Fabrication and Mechanical Properties Evaluation of Jute/Glass fiber Hybrid Composite

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Abstract: Now a day hybrid materials of any class are essential for current requirement of automobiles and aeronautical field. In this research the mechanical properties such as impact, tensile and flexural are analyzed as per ASTM standards. The hybrid composite is made of jute and glass fiber and fabricated using hand layup method. The result shows that hybrid composite has better strength as compared to jute fiber composite fabricated separately.

Index Terms **- Jute Fiber, Glass Fiber, Epoxy, Mechanical Properties.**

I. INTRODUCTION

Natural fiber reinforced composite materials are now accepted as one of the new class of engineering materials. this area in the field of material science is now a day very fastly growing both in terms of their industrial applications and fundamental research because they are less in cost , renewable and completely biodegradable and partially recyclable. Jute is relatively inexpensive and commercially available in the desirable form so it is a very promising material among all the natural fiber reinforcing materials . Glass Fiber Reinforced Polymers (GFRP) is a fiber reinforced polymer which is made of a plastic matrix and reinforced by fine fibers of glass. Due to its excellent properties and being strong, robust and light weight material it is used in different industries .Some other researcher having good results in glass fiber with Oil palm empty fruit bunch (OPEFB) resulted in composites having better mechanical performance. In the elongation property a positive hybrid effect is observed. Thus, in Phenol formaldehyde (PF) resin glass and Oil palm empty fruit bunch hybrid fiber reinforcement is good and cost effective and a lightweight composite having good performance qualities.

These composites have found their applications in various field like structural materials where higher strength and cost considerations are important factor [1]. by the incorporation of a small amount of glass fibers in these composites various mechanical properties like tensile, flexural and impact properties of pineapple leaf fiber (PALF) and sisal reinforced polyester composites are improved and showing positive hybrid effect [2]. when add glass fiber along with palmyra fiber in the matrix the mechanical properties of the composites improved after and the moisture absorption of the composites decreases [3]. with increasing content of fiber and the weight ratio of glass/sugar palm fibers Glass/sugar palm composites are found to have an increase in tensile, flexural, and impact properties [4]. with the increasing content of glass fiber the tensile properties of the flax/glass fiber reinforced hybrid composites improved. In terms of interlaminar shear strength and the interlaminar fracture toughness it is found that reinforced hybrid composites were better than those of GFRP [5].

The capability of this renewable and normal fiber for utilization in various consumable products found by experimental study of woven jute fabric-strengthened polyester composites which is untreated in nature [6]. Due to introduction of newer biodegradable polymers the market scenario for composite applications is.Now a day in various field like automotive, aerospace, packaging and other industrial applications Composite materials reinforced with natural fibers, such as flax, hemp, kenaf and jute, are gaining increasing importance [7]. Sanjay, M.R.[8] presented various Mechanical and water absorption behavior of banana/sisal reinforced hybrid composites. They observed that the flexural modulus and impact strength increases by increasing the length of fiber and weight percentage of fiber. Anshida [9] stated that density, apparent porosity and water absorption property plays important role, they concluded that volume fraction with low level of fibers under tensile and flexural loadings provided not only higher modulus of elasticity and mechanical strength but also have values of apparent porosity apparent density, and absorption of water. The thermal conductivity of epoxy nano composites filled with single filler system and hybrid filler system studied by Mr. Ramachandra [10] It is is obtain higher thermal conductivity of epoxy composites and the resistance the existence of big filler agglomeration . The combination of Silicon and carbon black powders decrease the negligible amount residual free Silicon and It found that increased the amount of internal reaction bonded SIC and filler reduced the flexural strength indicating damage to the fiber but it drastically improved the wear resistance characteristics of the composites [11].

GFRP /Sisal composites sample shows good tensile strength and Jute/GFRP composites samples possess the maximum flexural load[12]. The length of the fiber in the laminate is equal to the critical fiber length then maximum strength is achieved. Type of fiber matrix, fiber length, fiber orientation, fiber concentration and the bonding betweenthe fiber and matrix decided the strength of short fiber composites [13]. John, K. and Venkata found in their research that thermal properties such as TGA and DSC and the conclusion found that influence of change in fiber length (treated and untreated hybrid composites) shows significant improvement in tensile, flexural, and compressive strengths of the sisal/glass hybrid composite [14].

Kalaprasad, investigated on effect of bamboo fiber composite filled with chemosphere, result show that the impact property of bio-fiber reinforced composite is greatly influenced by addition of cenosphere as filler and the impact strength is increased with addition of filler up to a certain limit and after which it is decreased on further addition [15] Kuruvilla Joseph, et.al. Investigated on effects of ceramic fillers on bamboo fiber they conclude that the incorporation of particulate fillers to the fiber tensile strengths of the composites are found to be decreased. Among the particulate filled bamboo-epoxy composites, least value of void content are recorded for composites with silicon carbide filling and for the composites with glass fiber reinforcement minimum void fraction isnoted for red mud filling [17].

In this study we make use of natural eg. jute fiber, which is easily available in India and one synthetic fiber eg. glass fiber to enhance the mechanical properties. In this research paper, an effect of hybridization of jute/E-glass fiber reinforced epoxy composites is evaluated which help to determine the potential applications of the jute/E-glass fiber reinforced epoxy composites.

II. EXPERIMENTAL PROCEDURES

2.1. Materials

Jute fiber mats(Bidirectional) having thickness 0.5 mm and in woven E-glass fibers mat form of 300 gms are purchased from local market. EpoxySY-12 and HardnerSY30(B) purchased from M/S RESINOVA CHEMICAL Limited, Kanpur Bangalore, India. **Table 1** and **Table 2** indicate Physical properties of Jute fiber and E-glass fiber respectively.

Table 1 Composition of Jute[21]

Physical Property	**Glass Fiber**
Orientation	plain-woven fabric
GSM	280gsm
UTS	40 GPa
Modulus	1.0 GPa
Density	1.9 g/cc

Table 2. Physical properties of E-glass fiber [20]

S.N	**Composition**	**%**
1	Cellulose	64.4%
2	Hemicellulose	12%
3	Lignin	11.6%
4	Moisture	10%

2.2. Specimen Fabrication

To fabricate composites by using jute, E-glass and a hybrid of jute/E-glass fiber reinforced epoxy an hand layup method has been used and mechanical properties like tensile, impact, flexural are analysed.

2.3 Preparation of Epoxy-Hardner Mixture

For each laminate fabrication aprox 400 g of epoxy-hardner mixture is taken. Now take the hardner and resin in the ratio 1:10 (*i.e.*; for every 10 g of epoxy 1 g of hardner is added) now the mixture is thoroughly mixed for some time and then prepare laminates.

2.4 Fabrication Procedure

Hand layup method is used for preparing composite laminates in this research, as shown in Fig 1. First of all, to avoid the sticking of epoxy to the surface gel is used then for optaining good surface finish Cello tape is used. Woven mat jute fabrics and E-Glass fibers are prepared as per the mould size and put at the surface of mould after perspex sheet. The epoxy and hardner is now mixed in prescribed proportion with a prescribed ratio and now poured over the surface of mat in the mould[18].

The epoxy is uniformly spread with the help of the brush. The second layer of mat is then placed on the epoxy surface and with the help of roller air trapped as well as the excess epoxy present. This process is repeated for each and every layer of epoxy and mat, till the required layers are stacked. After curing either at room temperature or at some specific temperature at 50˚C - 70˚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 48 – 78 hours[19].
Table 3. Laminates designations.

Composites	Compositions
L1(Laminate 1)	J + J + J + J + J + J
L2(Laminate 2)	G + G + J + J + J + J + G + G

Each Jute layer is 0.4 mm and of glass is 0.28 mm. As per ASTM standard, the thickness of each laminates is 3 mm, for L1 it takes 6 layers of jute for L2 it takes 4 layers of glass and 4 layers of jute (mixture of glass/jute and epoxy-hardner mixture, where outer layers are of glass).

Figure 1 Resin and Hardener mixing

Figure 2 Mixing weighing

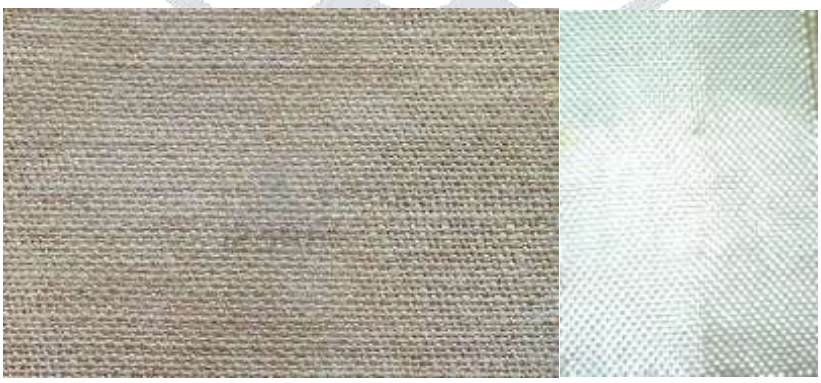

Figure 3 Bidirectional **(a)** jute fiber and **(b)** glass fiber

Figure 3(a) Hybrid Jute/glass fiber

2.5 Tensile Test

The tensile test is done by cutting the composite specimen as per ASTM: D638 standard (sample dimension is 216 × 19 × 3 mm^3). Composite specimens with different fiber combinations are tested in computerized UTM, which IS shown in **Fig 4**. In each case, three samples are tested and the average is determined. 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 [20].

Figure 4 tensile test specimens

2.6 Flexural Test

The flexural test is done in a three point flexural setup as per ASTM: D790 standard (sample dimension is 80 ×8 × 3 mm^3). When a load is applied at the middle of the specimen, it becomes bends and fractures as shown in **Fig 5**. This test is carried out in the computerised UTM from which the breaking load is noted and load vs length graphs are generated.

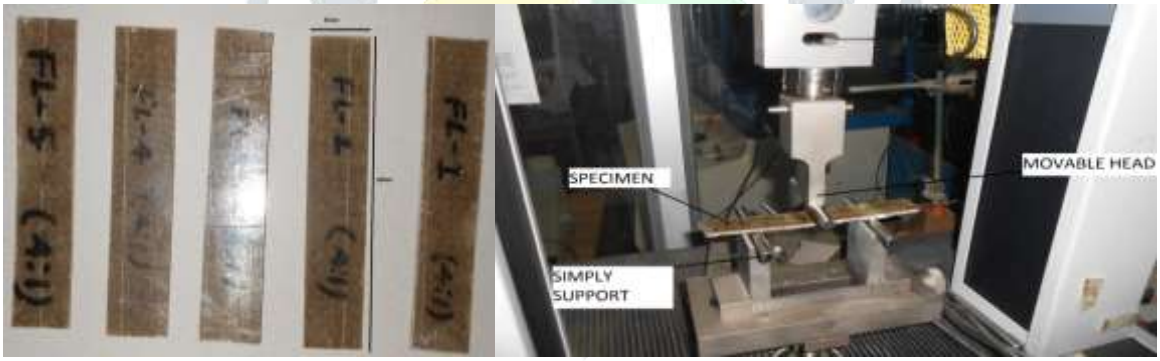

Figure 5 Bending Test Specimen and Testing Setup

2.7. Impact Test

The impact test is done in a charpy impact setup as per ASTM: D256 standard (sample dimension is 65 × 12.5 ×3 mm^3).. 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.

III.RESULT AND DISCUSSION

3.1. Tensile Properties

The composites specimens L1, L2, are tested for tensile properties in UTM and obtained tensile properties are shown in Table 4. The load vs Length curves are shown in Fig 6. The mechanical properties like break load, ultimate tensile strength (UTS) are shown in Table 4.The Laminate L1 which consists of pure jute layers shows tensile strength of 42.23 N/mm^2 and L2 which consists of jute and glass layers shows a higher tensile strength of 70.02 N/mm2, it shows that the mixture of jute/glass layers laminates shows better results.

3.2 Flexural Properties

Ultimate flexural strength (UFS) of composites L1, L2,are tabulated in **Table 5**. Typical load vs Length curves are shown in **Fig 7** The Laminate L1 shows low flexural strength of 162 N/mm2 and L2 which shows a higher flexural strength of 243 N/mm2. Again as like tensile strength here also the mixture of jute/glass laminates shows better results .

3.3. Impact Property

The loss of energy during impact is the energy absorbed by the specimen during impact. The values are tabulated in **Table 6**. **Fig 8** shows a comparison between energy absorbed by the different combination of composites. The L1 shows low impact strength of of 1.1 J. The L2 shows good impact strength of 3.25 J.

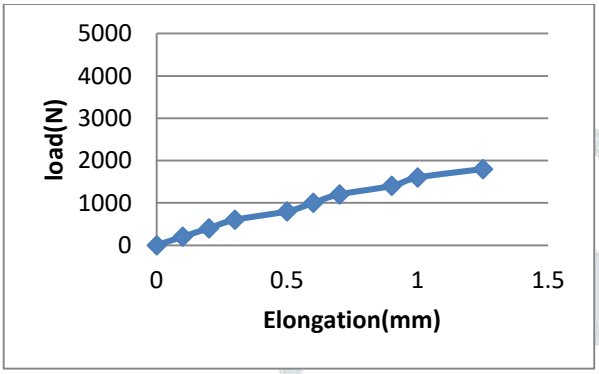

Figure 6 (a) Load Vs Elongation for jute fiber composite Tensile Test

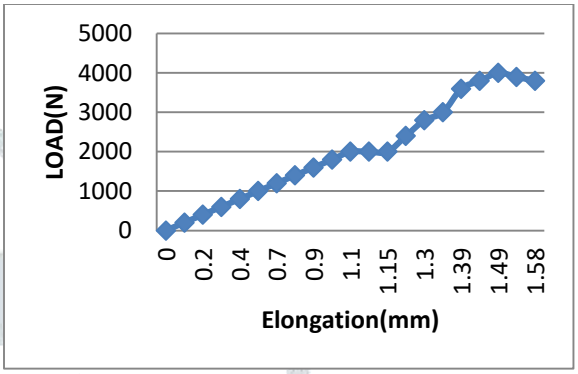

Figure 6(b) Load Vs Elongation for jute/glass fiber composite Tensile Test

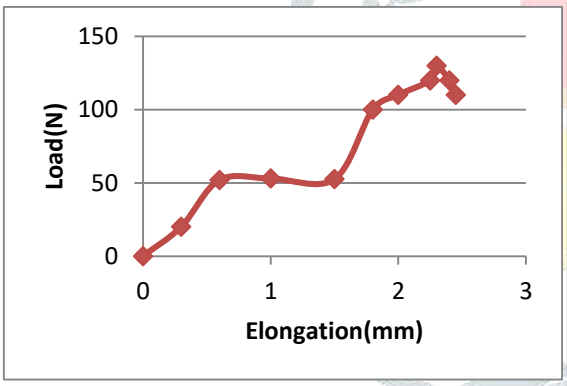

Figure 7(a) Load Vs Elongation for jute fiber composite Flexural Test

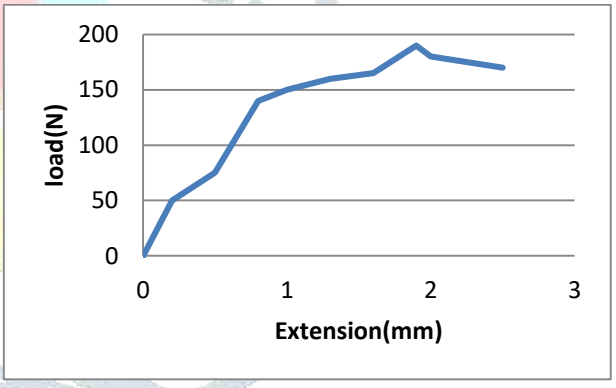

Figure 7(b) Load Vs Elongation for jute fiber composite Flexural Test

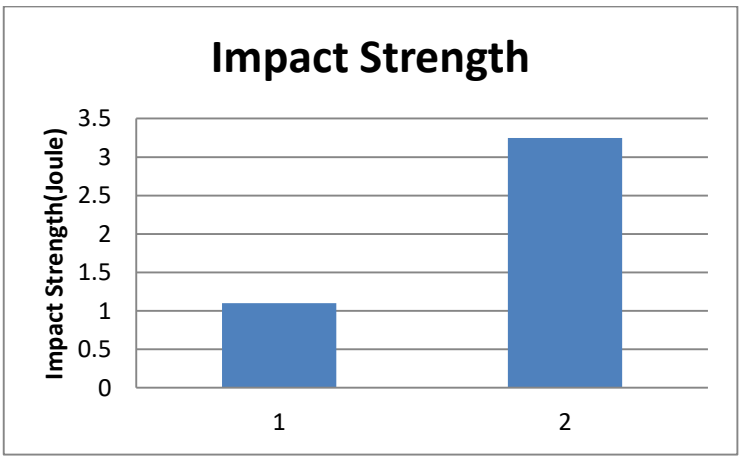

Figure 8 Impact Strength of Jute and Jute/Glass Hybrid Composite

Table 4 tensile properties of composites.

Composite	Break Load(KN)	Tensile Strength(N/mm^2)
C_1	3.99	42.23 N/mm^2
C_2	2.40	70.02 N/mm^2

Table 5 flexural properties of composites.

Composite	Flexural Strength(N/mm^2)
C_1	162 N/mm^2
C_2	243 N/mm^2

Table 6 Impact Strength of Composites

Composite	Impact Strength(Joule)
C_1	1.1
C_2	3.25

IV. CONCLUSIONS

This paper presents the fabrication of hybrid composite using jute and E-glass fiber reinforced epoxy composite by hand layup method. From the tests, the following conclusions are drawn:

- The composite L1 of jute fiber composition shows poor tensile strength compared with composite L2 of hybrid composites
- Hybrid composite shows better flexural strength than jute composite.
- Hybrid composite shows better Impact strength than jute composite.

The incorporation of glass fiber in jute fiber composites enhances the mechanical properties and it leads to the increase of the utilization of natural fibers in various applications

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