Sumitomo Electric's Air-Blown Optical Wiring Solution (Microduct Installation) for Data Centers

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Sumitomo Electric Industries, ltd.

1. Introduction

In recent years, communication traffic has increased rapidly due to progresses in cloud computing and video subscription services and support for 5G. Meanwhile, there is a growing demand for thin Ultra-High-Density (UHD) fiber-optic cables that contain optical fibers at a high density due in part to physical constraints in the internal spaces of ducts. In Europe and North America, air-blown optical cables are in widespread use in fiber-to-the-home (FTTH) applications. The air-blown optical cable enables networks to be constructed economically because once a duct (microduct) has been installed, it can be additionally installed without the need for additional roadwork. Small-diameter ducts, or microducts, are used for air-blown installations. Recent increases in transmission capacity and advances in FTTH have spurred the need to use high-fiber-count, UHD microduct optical cables.

Air-blown installation that uses high-pressure compressed air determines properties required of this cable. Namely, it should be thin, lightweight, low-friction, and adequately rigid so as not to yield during air-blown installation. We have developed a Freeform Ribbon™ (FFR) optical cable that reduces the connection cost more than single-fiber optical cables do, while being compatible with the above-described installations in microducts.

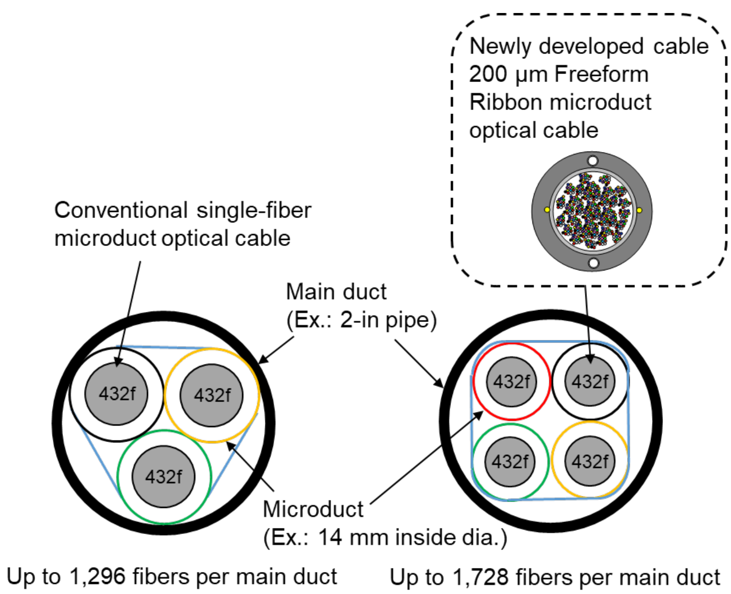


Fig. 1 Schematic diagram of microduct installation

Fig. 2 Air-blown installation method

2. Cable Design and Characteristics

2.1 200 µm Fiber Design

Fig. 3 provides a schematic cross section of the thin 200 µm optical fiber used for the recent development. The thin 200 µm optical fiber has its cross-sectional area reduced by 36% by reducing the cladding thickness, with the glass diameter remaining at 125 µm, as before.

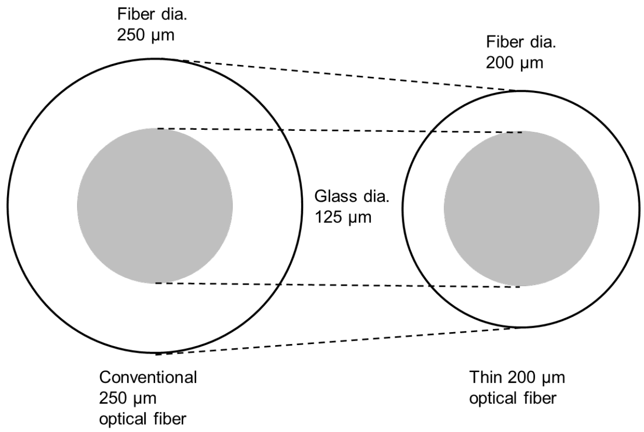


Fig. 3 Schematic cross section of thin 200 µm optical fiber

2.2 200 µm Freeform Ribbon™(FFR)

The 200 µm FFR used for the recent development is a 12-fiber ribbon in predominant use in advanced countries. Fig. 4 shows concepts and characteristics of FFR.

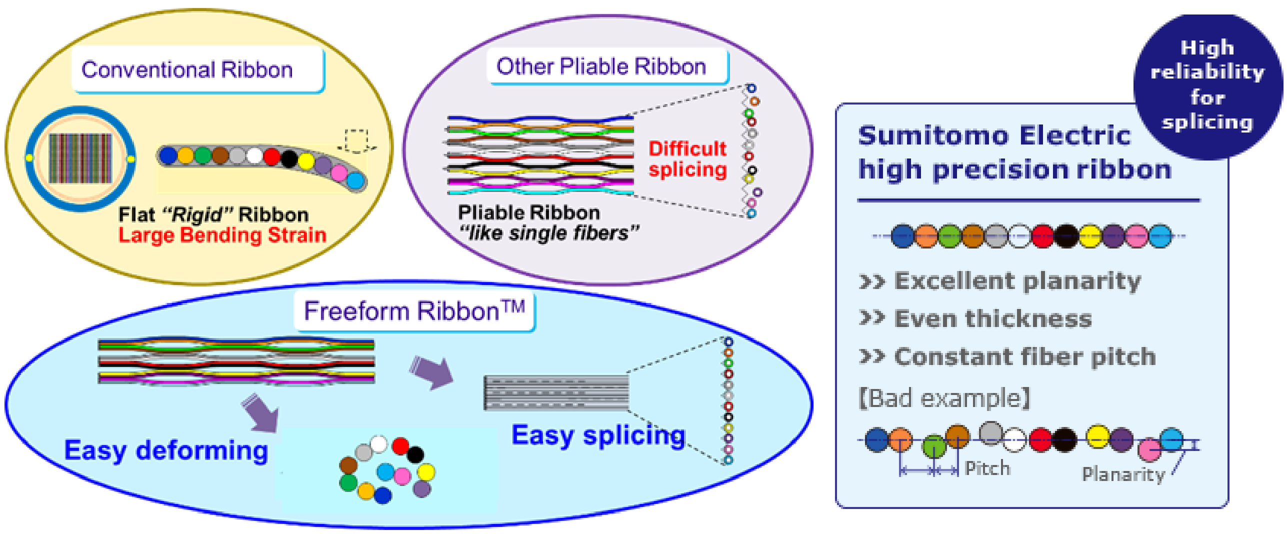


Fig. 4 Concepts and Characteristics of FFR

In general, conventional ribbon is flat and rigid ribbon design, so it has large bending strain at small bending radius. On the other hand, in case of other pliable ribbon such as a single fiber bonded type, it is difficult to splice easily because it occurs disarray of fibers set at fiber holder due to being like single fibers. The Newly developed FFR has both merits. For example, when it is spliced, it is like a flat ribbon, when it is used in a high density cable, it can be deformed at suitable form.

The flexibility and ribbon alignment of FFR for mass-fusion splicing can be controlled by changing the slit length/non-slit length ratio and length. The slit length/non-slit length ratio of the structure was optimized by taking into account ribbon flexibility based on the mass fusion splicing workability and cable characteristics.

2.3 Splicing solutions for 200 μm FFR

To ensure compatibility with existing optical cable installations, the authors envisioned two splice patterns about 200μm FFR. Fig. 5 shows fusion splice patterns about 200μm FFR.

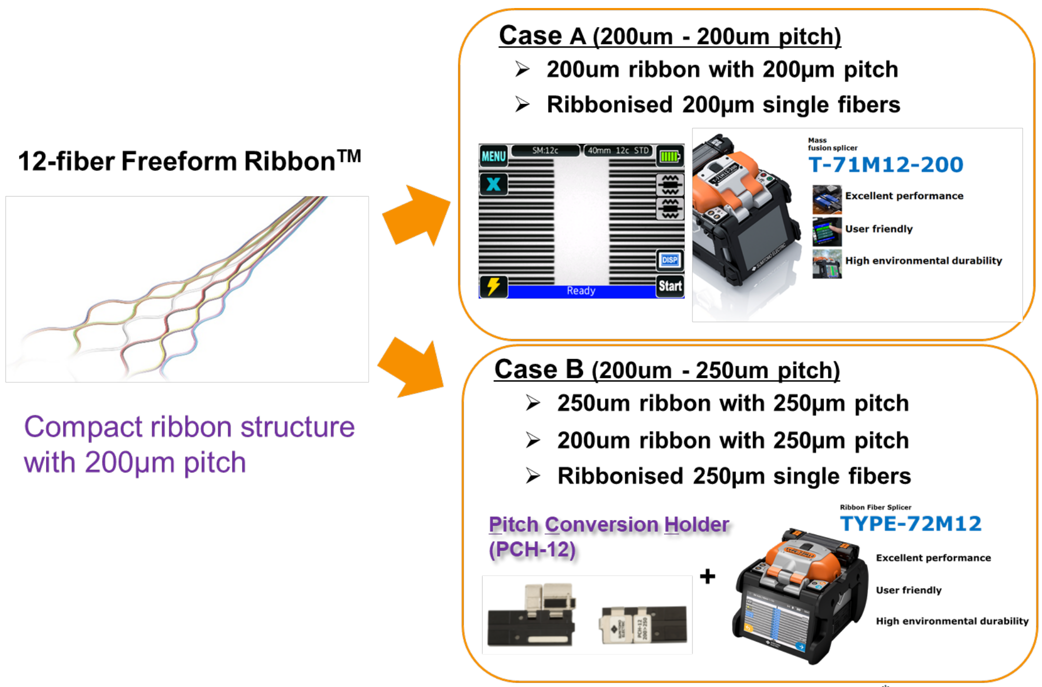
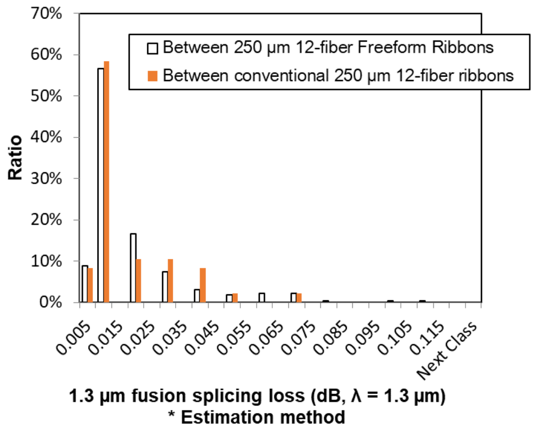


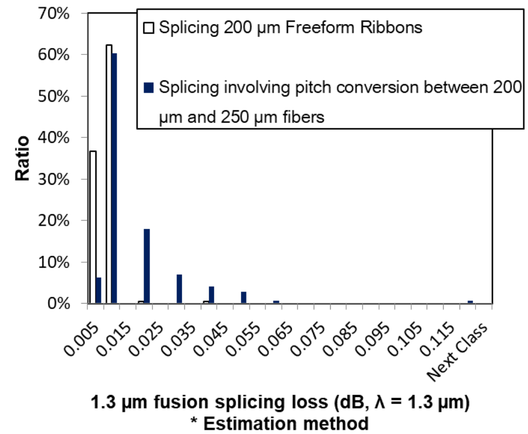
Fig. 5 Solutions of mass fusion splice using FFR

The Case A is the 200μm pitch splices, such as between 200μm pitch ribbons and between 200μm pitch ribbon and ribbonised 200μm single fibers.

The Case B is 250μm pitch splice using conventional splicer, such as between 250μm pitch ribbons and 200μm pitch ribbon and so on. In the former case, we developed new splicer which has 200μm pitch V-groove. In the latter case, we also developed pitch conversion holder to be compatible with 250μm V-groove. By utilizing the above solutions, this FFR has spliceablity with existing various fibers and ribbons.

Fig. 6 (b) presents distributions of splicing losses (estimates) produced by mass fusion splicing between 200 μm and 250 μm and between 200 μm and 200 μm fibers. Fig. 6 reveals no significant difference between loss distributions estimated for the conventional ribbon (a) and the newly developed ribbon (b).





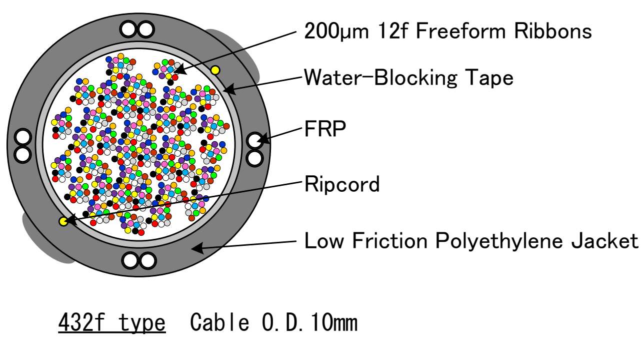
(a) Distribution of splicing loss of conventional 250 μm 12-fiber ribbons

(b) Distribution of splicing loss of thin 200 μm 12-fiber FFR

Fig. 6 Comparison of fusion splicing losses of different 12-fiber ribbons

2.4 Microduct Cable Design

We have developed new cable structure with emphasis on thin and lightweight construction for blowing performance (Fig. 7). The newly developed structure was adopted dielectric tension members predominantly used in overseas countries. Meanwhile, the optical fiber was a bend-insensitive single-mode fiber (ITU-T G.657A1 and G.652D specifications) incorporating a 200 μm core.



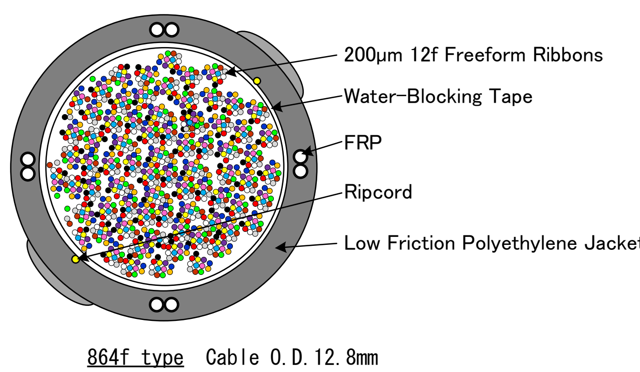


Fig. 7 Schematic cross sections of microduct optical cables

For improved blowing performance, a low-friction jacket was used for the new development. The coefficient of friction of the newly developed low-friction jacket material has been confirmed to be approximately one-sixth of that of conventional general-purpose jacket materials. The dielectric structure had tension members located in four positions to be less directional when bending.

In addition to the above-described 432-fiber and 864-fiber microduct cables, cable varieties ranging from 144 to 864-fiber count have been developed as options. Fig. 8 presents graphs comparing outside diameters of a conventional single-fiber loose-tube microduct optical cable and the newly developed cable.

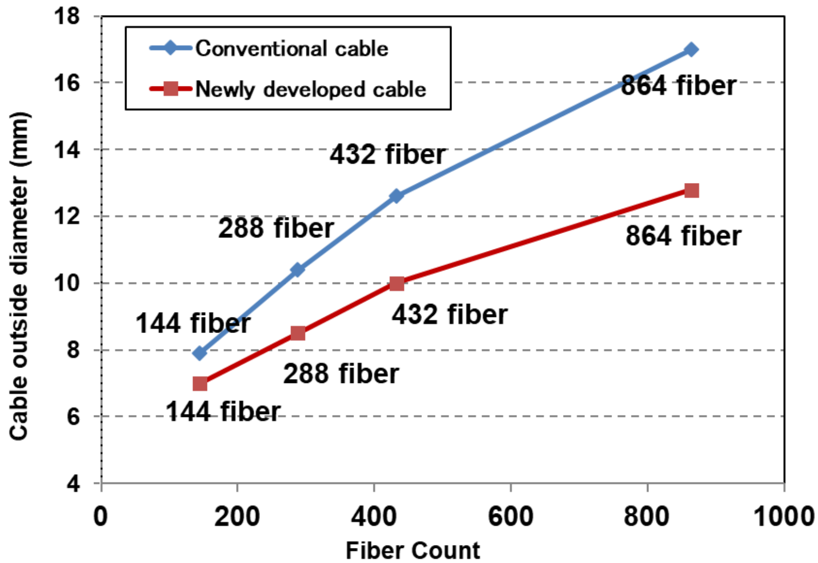


Fig. 8 Comparison of outside diameters of conventional and newly developed cables

The outside diameter of the newly developed cable is substantially smaller than that of the conventional cable, as shown in Fig. 8. A comparison of 864-fiber cables reveals that the newly developed structure enables the fiber count (fiber density) per unit cross-sectional area of cable to increase by a factor of approximately 1.8.

3. Installation Efficiency and Cost Benefit

We also compared with conventional single-fiber type loose-tube cable in the point of view of cable installation and splice time.

Today's ribbon fiber is so much faster and easier to install. Sumitomo's Microduct Cable with FFR has a smaller diameter, and it is easier and faster to prepare fibers and splices. When compared to loose tube cable, MD cable with FFR reduces a projects' cost in these key areas:

- Cost saving of duct, cable count and splice count
- Reducing working time of cable insertion
- Fiber Preparation and Splicing

3.1 Cost Saving of duct, cable count, splice count

In order to estimate installation efficiency, we assumed two case when 864 fiber count is installed in conventional duct.

Fig. 9 shows a comparison of installation efficiency between conventional 144f cables and newly developed 864f microduct cable with FFR. In case of 144f cable installation, it is need to install cables several times into many sub-ducts, on the other hands, in case of the developed 864f cable, only one installation is needed to be done. At the point of view with splicing, conventional cable needs to be 864 times splicing because of single-fiber splicing, but 864f cable with FFR is needs to be done only 72 times.

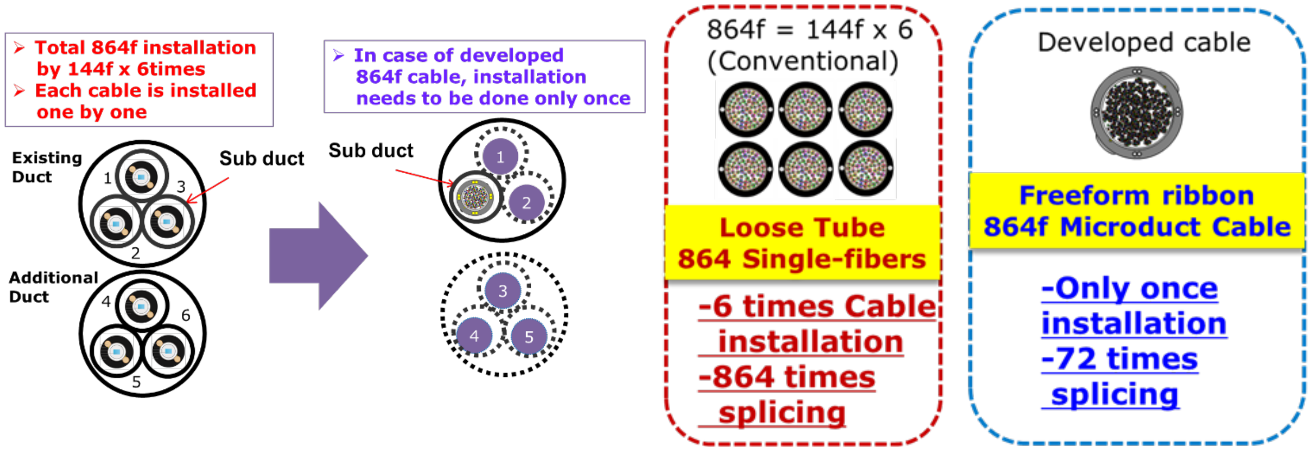


Fig. 9 Comparison of Installation efficiency between conventional 144f LT cable and 864f microduct cable with FFR

3.2 Reducing working time of cable insertion

Fig. 10 shows a comparison of installation efficiency between conventional pulling installation and air-blown installation.

When pulling installation method is used, it is estimated that it take total 400 hour per installation spun because it is need to make 8-figure coiling and two direction pulling by winching vehicles.

On the other hands, when air-blown method is used, it is estimated that the working time is reduced to total 66 minute per installation spun because it was not required to make 8-figure coiling and no need to prepare special vehicles. In addition, it is expected to install longer length than pulling method because of light weight and low friction cable.

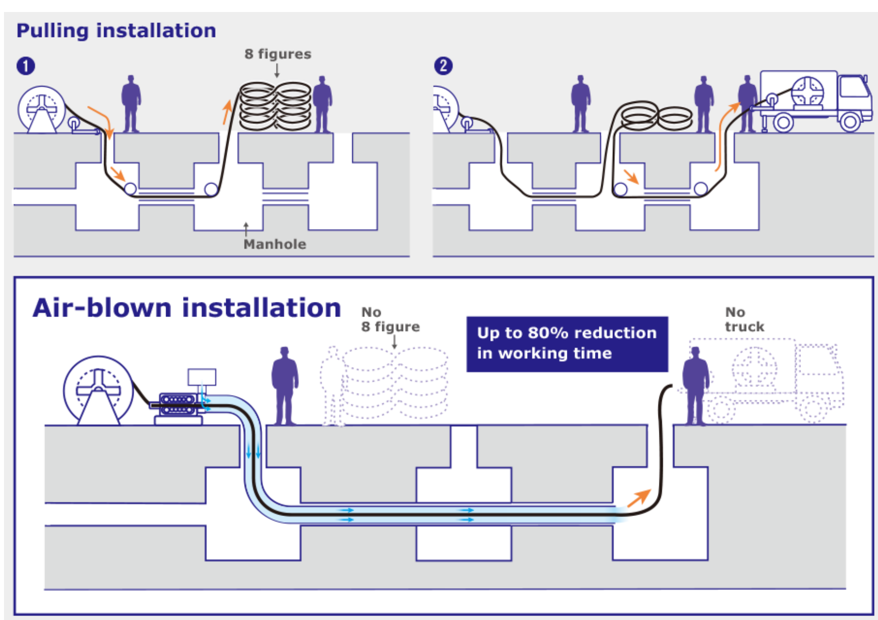


Fig. 10 Comparison of Installation efficiency between Pulling Installation and Air-blown installation

3.3 Easy preparation for splicing

Fig. 11 shows a fiber preparation method about Sumitomo's microduct cable with FFR. It is easy to tear and rip the cable sheath of the microduct cable by combination with ripcord and thin jacket thickness.

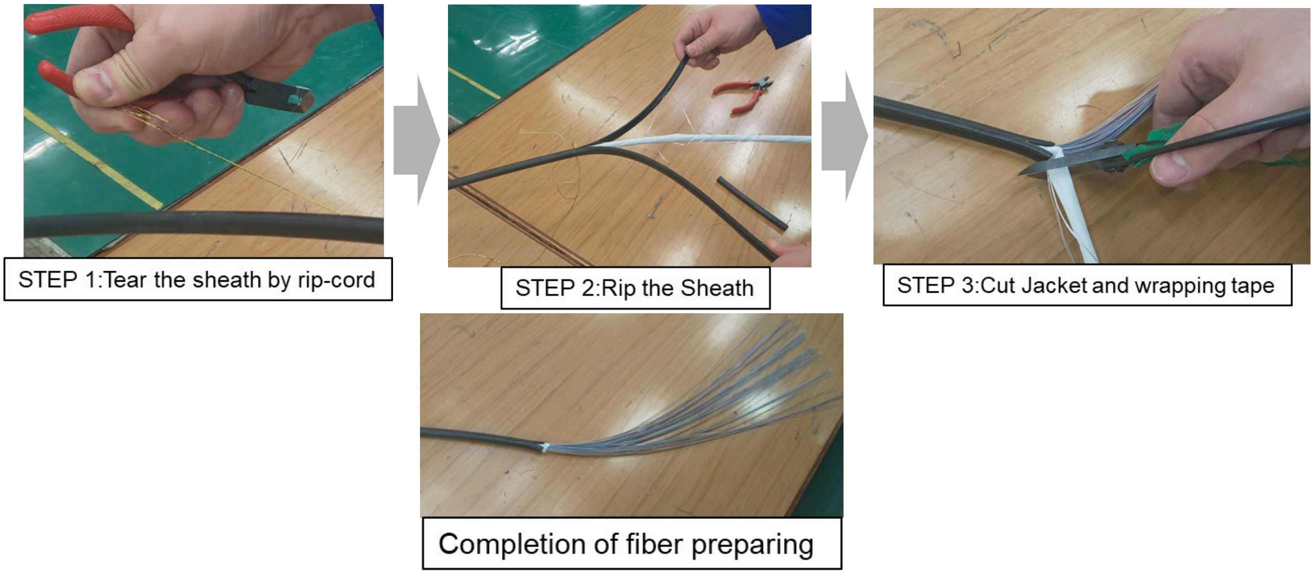


Fig. 11 Fiber preparation method about microduct cable with FFR

Fig. 12 shows a comparison of splice efficiency between conventional "jelly-filled" cable and "dry-core" microduct cable with FFR. It is not necessary that the developed microduct cable is not to need tube removal and wiping jelly on ribbons, so it is excellent workability about preparation for fusion splicing.

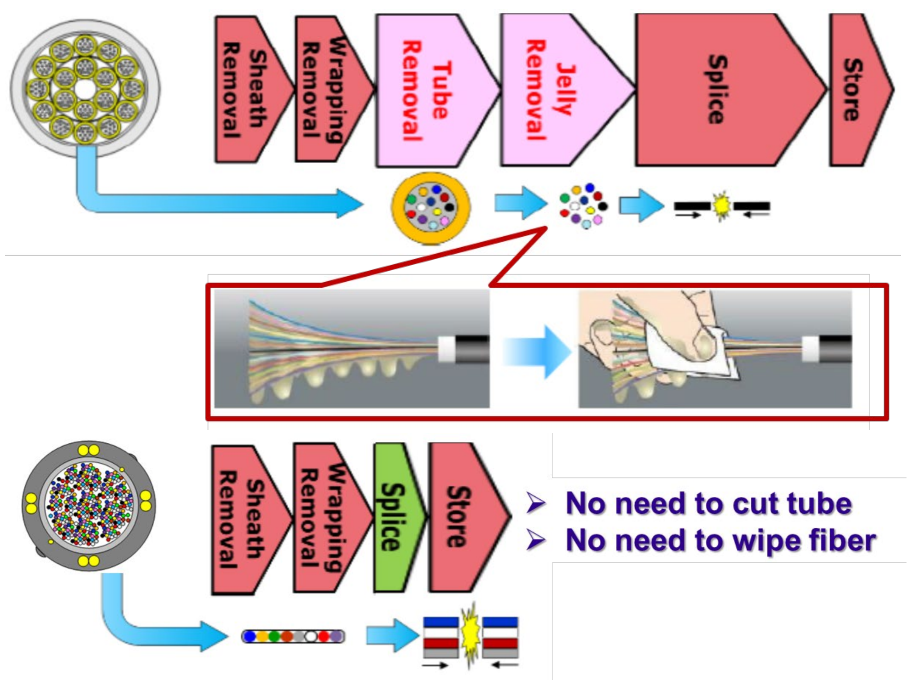


Fig. 12 Comparison of splice efficiency between conventional jelly cable and microduct cable with FFR

Summarizing the case study, it is expected that the total working time from duct installation to splicing is expected to reduce by 83% compared to the conventional case (Fig. 13).

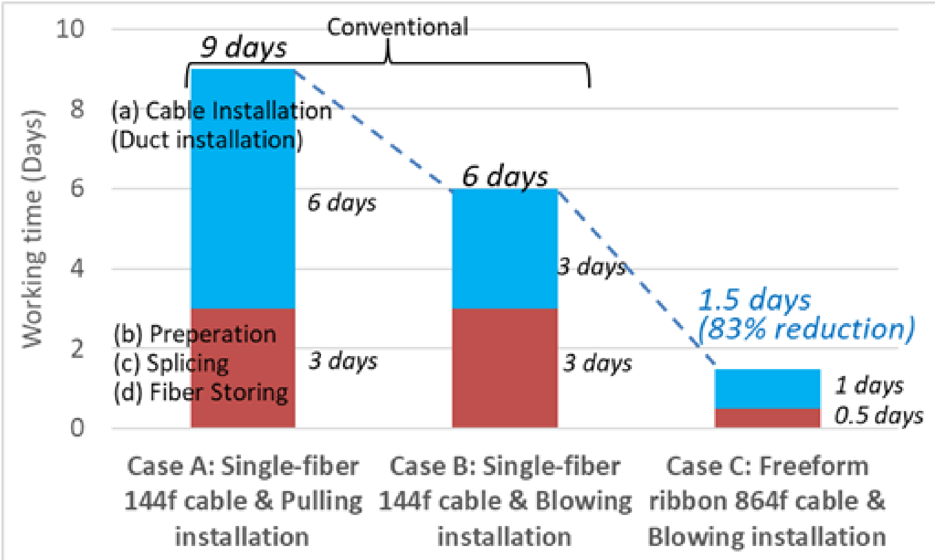


Fig. 13 Comparison of working time at several installation case

4. Conclusions

While air-blown microduct optical cables are predominantly used in Europe and other areas, we have developed a low-friction ultra-high-density microduct optical cable incorporating thin 200 μm 12-fiber FFR to enable both mass fusion splicing and high-density construction. The 200 μm 12-fiber FFR has been proven to connect with conventional 250 μm 12-fiber ribbons as well as with 200 μm fibers.

We also compared with conventional single-fiber type loose-tube cable in the point of view of cable installation and splice time. As a result, it can be expected that the total working time is reduced by 83%.

5. References

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