Experimental testing on mechanical properties of sandwich structured carbon fibers reinforced composites

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Abstract. The various types of structural sandwich composites panels available are based either in the method of preparation or on the basis of the core material used in between the skin material. The core material is used to increase the stiffness and strength of the entire panel and can be used according to the application or the area of use. For example the various core materials available for preparing a sandwich composite are Aluminum Honeycomb, Balsa wood, High Density Polyurethane Foam, Rohacell Foam or Nomex Core. In this work carbon fiber is a reinforcement phase with various core materials such as Aluminum Honeycomb, Rohacell and HDPU Foam and epoxy resin is used as a matrix to produce various sandwich-structured composites by Vacuum bag manufacturing process. Various tests Three point bending test, tensile and compressive tests carried out in order to validate the design. After the tests are conducted the obtained results and values are compared and graphs were plotted to compare the various Bending, Tensile and Compressive Load bearing capacity of the various sandwich panels prepared with varying core materials. Foam based sandwich panels tend to have better tensile and compressive load bearing capacity as compared to Aluminium Honeycomb due to their structure and Aluminium has better flexural properties because of its core line up which can undertake bending easily.

Key words: carbon, epoxy, aluminium honeycomb, rohacell, HDPU foam.
1. Introduction

Sandwich composite is a type of composite materials that is assembled by bonding of two thin facings on a lighter core where the core used to separate the thin facings. In this type of material the flexural rigidity is increased as the two skin surfaces separates. The objective of using sandwich structured composite materials is to reduce the weight and increase strength and also better excellent thermal insulation properties. Sandwich structure is used in area of aerospace and automotive industry due to its higher strength-to-weight ratio.

JeomKee et. al [1] examined the mechanical properties of aluminium sandwich panels with core as aluminium honeycomb both theoretical and experimental methods. Using Three- point bending test axial compression and lateral crushing loads are evaluated on sandwich composites. Froud [2] summarized how to design a composite sandwich structure to attain better bending strength and stiffness properties.

L J Gibson [3] explained the maximum stiffness per weight unit in sandwich structure beams using foam as a core material. The result analyzed that density of core, face thickness and core thickness are obtained optimal. Sakhi Jan et. al [4] analyzed the flexural properties of sandwich structure made of honeycomb panel both experimental and analytical method. Here material such as aluminium honeycomb core and glass fiber was used during fabrication of composites.

K KanthaRao et. al [5] investigated the bending properties of sandwich panels based composites by theoretical methods. Finally results are compared with strength to weight ratio of aluminium rods and aluminium honey comb panel. Surya Teja Varma et. al [6] explained the flexural behaviour of sandwich composites. The composites were manufactured in panel shape where glass fabric and epoxy is used as skin material and polyurethne foam is employed as a core material.

Henrik et al. [7] conducted a study to design and evaluate mechanical properties of sandwich beams with different cores, in order to develop a new composite material. Vitally et. al [8] summarized the strength properties of sandwich panels made of foam as core. Here, quasi-static indentation and low impact velocity on sandwich panel is analyzed which subjected to compression.

Royer et al. [9] investigated the mechanical properties of multilayered sandwich structure where polypropylene honey comb is used as a core material. Here, influence of core thickness and intermediate layer are analyzed. Yalkin et.al [10] Summarized mechanical characteristics of sandwich composite panels. This are fabricated using vacuum infusion method.

Here, perforated foam and perforated stitched foam are used as core material and glass fabrics are act as face sheet materials. The result depicts that core materials used in the work give better properties.

2. Materials and methodology

2.1 Materials

The raw materials involved in our experimental study are aluminium honeycomb with dimension of 6.35mmcell size, 12mm height and thickness of 0.06mm purchased from M/s covaiseenu and company, Coimbatore, Tamilnadu which is used as one of core material. The foam such as rohacell, HDPU (60mm*12mm) used as second core material. The synthetic fiber used in this study was carbon. The epoxy resin LY556, Hardener HY951 used as a matrix material in ratio of 10:1.
2.2 Methodology

2.2.1 Carbon fiber

Carbon fiber is one of the synthetic fibers which are made from precursor fibers organically. These structures are made of strongly bonded carbon atom with closed packed structure. The carbon fiber shown in Figure 1.

![Carbon Fiber](image1)

Figure 1. Carbon Fiber

2.2.2 Epoxy

The thermosetting epoxy LY556 is selected as matrix material in current research work. This material belongs to family of epoxide. The common name for epoxy matrix is bisphenol-A-diglycidyl-ether. The epoxy resin suitable harder HY951 at purchased form Sakthi glass fabrics, Chennai as shown below Figure 2.

![Epoxy LY556](image2)

Figure 2. Epoxy LY556

2.2.3 Core Materials

For preparing a sandwich structure, a light core material is necessary to separate the two thin facings. These thin sheets are bonded partially. Here, three different types of core materials are involved. They are aluminium honeycomb, rohacell, HDPU foam. Aluminium Honeycomb core material made of Hexagonal cells that are arranged in regular pattern. Such geometry can be obtained using a simple technique.

2.2.4 Manufacturing Process
Sandwich Structure one of the types of composite material are manufactured by Vacuum bag manufacturing process. Initially the carbon fiber fabrics were first incorporated with epoxy matrix and formed a laminated structure. Finally, thin core materials such as Aluminium honeycomb, Rohacell and HDPU foam was placed on the carbon fiber laminated structure. In my work the sandwich panels are made with three different compositions.

3. Mechanical Tests

3.1 Tensile Strength

The tensile test specimen was manufactured and evaluated as per ASTM standards undergone on a computerized universal testing machine. The dimensions of tensile specimens are 150mm*12mm*18mm. Generally, the specimen used for evaluation is in shape of dog-bone type.

3.2 Compressive test

A compression test determines the maximum amount of compressive load of a material before fracture. The specimen is evaluated as per ASTM standards. The specimens were prepared with dimensions of length150mm, width12mm and thickness 18mm was used.

3.3 Flexural test

The flexural specimens were prepared according to ASTM standards and properties are evaluated using computerized universal testing machine. Three point bending test is commonly used to evaluate flexural properties. This gives the flexural strength and modulus of all type of materials and products. The tested specimens are shown in below Figure 3.
4. Results And Discussion

The composite samples are tested using digitalized universal testing machines to determine the tensile, flexural and compressive properties. The strength of composite samples generated with respect to various sandwich structures to be reinforced with different core materials are analyzed. The results indicated that Foam based sandwich panels tend to have better tensile and compressive load bearing capacity as compared to Aluminium Honeycomb due to their structure and also Aluminium has better flexural properties because of its core line up which can undertake bending easily.
4.1 Tensile test

Table 1. Tensile Test Values

| S.No | Type of Core Material | Value of Load Obtained for Bending Test (KN) |
|------|-----------------------|---------------------------------------------|
| 1    | Rohacell Foam         | 2.68                                        |
| 2    | HDPU Foam 60          | 1.78                                        |
| 3    | HDPU Foam 80          | 1.96                                        |
| 4    | HDPU Foam 100         | 1.53                                        |
| 5    | Aluminium Honeycomb   | 1.37                                        |

![Figure 4](image.png)

Figure 4. Value of Load Obtained for Tensile Test

Table 1. shows the Tensile Test values for the samples of Aluminium Honeycomb, High Density PU Foam and Rohacell Foam. The Values are plotted in a graphical manner between loads versus different core materials. From Figure-4 shows that Aluminium Honeycomb has the lowest tensile load as it easily tears away on low amount of load. Rohacell based core sandwich composite had a higher value of tensile load as it can bear extension in a more easier method than HDPU or Aluminium Honeycomb due to its stronger bond between the particles of the foam.
4.2 Compressive test

Table 2 Compressive Test Values

| S.No | Type of Core Material          | Value of Load Obtained for Compressive Test (KN) |
|------|-------------------------------|-----------------------------------------------|
| 1    | Rohacell Foam                 | 8.36                                          |
| 2    | HDPU Foam 60                  | 7.8                                           |
| 3    | HDPU Foam 80                  | 6.5                                           |
| 4    | HDPU Foam 100                 | 7.25                                          |
| 5    | Aluminium Honeycomb           | 4.49                                          |

Figure 5 Value of Load Obtained for Compressive Test

Table 2 shows the Compressive tested values of different core materials. From Figure 5 it shows that Aluminium Honeycomb has a very easily crushable structure, the value of compressive load for Aluminium Honeycomb is the lowest and Rohacell with the chemical bonding between it has the highest value and the varying density HDPU Foam has the intermediate values of all the samples. The overall loads vary from a range of 4-8.5 KN.
### 4.3 Flexural test

**Table 3** Flexural Test Values

| S.No | Type of Core Material   | Value of Load Obtained for Three Point Bending Test (KN) |
|------|------------------------|--------------------------------------------------------|
| 1    | Rohacell Foam          | 0.93                                                   |
| 2    | HDPU Foam 60           | 0.6                                                    |
| 3    | HDPU Foam 80           | 0.47                                                   |
| 4    | HDPU Foam 100          | 0.83                                                   |
| 5    | Aluminium Honeycomb    | 1.87                                                   |

**Figure 6.** Value of Load Obtained for Three point Bending Test

Table 3 shows the three point bending test for the various samples and the graphs are plotted for the same. From figure 6 the result concludes that the value of Bending Load obtained for the samples and the sandwich panel with Aluminium Honeycomb has the highest Bending Load at 1.87KN.
5. Conclusion

The various mechanical tests which were conducted on the samples are 3 Point Bending Test, Tensile Test and Compression Test. All these mentioned tests were conducted by adhering to ASTM standards for testing of composites materials.

- For the Bending Test it was observed that Aluminium Honeycomb has the highest Bending Load of 1.87KN and HDPU Foam has the least 0.47KN. This shows that Aluminium Honeycomb has flexural strength 4 times more than that of HDPU Foam.
- For the Tensile Test it was observed that as Aluminium Honeycomb can easily tear in linear loading, the value of Tensile Load is least for it 1.37KN and Rohacell which had stronger bonding among the particles, due to is chemical composition has the highest value of Tensile Load at 2.67 which is almost 2 times the value of Aluminium Honey Comb.
- For Compressive Test, the value of compressive load is highest for Rohacell foam based sandwich panels and HDPU Based panels have a similar behaviour due to the chemical bonds of the foams which bind them together while loading along the axis. In case of Aluminium Honeycomb the value falls to 4.49KN which is lesser as it tends to crush easily when compressed.

6. References

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