

FORM OF BANK GUARANTEE FOR CONTRACT PERFORMANCE

(TO BE SUBMITTED BY THE MANUFACTURER OF OPGW)

[STIPULATED IN CLAUSE]
(ON NON-JUDICIAL STAMP PAPER OF APPROPRIATE VALUE)

Bank Guarantee No.

Date.....

Contract No.....

.....[Name of Contract].....

To: [Name and address of the Employer]

Dear Ladies and/or Gentlemen,

We refer to the Contract ("the Contract") signed on(insert date of the Contract)..... between you and M/s..... (Name of Contractor), having its Principal place of business at(Address of Contractor) and Registered Office at(Registered address of Contractor) ("the Contractor") concerning (Indicate brief scope of work) for the complete execution of the (insert name of Package along with name of the Project).....

Whereas, the Contractor has agreed to supply the OPGW Manufactured by M/s(Name of Manufacturer), having its Principal place of business at(Address of Manufacturer) and Registered office at(Registered address of Manufacturer)..... (Herein after Referred to as the 'Manufacturer') in collaboration with M/s. (Name of Collaborator/Parent/Principal Company), having its Principal place of business at(Address of Collaborator/Parent/Principal Company) and Registered Office at(Registered address of Collaborator/Parent/Principal Company) (hereinafter referred to as the "Collaborator"), as a pre-requisite for qualification of the Bidder/ Contractor and have submitted a deed of joint undertaking declaring that they are jointly and severally bound and responsible for the successful performance of the said equipment in accordance with the Contract Specifications and that the Manufacturer having agreed to furnish a Contract Performance Guarantee equivalent to (10%) ten per cent of the Ex-works cost of OPGW to be supplied by the Manufacturer/Contractor under the Contract. This CPG shall be in addition to Contract Performance Guarantee equivalent to 10% (ten per cent) of the value of the Contract to be provided by the Contractor for the faithful performance of the entire Contract.

By this letter we, the undersigned,(insert name & address of the issuing bank), a Bank (or Company) organized under the laws of and having its Registered/Head Office at(insert address of registered office of the bank)..... do hereby irrevocably guarantee payment to you up to i.e., ten percent (10%) of the Ex-works cost of OPGW to be supplied by the Manufacturer/Contractor under the Contract until ninety (90) days beyond the Defect Liability Period of the OPGW i.e., upto and inclusive of (dd/mm/yy).

We undertake to make payment under this Letter of Guarantee upon receipt by us of your first written demand signed by your duly authorized officer declaring the *Contractor/Manufacturer/ Collaborator/Parent/Principal Company* to be in default under the Contract and without cavil or argument any sum or sums within the above named limits, without your need to prove or show grounds or reasons for your demand and without the right of the *Contractor/Manufacturer/ Collaborator/Parent/Principal Company* to dispute or question such demand.

Our liability under this Letter of Guarantee shall be to pay to you whichever is the lesser of the sum so requested or the amount then guaranteed hereunder in respect of any demand duly made hereunder prior to expiry of the Letter of Guarantee, without being entitled to inquire whether or not this payment is lawfully demanded.

This letter of Guarantee shall remain in full force and shall be valid from the date of issue until ninety (90) days beyond the Defect Liability Period of the said equipment i.e. upto and inclusive of (dd/mm/yy) and shall be extended from time to time for such period (not exceeding one year), as may be desired by M/s. on whose behalf this Letter of Guarantee has been given.

Except for the documents herein specified, no other documents or other action shall be required, notwithstanding any applicable law or regulation.

Our liability under this Letter of Guarantee shall become null and void immediately upon its expiry, whether it is returned or not, and no claim may be made hereunder after such expiry or after the aggregate of the sums paid by us to you up shall equal the sums guaranteed hereunder, whichever is the earlier.

All notices to be given under shall be given by registered (airmail) posts to the addressee at the address herein set out or as otherwise advised by and between the parties hereto.

We hereby agree that any part of the Contract may be amended, renewed, extended, modified, compromised, released or discharged by mutual agreement between you and the Collaborator, and this security may be exchanged or surrendered without in any way impairing or affecting our liabilities hereunder without notices to us and without the necessity for any additional endorsement, consent or guarantee by us, provided, however, that the sum guaranteed shall not be increased or decreased.

No action, event or condition which by any applicable law should operate to discharge us from liability hereunder shall have any effect and we hereby waive any right we may have to apply such law so that in all respects our liability hereunder shall be irrevocable and, except as stated herein, unconditional in all respects.

Notwithstanding anything contained herein:

1. Our liability under this Bank Guarantee shall not exceed _____ (value in figures) [_____ (value in words)].
2. This Bank Guarantee shall be valid upto _____ (validity date).

3. We are liable to pay the guaranteed amount or any part thereof under this Bank Guarantee only & only if we receive a written claim or demand on or before _____ (validity date) _____."

For and on behalf of the Bank

[Signature of the authorized signatory(ies)]

Signature_____

Name_____

Designation_____

POA Number_____

Contact Number(s): Tel._____ Mobile_____

Fax Number_____

email_____

Common Seal of the Bank_____

Witness:

Signature_____

Name_____

Address_____

Contact Number(s): Tel._____ Mobile_____

email_____

Note :

1. For the purpose of executing the Bank Guarantee, the non-judicial stamp papers of appropriate value shall be purchased in the name of Bank who issues the 'Bank Guarantee'.
2. The Bank Guarantee shall be signed on all the pages by the Bank Authorities indicating their POA nos. and should invariably be witnessed.
3. **The Bank Guarantee should be in accordance with the proforma as provided. However, in case the issuing bank insists for additional paragraph regarding applicability of ICC publication No: 758, the following may be added at the end of the proforma of the Bank Guarantee [i.e., end paragraph of the Bank Guarantee preceding the signature(s) of the issuing authority(ies) of the Bank Guarantee]:**
"This Guarantee is subject to Uniform Rules for Demand Guarantee, ICC publication No. 758 except that article 15(a) is hereby excluded."
4. At the time of issuance of the Bank Guarantee (including its extensions) through SFMS facility, the issuing bank will input the IFSC code of Beneficiary Bank as mentioned at GCC clause 9.4 in SCC in their Trade Finance Portal.

Additional paragraph regarding issuance of the Bank Guarantee through SFMS Platform (if applicable), the following should be added at the end of the proforma of the Bank Guarantee [i.e., end paragraph of the Bank Guarantee preceding the signature(s) of the issuing authority(ies) of the Bank Guarantee]:

"This Guarantee has been issued using SFMS Platform and the requisite communication in this regard has been forwarded to the Beneficiary Bank."

**FORM OF DEED OF UNDERTAKING BY THE CONTRACTOR TO BE EXECUTED
BY THE BIDDER/MANUFACTURER FOR EXTENDED WARRANTY OF
TWO (02) YEARS OVER AND ABOVE THE WARRANTY PERIOD
SPECIFIED FOR OPGW CABLE**

[STIPULATED IN CLAUSE]
(ON NON-JUDICIAL STAMP PAPER OF APPROPRIATE VALUE)

**(Declaration by Contractor regarding _____ for GTR/Qualifying
Requirements for manufacturer of OPGW)**

THIS DEED OF UNDERTAKING executed this day of Two Thousand and by M/s., a Company incorporated under the laws of having its Registered Office at (hereinafter called the “**Contractor**” which expression shall include its successors, executors and permitted assigns) in favour of (insert names of the Employer), a Company incorporated under the Companies Act of 1956 having its registered office at(insert registered address of the Employer)..... (hereinafter called the “**Employer**” which expression shall include its successors, executors and permitted assigns)

WHEREAS the “**Employer**” invited Bid as per its Specification No. for the execution of (insert name of the package along with project name).....

AND WHEREAS Clause No., Section, of, Vol.-... forming part of the Bid Documents inter-alia stipulates that the **Contractor** must fulfill the General Technical Requirements for OPGW in the event of award/or post award stage and shall be bound and responsible for the successful performance of OPGW offered in the event the Bid submitted by the Contractor is accepted by the **Employer** resulting in a Contract.

AND WHEREAS the **Contractor** has submitted its Bid to the **Employer** vide Proposal No. dated

NOW THEREFORE THIS UNDERTAKING WITNESSETH as under:

- 1.0 In consideration of the award of Contract by the **Employer** to the **Contractor** (hereinafter referred to as the “Contract”) we, the **Contractor** do hereby undertake that we shall be bound unto the (insert name of the Employer), for the successful performance of OPGW and shall be fully responsible for the design, manufacture, testing, supply on FOR destination delivery at site basis and unloading at site, storage, erection, testing & commissioning and successful performance of OPGW in accordance with the Contract Specifications.
- 2.0 We confirm **the extended warranty obligations of additional one (01) year over and above the warranty period specified for the entire quantity of OPGW to be supplied from the Contractor.**
- 3.0 We, the Contractor agree that this Undertaking shall be irrevocable and shall form an integral part of the Contract and further agree that this Undertaking shall continue to be enforceable till the **Employer** discharges it. It shall become operative from the effective date of Contract.

4.0 We, the Bidder/Manufacturer agree that this Undertaking shall be irrevocable and shall form an integral part of the Contract and further agree that this Undertaking shall continue to be enforceable till the Employer discharges it. It shall become operative from the effective date of Contract.

5.0 This Deed of Undertaking shall be construed and interpreted in accordance with the laws of India and the Courts in Delhi shall have exclusive jurisdiction in all matters arising under the Undertaking.

IN WITNESS WHEREOF the Contractor have through their Authorised Representatives executed these presents and affixed Common seals of their respective Companies, on the day, month and year first above mentioned.

WITNESS

(For Contractor)

Signature

(Signature of the authorized representative)

Name

Name

Office Address

Common Seal of Company

WITNESS

WITNESS

Signature

Signature

Name

Name

Office Address

Office Address

Note:

1. For the purpose of executing the Deed of Undertaking, the non-judicial stamp papers of appropriate value shall be purchased in the name of executants parties.
2. The Undertaking shall be signed on all the pages by the authorised representatives of Contractor should invariably be witnessed.
3. This Deed of Joint Undertaking attested by Notary Public of the place(s) of the respective executant(s) shall be submitted by the Contractor after finalization of vendor for OPGW as per TS in the event of award/ post award stage.

** Strike-off whichever is not applicable.*

**FORM OF JOINT DEED OF UNDERTAKING BY THE COLLABORATOR/ PARENT
COMPANY
ALONGWITH THE BIDDER/MANUFACTURER**

[In line with Clause : Qualifying Requirements for manufacturer of OPGW of
Section-

I: Technical Specifications, Volume-II]

(ON NON-JUDICIAL STAMP PAPER OF APPROPRIATE VALUE)

THIS DEED OF UNDERTAKING executed this day of Two
Thousand and by M/s., a Company incorporated under the
laws of and having its Registered Office at
(hereinafter called the “**Collaborator**” which expression shall include its successors,
executors and permitted assigns), and M/s., a Company incorporated
under the laws of having its Registered Office at
(hereinafter called the “**Manufacturer**” which expression shall include its successors,
executors and permitted assigns) and Ms/., a Company incorporated under
the laws of having its Registered Office at (hereinafter
called the “**Bidder/Contractor**” which expression shall include its successors, executors and
permitted assigns) in favour of (*insert names of the Employer*), a Company
incorporated under the Companies Act of
1956 having its registered office at(*insert registered address of the
Employer*)..... (hereinafter called the “**Employer**” which expression shall include its
successors, executors and permitted assigns)

WHEREAS the “Employer” invited Bid as per its Specification No. for the
execution of (*insert name of the package along with project name*).....

AND WHEREAS Clause No., Section, of, Vol.-...
forming

part of the Bid Documents inter-alia stipulates that the Contractor and Manufacturer
alongwith its Collaborator must fulfill the Qualifying Requirements for OPGW and be
jointly and severally bound and responsible for the successful performance of OPGW
offered in the event the proposal for supply of OPGW from the Manufacturer submitted by
the Contractor is accepted by the Employer.

AND WHEREAS the Contractor has submitted its proposal to the Employer vide Proposal
No. dated for supply of OPGW from the Manufacturer based on the
collaboration/association of the Collaborator with the Bidder/Manufacturer.

NOW THEREFORE THIS UNDERTAKING WITNESSETH as under:

- 1.0 In consideration of the award of Contract by the Employer to the Contractor (hereinafter
referred to as the “Contract”) we, the Collaborator and the Contractor and the
Manufacturer do hereby declare that we shall be jointly and severally bound unto
the (*insert name of the Employer*), for the successful performance of

OPGW and shall be fully responsible for the design, manufacture, testing, supply on FOR destination delivery at site basis and supervision of unloading at site, storage, erection, testing & commissioning and successful performance of OPGW in accordance with the Contract Specifications.

2.0 Without in any way affecting the generality and total responsibility in terms of this Deed of Undertaking, the Collaborator in particular hereby agrees to depute their technical experts from time to time to the Contractor's/Indian Manufacturer's Works/Employer's Project site as mutually considered necessary by the Employer, Contractor, Manufacturer and the Collaborator to ensure

- (i) A valid technology transfer agreement, including license to manufacture and supply from India, between the Collaborator (the technology provider) and the Manufacturer covering the type, size and rating of the *.....sets specified, valid minimum up to the end of the defect liability period of the contract. The technology transfer agreement necessarily covers transfer of technological know-how for *..... in the form of complete transfer of design dossier, design software's, drawings and documentation, quality system manuals and imparting relevant training to the personnel of the Manufacturer.
- (ii) Proper design, engineering, manufacture, testing, supply transportation and delivery at site and supervision of unloading at site, storage, erection, testing & commissioning and successful performance of the equipment in accordance with Contract Specifications and
- (iii) If necessary, the Collaborator shall advise the Manufacturer suitable modifications of designs and implement necessary corrective measures to discharge the obligations under the contract.

3.0 This Deed of Undertaking shall be construed and interpreted in accordance with the laws of India and the Courts in Delhi shall have exclusive jurisdiction in all matters arising under the Undertaking.

4.0 As a security, the Manufacturer shall apart from the Contractor's performance guarantee, furnish **additional Contract Performance Guarantee** from its Bank in favour of the Employer in a form acceptable to the Employer. The value of such guarantee shall be equivalent to 10% of the Ex works cost of OPGW as identified in the Contract awarded by the Employer to the Contractor. The guarantee shall be unconditional, irrevocable and valid for the entire period of the Contract, and till the end of the **Defect Liability Period of** under the Contract. The Bank Guarantee amount shall be payable to the Employer on demand without any reservation or demur.

5.0 We, the Collaborator and Contractor and/or Manufacturer agree that this Undertaking shall be irrevocable and shall form an integral part of the Contract and further agree that this Undertaking shall continue to be enforceable till the Employer discharges it. It shall become operative from the effective date of Contract.

6.0 This Deed of Undertaking shall be construed and interpreted in accordance with the laws of India and the Courts in Delhi shall have exclusive jurisdiction to adjudicate any dispute arising under or in connection with this agreement.

IN WITNESS WHEREOF the Collaborator, the Manufacturer and the Contractor have through their Authorised Representatives executed these presents and affixed Common seals of their respective Companies, on the day, month and year first above mentioned.

(For Collaborator)

WITNESS	(Signature of the authorized representative)
Signature	Name
Name	Common Seal of Company
Office Address	

(For Contractor)

WITNESS	(Signature of the authorized representative)
Signature	Name
Name	Common Seal of Company
Office Address	

(For Manufacturer)

WITNESS	(Signature of the authorized representative)
Signature	Name
Name	Common Seal of Company
Office Address	

Note:

1. For the purpose of executing the Deed of Joint Undertaking, the non-judicial stamp papers of appropriate value shall be purchased in the name of executants parties.
The Undertaking shall be signed on all the pages by the authorised representatives of each of the partners and should invariably be witnessed.
2. This Deed of Joint Undertaking duly certified by the Company Secretary shall be submitted alongwith the bid. Further, the Deed of Joint Undertaking attested by Notary Public of the place(s) of the respective executant(s) or registered with the Indian Embassy/High Commission in that country shall be submitted by the bidder within ten (10) days from the date of intimation of post bid discussion.

Revised GTR for OPGW manufacturers

1.0 TECHNICAL EXPERIENCE

- (a) OPGW manufacturer should be a “Class-I Local Supplier” meeting the minimum local content as per latest MoP 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 one (01) year 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 one (1) year 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) and supplied 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.

For Live Line Installation (if applicable)

Agency must have installed at least 100 Kms of OPGW cable in live-line condition on 66 kV or higher voltage transmission line(s), as on the date of NOA

Section-1

Introduction, General Information and General Requirement

Table of Content

1.1 Scope and General Requirements.....	2
1.2 General Requirements.....	2
1.2.1 General Technical Requirements.....	3
1.3 Organization of the Technical Specification Document.....	4
1.4 References	6

Section 1

Introduction, General Information and General Requirement

This part of the Tender Documents describes the technical specifications of OPGW and associated hardware & fittings including joint box etc. This specification describes the functional and performance requirements of the system.

This part of specification describes the functional and performance requirement of the Fibre Optic cable and its associated hardware & fittings.

1.1 Scope and General Requirements

The scope of OPGW requirement is described as follows:

The scope shall include 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:

- (i.) 24F OPGW cable/ 48F OPGW Cable
- (ii.) All associated hardware, fittings and accessories (Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps etc.) required for installation of OPGW cable.
- (iii.) Joint box for above OPGW cable
- (iv.) Fibre Optic approach cable including associated installation material (as required if specified in BoQ).
- (v.) Underground Fiber Optic cable(UGFO)/All Dielectric Self Supporting(ADSS) cable including installation material, accessories and fixtures
- (vi.) Fibre Optic Distribution Panels (FODP) (as required if specified in BoQ).

The various Sections of this specification define the design, performance, test and implementation requirements for OPGW Cable system.

1.2 General Requirements

The Contractor must conform to the requirements and provide any special equipment necessary to meet the requirements stated herein.

It should be noted that parameters for OPGW cable design has been specified in the tender. The Contractor shall offer the product meeting the design accordingly. Standard OPGW designs are to be used for various voltage levels & wind zones of transmission lines that are mentioned at Section-02 of Technical Specifications. In case of constraints in adopting standard design for any of the transmission line(s) or for any specific sections such as higher spans (>600m), Valley crossings, snow covered sections or for other voltage levels & wind zones etc., the Contractor may propose customized design(s) during detailed engineering to meet the requirement.

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.

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 tests and field testing wherever required.

1.2.1 General Technical Requirements

List of items, goods, services or works from Class-I Local supplier meeting the Minimum Local Content notified in Annexure-1 of Ministry of Power (MoP) order on 'Public Procurement (Preference to Make In India) to provide for purchase preference (linked with local content) in respect of Power Sector ' dated 16.11.2021 is enclosed at Appendix-J to this Technical Specifications.

List of items, goods, services or works from Local supplier meeting the Minimum Local Content notified in Table-A, B & C of Department of Telecommunications(DoT), Ministry of Communications order dated 29.08.2018 on 'Public Procurement (Preference to Make In India) Order 2017 –Notification of Telecom products, Services or Works – regarding “ is enclosed at Appendix-K to this Technical Specifications.

Fibre Optic Cable

Fibre Optic Approach Cable and Under Ground Fibre Optic Cable shall be offered from a manufacturer(s) **who is a “Local Supplier” as per latest DPIIT and DoT notification.**

Aerial Fibre Optic (ADSS) Cable manufacturer

The Aerial Fibre Optic cable shall be offered from a manufacturer(s) who is a “Local Supplier” as per latest DPIIT and DoT notification and 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.

Provision to be complied as per latest guidelines of GOI/ MOP/DPIIT/DOT.

The Contractor shall ensure following things and at their own cost,:-

- (i) *Any imported equipment/material/item/parts/component to be supplied under the contract shall be tested in the certified laboratories to check for any kind of embedded malware/trojans/cyber threats and for adherence to Indian Standards as per the directions issued by Ministry of Power/Govt. of India from time to time. In case of such import from specified “prior reference” countries, the requirement of prior permission from the Govt. of India*

including protocol for testing in certified and designated laboratories by Ministry of Power/Govt. of India shall also be complied with by the contractor.

- (ii) *The equipment offered by the contractor shall at least conform to the requirements specified under relevant IS standard. In case of discrepancy between IS and other international standard, provisions of IS shall prevail. The Contractor shall also note that the list of standards presented in this specification is not complete. Whenever necessary, the list of standards shall be considered in conjunction with specific IS. If the IS standard is not available for an equipment/material, then other applicable International standard (IEC/Equivalent), as per the specification, shall be accepted.*
- (iii) *The bidder/contractor shall list out the products and components producing Toxic e-waste under the contract and shall furnish to the Employer the procedure of safe disposal at the time of closing of the contract.*
- (iv) *The Bidder shall have to furnish a certificate regarding cyber security/safety of the equipment/ process to be supplied/services to be rendered as safe to connect.*

1.3 Organization of the Technical Specification Document

Section 3 through 4 and Appendices provide the project requirements of the fibre optic cabling system to be provided.

<u>Section 2</u>	contains specifications for OPGW cabling & associated hardware & fittings
<u>Section 3</u>	contains the requirement for Inspection & Testing requirement
<u>Section 4</u>	contains the Support Services & documentation
<u>Section 5</u>	contains specifications for ADSS

Technical Specifications for UGFO is also provided.

The following is a list of the Appendices:

<u>Appendix A</u>	- General Information
<u>Appendix B</u>	- Data Requirement Sheets (DRS)
<u>Appendix C</u>	- Guidelines for Live Line Installation
<u>Appendix D</u>	- Guidelines for Off Line Installation
<u>Appendix E</u>	- Splicing Guide Lines
<u>Appendix F</u>	- Type Test Procedure
<u>Appendix G</u>	- FAT Procedure
<u>Appendix H</u>	- SAT Procedure
<u>Appendix I</u>	- Guidelines for Approach Cable Installation
<u>Appendix J</u>	- Annexure-1 of Ministry of Power (MoP) order on 'Public Procurement (Preference to Make In India)
<u>Appendix K</u>	- Table-A, B & C of Department of Telecommunications(DoT), Ministry of Communications order dated 29.08.2018 on 'Public Procurement (Preference to Make In India)

1.4 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied under this Contract:

(1) American Society for Testing and Materials ASTM

ASTM-B415 Standard Specification for Hard-Drawn Aluminium-Clad Steel Wire

(2) Bell Communication Research

GR-20 Generic requirements for optical fibre and optical fibre cable

(3) ITU-T/CCITT Recommendations

G.650 Definitions and test methods for the relevant parameters of single-mode fibres

G.652 Characteristics of a single-mode optical fibre cable

(4) IEEE

IEEE-1138, 2021 IEEE Standard for Testing and Performance for Optic Ground Wire (OPGW) for Use on Electric Utility power Lines

(5) Telecommunication Industry Association EIA/TIA

EIA/TIA-455-3 Procedure to Measure Temperature Cycling Effects on Optical Fibres, Optical Cable, and Other Passive Fiber Optic Components

EIA/TIA-455-16 Salt Spray (Corrosion) Test for Fibre Optic Components

EIA/TIA-455-20 Measurement of Change in Optical Transmittance

EIA/TIA-455-25 Repeated Impact Testing of Fibre Optic Cables and Cable Assemblies

EIA/TIA-455-32 Fibre Optic Circuit Discontinuities

EIA/TIA-455-33 Fibre Optic Cable Tensile Loading and Bending Test

EIA/TIA-455-41 Compressive Loading Resistance of Fibre Optic Cables

EIA/TIA-455-59 Measurement of Fibre Point Defects Using an OTDR

EIA/TIA-455-62 Measurement of Optical Fibre Macrobend Attenuation

EIA/TIA-455-78 Spectral Attenuation Cutback Measurement for Single- Mode Optical Fibres

EIA/TIA-455-80 Measurement of Cut-Off Wavelength of Single-Mode Fibre by Transmitted Power

EIA/TIA-455-81 Compound Flow (Drip) Test for Filled Fibre Optic Cable

EIA/TIA-455-82 Fluid Penetration Test for Fluid-Blocked Fibre optic Cable

EIA/TIA-455-91 Fibre Optic Cable Twist-Bend Test

EIA/TIA-455-164 Single-Mode Fibre, Measurement of Mode Field Diameter by Far-Field Scanning

EIA/TIA-455-167 Mode Field Diameter Measurement, Variable Aperture

	Method in the Far-Field
<i>EIA/TIA-455-168</i>	Chromatic Dispersion Measurement of Multimode Graded Index and Single-Mode Optical Fibres by Spectral Group Delay Measurement in the Time Domain
<i>EIA/TIA-455-169</i>	Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Phase-Shift Method
<i>EIA/TIA-455-170</i>	Cable Cut-off Wavelength of Single-Mode Fibre by Transmitted Power
<i>EIA/TIA-455-174</i>	Mode Field Diameter Measurement
<i>EIA/TIA-455-175</i>	Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Differential Phase-Shift Method
<i>EIA/TIA-455-176</i>	Method of Measuring Optical Fibre Cross-Sectional Geometry by Automated Grey-Scale Analysis
<i>EIA/TIA-598</i>	Optical Fibre Cable Colour Coding

(6) International Electrotechnical Commission IEC standards

<i>IEC-60793-1 series</i>	Optical fibres – Generic & product specifications, measurement methods & test procedures specification
<i>IEC-60794-1-1</i>	Optical fibre cables – Generic specification
<i>IEC-60794-1-2</i>	Optical fibre cables – Basic optical cable test procedure
<i>IEC-60794-3</i>	Optical fibre cables – Duct, buried and aerial cables – sectional specification
<i>IEC-60794-4</i>	Optical fibre cables – Overhead cables
<i>IEC-61089</i>	Round wire concentric lay overhead electrical stranded conductors
<i>IEC-61232</i>	Aluminium-clad steel wires for electrical purposes
<i>IEC-61284</i>	Overhead lines-Requirements and tests for fittings
<i>IEC-61395</i>	Overhead electrical conductors – Creep test procedures for stranded conductors

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

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

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

1.5 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
.....**End of this section**.....

Section-02
Specification for Fibre Optic cabling & associated items**Table of Content**

2.1	FIBRE OPTIC CABLING	2
2.1.2	FIBRE OPTIC CABLE CONSTRUCTION	3
2.1.3	OPTICAL GROUND WIRE (OPGW) CONSTRUCTION.....	6
2.1.4	INSTALLATION HARDWARE.....	9
2.1.5	FIBRE OPTIC SPLICE ENCLOSURES (JOINT BOX).....	12
2.1.6	FIBRE OPTIC APPROACH CABLES.....	13
2.1.7	FIBRE OPTIC DISTRIBUTION PANEL	15
2.1.8	OPTICAL FIBRE CONNECTORS.....	15

Section-02

Specification for OPGW cabling and associated hardware & fittings

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

2.1 Fibre Optic Cabling

In this section of the technical specification, the functional & technical specifications of OPGW cable, Fibre Optic Approach Cable, Joint Box and associated hardware & fittings for the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade optical fibre is specified. 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.

2.1.1 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristics :

2.1.1.1 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 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 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 2-1 (a) shall be “guaranteed” fibre attenuation of any & every fibre reel.

Table 2-1(a)
DWSM Optical Fibre Characteristics

Fibre 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_{cc}	$\leq 1260 \text{ nm}$
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:	1300 to 1324nm
Zero Dispersion Slope:	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 Fibre 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 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 meeting the design parameters specified in Technical Specifications.

2.1.2.1 Optical Fibre Cable Lengths

The estimated optical fibre 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 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.

2.1.2.3 Optical Fibre Strain& Sag-Tension chart

The OPGW cable the optical fibres shall 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 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 fibre cable construction, shall meet the following requirements:

2.1.2.4.1 Filling Materials

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

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

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

2.1.2.4.2 Metallic Members

When the fibre 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 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 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 fibre 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 fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for

splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel. The individually coated optical fibre(s) shall be provided directly in stainless steel tube in case stainless steel tube design.

(a) Central Aluminium tube type

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

(b) Central Stainless Steel tube type

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

Central Fibre Optic Unit

(a) Central Aluminium tube type

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

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

(b) Central Stainless Steel tube type

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.

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 Fibre 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	Stainles s Steel Tube
220 kV D/C WZ 1-4 132kV D/C WZ 1- 5	7376±50	51±2	0.355±.01	11.4±.0 2	12344±100	0.0000149± 0.0000003	Al Tube
River Crossing Section	20059±10 0	118±5	0.884±0.0 1	14.7±0. 2	16355±100	0.0000127± 0.0000003	Stainles s Steel Tube
800kV HVDC	10369.011 2	72.66	0.5719	13.5	13788.99	0.00001404	Al tube
	Or suitable to tower design				Or suitable to tower design		

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 fibre 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.

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 aluminium alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured. For river crossing and special transmission lines (where heavier earthwire 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 centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

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

2.1.5 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. 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 finalised after Survey

2.1.5.1 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:

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

2.1.6 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 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, laying 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 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.

2.1.6.4 Fibre Optic Approach cable Installation hardware

At all locations, 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/ POWERGRID Approved make
2	GI Elbow	Material type	Galvanized Iron
		Nominal Bore Diameter	32 mm
		Make	POWERGRID Approved make
		Certification	NABL Test Certificate
3	GI Flexible Conduit	Material type	Galvanized Iron
		Nominal Bore Diameter	32 mm
		Make	POWERGRID Approved make

		Certification	NABL Test Certificate
--	--	---------------	-----------------------

2.1.7 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:

- (a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.
- (b) 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. No more than 12 fibres shall be terminated in a single splice tray.
- (c) FODPs shall be supplied in suitable cabinets/racks with locking arrangement. The dimension 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 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.

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

Section - 03

Inspection & Testing

Index

3.1	Inspection	2
3.2	Test Plans and Procedures	4
3.2.1	<i>Factory and Site Test Plans.....</i>	4
3.2.2	<i>Test Procedures.....</i>	5
3.2.3	<i>Test Records</i>	5
3.2.4	<i>Rejection of Elements</i>	6
3.2.5	<i>Test Periods Defined.....</i>	6
3.3	Type Testing.....	7
3.3.1	<i>Type Test Samples.....</i>	9
3.3.2	<i>List of Type Tests</i>	9
3.3.2.1	Type Tests for Optical Fibres	10
3.3.2.2	Type Tests for OPGW Cables.....	11
3.3.2.3	Type Test on OPGW Cable Fittings	12
3.3.2.4	Type Test on Vibration Damper.....	16
3.3.2.5	Type Tests for Splice Enclosures (Joint Box)	19
3.3.2.6	Type Tests for Fibre Optic Approach Cable.....	21
Impact Test.....		21
3.3.2.7	Type Testing on Aerial Optical Fibre Cable	21
3.3.2.8	Type Tests on Aerial FO cable Accessories & fixtures	32
3.4	Factory Acceptance Tests	35
3.4.1	<i>Sampling for FAT.....</i>	36
3.4.2	<i>Production Testing.....</i>	36
3.4.3	<i>Factory Acceptance Tests on Optical Fibre to be supplied with OPGW.....</i>	37
3.4.4	<i>Factory Acceptance Test on OPGW Cable</i>	37
3.4.5	<i>Factory Acceptance Test on OPGW Fittings</i>	38
3.4.6	<i>Factory Acceptance Test on Approach Cable.....</i>	39
3.4.7	<i>Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP</i>	40
3.4.8	<i>Factory Acceptance Test on Test Equipment, Pigtail & other items</i>	40
3.4.9	<i>Factory Acceptance Tests on Self-supporting metal free Aerial optical fibre cable.....</i>	40
3.4.10	<i>Factory Acceptance Tests on Aerial FO cable accessories & fixtures.....</i>	41
3.5	Site Acceptance Tests	41
3.5.1	<i>Minimum Site Acceptance Testing Requirement for FO Cabling</i>	42
3.5.1.1	Phases of Site Acceptance Testing	42
Annexure-I		51
Page 1 of 1		51

Section - 03

INSPECTION & TESTING

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

All security related features shall be demonstrated during FAT/SAT as required by the Employer.

3.1 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate

this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

- (a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.
- (b) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings and labeling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.

- (c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.
- (d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.
- (e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

3.2 Test Plans and Procedures

Test plans for both factory and site acceptance tests shall be provided by the Contractor. Test plans shall be modular to allow individual test segments to be repeated upon request.

Procedures for type test, factory acceptance test, and site acceptance test for OPGW (including hardware accessories) and communication equipment (wherever applicable) have been provided in Appendix F, G & H respectively.

The Contractor shall submit a Test Schedule for the Employer's approval within one (1) week after the award of contract for Type Tests and three (3) months after the award of contract for all other tests. The test schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.

The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the corrections as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

3.2.1 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four

(4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table 3-1.

Table 3-1
Factory & field Test Plan Requirements

Item:	Description:
1.	Test schedule
2.	Record-keeping assignments, procedures and forms
3.	Procedures for monitoring, correcting and retesting variances
4.	Procedures for controlling and documenting all changes made to the communications equipment after the start of testing

3.2.2 Test Procedures

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

3.2.3 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table 3-2.

Table 3-2
Test Record Requirements

Item:	Description:
1.	Test Title and Revision Level, if applicable; contract references
2.	Date and time for test start and test completed
3.	Test title and reference to the appropriate section of the test procedures
4.	Description of any special test conditions or special actions taken (Includes test-

Table 3-2
Test Record Requirements

Item:	Description:
	case data).
5.	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6.	Test procedure modifications made during testing.
7.	Variance Report(s) tracking information and copies (if variance(s) was detected).
8.	Contractor's test engineer(s) identification, signature and remarks
9.	Employer's test witness identification, signature and remarks
10.	List of all attachments
11.	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

3.2.4 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary.

Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer for further inspection and/or tests.

3.2.5 Test Periods Defined

The terminology used in Volume I, General Conditions of Contract and their correlation with the tests requirements described within this section is as follows:

Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)

Operational Acceptance - Successful completion of SAT**3.3 Type Testing**

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

- (a) All cable & equipment being supplied shall conform to type tests as per technical specification.
- (b) Validity period of type tests conducted on the equipment i.e. the period for which Type Test Reports shall remain valid and acceptable to employer provided no major change has been introduced in the basic design/technology/material/mechanical construction/functionalities of the equipment/ performance characteristic/manufacturing process of the equipment, is as mentioned below:

S.No.	Name of Equipment	Periodicity (in years)
1	OPGW and its Hardware fittings & accessories / Fibre Optic Cable (Approach cable)	5
2	Telecom Equipment and all other items.	5
3	DCPS / Battery & Battery Chargers	7

Validity of type test reports shall be void in case of change in test procedure/method/criteria/test levels in case of revision/amendments to relevant standards.

In case of OPGW, the type tests conducted on OPGW design with 48fibers can be accepted for same OPGW design with 24fibers in line with IEEE 1138-2009 clause 6.2.

In case of Change in make of fibres in approved OPGW/ Approach Cable design, fibre specific type tests of OPGW/Approach cable shall be repeated provided all other OPGW/Approach cable design parameters remain same and the original design is type tested.

Further, the validity of Type Test reports shall be considered from Completion date of type testing up to the date of bid opening. The type tests of the equipment shall be repeated during its validity period, if there is change in technology, basic design, construction, electrical/thermal/mechanical stress,

performance characteristics or materials employed or changes in manufacturing process, setup or combination of any of above.

In case the type Test reports are not valid as per the conditions stipulated in this specification, the Contractor shall repeat the type tests at no extra cost to the employer/purchaser.

- (c) The Contractor shall submit, within 30 days of Contract Award, copies of previous test reports for Type Tests specified in the Technical Specifications. These reports may be accepted by the Employer only if they apply to materials and equipment that are due to be delivered under the Contract and are similar in design only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives.

The type test reports of hardware fittings and vibration dampers approved with a particular make of OPGW Cable, shall be accepted with OPGW designs of other manufacturers also (where both are Standard OPGW designs having similar parameters such as diameter , UTS, etc.).

In the event of any discrepancy in the test reports or any type tests not carried out same shall be carried out by Contractor without any additional cost implication to the Employer.

- (d) Contractor shall submit the details of laboratory(s) for the type tests.
- (i) Type Tests on indigenous equipment, for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National Accreditation Body of the Country, like Central power Research Institute(CPRI), Electrical Research and development Association(ERDA) etc.
 - (ii) Type Tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National Accreditation Body of that country.
 - (iii) Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National Accreditation Body of respective country.
 - (iv) Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by national Accreditation Body of the country and the tests have been witnessed by a representative of NABL accredited laboratory/Power Utility.

All the type tests shall be certified or performed by reputed laboratories using material and equipment data sheets as per procedures provided in under this technical specification.

- (e) The Contractor shall provide a detailed schedule for performing all specified type tests at least 30 days prior to planned commencement of each type test. These tests shall be performed in the presence of a representative of the Employer.
- (f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
- (g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

In case of failure in any particular type test(s) or type testing not done during the visit of employer representative, then all the expenses for re-deputation of Inspector/ Employer representative for type testing shall be borne by Contractor.

3.3.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. At least three samples of each of the proposed equipment/item/cable drum except FO cable installation hardware & fittings shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection.

3.3.2 List of Type Tests

The type testing shall be conducted on the following equipment/items

- (a) Optical fibres
- (b) OPGW Cable
- (c) OPGW Cable fittings
- (d) Vibration Damper
- (e) Splice Enclosure (Joint Box)

- (f) Approach Cable
(g) ADSS & its hardware fittings

Further, tests on various items other than those listed in this section of technical specifications but otherwise mentioned in relevant general requirements (GR) issued by Telecommunication Engineering Centre (TEC), DoT are also to be completed in compliance to Department of Telecommunications (DoT), Ministry of Communications order dated 29.08.2018 on 'Public Procurement (Preference to Make In India) Order 2017 –Notification of Telecom products, Services or Works – regarding’.

3.3.2.1 Type Tests for Optical Fibres

The type tests listed below in table 3-3 shall be conducted on DWDM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

Table 3-3
Type Tests For Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
2	Attenuation Variation with Wavelength	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending (Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 Or EIA/TIA 455-59

Table 3-3
Type Tests For Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
10	Core -Clad concentricity error		IEC 60793-1-20 Or EIA/TIA 455-176
11	Fibre Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455-31B
-End Of table-			

3.3.2.2 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 3-4 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 3-4
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure
1	Water Ingress Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.3.5
2	Seepage of filling compound	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.3.6
3	Short Circuit Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.3.3
4	Aeolian Vibration Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.3.1
5	Galloping test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.3.2
6	Cable Bend Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.2.3
7	Sheave Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.2.1
8	Crush Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.2.2

Table 3-4
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure
9	Twist Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.2.4
10	Creep Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.1.1
11	Strain Margin Test or MRDT Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.1.3
12	Stress Strain Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.1.2
13	Temperature Cycling Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.3.7
14	Corrosion (Salt Spray) Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.3.8
15	Ultimate Tensile Strength Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.1.4
16	Lightning Arc Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.3.4
17	DC Resistance Test	IEEE 1138-2021	IEEE 1138-2021 Method 6.5.1.5
-End Of Table-			

3.3.2.3 Type Test on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

(i) Mechanical Strength Test for Suspension/Tension Assembly

Applicable Standards: IEC 61284, 1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure

Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16° . This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder 'zeroed'. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

* Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.
- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.
- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.
- The Armour Rods shall not be displaced from their original lay or damaged**.

** Definition of no damage in accordance with convention expressed in IEC 61284: 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on a 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the UTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead -End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 % of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increased up to 95 % of the UTS and maintained for one minute. After one minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

(v) Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

3.3.2.4 Type Test on Vibration Damper

(a) Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian Vibration frequency band ranging from $0.18/d$ to $1.4/d$ – where d is the OPGW cable diameter in meters. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

- (i) Force Vs frequency
- (ii) Phase angle Vs frequency
- (iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

Acceptance criteria for vibration damper:

- (i) The above dynamic characteristics test on five damper shall be conducted.
- (ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
- (iii) The above mean reactance response curve should lie within following limits:
V.D. for OPGW - $0.060 f$ to $0.357 f$ kgf/mm*
Where f is frequency in Hz.
- (iv) The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
- (v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.

- (vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

- (i) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as 25% of UTS of fibre optic cable for a span ranging from 100 m to 1100 m.
- (ii) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.
- (iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.
- (iv) Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
- (v) From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.
- (vi) From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

(c) Fatigue Tests**(i) Test Set Up**

The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 25% of UTS of fibre optic cable and shall not be equipped with protective armour rods at any point.

Constant tension shall be maintained within the span by means of lever arm arrangement. After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than $\pm 25/f$ mm where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the

damper. The fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

- (1) There shall not be any resonant frequency shift before and after the test by more than $\pm 20\%$
- (2) The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than $\pm 20\%$

Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper

Sl No.	Test Name	Test Procedure
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip test	IEC 61897 Clause 7.5
3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachments of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

3.3.2.5 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to $+65^{\circ}\text{C}$ with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than $\pm 0.05\text{dB}$. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of $+55^{\circ}\text{C} \pm 2^{\circ}\text{C}$ with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than $\pm 0.05\text{dB}$, and the internal humidity rate measured, less than 2%.

(iii) Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be immersed in water for 24 hours. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than $\pm 0.05\text{dB}$.

(iv) Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than $\pm 0.05\text{dB}$. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

- a) 3 torsion cycles of $\pm 180^{\circ}$ shall be exercised on the cable. Each cycle shall be less than one minute.
- b) 3 flexure cycles of the cable, of $\pm 180^{\circ}$ with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than $\pm 0.05\text{dB}$. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test

With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall

remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

3.3.2.6 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in table 3-5: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 3-5:
Type Tests Fibre Optic Approach Cable

S.NO.	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning : 72 hours, Test duration : 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles
-End Of Table-		

Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius $\pm 10\%$. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

3.3.2.7 Type Testing on Aerial Optical Fibre Cable

The Bidder shall have valid Type Approval Certificate (TAC) from TEC/Technical Specification Evaluation Certificate(TSEC) given by BSNL QA for 24F/48F Self Supporting Metal Free Aerial Fibre Optic Cable (ADSS) OFCs suitable for Power Systems preferably for snow areas at the date of bid opening and a copy of valid TAC/TSEC

certificate shall be submitted and proof for submission shall be submitted along with the bid. However, the bidder shall ensure that in all the cases the TSEC/TEC certificate would be valid at the time of award. In case type approval certificate validity expires after placement of Letter of Award (LoA), the contractor shall take advance action so that the supply is not delayed due to non-availability of type approval certificate for the offered fibre optic cable meeting the requirement. In case, TSEC/TEC certificate of Self Supporting Metal Free Aerial Fibre Optic Cable (ADSS) Optical fiber cable is not available, the Contractor shall submit the previously carried out type test report for the same design of cable for the tests listed in Table 3-6 below. The fibre should have been type tested as per relevant indian standards/International standards for the tests listed in Table-3-6 and the Bidder shall submit the test reports and certificates along with the bid.

The mechanical and testing parameters of the cable shall meet the requirements defined in Table 3-6 below:

Table 3-6

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
1	Tensile strength Test	To test the tensile strength Self Supporting Metal Free aerial Optical Fibre cable in order to examine the behaviour of the attenuation as a function of the load on a cable during installation and while the aerial optical fibre cable encounters the excess ice loading and the winds at high speed and to check its design parameters.	IEC 794-1-E1 The cable shall sufficient strength to withstand UTS load. The load shall be sustained for 10 minutes and the strain of the fibre and the attenuation shall be monitored at MWT, Max installation load & UTS. MWT & UTS shall be derived from SAG-TENSION data for aerial cable.	The load shall produce no strain ($\leq 0.05\%$ is to be treated as no strain) up to MWT and fibre strain shall not exceeding 0.25% in the fibre upto max installation load. At UTS fibre shall not break and shall not cause any permanent physical and optical damage to any component of the cable. The attenuation shall be noted before strain and after the release of strain. The change in attenuation of each fibre after the test shall be $\leq 0.05\text{dB}$ both for 1310 nm and 1550 nm wavelength.
2	Abrasion Test	To test the abrasion	IEC-794-1-E2 or by any	There shall be no

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
		resistance of the sheath and the marking printed on the surface of the cable.	other international test method The cable surface shall be abraded with needle (wt. 150 gm) having diameter of 1mm with 500 grams weight (Total weight more than equal 650 gms.) No. of cycles : 100 Duration : One minute (nominal)	perforation & loss of legibility of the marking on the sheath.
3	Crush Test (Compressive Test)	The purpose of this test is to determine the ability of an optical fibre cable to withstand crushing.	IEC 794-1-E3 The fibres and component parts of the cable shall not suffer permanent damage when subjected to a compressive load of 2000 Newtons applied between the plates of dimension 100 x 100 mm. The load shall be applied for 60 Secs. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310 nm and 1550 nm wavelength.
4	Impact Test	The purpose of this is to determine the ability of an optical fibre cable to withstand impact.	IEC 794-1-E4 The cable have sufficient strength to withstand an impact caused by a mass weight of 50 Newtons, when falls freely from a height of 0.5 meters. The radius R of the surface causing impact shall be 300 mm. Ten such impacts shall be applied at the same place. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310 nm and 1550 nm wavelength.
5	Repeated Bending	The purpose of this test is to determine the ability of an optical	EIA-455-104 The cable sample shall be of	During the test no fibre shall break and the attenuation shall

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
		fibre cable to withstand repeated bending.	sufficient length (5 m minimum to permit radiant power measurements as required by this test. Longer lengths may be used if required. Parameters : Weight : 5 kg Minimum distance from Pulley Centre: 216mm To holding device Minimum distance from Wt. To Pulley Centre : 457 mm Pulley Diameter: 20 D (D-cable diameter) Angle of Turning: 90° No. of cycles: 30 Time Required for 30 cycles : 2 min	be noted before and after the completion of the test. The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310 nm and 1550 nm wavelength.
6	Torsion Test	The purpose of this test is to determine the ability of an optical fibre cable to withstand torsion.	IEC 794-1-E7 The length of the specimen under test shall be 1 meters and the load shall be 75 N. The sample shall be mounted in the test apparatus with cable clamped in the fixed clamp sufficiently tight to prevent the movement of cable sheath during the test. One end of the cable shall be fixed to the rotating clamp, which shall be rotated in a clockwise direction for one turn. The sample shall then be returned to the starting position and then rotated in an anti-clock wise direction for one turn and returned to	The cable shall be examined physically for any cracks, tearing on the outer sheath and for the damage to other component ports of the cable. The twist mark shall not be taken as damage. The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wave length.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			the starting position. This complete movement constitutes one cycle. The cable shall withstand ten such complete cycles.	
7	Kink Test	The purpose of this test is to verify whether kinking of an optical fibre cable results in breakage of any fibre, when a loop is formed of dimension small enough to induce a kink on the sheath.	IEC 794-1-E10 The small length shall be 10 times the minimum bending radius of the cable. The sample is held in both hands, a loop is made of a bigger diameter and by stretching both the ends of the cable in opposite direction, the loop is made to the minimum bend radius and no kink shall form. The cable is then normaled and attenuation reading is taken.	The kink should disappear after the cable is brought to normal position. The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wavelength.
8	Cable Bend Test	The purpose of this test is to determine the ability of an optical fibre cable to withstand repeated flexing. The procedure is designed to measure optical transmittance changes and requires an assessment of any damage occurring to other cable components.	IEC 794-1-E11 (Procedure-I) The fibre and the component parts of the cable shall not suffer permanent damage when the cable is repeatedly wrapped and unwrapped 4 complete turns of 10 complete cycles around a mandrel having diameter of 20 D, where D is the diameter of the cable. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wave length. Sheath shall not show any cracks visible to the naked eye when examined whilst still wrapped on the mandrel.
9	Snatch Test	This test is to determine the ability of the cable to withstand a sudden snatch load.	IEC 794-1-E9 The sample is terminated in a manner that the fibres, sheathing and any strength member/members are clamped together firmly.	There shall be no permanent physical damage to the cable and the change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310nm and

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			A hook of dimension has a shaft capable of bearing variable loads applied to it. The cable of 4.5 meters length is taken and firmly clamped at the two ends so that a sag of 300 mm., is formed. The attenuation is then measured. Testing load shall be 300 N and the radius of impacting surface of the crown of the hook shall be 12.5 mm. The hook with the mass attached, is held or supported over the cable so that the crown of the hook is centered over the lowest point of the cable at a height of 100 mm. The hook is then released so as to catch the cable after dropping from the height of 100 mm. It shall be repeated ten times. The attenuation is measured. The load is then removed from the cable and attenuation is noted.	1550 nm wave length.
10	Cable Bend Test at High & Low Temperature	To determine the ability of a optical fibre cable to withstand bending at low and high temperatures which might be encountered during cable placement.	EIA RS-455-37 Test Temperature : -30 °C to +70 °C Mandrel dia : 20D (D – dia of the cable) No of turns : 4 Conditioning time duration : 24 hours at each temperature.	Visual test for damage of the sheath shall be checked. The change in attenuation of the fibre after the test shall be ≤ 0.05 dB/Km both for 1310 nm and 1550 nm wave length. The attenuation shall be noted before and after the

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
				completion of the cycle.
11	Temperature Cycling	To determine the stability behaviour of the attenuation of a cable subjected to temperature changes which may occur during storage, transportation and usage.	IEC 794-1-F1 (To be tested on 2 Km $\pm$ 5% of cable) The permissible temperature range of the cable for storage shall be from -40°C to $+70^{\circ}\text{C}$. The rate of change of temperature during the test shall be 1 degree/minute approx. The cable shall be subjected to temperature cycling for 12 hours at each temperatures as given below: TA2 : -20°C TA1 : -10°C TB1 : $+60^{\circ}\text{C}$ TB2 : $+70^{\circ}\text{C}$ The test shall be conducted for 2 cycles at the above temperatures.	The change in attenuation of the fibre under test after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wave length for entire range of temperature.
12	Cable Aging Test	To check the cable material change dimensionally as the cable ages.	At the completion of temperature cycle test, the test cable shall be exposed to 85 ± 2 degree C for 168 hours. The attenuation measurement at 1310 & 1550 nm wavelengths to be made after stabilisation of the test cable at ambient temperature for 24 hours.	The increase in attenuation allowed : ≤ 0.05 dB at 1310 & 1550 nm wavelengths. (Note: The attenuation changes are to be calculated with respect to the base line attenuation values measured at room temperature before temperature cycling.)
13	Water Penetration Test	To ensure that the installed optical fibre cable will not allow water passage in the cable.	IEC 794-1-F5 (Fig. B) 1992. A circumferential portion of the cable end shall face the water head. The water tight	No dye shall be detected when the end of the 3m length is examined with UV light

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			sleeve shall be applied over the cable. The cable shall be supported horizontally and one meter head of water, containing a sufficient quantity of water soluble fluorescent dye for the detection of seepage, shall be applied over the inner sheath for seven days at ambient temperature. No other colour dye is permitted.	detector.
14	Test of Figure of Eight on the cable	To check of easiness in formation of figure of 8 of the cable during installation in the field.	1000 meters (approx) length of the cable shall be uncoiled from the cable reel and shall be arranged in figure of 8. The diameter of each loop of the figure of 8 shall be maximum 2 meters.	It shall be possible to make figure of 8 of minimum 1000 meter length of the cable uncoiled from the cable reel without any difficulty. No visual damage shall occur.
15	Cable Jacket Yield Strength and Ultimate Elongation	To check the yield strength and elongation of polyethylene (HDPE) cable sheath.	FOTP –89 or ASTM D1248 Type III Class. (a) Sample shall be taken from the completed cable (The nylon to be removed for this test). The aged sample shall be conditioned at 100 ± 2 °C for 120 hours before testing. The cross-head speed shall be 50 mm per minute.	Refer Table A-1 below.
16	Drip Test	To determine the ability of jelly in the cable to withstand a temperature of 70 °C.	Take a sample of 30 cm length of cable with one end sealed by the end cap. Remove nylon jacket, black sheath binder tape for 5 cm from open end of the sample. Clean the jelly.	There should be no jelly drip or oil impression on the paper.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			Then the sample is kept vertically with open end downwards in the oven for 24 hours at 70 °C with a paper under the sample. Examine the paper placed below the cable sample inside the oven for dripping of the jelly after 24 hours.	
17	ECSR Test	To check the outer sheath of the cable for ECSR.	ASTM D 1693.	There should not be any visible cracks on the surface of the outer sheath, when examined with the help of a magnifying glass.
18	UV Resistance Test	To check the effect of UV radiation on the following: (i) On the outer sheath material (HDPE) (ii) On the Orange colour lines. (iii) On the meter and other legend marking.	ASTM G-53-96 Duration : 2000 hours Four test samples of the finished cable of required length (as per test chamber specifications) are to be prepared. 2 samples shall be kept inside and these test samples are to be compared after test with the other 2 samples kept outside.	There should not be any fading or change in the colour of the marking and that of sheath. <i>(Note: Earlier Carried out test certificates may be accepted for same raw material and similar design/construction of the cable).</i>
19	Embrittlement Test of Loose Tube	To check the embrittlement test of the loose tube	The minimum length of the test sample depends of the outside diameter of the loose tube and should be 85mm for tubes up to 2.5mm outside dia. The length of the bigger tubes should be calculated by using the following equation : $L_o > 100 \times ((D_2 + d_2)/4)^{1/2}$ Where L_o = Length of tube under test D = Outside dia of loose	The tube should not get embrittled. No ink should appear on the tube up to the safe bend dia of tube (20 D) where D is the outside diameter of the loose tube. There should not be any physical damage or mark on the tube surface.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			tube. d = inside dia of loose tube. Both the ends of a buffer tube test sample may be mounted in a tool which is clamped in jaws of a tensile machine which exert a constant rate of movement. The movable jaw may move at a rate of 50 mm per minute toward the fixed jaw. Under load the tube will bend, so that the tube is subjected to tensile and compressive stresses. The fixture for holding the tube should be designed in a manner that the tube might bend in all directions without further loading.	
20	Kink Resistance Test on the Loose Tube	To check the kink resistance of the loose tube during installation and in splicing operation	A longer length of the loose tube is taken (with fibre and gel), a loop is made and loop is reduced to the minimum bend radius of loose tube i.e. $20 D$. (where D is the outside dia of the loose tube). This test is to be repeated 4 times on the same sample length of the loose tube.	No damage or kink should appear on the surface of the tube.
21	Drainage Test for Loose Tube	To check drainage of the loose tube	A tube length to 40 cm shall be cut and filled with filling gel ensuring there are no air bubbles and the tube is completely full. The filled tube is placed in a horizontal position on a clean worktop and cut 5 cm from each end so that the finished length of the sample is 30 cm. The	There shall be no gel or oil in the beaker.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			filled tube shall be left in a horizontal position at an ambient temperature for 24 hrs. The sample tube is then suspended vertically in an environment heat oven over a weighed beaker. It is left in the oven at a temperature of 70 °C for a period of 24 hrs. At the end of the 24 hrs. period the beaker is checked and weighed to see if there is any gel in the beaker.	
22	Check of Easy removal of Sheath	To check the easy removal of sheath of the optical fibre cable by using normal sheath removal tool.	The sheath shall be cut in circular way using a sheath removal tool and the about 300 mm length of the sheath should be removed in one operation. It should be observed during sheath removal process that no undue extra force is applied and no component part of the cable is damaged.	It shall be possible to remove the sheath easily. Easy removal of both the outer jacket and the inner sheath shall be checked separately.
23	Check of the effect of Aggressive Media on the Cable	To check the effect of aggressive media solutions of PH4 and PH10 on the cable.	ISO 175. The two test samples of the finished cable each of 600 mm in length are taken and the ends of the samples shall be sealed. These test samples are put in the PH4 and PH10 solutions separately. After 30 days these samples are taken out from the solutions and examined for any corrosion etc. on the sheath and other markings of the cables.	The sample should not show any effect of these solutions on the sheath and other marking of the cable. (Note: Earlier Carried out test certificates may be accepted for same raw material and similar design/construction of the cable).
---End of Table ---				

Table A-1

Jacket material	Minimum Yield Strength		Minimum Elongation (%)
	(Mpa)	(psi)	
HDPE unaged	16.5	2400	400
HDPE aged	12.4	1800	375

3.3.2.8 Type Tests on Aerial FO cable Accessories & fixtures

The accessories and fixtures shall subject to the following tests. The applicability of the tests for the particular type of accessories and fixtures shall be as given below:

Visual Examination : Applicable to all fittings

Objective: To check the quality and the workmanship.

Visual examination shall be carried out for all the accessories and fixtures for quality and workmanship which is required to be of the high order with super quality finish without any manufacturing defects.

Verification of dimensions : Applicable to all fittings

Objective: To check the dimensions of the accessories and fixtures : shall be checked as per approved DRS/drawings.

Tensile strength test : Applicable to tension & suspension clamp assemblies

Objective: To assess the mechanical performance of fixtures under ultimate tensile strength.
Requirement: Cable UTS with factor of safety 1.5

All the load bearing metal fittings except those of elastomer pads and helically formed fittings shall be tested to meet the above requirement.

Tensile strength test for helically formed product

This test shall be applicable to terminating Helix, Protective Helix and Armour grip suspension helix.

Objective : To check the tensile strength for the helically formed items.

Requirement : The tensile strength test shall be carried out to the method specified in the respective standards for wires and shall meet the requirements listed in earlier clauses.

Slip Strength Test

This test shall be applicable to the Terminating helix and Armoured grip suspension fittings.

Objective : To check the tensile load strength of the formed fittings to assess the performance for withstanding the guaranteed load.

Requirement : The helically formed terminating fittings shall not slip up to 90 % of the Cable UTS. The helically formed suspension fittings shall withstand the load up to a minimum of 25 % of cable UTS and shall slip before 50 % of cable UTS.

Resilience Test

This test shall be applicable to terminating Helix.

Objective : To check the resilience of the helically formed fittings (Terminating Helix)

Requirement : The helically formed fittings shall pass the resilience test while helically formed fittings are wrapped and unwrapped on a piece of optical fibre cable three times successfully. The helical fittings should not loose its resilience even after three applications and shall be able to pass the slip strength test after third application.

Galloping / Fatigue test

This shall be applicable to a complete assembly of one set of tension fittings together with one set of suspension fittings and spiral damper.

Objective : To assess the fatigue performance of fixtures and accessories and the performance of optical characteristics of the optical fibre cable under galloping conditions.

Requirement of test methods:

Length of the span	:	25 – 30 meters
Minimum vibration cycles	:	1 million
Frequency	:	> 30 Hz to 100 Hz.
Amplitude	:	Amplitude of vibration at antinodal points shall not be less than 100 % of the cable diameter.

Requirement : The accessories and fixtures shall pass the test when tested for the test conditions as above and shall meet the requirement given below:

1. Change in attenuation shall not exceed more than 0.1 dB after the recovery period.
2. No damage on the accessories and fixtures.
3. No physical damage to optical fibre cable.

Aeolian Vibration Test

Objective : To assess the fatigue performance of accessories and fixtures and the optical characteristics of the optical fibre cable under Aeolian vibration.

Requirement of test method :

Minimum length of span : 25 meters.

Minimum vibration cycles : 1 million

Frequency : 10 Hz to 100 Hz.

Amplitude : Free loop peak to peak antinode amplitude shall be maintained at a level equal to one half of the cable diameter.

Requirement :

1. Change in attenuation shall not exceed more than 0.1 dB after the recovery period.
2. No visual damage observed on the accessories and fixtures.
3. No physical damage to optical fibre cable.

Tension and Attenuation Test (Dead End Assembly)

Objective : To assess the attenuation and the optical characteristics of the optical fibre cable after fixing and installing dead end assembly on the optical fibre cable.

Requirement of test method :

Minimum length of span : 25 meters

The test shall meet the following:

- a. Change in attenuation shall not exceed more than 0.1 dB after the recovery period.
- b. Any visual damage observed on the accessories and fixtures.
- c. No physical damage to optical fibre cables.

Wrapping Test

Objective : To check quality of the aluminum alloy wires.

Test Method : The formed fittings made of aluminum alloy wires shall be wrapped on a wire of its own diameter to form a close helix.

Requirement : The wires should not break or show fracture and shall meet the requirement specified above.

Galvanising Test

Objective : To check galvanized coating and the quality of galvanizing on accessories and fixtures

Test method : IS 2633-1972 for uniformity.

Requirement : The fittings shall meet the requirement of the specifications.

Hardness Test of Elastomer pad

Objective : To check the Ploychloroprene compounded elastomer pads of the suspension and cable jumper clamp.

Requirement : The Ploychloroprene compounded elastomer pads of the suspension unit shall be subjected for the test parameters as listed earlier in this specifications. The compounded material should meet the minimum properties specified therein.

3.4 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable and associated hardware fitting, Joint Box, FODP, etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued CIP Clearance/Interim Inspection Report. Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer's representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system, NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance

tests for the other items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

3.4.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

3.4.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

3.4.3 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138, 1994 section 4.2.2.1 and section 5.2.2.1. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standards unless specified otherwise in the technical specifications.

Table 3-7
Factory Acceptance Tests for Optical Fibres: Optical Tests

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	TS Vol II ,Table 2-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS Vol II, Section 2.1.1.2	EIA/TIA 455-59
3	Attenuation at Water Peak	TS Vol II ,Table 2-1(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core – Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding diameter		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		EIA/TIA 455-31B
-End of table-			

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

3.4.4 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 3-8
Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC 60794

S. No.	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

3.4.5 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 3-9. The sampling plan shall be as per relevant standard:

Table 3-9
Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
5	Galvanising test
Tension Assembly	
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings
8	Mechanical strength of each component

Table 3-9
Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
9	Galvanising Test
Vibration Damper	
10	Galvanising test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires
14	Attachments of weights to messenger cable
15	Attachments of clamps to messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test.
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings
End of Table	

3.4.6 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 3-10:

Table 3-10
Factory Acceptance Tests On Approach Cable

S. No.	Factory Acceptance Test
--------	-------------------------

1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings

3.4.7 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table:

Table 3-11
Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S. No.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings.

3.4.8 Factory Acceptance Test on Test Equipment, Pigtail & other items

As per technical specification and approved DRS/Documents.

3.4.9 Factory Acceptance Tests on Self-supporting metal free Aerial optical fibre cable

The tests listed in Table 3-12 shall be carried out as Factory Acceptance Test for Self-supporting metal free aerial optical fibre cable meeting the requirements specified in this section. The factory acceptance tests for optical fibers listed in table 3-7 are applicable for the fibers in the ADSS cable. The factory acceptance test report for the optical fibers carried out by the Fiber Manufacturer and used in the Self-supporting metal free Aerial optical fibre cable (ADSS) shall be shown to the inspector during ADSS cable FAT and shall be submitted along with the ADSS cable FAT report.

Table 3-12
Factory Acceptance Tests on Self Supporting Metal Free Aerial Fibre Optic Cable

S. No.	Factory Acceptance Test
1	Attenuation Coefficient (1310, 1550): By EIA/TIA 455- 78A or OTDR

S. No.	Factory Acceptance Test
2	Point discontinuities of attenuation: By EIA/TIA 455- 78A or OTDR
3	Visual Material verification and dimensional checks as per approved drawings
4	Water Ingress test
5	Tensile strength test / Strain test
6	Impact test
7	Kink test
8	Environmental test
9	Crush Test
10	Drip test

3.4.10 Factory Acceptance Tests on Aerial FO cable accessories & fixtures

The FAT on accessories & fixtures of Self-supporting metal free aerial optical fibre cable shall be carried out as specified in Table 3-13.

Table 3-13

Factory Acceptance Tests on Fittings for Self Supporting Metal Free Aerial FO Cable

S. No.	Factory Acceptance Test
1	Visual and dimensional checks of all components
2	Tensile test
3	Slip test
4	Galvanising test
5	Wrapping test
6	Hardness test

3.5 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable, Telecom equipment, NMS etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO & Telecom equipment installation. The tests to be conducted during SAT of PLCC Equipment are specified in respective section.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

3.5.1 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

3.5.1.1 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Table 3-14(a) through 3-14(c) below:

Table 3-14(a)
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1.	Physical Inspection of the cable assembly for damage

Table 3-14(a)
Fibre Optic Cable Pre-Installation Testing

2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3.	Fibre Optic Cable length measurement using OTDR

Table 3-14(b)
Fibre Optic Cable Splicing Testing

Item:	Description:
1.	Per splice bi-directional average attenuation with OTDR
2.	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

Table 3-14(c)
Fibre Optic Cable Commissioning Testing

Item:	Description:
1.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3.	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4.	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.
-End of Table-	

QUALITY ASSURANCE PROGRAMME :

- 1) To ensure that the equipment and services under the scope of this Contract, whether manufactured or performed within the Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work as applicable, are in accordance with the specifications, the Contractor shall ensure suitable quality assurance programme to control such activities at all points necessary. A quality assurance programme of the Contractor shall be in line with ISO requirements & shall generally cover the following :
 - a) The organisation structure for the management and implementation of the proposed quality assurance programme.

- b) System for Document and Data Control.
- c) Qualification and Experience data of Bidder's key personnel.
- d) The procedure for purchases of materials, parts, components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
- e) System for shop manufacturing and site erection controls including process controls, fabrication and assembly control.
- f) System for Control of non-conforming products including deviation dispositioning, if any and system for corrective and preventive actions based on the feed back received from the Customers and also internally documented system for Customer complaints.
- g) Inspection and test procedure both for manufacture and field activities.
- h) System for Control of calibration of testing and measuring equipment and the indication of calibration status on the instruments.
- i) System for indication and appraisal of inspection status.
- j) System of Internal Quality Audits, Management review and initiation of corrective and Preventive actions based on the above.
- k) System for authorising release of manufactured product to the Employer.
- l) System for maintenance of records.
- m) System for handling, storage and delivery.
- n) A quality plan detailing out the specific quality control measures and procedure adopted for controlling the quality characteristics relevant to each item of equipment furnished and /or service rendered.
- o) System for various field activities i.e. unloading, receipt at site, proper storage, erection, testing and commissioning of various equipment and maintenance of records. In this regard, the Employer has already prepared Standard Field Quality Plan for transmission line/substation equipments as applicable, Civil/erection Works which is required to be followed for associated works.

The Employer or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and

procedure of the Contractor/his vendor's quality management and control activities.

➔ **Quality Assurance Documents**

The Contractor shall ensure availability of the following Quality Assurance Documents:

- i) All Non-Destructive Examination procedures, stress relief and weld repair procedure actually used during fabrication, and reports including radiography interpretation reports.
- ii) Welder and welding operator qualification certificates.
- iii) Welder's identification list, welding operator's qualification procedure and welding identification symbols.
- iv) Raw Material test reports on components as specified by the specification and in the quality plan.
- v) The Manufacturing Quality Plan(MQP) indicating Customer Inspection Points (CIPs) at various stages of manufacturing and methods used to verify that the inspection and testing points in the quality plan were performed satisfactorily.
- vi) Factory test results for testing required as per applicable quality plan/technical specifications/GTP/Drawings etc.
- vii) Stress relief time temperature charts/oil impregnation time temperature charts, wherever applicable.

INSPECTION, TESTING & INSPECTION CERTIFICATE :

- 1) Contractor shall procure bought out items from sub-vendors as per the list in "Compendium of Vendors" available on POWERGRID web-site www.powergridindia.com after ensuring compliance to the requirements/conditions mentioned therein. Contractor shall explore first the possibilities of procuring the bought out items from POWERGRID approved existing vendors. In case of their unavailability / non-response, Contractor may approach POWERGRID for additional sub-vendor approval. In that case, the assessment report of proposed sub vendor by Contractor along with the enclosures as per Annexure-I shall be submitted within 60 days of the award. The proposal shall be reviewed and approval will be accorded based on the verification of the document submitted and/or after the physical

assessment of the works as the case may be. The physical assessment conducted by POWERGRID, if required, shall be on chargeable basis. Charges shall be as per the POWERGRID norms prevailing at that time, which shall be intimated by POWERGRID separately. If proposal for sub-vendor is submitted after 60 days, the Contractor's proposal normally will not be considered for current LOA. However, POWERGRID may process the case for developing more vendors for referred items, if found relevant. In all cases, It is the responsibility of the Contractor that Project activities do not suffer on account of delay in approval/non approval of a new sub-vendor.

For TL packages, the makes/model of items shall be finalized during approval of DRS by LD&C department.

The responsibility and the basis of inspection for various items & equipment is placed at **Annexure-II** along with the requirement of MQP (Manufacturing Quality Plan), ITP(Inspection & Test Plan), FAT(Factory Acceptance Test) which should be valid & POWERGRID approved and Level of inspection envisaged against each item.

Contractor shall ensure that order for items where MQP/ITP/FAT is required will be placed only on vendors having valid MQP/ITP/FAT and where the supplier's MQP/ITP/FAT is either not valid or has not been approved by POWERGRID, MQP shall be generally submitted as per POWERGRID format before placing order. A Copy of MQP format is placed at **Annexure – III**.

Items not covered under MQP/ITP/FAT shall be offered for inspection as per POWERGRID LOA/technical Specifications/ POWERGRID approved data sheets/ POWERGRID approved drawings and relevant Indian / International standards.

Inspection Levels: For implementation of projects in a time bound manner and to avoid any delay in deputation of POWERGRID or its authorized representative, involvement of POWERGRID for inspection of various items / equipment will be based on the level below:

Level –I: Contractor to raise all inspection calls and review the report of tests carried out by the manufacturer, on his own, as per applicable standards/ POWERGRID specification, and submit to concerned POWERGRID inspection office/Inspection Engineer. CIP/MICC will be issued by POWERGRID based on review of test reports/certificates of manufacturers.

Level – II: Contractor to raise all inspection calls and carry out the inspection on behalf of POWERGRID on the proposed date of inspection as per applicable standards/specification. However, in case POWERGRID wishes to associate itself during inspection, the same would be intimated to Contractor and CIP/MICC will be issued by POWERGRID. Else, Contractor would submit their test reports/certificates

to POWERGRID. CIP/MICC will be issued by POWERGRID based on review of test reports / certificates.

Level - III: Contractor to raise inspection calls for both, stage (as applicable) & final inspection and carry out the stage inspections(if applicable) on behalf of POWERGRID on the proposed date of inspection as per applicable standards/specification. However, in case POWERGRID wishes to associate itself during stage inspection, the same would be intimated to Contractor and CIP will be issued by POWERGRID. Else, Contractor would submit the test reports / certificates of stage inspection after their own review and CIP will be issued by POWERGRID based on review of test reports / certificates. Final inspection will be carried out by POWERGRID and CIP/MICC will be issued by POWERGRID.

Level – IV: Contractor to raise inspection calls for both, stage (as applicable) & final inspections. POWERGRID will carry out the inspection for both stage & final inspection as per applicable standards/specification and CIP/MICC will be issued by POWERGRID.

- 2) Contractor shall ensure that to implement the above inspection levels, particularly for the quality control and inspection at sub-vendor's works, they would depute sufficient qualified & experienced manpower in their Quality Control and Inspection department. Further, to assure quality of construction, Contractor shall have a separate workforce having appropriate qualification & experience and deploy suitable tools and plant for maintaining quality requirement during construction in line with applicable Field Quality Plan (FQP).
- 3) The Employer, his duly authorised representative and/or outside inspection agency acting on behalf of the Employer shall have at all reasonable times access to the Contractor's premises or Works and shall have the power at all reasonable times to ensure that proper Quality Management practices / norms are adhered to, inspect and examine the materials & workmanship of the Works, to carry out Quality/Surveillance Audit during manufacture or erection and if part of the Works is being manufactured or assembled at other premises or works. The Contractor shall obtain for the Employer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. The item/equipment, if found unsatisfactory with respect to workmanship or material is liable to be rejected. The observations for improvements during product/ process inspection by POWERGRID shall be recorded in Quality Improvement Register (available & maintained at works) for review & timely compliance of observations.
- 4) Contractor shall submit inspection calls over internet through POWERGRID website. The required vendor code and password to enable raising inspection call will be furnished to the main Contractor with in 30 days of award of contract on submission of documents by Contractor. After raising the inspection calls, Contractor shall then

proceed as per the message of that particular call which is available on the message board.

- 5) The Employer reserves the right to witness any or all type, acceptance and routine tests specified for which the Contractor shall give the Employer/Inspector Twenty one (21) days written notice of any material being ready for testing for each stage of testing as identified in the approved quality plan as customer inspection point (CIP) for indigenous inspections. All inspection calls for overseas material shall be given at least forty five (45) days in advance. Such tests shall be to the Contractor's account except for the expenses of the Inspection Engineer. The Employer/inspector, unless witnessing of the tests is waived by Employer, will attend such tests within Twenty one (21) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector three copies of tests, duly certified. Contractor shall ensure, before giving notice for type test, that all drawings and quality plans have been got approved. The equipment shall be dispatched to site only after approval of Routine and Acceptance test results and Issuance of Dispatch Clearance in writing by the Employer. CIP/Material Inspection clearance certificate (MICC) shall be issued by the Employer after inspection of the equipment or review of test reports as applicable. Employer may waive off the presence of Employer's inspecting engineer. In that case test will be carried out as per approved QP and test certificate will be furnished by the supplier for approval. CIP/MICC will be issued only after review and approval of the test reports.
- 6) Contractor shall generally offer material for inspection as per supply bar chart approved by POWERGRID and not before 30 days from schedule indicated in the bar chart. In case Contractor offers material(s) for inspection prior to 30 days from the scheduled date with necessary approval of POWERGRID, POWERGRID shall inspect the material and issue CIP only. However, in such an exceptional case, MICC shall be issued only as per provision of original / revised approved supply schedule.
- 7) Contractor shall minimize the number of inspection calls by offering optimum quantities in each inspection call at the respective manufacturer's works.
- 8) Contractor shall inspect the material themselves and only after they are fully convinced about the Quality, they shall offer the material for POWERGRID inspection and shall also ensure that relevant portion of LOA/NOA, approved drawing and data sheets along with applicable Quality Plans are available at the works of Contractor or their Sub-vendor before the material is offered for inspection.
- 9) Contractor shall ensure that material which has been cleared for dispatch after inspection will be dispatched within 30 days in case of domestic supplies and within 60 days in case of Off-shore supplies from the date of issuance of CIP. Material

which is not dispatched within stipulated time as above will be reoffered for POWERGRID inspection or specific approval of POWERGRID QA&I shall be obtained for delayed dispatch .

- 10) The Employer or IE shall give notice in writing to the Contractor, of any objection either to conformance to any drawings or to any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Employer/Inspection Engineer giving reasons therein, that no modifications are necessary to comply with the Contract.
- 11) All Test Reports and documents to be submitted in English during final inspection of equipment by POWERGRID or as and when required for submission.
- 12) When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer/Inspection Engineer(IE) shall issue a certificate to this effect within fifteen (15) days after completion of tests & submission of documents by Contractor/manufacturer but if the tests are not witnessed by the Employer/IE, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Employer/IE. Contractor shall, on completion of all tests, submit test reports within Ten (10) days to POWERGRID IE. Failure of the Employer/IE to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract.
- 13) In all cases, where the Contract provides for tests whether at the premises or works of the Contractor or of any Sub- Contractor, the Contractor, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer/Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer/Inspection Engineer or to his authorised representative to accomplish testing.
- 14) The inspection and acceptance by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality assurance programme forming a part of the Contract, or if such equipment is found to be defective at a later stage.
- 15) The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.

- 16) The Employer reserves the right for getting any additional field tests conducted on the completely assembled equipment at site to satisfy that material complies with specifications.
- 17) Rework/ Re-engineering, if any, on any item/equipment shall be carried out only after mutual discussions and in accordance with mutually agreed procedure. Contractor shall submit Joint Inspection Report of equipments under Re-Work/Re-Engineering alongwith procedure for the same to POWERGRID for approval, before taking up the Re-Work/Re-Engineering, failing which POWERGRID reserves the right to reject the equipment.
- 18) Contractor may establish a field test Laboratory to execute Civil Construction testing requirements at site with the condition that all testing equipment shall be calibrated from POWERGRID approved accredited Testing laboratories, with calibration certificates kept available at site and all testing personnel employed in the Field Testing Laboratories to be qualified and experienced Engineers or testing to be carried out at POWERGRID approved Third Party Laboratories.
- 19) Contractor shall ensure that all possible steps are taken to avoid damages to the equipment during transport, storage and erection.
- 20) The Employer reserves the right to increase or decrease their involvement in inspections at Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work based on performance of Contractor/sub Contractor.

Assessment report from Contractor for proposed sub-vendor along with following enclosures (to the extent available):

1. Registration / License of the works
2. Organization chart with name and qualification of key persons
3. List of Plant and Machinery.
4. List of testing equipment with their calibration status.
5. List of Raw material, bought out items with sourcing details
6. List of out-sourced services with sourcing details.
7. List of supply in last three years.
8. Third party approval, if any (viz. ISO, BIS),
9. Pollution clearance wherever applicable
10. Energy Conservation & Efficiency report
(Applicable to industries having contract load more than 100 KVA)
11. Formats for RM, in process and acceptance testing
12. Type test approvals conducted in last 5 years, if applicable
13. Performance Certificates from customers
14. Photographs of factory, plant and machinery & testing facilities

Annexure-II

MQP & INSPECTION LEVEL REQUIREMENT

Sl. No.	Item / Equipment	Requirement of MQP/ITP/FAT	Inspection Level
1	Battery	No	II
2	Battery Charger	Yes	III
3	Test Equipment	No	I *
4	FO Cable	Yes	III
5	OPGW & H/W	Yes	III
6	FODP including pigtail	No	II
7	Hardware Fittings for Fibre Optic approach cable	Yes	III
8	SDH Equipments (ADM), PDH, Primary Multiplexer	Yes	IV
9	Drop & Insert Multiplexer	Yes	IV
10	DACS	Yes	IV
11	Main Distribution Frame	No	I
12	HDPE Pipe	No	II
13	NMS, TMN	Yes	IV
14	Synchronization Equipment	No	Level-I
15	48V DCPS	Yes	III
16	Furniture	No	I

Note:

- * MICC for test and measuring equipment shall be issued only after actual verification/demonstration of satisfactory performance at site.
- ** Though level-2 items, CIP can be issued also on review of TCs and visual inspection of these items.

MANUFACTURING QUALITY PLAN

Page 1 of 2

	Manufacturers Details (Name, Works Address etc.)	Customer POWERGRID	Vendor's Code:	Item:	Q.P. No. Rev. No. Date:	Valid From: Valid Upto:
--	--	---------------------------	-------------------	-------	---------------------------------------	--------------------------------------

Sr. No.	Components / Operations & Description of Test	Type of check	Quantum of Check / Sampling with basis	Reference document for Testing	Acceptance Norms	Format of Record	Applicable Codes						Remarks
							1	2	3	4	5	6	
	A. Section: RAW MATERIAL INSPECTION												
	B. Section : IN PROCESS INSPECTION												
	C. Section: FINAL TESTING												

D. Section: PACKING & DISPATCH															
-----------------------------------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

MANUFACTURING QUALITY PLAN

Page 2 of 2

		Customer POWERGRID	Vendor's Code:	Item:	Q.P. No. Rev. No. Date:	Valid From: Valid Upto:
--	--	---	-----------------------	--------------	--	--

Code 1 Indicates place where testing is planned to be performed i.e. Inspection location A At Equipment Manufacturer's works B At Component Manufacturer's works C At Authorised Distributor's place D At Independent Lab E At Turn Key Contractor's location F Not specified	Code 2 Indicates who has to perform the tests i.e. Testing Agency J The Equipment Manufacturer The Component K Manufacturer L The Third Party M The Turnkey Contractor
Code 3 Indicates who shall witness the tests i.e. Witnessing Agency P Component Manufacturer itself Q Component Manufacturer and Equipment Manufacturer Component Manufacturer, Equipment Manufacturer and Contractor R Equipment Manufacturer itself S Equipment Manufacturer and Contractor T Equipment Manufacturer, Contractor and POWERGRID U Third Party itself	Code 4 Review of Test Reports/Certificates By Equipment manufacturer during raw material/bought out component Inspection. W By Contractor during product/process inspection X By POWERGRID during product/process inspection Y By Contractor and/or POWERGRID during product/process inspection Z

Code 5	Whether specific approval of sub-vendor / Component make is envisaged?	Code 6	Whether test records required to be submitted after final inspection for issuance of CIP/MICC
E	Envisaged	Y	Yes
	Not Envisaged	N	No

-----**End of this Section**-----

Section-4 Support Services & Documentation

TABLE OF CONTENTS

4.1	Support Services	2
4.1.1	Technical Support	2
4.2	Spare Parts	2
4.2.1	Mandatory Spare Parts	2
4.2.2	Recommended Spare Parts List	2
4.3	Miscellaneous Supplies.....	4

Section – 4**Support Services & Documentation**

This section describes the requirements for Contractor-supplied support services and list of documents of the fibre optic cable system. The intent of the support program is to ensure for operation, maintenance and expansion of the system.

4.1 Support Services

Throughout design, implementation, factory testing, and site testing, the Contractor shall supply consulting assistance, as required by the Employer.

4.1.1 Technical Support

Consultation with Contractor's technical support personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining OPGW cable & associated items upon expiration of the warranty period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above.

4.2 Spare Parts and Test Equipment

The spare parts and test equipment shall be provided for each subsystem as described below.

4.2.1 Mandatory Spare

The mandatory spare BoQ represents the minimum spares the Contractor shall be required to supply.

4.2.2 Recommended Spare Parts List

The bidder shall propose a comprehensive spare parts strategy. The intent of the spare parts strategy is to ensure a readiness against unforeseen cabling system breakdowns, and to carry out replacement maintenance of susceptible or failed components. Consistent with the proposed spare parts strategy, the bidder shall provide a list of "Recommended Spare Parts", which may be required over and above the spares listed in Mandatory Spare parts list to support the fibre optic cabling system during a one-year period. This list of spares shall be called the "Recommended Spare Parts List".

The Recommended spare parts list shall not be considered for evaluation and shall be included in the final scope of supply. The Bid shall include the following minimum information for the recommended spare parts:

Original manufacturer and part number
Name and Description
Number of units in each set
Total number of sets to be provided

The unit as well as set prices shall be provided in the appropriate Bid Price Schedule.

4.3.1 Test Equipment (as required if specified in BoQ)

Mandatory test equipment requirements has been specified in the BoQ. The parameters / features of the mandatory equipments are enumerated in Table 4.1 below:

Table 4.1		
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 Talk set.	Equivalent to JDSU OTS55 or better.
6	Optical Fibre Fusion Splicer incl. Fibre cleaver	Equivalent to Sumitomo T-39-SE or better.
7	Calibrated Fibre	
8	Connectorization kit	FIS–FI-0053-FC-INST or equivalent
8	Splice kit	FIS – FI-0053-FF or equivalent
9	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.

4.3 Miscellaneous Supplies

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance. However, if there are any problems in the SAT and additional consumables are required, the same shall also be supplied by the Contractor free of cost.

----- End of Section-4 -----

Section 5
Specifications for Aerial cabling (ADSS) and associated hardware & fittings

Table of Contents

5.0 Self Supporting Metal Free Aerial Fibre Optic Cable

5.1 Basic Construction

5.1.1 Secondary Protection

5.1.2 Number of fibres

5.1.3 Required Optical Fibre Characteristics

5.1.4 Strength Member

5.1.5 Cable Core Assembly

5.1.6 Core Wrapping

5.1.7 Moisture barrier (Protection)

5.1.8 Filling compound

5.1.9 Inner Sheath

5.1.10 Reinforcement

5.1.11 Outer jacket

5.1.12 Cable diameter and tolerance

5.1.13 RIP Cord

5.1.14 Raw Material

5.1.15 Cable Material Compatibility

5.1.16 Safety Requirement

5.1.17 Operating requirement

5.1.18 Sag of the span lengths

5.1.19 FO Cable Link Lengths

5.1.20 Cable Ends

5.1.21 The nominal drum length

5.1.22 Optical Fibre Strain

5.1.23 Cable Marking

5.3 Installation, Accessories and Fixtures for Aerial Cable

5.3 Optical Fibre Splicing

5.3.1 Optical Fibre Termination and Splicing

5.3.2 Optical Fibre Connectors

5.3.3 Service Loops

5.4 Methodology for Installation and Termination

5.5 Cable Raceways

Section 5

Specifications for Aerial Fibre Optic cabling and associated hardware & fittings

This Chapter describes the functional & technical specifications of Aerial Fibre Optic cabling and associated hardware & fittings.

5.0 Self Supporting Metal Free Aerial Fibre Optic Cable (ADSS)

Self Supporting Metal Free Aerial Optical Fibre Cable shall be installed on existing 33/11kV lines. The estimated cable route length requirements are indicated in the appendices. However, the Contractor shall supply & install the Self Supporting Metal Free Aerial Optical Fibre Cable as required based on detailed site survey to be carried out by the Contractor during the project execution. The Contract price shall be adjusted accordingly.

5.1 Basic Construction

The Metal Free Aerial Optical Fibre Cable shall be low in weight, and shall have small diameter, small volume and high flexibility. The Optical Fibre cable shall also have good mechanical protection with stable temperature performance conditions, as it will be exposed to varying environmental conditions in the field like applicable wind loading.

5.1.1 Secondary Protection

The secondary protection may be provided for the primary coated fibres by loose packaging within a tube or tubes and or in groove, which shall be filled with thixotropic jelly.

5.1.2 Number of fibres

Twenty Four (24) nos. of DWSM G.652D fibres shall be provided in the cable.

5.1.3 Required Optical Fibre Characteristics

DWSM fibres shall conform to ITU-T G.652D and the characteristics are specified in Chapter-02 of this specification.

5.1.4 Strength Member

The strength member (s) shall be provided for strength and flexibility of the cable. The strength member(s) shall be solid FRP non-metallic and shall have anti buckling properties. These shall also keep the fibre strain within permissible values. The non-metallic strength member(s) may be in the cable core or embedded within the sheath.

5.1.5 Cable Core Assembly

Primary coated fibres in loose tube/tubes and/or in groove stranded together around a central strength member using helical or reverse lay techniques shall form the cable core. Alternatively multiple units of fibres may be placed loosely in a single tube with the strength members in the sheath.

5.1.6 Core Wrapping

The main cable core containing fibres shall be wrapped by layer/layers of Polyester foil/tape. The nylon/polyester binder tape or thread shall be used to hold the tape if required.

5.1.7 Moisture barrier (Protection)

The main cable core (containing fibres & core wrapping) shall be protected by flooding compound (jelly) have properties of non hygroscopic dielectric material and/or by water swellable tape. The core wrapping shall not adhere to the secondary fibre coating.

5.1.8 Filling compound

The filling compound used in the loose tube and in the cable core shall be compatible to fibre, secondary protection of fibre, core wrapping etc. The drip point shall not be lower than +70 degree C. The fibre movement shall not be constrained by stickiness & shall be easily removable for splicing. Reference material test method to measure drop point shall be as per ASTM D 556. The filling and the flooding jelly compound shall be as per the latest TEC specs or equivalent.

5.1.9 Inner Sheath

A non-metallic moisture barrier sheath may be applied over and above the cable core. The core shall be covered with tough weather resistant High Density Polyethylene (HDPE) sheath black in colour (UV Stabilised). Thickness of the sheath shall be uniform & shall not be less than 1.8 mm including the strength members if used in the sheath. The sheath shall be circular, smooth, free from pin holes, joints, mended pieces and other defects. Reference test method to measure thickness shall be as per IEC 189 para 2.2.1 and para 2.2.2.

5.1.10 Reinforcement

The aerial optical fibre cable shall be reinforced with Aramid Yarn in the periphery over the inner sheath. The Aramid Yarn shall be uniformly and equally distributed on the entire periphery (circumference) of the cable. The quantity of the Aramid Yarn used per kilometre length of the cable with its D-Tex value shall be indicated by the Contractor.

5.1.11 Outer jacket

Outer jacket shall be circular and uniform tough weather resistant & UV stabilised polyethylene compound HDPE material. Sheath/jacket black in colour shall be provided over and above the

reinforcement of aramid yarn. The thickness of the outer sheath/jacket shall not be less than 2.0 mm. The sheath shall be free from pin holes, joints, scratches, mended pieces and other defects etc. and it shall have smooth finish.

5.1.12 Cable diameter and tolerance

The manufacturer shall define the cable diameter. The finished cable diameter shall be within ± 0.5 mm from the defined cable diameter.

5.1.13 RIP Cord

The two suitable (minimum) water blocking rip cords shall be provided which shall be used to open the inner and outer (HDPE) sheath of the cable. It shall be capable of consistently slitting the sheath without breaking for a length of 1 meter at the installation temperature. The rip cord(s) shall be properly waxed to avoid wicking action and shall not work as water carrier. The rip cord used in the cable shall be readily distinguishable from any other components (e.g. Aramid Yarn etc.) utilized in the cable construction.

*The Contractor may offer cable(s) of other design, however, the offered cable shall meet the specified technical and testing requirements. The Bidder shall submit details of cable design, test reports and customers certificates for successful operation of the offered cable.

5.1.14 Raw Material

The cable shall use the raw materials approved against the latest TEC specs or equivalent. The change in the design of the optical cable shall call for fresh type testing. The HDPE Black in colour used for sheath shall be UV stabilized and shall withstand UV test for 2000 hrs (minimum). The material used in optical fibre cable must not evolve hydrogen that will affect the fibre loss.

A test certificate from a recognized laboratory or institute may be acceptable.

5.1.15 Cable Material Compatibility

Optical fibre, buffers/core tubes, and other core components shall meet the requirements of the compatibility with buffer/core tube filling material(s) and/or water-blocking materials that are in direct contact with identified components within the cable structure as per latest TEC specs or equivalent.

5.1.16 Safety Requirement

The material used in the manufacturing of the optical fibre cables and for use in splicing and maintenance shall be non-toxic and dermatologically safe in its life time and shall not be hazardous to health.

5.1.17 Operating requirement

The design and construction of aerial metal free optical fibre cable shall be inherently robust and rigid under all conditions of operation, adjustment, replacement, storage and transport. The optical fibre cable shall be able to work in the environment prevailing in Northern Part of India. The Contractor shall take into consideration the UTS of transmission line while designing the Aerial Cable. The details of the transmission lines are given in appendices.

Life of cable shall be at least 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

It shall be possible to operate and handle the aerial metal free optical fibre cable with tools as per latest TEC specs or equivalent.

It shall be possible to install the Aerial optical fibre cable with accessories and fixtures as per the latest TEC specs or equivalent.

The Aerial optical fibre cable shall work satisfactorily in electrical field environment of 11 KV and shall not degrade with presence of electrical field. The cable shall be installed on 33KV/11KV lines and the fittings location shall be so selected the field at the point of installation shall not exceed 11 KV.

The Self Supporting Metal Free Aerial Optical Fibre Cable shall be designed and manufactured to meet the following minimum conditions of operation, installation & storage:

- | | | | |
|-----|----------------------------|---|----------------------------------|
| (a) | Minimum design Span length | : | 100 meters |
| (b) | Wind Speed | : | As applicable for specified site |

The bidder may consider the minimum design span length of 100 meter for bidding purpose. However, actual span length shall be determined by the Contractor during the site survey.

The supplied cable shall meet the span, wind loading requirement of the specified location where the cable is to be installed.

5.1.18 Sag of the span lengths

- (i) Maximum sag allowed without excess load (i.e. with self weight and no wind & ice load condition) : 1% of the span length.

- (ii) Maximum sag allowed with excess load (i.e. with all applicable loads) : 2% of the span length

Temperature range

- | | | | |
|-------|--------------|---|-----------------|
| (i) | Operation | : | -20°C to +70°C |
| (ii) | Installation | : | -15°C to + 50°C |
| (iii) | Storage | : | -50°C to + 70°C |

Tensile force design parameter : As required to meet the specified requirement.
Minimum bending Radius : 20 D (D is diameter of the cable)

5.1.19 Optic 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 limit the wastages of cable upto 4% by utilising the cable optimally for various links and splicing shall be allowed on any pole for which hardware fittings as required shall be supplied. Extra length beyond 4% shall attract recovery of cost of OPGW and installation shall be payable on route length basis.

5.1.20 Cable Ends

Both cable ends (the beginning end and end of the cable reel) shall be sealed and readily accessible. Minimum 5 meter of the cable of the beginning end of the reel shall accessible for testing. Both ends of the cable shall be kept inside the drums and shall be located so as to be easily accessible for the test. The drum (confirming to latest TEC Specs or equivalent) should be marked to identify the direction of rotation of the drum. Both ends of cable shall be provided with cable pulling (grip) stocking and the anti twist device (free head hook).

Anti-twist device (Free head hook) shall be provided attached to the both end of the cable pulling arrangement. The arrangement of the pulling eye and its coupling system along with the anti twist system shall withstand the prescribed tensile load applicable to the cable.

5.1.21 The nominal drum length

Generally, the length of aerial optical fibre cable in each drum shall be 2 km $\pm$ 5 %. However, the

cable drum lengths shall be supplied as per the approved drum schedule. The drum shall be marked with arrows to indicate the direction of rotation. Packing list supplied with each drum shall have at least the following information: Drum no., Type of cables, Physical Cable length, No. of fibres, Length of each fibre as measured by OTDR, The cable factor – ratio of fibre/cable length, Attenuation per km. of each fibre at 1310 & 1550 nm, User's/consignee's name, Manufacturer's Name, Month, Year and Batch no., Name of the route.

5.1.22 Optical Fibre Strain

The following shall be ensured while performing sag tension calculations:

- (a) The Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is no fibre strain.
- (b) The cable strain margin is defined as the maximum cable strain at which there is no fibre strain.
- (c) The maximum allowable tension (MAT) is defined as the maximum tension experienced at worst wind load and snow load conditions.
- (d) The Cable everyday tension (EDT) is defined as the maximum cable tension at 32 degree C, no wind load and no ice load.
- (e) The ultimate/ rated tensile strength test is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.
- (f) The no fibre strain condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurement through IEC/ETSI(FOTP) specified optical reflectometry techniques.

The Contractor shall offer suitable aerial optical fibre cable for various spans for the aerial FO cable meeting the following conditions for Employer's approval:

- (i) The MAT / maximum strain shall be less than or equal to the MWT / strain margin of the cable.
- (ii) The sag shall meet the requirement specified in this technical specification
- (iii) The MAT shall be less than or equal to 0.4 times the rated UTS of the cable.
- (iv) The EDT shall not exceed 20 % of the rated UTS of the cable.
- (v) The ground clearance & Electrical clearance shall be met for the actual site conditions.

- (vi) There should not be any fibre strain at any condition.

5.1.23 Cable Marking

The cable marking shall be imprinted and indelible (indented). The marking on the cable shall be indelible of durable quality and at regular intervals of one meter length. Alternatively permanent printing with the laser shall also be acceptable. In case of laser printing method; the impression shall not exceed the depth of 0.15 mm. The accuracy of the sequential marking must be within -0.25% to $+0.5\%$ of the actual measured length. The markings on the cable must not rub off during normal installation.

The marking shall be of clearly contrast colour on the black HDPE sheath in case hot foil indentation method is used. The colour used must withstand the environmental influences experienced in the field.

Two orange colour (UV stabilized) lines of minimum 3 mm width diametrically opposite to each other, continuous over the length of the cable shall be applied (marked) for easy identification of this cable from other cables.

The type of legend marking on O.F. cable shall be as follows:

- (i) Company Legend
- (ii) Legend containing international acceptable Laser symbol
- (iii) Type of cable i.e. Slotted or Loose Tube or Uni-tube (Central Tube)
- (iv) Type of Fibre i.e. DWSM
- (v) Number of Fibres
- (vi) Year of manufacturer
- (vii) Sequential length marking
- (viii) Employer's Name

5.2 Installation, Accessories and Fixtures for Aerial Cable

The scope of supply of the Self Supporting Metal Free Aerial Optical Fibre Cable includes the assessment, supply and installation of all required installation accessories and fixtures. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware used. To ensure their satisfactory performance, the Contractor shall determine the exact requirements of all accessories and fixtures used to install and secure the cable.

The cable hardware accessories and fixtures shall follow the general requirements regarding design, materials, dimensions & tolerances and markings etc. as specified in latest TEC spec and equivalent. The cable accessories & fixtures 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 required joint box shall also be provided by the Contractor and the details of which shall be submitted for Employer's approval. The joint box shall comply to ingress protection class IP 66 or better. The in-line splice enclosures shall be metallic type and support mechanical opening and closing.

The required strengthening of existing structures/towers/poles shall be carried out by the Contractor for installation of offered aerial cable. Additional poles, if required, shall also be supplied and installed at no additional cost to the Employer.

As the aerial cable is designed for 100 m span for self supporting condition and for the span greater than 100 m, the additional strength wire alongwith the clipping arrangement and/or poles to support the aerial cable for installation of aerial cable system shall also be provided by the Contractor at no additional cost to the Employer. However, the actual span lengths may vary at site and the fittings & accessories shall be provided as per site requirement.

The above requirement of additional poles, strength wires, strengthening of existing structure/poles/towers shall be submitted by the Contractor for Employer's approval and same shall be provided as per approval.

5.3 Optical Fibre Splicing

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

- (a) All fibre splices shall be accomplished through fusion splicing.
- (b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
- (c) All splices and bare fibre shall be neatly installed in covered splice trays. No more than six (6) fibres shall be installed in each splice tray.
- (d) For each link, bi-directional attenuation of single mode fusion splices measured at 1550 nm shall not average more than 0.05 dB. The bi-directional splice loss of each splices shall not exceed 0.1 dB when measured at 1550 nm.
- (e) For in-line 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.

5.3.1 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

The technical specification of FODP is given in Chapter -02 of this specification.

5.3.2 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.

5.3.3 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.
- (f) 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.

5.3.4 Anti Rodent Compliance

ADSS cable is to be installed on rodent prone areas; ADSS should have anti rodent complied.

5.4 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

5.5 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

- (a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

- (b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to- paint bond.
- (c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review.

.....**End of this Chapter**.....

Underground Fibre Optic Cabling and associated hardware & fittings

- 1.1 Under Ground FO Cable
 - 1.1.1 General
 - 1.1.2 Applicable Standards
 - 1.1.3 Fibre Type(s) and Counts
- 1.2 General Cable Constructions
 - 1.2.1 Colour Coding & Fibre Identification
 - 1.2.2 Strength Members
 - 1.2.3 Filling Compound
 - 1.2.4 The Sheath / Inner jacket
 - 1.2.5 The Outer Jacket/ Termite protection
 - 1.2.6 Rip Cord
 - 1.2.7 Mechanical Parameters & Tests
 - 1.2.8 Cable drums, Marking, Packaging and Transport
 - 1.2.8.1 Optical fibre cable marking
 - 1.2.8.2 Operating Instructions
 - 1.2.9 Test and Inspection:
 - 1.2.9.1 Type Testing
 - 1.2.9.2 Factory Acceptance Testing
- 1.3 PLB HDPE pipe and ACCESSORIES
 - 1.3.1 Construction of PLB HDPE pipe
 - 1.3.2 General
 - 1.3.3 Material
 - 1.3.4 Dimension of pipe
 - 1.3.5 Accessories of PLB HDPE pipe
- 1.4 Workmanship
- 1.5 Marking
- 1.6 Type Tests and Factory Acceptance Tests
 - 1.6.1 Type Test
 - 1.6.2 Factory Acceptance Testing
- 1.7 Joint Box
 - 1.7.1 Construction of Joint Box
 - 1.7.2 Main Box
 - 1.7.3 Cable organizer (Strength member and cable termination)
 - 1.7.4 Fibre organiser/ Fibre Splice trays
 - 1.7.5 Holding Arrangements
 - 1.7.6 Compatibility
 - 1.7.7 Marking on body of the Joint box
- 1.8 General
- 1.9 Joint box Installation
- 1.10 Tests and Inspection:
 - 1.10.1 Type tests
 - 1.10.2 Factory acceptance tests
- 1.11 Packing and Transportation:
- 1.12 Installation of Underground Fibre Optic Cable System
 - 1.12.1 Survey
 - 1.12.1.1 Identification of under ground fibre cable route:
 - 1.12.1.2 Survey Report
 - 1.12.1.3 Payment

1.12.2 Clearances

1.12.3 Excavation and Backfilling for Open Cut Trenching

1.12.3.1 Excavation

1.12.3.2 Backfilling

1.12.3.3 Warning Bricks

1.12.3.4 Warning Tape

1.12.4 Payments

1.12.5 Installation of PLB HDPE Pipe

1.12.5.1 Payment

1.12.6 Manholes

1.12.6.1 Payment

1.12.7 Reinstatement

1.12.8 Installation of GI Pipe

1.12.8.1 Payments

1.12.9 Installation of RCC Hume Pipe

1.12.9.1 Payment

1.12.10 Underground Fibre Optic Cable Installation

1.12.10.1 Payment

1.12.11 Trenchless Digging

1.12.11.1 Contractor's Scope of Work for Trenchless Digging

1.12.11.2 Clearances

1.12.11.3 Site Investigation

1.12.11.4 Site Preparation

1.12.11.5 Excavation and Backfilling

1.12.11.6 Trenchless Digging method

1.12.11.7 Installation of PLB HDPE pipes and manholes

1.12.11.8 Acceptance testing of PLB HDPE pipes

1.12.11.9 As Built Drawings/details

1.12.11.10 List of Drawings/documents required to be submitted for Employer' approval

1.12.11.11 Payment

1.12.12 Optical fibre termination and Splicing

1.12.12.1 Fibre Optic Distribution panels

1.12.12.2 Optical Fibre Connectors

1.12.12.3 Joint Box

1.12.12.4 Optical Fibre Splices

1.12.12.5 Splicing of fibres in existing Joint Box or FODP

1.12.12.6 Service Loops.

1.12.13 Site Acceptance Testing (SAT)

1.12.13.1 SAT for Excavation, Backfilling, Installation of Pipes, Manholes.

1.12.13.2 SAT for Underground Fibre Optic Cable

1.12.13.3 SAT for Joint Box

1.12.13.4 SAT for PLB HDPE pipe

1.12.13.5 SAT for other items

1.12.14 Documentation

1.12.15 Interconnection

1.12.16 Miscellaneous Jobs

1.12.16.1 Routing of Cables inside building.

1.12.16.2 Installation of PLB HDPE pipe on wall

Underground Fibre Optic Cabling and associated hardware & fittings

This section describes the functional requirements, major technical parameters and Type testing, Factory Acceptance Testing & Site Acceptance Testing requirements for underground fibre optic cables, HDPE pipes, Joint Box, Marking, packaging, and transportation installation requirements have also been described. The under ground FO cable route length has been specified in the BOQ. The payment will be made for the executed route length only. However, specified service loops and lengths for wastage, installation/working for FO cable & HDPE ducts shall be considered as required by the bidder for which no additional payment will be made.

1.1 Under Ground FO Cable

1.1.1 General

The underground fibre optic cable (UGFO) shall be unarmoured metal free with double HDPE sheath wet core (Type-1). This non-Nylon, metal free Optical fibre cable shall be suitable for underground installation in pipes/ducts. The cable shall have double HDPE jacketing. The optical fibre cable shall be suitably protected for the ingress of moisture by flooding jelly/WS yarn and WS tape. The UGFO cable should be of low weight, small volume and high flexibility. The mechanical design and construction of each unit shall be inherently robust and rigid under all condition of operation, adjustment, replacement, storage and transport.

1.1.2 Applicable Standards

The cable shall conform to the standards named below and the technical specifications described in the following sections.

- i). ITU-T Recommendations G.652
- ii). Electronic Industries Association, EIA/TIA 455-78A, 455-3A, 455-62A, 455-164A/167A/174, 455-168A/169A/175A, 455-176, 455-59, EIA/TIA 598, EIA 455-104.
- iii). International Electro technical Commission standards, IEC60304, IEC60794-1-2, IEC60811-5-1.
- iv). Bellcore GR-20
- v). Telecom Engineering Centre (TEC), Department of Telecom, Govt. of India (TEC-spec no-GR/OFC-17/01, June 2007)
- vi). TEC GR for raw material (GR No. TEC/GR/TX/ORM- 01/04 Sept. -09 with errata no. 01 dtd. 25.03.2014 and subsequent amendments, if any.

1.1.3 Fibre Type(s) and Counts

The cable shall consist of Dual Window Single Mode (DWSM) fibres conforming to G.652D and the Technical parameters stipulated in Section-02 of the technical specification.

1.2 General Cable Construction

The optical cable shall consist of a central fibre optic unit protected by one or more layers of helically wound anti-hygroscopic tape or yarn. The central fibre optic unit shall be designed to house and protect the fibres from damage due to forces such as crushing, bending, twisting, tensile stress and moisture, wide temperature variations, hydrogen evolution etc. The fibre optic unit shall be of loose tube construction. The inner polyethylene jacket and outer sheath jackets shall be free from pinholes, joints, splits or any other defects. All fibre optic cable shall have a

minimum service 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.

The cable construction and mechanical parameters for the unarmoured OFC shall be as specified in the Table 3-1 below.

Table 1-1 Unarmoured Cable Construction and Mechanical Parameters		
Parameter	Units	Description
No. of fibers in the cable		24 / 48
Type of fibers		G.652D
No. of fibers per tube		4 for 24F 8 for 48F
No. of loose tubes		6
Cable diameter (Nominal + tolerance)	mm	13.2±1
Nominal Cable Weight	Kg/km	140(approx.)
Min Continuous length		2km±10%, 4km±5%,
Cable Design Life		More than 25 years

1.2.1 Colour Coding & 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. The colour coding system shall be discernible throughout the design life of the cable. 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 are included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibre shall be suitably bundled, tagged, and identified at the factory. The colouring scheme shall be submitted along with the cable DRS/drawing for Employer's approval.

1.2.2 Strength Members

The central fibre optic unit should include a central strength member of Fibre Reinforced Plastic (FRP) or other suitable material. Peripheral strength members and aramid yarns are also acceptable. The central FRP strength member may be slotted type with SZ lay (reverse oscillation lay) of fibre units or it may be cylindrical type with helical lay of fibre units.

1.2.3 Filling Compound

The interstices of the central fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any longitudinal water 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 **IEC60794-1-2-F5**. The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, anti-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the

generation of hydrogen within the cable. The filling compound shall remain stable for ambient temperature up to +70°C and shall not drip, flow or leak with age or at change of temperature. Reference method to measure drip point shall be as per **IEC 60811-5-1** and drip point shall not be less than 70°C.

1.2.4 The Sheath / Inner jacket

The sheath shall be black, smooth, concentric, and shall be free from holes, splits, blisters and other surface flaws. The sheath shall be extruded directly over the central fibre optic unit and shall also be non-hygroscopic. The cable sheath design shall permit easy removal without damage to the optical fibres or fibre units. The sheath shall be made from good quality of weather resistant polyethylene compound (Black High Density Polyethylene- HDPE) and thickness shall be > 1.2mm.

1.2.5 The Outer Jacket/ Termite protection

The outer jacket shall be made of non-Nylon HDPE sheath, the HDPE sheath shall be as outer jacket. The outer jacket shall have smooth finish and shall be termite resistant. HDPE sheath thickness shall be > 1.6mm.

1.2.6 Rip Cord: Suitable rip cord(s) shall be provided to open the outer sheath of the cable. The rip cord(s) shall be properly waxed to prevent wicking action and shall not work as a water carrier.

1.2.7 Mechanical Parameters & Tests : The offered cable shall meet requirement of mechanical characteristic & tests specified in latest TEC specifications.

1.2.8 Cable drums, Marking, Packaging and Transport

All optical fibre cable shall be supplied on strong wooden drums provided with lagging with adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. The cable drum shall be suitable to carry underground fibre optic cable of length upto 4 Km $\pm 5\%$ or 2 km $\pm 10\%$. The Contractor may offer higher cable drum length in straight routes subject to transportation, handling and installation limitations. However, the exact lengths for drums to be supplied for each link shall be determined by the Contractor during detailed engineering/survey. Drum schedule shall be approved by the Employer before manufacturing the FO cable. Both cable ends in the drum shall be sealed and shall be readily accessible. The drum shall be marked with arrows to indicate the direction of rotation. Both the ends of the cable shall be provided with pulling eye. The pulling eye and its coupling system should withstand the same tensile load as applicable to the cable. The following marking shall be done on each side of the cable drums.

- i) Drum number
- ii) Consignee's name and address
- iii) Contractor's name and address
- iv) Type of cable
- v) Number of fibres
- vi) Type of fibres
- vii) Year of manufacturing, month & batch no
- viii) Name of manufacturer

- ix) Total cable length
- x) Inner end marking and Outer end marking

Packing list supplied with each drum shall have all the information provided on marking on the respective cable drum and following additional information: OTDR length measurement of each fibre and Ratio of fibre and cable length.

1.2.8.1 Optical fibre cable marking

A suitable marking shall be applied in order to identify this cable from other cables. Marking on the cable shall be indelible, of durable quality, shall last long and shall be applied at regular interval of one-meter length. Marking shall be imprinted and must clearly contrast with the surface and colors used must withstand the environmental influences experienced in the field. The accuracy of the sequential marking must be within $\pm 0.5\%$ of the actual measured length. The sequential length marking must not rub off during normal installation. In case laser printing is used the marking shall not exceed 0.15 mm depth. The optical fibre cable shall have the following markings in every meter.

- i) Type of Cable
- ii) Running meter length
- iii) Number of fibres
- iv) Type of fibre
- v) Laser symbol & caution notice
- vi) Year of manufacture and batch no.
- vii) Manufacturer's name
- viii) Employer's Name

1.2.8.2 Operating Instructions

Complete technical literature in English with detailed cable construction diagram of various sub-component with dimensions and test data of the cable shall be provided. All aspects of installation shall also be covered in the handbook.

1.2.9 Test and Inspection:

The general conditions for Type, Factory Acceptance Testing & Site Acceptance testing shall be as per Section-08 of the technical specifications.

1.2.9.1 Type Testing

The Bidder shall have valid Type Approval Certificate (TAC) from TEC/Technical Specification Evaluation Certificate(TSEC) given by BSNL QA for 24F/48F Metal Free Optical Fibre Cable with double HDPE sheath OFCs at the time of bid submission and a copy of valid TAC/TSEC certificate shall be submitted and proof for submission shall be submitted along with the bid. However, the bidder shall ensure that in all the cases the TSEC/TEC certificate would be valid at the time of award. In case type approval certificate validity expires after placement of Letter of Award (LoA), the contractor shall take advance action so that the supply is not delayed due to non-availability of type approval certificate for the offered fibre optic cable meeting the requirement. In case, TSEC/TEC certificate of UGFO cable is not available, the Contractor shall submit the previously carried out type test report for the same design of cable for the tests listed in Table 3-2(a) below. The fibre should have been type tested as per relevant International

standards for the tests listed in Table-3-2(b) and the Bidder shall submit the test reports and certificates along with the bid. The Contractor shall submit the type test reports of fibres meeting the minimum requirement specified in Tables-3-2(b) below.

Table 3-2 (a) Type tests for Under ground Fibre Optic Cable	
1.	Tensile Strength Test
2.	Abrasion Test
3.	Crush Test (Compressive Test)
4.	Impact Test
5.	Repeated Bending Test
6.	Torsion Test
7.	Kink Test
8.	Cable Bend Test
9.	Temperature Cycling
10.	Cabling Aging Test
11.	Water penetration Test
12.	Flexural Rigidity Test on the optical fibre cable
13.	Test of Figure of 8 (Eight) on the cable
14.	Static Bend test
15.	Fibre curl
16.	Cable sheath yield strength and ultimate elongation
17.	Embrittlement Test on loose tube
18.	Kink Resistance on loose tube
19.	Drainage Test for loose Tube
20.	Check of easy removal of sheath
21.	Check of effect of aggressive media on the cable surface (Acidic and Alkaline behaviour)
22.	Seepage of filling compound

Table 1-2(b)
Type Tests For Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
2	Attenuation Variation with Wavelength	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles

Table 1-2(b)
Type Tests For Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
5	Attenuation With Bending (Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455- 164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455- 168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 Or EIA/TIA 455-59
10	Core -Clad concentricity error		IEC 60793-1-20 Or EIA/TIA 455-176
11	Fibre Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455-31B
-End Of table-			

1.2.9.2 Factory Acceptance Testing

The tests listed in Table 3-3 shall be carried out as Factory Acceptance Test for Underground fibre optic cable meeting the requirements specified in this section.

Table 1-3
Factory Acceptance Tests on Underground Fibre Optic Cable

S. No.	Factory Acceptance Test
1	Attenuation Coefficient (1310, 1550): By EIA/TIA 455-78A or OTDR
2	Point discontinuities of attenuation: By EIA/TIA 455-78A or OTDR
3	Visual Material verification and dimensional checks as per approved drawings
4	Water Penetration test
5	Tensile strength test
6	Impact test
7	Kink test

8	Environmental test
9	Crush Test

1.3 PLB HDPE PIPE and ACCESSORIES

The following paragraphs describe the functional requirements, major technical parameters and Type and Factory Acceptance Testing requirements for Permanently Lubricant High Density Polyethylene (PLB HDPE) Pipe. PLB HDPE pipe shall be suitable for underground fibre optic cable installation by blowing as well as conventional pulling. The PLB HDPE pipe shall be suitable for laying in trenches by directly burying, laying through G.I/RCC hume pipe and laying through trench less digging. The expected service life of HDPE pipe and accessories shall not be less than 50 years. Documentary evidence in support of guaranteed life span shall be submitted by the Contractor during detailed engineering.

The unit rates quoted in the price schedule shall be the composite price of PLB HDPE pipe along with all accessories.

1.3.1 Construction of PLB HDPE pipe

The PLB HDPE pipe shall have two concentric layers viz. outer layer and inner layer. The outer layer shall be made of HDPE material and the inner layer of solid permanent lubricant. These concentric layers shall be co-extruded and distinctively visible in cross-section under normal lighting conditions and generally conform to IS-9938. The colour of the PLB HDPE pipe shall be finalized during detail engineering. In the finished PLB HDPE pipe, the co-extruded inner layer of solid permanent lubricant shall be continuous and integral part with HDPE outer layer and preferably be white in colour. The inner layer of solid permanent lubricant shall not come out during storage, usage and throughout the life of the pipe. The pipe shall be supplied in a continuous length of 1000 (one thousand) meter in coil form, suitable for transportation, installation and handling purposes.

The finished pipe shall be of good workmanship such that the pipe is free from blisters, shrink holes, flaking, chips, scratches, roughness, break and other defects. The pipe shall be smooth, clean and in round shape, without eccentricity. The ends shall be cleanly cut and shall be square with axis of the pipe.

1.3.2 General

The HDPE pipe shall conform to the following standard and the technical specifications described in the following sections.

- IS: 4984 / IS: 2530/IS:14151/(part1)/ IS:9938/IS:7328/IS12235(Part-9)/IS:5175
- ASTM D 1693/ ASTM D 638/ ASTM D 648/ ASTM D 790 / ASTM D 1712/ ASTM D 2240/ ASTM D 4565 / ASTM F 2160/ ASTM G 154
- TEC-spec no. GR/CDS-08/02/NOV-04(including all amendments)-HDPE pipe for use as duct for optical fibre cable.

1.3.3 Material

The raw material used for the PLB HDPE pipe shall meet the following requirements:

- (i) The anti-oxidant establishers, color master batch and other additive used shall be physiologically harmless and shall be used only to minimum extent necessary to meet the specification.
- (ii) Usage of any additives used separately or together, should not impair the long-term physical and chemical properties of the PLB HDPE pipe.
- (iii) Suitable Ultra Violet stabilizers may be used for manufacture of the PLB HDPE pipe to protect against UV degradation when stored in open for a minimum period of 8 months.
- (iv) The ash content of the colour master batch shall not be more than 12% when tested as per method detailed below:
Test Method for ash content: About one gram of the sample under test shall be taken and dried at 105°C for two hours in a platinum or glazed porcelain or silica or quartz crucible. The weight of the sample shall be noted. Subsequently, the sample with the crucible shall be transferred to a muffle furnace maintained at 600±50°C and allowed to remain there for three hours. The ash content content may be calculated as a percentage of the weight of the original sample.
- (v) The base HDPE resin used for manufacturing outer layer of pipe shall conform to any grade of IS-7328 or to any equivalent standard meeting the following requirement when tested as per standards referred in this Section below.
 - a) Density (outer and inner layer): 940 to 958kg/m³ at 27°C. The density of completed PLB HDPE shall not be differ by more than 0.003gms/cc by this value when tested as per IS:2530 or IS:7328.
 - b) Melt Flow Rate (MFR): 0.2 to 1.1 g/10 minutes at 190°C & 5 kg load: when tested as per IS:2530. The MFR of the outer layer of the completed PLB HDPE pipe shall not differ by more than 30% of this value.
 - c) Tensile Strength at Yield: 20 N/mm² minimum, when tested As per ASTM D 638, Type-IV specimens
 - d) Elongation at break: >600%, when tested as per ASTM D638, Type-IV specimens
 - e) Flexural Modulus at 1% strain: 690 N/mm² minimum, when tested as per ASTM D 790.
 - f) Hardness, Shore-D: Between 60 and 65 units, when tested as per ASTM D 2240
 - g) Heat Deflection Temperature at 45 g/mm²: 65°C minimum, when tested as per ASTM D 648.
 - h) Environmental Stress Crack resistance, When tested with 10% Igepal, CO 0630 Solution 50°C: 96 hrs., when tested as per ASTM D 1693, No cracks.
 - i) Weathering in artificial (UV) light (Specimens shall be as per ASTM D 638 Type-IV) and cut from compression moulded sheet. After exposure for 720 hrs.,

Tensile strength shall be tested. The variation shall not be greater than 20% compared to tensile strength obtained at above.

j) OIT (in Aluminium Pan): 30 minutes minimum, when tested as per Annexure-I.

k) UV Stabiliser Content: Hindered Amine Light Stabiliser minimum 0.15%, when analysed as per FT-IR method.

- (vi) In the inner layer of PLB HDPE pipe, the friction reducing, polymeric material to be used as the inner layer lubrication material shall be integral with HDPE layer. The lubricant materials shall have no toxic or dermatic hazards for safe handling.

1.3.4 Dimension of pipe

The nominal size of the pipe shall be 40mm and shall meet the following requirements.

- | | |
|--|---|
| (i) Outside diameter | 40 mm + 0.4 mm |
| (ii) Wall thickness | 3.5 mm (+0.2 mm/ -0.00 mm) |
| (iii) Standard length | 1000 meters $\pm$ 100 meter |
| (iv) Thickness of permanent lubricant, | $\geq$ 0.4 mm |
| (v) Maximum outer diameter of FO cable
that can be installed by blowing technique | 13.4 $\pm$ 0.5 mm or cable dia whichever is
higher |

1.3.5 Accessories of PLB HDPE pipe

The following accessories are required for jointing the pipe and shall be supplied along with the pipe. The manufacturers shall provide complete design details, procedure for method of installation and type of the material used for the accessories. No part of the accessories shall contain metal part and minimum pulling force of the coupler shall be 330kgf. The accessories shall pass the ageing test at 70 $\pm$ 2°C and there shall be no leakage when tested for 168 hours.

- i) Plastic coupler: The coupler shall be used to join two PLB HDPE pipes. The coupling shall be able to provide a durable airtight and watertight joint between two pipes without deteriorating the strength of the pipes. The strength of coupler shall match the primary strength of the PLB HDPE pipe and threaded coupler is not acceptable. The jointing shall meet the air pressure test of 15 kg/cm² for a minimum period of 2 hours without any leakage.
- ii) End plug: This shall be used for sealing the ends of empty pipe, prior to installation of FO cable and shall be fitted immediately after laying of the PLB HDPE pipe, to prevent entry of any unwanted elements such as dirt, water, moisture, insects/rodents etc.
- iii) Cable sealing plug: This is used to hold the cable and prevent entry of any unwanted elements, as specified above.
- iv) End cap: This cap is made of hard rubber, shall be fitted with both ends of PLB HDPE pipe to prevent the entry of any unwanted elements such as dirt, water, moisture, insects/rodents during transportation and storage.
- v) Set of installation/maintenance accessories comprising of C-Spanners for tightening plastic coupler (4 nos.), Rotary duct cutter (2 nos.), spare cutting wheel

(4 nos. per Rotary Duct cutter), Chamferring tool for giving slight chamfer to the ends of PLB HDPE pipe shall be used during maintenance of the PLB HDPE pipes and these items (1set) shall be supplied along with the pipe.

1.4 Workmanship

The pipe shall be free of blisters, shrink holes, break and other defects. The PLB HDPE pipe ends shall be cut as square as possible to longitudinal aspects. The internal and external PLB HDPE pipe surfaces shall be smooth. The color should be uniform throughout.

1.5 Marking

All the pipe, shall be clearly marked at intervals of 1 meters with the following data which is not less than 5 mm high. The details of marking on pipe shall be approved by Employer before commencement of manufacturing.

- i) POWERGRID with logo
- ii) Manufacture's name or trade mark
- iii) Year of manufacturing
- iv) Type of PLB HDPE pipe and size
- v) Running length marking

1.6 Type Tests and Factory Acceptance Tests: The general condition of testing & inspection is mentioned as below:

1.6.1 Type Test

The PLB HDPE pipes & accessories offered to be supplied should have been type tested as per requirement specified in relevant TEC specification or equivalent standard. The Bidder shall enclose the previous type test report and/or type approval certificate from Telecom Engineering Centre (TEC), Department of Telecommunication/Technical Specification Evaluation Certificate(TSEC) given by BSNL QA, according to relevant TEC for the proposed PLB HDPE duct meeting the specified requirement.

1.6.2 Factory Acceptance Testing: The following tests shall be carried out during Factory Acceptance Testing (FAT) in Table 1-4.

Table 1-4 Factory Acceptance Test on PLB HDPE pipe & Accessories	
S.No.	Name of the test
1	Visual Inspection
2	Dimension Check
3	Hydraulic Characteristics
4	Reversion Test
5	Tensile Strength and Elongation Test
6	Environmental Stress Crack Test
7	Impact Strength Test
8	Crush Resistance
9	Mandrel Test

10	Ovality Test
11	Coil Set Test
12	Internal Co-efficient of Friction
13	Ash content
14	Colour fading
15	Optical Fiber Cable Blowing Test
16	Air Pressure test on plastic coupler
17	Ageing test on accessories

The air pressure test of plastic coupler shall be carried out for at least two joints made together with the offered PLB HDPE pipe. Each of the offered PLB HDPE pipe reels shall be weighed which should not be less than as specified in the DRS.

1.7 Joint Box

This following paragraphs specification gives the general requirements, type and factory testing requirements of Joint Box for underground optical fibre cables. The packaging and transportation requirements have also been specified.

The Joint Box should be suitable for use in Manholes as well as direct buried applications. It shall also be possible to branch out the cable from the Joint box as and when required without damaging the existing cables. The Joint box shall have minimum 4 single cable entry ports and one oval port (60x40mm) having sealed designed such that it will be opened by cutting only as and when required. All materials used for Joint box and sealing shall be termite resistant.

For specification of FODP refer Section-02 of technical specification.

1.7.1 Construction of Joint Box

The Joint box shall be manufactured as per the latest state of art technology. The design of the Joint box must ensure:

- (i) Mechanical and optical protection of the fibre.
- (ii) Environmental protection of the splice.
- (iii) The integrity of the connections and cable seals, fibres and buffers during mounting, functioning and dismounting.
- (iv) The possibility of the repeated reopening and re-closing of the joint box and fibre organizer without removing or modifying the joint box but only by replacing the sealing.
- (v) The addition of new cables shall be possible in the same joint box, if required.
- (vi) It shall be possible to terminate all cables having outer diameter from 8mm to 18mm.

The Joint Box shall be complete in all respect and shall consist of following main parts:

1.7.2 Main Box

The main box shall be sturdy, durable box having a base and dome shaped body. The dome shall be fixed on the base. The domed shaped body shall cover the entire junction while the base shall enable the entries of the optical fibre cable. The base and dome shall be made of thermoplastic/High density polypropylene material. The Joint Box should be suitable for opening and reentry frequently without impairing its properties. The body may have ribs as strength

member if required.

1.7.3 Cable organizer (Strength member and cable termination)

Cable organizer shall be suitable to secure extra length of fibre tubes with safe bending radius. It should not cause any strain or tension on the fibre. It shall be possible to fix the strength member(s) and the optical fibre cable firmly so that the cable arrangement will not shift or move laterally inside the Joint box. The Internal structure shall be metallic (made of stainless steel) to support and hold the cables and strength members etc. The metallic parts for making connections shall be made of Brass or Nickle Chromium plated steel and the total assembly shall be corrosion proof.

1.7.4 Fibre organiser/ Fibre Splice trays

Fibre organiser shall be non-metallic made of ABS material having following characteristic.

(i)	Specific gravity	1.01-1.21 gm/cc	ASTM-D-792
(ii)	Tensile strength	0.002kg/sqmm - 0.005kg/mm	ASTM-D-638
(iii)	Elongation	<50%	ASTM-D-638
(iv)	Water absorption	0.3-0.4	ASTM-D-57-59
(v)	Rock well hardness	R81-R111	ASTM-D785A

Contractor shall furnish test certificates in conformity to the above parameters of the ABS material. Fibre organiser cassettes shall be provided on which the fibre splice and service loops of fibres may be placed by making fibre coils. Slots on the splice tray for fixing splice protection sleeve shall be in such a way that they will not cause any stress or strain on sleeve or fibre and shall not shift, loose or move inside the tray or come into conflict with the fibre coils once fixed.

It shall be possible to fix a minimum of 4 secondary tubes at the entry port of each tray. No PVC or any other type of adhesive tape is permitted to hold fibres and loose tube inside the tray. All fibres of a tube shall be spliced in a single tray for better tube identity and fibre looping.

The fibre organiser shall be fixed inside the Joint box in such a way that this shall not loosen once fixed or to shift or move in any way.

1.7.5 Holding Arrangements

The box shall provide the following:

- (i) Holding arrangement and framework for properly securing cable organizers with splice trays.
- (ii) Securing arrangement for holding fibres.
- (iii) Holding device to hold strength member of fibre optic cable securely.
- (iv) Any other extra component required for providing strength and reliability to the Joint Box.

1.7.6 Compatibility

All the component and parts used shall be compatible with the optical fibre cable, fibre splices and cable components. Their use for long should not result in increase in transmission loss or deterioration in other properties.

1.7.7 Marking on body of the Joint box

The following information by marking on Joint box shall be provided:

- (i) Manufacturer's name & date
- (ii) Type of Joint box
- (iii) Number of Splice organiser cassettes
- (iv) Number of splices per cassette
- (v) Batch number and serial number.

1.8 General

The Joint Box shall confirm to the ITU-T Standards or latest standards prescribed by TEC. Other important requirements are as follows.

- (i) Assembly: - The method of assembly, box and reopening shall be simple and adoptable with minimum training.
- (ii) Component:- All component shall be durable and of good quality. Number of component should be minimum and adequate.
- (iii) Consumables:- Consumables mentioned in technical specification or any other items required shall form a part of Joint Box.
- (iv) Capacity of Joint Box:- The Joint Box shall be suitable for splicing for 24 fibre cables. Suitable Joint Box shall be provided to encase the optic cable splices in a protective, moisture and dust free environment. The Joint Box shall be designed for the storage and protection of a minimum of 24 optical fibre splices and equipped with sufficient number of splice trays for splicing all fibre in the cable. If and when required the capacity of Joint box can be increased by adding extra splice trays only.

1.9 Joint box Installation

Installation and sealing of Joint box shall be done according to the instruction manual provided with joint box. The following general criteria must be fulfilled.

- (i) Fibre loose tubes shall be placed safely inside the joint box and routed properly.
- (ii) Sheath shall be fully inside the joint box and FRP shall be properly fixed.
- (iii) Silica Gel shall be placed inside the joint box before closing the box.
- (iv) The sealing portion of the cable and joint box shall be filled before placing heat shrinkable sleeves. Rubber gaskets may be placed according to the instruction manual, if any.
- (v) The heat shrinkable sleeves shall be sealed with very low flame of Hot gun till sealing liquid properly melt and gripped. The cable entry ports being used for cable entry into the joint box shall be sealed by heat shrink sleeves only for ease of installation and reentry. The length of the sleeve shall cover the full length of the cable entry port and at least 30mm length of the cable. Heat shrink tube shall have wall thickness of at least 1.5mm before shrinkage and ≥ 2.5 mm after recovery. For sealing of base with dome, contractor may use mechanical sealing or heat shrink sleeve system. In case of mechanical sealing contractor shall indicate the exact method. The gasket or the "O" ring required for sealing shall be made of Neoprene rubber and after sealing it shall be air-tight.
- (vi) The Joint box shall be fixed vertically on the wall of the manhole with the help of

suitable holding SS ring and nut bolt arrangement keeping the cable entry point downwards.

- (vii) The Joint box shall be fixed on the poles with the help of suitable holding SS ring and nut bolts arrangement and preferably keeping the cable entry point downwards.

1.10 Tests and Inspection:

The general conditions for Type Testing and Factory Acceptance Testing (FAT) shall be as mentioned below:

1.10.1 Type tests:

The joint box offered to be supplied should have been type tested as per relevant TEC specifications including latest amendments or equivalent standard. The Bidder shall submit along with their bid the earlier carried out type test reports of last and/or TEC certificates/Technical Specification Evaluation Certificate(TSEC) given by BSNL QA for the offered joint box meeting the requirement.

1.10.2 Factory acceptance tests

The following test mentioned in table 1-5 shall be carried out as factory acceptance test for joint box.

Table 1-5	
FAT for Joint Box	
Sr.No.	Name of test
1	Visual Inspection
2	Tightness (Sealing) Test
3	Static Load test
4	Impact test
5	Axial pull out test
6	Bending test
7	Water ingress test
8	Reopening test

1.11 Packing and Transportation:

The Joint Box shall be transported after proper packing including the list of all sub-component, required maintenance spares. Consumables, mentioned in table 1-6 shall be supplied along with each Joint box. All Joint boxes shall be supplied with installation manuals. Each Joint Box shall be fully packed with all its components. All tools and accessories should be properly packed with each Joint Box and the Joint Box packets should be placed inside an adequate size container for good looking packing and safe transportation. The technical literature along with detailed drawing of all assemblies and parts shall be provided. All the aspects of installation, operation, maintenance, precautions and repair shall be covered in the manual.

Table 1-6
List of consumables to be supplied with Joint box

S.no	Item	Qty.
1	Protection sleeves For example, for 12fibre Joint box, protection sleeves shall be 18.	As per the fibre count in the cable + 50% extra quantity
2	Cable tie	12 numbers of required length
3	Tissue/Lens paper 3"x4"	100 numbers
4	Acetone (Lab grade)	100 ml
5	Hexane (Lab grade)	100 ml
6	Isopropyl (Lab grade)	100 ml
7	PVC adhesive tape (5meter length of 10mm width)	1 number
8	Double side adhesive tape	1 number
9	Sealing arrangement	1+1 (One complete set to be supplied as a spare) for all sealing ports.
10	Cable and fibre identification rings	2 sets
11	Transport tube	As per the requirements
12	Gasket or O-ring (in case of mechanical sealing)	1+1 (One O-ring to be supplied as a spare)
13	Silica Gel	2 packets each of 50 grams for each closure supplied. This shall be so packed that it can be tied with the internal mechanical structure of the closure inside the closure
14	Any other item	As per the requirements

1.12 Installation of Underground Fibre Optic Cable System

This part of the section describes the installation procedures and methods including survey, clearances, excavation of trenches and pits, trenchless digging, installation of PLB HDPE pipes, installation of RCC hume pipes and GI Pipes, marking, backfilling, installation of underground cable, construction of manholes, splicing, termination and site acceptance testing requirements of the underground fibre optic cabling system.

This specification is applicable for underground optical fibre installation work and some miscellaneous works to be executed inside city/town. The quantities indicated in the BoQ are indicative only and the final quantities against individual items will be approved by the Employer after detailed survey and depending upon the site condition.

1.12.1 Survey

The choice of route is most important aspect in planning an underground cable system. The correct choice is essential to reduce the cost of laying pipes, keeping the pipes safe from damage and to attain their maximum utilisation when they have been laid.

The survey shall be conducted for underground fibre optic cable routes as described below to finalise the route and paths for the underground fibre optic cable. For underground fibre optic cable links, location of customers such as: Telecom service providers (DoT/BSNL, other basic operator, Cellular, Pager, ISPs etc), Major business centres, Bulk data users (Corporate Houses, universities, colleges etc) shall be identified by the Contractor and submitted to Employer by suitably marking the locations on a city map of proper scale.

In certain cases there will be routes where the Employer has finalised the route for the installation of PLB HDPE pipe vis-à-vis the underground OFC, or PLB HDPE pipe is already installed by POWERGRID or other agency. In such cases, the Employer shall provide the details of the finalised route or existing PLB HDPE pipes routes to the extent possible. However, to carry out the fibre optic cable installation, the Contractor shall carry out the required survey of the routes.

1.12.1.1 Identification of under ground fibre cable route:

The Contractor shall propose preferably two most suitable routes (unless availability of a single route is obvious) for each link keeping in view the following broad criteria:

- a. The route shall be as straight and as short as possible.
- b. The route shall have minimum obstacles in order to minimise reinstatement cost.
- c. Clearances required from other authorities/bodies are minimum and that the clearances can be obtained expeditiously.
- d. Wet or unstable ground shall be avoided to the extent possible.
- e. The route for the pipes shall be away from the carriage-way of the road to the extent possible.
- f. The route shall be suitable for placing manholes wherever required.
- g. Future expansion of roads shall be taken into consideration.
- h. Road, rail, river, nallah crossings, horizontal direction drilling shall be minimum.
- i. Underground fibre optic cable route shall be so chosen that it would be possible maintain sufficient distance from existing underground cables and to do excavation and backfilling along the route without disturbing the existing cables laid by other operators/utilities during installation of PLB HDPE pipe or future maintenance, to the extent possible subjected to ROW clearance.

1.12.1.2 Survey Report

The Contractor shall submit the survey report with the most suitable two alternate routes for all the fibre optic links along with details described above. The Employer shall choose one of the two alternatives. On finalisation the Contractor shall carry out detail survey for the selected routes and submit the final survey report for approval before implementation. The final survey report shall include at least the following:

- a. A drawing of the proposed route indicating all details of the route including name of the road, GIS co-ordinates at every 25 mtrs, relevant details of soil strata, bridges, culverts, causeways, rail over/under bridges, defence area, underground gas / oil / water pipe line, power and communication cables routes, other important landmarks etc.
- b. The distance of the fibre optic cable route from the centre of the road/rail/river/bridge/culvert etc. shall be indicated on the route maps as well as documented in tables.

- c. Sections of the links where Horizontal Direction drilling, Moling and Manual auguring may be required.
- d. Sections where GI or RCC hume pipe may be required.
- e. Location and number of permanent and temporary manholes.
- f. Location of all turns, bends and major landmarks.
- g. Type, quantity and location of all the joint boxes. Care must be taken to minimise the number of splicing and joint boxes.
- h. Section lengths of the underground fibre optic cable, total length of each link and drum scheduling for all the link.
- i. List of authorities from which clearance shall be required to be obtained for each relevant section.

The final survey report shall have to be approved by the Employer and requisite clearances (as indicated below in this section) need to be obtained before the cable installation work is commenced.

For the routes where the Employer has finalised the route for installation of PLB HDPE pipe vis-à-vis the underground OFC or where PLB HDPE pipe is already installed by the Employer/Owner or other agency, the Contractor will survey the route to facilitate installation of optical fibre cable, and submit the final survey report as per above description.

The scope of survey shall also include the route and tentative Bill of Materials (pipes, couplers, manholes, G.I. pipes, RCC pipes, Joint box, conduits, bends, trays, warning bricks, Warning tape etc. and any other items required for successful implementation of the links) for the interconnection of optical fibre cable from the nearest manhole to the fibre termination box(FODP). It may be noted that routing of optical fibre cable inside the building may require installation on the walls and floors using suitable pipes, conduits, bends, trays etc and minor civil works (e.g. making holes on the walls, cutting grooves on walls/floor and making good etc.). The Contractor will also indicate sections where the OFC may be required to be installed overhead using poles/other supports and guide wires, because of non-feasibility in installation underground or lack of clearance from authorities.

1.12.1.3 Payment

The BoQ in the appendices indicates the fibre optic route length to be surveyed by the Contractor. The Contractor may be required to conduct additional surveys as per clause 3.12.2 Clearances, such survey shall not entitle the Contractor to any additional payment from the Employer/Owner. The payment for the survey shall be made after final survey report is submitted and approved by the Employer on per link basis based on the actual route length of fibre optic links.

1.12.1.4 Clearances

The Contractor shall be responsible for obtaining necessary clearances for excavation work from the authorities on behalf of the Employer and provide requisite copies of information, maps, survey report etc to the authorities. The Employer shall assist the Contractor in obtaining such clearances by providing the authority letter or any other relevant document. The Contractor shall make an all out effort with the concerned authority to get clearances expeditiously and to negotiate the least cost to the Employer. The Employer shall furnish all required bank guarantees and make payments to the concerned authorities directly based on the demand letter obtained by the Contractor from the concerned authorities. The Contractor shall ensure quick and speedy

clearances in order to implement the project within stipulated schedule. In case the authorities have some objections on certain sections of routes proposed and are unwilling to provide clearances, the Contractor shall propose an alternate route, promptly carry out the survey and submit specific survey report for that and reapply for clearance after taking into account the comments/objections of the authority.

3.12.3 Excavation and Backfilling for Open Cut Trenching

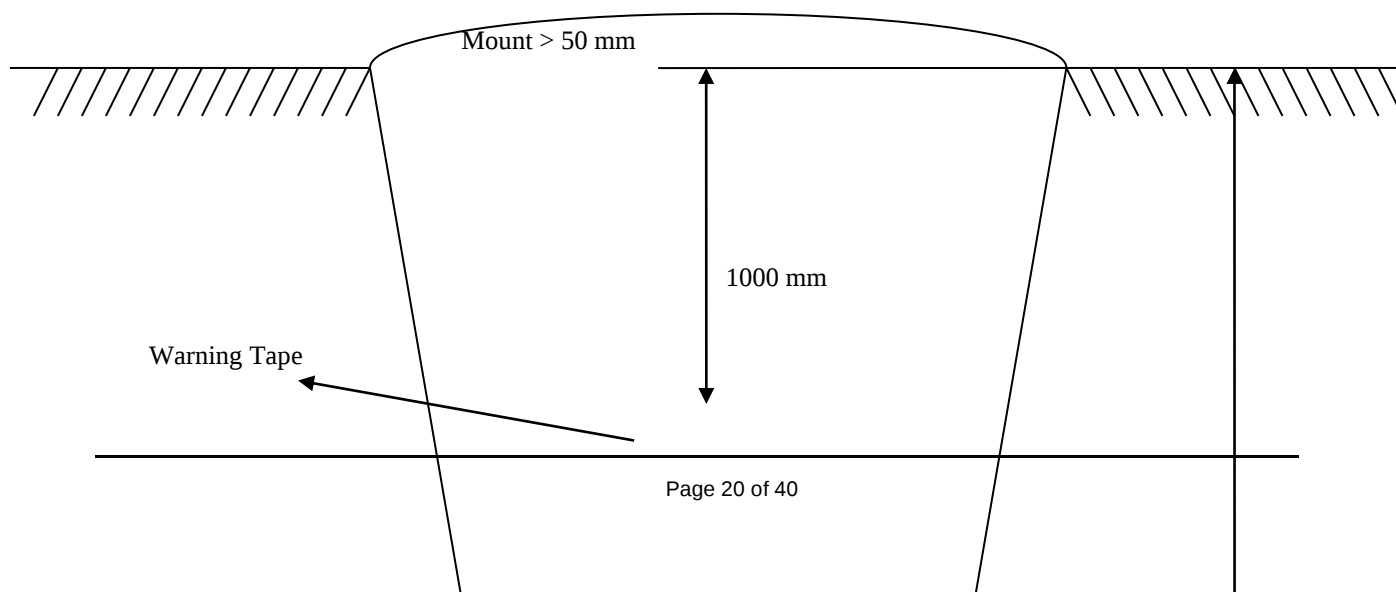
The Contractor shall carry out excavation and backfilling of trenches in all kinds of soil strata such as normal soil, soft rock, hard rock for laying PLB HDPE pipe, RCC hume pipe and GI pipe. In addition, the Contractor shall also make suitable arrangements (except trenchless digging, which is identified separately) for laying PLB HDPE pipes, RCC hume pipes and GI pipes at all type of crossings such as pavements, all types of roads, bridges, river, nallah, rail track etc.

3.12.3.1 Excavation

The cable trenches shall be dug as per route plan and detail trench drawings (indicating the various dimensions and other details of the trench) approved by the Employer for each type of soil strata. The Contractor shall take due care and precaution during excavation to avoid possible damage of other underground plants/facilities in the proposed underground fibre optic cable route and shall indemnify the Owner/Employer for all damages and shall be solely responsible for all the damages and losses. The Owner/Employer shall not be liable for any damages/losses.

Fig 1-1 shows the dimensional view of excavation of trench and other details of installation in normal soil for PLB HDPE pipe. For the purpose of this specification, soil strata types are defined below:

- | | |
|-------------|---|
| Normal Soil | All type of soil {i.e. dry, wet (partially or fully submerged)} except soft rock or hard rock as defined below. |
| Soft Rock | Lime stone, laterite, hard conglomerate or other fissured rock which can be quarried or split with crow bars, wedges or pickaxes. However, if required and permitted Government authority by light blasting may be resorted to for loosening the material, but this will not in any way entitle the material to be classified as hard rock. |
| Hard Rock | Any rock excavation other than specified under Soft Rock, for which blasting, drilling, chiselling are required. |



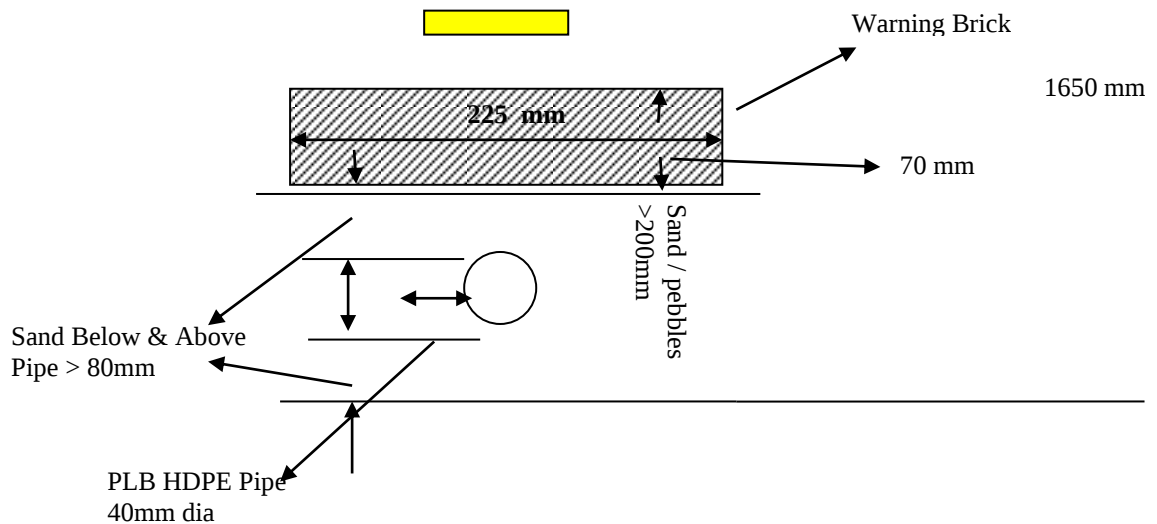


Figure 1-1: Trench in Normal Soil for PLB HDPE pipe (Not To Scale)

Depth of trench shall be at least 1650 mm in normal soil. However, for rail & road crossings the trench depth shall be at least 1000 mm. Depth of trench shall be at least 1000 mm in soft rock from the depth soft rock is encountered i.e. in case soft rock is encountered at say 500 mm then the actual depth of the trench shall be $500 + 1000 = 1500$ mm limited to a maximum depth of 1650mm. Depth of trench shall be at least 800 mm in hard rock from the depth hard rock is encountered i.e. in case hard rock is encountered at say 300 mm then the actual depth of the trench shall be $300 + 800 = 1100$ mm limited to a maximum depth of 1650mm. For excavation in hard rock, controlled blasting can be resorted to. The Contractor shall obtain necessary permission from the statutory authorities for blasting and the use of explosives for this purpose. No blasting is permitted near permanent work or dwelling. Blasting shall be so made that pits are as near to the design dimensions as practicable. Jackhammer can also be used for the excavation. The width of trench at the top and bottom shall be adequate for proper installation of PLB HDPE pipes, RCC hume pipes, GI pipes, Warning Brick/Stone, Warning tape etc. as per requirement. The trench depth shall be measured from the bottom of the trench. Trench shall be located at the lowest point of lower area if possible. Trench shall not be constructed at field boundary or any up-heap. In case of uneven ground, the Contractor ensure that the bottom of the trench is not uneven, the Contractor shall maintain minimum depth of the trench as per specifications and may be required to increase the depth at some locations and provide a suitable gradient in the trench.

During the construction of trenches, the Contractor shall be responsible for shoring and strutting the walls of the trench on either side by using suitable means such as wooden planks to avoid subsidence of soil. The Contractor shall also be responsible for supporting the exposed plant/facilities of other utilities such as water, gas and oil pipes, electric, telephone or fibre optic cables etc to avoid any possible damage. The Contractor shall also be responsible for any dewatering of the trench during digging and installation of pipes.

In case it is necessary to get around a large obstacle such as a boulder or an underground plant/facility, which has not been anticipated earlier the trench may be given a gentle bend within permissible radius or by construction of a manhole. Wherever possible, it is preferable to avoid additional manholes.

The Employer's Project Manager or his/her authorised representative will be the authority to decide the classification of the soil i.e. normal soil, soft rock or hard rock. The decision of the Project Manager shall be final and binding on the Contractor.

The Contractor shall make all efforts in order to achieve the requisite depth as stipulated above in various soil strata. However, under exceptional conditions, as may be decided by the Employer's Project Manager/ Engineer-in-Charge or his/her authorised representative, the excavation to a lesser depth may be acceptable. Under such circumstances, the reason for non-achievement of depth as per specification are to be recorded jointly by the Contractor and the Employer's site representatives representatives and approved by the Project Manager/Engineer-in-Charge or his/her authorised representative.

1.12.3.2 Backfilling

After installation of PLB HDPE pipes, RCC hume pipes or GI pipes, the backfilling of the trench shall be done. The PLB HDPE pipes shall be sandwiched with sand as per the Figure 3-1. Backfilling shall normally be done with the excavated soil, unless it consists of large boulders/stone in which case the boulders/stone shall have to be broken to a maximum size of 80mm. The backfilling should be clean and free from organic matter or other foreign material. The earth filling is done with a suitable mount to allow for any shrinking of soil at the later date. In case of regular footpath, temporary reinstatement shall be done after backfilling. The left out earth if any has to be disposed by the Contractor to a suitable location as indicated by authorities at his own cost. It is advisable to start backfilling of the trench from one end or after padding of the pipe to avoid uplifting. In case of soft rock as well as hard rock, the PLB HDPE pipe shall be covered with 1:2:4 concrete. The cross section of the concrete shall be 100 mm (depth) x 200 mm (width). The Contractor shall properly cure the concrete for four days. The backfilling of the remaining portion shall be done as stipulated for normal soil.

In lieu of PCC of 1:2:4, the Contractor may use RCC semi-circular split pipe sections (50 mm nominal inner radius of curvature, with minimum thickness of 20 mm) from top to cover the PLB HDPE pipes as a substitute and this will be treated at par with PCC of 1:2:4 for payment purpose. These RCC semi-circular split pipes shall be reinforced with wire mesh.

Under exceptional conditions, where the Employer agrees and approves excavation of trench to a depth lesser than 1650mm, as stated above, the backfilling shall be done as per following guidelines:

S.No.	Description	Additional protection of HDPE pipe
(a)	Excavation of 1650mm to 1000mm in normal soil or 1650 mm to 800 mm in footpath	No additional protection in addition to Warning Brick/Stone slab, Warning Tape etc.
(b)	Excavation of less than 1000mm to 500mm in normal soil or 800mm to 500 mm in footpath	PCC 1:2:4, 100mm (depth) x 200mm (width) over the layer of sand or RCC semi-circular split pipe sections (50mm nominal inner radius of curvature) from top to cover the PLB HDPE pipes in addition to Warning Tape, Warning brick/Stone Slab etc.
(c)	Excavation of less than 500 mm to 300 mm in normal soil	Additional protection using G.I. pipes in addition to Warning brick/Stone Slab, Warning Tape etc.
(d)	Excavation of less than 300 mm in normal soil	Additional protection using G.I. pipes encased in 1:2:4 PCC, 100mm (depth) x 200mm (width) in

		addition to Warning Tape.
However, wherever sub-soil water is encountered at depth less than 1000 mm but more than 500 mm, RCC pipe only to be used for additional protection.		

1.12.3.3 Warning Bricks

Bricks (non-modular) class designation-5(50) of the actual size 225 mm (Length) x 111 mm (Width) x 70 mm (Thick) shall be laid breadth-wise as per Figure: 3-1(average 8 bricks per metre) immediately above the sand layer in which PLB HDPE pipe is installed. Brick of size other than above may also be used. Warning bricks shall be used in city area i.e. within municipal limits. In lieu of Warning brick, the Contractor can use suitable stone slabs of 200mm (Width) x 25mm(Thick) as a substitute and this will be treated at par with warning brick for payment purpose.

1.12.3.4 Warning Tape

A warning tape, made of HDPE or LDPE (Low Density Poly Ethylene) other suitable inert material, containing a printed warning message, (Width:10 cm, Thickness: 500 micrometer) shall also be laid over the pipe, throughout the cable route at a depth of 1000mm in normal soil (the depth of Warning Tape in soft rock, hard rock and at less-depth stretches shall be proposed by the Contractor and approved by the Employer), for warning the person who will excavating the trench in future.

1.12.4 Payments

The unit rate quoted by the Bidder shall be irrespective of soil type such as normal soil, soft rock, hard rock and crossings such as pavements, all types of roads, rivers, nallah, bridges, culverts, rail track etc. encountered during the actual installation. The bidder are required to make their own estimates and offer a single uniform rate applicable for all kinds of soil strata and crossing. The Employer/Owner shall not entertain any additional claims/payments for any type of soil/crossing encountered during installation. Employer strongly recommends site visits/ investigation by the bidder (at their own cost) before submission of the bid for proper estimations. The Contractor shall be required to carry out excavation and back filling in accordance with this specification and provide all additional items required at its own cost for proper installation not limited to those described in this specifications.

Unit rate for excavation and backfilling shall inter alia include all related works/activities such as excavation, blasting of rocks and backfilling of trench, fixing of gradient of trench, excavation of trial pits if required, clearing of bushes, roots of trees along the trenches, cutting of bushes, trees, shoring, dewatering, excavation and backfilling of any temporary manhole, support of the existing facilities/plant, removal of left out material, breaking of pavement, clearing of obstacles, temporary reinstatement of footpath wherever required, providing and backfilling with sand, concreting for encasing of pipes/providing and covering with RCC semi-circular split pipe etc. suitable structures/techniques material for crossings (road, rail, culvert, bridge, river etc) for installation of PLB HDPE pipes, RCC hume pipes or GI pipes. The payment shall be made on actual route length where excavation and backfilling has been executed. Payment for warning tape shall be made as per actual quantity supplied and installed, as applicable.

In the event of excavation to a lesser depth, under exceptional conditions with the approval of the Employer's Project Manager/Engineer-in-Charge or his/her authorised representative as stated above, the payment for such route lengths shall be made in the proportion of depth of excavation & backfilling w.r.t. the minimum stipulated depth of 1650 mm in normal soil (e.g. if the excavation and backfilling is done upto a depth of 1000mm (say) in normal soil, and the unit rate for excavation & backfilling per route km is Rs.A (say), then the payment shall be made at the rate of $B = \text{Rs.}(1000/1650) \times A$). Further, no additional payment shall be made for PCC cover executed in the event of excavation to a lesser depth.

1.12.5 Installation of PLB HDPE Pipe

One PLB HDPE pipe shall be laid at bottom of the trench after making the surface smooth and providing 80 mm of sieved, stone free sand bedding. After laying the pipe additional sieved sand shall be added to increase the height of the sand layer to a total of 200 mm hence positioning the PLB HDPE pipe in the middle of the layer. Other important steps are described as under:

- a. PLB HDPE Pipe shall be laid in a flat bottom trench free from stones, sharp edged debris.
- b. The Pipe shall be placed in trenches as straight as possible. Minimum bending radius of pipe and fibre optic cable shall always to be taken into account.
- c. The ends of pipes shall always be closed with end plugs to avoid ingress of mud, water or dust i.e. all pipe opening shall be sealed to avoid entry of foreign material.
- d. The pipes shall be joined tightly & properly through plastic couplers and the joint shall be smooth and free from steps. The joints shall be made properly so that it passes the duct integrity test specified in this section. All joints shall be assembled with proper tools only.
- e. Coupler shall not be placed along the bend portion of the pipe
- f. Cable sealing plugs shall be provided at all manhole locations and at locations cable is coming out of the pipe and empty pipe ends i.e. all pipe openings shall be sealed to avoid entry of foreign objects.
- g. PLB HDPE pipes shall be installed in a manner that fibre optic cable can be pulled, blown, de-blown without damaging the fibre optic cable due to stresses.

The Contractor shall all joints inspected before carrying out the backfilling, by a representative of Owner/Employer. Joints shall be visually inspected and checked for tightness.

1.12.5.1 Payment

Unit rate for installation of PLB HDPE pipes shall interalia include all related works/activities including installation of all accessories/hardware described in this section. The BoQ in the appendices indicates the total route length where PLB HDPE pipe shall be installed. Accordingly the unit rate quoted shall include all wastages (beyond permissible limit), working length etc. and all other items/works required for PLB HDPE pipe installation. The Owner/Employer shall not entertain any claims or payment towards installation of hardware/accessories, installation of additional lengths of PLB HDPE pipe required to be taken for working lengths and wastages (beyond permissible limit) etc. However, payments shall be made on pro rata based on actual fibre optic route length executed (except where trenchless digging is used for installation).

1.12.6 Manholes

Manholes shall be provided at every proposed and future joint location to house Joint Box and Optical Fibre cable service loops. The location for Joint boxes shall be decided during survey and

detailed engineering. There can be three types of construction of manholes depending upon the location of the manhole. Each type of construction of manhole can be of two sizes (heights) depending upon the utility. Where the manholes are placed on the footpath or where heavy vehicular movement is not expected, manhole with brick masonry wall (wall thickness min. 225mm and inside dimension 1000mmx1000mm square, inside wall 12mm cement plaster with 1:4 mix) can be constructed. However, in case the manhole is required to be constructed at the middle of the road or where heavy vehicular movement is expected, the manhole shall necessarily be of RCC construction. Such manhole shall be pre cast RCC Cylindrical pipe (spun concrete) with minimum wall thickness of 80mm and shall include $\Phi 8$ mm or more steel reinforcement. The base of manhole in all types shall be minimum 80mm thick PCC and minimum internal diameter shall be 1000 mm. In case the base is constructed as integral part of the pre cast RCC cylinder, the base shall also be RCC. Height of the manhole, where joint boxes are to be kept, shall be of 1100 mm height. Manhole for keeping service loops of OFC shall be of minimum 400mm height. The cover shall be pre cast RCC, minimum 50mm thick. However, for easy handling purpose, the cover is to be constructed with suitable arrangement for lifting. The top of manhole should be flushed with the ground level. Manholes type approved by the Employer shall only be acceptable. Manhole shall be designed as per the typical drawing enclosed at Annexure-I. The manhole shall have two holes in each four perpendicular directions for PLB HDPE pipe entries and exits. Fixtures for placing cable and spliced Joint Box inside the manhole shall be provisioned. The joint box shall be mounted vertically on the wall of the manhole. The contractor shall carry out the required excavation and backfilling for the construction of the manhole. All PLB HDPE pipe entries, cable entries and holes shall be properly sealed.

The Contractor may propose double walled “Annual ring shaped conical manholes” meeting all the requirements of the manhole specified above. The assembly of conical manhole shall be made by using pre-cast steel (rod or wire-mesh) reinforced Concrete elements, which consists of annular rings different height and diameter (within permissible diameter range of conventional manhole manhole as specified above) placed over each other. Manholes type approved by the Employer shall only be acceptable. For installation of PLB HDPE pipe or trenchless digging or blowing of OFC, at times there might be requirement of providing temporary manhole or hand holes. No separate payment shall be admissible for such manholes or handholes and shall be deemed to be inclusive in the overall scope of work by the Contractor.

If required, as per the advice of the Employer, manholes shall also be installed along the existing installed PLB HDPE pipe routes to house joint boxes and cable service loops. Due care is to be taken so that the existing PLB HDPE pipe and OFC does not get damaged while placement of new manhole.

1.12.6.1 Payment

Unit rate for the manholes shall interalia include all related works/activities including RCC cylindrical pipe, Brick masonry work, PCC base, pre cast cover, excavation, backfilling, supply, transportation and installation of all material & accessories required for construction of manhole as per specification. Provisional quantity for all types of manholes (viz. manhole for service loops and for joint box, RCC and Brick Masonary Construction) manholes has been identified in the appendices, payment shall be made based on actual quantities executed.

1.12.7 Reinstatement

The contractor shall be required to carry out reinstatement of the excavated area in case the concerned authority requires so. Reinstatement shall include all works necessary (such as reconstruction of metalled/asphalt road, footpath etc) to restore the excavated area to original quality and shape. Temporary reinstatement of footpath stipulated in this section shall be carried out as a part of backfilling. The Contractor shall be responsible for carrying out complete reinstatement work irrespective of area or type of reinstatement without any additional cost implication to Employer.

1.12.8 Installation of GI Pipe

The GI pipe of nominal bore of minimum 100 mm shall be laid wherever road crossings, bridge crossings, railway crossings are encountered on the route as well as on wall/floor crossings in a building. PLB HDPE pipe shall be inserted into GI pipe. Whenever it is not possible to install the FO cable underground due to non availability of the right of way or any other unavoidable reasons, the HDPE ducts along with FO cable shall be installed in GI pipe on the wall inside the sewerage pipe and or on the existing rock/concrete/brick wall/surface with suitable fixing arrangement and concreting, if necessary, with specific approval of the Employer in case to case basis. The GI pipe shall conform to at least medium class and conform to IS: 1239 (Part –I). In regard to bridge and culvert crossing, GI pipe may be installed by concreting the GI pipe along the bridge or by using supporting brackets or by laying underneath the existing footpath etc. The PLB HDPE pipes shall be installed through this GI pipe. Wherever underground fibre optic cable is required to be spliced to overhead fibre optic cable using the outdoor FODPs/Joint Boxes installed on towers, GI pipes shall be used to protect the portion of the cable/duct upto a height of about 6 to 10 meters and shall be extended in the ground up to suitable depth of the trench so that minimum bending radius of the cable is maintained. The GI pipe shall be properly clamped/ fixed on the tower leg. The Contractor shall supply and install all necessary accessories as part of the installation work.

The Contractor shall propose the exact methods and procedures for implementation of crossings taking into consideration the following guidelines, for approval by the Employer:

- a. The GI pipe shall be extended at least 5 meters on each side of crossing subject to availability of space and approval of the Employer.
- b. Two GI pipes shall be joined using proper tools, sockets and accessories etc.
- c. Proper arrangements shall be made to seal the ends of GI pipe after installation of PLB HDPE pipes.
- d. Minimum bending radius of optical fibre cable shall always be taken into consideration.
- e. 1:2:4 concrete shall be used for encasing of the GI pipe, wherever required.
- f. The floor of the trench shall be levelled by laying at least 50 mm of soft soil or sieved sand before installing the GI pipe.
- g. The GI pipes shall be supplied in standard lengths of 6m or as approved by Employer.
- h. The GI pipe shall be sealed at both ends.
- i. The GI pipe of suitable length shall be provided at road crossings, bridge crossings, railway crossings encountered on the route as well as on wall/floor crossings in a building and also for protection of fibre optic cable at tower/pole mounted joint boxes.

1.12.8.1 Payments

The quoted unit rate for the supply of GI pipe shall interalia include all required accessories (sockets, joints, brackets, clamps etc) and material (cement, sand, chips etc). The quoted unit rate for the installation of GI pipe shall interalia include all related works/activities including installation of hardware and accessories (sockets, joints, brackets, clamps etc), fixing arrangement and concreting required for GI Pipe installation at road crossings, bridge crossing, railway crossing encountered on the route as well as on wall/floor crossings in a building. The BoQ given in the appendices indicate the total fibre optic route length where and also for protection. PLB HDPE Pipe shall be laid in the GI pipe, accordingly the quoted unit price shall take into account working lengths and wastages. The Owner/Employer shall not entertain any claims or payments towards installation hardware, accessories, concreting, cementing, working length and wastage etc. The Payment shall be made based on actual fibre optic route length executed inside GI pipe.

1.12.9 Installation of RCC Hume Pipe

Minimum inside diameter 100 mm, NP3 RCC hume pipe shall be laid wherever river, nallah crossing encountered on the route. The RCC pipe shall conform to IS:458. PLB HDPE pipe shall be inserted into RCC hume pipe. The Contractor shall propose the exact methods and procedures for implementation of crossings taking into consideration the following guidelines, for approval by the Employer.

- a. The RCC hume pipe shall be extended at least 5 meters on each side of river, nallah subject to availability of space and approval of the Employer.
- b. Two RCC hume pipes shall be joined using RCC collar and properly cemented.
- c. Proper arrangements shall be made to seal the ends of RCC hume pipe after installation of PLB HDPE pipes.
- d. Minimum bending radius of optical fibre cable shall always be taken into consideration.
- e. 1:2:4 concrete shall be used for encasing of the RC pipe collars, wherever required.
- f. The RCC hume pipes shall be supplied in standard lengths of 2m or as approved by Employer.
- g. The RCC hume pipe shall be sealed at both ends.

1.12.9.1 Payment

The quoted unit rate for the supply of RCC hume pipe shall interalia include all required accessories (collars, clamps etc) and material (cement, sand, chips etc). The quoted unit rate for the installation of RCC hume pipe shall interalia include all related works/activities including installation of accessories and other hardware, fixing arrangement, concreting required for RCC hume pipe installation. The BoQ given in the appendices indicate the total fibre optic route length where PLB HDPE Pipe shall be laid in the RCC hume pipe, accordingly the quoted unit price shall take into account working lengths and wastages etc. The Owner/Employer shall not entertain any claims or payments towards installation hardware, accessories, concreting, cementing, working length and wastage. The Payment shall be made based on actual fibre optic route length executed inside RCC hume pipe.

1.12.10 Underground Fibre Optic Cable Installation

The cable shall be installed inside one of the 40mm diameter PLB HDPE pipe installed under this package along the route(s). Generally the cable shall be installed by compressed air blowing technique. However, for spans upto 150 meter, the Contractor can use pulling method for installation of OFC in HDPE pipe. If any temporary manhole or handhole is required for installation of OFC, the same will be done by the Contractor without any additional cost implication. Adopting pulling method for installation of OFC for spans more than 150 meter, shall be subjected to approval of the Employer and shall be substantiated by proper justification. Contractor shall take into consideration the following guidelines, for installation of OFC approval by the Employer.

- a. The Optical Fibre Cable Drums shall be handled with utmost care. The drum shall not be subjected to shocks by dropping etc. They shall not be normally rolled along the ground for long distance and when rolled, shall in the direction indicated by the arrow. The battens shall be removed only at the time of actual laying.
- b. A blowing machine in association with an appropriate compressor shall be used for blowing.
- c. Temporary blowing chambers (if required) shall be constructed and then backfilled after blowing operation is completed.
- d. Locations along the route, which provide easy access points for blowing machine and compressor, shall be determined.
- e. Before starting the cable blowing, PLB HDPE pipe shall be checked for obstacles or damage. Checking shall be done by using a proper sized mandrel.
- f. Always blow downhill wherever possible.
- g. Multiple blowing machines may be used in tandem if so required.
- h. Care must be taken not to violate the minimum bending radius applicable for the fibre optic cable. Tension in the cable during laying shall not exceed tension limit of the OFC.

Installation by pulling may be permitted by the Employer only in specific cases where installation by blowing is not feasible on specific approval from the Employer. In case pulling is used, the pulling speed shall be determined considering the site condition.

While installing the cable, excess length of about 10 meters shall be stored at each joint location for each side. Excess length of 10 m shall be kept at one ends of a road crossing, culvert crossing and 20 meters at one end of bridges, However, exact excess lengths and manhole locations shall be finalised during detailed engineering depending upon the site requirement.

1.12.10.1 Payment

Unit rate for installation of fibre optic cable shall interalia include all related works/activities including associated accessories, tools & tackles, machinery etc. The BoQ in the appendices indicates the total fibre optic route length where fibre optic cable shall be installed. Accordingly unit rate shall include all working allowances and wastages, hardware and accessories required for installation of optical fibre cable. The Owner/Employer shall not entertain any claims or payment towards installation of hardware/accessories, any additional length of cable for working allowances and wastages etc. The payment shall be made on prorata based on actual fibre optic route length executed including cable service loops/excess cable as stipulated above.

1.12.11 Trenchless Digging

Trenchless technology is the science of installing, repairing or renewing underground pipes, PLB HDPE pipes and cables using trenchless techniques, which minimise or eliminate the need for excavation. Trenchless (also called “No-Dig”) techniques can reduce environmental damage and social costs, and at the same time provide an economic alternative to open trench methods of installation, renewal, and repair.

It is envisaged that trenchless digging shall be used in short section for crossing National highways, important road or rail crossings etc. Trenchless digging shall be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of HDPE pipe. The Bill of Quantity (BoQ) for various trenchless digging requirements is defined in the Appendices, however, the actual quantities shall be finalised based on the actual requirement.

1.12.11.1 Contractor’s Scope of Work for Trenchless Digging

The Contractor’s scope of work under this contract shall include, but shall not be limited to, the following:

- (a) Survey of the approved routes for installation of PLB HDPE pipe by trenchless digging.
- (b) Obtaining statutory clearances from regulatory bodies, statutory bodies such as municipality, highway authority, electrical utilities, forest department, gas authorities etc. on behalf of the Employer/Owner.
- (c) Identify, provide and transport all equipment to the locations along the route as per the requirement to install PLB HDPE pipe by trenchless digging method.
- (d) Excavation and backfilling of entry and exit pits.
- (e) Detection and protection of existing underground facilities of other utilities along the route.
- (f) Installation of 40 mm PLB HDPE pipe along the specified route by trenchless digging method and joining of PLB HDPE pipe by plastic coupler and sealing of PLB HDPE pipe at both ends by end plugs.
- (g) Installation of manholes, termination of PLB HDPE pipes into the manholes and sealing of PLB HDPE pipes at the manhole entry as per approved drawings.
- (h) Providing all plants, tools and tackles, consumables, marking and fencing required for the execution of the work as per the best engineering and safety practices.
- (i) Maintain all lights, guards, plates, safety measures, sign boards etc. when and where necessary and/or required by the Owner/Employer or by any other statutory authority for the protection of works and/or for the safety and convenience of the public or the workers at the installation sites.
- (j) Arrange electricity by arrangement of generators or other means at the site wherever required.
- (k) Arrange construction water at the sites.
- (l) Intimation to road maintenance agency, traffic police, other concerned utilities as necessary.
- (m) Testing and inspection of installed PLB HDPE pipes and manholes.
- (n) Rectifications, redigging and re-installation of PLB HDPE pipes in case of problem during testing and fibre optic cable blowing/pulling.

1.12.11.2 Clearances

The Contractor shall be responsible for obtaining necessary clearances for the work from the

authorities on behalf of the Employer/Owner and provide requisite copies of information, maps, survey report etc to the authorities. The Employer/Owner shall assist the Contractor in obtaining such clearances by providing the authority letter or any other relevant document. The Contractor shall make an all out effort with the concerned authority to get clearances expeditiously and to negotiate the least cost to the Employer/Owner. The Employer/Owner shall furnish all required bank guarantees and make payments to the concerned authorities directly based on the demand letter obtained by the Contractor from the concerned authorities. The Contractor shall ensure quick and speedy clearances in order to implement the project within stipulated schedule. In case the authorities have some objections on certain sections of routes proposed and are unwilling to provide clearances, the Contractor shall propose an alternate route, promptly carry out the survey and submit specific survey report for that and reapply for clearance after taking into account the comments/objections of the authority.

1.12.11.3 Site Investigation

The Contractor may collect all available information regarding existing underground services and take necessary care to identify and protect them during execution. Information regarding the subsoil, existing services or structure to be obtained by the Contractor from the local authorities and documentation of earlier jobs for used for laying of utilities, pipelines, crossings, existing pipes, type of soil etc. Ground penetrating radar system (GPRS) having capability of capturing greater information often detecting non-metallic pipes, cables, and zones of leakage and sub-surface discontinuities such as road construction layers or rock strata may also be used.

The available information shall be used to finalise the depth and method of trenchless digging for various crossings. The depth of trenchless digging shall not be less than 1.65 m, however, in case of uneven surface or for avoiding obstruction from other underground utilities, the depth may be higher. The Contractor shall take due care and precaution during trenchless digging to avoid possible damage of other underground plants/facilities in the route and shall indemnify the Owner/Employer for all damages and the Contractor shall be solely responsible for all the damages and losses. The Owner/Employer shall not be liable for any damages/losses.

1.12.11.4 Site Preparation

The required size of entry and exit pits shall be prepared by the Contractor for each site where trenchless digging and installation of manhole are required to be carried out.

Trench boundaries may be marked with rope / lime powder prior to digging in order to achieve desired straight route. Trees and their roots shall be negotiated properly to avoid damage while trenching and having safe passage to the OFC.

1.12.11.5 Excavation and Backfilling

The Contractor shall carry out excavation and backfilling for the entry and exit pits in all kinds of soil strata i.e. irrespective of the soil characteristics at all required installation sites for laying PLB HDPE pipe by trenchless digging.

The excavation of pits shall be done at such places and times so that the obstruction to pedestrian and vehicular traffic is minimum and as per the regulations by various administrative authorities. The Contractor shall take due care and precaution during excavation to avoid possible damage of other underground plants/facilities in the route and shall indemnify the Owner/Employer for all

damages and the Contractor shall be solely responsible for all the damages and losses. The Employer/Owner shall not be liable for any damages/losses. The positions of the entry/exit pits shall be matched with the required manhole locations for easy installation of manholes and easy termination of PLB HDPE pipes inside the manhole. The entry and exit depth of PLB HDPE pipes shall be about 1.5 m in normal soil.

After installation of PLB HDPE pipes and manholes, the backfilling of the entry and exit pits shall be done. Backfilling shall normally be done with the excavated soil, unless it consists of large boulders/stone in which case the boulders/stone shall have to be broken to a maximum size of 80mm. The backfilling should be clean and free from organic matter or other foreign material. The earth filling is done with a suitable amount to allow for any shrinking of soil at the later date. In case of regular footpath, temporary reinstatement shall be done after backfilling. The left out earth if any has to be disposed by the Contractor to a suitable location as indicated by authorities at his own cost.

Final inspection of the backfilling shall jointly be done by the Contractor and Employer/Owner after the backfilling is completed and the Contractor shall rectify the defects, if any, without any cost to the Employer/Owner.

1.12.11.6 Trenchless Digging

The Contractor shall use the suitable trenchless digging method depending on the actual site conditions, locations, soil characteristics, length of the digging etc. to complete all digging requirement. The trenchless digging shall be carried out at a depth not less than 1.65 m irrespective of the soil characteristics encountered at each site/route, however, in case of uneven surface the depth may still be higher. The Contractor may use the following trenchless digging methods for installation of PLB HDPE pipes:

- (i) Manual/hand augering
- (ii) Impact Moling
- (iii) Horizontal Directional Drilling (HDD)

The BoQ does not specifically indicate the method of trenchless digging to be adopted, instead the BoQ indicates various spans for which the bidder may quote different rates depending upon the method of trenchless digging to be adopted. The exact method of installation shall be finalized and approved by the Employer before execution.

The final bore size of digging shall be sufficient enough to directly install 40 mm PLB HDPE pipe easily and without any problem.

Generally, the trenchless digging shall be carried out continuously along the approved routes from manhole to manhole, however, long installation lengths can be achieved by dividing the working length into shorter sections depending upon characteristics of machines, soil/site conditions and permissions granted by the statutory authorities.

If any existing utilities pipes are detected at the digging depth, the Contractor shall carry out the trenchless digging at higher and adequate depth to avoid the damage of such existing utilities and no extra payment shall be payable for digging at higher depths. Further, in case the Contractor is required to make repeated attempts due to obstructions encountered, no additional payments shall be released for aborted attempts.

The required dewatering shall also be carried out by the Contractor at required installation sites for proper installation of PLB HDPE pipes and the manholes, wherever required. The Contractor shall ensure minimum inconvenience to public during dewatering.

The installation of PLB HDPE pipes shall be done as linear as possible in order to achieve smooth blowing/pulling of optical fibre cables through them. Bends, wherever unavoidable, shall be smooth and shall not be exceed 20 degrees.

1.12.11.7 Installation of PLB HDPE pipes and manholes

After achieving the final and adequate bore size, the PLB HDPE pipe shall be installed in the bored holes from manhole to manhole or as directed by the Employer based upon the actual site requirement. The manholes shall also be installed after excavating the soil for the required depths and size. The bottom surface shall be properly levelled and compacted before installation of the manhole. The manhole cover top surface shall be flushed with the ground surface within city areas. The PLB HDPE pipes shall be entered inside the manhole by the holes kept for this purpose. Smooth entry of PLB HDPE pipes into the manholes within permissible bending angle shall be ensured by proper method and planning during installation of PLB HDPE pipes. After installation of manholes, the PLB HDPE pipes shall be properly terminated inside the manholes and PLB HDPE pipes shall be sealed properly at the manhole entry as per the approved drawing/procedure. The Contractor shall submit the exact sealing method for Employer's approval.

PLB HDPE pipes shall be laid from manhole to manhole without any mid span joints. For longer sections without having manholes in between, the PLB HDPE pipes shall be joined properly with the plastic couplers. It shall be ensured that the PLB HDPE pipes are joined properly for smooth blowing/pulling of fibre optic cable. However, mid span joining of PLB HDPE pipes by plastic coupler may be allowed only under exceptional circumstances and shall be done only after Employer's approval. The manholes shall be installed as per the approved plan.

The PLB HDPE pipes shall be installed in a manner that the FO cable can be pulled, blown, de-blown without damaging the FO cable due to stresses.

In case of sharing of trenchless digged bore with other utilities or nearby existing other utility pipes/manholes, the manhole to be installed under this project and by the other utility shall be staggered properly and the PLB HDPE pipes shall be terminated accordingly as described above.

The PLB HDPE pipes shall be installed in a most possible straight way to avoid problems during FO cable blowing/pulling. In case, the blowing/pulling is not achieved due to improper PLB HDPE pipes installation, the Contractor shall rectify the problem and shall reinstall the PLB HDPE pipes, if necessary, to ensure the smooth blowing/pulling. However, no extra payment shall be made towards this rectification and reinstallation of PLB HDPE pipes. The installed and re-installed PLB HDPE pipes shall be checked as described below to avoid restriction or obstruction in FO cable blowing.

1.12.11.8 Acceptance Testing of PLB HDPE pipes

After installation of PLB HDPE pipes, the PLB HDPE pipes shall be checked over the whole lengths in order to ensure integrity and its suitability during fibre optic cable blowing/pulling. The installed PLB HDPE pipes shall be checked as per the requirements specified in Section 6.

In case of any problem, the Contractor shall rectify the same and re-digging and/or re-installing of PLB HDPE pipes shall be carried out by the Contractor at no additional cost to the Employer. After acceptance test, both ends of each PLB HDPE pipe shall be again properly sealed.

The Contractor shall submit the exact method/procedure for the above tests for Employer's approval.

1.12.11.9 As Built Drawings/details

The Contractor shall submit the as built drawings for the whole route indicating the route, depth of digging and manhole locations for easy maintenance of the installed system.

1.12.11.10 List of Drawings/documents required to be submitted for Employer's approval

The Contractor shall ensure that the required drawings and documents are submitted well in time to avoid any delay in approval and project execution. The following minimum drawings and documents are required to be submitted by the Contractor for approval of the Employer:

- a. Final Route Survey Report including manhole locations
- b. The methods/procedures and the equipment/machines to be used for different types of trenchless digging techniques
- c. Bill of quantities for various items as per contract
- d. SAT Reports
- e. As built drawings

3.12.11.11 Payment

The quoted unit rate for trenchless digging shall interalia include all related works/activities (listed in Trenchless Digging above, etc.) including supply and installation of accessories and other hardware required. The BoQ given in the appendices indicate the total fibre optic route length where various methods of trenchless digging shall be used for laying PLB HDPE Pipe. The BOQ indicated in the appendices are tentative and shall be finalised during detail engineering. For PLB HDPE pipe installed using trenchless digging, separate payment for installing PLB HDPE pipe shall not be made. The Owner/Employer shall not entertain any claims or payments towards any installation hardware, accessories etc. The Payment shall be made based on actual quantity executed for different spans of trenchless digging.

1.12.12 Optical fibre termination and Splicing

Termination and splicing of optical fibre cables is described in following sections.

1.12.12.1 Fibre Optic Distribution panels

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorised and terminated in FODPs in a manner consistent with the following.

- a. All fibre optic terminations shall be housed using FODPs provisioned with splice organisers and splice trays. All fibres within a cable shall be fusion spliced to pre-

connectorised pigtails and fitted to the backside of the provided couplings. The pigtails and the fibres shall be stored and dressed neatly in the provided trays and holders. The pigtails/fibres shall be numbered using suitable ferrules.

- b. Ground lugs shall be provided on all FODPs and the contractor shall properly ground all FODPs. The FODPs shall be properly fixed/grouted to the floor and or with wall with better support. Necessary installation material for fixing the FODP on wall or ground shall be provided by the Contractor
- c. The location of FODPs rack shall be fixed by the contractor, with the Employer's approval.
- d. Flexible protection shall be provided to the patch cord bunches going out from FODP to another equipments.

1.12.12.2 Optical Fibre Connectors

FC-PC type connectors shall be used. Average loss of the FC-PC connectors shall not exceed 0.5dB.

1.12.12.3 Joint Box

The joint box shall be properly installed, assembled and sealed as detailed in specification. Installation and sealing of joint box shall be done according to the instruction manual provided with the joint box. The following general criteria must be fulfilled.

- (a) Fibre loose tube shall be placed safely inside the joint box and routed properly.
- (b) Sheath shall be fully inside the joint box and FRP shall be properly fixed.
- (c) Silica gel shall be placed inside the joint box before closing the box
- (d) The sealing portion of the cable and joint box shall be filled before placing heat shrinkable sleeves. Rubber gaskets may be placed according to the instruction manual, if any.
- (e) The heat shrinkable sleeves shall be sealed with low flame of Hot gun till sealing liquid properly melt and gripped. The cable entry ports being used for cable entry into the joint box shall be sealed by heat shrink sleeves only for ease of installation and re-entry. The length of the sleeves shall cover the full length of the cable entry port and ≥ 30 mm length of the cable. The joint box shall be fixed vertically on the wall of the manhole with the help of suitable holding SS ring and nut bolt, arrangement keeping the cable entry point downwards. However, under exceptional conditions where joint boxes are required to be placed in manholes meant for keeping service loops, the same may be kept in horizontal position.

1.12.12.4 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful planning. It is important that all splicing work be done under clean conditions. All required splices shall be planned to occur at Joint location/manhole. All optical fibre splicing shall comply with the following:

- a. All fibre splices shall be accomplished through fusion splicing.
- b. Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

- c. For splicing of each fibre, every effort shall be made to minimise the bidirectional average splice loss.
- d. All splices and bare fibre shall be neatly installed in covered splice trays.
- e. Average bi-directional splice loss at any particular splice shall not exceed **0.1dB** but total bi-directional average of all splices in a link shall not exceed **0.05dB**.
- f. Fibre optic cable service loops as indicated in technical specifications shall be provided.

1.12.12.5 Splicing of fibres in existing Joint Box or FODP

In case it is required to do resplicing for rectification or splice new cable in an existing Joint Box, the above stipulations for splicing shall be applicable. In such conditions, splicing of only few fibres of the existing cables in the Joint Box with the new cable shall be done. For working in existing Joint Box/FODP, the Contractor shall take due care so that the traffic in the balance fibres is not affected.

1.12.12.6 Service Loops.

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

- a. Outdoor Cable Service Loops: At manhole chambers splices are installed with sufficient fibre optic cable service loops (as mentioned in Technical Specification) 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. Optical cable service loops (excess cable) shall also be provided at all crossings in manholes (as mentioned in Technical Specification).
- b. Indoor Cable Service Loops: At FODPs, Contractor 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 is 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 0.5 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.

1.12.13 Site Acceptance Testing (SAT)

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment/material for SAT shall be called Pre-SAT activities. During installation the Contractor shall maintain proper record of measurements in approved format and shall be given to the Owner/Employer (along with As Built drawing of the routes) for cross checking during SAT.

1.12.13.1 SAT for Excavation, Backfilling, Installation of Pipes, Manholes.

The tests shall include but shall not be limited to the following:

- a. Depth Check: One sample every 200 mtrs, Contractor shall prepare a sample pit at a location identified by the Employer. Depth of each item, warning tape, no. of warning bricks (if applicable), pipes, cable etc. shall be measured. Depth shall be as per technical specifications and shall correspond to recorded measurements.
- b. Crossings: 10% of each type, visual inspection for checking conformance with drawings, thickness of Concrete, RCC Hume Pipe and GI pipe.
- c. Manholes: As per technical specifications.

After inspection the Contractor shall backfill and carry out other restoration work at no additional cost to the Owner/Employer.

1.12.13.2 SAT for Underground Fibre Optic Cable

SAT for optical fibre cable shall be carried out link by link from FODP to FODP.

Prior to installation, every fibre optic cable segment shall be tested for continuity and attenuation and measurements shall be recorded. Test requirements are as per table 3-7.

Any discontinuity or attenuation beyond permissible limits in any of the fibres has to be recorded and brought to the notice of Employer.

Upon completion of a continuous cable path (FODP to FODP locations), all fibres within the cable path shall be demonstrated for acceptance of the cable path. Test requirements are indicated in table 3-9 and in no case losses attributed due to other factors viz. extra splice, kinks, will be acceptable to the limit determine by the following formula:

Max attenuation @ 1550nm: $0.21\text{dB/km} + 0.05\text{dB} \times \text{total no of splices} + 0.5\text{dB} \times \text{connector}$

Max attenuation @ 1310nm: $0.35\text{dB/km} + 0.05\text{dB} \times \text{total no of Splices} + 0.5\text{dB} \times \text{connector}$

Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable failure during installation. The Contractor shall have to either replace the concerned cable span at its own cost or provide additional splicing, joint box and manholes required to rectify the fault at its own cost. The fibre attenuation shall be tested again after replacement or rectification of fault.

In case it is found that the splices are bad (loss is unacceptable as per approved test procedures), the Contractor shall have to do re-splicing and provide new Joint Box wherever required at no additional cost to the Owner/Employer. After re-splicing the end to end testing shall be repeated. The splice testing requirements are indicated in table 1-8

Table 1-7:
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1.	Physical Inspection of the cable assembly for damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm

Table 1-8 :
Fibre Optic Cable Splice Testing

Item:	Description:
1.	Per splice attenuation with OTDR (bi-directional average) at 1550 nm
2.	Physical inspection of Joint Box for proper fibre routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

Table 1-9:
Fibre Optic Cable Commissioning Testing

Item:	Description:
1.	Fibre continuity and link attenuation (bi-directional) between FODP connectors at two ends for each fibre at 1310 & 1550 nm by OTDR
2.	Fibre continuity and link attenuation (bi-directional) between FODP connectors at two ends for each fibre at 1310 & 1550 nm by Power Meter & Laser Source
3.	Average splice loss (bi-directional) for each splices and average splice loss for the link by OTDR at 1550 nm.
-End of Table-	

1.12.13.3 SAT for Joint Box

All the joint boxes shall be physically inspected (visual) tightness checking of clamps and bolts, heat shrink sleeves and proper installation in the manholes. In case the Employer finds the workmanship of the installation of joint box to be poor, the Contractor shall make good the same. Consumable, if any e.g. joint box sealing, heat shrink sleeves, required for rectification work shall be provided by the Contractor at no extra cost to Employer/Owner.

1.12.13.4 SAT for PLB HDPE pipe

For PLB HDPE pipes, duct integrity tests shall be carried out as described below. The **Duct cleaning (Sponge test)** test shall be carried out on all the ducts before blowing/pulling of the cable between two consecutive manholes on the PLB HDPE pipes.

a. Duct cleaning (Sponge test)

Compressed air should be blown through the PLB HDPE pipe in order to remove dirt and water, if any, with the help of suitable Air Compressor. A short blast of air about 2-3 Bar shall be blown through the PLB HDPE pipe for about 2 minutes. Sponge shall be blown through the duct to thoroughly clean the duct from inside.

b. Crush and deformity test

Place a shuttle of length <15cm and O.D. 80% of the inner diameter of the offered PLB HDPE pipe. Connect the compressor pipe with a suitable flexible wire grip at the other end to catch the shuttle and start blowing operation to the pipe and check if shuttle reaches at the other end. If shuttle gets stuck the Contractor shall adopt suitable arrangement at site to locate the deformity/damage in the HDPE pipe, repair the pipe and ensure end-to-end continuity of the duct in sound condition

1.12.13.5 SAT for other items

Tests for other components such as FODP etc. shall be done as per the direction of Employer

1.12.14 Documentation

Apart from survey reports as mentioned above, the Contractor will submit the following documents after completion of the job and acceptance by the Employer:

- (a) As built drawing of the route indicating the distance from road centre, OFC drum length, location of other utilities, link BoQ, OFC loop length, name of the road, sections and positions of PLB HDPE pipes, couplers, warning bricks/stone, manholes, G.I. pipes, RCC pipes, joint box, conduits, bends, trays, optical fibre cable loop lengths in manholes etc.
- (b) Depth of PLB HDPE pipe in various sections of the route executed through open trenching.
- (c) Sections of trenching digging executed through various methods.
- (d) Splicing/termination details of each joint box/FODP. Attenuation and splicing loss measurement data shall be submitted for each fibre.
- (e) Specific deviation w.r.t. the installation and supply items, if any, from the technical specification. If there is no deviation, either explicit or implicit, the Contractor will provide a certification to this effect.
- (f) Without submission of the above documentations, the Site Acceptance Testing of various items as described above will be deemed to be incomplete.

1.12.15 Interconnection

The contractor shall also interconnect their Fibre Optic Cable system at both ends with existing Fibre Optic cable through splicing in Joint boxes or through connection by patch cords at FODPs, as required. The exact method of interconnection shall be finalized during project execution.

1.12.16 Miscellaneous Jobs

In order to provide end-to-end connectivity, it may be required to execute some miscellaneous jobs as detailed below.

1.12.16.1 Routing of Cables inside building.

In order to route the OFC (Optical Fibre Cable) from the underground trench to the FODPs it is necessary to install the cable on walls inside PLB HOPE pipe over the existing cable tray/raceways inside the building.

1.12.16.2 Installation of PLB HDPE pipe on wall

The PLB HDPE pipe may be required to be installed on the wall using steel or G.I clamps. The contractor will provide the required clamps and other consumables sufficient for such installation. The contractor will take care of aesthetics while installation. The OFC will be pulled through the PLB HDPE pipe with due care as described in relevant Para of this specification.

