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THE EFFECT OF ARRANGEMENT AND SYMMETRY IN GLASS AND CARBON FIBER REINFORCED EPOXY MATRIX HYBRID COMPOSITE ON FLEXURAL TEST.

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Abstract— **Polymer matrix composites have wide engineering applications where strength-to-weight ratio, high dimensional stability, high chemical resistance, low cost and ease of fabrication are required. Hybrid composites offer a range of mechanical properties that are difficult to achieve in composites containing one type of fiber. Recently, hybrid vehicles have been established as high-efficiency, high-performance structural materials and their use is rapidly increasing. Hybrid composites are typically used when combinations of properties of different types of fibers need to be achieved, or when longitudinal and lateral mechanical performance is required. In this study, the bending strength of a carbon- and glass-fiber-reinforced hybrid epoxy matrix composite was studied and to know the effect of the arrangement of glass and carbon fibers in building composite materials on the bending strength with respect to symmetry by angles and symmetry by layers. The results showed that the bending strength of the hybrid composite symmetric in the corners and asymmetric in the arrangement of the layers of carbon and glass has improved significantly compared to the hybrid compound symmetrical in the angles and symmetrical in the arrangement of the layers of carbon and glass**.

Keywords— **Hybrid composite, Flexural Strength, Resin Transfer Molding, Glass Fiber, Carbon Fiber.**

I. INTRODUCTION

Composite is a structural material made from two or more chemically different constituents combining at a macroscopic level to produce useful material with different properties. Designing a new composites or modifying existing composites is a real challenge for most materials engineers[1, 2] Matrix gives the required shape of the product whereas the reinforcement phase enhances the required strengths of the matrix material. Composites are widely used because of light weight, higher fracture toughness, Corrosion resistance. The mechanical properties such as tensile, flexural and impact strength depend on the orientation of fibre, fibre-resin ratio, number of plies and type of fiber and matrix[3, 4] Some compounds have many limitations because the fibers (glass, Kevlar, and carbon) have a difference in some specific mechanical properties. To solve this problem, hybrid composite materials are used. Hybrid composites have better behavior and mechanical properties compared to these single fiber composites [5-8]. Due to the tremendous properties achieved by hybrid materials, we find that they have become important in many industries such as construction, aviation and automobiles. A large number of researchers have investigated the properties of hybrid compounds under loading to study the mechanical properties of these materials. Previous studies into the effects of hybridization on the flexural properties of fiber-reinforced composites have shown varied results. The bending properties of hybrid glass and carbon-fibrereinforced epoxy composites were studied using a hand lay-up process in the formation within the layers of varying degrees of glass fibers added to the surface of the carbon sheets. Flexure behavior was also simulated using finite element analysis, and the bending modulus, bending strength and stress to failure were calculated. It was found that the bending modulus decreased with the increase of the percentage of glass fibers[9].. The bending properties of the hybrid composite were verified by experiment comparison and finite element analysis. Their results showed a decrease in the bending modulus of carbon fiber reinforced plastic (CFRP) with an increase in the number of fiberglass layers[10].The bending strength of epoxy carbon fiber glass-carbon hybrid matrix composites has been individually studied and studied extensively. It was found that the bending strength of the hybrid composite was significantly improved compared to that of the glass-fibre-reinforced composite/carbon-fibre-reinforced composite[11]. The bending properties of homogeneous carbon-fiberglass-reinforced hybrid composite sheets have been studied. Finite element aided analysis (FEA) was performed and the model was experimentally validated. It turns out that the hybrid composite has the highest flexural strength when it contains half carbon/epoxy layers and half

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glass/epoxy layers[12]. In this study, the flexural behavior of symmetric carbon and glass fibre reinforced hybrid composites was studied in greater depth for identifying if any hybrid effects exist. Various fibre volume fractions of both carbon and glass fibres were studied.

A. MATERIALS AND METHODS

Material preparations:

In this study, glass and carbon fiber reinforced epoxy matrix hybrid composite, two samples were fabricated was made one of samples symmetric in angles GA (0C0/90G0/90C0/0G0)s, and sample two is symmetric in type of reinforcement and angle orientations GB(0C0/90G0/90G0/0C0)s. The laminas in a composite laminate can be situation up in different orientations based on the properties required by using VARTM process[13]. In this, the properties of a laminate in different orientations are studied to obtain a laminate with optimum properties in all directions. Test plates were prepared; unidirectional carbon and glass fibers were cut to 300 mm x 300 mm before placing the fiber reinforcements. A die release agent has been applied to the flat Glass die to prevent the finished plate from sticking to the Glass die. Then, carbon fibers and e-glass were carefully stacked on the flat glass mold with the directions: GA [CGCG]s for sample one and GB [CGGC]s for sample two, where C and G are carbon fibers and glass fibers, respectively. Once the arrangement of the slides was completed, the air in the vacuum bag was removed by the vacuum pressure which was in the range of 10-20 mbar. Then, a mixture of epoxy resin and hardener was prepared in a ratio of 4:1 and soaked in the mold cavity under vacuum pressure. The plate was left soaked for 4h in woven under temperature 1100C and after that Placed under room temperature for 24h to complete the curing process. The finished treated plate was then cut into the required sample sizes for various flexural tests. Fig 1-6 shows the composite preparation.

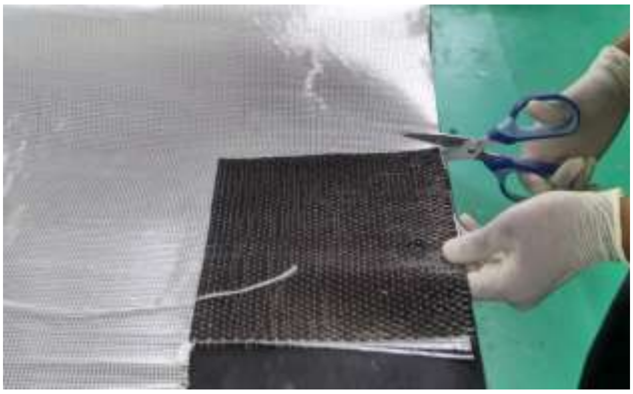

Fig.1. preparation of Glass and Carbon

fig.2. Glass and Carbon in the flat mold

fig.3. RTM Process

fig.4. Pump of RTM process

Fig.5. Hybrid composite of GA & GB

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fig.6. preparation of Epoxy

Flexural test:

Three-point flexural testing were conducted according to the ASTM D7264[14] standards. The specimens were machined for the dimensions of 130mm × 13 mm × 4.2 mm (GA & GB). The span of the specimens was considered 84mm. For this testing, the load cell of 100KN was utilized with the crosshead speed of 1mm/min. The test was performed four times for each sample, and abnormal results were excluded, Loading of bending specimen was done as shown in fig 7.For ASTM D7264, the test is stopped when the specimen reaches 5% deflection or the specimen breaks before 5%. The test is stopped when the specimen breaks. If the specimen does not break, the test is continued as far as possible and the stress at 3.5% (conventional deflection) is reported. The three points bending flexural test provides values for the modulus of elasticity in bending, flexural stress, flexural strain and the flexural stress-strain response of the material. The main advantage of a three point flexural test is the ease of the specimen preparation and testing[11]. The test method for conducting the test usually involves a specified test fixture on a universal testing machine. Details of the test preparation, conditioning, and conduct affect the test results. Calculation of the flexural strength (σ_f) for rectangular cross-section is as follows[11]:

$$\sigma_f = \frac{1.5FL}{bd^2}$$

Where:

σf is Flexural strength, (MPa), F is load at a given point on the load deflection curve, (N), L is Support span, (mm), b is Width of test beam, (mm) and d is Depth of tested beam, (mm).

Fig.7 Loading of bending specimen

II. RESULTS AND DISCUSSION

For each type of reinforcement, three specimens were tested experimentally, conforming to the appropriate ASTM standards. For each specimen, the initial dimensions were measured, and then maximum load (F), i.e. the force causing the flexural stress in the specimen, was determined by means of the testing machine. Based upon this value, the geometry of the tested specimen (width and thickness) and using the above equation, the flexural strength is found out. The Table1 and Table2 show the maximum load values and the corresponding flexural strength for GA and GB carbon/glass/epoxy hybrid composite respectively.

Table1: Flexural strength values of glass/carbon fiber reinforced hybrid composite specimens (GA)

Specimen	**Maximum Load (N)**	**σf (MPa)**
1	671.1644	368.771649
2	1081.523	594.243407
3	890.2749	489.162033
average	880.9874	484.05903

Table2: Flexural strength values of glass/carbon fiber reinforced hybrid composite specimens (GB)

Specimen	**Maximum Load (N)**	**σf (MPa)**
1	917.1216	503.9129
2	865.7241	475.6725
3	1196.477	657.4049
average	993.1077	545.6634

The $\boldsymbol{\sigma f}$ value of glass/carbon fiber - epoxy hybrid composite was evaluated (GA & GB) to know the influence of fibers. The flexural strength value in GA hybrid composite was obtained as 484.059 MPa (Table1) and value in case of GB hybrid composite is 545.6634 MPa (Table2). This result indicates that the flexural strength predominantly depends on the properties of the fibers[11, 15]. Even though the carbon fibers have very high tensile strength, they are very brittle compared to that of glass fibers[15]. As a result, the bending strength of GA composite made of carbon/glass fiber reinforcement of about a proportion less than the bending strength of carbon/glass fiber reinforced composite. This is because glass fiber has a modulus of bending it is larger than carbon fiber and glass fiber was covering the two outer layers. The GA sample had a delamination of the layers exactly in the middle, because carbon has less tensile stress than glass. [11, 16]. As for the GB sample, the glass has one outer layer and the other outer layer is carbon fiber. Three samples were tested for each material according to the ASTM standard. And find that the flexural strength will increase with the same percentage of the increase in load because the two samples are of the same thickness (thickness = 4.2mm).

III. CONCLUSION

the outcome of theis study is the effect of glass and carbon fiber reinforced epoxy matrix hybrid composite on the flextural test. The results showed that the bending strength of the hybrid composite symmetric in the corners and asymmetric in the arrangement of the layers of carbon and glass has improved significantly compared to the hybrid compound symmetrical in the angles and symmetrical in the arrangement of the layers of carbon and glass.

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