Vibration bandgap of immersed periodic plates with fluid surface sloshing effect

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Abstract

This article builds on previous work by implementing a unit cell-based symmetric fluid-structure formulation to predict vibration bandgaps of immersed periodic composite plates with the account for fluid surface sloshing effect. The significance of this study lies in integrating Bloch periodic boundary conditions into a symmetric hydro-elastic (u, η, ϕ) unit cell model with fluid-structure interaction (FSI). The unit cell comprises three subdomains: the immersed composite plate, the fluid domain and the fluid free surface. Bloch periodic conditions are applied simultaneously across all the three domains, allowing the prediction of vibration bandgaps that consider both fluid inertia and surface sloshing effects. This approach is applicable to immersed periodic structures across full-range immersion depths, whether distant from or approaching the fluid free surface. We conducted a study on the linear dynamics of periodic composite plates across various immersion depths and revealed a competitive relationship between the fluid inertial effect and the fluid surface sloshing effect. Specifically, for deeply immersed structures, the model converges to the classical added mass model, indicating that the fluid inertial effect dominates the influence on vibration bandgaps. While in shallow immersion scenarios, as structures approach the fluid surface, the free surface sloshing effect associated with fluid gravity becomes the dominant factor. The results are verified through comparison with the frequency response simulations that consider the same FSI conditions. The approach has also been applied to investigate the dispersive bandgaps for microstructures with anisotropic wave propagations. The results demonstrate the effectiveness of the proposed model in designing immersed meta-structures for vibration attenuation.

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