

Study report on the performance of pond & river fiber optic cables

Authors

Milind S Chavan, Anil Tanwani, Girish Sharma, Anil Lagad, G. Kardile

Document: WP0005

Abstract

In this paper we describe the underwater cable performance study report & requirements of these cables in network. General practice of laying optical fiber cables was lay cables at roadside, which is easy for maintenance. Now day's communication becomes part of life like electricity. Underwater cable is manufactured to reduce installation lengths due to water ponds between routes.



Keywords

Pond /River cable, pressure , alkaline , acidic

1. Introduction

Pond /River cables are designed for direct lying of cables through ponds, rivers etc. Cables are designed for high compressive strength, which is exerted by water head over cable. These cables will help service provider to get shortest route while providing services in rural areas. In most of cases villages are separated by rivers or ponds only roads between such villages is service road than permanent road, which is shortest distance for cable route. Permanent road route in such villages is very longer which is not cost effective solution for laying cables across permanent roads. Experiments are conducted to validate performance of the cable for effect of various types of water on the cable transmission parameter & physical properties of material in the cable.

Rural or scattered population areas are costly for providing communication facilities. Most of the cost involves in installation of cables on other hand wireless network solution is also costly due to wide geographical area. Cable installation cost can be reduced drastically in many geographical areas where population is separated by ponds & rivers. Most of cases villages are located on the coast of either side of rivers or ponds. These villages are connected by roads with longer distance where shortest distance is just passing of river. Pond /River cable is low cost solution for service providers. this will help to expand infrastructures in the low density areas . Today's networks are mostly Ring networks sufficient maintenance time is available to restore connections not connected to permanent road infrastructure. Pond /River cables are designed to meet the requirements of cable installation under pond or river water. Experiments are conducted to validate performance of the cable for effect of various types of water on the cable transmission parameter & physical properties of material in the cable.

2. Application of Pond /River cable

For better understanding of application typical geographical area is taken for study. Here we are presenting cost comparison of Pond /River cable laying & cable lying along permanent road routes. Most of situations are similar to the network shown in the figure-1 in such situation connecting each area via permanent roads is very costly. For service providers less population density areas are not attractive due to high installation cost & indefinite recovery cost.

Low population density area is rural area of any country this area plays important role in the economy of country. To globalize rural area by communication facilities like Internet, e-governance etc. it is a necessity of any nation to expand communication networks to rural areas. Necessity of Service providers is low cost connectivity. To fulfill these requirement way of cost reduction is shortest route of cable installation. Cable, trenching & cable joint cost reduces abruptly with the route length. One of the reasons for choosing longer routes for installation is no solution & familiarity of river crossing cables.

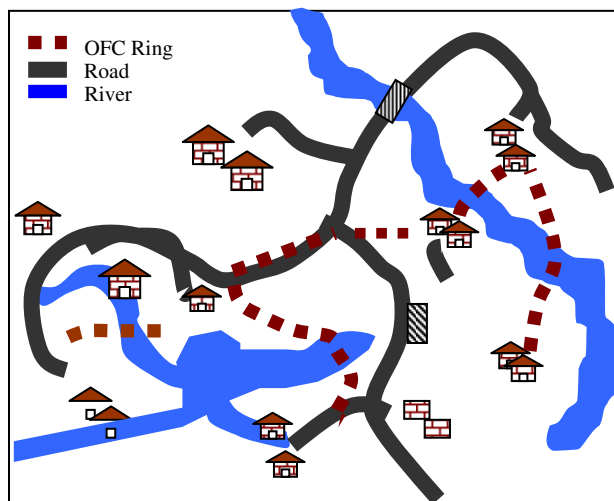


Figure – 1 Geographical area presenting scattered population divided by rivers

To summarize advantages of underwater cable we consider average length of villages connected by roads is 8 km where as generally short service roads available connecting each village of approximate 4 km. River crossing lengths are approximate 500 meters where as pond length are 1-2 km.

In this table we are comparing cost of installation of DBC cables with longer routes & DBC cable & Pond /River cable with short route

Table 1. Cost benefit for selecting Pond /River cables & short route

	DBC Cable	Pond /River cable	Installation Length
Permanent Road	8 km	0	8 km
Service road	3 km	1 km	4 km
Increase / decrease length	- 5 km	+ 1 km	- 4 km
% Cost difference	45 % + Splicing & Jointing cost		50 %

Pond /River cable cost is hardly 30% more than DBC cable per km. Where as in overall cable cost, Pond /River cable cost is 4 %. On other hand benefits are much more higher.

3. Cable construction

3.1 Requirements of Pond /River cable

During life time of cable Pond /River cable experience following external forces

- Compression force due to water level

- Water PH changes over period of time
- Force exerted due to flow of water in river
- Hydrogen generation
- Sheath abrasion by pond animals
- Floating of cable over water.
- Ice formation in ponds

Pond /River cable is designed keeping all above parameters in the mind & tested for its performance.

3.2 Construction

Considering above requirements Pond /River cable is designed for high compression, tensile strength as well as higher density. Construction diagram is shown in figure -2

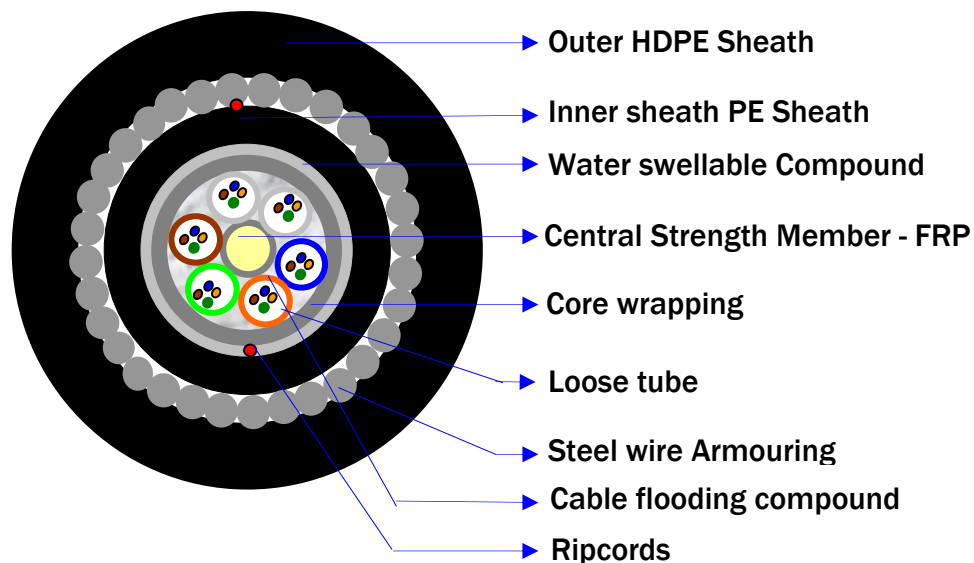


Figure 2. Cross sectional view of Pond /River cable

Cable core basic construction is loose buffer/tube. Loose tubes are manufactured with controlled excess fiber & filled with thixotropic jelly. Six elements of loose tubes are SZ stranded around central strength member made up of FRP SZ stranding provides extra protection for fiber under tension during installation & service. Core is wrapped by heat barrier polyester tape. Intermediate HDPE sheath is extruded over core. Steel wires are helically applied over this core for mechanical protection as well as increases density. Cable is designed with sufficient density so that cable get sink at bottom of pond without expiring buoyancy force exerted by water. Gap between the wires is filled with water swell able tape. The rugged external sheath is extruded onto the cable, giving it a tight fit, which eliminates air space between the jacket and the cable.

Hydrogen generation effect is considered while selecting materials for design.

4. Cable performance

To verify the performance of the cable, cable sample is conditioned in the big water tank. Sequence of tests conducted are as follows:

- Effect of acidic & alkaline water on the cable sheath.
- Effect of pressure on the cable.
- Effect of Pond animals on sheath.
- Tensile test.
- Temperature cycle

4.1 Effect of acidic & alkaline water

Pond water PH is generally changes between 5.5 to 9 PH. Pond water PH is not constant all time. This is one of the parameter to check the performance of the cable. Cable is tested for the behavior of jacket & attenuation change. Cable is kept in the water tank. One fiber from each tube is spliced to make loop. End of the loops are connected to Laser source & power meter. 5 PH water solutions is filled in the tank for 4 months. Change in loss is recorded after every month. After 4 months 9.5 PH water solution is replace in tank for next 4 month. Power loss is recorded for every month end. After completion of the test cable is visually observed for any material degradation no deterioration of sheath is observed, cable is tested for mechanical tests as per IEC 60794 standards.

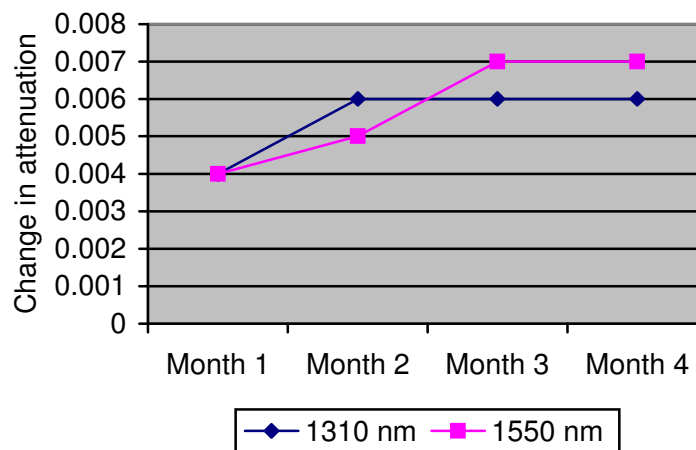


Figure 3. Attenuation change over period of time

4.2 Effect of water pressure

Pressure due to water is highest at the bottom end of the pond. Pond /River cable is always under the compression load due to water height above it. Compression load is the important characteristic considered in the cable design. Static load testing is not sufficient to check behavior of the cable under continues compression application. Cable is tested for long duration compression load. Considering pond depth of 15 meters. Pressure exerted on the cable is theoretically calculated as

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \quad (1)$$

$$\text{Pressure} = \frac{\rho V g}{A} \quad (2)$$

Where

$$\text{Volume} = \text{Area} \times \text{height} \quad (3)$$

$$\text{Pressure} = \frac{\rho A h g}{A} \quad (4)$$

$$\text{Pressure} = \rho h g \quad (5)$$

This shows that irrespective of size of ponds or rivers. Pressure is function of depth of reservoir. Considering approximate 15-meter depth for cable use. Calculated pressure is applied for 8 months during PH testing on the cable. After removing cable is tested for Mechanical tests as per IEC specifications. Results are summarized in Table 2

Table 2. Mechanical tests after completion of PH & compression conditioning

Test	Measuring spec.	Result
Tensile test	4 W	Maximum strain observed: 0.19 % Change in loss: No loss change No physical damage to sheath
Bend test	24 D	Change in loss: No loss change No physical damage to sheath
Torsion test	180°	Change in loss: No loss change No physical damage to sheath

4.3 Effect of pond water animals

Cable is constructed with Steel wires helically wrapped between two HDPE sheaths. A steel wire provides extra protection from rodent & animal bite. In the ponds mostly apparent animals are tortoise, small fishes & crabs, rare rodents are seen on the coast of ponds . All these animals cannot have strength to cut the cable. To check the performance of sheath cutting by these animals 200 m piece is kept in the nearest water dam having availability of all these animals in water as well as surrounded by heavy forest.

No sheath crack was observed after removal of cable for inspection after 30 days.

4.4 Tensile Strength Test

Pond /River cable is made for steady as well as flowing water rivers. In steady water tensile force will not be significant parameter. For flowing river in spite of zero velocity at bottom end cable is pulled in flow direction, force will exerted for long time like aerial cables.

There are many other factors like pulling of cable by pond animals etc. Cable is designed for 4 W (where W is weight of cable per km) strength. Cable is tested after ageing in the water. Results are summarized in the below in Figure 4.

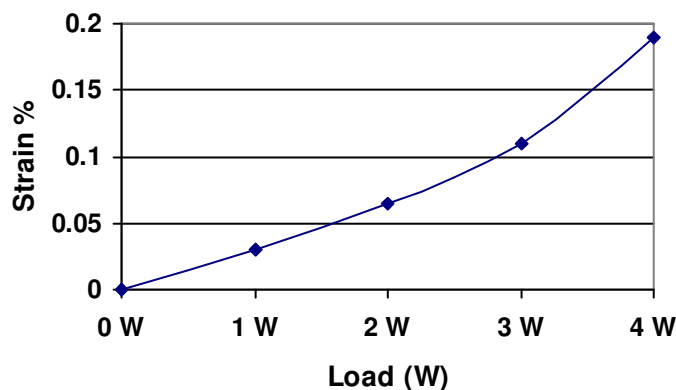


Figure 3. Tensile graph Load (w) Vs Strain (%)

Change in loss is measured with respect to initial attenuation measured before starting tensile test.

4.5 Temperature cycling

Water temperature varies with the seasons & day time mostly temperature at 15 meter is constant. During temperature variations, ice formation & water density changes. These effects are mostly happen at water surface than the lower level of water. Cable is tested for -30°C to $+70^{\circ}\text{C}$ for its performance under different environmental conditions. Temperature cycle is shown in figure 4

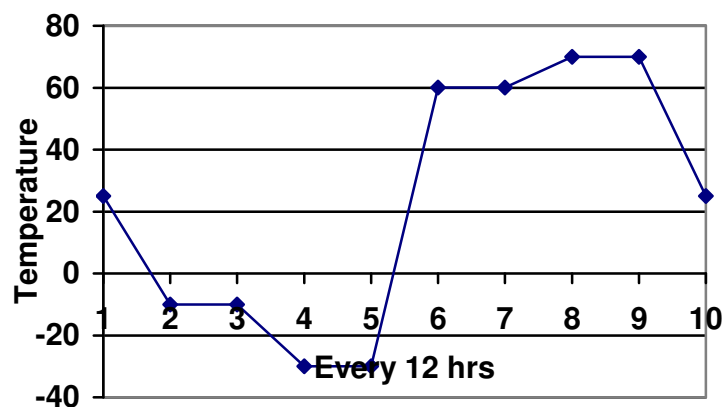


Figure 4. Temperature cycle

Change in loss is measured after completion of temperature conditioning for 12 hours the change in attenuation is shown in the figure 5.

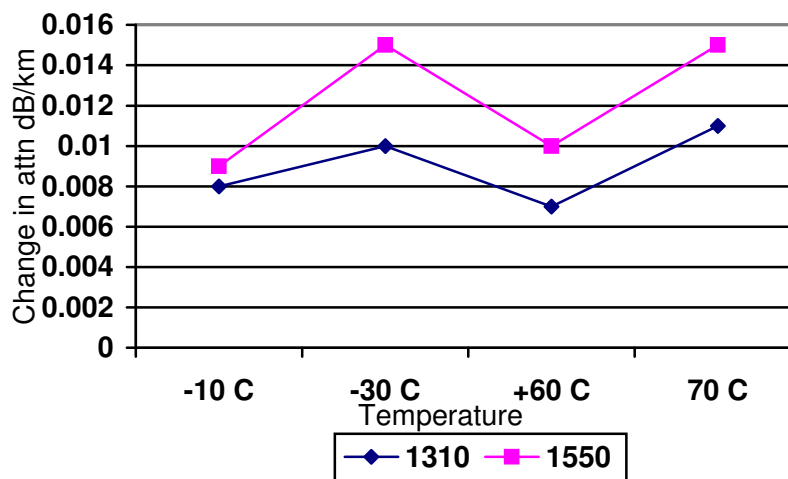


Figure 5. Temperature cycle

4.6 Attenuation change

Optical fiber cables are most sensitive to water & hydrogen. This cables designed & manufactured so that no water will pass or penetrate from outer sheath & cable. Water proofing of cable is important because water affects on cable when fibers are directly in contact with water.

This effect is most significant when fibers are under tension & flaws are generated in fiber. Materials are selected for zero hydrogen generation. In deep-water hydrogen pressure increases may affect fiber performance over a period of time. No significant change is observed in the attenuation. Results are summarized in Table 3.

Table 2. Mechanical tests after completion of PH & compression conditioning

Average	1310 nm	1550 nm
Initial attenuation	0.332 dB/ km	0.198 dB/ km
Final Attenuation	0.337 dB/km	0.205 dB/km
Change in attenuation	0.005 dB/km	0.007 dB/km

5. Pond /River cable Accessories

To fix Pond /River cables at coast of river of pond or river steel helix with protection roads. Protection roads used to protect cable from abrasion at clamping point. Over protection roads helix is applied. Cable is tested for 20 KN pulling force for grip. Under this force no cable slippage was observed.



Figure 3. Testing for cable Grip

6. Conclusion

We have tested performance of Pond /River cable for various tests. We found that the cable is passing all required criteria of specification. Change in basic parameter i.e. loss is well in range. Pond /River cable is best solution for the infrastructure having low-density area, which is mostly surrounded by ponds or rivers. These cables are highly usable in the areas of river delta where is no option for other cable installation. These cables are extensively tested for the standard specifications as well as practical conditions.

7. Acknowledgments

We are thankful to those who extended their kind assistance to the development of this cable.

Whitepaper

Fiber Optic Cable



Sterlite Technologies Limited

Aurangabad
Bangkok
Beijing
Boston
Haridwar
Johannesburg
Dadra
London
Moscow
Mumbai
New Delhi
Piparia
Pune
Rakholi
Shanghai

Phone: +91-20-30514000
communications@sterlite.com

www.sterlitetechnologies.com