# Mechanical Characterization of Coconut Coir and Banana Fiber Reinforced with Epoxy Resin Polymer Composite

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*Abstract*— Natural fibers are renewable resources which have been renewed by nature for thousands of years. These fibers are completely renewable, environmental friendly with high specific strength. They are non-abrasive and bio-degradable in nature. Since they are part of wastage, they are available with low cost. With these characteristics, natural fibers have recently become attractive area of research for scientists and they find it as an alternative to prepare various natural fibers reinforced composites. Having extensive range of properties, the natural fiber-reinforced polymer composite materials are suitable for large number of engineering application. The natural fibers have been available plentifully in the world. It reduces the usage of plastic with unique properties compared to synthetic fiber. Due to the high specific properties and low density of natural fibres, composites based on these fibres may have very good implications in industry. In the present research work we have chosen banana fiber as the major reinforcement and coconut coir as an additional fiber to improve the mechanical property of polymer composite with epoxy resin as the base material prepared by hand lay-up process according to ASTM standards. Test specimens are prepared with different weight fractions. Tests were conducted and the improvement in mechanical properties (tensile strength and flexural strength) of the hybrid composite material is observed.

***Key words:*** Fiber, Banana, Coir, Polymer Composite, Tensile and Flexural Strength

## I. Introduction

Ashik, K.P. et. al.[1] summarized the history of natural fibers and its applications. Also, he focused on different properties of natural fibers (such as hemp, jute, bamboo and sisal) and its applications which were used to substitute glass fiber.

M. A. Fuqua et al[2] addressed the use of bio-based fibers as composite reinforcement. Specifics on the varieties of natural fibers, and the resultant properties from their constituents and hierarchal structures are described. He reviewed the importance of fiber type, length, architecture, and surface characteristics as they pertain specifically to natural fibers as reinforcements in a variety of plastics. In addition, a thorough description of the natural fibers themselves as naturally occurring composites composed of lignin and hemicellulose polymers bonding reinforcing cellulose polymer chains together was provided.

Haneefa, A et al.[3] evaluated the influence of fiber content, fiber loading, and hybrid effect on the mechanical properties such as tensile strength, Young's modulus, elongation at break, and flexural properties of the composites. They showed that the volume fraction of glass fiber based on total fiber content increases all the mechanical properties, except elongation at break. The tensile and flexural properties of composites are observed to have improved as the fiber loading (vol%) increases.

Kumar, R et. al.[5] showed that Alkali treatment of the banana fibers decreased the lignin component, crystallinity and increased the roughness of the surface and mechanical properties of the fibers. Mechanical properties of the fiber reinforced composites strongly depend upon the volume fraction of the banana fibers and the amount of plasticizer used. He also showed that alkali treatment of the fibers is necessary to get composites with moderate mechanical properties as well as better adhesion between fibers and matrix.

Prakash Tudu [10] studied on Processing and Characterization of Natural Fiber Reinforced Polymer Composites. His work shows that successful fabrication of a coconut fiber reinforced epoxy composites by simple hand lay-up technique. The results indicate that impact velocity, erodent size and fiber loading are the significant factors in a declining sequence affecting the erosion wear rate. The composites exhibit semi-ductile erosion characteristics with the peak erosion wear occurring at 600 impingement angle. This nature has been explained by analyzing the possible damage mechanism with the help of SEM micrographs. It is concluded that the inclusion of brittle fibers in ductile polyester matrix is responsible for this semi-ductility.

## II. Materials and Processing

### A. Preparation of test samples

#### 1) Materials:

The materials used in the present research work are tabulated in TABLE I with their properties.

| Materials | Specifications |
|---|---|
| Epoxy resin | Density: 1.15 g/cm$^3$<br>UTS: 60MPa<br>Flexural strength: 130MPa<br>Heat distortion temperature:125$^0$ |
| Banana fiber | Density: 1.12 g/cm$^3$<br>Length : 2-10mm |
| Coconut coir | Bulk density : 0.28 g/cm$^3$<br>length : 3-6mm |

Table 1: Specifications of the Raw Materials

#### 2) Sample Preparation:

Banana fiber and coconut coir contain impurities like dust, small sand particle etc. They were cleaned in order to get pure raw material. 10 % NAOH solution was used to clean the material. The banana fiber and coconut coir were dried in direct sun light for 8-10 hours. The epoxy resin and hardener were mixed in a container and stirred well for 3-5 minutes. The banana fiber and coconut coir was then added gradually as per the required percentage of weight and stirred to allow proper dispersion of fiber within the gel like mixture. To prevent the composites from sticking to the mould, the mould was initially polished with a release agent. Subsequently, the mixture was poured in the mould and was left undisturbed at room temperature for 24 hours to get fully cured and hardened.

Composite laminate of 300 mm X 200 mm X 5 mm were fabricated according to ASTM standards for mechanical tests.

Density of Epoxy resin ($\delta$) = 1.15 g/cm$^3$

Volume of the mold (V) = 300x200 x5mm

= 300000mm$^3$

= 300cm$^3$

Mass of resin (m) = Volume of mold x Density of resin

= 300cm$^3$ x 1.15g/cm$^3$

= 345g

| Samples | Mass of Resin(g)/ (% wt) | wt of coconut coir(g) / (% wt) | wt of banana fiber(g) / (% wt) |
|---|---|---|---|
| A | 345 /100 | 0 / 0 | 0 / 0 |
| B | 318 / 80 | 16 /17 | 11 /3 |
| C | 318 / 80 | 14 / 15 | 19 / 5 |
| D | 281 / 80 | 12 / 13 | 27 / 7 |
| E | 264 / 80 | 10 / 11 | 34 / 9 |

Table 2: Proportions of raw materials for Sample preparation

The above samples were subjected to tensile and flexural strength according ASTM Standard to evaluate their mechanical properties.

## III. MECHANICAL CHARACTERIZATION

Composite materials were subjected to various mechanical tests to measure strength, elastic constants, and other material properties. The results of such tests were used for two primary purposes: 1) engineering design (for example, failure theories based on strength, or deflections based on elastic constants and component geometry) and 2) Quality control either by the materials producer to verify the process or by the end user to confirm the material specifications.

A Universal Testing Machine (UTM) instrument was used for the measurement of loads and the associated test specimen deflections such as those encountered in tensile, compression or flexural modes. It is used to test the tensile, compression, flexural and Inter Laminar Shear Strength (ILSS) properties of materials. Load cells and extensometers measure the key parameters of force and deformation as the sample was tested.

### A. *Ultimate Tensile Strength (UTS)*

Ultimate tensile strength, often referred to tensile strength is the maximum stress that a material can withstand while being stretched or pulled before fracture. The tensile test for the specimens was conducted according to ASTM D3039. The specimens of size 250 mm x 25 mm x 10 mm were tested with a span length of 100 mm in tensile mode at a cross head speed of 1 mm / min.

$$\text{Ultimate tensile strength} = \frac{\text{Maximum load in N}}{\text{Cross sectional area in mm}^2}$$

Young's modulus or tensile modulus was determined by using the equation

$$\text{Young's modulus (E)} = \frac{\text{stress}(\sigma)}{\text{strain}(\varepsilon)}$$

Stress can be calculated from the equation

$$\text{Stress } (\sigma) = \frac{\text{load (P)}}{\text{Area}(b*h)} \text{ N/mm}^2$$

Where,

P = maximum load in N

b = width of the specimen in mm

h = thickness of the specimen in mm

$$\text{Strain} = \frac{\text{change in length (mm)}}{\text{original length(mm)}}$$

### B. *Tensile Test Report*

Table III. Ultimate tensile strength of coconut coir/Banana fiber / Epoxy resin composite

| Samples | coconut coir (%) | banana fiber(%) | Avg UTS(MPa) |
|---|---|---|---|
| A | 0 | 0 | 29.35 |
| B | 17 | 3 | 32.86 |
| C | 15 | 5 | 34.69 |
| D | 13 | 7 | 35.19 |
| E | 11 | 9 | 31.99 |

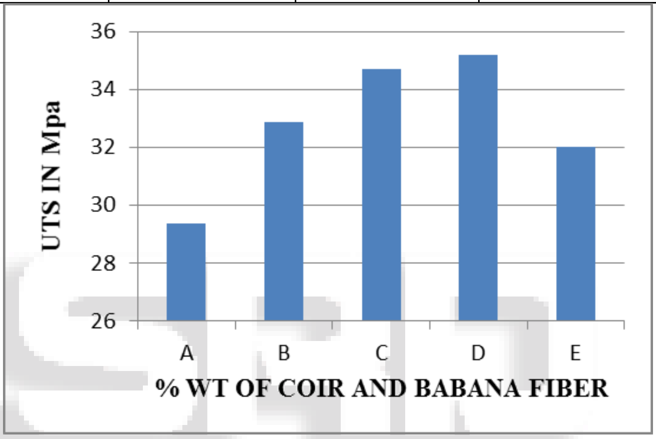


Fig. 1: Variation of UTS values for samples of coconut coir / banana fiber composite with different percentage loadings

### C. *Flexural Strength*

The flexural tests are conducted to determine the mechanical properties of resin and laminated fiber composite materials. These tests are used to determine the interlaminar shear strength of a laminate, shear modulus, shear strength, tensile and compression moduli along with flexural and shear stiffness.

The flexural strengths of the specimens were determined for specimens using the three-point bending test as per ASTM-D790. The specimens of dimensions 200 mm x 15 mm x 5 mm tested with a span length 50 mm.

The flexural strengths of the composites were determined using the formula.

$$\text{Flexural Strength [N/mm}^2\text{]} = \frac{3PS}{2bh^2}$$

Where,

P – Peak Load [N]

S – Support Span [mm]

b – width of the specimen [mm]

h – thickness of the specimen [mm]

| Samples | coconut coir (%) | banana fiber (%) | Avg FL (Mpa) |
|---|---|---|---|
| A | 0 | 0 | 75.60 |
| B | 17 | 3 | 82.00 |

| | | | |
|---|---|---|---|
| C | 15 | 5 | 85.13 |
| D | 13 | 7 | 88.13 |
| E | 11 | 9 | 82.27 |

Table 4: Flexural strength of prepared samples.

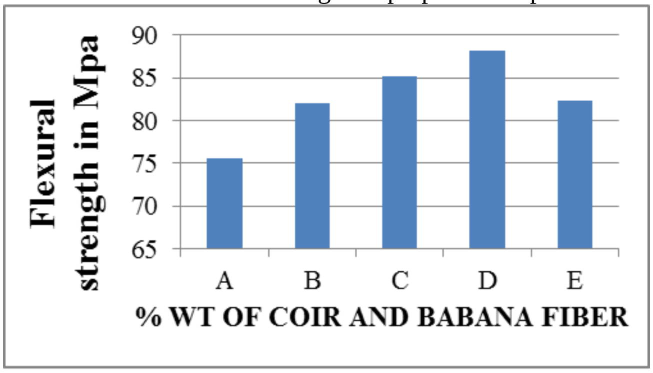


Fig. 2: Variation of Ultimate flexural Strength prepared composite sample at different percentage loading

### *D. Results*

Mechanical properties of coconut coir and banana fibe / epoxy resin

Experimental Study on : Coconut coir& Banana fiber /. Epoxy composite

Mechanical test : Tensile Test

| SAMPLES | ULTIMATE TENSILE STRENGTH, MPa | RESULTS |
|---|---|---|
| A | 29.35 | |
| B | 32.86 | Tensile strength increases by 11.96% |
| C | 34.69 | Tensile strength increases by 18.19% |
| D | 35.19 | Tensile strength increases by 19.89% |
| E | 31.99 | Tensile strength increases by 8.99% |

Table 5: Results of UTS of composite material.

Experimental Study on : Coconut coir &Banana fiber / Epoxy composite.

Mechanical tests : Three Point Bending Test (Flexural test)

| SAMPLES | ULTIMATE TENSILE STRENGTH, MPa | RESULTS |
|---|---|---|
| A | 75.60 | |
| B | 82.00 | Flexural strength increased by 8.46% |
| C | 85.13 | Flexural strength increased by 12.6% |
| D | 88.13 | Flexural strength increased by 16.57% |
| E | 82.27 | Flexural strength decreases by 8.82% |

Table 5: Results of flexural strength of composite material

## IV. CONCLUSIONS

To summarize, we have studied the composites with various combination of banana fiber & coconut coir percentage. It can be seen that there is significant increase in the tensile and flexural strength of the composite.

Random oriented coconut coir and banana fiber polyester composites are low-strength materials, but can be designed to have a set of flexural strengths that enable their use as non- structural building elements. to have better mechanical properties at higher fiber content. The bonding between the coconut coir/ banana fiber and epoxy resin can be improved by making homogenous mixture. of the fiber and matrix for further increasing the mechanical properties of the composite.

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