FTTx Optical Fiber Cable for Easy Mid-Span Access ("EZremove")

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This paper describes the newly developed SZ-slotted core optical fiber cable that provides fast and easy mid-span access. The cable uses new wrapping tape that can be peeled easily and safely without using any cutting tool, thus reducing the time required for mid-span access operation. The result of the mid-span access test confirms that the newly developed cable enables safe and easy mid-span access operation and 30% operation time reduction. These advantages are beneficial to the cost reduction of fiber-to-the-home (FTTH) network construction. It was also confirmed that the cable has excellent transmission, mechanical and environmental characteristics. In order to maximize the benefits that can be derived from the new cable, a down-sized aerial drop closure was also developed. In addition, a network configuration using these new products was also investigated, and the cost reduction effect was confirmed in a simulation study.

1. Introduction

In Japan, the number of FTTx subscribers has reached 10.5 million at the end of September 2007 and it is growing at an accelerated pace (1). Under this circumstance, the reduction of both time and cost of cable installation work has become significantly important for both telecommunications operators and subscribers. Various types of optical fiber cable have been developed and used for FTTx networks. Among the cables, SZ-slotted core cable is widely used in Japan, because of the following attributes.

1. Fiber ribbons can be taken out from any desired point of the cable.
2. Causes less movement of fiber ribbons.

Figure 1 shows the typical structure of a conventional SZ-slotted core cable. As shown in the figure, optical fiber ribbons are accommodated in the slots of the SZ-slotted rod spacer. On the outer surface of the spacer, threads and wrapping tape are wound spirally around the core, which is then covered with a polyethylene sheath.

In order to connect one of the fibers in the cable to a subscriber premise, cable installation workers have to take out the fiber ribbon from the cable at its mid-span. This is called "mid-span access". In performing the mid-span access of SZ-slotted core cable, after removing the sheath for several tens of centimeters in length, the wrapping tape and threads need to be cut with a cutting tool.

However, such procedure requires cable installation workers to take meticulous care not to damage fiber ribbons with cutting tools, because cutting tools are used very close to fiber ribbons. This is one of the biggest barriers to reducing the operation time of mid-span access.

This problem had motivated the authors to develop a new cable that allows the threads and wrapping tape in the cable to be cut without the use of any cutting tool.

In addition, components other than optical fiber cable are also used in access networks, such as aerial closure. In order to reduce the overall cost of access network construction, the authors also developed a down-sized compact aerial closure.

The aerial closure was successfully down-sized by specializing its function to connecting the SZ-slotted core cable with drop cable. This aerial closure is beneficial for both cost reduction and landscape conservation.

Network construction costs depend not only on network components but also on network configurations. With this point taken into consideration, the authors introduced a new network configuration that fully utilizes the drop closure for mid-span access.

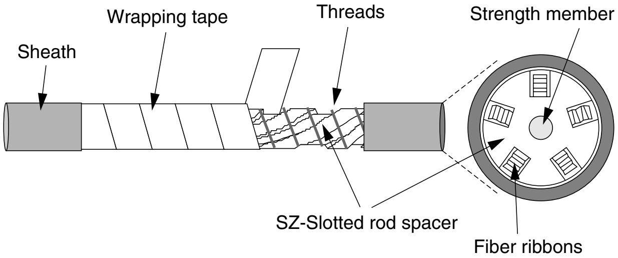

Fig. 1. Typical structure of conventional SZ-slotted core cable

2. Optical Fiber Cable Structure

Figure 2 shows the structure of the newly developed cable. Basically, this cable has the same structure as conventional SZ-slotted core cables except for the threads and wrapping tape. By using the same spacer and sheath as the conventional one, the new cable structure can achieve the same-level attributes in terms of transmission performance, mechanical properties, dimensions and environmental tolerance.

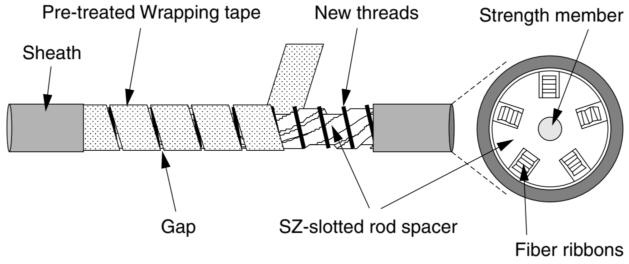

Fig. 2. Structure of newly developed SZ-slotted core cable

For improved ease and safety of thread removal, the new cable structure adopted a low melting point material for the threads, and the wrapping tape was wound so as to create the gaps between the turns of the tape. In this cable structure, the threads are cut at the gaps of the wrapping tape by the heat from polyethylene sheath during the sheath extrusion process. Because the threads are cut beforehand, no cutting of threads is needed in mid-span access operations. The authors named this technique the "pre-cut thread technique."

For easier removal of the wrapping tape, the authors have developed and adopted a new wrapping tape pretreatment technique that allows the tape to be peeled with fingers.

With the use of the pre-cut threads and the pre-treated wrapping tape, it has become possible to perform mid-span access without using cutting tools. This new cable structure leads also to the reduction in mid-span access operation time.

Using this new cable structure, 24-, 60-, 100-, and 200-fiber cables were manufactured. The dimensions of the cables are shown in **Table 1**. As mentioned above, the only differences between the new cables and typical conventional SZ-slotted core cables are threads and wrapping tape. Therefore, the new cables have the same diameters and weights as conventional cables. On this account, there is no difference workability at cable installation between the new cables and the conventional SZ-slotted core cables when all cables have the same number of fibers.

Table 1. Cable design and dimensions

Fiber count	(Number of slots) x (Number of 4-fiber ribbons)	Cable outer diameter (mm)	Cable weight (kg/km)
24	3 × 2	9.5	80
60	5 × 3	10.5	90
100	5 × 5	13.5	150
200	10 × 5	16.5	220

3. Cable Performance

3-1 Mid-span access performance

In order to assess the improved mid-span access

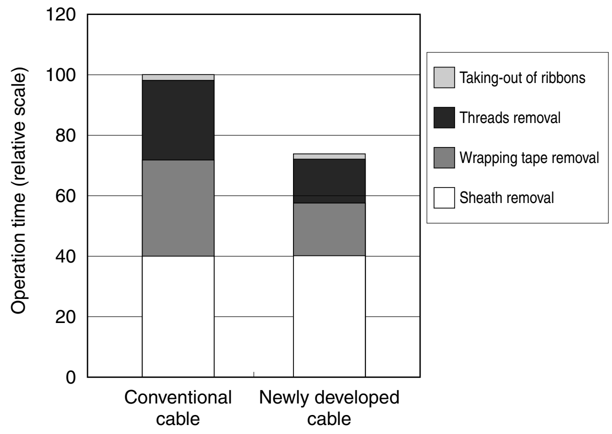

Fig. 3. Time required for taking out fiber ribbons from cable (Example: 60-fiber cable)

performance of the new cable structure, the authors performed a mid-span access test and evaluated the workability and measured the operation time.

The test was made on the new and conventional 60-fiber cables with the length of sheath removal set to 50 centimeters. The operation time was measured from the start of sheath removal to the completion of taking out of fiber ribbons from the cable.

The comparison of the measured operation times showed that the newly developed cable needed a 26% shorter time, as shown in **Fig. 3**.

In the mid-span access test, the wrapping tape of the newly developed cable was easily peeled with fingers without using any cutting tool, as shown in **Photo 1 and**

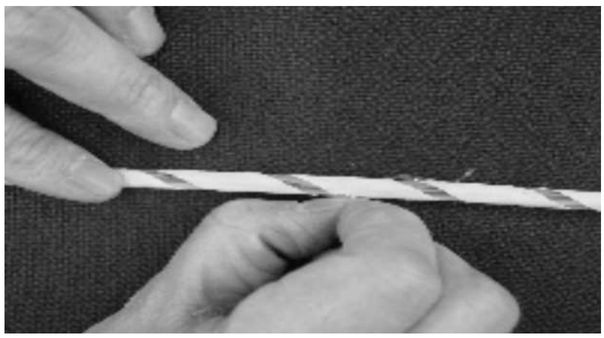

Photo 1. Holding wrapping tape with fingers

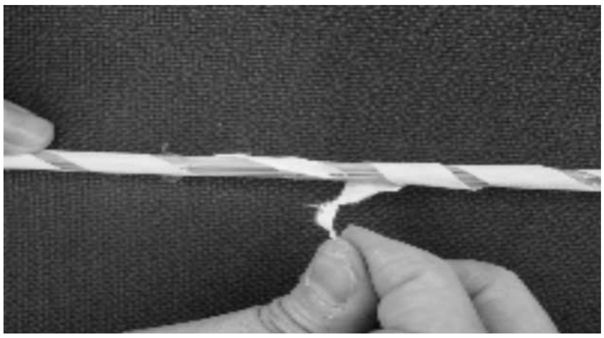

Photo 2. Peeling wrapping tape with fingers

2. Moreover, the pre-cut threads were cut into appropriate lengths, so the threads were not scattered, even after the removal of the wrapping tape. Moreover, the pre-cut threads were removed easily.

The mid-span access test confirmed that the newly developed cable achieves safe and easy mid-span access and shorter operation time.

3-2 Cable characteristics

SZ-slotted core cables are typically installed aerially, therefore they are required to have robust designs so that they can withstand severe conditions during and after installation.

The temperature cycling and mechanical tests were performed on a newly developed 60-fiber cable that was manufactured using conventional single-mode fibers (ITU-T G.652 B).

The test items, conditions and results are summarized in **Table 2**. The results of the tests confirmed that the newly developed cables have excellent characteristics in terms of transmission performance, mechanical properties and environmental tolerance as compared with conventional cables.

Table 2. Transmission performance and mechanical properties (Example: 60-fiber cable)

Test item	Test method	Test result
Temperature cycling	IEC-60974-1-2-F1 -20 to +60 deg. C	No loss change @ 1550nm
Crash	IEC-60794-1-2-E3 1960N/100mm	No loss change @ 1550nm No visible damage
Impact	IEC-60794-1-2-E4 4.9N, 1m	No loss change @ 1550nm No visible damage
Bending	IEC-60794-1-2-E11 R=210mm	No loss change @ 1550nm No visible damage
Torsion	IEC-60794-1-2-E7 +/-90 degrees	No loss change @ 1550nm No visible damage
Bending under tension	IEC-60794-1-2-E18 1180N, R=300mm	No loss change @ 1550nm No visible damage

4. Study on FTTH Network Construction Time/Cost Reduction

For providing FTTx services, it is necessary to connect an optical fiber cable with a drop cable in an aerial distribution closure and guide the drop cable into the subscriber's premises. The authors studied the FTTH network configuration to improve fiber utilization efficiency and reduce network construction time. In addition, the authors developed not only the new cables but also other products such as a new compact aerial drop closure in order to maximize the advantage of the new network configuration.

4-1 Study on network configuration

The authors made a study on FTTH network configuration. The aims of this study are to reduce network construction cost through the improvement of fiber utilization efficiency and to reduce network construction time. Then the authors proposed a new FTTH network configuration.

In this analysis, the model FTTH network assumed was 50 subscribers per cable distribution area that consists of an aerial cable strung on nine utility poles. Then the model FTTH network was divided into two sections. One is the section between the sub-node and the aerial drop closure, and this is constructed beforehand in advance of subscriber demand. The other section is between the drop closure and the subscriber premise, and this is constructed in response to subscriber demand.

A conventionally typical FTTH network configuration is shown on the upper side of **Fig. 4**. In this configuration, only one drop closure is installed per aerial cable distribution area. This typical configuration minimizes the number of drop closures, but requires long-distance installation of drop cable.

A candidate for new FTTH network configuration that the authors proposed is shown on the lower side of **Fig. 4**. In the proposed configuration, one drop closure is installed for every three utility poles. As a result, compared with the conventionally typical configuration, this new configuration can reduce the length of drop cable installation. Although the number of drop closures increases, the cost increase can be compensated by down sizing and workability improvement.

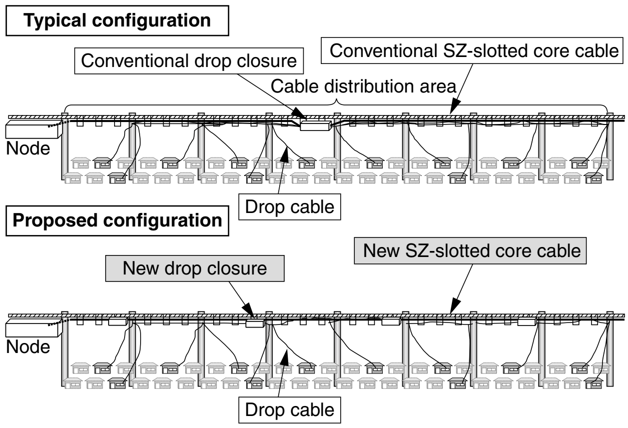

Fig. 4. FTTH network configuration models

4-2 Compact drop closure

Figure 5 shows the external view of the down-sized compact drop closure that was newly developed. The new drop closure is nearly 60% smaller than conventional drop closures in volume, and was designed to offer following functions.

1. Down sizing was realized by being specialized in feeding drop cables to subscriber premises.
2. A maximum of 6 drop cables can be connected.
3. Equipped with a pocket for storing the fibers tapes taken out from a cable and a tray into which a drop cable can be inserted without removing its sheath. The work process was simplified and the operation reliability was improved.
4. Optical fiber connection is by fusion splicing or by mechanical splicing. Connection by a connector is also possible by changing the tray to a connector adapter.

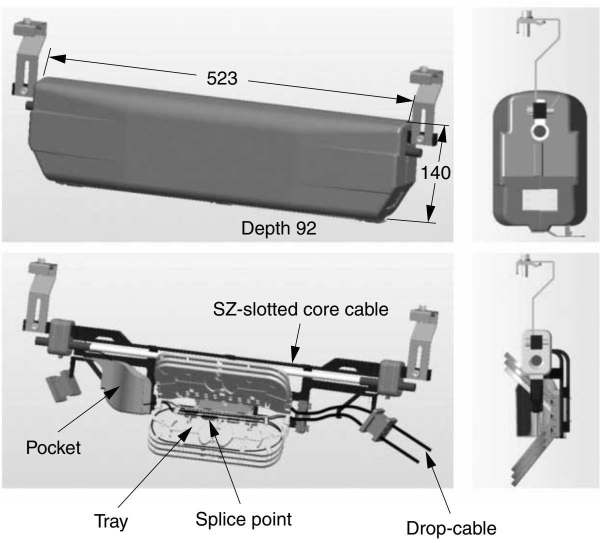

Fig. 5. Structure of new drop closure

4-3 Study on network configuration

The costs for components and construction were calculated for the typical and the proposed network configurations using the different fiber utilization rates (the ratios of the numbers of fibers used to the numbers of fibers installed). The calculation results are shown in **Fig. 6**. These results indicate that when the fiber utilization rate is higher than 8%, the construction cost for the proposed network configuration is lower than that for the typical configuration.

The results of the other analysis indicate that the network construction time for the proposed network configuration is also reduced by 50%, because of its shorter drop cable installation distance and the use of newly developed products.

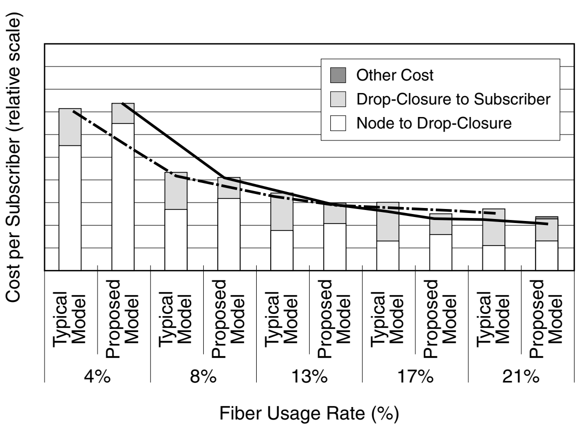

Fig. 6. Simulation result for FTTH network construction cost

5. Conclusions

The authors have developed new SZ-slotted core optical fiber cables for improved mid-span access. In the newly developed cables, the wrapping tape can be peeled easily and safely without using any cutting tool, thus reducing the time required for a mid-span access operation. This characteristic of the new cables is beneficial to the cost reduction of FTTx network construction. Other products such as a compact drop closure were also developed. A comparison was made on the newly proposed network configuration and the conventionally typical network configuration, and the cost reduction effect of the new network configuration was confirmed in simulation.

Presently the number of FTTx subscribers is growing at an accelerated pace. The authors will continue with further study in order to develop new products that contribute to the construction of optimal FTTx networks.

References

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