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Experimental Investigations of Mechanical Properties of Natural Hybrid Fiber, Reinforced Polymer Composite Materials

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Abstract

Natural fibers are used to reinforce the materials. Many types of natural fibers are investigated for use in plastics, including flax, hemp, jute, sisal and banana. Hybrid fibers have the highest strength they are renewable resources and have marketing appeal. The waste product is used to prepare fiber reinforced polymer composites for useful process. Here the commonly 35% fiber and 65% polymer used to fabricate material in various ratios. Application of composite materials to structures has presented work focused the fabrication of polymer matrix composites by using natural fibers like flax, banana and sisal which are abundant nature in desired shape. With the help of various ASTM standards of patterns and calculating its material characteristics by conducting tests like flexural test, tensile test, impact test, and their results are measured on sections of the material and make use of hybrid natural fiber reinforced polymer composite material.

Keywords: Natural Fibers, Banana, Sisal, Flax and Reinforced Polymer

I. INTRODUCTION

Natural fibers have many advantages compared to glass fibers, for example, they have low density, and they are recyclable and biodegradable. Additionally, they are renewable raw materials and have relatively high strength and stiffness. Their low specific mass values allow producing composites that combine good mechanical properties with a low density. In tropical countries fibrous plants are available in nature.

The interest in using natural fibers such as different plant fibers and wood fibers as reinforcement in plastics has increased dramatically during the last few years. The surrounding aspects it would be very interesting if natural fibers used instead of glass fibers as reinforcement in some structural applications.

Fiber Reinforced Polymer (FRP) composites have many applications as a class of structural materials because of their ease of fabrication, relatively low price and higher mechanical properties compared to polymer resins. Studies on the mechanical properties of short fiber reinforced polymer composites have shown that both fiber length distribution and fiber orientation distribution important to determining the mechanical properties.

Natural fiber composites combine plant derived fibers with a plastic binder. The natural fiber components may be wood, sisal, hemp, coconut, thread, flax, jute, banana leaf fibers, Bamboo, wheat straw or other fibrous material. The advantages of natural fiber composites include lightweight, low-energy production, and environmental friendly. Use of natural fibers reduces weight and lowers the energy needed for production, while the cost of the component lower than the comparable fiber glass reinforced component.

Banana fiber banana plant not only gives the fruit, but it also provides the textile fiber. Hence, without any cost input, banana fiber can be obtained for industrial purposes. Banana fiber is found to be a good reinforcement in polyester resin and epoxy resin.

Sisal is hard fiber strong fiber has been growing best hot and dry areas. Sisal ropes and twines are widely used for marine, transport and general industrial use.

Flax fibers have a relatively low price compared to glass fibers. In addition, glass fibers are suspected of causing lung cancer, but there is no such problem for natural fibers. The thermal recycling of the flax fibers has a great advantage over glass fibers.

II. METHODOLOGY

A. Natural Fiber Preparation

Natural fiber (discontinuous) is used for fabricating the natural fiber composites. First the natural fibers are cleaned in the distilled water. The cleaned natural fibers are dried. The dried natural fibers are again cleaned with distilled water. In the chemical cleaning process the 60% sodium hydroxide is mixed with 40% distilled water. The dried natural fibers dipped in the diluted sodium hydroxide solution. Its again dried in sunlight. The dried natural fibers are cut in the length of 1.5 mm by hand cutter. The cut natural fibers are used in fabricating the natural fiber composites.

B. Mould Preparation

The fabrication of the various composite materials is carried out through the compressed moulding. The mould used for preparing composites as per the ASTM standard having dimensions of 290mm×290mm×3mm. For beadings were used to maintain a 3 mm thickness all around the mould plates. The functions of these plates are to cover, compress the fiber after the matrix is applied, and also to avoid the dust particles from entering into the composite parts during the curing time.

C. Preparation of Epoxy and Hardener

The polymer matrix used to fabricate the fiber specimen was epoxy LY556 of density 1.15 to 1.20 g/cm^3, mixed with hardener HY951 of density 0.97 to 0.99 g/cm^3. The weight ratio of mixing epoxy and hardener was 10:1.

D. Preparation of Composites

Polymer composites reinforced with various ratios of natural fibers were prepared by compounding neat Epoxy with the three alkali treated natural fibers, those being Banana, Sisal and Flax.

Table – 1
weight ratio of fiber & resin

Sample Specimen	*Weight ratio*	*Banana %*	*Sisal %*	*Flax %*
A	*35:65*	*10*	*5*	*20*
B	*35:65*	*10*	*10*	*15*
C	*35:65*	*10*	*15*	*10*

E. Fabrication Process

The Compression Molding is used for fabricating the natural fiber composites. For fabricating the natural fiber composites 65% of the resin hardener mixture 10:1 ratio and remaining 35% natural fibers are used. The mixed Epoxy resin and hardener fills in the pattern. Natural fibers are randomly poured in the resin, hardener mixture without any gap. The roller is rolled in the mould. Again the mould is filled in pattern by next layer and fibers poured randomly done till the height of the mould 10mm.The lid is fixed on the top of the frame for distributing the load evenly on the mould. The setup is kept inside Compression molding with hot temperature 373K. After 2hours the mould is taken away from the pattern, finally the hybrid natural fiber composite is fabricated.

F. Properties of Material

To determine the material properties (Flexural Strength, Tensile strength, Impact strength) of natural fiber reinforced composite material by conducting the following respective tests.

- Tensile Test
- Flexural Test
- Impact Test

III. RESULT AND DISCUSSION

A. Flexural Test

The 3-point flexure test is the most common flexural test for composite materials using ASTM standard D790 specimen size 125mm×13mm×3mm.

Specimen deflection is measured by the crosshead position. Test results include flexural strength and displacement. The testing process involves placing the test specimen in the universal testing machine and applying force to it until it fractures and breaks. The specimen used for conducting the flexural test.

Table – 2
Flexural strength of 3 samples

Weight ratio	*Sample A (Mpa)*	*Sample B (Mpa)*	*Sample C (Mpa)*
35:65	*51.557*	*49.157*	*46.471*
35:65	*47.089*	*39.039*	*36.670*
35:65	*39.023*	*43.175*	*43.801*
Average Flexural strength (Mpa)	*45.889*	*43.790*	*42.314*

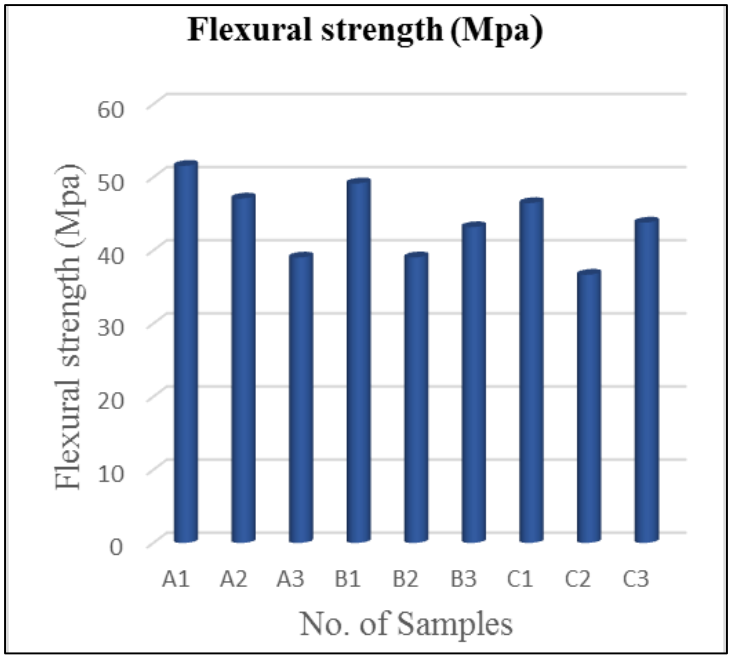

Fig. 1: No. of Samples Vs Flexural Strength (Mpa)

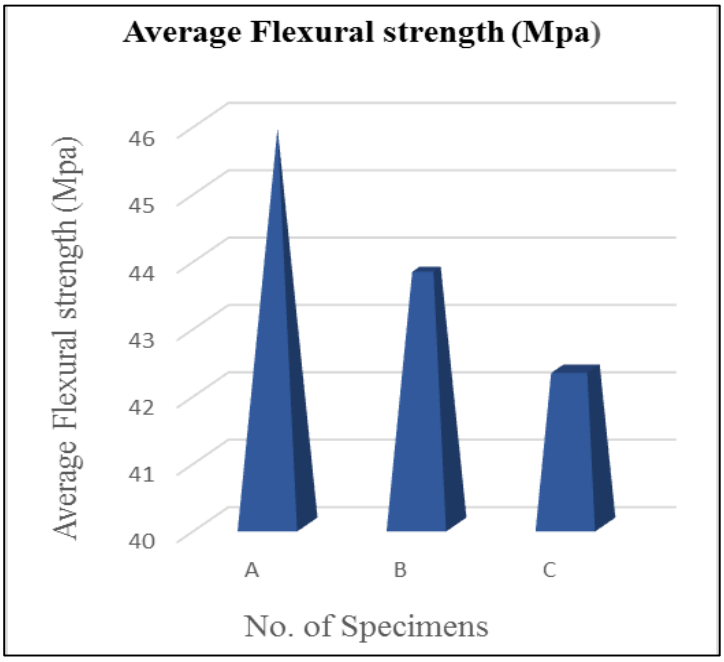

Fig. 2: No. of Specimens Vs Average Flexural strength (Mpa)

B. Tensile Test

Tensile tests are simple, relatively inexpensive, and fully ASTM D3039 standardized specimen size 250mm×25mm ×3mm. As the material is being pulled, we can establish its strength together with how much it will elongate. The point of failure of the material is of significant interest and it is typically called its Ultimate Tensile Strength.

Table – 3
Tensile strength of 3 samples

Weight ratio	*Sample A (N/mm^2)*	*Sample B (N/mm^2)*	*Sample C (N/mm^2)*
35:65	*30.460*	*21.523*	*21.994*
35:65	*18.874*	*22.985*	*21.454*
35:65	*17.835*	*19.326*	*21.415*
Average Ultimate Tensile Strength (N/mm^2)	*22.389*	*21.278*	*21.621*

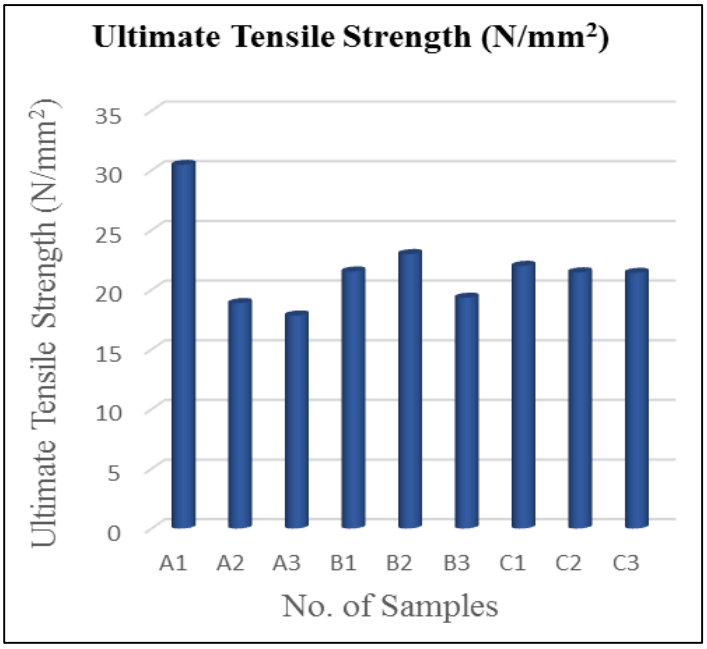

Fig. 3: No. of Samples Vs Ultimate Tensile Strength (N/mm^2)

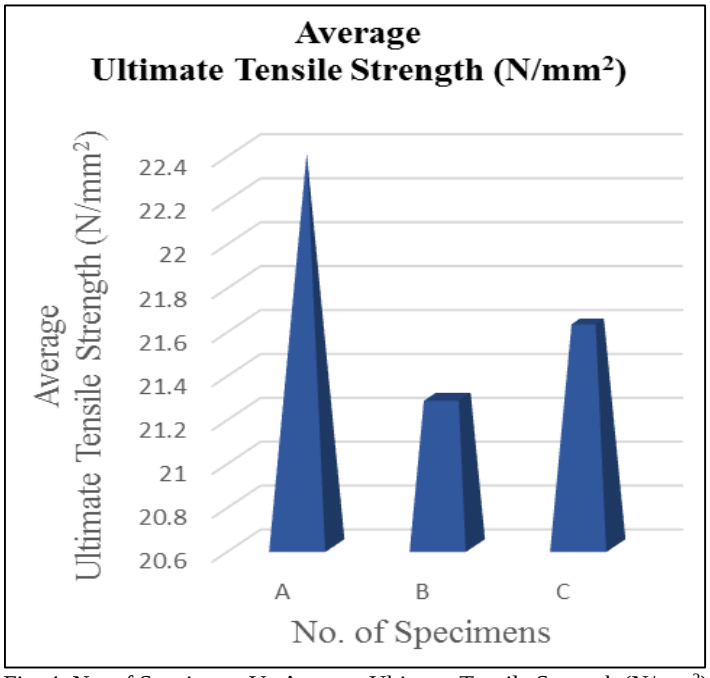

Fig. 4: No. of Specimens Vs Average Ultimate Tensile Strength (N/mm^2)

C. Impact Test

The impact test specimens are prepared according to the required dimension following the ASTM-D256 standard specimen size 65mm×13mm×3mm. During the testing process, the specimen must be loaded on the testing machine and allows the pendulum until it fractures or breaks.

Table – 4
Impact (Izod) strength of 3 samples

Weight ratio	*Sample A (J)*	*Sample B (J)*	*Sample C (J)*
35:65	*0.60*	*0.60*	*0.45*
35:65	*0.50*	*0.55*	*0.55*
35:65	*0.45*	*0.70*	*0.75*
Average Impact (Izod) value in J	*0.516*	*0.616*	*0.583*

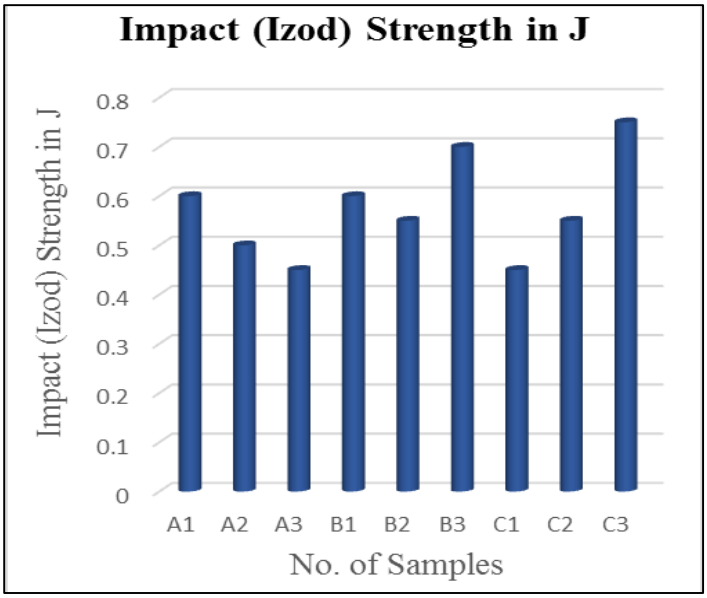

Fig. 5: No. of Samples Vs Impact (Izod) Strength in J

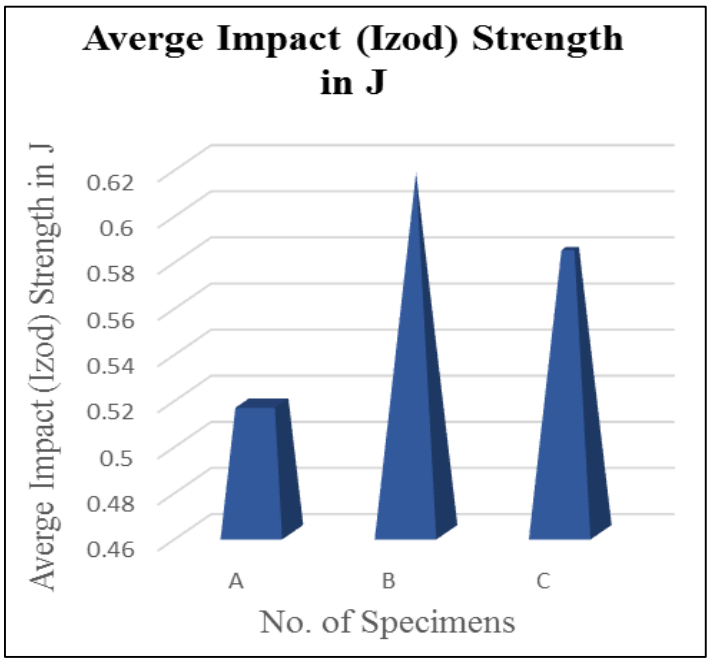

Fig. 6: No. of Specimens Vs Average Impact (Izod) Strength in J

IV. CONCLUSION

- The present work describes the effect on mechanical properties of Banana, Sisal & Flax fiber reinforced hybrid epoxy composite. The Polymer matrix composite have the various natural fibers as the reinforcement phase was fabricated successfully.
- The sample specimen with combination A gave the best Flexural Strength. When increasing the Banana & Flax Fiber in a higher ratio.

- The sample specimen with combination A gave the best Ultimate Tensile Strength. When increasing the Flax Fiber in a higher ratio.
- The sample specimen with combination B gave the good Impact (Izod) Strength. When increasing the Sisal Fiber in a higher ratio.

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