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Integrated design of cellular composites using a level-set topology optimization method

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Abstract

This paper proposes a hierarchical multi-scale topology optimization method for the design of integrated materials and structures by taking advantage of both cellular composites and functionally graded materials. The topology optimization involves two scales: firstly, macrostructural design using SIMP to generate an overall multilayered layout with free material distribution involving intermediate densities; and secondly, microstructural design to produce periodic cellular composite for each layer, by integrating the numerical homogenization into a level set approach. Thus, the cellular composites will be characterized by variation in microstructures and the corresponding changes of properties over layers. The proposed method can generate new artificial composites similar to functionally graded materials but layer-based, to achieve multifunctional properties for energy absorption, anti-impact, thermal isolation, etc. Several numerical examples are presented to demonstrate the effectiveness of the proposed method.

Keywords: Integrated design; Topology optimization; Level set method; Cellular composites; Functionally graded materials.