Design of Hybrid Auxetic Metamaterials for Enhanced Energy Absorption under Compression

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Abstract : Auxetic materials have a negative Poisson's ratio (NPR), which is not often found in nature. They are metamaterials that have potential applications in many engineering fields. Mechanical metamaterials are synthetically designed structures with unusual mechanical properties. These mechanical properties are dependent on the properties of the matrix structure. They have the following special characteristics, i.e., improved shear modulus, increased energy absorption, and intensive fracture toughness. Non-auxetic materials compress transversely when they are stretched. The system naturally is inclined to keep its density constant. The transversal compression increases the density to balance the loss in the longitudinal direction. This study proposes to improve the crushing performance of hybrid auxetic materials. The re-entrant honeycomb structure has been combined with a star honeycomb, an S-shaped unit cell, a double arrowhead, and a structurally hexagonal re-entrant honeycomb by 9 X 9 cells, i.e., the number of cells is 9 in the lateral direction and 9 in the vertical direction. The Finite Element (FE) and experimental methods have been used to determine the compression behavior of the developed hybrid auxetic structures. The FE models have been developed by using Abaqus software. The specimens made of polymer plastic materials have been 3D printed and subjected to compression loading. The results are compared in terms of specific energy absorption and strength. This paper describes the quasi-static crushing behavior of two types of hybrid lattice structures (auxetic + auxetic and auxetic + non-auxetic). The results show that the developed hybrid structures can be useful to control collapse mechanisms and present larger energy absorption compared to conventional re-entrant auxetic structures.

Keywords : auxetic materials, compressive behavior, metamaterials, negative Poisson's ratio
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