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Experimental and numerical study of flatwise compression behavior of carbon fiber composite sandwich panels with new lattice cores

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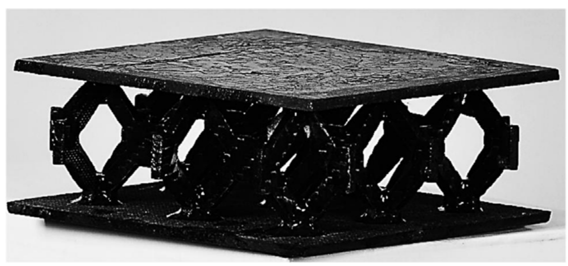
HIGHLIGHTS

- Improvement of mechanical strength peak of fiber/epoxy sandwich panels with new lattice cores.
- Study of force curves against extension obtained from sandwich panel compression tests.
- More compressive strength with the large seat design endured.

GRAPHICAL ABSTRACT



lattice core sandwich panel

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ABSTRACT

In this experiment, improvement of mechanical strength peak of fiber/epoxy sandwich panels with lattice cores in combination with their lightweight was investigated. In this regards, the method of VARTM (Vacuum Assisted Resin Transfer Molding) was used in order to achieve a laminate without any fault. Then, a unique design was presented to sandwich panel cores. The study of force curves against extension obtained from sandwich panel compression tests, showed that an optimum mechanical strength with a considerable lightweight. The accuracy of experimental data was evaluated by modeling of samples in ABAQUS software at the end of this study. The comparison between the results of experimental and finite element indicated that there was a good agreement between those which implies that the FE simulation can be used instead of time-consuming experimental procedures to study the effect of different parameters on the mechanical properties of lattice sandwich composites in the elastic range.

1. Introduction

There is increasing use of sandwich structures in industrial applications [1–5]. The main advantage of the panels sandwiching is that they cover almost any desired mechanical properties [6–8]. Other interests of panels sandwich is that sandwiching provide panels for a wider range of applications compare with other isotropic materials, such as advanced industries of maritime, aerospace, transportation, sports equipment and construction [9–12]. Sandwich panel structures actually represent an excellent balance between rigidity and lightness. Polymeric materials such as Nomex, Aluminum Honeycomb or other polymers and metal foams are usually used to build pyramidal cores [13–16]. These materials usually stick to lightweight and rigid surfaces [17].

Current simple methods have been mentioned as an alternative to solid cores to construction of metal sandwich panel using pyramidal truss cores [18,19]. When the sandwiches are under bended under bending load, the truss of these pyramidal core structures is exposed to non-axial tension or pressure while foams with the density as same as these cores are deformed, if bended [20]. Since truss components support axial load with higher efficiency, modules and

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strength of the lattice structures are significantly higher than their foam equivalents [21,22]. Sandwich structures with honeycomb cores are also able to effectively carry the bended loads. While simultaneously lattices start to elastically buckle by reduction of core's density. Core structures of lattice trusses have also other practical advantages. If the relative density is low, they can be easily linked in the form of multiple curved panels and then to the plates. These created panels are more flexible than Honeycomb structures and have a less waste (of strength and power) and are commonly used for application operations [23]. The interior interlocking space of networked trusses can easily be used for multifold operations such as heat exchange cross flow [24]. Lattice truss structures are also significantly used for shock reduction [25], protecting against Ballistic impact [26], and sound attenuation [27] and the structure deformation [28]. Structures are under maximum load in many of these applications. This matter involves both of the strength and rigidity of the structures and thus has brought them into consideration. Stiffness and strength of pyramidal structures depend on the topology, relative density and the mechanical properties used in the structure [20,29–31]. Lattice structures built of titanium [32,33] show high compressive strength and have great potential for aerospace operations at high temperatures. However, square honeycomb sandwich structures built recently of carbon fiber and reinforced with high special power are recommended in low temperature applications [34]. Such sandwich structures with pyramidal lattice cores are recently being built with laminates with 0° and 90° intersection using the Snap Fit method [35]. High special compressive strength in these structures is due to truss resistance to Elastic Buckling and delimitation. Sandwich panel structures are usually used for cases which are exposed to significant bended load [36].

Fig. 1. VARTM method setup.

Therefore, the aim of this research was to achieve a high compressive strength by changing in the design of lattice cores, and compare their performance with other lightweight cores. In addition, another objective of the current study was to investigate the agreement between experimental data and finite element method for determination of the peak point of the compressive strength.

2. Materials and manufacture

The laminate sheets were manufactured with VARTM (Vacuum Assisted Resin Transfer Molding) method (Fig. 1) which is the best method for wiping out porosity in laminate.

The lattice sandwich panels were manufactured from 0/90° laminate sheets of thickness t = 2.8 mm in a three step process. Briefly, patterns as shown in Fig. 2(a–c) were water-jet cut from the laminate sheets. Then, these patterns were snap-fitted into each other (Fig. 3(a)) to produce a lattice. Finally, the lattice was bonded to 2.8 mm thick composite face sheets using an epoxy adhesive (Fig. 3(b and c)). The cure cycle consisted of 12 h at room temperature, followed by heating to 40 °C for 3 h. The critical

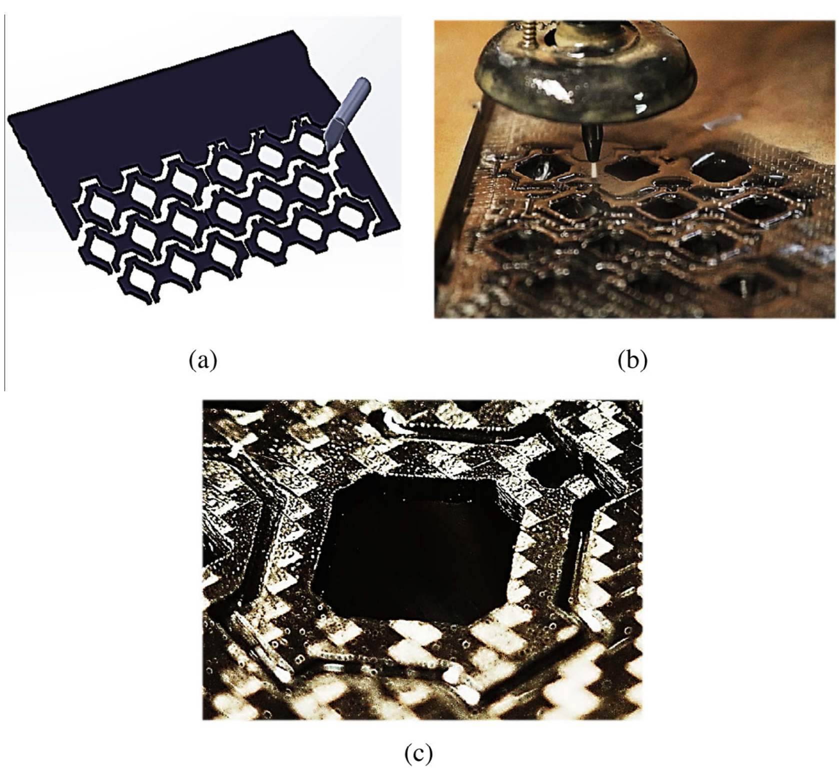

Fig. 2. Patterns water jet cut from the laminate sheets (a–c).