



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 9.935

Volume 15, Issue 5, May 2026

Mechanical Characterization of Banana Fiber Reinforced Hybrid Composite

Arun Das NM, Sreevishnu P, Roshith T , Muhammad Sinan MP, Dr. Sreeram D

UG Student, Dept. of Mechanical Engineering, AWH Engineering College, Kozhikode, India

UG Student, Dept. of Mechanical Engineering, AWH Engineering College, Kozhikode, India

UG Student, Dept. of Mechanical Engineering, AWH Engineering College, Kozhikode, India

UG Student, Dept. of Mechanical Engineering, AWH Engineering College, Kozhikode, India

Head of the Dept., Dept. of Mechanical Engineering, AWH Engineering College, Kozhikode, India

ABSTRACT: Banana fiber reinforced hybrid polymer matrix composites have emerged as eco-friendly alternatives to conventional synthetic composites due to their biodegradability, low cost, and good mechanical performance. This paper investigates the mechanical characterization of banana fiber reinforced hybrid composites fabricated using polymer matrices such as epoxy combined with synthetic fibers like glass fiber. The study evaluates key mechanical properties including tensile strength, flexural strength, impact resistance, and hardness. The influence of fiber content, orientation, and hybridization on mechanical performance is analyzed. The results indicate that hybridization significantly enhances the mechanical properties compared to single fiber composites, making them suitable for structural and semi-structural applications.

KEYWORDS: Banana Fiber, Hybrid Composite, Polymer Matrix, Mechanical Properties, Tensile Strength, Flexural Strength.

I. INTRODUCTION

In recent years, there has been a growing interest in the development of eco-friendly and sustainable materials due to increasing environmental concerns and the depletion of nonrenewable resources. Natural fiber-reinforced polymer composites have emerged as a promising alternative to conventional synthetic composites because of their biodegradability, low cost, light weight, and acceptable mechanical properties.

Among various natural fibers, banana fiber has gained significant attention due to its high tensile strength, good specific strength, and abundant availability as an agricultural waste product. Banana fibers are extracted from the pseudo-stem of the banana plant and possess excellent properties such as low density, biodegradability, and good compatibility with polymer matrices. Utilizing such fibers not only adds value to agricultural waste but also reduces environmental pollution.

Hybrid polymer composites, which combine two or more types of reinforcements or matrices, are designed to enhance overall material performance by balancing the advantages and limitations of individual components. The incorporation of banana fibers with other reinforcing materials (such as glass fiber or synthetic polymers) leads to improved mechanical properties, durability, and structural performance.

Mechanical characterization plays a crucial role in evaluating the suitability of these hybrid composites for engineering applications. Properties such as tensile strength, flexural strength, impact resistance, and hardness are essential to determine the behavior of the composite under different loading conditions.

This project focuses on the mechanical characterization of banana fiber reinforced hybrid polymer composites. The study aims to analyze the influence of fiber reinforcement and hybridization on the mechanical performance of the composite material, thereby assessing its potential for applications in automotive, construction, and other industrial sectors.

II. FABRICATION OF GLASS AND BANANA

The hand lay-up method is the simplest and most commonly used technique for manufacturing fibre-reinforced composites. In this process, fibres such as glass and banana are manually placed in a mould, and liquid resin is applied layer by layer using a brush or roller.

Banana = 15% Glass = 15% Epoxy = 70%

A release agent is first applied to the mould surface to prevent sticking. Then, a layer of fibre is placed, followed by the application of resin to ensure proper wetting. This process is repeated to build multiple layers until the desired thickness is achieved. Rollers are used to remove air bubbles and ensure uniform distribution of resin.

After lay-up, the composite is allowed to cure at room temperature or under controlled heating. Once hardened, the final product is removed from the mould and finished as required.

This method is widely used due to its low cost, simplicity, and suitability for large components, although it may have limitations such as uneven resin distribution and lower production speed.

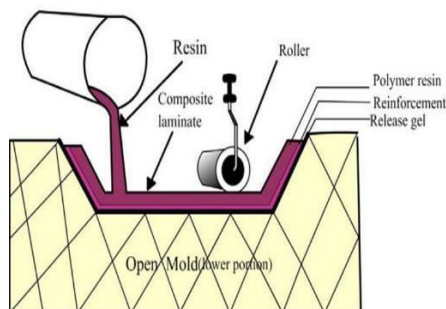


Figure 1 Hand Lay-up diagram



figure 2 Hand Lay-up

3. MECHANICAL TESTING

Tensile testing

Tensile testing is a mechanical test used to determine the behavior of a material when subjected to a uniaxial pulling force. In this test, a specimen is placed in a Universal Testing Machine (UTM) and pulled from both ends until it breaks.

The test measures important mechanical properties such as tensile strength, yield strength, elongation, and Young's modulus. As the load increases, the material undergoes deformation, and the corresponding stress-strain relationship is recorded.

Tensile testing helps in evaluating the strength and ductility of materials, making it essential for analyzing the performance of composites like banana fibre-reinforced materials



Flexural testing

Flexural testing is a mechanical test used to evaluate a material's ability to resist bending under load. It is commonly performed using a three-point or four-point bending setup in a Universal Testing Machine (UTM).

In this test, a specimen is placed on two supports and a load is applied at the center (in three-point bending) until it bends or fractures. The test measures properties such as flexural strength, flexural modulus, and stiffness.

Flexural testing is especially important for composite materials like jute fibre composites, as it helps assess their performance under bending conditions commonly encountered in real-life applications.



IV. RESULT AND DISCUSSION

Tensile test analysis

Tensile test analysis of a glass and banana fibre composite is carried out to determine its behaviour under axial pulling forces and to evaluate properties such as tensile strength, modulus, and elongation. The test is commonly performed according to **ASTM D3039**, where a prepared specimen is subjected to a uniaxial load until failure. Initially, the composite exhibits linear elastic behaviour, where stress increases proportionally with strain. As the load continues, the matrix begins to develop micro-cracks, and the load is effectively transferred to the glass and banana fibre, which bear most of the stress. Failure occurs due to fibre breakage, matrix cracking, and fibre-matrix debonding. Glass and banana fibre composites typically show moderate tensile strength and stiffness, with limited elongation compared to synthetic fibre composites. The tensile properties are significantly influenced by factors such as fibre alignment, fibre volume fraction, interfacial bonding, and moisture absorption. Overall, the tensile test analysis indicates that glass and banana fibre composites are suitable for lightweight, eco-friendly applications where moderate strength and acceptable mechanical performance are required.

Properties	Specimen 1(pure banana fibre)	Specimen 2 (banana and glass fibre)
Ultimate tensile strength	17.5000N/mm ²	39.3152/mm ²
Breaking load	1750.0000N	3931.5251N
Elongation at Break	8.5%	5.51%
Stiffness	1.7×10 ⁴ N/mm	7.1×10 ⁴ N/mm
Toughness	89.25Nmm	108.21Nmm
Ductility nature	Less ductile	More ductile

7.2 comparison of tensile test of banana and banana and glass

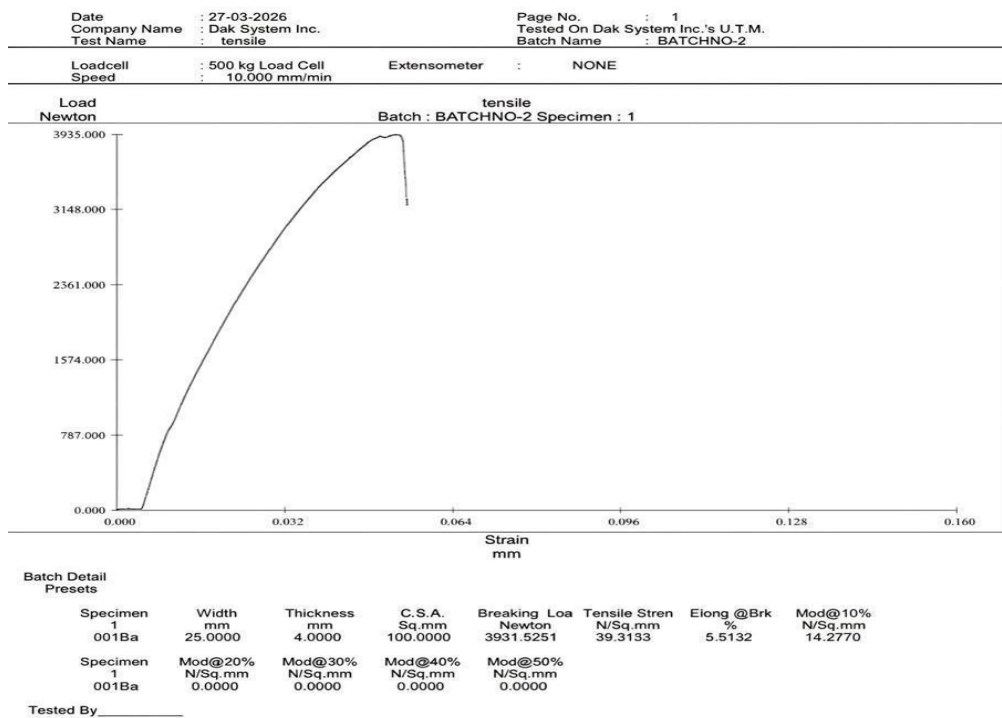


Fig: 7.3 tensile strength of banana and glass fibre

Flexural test analysis

Flexural test analysis of a glass and banana fibre composite is performed to evaluate its behaviour under bending loads and to determine properties such as flexural strength and stiffness. In this test, a specimen is subjected to a three point or four point bending setup, typically following the standard ASTM D7264. Initially, the composite exhibits linear elastic behavior where stress increases proportionally with strain. As the load increases, micro-cracks begin to form in

the matrix, and the load is transferred between the glass and banana fibres and the surrounding resin. The final failure occurs due to a combination of fibre breakage, matrix cracking, and fibre–matrix debonding

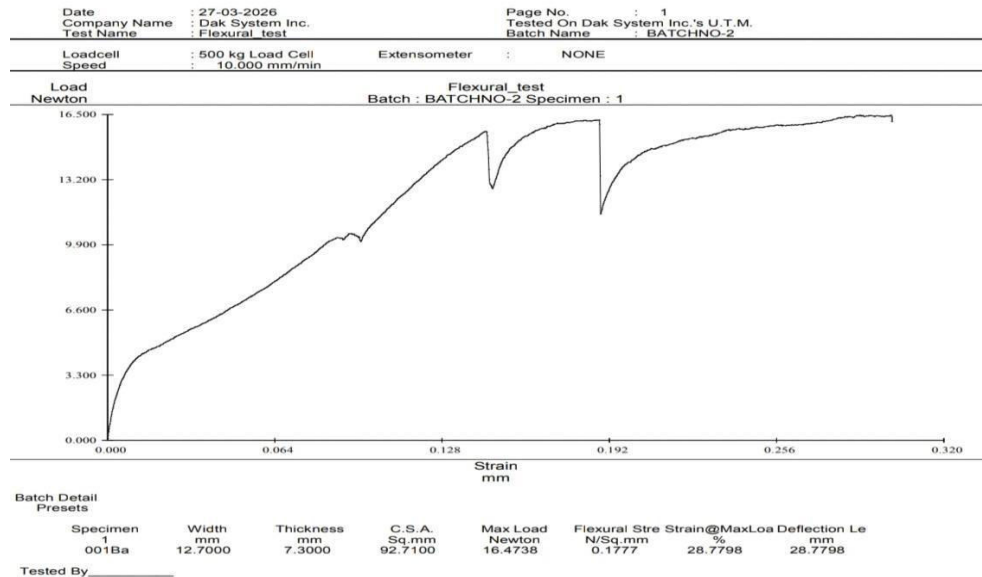


Fig: 7.7 flexural test

V. CONCLUSION

The present study on the mechanical characterization of banana fibre reinforced hybrid polymer composite demonstrates that hybridization with glass fibre significantly enhances the overall mechanical performance of the composite material. Experimental results reveal a substantial improvement in ultimate tensile strength and breaking load for the hybrid composite compared to the pure banana fibre composite. This improvement is primarily attributed to the superior strength, stiffness, and load transfer capability of glass fibres within the polymer matrix.

However, the elongation at break decreases with the addition of glass fibre, indicating reduced ductility and increased brittleness of the hybrid composite. This highlights a typical trade-off between strength and flexibility in fibre-reinforced composites.

Overall, the hybrid composite exhibits a balanced combination of properties, offering high strength and moderate stiffness, making it suitable for structural and semistructural applications such as automotive components, panels, and lightweight loadbearing structures. In contrast, pure banana fibre composites, with higher elongation, may be more appropriate for applications requiring flexibility and impact absorption.

In conclusion, the study confirms that banana fibre can be effectively combined with synthetic fibres like glass fibre to develop cost-effective, eco-friendly composites with enhanced mechanical properties, thereby expanding their potential for engineering applications.

REFERENCES

1. Alavudeen , N. Rajin , S. Karthikeyan, M. Thiruchitrabalam,
2. N. Venkateshwaren Mechanical properties of banana/kenaf fiber-reinforced hybrid polyester composites: Effect of woven fabric and random orientation <https://doi.org/10.1016/j.matdes.2014.10.067>
3. R. Karthick , K. Adithya , C. Hariharaprasath , V. Abhishek Evaluation of mechanical behavior of banana fibre reinforced hybrid epoxy composites <https://doi.org/10.1016/j.matpr.2018.02.265>

4. P. Sivaranjana & V. Arumugaprabu , A brief review on mechanical and thermal properties of banana fiber based hybrid composites <https://doi.org/10.1007/s42452-021-04216-0>
5. Ranjeet Kumar , Anurag Gupta , K.L.A. Khan Effect on the mechanical properties due to hybridization of banana-fiber composites <https://doi.org/10.1016/j.matpr.2022.04.436>
6. T. Hariprasad , G. Dharmalingam , P. Praveen Raj , Study of Mechanical Properties of Banana-Coir Hybrid Composite using Experimental and Fem Techniques <https://doi.org/10.15282/jmes.4.2013.16.0049>
7. Kazi Jubair , Md Shariful Islam , Dipto Chakraborty , Investigation of Mechanical Properties of BananaGlass Fiber Reinforced Hybrid Composites <https://doi.org/10.38032/jea.2021.04.002>
8. Ashwani Kumar ,Deepak Kumar Choudhary, Princ , Mechanical properties of epoxy based hybrid composite of glass and banana fibers <https://smenec.org/index.php/1/article/view/288>



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details