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Numerical Study of Nonlinear Guided Waves in Composite Laminates with Delaminations

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Abstract : Fibre-composites are widely used in various structures due to their attractive properties such as higher stiffness to mass ratio and better corrosion resistance compared to metallic materials. However, one serious weakness of this composite material is delamination, which is a subsurface separation of laminae. A low level of this barely visible damage can cause a significant reduction in residual compressive strength. In the last decade, the application of guided waves for damage detection has been a topic of significant interest for many researches. Among all guided wave techniques, nonlinear guided wave has shown outstanding sensitivity and capability for detecting different types of damages, e.g. cracks and delaminations. So far, most of researches on applications of nonlinear guided wave have been dedicated to isotropic material, such as aluminium and steel, while only a few works have been done on applications of nonlinear characteristics of guided waves in anisotropic materials. This study investigates the nonlinear interactions of the fundamental antisymmetric lamb wave (A0) with delamination in composite laminates using three-dimensional (3D) explicit finite element (FE) simulations. The nonlinearity considered in this study arises from interactions of two interfaces of sub-laminates at the delamination region, which generates contact acoustic nonlinearity (CAN). The aim of this research is to investigate the phenomena of CAN in composite laminated beams by a series of numerical case studies. In this study interaction of fundamental antisymmetric lamb wave with delamination of different sizes are studied in detail. The results show that the A0 lamb wave interacts with the delaminations generating CAN in the form of higher harmonics, which is a good indicator for determining the existence of delaminations in composite laminates.

Keywords : contact acoustic nonlinearity, delamination, fibre reinforced composite beam, finite element, nonlinear guided waves
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