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PROCEEDINGS

The Staggered Design of Multi-Diaphragm in Thin-Walled Structures for Improving Compressive Performance

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ABSTRACT

Bio-inspired thin-walled structures have attracted widespread attention in the engineering field due to their excellent energy absorption capacity. In this work, it was observed that the stem of the bird-of-paradise plant consisted of longitudinal thin walls and transverse diaphragms. The diaphragms inside of the stems are parallel to each other within a column and exhibit staggered arrangements in the adjacent columns. Inspired by the stem of the bird-of-paradise plant, the staggered diaphragm design was introduced to improve the compressive properties of structures. Considering the staggered arrangement method and the Centro symmetry method, three types of staggered diaphragm for the 3×3 multi-cell structures arrangement were designed. All structures were manufactured by 3D printing technique of fused deposition modeling, and made from short carbon-fiber-reinforced polyamide (PACF). The effects of diaphragm arrangement on energy absorption (EA) and undulation of the load-carrying capacity (ULC) of structures were investigated under quasi-static axial compression testing (10 mm/min). The compressive experimental results indicated that the structures with non-staggered and staggered diaphragms showed the stable and regular progressive deformation mode. Compared to structures with non-staggered diaphragm design, the structures with completely staggered diaphragm design exhibited a specific energy absorption (SEA) increase of 28.7% to 12.9 J/g and a ULC decrease of 48.1% to 0.167. The results of the mechanism analysis revealed that with the constraint of diaphragms, the decrease in diaphragm spacing induced thin walls to generate more plastic hinges and absorb more energy. The staggered diaphragms could separate curve peaks of thin walls to decrease the load fluctuation of structures. In addition, based on the stable deformation mode and the constraint effect of diaphragm, the superposition method was introduced and applied. Specifically, the response force of structures could be regarded as the sum of the response force of thin walls in structures. It was proved that the superposition method was an effective analysis way to deeply understand the fluctuation characteristics of response force curves. Therefore, the finding of this research offers an effective design concept for developing an efficient and stable energy absorber.

KEYWORDS

Thin-walled structure; 3D printing; staggered diaphragm; compressive property

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