Nonlinear Interval Finite Element for Structural Mechanics Problems

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Abstract

Interval Finite Element (IFEM) has been formulated to handle load, material, and geometric uncertainty introduced as intervals. Uncertain parameters are presented as interval numbers defined by their lower and upper bounds. However, the approaches developed to handle problems of interval uncertainty up till now are limited to linear problems. A new IFEM formulation developed earlier by authors (Rama Rao, Mullen, and Muhanna, 2010) has the capability of computing the structural response in terms of primary variables (such as displacements) and the derived quantities (such as forces and strains) efficiently and with a very high accuracy.

Recently, the authors have developed an interval secant approach for material nonlinearity (Rama Rao, Mullen and Muhanna, 2011). The present work handles material nonlinearity by introducing an alternative solution that exploits the modified Newton-Raphson method. In order to control the overestimation, internal forces at each node of the structure are calculated using a load-by-load approach. The algorithm is based on the previously developed high accuracy IFEM solutions. For each load increment the tangent stiffness matrix is computed and the solution is obtained using an iterative method that generates bounds on the solution of uncertain system. Results obtained show very tight enclosures even for large uncertainties. Examples are presented to illustrate the present formulation.

References

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