International Journal of
Electro Mechanics and Mechanical Behaviour

Journals Pub

Vol. 1: Issue 2
www.journalspub.com

Mechanical Characterization of Glass Fiber/Basalt Fiber Reinforced Epoxy Hybrid Composites

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ABSTRACT

In the course of the last two to three decades, composite materials have been utilized in various engineering fields. Composite materials possess high specific strength, corrosion-resistant property and low weight. Because of these facts, composites are becoming popular among scientists and researchers. In recent times, researchers working on variety of natural fibers to be used as reinforcing materials for composites instead of using carbon fiber, glass fiber and other man-made fibers. In the present work, basalt fiber and glass fiber reinforced epoxy hybrid composites were fabricated by hand layup method. Tensile, flexural and impact tests were carried out on prepared hybrid composites.

Keywords: *flexural test, hand layup method, impact test, tensile test*

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INTRODUCTION

Nowadays, composite is considered as an important material that can be used in any component in modern applications. A composite is a basic material that comprises at least two consolidated constituents that are joined at a macroscopic level and are not dissolvable in one another. One constituent is known as the reinforcing phase and the one in which it is implanted is known as the matrix [1]. The reinforcing phase material might be fibres, particles or flakes. The matrix phase materials are commonly continuous. The ongoing patterns request the composite having low weight with high quality and solidness. In this way, the present research work points toward to create diverse composite with low weight and improved mechanical property. Composite material strength relies on fibre and matrix property. Matrix property is to give adhesive strength and exchanges loads from fibre layer to other fibre layer [2, 3]. To get improved mechanical property and great wear conduct, composites are made with epoxy-based glass–basalt fibre with hybrid-reinforced composite. This is done to adapt to the demand in aerospace, automobile and sports industries.

Glass fiber has general equivalent mechanical properties to other fiber such as polymers and other carbon fibers, although not as rigid as carbon fiber. It is a lot less expensive and essentially less fragile utilized in composites. Glass filaments are in this manner utilized as reinforcing specialists for some polymer items to frame an exceptionally solid and generally

lightweight FRP composite material. This material contains little or no air or gas, is denser, and is much poorer thermal insulation than in glass wool.

In the course of the most recent years, basalt fiber has started to be utilized in a few applications, for example, assembling of CNG barrels which must be strong, lightweight and resistant to impact and temperature [7]. Mineral fibers obtained from basalt rocks are not new, but their suitability as reinforcement in polymer composite is relatively new. Basalt fibers are continuously extruded from the high-temperature melt of selected basalt stones [1]. The chemical structure of basalt is similar to that of glass, even though the density is slightly higher. Considering each material has its own characteristics and inherent limitations relative to other materials, hybrid structure that consists of more than one type of reinforcement fibers in a single matrix has been proposed to alleviate the weakness of single composite, and make these materials be of relatively lower cost and balanced performance [3]. Further, the strategy for hybridization gives us adaptability to tailor specific mechanical properties: precedent quality, solidness and sturdiness.

MATERIALS, FABRICATION AND MECHANICAL CHARACTERIZATION

Materials

Epoxy

In our present work, epoxy LY556 is taken as matrix material to manufacture hybrid composite materials. Epoxy is either any of the fundamental segments or the relieved final results of epoxy resins [4]. Epoxy resins, otherwise called polyoxides, are a class of reactive prepolymers and polymers which contain epoxide gatherings. The epoxy resins have anhydride-cured, low-viscosity standard matrix system with amazingly long pot life. It has good magnificent mechanical, dynamic and thermal properties. It has a fantastic chemical obstruction particularly to acids at temperatures up to 80°C. The reactivity of the system is customizable by variation of the accelerator content. Epoxy resins are a group of thermoset plastic materials which do not give reaction items when they fix; thus have low fix shrinkage. Hardener used for the present wok for the preparation of epoxy resin mixture is Araldite HY951. In this work, the optimum ratio of 10:1 is chosen for obtaining the best results.

Glass Fiber

GFRP is in all respects an ordinarily and broadly utilized polymer which is produced using very fine filaments of glass which is lightweight, solid and strong, which is a sort of plastic that uses glass fiber to build the quality and stiffness of plastic [4]. Woven roving of the filaments radically increases the tensile strength of the GFRP. While contrasted with metals, it has better mass quality and other mechanical properties. Because of its formable nature, it is utilized in numerous composite applications as reinforcements. Glass is one of the strongest material strands having more prominent explicit elasticity than steel wire of a similar diameter across, at a lower weight [2]. Glass textures have amazing heat opposition at generally low cost. Being inactive, glass fibers are unaffected by daylight, fungus or bacteria. Like glass itself, fiberglass fabrics are exceptionally impervious to assault by generally synthetic substances. Table 1

Table 1. *Properties of glass fiber.*

Property	Value
Tensile strength	2.5 GPa
Elastic modulus	76 GPa
Density	2.55 g/cm^3

Basalt Fiber

Basalt fiber is selected as another reinforcing material along with the glass

fiber to fabricate hybrid composite material. Basalt fiber of size 200 GSM was used in our work. Basalt is an igneous rock framed as a result of magma cooling on the outside of the earth which is a standout amongst the most widely recognized rocks on the earth's crust [6]. The creation of the basalt fiber is like the generation of glass fiber which is drawn into non-stop fiber by melting rock and drawn it at around 1500°C. When compared with carbon and Kevlar, it withstands temperature ranges from 280° to 640°C [7]. It opposes oxidation and radiation which makes it appropriate for structure development alongside great shear and pressure quality [8]. Basalt fiber is a material produced using incredibly fine strands of basalt, which is made out of minerals, for example, plagioclase, Pyroxene and Olivine. Table 2

Table 2. *Properties of basalt fiber.*

Property	Value
Tensile strength	2.9 GPa
Elastic modulus	86 GPa
Density	2.67 g/cm^3

Fabrication

Hand layup

The fabrication of composite laminates is carried out by traditional hand layup technique. Hand layup is an open mold technique suitable for making a wide variety of composites from very small to large. Hand layup is the least difficult composite-forming technique, offering minimal effort tooling, basic handling and a wide range of part sizes [5]. Cutting the glass fiber and basalt fiber fabric according to the dimensions and arrange fibers in desired sequence to produce hybrid composite. Figure 1 shows the specimen made using hand layup method. The 10% of hardener is mixed with the epoxy to initiate cross-linking reaction and the formation of gel. Then spread the blend on the mold, and then place the glass and basalt fibers one by one till the required thickness is achieved. After the finishing of the laminate, apply the weight on the laminate and keep it for 24 hours for healing. After the curing, specimens are prepared for each laminate to carry out distinct testing according to the standards [4].

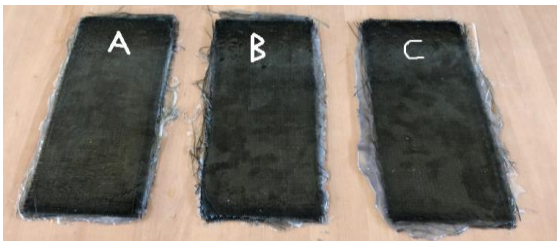

Fig. 1*. Specimen prepared by hand layup method.*

Table 3*. Classification of composites and its composition.*

Composites	Glass fiber %	Basalt fiber %	Epoxy resin %
A	20	40	40
B	30	30	40
C	40	20	40

Mechanical Characterization

Mechanical properties of glass and basalt fiber hybrid composites were performed on prepared materials. Tensile, flexural and impact tests were conducted on the universal and impact testing machine separately as per ASTM principles. The ASTM standards for tensile, flexural and impact tests are ASTM D638, ASTM D790 and ASTM D256, respectively. The tensile test is the most normally utilized mechanical test in which specimen is exposed to progressive stacking until it breaks/fails [4]. Flexural strength is one of the major mechanical characteristics of any material. Flexural strength is the capacity of the composite material to withstand bending loads applied perpendicular to its longitudinal hub until it cracks or begins yielding forever utilizing with three-point flexural test procedure. Impact strength is the capacity of the material to withstand a suddenly applied force or it can likewise characterize as the capacity of the material to retain mechanical energy during the time spent on deformation and break under impact loading. According to ASTM D256,

the impact tests were carried out on the impact testing machine. Figure 2 shows the specimen for various mechanical testing [5,9-10].

RESULT AND DISCUSSION

Mechanical properties like tensile strength, flexural strength and impact strength were analyzed for glass fiber and basalt fiber hybrid epoxy composites, and their outcomes are discussed as follows.

Tensile Test

Tensile test results for hybrid composites are as shown in Figure 3 and Table 3. By examining the results, it is seen that composite A with 40% of basalt fiber, 20% of glass fiber and 40% of epoxy resin has displayed great rigidity of 280 MPa compared with others [4]. And furthermore, by watching the pattern, it can be observed that with increment in basalt fiber rate in the composite, the rigidity was improved significantly.

Flexural Test

By conducting flexural test on prepared hybrid composite laminates of different composition, we get the result. The graph is plotted as shown in Figure 4. By investigating the results acquired, it tends to be seen that composite B has displayed great flexural strength of 448 MPa followed by composite C with 416 MPa and specimen A having low flexural strength of value 374 MPa.

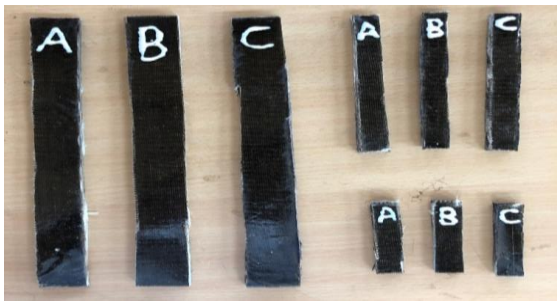

Fig. 2. *Hybrid composite specimen A, B and C for tensile, flexural and impact tests.*

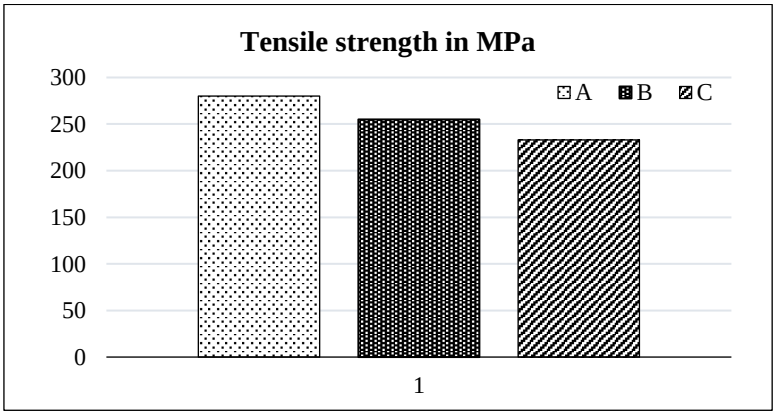

Fig. 3. *Tensile test results.*

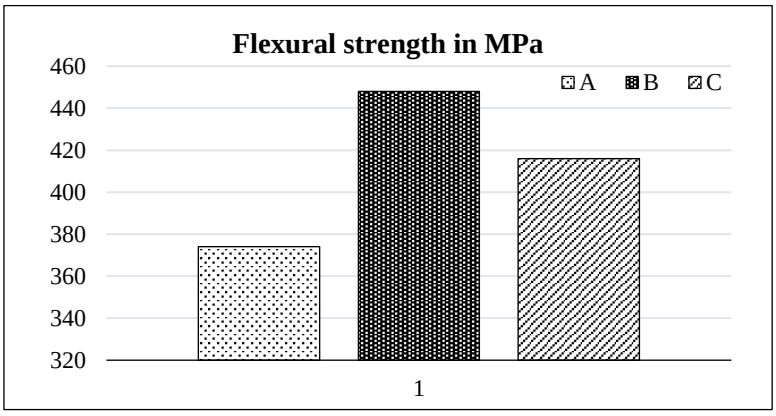

Fig. 4. *Flexural test results.*

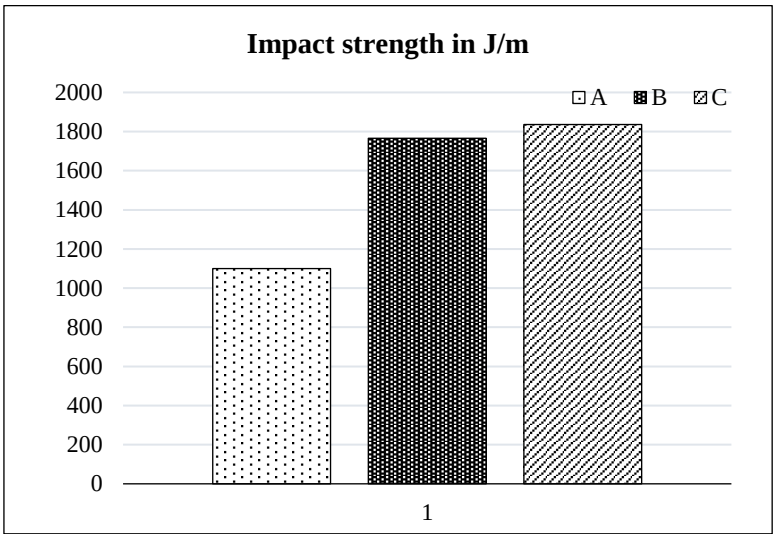

Fig. 5. *Impact test results.*

Impact Test

Impact test is conducted for the prepared specimen and the results were obtained and plotted as graph as in Figure 5. From the test and chart investigation, it is seen that composite C with 20% of basalt, 40% of glass and 40% of epoxy resin has displayed great impact quality of 1836 J/m compared with others.

CONCLUSIONS

In this study, the effect of hybrid composite with different composition ratios on the tensile, flexural and impact properties of the glass/basalt hybrid composites was experimentally evaluated. Based on the experimental results and analysis, the following conclusions were made:

- Hybrid composite laminate with varying hybrid ratio of glass fiber and basalt fiber as reinforcement and epoxy as matrix fabricated using hand layup method.
- By investigating tensile test result, it is noticed that material A with 20% glass fiber, 40% basalt fiber gives higher strength than laminates B and C with glass and fiber 30%, 30%, 40% and 20%, respectively.
- By analyzing the flexural test, it is seen that the laminate B has the highest strength followed by C and A, respectively.
- Impact test result shows that the laminate C with glass and basalt in 40% and 20%, respectively, has higher impact energy than the other two types A and B.
- From the mechanical characterization, it is observed that the by hybridization of glass and basalt hybrid composite will give better significant improvement in the mechanical properties [5, 9, 10].

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Cite this Article: Shafiyulla, Nishan Fernandes, Sheik Afridi, Suhayil, Sudesh Shetty, Susilendra Mutalikdesai. Mechanical Characterization of Glass Fiber/Basalt Fiber Reinforced Epoxy Hybrid Composites. *International Journal of Electro Mechanics and Mechanical Behaviour*. 2019; 1(2): 17–22p.