In-plane crashworthiness of bio-inspired hierarchical honeycombs

Hanfeng Yin, Xiaofei Huang, Fabrizio Scarpa, Guilin Wen, Yanyu Chen, Chao Zhang

PII: S0263-8223(18)30884-5
DOI: https://doi.org/10.1016/j.compstruct.2018.03.050
Reference: COST 9497

To appear in: *Composite Structures*

Received Date: 4 March 2018
Accepted Date: 12 March 2018

In-plane crashworthiness of bio-inspired hierarchical honeycombs

Hanfeng Yin [a], Xiaofei Huang [a], Fabrizio Scarpa [b], Guilin Wen [a], Yanyu Chen [c*], and Chao Zhang [d]

[a] State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, Hunan University, Changsha, Hunan 410082, PR China

[b] Bristol Composites Institute (ACCIS), University of Bristol, Bristol, BS8 1TR, UK

[c] Transportation and Hydrogen Systems Center, National Renewable Energy Laboratory, 15013 Denver West Parkway, Golden CO 80401, USA

[d] School of Aeronautics, Northwestern Polytechnical University, Xi'an, Shanxi 710072, PR China

* Corresponding author: Y. Chen, E-mail: yanyu.chen@nrel.gov, Tel: +1-303-275-4445

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