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Bending Strength and Hardness Investigation of Sizel/Coir Reinforced Composite Materials with Matrix Material (Epoxy LY 556)

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Abstract :-Polymer matrix composites reinforced with Synthetic fibers such as glass, carbon, aramid, etc. though they are expensive these are being used in various application since they favorable mechanical properties. Now a days natural fibers occurring such as sisal, flax, hemp, jute, coir, bamboo, banana, etc. are widely used for environmental concern over synthetic fibers. Engineered bio-composites are needed to meet the needs of users for construction and commodity products which will simultaneously maximize the sustainability of natural resources. These engineered bio-composites are opening new markets. In this project, Hybrid fibers like Jute and Glass fibers, Sisal and Coir fibers are reinforced with Epoxy matrix and composites have been developed by manual hand layup technique. These natural fibers were treated with NAOH (Alkali treatment) for better fiber matrix adhesion. The fiber percentages (20%, 30%, & 40% by weight) were used for the preparation of hybrid composites. These natural fiber reinforced hybrid composites were then characterized by Flexural test.

Keywords:-Polymer matrix Composite **,** Hybrid fibers, Sisal, Epoxy, Jute fiber

I. INTRODUCTION

Composites are becoming an essential part of today's materials because they offer advantages such as low weight, corrosion resistance, high fatigue strength, faster assembly, etc. Composite materials are formed by reinforcing two or more materials of varying properties. Composites are made up of individual materials referred to as constituent materials. There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required.

The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The

reinforcements impart their special mechanical and physical properties to enhance the matrix properties.

Composites typically have a fibre 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 fibre axis. The matrix is more ductile than the fibres and thus acts as a source of composite toughness. The matrix also serves to protect the fibres 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.

Composites are composed of resins, reinforcements, fillers, and additives. Each of these constituent materials or ingredients plays an important role in the processing and final performance of the end product. The resin or polymer is the "glue" that holds the composite together and influences the physical properties of the end product. The reinforcement provides the mechanical strength. The fillers and additives are used as process or performance aids to impart special properties to the end product. The primary reason for choosing composite is because of weight saving for their relative stiffness and strength and composite can have twice the modulus and up to seven times the strength.

A. Properties of Composites

The following are the various properties of composites

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

C. Classification Of Composites

Two phases make up the structure of composites.

- Matrix Phase.
- Reinforcing Phase.

i. Matrix Phase: This is the constituent that is continuous in a composite material. The matrix phase binds the fibres together and acts as the medium by which an externally applied stress is transmitted and distributed to the fibres; only a very small proportional of an applied load sustained by the matrix phase.

ii. Reinforcing Phase (Reinforcement): It reinforces or enhances the mechanical properties of the matrix. In the most cases, the reinforcement is harder, stronger and stiffer than the matrix. Reinforcement can either be particulate or fibrous. The dimensions of the reinforcement determine its capability of distributing its properties to the composite.

- *Matrix Phase*

Based on the types of Matrix used, the composites are classified as

i) Metal Matrix Composite (MMC)
ii) Ceramic Matrix Composite (CMC)
iii) Polymer Matrix Composite (PMC)

- Metal Matrix Composite (MMC)

Metal Matrix Composites are composed of a metallic matrix (aluminum, magnesium,iron,) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum)phase. This article reviews developments in the Metal matrix composites.

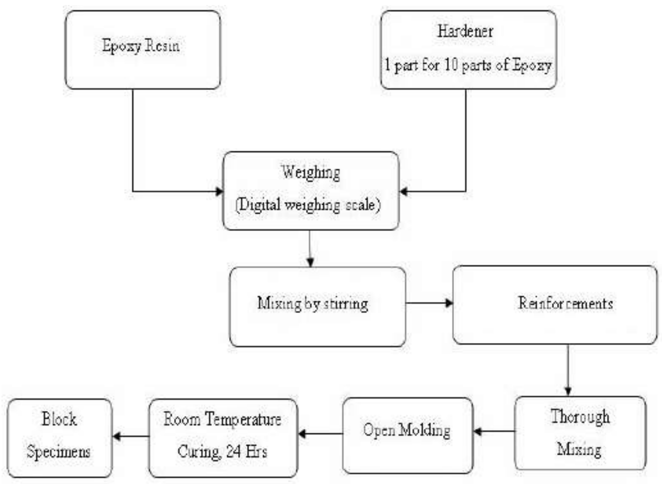
- Ceramic Matrix Composite (CMC)

Ceramic matrix composites are used in very high temperature environments. These materials use a ceramic as the matrix and reinforce it with short fibres, or whiskers such as those made from silicon carbide and boron nitride.

Polymer Matrix Composites (PMC)/Carbon Matrix Composites Or Carbon-Carbon Composites Polymers make ideal materials as they can be processed easily, possess lightweight, and desirable mechanical properties. It follows, therefore, that high temperature resins are extensively used in aeronautical applications.

II. METHODOLOGY

The methodology of fabrication of composite



A. Fabrication By Hand Lay-Up Technique

In this process resins are impregnated by hand into fibres which are in the form of woven or bonded fabrics. Hand layup process usually accomplished by rollers or brushes. The composite plates from which the test specimens were fabricated by employing the traditional Hand layup technique. This is a very popular method of composite fabrication, limited by its ability to produce simple shapes. Initially, a plate consisting of epoxy resin or polyester resin with glass and hemp fibre, jute fibre reinforcement was fabricated. The plate was made up of 55% fibre and 45% Resin by weight. The hand layup technique is as shown in Fig 2

Fig 2 Hand lay-up technique

C. Fabrication Procedure

Hand lay-up is a simple method for composite production. A mold must be used for hand lay-up parts unless the composite is to be joined directly to another structure. The mold can be as simple as a flat sheet as. The Fibre piles were cut according to dimensions from the sisal and coir. Depending on the thickness required numbers of Fibre plies were taken., resin and hardeners were weighed. Epoxy and hardener were mixed respectively 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. Before lay-up, a release sheet is placed in the mold to insure that the part will not adhere to the mold. A coat of laminating Epoxy resin was then applied by brush. Follow by the first layer of chopped strand mat one type Fibre ply. Then the laminating epoxy resin was applied to the reinforcement so that the trap air can be force out using roller. This procedure was continued for next layer of Fibre ply, until desired thickness is achieved. On the top of the last ply a epoxy or polyester coating is done which serves to ensure a god surface finish. Finally a releasing sheet was put on the top and light rolling was carried out. Then a 20 kgf weight was applied on the composite. Once finished, allow the resin to cure for 24 hrs and subsequent hardening. Finally, remove the Product from the mould.

III . THE ORETICAL STUDY

PURPOSE OF TESTING COMPOSITE MATERIALS

- Evaluate and optimize materials.
- To determine the effect of equipments and tool design.
- Evaluate and optimize manufacturing process available.
- To establish engineering design information.
- To measure quality and reproducibility of end products.
- To ensure quality of raw materials.

A. Types Of tests Conducted

- Flexural test
- Hardness test

B. Flexural Test

A flexural test produces tensile stress in the convex side of the specimen and compression stress in the concave side. This creates an area of shear stress along the midline. To ensure the primary failure comes from tensile or compression stress the shear stress must be minimized. This is done by controlling the span to depth ratio, the length of the outer span divided by the height of the specimen. For most materials S/d=16 is acceptable. Some materials require S/d=32 to 64 to keep the shear stress low enough.

C. Types of Flexure Tests

Flexure testing is often done on relatively flexible materials such as polymers, wood and composites. There are two test types; 3-point flex and 4-point flex. In a 3-point test the area of uniform stress is quite small and concentrated under the centre loading point. In a 4-point test, the area of uniform stress exists between the inner span loading points.

The 3-point flexure test is the most common for polymers. Specimen deflection is usually measured by the crosshead position. Test results include flexural strength and flexural modulus.

D. Flexural strength = 3PLo / 2Wot²

Align the loading nose and support such that the cylindrical surface is parallel and the loading nose is mid way between the supports. Apply the load to the specimen at the specified rate and take simultaneous load deflection data. Measure the deflection by gauge placed under the specimen at the centre of the supports span.

E. Calculations

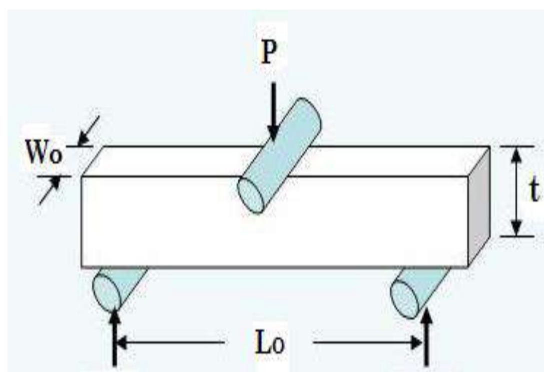


Fig 4.4 Three point bending specimen

Flexural strength = $3PL_o / 2W_ot^2$

Where P = Applied central load (KN)

Lo = Test span of the specimen (mm)

Wo = Width of the specimen (mm)

t = Thickness of specimen (mm)

Calculation for flexural strength of 20% Sisal / Coir Fiber [P=1.33KN]

$$FS = 3PL_o / 2W_ot^2$$

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$$FS = 3*1.33*120 / 2*50*5^2$$

$$\mathbf{FS = 191.52\ N/mm^2}$$

Calculation for flexural strength of 30% Sisal / Coir Fiber [P=1.82KN]

$$FS = 3PLo / 2Wot^2$$

$$FS = 3*1.82*120 / 2*50*5^2$$

$$\mathbf{FS = 262.08\ N/mm^2}$$

Calculation for flexural strength of 40% Sisal / Coir Fiber [P=2.14KN]

$$FS = 3PLo / 2Wot^2$$

$$FS = 3*2.14*120 / 2*50*5^2$$

$$\mathbf{FS = 308.16\ N/mm^2}$$

F. Flexural Test Setup

- Pre load: 50N
- Span: 64mm
- Stop at: 1kN

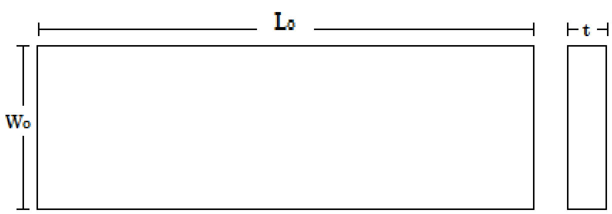


Fig 4.5 Flexural test specimen (All dimensions are in mm)

Overall length(Lo) : 120mm
Overall width(Wo) : 50mm
Thickness (t) : 5mm

Fig 4 Equipment for Flexural Testing

Fig 5 Loading Arrangement for Flexural Testing

G. Procedure

- Flexural test was conducted according to ASTM D-790
- Specimen is cut according to ASTM D-790
- Specimen plate is placed as simply supported beam and a central load is applied.
- Load is slowly applied by deforming the specimen.
- Load at which maximum deformation is noted down.
- Procedure is repeated for different trials.

H. Hardness Test

The Rockwell Hardness test is a hardness measurement based on the net increase in depth of impression as a load is applied. Hardness numbers have no units and are commonly given in the R, L, M, E and K scales. The higher the number in each of the scales means the harder the material. A minor load of 10 kg is first applied, which causes an initial penetration and holds the indenter in place. Then, the dial is set to zero and the major load is applied. Upon removal of the major load, the depth reading is taken while the minor load is still on. The hardness number may then be read directly from the scale.

Table 1 .Specification of Hardness scale

Rockwell Hardness scale	Minor load Kg	Major load Kg	Indenter diameter cm	Indenter diameter mm
R	10	60	1.27700	127.7
M	10	100	0.63500	63.5

Specimen size

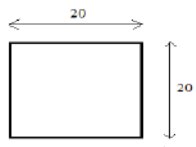


Fig 6 Hardness test specimen (All dimensions are in mm)

Fig .7 Equipment for Hardness Test

I. Procedure

- Hardness test conducted according to ASTM D-785
- Specimen is prepared according to ASTM D-785
- Specimen is placed an anvil
- Minor load is applied
- Major load is applied
- Rockwell hardness number is noted down.

1V. RESULTS AND DISCUSSION

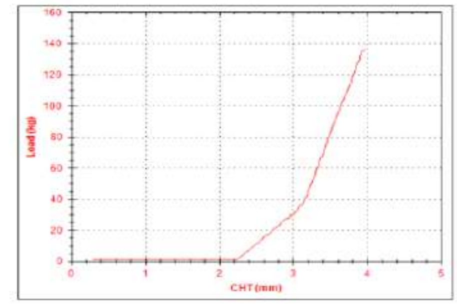
A. Flexural Test Results

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 conducted as per ASTM standard. The loading arrangement is shown in Fig. It is measured by loading desired shape specimen with a span length at least three times the depth. The flexural strength is expressed in Mpa. The flexural test results are tabulated in the table 2

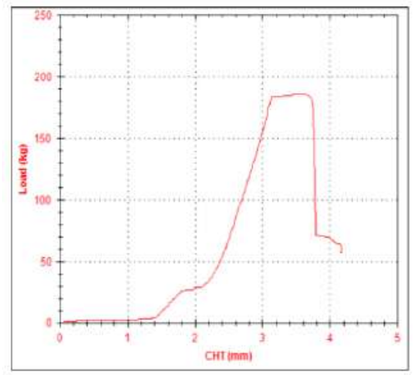
Wight fiber %	Bending Strength
Sisal/coir 20%	191.52
Sisal/coir 30%	262.08
Sisal/coir 40%	308.16

Table 2 Comparison of bending strength

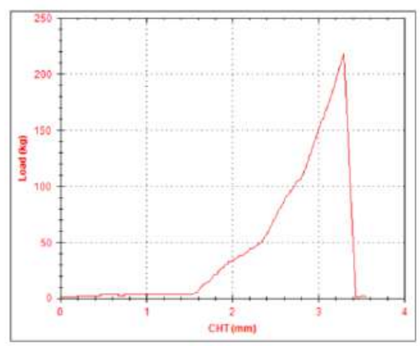
1. Testing is carried out According to ASTM D790
2. There is an improvement in the bending strength of the composites in every weight percentage. Due to the better packing of the fibers in the Composite as Fiber weight percentage increases. Graph 1, 2, 3 Shows bending strength of sisal-coir composites.



Graph 1 Load vs displacement Curve for 20% of Sisal / Coir fiber



Graph 2 Load vs displacement Curve for 30% of Sisal / Coir fiber



Graph 3 Load vs displacement Curve for 40% of Sisal / Coir fiber

B. Hardness Test Result

Rockwell hardness test was carried out to find the hardness of the composite material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. The result is a dimension less number noted as HRA, where "HR" is (Hardness Rockwell), A is the scale letter. The hardness test result is tabulated in table 3

Wight fiber %	Hardness
Sisal/coir 20%	82
Sisal/coir 30%	95
Sisal/coir 40%	102

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V. CONCLUSIONS

1. The new hybrid composite (Sisal - Coir Composite) produced with natural fibers as reinforcements gives good tensile properties as compared with pure matrix material. This hybrid composite can be used in industrial and domestic applications. (In automobile body building, office furniture packaging industries).

2. The low density Natural fibers is used to prepare the Composite Material in the place of synthetic fibers (Glass fibers, carbon fibers, etc...), hence the composites can be regarded as a useful light weight Engineering Material.

3. Bending strength and Hardness increases with increasing percentage of fiber from 20% to 40%.

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