International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 21, Issue 4 (April 2025), PP 161-166

Mechanical Properties of Composite Material for Reinforcing By Natural –Synthetic Fibers

T Jayakumar[1], M Sudhahar[2], P Vijayakumar[2], K Ram[3],T Ambikabathi[4]
[1]*M.Tech - Scholar, Department of Mechanical Engineering, Prist University,Thanjavur,*
[2&3] *Associate Professor, Department of Mechanical Engineering, Prist University, Thanjavur.*
[4] *HOD, Department of Mechanical Engineering, Pavandhar Bharathidasan Polytechnic College, Pudukkottai*

Abstract:
The mechanical characteristics of araldite matrix composites reinforced with fibers from the husk and coir of hybrid coconuts were assessed. There are signs that combining both fibers into one matrix—araldite resin—will stabilize mechanical characteristics and reduce production costs.
The impact strength, tensile strength, compression, and hardness of composite materials reinforced with hybrid fibers for coconut husk and coir were investigated in this study. The impacts on the aforementioned mechanical properties were examined after these fibers were combined with araldite resin at varying reinforcing percentages (20%, 40%, and60%).
These mechanical properties have been demonstrated to improve following fiber reinforcement, and their value will rise as the percentage of reinforcement increases.
Key words: *reinforcement, husk, coir, resin, tensile strength, mechanical test, and dynamic test.*

Date of Submission: 05-04-2025 Date of acceptance: 15-04-2025

I. Introduction:

A composite material is made up of two or more phases that are physically and/or chemically different and are dispersed or ordered appropriately. Typically, a composite material exhibits properties that none of its constituent parts alone could describe. It is clear from this definition that a variety of engineering materials are included in this group. Concrete, for instance, is a composite since it contains both aggregate and Portland cement. Because it is composed of glass fibers embedded in a polymer, fiber glass sheet is a composite. The creation of hybrid bio-composites is the result of combining many fiber types into a single matrix.

Hybrid composites behave as a weighted sum of its constituent parts, where the inherent benefits and drawbacks are more favorably balanced. Additionally, the benefits of one fiber type may be complemented by the shortcomings of another when a hybrid composite comprising two or more fiber kinds is used. As a result, appropriate material designs can be used to balance performance and cost. The fiber content, individual fiber length, orientation, degree of intermingling, fiber to matrix bonding, and arrangement of both fibers are the primary determinants of a hybrid composite's qualities.

The failure of individual fibers also affects the hybrid composite's strength. High strain compatibility of the fibers yields the best hybrid results. The strength, tensile strength, compression, and hardness of the combination of resin with husk and resin with coir pith were to be determined in this research.

II. Literature survey:

Numerous industries, including the building, automotive, and aerospace sectors, have made use of polymeric composites. In the fields of dentistry, orthopedics, biomedicine, and tissue engineering, they are also frequently utilized [1]. Several thermoplastics, including polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), and polystyrene (PS), are frequently utilized as matrices in polymeric composites. On the other hand, the thermosetting plastics most frequently employed in the creation of polymer-based composites include polyester and epoxy. Fiber reinforcement is primarily used to enhance the mechanical characteristics of polymers, such as their high strength-to-weight ratio [2].

Several tasks were completed in a sequential manner in order to conduct the experiment. High-quality coconuts have been collected for the first time. Following the acquisition of all required materials, glass fiber was combined with the extracted coconut fiber in a number of configurations using epoxy resin and hardener. Following fabrication, samples were put through a battery of tests, including tensile, impact, flexural, hardness, water absorption, and SEM, to see how their physical characteristics changed. Due to the specimen's lack of dimensions, there are certain restrictions while testing it for compression. After that, the composite's final specific attributes were identified. Various fiber orientations exhibited mechanical properties that surpassed those of current materials. Among the different fiber orientations, the Random Fiber orientation observed in the Type-I specimen yielded a notably high average value across all tests. It demonstrated superior performance compared to wood and could serve as an alternative for high strength in terms of hardness. Although it may be relatively expensive during this initial development stage, ongoing research may lead to cost reductions once mass production begins [3].

The research indicated that coir fiber reinforcement enhances epoxy resin. The optimal increase in coir fiber weight percentage occurs at a tensile strength of 32 MPa, a Young's modulus of 5800 MPa, and impact strength of 100 J/m, with an ideal coir fiber percentage of 8%. An increase to ten percent (10 wt.%) or more of coir fiber results in a decline in the composite’s tensile strength, Young's modulus, and impact strength, as this increase weakens the bonding force between the resin and the matrix. Nevertheless, raising the percentage weight of coir fiber strengthens the flexural strength of the composite materials up to ten percent (10 wt.%). In summary, the findings demonstrate that incorporating coir fiber into epoxy resin significantly enhances the mechanical properties of the composites [4].

Throughout the years, composites reinforced with coir fiber have found extensive use in various fields due to their resistance to corrosion and advantageous mechanical properties. Coir fiber reinforced polymer composites have been created for a range of industrial and socio-economic uses, including automotive interiors, paneling and roofing materials for construction, storage tanks, packaging materials, helmets, postboxes, mirror casings, paperweights, projector covers, and covers for voltage stabilizers [5]. A military helmet made from a coconut fiber reinforced polymer matrix demonstrated positive results upon evaluating the mechanical properties of the helmet samples produced. Nevertheless, they noted that the impact test, which is undeniably the most critical aspect of the study, showed a consistent enhancement as the amount of coir fiber increased to 8.733N/mm^2 [6]. Composites are formed by merging two or more materials, resulting in a distinctive set of characteristics; one component consists of rigid, elongated fibers, while the other serves as a matrix or binder that secures the fibers. They noted that these materials "contain one or more distinct phases embedded within a continuous phase, creating a multiphase material that exhibits enhanced properties unattainable by any of the individual materials when acting independently [7]."

The mechanical characteristics of the coir-polyester composites containing calcium carbonate and aluminum oxide particles were examined in this work. These composites have improved values for a variety of mechanical properties, the scientists determined. The researcher used epoxy resin as the matrix material and a bidirectional jute fiber mat as reinforcement. They learned how fiber loading affected the mechanical properties of the composites. They came to the conclusion that the formation of voids was one factor influencing the composites' mechanical qualities [8]. It examined the epoxy composite reinforced with a hybrid sisal and jute fibers' capacity to absorb heat and moisture. They demonstrated that hybridization affected the properties of moisture absorption (reduction) and heat stability (rise) [9].

The viability of employing coconut fibers as a reinforcing ingredient in polymer-based composites has been established by this research project. The fused filament fabrication technique was employed to create the composite samples additively. It has been investigated how the coconut fiber fractions affect the tensile, compression, and flexural characteristics of the composites. It was shown that the amount of coconut fibers in the composite had a significant impact on these characteristics. It was discovered that as the percentage of coconut fibers in the composite increased, its mechanical strengths increased as well. After a few optimal points, however, they began to decline. The composites reinforced with 2 weight percent coconut fiber had the highest tensile and flexural strengths, while the composite loaded with 3 weight percent coconut fiber had the highest compression strength. Carbon fiber-reinforced polypropylene, which is now utilized to build automotive elements like dashboards and bumper fascia, was shown to have lower tensile and flexural strengths than reinforced polypropylene. The created composites may serve as a substitute for polypropylene composite reinforced with carbon fiber [10]. The author examined how fibers' mechanical and water-absorbing qualities are affected by chemical treatment. They observed a clear relationship between mechanical characteristics, water absorption, and chemical treatment. The researchers came to the conclusion that chemically treating natural fibers improves their mechanical qualities and lowers their rates of water absorption [11]. These methods are marked by poor part consolidation, limited design freedom, high energy consumption, material waste, and a high degree of rework. Adopting new fabrication methods, such additive manufacturing, is required to address some of these issues. For use in automotive vehicle components such dashboards, door handles, and bumper fascia, the current study examined the mechanical properties of fused filament produced coconut fiber (Coir fiber) reinforced polypropylene. The process of creating natural fiber-reinforced polymeric composites most frequently involves fused filament fabrication, one of the additive manufacturing (AM) technologies with the quickest rate of growth. FFF has a number of advantages, including excellent energy efficiency, decreased material waste, and the capacity to create microscopic parts. Furthermore, the method is comparatively less expensive than other AM methods [12].

This study examines how the weight fraction of coconut fibers affects the mechanical characteristics of composites reinforced with coconut fibers. Tensile tests using a Universal Testing Machine Kinston 8872 and hardness tests using a Digital Shore Scale "D" were used to assess the mechanical properties of various composites made with varying weight percentages of coconut fiber. The results show that the weight percentage of coconut fiber significantly affected the composites' tensile strength, tensile strain, and hardness. This study emphasizes how crucial it is to optimize fiber content in coconut fiber-reinforced composites in order to attain balanced mechanical characteristics [13]. These fibers have many benefits over synthetic ones, including being biodegradable, renewable, and requiring less energy to produce. Furthermore, natural fibers provide advantageous mechanical qualities like sufficient stiffness, a high strength-to-weight ratio, and strong impact resistance [14].

It is evident from the gaps and publications that there is a dearth of research on hybrid composite materials made from natural coconut fiber with varying fiber orientation angles. The majority of studies on natural fiber-based composite materials have concentrated on natural fibers including banana, bamboo, and flax. For the production of hybrid composites based on coconuts with various fiber orientations, the information currently available is insufficient.

In this research the impact strength, tensile strength, compression, and hardness were studied for composite material reinforced with hybrid fibers for coconut coir and husk. These fibers were mixed with araldite resin in different reinforcement percentage (20%, 40%, and 60%) and the effects on the above mechanical properties are studied.

Experimental Procedure:

These types of fibers used as consecutive layers in same matrix with 50% coconut husk fibersand50% coconut coir fibers. Four samples were manufactured for each test which different by the resin and hardener and reinforcement percentage are below . Hand molding method was used to manufacture the samples. Some resin spread in the mould and the fiber layer put on it and this process repeated to obtain the desired thickness.

TableNo.1Structure of Sample

Sample number	**1**	**2**	**3**
Resin (weight%)	**80**	**60**	**40**
Coir and husk (weight%)	**20**	**40**	**60**

The core benefits of composite materials have their great strength and stiffness, for example Carbon Fibers have great specific strength, high modulus, good in fatigue resistance and dimensional stability and lower density Fibers. Composite materials have their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. The reinforcing phase of composite materials provides the durability, strength and stiffness. There are in many cases, the reinforcement is tougher, stronger, harder and stiffer than the matrix. The reinforcement is normally a fiber or a particulate. Particulate composites have dimensions that are almost the same in all directions. Particulate composite that consists of tiny particle of one material embedded in another material. Particulate composites tend to be feeble and less stiff than continuous fiber composites, but they are normally much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) duet processing difficulties and brittleness. The composite material industry, nevertheless, is novel. It has technologically advanced speedily in the earlier 35 years through the improvement of fibrous composites: to begin through, glass fiber reinforced polymers (GFRP) and, more recently, carbon fiber reinforced polymers (CFRP). Their use in boats and their growing replacement of metals in ground transport systems is an uprising in material us which is still accelerating. It finds application in composite, Automotive, sport goods, medical equipment & packaging Industry.

Material and Composition:

Sample number	Percentage of resin	**Percentage of coir and husk**
1	**80%(80g)**	**20%(20g)**
2	**60%(60g)**	**40%(60g)**
3	**40%(40g)**	**80%(20g)**

Material weights calculation:

Material volume = (Length x Breath x Thickness) / 1000
= (200 x 150 x 12) / 1000
= 360 g / cm^3

Resin weight = (Volume x density) / 1000
= (360 x 7.5) / 1000
= 2.700 kgs

Photography of raw material

Hardener **Resin**

220 g of Hardener and 240 g of Resin Mixture at one Ratio

Husk

800g added based on ratio

Coir

1200g added for based on ratio

Preparation coir with husk

Pouring to Mould

Resin pouring to the mould cavity

Molded Material

Wet and dry condition at room temperature

MANUFACTURED NATURAL - SYNTHETIC FIBER

80% resin and 20% coir & husk

60% resin and 40% coir & husk)

40 % resin and 60 % coir and Husk

Experimental analysis - Mechanical test

Tensile Strength Samples: these samples manufactured according to the (ISO-R-527) standard .The universal test instrument manufactured by (hel mech Instrument Co., Ltd) used to measure this property with a (20KN) load. Hardness test: In this test the "Brinell method" was used to measure hardness, this test made with a steel ball (5mm) diameter and (10kg) exposition load, loaded in to samples for (15sec), and the hardness number represents the diameter of impression after the load removal, which left on surface by the ball. Hardness samples are a disc shape with (25mm) diameter and (10mm) thickness. Flexural strength can be measured by three point test by using universal hydraulic press (helmech Instrument Co., Ltd) to calculate the maximum load exposed on middle of the sample. Flexural samples fabricated according to (ASTM-D790) standard as a rectangular shape (10mm×135mm).

TENSILETEST

Tensile Strength Samples: these samples manufactured according to the (ISO-R-527) standard. The maximum load 150KN. The % of elongation of Fiber was increased by sample number three but still showing the yield strength is comparable to sample number two. However the ductility is much higher than sample number one.

IMPACTTEST

Impact samples fabricated according to the (ASTM-E23) standard suitable to Charpoy Impact Instrument.
0.5mm and notch base radius is 0.25mm.

HARDNESS

In this test the "Brinell method" was used to measure hardness, this test made with a steel ball (5mm)diameter and(10kg) exposition load, loaded into samples for (15sec),and the hardness number represents the diameter of impression after the load removal, which left on surface by the ball and the load is 20 KN.

FLEXURAL

Flexural strength can be measured by three point test to calculate the maximum load exposed on middle of the sample. Flexural samples fabricated according to (ASTM-D790) standard as a rectangular shape (10mm×135mm).

III. RESULTAND CONCLUSION

The value of impact strength with fibers reinforcing percentage .Generally, the impact resistance considered low to the resins due to brittleness of these materials, but after reinforcing it by fibers the impact resistance will be increased because the fibers will carry the maximum part of the impact energy which exposition on the composite material. The impact resistance will continue to increase with increased of the fibers reinforcing percentage. The resin considered as brittle materials where its tensile strength is very low as shown in but after reinforcing by fibers this property will be improved greatly ,where the fibers will withstand the maximum part of loads and by consequence will raise the strength of composite material .The tensile strength will be increased as the fibers percentage addition increased , where these fibers will be distributed on large area in the resin .As mentioned above ,the resin is brittle ,therefore its flexural strength will below before reinforcement. But after added the fibers to this resin the flexural strength will be raised to the producing material because the high modulus of elasticity of these fibers will helps to carry a large amount of loads and raise this strength. Polymers have low hardness, which appears in the lowest value for araldite resin before reinforcement .But this hardness value will greatly increase when the resin reinforced by hybrid fibers, due to distribution the test load on fibers which decrease the penetration of test ball to the surface of composite material and by consequence raise the hardness of this material .The hardness will be increased with increasing the percentage of fibers reinforcement. The high mechanical properties (Impact, Tensile, Flexural Strength, and hardness) of the araldite resin .Improvement of mechanical properties after reinforcement by resin and coconut coir fibers. The entire test is carried out by using Universal hydraulic press (helmech Instrument Co., Ltd)

Acknowledgment:
Our sincere thanks to **Er.M.VIVEK,M.Tech,C.Engg**., HOD, Department of Electrical and Electronics Engineering, Royal Polytechnic College, Pudukkottai to give their valuable support to collect the materials and assist the technical support for the successful completion of the project. E – mail: maruvim@gmail.com

Reference:

[1]. Chowdhury, M.A. And Hossain, S. (2020) A Review on Tensile And Flexural Properties of Fiber-Reinforced Polymer Composites. IOSR Journal of Polymer And Textile Engineering, 7, 16-26.

[2]. Li, M., Pu, Y., Thomas, V.M., Yoo, C.G., Ozcan, S., Deng, Y., Et Al. (2020) Recent Advancements of Plant-Based Natural Fiber-Reinforced Composites and Their Applications. Composites Part B: Engineering, 200, Article 108254.

[3]. M. Ahasan Habib, Ayman Sajjad Akash "Fabrication and Testing of Mechanical Properties of Coconut-Glass Fiber Reinforced Polyester Composite Based on Fiber Orientation", Volume:05/Issue:07/July-2023 International Research Journal of Modernization in Engineering Technology and Science, E-ISSN: 2582-5208.

[4]. Charles Chikwendu Okpala, Emmanuel Chuka Chinwuko, "Mechanical Properties And Applications of Coir Fiber Reinforced Composites" Volume: 08 Issue: 07 July 2021, International Research Journal Of Engineering And Technology (IRJET) E-ISSN: 2395-0056.

[5]. Bongarde, U., And Khot, B. (2019), "A Review On Coir Fiber Reinforced Polymer Composite" International Research Journal Of Engineering And Technology, Vol. 6, Iss. 4

[6]. Natsa, S., Akindapo, J., And Garba, D. (2015), "Development of A Military Helmet Using Coconut Fiber Reinforced Polymer Matrix Composite" European Journal of Ngineering And Technology, Vol. 3, Iss. 7

[7]. Verma, D., Gope, P., Shandilya, A., Gupta, A., And Maheshwari, M. (2013), "Coir Fibre Reinforcement And Application In Polymer Composites: A Review" Journal Of Material And Environment Science, Vol. 4, Iss. 2

[8]. Sathiyamurthy, S., Syed Abu Thaheer, A., & Jayabal, S. (2013). Modelling and Optimization of Mechanical Behaviors Of Al2O3-Coir-Polyester Composites Using Response Surface Methodology. Indian Journal Of Engineering And Materials Sciences, 20(1), 59–67.

[9]. Gupta, M. K., & Srivastava, R. K. (2016). Mechanical Properties of Hybrid Fibers-Reinforced Polymer Composite: A Review. Polymer - Plastics Technology And Engineering, 55(6), 626–642. Https://Doi.Org/10.1080/03602559.2015.1098694

[10]. George Mosi, Bernard W. Ikua," Characterization And Modeling of Mechanical Properties of Additively Manufactured Coconut Fiber-Reinforced Polypropylene Composites" Advances In Materials Physics And Chemistry, 2024, 14, 95-112, ISSN Online: 2162-5328 ISSN Print: 2162-531X

[11]. Bachchan, A.A., Das, P.P. And Chaudhary, V. (2022) Effect of Moisture Absorption on The Properties of Natural Fiber Reinforced Polymer Composites: A Review. Materials Today: Proceedings, 49, 3403-3408.

[12]. Mazzanti, V., Malagutti, L. And Mollica, F. (2019) FDM 3D Printing of Polymers Containing Natural Fillers: A Review Of Their Mechanical Properties. Polymers, 11, Article 1094

[13]. K. A. Zakaria , M. F. A. Aziz," Evaluating Mechanical Performance of Coconut Fibre Reinforced Polymer Composites With Variable Fibre Content" ARPN Journal of Engineering And Applied Sciences, VOL. 19, NO. 15, AUGUST 2024, ISSN 1819-6608

[14]. Zulkafli N., Dhar Maligam S., Fadzullah S. H. S. M., Mustafa Z., Zakaria K. A. And Subramonian S. 2019. Mechanical Properties Of Cross-Ply Banana-Glass Fibre Reinforced Polypropylene Composites. Defence Science And Technology Technical Bulletin.