Experimental Characterization of Acacia Indica Reinforced Polymer Composites for Structural Applications

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Abstract.*Natural Fiber composites are the tremendous substitutes to the current available conventional and synthetic materials especially where there is a strong necessity of high strength to weight ratio type of applications. Natural fiber composites are having a very good scope for application in various industries like automotive, Aerospace and industrial fabrications especially due to their superior features like simplest process ability, excellent mechanical properties like light in weight, biodegradability and cheap cost. So Far various combinations of fiber reinforced polymer resin matrix composites were processed and tested successfully. The Current work is focused on development and study of mechanical properties of a new kind of acacia indica reinforced epoxy resin based composite material with altering weight percentage of fibers and their strand sizes, fabricated through hand layup method.*

Keywords:*Fiber reinforced polymer,Acacia indica, Hand layup method.*

1. INTRODUCTION

Fiber configuration plays an important role in obtaining high mechanical strength. Different mechanical properties in the form of tensile strength and flexural strength were recorded for PP/Raw banana fiber, PP/Banana yarn and PP/Banana mat polymer composites. It was found that, PP/Banana yarn composites possessed the highest tensile strength and flexural strength with the increment of 294% and 72%, respectively when compared to those of unreinforced PP[1]. The incorporation of pineapple leaf fibers (PALFs) into DGEBA/TETA epoxy matrix composites caused a significant reinforcement effect. As revealed by Weibull statistics, this reinforcement, above10 vol% up to 30 vol%, follow a linear increase to a value of flexural strength around 120 MPa[2]. The use of natural materials, such as chicken feather fibers, in the reinforcement of polymeric matrices, may lead to interesting properties of thermal and acoustic insulation. Thermal tests showed an increase of approximately 37% on thermal resistance, between samples with 60:40 and 80:20 ratios of chicken feather fibers and epoxy resin, respectively. The obtained results are competitive, comparing to other developments already carried out with similar materials, such as natural fibers. These results can be justified by the morphological characteristics of chicken feather, which presents hollow structure that favourably contributes to these properties. Moreover, since the density of the chicken feather fibers is lower than these natural materials, their use becomes even more interesting in the development of lighter composite materials [3].

2. LITERATURE SURVEY

Caroline G. de Oliveira[4] et al investigated that eucalyptus fibers, within the standard deviations, did not change the tensile strength of epoxy matrix composite and slightly decreased the tensile strength of polyester matrix composite. The introduction of eucalyptus fibers increased the elas-tic modulus in both composites, despite the relatively high dispersion of values. SEM fractographs revealed a poor adhesion between both the epoxy and polyester matrices with the eucalyptus fiber, which contributes to a small decrease in the composites tensile strength. A pre-treatment can be an alternative to make eucalyptus fibers better reinforcement material. Although, it implies in higher costs and chemical waste disposal to the environment.

Artur Camposo Pereira [5] et al found Composites with continuous and aligned jute fibers reinforcing an epoxy matrix display a significant increase in the tenacity, measured by the Charpy impact test, as a function of the amount of the fiber. The values of the absorbed energy are among the highest thus far obtained for ligno-cellulosic fiber composites. Most of this increase in tenacity is apparently due to the low jute fiber/epoxy matrix interfacial shear stress. This results in a higher absorbed energy as a consequence of a longitudinal propagation of the cracks throughout the inter-face, which generates larger rupture areas, as compared toa transversal fracture. Amounts of jute fibers above 20 vol% are associated with incomplete rupture of the specimen owing to the bend flexibility, i.e., flexural compliance, of the jute fibers.

ChrispinDasMohanDas [6] et al found that the AFF/PF composites were prepared by Taguchi's experimental design and their fabrication parameters and the mechanical properties were analyzed signal-to-noise ratio and analysis of variance. The results revealed that the fiber content is the most dominant fabrication parameter for the tensile strength among the four different parameters. In the flexural strength, dominant fabrication parameter is also found to be the fiber content. From the main effect plots of tensile strength, it can be seen that the tensile strength of composite increases with the increase of the fiber length, fiber content and alkali concentration for certain limit and then decreases. But, the tensile strength of composite decreased by the increasing of the alkali treatment duration.

Defang Zhao [7] et al in their investigation, found that the possibility of incorporating jute fibers into glass fiber reinforced composite by needle-punched system was explored and the hybrid effect on the flexural properties of different composites was studied. The following points are drawn from the experimental results: Flexural modulus of different composites showed little variation in the three-point flexural test. It is noteworthy that JF manifested the lowest flexural strength among the tested samples of different composites, but it also showed a low deflection, indicating a brittle property.

Lea Ghalieh [8] et al investigated that it is different from the failure of glass and carbon FRP confined columns in which the specimens fail by the debonding of the confining layer. 3- The ultimate stresses reached by the hemp FRP confined columns are influenced by the column slenderness ratio. The ultimate strength decreases with the increase of the slenderness ratio. The ductility enhancement also decreases with the increase of the slenderness ratio and this is interpreted by the reduction of the area under the stress strain curve with the increase of the slenderness ratio above the value 2.

3. PREPARATION OF COMPOSITE SPECIMEN

In the present investigation the specimen are fabricated with a hand layup technique. The fabricated specimen consists of uniform distribution of fibers of Acacia Indica respectively. Before entering the hand layup process the Acacia Indica fibers are exposed to sunlight for 6 hours to get the dry layers. A rubber matt mould is developed with the size of 20 X 20cm and Dura wax is applied on the surface applying Dura wax on the rubber matt surface will help in taking out the fabricated pieces with-out sticking to the matt very easily.A roller is used to remove air gaps between each a pair of successive layers. After the addition of layers the mould matt is closed and is kept under press for 24 hours any excess amount of air/air gaps are removed under hydraulic press. Once the hardness is accomplished the composites are taken out and trimmed to required dimensions. The three variations of composite specimen are varied by changing the strand sizes of fibers such as shown in below figures.

Fig: 3.1 Fiber Strands of size 10mm Fig: 3.2 Fiber Strands of size 30mm

4. EXPERIMENTAL INVESTIGATION

4.1. Mechanical Testings of Composites

4.1.1. Tensile Test:

Tensile test is performed by using ASTM D638 method.ASTM D638 is a standard test for evaluating behavior of both reinforced and unreinforced plastics under tensile loading. Conditions such as machine operating speed input humidity and some other pretreatment conditions should be defined before doing the test, the maximum thickness of the specimen in ASTMD638 should not exceed 14 mm, thin sheets and very thin films having 1mm thickness are less than that can be also tested through these standard tests. The composites are trimmed in to required dimensions and smooth finishing by using emery paper the gauge length dimensions and cross head speeds are followed as per ASTM D638 manual specimen for tensile test once the specimen are conformed to dimensions, each specimen is mounted in to the machine for conducting the tensile test . The load is gradually applied till the specimen is failed the results are recorded as a function of gauge length and applied force in each variety specimen are made to the encounter the test.

Fig: 4.1 Tensile test specimens of 10mm fiber strands

Fig: 4.2 Tensile test specimens of 30mm fiber strands

4.1.2.FLEXURAL TEST:

Flexural test is performed by using ASTM D790. Three point flexural test as per ASTM D790 standard is conducted on the specimen the specimen deflection is the out put of theflexural test and it is measured with cross head position, theresults of the test are displacement corresponded to flexural strength to conduct flexural test the test specimen is placed in the UTM and the force is applied till there is a fracture/break the specimen for flexural test,the specimen after testing are shown in fig. The flexural test is conducted at the room tempretaure is 24 deg centigarde with an average relative humidity of 50% the tested specimen using flexural test.

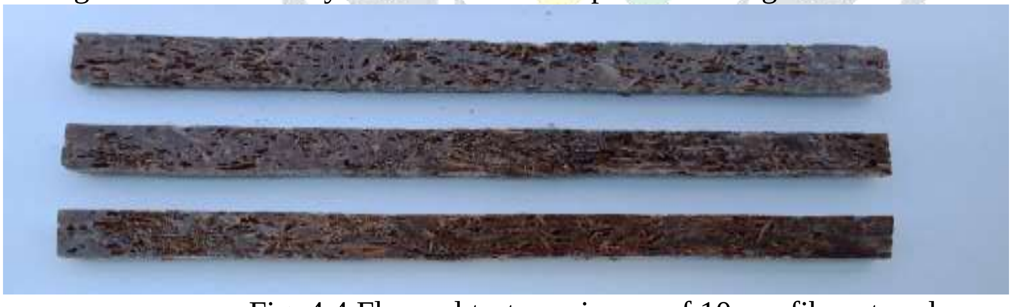

Fig: 4.4 Flexural test specimens of 10mm fiber strands

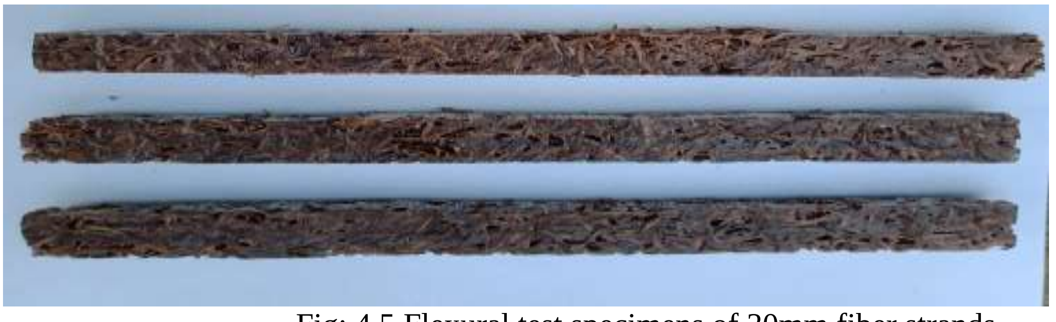

Fig: 4.5 Flexural test specimens of 30mm fiber strands

5 RESULTS AND DISCUSSION

5.1. Mechanical Properties of Composites:

The composites are prepared with a combination of Acacia Indica fibers with Epoxy resin. Mechanical testing's such as tensile test (ASTM D638), and flexural (ASTMD790) are conducted on three different specimen in each variety three specimen are fabricated .Totally 18 specimens are fabricated and tested for the evaluation of mechanical properties.

The following figures shows the tested specimens

Fig 5.1 flexure tested specimen of fiber strand size 10mm

Fig 5.2 flexure tested specimen of fiber strand size 30mm

Fig 5.4 tensile tested specimen of fiber strand size 10mm

Fig 5.5 tensile tested specimen of fiber strand size 30mm

The Following Graphs Shows the Results of the Tensile tested specimens

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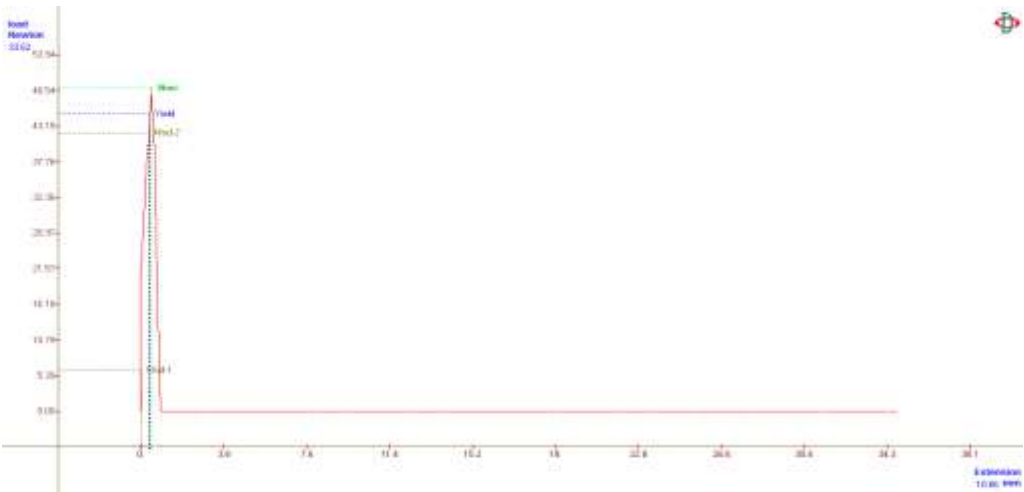


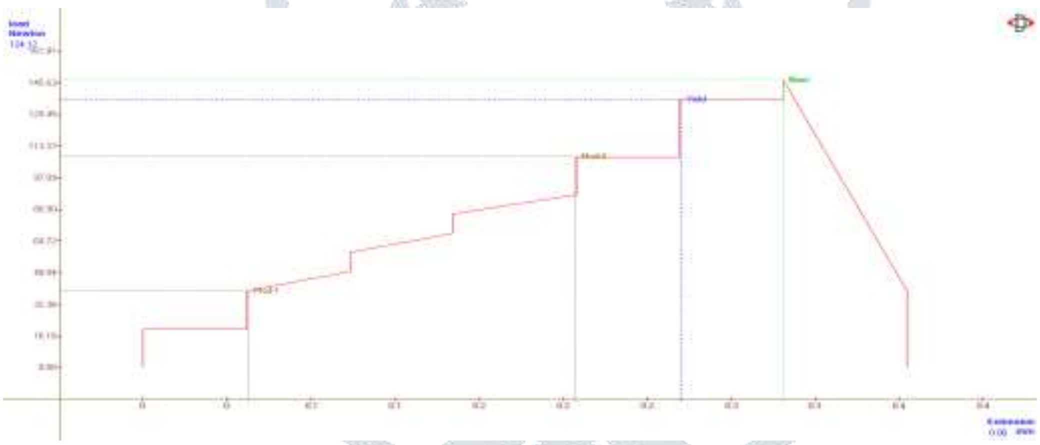
DISPLACEMENT

Graph:- 5.1 Load vs displacement graph of 10mm fiber size tensile tested specimen

Table: 5.1 Obtained average results of 10mm fiber size tensile tested specimen

Obtained Results

Sr. No.	Results	Value	
1	Area	**87.9092**	**mm²**
2	Yield Force	**44.98**	**N**
3	Yield Elongation	**0.40**	**Mm**
4	Break Force	**48.9**	**N**
5	Break Elongation	**0.48**	**Mm**
6	Tensile Strength at Yield	**0.51**	**N/mm²**
7	Tensile Strength at Break	**0.56**	**N/mm²**
8	Tensile Strength at Max	**0.56**	**N/mm²**
9	%Elongation	**0.68**	**%**
10	Max Force	**48.91**	**N**
11	Max Elongation	**0.48**	**Mm**
12	Modulus of Elasticity	**83.34**	**N/mm²**



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DISPLACEMENT

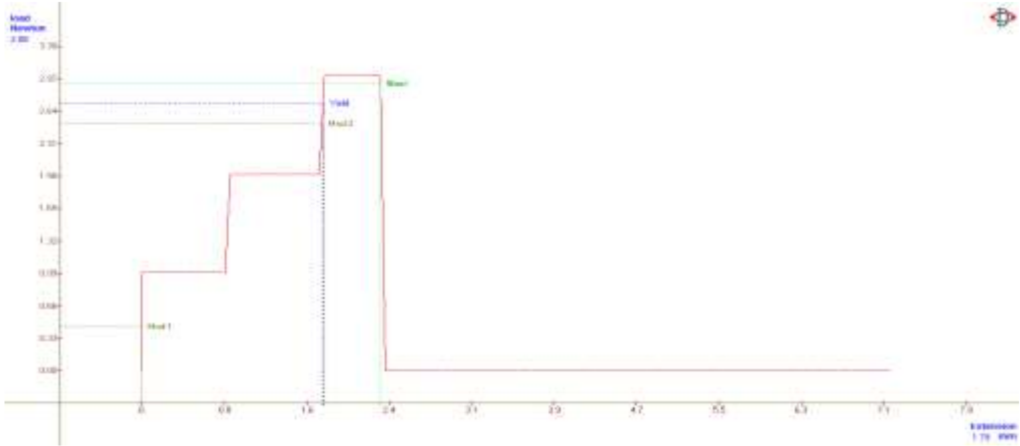
Graph:- 5.2 Load vs displacement graph of 30mm fiber size tensile tested specimen

Table: 5.2 Obtained average results of 30mm fiber size tensile tested specimen

Obtained Results

Sr. No.	Results	Value	
1	Area	**108.3894**	**mm²**
2	Yield Force	**137.22**	**N**
3	Yield Elongation	**0.26**	**mm**
4	Break Force	**147.1**	**N**
5	Break Elongation	**0.31**	**Mm**
6	Tensile Strength at Yield	**1.27**	**N/mm²**
7	Tensile Strength at Break	**1.36**	**N/mm²**
8	Tensile Strength at Max	**1.36**	**N/mm²**
9	%Elongation	**0.44**	**%**
10	Max Force	**147.10**	**N**
11	MaxElongation	**0.31**	**Mm**
12	Modulus of Elasticity	**280.02**	**N/mm²**

Results of flexural tested specimens



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Graph:- 5.4 Load vs displacement graph of 10mm fiber size flexural tested specimen

Table: 5.4 Obtained average results of 10mm fiber size flexural tested specimen

Obtained Results

S. No.	Results	Value	Unit
1	Area	157.4650	**mm^2**
2	YIELD Force	26.66731336	**N**
3	YIELD Deflection	1.74	**mm**
4	Max Force	2.9	**N**
5	Max Deflection	2.3	**mm**
6	Flexural Strength @ Yield	1.54	**N/mm^2**
7	FLEXURAL STRENGTH @ Max	0.447754903	**Mpa**
8	Flexural Strain	0.006822679	
9	Flexural Modulus at 1% Strain	149.02	**Mpa**
10	Flexural Modulus of Elasticity	223.9432767	**N/mm^2**

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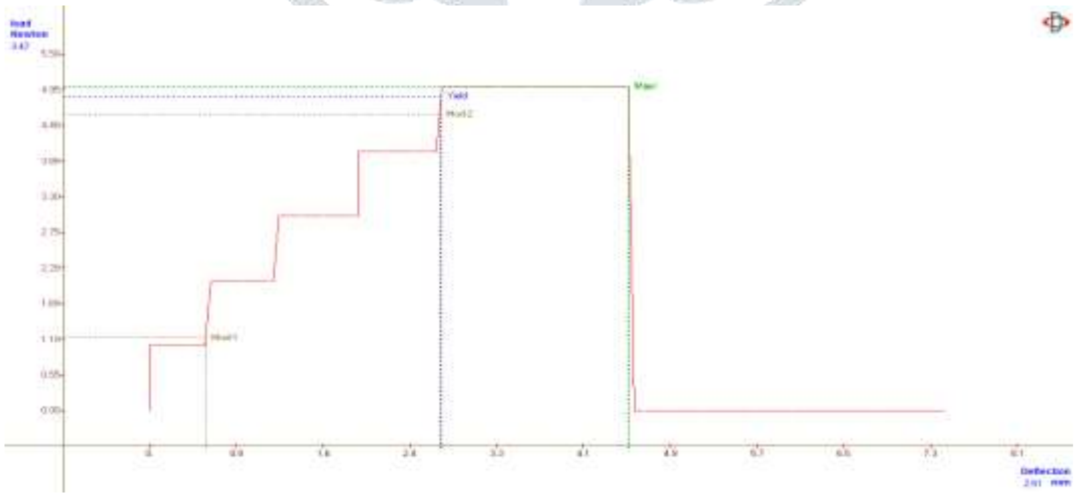

DISPLACEMENT

Graph:- 5.5 Load vs displacement graph of 30mm fiber size flexural tested specimen

Table: 5.5 Obtained average results of 30mm fiber size flexural tested specimen

Obtained Results

Sr. No.	Results	Value	Unit
1	Area	204.0381	**mm²**
2	YIELD Force	47.61292105	**N**
3	YIELD Deflection	2.74	**mm**
4	Max Force	5.0	**N**
5	Max Deflection	4.5	**mm**
6	FLEXURAL STRENGTH @ YIELD	2.59	**N/mm²**
7	FLEXURAL STRENGTH @ Max	0.585351101	**Mpa**
8	Flexural Strain	0.010911342	
9	Flexural Modulus at 1% Strain	240.89	**Mpa**
10	FLEXURAL MODULUS OF ELASTICITY	531.2971863	**N/mm²**

6 CONCLUSION

Finally after testing the samples of the different fiber variant specimens of acacia indica the following conclusions are drawn

1. The results of the tensile tested specimens indicated that the 30mm fiber variant sample is showing the maximum tensile strength and can hold up to 1.36N/mm^2.
2. The results of the Flexural tested specimens indicated that the 30mm fiber variant sample is showing the maximum Flexural strength and can hold up to 0.58Mpa.Hence this composition can be evaluated for further testing and utilized for more engineering Applications.

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