# Numerical modeling of curved waveguides : computation of elastic propagation modes in prestressed multi-wire helical structures

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**Résumé**

A methodology is presented for the numerical investigation of guided waves in curved structures. In a general framework, the existence of propagation modes is discussed in curved waveguides. Translational invariance constitutes the key property. This property, implicitly used for the analysis of straight waveguides, must be redefined in curvilinear coordinate systems. It is shown that using a helical coordinate system to rewrite the governing equations of physics allows to satisfy this invariance. The study is then focused on elastic waveguides. Owing to the difficulties to achieve fully analytical solutions, a purely numerical approach is proposed based on the so-called semi-analytical finite element (SAFE) method. With this method, only the cross-section of the waveguide needs to be discretized by finite elements. The leading application of this work is civil engineering cables, which are generally made of multi-wire helical components. The multi-wire nature of these structures complicates the question of existence of guided waves. It is proved that a twisting system allows to satisfy translational invariance in seven-wire strands, widely encountered in civil engineering. Twisting systems have zero curvature and constitute a particular case of helical coordinate systems. Finally, some other effects that further complicate the modeling of wave propagation in cables are discussed. These effects are related to the presence of axial loads (generating prestress) and surrounding materials (the cross-section getting unbounded) as well as the scattering of waves by defects.

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