11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Topology Optimization of Cellular Materials for Properties Governed by Nonlinear Mechanics

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Abstract

Topology optimization offers a means to leverage the advancement in manufacturing technologies that in recent years have made it possible to fabricate cellular materials with complex but prescribed topologies. Topology optimization has previously been used for unit cell design of materials with elastic properties and herein we look to extend these approaches to design materials with properties that are governed by nonlinear mechanics, such as energy absorption. One of the primary challenges in this setting is the lack of unit cell upscaling techniques for nonlinear behaviour, including both material and geometric nonlinearities. In its absence, we turn instead to the assumption of finite periodicity. The proposed formulation uses existing nonlinear sensitivity analysis schemes as the backbone of the design algorithm. Two new topologies optimized for energy absorption are presented and experimental results of actual fabricated samples are discussed.

Keywords: topology optimization; nonlinear mechanics; cellular materials.