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Review

Bending behavior of composite sandwich structures with graded corrugated truss cores

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ABSTRACT

In this paper a design method based on bending strength and continuum damage evaluation is developed for composite sandwich structures with graded corrugated truss core. Three types of sandwich panels with different graded corrugated truss core (the width of the core and inclination angle described by linear and exponential functions) are designed and analyzed by the continuum damage evolution model. The influences of the geometric parameters on the load capacity and damage distribution of the graded sandwich structures with graded corrugated truss core are studied. The numerical results show that the analyzed structure with the graded core width designed in a lower convex function arrangement will get a higher buckling load under three-point bending load, and the inclination angle parameter may influence the bending strength of the graded sandwich structure slightly.

1. Introduction

Sandwich structures are widely used in aerospace, marine and automobile industries because of high bending stiffness and strength and low density. Cores as principle component of sandwich structures have been studied widely. Honeycomb, foam, truss core and corrugated core are most common in sandwich structures [1]. Many researchers presented that lattice core, including tetrahedral, pyramidal, and kagome, supports higher specific strength. Lattice structures have been regarded as potential replacement for foam cores [2]. Lu et al. [3] found that the octahedral stitched composite cores showed higher specific shear stiffness and out of plane compressive strength than conventional sandwich cores. Queheillat et al. [10] designed a multifunctional sandwich panel based on a truncated square honeycomb sandwich structure. Many researchers developed interest in lattice sandwich structures, whose strength and stiffness are quite particular. Gao et al. [11] presented an improved design of laminate layer to fabricate composite sandwich panel with lattice truss core. Zhang et al. [9] investigated the response of pyramidal truss core sandwich structures under the compression and impact loading, and these pyramidal truss core sandwich structures consisted of carbon fiber reinforced polymer facesheets and aluminum alloy cores. Libove and Hubka [4] investigated the elastic constant of corrugated core sandwich panels in 1954. Rejab et al. [6] reported that the shear strength of corrugated cores in the longitudinal direction is comparable with square honeycombs, and it is significant greater than those exhibited by diamond cores and traditional foam cores.

Although lattice composite sandwich structures offer advantages over other types of structures, it is important to develop new types of structures in order to obtain the absolute minimum weight for given conditions such as structural geometry [2]. Xu et al. [2,7] introduced a new idea to combine graded material and lattice core for forming the graded lattice core sandwich, which shows great difference in their load capacity-per-weight. Comparing with the conventional truss core composite sandwich beam, the graded corrugated truss core composite sandwich beam shows weak struts in the middle region [7]. Wang et al. [8] presented a theoretical investigation in free vibration of a functionally graded beam.

We design a series of sandwich structures with graded corrugated truss core, whose parameters are gradually varied in the length direction. Sandwich structure with graded corrugated truss core could achieve its optimal design via a numerical simulation based on continuum damage model. The structure of the paper is as follows. We describe the analyzed corrugated truss cores and the parameters that we assume as design variables in Section 2. A continuum damage model [12] is adopted for prediction of strength of sandwich structure with graded corrugated core. The damage model employed in the paper is expressed in Section 3. The details of the finite element model are explained in Section 4. Next, in Sections 5 and 6, we present a parametric study on the strength and stiffness of three types of different structures

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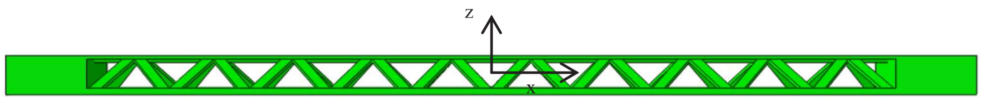
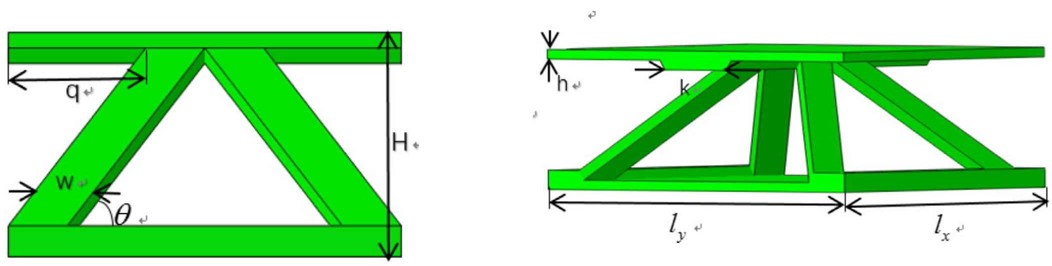
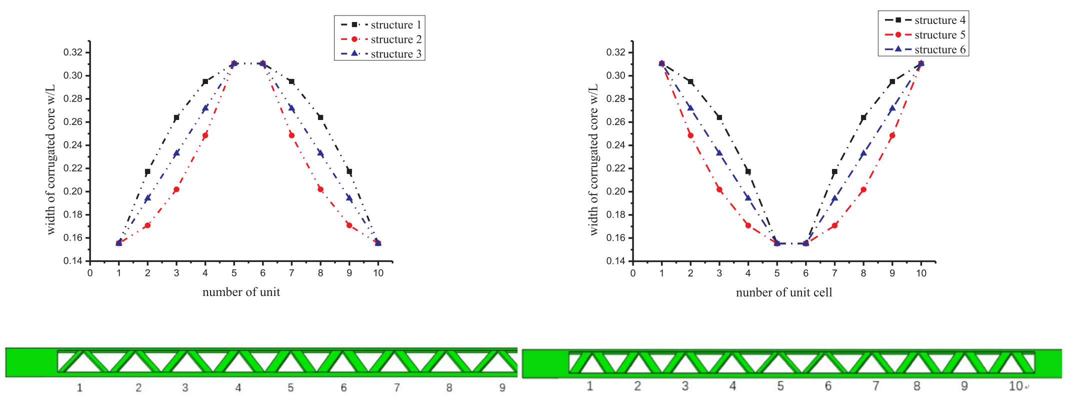


Fig. 1. Front view of a sandwich structure with graded corrugated core.

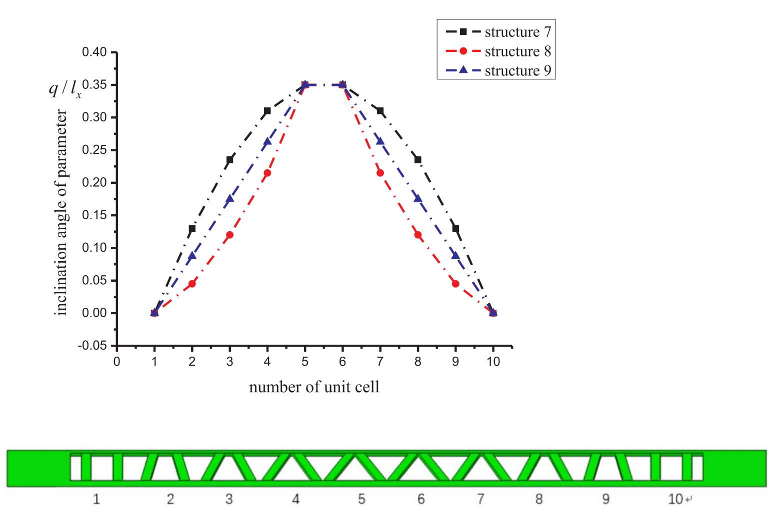


(a) **front view** (b) **Iso view**

Fig. 2. Unit cell of corrugated sandwich analyzed in this paper.



(a) **increasing gradient core wall thickness** (b) **decreasing gradient core wall thickness**



(c) **Inclination angle parameter q/l_x gradient variation**

Fig. 3. Geometric parameter gradient variation.

under 3-point bending load. At the end of the paper, we review the main results of the study (Section 7).

2. Design of typical graded corrugated truss core

The graded corrugated truss core sandwich structure is comprised of graded corrugated core between two facesheets (see Fig. 1). The graded corrugated truss core could be obtained by varying the width of core w and inclination angle θ from the center to ends of the plate for each unit cell. Fig. 2 shows a unit cell of the sandwich structure with graded corrugated truss core and its geometric parameters. We assume $l_x = 20$ mm, $l_y = 25$ mm, $H = 12$ mm, $h = 1.113$ mm, $k = 3$ mm and