Material design applying a multi-scale topology optimization for elastoplastic solids

J. Kato J*, S. Ogawa*, T. Kyoya* and K. Terada†

* Department of Civil and Environmental Engineering
Tohoku University
6-6-06, Aoba, Aramaki, Aoba-ku, Sendai 980-8579, Japan
e-mail: junji.kato.a5@tohoku.ac.jp

† International Research Institute of Desaster Science (IRIDeS)
Tohoku University
468-1, Aoba, Aramaki, Aoba-ku, Sendai 980-0845, Japan
Email: tei@irides.tohoku.ac.jp

ABSTRACT

The present study proposes topology optimization of a microstructure considering both micro- and macro von Mises elastoplastic deformation. In this study, a decoupling multi-scale analysis based on a homogenization approach is applied [1]. The decoupling multiscale analysis is intended to reduce the computational costs by deviding the original two-scale BVP into the individual micro- and macro BVPs.

This kind of material design scheme is called *multi-scale topology optimization* [2]. In this study, it is assumed that microstrucutre is unique over the macro-structure and only microstructure topology is optimized. Maxmization of energy absorption capacity of the macro-structure is chosen as the obejective function under a prescribed material volume of constituents. The design variable is defined as a volume fraction of each finite element in a unit cell.

A gradient-based optimization strategy is applied and analytical sensitivity analysis based on numerical material tests is introduced. With this method, the derived sensitivities of the objective function with respect to the design variables are highly accurate even without calculating the implicit sensitivity term [3]: this reduces the computational efforts dramatically. The theoretical background of this method will be clarified.

This kind of optimization problems undergoes non-uniqueness of optimization solution because of its periodic boundary condition of microstructure and this argument is discussed. It is verified from a series of numerical examples that the proposed method has great potential for advanced material design.

REFERENCES

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