Investigation of Mechanical Properties of Hybrid Natural Fiber Reinforced Polymer Composite Using Sisal Fiber and Borassus Flabellifier Fiber

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Abstract- *The natural fibers are used in the composite laminates increases highly due to the easy availability, bio-degradable, inexpensive and eco-friendly in nature reasons. The natural fiber are reinforced with the polymer matrix gains has the advantage like light weight, good stiffness, high modulus and strength. On the other side, the natural fibers having some limitations and it must overcome to make them competitive to the synthetic fibers. In this Paper, Work has been focus to investigate the mechancial properties such as flexural, tensile of the composites made by reinforcing of sisal and borassus flabellifier as the new natural fibers into epoxy resin matrix. The sisal fiber and borassus flabellifier fiber reinforcements were fabricated by retting and manual process. The natural fiber composite material were prepared using sisal/borassus flabellifier fibers of 20/10, 15/15 weight fraction ratios. From the study, weight fraction of the fibers improves the flexural and tensile properties up to a certain point. The hybridization of these natural fiber reinforcement in the composite expected to appear a better flexural and tensile strength related to the individual natural fibers reinforced composites*.

Keywords- Hybrid composites, sisal fiber, borassus flabellifier fiber

I. INTRODUCTION

Structural materials of high strength, less weight and low cost, in general strong materials are relatively dense and light materials have less strength. In order to achieve high strength and less weight, it requires combining two or more distinct materials to get composite materials. Fibers are of hair-like material which are in the form of unremitting threads or distinct elongated filament like pieces. Fibers can be easily turned into filaments or cord and also it can be matted into paper like sheets. Fibers plays as a vital role in the formation of composites materials. Fibers are of two types: natural fiber and man-made or synthetic fiber.

Natural fibers, as reinforcement, have the following advantages over other established materials. They are environmentally friendly, fully biodegradable, abundantly available, and renewable. Plant fibers are light compared to glass, carbon and aramid fibers. Natural fibers like banana, cotton, coir, sisal, jute etc., are widely used in the composite material formation and used individually or suitable combination of fibers which is necessary for the application selected. Study shows that the natural fiber composites are having additional advantageous like good electrical resistance, greater fracture resistance and better insulating properties in thermal and acoustics. These materials are also renewable, having high strength and it will not give any causes to human skins. On the other hand, there are also some disadvantages, such as moisture absorption, quality variations and low thermal stability. Natural fibers include those made from plant, animal and mineral sources. Natural fibers can be classified according to their origin as Animal fiber (like Sheep's wool), Mineral fiber (like Glass fibers) and Plant fiber like (cotton, jute).

Hybrid Composite materials are created by the combination of two or more fibers which are of different types in a common matrix and short fibers which are having variations in length and diameter will have over advantageous compare to the usage of single fibers in a polymer matrix. From the study, hybridization of the materials is mostly done with natural fibers combine with the glass fibers for the properties betterment and they possess good calorific value and less health and handling issues. More than that, it shows better mechanical properties with low density at cheaper rate. Due to these salient features the composite materials is often used in the field of automobile and construction.

In this present work of study, an Epoxy based Sisal and Borassus Flabellifier Fiber Hybrid composite has been considered and their behaviour are tested under the mechanical loading. Sisal fiber and borassus flabellifier fiber is a widely available in natural, which can grow abundantly in numerous climatic conditions. These plants can be found in the hot regions like Australia, India, West India, Sub-Saharan Africa, Argentina and Cold regions like East Asia and Northern United States. The mechanical properties sisal and borassus flabellifier such as stiffness, impact strength and flexibility are high and are comparable to the synthetic fibers such as glass fiber. The potential for development of structures made of sisal and borassus flabellifier is used minimal and its application as a composite materials is also limited. In the present work, their properties of sisal fiber in combination with borassus flabellifier in an epoxy based matrix have been studied.

Bledzki et al [1] have investigated the effect of introduction of Flax and jute fibers on the mechanical properties of the composites. Increasing the fiber content results in an increase in the shear modulus and impact strength of the composites. Joshi et al [2] investigated the effect of hybridization of chopped glass fibers with small amounts of mineral fibers. It was found that hybridization makes the glass fiber composites more suitable for technical applications. The hybridization of natural fibers with synthetic fibers, which are stronger and more corrosion resistant are gaining much interest. The idea is that by using two types of fibers in a hybrid composite, the shortcomings of one can be compensatedby the advantages of the other. Through proper material design, a balance in properties may be achieved. Velmurugan et al [5] studied the mechanical properties of randomly mixed short fiber composites and estimated the optimum fiber length and fiber loading. They dealt with the properties of randomly mixed palmyra fiber and glass fiber reinforced rooflite hybrid composites Valente et al [6] studied the mechanical properties of recycled glass fiberwood flour reinforced composites. The properties studied included flexural modulus and strength, hardness crew withdrawal resistance and water absorption behaviour. From the literature survey, the combination of sisal - borassus flabellifier fibers was never used as a composite material and the behaviour of these natural composite material were studied under the mechanical loading conditions.

II. MATERIALS AND METHODOLOGY

a) Specimen Fabrication (Fabrication of FRP).
- By Hand Lay-Up method.
- Compression moulding.
- Cutting of Laminates into samples of desired dimensions.

b) Tensile test.
c) Flexural test.

The palm tree which containing Borassus fruits are available abundantly especially in India which belongs to the palmae family. The palm trees well grown-up in the dry areas and they are drought resistant. The Borassus fruit fiber is a cellulosic fiber (Fig.1). Matured Borassus fruit contains cellulosic semi-solid flush which is reinforced by the Borassus fruit fibers and Borassus flabellifer is the botanical name of Borassus fruit fiber.

Fig.1 Borassus fruits

Sisal fibre is extracted from the leaves of the Agave sisalana plant. They fiber is prepared directly by hand and it is widely used for making ropes, carpets and clothing. The features of the sisal fibres is based on the individual constituents, fibrillar structure and the lamellae matrix. The fibre is collected of numerous extended fusiform fibre cells which is taper towards each end. The fibre cells which are linked together by middle lamellae which having hemicellulose, lignin and pectin.

Fig.2 Sisal Plant

The epoxy resins contribute to the strength, durability and chemical resistance of the composite. Epoxy is a copolymer and is formed from two different chemicals. These are referred to as the resin and the hardener. LY 556 is used as a resin for bonding the two different fibers. The performance of epoxy hardeners in the epoxy resins system depend on the chemical and physical characteristics of the epoxy. The chemical characteristics of the epoxy resins that influence epoxy hardeners are: viscosity and kind of diluents and fillers in epoxy resins. Hardener of grade HY 951 is used in the study.

III. FABRICATION OF COMPOSITE FIBER

a) Preparation of Fiber

Sisal and borassus flabellifier which are brought and cleaned with water and dried. Then the aggregations are gently dispersed with hand sitting patiently. Then its outer shell is removed by the knife and it is cut into required dimension. After that it is measured for proper weight and kept.

b) Preparation of Epoxy and Hardener

Epoxy LY556 of density 1.15–1.20 g/cm^3, mixed with hardener HY951 of density 0.97–0.99 g/cm^3 is used to prepare the composite plate. The weight ratio of mixing epoxy and hardener is 10:1. This has a viscosity of 10-20 poise at 250°C. Hardeners include anhydrides (acids), amines, polyamides, dicyandiamide etc.

Table.1 Percentage of Composite for preparation

Epoxy (%)	Hardener (%)	Sisal fiber (%)	Borassus fiber (%)
60	10	15	15
60	10	20	15

a) 15:15 Ratio b) 20:15 Ratio

Fig.3 Fabricated Composite Fiber

IV.EXPERIMENT PROCEDURE

A Wire Hacksaw blade was used to cut each laminate into smaller pieces, for various experiments:

- Tensile Test- Sample was cut into flat shape (250 x 25 x 10) mm.
- Flexural Test- Sample was cut into flat shape (150 x 25 x 10) mm, in accordance with ASTM standards.

Fig.4 Tensile and Flexural Test Specimen

The Tensile Test

The tensile properties of the composites were measured as per the standard test method ASTM D638-89. The test specimens with 250 mm long, 25 mm wide and 10 mm thick were prepared. Five identical specimens were tested for each type of composite.

Fig.5 Tensile Test on Composite Material

Overlapping aluminium tabs were glued to the ends of the specimen with epoxy resin filling the space at the tab overlap to prevent compression of the sample and also for effective gripping in the jaws of the chuck. The specimens were tested at a cross head speed of 1 mm/min.

Flexural strength was measured under a three-point bending approach using a universal testing T-machine according to ASTM D790 as shown in Fig.6. The dimensions of the samples were 150mm x 25mm x 10mm. The distance between the spans was 100mm, and the strain rate was 1 mm/min. Four specimens were tested for each case; the averages were reported as results.

Fig.6 Flexural Test on Composite Material

VII. RESULTS & DISCUSSION

THE TENSILE PROPERTIES

Tensile test was also carried out on UTM machine in accordance with ASTM standard and stress-elongation curve was plotted. The typical graph generated directly from machine for tensile test for sisal/borassus flabellifier composite.

1. Ratio: 20:10 (sisal: borassus)

Load cell: 500 kg
Speed: 20.000 cm/min

Table.2 Tensile Test for specimen ratio 20: 10

Specimen	C.S.A	Peak Load	Tensile Strength	Elongation	Modulus @100%
	Sq.cm	Kg	kg/sq.cm	%	kg/sq.cm
002Si	2.5000	184.775	73.9101	1.6732	0.0000

All the specimens were of flat shape of dimension (250x25x10) mm. The results are tabulated in the table 2 for ratio (20:10) and table.3 for ratio (15:15) and graphs were plotted for both ratio combinations.

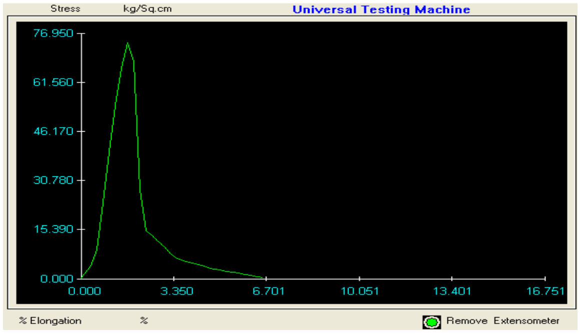

Fig.7 Stress – Elongation Curve for Specimen Ratio 20:10

2. Ratio – 15: 15 (sisal: borassus)

Load Cell: 500kg
Speed: 1.000 cm/min

Table.3 Tensile Test for specimen ratio 15: 15

Speci m-en	C.S.A	Peak Load	Tensile Strength	Elongat-ion	Modulus @100 %
	Sq.cm	kg	kg/sq.cm	%	kg/sq.cm
004Si	2.5000	41.3210	16.5284	1.8932	0.0000

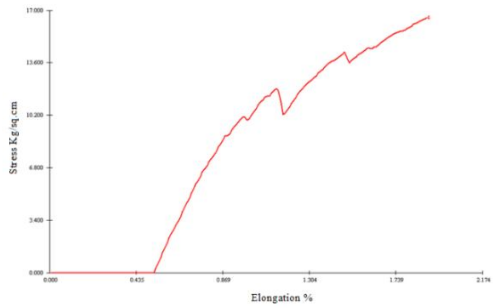

Fig.8 Stress – Elongation Curve for Specimen Ratio 15:15

Table.3 Comparison of Tensile Test

Specimen		C.S.A	Peak Load		Tensile Strength		Elongation	
1	2	Sq.cm	Kg		kg/sq.cm		%	
002Si	004Si	2.5000	184.77	41.32	73.91	16.52	1.67	1.89

THE FLEXURAL PROPERTIES

Three point bend test was carried out in the same UTM machine in accordance with ASTM standard to measure the flexural strength of the composites and stress-elongation curve was plotted. The typical graph generated directly from machine for tensile test for sisal-borassus flabellifier composite. The specimens (composites) were of rectangular shape having dimension of (150 x 25 x 10) mm. The span length was 75mm. The experiment was conducted on both samples of combinations. The results are tabulated in the table 4 for ratio (20:10) and table 5 for ratio (15:15) and graphs were plotted for both ratio.

1. Ratio – 20:10 (sisal: borassus)

Load cell: 500 kg
Speed: 1.00 cm/min

Table.4 Flexural Test for specimen ratio 20: 10

Specimen	Maximum load	Flexural stress	Width	Depth	Span
	kg	kg/sq.cm	cm	cm	Cm
002Si	22.4990	9.3746	2.5000	1.2000	10.000

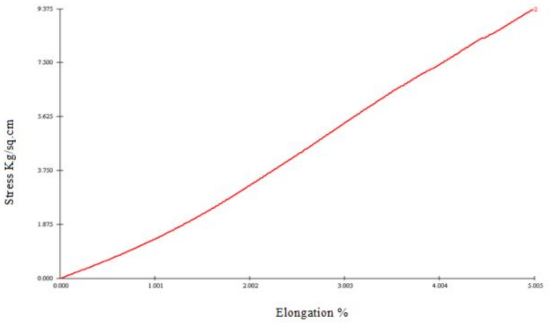

Fig.9 Stress – Elongation Curve for Specimen Ratio 20:10

2. Ratio – 15:15 (sisal: borassus)
Load cell: 500 kg
Speed: 1.000 cm/min

Table.5 Flexural Test for specimen ratio 15: 15

Specimen	Maximum load	Flexural stress	Width	Depth	Span
	kg	kg/sq.cm	cm	cm	cm
001Si	18.3190	76.3292	2.5000	1.2000	10.0000

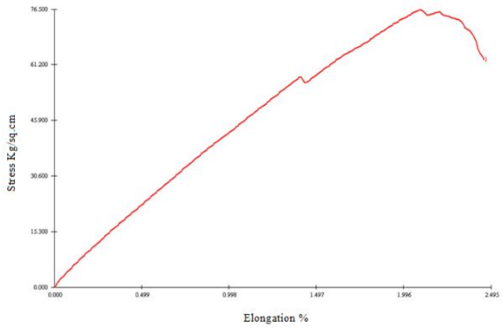

Fig.10 Stress – Elongation Curve for Specimen Ratio 15:15

Table.6 Comparison of Flexural Test

Specimen		Max. load		F.stress		Width	Depth	Span
1	2	kg		kg/sq.cm		cm	cm	cm
002Si	001Si	22.4990	18.390	9.3746	76.3292	2.5000	1.2000	10.0000

VIII. CONCLUSION

The mechanical properties of the natural fiber reinforced hybrid composites which is made-up of hand lay-up method is determined based on the experimental results the following conclusions are made. The sisal-borassus flabellifier hybrid composite with the weight fraction of 20/15 shows the maximum flexural strength and flexural modulus. The sisal-borassus flabellifier hybrid composite with the weight fraction of 20/15 proves maximum tensile strength. The test results indicated that the hybridization of these natural fibers shows sizeable improvement in the flexural strength compare to the individual reinforcement. Due to the low density properties of the natural fibers compared to the synthetic fibers this composites can be considered for light weight applications. This study can also be extended to the altered weight fraction and different combination of composites and the experimental results can be analysed in the same way. Tribological evaluation of these sisal and borassus flabellifier fiber reinforced epoxy resin composite may be studied and also other aspects like effect of fiber orientation, loading pattern, weight fraction of ceramic fillers on wear response can be studied in the future.

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