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Effect of fiber parameters on the mechanical properties of Banana-Glass fiber hybrid composites

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Abstract. Composite materials are widely used for their superior properties such as high strength to weight ratio, high tensile strength, low thermal expansion, low density etc. Due to environmental issues the eco-friendly composites are being explored. But natural fibers lack better mechanical properties when compared with synthetic fibers. Hence mixing the natural fiber with a synthetic fiber such as glass fiber will improve mechanical properties of the composites. In this study banana fiber is mixed with glass fiber, and the mixture is used as reinforcement in epoxy matrix. The composite specimens were prepared using hand layup technique, the fibers were randomly oriented. Further the fiber length was varied as 10, 15, 20 and 25mm and volume fraction as 10%, 15%, 20% and 25%. Experiments were conducted to find the effect of fiber length and volume fraction on tensile strength, flexural strength, water absorption properties of the composites. It was observed that a fiber length of 20mm and 20% fiber volume fraction gave better mechanical properties.

Introduction

The need for high strength, light weight materials in automotive industry necessiates the use of fiber reinforced polymer composites. However synthetic fibers pose a threat for environmental issues and natural fibers lack better mechanical properties. Lot of research is being done on the use of natural fiber as a reliable substitute for synthetic fibers [1-7]. Banana fiber was also reported as a suitable replacement for glass fibers for automotive applications[8-10] due to its high tensile strength, better Youngs modulus and low cost, which makes it as a potential substitute for glass fiber. In this study banana fiber is mixed with glass fiber at a proportion of 50:50 volume fraction. This fiber mixture was used as a reinforcement in epoxy matrix.The fiber length of banana fiber and glass fiber was varied as 5mm, 10mm, 15mm and 20mm. Also the composites were prepared with a fiber volume fractions of 10%, 15%, 20 % and 25%. The composites were prepared using handlayup method. Epoxy resin is used as matrix. The composite plates were then cut as per the ASTM standards to study the effects of volume fraction and fiber length on tensile strength, flexural strength and water absorption.

Materials and Methods

Raw materials.Raw materials used for this experimental work are:Glass fiber (E-Glass), Natural fiber (Banana fiber), Epoxy resin(LY556) and Hardener(HY951). Glass fiber was obtained from M/S sakthifibre glass ltd., E-Glass fiber having a density of 2.6 gm/cm^3 and tensile strength of around 2500 MPa is used in this study. Banana fiber was obtained from ROPE internationals, Chennai.The tensile strength of banana fiber is around 503Mpa – 790 Mpa. Specific tensile strength is 387 – 585 Mpa/gcm^{-3}. It has a density of approx. 1.3 gm/cm^3. Epoxy resin (LY556) used in this study was obtained from M/S sakthifibre glass ltd., Chennai. It has better mechanical properties when compared with other polymers like polyester and vinyl ester resins. It has a density of approx 1.1 – 1.4g/cm^3,and tensile strength of 35 – 100 Mpa.

Fabrication of composite. Initially the banana fiber and glass fiber were chopped for different lengths of 10mm, 15mm, 20mm and 25mm. Then the chopped fibers are thoroughly mixed with a volume proportion of 50% each. A wooden mold of dimension (300x300x3) mm was used for casting the composite sheet. The first group of samples was manufactured with 10, 15 and 20% volume fraction of fibers. For different volume fraction of fibers, a calculated amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed with gentle stirring to minimize air entrapment. Finally the composite plates were taken (Fig.1) and the samples are cut as per the ASTM standards.

Fig 1.Composite specimens(BF+GF) with 10,15 & 20mm fiber length and 15% volume fraction.

Tensile testing. The tensile strength was determined using Instron type universal Testing machine as per ASTM D 638 method. Four samples (Fig. 2) were used and the average tensile strength was reported.

Fig 2.Tensile testing samples.

Table 1: Experimental values of tensile strength with different Fiber length and Volume Fraction

S.NO	Fiber Length (mm)	% Volume Fraction	Avg. Tensile Strength (MPa)
1.	5	10	35.3
		15	48.2
		20	61.2
		25	59.5
2.	10	10	38.5
		15	55.2
		20	68.2
		25	66.2
3.	15	10	47.8
		15	59.2
		20	78.6
		25	76.6
4	20	10	48.9
		15	61.5
		20	81.6
		25	76.5

Flexural testing. The flexural specimens are prepared as per the ASTM D790 standards. The 3-point flexure test was performed. Test results include flexural strength and displacement. The testing process involves placing the test specimen (Fig.3) in the universal testing machine and applying force to it until it fractures and breaks.

Fig.3Testing for Flexural strength

Table 2: Experimental values of Flexural strength with different Fiber length and Volume Fraction

S.NO	Fiber Length (mm)	% Volume Fraction	Avg. Flexural Strength (MPa)
1.	5	10	15.2
		15	22.4
		20	26.3
		25	24.5
2.	10	10	20.8
		15	24.6
		20	32.4
		25	30.5
3.	15	10	27.8
		15	32.9
		20	39.3
		25	37.4
4	20	10	29.2
		15	35.6
		20	41.4
		25	38.4

Water Absorption. The samples containing different fiber fractions and treatments were immersed in a water bath at room temperature. After immersion for 5, 10, 15, 20,25hrs, the specimens were taken out of water and the surface water was removed by blotting with a clean dry cloth and after that specimen was weighed in a digital weighing machine of 0.01g accuracy. The percentage of water absorption in the composites was calculated by weight difference between the samples immersed in water and the dry samples. From the calculation it was found that the rate of water absorption is 10% in the composite with 25% volume fraction fiber. Also water absorption rate is 3.76% when the fiber content is low i.e. 10 % vol fraction of fiber. The stability reaches after 10 days of immersion.

Results and Discussion

The Tensile test results and flexural strength values were plotted in Fig 4 & Fig 5 respectively. This clearly shows the tensile strength increases with increase in fiber length and volume fraction. But the when a volume fraction of more than 20% fiber is used to fabricate the composite plate, a poor adhesion bonding was observed between banana fiber and the epoxy matrix. Hence 20% volume fraction of banana/Glass fiber composite can be used for practical applications.

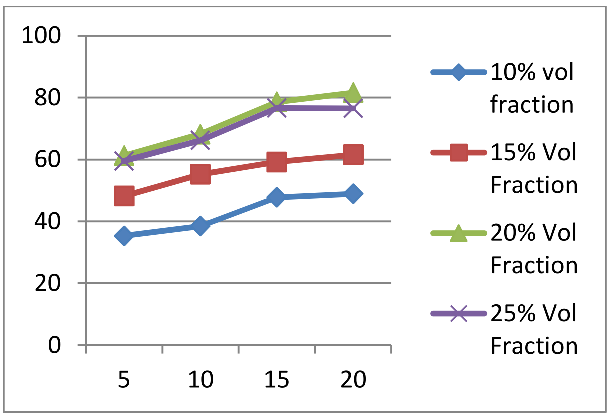

Fig 4. Variation of tensile strength(y axis) Vs Fiber length(x axis)

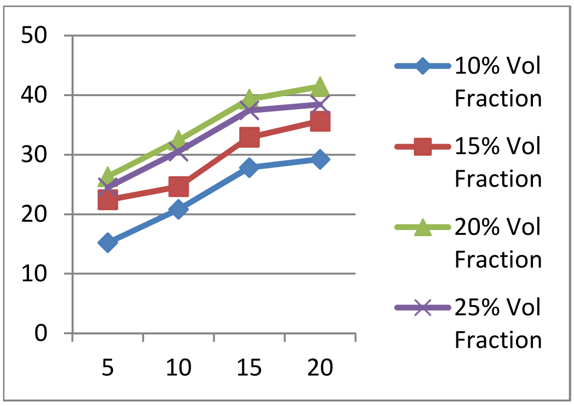

Fig 5. Variation of tensile strength(y axis) Vs Fiber length(x axis)

Conclusion

From the above results, optimum fiber length and volume fraction for maximum tensile strength of the composite is found out for 20mm and 20% is 81.6MPa. Similar results were observed in flexural strength also. The maximum flexural strength of the composite is found out as 41.4Mpa. It is observed that for the fiber length of 10mm and 10% volume fraction has lesser water absorption rate. Also it is well established that the fabrication of hybrid composite yields better mechanical properties when compared with pure banana fiber composites. Hence persistent research in hybridization of banana fiber will be most useful for automotive applications.

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