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Bimaterial 3D Printing and Numerical Analysis of Bio-inspired Composite Structures under In-plane and Transverse Loadings

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ABSTRACT

This work presents a novel design, additive manufacturing and modeling approach of three dimensional voronoi-based composite structures that closely mimics nacre's multilayer composite. Hierarchical structure of natural nacre is mimicked to produce multilayer composite laminates assembled from three dimensional polygonal tablets bonded with organic adhesives. Furthermore, various complex geometries of the nacreous shells observed from the nature, such as the dome-shaped structure, are developed into three dimensional mimicked designs. A novel mapping algorithm is developed to design complex structures of nacre-like composites readily to be fabricated by the unique dual-material 3D printing technology. Preliminary 3D-printed prototypes with complex shapes and material combinations are presented. A novel numerical model of nacreous composite is proposed including the tablet cohesive bonds and interlaminates adhesive layers to mimic the soft organic polymer matrix. The nacreous model is validated against the natural nacre platelet under uniaxial loading. To exemplify a potential application, a scaled model of nacre-mimetic composite made of Aluminum tablets and Vinylester adhesive are constructed and assessed against blast-induced impulsive loading. Performances of nacre-like composite panels are investigated in terms of deformation and energy dissipation.

Keywords: Bio-inspired composite, nacre, voronoi, 3D printing, cohesive model