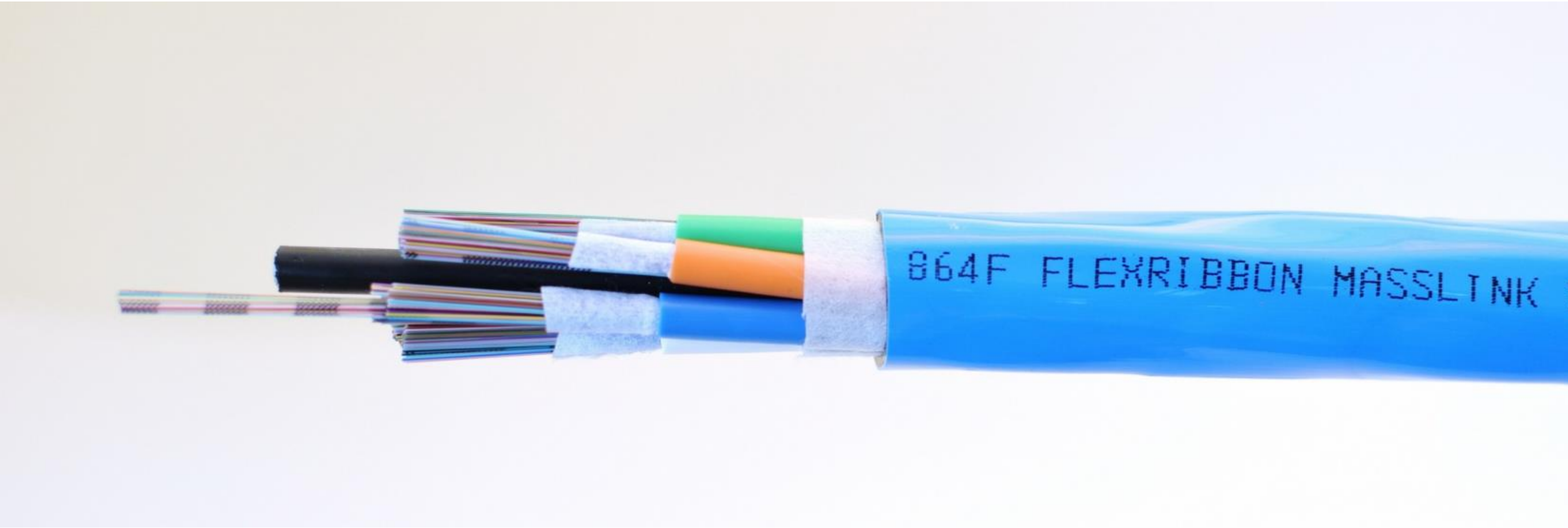
REPORT 2020/2021

Comparison of FlexRibbon™ and flat ribbon in MassLink™ cable



Prysmian Group

Linking the Future

Table of Contents

Introduction

The demand on wired and wireless telecommunication infrastructure has never been higher. As new technologies such as 5G and IoT roll out and diversification of workspaces continues, there is an increasing strain on critical infrastructure segments such as data centre interconnects. The demand for more bandwidth is here now, not in the future and so the Telecommunication Industry is faced with a challenge to boost network capacity at speed.

Maximising network capacity within the bounds of the existing infrastructure is a key objective of any Telco as this is generally the lowest cost option. High density cables such as Flextube® have been utilised for many years now to use duct space efficiently but these technologies rely on single fibre cable designs to achieve high densities. Single fibre splicing on very high fibre count cables can slow down the network build and not matching the demand.

Ribbon fibre cable technology is an established means of building high fibre count networks at rapid speed, through the use of mass fusion splicing. Traditionally the benefit of mass fusion splicing has been traded off for fibre density and duct utilisation as the cable designs are inherently large. This has left the network operator to balance duct utilisation with splice efficiency and speed of rollout.

FlexRibbon™ in MassLink™ is a new flexible ribbon technology designed to maximise fibre density and duct space whilst enabling mass fusion splicing for rapid network deployment. This is owed to FlexRibbon™ being suitable for mass fusion splicing and the ability to be rolled into a small package, reducing cable diameters.

This paper intends to measure the installation of FlexRibbon and conventional flat ribbon fibre cables to quantifiably compare which technology would be the most efficient choice for network operators to build a high fibre count network.

Executive Summary

A comparison of FlexRibbon™ and flat ribbon in MassLink™ cable was carried out in a small-scale duct network adjacent to Prysmian's Dee Why Factory in Sydney, Australia. The duct network was purpose built for product installation trials and conforms to Telstra specifications. FlexRibbon™ in MassLink™ proved to be easier to install, allowing higher fibre density in limited duct space and speedier installation. Prysmian FlexRibbon™ is expected to help network operators to reduce total cost of ownership and deployment costs of high-density optical networks.

The installation time to completely haul, terminate and splice 864 fibre FlexRibbon™ cable in the point to point connection took 22% less time than 864 fibre flat ribbon cable. The time saving lowers installation labour costs, shortens cable restoration times and reduces maintenance costs.

864 fibre FlexRibbon™ in MassLink™ was shown to occupy 29% less duct space than flat ribbon in MassLink™, enabling more fibres to be installed into a given duct.

FlexRibbon™ was found to equivalent predicted splice loss than flat ribbon, providing reliable network performance.

Objective

To compare the hauling, preparation and splicing of conventional flat ribbon MassLink™ to FlexRibbon™ MassLink™ in a point to point Outside Plant (OSP) installation.

Definitions

MassLink™ is the Prysmian trademark name for the cable design of ribbon fibres in a loose tube format.

FlexRibbon™ is the Prysmian trademark for a pliable ribbon bonded in a zig zag pattern.

Project Overview

Prysmian's small-scale duct network adjacent to the Dee Why factory in Sydney Australia has been purpose built to Telstra specifications to test new cable and connectivity technologies. The network consists of two parallel 50 mm internal diameter ducts, in a 144 metre loop. A dimensioned schematic of the network is shown below.

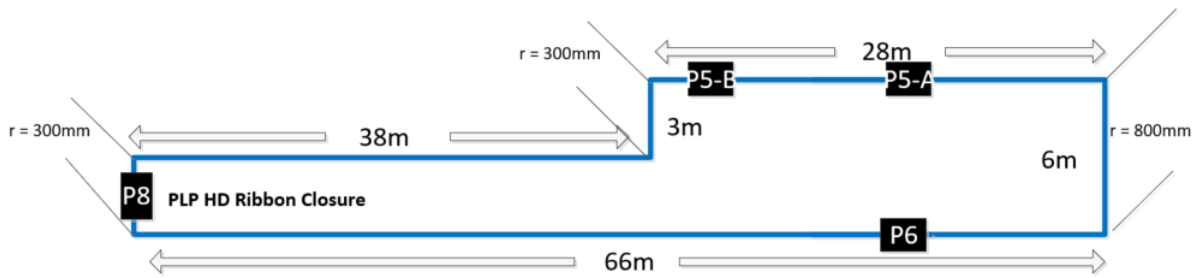


Figure 1 - Layout of duct network at Dee Why. The schematic shows the position of where the COYOTE® HD Ribbon Closure will be installed as well as run dimensions and bending radii.

The study compared 864F FlexRibbon™ MassLink™ with 864f flat ribbon MassLink™ as used by nbn. Each cable was hauled through its own unoccupied duct. The jointing of all 4 cables was completed in a PLP® (Preformed Line Products) COYOTE® HD Dome Closure situated in the P8 pit indicated in figure 1. In the COYOTE® HD closure, homogeneous splicing was completed so that the flat ribbon cables were spliced together and so were the FlexRibbon™ cables.

FlexRibbon™ ribbons can be rolled into bundles that increase fibre density within the cable. This reduces the overall diameter compared to conventional flat ribbon cable designs. The reduced diameter coupled with gel-free tubes and the flexibility of Flexribbon™ ribbons, make it easier for cable haulers and splicers to work with the cable.

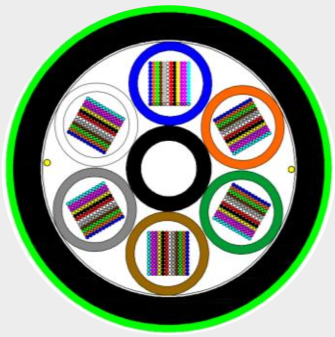
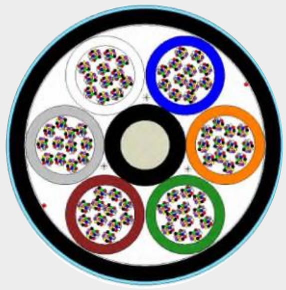
Cable Comparative Data			
Characteristic	**UOM**	**Cable Type**	
		Flat Ribbon MassLink™	**FlexRibbon™ MassLink™**
Cable cross-section			
Ribbon type - # of Fibres per ribbon		Flat ribbon – 12f per ribbon	FlexRibbon™ - 12f per ribbon
Cable fibre count		864	864
Fibre type and diameter		G.652.D - 242µm	G.652.D/G.657.A1 - 242µm
Number of elements		6	6
Tube diameter	mm	7.9	6.4
Tube water blocking method		Gel filled tubes	Dry tubes – water swellable tapes and yarns
Cable diameter	mm	26.8	22.6
Cable weight	kg/km	490	310
Max. installation tension		2.0	3.0
Max. crush resistance (short term)	kN/100mm	2	2
Min. bend radius (no load/full load)	mm	268/535	226/452
Temperature range (operation)	°C	-10 to 70	-10 to 70

Table 1 - Characteristics of cables used in study

Cable Hauling Comparison

Cable hauling procedure

The first part of the study was to compare the time and process to haul each 864f cable. The hauling was completed by Constructive Communications, an independent contractor who regularly undertakes work in the Sydney area for major Telco's. 4 field technicians were involved in completing the hauling.
The cables were hauled from the P8 pit in a counter clockwise direction, back to the P8 pit as illustrated in figure 2.

Due to the large diameter of the flat ribbon cable, 2 figure 8 loops at pits P6 and P5-A had to be made to prevent the hauler breaching the cables maximum allowable tensile load of the cable. As the FlexRibbon™ cable has less cross-sectional area reducing drag during hauling, only a single figure 8 loop was necessary.

15 metres was coiled at each end of each cable in the P8 pit.

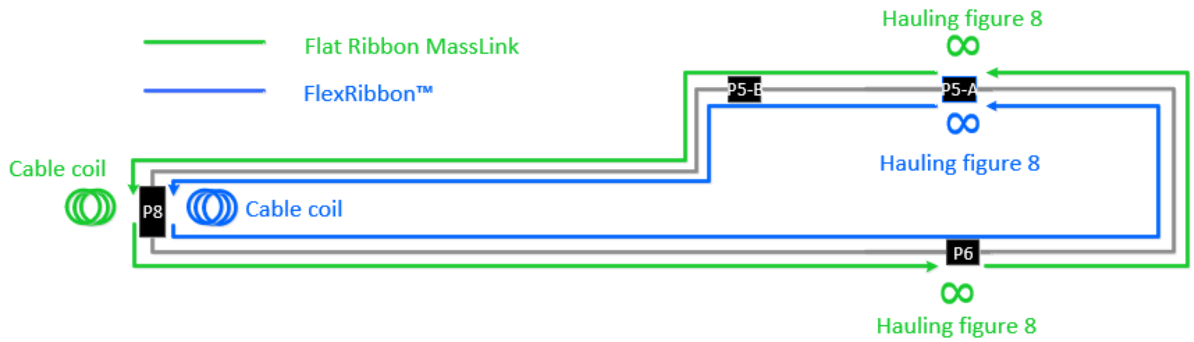


Figure 2 – Map of the cable installation path and position of cable layups and coils

Figure 3 - Haulers bringing the flat ribbon cable out of the first pit (P6)

Cable hauling results

Both cables were hauled using the same hauling sock which was a standard single eye wire grip.

The diameters of the flat ribbon and FlexRibbon™ cables with a hauling sock were measured and found to be 33.2 and 26.6mm respectively.

Figure 4 - Flat ribbon cable diameter measured with the hauling sock fitted

Figure 5 - FlexRibbon™ cable diameter measured with the hauling sock fitted.

The cable with the hauling sock fitted is considered the effective area for hauling. The effective area of the flat ribbon cable was 56% more than FlexRibbon™.

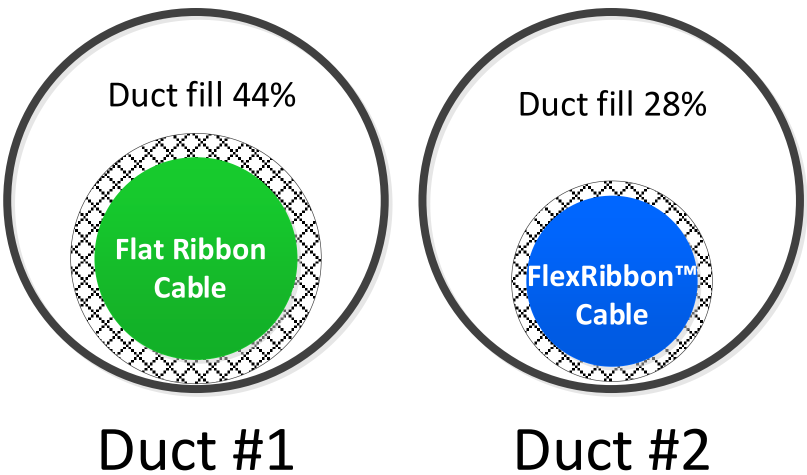


Figure 6- Representation of the occupancy in the 50mm ID duct with hauling socks fitted to each cable

The larger cross-section area of flat ribbon MassLink™ had 5 major effects on the installation.

Higher hauling tension

As the effective area was 56% larger for flat ribbon and the weight 58% heavier, the cable experienced more friction when being pulled through the duct.

The hauling tensions were measured during the installation and are indicated in Figure 7 – Map of hauling route with layup positions and recorded tension readings

The maximum tension measured during the FlexRibbon™ MassLink™ installation was 0.5kN whilst the maximum tension of the flat ribbon cable was 1.2kN.

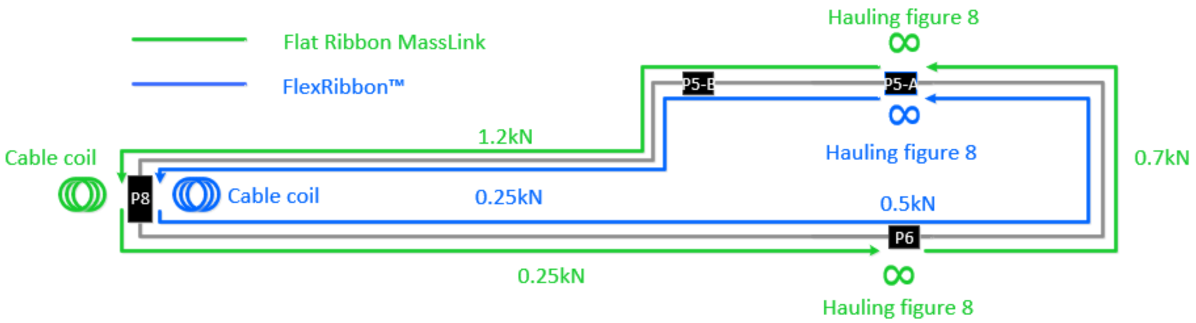


Figure 7 – Map of hauling route with layup positions and recorded tension readings

Increased number of cable lay ups

The size and weight of the larger flat ribbon cable required the installer to complete an extra cable lay up around the duct circuit. A decision was made by the contractor before the operation started that the cable would struggle to be hauled around the tight bends between the P8 pit and P5-A. The anticipated hauling tension could have over strained the cable and/or damaged the duct at 90 degree bends.

As a consequence, the installer completed two figure 8 lay ups for flat ribbon MassLink™ and only one for FlexRibbon™ MassLink™.

Figure 8 - Figure 8 lay up of flat ribbon cable as exiting from the first pit (P6)

More opportunity to damage cable during installation

Risk of cable damage and kinking increases with each lay up during installation. This is due to increased handling during the figure 8 process, and increased risk of damage to the cable upon insertion and removal from the duct. FlexRibbon™ required only one layup whilst flat ribbon required two.

Larger pit sizes

The larger, stiffer flat ribbon cable demanded more space in the pits during the installation. This was evident when feeding the cable back into the duct after a lay up. The cable needed a longer length within the pit to comfortably correct itself. The larger cable also occupied significantly more space in the pit after the cable had been coiled.

Figure 9 – P8 pit filled with cable coils after hauling. 15 + 25m of FlexRibbon™ cable was coiled with 15 + 15m of flat ribbon cable

Longer time to install

Due to the larger, heavier cable requiring an extra lay up and being harder to handle and coil, the flat ribbon MassLink™ cable took 100% longer to install than FlexRibbon™ MassLink™. FlexRibbon™ MassLink™ took 23 minutes to install, whereas flat ribbon MassLink™ took 47 minutes.

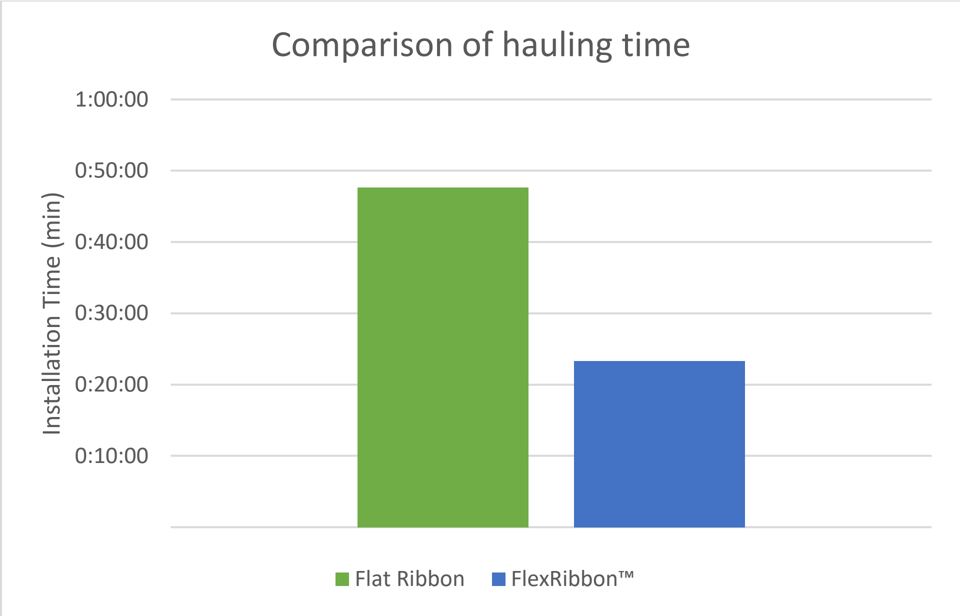


Figure 10 - Recorded hauling time of both cable technologies around the duct test track

Cable Preparation Comparison

Cable end access procedure

After each of the cables had been installed into the ducts, a second installer specialising in flat and pliable ribbon splicing, Alliance SI, completed the termination of both cable circuits. One field tech completed the end access and splicing steps.

Each of the ribbon cables were terminated to complete a circuit. Homogeneous splicing was completed so that flat ribbons were spliced to flat ribbons and FlexRibbon™ ribbons were spliced to FlexRibbon™ ribbons.
All four cables were terminated in a single COYOTE® HD Ribbon Dome Closure.

The COYOTE® HD products used in the study were:

Catalogue No. 80061406 - COYOTE® HD Dome Closure for Ribbon

Catalogue No. 80813121 - COYOTE® HD Deep Profile Splice Trays 288 Ct.

All four cables were looped so they could coil in the same direction. They were taped together, coiled and cut to the appropriate length.

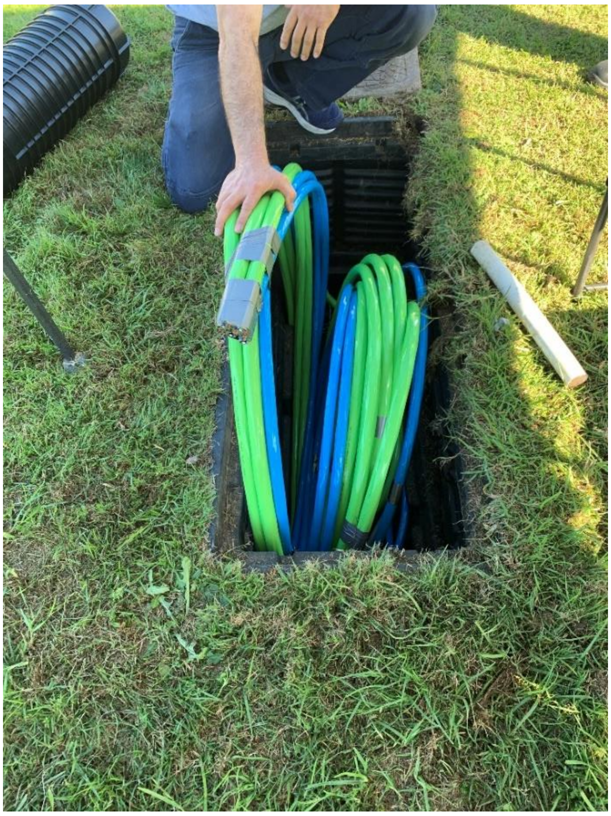


Figure 11 - Fitting the first cable into the COYOTE® HD Dome Closure

Figure 12 - Ribbon cables taped together, coiled and cut to the correct length to enter the closure

All the cables had 2.5 metres of sheath removed. Tapes and yarns were removed, and the cables were fitted into the base of the closure. The cables were anchored and CSM's cut to length. The cable loose tubes were measured to length, scored, removed and transport tube applied. As the flat ribbon cable comprised gel filled tubes, some bulk cleaning was completed. The transport tube was then cable tied to the respective tray and the ribbons were looped for splicing later.

These steps were completed until all cables were trayed up in the closure. With 24 ribbons per tray, flat ribbon cable occupied the bottom 3 trays of the joint and the FlexRibbon™ cable occupied the top 3 trays.

Figure 13 - First tray with 2 flat ribbon tubes looped and stored for further cleaning and splicing

Figure 14 - View of the ribbons looped in the first tray and the other tubes ready for termination

Figure 15 – COYOTE® HD Ribbon Closure with all ribbons looped and stored for splicing

Cable end access results

FlexRibbon™ in MassLink™ took 2 hours and 10 minutes to completely prepare the cable in the closure, ready for splicing. Flat ribbon in MassLink™ took 5 hours and 9 minutes to complete the same stage. Flat ribbon cable took 137% more time to complete this step.

A breakdown of each process is given in figure 16 below:

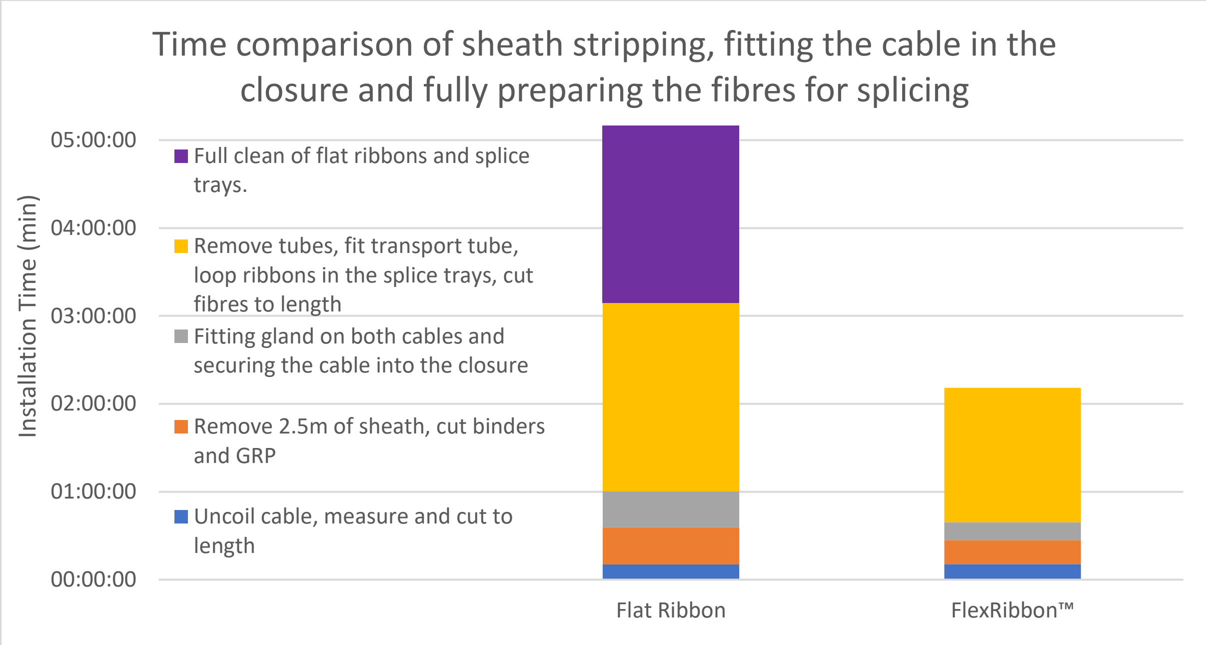


Figure 16 – Comparison chart of the recorded time taken to complete each of the cable preparation steps

Findings and comments about each of the process steps are detailed below:

Uncoil cable, measure to length

As the flat ribbon cable has 56% larger cross-section and is 58% heavier, the cable was harder to work with in terms of coiling, uncoiling and working the cable into the correct closure port. As the process was only completed once on a relatively short piece of cable, there was not a significant time penalty towards flat ribbon. However, it was found that two people would have been better suited to manage the flat ribbon during this process.

Figure 17 – Splicer working with the flat ribbon cable to cut it to the correct length

Remove 2.5m of sheath, cut binders and GRP

The flat ribbon cable took a marginally longer time to remove the outer layers of materials. The time difference between the two cable types was largely due to the sheath stripping. Due to the larger diameter of the cable, the sheath thickness of the flat ribbon cable was more than the FlexRibbon™. This caused the stripping process to take a little longer for the green cable as the thicker material was more difficult to work with.

Fitting the cable in the gland and securing the cable into the closure

The flat ribbon cable was larger and more difficult to position in the closure. The tubes were also more rigid. Both these factors resulted in this step taking slightly longer for the flat ribbon cable.

Remove tubes, fit transport tube, loop ribbons in the splice trays, cut fibres to length

Fitting transport tube and removing the buffered tubes proved to be a largely comparable process between both cable types. Preparing the ribbons in the splice trays took approximately 40 minutes more time however for the flat ribbon cable for two main reasons.

Firstly, the flat ribbon required an initial mass clean of gel from the ribbon bundles. The ribbons were maintained in their stack and the gel wiped off in large portions to allow them to be looped on the tray without leaving too much gel. This was an added step that was not required for FlexRibbon™ tubes as they are completely dry.

Secondly, to position the flat ribbons correctly and neatly on the tray so that they could be cut to the correct length, the ribbon bundles had to be carefully fed around the tray in an upright position. The upright position was required so that the ribbons could bend on their preferred axis when looped in the splice trays. If the flat ribbons were not positioned in this way they had a tendency to flip, causing potential bend losses and/or stress on the fibres.

Figure 18 – Flat ribbons being looped around the fibre tray. Care was taken so that the ribbons were collectively looped around the tray on their preferential axis

The FlexRibbon™ behaved completely differently to the flat ribbon. No initial cleaning was required as the tubes were dry and the ribbons did not have a preferential bend so could be looped in the trays without regard to axial orientation. It was found that two FlexRibbon™ tubes could be looped in the tray at the same time, significantly reducing the time spent preparing the ribbons to length.

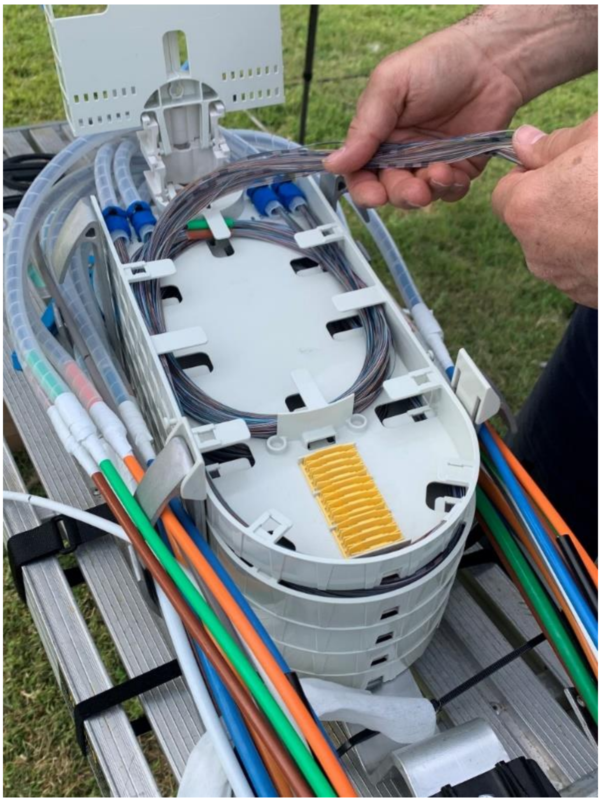


Figure 19 - FlexRibbon™ being looped around the splice tray. 2 tubes could be looped at the same time with no preferential bend

Full clean of flat ribbons and splice trays

FlexRibbon™ in MassLink™ is a completely dry cable, meaning that the cable is water blocked using water swellable tapes and yarns rather then gel inside the loose tubes. As such, no cleaning is required for FlexRibbon™ cable. The cleaning process added two hours to the flat ribbon cable preparation, a significant portion of the overall preparation time.

The field technician commented that soaking ribbons in a degreaser solution to remove the loose tube gel is a technique used by some contractors in the industry. From his experience, this was a risky procedure as the markings identifying each ribbon can be rubbed off if the ribbons are soaked for too long. This is a significant problem when each tube contains 12 ribbons and they cannot be identified.

Figure 20 – Flat ribbons having the gel cleaned by wiping and applying isopropanol

Splicing Comparison

Splicing procedure

The splicing of the ribbons commenced once all the ribbons had been laid in the trays, cleaned if necessary and cut to length. Only homogeneous splicing was completed meaning 72 flat ribbons were spliced to 72 flat ribbons and 72 FlexRibbon™ ribbons were spliced to 72 FlexRibbon™ ribbons.

Splicing of the flat ribbon was completed first on trays 1 to 3 and then splicing of FlexRibbon™ was completed on trays 4 to 6. Two loops of ribbon were made before routing to the splice bay.

Different splice machines were used for the ribbon types. V-groove chucks are preferred for pliable ribbon and as these chucks were available with the Sumitomo machine, it was preferred to use this machine for FlexRibbon™. The equipment used is detailed below:

Splicing Equipment		
Ribbon Technology	Flat Ribbon	FlexRibbon™
Splice Machine	Fitel S123M12	Sumitomo 66M12
Chucks	S712 12 W	FHM-12V
Thermal Strippers	Fitel S218R	Sumitomo JR-6
Clever	Fitel S326	Fitel S326

Table 2 – Equipment used to splice the ribbon fibre technologies

Twelve ribbons were taken from the splice tray at a time. The ribbon sequence was identified and splice protectors were applied. The flat ribbons had a final clean with Isopropanol alcohol. All ribbons were then thermally stripped, cleaved and placed in the splice machine. After completion of the fusion splice, the splice protector was fitted over the splice and heated. Once all 12 ribbon splices were completed, the ribbons were looped around the splice tray and placed sequentially into the splice bays.

After each splice, a record of each of the estimated splice losses as measured by the splice machine was recorded.

Splicing results

Splice time

The time taken to splice and put away the ribbons in the tray of the 864 fibre FlexRibbon™ was practically the same as flat ribbon. The time taken to complete the FlexRibbon™ cable took 9 hours and 29 minutes. The time taken to splice the flat ribbon cable took 9 hours and 33 minutes.

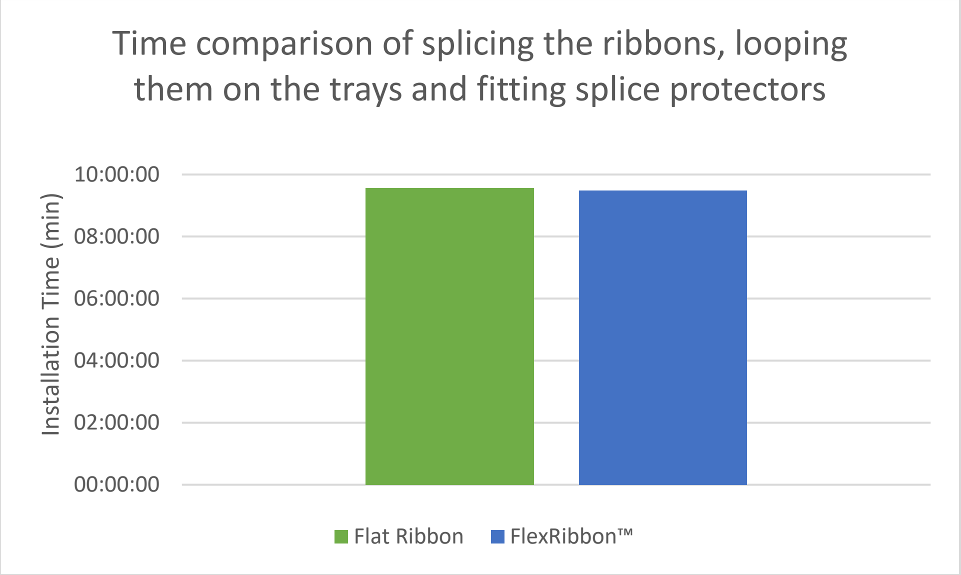


Figure 21 - Comparison chart of the time taken to splice and tray up flat ribbon and FlexRibbon™

Breaking down splicing into its component steps, stripping and cleaving required fewer repeats for flat ribbon compared with FlexRibbon™, however this was offset by the longer time required to manage the flat ribbons in the splice trays.

FlexRibbon™ inherently does not have a rigid bond between the fibres and so when thermal stripping, fibres can move unevenly. This can result in residual coating on the fibres or, if sufficient care isn't taken, broken fibres. A technique is required to reduce and minimise repeats. Similarly, when cleaving the fibres, as the fibres are not bonded in the same way as flat ribbon, there was a higher propensity for the FlexRibbon™ fibres to have an uneven cleave length or angle.

Once cleaving was completed, FlexRibbon™ and flat ribbon had the same splice success rate.

The extra time taken to repeat thermal stripping and cleaving with FlexRibbon™ was countered by the additional time taken to clean and manage the flat ribbons in the splice trays. As previously noted, the flat ribbons must be positioned on their preferred axis to facilitate stress-free looping in the splice tray. This was a tie consuming process as the flat ribbons had to be worked as a group when looping in the storage area of the tray and then stored in sequential order in the splice bay. This added considerable time to this process step. As FlexRibbon™ has no preferential axis it readily lays up in the splice tray.

Figure 22 - Photo of the first flat ribbon tube fully spliced on the closure tray

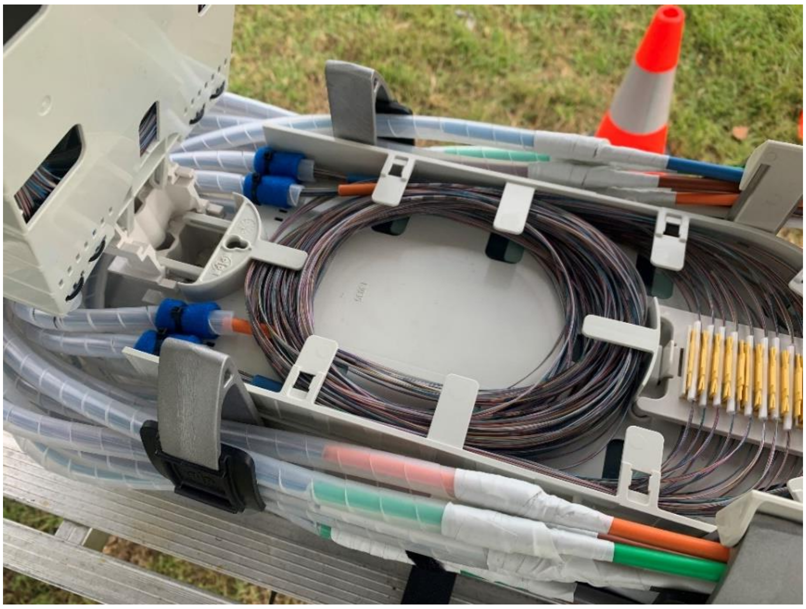


Figure 23 - Photo of the first 2 FlexRibbon™ tubes on the closure tray

Estimated Splice Loss Data

It was found that there was no significant difference in the estimated splice loss as measured by the splice machines. The population data of all 864 fibres in each cable is recorded below.

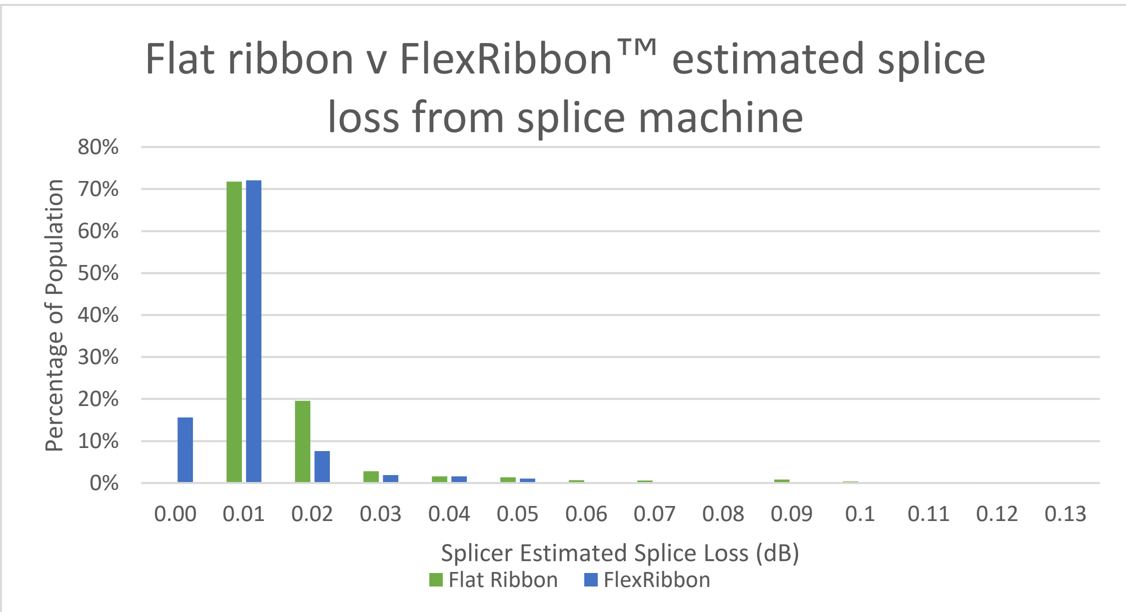


Figure 24 – Histogram of estimated splice losses as recorded from the Fitel and Sumitomo splice machines.

Estimated splice loss data		
	Flat ribbon	**FlexRibbon™**
Average Loss (dB)	0.016	0.011
Median Loss (dB)	0.01	0.01
Standard Deviation	0.014	0.008

Table 3 – Splice loss data as recorded from the Fitel and Sumitomo splice machines for all 864f

Figure 25 Screen shot of a flat ribbon splice on the Fitel splice machine

Figure 26 – Screen shot of a FlexRibbon™ splice on the Sumitomo splice machine

The average loss and standard deviation of both ribbon types was low, indicating good splice performance. It should be noted that a Fitel machine was used to splice the flat ribbon and a Sumitomo machine was used to splice FlexRibbon™ and the algorithms employed to estimate the splice loss are different amongst manufacturers.

Conclusion

The purpose of this study was to compare the differences between FlexRibbon™ and flat ribbon in a MassLink™ loose tube cable design. The work completed by the independent contractors demonstrated that the cable comprising FlexRibbon™ took 22% less time to fully install than the flat ribbon cable and occupied 29% less area in the duct. The flat ribbon cable took 15 hours and 31 minutes to complete the operation whilst the FlexRibbon™ cable took 12 hours and 3 minutes. A breakdown of the installation steps is given below:

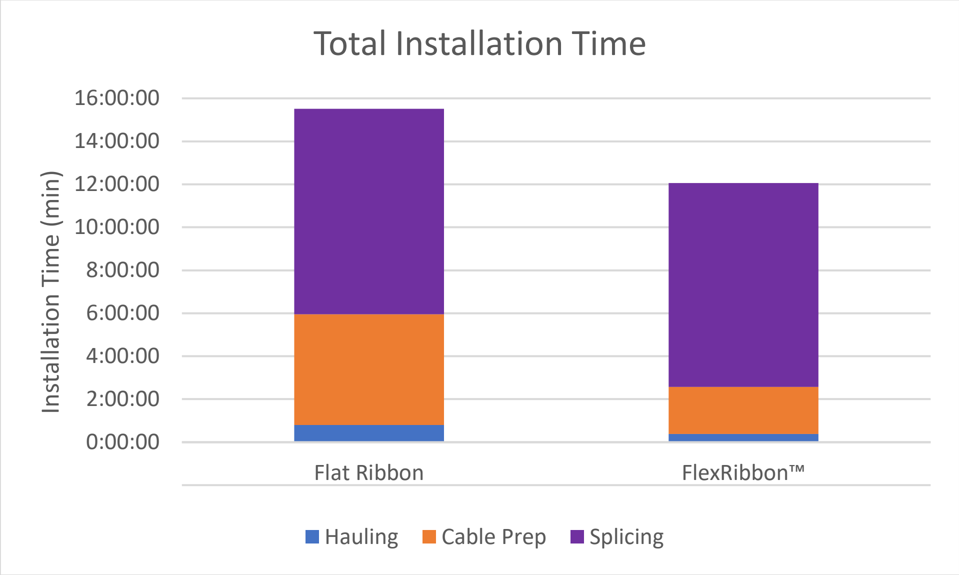


Figure 27 – Comparison chart of the total time taken to install flat ribbon and FlexRibbon™ during the study

FlexRibbon™ prove to be faster to haul due to the reduced diameter of the cable. The reduced diameter permitted the hauler to install the cable in a longer length with lower tension. Less cable handling and lower tension reduced the risk of cable damage during installation. Both cable designs feature a central strength member which facilitates easy coiling of the cables in the pit.

The dry technology of FlexRibbon™ MassLink™ cable saved considerable time and effort during cable preparation. As there was no need to clean water blocking gel, this also meant a reduction in consumables such as wipes and IPA could be realised. The smaller profile of the cable and tubes of FlexRibbon™ MassLink™ made the general handling easier and permitted all steps to be completed easily by one person.

The additional time taken to strip and cleave the FlexRibbon™ was offset by the longer time needed to manage the flat ribbons in the splice trays. From what was observed, maintenance and fibre reallocation will be substantially easier with FlexRibbon™ as the ribbons can be managed independently on the trays rather than needing to loop together as a group.

With the appropriate chucks, the splicing of FlexRibbon™ was shown to was shown to have equivalent performance as flat ribbon cable. This is an important feature in building new networks but also in integrating into existing and legacy networks.

A study such as the one discussed in this paper can only partially compare the cost of ownership in an optical fibre network build. The reduced diameter and weight characteristics of FlexRibbon™ in MassLink™ is known but the benefit to TCO through duct utilisation is less tangible.

Smaller cross-section cable can avoid new civil infrastructure which can be a significant cost in any network build. Reduced occupancy can allow more fibres to be installed in a given duct, unlocking additional revenue streams for the network operator.

Reduced size or increased capacity closures can also be utilised as the pliable ribbons are more flexible on splice trays. Efficiencies in joint closures can reduce pit occupancy, unlock previously unusable pit sizes or just avoid new pit builds, saving considerable cost of install.

From the data gathered in this study and for the reasons above, FlexRibbon™ in MassLink™ proved to be easier to install, allowed higher fibre density in limited duct space and was faster to install.
Prysmian FlexRibbon™ is expected to help network operators to reduce total cost of ownership and deployment costs of high-density optical networks.

Authors

This paper was written by James Rando, Technical Sales Manager (Telecom, Australia/New Zealand) with the assistance of many in the Prysmian Australia Telecom team. Particular thanks to Howard Yu, Andy Pierce, Shahin Molik, Richard Beattie and Danny Doyle for their contribution to the writing of this paper.