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Evaluation Of Shear Properties of Carbon Fiber Reinforced Polymer Matrix Composites Developed for Micro Wind Turbine Applications

D.G. Puttaraju[1]*, H.G. Hanumantharaju[2]

Department of Mechanical Engineering, UVCE Bangalore, India[1,2]

Abstract: Composite materials are the most promising. In comparison to current conventional materials, carbon fibre reinforced composites (CFRC) offer substantial advantages to the aerospace sector. As the market's demand for lightweight, high-strength materials for specific applications develops, composites reinforced with artificial or natural fibres are becoming ever more common. In the current work, a composite material made of carbon fibre reinforced polymer matrix is being created for use in wind turbine blade application. The composites are made by hand using a lay-up approach at room temperature. When a steady force is exerted parallel to the surfaces of the tape and substrate, shear tests are used to assess an adhesive tape's endurance to creep. The following results are drawn from this experimental study of the shear stress behaviour of carbon fibre reinforced epoxy matrix composites. The ultimate shear strength improved by the addition of carbon fibre material. In case of specimen 1, the failure stress was observed to be 30.71 MPa and displacement was found to be 4.25 mm. In case of specimen 2, the failure stress was observed to be 36.95 MPa and displacement was found to be 7.81 mm. Between the two specimens, the largest deviation in failure stress is found to be 20.31%.

Keywords: Composite Material, Shear stress, Wind turbine, CFRP.

I. INTRODUCTION

One of the main factors in a country's financial development is its access to energy. Oil, coal, hydropower, atomic energy, and other sources are among the major energy providers on the planet. The Indian economy will have a very tough time meeting its energy needs during the next ten years. [5-6] The level of imports in the energy mix is rising significantly as a result of the rising energy requirements and a slower than expected increase in domestic fuel production. One of the most practical non-conventional energy sources in the existing energy crisis is wind energy. Nonetheless, the wind turbine plant's initial cost is relatively high. About 15–20% of the cost of a wind turbine plant is spent on the manufacture of the blade. By extending the service life of the wind turbine blades, thus it is likely to lower the investment cost of the blade. Wind turbines are put under highly particular strains and loads. Wind's inherent characteristics result in highly varying loads [1-3]. Because the material becomes exhausted, handling varying loads is more problematic than dealing static loads. Further, because the air is a low-density working medium, a wide surface area is required to capture energy. The goal of wind turbine design is to achieve the maximum power output feasible under specific atmospheric conditions, and this is reliant on the blade shape.

Any substance created from a number of components is referred to as a composite material. When it comes to cost savings and weight reduction, composite materials are the most promising. In comparison to current conventional materials, carbon fibre reinforced composites (CFRC) offer substantial advantages to the aerospace sector [4]. Due to their intriguing special mechanical properties, they have been used to create a variety of structural components, including landing-gear doors, as well as other structural parts. A force known as shear stress causes a material to slip along one or more plane parallel towards the applied stress, which tends to distort the material.In order to regulate the safety factor of the blade against applied loads, the stress and strain in various orientations are taken into account.

T.M.Roberts et al. [7] studied the impact of shear deformation on the torsional, flexural and lateral buckling of pultruded fibre reinforced plastic profiles is investigated theoretically. Pre buckling displacements can raise buckling moments by over 20% in members exposed to bending, while shear deformation reduces buckling moments by less than 5%. Rajesh et al. [8] studied the mechanical characteristics of a unique intra-ply woven polyester composite containing glass fibre threads in one axis and natural fibre threads in another axis of a bowl woven fabric were examined in this study. Mahdi Farahani.et al. [9] investigated the mechanical characteristics of carbon fibre reinforced polymer matrix composites, a sequence of tensile, compression and shear testing were performed at ambient temperature. The increased transverse modulus of this composite is due to the bidirectional character of the fibres in comparison to the unidirectional continuous fibre CFR polymer matrix composite that was the topic of this investigation. Based on the literature study, it is observed that very less work has been carried out on carbon fiber composites. In the current work, a composite material made of

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carbon fibre reinforced polymer matrix is being created for use in wind turbine blade uses. The created material is used to conduct the shear stress study.

II. EXPERIMENTAL METHODS AND MATERIALS

This section describes the various materials and apparatus used in the experiment. The procedure for creating composite materials is also outlined. The composites are made by hand using a lay-up approach at room temperature. This method has several benefits and is also cost-effective for creating prototypes and small quantities of goods. This method involves completely mixing the necessary components of epoxy resin LY556 and hardener 951, and then continuously stirring the mixture in a basin. The open mould is manually filled with carbon fibres. In Fig. 1, a carbon fibre lamina is displayed. The finished slurry is uniformly brushed over the glass sheets. In order to remove the excess resin that accumulates during the hand-laying process, the drying chamber is positioned on the exposed mould (Fig 2). The air pressure pulls on the bag. The pressure applied to the laminate releases trapped air, excess resin, and compacts the laminate, increasing the amount of fibre reinforcement. The produced composite material is shown in Fig. 3.

Table.1: Ingredients of matrix system

Ingredients	Trade Name	Chemical Name	Density (gm/cm3)
Epoxy Resin	LY556	Diglyodal Either of Bisphenol A	1.16
Hardener	HY951	Tri ethylene tetra mine	0.95

Figure 1: Carbon fiber lamina

Figure 2: Carbon laminate in vacuum Bag

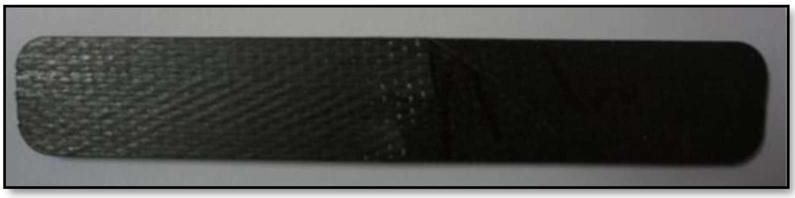

Figure 3: Composite Material

Shear test sample is shown in Figure 4. Whenever a consistent force is exerted parallel to the surfaces of the tape and substrate, shear tests are typically performed to assess an adhesive tape's susceptibility to creep. This test evaluates the mechanical responsiveness of an adhesive and compares its strength in a joint. The duration it takes to remove a specified region from the sample while applying a continuous load is measured by the shear test. Shear strength is the word used to describe internal strength of such adhesive material. Figure 5 shows Shear test specimens with Strain gauge attachment.

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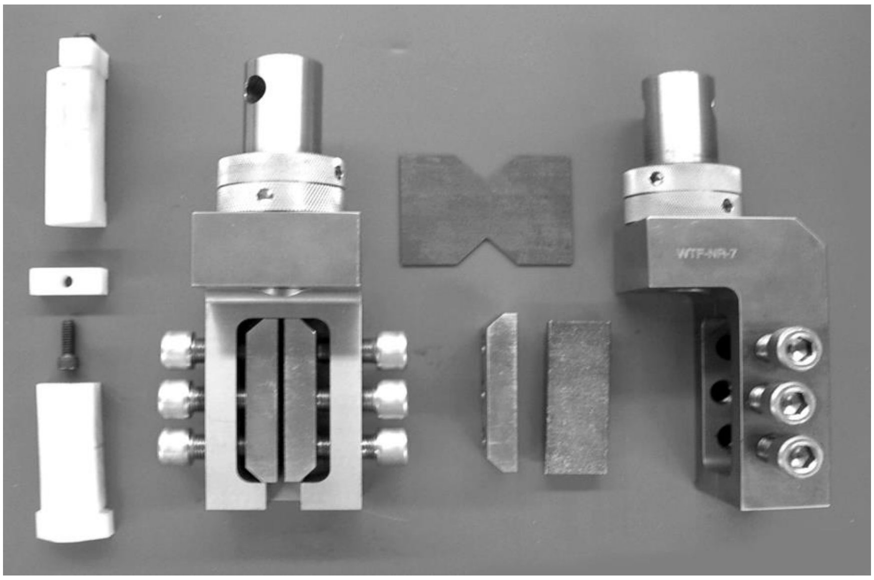

Fig 4. Shear Testing: Assembled Fixture with Specimen and Spacer Blocks

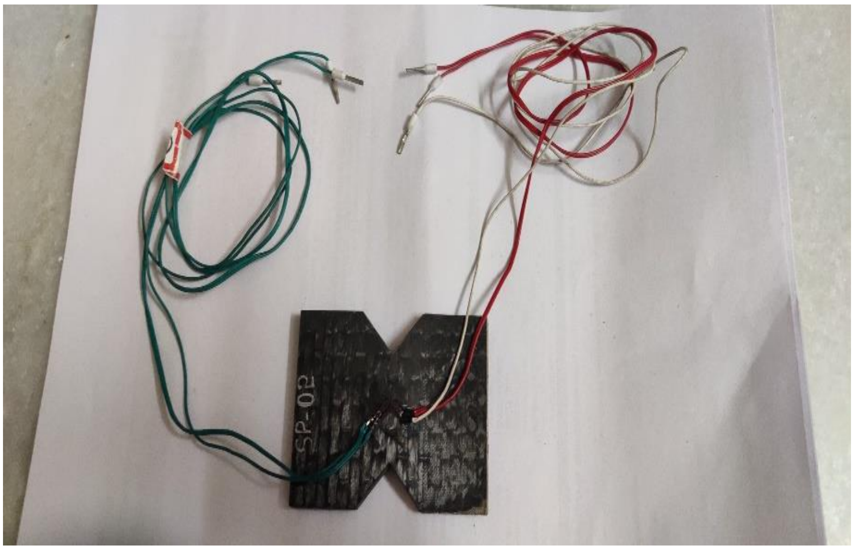

Fig. 5. Shear test specimens with Strain gauge attachment

III. RESULTS AND DISCUSSIONS.

This section presents the test's findings in terms of shear results. The test's outcome is displayed in table 1 below. The research results reported here offer fresh perspectives on how to create carbon fibre composite structures with distinctive mechanical characteristics for a variety of industrial and structural applications.

In case of specimen 1, the failure stress was observed to be 30.71 MPa and displacement was found to be 4.25 mm. In case of specimen 2, the failure stress was observed to be 36.95 MPa and displacement was found to be 7.81 mm. Between the two specimens, the largest difference in failure stress is found to be 20.31%. Because carbon fibre has a higher strength than other fibres, the composite has a lower failure stress. The shear tests for two distinct specimens of the same kind are shown in Figures 6 and 7. To guarantee accuracy and repeatability, only two samples are evaluated at once. Figures 8 and 9 depict the tested specimens.

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Table 1: Result from Shear Test

Specimen No	Length (mm)	Width (mm)	Thickness (mm)	Area (mm2)	Load (KN)	Displacement (mm)	Failure Stress (MPa)
1	50	32.03	7.96	254.95	7.83	4.25	30.71
2	50	32.03	7.85	251.43	9.29	7.81	36.95

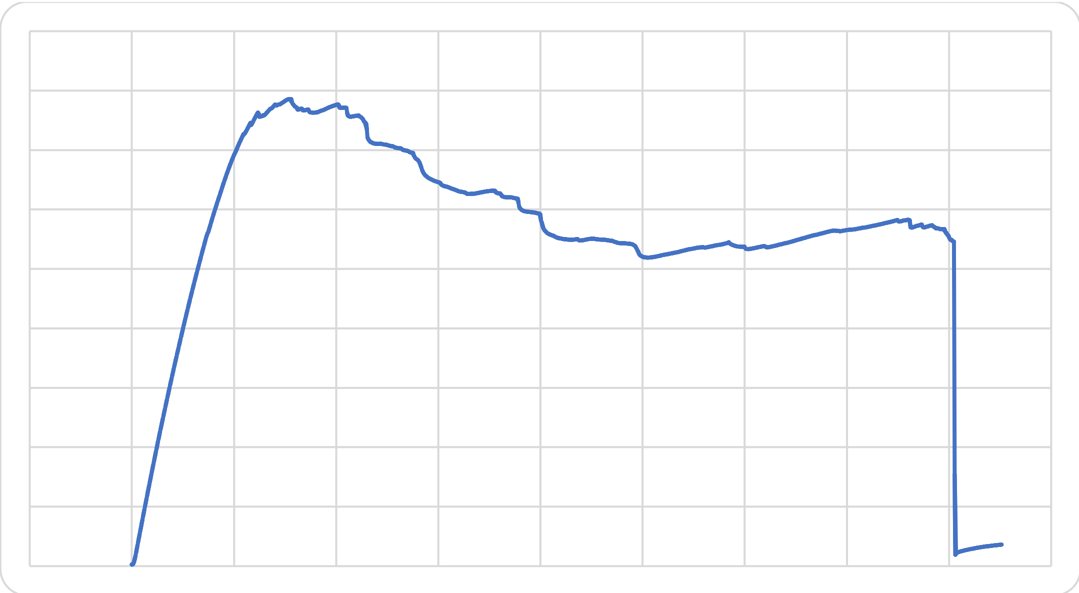

Fig. 6: Shear test Result for specimen 1

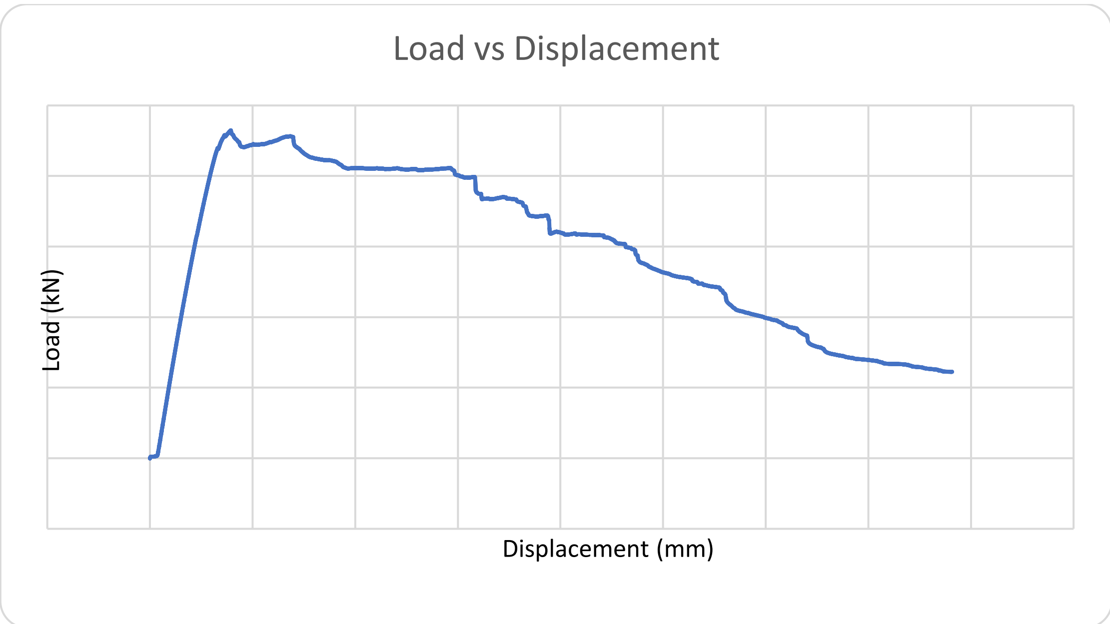

Fig. 7: Shear test Result for specimen 2

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Fig. 8: Shear test specimens after test (Specimen 1)

Fig. 9: Shear test specimens after test (Specimen 2)

IV. CONCLUSION

The hand layup and vacuum bag methods are used to construct the carbon fibre reinforced composite specimens for the current inquiry, and the experimental assessment of shear stress in accordance with ASTM requirement has been successfully completed.
The following conclusions are drawn from this experimental study of the shear stress behaviour of carbon fibre reinforced epoxy matrix composites:

- In case of specimen 1, the failure stress was observed to be 30.71 MPa and displacement was found to be 4.25 mm. In case of specimen 2, the failure stress was observed to be 36.95 MPa and displacement was found to be 7.81 mm. The maximum variation in failure stress was found to be 20.31% between the two specimens.
- The developed material can be successfully used in fabrication of micro wind turbine blades.

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