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Isogeometric analysis based topology optimization design with global stress constraint

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Abstract: This paper presents an isogeometric analysis (IGA) based design method to address the stress-constrained topology optimization problem of plane stress and bending of thin plates. Based on the popular SIMP model, the integrated framework of geometry modeling, structural stress analysis and optimization is established. Owing to the geometry exactness and high-order continuity between elements, the IGA improves the computational accuracy of stress, and thus enhances the credibility of optimum design. Meanwhile, the obvious zigzag boundaries are avoided in the optimized results, and the stress function of IGA maintains the continuity for a relatively coarse discretization. Moreover, the IGA-SIMP method can easily meet the requirement of C^1-continuity for the Kirchhoff plate formulations, which also facilitates the stress analysis and sensitivity calculation. To overcome the convergence difficulty of highly nonlinear stress aggregation constraint, two STM (stability transformation method)-based stabilization schemes combining with the P-norm function for global stress constraint are developed to achieve the stable iterations and acceptable designs. Finally, representative examples illustrate the effectiveness and convenience of the proposed approach. It is indicated that the IGA-SIMP method shows superior performance for solution accuracy and efficiency, and the local stress level is well controlled.

Keywords: Topology optimization; IGA-SIMP method; plane stress and bending of thin plates; global stress constraint; STM-based stabilization schemes

1. Introduction

Topology optimization is a conceptual design tool of multifunctional structures, which aims to determine the optimal material distribution inside the specific design domain for achieving the required superior performance. Since the pioneering work of [1], there have been rapid development and wide application for topology optimization of continuum structures over the past three decades. Up to now, various methods are available to deal with topology optimization design problem [2]. Therein, the density-based SIMP (solid isotropic material with penalization) method has been popularly used owing to its simple implementation and high computational efficiency. The comprehensive overviews on topology optimization of continuum are referred to the literature [3–5].

In some practical applications, the lightweight design of structures is desirable while

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