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Elimination of void element influence on optimization for nonlinear compliance with a buckling constraint using moving iso-surface threshold method

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Abstract

This article presents an algorithm that eliminates some of the adverse influences of the void elements used in nonlinear structural topology optimization with a buckling constraint by using moving iso-surface threshold (MIST) method. The basic idea of this algorithm is to conduct the finite element analysis in a sub design domain with solid and grey elements and to construct each updated response function in the full design domain. In this algorithm, void elements are excluded in all the finite element analyses but included in design variable update. In doing so in MIST, the material removed with void elements can reappear. In the present study, the strain energy density at the final state in a nonlinear finite element analysis is selected as the response function in MIST to minimize the nonlinear compliance, and the iso-surface threshold value is determined by using a prescribed volume constraint and then used to define optimal topology containing solid materials only. Exclusion of void elements in all the finite element analyses allows avoidance of several numerical issues, such as material reappearance, discontinuous design and numerical instability encountered in topology optimization for structures, in particular, with large displacements. In the present algorithm, a buckling constraint is also introduced to consider the influence of load level on nonlinear topology optimization.

Keywords: optimization; nonlinearity; void element; numerical stability; buckling constraint.