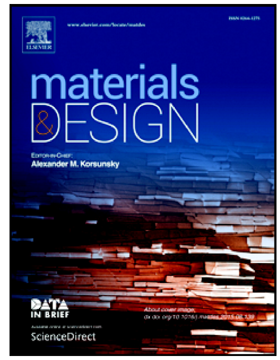

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Architected Multi-Directional Functionally Graded Cellular Plates

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Abstract

Inspired by natural materials like bamboo and the dentin-enamel junction of tooth, the concept of architected multi-directional functionally graded cellular materials (FGCMs) is introduced. These architected porous materials are made by assembling porous unit cells of dissimilar densities and cell topologies. To evaluate the potential of multi-directional FGCMs for improving the performance of lightweight structural elements, the mechanical properties of functionally graded cellular (FGC) plates are analyzed. For the numerical analyses, standard mechanics homogenization is used to predict the mechanical properties of cells with arbitrary superellipse voids. The homogenized effective properties along with finite element method and shear deformation theory are exploited to predict the mechanical responses of plates made of multi-directional FGCMs. Numerical results reveal substantial improvement in structural responses when FGCMs are appropriately used; e.g. 56% improvement in bending stiffness is found in an FGC rectangular plate compared to a cellular plate with the same weight and with uniform distribution of constitutive cells. Numerical results show that cell variation through the thickness of FGC plates is more effective on the structural responses than variation through the length or width. Finally, multi-objective optimization is implemented to show the maximum improvement achievable via architecture variation within FGC structures.

Keywords: Architected advanced materials, Cellular solids, Functionally graded cellular materials, Homogenization, 3D printing.

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