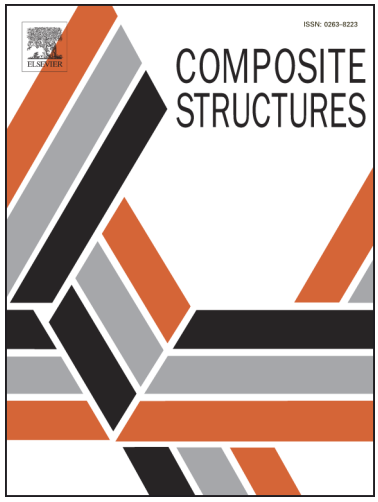

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Nonlinear steady-state responses of longitudinally travelling functionally graded material plates in contact with liquid

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Abstract

This study investigates the nonlinear steady-state responses of longitudinally traveling functionally graded material (FGM) plates immersed in liquid for the first time. The liquid is assumed to be ideal, and therefore it is inviscid, incompressible and irrotational. The velocity potential and Bernoulli's equation are utilized to describe the dynamic liquid pressure. The large amplitude motion of the FGM plate is considered so that the present model includes both geometry and material nonlinearities. Based on the Newton's second law, the equation of out-of-plane motion of the plate is obtained. The Galerkin method is used to discretize the partial differential equation of motion and then the method of harmonic balance is used to analytically solve a set of ordinary differential equations. Also, the numerical solutions are carried out by utilizing an adaptive step-size fourth-order Runge-Kutta technique. The analytical and numerical results agree with each other quite well. Furthermore, the stability of steady-state solutions is performed for the analytical results. The frequency characteristics, time- and frequency-domain response characteristics of the plate are fully discussed. The nonlinear frequency-response relationships show strong hardening-type behavior of the system. Additionally, the influences of different parameters on the nonlinear dynamical responses of the system are shown.

Keyword: Functionally graded material plate; longitudinally traveling; liquid; nonlinear response; mode coupling; harmonic balance method.

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