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BENDING BEHAVIOUR OF LAMINATED GLASS FIBER REINFORCED SANDWICH PANELS

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Abstract : Polymeric composites reinforced with natural fibers have raised more attention as the alternative building materials in this project, natural fiber composites prepared from jute and glass fiber sandwich panel. This project presented the bending behavior of the newly developed sandwich panel, Light weight sandwich laminated panels are increasingly being used as structural materials for a wide variety of applications in marine, aerospace, automobile, transportation and electronic packing sectors. The introduction of intermediate layer helped the sandwich panels to sustain a larger strain prior to reach their ultimate loads, resulting in a higher deformation capability.

KEY POINTS: Glass fiber, Aluminum honeycomb, Epoxy resin.

I. INTRODUCTION

Sandwich construction is widely used because of its ability to provide high bending stiffness coupled with light weight.

The use of composite sandwich structures has significantly increased particularly in marine and aviation applications in recent years the sandwich structures are mostly subjected to bending loading when they are used in ship hulls.

Since sandwich structures are manufactured by different manufacturing methods such as resin transfer molding (RTM), compression molding and autoclave vacuum bag molding two important factors are frequently overlooked.

First the bounding between the face and core of sandwich structures is assumed to be perfect bonding.

The conventional form of sandwich structure consists of two face layers separated by a core material. The faces usually consists of thin and high performing material, such as composite laminates made from jute or glass fibers, while the core material is a low density with relatively low performing material which results in highly specific mechanical properties of the panel under loadings..

II. OVERVIEW OF COMPOSITES

The first uses of composites date back to the 1500s B.C. In early Egyptians and Mesopotamian settlers used a mix of mud and straw to make hard and long-lasting constructions. Straw continued to provide reinforcement to ancient composite products including ceramics and boats. Later, in 1200 AD, the Mongols invented the first composite bow using a combination of wood, bone, and animal glue. Bows were pressed and wrapped with birch bark. These bows were extremely powerful and extremely precise. Over a past few decades composites, plastics and ceramics have been the dominant engineering materials because of their high stiffness, strength and light weight. The areas of applications of composite materials have grown rapidly and have even found new markets. Modern day composite materials consists of many materials which we are use in our daily life and also being used in sophisticated applications. As composites have already proven their worth as weight saving materials, the current challenge is to make them durable in tough conditions to replace other materials and also to make them cost effective[3]. .

III. OBJECTIVES

The objectives of the project work are outlined below

Develop the sandwich structures with Aluminum hexagonal honeycomb core and GFRP as face sheet.

- Conduct Three point Bending test on developed sandwich structures without hole.
- Conduct Three point Bending test on developed sandwich structures with hole.
- Conduct moisture absorption test on developed sandwich structures.

IV. METHODOLOGY

To achieve the above mentioned objectives, following methodology is adopted and followed carefully so as to get the accurate and reliable results.

The specimens were fabricated with the relevant ASTM standard using hand layup technique. The description of specimen preparation is explained in the following lines. Relevant to the present work the fabrication process start with procurement of essential things. Two plywood boards of size 3square feet with good surface finish are used as moulds for specimen preparation. These boards were covered with the thin plastic sheets on which wax is applied to prevent adhesion. After that calculated amount of resin and hardener in the ratio of 10:1 were taken in the measuring jar using syringe and mixed properly by stirrer. The mixture (matrix) is applied on the board using roller. The E-glass fiber mat is marked (size 315 mm×315 mm) using steel rule and marker and cut by scissor. Then single ply of fiber is placed on resin coating and the same procedure is repeated for number layers. The face sheets prepared on the two plywood boards and then core is placed between them. Finally dead loads will be applied on the plywood and keep it for curing under room temperature

figure 1: fabrication of test specimens

After curing by releasing dead loads the sandwich board is taken out from the mould (plywood boards). The boards were fabricated for 8, 12, 16, 20 and 24 layers. The specimens were marked as per ASTM Standards and cut by using jigsaw machine including holding provisions.

Conduct Three point Bending tests, and moisture absorption test on developed sandwich structure in accordance with ASTM standards.

Experimentation is carried out on hexagonal honeycomb core with GFRP face sheet under different loading condition to study the mechanical behavior in the face sheet of the aluminium honeycomb sandwich structure

3.1 Universal Testing Machine

The Universal Testing Machine and control unit along with display unit are as shown in the Figures 5.1. All the tests have been carried out in universal testing machine.

Figure 5.1 Universal Testing Machine used in this project work

Function of the control unit is to operate the UTM by the input given from the UTM control unit. Using this control unit loading, unloading and cross head moment of the fixture will be maintained. With this control unit large accuracy will be maintained. Control unit is having 2 ports one is connected to the control unit where the input is given and another port is connected to the UTM where the accurate output work is performed. For three point bending grippers are used.

3.2 Three Point Bending

The **ASTM** code **C393** is for three point bending test to determine the deflection and flexural stiffness of sandwich beam. The test specimen having width 80mm and a length of 200mm where the spam length is 150mm and the load is acted exactly at the center. The bending test has been carried out in universal testing machine for the specimens [20].The specimen description of three point bending test is shown in Table 1.

Table 5.1: Description of Three point bending test for various test specimen

Core Material	3003 Aluminium	
Total Length	100mm	
Breadth	25.4mm	
Core Thickness	3mm	
Total Thickness	8 layers	5
	12 layers	6
	16 layers	7
	20 layers	8
	24 layers	9
Face sheet Material	Glass Fiber Reinforced Plastic (GFRP)	
Number of bidirectional Layers	8 layers	Top-8 Bottom-8
	12 layers	Top-12 Bottom-12
	16 layers	Top-16 Bottom-16
	20 layers	Top-20 Bottom-20
	24 layers	Top-24 Bottom-24

Refers to fixture supporting the GFRP sandwich coupon for three point bending. The bottom fixture is movable which is requiring fixing the span length with a scale provided at the bottom. And the cross head is adjusted 0.5mm/min as a loading rate at the mid position of the sandwich composite. Once the fixture is fixed and all the adjustment has done the load is applied. The corresponding load verses deflection data has been recorded in the computer.

IV. RESULTS AND DISCUSSION

4.1 Three Point Bending

The Experimental Results of Three Point Bending is tabulated in fig the load versus Deflection plot in Three Point Bending. Consider specimens 8-layer, 12-layer, 16-layer, 20-layer, 24-layer and loads are applied to the specimen and bending loads of beam are noted down.

Table 2: results for three point bending test without hole

No of layers	Load in KN		Average load in KN
	S_1	S_2	
8 Layers	159.79	176.57	168.18
12 Layers	206.62	207.34	206.98
16 Layers	264.88	252.82	258.85
20 Layers	357.53	366.16	361.84
24 Layers	592.9	592.94	592.94

Comparison of three point bending test results are as shown in figure and tabulated results in the table 2. For 8, 12 ,16 20 and 24 layers of without hole . Due to increase in the layers of the sandwich load capacity of the specimen is also increases

Table 3. comparison of bending load for different layers with hole

No of layers	Load		Average load
	S_1	S_2	
8 Layers	90.58	79.05	84.815
12 Layers	113.49	108.66	111.075
16 Layers	207.34	206.62	206.98
20 Layers	258.46	264.88	261.67
24 Layers	397.46	412.7	405.8

Comparison of three point bending test results are as shown in figure and tabulated results in the table. For 8, 12 ,16 20 and 24 layers of with hole . Due to increase in the layers of the sandwich load capacity of the specimen is also increases.

Table.4.Comparison of three point bending test with various layers specimens

No of layers	Load in (kn)	
	Without hole	With hole
8 Layers	168.18	84.815
12Layers	206.98	111.075
16 Layers	258.85	206.98
20 Layers	361.84	261.67
24 Layers	592.94	405.08

Comparison of three point bending test results are as shown in figure and tabulated results in the table. For without hole and with hole . Due to hole in the sandwich specimen the load capacity of specimen decrease when compare with the without hole specimen .

CONCLUSION

Based on the experimental analysis the following conclusions are drawn.

- The three point bending test for 8, 12, 16, 20 and 24 layered specimen was found to be peak load of 166.18N, 206.98N, 258.85N, 361.84N and 592.94N respectively, this results shows the high bending load with increases in the number of layers.
- when compare bending load results with the specimen of without hole and with hole. Due to hole in the sandwich specimen the load capacity of specimen decrease when compare with the without hole specimen

SCOPE FOR FUTURE RESEARCH

Some of the scopes for future research are listed as follows.

- Nonmetallic core like Nomex, Kraft paper and foam may be used as a sandwich to study the mechanical behavior
- Sandwich beams with different types of skins should be tested for different boundary condition using Finite Element Method.
- Vacuum bagging techniques can be used for the perfect bonding between core and the facesheet.
- Filling the hexagonal aluminum core with Syntactic foams can improve the mechanical properties of the core and fire resistant.

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