» New Products

Bend-Insensitive Single-Mode Optical Fiber for In-Building Applications

1. INTRODUCTION

Fiber-to-the-home (FTTH) is now being deployed around the world. In order to generate revenue, it is essential to cost-effectively connect customers to the network.

Unfortunately, one challenge is that the number of the skilled operator is limited and connecting end users can be time-consuming. This has spurred considerable innovation in ultra-bend-insensitive single-mode optical fibers. These fibers are described in the International Telecommunication Union Telecommunication Standardization Sector (ITU-T) Recommendation G.657, and FTTH construction can be streamlined by this innovative fiber product.

AllWave FLEX Max Fiber and EZ-Bend Fiber, which are the optical fiber products of Furukawa Electric Group, are newly developed products which have superior properties that outperform the most stringent requirements of the G.657 recommendation, and can be easily and aesthetically friendly installed in buildings.

2. MINIMIZATION OF THE ALLOWABLE BENDING RADIUS

30 mm is adopted in the communication network for over 30 years as the allowable minimum bending radius of the single-mode optical fiber cable. With the rapid development of FTTH, the introduction of optical fiber cable to personal and home subscribers has been accelerated, but the effort to connect each subscriber by optical fiber remains a handicap for the following reasons.

- A variety of wiring techniques are adopted and the number of connections becomes substantial.
- The number of skilled installation contractor is small.

The wiring system achieved with the ultra bend-insensitive optical fiber, eliminated the problem of tight optical fiber cable bending in the building wiring, and therefore subscribers and the access network can be connected with a simpler technique.

ITU-T G.657 recommendation standardized several types of the bend-insensitive optical fibers. They differ in the minimum design bending radius. The minimum bending radius can be used while satisfying the guaranteed bending loss performance.

Table 1 shows subcategories of the standardized bend-insensitive single-mode optical fibers and Furukawa Electric Group products, which comply with those requirements.

Table 1 ITU-T standardized bend-insensitive single-mode fibers and the compliant Furukawa Group fibers.

Designed minimum bending radius	ITU-T subcategory	Maximum bending loss at 1550 nm for 1 full turn at the minimum bending radius Standard (Furukawa Electric Group products)	Furukawa Electric Group products
Conventional single-mode optical fiber			
16 mm	G.652.D	N/A (0.5 dB)	AllWave Fiber
Bend-insensitive single-mode fiber			
10 mm	G.657.A1	0.75 dB (0.20 dB)	AllWave FLEX Fiber
7.5 mm	G.657.A2 or G.657.B2	0.5 dB (0.5 dB)	AllWave FLEX + Fiber
5.0 mm	G.657.B3	0.1 dB (0.10 dB)	AllWave FLEX Max Fiber
2.5 mm	Exceed G.657.B3	N/A (0.2 dB)	EZ-Bend Fiber

The excellent bending loss performances of these products are obtained by optimizing the wave-guide design to control the bending loss performance, the fusion splicing performance and the optical properties. Figure 1 shows examples of the various designs of single-mode optical fiber products of Furukawa Electric Group. From the simplest design used for the standard single-mode fiber at the left end, to the construction used in EZ-Bend Fiber at the right end are listed.

It has been demonstrated that the best bending loss performance can be obtained by the hole-assisted fibers, though Furukawa Electric Group actively made efforts in the development of solid-type bend-insensitive optical fibers to improve the interconnect properties. As a result, all of our bend-insensitive optical fibers can be spliced in low attenuation with the fusion splicing and the connector splicing which are applied to the standard single-mode optical fibers. Fusion splicing losses of the combination of the various optical fibers shown in Figure 1, using a V-groove system fusion splicer, are less than 0.2 dB. Therefore, these products can be applied to the network without deteriorating interconnection performance.

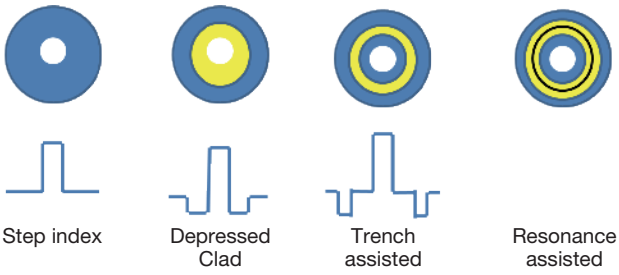

Figure 1 Wave-guide designs for bend-insensitive single-mode optical fibers.

Furthermore, the bending loss at 1550 nm of EZ-Bend Fiber at one full turn wound to a mandrel with 2.5 mm of radius is less than 0.2 dB. This unique performance has not been achieved by other solid-type single-mode optical fibers available on the market today.

3. DEPLOYMENT EXAMPLES OF THE ULTRA BEND-INSENSITIVE OPTICAL FIBER

Frequently, severe conditions are imposed in optical fiber wirings in buildings. In order to simulate the condition, an example was developed by Verizon Communications of the United States and was used to simulate multi-dwelling units (MDU). The simulation method is as follows. Using an optical fiber cable, 30 U-shaped staples fastening and 10 right angle bends are applied, and the optical cable is given 2-turns on a mandrel with 10 mm of radius. 2 kg of weight at one right angled part and 14 kg of weight at another right angled part are loaded. Thus, the wiring in the building is simulated. The setting situation of the test is shown in Figure 2. The required specification for this test is less than 0.4 dB of net attenuation increase at 1550 nm of wavelength.

Figure 2 Image of the MDU simulation apparatus for the Verizon TPR 9424 testing.

The optical fiber is housed in 2 kinds of cables to compare the optical fiber cable products for wiring in buildings and is tested; the test result is shown in Table 2.

Table 2 Cable test results for Verizon TPR 9424 MDU simulation.

	4.8 mm diameter cable (Fiber minimum bending radius : 5 mm)	3.0 mm diameter cable (Fiber minimum bending radius : 2.5 mm)
Competitive fiber sample Designed minimum bending radius : 7.5 mm Compliant with ITU-T G.657.A2	0.6 dB	Not tested
AllWave FLEX Max Fiber Designed minimum bending radius : 5.0 mm Compliant with ITU-T G.657.B3 and G.652.D	0.4 dB	Not tested
EZ-Bend Fiber Designed minimum bending radius : 2.5 mm Compliant with ITU-T G.657.B3	0.2 dB	0.3 dB

The result shows that the optical fiber bending loss of two ultra bend-insensitive optical fibers, AllWave FLEX Max Fiber and EZ-Bend Fiber, have better performance for this severe test than the ITU-T G.657.A2 compliant optical fiber.

Based on these early installation evaluation tests, the further thin optical cable InvisiLight was commercialized and its aesthetically friendly installations became possible. This is an optical fiber of 0.9 mm diameter that can be adhered directly to the wall, and already installed in various buildings. The installation examples of the optical cable of 4.8 mm diameter and InvisiLight are shown in Figure 3.

Figure 3 Examples of the deployed ultra-bend-insensitive single-mode optical fiber in the existing buildings.

4. CONCLUSION

The ultra bend-insensitive optical fiber has started to be widely deployed in FTTH networks. Quick and cost-effective installations in existing buildings are possible with the new cables such as drop cable having a diameter of 4.8 mm and InvisiLight products that are friendly to aesthetics. These innovative optical fibers were realized by AllWave FLEX Max Fiber.

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