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Mechanical Behavior of Polymer Resin Composites Reinforced with Banana Fiber

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Abstract*: The present work investigates the tensile and flexural strength of natural banana fiber composites. Natural fibers have incontrovertible advantages over synthetic reinforcing materials such as non-toxicity, low density, low cost, comparable durability, and limited waste disposal issues. Banana fiber reinforced composites are being prepared in the current experiment and the strength properties of these composites have been evaluated. Using the hand lay-up process, the composite specimens with variable fiber lengths were prepared and pressed at room temperature. Mechanical testing such as tensile, flexural are applied to the specimens. Analysis of the scanning electron microscope (SEM) is performed to examine fiber matrix interfaces and to analyze the fractured surface structure.

Keywords: Composite, Mechanical Properties, Banana Fiber, SEM.

I. INTRODUCTION

Growing factors such as threats to the environment, biodegradability, non-toxicity etc. lead the researchers to concentrate on investigating the characteristics of natural materials such as natural fibers. A lot of research is going on in the polymer matrix composites to make use of natural fibers as a reinforcement material. Because of its hydrophilic nature, thermal and chemical instability, the researchers face many challenges in making the natural fiber appropriate for their needs. But now natural fibers of a day can to some degree replace synthetic fibers by making them compliant with polymer matrixes with certain techniques of surface modification.Santhosh et.al. [1] have studied various natural fibers such as coir, sisal, jute, coir and banana are used as reinforcement materials. Baburaja et al.[2,4] have worked on utilization of aluminium and the challenges concerned in manufacturing and machining of hybrid aluminium MMC. Hybrid materials are those materials which consists of two or more different materials, one is of organic origin.

Chintalapudi et al.[3] have focused on casting and fabrication of duralumin with E- glass fiber hybrid composite where epoxy resin was used as a binder and prepared a sandwich panel by hand lay-up process to analyze tensile, flexural and impact strengths. Jagadale and Padhi[5,6] have performed a series of experiments to examine the ability of coir fiber as a polymer composite refurbishing material and the effect of the resulting fiber length change composites on the mechanical and thermal behavior.

Pothan et al. [7] have studied the significance of fiber length and fiber quantity on short banana fiber filled polyester composite. The maximum tensile strength was obtained at a fiber length of 30 mm and impact strength was getting maximum at of 40 mm fiber length banana fiber polyester composite. As the fiber quantity increased up to 40%, the tensile strength increased by 20% and there was a 34% increase in impact strength. Functionally graded materials (FGMs) are a class of composite materials that are made of a mixture of ceramics and metals graded by a gradual change in the mechanical properties from surface to surface and thus remove the residual stresses at the interface of the layers found in laminated composites. Padhi et al.[8,10,13] have analyzed the property variation and effect of hub radius on the stability of FGM beams. Pujari et.al. [9] discussed in detail about the uses & applications of jute and banana fiber composites. Sumaila et.al [11] have analyzed the effects of Banana fiber length on the physical and mechanical properties of banana fiber/epoxy composite were investigated. Five separate specimens were obtained by varying the fiber length at 30 percent wt from 5 mm to 25 mm. Fiber loading using the technique of hand layout molding. The composite was tested for mean density, percent absorption of moisture, void material, tensile strength, tensile modulus, percent elongation, compressive strength, impact power, flexural strength and modulus. Results showed that the percentage of absorption of moisture, void content and compressive strength increased with fiber length increases while density decreases were observed. Nevertheless, at 15 mm fiber lengths the tensile strength, tensile module and percent elongation had their highest values of 67.2 MPa, 653.07 MPa and 5.9 percent indicating critical fiber length for efficient and total stress transfer. On the other hand, the impact energy at failure decreased for 5 mm and 25 mm fiber lengths respectively with an increase in fiber length from 80J to 40J.Raghavendra et.al [12] have worked on composites that are made up of using short Banana fibers and natural rubber. Composites are prepared using vulcanizing at 1500c. And composites obtained were determined for mechanical properties like tensile strength were determined. Kumar and Choudhary [14] have studied the Banana fiber reinforced epoxy composite for evaluation of tensile strength ,

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flexural strength and impact strength .they have proposed that 30%weigth fraction of fiber had much better mechanical properties than 20%, and 10% weight fraction of fiber reinforcement in case of both glass fiber as well as banana fiber reinforced. Lakshman et.al [15] have prepared specimen of continues fiber by varying the weight percentage of fiber (5% to 20%). and finally they have determined the tensile strength & impact strength to determine the stresses, strain and displacement. Mishra et al.

[16] have fabricated jute fiber epoxy composites by hand lay-up method and studied the physical and mechanical properties of the prepared composites. They concluded that the presence of voids in the composites adversely affect its mechanical properties. Hariprasad et al. [17] have carried out study on mechanical properties of banana-coir hybrid composite using experimental and FEM techniques. The stresses at the interface of the banana-coir and matrix, induced by the different loading conditions, were applied to predict the tensile, impact, and flexural properties by using the FEA models. The model output was compared with the experimental results and located to be shut. This analysis is beneficial for realizing the benefits of hybrid fiber strengthened composites in structural applications and for characteristic wherever the stresses are vital and injury the interface underneath varying loading conditions. Shringi et al. [18] have studied on Mechanical Properties Characterization of Natural Fiber Polymer Composite by Numerical Methods. This includes evaluation of tensile strength, flexural strength, has been studied and discussed. The interpretation of the results and the comparison among various composite samples are also presented under this study.Natural fibers, especially in Konaseema Coast, are not only strong and light weight, but mostly cheap and abundantly available material. The present work describes natural banana fiber composites formation and analysis. Using UTM, the mechanical properties were measured and the results are tabulated at various volume fractions. Experimental results showed that Tensile, static composites are greatly influenced by the percentage of volume fraction of reinforcement and indicate that bananas can be used as reinforcing material for many structural and non-structural applications.

II. EXPERIMENTAL

In this paper each treated and untreated banana fiber are taken for the event of the hybrid material. The untreated banana fiber and caustic soda treated banana fiber are used as reinforcing material for each organic compound epoxy glue/synthetic resin matrix and Vinyl organic compound resin matrix. The banana fiber content is unbroken constant to half-hour of weight fraction of entire material. Study and analyze the difference of mechanical properties. There, the durability is measured by the universal testing machine, the impact strength is calculated by the pendulum impact test and the flexural strength is determined by the universal testing machine with the specimen's flexural test structure. Then the treated and untreated specimens are analyzed and compared through Scanning microscope to check concerning its adhesion between fiber and rosin matrix and surface morphology.

A. Materials:

Banana fibers and epoxy resin are the components used in this manufacturing project. Epoxy resin 520 and Epoxy hardener-PAM. Weight combined the epoxy resin and epoxy hardener. The density of the epoxy resin is 1.22 g / cc. Until fiber mats were inserted in the matrix material, epoxy resin and hardener mixture were thoroughly stirred. Each laminate was healed in the mould under constant pressure nearly 24hrs and healed at room temperature at least 12 hours later. The banana fiber is extracted from the banana plant as shown in figure, which was collected from local sources. The extracted banana fiber was then dried in the sun for eight hours and dried in the oven for 24 hours in order to remove free water in the fiber. The Physical properties of Banana fiber is shown in Table.1.

Fig 1: Raw Banana fiber

Fig 2: Dried and segregated banana fiber

Table.1: Physical properties of Banana fiber

Property	Range
Cellulose (%)	63-64
Hemi cellulose (%)	19
Lignin (%)	5
Moisture (%)	10-11
Density (g/cm3)	1-1.5
Elongation at break (%)	4.5-6.5
Young's modulus (gpa)	20
Microfibrillar angle (deg.)	11
Lumen size (mm)	5

B. Preparation of composites

The preparation method used here is the process of hand lay-up followed by the application of compression moulding to apply pressure. The standardized fiber laminates of 4 mm thickness are made of banana fibers of similar length. There are many layers in the matrix. The laminates are impregnated with epoxy resin. Hardner is mixed with epoxy resin in order to ensure good binding. Originally, the banana fibers were dried under the hot sun to extract moisture for more than 24 hours. The fiber sheets are washed in the acetone thinner before delivery. It removes impurities from them and allows them to bind to the resin. The banana fibers are mounted on the board on the base plate and the epoxy resin is then filled completely. The resin is mixed with the fiber and may dry up in the open atmosphere under the hot sun for 48 hours. Before the resin is dried, the second layer must be placed on it.

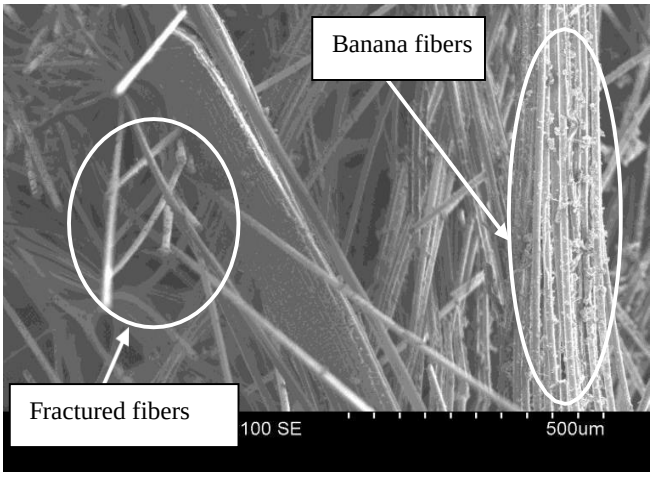
Also the process is repeated for another sheet. The applied epoxy resin is distributed over the entire surface through a roller and gently squeezing removes the air gaps created during manufacture between layers. The specimen is then pressed under the pressure of 6MPa at a temperature of 32 ° C and the average relative humidity is 65%. Three such specimens are prepared, checked with different lengthssuch as 5mm, 10mm and 15mm and the average values are used for detailed analysis.

III. RESULTS AND DISCUSSION

A. Scanning Electron Microscopy (SEM) Analysis

Due to mechanical mounting, SEM analyzes consider the structure of the broken surfaces. The SEM micrographs are used to identify the internal cracks, broken surfaces and internal structure of the sample samples of the structural materials. The sample that is subjected to SEM micrograph tensile loading is shown in Fig.3. Thanks to tensile stacking, the micrograph shows clearly the strengthening of banana fibers and fiber fracturing.

The composite sample's SEM image was subjected to flexural loading in Fig.4. The figure clearly showed that the broken banana fibers acted in the perpendicular direction of the banana fiber reinforcement due to the load usage. The figure also showed the banana fiber and fiber dispersion structure in the matrix. Figure shows the SEM micrograph of the sample that is subject to impact loading. The banana fiber layer break is clearly visible in the picture.



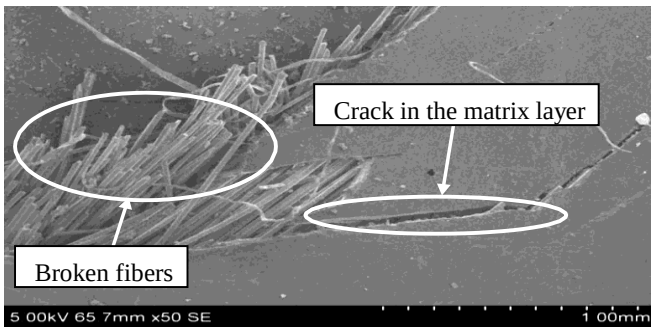


Fig 3: SEM Image of Tensile testing fractures

Fig 4: SEM Image of Flexural testing fractures

B. Tensile Testing:

Using a hand cutter, the prepared specimen is shaped into the required size and the edges are polished using polish paper. It is formulated in compliance with standard ASTM D638. According to the ASTM D638 standard, the dimensions, gage length and cross head speeds are selected. On the Universal Testing Machine (UTM) as shown in fig.5, the tensile test is performed.

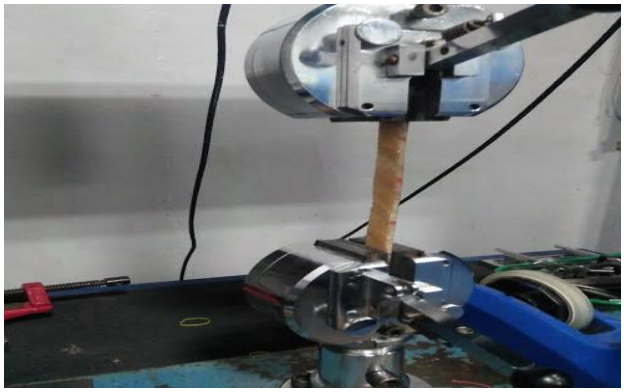


Fig 5: Tensile Testing Setup

The process involves placing the sample of the test in the UTM and applying tension to it until the material is fractured. The force is then recorded as a function of the gauge length increase. The elongation of the gauge section is recorded against the applied force during the application of tension. Three different types of samples were prepared in accordance with ASTM standards and multiple tensile test experiments

Sr. No.	Specimens of different fiber length	U.T.S. (N/mm^2)		Average U.T.S. (N/mm^2)
		Trial 1	Trial 2	
1	A (5mm)	15.336	15.093	15.21
2	B (10mm)	17.025	16.957	16.99
3	C (15mm)	18.015	18.925	18.47

were conducted. The average values of Tensile strength were used for discussion and shown in Table.2 and their tensile strengths were compared in fig.6.

Table.2: Tensile Test results of Banana fiber specimens

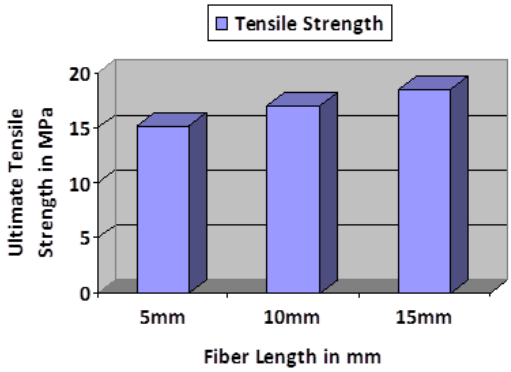


Fig 6: Effect of fiber length on Tensile strength.

C. Flexural testing

Flexural testing involves bending a material to determine the relationship between bending stress and deflection, rather than pushing or pulling it. Brittle materials such as ceramics, stone, masonry and glasses are commonly used for flexural testing.

It can also be used to examine the behavior of materials intended to bend during their useful life, such as wire insulation and other elastomeric products.

The main advantage of a three-point flexural test is the ease of preparation and testing of the specimen. Nonetheless, this approach also has some drawbacks: the test method results are prone to sample and load geometry and strain frequency.

Three different types of samples were prepared similar to tensile testing in accordance with ASTM standards and multiple flexural test experiments were conducted in the flexural testing setup as shown in fig.7. The average values of flexural strength were used for discussion and shown in Table.3 and their flexural strengths were compared in fig.8.

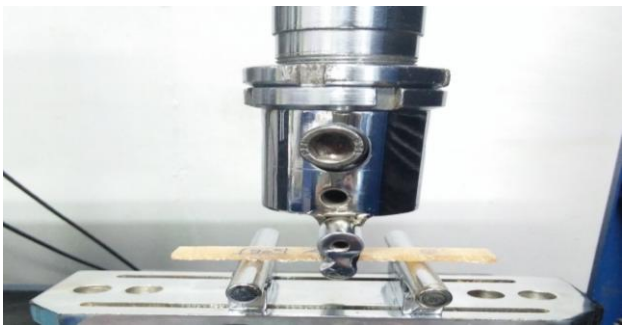


Fig 7: Flexural Testing setup

Table.3: Flexural Test results of Banana fiber specimens

Sr. No.	Specimens of different fiber length	Flexural Strength (N/mm^2)		Average Flexural Strength (N/mm^2)
		Trial 1	Trial 2	
1	A (5mm)	31.503	32.158	31.83
2	B (10mm)	43.247	47.203	45.23
3	C (15mm)	40.471	45.490	42.98

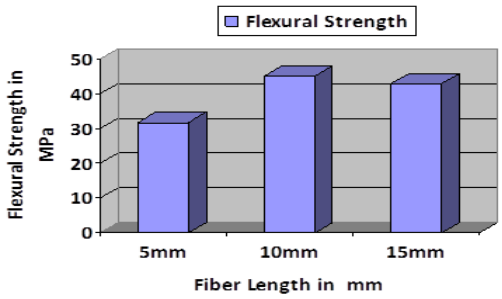


Fig 8: Effect of fiber length on flexural strength.

IV. CONCLUSION

A detailed study has been conducted on the mechanical behavior of banana fiber/epoxy composite on the basis of different fiber lengths. The study led to the conclusions mentioned below.

1. Epoxy resin reinforced with fiber has been fabricated by hand lay-up method.
2. From these experimental results we can say that tensile strength and flexural strength are function of fiber length. As fiber length increased strength increased up to certain limit and then decreases drastically as due to internal failure within the material.

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