ISSN (Online): 3139-7689

Available online: www.ijsrmes.com

International Journal for Scientific Research in Modern Engineering and Science

Published in: Vol. 1, Issue 4, pp. 13-22, September-October 2026

INVESTIGATIONS ON THE MECHANICAL PROPERTIES OF COMPOSITE MATERIALS REINFORCED WITH NATURAL FIBRES

Mayank Sharma [1]*, Anoop Kumar [2], Dr. Rajeshwar Verma [3], Ashwini Bhoi [4]

[1]*M. Tech Scholar, Department of Mechanical Engineering, Raipur Institute of Technology, Raipur (CG) INDIA.*
[2]*Assistant Professor, Department of Mechanical Engineering, Raipur Institute of Technology, Raipur (CG) INDIA.*
[3]*Associate Professor, Department of Mechanical Engineering, Raipur Institute of Technology, Raipur (CG) INDIA.*
[4]*Assistant Professor, Department of Mechanical Engineering, Raipur Institute of Technology, Raipur (CG) INDIA.*

Abstract

Natural Fibres are the abundantly found fibres which are very cheap and can be found in almost every part of India. They can be used to reinforce the epoxy to increase the strength and hardness and can affect their mechanical properties or we can say enhance it so their applications and uses thus can be increased to a level where they can be used efficiently and cheaply. Here we are using natural fibres of jute and coconut as they are available in large quantity and are very cheap. Coconut coir which is natural fibre is throwed away in waste and is a waste product which can be used to reinforce the epoxy, which can impact its mechanical properties and so, the jute fibres. In this paper, the coconut coir and jute fibre will be used to see the impact they made on the mechanical properties of the Lapox L-12 mixed with the hardener K-12. The fibres will be first treated with the NaOH solution and will be kept soaked in it for 24hrs. and the samples then created will be tested for the mechanical properties like Tensile Strength, compressive strength, hardness, etc. Thus, the result achieved from the above will show the effect natural fibres made in reinforcing the epoxy material and what effect they do on the properties of the epoxy material.

Keywords: *Natural Fibre, Hardness, Lapox L-12, Hardener K-12, Tensile Strength, Compressive Strength.*

* *Corresponding author*

1. INTRODUCTION

In today’s fast-paced world, optimizing material properties and environmental sustainability is crucial. Natural and eco-friendly materials offer cost benefits and ease of handling, as well as being abundant.

Composite materials consist of a resin/matrix and a fiber, used historically and in modern applications like household appliances and automobiles. They offer a balance of strength, weight, and cost, outperforming plastics and metals in many cases.

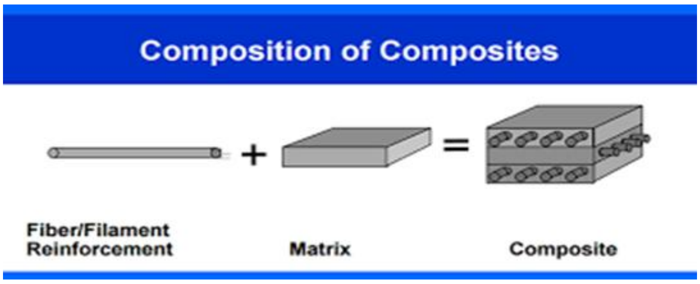

Figure 1: - Composition of Composite material

Initial attempts with polypropylene were challenging due to melting issues and fiber damage. Epoxy, which doesn't require heating and allows time for proper mixing and shaping, was chosen. Despite longer curing times, epoxy provides better results without damaging natural fiber

Natural Fibres are harvested, dried, and extracted from plants through processes like decortication and retting. Proper retting ensures quality fiber separation.

Epoxy Resin are versatile, offering high chemical resistance, durability, and excellent adhesion. They are used in various applications, including coatings, adhesives, and composites.

Epoxy resins are characterized by their chemical resistance, durability, and versatility. They are used in automotive, aerospace, marine industries, and more.

Lapox L-12 epoxy with K-6 hardener, mixed in a 10:1 ratio, was chosen for its ease of use at room temperature and compatibility with natural fibers. The mixture is cured for 48 hours to ensure proper bonding and strength.

2. LITERATURE REVIEW

Dielectric Properties

- Jayamani E. et al. [1]: Investigated dielectric properties of jute/bamboo composites, observing a decrease in dielectric constant with frequency increase.

Wood Dust Particle Reinforcement

- B. Chanda et al. [2]: Analyzed wood dust reinforced epoxy, optimizing mechanical performance with 10% filler content.

Jute Fiber Composites

- Ajith Gopinath et al. [3]: Found jute-epoxy composites to have better mechanical properties than jute-polyester composites.

Hybrid Composites for Automotive Applications

- A. Srivastava et al. [4]: Studied jute and E-glass fiber hybrids for automotive leaf springs, achieving a 55% weight reduction compared to steel.

NaOH Treatment Effects

- Nguyen Minh Hai et al. [5]: Found NaOH treatment significantly improved tensile strength and modulus of jute and coconut coir fibers.

Carbon Nanotubes Reinforcement

- Smrutisikha Bal [6]: Improved flexural moduli, electrical conductivity, and glass transition temperature with carbon nanotube reinforcement.

Henequen Fiber Composites

- P. J. H. Franco et al. [7]: Improved bonding and mechanical properties in henequen fiber reinforced polyethylene with silane coupling agent.

Bio-fiber Based Composites

- R. P. Kumar et al. [8]: Recommended banana, bamboo, and pineapple fiber composites for automotive applications.

Household Utility Applications

- S. M. Sapuan et al. [9]: Used banana fiber-reinforced epoxy for household utilities like telephone stands.

Mechanical Properties of Coir Fiber

- Abdul Nazeer [10]: Found NaOH-treated coconut coir fiber improved tensile properties, ductility, and hardness.

Jute Epoxy Composites

- Kumar A. et al. [11]: Found jute epoxy composites improved tensile and compressive strength with increasing jute fiber content.

Selected Citations: Abdul Nazeer [12] and Kumar A. et al. [29] were chosen for their findings on optimal mechanical properties. This project will use a single epoxy with both natural fibers to compare and enhance mechanical properties.

3. METHODOLOGY

Composite Materials Used

- Coconut with Lapox L-12 and K-6 Hardener
- Jute with Lapox L-12 and K-6 Hardener

Lapox L-12, characterized by medium viscosity, serves as an epoxy resin, while Hardener K-6, a low viscosity curing agent, is ideal for room temperature applications. The selection of hardener depends on the manufacturing system and desired material properties.

Properties of Lapox L-12 and Hardener K-6

- Lapox L-12:
  - Epoxide equivalent: 182-192 gm/eq
  - Epoxy value: 5.2-5.5 eq/kg
  - Viscosity at 25°C: 9000-12000 mPa.s
- Hardener K-6:
  - Visual appearance: Pale Yellow liquid

  - Refractive index at 25°C: 1.4940-1.5000

Mould Preparation

Moulds are essential for shaping composite materials into desired forms. Two types of moulds are utilized:

- Square Plate Mould:
  - Material: Plywood
  - Dimensions: 12.5”x12.5” base, 10mm wall height, 5mm plate thickness

Figure 2: - Square Plate Mould

- Cylindrical Pipe Mould:
  - Specifications: 16 mm diameter, 120 mm length

These moulds are meticulously prepared to ensure consistency and precision in sample fabrication.

Figure 3: - Cylindrical Pipe Mould

Sample Preparation

For the sample preparation the jute and coconut coir fibres are first treated with the NaOH solutions to get the best results out of them. since the studies have showed that the jute fibre gives the best result when treated with the 2% concentration NaOH solution and coconut coir fibres gives best result when treated with 6% concentrated NaOH solution, both kept for soaking for 24 hrs.

As keeping the jute fibres in 2% NaOH concentration for 24 hrs increases its tensile strength by 40% and keeping the coconut coir fibres in 6% NaOH concentration for 24 hrs increases the tensile strength by 62%.

Figure 4: - NaOH solution

Figure 5: - Jute fibre soaked in NaOH solution

Figure 6: - Coconut coir fibres soaked in NaOH solution

Plate Sample Preparation

1. Prepare a mixture of Lapox L-12 resin (350 ml) and 1/10th part K-6 hardener (35 ml).
2. Apply a thin layer of polythene and grease on the mould surface to facilitate easy sample removal.
3. Distribute natural fibres (jute or coconut coir) evenly over the mould surface in a 50:50 ratio with the resin mixture.

Figure 7: - Sample Plate of Jute and Lapox

Figure 8: - Sample Plate of Coconut Coir and Lapox

4. Pour the resin-hardener mixture into the mould, ensuring complete coverage of fibres.
5. Allow the sample to cure for 48 hours at room temperature to achieve optimal strength and durability.
6. After curing, cut the large plate into smaller samples (35 mm x 35 mm) for subsequent mechanical tests.

Figure 9: - Sample Plate of Jute Fibre and Lapox of 35mm x 35mm

Figure 10: - Sample Plate of Coconut Coir and Lapox of 35mm x 35mm

Cylindrical Sample Preparation

Figure 11: - Cylindrical sample of Coconut Coir and Lapox

Figure 12: -Cylindrical Sample of Jute and Lapox

4. RESULT AND DISCUSSION

Results from Previous Works

The comparative study incorporates results from recent research on similar composite materials to evaluate any improvements in properties achieved in the current study.

Jute Epoxy Composite:

- Tensile Strength: 33 MPa
- Compressive Strength: 31.3 MPa

Coconut Coir Epoxy Composite:

- Tensile Strength: 43 MPa

These results serve as benchmarks against which the newly developed composite materials will be compared. The goal is to determine whether the developed materials demonstrate enhanced tensile and compressive strengths compared to these established values, thereby assessing the effectiveness and success of the current research efforts.

Results Obtained from This Work

The testing of the material is done under the UTM.

The following compressive test are obtained by keeping a sample specimen under the UTM machine and the result are as follows-

- For jute fibre – 9840 Kgf
- For coconut fibre – 17800 Kgf

The conversion in the form of MPa is done so that proper comparison can be done with the results of the previous works. Thus, converting the Kgf into N we get-

- For jute fibre – 9840 x 9.80665 = 96497.44 N
    - Compressive strength = Load / area of cross-section

= 96497.44 / (35 x 35)
= 78.77 N/mm^2 = 78.77 MPa

- For coconut coir fibre – 17800 x 9.80665 = 174558.37 N
    - Compressive strength = Load / area of cross-section

= 174558.37 / (35 x 35)
= 142.496 N/mm^2 = 142.50 MPa

Hardness test for the material by Rockwell method under 60 kgf load

- For jute fibre – 83.33
- For coconut fibre – 81.5

Tensile testing of the materials from a recognised testing centre as follows:

- For jute fibre – 54.96 MPa with Elongation of 12.21%
- For coconut fibre – 74.53 MPa with Elongation of 7.24%

Comparison of Tensile Strength

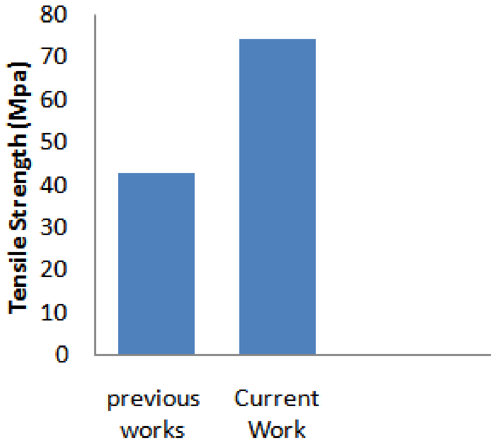

Figure 13: - Comparison of Tensile Strength of coconut coir epoxy composite material

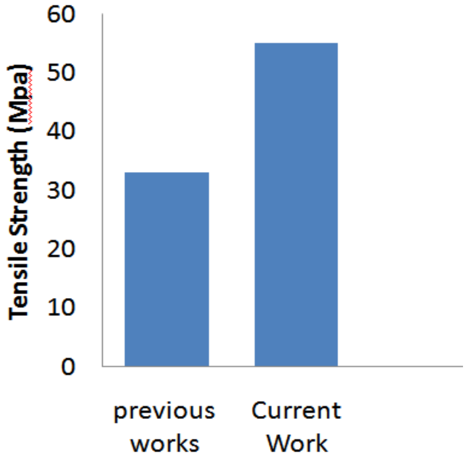

Figure 14: - Comparison of Tensile Strength of jute fibre epoxy composite material

Above fig. shows the comparison of the tensile strength between the composite material that have been tested in themost recent previous work done on the composite material reinforced with the natural fibres of jute and coconut coir and the composite material used in this work.

5. CONCLUSION

This paper demonstrates significant improvements in natural fibre reinforced composite materials by utilizing Lapox L-12 epoxy with hardener K-6. For jute fibre composites treated with 2% NaOH, tensile strength increased from 33 MPa to 54.96 MPa, a 64% enhancement. Similarly, coconut coir fibre composites treated with 6% NaOH showed a tensile strength increase from 43 MPa to 74.53 MPa, an improvement of approximately 79%. While jute fibre exhibited no significant change in compressive strength and slight enhancement in tensile strength compared to pure epoxy, coconut coir showed substantial increases in both compressive (from 43 MPa to 142.50 MPa) and tensile strength. This indicates coconut coir as a superior reinforcement over jute, despite jute offering better elongation during tensile testing.

REFERENCES

[1] Jayamani E, Hamdan S, Rahman MR, Bakri MKB (2014) Dielectric Properties of Hybrid Natural Fibre Composites. Procedia Eng 97: 536-544.

[2] Chanda B, Kumar R, Kumar K, Bhowmik S (2015) Optimisation of Wood Dust-reinforced Epoxy Composite. Springer, Adv Intelligent Syst Comput 336.

[3] Gopinath A, Kumar S, Elayaperumal A (2014) Mechanical Properties of Jute Fibre Reinforced Composites. Procedia Eng 97: 2052–2063.

[4] Srivastava A, Choudhary S (2013) Design and Structural Analysis of Jute/E-glass Woven Fibre Reinforced Epoxy Composite Leaf Spring. Int J Mech Eng Res 3: 573-582.

[5] Nguyen MH, Kim BS, Lee S (2008) NaOH Treatments on Jute and Coir Fibre PP Composites. J Adv Compos Mater 18: 253-263.

[6] Bal S (2010) Dispersion and Reinforcing Mechanism of Carbon Nanotubes in Epoxy Nanocomposites. Bull Mater Sci 33(1): 27–31.

[7] Franco PJH, Gonzalez AV (2004) Mechanical Properties of Continuous Natural Fibre-Reinforced Polymer Composites. Compos Part A 35: 339–345.

[8] Kumar RP, Chandan GK, Ramamoorthi R (2017) Fabrication and Testing of Natural Fibre Hybrid Composites. Int J Eng Res 5(4): 285-288.

[9] Sapuan SM, Maleque MA (2004) Design and Fabrication of Natural Woven Fabric Reinforced Epoxy Composite for Household Telephone Stand. Mater Des 26(1): 65-71.

[10] Nazeer A (2014) Mechanical Properties of Coconut Coir Fibre Reinforced Epoxy Composites. IJMER 4(7): 2249–6645.

[11] Kumar A, Srivastava A (2017) Preparation and Mechanical Properties of Jute Fibre Reinforced Epoxy Composites. Ind Eng Manage 6(4).

[12] Lapox Epoxy Resin L-12 with Hardener K-6 (2013) [Online]. Available: https://5.imimg.com/data5/VR/WS/MY-34403803/lapox-epoxy-resin-l12-with-hardener-k-6-1-1-kg-packing.pdf