Topology optimization of multi-material structures with interface strength constraints

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Abstract

In topology optimization of multi-material structures, interface behaviors are of great importance for avoiding structural failure and ensuring the structural integrity. In this paper, we consider the minimum compliance optimization problem with three-phase materials: a soft material, a stiff material and the void phase. The interface between the soft and the stiff materials is defined as a bonding interface. The color level set method is employed to represent the distribution of the materials and the material interfaces. By enriching the interpolation functions of the displacement field with discontinuous function, the extended finite element method (XFEM) is adopted to describe the displacement discontinuity on the interface. As the response of the structure is nonlinear, an incremental solution procedure is employed. We use the mathematical programming algorithm MMA to seek the optimal boundary velocities for evolving the level set functions. The sensitivity scheme is derived using the adjoint variable method. Numerical examples are presented to demonstrate the validity of the present method. Numerical results show distinct differences between the obtained solutions and those by the conventional method.

Keywords: topology optimization, multi-material, level set, interface, XFEM

References

[1] M.Y. Wang, X. Wang, “Color” level sets: a multi-phase method for structural topology optimization with multiple materials, Computer Methods in Applied Mechanics and Engineering, 193 (2004) 469-496.
[2] M.Y. Wang, S. Chen, X. Wang, Y. Mei, Design of multimaterial compliant mechanisms using level-set methods, Journal of Mechanical Design, 127 (2005) 941-956.
[3] Y. Wang, Z. Luo, Z. Kang, N. Zhang, A multi-material level set-based topology and shape optimization method, Computer Methods in Applied Mechanics and Engineering, 283 (2015) 1570-1586.