International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 03 Issue: 07 | July -2019 ISSN: 2590-1892

EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF WOVEN HYBRID BAMBOO AND JUTE FIBERS REINFORCED EPOXY COMPOSITES

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Abstract - Composites are the materials, which are satisfying the needs of recent technology. There has been a growing interest in natural fibers as reinforcements in different polymer composites for making construction materials at a low cost.
The present work focuses on the mechanical properties of Bamboo and Jute fiber reinforced epoxy polymer. In this investigation, both biowaste material i.e., Bamboo and Jute fibers are used in the form of a mat. A new hybrid composite with epoxy as the resin is used by keeping the position 0^0-90^0 for all stacking sequences. The study on the effect of fiber volumes on tensile, flexural and hardness properties of treated woven bamboo and jute fabric reinforced epoxy hybrid composite has been investigated experimentally. The results indicated that the properties of composite with constituents 15% of Bamboo, 15% Jute with 70% epoxy shows better Tensile strength, Flexural strength and Hardness number than other fiber volume ratios

Key Words: Bamboo, Jute, Epoxy, Natural fibers, Tensile, Flexural, Hardness,

1. INTRODUCTION

The natural material is a product, which comes from plants, animals or ground. Natural fibers come under these natural materials. Natural fibers like jute, sisal, hemp, flax, bamboo have a number of advantages over many synthetic fibers.[1] The physical and mechanical properties combining with environmentally friendly characteristics have motivated a number of industries like aerospace, automobile, and marine industries. The first natural fiber was used for aerospace components for better strength to weight ratio between the 1920s to 1930s [2].
Bamboo plant has high growth rate compared to other natural fibers. In addition, most importantly these natural fibers fix the carbon dioxide of the atmosphere [3]. Jute fibers are easily available around all the other kinds of fibers and have good mechanical and thermal properties [4].
Hybrid composites consist of a combination of two or more fibers in the matrix. The combination includes natural fibers with artificial fiber, artificial fiber with artificial fiber and natural fiber with natural fibers. These have many applications in the engineering field due to its high strength to weight ratio, ease of manufacturing and low cost.
The present work focuses on the experimental study on the mechanical properties of woven hybrid bamboo and jute fiber reinforced epoxy hybrid composites. Woven fabrics are made by interweaving of warp 0^0 and weft 90^0 fibers in a regular pattern [5]. The fabric is symmetrical with good stability. Initially, both woven fabrics were treated with 0.1N NaOH Solution and dried; this is done to improve the bonding strength in the composite material. Epoxy is used as adhesive material and hardener is used as binding material

2. MATERIALS

In this study, Bamboo and Jute fibers are used as reinforcements and epoxy as matrix material.
Bamboo: The composition of bamboo fibers are mainly cellulose 60%, lignin about 32% and hemicelluloses [6-9]. The bamboo fiber is brittle in nature as compared to other natural fibers. Therefore, different methods are adopted to extract the fibers. Extraction methods are chemical Processing, Mechanical processing and Steam explosion processing [10]

Fig-1. Raw bamboo fiber

Fig-2. Woven bamboo fiber

Jute: The composition of Jute fiber is Cellulose 83%, hemicelluloses 20%, lignin 13% and pectin 90% [11-17]. It is optimistic or promising reinforcement material due to its high content of cellulose. Jute fibers are extracted by the mechanical Process [18].

Fig-3. Raw Jute Fiber

Fig-4. Woven Jute Fiber

Matrix: These are thermoset class of materials used in composites and structural applications because these are having properties like high strength and low shrinkage. These are excellent adhesive to various substrates. These are having properties like effective electrical insulation, low cost and low toxicity compared to other polymers. In this investigation, Lapox L-12 type and hardener K6 are used.

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3. FABRICATION PROCESS

3.1 FABRICATION OF MOULD

A metallic mold made up of mild steel is fabricated to the size of 300 x 300 x 3 mm^3 (LxWxT) as shown in the figure

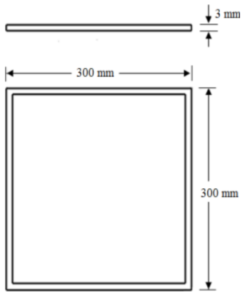

Fig-5 Mould Box used for the preparation of specimens**.**

3.2 Process: Hand layup technique is used for the fabrication process. This method required a limited amount of tooling and is less expensive. Initially, a gel coat is applied on the mold surface; this is done to detach the composite material. The reinforcements are placed in the mold cavity by hand based on the orientations, and then resin is applied by pouring or by using rollers. The entrapped air is removed.

3.3 Preparation of Specimen: The composite materials are made up of hybrid bamboo, jute, and Epoxy. The hybrid composite material will be bidirectional. This bidirectional orientation is proved to produce more strength.

1. At room temperature, the gel coat is applied on the surface of the mold cavity to prevent adhering of the specimen.
2. Single-layer of Bamboo fiber is placed on the surface along x-direction (0^0). Resin is added on the surface of the Bamboo fiber then another layer of Jute is placed on the surface in the y-direction (90^0).
3. Steps 1 and 2 are repeated for the required fiber volumes.
4. The mold is kept for curing for 48 hours. For different Stacking ratios, the specimens are prepared as shown in the table below

Table-1 Percentage values of the specimens used.

Specimen	Fiber Volume% Bamboo	Fiber Volume% Jute	Matrix Volume %	Stacking Ratio
S1	15	15	70	BJBJBJB
S2	20	20	60	BJBJBBJBJB
S3	25	25	50	JBBJBBJBBJB

4 EXPERIMENTAL DETAILS

4.1 Tensile Test: As per the ASTM Standard ASTM D, 3039 specimens were prepared [19]. The specimen is firmly fixed in the fixture. The specimen details are shown in the figure. Computerized Universal Testing Machine of 1-ton capacity is used for testing. In this test, the specimen elongates in a direction parallel to the applied load. The load is applied by gripping opposite ends and paralleling it apart. The test is conducted at a speed of 5mm/min.

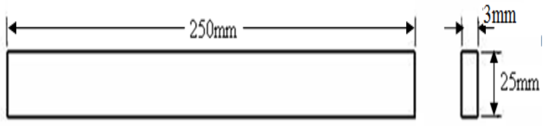

Fig-6 Standard test specimen for tensile test

4.2 Flexural Test: This test is conducted to obtain the values of modulus of elasticity, flexural stress, and strain of the material. The advantage of the three-point bending test is the ease of specimen preparation and testing. As per the ASTM Standard D, 790 specimens were prepared [20]. Specimen deflection is measured by the crosshead position. The test is conducted at a speed of 2mm/min.

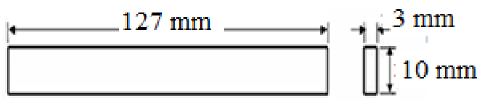

Fig-7 Standard test specimen for flexural test**.**

4.3 Hardness Test: As per ASTM standard D785, the specimens were prepared. In this test, the specimen is placed on the hard surface, then the load is applied which produced the permanent depth of indentation. The hardness number is read on the scale. [21]

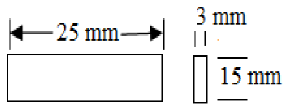

Fig-8 Standard test specimen for Hardness test**.**

5 RESULTS AND DISCUSSIONS

For the woven hybrid bamboo and jute fiber, reinforced epoxy composites following test results were obtained.

Table-2 Mechanical Properties of the different fiber volumes

Specimen	Tensile strength (MPa)	Tensile modulus (MPa)	Flexural Stress (MPa)	Flexural Modulus (GPa)
S1	48.187	761.10	110.175	15.807
S2	43.462	556.314	64..382	12.211
S3	40.755	425.541	56.254	8.043

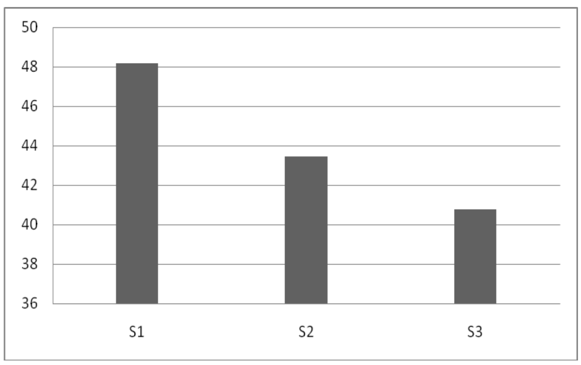

Fig-9 Tensile strength Graph

Tensile Strength: The strength of the woven fiber composite material depends upon the fiber orientation, weave style and bonding between fibers and matrix [22]. In-plane weaving, the fibers are interlaced one to one in warp and weft directions. From Figure 9, hybrid composite shows a significant increase in tensile strength with an increase in the Percentage of the matrix. The tensile strength of the composite material compared with the other fiber volumes as shown in the table2, the maximum tensile strength of 48.18 MPa was observed for S1 hybrid Composites with deflection of 4.68mm. There is a 49.22% percentage of elongation in the material. It is also showing the highest elasticity modulus of 761 MPa from figure 10.

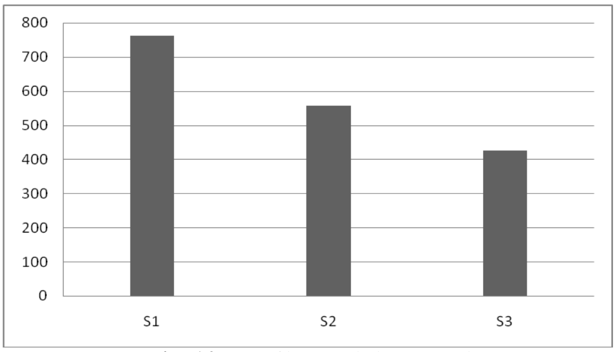

Fig-10 Tensile Modulus Graph

Flexural Strength: The bending properties were analyzed using the three-point flexural test. The flexural strength was found to be higher for S1 Composite i.e., 110.175 MPa from figure 11. With plane weaving the composite can create interlocking structure; this will be one of the constraints to extend in the transverse and longitudinal direction. In hybrid composites, the flexural strength mainly depends on the outer layer fibers. It is reported that flexural property not only depends on the material but also on the sequence or the arrangement of the layers [23]. The hybrid Composite S1 has 46% higher flexural strength than S2 and 54% higher flexural strength than S3. From figure 12 the hybrid composite S1 shows the highest flexural modulus of 15.80GPa.

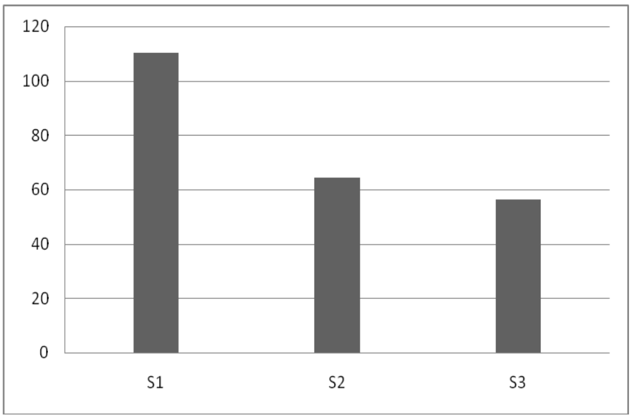

Fig-11 Flexural Strength Graph

The table3 show the effect of hardness number for different fiber volumes found from the Rockwell hardness-testing machine,

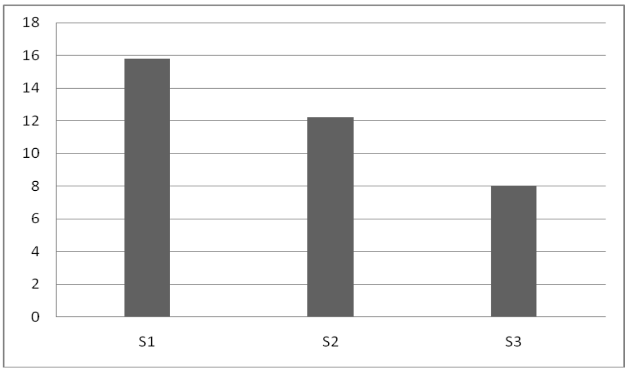

Fig 12 Flexural Modulus Graph

Hardness Test: The hardness test is conducted with a ball indenter. The results were obtained for all the samples shown in table3. Hardness value found to be 67 for S1, 56 for S2 and 65 for S3.Figure 13 shows that there is no much effect on the hardness of the composite due to changes in resin Percentage. It mainly depends upon the type of reinforcement and the arrangement of the fibers. Due to good interfacial fiber bonding between fibers and matrix, this makes the composite more hard and brittle in nature [23, 24]

Table-3 Values of Hardness

Specimen	Rockwell Hardness Number
S1	67
S2	56
S3	65

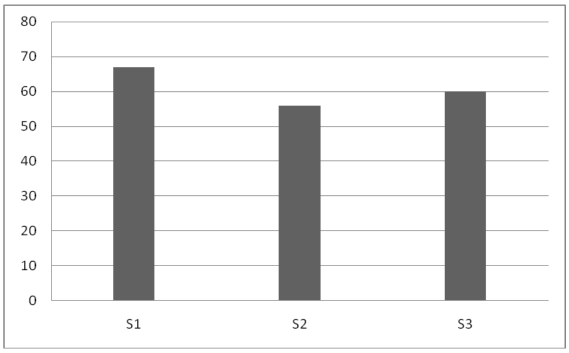

Fig-13 The hardness of the composites

6. CONCLUSIONS

In this experimental study of three different combinations of the woven Bamboo/Jute fiber reinforced epoxy hybrid composites, yields the following conclusions:

1. By incorporation of both bamboo and jute fiber composites enhances the properties of the resulting hybrid composites.
2. The stacking sequence has an impact on the flexural and tensile properties.
3. By the above test results, it is suggested that the Composite fiber Volume ratio S1 i.e., 30% fiber and 70% reinforcement is best suited for the different applications like automobile body parts, structural applications, etc for reducing the overall weight of the structure and to satisfy the necessary structural strength requirements

GRANTS
We are thankful to the research committee of RRGI for approving and selecting this research work.

ACKNOWLEDGMENTS
We are very much thankful to the management of RRGI, Principal for the generosity, financial support extended to carry out this research work. We are also thankful to the students of mechanical engineering who are directly or indirectly supported for this work.

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