Fabrication and Experimental Strength Analysis of Natural Fiber Composite Material

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Abstract— The composite materials are replacing the traditional materials, because of its superior properties such as high tensile strength, low thermal expansion, high strength to weight ratio. The developments of new materials are on the anvil and are growing day by day. Natural fiber composites such as became more attractive due to their tensile and compressive strength and also lightweight. Mixing of natural fiber with Natural-Fiber Reinforced Polymers (NFRPs) is finding increased applications. In this study, Natural fiber composite material is developed and their mechanical properties such as tensile strength and flexural strength are evaluated. The test was carried out by using the universal testing machine. The results indicated that the Natural fiber composite material can improve the tensile and compressive properties. These type of natural fiber material is used in many fields such as tent poles, pole vault poles, arrows, bows and crossbows, translucent roofing panels, automobile bodies, hockey sticks, surfboards, boat hulls, and paper honeycomb. It has been used for medical purposes in casts.

Keywords: natural-fiber, composite, polymers, tensile and compressive strength, UTM machine, lightweight

I. INTRODUCTION

Composites are the class of materials referring to a combination of two or more materials mainly divided into matrix and reinforcement. "Materials composed of two or more distinctly identifiable constituents" are used to describe natural composites like timber and organic materials, like tissue surrounding the skeletal system. Composites are mainly classified as Polymer Matrix, Metal Matrix and Ceramic Matrix Composite. Reinforcement can be in the form of fiber, particulates or whiskers made up of polymer, metal or ceramic. The need for a composite material is that combined properties can be achieved depending on matrix and reinforcement satisfying the application needed. The reinforcing fiber provides strength and stiffness to the composite whereas the matrix provides rigidity and resistance. The matrix binds the reinforcement phases. Composites are anisotropic and have a non-homogeneous structure. The volume fraction of matrix and fiber decides the total strength of composites.

Composites cannot be made from constituents with divergent linear expansion characteristics. Fibers may be long continuous or short chopped resulting in different properties. The alignment of fibers is most important in determining the strength of composite. So the fibers can be unidirectional, bidirectional or random directional and they are woven. The main property of composite is that it provides high strength to weight ratio compared to metals. Most composite materials remain elastic till failure occurs and show decreased failure strain, when loaded in tension and compression so they are almost brittle. The other properties cannot be defined without specifying the type of composite.

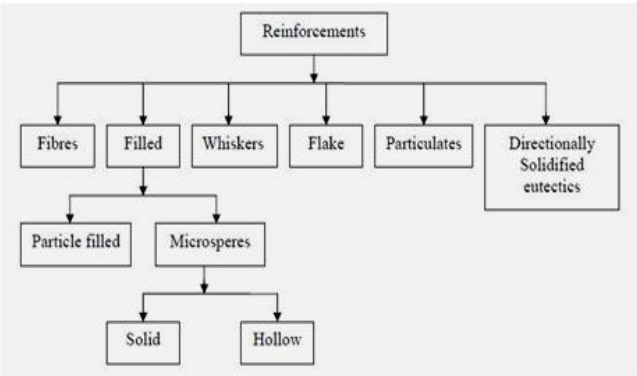

Fig. 1: Reinforcements

II. FABRICATION OF NATURAL FIBER COMPOSITE MATERIAL

Fabrication of natual fiber reinforced epoxy resin composite is done by hand lay-up technique. Hand lay-up method is the very easiest and cheapest way of fabricating a composite. In hand lay-up technique the achieved composite contains many voids as matrix material cannot occupy the fiber voids evenly, so the thickness of the composite is varying by 0.2mm. But measures can be taken to minimize the variation.

A. *The Raw Materials Are:*

1) Treated fiber rovings (200 GSM).
2) Epoxy Resin.
3) Epoxy Hardener.
4) PVA Mould release agent.

B. *The Raw Material Shape and Size:*

- Shape - Rectangle
- Size - 220 X 155 X 4 mm

III. NATURAL FIBER REINFORCED EPOXY RESIN COMPOSITE

A Natural Fiber Reinforced Epoxy Resin Composite (NFREC) is a polymer matrix composite with epoxy resin as matrix and glass fiber as reinforcement. GFREC is used in aircraft gliders, automotive leaf springs, etc... The volume fraction of fiber and matrix decides the strength of the composite. Since it is a NFRP it is manufactured by hand lay-up technique. A hardener is mixed with epoxy resin during fabrication in 1:10 ratio which acts as matrix. NFREC has high strength to weight ratio and so engineers are trying to replace metals by NFREC. Composites offer significant weight saving over existing metals. Composites can provide structures that are 25-45% lighter than the conventional aluminum structures designed to meet the same functional requirements. This is due to the lower density of the composites.

IV. WOVEN NATUAL FIBER ROVINGS

This light weight 200 GSM woven natural fabric is a very high performance E-glass perfect for more advanced composites products such as radio controlled planes, UAVs, robotics and other precision applications. GSM refers to grams per square meter. Higher GSM refers to high strength. Alumina-calcium-borosilicate glasses with a maximum alkali content of 2 wt. % used as general purpose fibers where strength and high electrical resistivity are required.

Fig. 2: Woven Natural Fiber

V. TENSILE TESTING OF FABRICATED MATERIAL

The hybrid composite material fabricated is cut into required dimension using a saw cutter and the edges finished by using emery paper for mechanical testing. The tensile test specimen is prepared according to the ASTM D638 standard. The dimensions, gauge length and cross-head speeds are chosen according to the ASTM D638 standard. A tensile test involves mounting the specimen in a machine and subjecting it to the tension. The testing process involves placing the test specimen in the testing machine and applying tension to it until it fractures. The tensile force is recorded as a function of the increase in gauge length. During the application of tension, the elongation of the gauge section is recorded against the applied force. The tensile test is performed on the Universal Testing Machine (UTM) Make FIE (Model: UTN 40, S.No. 11/98-2450). The fabricated specimen for tensile test is presented in Fig.3

Fig. 3: Specimen for Tensile Test

Batch Test Report	
Test Name	TENSILE Test
Test Type	Normal
Test Mode	Tensile
Elongation Device	Cross Head
Test Parameter	Peak Load
Test Speed [mm/min]	2.00

Sample No.	CS Area [mm^2]	Peak Load [N]	% Elongation	UTS [N/mm^2]
000001	75.000	14611.563	11.800	194.817

Table 1: Tensile Test Report

Variables	**CS Area [mm^2]**	**Peak Load [N]**	**% Elongation**	**UTS [N/mm^2]**
Min	75.000	14611.563	11.800	194.817
Max	75.000	14611.563	11.800	194.817
Avg	75.000	14611.563	11.800	194.817
Std. Dev.	0.000	0.000	0.000	0.000
Variance	0.000	0.000	0.000	0.000
Median	75.000	14611.563	11.800	194.817

Table 2: Summary Report

VI. FLEXURAL TESTING OF FABRICATED MATERIAL

The flexural specimens are prepared as per the ASTM D790 Standards. The 3-point flexure test is the most common flexural test for composite materials. Specimen deflection is measured by the crosshead position. Test results include flexural strength and displacement. The testing process involves placing the test specimen in the universal testing machine and applying force to it until it fractures and breaks. The specimen used for conducting the flexural test is presented in Fig.4

Fig. 4: Specimen for Flexural Testing

Batch Test Report	
Test Name	BENDING Test
Test Type	Normal
Test Mode	Compression
Elongation Device	Cross Head
Test Parameter	Peak Load
Test Speed [mm/min]	2.00

Sample No.	CS Area [mm^2]	Peak Load [N]	Flexural Strength [Mpa]	Flexural Modulus [GPa]
000001	39.000	466.466	376.761	2282.658

Table-3: Flexural Test Report

Variables	**CS Area [mm^2]**	**Peak Load [N]**	**Flexural Strength [Mpa]**	**Flexural Modulus [GPa]**
Min.	39.000	466.466	376.761	2282.658
Max.	39.000	466.466	376.761	2282.658

Avg.	39.000	466.466	376.761	2282.658
Std. Dev.	0.000	0.000	0.000	0.000
Variance	0.000	0.000	0.000	0.000
Median	39.000	466.466	376.761	2282.658

Table 4: Summary Report

VII. CONCLUSION

The use of composite materials in the different fields is increasing day by day due to their improved properties. Engineers and Scientists are working together for number of years for finding the alternative solution for the high solution materials. In the present study of natural fiber composite materials and their effect on mechanical properties is evaluated. The test results for the Tensile and Flexural testing for the fabricated glass fiber material is shown in previous pages. From that result we found that,

- The tensile strength is 194.817 N/mm^2
- The flexural strength is 376.761 N/mm^2

From the results, it can be asserted that the Natural fiber composite materials are performing well compared to the other type of fibers used.

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