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Study on Tensile Analysis of Untreated Chopped Natural Areca Sheath Fiber Reinforced Polymer Matrix Bio-Composites

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Abstract

In the present work, the natural areca sheaths are soaked in water for 4 to 5 days to extract the fibers with help of wire brush. Extracted areca fibers are then dried in an ambient room temperature for 2 days. Then these dried fibers are cut into required length and will be used in preparation of polymer matrix bio composites. Natural areca sheath fibers are oriented in random direction. Natural areca sheath fibers with 30% volume fraction are poured into the prepared mould and compacted for 15 min. then the compact will be extracted from the mould are allowed to dry for 2 days to obtain the finally untreated natural areca sheath fiber reinforced polymer matrix bio composites. In the present work, tensile properties of untreated natural areca sheath fiber composites will be evaluated with experimental techniques. Finally, the obtained tensile properties will be validated with numerical simulation method. These untreated natural areca sheath fiber reinforced polymer matrix bio-composites may be used for small load carrying structural and non structural application.

Key Words: *Ambient Room Temperature, Bio-Composites, Fiber Volume Fraction, Natural Areca Sheath Fiber.*

1. INTRODUCTION

The use of Fiber reinforced polymer (FRP) for reinforcement of natural fibers has emerged as one of the most exciting and promising technologies in engineering structure, with a wide range of usage ranging from aircraft, boats, offshore platforms, automobiles, sports goods etc. Thus due to the wide range of application of FRP composites are growing continuously at an impressive rate due to their more usage in the existing market. There has been much research conducted in the area of epoxy bonded with natural fibers. Composites obtained by using natural fibers reinforced with epoxy resin have been investigated on tensile Strength has been determined. Padmaraj N H et al. [01] studied the development of bio-degradable composites using areca nut frond fibers. The tensile strength of the composite obtained was 45.29N. Chethan M. R. et al. [02] the areca leaf were collected from the areca field. The areca fiber layers were chemically treated to improve the mechanical properties. The fiber layers are washed with few drop of acetic acid and distilled water and prepare the Natural Areca Leaf Fiber Using Polymer Matrix Composites. S. G. Gopala Krishna et al. [03] Mechanical and physical properties were studied and compared as per the standard procedure. It has been found that the compressive strength of areca leaf fiber reinforced vinylester composites were more than epoxy composites. The water absorption properties were also evaluated.

Noor Ahmed R. [04] Fiber Reinforced Polymer composite has a very dominant role in variety of applications for their high specific strength and modulus. Lot of work is carried by various researches with different reinforcements. The mechanical properties of a natural fiber reinforced composite depend on parameters like fiber strength, fiber length, chemical treatment and orientation in addition. Vishnu Prasada et al. [05] the work described the development and characterization of natural fiber based composites consisting of jute fiber as reinforcement polymer matrix material composites. The tensile strength is studied using experimental and numerical analysis. Premkumar Naik et al. [06] Areca fibers were chemically treated and the effect of treatment on fiber strength is studied. Areca fiber composite laminates were prepared with randomly distributed fibers in wood powder and Phenol Formaldehyde. Tensile test on these laminates were carried out. Janis Sliseris et al. [07] the microstructures of short flax fibres with different fibre length-to-diameter ratios were generated by algorithm taking fiber defects and fiber bundles. The study shows that the simulation can capture the main damage mechanisms of the composites such as fibre breakage and damage of polymer matrix and the fibre deboning accurately. The simulation results exhibit good agreements with the experimental result of the short fibre and the fibre fabric reinforced polymer composites.

H.F. Lei et al. [08] developed a three-dimensional (3D) ‘‘tension–shear chain’’ theoretical model to predict the mechanical properties of unidirectional short fiber reinforced composites. The accuracy of its predictions were validated by simulations of finite element method (FEM). The proposed 3D tension–shear chain model may provide guidance to the design of short fiber reinforced composites. L. Yusriah et al. [09] presented investigations on the effect of three different stages of fiber maturity and mechanical properties of betel nut husk (Areca catechu) (BNH). Density analysis, moisture content and water absorption study were carried and evaluated physical properties of BNH fiber. Mechanical properties of BNH fiber at different maturity were determined from single-fiber tensile tests. Water absorption and highest moisture content were found to be the highest for raw and ripped BNH fiber and vice-versa. Dhanalakshmi Sampathkumar et al. [10] investigated the effect of fiber loading on the tensile strength of areca fiber reinforced natural rubber composites. Composite boards were analysed for tensile strength according to ASTM standards. Areca fiber reinforced natural rubber composites with 60% fiber loading showed maximum tensile strength.

The natural composites finds greater advantages in the latest development of composite materials, since it is a eco-friendly material. Hence the emphasis of this work is on development and testing of natural composites to their suitability and adaptability for various applications. In this present work areca sheath fiber which is extracted from areca leafs. The extracted fibers are reinforced with epoxy resin to obtain the composites with various fiber lengths. The composites are fabricated using hand lay-up technique and are characterized with respect to their physical and mechanical properties. Frequency response is an important parameter to be studied in order to use the natural composites in dynamic environment which finds greater application in aerospace and automobile industries.

2. MATERIALS AND METHODS

The fibrous materials, when introduced into polymer matrix produce a dramatic improvement in physical properties of a composite. Reinforcement improves overall mechanical properties of the matrix. A wide range of chopped fibers of various lengths are used to fabricate the composites. The fibers length are 30mm.The plants leaves are even pinnately compound and 1 to 1.5 m long, longest near middle frond. The leaf of the areca is a hard fibrous portion covering endosperm, mainly composed of hemicelluloses. Areca sheath fibers contain 13 to 24 % of lignin, 35 to 64.8% of hemicelluloses, 4.4 % of ash content and remaining 8 to 25% of water content.


Fig. 1 Areca Palm Trees


Fig. 2 Fallen Leaves


Fig. 3 Raw Areca Leaf


Fig. 4 Areca Leaf Soaked in Water

In this process resins are impregnated by hand into fibers which are in the form of randomly distributed fabrics. Hand lay-up process accomplished by rollers or brushes. The composite plates from as the test specimens were fabricated by employing the traditional Hand lay-up technique. This is a very popular method of composite fabrication, limited by its ability to produce simple shapes. A plate consisting of Epoxy resin with short areca sheath fiber reinforcement was fabricated with addition of Hardener. The plate was made up of 70% of Epoxy resin and 30% of short areca sheath fiber by volume.


Fig. 5: Specimens for before the tensile test (ASTM 3039)


Fig. 6: Computerized UTM for tensile setup.

Tensile test is probably the most fundamental type of mechanical test can be performed on a material. Tensile tests are simple, relatively inexpensive and fully standardized. By pulling a specimen we can find its tensile strength by measuring its deformations. As we continue to pull on the material until it breaks, we will obtain a good, complete tensile profile. A curve will result showing how it reacted to the forces being applied. Ultimate strength is calculated based on gross cross sectional area.

3. RESULTS AND DISCUSSION

Strength and modulus of fiber as well as bonding strength between fibers and matrix are the prime factors, which accounts for the tensile strength of composite materials. The ultimate point in the curve represents the complete fracture of the fibre composite Shown in Fig. 7.


Fig. 7 Fractured specimens for after the tensile test.

Table 1.1 Tensile Properties of 30% FVF Composite (30 mm fiber)

Specimen Numbers	Stress (N/mm^2)	Modulus of Elasticity (N/mm^2)

Specimen 1	11.41	2199.96
Specimen 2	12.30	2487.14
Specimen 3	13.98	3045.73
Specimen 4	16.15	3345.16
Specimen 5	13.91	2761.99

Failure mode exhibits little pull out of fibers and progressive failure of fibers. The drops in the curve are indications of progressive failure of fibers as the applied load increases and end of the curve represents the ultimate stress which is due to fiber fracture and may be fibre pull out. However, the failure mode exhibits breakage and little pull out of fibers. The values of ultimate tensile strength and Young's modulus for these composites are shown in Table 1.

The tests were subjected to tensile loads on a computer controlled Universal testing machine and the tests were performed at a constant crosshead speed of 2mm/min. The tests were closely monitored and conducted at room temperature. As expected the strength of the 30mm fiber length and specimen no. 4 chopped fiber composite is greater than others. The Tensile strength of 30mm fiber length of areca sheath fiber reinforced polymer matrix composites are presented in the Table 1 and 2. It is observed that the tensile strength of 30mm fiber length and specimen no. 4 of areca fiber is 16.15 N/mm^2 for random orientation. From this it can be concluded that in any application where tension load is considered we can go for 30mm fiber length of areca fiber reinforced polymer matrix composites.

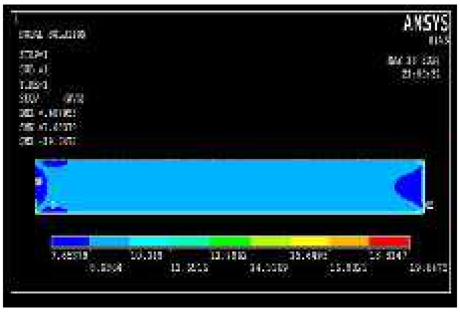

Fig. 8 Von-Mises Stress for 30mm Specimen

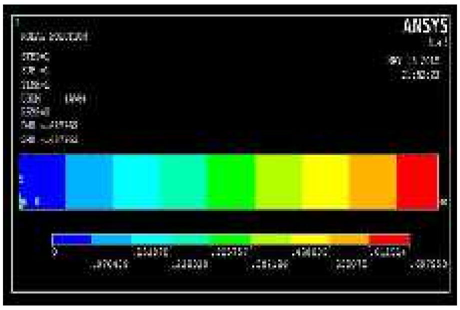

Fig. 9 Displacement Plot for 30mm Specimen

Finite element analysis, described in the present work, attempt to investigate the effect of various parameters on the areca fiber composite. In the present analysis, the Von-Mises stresses and deformation of the areca composite at tracked through the contours as shown in Fig. 8 and Fig. 9. The analysis is done for tensile specimen of same dimension used in experimental work. Maximum Von-Mises stress was developed in 30mm fiber length, specimen no. 4 compared to others. This finite element analysis investigations on the fiber lengths reported in the present work give some insight into areca composite behaviour. This validates the findings of the experimental work.

Table 2: Comparison of Experimental Results and FEA Results

Experimental Result (N/mm^2)	**FEA Result (N/mm^2)**
16.15	19.6473

Considering this result, it is confirmed that experimental result is similar to the result of FEA analysis are has shown in Table 2. The errors may occur due to some possible measurement errors are done in experimental tests such as measurement, non-uniformity in the specimens properties (voids, variations in thickness, non-uniform surface finishing) and fiber misalignment and resin flow or bleed-out during curing that created slight differences in the modulus, density and thickness of the composite which affects the results.

4. CONCLUSION

The natural fibers like areca, jute, hemp, sisal, coir, banana, palm etc. are the fibers of choice. Tensile strength and modulus of 30mm fiber length (30% FVF) areca sheath fiber reinforced polymer composite is found to be 16.15 N/mm^2 and 3345.16 N/mm^2 respectively. UASFRPMC can be used in applications such as Suitcases, post-boxes, grain storage, automobile interiors, partition boards and indoor applications. Based on the studies carried out by experimental as well as FEA methods are near to matched close values, it concluded that the natural areca leaf fiber reinforced polymer matrix material is best suitable for structural and non-structural application.

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