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Mechanical Behaviour of Glass and Carbon Fiber Reinforced Composites

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Abstract

Components made with fiber reinforced composites are replacing components made with the conventional materials is due to holding superior mechanical properties and high specific strength with good corrosion resistance. These favourable attributes are not possible with a conventional monolithic material. Composites are developed with matrix and fibers as reinforcement material, the reinforcement fibers are playing a crucial role to attain a high strength property. Glass and carbon fibers are using in the development of polymer composites as fiber materials. In this study, composites were developed with hand lay-up method using epoxy as resin matrix material and glass or carbon fibers as reinforcement materials. The tensile, compression and flexural strengths are evaluated at room temperature and compared the properties of glass and carbon fiber composites. It is observed that the composites made with carbon fibers holds superior properties than the composites developed with Glass fiber reinforcement. It is also observed that a significant enhancement in tensile, compression and flexural strengths are achieved for carbon fiber reinforced composites is because of Carbon fibers are high strength fiber as compared to glass fiber. Carbon fiber composites achieved an improvement of 46% in tensile strength, 48% in compression strength and 67% enhancement as compared to glass fiber composites.

Keywords: Epoxy composite, glass fiber, Carbon fiber, tensile strength, compression strength

INTRODUCTION

The development of engineering materials with modern technology is inevitable for the better future. As the levels of technology increases, the use of materials has to be made more efficient and economical. composite materials are manufactured using more than one material. This composite material comprises a high strength and stiffness properties to withstand for different loads without fracture. Composites materials holding better properties that cannot be obtained with any other made with a single monolithic material [1,2]. Composites are fabricated with two materials such as matrix which acts as body and reinforcement materials which increases the strength. The strength of the composite is based on fiber shape and direction, fabrication process and volume of fibers, theoretically defined as more the volume of fibers more the strength of composites. Additionally, composites are fabricated in required shape and size, this reduces machining operations leads to reduces the production cost [3,4]. Nowadays the researchers are working on fabrication of fiber composites for the sophisticated mechanical and structural properties for the emerging fields of automotive and aerospace [5]. Polymeric based composites are found in many engineering applications due to beneficial properties like good strength, corrosion resistance and fatigue strength [6,7]. These properties are mainly due to two elements such as type of

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reinforcements and polymer. Few composites hold less compression to tension strength property and this is the main reason for not using in some applications [8]. In past years, the use of Glass fiber and Carbon fiber composites are being increased to in the application of aerospace and naval components. Composite materials particularly carbon-epoxy composites are strength bearing materials which are useful in aerospace like re-entry vehicle structures of missiles, aircraft structures. Reddy et al. [9] studied the mechanical properties of Glass fiber epoxy composites. Yerramalli [10] studied glass/carbon composites with addition of fiber volume of 30% and observed that some splitting and kinking failures in composites in static as well as dynamic loadings. Zhang et al. [11] studied the properties of glass-fiber and carbon-fiber reinforcements after developing through wet lay-up and found that this technique not suitable to develop best composites. With addition of some strong reinforcement materials like silicon carbide or alumina enhance the strength and hardness of composites. [12,13]. Yeon-Jae Jeong et al. [14] evaluated the mechanical properties of glass and carbon fiber composites based on length and structural anisotropy. Apart from few more researchers are also worked to develop composites with the use of glass and carbon fiber as reinforcement materials [15-17]. The latest technology trend to develop the glass fiber and carbon fiber composites is additive manufacturing technique [18,19]. From the available literature, it is found that limited research has been conducted using polymer matrix with reinforcement fibers as Glass and Carbon materials. This work proposes the development of composites using Glass and Carbon reinforcement materials and evaluation of tensile, compression and flexural strength properties.

EXPERIMENTAL DETAILS

For Glass fiber composites, epoxy resin is considered as matrix and glass as fiber material. The glass fiber mat is of 200 grams per square meter with a density of 2.5 gm/cc and length of 200 X 200 mm was used. Glass fiber composites were developed using hand layup method. The resin and hardener were mixed properly and stirred persistently. The glass mats were developed as per size and kept one mat in the mold and resin and harder mixture is applied on the mat surface with brush uniformly. Later, a second mat is placed on the mixture surface and placed the third mat. In case of Carbon composites preparation, the mats of Carbon fibers were placed alternately laminated with resin and harder mixture. Carbon fibers mat is of 200 grams per square meter and density of 1.78 gm/cc were used to develop Carbon composites. The entrapped air in laminates is removed with the help of rollers manually. In Vacuum bagging technique, a pressure of 0.1millibars is maintained in the mold, resulting in uniform distribution of resin and removal of leftover air between the mats. The prepared composites were drawn from the mold and specimens were sliced according to dimensions as per standard guidelines of ASTM D638 for the evaluation of tensile, compression and flexural properties. Specimens were prepared as length of 60mm, breadth of 12mm and thickness of 3mm. Mechanical properties of prepared composite specimens were evaluated on Universal Testing Machine (UTM) at room temperature. Specimens were placed between the grippers of the testing machine and tensile load was applied until fracture. The maximum consumed load and elongation were recorded in the data logger which is connected to the machine. Furthermore, maximum tensile strength is recorded at the time of specimen fracture. For compression strength measurements, the specimen was placed in between the grips of UTM and applied compressive load up to fracture of the specimen. The developed load and elongation values were calculated from the data logger and maximum compression strength is recorded at the time of specimen fracture. Flexural strength property of prepared composite specimens was evaluated in flexural testing machine at room temperature. Specimens were placed in two grippers of UTM machine and load is applied. The load is applied until the fracture occurred in the specimen and flexural strength is calculated. All the tests were repeated three times and the average values are taken into consideration for the evaluation of properties.

RESULTS AND DISCUSSIONS

The Glass fiber composites and Carbon fiber composites were fabricated and sliced specimens for testing purpose as shown in Figure. 1. Figure. 2 illustrates fractured specimen after tensile testing and

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Figure. 3 illustrates fractured specimen after compression testing. Figure. 4(a) exhibits the effect of Glass and Carbon fibers on tensile strength of composites. It is observed that the tensile strength of Carbon fiber (514 MPa) is higher than Glass fiber (352 MPa) composites. Carbon fiber composites exhibits an improvement of 46% in tensile strength as compared to glass fiber composites. Figure. 4(b) illustrates the influence of Glass and Carbon fibers on compression strength. It is observed that the compression strength noted for Carbon based composites is 135 MPa and whereas, Glass fiber composites is 91 MPa and there is a significant improvement in compression strength of 48%. Fig. 4(c) shows the effect of Glass and Carbon fibers on flexural strength of composites. It can note that the flexural strength is obtained for Glass fiber composites is 226 MPa and for Carbon fiber composites is 337 MPa and there is very significant improvement was noted as 67%. Enhancement in tensile, compression and flexural strength of Carbon fiber composites is due to high strength carbon fibers and these fibers are attributed with elasticity and glass fiber attributed with brittle [20].

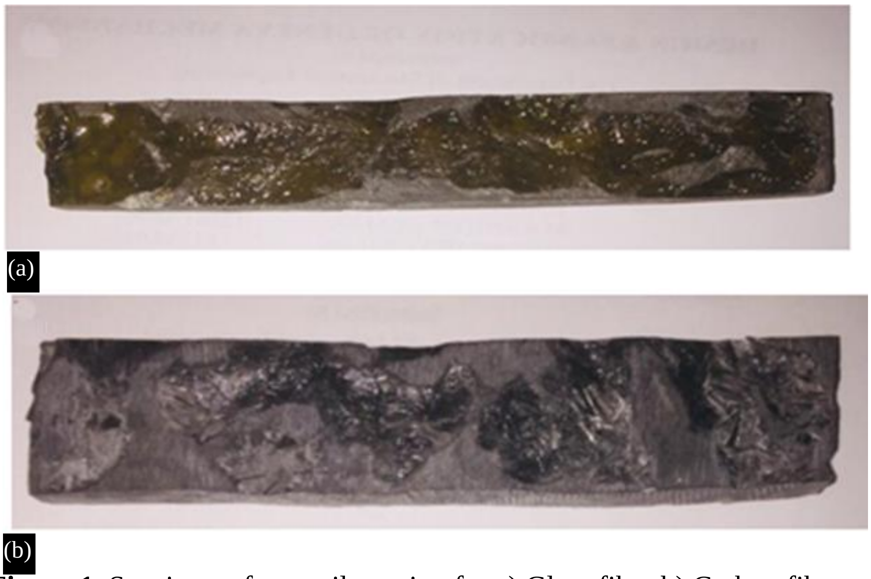

Figure 1. Specimens for tensile testing for a) Glass fiber b) Carbon fiber composites.

Figure 2. Fractured specimens after tensile testing for a) glass fiber b) carbon fiber composites.

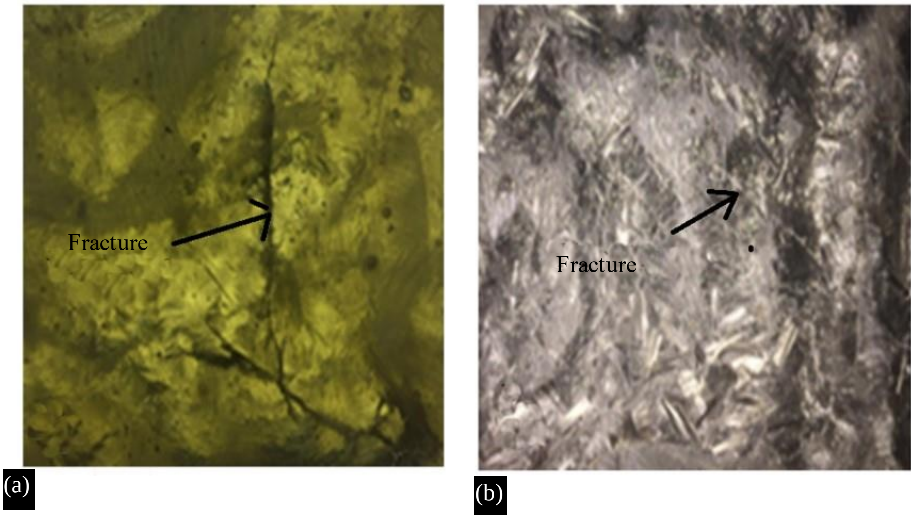

Figure 3. Fractured specimens after compression testing for a) glass fiber b) carbon fiber composites.

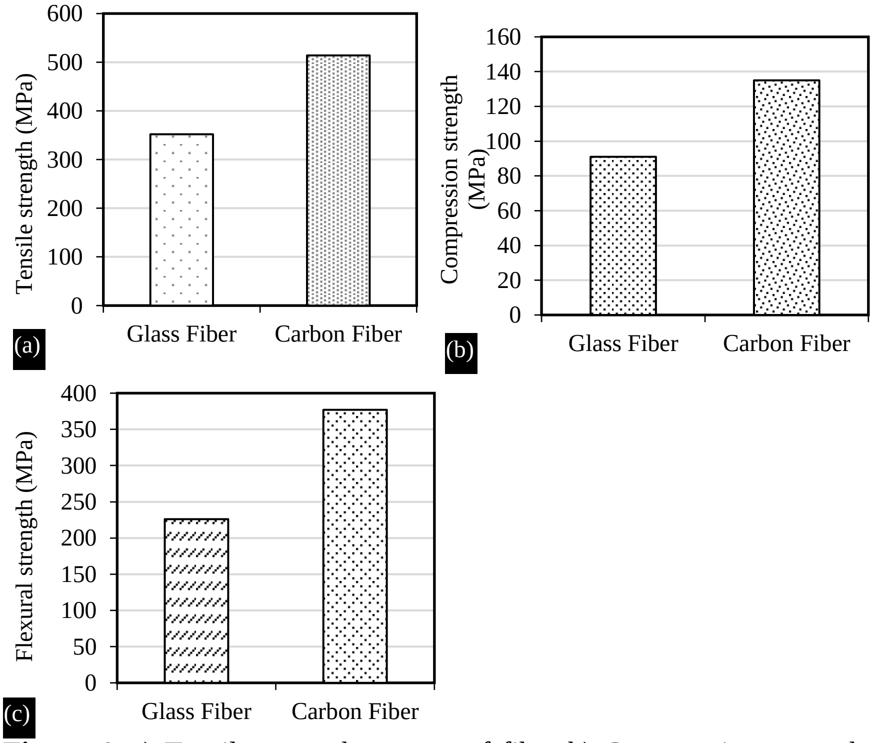

Figure 4. a) Tensile strength vs type of fiber b) Compression strength vs type of fiber c) Flexural strength vs type of fiber.

CONCLUSIONS

Composites were developed successfully using Glass and Carbon fibers as reinforcement materials. Carbon based composite shows better tensile, compression and flexural properties when compared with glass fiber-based composites. A significant enhancement is achieved with use of Carbon fiber reinforcement material, there is a 46% of improvement in tensile strength, 48% improvement in compression strength and 67% of improvement in flexural strength are achieved for composites which were made from Carbon material as reinforced fibers.

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