

Section-02
Specification for Fiber Optic cabling & associated items

Table of Content

| | | |
|------------------|--|-----------|
| 2.1 | Fiber Optic Cabling..... | 3 |
| 2.1.1 | Required Optical Fiber Characteristics | 3 |
| 2.1.1.1 | Physical Characteristic..... | 3 |
| 2.1.1.2 | Attenuation..... | 3 |
| 2.1.2 | Fiber Optic Cable Construction | 4 |
| 2.1.2.1 | Optical Fiber Cable Lengths..... | 5 |
| 2.1.2.2 | Optical Fiber Identification | 5 |
| 2.1.2.3 | Optical Fiber Strain& Sag-Tension chart..... | 5 |
| 2.1.2.4 | Cable Materials..... | 6 |
| 2.1.2.4.1 | Filling Materials | 7 |
| 2.1.2.4.2 | Metallic Members..... | 7 |
| 2.1.2.5 | Marking, Packaging and Shipping | 7 |
| 2.1.3 | Optical Ground Wire (OPGW) construction | 8 |
| 2.1.3.1 | OPGW design | 8 |
| 2.1.3.2 | OPGW Parameters to be considered for different line voltage and wind zones..... | 10 |
| 2.1.3.2 | Basic Construction..... | 10 |
| 2.1.3.3 | Breaking Strength | 10 |
| 2.1.3.4 | Electrical and Mechanical Requirements..... | 11 |
| | Table 2.2(a)..... | 11 |

| | | |
|---------|---|----|
| 2.1.1 | Installation Hardware..... | 11 |
| 2.1.2 | Fiber Optic Splice Enclosures (Joint Box) | 15 |
| 2.1.2.1 | Optical Fiber Splices..... | 15 |
| 2.1.3 | Fiber Optic Approach Cables..... | 16 |
| 2.1.3.1 | Basic Construction..... | 16 |
| 2.1.3.2 | Jacket Construction & Material | 16 |
| 2.1.3.3 | Optical, Electrical and Mechanical Requirements | 16 |
| 2.1.3.4 | Fiber Optic Approach Cable Installation hardware..... | 16 |
| 2.1.4 | Fiber Optic Distribution Panel..... | 17 |
| 2.1.5 | Optical Fiber Connectors | 18 |

Section-02

Specification for OPGW cabling and associated hardware & fittings

This section of the technical specification describes the functional and technical specifications of Fiber Optic cabling and associated items.

2.1 Fiber Optic Cabling

In this section of the technical specification, the functional & technical specifications of OPGW cable, Fiber Optic Approach Cable, Joint Box and associated hardware & fittings for the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade optical fiber is specified. Bidders should furnish with their bids detailed descriptions of the fibers & cable(s) proposed.

All optical fiber cabling including fiber itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years.

2.1.1 Required Optical Fiber Characteristics

The optical fiber to be provided should have following characteristics:

2.1.1.1 Physical Characteristic

Dual-Window Single mode (DWSM), G.652D optical fibers shall be provided in the fiber optic cables. DWSM optical fibers shall meet the requirements defined in Table 2-1(a).

2.1.1.2 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fiber shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fiber attenuation characteristics specified in table 2-1 (a) shall be “guaranteed” fiber attenuation of any & every fiber reel.

Table 2-1(a)
DWSM Optical Fiber Characteristics

| | |
|---|---|
| Fiber Description: | Dual-Window Single-Mode |
| Mode Field Diameter @ 1310nm: | 8.6 to 9.5 μm ($\pm 0.6\mu\text{m}$) |
| Cladding Diameter: | 125.0 $\mu\text{m} \pm 1 \mu\text{m}$ |
| Mode field concentricity error | $\leq 0.6 \mu\text{m}$ |
| Cladding non-circularity | $\leq 1 \%$ |
| Cable Cut-off Wavelength λ_c | $\leq 1260 \text{ nm}$ |
| 1550 nm loss performance | As per G.652 D |
| Proof Test Level | $\geq 0.69 \text{ Gpa}$ |
| Attenuation Coefficient: | @ 1310 nm $\leq 0.35 \text{ dB / km}$ @ 1550 nm $\leq 0.21 \text{ dB / km}$ |
| Chromatic Dispersion; Maximum: | 18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm |
| Zero Dispersion Wavelength: Zero Dispersion Slope: | 1300 to 1324nm 0.092 ps/(nm ² xkm) maximum |
| Polarization mode dispersion coefficient | $\leq 0.2 \text{ ps/km}^{1/2}$ |
| Temperature Dependence: | Induced attenuation $\leq 0.05 \text{ dB}$ (-60°C to +85°C) |
| Bend Performance: | @ 1310 nm (75 \pm 2 mm dia Mandrel), 100 turns; Attenuation Rise $\leq 0.05 \text{ dB/km}$ @ 1550 nm (75 \pm 2 mm dia Mandrel), 100 turns; Attenuation Rise $\leq 0.10 \text{ dB/km}$ @ 1550 nm (32 \pm 0.5 mm dia Mandrel, 1 turn; Attenuation Rise $\leq 0.50 \text{ dB/km}$ |

2.1.2 Fiber Optic Cable Construction

The OPGW (Optical Ground Wire) cable is to be installed on the transmission lines in place of Earth wire for 765/400/220/132kV lines. The design of the cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall meet the design parameters specified in Technical Specifications.

2.1.2.1 Optical Fiber Cable Lengths

The estimated optical fiber cable length for F.O. link(s) are provided in BPS considering 5% for plain and 7% for hilly areas over and above route length of the transmission line to take care of sag, splicing length, loop length, tower height/down lead length, wastages, etc.

The Contractor shall supply the OPGW cable in standard drum length mostly in 5 km (with $\pm 5\%$ tolerance) for plain terrain & 3 km (with $\pm 5\%$ tolerance) for hilly terrain.

BoQ of OPGW & its associated items (i.e., Hardware fittings, vibration dampers, Joint box, Approach cable & its installation hardware, FODP etc.) along with mandatory spares shall be released by Project Manager for purpose of supply in consultation with contracting agency.

2.1.2.2 Optical Fiber Identification

Individual optical fibers within a fiber unit and fiber units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibers shall be integrated into the fiber coating and shall be homogenous. The colour shall not bleed from one fiber to another and shall not fade during fiber preparation for termination or splicing.

Each cable shall have traceability of each fiber back to the original fiber manufacturer's fiber number and parameters of the fiber. If more than the specified number of fibers is included in any cable, the spare fibers shall be tested by the cable manufacturer and any defective fibers shall be suitably bundled, tagged and identified at the factory by the vendor.

2.1.2.3 Optical Fiber Strain& Sag-Tension chart

The OPGW cable, the optical fibers shall experience no strain under all loading conditions defined in IS 802. Zero fiber strain condition shall apply even after a 25-year cable creep. For the purpose of this specification, the following definitions shall apply:

- Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is *no fiber strain*.
- The no fiber strain condition is defined as fiber strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry.
- The Cable strain margin is defined as the maximum cable strain at which there is no fiber strain.
- The cable Maximum Allowable Tension (MAT) is defined as the maximum tension

experienced by the Cable under the worst-case loading condition.

- The cable max strain is defined as the maximum strain experienced by the Cable under the worst-case loading condition.
- The cable Everyday Tension (EDT) is defined as the maximum cable tension on any span under normal conditions.
- The Ultimate Tensile Strength (UTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.45 times the UTS.
- The 25-year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25-year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted under various conditions mentioned below:

1. 53° C , no wind and no ice
2. 32° C, no wind and no ice
3. 0°C, no wind and no ice
4. 32° C, full wind and no ice
5. 32° C, 75% full wind and no ice
6. 0° C, 2/3rd / 36% of full wind (IS 802:1977 / 1995)

The above cases shall be considered for the spans from 100 m to 600 m or higher span length in the range of 50 m spans. Max. Vertical sag, max. tension and max sag at 0° C & no wind shall be considered in line with the design parameter of transmission line. The full wind load shall be considered as the design wind load for all the specified transmission lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the transmission lines.

2.1.2.4 Cable Materials

The materials used for optical fiber cable construction, shall meet the following requirements:

2.1.2.4.1 Filling Materials

The interstices of the fiber optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fiber optic unit or along the fiber optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-hygrosopic, electrically nonconductive, and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fiber coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

2.1.2.4.2 Metallic Members

When the fiber optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

2.1.2.5 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fiber optic cable.

- (a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser's destination address, cable part number and specification as to the type of cable, length, number of fibers, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.
- (b) Cable Drums and Packing: The OPGW shall be supplied in returnable steel drums for main supply & non-returnable steel drums for spare supply. These painted steel drums shall be corrosion free, shall be of adequate strength, and constructed to protect the OPGW against all damage and displacement during transit, storage, subsequent handling & stringing operations in the field. The supplier shall be responsible for any loss or damage during transportation, handling, and storage due to improper packing. The ownership of the empty OPGW drums shall lie with the OPGW supplier who shall ultimately take back the empty OPGW drums Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on standard drum length.

2.1.3 Optical Ground Wire (OPGW) construction

OPGW cable construction shall comply with IEEE-1138, 2021. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fiber integrity and optical transmission characteristics are suitable for the intended purpose.

2.1.3.1 OPGW design

Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fiber(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fiber coating and buffer shall be strippable for splicing and termination. Each fiber unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel. The individually coated optical fiber(s) shall be provided directly in stainless steel tube in case stainless steel tube design.

(a) Central Aluminium tube type

The composite fiber optic overhead ground wire shall be made up of multiple buffer tubes embedded in a watertight aluminum/aluminum alloy protective central fiber optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibers. All fibers in single buffer tube or directly in central fiber optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fiber.

(b) Central Stainless Steel tube type

The composite fiber optic overhead ground wire shall consist of a central fiber optic unit made up of stainless steel with aluminum coating/tube surrounded by concentric-lay stranded metallic wires in single or multiple layers. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fiber.

Central Fiber Optic Unit

(a) Central Aluminum tube type

The central fiber optic unit shall be designed to house and protect multiple buffered optical fiber units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fiber optic unit 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 current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials for stranded wires and tubes are not allowed. Central fiber optic unit may be of aluminum / aluminum alloy tube. There shall be no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc. with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

(b) Central Stainless Steel tube type

The central fiber optic unit shall be designed to house and protect optical fibers provided in single buffered tube of stainless-steel tube from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fiber optic unit 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 current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials for stranded wires and tubes are not allowed. Central fiber optic unit shall be of stainless-steel tube with aluminum protective coating or stainless-steel tube with Al protecting outer tube. In case of aluminum protective coating, the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc. with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

2.1.3.2 OPGW Parameters to be considered for different line voltage and wind zones

| Transmission Line Voltage and wind zone | OPGW Cable Parameters | | | | | | |
|--|-----------------------|-------------|-------------|------------|---------------------------------|--|---------------------------------|
| | UTS (Kg) | Area (sqmm) | Wt. (Kg/m) | Dia. (mm) | Modulus of Elasticity (Kg/sqmm) | Coeff. Of linear Expansion (per deg C) | Central Fiber optic unit design |
| 765 kV D/C WZ 1-4 400kV M/C WZ 1-5 400kV D/C WZ 1-5 | 9350±150 | 56.5± 2.5 | 0.45±0.01 | 12 ± 0.2 | 14290±110 | 0.0000138 ± 0.0000003 | Al tube |
| 765 kV WZ 5 | 9098±150 | 57.5±2.5 | 0.49 ± 0.01 | 11.5 ± 0.2 | 14114 ± 110 | 0.0000136 ± 0.0000003 | Stainless Steel Tube |
| 220 kV D/C WZ 1-4 132kV D/C WZ 1-5 | 7376±50 | 51±2 | 0.355±.01 | 11.4±.02 | 12344±100 | 0.0000149 ± 0.0000003 | Al Tube |
| River Crossing Section | 20059±100 | 118±5 | 0.884±0.01 | 14.7±0.2 | 16355±100 | 0.0000127 ± 0.0000003 | Stainless Steel Tube |

For Al tube & Stainless steel tube design details refer clause 2.1.3.1 above.

2.1.3.2 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 2.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

2.1.3.3 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fiber optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

2.1.3.4 Electrical and Mechanical Requirements

Table 2-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. The OPGW mechanical & electrical characteristics shall be similar to the electrical & mechanical characteristics of the earth wire being replaced such that there is no or minimal consequential increase in stresses on towers. The existing earth wire parameters are listed in appendices.

The Contractor shall submit sag-tension charts as per clause 2.1.2.3

Table 2.2(a)

OPGW Electrical and Mechanical Requirements

| | | |
|-----|--------------------------|---|
| (1) | Everyday Tension | $\leq 20\%$ of UTS of OPGW |
| (2) | D.C. Resistance at 20°C: | < 1.0 ohm/Km |
| (3) | Short Circuit Current | ≥ 6.32 kA for 1.0 second (for 220 kV & above lines) ≥ 5.6 kA for 1.0 second (for 132 KV & 66KV lines) Short Circuit shall be applicable as per the Voltage level of the lines |

2.1.4 Installation Hardware

Installation Hardware includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The estimated quantity for hardware fittings are provided in BPS. Initially 70% of total hardware shall be supplied based on quantities in BPS or as directed by Project Manager and balance 30% shall be supplied as directed by Project Manager.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 &

lower drawings. All component reference numbers, dimensions and tolerances, bolt

tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

- (a) Suspension Assemblies: Preformed armour grip suspension clamps and aluminum alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25kN (70% OF UTS of OPGW). The suspension clamps slippage shall occur between 12kN and 17 kN as measured. For river crossing and special transmission lines (where heavier earth wire used e.g. 7/4.5) OPGW installation hardware design slippage shall occur between 9% and 14% of UTS of OPGW.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the center point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

- (b) Dead End Clamp Assemblies: All dead-end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the Ultimate tensile strength of the OPGW.
- (c) Clamp Assembly Earthing Wire: Earthing wire consisting of a 1500 mm length of aluminum or aluminum alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead-end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.
- (d) Structure Attachment Clamp Assemblies: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.
- (e) Tension Fitting for Suspension Tower: The OPGW cable sections shall also be

terminated & spliced on suspension towers as per requirement. For this, a special fitting namely Yoke plate along with tension fittings shall be provided for termination/jointing of OPGW on Suspension tower. A typical drawing of suspension fitting where cable may be terminated on suspension tower is given in Appendices.

- (f) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration dampers shall be as per manufacturer recommendation and damper placement chart.

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

The messenger cable shall be made of high strength galvanized steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanized in accordance with the recommendations of IS: 4826 for heavily coated wires.

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

The damper clamp shall be casted over the messenger cable and offer sufficient

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

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

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

| Sl. No. | Description | Technical Particulars |
|---------|---|---|
| 1 | Span Length in meters (i) Ruling design span: (ii) Maximum span: (iii) Minimum Span: | 400 meters 1100 meters 100 meters |
| 2 | Configuration: | As per Specifications |
| 3 | Tensile load in each: | As per sag tension calculations |
| 4 | Armour rods used: | Standard preformed armour rods/ AGS |
| 5 | Maximum permissible dynamic strain: | +/- 150 micro strains |

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Contractor. Placement charts should be duly supported with sample calculations and manufacturer recommendations.

The damper placement charts shall include the following.

- (1) Location of the dampers for various combinations of spans and line

tensions clearly indicating the number of dampers to be installed per OPGW cable per span.

- (2) Placement distances clearly identifying the extremities between which the distances are to be measured.
- (3) Placement recommendation depending upon type of suspension clamps (viz Free center type/ Armour grip type etc.)

2.1.5 Fiber Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fiber Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in a protective, moisture and dust free environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of the required number of optical fiber splices and equipped with sufficient number of splice trays for splicing all fibers in the cable. No more than 12 fibers shall be terminated in a single splice tray. A minimum number of 04 splice trays shall be provided in a Joint Box. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalized after Survey

2.1.5.1 Optical Fiber Splices

Splicing of the optical fiber cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fiber splicing shall comply with the following:

- (a) All fiber splices shall be accomplished through fusion splicing.
- (b) Each fiber splice shall be fitted with a splice protection sheath fitted over the final splice.
- (c) All splices and bare fiber shall be neatly installed in covered splice trays.
- (d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.
- (e) For splicing, fiber optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

2.1.6 Fiber Optic Approach Cables

For purposes of this specification, a fiber optic approach cable is defined as the Armoured underground fiber optic cable required to connect Overhead Fiber Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fiber cable on the power line and the Fiber Optic Distribution Panel (FODP) installed within the building. The estimated fiber optic approach cabling length requirements are indicated in the BoQ. Actual supply to be done as per directives of Project Manager.

2.1.6.1 Basic Construction

The cable shall be suitable for direct burial, lying in trenches, G.I. Pipes, PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

2.1.6.2 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering, and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

2.1.6.3 Optical, Electrical and Mechanical Requirements

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

2.1.6.4 Fiber Optic Approach Cable Installation hardware

At all locations, the approach cable shall be laid within G.I. pipe along with necessary accessories. The bend radius of fiber optic Approach cable during installation inside G.I. pipe must be within safe limits. Minimum technical specifications of G.I. pipe are brought out below:

| Minimum Technical Specification of GI Pipe for Approach Cabling | | | |
|---|---------|-----------------------|----------------------------|
| Sl. No | Item | Parameter | Range |
| 1 | GI Pipe | Material type | Galvanized Iron Round Tube |
| | | Nominal Bore Diameter | 32 mm |
| | | Wall thickness | 4 mm or better |

| | | | |
|----------|----------------------------|-----------------------------|---|
| | | Manufacturing Process | Electric Resistance Welded (ERW) |
| | | Conformity to specification | IS 1239 OR BS 1378 |
| | | Series | Heavy |
| | | Outer Diameter (Min.) | 42 mm or better |
| | | Outer Diameter (Max.) | 42.9 mm or better |
| | | Type | Screwed and socketed |
| | | Weight (KG/m) | 3.82 or better |
| | | Make | Jindal/Tata/Surya/ PrKTCL Approved make |
| 2 | GI Elbow | Material type | Galvanized Iron |
| | | Nominal Bore Diameter | 32 mm |
| | | Make | PrKTCL Approved make |
| | | Certification | NABL Test Certificate |
| 3 | GI Flexible Conduit | Material type | Galvanized Iron |
| | | Nominal Bore Diameter | 32 mm |
| | | Make | PrKTCL Approved make |
| | | Certification | NABL Test Certificate |

2.1.7 Fiber Optic Distribution Panel

At each location requiring the termination of at least one fiber within a cable, all fibers within that cable shall be connectorized and terminated in Fiber Optic Distribution Panels in a manner consistent with the following:

- (a) All fiber optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibers within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fiber optic couplings.
- (b) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fiber terminations. No more than 12 fibers shall be terminated in a single splice tray.

- (c) FODPs shall be supplied in suitable cabinets/racks with locking arrangements. The dimensions of FODP cabinet shall be minimum 2200mm x 600mm x 600mm (HxWxD) and shall meet or exceed ingress protection class IP55 specifications.
- (d) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs, and the Contractor shall ensure that all FODPs are properly grounded.
- (e) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

2.1.8 Optical Fiber Connectors

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

.....**End of this Section**.....