2370 N/m^2
- 6) Maximum Tension of wires: The maximum tension of overhead conductor's wires shall be based on the most stringent case of either:
- a) At 0°C at 36% full wind pressure, conductor in initial state
 - b) At 32°C with full wind pressure, conductor in initial state
- 7) The maximum initial conductor and ground wire tension at 32 degrees Celsius without wind shall be 22% of the ultimate tensile strength of the conductor and 20% of the ultimate tensile strength of the ground wire and OPGW cable.
- 8) Limiting Tensions of Conductor and Ground wire, OPGW: The tension of conductors under any loading case shall not exceed 60% UTS.

3.2.6 Tower Loading Conditions

Tower loading conditions shall consider the followings and shall be in accordance with ASCE 52 or other equivalent standards.

Suspension Tower (DA type, Angle of Deviation: $0 - 2$ Degrees)

1) Normal working conditions

- a) Transverse loads are comprised of:
 - Wind loads (90 Degrees & 45 Degrees) on towers.
 - Wind loads (90 Degrees & 45 Degrees) on wires with design wind span, insulator strings, and other fittings
 - Horizontal resultants of the max. tensions of wire design angle of line deviation
- b) Vertical loads are comprised of:
 - Dead weight of tower
 - Weight of wires with design weight span, insulator strings, and other fittings

2) Broken wire conditions

- a) Transverse loads are comprised of:
 - Wind loads (90 Degrees & 45 Degrees) on towers
 - Wind loads (90 Degrees & 45 Degrees) on wires with design wind span, insulator strings, and other fittings
 - Horizontal resultants of the max. tension of wire design angle of line deviation
- b) Longitudinal loads are comprised of:
 - Breakage of any one earth wire or entire phase conductor bundle
 - Longitudinal components of wire are:
 - Phase conductor: 100% of max. tension
 - Ground wire: 100% of max. tension
- c) Vertical loads
 - Dead weight of tower
 - Weight of wires with design weight span, insulator strings, and other fittings

Angle Tower (DB, DC, DD type)

(DB type - Small Angle Tower, Angle of Deviation: 2 – 15 Degrees)

(DC type - Large Angle Tower, Angle of Deviation: 15 – 30 Degrees)

(DD type – Large Angle/Deadend Tower, Angle of Deviation: 30 – 60 Degrees)

1) Normal working conditions

a) Transverse loads

- Wind loads (90 Degrees & 45 Degrees) on towers
- Wind loads (90 Degrees & 45 Degrees) on wires with design wind span, insulator strings, and other fittings
- Horizontal resultants of the max. tension of wire design angle of line deviation

b) Vertical loads

- Dead weight of tower
- Weight of wires with design weight span, insulator strings, and other fittings, or uplift loading equivalent to weight of wires with design weight span

2) Broken wire conditions

a) Transverse loads

- Wind loads (90 Degrees & 45 Degrees) on towers
- Wind loads (90 Degrees & 45 Degrees) on wires with design wind span, insulator strings, and other fittings
- Horizontal resultants of the max. tension of wire design angle of line deviation

b) Longitudinal loads

- Breakage of two adjacent phase conductors on the same side of the tower or of one ground wire
- Longitudinal components of wire are

- a. Phase conductor: 100% of max. tension
- b. Ground wire: 100% of max. tension

c) Vertical loads

- Dead weight of tower
- Weight of wires with design weight span, insulator strings, and other fittings or uplift loading equivalent to weight of wires with design weight span

Dead End Tower (DE type, Angle of Deviation: 0 – 90 Degrees)

1) Normal working conditions

a) Transverse loads

- Wind loads (90 Degrees & 45 Degrees) on towers
- Wind loads (90 Degrees & 45 Degrees) on wires with design wind span, insulator strings, and other fittings
- Horizontal resultants of the max. tension of wire design angle of line deviation

b) Longitudinal loads

- 100% of max. tension of wires at full tension side

c) Vertical loads

- Dead weight of tower
- Weight of wires with design weight span, insulator strings, and other fittings, or uplift loading equivalent to weight of wires with design weight span

2) Broken wire conditions

a) Transverse loads

- Wind loads (90 Degrees & 45 Degrees) on towers
- Wind loads (90 Degrees & 45 Degrees) on wires with design wind span, insulator strings, and other fittings
- Horizontal resultants of the max. tension of wire design angle of line deviation

b) Longitudinal loads

- Breakage of all wires on same side of the tower Longitudinal components of wire are:
 - Phase conductor: 100% of max. Tension
 - Ground wire: 100% of max. Tension

c) Vertical loads

- Dead weight of tower
- Weight of wires with design weight span, insulator strings, and other fittings or uplift loading equivalent to weight of wires with design weight span

Erection loads

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

3.2.7 Factors of Safety

Each type of tower shall be designed such that no failure or permanent distortion shall occur when tested with applied loading equivalent to the maximum working loading multiplied by the specified safety factors as listed in Schedule A.5

Design tests will be carried out on supports selected by the Employer at rates entered in the appropriate Price Schedule.

3.3 Tower Steel works

3.3.1 Materials

3.3.1.1 Design stresses

Support members shall comply rigidly with the following design requirements:

Rolled steel section, flats, plates, bolts and nuts, and bars shall, unless otherwise approved, consist of steel materials in accordance with JIS G 3101: SS400 or equivalent. High strength steel, where approved, shall comply with the requirement of steel materials in accordance with JIS G 3101: SS540 or equivalent. The Contractor can use other grades of structural steel angle sections and plates conforming to other International Standards. In such a case, the Bidder shall prove by design calculations that the towers designs fulfil all the requirements specified in the specifications and that the towers are safe.

The ultimate design stress in tensile members shall not exceed the elastic limit strength of the materials. The ultimate stress in the compression members shall not exceed a figure obtained from a formula for the design compression stress stated in ASCE (American Society of Civil Engineers) standard (ASCE 10-97) or equivalent. The bidder shall enter his proposed formula and standard in the Technical Proposal.

In calculating net sectional area of a member, the diameter of bolthole shall be assumed to be 3 mm larger than that of nominal bolt diameter. Net sections shall be figured on both straight and zigzag sections across the member, as specified in British Standard BS 449 or approved equivalent standards.

Bolts with threads shall be of such length that the threaded portion does not extend beyond 3 mm into the ply portion of the members connected. In this condition, full diameter of bolt may be considered as effective for bearing and shear. If threads extend into the ply portion of the members connected, the permissible stresses for bolts given above for shear and bearing shall be reduced by twenty (20) percent. The full diameter shall be the nominal diameter of bolt and, the gross area shall be that computed based on the nominal diameter.

3.3.1.2 Slenderness Ratio:

Slenderness ratios for members shall be limited as follows:

i.	Tower legs, main compression members in cross-arm, ground wire peak	120
ii.	Other compression members carrying Computed stresses	220
iii.	Redundant members or members carrying Nominal stresses	250
iv.	Members subjected to tension only	250

Upon the discretion of the Employer, Slenderness ratios up to 200 may be accepted if the bidders utilize advanced computer based tower analysis programs.

In determining the slenderness ratios for various members, suitable provisions shall be taken into consideration for various types of end connections, eccentricity of load transfer in the members, etc. The unsupported length 'L' shall be considered from center to center of intersections or working lines at both ends of members. A single bolt connection shall not be considered as offering restraint against rotation. A multiple-bolt connection, with minimum two (2) bolts, properly detailed to minimize eccentricities, shall be considered to offer partial restraint, if such connection is to a member having adequate flexural strength to resist rotation of joint. Points of intermediate supports shall not be considered as offering full restraint to rotation, if the same is provided only on one flange of the member. The Bidder shall clearly indicate the percentage of restraint assumed by him in such cases.

For members of double-diagonal web system which are bolted at their point of intersection, the maximum L/r shall be determined from the following criteria:

'L' is the greatest distance from the point of the intersection to either of the end connections and 'r' is the minimum radius of gyration of the member.

'L' is equal to 0.75 times the distance between the end connections and 'r' is the radius of gyration of the member for its axis parallel to the plane of connected leg.

3.3.2 Tower Fabrications

3.3.2.1 Member fabrication-galvanizing

All galvanizing shall be carried out by the hot dip process and shall conform in all respects with BS 729/IS: 209.

All surface defects in the steel, including cracks surface laminations, laps and folds, shall be removed in accordance with BS 4360. All drilling, cutting, welding, forming and final, fabrication of unit members and assemblies shall be completed before the structures are galvanized. The surface of the steelwork to be galvanized shall be free from welding slag, paint, oil, grease and similar contaminants.

The preparation for galvanizing and the galvanizing itself shall not distort or adversely affect the mechanical properties of the material.

For all parts other than steel wires, the coating shall consist of at least 610 grams of zinc per square meter of surface and be not less than 0.086 mm in thickness.

On removal from the galvanizing bath the resultant coating shall be smooth, continuous and free from gross surface imperfections such as bare, spits, lumps, blisters and inclusions of flux, ash or dross.

During off loading and erection of supports the use of nylon or braided slings shall be used.

Galvanized steelwork, which is to be stored in the works or on site, shall be stacked properly to provide adequate ventilation to all surfaces to avoid wet storage staining.

Small areas of the galvanized coating damaged in any way shall be restored in accordance with the requirements of item 1.14 of General Technical Specifications.

Tests on samples shall be carried out in accordance to BS 729.

3.3.2.2 Bolts, nuts and washers

All bolts and nuts shall conform to ISO898-1.

No bolt of diameter less than 16mm shall be used for structural connections. No screwed threads shall form part of shearing plane between members.

When in position, all bolts or screwed rods shall project through the corresponding nuts by, at least, one full thread but, such projection shall not exceed 10mm.

Bolts shall be galvanized, after thread cutting, to the same specified coating weight as specified in BS 729. Nuts and heads of all bolts shall be hexagonal.

All bolts, nuts and washers shall be hot dip galvanized and subsequently centrifuged (according to BS 729). Nuts shall be tapped after galvanizing and the threads oiled, to permit the nuts to be finger turned on the bolt for the full depth of the nut.

After fixing, bolt heads, washers and nuts shall receive two coats of zinc rich paint. Only one type of bolt for the whole project, either mild steel or high-tension steel will be permitted in order to prevent inadvertent misuse. The Contractor shall state clearly which type of bolt his designs are based upon.

All bolts supplied for this contract will be provided with one nut and one spring washer of approved design. Taper washers and packers are to be fitted where necessary.

Samples of the bolts used to affix lattice tower members should be independently hardness tested by the Contractor to show conformity to ISO 898-1. Results of the bolt hardness test shall be sent to the Employer at his Project Office.

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 along with the bolt hardness test to the Employer at his Project Office for approval within one month of the date of issuing the sub-order.

The Contractor shall submit two samples of each type of bolt and nut to be used on the Contract and send these samples to the Employer or the Employer's Representative for approval within one month of the date of issuing the order. The Employer or the Employer's Representative will reject bolt consignments, which, in his opinion, fall in any respect below, the standard of samples submitted and approved.

3.3.2.3 Construction of Tower Steelwork

All designs shall be such that no trouble shall arise in service from vibration or excessive deflection due to the use of very light section.

Bolt-holes shall not be more than 1.5 mm larger in diameter than the corresponding bolt diameter. The distance from the center of boltholes to the edge of any steel section shall not be less than 1.5 times the diameter of the bolt.

All tower member joints or joints between prefabricated panels to be made at Site shall be secured with bolts, nuts and washers. As far as conveniently possible, bolt heads, rather than nuts, shall be on the inner or upper faces of support joints.

Structure cross-arms shall be so arranged that they can be disconnected from the body without disturbing main structure body members.

The conductor landing points on cross-arms shall be so arranged that an additional hole for the attachment of conductor erection and maintenance tackle be provided adjacent to each hole for tension shackles. It shall be possible to apply full conductor tension and weight safely to these additional attachment points.

Mild steel when stored in the fabricators stockyard prior to fabrication and galvanizing shall be marked continuously throughout its length with a light blue water paint line. In addition, the grade number of the steel shall be painted on and ringed around with paint.

Members that are capable of being fitted in more than one position on the structure shall all be of the grade of steel suitable for the most onerous loading conditions.

3.3.2.4 Workmanship

All work shall be in accordance with the best modern practice in the manufacture and fabrication of materials covered by this specification. The Contractor shall be responsible for the correct fitting of all parts, shall replace free of cost any defective material discovered during erection and pay all costs of field corrections for such replacement. All parts of the structure shall be neatly finished and free from kinks, twists or bends. All holes shall be made with sharp tools and shall be clean cut without torn or ragged edge. The fabrication shall be in strict accordance with the shop drawings prepared by the Contractor and approved by the Employer or the Employer's Representative.

Structural materials shall be straight and cleaned of all rust and dirt before laid out or worked in any manner. Shearing and cutting shall be performed carefully. Manually guided cutting torches shall not be used.

All bolt holes in steel members shall be punched, sub punched, reamed or drilled before galvanizing.

Holes shall be drilled instead of being punched, if the thickness of the metal exceeds the diameter of the hole. All holes shall be cylindrical and perpendicular to the member.

The diameter of the finished bolthole shall not be greater than the normal diameter of the bolt plus 1.5mm. Plugging, welding or slotting of mis-punched, mis-reamed or mis-drilled holes will not be

permitted. The holes shall be located accurately so that when the members are in position the holes will be lined up before being bolted.

3.3.2.5 Anti-climbing device

At a height of at least 3m from floor or normal ground level (whichever is the higher), an adjustable galvanized anti-climbing frame shall be fitted to all faces of each tower.

The device for tower shall also prevent climbing access inside the structure body.

At each climbing leg, a suitable gate shall be provided to allow access to the Employers maintenance staff.

Payment for the contract item "Anti-climbing Device" will be made at the unit bid price per number.

3.3.2.6 Step-bolts

Two diagonally opposite legs of all supports shall be equipped with galvanized step bolts (M16 x 160mm) at intervals not exceeding 380mm, on each leg, commencing immediately above the anti-climb device and extending to within one meter of ground wire. Step-bolt design shall be subject to the approval of the Employer or the Employer's Representative. Holes for removable step-bolts, below the anti-climbing device, shall be provided at intervals not more than 380mm on the legs to which the permanent step-bolts are fitted.

3.3.2.7 Steel Towers on Aeronautical Routes

The following applies only to steel towers on aeronautical routes in accordance with the Civil Aviation Authority of Nepal (CAAN).

- The Contractor shall paint the steel towers in the vicinity of airports or aviation route in accordance with the following stipulations:

Painting on steel towers shall be applied on all outer surfaces of steel members from top to bottom cross-arm after erection works have been completed. No painting shall be done in cold, damp, foggy or dusty atmospheres or, started when the weather forecast indicates such conditions for the day. Prior to painting, the Contractor shall submit a painting plan including the quality of paint and the division of painting for the approval of the Employer.

The colour of the paint shall be red and white alternately in strips from the top of the tower.

Painting shall be applied in four coats including prime coat. The primer paint shall be zinc dust-zinc oxide/ metal primer.

- Towers should be equipped with an obstacle light.
- The overhead ground wires and OPGW should be equipped with alternating red and white or alternating orange and white marker balls.
- The tower height should be limited to 40 meters as much as possible.

3.3.2.8 Extensions

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

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. Additional volumes of foundation compared with the normal foundation type due to chimney extensions shall be paid from the quoted price of the item "Protection of Tower Foundation" for excavation, concrete and reinforcement bar separately.

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

3.3.2.9 Payments for Line Tower

Payment for the contract item “Design, fabrication & supply of following types of towers & tower extension parts complete with stubs, step bolts, hangers, D-shackles, bolts & nuts etc but excluding tower accessories such as danger plates, number plates, phase plates, anti-climbing devices”, including any required painting (including bituminous paint for the buried parts of the legs), will be made separately for Basic Tower, Stub and Leg extensions as per price schedule at the unit bid price per item. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labour and all other operation related to tower design, fabrication, delivery etc. as specified for complete tower.

Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labours and all other operation related to design, fabrication, delivery etc. as specified in price schedule.

3.3.2.10 Supply of additional galvanized steel tower parts

Exceptionally, if, further strengthening is required for standard DA, DB, DC, DD or DE towers at major river/valley crossing, some quantity of additional galvanized steel tower parts have been provisioned in price schedule. The Contractor shall have to justify the necessity through the design calculations to the satisfaction of the Employer/Engineer. The Contractor shall have to get approval from the Employer before using this quantity. The Bidder is required to quote the price per ton as provided in Price Schedule. These Towers shall be developed by strengthening the standard DA, DB, DC and DD type towers as per the site requirement. Additional weight of tower due to strengthening shall be made per ton for additional galvanized steel tower parts.

3.3.2.11 Payments for supply of additional galvanized steel tower parts

Payment for the contract item, Supply of additional galvanized steel tower parts, including any required painting (including bituminous paint for the buried parts of the legs), will be made at the unit bid price per ton. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labour and all other operation related to tower parts design, fabrication, delivery etc. as specified for additional galvanized steel tower parts.

Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labours and all other operation related to design, fabrication, delivery etc.

3.3.2.12 Supply of Spare Tower Type A, B, C and D (with +9 m leg extensions to each type)

The Contractor is required to supply one set each of type DA, DB, DC and DD (with +9 m leg extensions to each type) as spare. The Bidder is required to quote the price per tower as provided in price schedule.

3.3.2.13 Payments for Supply of Spare Tower Type A, B, C and D (+9 m leg extensions)

Payment for the contract item, Supply of Spare Tower Type A, B, C and D (with +9 m leg extensions to each type) including any required painting (including bituminous paint for the buried parts of the legs), will be made at the unit bid price per number. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labour and all other operation related to tower parts design, fabrication, delivery etc. as specified for complete tower.

Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labours and all other operation related to design, fabrication, delivery etc.

3.4 Tower Grounding

1) In addition to the mechanical earth wire termination requirement, all steel towers shall be fitted with separate earth bonds for earth wire continuity and the Contractor shall provide all necessary connecting facilities.

All the four legs of the tower shall be connected to the earth through electrode.

The footing resistance shall be measured by the Contractor and approved by the Employer or the Employer's Representative for every tower prior to the stringing of the earth wire. The maximum footing resistance to the general mass of earth shall be 10 ohms.

Steel towers need not be fitted with a separate earth bond and earthing continuity throughout the support will, therefore, depend upon surface contact between members.

All towers shall be provided with means for connecting an additional earthing device as required by the Employer's Representative. Holes are to be provided in all supports near ground level to take bolts for earth lead connections.

All legs of every tower shall be equipped with galvanized steel wire and cast into the foundation concrete to be readily available for the connection of additional earth electrodes in the event of the initial footing resistance exceeding 10 ohms. Bidder's rates for the structures shall include for such additional works.

Galvanized steel rods shall be driven where necessary in sufficient number to ensure the combined structure footing and earth electrode resistance does not exceed 10 ohms. Where it is necessary to drive more than one earth electrode at any support, the locations shall be subject to the approval of the Employer or the Employer's Representative. All earth electrodes shall be electrically bonded together using galvanized steel wire.

The tops of all electrodes shall be at least 500 mm below the surface of the normal reinstated ground level.

Connection of earth wires to the structure stub-angles shall be by bolting. Bidders shall submit details of his proposals in this regard.

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

IS: 3043 Code of practice for Earthing.

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

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

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

Earthing for River Crossing Towers /Pile foundation

Galvanised 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 Owner before installations.

2) Payment for Grounding Materials

The provisional quantities for pipe type earthings and counterpoise earthing are furnished in the Price Schedule under the item "Supply of Grounding of Towers". The bidders are required to quote unit rates for the same in appropriate Price Schedule. The quoted price shall include fabrication, supply

and installation of earthing material including supply of coke, salt etc. In case of counterpoise type earthing, the quotation shall be based on 120 meters of wire per tower. Payment for supply work and for installation work will be made separately as provisioned in the corresponding Price Schedule. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labours and other operation related to the scope of work of grounding as specified. Each set shall mean one complete set for each tower i.e. for four legs.

3.5 Tower Accessories

1) Step Bolts & Ladders

Each tower shall be provided with step bolts. For single and double circuit towers the step bolt shall be fixed on two diagonally opposite legs up to top of the towers. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN. If tower height exceeds 50 meters, ladders along with protection rings 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 structure. From 2.5m to 30m height of structure (- for structures above 50 meters) 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

All recommended tower climbing designs must be reviewed and approved by the Employer.

2) Danger, Phase, and Number Plate

All structures shall be equipped with a suitable framework, mounted immediately above the anti-climb device level, to accommodate a danger plate and support- number plate in a conspicuous position. One plate each is to be supplied for every tower, except for phase identification plates, which shall be supplied for angle towers only.

All terminal structures shall be equipped with additional frameworks, mounted immediately above the anti-climb device level, to accommodate a set of three phase colour plates.

All plates shall be affixed to the framework by means of galvanized bolts, nuts and lockouts. Washers should be of such material and so positioned that damage to the enamel will be prevented.

All plates shall be manufactured from mild steel sheet with vitreous enamelled finish. Contractor shall prepare a detail drawing for such plates subject to the Employer's approval.

Line color-coded vitreous enamel identification plates should be fitted to the climbing legs of every structure in accordance with line colour code scheme to be supplied to the successful Bidder. Each plate shall be approximately 70mm wide and shall be applied one immediately below the anti-climb device, one halfway up the towers and one immediately below the lowest cross arm.

3) Payment for Tower Accessories

Payment for danger plate, phase plate, circuit plate, number plate, anti-climbing device and bird guard shall be made at the unit price bid. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labours and other operation related to the scope of work as specified.

3.6 Marking of Overhead Ground Wire

1) Where directed by the Employer or the Employer's Representative, the Contractor shall supply and install birds ball as marking of overhead ground wire for aeronautical signal. The birds'-ball shall

be 300 to 400 mm in diameter. Any metal parts, if used, for holding the spheres in position, shall not cause rust or harmful effects to the overhead ground wire.

The position of the birds'-ball shall meet the following requirements:

- a) In any span, the spheres shall be spaced at a minimum distance of 50 m from each other along the span.
- b) The first and the last spheres in any span shall be approximately 10 m from the towers defining span.

2) Payment for Marking of Overhead Ground Wire

No separate payment for markings shall be made at the unit price bid. Therefore, in the Price Schedule, the unit bid price for the item 24 Fiber (DWSM) OPGW Fiber Optic Cable shall include full compensation for all the costs incurred in fixing and furnishing all materials, equipment, labours and other operation related to the scope of work as specified.

4 Insulators

4.1 General

The proposed manufacturers of Insulators shall meet the criteria as specified in the Evaluation and Qualification Criteria, Vol. I, Section III of the Bidding Document.

4.2 Details of Disc Insulators

The Insulator strings shall consist of discs for a three phase, 50Hz, effectively earthed 220 kV transmission system in a light polluted atmosphere. The discs shall be cap and pin, ball and socket type. The Insulator strings shall conform IEC 60305, IEC 60383, IEC 60575, IEC 60120.

Bidder shall quote for disc insulators made of either electro-porcelain or toughened glass.

The size of disc insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware fittings shall be as per Schedule A.8.

The insulators and the insulator string (excluding insulators) shall be considered as separate item for supply purpose.

It is the responsibility of the Contractor to ensure that each insulator has a sufficient electrical and mechanical strength specification for use in the appropriate span.

4.3 Pin and Cap

Pin and cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric, of such design that will not yield or distort under load conditions.

The pin ball shall move freely in the cap socket but without danger of accidental uncoupling during erection or in position. The design of the disc should be such that stresses due to expansion or contraction in any part of the insulator shall not lead to deterioration.

4.4 Security Clip

Security clip for use with ball and socket coupling shall be of R-shaped hump type which shall provide positive locking of the coupling as per IEC60372. The legs of the security clips shall be spread after installation to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no rise of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall locking device allow separation of insulator units or fittings.

The hole for the security clip shall be countersunk and the clip shall be of such 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).

4.5 Ball and socket Designation

The dimensions of the balls and sockets shall be of 16mm designation for 70 kN and 120 kN disc insulator and 20mm designation for 160 kN disc insulator in accordance with the standard dimensions stated in IEC60120.

4.6 Dimensional Tolerance of Insulator Disc

Permitted dimensional tolerances of Type disc insulators shall be as under:

- a) On all insulator dimensions for which other special tolerances do not apply:

$$\pm (0.04d + 1.5) \text{ d being the said dimension in mm.}$$

- b) On spacing of string insulator units:

$$\pm (0.03S + 0.3) \text{ mm where, S is spacing in mm.}$$

4.7 Interchangeability

The disc insulators inclusive of the ball and socket fittings shall be of standard design suitable for use with the hardware fittings of any make confirming to relevant international standards.

4.8 Corona and RI performance

All surfaces must be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The metal parts and porcelain shall be so designed and manufactured that it shall not generate any Radio Interference beyond specified limit and not produce any noise generating corona under all operating conditions.

4.9 Maintenance

The disc insulators offered shall be suitable for employment of hot line maintenance techniques so that the usual hot line operations can be carried out with ease, speed and safety.

Bidders shall indicate the methods generally used in the routine hot and dead line maintenance of EHV line for which similar disc insulators have been supplied by them. Bidders shall also indicate the recommended periodicity of such maintenance.

4.10 Materials

- 1) Porcelain: The porcelain used in the manufacture of shells shall be sound, free from defects thoroughly vitrified and smoothly glazed.
- 2) Glaze: The finished porcelain shall be glazed in Brown colour. The glaze shall cover all exposed parts of the insulator and shell have a good lustre, smooth surface and good performance under the extreme weather conditions of a tropical climate. It shall not be cracked or chipped by ageing under the normal service conditions. The glaze shall have the same coefficient of expansion as that of the porcelain body throughout the working temperature range.
- 3) Toughened Glass: The glass used for the shells shall be sound, free from defects such as flaws, bubbles, inclusions etc. and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.
- 4) Cement: Cement used in the manufacture of the insulator shall not cause fracture by expansion or loosening by contraction. The cement shall not give rise to chemical reaction with metal fittings and its thickness shall be as small and uniform as possible. Proper care shall be taken to correctly center and locate individual parts during cementing.
- 5) Pins and Caps: Pins and caps shall be made of drop forged steel and malleable cast iron/spheroidal graphite iron / drop forged steel respectively, duly hot dip galvanized and shall not be made by jointing, welding, shrink fitting or any other process from more than one piece of material.
- 6) Security Clips: Security clips shall be made of good quality stainless steel or phosphor bronze. 2.5% extra security clip shall be provided.

4.11 Workmanship

- All the material shall be of the 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 220 kV transmission line and will give continued good service.

- The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.
- The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.
- Metal caps shall be free from cracks, seams, shrinks, air holes, burrs and rough edges. All surfaces of the metal parts shall be perfectly smooth with no projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.
- All ferrous parts shall be hot dip galvanized to give a minimum average coating of Zinc equivalent to 610 gm/sqm (86 microns). The zinc used for galvanizing shall be of grade Zn 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 part shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test.
- 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
- The design of the insulators shall be such that the shell shall not engage directly with hard metal. The design shall also be such that when units are coupled together there is no contact between the shell of one unit and metal of the next adjacent unit. The design of the shell ribs shall be such that the security clip of the insulator can be engaged and disengaged easily with hot stick without damaging the shell ribs.
- Insulator units after assembly shall be concentric and co-axial within limits.
- The manufacturer of the disc insulators shall guarantee an insulator failure rate not exceeding 1 (one) per 10000 (ten thousand) per year. In case the annual failure rate during the first ten years of service exceeds the above figure, the manufacturer shall supply to the Employer free of cost spare insulators equal to 10 times the excess failure.
- The manufacturer shall guarantee that there shall not be any de-capping of insulators on line under normal operating conditions. In event of any de-capping and subsequent line drop, during the first three years of service the manufacturer shall have to pay Rs. 50,000/- (Rs. Fifty thousand only) per dropped string towards expenditure to be incurred by Employer for this repair.

4.12 Equipment Marking

Each insulator disc shall be legibly and indelibly marked with the trademark of the manufacture and year of manufacture. The guaranteed combined mechanical and electrical strength shall be indicated in kilo Newton's followed by the word "kN" to facilitate easy identification and to ensure proper use.

For porcelain insulator, the marking shall be on porcelain. The marking shall be printed, not impressed and shall be applied before firing. For toughen glass insulators the marking shall be on the metal parts.

One 10 mm thick ring of suitable quality of paint shall be marked on the cap of each insulator of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark:

For 120 KN disc:	Yellow
For 160KN disc:	Green

4.13 Packing and Marking

All insulators shall be packed in strong seasoned wooden crates. The gross weight of the crates along with the material shall not normally exceed 200 kg to avoid handling problem. For marine transportation crates shall be loaded on pallets.

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

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

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

4.14 Payment for Insulators

Payment for the supply and delivery for insulators will be made at the unit bid price. Therefore, in the Price schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labors and all other operations related to insulator fabrication, delivery, etc.

5 Line Conductor, Ground Wire and OPGW

5.1 General

The proposed manufacturers of ACSR conductors, ground wires, and optical ground wire shall meet the criteria as specified in the Evaluation and Qualification Criteria, Vol. I, Section III of the Bidding Document.

5.2 Conductor

5.2.1 Standards

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.

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

Sl. No.	Indian Standard	Title	International Standard
1.	IS: 209	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 Galvanised Steel Reinforced	BS:215 IEC:61089
4.	IS:398 Part-V	Aluminum Conductor Galvanised 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 Galvanising of Iron and Steel	
8.	IS : 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
9.	IS : 4826	Galvanised 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

Sl. No.	Indian Standard	Title	International Standard
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

5.2.2 Conductor Specification

Details of conductors shall be as stated in Schedule A.9.

All conductors shall be of aluminium conductor steel reinforced (ACSR) construction and shall be manufactured in strict conformity with BS 215 Part 2, IEC, IS:398 Part-V. Bidders must offer conductor and wire from reputed and experienced manufacturers.

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

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

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

Precautions shall be taken during the manufacture, storage and erection of steel-cored aluminium conductors to prevent the possibility of contamination by copper or other materials, which may adversely affect the aluminium. The manufacture of steel-cored aluminium 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 aluminium or steel wires.

5.2.3 Workmanship

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

The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

The steel strands shall be hot dip galvanized and shall have a minimum zinc coating of 260 gms/sq.m after stranding. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand minimum three dips in standard Preece test. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC: 888.

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

5.2.4 Joints in Wires

No joints or splices shall be made in the spans crossing over power lines, main roads, railways and rivers.

1) Aluminium /Aluminium Alloy Wires

During stranding, no Aluminium/Aluminium Alloy wire welds shall be made for the purpose of achieving the required conductor length.

No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However joints are permitted in the 12 wire and 18 wire inner layer of the conductor unavoidably broken during stranding, provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium/aluminium alloy wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium/aluminium alloy wire of the completed conductor.

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

2) Steel Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

5.2.5 Tolerances

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

1) Diameter of Aluminium and Steel Strands

	Standard	Maximum	Minimum
Aluminum/Aluminum Alloy Steel	3.00 mm	3.03 mm	2.97 mm
	3.00 mm	3.06 mm	2.94 mm

2) Lay ratio of Conductor

		Maximum	Minimum
Steel	6 wire layer	28	13
Aluminum/Aluminum Alloy	12 wire layer	17	10
	18 wire layer	16	10
	24 wire layer	14	10

5.2.6 Materials

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

1) Aluminium and Aluminium Alloy

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%.

They shall have the same properties and characteristics as prescribed in IEC: 889 or BS 2627.

Aluminium Alloy Strands shall be drawn from Silicon-Magnesium Alloy rods (6201) with appropriate tempering followed by solution treatment.

2) Steel

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the following requirements as to the chemical composition:

Element	% Composition
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorous	Not more than 0.035
Sulphur	Not more than 0.045
Silicon	0.10 to 0.35

The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 888 or BS4565.

5.2.7 Standard Length

The standard length of the conductor shall be 1800 meters. A tolerance of +/-5% on the standard length offered by the Bidder shall be permitted. All lengths outside this limit of tolerance shall be treated as random lengths. Not less than 90% total quantity of the conductor shall be supplied in standard lengths. For valley crossings specific single length conductor will be required for which length shall be estimated after tower spotting.

Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. When one number random length has been manufactured at any time, five (5) more individual lengths each equivalent to the above random length with a tolerance of +/- 5% shall also be manufactured and all the above six random lengths shall be dispatched in the same shipment. At no point, the cumulative quantity supplied of such random lengths shall not be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.

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

5.2.8 Conductor drum lengths

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

Each drum shall be marked gross weight, net weight, the length and size of the conductor and, in addition, the conductor manufacturing batch number shall be inscribed on the drum. Empty drums

shall become the property of the Employer and be returned by the Contractor to the Employer's stores designated by the Employer. The maximum length of conductor shall not exceed 2 km per drum.

5.2.9 Packing

- a. The conductor shall be supplied in non-returnable, strong, wooden drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Supplier shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS: 1778, except as otherwise specified hereinafter.
- b. 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.
- c. The Bidder should submit their proposed drum drawings along with the bid.
- d. For conductor, one standard length shall be wound on each drum.
- e. 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.
- f. The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3mm. 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.
- g. 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.
- h. 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.
- i. 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.
- j. 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.
- k. The ends of barrel shall generally be flushed with the top of the nuts.
- l. The inner cheek of the flanges and drum barrel surface shall be painted with abiturmen based paint.
- m. 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.
- n. 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.
- o. 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.
- p. 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.
- q. 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.
- r. Outside the protective lagging, there shall be minimum of two binder consisting of hoop iron/galvanized steel wire. Each protective lagging shall have two recesses to accommodate the binders.

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- s. 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.
 - t. As an alternative to wooden drum Bidder may also supply the conductors in nonreturnable painted steel drums. After preparation of steel surface, synthetic enamel paint shall be applied after application of one coat of primer. Wooden/Steel drum will be treated at par for evaluation purpose and accordingly the Bidder should quote in the package.

5.2.10 Marking

Each drum shall have the following information stencilled on it in indelible ink along with other essential data:

- Contract/Award letter number.
- Name and address of consignee.
- Manufacturer's name and address.
- Drum number
- Size of conductor
- Length of conductor in meters
- Arrow marking for unwinding
- Position of the conductor ends
- Distance between outer-most Layer of conductor and the inner surface of lagging.
- Barrel diameter at three locations & an arrow marking at the location of the measurement.
- Number of turns in the outer most layer.
- Gross weight of drum after putting lagging.
- Tear weight of the drum without lagging.
- Net weight of the conductor in the drum.
- Material Inspection & Clearance certificate No.

5.2.11 Verification of Conductor Length

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

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

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

Example: Length of Line as per detail/check survey = X km,

Quantity of conductor = $X \times 3 \times 2 \times 2$ km

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

Quantity of earth wire = X km

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

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

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

Any conductor and earth wire drum which has been opened by the Contractor shall not be taken back by Employer and the unused conductor or earth wire in such drums shall be treated as waste.

For calculation of conductor & earth wire consumption in hilly (mountainous) stretches inclined distance between towers may be considered, instead of horizontal distance between them.

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

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

5.2.12 Payment for Conductor

Payment for the supply and delivery for conductor will be made at the unit bid price. Therefore, in the Price schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labours and all other operations related to conductor fabrication, delivery, etc. Same rate will be paid for moose conductor, if it is used in long span.

Separate payment for stringing of conductor will be made in rate per km in the title "Normal Stretch (Double Circuit Portion)" in the corresponding Price Schedule. This includes installation of insulator strings complete with arcing horns/corona rings & necessary hardware, installing of bundle conductor (ACSR Bison) including fixing of conductor accessories, installing & stringing of earthwire including fixing of earth wire accessories (Twin bundle Conductor) in Double Circuit Line.

5.3 Earth-Wire

5.3.1 Earth-wire Specification

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

The technical characteristics of the earth wire are stated in Schedules A.10 and A.12.

5.3.2 Workmanship

- All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.
- The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.
- The steel strands shall be hot dip galvanized and shall have minimum, Zinc coating of 275 gms/sq m after stranding. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand three and half dips after stranding in standard Preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-M.
- 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.
- To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

5.3.3 Wire Joints

No joints or splices shall be made in the spans crossing over power lines, main roads, railways and rivers. There shall be no joints of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

5.3.4 Tolerances

The manufacturing tolerance to the extent of the following limits only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire:

For 7/3.35 mm size Earth wire

	Standard	Maximum	Minimum
Diameter	3.35 mm	3.43 mm	3.31 mm
Lay length	181 mm	198 mm	165 mm

5.3.5 Materials

1) Steel: The steel wire strands shall be drawn from high carbon steel rods and shall conform to the following requirements as to the chemical composition:

Element	% Composition
Carbon:	Not more than 0.55
Manganese:	0.4 to 0.9
Phosphorous:	Not more than 0.04
Sulphur:	Not more than 0.04
Silicon:	0.15 to 0.35

2) Zinc: The zinc used for galvanizing shall be electrolytic High Grade Zinc of 99.95% purity.

5.3.6 Standard Length

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

Random length will be accepted provided no length is less than 70% of standard length and the total quantity of random lengths is not more than ten (10) percent of the total quantity in each shipment.

5.3.7 Packing for Earth wire

- 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.
 - u. The drums shall be suitable for wheel mounting and for letting off the earth wire under aluminium controlled tension of the order of 5 kN
 - v. 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.
 - w. For Earth wire, two standard lengths shall be wound on each drum.
 - x. 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.
- y. 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.
 - z. The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3 mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75 mm. Where a slot is cut in the flange to receive the inner end of the earth wire the entrance shall be in line with the periphery of the barrel.
 - aa. 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.
 - bb. 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.
 - cc. 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.
 - dd. The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.
 - ee. 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.
 - ff. 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.
 - gg. 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.
 - hh. 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.
 - ii. Outside the protective lagging there shall be minimum of two binder consisting of hoop iron/galvanized steel wire. Each protective lagging shall have two recesses to accommodate the binders.
 - jj. 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.

5.3.8 Marking

Each drum shall have the following information stencilled on it in indelible ink along with other essential data.

- Contract/Award letter number.
- Name and address of consignee.
- Manufacturer's name and address.
- Drum number
- Size of earth wire
- Length of earth wire in meters
- Gross weight of drum with earth wire & lagging
- Weight of empty drum with lagging
- Arrow marking for unwinding
- Position of the earth wire ends

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- Distance between outer most layer of Earth wire and the inner surface of lagging
 - Barrel diameter at three locations and an arrow marking at the location of measurement

5.3.9 Verification of Earth wire Length

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

5.3.10 Payment for Earth wire

Payment for the supply and delivery for earth-wire will be made at the unit bid price. Therefore, in the Price schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labors and all other operations related to conductor fabrication, delivery, etc.

5.4 Optical Fiber Ground Wire (OPGW)

5.4.1 Earth-wire (OPGW) Specification

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

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

The technical characteristics of the earth wire are stated in Schedules A.10 and A.12.

All fiber installed as a part of this Contract shall have a minimum life of 30 years from the date of final acceptance.

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).

5.4.2 Technical Requirements

Aluminium clad steel or/and aluminium alloy wires shall form the stranding part of earth wire. The earth wire of the 220kV line shall be a steel wire with an OPGW Composite Fiber Optic communication cable in the center. The Optical Fiber Cable, containing 24 single-mode optical fibers shall be embedded loosely inside the protective tube. The protective tube shall be of aluminium alloy or stainless steel. Both fiber optic and stranding part of OPGW shall comply with this Specification, and with the following standards:

- 1) Single mode fibers: ITU-T (former CCITT) G. 652
- 2) Optical fiber cables: IEC 60793-1 & 2 IEC 1089/91, IEC 60889/87
- 3) Stranding part: IEC 60104/87; BS 3242

The earth wire shall be suitable for the climatic conditions with no attenuation changes or negative effects on the cable, and compatible with the stringing condition of the phase conductor. Under no condition shall the OPGW sag exceed the conductor sag.

The optical fiber shall be made of germanium doped silica glass or pure silica glass. It shall have a primary coating made of silicone or similar material with physical and mechanical properties at least those of silicone (acrylic or similar).

The tube shall be made of suitable material sufficiently strong to hold its shape and provide protection for the optical fibers against deformation and friction. The strength member of the fiber optic cable shall provide protection against buckling, kinking and strain. The material to be used shall be fiber reinforced plastic.

The direction of lay of the outer layer of strands shall be right hand. Lay ratio of any layer shall be not greater than the lay ratio of the layer immediately beneath it.

The makeup of shield wire shall be such that the strand shall remain and shall not twist when the conductor is cut. The earth wire shall be manufactured so that no twisting occurs when subjected to axial loads, i.e. when unrolling and stringing.

All wires used in the manufacture of the earth wire shall be free from protrusion, sharp edges, abrasion and any other imperfections.

No jointing of the aluminium clad steel wires shall be permitted.

There shall be no joints or splices in any optical fiber in any reel length of the complete optical cable. The creep characteristic of the finished earth wire shall be of virtually unvarying uniformity.

5.4.3 Attenuation

The attenuation coefficient for wavelengths between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than + 0.05 dB/km.

The attenuation coefficient for wavelengths between 1535 and 1565 shall not exceed the attenuation coefficient at 1550 nm by more than + 0.05 dB/km. The attenuation of the fiber shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.1 dB.

The cable shall consist of single mode dual-window colour coded optical fibers. There shall be no factory splices within the cable structure.

5.4.4 Optical fiber identification

Color-coding is essential for identifying individual optical fibers and groups of optical fibers.

Individual optical fibers within a fiber unit and fiber units will be identifiable using a color-coding scheme. The color-coding system shall be discernible throughout the design life of the cable.

Each cable shall be traceable of each fiber back to the original fiber manufacture's fiber number and parameters of the fiber.

If more than the specified numbers of fibers are included in any cable, the cable manufacturer shall test the spare fibers and any defective fibers shall be suitably bundled, tagged and identified at the factory by the fiber manufacturer.

5.4.5 Buffer tube

Loose tube buffer construction shall be applied. A buffer for protection from physical damage shall surround the individually coated optical fiber(s) during fabrication, installation and performance of the cable. The fiber coating and buffer shall be strippable for splicing and termination. The inside diameter of the buffer tube shall be of appropriate size to allow free movement of the fibers during cable Contraction or elongation resulting from thermal, tensile or vibration loads.

Buffer tubes shall be sleeved over multiple fibers forming a fiber unit. A fiber unit may consist of up to 6 fibers, individually identifiable utilizing the color code in conformance with EIA 359 A.

5.4.6 Optical fiber termination and splicing

Suitable splice boxes (enclosures) shall be provided to encase the optical cable ends and fusion splices in protective, moisture and dust free environment. The splice boxes shall be designed for the storage and protections of a minimum of 12 fibers cables and provide access through locked doors.

Fiber-optic cable of adequate length shall be provided so that all splicing can be performed at ground level at the towers. All splicing and necessary material shall be included in the price schedule presented by the Contractor.

5.4.7 Outdoor splice boxes

Splice boxes provided by the Contractor for outdoor use shall be suitable for use with the cable type provided as part of this Contract. The splice boxes shall be appropriate for mounting on steel structures and accommodate pass-through splicing and fiber terminations.

The splice box, including organizer/ splice trays, shall be designed to seal and protect the fiber cable splices from the environment defined in this specification and it shall provide easy access for any maintenance function.

All splice boxes shall be of metal construction that are clean and smooth finished, treated to resist rust, accommodate the storage of a minimum of 3 meters of coiled fiber and allow easy access to the splice trays. In addition there shall be a steel frame to coil up about 10 meters of OPGW outside the protection box.

5.4.8 Testing

The testing must be done by recognized equipment and it shall be possible to produce a computerized print out from the computer and the software, all of which (lap top computer, printer and software) must be included in the testing, commissioning or installation unit prices.

5.4.9 Maintenance

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

5.4.10 Joints

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

5.4.11 Particular requirement for OPGW earth wire fittings and accessories

The associated fittings and other accessories have to satisfy the specific function of OPGW and fiber optics requirements for a total integrity of their components. The best way to achieve these goals shall be in application of suitable performed products. A brief description of the accessories is as follows:

- a) Suspension Assembly: Suspension assembly shall consist of:
 - armour grip suspension clamp (aluminium alloy hyper formed armour rods and suspension clamp);
 - associated hardware for earth wire suspension:
 - Flexible grounding loop connection.
 - b) Tension Assembly: The tension assembly shall consists of:
 - hyper formed alum weld dead end grip;
 - associated hardware for earth wire attachment (shackle, link, clevis, clamps);
 - Flexible grounding loop connection.
 - c) Vibration Dampers: Dampers where necessary, shall be of Stockbridge type installed complete with the armour rods of the size suitable to the earth wire size.
 - d) Fiber Optic Splice Closure-Joint Box
- The fiber optic splice closure allows clamping of the cables to be spliced. It shall have the following characteristics:
- i) The splice capacity for minimum 24 single-mode fibers from metal free optical cable with loose tube construction;

- ii) waterproof housing of the closure aluminium or stainless steel construction with protection class IP 65 of IEC 60529;
- iii) Box and cable glands tightened by sealing compound.
- iv) Installation height shall be 1.5 m above the anti-climbing devices of the towers.

e) **Fiber Optic Hood Closure-Terminal Box**

The fiber optic splice closure allows termination of OPGW on the substation gantry and interface with the underground fiber optic cable leading into the control building. It shall have the following characteristics:

- i) the cable glands for accepting of one metal free optical cables with minimum 24 single-mode fibers and loose tube construction;
- ii) waterproof housing of the closure aluminium or stainless steel construction with protection class IP 65 of IEC 60529;
- iii) Box and cable glands tightened by sealing compound.
- iv) It shall be installed on the terminal gantry 1.5 m above ground level.

5.4.12 Fiber Optic Approach Cables

For purposes of this specification, a Fiber optic approach cable is defined as the Armoured underground Fiber optic cable required to connect Overhead Fiber Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the Fiber cable on the power line and the Fiber Optic Distribution Panel (FODP) installed within the building. The estimated Fiber optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical Fiber 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.

5.4.12.1 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.

5.4.12.2 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. 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.

5.4.12.3 Optical, Electrical and Mechanical Requirements

Approach cable shall contain Fibers with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), Fiber support/bedding structure, core wrap/bedding, and an overall impervious jacket.

5.4.13 Fiber Optic Distribution Panel

Fiber Optic Distribution Panels is required for each location for termination of Fibers in a manner consistent with the following:

1. 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 Fiber terminations.

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2. FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement.
 3. 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.

5.4.14 Optical Fiber Connectors

Optical Fibers shall be connectorised with FC-PC type connectors preferably. Alternatively connector with matching patch cord shall also be acceptable. Fiber optic couplings supplied with FODPs shall be appropriate for the Fiber connectors to be supported. There shall be no adapters.

5.4.15 Service Loops

For purposes of this specification, cable and Fiber service loops are defined as slack (extra) cable and Fiber provided for facilitating the installation, maintenance and repair of the optical Fiber cable plant.

- i. Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient Fiber 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.
- ii. Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.
- iii. Fiber Units Service Loops: For all Fiber optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of Fiber units shall provide for at least one (1) metre of Fiber unit service loop between the stripped cable and the bare Fiber fan-out.
- iv. Pigtail Service Loops : Connectorised pigtails spliced to bare Fibers shall provide at least 1 metre of service loop installed in the FODP Fiber organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.
- v. Fiber Service Loops : At least 0.5 metre of bare Fiber service loop shall be provided on each side of all Fiber splices. The bare Fiber service loops shall be neatly and safely installed inside covered splice trays.

5.4.16 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 Aluminium-Clad Steel Wire
- b. **Bell Communication Research**
GR-20 Generic requirements for optical Fiber and optical Fiber cable
- c. **ITU-T/CCITT Recommendations**
G.650 Definitions and test methods for the relevant parameters of singlemode Fibers
G.652 Characteristics of a single-mode optical Fiber cable
- d. **IEEE**
IEEE-1138 IEEE Standard Construction of Composite Fiber Optic Ground Wire (OPGW) for Use on Electric Utility power Lines
- e. **Telecommunication Industry Association EIA/TIA**
EIA/TIA-455-3 Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components
EIA/TIA-455-16 Salt Spray (Corrosion) Test for Fiber Optic Components
EIA/TIA-455-20 Measurement of Change in Optical Transmittance

EIA/TIA-455-25 Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies
EIA/TIA-455-32 Fiber Optic Circuit Discontinuities
EIA/TIA-455-33 Fiber Optic Cable Tensile Loading and Bending Test
EIA/TIA-455-41 Compressive Loading Resistance of Fiber Optic Cables
EIA/TIA-455-59 Measurement of Fiber Point Defects Using an OTDR
EIA/TIA-455-62 Measurement of Optical Fiber Macrobend Attenuation
EIA/TIA-455-78 Spectral Attenuation Cutback Measurement for Single- Mode Optical Fibers
EIA/TIA-455-80 Measurement of Cut-Off Wavelength of Single-Mode Fiber by Transmitted Power
EIA/TIA-455-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable
EIA/TIA-455-82 Fluid Penetration Test for Fluid-Blocked Fiber optic Cable
EIA/TIA-455-91 Fiber Optic Cable Twist-Bend Test
EIA/TIA-455-164 Single-Mode Fiber, 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 Fibers by Spectral Group Delay Measurement in the Time Domain
EIA/TIA-455-169 Chromatic Dispersion Measurement of Single-Mode Optical Fibers by the Phase-Shift Method
EIA/TIA-455-170 Cable Cut-off Wavelength of Single-Mode Fiber by Transmitted Power
EIA/TIA-455-174 Mode Field Diameter Measurement
EIA/TIA-455-175 Chromatic Dispersion Measurement of Single-Mode Optical Fibers by the Differential Phase-Shift Method
EIA/TIA-455-176 Method of Measuring Optical Fiber Cross-Sectional Geometry by Automated Grey Scale Analysis
EIA/TIA-598 Optical Fiber Cable Colour Coding

f. International Electrotechnical Commission IEC standards

IEC-60793-1 series Optical Fibers – Generic & product specifications, measurement methods & test procedures specification
IEC-60794-1-1 Optical Fiber cables – Generic specification
IEC-60794-1-2 Optical Fiber cables – Basic optical cable test procedure
IEC-60794-3 Optical Fiber cables – Duct, buried and aerial cables – sectional specification
IEC-60794-4 Optical Fiber 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.

5.4.17 Payment for Fiber Cable and Accessories

Payment for the supply and delivery for the contract item "Fiber Cable and Accessories" will be made at the unit bid price. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labors and all other operations related to Fiber cable and accessories fabrication, delivery etc.

6 Hardware Fittings

6.1 General

The proposed manufacturers of Insulators shall meet the criteria as specified in the Evaluation and Qualification Criteria, Vol. I, Section III of the Bidding Document.

6.2 Hardware Fittings

6.2.1 Details of Hardware Fittings

6.2.1.1 Arcing Horn / Intermediate Arcing Horn

The arcing horn / Intermediate Arcing Horn shall be either ball-ended rod type or tubular type. The air gap shall be so adjusted to ensure effective operation under actual field conditions.

6.2.1.2 Yoke Plates

The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength. 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 unfavourable 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 3mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the bidder.

6.2.1.3 Corona Control Rings/Grading Ring

The Corona control rings/grading ring shall be provided with hardware fittings and shall be of such design that it should cover at least one disc insulator in disc insulator strings so that they will reduce the voltage across the insulator units. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.

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.

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.

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.

6.2.1.4 Sag Adjustment Plate

The sag-adjustment plate to be provided with the double tension hardware fitting shall be of three plate type. The sag adjustment plate shall be provided with a safety locking arrangement. The device shall be of such design that the adjustment is done with ease, speed and safety.

The maximum length of the sag adjustment plate from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible and the steps

of adjustment shall be clearly indicated in the drawing. An adjustment of 150 mm minimum at the interval of 6 mm shall be possible with the sag adjustment plate.

Design calculations for deciding the dimensions of sag adjustment plate shall be furnished by bidder.

6.2.1.5 Suspension Assembly

The suspension assembly shall be suitable for ACSR 'BISON' Conductor.

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.

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.

The suspension clamp along with standard preformed armour rods/armour grip suspension clamp set shall have a slip strength between 18 to 26 kN for ACSR 'BISON' Conductor.

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.

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

Bids offering suspension assemblies with magnetic power loss more than 4 watts except for envelope type clamps for which magnetic power loss more than 8 watts at sub-conductor current of 600 amps shall be liable to be rejected. The Bidders are requested to enclose test certificates for magnetic power loss test along with the bid.

6.2.1.6 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.

6.2.1.7 Standard Preformed Armour Rod Set

The Preformed Armour Rods Set suitable for ACSR 'BISON' Conductor shall be used to minimise the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs. Chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

The preformed armour rods set shall have right hand lay and the inside diameter of the helix 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.

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

The length of each rod shall be as follows:

	Length	Diameter
ACSR 'BISON'	2540±25 mm	9.27±0.10 mm

The tolerance in length of the rods in complete set should be within 13 mm between the longest and shortest rod. The end of armour rod shall be parrot billed.

The number of armour rods in each set shall be twelve for ACSR 'BISON'. Each rod shall be marked in the middle with paint for easy application on the line.

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

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

6.2.1.8 Armour Grip Suspension Clamp

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

Elastomer insert shall be resistant to the effects of temperature up to 75degrees Celcius, 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.

The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength and shall not introduce unfavourable stress on the conductor under all operating conditions. However the length of AGS preformed rods shall not be less than 2235 + 25 mm for ACSR 'BISON'.

6.2.1.9 Envelope Type Suspension Clamp

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.

6.2.1.10 Dead end Assembly

The dead end assembly shall be suitable for ACSR 'BISON' Conductor.

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 30o 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.

Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' suitably inscribed near the point on each assembly where the compression begins. If the dead end assembly is designed for intermittent die compressions it shall bear identification marks 'COMPRESSION ZONE' AND 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. Tapered aluminium filler plugs shall also be provided at the line of demarcation between compression & non-compression zone. The letters, number and other markings on the finished clamp shall be distinct and legible.

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.

6.2.1.11 Interchangeability

The hardware for insulator strings with disc insulators / porcelain long rod insulators together with ball and socket fittings shall be of standard design, so that these hard wares are inter-changeable with each other and suitable for use with insulators of any make conforming to relevant Indian/International Standard.

6.2.2 Corona and RI Performance

Sharp edges and scratches on all the hardware fittings shall be avoided. All surfaces must be clean, smooth, without cuts and abrasions or projections. The Contractor must give suitable assurance about the satisfactory corona and radio interference performance of the materials offered by him. The Contractor shall furnish, prior to Commissioning, an RI Report showing that noise falls under regulations.

6.2.3 Maintenance

The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be generally bare hand method & hot stick method. The Bidder should clearly establish in the bid, the suitability of his fittings for hot line maintenance.

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.

6.2.4 Ball and Socket Designation

The dimensions of the ball and socket shall be of 16mm designation for 70 kN and 120 kN insulators and 20 mm for 160 kN insulators. The designation should be in accordance with the standard dimensions stated in IEC:120. The dimensions shall be checked by the appropriate gauge after galvanizing only.

6.2.5 Security Clips and Split Pins

Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking of the coupling as per IEC:372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances, the locking devices shall allow separation of fittings.

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).

Split pins shall be used with bolts & nuts.

6.2.6 Fasteners: Bolts, Nuts and Washers

All bolts and nuts shall be galvanized. 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.

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. Bolts should be provided with washer face to ensure proper bearing.

Nuts should be double chamfered. 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.

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.

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.

Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanized.

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

To obviate bending stress in bolt, it shall not connect aggregate thickness more than three times its diameter. Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

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.

Fasteners of grade higher than 8.8, are not to be used.

6.2.7 Materials

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

The details of materials for different component are listed as in Table-I

TABLE-1
(Details of Materials)

Sl. No.	Name of item	Material treatment	Process Standard	Reference	Remarks
1.	Security Clips	Stainless Steel/ Phosphor Bronze	-	AISI 302 or 304-L/ IS- 1385	
2.	Arcing Horn	Mild Steel Rod/ Tube Type	Hot dip galvanised	As per IS- 226 or IS-2062	
3.	Ball Fittings, Socket, all shackles links cleves	Class-IV Steel	Drop forged & normalized Hot dip galvanised	As per IS: 2004	

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
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 less than 20 KN
6(b).	Supporting Brackets & Mounting Bolts	High Strength Al Alloy 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 galvanised	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 Galvanised	IS:226/ IS-2062	

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

6.2.8 Workmanship

All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 220 kV transmission lines and will give continued good performance.

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.

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. Fasteners shall withstand four dips while spring washers shall withstand three dips of one minute duration in the standard preece test. Other galvanized materials shall have a minimum average coating of zinc equivalent to 600/gm/sq.m., shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard preece test for galvanizing.

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.

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.

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

Socket ends, before galvanizing, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions or high spots. The internal contours of socket ends shall be concentric with the axis of the fittings.

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.

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.

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

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.

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.

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

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, undercutting 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.

6.2.9 Payment for Hardware Fittings

Payment for the supply and delivery of hardware fittings; single 'I' suspension string, single 'I' suspension pilot string and double tension insulator string will be made at the unit bid price. Therefore, in the Price schedule, the unit bid price shall include full compensation for all the costs

incurred in furnishing all materials, equipment, labors and all other operations related to hardware fitting fabrication, delivery, etc.

6.3 Conductor and Earthwire Accessories

6.3.1 Detail of Conductor and Earthwire Accessories

6.3.1.1 Mid Span Compression Joint Bison ACSR conductor

Mid Span Compression Joint shall be used for joining two lengths of conductor. The joint shall have a resistivity 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.

The joint shall be made of steel and aluminium/aluminium alloy sleeves for jointing the steel core and aluminium/aluminium alloy wires respectively. The steel sleeve should not crack or fail during compression. The Brinell Hardness of steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanized.

The aluminium sleeve shall have aluminium of purity not less than 99.5%.

Tapered aluminium filler plugs shall also be provided on the line of demarcation between compression and non-compression zone.

6.3.1.2 Repair Sleeve

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

6.3.1.3 Vibration Damper

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

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.

One damper minimum on each side per Conductor/Sub-conductor for suspension points and two dampers minimum on each side per conductor/sub-conductor for tension points shall be used for ruling design span of 350 meters for 220 kV.

The Bidder may offer damping system involving more number of dampers per ruling design span than the specified.

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.

The messenger cable shall be made of high strength galvanized steel/stain less steel with a minimum strength of 135 kg/sq.mm. It shall be of preformed and post formed quality in order to prevent droop 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.

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.

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

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

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.

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.

The vibration damper shall not have magnetic power loss more than 1 watt at 600 Amps. 50 Hz alternating current per sub-conductor when installed on a twin bundle system for 220 kV line.

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

Performance Technical Particulars ACSR 'BISON'

Span length in meters:

- 1) Ruling design span: 350 meters
- 2) Maximum span: 1200 meters
- 3) Minimum span: 100 meters

Configuration:

- a) Twin bundle conductor per phase in vertical double circuit configuration (D/C)

Approximate tensile load in each:

- b) 22 kN @ each sub-conductor at temperature of 0 degrees Celsius and in still air

AGS Armour Rods used:

- c) Yes

Maximum permissible bending strain:

- d) +/- 150 micro strains dynamic

The damper placement chart for spans ranging from 100 m to 1200 m shall be submitted by the Bidder. 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 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.

6.3.1.4 Bundle Spacer

Armour grip bundle spacers shall be used to maintain the spacing of 450 mm between the two sub-conductors of each bundle under all normal working conditions.

Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.

The offer shall include placement charts recommending the number of spacers per phase per span and the sub span lengths to be maintained between the spacers while installing on the twin bundle conductors. The placement chart shall be provided for spans ranging from 100 m to 1200m

The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hr and to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.

The number of spacers recommended for a ruling design span of 350m shall however be seven with no sub-span greater than 70m and no end sub-span longer than 40m.

The Bidder may offer more number of spacers per ruling design span than the specified.

The Bidder shall also furnish all the relevant technical documents in support of their placement charts along with the bid.

Jumpers at tension points shall also be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm.

Bidder shall quote for rigid spacer for jumper. It shall meet all the requirements of spacer used in line except for its vibration performance. Spacers requiring retaining rods shall not be quoted for jumpers.

The spacer offered by the Bidder shall satisfy the following requirements.

1. Spacer shall restore normal spacing of the sub conductors after displacement by wind, electromagnetic and the electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation damage either to conductor or to the assembly itself. They shall have uniform grip on the conductor
2. For spacer requiring retaining rods, the retaining rods shall be designed for the specified conductor size. The preformed rods shall be made of high strength, special aluminium alloy of type 6061/65032 and shall have minimum tensile strength of 35 kg/sq.mm. The ends of retaining rods should be ball ended. The rods shall be heat-treated to achieve specified mechanical properties and give proper resilience and retain the same during service.
3. (Four) number of rods shall be applied on each clamp to hold the clamp in position. The minimum diameter of the rods shall be $7.87 + 0.1$ mm and the length of the rods shall not be less than 1100 mm.
4. Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061/65032. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.
5. Any nut used shall be locked in an approved manner to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.
6. Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.

7. The clam grooves shall be in uniform contact with the conductor over the entire surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material, which cause damage to the conductor when the clamp is installed.
8. For the spacer involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
9. Universal type bolted clamps, covering a range of conductor sizes, will not be permitted.
10. No rubbing, other than that of the conductor clamp hinges or clamp swing bolts, shall take place between any parts of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them.
11. The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.
12. Rigid spacers shall be acceptable only for jumpers.
13. The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.
14. The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.
15. The spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.
16. The spacer tube shall be made of aluminium alloy of type 6061/65032. If fasteners of ferrous material are used, they shall conform to and be galvanized conforming to relevant Indian Standards. The spacer involving ferrous fasteners shall not have magnetic power loss more than one watt at 600 Amps 50 Hz alternating current per sub-conductor.
17. Elastomer, if used, shall be resistant to the effects of temperature up to 75deg.C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard.
18. The spacer assembly shall have electrical continuity. The electrical resistance between the sub- conductors across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.
19. The spacer assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.
20. The spacer assembly shall be capable of being installed and removed from the energized line by means of hot line technique.

6.3.2 Material and Workmanship

All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 220 kV transmission line application with bundle conductors and will give continued good performance.

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.

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. The bolt threads shall be undercut to take care of increase in diameter due to galvanizing. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanized materials shall have a minimum overall coating of Zinc equivalent to 600 gm/sq.m and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanizing unless otherwise specified.

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

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

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

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.

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

All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

6.3.3 Compression Markings

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

6.4 Accessories for Galvanized Steel (G.S.) Ground wire

6.4.1 Detail of Accessories for G.S. Ground wire

6.4.1.1 Mid Span Compression Joint

Mid Span Compression Joint shall be used for joining two lengths of earth wire. The joint shall be made of mild steel with aluminium encasing. The steel sleeve should not crack or fail during compression. The Brinell Hardness of steel should not exceed 200. The steel sleeve shall be hot dip galvanized. The aluminium sleeve shall have aluminium of purity not less than 99.5%. Filler aluminium sleeve shall also be provided at the both ends. The joints shall not permit slipping off, damage to or failure of the complete earth wire or any part thereof at a load not less than 95% of the ultimate tensile strength of the earth wire. The joint shall have resistivity less than 75% of resistivity of equivalent length of earth wire.

The dimensions and the dimensional tolerances of the joint shall be as per the table given below.

7/3.35 G.S. Earth wire

S. No.	Item	Dimensions before Compression		Dimensions after compression		
		Inner dia.	Outer dia.	Length	Corner to	Face to
		(mm)	(mm)	(mm)	Corner (mm)	Face
1.	Aluminum Sleeve	22+0.5	32+0.5	400+5	29.4+0.5	25.0+0.5
2.	Steel Sleeve Filler	11.5+0.2	21+0.5	230+5	20.2+0.5	17.5+0.5
3.	Aluminum Sleeve	11.5+0.2	21+0.5	60+5		

6.4.1.2 Vibration Damper

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

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.

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

The Bidder may offer damping system involving more number of dampers per ruling design span than the specified.

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

Clamping bolts shall be provided with self-locking nuts designed to prevent corrosion of the threads or loosening during service.

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 droop 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.

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.

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

Sl.	Description	Technical Particulars No.	
			220 kV
1.	Span length in meters		
	(i) Ruling design span :	350 meters	
	(ii) Maximum span :	1200 meters	
	(iii) Minimum span :	100 meters	
2.	Tensile load in each		
	earth wire at temperature	1340	
	: of 0° C and still air Kgf		
3.	Tensile load in each		
	earth wire at temperature :	2620	
	of 32° C and full wind Kgf		
4.	Maximum permissible :	±150 micro	
	dynamic strain strains		

The damper placement chart for spans ranging from 100 m to 1200 m shall be submitted by the Bidder. All the placement charts should be duly supported by relevant technical documents.

The damper placement charts shall include the following:

- 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.
- Placement distances clearly identifying the extremities between which the distances are to be measured.
- Placement recommendation depending upon type of suspension clamps.
- The influence of mid span compression joints in the placement of dampers.

6.4.1.3 Flexible Copper Bond

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

6.4.1.4 Suspension Clamp

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

At all suspension towers, suitable suspension clamps shall be used to support the earth wire of 7/3.35 mm size for 220KV. The clamps shall be of either free center type or trunion type and shall provide adequate area of support to the earth wire.

The groove of the clamp shall be smooth, finished in 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.

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.

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.

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.

The complete assembly shall be guaranteed for slip strength of not less than 12 kN and not more than 17 kN. The breaking strength of the assembly shall not be less than 25 kN.

6.4.1.5 Tension Clamp

At all tension towers suitable compression type tension clamps shall be used to hold 7/3.35 mm galvanized steel earth wire for 220KV. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates

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° with respect to the vertical line.

The clamps shall be made of mild steel with aluminium encasing. The steel should not crack or fail during compression. The Brinell 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.

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.

The slip strength of the assembly shall not be less than 95% of the ultimate strength of the earth wire. The clamps shall be complete with all the components including anchor shackle, bolts, nuts, washers, split pin, jumper arrangement etc.

6.4.2 Material and Workmanship

All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 220 kV transmission line application with bundle conductors and will give continued good performance.

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.

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. The bolt threads shall be undercut to take care of increase in diameter due to galvanizing. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanized materials shall have a minimum overall coating of Zinc equivalent to 600 gm/sq.m

and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanizing unless otherwise specified.

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

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

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

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.

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

All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

6.4.3 Compression Marking

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

6.5 Payment for Conductor and Earth wire Accessories

Payment for the supply and delivery of accessories for conductors and earth wires will be made at the unit bid price. Therefore, in the Price schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labors and all other operations related to conductor and earth wire accessories fabrication, delivery, etc.

7 Tower Foundations and Associated Civil Works

7.1 General

The Contractor shall furnish all materials, equipment and labour and perform all operations required for the design and construction of all of the concrete foundations and other relevant civil works, as specified herein and as evidently necessary to complete the work.

7.2 Foundation Design

7.2.1 General

The Contractor shall design different type of foundations for different classes of soils and rocks as given in Schedule A.13 "Foundation Applicable Schedule". Upon completion of "Detail Soil Investigation", the Contractor shall design and prepare the foundation drawing and calculations subject to the approval of the Employer or Employer's representative before commencement of construction. Structure designs shall take into account seismic factor of 0.15g.

The Contractor shall design at least one foundation for each of the foundation types for every structure type used in the line to produce an economical family drawings and calculation for the approval of the Employer or Employer's representative before commencement of construction. Upon completion of "Detail Soil Investigation", the Contractor shall select the most economical foundation subject to the approval of the Employer or Employer's representative. The general foundation design parameters are given in Schedule A.13 and Conceptual Drawings are also given in the Drawings section.

7.2.2 Submittals

The Contractor shall submit one set of design calculations, detail drawings and reinforcing steel and concrete schedules for each type of foundation to the Employer or Employer's representative for review and comments before its approval. The Contractor shall submit these design calculations, detail drawing, reinforcing steel and concrete schedules to the Employer incorporating all comments for approval. Approval of the foundation designs by the Employer or Employer's representative in no way relieves the Contractor from his responsibility for an adequate foundation design, even though this specification sets forth the basic foundation design criteria. Upon receiving the Employer's representative's comments, the Contractor shall submit to the Employer's Representative one set of electronic copy and sets of drawings of all foundation details, including reinforcing steel schedules on drawing sheet sizes, form, heading, etc., as required by the Employer's Representative for record file.

7.2.3 References

Unless specified otherwise, design and details shall comply with the latest published editions of BS or with other official standard Specifications, provided they are of equal or higher standard, where such standard exists with accepted national or international good practice. Support foundation designs as detailed in the specification, which in the opinion of the Employer or Employer's Representative, do not demonstrate an acceptable type of foundation for the type of soil condition so described, will be rejected.

7.2.4 Classifications of Foundations

Classification of foundations and design of foundation depend upon the type of soil or rock which have been classified as follows:

Table: Soil Properties to be considered in Foundation Designs for various types of soil.

Foundation type	Type of soil	Angle of Earth Frustum (degrees)	Unit weight of soil (kg/cu.m.)	Limit bearing capacity (kg/sq.m.)

Type I	Normal Dry Soil			
	a. Without undercut	30	1440	25,000
	b. With undercut	30	1600	25,000
Type II	Wet soil due to presence of sub soil water/surface water	15	940	12,500
Type III	Sandy soil			
	a. With clay content 0-5%	10	1440	25,000
	b. With clay content 5-10%	20	1440	25,000
Type IV	Fissured Rock/Soft Rock (With undercut)			
	a. In dry portion	20	1700	62,500
	b. In wet portion	10	940	62,500
Type V	Hard Rock	--	--	1,25,000

Foundation type shall be decided upon the “Result of soil Investigation Report”.

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

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

The physical properties of soil under various conditions as presented in above table are to be considered for the design of foundations. These types of foundations correspond to type of foundations furnished in Price Schedule. Five types of foundations are envisioned for five categories of soil, so, whatever is the size of foundation within one class of soil, only one foundation type will be considered for each soil type. Sets of foundation of four legs of a tower shall be considered as one foundation in the price schedule.

7.2.5 Concrete Spread Footing

The foundation shall be designed to carry maximum shear loads below ground level, that is, the stub legs are not to be considered as reinforcement. Allowance shall be made for the loss of uplift resistance due to overlap of frusta where applicable. Uplift foundations shall be cast against undisturbed soil for a minimum height of 250mm and 50mm lean concrete.

For the purpose of bidding, the Bidder shall design each type of foundation with the value of soil bearing capacity as stated in Foundation Application Schedule, Schedule A.13.

After award of the contract the Contractor shall carry out “Detail Soil Investigation” of support site and shall design each type of support foundation accordingly.

7.2.6 Design loads

The loads used to design the foundations shall be actual working loads applied to the foundations by the towers.

The foundations shall be designed in such a manner that the factors of safety shall not be less than the following requirements:

Type of Foundation	Type of Stability	Normal Condition	Broken wire Condition
Pad or Rock	Direct soil pressure against compression Loads	2.0	1.5
	Uplift against Uplift loads	2.0	1.5
Raft	Soil pressure against overturning moment and compression loads	2.0	1.5
	Uplift against over turning moment	2.0	1.5

7.2.7 Compression loads

The Contractor shall use the following parameters in the design of the foundations for bearing loads.

- The foundations shall be designed such that all allowable soil bearing capacities are not exceeded by the greatest bearing loads from the loaded foundation. The allowable soil bearing values for the foundation types shall be the values given in the "Foundation Application Schedule" given in Schedule A.13.
- Bearing loads shall include the weight of the soil directly above the foundation.
- The bearing area of concrete spread footings shall be the actual area at the bottom of the mat.
- The following unit weights shall be used in the foundation design calculations when determining the bearing capacity:

- Soil1,600 kg/Cum
- Concrete2,400 kg/Cum

7.2.8 Uplift loads

The uplift loads on concrete spread footings shall be resisted by the weight of a volume of earth in the form of an inverted frustum of a cone or pyramid. The cone or pyramid shall have height that is 30 cm less than the depth from finish grade to the top of the concrete mat and with a bottom area that is the same as the top area of the mat and with a top that is determined by this intersection of planes starting at the mat edges and sloping outward at the specified cone angle from the vertical and the horizontal plane 30 cm below finish grade. For special foundations supporting river-crossing structures, the assumed cone will have a height, which is 75 cm below finish grade. Assumed cone of earth angles for each foundation type area listed in the Schedule A.13 "Foundation Application Schedule" of the foundation bid drawings.

7.2.9 Units weights for uplift and lateral loads

The following unit weights shall be used in the foundations design calculations when determining the uplift and lateral load capacity:

- Soil 1,200 kg/Cum
- Concrete 1,600 kg/Cum

Unless specified otherwise, design and details shall comply with the latest published editions of BS or with other official standard specifications provided they are of equal or higher standard where such standard exists with accepted national or international good practice. Support foundation designs as detailed in the specification which in the opinion of the Employer or Employer's representative do not demonstrate an acceptable type of foundation for the type of soil condition so described will be rejected.

7.2.10 Foundation type

The Bidder 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. Bidder has to furnish along with the bid one sample calculation for each type of foundation required as per Price Schedule for verification of correctness of design procedure adopted by the Bidder.

In the presence of high water table, the foundation shall be designed for a maximum depth of 1.5 meter below the existing ground level. The foundation is to be designed for fully submerged condition.

7.2.11 Foundation Design

The quantity of foundations in every type given in the Price Schedule is provisional only and may vary as per the result of the "Detail Soil Investigation". The provisional quantities of fabricated & galvanised steel towers as per specifications requirement, foundation type and their numbers, quantity of various line materials and other items are given in appropriate Price Schedule in Volume-III of the bid documents. However, the work shall be executed as per approved construction drawings and project requirement.

Contractor shall develop design, structural drawings, shop drawings & Bill of Materials of all 220 kV Double circuit towers and carryout the proto testing of towers. Similarly, the design and drawings for all type of foundations for the towers shall also be developed by the contractor, in sequence, suiting the project requirement.

Foundations should be designed for a working life of 50 years and Bidders should comply in full with the requirements of these specifications in establishing his design. In all locations, all steelwork, whether part of the tower or part of the stub-angle foundations shall be completely encased in concrete to ensure a cover of 100mm from any part of the stub leg or tower from a point 300mm above ground down to the base of the main foundation block. All Stubs shall have cleats designed to carry the entire stub load.

The tower foundations shall be designed to take into account the most adverse combination of loading conditions. The bearing pressure under the foundations shall be calculated for the maximum vertical compression forces which can exist in any leg due to the over turning forces, dead weight and other imposed loads. To establish ultimate bearing pressures the working pressures derived from the severest combination of imposed loads shall be multiplied by the relevant factor of safety specified before.

Ultimate foundation loading per leg shall be calculated as follows:

- 1) Straight line structures and towers

Compression - (Force due to overturning moment + 0.25 max. applied vertical loads + 0.25 support weight) x factor of safety

Uplift - (Force due to overturning moment - 0.25 x 1/3 max. applied vertical loads - 0.25 support weight) x factor of safety.

2) Tension structures and towers

As above but zero applied loads in uplift case or special uplift loading for Section Towers. In computing compression ultimate bearing stresses, the weight of concrete shall be multiplied by the relevant factor of safety.

3) Stub angle anchor

Stub angles shall be of galvanized steel and shall have cross-sectional area of not less than the structure leg member to which it will be attached. The stub angle shall not be included in the calculation of the steel reinforcement requirements against bending and tension forces in concrete foundation design.

Only those holes in the stub which have been previously punched and galvanized at the manufactures works will be used for the attachment of cleats. Site drilling will not be permitted.

4) Stub setting template

Stub setting templates, to approval of Employer or Employer's representative, shall be provided by the Contractor. They shall be of such design and construction as to resist distortion and damage and withstand repetitive use. They shall be manufactured from mild steel angle or channel or a combination of both, of approved and adequate cross- section, and shall be equipped with central alignment notches or holes corner braces, riser braces, and stub-angles in respect of the following requirements:

- route longitudinal center line
- structure lateral central line
- stub elevations (with reference to datum)
- stub leveling
- stub rake
- stub hip bevels
- stub angle spacing

No concreting shall be commenced before the stub setting is approved by the Employer or Employer's representative. After the completion of Works all the template sets shall be handed over to Employer. No extra payment for the design, manufacturing and delivery for the templates shall be claimed by the Contractor.

7.3 Excavation and Backfilling

7.3.1 Scope

This specification covers the general requirements of earthwork in excavation in different materials, filling back around foundations, conveyance and disposal of surplus spoils or, stacking them properly as directed by the Employer or Employer's Representative and, all operations covered within the intent and purpose of this specification.

7.3.2 General

- a) The Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials, any temporary works, consumable, and everything necessary, whether or not such items are specifically stated herein, for completion of the job in accordance with specification requirements.
- b) The Contractor shall carry out the check survey of the site before excavation and set properly all lines and establish levels for foundations.
- c) The excavation shall be done to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades on ground excavated areas and warning lamps at night for ensuring safety.
- d) The item also includes for dumping of excavated materials in regular heaps, bunds, riprap with regular slopes as directed by the Employer or Employer's representative, within the lead specified and levelling the same so as to provide natural drainage. Rock/Soil excavated shall be stacked properly as directed by the Employer or Employer's representative. As a rule, all softer material shall be laid along the center of the heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.
- e) Clearing: The area to be excavated /filled shall be cleared of trees, plants, logs, stumps, bush, vegetation, rubbish, slush etc. and other objectionable matter. If any roots or stumps of trees are met during excavation, they shall also be removed. The materials so removed shall be burnt or disposed of as directed by the Employer. Where earth fill is intended, the area shall be stripped off of all loose/soft patches and topsoil containing objectionable matter/materials, before filling commences.
- f) Precious object, relics, objects of archaeological importance; all gold, silver, oil, mineral, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of the Employer and the Contractor shall duly preserve the same to the satisfaction of the Employer and from time to time deliver the same to such person or persons as the Employer may from time to time authorize or appoint to receive the found goods.
- g) The Contractor shall excavate earth, rock, stumps and all other materials encountered as required for construction of each foundation. The Contractor shall place all suitable excavated material in backfill or in graded embankment in the immediate area at structures. Materials found to be unsuitable for foundation backfill or grading shall be wasted and disposed at Contractor's own cost.
- h) The Contractor shall excavate each foundation hole to the nominal excavation depth for the applicable foundation type except in case where the material being excavated is not capable of supporting 0.5 kg/sq.cm.
- i) At the nominal excavation depth, the foundation shall be carefully graded to a level plane and all loose or disturbed material shall be removed. The Contractor shall then examine the foundation excavation and a final determination will be made on the foundation type to be used.
- j) Excavations shall be maintained in a clean, safe and sound condition until completion of the foundation construction and shall be dike to prevent flooding by surface runoff. Suitable pumping equipment shall be provided and used to dewater excavations so that all installation work and backfilling is performed in the dry state. Any previously prepared foundation-bearing surface, that is softened by water runoff or otherwise contaminated before placement of the structure foundation, shall be excavated and replaced at the Contractor's expense.
- k) Those excavations where the base is unstable, lies below groundwater level, or has been over excavated, the Contractor shall furnish and place a layer of crushed stone, or selected backfill, or borrow to stabilize the base for placement of foundation materials. No extra payment shall be done for over-excavation and backfilled crushed stone layer.
- l) Topsoil and excavated material that is suitable for backfill around the foundations shall be stockpiled separately for use in backfill. Material that is unsuitable for backfill shall be disposed of. The stockpiles shall be sloped to drain and shall be protected from rainfall or other elements, which render the material unsuitable for backfill.
- m) Backfill shall be placed in not greater than 20cm lifts before compaction. Each lift shall be thoroughly compacted before the following lift is placed. Pneumatic or equivalent tampers

shall be used on cohesive materials; vibratory compactors shall be used on non-cohesive materials. Compaction shall achieve a density, at least, equal to that of the surrounding undisturbed earth.

- n) Large stones or rock fragments may be used in the backfill, provided they do not interfere with proper compaction. Particles larger than 25 cm shall be placed not nearer than 0.5 m of the structure and at least 1.0m below ground surface.
- o) Rock particles larger than 10 cm shall not be in contact with the concrete.
- p) Following completion of 75 percent of the compacted backfill portion, the remaining backfill and topsoil shall be placed and the topsoil mounded 30 cm above the ground surface and sloped to drain. Compaction of this material will not be required. Before final acceptance of the Works, the Contractor shall refill any locations that settle below the surface of the surrounding ground.
- q) Earth is defined as material which shall include all kinds of soil containing kankar, sand, silt, moorum or shingle, gravel, clay, loam, peat, ash, etc., which can generally be excavated with the aid of shovels and pick axes. This shall also include embedded rock boulders not longer than one meter in any direction and not more than 200 mm in any of the other two directions.
- r) Rock is defined as material which shall include rock, boulders, shale, chalk, slate, hard mica, schist, laterite and all other materials which, in the opinion of the Employer's Representative is rock and can be removed with picks, hammer, wedges, crowbars, pneumatic breaking equipment and blasting. This category shall also include excavation in macadam and tarred roads and pavements.
- s) Rock excavation may be made by drilling, barring, wedging, or compressed-air tools. No blasting will be permitted. The Contractor shall furnish all material and equipment to perform all works required for excavation of rock.
- t) For selection of rock type foundation for any tower location, the characteristics of rock shall be thoroughly investigated by the Contractor. Disintegrated rock or other types of rock such as soluble limestone, soft shale, slate, hardpan and organic rocks may not be suitable for construction of rock foundation.
- u) All loose boulders, semi-detached rocks (along with earthy mounds), not directly in the excavation area but so close to the area to be excavated as to be liable, in the opinion of the Employer's Representative, to fall or endanger the workman, equipment or the Works, shall be stripped off and removed away from the area of the works. Any material not requiring removal as contemplated in the work, but which, in the opinion of the Employer's Representative is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by the Employer.
- v) Payment: No separate or direct payment will be made to the Contractor for preparation of site, excavation, and backfill and rock excavation of tower foundation. All costs of soil and rock excavation incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

7.4 Dewatering

7.4.1 Scope

This specification covers the general requirements of dewatering excavations in general. All excavations shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas.

The Contractor shall remove, by pumping or other means approved by the Employer or Employer's Representative, any water, inclusive of rainwater and subsoil water accumulated in excavation and keep all excavations/trenches free of water required for further work.

Method of pumping shall be approved by the Employer or Employer's representative; but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing-in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

- a) When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of the Employer's Representative as large, well- point system- single stage or multistage shall be adopted. The Contractor shall submit to the Employer his

scheme of well- point system (dewatering) including the stages, the spacing number and diameter of well points, headers, etc., and the number, capacity and location of pumps for approval.

- b) Payment: No separate or direct payment will be made to the Contractor for dewatering of tower foundation and any other foundation works. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundations and other civil works.

7.5 Timber Shoring

7.5.1 Scope

This specification covers the general requirements of timber shoring for open excavations for structure foundations.

- a) Close timbering shall be done by completely covering the sides of the pits generally with short, upright members, called polling boards. These shall be of minimum 25 cm x 4-cm sections or as directed by the Employer or Employer's representative. The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 meters spacing, strutted with bellies or as directed by the Employer or Employer's representative. The length of the bellies struts shall depend on the excavation and supported by vertical walling, which, in turn, shall be suitably strutted. The lowest boards, supporting the sides of the trench or pit, shall remain exposed, so as to render the earth liable to slip out.
- b) Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit. The type of timbering shall be as approved by the Employer. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of excavations, pits, etc., from collapsing.
- c) Timber shoring may be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or, for other reasons. Such shoring shall be carried out, except in an emergency, only under instruction from the Employer.
- d) Payment: No separate payment will be made to the Contractor for timber shoring. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types and other civil works.

7.6 Select Borrow

- a) Where the material excavated for the foundation is unsuitable for backfill or is required for construction of embankment, the Contractor shall provide and compact select borrow. Excavated material shall be disposed at the Contractor's own expense.
- b) Material for select borrow shall be well-graded bank-run gravel, relatively free from clay, loam or vegetation matter and with no stones over 10 cm in maximum dimensions, or materials of equivalent strength and characteristics. Representative sample from proposed borrow sources shall be submitted to the Employer for approval of the borrow source. Approval of borrow source shall not mean automatic approval of all materials obtained from that source.
- c) The Contractor shall, at his option, use areas approved by the Employer or Employer's representative for production of select borrow or, at his own expense, make arrangements for obtaining select borrow from other sources.
- d) The select borrow shall be placed and compacted as specified for the backfill in Article 4.3 Excavation and Backfilling.
- e) Payment: No separate payment will be made to the Contractor for select borrow required for back filling of tower foundations. Hence, all costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types and other civil works.

7.7 Foundation Construction

7.7.1 General Requirement

The Contractor shall furnish all materials and labour required for the construction of foundations.

- a) The Contractor will be required to remove and replace, at his expense, any materials incorporated in the work that do not conform to these specifications.
- b) The Contractor shall furnish, without any extra cost, all materials that the Employer requires for testing. The cost of the tests shall be borne by the Contractor.
- c) The final selection of the type of foundation footing to be actually constructed for each particular structure will be done by the Contractor after the results of the sub soil tests and, shall be subject to the approval of the Employer.

7.7.2 Reference to Standard Specifications

Standards referred to in these specifications are as follows:

- a) ASTM referred to the latest edition of publications of American Society for the Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.
- b) ACI refers to the latest edition of publications of American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, Michigan 48219.

7.7.3 Measurement Standards

Measurement standards referred to in these specifications are as follows:

- a) Gallons - Wherever used in these specifications, gallons shall be understood to be U.S.gallons.
- b) Bag - Wherever used in these specifications, bag will be understood to mean 50-kg bag of Portland cement. Concrete shall be composed of cement, sand, coarse aggregate, water and admixtures; if required, all well mixed and brought to the proper consistency.

7.7.4 Concrete

The Contractor shall design and test concrete mixes, which have 28-day cubicle compressive strength of 210 kg/sq.cm. (Approx. M20)

- a) At least one month prior to the placement of any concrete, the Contractor shall make a set of concrete compressive strength test cubes for each design mix under field conditions, at the presence of the Employer's representatives, as required. The test cubes shall be made and tested in accordance with the applicable standards and will be witnessed by the Employer's representatives.
- b) The concrete mix shall be of such proportions as to produce a plastic and workable mix that will not separate during the placing and, will finish well without using excessive quantities of mixing water. Addition of water to compensate for stiffening of concrete before placing will not be permitted. Uniformity in concrete consistency from batch to batch will be required.
- c) After the test results are known for the field conditioned test cubes, the Contractor shall submit these results to the Employer or Employer's representative and the Employer or Employer's representative will notify the Contractor of the approval of test results and the acceptable design mixes.
- d) When placing concrete in hot weather, the recommendations of the American Concrete Institute's publication "Recommended Practice for Hot Weather Concreting"(ACI 605), or equivalent, shall be followed insofar as the Employer or Employer's representative may direct. The use of set accelerators will be at the Employer's or Employer's representative's discretion. For concrete placed during extremely hot weather, the aggregate shall be cooled by frequent water spraying in such a manner as to utilize the cooling effect of evaporation. Concrete with a temperature of 35°C, or higher, before placement will be rejected and shall be wasted at the Contractor's expense.

- e) Submerge concrete: Concrete to be placed under water shall be deposited by tremie, and only after it has been determined by the Employer or Employer's representative that placing of concrete in an un-watered excavation cannot be practically accomplished by any other means. The tremie will not be allowed to drop below the level of water outside. Under no circumstances will concrete be allowed to drop through water within the tremie. The tremie shall be watertight and sufficiently large to permit a free flow of concrete. The bottom of the tremie shall be as near to the surface against which the concrete is to be placed, as practicable and the tremie shall not be raised until seal has been established by the concrete sufficiently to prevent the entry of water of the tremie. The discharge of the tremie shall be kept submerged in concrete at sufficient depth so as to maintain an adequate seal during underwater placement. Placing of concrete shall proceed without interruption until underwater placing in the foundation has been accomplished. As placing of concrete under water progresses, the Contractor shall remove water displaced by the concrete when the top of the concrete being placed by tremie reaches the elevation of the water table level; no further placement by tremie shall be performed.
- f) Payment: No separate payment will be made to the Contractor for concrete used in tower foundation. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

7.7.5 Cement and Aggregates

In locations where conditions do not require high sulphate resistance, cement shall conform to the requirements of ASTM C150 Type T or equivalent. In locations where, in the opinion of the Employer's representative, the conditions require the use of high sulphate resistance cement, cement conforming to the requirements of ASTM C150 Type V or equivalent, shall be used. No extra payment will be made to the Contractor for the use of high sulphate resistance cement.

- a) In locations where, in the opinion of the Employer or Employer's representative, the conditions require the use of high sulphate resistance cement, cement conforming to the requirements of ASTM C150 Type V or equivalent shall be used. No extra payment will be made to the Contractor for the use of high sulphate resistance cement.
- b) The aggregates shall consist of clean, natural material or, subject to the approval of the Employer or Employer's representative, manufactured aggregates may be used.
- c) Aggregates shall be separated into sand and coarse aggregate before being used. The Employer or Employer's representative will permit no pit or crusher-run materials without prior approval.
- d) Natural fine aggregate or sand shall be graded within the following limits and the fineness module shall be between 2.5 and 2.8:

Sieve size Amounts Finer than Each Laboratory (U.S Std. Sieve) weight Percent

3/8 (9.5mm)	100
4 (4.75)	95 to 100
8 (2.36mm)	80 to 100
16 (1.18mm)	50 to 85
30 (600 micron)	25 to 60
50 (300 micron)	10 to 30
100 (150 micron)	2 to 10

Natural coarse aggregate shall be graded within the following limits, depending upon the clear spacing between reinforcing bars.

U.S. Standard Sieve	Nominal 1-1/2"	Nominal 3/4" (19mm)
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2" (50.8mm)	100	
1-1/2" (25-38mm)	95-100	
1" (25mm)	100	
3/4" (19mm)	35-70	90-100
3/8" (9.5mm)	10-30	20-55
No.4 (4.75mm)	0-5	0-10
No.8 (2.36mm)		

7.7.6 Slump

All concrete used shall have a slump of maximum 120 mm and minimum 75mm at the time of placing.

The water cement ratio shall be determined by consideration of the specified strength, the water reducing admixtures, the slump required for proper placement, air entraining requirements, the available and maximum allowable aggregate size, its specific gravity, and the amount of water carried on the aggregates.

The slumps and maximum sizes of aggregate as well as, the computation of trial mixes shall be as described in the American Concrete Institute Recommended Practice for Selected Proportions for concrete (ACI 613). The minimum amount of cement used per cubic meter of concrete when using 38 mm aggregate, shall be 6 bags (300kg) for a concrete strength of 210 kg/sq.cm. But with this cement content if the 28 days concrete strength is less than 210 kg/sq.cm, extra cement should be added to get the required strength, without any extra cost to the Employer. The proportions of all materials in the concrete shall be subject to approval of the Employer or Employer's representative. The Contractor shall provide all plant and equipment necessary to determine and control the actual proportions of materials entering the batch.

- a) In calculating the total water content in any mix, the amount of water carried on the aggregate shall be included. The water on the aggregate shall be determined periodically by test and the amount of free water on the aggregate subtracted from the water added to the mix. In all cases, the amount of water to be used shall be the minimum amount required to produce a plastic mixture of the strength specified and of the required density, uniformity and workability. The consistency of any mix shall be that required for the specific placing conditions and methods of placement.
- b) Water used in mixing and curing concrete shall be tested and not contain more than 1,000 parts per million of chlorides, nor more than 1,300 parts per million of sulphate, shall not have a turbidity count greater than 2,000 parts per million and shall also be free of objectionable quantities of oil and organic materials. Water source will be clearly identified and tested before using at the construction site.
- c) Payment: No separate payment will be made to the Contractor for slump. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

7.7.7 Storage of Material

Cement and aggregates shall be stored at the Site of the work in such manner as to prevent deterioration or intrusion of foreign matter. Special care shall be taken in storing cement to keep it thoroughly dry at all times.

- a) Cement that has been caked in storage is still usable, only if, when pressed between the thumb and fingers, it powders readily. Otherwise, its use will not be permitted.
- b) When reinforcing steel is delivered to the job in advance of the Contractor's requirements, the Contractor shall provide suitable protection in order to prevent excessive rust developing on the reinforcing steel, as it will be Contractor's responsibility to remove the excessive rust.

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- c) Payment: No separate payment will be made to the Contractor for storage of material. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

7.7.8 Concrete Mixing and Placing

Before any concrete mixing is begun, all equipment for mixing, transporting etc. shall be cleaned for all dirt and debris. All dirt and debris shall also be removed from the places to be occupied by the concrete.

- a) All mechanical equipment shall be checked before starting a concrete pour to ascertain whether or not it is in good operating condition and, if not, shall be tuned-up, or repaired, or replaced to the satisfaction of the Employer or Employer's representative. Also, the stock of construction material (cement, aggregate and sand) shall be checked before starting the concreting work to ascertain whether or not it is in sufficient quantity for one foundation work.
- b) When a foundation location is ready for concrete placement, the Employer's Representative shall be notified with a check out list at least 24 hours prior to concreting so that he may inspect to assure that the excavation is free of water, mud and debris; that the bottom surface of the excavation is well levelled and compacted; and where required, a crushed stone sub-base has been placed; that the reinforcing steel is properly secured in place; and that the formwork is properly braced.
- c) Rock surfaces shall be as flat as possible and projecting ridges shall be levelled off before the concrete is placed or, spaces between the ridges shall have been previously filled with concrete to form a horizontal surface.
- d) The Contractor shall see that all material that is to be embedded in the concrete has been placed before the concrete is placed. The Contractor shall be responsible for the accurate location of all embedded materials. Any work inaccurately or improperly set shall be relocated and reset at the Contractor's expense.
- e) All batching components of the concrete shall be accurately measured. Measuring on a weight basis is preferred. However, measuring on a volume basis will be allowed as long as careful controls are maintained. Weight measurements shall be made using standard batching equipment for large quantities and wheelbarrow scales for small quantities. Volume measurements shall be made in batching boxes. The batching boxes shall be as large as practical.
- f) The batch mixer shall be rotated at a speed recommended by the manufacturer and mixing shall be continued for at least one to one-half (1-1/2) minutes after all materials are in the mixer, unless the size of the batch is over 1.2 cubic meter. When additional mixing time shall be required as advised by the Employer. A mechanically-operated batch mixer shall be used for mixing, unless otherwise approved by the Employer.
- g) The tempering of concrete, which has partially hardened, that is, remixing with or without additional cement, aggregate or water, will not be permitted.
- h) Concrete shall be conveyed from the mixer to the place of final deposit within 30 minutes by methods that will prevent the segregation or loss of the materials. After 30 minutes of mixing, the concrete shall be rejected and replaced by fresh concrete without any extra cost to the Employer.
- i) Equipment for chute, pumping and pneumatically conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete at the delivery end without separation of the materials. The chutes shall never be on a slope that is steeper than two vertical to three horizontal. Conveying equipment shall not have any aluminium parts that come in contact with the concrete.
- j) When the concrete is to be placed on hard rock or other concrete, after the existing surface has been properly cleaned and otherwise prepared, the existing surface is to be wetted until it is saturated. The first batch of concrete placed shall be a grout obtained by omitting the coarse aggregate from the mix and reducing the water as required. The grout shall be evenly spread on the water-saturated surface and then the concrete shall be deposited continuously and as rapidly as practicable.
- k) The concreting shall be carried on at such a rate that the concrete is, at all-time plastic and flows readily into the spaces between the bars so that each successive layer properly bonds with its predecessor. Successive layers shall be placed within 15 minutes of the preceding layer.

- l) When placing foundations with drops over 2 meters, hoppers and trunks must be provided of a size to allow for proper placing. Not less than four hoppers of any size shall be available and used, if requested, and a sufficient number of sections of trunk shall be furnished to reach within 500 mm of the bottom of the foundation.
- m) The concrete shall be compacted during and after depositing by vibration. The concrete shall be thoroughly worked around embedded materials.
- n) All concrete must be consolidated by means of internal vibration except, where the Employer's Representative has given written permission to use some other method of consolidation. The type and make of vibrator must have a speed of at least 6,000 vibrations per minute (VPM) when the machine is being supplied at its rated voltage, air pressure, etc. The Contractor shall at his own expense, furnish sufficient transformers, compressors, etc. of approved type to operate all vibrators at the voltage, pressure, etc., specified by the manufacturer.
- o) The Contractor shall always have, at least, two vibrators in operating condition at the location of the concrete placement.
- p) Payment: No separate payment will be made to the Contractor for concrete mixing and placing for the foundation works. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

7.7.9 Concrete Test

The Contractor shall make one set of concrete compressive strength test-cubes for each structure or as directed by the Employer or Employer's representative. There shall be three cubes to a set and the cubes shall be made in accordance with ASTM C31. Only one cube shall be made from any one batch containing less than 1/2 cubic meters of concrete. The Contractor shall also make one set of concrete compressing strength test cube for each new batch of cement purchased two weeks before using that cement.

After the cubes have aged, at least, 24 hours in the field, the Contractor shall deliver them to a location designated by the Employer where they will be tested in accordance with ASTM C39. If two of the cubes tested at 28-day tests indicate a compressive strength of 210kg/sq.cm or more, the remaining cubes shall be discarded. If the 28-day compressive strength indicates a compressive strength of less than 210kg/sq.cm., the Employer or Employer's representative will determine what remedial measures are necessary and the Contractor shall perform the remedial measures at his own expense. The remedial measures may include, but are not limited to, the replacement of the entire foundation.

Payment: No separate payment will be made to the Contractor for concrete test. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

7.7.10 Concrete Formwork

Forms shall be used, wherever necessary, to confine the concrete for structures and shape it to the required lines, or to insure against contamination of the concrete by materials caving or sloughing from adjacent surfaces left by excavation.

- a) Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete, and shall be maintained rigidly in position. Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Molding strips shall be placed in the corners of forms so as to produce chamfered edges on permanently exposed concrete surfaces. All exposed surfaces may be formed with any material of adequate strength and tightness to hold the wet concrete in proper position and prevent the loss of mortar.
- b) If plywood or steel forms are not readily available, the Contractor, with Employer's special recommendation, may substitute wood planking provided exposed surfaces are rubbed to remove ridges on exposed surfaces.
- c) The Contractor shall provide templates, which firmly hold the stub angles within 10 mm of the horizontal side setting dimensions and within 5 mm of the required elevation during the placing of the concrete. Details of the templates shall be submitted to the Employer or Employer's representative at least one month before the commencement of any

foundation construction. The bottom portion of the structure may be used for this purpose provided that adequate cribbing and bracing are supplied for support.

- d) Before concrete is placed, the surfaces of all forms shall be oiled with form oil that effectively prevents sticking and will not stain the concrete surfaces. For wood forms, form oil shall consist of refined, pale paraffin mineral oil. For steel forms, form-oil shall consist of refined mineral oil compound.
- e) Forms shall be removed only when the strength of the concrete is such that form removal will not result in cracking, spalling, or breaking of edges of surfaces or other damage to the concrete. Usually, formwork shall be removed after 48 hours from concreting times. Any concrete, damaged by form removal or otherwise, shall be repaired immediately without any extra cost to the Employer.
- f) Payment: No separate payment will be made to the Contractor for concrete formwork. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

7.7.11 Concrete Finishing and Curing

- a) The exposed top surfaces of all concrete foundation piers shall be slightly sloped to prevent the accumulation of water.
- b) Immediately after the removal of forms, the holes left by form tie rod fasteners shall be filled with mortar and all damaged or defective concrete shall be repaired or removed and replaced to the satisfaction of the Employer or Employer's representative. Improperly consolidated concrete shall be removed by chipping. The chipped openings or recesses shall be of such depth and shape as required by the Employer or Employer's representative to insure that the patching material placed in the openings or recesses will be thoroughly keyed and bonded to the concrete.
- c) "Dry pack" mortar shall be used for filling relatively deep required for the replacement of defective concrete where surface dimensions of the chipped openings or recesses are relatively large. The depth of chipped recesses for concrete patches shall extend at least 25 mm beyond the nearest reinforcing steel.
- d) To ensure proper curing, all concrete shall be kept moist for a period of at least 10 days. Burlap or, an equivalent material or a curing compound, shall be applied over exposed concrete surfaces. The burlap shall be kept moist at all times. If the foundation is backfilled before the one-week curing time has elapsed, the burlap protection shall remain on the exposed projection.
- e) Payment: No separate payment will be made to the Contractor for concrete finishing and curing. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

7.7.12 Membrane Curing Compound

Membrane curing compound shall be applied uniformly by spray, leaving no pinholes or gaps, at a rate not to exceed 4.91 square meters per litre. The curing compound shall be applied after finishing operations are completed and surface moisture has disappeared. If forms are removed prior to 7 days after placing the concrete, the uncovered surfaces shall be coated with the curing compound as specified herein.

- a) Foundation shall not be backfilled before they have been inspected to see that they are free from surface defects and voids, or that the defects and voids have been properly repaired.
- b) The foundations shall not be subjected to any loads in addition to those existing at the time of the placing of the foundation concrete, until the curing period has elapsed.

7.7.13 TOR Steel Reinforcing Bar

All TOR steel-reinforcing bars shall conform to the requirements of Grade fe-415 and shall be fabricated in accordance with the "Manual of Standard Practice" of the Concrete Reinforcing Steel Institute.

- a) Mill scale, rust, oil and mud shall be removed from reinforcing steel by firm rubbing with burlap or equivalent treatment before the reinforcing steel is placed.
- b) The minimum center-to-center distance between parallel bars shall be two and one-half (2-1/2) times the diameter of the bars. In no case shall the clear spacing between bars be neither less than 25 mm nor less than one and one-third (1-1/3) times the maximum size of coarse aggregate. It is preferable to submit re-bar schedule for the said tower foundation.
- c) All TOR steel-reinforcing bars shall have a protective concrete cover of not less than:
 - 80 mm - on the bottoms of footings and on any surface of concrete that will be exposed to salt water.
 - 50 mm - concrete exposed to weather or ground.
- d) TOR steel reinforcing bars shall be accurately located and shall be secured in position by the use of annealed iron wire of no less than No.16 gauge, and shall be supported in a manner that will keep the reinforcement away from the exposed concrete surfaces. Concrete blocks shall be used to support the reinforcing steel in the foundation mat; broken stones or wooden blocks shall not be used for supporting the reinforcing steel.
- e) Payment: No separate payment will be made to the Contractor for TOR steel reinforcing bar for construction of foundation works. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

However, payment for reinforcing bars required for protection works of foundation will be made at unit bid price quoted in "Protection of Tower Foundation" in the Price Schedule..

7.7.14 Measurement, Unit Rates and Payment for Foundation

Measurement

Measurement for payment for the Contract item "Work associated with Tower Foundations" shall be on the basis of the actual number of each type of structure foundations constructed by the Contractor for each type of tower. The rate of foundation per tower shall include transportation of construction materials to the Site, excavation, form works, 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 as per specification.

Payment for each tower foundation type shall be according to the price entered in the Price Schedule and the number of foundation types measured. Payment for a tower foundation will be deemed to cover the costs of all required labour, equipment and materials. The indicative shape of foundations is enclosed in the drawing section.

Breakdown of Foundation Volume/Weight/Rate

The Bidder is required to provide the breakdown of 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 for each type of tower in the Bid as provided in the Price Schedule as "Breakdown of Foundation Volume/Weight/Rate". Price quoted in respective Schedule for each type of foundation for each type of tower must comply with unit rate quoted in "Breakdown of Foundation Volume/Weight/Rate" schedule.

In the "Breakdown of Foundation Volume/Weight/Rate" Schedule, the unit rates of excavation for each type of foundation 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.

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.

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.

Payment for Foundation

Payment for each foundation type in different tower type shall be according to the price entered in the Schedule 4(a) of Price Schedule and the number of foundations measured. Payment for a tower foundation will be deemed to cover the costs of all required labour, equipment and materials including, but not limited to, the following:

- a) Performing detail foundation design and preparation of all necessary construction drawings.
- b) Supply and transport of all required equipment and materials to the job site.
- c) Tower pegging and foundation orientation.
- d) Excavation, dewatering, timber shoring and backfilling with compaction for the foundation.
- e) Gravel packing in the base of footings, where necessary.
- f) Template and stub setting.
- g) Supplying, transporting and fixing in place all required formwork.
- h) Designing, testing, batching, mixing, transporting, placing and curing of all required concrete.
- i) Designing, testing, transporting and fixing of all required reinforcing steel.
- j) Construction of foundations.
- k) Water curing works for foundation
- l) Backfilling works of foundation
- m) Curing with membrane curing compound

7.8 Foundation Protection Works

Structure foundation located near the bank of the river, and other unstable places as directed by Employer shall be protected by stone masonry works, gabion wall and/or concrete wall as per site condition. The Contractor shall undertake detailed study of such requirements during check survey in close consultation with the Employer or Employer's representative and submit design of such protection works for Employer's approval.

7.8.1 Stone Masonry Works

- a) The stone shall be hand placed with un-coursed close joints to the lines and grades as designed. The rubble stone shall be placed with 1:3 cement sand mortar after having joints thoroughly moistened. The surface joints shall be finished with 1:3 cement sand mortar. After completion of masonry wall, it shall be cured with water for more than 10 hrs
- b) Weep-holes with perforated Poly Vinyl Chloride (PVC) pipes of 10 cm in diameter shall be placed in each 2 sq.m. of slope surface of the masonry wall or as required by site conditions. The upper surface of the masonry wall shall be finished smooth with concrete. The perforated pipe shall be extended at least 30 cm both ends from the stone masonry wall and in the backfilling end the perforated PVC shall be covered with gravel at least 30 cm in all-around insuring the filter zone.
- c) Payment: Measurement for payment of stone masonry works shall be made on the basis of actual placed volume of stone masonry, in cubic meters. Payment shall be made for the number of cubic meters measured as provided at the unit price specified in the schedule. The unit price shall include all labour, tools and equipment, materials including furnishing, transporting and placing, installation of PVC pipes, gravel packing and all other cost necessary for the performance and completion of the works.

7.8.2 Gabion Wall

The standard type gabion (Maccaferri) shall be a flexible hot dip galvanized gabion of the type and size specified below. It is made of wire mesh of the type and size and selvedge as specified in the following:

- a) The mesh shall be hexagonal woven mesh, with the joints formed by twisting each pair of wires through three and half turns.

- b) The size of mesh shall conform to the standard specification issued by the factory and shall be not greater than 1/3 of the smallest stone filled in the gabion.
- c) All wires used in the fabrication of the gabions and in the wiring operations during construction shall be "Mild steel wire", i.e. wire having average tensile strength of 44 kg/sq.mm.
- d) The diameter of the wire used in the fabrication of the netting shall be at least 3.0 mm depending on the design requirement.
- e) All wires used in the fabrication of the gabions and in the wiring operations during construction shall be hot dip galvanized.
- f) All edges of the standard gabions including end panels and the diaphragms, if any, shall be mechanically selvage in such a way as to prevent unravelling of the mesh and to develop the full strength of the mesh. The wire used for the selvage shall have a diameter greater than that of the wire used to form the mesh. Wire having a diameter of 3.0 mm and the selvage wire shall have diameter equal to or greater than 3.9 mm.

The stone for the gabion shall be taken from the river deposit material or as approved by the Employer or Employer's representative. The rock shall be of compact, firmly bound and uniformly grain texture and absolutely weather-resistance and shall not have cracks, holes, laminations or detrimental materials. The stone blocks shall be of natural irregular cubical shape. The thin sliced blocks shall not be accepted. The size of stone shall be at least 10 cm.

The standard gabion shall have following dimension:

Length : 2.0 meter
Width : 1.0 meter
Height : 1.0 meter

Sufficient lacing and connecting wires shall be supplied with the gabions, for all the wiring operations to be carried out in the construction of the gabion work. The quantity of such wire is estimated to be 8% of the gabion supplied. The 2.4 mm lacing wire shall be used for the gabion made of wire gauge 3.0 mm.

Payment: Measurement for payment of gabion works shall be made on the basis of actual placed volume of gabions in cubic meters. Payment shall be made for the number of cubic meters measured as provided at the unit price specified in the schedule. The unit price shall include all labours, equipment, materials and all other cost necessary for the performance and completion of the works.

7.8.3 Plain Cement Concrete (PCC) Works

PCC works used for the foundations of gabion walls and stone masonry works shall be of grade M10, M15 and M20 as approved by the Employer.

Payment: Measurement for payment of PCC works shall be made on the basis of actual placed volume in cubic meters. Payment shall be made for the number of cubic meters measured as provided at the unit price specified in the schedule. The unit price shall include all labours, equipment, materials and all other cost necessary including formworks etc. for the performance and completion of the works.

7.8.4 Reinforcement Bar

Size of reinforcement bars should be used based on designs approved by Employer.

Payment: Measurement for payment of reinforcement bar shall be made on the basis of actual placed weight in kg. Payment shall be made per kg measured as provided at the unit price specified in the schedule. The unit price shall include all labours, equipment, materials and all other cost necessary for the performance and completion of the works.

7.8.5 Excavation / Backfilling

The scope of Excavation and Backfilling works covers for foundation of gabion walls, Stone Masonry works and cutting of earth wherever sufficient electrical ground clearance of the line is not available.

Back filling also covers construction of embankment. If required by the Employer, the Contractor shall construct embankments for tower sites where footings are located in standing water of sloughs, potholes and marshes. The embankments shall consist of suitable material obtained from select borrow. Proper compaction will be carried out while backfilling.

Payment: Measurement for payment of excavation/backfilling shall be made on the basis of actual placed volume in cubic meter separately for excavation of all types of soil and excavation of all types of rock separately as provided in unit price specified in price schedule. Payment shall be made per cubic meter measured for excavation and backfilling separately as provided at the unit price specified in the schedule. The unit price shall include all labours, equipment, materials and all other cost necessary for the performance and completion of the works.

7.8.6 Payment for Tower Foundation Protection Works

Contract items shall be measured for payment as follows:

- 1) Stone masonry works by the actual gross volume (m³) of stone and mortar placed in its completed state in accordance with the requirements of the contract and approved by the Employer or his Representative.
- 2) Gabion wall works by the actual gross volume (m³) of gabions placed in accordance with the requirements of the contract and approved by the Employer or his Representative.
- 3) Plain cement concrete works by the actual volume (m³) of concrete placed in accordance with the requirements of the contract and approved by the Employer or his Representative. The additional concrete and re-bar required by the other foundation works apart from the tower foundation schedule shall be paid as per the unit rates of the foundation protection works for concrete and re-bars.
- 4) Excavation by the volume (m³) of excavation within vertical planes located 0.5 m outside the widest part of the foundation structure. Slopes outside the vertical planes and bracing of the sides, if required, will not be measured and shall be included in the rate for the excavation. Preparation and cleaning of bedrock surfaces prior to concreting shall be included in the rate for excavation.
- 5) Backfilling by the volume (m³) of backfill around, above or against a finished structure (concrete works, gabion wall works or stone masonry works). If backfilling a previously excavated volume, then the volume of backfill will be measured as that volume within the approved excavation lines, net of any solid structure constructed within the excavated volume.

Payment of the above contract items shall be according to the unit price entered in the Price Schedule and the number of units measured and approved by the Employer or his Representative. Payment for any of the above contract items shall be deemed to cover the costs of all labour, equipment and materials required to meet all the relevant contract requirements.

8 Erection, Stringing, and Miscellaneous Works

8.1 General

The scope of erection and stringing works shall include the cost of all labour, tools and plant such as tension stringing equipment and all other incidental expenses in connection with erection and stringing work. The bidders shall indicate in the offer the stringing technique and sets of stringing equipment he would deploy exclusively for this transmission line package. The stringing equipment shall be of sufficient capacity to string simultaneously a bundle of Double Bison and Moose Conductors. The Contractor shall be responsible for transportation to site of all the materials to be provided by the Contractor as per the scope of work to site and proper storage and preservation at his own cost, till such time the erected line is taken over by the Employer.

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

8.2 Erection of Steel Towers

8.2.1 Assembly of Tower

All towers shall be vertical under the stresses set up by the completed overhead line. Precautions shall be taken to ensure that no parts of the structures are strained or damaged in any way during erection and, drifting shall not be allowed. Support members, which arrive on site with slight distortions due to handling in transit, shall be straightened by the Contractor using an approved means and, offered to the Employer or Employer's representative for inspection and subsequent acceptance or rejection before erection commences. Suitable ladders shall be used whenever necessary during erection but such ladders and removable step bolts shall be removed when erection is not in progress.

Spanners used during erection shall be well shaped and fit closely on the hexagon to avoid damaging of nut and bolt heads. Reaming or drilling for correction of mismatched holes will not be allowed without the written approval of the Employer or Employer's representative. All nuts shall be tightened properly using correct size spanner and torque wrench.

The Contractor shall ensure that a rigid bolt-checking or Tower Inspection program is carried out on all supports. On completion of initial assembly of towers, an organized bolt checking team with representatives from both Contractor's and Employer's side shall check all bolts for tightness and any other defects in tower member from the structure top downwards. The Contractor shall manage all the tools and equipment required for inspection and if found the loose bolts during the inspection, the entire checking process will be repeated upon the request from the contractor after the remedial measures has been carried out as required. Upon completion of tower inspection, all the comments must be reflected in an approved format of tower inspection card and submitted to the Employer's Representative for approval. Unless major defects are found in erection, the tower shall be allowed for stringing.

Bolt checking shall be carried out within one week from the time the support is erected. Throughout the course of support erection, the Contractor shall ensure that stays or guys adequately support unbraced members or temporary struts, prior to being braced.

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

In no case the tower structure shall be erected until twenty eight (28) days after completing the foundation concrete work, and until proper backfilling and compaction. Safety belts and helmet must be used while erecting the towers.

The Contractor shall notify the Employer two weeks before that the supports are ready for inspection.

The inspection and correction of defects, if any, shall be completed before the start of the stringing operation.

Damaged galvanizing may be repaired on site by galvanizing paint.

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

8.2.2 Payment

Payment for the steel tower erection will be made at the unit price bid for each type of tower as given in price schedule. This work shall include the erection of towers and tower extension parts complete with stubs, step bolts, hangers, D-shackles, bolts and nuts etc, tack welding and supply and application of enamel and zinc rich paint but excluding tower accessories such as danger plates, number plates, phase plates, circuit plate, anti-climbing devices and bird guards. Therefore, in the Price Schedule the unit bid price shall include full compensation for all cost incurred in furnishing all materials, tools, labours etc. for erection work related to this item.

8.3 Conductors Stringing

8.3.1 Insulator Hoisting

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

8.3.2 Handling of Conductor and Earth wire

At least 3 months before conductor stringing commences, the Contractor shall submit to the Employer's Representative for approval a detailed account of his proposed stringing procedure (method statement), which should include details of temporary support, stays and compensation for initial stretch and long term creep of the conductors. The detail shall also include the drum schedule along with the puller locations; approximate conductor joints locations; road crossing scaffoldings; schedules of insulator strings and vibration dampers etc.

Stringing shall be carried out mechanically pulling method. Each of the phase conductors shall be pulled out one by one by the use of the pilot wires. The pilot wire shall be pulled out first and then followed the phase conductors. Precaution must be taken so as not to damage the phase conductors while laying and pulling the pilot wire.

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

There shall not be more than one joint per conductor in any one span, and tension joints shall not be less than 15 meters from any conductor clamp.

No tension joints shall be used:

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

Conductor repair sleeves shall not be used without the permission of the Employer or Employer's representative. Specifically when more than 3 strands of outer core of conductor are found cut, the

conductor shall not be repaired with repair sleeves or as it will be corrected directed by the Employer's representatives.

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

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

Phase conductors and earth wire shall be erected with such sags that at everyday temperature in still air at 0 degrees Celsius temperature with maximum wind pressure, the final tensions shall provide factors of safety on the ultimate tensile strength of the conductor. The Contractor shall submit erection and final sag and tension charts for each type of conductor. These charts shall plot inter-related curves of tensions against equivalent span lengths, and actual span lengths against sags, at temperatures of 0°C, 20°C, 32°C, 40°C, and 80°C in still air conditions, and shall show details of conductor size, conductor breaking load, and conditions of loading.

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

The term "final tension" shall mean the tension existing in a line conductor, for any given condition of loading after sufficient period in service, to allow for "bedding down" stretch and creep to take place.

For purposes of calculating creep allowance, this shall be taken as ten years from erection.

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

At the end of the guarantee period the specified ground clearance plus the conductor creepage allowance shall not be infringed, in addition, the sag of any phase conductors in the same span.

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

The Contractor shall provide dynamometers, sighting boards and levels suitably mounted for clamping to support steelworks and other approved apparatus necessary for the proper checking of the work.

When required by the Employer, dynamometers shall be tested and, if necessary, recalibrated at the Contractor's expense.

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

Blocks for running out conductors shall be of approved type and shall be robust and full running.

The wheel of the running out block shall have a diameter of not less than 20 times the outside diameter of the conductor and shall be fabricated from aluminium.

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

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

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

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

The Contractor shall identify the spans where aeronautical signs on the earth wire may need or on the locations as directed by the Employer's Representative.

8.3.3 Offset Clipping

To obtain the correct sags and to ensure that the suspension insulators will hang vertically once clipped in, the Contractor shall employ offset clipping analysis.

8.3.4 Payment

Payment for the conductor stringing will be made at the unit price bid "normal stretch (double circuit)" under the "Installation of insulator strings complete with arcing horns/corona rings & necessary hardware, installing of bundle conductor (ACSR Bison) including fixing of conductor accessories, installing and stringing of earthwire including fixing of earthwire accessories (Twin bundle Conductor) in Double Circuit Line on per kilometre basis.". Therefore in the schedule the unit bid price shall include full compensation for all cost incurred in furnishing all materials, equipment and labour related to this item.

8.4 Optical Ground Wire Stringing

At least 3 months before OPGW stringing commences, the Contractor shall submit to the Employer's Representative for approval a detailed account of his proposed stringing procedure (method statement), which should include details of temporary support, stays and compensation for initial stretch and long term creep of the conductors. The detail shall also include the drum schedule along with the puller locations; approximate opgw splice locations; road crossing scaffoldings and schedules of vibration dampers etc.

Stringing shall be carried out mechanically pulling method. The optical ground wire shall be pulled out by the use of the pilot wires. The pilot wire shall be pulled out first and then followed the optical ground wire.

Precaution must be taken so as not to damage the ground wire conductors while laying and pulling the pilot wire.

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).

8.4.1 Payment

Payment for the contract item installation of Optical Fibre Cabling shall be made at the unit price bid specified in Price Schedules. Therefore, in the Price Schedule the unit bid price shall include full compensation for all cost incurred in furnishing all materials, equipment and labour related to this item.

9 Inspection, Testing

9.1 Scope

The whole of the Works supplied under the Contract shall be subject to inspection and testing by the Employer or their Representatives during manufacture, erection and after completion. The inspection and tests shall include, but not be limited to, the requirements of this chapter of the Specifications.

The Contractor shall provide all costs (which shall be treated as included in the quoted unit price of each respective item), appliances, apparatus, supervision, labour and services necessary to carry out all tests; (Type test, Acceptance tests, Routine tests and tests during manufacture), except for the expenses of the inspector/purchaser's representative, unless specifically stated otherwise.

9.1.1 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 works are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all necessary points. Such programs shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions, before the award of the Contract. A quality assurance program of the Contractor shall generally cover, but not be limited to, the following:

- The Organization structure for the management and implementation of the proposed quality assurance program.
- Documentation control system.
- Qualification data for bidder's key personnel.
- The procedure for purchases of materials, parts, components, and selection of subcontractors' services including vendor analysis, source inspection, incoming raw materials inspection, and verification of materials purchases.
- System for shop manufacturing including process controls and fabrication and assembly controls.
- Control of non-conforming items and system for corrective actions,
- Control of calibration and testing of measuring and testing equipment.
- Inspection and test procedure for manufacture.
- System for indication and appraisal of inspection status.
- System for quality audits.
- System for authorizing release of manufactured products to the Employer.
- System for maintenance of records.
- System for handling storage and delivery.
- A quality plan detailing out the specific quality control procedure adopting for controlling the quality characteristics relevant to each item of supply.
- Construction management.

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

9.1.2 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.

9.1.3 Inspection, Testing and Inspection Certificates

The provisions of the clauses on Test and Inspection of the General Conditions of Contract shall be applicable to the supply and erection portions of the Works. The Employer shall have the right to re-inspect at his own expenses, any material though it would have been previously inspected and approved by him at the Contractor's works before, and if, after the same are inspected at site latter, the material is found defective, then the Contractor shall bear the costs of this inspection and reinstatement according to specification.

The Employer shall have, at all reasonable times, access to the premises and /or works of the contractor and/or their sub-contractor(s)/sub-vendors and shall have the right, at all reasonable times, to inspect and examine the materials and workmanship of the product during its manufacture.

The Employer shall give notice in writing to the Contractor, of any objection to any drawings and all or any equipment and workmanship, which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall make the modifications that may be necessary to meet the said objections.

The Contractor except where otherwise specified shall provide free of charge such item as labour, materials, electricity, fuel, water, stores.

Apparatus and instruments as may be reasonably demanded by the Employer's inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer or to his authorised representative to accomplish testing.

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. 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. 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.

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. 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. 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.

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

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.

9.2 Guarantees

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

9.3 Tests at Manufacturers Works

9.3.1 General

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

At least fourteen days' prior notice, in writing or by fax, shall be given to the Employer of the readiness of 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 inspection.

Inspection of equipment will 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 the Employer has waived inspection.

Functional electrical and mechanical tests shall be carried out on the completed plant after assembly in the Works. The extent and method of recording the results shall be agreed by the Employer in sufficient time to enable the tests to be satisfactorily witnessed or to make any change 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 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 cost of carrying out such calibration shall be borne by the Contractor in all cases.

9.3.2 Material tests

Test report of the materials to be used for the following items shall be submitted with drawings for approval to the Engineer including mill sheets.

- 1) Support members, plates, bolts, and nuts for towers
- 2) Steel reinforcing bars for tower foundations

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 standards or codes on the request of the Employer.

9.3.3 Test certificates

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

These test records, certificates and performance curves shall be supplied for all tests, whether or not the Employer or his Representative has witnessed them. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the contract reference title. Specified requirements shall be shown on each certificate for comparison with actual test results.

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

9.3.4 Type tests

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

The Contractor shall offer the type tested following items:

- ACSR Bison Conductor
- ACSR Moose Conductor
- Optical Ground Wire (OPGW)
- Galvanized Steel Earth wire (GSW)
- Insulators
- Insulator Hardware
- Vibration Dampers
- Compression Fittings
- Other Hardware and accessories for Conductor, OPGW and GSW

The Type Test must have been carried out within 5 years prior to the date of bid opening by a recognized national/international accredited laboratory. If the type test reports are older than 5 years or insufficient, the bidders shall undertake to repeat the same to the satisfaction of the Employer at their own cost. The cost in connection of the visit of the Employer's representative to witness the type test shall also be borne by the Contractor.

9.4 Tower Test

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

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

- Tower: The tower shall be fabricated from approved detail drawings in a manner as close to final production procedures as practicable. The tower shall be complete in every detail.
- Erection: The tower shall be erected on rigid foundation using the specified tower and bolts and nuts shall be tightened to the specified torque. The vertical axis through the center of gravity of the erected tower shall not be out of plumb by more than 1 cm for every 500 cm height.
- Rigging: The Contractor shall submit for approval as to compliance with the specifications, diagrams showing the proposed methods of applying loads and measuring deflection.
- Loading: All test loads, corresponding to conductor and overhead ground wire loading, shall be applied directly to the regular attachment. Details shall be provided for these loads. Test wind loads, equivalent to wind loads on the tower, shall be applied where convenient and, in such a manner that the summations of applied load and overturning moment are as close as possible to the actual behaviour as designed.
- Extra compressible member is not allowed for use of applying wind loads on tower. To ensure application of full-test loads to the tower, friction losses in rigging shall be added to the rigging loads.
- Load Programs: The Contractor shall program the tests to most favourably demonstrate that the towers will carry all design loads and conditions specified in the loading diagrams. Test wind loads on tower shall be the same as applied in design calculation.
- Deflection Measurements: Deflections shall be recorded for the "before-load", "load-on" and "load-off" condition to provide longitudinal and transverse deflections at the tower top center, at the elevation of the middle cross arm (s) and at least one intermediate point of tower body.

- **Design Load Tests:** The initially applied loads and the increment of loading shall be 25 percent of the loads given in the loading diagrams. Each load increment shall be maintained for not less than two minutes for each assumption except under maximum (full) design loads the period of five minutes shall be maintained and during which time there shall be no slacking off or adjustment of the loads. Should it become necessary to adjust the loading, the two or five minutes period shall start after the loading is stabilized and constant. All test loads shall be removed completely before the loads for testing under different assumptions are applied.
- **Destruction Tests:** After the successful completion of the design load tests, the tower shall be further tested to destruction by increasing the transverse loads under any condition specified by Employer, in increments not to exceed five per cent of full design transverse loads. The vertical and/or longitudinal load (s) is kept constant at their full design values while deflections are being recorded.
- **Modification of Tower Components:** Any conspicuous yielding or any failure of any part of the tower under any of the tests specified in sub-article shall be considered a defect. If a defect develops, the Contractor shall modify his design of the tower and send to Employer's Representative 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.
- **Material Tests:** Steel materials used for tested towers shall be subject to tension or bend test in accordance with ASTM A370. The Contractor at no additional cost to Employer shall, perform these tests. The test specimens shall be selected as follows:
 - Two sets selected from the destructed members of each tested tower.
 - Two sets selected from the undisturbed members of each tested tower.
- **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.

9.5 Tests on Insulators and Insulator Assemblies

9.5.1 General

Routine, Sample and Type tests shall be carried out on all types of insulators used in the Contract. The Bidder shall submit with their Bid, test certificates showing that the insulator concerned have successfully passed type test in accordance with the relevant international standards, which shall be issued by any internationally acknowledged independent reputable laboratory.

9.5.2 Standards

The insulator strings and its components shall conform to the following 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 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 Supplier to establish equivalence.

Sl. No.	Indian Standard	Title	International Standard
1.	IS:209-1992	Specification for zinc	BS:3436
2.	IS:406-1991	Method of Chemical Analysis of Slab Zinc	BS:3436
3.	IS:731-1991	Porcelain insulators for overhead Power	BS:137- (I&II)

Sl. No.	Indian Standard	Title	International Standard
		lines with a nominal voltage greater than 1000 V	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 Galvanisation for iron and steel	ISO-1461 (E)
7.	IS:2633-1992	Testing of Uniformity of Coating of 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 NEMAPubli- cation No.07/ 1964/ CISPR
10.	IS:8269-1990	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	IEC 61466-2

Sl. No.	Indian Standard	Title	International Standard
		overhead lines with a nominal voltage above 1000V : Dimensional and electrical characteristics	
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

9.5.3 Tests

9.5.3.1 Type Tests

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

On unit disc Insulators

The following Type tests are required on individual standard disc insulator units:

- Verification of dimensions as per IEC 60383
- Dry lightning impulse withstand voltage as per IEC 60383
- Wet and Dry power frequency withstand voltage as per IEC 60383
- Visible Discharge test (dry) as per IS731, Cl. 10.2
- Radio interference test as per IEC60437
- Thermal mechanical performance test in accordance with IEC-575.
- Residual strength Test
- Impact Test
- Residual strength test
- Steep wave front Test

Sample test

Every insulator shall pass the tests in accordance with IEC-383. The insulators for sample test shall be selected at random from batches. Number of samples shall be as indicated in IEC-383 and the samples are subjected to the test in accordance with IEC-383.

On the complete Disc Insulator String with Hardware Fittings

One suspension and one tension string of each type selected by the Employer shall be subjected to the following Type tests in accordance with the provisions of BS-137 or IEC-383 and 437.

- Impulse test: Dry withstand and 50% flashover, positive and negative.
- Power frequency test: Wet and dry withstand and wet flashover.
- Radio interference test in accordance with IS: 8263/ IEC: 60437.
- Corona Extinction Voltage Test (Dry) as stipulated in IEC: 60383.
- Voltage distribution test
- Vibration Test
- Mechanical Strength Test
- Power Arc Test
- Assembly Test

Sample Batch for Type Testing

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

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

9.5.3.2 Acceptance Tests

For Disc Insulators

- Visual examination :As per IEC : 60383
- Verification of dimensions :As per IEC : 60383
- Temperature cycle test :As per IEC : 60383
- Galvanising test :As per IEC : 60383
- Mechanical performance test :As per IEC:60575 Cl 4.0
- Test on locking device for ball and socket coupling :As per IEC:60372
- Eccentricity test :As per IEC:60383
- Residual Strength Test*
- Metallurgical Test (For metal fittings only in black condition)
 1. Grain size
 2. Inclusion rating
 3. Chemical analysis
 4. Microstructure
- Chemical analysis of Zinc Sleeve (if applicable)
- IR Measurement
- Impact Test
- Steep Wave front test*
- Thermal Mechanical performance test*

Note : 'Residual Strength Test' shall be performed as acceptance tests once for every supply of 25,000 nos. of a particular rating AND 'Steep Wave front test' & 'Thermal Mechanical performance test' shall be performed as acceptance tests once for every supply of 50,000 nos. of a particular rating.

For Porcelain disc Insulators Only

- Electro-mechanical strength test
- Porosity test :As per IEC : 60383
- Puncture test :As per IEC : 60383

For Glass Insulators Only

- Thermal shock test :As per IEC : 60383
- Steep wave front test/Puncture test
- Mechanical failing load Test

9.5.3.3 Routine Tests

Routine and sample mechanical tests shall be carried out on fittings in accordance with the appropriate section of BS3288 Part 1, IS:731 or IEC60383

- Visual Inspection :As per IS:731, Cl. 10.13
- Mechanical routine test :As per IS:731 Cl. 10.14
- Electrical routine test (for porcelain disc insulator only) :As per IS:731 Cl. 10.15
- Thermal shock routine test (for glass insulator only) :As per IEC:60383

9.5.3.4 Tests during Manufacture

- Chemical analysis of zinc used for galvanising
- Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.
- Chemical analysis hardness tests and magnetic particle inspection for forgings
- Hydraulic Internal Pressure tests on disc insulator shells
- Autoclave Test on Cement

9.5.4 Insulator and Insulator Assembly Test Descriptions

- Power frequency test:
 - Wet and dry withstand and wet flashover.
- Impulse test:
 - Dry withstand and 50% flashover, positive and negative.
- Radio interference test (Dry)

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.
- Corona Extinction Voltage Test (Dry)

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

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 13% for suspension insulator strings and 14% for tension insulator strings for 220 kV line.
- Mechanical Strength Test for insulator strings for 220 kV line.

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.
- Vibration Test

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 metres. In the case of suspension string a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and specified no. of sub-conductors each tensioned at 25 % of UTS of the conductor shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductors throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point, nearest to the string, shall be measured and the same shall not be less than $1000/f^{1.8}$ where f is the frequency of vibration in cycles/sec. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test the insulators shall be examined for looseness of pins and cap or any crack in the cement. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and insulators after the vibration test. The insulators shall be subjected to the following tests as per relevant standards:

Tests	Percentage of units to be tested
Temperature cycle test followed by mechanical performance test	60
Puncture test/steep wave front test	40

- 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	$I_n = I_{sys} = 40 \text{ KA}$	Two of $t_n = 0.2\text{s}$ and one of $t_n = 0.5\text{s}$

The acceptance criteria after the completion of test series shall be as follows.

- Insulator separation not permitted.
- Burning/melting of metal components, breaking of insulator sheds, glaze removal are permitted.
- The complete insulator string along with its hardware fittings including arcing horn, corona control ring/grading ring shall withstand 80% of UTS.

- Assembly Test

This test shall be carried out to ensure that the cotter pins, bolts, clamps etc., fit freely and properly.

- Steep Wave Front Test

Test following test shall be performed on 10 insulator units in case of disc insulators selected at random from the lot offered for selection of sample for type test.

- Each insulator unit shall be subjected to five successive positive and negative impulse flashovers with a wave having minimum effective rate of rise of 2500 kV per microseconds.
- Each unit shall then be subjected to three dry power frequency voltage flashovers.

- Acceptance Criteria

An insulator shall be deemed to have met the requirement of this test if, having been successfully subjected to the ten impulse flashovers, the arithmetic mean of the three subsequent dry/power frequency voltage flashover values equals or exceeds 95% of the rated dry power frequency flashover voltage.

An insulator shall be deemed to have failed to meet the requirement of above testing if,

- It has not flash over when the oscillogram or peak voltage indicator shows a marked reduction in voltage.

or

- Any one of the subsequent three dry power frequency voltage flashover value is less than 80% of the value specified.

Failure of any one unit either in the steep wave front or subsequent low frequency voltage test shall cause for testing on double number of units.

- Hydraulic Internal Pressure Test on Shells (only for Disc Insulator)

The test shall be carried out on 100% shells before assembly. The details regarding test will be as discussed and mutually agreed to by the Supplier and Employer in Quality Assurance Programme.

- Thermal Mechanical Performance Test

Thermal Mechanical Performance Test shall be performed in accordance with IEC-60383-1 Clause 20 with the following modifications:

- a. The applied mechanical load during this test shall be 70% of the rated electromechanical or mechanical value.
- b. The acceptance criteria shall be
 - i. X greater than or equal to $R + 3S$.

Where

X = Mean value of the individual mechanical failing load.

R = Rated electro-mechanical / mechanical failing load.

S = Standard deviation.

- ii. The minimum sample size shall be taken as 20 for disc insulator units and 5 units for long rod units.
- iii. The individual electromechanical failing load shall be at least equal to the rated value. Also puncture shall not occur before the ultimate fracture.

- Electromechanical/Mechanical Failing Load Test

This test shall be performed in accordance with clause 18 and 19 of IEC 383 with the following acceptance

- (i) X greater than or equal to $R + 3S$

Where

X = Mean value of the electro-mechanical/mechanical/ failing load.

R = Rated electro-mechanical / mechanical failing load.

S = Standard deviation.

- (ii) The minimum sample size shall be taken as 20 for disc insulators units and 5 for long rod units. However, for larger lot size, IEC 591 shall be applicable.
- (iii) The individual electro-mechanical/mechanical failing load shall be at least equal to the rated value. Also electrical puncture shall not occur before the ultimate fracture.

- Residual Strength Test

The above test shall be performed as per clause 4.4 and 4.5 of IEC 797 preceded by the temperature cycle test, on both glass and porcelain disc insulators. The Sample size shall be 25 and the evaluation of the results and acceptance criteria shall be as per clause No. 4.6 of IEC:797.

Chemical Analysis of Zinc Sleeve

The purity of the zinc used in zinc sleeve shall be tested as per IS:209. The purity of zinc shall not be less than 99.8%.

- IR Measurements

IR measurement shall be carried out by the instrument operating at 5 / 10 kV DC. IR value when measured under fair weather condition, shall not be less than 2000 M-ohm.

- Impact Test

The Impact Test shall be carried out in accordance with ANSI-C-29.2 Clause 8.2.8 with the following modification.

The breaking point of the pendulum shall be so adjusted that, when released the copper nose will strike the outer rim of the shell or the most protruded rim of the shell squarely in a direction parallel to the axis of the unit and towards the cap.

The test specimen shall receive an impact of 7 N-m for 70kN & 120 kN Disc by releasing the pendulum.

- Chemical Analysis of Zinc used for Galvanizing

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

- Tests for Forgings

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

- Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic, particle inspection for castings will be as per the internationally recognised procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Employer in Quality Assurance Programme.

- Autoclave Test

For cement used in the assembly of the insulators six samples from different batches shall be tested in accordance with ASTM C-151. The cement shall have an expansion less than 0.12%.

9.5.5 Insulator Fittings

Tensile tests, resistance tests and galvanizing tests shall be carried out in accordance with the requirements of BS 3288 Part 1 and BS 729.

On Suspension Hardware Fittings only

(a)	Visual examination & Dimensional and material Verification	IEC:61284; Clause 7 & 8
(b)	Magnetic power loss test for suspension assembly	
(c)	Clamp slip strength Vs torque test for suspension clamp	IEC:61284; Clause 11.4.2
(d)	Vertical damage load & Failure load test for suspension clamp	IEC:61284; Clause 11.4.1
(e)	OZONE resistance Test on elastomer	IEC:61854

On Tension Hardware fittings only

(a)	Visual examination & Dimensional and material Verification	IEC:61284; Clause 7 & 8
(b)	Heat cycle test for dead end Assembly	IEC:61284; Clause 13.0
(c)	Mechanical Damage & Failure load Test (excluding clamp)	IEC:61284; Clause 11.5.2
(d)	Tensile test for dead-end clamp	IEC:61284; Clause 11.5.1

9.5.6 Schedule of Testing

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

- Submission of drawing for approval.
- Submission of Quality Assurance Programme for approval.
- Offering of material for sample selection for type tests.
- Type testing.

9.5.7 Guarantee

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators with the hardware fittings.

9.6 Conductor Tests

The conductors shall be tested in accordance with the requirements of the appropriate IS, IEC, ISO or ANSI standards and not limited to the following tests.

9.6.1 Tests on Conductor**• D.C. Resistance Test on Stranded Conductor**

On a conductor sample of minimum 5m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge 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°C as per IS:398. The resistance corrected at 20°C shall conform to the requirements indicated in the STP.

• 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.

- Corona Extinction Voltage Test

The sample assembly with each conductor of 5 m length shall be strung as per the configuration show in the Table below:

Line Configuration	No of conductors per Bundle	Sub-conductor Spacing (mm)	Maximum Height of the conductor above ground (m)	Minimum Corona extinction voltage (kV)
220 kV with Twin ACSR BISON conductor	2	450	7	154

The sample assembly when subjected to power frequency/dc voltage under dry condition shall have a corona extinction voltage of not less than the values indicated in the table above. 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.

- Radio Interference Voltage Test

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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- Drum Strength Test of Steel drums

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

- Barrel Batten Strength Test of Wooden Drums

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

- 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.

- 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.

- 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.

9.7 Earth wire Tests

9.7.1 Standards

The earth wire shall conform to the following Indian/ International Standards, which shall mean latest revisions, amendments/changes adopted and published, unless otherwise in the Specification.

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

Sl. No.	Indian Standard	Title	International Standard
1.	IS: 209-1992	Specification for zinc	BS:3436-1986
2.	IS: 398-1990	Specification for Aluminum Conductors for Overhead Transmission Purposes	IEC:1089-1991 BS:215-1970
3.	IS:398-1998 Part-II	Aluminum Conductor Galvanized Steel Reinforced	BS:215-1970 IEC:1089-1991
4.	IS :398-1996 Part-IV	Aluminum Alloy stranded conductor	BS-3242-1970 ASTM-8399 M86 IEC:1089-1991
5.	IS:398-1992 Part-V	Aluminum Conductor Galvanized Steel-Reinforced For Extra High Voltage (400 KV) 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	Method of Testing 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 : 6745-1991	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433-1969 ISO 1460 - 1973
12.	IS : 9997-1991	Aluminum Alloy Redraw Rods	IEC 104 - 1987
13.		Zinc Coated steel wires for stranded Conductors	IEC : 888-1987
14.		Hard drawn Aluminum wire for overhead line conductors	IEC : 889-1987

9.7.2 Type Tests on Earth wire

The required type clause shall not be required to be carried out if a valid test certificate is available for the same Earth wire. The tests on Earth wire are stipulated hereunder. The specified type tests under the following tests certificate shall be considered valid if:

- 1) 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
- 2) Tests have been conducted not prior to 5 (five) years from the date of bid opening.

In case the test 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.

The following tests are required on samples of Earth wire from each manufacturing works:

- UTS test
- DC resistance test

9.7.3 Acceptance Tests on Earth wire

- Visual and dimensional check on drum
- Visual check for joints scratches etc. and lengths of Earth wire
- Dimensional check
- Lay length check
- Galvanising test
- Torsion test
- Elongation test : As per IS:398 (Part-II)
- Wrap test : As per IS:398 (Part-II)
- DC resistance test : As per IS:398 (Part-II)
- Breaking load test : As per IS:398 (Part-II)
- Chemical Analysis of steel

9.7.4 Routine Tests on Earth wire

- Check for correctness of stranding
- Check that there are no cuts, fins etc. on the strands.
- Check that drums are as per Specification.

9.7.5 Tests During Manufacture of Earth wire

- Chemical analysis of zinc used for galvanising
- Chemical analysis of steel

9.7.6 Earthwire Test Descriptions

- 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.

- D.C. Resistance Test

On a earth wire sample of minimum 5m length two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge 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 20⁰C. The resistance corrected at 20⁰C shall conform to the requirements of this Specification.

- Chemical Analysis of Zinc

Samples taken from the zinc ingots shall be chemically/ spectrographically analysed. The same shall be in conformity to the requirements stated in the Specification.

- Chemical Analysis of Steel

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

- 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.

- 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.

- Dimensional Check

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

-
- Lay Length Check

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

- Galvanising 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.

- 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.

9.7.7 Sample Batch for Type Testing

The Contractor shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from Owner's Quality Assurance Dept. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Owner.

The Contractor shall offer at least three drums for selection of sample required for conducting all the type test.

The Contractor is required to carry out all the Acceptance tests successfully in presence of Owner's representative before sample selection.

9.7.8 Test Facilities

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

- i. Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer etc.
- ii. Standard resistance for calibration of resistance bridges.
- iii. Finished Earth wire shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc., with traverse laying facilities.

9.8 Conductor, Earth wire Hardware Fittings and Accessories Tests

9.8.1 Test of Conductor, hardware fitting and accessories

Conductor, both wire hardware fittings and accessories shall be tested in accordance with the requirements of the appropriate IS, IEC, ISO, or ANDI standards and not limited to the following tests:

- Galvanising/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.

- **Mechanical Strength Test of Welded Joint**

The welded portion of the component shall be subjected to a Load of 2000 kgs for one minute. Thereafter, it shall be subjected to die-penetration/ultrasonic test. There shall not be any crack at the welded portion.

- **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.

- **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 recognised 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.

T-Connector for Conductor

- **Axial Tensile Load Test for Welded Portion**

The sleeve portion of the T-Connector shall be compressed on conductor. The compressed portion shall be held rigidly on some fixtures and axial load shall be applied along with the jumper terminal the load shall be increased gradually till breaking of welded joint occurs. The breaking load should be above the value indicated in the Standard Technical Particulars.

Flexible Copper Bond

- **Slip Strength Test**

On applying a load of 3 kN between the two ends, stranded flexible copper cable shall not come out of the connecting lugs and none of its strands shall be damaged. After the test, the lugs shall be cut open to ascertain that the gripping of cable has not been affected.

Vibration Damper for Conductor and Earth wire

- **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 ± 0.5 mm to determine following characteristics with the help of suitable recording instruments:

- i. Force Vs frequency
- ii. Phase angle Vs frequency
- iii. Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the aeolian vibration frequency-band between the lower and upper dangerous frequency, limits determined by the vibration analysis of conductor/earth wire without dampers.

Acceptance criteria for vibration damper:

- i. The above dynamic characteristics test on five damper shall be conducted.
- ii. The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
- iii. The above mean reactance response curve should lie within the limits specified for ACSR BISON conductor & 3.35 mm Earth wire.
- iv. The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
- v. If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
- vi. Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

Vibration Analysis

The vibration analysis of the conductor/Earth wire shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis:

- i. The analysis shall be borne for single conductor/Earth wire 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.
- ii. The self-damping factor and flexural stiffness (EI) for conductor and Earth wire shall be calculated on the basis of experimental results. The details of experimental analysis with these data should be furnished.
- iii. The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.
- iv. Examine the aeolian vibration level of the conductor/Earth wire with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
- v. From vibration analysis of conductor / Earth wire without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the aeolian vibration levels exceed the specified limits shall be determined.
- vi. From vibration analysis of conductor/Earth wire with damper/dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment point and the antinodes on the conductor/Earth wire shall be determined. In addition to above damper clamp vibration amplitude and antinode vibration amplitudes shall also be examined.
- vii. 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.
- viii. 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/Earth wire shall be tensioned at 25% of RTS of conductor/Earth wire 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/Earth wire has been tensioned, clamps shall be installed to support the conductor/Earth wire 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/Earth wire. 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 $\pm 25/f$ 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 retouring 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 / Earth wire 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/Earth wire under clamp shall also be free from any damage.

For the purpose of acceptance, the following criteria shall be applied.

- i. There shall not be any resonant frequency shift before and after the test by more than ± 20 %.
- ii. The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ± 20 %.

Spacer (for twin bundle)

• Vibration Tests

The spacer assembly shall be clamped to conductor. During the vibration tests the axis of the clamp of sample shall be maintained parallel to its initial static position by applying a tension of 25% of RTS of conductor. The spacer assembly shall be free to vibrate and shall not be retorqued or adjusted between the tests.

All the vibration tests mentioned hereunder shall be conducted on the same sample on the same test span. The samples shall withstand the vibration tests without slipping on the conductor. Loosening, damage or failure of component parts. After each vibration test, clamp slip test shall be carried out as per the procedure given in Clause No3.5 (b) below

a. Longitudinal Vibration Test

The stationary conductor and the vibrating conductor/equivalent diameter of aluminium alloy tube shall be restrained by fixed clamps. The displacement of the vibrating conductor shall be 25mm minimum on either side. The longitudinal movement shall be parallel to the conductor at frequency not less than 2 Hz for minimum one million cycles.

b. Vertical Vibration Test

The spacer/spacer damper shall be installed in the middle of the test span and the frequency chosen so as to get an odd number of loops. The shaker shall be positioned at least two loops away from the test specimen to allow free movement of the conductor close to the test specimen. One conductor shall be connected to the shaker and vibrated to an amplitude such that.

$$f^{1.8} Y_{\max} > 1000 \text{ mm/sec.}$$

Where Y_{max} being the antinode displacement (mm) and f is the test frequency (Hz). The test frequency shall be greater than 24 Hz and the total number of cycles shall be more than 10 million.

c. Sub-span Oscillation Test

The test shall be conducted for oscillation in horizontal plane at frequency higher than 3 Hz for minimum one million cycles. The amplitude for oscillation shall be kept equivalent to an amplitude of 150 mm for a full sub-span of 80m. Both the conductor shall be vibrated 180 deg. out of phase with the above minimum amplitude.

- Magnetic Power Loss Test for Damper/Spacer

The sample involving ferrous parts shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. The test should be carried out at various currents ranging from 400 amperes to 800 amperes. 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.

- 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.

- 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

- 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.

Tests on All components (As applicable)

Chemical Analysis of Zinc used for Galvanizing

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

Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognised 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.

Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally recognised 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.

Acceptance Tests

Mid Span Compression Joint for Conductor and Earth wire

- i. Hardness Test

The Brinell hardness at various points on the steel sleeve of conductor core and of the Earth wire compression joint and tension clamp shall be measured.

T-Connector for Conductor

- i. Axial Tensile Load Test for Welded Portion

Flexible Copper Bond

- i. Slip Strength Test

Vibration Damper for Conductor and Earth wire

- i. 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.

- ii. 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

- iii. Damper Characteristics Test

The test will be performed as an acceptance test with the procedure mentioned for type test with sampling mentioned below:

- a. 1 Sample for 1000 Nos. & below
- b. 3 Samples for lot above 1 000 & up to 5000 nos.
- c. Additional 1 sample for every additional 1500 pieces above 5000.

The acceptance criteria will be as follows

1. 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 ± 1 mm amplitude up to 15 Hz frequency and beyond 15 Hz at ± 0.5 mm
2. 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.
3. If individual results do not fall within the envelope, averaging of characteristics shall be done.
 - a. Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.
 - b. Similar averaging shall be done for phase angle.
 - c. Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.
 - d. The above curves shall be within the envelope specified.

9.9 OPGW Testing

9.9.1 List of Type Tests

The type testing shall be conducted on the following items

- Optical Fibers
- OPGW Cables
- OPGW Cable fittings
- Vibration Damper
- Splice Enclosure (Joint Box)
- Approach Cable

9.9.2 Type Tests for Optical Fibers

The type tests listed below in table 2-1 shall be conducted on DWSM Fibers to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

Type Tests For Optical Fibers

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
2	Attenuation Variation with Wavelength	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending (Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174

S. No.	Test Name	Acceptance Criteria	Test procedure
7	Chromatic Dispersion	As per Section-01 of TS	IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter	As per Section-01 of TS	IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of attenuation	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA 455-59
10	Core -Clad concentricity error	As per Section-01 of TS	IEC 60793-1-20 Or EIA/TIA 455-176
11	Fiber Tensile Proof Testing	As per Section-01 of TS	IEC 60793-1-30 Or EIA/TIA 455-31B

9.9.2.1 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in table: 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.

Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
1	Water Ingress Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) : Test duration : 24 hours	
2	Seepage of filling compound	IEEE 1138-2009	IEEE 1138-2009 (EIA/TIA 455-81B)	Preconditioning period:72 hours. Test duration: 24 hours.

S. No.	Test Name	Test Description	Test Procedure	
3	Short Circuit Test	IEEE 1138-2009	IEEE 1138-2009	<p>Fiber attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means.</p> <p>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.</p> <p>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.</p>
		Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1		<p>Initial temperature during the test shall be greater than or equal to ambient field temperature.</p>
4	Aeolian Vibration Test	IEEE 1138-2009 Or IEC60794-4-10 / IEC 60794-1-2, Method E19	IEEE 1138-2009	<p>Fiber attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means.</p> <p>The vibration frequency and amplitude shall be monitored and recorded continuously. All Fibers of the test cable sample shall be spliced together in serial for attenuation monitoring.</p> <p>Test shall be conducted</p>

S. No.	Test Name	Test Description	Test Procedure	
				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	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 Fibers 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 Fiber 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	IEEE 1138-2009	Fiber 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 Fibers of the test cable sample shall be spliced together in

S. No.	Test Name	Test Description	Test Procedure	
				serial for attenuation monitoring.
8	Impact Test	IEEE 1138-2009	IEEE 1138-2009, (IEC 60794-1-2 E4/ EIA/TIA 455-25B)	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 applied. The radius of the intermediate piece shall be the reel drum radius \pm 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.
9	Creep Test	IEEE 1138-2009	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.
10	Fiber Strain Test	IEEE 1138-1994	IEEE 1138-1994	
11	Strain Margin Test	IEEE 1138-2009	IEEE 1138-2009	
12	Stress strain Test	IEEE 1138-2009	IEEE 1138-2009	

S. No.	Test Name	Test Description	Test Procedure
13	Cable Cut-off wavelength Test	IEEE 1138-1994	IEEE 1138-1994
14	Temperature Cycling Test	IEEE 1138-2009	IEEE 1138-2009 Or IEC 60794-1-2, Method F1
15	Corrosion (Salt Spray) Test	EIA/TIA 455-16A	
16	Tensile Performance Test	IEC 60794-1-2 E1 / EIA/TIA 455-33B	<p>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 Fiber optic cable.</p> <p>The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The Fiber 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.</p>
17	Lightning 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.
18	DC Resistance Test (IEC 60228)	On a Fiber 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.	

9.9.2.2 Type Test 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°. 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:

- a. No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- b. 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 Fiber 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:

- a. 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.
- b. Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.
- c. There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
- d. 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.
- e. 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 8 m length of Fiber 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 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:

- a. No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- b. 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 Fiber optic cables installed, one series of tests with one Fiber optic cable installed in one groove, and one series of tests with one Fiber optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the Fiber optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 Kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the Fiber optic cable and examine all its components for distortion, crushing or breaking. Also the Fiber 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 Fiber 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 Fiber 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.

9.9.2.3 Type Test on Vibration Damper

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 Fiber optic cable without dampers.

Acceptance criteria for vibration damper:

- a. The above dynamic characteristics test on five damper 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:
- d. V.D. for OPGW - $0.060 f$ to $0.357 f$ kgf/mm*
- e. Where f is frequency in Hz.
- f. The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
- g. If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
- h. 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 Fiber 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.

1. The analysis shall be done for single Fiber optic cable without armour rods. The tension shall be taken as 25% of RTS of Fiber optic cable for a span ranging from 100 m to 1100 m.
2. The self-damping factor and flexural stiffness (EI) for Fiber optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.
3. The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.
4. Examine the Aeolian Vibration level of the Fiber 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.
5. From vibration analysis of Fiber 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.
6. From vibration analysis of Fiber optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the Fiber optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.
7. 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.

i. **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 Fiber optic cable shall be tensioned at 25% of RTS of Fiber 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 Fiber optic cable has been tensioned, clamps shall be installed to support the Fiber 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 Fiber 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 $\pm 25/f$ 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 Fiber 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 Fiber optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

- a. There shall not be any resonant frequency shift before and after the test by more than $\pm 20\%$
- b. The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than $\pm 20\%$

Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper

S. No.	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

9.9.2.4 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 Fiber optic cable shall be installed in the splice box, and the Fibers must be spliced and looped in order to simulate conditions of use. The attenuation of the Fibers shall be measured, during certain tests, by relevant Fiber Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

Temperature Cycling Test

FO cable is installed in the splice enclosure and optical Fibers 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.

Fiber loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than $\pm 0.05\text{dB}$. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

Humid Heat test

The sealed splice enclosure, with Fibers spliced and looped inside, must be subjected to a temperature of +55°C $\pm 2^\circ\text{C}$ with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the Fibers during the duration of the test shall be less than $\pm 0.05\text{dB}$, and the internal humidity rate measured, less than 2%.

Rain Withstand Test / Water Immersion test

The splice enclosure with optical Fibers cable installed and Fibers 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 Fibers after the test shall be less than $\pm 0.05\text{dB}$.

Vibration Test

The splice enclosure, with Fibers 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 Fibers, shall be less than $\pm 0.05\text{dB}$. 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.

Bending and Torsion test

The splice enclosure, with Fibers spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

- 3 torsion cycles of $\pm 180^\circ$ shall be exercised on the cable. Each cycle shall be less than one minute.
- 3 flexure cycles of the cable, of $\pm 180^\circ$ with one cycle less than one minute.

The variation in the attenuation, of the Fibers, shall be less than $\pm 0.05\text{dB}$. 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

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.

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.

9.9.2.5 Type Tests for Fiber Optic Approach Cable

The type tests to be conducted on the Fiber Optic Approach cable are listed in t: Type Tests for Fiber 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.

Type Tests Fiber Optic Approach Cable

S.NO.	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
-End Of Table-		

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 $\pm 10\%$. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

9.9.3 Factory Acceptance Tests

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.

9.9.3.1 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.

9.9.3.2 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.

9.9.3.3 Factory Acceptance Tests on Optical Fiber to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical Fibers 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.

Factory Acceptance Tests for Optical Fibers: Optical Tests

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	T S, Table 1-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS, Section 1.1.2	EIA/TIA 455-59
3	Attenuation at Water Peak	TS ,Table 2-1(a)	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	Fiber 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.

9.9.3.4 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 Fibers of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC 60794

S. No.	Factory Acceptance Test on Manufactured OPGW
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

9.9.3.5 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings are specified below. The sampling plan shall be as per relevant standard:

Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
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
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
Vibration Damper	
10	Galvanising 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

S. No.	Factory Acceptance Test
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
Structure Mounting Clamp	
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings
End of Table	

9.9.3.6 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below.

Factory Acceptance Tests On Approach Cable

S. No.	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

9.9.3.7 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below.\

Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S. No.	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.

9.9.3.8 Factory Acceptance Test on Test Equipment & other items

As per technical specification and approved DRS/Documents.

9.9.4 Site Acceptance Tests

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.

9.9.4.1 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled Fiber 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.

9.9.4.2 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 Fibers within the cable path shall be demonstrated for acceptance of the cable path. Fiber Optic cable site testing minimum requirements are provided as follows:

Fiber Optic Cable Pre-Installation Testing

Item:	Description:
1.	Physical Inspection of the cable assembly for damage
2.	Optical Fiber continuity and Fiber attenuation with OTDR at 1550 nm
3.	Fiber Optic Cable length measurement using OTDR

Fiber Optic Cable Splicing Testing

Item:	Description:
1.	Per splice bi-directional average attenuation with OTDR
2.	Physical inspection of splice box/enclosure for proper Fiber / cable routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

Fiber Optic Cable Commissioning Testing

Item:	Description:
1.	End to End (FODP to FODP) bi-directional average attenuation of each Fiber at 1310 nm and 1550 nm by OTDR.
2.	End to End (FODP to FODP) bi-directional average attenuation of each Fiber 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 Fibers & Fiber optic cables at FODP as per approved labelling plan.

9.10 Routine Test

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

9.10.1 Operational tests

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

9.10.2 Clamps, joints and insulator fittings

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

9.10.3 Insulators, fittings and conductor overall tests

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

9.11 Site Tests**9.11.1 Measurement of footing resistance**

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

9.11.2 Measurement of earth electrode resistance

Where the footing resistance is found to exceed 10 ohms, additional earth electrodes are to be installed and the combined earth electrode and footing resistance shall be measured together and recorded using the same test instrument. Additional electrodes are to be installed to obtain a maximum resistance value of 10 ohms.

9.11.3 Conductor joint tests

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

9.11.4 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 steel work 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.

9.12 Tests on completion

The Contractor on each section of the Works shall carry out acceptance tests on Site. 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 labour, transport and other assistance as is required without any extra charge. The Contractor shall provide apparatus for special tests.

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

9.13 Test instrumentation

The method of measuring all quantities and qualities and the measurement tolerances shall be in accordance with the appropriate BS, ISO or ANSI.

The terminal conditions required for establishing whether the guarantees are met shall be measured by precision test equipment to be installed by the Contractor in addition to the permanent measuring equipment where supplied under the contract.

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

All the precision test equipment to be used for carrying out tests shall be calibrated against standard instruments before and also after the tests, if required by the Employer. 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.

9.14 Test reports

For each of the specified tests, the Contractor shall agree the test figures with the Employer's Representative 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 tests. Eight copies of the final approved report shall be submitted to the Employer's Representative.

10 Commissioning and Energization

10.1 Pre-Commissioning Check

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

- a. Sufficient backfilled earth is lying over each foundation pit and it is adequately compacted and levelled.
- b. All the tower members are correctly used, strictly according to final approved drawings and are free from any defect or damage whatsoever.
- c. All bolts are properly affixed as per specification.
- d. The stringing of the conductors and Earth wire/OPGW has been done as per the approved sag and tension charts and desired clearances are clearly available.
- e. All conductor and Earth wire/OPGW accessories are properly installed.
- f. All other requirements to complete the work like fixing of danger plate, phase plates, number plate, anti-climbing device, Bird guards etc. are properly installed.
- g. Wherever required, it should be ensured that revetment (or other foundation protection) is provided.
- h. The original tracings of profile, route alignment and tower design, structural drawings bill of material, shop drawings of all towers are submitted to the Employer for reference and record.
- i. IR Report showing noise falls under regulations
- j. The line insulation is tested by the Contractor by providing his own equipment, labour etc. to the satisfaction of the Employer.
- k. The line is tested satisfactorily for commissioning purpose.
- l. The right-of-way all along the route of line is clear of all.
- m. The contractor shall arrange for inspection of the transmission line with the Employer, related authorities and other parties before energizing the line.
- n. Any defects found as a result of inspection and testing shall be rectified by the Contractor forthwith to the satisfaction of the Employer without any extra charges.

On the request of the Contractor, Employer will inform concerned authorities and obtain approval, if required for Commissioning testing of the line.

10.2 Commissioning Test

Upon completion of each section of transmission line, the Contractor shall carry out the following tests:

Insulator strength test between each phase conductor by means of an approved megger tester to prove that the erected line is ready for energization.

10.2.1 Insulation Resistance Test

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

10.2.2 Measurement of Insulation Resistance

One of the most common devices used for testing electrical insulation is the Megger Insulation Tester. The DC test voltage is generated by a permanent magnet generator. This generator is turned either by hand or by an electric motor. In either case a slip clutch maintains the generator speed at a constant value so long as the slipping speed is exceeded. A constant voltage is important when the

insulation under test has a high capacitance. Common generator output voltage are 500, 1000, 2500 and 5000 volts.

Many Meggers have a “guard” terminal as well as “line” and “earth”. The guard terminal is useful shall one wish to exclude part of the insulation under test from the measurement. This is possible since current flowing to the generator via the guard circuit does not pass through the deflecting coil. Another use of the guard circuit is to shield the “line” lead between the Megger and the apparatus under test. This prevents leakage to ground from the “line” lead which would invalidate the Megger reading. Insulation resistance is the ratio VDC/IDC. VDC is applied across two conductors separately by the insulation under test. IDC is the current flowing through/over the insulation. For a healthy and clean insulation the megger reading is in mega-Ohms to infinity. For dirty in, insulation and defective, moist insulation the meggers shows a very low insulation

resistance value. Megger test gives clear indication about the health, cleanliness and dryness of the line/equipment insulation. 5 KV megger or 10 KV megger or 12 KV megger may be used for the Transmission line keeping all safety requirements, Permit to work, clearance from statutory bodies and other conditions prevailing at the Sub-station where charging of the line is being co-ordinated.

10.2.3 Conductor Continuity Test

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

A simple method of continuity test is illustrated below :

Once the insulation test is completed and the results confirms no short circuit carry the following:

SENDING END	RECEIVING END	RESULTS (OHMS)
CLOSE R-Ph GS	MEGGER R- Ph	ZERO/LOW
OPEN Y – Ph GS	MEGGER Y-Ph	HIGH
OPEN B-Ph GS	MEGGER B-Ph	HIGH
OPEN R-Ph GS	MEGGER R-Ph	HIGH
CLOSE Y – Ph	GS MEGGER Y-Ph	ZERO/LOW
OPEN B-Ph GS	MEGGER B-Ph	HIGH
OPEN R-Ph GS	MEGGER R-Ph	HIGH
OPEN Y–Ph GS	MEGGER Y-Ph	HIGH
CLOSE B-Ph GS	MEGGER B-Ph	ZERO/LOW

(ALL GS OPEN CONDITION)

GS means GROUND SWITCH

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

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

SENDING END	RECEIVING END MEGGER BETWEEN	RESULTS (OHMS)
-------------	---------------------------------	----------------

CONNECT R&Y PHASE B-PHASE & ALL GS OPEN	R PHASE & Y PH Y PHASE & B PH B PHASE & R PH	ZERO OR LOW HIGH HIGH
CONNECT R & B PHASE Y PHASE & ALL GS OPEN	R PHASE & Y PH Y PHASE & B PH B PHASE & R PH	HIGH HIGH ZERO OR LOW
CONNECT Y & B PHASE R-PHASE & ALL GS OPEN	R PHASE & Y PH Y PHASE & B PH B PHASE & R PH	HIGH ZERO OR LOW HIGH

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

10.2.4 Phase Sequence

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

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

NEW CIRCUIT	OLD CIRCUIT	VOLTAGE
R-Phase	R-Phase	0
R-Phase	Y-Phase	110
R-Phase	B-Phase	110
Y-Phase	R-Phase	110
Y-Phase	Y-Phase	0
Y-Phase	B-Phase	110
B-Phase	R-Phase	110
B-Phase	Y-Phase	110
B-Phase	B-Phase	0

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

10.2.5 Line Parameters

Measurement of Line parameters i.e., zero, positive and negative sequence impedances; the procedures of which shall be approved by the Employer.

10.2.6 Commissioning Tests on OPGW

Commissioning tests on OPGW (including Optical Approach Cable and Optical Distribution Frame):

The following commissioning tests shall be carried out for OPGW:

1. Bit error rate count over 360 hrs. (15 days) of continuous transmission test code at 8/34/140 M
2. Bit installed by OLTE Contractor. End-to-end optical wave-guide Fiber continuity and attenuation measurement.

This test shall be carried out from equipment connector end at one side to corresponding end of the remote site. This test shall be carried out in both directions.

Bit error rate count over 360 hrs. (15 days) of continuous transmission test code at 8/34/140 MBit installed by OLTE Contractor.

The test procedure, recording sheets, schedule for commissioning tests shall be submitted for the Employer's Representative approval. The Contractor shall provide all the test equipment required for the commissioning.

Upon completion of the above tests, the line shall be energized at full working voltage before handing over and the arrangement for this, and such other tests as the Employer or the Engineer shall desire to make on the completed lines, shall be carried out by the Contractor who shall provide such labour, linesmen, transport and other assistance as is required without extra charge.

10.3 Protective System

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

10.4 Dispatch Procedures

All operational activities (switching etc.) must be coordinated and communicated with the System Dispatcher. In this respect the general procedures already established by the Nepali Electric Authority will be followed.

10.5 Switching Procedures

The switching procedures are to be properly documented step by step and understood by everybody involved in the switching operation prior to the energization. Any clarification required in the procedures must be resolved. The format established by Employer for switching orders and operational data logging shall be followed. The implication of this is that each and every activity must be listed and described, so that complete information is available for detail investigation, if required in future. The Contractor shall assist in performing these activities.

10.6 Observation and Duration

Visual and audible inspection (look and listen) of the relevant equipment and reading of permanent instrumentation will be made. The system shall be charged at least for a predetermined duration. During this time continuous monitoring and inspection will be maintained in control room, auxiliary systems areas and switch yards. This will include frequent, scheduled inspection of all equipment and reading of all permanent instruments and recorders, and surge arrester counters, especially system parameters as per Standard procedures.

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

10.7 Handing Over

The transmission line shall be inspected prior to energization and a formal handing over procedure jointly followed by the Contractor. Any outstanding points or remaining activities are to be listed jointly.

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

10.8 Documentation

Switching and operational activities will be recorded in regular manner in the operator's log.

Likewise all readings of permanent instruments, Copies of this log, notes on special observations from inspections and other measurements will constitute the test records.

11 Training

11.1 Line Modelling using PLS CADD

The preferred method for tower spotting and tower optimization in mountainous terrain is through the use of computer aided design. The Contractor shall model the transmission line using PLS Cadd with a version no older than version 12.0. Final structure models should utilize PLS Tower method 4 structure models. Tower body, leg extensions and all insulators and attachment apparatus should be modelled as accurately as possible. Appropriate power cable and ground wire files including the OPGW should be sourced from the manufacturer or supplier for use in the PLS Cadd model. The transmission line wire and structure system should be modelled using PLS Cadd with SAPS engine to optimize the line design process and generate a more accurate and diligent design methodology used in this region with severe elevation changes.

11.2 PLS-CADD and Tower Training at Contractor Site

The Contractor shall setup a training lab at the Contractors location to simultaneously train 3 trainees in the use of PLS Cadd over a 10 day period and PLS Tower over a 10 day period.

The Contractor is responsible for associated training charges;

- a) Accommodation charges.
- b) Payment of per Diem allowance to trainees @ USD 200 per day per trainee for the duration. of training abroad towards meals and other incidental expenses.
- c) Two way economy class air tickets from Nepal to the place of training abroad.

The Contractor is required to provide the necessary computer hardware and PLS Cadd and Tower licenses needed for the training demonstration.

11.2.1 PLS Cadd Training

The PLS Cadd training course should include the basics of PLS Cadd including but not limited to:

1. General Overview of PLS-Cadd

- a) PLS Modules/Programs – Quick Overview
- b) PLS-CADD Overview
 - What is a “Model”
 - Directory Structure
- c) Electronic Help Menu

2. Surveying and Terrain Modeling in PLS-CADD

- a) Survey Data
 - PFL vs. XYZ Files
- b) Feature Codes (Terrain / Feature Codes)
- c) Survey Data
 - Manual Entry (Terrain / Edit / Edit XYZ or PFL)
 - Importing User Defined Data (Terrain / Edit / Merge....)
- d) Alignment & PI's (Add / Move / Insert / Delete P.I. Buttons)
 - Add/Move/Insert/Delete PI's
 - Terrain Width

- e) Terrain Modeling (TIN) Parameters, Options, and Functions
 - Creating a TIN (Terrain / TIN / Create TIN)
 - Displaying a TIN (Terrain / TIN / Display Options)
 - Creating Interpolated Points (Terrain / TIN / Create Interpolated Points)
- f) Basemap Attachments (Drafting / Attachments / Attachment Manager)
 - Attaching Drawings, Aerial Photos, and USGS Quad Sheets
 - Understanding Attachment Options (Drafting / Attachments / Image Drawing Options)

3. Design Criteria Requirements

- a) Load Standard Criteria File (Criteria/Load Criteria)
- b) Understanding Criteria Files (Criteria)
 - Weather Conditions
 - Sag/Tension Criteria
 - Structure Design Criteria
 - Clearance Design Criteria

4. Line Modeling

- a) Creating New "Stick Structure" (Structures / Create New Structure)
- b) Editing Existing "Stick Structures" (Structures / Edit Structure)
- c) Spotting Structures
 - Manual (Structures/Add/Move/Modify)
 - Automatic
 - 1. Copy/Paste
 - 2. Spot at Feature Code
 - 3. Spot at Line Angles

5. Stringing Conductors

- a. Cable Files (Sections / Edit Cable Data)
- b. Manual Stringing (Sections / Add/Remove/Modify)
- c. Automatic Stringing (Sections/ Automatic Stringing)
 - Table Edits (Sections/Table)
- d. Sag Tension Review (Sections/Sag-Tension)
- e. Section Display Options
- f. View Display Options
- g. Using Multiple Lines (Lines/Edit)

6. Project Checks and Reports

- a. Clearances
 - Ground and Survey Points (Sections/ Clearances/ To Ground)
 - Between Sections (Sections/ Clearances/ Between Sections)
 - Galloping (Sections / Clearances/ Galloping)
- b. Stringing Charts (Sections / Stringing Charts)
- c. Useful Engineering Reports (Lines/ Reports)

-
- Structure/Section Usage
 - Clearance to Survey Points and TIN
 - Wind & Weight Spans
 - Construction Staking Report

7. Advanced Structures (PLS-TOWER)

- a. Modeling Full Structural Analysis Structures
 - PLS-TOWER
 - General Overview
 - Component Libraries
 - Modeling Structures

8. Drafting – PLS-CADD

- a. Page Size and Layout (Drafting / Page Size and Drafting / Page Layout)
- b. Scales and Drawing Formats (Drafting / Scales)
- c. Text and Layer Controls
 - Layer and Text Size Control (Drafting / Text Size ...)
 - Structure and Section Labeling (View / /Display Options / Sheet View...)
- d. Importing P&P Border and North Arrow into PLS (Drafting / Attachments)
- e. Developing User Defined Text (Drafting / Lines and Annotation...)
- f. Exporting Drawings from PLS

11.3 PLS-Tower Training at Contractor Site

11.3.1 PLS TOWER Training

The PLS Tower training course should include the basics of PLS Tower including but not limited to:

1. General Overview of PLS-Tower
2. Tower modeling concepts
3. Component libraries
4. Defining joints, members, and connections
5. Tower point loads
6. Tower wind loads
7. Review of analysis results and output Batch manipulation of multiple models
8. Analysis of existing towers
9. Determining allowable spans Using Tower models in PLS-CADD

SCHEDULES

1. Schedules A1-A14

Schedule A.1

System and Line Data

Item	Description	Unit	Data

1.	System Data		
1.1	System Nominal Voltage	kV	220
1.2	System Maximum Voltage	kV	245
1.3	System Nominal Frequency	Hz	50
1.4	Line Data		
	Tanahu Hydro Electric P/S – Quad (four) circuit	km	33.4

Schedule A.2

Design Data

Item	Description	Unit	Data
<hr/>			
1.	Temperature		
1.1	Maximum ambient temperature	°C	50
1.2	Minimum ambient temperature	°C	0
1.3	Maximum temperature of conductor	°C	80
1.4	Everyday temperature of conductor	°C	32
2.	Wind Loads		
2.1	Wind pressure on the whole projected area of conductors	N/m ²	740
2.2	Wind pressure on the whole projected area of steel angle members	N/m ²	1384
2.3	Wind pressure on 1.71 times projected area of steel angle face of structure	N/m ²	2370

Schedule A.3

Minimum Clearances

The followings are the minimum clearances between live conductors and other objects, which correspond to the maximum conductor sag conditions.

Item	Description	Minimum clearances in normal conditions
1.	Normal ground for pedestrians only	8.5 m
2.	Residential areas	8.5 m
3.	Roads and streets	8.5 m
4.	Highways	8.5 m
5.	To metal clad or roofed buildings or building or structures upon which a man may stand	8.0 m
6.	Power lines (above or below)	4.58 m
7.	Telecommunication lines	8.0 m

For other objects not listed in the Schedule, the requirements for minimum clearances shall comply also with NESC (National Electric Safety Code).

Crossing of houses, huts, and other objects with soft roofing is not allowed.

- (1) Minimum clearances from live conductor to the nearest part of tower body for suspension tower;

- (a) for still air condition and up to 20° swing of insulator strings; 2800 mm
(b) for 20° to 60° swing of condition of insulator strings; 650 mm

- (2) Minimum clearances from live conductor to the nearest part of tower body for tension tower;

- (a) jumper loop, from still air to 15° swing; 2800 mm
(b) jumper loop, from 15° to 55° swing; 650 mm
(c) jumper suspension insulator-set, from still air to 15° swing; 2800 mm
(d) jumper suspension insulator-set, from 15 to 55° swing; 650 mm

Schedule A.4 Tower Types and Design Spans

Tower Types

For Double Circuit

Item	Tower Type	Position where used	Angle of deviation (degree)	Insulator type
1	DA	Straight line	0-2	Suspension
2	DB	Angle	2-10	Tension
3	DC	Angle	10-30	Tension
4	DD	Angle	30-60	Tension
5	DE1	Angle and Dead-end	60-90	Tension
6	DE2	Angle and Dead-end	60-90	Tension

For Single Circuit

Item	Tower Type	Position where used	Angle of deviation (degree)	Insulator type
1	E1	Angle and Dead-end	0-10	Tension

Design Spans

Item	Tower Type	Ruling Span (m)	Wind Span (m)	Weight Span (Normal conditions)		Weight Span (Broken wire conditions)	
				Max.(m)	Min.(m)	Max.(m)	Min.(m)
1	DA	350	700	700	0	525	0
2	DB	350	700	+1050	-1050	+790	-790
3	DC	350	700	+1050	-1050	+790	-790
4	DD	350	700	+1050	-1050	+790	-790
5	DE1	350	700	+1050	-1050	+790	-790
6	DE2	350	700	+1050	-1050	+790	-790
7	E1	350	700	+1050	-1050	+790	-790

Schedule A.5

Factors of Safety

Item	Description	Minimum Factor of Safety
1.	Tower	
1.1	All types of towers under normal working conditions	2.0
1.2	All types of towers under broken wire conditions	1.5
2.	Foundation	
2.1	Foundations for all types of towers under normal working conditions	2.0
2.2	Foundations for all types of towers under broken wire conditions	1.5
3.	Conductors and Insulators	
3.1	Conductor based on ultimate tensile strength	2.5
3.2	Conductors based on ultimate tensile strength at still air everyday temperature	5.0
3.3	Complete insulator strings and fittings on minimum breaking load of insulator	3.0
3.4	Dead end compression clamp and compression splices based on conductor ultimate tensile strength	0.95
4.	Ground Wires	
4.1	Ground wire based on ultimate tensile strength	4.0
4.2	Complete tension assembly at earth wire maximum working tension	3.0
4.3	Complete suspension assembly at maximum vertical load	3.0

Schedule A.6 Tower Particulars

1. Unit Stresses

The quality of steel used for support members and bolts

Item	Description	Unit	Minimum values	
<hr/>				
(i)	Structural Mild Steel:			
	Designation		SS400 of JIS G 3101	
	Thickness (t)	mm	t<16	16<=t<40
	Upper yield strength	N/mm2	245	235
	Tensile strength	N/mm2	400	400
(ii)	Structural High Tensile Steel			
	Designation		SS540 of JIS G 3101	
	Thickness (t)	mm	t<16	16<=t<40
	Upper yield strength	N/mm ²	400	540
	Tensile strength	N/mm ²	390	540
(iii)	Bolts and Nuts			
	Designation Grade		5.8 of ISO898-1	
	Minimum Tensile Strength	N/mm ²	500	
	Lower yield strength	N/mm ²	400	

2. Slenderness Ratios (L/R)

The slenderness ratio of unsupported length of steel compression members to their least radius of gyration.

Items	Description	Maximum value

2.1	Main legs	120
2.2	Main members of cross arm	200
2.3	All other loaded members	220
2.4	Redundant members	250
2.5	Members loaded in tension only	250

Schedule A.7 Tower

Member Particulars

The minimum thickness and diameter of material used in members and bolts shall be as follows.

Item	Description	Unit	Minimum value
1.	Calculated members	mm	45x45x4
2.	Redundant members	mm	45x45x4
3.	Thickness of leg, members in cross-arms, and in earth-wire peaks,	mm	6
4.	Diameter of bolts for members carrying stress	mm	16
5.	Diameter of bolts for redundant members without calculated stress	mm	16
6.	Gusset plates	mm	6
7.	Stub angle	mm	8

The Bidder may propose tower designs with different member thickness and the grades of the structural steels from those specified in Schedules A.6 and A.7 above. If the Bidder provides tower designs with different minimum member thickness other than those specified in Schedule A.7 and other grades of steel other than those specified in Schedules A.6, the Bidder shall prove by design calculations that the tower designs fulfill all the requirement specified in the specification and that the towers are safe. All other requirements of the specifications are mandatory and any changes in those requirements are not permissible.

Schedule A.8

Insulators

Item	Description	Unit	Data		
1.	Insulator unit				
1.1	Type of Insulator		Electro-Porcelain or Toughened Glass		
1.2	Type of Coupling		Ball and Socket		
1.3	Dimensions				
	a) Spacing of Insulator	mm approx.	146	146	146
	b) Diameter of Sheds	mm approx.	255	255	280
	c) Creepage Distance	mm approx.	295	295	315
1.4	Minimum Breaking Load	kN	70	120	160
	a) Suspension String				
	b) Tension String				
1.5	Power frequency withstand voltage				
	a) Dry one minute		As per IEC 60383		
	b) Wet one minute		As per IEC 60383		
1.6	Impulse withstand voltage				
	a) Positive (Suspension / Tension)		As per IEC 60383		
	b) Negative (Suspension / Tension)		As per IEC 60383		
1.7	Power frequency puncture voltage				
	a) Suspension-disc		As per IEC 60383		
	b) Tension-disc		As per IEC 60383		
2.	Insulator Strings				
2.1	Number of units: (minimum)				
	a) Single Suspension String		17		
	b) Double Suspension String		2x17		
	c) Single Tension String		17		
	d) Double Tension String		2x17		
	e) Jumper Suspension set		17		
2.2	Standards		IEC		
2.3	Electrical Characteristics of Insulator Strings				
	a) Impulse withstand voltage (peak)	kV	1050		
	b) Power frequency withstand voltage	kV	460		

Schedule A.9

Overhead Conductor Properties for BISON ACSR

Aluminum Area mm ² :	381.70
Steel Area mm ² :	49.48
Total Cross Section mm ² :	431.20
Overall Diameter mm:	27.00

Stranding: 54 - 3.0 mm aluminum strands wrapped in 3 layers
7 - 3.0 mm steel strands wrapped in 2 layers

Aluminum mass (kg/km):	1056
Steel mass (kg/km):	388
Total Mass (kg/km):	1444

Conductor weight (N/m):	14.16
Conductor breaking load kN:	120.9
DC Resistance at 20 degrees Celsius:	0.0757 Ω/km

Polynomial Coefficients for conductor Stress-Strain-Creep numerical models:

$$\sigma_{\text{Stress-Strain-Creep}} = a0 + a1 \cdot \varepsilon + a2 \cdot \varepsilon^2 + a3 \cdot \varepsilon^3 + a4 \cdot \varepsilon^4$$

Initial Stress-Strain	a0	a1	a2	a3	a4
Alum Layers	-3.25846	365.227	-358.214	94.5959	42.3199
Steel Layers	0.952854	196.405	111.231	-362.491	198.941

10 Yr Creep	a0	a1	a2	a3	a4
Alum Layers	-0.245453	145.536	-74.455	10.1353	8.56327
Steel Layers	0.952854	196.405	111.231	-362.491	198.941

Final Elastic Modulus	MPa/100	Thermal Expansion	/100 Deg. C
Alum	441.26	Alum	0.002304
Steel	217.18	Steel	0.001152

Composite Conductor Properties

Final Elastic Modulus: 658.44 MPa/100

Thermal Expansion Coefficient: 0.00192402 /100 Deg. C

IEC:61089

Specification for aluminum conductors and aluminum conductors, steel-reinforced for overhead power transmission. Test data above collected at 21.1 degrees Celsius

Schedule A.10**Ground Wire**

Item	Description	Unit	Data
1.	Galvanized Steel Wire		7/3.35
1.1	Nominal Sectional Area	mm ²	61.7
1.2	Number and Diameter of Component wire	No./mm	7/3.35
1.3	Weight of wire	kg/m	0.550
1.4	Overall Diameter	mm	10.05
1.5	Ultimate Breaking Strength	kN	68.4
1.6	Modules of Elasticity final	kg/mm ²	19000
1.7	Coefficient of linear expansion	/°C	15.0 x10 ⁻⁶
1.8	Electrical D.C. Resistance at 20 °C	ohm/km	2.5
1.9	Standard unjointed length on Reel	m	2000
1.10	Everyday Stress	kN	10.423
1.11	Standard		IEC 209

Schedule A.11

Material for Tower Grounding

Item	Description	
1.	Ground Rods	
1.1	Galvanized Steel Pipes/Angles	60mm dia./50x50x5mm steel angle 2m long
2.	Ground Wire	
2.1	Galvanized Steel Wire/Strip	38mm ² /Strip 25/3mm
3.	Connection of Ground Electrode with Stub Angle	
3.1	For Connection of Steel Angle	Steel Wire as above
3.2	For Connection of Copper Weld Rods	Copper Conductor as above

Schedule A.12

Optical Ground Wire (OPGW)

A. OPGW

1. Standards

Aluminum Alloy Wires	IEC 104 type A
Aluminum Crad Steel Wire	IEC 1232
Cable Construction	IEC 1089 (where applicable)
Optical Unit	ITU-T (former CCIT) G652

2. Properties of the Optical Fibers

Single Mode Fibers	24
Dimensions and Geometry of Fiber	according to ITU-T G652
Fiber Attenuation at 1310 nm at 20 °C max.	0.4dB/km
Fiber Attenuation at 1550 nm at 20 °C max.	0.25dB/km
Attenuation Deviation at 1310 nm and 1550 nm	0.1dB/km within -45 to 80 °C

3. Other Properties of Fibers

Outer Diameter	11.4mm
Cable Weight (approx.)	487kg/km
Calculated Breaking Load	86.6kN
Modules of Elasticity	162kN/mm ²
Coefficient of Thermal Expansion	13.0 x10 ⁻⁶ per degree K
Nominal Short Time Current Capacity at Initial/Final Temperature 20/200 °C	5.5kA
DC Resistance at 20 °C	Not more than 1.247 ohm/km

Schedule A.13

Foundation Applicable Schedule

Soil Properties to be considered in Foundation Designs for various types of soil.

Foundation type	Type of soil	Angle of Earth Frustum (degrees)	Unit weight of soil (kg/cu.m.)	Limit bearing capacity (kg/sq.m.)
Type I	Normal Dry Soil			
	a. Without undercut	30	1440	25,000
	b. With undercut	30	1600	25,000
Type II	Wet soil due to presence of sub soil water/surface water	15	940	12,500
Type III	Sandy soil			
	a. With clay content 0-5%	10	1440	25,000
	b. With clay content 5-10%	20	1440	25,000
Type IV	Fissured Rock/Soft Rock (With undercut)			
	a. In dry portion	20	1700	62,500
	b. In wet portion	10	940	62,500
Type V	Hard Rock	--	--	1,25,000

- a. Limit bearing capacity of soil has been arrived at taking FOS 2.5 over the safe bearing capacity values.
- b. Where clay content is more than 10% but less than 15%, the soil will be classified as Normal Dry Soil
- c. Angle of Earth Frustum shall be taken with respect to vertical.

**Schedule A.14 Inspection Tests at
Manufacturer's Plant**

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

Item	Description	Standards
1.	Rolled Steel Angle and Bolts	
1.1	Tensile Strength Test and Chemical Analysis, Zinc-Coating Test	Steel mill Certificates
1.2	Full scale tower load test to destruction	IEC 652
2.	Insulators	
2.1	Temperature Cycle test, Mechanical failing load test	IEC383 and IEC575
2.2	Porosity test, continuity of Zinc Coating	BS 137
2.3	Electrical Test on Complete Insulator Strings	ANSI C 29.1
3.	Insulator Fittings	
3.1	Routine and Sample Mechanical Tests	BS 3288
3.2	Galvanizing Tests	BS 729
4.	Clamps and Joints	
4.1	Mechanical and Electrical Type Tests, Galvanizing and Mechanical routine tests	BS 3288 BS 729
5.	Dampers	
5.1	Fatigue Resistant Tests	
5.2	Test of clamp slippage resistance	BS 729
5.3	Galvanizing tests	ISO
6.	Line Conductor and Earth wire	
6.1	Mechanical tests, Galvanizing test and resistivity test, ultimate tensile stress of complete conductor	IEC 209 BS 2627

Employer's representatives will inspect and witness the tests of tower and other materials at manufacturer's plant as per the Technical Specification.

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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	Project In-charge
		b) Route profiling & tower spotting.	1. Ground clearance. 2. Cold wt. Span 3. Hot wt. Span 4. Sum of Adj. Span (wind span) 5. Angle of Devn. 6. Suitability of Tower spotting in hilly area	a. Sag template b. Tower Spotting data c. Route alignment	Contractor -do- -do- -do-	100% at Field -do- -do- -do-	100% based on record documents -do- -do- -do- Verification of 100% at Field	Site In-charge
2.	Check Survey	Tower Location & Final Length	i) Alignment ii) Final Length iii) Angel of deviation & pit marking-	a. Route alignment b. Tower Schedule c. Profile	Contractor -do-	100% at Field -do-	i) All angle towers in plains and 50% in hilly terrains. ii) Final length to be checked on 100% basis based on records/documents 20 % test check at site for physical verification.	Site Engineer
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	Site Engineer

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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) Tests on samples	As per tech. Specs.	As per Specification	Contractor (Testing in THL 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)	Site In-charge based on the guide line issued by EMPLOYER as Annex-6
		c) Special foundations	As per tech. Specs	As per Specification	Contractor (Testing of samples in THL 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)	Site In-charge based on the guide line issued by EMPLOYER as Annex-6
4	Revetment	RR Masonry	a) Size of Stone b) Water absorption	CPWD Spec. -Do-	Contractor -Do- (Testing in THL accepted Lab)	100% physical verification per source 1 sample/ source	Physical verification on random basis Review of Lab Test results	Site Engineer -Do-
			c) Cement : sand ratio in mortar	As per Specification	Contractor	100%	Physical verification in random.	-Do-

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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 in Employer
					Agency	Extent		
5	Benching	Checking of Reduced Level	Reduced Level	As per approved drawings	Contractor	100%	100% by Site Engineer and 20% by Line In-charge	Site In-charge
6.	Tower Foundation							
		A) Materials 1. Cement	1. Brand approval	Cement of THL approved brands may be procured.	Contractor	100%	Any new brand cement proposed by Contractor shall be assessed by THL.	THL
			2. Physical tests	As per document at Annexure-I of this FQP	Contractor Samples to be taken jointly with Employer and tested at THL 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.	Site In-charge
			3. Chemical Tests Chemical composition of Cement	-do-	Contractor	Review of all MTC's	100% review of MTC test results	Site In-charge

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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. 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.	Site In-charge
	2. a) Reinforcement Steel				Contractor to submit MTC	100% MTC's One sample * / 500MT / Manufacturer shall be jointly sealed by Employer and tested at THL 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 THL; further, hard copy of test certificate shall also be sent by the Lab. directly to THL by postal Address.	Site In-charge
			2. Physical and Chemical analysis test	As per annexure-2 of this FQP				
	2. b) Miscellaneous structural steel .	Source Approval.		Source with material meeting Specification	contractor	As proposed by contractor	To verify documents.	Site In charge

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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		
		3. Coarse Aggregates	1. 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 THL accepted Lab.	To review the proposal based on the documents	Site In-charge Once approved, the particular quarry shall be used for all the running contracts under various packages.
			2. 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 THL 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.	Site In charge.
		4. Fine aggregate	1. 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 THL 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.
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. Physical test	As per Annexure-4 of this FQP	Contractor	One sample per 1000 cum or part thereof per source	100% review of lab test results.	Site In charge.

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					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 THL approved lab	Out of these 100% samples, THL shall witness at TPL, 5 samples selected at random, spread during the overall execution period of contract.	
	5. Water	1. Cleanliness (Water shall be fresh & clean) 2. PH Value	Specification - do -	Contractor Contractor at site with calibrated PH meter or any other approved method	100% visual check at Field One sample per source	Verification at random 100% review of the test results Ph not less than 6	Site Engineer Site Engineer
	B) Foundation Classification	1. Visual observation of soil strata 2. Ground water level 3. History of water table in adj. Area/surface water 4. Soil Investigation wherever required	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 THL after visiting at least 5% locations. c. For Spl. Fdns. (shallow depth, pile foundation, well foundation etc.) Acceptance by Regional head.

STANDARDISED FIELD QUALITY PLAN

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) Concrete Works a)Before concreting							
		1. Bottom of excavated earth	Depth of foundation	Construction Drgs.	Contractor	100% at Field	100% check by Employer	Site Engineer
		2.P.C.C Grade , thickness & Size	Completeness	IS:456 and THL approved construction drawings & specification.	Joint Inspection by THL and CONTRACTOR	For all locations	For all locations	Site Engineer
		3. Slab setting	1) Centre Line 2) Diagonals 3) Level of stubs	Construction Drgs -do- -do- -do-				
		4.Reinforcement steel	Placement	Bar bending schedule.				
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		

STANDARDISED FIELD QUALITY PLAN

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				Contractor	Minimum One per day per location	check at random	Site Engineer
b) During concreting	1. Workability	Slump test	Range 25 mm to 55 mm refer document at Annexure-5 of this FQP				
	2. Concrete Strength	Cubes Comp Strength	As per annexure-5 of this FQP	<p>Contractor</p> <p>Casting of cubes at site. Cubes to be tested for 28 days strength at THL approved. Lab /THL Lab/At site (if testing machine installed by contractor is duly calibrated by NABL Lab.)</p> <p>Cubes at 100% location are to be taken in presence of Employer officials</p>	<p>One sample of 3 cubes in each lower locations if all the legs are cast continuously without interruption. If otherwise, additional 3 cubes to be taken for every subsequent continuous casting case.</p> <p>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.</p>	<p>Normally testing shall be carried out at the cube Testing Facility installed by contractor at THL premises, in the witness of Employer. Alternatively, samples shall be tested at THL approved Labs/ THL Lab. In this case, test results shall be sent by the Lab, by E-mail directly to THL; further, hard copy of Test Certificate shall also be sent by the Lab directly to THL by Postal Address.</p> <p>Further, Employer to witness testing on 20% samples and also to review 100% test results.</p>	<p>Site Engineer.</p> <p>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.</p> <p>In-case of Site/ THL Lab, 100% witness by Employer Representative.</p>

STANDARDISED FIELD QUALITY PLAN

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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		
		3.Chimney Concrete	Top level of chimney concrete w.r.t GL	Appd. Drgs.	Contractor	100% at Field	100% check by Employer	Site Engineer
	c) After Concreting	Back filling	Completeness	As per Specification	Contractor	100%	100%	Site Engineer
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	Site Engineer
		2. Erection of Super-structure	1. Sequence of erection	As per Appd. Drgs./ specification	Contractor	100% at field	Random	Site Engineer
			2. Check for completeness	As per Appd. Drgs./ specification	Contractor	100% at field	25% by Site Engr and random by Site Incharge.	Site In charge

STANDARDISED FIELD QUALITY PLAN

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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		
			3. Tightening of nuts and bolts	-do-	-do-	-do-	-do-	-do-
			4. Check for vertically	-do-	-do-	-do-	-do-	-do-
			5. Tack welding for bolts & nuts	Specification	Contractor	100% at Field	-do-	Site Engineer
		3. Tower footing resistance (TFR)	TFR at locations before and after earthing.	Specification	Contractor	100% at Field	20% locations to be verified	Site In-charge
9	Earthing	Pipe Type	Salt & charcoal	As per approved drawings	Contractor	100%	Checking of record 100% and physical verification in Random	Site Engineer
		Counterpoise Type	Length & Depth of earth electrode.	As per approved drawings	Contractor	100%	---do---	Site Engineer

STANDARDISED FIELD QUALITY PLAN

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		
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 and to carry Physical verification random checks 10%	Site Engineer
			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 and record review by Employer and joint witnessing by Employer on 05% insulator	Site In-charge
			3. Traceability (Make/batch No./Locations where installed)	Packing list/CIP	Contractor	100% at field	100% Review of records	Site Engineer

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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) Conductor	On receipt, 1. Visual check of drum.	Packing list/CIP	Contractor	100% at stores	20% check	Site Engineer
			2. Check for seals and Employer signed sticker on outer end	-do-	-do-	-do-	-do-	-do-
			3. Check depth from top of flange to the top of the outer most layer	-do-	-do-	-do-	-do-	-do-
		c) Earth wire	Check for seals at both ends	Packing list/ CIP	Contractor	100% at stores	20% check	-do-
		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	Site In-charge

STANDARDISED FIELD QUALITY PLAN

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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 stringing	(Conductor/Earth-wire)					
			1. Scratch/cut check (Visual)	Appd. Drawings/ Specn.	Contractor	100% at Field	100% verification of record & 20% Field check	Site Engineer
			2. Repair sleeve	-do-	-do-	-do-	-do-	-do-
			3. Mid span joints	-do-	-do-	-do-	-do-	-do-
			4. Guying (In case of towers not designed for one side stringing)	Appd. Guying arrangement/ Specn.	-do-	-do-	100%	Site Engineer
		c) After stringing	Check for,					
			1. Sag/Tension	Stringing Chart / tower Spotting data	-do-	-do-	100% verification of record & 20% field check	Site Engineer
			2. Electrical clearances	As per Appd. Drgs./ specifications	-do-	-do-	-do-	-do-

STANDARDISED FIELD QUALITY PLAN

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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		
			i) Ground clearance	-do-	-do-	-do-	-do-	-do-
			ii) Live metal clearance etc.	-do-	-do-	-do-	-do-	-do-
			3. Jumpering	-do-	-do-	-do-	-do-	-do-
			4. Copper bond	As per Appd. Drgs./Specification	Contractor	100% at Field	100% record & Field Check 20%	Site Engineer
			5a). Placement of spacer/damper	As per Specn./Drgs/ placement chart	-do-	-do-	-do-	-do-
			5b) Tightening of bolts & nuts as per manufacturer recommendations.	-do -	-do-	100% with fixed torque wrench.	-do-	-do-
11.	Final Testing a) Pre-commissioning of lines	a) 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%	Site In-charge

STANDARDISED FIELD QUALITY PLAN

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)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) THL clearance	-do-	-do-	-do-	-do-

STANDARDISED FIELD QUALITY PLAN

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Annex-1
(Sheet 01 of 03)

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CEMENT

ORDINARY PORTLAND CEMENT					
S. No.	Name of the test	Ordinary Portland Cement 33 grade as per IS 269	Ordinary Portland Cement 43 grade as per IS 8112	Ordinary Portland Cement 53 grade as per IS 12269	Remarks
a)	Physical tests				To be conducted in apprd. Lab
(i)	Fineness	Specific surface area shall not be less than 225 sq.m. per Kg. or 2250 Cm2/gm.	Specific surface area shall not be less than 225 sq.m. per Kg or 2250 Cm2/gm.	Specific surface area shall not be less than 225 sq.m. per Kg or 2250 Cm2/gm.	Blaine's air permeability method as per IS 4031 (Part-2) / Sieve analysis as per IS 4031 (part-3)
(ii)	Compressive strength	72 ± 1 hour : Not less than 16 Mpa (16 N/mm2) 168 ± 2 hour : Not less than 22 Mpa (22 N/mm2) 672 ± 4 hour : Not less than 33 Mpa (33 N/mm2)	72 ± 1 hour : Not less than 23 Mpa (23 N/mm²) 168 ± 2 hour : Not less than 33Mpa (33 N/mm²) 672 ± 4 hour : Not less than 43 Mpa (43 N/mm²)	72 ± 1 hour : Not less than 27Mpa (27 N/mm²) 168 ± 1 hour : Not less than 37Mpa (37 N/mm²) 672 ± 1 hour : Not less than 53 Mpa (53 N/mm²)	As per IS 4031 (Part-6)
(iii)	Initial & Final setting time	Initial setting time : Not less than 30 minutes Final setting time : Not more than 600 minutes	Initial setting time : Not less than 30 minutes Final setting time : Not more than 600 minutes	Initial setting time : Not less than 30 minutes Final setting time : Not more than 600 minutes	As per IS 4031 (Part-5) -do-
(iv)	Soundness	Unaerated cement shall not have an expansion of more than 10mm when tested by Le Chatlier and 0.8% 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)

STANDARDISED FIELD QUALITY PLAN

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Annex-1
(Sheet 02 of 03)

S. No.	Name of the test	Ordinary Portland Cement 33 grade as per IS 269	Ordinary Portland Cement 43 grade as per IS 8112	Ordinary Portland Cement 53 grade as per IS 12269	Remarks
b)	Chemical composition tests				Review of MTCC only
		a) Ratio of percentage of lime to percentage of silica, alumina & iron oxide 0.66 to 1.02	a) Ratio of percentage of lime to percentage of silica, alumina & iron oxide 0.66 to 1.02	a) Ratio of percentage of lime to percentage of silica, alumina & iron oxide 0.80 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%	
		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 (SO ₃), 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 sulphuric anhydride (SO ₃), 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 sulphuric anhydride (SO ₃), 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	

STANDARDISED FIELD QUALITY PLAN

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Annex-1
(Sheet 03 of 03)

S. No.	Name of the test	Remarks
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
	ii) Compressive strength	a) 72 ± 1 hour : Not less than 16 Mpa (16 N/mm ²) b) 168 ± 2 hour : Not less than 22 Mpa (22 N/mm ²) c) 672 ± 4 hour : Not less than 33 Mpa (33 N/mm ²)
	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 chatelier 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 (SO ₃), percentage by mass not more than 3.0	-do-
	Total loss on ignition shall not be more than 5 percent	

STANDARDISED FIELD QUALITY PLAN

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
i)	Chemical analysis test		
	Carbon	0.30 Percent Maximum	0.30 Percent Maximum
	Sulphur	0.060 Percent Maximum	0.055 Percent Maximum
	Phosphorus	0.060 Percent Maximum	0.055 Percent Maximum
	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

STANDARDISED FIELD QUALITY PLAN

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR COARSE AGGREGATES AS PER IS 383

3. Coarse Aggregates										
i) Physical Tests										
a) Determination of particles size	a. IS Sieve Designation	%age passing for Single-Sized Aggregate of nominal size					Percentage Passing for 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									

STANDARDISED FIELD QUALITY PLAN

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Annex-4

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR FINE AGGREGATES AS PER IS 383

4. Fine aggregates																																																
i) Physical Tests																																																
a) Determination of particle size	<table><thead><tr><th rowspan="2">IS Sieve Designation</th><th colspan="3">Percentage passing for</th></tr><tr><th>F.A. Zone I</th><th>F.A. Zone II</th><th>F.A. Zone III</th></tr></thead><tbody><tr><td>10 mm</td><td>100</td><td>100</td><td>100</td></tr><tr><td>4.75 mm</td><td>90-100</td><td>90-100</td><td>90-100</td></tr><tr><td>2.36 mm</td><td>60-95</td><td>75-100</td><td>85-100</td></tr><tr><td>1.18 mm</td><td>30-70</td><td>55-90</td><td>75-100</td></tr><tr><td>600 microns</td><td>15-34</td><td>35-59</td><td>60-79</td></tr><tr><td>300 microns</td><td>5 to 20</td><td>8 to 30</td><td>12 to 40</td></tr><tr><td>150 microns</td><td>0-10</td><td>0-10</td><td>0-10</td></tr><tr><td>b) Silt content</td><td>Not to exceed 8%</td><td>Not to exceed 8%</td><td>Not to exceed 8%</td></tr><tr><td>c) Presence of deleterious material</td><td colspan="3">Total presence of deleterious materials shall not exceed 5%</td></tr><tr><td>d) Soundness Applicable to concrete work subject to frost action</td><td colspan="3">12% when tested with sodium sulphate and 15% when tested with magnesium sulphate</td></tr></tbody></table>	IS Sieve Designation	Percentage passing for			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		
IS Sieve Designation	Percentage passing for																																															
	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																																															

STANDARDISED FIELD QUALITY PLAN

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CONCRETE WORK

1)	Concrete	a) Workability	Slump shall be recorded by slump cone method and it shall be 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 Regional Head.
 - 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/recified. All the charges in connection with these additional tests shall be borne by the Contractor.
- 2) 53 Grade cement 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.

STANDARDISED FIELD QUALITY PLAN

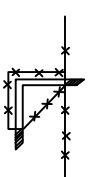
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General Notes:

- 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.

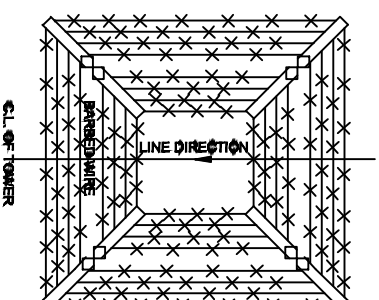
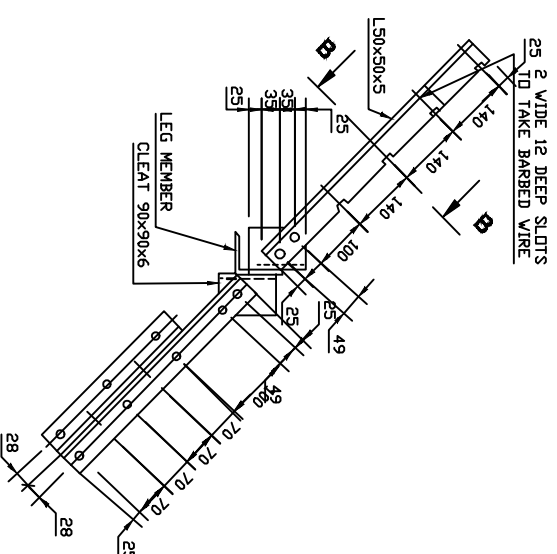
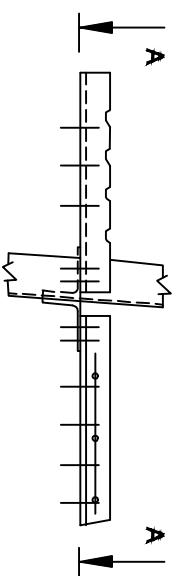
SECTION 2

DRAWINGS



SEC - B-B

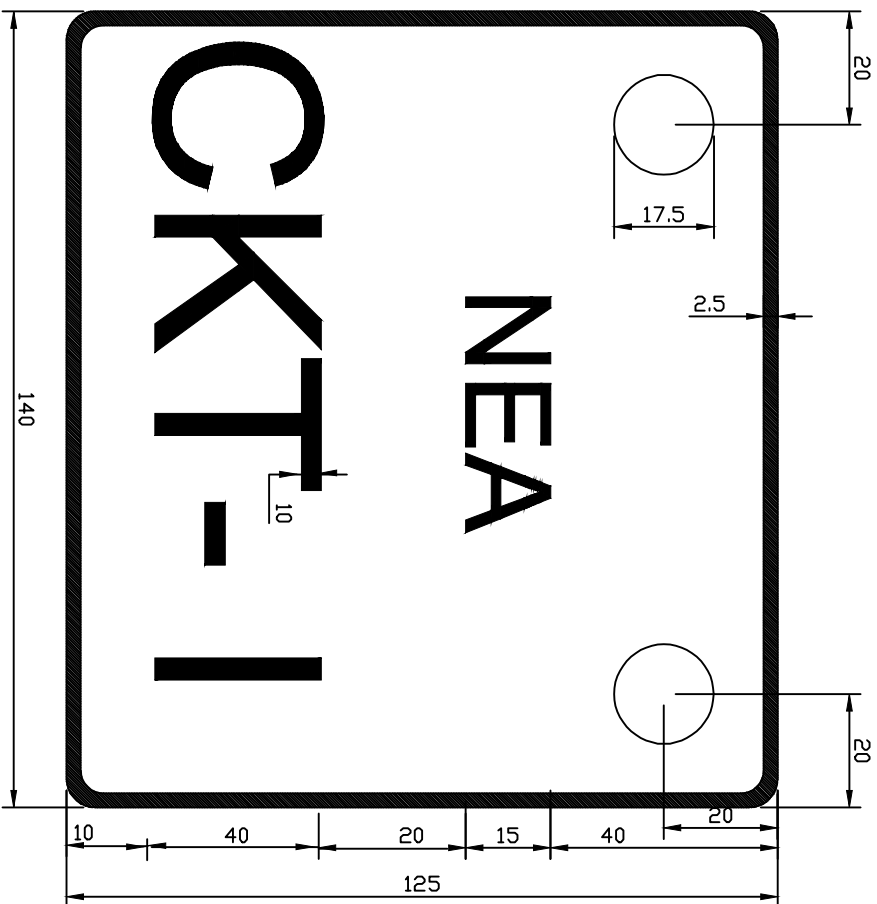
METHOD OF WRAPPING BARBED WIRE



GATE DETAIL PLAN AT A-A

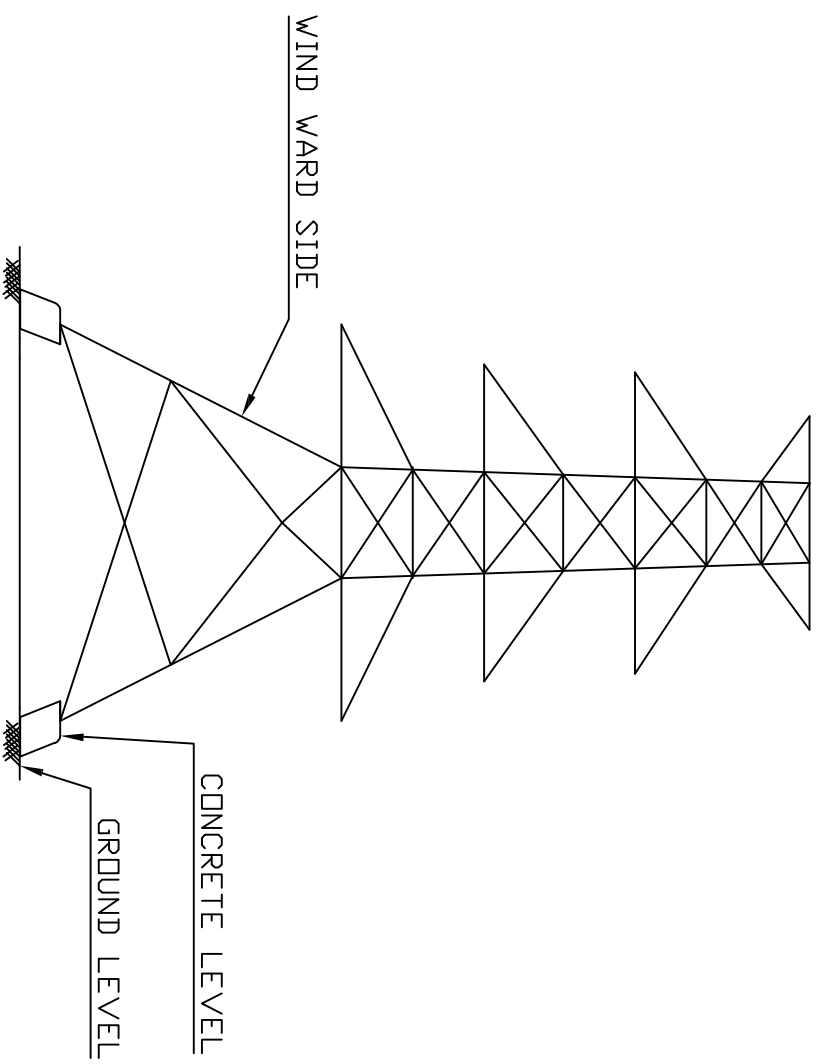
NOTES

- 1: ALL DIMENSION ARE IN MILLIMETERS
- 2: ALL HOLES ARE 12.5MM Ø TO SUIT 16mm Ø BOLTS
- 3: BLANK HOLES AT GATES ARE TO RECEIVE BARBED WIRE
- 4: ONE 3 MM SPRING WASHER TO BE PROVIDED UNDER EACH NUT
- 5: BARBED WIRE SHALL CONFORM TO IS 226 (SIZE DESIGNATION A1)



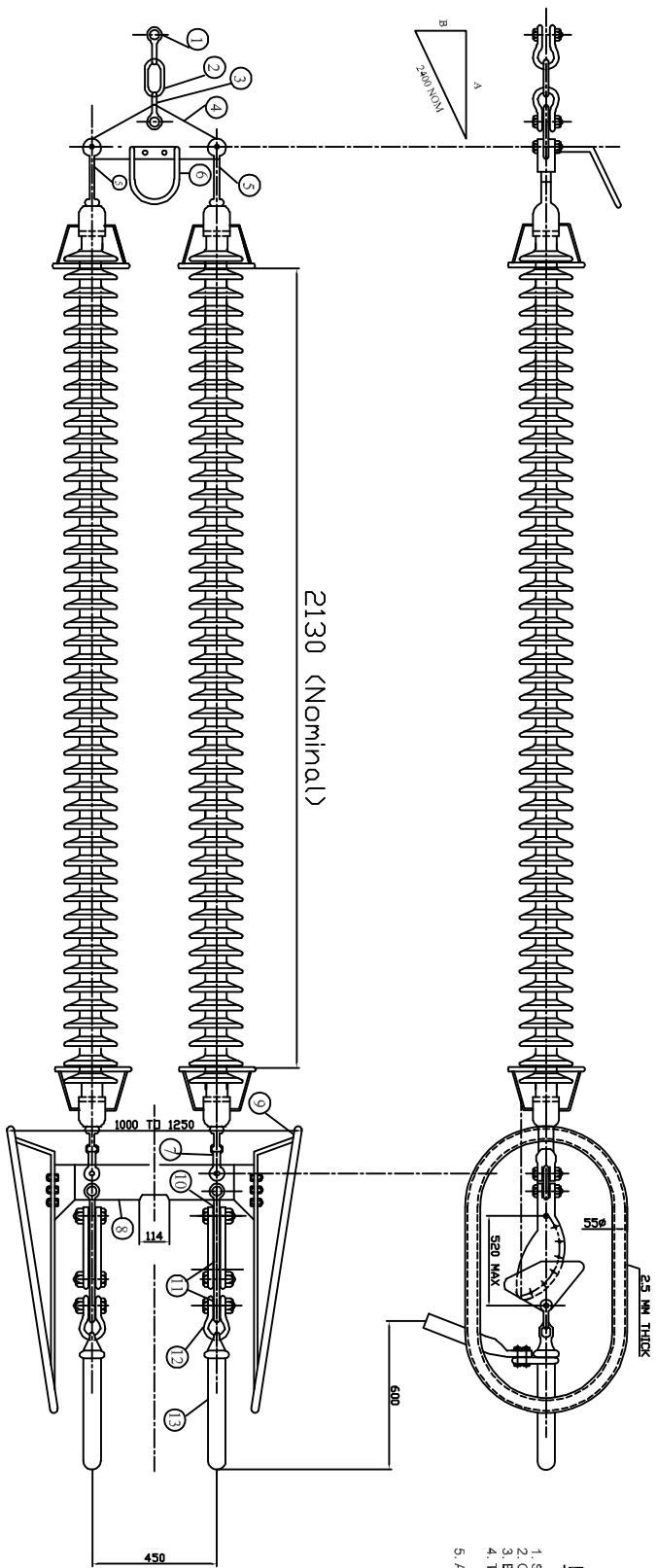
NOTES

- 1: ALL DIM. ARE IN MM
- 2: M.S. PLATE 1.6mm THICK GAID
- 3: WHITE ENAMELLED BACKGROUND AND RED ENAMELLED LETTERING
- 4: EQUAL NO. OF CKT. PLATE FOR EACH CKT. ARE TO BE SUPPLIED
- 5: 2 NOS. 16mm Ø H.R.H. BOLTS X 55mm LONG. TO BE SUPPLIED ALONG WITH EACH PLATE.
- 6: 2 NOS. 2MM THICK LEAD WASHERS TO BE PROVIDED WITH EACH PLATE
- 7: REAR SIDE SHOULD BE ENAMELLED BLACK.



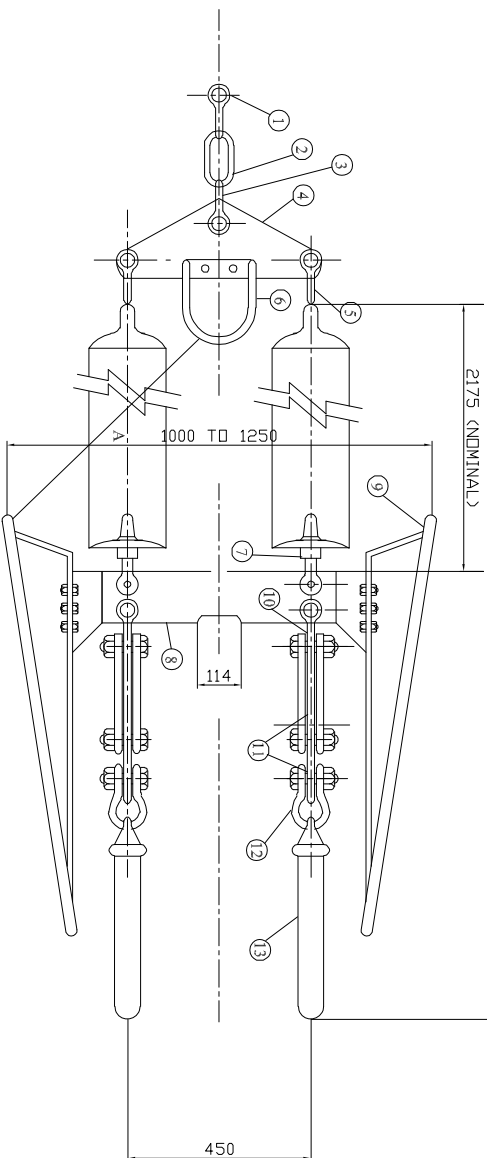
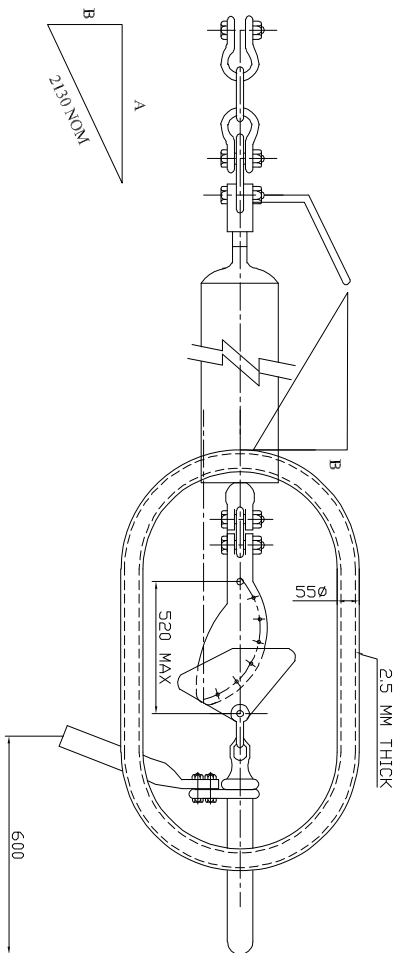
TYPICAL. D/C TOWER

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.	SLIP STRENGTH= 95% of cond. UTS



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.



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	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	1	MILD STEEL	240KN
9	CORONA CONTROL RING/	1/SET	AL ALOY PIPE	N.A.
10	GRADING RING	2	FORGED STEEL	120KN
11	CLEVIS EYE	2	MILD STEEL	120KN
12	SAG ADJUSTING PLATE	2	FORGED STEEL	120KN
13	ANCHOR SHACKLE TENSION CLAMP	2	E.C. GRADE AL. & M.S.	SLIP STRENGTH= 95% COND. UTS

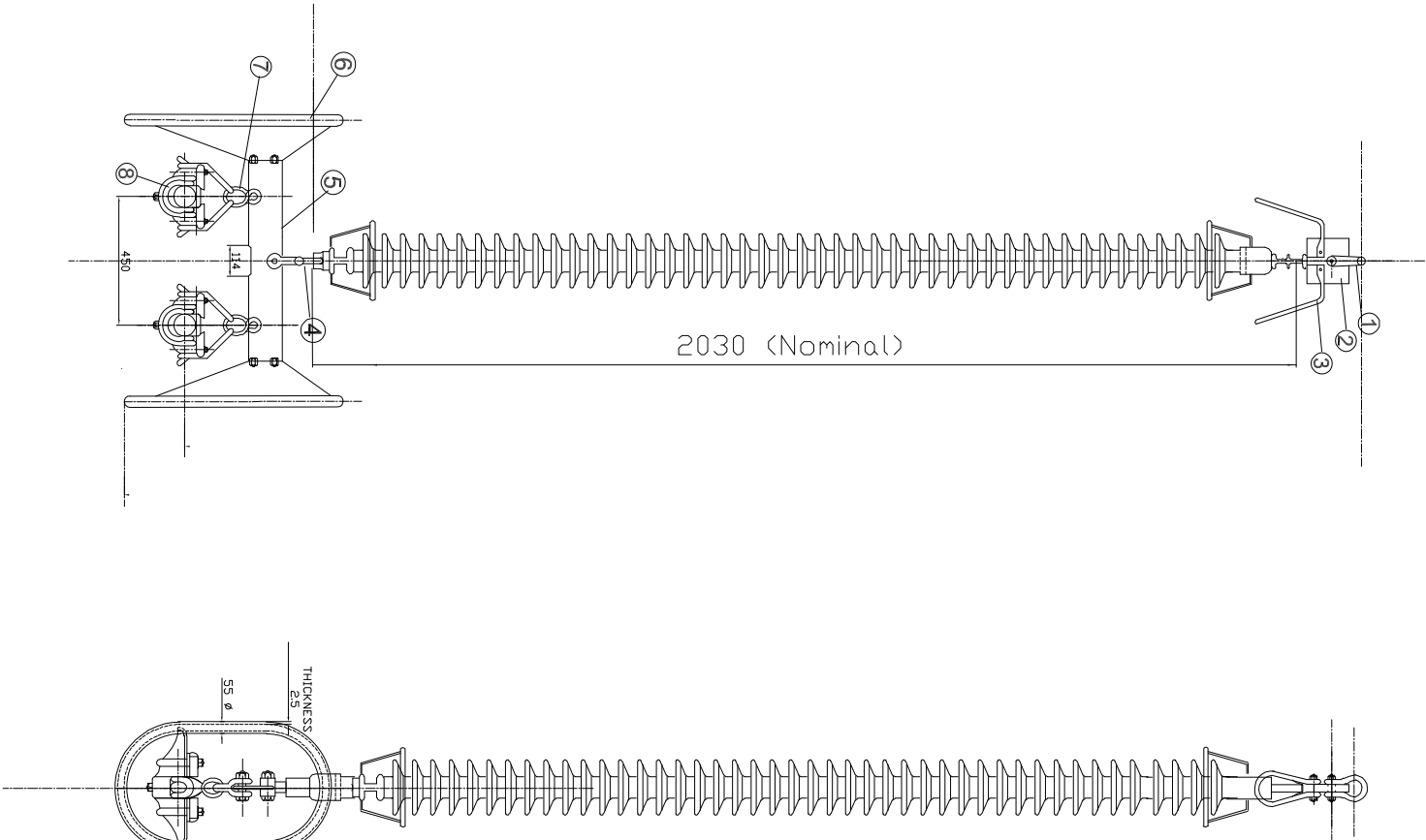
NOTES:-

1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. BALL & SOCKET SIZE OF 20MM. DESIGNATION.
4. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE INCLUSIVE OF MAX. VARIATION IN LENGTH DUE TO..
 - A) INSULATOR DISC TOLERANCE OF ± 5 MM
 - B) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING OF $\pm 2\%$
 - C) ADJUSTMENT OF SAG ADJUSTMENT DEVICE
5. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
6. ALL DIMENSIONS ARE IN MM.

			TENSILE STRENGTH
1	ANCHOR SHACKLE	1	70 K.N.
2	HORN HOLDER BALL EYE	1	70 K.N.
3	ARCING HORN	1	N.A.
4	SOCKET CLEVIS	1	70 K.N.
5	YOKE PLATE	1	70 K.N.
6	CORONA CONTROL RING/ GRADING RING	1/SET	N.A.
7	TWISTED SHACKLE	2	70 K.N.
8	SUSPENSION CLAMP	2	70 K.N.

NOTES:-

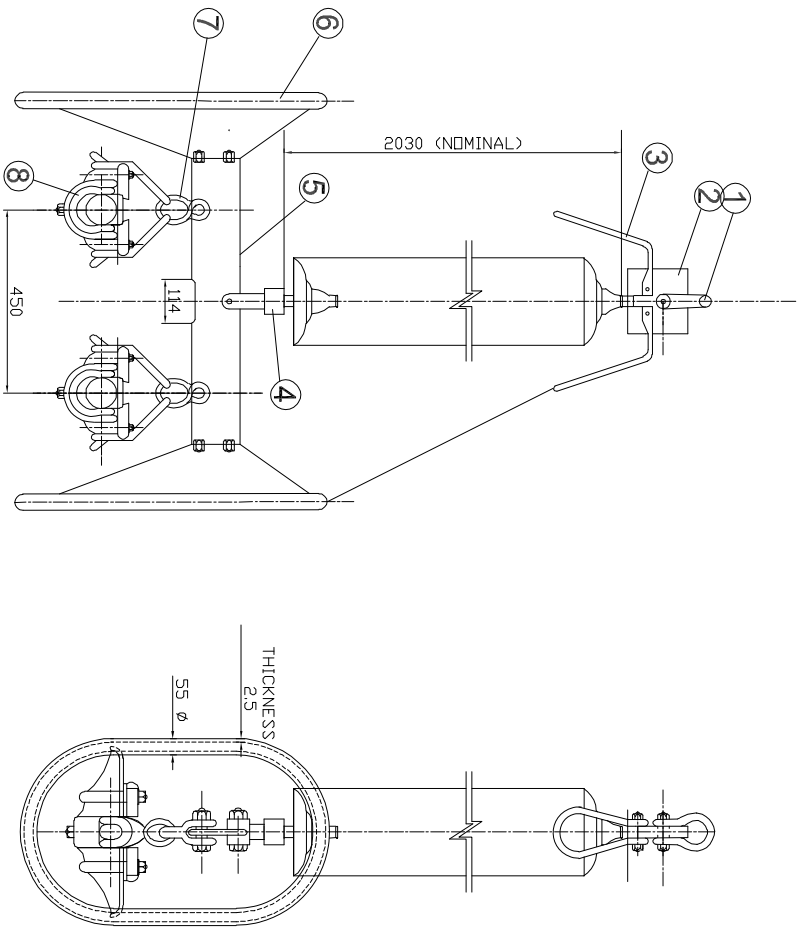
1. OTHER FERROUS PARTS HOT DIP GALVANISED.
2. BALL & SOCKET DESIGNATION 16mm
3. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
4. ALL DIMENSIONS ARE IN MM.
5. SUITABLE COUNTER WEIGHT ASSEMBLY TO BE PROVIDED WITH PILOT

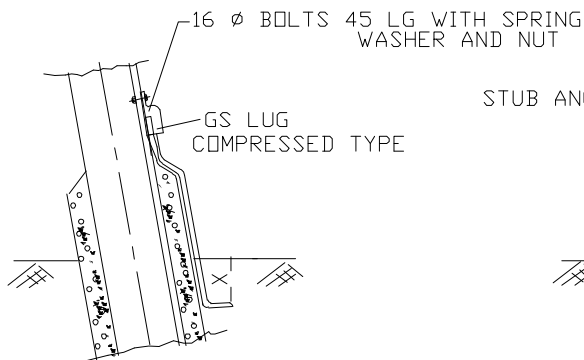


S.NO.	DESCRIPTION	QTY.	MATERIAL	MIN. ULTIMATE TENSILE STRENGTH
1	ANCHOR SHACKLE	1	FORGED STEEL	70 K.N.
2	HORN HOLDER BALL EYE	1	FORGED STEEL	70 K.N.
3	ARCING HORN	1	MILD STEEL	N.A.
4	SOCKET CLEVIS	1	FORGED STEEL	70 K.N.
5	YOKE PLATE	1	MILD STEEL	70 K.N.
6	CORONA CONTROL RING/ GRADING RING	1/SET	AL ALOY PIPE	N.A.
7	TWISTED SHACKLE	2	FORGED STEEL	70 K.N.
8	SUSPENSION LAMP	2	AL ALOY	70 K.N.

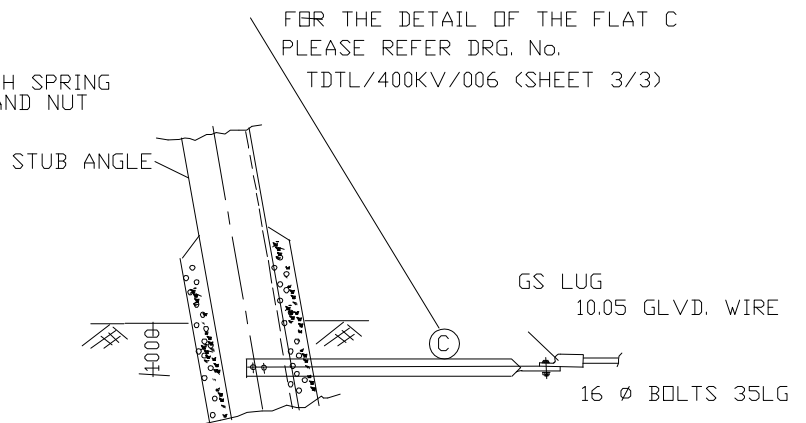
NOTES:-

1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. BALL& SOCKET SIZE 16 MM. OF DESIGNATION.
4. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE INCLUSIVE OF MAX. VARIATION IN LENGTH DUE TO..
A) INSULATOR DISC TOLERANCE OF +/- .4MM
B) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITING OF +/-2%
5. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
6. ALL DIMENSIONS ARE IN MM.
7. SUITABLE COUNTERWEIGHT ASSEMBLY TO BE ADDED FOR PILOT

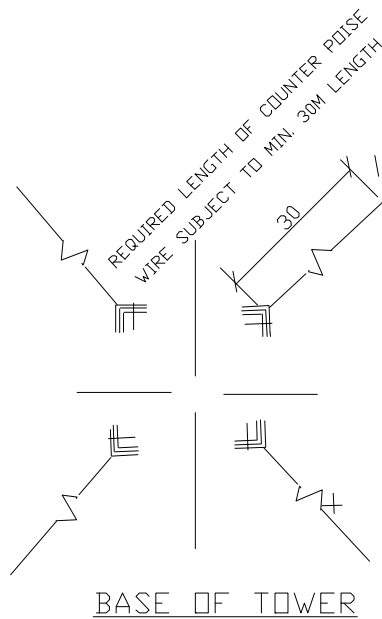




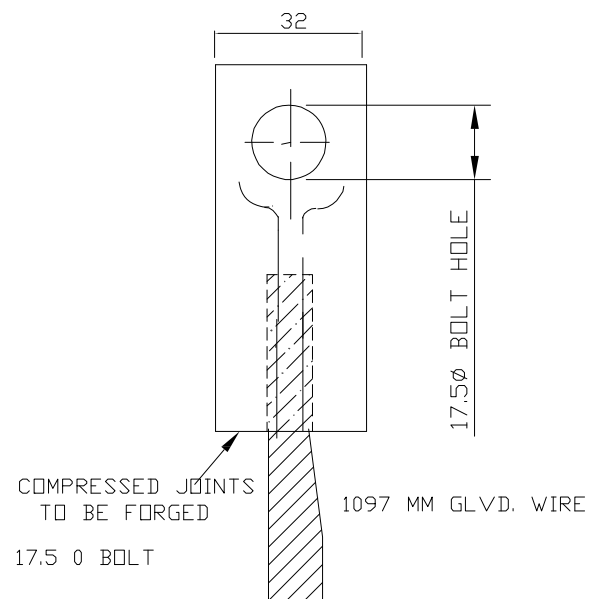
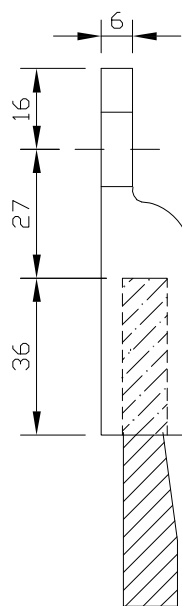
X IS NOT LESS THAN 1000MM
LUG FITTING (TYPICAL)
FOR THREE LEGS



LUG FITTING ON FOURTH LEG



BASE OF TOWER



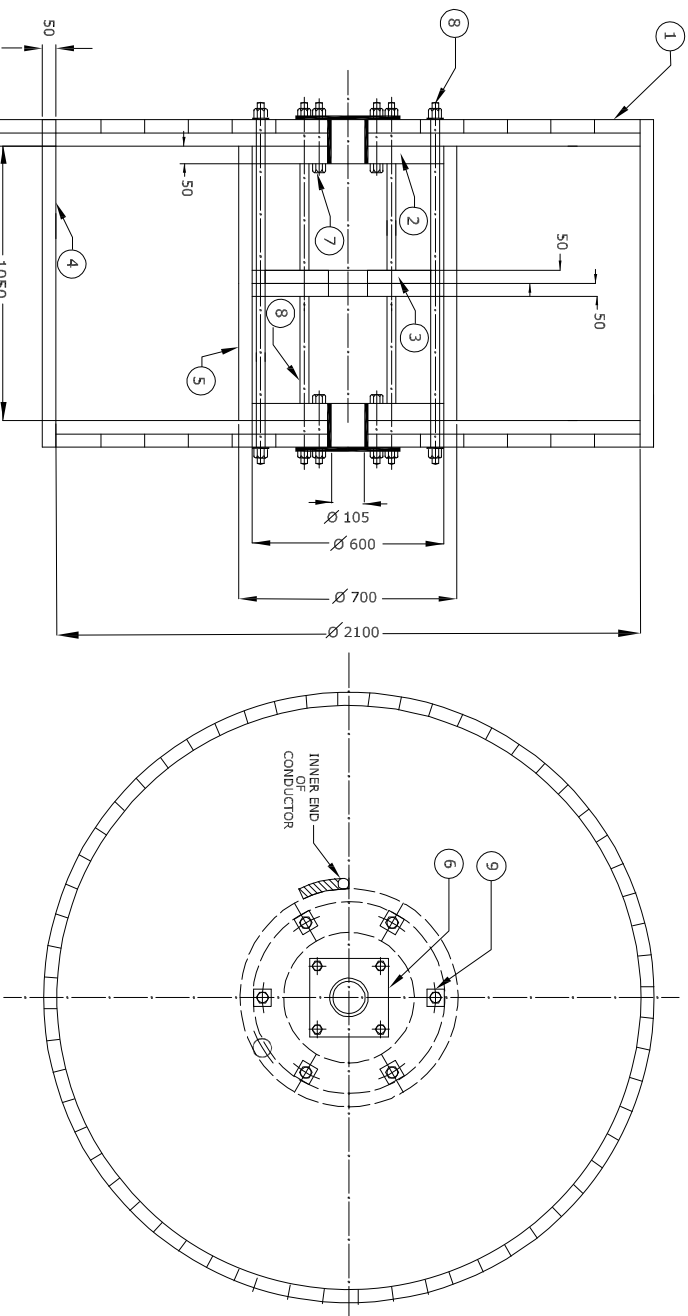
DETAIL OF LUG

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



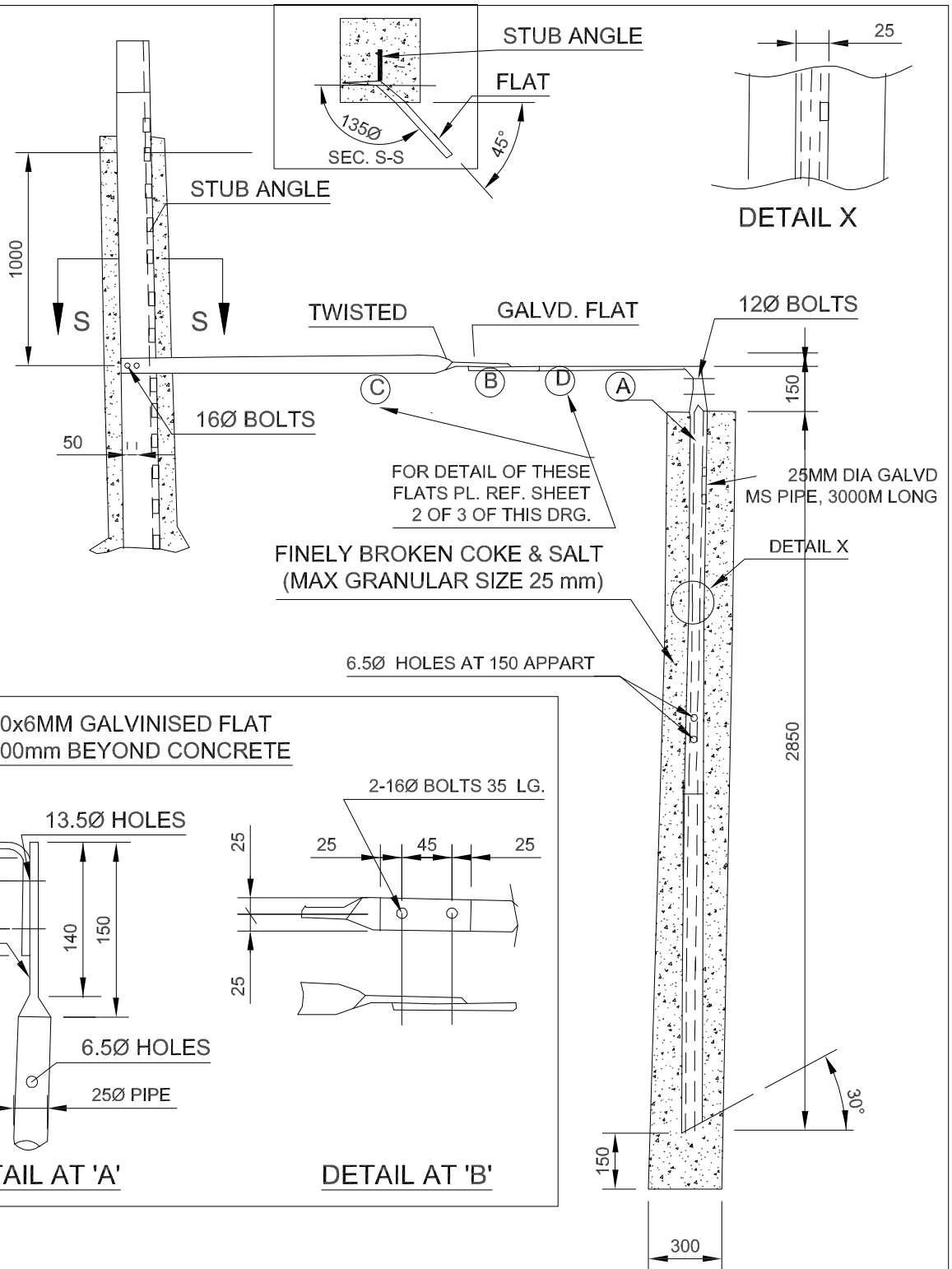
NOTE :

- ALL DIMENSIONS ARE IN MM.
- DRUMS SHALL GENERALLY CONFIRM TO IS 1778-1980 AMENDMENT No.1. Of June 1989 EXCEPT OTHERWISE SPECIFIED.
- ONE LENGTH OF CONDUCTOR SHALL BE WOUND ON EVERY DRUM
- THE STANDARD LENGTH OF THE CONDUCTOR AND EQUIVALENT SIZE OF CONDUCTOR IS L mtrs (INDICATED IN THE TABLE BELOW) WITH TOLERANCE OF $\pm 5\%$.
- TOLERANCE ON DIMENSIONS OF WOOD IS $+ 3\text{mm}$.
- TOLERANCE ON STEEL COMPONENTS OF THE DRUM IS $\pm 0.50\text{mm}$.
- INNER & OUTER SURFACE OF FLANGE & BARREL SHALL BE BITUMIN PAINTED.
- BARREL & INNER SURFACE OF FLANGE SHALL HAVE WATER PROOF HDPE SHEET
- OUTER SURFACE OF CONDUCTOR SHALL BE COVERED BY WATER PROOF POLYTHENE PAPER
- MEDIUM GRADE CRAFT/CREPE/POLYTHENE PAPER SHALL BE USED IN BETWEEN THE LAYERS
- ALL NUTS OF ROD SHOULD BE TACK WELDED.
- 3 nos. BINDER SHALL BE USED FOR BINDING THE EXTERNAL LAGGING.
- FLANGE SHALL BE NAILED IN 5 CIRCLES WITH NAIL SIZE OF 125X4.

STANDARD DRAWING

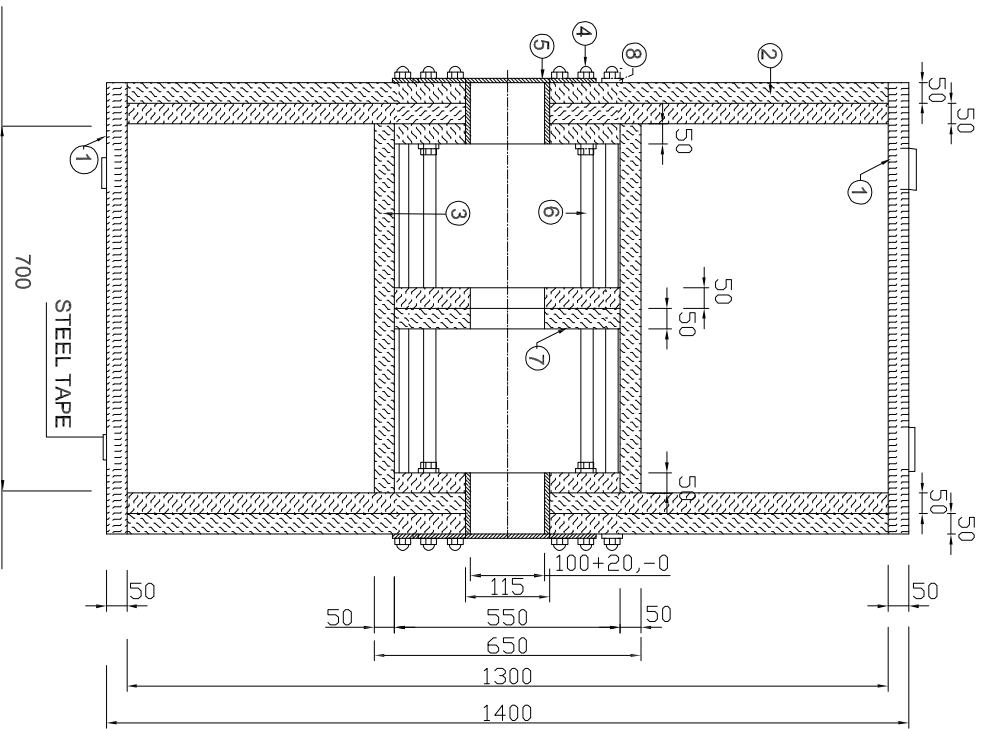
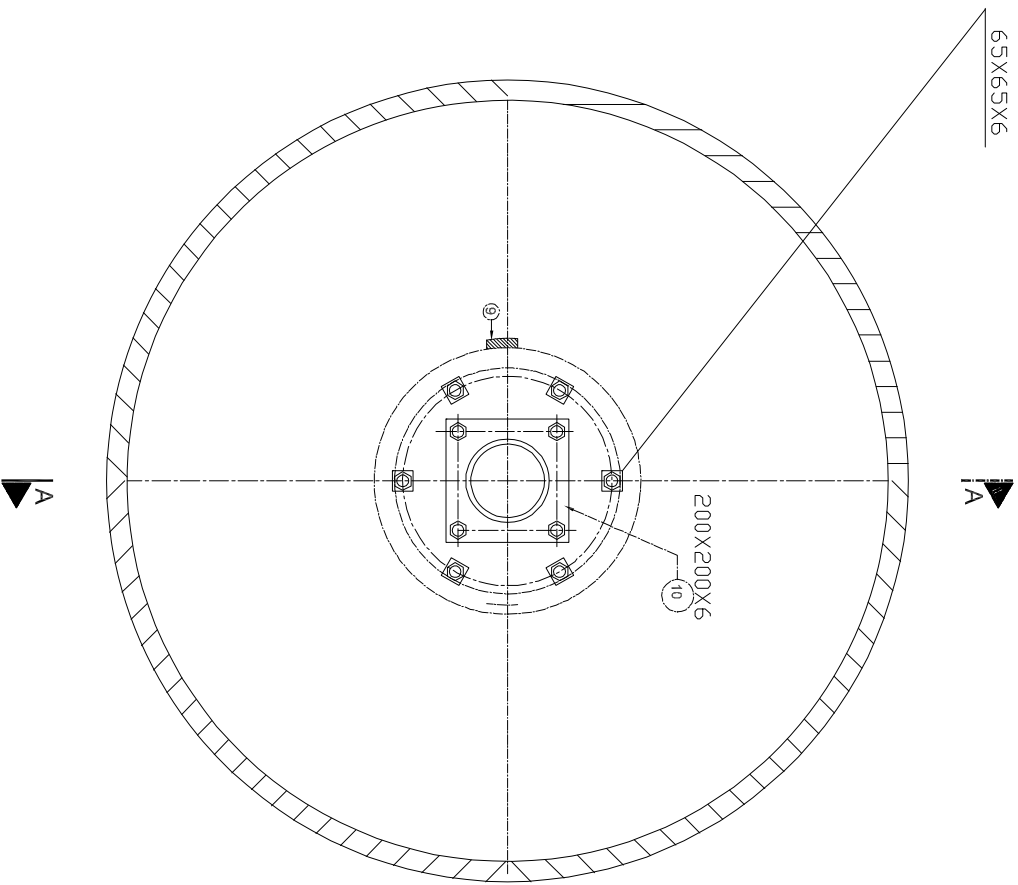
STANDARD CONDUCTOR LENGTH	ACSR LAPWING	ACSR BERSIMIS	ACSR MOOSE	ACSR SNOWBIRD	ACSR ZEBRA	ACSR BISON
L in Meters	1800	2100	2100	2100	2200	2200

	DRUM COMPONENTS	MATERIAL SPECIFICATION	QUANTITY	DIMENSION
1.	FLANGE	SEASONED WOOD	2	$\varnothing 2100 \times 100(50+50)$
2.	BARREL END SUPPORTS	SEASONED WOOD	2	$\varnothing 600 \times 50$
3.	BARREL MIDDLE SUPPORT	SEASONED WOOD	1	$\varnothing 600 \times 100(50+50)$
4.	OUTER LAGGING	SEASONED WOOD	--	1250×50
5.	BARREL BATTENS	SEASONED WOOD	--	$1050 \times 75 \times 50$
6.	SPINDLE PLATE	MS	2	$300 \times 300 \times 8$
7.	BUSH PLATE STUD	MS	8	$\varnothing 16 \times 180$
8.	TIE ROD	MS	6	$\varnothing 22 \times 1325$
9.	TIE ROD WASHER	MS	12	$75 \times 75 \times 6$



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

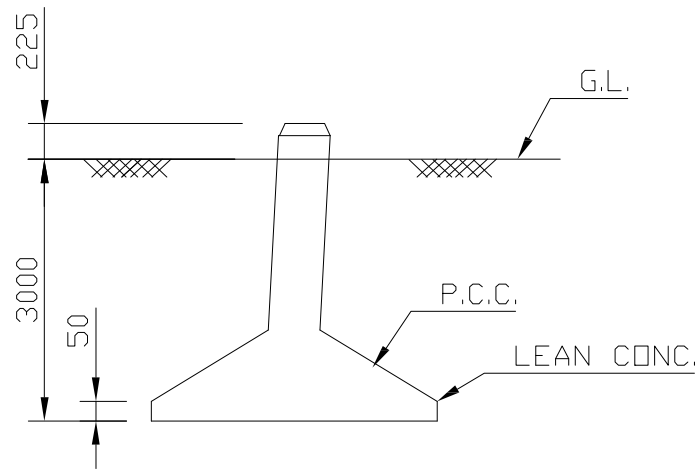


SECTION A-A

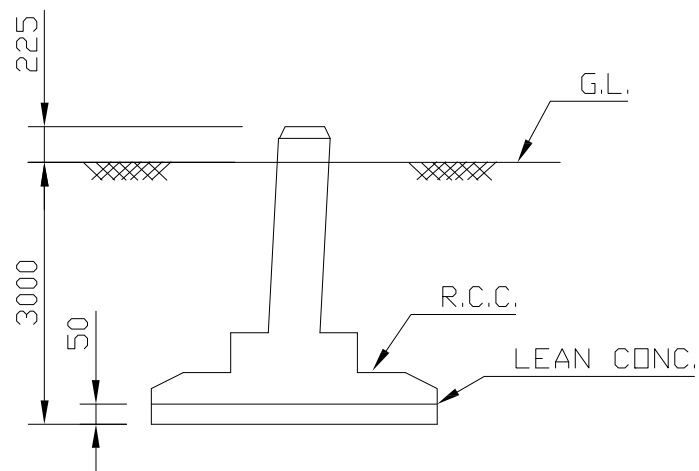
NOTES

- 1 : ALL DIM. ARE IN MM
- 2 : CLEARANCE FROM OUTER SURFACE OF OUTER LAYER OF EARTH WIRE TO INNER SURFACE OF PROTECTIVE LAGGING IS AT LEAST 50mm
- 3 : TWO LENGTHS OF EARTHWIRE ARE WOUND ON EVERY DRUM
- 4 : THICKNESS OF PROTECTIVE LAGGING SHOULD BE 50 mm.
- 5 : STANDARD LENGTH OF EARTHWIRE 2000m \pm 5%
- 6 : TOLERANCE ON WOOD DIMENSION = +3MM

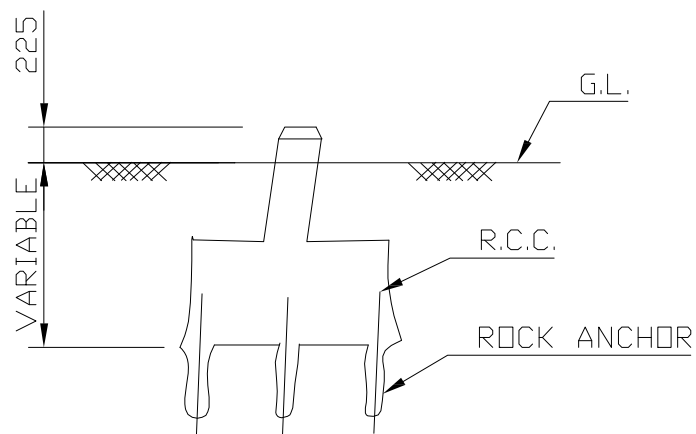
S.NO.	DESCRIPTION	Qty	Material
10	BUSH PLATE	2	MS
9	SLOT FOR INNER END OF EARTHWIRE	-	-
8	WASHER	24	MS
7	BARREL SUPPORT	3	WOOD
6	TIE RODS	6	MS
5	MILD STEEL BUSH	2	MS
4	BARREL STUD	8	MS
3	BARREL	1	WOOD
2	FLANGE	2	WOOD
1	PROTECTIVE EXTERNAL LAGGING	1	WOOD



TYP. FOUNDATION SHAPE FOR P.C.C. TYPE

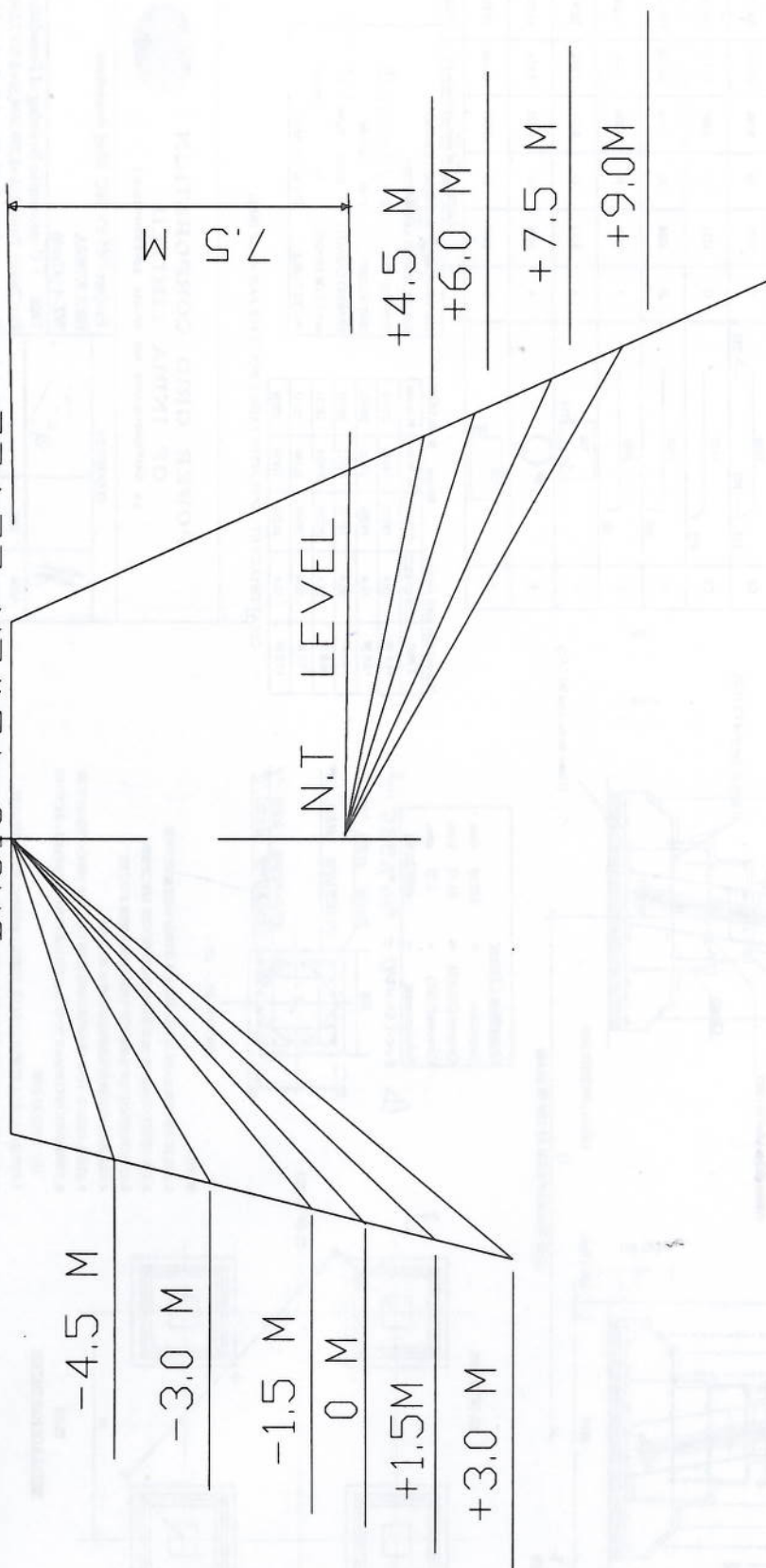


TYP. FOUNDATION SHAPE FOR R.C.C. TYPE



TYP. FOUNDATION SHAPE FOR HARD ROCK

BASIC TOWER LEVEL



Possible Other Legs For Maximum Level Difference of

Shoretest Leg	3 m for Tower DA	6 m for Tower DB, DC & DD
-4.5	-4.5, -3.0, -1.5	-4.5, -3.0, -1.5, ±0, +1.5
-3.0	-3.0, -1.5, ±0	-3.0, -1.5, ±0, +1.5, +3.0
-1.5	-1.5, ±0, +1.5	-1.5, ±0, +1.5, ±0, +3.0
±0	±0, +1.5, +3.0	±0, +1.5, +3.0
+1.5	+1.5, +3.0	+1.5, +3.0
+3.0	+3.0	+3.0
+4.5	+4.5, +6.0, +7.5	+4.5, +6.0, +7.5, +9.0
+6.0	+6.0, +7.5, +9.0	+6.0, +7.5, +9.0
+7.5	+7.5, +9.0	+7.5, +9.0
+9.0	+9.0	+9.0

SCALE - NTS

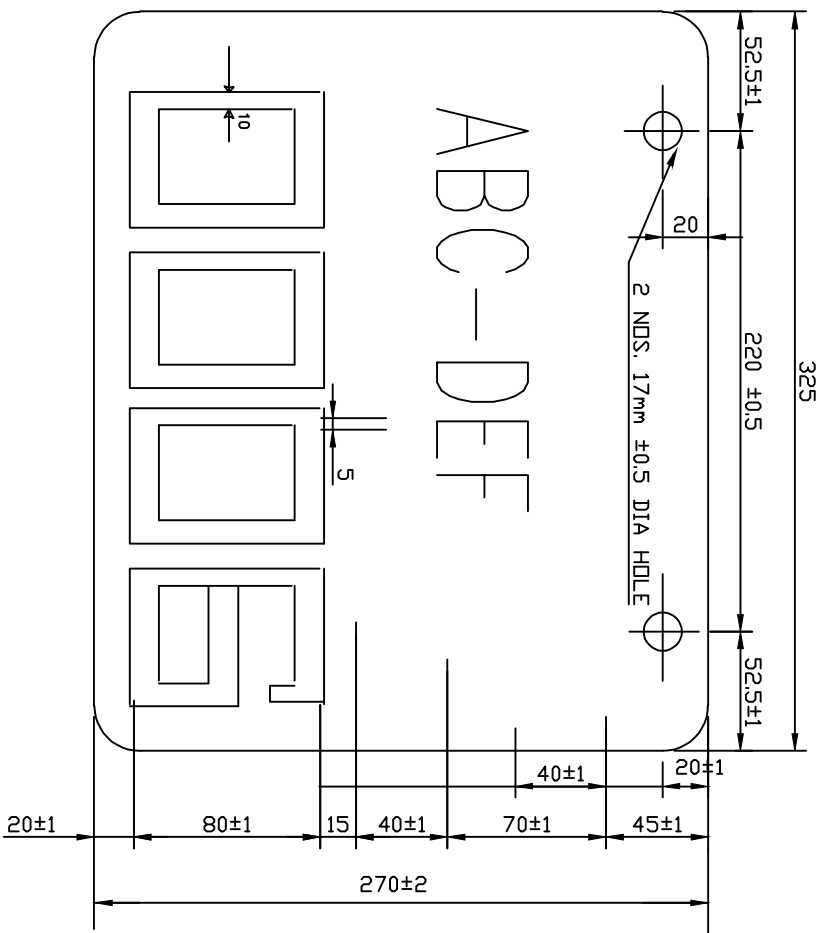
FOR BID PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
TRANSMISSION AND SYSTEM OPERATION
TRANSMISSION LINE SUBSTATION CONST. DEPARTMENT

LEG PROJECT

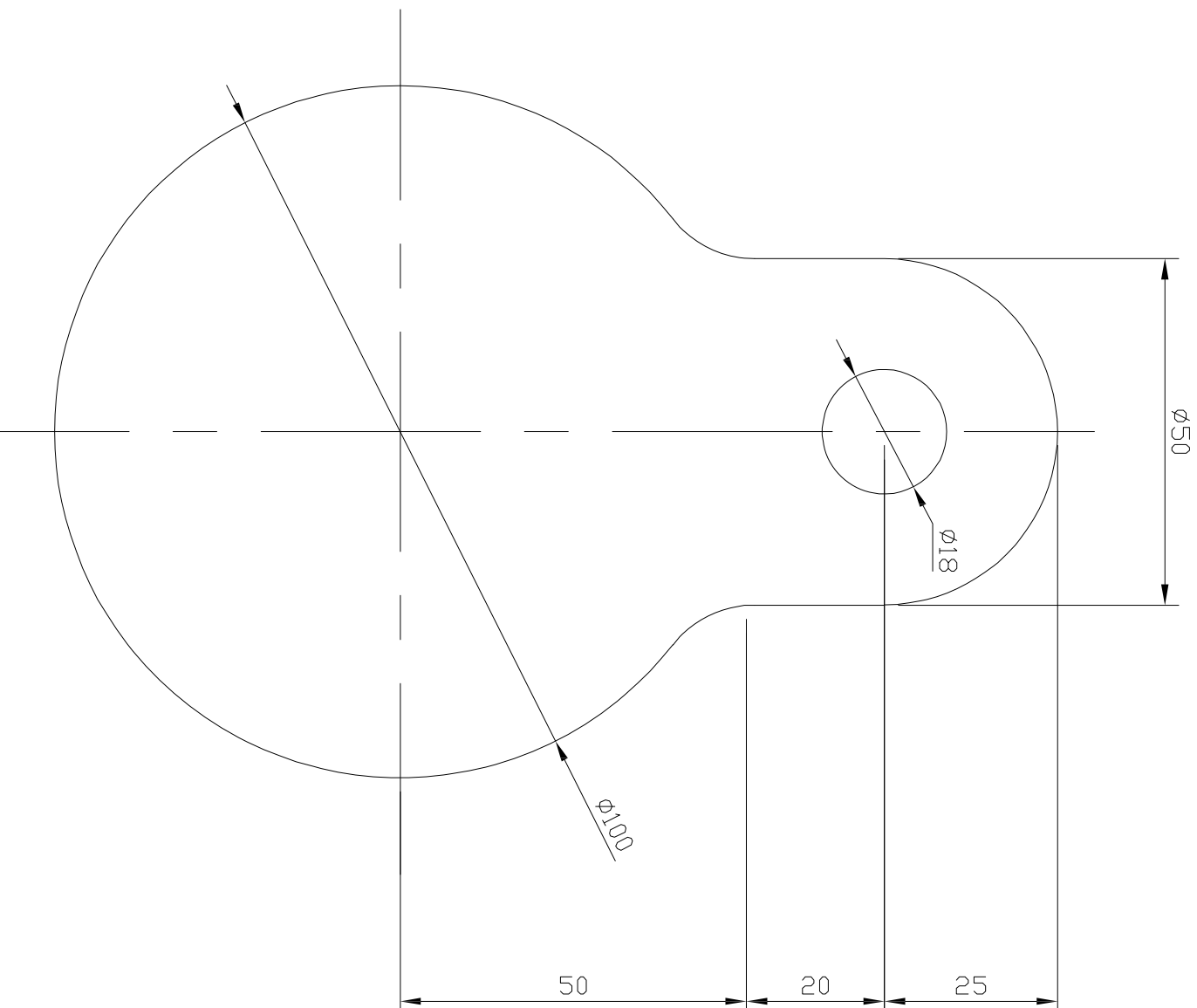
LEG SCHEME FOR TOWER TYPES DA, DB, DC, DD, DBH, DDH

PREPARED BY
CHECKED BY
APPROVED BY
SCALE NOT TO SCALE
DRAWING NO. T K400KV/LEGScheme
DATE



NOTES

- 1 : ALL DIM. ARE IN MM
- 2 : LETTER RED ENAMELLED
- 3 : GROUND WHITE VITREOUS ENAMELLED
- 4 : BACK : BLACK VITREOUS ENAMELLED
- 5 : 1.5 MM THICK MS PLATE
- 6 : 2 NOS. 2 MM THICK LEAD WASHER TO BE PROVIDED WITH EACH PLATE
- 7 : EACH NO. WILL HAVE FOUR DIGITS AS SHOWN,
NO TO BE STARTED FROM 1 ONWARDS
- 8 : TWO NO 16 MM DIA.H.R.H. BOLTS X 35 MM LONG ARE TO BE SUPPLIED ALONG WITH EACH PLATE
- 9 : ABC CODE FOR SENDING END AND DEF CODE FOR RECEIVING END.

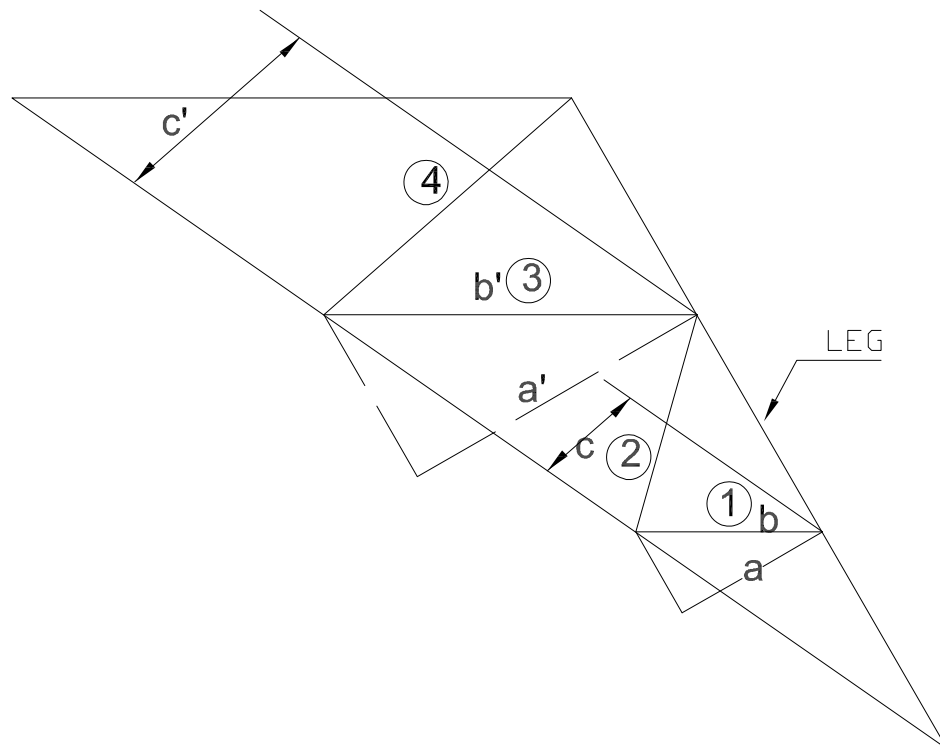


QUANTITIES PER TOWER

- 1 : ONE OF EACH COLOUR FOR S/C TENSION TOWER
- 2 : TWO NO. OF EACH COLOUR FOR D/C TOWER

NOTES

- 1 : ALL DIM. ARE IN MM
- 2 : M.S. PLATE 1.6 MM THICK
- 3 : PHASE PLATES TO BE ENAMELLED RED, YELLOW AND BLUE ON FRONT AND BACK
- 4 : 2 NOS 2MM THK. LEAD WASHERS TO BE PROVIDED WITH EACH PLATE
- 5 : 1 NO. 16MM DIA BOLT FASTNERS & WASHERS PER PLATE



$$X = 2.5\% \text{ OF LEG LOAD}$$

REDUNDANT

DESIGN LOAD FOR
REDUNDANT

①

$X \ b/a$

②

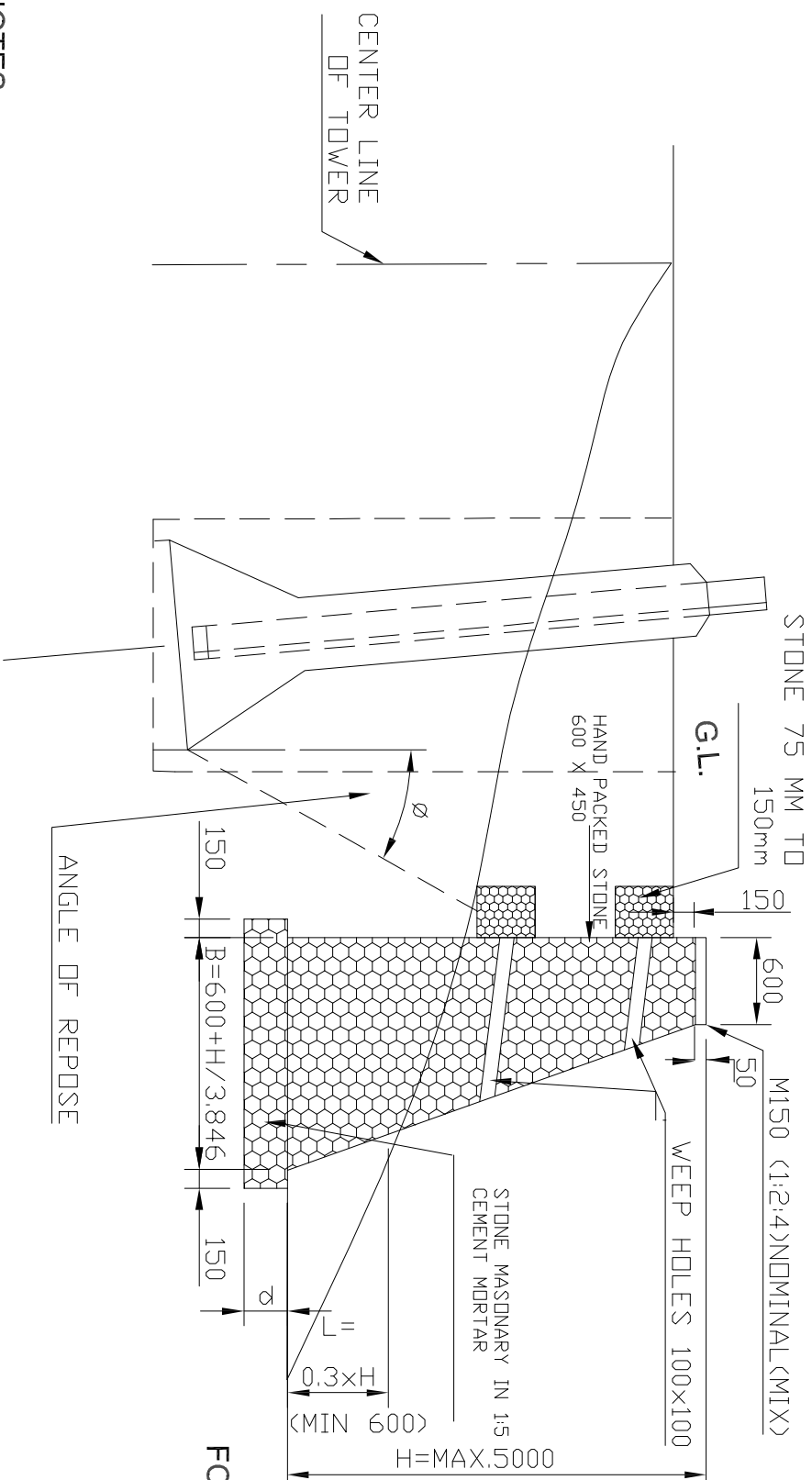
$X \ c/a$

③

$X \ b'/a'$

④

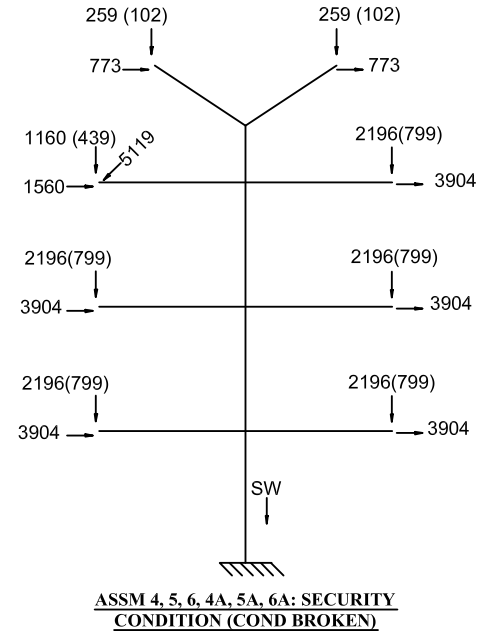
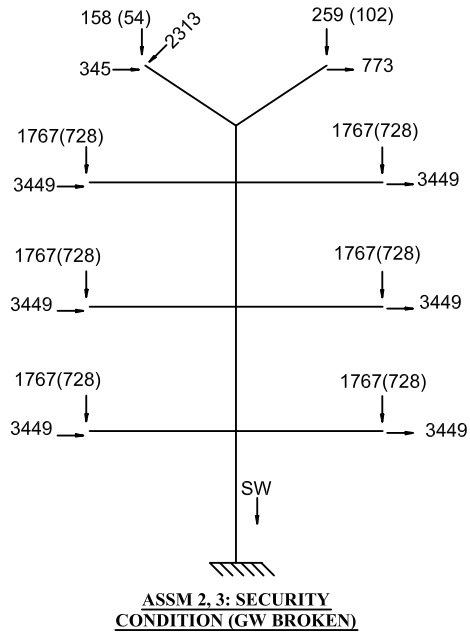
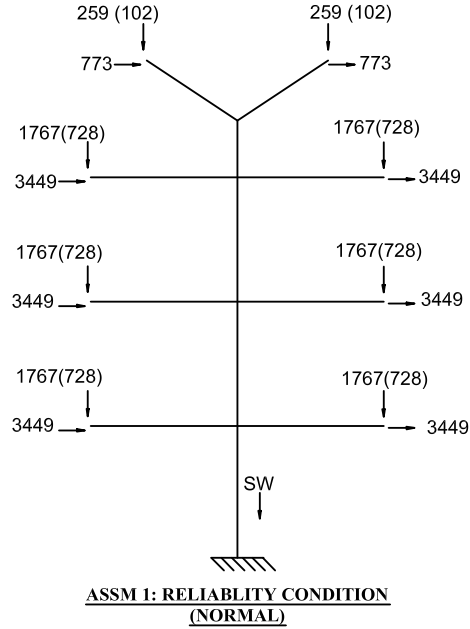
$X \ c'/a'$



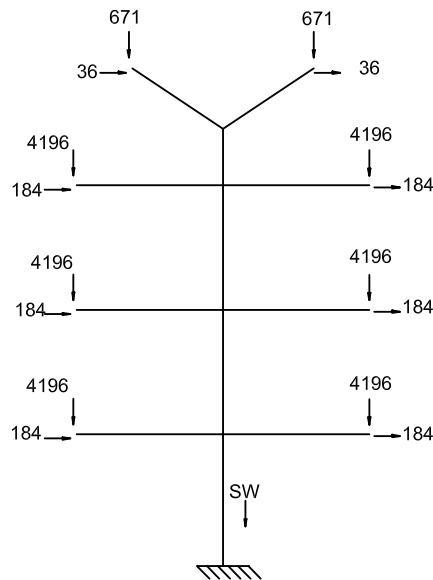
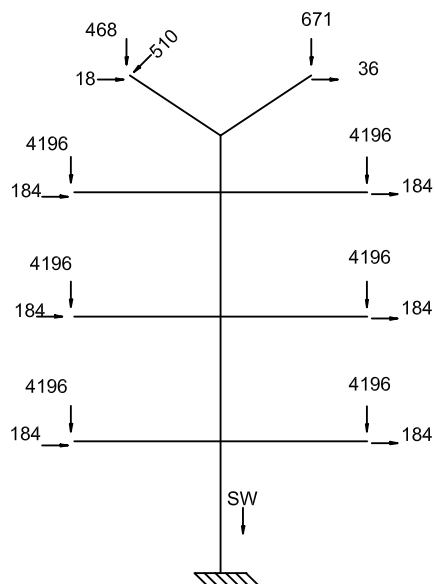
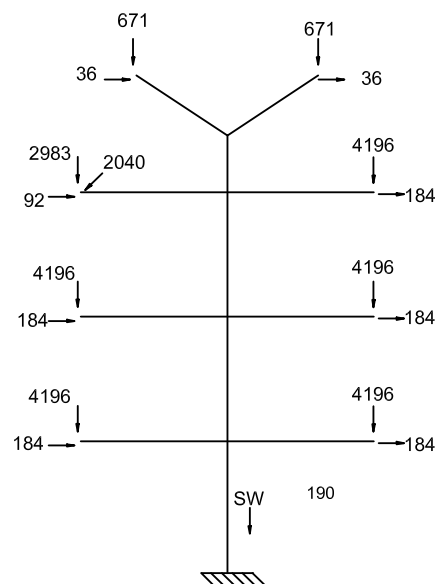
FOR $H \geq 1000$, $d = 230$
 $H < 1000$, $d = 150$

NOTES

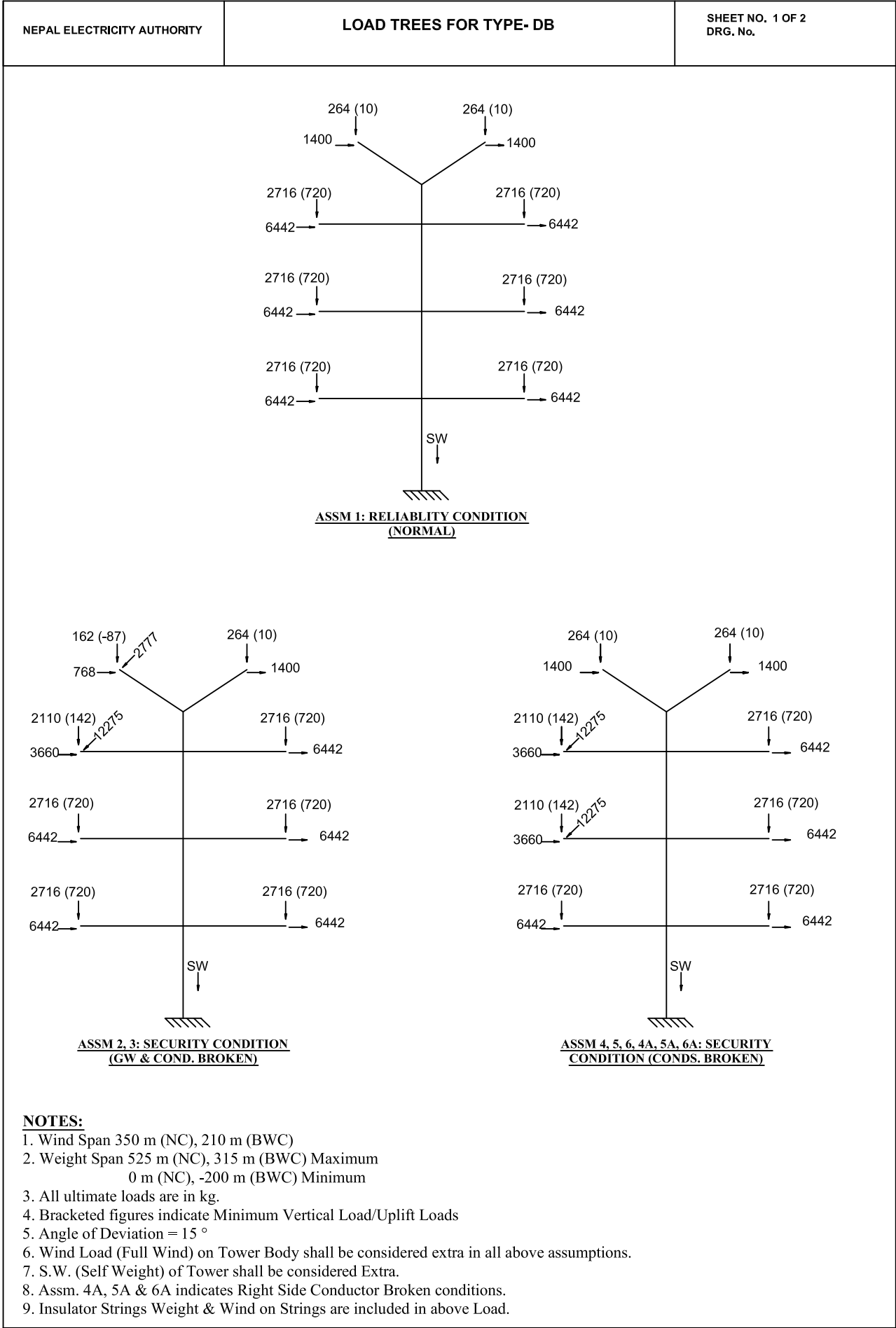
- 1 : ALL DIM. ARE IN MM UNLESS OTHERWISE SPECIFIED.
- 2 : WEEP HOLES SHOULD BE OF SIZE 100mm x 100mm OR 150mm x 150mm IN CASE OF LARGE SIZE REVETMENT.
- 3 : WEEP HOLES SHOULD BE 2.5M C-C APART HORIZONTAL
- 4 : CENTER OF TOP MOST WEEP HOLES TO BE NOT LESS THAN 300 mm BELOW TOP
- 5 : THE MIN. DEPTH OF 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 MASONRY 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

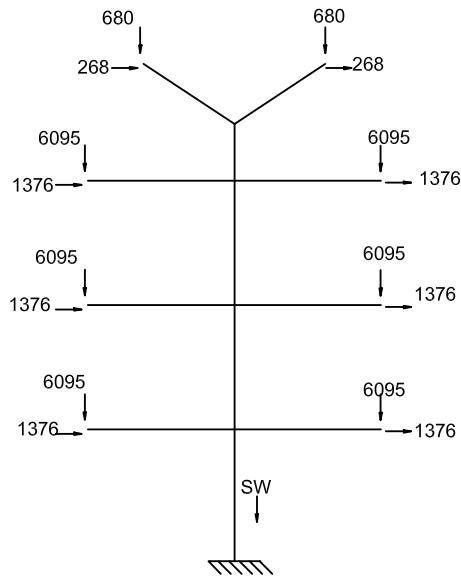
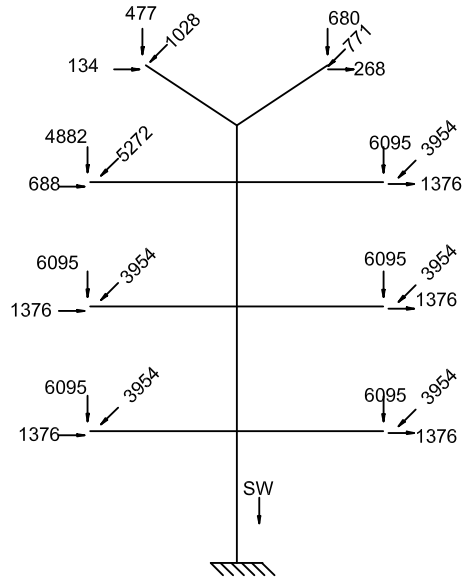
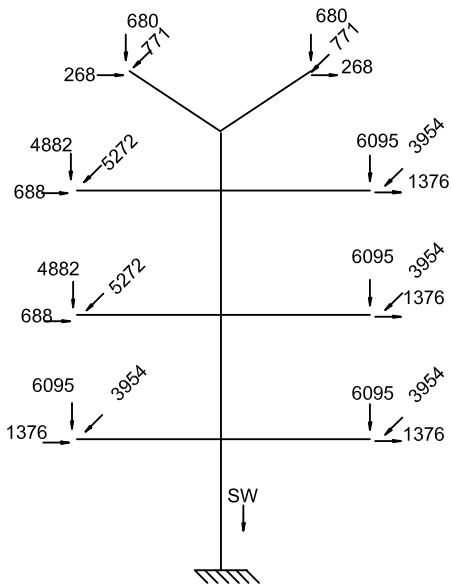
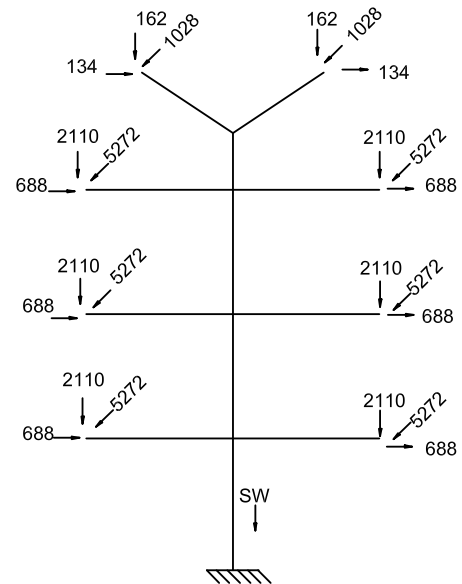
**NOTES:**

1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 525 m (NC), 315 m (BWC) Maximum
200 m (NC), 100 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 2 °
6. Wind Load (Full Wind) on Tower Body shall be considered in Assm. 1.
7. 75 % Wind Load on Tower Body shall be considered in Assm. 2, 3, 4, 5, 6, 4A, 5A & 6A
8. S.W. (Self Weight) of Tower shall be considered Extra.
9. Assm. 4A, 5A & 6A indicates Right Side Conductor Broken conditions.
10. Insulator Strings Weight & Wind on Strings are included in above Load.

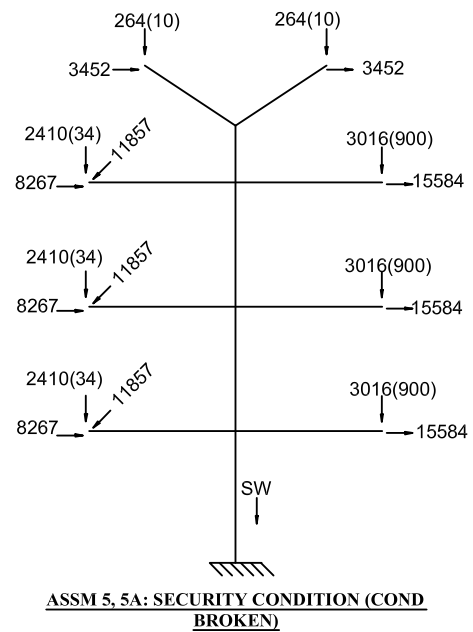
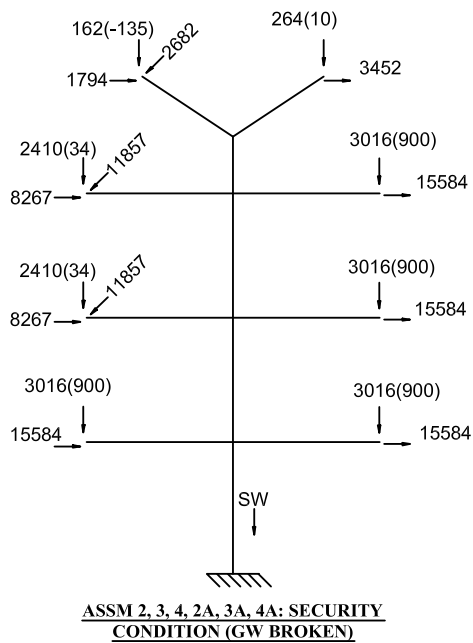
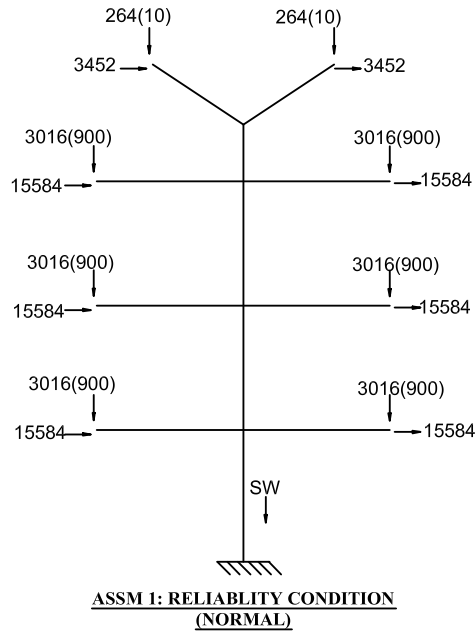
ASSM 7: SAFETY CONDITIONS (NORMAL)ASSM 8, 9: SAFETY CONDITION
(GW BROKEN)ASSM 10, 11, 12, 10A, 11A, 12A: SAFETY
CONDITION (COND BROKEN)**NOTES:**

1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 525 m (NC), 315m (BWC) Maximum
200 m (NC), 100 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Angle of Deviation = 2 °
5. Wind Load on Tower Body need not be considered in all above assumptions.
6. S.W. (Self Weight) of Tower shall be considered Extra.
7. Assm. 10A, 11A & 12A indicates Right Side Conductor Broken conditions.
8. Insulator Strings Weight are included in above Load.

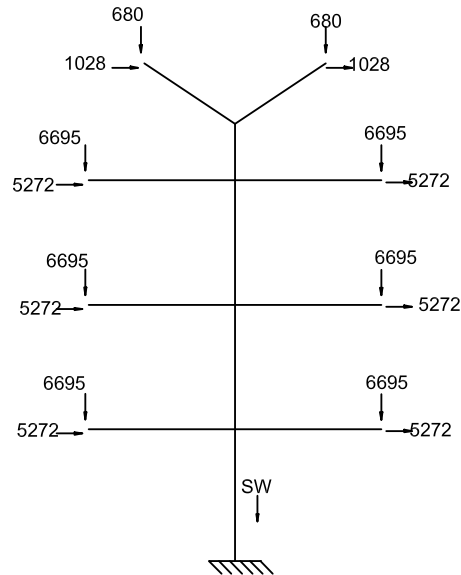
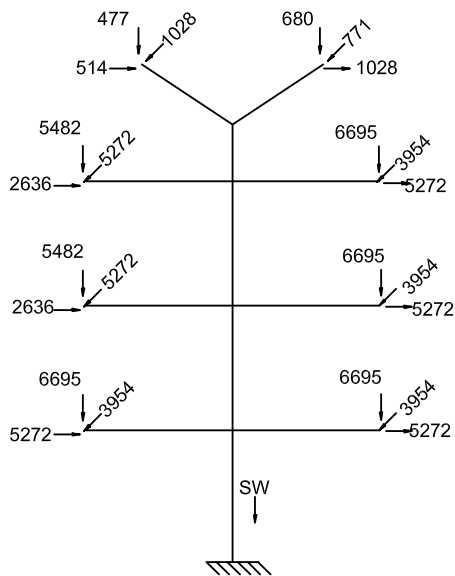
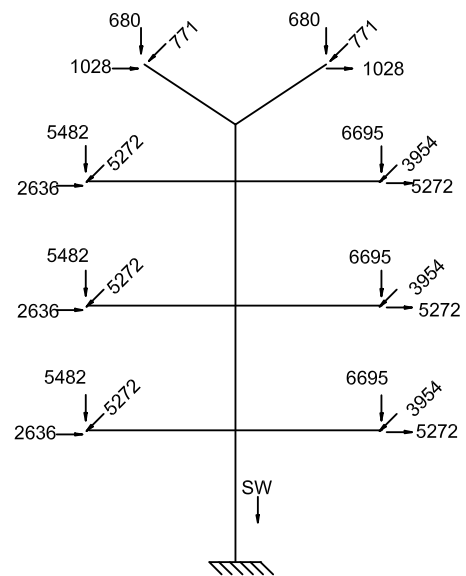


ASSM 7: SAFETY CONDITIONS (NORMAL)ASSM 8, 9: SAFETY CONDITION
(GW & COND. BROKEN)ASSM 10, 11, 12, 10A, 11A, 12A: SAFETY CONDITION
(CONDS. BROKEN)ASSM 13: SECURITY CONDITION
(ANTICASCADING)**NOTES:**

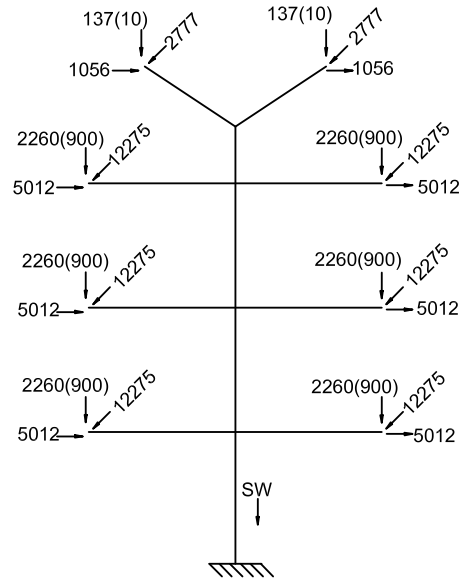
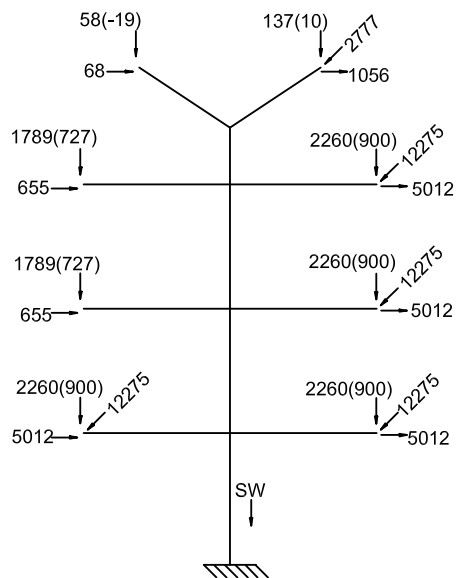
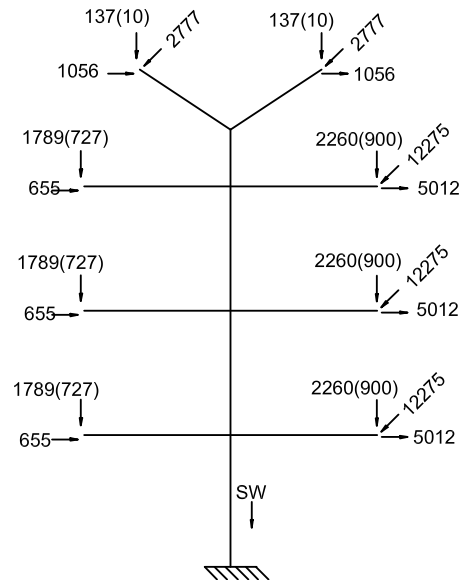
1. Wind Span 350m (NC), 210 m (BWC)
2. Weight Span 525 m (NC), 315 m (BWC) Maximum
0 m (NC), -200 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Angle of Deviation = 15 °
5. Wind Load on Tower Body need not be considered in all above assumptions.
6. S.W. (Self Weight) of Tower shall be considered Extra.
7. Assm. 10A, 11A & 12A indicates Right Side Conductor Broken conditions.
8. Insulator Strings Weight are included in above Load.

**NOTES:**

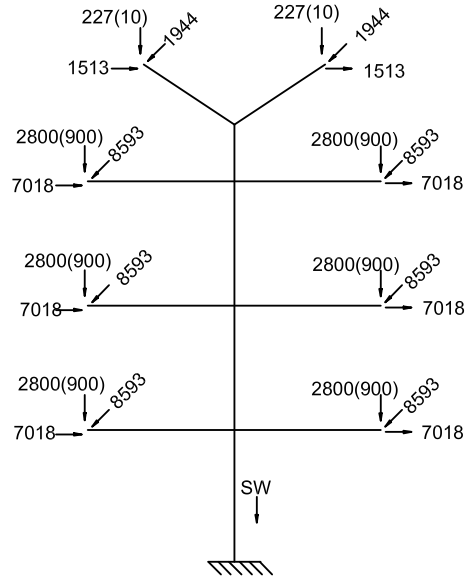
1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 525 m (NC), 315 m (BWC) Maximum
0m (NC), -300 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 60 °
6. Wind Load (Full Wind) on Tower Body shall be considered extra in all above assumptions.
7. S.W. (Self Weight) of Tower shall be considered Extra.
8. Assm. 2A, 3A & 4A indicates Right Side GW Broken conditions.
9. Assm. 5A indicates Right Side Conductors Broken condition.
10. Insulator Strings Weight & Wind on Strings are included in above Load.

**ASSM 6: SAFETY CONDITIONS (NORMAL)****ASSM 7, 8, 9, 7A, 8A, 9A: SAFETY
CONDITION (GW BROKEN)****ASSM 10, 10A: SAFETY CONDITION (COND
BROKEN)****NOTES:**

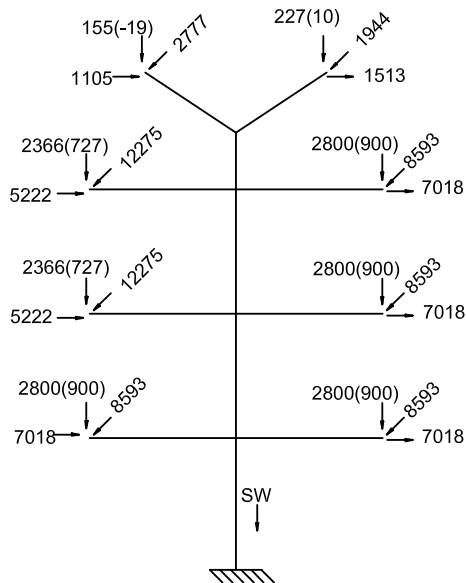
1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 525 m (NC), 315 m (BWC) Maximum
0 m (NC), -300 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Angle of Deviation = 60 °
5. Wind Load on Tower Body need not be considered in all above assumptions.
6. S.W. (Self Weight) of Tower shall be considered Extra.
7. Assm. 7A, 8A & 9A indicates Right Side GW Broken conditions.
8. Assm. 10A indicates Right Side Conductor Broken condition.
9. Insulator Strings Weight are included in above Load.

**ASSM 11: DEAD END CONDITION (NORMAL)****ASSM 12, 13, 14, 12A, 13A, 14A: DEAD END
CONDITION (GW BROKEN)****ASSM 15, 15A: DEAD END CONDITION
(COND BROKEN)****NOTES:**

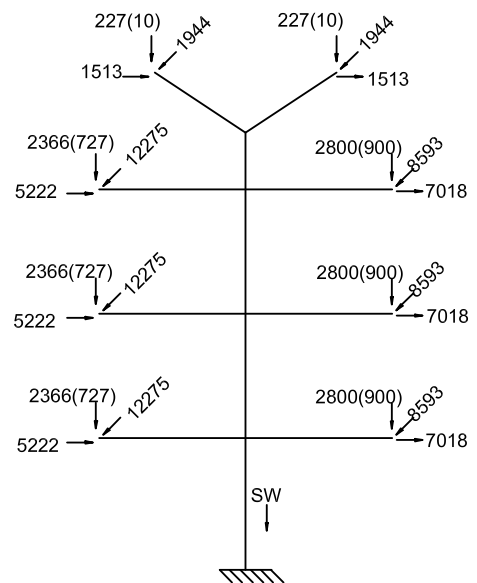
1. Wind Span 200 m (NC), 35 m (BWC)
2. Weight Span 263 m (NC), 100 m (BWC) Maximum
0 m (NC), -60 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 15 °
6. Wind Load (Full Wind) on Tower Body shall be considered extra in all above assumptions.
7. S.W. (Self Weight) of Tower shall be considered Extra.
8. Assm. 12A, 13A & 14A indicates Right Side GW Broken conditions.
9. Assm. 15A indicates Right Side Conductors Broken condition.
10. Insulator Strings Weight & Wind on Strings are included in above Load.



**ASSM 21: DEAD END WITH SLACK SPAN
CONDITION (NORMAL)**



**ASSM 22, 23, 24, 22A, 23A, 24A: DEAD END WITH SLACK
SPAN CONDITION (GW BROKEN)**



**ASSM 25, 25A: DEAD END WITH SLACK
SPAN CONDITION (COND BROKEN)**

NOTES:

1. Wind Span 300 m (NC), 200 m (BWC)
2. Weight Span 450 m (NC), 300 m (BWC) Maximum
0 m (NC), -60 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 15° (Both on Line and Substation side).
6. Wind Load (Full Wind) on Tower Body shall be considered extra in all above assumptions.
7. S.W. (Self Weight) of Tower shall be considered Extra.
8. Assm. 22A, 23A & 24A indicates Right Side GW Broken conditions.
9. Assm. 25A indicates Right Side Conductors Broken condition.
10. Insulator Strings Weight & Wind on Strings are included in above Load.

Sag-Tension Calculation of ACSR BISON

Conductor Properties

Conductor Name	ACSR BISON
UTS (Kg)	11981.6655
Area of Conductor (sqmm)	431
Wt. Of Conductor (Kg/m)	1.444
Dia. Of Conductor (mm)	27
Modulus of Elasticity (Kg/sqmm)	7036
Coeff. Of linear Expansion (per deg C)	0.0000193

Initial Condition

Normal Span (m)	350
Wind Pressure on Cond.(Kg/sqm)	156
Initial Cond. temp.(deg C)	32
Initial Wind %	0
Initial Cond. tension at above temp.and wind condition (% of UTS OR value in Kg)	22

Note: The tension should be below 22% of UTS in day to day condition and should not exceed 70% of UTS in any condition..
% of UTS = 2635.96641054794, % of UTS = 8387.16585174346

Initial Sag, Ten at 32 deg C, 0% Wind		
Ten (% of UTS)	Ten (kg)	Sag (mts)
22.00	2635.97	8.39

Standard Conditions							Any other condition
Temperature (deg C)	0	0	32	32	75	85	65
Pressure (% of full wind)	0	36	0	75	0	0	0
Resultant Tension (Kg)	3139.13	4034.04	2635.97	5118.55	2191.92	2113.61	2278.17
Resultant Sag (mts)	7.044	#	8.388	#	10.088	10.461	9.706

PRINT

Sag-Tension Calculation of Earthwire (7/3.35)

Conductor Properties

Earthwire (7/3.35)

Conductor Name	6230
UTS (Kg)	61.7
Area of Conductor (sqmm)	0.483
Wt. Of Conductor (Kg/m)	10.05
Dia. Of Conductor (mm)	19000
Modulus of Elasticity (Kg/sqmm)	0.0000115
Coeff. Of linear Expansion (per deg C)	

Initial Condition

Normal Span (m)	350
Wind Pressure on Cond.(Kg/sqm)	192
Initial Cond. temp.(deg C)	32
Initial Wind %	0
Initial Cond. tension at above temp.and wind condition (% of UTS OR value in Kg)	16.5

Note: The tension should be below 20% of UTS in day to day condition and should not exceed 70% of UTS in any condition..		
20% of UTS = 1246 Kg	70% of UTS = 4361 Kg	

Initial Sag, Ten at 32 deg C, 0% Wind		
Ten (% of UTS)	Ten (kg)	Sag (mts)
16.50	1027.95	7.19

Standard Conditions								Any other condition
Temperature (deg C)	0	0	32	32	75	85	53	
Pressure (% of full wind)	0	36	0	75	0	0	0	
Resultant Tension (Kg)	1165.66	1671.47	1027.95	2312.16	889.90	863.69	954.85	
Resultant Sag (mts)	6.345	#	7.195	#	8.311	8.563	7.746	

PRINT

TANAHU HPP SWITCHYARD

LOCATION OF SPECIAL TOWERS
(DE 60° - 90°)
BETWEEN AP1 - AP4

VICINITY OF AP40
DAMAULI - BHARATPUR 220KV AND MCTLP
MERGE ON QUAD CIRCUIT TOWER PRIOR TO GOING
INTO BHARATPUR SUBSTATION

BHARATPUR SUBSTATION

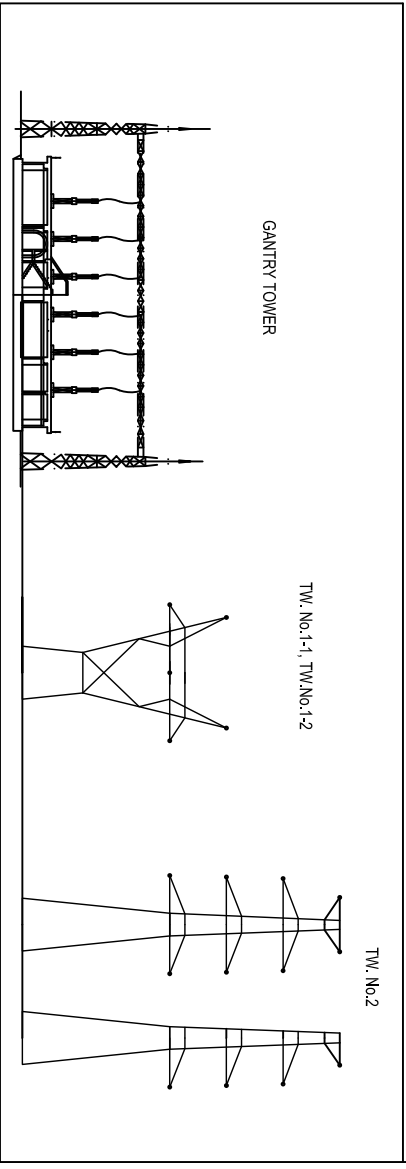
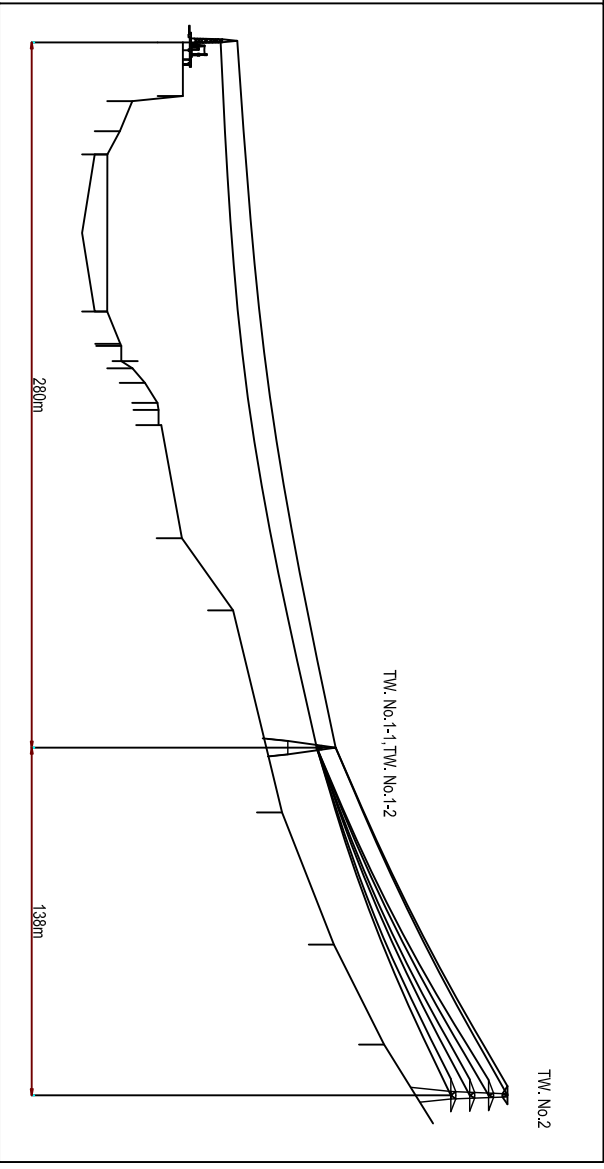
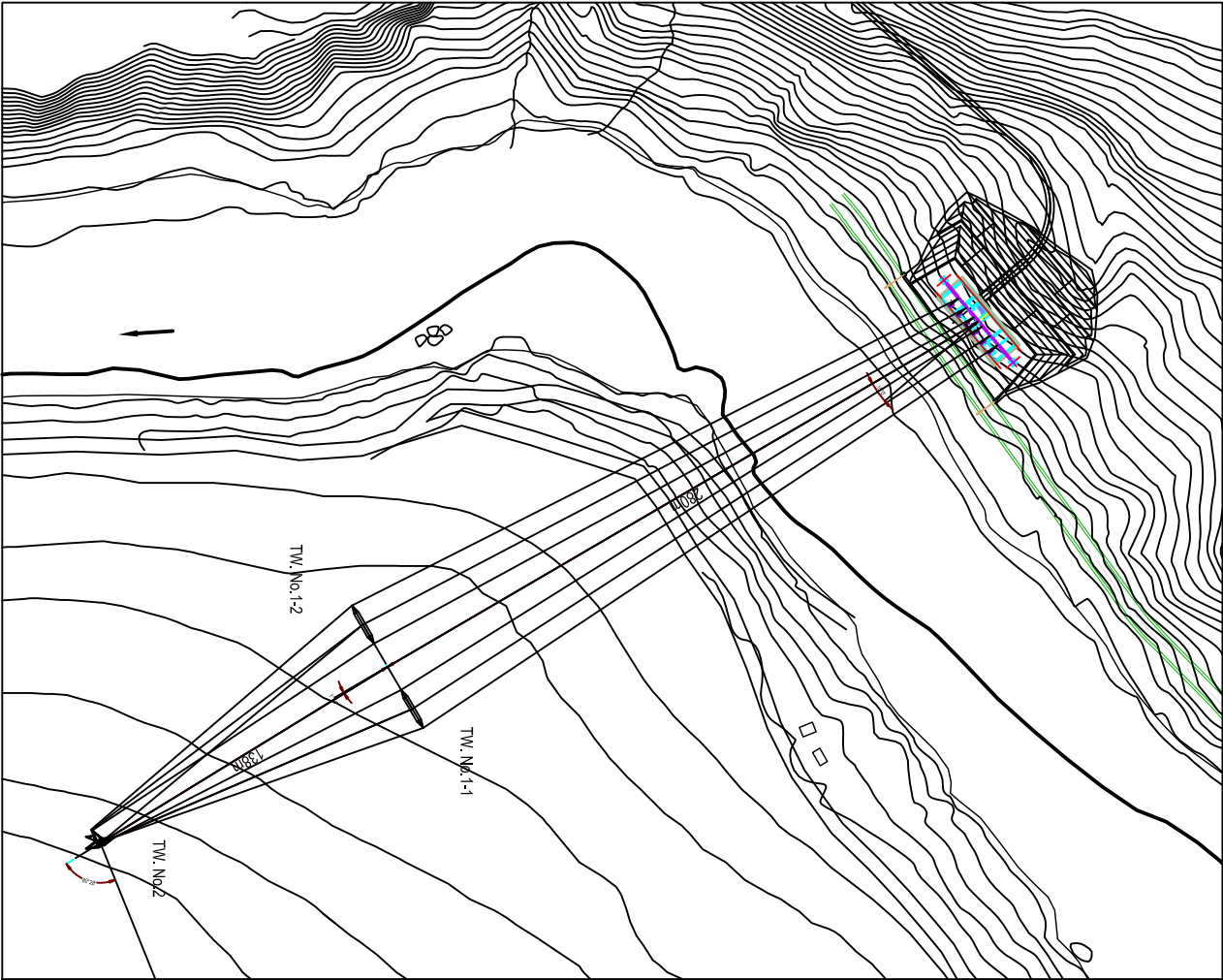
(Legend)

— Proposed Transmission Line Route
— Existing Transmission Line Route

TANAHU HYDROPOWER LIMITED

Project: 220KV Transmission Line Project For Tanahu Hydropower Project

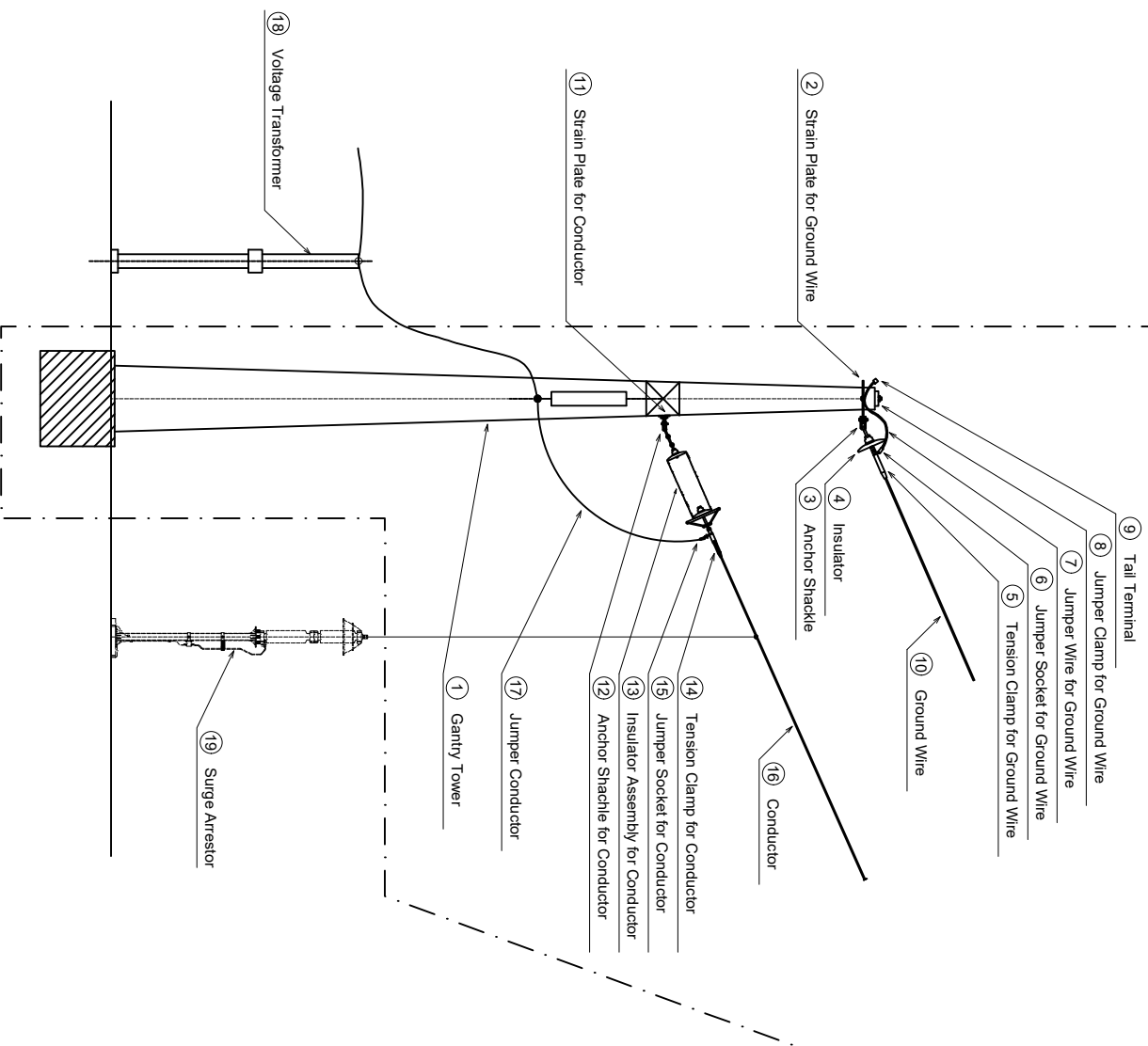
PREPARED	CHECKED	APPROVED
(Signature)	(Signature)	(Signature)
DATE	DATE	DATE
12/04/2021	12/04/2021	12/04/2021
PREPARED BY : Lahmeyer International		DWG. NO. TH2BH-TR-001
TITLE		
Transmission Line		
Proposed Transmission Line Route		



TANAHU HYDROPOWER LIMITED				
Project: 220KV Transmission Line Project For Tanahu Hydropower Project				
	PREPARED	CHECKED	APPROVED	
	D. Doshi	D. Doshi	A. B. Sharma	
DATE	12 / September 2017	12 / September 2017	12 / September 2017	
PREPARED BY : Lahmeyer International			DWG. NO. TN-HH-TR-0002	
TANAHU, INDIA				
TITLE				
Transmission Line				
Arrangement of Out - Going Span				

Between Package 2 and Package 3

Supplied and Installed by →



No.	Name of Parts	Supply	Installation
1	Gantry Tower	Package 3	Package 3
2	Strain Plate for Ground Wire	Package 3	Package 3
3	Anchor Shackle	Package 3	Package 3
4	Insulator	Package 3	Package 3
5	Tension Clamp for Ground Wire	Package 3	Package 3
6	Jumper Socket for Ground Wire	Package 3	Package 3
7	Jumper Wire for Ground Wire	Package 3	Package 3
8	Jumper Clamp for Ground Wire	Package 3	Package 3
9	Tail Terminal	Package 3	Package 3
10	Ground Wire	Package 3	Package 3
11	Strain Plate for Conductor	Package 3	Package 3
12	Anchor Shackle for Conductor	Package 3	Package 3
13	Insulator Assembly for Conductor	Package 3	Package 3
14	Tension Clamp for Conductor	Package 3	Package 3
15	Jumper Socket for Conductor	Package 3	Package 3
16	Conductor	Package 3	Package 3
17	Jumper Conductor	Package 3	Package 3
18	Voltage Transformer	Package 2	Package 2
19	Surge Arrestor	Package 2	Package 2

FOR TENDER PURPOSES ONLY

E			
D			
C			
B			
A			
NO. CHECK.	APPR.	DATE	DESCRIPTION

REVISIONS

DOCUMENT No.	DESCRIPTION

REFERENCES

Tanahu Hydropower Limited (THL)
Nepal

LAHMEYER
INTERNATIONAL

Manitoba
HYDRO INTERNATIONAL

In association with:

TANAHU HYDROPOWER PROJECT

TENDER DESIGN		
NAME	SIGN.	DATE

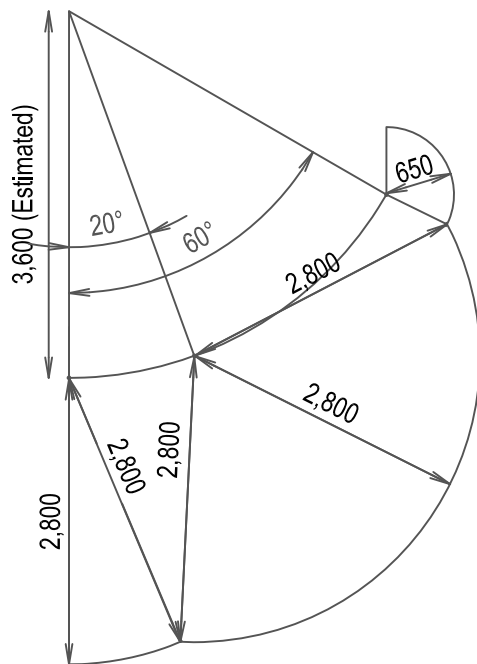
Prep.	S.I.	
Check	A.G.	
Approv.	R.W.	

TRANSMISSION LINE

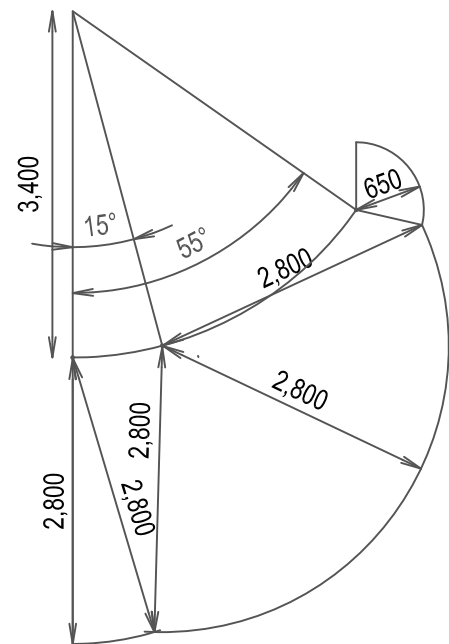
ORIGINAL SCALE NOT TO SCALE

PROJECT NO.		ORIG. SIZE	DRAWING No.	REV.
TNL-PKG-3/2018		A3	TN-D-TR-0004	0

Suspension Tower

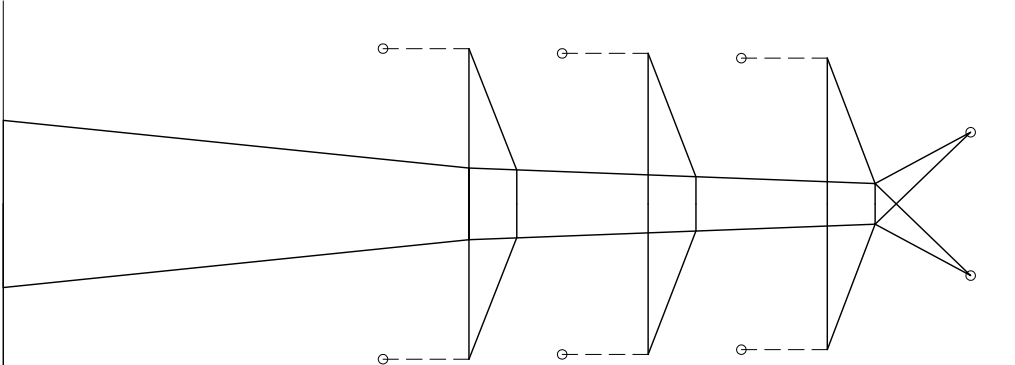


Tension Tower

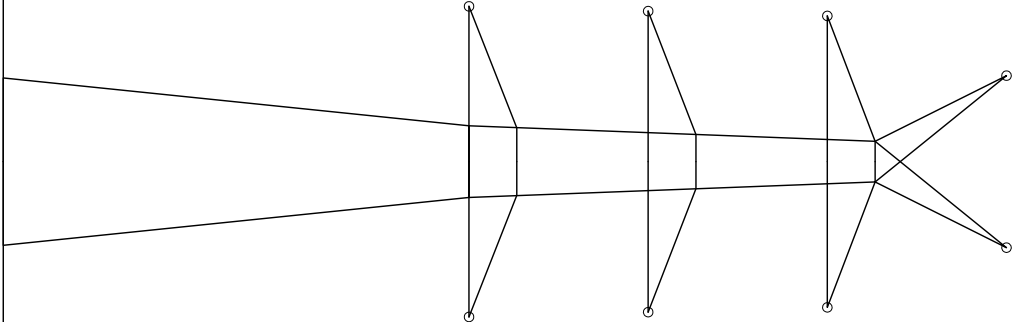


<h1 style="text-align: center;">TANAHU HYDROPOWER LIMITED</h1>			
<h2 style="text-align: center;">Project: 220kV Transmission Line Project For Tanahu Hydropower Project</h2>			
	PREPARED D. Dodds	CHECKED D. Dodds	APPROVED A. B. Ghimire
DATE	12 / September /2017	12 / September /2017	12 / September /2017
PREPARED BY : Lahmeyer International <small>in association with MHI</small>			DWG. NO. TN-BH-TR-0006
TITLE <h2 style="text-align: center;">Transmission Line Clearance Diagram</h2>			

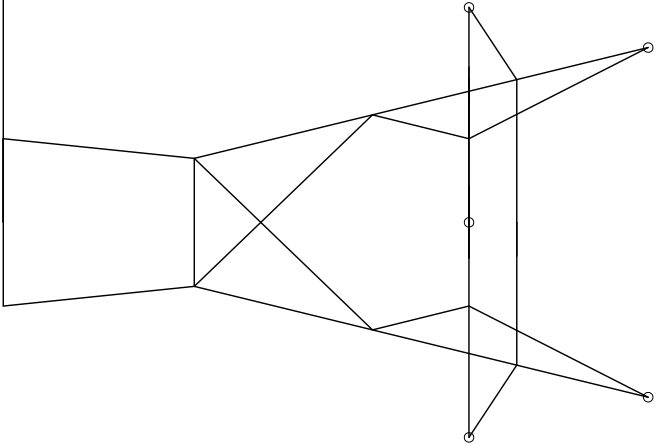
Suspension Tower



Tension Tower



Tw. No.1-1, No.1-2
(For Outgoing Span)



TANAHU HYDROPOWER LIMITED

Project: 220kV Transmission Line Project For Tanahu Hydropower Project

PREPARED

CHECKED

APPROVED

DATE

12/ September /2017

12/ September /2017

12/ September /2017

PREPARED BY : Lahmeyer International

For consultation: MHI

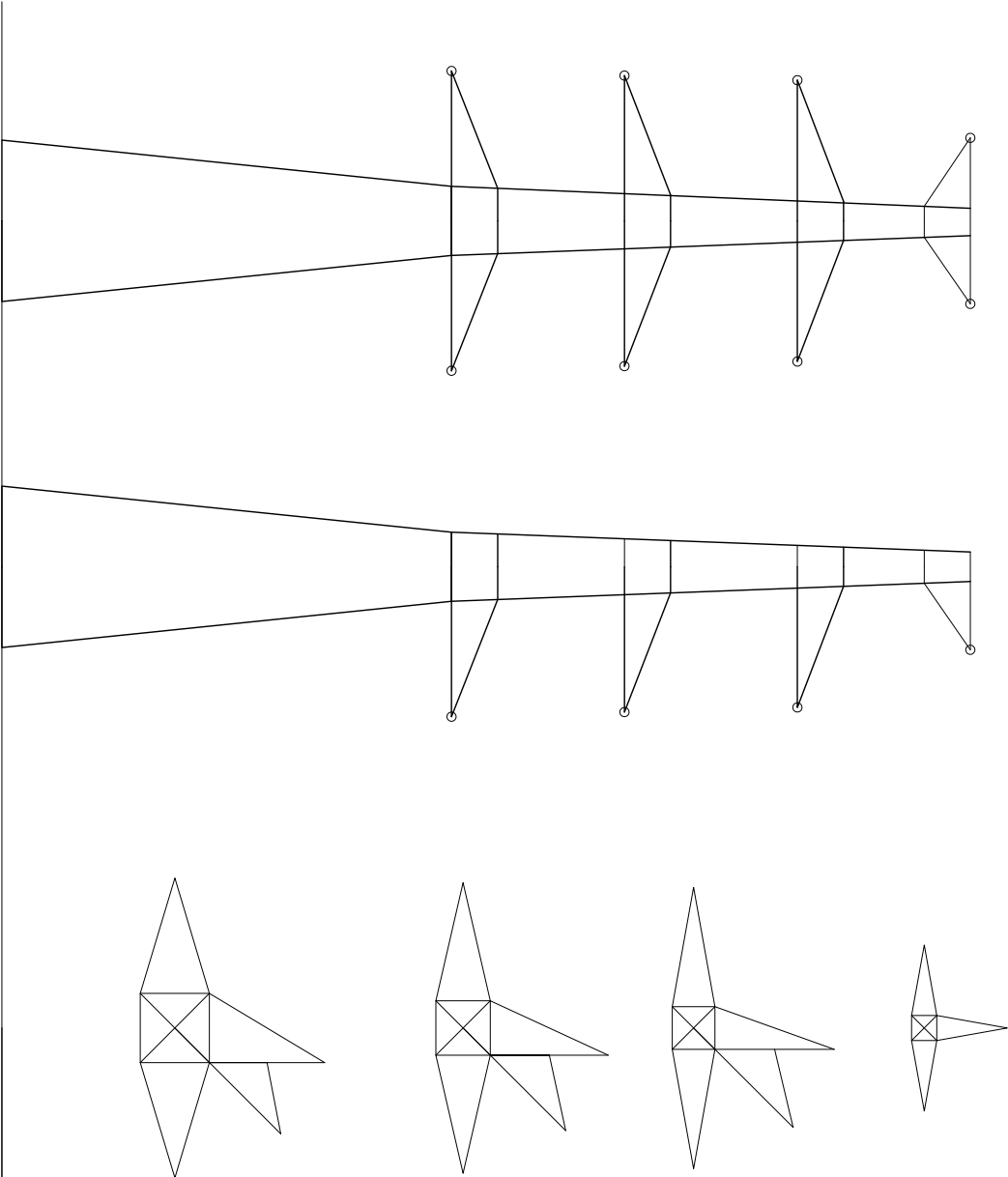
DWG. NO. TN-BH-TR-0007

TITLE

Transmission Line

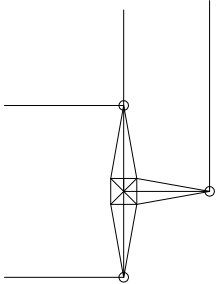
Typical Drawing of 220kV Transmission Tower (1/2)

Tension Tower (Heavy angle)

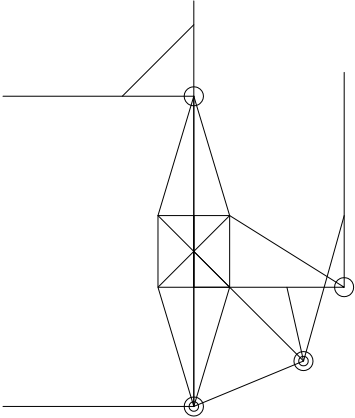


(Wire Conditions)

Ground Wires



Conductors



TANAHU HYDROPOWER LIMITED

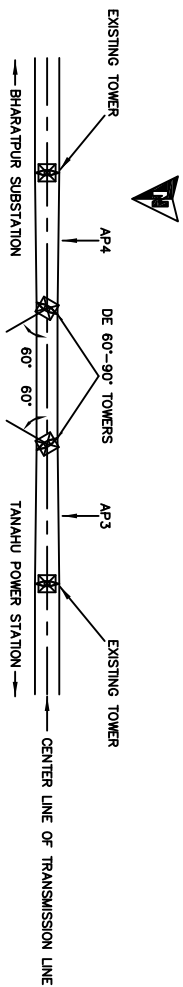
Project: 220kV Transmission Line Project For Tanahu Hydropower Project

PREPARED	CHECKED	APPROVED
D. Dods	D. Dods	A. B. Ghimre
DATE	12 / September / 2017	12 / September / 2017
PREPARED BY :	Lahmeyer International Kathmandu, Nepal	
	DWG. NO.	TN-BH-TR-0007

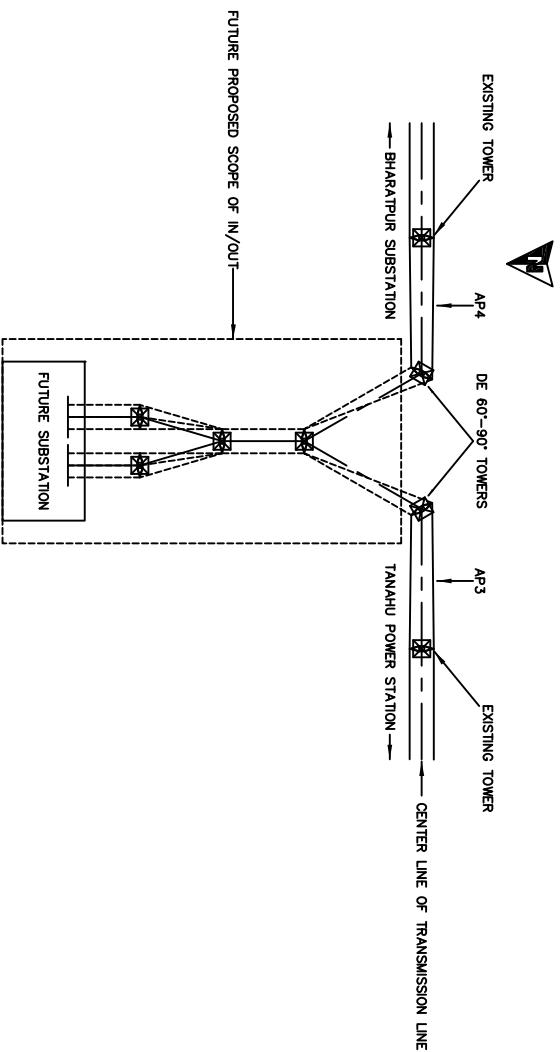
TITLE

Transmission Line

Typical Drawing of 220kV Transmission Tower (2/2)

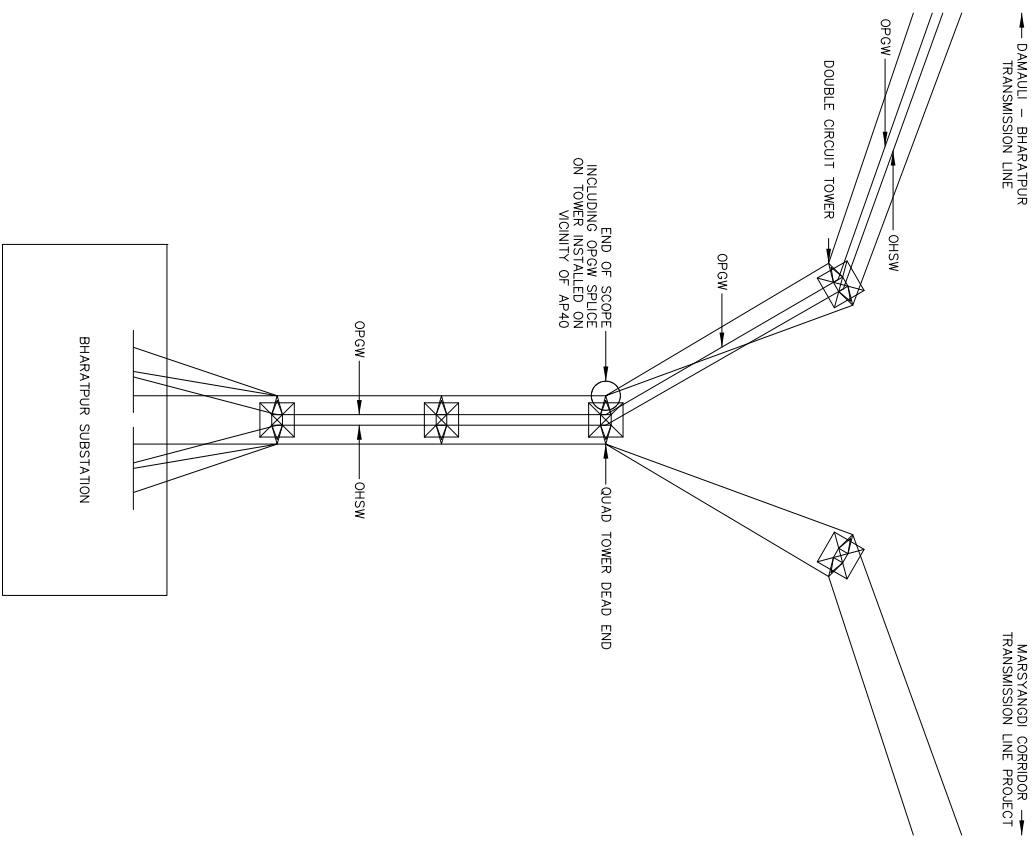


STRINGING CONFIGURATION #1 - SCOPE OF CONTRACTOR



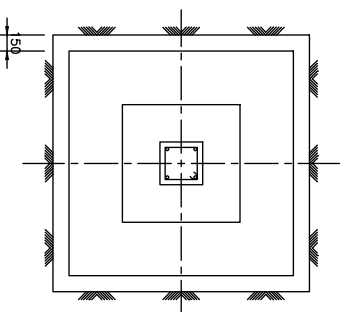
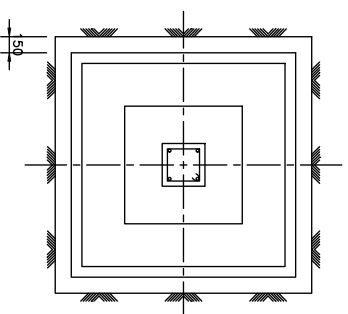
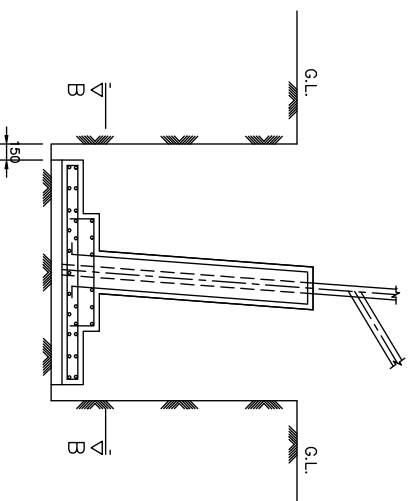
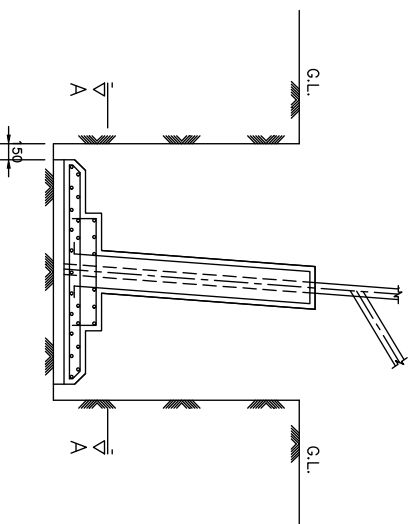
STRINGING CONFIGURATION #2 - FUTURE SCOPE OF OTHERS

TANAHU HYDROPOWER LIMITED			
Project: 220kV Transmission Line Project For Tanahu Hydropower Project			
PREPARED	CHECKED	APPROVED	
D. Dada	D. Dada	A. B. Ghimire	
DATE	12 September 2017	12 September 2017	12 September 2017
PREPARED BY : Lahmeyer International			
f association with MHI			
DWG. NO. TN-BH-TR-0008			
TITLE			
Transmission Line			
SPECIAL TOWERS (DE 60° - 90°)			



AP40, QUAD TOWER INTERCONNECTION TO THE 220KV DAMAULI - BHARATPUR LINE

TANAHU HYDROPOWER LIMITED				
Project: 220kV Transmission Line Project For Tanahu Hydropower Project				
	PREPARED	CHECKED	APPROVED	
	D. Dicks	D. Dicks	A. B. Ghimire	
DATE	12/ September 2017	12/ September 2017	12/ September 2017	
PREPARED BY :	Lahmeyer International in association with MHI			
	DWG. NO. TN-BH-TR-0009			
TITLE	Transmission Line			
DAMAULI-BARATPUR 220kV				



R.C.C. Spread Type Foundation (Chamfered Type) with 150 mm Working Clearance

R.C.C. Spread Type Foundation (Step)
with 150 mm Working Clearance

FOR TENDER PURPOSES ONLY

E			
D			
C			
B			
A			
No.	CHECK	APPR.	DATE
REVISIONS			

DOCUMENT NO.	DESCRIPTION
	REFERENCES

Tanahu Hydropower Limited (THL)
Nepal

**zi LAHMEYER
INTERNATIONAL**

In association with:

Manitoba
HYDRO INTERNATIONAL

NAME	SIGN.	DATE
Prep.	A.G.	06/07/18
Check	S.T.	06/07/18
Approv.	R.W.	06/07/18
ORIG. SCALE		
NOT TO SCALE		
SUPERSEDED BY DWG. NO.		

TANAHU HYDROPOWER PROJECT

TECHNICAL DESIGN

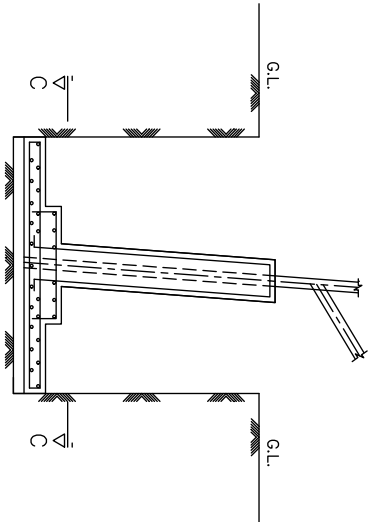
TRANSMISSION LINE

GENERAL OUTLINE

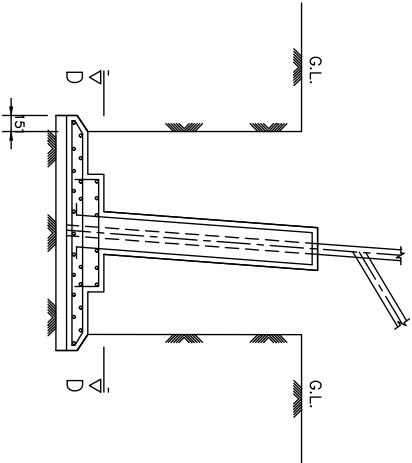
TOWER FOUNDATION

SECTION A-A, B-B

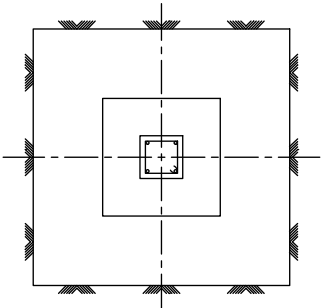
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THL-PKG-3/2018	A3	TN-GEN-TR-0001	



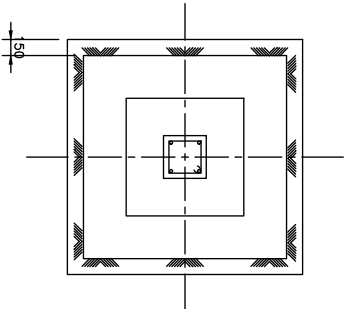
ELEVATION



ELEVATION



PLAN C-C



PLAN D-D

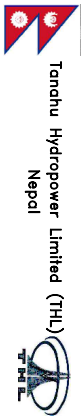
R.C.C. Spread Type Foundation (Step)
Cast Directly Contact with the Soil
and without 150mm Working Clearance

R.C.C. Spread Type Foundation (under Cut Type)

FOR TENDER PURPOSES ONLY

E				
D				
C				
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A				
No.	CHECK	APPR.	DATE	DESCRIPTION
REVISIONS				

DOCUMENT No.	
DESCRIPTION	
REFERENCES	

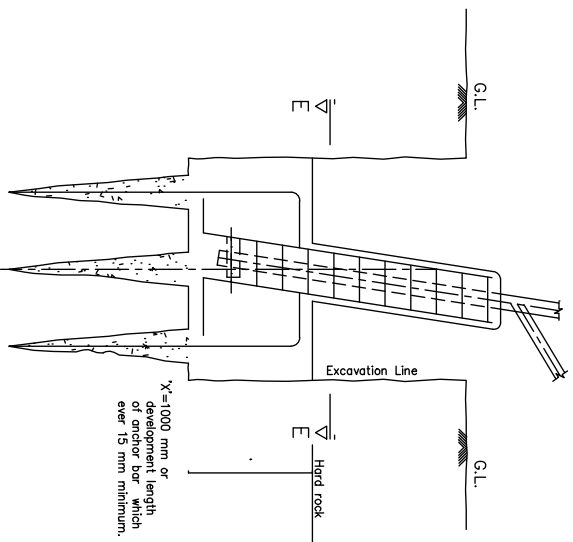


LAHMEYER
INTERNATIONAL
In association with:
Manitoba
HYDRO INTERNATIONAL

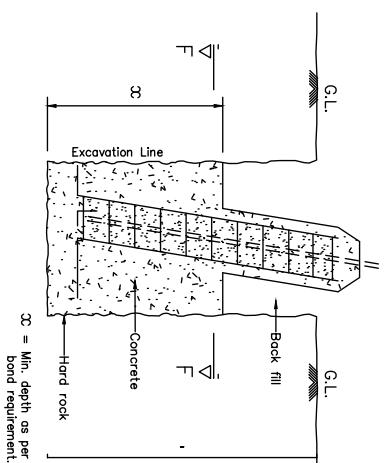
TANAHU HYDROPOWER PROJECT

NAME	SGN.	DATE
Prep.	S.T.	06/07/18
Check.	A.G.	06/07/18
Approv.	R.M.	06/07/18
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NOT TO SCALE		
SUPERSEDED BY DWG. No.		

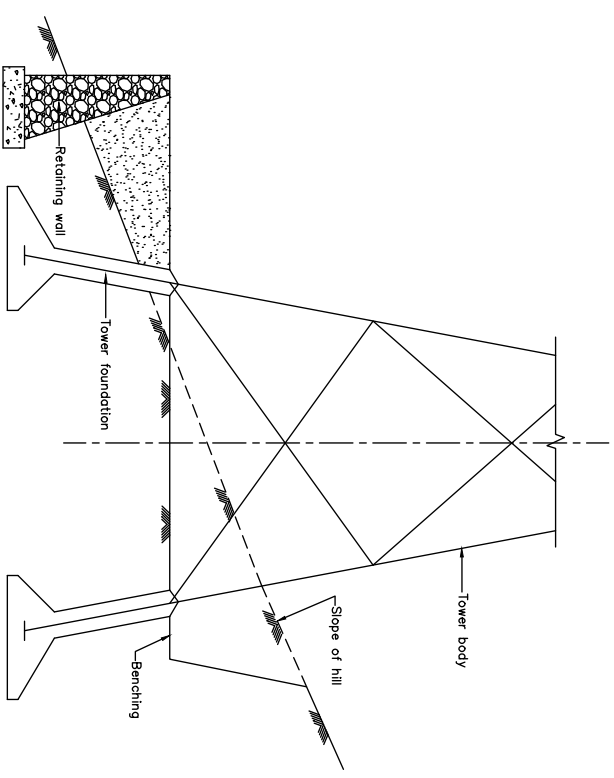
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THL-PKG-3/2018	A3	TN-GEN-TR-0002	



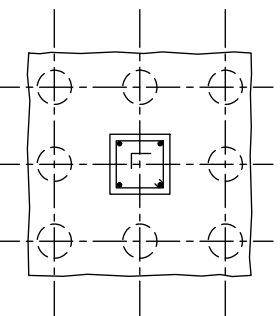
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ELEVATION

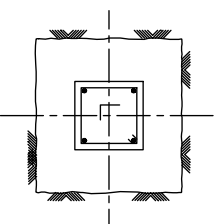


Rivetment on Foundation



PLAN E-E

Rock Anchor Type Foundation




PLAN F-F

Hard Rock Foundation (Block Type)

FOR TENDER PURPOSES ONLY

E			
D			
C			
B			
A			
NO. CHECK	APPR.	DATE	DESCRIPTION

REVISIONS	
DOCUMENT No.	DESCRIPTION
REFERENCES	

 Tandhu Hydropower Limited (THL)
Nepal

LAHMEYER
INTERNATIONAL

in association with:

Manitoba
HYDRO INTERNATIONAL

TANAHU HYDROPOWER PROJECT

TENDER DESIGN			
	NAME	SIGN.	DATE
Prep.	G.M.		08/07/18
Check.	A.G.		08/07/18
Approv.	R.M.		08/07/18

ORIG. SCALE

NOT TO SCALE

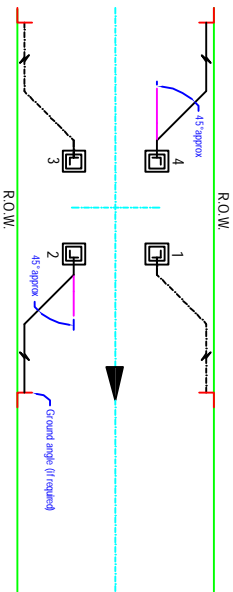
SUPPLEMENTED BY DWG. NO.

TRANSMISSION LINE

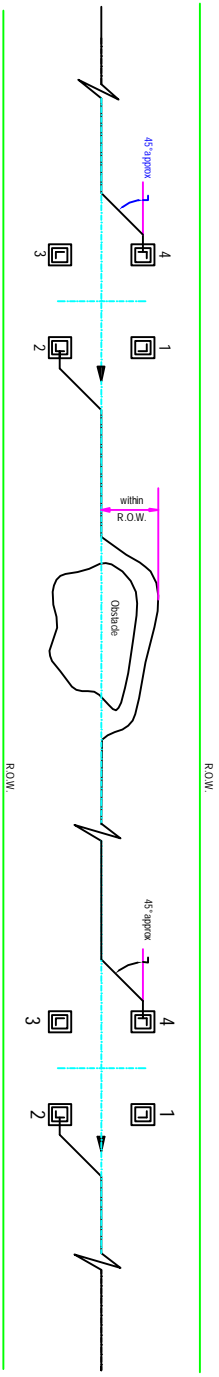
GENERAL OUTLINE

TOWER FOUNDATION

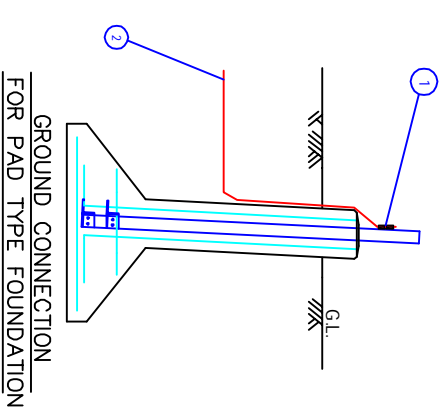
SECTION F-F, F-F



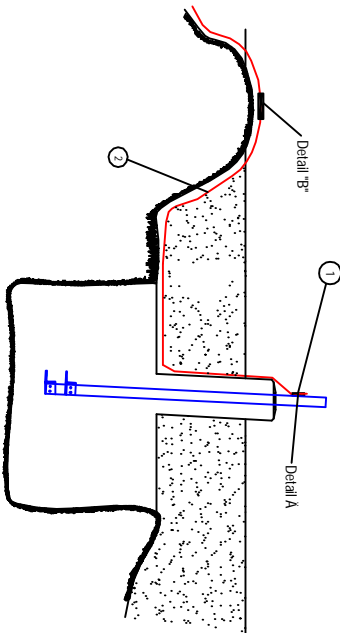
RADIAL COUNTERPOISE CONNECTION



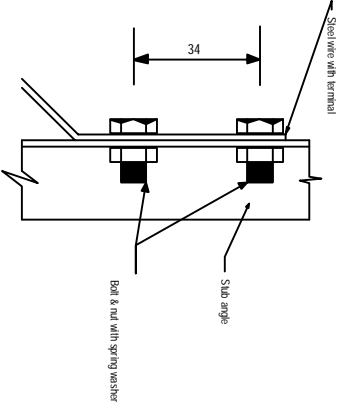
ONE WIRE CONTINUOUS COUNTERPOISE CONNECTION



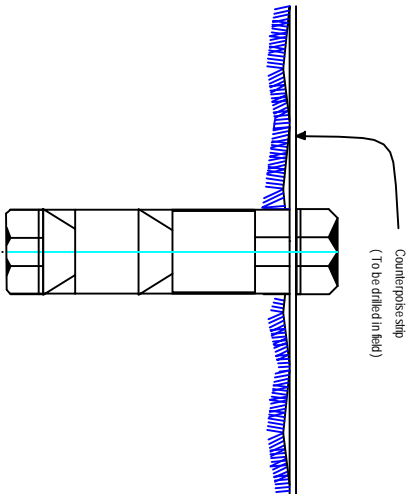
GROUND CONNECTION
FOR PAD TYPE FOUNDATION



GROUND CONNECTION
FOR PAD TYPE FOUNDATION



DETAIL "A"

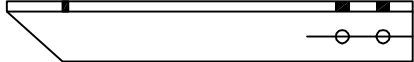
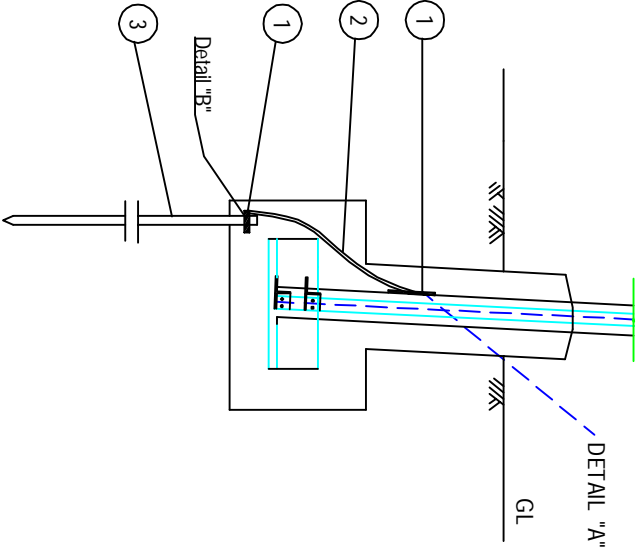


DETAIL "B"
COUNTERPOISE ROCK ANCHOR

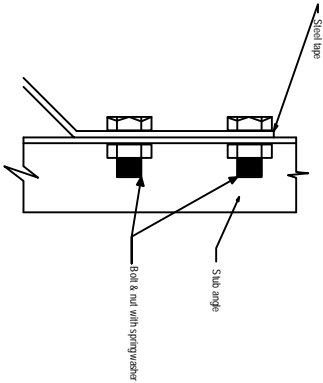
Legend	DESCRIPTION	Ref. Dwg.
1	galv. steel bolt & nut with spring washer.	
2	Galv. steel wire	
	a. Radial counterpoise	

COUNTERPOISE SET

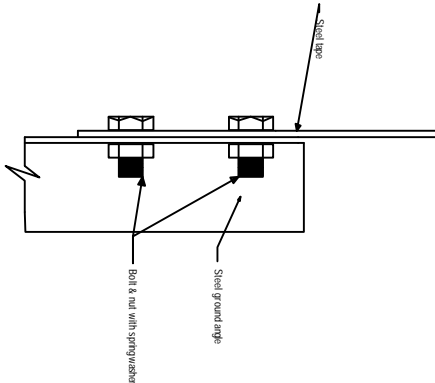
NOTE:
1. Dimensions are in millimeters except otherwise specified.
2. All grounding material shall have galvanizing weight of not less than specified in ASTM A 123-30%.



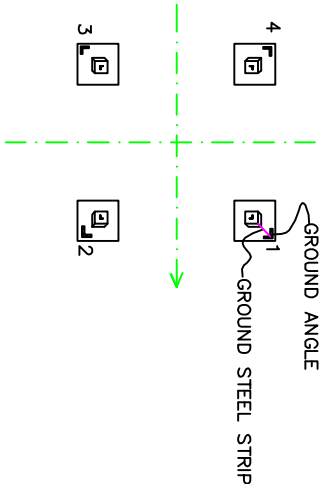
GROUND ANGLE



DETAIL "A"



DETAIL "B"



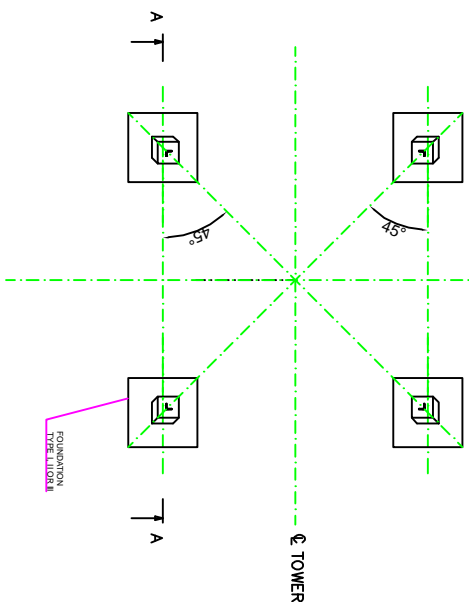
GROUND ANGLE CONNECTION

NOTE :

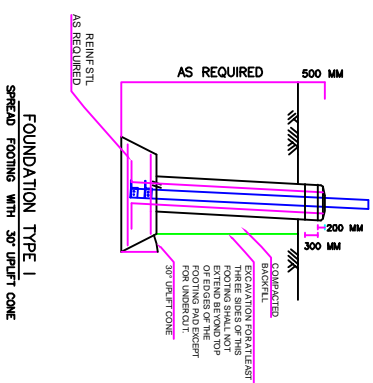
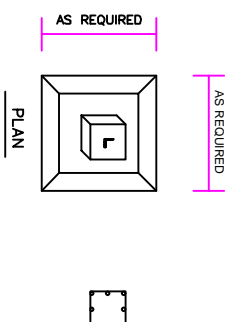
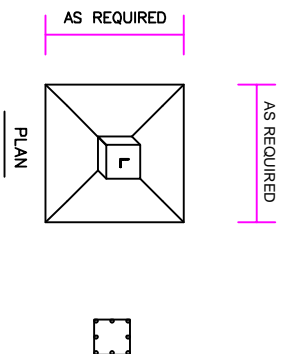
- 1. Dimensions are in millimeters except otherwise specified.
- 2. All grounding material shall have galvanizing weight of not less than specified in ASTM A 123+30%.

GROUNDING ELECTRODE SET		Ref. Dwg.
Legend	Description	
1	galv. steel bolt & nut with spring washer.	
2	Galv. steel tape	
3	Galv. steel angle.	

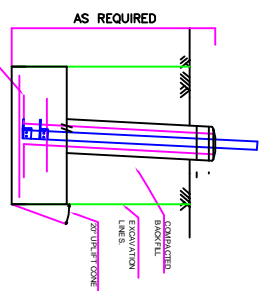
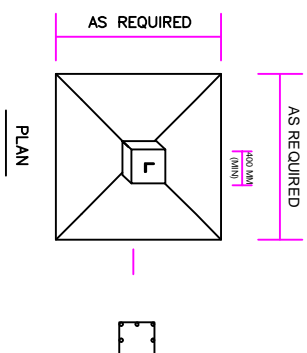
CL OF TRANSMISSION LINE & STRUCTURE



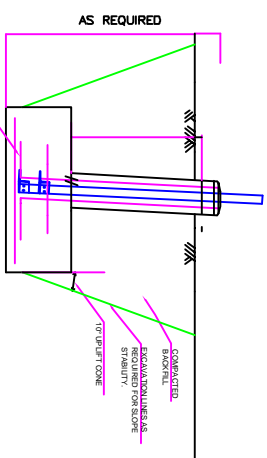
FOUNDATION ORIENTATION PLAN



FOUNDATION TYPE I
SPREAD FOOTING WITH 30° UP-LIFT CONE



FOUNDATION TYPE II
SPREAD FOOTING WITH 20° UP-LIFT CONE



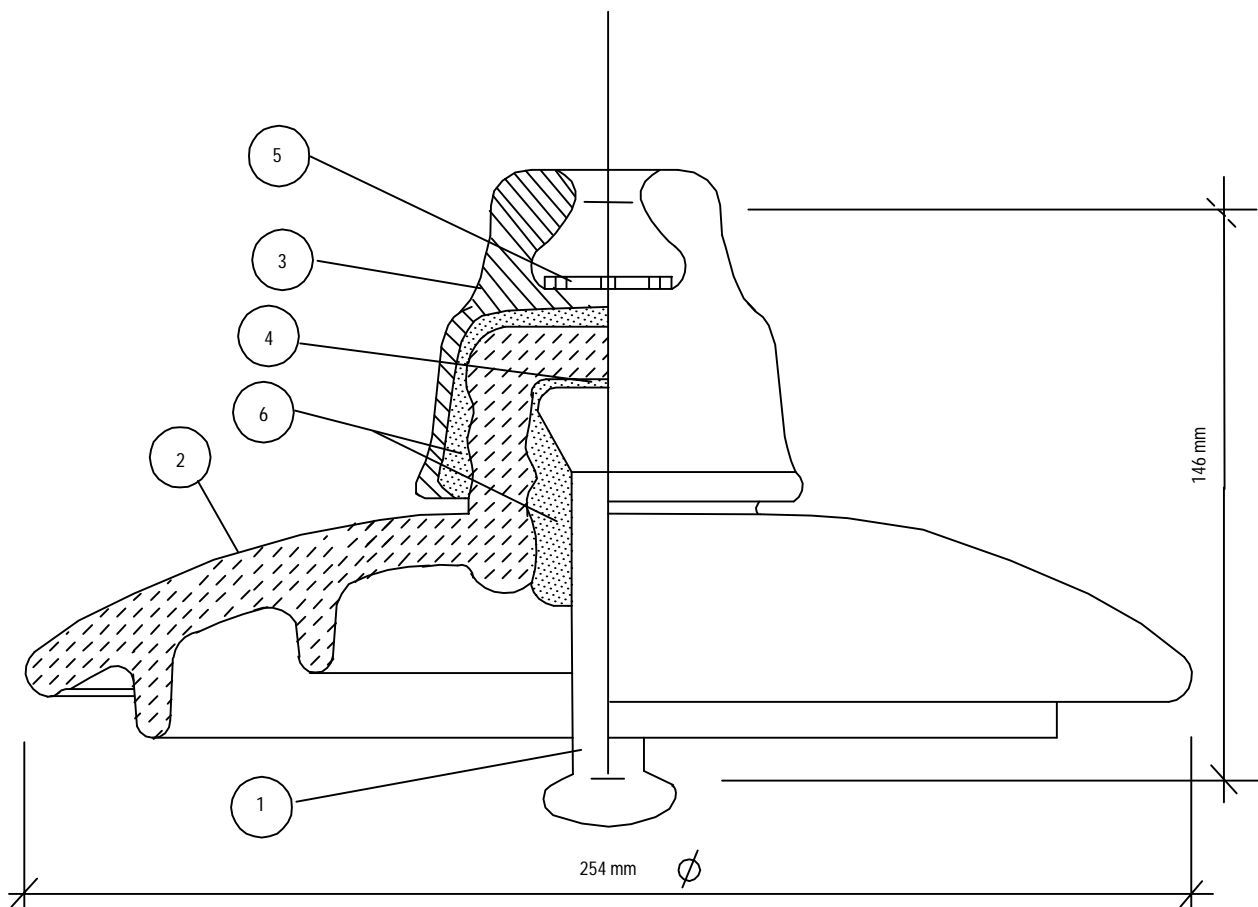
FOUNDATION TYPE III
SPREAD FOOTING WITH 10° UP-LIFT CONE

GENERAL NOTES:

1. FOUNDATIONS OUTLINES AND DETAILS ILLUSTRATED ON THIS DRAWING ARE CONCEPTUAL ONLY AND ARE NOT RESTRICTED BEYOND THE GENERAL OUTLINE CONFIGURATION AND FOUNDATION DIMENSIONING.
2. FINAL FOUNDATION DESIGN SHALL BE BASED ON THE RESULT OF DETAIL SOIL TEST.
3. FINAL FOUNDATION SELECTION SHALL BE MADE AFTER COMPLETION OF EXCAVATION.
4. THE VALUES OF SOIL BEARING CAPACITY GIVEN IN THE FOUNDATION APPLICATION SCHEDULES ARE ONLY REFERENCE VALUES AND DETAIL DESIGN SHALL BE BASED ON THE RESULT OF DETAIL SOIL TEST CARRIED OUT BY THE CONTRACTOR.
5. FOR ADDITIONAL FOUNDATION REQUIREMENTS, SEE SPECIFICATION.

CONCRETE NOTES:

1. CONCRETE SHALL HAVE A 28 DAY MINIMUM COMPRESSIVE STRENGTH OF 210 KG/CM².
2. ALL REINFORCING BARS SHALL BE TORSTEEL BAR CONFORMING TO Fe - 415.
3. REINFORCING STEEL SHALL BE DETAILED AND FABRICATED IN ACCORDANCE WITH - MANUAL OF STANDARD PRACTICE OF THE CONCRETE REINFORCING STEEL INSTITUTE.
4. MINIMUM COVER FOR REINFORCING STEEL SHALL BE
 - a. CONCRETE CAST AGAINST EARTH 80 mm.
 - b. ALL OTHER CONCRETE 50 mm.
5. CONCRETE FOUNDATIONS SHALL HAVE THE FOLLOWING MINIMUM STEEL
 - a. FOUNDATION PIERS - .001 GROSS AREA
 - b. FOUNDATION FOOTINGS - .003 AVERAGE GROSS AREA
6. ALL EXPOSED CONCRETE SHALL HAVE TOOLED EDGES.



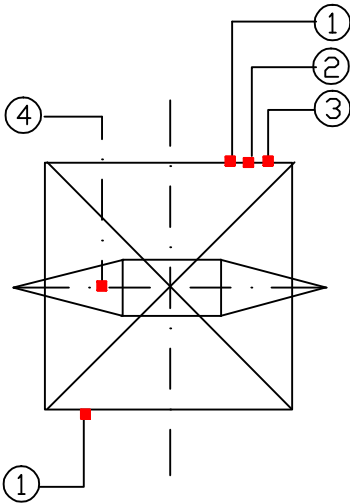
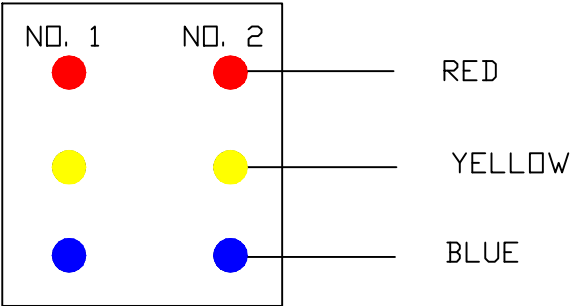
NOTE:

- 1) ALL DIMENSIONS ARE IN mm
- 2) ALL FERROUS PARTS HOT DIP GALVANISED
- 3) BALL & SOCKET SIZE : 16 mm AS PER IEC - 120
- 4) THE DIMENSION HEREIN MENTION IS FOR THE CONCEPTUAL PURPOSE ONLY.

No	DESCRIPTION	MATERIAL	QTY
6	CEMENT BOND		
5	LOCKING DEVICE	STEEL	1
4	GASKET	POLYETHYLENE	1
3	SOCKET CAP	GALVANISED CAST IRON	1
2	INSULATING PART	CHINA CLAY	1
1	BALL PIN	GALVANISED STEEL	1

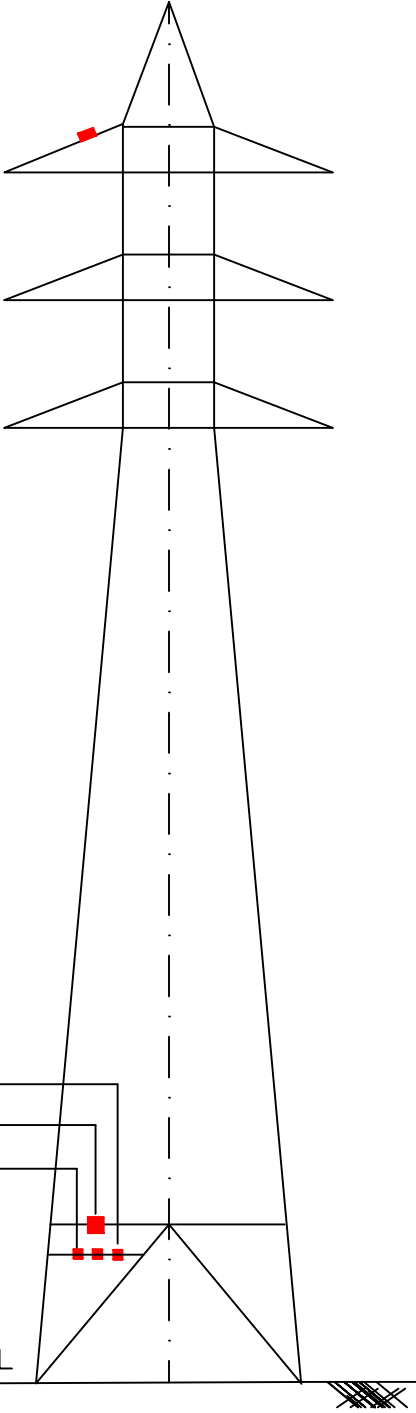
④ ARIAL PATROL SIGN

PHASING SIGN



- ① NUMBER SIGN
- ② DANGER SIGN
- ③ PHASING SIGN

GROUND LEVEL



SECTION 3
TECHNICAL DATA SHEETS

Volume II

EMPLOYER'S REQUIREMENTS

DAMAULI - BHARATPUR TRANSMISSION LINE

Section 3 Technical Data Sheets

ITEM No. A1 220kV Transmission Towers

[illegible]

ITEM No. A1 220kV Transmission Towers

[illegible]

ITEM No. A1 220kV Transmission Towers

[illegible]

ITEM No. A2 Insulators and Insulator Strings

	DESCRIPTION	UNIT	REQUIREMENT				OFFERED			
			Tension String		Suspension String		Tension String		Suspension String	
1.	Manufacturer and Country of Origin	nos	2x17	2x17	1x17	2x17	1x17			
2.	Insulator Disc / Unit type number	kN								
3.	Maximum Working Load per string	kN								
4.	Minimum Elastic Limit of fittings	kN								
5.	Electro mechanic minimum failing load per disc/unit	kN	120	160	120	120	70			
6.	Electric static capacity per disc/unit	pF								
7.	Weight of disc/unit	kg								
8.	Overall leakage path per disc/unit	mm	295	315	295	295	295			
9.	Spacing between insulators in the string	mm	146	146	146	146	146			
10.	Protected leakage path per disc/unit	mm								
11.	Overall leakage path per string	mm								
12.	Protected leakage path per string	mm								
13.	a) Single string Length of string	mm								
14.	b) Double string Length from tension string jumper lug to crossarm attachment point	mm								
15.	c) Weight of string complete with all fittings and clamps	kg								
	a) Single string	kg								
	b) Double string	kg								
16.	50 Hz, withstand voltage per disc/unit (dry, one minute)	kV								
17.	50 Hz, withstand voltage per disc/unit (wet, one minute)	kV								
18.	50 Hz, minimum puncture withstand voltage per disc/unit	kV								

TECHNICAL DATA SHEET

ITEM No. A3 Conductor and Accessories

	DESCRIPTION	UNIT	REQUIREMENT	OFFERED
1.	Manufacturer and Country of Origin			
2.	Applicable Standard		BS215	
3.	Type (Code Name)		ACSR BISON	
4.	Nominal Sectional Area	mm ²	380	
5.	Numbers and Diameter of wires			
	a) Aluminium	Nos./mm	5/3.00	
	b) Steel	Nos./mm	7/3.00	
6.	Actual Sectional Area			
	a) Aluminium	mm ²	381.7	
	b) Steel	mm ²	49.5	
	c) Total	mm ²	431.2	
7.	Layer of Aluminium Wires			
	a) Outer Diameter of Inner Layer	mm		
	b) Outer Diameter of Middle Layer	mm		
	c) Outer Diameter of Outer Layer	mm	27	
8.	Outer Diameter of Steel Wires	mm		
9.	Steel Quality (Grade)			
10.	Overall Diameter	mm	27	
11.	Weight	kg/m	1.4425	
12.	DC Electrical Resistance (at 20 deg.C)	ohm/km	0.0758	
13.	AC Electrical Resistance (at 20 deg.C)	ohm/km	0.0758	
14.	Ultimate Tensile Strength	kN	120.9	
15.	Tension of Conductor in still air at everyday temperatur	kN		
16.	Maximum Working Tension of Conductor	kN		
17.	Elastic Modules	kg/mm ²	7990	
18.	Liner Expansion	/deg.C	19.5 x 10 ⁻⁶	
19.	Maximum length of Conductor on Drum	m		
20.	Maximum Weight of conductor plus Drum	kg		
21.	Aluminium Wire before stranding :			
	a) Minimum breaking load	kg		
	b) Tensile breaking stress	kN		
	c) Cross Sectional Area	mm ²		
22.	Steel Wire before stranding :			
	a) Minimum tensile strength	kN		
	b) Minimum stress of 1 % elongation	kN		
	c) Elongation in 200mm length of breaking	%		
	d) Yield stress / breaking strength	%		
23.	Conductor manufacturing process			
24.	Conductor Grease :			
	a) Type			
	b) Density	kg/m ³		
	c) Weight of Grease per kilometer	kg		
25.	Joint Compressors :			
	a) Type of compressor			
	b) Dies to be supplied			
	c) List of Recommended Spares			
26.	Vibration Dampers :			
	a) Type			
	b) Weight	kg		
	c) Distance from clamp mouth to attachment point :			
	i) 1st damper	mm		
	ii) 2nd damper (if required)	mm		

TECHNICAL DATA SHEET

ITEM No. A4 Ground Wire (GSW) and Accessories

[illegible]

TECHNICAL DATA SHEET

ITEM No. A5 Ground wire (OPGW) and Accessories

	DESCRIPTION	UNIT	REQUIREMENT	OFFERED
1.	Manufacturer and Country of Origin			
2.	Applicable Standard			
3.	ISO Certificate submitted			
4.	Manufacturer sales record submitted			
5.	Type (Code Name)		OPGW	
6.	Aluminium Crad and/or Aluminium Alloy wire	mm ²		
	Numbers and Diameter of wires (Steel)	Nos./mm	7/3.35	
	Outer Diameter of Outer layer	mm		
	Actual Sectional Area	mm ²	136	
	Steel Quality (Grade)			
7.	Overall Diameter	mm	11.4	
8.	Weight	kg/m	0.487	
9.	Ultimate Tensile Strength	kN	86.6	
10.	Tension of OPGW in still air at everyday temperature	kN		
11.	Maximum Working Tension of OPGW	kN		
12.	Elastic Modules	kg/mm ²	162	
13.	Liner Expansion	/deg.C	13.0 x 10 ⁻⁶	
14.	Maximum length of OPGW on Drum	m		
15.	Maximum Weight of OPGW plus Drum	kg		
16.	Vibration dampers :			
	a) Type			
	b) Weight	kg		
	c) Distance from clamp mouth to attachment point :			
	i) 1st damper	mm		
	ii) 2nd damper (if required)	mm		
17.	Optical Wires:			
	a) Optical Fiber Type	mode		
	b) Nos. of Optical Fiber	Nos.	24	
	c) Lay of Outer layer			
	- Cross sectional Area	mm ²		
	d) Fiber Diameter			
	- Mode Field Diameter	µm		
	- Cladding Diameter	µm		
	e) Standard			
	- Single Mode Fiber			
	- Optical Fiber Cable			
	- Stranding part			
	f) Optical Attenuation at wave length			
	- 1310nm	dB/km		
	- 1550nm	dB/km		
	g) Short Circuit Carrying Capacity	kA x sec		
18.	Other Properties			
19.	OPGW manufacturing Prosscess			
20.	Optical Fiber termination and splicing :			
	a) Line termination unit			
	b) Outdoor splicing box			
21.	OPGW fittings and accessories			
	a) Suspension assembly			
	b) Tension assembly			
22.	List of Recommended Spares			

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Part A Transportation Route for Heavy Equipment	1-1
Annex-A-1 Daily Precipitation and Air Temperature Data	1-2

Section 3 Supplementary Information

Part A Transportation Route for Heavy Equipment

Actual road conditions of the transportation route in Nepal should be re-investigated by the contractor before transportation is commenced to confirm whether the reinforcement or replacement of bridges will be necessary or not and to check conditions during rainy season. The information mentioned below is given.

It is considered there are two alternative transport routes for heavy equipment according to the past hydropower projects located near the Tanahu Project site.

(1) **Middle Marshangdi Hydropower Project**

The following route was adopted for heavy equipment transportation;

- Indian border (Birganj) - Hetauda - Bara - Mugling - Middle Marshangdi site

When the same route from the Indian border to Mugling is used for the Tanahu Project, total distance is around 230 km via Damauli.

(2) **Kali Gandali 'A' Hydropower Project**

Heavy equipment for the Kali Gandali 'A' Hydropower Project was transported from the Indian border - Indian border (Bhairahawa) - Butwal - Bartung - Ramdi - Pokhara to the project site.

When the same route from the Indian border to Pokhara is adopted for the Tanahu Project, total distance is around 250 km.

In both cases, it seemed that the heaviest equipment transportation from the Indian boarder to the project site did not have any problem but the weight limit was 25 tons for passage. Government of Nepal has received a credit from the Asian Development Bank (ADB) toward the cost of Part B: Transmission Line and Associated substation in association with Tanahu Hydropower Project, and it intends to apply part of the proceeds of this credit to payments under the contract for Procurement of Tanahu - Bharatpur 220kV Transmission Line and Associated Substation.

The Bidders are encouraged to propose standard equipment of state-of-the-art technology to the extent possible, as long as it meets or exceeds the requirements of this specification.

All works described herein and other works necessary to complete the job for proper coordination and operation, even if not stated, shall be within the scope of the Contractor's work and the cost of such works shall be considered to be included in the bid price.

The Contractor shall provide spare parts and tools for the transmission line and substations as specified in this Specification, furnish qualified supervision and construction personnel for the installation, testing, commissioning and remedying defects within warranty period and checking out of the equipment necessary to complete the scope of work as mentioned in this specification and detailed in the Price Schedules. The work shall be performed in close cooperation with the Employer.

Locally available goods, construction materials including asphalt, fuel, lubricating oil, cement, timber, iron and steel goods, etc. shall be procured locally.

Annex-A-1 Daily Precipitation and Air Temperature Data

Annex-A-1-1 Daily Precipitation Data at Damauli (No. 817)

Annex-A-1-2 Daily Air Temperature Data at Damauli (No. 817)

Sources: Department of Hydrology and Meteorology (DHM)

Location : Damauli Latitude : 27° 58' N
Index No. : 0817 Longitude : 84° 17' E
District : Tanahun Elevation : 358 m.
Note : DNA means data not available T means data less than 0.1

Month	Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Day																	
1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	T	0.0	0.0	0.0	0.0
1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.1	0.0	0.0	0.0	0.0
1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.1	0.0	0.0	0.0	0.2
1	5	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	2.5	0.0	0.0	0.0	0.0
1	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	8	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	40.0
1	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	40.0
1	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	2.0	0.0	0.0
1	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	13	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	14	25.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	17.0	0.0
1	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	16.0	0.0	0.0	T	0.0	0.0
1	18	0.0	0.0	24.5	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	19	0.0	0.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	22	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	27	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	29	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	1.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	30	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
1	31	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	1	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	1.0	0.0	0.0	0.0	0.0
2	3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	4	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	9.0	0.0	0.0
2	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	T	0.0	0.0	0.0	0.0
2	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	8	0.0	0.0	0.0	0.0	0.0	18.3	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.1	0.0	0.0	0.0	0.0	0.0
2	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.6	0.0	0.0	0.0
2	11	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	DNA	T	0.0	12.0	0.0	0.0	0.0
2	12	76.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	1.0	0.0	0.0	0.0
2	13	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	19.0	0.0	4.0	0.0
2	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	2.5	2.0	0.0	0.0
2	17	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	1.0	0.0	0.0
2	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	2.0
2	20	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	DNA	2.5	0.0	0.0	0.0	0.0	0.0
2	21	0.0	2.0	0.0	0.0	0.0	0.0	0.0	T	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	1.4	0.0
2	23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	19.5	7.4	0.0
2	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	1.0	0.0
2	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	27	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
2	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	DNA	0.0	0.0	0.0	1.0	0.0	0.0
2	29			0.0				10.0				0.0				3.6	

Daily Precipitation (mm)
Location : Damauli

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Month
Day																	
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
3	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	64.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
6	0.0	4.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	DNA	0.0	0.0	T	0.0	0.0	0.0	3
7	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	DNA	0.0	0.0	T	0.0	0.0	0.0	3
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	DNA	0.0	0.0	0.0	2.0	0.0	0.0	3
9	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	DNA	0.0	0.0	0.0	1.3	8.0	0.0	3
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.3	36.0	0.0	3
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	2.5	0.0	0.0	3
12	0.0	0.0	0.0	0.0	30.1	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.3	14.0	4.0	3
13	0.0	0.0	0.0	0.0	9.2	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.5	0.0	0.0	3
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	T	0.0	0.0	0.0	0.0	3
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	T	16.5	0.0	0.0	3
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	13.4	0.0	0.0	0.0	3
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	DNA	0.0	0.0	0.0	7.0	0.0	0.0	3
18	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	20.0	0.0	0.0	3
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	T	0.0	2.8	18.0	3
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	DNA	0.0	0.0	T	0.0	9.0	0.0	3
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	DNA	0.0	0.0	0.0	0.0	0.0	13.0	3
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
24	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
25	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	DNA	0.0	T	0.0	0.0	0.0	0.0	3
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	T	0.0	0.0	2.8	0.0	3
27	18.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	7.0	T	0.0	0.0	0.0	0.0	3
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	16.0	0.0	0.0	0.0	0.0	3
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	1.0	0.0	0.0	0.0	0.0	3
30	1.4	0.0	0.0	0.0	0.0	0.0	4.0	3.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	4.0	3
31	3.4	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	3
1	11.8	0.0	0.0	33.0	0.0	0.0	0.0	4.0	0.0	0.0	63.8	0.0	0.0	7.5	0.0	0.0	4
2	10.2	0.0	0.0	13.5	0.0	0.0	0.0	10.0	0.0	0.0	12.0	0.0	0.0	31.7	0.0	0.0	4
3	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
4	0.0	0.0	0.0	43.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	4
5	3.8	0.1	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
6	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
8	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	4
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	4
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	11.0	0.0	2.0	0.0	0.0	4
11	0.0	0.0	0.0	24.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	0.0	0.0	4
12	76.5	0.0	0.0	82.0	0.0	8.0	0.0	0.0	0.0	3.0	0.0	0.0	1.0	0.0	0.0	0.0	4
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	30.0	0.0	0.0	0.0	4
14	153.5	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	22.0	0.0	4
15	0.0	0.0	0.0	0.0	0.0	6.0	T	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	4
16	0.0	0.0	0.0	0.0	0.0	31.0	0.0	16.0	5.0	T	0.0	0.0	0.0	0.0	0.0	0.0	4
17	0.0	0.0	0.5	35.5	0.0	0.0	0.0	45.0	2.0	T	0.0	0.0	0.0	0.0	19.6	0.0	4
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	4.0	7.0	47.0	0.0	0.0	0.0	4.8	0.0	4
19	0.0	0.0	0.0	0.0	0.0	11.0	6.5	0.0	7.0	0.0	4.0	7.0	0.0	2.0	0.0	0.0	4
20	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	4.0	0.0	0.0	16.0	0.0	4
21	0.0	0.0	T	0.0	0.0	0.0	0.0	0.0	47.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	4
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.3	0.0	33.0	0.0	0.0	0.0	4
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	13.0	3.0	10.2	0.0	4
24	0.0	0.0	0.0	30.0	0.0	0.0	0.0	4.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
25	0.0	0.0	5.1	36.5	0.0	0.0	0.0	0.0	7.0	T	4.5	0.0	3.3	9.5	2.8	0.0	4
26	0.0	0.0	0.0	0.0	0.0	T	0.0	7.0	24.0	5.0	1.0	0.0	5.5	5.5	0.0	0.0	4
27	21.0	0.0	17.1	0.0	0.0	10.5	0.0	0.0	6.0	5.0	0.0	0.0	1.0	8.5	0.0	0.0	4
28	0.0	0.0	8.5	0.0	0.0	T	0.0	1.0	0.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	4
29	0.0	0.0	28.2	0.0	0.0	3.0	5.0	6.0	0.0	2.0	24.4	9.0	28.0	0.0	0.0	0.0	4
30	0.0	2.0	9.0	6.0	0.0	13.0	11.0	16.0	0.0		21.0	0.0	2.0	31.5	0.0	0.0	4

Daily Precipitation (mm)
Location : Damauli

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Month
Day																	
1	0.0	0.0	16.4	0.0	0.0	T	0.0	9.0	0.0	51.0	5.0	1.5	0.0	10.0	0.0	0.0	5
2	51.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	2.0	0.0	0.0	0.0	9.4	0.0	5
3	11.2	16.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0	0.0	13.5	14.0	6.6	0.0	5
4	26.5	0.0	0.0	9.5	0.0	0.0	0.0	0.0	0.0	38.0	20.0	3.5	17.0	0.0	0.0	0.0	5
5	70.0	6.2	0.0	15.4	8.3	0.0	0.0	7.0	0.0	8.0	0.0	29.0	24.0	0.0	2.6	0.0	5
6	0.0	0.0	3.4	0.0	58.9	0.0	29.0	3.0	0.0	36.0	55.0	11.0	0.0	7.5	0.0	0.0	5
7	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	57.0	T	0.0	14.0	0.0	0.0	5
8	1.2	0.0	14.5	3.0	13.1	0.0	8.0	79.0	0.0	3.0	6.0	0.0	0.0	15.0	0.0	0.0	5
9	0.0	0.0	20.4	0.0	3.2	0.0	0.0	0.0	0.0	39.0	43.0	0.0	10.0	0.0	0.0	0.0	5
10	11.3	0.0	0.0	0.0	0.0	3.0	0.0	170.0	0.0	0.0	23.0	0.0	0.0	0.0	3.0	0.0	5
11	50.1	0.0	7.3	0.0	0.0	1.9	20.0	10.0	0.0	0.0	0.0	2.0	13.5	0.0	0.0	0.0	5
12	40.0	0.0	0.0	0.0	15.5	1.9	0.0	2.0	0.0	1.0	0.0	9.0	3.4	0.0	0.0	0.0	5
13	0.0	0.0	24.1	0.0	12.3	0.0	0.0	0.0	0.0	37.0	66.0	10.0	4.5	0.0	0.0	37.0	5
14	1.2	0.0	18.9	40.1	0.0	2.2	0.0	15.0	0.0	1.0	0.5	15.0	1.5	2.5	9.0	10.0	5
15	0.0	0.0	0.0	5.2	76.2	T	2.0	50.0	0.0	0.0	0.0	4.5	3.4	0.0	0.0	0.0	5
16	48.0	0.0	11.6	0.0	53.5	33.0	2.0	70.0	0.0	6.0	24.0	0.0	16.0	0.0	0.0	0.0	5
17	2.1	0.0	0.0	0.0	107.1	0.0	36.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	10.0	0.0	5
18	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	2.0	26.0	0.0	6.6	16.8	5
19	42.5	0.0	0.0	0.0	0.0	T	6.0	0.0	0.0	T	0.0	25.0	13.0	0.0	27.0	0.0	5
20	52.2	0.0	0.0	15.1	30.0	3.0	3.0	0.0	6.0	3.0	5.0	0.0	0.0	1.0	6.8		5
21	30.0	0.0	70.4	10.1	5.1	5.1	1.0	0.0	0.0	T	12.0	5.0	10.5	0.0	0.0	37.0	5
22	7.0	0.0	34.2	5.9	15.0	0.0	40.0	0.0	0.0	25.0	23.0	5.0	0.0	1.5	0.0	0.4	5
23	0.0	0.0	0.0	0.0	0.0	0.0	42.0	0.0	0.0	7.0	33.0	0.0	8.0	16.5	0.0	0.0	5
24	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	5.0	12.0	0.0	0.0	0.0	63.0	0.0	5
25	0.0	0.0	20.9	0.0	7.0	0.0	3.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	10.8	0.0	5
26	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	T	39.0	T	0.0	0.0	0.0	6.0	5
27	0.0	0.0	0.0	0.0	29.5	0.0	19.0	0.0	0.0	T	T	1.0	1.0	0.0	63.0	60.0	5
28	0.0	0.0	0.0	0.0	39.7	0.0	0.0	31.0	0.0	T	18.0	1.0	0.0	0.0	2.6	0.0	5
29	0.0	0.0	0.0	24.1	21.5	0.0	0.0	0.0	0.0	T	11.0	1.0	0.0	0.0	24.8	40.5	5
30	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	33.0	0.0	1.0	0.0	11.0	5
31	0.0	0.0	0.0	21.0	0.2	0.0	18.0	0.0	0.0	8.0	0.0	8.0	0.0	0.0	0.0	30.0	6
1	10.0	0.0	24.6	10.1	21.7	0.0	0.0	0.0	0.0	0.0	0.0	67.0	5.0	2.5	0.0	0.0	6
2	8.0	2.2	0.0	0.0	T	0.0	22.0	41.0	0.0	33.0	0.0	52.0	0.0	16.0	0.0	0.0	6
3	0.0	0.0	0.0	25.0	14.3	0.0	9.0	0.0	0.0	0.0	25.0	0.0	0.0	13.5	0.0	34.0	6
4	0.0	7.5	0.0	45.9	0.0	0.0	0.0	12.0	0.0	4.0	0.0	8.0	0.0	31.0	0.0	47.0	6
5	0.0	0.0	0.0	5.1	15.4	0.0	0.0	24.0	0.0	8.0	62.0	0.0	0.0	0.2	9.0	0.0	6
6	68.0	0.0	93.1	6.5	7.3	0.0	0.0	0.0	0.0	10.0	0.0	35.0	0.0	1.5	0.0	0.2	6
7	10.0	8.6	0.0	0.0	5.1	0.0	3.0	0.0	0.0	0.1	0.0	27.0	43.5	11.0	0.0	0.0	6
8	5.0	0.0	0.0	5.0	48.1	15.0	26.0	0.0	0.0	18.0	0.0	20.0	0.0	0.0	0.6	18.0	6
9	1.0	0.0	0.0	0.0	20.5	35.0	168.0	0.0	0.0	19.0	0.0	21.0	5.4	50.5	0.0	0.0	6
10	0.0	0.0	47.5	0.0	9.1	T	30.0	0.0	0.0	T	86.0	0.0	0.0	59.0	2.0	0.0	6
11	28.8	0.0	0.0	12.5	3.2	T	0.0	0.0	0.0	0.0	10.0	32.0	0.0	9.0	0.0	4.0	6
12	0.0	0.0	20.0	0.0	0.0	3.0	32.0	0.0	0.0	1.0	26.0	0.0	18.0	0.0	32.6	0.0	6
13	0.0	0.0	10.4	0.0	0.0	66.2	0.0	0.0	0.0	0.0	12.0	0.0	16.4	0.0	45.6	14.3	6
14	26.5	40.5	0.5	0.0	79.7	T	17.0	0.0	0.0	0.0	0.0	85.0	12.0	0.0	5.4	1.6	6
15	0.0	50.0	26.4	0.0	2.8	26.2	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	T	6
16	0.0	0.0	0.0	24.6	1.1	0.0	8.0	0.0	0.0	21.0	25.0	14.0	0.0	1.0	0.0	5.0	6
17	10.0	0.0	12.0	0.0	0.0	0.0	6.0	0.0	4.0	0.0	0.0	0.0	0.4	30.0	0.0	26.0	6
18	5.5	0.0	0.0	0.0	T	10.0	0.0	3.0	8.0	0.0	115.0	19.0	30.5	2.0	0.0	111.0	6
19	10.0	0.0	0.0	0.0	79.0	70.0	0.0	5.0	0.0	0.0	0.5	15.0	24.0	0.0	7.2	3.0	6
20	40.0	0.0	0.0	0.0	2.0	0.0	0.0	1.0	0.0	0.0	T	6.0	2.0	0.0	0.0	2.0	6
21	20.0	0.0	0.0	0.0	20.0	51.0	3.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.4	6
22	10.8	1.0	0.0	40.2	0.6	3.0	9.0	28.0	0.0	0.0	2.5	0.0	23.0	0.0	29.0	0.0	6
23	384.2	2.0	0.0	10.2	4.4	0.0	8.0	0.0	0.0	26.0	0.0	6.0	9.4	17.0	0.0	0.0	6
24	2.2	1.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	6.0	3.0	0.0	51.0	9.5	15.0	0.0	6
25	10.0	10.0	16.7	0.0	3.8	1.5	0.0	0.0	5.0	4.0	0.0	0.0	11.4	0.2	10.0	34.0	6
26	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	8.0	4.0	3.0	1.0	36.0	34.5	0.0	1.0	6
27	0.0	0.0	0.0	20.2	T	9.0	0.0	0.0	0.0	54.0	0.0	0.0	99.5	T	0.0	0.8	6
28	0.0	0.0	5.3	0.0	9.2	14.0	2.0	43.0	14.0	7.0	9.0	42.5	11.5	25.0	0.0	8.0	6
29	12.0	1.0	41.1	0.0	17.3	T	32.0	80.0	0.0	86.0	0.0	1.0	22.5	81.0	45.0	1.3	6
30	26.5	9.0	84.1	10.5	27.5	T	0.0	17.0	0.0	8.0	0.0	0.0	0.4	30.0	0.4	0.0	

Daily Precipitation (mm)
Location : Damauli

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Month
Day																	
1	19.0	4.0	0.0	14.2	30.9	115.0	0.0	24.0	0.0	3.0	5.5	6.0	0.4	0.0	0.0	85.0	7
2	37.2	1.0	44.0	0.0	11.7	39.4	0.0	1.0	0.0	50.0	27.0	4.0	5.0	31.0	128.0	0.0	7
3	27.0	8.0	20.1	0.0	16.6	3.0	0.0	38.0	0.0	19.0	16.0	0.0	0.0	197.0	0.0	27.0	7
4	0.0	0.0	30.2	10.2	T	9.0	2.0	0.0	22.2	28.0	5.0	39.0	0.4	100.0	2.0	0.2	7
5	0.0	0.0	0.0	16.0	4.2	0.0	1.0	4.0	1.0	7.0	1.0	19.0	0.0	9.0	48.0	0.0	7
6	0.0	0.0	0.0	11.0	32.4	0.0	46.0	0.0	14.0	11.1	16.5	6.5	19.5	12.3	47.0	14.0	7
7	0.0	0.0	0.0	20.1	T	0.0	7.0	9.0	100.0	0.0	0.0	52.0	T	15.0	0.0	1.0	7
8	0.0	0.0	0.0	41.0	27.7	0.0	17.0	30.0	0.0	0.0	33.5	10.0	3.0	63.5	0.4	10.0	7
9	0.0	0.0	0.0	46.0	27.8	T	30.0	1.0	0.0	T	30.5	3.0	5.0	48.0	10.0	0.0	7
10	0.0	0.0	6.0	49.5	0.0	32.0	0.0	2.0	17.0	7.0	12.0	2.7	0.2	27.0	1.6	0.0	7
11	0.0	0.0	0.0	29.5	4.0	36.0	0.0	0.1	9.0	0.0	11.0	21.0	5.5	14.0	0.2	143.0	7
12	5.0	1.0	0.0	5.0	4.8	20.0	0.0	2.0	0.0	T	25.0	9.0	0.0	1.5	55.0	0.2	7
13	15.0	8.0	0.0	10.1	T	31.8	0.0	28.0	0.0	0.0	3.0	4.6	2.0	1.0	15.0	16.2	7
14	70.6	0.0	20.5	25.5	0.0	8.0	1.0	7.0	0.0	0.0	0.0	29.0	42.5	0.0	2.0	72.0	7
15	2.0	0.0	75.6	24.5	1.8	14.0	13.0	51.0	0.0	94.0	0.0	4.6	4.0	36.5	12.0	49.0	7
16	0.0	0.0	0.0	20.2	110.0	18.0	18.0	22.0	0.0	74.0	7.0	3.0	96.0	0.0	4.2	16.2	7
17	4.0	0.0	0.0	6.0	10.0	2.0	0.0	11.0	0.0	210.0	8.0	3.0	42.5	14.0	0.0	0.0	7
18	1.2	0.0	0.0	8.5	33.1	0.0	0.0	36.0	26.0	1.1	9.5	0.0	5.0	3.0	1.0	3.0	7
19	0.0	1.0	0.0	0.0	0.6	0.0	1.0	26.0	81.0	0.0	15.0	8.0	0.2	14.0	34.0	122.0	7
20	13.8	3.0	0.0	0.0	27.4	3.0	19.0	21.0	23.0	24.5	0.0	0.0	2.0	0.5	2.0	4.0	7
21	17.0	1.0	0.0	5.0	2.2	13.0	9.0	3.0	0.0	34.0	2.0	0.7	23.0	2.5	32.0	3.0	7
22	21.0	8.0	0.0	10.5	6.7	6.0	11.0	5.0	0.0	13.0	5.0	0.0	12.5	19.5	16.0	2.0	7
23	11.5	2.0	0.0	10.0	14.8	3.0	6.0	3.0	0.0	1.0	2.0	28.0	2.0	49.5	0.0	27.0	7
24	9.0	2.0	0.0	12.2	10.1	86.0	11.0	9.0	42.0	0.0	54.5	15.5	0.2	5.5	0.0	0.0	7
25	48.0	4.0	0.0	5.1	1.3	0.0	7.0	0.0	32.0	3.0	13.5	42.0	16.0	92.0	8.0	0.4	7
26	21.0	3.0	16.0	6.0	0.0	2.0	1.0	6.0	0.0	55.0	7.0	73.0	35.3	17.0	0.0	0.0	7
27	36.0	4.5	0.0	8.1	4.2	3.0	9.0	118.0	4.0	28.0	51.0	0.0	12.0	1.2	2.8	41.4	7
28	12.0	0.0	0.0	2.5	28.2	13.0	64.0	45.0	14.0	0.5	52.0	6.0	0.0	2.5	4.0	10.0	7
29	27.0	0.0	0.0	41.5	19.8	27.0	4.0	0.2	0.0	2.0	14.0	0.3	0.0	3.0	1.0	64.0	7
30	18.0	0.0	10.0	25.5	15.4	0.0	4.0	6.0	0.0	4.5	11.1	0.0	9.0	2.0	0.0	20.0	7
31	9.0	0.0	20.7	6.0	T	9.0	6.0	35.0	0.0	T	26.5	0.0	2.0	3.0	30.0	26.0	7
1	20.0	0.0	25.0	2.1	28.1	52.0	32.0	29.0	0.0	0.0	2.0	7.0	5.5	5.5	7.0	10.0	7
2	31.0	0.0	1.7	10.3	1.8	48.0	36.0	1.0	0.0	33.0	5.0	8.0	7.0	T	6.0	0.4	8
3	16.0	16.0	0.0	20.5	3.4	51.0	1.0	0.1	0.0	1.0	0.0	0.0	3.0	5.5	0.0	0.0	8
4	68.0	0.0	20.0	0.0	0.0	10.0	12.0	2.0	0.0	4.0	10.0	0.0	1.5	5.5	17.0	0.0	8
5	13.0	0.1	25.0	0.0	14.0	19.0	0.0	17.0	53.0	19.0	0.0	4.0	1.5	0.0	0.0	0.0	8
6	0.0	0.0	13.0	20.5	0.2	9.0	4.0	0.0	0.0	9.0	0.0	0.0	0.0	19.0	0.0	0.0	8
7	14.0	0.0	0.0	14.5	0.0	T	22.0	1.0	0.0	2.0	0.0	0.0	15.0	2.5	70.0	0.0	8
8	0.0	0.0	0.0	24.0	9.1	89.0	1.0	3.0	77.0	0.4	0.3	0.0	14.0	0.3	0.0	11.0	8
9	31.0	0.0	0.0	5.5	31.0	5.0	0.0	35.0	0.0	0.0	12.0	2.0	0.0	0.3	0.0	28.0	8
10	30.5	0.0	0.0	2.2	2.6	62.0	0.0	0.0	0.0	T	0.0	2.0	3.0	4.5	16.0	5.0	8
11	5.0	0.0	28.0	23.1	3.9	T	0.0	0.0	0.0	0.0	0.2	0.6	0.0	4.5	0.0	5.0	8
12	18.0	0.0	11.2	41.5	35.0	8.0	25.0	2.0	0.0	T	0.3	0.0	40.0	34.0	31.0	32.0	8
13	0.0	0.0	9.8	45.0	0.0	13.0	1.0	0.0	0.0	0.0	3.0	0.0	0.0	76.0	9.0	0.0	8
14	0.0	0.0	10.0	39.0	0.0	8.0	24.0	1.0	0.0	0.0	19.0	2.0	0.0	14.0	0.0	0.0	8
15	0.0	0.0	13.1	0.0	0.6	10.0	12.0	0.0	0.0	0.0	0.0	13.0	0.0	1.5	1.0	0.0	8
16	0.0	0.0	41.0	2.5	1.5	0.0	0.0	0.0	0.0	T	9.5	1.0	8.0	0.0	9.0	11.0	8
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	7.5	0.3	5.0	3.0	0.0	29.0	8
18	0.0	0.0	0.0	0.0	35.5	0.0	0.0	0.0	0.0	15.0	9.0	0.3	0.0	2.0	35.0	2.0	8
19	48.0	0.0	0.0	0.0	12.3	0.0	0.0	4.0	0.0	0.0	17.5	17.0	0.0	T	20.0	0.0	8
20	31.0	0.0	0.0	0.0	2.8	4.0	0.0	79.0	0.0	23.0	3.5	T	15.0	3.3	0.0	14.0	8
21	21.0	0.0	0.0	0.0	T	77.0	0.0	2.0	0.0	0.0	29.1	0.0	2.0	0.0	24.0	11.0	8
22	22.5	0.0	10.0	0.0	T	9.0	0.0	1.0	0.0	T	0.0	14.0	0.0	0.3	21.0	1.0	8
23	0.0	0.0	27.5	0.0	20.9	0.0	1.0	5.0	0.0	3.4	7.0	9.5	0.1	0.0	92.0	0.0	8
24	0.0	0.0	10.0	0.0	T	0.0	3.0	1.0	0.0	1.7	0.0	9.0	36.5	12.5	28.0	0.0	8
25	47.0	0.0	0.0	5.1	0.0	0.0	5.0	0.0	0.0	36.0	13.0	0.0	11.5	0.0	10.0	0.0	8
26	32.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	2.0	0.0	0.0	0.4	36.0	68.0	4.0	8
27	0.0	0.0	7.0	6.2	0.0	0.0	4.5	0.0	0.0	15.0	26.0	4.0	2.5	0.0	0.0	0.0	8
28	42.0	0.0	0.0	0.0	T	0.0	5.0	0.0	8.0	0.0	2.0	1.5	6.0	4.0	4.0	1.2	8
29	31.5	0.0	0.0	0.0	0.2	6.0	4.5	0.0	0.0	11.0	0.0	24.0	0.0	1.0	11.0	0.0	8
30	51.0	2.0	0.0	0.0	0.3	4.0	12.0	0.0	0.0	2.0	8.0	8.0	0.0	1.0	1.0	1.4	8
31	59.3	0.0	10.0	0.0	13.4	3.0	8.0	108.0	0.0	8.0	11.0	0.0	0.0	0.0	0.0	1.0	8
31											74.0						8

Daily Precipitation (mm)
Location : Damauli

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Month
Day																	
1	3.0	DNA	19.0	0.0	0.0	T	190.0	9.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.4	9
2	12.0	DNA	30.2	0.0	0.1	8.0	15.0	0.0	0.0	4.0	3.0	0.0	3.0	41.5	0.0	0.0	9
3	0.0	DNA	0.0	0.0	3.4	29.0	4.0	0.0	0.0	T	0.0	28.0	0.0	17.0	0.0	0.0	9
4	0.0	DNA	0.0	0.0	0.1	52.0	3.0	0.0	0.0	T	0.0	98.0	0.0	3.0	10.0	0.0	9
5	0.0	DNA	0.0	0.0	4.5	54.0	37.0	0.0	0.0	T	10.0	6.0	1.5	T	18.0	1.0	9
6	0.0	DNA	3.0	0.0	18.2	7.5	33.0	0.0	0.0	8.0	17.0	0.0	40.0	6.0	1.4	0.0	9
7	0.0	DNA	0.0	0.0	19.9	1.0	0.0	3.0	0.0	T	133.0	0.0	0.0	0.9	46.0	0.0	9
8	0.0	DNA	0.0	0.0	2.0	0.0	0.0	2.0	0.0	2.0	38.0	0.0	0.0	T	57.0	0.0	9
9	0.0	DNA	0.0	0.0	14.4	0.0	0.0	10.0	0.0	5.0	0.0	0.0	1.5	10.0	12.0	0.0	9
10	0.0	DNA	0.0	0.0	11.5	0.8	0.0	46.0	0.0	17.0	0.0	0.0	4.0	2.0	0.0	0.0	9
11	21.0	DNA	0.0	12.2	4.1	0.0	0.0	0.0	0.0	5.0	1.0	21.0	16.0	T	0.0	34.0	9
12	0.0	DNA	8.0	0.0	T	0.0	0.0	0.0	0.0	16.0	17.0	0.3	100.0	0.0	0.0	16.0	9
13	0.0	DNA	20.0	21.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.0	0.0	0.0	0.0	9
14	12.0	DNA	14.0	2.2	36.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	65.0	0.0	0.0	18.6	9
15	32.0	DNA	3.2	0.0	0.9	0.0	41.0	2.0	0.0	0.0	135.0	0.0	28.0	0.0	0.0	3.6	9
16	3.2	DNA	0.0	0.0	0.0	35.8	0.0	0.0	0.0	0.0	17.0	52.0	0.0	0.0	36.0	0.0	9
17	32.0	DNA	0.0	0.0	T	0.0	0.0	0.0	0.0	3.0	51.0	86.0	0.0	0.0	0.2	0.6	9
18	0.0	DNA	0.0	25.2	0.0	0.0	0.0	0.0	0.0	27.0	43.0	0.0	0.0	0.0	7.0	19.0	9
19	0.0	DNA	0.0	10.5	21.6	0.0	1.0	0.0	0.0	51.0	16.0	0.0	0.0	0.0	0.2	21.6	9
20	0.0	DNA	0.0	0.0	0.0	0.0	2.0	0.0	0.0	T	2.0	0.0	0.0	0.5	0.4	0.0	9
21	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.9	2.5	0.0	2.6	9
22	0.0	DNA	0.0	0.0	1.2	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	3.0	0.0	0.0	9
23	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.0	0.0	0.0	0.8	2.0	0.0	0.0	9
24	0.0	DNA	0.0	0.0	T	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	0.0	32.0	0.0	9
25	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	6.0	6.5	0.0	0.0	0.0	9
26	0.0	DNA	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	13.0	1.5	0.0	0.0	0.0	9
27	0.0	DNA	0.0	0.0	10.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	9
28	0.0	DNA	0.0	0.0	8.4	0.0	0.0	0.0	0.0	0.2	0.0	0.0	13.0	0.0	32.0	0.0	9
29	0.0	DNA	0.0	24.1	0.0	0.0	0.0	265.0	0.0	0.0	0.0	0.0	12.0	2.5	0.0	0.6	9
30	0.0	DNA	0.0	0.0	6.2	0.0	0.0	8.0	0.0	0.0	0.0	12.0	3.0	3.5	0.0	24.0	9
1	DNA	DNA	0.0	0.0	43.0	0.0	0.0	0.0	T	0.0	0.0	1.0	22.3	0.0	0.0	0.4	10
2	DNA	DNA	0.0	0.0	0.0	5.0	3.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	10
3	DNA	DNA	0.0	T	0.0	0.0	0.0	0.0	0.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0	10
4	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	10
5	DNA	DNA	0.0	0.0	0.2	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	10
6	DNA	DNA	0.0	44.1	10.5	0.0	0.0	0.0	0.0	0.0	0.0	7.0	4.0	0.0	2.0	0.0	10
7	DNA	DNA	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	10
8	DNA	DNA	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	10
9	DNA	DNA	0.0	0.0	0.0	T	0.0	0.0	0.0	10.0	1.5	61.0	T	0.0	0.0	0.0	10
10	DNA	DNA	0.0	0.0	0.0	12.0	0.0	0.0	0.0	2.0	0.0	64.0	0.0	0.0	0.0	0.0	10
11	DNA	DNA	0.0	0.0	0.0	5.0	0.0	0.0	0.0	15.5	0.0	0.0	2.0	0.0	0.0	0.0	10
12	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.0	0.0	0.0	2.5	0.0	0.0	0.0	10
13	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	19.0	0.0	0.0	0.0	10
14	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
15	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	0.0	26.0	0.0	0.0	0.0	10
16	DNA	DNA	0.0	0.0	T	0.0	0.0	0.0	0.0	0.0	3.0	0.0	1.5	0.0	0.0	0.0	10
17	DNA	DNA	45.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	10
18	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0	0.0	0.0	0.0	0.0	10
19	DNA	DNA	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	0.0	28.0	0.0	1.0	10
20	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0	67.0	0.0	0.0	10
21	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
22	DNA	DNA	20.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
23	DNA	DNA	0.0	0.0	0.2	0.0	4.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	10
24	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	10
25	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
26	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
27	DNA	DNA	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
28	DNA	DNA	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0	10
29	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
30	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
31	DNA	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	0.0	10

Location : Damauli

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Day																Month
1	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
2	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	DNA	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4
4	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0
6	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
21	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	DNA	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
26	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
27	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28A	DNA	0.0	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
29	DNA	0.0	0.0	0.0	0.1	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	DNA	0.0	0.0	0.0	T	45.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
1	DNA	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	DNA	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	DNA	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	DNA	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
12	DNA	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	0.0	0.0
13	DNA	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0	0.0	6.0	0.0	25.0	0.0	0.0	0.0
14	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	DNA	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0
18	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.5	0.0	0.0	0.0
19	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
21	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
22	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	DNA	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	DNA	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0	51.0	0.0
26	DNA	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	16.5	0.0	33.0	0.0	0.0	16.0	7.0
27	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.5	0.0	0.0	0.0	0.0
28	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	DNA	0.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	DNA	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
31	DNA															

Location : Damauli

	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Month	Day															
1	1	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	21.9	0.0
1	2	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	7	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	8	0.0	0.0	0.0	2.0	0.0	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	9	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0
1	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0
1	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	12	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0
1	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	16	0.0	0.0	0.0	0.0	25.4	0.0	58.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3	0.0	0.0
1	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
1	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T
1	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0
1	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
1	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.4	0.0	0.0	1.0	0.0	0.0	0.0	3.8
1	23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	T	0.0	0.0	0.0	0.2
1	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	6.6
1	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
1	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
1	29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	6.7	0.0	0.0	0.0
1	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.0	0.0	0.0
1	31	0.0	0.0	3.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.8	0.0	0.0
2	1	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	8.6	0.0	0.0
2	2	0.0	0.0	0.0	10.0	0.0	0.0	0.0	DNA	0.0	0.0	T	0.0	0.0	17.0	0.0
2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.9	0.0
2	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	T	0.0
2	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	6	0.0	0.0	0.0	0.0	0.0	1.0	0.0	DNA	0.0	0.0	2.7	0.0	0.0	0.0	0.0
2	7	0.0	0.0	15.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	9	0.0	0.0	0.0	0.0	0.0	0.0	4.0	DNA	0.0	0.0	0.0	0.0	19.0	0.0	0.0
2	10	0.0	0.0	0.0	0.0	28.6	0.0	14.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	11	0.0	0.0	0.0	0.0	6.8	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	12	10.0	0.0	0.0	0.0	0.0	0.0	21.6	DNA	0.0	0.0	4.0	0.0	0.0	0.0	0.0
2	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	15.3	0.0	0.0
2	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	15	20.0	0.0	0.0	0.0	0.0	T	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	16	13.0	0.0	0.0	0.0	0.0	12.6	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	17	0.0	0.0	0.0	0.0	0.0	0.0	4.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	19	0.0	0.0	0.0	0.0	0.0	8.8	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	25.2	0.0
2	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	17.3	0.0
2	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	23	0.0	0.0	0.0	0.0	12.6	0.0	0.0	DNA	0.0	0.0	0.0	6.4	0.0	0.0	0.0
2	24	0.0	0.0	0.0	0.0	0.8	23.2	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	13.0	0.0	0.0	0.0	T	0.0	0.0
2	26	0.0	0.0	0.0	0.0	0.0	0.0	2.2	DNA	0.0	0.0	0.0	1.2	9.3	5.7	0.0
2	27	0.0	0.0	0.0	1.0	0.0	0.0	10.8	DNA	0.0	0.0	0.0	10.0	5.0	5.2	0.0
2	28	8.0	14.4	0.0	0.0	0.0	16.6	0.0	DNA	0.0	0.0	0.0	0.0	0.0	24.6	0.0
2	29	0.2	0.0	0.0	0.0	0.0	4.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	T	31.2
2																

Daily Precipitation (mm)
Location : Damauli

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Day	Month														
1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.0	2.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
5	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	10.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	9.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	T	0.0	0.0	7.6	1.2
14	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
15	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	3.2	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4
21	0.0	0.0	0.2	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	T	0.0
23	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	11.0	0.0	0.0
24	15.2	22.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.8	5.2	T	0.0	0.0
25	0.0	3.8	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	1.8	28.1	0.0
26	0.0	0.0	0.0	46.0	0.0	9.2	0.4	0.0	0.0	0.0	0.0	T	0.0	T	0.0
27	0.0	0.0	0.0	6.6	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	T	0.0
28	0.6	0.0	0.0	0.0	1.0	0.0	0.0	0.0	19.0	0.0	2.0	0.0	0.0	0.0	0.0
29	6.0	0.0	0.0	0.0	15.8	10.0	0.0	0.0	67.0	0.0	0.0	0.0	0.0	T	0.0
30	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	42.0	0.0	0.0	T	0.0	14.3	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	15.4	1.7	0.0
1	0.0	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	T	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	3.7	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	T	71.2
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	3.2	11.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	10.0
6	0.0	0.0	0.0	0.0	34.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	1.2	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T
8	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0	1.5	T	0.4	0.0
9	1.8	24.0	0.0	1.0	0.0	3.6	0.0	10.0	0.0	0.0	0.0	0.0	0.7	0.0	7.0
10	0.2	0.0	0.0	0.6	0.0	23.0	0.0	50.0	0.0	0.0	0.0	0.0	14.2	0.0	13.3
11	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0
12	0.0	0.8	0.0	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
13	0.0	0.0	0.0	15.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.3
14	0.0	0.0	0.0	0.4	0.0	0.0	0.0	32.0	0.0	0.0	0.0	1.1	0.0	T	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	6.1	0.0	24.4	0.0	0.0
16	0.0	0.0	0.0	1.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	T	0.0	0.0	0.0
17	0.0	0.0	0.0	0.8	0.0	7.2	0.0	0.0	0.0	9.2	1.2	0.0	6.5	0.0	0.0
18	0.0	0.0	0.0	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4	0.0	0.0
19	0.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0
20	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.0	0.0	46.6	0.0	T	T	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.0	0.0	0.0	0.6	1.3	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0	0.0	54.6	32.0	7.2	6.3	T	1.0
23	0.0	0.0	0.0	43.8	3.4	0.0	0.0	0.0	8.0	0.0	45.6	1.4	0.0	T	10.4
24	0.2	0.0	0.0	37.0	3.0	0.0	0.0	0.0	0.0	3.4	3.2	0.0	15.4	T	0.0
25	0.0	24.4	0.0	0.0	0.0	2.0	0.0	3.0	3.0	0.0	7.4	7.3	2.3	0.0	0.0
26	0.0	0.0	0.0	0.2	0.0	0.0	2.0	0.0	3.3	0.0	21.3	T	0.0	3.0	0.0
27	5.0	0.0	0.0	0.0	0.0	72.0	0.0	0.0	19.0	0.0	4.6	11.0	15.6	0.0	0.0
28	0.0	2.2	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	11.8	23.3	T	T	20.1
29	0.0	4.2	0.0	66.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	8.1
30	0.0	22.4	0.0	0.0	T	0.0	80.4	0.0	0.0	21.4	6.2	11.4	16.5	2.7	0.0

Daily Precipitation (mm)
Location : Damauli

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Day	Month														
1	6.0	5 T	0.0	0.0	0.0	0.0	31.0	0.0	0.0	16.2	1.6	T	0.0	0.0	2.4
2	0.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	76.0	0.0	12.6	24.2	T	0.0	0.2
3	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.2	0.0	3.0	22.3	0.0	0.0
4	22.8	8.0	0.0	3.8	0.0	0.0	0.0	11.0	76.0	0.4	0.0	20.2	12.3	6.4	0.0
5	7.6	8.0	0.0	25.0	0.0	0.0	17.6	0.0	29.3	40.2	0.0	5.2	0.0	T	0.3
6	0.0	8.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.2	T	0.0	0.3
7	26.4	68.0	0.0	25.0	3.4	67.6	0.0	0.0	22.2	0.0	82.0	27.2	14.3	0.0	0.0
8	1.4	18.0	0.0	13.0	13.0	0.0	0.0	15.0	3.0	4.8	0.0	3.0	T	0.0	0.0
9	0.0	18.0	0.0	0.0	0.0	9.4	6.6	0.0	0.0	9.0	0.0	2.5	0.0	0.0	0.0
10	0.0	18.4	0.0	34.0	4.0	0.0	0.0	5.0	9.0	16.4	17.6	32.0	50.2	2.1	0.0
11	0.0	9.0	0.0	0.0	5.0	0.0	0.0	9.0	0.0	38.0	0.0	5.0	14.2	T	4.2
12	0.0	8.0	0.0	0.0	0.0	25.0	0.4	0.0	0.0	0.4	23.7	3.0	0.0	0.0	0.0
13	20.2	9.0	0.0	0.0	0.0	40.0	1.0	0.0	0.0	25.5	7.4	0.0	0.0	0.0	1.3
14	1.6	9.0	0.0	16.0	5.8	T	0.0	0.0	3.3	0.0	1.4	T	28.0	15.0	T
15	0.0	8.0	0.0	9.8	2.4	3.2	24.4	0.0	5.0	0.0	0.0	1.2	1.2	0.2	0.0
16	0.0	62.0	0.0	1.0	4.2	45.0	18.0	0.0	0.0	5.0	25.4	7.0	T	30.4	T
17	0.4	9.0	0.0	25.0	1.0	1.0	52.0	0.0	0.0	0.0	0.0	T	1.0	2.4	T
18	27.0	6.0	0.0	10.0	8.4	0.0	31.0	0.0	9.0	9.6	48.2	T	6.5	32.3	2.8
19	0.0	44.4	0.0	12.0	0.0	21.4	0.0	0.0	0.0	0.0	39.0	1.5	8.0	31.5	12.0
20	9.0	0.0	0.0	37.0	0.0	0.0	0.0	37.0	0.0	0.0	19.8	7.8	T	0.0	7.8
21	10.4	5.0	0.0	38.0	23.8	0.0	0.0	13.0	0.0	0.0	0.0	1.2	9.8	T	21.8
22	1.4	0.0	0.0	0.0	18.4	0.0	0.0	0.0	0.0	18.4	18.0	T	0.0	13.3	0.6
23	0.0	21.0	0.0	0.0	40.0	0.0	0.0	0.0	2.0	35.4	5.0	12.6	T	T	T
24	10.0	0.0	0.0	0.0	50.0	0.0	0.0	10.0	2.0	0.0	42.6	3.8	T	9.4	13.2
25	0.0	0.0	15.2	12.6	1.0	0.0	0.0	9.0	2.0	0.0	34.0	20.1	10.2	26.5	T
26	14.6	0.6	3.6	0.0	0.0	0.0	0.0	2.0	31.0	113.4	13.8	18.4	20.4	2.7	22.8
27	0.0	11.0	0.0	8.6	0.0	0.0	0.0	0.0	25.0	0.0	26.6	20.2	5.2	T	20.6
28	0.0	0.2	9.0	67.8	T	0.0	0.0	4.0	0.0	6.1	18.1	0.0	0.0	0.0	53.8
29	43.0	20.2	0.0	0.0	40.2	0.0	0.0	27.0	7.0	19.0	7.0	5.0	T	0.0	1.2
30	19.4	10.4	0.0	0.0	0.0	0.0	24.4	0.0	0.0	0.0	27.0	15.0	23.8	0.0	0.0
31	0.0	9.2	38.2	15.2	T	0.0	20.7	0.0	7.0	25.2	0.0	5.1	5.3	T	0.0
1	0.0	10.4	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	T	T	10.2	0.0
2	0.0	6.0	0.0	1.0	54.0	4.6	20.8	0.0	0.0	0.0	0.0	31.0	T	1.4	6.2
3	16.0	6.0	0.0	0.0	22.0	0.0	12.2	0.0	0.0	0.0	0.0	73.6	2.3	T	7.4
4	1.0	6.0	0.0	5.0	20.0	40.8	24.0	0.0	3.0	0.0	0.0	7.7	4.8	12.4	3.6
5	12.0	6.0	0.0	8.0	17.2	T	0.0	0.0	11.0	0.0	0.0	63.7	15.0	6.2	5.0
6	3.0	6.0	0.0	9.4	0.0	3.0	0.0	0.0	22.0	0.0	4.4	6.3	0.5	1.4	2.0
7	38.0	39.4	3.0	31.8	0.0	0.0	0.0	18.0	37.0	0.0	33.6	1.8	11.0	0.0	1.6
8	25.0	19.8	0.0	4.0	0.0	T	0.0	15.0	0.0	0.0	83.2	53.2	0.0	T	9.6
9	3.0	6.0	76.0	2.0	39.4	17.0	0.0	0.0	0.0	0.0	47.8	14.7	0.0	T	0.0
10	4.0	19.4	0.0	18.8	43.8	54.6	0.0	7.0	0.0	10.6	0.4	0.0	0.0	46.6	0.8
11	4.0	9.0	1.4	2.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	29.8	36.0	0.0
12	0.0	19.4	0.0	9.0	2.0	30.0	15.6	0.0	0.0	32.8	1.6	0.0	0.0	12.2	8.0
13	0.0	19.2	11.0	4.0	0.0	7.0	0.0	104.0	0.0	122.4	0.0	5.1	49.4	T	0.0
14	0.0	78.2	60.0	3.8	4.8	0.0	0.0	0.0	0.0	30.4	0.0	0.0	T	8.2	1.0
15	0.0	19.8	0.0	0.0	16.2	4.8	0.0	13.0	2.0	0.0	60.0	0.0	T	T	0.0
16	3.8	6.2	13.4	0.0	72.6	5.0	0.0	0.0	1.0	0.0	18.6	39.4	0.0	8.5	0.6
17	0.0	26.8	0.0	0.0	0.0	27.4	8.7	35.0	0.0	9.2	6.6	23.0	5.0	0.0	1.6
18	36.0	0.2	0.0	0.0	22.2	78.4	0.0	5.0	0.0	0.0	5.0	52.1	6.4	0.0	4.0
19	0.0	18.8	0.0	4.0	5.6	0.0	5.0	0.0	0.0	1.0	11.6	5.7	2.3	0.0	80.0
20	6.0	6.0	0.0	5.0	7.0	0.0	0.0	0.0	0.0	0.0	1.2	7.4	91.5	T	12.0
21	4.0	8.8	30.2	0.0	26.6	24.4	14.0	76.0	49.3	0.0	8.4	25.0	103.8	0.0	1.0
22	8.4	0.0	43.1	0.0	0.0	31.6	9.2	0.0	52.0	0.0	85.2	45.0	3.2	40.1	0.0
23	2.4	8.4	25.1	12.4	21.2	85.0	0.0	98.4	0.0	8.0	42.8	9.2	0.0	19.1	52.0
24	0.0	8.8	30.3	0.0	0.0	75.0	10.6	0.0	0.0	25.0	12.0	0.0	31.8	10.4	1.4
25	0.0	6.0	40.0	0.0	2.8	0.0	0.0	0.0	33.0	5.4	1.0	4.0	T	24.4	17.0
26	2.4	78.0	25.0	27.0	10.6	0.0	0.0	0.0	0.0	0.0	0.0	3.8	7.0	0.0	T
27	17.0	6.0	30.3	0.2	0.0	0.0	2.0	0.0	0.0	45.0	T	0.0	16.4	0.0	0.0
28	0.0	6.0	0.0	12.0	6.2	16.0	0.0	7.0	49.0	22.4	22.3	0.0	0.0	8.0	0.0
29	13.0	6.0	13.0	6.0	32.2	49.0	13.0	24.3	0.0	3.6	4.5	0.0	0.0	21.2	0.0
30	35.0	18.4	18.4	0.0	6.6	32.0	39.7	75.0	82.0	22.2	9.9	43.5	20.8	48.1	0.0
		6	0.0	0.0			2.0		0.0	42.0					0.0

Daily Precipitation (mm)
Location : Damauli

Month	Year Day	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
7	1	0.0	0.0	0.0	38.4	0.0	24.4	1.4	0.0	2.0	26.2	8.3	16.8	16.0	44.2	41.4
7	2	0.0	0.0	0.0	26.0	42.4	62.4	0.0	0.0	0.0	50.6	76.8	0.9	88.6	T	0.2
7	3	28.0	2.0	3.2	0.6	T	0.0	0.0	0.0	9.3	119.0	0.0	2.4	1.0	T	23.2
7	4	5.0	37.0	0.0	18.0	12.8	0.0	0.0	39.0	0.0	55.0	0.0	0.0	0.0	82.7	1.4
7	5	14.0	0.2	11.2	17.0	0.0	4.2	0.0	4.3	32.0	0.0	33.8	45.7	8.0	18.0	0.0
7	6	9.0	18.4	0.0	0.0	0.0	52.4	8.4	0.0	10.0	2.0	32.6	0.0	0.0	16.3	94.0
7	7	0.0	36.0	12.6	6.0	0.0	30.0	4.0	0.0	30.0	1.2	36.8	0.0	0.0	T	2.0
7	8	61.0	18.0	0.0	10.0	0.0	0.0	1.4	60.0	90.3	8.2	15.0	4.0	0.0	17.5	8.8
7	9	27.0	38.4	0.4	0.0	4.6	12.8	11.0	0.0	33.0	39.4	0.0	0.8	T	167.8	8.6
7	10	4.4	4.0	1.8	0.0	10.0	0.0	34.0	54.2	23.0	49.6	0.0	10.7	39.2	146.9	29.0
7	11	60.4	55.0	2.0	0.0	0.0	62.4	47.4	3.3	0.0	21.0	10.8	21.3	4.7	6.3	27.2
7	12	2.0	11.8	7.6	0.0	2.8	13.6	18.0	0.0	0.0	0.0	0.0	30.3	3.2	T	43.6
7	13	0.0	0.0	22.2	0.0	0.0	9.4	120.5	36.0	0.0	10.2	4.3	T	0.0	T	1.2
7	14	37.0	9.0	0.2	0.0	11.2	9.6	76.2	0.0	3.0	0.0	14.5	T	87.3	29.2	2.4
7	15	11.0	44.0	0.0	0.0	0.0	0.0	2.0	25.3	0.0	T	13.0	25.5	11.2	21.3	0.8
7	16	0.0	4.4	0.0	18.0	0.0	19.0	3.2	0.0	12.0	T	16.8	39.8	0.0	3.1	0.6
7	17	0.0	0.0	25.2	16.0	0.0	13.2	64.2	0.0	16.0	17.0	8.1	30.6	0.0	0.8	1.6
7	18	66.0	0.0	25.2	0.0	25.6	5.0	32.6	13.2	18.0	21.0	8.0	1.3	0.0	T	8.2
7	19	69.6	18.0	2.2	38.0	0.0	40.4	4.4	0.0	21.0	0.0	2.0	T	0.0	23.6	6.4
7	20	35.0	20.0	3.0	40.0	0.0	6.8	0.0	12.3	11.4	10.0	0.4	14.5	10.2	16.8	2.4
7	21	0.0	7.0	2.6	0.0	5.6	0.0	0.0	33.0	82.0	1.4	8.2	0.0	11.0	7.3	8.0
7	22	2.6	0.2	21.6	0.0	2.4	6.8	0.0	0.0	0.0	1.4	8.2	1.3	8.0	39.7	0.4
7	23	0.4	1.4	2.0	36.0	7.2	0.0	0.0	0.0	96.0	9.2	0.0	0.0	54.9	9.2	0.0
7	24	0.0	0.0	4.0	10.6	0.0	0.0	40.0	18.0	0.0	4.2	4.7	T	46.9	26.3	0.4
7	25	1.0	42.0	0.0	0.0	5.2	2.0	0.0	0.0	0.0	74.8	5.2	13.1	20.3	T	7.0
7	26	7.0	4.4	0.0	79.0	0.0	6.0	0.0	0.0	0.0	18.8	0.0	T	10.6	0.0	78.0
7	27	4.4	0.0	10.0	0.0	0.0	14.0	6.3	0.0	3.0	3.0	7.5	T	0.0	8.2	0.2
7	28	16.4	0.0	0.2	24.2	6.2	0.0	0.0	40.0	17.3	42.2	0.0	6.3	1.2	12.4	23.2
7	29	1.4	10.4	0.0	12.4	10.0	0.0	0.0	13.0	1.3	0.2	5.6	78.6	5.2	3.1	2.4
7	30	7.0	0.0	0.0	20.0	2.0	0.0	0.0	0.0	0.0	0.2	5.6	67.6	0.0	13.2	2.0
7	31	14.0	0.0	8.0	17.4	0.0	0.0	0.0	16.0	0.0	20.8	7.4	28.0	T	158.8	0.0
8	1	37.0	3.0	41.8	0.2	9.2	0.0	6.0	3.0	0.0	13.0	40.0	22.5	23.8	22.3	0.8
8	2	12.4	2.4	4.6	0.0	20.0	0.0	26.6	0.0	0.0	0.0	46.0	12.3	5.3	3.2	T
8	3	8.0	0.0	9.0	6.4	0.0	0.0	0.0	0.0	35.0	0.0	15.0	10.4	T	0.0	15.8
8	4	1.0	45.4	0.0	0.0	5.6	9.6	5.9	10.0	20.0	0.4	26.1	6.4	T	0.0	18.2
8	5	6.0	37.4	0.0	0.0	0.0	11.8	12.0	20.0	24.0	2.0	0.0	26.7	2.3	0.0	0.4
8	6	0.0	0.6	0.0	4.0	32.0	0.0	0.0	14.0	9.0	6.4	0.0	0.0	4.8	T	0.6
8	7	2.4	11.6	16.0	68.6	0.0	0.0	0.0	4.0	4.0	0.6	0.0	0.0	15.0	2.1	1.2
8	8	0.4	10.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	5.8	8.3	0.5	0.0	0.0
8	9	10.0	34.0	3.0	12.4	11.4	0.0	16.0	15.0	11.0	1.4	35.7	2.4	11.0	43.4	23.2
8	10	7.0	2.4	0.0	87.2	2.0	0.0	3.2	29.0	0.0	0.6	3.2	30.0	0.0	0.0	9.2
8	11	1.8	0.0	0.0	66.0	6.0	0.0	8.4	3.4	57.3	3.2	64.2	T	0.0	0.0	0.8
8	12	79.0	0.0	0.0	18.0	30.2	0.0	0.0	26.0	70.0	0.0	1.8	0.0	0.0	T	T
8	13	38.0	0.0	1.0	0.0	16.0	19.4	75.4	2.0	3.0	1.4	0.0	34.7	29.8	T	0.0
8	14	28.4	8.0	0.0	0.0	34.0	0.0	21.0	0.0	22.0	85.4	T	3.2	0.0	1.3	0.4
8	15	6.0	33.8	78.0	0.0	3.8	6.3	0.0	0.0	21.0	79.8	6.9	0.0	49.4	0.0	0.8
8	16	0.0	81.0	6.0	0.0	4.0	10.0	3.6	0.0	34.0	38.4	1.4	11.3	T	0.0	12.0
8	17	2.6	40.0	2.2	4.0	4.8	0.0	32.3	2.0	0.0	1.8	23.4	T	9.4	3.1	23.2
8	18	1.4	10.0	0.4	6.0	0.0	4.0	18.5	16.0	123.0	14.0	0.0	62.3	5.3	T	1.0
8	19	1.6	0.0	0.0	0.0	1.6	1.6	13.4	0.0	13.0	1.4	8.9	0.0	39.7	82.7	22.6
8	20	0.4	28.0	0.0	12.0	32.6	23.4	12.6	0.0	0.0	31.4	63.4	58.4	20.7	76.1	28.0
8	21	0.0	0.0	61.0	16.0	T	7.6	4.4	1.0	39.0	4.2	0.0	4.6	35.7	0.0	1.6
8	22	0.0	0.0	26.6	0.0	16.2	0.0	44.6	10.0	4.0	0.0	8.5	74.2	22.3	0.0	0.0
8	23	0.0	0.0	1.8	0.0	3.0	0.0	2.4	0.0	0.0	39.4	0.0	138.1	3.5	26.4	0.0
8	24	0.0	1.6	38.8	0.0	47.4	18.0	0.0	0.0	0.0	30.0	0.7	0.0	10.7	21.6	0.0
8	25	0.0	0.0	17.0	39.0	24.0	0.0	0.0	22.0	7.0	8.0	0.2	0.0	T	0.8	0.0
8	26	39.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	74.6	9.0	0.0	0.0	0.0	0.0
8	27	72.0	1.8	0.0	0.0	12.2	43.0	25.6	0.0	12.0	71.3	0.0	19.3	T	0.0	0.0
8	28	8.0	36.0	0.0	27.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	T	0.0	0.0
8	29	3.4	2.8	0.0	10.8	0.0	0.0	0.0	15.0	16.0	T	34.8	1.3	0.0	4.3	2.6
8	30	0.0	0.0	0.0	0.0	0.0	2.0	28.0	3.0	56.3	8.0	3.2	0.0	0.0	0.8	0.4
8	31	0.0	0.4	0.0	17.0	0.0	0.0	0.0	4.0	0.0	0.0	30.3	0.0	0.0	6.7	2.2
8					31.8		0.0				0.4	18.0			3.4	

Daily Precipitation (mm)
Location : Damauli

Month	Year Day	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
9	1	0.0	0.0	0.0	17.0	40.4	0.0	28.6	20.0	0.0	T	2.0	17.4	0.0	4.1	65.2
9	2	0.0	10.0	0.0	0.0	0.0	29.6	2.0	0.0	0.0	45.4	29.0	31.7	0.0	17.6	1.8
9	3	0.0	5.0	2.0	7.4	26.8	24.0	0.0	0.0	0.0	3.6	0.0	28.6	0.0	18.2	10.8
9	4	0.0	0.2	0.0	0.4	0.0	32.0	0.0	0.0	13.0	0.0	7.0	0.0	59.7	T	26.6
9	5	0.0	5.0	0.0	39.0	0.0	11.0	0.0	17.0	0.0	0.0	8.2	93.0	13.2	8.1	T
9	6	0.4	1.0	6.0	82.0	0.0	0.0	5.6	8.0	49.0	10.6	1.0	28.3	T	T	0.0
9	7	0.6	0.0	0.0	6.0	6.6	0.0	0.0	6.0	1.2	20.6	8.2	T	T	6.4	0.2
9	8	0.0	0.6	0.0	6.8	0.0	0.0	0.0	6.0	0.0	1.0	6.4	9.6	0.0	0.0	15.8
9	9	0.0	3.2	7.0	6.0	0.0	0.0	0.0	10.0	0.0	2.0	7.8	0.0	0.0	T	14.8
9	10	0.4	16.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	2.6	10.4	0.0	0.0	0.0	131.2
9	11	32.0	2.2	2.0	0.0	30.0	0.0	0.0	3.0	0.0	T	23.4	0.0	0.0	0.0	0.2
9	12	4.4	7.0	0.0	0.0	22.0	0.0	0.0	17.0	0.0	0.0	0.0	4.0	2.1	0.0	12.6
9	13	0.0	0.0	26.0	2.6	0.0	0.0	0.0	3.0	0.0	3.0	0.0	35.3	0.0	T	T
9	14	0.0	2.0	34.0	0.0	64.0	0.0	6.0	0.0	0.0	2.3	0.0	12.3	T	T	3.6
9	15	5.0	0.0	7.0	13.0	56.0	0.0	0.0	0.0	0.0	3.4	17.6	0.0	T	0.0	0.4
9	16	0.0	1.0	0.0	17.0	59.6	0.0	12.4	0.0	0.0	2.4	T	0.0	8.2	T	5.4
9	17	0.0	6.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	1.4	0.0	28.6	1.3	T
9	18	20.0	0.0	0.0	0.0	1.0	4.0	0.0	0.0	0.0	T	13.6	0.0	25.9	1.6	18.2
9	19	1.4	0.0	0.0	0.0	30.6	0.0	0.0	0.0	0.0	0.0	14.8	0.0	28.7	T	0.0
9	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	12.1	31.8
9	21	1.6	0.0	0.0	5.2	0.0	0.0	0.0	18.0	20.0	15.8	0.0	0.0	0.0	3.8	0.4
9	22	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0	53.1	0.0	1.6
9	23	0.0	0.0	0.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	2.7	0.0
9	24	0.4	0.0	0.0	86.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	20.1	0.0
9	25	30.0	0.0	0.0	38.0	0.0	0.0	0.0	0.0	0.0	1.8	T	0.0	7.3	22.3	0.0
9	26	0.0	0.0	0.0	34.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	26.0	2.4	0.0
9	27	0.0	0.0	0.0	0.0	0.0	6.0	43.0	8.0	0.0	T	0.0	0.0	0.0	0.0	0.0
9	28	0.0	0.0	8.0	0.0	0.0	0.0	27.4	0.0	40.0	T	0.0	0.0	0.0	T	6.0
9	29	0.0	0.0	0.0	0.0	0.0	18.0	2.0	1.0	10.0	0.0	0.0	0.0	0.0	0.0	17.5
9	30	0.0	0.0	0.0	0.0	0.0	10.0	2.4	1.0	0.0	3.2	0.0	0.0	0.0	3.1	3.0
10	1	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	2.4	0.0	1.8	0.0	0.0	18.0
10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	2.5	0.0	0.0	8.8
10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	12.0	0.0	0.0	0.0	0.0	0.0	4.2
10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.8	0.0	8.0	0.0	0.0	16.6
10	5	0.0	0.0	4.0	0.0	0.0	0.0	1.0	0.0	0.0	2.0	0.0	0.2	0.0	0.0	0.4
10	6	0.0	0.0	0.0	0.0	0.0	0.0	48.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	T
10	7	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0
10	8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	4.5	0.0	0.0
10	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0
10	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	6.2
10	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	12	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	13	0.0	22.2	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	14	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
10	15	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0	16.6
10	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0
10	17	0.0	0.0	3.0	0.0	0.0	4.0	0.0	0.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0
10	18	0.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0
10	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0
10	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0	0.0
10	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
10	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	9.4	0.0	0.0	0.0	0.0
10	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	26	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0
10	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	31							0.0			0.0					0.0

Location : Damauli

Month	Year Day	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	T	0.0	0.0	0.0
11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.8	0.0	0.0	0.0
11	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	10	0.0	0.0	0.0	0.0	0.0	38.6	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	11	0.0	0.0	0.0	0.0	0.0	39.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	25.8	0.0	0.0
11	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	T	0.0	0.0
11	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	1.0	0.0
11	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.8	0.0	0.0	0.0	0.0
11	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	23	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	24	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	14.6
11	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	T	0.0	0.0	0.0	0.0	0.0
11	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	29	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
11	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	2	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	3	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	4	0.0	0.0	24.2	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.0	DNA	1.6	0.0	0.0	0.0	0.0	0.0
12	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.8	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	24	0.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	25	0.0	35.0	0.0	0.0	0.0	2.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	T
12	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	10.8	0.0
12	27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	3.0	0.0
12	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	30	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DNA	0.0	0.0	0.0	0.0	0.0	0.0
12	31															

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
/Day													
1	0.0	0.0	0.6	0.0	0.0	0.0	0.0	1.0	24.8	9.2	0.0	0.0	0.0
2	0.0	0.0	6.0	0.0	0.0	0.0	0.0	T	4.0	0.2	0.0	0.0	0.0
3	0.0	0.0	5.8	0.0	0.0	0.0	0.0	0.4	4.2	33.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	17.0	0.6	0.0	22.4	0.0	0.0	0.0	8.7
5	0.0	11.4	0.0	0.0	0.0	1.0	0.0	2.5	14.4	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	50.2	0.0	0.0	65.8	0.0	0.0	0.0	0.0
7	0.0	3.2	0.0	0.0	2.6	46.4	4.0	0.2	24.6	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	15.2	0.0	46.6	0.6	31.6	0.2	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	13.6	11.0	5.4	6.4	5.0	26.6	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	161.4	0.0	0.0	5.6	0.0	0.0	0.0	0.0
11	0.0	0.4	0.0	0.0	12.6	0.0	51.4	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	2.8	0.0	0.2	30.6	0.0	3.4	1.4	0.0	0.0	0.0	0.0	0.0
13	0.0	0.2	23.4	0.0	0.0	21.4	7.6	0.2	0.0	0.0	0.0	0.0	0.0
14	0.0	75.6	4.0	0.0	0.0	0.0	T	6.2	0.0	0.0	0.0	0.0	0.0
15	0.0	9.2	0.0	0.0	4.6	26.6	0.0	2.8	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.2	0.0	0.0	2.5	1.4	11.2	0.0	66.2	0.0	0.0	0.0
17	0.0	20.6	0.0	7.8	0.8	22.5	6.6	63.8	0.0	12.4	0.0	0.0	0.0
18	0.0	1.8	0.0	0.4	1.8	10.0	12.6	19.6	7.4	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	1.0	0.0	0.0	4.0	18.6	15.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	T	0.0	78.8	89.2	3.6	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	3.4	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	13.2	6.0	10.6	0.8	12.2	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	2.0	0.0	0.0	0.0	31.6	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	16.6	0.0	0.0	18.4	26.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	24.2	0.0	2.0	16.2	0.2	15.2	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	2.0	0.0	0.0	7.0	0.0	14.6	0.0	0.0	0.0	0.0
27	0.0	1.0	0.0	1.0	0.0	24.2	36.6	11.2	3.8	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	16.2	0.4	0.0	0.0	0.0	0.0	0.0
29	0.0		0.0	0.0	0.0	4.0	5.2	0.0	58.0	0.0	0.0	0.0	0.0
30	0.0			11.0	0.0	5.6	50.0	0.0	146.0	0.0	0.0	0.0	0.0
31	0.0		0.0		0.0		19.0	18.0		0.0		0.0	0.0
Total Annual	0.0	126.2	55.2	99.0	78.0	526.3	410.6	251.5	465.8	78.8	0.0		8.7 2,100.0

Year	2008											
Month/Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	4.6	12.4	24.6	0.8	26.2	0.0	0.0	0.0
2	0.0	0.0	0.0	0.4	4.6	0.0	28.2	0.0	0.4	0.0	0.0	0.0
3	0.0	0.0	0.0	20.6	10.4	13.2	1.6	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	21.4	0.4	92.0	14.2	1.8	12.2	43.6	0.0	0.0	0.0
5	0.0	0.0	0.0	18.4	0.0	13.8	6.0	8.5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	15.2	8.4	11.2	12.6	1.4	6.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	18.2	6.0	0.0	28.4	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	T	24.2	0.0	10.0	0.0	0.0
9	0.0	0.0	0.0	0.0	2.0	4.6	0.0	0.0	6.0	5.0	0.0	0.0
10	0.0	0.0	0.0	0.0	22.0	46.8	0.0	13.0	0.6	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	4.5	12.4	0.0	8.4	T	8.0	0.0	0.0
12	0.0	0.0	0.0	9.2	0.0	0.8	T	8.6	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	10.2	T	8.8	7.4	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	8.2	0.0	0.0	8.4	39.8	0.4	0.0	0.0	0.0
15	0.0	0.0	0.0	4.0	0.0	84.0	T	49.5	5.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	2.8	19.4	6.6	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	7.2	0.0	0.6	8.4	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	3.0	0.0	0.0	T	8.4	0.0	1.0	0.0	0.0
19	8.0	0.8	13.8	0.0	0.6	14.2	27.0	5.0	40.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	T	26.8	20.2	10.8	41.0	0.0	0.0	0.0
21	0.0	0.0	4.0	0.0	T	5.6	25.4	11.0	32.6	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	3.0	0.0	2.0	0.0	T	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	2.7	T	0.0	0.2	0.0	0.0
24	0.0	0.0	45.6	19.6	9.4	1.3	3.0	1.2	0.0	0.0	0.0	0.0
25	0.0	0.0	0.6	0.0	4.5	T	20.3	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	2.6	0.0	2.2	34.5	1.0	0.0	0.0	1.0
27	0.4	0.0	0.0	0.0	0.0	0.5	0.6	87.0	0.0	0.0	0.0	0.0
28	0.0	0.0	2.2	0.0	3.6	2.6	5.4	14.2	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	36.0	0.0	18.4	7.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.6	0.0	22.2	3.6	8.5	2.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	12.7	0.0	1.6	6.0	0.0	0.0	0.0	0.0
Total Annual	8.4	0.8	90.4	97.2	170.5	337.0	231.7	412.1	209.5	23.0	0.0	1.0

Year	2009
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Month /Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	11.2	0.0	0.0	16.4	1.2	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	1.2	8.0	T	16.4	0.0	37.2	0.0	0.0
3	0.0	0.0	0.0	0.0	T	0.0	0.0	1.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	T	0.0
5	0.0	0.0	0.0	0.0	13	0.0	T	13.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	20.2	56.4	4.8	26.2	3.8	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	45.8	3.0	50.2	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.6	0.0	0.0	35.2	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8	18.2	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	2.5	T	0.0	15.2	0.0	0.0	0.0
12	0.0	2.6	0.0	0.0	0.0	20.6	T	15.2	0.0	0.0	0.0	T
13	0.0	0.0	0.0	0.0	0.0	29.8	5.2	4.4	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	25.2	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	T	0.0	28.2	45.2	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	8.2	6.2	0.0	0.0	5.5	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	16	10.2	0.0	17.6	27.2	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	16.4	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	2.4	51.4	0.0	1.0	0.0	T	0.0	0.0
21	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	8.0	22.4	39.4	4.2	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	14.2	25.2	0.0	0.0	12.8	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	44.2	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	2.0	1.6	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	7.2	0.0	0.0	0.0
27	0.0	0.0	0.0	4.0	0.0	8.2	60.2	29.4	40.4	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	2.4	38.6	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	1.0	4.4	0.0	15.2	21.4	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.8	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	6.2	0.0	12.5	20.2	0.0	0.0	0.0
Total Annual	0.0	2.6	5.0	38.3	201.9	280.0	308.1	296.5	74.8	85.4	0.0	1,292.0

1,292.6

Year	2010
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Month /Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	0.0	12.2	0.0	18.2	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	35.4	0.0	14.3	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	13.2	9.3	0.0	28.2	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	T	0.0	0.0	0.0	45.2	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	25.4	0.0	0.0	22.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	10.6	21.2	14.2	0.0	20.2	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	2.6	9.4	0.0	6.1	36.2	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	9.2	0.0	0.0	0.0	5.2	0.0	0.0	0.0
9	0.0	12.4	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0
10	0.0	29.8	0.0	37.6	0.0	0.0	10.2	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	2.4	0.0	67.2	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	8.0	24.2	0.0	37.2	0.0	0.0	0.0
13	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	6.5	0.0	6.5	0.0	0.0	0.0	6.2	14.2	0.0	0.0	0.0	0.0
15	0.0	0.0	20.2	0.0	0.0	0.0	3.4	4.4	0.0	T	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	45.2	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	20.4	0.0	31.3	12.2	0.0	0.0	0.0
18	0.0	0.0	0.0	8.2	30.2	0.0	29.2	0.0	13.2	0.0	0.0	0.0
19	0.0	0.0	0.0	74.6	0.0	0.0	50.2	18.2	48.4	0.0	0.0	0.0
20	0.0	0.0	0.0	6.2	9.4	0.0	8.2	54.4	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	12.2	0.0	0.0	50.2	0.0	10.2	0.0	0.0
22	0.0	0.0	T	0.0	0.0	0.0	9.2	34.2	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	13.2	0.0	30.0	0.0	6.2	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.2	10.2	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	2.2	0.0	6.2	18.2	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	T	0.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	T	0.0	0.0	50.4	2.2	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	16.2	44.6	0.0	135.1	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	4.2	0.0	14.2	0.0	0.0	0.0	0.0
30	0.0	12.8	20.4	0.0	0.0	0.0	45.2	59.4	0.0	0.0	0.0	0.0
31	0.0	32.0	0.0	0.0	46.5	0.0	15.2	20.2	0.0	0.0	0.0	T
Total Annual	6.5	38.3	71.5	147.0	166.9	172.8	365.9	575.0	319.6	16.4	0.0	1,879.9

1,879,9

Month /Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.2	2.2	0.0	25.2	5.1	20.4	6.2	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	2.2	6.2	11.2	45.2	0.0	6.2	0.0	T	0.0
3	0.0	0.0	0.0	0.0	T	0.0	10.2	40.2	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	48.2	14.2	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	12.2	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2	0.0
7	0.0	0.0	0.0	0.0	11.2	0.0	0.0	24.2	24.2	0.0	10.2	0.0
8	0.0	0.0	0.0	0.0	0.0	7.2	0.0	14.2	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	T	0.0	29.4	0.0	T	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	T	0.0	36.2	12.2	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	34.2	10.2	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	4.5	0.0	0.0	40.2	180.2	0.0	0.0	0.0	0.0
15	0.0	20.0	0.0	0.0	0.0	0.0	60.2	0.0	0.0	0.0	0.0	0.0
16	0.0	8.2	0.0	0.0	0.0	8.2	4.2	0.0	0.0	0.0	18.4	0.0
17	5.2	12.2	0.0	0.0	0.0	0.0	0.0	10.3	0.0	0.0	10.4	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.2	0.0	0.0	0.0
19	0.0	0.0	0.0	T	26.2	0.0	0.0	26.2	6.2	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	26.2	0.0	58.2	18.0	4.2	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	26.2	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.2	29.3	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	5.2	0.0	8.2	4.2	40.2	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	T	25.2	0.0	80.2	35.2	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	3.2	30.2	0.0	3.3	10.2	0.0	0.0	0.0
27	0.0	0.0	0.0	30.4	0.0	6.2	0.0	4.3	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	50.2	42.2	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	28.2	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	6.0	7.4	14.0	24.2	30.6	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	19.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Annual	7.4	42.6	25.4	69.7	131.5	250.8	392.0	480.1	191.1	0.0	54.2	1.644.8

Year	2012											
Month /Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	00	00	00	32	00	00	32	00	00	602	00	00
2	00	00	00	00	00	00	00	54	00	00	00	00
3	00	00	00	00	00	00	00	282	00	00	00	00
4	00	00	00	00	41	134	00	222	00	234	82	00
5	00	00	00	00	31.3	2.2	12.2	8.5	00	12.2	00	00
6	00	00	00	00	152	00	00	1110	00	112	00	00
7	00	00	00	00	00	00	00	550	00	00	00	00
8	00	22.3	00	112	00	00	00	85	00	00	00	00
9	00	35.2	00	52	00	00	00	542	00	00	00	00
10	00	00	00	102	00	82	00	52	42	00	00	00
11	00	00	00	52	64	00	00	00	52	00	00	00
12	00	00	00	00	00	00	00	152	00	142	00	00
13	00	00	00	00	00	32	00	1200	00	00	00	00
14	00	00	00	00	00	00	00	00	00	192	00	00
15	00	00	00	00	00	00	00	222	00	242	00	00
16	00	00	252	00	182	00	00	00	552	00	00	00
17	00	00	00	00	00	00	152	133	00	502	00	00
18	00	00	00	00	134	22	00	134	152	00	00	00
19	00	00	00	00	00	00	00	30.3	00	00	00	00
20	00	00	00	00	65	00	164	00	00	00	00	00
21	00	00	00	00	00	00	4.5	00	00	00	00	00
22	00	00	00	00	65	00	00	552	00	00	00	00
23	00	00	00	00	00	00	124	254	00	00	00	00
24	00	00	00	00	00	02	134	42	00	00	00	00
25	00	00	00	00	00	00	152	547	00	00	00	00
26	00	00	00	00	00	00	15.2	142	00	00	00	00
27	00	00	00	00	00	00	54	00	00	00	00	00
28	00	00	00	00	00	00	30.0	54	00	00	00	00
29	00	00	00	00	00	130	00	00	00	00	00	00
30	00	00	00	00	00	00	182	00	00	00	00	00
31	00	00	00	00	00	00	00	00	00	00	00	00
Total Annual	00	575	284	824	988	2658	5454	1912	2946	82	00	1572.3

Year		2005		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Month	Day	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin
1	16.5	11.0	21.5	12.5	28.0	14.5	33.5	13.0	22.5	17.0	37.5	19.5	33.5	25.0	38.0	25.5	35.5	25.0	34.0	23.0	28.0	17.5	20.0	13.5	20.0	13.5	
2	20.0	11.5	21.5	11.5	29.5	17.0	32.5	13.0	30.5	17.0	37.0	18.0	34.5	25.5	38.0	25.0	35.0	25.0	38.0	23.0	27.0	17.0	20.0	13.5	20.0	13.5	
3	20.0	10.5	21.0	10.0	29.5	15.0	32.0	14.0	32.5	17.0	36.5	15.5	33.5	25.0	38.0	25.0	35.0	25.0	38.0	23.0	27.0	17.0	20.0	13.5	20.0	13.5	
4	20.0	11.0	21.0	11.0	29.5	15.0	32.0	14.0	32.5	17.0	36.5	15.5	33.5	25.0	38.0	25.0	35.0	25.0	38.0	23.0	27.0	17.0	20.0	13.5	20.0	13.5	
5	22.0	11.0	22.5	11.0	28.5	18.0	32.5	15.5	32.5	20.0	38.5	15.0	31.5	24.5	38.5	22.0	32.0	24.0	34.0	22.5	27.5	14.0	19.5	13.0	20.0	13.5	
6	22.0	11.0	22.5	11.0	31.5	15.5	32.5	20.0	34.5	24.5	34.0	16.0	32.5	23.5	31.5	24.5	31.0	25.0	34.0	23.0	28.0	13.5	21.5	13.0	20.0	13.5	
7	23.5	11.5	23.0	11.0	32.0	14.5	34.0	18.0	29.5	18.5	31.0	16.5	36.0	25.0	31.5	25.0	33.0	24.0	34.0	22.0	24.5	13.0	21.5	12.5	20.0	13.5	
8	22.5	10.5	17.0	11.5	30.0	16.0	32.0	18.5	31.5	18.0	33.5	17.5	32.5	21.5	35.0	23.0	33.0	23.0	31.5	24.5	21.5	23.5	13.0	20.5	12.0	20.0	13.5
9	21.0	10.0	17.6	11.5	32.5	18.0	32.5	20.0	31.5	22.0	35.5	18.0	34.5	25.0	35.5	25.0	33.0	22.0	31.5	21.5	25.5	13.5	20.5	11.5	20.0	13.5	
10	19.0	10.5	25.5	10.5	32.0	17.0	33.0	15.0	35.0	22.5	37.5	18.5	28.8	25.5	34.5	28.0	34.0	24.0	31.5	20.5	25.0	13.5	21.0	12.0	20.0	13.5	
11	19.0	8.5	26.5	12.0	28.5	14.5	34.0	15.0	34.5	20.5	38.0	19.0	33.0	24.5	34.5	28.0	35.5	24.0	31.0	20.5	25.0	14.0	20.5	10.5	20.0	13.5	
12	19.5	9.5	27.0	14.0	29.5	13.5	34.0	13.5	33.0	17.5	35.5	14.0	34.5	24.5	34.8	25.0	33.5	24.5	31.0	20.0	25.0	15.5	19.5	10.0	20.0	13.5	
13	19.0	9.5	27.0	14.0	29.5	13.5	34.0	13.5	33.0	17.5	35.5	14.0	34.5	24.5	34.8	25.0	33.5	24.5	31.0	20.0	25.0	15.5	19.5	10.0	20.0	13.5	
14	21.0	8.5	26.0	12.0	28.5	14.5	34.0	15.0	34.5	20.5	38.0	19.0	33.0	24.5	34.5	28.0	35.5	24.0	31.0	20.5	25.0	14.0	20.5	10.5	20.0	13.5	
15	21.0	8.5	26.0	12.0	33.0	13.0	35.0	13.0	33.5	17.5	36.0	25.5	33.0	24.5	35.5	29.0	30.0	23.0	31.5	19.5	24.0	15.0	19.0	9.0	20.0	13.5	
16	20.5	10.0	25.5	14.0	32.5	14.5	37.0	18.2	34.5	19.5	37.5	26.0	33.0	24.5	34.5	24.5	29.5	24.5	31.5	19.5	23.5	15.5	19.0	9.5	20.0	13.5	
17	21.0	11.5	27.0	12.5	27.5	18.5	34.0	17.0	33.0	19.5	37.5	25.0	29.5	23.5	34.5	24.5	25.5	23.0	32.0	19.0	24.0	15.0	19.0	9.0	20.0	13.5	
18	17.5	11.5	27.0	10.5	31.0	19.5	35.0	18.0	33.5	21.0	36.0	24.5	31.5	24.5	35.5	26.5	32.5	23.5	31.5	18.0	23.0	15.0	18.0	9.5	20.0	13.5	
19	18.0	10.0	27.5	11.0	31.0	13.0	36.5	15.5	34.0	18.0	35.0	21.5	30.5	23.0	32.5	23.5	36.0	25.0	27.0	19.5	23.5	14.5	18.5	10.0	20.0	13.5	
20	19.5	9.0	25.5	9.5	30.5	17.0	36.5	15.0	34.5	18.5	31.5	17.5	32.0	23.5	33.5	24.0	35.5	23.5	21.5	17.0	23.5	13.5	21.0	9.5	20.0	13.5	
21	20.0	8.5	27.0	9.5	31.0	17.0	35.0	18.5	33.5	17.5	32.0	23.5	34.5	21.5	33.0	24.5	32.5	23.5	22.5	16.5	24.0	14.5	22.5	10.0	20.0	13.5	
22	21.0	11.5	26.0	9.5	27.5	17.5	32.5	18.0	34.0	22.0	30.5	23.5	35.5	25.0	31.0	24.5	33.0	24.5	22.0	18.0	23.5	14.5	22.0	11.0	20.0	13.5	
23	17.5	11.5	27.0	10.5	31.0	15.0	34.5	19.0	33.5	20.0	30.5	17.5	31.5	23.0	31.5	24.5	33.0	25.5	28.5	18.0	23.5	14.5	22.0	11.0	20.0	13.5	
24	19.5	10.5	27.0	11.5	31.0	14.5	34.0	18.5	33.5	20.0	30.5	17.5	31.5	23.0	31.5	24.5	33.0	25.5	28.5	18.0	23.5	14.5	22.0	11.0	20.0	13.5	
25	20.0	10.5	28.5	12.0	28.5	12.0	35.5	18.5	35.0	18.0	36.5	18.5	35.5	23.0	31.5	24.0	34.5	24.0	25.0	19.0	22.0	15.5	20.5	10.0	20.0	13.5	
26	20.0	11.0	27.5	13.5	30.5	14.5	35.5	18.5	36.0	21.0	35.5	25.5	34.5	25.0	31.0	24.5	33.5	24.0	28.5	19.5	22.5	15.0	21.0	10.5	20.0	13.5	
27	21.0	10.5	28.5	14.0	30.5	15.5	35.0	17.5	36.0	21.0	35.5	24.5	35.0	25.0	30.0	25.0	33.5	24.0	28.0	19.0	21.5	14.5	19.5	10.0	20.0	13.5	
28	18.0	11.5	28.5	14.5	32.0	16.0	32.5	19.0	36.5	25.0	34.5	25.0	35.5	25.0	31.0	26.0	35.5	23.5	29.0	19.0	21.0	14.0	18.5	8.5	20.0	13.5	
29	19.5	11.0		31.5	15.5	34.0	11.0	36.5	22.5	33.5	25.5	36.0	25.5	34.0	24.0	34.5	25.0	29.0	17.5	20.5	13.0	17.5	9.0	20.0	13.5		
30	21.0	10.0		31.5	14.5	22.5	17.0	36.5	17.5	34.0	25.0	36.0	25.5	35.0	24.5	34.5	23.5	28.0	18.5	19.5	13.0	17.5	9.5	20.0	13.5		
31	22.0	13.2		33.0	14.0			37.0	19.0			35.5	26.0	35.0	25.0				26.5		18.0		18.5	10.0	20.0	13.5	

Year 2008

Month	Day	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin
1	18.5	9.5	25.0	10.0	32.0	12.5	33.0	14.5	38.0	21.0	38.0	23.0	36.0	24.5	37.0	25.5	34.5	23.5	33.0	24.0	28.0	16.5	21.0	11.5	
2	18.5	9.5	25.0	11.5	29.5	10.5	34.0	14.5	35.0	19.0	31.5	23.5	36.5	24.5	34.5	24.5	34.5	23.0	33.5	24.5	28.5	16.5	21.5	11.5	
3	19.5	8.5	25.0	10.5	30.5	12.5	33.5	12.5	33.5	18.5	31.5	23.5	37.0	25.0	33.5	23.0	33.0	23.5	33.0	24.0	28.5	17.5	24.5	12.0	
4	19.5	9.5	25.0	11.5	30.0	12.5	34.0	14.5	36.0	19.5	32.5	24.5	37.5	25.5	34.5	24.5	34.5	23.5	33.5	24.5	29.0	17.5	24.5	12.5	
5	20.0	9.5	25.0	11.5	31.5	13.5	35.0	15.5	37.0	20.5	33.5	25.5	38.5	26.5	35.5	25.0	35.0	24.0	34.0	25.0	29.5	17.5	24.5	12.5	
6	18.5	10.0	25.0	12.5	32.0	11.0	32.0	17.0	35.0	20.0	33.0	23.5	34.5	23.0	34.0	23.5	34.0	23.5	34.1	24.0	32.5	20.0	18.5	20.0	
7	19.5	10.5	25.0	13.0	31.5	12.5	31.0	18.5	34.5	22.5	33.5	24.0	32.0	25.0	35.0	24.0	34.0	24.0	33.0	23.0	29.0	15.5	22.5	12.0	
8	19.0	10.0	25.0	13.5	31.2	15.5	30.0	18.5	29.5	21.0	34.5	24.8	33.5	25.0	35.5	23.5	32.5	24.0	34.0	23.5	28.5	14.5	23.0	12.5	
9	20.0	9.0	25.0	12.5	31.5	15.5	31.0	20.0	31.5	22.0	33.5	25.0	35.5	25.0	35.5	23.5	26.5	23.2	32.5	24.0	23.5	13.5	24.0	13.5	
10	18.5	9.5	26.5	11.5	30.0	15.0	33.5	19.5	30.0	20.0	33.5	23.5	31.5	24.5	34.5	23.5	27.0	22.0	32.5	21.0	28.5	14.0	21.0	13.0	
11	19.5	10.0	26.5	11.0	31.5	15.0	33.5	17.5	33.0	21.5	34.0	24.0	33.5	24.5	36.5	24.0	27.5	23.0	33.0	22.5	27.0	13.0	13.0	16.5	
12	20.5	10.0	26.5	12.5	32.0	15.0	34.0	19.5	30.5	20.0	36.0	24.5	33.5	29.5	36.5	24.5	31.0	23.5	32.0	21.5	28.0	15.5	22.0	12.2	
13	20.5	9.0	27.5	12.5	29.5	13.5	33.5	17.0	33.0	20.5	38.0	21.5	33.0	25.0	35.0	25.0	31.0	23.5	30.0	21.5	29.0	15.5	21.0	12.0	
14	21.0	10.5	27.5	12.0	32.0	13.5	33.5	17.0	33.5	20.0	35.0	25.0	32.0	26.0	34.5	23.0	31.0	23.5	30.0	21.5	27.0	16.5	21.0	11.5	
15	20.0	9.5	26.0	12.0	22.0	13.5	34.0	16.5	33.0	24.5	34.5	20.5	34.5	24.5	33.5	23.5	33.5	20.0	31.5	22.5	27.5	16.5	20.5	12.5	
16	18.5	9.5	26.0	14.5	28.5	15.0	35.0	17.5	35.0	23.0	34.0	20.5	34.5	24.5	33.5	23.5	33.5	20.0	31.5	21.5	27.5	16.5	20.5	12.0	
17	18.0	10.5	26.5	13.5	29.0	11.0	34.5	15.5	36.5	21.5	35.0	22.5	31.5	24.0	37.0	24.0	33.5	22.5	31.0	20.0	26.0	15.5	18.5	13.0	
18	19.5	11.5	27.0	12.5	30.0	10.5	23.0	16.5	34.5	23.5	35.0	21.5	36.0	25.5	37.0	25.0	34.5	22.5	31.0	20.0	25.5	14.5	21.0	12.0	
19	20.5	11.5	27.5	13.0	31.0	12.0	21.6	16.5	34.5	20.5	35.5	22.0	33.0	23.5	34.0	25.5	34.5	23.5	29.0	16.5	26.5	15.5	21.5	12.0	
20	19.5	10.0	29.0	13.5	31.5	12.5	30.0	16.0	34.0	21.0	35.0	22.5	35.5	25.0	36.5	24.5	34.0	24.0	30.0	19.5	24.5	16.0	21.0	12.0	
21	22.0	8.5	30.0	17.5	32.0	14.0	29.5	19.0	30.0	21.5	35.5	24.5	33.5	24.5	36.5	25.5	33.5	23.5	30.0	18.0	23.0	15.5	22.0	12.0	
22	21.5	8.5	29.5	18.5	31.5	17.5	31.0	17.5	34.0	24.5	34.0	23.0	32.5	24.5	34.5	24.0	27.5	23.5	29.5	18.5	25.5	15.0	20.0	12.5	
23	21.0	8.0	30.0	18.0	31.5	15.5	32.5	18.0	35.0	22.0	34.0	24.0	32.5	25.0	33.0	24.5	30.0	23.5	30.5	18.0	24.0	14.0	20.0	12.5	
24	21.0	8.0	30.0	18.0	31.5	15.5	32.5	18.0	35.0	22.0	34.0	24.0	32.5	25.0	33.0	24.5	30.0	23.5	30.5	18.0	24.0	14.0	20.0	12.5	
25	20.5	7.5	30.5	17.5	33.5	15.5	33.0	18.0	36.0	27.0	31.5	24.0	33.0	23.0	32.0	24.5	32.0	23.0	29.5	17.5	21.5	13.0	19.5	11.5	
26	20.5	7.0	30.5	17.5	34.0	15.5	35.0	20.0	33.5	24.0	31.0	24.5	31.5	23.5	26.0	24.0	33.0	22.0	30.5	17.5	23.5	11.5	18.5	11.5	
27	21.0	7.5	33.5	17.0	35.0	14.0	35.0	20.0	33.5	24.0	31.0	24.5	31.5	23.5	34.0	23.5	34.0	23.0	30.0	18.0	23.5	11.5	20.0	12.5	
28	21.0	8.5	34.0	12.0	36.5	15.0	36.5	22.5	35.5	22.5	33.5	23.5	34.0	23.5	34.0	23.5	34.0	23.5	30.5	18.5	23.5	11.5	20.0	12.5	
29	21.0	8.5	34.0	12.0	36.5	15.0	36.5	22.5	35.5	22.5	33.5	23.5	34.0	23.5	34.0	23.5	34.0	23.5	30.5	18.5	23.5	11.5	20.0	12.5	
30	23.5	8.5	34.0	12.0	38.5	15.0	36.5	18.0	34.5	19.5	34.0	24.0	35.0	24.0	35.0	23.5	33.5	25.0	31.0	17.5	22.0	10.5	16.5	12.5	
31	24.0	10.0	34.0	12.0	38.5	15.0	36.5	23.5	35.5	22.5	34.5	24.5	35.5	24.5	35.5	23.0	31.0	24.0	33.5	23.5	21.0	17.5	17.0	12.5	

Year	Month	Day	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		
			Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	
2007	1	17.5	12.0	17.5	12.0	22.0	13.5	36.5	20.5	38.5	20.0	38.0	21.0	36.0	25.5	31.3	23.4	34.5	24.2	27.7	23.0	27.5	18.2	23.6	11.2	23.6	
	2	18.0	9.5	23.5	16.5	24.0	13.0	36.5	19.5	38.5	20.5	38.5	20.5	34.5	26.5	34.0	34.0	34.0	34.0	34.0	34.0	28.0	18.5	22.5	10.6		
	3	19.0	11.5	24.5	19.5	25.5	12.5	36.5	18.5	38.5	20.5	37.0	18.0	34.5	26.5	33.5	30.0	32.0	33.8	33.0	23.7	28.0	18.5	24.0	11.6		
	4	22.5	9.0	22.5	17.5	12.5	34.0	16.5	35.5	22.0	34.5	20.0	36.2	24.5	24.5	34.0	34.0	34.0	34.0	34.0	34.0	34.0	28.0	18.5	24.0	11.6	
	5	19.0	10.0	22.0	15.0	26.5	12.5	33.5	18.5	37.0	20.0	36.5	17.5	36.5	24.5	34.0	34.0	34.0	34.0	34.0	34.0	34.0	28.0	18.5	24.0	11.6	
	6	19.0	10.0	20.0	15.0	26.5	12.5	33.5	18.5	37.0	20.0	36.5	17.5	36.5	24.5	34.0	34.0	34.0	34.0	34.0	34.0	34.0	28.0	18.5	24.0	11.6	
	7	19.5	10.0	16.5	13.0	27.0	11.5	35.0	18.5	32.0	21.0	34.0	23.0	34.5	25.5	36.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	
	8	20.0	9.5	21.5	13.0	27.0	12.0	35.5	18.5	34.5	21.0	32.0	23.5	34.5	25.5	36.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	
	9	20.0	10.0	22.5	12.5	27.5	12.5	34.5	17.5	38.5	20.0	32.0	25.0	35.5	25.5	36.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	
	10	19.0	10.0	22.5	13.0	28.0	13.0	34.0	16.5	35.0	21.0	32.0	25.0	35.5	25.5	36.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	
	11	20.0	10.0	19.5	13.0	29.0	10.5	32.5	18.0	33.0	19.0	37.5	24.5	31.5	24.5	31.5	24.5	31.5	24.5	31.5	24.5	31.5	24.5	31.5	24.5	31.5	
	12	21.5	9.5	22.5	13.5	22.5	13.0	32.5	19.0	35.5	19.5	36.0	25.5	32.5	24.5	32.5	24.5	32.5	24.5	32.5	24.5	32.5	24.5	32.5	24.5	32.5	
	13	22.5	9.5	22.5	13.5	22.5	13.0	32.5	19.0	35.5	19.5	36.0	25.5	32.5	24.5	32.5	24.5	32.5	24.5	32.5	24.5	32.5	24.5	32.5	24.5	32.5	
	14	19.5	7.0	16.0	11.0	26.0	14.0	32.5	18.5	34.0	24.0	32.0	33.5	24.5	35.5	25.5	32.5	26.0	34.0	27.0	23.0	25.0	12.0	21.0	10.6	21.0	
	15	18.5	6.5	20.5	8.5	26.5	11.0	35.5	17.5	31.5	18.5	32.5	34.5	32.5	25.0	36.4	34.5	34.6	24.3	29.2	21.3	25.0	11.0	19.5	9.5	19.5	
	16	17.0	7.0	19.0	9.5	26.5	11.5	35.0	22.0	32.5	17.0	30.2	25.2	37.0	25.0	27.7	24.5	34.8	24.0	23.3	19.0	25.0	11.5	19.2	8.5	19.2	
	17	17.5	7.5	19.5	9.5	27.5	13.5	34.5	20.5	33.0	16.0	35.0	25.1	27.0	25.0	28.0	24.0	34.4	23.3	28.0	18.5	24.0	12.0	19.0	7.0	19.0	
	18	17.5	8.0	22.5	10.0	28.0	13.5	36.5	19.5	33.5	17.8	34.5	24.5	34.7	24.0	31.6	24.0	28.4	22.4	28.2	18.6	25.0	12.2	18.8	7.2	18.8	
	19	21.0	8.5	24.5	15.5	30.0	14.0	33.5	20.0	32.5	18.2	35.5	26.0	35.5	26.0	35.5	25.0	34.3	22.5	28.0	19.8	25.5	12.0	19.5	7.5	19.5	
	20	21.5	9.0	25.5	16.0	31.0	15.5	36.0	18.0	34.0	19.5	36.0	26.0	36.0	26.0	36.0	26.0	34.4	23.4	28.2	19.8	25.5	12.0	19.5	7.5	19.5	
	21	17.5	9.5	26.0	12.0	31.5	16.0	33.0	18.0	34.5	23.0	35.0	26.0	35.0	25.0	34.0	25.0	24.0	34.3	25.2	26.8	19.2	24.5	12.8	16.6	9.0	
	22	18.5	10.0	27.0	13.5	32.0	16.5	33.5	18.5	35.0	22.0	35.5	26.0	29.8	24.8	35.0	24.0	34.2	24.4	26.0	19.8	25.0	12.4	18.0	9.5	18.0	
	23	20.5	9.5	28.0	13.5	31.5	18.5	33.5	17.0	37.0	20.5	35.5	23.5	32.2	23.5	34.6	23.8	34.0	23.5	30.0	19.2	25.0	11.7	17.8	9.4	17.8	
	24	20.0	10.5	28.0	14.0	32.0	18.5	31.0	17.5	38.5	22.0	34.5	25.5	27.2	19.5	32.0	23.5	35.2	22.0	30.0	19.0	25.5	12.0	16.8	9.6	16.8	
	25	21.0	10.0	29.0	14.0	32.0	18.5	31.0	17.5	38.5	22.0	34.5	25.5	27.2	19.5	32.0	23.5	35.2	22.0	30.0	19.0	25.5	12.0	16.8	9.6	16.8	
	26	21.0	10.0	24.5	13.0	32.0	14.0	33.0	16.5	37.5	21.0	34.2	25.2	29.4	24.0	33.0	23.3	32.4	21.9	26.8	15.5	23.3	11.0	19.0	10.0	19.0	
	27	22.5	10.0	24.5	13.0	32.0	14.0	33.0	16.5	37.5	21.0	34.2	25.2	29.4	24.0	33.0	23.3	32.4	21.9	26.8	15.5	23.3	11.0	19.0	10.0	19.0	
	28	24.0	11.0	24.5	13.5	31.5	18.5	33.0	16.0	38.0	20.5	36.2	24.0	27.3	23.4	32.2	23.4	32.2	23.4	18.0	26.5	13.5	23.3	11.3	19.0	10.0	19.0
	29	21.0	10.0	21.5	12.5	33.5	19.5	34.5	19.5	38.0	21.0	36.5	25.0	29.3	23.5	34.4	26.0	23.0	28.2	19.0	23.0	10.5	19.0	9.2	19.0	9.2	
	30	21.5	11.0	24.5	13.5	33.5	19.5	34.5	19.5	38.0	21.0	36.5	25.0	29.3	23.5	34.4	26.0	23.0	28.2	19.0	23.0	10.5	19.0	9.2	19.0	9.2	
	31	25.0	9.5	25.0	9.5	34.5	17.5	30.5	20.0	37.5	20.0	35.0	26.0	29.5	23.0	33.0	24.8	35.6	24.5	27.5	18.5	23.2	11.0	18.2	8.8	18.2	
32	25.5	11.0	31.5	18.5	35.5	18.5	32.5	21.0	38.5	21.0	35.0	26.0	29.5	23.0	33.0	23.7	35.0	24.5	27.5	18.5	23.2	11.0	18.2	8.8	18.2		

Year 2008

Month Day	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin
1	19.0	9.6	16.2	4.0	25.8	10.6	30.3	12.0	34.2	19.4	35.0	19.4	34.0	13.6	35.2	22.5	33.5	21.0	33.2	19.8	30.5	14.5	24.0	8.5
2	18.0	9.4	15.0	4.8	25.8	11.5	30.3	13.5	34.2	19.4	35.0	19.4	34.0	13.6	35.2	22.5	33.5	21.0	33.2	19.8	30.5	14.5	24.0	8.5
3	19.8	9.4	18.0	4.8	27.0	12.5	32.0	12.5	34.0	19.2	34.2	18.5	35.4	13.0	35.0	22.0	34.8	21.7	32.7	21.5	29.5	15.5	23.0	10.2
4	19.2	9.0	23.5	6.0	27.4	11.6	30.0	12.5	32.0	15.5	35.5	18.5	35.0	21.4	33.5	21.8	35.0	23.7	32.8	22.5	29.5	14.2	23.0	8.6
5	20.6	8.0	25.5	6.4	27.5	13.2	29.7	12.7	35.0	17.2	35.4	20.5	35.8	22.0	33.5	21.5	35.0	20.0	33.0	22.0	27.5	13.4	25.0	8.3
6	19.2	8.0	24.8	7.4	27.0	14.8	25.2	14.5	32.2	16.0	33.8	20.0	34.8	21.8	34.5	21.7	30.7	20.6	33.5	20.0	28.2	14.5	25.5	9.0
7	19.5	8.2	24.8	7.4	28.4	13.4	27.8	14.8	32.5	15.2	32.5	19.8	37.0	23.6	30.8	21.5	34.2	21.0	32.5	22.5	28.5	14.0	23.5	8.5
8	18.5	8.5	25.5	9.0	29.0	13.2	29.5	15.0	33.7	21.0	31.4	18.8	36.4	22.6	35.3	21.0	34.7	21.0	31.0	19.0	27.5	12.0	25.0	9.0
9	22.5	9.0	25.4	8.4	29.5	13.4	32.0	14.0	32.2	15.0	33.0	20.2	36.0	21.4	32.5	23.0	35.0	21.5	30.0	20.0	27.0	13.6	22.5	7.5
10	20.0	11.0	24.5	7.0	30.0	15.0	34.8	15.8	30.8	15.0	31.5	19.5	35.4	21.8	35.0	21.5	35.5	22.0	31.0	20.5	26.0	14.0	21.5	7.5
11	21.4	10.0	24.0	7.4	29.8	14.5	35.0	23.0	32.3	15.8	33.8	20.0	36.0	23.2	36.0	22.5	35.0	21.0	31.4	19.5	28.0	16.0	20.5	7.5
12	21.0	9.4	25.5	7.5	31.0	14.0	35.2	18.6	35.0	17.0	36.8	24.2	34.5	22.2	35.8	22.0	35.0	22.0	31.7	19.5	28.0	16.0	20.5	8.0
13	18.5	9.5	22.5	7.8	31.8	13.4	34.0	15.0	34.4	15.8	35.0	21.2	34.2	22.2	35.2	21.5	35.4	21.5	30.5	18.4	25.0	12.0	21.5	7.0
14	18.5	9.5	22.5	6.2	33.7	15.0	35.0	15.2	35.2	17.2	35.2	21.4	34.2	21.5	35.5	20.5	34.0	20.5	30.5	18.0	25.0	12.0	21.5	7.0
15	22.5	9.0	22.2	6.0	32.4	11.5	32.0	14.8	35.2	17.2	35.8	23.4	35.2	21.5	35.5	20.5	34.0	20.5	31.8	17.5	25.5	12.5	21.0	6.0
16	20.0	10.0	24.5	9.0	32.5	14.5	34.4	14.5	35.2	18.2	35.2	25.0	34.0	17.2	36.5	21.5	35.5	22.0	31.5	17.8	25.5	12.0	21.0	6.0
17	22.0	10.4	24.5	9.0	33.2	11.2	34.5	15.0	34.0	18.5	35.6	25.5	33.5	22.2	31.5	21.5	34.2	20.5	32.0	17.8	25.8	11.8	21.0	6.0
18	18.0	9.8	25.5	8.0	28.0	15.5	36.3	14.6	33.2	19.0	34.2	21.2	33.5	22.2	31.5	21.5	34.2	20.5	32.0	17.8	25.8	11.8	21.0	6.0
19	22.6	10.5	23.0	8.4	29.8	14.2	36.5	14.8	34.6	17.0	34.0	20.5	32.4	23.0	32.2	22.0	29.5	21.4	31.0	17.0	25.4	11.4	18.5	4.0
20	23.0	10.0	25.5	7.8	32.2	11.8	35.5	15.4	35.0	18.0	30.0	20.0	32.0	22.5	34.5	21.5	30.0	19.6	31.5	17.0	26.2	11.8	18.8	7.0
21	23.6	10.2	26.5	7.6	32.3	12.0	33.0	15.0	32.5	17.2	34.0	20.5	32.7	22.2	33.7	20.8	33.0	20.4	31.0	18.5	26.5	13.5	19.2	5.5
22	19.5	8.5	25.0	8.5	33.2	13.2	34.4	20.2	34.3	18.0	34.2	22.0	32.5	22.0	34.2	22.0	32.0	20.2	31.0	19.5	25.5	10.0	19.8	6.0
23	17.8	9.2	27.0	9.0	31.4	12.8	35.2	20.5	30.8	19.8	33.0	21.0	32.5	22.5	36.2	22.0	32.2	20.0	30.0	15.0	24.0	11.0	21.5	7.0
24	17.8	9.0	28.0	9.5	31.8	13.2	34.2	18.5	28.5	19.0	34.0	21.8	31.5	20.0	36.2	22.4	32.0	19.0	28.2	15.0	25.0	10.0	18.0	6.0
25	18.0	8.2	26.5	10.5	31.4	13.6	35.0	18.5	30.4	19.5	34.2	22.2	33.3	22.5	36.8	22.6	32.4	18.4	28.0	15.5	24.2	11.0	19.5	7.0
26	21.6	8.2	26.3	8.6	31.4	13.6	36.0	18.5	34.4	19.5	35.0	24.0	33.5	22.0	35.0	21.4	33.5	19.5	29.4	14.5	23.8	10.4	18.4	6.5
27	22.0	4.8	27.8	8.0	32.0	13.5	36.0	18.5	34.8	19.3	34.0	19.2	35.5	22.5	37.0	21.4	33.5	19.5	29.4	14.5	23.8	10.4	18.4	6.5
28	19.2	4.8	26.0	8.5	32.0	14.0	35.2	19.4	35.0	18.5	33.5	21.5	34.8	21.0	37.0	20.0	33.0	19.8	29.0	15.5	23.0	10.5	22.5	6.5
29	20.5	7.0	27.6	9.5	32.0	13.0	36.0	19.8	35.6	18.0	34.0	19.0	35.8	22.5	31.0	20.5	26.5	21.0	25.2	18.5	22.5	9.2	20.0	5.5
30	18.5	5.8	26.3	10.5	32.4	12.0	36.0	19.8	35.8	18.0	34.0	19.0	35.8	22.5	26.5	20.0	35.0	19.8	29.0	15.0	22.0	8.8	20.5	3.0
31	19.2	8.4			31.2	12.2	34.2	22.2	35.8	19.3	33.2	19.2	33.5	22.5	33.7	20.0	35.0	19.8	29.0	15.0	22.0	8.8	20.5	3.0
									36.0	18.2			33.7	21.7	33.7				29.5	14.0			18.4	3.0

[illegible]

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Year	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035		2036		2037		2038		2039		2040		2041		2042		2043		2044		2045		2046		2047		2048		2049		2050		2051		2052		2053		2054		2055		2056		2057		2058		2059		2060		2061		2062		2063		2064		2065		2066		2067		2068		2069		2070		2071		2072		2073		2074		2075		2076		2077		2078		2079		2080		2081		2082		2083		2084		2085		2086		2087		2088		2089		2090		2091		2092		2093		2094		2095		2096		2097		2098		2099		2100		2101		2102		2103		2104		2105		2106		2107		2108		2109		2110		2111		2112		2113		2114		2115		2116		2117		2118		2119		2120		2121		2122		2123		2124		2125		2126		2127		2128		2129		2130		2131		2132		2133		2134		2135		2136		2137		2138		2139		2140		2141		2142		2143		2144		2145		2146		2147		2148		2149		2150		2151		2152		2153		2154		2155		2156		2157		2158		2159		2160		2161		2162		2163		2164		2165		2166		2167		2168		2169		2170		2171		2172		2173		2174		2175		2176		2177		2178		2179		2180		2181		2182		2183		2184		2185		2186		2187		2188		2189		2190		2191		2192		2193		2194		2195		2196		2197		2198		2199		2200		2201		2202		2203		2204		2205		2206		2207		2208		2209		2210		2211		2212		2213		2214		2215		2216		2217		2218		2219		2220		2221		2222		2223		2224		2225		2226		2227		2228		2229		2230		2231		2232		2233		2234		2235		2236		2237		2238		2239		2240		2241		2242		2243		2244		2245		2246		2247		2248		2249		2250		2251		2252		2253		2254		2255		2256		2257		2258		2259		2260		2261		2262		2263		2264		2265		2266		2267		2268		2269		2270		2271		2272		2273		2274		2275		2276		2277		2278		2279		2280		2281		2282		2283		2284		2285		2286		2287		2288		2289		2290		2291		2292		2293		2294		2295		2296		2297		2298		2299		2300		2301		2302		2303		2304		2305		2306		2307		2308		2309		2310		2311		2312		2313		2314		2315		2316		2317		2318		2319		2320		2321		2322		2323		2324		2325		2326		2327		2328		2329		2330		2331		2332		2333		2334		2335		2336		2337		2338		2339		2340		2341		2342		2343		2344		2345		2346		2347		2348		2349		2350	
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Year		2012		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Month	Day	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin
1	1	21.5	8.5	24.0	11.5	34.5	15.0	35.0	14.5	36.5	23.5	35.0	19.5	31.0	24.0	34.0	22.5	34.5	22.0	28.5	13.5	22.5	25.0	13.5	22.0	11.0	
2	2	21.5	11.8	22.5	6.0	28.2	11.5	34.5	15.5	35.0	13.0	36.5	19.5	32.0	23.0	32.0	24.0	33.0	22.5	25.0	13.5	22.5	25.0	13.5	22.0	10.0	
3	3	21.5	11.5	22.5	7.5	27.5	11.5	34.5	18.0	34.5	14.5	37.5	23.5	35.0	25.0	35.0	28.5	32.0	35.5	24.4	32.0	21.5	27.0	13.5	21.5	11.0	
4	4	22.5	11.5	23.0	8.0	28.5	10.5	32.5	19.0	32.5	14.5	35.5	19.0	31.5	23.0	35.0	22.5	34.5	22.5	32.0	22.5	27.5	11.5	21.5	11.0	11.0	
5	5	19.5	10.0	26.0	8.5	27.5	11.0	31.0	13.5	32.5	18.5	35.5	20.0	33.0	23.0	35.0	35.0	34.5	22.5	32.0	20.0	27.5	13.0	21.0	11.0	11.0	
6	6	19.5	8.5	26.5	9.5	36.5	12.5	30.0	14.0	32.5	18.5	37.0	22.0	28.5	22.0	28.5	22.0	35.5	23.0	32.0	20.5	27.5	12.5	20.0	11.5	11.5	
7	7	19.5	8.0	28.0	9.5	29.0	12.5	30.0	13.0	36.0	17.2	36.0	21.5	31.5	22.0	33.5	23.5	33.0	23.0	31.5	20.5	27.0	12.0	20.0	12.0	12.0	
8	8	20.5	8.0	28.0	13.0	29.5	12.5	31.5	14.0	36.5	19.3	37.5	23.5	32.4	23.5	33.0	24.0	36.0	23.5	32.5	20.5	26.0	12.0	20.0	12.0	12.0	
9	9	20.5	9.5	22.5	10.5	36.0	12.5	31.5	15.0	30.0	19.5	35.5	22.0	35.5	24.0	32.0	35.5	32.0	33.0	23.5	20.5	26.0	12.5	21.5	11.5	11.5	
10	10	18.5	10.5	23.5	9.5	29.5	11.0	31.5	15.0	24.5	19.6	36.5	20.5	35.5	23.5	35.5	22.0	34.5	23.5	25.4	20.5	25.5	12.5	21.5	12.5	12.5	
11	11	19.0	9.5	23.5	8.2	31.5	10.5	32.0	15.0	35.0	18.0	37.0	21.0	35.0	24.5	34.0	23.0	34.5	24.0	31.5	19.5	25.5	12.5	19.5	12.5	12.5	
12	12	23.0	8.5	23.5	9.5	30.0	10.5	32.4	14.5	37.5	20.0	37.5	22.0	35.2	24.0	34.5	24.0	33.5	23.0	32.0	20.0	25.5	13.0	23.5	12.5	12.5	
13	13	23.0	6.5	23.5	9.2	29.5	12.5	33.5	13.5	35.0	19.5	37.5	22.0	36.0	23.0	35.5	23.5	31.5	23.0	31.5	19.5	25.5	11.0	23.5	9.5	9.5	
14	14	20.5	6.5	23.5	10.5	29.0	13.0	33.0	16.5	36.0	17.5	37.5	24.0	34.5	23.5	36.0	23.5	36.0	23.5	22.5	31.5	17.5	28.0	12.0	23.0	10.0	
15	15	20.5	6.5	21.5	11.0	22.0	13.0	30.0	14.5	37.5	18.5	37.4	23.5	35.5	24.5	36.5	24.5	29.0	22.5	30.0	18.0	26.0	12.0	20.0	10.0	11.0	
16	16	20.5	7.5	21.5	11.0	29.0	11.0	33.5	14.5	36.5	18.0	38.0	25.0	30.5	23.5	36.5	24.5	29.5	21.0	30.5	17.0	25.0	11.5	21.5	9.5	9.5	
17	17	20.5	8.5	18.0	11.0	29.0	10.5	33.5	14.0	36.5	18.5	34.0	25.0	30.5	23.5	36.5	24.5	29.5	21.0	31.0	19.0	25.5	11.5	19.5	11.5	11.5	
18	18	20.5	8.5	18.0	10.5	30.0	12.5	36.0	14.5	35.5	19.5	30.5	23.0	31.0	25.4	35.0	23.5	35.0	24.3	29.5	21.0	17.5	25.5	11.5	19.5	11.5	
19	19	22.0	0.5	19.5	10.5	31.0	13.5	36.5	16.5	35.5	19.5	35.0	23.5	29.3	29.3	34.5	24.5	31.5	31.0	17.5	25.5	11.5	19.5	11.5	19.0	10.5	
20	20	25.5	8.5	29.5	10.5	33.0	13.0	36.5	18.0	35.0	18.5	35.5	24.5	33.5	33.5	30.5	22.0	34.5	21.5	30.0	17.5	25.0	11.5	19.0	10.0	10.0	
21	21	22.5	8.0	29.5	10.5	34.5	11.5	35.0	20.2	37.0	10.0	35.0	25.0	35.0	35.0	32.0	23.0	34.0	22.5	30.5	17.0	25.0	11.5	19.0	9.0	9.0	
22	22	21.0	7.5	25.5	12.5	35.0	16.0	36.5	19.0	36.0	18.5	35.0	13.5	35.0	23.5	32.0	23.0	34.0	23.0	29.5	17.0	24.5	11.5	19.0	9.0	9.0	
23	23	21.0	7.5	27.5	11.5	31.5	13.5	36.5	19.0	36.5	19.0	36.5	19.0	36.5	19.0	35.0	23.5	32.0	33.0	16.5	29.5	16.5	24.5	11.5	19.5	10.0	
24	24	21.0	8.5	27.5	11.5	31.5	13.5	36.5	19.0	36.5	19.0	36.5	19.0	36.5	19.0	35.0	23.5	32.0	33.0	16.5	29.5	16.5	24.5	11.5	19.5	9.5	
25	25	21.0	8.5	30.5	12.5	31.5	15.5	36.5	15.5	38.0	21.0	40.4	23.5	36.5	23.5	35.5	23.5	33.0	23.5	19.5	29.0	16.0	23.0	11.5	19.5	7.5	
26	26	21.0	9.0	31.5	12.5	35.5	15.5	37.5	14.5	38.3	23.3	40.3	23.3	36.0	22.3	33.0	21.5	29.0	21.5	16.0	23.0	11.0	19.0	7.0	7.0	7.0	
27	27	23.5	7.5	30.5	10.5	35.5	15.5	37.5	15.5	37.5	15.5	37.5	15.5	37.5	15.5	37.5	15.5	37.5	15.5	37.5	15.5	37.5	15.5	37.5	15.5	37.5	15.5
28	28	23.0	9.0	30.8	10.5	36.0	16.0	37.5	16.5	36.5	21.4	34.5	22.0	35.0	22.4	34.0	23.0	33.5	22.0	27.5	12.0	22.5	10.0	20.5	6.0	6.0	
29	29	23.5	7.0	18.0	10.5	34.0	14.5	36.0	14.5	38.5	23.5	35.0	22.0	33.5	22.4	34.0	23.0	33.5	22.0	28.0	13.5	22.5	10.0	20.8	6.0	6.0	
30	30	24.2	6.5	18.0	10.5	34.4	14.5	36.5	15.5	38.5	23.5	35.0	22.0	33.5	22.4	34.0	23.0	33.5	22.0	28.0	13.5	22.5	10.0	20.8	6.0	6.0	
31	31	24.0	7.5			34.5	14.5	36.5	15.5	36.5	23.5	35.0	22.0	34.0	23.5	34.0	23.5	35.5	23.5	22.0	28.0	13.0	22.0	11.5	20.0	7.5	10.0

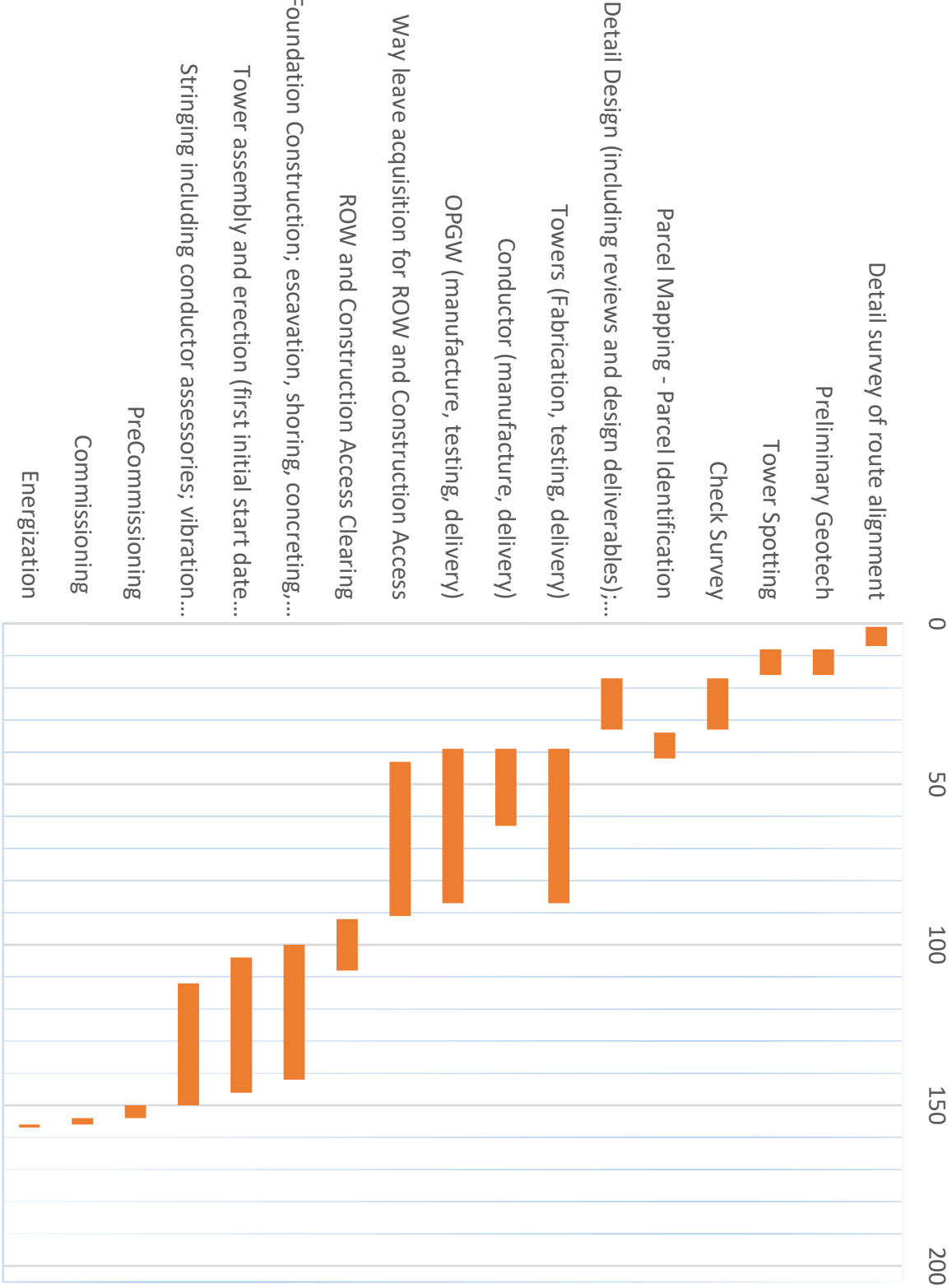
SECTION 4
CONSTRUCTION SCHEDULE

Task	Start (Week #)	Start (Date)	End (Week #)	End (Date)	Duration (weeks)	Duration (months)
Commencement of Work (as per P3 Timeline)	0	December 31, 2017	0	N/A	0	0
Detail survey of route alignment	1	December 31, 2017	7	February 11, 2018	6	1.5
Preliminary Geotech	8	February 18, 2018	16	April 15, 2018	8	2
Tower Spotting	8	February 18, 2018	16	April 15, 2018	8	2
Check Survey	17	April 22, 2018	33	August 12, 2018	16	4
Parcel Mapping - Parcel Identification	34	August 19, 2018	42	October 14, 2018	8	2
Detail Design (including reviews and design deliverables); inc. Tower Modeling in PLS Tower, Line Design in PLS Cadd, preliminary foundation design	17	April 22, 2018	33	August 12, 2018	16	4
Towers (Fabrication, testing, delivery)	39	September 23, 2018	87	August 25, 2019	48	12
Conductor (manufacture, delivery)	39	September 23, 2018	63	March 10, 2019	24	6
OPGW (manufacture, testing, delivery)	39	September 23, 2018	87	August 25, 2019	48	12
Way leave acquisition for ROW and Construction Access	43	October 21, 2018	91	September 22, 2019	48	12
ROW and Construction Access Clearing	92	September 29, 2019	108	January 19, 2020	16	4
Foundation Construction; excavation, shoring, concreting, curing (28 days minimum)etc. - (Assume 3 days per foundation, 108 foundations, and excluding 28 days to cure) Two crews to be utilize at a time.	100	November 24, 2019	142	September 13, 2020	42	10.5
Tower assembly and erection (first initial start date includes 4 weeks for foundation curing. 1.5 weeks for tower assembly, 1.5 days for erection); including tower accessories (insulator strings), foundation protection, etc. (Two crews to be utilize at a time.)	104	December 22, 2019	146	October 11, 2020	42	10.5
Stringing including conductor accessories; vibration dampers, etc	112	February 16, 2020	150	November 8, 2020	38	9.5
PreCommissioning	150	November 8, 2020	154	December 6, 2020	4	1
Commissioning	154	December 6, 2020	156	December 20, 2020	2	0.5
Energization	156	December 20, 2020	157	December 21, 2020	1	0.25
				Total Weeks (Start to Energization)	156.00	
				Total Months (Start to Energization)	39	
				Total Days (Start to Energization)	1092	

Starting Date: December 31, 2017
End Date: December 21, 2020

INPUT VALUES

220kV Damauli - Bharatpur Construction Schedule



SECTION 5

SUPPLEMENTARY INFORMATION