Analytical Study of Composite Sandwich Panels

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Abstract- *Composite sandwich panels are used in various applications such as in automobiles, space stations, boats and airplanes etc. due to its low mass and high strength to weight ratio. Aim of this paper is to represent the toughness characteristics of composite sandwich panel with core material as aluminum honeycomb and outer skin/facings as carbon fiber sheets conceptually and experimentally. Composite sandwich panel will undergo through 3 point bending test to determine its toughness characteristics. Also, we conceptually calculated stiffness and deflection of composite sandwich panel.*

Keywords- Composite Sandwich Panel, Aluminum Honeycomb Core, Carbon Fiber, Three point bending test.

I. INTRODUCTION

Since the past few years, the use of composite structures and materials has risen in various fields like airplane, on road vehicles and ships etc. because it offers various advantages in terms of low weight, toughness and more stiffness. High strength to weight ratio is provided by sandwich. There are 3 essential layers in sandwich panel out of which two are thin face sheets and one is thick lightweight core material which is placed between them. These three layers are connected together by epoxy resin.

The core materials are usually of low strength, but have greater thickness which provides the sandwich panel with more bending stiffness. Cellular foams, trusses and honeycomb are usually used in core making. Honeycomb core is cheapest and has less density and provides more value for money.

Facing or skin is the outer thin layer which covers the sandwich panel. Face sheets are held together with core material with the help of epoxy resins. The requirements of outer skin are that it should be light in weight, tough and resistant to environmental conditions. Correct material should be used to avoid failure of the composite and to ensure long term use. It should sustain all the sheets of composite sandwich structure firmly together. Favorable properties of adhesive are that it should be corrosion and thermal resistant.

Composite sandwich panel is made with aluminum honeycomb core and carbon fiber. These panels are used in aircrafts to lower the weight, increase the speed and to help during takeoff. To understand its strength characteristics, we performed 3 point bending test.

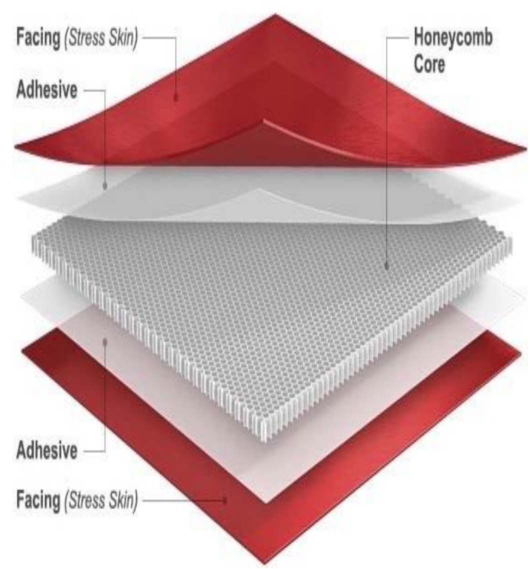


Fig. 1 Descriptive view of a Composite Sandwich Structure

II. OBJECTIVE

The main objectives of this project are

- To study properties of face sheets and core material.
- Calculate bending stiffness, shear stiffness and deflection of the sandwich structure for different applicable forces.
- To produce a sandwich structure with core material and outer sheets.
- To analyze experimental values with theoretical values.

III. PROBLEM DEFINITION

Composite structures should be as light in weight, must have high stiffness, enough strength and should tolerate damage. Efficiency of the composite can be increased by using optimized geometry and efficient core materials.

They are superior to conventionally used materials in and also possess properties other than their own properties.

Maintenance cost of the composite panel is less due to less carrion and other properties .

IV. MATERIAL SELECTION

In composite sandwich panel can be made by infinite different combinations of core and face material. Properties such as increased strength, more stiffness, more durability, low weight and specific design etc. are favorable. Material selection is done on the basis of the following:

Strength: Improvement in overall strength is the main reason for manufacturing of composite sandwich panels.

Stiffness: Since the core material has low shear modulus it is easy to sustain fatigue which makes it an important property of composite sandwich panel.

Weight: Low weight of composite sandwich panel makes it more favorable to their wide use in day to day life.

By considering the above mentioned criteria, following materials were selected:

Core – Aluminum Honeycomb

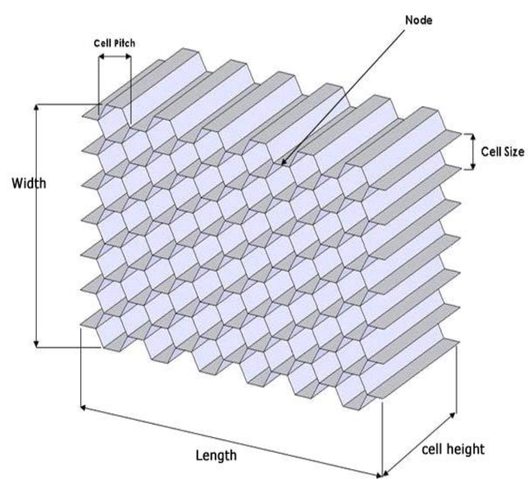


Fig. 2 Honeycomb Structure

Properties such as high strength, corrosion resistance, fire resistance make aluminum the best material for the use of core. It is also recyclable.

Facing – Carbon Fiber

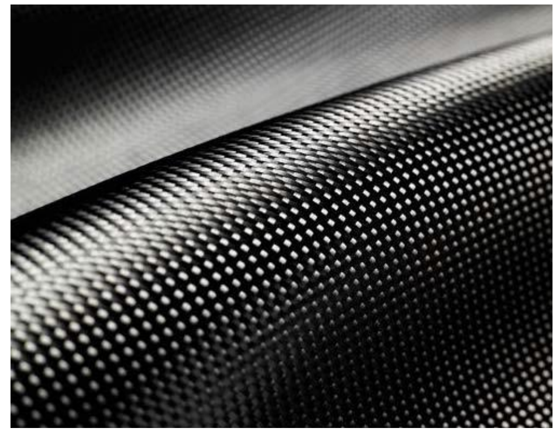


Fig. 3 Carbon Fiber Sheet

Carbon fiber is the perfect material for making the sheets of composite panels. Epoxy resin is applied for the bonding purposes. Due to this, high tensile strength is obtained which is useful in high speed requirements since it has high resistance to strain.

V. THEORETICAL ANALYSIS OF THE SANDWICH PANELS

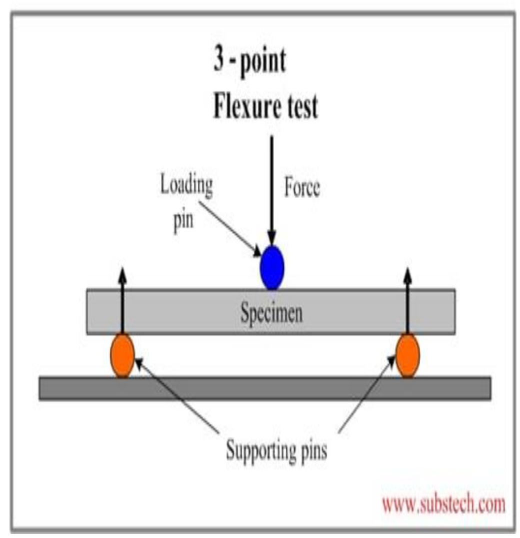


Fig. 4 3-Point Bending Test Setup

As shown in the figure 4, 2 supports are provided in each ends with point load at the center.

The panel bends due to application of point load the middle of the panel which creates compression in lower skin and tension in the upper skin. The bending moment is highest at the center and zero at the edges due to the point load in the middle. Variation of shear force which takes place is shown in figure 5.

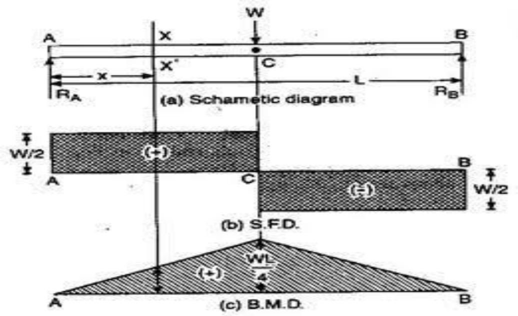


Fig. 5 SFD and BMD diagram for a Simply Supported Beam

The formula used to calculate deflection is

δ = (Wl3/48EfIf) + (Wl/4AcGca)

Where,

δ = Deflection in the panel

W = Force applied

l = Length between the two supports

Ef = Young's Modulus of facing

If = Area moment of inertia of the facing

Ac = Cross sectional area of the core

VI. THEORETICAL CALCULATIONS

Calculations are done using the formulae by applying various different loads and graphs for the results are plotted.

The main data of the panel that remains same throughout the calculations are:

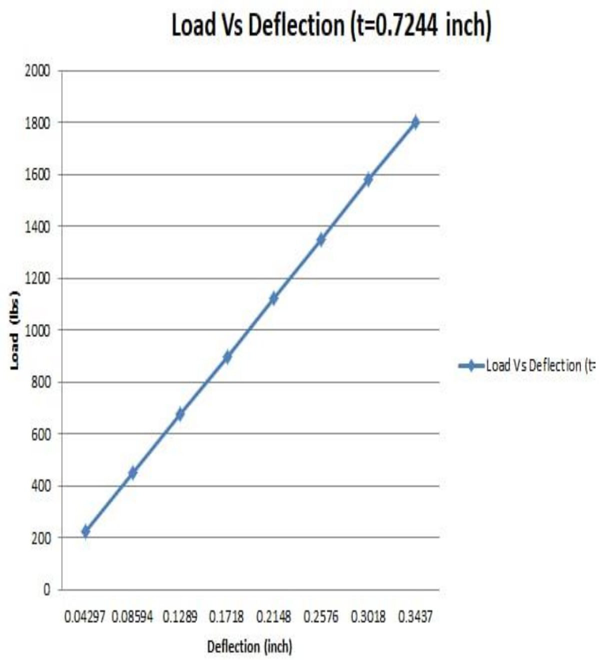
1. Length (l) =17.61inches
2. Young's modulus (Ef) = 34*106 psi
3. Breadth (b) = 10.8260 inches
4. Height of core (hc) = 0.70855 inches
5. Cross sectional area of core (Ac) = b*h = 7.55 inch2
6. Shear modulus of core along the length (Gcl) = 21000 psi
7. Shear modulus of core along the width (Gcw) = 11000 psi
8. Average shear modulus of core (Gca) = (Gcl + Gcw)/2 = 15000 psi

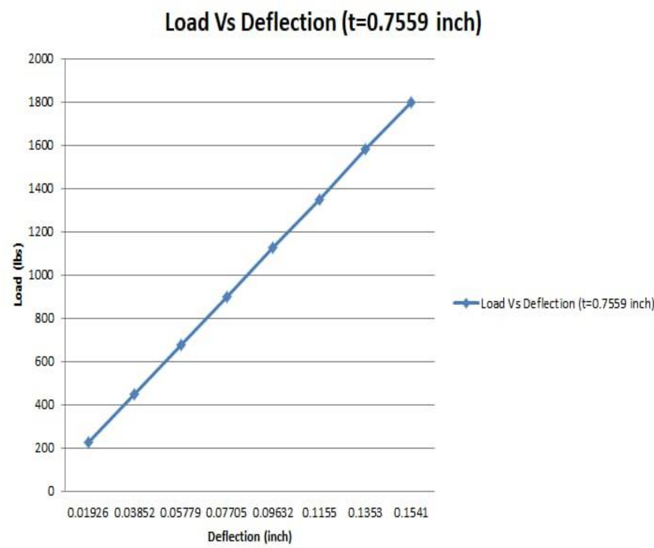
Variation of Mechanical Properties w.r.t. changing panel thickness and varying loads

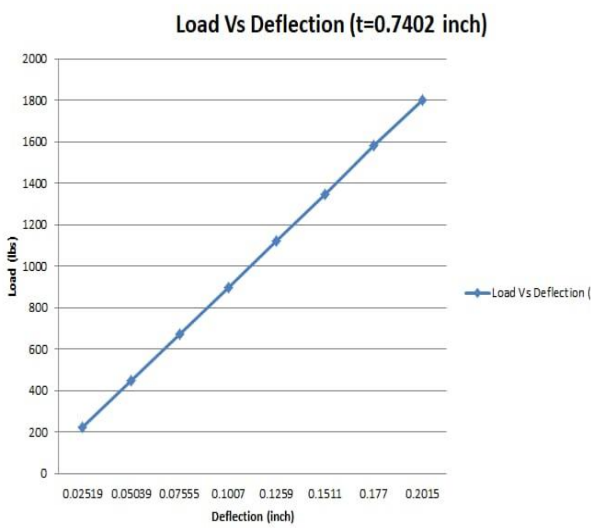
Sr. No.	**Thickness (inches)**	**Moment of Inertia (inch⁴)** $I = b(h^3-h_c^3)/12$	**Bending Stiffness** $K_b = E*I$ **(lbs-inch²)**	**Shear Stiffness** $K_s = (5G_{ca}*A)/6$ **(lbs-inch²)**	**Load (lbs)**	**Deflection** $\delta = (Wl^3/48E_fI_f) + (Wl/4A_cG_{ca})$ ***(inch)***
1.	0.7234	0.3423	11658500	103933	224.2	0.04295
					449.6	0.08594
					674.4	0.1289

					899.2	0.1718
					1124	0.2148
					1318	0.2576
					1579	0.3018
					1798.4	0.3437
2.	0.7402	0.3658	12433800	105380	224.4	0.02515
					449.6	0.05039
					674.4	0.07555
					899.2	0.1007
					1124	0.1259
					1318	0.1511
					1579	0.1770
					1798.4	0.2015
3.	0.7559	0.3896	13246400	108266.67	224.8	0.01926
					449.6	0.03852
					674.4	0.05779
					899.2	0.07705
					1124	0.09632

					1318	0.1155
					1579	0.1353
					1798.4	0.1541







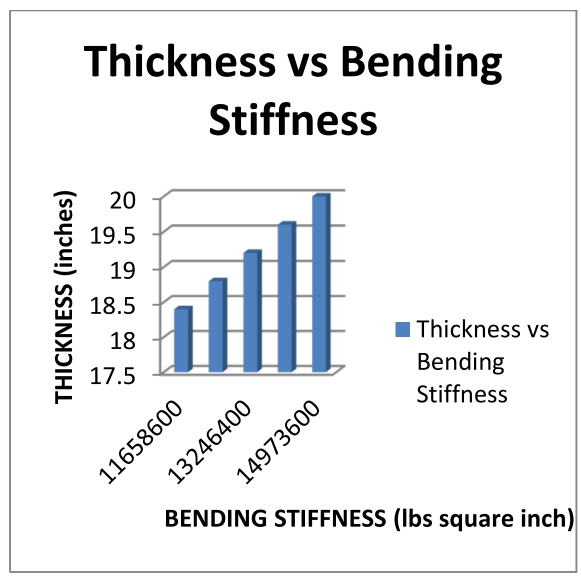


Fig. Variation of Bending Stiffness with Panel Thickness

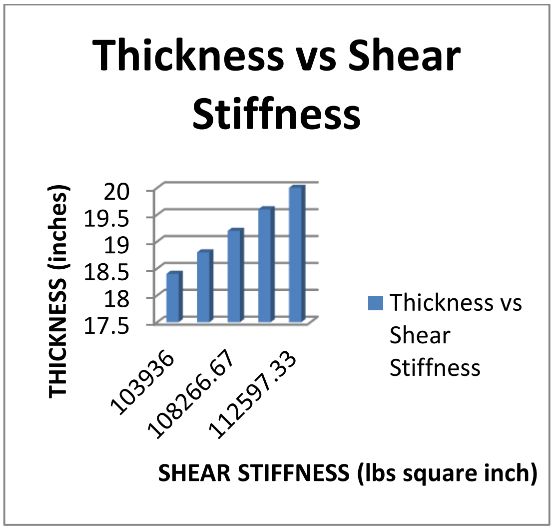


Fig. Variation of Shear Stiffness with Panel Thickness

VI. CONCLUSION

We conducted 3 point bending test and their results were seen clearly. We saw increase in strength and other properties by making a composite sandwich panel which was made by the core of aluminum honeycomb and the facings of carbon fiber. We observed that, increasing the thickness of the facing, the deflection that was occurring in the panel gets reduced which is the reason for its high strength and durability.

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