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FABRICATION AND TESTING OF BABASSU FIBER (ATTALEA SPECIOSA) REINFORCED COMPOSITES

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Abstract. A study has been carried out to investigate the tensile and flexural properties of composites made by reinforcing Babassu fiber (Attalea Speciosa) as a new natural fibre into a polyester resin matrix. The fibres extracted by retting and manual processes have been used to fabricate the composites. These composites are tested for tensileand flexural properties and compared with those of established composites like vakka, sisal, bamboo and banana made under the same laboratory conditions. The composites are fabricated up to a maximum volume fraction of fibre of 0.30 in the case of tensile and flexural testing. It has been observed that the tensile properties increase with respect to volume fraction ofBabassu fibre for the composite and are also more than those of sisal and banana composites. The flexural strength of Babassu fibre composite is also found to be greater than that of vakka, sisal, bamboo, and banana composite.Also, the density of the Babassu fibre is found to be 587.85 kg/m^3, which is way below that of Sisal (1450 kg/m^3), Bamboo (910 kg/m^3) and Banana fibres (1350 kg/m^3) and after chemical treated babassu fibers it is 454.88 kg/m$^{3.}$ This is very vital as it leads to obtaining low density natural composites which can be used for light weight applications.
Keywords: Tensile and Flexural properties, Natural fibre, Low density natural composites, Retting.

1. Introduction

Natural fibres' current applications, which have been approved down for hundreds of years to suit human requirements such as clothing and shelter, has been significantly harmed by the usage of synthetic fibres toward the end of the twentieth century. Environmental concerns and the depletion of petroleum resources have reignited interest in natural fibres, encouraging researchers and businesses to adopt sustainable fibres rather than standard synthetic fibres[1-4]. Aside from mechanical and physical assets such as good specific modulus values, low density, and significant toughness properties of natural fibres[5], natural fibres also have low cost, recyclability, nontoxicity, and easy accessibility properties, which permit for the usage of natural fibre reinforced composite products in various industries such as automotive, aerospace, and defence.The tensile, bending, and dielectric properties of composites formed by reinforcing Vakka as a novel natural fibre in the polyester resin matrix have been investigated. The composite material was made from fibres acquired through roasting and hand methods. These composites are compared to proven composites like as sisal, bamboo, and bananas made under the same laboratory circumstances for tensile, bending, and dielectric properties[6].The Babassu palm is indigenous to Brazil's Amazon Rainforest. The Babassu palm is known as the "Tree of Life," and its kernel is the most difficult to break on the world.Babassu oil, also known as babassu wax or babassu butter, is derived from the babassu tree's kernels.

Even though, a very large quantity of work has been publishedon various natural fibres and its composites, an effort has beenmade in the present work to introduce a new natural fibre i.e.,Babassu fiber (Attalea Speciosa)as reinforcement in the development of new composite materialsfor lightweight structures.This economical source compared to othernatural sources is still underutilized. The overall objective of thiswork is to extract the fibres by retting and mechanical proceduresand incorporating them into polyester resin matrix to prepare thecomposites at various volume fractions of fibre. The resulting compositeswere tested and characterized to evaluate the tensile& flexuralproperties.

2. Materials and methods

2.1. *Matrix*

ECMALON 4411 is an unsaturated polyester resin with a viscosity of 500-600 cps and a specific gravity of 1258 kg/m3 at 250°C (Brookfield viscometer). It has an acid number of 22 (mg KOH/g) and a monomer content of 35%, Young's modulus of 440 MPa, tensile strength of 15.1 MPa and elongation at break of 3.4%. Fibers were extracted using two different methods: (1) retting and manual extraction, and (2) chemical and manual extraction.

2.2. *Extraction of fibres*

The babassu fibre was collected from the tree's waste dry stem, and the leaves at the nodes and end were cut. The stem was cut into small pieces after trimming. Cutting was used to remove the node parts, and the stem was cut into 180 mm pieces. The single fibre was extracted in longitudinal direction using the hollow cylindrical part. These stem strips are steeped in water for two to three weeks. After that, the stem went through a mechanical procedure to separate the fibres.As after soaking of dry stem of babassu fiber start removing of fibers from, it manually by use of thumbs and knifes as show in pictures. Initially removing very thin fiber as in 1-2 weeks of fiber as not fully soaked properly then after 4-5 weeks fibers as removed in ideal length and dry up in sun to remove moisture [7].

2.3 *Fiber surface treatment*

The extracted mechanical fibres (M) weighing 20 gm each were separated and soaked in 11 parts KMnO4 in acetone medium at a concentration of 0.055 percent before being air dried. Mechanical fibre (M) and chemical fibre (C) fibres were denoted by mechanical fibre (M) and chemical fibre (C), respectively, after surface treatment.So, collecting fiber manually need chemical treatment on half of the fibers as $KMnO_4$ and Acetone medium would change some of the properties of fibers such as density, specific flexural strength etc. Then chemical treatment is performed on the fibers and then further dried it in air for 24 hours.

3. Composite preparation

To test the reinforcing potential of babassu fibres, unidirectional composites were made with a polyester matrix. At room temperature, one percent by volume of resin is added to each of the accelerator and catalyst for curing. The prepared mould was filled with a proper amount of resin mixture and unidirectional babassu fibres using the hand lay-up method, starting and finishing with layers of resin. To produce high-quality unidirectional fibre composites, fibre deformation and movement should be avoided. As a result, a compression pressure of 0.05 MPa was applied to the mould during curing, and the composite specimens were cured for 24 to 48 hours. After extracting the specimens from the mould, they were post-cured at room temperature.

Two of the most critical parameters that determine the composite's qualities are fibre configuration and percentage volume. The configuration in this work is only unidirectional, continuous babassu. Fibres of the same length as the specimen, i.e., 160 mm, and five different percentage volumes of babassu fibres were used to make the composite samples: 0.06,0.12,0.18,0.24,0.30.To validate the requisite dimensions, the specimens were made by hand lay up in the procedure of a rectangular strip. A smooth surface, such as a wooden table, was prepared for the mould by placing a rubber sheet mould on it. Babassu fibres of the requisite length (160mm for tensile testing, 75mm for impact testing, and 100mm for flexural testing) were precisely weighed and moulded through an unsaturated polyester resin, catalyst, and accelerator mixer (1.0 percent each by volume of resin). The manner of fibre orientation in the mould, the pressure applied to it, and the curing period were all allowed time to dry up.

4. Testing of composites

4.1. Tensile and flexural testing

To quantify the tensile qualities, tensile test specimens were constructed in line with the ASTM D 638 M standard [8-11]. Each composition was evaluated on five identical specimens that were 160 mm long, 12.5 mm broad, besides 3 mm thick. The homogeneous material was attached to the ends of the specimen, filling the gap between the tab overlaps to prevent compression of the sample at the grip. An extensometer was used to assess strain on the samples, which were evaluated at a crosshead speed of 0.5 mm/min. To determine flexural characteristics, three-point bend tests were done in accordance with the ASTM D 790 M test technique. 100 mm long, 25 mm wide, and 3 mm thick were the dimensions of the samples. In the three-point bending test, the outer rollers were 64 mm apart, and the samples were tested at a strain rate of 0.5 mm/min. Because it utilises less material per test and eliminates the need for test equipment to correctly estimate centre point deflections, the three-point bend test was chosen.

5. Results and discussion

5.1Densityof Babassu Fiber (Attalea Speciosa)

The density of the Babassu fiber fibre was found to be 578.85 kg/m^3.The density of the Babassu fiber was very less compared to the established fibres like sisal (1155 kg/m^3), coir (1288 kg/m^3) and banana (1101kg/m^3), which wasan attractive parameter in designing lightweight material.

5.2Tensile graphs

Tensile testing is a form of tensile test, a fracture mechanics and materials science test in which a specimen is subjected to controlled stress until it is entirely broken. We use universal testing machine for tensile test, clamp a single piece of specimen on each of its ends and pull it apart until it breaks. This measures how strong it is (tensile strength) how stretchy it is (elongation), and how stiff it is (tensile modulus). The tensile strength of Babassu fiber is calculated at various volume fractions i.e., 0.06, 0.12, 0.18, 0.24 & 0.30. the Tensile modulus of the Babassu fiber is also determined to compare the stiffness of fibers at the five-volume fractions. The values obtained from the tensile test graphs are used to calculate tensile strength and tensile modulus for the different volume fractions of the composites fabricated.

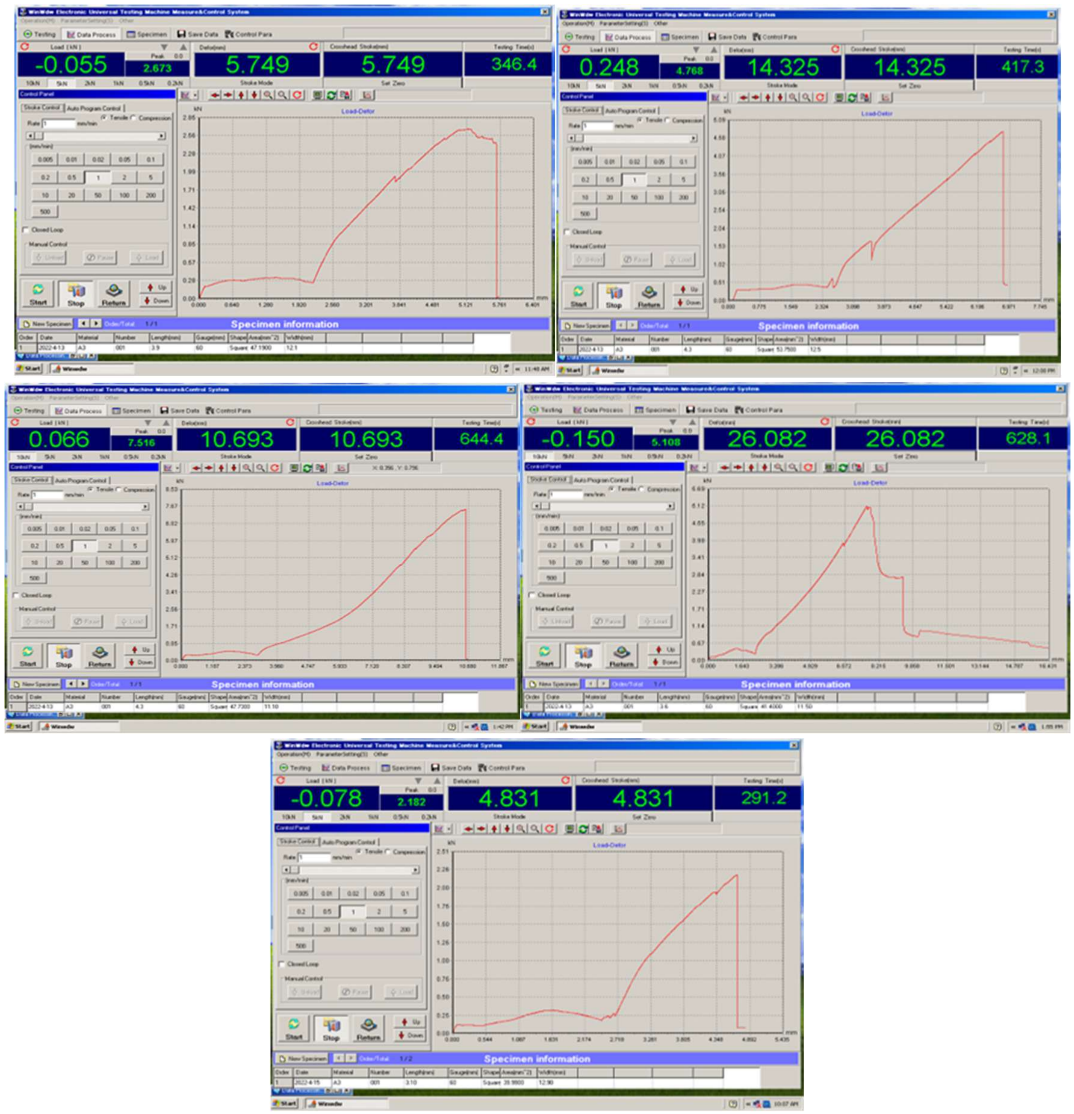


Fig.1Tensile test graphs obtained for Volume fraction of 0.06 M, 0.12M ,0.18 M, 0.24 M &0.3 M

As per testing, the graphs are obtained, and there is a need to calculate the load and change in length as shown below:

1. Mean ultimate tensile strength (σ): Load / cross sectional area (MPa)

where,

Load = calculated from graphs

cross sectional area = (width * thickness) = (12.5 * 3)

2. Tensile modulus or young's modulus (E): tensile strength / strain, or proportional deformation (MPa)

where,

length $\varepsilon = \Delta\ell/\ell_0$, change at length /original length(160mm)

So, as per formula given above, the tensile-strength and tensile-modulus are calculated.

The tensile strength values and the tensile modulus values are listed in the table 1 and table 2 below for the various volume fractions of the natural fibre composite samples when examined in an UTM.

Table 1Tensile strength values

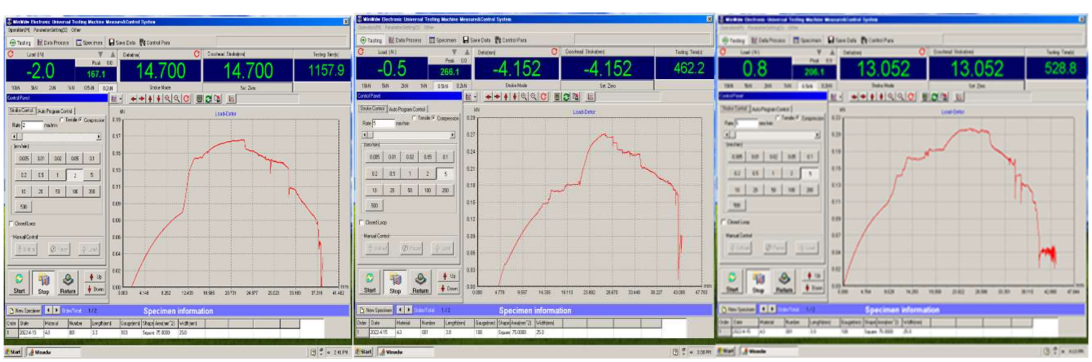
Volume fraction	Tensile strength (MPa)
0.06	65
0.12	90.75
0.18	130
0.24	167
0.30	186

Table 2Tensile modulus values

Volume fraction	Tensile modulus (GPa)
0.06	3.78126
0.12	4.87084
0.18	3.118777
0.24	4.02118
0.30	4.93997

5.3 Flexural test

Flexure (Bend) tests are commonly performed to assess a material's flexural modulus or strength. A flexure test is less expensive than a tensile test, and the results differ slightly. The material is laid horizontally over two points of contact (lower support span), and then a force is applied to the top of the material (upper loading span) until the sample fails. The flexural strength of that sample is represented by the greatest recorded force. The graphs obtained for the flexural tests are shown in figure 2 below.



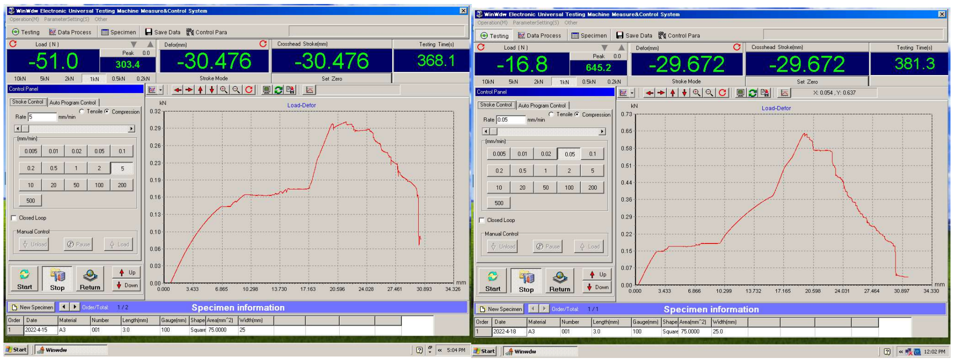


Fig.2 Graphs of flexural test (0.06 M,0.12 M,0.18M 0.24 M &0.30 M)

A flexure test is most used to determine flexural-strength and flexural-modulus. On either the compression or tension side of the specimen, flexural strength is defined as the greatest stress at the outermost fibre. The slope of the stress vs. strain deflection curve is used to compute the flexural modulus. These two numbers can be used to assess a sample's ability to tolerate bending or flexure forces. The following formulas are used to calculate flexural strength:

Flexural strength (σ) = $3 P L / 2bt^2$(MPa)

Flexural modulus (E) = $P t^3 / 4bt^3 * d$

Where,

P = max. load (N)

L= span length (64mm)

l = original length (100mm)

b = width of specimen (25mm)

t = thickness (3mm)

d = deflection (mm)

The flexural strength values and the flexural modulus values for the different volume fractions are listed in the table 3 and table 4 respectively.

Table 3Flexural strength values

Volume Fraction	Flexural Strength (MPa)
0.06	82.0565
0.12	115.9082
0.18	147.2938
0.24	167.07
0.30	203.451

Table 4Flexural modulus values

Volume fraction	Flexural Modulus (MPa)
0.06	545.811
0.12	650.5178
0.18	1078.49
0.24	1092.521
0.30	1462.0739

6. CONCLUSION

The removal of babassu fibre is done by hand, and the fibre is of outstanding quality, quantity, and length, making it ideal for fabricating large composite components. When compared to other fibres addressed in this study and research, the lower density of babassu fibre is also a significant parameter in constructing lightweight materials. The mean tensile strength of fibre composite at the peak volume-fraction of fibre in the current study is abundant higher than that of sisal and banana composites, and comparable to that of bamboo composites available in other papers.At the maximum volume fraction of fibre, the mean tensile modulus of fibre composite is higher than that of banana and sisal fibre composites, and comparable to that of bamboo composite. In this study, the flexural strength of babassu fibre composites is higher than that of sisal and banana composites as the volume proportion of fibre in the composite increases. As the volume-fraction of fibre increases active to 0.30 in the composite, the flexural modulus of babassu fibre composite is abundant higher than that of banana and sisal fibre composites of dissimilar flexural strength, and is also very close to that of bamboo composite.. As a result of the light weight and low density of babassu fibre composites explored in this study, the composite can be evaluated for aerospace applications due to its availability, lower cost, and good impact strength, in addition to manufacturing of lightweight materials used in vehicle body building, packaging, barrier panels, and other applications.

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