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Two-scale Design Optimization of Bending Plate Made of Periodic Lattice and Foam Material Subject to Buckling Constraint

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Abstract

The presentation briefly reviews the recent development of concurrent multi-scale structural and material topology optimization and discusses its potential extension. Following the basic idea, this paper studies maximum buckling load design of thin bending plate for a given amount of material. The plate is made of periodic homogeneous lattice and foam material. The plate shape, thickness and boundary conditions are given. The pattern of prescribed external load or displacements along the part of boundaries, which moves freely, is given. Both plate topology and material micro-structural topology are optimized. The design variables include artificial material density in both macro and micro-scale.

The homogenization and dimensional reduction of the periodic plate structure is carried out by the new implementation developed in Cheng et al.[1] and Cai et al.[2]. In this new implementation, the bending rigidity of the equivalent plate is rewritten in terms of the nodal quantities of the FEM model of the unit cell. And the unit cell can be modeled by various type of finite elements and modeling techniques and solved by using the commercial software as a black box. Furthermore, the sensitivity of the bending rigidity and buckling load with respect to the topological design variables in both macro-scale and micro-scale is obtained analytically, which enables the application of gradient-based search algorithm in the optimization.

In structural topology optimization with buckling constraints, one of the well known troubles is the spurious local buckling modes in the low density area. Various methods were proposed in literature. The present paper suppresses the spurious buckling modes by adding artificially positioned nodel spring in the low density area. Several numerical examples are given to show the potential of the proposed method.

References

[1] G.D. Cheng, Y.W. Cai, L. Xu, Novel implementation of homogenization method to predict effective properties of periodic materials, Acta Mechanica Sinaica, 29 (4), 550-556, 2013

[2] Y.W. Cai, L. Xu, G.D. Cheng, Novel numerical implementation of asymptotic homogenization method for periodic plate structures, International Journal of Solids and Structures, 51 (1), 284-292, 2014