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Experimental Investigation of Tensile Properties of Banana Reinforced Epoxy Composites

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Abstract: ***In this paper, the experiments of tensile tests are carried out using banana fibre reinforced epoxy composite. Samples of banana fibre reinforced composites of different diameter used in this research. Fibres are of diameter 1mm, 2mm and 3mm in the form of yarns. And as the diameter of fibres (volume fraction) increases the tensile strength increases. From the obtained results the percentage elongation of banana reinforced epoxy composites is 9%. And it is found that the stress is maximum if it is loaded along the length of the fibre and minimum value of stress when it is loaded perpendicular to the length of fibre. Finite element analysis using ANSYS software has showed that the differences of results obtained from these samples are not significant compared to experimental results. Definitely this shows the importance of this product and attracts many researchers for the improvement of this composite.***

Keywords: Banana fibres, tensile Strength, Volume fraction, Natural fibres, yarns of banana fibers

1. Introduction

In the world of materials the development of composites material the most common advanced materials in the later part of 20th century has given a boost to the engineering field. Composites were developed mainly with the considerations high strength and light weight. The aerospace and defense sectors are responsible for this growth, which always gave thrust for light weight but high strength material. However, nowadays, all the fields of life like Civil, transportation, medical and general construction industries are also extensively using composite materials. The word composite in the term composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material The advantage of composite materials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses In the world of materials the development of composites material the most common advanced materials in the later part of 20th century has given a boost to the engineering field. Composites were developed mainly with the considerations high strength and light weight. The aerospace and defense sectors are responsible for this growth, which always gave thrust for light weight but high strength material. However, nowadays, all the fields of life like Civil, transportation, medical and general construction industries are also extensively using composite materials. The word composite in the term composite material

Signifies that two or more materials are combined on a macroscopic scale to form a useful third material. Naturally, not all of the properties are improved at the same time nor is there usually any requirement to do so. In fact, some of the properties are in conflict with one another, e.g., thermal insulation versus thermal conductivity. The objective is merely to create a material that has only the characteristics needed to perform the design task.

The interest in natural fiber-reinforced composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber-containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc.

Reinforcements for the composites can be fibers, fabrics particles or whiskers. Fibers are essentially characterized by one very long axis with other two axes either often circular or near circular. Particles have no preferred orientation and so does their shape. Whiskers have a preferred shape but are small both in diameter and length as compared to fibers. Fibers are the important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. There are several methods of random fiber orientations, which in a two-dimensional one, yield composites with one-third the strength of a unidirectional fiber-stressed composite, in the direction of fibers. In a 3-dimension, it would result in a composite with a comparable ratio, about less than one-fifth. In very strong matrices, moduli and strengths have not been observed. Application of the strength of the composites with such matrices and several orientations is also possible. The longitudinal strength can be calculated on the basis of the assumption that fibers have been reduced to their effective strength on approximation value in composites with strong matrices and non-longitudinally orientated fibbers.

It goes without saying that fiber composites may be constructed with either continuous or short fibers. Experience has shown that continuous fibers (or filaments) exhibit better orientation, although it does not reflect in their performance. Fibers have a high aspect ratio, i.e., their lengths being several times greater than their effective diameters. This is the reason why filaments are manufactured using continuous process. This finished filaments. Mass production of filaments is well known and they match with several matrices in different ways like winding, twisting, weaving and knitting, which exhibit the characteristics of a fabric. Since they have low densities and high strengths, the fiber lengths in filaments or other fibers yield considerable influence on the mechanical properties as well as the response of composites to processing and procedures.

Generally, not much of the papers have published on the banana fibre reinforced Epoxy composites. Sapuan *et.al.* (2006) [1] conducted the experiments of tensile and flexural (three-point bending) tests were carried out using natural fibre with composite materials (woven banana fibre/epoxy). From the results obtained, it was found that the maximum value of stress in x-direction is 14.14 MN/m^2, meanwhile the maximum value of stress in y-direction is 3.398 MN/m^2. For the Young's modulus, the value of 0.976 GN/m^2 in x-direction and 0.863 GN/m^2 in y-direction were computed. As for the case of three-point bending (flexural), the maximum load applied is 36.25 N to get the deflection of woven banana fibre specimen beam of 0.5 mm. The maximum stress and Young's modulus in x-direction was recorded to be 26.181 MN/m2 and 2.685 GN/m2, respectively. Sakthive and Ramesh (2013) [2] conducted a experiment on mechanical properties of natural fibre (Banana, Coir, Sisal) The material properties of fabricated natural fibre reinforced composites were observed. They found its material characteristics(flexural modulus, flexural rigidity, hardness number,% gain of water) by conducting tests like flexural test, hardness test, water absorption test, impact test, density test, and their results are measured on sections of the material and make use of the natural fibre reinforced polymer composite material for automotive seat shell manufacturing. It is found that polymer banana reinforced natural composites is the best natural composites among the various combination. It can be used for manufacturing of automotive seat shells among the other natural fibre combinations. Paul *et.al* (2008) [3] studied the Influence of polarity parameters on the mechanical properties of composites from polypropylene fiber and short banana fibre.BF surfaces were modified chemically to bring about improved interfacial interaction. The polarity parameters of the chemically modified BF were investigated using the solvatochromic technique. It was found that the polarity of the BF was decreased after the chemical treatment. The fiber/matrix interactions were found to depend on the polarity of the BF. The improved fiber/matrix interaction was evident from the enhanced tensile and flexural properties. The diameter of the chemically modified BF was measured using an optical microscope. Scanning electron microscopy studies revealed the changes of the surface morphology of the fibers after the chemical treatments. Of all the treatments the 10% NaOH treated BF composites showed the best mechanical properties. Mukhopadhyay *et.al.* (2008) [4] investigated the Banana Fibers – Variability and Fracture Behavior the stem of banana plant (Musa sapientum) have been characterized for their diameter variability and their mechanical properties, with a stress on fracture morphology. . Banana fibers have shown high variability along the length and between fibers, which is a characteristic of natural fibers. The standard deviation has been found to decrease with increasing diameter of fibers. At higher speeds however, the faults dominate with catastrophic failure at the highest strain rates. Shankar *et.al* (2013) [5] studied mechanical performance and analysis of banana fiber reinforced epoxy composites. In this work the three mechanical properties are evaluating as per the ASTM standards and analyzed the stress, strain and deflection by using ANSYS 13.0 software package. The Ultimate tensile strength value maximum at 15% (45.18Mpa) and decreasing starting from 15% to 20% (45.18Mpa to 38.30 Mpa) of the fiber. The flexural strength value slightly decreasing from 5% (92.12%Mpa) to 10% (87.31Mpa) and after that the value increased from 10% to 20% (87.31 Mpa to 321.38 Mpa) of the fiber. Raghavendra *et.al* (2013) [6] conducted the experiment on Mechanical Properties of Short Banana Fibre Reinforced Natural Rubber Composites As the fiber concentrations increases tensile strength also increased. When fibre concentrations are less the matrix and fiber interface shows weak bonding. The incorporation of fibre into rubber matrix increases the hardness of the composite, which is related to strength and toughness. The close packing of fibres in the compounds increases the density while resilience decreases. The composites made from 15mm length banana fibers shows the maximum tensile strength and good tear strength. Surya Nagendra *et.al* (2014) [7] conducted the experiment on the synthesis of bio – degradable banana nanofibers. The lignin present in the Banana fibers is removed treating with 8% NaOH. The phase present in the ball milled banana fibers is identified as cellulose by analysis. The size of banana fibers is brought to Nano level using high energy ball milling and concluded that 80 hours is the optimum milling time.

2. Methodology

Before starting the tensile tests, specimens are prepared of different volume fractions. Initially the fibres are extracted.

2.1. Extraction of Fibres

Initially the Pseudo stem is abstracted form the fully grown trunk. The stem is kept under the sunlight for 15 – 20 days. Then the dried fibers were soaked in water for at least 20 days. And again it is dried under the sunlight until all the moisture is taken out. And finally the stem is cut horizontally and then the fibres are extracted.

2.2. Preparation of yarns

Yarns of diameter 1 mm, 2mm and 3mm. Yarns are prepared by process called spinning, of length 150 mm which is to be reinforced in composite.

Figure 2.1: Yarn prepared of Banana Fibres

2.3. Mould Preparation

The mould used for composite fibres is made from rectangular plywood 150 mm in length and 50 mm in width, and it is coated with plastic tape so as to prevent epoxy from sticking to the plywood. The initially the upper side is kept open and then after poring the epoxy the upper side is closed during the curing time so as to avoid the debris entering the composite. Holes were drilled at the sides of the mould box of diameter 3mm for reinforcing of fibers through it so as to avoid the change in the orientation of fibers during layup.

2.4. Preparation of Epoxy and hardener

The matrix that is used to fabricate the fibre specimen is epoxy of density 1.0 g/cm^3 and it is mixed with hardener of density 1.0 g/cm^3. The weight ratio of mixing epoxy and hardener is 3:1.

2.5. Preparation of Specimen

Initially the mould box is cleaned and dried and then the mould box is coated with plastic tape. Epoxy is laid on the box and then the yarns are reinforced through the holes. Then again another layer of epoxy is laid on the fibres. Then the composite is kept it to dry at room temperature for 12 to 15 hours.

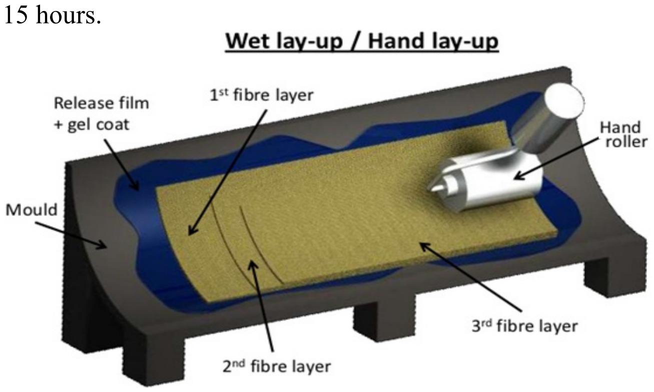

Figure 2.2: Hand Layup Process

2.6 Tensile test

Before performing the tensile test the specimen dimensions are measured i.e. initial length (Li), width (W_i) and height (t_i). The specimens are made of dimension 150mm x 50mm x 10 mm. 8 specimens are prepared of diameter 1mm , 2mm and 3mm. Three samples were prepared in which the fibres are reinforced along the length and three specimens in which the fibres are reinforced along the width of the composite. Two samples are prepared in the form of mat of diameter 1 mm and 3mm.

3. Results and Discussion

Banana Reinforced Epoxy Composites were prepared and tested for tensile properties in universal testing machine. Parameters such as tensile strength, tensile modulus, and strain elongation were determined. For all the tensile test of the specimen the speed of the jaw is kept constant at 5mm /min.

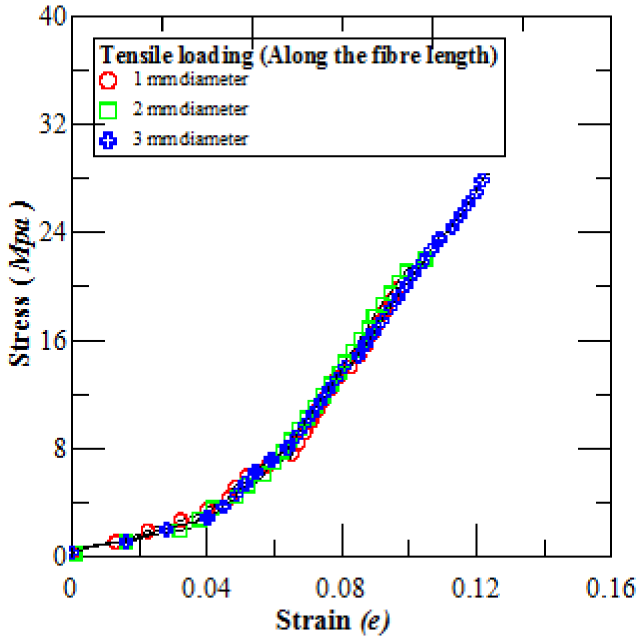

Figure 3.1: Stress strain diagram shows the effect of diameter of fibres

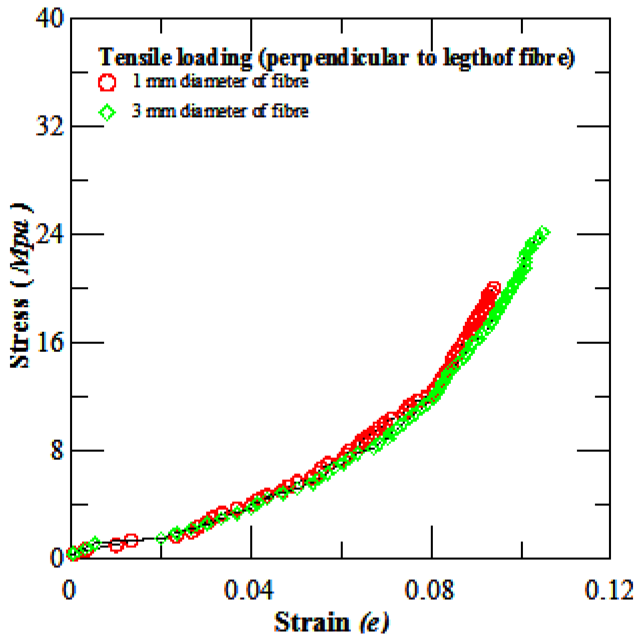

Figure 3.2: Stress-strain diagram shows the effect of diameter of fibres.

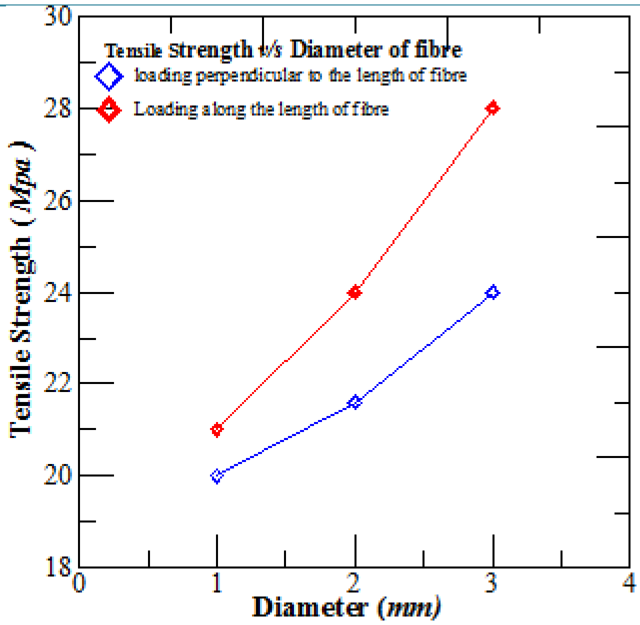

Figure 3.3: Tensile strength *v/s* diameter of fibre

Figure 3.1 shows the stress- strain diagram for banana reinforced epoxy composite for diameter 1mm, 2mm and 3mm in which loading is done along the length of the fibre. Figure 3.1 clearly shows that as the diameter of fibre increases tensile strength increases which in turn reveal that there is definite effect of volume fraction of fibres. As the Volume fraction increases the tensile strength also increases. This may be due to increase in interfacial bonding between the fibre and matrix .However the nature of graph remained same. Figure3.2 shows the stress- strain diagram for banana reinforced epoxy composite for diameter 1mm and 3mm in which the loading is done perpendicular to the length of the fibre.

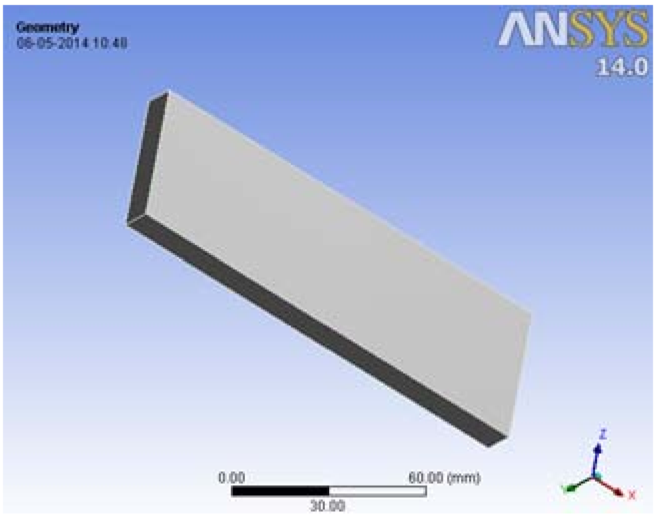

Figure 3.4: shows the geometric model for the Banana fibre reinforced epoxy composite.

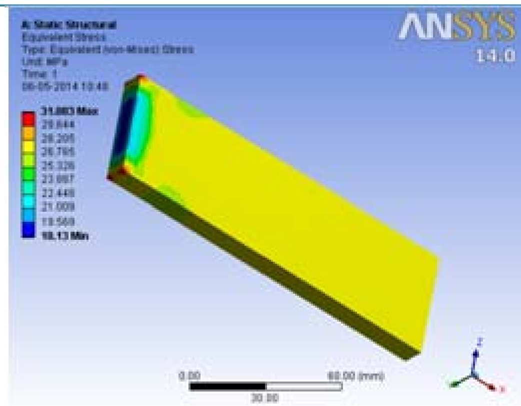

Figure 3.5: shows the von misses stress model for the diameter of 3mm fibre loaded along the length of fibre

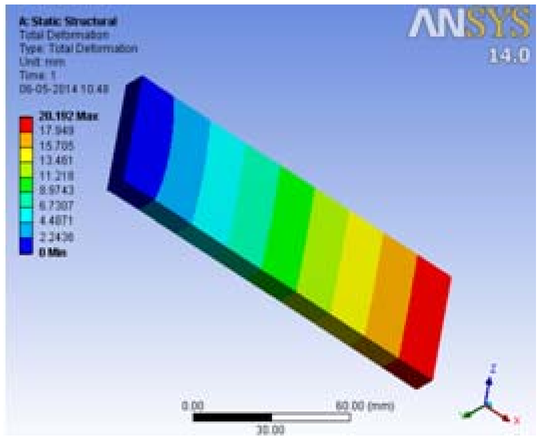

Figure 3.6: shows the deformed model for the diameter of 3mm fibre loaded along the length of fibre

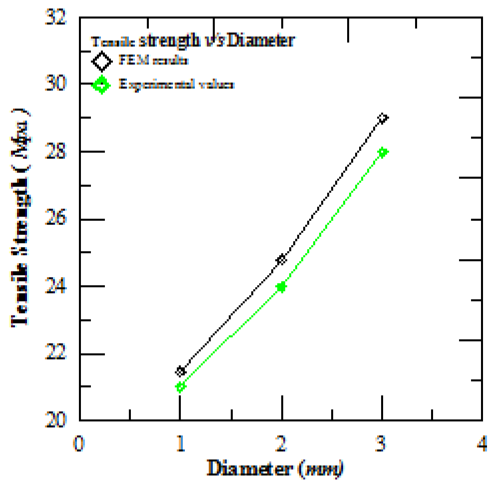

Figure 3.7: comparison of FEM and experimental Results

However the tensile strength of composite decreases if it is loaded perpendicular to the length of fibre but the nature of graph remained same for all the types of loading. The effect of loading on tensile strength is clearly shown in figure 3.3.loading of composite has definite effect and also difference in graph gets broadened as the volume fraction increases. Figure 3.7 shows the comparison of results for finite element method and experimental values. Results obtained from experiments are approximately equal to the finite element method.

4. Conclusions

Banana Reinforced Epoxy Composites were prepared and tested for tensile properties in universal testing machine. Parameters such as tensile strength, tensile modulus, and strain elongation were determined. For all the tensile test of the specimen the speed of the jaw is kept constant at 5mm /min. The banana fibers have definite effect on the tensile strength of composite. Tensile strength is more when it is loaded along the length fiber and it becomes weak if it is loaded perpendicular to the length of fibre. As the fiber diameter increases the tensile strength increases and the tensile Modulus decreased as the diameter of the fiber increases. Increase in interaction between fiber/matrix enhances the tensile strength. The experimental results obtained are almost similar to the Analytical Results.

5. Future Scope of the Present Work

For the given tensile strength of the banana reinforced epoxy composite several products may be fabricated in the field of aerospace, automotive, Sports, Leisure household Equipments etc. Further from chemical treatments we may enhance the strength of the composites and product and attracts many researchers for the improvement of this composite.

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