**Università degli Studi di Pavia**
**Computational Mechanics & Advanced Materials Group - DICAr**

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# Finite Element Analysis of wave propagation in 1D and 2D waveguides

Theoretical understanding of wave propagation provides information about the dynamic behavior and stress state of structures, and is essential in many applications such as structural health monitoring, transmission of structure–borne sound, statistical energy analysis and vibration transmission (especially in complex, built-up structures), shock-response, and so on. In recent years there has been an increased interest in numerical methods for the analysis of wave propagation in elastic structures, in particular due to developments in non–destructive testing and structural health monitoring techniques. This lecture aims at giving an overview to a numerical approach, the Wave Finite Element (WFE) method, for the numerical prediction of wave characteristic in elastic structures. The structure of interests are 3D structures which confines wave propagation in 1 or 2 dimensions. These can be periodic or homogeneous structure in 1 and 2 dimensions, but whose properties may vary arbitrarily through the thickness. The method combines conventional Finite-Elements (FE) and the theory of wave propagation in periodic structures. The mass and stiffness matrices of a small segment of the structure, which is typically modeled using either a single shell element or, especially for complicated structures, a stack of solid elements meshed through the cross-section, are post-processed using periodicity conditions. The matrices are typically found using commercial FE packages. The solutions of the resulting eigenproblem provide the frequency evolution of the wavenumber and the wave modes. Recently a hybrid FE/WFE approach for calculating the scattering properties of joints connecting homogeneous waveguides has been developed. Once wave and scattering properties are known, the forced response of structures (comprising a number of waveguides) can be analysed by a systematic application of the equations describing wave excitation, propagation, reflection and transmission. The advantages of the method include the fact that conventional FE software can be used, frequency dependent material properties can be included, the models are very small, and thus results are found at very little computational cost. This makes the technique particularly suitable for studying complex waveguides and for automated design cycles

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