Ultra-High-Density Optical Fiber Cable

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In order to construct optical fiber networks economically and efficiently, we have successfully developed new Ultra-High-Density optical fiber cables which are applied for underground and aerial networks. These cables contain our novel optical fiber ribbons "Spider Web Ribbon" which consists of a group of 250 micron coated fibers bonded intermittently. The novel fiber ribbons are easily bundled or bunched without loss increase that helps to reduce the dead-space of conventional cables. By optimizing several structural parameters, the new cable dimension has been reduced by 29 % in diameter and 52 % in weight compared with the conventional cable. We have achieved the highest level of the fiber packing density in the world.

1. Introduction

In recent years, the demand for broadband services using optical access networks have grown explosively with the spread of the Internet and smart phones. Therefore, it is strongly required to install optical fiber networks economically and effectively. In order to minimize the construction cost of the access cable networks, it is necessary to reduce the diameter and weight of the cable. The decreased cable diameter and weight allow effective utilization of existing facilities such as underground ducts or telephone poles, and reduce the cable cost and installation cost. Thus, optical cables with a small diameter and light weight have been studied enthusiastically.

When conventional ribbon fibers are packed with high density in a cable for reducing cable diameter and weight, a high strain is given to the optical fiber by bending the cable [1)]. It causes degradation of optical characteristics and increases fracture probability of optical fiber. To solve these issues, we have developed Ultra-High-Density optical fiber cables packed with new ribbon fibers, Spider Web Ribbon (SWR) [2)3)]. By optimizing cable and ribbon structural parameters, the new cable dimension has been reduced by 29 % in diameter and 52 % in weight compared with the conventional cable.

2. Spider Web Ribbon

2.1 The structure of SWR

The structure of SWR is shown in Figure 1. An SWR consists of 250 micron coated fibers fixed intermittently with UV curable resin. Three main features of SWR are as follows. First, this ribbon can be bundled easily as shown in Figure 1. Therefore, this structure is extremely effective to pack fibers with high density in a cable. Second, fibers of SWR can be spliced simultaneously using a mass fusion splicer. Third, an SWR can be separated into individual fibers easily by using a simple tool like a brush. The important structural parameters of SWR are a bonding pitch, bonding part length, and bonding pattern. These parameters determine easiness in folding to achieve high packing density, fusion spliceablity and separatability into single fibers. In addition, bonding strength is also an important factor to prevent splitting into single fibers during the cable manufacturing or the cable installation.

2.2 Characteristics in fusion splicing

Characteristics of an SWR and a conventional 4-fiber ribbon are compared in terms of handling in fusion splicing and time of the operation. Figures 2 and 3 show the results. The SWR shows good compatibility

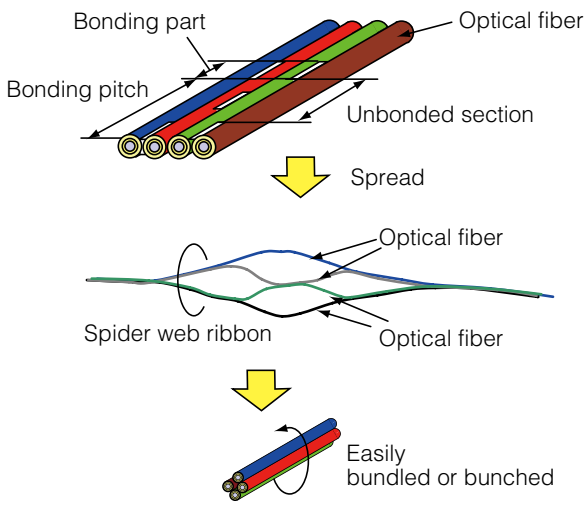

Fig. 1. Structure and feature of spider web ribbon.

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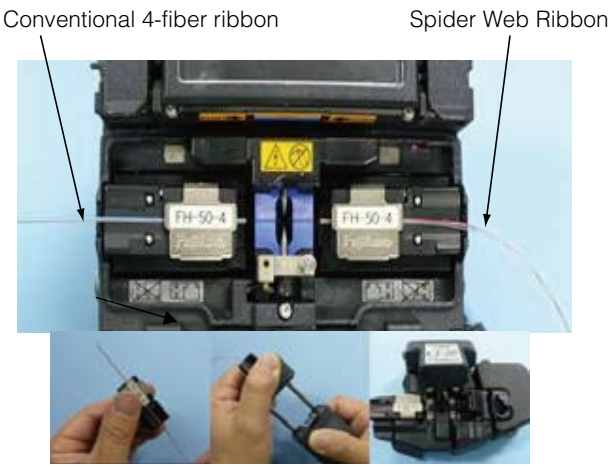
with the mass fusion splicer and the peripheral tools and equipment such as a fiber holder, a fiber cleaver and a coating stripper. The time of splicing is almost the same as the conventional fiber ribbon.

3. Ultra-high-density optical fiber cables

3.1 The structure of cable

New aerial cables from 24-fiber to 200-fiber, and 100 and 200-fiber underground cables have been developed. Figure 4 illustrates cross sectional views of 200-fiber ultra-high-density optical fiber cable family. They are classified into 3 types such as a self-supporting aerial cable type, a non-supporting aerial cable type, and an underground water-blocking cable type. The self-supporting aerial cable consists of cable elements and a supporting wire which are partially attached to each other, creating windows which improves aerodynamic characteristics. The non-self supporting aerial cable has no supporting wire. In the underground water blocking cable, a water swellable tape is wrapped around the fiber units to prevent water ingression. All of the new cables consist of two strength members, and two rip-cords. As shown in Figure 4, projections of two rip-cords are formed on the cable jacket. The projections allow operators to recognize the rip-cord positions to open the jacket at the mid-span access point.



SWR has a compatibility with conventional mass fusion splicer, holder and cutter.

Fig. 2. Fusion splicing of a Spider Web Ribbon with a conventional fiber ribbon.

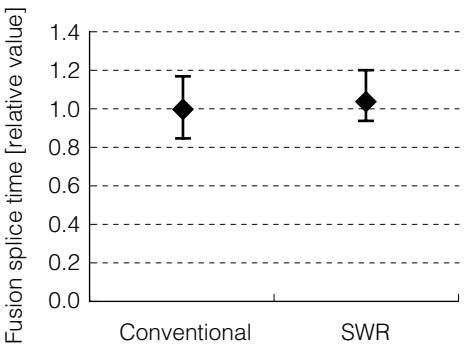


Fig. 3. Fusion splice time.

3.2 Comparison between new cables and conventional cables

Table 1 shows comparison of cable structures between conventional cables and newly developed cables. We have reduced the cable diameter and weight dramatically by eliminating much of the dead-space inside the cable. The dead-space has been formerly occupied by plastic buffer layers or a slotted core in the conventional cable. Compared with the conventional

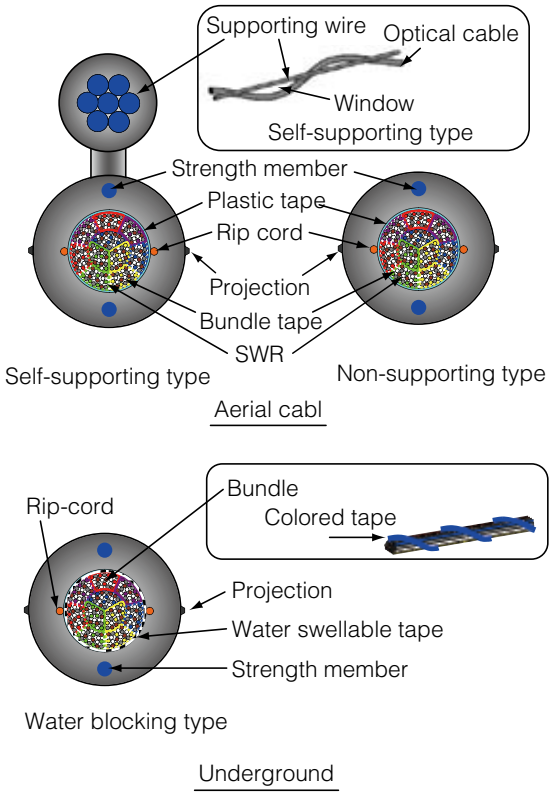
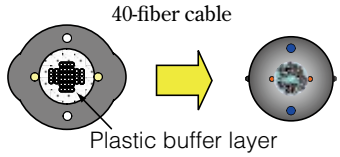
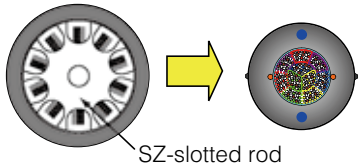


Fig. 4. Cross sectional view of newly developed cables.

Table 1. Comparison between new cables and conventional cables.

Cross sectional view	
Conventional	New
40-fiber cable	
	
Plastic buffer layer	
200-fiber cable	
	
SZ-slotted rod	

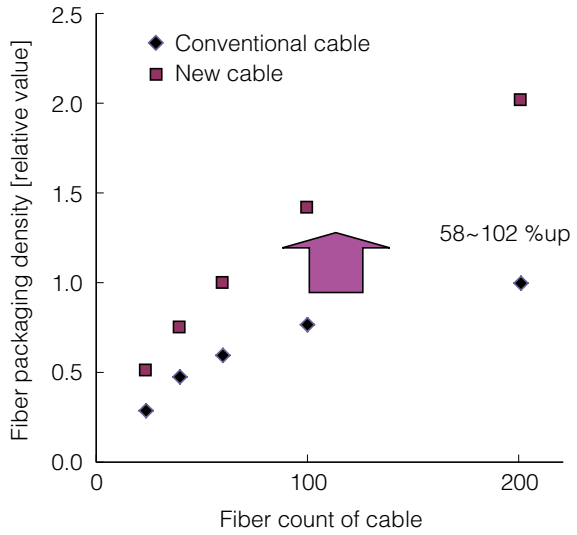


Fig. 5. Fiber packaging density.

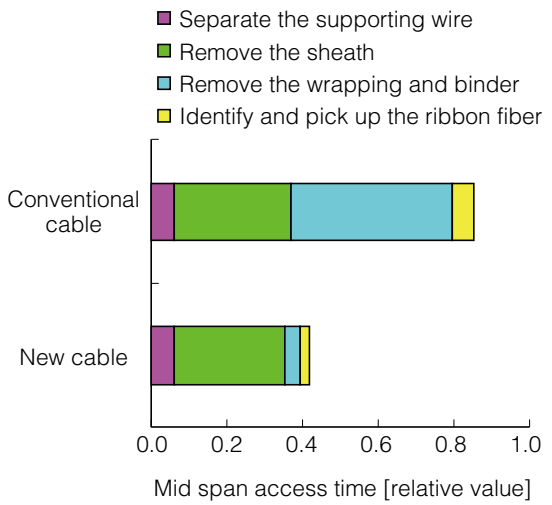


Fig. 6. Mid span access time.

slotted core cable, the diameter of the new 200-fiber cable has been reduced by 29 % and the weight by 52 %, respectively. Figure 5 indicates relative fiber packing densities of the new and conventional cables. The new cables show almost 50 % to 100 % increase of the fiber packing density.

3.3 Identification characteristics of fibers in a cable

Since a new optical cable contains a maximum of 50 SWRs in 200-fiber structure, we apply 2-mm-wide tapes of 10 colors as a bundle tape for ribbon identification. Around 5 SWRs are subunitized by a bundle tape. Individual fibers can be identified by the color of bundle tapes and SWR in which individual fibers are color-coded.

3.4 Mid span access operation

We performed a mid span operation on an already installed aerial cable. Another optical cable was connected to the aerial cable in a closure, which was additionally set up on the pole. Figure 6 shows the comparison of the mid span operating time of the conventional slotted core cable and the new cable. The mid span access operation time was shortened more than 50 % by optimizing cable design.

Table 2. Characteristics of new cable.

Item	Condition	Result
Crush	IEC60794-1-2 1960 N/100 mm	<0.05 dB*
Impact	IEC60794-1-2 10 J	<0.05 dB*
Repeated bending	IEC60794-1-2 R=160 mm	<0.05 dB*
Torsion	IEC60794-1-2 ±90 deg.	<0.05 dB*
Water penetration (Only underground cable)	Height of water=1 m Sample length=40 m Artificial sea water	No water detected at unsealed end
Bending under tension	R250 mm, 90 deg.	<0.05 dB*
Temperature cycling	IEC60794-1-2 −30/+70 deg.C 3 cycles	<0.05 dB/km*

*Measurement wave length:1550nm

3.5 Cable performance

The mechanical and environmental test results of the developed cables are listed in Table 2. Induced attenuation at 1550nm was measured on test conditions in accordance with IEC 60794-1-2 and requirements from a specific customer. We confirmed no break of the bonding parts of SWR in the cable after installation test. The new cables have shown excellent mechanical and environmental performance.

4. Conclusion

We have developed 24, 40, 60, 100 and 200-fiber Ultra-High-Density optical fiber cables with Spider Web Ribbons. The new cables are suitable for both underground and aerial optical networks because the SWR structure has packed fibers in a cable with high packing density and drastically reduced the cable diameter and weight. The developed cables have shown an eminent mechanical and optical performance, and have also proved well compatible with the conventional fiber ribbons in terms of mid-span cable access and splicing with the existing fiber splicer.

We believe that the new optical cables will help economical and efficient construction of future optical fiber networks.

References

1) Yamada, et. al.: Design and performance of ultra-high-density optical fiber cable with rollable optical fiber ribbon, IEICE., OFT2010-49, pp.9-14, 2011
2) Takeda, et. al.:Development of Ultra-high density optical fiber cable, IEICE., OFT2012-53, pp.5-8, 2013
3) Yamanaka, et. al.: Ultra-high density optical fiber cable with “Spider Web Ribbon”, 61st IWCS, pp37-41, 2012