

FAIL-SAFE TOPOLOGY OPTIMIZATION ANALYSIS IN GEOMETRICALLY NONLINEAR STRUCTURES COMPOSED OF HYPERELASTIC MATERIALS

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Abstract

Topology optimization (TO) can be applied to continuum structures to generate efficient designs accounting for performance measures, such as compliance. However, the resulting solutions are often sensitive to the occurrence of local damage, which can be modeled by removing a group of elements from the optimized configuration. Fail-safe TO leads to redundant structures by considering a distribution of square damage patches over the domain to simulate local damage, and the optimization problem can be formulated to avoid disproportionate consequences of such damage. Nevertheless, most studies in this field rely on the small-displacement hypothesis, which has several limitations for many engineering applications. Therefore, this study proposes a fail-safe TO approach within a geometrically nonlinear description for plane structures. The optimization problem minimizes the worst-case compliance among all damage scenarios using the Solid Isotropic Material with Penalization (SIMP) method. A hyperelastic neo-Hookean material model has been considered within a total Lagrangian finite element formulation, in which the current nodal positions are used as parameters. An energy interpolation scheme has been employed to avoid convergence loss caused by excessive deformation of low-density elements. Numerical results demonstrate the capability of the proposed formulation to handle structures undergoing large displacements in a fail-safe context. Finally, the influence of the applied load is investigated to analyze the role of geometric nonlinearity.