Advanced Optical Fibers Help Navigate the Bends inside MDUs

Until this year, most "bend-tolerant" fibers could withstand a 12- to 15 mm bend. The limit is getting smaller. Here's how vendors make the stuff

By Dr. Dave Mazzarese ■ *OFS*

Bend-capable fibers are enabling new solutions for MDU FTTH. With the drive to smaller enclosures and a push to make deployment of optical fibers as easy as copper, the macrobend loss performance of standard single-mode fiber (SMF) does not meet providers' needs.

Single-mode fiber has difficulty transmitting video signals through bends tighter than about 30 mm (1.2 in.) in diameter. This has opened the door for many new products to fill this application space.

The three new bend-capable fiber structures discussed here all use a fundamental design taught by AT&T Bell Labs (now OFS Labs) patent 4,852,968, which describes fibers with refractive index trenches in the cladding that surrounds the core. New designs include a recently developed Random Void Fiber (RVF), which features a ring of randomly sized and shaped voids in the fiber's cladding, and Trench Assisted Fiber (TAF), which has a deep refractive index trench away from the core of the fiber.

Another new design, Protected Core Fiber (PCF), uses a specially treated ring of glass directly around the core of the fiber to help keep the light from escaping during fiber bends. While RVF and TAF are new types of fiber structure, the PCF is a recent evolution of a fiber design with 20 years of installed service.

When selecting a bend-capable fiber, there are several key considerations beyond bending loss performance. These include:

- Splicing and connectorization
- Full-spectrum performance
- Reliability

Fibers need to be joined both to themselves and to the existing network. Therefore, any fiber should cleave well and produce a low-loss splice using a standard single-mode recipe with core-aligned *or* cladding-aligned splicing machines. This requires a waveguide design that can be identified by existing

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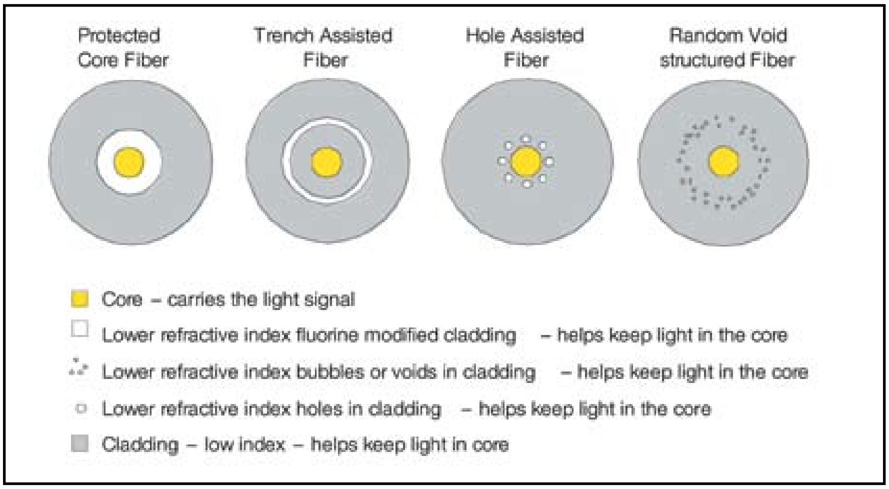

Schematic showing the various ways fiber can be made more bend-tolerant. "Hole-assisted" fiber has been commercialized by NTT; it is very expensive. Random-void fiber is being commercialized by Corning.

Benefit	Enabling Feature	Protected Core Fiber	Trench Assisted Fiber	Hole Assisted Fiber	Random Void structured Fiber (new)
Improved network performance	G.657B compliant low bending loss for inside wiring and G.652D compliant.	Yes	Yes	No	G.652?
	Easy to clean connector end faces to facilitate low reflection for video support	Yes	Yes	Holes/voids can trap fluids/debris and create film	
Compact fiber management	<15 mm bend radius fiber management	Yes	Yes	Yes	Yes
Fast and easy installation	Backward compatible - Easy splicing and testing with standard SMF parameters to installed base.	Yes	Requires special splice recipe	Holes or voids can complicate and slow splicing	
Reliability under bending	Solid Fiber Structure	Yes	Yes	??? – current reliability theory and experience is based on solid fiber structure	
	Pure, inclusion free synthetic silica glass	Yes	??? if natural quartz used	Yes	Yes

Table showing advantages and disadvantages of each method for making fiber more bend-tolerant.

fusion splicers. Some new designs using voids, holes or trenches in the cladding have significant splicing issues with core alignment machines.

In the case of connectorized fiber, in order to support video applications it is critical that the fiber end-faces can be properly cleaned and polished to reduce reflections that can disrupt video services. Fibers that have voids or holes in the cladding may trap fluids or particles in these voids, and make proper cleaning difficult or impossible.

Attenuation is always important for an optical network. The industry shift to full-spectrum and zero water peak fibers to support coarse wavelength division multiplexing should not be sacrificed in first-mile applications. Zero water peak fibers provide added power margin in the widely used 1490 nm wavelength band, and are ready for future bandwidth upgrades.

Perhaps the most important issue with bend-capable fibers is reliability. When any fiber is in a tight bend, considerable tensile stress is present on the surface of the glass. As the fiber bend diameter drops below 15 mm, this stress becomes greater than the traditional 100,000 psi proof test level applied in standard optical fiber manufacturing production.

Exceeding the reliability limit can result in a catastrophic failure of the optical link at a random time within a 40-year timeframe. Fiber attachment methods such as stapling can be particularly troubling if the stapling causes uncontrolled kinks in the glass, potentially causing premature fiber breakage and service outages. With smaller bending diameters in FTTH networks, careful attention must be paid to fiber reliability. **BBP**

About the Author

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