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Robust free vibration analysis of functionally graded structures with interval uncertainties

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Abstract

In this paper, a robust interval free vibration analysis for 3D functionally graded frame type engineering structure is presented through the finite element method (FEM). Uncertain material properties, which are including the Young's modulus and material density, of the functionally graded material are considered. Unlike the conventional uncertainty quantification through stochastic approach, the uncertain system inputs are modelled by the interval approach. Instead of straining on the precise statistical information of the uncertain parameters, only upper and lower bounds of the uncertain system inputs are required for valid structural safety assessment. By implementing the mathematical programming approach combined with the intrinsic characteristics of the non-deficient engineering structures, the upper and lower bounds of the natural frequencies of 3D functionally graded frame structure can be explicitly formulated by two independent eigen-problems. The sharpness and physical feasibility of the interval natural frequencies of the functionally graded structure can be well preserved. To demonstrate the competence of the proposed method, two numerical examples have been thoroughly investigated. In addition, diverse numerical investigations have been conducted to explore the impacts of uncertain material properties and the power-law index of the functionally graded materials on the overall structural performance.

Keywords:

Functionally graded structures; 3D structural analysis; Interval free vibration; Interval uncertainty analysis; Finite element method.

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