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INVESTIGATIVE STUDIES ON THE MECHANICAL BEHAVIOUR ON BANANA FIBER REINFORCED NATURAL COMPOSITES

[1]JAFFARSADIK MULLA, [2]FAROOQUE MURSAL,
[1]SECECTION GRADE LECTURER [1]AUTOMOBILE ENGINEERING DEPT. [1] GOVERNMENT POLYTECHNIC BELAGAVI
, [2] LECTURER, [2] MTT DEPT. [2] Govt cpc polytechnic Mysore

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Abstract - *Fiber-reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. The fiber which serves as a reinforcement in reinforced plastics may be synthetic or natural. Past studies show that only synthetic fibers such as glass, carbon etc., have been used in fiber reinforced plastics. Although glass and other synthetic fiber reinforced plastics possess high specific strength, their fields of application are very limited because of their inherent higher cost of production. The present experimental study aims at learning the mechanical behavior of natural fiber composites. Samples of banana fiber and sugarcane powder composition and the weight fraction of fiber and matrix was kept at 30%-70%. Specimens were cut from the fabricated according to the ASTM standards for different experiments For Tensile, flexural, compression, impact, hardness test and water absorption test. After that experiment is performed under Universal testing machine (UTM). From the results it was found that, the mechanical properties of treated banana fiber content composites is more compared to the un-treated banana fiber content composites. And increasing of sugarcane powder percentage get good mechanical properties.*

Key Words: Fiber-reinforced polymer, Synthetic fiber, Universal testing machine, Banana fiber etc

1.INTRODUCTION

The modification of the filler surface is to improve the interfacial adhesion between filler particles and polymer macromolecules and their dispersion in the matrix. This is a very important issue, since the simple addition of natural organic fillers to a polymer matrix may lead to poor mechanical properties in comparison to the neat polymer; this can be especially true when filler particles with low length to diameter ratios are used.

Polymer composites have been prepared and combined with various types of synthetic reinforcing fillers in order to improve the mechanical properties and obtain the characteristics in actual applications. The use of natural filler for the reinforcement of the composites has received increasing attention both by the academic sector and the industry. In this project, composites are prepared by sugarcane bagasse powder, chopped banana fibers and epoxy resin. In this study, the effect of treated and un-treated banana fibers on the mechanical properties and water absorption of the natural composites are investigated.

2. MATERIALS

The materials which have been used in the present work are shown below. Composites were prepared for two material combinations. The chosen composite includes Matrix Material and Reinforcements.

2.1 Matrix Material-Epoxy Resin

Epoxy resin is widely used in industrial application because of their high strength and mechanical adhesiveness characteristic. It is also good solvent and have good chemical resistant over a wide range of temperature. Atul Ltd. Lapox L – 12 purchased from Yuje Marketing, Bangalore, India is used in the present investigation. The properties and curing
details of epoxy resin and hardener K – 6 purchased from Yuje Marketing, Bangalore, India is used as curing agent. In the present investigation percentage of weight has been used in all materials developed. The weight percentage of hardener used in the present investigation is in the ratio of 10:1.

Table -1: Properties of Epoxy Resin (L – 12)

Properties	Values
Density	1.25 g/cc
Tensile strength	50 – 60 MPa
Compressive strength	110 – 120 MPa
Modulus of elasticity	4.4 – 4.6 GPa
Coefficient of thermal expansion	64 – 68 μ/°C

2.2 Reinforcements

Reinforcing agents are added to the resin to improve the mechanical properties and failure rates of the material.

2.2.1 Banana fiber

In the present experiments, initially the banana plant sections were cut from the main stem of the plant and then rolled lightly to remove the excess moisture. Impurities in the rolled fiber such as pigments, broken fiber, coating of cellulose etc. were removed manually by means of comb, and then the fiber were cleaned and dried. The length of the banana fiber is taken as 10mm.

Fig -1: Treated banana fibers chopped

Table -2: Properties of Epoxy Resin (L – 12)

Properties	Values
Density (kg/m$^{3)}$	950
Water absorption %	60
Modulus of elasticity (Gpa)	23
Tensile streangth (Mpa)	180-430

2.2.2 Sugarcane powder

The preparation of sugarcane Powder begins after crushing the sugarcane stalk and extracting the sucrose. Then bagasse fiber was repeatedly washed with water and the sugarcane fiber are separated from undesirable foreign matter and shifted manually from fiber bundles that fibers are chopped then we use the grind mill to get a powder form after that finally sieves in 300 micron.

Fig -2: Sugarcane bagasse powder

Table -2: Properties of sugarcane fiber

Properties	Values
Density (kg/m^3)	1025
Water absorption %	70
Modulus of elasticity (Gpa)	15-19
Tensile streangth (Mpa)	190-380

3. BANANA FIBER TREATMENT

Chemical Treatment

- The fibers are cut to the required size of 10mm.
- Then the fibers are cleaned normally in clean running water and dried.
- A glass beaker is taken and 6% NaOH is added and 80% of distilled water is added
- and a solution is made.
- After adequate drying of the fibers in normal shading for 2 to 3 hours the fibers are taken and soaked in the prepared NaOH solution.
- Soaking is carried out for different time intervals depending upon the strength of fiber required.
- For our project the fibers are soaked in the solution for three hours.
- After the soaking process is complete the fibers are taken out and washed in running water and dried for another 2 hours.
- Now the fibers are taken for the next fabrication process.

4. METHODOLOGY

- Specimens are prepared as per ASTM standards for the tests to be conducted.
- The inner surface of the mold was initially smeared with a releasing agent to prevent the composites from sticking on to the mold wall.
- Sugarcane bagasse powder, banana fiber (in chopped form) with Epoxy and hardener were mixed in a container and stirred well for 5 – 7 minutes.
- The prepared mixture is poured in to the prepared moulds.
- The samples so prepared are kept for drying for a duration of 24 hours at room temperature.
- After drying the samples are cut in accordance with ASTM standards.

5. SPECIMEN PREPERATION

The specimens were prepared according to ASTM standards. The test specimen along with specimen dimension and standards for different tests are discussed below.

5.1 Tensile Test Specimens

Tensile test specimens were prepared according to ASTM D3036 standard. The pictorial view of specimen is shown in Fig-3 below. The specimen used is a rectangular bar of length 220mm, width 25mm and thickness 6mm.

Fig -3: Tensile test specimens as per ASTM standards

5.2 Compression Test Specimens

Compression test specimens were prepared according to ASTM D695 standard. The photographic view of specimen is shown in Fig-4 below. The specimen used is a rectangular bar of length 25.4mm, width 12.7mm and thickness 12.7mm.

Fig -4: Compression test specimen as per ASTM standards

5.3 Flexural Test Specimens

Flexural test specimens were prepared according to ASTM D790 standard. The photographic view of specimen is shown in Fig-5 below. The specimen used is a rectangular bar of 130mm length, 25mm width and 6.5mm thickness.

Fig -5: Flexural test specimen as per ASTM standards

6. EXPERIMENTATION

Following tests were conducted in the present work.

- Tensile test
- Compression test
- Flexural test

Tensile, Compression, and Flexural tests are conducted using a calibrated Universal Testing Machine (UTM).The pictorial view of the UTM used in the present work is shown in Fig. Fig-6 below tests are conducted using a calibrated Universal Testing Machine (UTM).

Table -3: Specification of UTM

Sl. No.	Description	Range
1	Model	UTE/E – 40
2	Capacity	0 – 400 kN 0 – 200 kN 0 – 100 kN 0 – 40 kN
3	Tensile clearance at fully descended working piston	50-700 mm
4	Resolution of piston movement (Displacement)	0.1 to 0.01 mm
5	For traverse test maximum clearance between supports Width of roller Dia. of roller Radius of bending Pan	500 mm 160 mm 30 mm 12 R & 16 R
6	Ram Stroke	200 mm

Fig -6: Universal Testing Machine

Fig -7: Experimental Set-Up for tensile

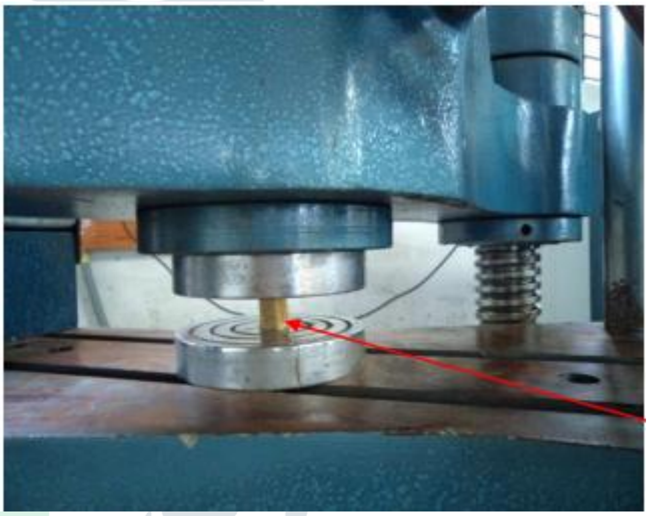

Fig -8: Experimental Set – Up for compression test

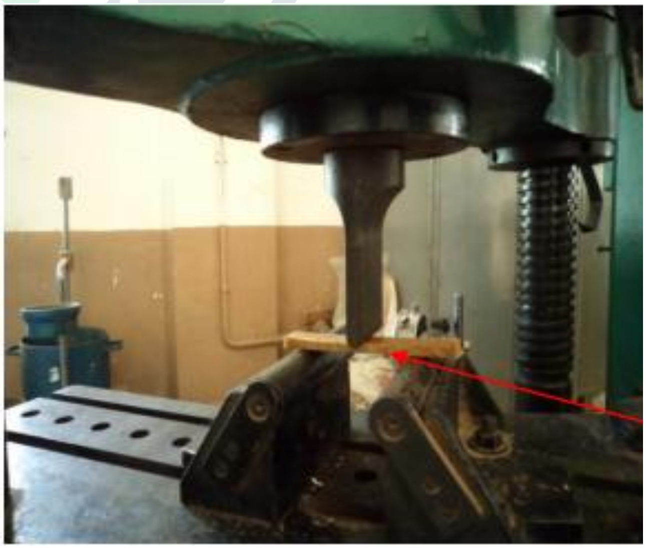

Fig -9: Experimental Set – Up for Flexural test

6. TESTED SPECIMENS

After conducting the tensile test, compression test and flexure test the specimens are broken at ultimate load as shown in Fig below.

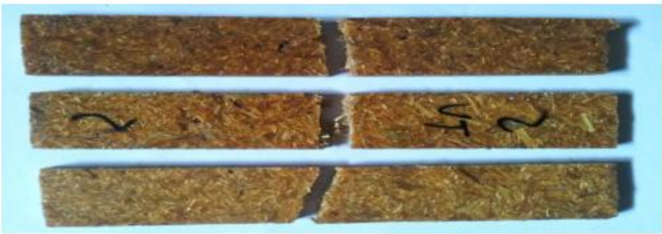

Fig -10: Tested tensile specimens

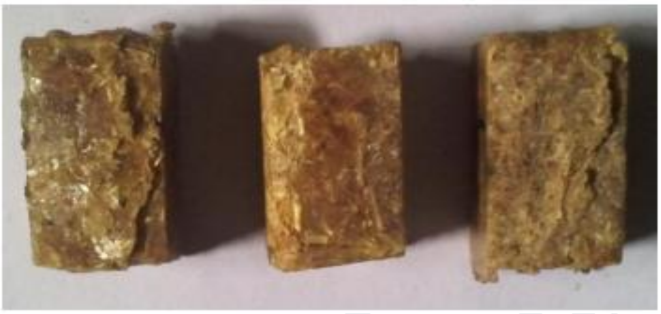

Fig -11: Tested compressive specimens

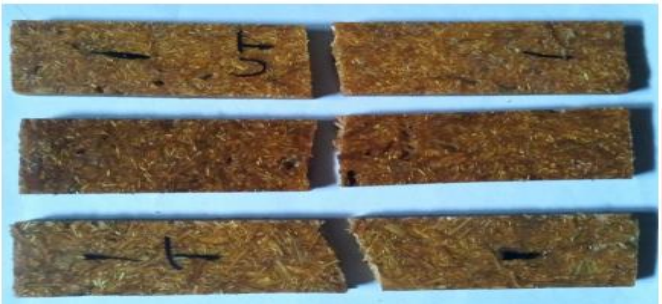

Fig -12: Tested flexural specimens

7. RESULTS AND DISCUSSIONS

Analysis of the mechanical behavior of natural composites is one of the most important stages of the investigation. Mechanical properties of fiber and fiber reinforced composites depend on the nature of matrix material, the distribution and orientation of the reinforcing fibers, the nature of the fiber-matrix interfaces. Even small changes in the physical nature of the reinforcement for a given matrix may result in prominent changes in the overall mechanical properties of composites.

7.1 Tensile Strength of Composites

The Fig-13 shows the effect of NaOH – treated banana fiber with three different combinations on the composite specimens. From the Fig 5.1 it is clear that the composite specimen with the composition of B10%-S20% sustain more load up to 2968N, and other two specimens with composition of B15%-S15% and B20%-S10% sustain loads up to 2101N and 1526N respectively. The composites made of powder fiber content reinforcement found to have greater tensile strength compared to fiber reinforced composites. Because the sugarcane bagasse has high lignin content is 24%. The bio-flour materials are mainly composed of a complex network of three polymers: cellulose, hemicelluloses and lignin. The lignin not only holds the bio–flour together but also acts as a stiffening agent for the cellulose molecules within bio–flour cell wall. Therefore, the lignin and cellulose content of sugarcane bagasse have increases the tensile strength. This might be the reason for the braking of the composite specimen with 20% Banana fiber and 10% sugarcane powder at earlier stage of load 1800 N.

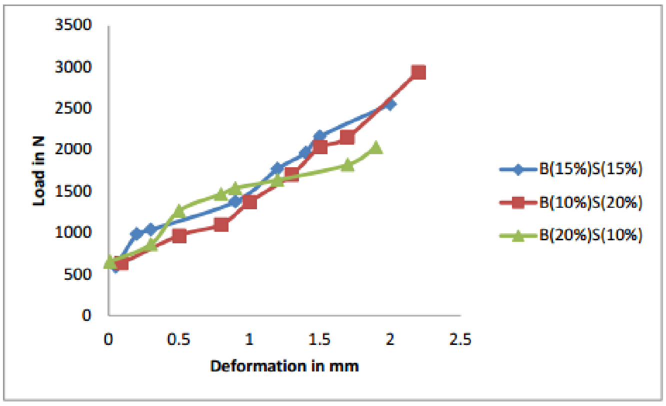

Fig -13: Effect of NaoH– treated fiber content on the tensile strength of natural composites

7.2 Compressive Strength of Composites

Fig-14 shows the relation between the load and deformation for treated different combination composites under compressive test. In the Fig. 5.6 it is clear that load bearing capacity of treated B20% - S10% composite is very less compared to the other two composites. This is due to the poor adhesion of reinforcements with matrix materials. But the B15% - S15% fiber content shows the more load absorbing capacity than other two composites. This is due to the sufficient of fiber and fiber content to interface the matrix of the composite. For treated composites the maximum load bearing capacity is 11956 N.

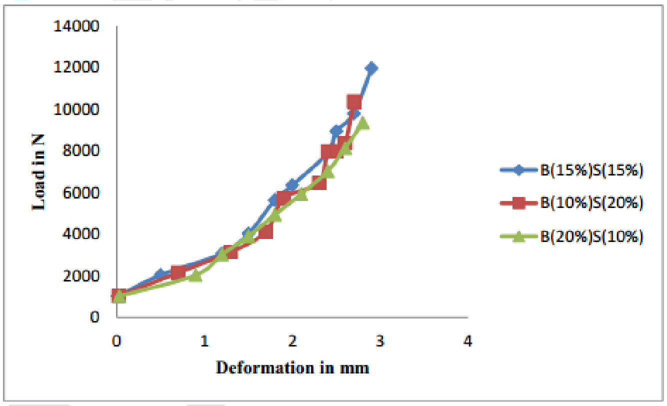

Fig -14: Effect of NaoH– treated fiber content on the compression strength of natural composites

7.3 Flexural Strength of Composites

Fig-15 shows the flexural strength for different combination of treated composites. It can be clearly seen that the B10% - S20% composites are having highest resistance to deformation. . Because the sugarcane bagasse has high lignin content is 24%. The bio-flour materials are mainly composed of a complex network of three polymers: cellulose, hemicelluloses and lignin. The lignin not only holds the bio–flour together but also acts as a stiffening agent for the cellulose molecules within bio–flour cell wall. Therefore, the lignin and cellulose content of sugarcane bagasse have increases the flexural strength. The composite with B20% - S10% content is exhibit low flexural strength. This is due to insufficient fiber content compare to other composite. The treated B10% - S20% shows maximum flexural strength of 1395 N.

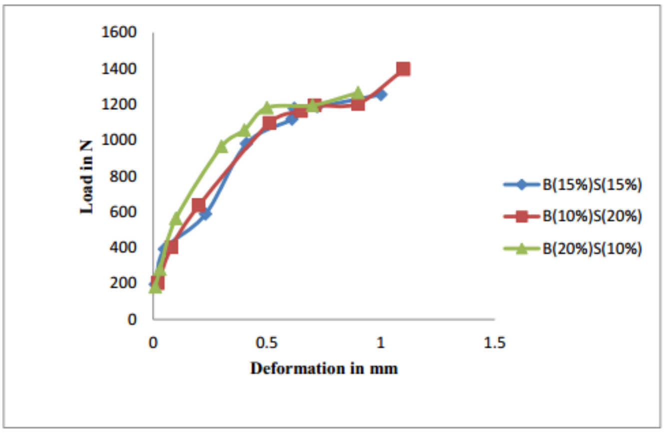

Fig -15: Effect of NaoH– treated fiber content on the flexural strength of natural composites

8. CONCLUSIONS

- The banana fiber and sugarcane powder was successfully used to fabricate the hybrid natural composites with 30% fiber and 70% resin. So it has been known that they have higher tensile strength, compressive strength, flexural strength and hardness value compared to commercial nuwood.
- The amount of sugarcane powder content positively affects the tensile strength of composites. The specimen B10%-S20% found to have a greater tensile strength of 2939 N.
- The compressive strength of the specimen with composition B15%-S15% shown greater value of 11956 N compared to other two composites
- The flexural strength of composites increases with increase in the amount of sugarcane powder content. The specimen with B10%-S20% was found to have more flexural strength of 1395 N

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