Buckling Analysis of Structures with Uncertain Properties and Loads Using an Interval Finite Element Method

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In order to ensure the safety of a structure, one must provide for adequate strength of structural elements. In addition, one must prevent large unstable deformations such as buckling. In most analysis of buckling, structural properties and applied loads are considered certain. This approach ignores the fact that imperfections and unknown changes in properties, albeit small, are required for the onset of buckling. In this paper, we extend the interval finite element methods developed by the authors to solve for the possible values of loads that will result in a structural stability failure. The analysis requires the calculation of interval axial element forces in each frame element in a structure. These values are calculated from a linear system of interval equations resulting from the static structural analysis. Using the calculated axial loads, a subsequent interval eigenvalue problem is solved for the buckling loads. For both the solution of the linear system of equations and the eigenvalues problem, the unique properties of the finite element method result in sharp solutions. Several structural problems are presented as exemplars. The sharpness of the solution is demonstrated by comparing to combinatorial solutions.
The scaling behavior of the algorithm when applied to large problems is discussed.