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CONVERGENCE OF THE DISCRETE ANALYTICAL METHOD FOR FORCED VIBRATION OF FGM PLATE–VISCIOUS FLUID SYSTEMS

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Abstract

Hydroelastic vibration of elastic and functionally graded material (FGM) plates interacting with viscous or compressible fluids has been extensively studied, yet most works have focused on free or thermal vibration cases. The convergence and stability of analytical or semi-analytical methods for forced vibration in viscous–compressible media remain less explored, though they are essential for ensuring accurate modeling of coupled fluid–structure systems. Hydroelastic systems are fundamental in many modern applications, such as aerospace components, marine structures, biomedical devices, and energy systems, where precise vibration prediction is crucial for safety and performance. This study investigates the convergence and computational efficiency

of the discrete analytical method (DAM) applied to the forced vibration of an FGM plate coupled with a viscous, compressible fluid layer bounded by a rigid wall. The hydroelastic model is formulated using three-dimensional elastodynamic equations for the plate and linearized Navier–Stokes equations for the fluid. Material gradation across the plate thickness is represented through discretization into homogeneous sublayers, with strict continuity of stresses and displacements across interfaces. Fourier transformation and recursive analytical formulations are employed to derive solvable algebraic systems, and the analytical solutions are implemented and validated using MATLAB. Convergence analysis with respect to the number of sublayers, integration density, and truncation limit demonstrates rapid and stable convergence, with residual errors below 10^{-6} . These results confirm that the discrete analytical method provides an accurate, efficient, and reliable framework for analyzing hydroelastic vibration of FGM structures in viscous and compressible fluid environments.

Keywords:

FGM Plate, Forced Vibration, Discrete Analytical Method, Convergence