HOLLOW LATTICE TRUSS REINFORCED HONEYCOMBS (HONEYTUBES): EXPERIMENT AND SIMULATION

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ABSTRACT

A novel designed cellular structures, termed as honeytubes, combining the microstructures of hollow lattices and honeycombs was developed forming hollow lattice truss reinforced honeycombs (LTRHs)[1] which had shown great crush protection abilities. Different geometrical configurations were further designed to investigate their properties. Selected laser sintering 3D-printing technology were adapted to manufacture designed structures. Glass-filled polyamide powder was used as raw material to cooperate with 3D printing machine. The obtained square LTRHs were subjected to out-of-plane compression tests. Subsequently, a finite element model was developed and validated by comparing with experimental results. A parametric study was performed to investigate the influence of geometry parameters on structure performance. The calculated results fitted well with experimental results. Results showed that the specific properties and energy absorption of honeytubes varied evidently with normalized geometries comparing with honeycombs. The novel honeytubes in the present study will provide more selection for lightweight crush protection materials used in aerospace and automotive industries.

1 INTRODUCTION

The aerospace and automotive industries are continuously looking for lightweight materials with advanced performance. During the past decade, lattice structures have been studied extensively due to their high specific properties and excellent energy absorbing capacities[2]. Despite its great success in market, honeycombs tend to buckle easily at low density which somewhat restricts their structural application.

3D printing technologies have been widely used in industrial as well as research area recently. Producing flexible parts via 3D printing is attractive as it is capable to manufacture complex geometries with high resolution. In this paper, A novel designed cellular structures, termed as honeytubes, combining the microstructures of hollow lattices and honeycombs was developed forming hollow lattice truss reinforced honeycombs (LTRHs) which had shown great crush protection abilities. Compression and energy absorption abilities of LTRHs were investigated through experiments and simulation methods.

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2 EXPERIMENTS AND SIMULATION

Hollow lattice truss reinforced honeycombs (LTRHs) were designed with various geometrical configurations., as shown in Fig. 1: Fig.1a is lattice truss reinforced square honeycomb (square honeytube); Fig. 1b is lattice truss reinforced triangular honeycomb (triangular honeytube) and Fig. 1c is lattice truss reinforced Kagome honeycomb (kagome honeytube). Selected laser sintering 3D-printer was adapted to fabricate those structures. Glass-filled polyamide powder was used as row materials, which is characterized by an excellent stiffness in combination with good elongation at break.

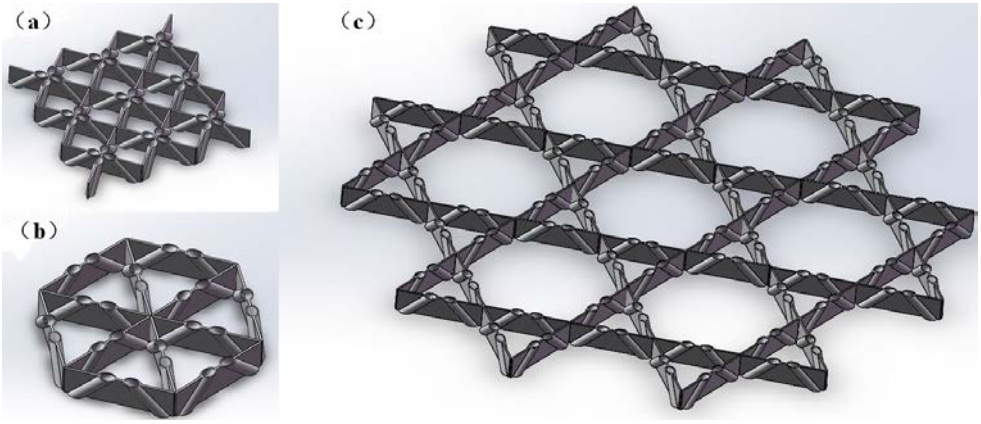

Figure 1: Three types of honeytubes: (a) square honeytubes; (b) triangular honeytubes ;(c) kagome honeytubes

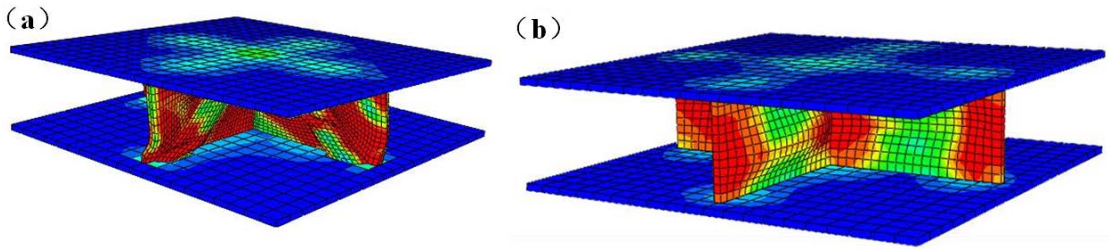

Figure 2: Finite element models: a) square LTRHs in compression; b) square honeycombs in compression

Compression experiments were applied to LTRHs to measure their mechanical properties. Representative stress-strain curves accompanying with failure modes were studied and compared with the corresponding honeycombs without lattice trusses. Finite element models were developed and validated by comparing with experimental results as shown in Fig. 2. Parametric study with different tube incline angles and normalized geometry values was then performed to investigate the influence of geometry parameters on structure performance.

3 CONCLUSIONS

Novel structures were designed and fabricated with 3D printing technology. Compression experiments and simulations methods were applied to evaluate their mechanical properties comprehensively. Results showed that the enhancing effects of specific properties and energy absorption of honeytubes comparing with honeycombs varied evidently with normalized geometries. The novel honeytubes in the present study will provide more selection for lightweight crush protection materials used in aerospace and automotive industries.

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