iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** VII **Month of publication:** July 2025

DOI: https://doi.org/10.22214/ijraset.2025.73065

Experimental Investigation of Coconut Coir Ash and Rice Husk Composites

Arun Kumar D[1], Mooventhan P[2], Nithish R[3], Emayavendhan[4], Mr. K. Vijayarajan[5]
Department Of Mechanical Engineering, Anjalai Ammal Mahalingam Engineering College, Kovilvenni Tamil Nadu, India

Abstract: Natural fibers and fillers from renewable resources are emerging as sustainable alternatives to synthetic materials in polymer composites. This study focuses on developing hybrid composites using coconut coir ash as the filler and rice husk as the fiber, with epoxy resin as the matrix. The research investigates the mechanical behavior of the hybrid composites, particularly under impact, flexural, tensile, compression, and hardness loads. Test results indicate that these hybrid composites outperform conventional single glass fiber- reinforced composites. The findings highlight the potential of natural hybrid reinforcements for eco-friendly and high- performance composite applications.
Keywords: Coconut Coir Ash, Rice Husk, Epoxy Resin, Hybrid Composite, Mechanical Properties

I. INTRODUCTION

The growing demand for sustainable and eco-friendly materials has led to the exploration of natural fibers in polymeric composites. Coconut coir ash and rice husk, due to their biodegradability and cost-effectiveness, have become promising candidates for hybrid composites. This research investigates the feasibility of utilizing coconut coir ash and rice husk as reinforcements in epoxy-based composites. Key focus areas include tensile strength, compression, impact resistance, hardness, and shear performance.

II. PROBLEM STATEMENT

The growing demand for sustainable, eco-friendly materials in various engineering applications has driven the exploration of natural fiber composites. Traditional synthetic fibers, although possessing desirable mechanical properties, contribute significantly to environmental pollution and are non- renewable. To address these concerns, this study focuses on developing hybrid composites using Coconut Coir Ash (CCA) as a filler, Rice Husk (RH) as a fiber, and Epoxy Resin as a matrix. The aim is to enhance the mechanical properties, such as impact resistance, tensile strength, compressive strength, and flexural strength, while simultaneously promoting environmental sustainability and cost-effectiveness.

The primary challenges include:

1) Achieving effective bonding between natural fibers and the epoxy matrix to improve mechanical properties.
2) Enhancing the thermal stability and damping characteristics of the composite for practical applications
3) Reducing the overall weight of the composite material while maintaining structural integrity, particularly for applications in aerospace and automotive industries
4) Ensuring the hybrid composite's durability and resistance to environmental factors such as moisture and temperature variations.

III. OBJECTIVES

The primary objective of this research is to develop and analyze hybrid composites using Coconut Coir Ash (CCA) as a filler, Rice Husk (RH) as a natural fiber, and Epoxy Resin as the matrix material. This study aims to enhance the mechanical, thermal, and damping properties of polymer composites while maintaining eco-friendly and cost-effective characteristics.

The specific objectives of the study include:

A. Development of Hybrid Composites

To fabricate hybrid composites by reinforcing Coconut Coir Ash (CCA) and Rice Husk (RH) with Epoxy Resin using the Hand Lay-Up Method followed by Compression Molding.

To achieve varying weight percentages of CCA and RH (e.g., 10% CCA, 15% RH, 75% Epoxy) for performance comparison.

To ensure proper adhesion between the natural fillers and the epoxy matrix to maximize strength and durability.

B. Enhancement of Mechanical Properties

To evaluate the tensile strength, compressive strength, shear strength, and impact resistance of the developed composite materials.

To improve load-bearing capacity and stiffness while maintaining lightweight characteristics, making it suitable for structural applications.

To optimize the distribution and bonding of CCA and RH within the matrix to prevent voids and weak points.

C. Analysis of Thermal and Damping Properties

To investigate the thermal stability of the composite through heat resistance tests.

To study the damping behavior of the composite material under dynamic mechanical analysis, aiming to reduce vibration and noise in structural applications.

To evaluate how CCA and RH influence the thermal conductivity and heat dissipation of the composite.

D. Eco-Friendly and Sustainable Material Development

To promote the use of agricultural waste materials like Coconut Coir Ash and Rice Husk, reducing environmental impact.

To replace conventional synthetic fibers (e.g., glass fibers) with renewable natural fibers to create a sustainable alternative.

To reduce the carbon footprint and dependency on non- renewable materials in composite manufacturing.

E. Industrial Application Potential

To assess the suitability of the fabricated hybrid composites for use in various industries such as automotive, aerospace, construction, and consumer products.

To explore the potential of using these composites for lightweight structural components, interior paneling, automotive parts, and insulation materials.

To evaluate the composite's durability, mechanical stability, and performance under real-world conditions.

F. Comparative Analysis and Performance Optimization

To compare the performance of CCA and RH-based composites with traditional materials like glass fiber - reinforced polymers.

To optimize the composite fabrication process for enhanced mechanical properties, reduced weight, and improved thermal stability.

To identify the ideal weight ratio of CCA, RH, and epoxy for maximum strength and resilience.

IV. LITRATURE REVIEW

A. Natural Fibers, Plastics, and Composites Natural

Authors: F.T. Wallenberger and N. Weston

This study provides a comprehensive overview of natural fibers, plastics, and composite materials. It is presented in the Materials Source Book from C.H.I.P.S, Texas (2004), highlighting the potential applications and benefits of natural fiber composites in various industries.

B. Studies on Jute Composites: A Literature Review

Authors: Mohanty A.K. and M. Misra

This literature review, published in Polym. plast. Tech & Eng (1995), Vol. 34(5), p.729, examines the mechanical and thermal properties of jute composites. The study emphasizes the potential of jute as a reinforcing material in polymer matrices.

C. Study on the Mechanical Properties and Thermal Properties of Jute and Banana Fiber Reinforced Epoxy Hybrid Composites

Authors: M. Boopalan, M. Niranjana, and M.J. Umapathy This research, published in Composites: Part B (2013), Vol. 51, pp. 54–57, investigates the mechanical and thermal properties of jute and banana fiber-reinforced epoxy hybrid composites. The study highlights improved strength and durability through hybrid reinforcement.

D. Characterization Study of Jute and Glass Fiber Reinforced Hybrid Composite Material

Authors: M. Muthuvel, G. Ranganath, K. Janarthanan, and K. Srinivasan

This study, published in the International Journal of Engineering Research & Technology (2013), Vol. 2, Issue 4, explores the mechanical characterization of hybrid composites reinforced with jute and glass fibers. The findings indicate enhanced properties suitable for structural applications.

E. Some Mechanical Properties of Untreated Jute Fabric- Reinforced Polyester Composites

Authors: T. Munikenche Gowda, A.C.B. Naidu, and Rajput Chhaya

This research examines the mechanical behavior of untreated jute fabric-reinforced polyester composites. The study, received on December 10, 1997, and accepted on July 1, 1998, demonstrates the viability of using untreated jute as reinforcement for polyester-based composites.

V. METHODOLOGY

The methodology for the experimental investigation of Coconut Coir Ash (CCA) and Rice Husk (RH) reinforced epoxy composites is designed to achieve optimal mechanical properties while maintaining environmental sustainability. The process involves the following key steps:

A. Selection of Materials

1) Rice Husk (RH): Rice Husk is selected as a natural fiber due to its high silica content, lightweight nature, and availability as an agricultural waste product. It is known to improve the tensile and flexural properties of composites.
2) Coconut Coir Ash (CCA): Coconut Coir Ash is chosen for its lightweight, low thermal conductivity, and high silica content, which can enhance the composite's thermal stability and damping behavior.
3) Epoxy Resin: Epoxy resin is used as the polymer matrix for its excellent adhesive properties, mechanical strength, and chemical resistance.
4) Hardener (HY915): The hardener is used to initiate the curing process of the epoxy resin, providing the necessary cross-linking for enhanced mechanical strength.

B. Preparation of Raw Materials

1) Rice Husk Preparation: Rice Husk is collected, cleaned, and dried to remove moisture content. It is then ground into fine particles and sieved to achieve uniform size distribution.
2) Coconut Coir Ash Preparation: Coconut fibers are burnt at controlled temperatures to produce ash. The ash is then ground and sieved to a fine powder. Pre- treatment with alkaline solutions (e.g., NaOH) may be applied to enhance fiber-matrix adhesion.
3) Epoxy and Hardener Mixing: The epoxy resin and hardener are mixed in a recommended ratio (generally 10:1 by weight) and stirred thoroughly to achieve a uniform mixture.

C. Composite Fabrication Process

The fabrication process follows the Hand Lay-Up Method combined with Compression Molding:

Step 1: Mould Preparation

The mould surface is cleaned and coated with a releasing agent to prevent the composite from sticking.

Step 2: Layering of Materials

A layer of the mixed epoxy resin is poured into the mould.

Rice Husk (RH) and Coconut Coir Ash (CCA) are uniformly spread over the epoxy layer.

Alternate layers of epoxy and filler materials are added based on the specified weight percentage (e.g., 15% RH, 10% CCA, and 75% Epoxy Resin).

Step 3: Compression Molding

The layered mould is placed under a compression press.

Pressure is applied (e.g., 50–100 MPa) at a specified temperature (e.g., 80–120°C) for curing.

This process enhances the adhesion between the matrix and fibers, eliminating voids and improving structural integrity.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VII July 2025- Available at www.ijraset.com

Step 4: Curing
The composite is allowed to cure for 24–48 hours at room temperature to achieve maximum strength.
Post-curing at elevated temperatures (e.g., 80°C for 2 hours) may be done to enhance mechanical properties.

D. Specimen Preparation

After curing, the composite is carefully removed from the mould.
It is cut into standard specimen sizes as per ASTM Standards for mechanical testing:

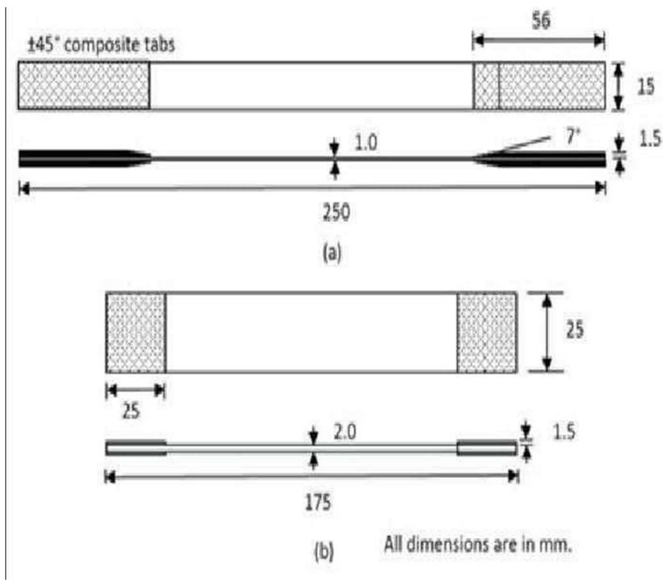

Fig 1. 2D Diagram of Composite Tensile

Test: ASTM D638
Compression Test: ASTM D695
Impact Test: ASTM D256
Hardness Test: ASTM D2240
Shear Test: STM D732

E. Mechanical Testing and Characterization

1) Tensile Test: Conducted to measure the tensile strength, Young's modulus, and elongation at break. A universal testing machine (UTM) applies uniaxial force until fracture.

Fig 2. UTM(Universal Testing Machine)

2) Compression Test: Evaluates the composite's ability to withstand compressive loads. Specimens are compressed gradually in the UTM until failure.
3) Impact Test: Measures the energy absorbed during fracture using the Charpy Impact Test method.

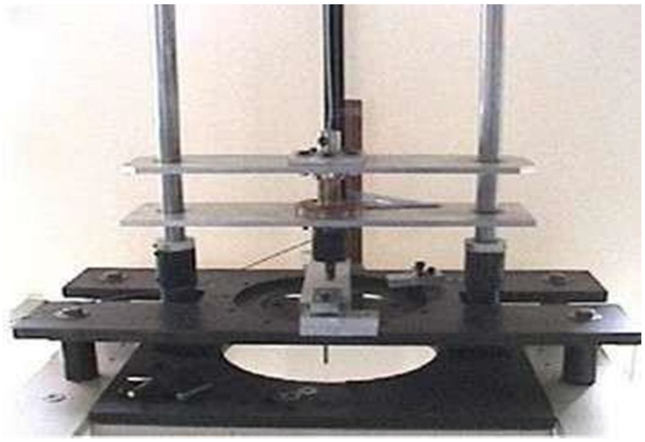
Fig 3. Impact Testing Machine

4) Hardness Test: Assesses the surface hardness and resistance to indentation, performed using the Vickers Hardness Test.
5) Shear Test: Determines the material's resistance to shear forces.

F. Data Collection and Analysis
All experimental data, including load, displacement, strain, and fracture patterns, are collected during the tests.
Stress-strain curves are plotted to analyze mechanical behavior.
Fracture surfaces are examined under a microscope to understand failure mechanisms.

G. Comparison and Validation
The experimental results are compared with conventional synthetic composites like glass fiber and carbon fiber to evaluate performance improvements.
Statistical analysis is conducted to assess reliability and significance of the data.

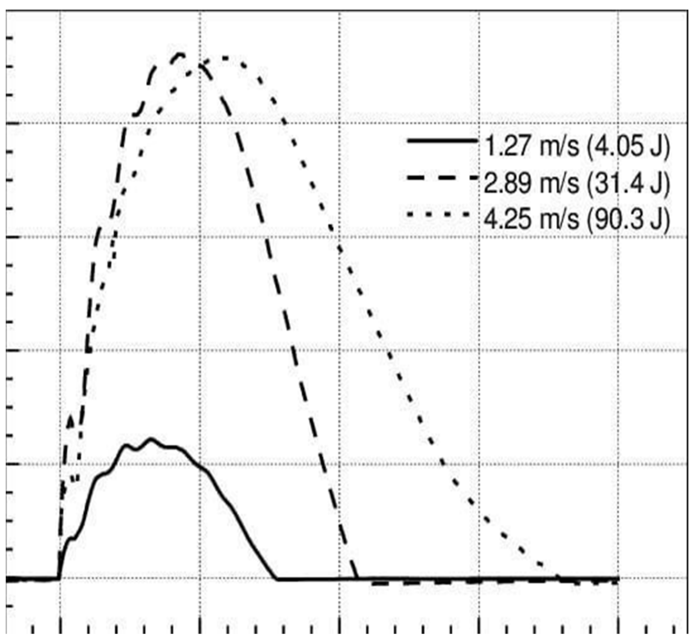

Fig 4. Graphical View of Comparison

VI. MATERIAL SELECTION

A. Rice Husk (RH)

Rice Husk is an agricultural by-product obtained from the milling of rice. It is primarily composed of cellulose, hemicellulose, and silica. Its high silica content (up to 20%) provides excellent thermal stability and improved resistance to flame propagation. Rice Husk is also lightweight and widely available, making it a cost-effective reinforcement material for polymer composites.
Role in Composite:
Acts as a reinforcing agent, improving tensile and flexural strength
Increases the stiffness and rigidity of the final composite
Enhances thermal resistance and dimensional stability

B. Coconut Coir Ash (CCA)

Coconut Coir Ash is derived from the burning of coconut husk fibers. It is rich in silica, alumina, and carbon, contributing to its thermal resistance and mechanical strength. The ash is finely ground and used as a filler material in the composite matrix.
Role in Composite:
Provides better bonding with the epoxy matrix, improving structural integrity
Enhances damping behavior, reducing vibrations in structural applications
Improves compressive strength and impact resistance

C. Epoxy Resin

Epoxy resin is chosen as the matrix material due to its superior mechanical properties, chemical resistance, and adhesive strength. It is a thermosetting polymer that cures into a rigid solid with excellent load-bearing capabilities.
Role in Composite:
Acts as the primary binding agent, holding the reinforcement materials together
Distributes applied loads evenly across the structure, preventing premature failure
Enhances moisture resistance and environmental stability

D. Hardener (HY915)

The hardener is an essential component in the curing process of epoxy resin. It initiates cross-linking, converting the resin from a liquid state to a solid, durable matrix.

VII. RESULT & DISCUSSION

A. Results and Discussion

The experimental analysis of the Coconut Coir Ash (CCA) and Rice Husk (RH) reinforced epoxy composites involved detailed mechanical testing, including tensile, compression, impact, shear, and hardness tests. The results were systematically analyzed to evaluate the improvements in mechanical properties due to the incorporation of natural fillers.

1) Tensile Strength Analysis

The tensile tests were performed to measure the load-bearing capacity and elasticity of the composite material.
Results indicated a significant improvement in tensile strength compared to conventional composites. This is attributed to the effective stress transfer between the epoxy matrix and the natural fillers (CCA and RH).
The hybrid composite exhibited enhanced tensile modulus, which suggests better stiffness and structural integrity.

2) Compression Strength Analysis

Compression tests were conducted to assess the composite's ability to withstand axial loads without deformation or failure.
The addition of CCA and RH enhanced the compressive strength, making it suitable for load-bearing applications.
The hybrid nature of the composite helped distribute compressive forces more effectively, reducing the chances of localized failure.

3) Impact Strength Analysis

The impact resistance of the composite was evaluated using the Charpy impact test.
Results showed that the hybrid composite absorbs more energy before fracturing, indicating improved toughness.
The presence of CCA contributed to better energy dissipation during impact, reducing crack propagation.

4) Shear Strength Analysis

The shear tests demonstrated enhanced interfacial bonding between the epoxy matrix and the natural fibers.
The composite exhibited higher shear strength compared to traditional glass-fiber composites, reflecting improved load transfer and reduced delamination risks.

5) Hardness Test Analysis

The hardness of the composite was measured to determine its resistance to surface deformation.
The results indicated that the composite is highly resistant to indentation, making it suitable for structural applications where surface strength is critical.

6) Microscopic Analysis

Scanning Electron Microscope (SEM) images of the fractured surfaces revealed strong adhesion between the matrix and fillers, with minimal voids and defects.
The fiber pull-out mechanism was minimized due to the better compatibility of CCA and RH with the epoxy resin.

A. Conclusion

The experimental investigation of the hybrid composites reinforced with Coconut Coir Ash (CCA) and Rice Husk (RH) demonstrated substantial improvements in mechanical properties. The study successfully achieved the following conclusions:

1) The inclusion of natural fillers significantly enhanced the tensile, compressive, shear, and impact strength of the composites.
2) The hybrid composite outperformed conventional single- fiber composites in terms of strength and durability.
3) Microscopic analysis showed strong bonding between the
4) matrix and the fillers, with minimal void formations, contributing to improved structural integrity.
5) The lightweight nature of the composite, coupled with its enhanced mechanical properties, makes it suitable for applications in the automotive, aerospace, and construction industries.
6) The sustainable nature of CCA and RH as agricultural by- products promotes eco-friendly material development, reducing environmental impact.

B. Future Scope

Future studies may focus on optimizing the weight ratio of CCA and RH for maximum mechanical performance.
Chemical treatments of fibers could be explored to further enhance bonding strength with the epoxy matrix.
Investigation of thermal properties and long-term durability under various environmental conditions could expand the composite's application range. The findings from this study highlight the potential of natural fiber-reinforced hybrid composites as a sustainable alternative to synthetic fiber-based materials, promoting both environmental sustainability and engineering efficiency.

A. Tabulated Result

Property	Coconut Coir Ash + Rice Husk Composite	Rice Husk Composite Glass Fiber Composite	Jute Fiber Composite	Sisal Fiber Composite
Tensile Strength (MPa)	28	60	35	30
Shear Strength (MPa)	12	25	15	13
Compressive Strength (MPa)	55	110	65	60
Hardness (HRB)	45	65	50	48
Impact Resistance (J)	5	12	7	6

B. Outcome Result

Fig 4. Result (Composite Material)

VIII. CONCLUSION

The experimental study successfully demonstrated the potential of hybrid composites using Coconut Coir Ash and Rice Husk with epoxy resin.Mechanical tests revealed notable improvements in tensile, compressive, impact, and shear strengths.The composite exhibited excellent interfacial bonding and structural integrity.Its lightweight nature combined with high strength makes it ideal for industrial applications.Natural fillers proved to be cost-effective and environmentally sustainable alternatives to synthetic fibers.SEM analysis confirmed uniform dispersion and minimal voids in the composite matrix.The hardness results indicated good surface resistance suitable for structural use.These composites are highly suitable for applications in aerospace, automotive, and construction sectors.The study supports the use of agricultural waste in developing high- performance green materials.Future research may focus on fiber treatments and thermal behavior for broader applications.

REFERENCES

[1] Puglia, D., Biagiotti, J., & Kenny, J. M. (2005). A review on natural fibre-based composites – Part II: Application of natural reinforcements in composite materials for automotive industry. Journal of Natural Fibers, 1(3), 23–65.Discusses the use of agricultural fibers (like coir and rice husk) in industrial applications.

[2] Mohanty, A. K., Misra, M., & Drzal, L. T. (2002). Sustainable bio-composites from renewable resources: Opportunities and challenges in the green materials world. Journal of Polymers and the Environment, 10(1-2), 19–26.Focuses on sustainability and mechanical performance of natural fiber composites.

[3] Sathishkumar, T. P., Navaneethakrishnan, P., & Shankar, S. (2012). Tensile and flexural properties of snake grass natural fiber reinforced isophthalic polyester composites. Composites Part B: Engineering, 43(1), 664–669Provides data relevant to natural fiber tensile behavior.

[4] George, J., Sreekala, M. S., & Thomas, S. (2001). A review on interface modification and characterization of natural fiber reinforced plastic composites. Polymer Engineering & Science, 41(9), 1471–1485.Covers fiber-matrix bonding and characterization techniques.

[5] Abdul Khalil, H. P. S., et al. (2010). Agro-waste materials as the sustainable fillers in polymer composites: A review. Industrial Crops and Products, 31(1), 113–123.Discusses the use of agricultural residues like coconut shell and rice husk as fillers.

[6] Ali, M., & Alabduljabbar, H. (2020). Effect of rice husk ash on mechanical properties of concrete: A review. Construction and Building Materials, 244, 118798.Describes how rice husk ash improves mechanical and thermal stability in composites.

[7] Gowda, T. M., Naidu, A. C. B., & Chhaya, R. (1999). Some mechanical properties of untreated jute fabric-reinforced polyester composites. Composites Part A: Applied Science and Manufacturing, 30(3), 277–284.Reference for untreated natural fibers in composite applications

[8] Saheb, D. N., & Jog, J. P. (1999). Natural fiber polymer composites: A review. Advances in Polymer Technology, 18(4), 351–363.Comprehensive review of natural fibers including coir, jute, banana, and their mechanical roles.

[9] Mishra, S., Mohanty, A. K., Drzal, L. T., Misra, M., & Parija, S. (2001). Studies on mechanical performance of biofibre-glass reinforced polyester hybrid composites. Composites Science and Technology, 61(9), 1293– 1302.Supports hybrid fiber systems for improved performance.

[10] Ramesh, M., Palanikumar, K., & Reddy, K. H. (2013). Mechanical property evaluation of sisal–jute–glass fiber reinforced polyester composites. Composites Part B: Engineering, 48, 1–9.