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Study of Mechanical Properties of Bamboo /Glass Fiber /Reinforced Polyester Laminated Composites

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Abstract: Now-a-days, there is an increasing interest in hybrid composites made by combination of two or more different types of fiber in a common matrix because these materials offer a range of properties that cannot be attained with a single type of reinforcement. The fibres are either natural or synthetic and both types of fiber have advantages and disadvantages. Therefore, in this work a new class of hybrid composite reinforced with a synthetic fiber and a natural fiber is developed to get the advantage of both the fibres in terms of superior tribological properties and economy. The present research work is undertaken to examine the Mechanical behaviour of bamboo and glass fiber reinforced unsaturated polyester based hybrid composites.

Keywords: *Hybrid composites, bamboo, glass fiber, Mechanical properties, Tribological properties*

1 Introduction

Composite materials, often shortened to composites, are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct at the macroscopic or microscopic scale within the finished structure.

Composite material refers to the engineered materials that are made by combing two or more different materials. They adopt the physical and the chemical properties of the materials and offer a better alternative which is stronger, durable and more beneficial. Some of the common composite materials that are used in the different industries include fiberglass reinforced plastic, which is made from fiber glass and plastic, and is especially used in the
Fiber glass pipe and tank industry. Concrete, bricks etc. are also some of the popular composite material, used in different industries.

Composites are made up of individual materials referred to as constituent materials. There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties

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unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination.

2. Literature Review

The mechanical properties of a composite laminate based on natural flax fiber reinforced recycled high density polyethylene under conditions of tensile and impacts loading were investigated by Singleton. They determined the stress–strain characteristics, of yield stress, tensile strength, and tensile (Young's) modulus, of ductility and toughness as a function of fiber content experimentally. It was seen that by changing the fiber loading and by controlling the bonding between the layers of the composite, improvements in strength and stiffness combined with high toughness can be achieved. The mechanical properties were found to be optimum for 15 – 20 % of flax fiber loading. It was also seen that material properties show greater degree of variation at higher fiber volume fractions, due to fiber clumping.

The mechanical properties of randomly mixed short fiber composites and estimated the optimum fiber length and fiber loading. They deal with the properties of randomly mixed Palmyra fiber and glass fiber reinforced roof lite hybrid composites.

Mechanical properties such as tensile, impact, shear and bending properties of the composites were studied. The mechanical properties of the composites are found to be improved on account of the hybridization of the fibers used for reinforcement. The composites reinforced with 50mm fibers and having a fiber loading of 50% were found to have the best mechanical properties. The properties were found to be increasing continuously due to the addition of the glass fibers. It was also found that the water absorption decreases considerably with the addition of glass fibers.

Joshi investigated the effect of hybridization of chopped glass fibers with small amounts of mineral fibers. It was found that hybridization makes the glass fiber composites more suitable for technical applications. This study was based on the performance of polypropylene based short wollastonite fiber (injection moulded) and chopped glass fiber reinforced hybrid composites. Results showed that properties of the hybrid glass fiber and wollastonite composite was found to be comparable to that of polypropylene glass fiber composites.

3. Materials and Sample Preparation

The bamboo fiber and E- Glass fibers are mixed with unsaturated polyester resin by simple mechanical stirring and the mixture was poured into various moulds, keeping in view the requirements of various testing conditions and characterization standards. The composite samples of three different compositions (S-1 to S-3) are prepared.

Before the Un Saturated Polyester resin is laid up on the mould, the mould should be well cleaned and dry. Using a brush, the Un Saturated Polyester resin mixture is laid up uniformly for the first layer onto the mould. Then the Un Saturated Polyester resin is mixed with the fiber. The mixed Un Saturated Polyester Resin with the fiber is poured into the mould. The mould is closed and the composite material was pressed uniformly for 24h for curing. After the composite laminate is fully dried, then it is separated from the mould then the mould is compression mould machine.

4. Results and Discussion

TENSILE TEST:

Tensile test is widely performed test to determine several mechanical properties of material that are important in design. In this test, a standard specimen is subjected to a gradually increasing uniaxial tensile load until it fractures. Universal testing machine is used to perform the tensile test. The specimen is mounted between the upper and lower cross heads. The lower cross head is movable and is designed to elongate the specimen at a constant rate. The applied load and resulting elongation are measured simultaneously and continuously.

After making the laminates, specimens have to be cut according to the ASTM standards. The standard used for the tensile test is ASTM E8. The experimental is conducted using universal testing machine.

Test Procedure

Tensile test was conducted according to ASTM E8 standard 3 dog bone shaped specimen (BPC, GFC and BP+GFC) were obtained from composite block and were tested in an UTM machine. The average value of these 3 material samples was taken as the tensile stress and young's modulus of the composite.

Figure 4.1 Tensile Test Specimens

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Displacement(mm)	Load(N)	stress(MPa)	Strain	Young's modulus(MPa)
0.4	225	1.8	0.008	225
0.6	300	2.4	0.012	200
0.8	412	3.3	0.016	206
1	487	3.9	0.02	195
1.2	398	2.8	0.015	196

Table 4.1 Tensile Strength Test Result for Bamboo Powder Composite

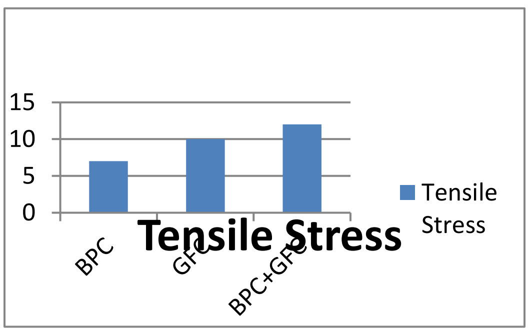

Figure 4.2 Tensile Stress Chart

Tensile Stress Average value:

Bamboo Powder Composite =7Mpa

Glass Fibre Composite =10Mpa

Bamboo Powder and Glass Fibre Composite =12Mpa

Young's Modulus Average Value

Bamboo Powder Composite =108Mpa

Glass Fibre Composite =310Mpa

Bamboo Powder and Glass Fibre Composite =420Mpa

BENDING TEST

The three point bending test is very common and universal testing machine can be used for this purpose. The specimen is of rectangular cross-section and is supported by two bottom supports. By applying the load on the top member and causing bending, the specimen is subjected to tension at its lower surface. The load and the deflection of the specimen are measured. The stress at fracture in bending is known as flexural strength or Transverse rupture strength.

Figure 4.3 flexural test specimen

Figure 4.4 experimental setup

Flexural rigidity EI $= \frac{FL^3}{48y} \frac{N}{mm^2}$

Modulus of elasticity E $= \frac{FL^3}{48yI}$ N-mm^2

Moment of inertia I $= \frac{BH^3}{12}$ mm^4

Where,

F - Fracture load, N

L - Distance between the bottom supports in mm

y – Deflection of the specimen in mm

I - moment of inertia in mm^4

Another most important property that is measured for the composite used in the structural application is the flexural strength and modulus. Flexural test was carried out according to the standard ASTM E8.Three point bend test were prepared to measure flexural strength. The samples were 250mm long and 25mm wide. Thickness depended upon the number of layers. Three samples each was tested for 4, 6, and 8 layered JFRP composites

Table 4.2: Flexural Test Result for Glass Fiber Composite

Sl.No	Proving Ring Division	Load F in		Deflection Y in mm	Modulus of elasticity E N/mm2	Flexural Rigidity E.I $N\text{-}mm^2$
		Kg	N			
1	1	6.25	61.31	0.39	10.48×10^{3}	26.20×10^{6}
2	3	18.75	183.93	1.41	8.69×10^{3}	21.74×10^{6}
3	5	31.25	306.56	2.38	8.58×10^{3}	21.46×10^{6}
4	7	43.75	429.18	3.48	8.22×10^{3}	20.55×10^{6}
5	9	56.25	551.81	4.65	7.91×10^{3}	19.77×10^{6}
6	11	68.75	674.43	5.41	8.31×10^{3}	20.77×10^{6}
				Average	8.669×10^{3}	21.748×10^{6}

IMPACT TEST:

The impact test method used here is charpy impact test. The test standard is ASTM E8. Impact test specimen dimension is 55×10×10mm.

Figure 4.5: Impact Test Specimen

Table 4.3: Impact Test Result for Specimen no S1 to S3

SAMPLE	POLYMER MATRIX COMPOSITE MATERIAL	IMPACT ENERGY IN SCALE(Joule)
Specimen no 1	Bamboo Powder Composite	10
Specimen no 2	Glass Fiber Composite	17
Specimen no 3	BPC+GFC	23

5. CONCLUSION

The experimental investigation on the effect of fiber loading and filler content on mechanical behaviour of Bamboo powder reinforced polymer matrix composite were conducted. Mechanical properties such as the tensile strength, hardness test, flexural test, and water absorption and impact test were evaluated from various experiments. The experiment leads us to the following conclusion obtained from this study. The successful fabrication of a new class hybrid polymer based composite reinforced with Bamboo powder and glass fiber have been done. It is found that polymer hybrid glass fiber and Bamboo powder composite is the best composite among the various combinations. Possible use of these composite such as pipes carrying coal dust, industrial fans, and helicopters fan blades, low-cost housing etc is recommended.

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