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Experimental Investigation of Hybrid Bamboo/Glass Fibre Reinforced Polyester Composites

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ABSTRACT

Polymer matrix composites (PMC) materials had acquired much attention in the field of Aeronautics over the recent decades as high strength-lightweight materials. These abundantly available fibres are embedded with a light polymer matrix resulting in a high strength and light weight fibre reinforced polymer composites. In this paper, we have investigated the mechanical behaviour of fabricated composite materials with seven different combinations consists of Bamboo/E-glass fiber as a reinforcing agents and polyester as a polymer matrix. Several tests have been carried out to enhance the properties such as tensile strength, flexural strength, hardness and impact strength and it was compared for different orientations (±30º). It is reported that the hybridization of the constituents with 20% of Glass, 10% of Bamboo shows better Tensile strength, Flexural strength and Hardness number than other combinations examined.

1. Introduction

Short Bamboo/E-glass fibers are predominantly available resources in nature. Due to high strength along a longitudinal axis and low strength towards the transversal axis, bamboo fiber is also called as natural glass fibre and they are orthotropic in nature. The tensile properties of bamboo-based polymer composites are investigated by Kazuya et.al [6]and evaluated that compared to matrix, the tensile and modulus is increased by 15% and 30%, respectively. The ability of natural fibers such as E-glass, sisal, hemp, coir and banana to form a composite were also studied and proved [7]. The comparisons of numerous polymer matrix composites which are reinforced with the fibers for their mechanical performance [9]. E-glass fibers have several properties such as high tenacity, bulkiness, heat insulation property and low thermal conductivity and they are eco-friendly because of their high degradability. Polyester is one kind of thermoset polymer which is brittle in natureand contains carbon oxygen bond. Generally, the fabrication of composites is done by different methods by changing the matrix for reinforcement. For PMC, we use two kinds of the fabrication process. Open Mould Process and Closed Mould Process.

In this experiment, we have done fabrication of composites by the hand lay-up process (a kind of open mould process) in bi-directional orientation with short fibres. Tensile testing and flexural testing for the material are carried out by Universal Testing Machine (UTM). Impact test has been done by Charpy testing machine. From the stress and strain value, the values of flexural strength and flexural modulus are derived.

Rockwell Hardness test is completed with the help of ball indentor. properties of reinforcement. Mostly fibers which have advantages such as low density, high strength-to-weight ratio and high stiffness are used as a reinforcing phase. The properties of matrix along the direction of the reinforcement orientation together with the reinforcement properties show high performance in the mechanical properties of the composites. Hence the finished product has an overall structure versatility. The load and stresses always transfer from matrix to the reinforcement. Natural fibers (bamboo/E-glass) and polymer matrix (Polyester polymer) are the considered ingredients for the present analysis. The term natural fibers is defined as the fibers which are extracted from the natural resources such as plants, trees, animals etc. They are initially utilized in the commercial industries in the field of automobiles and household tools… etc. [2]. Natural fibers are recyclable, less expensive and resistive to breakage or damage, strong and low weight constituents [3]. Mechanical properties of the composite materials made up of quite a few of thefibers such as kenaf, hemp, flax, bamboo and E-glass are examined numerously by several authors [4,5]. For 45o Orientation of hybrid FRP (mixture of polyester, Bamboo and E-glass) yielded better results of mechanical properties.

2. Preparation of Materials

Polyester is used as a polymer matrix material and bi-directional hybrid Bamboo/E-glass fibre is picked as reinforcing material. The material is fabricated by hand layup process and expurgated according to the ASTM D standard for the test mentioned above and specimen is aligned for orientation of ±90º.

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Table 1 shows the different combinations with different percentage of materials. Every specimen will have different values of strength in tensile force, flexural force, impact and hardness number.

Table 1. Combination of Polyester resin, Bamboo fibre and E-Glass fibre.

S.No	Specimens	Combinations	Volume (%)	Weight (gm)
1	A	Polyester resin	70	1080
		Bamboo fibre	30	450
2	B	Polyester resin	75	1150
		E-glass fibre o fiber	25	425
3	C	Polyester resin	70	1100
		Bamboo fibre	15	200
		E-Glass fibre	15	200
4	D	Polyester resin	70	1125
		Bamboo fibre	10	150
		E-Glass fibre	20	300
5	E	Polyester resin	70	1125
		Bamboo fibre	20	300
		E-Glass fibre	10	150
6	F	Polyester resin	70	1125
		Bamboo fibre + Glass	27	280
		Coconut shell powder in micro size	3	12
7	G	Polyester resin	70	1125
		Bamboo fibre + Glass	27	280
		Coconut shell powder in Nano size	3	10

3. Fabrication Process And Methodology

The hybrid composite materials made up of bamboo, glass and polyester will have weaves in bi-directional. The bidirectional orientation is proved to produce more strength than the unidirectional orientation. Hybrid composite will possess superior characteristics against individual composite because natural fibre has high level of weight reduction comparing to the glass fibre. Here, we considered 7 combinations aligning with bamboo, glass and polyester.

The fabrication is processed by the above-mentioned Compression Moulding process. The Fabricated plates are shown in figure 1. We have made seven specimens with different percentages of the bamboo, glass and polyester. We have done all the experiments to get the values of tensile strength, flexural strength, hardness and impact test on the specimen so that the points of failure of the material, elongation of material and impact resistance of the material can be determined. All the manufacturing and fabrication are done according to the ASTM standard.

Tensile strength and tensile modulus are determined after the point of failure. Flexural strength and flexural modulus are also explored by the values of stress, strain, bending stress etc. Rockwell hardness test material is presented on the platform and by ball indenter, the force is being applied on it and the relative hardness of the material was indicated by the dial gauge. There is only one notch for Charpy test and

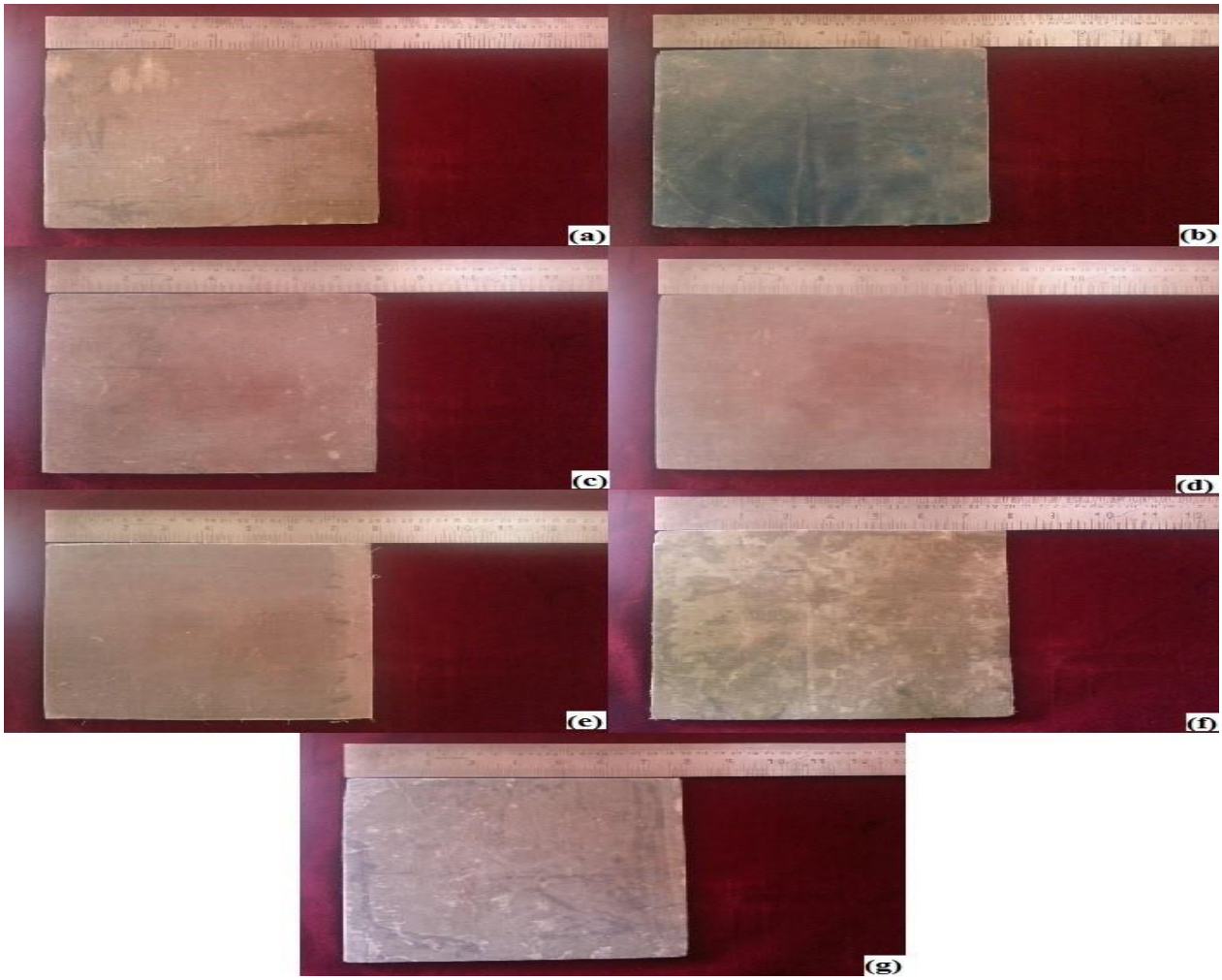

Figure 1. a) Pure Bamboo fibre (30%) + Polyester Resin. b) Pure Glass fibre (30%)+ Polyester Resin.c) Bamboo fibre(15%)+Glass fibre(15%)+ Polyester Resin.d)Bamboo fibre(10%)+Glass fibre(20%)+Polyester Resin.e) Bamboo fibre(20%)+Glass fibre(10%)+ Polyester Resin.f) Bamboo fibre (15%)+Glass fibre(12%)+Coconut shell powder in micro size(3%).g)Bamboo fibre(15%)+Glass fibre(12%)+Coconut shell powder in Nano size (3%).

4. Results and Discussions

For the all combinations of Polyester + Glass + Bamboo with the addition of diverse quantities, the specific mechanical properties (Tensile strength, tensile modulus, Flexural strength, Flexural Modulus, Hardness and Impact strength) are obtained. The mentioned tests are carried out by the Universal Testing Machine. The tensile strength is the measurement of maximum force required to break the specimens whereas tensile modulus is a measure of the stiffness of a solid material. Flexural test is also known as a breaking test is done by the application of pointload on the prepared composites

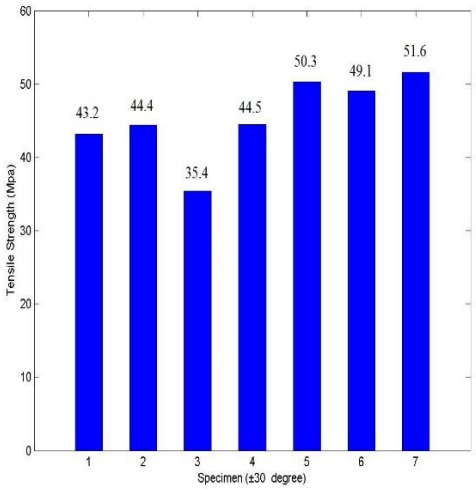

Figure 2. Tensile Strength Graph.

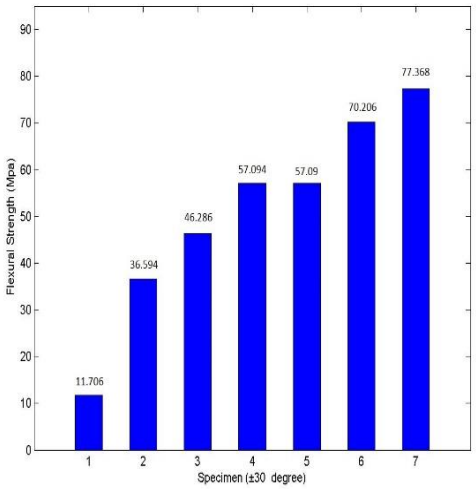

Figure 3. Flexural Strength Graph.

Figures 2 and 3 shows that the hybrid specimen 7 which contains short Bamboo fibres with nano powder in greater proportion than hybrid indicated a high resistance to beak compared to the other orientations. Along with it the modulus of rupture or flexural strength is shown to be promising for the hybridization of the composite 7 which implies that the material has higher ability to resist deformation under load. Bending modulus or a flexural modulus exposes the tendency for a material to bend is high for the hybrid composite specimen A with the same fraction of Glass and Bamboo

Figure 4 and 5 reveals that rigidity of the material is evaluated as hardness using the Rockwell hardness tester and the related Rockwell hardness numbers are determined. The impact toughness of the material is found by Charpy Impact test.

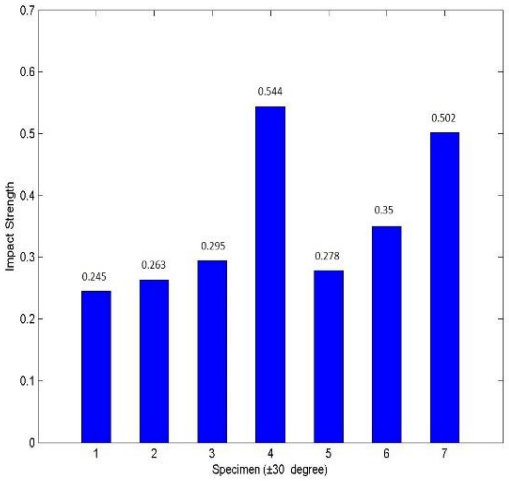

Figure 4. Impact strength graph.

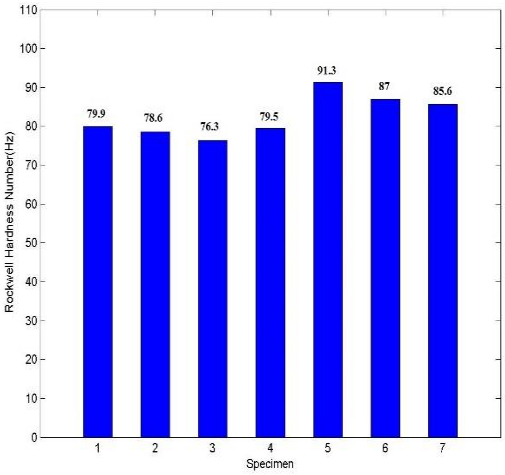

Figure 5. Hardness number.

Conclusion

In this analysis of seven combination of the Bamboo/E-glass fibre reinforced with the Polyester matrix yields the following conclusions

- The structural strength exposed by E-glass is greater than the Bamboo and thus the accountability of that fibre is more.
- From the analysis, it is observed that the hybrid specimen 7 shows high tensile strength of 51.6MPa andflexural strength of 77.74 MPa compared to other combinations
- Also, The Specimen A consists each of E-glass and Bamboo as15% resulted in higher flexural modulus of 24.68 GPa.
- Hardness test and impact test on the specimen 4 reportedly exposed high values in hardness number and impact strength.
- By the above results, it is suggested that this composite can be used in the commercial aircrafts for reducing the overall weight of the aircraft and to satisfy the necessary structural strength requirements.
- The overall value of strength of the PMC material performs better mechanical properties and sustainability over the individual forms of reinforcement and matrix.

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