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Study of mechanical properties of hybrid natural fiber composite

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ABSTRACT: *The present experimental study aims at learning the mechanical behaviour of hybrid natural fiber composites. Samples of several Jute-Bagasse-Epoxy & Jute-Lantana camara-Epoxy hybrids were manufactured using hand layup method where the stacking of plies was alternate and the weight fraction of fibre and matrix was kept at 40%-60%.Specimens were cut from the fabricated laminate according to the ASTM standards for different experiments. For Tensile test & flexural test samples were cut in Dog-bone shape and flat bar shape respectively.*

I. INTRODUCTION

A composite is combination of two materials in which one of the materials, called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. The matrix is more ductile than the fibers and thus acts as a source of composite toughness. The matrix also serves to protect the fibers from environmental damage before, during and after composite processing. When designed properly, the new combined material exhibits better strength than would each individual material. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications.

Jartiz [1] stated that “Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form”.

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.

Beghezan [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. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

Classification of composites

According to the type of reinforcing material composites can be classified as:

(1)Fibrous Composite:

A fiber is characterized by its length being much greater compared to its cross-sectional dimensions. The dimensions of the reinforcement determine its capability of contributing its properties to the composite. Fibers are very effective in improving the fracture resistance of the matrix since a reinforcement having a long dimension discourages the growth of incipient cracks normal to the reinforcement that might otherwise lead to failure, particularly with brittle matrices.

(2)Particulate Composites:

In particulate composites the reinforcement is of particle nature. It may be spherical, cubic, tetragonal, a platelet, or of other regular or irregular shape. In general, particles are not very effective in improving fracture resistance but they enhance the stiffness of the composite to a limited extent.

According to type of matrix material they are classified as:

Metal Matrix Composites (MMC)

Ceramic Matrix Composites (CMC)

Polymer Matrix Composites (PMC)

(1)Metal Matrix Composites:

Higher strength, fracture toughness and stiffness are offered by metal matrices. Metal matrix can withstand elevated temperature in corrosive environment than polymer composites. titanium, aluminium and magnesium are the popular matrix metals currently in vogue, which are particularly useful for aircraft applications. Because of these attributes metal matrix composites are under consideration for wide range of applications viz. combustion chamber nozzle (in rocket, space shuttle), housings, tubing, cables, heat exchangers, structural members etc.

(2)Ceramic matrix Composites:

One of the main objectives in producing ceramic matrix composites is to increase the toughness. Naturally it is hoped and indeed often found that there is a concomitant improvement in strength and stiffness of ceramic matrix composites.

(3)Polymer Matrix Composites:

Most commonly used matrix materials are polymeric. In general the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. These difficulties are overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites need not involve high pressure and doesn"t require high temperature. Also equipments required for manufacturing polymer matrix composites are simpler. For this reason polymer matrix composites developed rapidly and soon became popular for structural applications. Two types of polymer composites are:

(a) Fiber reinforced polymer (FRP)

(b) Particle reinforced polymer (PRP)

(a)Fiber Reinforced Polymer:

Common fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcement and the main source of strength while matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. Sometimes, filler might be added to smooth the manufacturing process, impact special properties to the composites, and / or reduce the product cost.

(b)Particle Reinforced Polymer:

Particles used for reinforcing include ceramics and glasses such as small mineral particles, metal particles such as aluminium and amorphous materials, including polymers and carbon black. Particles are used to increase the modules of the matrix and to decrease the ductility of the matrix.

1.3 Hybrid composite

Hybrid composites are more advanced composites as compared to conventional FRP composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other fiber reinforced composites. Normally it contains a high modulus fiber with low modulus fiber.The high-modulus fiber provides the stiffness and load bearing qualities, whereas the low-modulus fiber makes the composite more damage tolerant and keeps the material cost low. The mechanical properties of a hybrid composite can be varied by changing volume ratio and stacking sequence of different plies.

1.4 Natural fiber reinforced composites

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocellulosic fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber-containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc.

1.5 Applications of natural fiber composites

The natural fiber composites can be very cost effective material for following applications:

Building and construction industry: panels for partition and false ceiling, partition boards, wall, floor, window and door frames, roof tiles, mobile or pre-fabricated buildings which can be used in times of natural calamities such as floods, cyclones, earthquakes, etc.

II. MATERIALS AND METHODS

The following section will elaborate in detail the experimental procedure carried out during the course of our project work. The steps involved are:
1. Specimen Fabrication (Fabrication of FRP).
By Hand Lay-Up method.
Cutting of Laminates into samples of desired dimensions.
2. Tensile test
3. Flexural test (3-Point Bend test)
4. SEM of fractured surface

Raw materials

Raw materials used in this experimental work are:
(i) Natural fiber
Jute
Bagasse
Lantana camara
(ii) Epoxy resin
(iii)Hardener

A. Hand lay-up technique:

The fiber piles were cut to size from the jute fiber cloth. The appropriate numbers of fiber plies were taken: two for each. Then the fibers were weighed and accordingly the resin and hardeners were weighed. Epoxy and hardener were mixed by using glass rod in a bowl. Care was taken to avoid formation of bubbles. Because the air bubbles were trapped in matrix may result failure in the material. The subsequent fabrication process consisted of first putting a releasing film on the mould surface. Next a polymer coating was applied on the sheets. Then fiber ply of one kind was put and proper rolling was done. Then resin was again applied, next to it fiber ply of another kind was put and rolled. Rolling was done using cylindrical mild steel rod. This procedure was repeated until eight alternating fibers have been laid. On the top of the last ply a polymer coating is done which serves to ensure a god surface finish. Finally a releasing sheet was put on the top; a light rolling was carried out. Then a 20 kgf weight was applied on the composite. It was left for 72 hrs to allow sufficient time for curing and subsequent hardening.(Figure(1))

III. EXPERIMENT PROCEDURE

Cutting of laminates into samples of desired dimensions:

A WIRE HACKSAW blade was used to cut each laminate into smaller pieces, for various experiments:
TENSILE TEST- Sample was cut into dog bone shape(150x10x5)mm.
FLEXURAL TEST- Sample was cut into flat shape(20x150x5)mm, in accordance with ASTM standards. fig(3.1& 3.2)

Tesnsile test:

The tensile strength of a material is the maximum amount of tensile stress that it can take before faliure. The commonly used specimen for tensile test is the dog-bone type. During the test a uniaxial load is applied through both the ends of the specimen.fig 4

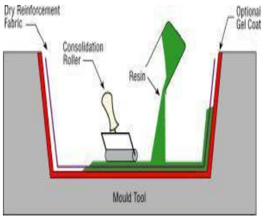
Flexural test

Flexural strength is defined as a materials‟s ability to resist deformation under load. The short beam shear (SBS) tests are performed on the composites samples to evaluate the value of inter-laminar shear strength (ILSS). It is a 3-point bend test, which generally promotes failure by inter-laminar shear. This test is conductedas per ASTM standard using UTM. The loading arrangement is shown in figure . The dimension of the specimen is (20x150x5)mm. It is measured by loading desired shape specimen(6x6-inch) with a span length at least three times the depth. The flexural strength is epressed as modulus of rupture(MR) in psi (MPa) .fig 5

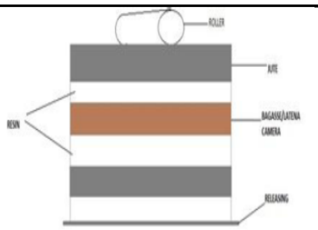
SEM FRACTROGRAPHY

The surfaces of the specimens are examined directly by scanning electron microscope JEOL JSM-6480LV as shown in Figure 3.4. The composite samples are mounted on stubs with silver paste. To enhance the conductivity of the samples, a thin film of platinum is vacuum-evaporated onto them before the photomicrographs are taken.fig 6

Figures and Tables



Fig(1). Hand Lay-Up Technique


Fig(2).Hybrid Natural Fiber Composite


Fig(3.1) Dog-Bone Shape


Fig(3.2) Flat Bar Shape


Fig(4)UTM Machine Sample Loaded Condition For Tensile Testing


Fig(5)UTM Machine Sample Loaded Condition For Tensile Testing


Fig(6) Scanning Electron Microscope(SEM)

IV. CALCULATION TABLE :

For the preparation of the composite we calculate the percentage of fibers, polymer and hardener required from the table we come to know about the amounts accurately.

S No	Jute (%)	Lantana Camara (%)	Bagasse (%)	Epoxy (%)
1	20	-----	20	60
2	20	20	-----	60

V. RESULT & CONCLUSION

FLEXURAL TEST

Table 1:

SAMPLE NAME	LENGTH mm	BREADTH mm	THICKNESS mm	EXTENSION mm	MAXIMUM LOAD(N)
J-B-J	150	20	5	1.45	701
J-LC-J	150	20	5	1.86	691.1

TABLE 2 THREE POINT BEND TEST DATA

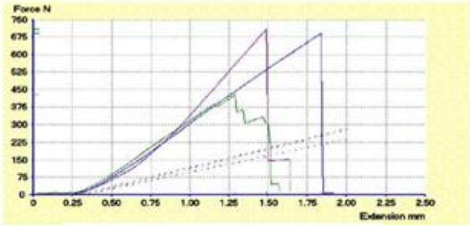
Graph: Variation of force with extension in 3 point bend test

Tensile Test

SAMPLE NAME	LENGTH mm	BREADTH mm	THICKNESS mm	EXTENSION mm	MAXIMUM LOAD(N)
J-B-J	150	(20-10)	5	2.803	859.3
J-LC-J	150	(20-10)	5	3.168	1651.7

TABBLE 3 RESULTS OF TENSILE TEST

SEM ANALYSIS



Graph: Variation of force with extension in 3 point bend test

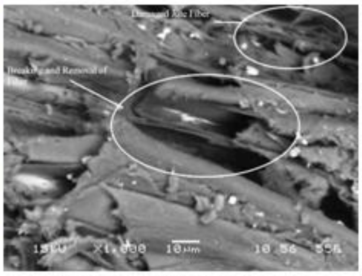


FIG 6 SEM MICROGRAPH OF JUTE BAGASSE FLEXURAL

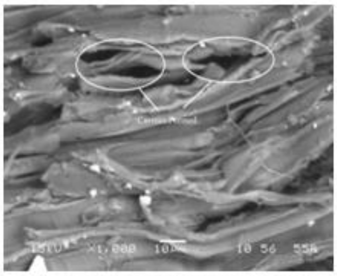


FIG 7 SEM MICROGRAPH OF JUTE LANTANA CAMARA FLEXURAL

1. The jute, bagasse and lantana camara fibers was successfully used to fabricate hybrid natural composites with 40% fiber and 60 % resin, these fibers are bio-degradable and highly crystalline with well aligned structure. So it has been known that they also have higher tensile strength than glass, good elasticity, excellent resilience and in turn it would not induce a serious environmental problem like in glass fibres.
2. The flexural strength of pure epoxy resin is 130-136 MPa with (7-9.5)% elongation. With increase of fiber loading capacity by 20%, the flexural strength value increases to 155.5MPa for Jute-bagasse and 310.9MPa for jute-lantana camara.
The tensile strength of epoxy is 62-72 MPa wit 3-4 % elongation and with increase of fiber loading capacity by 20 % the tensile strength increase.
So, it is clearly indicates that inclusion of natural fibers improves the load bearing capacity (tensile strength) and the ability to withstand bending (flexural strength) of the composites.
3. In flexural test, Jute-lantana camara combination sustains more elongation than jute-bagasse combination, but there is no large difference in maximum load of both samples. Due to more elongation in jute-lantana combination it has more flexural strength than jute-bagasse sample.
4. In tensile test also jute-lantana has more elongation than jute-bagasse combination, and hence the tensile strength of jute-lantana camara is more than jute-bagasse sample.
5. By comparing the flexural strength and tensile strength of the composites with varying, the best mechanical property results are obtained with jute-lantana camara combination.
6. From SEM micrograph it is clearly visible that fiber is nicely embaded with matrix but still there are some cavaties.

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