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Robust safety assessment of functionally graded structures with interval uncertainties

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Abstract

This paper investigates the problem of non-deterministic static analysis of functionally graded structures involving interval uncertainties through both Euler-Bernoulli and Timoshenko beam theories. Within the generalized analysis framework of the Finite Element Method (FEM), a novel computational scheme is developed to effectively tackle such intricate, yet frequently encountered, engineering problems. The proposed method establishes a unified non-stochastic uncertainty analysis framework, which can incorporate the interval uncertainties of material properties of the functionally graded structural members, the dimensions of structural elements, as well as the externally applied thermal and mechanical loads. By introducing an alternative FEM formulation, the governing equation for the interval uncertain static analysis of functionally graded structures can be meticulously transformed into two standard nonlinear programming (NLP) problems, so the extreme bounds of any concerned structural behaviours can be effectively determined. In addition, the proposed method is able to provide the critical information regarding the uncertain parameters that are actually causing such extreme structural behaviours at zero computational cost. Consequently, such by-products of the analysis can certainly be beneficial for subsequent structural design, and also the physical feasibility of the original problem can be rigorously maintained.

Keywords: Functionally graded structures; Euler-Bernoulli type; Timoshenko type; Interval uncertain static analysis; Interval Finite Element Method.

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