Manufacturing & Experimental Analysis of Carbon Epoxy, Glass Epoxy Composite Laminated Plates

Chaurasia Raj[1] N. Jeevan Kumar[2]
[1]B.Tech Student [2]Professor
[1,2]Department of Mechanical Engineering
[1,2]CMR Engineering College, Kandlakoya (v), Hyderabad-501401, India

Abstract— A composite material is a combination of two or more different materials; it gives superior quality than its constituents. Composite materials can be used not only for structural applications, but also in various other applications such as automobiles, aerospace, marine, etc. Composite materials have replaced most of the commonly used materials due to its advantages over the other materials. The composite material is fabricated using manual layup technique; the laminated plate's specimen will be tested as per ASTM standards to study various mechanical properties like ultimate tensile strength, bending strength, and physical property like density, at room temperature. The prime objective of this work is to fabricate and analyze the mechanical properties and physical property of carbon epoxy and glass epoxy composites. The main aim of this work is to estimate the mechanical properties and physical property of carbon epoxy and glass epoxy material. Also, the testing of aluminum has been performed and compared with glass epoxy and carbon epoxy composites. Thus this paper will assist to understand the mechanical properties and physical property of composite.

Key words: Carbon Epoxy, Glass Epoxy, Manual Layup Method

I. Introduction

A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with a unique characteristics. The new material may be preferred for many reasons common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials. The different authors as given many definitions for composite materials as follows below.

Kelly [2] very clearly stresses that the composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them.

Berghezan [3] defines as “The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings”, in order to obtain improved materials.

Van Suchetclan [4] explains composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale.

In 1961, the first carbon fiber was patented and several years later, became commercially available. Carbon fibers improved thermoset part stiffness to weight ratios, for use in even more applications such as aerospace, automotive, sporting goods, and consumer goods. In the 1960's, the marine market was the largest consumer of composite materials. Over the next twenty years, the composite materials market advanced. New ultra-high molecular weight polyethylene joined other advanced fibers used in breakthroughs in aerospace components, structural and personal armor, sporting equipment, medical devices and other applications.

II. Methodology

The making of composite material by wet/hand lay-up technique. It is the oldest molding method for making composite products.

- It requires no technical skill and no machinery.
- A release gel is sprayed on the mold surface.
- Epoxy is applied on surface and polymer is uniformly spread with help of brush.
- The process is repeated for each layer of polymers and mat, till the required thickness is acquired.

Fig. 1: Wet/Hand Lay-Up Technique

- Leave it for 24-48 hours to get dry.
- Later on dryed composite laminated plates is cut according to ASTM size for tensile testing is ASTM D3039 and for 3-point testing is ASTM D3410
- The most common specimen for ASTM D3039 is a constant rectangular cross section, 25 mm (1 in) wide and 250 mm (10 mm) long and thickness of 5mm for tensile test.
- Specimens should have a uniform rectangular cross section, 140 mm (5.5 in) long. The recommended width can be 25 mm (1 in) and thickness is 5mm from ASTM D3410 for 3-point bending test.
- The entire dimension is taken from the American society of testing and material for accurate for experimental

analysis and analytical analysis of glass epoxy, carbon epoxy and aluminum.

A. *Material Selection for Composite Laminated Plates*

Carbon fiber and glass fiber was selected as reinforcement and epoxy and matrix material.

1) Reinforcement

- Bidirectional carbon fiber 400(GSM)
- Bidirectional glass fiber 600(GSM)

2) Matrix

- Isopthalic resin
- Isopthalic hardener (catalic)

III. TESTING OF SPECIMEN

Following tests are conducted on glass epoxy, carbon epoxy and aluminum specimens.

- Ultimate tensile strength
- 3-point Bending strength and
- Density

A. *Ultimate Tensile Test*

The tensile test generally performed on flat specimen. Tensile test of composite sample is carried out in ASTM D3039 test standard. In tensile test, a uniaxial load was applied through both the end. The tensile test specimen of bidirectional carbon epoxy, bidirectional glass epoxy and aluminum is done is shown in Figure 2

Fig. 2: Tensile Test Specimen

Fig. 3(A)

Fig. 3(B)

The Above Fig. 3(A) & 3(B): Shows the Experimental Setup & Loading Arrangement of Specimens for Tensile Strength Test

B. *3-Point Bending Test*

ASTM D3410 is followed for the 3- point bending test. The test is performed to measure the bending stress of the material in a universal testing machine with a three point fixture. The specimen is placed on a two point support and the stress is applied on the specimen by the third point at the middle of the specimen till it fractures.

Fig. 4(A)

Fig. 4(B)

Fig. 4(A) & 4(B): Shows The Experimental Setup & Loading Arrangement of Specimen for 3point Bending Stress. Bending Test Is To Determine The Capability Of A Material To Withstand The Bending Before Reaching The Breaking Point.

Bending stress = $\frac{MY}{I}$

Where M=$\frac{wl}{4}$, i=$\frac{bd^3}{12}$ and y =2.5

C. *Density Test*

The experimental density is calculated by the standard formulae

i.e., Density =$\frac{mass}{volume}$

IV. RESULT ANALYSIS & DISCUSSION

A. *Tensile Strength Results*

The load – displacement graph of specimens for tensile test as show below

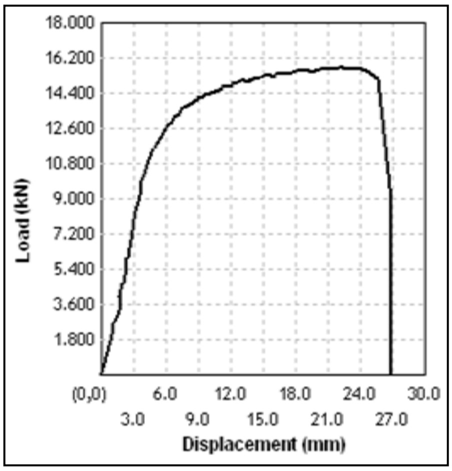

Fig. 5(a):

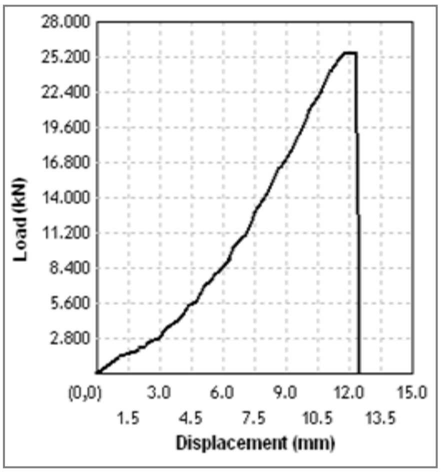

Fig. 5(b):

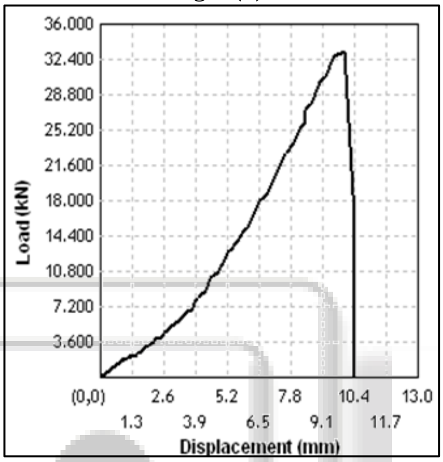

Fig. 5(c):

The Fig. 5(a): show the load –displacement curve graph for aluminum with the maximum load 15.720kN.

The Fig. 5(b): show the load –displacement curve graph for glass epoxy with the maximum load 25.800kN.

The Fig. 5(c): show the load –displacement curve graph for carbon epoxy with the maximum load 33.280kN.

Specimens	Ultimate Tensile Load(kN)	Ultimate Tensile Strength (Mpa or N/mm)
Aluminum	15.720	125.760
Glass Epoxy	25.800	206.400
Carbon Epoxy	33.280	266.240

Table 1: Tensile Test Result

The below table 1 show that ultimate tensile strength is maximum in carbon epoxy when compared to glass epoxy and aluminum.

The figure 6 shows the bar diagram for the comparison of ultimate tensile strength in carbon epoxy, glass epoxy and aluminum.

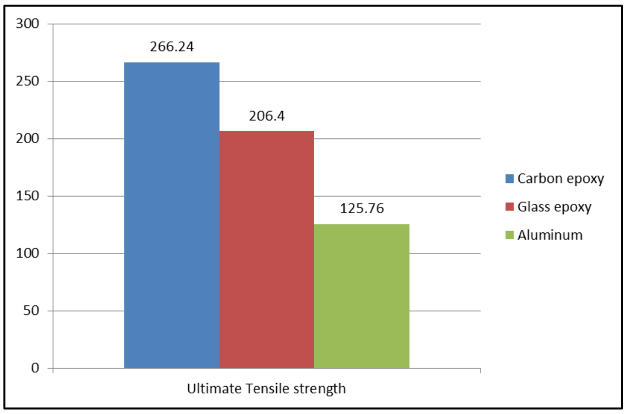

Fig. 6: Comparison of Ultimate Tensile Strength in Specimens

B. 3-Point Bending Test Results

The load – displacement graph of specimens for bending test as show below

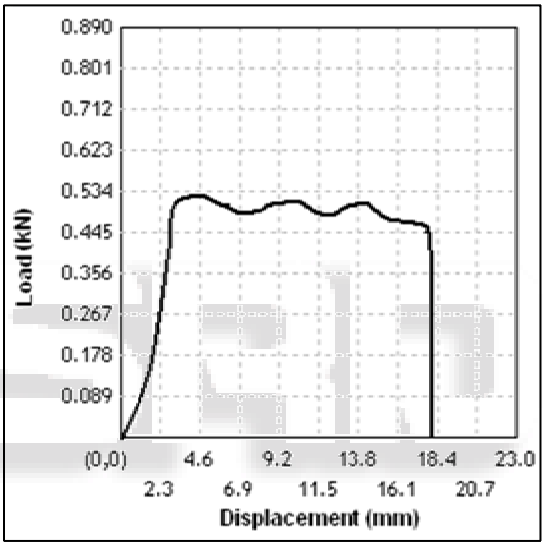

Fig. 7(A):

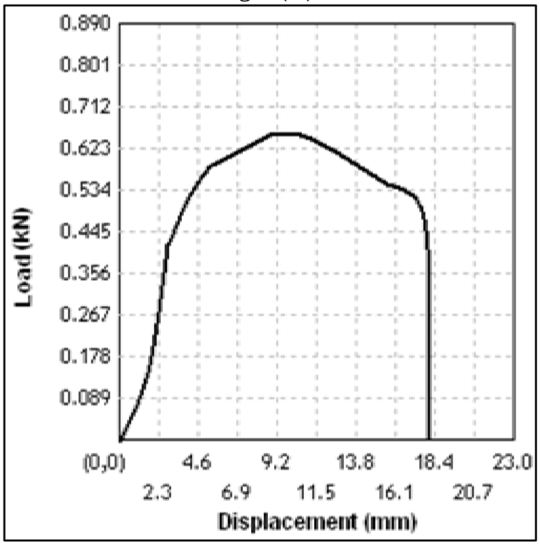

Fig. 7(B):

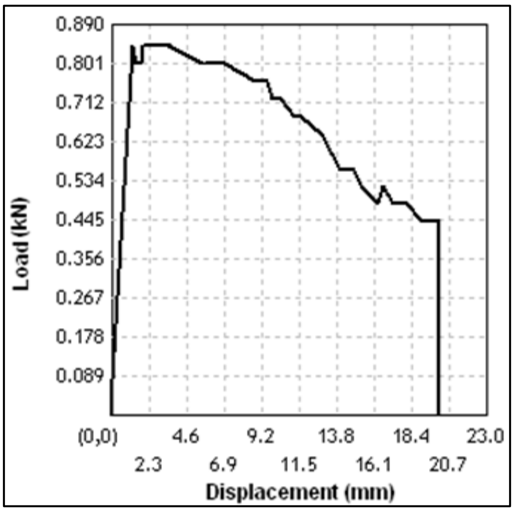

Fig. 7(C):

The Figure 7(A) Show The Load –Displacement Curve Graph For Glass Epoxy With The Maximum Load 0.520kn.

The Figure 7(B) Show The Load –Displacement Curve Graph For Carbon Epoxy With The Maximum Load 0.640kn.

The Figure 7(C) Show The Load –Displacement Curve Graph For Aluminum With The Maximum Load 0.840kn.

Specimens	Bending Load(kN)	Experimental Bending Stress(Mpa)
Glass Epoxy	0.520	174.72
Carbon Epoxy	0.640	215.04
Aluminum	0.840	282.24

Table 2: 3 Point Bending Test Results

The above table 2 shows the result obtained from 3 point bending test as it can see that the bending stress is maximum for aluminum when compared to glass epoxy, carbon epoxy.

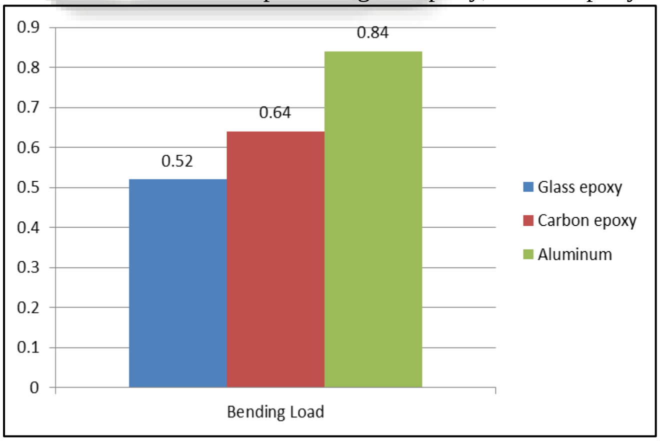

Fig. 8: Comparision of Bending Load in Specimens

The figure 8 shows the bar diagram for comparison of bending load in aluminum, carbon epoxy and galss epoxy.

C. *Density Test Results*

The experimental density is calculated by the standard formulae

i.e., Density $=\frac{\textbf{mass}}{\textbf{volume}}$

The table 3 shows the calculation of experimental density from the above formulae.

specimens	Dimensions (mm)	Mass (gm)	Volume (mm)	Density= $\frac{\textbf{mass}}{\textbf{volume}}$ (g/mm^3)
Aluminum	250×25×5	95	3.125×10^{-5}	3.040
Glass Epoxy	250×25×5	42	3.125×10^{-5}	1.344
Carbon Epoxy	250×25×5	33	3.125×10^{-5}	1.056

Table 3: Experimental Density

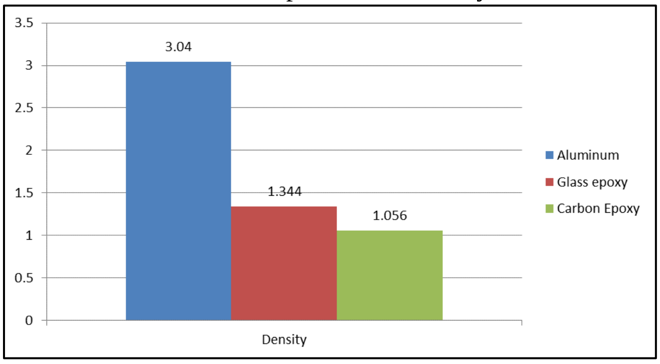

Fig. 9: Comparison of Density in Specimens

The figure 9 shows the bar diagram for density in aluminum, glass epoxy and carbon epoxy and it found that density is less in carbon epoxy.

V. CONCLUSIONS

The manufacturing and experimental investigation on carbon epoxy, glass epoxy and aluminum, has led to the following specific conclusions:

1) Mechanical behavior of bidirectional carbon epoxy, bidirectional glass epoxy composite material and aluminum under static loading at room temperature was experimentally investigated as per standards. The failure of composite materials and aluminum specimens under tensile, 3-point bending, were investigated. Based on the test results, the following conclusion are drawn:
2) Fabrication of carbon woven reinforcement sheet and glass woven reinforcement sheet with isophthalic epoxy is done by hand lay-up technique.
3) The stress-strain behavior of laminate under tensile loads in longitudinal direction was linear elastic until breakage and it found that strength is maximum in carbon epoxy composite material.
4) The experimental values of bending load and bending stress is compared with glass epoxy, carbon epoxy and aluminum and it found that bending load is maximum in aluminum because of ductility and composite materials is less ductility in nature.
5) Density of specimens is experimentally done. And it found that carbon epoxy as less density which increases the material rigidity, strength and has low coefficient of friction when compared to glass epoxy and aluminum.

REFERENCES

[1] Mahammad a torabizadeh 2013. "Tensile, compressive and shear properties of unidirectional glass/epoxy

composites subjected to mechanical loading and low temperature service". Vol. 20, 299-309.
[2] Sudhir s mathapathi 2015. "Testing and Analysis of Mechanical Properties of E- Glass Fiber Reinforced Epoxy Polymer Composites". Vol.2, 46-52.
[3] T D Jagannatha, G Harish 2015. "Mechanical properties of carbon/glass fiber reinforced epoxy hybrid polymer composites". Vol.4, 1-7.
[4] Haidar F. AL-Qrimli 2015. Studied regarding Carbon/Epoxy Woven Composite Experimental and Numerical Simulation to Predict Tensile Performance. Vol.4, 33-41.
[5] Y.Karnakar/K.Madh 2015. "International Journal of Innovative Science, Engineering & Technology, Experimental analysis on glass/epoxy composite beams". Vol.2, 24-41.
[6] Karthick Saravanan 2016. "Experimental Analysis of Carbon/Glass Fiber Reinforced Epoxy Hybrid Composites". Vol.5, 6767-6780.
[7] Mr.Hariharan E 2016. "Experimental Analysis of Fiber Metal Laminate with Aluminum Alloy for Aircraft Structures". Vol.5, 95-102.
[8] Husain Mehdi 2014. "Experimental Analysis of Mechanical Properties of Composite Material Reinforced By Aluminum-Synthetic Fibers". Vol.4, 59-69.