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ORIENTATION EFFECT OF JUTE-GLASS FIBER REINFORCED COMPOSITE ON MECHANICAL PROPERTIES

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Abstract- *Composite material has a great deal of use in different fields of engineering section due to its predominant properties like low density, lightweight, toughness with it's better mechanical properties. In this study, a reinforced polymer composite consist of glass and jute fiber layers was fabricated with different orientation, so that different mechanical properties such as impact, hardness and flexural strength of the fabricated sample could be investigated. The reinforcement materials selected for this study were jute & glass fiber as fiber and epoxy resin as binder. There were five layers in the fabricated composite material (Jute-Glass-Jute-Glass-Jute). The middle layer of jute fiber was unidirectional while other layers of jute fiber is bidirectional. For the orientation of fiber, three angular orientations i.e. 0°, 45°, and 60° of Jute fiber were taken. For improving the outcomes, hand layup method had been utilized to manufacture the composite. The first sample was made with 0° orientation and then similarly for 45° and 60°. The specimen fabricated with 0° fiber orientation was observed with high impact energy value, high Rockwell hardness value and high flexural strength among the others.*

Keywords: Composite Material, Mechanical Properties, Jute and Fiber Glass, Fiber Orientation

1. INTRODUCTION

A composite is defined as blend of more than one particular materials which has their own properties, finalized to make novel properties that can't be found acting alone of those materials. As there are many different type of material exist in the world, a wide scope of different novel properties material can be fabricated.

Concrete is a very common composite material as it made from mixing cement, sand and other reinforcements. A glass fiber is also a composite substance as it made of glass strands embedded in polymer. Composite materials are said to have two phases. The reinforcing phase is the filaments, sheets, or particles that are implanted in the matrix phase. Composites are one of versatile materials used in different field of application throughout the world. Simplicity of blending with different materials, this is a significant issue in many designing works. Composite material is lightweight, incredibly solid, has high explicit solidness, consumption and synthetic safe. Jute can be easily available in Bangladesh and it is easily accessible, mouldable item. So, jute can be utilized as composite material alongside glass fiber that can allow great mechanical properties just as its fabrication cost will be lower [1]. Composite materials are commonly used by civil, mechanical, material engineer for making different structures, extensions, skate board, vessel frames, pool boards, dashing vehicle bodies, automobile bodies, stockpiling tanks, impersonation rock, refined marble sinks and ledges. It is also utilized in aerospace industry, sporting goods industry, automotive industry, home appliance industry and so on.

Fiber properties and structure are important parameters influencing the final composite's mechanical properties. The selection of the correct fiber structure depends on many things like fiber mechanical properties, tensile, flexural strength, stacking conditions like uniaxial, biaxial and loading effect.

Another important parameter affecting the mechanical behavior of short-fiber composites is fiber orientation. This is because the fibers are rarely directed in a single direction in such composites, which is necessary to obtain the full reinforcement effect. A continuous and progressive orientation of individual fibers occurs during the manufacturing of short-fiber composites. In plants, the fiber orientations are designed for the forces that occur, especially the bending of plants by wind forces. It is very important to investigate the fiber orientation as fibers of those materials carried the load mostly.

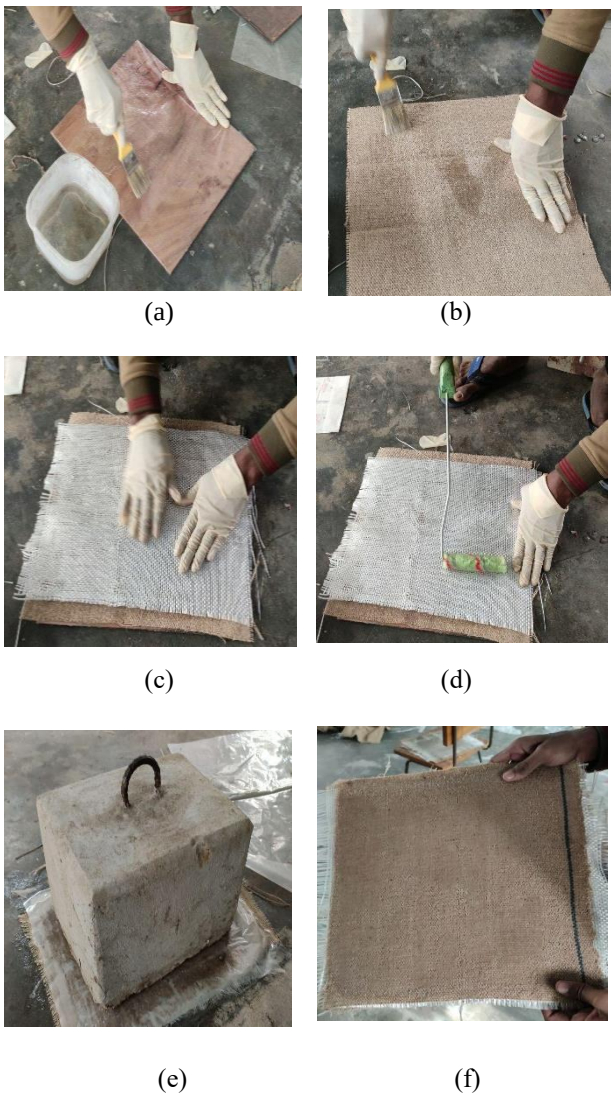
Interaction between fibers prevents precise quantitative analysis of specimens containing fibers at more than one orientation, although the composite strength and fracture behavior can be described qualitatively in terms of the same general principles governing the actions of unidirectionally oriented fiber composites.

Md. Rafiquzzaman et al. researched on manufacturing of jute and glass fiber composite without the effect of orientation and attempts to produce jute-glass fiber composite skateboards. They also investigated their performance. With 20% jute and 20% glass composite, they found tensile strength was about 74.65 MPa, flexural strength was about 82.76 MPa, impact strength was about 206.98 Kg/m^2 [2]. R.Yahaya et al. researched on kenaf fiber composites orientation and concluded that wooven fiber showed higher tensile strength, higher module compared to unidirectional and random mat fibers but unidirectional fiber provides higher flexural strength and modulus. They observed highest tensile strength was about 145 MPa in woven fiber and highest flexural strength in unidirectional fiber was about 100 MPa. Random mat showed poor characteristics compared to woven and unidirectional fibers for all loading conditions [3]. Micheal Cordin et al. evaluated effect of fiber-reinforcement (FR) orientation of bio-based lyocell-reinforced polypropylene composite. They used special method to manufacture composites with given fiber orientation and mixed hybrid yarn fiber by wetting thermoforming processes. They got highest tensile strength in unidirectional fiber orientation and it was about 147 MPa [4]. S.Nallusamy and Gautam Majumdar had studied the fabrication of jute and glass fiber composite without fiber orientation. They described the tribological properties of natural jute and glass fibers reinforced composite using in underground pipelines and marine applications based on the necessary mechanical properties. They investigated and evaluated the properties of these hybrids and comparing their properties through different experimental techniques. They got highest tensile strength about 89 MPa [5].

Soma Dalbehera and S. K. Acharya studied the fabrication of jute and glass fiber composite with the effect of orientation. They experiment hybrid reinforced composite with bio squander (jute) and conventional filler (glass) as a constant layered with epoxy as a resin. Glass and jute texture made as (0°- 90°) and (45°-45°) orientation for all stacking arrangements. They examined on the impact of stacking arrangement for tensile, flexural and interlaminar shear properties of untreated woven jute and glass texture fortified epoxy hybrid composite tentatively. They got highest flexural strength in glass-jute-jute-glass composite and it was about 241.3 MPa and tensile strength was about 42 MPa [6]. Jawaid et al. contemplated jute and oil palm fiber composites and discovered that hybrid system was powerful in expanding for elastic and dynamic mechanical properties of the oil palm-epoxy composite because of improved fiber/lattice interface holding. They investigated different composition of jute fiber and oil palm EFB (empty fruit branches) and found highest tensile strength was about 37.9 MPa with 4:1 ratio [7]. Verma et al. analyzed mechanical properties of glass/jute hybrid composites where the jute textures were interchanged by different synthetic substances. It resulted that jute treatmented by titanate brings improved execution attributes and mechanical properties of hybrid composite.They found improve in tensile and flexural strength in titanated composite sample with respect to untreated jute [8]. Ahmed et al. preliminary researched impact Mechanical properties of stacking grouping of woven jute and glass texture reinforced polyester crossover composites. Layering has a bigger impact on the flexural, laminar shear properties than tensile properties. Hybrid of two extraordinary glass utilizesed with decent harmony on each side improve the properties and expense. They found highest tensile strength was 125 MPa in GGGJJJJGGG composite and they got flexural strength was 160 MPa in the above mentioned composite[9]. Thew et al. found that different mechanical properties regarding bamboo/glass fiber reinforced hybrid composites rely upon bamboo or glass fiber length, attachment of lattice and fiber weight proportion. They discovered that with the increased percentage of glass fiber with bamboo fiber, tensile strength significantly improves. [10].

2. METHODOLOGY

In this research work, jute and glass fiber as reinforcement and epoxy resin as the matrix was used. Jute fiber was collected locally from the market and glass fiber was purchased from online platform. Resin and hardener were collected from a chemical company. After the fibers being collected, the bidirectional fibers were cut according to the dimension of 12×10 inch and the unidirectional jute fiber were cut at 0°, 45°, and 60° for the fabrication process. There were five layers in the fabricated composite material (Jute-Glass-Jute-Glass-Jute). The middle layer of jute fiber was unidirectional and other layers of jute fiber were bidirectional. The fabrication process of this composite was done by conventional technique known as hand layup technique. Hand layup is a method of molding where fiber reinforcements were manually placed with resin. Any reinforcing materials like chopped strand or mat can be allowed with this process. The epoxy resin and hardener were blended by weight percentage ratio of 10:1. Hardener generally improve the interfacial adhesion along with give strength to the composite. Using discharging agent and resin on forming surface, a pile of jute-glass fiber was set down and trailed by an amount of fluid sap epoxy poured inside. Brushes, hand rollers utilized to expel any void in the fiber structure also to spread the resin uniformly all through the fibers. The procedure was rehashed until the necessary number of layers was developed. Finally, these specimens were taken under the weight to force the air hole out or evacuate any overabundance air present in the middle of the fibers and resin and afterward kept for a few hours (almost 24 hours) to get the ideal specimen. The total consecutive manufacturing process showen in Fig 1. After the composite material gets solidified totally, the composite material was taken out from the weight and unpleasant edges were perfectly cut and expelled according to the necessary measurements. Then the fabricated composites were sliced utilizing a grinding machine to get the required specimen for mechanical testing.



(a) (b)

(c) (d)

(e) (f)

Figure 1. Fabrication Process of sample materials

3. MECHANICAL TESTING AND PROCEDURE

Mechanical properties of Jute-Glass fiber composite like impact, hardness and flexural properties were tested. Impact and hardness testing were carried in the department of Industrial Engineering & Management, KUET. Flexural Testing was carried out in department of Civil Engineering, KUET.

3.1 Impact Test

Impact testing of the specimen was completed by Charpy impact testing machine shown in fig. 2. The specimen shown in fig. 3 was put in the impact machine and impact force was applied to the specimen at the opposite side of the V-notch by discharging the sledge to create impact on specimen from a specific height. After impact the height of the sledge starting from the earliest stage noted. Every single exploratory test was rehashed three times to create the data. Further impact energy was calculated from the data with using the following eqn.

$$E = mg(h_1 - h_2) \quad \text{.....(1)}$$

Figure 2. Charpy Impact Tester Machine

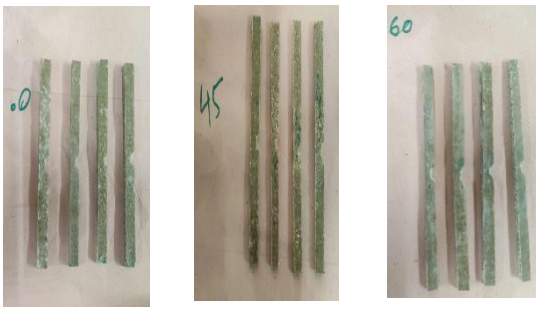


Figure 3. Specimens prepared for Impact Test

Figure 4. Rockwell Hardness Testing Machine

Figure 5. Specimen for Hardness Test

3.2 Hardness Test

Hardness is a proportion of the protection from confined plastic disfigurement incited by either mechanical space or scraped spot. There are numerous hardness testing scales. The Rockwell scale is one of them shown in fig. 4. The Rockwell scale is a hardness

scale dependent on the surface hardness of a material. The Rockwell check, which tests an indenter's penetration depth under a large load compared to a preload penetration. Various scales use different loads or indenters, denoted by one single letter. A hardness number is a dimensionless number marked as HRA, HRB, HRC, and so on, where the last letter is the Rockwell size, individually. Specimen for this test shown in fig. 5.

3.3 Flexural Test

Flexural testing is normally known as three-point bending testing which machine shown in fig. 6. The dimension of the specimen for the bending test was 152.4 × 25.4 ×5.08 mm. The specimen shown in fig. 7 was set in the flexural testing machine were horizontally mounted on two supports. Then, the load was slowly added by roller to the center of the specimen. At a particular load, the specimen was broken.The deflection was determined at the middle by the scale mounted underneath the specimen. The respective load was noted for the increasingly increasing deformation of the specimen and then bending strength was calculated from data by using the bending strength equation.

$$\sigma = \frac{3FL}{2bh^2} \quad \text{.....(2)}$$

Figure 6. Flexural Strength Testing Machine

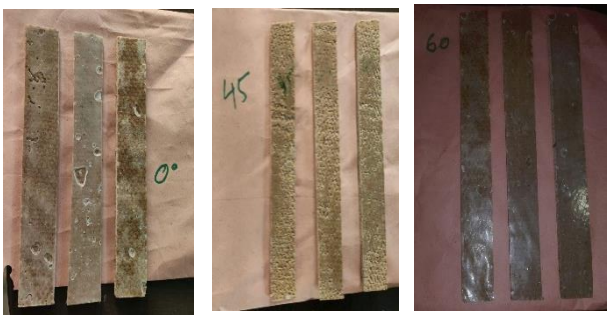


Figure 7. Specimen prepared for three point bending Test

4. RESULT AND DISCUSSION

4.1 Impact Strength Test

Charpy Impact test has been done with 20 kg pendulum. Using eqn. 1 and experimenting data impact energy was determined and ploted which shown in fig. 8.

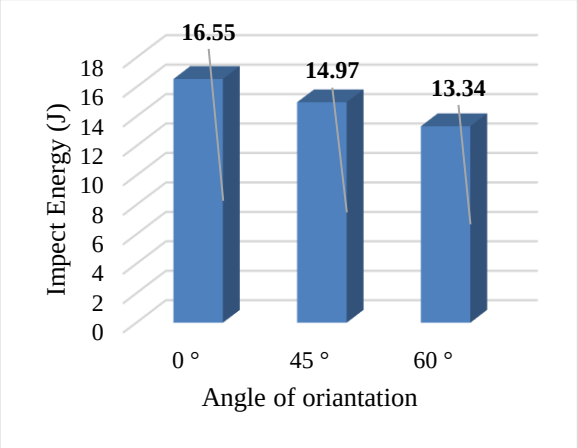


Figure 8. Impect energy comparison result

Here, it was clearly seen that, with parallel orientation of jute fiber with glass fiber, highest impact energy was found and it was about 16.55J. These impact energy was calculated by averaging 3 sample's impact energy for each orientation.

4.2 Hardness Test

Rockewell hardness test has been tested in HR-150A hardness tester machine.

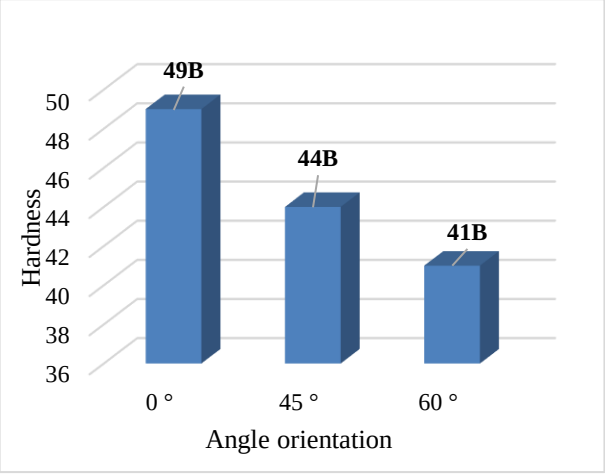


Figure 9. Rockwell Hardness test result for different orientations

From this test, the parallel orientation of jute fiber with glass fiber, highest Rockwell hardness no. was found and it was about 49B. 3 samples of each specimen have been tested to get the hardness number shown in fig. 9.

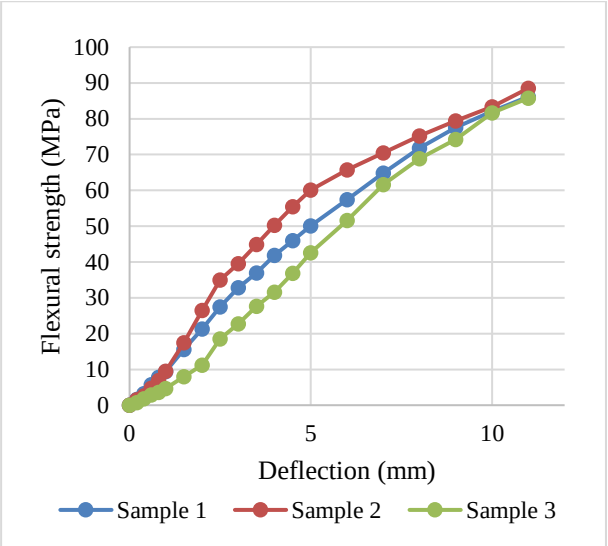


Figure 10. Flexural strength vs deflection curve for 0° orientation

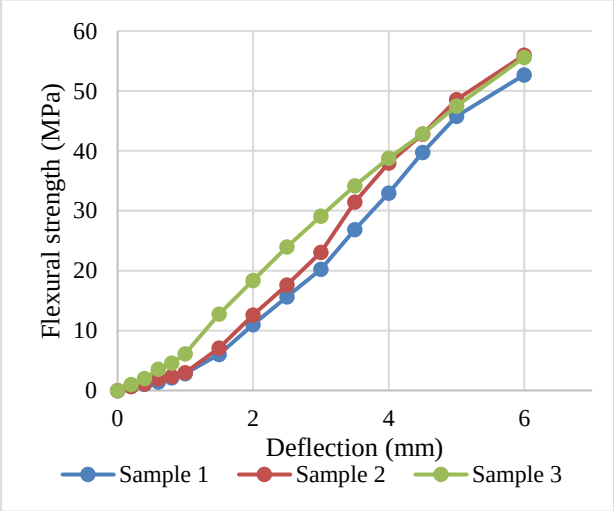


Figure 11. Flexural strength vs deflection curve for 45° orientation

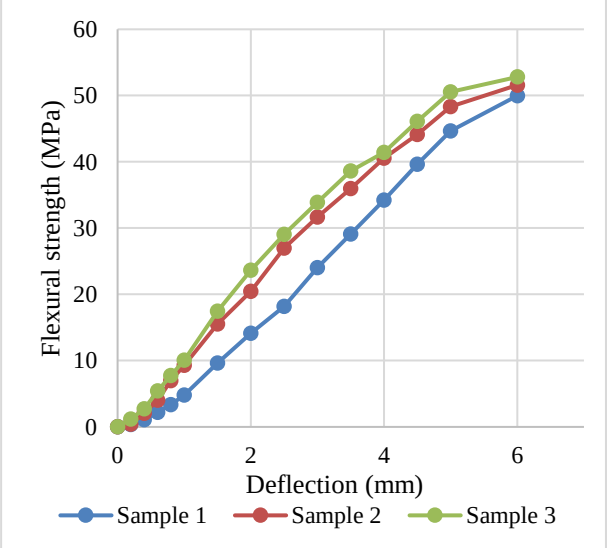


Figure 12. Flexural strength vs deflection curve for 60° orientation

4.3 Flexural Strength test

Flexural strength has been tested in a three-point bending tester machine. 3 samples of each specimen were prepared to investigate the flexural strength. Flexural strength was calculated by equation 2. With this eqn. and mentioned sample size flexural strength of 3 specimens were calculated and ploted in fig. 10 to fig. 12.
From the above flexural strength vs deflection curve, comparision among 3 samples flexural strength can easily done.

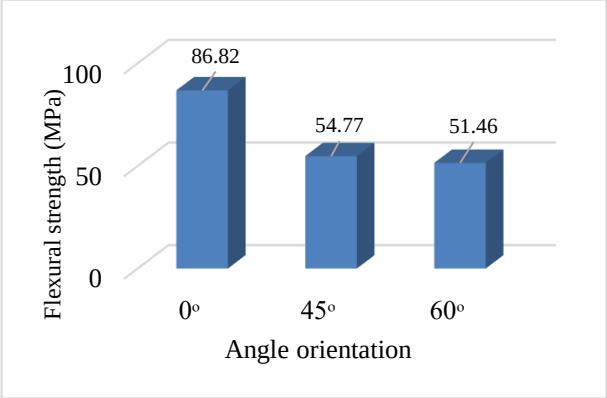


Figure 13. Ultimate Flexural strength comparison

From fig.13, the highest flexural strength in 0° orientation of jute fiber with glass fiber was found and it was about 86.82 MPa. This is because the load was acting along the fiber orientation which resulted in the highest flexural strength.

5. CONCLUSIONS

Jute and glass fiber reinforced hybrid composite with the effect of orientation of fiber has been successfully fabricated by hand layup technique and the mechanical properties of these composites have been successfully investigated. From the impact test, flexural strength test and hardness test, it was found that the impact energy, flexural strength and Rockwell hardness number decreases with the increase of fiber orientation angle. Finally, it was concluded that the best fiber orientation was 0° orientation because of its high value of impact energy, Rockwell hardness number and flexural strength.

6. ACKNOWLEDGMENT

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8. NOMENCLATURE

Symbol	Meaning	Unit
m	Mass	(Kg)
E	Impect Energy	(J)
h	Height	(mm)
L	Length	(mm)
b	Width	(mm)
F	Force	(Pa)
σ	Flexural Strength	(MPa)