International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 08 , August - 2026

Development & Analysis of Epoxy Based Composite Material by using Natural Fibers and Finding Its Mechanical Properties and Sliding Wear Behavior

Sumit Pawar[1], Dr. Mukund Harugade[1], Mr. Nikhil Ambole[1], Mr. Pravin Shinde[1]
[1]Department of Mechanical Engineering, PVPIT, Budhgaon, Sangli, Maharashtra, India.

Abstract - This study focuses on developing and analyzing sisal fiber-reinforced epoxy composites. Manual fiber extraction yielded stronger, cleaner fibers compared to retting. Surface treatment with 5% NaOH improved fiber-matrix bonding, enhancing mechanical properties. Composites were fabricated using the hand lay-up method with a 50:50 fiber-to-resin ratio. Wear behavior was assessed through pin-on-disk testing, revealing reduced mass loss and improved durability. Optical microscopy showed better crack resistance with uniform fiber distribution. The study highlights the importance of extraction method, surface treatment, and fabrication technique in improving performance. These findings support the potential of sustainable natural fiber composites in industrial use.

Keywords: Epoxy, resin, application, fiber etc.

I. INTRODUCTION

Over the past three decades, composite materials have emerged as dominant engineering materials, penetrating markets from everyday products to sophisticated niche applications. Modern composite materials constitute a significant proportion of the engineered materials market, offering weight-saving advantages while presenting challenges in cost-effectiveness [1]. The composites industry has increasingly recognized that commercial applications offer larger business opportunities than aerospace sectors, particularly due to the transportation industry's scale. This shift has driven innovation in manufacturing techniques and material development.

Composite materials consist of two or more physically and/or chemically distinct phases separated by an interface, with characteristics not depicted by any individual component. The matrix phase, typically continuous and ductile, holds the dispersed reinforcement phase and shares loads with it. The dispersed (reinforcing) phase, usually harder and stronger, provides mechanical reinforcement [2].

II. LITRATURE REVIEW

Researchers have explored natural fiber composites (NFCs) for improved mechanical performance and sustainability. Mohit Sood et al. (2018) reviewed how chemical and physical fiber treatments (like alkali, silane, epoxy) enhance flexural strength by improving fiber-matrix bonding. K.L. Pickering et al. (2016) highlighted significant advancements in NFC mechanical properties, enabling use in automotive and marine sectors. Naheed Saba et al. (2015) emphasized epoxy modification to overcome brittleness and improve performance in natural fiber-reinforced composites. D. Saravana Bavan et al. (2014) discussed India's potential in NFC production due to resource availability. Fairuz I. Romlia et al. (2012) found fiber volume fraction and curing time as key factors in coir composite strength. Junjun et al. (2012) used treated rice straw with corn starch for eco-friendly composites with improved flexural strength. Enrique Bonugli et al. (2017) recommended concrete as a realistic testing surface for motorcycle helmets due to its closer resemblance to roadway conditions compared to abrasive papers.

III. MATERIAL AND METHODS

This chapter presents the methodology adopted for composite fabrication and outlines the experimental procedures employed to evaluate their mechanical properties. The materials selected and utilized for the preparation of the composites are described below.

Fig.3.1. Materials and Equipment's used in prepare composite material.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 08 , August - 2026

3.1 MATERIALS

3.1.1 Epoxy resin (LY-556)

Epoxy is lightweight, resistant to chemicals and stress cracking, with low moisture absorption and good **flexibility**. It is easily fabricated and retains stiffness under load. Epoxy is widely used in structural applications, industrial tooling, and electronic systems.

3.1.2. Hardener (HY-951)

The hardener acts as a curing component in an epoxy-based composite system. When mixed with the epoxy resin, it initiates the chemical curing reaction and converts the resin into a rigid and stable matrix. The hardener is sometimes referred to as a curing agent or catalyst. The type and proportion of resin and hardener significantly influence the final mechanical, thermal, and chemical properties of the cured epoxy system. Therefore, appropriate selection and mixing of these components are essential to obtain the desired performance and ensure the suitability of the composite for its intended application.

3.1.3 Natural fibers such as Sisal

Fiber-reinforced polymer composites have been extensively used in engineering applications because of their excellent strength-to-weight ratio and high specific stiffness. Conventional fiber-reinforced plastics commonly employ synthetic reinforcements such as glass, carbon, or aramid fibers combined with thermoplastic or thermosetting polymer matrices. However, concerns related to their manufacturing processes, service life, disposal, and environmental impact have encouraged researchers to explore more sustainable alternatives. Natural fiber composites are a class of composite materials in which the reinforcing phase is obtained from naturally occurring or renewable sources. These reinforcements may be used in the form of fibers, particles, or platelets, providing an environmentally favorable alternative to synthetic fibers such as carbon and aramid.

IV. TESTING AND RESULTS

4.1 Tensile Strength Test:

The mechanical performance of the fiber-reinforced vinyl ester composites was evaluated in terms of ultimate tensile strength (UTS), flexural strength, and impact strength. These properties were determined experimentally using a Universal Testing Machine (UTM), with the test specimens prepared in accordance with the relevant ASTM standards. The specifications of the UTM used for the experimental investigation are provided in Table 4.1.

Table. 4.1 Specification of Universal Testing Machine

Parameter	Specifications
Capacity	10 tones
Mounting	Free standing
Load range	1 -1000 kg using 1 ton load cell 1-10000 kg using 10 ton load cell

Fig. 4.1 Tensile test specimen as per ASTM E8 Standard

This test done on UTM machine as per standard procedure of test. For this test ASTM- E8 Standard Three specimen developed and then test done on it. The results of these testsare as follows;

Fig. 4.2 Tested specimen on UTM machine

Results of Tensile Test:

Specimen no. 1:

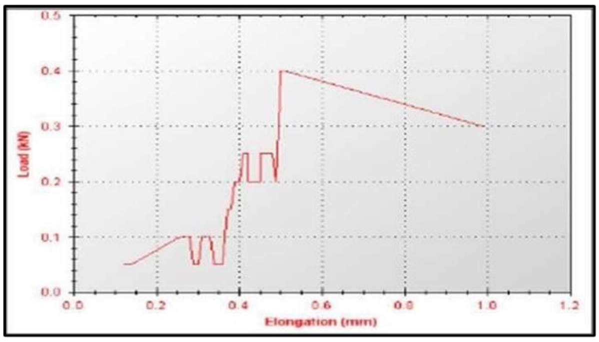

Fig. 4.3 Load Vs Elongation Graph

4.2 Bending Test:

Flexural characterization of the composite specimens was carried out in accordance with ASTM D790, which specifies the standard procedure for determining the bending properties of polymer-based composite materials. The specimens were prepared and machined to the dimensions prescribed by the standard. For the balanced and symmetric epoxy–sisal fiber composite, the specimen dimensions were maintained at 12.7 mm in width, 127 mm in length, and 6 mm in thickness. The flexural test was performed using a Universal Testing Machine (UTM) under a three-point bending configuration. A span of 100 mm was maintained between the two supporting points during the test. The maximum load sustained by each composite

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 08 , August - 2026

specimen before failure was recorded to evaluate its flexural load-carrying capacity. The experimental test arrangement is presented in Fig. 4.6, while the specimen dimensions are illustrated in Fig. 4.4 and Fig. 4.5.

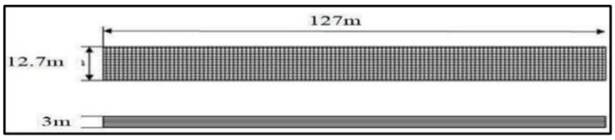

Fig. 4.4 Specimen Details

Fig. 4.5 Bending Test Specimen

Fig. 4.6 Test set up for three-point bending

Result of Bending Test:

Table No. 4.2. Bending Test Results

Specimen	Load in KN
Specimen 1	**11.60**
Specimen 2	**12.80**

4.3 Impact Strength Test:

The impact behavior of the composite specimens was evaluated in accordance with ASTM D256. Both Charpy and Izod impact tests were performed using an Impact Testing Machine to determine the impact strength of the prepared composite samples. The experimental test arrangement used for the impact characterization is shown in Fig. 4.7.

Fig. 4.7 Standard specimen of Charpy Impact Test.

The Impact test of composite material is conducted on Impact testing machineas shown in Fig. 4.8.

Fig. 4.8 Charpy Test Machine position

Result of Impact Test:

Table No. 4.3. Impact Test Results

Specimen	Impact Energy Absorbed in joules
Charpy test	178
Izod Test	58

4.4 Friction Test

The pin-on-disc test is a widely used experimental technique for assessing the wear behavior and tribological performance of material pairs under controlled contact conditions. In this method, a pin specimen is brought into contact with a rotating disc, allowing the wear characteristics of the interacting materials to be evaluated. The technique is useful for comparing different materials or material combinations under specified test conditions. Wear performance can be assessed by measuring parameters such as mass loss, wear rate, and changes in the surface profile after testing. Examination of the worn surfaces can provide additional information regarding the mechanisms responsible for material degradation. Surface profilometry may also be employed to determine changes in surface topography, while microscopic or metallurgical examination can be used to study the characteristics of the wear tracks. The pin-on-disc method therefore provides a convenient and controlled approach for comparative evaluation of the wear resistance of composite materials.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 08 , August - 2026

Fig. 4.9(a): Tribometer Machine

Fig. 4.9(b): Pin on Disc Arrangement

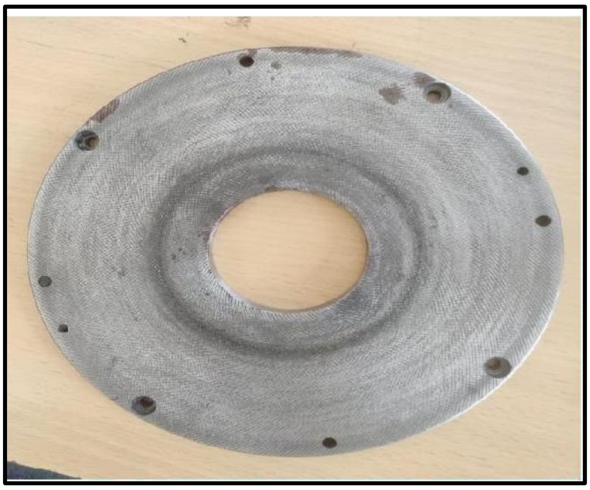

Fig. 4.9 (c): M.S. Disc

Fig. 4.9 (d): Composite Material Pin

V. CONCLUSION

The study successfully demonstrates the influence of extraction methods, surface treatment, fabrication techniques, and testing processes on the performance of natural fiber-reinforced polymer composites. Manual extraction of sisal fibers was preferred over retting due to its simplicity, efficiency, and ability to produce long, clean fibers with minimal degradation. Surface treatment using 5% NaOH significantly improved the fiber–matrix bonding by removing surface impurities and enhancing interfacial adhesion, which is critical for load transfer in composites. The hand lay-up method, owing to its simplicity and flexibility, was effectively utilized to fabricate composite samples with controlled fiber alignment and matrix distribution. Maintaining a consistent epoxy-to-fiber ratio (50:50) helped achieve uniform material properties across specimens.

Pin-on-disk friction testing revealed that wear resistance and surface integrity depend highly on the quality of fiber–matrix bonding and material consistency. Post-test analyses using mass-loss evaluation, profilometry, and metallurgical inspection helped to characterize the wear mechanisms and confirmed the relevance of simulating real-world contact scenarios using controlled laboratory techniques. Optical microscopy analysis of surface morphology before and after tensile testing revealed that failure in composites often initiates at zones of uneven fiber distribution or weak bonding. While fibers initially inhibit crack propagation, failure ultimately occurs once the applied stress exceeds the matrix's strength and bonding capability. In conclusion, the combined approach of optimizing extraction, treatment, fabrication, and testing methods provides a robust framework for improving the mechanical performance and durability of natural fiber-reinforced composites. These insights are particularly valuable

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 08 , August - 2026

for applications requiring sustainable, lightweight, and cost-effective material solutions.

REFERENCE

[1] Mohit Sood, Gaurav Dwivedi, “Effect of fiber treatment on flexural propertiesof natural fiber reinforced composites: A review”, SciVerse Science Direct,(2018), pp. 775-783.

[2] K.L. Pickering, M.G. Aruan Efendy,T.M. Le. “A review of recent developments in natural fiber composites and their mechanical performance”, SciVerse Science Direct, (2016), pp.98-112.

[3] Naheed Saba, Mohammad jawaid, MT Paridah, Azman Hassan. “Recent advances in epoxy resin, natural fiber -reinforced epoxy composites and their applications”, Journal of Reinforced Plastics and Composites, (2015), pp.1-24.

[4] Fairuz I. Romlia, Ahmad Nizam Alias, Azmin Shakrine Mohd Rafie, Dayang LailaAbang Abdul Majd. “Factorial Study on the Tensile Strength of a Coir Fiber- Reinforced Epoxy Composite”, SciVerse Science Direct, (2012), pp.242-247.

[5] Junjun LIU, Chanjuan JIA, Chunxia HE. “Flexural properties of Rice Strawand Starch Composites”, SciVerse Science Direct, (2012), pp. 89-94.

[6] Omar Faruk, Mohini Sain,Andrzej K. Bledzki. “Bio composites reinforced with natural fibers:2000–2010”, SciVerse Science Direct, (2012), pp.1552-1596.

[7] D Saravana Bavan and GC Mohan Kumar.“Potential use of natural fiber composite materials in India”, Journal of Reinforced Plastics and Composites, (2010), pp. 3600-3613.

[8] Joo-teck Jeffrey, Tarlochan Faris, “Finite element analysis on the static and fatigue characteristics of composite multi-leaf spring”, Journal of Zhejiang University- Science, Vol. 13, 2022, pp 195-164.

[9] Mahajan, G. V. & Aher, V. S. (2022). Composite Material: A Review over Current Development and Automotive Application. International Journal of Scientific and Research Publications, 2(11), 1-5. ISSN 2250-3153.

[10] Agrawal, P. et al. (2022). A Review Paper of Composite Materials: Advantages and Applications. International Journal of Advances in Engineering and Management (IJAEM), 4(11), 369-370.