A 3D Finite Element Approach for Dispersion Curve Extraction in Complex Structures

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The guided waves are essential for non-destructive testing and provide an effective means to inspect various structures and materials reliably. The dispersion character is the most important feature for guided wave propagation analysis and signal processing. This paper introduces an implementation of a 3D finite element approach to extract dispersion curves, offering a practical method to analyze guided wave propagation in structures characterized by intricate geometries and diverse material properties. We explore numerous numerical examples, encompassing layered composites, functionally graded materials, rail sections, and metastructures, to demonstrate the versatility of this method. The presented method generates various guided wave dispersion curves on different cross-sectional shapes and materials. Additionally, to improve precision, dispersion calculations incorporate micro-modeling techniques tailored for composite materials. The presented method can generate dispersion curve with accurate data and it is well matched to conventional analysis methods. The study also investigates the impact of initial stress on dispersion curves, revealing variations in the effects of tensile and compressive stresses across different frequencies and modes. The proposed method presents an accurate and viable solution for obtaining dispersion curves in structures with complex geometries and material properties, thereby facilitating comprehensive analyses in the field of guided wave-based inspection and assessment.