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DEVELOPMENT AND FLEXURAL TESTING OF CARBON FIBER REINFORCED PLASTIC (CFRP)

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Abstract: *This report aims to assist engineers in understanding and applying their knowledge in replacement of conventional materials. Many structures utilized in Automobile, Aerospace, Naval and other Transportation vehicle structural parts are subjected to various sorts of loads. Added to these structures bending loads, which results in flexural stress in the structures. Structures that are subjected to bending loads are vulnerable to several problems. In order to prevent bending, structures' structural integrity is essential. Structures subjected to pure bending load frequently experience the specimen's maximum flexural stress at either the outer or inner fiber, which causes failure. The neutral axis or intermediate axis will experience zero stress. With the help of a Flexural Test system, the current study intends to examine the flexural characteristics of carbon fiber reinforced E-poxy composites under static flexural loading. By performing the three-point bend test on a composite specimen in accordance with ASTM D790 standards, the flexural parameters are identified. These tests will also be utilized to demonstrate how carbon fiber reinforced polymer's flexural characteristics are affected by thickness.*

Keywords: Carbon fiber, E-poxy, Flexural strength, Composite material

1. INTRODUCTION

Current materials frequently reach their practical limits in the ongoing search for enhanced performance, which can be defined by a variety of factors, including less weight, more strength, and lower cost. Therefore, scientists, engineers, and researchers in the field of materials are constantly driven to develop either new or enhanced versions of existing materials. Composites are an illustration of the second group. Composite materials, plastics, and ceramics have been the most popular new materials during the past thirty years. The quantity and variety of uses for composite materials have grown continuously, persistently entering and dominating new markets. Modern composite materials dominate the market for engineered materials, appearing in a wide range of products and applications, from simple consumer goods to complex machinery.

The key concern for car manufacturers is weight reduction in order to save energy and natural resources. The perfect replacement for metallic parts is composite material.

A composite material is described as a combination of two or more materials that exhibits superior qualities than those of the component parts utilized separately.

We are aware that the flexural properties of laminated composites are influenced by thickness, and that various types of loads are applied to the structural components of vehicles used in the automotive, aerospace, naval, and other transportation industries.

These constructions are additionally subjected to bending loads that put them under flexural stress. This study's goal is to conduct an experimental analysis of laminated composites' progressive failure process under flexural loads,

Composites experience stresses due to flexural loading, which vary according on the thickness. These flexural stresses are zero at the neutral axis in the middle and highest at the outer surfaces. The stress in a single ply is influenced by its stiffness and proximity to the neutral axis of the laminate.

2. OBJECTIVES:

1. To learn the orthotropic properties of Composites.
2. To synthesize material and test for validation.
3. To study flexural properties tests applying 3-Point bending test.
4. To identify/establish characteristics Structure – Property relationship based on outputs.
5. To study flexural properties of composite materials at different thickness.

3. LITERATURE REVIEW

[1][Patel and Patel](1993), the researcher detailed about the effect of tetra functional epoxy resins on the mechanical properties of the carbon fiber reinforced polymer. Two epoxy resins were going to use for the fabrication of carbon fiber epoxy composites and the comparison takes place. The specimen was made according to ASTM D standard.

[2][Mujika et al](2002), the research explained about the woven carbon fiber epoxy composites demands were increased in the research areas and the industries because of ease of manufacturing. Two different epoxies were used with the filler known as polysulfide. The sample were made according to ASTM d standard through vacuum technique.

[3][Solomon et al](2017), survey of the research paper explained about the mixing ratio of the fiber and the matrix contained in it.

In this paper carbon fiber chosen as the fiber and the matrix was epoxy resins araldite. The sample were made according to ASTM D standard through vacuum bagging technique.

[4][Giovedi et al] (2005), the literature survey of the paper inform that the adhesion between the fiber and the matrix play an important role for the mechanical properties of the composites. In this paper two different types of carbon fiber were taken to observe the adhesion parameter. The effect of the EB irradiation was analysed on the specimen.

[5][Han-kiyoon](2007), the researcher explained about the effect of the fiber orientation and the volume fraction for hybrid composites. The combination of the two reinforcement was Carbon Fiber Reinforced Polymer (CFRP) and the metal.

[6][F.H. et al](2008), the aim of the research paper was to find out the volume fraction of the fiber form the composites material. Two different types of fiber were chosen to find out the separate volume fraction. One was the glass fiber and the other was carbon fiber and compare them itself. The sample were made according to ASTM d standard with filament winding method.

[7][Coban et al](2010), the researcher explained about the use of carbon fiber reinforced polymer because of their important mechanical properties. In this research paper one of the important parameters were going to evaluate was viscoelastic properties which were going to be affected by the orientation of the fiber on thermal cycles.

[8][Gururaja and Harirao](2013), the benefits of the hybrid composites drawn a researcher attraction to combine the advanced composites material such as carbon fiber and the glass fiber with three different orientation to obtain the required properties of the composites. The sample were made according to ASTM d standard through vacuum bagging technique.

4. DESIGN CONSIDERATIONS

The depth of the specimen for flatwise tests must equal the material's thickness. For edgewise tests, the specimen's breadth must match the sheet's thickness and its depth cannot be greater than its width.

The support span must be 16 (tolerance 1) times the depth of the beam for all tests. For specimens deeper than 3.2 mm (1/8 in), the specimen breadth must not be higher than one-fourth of the support span. Specimens with a depth of 3.2 mm or less must have a breadth of 12.7 mm (1/2 inch). The specimen must be long enough to provide at least 10% of the support span of overhanging on each end, but in no circumstance less than 6.4 mm (1/4 in.) on each end.

5. MATERIALS AND METHODS

1. Laminated Fabrication
   - Selection of Composite Materials
   - Reinforcement-Carbon (200GSM)
   - Matrix- Epoxy Epolom resin & Hardener 5015

2. Regional resources are first used to gather the carbon fiber that will be used as reinforcement in this investigation. After that, it is carefully cleaned and sized. A calculated amount of epoxy resin and hardener (ratio of 70:30 by weight) was thoroughly mixed in a glass jar for various volume fractions of fibers. Place a peel layer of plastic on top, followed by a peel layer of fabric. After covering it with glue, add ply after ply of carbon fiber between 00 and 900. Fibers are impregnated with resin. Typically, rollers or brushes are used for this, but roller-type impregnators, which use rotating rollers and a resin bath to force resin into the fabrics, are becoming more popular. To remove bubbles from production sheets, use a roller. Peel ply of plastics should be placed after peel ply of cloth. The pressure was then applied from the top, and it was left to preserve for 24 hours at room temperature. A small amount of the epoxy and hardener mixture is squeezed out when pressure is applied.

Figure 1: Specimen preparation and Specimen

- Properties calculate from micro mechanics of composite Materials Used are tabulated as Follows:

Table-1: Material Properties (SI Unit)

Material	Properties	Value
Carbon Fiber	E_f	242
	ρ_f	1.81
	v_f	0.25
Epoxy Resin	E_m	3.7
	ρ_m	1.14
	v_m	0.245
Laminate (Orthotropic)	E_1	134.766
	E_2=E_3	8.701
	ρ_C	1.62
	G12=G13	3.102
	G23	3.241
	v12	0.25
	V_f	0.60

6. TESTING:

Three-point bend test was carried out in an3-Point Bending machine in accordance with ASTM D790 to measure the flexural strength of the composites. The loading arrangement for the specimen and the photograph of the machine used are shown in figure. Theflexuralstrengthofcompositeswasfoundoutusingthefollowingequation:

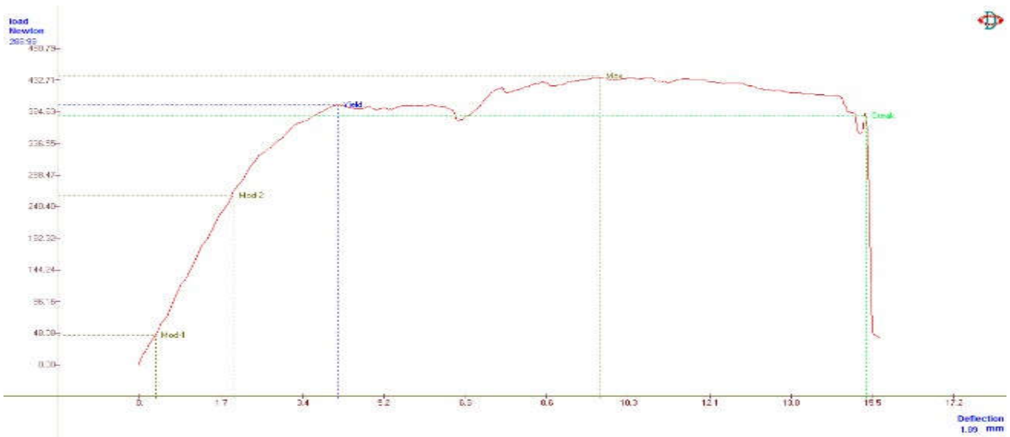
$$\sigma = \frac{3PL}{2bh^2}$$

Where, σ is the flexural strength , P is the load, L is the span length ,b is the width and the thickness of the specimen under test.

Figure2: 3-Point Bending machine Sample loaded condition for Flexural testing

7. EXPERIMENTAL RESULTS:

Three-point bending tests were performed on $0^0/90^0$ lay-up composite specimens. The load-deflection curve was evaluated. Three types of laminates were tested with three different thicknesses. Graph obtained for specimens plotted are as follows:



Graph Plotted Between Load and Deflection

- It has been noted that the strength of carbon laminates has significantly improved as test thicknesses have increased. This can be as a result of the carbon fiber and matrix having strong adherence.
- Results for flexural stress calculated using experimental, analytical, and FEA approaches are shown to be in great agreement.
- The findings of this study are suggested for the community of composites designers for better strengthening of FRP composites.

Experimental results obtained from testing the specimens on 3-Point Bending is tabulated are as follows:

Table-2: Testing results of specimens:

Carbon Fiber Specimen	Load(N)	Flexural Strength (MPa)	Flexural Modulus (MPa)
Specimen1	440	44	683
Specimen2	221	12	100
Specimen3	332	21	204
Specimen4	428	53	725
Specimen5	395	64	695
Specimen 6	578	67	592
Specimen 7	432	13	135
Specimen 8	221	69	674
Specimen 9	394	54	731

8. CONCLUSIONS

- This study examines the behavior of composite materials and laminates, including anisotropic, quasi-isotropic, orthotropic, and isotropic materials.
- The nature of the matrix and several reinforcing fiber types, including, carbon, and graphite, are investigated.
- Based on the findings, it is obvious that flexural properties are essential for testing composite materials.
- In components made of composite materials, delamination is found to be a measure of failure.

9. FUTURE SCOPE

Although the current work includes various inquiries, there are still some unanswered questions, such as:

- There is a huge amount of room for future academics to pursue this field of study. This research can be expanded upon to investigate further tribological features of the composite, such as abrasion, wear, and hardness behaviour.
- There is scope to investigate more aspects of these composites, such as the use of other possible fillers to create hybrid composites, evaluation of their mechanical behaviour, and the analysis of the experimental results.
- Additional research can be done using various matrix materials and fiber kinds.
- Stitching and interleaving techniques are used to investigate composite delamination processes.
- Impact and fatigue tests can be used to gauge the laminated composites' impact and fatigue resistance.
- Vibration and modal analysis can be used to assess the laminates' resistance to vibration.
- It is feasible to study laminated composites with cut outs and determine the stresses at the bearings.

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