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AN EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF NATURAL FIBRE COMPOSITES

K. MANIKANDAN[1], M. NAGARAJ[2], R. PAVEEN[3], K.S. SANJAI NITHISH[4], A.M. THASIM[5]

1 – Professor, Department of Mechanical Engineering, P.A. College of Engineering and Technology, Pollachi, Tamil Nadu, India.

2,3,4,5- Students Department of Mechanical Engineering, P.A. College of Engineering and Technology, Pollachi, Tamil Nadu, India.

ABSTRACT

Natural fiber reinforced composites have drawn a lot more attention recently than synthetic fiber composites due to their many benefits, including low cost, light weight, non-abrasive, non-toxic, and biodegradable qualities. Because of its mechanical qualities and dimensional stability, epoxy resin has drawn the attention of numerous researchers who prefer it to other thermosetting and thermoplastic polymers for creating composites. In this investigation, fish tail palm fiber was chosen for its superior surface shape and matrix bonding. Using the compression molding technique, groundnut powder, shrimp tail palm leaf stalk fiber, and mango powder were used as bio fillers to create natural hybrid composites in this study. Fishtail leaf stalk fiber, tamarind powder, and groundnut powder were added to an epoxy composite matrix to create the composites. Experiments as specified by ASTM were conducted to evaluate the effect of fishtail palm leaf stalk fibre on the mechanical and tamarind powder characteristics of the composite.

INDRODUCTION

Two or more fibers are combined into a single matrix to create hybrid composites. The term "Caryotos urens" refers to the scientific name for the fishtail palm tree, which has divided leaves with triangular leaflets. Artificial, natural, or a combination of artificial and natural fibres can be used to create hybrid composites. This is a member of both the "palmae family" and the "Aceraceae family." Though the fiber extracted from the fishtail is unquestionably the least valuable component of the tree, it is incredibly strong.

Because of natural fibers' superior mechanical qualities, low density, and biodegradability, their uses are expanding rapidly in the modern world. Compared to fiber-reinforced composites, hybrid composites can assist us in achieving a superior combination of qualities. This work is important because it could help with two pressing issues: the need for better mechanical performance and the search for sustainable materials. Through investigating the mechanical characteristics of hybrid composites made of natural fibers, this research aims to provide significant contributions to the domains of material science and engineering.

Through meticulous experimentation and analysis, we aim to identify the optimal combinations of natural fibres that lead to improved strength, stiffness, and toughness, while also considering factors such as cost-effectiveness and environmental impact. The findings of this study hold the promise of not only advancing the development of eco-friendly materials but also inspiring the design of innovative solutions in industries ranging from automotive and aerospace to construction and consumer goods.

Natural hybrid composite materials are new materials that combine elements from two or more natural sources to create a material with better properties and performance. Because of their superior mechanical properties, renewable resource availability, and eco-friendliness, these composites are garnering more and more attention across a range of industries.

The use of natural fibres, such as jute, flax, hemp, sisal, and kenaf, combined with a biopolymer matrix (e.g., starch, soy protein, cellulose, or chitosan), forms the basis of most natural hybrid composites. These materials offer several advantages over traditional synthetic composites, including lower production costs, reduced carbon footprint, and biodegradability, making them more sustainable alternatives.

LITERATURE REVIEW

Selvakumar, K. and Meenakshisunda [1] 'Mechanical and dynamic mechanical analysis of jute and human hair-reinforced polymer composites & Polymer Composites'. From this review author studied the mechanical properties of epoxy composites reinforced with human hair and jute fibre. As the amount of human hair in the composites increased, so did their mechanical qualities.

Sailesh. A and Arun Kumar. R [2] 'Mechanical properties and wear properties of Kenaf–aloe vera–jute fibre reinforced natural fibre composites. The current study focuses on experimental work using compression molding to create Kenaf-Aloe Vera-Jute Reinforced Natural Fiber Composites. These composites are then examined for mechanical qualities like impact, flexural, and tensile strength. Additionally, the wear qualities of the manufactured composite materials are examined.

C. Elanchezhian, B. Vijaya Ramnath and et al [3] 'Review on mechanical properties of natural fibre composites. & Science Direct'. The current experimental investigation seeks to understand the mechanical properties of composites made of natural fibers.

Ramalingam, V., Ramesh and et al [4]. 'Effect of natural fish tail palm fibre on the workability and mechanical properties of fibre reinforced concrete'. The authors of this study employed fish tail palm fibres, a novel kind of natural fibre, as micro reinforcement in concrete to improve the pre-cracking behavior and post-peak strength of concrete composites.

Praveen kumara Jagadeesha , Yashas Gowda and et al [5]. 'Effect of natural filler materials on fibre reinforced hybrid polymer composites: An Overview & Journal of Natural Fibers'. When bio-composites are required, natural fillers can be the better option. These composites are recognized as renewable and environmentally friendly materials. Up to the ideal weight percentage, natural fillers will work well; adding more could degrade the composites' qualities.

S. Nandhakumar, K. Mithresh Kanna and et al [6]. 'Experimental investigations on natural fibre reinforced composites" & Elsevier'. For this study, three samples were made and their mechanical properties assessed. These samples included Luffa fibre reinforced composites, Coir fibre fortified composites, and Luffa + Coir fibre strengthened polyester composites.

Jashanpreet Singh, Mandeep kumar and et al [7]. 'Properties of Glass-Fiber Hybrid Composite'. A thorough assessment of the literature in the topic of glass-fiber composites is presented in this work. Glass-fiber composites are a type of fiber-reinforced polymer composite. Glass-fibre composite is widely utilised in the building, automotive, and aerospace industries due to its many advantages, which include low density, high strength, and ease of production. The creation of glass-fibre composite has been discussed in this study.

N Kistaiah, C udhaya Kiran and et al [8]. "Mechanical description of composite hybrids." Although natural fiber-based composite materials are attractive because of their special features, like low specific weight, biodegradability, and ease of processing, these fibres also have interesting properties when combined with artificial fibres, which can be useful in some engineering applications.

Enrico Mangino, Joe Carruthers and et al [9]. 'The future use of structural composite materials in the automotive industry'. Though there hasn't been a mass transition from metal to composites in the automotive industry, Since then, it has been demonstrated that composites are fatigue resistant, lightweight, and easily shaped in other words, they seem like a good substitute for metals.

G Velmurugan, SP Venketasan and et al [10]. 'Mechanical testing of hybrid composite material (Sisal and Coir)'. The need for wood as a building material is increasing globally, but there is a rising shortage of this natural resource. Alternative materials have been developed as a result of this circumstance. It has been determined that polymer composites are a significant class of synthetic materials that can be used in building.

PROBLEM IDENTIFICATION

Pure EPOXY does not give required efficient material strengths. Problems were identified from literature reviews as given below

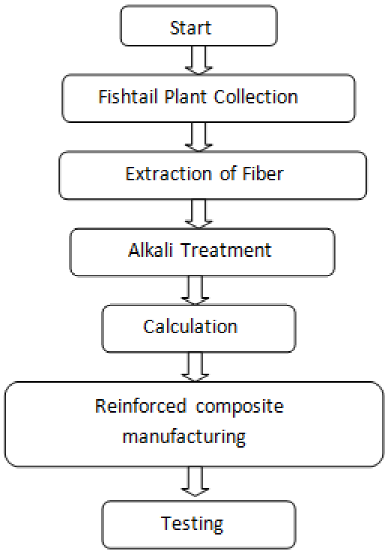
- Low Tensile Strength compare to
- Low Flexure Strength compare to
- Less Brittleness Hardness of the material is poor

PROBLEM RECTIFICATION

Apply surface treatments to improve the natural fibers' adhesion to the matrix. Develop moisture-resistant coatings or treatments to shield the composite from environmental humidity. Investigate additives Research cost-efficient sourcing of raw materials without compromising quality. Optimize manufacturing processes to reduce or thermal treatments that improve the composite's resistance to high temperatures.

METHODOLOGY

The below figure indicates, the process from which the project work starts.



LIST OF COMPONENTS

SL.NO	NAME OF THE COMPONENTS
1	FISH TAIL PALM TREE
2	GROUDNUT SHELL
3	TAMARIND SHELL
4	EPOXY RESIN LY556
5	HARDNER HY951

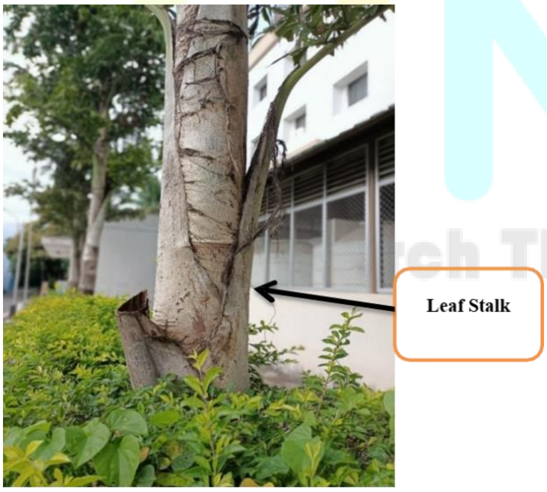


Figure 1.1 Fish tail palm tree

Figure 1.2 Leaf stalk

The top layer separates after 15 to 20 days. These separated layers are then cleansed with enough water and stored in the second retting tank for three days. The fibre straps are taken out of the second retting tank after three days, given a hand rub, and then rinsed with enough water.

After that, the fibres are divided and graded to have the same length and size. To eliminate the majority of related dirt and pith, fibers are first soaked in a mild detergent soap solution for an hour. They are then vigorously stirred and combed inside the soap bath.

WATER RETTING PROCESS

The extraction of fibres has been achieved through a process, named retting ordegumming. Microbial retting is a commonly used method for extracting fibres in water retting process, the fibrous materials were immersed in water for about 7–14 days. The water breaks the outermost layer and enters into the central portion of the stalk that absorbs moisture and develops a pectinolytic Al bacterial community.

After the water retting process, the raw fibres are separated as single fibre by using wooden rammers by tapping into the stem. The fibres are separated into pieces. These are again cleaned and prepared and ready for further process. That the final cleaning process of the fibres separated from theraw stack of the tree. The Fibres are cleaned with fresh water and used for further process.

Figure 1.3 Water Retting Process **Figure1.4 Fibre Extraction**

Figure 1.5 Cleaning process

ALKALI TREATMENT

Changes in the fibre's dimensions, shape, mechanical characteristics, and structure occur during the alkaline treatment process. This method is thought to decrease fibre bundles into smaller pieces, eliminate artificial and natural contaminants from fibres, and provide a rough surface topography on the fibres.

The NaOH solution used for Alkali treatment. The fibre treatment helps to modify the fibre surface and improve the fibre properties like moisture resistance, interfacial bonding and mechanical properties of the fibre as well as composites. For forty-five minutes, the fibres were treated with a 5% NaOH solution to eliminate any grit, grime, or contaminants from their surface. Among alkaline treatments, NaOH aqueous solution is a simple and most cost-effective method that modifies the fibre surface roughness.

Figure 1.5 NaOH Solution

FABRICATION OF COMPOSITES

CALCULATION

Calculation has been done according to metal Die we use for the compression molding process. We derived the mass of matrix **(Epoxy Resin)** and reinforcement **(Fishtail palm fibre)** required for the different compositions.

Total mass of the composite density = Mass/Volume

Density of Fishtail palm fibre = 950g/m^3

Density of Epoxy resin = 1400g/m^3

Density of Filler = 30g/m^3

Total volume of specimen = 18862.30mm^3

S1 & S3 Specimen

Resin 70% - 15g

Fibre 25% - 5g

Tamarind Filler 5% - 1g

Total specimen weight = 21g

S2&S4 Specimen

Resin 70% - 16g

Fibre 25% - 6g

Ground Nut Filler 5% - 1g

Total specimen weight = 23g

Figure 1.6 Tensile test specimen

Figure 1.7 Impact test specimen

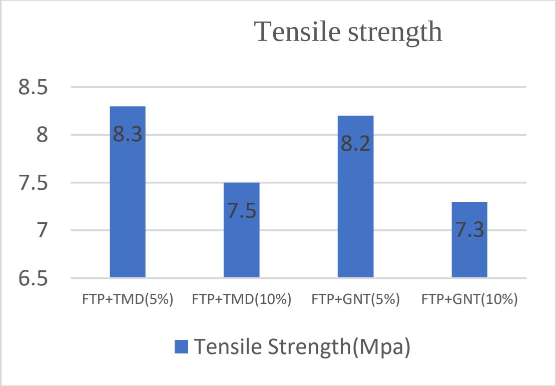
Figure1.8 Wear test specimen

Specimen No	Load in Kg	Speed in Rpm	Initial Weight in (g)	Final Weight in (g)	Abrasion Loss in (g)
S1	1	40	1.7326	1.6974	0.035
S2	1	40	1.7845	1.7315	0.053
S3	1	40	1.7356	1.6906	0.045
S4	1	40	1.7624	1.7044	0.058

MECHANICAL PROPERTIES

TENSILE TEST

Increased interfacial addition and a higher stress transfer from the matrix to the fibres during tensile testing are the results of a stronger link between the matrix and thfibre. Using ASTM D 638 standard specimens, the tensile test is performed with the aid of a Computerised UTM Machine.



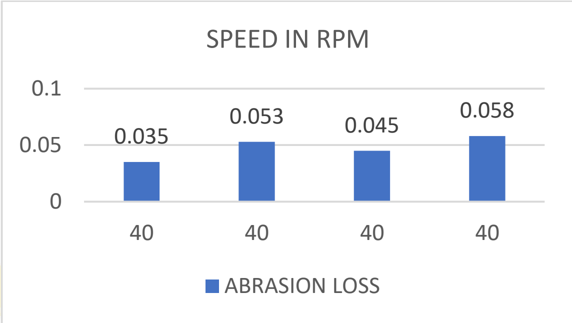
WEAR TEST

Wear test is performed with the help of pin-on-disc apparatus, the load is keptconstant for all the specimens and the speed of the disc is kept changing for each 5 minutes. The track radius of the disc is 150 mm and velocity is 3 m/s. The reading for the wear loss and the frictional force is noted down for each specimen. The maximum wear loss obtained in the sample 2 at 40 RPM, the minimum wear loss obtained in sample 1 at 40 RPM. The above graph shows that the sample 1 is having

Wear test results

good wear resistance property when compared to the other three samples. The specimen 2 & 4 had maximum wear loss when compared to 1& 3.

Specimen No	Area of sample mm^2	Maximum Force in KN	Displacement in mm	Tensile Strength (Mpa)
S1	96.620	0.810	3.82	8.3
S2	98.620	0.730	3.63	7.5
S3	98.420	0.793	3.71	8.2
S4	96.520	0.712	3.51	7.3



Wear Test Graph

IMPACT TEST

Impact test results

This experiment's impact testing apparatus has a heavy swing pendulum. An indenter on a scale within the machine that goes from 0 to 264 feet per pound will move when the pendulum is allowed to travel from its horizontal, static position to make contact with the V-notched specimen. The machine's bottom has a platform that supports the V-notched specimen as a horizontal beam. A square specimen with a V-notch must be inserted into the device in order to conduct the impact test. A square cross section measuring 10 mm by 10 mm by 65 mm is characteristic of the Charpy specimen. It features a 450 V notch with a root radius of 0.25 mm and a depth of 2 mm.

S. No	Gauge length in mm	Width in mm	Thickness in mm	Area in mm^2	Impact value in Joules
S1	50	12.03	8.76	105.382	2
S2	50	12.24	8.32	101.836	2
S3	50	12.30	8.50	104.550	2
S4	50	13.15	9.08	119.402	2

CONCLUSION

Renewable natural fibres are potentially a possible substitution for harmful synthetic fibres, which are supported by recent research. Developing alternate reinforcing material is needed to sustain the speedy growth of polymer composite industry in a healthy way.

In this investigation, the Fishtail Palm fibre with bio filler is taken reinforced hybrid composites were fabricated using compression moulding technique. These fabricated composites were tested for the mechanical properties according to ASTM standards under four different combinations. After examining the mechanical characteristics of the created composites, the following findings were made. The Tensile test conducted on four different combinations of FTP composites, the of (**specimen 1 Fishtail leaf stalk fibre with Tamarind filler (25% + 5%)**) gives better results maximum tensile strength obtained of 8.3 MPa.

- The wear test conducted on 4 specimens at different speed for constant load the results shown that the (**specimen 1 Fishtail with Tamarind filler)** having less wear loss (0.035g) when compared to other 3 specimens.

REFERENCES

1. Alavudeen, A., N. Rajini, Subramanian Karthikeyan, Mani Thiruchitrambalam, and N. Venkateshwaren. "Mechanical properties of banana/kenaf fibre-reinforced hybrid polyester composites. (2015)
2. Enrico Mangino, Joe carruthers and et al,2007. 'The future use of structural composite materials in the automotive industry'.
3. G Velmurugan, SP Venketasan and et al,2014. 'Mechanical testing of hybrid composite material (Sisal and Coir)'.
4. J Mussig, M Karus and et al,2015. 'Bast and leaf fibre composite materials.
5. Jagadeesh, Praveenkumara, Yashas Gowda Thyavihalli Girijappa, Madhu Puttegowda, Sanjay Mavinkere Rangappa, and Suchart Siengchin. "Effect of natural filler materials on fiber reinforced hybrid polymer composites: An Overview." Journal of Natural Fibers (2020).
6. Jashanpreet Singh, Mandeep kumar and et al,2017. 'Properties of Glass-Fiber Hybrid Composite'.
7. K.P. Ashik, Ramesh S. Shama and et al,2015. 'A Review on Mechanical Properties of Natural Fiber Reinforced Hybrid Polymer Composite'.
8. N Kistaiah, C udhaya Kiran and et al,2014. 'Mechanical characterization of hybrid composites.
9. Naheed Saba, Mohammad Jawaid and et al,2017. 'Epoxy resin-based hybrid polymer composites.
10. Nimala H. Bhingare, S. Prakash and et al ,2019. 'A review on natural and waste material composite as acoustic material'.
11. Ramalingam, V., Ramesh, K., Arumugam, M. and Muralidharan, V., 2022, "Effect of natural fish tail palm fibre on the workability and mechanical properties of fibre reinforced concrete".
12. S. Nandhakumar, K. Mithresh Kanna and et al. 2021. 'Experimental investigations on natural fibre reinforced composites" & Elsevier'
13. Sailesh, A., Arunkumar, R. and Saravanan, S., 2018, "Mechanical properties and wear properties of Kenaf–aloe vera–jute fibre reinforced natural fibre composites".
14. Selvakumar, K. and Meenakshisundaram, O., 2019. "Mechanical and dynamic mechanical analysis of jute and human hair-reinforced polymer composites", Polymer Composites,
15. Yentl Swolfs, Ignaas Verpoest and et al ,2019. 'Recent advances in fibre-hybrid composites: materials selection, opportunities and applications.
16. Ayyappa Atmakuri,Arvydas Palevicius and et al, 2021 'Development and analysis of mechanical properties of caryota and sisal natural fibres reinforced epoxy hybrid composites'.
17. Srinivas Nunna, P Ravi Chandra and et al, 2012 'A review on mechanical behaviour of natural fibre-based hybrid composites'.
18. Syafiqah Nur Azrie Safri, Mohamed Thariq Hameed Sultan and et al, 2018'Impact behaviour of hybrid composites for structural applications.
19. A.B.M. Supian, M. Jawaid and et al, 2021 'Mechanical and physical performance of date palm/bamboo fibre reinforced epoxy hybrid composites.