Technical Insight: Bend-Sensitive Fibers

Optical fiber attenuation is, by nature, sensitive to a number of factors, whatever the fiber design and its application. It is just a question of whether the loss is noticeable or not, given the location of the fibers (within a cable or coiled in a joint box). When the loss does become significant, this may translate in attenuation increases that can disappear when a particular constraint is removed.

Among the factors causing attenuation, the most common is bending or micro-bending. In this case, the fiber sensitivity is basically a question of "how strong the fiber design performs as a waveguide" – leading to how the waveguide is built, i.e. its index profile. For micro-bending, this is associated with how efficient the fiber coating is in the protection it brings.

As light travels in a straight line, the transmission of light through an optical fiber, as it is flexed, relies upon the reflection of the light (total internal reflection) off the boundary wall (the boundary being any change in the composition (refractive index) of the glass, the wave guide being the inner-most core of the glass fiber with a homogeneous composition and hence refractive index. When a fiber is subjected to increasing bending, macro-bend loss or micro-bend loss may occur. Macro-bending loss may occur when a fiber is coiled or subjected to a large radius bend, resulting in some light not being internally reflected within the fiber. For a single bend or coil, the macro-bending loss may be immeasurably small. Micro-bending loss can occur when a fiber is subjected to a tight, small radius bend, for example if it is wound onto an uneven surface or over a sharp edge. Micro-bending loss may be significant, impacting a cable system's power budget and can usually be measured. Fibers with larger cores are more sensitive to Macro-bending losses, which are cumulative with more coils of the fiber.

The question of whether bending or micro-bending affects the attenuation to a measurable level or not mostly depends on how the fiber is actually packaged (namely the cable core and the joint box designs, including how spacious the joint housing is) and what it is being submitted to (assembly, installation, repair, etc.) all causing constraints to a various extent. As a result there can be a lot of variability in the outcome, i.e. the amount of change in attenuation.

Joint boxes such as the UJ, UQJ, UC, in which the excess fiber length necessary for the splicing operation is coiled in the joint housing, may thus be exposed to changes in attenuation. Until recently, nothing measurable has been reported, however as the evolution of transmission technology leads to the use of fibers with larger and larger effective areas, this brings as well products having a greater sensitivity to bending and possibly micro-bending. Attenuation due to bending is likely to be kept to negligible levels with UJ technologies, but may bring some effects in UQJ, depending on actual fiber design and parameters. This subject is currently being investigated by the UJC.