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Mechanical Characterization of Unidirectional Banana-Glass Fiber Reinforced Hybrid Composites

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ABSTRACT: This study has been undertaken to the mechanical characterization of unidirectional banana-glass fiber reinforced epoxy hybrid composites. Natural fabrics have miniature in density and greater economic impact when compared to glass fibers when composites are made. Although natural fibers strength is not as high as glass fibers, these specific properties are comparable. A study was carried out in this work to characterize the mechanical properties of hybrid composites by intruding unidirectional banana and unidirectional fibers of glass into epoxy resin mixture. The unidirectional banana-glass fiber reinforced epoxy composite laminates are prepared by adopting the hand lay-up method. The aim of this work is to analyse and compare the mechanical properties of laminates such as tensile strength, flexural strength and impact strength of various stacking sequences of unidirectional banana and glass fabrics.
***Keywords*:** Hybrid Composites, Tensile Strength, Flexural Strength and Impact Strength

INTRODUCTION

There has been a growing environmental awareness and awareness of the need for sustainable development in recent years, which has raised interest in focusing on natural fibers for engineers, scientists, professionals and research scholars. Natural fibers act as an alternative composite reinforcement because of their benefits such as low density, high specific weight, low cost, eco-friendly, and bio-degradable in nature to replace the synthetic fibers [1]. This good ecological friendly features makes the materials exceptionally mainstream in building markets, like automobile and construction development industry [2]. The fusion of natural fibers with glass fiber increases its mechanical properties and these composites can be utilized for medium strength applications [3]. K. palanikumar et al. [4] studied the tensile properties of unidirectional banana and glass fiber reinforced epoxy composites and compared the results with single reinforced composite in both experimental and numerical analysis tests. From the test results it is found that unidirectional Glass fiber reinforced composite possess higher tensile strength 567 MPa than the unidirectional banana–glass reinforced composites. M.R. sanjay et al. [5] presented the mechanical and physical properties of Banana and E-Glass fabrics reinforced polyester hybrid composites. In this different composition of banana and E-glass fabric laminates are fabricated by using hand layup and vacuum bagging methods. The testing of composite specimens are performed according to the ASTM standards. From the test results, it is observed that the higher tensile strength, flexural strength, impact strength and hardness values are found in glass fabric laminate and while it is low for banana fabric laminate. Sandhyarani Biswas et al. [6] presented the physical and mechanical conduct of unidirectional banana/jute fiber reinforced epoxy based hybrid composites and compared it with the single natural fiber reinforced composites. From the observed results it is found as the fiber loading increases the void content of the composite also increases. M. Ramesh et al. [7] investigated the processing and mechanical evaluation of banana fiber reinforced with epoxy based composites. In the present work is to analyse and compare the mechanical properties of laminates such as tensile strength, flexural strength and impact strength of various stacking sequences of unidirectional banana and glass fabrics.

EXPERIMENTAL DETAILS

Materials

The materials which are used in fabrication process is unidirectional banana fabric, unidirectional E-glass fabric, Epoxy resin LY556, Hardener HY951, acetone, wax, and transparent sheet. The unidirectional banana fabric is purchased in the form of Mats from Go Green Products private Ltd from Chennai, India. The unidirectional E-Glass fabric, epoxy resin, Hardener and acetone are bought from a local retailer in Hyderabad.

Preparation of Composite Laminates

In this preparation of composite laminates the hand lay-up method is adopted for the fabrication of composite laminates. To remove impurities on the mould surface, the 365 mm X 365 mm mould must be cleaned with acetone before starting process. The transparent sheet is then placed over the surface of the mould and wax is applied to it for easy removal from the mould of laminates. Depending on the mould dimensions, the unidirectional banana and unidirectional E-glass fibers are cut. The Epoxy resin LY556 and hardener HY951 are mixed in the proportion of 10:1 and mix thoroughly with the help of mechanical stirrer. For every laminate the different combinations of banana and E-glass fabric laminates are prepared to obtain the required thickness of the laminates and named as L-1, L-2, L-3, L-4, L-5 and L-6 and their detailed composition and designations are shown in the below Table 1.

Table. 1. Laminates stacking sequence

Laminates	Composition of Fiber (%)		Stacking Sequence
	Banana (B)	Glass (G)	
L-1	0	100	G+G+G+G+G
L-2	20	80	G+G+B+G+G
L-3	40	60	G+B+G+B+G
L-4	60	40	B+G+B+G+B
L-5	80	20	B+B+G+B+B
L-6	100	0	B+B+B+B+B

MECHANICAL TESTING

Tensile Strength

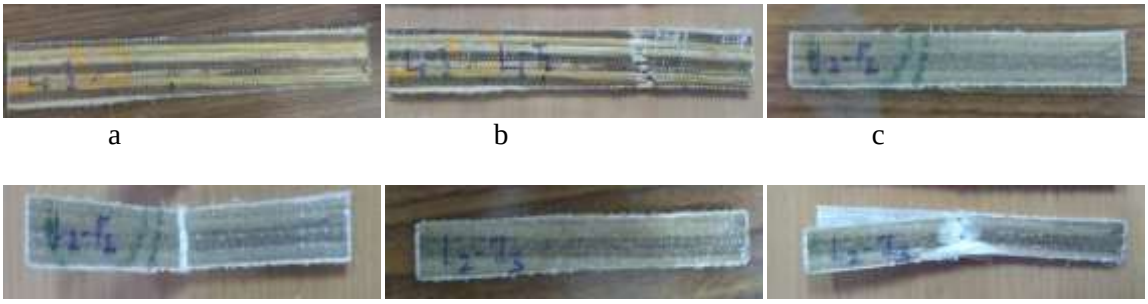
The tensile test is carried out on flat specimens in the present work. The standard for fiber reinforced composite is ASTM D 3039. For longitudinal direction, the dimensions of the composite specimen according to ASTM standard are 250 mm X 25 mm X3 mm. The tensile test is performed on model Instron 1195 computerized UTM at a speed of 10 mm/min and load of 25 kN. Figure 1(a) shows the tensile test specimen of unidirectional banana-glass fiber reinforced epoxy hybrid composite.

Flexural Strength

In this, the flexural test is three point bend test. The standard for flexural properties of fiber reinforced composites is ASTM D 790. For longitudinal direction, the dimensions of the composite specimen according to ASTM standard are 125 mm X 13 mm X 3 mm. The flexural test is performed on model Instron 1195 computerized UTM at a speed of 10 mm/min and load of 25 kN. Figure 1(c) shows the flexural test specimen of unidirectional banana-glass fiber reinforced epoxy hybrid composite.

Impact Strength

The Impact test on rectangular flat specimens was performed. The standard for impact properties of fiber reinforced composites is ASTM D 256. For longitudinal direction, the dimensions of the composite specimen according to ASTM standard are 100 *mm* X 10 *mm* X 3 *mm*. The impact test conducted in the present work was charpy impact testing of the specimen with a pendulum hammer, measuring the energy spent and related to the specimen cross section. Figure 1(e) shows the impact test specimen of unidirectional banana-glass fiber reinforced epoxy hybrid composite.



a b c

d e f

Fig.1. Tensile, Flexural and Impact test specimens before and after testing

RESULTS AND DISCUSSION

The different test specimens of laminates are shown in the figures above before and after failure modes. Then it is determined the ultimate tensile strength, flexural strength and impact strength of the composites.

Tensile Strength Analysis

The ultimate tensile strength of unidirectional Banana-Glass fiber reinforced with varying wt. % combination of the hybrid composite was studied here, and its failure mode is shown in figure 1(b). The comparative charts for the ultimate tensile strength of different laminates are presented in figure 2. Among the all six laminates the average ultimate tensile strength of the laminate L-1 is noted as 510 MPa and average ultimate tensile strength of the laminate L-6 is noted as 55 MPa. Moderate tensile strength is observed from this set of results when the natural banana fiber is hybridized with glass fiber.

Flexural Strength Analysis

Flexural strength of unidirectional Banana-Glass fibre reinforced epoxy Hybrid composites was studied and its failure mode is shown in figure 1(d). The comparative charts for flexural strength of different laminates are presented in figure 3. Among the all six laminates the average flexural strength of the laminate L-1 is noted as 168 MPa and average flexural strength of the laminate L-6 is noted as 31 MPa. Moderate flexural strength is observed from this set of results when the natural banana fiber is hybridized with glass fiber.

Impact Strength Analysis

Impact strength and energy absorbed of unidirectional Banana-Glass fibre reinforced Hybrid composite was studied and its failure mode is shown in figure 1(f). Hybridization of Banana with glass plays a major role in the Impact strength. The comparative charts for Impact strength of laminates are presented in figure 4. Among the all six laminates the average Impact strength of the laminate L-1 is noted as 0.222 J/mm^2 and average Impact strength laminate L-6 is noted as 0.04 J/mm^2.

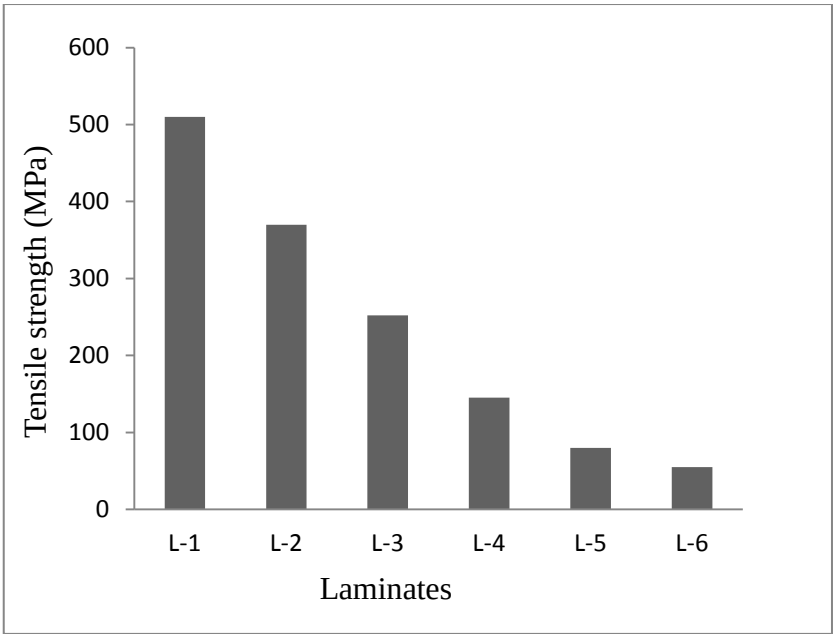


Fig.2. Tensile strength comparison chart

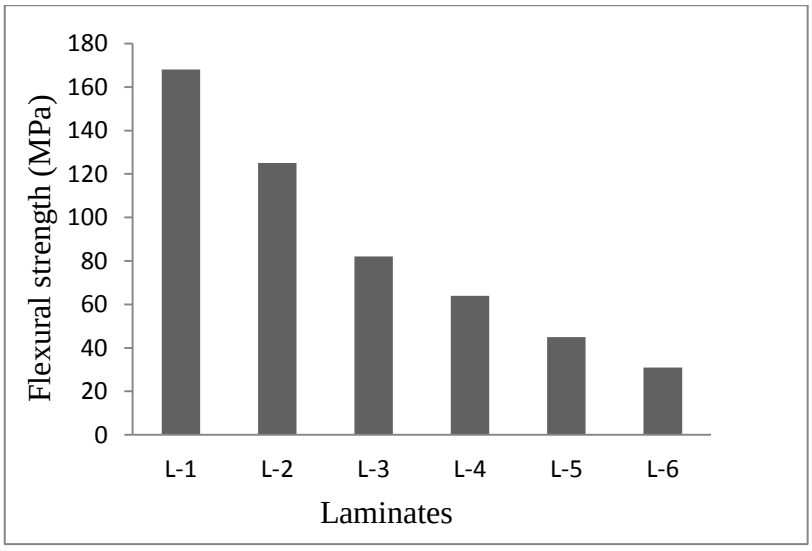


Fig.3. Flexural strength comparison chart

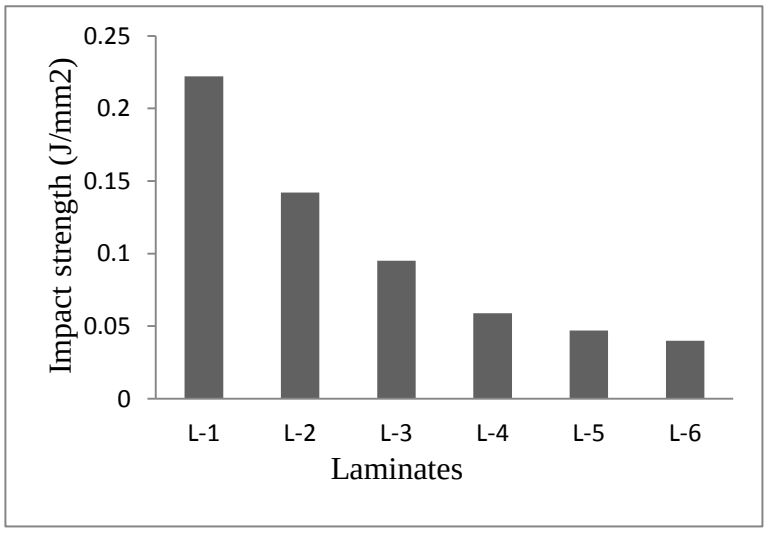


Fig.4.Impact strength comparison chart

CONCLUSIONS

The epoxy based unidirectional Banana-Glass fiber reinforced hybrid composites were fabricated by simple hand lay-up technique. It is found that it enhances mechanical properties as the glass layer in the laminates increases. A moderate strength is observed in the composites when the natural banana fiber is hybridized with glass fiber. These hybrid composites can be used for medium load bearing applications.

The unidirectional glass fiber composite has a higher ultimate tensile strength among all laminates and can withstand at a load of 61 kN at a maximum tensile strength of 510 MPa. The unidirectional banana composite has a lower ultimate tensile strength of 55 MPa at 6 kN load. From the flexural test shows that laminate L-1 has the higher flexural strength 168 MPa and laminate L-6 has the lowest flexural strength 31 MPa. From the charpy impact test it is noticed that the impact strength is high for the laminate L-1 of 0.222 J/mm^2 and while it is low for the laminate L-6 of 0.04 J/mm^2.

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