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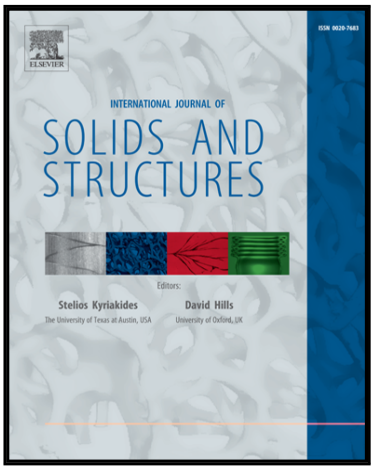

Propagation of Rayleigh-Lamb waves in multilayered plates through a multiscale structural model

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Propagation of Rayleigh-Lamb waves in multilayered plates through a multiscale structural model

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Abstract

The propagation of plane-strain harmonic waves in multilayered plates is studied using a multiscale approach which couples an equivalent first-order single-layer theory and a discrete-layer cohesive-interface model using a homogenization technique to enforce continuity conditions on tractions at the layer interfaces. The model captures the effects of the inhomogeneous material structure and the presence of interfacial imperfections on local fields and global behavior through homogenized equilibrium equations which depend on the kinematic variables of the equivalent single-layer theory only. The equations are tractable and frequency equations and dispersion curves are derived in closed-form for plates with an arbitrary number of layers, interfacial imperfections and layup anisotropy. Among the advantages of the multiscale treatment over classical structural approaches: prediction of lowest modes is accurate over a larger range of frequencies and material inhomogeneities; the correction factors in the low-frequency regime are independent of the layup and accurate explicit expressions are derived for the first two cut-off frequencies; zig-zag displacement fields and jumps at the imperfect interfaces are reproduced; changes in modes of propagation and reduction of the cut-off frequencies due to softer layers, adhesives or delaminations are captured.

Keywords: wave propagation, dispersion, laminate, plate theory, zigzag, homogenization, interfaces

1. Introduction

When a layered structure is hit by a sudden disturbance, such as a blast or an impact, stress waves are generated and propagate through the body. These stress waves may cause damage, either directly or indirectly through the impulse they deliver. Elastic stress waves may also be generated as part of nondestructive evaluation techniques to define material properties or determine the integrity of a structure ([1],[2],[3]). Predicting how stress waves propagate in the phase that precedes damage is a prerequisite to the solution of dynamic problems, the design of blast/impact mitigation strategies and the design and application of damage detection techniques. In particular,