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(Research Article)

Experimental Study on Torsional Strength of GFRP and Copper Mesh Embedded Hybrid Composite

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Abstract

Fiber-reinforced polymer-matrix composites have been widely applied in various areas due to their excellent mechanical properties. The hybrid composite that was employed in this study is typically a GFRP (Glass Fiber Reinforced Plastic) composite. This type of hybrid composite consists of layers of fiberglass that are interspersed with a copper strip mesh that has a plain weave. Both GFRP composites and hybrid composites were fabricated using 20% weight of e-glass fiber as reinforcement. Epoxy resin LY556 was utilized as the substance for the matrix. The torsion strength of GFRP and hybrid composites is one of the aspects that are investigated in this work. The GFRP composite has more torsional strength as compared to the hybrid composite. This is because hybrid composites have coper strips in between them, resulting in some unfused areas, whereas GFRP composites have all of the fibers completely fused into the resin. The GFRP composite has approximately 58 % more torsional strength.

Keywords: Copper strips mesh, Epoxy Resin, E-Glass Fiber, Torsion, GFRP, etc.

1. Introduction

The polymer matrix of FRP is what holds the reinforcing fibers together in this composite material. In the context of FRP composites, reinforcements are frequently referred to as "fibers," regardless of whether they are made of natural or synthetic materials. Carbon fiber, fiberglass, aramid fiber, and basalt are just few of the many types of fibers that are utilized on a consistent basis. In addition, several kinds of fibers, including as asbestos, paper, and wood, are used in the manufacturing process. Many natural fibers have a lower density than synthetic fibers, which leads in the natural fibers having a lower total weight. This is because the density of natural fibers is lower. The three forms of polymer matrix that are utilized the most frequently are epoxy resin, vinyl ester resin, and polyester resin. When high performance is necessary, FRP is a material that is commonly used not only in the aerospace and marine sectors, but also in the automotive industry [1-2]. The matrix is made up of a durable but brittle plastic that contains a large quantity of additional reinforcing that is of a strong nature [3]. The mechanical and physical qualities of both the fiber and the matrix have an effect on the degree to which the properties of strength and elasticity are enhanced in FRP composites. This effect is proportional to the amount of improvement in the properties. Other attributes, such as the weight of the fiber and the matrix, the length of the fiber, and the orientation of the fiber inside the matrix, all have a role in the outcome [4]. According on the findings of previous studies, we are able to draw the conclusion that some modifications may be made to polymer matrix composites by including a wide range of different filler materials in order to get the outcome that is sought. Borosilicate glass microspheres were mixed into epoxy composites in order to bring about the desired change [5]. Incorporating copper metal powder into the matrix, which results in the development of a hybrid composite [6]. Production of hybrid composites with the incorporation of waste products like fly ash [7]. The addition of iron fillers to a composite made of glass fiber reinforced plastic (GFRP) [8]. One potential use for this is the creation of metal matrix composites [9].

2. Composite Laminates Preparation

When making composite, the hand lay-up [10] technique is the method of choice. The production of composite material involves a number of stages.

At the very beginning of the procedure, the surface of the mold is prepared for use by being cleaned with acetone. Because of this, any dirt that could have been on the surface of the mold

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will now be removed. After that, a very thin layer of wax is placed, and it is left to sit for a quarter of an hour. Afterwards, the wax is removed. When we use PVA as a release agent, we also utilize wax since using PVA too frequently might harm the mold. Wax is employed to prevent this damage. Following the application of a thin coating of PVA (Poly Vinyl Alcohol), which is then allowed to cure at room temperature for forty-five minutes, the wax layer is allowed to become completely dry. Following that, a second coating of PVA is likewise applied to the surface. This layer is considerably more substantial than the one that came before it, and it also requires an additional half an hour to dry when left out at room temperature. Following the application of PVA to the mold on many occasions, the quantity of epoxy resin and fiber glass is determined. We utilize about twenty percent (20%) of the total weight in fiber glass. An electronic scale with an accuracy of within 0.1 gram is used for all of the measurement that has to be done. Snips does both the cutting and weaving of the 35-gauge copper sheet by hand. The sheet is cut by hand. Before beginning to make woven copper strip mesh, the sheet of copper is first cut into strips of 350 millimetres in length and 4 millimetres in width. This is due to the fact that the strips are cut by hand to a consistent thickness of 0.213 millimetres. Following this step, the strips are weaved with a gap of 4 mm, as seen in Figure 1. It is necessary to have this space because when we use plain metal sheets, the epoxy does not adhere to them very effectively. Because of this, there must be some distance between the two of them.

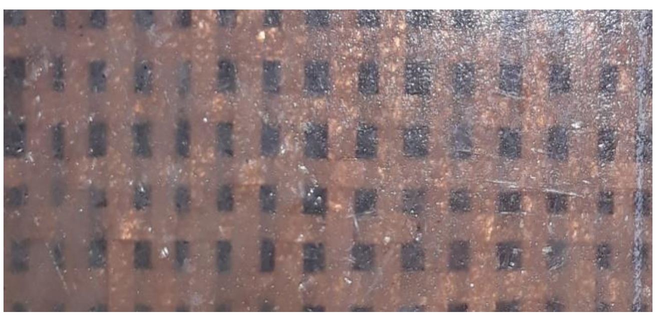

Figure 1. Woven copper strips

3. Torsion Test Procedure

Torsion testing involves twisting a sample along an axis, and it is a useful test for acquiring information such as torsion shear stress, maximum torque, shear modulus, and breaking angle of a material or the interface between two materials. Torsion testing can be performed on a single sample or on the interface between two samples. Tests of torsion can be carried out either directly on the sample being examined or on the interface between the two materials being analyzed. The vast majority of the time, a longitudinal sample is placed inside a torsion tester, and then one end of the sample is twisted along the long axis until it breaks [11]. During this period, the force, or in the case of rotation, the torque, and the displacement, or in the case of rotation, the angular displacement, are both recorded. In the event of rotation, the angular displacement is measured in degrees. Both the GFRP sample and the hybrid composite sample are inserted into the torsion testing machine, as illustrated in Figure 2 and 3, respectively. This is done so that the results of both tests may be compared. Torsion testing is appropriate for materials that may experience a torsional load, such as a metallic bone screw, an intramedullary rod, rubber tubing that may become twisted, or to measure the shear strength of a bond between an implant and native tissue like bone. Examples of these types of materials include a metallic bone screw, an intramedullary rod, and rubber tubing that may become twisted. An intramedullary rod is another example of a material that may be subjected to a torsional load.

For the purpose of evaluating the torsional strength of both composites, the ASTM-E143-02 test standard was applied.

Figure 2. GFRP composite in torsion testing machine

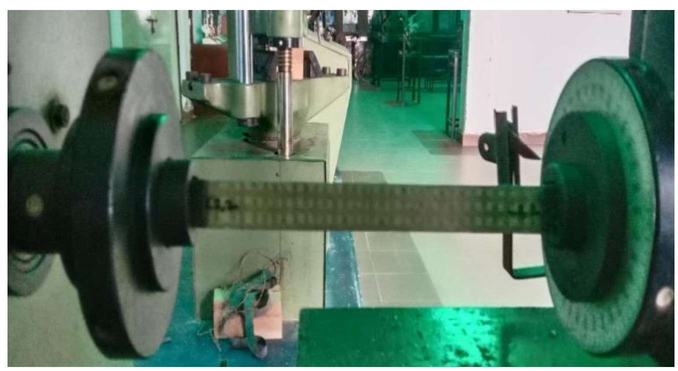

Figure 3. Hybrid composite in torsion testing machine

4. Experimental Results

The hybrid composite has torsion of 4.3 Newton-meters, whereas the GFRP composite has a torsion of 6.8 Newton-meters which is shown in Table 1. Because of the presence of copper strips mesh in between the layers of fiberglass, torsion in hybrid composites is significantly lower when compared to other improved mechanical properties found in earlier research (as shown in Table 2). This is due to the fact that the hybrid composites contain copper strips. The distance between them is currently set at 4 millimeters, but this can be decreased or raised to provide the epoxy with additional space to bond.

Table 1. Result comparison of torsion for both composite

Sample code	Composite type	Torsion (N.m)	Angle of rotation (degree)
C1,1	GFRP	6.8	195
C2,1	Hybrid	4.3	198

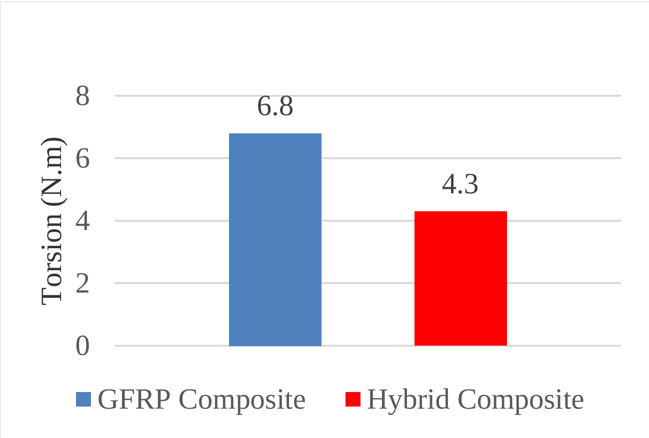

Figure 4. Comparison of torsion of both composites

The above figure 4 shows the graphical representation of torsion of both hybrid and GHRP composite.

Table 2. Experimental results from our previous research[12]

Sample code	Composite type	Test name	Result value	Unit
C1,1	GFRP	Tensile	59.3	(N/mm2)
C2,1	Hybrid	Tensile	69.0	(N/mm2)
C1,2	GFRP	Flexural	124.4	(N/mm2)
C2,2	Hybrid	Flexural	160.5	(N/mm2)
C1,3	GFRP	Izod impact	60.677	(Kg.cm/cm)
C2,3	Hybrid	Izod impact	93.613	(Kg.cm/cm)
CII	GFRP	Density	1.2409	(gm/cm3)
CI	Hybrid	Density	1.9508	(gm/cm3)
CII	GFRP	Shore D hardness	65	Shore D
CI	Hybrid	Shore D hardness	74	Shore D

5. Conclusion

Because the hybrid composite contains a copper mesh sandwiched in between the layers of fiberglass, the torsional strength of the GFRP composite is significantly greater than that of the hybrid composite. Although the layer of metal is not fully attached to the epoxy, it does a good job of increasing the other mechanical characteristics of the GFRP composite, such as its flexural strength, tensile strength, and impact strength. This may be investigated further by widening the distance between the solid copper strips in the mesh so that a suitable connection can be formed using epoxy. The torsional strength of the GFRP composite is increased by about 58%.

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