Topology optimization of modulated and oriented periodic microstructures by the homogenization method in 2-d and in 3-d

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ABSTRACT

The work presented here is motivated by the optimization of so-called lattice materials which are becoming increasingly popular in the context of additive manufacturing. We propose a method for topology optimization of structures made of periodically perforated material, where the microscopic periodic cell can be macroscopically modulated and oriented in the working domain.

This method is made of three steps. The first step amounts to compute the homogenized properties of an adequately chosen parametrized microstructure (here, a cubic lattice with varying bar thicknesses). The second step optimizes the homogenized formulation of the problem, which is a classical problem of parametric optimization. The third, and most delicate, step projects the optimal oriented microstructure at a desired length scale. In 2-d case, rotations are parametrized by a single angle, to which a conformality constraint can be applied. A conformal diffeomorphism is then computed from the orientation field, thanks which each periodic cell is well oriented in the final structure. The 3-d case is more involved and requires new ingredients. In particular, the full rotation matrix is regularized (instead of just one angle in 2-d) and the projection map which deforms the periodic lattice is computed component by component.

Several numerical examples are presented for compliance minimization in 2-d and in 3-d.