NATIONAL TRANSMISSION AND DESPATCH COMPANY LIMITED (NTDCL)

ADB LOAN NO.2846-PAK: MFF 0007 – POWER TRANSMISSION ENHANCEMENT INVESTMENT PROGRAM, TRANCHE-3

BIDDING DOCUMENTS NO. ADB-65-2012 (PACKAGE-1) FOR PROCUREMENT OF PLANT: DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 500kV TRANSMISSION LINE 3rd CIRCUIT JAMSHORO–MORO–DADU TO RAHIM YAR KHAN

(Single-Stage One-Envelope Bidding Procedure)

VOLUME - II

TECHNICAL SPECIFICATIONS

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3206/169/TD/09/10

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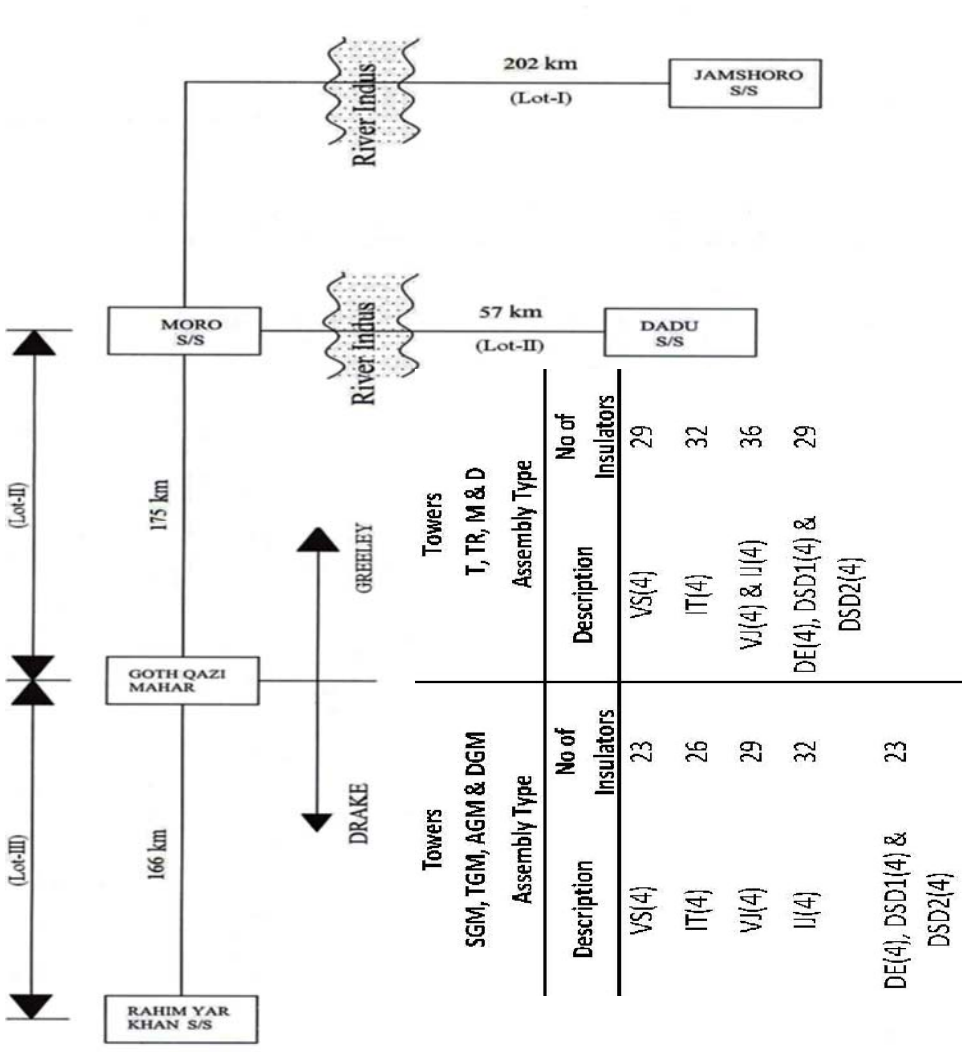
1. MATERIAL AND WORKMANSHIP

1.1 Scope

500kV Transmission Line 3rd Circuit Jamshoro-Moro-Dadu to Rahim Yar Khan (600km) Package-1 to be constructed under these Specifications is quad bundle single circuit as per following sections.

Lot-I: Jamshoro-Moro Section	(202 km)
Lot-II: Dadu-Moro-Goth Qazi Mahar Section	(232 km)
Lot-III: Goth Qazi Mahar-Rahim Yar Khan Section	(166 km)

The Line shall be of quad bundle AAAC "GREELEY" and ACSR "DRAKE" conductor per phase as per following sketch for the above sections having two overhead shield wires, i.e. one is EHS and the other is OPGW. Moro-Goth Qazi Mahar Section Transmission line shall pass within 300-500 m distance of New Rohri 220kV substation and the OPGW on Moro-Goth Qazi Mahar Section shall be tapped/extended to New Rohri 220kV substation.



The facilities to be provided under these specifications on the rates given in the Price Schedules include but not limited to the following:

(i) Preparation of design/fabrication drawings, generate bill of material sheets for each type of Tower/, detailing of tower fabrication drawings (meant for fabrication of towers) supplied by Employer, approval of drawings, data, documentation for all Facilities from the Project Manager, and construct, complete and commission above said transmission line in accordance with the requirements of the Contract Documents.

(ii) Design Manufacturing, Supplying, testing, furnishing, insuring, transportation, (complete or partial items to be transported from port or NTDC's stores at Sehwan and Rahim Yar Khan), delivering to site (or to Employer designated warehouses in case of dismantled material and spare parts) and storing thereof of steel towers including stubs angles for foundations, conductor, EHS shield wire and OPGW along with associated equipment, conductor, EHS shield wire & OPGW accessories and dampers, fog type porcelain disc insulators along with associated hardware, grounding materials and all other Facilities

(iii) Provision of all guarantees, insurances, field offices/camps, storage camps, labour, services, Plant and Contractor's tools and equipment (including construction and tension stringing equipment) to construct, complete, test and commission the said transmission line in accordance with the requirements of the Contract Documents.

(iv) Prepare and furnish all drawings and documents.

(v) Provision of access roads where necessary.

(vi) Making all necessary arrangements to access to tower locations on dry patches/land engulfed in river Indus creeks.

(vii) Clearing right-of-way including disposal of cleared materials.

(viii) Establishing route alignment and detailed survey not limited to chainage & leveling, preparation of plan & profile drawings, spotting of towers and preparation of construction structure list. Validation, updating & preparation of as-built of the already prepared plan & profile drawings and construction lists (to be provided after award of Contract).

(ix) Surveying of tower sites, tower staking and establishing correct locations of footings.

(x) Excavation, drilling, formation of ramps, grading, leveling, cutting and backfilling including disposal of surplus/excavated material.

(xi) Furnishing materials for constructing reinforced concrete tower foundations including installation of steel stub angles and tower grounding.

(xii) Ground assembly of tower sections and erection of steel towers.

(xiii) Installing insulator assemblies for conductors.

(xiv) Stringing conductors, overhead EHS shield wire and OPGW complete with hardware, accessories and dampers up to substation gantry towers at both ends of the line.

(xv) Furnishing and installing tower signs (Aerial Markers, Danger Signs, Number and Phase Plates etc.), anti-climbing devices and welding of bolts & nuts.

(xvi) Sub-soil investigation along the route including laboratory tests and preparation & submission of sub-soil investigation report along with foundation recommendation.

(xvii) Provide latitude and longitude by hand held GPS of each tower location.

(xviii) Checking the structural integrity, dimensions (back to back & diagonal, stub level and if required with the help of Schmidt hammer test) of already concreted conventional foundations & pile caps. Assessment of the damage (if found damaged) and preparation of the "Damage Assessment and Remedial Measures Report" for review and approval of Project Manager and rectification of the damaged tower foundations.

(xix) Demolishing of existing pile up to 2.4 m from the existing pile head, removal of spiral from the existing vertical rebars, providing new vertical rebar, placement of formwork, application of bonding agent, concreting, removal of formwork and curing etc., complete in all respect as per drawing No. 3206/169/TD/01G124.

(xx) Verification/checking of compatibility of insulator hardware material with hardware components to be supplied by the Employer.

(xxi) Testing and commissioning of the aforesaid Transmission Lines.

(xxii) Dismantling of 500 kV towers of existing 2nd Jamshoro-Dadu Circuit (maximum up to two towers) including removal of shield wire, conductor, insulators, hardware etc, preparation of material inventory and shifting of dismantled material to NTDC store at Sehwan.

(xxiii) Checking and confirmation of the stress analysis of tower type "M" & "D" for various loading conditions and full scale load testing of one tower type "M" and "D" of maximum height including erection, rigging, testing, assuming five load tests to ultimate load without failure followed by one test to destruction. Load cases shall be provided by the Project Manager.

(xxiv) Provide security to his own staff and to the supervisory staff of the Employer and the Project Manager.

(xxv) Preparation & submission of monthly progress reports including site photographs, as-built data and drawings including copies on reproducible transparencies and computer compact diskettes (CD/DVD) using AutoCAD, manuals (including Operation & Maintenance Manual) and Project Completion Report.

(xxvi) Any other item which is not included here but is necessary for integrated operation of the Transmission Line as advised by the Project Manager.

(xxvii) The following vehicles to be delivered in accordance with Schedule No.4 Item (IV) Vehicles of the Price Schedules shall be supplied to the office of the Chief Engineer EHV-II Hyderabad and Head Office of the Project Manager Lahore by the Contractor within the forty five (45) days from the date of signing of the Contract, failing which the Contractor shall arrange, free of cost, vehicles of the same type/size and of acceptable condition for the Employer and the Project Manager till such time the vehicles specified below are delivered. The balance vehicles shall be provided according to the schedule intimated by the Project Manager.

Lot No.	Vehicle Description	Qty. for Project Manager	Qty. for Employer
Lot-I	Locally Assembled Double Cabin Pick-Up Turbo 4x4	4	1
Lot-II	Locally Assembled Double Cabin Pick-Up Turbo 4x4	4	1
Lot-III	Locally Assembled Sedan Car (1300CC) AC	1	1
	Locally Assembled Double Cabin Pick-Up Turbo 4x4	3	

NOTE:-

Employer (NTDC) shall not be liable to give any equipment/T&P for survey, foundation, erection and stringing to the Contractors for this project. It is also mentioned that the stringing equipment/T&P and other construction equipment/T&P is not available in Pakistan and the same shall have to be arranged/imported by the Contractors at their own risk & cost.

The Contractor is responsible to mobilize sufficient numbers of crews for foundations, piling, tower erection and stringing etc. equipped T&P complete in all respects for smooth execution of each activity. For timely completion of the Project, Contractor is responsible to adhere to project schedule and ensure that the sufficient resources are available with the crews before commencement of each activity. Detailed methodology and list of T&P shall be got approved from the Engineer well before the commencement of each activity. The detail of construction equipment/T&P to be arranged/imported from abroad by the Contractor must be furnished in his Bid.

In case Contractor fails to arrange the required numbers of crews along with requisite T&P in good working condition for inspection at site prior to commencement of respective activity, Employer has the right, in addition to withhold current payments, terminate the Contract at any stage and to get executed the balance work through other Contractors at the Contractor's risk and cost.

1.2 Materials

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, shall have suitable corrosion resistant characteristics and of the classification and grades designated, conforming to the requirements of the latest issue of the appropriate specifications cited herein.

1.3 Workmanship

Workmanship and general finish shall be of the highest grade, in accordance with the requirements specified herein, and the best modern standard practice.

All components of the same design and designation shall be identical and like components shall be interchangeable.

All necessary tests shall be performed to ensure that technical requirements are fulfilled.

1.4 Standards

Unless otherwise specified in these Specifications or in the drawings, the Contractor shall conform to the applicable requirements of the latest revisions of the following standards or equivalent as approved by the Project Manager. The latest applicable standards shall be those which are enforced thirty (30) days prior to the date of Bid opening and the same shall be provided on request of the Engineer.

1.4.1 Tower Steel

(a) ASTM A6: General Requirements for Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural use.

(b) ASTM A36: Standard Specification for Structural Steel.

(c) ASTM A572: Grade 60 Standard Specification for High Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality.

(d) EN 10025: EURONORM Standard Specification for Structural Steel; Rolled Steel, Steel Sheets and Plates etc.

(e) ASTM A123: Zinc (Hot Galvanized) coatings on products fabricated from rolled, pressed, and forged steel shapes, plates, bars and strip.

(f) ASTM A143: Safe-guarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement.

(g) ASTM A563M: Standard Specification for Carbon and Alloy Steel Nuts.

(h) ASTM A153: Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.

(i) ASTM A239: Standard Method of Test for Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulphate Dip).

(j) ASTM A325: High-strength bolts for structural steel joints including suitable nuts and plain hardened washers.

(k) ASTM A370: Standard test methods and definitions for mechanical testing of steel products.

(l) ASTM A384: Standard practice for safe-guarding against warpage and distortion during Hot-dip Galvanizing of Steel Assemblies.

(m) ASTM A394: Standard specification for Steel Transmission Tower Bolts, Zinc-coated and Bare.

(n) ASTM F436: Standard specification for hardware steel washers.

(o) ASTM B201: Chromatic treatment test.

(p) ASTM E 94: Radiographic Testing.

(q) ASTM E109: Dry powder magnetic particle inspection.

(r) ISO 898-1: Mechanical Properties of Fasteners made of carbon steel and alloy steel.

(s) DIN 267: Fasteners technical delivery conditions steel spring washers for bolt/nut assemblies.

(t) DIN 7990: Hexagon head bolts for structural steel bolting for supply with nut.

(u) DIN 555: M5 to M100 x 6 hexagon nuts.

(v) DIN 127: Spring lock washers with square ends or tang ends.

(w) DIN 128: Spring lock washers, curved and wave.

(x) ASCE Manual No. 74: “Guidelines for Transmission Line Structural Loading” prepared and published by the American Society of Civil Engineers in 2010 (3rd Edition).

(y) ASCE Standard 10-97: “Design of Latticed Steel Transmission Structures”.

1.4.2 Conductor and Shield wire

(a) ASTM A90: Standard Method of Test for Weight of Coating on Zinc Coated (galvanized) Iron or Steel Articles.

(b) ASTM A153: Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.

(c) ASTM B230: Standard Specification for Aluminum Wire, EC-H19 for Electrical Purposes.

(d) ASTM B232: Standard Specification for Aluminum Conductor Concentric-Lay-Stranded Coated Steel Reinforced (ACSR).

(e) ASTM A239: Standard Method of Test for Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulphate Dip).

(f) ASTM A363: Standard Specification for Zinc Coated (Galvanized) Steel Overhead Ground Wire Strand.

(g) ASTM B398: Standard Specification for Aluminum Alloy 6201-T81 Wire for Electrical purpose.

(h) ASTM B399: Standard Specification for concentrically stranded Aluminum Alloy 6201-T81 conductors.

(i) ASTM B498: Standard Specification for Zinc Coated Galvanized Steel Core Wire for Aluminum Conductors Steel Reinforced (ACSR).

(j) IEC-61089: Round wire concentric lay overhead electrical stranded conductors.

(k) IEC-61395: Overhead electrical conductors – creep test procedures for stranded conductors

(l) Standard Method of Stress-Strain Testing of Aluminum Conductor and ACSR prepared by the Aluminum Association.

1.4.3 OPGW and Associated Hardware

(a) ITU-T G.652: Characteristics of a single-mode optical fiber cable

(b) ITU-T G.654: Characteristics of a cut-off shifted single-mode optical fiber cable

(c) IEC 60793: Optical fibers

(d) IEC 60794: Optical fiber cables

(e) EIA 598A: Color coding of optical fibers

(f) ASTM B415: Standard specification for hard-drawn Aluminum-clad steel wires

(g) ASTM B416: Standard specification for hard-drawn aluminum-clad steel wires

(h) ASTM B398: Standard Specification for Aluminum-Alloy 201Aluminum-alloy 6201-T81 Wire for Electrical Purposes

(i) IEEE Std 1138: Construction of Composite Fiber Optic Overhead Ground Wire (OPGW) for use on Electric Utility Power Lines

(j) IEC 61300-2-36: Fiber Optic Interconnection Devices & Passive component-Basic Test and Measurement Procedures – Part 2-36: Tests-Flammability (Fire hazards)

(k) IEC 60068-2-14: Joint boxes/hardware fittings

(l) EN 60529: Protection class of cabinets/cubicles

1.4.4 Insulators and Hardware

(a) ASTM A47: Specifications for Ferritic Malleable Iron Castings.

(b) ASTM A143: Standard Recommended practice for safeguard against embrittlement of Hot-dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.

(c) ASTM A153: Standard Specification for Zinc coating (Hot dip) on Iron & Steel Hardware.

(d) ASTM A220: Specifications for Pearlitic Malleable Iron Castings.

(e) ASTM A384: Standard practice for safeguarding against warpage and distortion during Hot-dip Galvanizing of Steel Assemblies.

(f) ASTM A239: Standard Method of Test for Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulphate Dip).

(g) ASTM A536: Specifications for Ductile Iron Casting.

(h) ASTM A668: Specifications for Steel Forgings, Carbon and Alloy, for general industrial use.

(i) ASTM C151: Test Method for Autoclave Expansion of Portland Cement.

(j) ANSI C29.1: American National Standard Test Methods for Electrical Power Insulators.

(k) ANSI C29.2: American National Standard for Wet Process Porcelain and toughened Glass Insulators.

(l) IEC 575: Thermal mechanical performance test and mechanical performance test on string insulator units.

(m) IEC 61284: Overhead Lines – Requirements and Tests for fittings.

(n) BS 3288: Insulators and Conductor fittings for overhead power lines Part I. Performance and General Requirements.

(o) IEC 61467: Insulators for overhead lines – Insulator strings and sets for lines with a normal voltage greater than 1000V-AC power arc tests.

(p) IEC 60437: Radio Interference Test on High Voltage Insulators

(q) Other relevant ANSI, ASTM and IEC standards.

1.4.5 Accessories and Dampers

(a) ASTM A153: Standard Specification for Zinc coating (Hot Dip) on Iron and Steel Hardware.

(b) ASTM A164: Standard Specification for Electrodeposited Coatings of Zinc on Steel.

(c) ASTM A239: Standard Method of Test for Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulphate Dip).

(d) ASTM D1149: Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber.

(e) ANSI B.1.1: "Unified Screw Threads" class 2A.

(f) U.S Military Specifications MIL A-8025 C.

(g) IEEE Paper No. 31 TP 65-156: Recommended Method of IEEE Task Force on Conductor Vibration.

(h) IEEE Paper T74 061.8: Decay Test Evaluation

(i) IEEE Paper 31 TP 65-707: An Investigation of the Forces of Bundle Conductor Spacers under Fault Conditions.

(j) CISPR 18-1 (Part 1): Radio interference characteristics of overhead power lines and high voltage equipment.

(k) CISPR 18-2 (Part 2): Methods of measurement and procedure for determining limits.

(l) CISPR 18-3 (Part 3): Code of practice for minimizing the generation of radio noise.

(m) IEC 61284: Overhead Lines – Requirements and Tests for fittings.

(n) BS3288: Insulators and Conductor fittings for overhead power lines Part I. Performance and General Requirements.

(o) IEC 61897: Overhead Lines – Requirements and Tests for stockbridge type Aeolian vibration dampers.

(p) IEC 61854: Overhead Lines – Requirements and Tests for spacers.

(q) IEC 60437: Radio Interference Test on High Voltage Insulators.

(r) IEEE 1368-2006: IEEE Guide for Aeolian Vibration Field Measurement of Overhead Conductors

(s) Other relevant IEEE, IEC and ASTM Standards.

1.4.6 Transmission Line Construction

(a) ASTM A615: Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
(b) ASTM C33: Standard Specification for Concrete Aggregates

(c) ASTM C39: Test Method for Compressive Strength of Cylindrical Concrete Specimens.

(d) ASTM C150: Standard Specification for Portland Cement.

(e) ASTM D1556: Test Method for Density and Unit Weight of Soil in-place by Sand Cone Method.

(f) ASTM D1557: Test Method for Laboratory Compaction Characteristics of soil Using Modified Effort.

(g) ASTM D1586: Standard Penetration Test

(h) ASTM C989: Ground Granulated Blast Furnace Slag for use in concrete and mortars.

(i) ASTM C494: Chemical Admixtures for Concrete.

(j) ACI Building Code: Building Code Requirements for Reinforced Concrete (ACI-318M, latest edition) and Commentary (ACI 318RM, latest edition).

1.4.7 Standards Other than those Specified

Where requirements for material or equivalent are specified by reference to a standard which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. Other standards, including standard of other countries, will be accepted provided the requirements thereof, in the opinion of the Project Manager, are at least equal to the requirements of the standard specified. The manufacturer may propose to the Project Manager an equivalent standard other than that specified, in which case he shall submit the proposed standard and all other information required in this respect and shall submit written proof that proposed standard is equivalent in all significant respects to the standard specified. All submission must be made in the English language.

1.5 Cleaning and Galvanizing

All fabricated structural steel material and ferrous components shall be cleaned of rust, loose scale, dirt, oil, grease and other foreign substances, after the shop work has been completed. Unless otherwise specified or directed, all material, including bolts, nuts and washers shall be hot-dip galvanized, in accordance with the relevant ASTM Specifications, after all shop work is completed except that nuts shall be re-tapped after galvanizing, and threads of nuts left bare.

All structural steel shapes shall be galvanized in accordance with ASTM A123.

The coating shall be clean, smooth and free from defects. Bare spots, loosely attached spelter, unevenness of coating, and globules which may be broken in handling, will be cause for rejection by the Inspector.

If more than 5% of the galvanized material is rejected, galvanizing shall be stopped and the process altered so that satisfactory work will be produced.
During galvanizing, the Inspector will carry out such tests on the coating and analysis of the spelter as he may consider necessary.

The Preece Test will also be included in these tests which will be carried out in accordance with ASTM Specification A239 latest edition but the required number of dips will be six (6).

All tower material shall, prior to shipping, be dipped in a suitable solution such as Sodium Bi Chromate to protect the galvanizing from "white rust" corrosion during transit. Full details of the treatment proposed shall be submitted to the Project Manager for Approval. The effectiveness of the treatment shall be verified in accordance with ASTMB201.

All fabricated structural steel and plates that have been warped by the galvanizing process shall be straightened by being re-rolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. If in the opinion of the Project Manager, the material has been harmfully warped or bent in the process of fabrication or galvanizing, such defects will be cause for rejection.

Material on which galvanizing has been damaged shall be redipped. Any member on which the galvanized coating becomes damaged after having been dipped twice shall be rejected.

1.5.1 Galvanizing of Nut, Bolts and Washers.

The galvanizing of nuts, bolts and washers shall be in accordance with ASTM A153. Bolts shall be galvanized in such a manner that the Zinc in the threads will not interfere with the application of the nut. Re-threading of bolt threads after galvanizing will not be permitted.

1.6 Inspection

All work covered by this specification, and the inspection thereof by the Contractor, shall be subject to surveillance and/or further inspection by the Project Manager. The Contractor's inspector shall include, but not necessarily limit his duties to the following:

A. Material

The Contractor shall:

(i) Work only to those specifications provided herein and/or as specified by the Project Manager.

(ii) Inspect the following materials for both quality and dimensions.

- (a) Structural steel
- (b) Sheet steel
- (c) Nut and bolts
- (d) Washers and fillers
- (e) Conductor
- (f) Overhead EHS shield wire and OPGW along with associated equipment and hardware
- (g) Insulators, Hardware & Grounding Material
- (h) Conductor & Shield wire Accessories
- (i) Dampers for Conductor, EHS Shield wire and OPGW

(iii) Check and remit to the Project Manager certified copies of the mill sheets covering the total quantity of the above applicable material.

B. Fabrication & Manufacturing Process

The Contractor shall:

(i) Work only to drawings and specifications approved by the Project Manager.

(ii) Be responsible for ascertaining that all fabrication is carried out in compliance with the following:

- (a) Exact shop drawing dimensions and notes
- (b) The appropriate specifications
- (c) Good shop practice
- (d) Bending according to Clause 2.1.3.2 for tower steel herein
- (e) Member markings, corresponding to those shown on the detail drawings, are clearly stamped on each individual member.
- (f) Galvanizing in accordance with the ASTM standards.

(iii) Inspect the fabrication for all the foregoing items, (a) to (e) of A(ii) before galvanizing, and check that no further fabrication is carried out after galvanizing where dissimilar metals are used, suitable precautions shall be taken at the metal interface to prevent electrolytic corrosion.

(iv) Casting of ferrous materials is not permitted, except for components not subject to stress.

(v) All ferrous components which have been cold formed & forged shall be normalized or otherwise heat treated to relieve stresses before galvanizing, if applicable.

(vi) Threads may be either cut or rolled except that the threads of ferrous bolts which are to be installed with a given torque value shall be rolled after galvanizing.

(vii) Necessary precautions shall be taken to prevent embrittlement of ferrous components, as specified in ASTM A143 & A384.

Periodically check the galvanizing against the appropriate specification requirements, which include the testing of the galvanizing bond by the use of the Chisel-faced hammer.

C. Note and have corrected such items as:

1. Quality of materials not complying with specifications;
2. Incorrect quantities;
3. Incorrect dimensions and sizes;
4. Missing components and holes;
5. Substitution of unapproved material;
6. Incorrect location of bolt holes;
7. Burrs on punched holes;
8. Conically punched holes due to poor dies;
9. Under-sized members;
10. Members not bent or incorrectly bent; and
11. Left and Right of members not correctly bent or punched.

D. Electrical Requirements

1. The corona extinction voltage shall not be less than 346 kV line to ground. All energized hardware assemblies shall be corona free at this voltage.

2. All energized hardware shall be designed and constructed so that the potential difference between the conductors and any part of energized hardware will not exceed 300 V.

3. If the Manufacturer cannot show, to the satisfaction of the Project Manager, that the materials have been previously subjected to corona testing to the levels specified, then the Manufacturer shall submit to the Project Manager a proposal for corona testing. Following the Project Manager's approval of the Manufacturer's proposed test program, the Manufacturer shall carry out these tests and if required shall modify his design so that the requirements are all met at no expense to the Employer.

E. Testing and Quality Control

1. It shall be the Manufacturer's responsibility to provide and perform all the inspection and testing necessary to ensure compliance with these specifications.
2. Quality surveillance will be provided by the Project Manager or his authorized representative (hereinafter called "the Inspector").

3. The Inspector shall have free access to those parts of the Manufacturer's Works that concern the manufacturing of this material at all times while work on this Contract is being performed. The Manufacturer shall provide the Inspector, with all reasonable facilities to enable him to be satisfied that the material is being furnished in accordance with these specifications.

4. The Inspector shall have the authority to ask any additional testing or inspection he considers necessary in order to ensure compliance with the specifications and drawings.

5. The Inspector's decision for acceptance or rejection of any work shall be final.

F. Quality Control

1. The Manufacturer shall ensure that an adequate system of marking and/or coding of production lots for components are maintained. Once a size of production lot for a component is established, the size of that production lot shall remain constant until the work on the contract is completed.

2. Standards to be checked, in the Manufacturer's Quality Control Plan shall include, but not be limited to the following:

   (a) Dimensional tolerances;

   (b) Quality, surface finish and ease of fit;

   (c) Assembly procedures and requirements; and

   (d) Production tests.

3. The schedule of production tests may be amended or changed by the Project Manager at any time prior to the completion of this Contract.

G. Reports

Inspector shall submit to the Project Manager four (4) copies of his inspection report, covering the following:

1. Progress of fabrication;

2. Progress of fabrication and galvanizing for steel;

3. Any change in completion dates;

4. Substitution of material;

5. Detailed remarks on any technical difficulties; and

6. Detailed remarks on any material rejected before fabrication, after fabrication and after galvanizing.

Whether the Employer and Project Manager are present or not, the Contractor shall carry out all tests as specified in the relevant standard and he shall supply the Project Manager with three (3) copies of all test data obtained.

2. STEELTOWERS

2.1 Scope

This specification covers the technical requirements of manufacturing and testing of transmission line towers.

2.1.1 Type of Towers

Following types of towers shall be used.

Single Circuit Suspension Tower Type "SGM"

Single circuit suspension tower type "SGM" will be utilized for straight line position or maximum line angle of 2°.The tower consists of a 25.22 m basic body, 4.5 m & 9.0 m body extension of and leg extensions of 1.5 m, 3.0 m, 4.5 m & 6.0 m. Maximum wind and weight spans at 0° line angle will be 410 m & 500m respectively.

Single Circuit Suspension Tower Type "T"

Single circuit suspension tower type "T" will be utilized for straight line position or maximum line angle of 2°. The tower consists of a 25.11 m basic body, 6.0 m body extension and leg extensions of 2.0 m, 4.0 m, 6.0 m &8.0 m. Maximum wind and weight spans at 2° line angle will be 410 m & 500 m respectively.

Single Circuit Transposition Tower Type "TGM"

Single circuit transposition tower type "TGM" will be utilized for straight line position. The tower consists of a 25.22 m basic body, 4.5 m body extension and 6.0 m leg extension. Maximum wind and weight spans will be 410 m & 500 m respectively.

Single Circuit Tower Type "TR"

Single circuit transposition tower type "TR" will be utilized for straight line position. The tower consists of a 25.11 m basic body, 6.0 m body extension and 6.0 m leg extension. Maximum wind and weight spans will be 410 m & 500 m respectively.

Single Circuit Light Angle Tower Type "AGM"

Single circuit strain tower type "AGM" will be utilized for line angles up to 20°.The tower consists of a 21.33 m basic body,4.6 m & 9.1 m body extensions and leg extension of 1.5 m, 3.1 m, 4.6 m & 6.1 m. Maximum wind and weight spans at 20° line angle will be 366 m &610 m respectively.

Single Circuit Light Angle Tower Type "M"

Single circuit strain tower type "M" will be utilized for line angles up to 30°. The tower consists of a 23.23 m basic body, 6.0 m body extensions and leg extension of 2.0 m, 4.0 m, 6.0 m &8.0 m. Maximum wind and weight spans at 30° line angle will be 410 m & 800 m respectively.

Single Circuit Heavy Angle/Terminal Tower Type "DGM"

Single circuit strain tower type "DGM" will be utilized for line angles up to 60° and 20° in terminal condition. The tower consists of a 21.33 m basic body, 4.6 m & 9.1 m body extension and leg extension of 1.5 m, 3.1 m, 4.6 m & 6.1 m. Maximum wind and weight spans will be 366 m & 610 m respectively for line angles up to 60° and 20° in terminal condition.

Single Circuit Heavy Angle/Terminal Tower Type "D"

Single circuit strain tower type "D" will be utilized for line angles up to 60° and 20° in terminal condition. The tower consists of a 23.23 m basic body, 6.0 m body extension and leg extension of 2.0 m, 4.0 m, 6.0 m &8.0 m. Maximum wind and weight spans will be 410 m & 800 m respectively for line angles up to 60° and 20° in terminal condition.

2.1.2 Drawings

Detailed shop drawings to be used to fabricate the towers are attached in Volume-III of the Bidding Documents.

If any changes are made to suit conditions in the country of origin for good and sufficient reasons, the burden of proof shall be on the Contractor to show that such change or changes will result in completed tower/towers of equal or increased capability.

No work shall be commenced prior to written approval of the Project Manager.

2.1.3 Detailed Requirements

2.1.3.1 Connection Details

The connection details for insulator hardware, EHS shield wire & OPGW hardware shall be similar to the typical details shown on the drawings. Holes for moving parts shall be drilled and chamfered unless otherwise specified. Such holes shall have adequate bearing area and in addition to the normal edge distance shall have an extra 6.5 mm edge distance to provide for wear.

Details of holes for danger signs, number signs, phase plates, aerial markers, grounding and anti-climbing devices shall be in accordance with Specification Drawings.

2.1.3.2 Structural Steel

All rolled steel sections, plates shall be supplied in accordance with latest edition of ASTM A572 Grade 60 High Strength Low-Alloy Columbium-Vanadium Steel of Structural quality, EN10025 S355J2 and ASTM-A36. In addition to requirements specified herein and in the relevant standards, the offered steel shall withstand the following bend test requirements. However, procedure of bend test requirement shall be followed as per ASTM A370.

Type of Steel	Thickness of Material	Ratio of bend dia. to thickness of specimen at 180°
- Mild steel	for all thickness	1.5
- High tensile steel	up to 25 mm	1.5
	Over 25 mm	2.0

For the fabrication of the towers, the Contractor may propose the use of any steel, provided that the proposed steel have characteristics and properties equal to or better than those listed for steel mentioned in the specifications.

2.1.3.3 Nut, Bolts and Washers

For all types of towers, all connections shall be secured by bolts, nuts, plain and spring washers. Hexagonal head bolts and hexagonal nuts shall be used. Only one plain and one spring washer per bolt shall be used.

Bolts shall be designed for only bearing and shear and the shank of all bolts except U-bolts shall extend completely through all connected members. When in position bolts shall project through the corresponding nuts neither less than 2 thread lengths nor greater than 10 mm. Members shall not bear on thread. Washers shall be used under all nuts. Bolts shall be free from fins, scale or other defects and the head shall be concentric and square with the shank. The diameter of the shank shall be full nominal size of the bolts. The ends shall be sharp and clean and of the proper contour.

All U-bolts shall be threaded for a sufficient length to take two standard nuts plus member and washer thicknesses.

Step bolts shall be provided as shown in the drawings.

Nuts shall be of sufficient height to develop the full strength of the bolt. Threads must not be torn or ragged and shall be of proper contour. The nuts shall fit the bolts after they have been galvanized so that they can be started and threaded by hand for the full length of the bolt thread.

The fit of the nut on to the bolt shall be such that no rocking of the nut will occur.

Nut and bolt of the same size shall be interchangeable. The bolt related dimensions for fabrication can be referred from DIN 7990 and nut according to DIN 555. The length of bolts shall be calculated to accommodate the thickness of one plain and one spring washer.

Material of bolts and nuts shall conform to ASTM A325 and/or ISO 898 standards.

The dimensions and material of plain washers (circular) shall be according to ASTM F436.

The dimensions and material of spring lock washers shall be according to DIN127 and 128.

At least 5% surplus of bolts, nuts and washers shall be supplied to cope with losses and future maintenance.

The fabricated material shall not have physical properties inferior to those specified.

Bolt hole diameter shall not exceed the nominal diameter of the fastener plus 1.5 mm.

Ring fillers for the towers to be supplied in accordance with the dimensions given in the drawing No. 3206/169/TD/01F203. The material of ring filler shall conform to the properties of mild steel as per ASTM A36.

The minimum edge distance of bolts shall be as follows:

(i) Minimum Edge Distance: The minimum edge distances measured from the centre of the bolt hole to the end of the member shall be as follows:

(a) For Compression Members: One and one-half bolt diameters.

(b) For Tension Members: In an end connection of not more than three bolts the end distance shall not be less than that given in (a) above or the following quantity, whichever is greater.

Minimum Bolt Diameter	Minimum Edge Distance	
	Rolled Edge	Sheared &Mechanical Guided
16 mm	19 mm	24 mm
20 mm	26 mm	30 mm
24 mm	30 mm	38 mm

(c) For gusset plates one and one-half bolt diameter.

(d) Minimum spacing of bolts shall be as follows:

Bolt Diameter	Minimum Bolt Spacing
16 mm	35 mm
20 mm	45 mm
24 mm	55 mm

2.1.3.4 Workmanship

The workmanship and finish throughout shall be of a quality equal to the best that is known to the art at the present time for this class of work. All work shall be carefully and accurately performed.

Members shall be cut to jig and holes shall be drilled or punched to jig. All holes shall be cylindrical and perpendicular to the member. Where necessary to avoid distortion of holes close to the points of bends, the holes shall be made after bending.

Fabricated steel work shall be in accordance with the drawings, and drilling, punching, cutting and bending shall be carefully and accurately performed to prevent any possibility of irregularities occurring which might introduce difficulty in the erection of towers or result in straining or distortion of the parts thereof.

2.1.3.5 Bending

Tower members which are cold bent shall be normalized before galvanizing. Hot bending is preferred. The heating shall be done in an oven, so that the member is uniformly heated to a distance of approximately 150 mm either side of the bend point. Proper heat treating procedures shall be used in order to preserve the original physical properties of the metal. Bending of thick members shall be done in a hydraulic press with a suitable die to prevent buckling of an unrestrained leg. This process shall not be done under quick impact but through a slow moving press.

2.1.3.6 Punching & Drilling

Punching and drilling shall be done by methods designed to ensure accuracy. The center of any hole shall not vary more than 1.5 mm from its position neither shall the center to center distance of end holes in a group of holes vary by more than 1.5 mm. Plugging and welding of drilled holes shall not be permitted.

Drills, punches and dies shall be sharp and true, and holes shall be round, true to size, and free from ragged edges and burrs.

Bolt holes shall have diameter 1.5 mm larger than the nominal diameter of the bolt.

It is preferable to have fabrication, punching and drilling carried out by means of a modern computer program technique.

All holes in material over 19.0 mm in thickness shall either be drilled or sub-drilled and reamed.
For high tensile steel (yield point equal or greater than 35 kg/mm²) holes shall be directly drilled at the definitive diameter or punched and reamed out. The difference between the punched and reamed diameter shall be at the minimum 4mm.

The die for all sub-punched holes, and the drill for sub-drilled holes, shall be at least 1.5 mm smaller than the diameter of the bolt. Drifting to enlarge holes shall not be permitted.

2.1.3.7 Welding

Welding of structure members, filling or plugging of defective parts and mispunched holes shall not be permitted in tower fabrication. When holes are mispunched so that the net section of a member is decreased, the member shall be discarded. However, if welding cannot be avoided and is required in certain structure components, such as for rigging/attachment plates, prior written approval shall be obtained. In such cases welding procedures shall comply with ANSI/AWS D1.1M standards. Special care shall be taken regarding seal welding to assure proper galvanizing and to avoid acid “bleeding” at pockets in structural assemblies.

2.1.3.8 General Requirements for Fabrication

The towers shall be fabricated having members' sizes according to the approved drawings. No angle substitution shall be allowed for main leg and cross arm members and stubs. However member substitution for other tower members and redundant or secondary members may be allowed with the prior approval of the Project Manager. In such a case the total number of member substitution would not exceed three (3).

2.1.3.9 Allowance for Galvanizing

Allowance shall be made in gauge dimensions for the thickness of galvanizing and the possible formation of spelter fillets inside the angles so as to allow adequate erection clearance after galvanizing.

2.1.3.10 Blocking

Blocking of outer legs of angles will not be permitted.

2.1.3.11 Angle Laps

Where angles are lap spliced, the heel of the inside angle shall be chamfered to clear the fillet of the outside angle.

2.1.4 Marking

All structural members shall be marked with the correct designation shown on the shop drawing. Marking shall be done by stamping the members prior to galvanizing with numerals or letters of 12mm minimum height, and shall be clearly legible after galvanizing.

2.1.5 Tolerances

Ease of assembling the structure in the field is of utmost importance. The structure shall be so manufactured that all members carrying the same mark shall be interchangeable when assembled. The structure shall fit without undue pressing and no reaming or drifting of holes shall be required. When erected, the structures shall not deviate from the vertical by more than 1/300 ratio.

The Manufacturer shall be responsible for the correct fitting of all parts and shall replace free of cost any defective materials discovered during erection and shall pay all costs of the correction in the field of any errors not previously discovered.

The permissible variation from dimensions for structural size steel shapes shall not exceed the prescribed limits in ASTM A6.

2.1.6 Drawings

The Manufacturer will be supplied the drawings indicating various dimensions, angle sizes used, sizes of bolts used, type of steel and various standards/process to be followed for fabrication and galvanizing of the structure.

After approval of contract, the Manufacturer shall submit for approval, the following drawings.

(a) <u>Shop Details Drawings:</u>

The detailed drawings shall show shop details including dimensions, shearing, punching, bevel cutting, bending and identification mark and weight for each member.

(b) Erection Drawings:

Erection drawings shall show the complete assembly of the structure indicating clearly the positioning of the members. Each member shall be piece-marked and the number and lengths of bolts shall be given for each connection. Shop details may be shown either by assembled sections (in place) or piece by piece (knocked down)

(c) Footing Installation Drawings:

Footing erection drawings showing each member with its identification mark, number and size of connection bolts and all dimensions required for the proper setting and positioning of stub angle footings with relation to the centre of the structure.

(d) Bills of Material:

Bills of material for each tower shall show the quantity, type, size, length; weight and assembly mark for each member, including bolts, washers, plates and all fittings complete for each structure.

(e) Outline Drawing:

The Manufacturer shall prepare single line diagram from the detailed drawings shall show the complete information like dimensions and member, angle sizes.

2.1.7 Sign Plates

All the plates i.e. danger sign, number & phase plates and aerial markers shall be baked ceramic surfaces on high grade steel base plates of minimum thickness of 1.5 mm except aerial marker plate which shall be of 3.0 mm thickness. The fabrication details and dimensions of the plates are shown on the drawing Nos.3206/169/TD/01E206 & 207.

The plates shall be painted with ceramic paint on both sides and they shall be thoroughly cleaned before painting and the ceramic paint shall completely cover the front and back of the plates and also the edges of plates and the interior edges of the attachment holes. The ceramic paint shall be of even thickness, reasonably free from cracks, patches, pin holes, blisters and shall have a uniform gloss. The ceramic paint around the holes shall be protected by means of fiber washers.

Three coats of ceramic paint shall be applied on the danger sign and number plates. The first coating of black ceramic paint shall be applied on both sides of the plates. The other two coats of white ceramic paint shall be applied on the front side of the danger & number plates and yellow on aerial marker plates.

In case of phase plates, three coats of ceramic paint shall be applied. The first coat of black ceramic paint shall be applied on both sides. The other two coats of red, yellow and blue colour shall be applied as specified on both side of the plate.

Nos. of bolts, nuts, washers and fixtures where required shall be supplied with each plate as shown in the drawings. Bolts, nuts and washers to be supplied with the fixture shall be galvanized in accordance with ASTM A153.

2.1.8 Barbed Wire

Material, dimensions and testing of the barbed wire shall be in accordance with ASTM A121.

The size and characteristics of the zinc coated barbed wire shall be as per design number 12-2-4-14R, Type Z with Class 3 coating.

2.2 Tests for Tower Steel, Associated Hardware and Accessories

2.2.1 Manufacturer's Tests

The Manufacturer shall select two samples from each heat to carry out the following tests to satisfy him that the products comply with the specifications.

(a) For Sections and Plates

1. Chemical composition (Ladle Analysis)
2. Tensile Tests
3. Bend Tests

(b) For Nuts and Bolts

1. Proof Load test
2. Ultimate Tensile Strength test
3. Ultimate tensile strength test under eccentric load
4. Cold bend test
5. Hardness test
6. Galvanizing test

(c) For Washers and Ring Fillers

1. Hardness test
2. Galvanizing test

The Manufacturer shall maintain a record of tests carried out by him for examination by Inspector.

2.2.2 Prototype Testing

2.2.2.1 Prototype Tower Assembly

Before starting prototype load testing of towers type “M” and “D”, one tower of each type of maximum height combination of body and leg extensions shall be shop assembled and vertically erected on a suitable foundation bed to assure proper fit of all parts. Following should be kept in view during prototype tower assembly.

(a) Check carefully each member while assembling the prototype to revise and amend the detailed drawings according to the correct solution;

(b) For each member, the length, position of holes and interface with other members shall be checked accurately for proper fitness;

(c) Quantity of each member and bolts shall be carefully checked from the bill of materials when assembling the prototype;

(d) On the assembled tower eventual modifications shall be examined and performed, if necessary, without modifying the functionality of the structure; and

(e) Drawings and bill of materials, sizes of bolts, fillers etc. shall be put up-to-date accordingly, in all details before starting mass production.

All changes/modifications incorporated in the drawings shall be brought to the notice of Project Manager along with corrected final copies of the drawings for approval. The Manufacturer shall also submit details of all the changes/modifications carried out.

2.2.2.2 Prototype Load Testing

(i) Scope of Tests

Full scale tower tests shall be made on towers type “M” & “D” of maximum height as shown on the drawings. Five cases are to be tested to the ultimate design loads without failure. The towers will then be tested to destruction. Load cases shall be provided by the Project Manager. In case any reinforcement/modification is required in the tower during the prototype testing, the Contractor shall be paid for the additional weight of steel used in the supply of “M” & “D” type towers in accordance with the applicable unit rate of steel calculated as per Schedule No. 1 or 2 of Schedule of Prices. In case of retesting of tower, all material required on account of reinforcement/modification shall remain the responsibility of the Contractor and all costs in this respect shall be deemed to be included in the Bid price.

(ii) Test Foundations

The tower maximum height shall be erected on a foundation structure and tower anchorage which shall be of adequate strength and stiffness to withstand safely the tower reactions under test loadings without any mobility. Tower members shall be connected to the anchorage with the same member size and spacing of bolts as used in the normal stub angle details thus simulating the conditions which will be encountered in service.

(iii) Check of Quality of Materials Used for Test Tower

(a) If the materials used for the fabrication of the test tower are selected at random from the Contractor's stocks and if they can be considered as representative of the materials used in production structures, no limitation shall be required on their yield point and ultimate tensile strength value, and no tolerances of their geometrical dimensions other than those specified to the material supplier.

(b) If this requirement is not satisfied, the material of the test tower shall be checked for mechanical characteristics and dimension tolerances. The tower testing shall not be considered complete without material testing.

(c) The test shall be considered satisfactory if bending and compression members with slenderness ratios smaller than 150 and tension members have the following average yield point:

(i) Steel members having a minimum guaranteed yield point lower or equal to 26 kg/mm^2. Average value ≤ guaranteed minimum value x 1.25

(ii) Steel members having a minimum guaranteed yield point lower or equal to 35 kg/mm^2. Average value ≤ guaranteed minimum value x 1.17

(iii) Steel members having a minimum guaranteed yield point lower or equal to 42kg/mm^2. Average value ≤ guaranteed minimum value x 1.17

(iv) Steel members having a minimum guaranteed yield point lower or equal to 46 kg/mm^2. Average value ≤ guaranteed minimum value x 1.17

The averages are obtained from eight test specimens taken from eight different most heavily loaded members of the structure for each grade of material.

However, for members with slenderness ratio higher than those indicated in clause 2.2.2.2(iii) above and for redundant members, the above limit may be exceeded since their yield point has little influence on their collapse.

For the average value of the ultimate strength the following limit shall be accepted.

Average value less than guaranteed minimum value x 1.2.

(d) The average is obtained from the eight test specimens used for the determination of the average value of the yield point of the material.

(e) If all these conditions are not satisfied, the test is not valid and the test tower shall be rejected.

(iv) Project Manager Approval

Prior to testing, the Contractor shall submit for approval of the Project Manager a line diagram showing a layout of the test site, rigging, location of load measuring instruments to be used and a series of line diagrams showing the loads to be applied, taking into account the weight of rigging and angle of load application. The Contractor shall submit for approval a tabulated form on which the applied load and corresponding deflection readings will be entered for each load case.

The Project Manager may require from the Contractor to install strain gauges on leg and other members carrying high compression loads to monitor closely their behavior during failure under critical load cases. All costs related to this installation shall be deemed to be included in the bid price.

(v) Test Facilities

Test frame at the test site shall be capable of handling ultimate loads with safety. Test frame shall be capable of handling increased loads during destruction testing with adequate safety of personnel working on the test facility.

Load lines shall be attached to the load points on steel structure in a manner that simulates the in-service load application as much as possible. The attachment hardware for the test shall have the same degree of movement as in the in-service hardware. If the applied loads are not measured at the point of application and sheaves (only roller bearing type permitted) are to be located between point of load application and the load measuring device, then an additional 5% load may be added to all applied loads to offset friction drag in the rigging. This requirement can be adjusted where the Testing Station Staff can verify the actual fraction drag.

Where the Vee-strings or other multi-leg insulator assemblies are part of the structure design, test loads shall be applied at the conductor attachment points. The Vee-strings shall be simulated using a series of straps to ensure complete transverse and vertical articulation (i.e. the linkage shall not be capable of withstanding compressive forces).

Wind loads on structure body shall be applied at panel points.

(vi) Load Monitoring Equipment

The load monitoring equipment shall be electronic transducers complete with appropriate digital read-out meters and recorders with an overall accuracy ±1%. All load monitoring equipment shall be calibrated before and after testing of the towers in the presence of inspectors.

The Project Manager may require from the Contractor to install strain gauges on leg and other members carrying high compression loads to monitor closely their behaviour during failure under critical load cases. All costs related to this installation shall be deemed to be included in the bid price.

(vii) Deflection Measurement

Longitudinal deflections of the tower under incremental loading for each test case shall be measured at the top of each shield wire peak and at the ends of cross arms. Transverse deflections shall be measured at the centre of tower waist level. Deflection readings shall be recorded for the “before-load”,

"load-on", and "load-off" condition as well as during intermediate holds during loading. All deflections shall be referenced to common base readings, such as the initial positions taken before any test loads are applied. Measurements shall be recorded photographically.

(viii) Tower Assembly

The test tower shall be sub-assembled on the ground and erected on the test bed using a crane or a gin pole. The tower shall be erected so that the vertical axis through the centre of gravity shall not be out of plumb by more than 25 mm for every 12 m height.

(ix) Witnessing

The tower test shall be carried out in the presence of personnel of the Project Manager and the Employer.

(x) Test Procedure

The ultimate loads shall be applied. The drawing showing the combination of loads for testing shall be supplied by the Project Manager at a later stage. The loads shall be applied in increments of 50%, 75%, 90%, 95% and 100% of the ultimate loads. Each test loading shall be applied according to the drawings and maintained for not less than 5 minutes, during which time there shall be no slacking or adjustment of the loads. Should it become necessary to adjust the loading the 5 minutes period shall start after the loading is stabilized and constant. All test loads shall be removed completely in a controlled manner to avoid overstressing any members before the loads for the next test are applied. All test loads corresponding to conductor and ground wire loading shall be applied directly to the regular attachment details provided for these loads. Test loads equivalent to wind load on the tower shall be applied at specified panel locations. To ensure application of full test loads to the tower, friction losses in rigging shall be added to specified loads, if there is rigging between the tower and the load measuring device. Application of impact loads shall be avoided.

(xi) Failure due to Faulty Workmanship or Material

Any conspicuous yielding or any failure under any of the above test loading shall be considered a defect. If a defect develops because of faulty workmanship or materials, the Contractor shall correct the defect and repeat the test loading at his own expense, including any additional cost incurred by the Employer for the witnessing of the repeat test loading by the Project Manager.

(xii) Test to Destruction

After tower has been tested in accordance with the foregoing requirements, the test tower shall be tested to destruction as directed. Test samples shall be cut from members which fail in the destruction tests and from those members indicated as most critical by low capacity to load ratios, and standard tensile tests shall be performed at the Contractor's expense. Upon completion of the testing, disassembly of the structure shall include inspection of all members for any evidence of excessive permanent set, shear failure of the bolts, or member failure in bearing not determined during the full-scale testing program.

All design and detailing defects determined during the tests or during the disassembly shall be considered as having incurred and shall be corrected on all structures of that type.

(xiii) Ownership

Each member of the tower structure fabricated for testing shall be punched as "TEST". After the test to destruction of the test tower, all test tower materials shall become the property of the Contractor.

No parts of this tower shall be used in any tower to be furnished for this Project.

(xiv) Report on Testing

Within thirty (30) days following completion of the tower tests, the Contractor shall furnish full reports in quadruplicate of all tower tested, shall include the following data:

(a) The type of tested tower;

(b) The name and address of the tower manufacturer and of the tower designer;

(c) The name and address of the client;

(d) The dates and location of testing;

(e) The names of persons present during the tests;

(f) A list of various assembly and detail drawings relating to the tower tested, including any modification of the drawings referred to;

(g) A dimensioned line diagram of the tower showing the various load points and directions of loading to be applied and a table with the specified loads;

(h) Diagram showing the rigging arrangement used to apply the test loads;

(i) Brief description of the test facility including the number, location, range and calibration charts or tables of every loads transducer or other load measuring devices, as well as the accuracy of the equipment used to measure the test loads;

(j) One table per test showing the loads required at the various points on the structure and for the various loading steps;

(k) One table per test showing the various deflection values measured; and in the case of failure:

(l) a table showing the maximum loads applied to the structure just before the collapse;

(m) a brief description of the failure;

(n) the dimensional and mechanical characteristics of the failed elements.

(o) Photographs showing the whole of the structure and details of the possible failure.

(p) Environmental meteorological data during the sequences of tests.

(xv) Colour Coding

Critical members on the tower shall be colour coded prior to the test.

2.2.3 Acceptance Tests

2.2.3.1 Acceptance Tests for Sections and Plates

2.2.3.1.1 For Sections and Plates, the following acceptance tests shall be carried out:

(i) Visual examination
(ii) Verification of dimensions
(iii) Chemical composition
(iv) Tensile tests

(v) Bend tests
(vi) Galvanizing tests
(vii) Prototype Tower Assembly

The Contractor shall render all necessary assistance to the Inspector in carrying out above mentioned tests.

(i) Visual Examination:

Samples for the tests shall be visually examined but not limited for material type, shape, galvanizing and generally finish with respect to applicable specifications and drawings.

(ii) Verification of dimensions:

The binding dimensions of the material shall be measured as shown on the relevant approved drawings subject to the tolerances given in ASTM A6.

Weight of each tower type in the offered Lot	Minimum nos. of samples to be taken from each type of tower
≤600 tons	15
>600tons and ≤1000tons	20
>1000tons and ≤1400tons	25
>1400tons	30

(iii) Chemical Composition:

To indicate adequately, the chemical composition of a heat or a lot, the minimum number of samples of each grade of steel selected to represent the heat shall be as follows:

	No. of Samples
500 tons or more	2
500 tons or less	1

If a sample fails to meet the requirement, the material of the respective steel grade in the lot shall be rejected.

(iv & v)Tensile and Bend Tests:

Sampling plan for tension and bend tests shall be made for each grade of steel as per following Table from the offered lot.

Weight of the finished shape of angle section/plate of each steel grade in the offered Lot	Tension Test	Bend Test
≤600 tons.	4	2
>600 and ≤1000 tons.	8	4
>1000 tons and ≤1400 tons.	12	6
>1400 tons	15	8

If a test sample fails to meet the specified requirements then four more samples shall be selected for tension and bend tests from the same grade of steel. If a test sample fails in the retest then the respective steel grade of the offered lot shall be rejected.

(vi) Galvanizing Tests:

To check that whether the galvanization is according to the specified standard or not, following tests shall be carried out on all ferrous parts complying with the following requirements.

(a) Weight of zinc coating
(b) Uniformity of zinc coating (minimum no. of dips shall be six (6))
(c) Adherence of zinc coating
(d) Embrittlement test

Sampling for determination of compliance to the tests specified shall be performed in accordance with relevant ASTM Specification and shall be taken from each lot. The lot shall consist of a quantity as specified in the relevant specifications.

(vii) Before starting mass fabrication of towers, one tower of each type including all combinations of body and leg extensions shall be shop assembled and vertically erected on a suitable foundation bed to assure proper fit of all parts as finally manufactured. Following should be kept in view during shop assembly:

(a) Check carefully each member while assembling the prototype to revise and amend the detailed drawings according to the correct solution;

(b) For each member, the length, position of holes and interface with other members shall be checked accurately for proper fitness;

(c) Quantity of each member and bolts shall be carefully checked from the bill of materials when assembling the prototype;

(d) On the assembled tower eventual modifications shall be examined and performed, if necessary, without modifying the functionality of the structure; and

(e) Drawings and bill of materials, sizes of bolts, fillers etc. shall be put up-to-date accordingly, in all details before starting mass production.

All changes/modifications incorporated in the drawings shall be brought to the notice of Project Manager along with corrected final copies of the drawings for approval. The Manufacturer shall also submit details of all the changes/ modifications carried out.

The Project Manager may witness a shop assembly of any or all types of towers before shipment.

2.2.3.1.2 For Nuts and Bolts, the following acceptance tests shall be carried out:

(i) Visual inspection
(ii) Verifications of dimensions
(iii) Mechanical Tests

(a) Proof load test
(b) Ultimate tensile strength test
(c) Ultimate tensile strength test under eccentric load

(iv) Galvanizing tests
(v) Hardness test (Alternatively to Ultimate Tensile Strength for the bolts less than M16x35).

The Contractor shall render all necessary assistance to the Inspector in carrying out above-mentioned tests.

(i) Visual Inspection:

The inspection shall cover finish defects such as rough galvanizing, bare spots, fins and any other defects not permissible under the specifications.

(ii) Verification of Dimensions:

The dimensions of the nuts and bolts shall be checked according to the specified standard hereinabove.

(iii) Mechanical Tests:

(a) Proof Load Test (b) Ultimate Tensile Strength Test (c) Ultimate tensile strength test under eccentric load.

These tests shall be carried out on the selected samples as per the test procedure defined in the relevant specifications.

(iv) Galvanizing:

The galvanizing tests shall be carried out as per relevant ASTM standard, however required number of dips will be six for the preece test.

(v) Hardness Test:

These tests shall be carried out on the selected samples of the bolts which shall have size less than M16x35 and shall not be undergo for tensile tests.

Sampling, Acceptance and Rejection:

Lot offered for inspection should be according to the size of bolts i.e. M16, M20 & M24. Each lot shall be divided into the batches of 5000 units (1 unit = 1 nut & bolt). Five units shall be selected from a batch of 5000 units or lesser in quantity and shall be tested for the above tests in the order as defined herein above except the galvanizing tests for which sampling shall be as per ASTM A153. If any unit selected from a batch fails (even if only bolt or nut) to meet the requirements of specified tests then five more units shall be selected at random from the same batch for retesting. If during retesting, the entire unit meets the specified requirements then the batch shall be accepted and, if any unit does not meet the specified requirement during retesting, the lot of that size shall be rejected.

2.2.3.2 Acceptance Tests for Plain & Spring Lock Washers and Ring Fillers

The following acceptance tests on spring lock washers, plain washers and ring fillers shall be carried out:

(i) Verifications of dimensions	Tests shall be carried out as per DIN127 & 128 on spring lock washers for ring fillers as per drawing
(ii) Visual inspection	
(iii) Galvanizing tests	As per ASTM A153
(iv) Hardness test	Tests as per DIN 127 & 128 on spring lock washers, ASTM F436 on plain washers and as per ASTM A36 on ring fillers.

(v) Twist test for spring lock washer	Tests shall be carried out as per
(vi) Spring force test	DIN267 on spring lock washers only

The Contractor shall render all necessary assistance to the Inspector in carrying out above mentioned tests.

Lot offered for inspection should be according to the size of spring lock washers and ring fillers i.e. M16, M20 & M24. Each lot shall be divided into batches of 5000 units. Three units shall be selected from a batch of 5000 units or lesser in quantity and shall be tested for the above tests in the order as defined herein above, except the galvanizing tests for which sampling shall be as per ASTM A153. Two samples each shall be selected from M16, M20 & M24 sizes for twist test for spring lock washer and spring force test from the lot having a quantity of less than 20,000 and four samples each from the lot having a quantity of more than 20,000. If any unit selected from a batch fails to meet the requirements of specified tests then five more samples shall be selected at random from the same batch for retesting. If during retesting, the entire unit meets the specified requirements then the batch shall be accepted and if any sample does not meet the specified requirements during retesting the lot of that size shall be rejected.

Plain washers (circular) shall meet the material and testing requirements as per ASTM F436M.

2.2.3.3 Acceptance Tests for Sign & Number Plates and Aerial Markers

The following acceptance tests for Sign & Number Plates and Aerial Markers shall be carried out:

(i) Visual examination
(ii) Verification of dimensions
(iii) Galvanizing test (on fixture and nuts & bolts only)
(iv) Resistance to thermal shock (vitreous enamel finish)

(i) Visual Examination:

Examination	Defects
a. Construction	Not of the shape given in relevant Drawing. Any crack on the nut& bolt.
b. Material	Not of proper material.
c. Finish	Galvanizing of bolts, nuts, washers and fixture not proper, presence of black spots, blisters, flux, dress, un-coated areas or any other defects. Bolts and nuts, rusty. Threads marred. The plates not properly enameled or presence of cracks, patches, pin-holes, blisters or any other defect. Letters and numbers broken or not properly enameled.
d. Marking	Missing or in-complete or not as per drawing.

(ii) Verification of Dimensions:

Dimensions of the danger, number, aerial markers, phase plates and fixtures shall conform to those given in drawing Nos. 3206/169/TD/01E205 with allowable tolerances as marked on the individual drawings. Any variation from the specified dimensions shall constitute a defect.

(iii) Galvanizing Test:

The galvanizing of the nuts, bolts, washers and fixtures shall be tested in accordance with ASTM Specifications.

(iv) Resistance to Thermal Shock:

This test shall be carried out by subjecting the test specimen to radiant heat so as to reach a steady temperature of 185-195°C in about ten minutes. The temperature shall be measured by means of a surface pyrometer in contact with the top surface of the heated part of the specimen.

Remove the radiant heat and within 5 seconds quench the surface with 1000 ml of water at 15-20°C direct from an aspirator or other container through a 5 mm diameter tube, the end of the tube being 150 mm above the centre of the heated portion of the test specimen. The flow rate of water shall be adjusted to 10 ml per second. It is convenient to mark the test area to ensure that the water is correctly applied. Dry the plate, replace in the same position under radiant heat source and repeat this procedure until six cycles have been completed.

After subjecting the test specimen to the above test, the vitreous enamel surface shall be considered to be resistant to thermal shock provided that the enamel shows no signs of flaking-off or crazing.

Sampling, Acceptance and Rejection:

Danger, number, phase plates, aerial markers and fixtures offered for acceptance shall be divided into lots containing up to 200 units in each lot. A sample of 12 units (3 each from danger, number, phase and aerial marker) shall be drawn at random from each lot. For thermal shock test two samples each shall be randomly selected from the offered lot.

The selected samples shall be subjected to the visual examination, verification of dimensions and galvanizing. If the number of defective units is two, the lot shall be accepted. If the number of defective units is more than two the lot shall be rejected. If the number of defective units is three, another sample of 12 units shall be selected at random and subjected to tests. If the number of defective units is again three or more then the lot shall be rejected and if the number of defective units is less than three then the lot shall be accepted.

2.2.3.4 Acceptance Tests for Barbed Wire

The following acceptance tests for barbed wire shall be carried out:

(i) Visual examination
(ii) Verification of dimensions
(iii) Galvanizing
(iv) Physical

These tests shall be carried out on the selected samples as per the test procedure defined in the relevant ASTM specification.

3 CONDUCTOR

3.1 Scope

This specification covers the technical requirements for design, manufacture and testing of transmission line conductors.

3.2 Detailed Requirements

3.2.1 Conductors Characteristics

The conductors shall be Aluminum Conductor Steel Reinforced (ACSR) and "DRAKE" and All Aluminum Alloy (AAAC) “GREELEY”. ACSR “DRAKE” shall conform to the requirements of ASTM B498 and B232 and AAAC “GREELEY” shall confirm to the requirements of ASTM B398 and B399 plus the following requirements:

Description of Characteristics	Requirements for ACSR "DRAKE"	Requirements for AAAC GREELEY”
- Conductor size, KCM	795	927.2
- Stranding		
· Aluminum/Aluminum Alloy	26	37
· Steel	7	-
- Diameter of wires		
· Aluminum, mm	4.44	4.02
· Steel mm	3.45	-
- Conductor Diameter (Nominal), mm	28.14	28.14
- Cross Section Area (Nominal)		
· Aluminum, mm²	402.6	469.6
· Steel, mm²	65.4	-
· Total, mm²	468	469.6
- Nominal Weight		
· Aluminum, kg/km	1116.2	1295
· Steel, kg/km	511.95	-
· Total, kg/km	1628	1295
- Rated Ultimate Tensile Strength, kg	14174	13835
- Minimum DC Resistance at 20°C, ohm/km	0.07195	0.0713
- Normal Reel Length, m	3200	3200

3.2.2 Conductor Wires

Each individual Aluminum wire entering into the construction of the complete conductor shall conform to ASTM B230 for ACSR “DRAKE” and ASTM B398 for AAAC “GREELEY”.

The steel core strands must be able to withstand 4 dips of the preece test in accordance with the ASTM A239. The other requirements of steel core shall conform to ASTM B498; Standard Specification for Zinc Coated (galvanized) Steel Core Wire for Aluminum Conductor Steel Reinforced (ACSR). The Zinc coating for steel core wire for conductor shall conform to class A zinc coated steel wire.

3.2.3 Joints

Joints in finished individual Aluminum and Aluminum Alloy wires composing the conductors may be made in accordance with ASTM B232 and B398 respectively, but there shall be no joints of any kind made in the finished individual zinc coated steel wire used for the core for ACSR conductor. Joints in

the hot-rolled rods or semi-finished wires before cold drawing may be made in accordance with ASTM B498.

3.2.4 Stranding

The lay factors used shall be within the limits specified in relevant ASTM Standard. Once stranding has been started, the same lay factor shall be maintained for all conductor shipments.

The conductor shall be stranded in one pass if this is practical. If this cannot be done, the conductor shall be stranded in a maximum of two passes.

When stranding the steel core or the partially stranded conductor and the wires to be added shall be inside the stranding premises for a long enough time period to ensure that the steel core or partially stranded cable and the wires to be added are at the same temperature that will be maintained throughout the stranding process.

Once the stranding and storing procedure has been started, the same procedure shall be followed for the balance of the wire for a given destination in order to give all wire as near the same stranding history as possible.

For ACSR "DRAKE" conductor, steel wire from various manufacturers may be used. However, all conductors for a given destination shall be manufactured from the steel core wire from one manufacturer. If steel core wire from more than one source is being used, this shall be indicated on the reels.

The same stranding machine or combination of stranding machines if more than one pass is required, shall be used for all conductor for a given destination unless otherwise approved in writing by the Project Manager. Marking on the reels shall indicate when a different machine or combination of machines is being used.

3.2.5 Fabrication

The nominal conductor weight is based on ASTM standard, stranding increments. The actual weight will be dependent on production of lengths.

The wires shall be so stranded that when the conductor is cut, it shall be essentially free from a tendency to untwist or spring apart.

The finished conductor shall be uniformly cylindrical and shall be capable of withstanding the normal handling in manufacturing, shipment and installation without being deformed in such a way as to increase corona losses and radio interference.
The conductor shall be free from excessive amounts of die grease, metal particles and dust, and all imperfections not consistent with best commercial practice. The finished product shall be free from projections to limit corona and radio interference.

3.3 Testing

3.3.1 Tests on Individual Wires

Before stranding, wire shall be tested in accordance with ASTM B230 and ASTM B398 respectively for ACSR and AAAC conductors.

Tensile properties, electrical resistivity and diameter shall be checked using sampling described in ASTM B230 for ACSR and ASTM B398 for AAAC conductors. For bending properties, ten percent (10%) of reels shall be checked.

3.3.2 Ductility Test

This test shall be made on Zinc-coated Steel wires only.

One specimen cut from each of the sample shall be gripped at its ends in two vices, one of which shall be free to move longitudinally during the test. A small tensile load, not exceeding 2% of the breaking strength of the wire, shall be applied to the sample during testing. The specimen shall be twisted by causing one of the vices to revolve until fracture occurs and the number of twists shall be indicated by a counter or other suitable device. The rate of twisting shall not exceed 60 rev/min.

When tested before stranding, the number of complete twists before fracture occurs shall be equivalent to not less than 18 on a length equal to 100 times the diameter of the wire. The fracture shall show a smooth surface at right angles to the axis of the wire.

When tested after stranding, the number of complete twists before fracture occurs shall be equivalent to not less than 16 on a length equal to 100 times the diameter of the wire. The fracture shall show a smooth surface at right angles to the axis of the wire.

As an alternative to the torsion test, an elongation test may be made on zinc-coated steel wires. The elongation of one specimen cut from each of the sample shall be determined. The specimen shall be straightened by hand and an original gauge length of 200 mm shall be marked on the wire. A tensile load shall be applied gradually. The rate of separation of jaws of the testing machine shall not be less than 25 mm/min and not greater than 100 mm/min and the elongation shall be measured after the fractured ends have been fitted together. If the fracture occurs outside the gauge marks, or within 25 mm of either mark and the required elongation is not obtained, the test shall be disregarded and another test made. When tested before stranding, the elongation shall be not less than 4%. When tested after stranding, the elongation shall be not less than 3.5%.

Note: The choice between a torsion test and an elongation test is to be at the discretion of the manufacturer and the choice of one test or the other in no way prejudices the quality of the steel used.

3.3.3 Type Tests on Complete Conductor

Following tests shall be performed to qualify the design before regular production:

(a) Stress – Strain Test:

The stress-strain test shall be performed on the conductor in accordance with the method given in Annex B of IEC-61089.

(b) Stress – Strain Curves:
The Contractor shall provide the data with initial and final stress-strain curves for the conductor. These stress-strain curves shall be obtained using the "Standard Method of Stress-Strain Testing of Aluminum Conductor and ACSR" prepared by "The Aluminum Association", 420 Lexington Avenue, New York N.Y.10017, USA.

The creep curves shall be shown for the conductor held at a constant tension of 15%, 20%, 25% and 30% of the rated ultimate tensile strength of the conductor. These shall be presented on log-log paper, with a minimum of 5 cycles on the time scale. These data shall be based on tests carried out for a minimum of 1000 hours to obtain the degree of accuracy required.

(c) Creep Test:

In addition to above, creep test for conductor shall be performed in accordance with IEC-61395 to qualify the design and creep curves be provided accordingly.

(d) Longitudinal Smoothness Test:

When the dies are ready for the conductor but before regular fabrication commences, a sample of conductor having a minimum length of 12 meters shall be prepared and tested in the presence of the representatives of Employer and Project Manager to ensure compliance with outside diameter, cross-sectional area, lay, weight, ultimate strength, tightness of stranding, and longitudinal smoothness requirements. The conductor shall comply with the requirements of ASTM B232/B399 and Clause 3.3.1 and 3.3.2 of this Specifications.

The ultimate strength and longitudinal smoothness shall be carried out on a minimum length of 12 meter of conductor. The Contractor shall supply and install the compression fittings required at the ends of the sample for testing.

During the test, the conductor shall be checked for longitudinal smoothness as follows:

When the conductor is subjected to a tension of 50% of the rated ultimate strength of the conductor, a straight edge not less in length than twice the lay of the surface layer shall be placed parallel to the length of the conductor. The maximum variation from the straight edge shall not exceed 10% of the nominal aluminum strand diameter.

At the end of the test, the nominal ultimate strength of the conductor shall be determined without the fracture of any wire at 95% of rated tensile strength when pulled steadily and continuously in a tensile machine whose moving head has a no-load speed of approximately, but no greater than 75 mm/minute.

The sample shall develop the ultimate tensile strength as calculated from the sum of minimum average ultimate strength of the aluminum wires and the procedure specified in ASTM B232/B399.

3.3.4 Sample Tests on Complete Conductor during Fabrication

The manufacturer shall carry out during fabrication in addition to the tests specified in ASTM Standards, any other tests specified elsewhere in this specification. A minimum 1.25 meter length sample of finished conductor shall be cut from the finishing end of the first length in production between the capstan and the take-up reel. To preserve the proper condition of the sample, both ends shall be taped before cutting. This sample shall be checked for the following characteristics:

a. Finished diameter
b. Length and direction of lay
c. Finished weight
d. D.C. resistance of each aluminum strand
e. Cracks, scores, undue cross-over marks, indentations etc. of each of the 54 layers of the conductor.

When the conductor sample is found to be satisfactory, 1.25 meter minimum length samples shall be taken from every 10th reel subsequently produced and the above characteristics shall be checked. If on testing the sample from any drum fails to conform to the requirements of the specifications, two additional samples shall be taken from the same drum for another testing. If both of these samples shall not conform to the specified requirements the drum shall be rejected. Samples then shall be taken from all the drums offered for acceptance and shall be tested. If sample from a drum does not meet the requirements, that drum shall be rejected. If number of rejected drums exceeds 20% of the offered lot, the complete lot shall be rejected.

In addition to the tests specified above, a minimum length of 12 meters of conductor shall be cut off from reels arbitrarily selected by the Project Manager, but no more than one reel out of every 100 will be chosen unless a production run comprises less than 100 reels of conductor. In that case, the

Project Manager reserves the right to test one sample from each production run of less than 100 reels. These samples shall be checked for the ultimate strength and longitudinal smoothness following the procedure described in Clause 3.3.3(d) of this specification.

If a conductor test piece does not meet the strength and elongation requirements, further samples shall be tested from reels number x, x+10 and x-10, where x is the reel number from which the rejected sample was taken.

If these three conductor samples meet the specification, the lot shall be accepted. If one of the last three samples does not meet the specification, samples shall be tested from reels x+5 and x-5 where x is the reel number from which the sample that did not meet the specification was taken. This process shall be repeated until all reels containing faulty material have been located and rejected.

3.4 Markings & Packing

Flange of the reel shall bear a non-corroding tag, written in English language, identifying the following:

a. Type of conductor and code word
b. Weight of conductor
c. Length of conductor
d. Stranding

Each reel shall be stenciled to show all information as follows:

a. Manufacturer's name and country of origin
b. Year of manufacture
c. Reel number
d. Size of reel
e. Gross weight
f. Net weight
g. Consignee address
h. Direction of rolling with instruction "ROLL THIS WAY"
i. Instructions "DO NOT LAY FLAT"

The overhead line conductor shall be furnished on non-returnable wooden reels, protected by wood lagging or other suitable method against damage during shipment and to facilitate safe and easy field handling and long-term outdoor storage. The Contractor is required to follow the sample drawing No 3206/169/TD/01E210 for wooden reel attached in Volume-III for minimum compliance; however it is the responsibility of the Contractor to ensure that the method of packing shall be strong enough to withstand wear and tear during sea/inland transportation and handling at site.

However, the manufacturer may at his own option furnish the conductor on non-returnable steel reels at no additional cost to the Employer.

Methods of packing, marking and shipping shall be submitted to the Project Manager for review and acceptance.

4. SHIELD WIRE AND OPTICAL FIBER EQUIPMENT

4.1 EHS Shield Wire

4.1.1 Scope

This specification covers technical requirements for the design, manufacture and testing of galvanized overhead shield wire.

4.1.2 Detailed Requirements

4.1.2.1 Shield Wire Characteristics

The overhead shield wire shall conform to high strength grade, class B steel in accordance with ASTM A363, plus the following requirements.

Diameter of galvanized steel wire	9.15 mm
Number of strands of wire	7 (seven)
Diameter of each strand	3.05 mm
Nominal weight of the wire	407 kg/km
Rated ultimate tensile strength	6985 kg
Cross-Sectional area	51.14 mm^2

4.1.2.2 Joints

There shall be no joints of any kind made in the finished strand entering into construction of galvanized steel overhead shield wire. Welding before cold drawing of the strand may be made in accordance with ASTM A363 latest edition.

4.1.2.3 Stranding

The lay factors used shall be within the limits specified in the ASTM Standards. Once stranding has been started, the same lay factor shall be maintained for all wire shipments. The wire shall be stranded in one pass.

4.1.2.4 Tensile Strength and Elongation of Wire and Other Tests

The Contractor shall test complete sections of the wire and follow the procedure as laid down in the relevant ASTM Standard. The pieces of wire to be tested shall be cut off from reels arbitrarily selected by the Project Manager but no more than 2 reels out of every 15 will be chosen unless a production run produces less than 15 reels of wire. In that case, the Project Manager reserves the right to test 2 samples from each production run of less than 15 reels, and if the wire or strand fails in the first test to meet any requirement of this Specification, further samples shall be tested from reels numbered, x, x+10 & x-10 where x is the reel number from which the rejected sample was taken. If these three samples meet the Specification, the lot shall be accepted. If one of the last three samples does not meet the Specification, samples shall be tested from reels x+5 & x-5 where x is the reel number from which the sample that did not meet the Specification was taken. This process shall be repeated until all reels containing faulty material have been located and rejected.

The wire shall also withstand ductility test by wrapping 8 turns on and off round a bar of its own diameter without fracture.

The number of samples to be tested shall be as given in the relevant ASTM Standards and test samples shall be subjected to all tests specified in the standard from which the steel wire strand is manufactured.

The strength and elongation test shall be done by obtaining stress-strain curves of the sample to determine that the requirements of ASTM Standards are met. This test shall be done to destruction.

4.1.2.5 Galvanizing

(a) Weight of Coating. The weight of Zinc coating of uncoated wire surface shall not be less than 519 grams/m^2.

The weight of Zinc coating shall be determined in accordance with ASTM standard method A-90.

(b) Adherence of Coating. The zinc-coated wire shall be capable of being wrapped at a rate not exceeding 15 times per minute in a close helix of at least two turns on a cylindrical mandrel equal to three times the nominal diameter of the wire under test, without cracking or flaking the Zinc coating to such an extent that any Zinc can be removed by rubbing with the bare fingers.

(c) Preece Test. The galvanized steel wire must be able to withstand 4 dips of the preece test in accordance with ASTM A-239 standard.

4.1.2.6 Supply of Stress-Strain Curves

The Contractor shall supply the initial and final stress-strain curves, for the overhead shield wire.

4.1.2.7 Markings and Packing

Each end of the overhead shield wire (SW) in the reel shall bear a non-corrosive tag identifying the following:

a. Grade/Type of SW;
b. Diameter/Size of SW;
c. Minimum breaking Strength;
d. Length of SW;
e. Stranding; and
f. Type and Class of Coating.

Each reel shall be stenciled or provided with metal plates to show all information under the above paragraph plus additional information as follows:

a. Manufacturer's Name and Country of Origin;
b. Year of Manufacture;
c. Reel Number;
d. Size of Reel;
e. Gross Weight;
f. Net Weight
g. Consignee Address; and
h. Direction of Rolling.

All markings shall appear on both sides of the reel.

The overhead shield wire shall be furnished on non-returnable wooden reels, protected by wood lagging or other suitable method against damage during shipment and to facilitate field handling and long-term outdoor storage. However it is the responsibility of the Contractor that the method of packing shall be strong enough to withstand wear and tear during sea/inland transportation and handling at site.

However, the manufacturer may at his own option furnish the shield wire on returnable steel reels at no additional cost to the Employer.

Methods of packaging, marking and shipping shall be submitted to the Employer's Representative for review and acceptance.

4.2 Optical Fiber Equipment

These Technical Specifications pertain to the following:

- Optical Fiber Ground Wire (OPGW)
- Joint Boxes
- Test Equipment, Installation and Maintenance Tools

- Fiber Optic Cable

In the following sections, technical specifications for each of the above items are given.

4.2.1 General

The OPGW, installed on the transmission line towers, shall be designed to withstand the prevailing environmental conditions including the effects of high electric and magnetic fields produced in the proximity of live power conductors. The design of OPGW shall be mechanically and electrically compatible with the design of the transmission line. The OPGW shall be able to withstand the system fault current and lightning current without irreversible degradation of the optical properties of the fibers.

The stringing of OPGW shall be similar to conventional earth wires (bending radius, tension forces) and shall be executed under guidance and supervision of the Manufacturer's site supervisor, the cost of which is deemed to be included in the Contract price. The bidder shall provide full details of the method of support and installation procedures, including the jointing and splicing techniques.

The service life of OPGW shall be similar to that of conventional earthwires (i.e. 25 to 30 years) and test evidence to support Supplier's claim in this respect shall be submitted with the Bid.

4.2.2 Standards

Unless otherwise specified herein, the Contractor shall conform to the applicable requirements of the latest revisions of the standards stated in clause 1.4.3 or equivalent as approved by the Project Manager.

4.2.3 Optical Fiber Ground Wire (OPGW)

4.2.3.1 Material and Workmanship

The material(s) used for the manufacture of the OPGW shall be of highest grade free from defects and imperfections conforming to the requirements of the latest issue of the relevant standards.

The materials used shall be:

- Aluminum Clad Steel (ACS) and/or Aluminum Alloy (AA) wires for outer conducting layer (armor);
- Aluminum Clad Steel (ACS) for inner conducting layer (if additional layer is used);
- Glass fibers;
- Metallic buffer tube;
- Aluminum tube; and
- Moisture proof and hydrogen absorbent gel.

Proper arrangements shall be made for the provision of corrosion prevention material and suitable filling compounds as hydrogen absorbing gel in the offered OPGW. The bidder shall provide details in this regard.

4.2.3.2 Cable Construction

The OPGW shall comprise:

- a central fiber optic unit designed to house and protect the optical fibers from damage to forces such as crushing, bending, twisting, tensile stress and moisture;

- an aluminum tube over the central fiber optic unit; and

- an outer metallic part (armor) designed to function as the conventional shield wire and to protect additionally the central fiber optic unit.

The fiber optic unit, Aluminum tube and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibers from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault currents as well as environmental effects that may produce hydrogen.

- Central fiber optic unit

  The optical fibers shall be protected by metallic buffer tube made of appropriate material to withstand temperatures of 200°C under short circuit current without continuous degradation. The buffer tubes shall not be on the outer layer in order to be protected from external mechanical forces and electrical disturbances. Inside the buffer tube the fibers shall be loosely housed in a waterproof gel to prevent water penetration and protection against friction.

  The metallic buffer tubes shall have aluminum covering which shall be applied to prevent corrosion. The housing of the buffer tube shall ensure protection against tensile and crushing forces on the buffer tubes and optical fibers. The maximum number of fibers in one tube shall not be more than eight (8). Each fiber in a tube shall be distinguishable from other fiber in the same tube by means of colour coding in accordance with EIA-598A.

- Stranded metallic wires (armor)

  The OPGW shall be stranded with Aluminum Clad Steel wires (ACS). However, if more than one stranding layer is used, Aluminum Alloy (AA) may be used in the outer layer.

  The basic construction shall have bare concentric lay stranded metallic wires. The stranded wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay shall be reversed in successive layers.

  The wires shall be stranded such that when the OPGW cable is cut the individual wires can be regrouped and held in place.

- Sag and Tension Limits

  Physical design of the proposed OPGW for installation on new overhead transmission lines shall have sag and tension characteristics similar to the 9.15 mm diameter, extra high strength, 7 strands, galvanized steel overhead shield wire for the spans.

4.2.3.3 Cable Characteristics

From the environmental point of view, it is reminded that the OPGW will be exposed to a harsh environment viz:

- maximum summer temperature : +80°C;

- maximum summer relative humidity: approaching 100%; and

- sand and wind storms.

The Contractor shall take these atmospheric constraints into account to select a suitable OPGW for which 25-30 year's service life is guaranteed.

The main features of the cable shall be:

-	Number of fibers	24
-	Outer diameter	≤ 12 mm
-	Breaking load	≥ 7000 kg
-	DC resistance at 20°C	≤ 0.75 ohm/km
-	Nominal weight	≤ 460 kg/km
-	Minimum bending radius (without fiber damage)	≤ 200 mm
-	Short circuit current for 1 sec.	≥ 5kA for temperature rise from 20 - 200° C

4.2.3.4 Fiber Characteristics

The main features of the optical fiber shall be as follows:

- transmission mode	single mode complaint with ITU-T Rec G.652
- wave length	1310nm and 1550nm,
- attenuation	≤ 0.35dB/km at 1310nm, ≤ 0.22dB/km at 1550nm on Jamshoro-Moro and Dadu-Moro links ≤ 0.2dB/km at 1550nm on Moro-Goth Qazi Mahar and Rahim Yar Khan-Goth Qazi Mahar links
- maximum splicing loss	0.05dB,
- maximum end-connector loss	0.5dB,
- core diameter	9-10µm ± 0.5µm,
- cladding diameter	125µm ± 2µm,
- maximum concentricity error	1µm,
- maximum cladding non-circularity	2%,
- chromatic dispersion	≤ 3.5ps/nm.km at 1310nm, ≤ 18ps/nm.km at 1550nm,
- cut-off wavelength	≤ 1270nm,
- mode field diameter	8.1-9.7µm,
- operational temperature range	-10 to 80°C.
- optical channel capacity for WDM	>6.

Inside the buffer tube the reserve length of fibers shall be at least 0.45% against the linear length of the complete OPGW to prevent the fibers from coming under stress. To prove this a sample of at least 80 m shall be pulled up to endurance tensile strength while a continuous optical measurement of fiber length and attenuation is done simultaneously.

4.2.3.5 OPGW Tests

(a) Factory Tests

The following tests shall at least be performed. The Contractor shall indicate the standards according to which the tests shall be performed and shall be internationally acceptable (i.e. DIN,

BS, ASTM, IEC...). In case OPGW is of special design, the Contractor shall attach tests of similar design. The tests are:

(i) Tensile Test: with indicated over length of fiber and simultaneously measured attenuation at 1310nm and 1550nm;

(ii) Bending Test: Similar to DIN VDE 0472 Teil 232; the bending radius shall be 25 x outer diameter of OPGW and the test shall be carried out successfully if the attenuation of the straightened fiber is within the fiber standards limits;

(iii) Attenuation test using OTDR;

(iv) Chromatic Dispersion test; and

(v) Geometry tests of optical fibers, central optical unit, aluminum tube and outer strands.

In addition, the Contractor shall carry out tests of the single wires according to one of the above mentioned standards. If parts of the OPGW are greased, the Contractor shall attach data sheets of the grease.

(b) Type Tests

OPGW cable shall be subjected to the following type tests as described in IEEE 1138. Failure criteria for each test as per IEEE 1138 are given under each type test.

(i) Short circuit test:

A permanent increase in optical attenuation greater than 0.05 dB/fiber at1550 nm shall constitute a failure. Permanent bird caging of any of the strands after five (5) hits shall also constitute a failure. Cracking or breaking of any component of optical sample shall also constitute a failure. There shall also be no excessive wear, discoloration of fibers, deformation or other signs of breakdown. The maximum temperature of optical core attained during short circuit testing shall not exceed 180°C.

(ii) Aeolion vibration test:

Permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at 1550 nm shall constitute failure. Cracking or breaking of any component of the cable or supporting hardware shall also constitute failure.

(iii) Galloping test:

Permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at 1550 nm shall constitute failure. Cracking or breaking of any component of the cable or supporting hardware shall also constitute failure.

(iv) Sheave wheel test:

Permanent increase in optical attenuation greater than 0.1 dB/test fiber km at 1550 nm shall constitute failure. Cracking or breaking of any component of the cable shall also constitute failure. Ovality of cable or optical units > 10% shall also constitute failure.

(v) Crush test:

The cable shall be subjected to a crush load to be provided by the manufacturer. Permanent increase in optical attenuation greater than 0.05 dB/test fiber km at 1550 nm

shall constitute failure. Cracking or breaking of any component of the cable shall also constitute failure. Ovality of cable or optical units > 10% shall also constitute failure.

(vi) Impact test:

An increase in attenuation greater than 0.10 dB/km at 1550 nm shall constitute failure.

(vii) Creep test:

There is no criteria stated for this test in the standard.

(viii) Strain margin test:

A strain margin test shall be conducted on the cable to determine the amount of strain that the cable can withstand without placing strain on the optical fiber. Permanent increase in optical attenuation > 0.2 dB/test fiber km from preload up to maximum rated design tension (MRDT) = 42% of RTS at 1550 nm shall constitute failure.

(ix) Temperature cycling test:

A change in optical attenuation greater than 0.20 dB/km at 1550 nm shall constitute failure.

(x) Lightning arc test:

The test shall be performed according to class 1. Permanent increase in optical attenuation greater than 0.05dB dB/fiber at 1550 nm shall constitute failure. Minimum remaining strength <75% of the cable RTS of any tested cable section shall also constitute a failure.

(xi) Water ingress test:

Any leakage of water through open end of 1 m sample after 1 hour shall constitute failure.

(xii) Seepage of flooding compound test:

Any flow (drip or leak) of the filling and flooding compound at 65°C shall constitute failure.

The above type tests, as a minimum, shall be performed at an NTDC approved laboratory in the presence of an independent laboratory representative who shall sign the certificates on successful tests and the certified Type Test Certificate/Test Report shall be submitted on completion of the tests for review. In case any test fails to comply with the requirement, the same shall be repeated at no additional cost to the Employer. Costs for the type tests shall be deemed to be included in the Bid Price.

4.2.3.6 Markings & Packing

Flange of the reel shall bear a non-corroding tag, written in English language, identifying the following:

a. Type of OPGW and code word;
b. Weight of OPGW;
c. Length of OPGW; and
d. Stranding.

Each reel shall be stenciled to show all information as follows:

a. Manufacturer's name and country of origin;
b. Year of manufacture;
c. Reel number;
d. Size of reel;
e. Gross weight;
f. Consignee address;
g. Direction of rolling with instruction "ROLL THIS WAY"; and
h. Instructions "DO NOT LAY FLAT".

The OPGW shall be furnished on non-returnable wooden reels, protected by wood lagging or other suitable method against damage during shipment and to facilitate field handling and long-term outdoor storage. However, it is the responsibility of the Contractor that the method of packing shall be strong enough to withstand wear and tear during sea/inland transportation and handling at site.

However, the manufacturer may at his own option furnish the OPGW on returnable steel reels at no additional cost to the Employer.

Methods of packaging, marking and shipping shall be submitted to the Project Manager for review and acceptance.

4.2.4 Joint Boxes

Joint boxes shall be provided to protect splices from all construction and working stresses likely to deteriorate their characteristics. Attachment of OPGW or Fiber Optic approach Cable (FOC) ends to joint box shall also be ensured. Operating temperature range shall be -10°C to +80°C.

Weather-proof units of protection Class IP65 made of non-corrosive aluminum alloy or stainless steel shall be provided. The joint boxes shall include all necessary hardware to terminate, protect and fix the spliced fibers. A name plate giving important information shall be attached to the joint box. This name shall have embossed characters and shall be made of weather proof material.

Two types of joint boxes shall be provided:

Type A: Joint boxes on OHL used to connect two sections of OPGW fibers anchored on a tower. These will be installed in about middle portion of towers or portal structure along their body. A spare fiber length (approximately 1.5 m) shall be left inside so as to be able to remake a faulty splice.

Type B: Terminal joint boxes on OHL used to connect the optical fibers of OPGW to Fiber optic approach cable (FOC) within the substation. These shall be similar to above type except for the connection arrangement.

The Contractor shall also design and supply the supporting devices made of galvanized steel to install joint boxes on the galvanized steel towers/terminal structures. Fasteners for installation of the supporting devices on the towers/terminal structures and the joint boxes on the supporting devices shall also be supplied by the Contractor. Design and materials of the supporting devices are subject to approval of the Project Manager. Galvanizing on the structural steel shapes of supporting device shall conform to ASTM A123 latest edition with average weight of zinc coating as 705 gm/m^2 and on the fasteners shall conform to ASTM A153 (latest edition) with average weight of zinc coating as 381gm/m^2. One supporting device for each joint box will be supplied.

4.2.5 Fiber Optic Cable

4.2.5.1 General

The fiber optic cable (FOC) shall be designed to withstand all prevalent environmental conditions including the effects of high electric and magnetic fields produced in proximity of live power cables.

A service life of at least 25 years is required, and test evidence to support Supplier's claim in this respect shall be submitted with the bid.

4.2.5.2 Cable Type

The fiber optic cable shall be of the single mode type equipped with at least 24 fibers complying with ITU-T recommendation G.652 and shall be suitable for underground installation and laying in trenches/cable trays.

4.2.5.3 Fiber Optic Cable Requirements

(i) Water-tightness

The cable shall be fully moisture-resistant and meet the longitudinal water-tightness test requirements.

(ii) Electrical withstand

Considering there is a potential danger through fault or leakage currents, the cable must be non-metallic.

(iii) Mechanical withstand

The cable shall suitably withstand the mechanical radial stresses and shall be protected against rodents and termites. The crush resistance shall be at least 2kN/10cm.

(iv) Temperature withstand

The operating temperature range shall be 0 to +70°C and the cable shall be suitable for operation in tropical climate with humidity approaching 100%.

4.2.5.4 Fiber Characteristics

Identical to those given in Section 4.2.3.4.

4.2.5.5 Cable Construction

A loose tube, minimum strain configuration, which provides protection from external forces and possesses high tensile strength/resistance to crushing, shall be supplied. The fibers shall lie loosely inside plastic tubes filled with a gel to protect the fibers from the ingress and propagation of moisture. The maximum number of fibers inside any one tube shall be 8. Each tube and fiber shall be colour coded to be distinguishable from the other.

The cable construction shall comprise a dielectric central strength member surrounded by loose buffer tubes and fillers covered by moisture-resistant wrapping. The interstices among the loose tubes shall be filled with water blocking jelly compound. The wrapping shall be covered with thermoplastic sheath surrounded by aramid or glass yarn reinforcement. Anti-rodent protection shall be applied around the reinforcement layer by means of glass tape. The outer jacket of the cable shall be made of rugged non-metallic material of thickness not less than 1.5mm and covered with anti-termite coating.

Full constructional details of the cable offered shall be submitted with the bid.

4.2.5.6 Ending Rules

After factory acceptance, the inner end of the cable shall be fitted with an end cap to ensure water-tightness; the outer end shall be fitted with a water-tight head compatible with cable pulling. Caps (material and implementation) shall comply with applicable standards. They shall not be removed until immediately prior to optical jointing.

4.2.5.7 Cable Installation

The fiber optic cable shall be laid in a buried 100mm PVC duct from/to the terminal joint boxes. However within building premises it shall be laid in a flexible duct on cable trays. Drawings showing the installation details shall be submitted to the Project Manager/ Employer for approval.

Any damage to the cable which is laid and exposed but not protected and during installation shall be made good by the Contractor at his expense and to the satisfaction of the Engineer/Employer.

For buried PVC duct, a trench 0.5 m wide x 1m deep shall be excavated with provision of manholes at every 1km distance for cable pulling and future maintenance.

PVC duct shall be laid on a sand bed of at least 100mm thickness and shall be covered by sand layer of 300mm thick

A cable warning tape shall be placed on the top of sand layer. It shall be bright yellow in colour and of plastic material 300 mm wide by 0.1mm thick shall be supplied. The tape shall be continuously and indelibly marked in English and Urdu with the words:

CAUTION CAUTION CAUTION
FIBER OPTIC CABLE 700 mm BELOW

The lettering shall be black on yellow.

The excavated material shall be used for the remaining back filling of the trench.

The openings to the ducts shall be closed with a suitable compound after the cable has been laid. A 10m loop shall be kept in manholes.

4.2.5.8 Labeling

All cables and cable ends should be labelled clearly in accordance with the specification. The meter run should be marked on the outer sheath. This speeds up localisation of faults which are detected during calibration of cable.

Drums shall be fitted with securely attached, unalterable identification plate bearing the following information:

- Employer's name,
- supplier's name,
- contract number,
- content (including drum no.),
- manufacturing date,
- length of cable on drum,
- direction of rotation of the drum,
- position of the cable nose,
- weight of drum.

The cable shall be furnished on non-returnable wooden reels, protected by wood lagging or other suitable method against damage during shipment and to facilitate field handling and long-term outdoor storage. However, it is the responsibility of the Contractor that the method of packing shall be strong enough to withstand wear and tear during sea/inland transportation and handling at site.

However, the manufacturer may at his own option furnish the cable on returnable steel reels at no additional cost to the Employer.

Methods of packaging, marking and shipping shall be submitted to the Employer's Representative for review and acceptance.

4.2.6 Splices

Fusion splicing shall be employed to join the fibers, and shall be carried out by trained personnel of the Contractor, using the tools and instruments recommended by the Manufacturer. Prior to splicing, the fiber ends shall be cleaned and prepared, using tools and methods recommended by the Manufacturer of OPGW/FOC. A splice shall be suitably supported within the joint box. It shall be possible to remove and replace the splice in the support device without risk of damage to the splice or fiber.

4.2.7 Test Equipment, Installation and Maintenance Tools

The bidder shall provide technical details, manufacturer's catalogues and drawings of all the mandatory test equipment, installation and maintenance tools being supplied, which shall include, as a minimum, the following:

(a) 1 No. Optical Time Domain Reflectometer (OTDR), Yokogawa make, type AQ7260 or equivalent with a range ≥ 400km and including:

(i) Software and PC notebook for operation of above
(ii) Accessories consisting of, as a minimum:

- Optical adapters
- Cleaning tape for optical parts
- Battery backup including charger
- AC Adapter
- Connection cable to PC, printer, remote etc.
- Hand carrying case

(b) 1 No. Fiber Optic Splicing Unit, Fujikura make, type FSM60S or equivalent/better including:

(i) Carrying case
(ii) Mini tools and spares kit
(iii) AC & DC leads
(iv) Re-chargeable battery and battery charger

(c) 2 No. Fiber Optic Toolkit including at least the following:

(i)	Stripper for 0.9 mm tight secondary coated and for 250 μm primary coated fibers.	1 pc
(ii)	Stripper for buffer tubes and cord-type fiber optic cables	1 pc
(iii)	Cutting tool for the core of OPGW	1 pc
(iv)	Fiber holder for stripping optical fibers	1 pc
(v)	High-precision cleaving tool	1 pc
(vi)	Cleaning tissues, 200 pcs/pack	1 pack
(vii)	Cotton sticks for cleaning the V-grooves of a fusion splicer, 100 pcs/pack	1 pack
(viii)	Cleaning solution, 300 ml/bottle	1 pc
(ix)	Air blast, dust-off	1 pc
(x)	Tweezers for handling optical fibers	1 pc
(xi)	Microscope 30X with universal connector adapter	1 pc
(xii)	Cleaning cassette for fiber optic connectors	1 pc
(xiii)	Self-adhesive warning label "FIBER OPTIC CABLE" Size 185 mm x 15 mm, 120 pcs/pack	1 pack
(xiv)	Number tape set with replacement rolls of Numbers 0-9	1 set

(xv)	Rugged carrying case	1 pc
(d)	Instruction Manuals of tools and test equipment (in English).	1 set

Additional recommended tools shall be listed and described separately.

4.2.8 Site Tests

Testing of the OPGW on site will be carried out as mentioned below. Any micro bend, irregularity or any other defect found during testing shall constitute failure.

The Contractor shall depute a competent person(s) for carrying out the site tests mentioned below. The experience and CVs of the person(s) to carry out the tests shall be submitted to the Engineer/Employer before any site test is carried out. All costs including traveling, boarding, lodging etc. in respect thereof shall be deemed to be included in the Bid Price.

A. Testing of OPGW on receipt at Site

The following test shall be carried out on each individual fiber on each drum. Any defect found in the fiber shall constitute failure of the whole OPGW cable drum.

(i) OTDR test
(ii) Attenuation test

B. Testing of OPGW during/after installation

a) OTDR test of each fiber for each of the individual section of OPGW laid and prior to splicing of fibers.
b) Measurement of Splice loss of all fibers at the jointing locations.
c) End to end testing of all fibers (to be done from both ends) consisting of:
   i. OTDR test
   ii. Attenuation loss measurement for all fibers
   iii. Measurement of length of OPGW/Continuity test

5 INSULATORS

5.1 Scope

These specifications cover the technical requirements for design, manufacture, and testing of porcelain fog type disc insulators.

5.2 Detailed Requirements

5.2.1 Physical Characteristics

1. The insulators shall be of high impact strength, glazed, wet-process porcelain.
2. The entire exposed surface shall be glazed and free from imperfections.
3. The insulators shall have clevis and tongue fittings, securely connected to insulators.
4. Care shall be taken when providing the required leakage distance to avoid designs in which skirts are mechanically fragile.
5. The design of the insulators shall be such that breakage of the porcelain cannot materially affect the mechanical strength of the insulators.
6. The strength of the insulators shall comply with the requirements of applicable ANSI standards. The criteria for acceptance shall be the same as for Clause 5.5(2)(e).

5.2.2 Minimum Electrical & Mechanical Characteristics

		16,300kg E&M Strength	8,200kg E&M Strength
1.	ANSI Class	52-10	52-6
2.	Dimensions		
	(a) Disc diameter (maximum), mm	320	254
	(b) Spacing (maximum), mm	170	146
3.	Withstand Values		
	(a) Low Frequency:		
	1. Dry, kV	90	90
	2. Wet, kV	50	50
	(b) Critical Impulse 1.2 x 50 Micro-second wave:		
	1. Positive, kV	135	135
	2. Negative, kV	145	145
4.	Radio Influence Voltage		
	(a) Test Voltage, kV to ground	10	10
	(b) Max. RIV at 1000 kHz, Micro V	50	50
5.	Leakage distance (minimum), mm	545	432
6.	Dry arcing distance (minimum), mm	225	203
7.	Low frequency puncture voltage, kV	140	130
8.	Combined, Electrical and Mechanical strength (minimum), kg	16300	8200
9.	Impact Strength, kg-cm	115	115
10.	Glaze Colour	Light Grey	Brown

5.2.3 Manufacture

(a) Porcelain Components

The porcelain shell shall be wet process, homogeneous, free of laminations, cavities or other flaws affecting the mechanical and electrical strength and shall be well vitrified, tough and impervious to moisture. Porcelain head shall be straight head type so that it shall have uniform electrical and mechanical strength in long service of life.

The entire surface that will be exposed after assembly shall be glazed and free from imperfections such as blisters and burrs.

The shell shall be subject to porosity test in accordance with ANSI C29.1 Standard, "Test Method for Electrical Power Insulators".

The maximum tolerance on length of individual units shall be as specified in ANSI Standard.

(b) Metal Components

(i) General

The metal parts shall be designed to transmit the mechanical stresses to the porcelain by compression and to develop maximum and uniform mechanical strength of insulators. In general, the contours of the metal and porcelain parts shall be such as to eliminate area of high electrical stress concentrations. All surfaces of metal parts shall be smooth with no projecting points or irregularities which may cause corona.

(ii) Caps

The metal cap shall be made of one of the following ferrous materials conforming to the applicable ASTM Standard:

1) Malleable cast iron - ASTM standard A47 or A220

2) Ductile (spheroidal) cast iron - ASTM standard A536, Grade 60-40-18 or 65-45-12.

These shall be free from cracks, shrinks, air holes, burrs or rough edges. The cap shall be circular with the inner and outer surfaces concentric and of such design that they will not yield or distort under the specified mechanical loading in such a manner as to add undue stresses to the shell.

(iii) Pins

The pin shall be made of forged steel and shall be free from laps, folds, burrs or rough edges. All bearing surfaces shall be smooth and uniform so as to distribute the stresses evenly. The pins shall be of such a design that they will not yield or distort under the specified mechanical loading in such a manner as to add undue stresses to the shells. The steel forging shall meet the mechanical properties of ASTM A668.

(iv) Locking Device

Standard split pin locking device shall have the shapes and dimensions in accordance with ANSI Standard/IEC Publication 372-1.

The split pins shall show no cracks by visual inspection when the prongs of the key are opened to 180° and then returned to the original position.

The material for split pin shall be standard quality stainless steel or bronze as per ANSI 304, having quality for resistance to internal corrosion.

Steel parts shall exhibit a minimum elongation at room temperature of 16% when tested in accordance with ASTM A370 (standard 50 mm gauge length).

(v) Galvanizing

All ferrous material shall be hot dip galvanized in accordance with ASTM A153 "Specifications for Zinc coating (Hot-dip) on Iron and Steel hardware", however, the thickness of Zinc coating shall not be less than 850 &770 gm/m² for insulator cap & pin respectively for fog type insulators.

(vi) Metal Corrosion

The insulator unit shall be designed to inhibit the accelerated corrosion of metal fittings due to leakage currents. Enlarged pin with greater surface area for decreasing the current density and thus counteracting corrosion action or corrosion intercepting zinc sleeve fused to the pin shall be provided at the point where the steel pin emerges from the cement. The sleeve shall be formed from zinc having a purity of not less than 99.8%. The total fused area of the interface shall be more than 80% of the total area of interface between zinc sleeve and pin shank. The exposed part of the sleeve should have a mass of at least 5g and 50% of the total length of the sleeve shall be exposed.

(vii) Assembly

The cap, porcelain shell and pin shall be concentric and coaxial within production limits.

Portland cement or Alumina cement shall be used as the bonding agent between the porcelain and the metal parts.

(c) Marking

Each wet-process porcelain insulator shall bear a durable marking in accordance with ANSI Standards, identifying the following:

a. Manufacturer's Name/Insignia
b. Year of Manufacture
c. Combined Mechanical and Electrical Strength, "M&E"
d. Tension Proof Test Load, "TEST"
e. Country of Origin

5.3 Insulator Assemblies

Insulator class and number of insulators for the various assemblies to be used shall be as follows:

(a)Type VS(4) Suspension Assembly, using 23 or 29 nos. of 16,300kg E&M Strength Insulators.
Drawing No. 3206/169/TD/01E151

(b)Type IT (4) Suspension Assembly for Transposition, using 26 or 32 nos. of 16,300kg E&M Strength Insulators.
Drawing No.3206/169/TD/01E152

(c)Type VJ(4) Jumper Assembly using 29 or 36 nos. of 8,200kg E&M strength Insulators for tower type "AGM", "M", "D", "DGM"(for middle phase only) & "DD1".
Drawing No. 3206/169/TD/01E153

(d)Type IJ(4) Jumper Assembly, using 32 or 36 nos. of 8,200kg
E&M Strength Insulators for tower types "AGM", "M", "D"& "DGM" (for outer phases only).
Drawing No. 3206/169/TD/01E154.

(e)Type DE (4) Tension Assembly, using 23 or 29 nos. of 16,300kg E&M Strength Insulators.
Drawing No. 3206/169/TD/01E155

(f)Type DSD1 Tension Assembly (tower side in gantry span), using 23 or 29 nos. of 16,300 kg E&M strength insulators.
Drawing No. 3206/169/TD/01E156

(g)Type DSD2 Tension Assembly (gantry side in gantry span), using 23 or 29 nos. of 16,300 kg E&M strength insulators.
Drawing No. 3206/169/TD/01E157

5.4 Main Design

(1) The performance characteristics under various ESDD values shall be supplied with the Bid by filling the Table of Insulator Performance Data" attached as Appendix "A" tests shall be carried out in accordance with clean fog test method recommended by EPRI. The insulators are required to perform satisfactory in a "I" string configuration under maximum ESDD condition of 0.12, 0.50 & 1.0 mg/cm². Testing required as above shall be from an independent laboratory of international repute.

(2) The insulators shall be suitable for dust contamination conditions and of modern fog type design embodying outer deeper skirts and shallow inner grooves. The manufacturer shall prove to the satisfaction of the Project Manager that the contamination collection properties of the insulator units are 60-70 percent of the standard disc insulators of the same diameter and spacing.

(3) The FOV 5% (withstand voltage) for 200-Multiple string shall be applicable for its performance.

(4) The arrangements of insulators in suspension, tension and jumper assemblies are shown in drawings attached in Volume III of the Bidding Documents.

5.5 Testing and Inspection

Acceptance tests shall include all of the applicable tests, specified in ANSI C29.1 "Test Methods for Electrical Power Insulators" and ANSI C29.2 "Wet Process Porcelain Insulators". Each insulator shall also be subjected to Tension Proof Test at the minimum load of half the Electrical and Mechanical strength of insulators.

The Project Manager may require the Contractor to perform all the type tests in accordance with the applicable standards to verify the main electrical and mechanical characteristics of an insulator unit, if the type test reports/results provided are not for the identical insulator to be supplied under the Contract. The contractor will carry out Type Tests to be witnessed by the representatives from Employer and Project Manager from an independent internationally reputed laboratory (accepted/approved by the Employer/Project Manager).

These tests are generally required to be done once to qualify the design. Type tests shall also be done if dimensions or materials described on manufacturers' drawings are modified or if manufacturing processes or manufacturing place have been changed.

Design Tests

Following design tests are to be carried out in accordance with the requirement and methods laid down in the standard mentioned therewith.

1.	Visual and Dimensional Test	(as per approved drawings and ANSI C29.2)
2.	Low-frequency dry flashover test	(ANSI C29.2)
3.	Low-frequency wet flashover test	(ANSI C29.2)
4.	Critical Impulse flashover test-positive and negative	(ANSI C29.2)
5.	Radio-Influence Voltage Test	(ANSI C29.2)
6.	Thermal-Mechanical Load Cycle Test	(as per clause 5.5(2) specified herein below)
7.	Thermal Shock Test	(ANSI C29.2)

8.	Residual-Strength Test	(ANSI C29.2)
9.	Impact Test	(ANSI C29.2)
10.	Cotter Key Test	(ANSI C29.2)
11.	Cement Expansion	(as per clause 5.5(3) specified herein below)
12.	Steep Wave Front	(as per clause 5.5(1) specified herein below)
13.	Power Arc Test	(as per clause 5.5(4) specified herein below)

Quality Conformance Tests

1.	Visual and Dimensional Test	(as per approved drawings & ANSI C29.2)
2.	Porosity Test	(ANSI C29.2)
3.	Galvanizing Test	(ASTM A-153 and coating Thickness as per clause 5.2.3(b)(v) and ASTM A-239)

4. Combined Mechanical and Electrical Strength Tests

Test method

The test shall be performed in accordance with clause 8.3.4 of ANSI C29.2. The applied load shall be increased up to the ultimate fracture of insulators. The individual measured failing load shall not be lower than the rated value and electrical puncture shall not occur before the ultimate fracture. Furthermore, the fracture pattern shall be also recorded, for hardware breakage or broken insulating part.

(i) Criteria for judgment

$\overline{X} \geq R + 3S$:

Where,

$\overline{X}$ = average value of measured failing loads.
R = rated value
S = standard deviation

(ii) The individual measured failing load shall not be lower than the rated value. Electrical puncture shall not occur before the ultimate fracture.

5.	Puncture Tests	(ANSI C29.2)
6.	Thermal-Mechanical Load CycleTest	(as per clause 5.5(2) specified herein below)
7.	Steep Wave Front	(as per clause 5.5(1) specified herein below)
8.	Thermal Shock Test	(ANSI C29.2)

Routine Tests

1.	Cold-to-Hot Thermal Shock Test	(ANSI C29.2)
2.	Hot-to-Cold Thermal Shock Test	(ANSI C29.2)
3.	Tension Proof Test	(ANSI C29.2)
4.	Flashover Test	(ANSI C29.2)

For quality conformance tests, insulators shall be offered in lots of 15,000 insulators or fraction thereof.

The insulators intended for the quality conformance tests as per ANSI C29.2 shall be taken at random from each lot by the Project Manager after performing routine tests as per requirement of ANSI C29.1 and elimination of any defective insulator.

All quality conformance tests required under the above standards shall be made at the Manufacturer's factory and the Manufacturer shall furnish all test apparatus and instruments required for the tests. The Project Manager reserves the right to witness all tests and to approve the manner in which tests are conducted.

Two (2) certified copies of the results of routine factory tests shall be submitted for each lot of 15,000 insulators or fraction thereof whether or not inspection is conducted by the Project Manager.

If required by the Project Manager, the Manufacturer shall make each mechanical test on caps, pins and split pins as necessary to demonstrate their conformance to the Technical Specifications.

In addition to the above ANSI test requirements, the following tests shall be carried out:

(1) Steep Wave Front Impulse Test

Ten (10) insulator units shall be selected at random from the first lot brought for acceptance.

(a) Insulators shall be subjected to five successive positive and negative impulse flashover voltages with wave having an effective rate of rise of 2500 kV per micro second. Each of the ten (10) insulators shall be individually tested.

(b) Each unit shall then be subjected to five flashovers of low frequency dry flashover test as per ANSI C29.1 latest revision and shall pass a flashover test of not less than 95 percent of the rated value. No electrical puncture shall occur, and the flashovers arc must be external.

(c) Failure of any one unit of either of steep wave front or flashover tests shall be cause for testing additional twenty (20) units. Failure of any one unit from this group of twenty, to the tests in (a) and (b) above, shall be cause for rejection of the lot brought for acceptance.

(d) In case of non acceptance of one lot, subsequent lots shall be tested till a successful test indicates the design of the insulators has been corrected.

(2) Thermal-Mechanical Performance Test.

Ten (10) insulator units of each type shall be selected at random from the first lot and tested in accordance with IEC Publication 575; latest revision except that the temperature variations shall be from -5 deg to 70 deg C and the criteria for acceptance of the lot is as below:

(a) The results of the Performance tests shall match the results of ordinary electromechanical or mechanical failing load test. Thus, the specified electro-mechanical or mechanical failing load that applies to the ordinary electro-mechanical or mechanical failing load test should be reached also in the performance tests.

(b) The test equipment shall be such as to generate graph automatically as exhibited in Fig.1 of IEC 575. Graphs generated shall be Load-Time graph and Air Temperature-Time graph for a time period of 96 hours.

(c) Fracture pattern shall not change.

(d) Electrical puncture or shattering should not occur before reaching the maximum load and the ultimate fracture.

(e) The quality index Qs should be equal to or greater than the acceptance constant K to meet the requirements of the test. The acceptance constant K shall be equal to or greater than 3 for a sample size of ten insulators. The quality index is defined by:

$$Qs = \frac{\overline{R} - Rs}{S}$$

$$\text{Average Value } \overline{R} = \frac{R1 + R2 + \ldots\ldots + Rn1}{n1}$$

R1, R2, R3, ……, Rn1 are the measured values of electro-mechanical failing load.

Rs. = Specified electromechanical or mechanical failing load (rated load value)

$$S = \sqrt{\frac{\sum_{1}^{n1}(R - \overline{R})^2}{n1 - 1}}$$

S = Standard deviation

(3) Autoclave Expansion Test for Portland Cement

The soundness of Portland cement to be used as the bonding agent for insulators shall be tested in accordance with the ASTM C151, "Standard Test Method for Autoclave Expansion of Portland Cement". Six (6) samples of cement for the test specimens shall be selected at random from the batch to be used for insulators.

The bars prepared from neat cement when subjected to high pressure steam at 295 psi for three hours at 216°C shall not show an expansion of more than 0.12 percent. The expansion of cement more than 0.12 percent in the test shall be the cause for the rejection of the whole batch of cement brought for acceptance.

Alternatively the soundness of Portland cement may be tested on the full assembled insulators as described below:
Ten (10) insulator units of each type shall be selected at random from the first lot and tested in accordance with ASTM C151. After this test, each unit shall be subjected to combined mechanical and electrical strength test of ANSI C29.2. The acceptance criteria shall be the same as for Clause 5.5(2)(e).

(4) Power Arc Test

The power arc test shall be performed in accordance with IEC 61467 for short string insulators. The results thus obtained should comply with the acceptance criteria of IEC 61467.

6 HARDWARE

6.1 Scope

These specifications cover the design, manufacture and testing of clevis & pin type disc insulator hardware for conductor and hardware for EHS shield wire and OPGW of characteristics specified below. Specifications for design, manufacture and testing of grounding material are also included in this section. Each hardware item shall be marked with manufacturer trade mark, strength and year of manufacture.

6.2 Conductor and Shield Wire Data

Characteristics	Conductors		EHS Shield wire	OPGW
Type	ACSR code word "DRAKE"	AAAC code word "GREELEY"	EHS Galvanized Steel Wire	Alumoweld OPGW
Size	795 KCM	927.2 KCM	51.076 mm²	-
Stranding	26x4.44mmAl. 7x3.45 mm St.	37x4.02mmAl. Alloy	7x3.048 mm	-
Outside Diameter	28.14 mm	28.14 mm	9.15 mm	≤12mm
Ultimate Tensile Strength	14,152 kg	13,835 kg	6,985 kg	≥ 7000 kg
Nominal Weight	1,628 kg/km	1295 kg/km	406 kg/km	≤460 kg/km

6.3 Conductor Suspension Assemblies

6.3.1 General

The suspension assemblies shall be in a 'V' configuration, except for jumper assembly for outer phases of single circuit towers, which shall be a single string 'I' type. For transposition, I-suspension assembly shall be used. The general arrangement of assemblies and attachment details are shown on drawings No. 3206/169/TD/01E151 ~154.

All hardware between the point of attachment and the conductors shall be supplied under this Section of Specification except insulator discs covered under Section 5 of Technical Specifications.

V-String and I-String assemblies required under this Section of the Specifications shall be as follows:

(1) 'V' single string suspension assembly type 'VS(4)' for 16,300 kg E&M strength insulators for tower type “SGM” and “T”.

(2) 'V' single string jumper assembly type 'VJ(4)' for 8,200 kg E&M strength insulators which shall be used on center phase of single circuit and double circuit angle towers types “AGM, “M”, “DGM”, “D” & “DD1”.

(3) 'I' single string suspension assembly for transposition type 'IT(4)' for 16,300 kg E&M strength insulators to tower “TGM” and “TR”.

(4) 'I' single string jumper suspension assembly type 'IJ(4)' for 8,200 kg E&M strength insulators which shall be used on outer phases of single circuit angle towers “AGM, “M”, “DGM” & “D”.

Each phase conductor assembly shall be in a quad bundle with the sub-conductors at each corner of a square. The spacing between any two sub-conductors on each corner of the square shall be 457 mm (18 inches) centre to centre.

The shielding of the bottom insulator units shall be done keeping the conductors distance between the bottom insulators and conductors to the minimum without violating other requirements of these Technical Specifications.

All suspension assemblies are designed for short circuit current of 40kA for duration of 1 sec.

Contours, edges and corners of line hardware shall be rounded to eliminate areas of high corona stress concentration.

All hardware shall be designed for hot line maintenance operation with minimum hole size of 25mm.

The assembly shall be corona free at a voltage of 346kV line to ground.

6.3.2 Conductor Suspension Clamps

(1) The suspension clamp shall be of aluminum alloy, non-magnetic type required to support KCM ACSR “DRAKE” and 927.2 KCM AAAC “GREELEY” conductors.

(2) Conductor take-off angle shall be in a range of 15 degrees and the minimum radius of curvature of the clamp shall be 360 mm approximately in the centre part of the clamp and 250mm at bell ends with the conductor to be always on a rounded smooth surface.

(3) The clamp seat shall be rounded and curved into bell mouth at each end with a rounded lip edge. The clamp shall be shaped in such a way that the clamping pressure on the conductor will increase gradually from the point at which the conductor enters the clamps to a maximum at the centre of the clamp. The conductor shall be supported by the suspension clamp for a minimum of 165 mm for the minimum angle of entry of the conductor.

(4) The radius of the curvature of the keeper portion of the clamp shall not be less than the radius of curvature of the seat of the clamp.

(5) The suspension clamp shall be free to operate in a vertical plane parallel to the conductor up to an angle of at least ±30° to the horizontal. The suspension clamp shall be free to swing transversely to the yoke plate up to an angle of at least 55° from the vertical.

(6) The conductor suspension clamp shall withstand an unbalanced conductor tension of upto 1400 kg without any slippage and must slip at a maximum tension of 1900 kg.

(7) The suspension clamp shall permit the conductor to slip before failure of the conductor occurs.

(8) The conductor suspension clamp shall be designed to withstand a vertical load of 12000 kg without any permanent deformation in any of the components.

(9) The suspension clamp shall be corona free at a voltage of 346 kV line to ground.

(10) The clamps shall have sufficient contact surface to minimize damage due to fault current.

(11) The bodies and keepers shall be of cast or forged high strength corrosion resistant aluminum alloy with silicon and copper contents of less than 2% and 1% respectively. Connecting pieces, bolts, nuts and locks washers shall be made of hot dip galvanized steel. Cotter pins shall be made of stainless steel. The wire groove shall be within the limits of 0.9 and 1.15 times the diameter of the conductor.

6.3.3 Yoke Plate

(1) When the yoke plate is swung about one of the 'V' assembly insulator-string so that the other string becomes slack as in a maximum wind condition, the bottom insulator unit of the slack string shall be able to freely swing downwards relative to the yoke plate up to an angle of at least 75° from its normal position, measured with the top edge of the yoke plate held horizontal.

(2) The clevis connecting the yoke plate to the tongue of the bottom insulator shall be designed in such a way that the bottom insulator unit shall not rotate to such an extent as to contact the yoke plate when the bottom insulator on a slack string is swung to its extreme downward position relative to yoke plate.

(3) The yoke plate shall be free to swing longitudinally to the conductor up to an angle of 20° from the vertical.

(4) The yoke plate shall be made from high grade, hot dipped galvanized steel and subject to normalizing process. The yoke plate shall have round smooth edges and be free of burrs.

6.3.4 Connection Fittings

(1) Hot dip galvanized steel fittings suitable for hot line maintenance work shall be provided to perform the following functions:

(a) Connect insulators to tower

(b) Connect insulators to yoke plate

(c) Connect suspension clamp to yoke plate

(2) Bolts and nuts with cotter pins shall be used where the cotter pin can be subjected to abnormal wear or strain. The edges of bolts and nuts shall be rounded smoothly.

(3) Cotter pins shall be made from bronze or stainless steel.

6.4 Conductor Dead End Assemblies

6.4.1 General

The tension assemblies shall be in a horizontal configuration. The general arrangement of assemblies and attachment details are shown on drawing Nos. 3206/169/TD/01E155~157.

All hardware between the point of attachment and the compression deadend shall be supplied as per the specified requirement mentioned in this Section of the Technical Specifications except insulators discs, which are specified in Section 5 of these Technical Specifications.

Tension string assemblies required under this Section of the Specifications shall be as follows:

(1) Quad string deadend assembly type “DE(4)” for 16,300 kg E&M strength insulators which shall be used on single circuit and double circuit towers.

(2) Double string dead end assembly type “DSD1” for 16,300 kg E&M strength insulators shall be used on tower side of gantry span.

(3) Double string dead end assembly type “DSD2” for 16,300 kg E&M strength insulators shall be used on gantry side of gantry span.

(4) Three attachment points will be provided on each face of the cross arm of the single circuit tower types “AGM” & “DGM” and “DE(4)” assembly will be attached on the outermost attachment hole when faces towards the cross arm whereas on single circuit tower type “M”, “D” and double circuit tower type “DD1”, only one attachment hole will be provided for “DE(4)” assembly.

(5) All hardware from the hole on a horizontal attachment plate of tower up to, but not including the compression deadend shall be supplied as per the specified requirement mentioned in Section-6 of Technical Provisions.

(6) Hot dip galvanized steel fittings suitable for hot line maintenance work shall be provided to perform the following functions:

(a) Connect insulators to tower
(b) Connect insulators to yoke plate
(c) Connect tension clamp to yoke plate

(7) The yoke plates shall be made from high grade, hot dipped galvanized steel and subject to normalizing process. The yoke plates shall have round smooth edges and be free of burrs. Yoke plate on the line end of the "DE(4)" assembly shall be as shown in drawing No. 3206/169/TD/01E159.

6.4.2 Strength

The dead end assembly type DE(4) shall withstand without breakage of any of the components, at conductor tension equal to the full rated ultimate strength of the conductor applied simultaneously on all of the four conductors in a bundle.

6.4.3 Tower Attachment Fittings

(1) The fittings between the tower/gantry attachment point and the insulator string shall be as shown on the specification drawings.

(2) Sufficient articulation shall be provided such that the complete assembly including the insulator units can be attached in the vertical position and then moved to the horizontal position.

6.4.4 Hot Line Maintenance

(1) Provisions shall be made on both sides of insulator strings for the attachment of a strain carrier to facilitate the replacement of insulator strings for all types of assemblies during hot line maintenance.

(2) These provisions shall be in the form of hot line socket eye below each insulator string as shown on drawing No. 3206/169/TD/01E159 on the strain yoke set or with two maintenance holes on each suspension yoke plate or equivalent.

(3) Contours, edges and corners of line hardware shall be rounded to eliminate areas of high corona stress concentration.

(4) The assembly shall be corona free at a voltage of 346 kV line to ground.

6.4.5 Articulation

(1) The assembly shall be designed in such a way that the load will be evenly distributed among the four insulator strings at all time. The assembly shall be designed to withstand a broken conductor without permanent deformation on any of the component when the tension on each of the remaining three conductors is 5500 kg.

(2) The assembly shall be designed to withstand a broken insulator string without permanent deformation of any of the components when the tension on each of the four conductors is 5500 kg. The spacing among the conductors shall be maintained under this condition.

6.4.6 Power Arc Rating

All deadend/tension assemblies shall be designed for short circuit current of 40kA for duration of 1 sec.

6.5 Overhead EHS Shield Wire Suspension Assembly

The general arrangement shall be as shown on the specification drawing No. 3206/169/TD/01E158.All hardware shown on the specification drawing shall be supplied under this clause of the Specifications.

The suspension clamps shall be suitable for 9.15 mm diameter 7-strand EHS galvanized shield wire.

The suspension assembly shall withstand a vertical load of 5000 kg without permanent deformation on any of the components. The assembly shall withstand an unbalanced shield wire tension of upto 700 kg without any slippage and must slip at a maximum tension of 900 kg.

The radius of curvature of the keeper portion of the clamp shall not be less than the radius of curvature of the seat of the clamp.

The assembly of the suspension clamp and its hanger shall be able to swing freely in both the longitudinal and transverse directions up to an angle of 70 deg with the vertical.

The clamps shall be shaped in such a way that when the ground wire enters and leaves the clamp at the maximum angle of 15 deg with the horizontal, the shield wire shall always be on a rounded smooth surface. The clamp seat shall be rounded and curved into bell mouth at each end with a rounded lip edge.

6.6 Overhead EHS Shield Wire Tension Assembly

The general arrangement shall be as shown on the specification drawing No. 3206/169/TD/01E158. All the materials between a take-off hole on a horizontal flat strain plate on the tower and the overhead shield wire shall be supplied as per the requirements mentioned in this clause.

The assembly shall develop 95 percent of the full rated strength of the overhead shield wire. Under this condition the overhead shield wire shall not slip through the clamp after final makeup of the assembly, and there shall be no permanent deformation on any of the components of the assembly when subjected to slippage test.

The assembly shall be free to swing so that the clamp will stay in line with the overhead shield wire when the overhead shield wire approaches the tower at any horizontal angle within ±30° from the

longitudinal direction of the transmission line and at any vertical angle between the horizontal and 20° below the horizontal.

The distance from the centre of the take-off hole to the edge of the plate will be 32mm. The maximum thickness of the strain plate will be 16mm.

The clamp shall be a bent-leg bolted type malleable iron strain clamp with provisions for attachment of pulling fittings for erection and maintenance.

6.7 Hardware and Fittings for OPGW

All hardware & fittings shall be designed in such a way that no degradation of the optical transmission in the fibers of the wire will occur under all service conditions. The optical fibers shall be freely moveable in the wire under service load.

6.7.1 Overhead OPGW Suspension Assembly

At suspension points, armour grip suspension clamps must exclusively be used. The clamp body shall be of Aluminum alloy, which shall preferably be forged. The rod material shall be drawn from aluminum alloy.

The assembly of the suspension clamp and its hanger shall be able to swing freely in both the longitudinal and transverse directions up to an angle of 70° with the vertical.

The general arrangement for suspension set for OPGW is given in drawing No. 3206/169/TD/01E160.

6.7.2 Overhead OPGW Tension Assembly

The tension assembly shall consist of a line guard and a preformed dead end, which is placed on the line guard. The line guard shall be laid in the opposite direction of the outer layer of the OPGW and the dead end must be laid in the opposite direction of the line guard. The length of line guard shall be sufficient to install vibration dampers, if necessary. It shall protect the OPGW against concentrated radial forces in the region of contact between the dead end and the OPGW. All helical rods shall be made of aluminum clad steel.

The distance from the centre of the takeoff hole to the edge of the plate will be 32mm. The thickness of the strain plate will be 16mm.

The assembly shall have provisions for attachment of pulling fittings for erection and maintenance.

The assembly shall be free to swing so that the clevis will stay in line with the OPGW when the OPGW approaches the tower at any horizontal angle within $\pm$30° from the longitudinal direction of the transmission line and at any vertical angle between the horizontal and 20° below the horizontal.
The general arrangement of tension assemblies for single and double tension set for OPGW are given in drawing Nos. 3206/169/TD/01E161 ~ 163.

6.7.3 OPGW Attachment Clamps

Attachment clamps to hold the OPGW to the tower for splicing shall be made of Alumoweld and shall be provided as shown in the drawing No. 3206/169/TD/01E165 and166.

6.8 Parallel Groove Connectors

The material of parallel-groove connectors shall be hot dip galvanized for EHS shield wire and Aluminum Alloy for OPGW.

6.9 Tests

6.9.1 Type Tests

The Project Manager may require the Contractor to perform all the type tests in accordance with the applicable standards to verify the main electrical and mechanical characteristics of the hardware assemblies, if the type test reports/results provided are not for the identical hardware assemblies to be supplied under the Contract.

These tests are generally required to be done once to qualify the design. Type tests shall also be done if dimensions or materials described on manufacturers' drawings are modified or if manufacturing processes or manufacturing place have been changed. The number of samples shall be as per BS 3288: Part 1. The type tests to be performed are as follows:

(i) Mechanical Test:

On each individual item of hardware

(ii) Resistance to Conductor, EHS Shield wire and OPGW Slippage Test:

On conductor, EHS shield wire and OPGW suspension clamps and EHS shield wire & OPGW tension clamps.

(iii) Magnetic Losses Test:

The test shall be performed on conductor suspension clamp in accordance with IEC 61284 to ascertain the magnetic losses.

(iv) Corona (Visible Discharge) and RIV Test:

The corona test shall be performed on complete insulator assemblies of each type i.e. VS (4), DE (4) & IJ (4).

The test shall be performed on complete insulator suspension as well as tension strings completely assembled with all fittings in a manner as nearly as possible to the arrangement to be used. A test voltage of 346 kV shall be applied between the conductor and earth for five minutes during which time no corona formation shall be visible or audible with the room in complete darkness.

The RIV test shall be performed in accordance with IEC 60437 with 60dB μV as the limiting value of radio interference characteristic.

(v) Power Arc Test:

The power arc test shall be performed in accordance with IEC 61467 for test series "X" on hardware assembly type VS (4) & DE (4).

6.9.2 Sample Tests

Sample tests on each item of hardware shall be made to verify the quality and workmanship. The number of samples shall be as per BS3288-1. The sample tests to be performed are as follows:

(i) Visual examination (on each item of hardware):

The objects shall be examined visually for the following defects:

Examination	Defects
Material	Not as specified in the relevant clauses/drawings.
Construction	Not of the shape given in relevant Drawing. Any part missing.
Finish	Galvanizing not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

(ii) Verification of dimensions (on each item of hardware):

The binding dimensions of the hardware shall be measured and shall be as shown on the relevant approved drawings subject to the tolerances given in BS 3288-1.

(iii) Mechanical test (on each item of hardware)

(iv) Resistance to conductor, EHS shield wire and OPGW slippage test:

The test shall be performed on conductor suspension clamp and EHS shield wire and OPGW suspension and tension clamps in the following manner:

Test piece shall be assembled in accordance with the Manufacturer's recommendation on conductor and shield wires of size and type which is to be used. The assembly shall be mounted in a manner approximating as nearly as possible to the arrangement to be used in service. Precautions shall be taken to avoid bird caging of the conductor. The length of the conductor and shield wires in the test assembly should preferably be not less than 100 times the overall diameter of the conductor and shield wires respectively.

A tensile load of about 50% of the relevant minimum failing loads as specified for conductor suspension clamp and shield wires suspension and tension clamps shall be applied and the conductor or shield wires be marked in such a way that the movement relative to the fitting can easily be detected, without any subsequent adjustment of the fitting, the load shall be steadily increased to 95% of the minimum failing load and then reduced to 90% of the minimum failing load and maintained for one minute. There shall be no movement of conductor or shield wires relative to the fitting due to slip during this one minute period and no failure of the fitting.

The conductor and shield wire suspension clamps shall also be subjected to loads which will cause the slippage of clamps. The maximum specified loads in this case shall be of 1900 kg and 900 kg for conductor suspension clamp and shield wires suspension clamp respectively. The procedure for application of loads shall be similar as mentioned in the above paragraph.

(v) Galvanizing test:

Following tests shall be carried out on all ferrous parts complying with the relevant ASTM standards.

- Weight of zinc coating
- Uniformity of zinc coating

- Adherence of zinc coating

6.10 Ground Rods

The ground rods shall be copper-weld/copper covered high strength carbon steel of circular cross-section 16 mm in diameter and 3.0 meters long. Each ground rod shall have a conical machined point at one end and shall be chamfered at the other end for ease in driving in the soil. The copper weld/copper cover shall be of uniform thickness not less than 0.38 mm for copper weld and 0.45 mm for copper cover. The copper covering shall be applied by either the molten-welded or copper bonded process (electro-deposited), giving a moisture proof seal between copper and core. The Contractor shall clearly state the process of manufacture. The length, diameter and copper thickness shall be marked on the rod. The applicable ANSI standard for material, fabrication and testing shall be ANSI/UL467.The steel used in the manufacturing of earth rods shall have the following characteristics:

Tensile Strength	:	41-56 kg/mm^2
Yield Point (min)	:	25 kg/mm^2
Elongation (min)	:	20% in 200 mm gauge length

6.10.1 Sample Tests

Sample tests shall be made to verify the quality and workmanship of ground rods as per following procedure:

Individual rods shall be visually examined for the defects given below:

Examination	Defects
Construction	Not of shape shown in drawing. Not of correct material. Any crack on the material
Finish	Copper thickness not proper, presence of burrs, black or base spots, and projections which will interfere with the proper use of the article. Corner edges not rounded.
Marking	Missing, not legible, incomplete or not permanent.

(i) Verification of Dimensions:

The dimensions shall conform to the approved drawing.

(ii) Bending Test:

The earth rod shall be subjected to a cold bending test at ambient temperature. The rod shall be held in a suitable rigid clamp or vice and the free end bent by applying a force perpendicular to the rod at a distance of 40 times rod diameter from the clamping device. The normal force shall be applied until a permanent angular bent of 30 degree is achieved by the rod. The rod shall be capable of withstanding the cold-bent test without any evidence of pits, cracking, or separation of copper from steel on the surface of the bent portion.

(iii) Tensile Test:

The steel shall be tested for mechanical strength and elongation mentioned in Clause 6.10.

(iv) Adherence Test:

The earth rod shall be subjected to adherence test to determine the bondage between copper and steel surfaces. A half meter length of rod with one end cut to a 45 degree point. This end shall be driven between two steel clamping jaws of a vice set at one millimeter less than the diameter of a vice set at one millimeter less than the diameter of the rod so as to shear off sufficient metal to expose the bond between the jacket and steel core. There shall be no evidence of any separation.

(v) Sample, Acceptance and Rejection:

The earth rod shall be divided into lots containing up to 500 units each. A sample of 20 rods shall be drawn at random from each lot.

The selected samples shall be subjected to visual examination and verification of dimensions. If the number of defective units is two the lot shall be accepted, if the number of defective units is more than three the lot shall be rejected. If the number of defective units is three, another sample of 25 units shall be selected at random and subjected to tests. If the number of defective units is again three or more, the lot shall be rejected. If the number of defective units is three or less the lot shall be accepted.

Three random samples shall be selected from a lot of 500, each rod shall be subjected to tensile, bending and adherence tests.

If one rod from any group of three units selected fails to meet the requirement, another group of three rods shall be selected at random. If any unit in the second group fails the test, the lot shall be rejected.

6.11 Grounding Connectors for Ground Rods

The connector for attaching ground wire to ground rods shall be bronze or high strength copper alloy. The clamps shall be as shown on the specification drawings.

The connector for attaching ground wire to tower stub angle shall be hot dipped galvanized steel. The clamps shall be secured by one 16 mm diameter steel bolt.

The connectors shall be tested for mechanical strength test specified in ANSI/UL467.

6.12 Bare Copper-Clad Steel Grounding Conductor

The material, fabrication, sampling and testing of copper-clad steel grounding conductor connecting the ground rods to the tower stub angles shall be made from bare round 7 No. 10 annealed copper-clad steel wires of 40% conductivity of IACS, conforming to ASTM B227 and B228.

7. CONDUCTOR AND SHIELD WIRE ACCESSORIES

7.1 Scope

These specifications cover the technical requirements for the design, testing, fabrication and furnishing the accessories for ACSR “DRAKE” and AAAC “GREELEY” Conductors as specified in Clause 3 hereinbefore and for 9.15 mm diameter, 7 strands galvanized steel EHS Overhead Shield Wire as specified in Clause 4 hereinbefore. The accessories to be furnished are as follows:

1. Conductor compression splices
2. Conductor repair sleeves
3. Conductor compression dead end splices

4. Overhead shield wire compression splices
5. Hydraulic compressors
6. Compression dies

7.2 Detailed Requirements

The compression splices shall not permit slipping of or cause damage to or failure of the complete line conductor or any part thereof at a load less than ninety-five percent (95%) of the ultimate strength of the conductor.

Contours and edges of line accessories shall be rounded to eliminate areas of high corona stress concentration.

The line accessories shall be corona free at a voltage of 346 kV line to ground.

The conductance per unit length of the splices shall not be less than that of the conductor itself. The temperature rise shall not be greater than the temperature rise in the conductor.

All splices shall be pre-filled with appropriate filler compound. Besides, the filler compound shall also be supplied separately. The open mouths of the splices shall be capped properly to provide protection against moisture and dust etc.

All current carrying parts shall be coated with plastic to inhibit corrosion on such surfaces during transportation.

The ends of compression accessories (mid span joint, deadend joint and jumper terminals) shall be tapered in such a manner that the applied pressure shall be gradually reduced to zero on that part of the conductor leaving the accessory and that the conductor stresses caused from bending and vibration reduced to a minimum.

The compression fittings shall meet the specification requirements of Duty of Heat Cycling as per Clause 7.7.1(ii) herein when subjected to a Heat Cycle Test. This requirement shall be met for the compression dead end assembly when bolted jumper terminals are included in the test.

On each compression accessory, manufacturer's name/trade mark, country of origin, catalog number, year of manufacturing, die size, start knurl, stop knurl and knurl locations (if applicable) and name/code of conductor shall be stamped legible.

7.3 Conductor Compression Splice

The conductor splice shall be of two piece compression type consisting of inner galvanized steel sleeve for jointing steel core and an outer aluminum sleeve alloy for connecting aluminum strands for ACSR conductor whereas one piece of aluminum alloy sleeve for AAAC type conductor. The splice shall be suitable for two step compression requiring separate compression for steel sleeve for ACSR conductor and one step compression for AAAC conductor. The splice shall develop at least ninety-five percent (95%) of the ultimate strength of the conductor.

7.4 Conductor Repair Sleeve

Repair sleeve shall be of aluminum alloy open type, consisting of body and keeper, which interlock when compressed. The sleeve should restore 95% of the conductor rated strength with a condition where no more than 1/3 of the aluminum strands are damaged.

7.5 Conductor Compression Dead End Splice

Dead End compression splice for ACSR "DRAKE" and AAAC "GREELEY" conductors shall be of two piece compression type consisting of single aluminum alloy body, steel body of the eye and provided with a four-hole terminal pad and jumper compression sleeve. The steel eye shall be vertical as shown in the specification drawing No.3206/169/TD/01E169 and 192 respectively.

The compression dead end shall be supplied with one steel compression dead-end body separately for ACSR and AAAC conductor and shall be suitable for two step compressions requiring separate compression for aluminum alloy body on steel eye.

The required nuts, bolts and spring washers/belleville washers to connect the jumper terminal pad to the dead end terminal pad shall be supplied and made of aluminum alloy/stainless steel. The bolts, nuts and washers shall be M16 aluminum alloy or M12 stainless steel.

The jumper and terminal connector and its pad shall be constructed with a 15 degree angle, which permits the terminal connector to be bolted in either the straight or the 30 degree position. The jumper sleeve shall be one piece compression type. Both sides of the pad shall have even surfaces for better electrical contact.

Pads of the jumper terminal connector and dead end compression joint shall be factory protected by removable plastic.

7.6 Overhead Shield Wire Compression Splice

The splice for overhead shield wire shall be a one part steel sleeve with open mouth and when compressed will grip the shield wire and develop 95% of the full rated strength of the shield wire.

The conductivity of the splice shall equal the conductivity of the shield wire. The shield wire splice shall withstand the high currents caused by lightning.

On each compression splice, the catalog number, die size and diameter of shield wire shall be stamped.

7.7 Tests

7.7.1 Type Tests

The Project Manager may require the Contractor to perform all the type tests in accordance with the applicable standards to verify the main electrical and mechanical characteristics of the accessories, if the type test reports/results provided are not for the identical accessories to be supplied under the Contract.

These tests are generally required to be done once to qualify the design. Type tests shall also be done if dimensions or materials described on manufacturers' drawings are modified or if manufacturing processes or manufacturing place have been changed. The number of samples shall be selected as per BS 3288: Part 1. The type tests to be performed are as follows:

i) Mechanical Test ii) Heat Cycle Test iii) Resistance Test iv) Corona Test	On conductor compression splice and conductor compression dead end only

i) Mechanical Test:

Test piece shall be assembled in accordance with manufacturer's recommendations on conductor of the size and type with which it is to be used. The fittings when tested in accordance with BS 3288-1 or ANSI C119.4 shall withstand a load of minimum ninety five percent (95%) of the rated strength of the conductor. There shall be no movement of the conductor relative to the connector and no failure of the connector due to slip during one-minute hold period at ninety percent (90%) of the conductor rated strength.

ii) Heat Cycle Test:

The test current shall be the power frequency current and should raise the surface temperature of the conductor to 140 degrees centigrade. The ambient temperature must be kept between +15°C and +30°C. The minimum length of conductor used for determining this current shall be 2 meters and the conductor temperature shall be measured near the centre of the test length.

The compression fittings (compression splices, repair sleeve and compression dead-end) shall be assembled in accordance with the Manufacturer's recommendations on conductor of the size and type with which it is to be used. The assembly, to which a tensile load not exceeding 20% of the UTS of the conductor may be applied, shall be erected indoors so that the conductor is roughly horizontal. Air shall be able to circulate freely around the assembly which shall not however, be exposed to draughts. The minimum length of conductor on each side of the fitting shall be 2 meters.
The test current shall be passed continuously through the assembly for a period of 30 minutes. The current shall then be interrupted, and the assembly shall be allowed to cool to within 5°C above the ambient temperature. The sequence of operation shall be repeated so that 500 cycles of heating and cooling are applied. Temperatures of joint, jointed conductor and of room shall be recorded in a continuous way.

During the last 5 cycles, the maximum temperature measured when the test current is flowing at any points on the surface of the fittings, shall not exceed that of the conductor.

The strength of the fittings and that of the reference conductor shall be measured before and after completion of heat cycle test. All measurements shall be made at ambient temperature.

At the end of the test the resistance shall be measured between points on the conductor on either side and just clear of the fittings and shall not exceed 75% of the measured resistance of the equivalent length of conductor. There shall be no sign of local heating, burning or fusing of any part of the joint or of the conductor.

iii) Resistance Test:

The electrical resistance of the assembly when tested in accordance with BS 3288-1 or ANSI C119.4 shall not exceed seventy five percent (75%) of the measured resistance of the equivalent length of the conductor. The test shall be made with a direct current and test shall be repeated with the polarity and the average of the two results taken as the measured value.

iv) Corona (Visible Discharge) and RIV Test:

The connectors shall be attached to a length of conductor of the size and type with which these are to be used. The connectors when tested in accordance with NEMA 107 shall not exhibit any sign of visible corona at a power frequency voltage of 346 kV line to ground. The test shall be performed on a quad bundle conductors arrangement with inter spacing of 457 mm.

The RIV test shall be performed in accordance with IEC 60437 with 60dB μV as the limiting value of radio interference characteristic.

7.7.2 Sample Tests

Sample tests shall be made to verify the quality and workmanship. The number of samples shall be selected as per BS 3288-1.

The following sample tests shall be performed on all conductor fittings.

i) Visual examination
ii) Verification of dimensions
iii) Mechanical tests
iv) Resistance tests
v) Galvanizing tests on ferrous parts

Note: The compression of the accessories for testing shall be carried out with the dies to be supplied by the Contractor under this Contract.

i) Visual Examination:

The tests objects shall be examined visually for the following defects:

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant Drawing. Any part missing.
Finish	Galvanizing not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

ii) Verification of Dimensions:

The binding dimensions of the hardware shall be measured and shall be as shown on the relevant approved drawings subject to the tolerance given in BS 3288-1.

iii) Mechanical and Resistance Tests:

These tests shall be carried out as per procedure defined herein above.

iv) Galvanizing Tests:

These tests shall be carried out on all ferrous parts complying with the following requirements:

a) Weight of Zinc coating
b) Uniformity of Zinc coating
c) Adherence of Zinc coating

These tests shall be performed in accordance with relevant ASTM Standards.

7.8 100 Ton Hydraulic Compressors (Engine Driven)

The hydraulic compressor shall be supplied with hydraulic power pump (with gasoline engine drive). The compressor shall be of latest model capable of being operated remotely and shall permit fast field installations. The compressor shall be supplied with ground stand and shipping steel case. The design of compressor shall be coordinated with the design of accessories. The compressor shall develop a thrust of 100 tons at a nominal pressure of 700 kg/cm². The above would include 5 m long, low and very high pressure hoses along with necessary adaptors, fittings compatible with the actual site temperature and pressure gauge (range 0 - 1500 kg/cm²).The working temperature range shall be -10°C ~ 55°C.

7.9 60 Ton Hydraulic Compressors (Engine Driven)

The hydraulic compressor shall be of portable type supplied with hydraulic power pump (with gasoline engine drive). The compressor shall be of latest model equipped with an integral hinged head with eyes suitable for hot line maintenance work. The compressor shall be supplied with ground stand and steel carrying case. The design of compressor shall be coordinated with the design of accessories. The compressor shall develop a thrust of 60 tons at a nominal pressure of 700 kg/cm². The above would include 5 m long low and very high pressure hoses along with necessary adaptors, fittings compatible with the actual site temperature and pressure gauge (range 0 - 1500 kg/cm²). The working temperature range shall be –10°C ~ 55°C.

7.10 Compression Dies for ACSR & AAAC Conductor and Shield wire

Conductor compression dies for aluminum and steel parts shall be suitable for use on accessories of 795 KCM ACSR "DRAKE" and 927.2 KCM AAAC “GREELEY” Conductors. The dies shall be of steel having hexagonal configuration. The design of all compression fittings shall be such that only one pair of dies is necessary. The die for the steel core of ACSR conductor should be marked/ painted to distinguish it from the EHS shield wire die.

Shield wire compression dies shall be suitable for use on accessories of 9.15 mm dia, 7 strands galvanized steel overhead shield wire of extra high strength. The dies shall be of steel having hexagonal configuration.

The dies (conductor & shield wire) should be compatible with type of compressors and accessories being supplied.

In addition each die cavity will be imprinted with die section/identification number so that the same is embossed on the compression fitting each time a crimp is made.

The Contractor shall provide the detailed drawings along with the dies material properties for approval.

7.11 Filler Compound

The filler compound shall be of suitable material to be used as filler for compression accessories. The filler should effectively seal out the compression fitting against air and moisture. The filler compound shall be supplied in a package/carton of hundred (100) tubes each having 0.5 kg filler weight.

7.12 Electrical Joint Compound

The electrical joint compound shall be of suitable material to be used for making aluminum-to-aluminum & flat-to-flat surface contacts such as jumper terminal to deadend joint. The compound shall be an active chemical in a grease type sealer and shall act to dissolve the oxide film and seal the joint against moisture especially formulated to ensure high conductivity. The drop point of the compound shall not be less than 100°C. The flash point should not be less than 190°C and alkalinity/basicity $\leq$ 0.1%. The compound shall be supplied in a package/carton of 10 tubes each having 0.25 kg compound weight.

8. SPACER DAMPERS FOR CONDUCTOR AND STOCKBRIDGE DAMPERS FOR OVERHEAD EHS SHIELD WIRE AND OPGW

8.1 Scope

These specifications cover the specific requirements for design, manufacture, performance, qualification tests and furnishing of Spacer-Damper for quad-bundle conductor and Stockbridge Vibration Dampers for overhead EHS shield wire and OPGW.

The spacer dampers shall be designed for use on quad-bundle 795 KCM 26/7 ACSR "DRAKE" and 927.2 KCM 37/0 AAAC “GREELEY” conductors. The vibration dampers for the overhead shield wires shall be Stockbridge type to be used with 9.15 mm diameter 7 strands EHS grade galvanized steel shield wire and on the OPGW to be supplied.

The supplier shall guarantee that the proposed vibration damping systems will be adequate for the purpose and capable to perform within the established safe limits.

8.2 Detailed Requirements

8.2.1 General

All items furnished shall be standard manufactured products, as supplied to the major portion of utility industry.

The spacer dampers shall be designed to prevent physical contact between sub conductors in sub spans between spacers, except during the passage of short circuit currents when the possibility of contact is accepted provided that the specified spacing is restored immediately following fault clearance.

During installation, maintenance and service (including short circuit conditions), it should withstand mechanical loads without any component failure or any unacceptable permanent deformation.

The spacer dampers shall be designed so as to ensure that individual components will not become loose in service and permit relative vertical, horizontal, torsional and axial movement between sub conductors.

All materials shall be of recent manufacture, unused and free of defects or irregularities and shall be resistant to corrosion formed by electrolytic action due to application of dissimilar materials.

Workmanship shall follow the best practices of the industry. All components of the same design and designation shall be identical and like components shall be interchangeable.

Where different materials are used in the spacer dampers, then the design shall ensure that neither electrochemical action nor any other adverse effects associated with dissimilar materials can occur.

All ferrous components shall be protected by zinc coating, nuts and screws by hot dip galvanizing and washers by zinc plating.

The clamp bore shall be smooth and free of projections and shall not be sand blasted or refilled to increase artificially the coefficient of friction between the clamp and the conductor as these can cause damage to the conductor.
Screw and bolt threads shall be in accordance with ANSI B.1.1. "Unified Screw Threads" class 2A. All internal threads shall be machined after manufacture to allow for galvanizing and conforming to appropriate class tolerances.

All ferrous metal shall be galvanized to conform to ASTM A153 and A239 specifications. Electrolytic zinc plating shall be in accordance with ASTM A164 and heat treated to overcome hydrogen embrittlement.

Anodic coating for Aluminum and Aluminum Alloy shall be in accordance with U.S. Military Specification MIL- A-8025 C.

8.2.2 Manufacturer's Drawings

The Contractor shall submit detailed drawings of the assemblies and component parts, which show all dimensions and necessary tolerances.

Catalog and part numbers including material and specified finishes and coatings shall be included.

Assembly drawings shall include:

- Installation instructions.
- Rated mechanical strength in tension and compression.
- Design installation torque for break-away head bolts or cap screws showing minimum and maximum values.
- Weight of the assembly.

8.2.3 Conductor Spacer Dampers

8.2.3.1 Physical Requirements

The spacer dampers shall be designed for use on quad-bundle 795 KCM 26/7 ACSR "DRAKE" and 927.2 KCM 37/0 AAAC "GREELEY" conductors.

All break-away bolts or break-away cap heads must be oriented for ground-level viewing.

The spacer-dampers shall be capable of being installed and removed from energized lines by means of hot-line tools. The Contractor shall furnish detailed information on tools needed and procedure required to perform the hot-line removal and installation of spacer-dampers.

8.2.3.2 Energy Absorbing Assembly

The energy absorbing assembly shall have the ability to:

a. Withstand any heat generated
b. Avoid any displacement in the housings
c. Resist bond failure
d. Avoid any other damage which would appreciably decrease the damping efficiency

Where elastomers or other non-metallic materials are used, they shall be capable of withstanding temperatures of -10°C to +100°C without permanent loss of essential properties. Assembly shall be designed to provide effective damping for the line technical and environmental conditions prevailing in the area.

The elastomer materials or other energy absorbing assembly shall have adequate resistance to the effects of ozone, ultra violet radiation, dust particles and other atmospheric contaminants over the entire temperature range, including fatigue and work softening.
The energy absorbing assembly shall be electrically conductive. The conductivity of individual components shall be stated by the Contractor.

8.2.3.3 Clamps and Bolts

Clamps, which are fastened with bolts, shall be provided with breakaway heads or caps and suitable washers. The bolts shall be lubricated with an appropriate lubricant.

The clamps shall be designed so that they will seat firmly and smoothly on the conductor with sufficient pressure to compensate for creep, cold flow, and/or nesting.

The arm clamp shall be of aluminum alloy commensurate with the design requirements. The clamp cap shall also be of aluminum alloy.

The arm clamp and clamp cap shall each have an effective length in bearing on the conductor of not less than 65 mm for metal surfaced clamps. Exit radii shall be excluded in meeting this requirement.

Bolted type spacer assembly clamps shall be capable of withstanding a torque equal to 150 percent of nominal design installation torque, without failure of component parts when installed on the conductor. This value shall be obtained by applying the torque to the lower head of the breakaway bolt or cap screw.

Clamping bolts or cap screws shall be M16 aluminum alloy or M12 stainless steel with a break-away type head or cap. The break-away bolt or cap screw shall be furnished with a wrench stop to prevent the socket from engaging the lower head during installation.

The torque required to break away the upper head from the lower head shall be within a tolerance of plus or minus ten percent of the Contractor's design value.

The break-away head bolts or cap screws shall be fabricated from 6101-T8 or AA7075 high strength aluminum alloy or stainless steel (austenitic stainless steel ANSI 300 series). Any other material must be approved by the Project Manager.

The anodization for aluminum alloy shall be according to US Military Specifications MIL A-8025C.

Clamping bolts or cap screws are to be equipped with steel belleville type spring washers designed to compensate for a potential relaxation in bolt tension, the washer(s) shall be displaced at least 50% of the total as-flat deflection at nominal installation torque, the washer(s) shall have a recoverable deflection of at least 0.9 mm as determined by the difference between the loaded and subsequent unloaded height.

8.2.3.4 Performance Requirements

The Contractor will submit with the bid, the spacer-damper's proven ability to effectively suppress sub-conductor oscillation and to control Aeolian vibration. The Contractor will also submit with the bid, the number of similar units in service at the time of bidding. This will also include their location, approximate date of installation, the conductor size and configuration.

The dynamic strain caused by vibration in the vertical direction shall not exceed 150 micro-meter/meter peak-to-peak for AAAC “GREELEY” Conductor and 200 micro-meter/meter peak-to-peak for ACSR “DRAKE” Conductor, at the suspension point as measured according to the method recommended in IEEE 1368-2006.

The positioning of spacer dampers shall be optimized in such a manner that the sub span ratio is 0.85-0.90 between lengths of adjacent sub spans and 0.55-0.65 between the length of an end sub span and adjacent sub span.
Proposed material shall meet the performance requirements without failure in service or damage to conductors. For the purposes of these specifications, the word "failure" as applied to design tests and service conditions shall mean the following:

a. Failure of any component, part, or damage to conductor other than the normal deformation which results from conductor clamping action.

b. The torque in clamp bolt or bolts is reduced to such an extent that the conductor has rotated or slipped in the clamp or if the torque is reduced to 60 percent of the Contractor's recommended installing torque, regardless of whether the conductor rotates or slips in the clamp. All torque measurements will be taken in the tightening direction.

c. Any wear of any conductor strand which exceeds 70 percent in width or 10 percent in depth of the conductor strand diameter shall constitute a failure.

8.2.3.5 Verification of Vibration Behavior by Computer Program

Vibration study of the spacer dampers for the transmission line shall be carried out using computer simulation. The vibration behavior shall be observed by simulating the load due to various kinds of conductor motions as per the environment parameters such as temperature, wind speed and EDS etc. The final staggering scheme of the spacer dampers shall be mentioned according to the bending strain curve.

8.2.3.6 Electro-Mechanical Characteristics

The spacer damper shall be designed to be free from visible corona when viewed in a darkened laboratory at a system voltage of 346 kV (line to ground).

The spacer damper shall be designed to withstand the electromagnetic forces resulting from short-circuit currents of 40,000 Amps. r.m.s. symmetrical for 4 cycles (50 Hz.).

The load arising from such a fault condition is estimated to be towards the geometric centre of the units on the basis of the relationship given in the IEEE Paper 31TP 65.707 by C. Manuzio, "An investigation of the Forces of Bundle Conductor Spacers Under Fault Conditions".

8.2.3.7 Performance Guarantee for Damping Systems

By way of further definition, all the guarantee provisions set out in the Contract Documents shall extend to cover not only the individual pieces of material supplied but also the capability of the spacer damper system to control Aeolian vibration to within accepted safe limits with no other damping device fitted to the line, when installed in accordance with the Contractor's installation instructions and recommended sub-span locations.

The spacer damper system will be considered defective if unacceptable Aeolian vibration above the limits as defined in Clause 8.2.3.4 herein occur in more than 1% of the total number of spans fitted with the Contractor's units; this quantity of 1% should be considered as being distributed over the entire length and not concentrated in any one location. Should this 1% limit be exceeded, additional damping devices shall be provided, free of charge, by the Contractor to reduce Aeolian vibration amplitude on affected spans to acceptable safe limits.

The spacer damper system shall also control sub- conductor oscillation.

This guarantee in respect of system performance is applicable under the basic line data and environmental conditions prevailing in the area.

8.2.4 Qualification Tests Requirements

8.2.4.1 General

The following tests shall be performed by the Contractor to establish the characteristics of the spacer dampers when installed on the conductor and to assure compliance with all requirements specified.

Three certified copies of test data which show that the spacer damper assemblies meet all the requirements of these specifications shall be submitted. The performance of tests must have been completed and test data approved before any of the spacer assemblies are shipped. All tests shall be performed on each of at least three assemblies selected at random from the first offered lot and performed in the order prescribed below. The failure of any one sample shall constitute failure to meet the requirements of this specification.

8.2.4.2 Clamp Slippage Tests at Ambient Temperature

Each clamp of the spacer damper assembly shall be separately tested. The Spacer Damper shall be installed in accordance with manufacturer's installation instructions on a minimum length of 4.0 m conductor tensioned to approximately 20% of its rated strength. A load shall be applied to each clamp parallel to the axis of the conductor. For each of the following tests, the loads at which initial slip and continual slip of each spacer occurs shall be recorded.

For metal surfaced clamps, the initial slip load is defined as the load at which the spacer clamp moves 0.5 mm or more on the conductor.

For rubber surfaced clamps, the initial slip is defined as the load at which the permanent displacement between the conductor and the metal body of the clamp exceeds 1.5 mm, measured after removal of the load. Deflection may be measured between the third or fourth loading to compensate for temporary rubber set.

The continual slip load is defined as the maximum obtainable load.

The clamps of the spacer assembly that have successfully passed the longitudinal and vertical slippage tests shall withstand a load of 450 kilograms for metal-surfaced clamps and 200 kilograms for rubber-surfaced clamps for a minimum period of 60 sec without slipping on the conductor. Clamps shall not be re-installed and bolts or cap screws shall not be re-torqued after the longitudinal and vertical slippage tests.

8.2.4.3 Energy Absorbing and Fatigue Tests

a. General

The spacer damper assembly shall be clamped to ACSR "DRAKE" and/or AAAC "GREELEY" conductors. During the tests, the axis of each spacer clamp shall be parallel to its initial static position by applying of at least 25% of the U.T.S of the conductor tension on each conductor or by two or more fixed clamps on each conductor. Where fixed clamps are used, there shall be no more than 200 mm of conductor between the spacer and the clamp for the vertical test and as recommended by manufacturer for longitudinal test.

The spacer damper assembly shall withstand the tests without slipping on the conductors or failure of component parts. These tests shall be performed on the same spacer-damper. The clamps shall not be removed from the conductors, nor shall any bolts or cap screws be re-torqued until completion of the clamp slip tests.

b. Vertical Vibration

The spacer damper assembly shall be vibrated vertically from 5 to 50 Hz to determine if the spacer assembly has resonant frequencies within that range. If resonant frequencies are observed, the vertical vibration fatigue test shall be run at the highest resonant frequency found. If no resonant frequency between 5 and 50 Hz is observed, the test shall be run at a frequency from

20 to 30 Hz with amplitude of ±3 mm for 1,000,000 cycles. A check for resonance and the fatigue test shall be run for.

i) Two upper conductors fixed by clamps
ii) One upper and lower conductor fixed by clamps

c. Longitudinal Displacement

The displacement of the unrestrained conductor shall be either plus and minus 25 mm or the displacement from a 22.7 kg static force whichever is smaller. The longitudinal movement shall be parallel to the conductor at a frequency not less than 2 Hz for 1,000,000 cycles.

i) Two upper conductors fixed by clamps
ii) One upper and lower conductor fixed by clamps

8.2.4.4 Simulated Oscillation Test

Using the same spacer damper that was tested in Clause 8.2.4.2 hereof, the spacer arm cycled in Clause 8.2.4.3 shall be tested. With the body of the spacer damper restrained, each arm shall be cycled in a plane at right angles to the normal conductor axis continuously for 1,000,000 cycles at not less than 4 Hz. The motion at each conductor clamp shall be in a path around the pivot point(s) of the arm which:

a. Produces a conductor displacement of plus and minus 38 mm, or

b. Produces a displacement resulting from the application of sinusoidal force having a peak to peak value of 600N. The displacement shall be determined at the beginning of the test and kept constant during the test, or

c. Produces at least 95 percent of the total stop to stop displacement. The clamp need not be installed on conductor. Endurance shall be assessed in accordance with the requirements of Clause 8.2.3.2, hereof.

8.2.4.5 Conical Fatigue Test

The same spacer damper used in test under Clause 8.2.4.4 shall be tested for conical fatigue by fixing the central frame and installing the clamp on a cylindrical bar of dia equal to the specified conductor dia. The clamp shall be excited through rotation so that a conical movement is achieved. The angle between the conical surface of the revolution generated by the cylindrical bar and the longitudinal axis of the clamp shall not be less than 2 degrees. The test shall be performed for 1 million cycles at frequency between 2 to 5 Hz. After the test, there should be no damage to any of the components or loosening of the bolt.

8.2.4.6 Bolt Torque Test

The four clamps of the spacer damper assembly shall be attached to the ACSR "DRAKE" conductor, AAAC “GREELEY” conductor or to a bar of 28.14 ±0.254 mm diameter. Torque shall be applied to the upper head of each break-away bolt. The head shall not break away at a value other than the Contractor's design installation torque plus or minus ten percent. The torque required to break away each upper head shall be recorded.

At a torque of 150 percent of nominal design installation torque there shall be no failure of component parts. The torque shall then be recorded.

Records shall be made of the lower head withstand torque, failure torque, and the part(s) of the clamp assemblies that fail.

8.2.4.7 Simulated Short Circuit Current Test

The spacer damper shall be tested to withstand three consecutive "shots" at a current of 40,000 Amperes r.m.s. for four cycles (50 Hz) without permanent deformation or damage when installed at spacing up to a maximum of 76meters, between spacers. The tension on all sub-conductors will be minimum 25% of the U.T.S of the conductor. The spacer damper shall be capable of restoring the sub-conductors to its original spacing without deformation or damage to spacer damper or conductor.

Mechanical testing will be considered in lieu of the above short-circuit test. The mechanical tests will be defined by mutual agreement between the Contractor and the Project Manager. After the test, there shall be no indication of failure of any component or any permanent deformation from the original geometric configuration.

Compression

The compressive forces shall be gradually increased until they reach 1000 kg. At this value the forces shall be held constant for 60 sec. and then removed. The test shall be executed twice; the first one with the spacer in its normal position and the second one with one clamp displaced longitudinally of an agreed amount, with reference to the other clamp(s).

Tension

Following compressive forces, tensile forces shall be applied. These forces shall be gradually increased until they reach the specified value at which they shall be maintained for 60 sec. The value of the tensile forces shall be taken as 50% of the corresponding compressive forces.

8.2.4.8 Corona and RIV Test

The corona extinction voltage for the spacer damper shall be determined visually in a virtually dark laboratory. The corona extinction voltage is the voltage at which the spacer damper is free of all visual corona.

The spacer damper assembly shall be installed on section of ACSR "DRAKE" and/or AAAC “GREELEY” conductors or bar not larger than 28.14 mm diameter. The conductor or bar shall be arranged as a quad bundle.

The spacer damper assembly shall be subjected to a voltage to determine that the corona extinction voltage level is not less than 346 kV line-to-ground. The ground plane shall be a maximum of 4 meters from the assembly.

The exposure shall be made with an applied voltage and the laboratory virtually dark. There shall be no evidence of corona on the spacer-damper.

Digital camera shall be used to satisfy the condition of corona.

The RIV test shall be performed in accordance with IEC 60437 with 60dB μV as the limiting value of radio interference characteristic.

8.2.4.9 Electrical Resistance Test

This test shall be performed in accordance with clause 7.7.2 of IEC 61854.

8.2.4.10 Elastomer Tests

Typical properties and values of the elastomer or other energy absorbing assembly shall be specified. The tests shall be performed on samples taken from elastomeric components. The following tests on

elastomers shall be performed as per relevant ASTM Standards to ascertain the requirements specified in Clause 8.2.3.2:

(i) Specific Gravity and Density Test (ASTM D 792).
(ii) Temperature Test.
(iii) Shore A Hardness Test (ASTM D 2240).
(iv) Electrical Resistance Test (IEC 61854).
(v) Ultraviolet Resistance Test.
(vi) Ozone Resistance Test:

Non-metallic spacer damper parts shall resist Ozone attack and shall show no sign of damage after the following Ozone test as per ASTM D-1149 modified as follows:

Two finished full size specimens, mounted in their normal housing will be placed in an Ozone chamber for 72 hours at a temperature of 60°C. The concentration of Ozone shall be 50 parts per 100 million. One specimen shall be unstressed, and the second specimen will be subjected to the maximum stress.

No cracks shall be visible under 7 × Magnification.

(vii) Tension and Elongation Test (ASTM 412 C).
(viii) Tear Resistance Test (ASTM D 624 B).
(ix) Compression Set at 70h, 20°C-100°C-0°C (ASTM D 395 B).
(x) Rebound Resilience at 20°C-100°C-0°C.
(xi) Air-Oven Deterioration Test 72h, 70°C (ASTM D 573).
(xii) Deterioration in Oils 72h, 70°C (ASTM D 471).
(xiii) Water Immersion Test (ASTM D 471).

The values for these tests shall fulfill the requirements specified in the Clause 8.2.3.2 and those guaranteed by the supplier.

8.2.5 Sample Tests

Sample tests shall be made to verify the quality and workmanship of the offered lot. The number of samples shall be selected as per BS 3288-1 for the following tests.

i) Visual examination
ii) Verification of dimensions
iii) Galvanizing tests on ferrous parts
iv) Clamp Slippage Test at Ambient Temperature
v) Bolt Torque Test

i) <u>Visual Examination:</u>

The tests shall be examined visually for the following defects:

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant Drawing. Any part missing.

Finish	Galvanizing not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

ii) Verification of Dimensions:

The binding dimensions of the spacer dampers shall be measured as shown on the relevant approved drawings.

iii) Galvanizing Tests:

This test shall be carried out on all ferrous parts complying with the following requirements:

a) Weight of zinc coating
b) Uniformity of zinc coating
c) Adherence of zinc coating

This test shall be performed in accordance with ASTM A123 & A153.

iv) Clamp Slippage Test at Ambient Temperature:

This test shall be performed in accordance with clause 8.2.4.2

v) Bolt Torque Test:

This test shall be performed in accordance with clause 8.2.4.6

8.2.6 Vibration Dampers for Overhead EHS Shield Wire and OPGW

8.2.6.1 General

The vibration dampers for the overhead shield wires shall be suitable for use on 9.15 mm diameter 7-strand EHS grade galvanized shield wire and OPGW.

Technical characteristics of EHS shield wire and OPGW are given in Clause 4 hereinbefore.

Contractor shall submit with his bid, data showing similar type units in service at that time along with the location and approximate installation dates. All general requirements as related to materials, standards, drawings and performance guarantee specified for conductor spacer damper hereinabove apply for vibration dampers as well.

8.2.6.2 Physical Requirements

The vibration dampers shall be of the stockbridge type having clamp compressed or cast onto the stainless steel messenger wire of minimum 19 strands between the weights. Dampers weights shall not be cast on the messenger strands. All ferrous components shall be protected by zinc coating and shall be according to ASTM A 153 and ASTM 239.The dampers clamp shall be designed in such a manner that moisture cannot accumulate anywhere in the dampers. Each damper weight shall be provided with drain hole.

No line-guard or armour-rods are to be used for EHS shield wire.

Dampers clamps shall have bolts having break-away type head or cap made of aluminum alloy or stainless steel with belleville washers. The materials of the damper clamp/cap and clamping bolt/breakaway caps shall not exhibit galvanic corrosion due to bimetallic action. Contractor shall

ascertain the damper spacing and the number required in accordance with the sag-tension, span lengths limits and environmental conditions of the line.

8.2.6.3 Performance Requirements for Vibration Dampers

The dynamic strain caused by vibration in the vertical direction shall not exceed 600 μm/m peak-to-peak at the suspension point as measured by the recommended method of the IEEE Task Force on Conductor Vibration (IEEE Paper No 31 TP 65-156) for galvanized steel shield wire and 200 μm/m peak to peak alumoweld OPGW. Proposed material shall meet the performance requirements without failure or damage to overhead shield wires.

The status of the device clamping the damper to the overhead shield wires shall be capable of being determined from the ground. Sufficient detailed information shall be provided to substantiate Contractor's recommendations for system.

8.2.6.4 Type Tests

8.2.6.4.1 General

The following tests shall be performed by the Contractor to establish the characteristics of Stockbridge Vibration Dampers and to assure compliance with the specified requirements.

Three certified copies of test data which shows that all the specified requirements have been met shall be submitted. The performance of all the tests shall be completed and approved before any of the Stockbridge vibration dampers are shipped.

8.2.6.4.2 Clamp Slippage Test at Ambient Temperature

The vibration damper shall be installed on the EHS shield wire/OPGW in accordance with manufacturer installation instructions. The minimum free length of test shieldwire/OPGW between its terminating fittings shall be 2m. The EHS shieldwire/OPGW shall be tensioned to approximately 20% of its rated strength and by applying a tightening torque on the upper head of break-away bolt until breakage of the upper head occurs. The relevant torque shall be recorded. By means of a suitable device a load parallel to the axis of the EHS shield wire/OPGW shall be applied to the clamp. The load shall be gradually increased (not faster than 100 N/s) until it reaches 2.5 kN and held for minimum 1 minute without initial slip. The initial slip load is defined as the load at which the clamp moves 0.5mm or more on the EHS shield wire/OPGW. The load shall be increased until the continual slip occurs. The relevant value shall be recorded.

8.2.6.4.3 Bolt Torque Test

Using the same dampers that were tested in Clause 8.2.6.4.2 hereof, a torque of 150 percent of nominal design installation torque shall be applied at lower head of the bolt in order to see that there shall be no failure of component parts. Records shall be made of the lower head withstand torque, failure torque and the part(s) of the clamp assemblies that fail.

8.2.6.4.4 Attachment of Weights to Messenger Cable Test

This test shall be performed in accordance with Clause 7.8 of IEC 61897 should conform compliance to the acceptance criteria stated therein.

8.2.6.4.5 Attachment of Clamp to Messenger Cable Test

This test shall be performed in accordance with Clause 7.9 of IEC 61897 should conform compliance to the acceptance criteria stated therein.

8.2.6.4.6 Damper Performance Tests

Damper Performance Tests shall be performed in accordance with Clause 7.11 of IEC 61897 according to variant B in conjunction with the respective acceptance criteria. The Damper Perforamance Tests include:

(i) Damper Characteristic Test

This test shall be performed in accordance with Clause 7.11.2 of IEC 61897. The results thus obtained should fulfill the respective acceptance criteria.

(ii) Damper Effectiveness Evaluation

The laboratory tests evaluation method of this test should be adopted and the test shall be performed in accordance with Clause 7.11.3 of IEC 61897. The results thus obtained should fulfill the respective acceptance criteria.

8.2.6.4.7 Vertical Fatigue Test

Two samples of dampers each from EHS shield wire and OPGW shall be selected at random and tested from the offered lot of 1500or lesser in quantity.

The stockbridge dampers shall be installed on a shaker at the recommended torque and vibrated at the highest resonance frequency with an amplitude of ±1 mm. The test shall be continued for 10 million cycles. After the test, no breakage of any part shall occur and the torque on the bolt is not less than 60% of the recommended value of the torque.

8.2.6.5 Sample Tests

Sample tests shall be made to verify the quality and workmanship of the offered lot of EHS shield wire and OPGW dampers. The number of samples shall be selected as per BS 3288-1 for the following tests.

i) Visual examination
ii) Verification of dimensions
iii) Galvanizing tests on ferrous parts
iv) Clamp Slippage Test
v) Bolt Torque Test
vi) Attachment of weights to messenger cable
vii) Attachment of clamp to messenger cable
viii) Vertical Fatigue Test

(i) <u>Visual Examination</u>

The tests shall be examined visually for the following defects:

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant Drawing. Any part missing.
Finish	Galvanizing not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

(ii) Verification of Dimensions

The binding dimensions of the dampers shall be measured and shall be as shown on the relevant approved drawings.

(iii) Galvanizing Tests

a) Weight of zinc coating
b) Uniformity of zinc coating
c) Adherence of zinc coating

This test shall be performed in accordance with ASTM A123 & 153.

(iv) Clamp Slippage Test

This test shall be performed in accordance with Clause 8.2.6.4.2.

(v) Bolt Torque Test

This test shall be performed in accordance with Clause 8.2.6.4.3

(vi) Attachment of Weights to Messenger Cable

This test shall be performed in accordance with Clause 8.2.6.4.4.

(vii) Attachment of Weights to Messenger Cable

This test shall be performed in accordance with Clause 8.2.6.4.5.

(viii) Vertical Fatigue Test

This test shall be performed in accordance with Clause 8.2.6.4.7.

8.2.6.6 Test Requirements

Three certified copies of test results showing that the dampers meet the performance requirements of these specifications shall be furnished. Results of laboratory tests may be furnished in lieu of the tests results on outdoor spans.

The effectiveness of dampers shall be determined on span lengths which may be encountered in the line. Three spans, one with two dampers, one with one damper and one without shall be used. 9.15 mm diameter EHS galvanized steel shield wire and alumoweld OPGW with tension equal to the everyday stress shall be used. Duration of tests shall not be less than one year.

A certified curve shall be furnished for the damper proposed showing the frequency response in watts versus frequency from 1 Hz to 60 Hz.

If available, the bidder shall supply the data regarding fatigue life of the dampers with sinuous able force at the clamp and at a frequency of maximum power absorption.

The Contractor shall perform the bending amplitude test for shield wires dampers for frequency range of 15-140 Hz for shield wires at an average span of 365 m.

8.2.7 Technical Assistance and Research

It is intended to make vibration measurements on the lines (both for conductors and shield wires (i.e. EHS & OPGW) for the purpose of evaluating damper systems performance.

The Contractor shall provide at least four (4) vibration recorders (two for conductors and one for shield wire/and one for OPGW) will be installed on completed sections of the line before energizing. Proposed type, and number of vibration recorders provided by the Contractor, the rental price, cost of supervision, cost of interpretation and any other cost incidental to the work shall be deemed to be included in the unit price bided for dampers. Installation of the recorders in the field will be done by the Contractor himself under the supervision of the manufacturer.

The Project Manager shall select the line(s) and span(s) where recorders are to be installed.

Each interpretation shall be of a minimum fourteen (14) days duration record or as proposed by the Contractor and approved by the Project Manager.

Two graphs per interpretation are required and these will be as follows:

1. Number of megacycles per day at various frequencies.
2. Cumulative number of megacycles per day exceeding the following amplitudes:

    a. From 0.05 mm to 0.50 mm in 0.05 mm increments.
    b. From 0.50 mm to 2.0 mm in 0.1 mm increments.

The bending amplitudes shall be measured at a distance of 89 mm from the closest contact between the conductor and the suspension clamp. The bending amplitudes measured shall not exceed the endurance limits as per IEEE 1368-2006.

8.3. Basic Line Data and Environment

8.3.1 Basic Line Data

The following information is to be considered for determining the spacer and stockbridge vibration dampers application:

(a) Total line length of transmission line is 600 km (approx.)

(b) Estimated total number of structures is 1615

Conductors:	927.2 KCM 37/0 strands AAAC code word “GREELEY” 795 KCM 26/7 strands ACSR code word "DRAKE"	
Shield wires:	9.15 mm diameter galvanized steel EHS overhead shield wire and Alumoweld 24 Fibers OPGW	
Limiting Conditions: (Every day stress)	22% UTS, final bare for conductors at 25°C 15% UTS, final bare for shield wires at 25°C	
Span Schedule:	Average span	360 meters
	Ruling span	395 meters
	Minimum span	154 meters
	Maximum span	620 meters
Average conductor attachment height		21m

Average shield wire attachment height 31m

9. TECHNICAL PROVISIONS FOR CONSTRUCTION

9.1 General

(1) Clearing Right-of-Way

Right-of-Way clearing shall be restricted to the minimum necessary for the safe construction and operation of the line. Clearing shall generally consist of brushing out the centre line, tower locations and conductor pulling sites within 25 meters on each side of the centre line. Trees over 2.5 meters in height which constitute a hazard or danger to the transmission line, or whose tops are within 6 meters at 65°C final conductor sag position, shall be removed.

The clearing of desert vegetation shall be restricted to that required for placement of footings and for the assembly and erection of towers and wire pulling Site.

No clearing will be allowed in orchards or other areas of fruit bearing trees, except as specifically approved by the Project Manager.

The cleared materials will be the property of the Land Owner. If any disposal of cleared material is required it will be disposed of by burning or other methods approved by the Project Manager.

(2) Engineering and Surveying

The transmission line route marked on SOP sheets is firm and final as established by the Employer and is shown in the specification drawings. However, the Contractor shall check this line route prior to start the field ground survey.

The Contractor shall be responsible to carry out final route alignment detailed survey, prepare plan and profiles, tower spotting and prepare construction structure list for transmission line portion for which plan & profile drawings are not available with the Employer.

The work to be done by the Contractor shall include but not limited to the following:

(i) Before starting the detailed survey, walkover survey of the line route as shown in the specification drawings shall be carried out to mark underground utilities/services and built up areas falling in ROW corridor on SOP sheets of 1:50,000 scale for the approval from Project Manager.

(iii) Carry out final route alignment and the detailed survey along the approved line route.

(iii) If any line diversion along the proposed transmission line route is necessitated as decided/approved by the Project Manager, the Contractor will carry out an investigation of the route along with necessary plan tabling of the area and shall make necessary modifications and establish the terminal points, the angles locations, road crossings and other points of interest as advised by the Project Manager or his nominated person.

All the proposed modifications are then to be transferred on to the route map by the Contractor and submitted to the Project Manager for approval.

(iv) Contractor shall be responsible for obtaining approvals from various agencies following the necessary rules and regulations. Survey of Pakistan maps will be shown to the successful bidder in the office of the Project Manager when requested.

(v) During the survey, the Contractor will ascertain whether the route indicated to him is most desirable. If in his opinion another route would be more desirable on technical grounds or more economical, he shall report his findings to the Project Manager who will then decide about the adoption of new route.

(vi) The survey shall be executed using high precision Electronic Total Station equipment. Ground elevations are to be taken at regular intervals as directed by the Project Manager and at locations of change of slope and for various features like roads, rail tracks, canals, power & communication lines, water courses etc. The leveling along the route shall be connected and confirmed from the nearest available bench marks (BM) of national reference datum i.e. Survey of Pakistan. In the absence of such bench marks, leveling and check leveling should be done by using high precision handheld GPS.

(vii) The line route has to be marked on the ground with permanent concrete markers. However if markers have not been installed or found missing anywhere or if required by the Project Manager, the Contractor will install the Concrete markers of at least 130 x 150 mm at top and bottom with a height not less than 1m. The markers shall be buried 0.5 m below existing ground level. The markers shall be white washed and a red point shall be made on the top of the marker to indicate the exact centre of the line.

(viii) Total accumulated error in longitudinal and transverse measurements should not exceed 0.05% and in the vertical direction should not exceed 0.20%.

(viii) Longitudinal profiles and strip plans are to be prepared by the Contractor and shall be submitted for Project Manager's approval as per following scales;

Horizontal	1: 2000
Vertical	1: 200

The profile shall be prepared on plans of 700 mm x 2000 mm size, or other size approved by the Project Manager. Each sheet shall repeat 1/5 km of route on either side. Also the sheet numbers shall be indicated on a key map for reference.

(ix) Profiles shall include all details relevant to the survey of the routes including position of concrete markers, crossings, transversal slopes, location of forest reserves, population limits and position of road.

The ground profile shall be along the centre line of the approved route. All obstacles, and important features within 50 meters on either side shall be shown on the profiles.

Tower spotting shall be carried out by the Contractor using template (for "DRAKE" and "GREELEY" conductors) approved by the Project Manager. The template shall be based on the actual ruling span calculated from angle to angle, with maximum & minimum temperatures shall be 65°C and -4°C. Templates of various ruling spans will be provided free of cost to Project Manager on celluloid sheets indicating hot, cold and ground clearance curves. The tower positions shall be verified for suitability.

Construction structure lists shall be prepared by the Contractor as approved by the Project Manager.

(3) Validation, updating & preparation of as-built of the already prepared plan & profile drawings and construction structure lists (to be provided to the Contractor after award of contract) of the proposed transmission line route with the actual field developments. Staking (centre and reference pegs) of the tower locations which have to be concreted are included in the Contractor's scope.

Latitude and longitude by hand held GPS of each tower location should be collected and submitted to the Project Manager.

(4) Contractor shall be responsible for obtaining approvals from various agencies following the necessary rules and regulations.

(5) In case of route diversion, survey shall be conducted as per 9.1(2).

(6) Tower Staking (for all remaining tower locations which are to be concreted)

Tower centers shall be staked in the field alongwith two-reference stakes on either side of the tower along the line route, using wooden pegs are included in the Contractor's scope. All angle tower locations shall be bisected. Tower centers of angle locations with line angle in excess of 20° shall be fixed at off set distance 'X', which will be calculated from the following formula:

$X = A \tan\theta/2$ (only for tower types "M" (angle more than 20^o), "D" and "DGM", "DD1")

Where

A = Distance (width) from centre of tower bridge/cross-arm to the centre of attachment hole for tension assembly.

θ = Line deviation angle

All surveying not mentioned in these specifications as being the responsibility of the Contractor.

The footings for terminal dead-end tower shall be so placed that the transverse axis of the tower cross-arms shall be parallel to the transverse axis of the gantry structures of the substation up to 20° line angle. If line angle is more than 20° then terminal dead-end tower location shall be bisected as stated herein above.

9.2 Sub Soil Investigation

The Work specified herein is to determine the type and geotechnical characteristics of the foundation strata to the specified depth and location. This is to be accomplished through rotary drilling, field testing, ground water observations, soil sampling and laboratory testing. The location along with depth of investigation boreholes on the ground shall be established by the Contractor in accordance with the Drawings and from reference points approved by the Project Manager.

(a) Method of Drilling

Drilling shall be done by rotary including rock coring method by means of which a hole of specified diameter is extended in depths. Use of bottom discharge drilling bit shall not be permitted. The contractor shall be allowed to use percussion method where gravels and boulders are encountered.

(b) Drilling of boreholes in flowing water conditions

Drilling may be carried out under water conditions. During the investigation, the Project Manager may change such locations to land drilling depending upon the prevailing water way conditions.

(c) Test Pit (Not required)

The test pits shall be excavated at the locations as specified by the Project Manager. Excavations of test pits shall be made to the depths as directed by the Project Manager by manual labour and with the help of suitable digging tools. Test pits shall generally be excavated

to a depth of about 3 meters below the ground surface or bed rock whichever is encountered earlier. Undisturbed black (30cm x 30cm x 30cm) sample shall also be extracted from each test pit. The dimension at the bottom of pit shall not be less than 1.5 m x 1.5 m. After field testing and sampling, the test pit should be backfilled as instructed by the Project Manager.

(d) Drilling Fluid

The drilling fluid used for rotary drilling shall be clean water clear from suspended sediments. The Contractor may use the natural or commercial drilling mud/bentonite slurry as drilling fluid.

(e) Casing of Boreholes.

(i) Casing of a required size allowing entry of sampling tools shall be used in conjunction with drilling to wall the boring to the bottom of the hole.

(ii) The casing shall be made of cylindrical steel pipes and shall have sufficient strength so as to maintain position and shape during drilling operations.

(iii) The casing may be omitted only where it can be shown to the satisfaction of the Project Manager that sampling operations without the casing will not entrain soils from an elevation higher than the depth at which field testing or sampling is to be made.

(iv) It shall be the Contractor's responsibility to pull out casing from the bore holes after its completion for which no extra payment shall be made.

(f) Field Testing

Field testing shall include Standard Penetration Test. Standard Penetration Test shall conform to ASTM D-1586. This designation describes as procedure to obtain a record of the resistance of subsoils to the penetration of a standard sampler and to obtain representative disturbed samples of the material for identification purposes and laboratory testing. The penetration resistance shall be expressed as the number of blows of a 63.4 kg (140 lbs) hammer freely dropping 762 mm (30 inches) required to force the standard sampler 305 mm (12 inches) into the soil. Standard Penetration Tests shall be conducted in the bore holes at one meter interval from 1 meter depth to 10/15 meter depth of bore hole and up to 40 m in case of river crossing locations, unless otherwise directed by the Project Manager. Immediately after each penetration test a representative portion of the soil core shall be placed in moisture proof container.

(g) Undisturbed Sampling

The undisturbed samples shall be taken in cohesive and non-cohesive materials. Samples shall be obtained using Denison or Pitcher sampler or equivalent double tube core barrel or shelby tube. The sampling procedure shall conform to latest B.S./ASTM Standards. The length of undisturbed samples obtained shall not be less than 30 cm. Immediately upon extraction from the hole, the sample shall be properly waxed. The number and depth of undisturbed samples from each hole shall be as directed by the Project Manager during the progress of the drilling work at site.

(h) Labeling and Disposition of Samples

Each sample shall have identification tags giving information regarding Sample No., Top Elevation of Hole/Test Pit, Date of Sampling, Depth and Length of Sample, and Description of Sample.
The selected undisturbed and disturbed samples shall be carefully transported for testing by the Contractor to the approved testing laboratory. Every precaution shall be taken to avoid damage to samples as a result of careless handling and undue delay in transportation. The tubes containing

undisturbed samples and cores shall be well packed in wooden boxes to protect the samples against vibration.

(i) Ground Water Observations

Whenever required by the Project Manager, bore holes shall be preserved for observations of ground water conditions. When the borings are advanced by using natural or commercial drilling mud/bentonite to stabilize the hole, the hole shall be flushed thoroughly with clean water at the completion of boring for the purpose of observing ground water levels.

(j) Laboratory Tests

(i) General

- The laboratories in which the samples are to be tested shall be approved by the Project Manager.
- The person representing to the Project Manager shall have access to the laboratories to supervise and check the laboratory testing of the samples.
- The testing shall be carried out in accordance with ASTM or equivalent British Standards, or as directed by the Project Manager.

(ii) Tests

The Contractor shall arrange to carry out laboratory tests on the specified samples of the subsoil material. The samples to be tested and the tests to be carried out for each sample shall be specified by the Project Manager. Laboratory testing may include but not limited to the tests listed below:

- Grain Size Analysis (Sieve + Hydrometer)
- Atterberg's Limits
- Chloride Content (soil and water)
- Natural Moisture Content
- Bulk and Dry Densities
- Organic Matter Content
- Sulphate Content (soil and water)
- PH value (soil and water)
- Unconfined Compression Test
- Direct Shear Test
- Consolidation Test
- Total Soluble Salts.
- Magnesium Content

(k) Confirmatory Sub-soil Investigation

After preliminary subsoil investigations confirmatory investigation (if required) up to maximum depths of 25 meters will be carried out by the Contractor. The location of selected confirmatory investigation will be conveyed to the Contractor by the Project Manager.

(l) Record

The Contractor shall have at site, at all times only qualified, experienced, orderly and thoroughly competent graduate Geologist who shall conduct and supervise drilling operations sampling and logging. The Contractor shall keep accurate logs and records of all the Work accomplished under

this Contract. All such records shall be preserved in good condition by the Contractor until they are delivered and accepted by the Project Manager. The Project Manager shall have the right to examine such records at any time prior to their delivery to him. The following information shall be included in the records for each investigation borehole:

(i) Hole/test pit number or designation, coordinates and elevation of top of the hole/test pit;

(ii) Type of drilling operations;

(iii) Dates and time by depths when drilling operations were performed;

(iv) Depths at which samples were recovered and field-testing was performed including complete data of field-testing;

(v) Depth of Ground water table from NSL; and

(vi) Description of subsoil conditions.

The presence of the Project Manager Representative or keeping of separate records by him shall not relieve the Contractor of the responsibility for the Work specified in this clause. Payment will not be made if the Contractor has not furnished the records.

(m) Foundation design/designation (for diverted portion only)

Contractor shall submit the foundation design/designation along with the following data/calculations to establish that the proposed foundation type is optimized and cost effective for the review and approval of the Project Manager:

- Necessary soil design parameters to verify the bearing capacity based on geological data (bore log) and laboratory test results i.e. from (a) standard penetration test & (b) analytical method.
- Immediate and consolidation settlements of soil.
- Seasonal fluctuation of ground water.
- Cement type to be used for foundation construction (based on ACI-318 Table 4.3.1).

9.3 Foundation Requirements

(1) General

The items in the Price Schedules for constructing the various types of concrete foundations (including pile foundations) for steel towers include the following:

(a) Tower staking;

(b) Performing all clearing, grading, cutting and leveling as required to construct the footings and erect the steel towers;

(c) Performing all required excavation, dewatering, shuttering, curing and compacting backfill for the concrete footings;

(d) Installing steel stub angles in the concrete footings;

(e) Tower grounding before placement of concrete;

(f) All concrete work for the concrete footings, including the cost of furnishing all reinforcing bars, and all materials for concrete;

(g) Installing pile foundations (pile, pile cap & tie beam) where required, including the cost of furnishing all reinforcing bars and all materials for concrete; and

(h) Assessment of damage and prospect of rectification of already concreted tower foundations.

(i) The foundation drawings included in Bidding Document are firm & final and only be changed (if required) as directed by Project Manager.

(2) Excavation for Tower Footings

The Contractor shall perform all excavation required for constructing various types of concrete foundations for the steel towers. During excavation of towers sites near to amenities, the Contractor shall ensure to perform the work in such a manner as to minimum damage to them and if any prior approval is required that must be obtained at his own. However, in case of any damage the Contractor shall be get repair of it at his own risk and cost under intimation to the concerned agency.

The tower sites shall be leveled, graded/cut and cleared of trees, brush and stumps as may be required to construct the tower footings and to erect the steel towers. Cleared materials shall be disposed off, as directed by the Project Manager or his nominated person.

All excavations shall be sufficient to provide concrete footings with dimensions not less than shown on the drawings.

After the Contractor has excavated the footing to the required depth, the Project Manager will inspect the bottom of the excavation and determine if the bearing material is suitable for the type of footing designated for that location. If it is found that the bearing material is unsatisfactory for the type of footing designated, the Project Manager or his nominated person will either designate another type of footing or ask for compacted crushed stone mixed with sand 50:50 ratio to be placed underneath the footing for a depth of up to 1.2 meters. The Contractor will be paid only for the type of footing actually installed. However, no payment will be made to the excavation & replaced material underneath the footing.

A maximum variation of 60 mm above or below established grade will be permitted. However, if excavations are below specified grade plus tolerance, those shall be backfilled to required grade by the Contractor with the Contractor's furnished concrete at his own cost.

All excavated material which is suitable for backfilling shall be laid aside to be used for backfilling at the tower site from which it was excavated, and the excess material shall be spread evenly around the site as directed by the Project Manager or his nominated person.

Concrete shall be placed as soon as practicable after each excavation is completed and all excavations shall be protected so as to maintain a clean sub-grade until the footing is placed, using dewatering, timbering, shoring, or casing, as necessary. Any sand, mud, silt, or other objectionable material which may accumulate in the excavation shall be removed at the expense of the Contractor before placing concrete. After completion of foundations all the dewatering holes shall be filled with dry sand.

(3) Rock Excavation (Not required)

Rocks shall be excavated to the depth required to provide suitable base for the foundations as indicated on relevant drawings. Rocks are classified as sound and mashes, layers or ledges of mineral material 0.241 cubic meters in volume in place and of such hardness and texture that it cannot be easily loosened or broken down.
Rock excavation includes drilling, blasting, removal, drainage and pumping as required. Drilling and blasting techniques shall keep overbreak to a minimum and no extra compensation shall be paid for the removal of overbroken material. The contact surface of the rock shall be cleared of all loose rock and soil.

The cost of any damage whatsoever caused by blasting shall be payable by the Contractor. He shall not be relieved of these costs in spite of having received approval of his methods from the Project Manager.

(4) Erosion/Slope Protection (Not required)

For erosion protection against water current, gravel blankets shall be placed such that they do not flow away with water current. These gravel blankets shall be placed at or adjacent to tower sites in the manner as directed by the Project Manager or his nominated person. Gravel for the blankets shall be furnished by the Contractor, and it shall be pit-run, free draining, containing no stones larger than 635 mm size obtained from the closest source approved by the Project Manager or his nominated person. The gravel shall be reasonably clean and free from vegetation, pieces of timber, or other foreign matter, and shall be distributed and graded evenly over the required areas. No compaction will be required.

Slope protection will be provided for foundations, which are located/placed on uneven ground, and/or they are partially or fully exposed in such a way that designed burden cannot be provided on these foundations safely. Slope protection shall include but not limited to construction of retaining walls of stone or brick masonry to a height and depth so as to provide adequate protection and necessary burden by making a leveled platform with or without brick/stone mortar after filling with earth as per specifications/drawings or as directed by the Project Manager. The slope protection drawings will be prepared by the Contractor and submitted to the Project Manager for review/approval prior to execution of Project.

(5) Concrete Foundations

Each tower foundation will have four footings and each footing will consist of a steel stub angle embedded in reinforced concrete. The footings for each tower in a tangent section of the line shall be placed so that the longitudinal axis of the tower cross-arm will lie in a plane perpendicular to the traverses of the line. Unless otherwise directed by the Project Manager, the footings for each angle tower shall be placed so that the tower cross-arm will lie in a plane bisecting the interior angle formed by the inter-section of the traverses of adjacent sections of the line.

The footings at the various tower sites shall be constructed in accordance with the criteria shown on Drawings.

Pile foundations will be required where the field and laboratory tests confirm the requirements. The pile foundations will be installed as shown on the relevant drawings and in accordance with these Specifications.

Any type of spread footing foundation may be changed to another type of spread footing foundation or pile foundation in accordance with field requirements during execution of the project with the prior approval of the Project Manager.

(6) Placing of Stub Angles in Footings

Stub angles shall be placed in the tower footings as shown on the drawings and shall be supported in the proper position by means of a rigid frame or equivalent suitable device to ensure placement of the stubs within the tolerances specified below. The stub angles shall be held rigidly in a manner to prevent displacement during placing of concrete.

All stub angles for the tower legs shall be set accurately to the grade and alignment designated on the drawings and as directed by the Project Manager. Work that is not within the tolerance will be corrected as directed by the Project Manager, and at the Contractor's expense. The setting tolerances following complete foundation installation including backfilling and compacting are as follows:

(a) Tower Center from theoretical location:

(i) Transverse ..... ± 150 mm

(ii) Longitudinal ..... ± 500 mm

(b) Tower Orientation (angular departure from the theoretical location measured at the point of intersection of a tower face and the longitudinal centre-line).....25 mm

(c) Difference in Elevation between working point marks on Stub Angles including diagonally opposite legs ..... 8 mm

(d) Departure from theoretical Horizontal Dimensions between tower centre line and working point marks on stub angle:

(i) Along the tower face,
plus minus ..... 5 mm

(ii) Along the tower diagonal,
plus minus ..... 7 mm

(e) Batter …..... 5 mm
per meter

(f) Twist (about heel of stub angle) ..... 2°

(7) Tower Grounding

Each tower shall be grounded by installing one ground rod below each of two diagonal footings. Ground rods shall be driven at least 2.5 meters into undisturbed soil at the bottom of the footing excavation, as shown on the Drawings. The ground rod shall be connected to the stub angle by a 7 No. 10 stranded annealed copper covered ground wire. The connection of this wire to the ground rod and to the stub angle shall be made by a bolted clamp in accordance with the Drawings.

Where it is not possible to drive a ground rod an alternative grounding by installing 'crowfoot' shall be adopted.

The resistance of the two rods/crowfoot in parallel shall be measured and recorded before concrete footings are poured. If the resistance is more than 10 ohms, additional rods/crowfoot shall be installed as directed by the Project Manager or his nominated person. No extra payment would be allowed for laying on account of this.

The dead end terminal tower of the overhead lines must be connected to the earthing system of the grid stations.

(8) Concrete

(a) General

All concrete and reinforcement placed for tower footings shall conform to the requirements of this section.

At least 30 days prior to beginning concrete placement, the Contractor shall submit to the Project Manager for approval, a design mix (along with quantity and source of each material) along with six (6) test cylinders using the actual materials to be incorporated into the Work. Approval of the design mix will in no way relieve the Contractor from meeting all the requirements of these Specifications. Whenever the Contractor proposes to use a different material source, a new design mix must be submitted and approved as outlined above. During construction if in the Project Manager's opinion the mix shall be adjusted, the Contractor shall submit a new design mix as directed by the Project Manager.

(b) Materials

The Contractor shall furnish all materials for use in concrete, including but not limited to cement, sand, coarse aggregate, water, reinforcing bars, admixture,(including ground slag) and concrete curing compound. Air-entraining agent and curing compound shall be accepted on manufacturer's certification of compliance with specification requirements. However, the Project Manager reserves the right to require submission of and to perform tests on samples of the agent and/or compound prior to shipment and use in the Work at the cost of Contractor.

(i) Cement

Cement shall meet the requirements of ASTM C150 and shall meet the false-set limitation specified therein. The cement shall be free from lumps and damaged cement, when used in concrete. Adequate provisions shall be made by the Contractor to prevent absorption of moisture when cement is stored. Cement Type-V shall be used for all foundations (Lot-I & Lot-II). Cement Type-I shall be used for all types of foundations other than those for which sulfate resistant cement Type-V is required by the Project Manager (for Lot-III only). No extra payment shall be made to the Contractor in case of use of sulfate resistant cement.

(ii) Sand and Coarse Aggregate

Sand and coarse aggregate shall be furnished from any approved source. The sand particles shall be clean, hard, dense, durable, uncoated rock fragments that will pass a screen having 6.5 mm square openings. The sand shall be well graded from fine to coarse and shall be free from injurious amounts of dirt, organic matter, and other deleterious substances.

The coarse aggregate shall consist of clean, hard, dense, durable, uncoated rock fragments, shall be free from injurious amounts of flat and elongated pieces, organic matter, or other deleterious substances. The maximum size of crushed coarse aggregate for piles shall be 19 mm and for spread footings, pile cap and tie beam 38 mm or as directed by the Project Manager. The grading of these sizes shall conform to ASTM C33.

The Contractor shall submit, for testing and approval, representative samples of the sand and coarse aggregate proposed for use in the concrete work. All aggregates shall conform to the requirements of ASTM C33 including petrographic test. During construction the Contractor shall also arrange testing of sand and coarse aggregate if directed by the Project Manager to determine compliance with Specifications. The cost of all laboratory testing of these samples shall be borne by the Contractor.

(iii) Water

Water used for mixing concrete shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete or reinforcement and shall meet the requirements shown in Table-1 below. A complete chemical analysis of water shall be submitted prior to the start of construction work and shall be required for each new water source being chosen. The cost of all laboratory tests of the samples shall be borne by the Contractor. No change in water source shall be permitted without prior approval by the Project Manager.

TABLE-1

Total Dissolved Solids (TDS)	700 ppm (max)
Magnesium, Chlorides and Sulfates	250 ppm (max)
pH Value	6.5 – 8.0

(iv) Reinforcing Bars

Reinforcing bars shall be deformed bars conforming to ASTM Designation A615, Grade 40 & Grade 60. Representative steel bar samples shall be collected from the site and tested in the laboratory approved by the Project Manager. The testing shall be witnessed by the Project Manager. The cost of all laboratory tests and traveling of Project Manager shall be arranged/borne by the Contractor.

Negative variation in weight [mass] maximum up to 1.5% of reinforcement bar(s) from the applicable weight [mass] per unit length prescribed in Table 1 of ASTM A615 will be allowed for bar(s) placement. Contractor will have to make adjustments in bar spacing/number of bars to accommodate the excessive negative variation in weight [mass] if greater than 1.5%. Contractor will not be allowed for bar(s) adjustment in case of overweight [excessive mass] of any deformed bar.

(v) Curing Compound

Curing compound shall be wax-base and white-pigmented (Type 2) and conforming to ASTM Designation C-309 to reflect solar radiation.

(vi) Admixtures and Ground Slag

Admixtures to be used in concrete shall be subject to prior approval of the Project Manager and shall meet the following requirements:

(1) Chemical Admixtures

a) Air-entraining admixtures shall conform to ASTM C 260,"Specification for Air-Entraining Admixtures for Concrete.

b) Water reducing or water reducing and retarding admixtures (Normal Plasticizers) shall conform to ASTM C 494, “Specification for Chemical Admixtures for Concrete”, Type A or D, respectively.

c) Super plasticizers shall conform to ASTM C 494, Type F or G, respectively

d) Only one of the Admixtures A, D, F or G, shall be added at a time.

e) Chloride-bearing admixtures shall not be permitted.

f) Super Plasticizers shall be checked for their compatibility with pozzolanic materials in blended cement concrete.

(2) Ground Granulated Blast-Furnace Slag

In area where high sulphate and chloride contents are present in soil/water, finely ground granulated blast-furnace slag can be used as cementatious material in concrete by replacing SRC cement by maximum up to 30%. The properties of ground granulated blast-furnace slag should meet ASTM C 989. The cost of all laboratory testing of these samples shall be borne by the Contractor. Contractor will not be paid extra for the purchase/procurement of ground granulated blast-furnace slag to the construction sites.

(c) Composition

The Contractor shall determine the proportions of the sand, coarse aggregate, and cement needed to provide concrete, meeting the requirements of these Specifications, and shall be approved by the Project Manager. Concrete which contains 38 mm maximum-size aggregate shall have a cement content of not less than 380 kg per cubic meter and concrete which contains 19 mm maximum size aggregate shall have a cement content of not less than 440 kg per cubic meter. 38 mm maximum size aggregate shall be used for spread footing, pile caps, tie beams and 19 mm aggregate for piles. The net water cement ratio by weight shall not exceed 0.5. Surface water contained in the aggregate shall be included as part of the mixing water in determining the water content. Reinforced concrete design will be checked in accordance with the ACI Building Code.

The Contractor will take minimum three test cylinders (152mm x 305mm) per leg, and the average compressive strength at 28 days shall exceed 210 kg/cm² (3000 psi) and no individual test value should fall more than 35 kg/cm² (500 psi) from the minimum specified value.

The compressive strength of the concrete will be determined by the Project Manager through the medium of test of (152 x 305 mm) cylinders made and tested in accordance with ASTM C39. The Contractor shall furnish all necessary sampling equipment such as slump cones, test cylinders, etc. at the site. This equipment is to be approved by the Project Manager or nominated person by Project Manager. The cost of the material lab tests shall be borne by the Contractor.

In the event that the concrete cylinder fails to meet the specified strength requirements then in-place testing of concrete shall be conducted under the supervision of the Project Manager. In-place as approved by Project Manager testing of concrete shall be conducted by one or a combination of the following methods:

(i) ASTM C42 "Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete."

(ii) ASTM C805 "Test Method of Rebound Number of Hardened Concrete."

The use of calcium chloride in concrete will not be permitted.

The slump of the concrete shall not exceed 75 mm for conventional foundation, pile cap & tie beam and 150 mm for piles.

(d) Batching and Mixing

Unless specifically approved by the Project Manager, all concrete used on the Project shall be machine mixed. Hand mixing shall only be used when authorized by the Project Manager and shall be performed under his directions.

The sand and coarse aggregate shall be weighed and shall be proportioned on the basis of integral bags of cement unless the cement is weighed. After weighing, the materials may be proportioned on the basis of equivalent volumes. The Contractor shall provide equipment and shall maintain and operate the equipment as required to accurately determine and control the amount of each separate ingredient entering the concrete. Batching shall be such that combined inaccuracies in feeding and measuring the materials will not exceed 1.5 percent for water and weighed cement and 2 percent for sand and each size of coarse aggregate. The concrete shall be uniform in composition and consistency throughout the mixed batch, and from batch to batch, except where changes in composition or consistency are directed. The mixing time shall be at least 1.5 minutes for stationary mixers. Excessive over-mixing requiring the addition of water to preserve the required consistency will not be permitted. The temperature of the concrete when it is being placed shall be not more than 35°C and not less than 5°C in moderate weather or 10°C when the mean daily temperature drops below 5°C. Truck mixers will be permitted only when the mixers and their operation are such that the concrete throughout the mixed batch and from batch to batch is uniform with respect to consistency and grading. Any concrete retained in truck mixers so long as to require additional water to permit satisfactory placing shall be wasted.

(e) Forms Preparation for Placing of Concrete

Unless otherwise provided for on the Drawings or approved by the Project Manager, all concrete placed will be monolithic.

Forms shall be sufficiently tight to prevent loss of mortar from the concrete and shall be maintained rigidly in position until the concrete has hardened sufficiently to prevent damage by form removal. All surfaces of foundations upon or against which concrete is to be placed shall be free from standing water, mud and debris. The surfaces of absorptive foundations against which concrete are to be placed shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete. The surfaces of construction joints shall be clean, rough and surface dry when covered with fresh concrete. Cleaning shall consist of the removal of all laitance, loose or defective concrete, coatings, sand, curing compound if used, and other foreign material. A mortar layer shall not be used on concrete construction joints.

The methods and equipment used for transporting concrete, and the time that elapses during transportation shall be such as will not cause appreciable segregation of coarse aggregate or slump loss in excess of 25 mm in the concrete as it is delivered into the Work. Concrete may be transported from the mixer to the forms and deposited in the forms by any method approved by the Project Manager such as transit mixers, buckets, chutes and pumping. Aluminum pipe or chutes shall not be used for tremie trunk line, or chute for placing of concrete, or for the delivery of pumped concrete. Re-tempering of concrete will not be permitted. Any concrete which has become so stiff that proper placing cannot be assured shall be wasted. Formed concrete shall be placed in continuous approximately horizontal layers, the depths of which generally shall not exceed 500 mm. Concrete shall be vibrated (internal vibrators having a minimum frequency of 8,000 vibrations per minute) until it has been consolidated to the maximum practicable density, is free from rock pockets of coarse aggregate, and closes snugly against all surfaces of forms and embedded materials. Standby vibrators shall be available during concrete placement.

Exposed unformed surfaces of concrete shall be brought to uniform surfaces and worked with suitable tools to a reasonably smooth wood float or steel-trowel finish as directed. Concrete in the tops of foundations in which stub angles are embedded shall be sloped to provide drainage away from the stub angles.

(f) Reinforcement

Steel reinforcing bars shall be placed in the concrete where shown on the drawings. Before reinforcement is placed, the surfaces shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease, or other foreign substances. Reinforcement shall be accurately placed and secured in position so that it will not be displaced during placing of concrete.

The Project Manager shall not furnish supplemental bar-placing diagrams, bar lists, and bar-bending diagrams. Any such additional diagrams and bar lists of this type which the Contractor may require to facilitate the fabrication and placement of reinforcement shall be provided by the Contractor.

Reinforcement will be inspected for compliance with requirements as to size, shape, length, splicing, position, and amount after it has been placed.

Any bar-placing diagrams, bar lists, and bar-bending diagrams prepared by the Contractor shall conform to the requirements shown on the reinforcement design drawings and shall be approved by the Project Manager. Maximum two numbers of bars (2+2) in pad and chimney can be lapped.

Lap splices shall be as under:

Bar #	3	4	5	6	7	8	9	10	11
Lap(mm)	305	360	460	610	840	1095	1400	1750	2160

(g) Protection and Curing

The Contractor shall protect all concrete against injury until final acceptance. The concrete shall be cured with two applications (coats) at right angles to each other to ensure uniform and more complete coverage with approved membrane type curing compound to be applied preferably by power sprayer as soon as possible after concrete placement and in no case later than 2 hours. Curing with water shall be used only as an

alternative to the type curing and with Project Manager approval. The application of the curing compound shall be in accordance with the procedures outlined by the Manufacturer. In case of pile-cap & tie beam with form, ties are loosened and vertical forms are still in place water should be applied to run down on the inside of the form to keep the concrete wet. Immediately after form removal, the surfaces should be kept continuously wet by water spray or water-saturated fabric until the membrane-forming curing compound is applied.

In exceptional cases where extremely corrosive soil conditions are encountered, or as directed by the Project Manager, the surfaces of the concrete, both exposed and unexposed, shall be treated with an approved type of bituminous compound. A minimum of two applications shall be required, and the applications shall be 100 percent effective. Surfaces to be treated shall not be coated with curing compound. No extra payment will be made to the Contractor for procurement/treating concrete surfaces with bituminous compound.

(h) Repair of Concrete

Any concrete that is damaged or defective from any cause; concrete that is honey-combed, fractured, or otherwise defective, and concrete damaged because of excessive surface depressions, must be excavated and built up to bring the surfaces to the prescribed lines, shall be removed and replaced and any imperfections and irregularities on concrete surfaces shall be corrected. The removal and replacement of damaged or defective concrete, and the correction of surface imperfections and irregularities shall be made with concrete dry pack, or mortar (Portland cement mortar), or at the option of the Contractor, with epoxy-bonded concrete, or epoxy-bonded epoxy mortar, where and as applicable for the type of repair involved. All repairs should be completed within 24 hours after removal of forms, and as directed by the Project Manager or his nominated person. However, forms shall not be removed for a period of at least 24 hours after the concrete work until it has acquired sufficient strength to safely carry its own weight and any construction loads that may be imposed on it.

(i) Tolerances for Concrete Construction

The Contractor shall be responsible for setting and maintaining concrete forms within the tolerance limits necessary to insure that the completed Work will be within the tolerances specified or within good construction practices. Concrete work that exceeds the tolerance limits specified herein shall be inspected by the Project Manager and he will determine what effect the deviations will have upon the structural action or operational function of the structure, and what remedies may be necessary. If after such inspection the Contractor is directed to remove or replace any defective Work, he will do so at his own expense.

(aa) Tolerances for footings:

-	Variation from plumb or specified batter for lines and surfaces of stems	In any length of 3.0 meters	13 mm
		Maximum for entire length	26 mm
-	Variation in cross-sectional dimensions of stems	Minus.....	7 mm
		Plus	26 mm
-	Variation from specified	Minus	13 mm

	elevation for top of concrete	Plus	13 mm
-	Variation of dimensions in plan	Minus ..... Plus	13 mm 52 mm
-	Misplacement or	2 percent of the footing Eccentricity width in the direction of misplacement but not more than 52 mm	
-	Reduction in thickness	5 percent of specified thickness	

(bb) Tolerance for placing reinforcing steel:

-	Variation of protective covering:	with cover of 64 mm or less 7 mm with cover of more than 64 mm ..... 13 mm
-	Variation from indicated spacing	..... 26 mm

(9) Backfill for Tower Footings

Backfill shall be placed about the tower footings to elevations indicated on the drawings or as directed. The material used for backfilling, the amount thereof, and the manner of depositing this material shall be approved by the Project Manager. Where the excavated materials are insufficient in quantity or are not suitable, as determined by the Project Manager nominated person, for use as backfill, the Contractor shall obtain suitable material from the borrow. No borrow pits shall be made within 25 meter radius from centre of tower. Backfill shall be placed about the tower footings as soon as practicable after removal of concrete forms, but not earlier than 8 hours from application of sealing compound or bitumen coating to concrete surfaces.

The excavated material not suitable for backfilling or in excess of backfilling requirement shall be spread evenly over or adjacent to the Site. The backfill adjacent to footing stems shall be approximately 150 mm above the original ground, and shall be graded and sloped uniformly away from the stems so that there is no pond at or around the footing.

In backfilling for concrete footings, the pad of the footing shall be covered with fine material of 300 mm thickness (after compaction) before any coarse material is deposited. Care shall be taken to avoid damage to the concrete when backfilling. The backfill material shall be clean and free from vegetation, pieces of timber, or other foreign matter. Suitable material for backfilling shall be a compatible granular material having a granularity within the following limits.

Sieve	% Passing
76 mm (3 in)	100
No. 200	0-15

(10) Compacting Backfill

Backfill shall be placed in horizontal layers which after compaction shall not be more than 150 mm thickness. Each layer shall be compacted by tamping machines or other mechanical means approved by the Project Manager.

Backfill shall be moistened properly where required. When excavated material is so wet that it is not suitable for backfilling, it shall be spread and aerated until the proper moisture content is attained, at which time the material shall be used as backfill around tower footings. The backfill material shall not be placed until all forms and timber used for shoring or bracing have been removed, unless otherwise permitted by the Project Manager or his nominated person.

The Contractor shall submit, for laboratory testing and approval, representative samples of the materials proposed to be used as backfill. On the basis of laboratory test results the Project Manager shall specify the degree of compaction to be obtained in the field, which shall not be less than 90% of the maximum dry density as obtained by ASTM D-1557.

Density shall be measured in the field according to ASTM D1556 or ASTM D2937 by the Contractor in the presence of nominated person of the Project Manager to determine compliance with the specified degree of compaction. The cost of all laboratory and field testing shall be borne by the Contractor.

(11) Additional Foundations

In case other foundations are required to be installed, which are of different design than the specific types listed, the Contractor shall install these foundations as directed by the Project Manager. All work performed will be in accordance with these Specifications. Payment for additional foundations will be made at the applicable unit prices provided in the Price Schedules for similar works.

(12) Foundation Test (Not Required)

The Contractor may be required to perform an uplift load test on any one footing for double circuit suspension type tower. The Project Manager will designate the location and type of footing to be tested. All methods, procedures, equipment, jigs, apparatus etc., shall be subject to approval by the Project Manager. No testing shall be commenced until 28 days after the final concreting nor until all backfill is placed and compacted as specified herein.

An uplift load shall be applied until a design value is reached or the footing fails. The rate of load application will be determined by the Project Manager.

9.4. Pile Foundations

(1) General

(a) Description of Work

The Work to be performed under these Specifications shall be carried out at the proposed site of towers after the field and laboratory test results confirmation. The Work includes, but is not limited to the following:

(i) Carrying out subsoil investigations at the tower locations through drilling, testing and sampling (if required by the Project Manager).

(ii) Construction of bored, cast-in-place reinforced concrete piles, pile cap and tie beam as shown in the Bid Drawings or as directed by the Project Manager.

(iii) Complete borehole logs and record of all operations performed during the investigations and the execution of the Work.

(b) Location of Investigation Borehole and Piles

(i) The location of investigation boreholes and piles on the ground shall be established by the Contractor in accordance with the Drawings after the approval by the Project Manager. Establishing the investigation borehole and pile locations accurately in the field shall be the sole responsibility of the Contractor.

(ii) The Contractor will provide the levels, survey and ground elevations for each investigation borehole and pile location. The elevations will be given with respect to permanent Bench Marks in the vicinity of the Site.

(c) Number, Diameter and Length of Investigation Borehole and Piles

(i) One investigation borehole, not smaller than NX size, the hole diameter approximately 75 mm shall be drilled at each location of tower where pile foundations are proposed to a depth of 20 meters from the general ground level, or 5meters below the pile tip whichever is greater.

(ii) Bored, cast-in-place reinforced concrete piles shall be constructed having uniform diameter throughout the length as specified (minimum) in the relevant Bid drawings or as directed by the Project Manager. Pile footings shall only be installed where the field and laboratory tests confirm the requirements. The final length of the piles shall also be determined based on field and laboratory test results confirmed after testing.

(d) Containers

For preserving and transporting soil and water samples collected from subsoil investigations the Contractor shall furnish jars, tubes, boxes, bags and crates, meeting the requirements as specified in these Specification and the cost thereof shall be included in the Contract Price.

(e) Care and Delivery of Samples

(i) Contractor shall be solely responsible for preserving all samples in good condition. He shall keep samples away from undue exposure to the weather, and shall keep descriptive labels and designations on sample jars and boxes clean and legible until final delivery of samples to the laboratories approved by the Project Manager. The Contractor shall make arrangements for waxing of samples as directed by the Project Manager.

(ii) The Contractor shall arrange for all samples to be safely packed and careful transportation to a laboratory as approved by the Project Manager.

(f) Drillers and Supervisory Staff

The Contractor shall have at Site, at all times only qualified, experienced, orderly and thoroughly competent persons including graduate civil engineers/geologists who shall conduct and supervise drilling/concreting operations during, sampling, logging, in-situ testing and piles construction.

(2) Execution of Piles

(a) General

This clause covers all the work necessary for the execution of the bored, cast-in-place reinforced concrete piles namely:

(i) Drilling and stabilizing of bore holes for the piles.

(ii) Placing of steel reinforcement.

(iii) Mixing and placing of concrete.

The Contractor shall perform all such work in accordance with requirements of this clause as well as in accordance with the methods proposed or described by him at the time of submitting his Bid and approved by the Project Manager.

(b) Method of Drilling

The drilling of holes for piling shall be done by mud circulation or reverse rotary or percussion method or any other method suggested by the Contractor and approved by the Project Manager. Regardless of the method used for drilling holes, drilling operations shall be carried out in such a way as to avoid any disturbance of the surrounding soil especially at the bottom of the hole and successful drilling through all types of soil/rock/boulder.

(c) Stabilizing of Holes

There will be no permanent casing installed. Any temporary protective casing at the start of the drilling shall be later pulled out. The stabilizing of the drilled holes shall be achieved by using natural or commercial drilling mud/bentonite. Permanent casing shall only be allowed with the prior approval of the Project Manager, for which no extra cost procurement/placement shall be paid to the Contractor.

(d) Tolerances

Tolerances for setting out and for concrete construction shall conform to Clause 9.3 of these Technical Provisions. In case of piles, deviation from the vertical shall not exceed one percent on any section of the length of the holes.

(e) Concrete

All concrete and reinforcement placed in the construction of piles shall conform to the requirements of Clause 9.3(8) of these Technical Provisions. In addition to this, following requirements shall also be fulfilled.

(i) Promptly after cleaning of the borehole to the entire satisfaction of the Project Manager Representative, concrete shall be placed in a manner that will not cause segregation of the particles or permit infiltration of water or any other occurrence which would tend to decrease the strength of the concrete or the capacity of the finished pile. The slump shall be limited to 150 mm maximum.

(ii) The minimum clear distance between vertical reinforcement, including lapped bars, shall be 100 mm (if applicable).

(iii) Either tremied or pumped-in concrete can be used in presence of water or of drilling mud. Tremie or pump pipe shall be made of steel and have watertight joints. Tremie pipe shall have a minimum diameter of 8 inches (200 mm) and pump pipe shall have a minimum diameter of 4 inches (100 mm) should be used. Embed tremie or pump pipe a minimum of 3 meters in the concrete throughout

concreting. The method and equipment used shall be subject to the prior approval of the Project Manager.

(iv) Concrete placement shall proceed without interruption until the pile is complete.

(v) Vibrate top 3 to 4 meters of concrete after temporary casing has been withdrawn.

(vi) The Contractor shall make three test cylinders per pile or as directed by the Project Manager during the concreting of piles.

(vii) The vertical bars of pile can be coupled together as directed by the Project Manager according to the site requirement.

(viii) The dia of stand casing/permanent casing should be at least 25mm larger than the pile dia, whereas bit dia should be equal to pile design dia.

(f) Record

The Contractor shall keep accurate logs and records of all the Work accomplished under this Contract. All such records shall be preserved in good condition by the Contractor until they are delivered and accepted by the Project Manager. The Project Manager shall have the right to examine such records at any time prior to their delivery to him. The following information shall be included in the records for each pile.

(i) Investigation Bore-hole (if applicable)

- Hole number of designation, coordinates and elevations of top of the hole.
- Type of drilling operations.
- Date and time by depths when drilling operations were performed.
- Depths at which samples were recovered and field testing was performed including complete data of field testing.
- Depth of ground water table from NSL.
- Description of subsoil conditions.

(ii) Piles

- A general description of sub-soil conditions and water table position at the location of the pile.
- Pile number, ground elevation of borehole and elevation of top of pile.
- Type of drilling operations.
- Date and time by depths when drilling operations were performed and piles constructed.
- Total depth of each borehole.
- Quantity of concrete and steel used for the construction of each pile.

- Quantity of constituents for each batch of mix, water cement ratio and the results of all quality control tests.

- Time of start and completion of Concrete.

- Remarks concerning any unusual occurrence during drilling and concreting of piles.

9.5. Tower Erection

(1) General

Contractor's work includes supply of manpower, providing construction equipment, vehicles, rigging tackles for complete assembly of towers.

Profile drawing indicating the location, height and type of each tower and the construction data sheets showing the length of leg extension for each of the four legs of each tower will be submitted by Contractor after final survey for approval of the Project Manager.

Erection shall be done strictly in accordance with the approved manufacturer's drawings, material lists and approved construction data sheets.

No tower shall be erected until seven days after the last concrete was placed in the foundation, nor until backfill has been completed where and as required.

(2) Handling

Tower steel shall be handled so as to prevent deformation of the members and damage to the galvanizing. Materials shall not be dumped, dragged, barred; rolled or dropped but shall be carefully loaded, unloaded and stored. A mechanical means such as hoist or crane shall be used when material cannot be properly handled or placed by hand.

Bare wire rope or steel chains shall not be used for handling without adequate protection of the surface coating. Heavy members shall not be stacked on top of lighter members. Structural members shall be stored according to size, lengths and markings. The maximum weight of steel bundles shall not exceed a specified weight, typically 1600 kg to 1800 kg, to facilitate handling and unloading. Members with dissimilar finishes shall not be stored over one another to minimize discoloration of the lower members.

All members shall be placed on wood blocking or other suitable material to ensure that the materials to be stored are not in contact with the ground. Blocking shall also be used to separate layers of stacked materials. Members shall be supported in such a manner as to prevent bending and distortion as well as to allow water to drain from the materials.

Failure to provide for proper drainage of stacked galvanized steel members could result in the formation of white rust. White rust (zinc oxide) forms when two galvanized surfaces are closely rested for an extended time without adequate ventilation. Ingress of water between the surfaces forms an electrolytic cell, which may, in time, erode some of the zinc layer. The white rusting action will stop after exposure to air. Spacers placed between the nested pieces ensure adequate ventilation when extended transport storage is anticipated.

The material yard shall be kept relatively neat and clean and the growth of vegetation kept to a minimum. Good housekeeping minimizes damage and loss of material handling; periodic physical inventories and complies with environmental considerations.

(3) Assembly Methods

All assembly and erection shall be done by methods and equipment that will not cause damage to, or distort any part of the tower. Extreme care shall be taken to establish and maintain the true geometric shape of the sections of tower assembled.

Preassembly techniques are generally influenced by site terrain and available equipment. Generally, the larger section that can be pre assembled, the more efficient is the assembly/erection operation. Preassembly techniques shall consider placement of the assembled sections to provide for the most efficient, safe lifting for erection. Structural assemblies, which are not sufficiently rigid to be raised in one piece, shall be stiffened by means of adequate temporary bracings.

Towers assembled on the ground shall be placed on suitable blocking so as to be kept free of dirt, mud or other foreign material that might adhere to the structure and damage the coating. Blocking shall be placed in such a manner as to provide a flat surface in order to prevent over stressing or distortion of members and to maintain the true geometric shape of the assembled members. Mud, dirt, white rust and other foreign material shall be removed from the contact surfaces of joints prior to assembly. Steel members shall not be dragged over the ground or otherwise handled in such a manner as to damage the galvanizing.

The structures shall be assembled in accordance with the fabricator's erection and detail drawings. The diameter, type, and length of bolts as shown on these drawings shall be used for each connection. Orientation of bolts can facilitate access, final tightening, installation of locking devices and subsequent checking of the erected structure. Tower bolts shall normally be installed so that the nuts are to the outside of the tower or, in the case of horizontal members, to the top of the connection unless such positioning is clearly impracticable.

Installation of bolts by hammering or any method that damages the galvanized coating shall not be allowed.

When sections of towers are being assembled prior to erection, assembly shall be on blocks that will provide support, sufficient to prevent distortion of tower steel. If all bolts in an assembly are not inserted, at least 50 percent of the bolts in each connection shall be inserted and those bolts shall be finger-tightened only. All bolts in an assembly shall be inserted before any bolt in the assembly is fully tightened.

Only wrenches which properly fit the nuts and bolt heads shall be used. The use of wrenches, which in any way deform the nut or cut or flake the galvanizing is prohibited. All bolts shall be entered clear to the head. All 16 mm diameter bolts shall be tightened to a torque of 10-14 kg - meters and 20 mm and 24 mm diameter bolts to a torque 17-23 kg-meters. All bolts after torque shall be centre punched adjacent to the nut in order to prevent loosening of the nut. This method of locking the nuts will be used instead of locknuts.

(4) Method for Erection

Towers shall be erected by any suitable method in the sequence best adapted to the equipment, workers' experience and site conditions which will not overstress structure members.

When handling assembled portions of the structure, spreader bars or other devices with proper points of attachment shall be used to avoid distorting or overstressing members and to maintain the true geometric shape of the section.
Adequate tag lines shall be used to ensure that no section of the tower being lifted will drag on the ground or against any section of the tower already erected.

Temporary guying may be required when erecting a structure in sections. Any temporary guying system shall be checked to ensure that the structure section is stable before workers are allowed to work on the section.

Structures shall be completely erected, correctly oriented, with all members in place, all bolts installed and properly tightened, and the entire structure checked in accordance with the specifications prior to the installation of insulators, conductors and shield wires.
When erecting structure members or sections in the vicinity of energized lines, care shall be taken to ground these members or sections before any workers come in contact with them.

The use of a crane erection is generally an efficient method of erecting latticed steel structures. With ground pre-assembly of sections, the time spent in final erection can be greatly reduced.

Cranes with telescoping booms can be more efficient than rigid boom cranes in rough terrain. Considerable productivity can be lost in the process of assembly and disassembly of rigid boom cranes. In addition, continuous handling of boom sections can lead to boom damage. Preplanning of the crane location at the structure site allows for any necessary grading work (building of ramps, soil stabilization etc.) to be accomplished during the foundation construction operations when suitable equipment is available at the site. Depending on soil conditions, additional bearing support may be required under outriggers, tracks, and tires. All soil shall be returned to a condition acceptable to the Project Manager after erection.

Gin Pole is a boom of steel or aluminum pipe, wood pole or latticed truss secured at its base and usually inclined at a slight angle to the vertical is also used for tower erection. Two wire-guys about 60º to 90º apart in the plan view are attached to the top of the gin pole to resist or support the load to be lifted. For safety, a third, and preferably a fourth guy, is installed in front to prevent the pole from falling over backward in the event of an unexpected impact or the sudden release of load.

(5) Correction of Misfabricated and Damaged Steel

All shop errors and damaged steel shall be reported to the Project Manager who will decide the manner in which corrections shall be made. All costs incurred due to punching, drilling or cutting shall be deemed to be included in the steel erection cost.

Pieces bent in handling may be used if they can be straightened to the satisfaction of the Project Manager, without structurally damaging the metal. If bent pieces cannot be satisfactorily repaired, they shall be replaced.

Field punching or drilling of holes and field clipping shall be done only with the approval of Project Manager, if the hole or clip was missed in fabrication of the member but was called for on the fabrication detail drawings. The edges of clipped angles, new or reamed holes or any member which has its coating scratched or damaged shall be repaired with a coating approved by the Project Manager. Members having mis-punched holes shall not be repaired by welding and shall be replaced with correctly fabricated members. If the field fabrication of a member is required, the bolt spacing and edge distances shall be in accordance with the fabrication detail drawings.

Reaming shall be done only with the approval of the Project Manager, and will be permitted, for the correction of undersized holes, for removing excessive galvanizing, and for holes off gauge line, to the extent that the connection cannot be made by loosening bolts in related connections. No hole shall be reamed more than one-eighth of its original diameter.
Reaming to remove fitting difficulty due to improperly set footings, to correct improper tower assembly and erection, that would distort holes or distort any member, or that would damage the galvanizing, is prohibited.

(6) Damage to Galvanizing

Small areas of galvanizing damaged by abrasion, in straightening bent pieces or by necessary clipping-in the field, shall be repaired by carefully cleaning the affected area and painting. The paint will be furnished by the Contractor.

Damaged area shall be wiped with clean rags saturated with Xylene or equivalent solvent, followed by wire brushing then recleaned with solvent to remove residue, and painted with one coat of "Galvanox", or approved equivalent.

Galvanizing damaged by drilling or punching shall be repaired by applying an Aluminum paste or zinc rich coating material to completely fill all voids between the bolt and the surfaces bared, or all exposed steel surfaces around the holes or on cuts on which such corrective work is permitted. The coating material shall be "Galvanox" or approved equivalent.

(7) Tower Signs and Aerial Markers

Tower signs (danger sign and number signs) shall normally be installed on the tower so that they will be readily visible when viewed in the direction of increasing tower numbers. However, if signs installed in the normal position will not be readily visible from a permanent access road, they shall be installed on the tower faces best exposed to view from the access roads. These signs shall be supplied by the Contractor, and before the manufacturing, a sample shall be submitted to the Project Manager for approval.

Aerial markers shall be installed on the upper side of bridge structure, as shown on the drawings. Two markers shall be installed on every tenth tower of the line; one marker faced back on line and the other ahead on line. These shall also be supplied by the Contractor.

(8) Anti-climbing Devices

An anti-climbing device will be installed on each tower as shown on the relevant drawings. The anti-climbing device normally will not be installed until all the tower and wire stringing work is completed.

The tower steel will be provided with holes for mounting the anti-climbing device brackets. The brackets shall be fabricated from mild steel and shall be galvanized in accordance with ASTM A153. The brackets along with barbed wire shall be supplied by the Contractor. Any holes required to be punched/drilled for installation of Anti-climbing Devices and applying of Galvanox, shall be carried out by the Contractor without any extra cost.

Anti-climbing device will be provided with an arrangement of barbed wire around the tower to prevent unauthorized person(s) from climbing the tower.

After erection, tower shall be cleaned of any foreign matter.

(9) Supporting Device for Joint Boxes of OPGW

Supporting device for joint boxes of OPGW to be designed, manufactured and supplied by OPGW manufacturer will be installed on the towers where joint boxes are required to be installed. Joint boxes will be installed on the tower on completion or just before completion of each OPGW reels of about 3.2 km length or wherever particularly required. The holes required to be drilled in the tower braces for installation of these supporting devices including provision and applying of Galvanox at the holes drilled shall be responsibility and to the cost of the Contractor.

(10) Welding of Nuts & Bolts

All nut & bolt connections of all types of towers shall be welded according to drawing No. 3206/169/TD/01F202, up to 8.0 m height from the top of chimney.

9.6. Installation of Insulators and Hardware

Insulators and insulator hardware shall be assembled and installed as shown on the drawings and in accordance with the recommendations of the manufacturers.

No insulator with chips or cracks in the porcelain or defects in the fittings shall be installed.

Uncrated or otherwise unsupported strings of insulators shall not be picked up or suspended except by the upper units of the string. All cotter pins installed by the Manufacturer shall be checked.

All insulators shall be cleaned with a clean cloth when installed. The porcelain shall be bright and all other parts free from dirt. Only clean rags free from any abrasive material shall be used for cleaning insulators.

Wire brushes shall not be used for the cleaning of any parts, metal or otherwise. The use of solvents will not be permitted.

Each completed suspension assembly shall be adjusted to hang in a vertical plane through the axis of the tower. Where it would be possible, nuts, locknuts and cotter pins shall be placed to face the tower body.

Workmen shall not climb on insulators during stringing operations or at any other time.

When raising conductor strain assemblies, the insulators shall be kept under tension to avoid possibility of those being damaged due to excessive bending.

9.7 Stringing Conductors, Overhead EHS Shield Wire and OPGW

(1) General

The conductor, overhead shield wire and OPGW shall be installed as shown on the drawings and as specified herein.

(2) Safety Grounding

It shall be the Contractor's responsibility to take adequate safety precautions to protect his employees and others from the potential voltage build-up during construction. The voltage build-up may be comparatively small during normal operations, but could be lethal during switching and ground fault conditions on the energized parallel line. The following minimum safety and grounding procedures shall be followed by the Contractor during stringing operations in the Sections with parallel existing high voltage lines.

Temporary electrical grounds shall be placed at both ends of the section requiring special safety precautions and at intervals along the line which is under construction. The grounding sets installed at both ends of the section of line shall remain in place until the completion of the work and shall be removed as the last phase of cleanup. Hot stick shall be used for installing and removing the grounding sets.

All temporary grounds furnished and installed for protection shall be clearly visible for inspection and shall be flagged by use of a red cloth placed at the point of grounding. All grounds, except

those placed at both ends of the section, and red flags shall be removed when they are no longer needed for protection.

All pulling and tensioning equipment shall be bonded and effectively grounded with approved-type driven grounds securely attached to the equipment. At least two driven grounds shall be used at both the pulling and tensioning set up. All conductive parts of the tensioning set up and equipment shall be operated from grounded or insulated platform provided with barricades or insulated walkways.

Running grounds shall be installed within 6 meters of the tensioning set up to constantly ground each sub-conductor, overhead shield wire and OPGW. At the pulling set up grounding shall be achieved by the use of block grounds connected to the adjacent tower by approved type ground leads bonded to the tower with approved type clamps. These connections shall be removed by the use of a hot-stick.

An approved-type driven ground shall be located at each side and within 3 meters of working areas where conductors or overhead shield wires or OPGW are being compressed to dead-end assemblies or spliced at ground level or jointed. The two ends to be spliced shall be effectively bonded together prior to and during splicing operation. Splicing and compression operations at dead-end assemblies shall be carried out on either an insulated platform or on a conductive metallic grounding mat roped off with an insulated walkway provided for access to the mat.

Installation and removal of temporary jumpers, at any time the conductor is not continuous, shall be performed by hot stick methods.

All conductors, overhead shield wires and OPGW shall be bonded to the tower with approved-type tower grounds at any isolated tower where it may be necessary to complete Work. Work on dead-end towers shall require grounding on both sides of the tower. Grounds may be removed when the Work is completed, providing the line is not left open circuited at an isolated tower at which work is being completed.

For all sections of the line under work, which are not in parallel with energized high voltage lines or otherwise requiring special safety precautions, only the provision of the grounding at the pulling and tensioning stations shall be required.

All provisions specified herein shall not prevent the Contractor from installing as many additional grounds as deemed necessary for the protection of workmen against static and accidental contacts with foreign circuits.

Clipping crews and all others working on the conductive pulling lines, isolated conductors, overhead shield wires or OPGW shall be protected by individual hot stick clamp type grounds installed at every work location.

(3) Approved Type Grounding Material

Approved type moving grounds shall be such as to exert constant pressure on the conductor, overhead shield wire or OPGW, and the contact rollers shall be with permanently lubricated-type bearings.

Approved-type driven ground rods shall be minimum of 16 mm diameter copper-weld or equivalent. Ground rods shall be driven into the ground a minimum of 2.5 meters.

Approved-type tower grounds shall be hot stick clamp grounds, bonded to the tower with a flexible ground lead.
Approved-type ground leads shall be at least 43 mm² cross-section copper or equivalent.

Approved-type insulated platforms shall be constructed of 65 mm nominal dimension lumber supported on 102 mm nominal dimension sills, or of materials of equivalent insulation.

At the tensioning set up, the insulated platform and rope barriers shall extend completely around the equipment set up in such a manner as to prevent any one standing on the ground from contacting any conductive part of the equipment.

(4) General Safety Precautions

Prior to initiation of the stringing in any section of the line the following shall be insured.

(a) The installation of all towers within the section of the line is satisfactorily completed.

(b) The stringing loads will not exceed the design loads for any of the towers.

(c) If any tower is to be subjected to loads exceeding the design loads, the Contractor shall provide temporary bracing for such tower, and the bracing is subject to approval by the Project Manager.

(d) The stringing and sagging operation is such that no sudden loads will be applied on the towers.

(5) Safety Precautions at Crossings

Wherever any power line, communication line, highway or railroad is to be crossed, the owners shall be notified 30 days in advance and all temporary changes shall be pre-arranged.

The Contractor shall not erect towers near, or string conductors or overhead shield wire or OPGW over energized power circuits until a Hot-Line Order is placed on the energized line.

Qualified personnel shall remain at the site of work while the Hot-Line Order is in effect and shall ascertain that all personnel are in the clear and properly notified before the Hot-Line Order is released.

All existing lines which are de-energized for crossing shall be short-circuited and grounded at each side of the crossing.

Guard structures shall be provided at all crossings, as required for the protection of the conductor, line, road, structure, or feature being crossed, and as required by the owner, or the Employer.

Guard structures shall be of sufficient strength and stability to withstand the stresses to which they may be subjected.
As soon as a guard structure has served its purpose, it shall be removed and all holes shall be backfilled.

(6) Atmospheric Adverse Conditions

All pulling and stringing operations shall cease when either wind velocities are such as to cause conductors to deflect more than 1.5 meters at mid-span from the normal no wind position or there is any indication of lightning activity in the area.

(7) Handling and Stringing of Conductors

The conductor will be furnished in matched sets of twelve reels and shall be strung by the controlled tension method. At no time will the conductor be allowed to contact the ground or any object which might cause damage to the conductor.

All reels shall be inspected in the field prior to installation. Reels showing signs of careless or unusually rough handling, such as split frames or crashed outer protective lagging shall be inspected carefully for conductor damage.

Preparatory to unreeling a conductor from the reel, the outer protective lagging shall be removed carefully, and all surfaces in contact with the running conductor shall be examined for protruding objects which might damage the conductor.

Care shall be taken to insure that no dirt is carried by the conductors from the reels. Reels shall be properly cleaned before starting stringing operation of any line section.

A spreader bar shall be used when lifting or lowering the reels. Full or partial reels shall not be dropped or rolled under any circumstances.

The four conductors in a bundle shall be strung simultaneously and shall hang in stringing blocks for the same period of time not exceeding 24 hours and, in exceptional cases, up to 48 hours before being sagged to the specified sag.

Four conductors shall start and end approximately at the same points of the line and stringing operations shall be planned to keep waste to a minimum. Lengths of conductor less than 100 meters are scrap lengths and shall not be spliced into the line without the approval of the Project Manager. Jumpers shall be cut only from scrap lengths unless otherwise permitted.

Stringing sheaves may be hung on the insulator strings or in straps of equal length attached to the structure arms with suitable hooks or clamps. The sheave shall support the conductors at the same elevation as when clipped in.

Stringing of conductors and temporary guying of conductors shall be done by methods that will prevent damage to the conductor and structures in any way. Temporary guying/dead ending to tower footings will not be permitted. Where temporary dead end is required, the conductors shall be attached to suitable temporary anchors.

The general requirements for installation of the temporary anchors are as follows:

The angle formed by conductors/EHS shield wire/OPGW to the horizontal shall not exceed 15 degrees.

The anchors shall be aligned in the direction of stringing:

The anchors and their accessories shall withstand the maximum conductor tensions with a factor of safety of three.

Four sub-conductors of one phase shall be strung simultaneously by means of running board attached to a single pulling line with a swivel. Sub-conductors shall be connected to the running boards with a swivel connection and a stocking-type grip. The grips shall be secured to the conductor by means of a band installed around the tail end of the grip.

Following stringing, measures shall be taken to prevent the sub-conductors of the bundle from contacting each other. Before adjusting the sag of the conductors, sub-conductor slapping may be prevented by pulling each of them to a different sag which will separate them at least 153 mm vertically from either of the other sub-conductor at mid-span. After adjusting the sag, the following conditions will require sub-conductors tie-off: any time that sub-conductors slapping is noted, any time that prior to spacer installation the conductors are left unattended.

Two reel lengths of conductor may be pulled into the sheaves using only approved swivels and grips to make the connections between reel lengths. Double socking will be permitted, but permanent splices shall not be pulled through a sheave or bull-wheel.
All sheaves, swivels and grips shall be inspected daily for free and easy movements and to assure that such may be safely used. Sheaves carrying pulling lines shall not be used for conductors.

The conductor shall be kept clean by removing grease, dust or any other contamination. Cleaning shall be done immediately after the conductors leave the tensioning device. The method of cleaning shall be wiping with a clean cloth saturated with proper cleaning agent. When it is necessary to slack the conductor at any time during the stringing operation, it shall be done with the approval of the Project Manager. Rigid plank guard or lagging, or a combination of both shall be used to prevent damage. Lagging shall consist of nonmetallic material which will not damage the conductor and shall be rigid so that it will not be displaced by the motion of the conductor. It shall be free of any material, which can be transferred to the conductor.

Sections of the conductor damaged by application of gripping attachments or any other way during stringing shall be removed before the conductor is sagged in place.

The conductor repairs shall be done as outlined in Clause 9.7(11) (b) of the Technical Provisions.

All stringing operation must be conducted so that at no time will any suspension structure be subjected to longitudinal loads and at no time will any tension structure except dead end structure be subjected to excessive unbalanced loads resulting from longitudinal loads on opposing faces. At no time shall any structure be subjected to torsion. The vertical angles of pulling lines shall be such as to minimize the vertical loading on towers. The attachment of temporary guys and stringing equipment on towers shall be done only with approval of the Project Manager.

The conductor and shield wire reels, tensioners, and pulling machines shall be located as near to mid-span as possible but in no case shall the slope of the OPGW or shield wire or conductor between any machine and the stringing block or any anchor lead be steeper than three horizontal to one vertical (15°-20° to the horizontal).

The tension in the conductor during stringing shall be maintained as constant as practicable. The sag in each conductor must be maintained at least 20 percent greater than the sagging value specified in sag charts and the maximum pulling tension shall never exceed the sagging tensions.

If the conductor is left unattended, during stringing operations, it shall be freely suspended between stringing sheaves so as to provide a safe clear distance over ground or obstructions.

The minimum tension shall be such as to maintain the conductors at a minimum distance of 3 meters above ground or any obstacle.

When there is possibility of conductor being damaged due to wind or other conditions they shall immediately be fully tensioned. It is recommended that variations in stringing tensions be as small as possible and the tension shall be near the maximum permitted. Immediately after completing stringing of a section of the line, the tensions shall be increased to the maximum permitted stringing values.

The spinning of the conductors and shield wires shall be prevented during stringing. Unreeling of the conductors shall be closely watched at all times in order to detect any damage or flaw in the conductor.

(8) Handling and Stringing of Shield wire and OPGW

One 9.15 mm dia.7 strand extra high strength (EHS) galvanized steel overhead shield wire and one 12mm OPGW shall be strung for the entire length of line.

The specifications used for handling and stringing the OPGW & overhead shield wires shall be the same as for the conductors.

(9) Conductor Sagging

After being pulled into the sheaves all sub-conductors in a sag section shall be sagged within 24 hours.

The conductors shall be sagged in accordance with sag charts, furnished by the Contractor. The exact value of sag for a given span length at a given temperature can be ascertained from the appropriate table or by linear interpolation of data.

Conductor sagging temperature shall be measured by an accurate thermometer. A length of core shall be pulled from a 0.5 meter length of the conductor sufficient for thermometer to be inserted into the space vacated by the core.

The length of conductor shall be placed in the full sun at least 4 meters above the ground for a minimum period of 15 minutes. A thermometer in a container which stimulates the effect of the conductor may also be used.

The length of conductor sagged in one operation shall be limited to the length that can be sagged satisfactorily, usually 3,000 meters to 6,000 meters.

Temporary snubs shall be used between a section previously sagged and clipped in and the section being sagged. Dead ending or snubbing will not be permitted on any tower except dead end towers at the normal point of attachment.

When conductors are sagged a mark shall be placed on each conductor at the last structure in each pull. The location of this mark shall be checked after the succeeding sag has been made to ascertain whether or not the back spans are still sagged properly. The wire grips may be removed only after the next section of the line has been sagged.

When sagging conductor shall have lengths of more than four spans, the sag shall be checked near each end span and at or near the middle span of the length being sagged. The length of the spans used for checking sag shall be as nearly equal to the ruling span as practicable.

The sag of each span more than 600 meters in length shall be checked in addition to above. Sag at sharp vertical angles and horizontal angles of 10 or more degrees shall also be checked on both sides of the angle.

The sags shall be determined by means of a transit or other approved methods. At least one person shall be provided to measure the correct sag for pulls up to five spans, two persons for six to ten spans and three persons for eleven spans or more.

The total number of spans to be checked shall be not less than two in a four-span section, three for a section up to two kilometers and in proportion for a longer section.

In the quad conductor bundle the sag of the two upper sub-conductors shall be the same. The lower sub-conductors shall be sagged from 30 to 60 mm more than the upper sub-conductors.

A tolerance of plus or minus 10 mm of sag per 30 meter of horizontal span length, but not to exceed 150 mm in any one span, will be permitted, provided: 1) that: (1) upper sub-conductors in the span assume the same sag; (2) the necessary ground clearance is obtained; (3) the conductor tension between successive sagging operations is equalized so that the suspension insulator assemblies will assume the proper position when the conductor is clipped in; (4) the sag in the lower sub-conductor of the bundle is 30 to 60 mm more than the sag in the upper sub-conductors.

Log books shall be maintained to record all conductor installation data and chronological progress.

The temperature, spans, tower, general weather, wind velocity and direction, sags, tensions, and drawing references shall be recorded for each section of conductor as it is being installed, tensioned and sagged. When possible, sagging operations shall be scheduled when wind velocity is at or near zero.

Radio or telephone communication shall be used to relay information and instructions between the conductor payout station, intermediate check points, mobile stations and the pulling stations at all times during stringing operations. A failure of communication requires immediate cessation of the conductor pulling operation.

(10) Conductor Clipping-in

After being sagged, the conductor shall be allowed to hang in the stringing blocks for not less than 2 hours before clipping-in is commenced, to permit the conductor tension to equalize.

Plumb marks shall be made on the conductors in the vertical plane through the centerline of the tower prior to clipping-in. Only paint, crayon, or wax pencil shall be used for marks on conductors.

All conductors marking in the section being sagged shall be accomplished while the conductors are in the sheaves and before clipping-in or dead ending is begun.

The total time during which the conductor is allowed to remain in the stringing blocks before being clipped-in shall not exceed 72 hours.
Torque wrenches shall be used to tighten all nuts on clamps. The torque applied shall be in conformance with the recommendation of the manufacturer.

Yoke plates for V-Vee string insulators shall be installed as shown on the drawings and shall hang at 90 degrees to the conductor axis within a tolerance of plus or minus 2.5 cm.

Well-padded pull-lift hooks or other approved methods shall be used for handling conductors during the clipping-in operation.

(11) Installation of Conductor, Shield wire and OPGW Accessories

(a) Splices and Dead Ends

All splices shall be of the compression type.

All splices shall be made at least 15 meters away from structures and no splices shall be made in dead end spans or spans greater than 600 meters or spans crossing over the highways, railroads, major canals, rivers and transmission lines of voltages greater than 33 kV unless approved by the Project Manager.

As a rule not more than one joint or splice should be made in any one conductor in any one span. However, in exceptional cases, as in the repair of damaged conductors, or when necessary owing to stringing limitations two splices will be allowed.

The splices and compression dead ends shall be installed in accordance with the recommendations of the Manufacturer of the accessories.

Conductor shall be laid out straight for a distance of 15 meters and straightened at the end before preparation of the ends for splicing or dead-ending. The ends of the conductor shall be thoroughly cleaned immediately prior to compressing. After the compression has been completed, all corners, sharp projections and indentations shall be carefully rounded and smoothed, and tape, tape residue, and filler paste shall be removed from splice and conductor. If the completed splice requires straightening, it shall be straightened on a wood block by use of a wooden maul.

Splicing, dead-ending and repair of damaged conductor shall be done in the presence of nominated person of the Project Manager.

If the completed splice or dead-end is not satisfactory, in the opinion of the Project Manager or his nominated person, it shall be removed and a new splice or dead-end shall be properly installed.

The Contractor's inspector shall stamp his own initials on the aluminum sleeve of each compression joint and compression dead end completed under his supervision.

(b) Repair of Conductors and Shield wire

Damage is any deformity on the surface of the conductor or shield wire which can be detected by eye or by feel and shall be repaired by whichever the following methods is appropriate:

(i) Repair by manual polishing
(ii) Installation of repair sleeves over the damaged part
(iii) Installation of compression joints
(iv) Replacement with new conductor or shield wire

Slight damage such as superficial scratches or abrasions, which are not deeper than one-third the strand diameter, can be repaired by dressing with a fine emery cloth.

Severe cuts which cannot be repaired with emery cloth due to their depth or extension, and cause increase in the resistance of the external layers shall be repaired by use of repair sleeves, provided that not more than one-third of the outer layer is cut or damaged over a length of less than 10 centimeters.

Damages of extent greater than described in above paragraphs shall be repaired by replacing the damaged length of the cable using compression joints.

When there is repeated damage in the same span or in consecutive spans, the Project Manager or his nominated person may require all conductors in these spans to be replaced.

In the case when signs of corrosion are detected during the stringing operation, the reels containing corroded conductors shall be set aside, the operation shall be interrupted and the Project Manager or his nominated person shall be informed immediately.

Whenever a repair sleeve is installed, a rope cage shall be placed on the sleeve to ensure that there will be no damage from sub-conductor slapping prior to installation of the spacer-dampers.

For the repair of the shield wires, only compression joints shall be used.

(c) Jumper Connections

Where compression type dead-ends are used, the jumper shall be one continuous piece, and compression-type jumper terminals bolted to the compression-type dead-ends shall be used.
At overhead shield wire dead-ends with bolted strain clamps and OPGW with thimble clevis and grip dead end, sufficient length of wire to form the jumper loop to clear the tower shall be allowed. Parallel groove bolted clamps will be used for connection.

(12) OPGW Jointing/Splicing and Installation of OPGW Joint Boxes

OPGW jointing/splicing and joint boxes installation will be carried out by the Contractor.

However, following general instructions should be followed:

No mid span joint shall be allowed in the OPGW. All joints shall be performed in a joint box located on the tower just above the location of anti-climbing device. OPGW jointing (splicing) and joint boxes installation including supporting device for joint boxes shall be executed by the Contractor. OPGW shall be dropped to the joint boxes along with tower braces by installing OPGW attaching clamps at about one meter interval.

9.8 Installation of Dampers

(1) Spacer Dampers

The four sub-conductors of each phase shall be secured to each other by means of spacer dampers installed strictly in accordance with data furnished.

The intervals, measured along the length of the conductors at which spacers are installed shall be as shown on the data sheets with tolerances not more than plus/minus 1.0 meter.

Spacer-dampers shall be installed in a span only after that span has been dead-ended and clipped-in. The installation of spacer dampers shall be completed in each section within 72 hours after the sub-conductors have been sagged.

The clamps shall be properly aligned on the conductors. Distorted shape of the spacer dampers will be considered an unsatisfactory installation and shall be corrected or the spacer damper replaced.

The bolts of the breakaway type shall be tightened until the outer head breaks off.

Spacer dampers shall be installed with the bolt heads in a downward position for viewing from the ground.

(2) Vibration Dampers

Vibration dampers shall be attached to the overhead shield wires and OPGW at the ends of all spans and as designated on the data sheets. The vibration dampers shall be fastened securely to overhead shield wires & OPGW so that they will hang in vertical planes. Spacing of dampers shall

be in accordance with the Drawings. Breakaway type bolts shall be tightened until the outer head breaks off.

10 Pre Commissioning and Commissioning Tests

10.1 Pre Commissioning Tests

(a) Mechanical Tests

1. For steel structures, ensure that structure type is as per specification/drawings/structure list.
2. Check galvanizing and thickness (rust is not acceptable).
3. Check bolt types and tightness (torque wrench method).
4. Ensure anti-climbing guards are correctly installed.
5. Check step bolt tightness.
6. For porcelain insulators, check insulators for chips, cracks, etc. Ensure correct number of insulators have been installed in each string. Ensure that cotter keys have been properly installed.
7. Make sure that insulators are clean and line is safe to be energized.
8. Check that all line hardware and fittings (insulators, corona rings, vibration dampers, spacer dampers, conductor clamps, armor rods, etc) is installed correctly and in correct locations as per specifications and drawings.
9. Check that all splices are correct and installed in correct span locations.
10. Check that all jumpers are installed correctly. Ensure correct clearances between jumper and structure as well as with other phases at acute angle locations.
11. Ensure there is no twist in the insulator string.
12. Check that overhead shield wire and OPGW are grounded to towers as specified.
13. Ensure that sags for phase and overhead ground conductors are even and according to the specification.
14. Check that ground clearances are as per specification.
15. Check circuit/phase identification plates, structure number plates, danger sign plates, etc have been correctly installed at each structure and aerial markers at the required structures.
16. Check line/phase correctly transposed at the specified locations and clearance between the phases is as per specification.

(b) Electrical Tests

1. Check tower footing resistance as per specification.
2. Verification of physical phase arrangement.

3. Perform sequence impedance test (both zero and positive sequence).
4. Perform continuity and insulation test of complete transmission line with appropriate test equipment.

5. Tests on OPGW:
   - OTDR test of each fiber
   - Attenuation test
   - Continuity test

10.2 Commissioning Tests

1. Perform phase sequence/rotation check.

2. Inspection of Facilities for any visual/audible abnormality.

INSULATOR PERFORMANCE DATA
FOR
16,300 kg E&M STRENGTH

Contamination Level ESDD-mg/cm²	Single String		200 Strings in Parallel			
			Vertical String		V-String	
	FOV_5 -kV/Unit	FOV_{50} - kV/Unit	FOV_5 -kV/Unit	FOV_{50} - kV/Unit	FOV_5 - kV/Unit	FOV_{50} - kV/Unit
0.06						
0.12						
0.50						
0.75						
1.00						

1. ESDD = Equivalent Salt Deposit Density

2. FOV_5 = 5% probability flashover voltage (withstand)
0.835 CFO (For normal distribution and 10 percent deviation)

3. FOV_{50} = 50% probability of flashover (critical flashover voltage = CFO)

4. For 200 Strings in parallel $\dfrac{FOV_5}{CFO(\text{Single String})}$ = ...

and $\dfrac{FOV_{50}}{CFO(\text{Single String})}$ = 0.725 (see Transmission Line Reference Book 345kV and above - EPRI - 1982)

4. FOV (V-String) = 1.105 fov (Vertical String)

TESTS

1. The performance of these insulators is based on the 5% flashover probability (withstand voltage) for 200 multiple strings.

2. FOV (5% or 50%) = kV (5% or 50%)/Unit x No. of insulators for string

NOTE: For contamination test following contaminants simulating the site condition were used:

ESDD (mg/cm²)	Percentage Constitution of Salt Contaminants	Tonoko deposit density (mg/cm²)

INSULATOR PERFORMANCE DATA
FOR
8,200 kg E&M STRENGTH

Contamination Level ESDD-mg/cm²	Single String		200 Strings in Parallel			
			Vertical String		V-String	
	FOV_5 -kV/Unit	FOV_{50} - kV/Unit	FOV_5 -kV/Unit	FOV_{50} - kV/Unit	FOV_5 - kV/Unit	FOV_{50} - kV/Unit
0.06						
0.12						
0.50						
0.75						
1.00						

1. ESDD = Equivalent Salt Deposit Density

2. FOV_5 = 5% probability flashover voltage (withstand)
   0.835 CFO (For normal distribution and 10 percent deviation)

3. FOV_{50} = 50% probability of flashover (critical flashover voltage = CFO)

4. For 200 Strings in parallel $\dfrac{FOV_5}{CFO(\text{Single String})}$ = ...

   and $\dfrac{FOV_{50}}{CFO(\text{Single String})}$ = 0.725 (see Transmission Line Reference Book 345kV and above - EPRI - 1982)

4. FOV (V-String) = 1.105 fov (Vertical String)

TESTS

1. The performance of these insulators is based on the 5% flashover probability (withstand voltage) for 200 multiple strings.

2. FOV (5% or 50%) = kV (5% or 50%)/Unit x No. of insulators for string

NOTE: For contamination test following contaminants simulating the site condition were used:

ESDD (mg/cm²)	Percentage Constitution of Salt Contaminants	Tonoko deposit density (mg/cm²)