SSRG International Journal of Civil Engineering
ISSN: 2348-8352 / https://doi.org/10.14445/23488352/IJCE-V9I8P103

Volume 9 Issue 8, 16-21, August 2022
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Original Article

Comparative Study on Composite Square Honeycomb Structure of Aircraft Floor Panel

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Received: 22 June 2022 Revised: 27 July 2022 Accepted: 08 August 2022 Published: 20 August 2022

Abstract - *Honeycomb sandwich panels can reduce weight, and particular strength needs are crucial to the modern aerospace industry. The principal benefits of honeycomb panels include rigidity, stress absorption, fatigue resistance, resistance to weather, chemicals, fire and isolation. Today, choosing a sandwich design with a cheap and recyclable core material is common due to mechanical and acoustic requirements of high strength and a weight target. Aeroplane wings, ships, cars, and civil constructions, among other things, all utilize honeycomb sandwich structures. These designs are the greatest approach to getting high strength and little material utilization. For the optimal structural outcome, the designs of hexagonal and square honeycomb constructions will be analyzed and compared in this study. Using CATIA software, a honeycomb panel was created. LS-DYNA software is used to perform structural analysis on the intended model for four distinct materials, i.e. steel, copper, titanium, and aluminum. Finally, simulation findings are provided and debated.*

Keywords - *Stress, Deflection, Failure load, Finite element, Three-point bending*.

1. Introduction

In the application where high rigidity and lightness are crucial, core-based sandwich panels such as honeycomb structures have been created and employed. Honeycomb structures are fabricated or natural structures. The honeycomb geometry reduces both weight and material cost. Because of its better shear or bending stiffness per unit weight, stronger heat resistance, and increased corrosion resistance, the honeycomb structure has become more common in various fields, including packaging, aeronautics, aerospace, mechanical engineering, railway marine, cars, and civil infrastructure. The honeycomb geometry can vary, but all such structures share hollow cells produced between the vertical wall (thin). The cells could have a columnar or hexagonal form. A material with a honeycomb structural shape has a low density and has out-plane compression and shear characteristics that are both reasonably high.

One of the most significant forms of energy absorbers is the sandwich panel, which has a thin and complicated construction with two constrained plates on either side, a thin, thick core made of various materials, and various shapes in the middle. The panel size, the material used as the face, and the number or density of the honeycomb cells inside it all affect how strong laminated or sandwich panels are Steel, copper, aluminum, titanium, fibreglass, and sophisticated composite materials make honeycomb. The materials utilized for the honeycomb cores should have benefits such as low dielectric constants, good mechanical qualities, fluid control, good acoustic properties, and great crushing properties.

It is based on the idea that the faceplates bear the bending loads and the core bears the shear stresses in sandwich panels. The honeycomb sandwich construction expects high rigidity and a high strength-to-weight ratio.

2. Methodology and Materials

1. 3D Modelling of the honeycomb structure.
2. Generating finite element model.
3. To carry out Finite element analysis.
4. Extracting the results.
5. Comparing the FEA results.

Fig. 2.1 and Fig. 2.2 depict the square honeycomb structure's FE model, respectively. The top and bottom plate size is 133mmx96 mm, with the core height being 5mm.

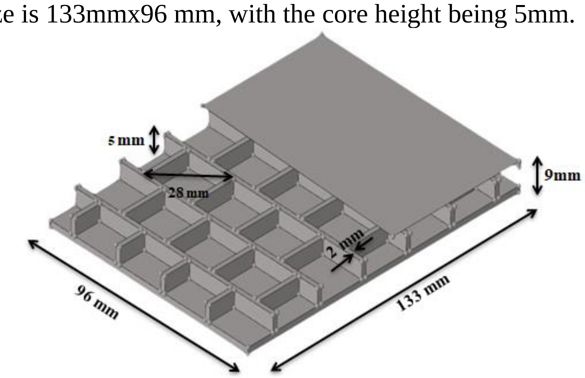

Fig. 1 Square honeycomb structure

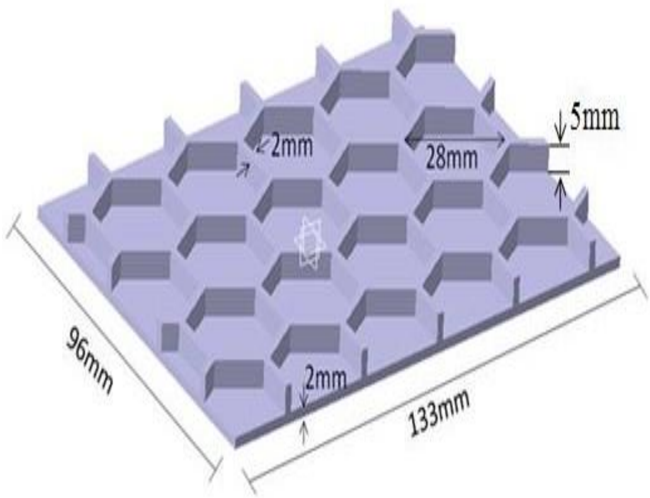

Fig. 2 Hexagonal honeycomb structure

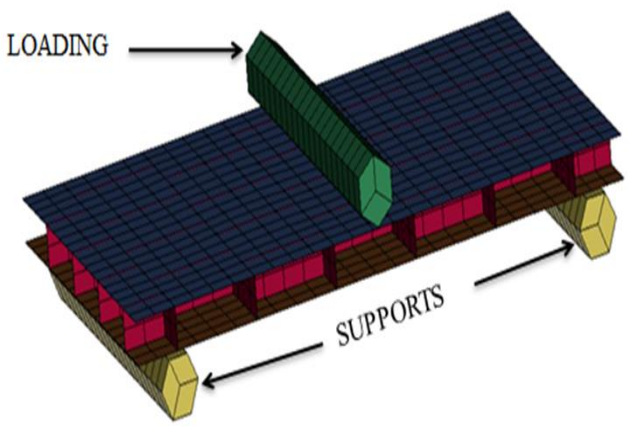

Fig. 3 FE model of the honeycomb structure with supports and boundary conditions

For comparative analysis, we have modelled four major models of the honeycomb structure. The materials for the faceplates are kept the same for all four models, and the only core material is varied; each model is modelled with different thicknesses, i.e. 2mm, 1.5mm and 1mm.

Table 2.1 shows the different models with details of the material used. Table 2.2 shows the material properties of the different models used in the honeycomb structure.

Table 2.1 Model specifications for honeycomb structure's faceplates and core wall material.

	Model 1	**Model 2**	**Model 3**	**Model 4**
Top faceplate material	Steel	Steel	Steel	Steel
Core material	Copper	Steel	Aluminum	Titanium
Base faceplate material	Steel	Steel	Steel	Steel

Table 2.2 Material properties

Material / Properties	**Steel**	**Copper**	**Aluminum**	**Titanium**
Young's Modulus (GPa)	210	128	68.3	113
Poisson'sRatio	0.29	0.36	0.34	0.35
Yield Strength (GPa)	0.215	0.100	0.276	0.880
Shear Modulus (GPa)	74	45	26	44
Density (Kg/mm^3)	$7.85X 10^{-6}$	$8.96X 10^{-6}$	$2.68X10^{-6}$	$4.505X10^{-6}$

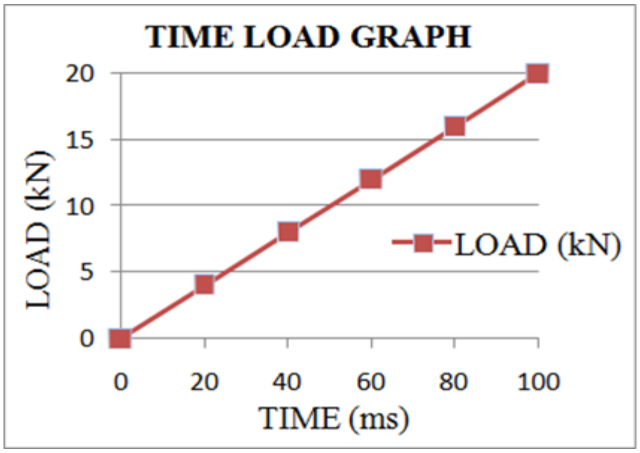

Fig. 4 Time vs Load graph for model 1.0, 1.1, 1.2, 2.0, 2.1, 2.2, 3.0, 3.1 and 3.2

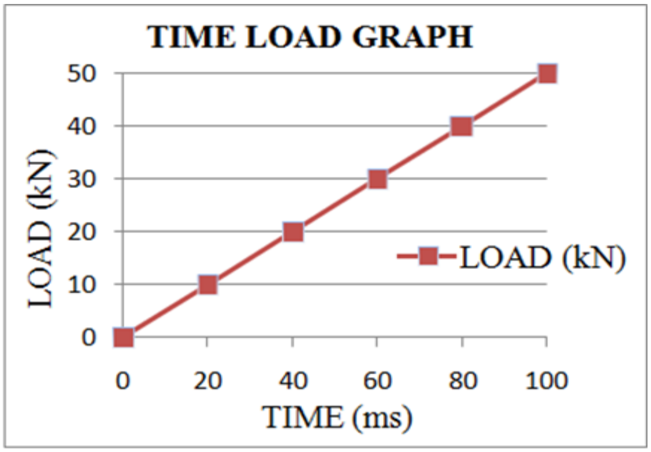

Fig. 5 Time vs load graph for models 4.0, 4.1,

3. Analysis

The top and bottom faceplates of Model 1 are composed of steel, and its copper honeycomb core has a 5mm core height. The model 1 has been divided into three variations due to changes in the faceplates thickness and the walls of the honeycomb core cells. Table 4.1 shows the comparison between square and hexagonal honeycomb structure of which the thickness ranges between 2mm, 1.5mm, and 1mm. The naming has been done in accordance with the change in thickness. The results of three models' finite element analyses are shown in Table 4.1 below.

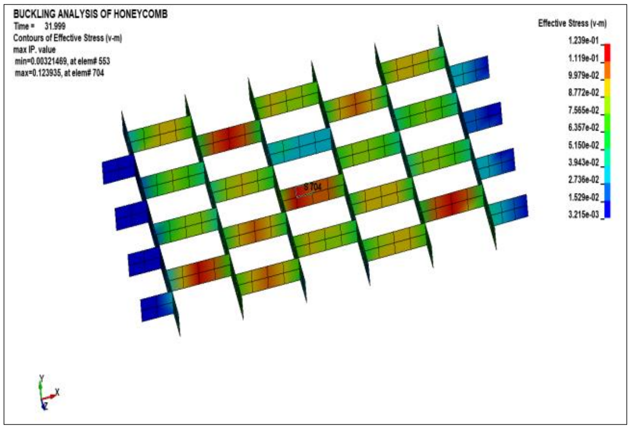

Fig. 6 Stress in the core at failure load in the square honeycomb of model 1.0

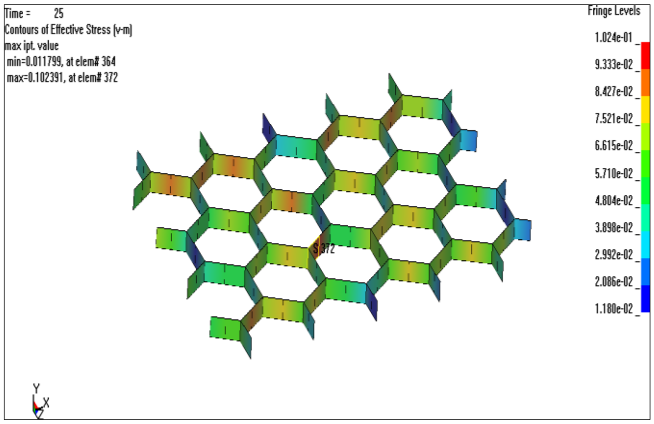

Fig. 7 Stress in the core at failure in the hexagonal honeycomb of model 1.0

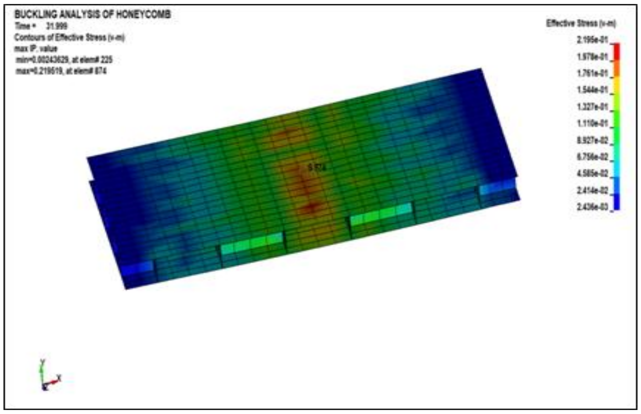

Fig. 8 Stress in plate at failure load in square honeycomb of model 1.0

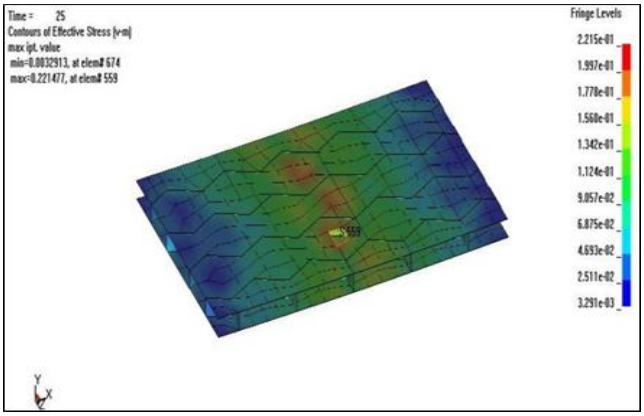

Fig. 9 Stress in core at failure load in hexagonal honeycomb of model 1.0

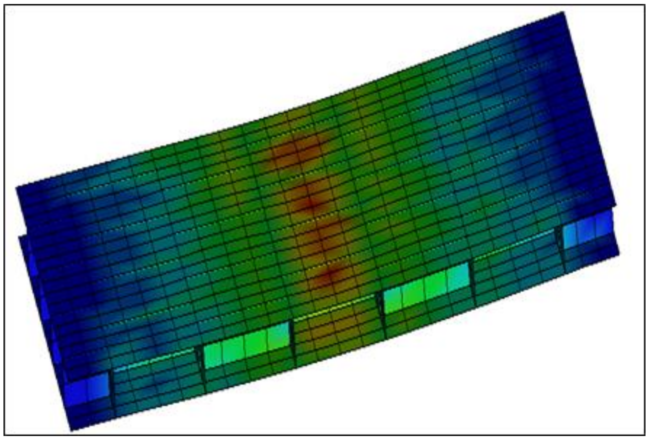

Fig. 10 Deflected shape at maximum load in the square honeycomb of model 1.0

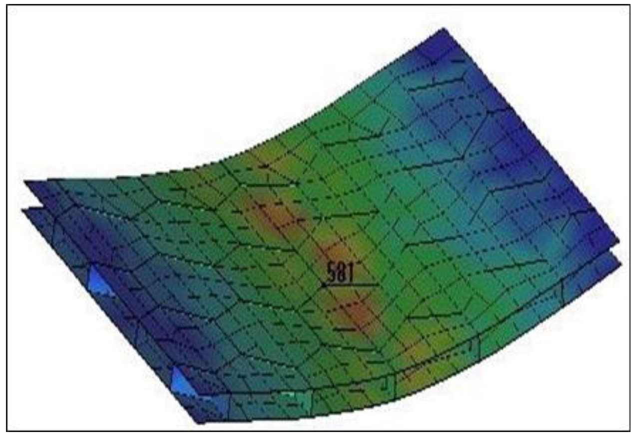

Fig. 11 Deflected shape at maximum load in hexagonal honeycomb of model 1.0

4. Results

Fig. 4.1 to Fig. 4.4 shows the maximum deflection, critical load, failure load, and variation in stress graphs of models 1.0, 1.1, and 1.2.

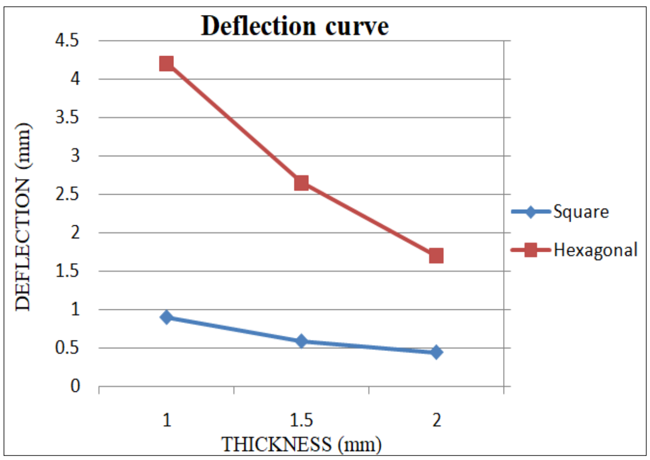

Fig. 12 Thickness vs Deflection graph for models 1.0, 1.1, 1.2

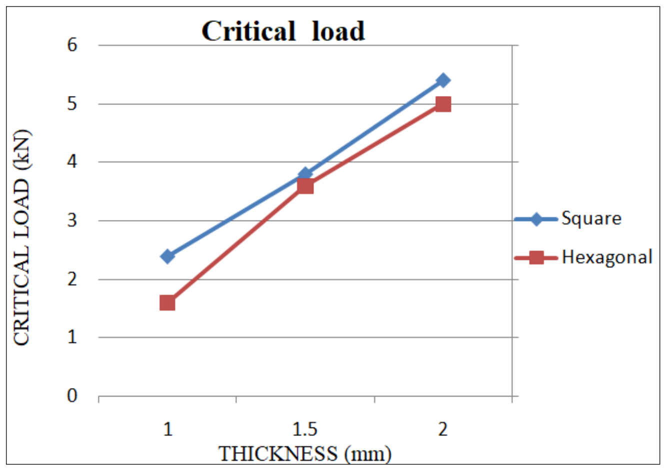

Fig. 13 Thickness vs Critical load graph for models 1.0, 1.1, 1.2

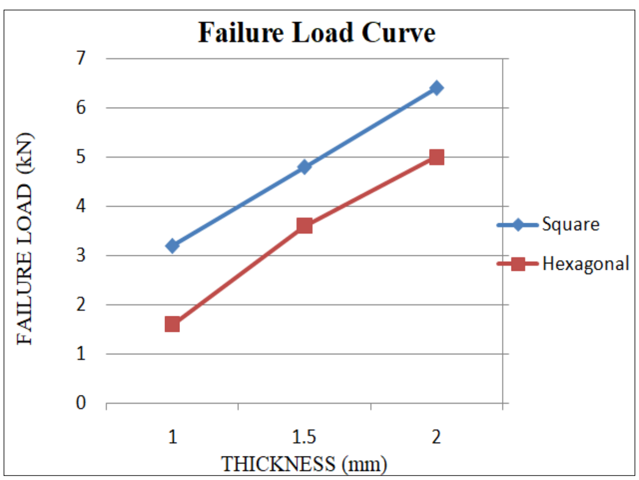

Fig. 14 Thickness vs Deflection graph for models 1.0, 1.1, 1.2

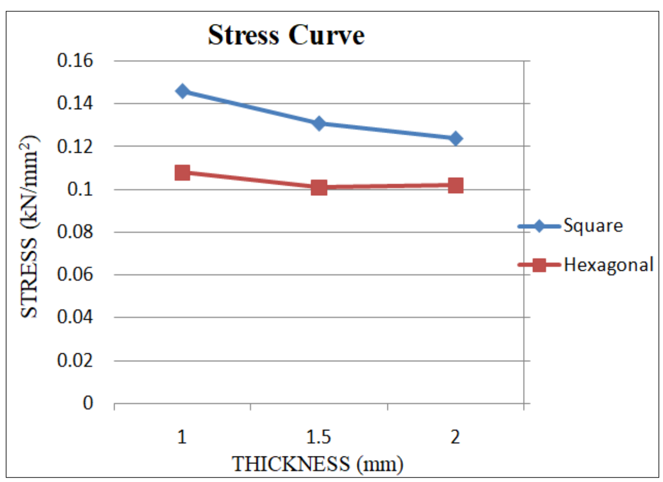

Fig. 15 Thickness vs Stress graph for models 1.0, .1, 1.2

Table 4.1 Results of model 1, 2, 3 and 4

Model No.	Deflection at maximum load(mm)		Analytical Critical load in the core (kN)		Analytical failure load (kN)		Analytical stress in the core at failure load (kN/mm^2)	
	Square	Hexagonal	Square	Hexagonal	Square	Hexagonal	Square	Hexagonal
1	0.449	1.7	5.4	5	6.4	5	0.124	0.102
1.1	0.592	2.648	3.8	3.6	4.8	3.6	0.131	0.101
1.2	0.903	4.2	2.4	1.6	3.2	1.6	0.146	0.108
2	0.466	1.6	9.4	9.2	6.8	5.3	0.162	0.124
2.1	0.606	2.5	7.4	6.8	5	4	0.146	0.128
2.2	0.897	4.03	4.6	4.2	3.4	2.4	0.163	0.145
3	0.524	1.88	16.4	16.4	5.8	4.8	0.099	0.0829
3.1	0.704	2.88	11	11.6	4.6	3.8	0.117	0.0897
3.2	1.1	4.725	6.6	6.8	3	2	0.129	0.109
4	1.12	4.343	31.5	46	6.5	5	0.121	0.102
4.1	1.62	6.33	33	32	5	4.5	0.135	0.109
4.2	2.63	12	20	19	3.5	1.5	0.16	0.139

5. Conclusion

The present study compared Square and Hexagonal honeycomb sandwich structures with steel face plates at the top and bottom of the honeycomb core with heights of 2mm and 5mm honeycomb core. Three-point bending for different honeycomb core materials such as copper, steel, aluminium and titanium, and different thicknesses of faceplates and walls of honeycomb core as 2mm, 1.5mm and 1mm were studied. Different parameters such as deflection, critical load and stress were studied. From theoretical and finite element analysis results and comparison of both the results, it was concluded that,

1. The square honeycomb structure deflection is less than the Hexagonal honeycomb structure.
2. Critical load in the core of the square honeycomb structure is more than hexagonal honeycomb structure.
3. The Load carrying capacity of the square honeycomb structure is more than the hexagonal honeycomb structure.
4. The stress in the core at failure load is higher in the square honeycomb structure than in the hexagonal honeycomb structure.

Future scope of the work

The finite element analysis for square honeycomb sandwich structure for various core and face plate materials, with varying plate and core thickness, has been compared with the results of a hexagonal honeycomb structure. The results obtained were preferably satisfying. This study can be carried out experimentally by varying the core height and material for future studies. This study can be continued for Rhombus shape honeycomb sandwich panels.

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