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Evaluation of Mechanical Behaviour and Structural Simulation of Jute-Glass/Epoxy Hybrid Composites

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Abstract:

Composite materials changed the picture of materials scope and applications with their wide vareity of properties and ease of manufacturing. Especially natural fibre polymer based composites are attained more inclination with their good structural properties, ease of availability and less cost. In the similar way artificial fibres like glass and carbon fibre composites are already created their trademark in material applications. Mechanical behaviour of composite material depends on many factors such as fibre content, orientation, types, length etc. A hybrid composite is a combination of two or more different types of fibre in which one type of fibre balance the deficiency of another fibre. An effort is made in this work to evaluate the mechanical behaviour of jute/glass fibre reinforced epoxy based hybrid composites. Since India is the largest jute producing country in the world and jute has more structural applications from ancient days, jute and glass fibres have been considered in this book, Properties of the jute/glass fibre reinforced epoxy are evaluated at Various stacking sequences [with ply angles $0^0 - 90^0$] and also for one, two, three and four layers of fibres. Structural properties are evaluated by tensile test, flexural test and Impact test.FEA analysis using ANSYS has been carried out for structural simulation of the hybrid composites.

Keywords:

Jute, Glass fibre, Epoxy

1. INTRODUCTION:

Natural fibre reinforced composite materials are considered as one of the new class of engineering materials. Interest in this area is rapidly growing both in terms of their industrial applications and fundamental research as they are renewable, cheap, completely or partially recyclable, and biodegradable. Among all the natural fibre reinforcing materials, jute appears to be a promising material because it is relatively inexpensive and commercially available in the required form. Glass Fibre Reinforced Polymers (GFRP) is a fibre reinforced polymer made of a plastic matrix reinforced by fine fibres of glass.

Fibre glass is a lightweight, strong, and robust material used in different industries due to their excellent properties. Hybridization of glass fibre with Oil palm empty fruit bunch (OPEFB) resulted in composites having a superior mechanical performance. A positive hybrid effect is observed in the elongation property. Thus, glass and OPEFB hybrid fibre reinforcement in Phenol formaldehyde (PF) resin resulted in a cost effective and a lightweight composite having good performance qualities. These composites may find applications as structural materials where higher strength and cost considerations are important. The tensile, flexural and impact properties of pineapple leaf fibre (PALF) and sisal reinforced polyester composites are improved by the incorporation of a small amount of glass fibres in these composites, showing positive hybrid effect.



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The mechanical properties of the composites are improved due to the addition of glass fibre along with palmyra fibre in the matrix and decrease the moisture absorption of the composites. Glass/sugar palm composites are found to have an increase in tensile, flexural, and impact properties with increasing fibre content and the weight ratio of glass/sugar palm fibres. The tensile properties of the flax/glass fibre reinforced hybrid composites were improved with the increasing of glass fibre content. Experimental study on untreated woven jute fabric-strengthened polyester composites shows the capability of this renewable wellspring of normal fibre for utilization in various consumable products. The market scenario for composite applications is changing due to the introduction of newer biodegradable polymers. Composite materials reinforced with natural fibres, such as flax, hemp, kenaf and jute, are gaining increasing importance in automotive, aerospace, packaging and other industrial applications. The purpose of this study is to make use of natural fibre like jute fibre, which is abundantly available in India and to incorporate with synthetic fibre like glass fibre to enhance the mechanical properties

2.EXPERIMENTAL PROCEDURE 2.1Materials:

Bidirectional Jute fibre mats of thickness 0.4 mm are purchased from Chandra Prakash & Co. Jaipur, India.E-glass fibres in woven mat form of 280 gsm are supplied by Suntech Fibre Private Limited, Bangalore. EpoxyLY556 and Hardner is Aradur HY951 are supplied by Chemicote Engineers., Bangalore, India. **Table 1** and **Table 2** indicate Physical properties of Jute fibre and E-glass fibre respectively.

Physical	Jute fibre
property	
Density (g/cm3)	1.4
Elongation at	1.8
break (%)	
Cellulose content	50 - 57
(%)	

Lignin conte	ent	8 - 10	
(%)			
Tensile streng	gth	700 - 800	
(MPa)			
Young's modul	lus	30	
(GPa)			

Table 1. Physical properties of Jute fibre .

Physical	Glass fibre
property	
GSM	280gsm
Orientation	plain-woven fabric
UTS	40 GPa
Modulus	1.0 GPa
Density	1.9 g/

Table 2. Physical properties of E-glass fibre.

2.2.Specimen Fabrication:

An attempt has been made to fabricate composites by using jute, E-glass and a hybrid of jute/E-glass fibre reinforced

epoxy. The mechanical properties like tensile, impact, flexural and inter laminar shear strength are analyzed.

2.2.1. Preparation of Epoxy-Hardner Mixture:

For each laminate nearly 400 g of epoxy-hardener mixture is taken. Hardener is taken in the ratio of 1:10 (i.e.; for every 10 g of epoxy 1 g of hardener is added). Then the mixture is thoroughly mixed for some time and is used for preparing laminates.

2.2.2.Fabrication Procedure:

In this study, manual hand layup method is used for preparing composite laminates as shown in **Figure 1**. First of all, a release gel is sprayed on the mould surface to avoid the sticking of epoxy to the surface. Thin plastic sheets are used at the top and bottom of the mould plate to get a good surface finish of the product. Reinforcement in the form of woven mat jute fabrics and E-Glass fibers are cut as per the mould size and placed at the surface of mould after Perspex sheet. Then epoxy in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing



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agent) and poured onto the surface of mat already placed in the mould. The epoxy is uniformly spread with the help of the brush. The second layer of mat is then placed on the epoxy surface and a roller is moved with a mild pressure on the mat-epoxy layer to remove any air trapped as well as the excess epoxy present. The process is repeated for each layer of epoxy and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mould plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature at 60°C - 80°C, the mould is opened and the developed composite part is taken out and further processed. For epoxy based system, normal curing time at room temperature is 24 - 48 h

3.TESTING OF COMPOSITES:

The mechanical properties are carried out by different instruments for the fabricated composites. **Table 3** shows laminates designations and layer sequence of each laminate are as shown in **Figures**.



Figure 1. Laminates making using hand lay-up technique.

Composites	Compositions
L1	G + G + G + G + G + G + G + G + G
	G + G
L2	$J \qquad +J+ G \qquad +G+J+J+G+ G+J+J+$
	G+G+ J

Table 3. Laminates designations

*(G—Glass layer, J—Jute layer).

Glass Layer
Glass Layer

Figure 2. Schematic representation of composite 1.

Jute Layer
Jute Layer
Glass Layer
Glass Layer
Glass Layer
Jute Layer
Jute Layer

Figure 3. Schematic representation of composite 2.

The thickness of each layer of Jute is 0.4 mm and each layer of glass is 0.28 mm. As per ASTM standard, the thickness of each laminates is 3 mm, So as to maintain the ASTM standard, considering 10 layers of glass for L1 (Pure glass and epoxy-hardener mixture), for L2 it takes 4 layers of glass and 3 layers of jute (mixture of jute/glass and epoxy-hardener mixture, Note: outer layers are jute

3.1 Tensile Test:

The tensile test is done by cutting the composite specimen as per ASTM: D638 standard (sample dimension is $216 \times 19 \times 3$ mm3). A universal testing machine (UTM) (Model: KIC-2-1000-C) is used for testing with a maximum load rating of 100 KN to200 KN . Composite specimens with different fibre combinations are tested, which are shown in Figure 6. In each case, three samples are tested and the average is determined and noted. The specimen is held in the grip and load is applied and the corresponding deflections are noted. The load is applied until the specimen breaks and break load, ultimate tensile strengths are noted. Tensile stress and strain are recorded and load vs length graphs are generated.



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3.2 Flexural Test:

The flexural test is done in a three point flexural setup as per ASTM: D790 standard (sample dimension is 80 $\times 8 \times 3$ mm3). When a load is applied at the middle of the specimen, it becomes bends and fractures as shown in **Figure 7**. This test is carried out in the UTM from which the breaking load is recorded and load vs length graphs are generated.

3.3 Impact Test:

The impact test is done in a charpy impact setup as per ASTM: D256 standard (sample dimension is $65 \times 12.5 \times 3$ mm3). The specimens are shown in **Figure 8**. The specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material is noted and used to measure the toughness of the material and the yield strength. The effect of strain rate on fracture and ductility of the material is analyzed.



Figure 2. Tensile test specimen



Figure 3. Flexural test specimen



Figure 4. Impact test specimen.

4. Result and Discussion:

4.1 Tensile Test(G+G+G+G+G+G+G+G+G+G+G):

The composites specimens L1, and L2 are tested for tensile properties in UTM and obtained tensile properties are shown. The mechanical properties like break load, tensile modulus and ultimate tensile strength (UTS) are shown. The Laminate L1 which consists of pure glass layers shows a high tensile strength of 280.25 N/mm2, but the mixture of jute/glass layers laminates L2 shows better results than the L1.



Figure 5 Geometric model of the composite

The geometric model of the composite 1 is taken into consideration and drawn in the geometry using ANSYS in static structure. Here firstly the axis is set and then the surface layer is drawn with the help of given dimensions. Analysis for the first layer, the first layer consists of nine E-Glass layers and the thickness of each layer is 0.28.



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Figure 6 Total deformation

We apply 2000N for the glass layers and we find total deformation and Extrude. the maximum deformation is 3.3975 and the minimum deformation is 0.

4.2 Tensile Test(G+G+J+J+G+G+J+J+G)



Figure 7 Total deformation

4.3Flexural Test(G+G+G+G+G+G+G+G+G+G+G):

The flexural properties including flexural modulus and ultimate flexural strength (UFS) of composites L1, and L2 are tabulated in **5**. The Laminate L1 shows a high flexural strength of 359.14 N/mm2 Again as like tensile strength here also the mixture of jute/glass laminates L2 shows better results than the L1.



Figure 8 Geometric model of the composite

The geometric model of the composite 1 is taken into consideration and drawn in the geometry using ANSYS in static structure. Here firstly the axis is set and then the surface layers drawn with the help of given dimensions.



Figure 9 Total deformation

Applying 2000N on the glass layer we find out the total deformation. The maximum deformation is 11.438 and the minimum deformation is 0.

4.4 Flexural Test(G+G+J+J+G+G+J+J+G)



Figure 10 Total deformation

Applying 1000N on the layer we find the total deformation. The maximum deformation 0.62866 and the minimum deformation is 0.

4.5 Impact Test(G+G+G+G+G+G+G+G+G+G):

The loss of energy during impact is the energy absorbed by the specimen during impact. The values are tabulated and it shows comparison between energy absorbed by the different combination of composites. The L2 shows very high impact strength compare to other laminates, but L2 shows similar impact strength of 4.35 J which is better than L1. The L shows very poor impact strength of 1.3 J.



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Figure 11. Geometric model of composite

The geometric model of the composite 1 is taken into consideration and drawn in the geometry using ANSYS in static structure. Here firstly the axis is set and then the surface layers drawn with the help of given dimensions.



Figure 12 Total deformation

Applying force of 10000N we find out the total deformation. The maximum deformation is 2283.2 and the minimum deformation is 0.





Figure 13 Total deformation

5. ADVANTAGES:

- Reduced weight.
- Easy of availability.
- Low concentration, low fabrication cost and satisfactory mechanical assets.

• Very flexible when compare to other materials.

6. CONCLUSION:

This work demonstrates the fabrication of hybrid composite using jute and E-glass fibre reinforced epoxy composite by hand layup method. Experimental and theoretical analysis has been carried out on the test specimen. From the analysis, the following conclusions are drawn:

1. The composite L1 of jute fibre composition shows very poor results when compared with composite L2 of E-Glass fibre composition.

2. The hybrid composites L2 of Jute/E-Glass fibre compositions show better results than composite L1. Laminate L2shows better than L1, because it consists of glass as outer layers.

3. The incorporation of glass fibre in jute fibre composites enhances the mechanical properties and it leads to the increase of the utilization of natural fibres in various applications.

7. SCOPE OF FUTURE WORK:

There is a wide scope for future scholars to explore the current research area. The present work can be further extended to study other aspects of composites like use of other natural fibres and evaluation of their dynamic mechanical, thermal, tribological properties and the experimental results can be similarly be analyzed.

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