IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 09 Issue 05, May 2022
ISSN (Online) 2348 – 7968 | Impact Factor – 6.72
www.ijiset.com

Investigation on Mechanical Strength of Synthetic, Natural and Hybrid Composite Laminates

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Abstract - Composites play a significant role as an engineering material and their use has been increasing day by day due to their specific properties such as high strength to weight ratios, high modulus to weight ratio, corrosion resistance and wear resistance. In composite material matrix and fiber play an important role; as the load is taken by matrix and transmitted to the reinforcement. Reinforcement can be either synthetic or natural fiber. Manufacturing of synthetic fibers is harmful from the environmental point of view; hence recent research work is focused on the use of natural fiber as reinforcement. In this current work jute as natural fiber taken into account for reinforcement along with synthetic glass fiber along with LY556 Epoxy resin and HY951 hardener. Three types of composites materials were prepared such as Glass-Epoxy unidirectional, Jute-Epoxy, Glass & Jute Epoxy hybrid composite laminates had been prepared using hand lay-up process and the testing was done by using ASTM Standards. The major properties that govern the strength of composites materials are tensile strength, compressive strength and flexural strength. The content of natural and synthetic reinforcement was found to be 60% and 40% respectively. The experimental results show that the Glass Epoxy composites give the major withstanding capacity for flexural and compression test, but in tension test Glass & jute epoxy reflects its higher mechanical strength. The additional use of jute with glass reduces the cost and thus it is eco-friendly.

Index words: Natural, Synthetic & Hybrid Composites, Mechanical Testing, Hand Lay-Up.

I. INTRODUCTION

Material science is an interdisciplinary field involving the properties of matter and its applications to various areas of science and engineering. It includes elements of applied physics as well as mechanical property, electrical engineering and civil. In material science rather than haphazardly looking for and discovering materials and exploiting their properties fundamentally so that new materials with the desired properties can be created. It involves relating the desired properties and relative performance of a material in a certain application to the structure of the atoms and phases in that material through characterization. A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions. The new material may be preferred for many reasons. Common examples include materials that are stronger, lighter or less expensive when compared to traditional materials. Typical engineered composites include reinforced concrete and masonry, composite wood such as plywood, reinforced plastics, such as fiber-reinforced polymers or fiber glass, ceramic and matrix composites, Metal Matrix composites and other advanced composites materials. Hybrid materials are composites consisting of two constituents at the nanometer or molecular level. Commonly one of these compounds is inorganic and the other one organic in nature. Thus, they differ from traditional composites where the constituents are at the macroscopic (micrometer to the millimeter) level. Mixing at the microscopic scale leads to a more homogeneous material that either show characteristics in between the two original phases or even new properties. Many natural materials consist of inorganic and organic building blocks distributed on the nanoscale. In most cases, the inorganic part provides mechanical strength and an overall structure to the natural objects while the organic part delivers bonding between the inorganic building blocks and/or the soft tissue. Typical examples of such materials are bone or nacre. The literature survey has to be conducted and as per our survey, we took a survey from the following paper. (1) Ramesh.et.al. investigated on the hybrid composites and the effect of various parameters on the performance of the hybrid composites are subjected to mechanical testing, flexural and impact tests. The results indicated that the jute composite material shows maximum tensile strength and the jute composite material shows the incorporation of sisal – jute fiber with GFRP can improve the properties and as an alternate material for glass fiber reinforced polymer composites. (2) Boopalan.et.al made a comparative study on the mechanical properties of jute and sisal fiber-reinforced polymer composites and concludes that the mechanical properties of the jute fiber-reinforced composites are higher thanthe sisal fiber-reinforced composites. (3)M.

Muthuvel.et.al investigated that the jute and glass fiber hybrid composite leads to the successful fabrication of Glass, Jute fiber and chopped fiber reinforced polyester composites with different fiber lengths is possible by simple hand lay-up technique. The mechanical properties of the composites like tensile, flexural and impact strength of the composites are also greatly influenced by the fiber lengths. (4) M Alamgir Kabir.et.al studied that with the increase of fiber loading the values of flexural strength and Charpy impact strength of composite material have been decreased. But the values of other mechanical properties remain almost the same. (5) Sanjay M R .et.al This experimental investigation on Jute - Glass Fiber Reinforced Polyester composites leads to the high tensile strength for the 50%-50% of glass & jute for flexural specimen 60%-40% of glass & jute shows higher flexural strength and for impact strength, 50%-50% of glass & jute shows higher impact energy. (6) Zhanh.et.al The tensile properties of the flax/glass fiber reinforced hybrid composites were improved with the increasing of glass fiber content. The interlaminar shear strength and the interlaminar fracture toughness of flax/glass fiber reinforced hybrid composites were higher than those of GFRP.(7) D. Dash.et.al Mechanical properties are decreased with decreasing in the total percentage of the reinforcement of the glass. (8) T. Munikenche Gowda.et.al concluded that although the mechanical properties of jute/polyester composites do not possess strengths and modules as high as those of other conventional composites, they can process better strengths than wood composites and some plastics. (9)Satish Pujari.et.al explores the potentiality of jute &banana fiber composites, emphasizes both mechanical and physical properties and their chemical composition. The utilization and application of the cheaper goods in the high-performance appliances are possible with the help of this composite technology. (10) Md Rafiquzzaman .et.al. glass-jute fiber polymer composites were studied, results showed that by incorporating the optimum amount of natural fibers, the overall strength of glass fiber reinforced hybrid composites can be increased and cost saving of more than 30% can be achieved. The utilization and application of the cheaper goods in higher performance appliances are possible with the help of this composite technology. Combining the higher properties of two different materials, lower manufacturing cost, versatility, etc., Hence with this background, it is concluded that, the composites stand the most wanted technology in the fast-growing trend.

Fig. 1.1 Glass Fibre

Fig. 1.2 Jute Fibre

II. EXPERIMENTAL STUDY

The material used in the project is selected on the basis of their properties. The materials are classified as synthetic and natural fibres based on their nature. Here we choose glass fibre as synthetic, jute as natural and Glass-Jute fibre composition as hybrid composites. Jute material show high corrosive resistance and comparatively low cost. Glass material is also well known for its heat resistance and corrosive resistant properties it shows high strength to less weight ratio thus combining both the materials shows combined mechanical properties for the materials obtained. To manufacture the composites there are so many methods that are used currently some of the manufacturing procedures are mainly classified into two types open mould and closed mould in open mould hand layup, spray up and filament winding processes are used. In closed mould vacuum bag moulding, vacuum infusion processing, Resin transfer moulding, compression moulding, pultrusion moulding, reinforced reaction injection moulding, centrifugal casting, continuous lamination process are used. We selected hand lay up process Since it is an easier process and more effective one. The fabrication process includes unidirectional laminate it includes the basic principle of hand lay up process with the binding of epoxy resin the process is done in three separate process as Glass epoxy composites, Jute epoxy composites and Glass-Jute epoxy composites. The fabrication of glass epoxy includes 12 ply of fibre mixed with 10:1 ratio of resin and binder, the geometry of jute epoxy includes 6 ply of jute fibre and the hybrid laminate is fabricated in the of 60 & 40 % as 6 ply of jute fibre and 4 ply of glass fibre, thus the fabricated composite is set to dry for 4 days and it is bought for testing. The final fabricated plates were cut into required dimensions for testing.

Fig 2.1 Hand lay-up Technique

TABLE 2.1 SPECIMEN DIMENSION

Specimen	**Dimension (in mm)**		
	Glass-Epoxy	Jute Epoxy	Glass& Jute Epoxy
Tension test	100x20x3.2	100x20x5.4	100x20x6.3
Compression test	30x30x3.2	30x30x5.4	30x30x6.3
Flexural test	100x15x3.2	100x15x5.4	100x15x6.3

Fig 2.2 Compression test Specimen

Fig 2.3 Tension test Specimen

Fig 2.4 Flexural test Specimen

III. TESTING PROCEDURE:

The various mechanical properties of the fabricated composites are carried out by different instruments for testing. The specimen was sized as per the ASTM standards for composite materials testing methods. The shimadzu AD-Xplus universal testing machine with strokerate of 0.0005 to 1000 mm/min and top load cell of capacity up to 50KN.

Fig 3.1 Shimadzu AD-X Plus Universal Testing Machine

3.1 TENSILE TEST

The tensile test was carried out by sizing the specimen as per the ASTM D3039 standard. Tensile testing is used to measure the force required to break a polymer composite specimen and the extent to which the specimen stretches or elongates to that breaking point. The specimen is loaded in the universal testing machine and load is applied until the specimen breaks. The maximum tensile load, tensile stress, displacements are noted and the stress-strain curve is generated.

Fig 3.1.1 Tensile test set up

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3.2 COMPRESSION TEST

The compression test was carried out by sizing the specimen as per the ASTM D3410 standard. The specimen is loaded in the universal testing machine and the compressive load is applied until the specimen breaks. The maximum compressive load, compressive stress, displacements are noted and the stress-strain curve is generated.

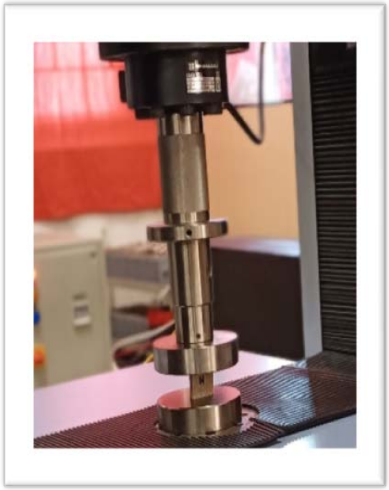


Fig 3.2.1 Compression test set up

3.3 FLEXURAL TEST

The flexural or three-point bending test was carried out by sizing the specimen as per the ASTM D7264 standard. Testing of flexural properties of polymer matrix composites using a bar of rectangular cross section supported on a beam and deflected at a specified rate. The specimen is lied on the support span and the load is applied to the center by the loading nose producing three-point bending at a specified rate.

Fig 3.3.1 Flexural test set up

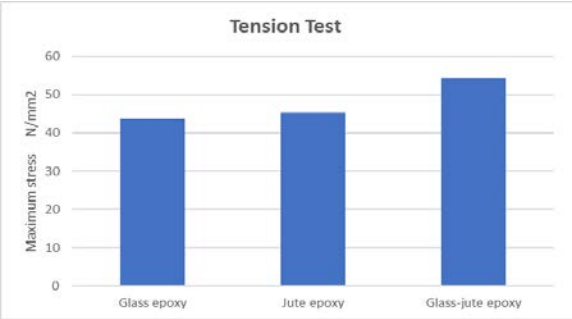
IV. RESULTS AND DISCUSSIONS

4.1 TENSILE TEST

The tensile test results shows that the Glass-Jute Epoxy laminate has higher tensile load carrying capacity and maximum tensile stress.

Composite material	Maximum stress N/mm2
Glass epoxy	**43.7036**
Jute epoxy	**45.3127**
Glass-jute epoxy	**54.1983**

Table 4.1.1 Experimental Values



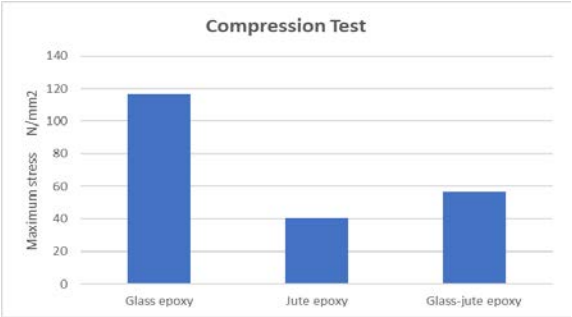
Graph 4.1.1 Comparitive stress curves for tensile test

4.2 COMPRESSION TEST

The compression test results shows that the glass fiber laminate has the higher compressive stress.

Composite material	Maximum stress N/mm2
Glass epoxy	**116.522**
Jute epoxy	**40.6425**
Glass-jute epoxy	**56.7664**

Table 4.2.1 Experimental Values



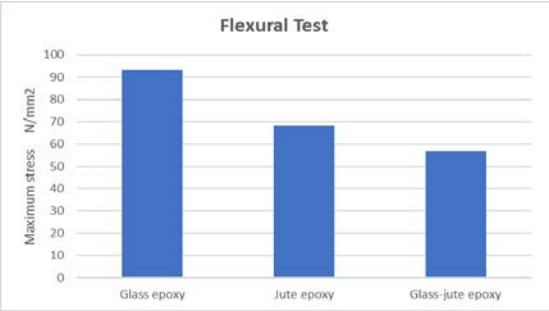
Graph 4.2.1 Comparitive stress curves for Compression test

4.3 FLEXURAL TEST

The flexural test results shows that the glass-jute epoxy laminate has higher load carrying capacity and the Glass Epoxy has higher flexural modulus.

Composite material	Maximum stress N/mm2
Glass epoxy	**93.293**
Jute epoxy	**68.072**
Glass-jute epoxy	**79.0762**

Table 4.3.1 Experimental Values



Graph 4.3.1 Comparitive stress curves for Flexural test

V. CONCLUSION

The experimental investigation on glass, jute, glass-jute fiber reinforced polymer composites with different fiber composition is possible by simple hand lay-up technique, it has been noticed that the mechanical properties of the glass-jute fiber reinforced polymer composites exhibit the higher tensile strength. While compression and flexural glass fiber reinforced composites exhibits higher compressive force. During the compression test, the glass-jute fiber doesn't withstand compressive force due to the delamination of plies. The addition of jute fiber to the glass fiber enhances its tensile load carrying capacity by 20%. The results showed that by incorporating the optimum amount of natural fibers, the overall strength of glass fiber reinforced hybrid composites can be increased and a considerable amount of mechanical properties could be achieved.

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