HIGH FIBER COUNT CABLE FOR SDM SYSTEM

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Abstract: The development towards higher bit rate optical communication systems has been rapidly evolving in recent years and advances in transmission technologies have increased the level of requirements for each element of the system. For high capacity long haul submarine transmission systems, the deployment of High Fiber Count Cable has become a must to improve system performance from both transmission and cost per bit points of view. We completed the cabling evaluation and qualification for High Fiber Count Cables with excellent results. These new High Fiber Count Cables are based on our well-known 3-divided steel segment cable structure. In this paper, we introduce submarine cable equipped with 16 fiber pairs and 12 fiber pairs.
Performance of these cables has been tested and successfully qualified in accordance with ITU-T Recommendation G.976 and internal programs, demonstrating its high reliability and conformity to the latest requirements.

1. INTRODUCTION

Data traffic over optical networks is at constant growth. By 2020, 3 times as much traffic is estimated in comparison to the year of 2015. [1] Explosive growth in usage of Smart phones, Cloud services, and Movie Streaming around the world is pushing up this data traffic growth. To meet the world-wide transmission requirements, developments toward higher speed and higher capacity optical communication systems have been actively evolving with digital coherent technology. For long haul high capacity optical communication systems the front line technology is based on the usage of 100Gbps digital coherent and highly efficient modulation techniques.

As a cable manufacturer we have several effective methods to contribute to the requirements. For example, cabling of low loss (large effective area) optical fibers, expanding the transmission bandwidth, cabling of multi-core fibers, and the development of High Fiber Count Cable for SDM system.

Among them mass production of cable with “Ultra Low Loss” and “Large effective area” fibers has been already achieved and reported in our previous papers. [2] [3] [4]

Our next challenge is developing High Fiber Count Cable to improve system performance from both transmission and cost per bit points of view.

In this paper, we report our evaluation results φ20.4mm cable equipped with 16 fiber pairs and φ17.0mm cable equipped with 12 fiber pairs.

2. CABLE STRUCTURE

Our φ20.4mm and φ17.0mm cable had similar structure adopting 3 divided steel segment tube, which optical fibers are directly cabled into. To achieve this design, we developed a state-of-the-art fiber insertion manufacturing technology. The 3 divided steel segment structure is followed by a layer of stranded high strength steel wires, which is then covered with seam-welded copper layer that serves as both the hermetic barrier against moisture ingress and the power feeding conductor. The cable structure is shown in Figure 1.

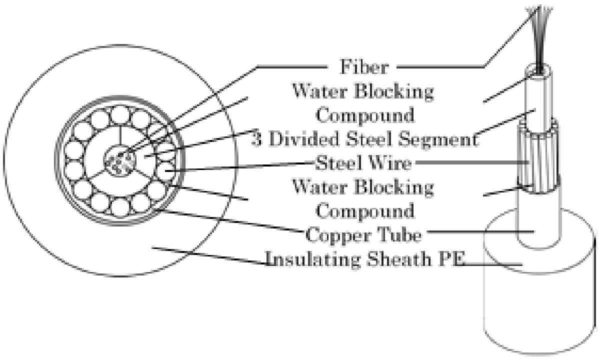

Figure 1. OCC-LW (Light Weight) cable structure

The cable manufacturing technology developed for this structure is based on a state-of-art fiber insertion technique allowing both:

- zero fiber back tension, and
- fiber excess length control.

Our conventional φ20.4mm and φ17.0mm cables were designed to allow maximum 12 and 8 fiber pairs. Our new High Fiber Count Cables are mostly based on the conventional cable structure with some improvements. We have manufactured and tested the new cables, that were equipped with 16 fiber pairs and 12 fiber pairs for φ20.4mm and φ17.0mm cable.

3. CABLING DIFFICULTIES

To achieve development of High Fiber Count Cable, there are some difficulties to overcome during cabling process.

Illustrative drawing of optical signal propagation is described in Figure 2. Ideal signal propagation inside the fiber for long haul transmission is show in Figure 2(a). Effective transmission can be achieved by the full reflection in the fiber core. However, due to the Macrobending as in figure 2(b) and the Microbending as in figure 2(c), the light leaks out of the fiber core. The larger the effective area becomes, the larger optical power leakage occurs. The leakage from the fiber core due to Macro/Micro bending results in fiber attenuation increase. This attenuation increase results in an inefficient transmission performance.

Cabling large effective area fibers without increasing the attenuation is very important. There are two key points to cable large effective area optical fibers. The first point is not to bend the fibers to avoid Macrobending induced loss increase. The second one is not to give local stress on the fibers to avoid Microbending induced loss increase. These two points can be achieved by the 3 divided steel segment structure design mentioned in Section 2.

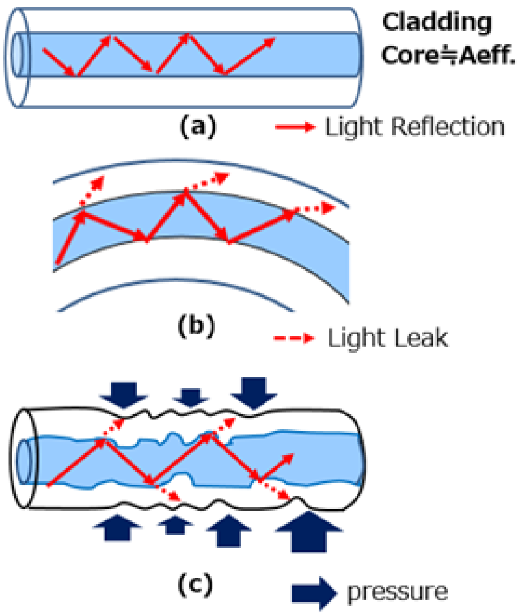

Figure 2.
(a) Total Reflection of the Optical signal
(b) Macrobending loss
(c) Microbending loss

Increasing number of fiber pairs in the 3 divided steel segment may lead to larger

mutual stress increase on fibers, which causes Macro/Micro bending induced attenuation.
A mentioned above optical fibers with large effective area are especially sensitive to Macro/Micro bending. In High Fiber Count Cable evaluation we include the new type fibers.

4. QUALIFICATION AND EVALUATION TEST

4.1 Evaluation Items

There are two main points to evaluate High Fiber Count Cable. The first point is attenuation variation during cabling process and the second one is attenuation variation during cable laying operation.

Since the cable structure is based on conventional φ20.4mm and φ17.0mm design, mechanical performance of cable is not changed.

The cable evaluation items are listed in Table.1. They were implemented according to ITU-T Recommendations G.976. .

No.	Item
1	Manufactured Cable Loss
2	Temperature Stability
3	Hydraulic Pressure Resistance
4	Tensile Test with Twist Restrained
5	Tensile Test with Torque Minimized
6	Mechanical Fatigue Test
7	Sheave Tests
8	Crush Resistance
9	Impact Resistance
10	Flexure Resistance
11	Water Ingress Tests

Table 1. Test Items for High Fiber Count Cable

4.2 Attenuation variation during cabling process

In 2017, our manufacturing and evaluation tests of φ20.4mm cable with 16 fiber pairs were completed with excellent results.

Figure 3 shows optical attenuation behavior during cabling process, attenuation values after Copper Tubing and LW (PE insulating sheath) process shows small variations from fiber's original optical attenuation.

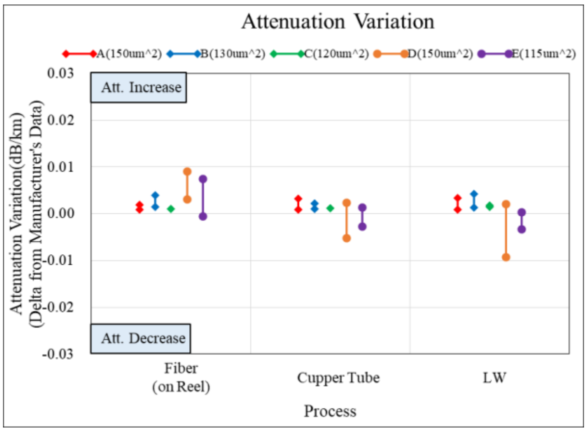

Figure 3. Attenuation Variation During Cabling (16 fiber pairs)

Following the φ20.4mm cable evaluation, we manufactured and evaluated φ17.0mm cables with 12 fiber pairs in 2018. We obtained excellent results. Figure 4 shows optical attenuation behavior during cabling process, attenuation values after cabling process show small variations, too.

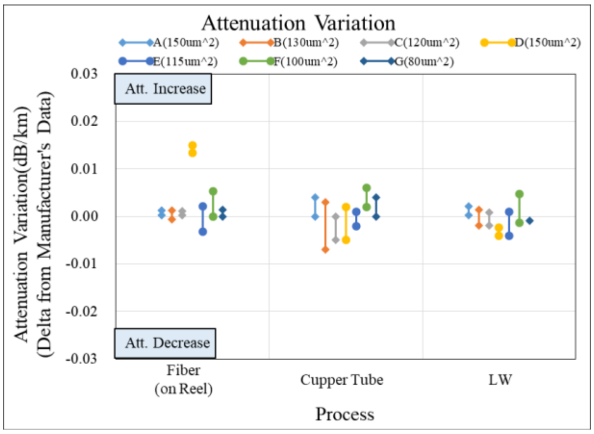

Figure 4. Attenuation Variation During Cabling (12fiber pairs)

4.3 Attenuation variation during cable laying operation

Attenuation variation during cable laying operation was evaluated through ITU-T Recommendations G.976 test. Our past study supports that the ITU-T test results are well consistent with attenuation variation during/after field laying operations. [4]

All evaluation tests were performed on cable samples and completed with excellent results. Table 2 summarizes the test conditions of the tensile test with twist restrained. Optical attenuation is continuously monitored during the test to record any variations.

Sample Length	Approx. 123m
Condition of cable end	Twist restrained at both ends
Load	NTTS
Time	1hour cycle + short time 2cycles
Target (Optical attenuation)	Variation: ±0.020dB/km Residual: ±0.005dB/km

Table 2. Test Conditions a of Tensile with twist restrained

The test result is depicted in Table 3. We obtained excellent results. Attenuation variation of "Large Effective Area" optical fibers was small during/after test. It proves 3-divided steel segment design and our technology of fiber insertion is suitable to avoid Macro/Micro bending effects.

	φ17mm 12 fiber pairs cable	φ20.4mm 16 fiber pairs cable
NTTS	60kN	80kN
Optical Attenuation (Variation)	-0.004 ~+0.001 dB/km	-0.005 ~+0.005 dB/km
Optical Attenuation (Residual)	+0.001 dB/km	+0.004 dB/km

Table 3. Test Result of Tensile with twist restrained

5. CONCLUSION

We developed and evaluated φ20.4mm cable with 16 fiber pairs and φ17mm cable with 12 fiber pairs. The evaluation results show that our cable design is capable of delivering all the properties of high end optical fibers to realize high bit rate systems of 100Gb/s and higher, over transoceanic distances. Now our goal is to enhance our cabling technology and challenge to the next step of High Fiber Count Cable development, φ20.4mm cable with 24 fiber pairs and φ17mm cable with 16 fiber pairs.

6. REFERENCES

[1] Cisco public, "Cisco Global Cloud Index: Estimation and method, 2015 – 2020", Cisco White Paper C11-738085.

[2] D. MASUDA et al., "Mass production results of submarine cable applying "Ultra Low Loss" and "Ultra Large Effective Area" Fiber", IWCS2016, Section2-Paper3.

[3] M. KOBIKI et al., "Successful Mass Production of Extremely Low Attenuation Submarine Cables", IWCS2017, Section2-Paper2.

[4] M. OHARA et al., "Measurement Results of Submarine Cable after Actual Installation", IWCS2018, Section15-Paper2.