High-density Aerial Optical Cable with High Strength Sheath

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An innovative self-supporting high-density cable with high strength sheath for aerial application was developed. By using Spider Web Ribbon® / Wrapping Tube Cable® (SWR^{TM} / WTC^{TM}) technology, extremely reduced outer diameter and weight were achieved compared to existing cable. In addition, the developed cable has not only functions equivalent to existing cable but also excellent mid-span access workability.

1. Introduction

In recent optical fiber cable market in the world, higher density cables are in demand for underground and aerial installation. This is because mobile and fixed network are rapidly expanding by widened 4G and 5G service area, increased date storage in cloud computing and IoT service which has stimulated expansion of date centers. In response to this demand, some of the solutions to achieve faster and economical deployment has been reported in 62 nd IWCS paper of SWR / WTC.

Due to the viewpoint of excellent workability, slotted core cables tend to be replaced by SWR / WTC structure in Japanese optical cable network. However, as a problem in some aerial application, there have been cases where optical fibers within the optical cable are damaged due to the cable being bitten by animals, such as woodpeckers or squirrels.

In response, measures such as the provision of a protection structure should be required. For example, a stainless steel tape, which surrounds slotted core cable using rigid ribbon has been taken. Because the rigid ribbon is susceptible to fiber strain, it was difficult to reduce the cable diameter and weight. In addition, at the time of mid-span access, a special tool was needed. Even though the special tool was used, when inserting a blade into the outer sheath, there was a risk of damage to the optical fibers since there was no protection layer inside the stainless steel tape. Besides, in case of using rigid ribbon, when it is separated into single fibers, the time and skills were needed due to the work requiring special tools. Therefore, the cable which has reduced outer diameter, weight, high strength sheath and adequate mid-span access workability were required.

In response to this demand, a new high-density cable with high strength sheath for aerial application was developed extending fiber counts up to 200 fibers. The existing slotted core cables used in Japanese aerial optical network do not have the functions that the new cable have. Therefore, this cable is expected to replace existing slotted core cables and be used worldwide.

2. Design Concept of New WTC

2.1 Features of SWR and WTC

The structure of SWR is shown as Figure 1. SWR has single fiber part and bonding part where the adjacent fibers are fixed together intermittently. Thus, it is possible to flexibly change its shape like bundled fiber units. Therefore, it is possible to pack SWR into the cable to be high density without increasing the attenuation or subjecting large fiber strain. Additionally, in case of using rigid ribbon, when it is separated into single fibers, the time and skills are needed due to the work requiring special tools. On the other hand, SWR can be separated into single fibers easily without special tools.

WTC is central tube cable without slotted core and consists of SWR which is wrapped in a tube made by overlapping tape. Moreover, strength members are embedded side place in the sheath. Therefore, WTC structure achieves extreme reduction in outer diameter and weight and offers full dry structure to help quick installation.

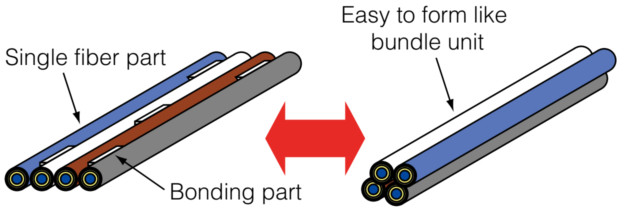

Fig. 1. Structure of 4-fiber ribbon.

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2.2 *Features of New WTC*

The design concept of new WTC is that this cable has not only functions equivalent to existing cables but also excellent mid-span access workability. The structure of new WTC is shown in Figure 2. This cable consists of double sheath construction. Outer sheath which includes the sheath and a corrugated steel tape that surrounds inner sheath can pass the repeated impact test simulated being hit by woodpeckers. In addition, due to the double sheath structure, when inserting a blade into the outer sheath, there is no risk of damage to the optical fibers.

Moreover, this cable includes the following five key technologies mainly:

1) This cable has ripcords for outer sheath in order to be easy mid-span access with existing tools. This enables the operator to pull ripcords using plier and remove the outer sheath easily.

2) The ripcords for outer sheath are embedded to the inner sheath. The operator can handle even short cables because the ripcords are fixed.

3) This cable has a projection to show the position of a steel tape overlap. Because of it, it is not necessary to remove the sheath all around to look for that position at the time of mid-span access.

4) The position of a steel tape overlap is controlled to avoid being placed at the same circumferential direction with the ripcords because large tearing force is required to pull the ripcords at that position.

5) The mark after tearing the outer sheath by using the ripcords for outer sheath is the indication of the position of the ripcords for inner sheath. Besides, the small thickness of the inner sheath makes the inner sheath easy to tear.

Consequently, the newly developed WTC has excellent mid-span access workability.

2.3 *Mid-span Access Workability*

The new cable mid-span access process is shown in Figure 3. First, by using existing tools, such as S cutter, which is one of the standard tool in Japan, the cable sheath can be sliced off along the projection to the steel tape overlap easily. Next, by using a nipper, the steel tape and outer sheath are removed easily. Finally, it is easy to pick up the ripcord for outer sheath and pull it using plier. Therefore, the steel tape and outer sheath are easy to be removed without special tools.

After removing the outer sheath, the mark after pulling the ripcords for outer sheath remains on the surface of the inner sheath, and it becomes the ripcord's position indicator for inner sheath because the ripcords for inner sheath are located inside the ripcords for the outer sheath. Besides, the small thickness of the inner sheath makes the inner sheath easy to tear. Thus, inner sheath is easy to be removed.

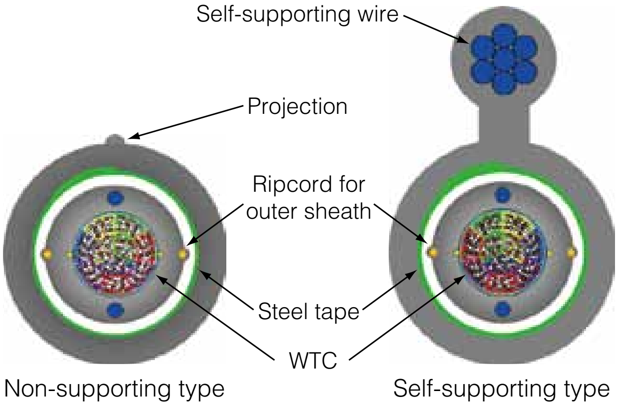

Fig. 2. Structure of developed cable.

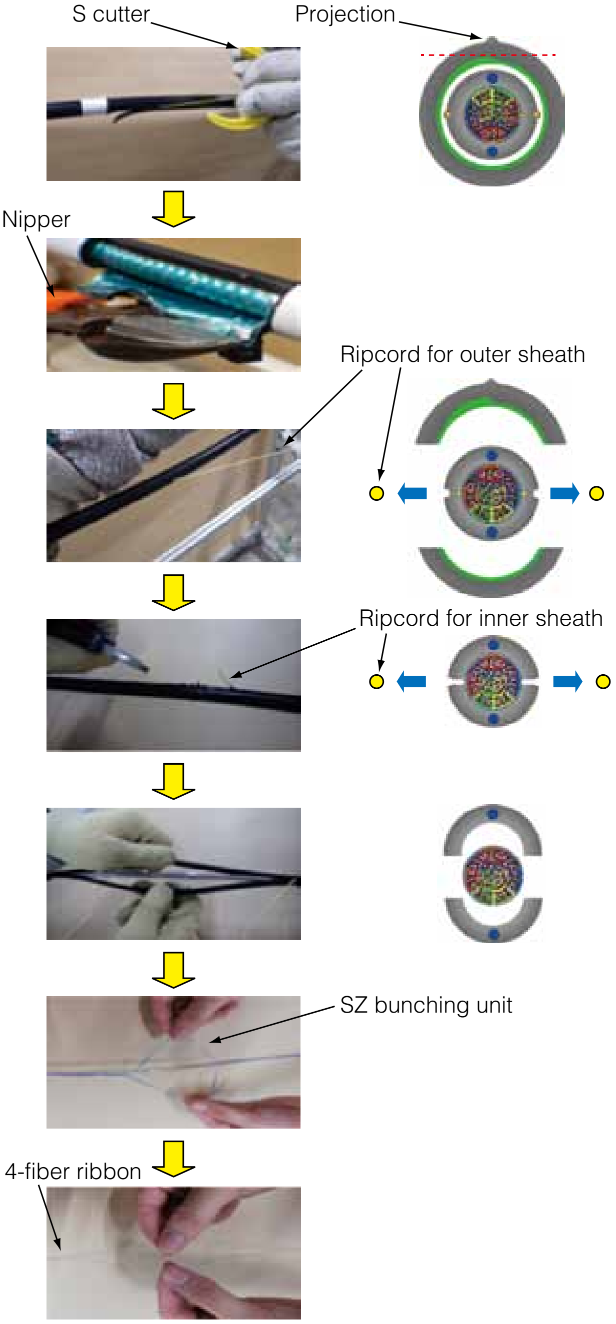

Fig.3. Process of mid-span access.

Additionally, this cable includes heat-bonded SZ bunching units which consist of two colored tapes. The two colored tapes are bonded by heat intermittently and can be peeled off easily by hands. Furthermore, this cable consists of multiple SWR. Accordingly, SWR can be separated into single fibers easily by hands. Consequently, this cable has excellent mid-span access workability.

3. Comparison of Cable Design

Based on the design concept, new WTC extending fiber counts up to 200 fibers was designed. By using SWR / WTC technology, much higher fiber packing density has achieved than slotted core cable. Focusing on 200-fiber cable, fiber packing density of new WTC is higher than that of slotted core cable approximately 62%. As a result, reduced outer diameter is achieved compared to the slotted core cable. The cross section of 200-fiber cable of self-supporting type structure is shown in Figure 4.

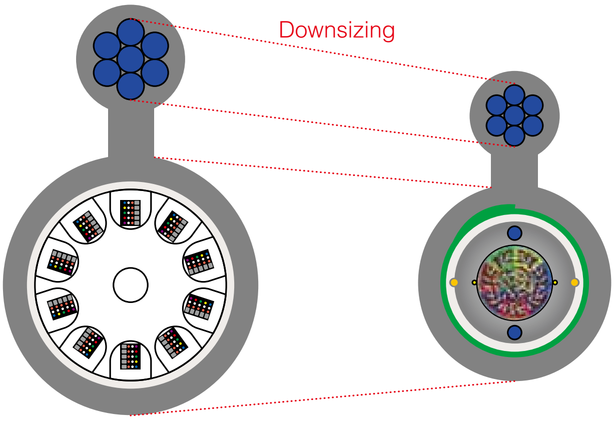

Fig. 4. Comparison of 200-fiber cable of self-supporting type.

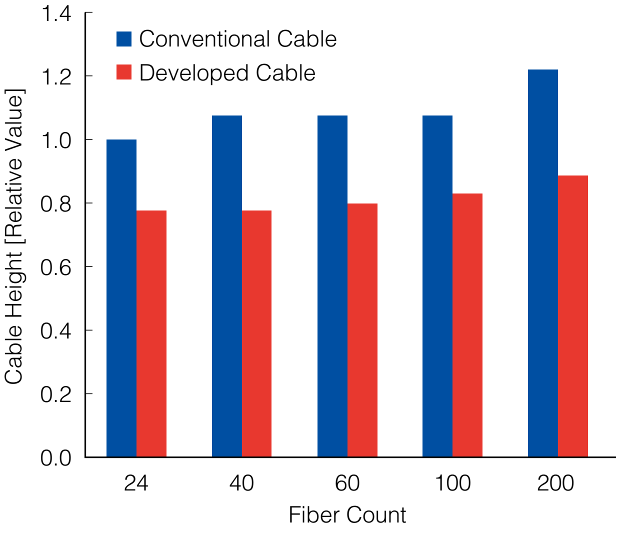

Fig. 5. Comparison of cable height.

By the reduction of outer diameter, in case of self-supporting type structure, it is possible to be lower the size of self-supporting wire. Therefore, extremely reduced outer diameter and weight are achieved compared to the slotted core cable. The comparison of cable height and weight of self-supporting type structure is shown in Figure 5 and Figure 6. As shown in Figure 5 and Figure 6, focusing on 200-fiber cable, cable height of new cable is reduced approximately 27% and cable weight is reduced approximately 40% compared to the slotted core cable.

4. Characteristics of New WTC

4.1 Non-supporting Type Structure

The mechanical test results of 200-fiber cable of non-supporting type structure are shown in Table 1. A measurement wavelength for mechanical test was 1550 nm. This cable showed excellent mechanical characteristics.

The result of temperature cycling test was measured between −30 degree C and +70 degree C for 3 cycles.

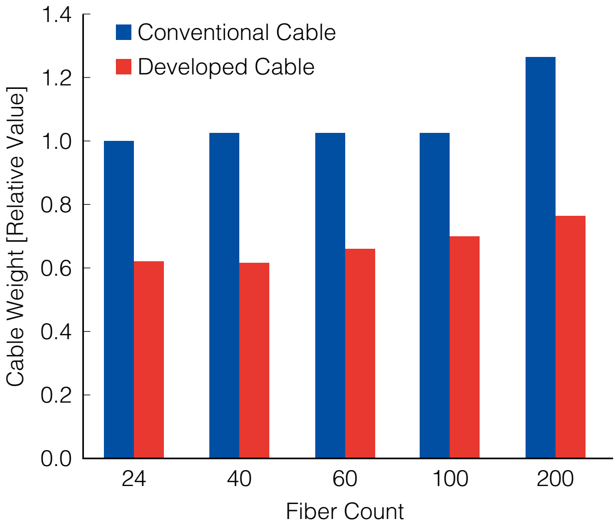

Fig. 6. Comparison of cable weight.

Table 1. Result of mechanical test (Non-supporting type).

Item	Condition	Result
Crush	1960 N/100 mm, 1 minute	<0.05 dB No damage
Impact	Impact energy: 10 J	
Repeated bending	Bending radius: 200 mm Cycle: 10	
Tensile strength	Load: 392 N	
Torsion	Sample length: 1 m Test angle: ± 90 deg	
Bending under tension	Load: 392 N, Bending radius: 250 mm Test angle: 90 deg, Cycle: 4	
Repeated impact of steel tape	Impact energy: 0.012 N·m/mm Cycle: 200	No damage

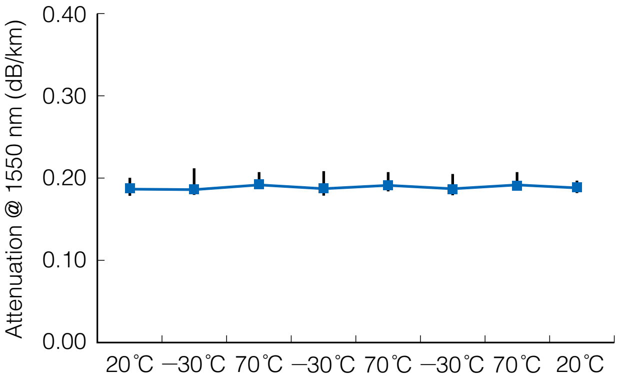

Fig. 7. Result of temperature cycling test (Non-supporting type).

The result is shown in Figure 7. Within this specified temperature range, maximum variation of attenuation is less than 0.05 dB/km at 1550 nm. The developed cable showed excellent temperature cycling characteristics.

4.2 Self-supporting Type Structure

The mechanical test results of 200-fiber cable of self-supporting type structure are shown in Table 2. A measurement wavelength for mechanical test was 1550 nm. This cable showed excellent mechanical characteristics.

The result of temperature cycling test was measured between −30 degree C and +70 degree C for 3 cycles. The result is shown in Figure 8. Within this specified temperature range, maximum variation of attenuation is less than 0.05 dB/km at 1550 nm. The developed cable showed excellent temperature cycling characteristics.

5. Conclusion

An innovative self-supporting high-density cable with high strength sheath was successfully developed extending fiber counts up to 200 fibers. By using SWR / WTC technology, extremely reduced outer diameter and cable weight are achieved compared to the slotted core cable. Furthermore, this cable showed not only adequate mechanical and environmental characteristics but also excellent mid-span workability performance.

By this innovative cable, we can expect further expansion of applicable ranges of SWR / WTC.

Table 2. Result of mechanical test (Self-supporting type).

Item	Condition	Result
Crush	1960 N/100 mm, 1 minute	<0.05 dB No damage
Impact	Impact energy: 10 J	
Repeated bending	Bending radius: 200 mm Cycle: 10	
Torsion	Sample length: 1 m Test angle: ± 90 deg	
Bending under tension	Load: 1960 N, Bending radius: 250 mm Test angle: 90 deg, Cycle: 4	
Repeated impact of steel tape	Impact energy: 0.012 N·m/mm Cycle: 200	No damage

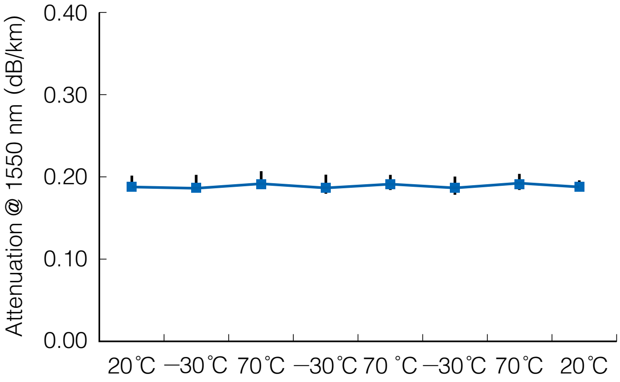

Fig. 8. Result of temperature cycling test (Self-supporting type).

Reference

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