BEHAVIOUR OF MECHANICAL PROPERTIES OF NATURAL FIBER COTTON AND SILK REINFORCED EPOXY COMPOSITE

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Abstract - *Now- a-days, the natural fibers from renewable natural resources offer the potential to act as a reinforcing material for polymer composites alternative to the use of, carbon and other manmade fibers. Among various fibers, cotton silk is the most widely used natural fiber due to its advantages like easy availability, low density, low production cost and satisfactory mechanical properties. For a composite material, its mechanical behavior depends on many factors such as fiber content, orientation, types, length etc., attempts will be carried to find the tensile, compression &bending properties for the specimen prepared as per ASTM standard. They are insoluble in each other and differ in form or chemical composition. Experimental techniques can be employed to understand the effects of various fibers, their volume fractions and matrix properties in hybrid composites. These experiments require fabrication of various composites with the above mentioned parameters, which are time consuming and cost prohibitive. Therefore, a computational model is created as will be described in detail later, which might be easily altered to model hybrid composites of different volume fractions of constituents, hence saving the designer valuable time and resource*

Key Words: **Natural fiber, epoxy composites, compression test, wear test.**

1.INTRODUCTION

This module introduces basic concepts of stiffness and strength underlying the mechanics of fiber-reinforced advanced composite materials. This aspect of composite materials technology is sometimes terms micromechanics because it deals with the relations between macroscopic engineering properties and the microscopic distribution of the material's constituents, namely the volume fraction of fiber. This module will deal primarily with unidirectional reinforced continuous fiber composites, and with properties measured along and transverse to the fiber direction. Materials are the basic elements of all natural and man-made structures. Materials used in the design and manufacture of products are as follows.

Fig 1. Different types of materials

High stiffness means that material exhibits low deformation under loading. However, by saying that stiffness is an important property we do not mean that it should be necessarily high. The ability of a structure to have controlled deformation (compliance) can also be important for some applications (e.g., springs; shock absorbers; pressure, force, and displacement gauges). Stiffness and strength the structure cannot exist. Naturally, both properties depend greatly on the structure's design but are determined by the stiffness and strength of the structural material because a good design is only a proper utilization of material properties.

In the past ten years, materials R&D has shifted from monolithic to composite materials, adjusting to the global need for reduced mass, low cost, quality, and high performance in structural materials.[1]

1.1 DEFINITION OF COMPOSITE: Composite materialism a material composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc.

1.1.1 Matrix phase:

1. The primary phase, having a continuous character,

2. Usually more ductile and less hard phase,

3. Holds the reinforcing phase and shares a load with it.

1.1.2 Reinforcing phase:

1. Second phase (or phases) is imbedded in the matrix in a discontinuous form.

2. Usually stronger than the matrix, therefore it is sometimes called reinforcing phase.

1.2 MATRIX

The matrix binds the fibers together and acts as the medium by which an externally applied stress is transmitted and distributed to the fibers and only a small portion of an applied load is sustained by matrix phase. [3]

1.2.1 FUNCTIONS OF A MATRIX

1. The matrix Binds Fiber together.
2. It protects the individual fibers from surface damages as a result of mechanical abrasion or chemical reaction with the environment.
3. It separates the fibers by virtue of its plasticity and relative softness it prevents the propagations of brittle cracks from fiber to fiber, which can result in failure.
4. Adequate bonding forces between fiber and matrix is essential to maximize the stress transmittances from weak matrix to strong fibers.

1.2.2 PROPERTIES OF MATRIX: The ideal matrix should have following properties.

- It must be thermally and chemically compatible with the fibers.
- It must adhere properly with the fibers.
- It must have a low shrinkage during cure, thus residual stresses.
- It must have good mechanical properties.

1.3 REINFORCEMENT:

The addition of strong reinforcement fibers significantly increases the mechanical properties of thermoplastic and thermo set materials. Typical reinforcements include glass fibers, carbon fibers, aramid fibers and bio fiber. Fiber morphologies include continuous strand, woven, roving, and / or chopped fibers, the nature of the fiber used depends on the application of the plastic. For example, chopped fiber is typically used in resins destined for injection or compression molding In the present work natural fibers are used. [3]

1.3.1 REQUIREMENTS OF A FIBER: The properties required by the fibers in composites are

- The fiber should have a high modulus of elasticity in order to give efficient reinforced.
- The fiber should have a greater ultimate strength.
- The fiber should be stable and retain their strength during handling and fabrication.
- The variation of strength between individual fibers should be low.

1.3.2 NATURAL COMPOSITES: Several natural materials can be grouped under natural composites. E.g. bones, wood, shells, pearlite.

1.3.3 MAN-MADE COMPOSITES: Man-made composites are produced by combining two or more materials in definite proportions under controlled conditions. e.g. bricks, Plywood, Chipboards, Decorative laminates etc.

1.4 COMPOSITES:

The term composite could mean almost anything if taken at face value, since all materials are composed of dissimilar subunits if examined at close enough detail.

Many composites used today are at the leading edge of materials technology, with performance and costs appropriate to ultra-demanding applications such as spacecraft. But heterogeneous materials combining the best aspects of dissimilar constituents have been used by nature for millions of years.

1.4.1 PROPERTIES OF COMPOSITES: The following are the various properties of composites

- Composites possess excellent Strength and Stiffness
- They are very light Materials
- They possess high resistance to corrosion, chemicals and other weathering agent
- High strength to mass ratio (low density high tensile strength)
- High toughness

1.4.2 TYPES OF COMPOSITES: In a broad way composite materials can be classified on basis of matrix materials

- 1. Metal matrix composites
- 2. Ceramic matrix composites
- 3. Polymer matrix composites
- 4. Carbon and Graphite composites

1.4.3 CLASSIFICATION OF NATURAL FIBRES

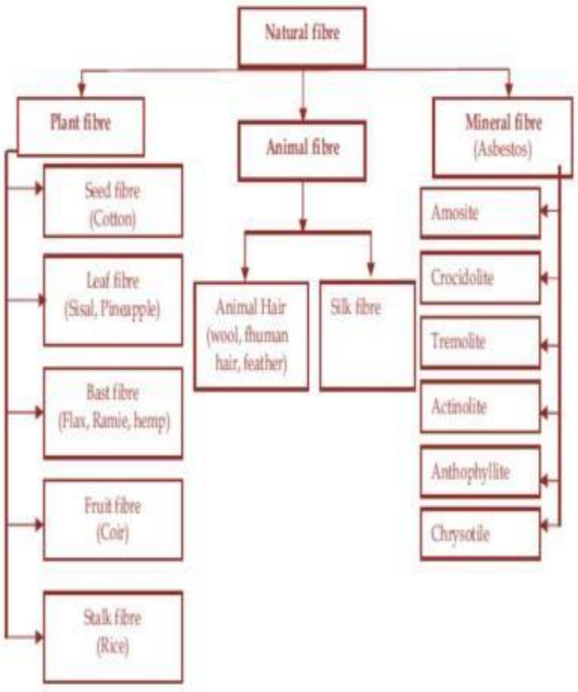


Fig2. Classification of natural fiber

Fig3. cotton and silk used as fiber

2. LITRATURE SURVEY

1. **Sang Muk Lee , Donghwan Cho , Won Ho Park , Seung Goo Lee , Seong Ok Han , Lawrence T. Drzal:** shows that, novel short silk fibre (Bombix mori) reinforced poly(butylenes succinate) bio-composites have been fabricated with varying fibre contents by a compression molding method and their mechanical and thermal properties have been studied in terms of tensile and flexural properties, thermal stability, thermal expansion, dynamic mechanical properties, and microscopic observations.

2. N. Venkateshwaran et.al: in this study, the tensile strength and modulus of short, randomly oriented natural fiber reinforced hybrid composites was predicted using the Rule of Hybrid Mixtures equation. It was observed that the Rule of Hybrid Mixtures equation predicted tensile properties of hybrid composites are little higher than experimental values.

3. M. Ashok Kumar, et.al: In this article, the epoxy-based hybrid composites were developed by combining the areca and glass fibers into epoxy matrix. Hardness, impact strength, frictional coefficient, and chemical resistance of hybrid composites with and without alkali treatments.

4. Mansur and Aziz: studied bamboo-mesh reinforced cement composites, and found that these reinforcing materials could enhance the strength and toughness of the cement matrix, and increase its tensile.

5. Maryam, Che, Ahmad, Abu Bakar: studied The effect of surface treatment on the inter-laminar fracture toughness of silk/epoxy composite has been studied. The multi-layer woven silk/epoxy composites were produced by a vacuum bagging process in an autoclave with increasing layers of silk fiber of between 8 and 14 layers.

3. OBJECTIVES

1. Preparation of hybrid composites by combining different types of fibers Like Areca–Glass fiber and Jute-Glass fiber with Matrix material Epoxy (CY-230) (2%, 4% and 6%) using hand layup Technique.

2. Fabricated specimens will be subjected to mechanical testing like bending, tensile test and compression test of Specimens as per ASTM standards.

3. Comparison of test results for the combination of cotton-silk fiber and glass.

4. EXPERIMENTAL WORK

This chapter describes the details of Fabrication of the composites the raw materials used in this work are:

1. Epoxy resin
2. Silk
3. Cotton
4. Glass fibers

4.1 MATERIAL SELECTIONMATRIX:

Epoxy is a thermosetting polymer that cures (polymerizes and cross links) when mixed with a hardener.

Epoxy resin is the most important matrix used in the high performance of transport system.

Epoxy resin of the grade CY-230 with a density of 1.1–1.3 g/cm3is used. The hardener used is HY-951. The matrix material was prepared with a mixture of epoxy and hardener HY-951 at a ratio of 10:1.

4.2 FIBERS: When natural fiber composite were subjected to at the end of their life cycle, to a combustion process or landfill the amount of CO_2 released of the fibers is neutral with respect to their assimilated amount during their growth.

4.2.1COTTON FIBERS: Cotton is a natural cellulosic fiber. It is widely used natural fiber. It is a soft, fluffy staple fiber that grows in a boll, or protective capsule. The fiber is almost pure cellulose. Cotton plants of the genus gossypium in the mallow family malvaceae. The cotton fibers contains 91.00% of Cellulose ,0.55% of Protoplasm, Pectins, 0.40% of oil, Waxes and Fatty Substances ,0.2%mof Mineral Salts , 1% of protein and 6.85% of water.

Fig5. Cotton fibers

4.2.2 SILK FIBER: Silk is a natural protein fiber, some forms of which can be woven into textiles. The protein fiber of silk is composed mainly of fibroin and is produced by certain insect larvae to form cocoons. The silk fiber consist of 75% of Fibroin 22.5% of Sericin 1.5% of fat and wax 0.5% Ash of Silk Fibroin 0.5% Mineral Salt.

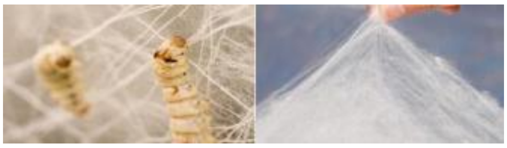


Fig6. Silk Fiber

4.2.3 GLASS FIBRE

Glass fiber (also spelled glass fiber) is a material consisting of numerous extremely fine fibers of glass. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer.

The types of glass fiber most commonly used are mainly E-glass (alumino-borosilicate glass with less than 1% w/w alkali oxides, mainly used for glass-reinforced plastics), but also A-glass (alkali-lime glass with little or no boron oxide), E-CR-glass (alumino-lime silicate with less than 1% w/w alkali oxides, has high acid resistance), C-glass (alkali-lime glass with high boron oxide content, used for example for glass staple fibers), R-glass (alumino silicate glass without MgO and CaO with high mechanical requirements), and S-glass (alumino silicate glass without CaO but with high MgO content with high tensile strength).

Fig.7. Glass Fibers

5 TESTING OF COMPOSITE MATERIAL

5.1. BENDING TEST:

The bending test method measures behavior of materials subjected to simple beam loading. It is also called a transverse beam test with some materials. Bending testing is often done on relatively flexible materials such as polymers, wood and composites. Test results include bending strength and bending modulus.

The flexural strength was measured using the following equation.

$$\xi = 3.P.L/2.b.e^2$$

Where, ξ - Bending strength, MPa
P - Rupture load, N
L - Support span, mm
b - Width of specimen, mm
e - Thickness of specimen, mm

Fig 8. Bending test specimen

Table 1. Bending test Dimension of specimen

Length	240mm
Breadth	50mm
Thickness	10mm

5.2 COMPRESSION TEST: To study the behavior of given specimen under compressive load and to determine the compressive strength. The compression test is just opposite to tensile test with regard to direction.

Formulae
Compressive strength = (Load in N/ Area in mm2)

Fig9 . compression test specimen

Table 2. Compression test standard Dimension of specimen

Length	10 mm
Breadth	10 mm
thickness	10 mm

5.3 .WEAR TEST

Wear generally defined as a progressive loss or displacement of material from a solid surface as a result of relative motion between that surface and another. All mechanical components that undergo sliding or rolling contact are subject to some degree of wear.

Fig 10. wear test specimen

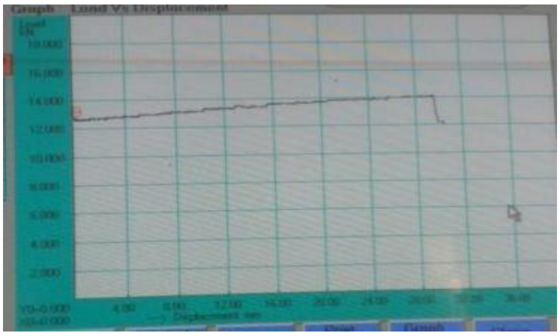
Table 3. Wear standard Dimension of specimen

Length	50mm
Breadth	10mm
Thickness	10mm

6 TEST RESULTS

6.1 BENDING TEST RESULTS

6.1.1. FOR 2% NATURAL FIBER

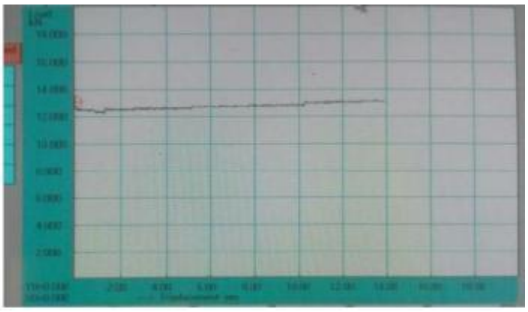


Graph 1. 2% Natural Fiber

Results of bending test

Maximum force(Fm) : 12.960 KN
Bending strength : 0.9675 KN/mm^2

6.1.2 . FOR 4% NATURAL FIBER

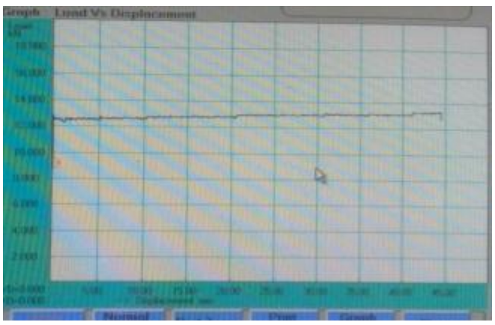


Graph 2. 4% Natural Fiber

Results of bending test

Maximum force (Fm) : 13.140 KN
Bending strength : 0.9855 KN/mm^2

6.1.3. FOR 6% NATURAL FIBER



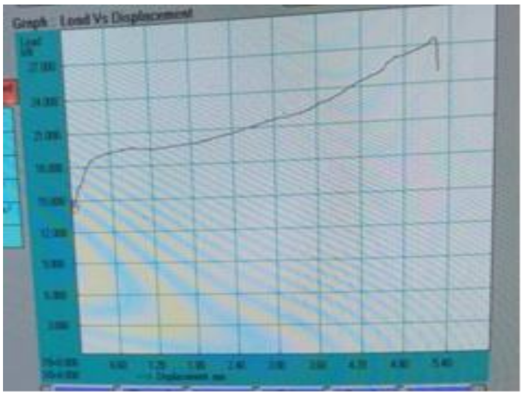
Graph 3. 6% Natural Fiber

Results of bending test

Maximum force (Fm) : 13.860KN
Bending strength: 1.039 KN/mm

6.2 COMPRESSION TEST RESULTS

6.2.1. FOR 2% NATURAL FIBER

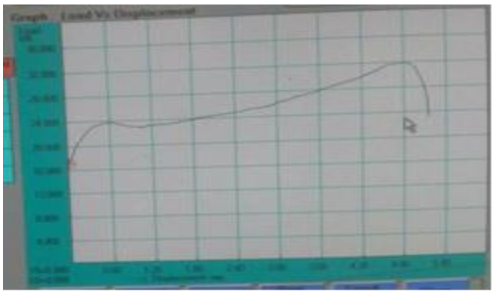


Graph 4 . 2% Natural Fiber

Results of compression test

Maximum force (Fm) : 20.550 KN
Disp. at Fm :4.690 mm
Max. disp. :5.860 mm
C/s area : 78.571 mm^2
Compressive strength : 0.262 KN/mm^2

6.2.2. FOR 4% NATURAL FIBER

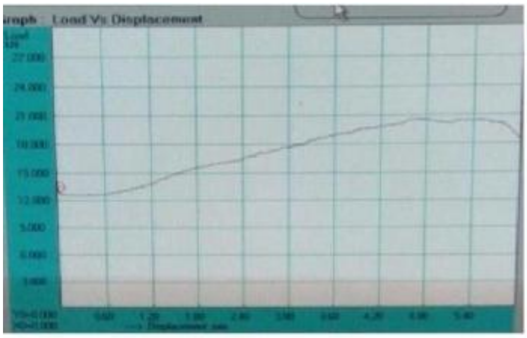


Graph 5 . 4% Natural Fiber

Results of compression test

Maximum force(Fm): 27.510 KN
Disp. at Fm : 5.140 mm
Max. Disp. : 5.270 mm
C/s area : 100.00mm2
Compressive strength : 0.350 KN/mm2

6.2.3. FOR 6% NATURAL FIBER



Graph 6. 6% Natural Fiber

Results of compression test

Maximum force (Fm) :31.770 KN
Disp. at Fm : 4.660 mm
Max disp : 5.050 mm
C/s area : 78.571 mm^2
Compressive strength : 0.404 KN/mm^2

6.3 Results of wear test

Wear test were conducted to get the wear volume of the given specimen.

6.3.1. For 2%,4%,6%of natural fiber The wear volume V= KLW/P mm^3
Wear coefficient, K=% of wt loss/(sliding dist.* load)
Sliding distance, L=2πRNT/1000 in m.
P=Indentation hardness in kg/sq .mm.(P=74.25 hardness of brass std)
R=dist. b/w center of disc to center of pin(R=50mm)

Table 4. Wear test results

Fiber	Load (kg)	Speed(rpm)	Time (min)	Weight of specimen		Loss of weight	% of wt loss
	W	N	T	w1	w2	w1-w2	%
2%	2.4	400	15	5.98	5.94	0.04	0.668
4%	2.4	400	15	5.74	5.71	0.03	0.522
6%	2.4	400	15	6.13	6.11	0.02	0.326

6.4 CALCULATION

1) For 2% fiber

$L=2\pi x50x400x15/1000=1884.95m$

$K=0.668/(1884.95x2.4) =3.02x10^{-3}$

$V=(3.02x10^{3}x1884.95x2.4)/74.25=1.84x10^{2}mm^{3}$

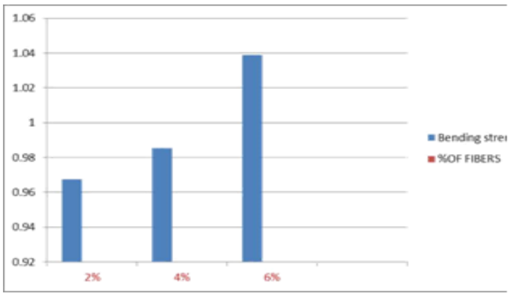
2)For 4% fiber

L=2πx50x400x15/1000=1884.95mm
K=0.522/(1884.95x2.4) =2.36x10^{-3}
V=(2.36x10^{3}x1884.95x2.4)/74.25=1.43x10m^{3}

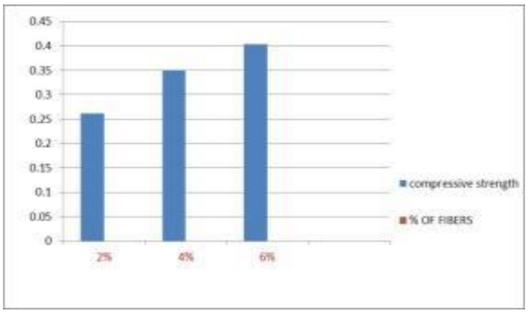
3)For 6% fiber

L=2πx50x400x15/1000 =1884.95
K=0.326/(1884.95x2.4) =.1.47x10^{3}
V=(1.47x10^{3}x1884.95x2.4)/74.25=8.956X10^{5}mm

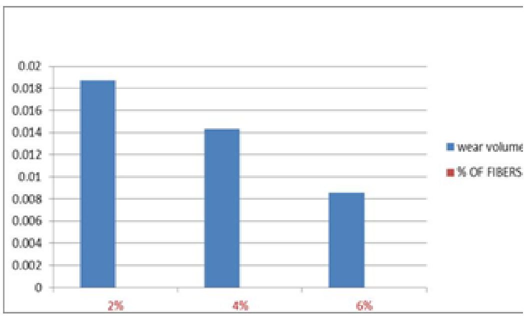
6.4.1 COMPARISON GRAPH



Graph 7. Comparison graph of bending



Graph 8. Comparison graph of compression



Graph 9. Comparison graph of wear

7 CONCLUSION

The object is to find the mechanical behavior of natural fiber reinforced Hybrid epoxy composites. The glass fiber, Cotton and silk were used to fabricate hybrid natural composites with varying the fiber percentage from 2-6%. The maximum compressive strength of 0.402 KN/mm^{2} was found for the fiber loading (mass fraction) of 6% for both glass fiber, Cotton and silk fiber Hybrid Epoxy composite., Cotton and silk fiber Hybrid Epoxy composite. The maximum bending strength of1.0395 KN/mm^{2} was found for the fiber loading (mass fraction) of 6% for both glass fiber, Cotton and silk fiber Hybrid Epoxy composite.

SCOPE FOR FUTURE WORK

1. In the present, work interest is given for the study of Bending, wear and compressive strength analysis only. But the same work can be extended for shear, and fatigue strength analysis.

2. FEA can be used for all the elastic constants.

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