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### 轻质材料与结构的一体化设计

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### Integrated Design Methodology of Lightweight Materials and Structures

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摘要

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**摘要** 针对多孔材料微结构构型的可设计性,基于材料多尺度均匀化计算理论,提出以宏观结构最大刚度为目标,材料微结构构型为变量的材料与结构一体化设计新方法,实现了材料宏观布局设计与材料微结构精细设计的统一。采用凸规划对偶优化求解技术与二次型周长约束格式相结合的途径,实现了快速求解与材料分布棋盘格效应的控制。数值计算结果表明,在材料用量一定的情况下,本方法能有效地实现蜂窝结构及夹层结构的拓扑优化设计,为满足极端环境下航空航天结构的设计需求提供了新的设计思想。

**关键词:** 多孔材料 拓扑优化 复合材料 微结构 材料设计

**Abstract:** It is recognized that the structural behaviors of cellular solids are directly related to the effective properties of material that depend greatly upon the involved microstructure. In this paper, an integrated design methodology is proposed for the global stiffness maximization of the overall structure and the local design of material microstructure based on the homogenization method of multi-scale computing. By means of the dual optimization scheme and perimeter constraint, the material microstructures are efficiently optimized with elimination of checkerboards. Numerical results show that the proposed method is well adapted to the design of lightweight structures such as honeycomb panels and sandwich panels. This provides an innovative design concept for the requirements of aerospace lightweight structures satisfying extreme working conditions.

**Keywords:** cellular solids topology optimization composite materials microstructure material design

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