Chapter-01

Introduction, General Information and General Requirement & Specification for OPGW cabling and associated hardware & fittings

Table of Content

I.1 GENERAL REQUIREMENTS 4

I.2 ORGANIZATION OF THE FO CABLING TECHNICAL SPECIFICATION DOCUMENT 6

I.3 APPLICABLE STANDARDS 6

I.4 REFERENCES 7

1.0 FIBRE OPTIC CABLING 8

1.1 REQUIRED OPTICAL FIBRE CHARACTERISTICS 8

1.1.1 PHYSICAL CHARACTERISTIC 8

1.1.2 ATTENUATION 8

1.2 FIBRE OPTIC CABLE CONSTRUCTION 9

1.2.1 OPTICAL FIBRE CABLE LINK LENGTHS 10

1.2.2 OPTICAL FIBRE IDENTIFICATION 10

1.2.3 BUFFER TUBE 10

1.2.4 OPTICAL FIBRE STRAIN & SAG-TENSION CHART 10

1.2.5 CABLE MATERIALS 11

1.2.5.1 FILLING MATERIALS 12

1.2.5.2 METALLIC MEMBERS 12

1.2.6 MARKING, PACKAGING AND SHIPPING 12

1.3. OPTICAL GROUND WIRE (OPGW) 13

1.3.1 CENTRAL FIBRE OPTIC UNIT 13

1.3.2 BASIC CONSTRUCTION 13

1.3.3 BREAKING STRENGTH 13

1.3.4 ELECTRICAL AND MECHANICAL REQUIREMENTS 14

1.3.5 OPERATING CONDITIONS 14

1.4 INSTALLATION HARDWARE 14

1.5 FIBRE OPTIC SPLICE ENCLOSURES (JOINT BOX) 17

1.5.1 OPTICAL FIBRE SPLICES 17

1.6 FIBRE OPTIC APPROACH CABLES 18

1.6.1 BASIC CONSTRUCTION 18

1.6.2 JACKET CONSTRUCTION & MATERIAL 18

1.6.3 OPTICAL, ELECTRICAL AND MECHANICAL REQUIREMENTS 18

1.7 FIBRE OPTIC DISTRIBUTION PANEL 18

1.7.1 OPTICAL FIBRE CONNECTORS 19

1.8 SERVICE LOOPS 19

1.9 TEST EQUIPMENT 20

Chapter-01

Introduction, General Information and General Requirement

This Volume of the Tender Documents describes the technical specifications for Fibre Optic Cabling requirements which includes overhead fibre optic cable (OPGW), Aerial fibre optic cable, and associated hardware & fittings including joint box, approach cable & FODP. This specification describes the functional and performance requirements of the system.

The purpose of this section of the specification is to provide introduction, general information, and general requirement and define the scope of the FO Cabling requirements alongwith specification for OPGW Cable.

I. Scope and General Requirements

The broad scope of the procurement of this specification include the survey, planning, design, engineering, manufacturing, supply, transportation, insurance, delivery at site, unloading, handling, storage, Supervision of erection/installation , installation, splicing, termination, testing, training, and demonstration for acceptance, commissioning and documentation for:

a) OPGW fibre optic cable including all associated hardware , accessories & fittings
b) Aerial fibre optic cable including all associated hardware , accessories & fittings
c) Underground Fibre Optic Cable (UGFO)
d) Fibre Optic approach cable including installation material
c) Fibre Optic Distribution Panels (FODP) & Joint Box
d) Supply of spares
e) Supply of test equipments
f) All other associated work/items described in the technical specifications.

The Bill of Quantity (BoQ) is indicated in the Bid Price Schedules.

Mostly, the OPGW Cable under this specification shall be installed under off-line conditions, i.e. to be installed alongwith new Transmission/Distribution lines. However, in some cases OPGW/Aerial Cable under this specification shall be installed under live line conditions, i.e. with all circuits of the Transmission/Distribution line charged to their voltage. The actual quantities for the requirement may vary during implementation which shall be finalised after detailed survey. The Contractor has to carry out the detailed survey and collect the required data for preparation of OPGW/Aerial Cable BoQ.

The list if lines where OPGW is to be installed are mentioned in the General scope of Technical Specification of DMS system. Aerial (ADSS) cable to be installed to meet FO optic network connectivity wherever applicable. The scope of same shall be finalized during detailed engineering and as per site requirement.
In this specification Aerial cable may be referred as ADSS Cable (All di electric self-supporting

cable).

The various sections of these specifications defines the survey, design, performance, installation, testing & implementation for the fibre optic cable system.

I.1 General Requirements

The Contractor is encouraged to offer standard products and designs. However, the Contractor must conform to the requirements and provide any special equipment necessary to meet the requirements stated herein.

It should be noted that preliminary design information and bill of quantity (BoQ) specified in this specifications are indicative only. The Contractor shall verify the design data during the site surveys & detail engineering and finalise the BoQ as required for ultimate design & system performance.

The Bidder's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

The Bidder's proposal shall clearly identify all features described in the specifications or in any supporting reference material that will not be implemented; otherwise, those features shall become binding as part of the final contract.

An analysis of the functional and performance requirements of this specification and/or site surveys, design, and engineering may lead the Contractor to conclude that additional items are required that are not specifically mentioned in this specification. The Contractor shall be responsible for providing at no added cost to the Employer, all such additional items such that a viable and fully functional Overhead Fibre Optic Cable System is implemented that meets or exceeds the capacity, and performance requirements specified. Such materials shall be considered to be within the scope of the contract. To the extent possible, the Bidders shall identify and include all such additional items in their proposal.

The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

The Contractor shall demonstrate a specified level of performance of the offered items during well structured factory and field tests.

The Bidders are advised to visit sites (at their own expense), prior to the submission of a proposal, and make surveys and assessments as deemed necessary for proposal submission. The successful bidder (Contractor) is required to visit all sites. The site visits after contract award shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the Employer well in advance. The site survey schedule shall be finalised in consultation with the Employer. The Employer shall also be associated with the Contractor during their site/route survey activities.

After the site/route survey the Contractor shall submit to the Employer a survey report on each link and site. This report shall include at least the following items:

a) List of all span lengths and the total link length for OPGW.
b) Suitability of low voltage Distribution line for OPGW cable installation on the present infrastructure, towers, earthwire, etc.
c) Tower/Pole wise identification of type(s) and numbers of fittings & accessories required. Proposed splice locations, cable drum schedules and types of in-line splice enclosure requirement at each location.
d) Proposed routing of the approach FO cable from the end tower / gantry to the communication room to be marked on the site layout drawing. The existing cable trenches/ cable raceways proposed to be used shall be identified.
e) The positions of fibre optic distribution panel (FODP) shall also be finalised during survey and the same shall be indicated in the survey report.

I.1.1

Notwithstanding anything stated elsewhere in this technical specification, the subcontractor/sub vendor for different items as per General Technical Requirement shall be tied up with the contractor in the event of award/ at post award stage. Relevant documents as stipulated in the Technical Specification in this regard, including Joint Deed of Undertaking (JDU) wherever specified shall be submitted at that stage.

Format for JDU is enclosed with this technical specification which shall be suitably modified, if required as per the package specific requirement at the stage of submission.

Formats for JDUs and Performance Bank Guarantees are attached under Formats for Undertaking & Performance BG.

I.2 General Technical Requirements for Fibre Optic Cabling

I.2.1 OPGW manufacturer

1.1.1 TECHNICAL EXPERIENCE

(a) OPGW manufacturer should be a “Local Supplier” as per latest DPIIT and DoT notification.
(b) (i) OPGW manufacturer must have manufactured, type tested (as per IEC or equivalent standard) and supplied at least 100 Kms of OPGW during last seven (7) years and the same must be in satisfactory operation# for at least two (02) years on 66kV or above transmission line(s), as on the date of NOA.
OR
(ii) OPGW manufacturer must have manufactured, type tested (as per IEC or equivalent standard) and supplied at least 100 Kms of OPGW as on the date of NOA. Further, extended warranty of two (2) years over and above the warranty period specified for OPGW shall be submitted.

(c) OPGW manufacturer established as Subsidiary/JVC/Group company who has manufactured, type tested (as per IEC or equivalent standard) OPGW and meets the requirement at (a) but not (b)(i)

above, shall also be considered, provided its Parent/Principal company meets the requirement at (b)(i) above. Further the following shall also be submitted by OPGW manufacturer:

i) Performance guarantee for an amount of 10% of the cost of OPGW cable.

ii) Valid collaboration agreement (between Parent/ Principal and OPGW manufacturer) for technology transfer / license to design, manufacture, test and supply OPGW in India.

Note 1: #Satisfactory operation – means Certificate issued by the Employer certifying the operation without any adverse remark.

I2.2 Aerial Fibre Optic cable manufacturer

The **Aerial Fibre Optic cable** shall be offered from a manufacturer(s) who has been manufacturing Aerial Fibre Optic cable for the last three (3) years and at least 100 Km of Aerial Fibre Optic cable manufactured by such manufacturer(s) shall have been in satisfactory operation for at least two (2) years as on the date of bid opening.

I.3 Organization of the FO Cabling Technical Specification Document

Chapter 1 through 6 and Appendices provide the project requirements of the fibre optic cabling system to be provided.

Chapter 1 contains specifications for OPGW cabling & associated hardware & fittings
Chapter 2 contains the requirement for Inspection & Testing requirement
Chapter 3 contains the Installation requirements
Chapter 4 contains specifications for Aerial Fibre Optic cable
Chapter 5 contains the documentation and deliverables requirements
Chapter 6 describes project management, schedule and implementation plan
Chapter 7 contains specifications for Underground Fibre Optic cable

The following is a list of the Volume II Appendices:

Appendix A - Data Requirement Sheets (DRS)

I.4 Applicable Standards

The applicable standards are mentioned in the respective technical section. The offered equipment shall conform to the standards mentioned in the specification except to the extent modified by this specification. In case of any discrepancy between the description given in the specification and the standards, the provisions of the technical specification shall be followed. The parameters not specifically mentioned in this specification shall conform to the standard mentioned in this specification.

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

I.5 References

(1) CIGRE Guide for Planning of Power Utility Digital Communications Networks
(2) CIGRE Optical Fibre Planning Guide for Power Utilities
(3) CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities
(4) CIGRE guide to fittings for Optical Cables on Transmission lines
(5) IEEE standards as applicable (indicated in the relevant sections of this specification)
(6) IEC standards as applicable (indicated in the relevant sections of this specification)
(7) IS standards as applicable (indicated in the relevant sections of this specification)
(8) REC Standard for Distribution System.

Specification for OPGW cabling and associated hardware & fittings

1.0 Fibre Optic Cabling

In this section of the technical specification, the functional & technical specifications of OPGW cable, associated hardware & fittings for the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable is mentioned. Bidders shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

1.1 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristic:

1.1.1 Physical Characteristic

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

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 fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 1-1 (a) shall be “guaranteed” fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm : 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors

Maximum attenuation @ 1310nm : 0.35 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors

Table 1-1(a)
DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 μm (± 0.6μm)
Cladding Diameter:	125.0 μm ± 1 μm
Mode field concentricity error	≤ 0.6μm
Cladding non-circularity	≤ 1%
Cable Cut-off Wavelength λ_{cc}	≤ 1260 nm
1550 nm loss performance	As per ITU-T G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1300 to 1324nm 0.092 ps/(nm^{2}xkm) maximum
Polarization mode dispersion coefficient	≤ 0.2 ps/km^½
Temperature Dependence:	Induced attenuation ≤ 0.05 dB (-60°C - +85°C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (30±1 mm radius Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

1.2 Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable is proposed to be installed on the Transmission/Distribution lines. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the Transmission/Distribution lines. The Tower span details shall be collected by the Contractor during survey. To meet the overall requirement of the Transmission/Distribution line(s), the contractor may offer more than one design without any additional cost to Employer, in case single design is not meeting the requirement. Transmission/Distribution line details are enclosed along with the specification. Any other details, as required for cable design etc. shall be collected by the Contractor during survey.

1.2.1 Optical Fibre Cable Lengths

The estimated optical fibre lengths provided are indicative only. However, the Contractor shall supply & install the optical fibre cable as required based on detailed site survey to be carried out by the Contractor during the project execution.

OPGW cable to be supplied shall be in drum lengths to be specified by the Employer. Payment shall be made on actual optical fibre lengths delivered which will include route length plus length required for sag, splicing and service loop etc, which has been considered as around 4%. Hence contractor shall utilise the cable optimally for various links and splicing shall be allowed on any pole for which hardware fittings as required shall be supplied. Installation shall be payable on route length basis.

1.2.2 Optical Fibre Identification

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

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

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

1.2.3 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be provided directly in stainless steel tube. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre shall be individually identifiable utilizing colour coding. The tube housing the optical fibre(s) completely filled with a water-blocking gel shall be provided.

1.2.4 Optical Fibre Strain & Sag-Tension chart

The OPGW cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions defined in IS 802. Zero fibre strain condition shall apply even after a 25 year cable creep.

For the purpose of this specification, the following definitions shall apply:

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

- The *Cable strain margin* is defined as the maximum cable strain at which there is no fibre strain.
- The cable *Maximum Allowable Tension (MAT)* is defined as the maximum tension experienced by the Cable under the worst case loading condition.
- The cable *max strain* is defined as the maximum strain experienced by the Cable under the worst case loading condition.
- The cable *Every Day Tension (EDT)* is defined as the maximum cable tension on any span under normal conditions.
- The *Ultimate /Rated Tensile Strength (UTS/* RTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

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

- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.45 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 during detailed engineering:

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 applicable to 33kV lines. Max. Vertical sag, max. tension and max sag at 0° C & no wind shall be considered in line with the design parameter of Transmission/Distribution line. The full wind load shall be considered as the design wind load for all the specified Transmission/Distribution lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the Transmission/Distribution lines. In case of any higher span (river crossings etc.), suitable OPGW cable meeting sag-tension requirement of Transmission/Distribution line shall also be provided by the Contractor. The Contractor shall submit the stringing chart for review of Employer.

1.2.5 Cable Materials

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

1.2.5.1 Filling Materials

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

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

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

1.2.5.2 Metallic Members

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

1.2.6 Marking, Packaging and Shipping

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

(a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the Transmission/Distribution line & segment no., factory inspection stamp and date.

(b) Cable Drums: All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the owner.

1.3. Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall consist of a central fibre optic unit made up of stainless steel with aluminium coating/aluminium protective 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 fibre.

1.3.1 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect optical fibres 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 fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials for stranded wires and tubes are not allowed. Central fibre optic unit shall be of stainless steel tube with aluminium protective coating or stainless steel tube with Al protecting outer tube. In case of aluminium 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.

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 1.2 (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.

1.3.3 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

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

1.3.4 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. For the purposes of determining the appropriate Max Working Tension limit for the OPGW cable IS 802:1995 and IS 875: 1987 shall be applied. However the OPGW installation sag & tension charts shall be based on IS 802 version to which the line is originally designed. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

Table 1.2(a)
OPGW Electrical and Mechanical Requirements

(1)	**Everyday Tension**	≤ 20% of UTS of OPGW
(2)	**D.C. Resistance at 20ºC:**	< 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 & 66 kV lines) **≥ 5.0 kA for 1.0 second (for 33 kV lines)**

1.3.5 Operating conditions

Since OPGW shall be located at the top of the Transmission/Distribution line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

1.4 Installation Hardware

The scope of supply includes all required fittings and hardware such as Tension assembly, Suspension assembly, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation minimum @ 1% shall also be provided as part of set/km for each Transmission/Distribution line without any additional cost to Employer.

However, designs of the hardware fittings and accessories shall be finalised during detailed engineering meeting the technical requirement of 33kV lines.

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:

(1) Suspension Assemblies: Preformed armour grip suspension clamps and aluminium alloy armour rods/ reinforcing rods shall be used.

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

(2) Dead End Clamp Assemblies: All dead end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

(3) Clamp Assembly Earthing Wire: Earthing wire of aluminium or aluminium alloy conductor equivalent in size to the OPGW (length to be finalised in detailed engineering) 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.

(4) Structure Attachment Clamp Assemblies: Suitable design of clamps shall be provided to attach the OPGW with the Tower/Pole structure.

(e) Pole Clamps & Loop bracket: Contractor to supply Pole Clamps alongwith Suspension & Tension Fittings and Loop Bracket for holding extra OPGW length at splicing locations without extra cost alongwith OPGW hardware fittings. Specifications for the same shall be finalised during detailed engineering.

(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.

Vibration dampers shall be provided for higher spans, valley crossing, river crossing etc. and as per manufacturers guidelines as per site requirement, if applicable without any extra cost implication to employer. There is no separate payment shall be made for the vibration dampers. No. of dampers required for suspension and tension locations shall be finalised during detailed engineering with manufacturer's 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 galvanised steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS: 4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanised 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 maximum permissible dynamic strain should be +/- 150 micro strains.

The damper placement chart for different spans shall be submitted by the Contractor. Placement charts should be duly supported with sample calculations and manufacturer recommendation.

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.)

1.5 Fibre Optic Splice Enclosures (Joint Box)

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

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on Transmission/Distribution line at about 5 metres from top of the tower/pole and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

Splice enclosures to be installed on 33kV poles, Gantry, Double Pole cross arms structures, contractor to provide suitable arrangement to install the splice enclosure (e.g. pole clamp, mounting arrangement) without any extra cost to employer.

1.5.1 Optical Fibre Splices

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

(1) All fibre splices shall be accomplished through fusion splicing.

(2) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(3) All splices and bare fibre shall be neatly installed in covered splice trays.

(4) 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.

(5) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

1.6 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

1.6.1 Basic Construction

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

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.

1.6.3 Optical, Electrical and Mechanical Requirements

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

1.7 Fibre Optic Distribution Panel

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

(1) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to preconnectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(2) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

(3) FODPs shall be supplied in suitable cabinets/racks with locking arrangement 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.

1.7.1 Optical Fibre Connectors

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

1.8 Service Loops

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

(a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

(b) Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) Pigtail Service Loops : Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) Fibre Service Loops : At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside

covered splice trays.

1.9 Test Equipment (if applicable)

The parameters / features of the mandatory equipments are enumerated in Table 1.3 below :

Table 1.3

S. No.	Test equipment	Parameter
A.	**Test Equipments for OPGW cable**	
1	OTDR (Optical Time Domain Reflectometer) for 1310/1550 nm with laser source.	Equivalent to Anritsu MW9076B1 or better.
2	Optical Attenuators (variable 1310/1550nm).	Equivalent to JDSU OLA55 or better.
3	Optical Power meter (1310/1550nm)	Equivalent to JDSU OLP55 or better
4	Laser Light Source (1310/1550nm)	Equivalent to EXFO FLS300-23BL or better.
5	Optical Fibre Fusion Splicer incl. Fibre cleaver	Equivalent to Sumitomo T-39-SE or better.
6	Splice kit	FIS – FI-0053-FF or equivalent
7	Optical test accessory kit including all necessary connectors, adaptors, cables, terminations and other items required for testing	FIS – FI-0053-TS-ST or equivalent

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer. The Contractor shall offer only reputed make test equipment such as Acterna (JDSU)/Anritsu/Sumitomo/Agilent/EXFO etc.

…….....……..…End of this Section……...……...