International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

Mechanical Characterization of Banana fibre reinforced Natural fibre composite

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***Abstract:** Fibre reinforced composites have been an essential concern in various fields, especially in the field of aerospace owing to its high strength to weight ratio, toughness, corrosion resistant and low cost. Natural fibre reinforced composites have produced better results in mechanical properties like impact, toughness and fatigue strengths when compared to synthetic fibre reinforced composites. Recently researches have been conducted on different varieties of natural fibres for use in plastics such as jute straw, wood, rice husk, wheat, barley etc. Natural fibres have also attracted the attention of researchers due to its availability, renewability, degradability and most importantly ecofriendly. In this work an attempt is made to improve the mechanical properties of the composite and also to enhance the compatibility of the fibres with the matrix. The composite is prepared by reinforcing banana fibres into unsaturated epoxy matrix using hand layup method. Mechanical properties such as tensile strength, flexural strength and hardness strengths are carried out on the specimens made by reinforcing with 5%, 10 % and 15 %concentration of banana fibre by weight. The results showed that the composite with 15% concentration of banana fibre produced higher tensile strength of 21.43 MPa, flexural strength of 0.895 kPa and Shroud hardness of 59.3.*

***Key words:** Fibre reinforced composites, Natural fibres, Epoxy matrix, Banana fibre, Mechanical properties.*

I. INTRODUCTION

Natural fibres have acquired huge focus as potential alternative for synthetic fibres, as reinforcement of resins for superior applications owing to their properties, like lesser density, higher specific strength and also due to its renewability, sustainability, and eco-friendly behaviour.

Revised Manuscript Received on December 30, 2019.
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Researches are being undergone using various types of natural fibres and few of those developments from those researches are discussed below.

Sapuan et al has studied the mechanical properties of composites made by reinforcing coconut shell filler particles with epoxy resin using three different filler compositions at 5%, 10%, and 15%, and identified that the amount of filler has an impact in the strengths of the composite as it increases with the increase in the amount of fillers.

Alok Singh et al investigated a polymer matrix composite by reinforcing different particle size of coconut shell powder (CSP) in different volume concentration and evaluated that reinforcement of 20% CSP volume fraction has acquired superior mechanical properties.

Verma et al reviewed the usage of natural fibres such as palm, sisal, jute, etc as reinforcements for composites and focused to discover the potential of the Palm fibre reinforced composites and also investigated the mechanical properties of composites with respect to the wide range of applications.

Vasanta et al conducted tests on hybrid composites prepared by reinforcing palm fibre and rice husk at different weight fractions with vinyl ester by hand layup process and found that the tensile strength has varied from 27.80% at 15% reinforcement to 20.85% at 20% reinforcement and flexural strength varied from 39.40% at 15% reinforcement to 43.84% at 20% reinforcement.

Sakthivel et al fabricated polymer matrix composites made by reinforcing natural fibres like palm, banana and sisal and evaluated that the composite with banana fibre reinforced composite as the best composition as it provided enhanced mechanical properties in comparision with the other natural fibres.

Venkateshwaran and Elayaperumal reviewed the usage of banana fiber as reinforcements for producing polymer composites and proposed that further research in banana fibres and its composites has huge hope in the future owing to its availability and better mechanical properties.

Subba Reddy et al tested the composites made by reinforcing 10%, 25%, 35% and 40% volume fraction of banana fibres with epoxy resin and found that the composite with 35% reinforcement has produced better tensile strength and the impact strength decreased with the increase in reinforcements.

Lakshman et al has evaluated the mechanical properties of composite by reinforcing 5%, 10%, 15%, 20% wt. fractions of banana fiber with polyester resin and found the ultimate tensile strength to be maximum at 15% reinforcement, flexural strength has increased from 5% to 10% and on further addition it decreased and the impact value is maximum at 15% and on further addition it decreased.

Santhosh et al assessed the mechanical properties of hybrid composites produced by reinforcing treated and untreated banana fibres and coconut shell powder with vinyl ester and epoxy composites and observed that the alkali treated banana fibre composite has showed superior results than the untreated composites.

Sapuan et al studied the mechanical behavior of composite produced by reinforcing woven banana fibre with epoxy resin and found the maximum stress value to be 14.14 MN/m^2 and statistical analysis is also carried out using ANOVA-one way method.

Dilleswara Rao et al explained about the manufacturing method of banana reinforced composite by mixing banana fibre and virgin fibre with appropriate resin by compression moulding process and proposed it to be the less expensive method of producing the composite.

Fan-Long Jin et al conducted a review process on numerous epoxy resins and various curing agents and proposed that thermoplastic components improves the toughness of the epoxy resin.

From the above literature reviews, it is evident that the usage of natural fibres as reinforcement material in compositeis increasing. Banana fibres are a leftover produce of banana farming and so it is easily available and also economical. Banana fibre has good reinforcement characteristics in epoxy resin and so natural fibre reinforced composite with superior mechanical properties can be obtained.

II. METHODOLOGY

A. Preparation of Banana fibre

The extraction process of banana fibre comprises of two important steps.

First, the banana fibre is extracted from the banana tree. Then, the drying process of the banana trunks are carried out by keeping it under the sunlight up to two weeks. After the drying process gets completed the banana trunks are soaked in diluted NaOH solution for two hours so that the wettability of the fibre can be improved. If it is not soaked for two hours, the fibre won't get separated from the unwanted part also. Then the fibres are dried by keeping it in an oven. After banana fibres have dried completely, they are cut horizontally in order to get the required specifications that are needed to produce the composite that we desire. Then roller machines are used to thin the fibres which will make the process of weaving easier. Then the fibres are woven as per the requirement. The woven banana fibres are shown in Fig. 1.

Fig. 1. Woven banana fibre

B. Preparation of Pattern

The Pattern used for preparing the composite is made of plywood. The plywood is made in rectangular shape with 250 mm length and 150 mm width. Then the inner part to be filled with resin is coated with plastic and this helps to remove the composite from the plywood after preparation. The upper side is used to supply the resin and also it is covered, so that the dust does not get integrated in the composite when allowing it to cure and also it is used for compression.

C. Preparation of Specimen

The method of preparation of the specimen involves the following steps

- The pattern made of plywood is cleaned well before the process.
- The composite is prepared by using hand layup method.
- A layer of epoxy resin mixed with hardner in the ratio4:1 is laid on the mould. The hardener is used for fast settling of the composite.
- Now the woven banana fibre contributing a 5% wt is positioned on the resin poured in the pattern.
- Then the second layer of epoxy resin is dispensed on the woven banana fibre placed in the pattern so that the banana fibre lays at the middle like a sandwich.
- A roller is rolled over the resin poured to get uniformity and also to avoid void formations in the composite.
- Now the mould with the composite is closed and kept for drying for 24 hours.

After it is fully dried, the composite is removed from the mould.

- The above process is repeated to obtain the composites with 10% and 15% wt. reinforcement of woven banana fibres.
- Now the composite is cut into pieces based on the specifications required for testing the tensile strength, flexural strength and hardness.

Fig. 2. Banana Fibre Reinforced Composite

D. Tensile Strength

The dimensions of the specimen for tensile test is prepared as per the standard specifications. Fig. 3 shows the sample specimen prepared for tensile load test. Fig. 4 shows the tensile load test performed in the UTM machine.

The specimen is fixed in the upper and lower jaws of the UTM and then the load is applied gradually. The maximum load at which the specimen breaks and also the elongation of the specimen were recorded by the computer software linked with UTM.

Fig. 3. Specimen for Tensile test

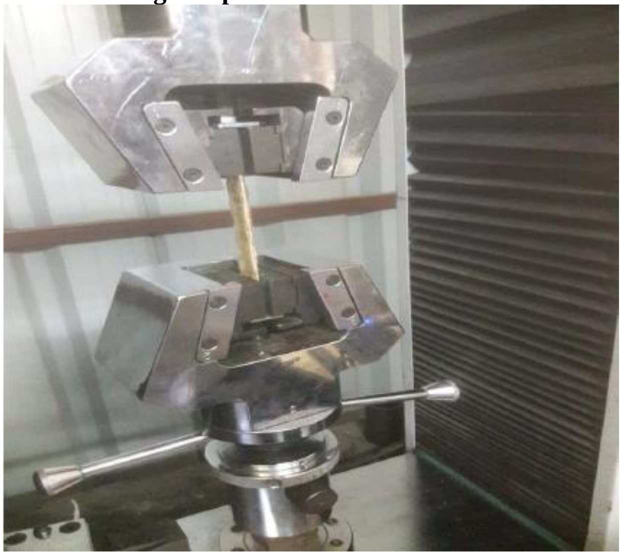

Fig. 4. Tensile load test setup

E. Flexural Strength

It is the capability of a material to resist distortion on the application of load. Fig. 5 shows the sample specimen of standard dimensions for which the flexural strength has to be tested. Fig. 6 shows the setup of the flexural strength test to be conducted. The specimen is kept on the jaws of the machine like simply supported and the point load is employed at the centre of the specimen. The continuous deformation of the specimen with the application of load is recorded in the computer software continuously until the specimen breaks.

Fig. 5. Specimen for Flexural strength test

Fig. 6. Flexural strength test setup

F. Hardness

It the degree of resistance to distortion. Fig. 7 shows the sample specimen for the hardness test. The specimens are prepared with a dimension of 20 mm × 20 mm. Enclosed indenter shrouds for which 3/8th of the surface area of the indenter is only visible is used for finding the hardness of the specimen. Tests are conducted by keeping indents at different positions on the specimens.

Fig. 7. Specimen for hardness test

III. RESULT AND DISCUSSION

A. Tensile strength

The tensile test is performed on the specimens made for the same and the results observed are tabulated. The specimen, after conducting the tensile load test in UTM is shown in Fig.8. The results obtained from tensile tests for all the specimens are mentioned in Table-I. It shows that the tensile stress is increasing with the increase in the concentration of banana fibre. Elongation of the length of the specimen is also increased. The variation of stresses with respect to strains for the specimens with 5%, 10% and 15% reinforcements of Banana fibres respectively are shown in Fig. 9-11..All the graphs show that the elongation is almost linear till breakage. From the graphs and table I we find that there was a considerable increase in the tensile strength, elongation in length and strain with the increase in the concentration of banana fiber. The maximum tensile stress (21.43 MPa) is obtained for the composite with 15% reinforcement. This shows that the fibres bonded strongly with the resin. The maximum elongation in length (15%) for 15% reinforcement shows the improvement of the elasticity of the composite.

Fig. 8. Specimen after tensile test

Table-I: Results from Tensile test

Reinforcement Concentration of Banana fibre	Tensile Strength MPa	Maximum Strain %	Elongation %
5%	2.37	7.11	3.92
10%	5.79	10.42	6.67
15%	21.43	26.93	15

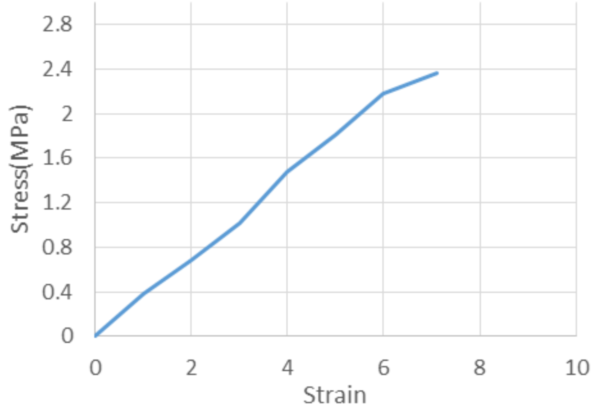

Fig. 9. Stress Vs strain for specimen with 5% reinforcement

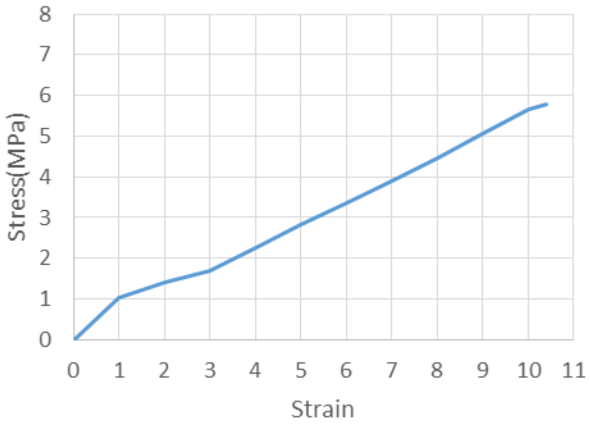

Fig. 10. Stress Vs strain for specimen with 10% reinforcement

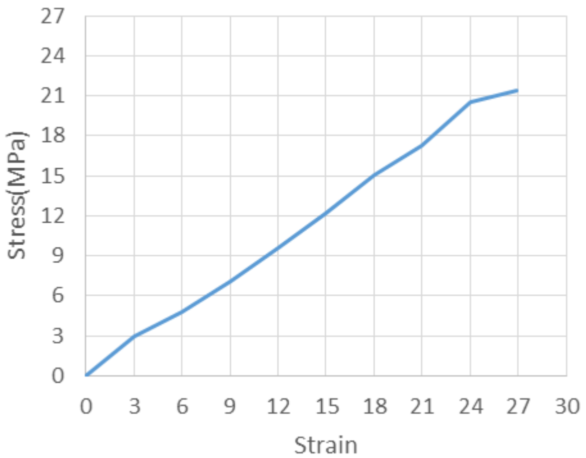

Fig. 11. Stress Vs strain for specimen with 15% reinforcement

B. Flexural strength

Fig. 12. Specimen after flexural strength test

Table-II: Results from Flexural strength test

Reinforcement Concentration of Banana fibre	Ultimate Load kN	Maximum Displacement mm	Ultimate stress N/mm^2
5%	0.291	0.9	1.3
10%	0.455	1.4	3
15%	0.895	1.9	5

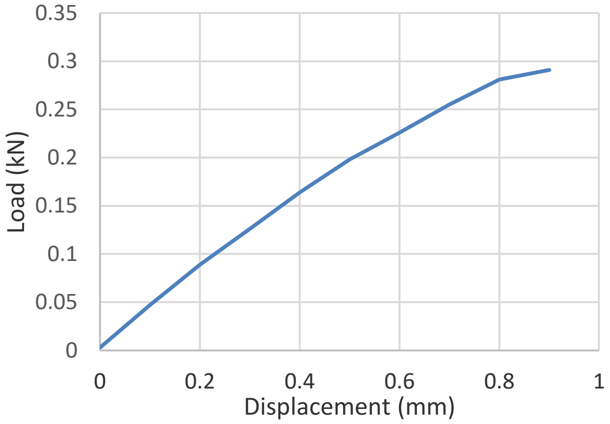

Fig. 13. Load vs Displacement for specimen with 5% reinforcement

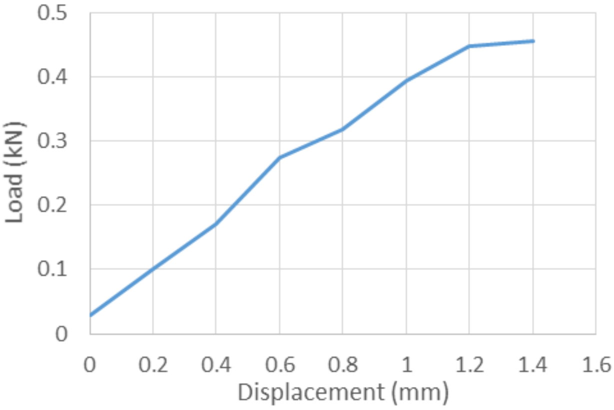

Fig. 14. Load vs Displacement for specimen with 10% reinforcement

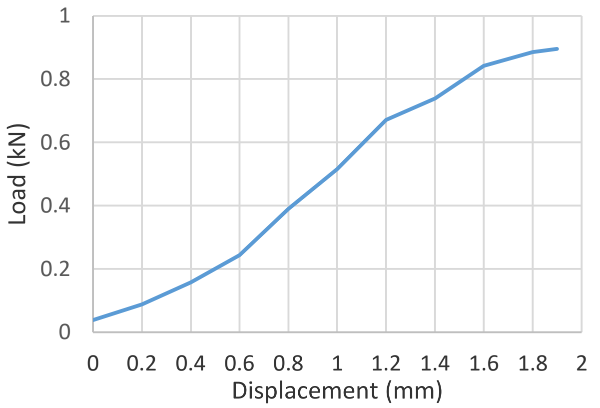

Fig. 15. Load vs Displacement for specimen with 15% reinforcement

Retrieval Number: B7034129219/2019©BEIESP
DOI: 10.35940/ijitee.B7034.129219
Journal Website: www.ijitee.org

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Blue Eyes Intelligence Engineering
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Flexural strength test is undergone for the specimens with the specified dimensions. Fig. 13-15 shows the results obtained from the flexural load test for specimens with 5%, 10% and 15% reinforcements respectively. From the above graphs the deformation range of the specimens are found to be increased with the increase in the reinforcement concentration. The maximum breaking or ultimate load (0.895kN) is obtained for 15% reinforcement concentration. The maximum displacement is also found to be 1.9 mm. The maximum ultimate stress (5 N/mm^2) is also exhibited for 15% reinforcement concentration. From fig. 14&15, it can be identified that the deformation occurs gradually and slows down towards the end.

C. Hardness

Shourd hardness tests are carried out on the specimens. Indents are placed on the specimen at various places by applying load and holding it for 10 seconds. The shourd hardness number is found from the depth of indent produced due to the application of load. The hardness values obtained for the various specimen are listed in Table-III. The highest average shourd hardness is found to be 57.5 for 15% reinforcement concentration of banana fibre.

Table-III: Hardness test results

Specimen (% reinforcements)	Shourd Hardness Number (at various positions)			
	Position 1	*Position 2*	*Position 3*	*Average*
5% reinforcement	33.9	34.7	34.5	34.4
10% reinforcement	41.7	41.9	39.4	41
15% reinforcement	58.5	54.8	59.3	57.5

IV. CONCLUSION

From the above results, the mechanical properties of the specimens can be seen increasing with the increase in reinforcement concentration. The utmost value of tensile stress is attained at 15% reinforcement of banana fibre and the value is 21.43MPa. The elongation has also increased considerably to 15% with the increase in reinforcement concentration.

The flexural strength is found to be maximum at 15% reinforcement and the maximum displacement has increased to 1.9 mm for 15% reinforcement. The ultimate stress has also increased to 5 MPa.

The shourd hardness also has considerably increased with the increase in reinforcements. So from the above tests results, all the mechanical properties are found to be considerably increasing with the increase in the reinforcement concentration of Banana fibre. Researches can be continued further by increasing the concentration of reinforcement to find the optimum mix ratio.

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Retrieval Number: B7034129219/2019©BEIESP
DOI: 10.35940/ijitee.B7034.129219
Journal Website: www.ijitee.org

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