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In-plane crashworthiness of bio-inspired hierarchical honeycombs

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Abstract: Biological tissues like bone, wood, and sponge possess hierarchical cellular topologies, which are lightweight and feature an excellent energy absorption capability. Here we present a system of bio-inspired hierarchical honeycomb structures based on hexagonal, Kagome, and triangular tessellations. The hierarchical designs and a reference regular honeycomb configuration are subjected to simulated in-plane impact using the nonlinear finite element code LS-DYNA. The numerical simulation results show that the triangular hierarchical honeycomb provides the best performance compared to the other two hierarchical honeycombs, and features more than twice the energy absorbed by the regular honeycomb under similar loading conditions. We also propose a parametric study correlating the microstructure parameters (hierarchical length ratio r and the number of sub cells N) to the energy absorption capacity of these hierarchical honeycombs. The triangular hierarchical honeycomb with $N = 2$ and $r = 1/8$ shows the highest energy absorption capacity among all the investigated cases, and this configuration could be employed as a benchmark for the design of future safety protective systems.

Keywords: hierarchical structure, honeycomb, impact, energy absorption, crashworthiness

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