



EXPERIMENTAL INVESTIGATION OF MECHANICAL PROPERTIES OF COCONUT FIBER, HUMAN HAIR AND HYBRID FIBER REINFORCED EPOXY COMPOSITES FOR LIGHTWEIGHT STRUCTURAL APPLICATIONS

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Abstract:

The demand for sustainable material alternatives has led to increased research into bio-composites. This study investigates the mechanical performance of epoxy-based composites reinforced with coconut coir and human hair waste. Utilizing the hand lay-up technique, five distinct laminate configurations were fabricated and subjected to tensile, compression, and Izod impact characterization. Experimental results indicate that the hybridization of agricultural (coconut/ banana) and biological (human hair) fibers significantly enhances the structural integrity of the epoxy matrix. The hybrid "mixed" specimen demonstrated peak performance with a tensile strength of 6.33 MPa and an impact energy absorption of 80 kJ/m², representing a 111% and 100% improvement over pure epoxy, respectively. These findings confirm the viability of multi-phase waste-derived reinforcements for sustainable engineering applications.

Keywords: Bio composites, Natural fiber composites, Human hair reinforcement, Hybridization, Epoxy matrix, Mechanical characterization, Waste valorisation.



1. INTRODUCTION

This study explores the fabrication and mechanical evaluation of eco-friendly composite panels utilizing coconut fiber, banana fiber, and human hair waste as reinforcement. Using the hand lay-up method, specimens were developed with an epoxy resin (LY556) matrix and hardener (HY951). Five distinct variants—pure epoxy, coconut-reinforced, banana-reinforced, human hair-reinforced, and a hybrid "mixed" fiber composite—were tested for tensile, compressive, and impact properties. Results demonstrate that the hybrid composite exhibited superior performance, achieving a tensile strength of 6.33 MPa and an impact strength of 80 kJ/m². These findings suggest that integrating waste-derived natural fibers offers a sustainable, low-cost alternative to synthetic composites for non-structural applications.

2. LITERATURE REVIEW

Recent research indicates that natural fibers can significantly enhance composite mechanical properties when effective load transfer is achieved through proper matrix bonding. Banana fiber is noted for its high cellulose content, providing substantial tensile strength and stiffness. Human hair, rich in keratin, introduces unique elasticity and crack resistance to the matrix. Coconut fiber (coir) is valued for its high lignin content, which contributes to exceptional toughness and shock absorption. Scholars conclude that while these materials may not replace synthetic fibers in high-load structural roles, they are ideal for medium-load and eco-friendly applications.

3. METHODOLOGY AND MATERIALS

Material Selection: Epoxy resin LY556 served as the matrix, with HY951 as the hardener, mixed at a 10:1 ratio. Reinforcements included cleaned and dried banana fiber, coconut coir, and human hair.

Design: Specimens were fabricated with dimensions of 20 cm × 20 cm and a uniform thickness of 1 cm.

Fabrication: The hand lay-up method was utilized. A release agent was applied to a metal mold to prevent sticking. Fibers were placed evenly, and the resin-hardener mixture was poured and spread using a roller to minimize air bubbles. The panels were cured at room temperature for 24 to 48 hours.



Figure 1 Banana Fiber



Figure 2 Human Hair



Figure 3 Coconut Fiber



Fig: Banana Plate



Fig: Human Hair Plate



Fig: Pure Epoxy Plate



Fig: Mix Plate

Figure 4 Fabricated Composite Plates (Banana, Human Hair, Pure Epoxy and Mixed)

4. RESULTS AND DISCUSSION

Mechanical testing was performed to compare the reinforced specimens against a pure epoxy control group. The results of the compression, tensile and impact tests are summarised in Table 1.

Table 1 Mechanical Test Results of the Fabricated Composite Specimens

Material Specimen	Compression Load (N)	Tensile Strength (MPa)	Impact Strength (kJ/m ²)
Pure Epoxy	720.20	3.00	40
Coconut Fiber	870.14	5.00	68
Banana Fiber	814.35	5.53	65
Human Hair	850.50	5.33	60
Hybrid (Mixed)	875.20	6.33	80

The hybrid (Mixed) plate demonstrated the highest values across all tests, indicating a synergistic effect when combining different fiber types. The inclusion of natural fibers improved tensile strength by over 100% compared to pure epoxy. Human hair contributed significantly to flexibility, while coconut fiber enhanced toughness.

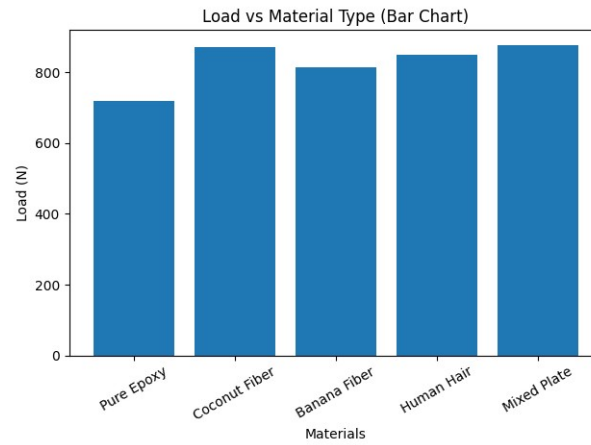


Figure 5 Compression Test Results

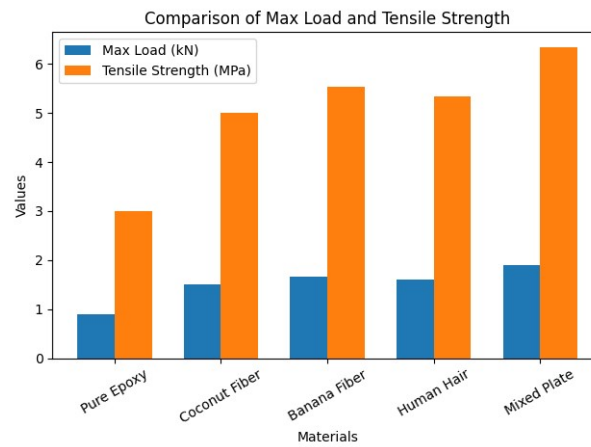


Figure 6 Tensile Test Results

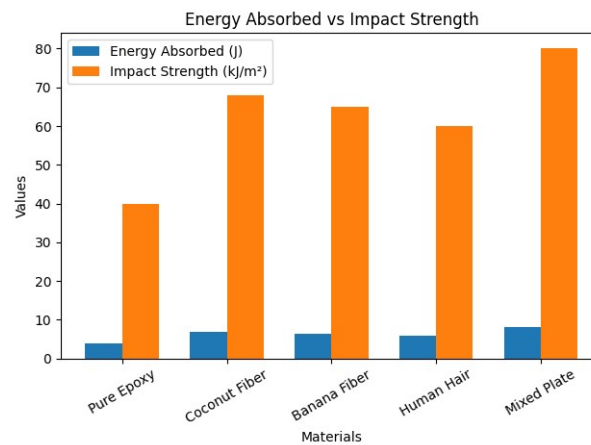


Figure 7 Impact Test Results



5. APPLICATIONS AND FUTURE SCOPE

The developed panels are suitable for interior furniture (partitions, tables), decorative wall panels, insulation boards in construction, and protective packaging. Future improvements could involve chemical treatments of fibers to enhance matrix bonding and machine-based manufacturing (e.g., compression molding) to eliminate manual defects like air bubbles.

6. CONCLUSION

This project successfully demonstrates the viability of human hair and natural fibers as reinforcements in epoxy-based composites. The resulting materials are lightweight, cost-effective, and environmentally sustainable. The hybrid specimen's performance confirms that waste materials can be repurposed into high-value engineering components.

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