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Bioinspired Arched Structure for Enhanced Energy Absorption in Hierarchical Re-Entrant Honeycombs

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ABSTRACT

Although the arched structures inspired by biomaterials have been extensively applied in construction for load bearing, they remain a relatively new component for absorbing energy in impact scenarios. The hierarchical re-entrant honeycomb (RH) with horizontal and vertical arched units (namely, horizontally and vertically arched hierarchical RH (AHRH) – HAHRH and VAHRH) are constructed, and their metallic specimens are fabricated for compression testing. Compared to well-known circular units, the horizontal and vertical arched units exhibit an increase in plateau stress (PS) by 16.8% and 23.8%, and an enhancement in specific energy absorption (SEA) by 10.8% and 25.0%, respectively. Moreover, they result in declines of 7.7% and 38.7% in the average Poisson's ratio, respectively. The premature collapse of the circular and vertical arched units compromises the inherent auxetic deformation of RH, resulting in some undeformed units. The better energy absorption of HAHRH is attributed to the horizontal arched units, which not only leverage the superior energy absorption of arched structure but also achieve more significant auxetic deformation simultaneously. The PS of hierarchical RH is theoretically induced with a relative error of less than 6.0%. Additionally, the SEA of circular hierarchical RH outperforms others under low-velocity impact, whereas VAHRH and HAHRH are better under medium and high velocities. Whether the hierarchical units can benefit the energy absorption of hierarchical RH depends on both densification strain and auxetic deformation. The primary results obtained from this study provide insightful suggestions for applying arched structures in hierarchical honeycombs.

KEYWORDS

Bio-inspired design; re-entrant honeycombs; hierarchical design; arched structures; energy absorption

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