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MECHANICAL PROPERTIES OF EPOXY BASED HYBRID COMPOSITE OF GLASS AND BANANA FIBERS

Ashwani Kumar[1], *Deepak Kumar Choudhary[2] and Prince[3]

[1]Department of Mechanical Engineering, Maharishi Markandeshwar University, Ambala, Haryana- 133-207, India
[2]Department of Mechanical Engineering, Yamuna Institute of Engineering &Technology, Yamuna Nagar, Haryana- 133103, India.
[3]Department of Mechanical Engineering, Ambala college of Engineering & Applied Research, Ambala, Haryana- 133 101 ,India

ABSTRACT

Banana fiber and Glass fiber reinforced epoxy composite and Hybrid fiber reinforced epoxy composite have been prepared for the evaluation of hardness, tensile strength, flexural strength and impact strength. Glass fiber is synthetic fiber having more strength than steel and banana fiber is natural fiber. Natural fibers present important advantages such as low density, appropriate stiffness, good mechanical properties, high disposability and renewability. Also, they are recyclable and biodegradable. Banana fibers in combination with glass fibers have proved to be excellent for making cost effective composite materials. The hybridization of FRP (Fiber Reinforced Polymer) at 20% weight fraction of reinforcement results in increase in the tensile strength of HFREC by an amount of 2.8% than that of GFREC and by 67.9% than that of BFREC. The hybridization of FRP at 30% wt. fraction of reinforcement results in increase in the tensile strength of HFREC by an amount of 3.3% than that of GFREC and by 60.7% than that of BFREC. The tensile strength has shown the highest value when a 10% of banana fiber and 20% of glass fiber is used and an interleaving arrangement of glass and banana fiber is followed. The hybridization of FRP at 20% wt. fraction of reinforcement results in increase in the flexural strength of HFREC by an amount of 6.1 % than that of GFREC and by 26.9 % than that of BFREC. The hybridization of FRP at 30% wt. fraction of reinforcement results in increase in the flexural strength of HFREC by an amount of 6.8% than that of GFREC and by 22.5 % than that of BFREC. Highest value of impact strength is observed, when banana fibers and glass fibers are reinforced in a ratio of 1:2 .The impact strength of HFREC is found to be 5% higher than GFREC and 90.8% more than BFREC. Hardness results are similar to the tensile test results.

Keywords: *FRP (Fiber Reinforced Polymer), Natural Fiber and Hybrid Composite.*

1. Introduction

Composites play a significant role as engineering materials due to their ever increasing use in view of their specific properties such as high strength to weight ratio, high modulus to weight ratio, better corrosion resistance and superior wear resistance. Composites are well ahead of traditional materials when we compare their specific strength i.e. strength per unit density [1].

Over the past few decades, polymers have replaced many conventional materials in various applications, which are obviously due to the advantages of polymers over conventional materials [2]. Polymers can be modified by the use of fillers and reinforcing fibers to suit high strength/high modulus requirements. Fiber-reinforced polymers offer additional options over other conventional materials when specific properties are required and find applications in diverse fields, ranging from appliances to spacecraft [3].The specific strength of glass fiber is greater than steel [4].

The natural fibers are renewable, cheap, completely or partially recyclable, and biodegradable in nature. Natural fibers can be obtained from plants, such as banana, bamboo, jute, sisal, hemp, kenaf, pineapple, ramie, cotton, flax, etc. The renewability, availability, low density, and cost as well as satisfactory mechanical properties make the natural fibers an attractive ecological alternative to glass, carbon and other man-made fibers used for the manufacturing of composites [5].

Natural fiber is a reinforcement which has recently attracted the attention of researchers because of its advantages over the other established materials. In this context, banana fiber reinforced composites have recently gained importance. Banana fibers are mainly used in lightweight composites finding application in various industries with special reference to door panels, room partitions, wall cladding, food packaging, home appliances, automotive parts, building and construction, and electrical housing. Banana fibers are a waste

**Corresponding Author - E- mail: deepaksliet@yahoo.co.uk*

product of banana cultivation. They are easily available, and may be used as reinforcement in thermosets and thermoplastics.

This paper reports the fabrication of composites with different weight fractions of glass fibers and banana fibers as reinforcement in epoxy resin. The test results on the samples taken from different composites have been compared and hybrid composites have been found to exhibit better properties compared with composites containing one type of reinforcement.

2. Experimentation

2.1 Material

Material used for the hybrid composite was glass fiber, banana fiber, epoxy resin and epoxy hardener were the raw material for the composite. In this research a plain weave mat of E-glass fabric of 0.3 mm thickness as synthetic reinforcement was used to manufacture the composite material. Banana fiber mat was used as natural reinforcement. Banana fiber and glass fiber were supplied by Chander Parkash and Company, Jaipur. The matrix material was epoxy resin with epoxy hardener, which is thermosetting resin supplied by Araldite.

2.2 Method for Composite Manufacturing

Various techniques available in industries for the manufacture of polymer based composites are hand lay-up, compression molding, vacuum molding, pultruding, and resin transfer molding etc. The hand layup process is one of the simplest and easiest methods for manufacture of composites [6]. A primary advantage of the hand layup technique is to fabricate very large, complex parts with reduced manufacturing times. Additional benefits are simple equipment and tooling that are relatively less expensive than other manufacturing processes. The prepared specimens are shown in Fig. 1

Fig. 1 Composite Specimens

2.3Testing of Composite

(i). Tensile Testing:

This test was carried out at Central Institute of Plastic engineering & Technology (CIPET), Murthal on Autograph machine. Rectangular specimens of the composite were made as per ASTM D638M to measure the tensile properties. The length, width and thickness of the specimen were 165, 19 and 4mm respectively and the test was conducted at room temperature. Composite specimens were placed in the grips and were pulled at a speed of 5 mm/min until failure occurred. The strain gauge was used to measure the displacement. The test set up on the Autograph machine is shown in Fig. 2

Fig. 2 Tensile Testing of Composite

(ii) Flexural testing:

Flexural test also known as three point bending test was also carried out at Central Institute of Plastic engineering & Technology (CIPET), Murthal on Autograph machine. In this the Composite specimens of dimensions 130×12×4 mm were prepared and the flexural test was carried on Autograph machine as per ASTM D 790. In this testing the specimen were horizontally placed on two supports and load was applied at the centre. The deflection was measured by the gauge placed, under the specimen, at the centre. The set up for flexural test on Autograph machine is shown in Fig. 3.

Fig. 3 Flexural testing of Composite

(iii). Impact testing

This test was carried out on Tinius Olsen machine as shown in Fig. 4 as per procedure mentioned in ASTM D 256. Composite specimens were placed in vertical position (Izod Test) and CRT reader gave the reading of Impact strength.

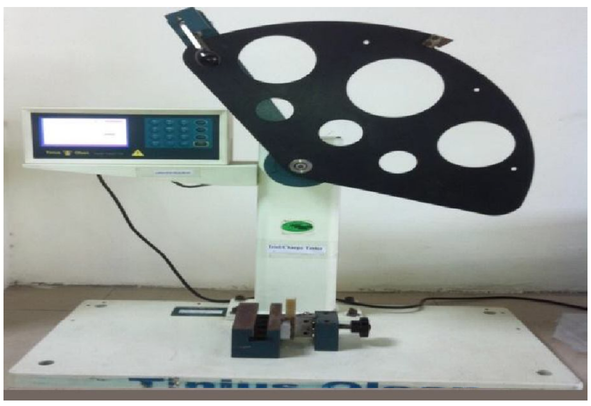

Fig. 4 Impact Testing of Composite

(iv). Hardness Testing of Composites

Hardness testing was done using Rockwell hardness tester as per ASTM D785.

Fig. 5 Composite Specimen for Hardness Testing

3. Results and Discussions

The results of various tests are reported here which includes evaluation of tensile strength, flexural strength, and impact strength.

3.1 Tensile Testing

Experimental results of tensile testing of different composites withdifferent weight fraction of reinforcements are shown in Table 1 and Fig. 6.

Table1: Tensile Strength of BFREC, GFREC and HFREC at 20% and 30% wt. Fraction of Fiber.

Sr. no	Total %age of reinforcement in composite (weight fraction)		%age of fibers in reinforcement BANANA %age	GLASS %age	Tensile strength (N/mm²)
		GFREC	0	20	84.17
			5	15	83.9
1	20%	HFREC	**10**	**10**	**86.6**
			15	5	58.34
		BFREC	20	0	51.56
		GFREC	0	30	92.7
			5	25	88.3
			10	**20**	**95.8**
2	30%	HFREC	15	15	74.9
			20	10	70.10
			25	5	65.7
		BFREC	30	0	59.6

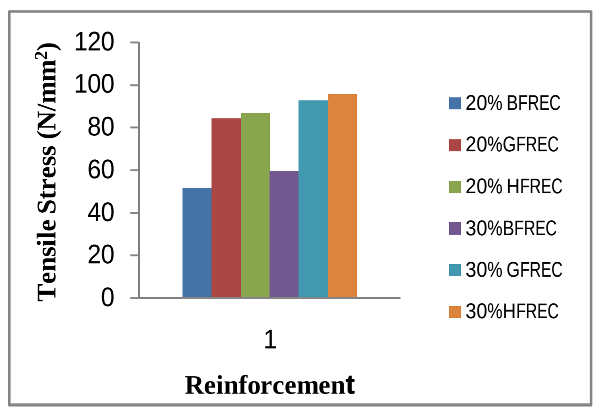

Fig. 6 Comparison of Tensile Strength of BFREC, GFREC and HFREC at 20% and 30% wt. fraction of reinforcement.

The results show that 20% hybridization of fiber reinforced plastic results in increase in the tensile strength of HFREC by 2.8% over that of GFREC and by 67.9% over that of BFREC. For 30% hybridization of fiber reinforced polymer, tensile strength of HFREC increases by 3.3% over that of GFREC and by 60.7% over that of BFREC. The reason for increase in tensile strength of hybrid fiber reinforced epoxy composite may presumably due to higher interfacial strength of natural banana fibers with the matrix [7] than that of synthetic glass fiberswith the matrix, though this aspect needs to be investigated in detail.

3.2 Flexural Testing

The experimental results of flexural tests of composites with different weight fraction of reinforcement are shown in Table 2 and Fig 7.

From the test results it can be seen that 20% hybridization of FRP leads to increase in the flexural strength of HFREC by 6.1 % than that of GFREC and by 26.9 % than that of BFREC when banana fibers and glass fibers are used in a ratio of 1:2.

Table 2: Flexural Strength of BFREC, GFREC and HFREC at 20% and 30% Wt. Fraction of fiber.

Sr. no	Total %age of reinforcement in composite (weight fraction)		%age of fibers in reinforcement		Flexural strength (N/mm²)
			BANANA %age	GLASS %age	
1	20%	GFREC	0	20	63.7
			5	15	64.13
		HFREC	**10**	**10**	**67.62**
			15	5	55.72
		BFREC	20	0	53.28
2	30%	GFREC	0	30	70.1
			5	25	69.7
			10	**20**	**74.9**
		HFREC	15	15	72.3
			20	10	66.1
			25	5	63.3
		BFREC	30	0	61.12

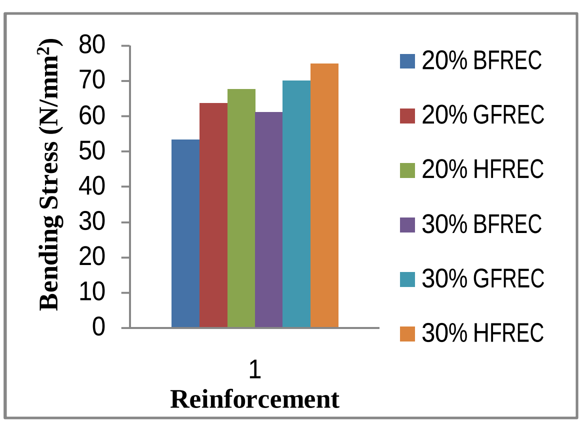

Fig. 7 Comparison of Impact strength of FRP at 20% and 30% wt. fraction of Reinforcement.

In contrast to above, for 30% hybridization of FRP an increase of 6.8% in the flexural strength i.e. bending stress of HFREC and of 22.5%over that of BFREC has been observed. The glass fiber reinforced composites show better flexural strength than banana fiber reinforced composites because glass fiber can take more bending loads than banana fibers. However banana fibers reinforced along with glass fibers in epoxy matrix produce better results as compared to glass fiber reinforced composites. The reason for this increase in flexural strength may be due to the combined effect of high stiffness of glass fibers and high capacity of banana fibers to take high bending forces.

3.3 Impact Testing

The experimental results of impact tests of composites with different weight fraction of reinforcement are shown in Table 3 and Fig. 8.

Table 3 presents the impact strength of BFREC, GFREC and HFREC at 20% weight fraction of reinforcement. It can be seen that HFREC has higher impact strensgth than that of BFREC and GFREC. The HFREC shows maximum impact strength at 20% weight fraction of reinforcement, when banana fibers and glass fibers are added to epoxy matrix in the ratio of 1:1. The reason for such increase in impact strength of HFREC may be due to higher interfacial strength of banana fiber with epoxy matrix and the ability of glass fiber to arrest crack propagation more effectively.

Table 3: Impact Strength of BFREC, GFREC and HFREC at 20% and 30% wt. Fraction of Reinforcement.

Sr. no	Total %age of reinforcement in composite (weight fraction)		%age of fibers in reinforcement		Impact strength (J/m²)
			BANANA %age	GLASS %age	
1	20 %	GFREC	0	20	139.9
			5	15	124.82
		HFREC	**10**	**10**	**146.12**
			15	5	104.2
		BFREC	20	0	79.91
2	30 %	GFREC	0	30	175.9
			5	25	166.7
			10	**20**	**184.97**
		HFREC	15	15	147.16
			20	10	123.2
			25	5	106.92
		BFREC	30	0	96.9

Similar results are obtained at 30% weight fraction of banana and glass fiber reinforcement addition to epoxy resin in the ratio of 1:2 with overall effect being larger than that due to 20% reinforcement addition of banana and glass fibers in the ratio of 1:1.

3.4 HardnessTesting

The experimental results of impact tests of composites with different weight fraction of reinforcement are shown in Table 4 and Fig. 9.

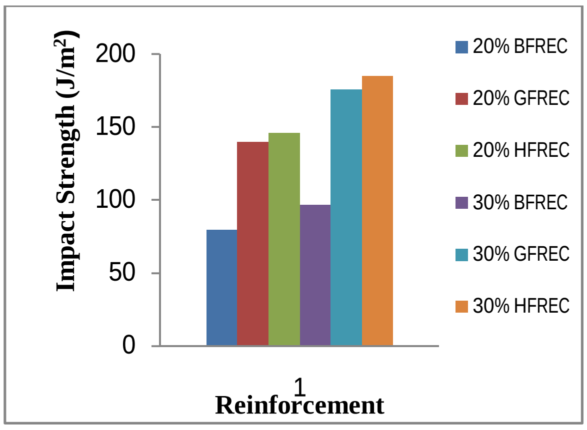

Fig. 8 Comparison of Impact Strength of BFREC, GFREC and HFREC at 20% and 30% wt. fraction of reinforcement.

Table 4: Hardness of BFREC, GFREC and HFREC at 20% and 30% wt. fraction of Reinforcement.

Sr. no	Total %age of reinforcement in composite (weight fraction)		%age of fibers in reinforcement		Hardness (HRL)
			BANANA %age	GLASS %age	
1	20%	GFREC	0	20	97
		HFREC	5	15	108
			10	**10**	**111**
			15	5	105
		BFREC	20	0	93
2	30%	GFREC	0	30	95
		HFREC	5	25	101
			10	**20**	**104**
			15	15	99

Hardness generally follows the same trend as the tensile strength. In the present investigation, similar trend has been corroborated as can be seen in Table 4 and Fig. 8. The probable reason for these results is same as that indicated in discussion for tensile strength.

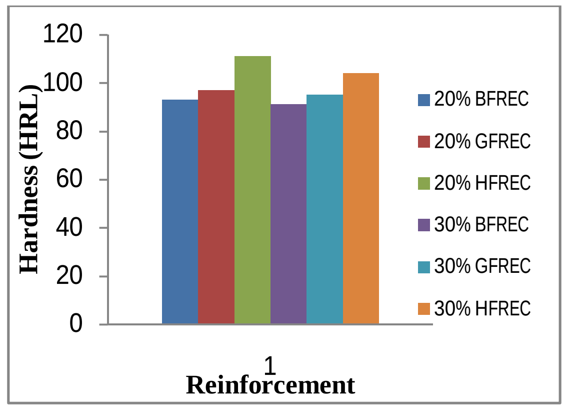

Fig. 9 Comparison of Hardness of BFREC, GFREC and HFREC at 20% and 30% wt. fraction of reinforcement.

4. Conclusion

The analysis of test results obtained in the present investigation indicates that

i. Tensile strength, flexure strength, impact strength and hardness values are higher for composite structure containing two types of fibers i.e. glass fibers and banana fibers with total weight fraction of 20% compared with the values of these properties with either 20% only banana fibers or 20% only glass fibers.
ii. Values of all the four properties are also higher for the composite containing a total addition of 30% of banana and glass fibers.
iii. All the four properties of the composite are highest, when banana fibers and glass fibers are in the ratio of 1:1 at total fiber addition of 20% in the epoxy resin.
iv. Values of all the four properties are again highest at 30% of total addition of fibers, when banana and glass fibers are in the ratio of 1:2.
v. The probable reason for the above-mentioned results is better interface properties in case of natural banana reinforcement up to 10%. Glass fibers offer higher resistance to crack propagation as the weight % of glass fibers is increased. However, above 20% addition of glass fibers, more micro-cracks may originate at the fiber matrix interface and may lead to lower value of above-mentioned properties.
vi. More detailed investigation is needed to explore more precise reasons for the interesting results obtained in the present investigation.

References

1. *Amit Bindal et al. (2013),"Development of Glass/ jute Fibers Reinforced Polyester composite", Indian Journal of Materials Science Article ID 675264.*

2. *Georgopoulos G et al. (2005), "Thermoplastic polymers reinforced with fibrous agricultural residues, Polymer Degradation and stability, Vol. 90 (2), 303-312.*

3. *Nabi Saheb et al. (1999), "Natural fiber polymer composite: A review". Advance in Polymer Technology. Vol. 18 (4), 351-363.*

4. *Raoi M et al. (2011), "Hybrid Composites, Effect of Fibers on Mechanical Properties", International Journal of Macromolecular Science, Vol.1, 9-14.*

5. *Kuruvilla Joseph et al (1999), "A Review on Sisal Fiber Reinforced Polymer Composites RevistaBrasileira de Engenharia Agrícola e Ambiental", Vol. 3 (3), 367- 379.*

6. *Davim J P, Reis P and Ant´onio C C (2004), "Experimental study of drilling glass fiber reinforced plastics (GFRP) manufactured by hand lay-up", Composites Science and Technology, Vol. 64 (2), 289–297.*

7. *Seena Joseph et al. (2002), "A comparison of the mechanical properties of phenol formaldehyde composites reinforced with banana fibers and glass fibers", Composites Science andTechnology, Vol. 62, 1857–1868.*

