Long-range SHM in structured media

Structural health monitoring aims to ensure a reliable, long-term surveillance in order to detect fatigue cracks in operational conditions. The damage characterization must be extracted from measured signals. The wave propagation in structural components is here considered as the information phenomenological support for structural health monitoring.

Traveling waves necessarily interact with singularities along their path. Singularities are, in the case of Structural Health Monitoring, elements to be identified. Numerical simulation can necessarily help to forecast the interaction of propagating wave with singularities. These singularities are geometrical or material discontinuities in accordance with the initial design but they can also be the result of the evolution of critical damages.

For such a purpose, the Wave Finite Element Method (WFEM) is particularly adapted. It uses Bloch's theorem to provide significant reduction of the modeling effort. Wave dispersion characteristics of a waveguide whose cross-section is modeled with FEM can be derived by solving a small quadratic eigenvalue problem.

The wave propagation and scattering in a structured composite component is studied using time-response analysis and compared to the Wave Finite Element Methods' predictions. These waves are generated by pulse excitations of the medium. Guided waves occurrence is not limited to structures whose shape exhibits a significant elongation in one direction. Indeed, guided waves can be generated in other structures with specific inner-structure settings.

The Wave Finite Element have been therefore applied to propagative characteristic evaluation on specific pipe elements. These structural component are, by design, natural waveguides. The main aim was to extract reflection and transmission coefficients that could reveal specific interaction with local singularities. The numerical results are used to not only validate the monitoring protocol but they also establish a baseline, like a mapping of the likeliness of a defect occurrence.

High-order waves' propagation with low spatial attenuation in broadband frequency range happen to be an alternative to some structural health monitoring techniques based on first-order wave propagation. It may encompass some of the drawbacks encountered when dealing with boundary conditions in 2D-waveguides or provide accurate wave-based inspection techniques for heterogeneous or composite beams. Their efficiency is shown on a sandwich plate made of transverse isotropic honeycomb core surrounded by fiber-reinforced skins.