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Experimental Investigation of Mechanical Behaviour of Carbon Fiber and E-Glass Fiber Reinforced with Epoxy Resin

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***Abstract*:- High performance polymeric composites are preferred over conventional materials due to their high mechanical behaviour, stiffness to weight ratio and damage tolerance. Fiber-reinforced polymer (FRP) composites are synthesized by reinforcing fibres with a plastic polymer resin. Due to improved mechanical behaviour, FRP composites are mostly used in automobiles, aerospace, defence, space, energy sectors, etc. In present years, there is significant research and market attention to advanced carbon and E-glass fibre composites. The present work aims to develop carbon and glass fibre reinforced with epoxy resin. Experiments are conducted to study the mechanical behaviour such as tensile, compression, Flexural, impact strength and hardness at 20%, 30% and 40% fibre by weight. The specimens are prepared by ASME standard using Hand lay-up method. Finally, it is concluded that at 40% of fiber load, both CFRP and GFRP shows maximum values. However, CFRP is having overall strength better than GFRP.**

Keywords:- Carbon, E-Glass, Epoxy, Composite. Mechanical behavior.

1 INTRODUCTION

Composites are a combination of fiber and resin, mixed in proper form which has the unique property of high specific strength and are considered as viable alternatives to metallic materials in structures where weight is a major consideration[1]. Fibers such as glass and carbon are abundant, renewable, light weight, with low density and high strength and they have the potential to be used as a replacement for traditional reinforcement materials in composites[2]. the mechanical strength of glass fiber and carbon fiber reinforced vinyl ester resin composites and observed that the carbon fiber and resin of vinyl ester with mixture of Promoter, accelerator, catalyst showed better Mechanical properties, and also observed that shortest fibers have good adhesion with the vinyl ester resin for tensile properties[3]. The mechanical properties of hybrid composite by varying weight percentage of glass fiber from 15% to 60% in steps of 15% and keeping 40% of carbon fiber reinforced with epoxy polymer, under vacuum bag process[4, 5]. The mechanical behavior of polymer–matrix composites unidirectional reinforced with carbon or glass fibers subjected to compression, perpendicular to the fibers using computational micromechanics[6]. The tensile behavior of the GFRP composites exposed to selected environmental conditions such as brine, acid and base solution, Ganga water, freezing conditions and kerosene oil for different exposure times[7]. Two types of reinforced glass fibers: chopped and 0/90 fiber glass composted with unsaturated polyester resin. The flexure properties are studied by using three-roller bending test[8]. In the present work, an attempt is made to study the mechanical behavior of composites manufactured by using bi-directional E-glass and carbon fiber by varying weightage percentage of fibers and the matrix.

2. EXPERIMENTAL INVESTIGATION

2.1 Material Selection

Bi-directional E-glass and Carbon fibers with thickness 0.2 mm are used as ply direction of 0/90 reinforcements and Epoxy Resin (LY566) and hardener (HY951) are used as matrix material.

2.2 Composite Fabrication

The epoxy resin (LY566) and the hardener (HY951) are heterogeneous mixed in the ratio of 10:1 by weight and cured at room temperature. The mixing was done thoroughly and then the fiber layers were reinforced in the matrix body. The composites are made by hand-lay-up method followed by a light compression molding technique. A casted mold having dimensions of 250× 250×5 mm was used. A releasing handler (Candle Wax) was used to facilitate quick removal of the composite from the mold after curing. The fabrication of each composite are cured under a load of tighten mold for 24 hours and then post cured in air for another 5 hours. Specimens are prepared as per ASME standards.

2.3 Testing of composites for mechanical properties

The tensile and compression tests are performed on a universal testing machine (UTM) according to ASTM D3039- 76 standard. A 250mm x 25mm x 4mm specimen is used for a tensile test and a 140mm x 25mm x 4mm specimen is used for the compression test. The results are shown in table 1 and table 2.

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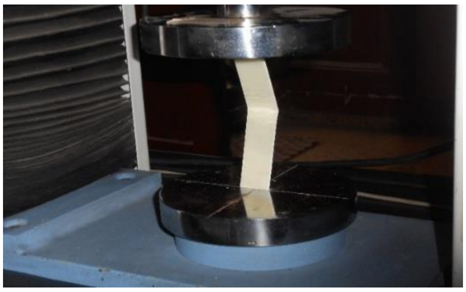
(a)



(b)

Fig. 1. Tension and Compression Tests on UTM

Table .1 Tensile test Results

No	% of fiber by weight	Max stress σ (MPa)	
		Glass Fiber	Carbon Fiber
1	20	8.91	24.90
2	30	6.34	28.44
3	40	14.62	45.00

Table .2 Compression test Results

No	% of fiber by weight	Max stress σ (MPa)	
		Glass Fiber	Carbon Fiber
1	20	146.91	172.8
2	30	145.33	181.0
3	40	169.42	240.0

Flexural test is performed with rectangular specimens of dimensions 100mm x 25mm x 4mm according to ASTM D-790 using a universal testing machine, fitted with a three roller bending fixture at a cross head speed of 2mm/min and the results are shown in table 3.

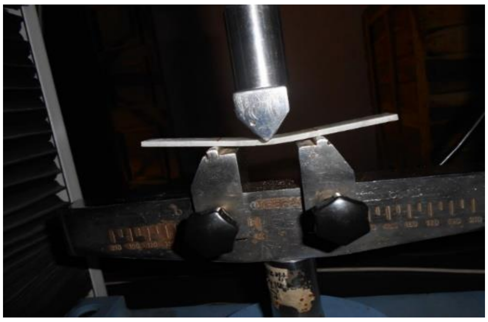


Fig. 2. Flexural Strength Test.

Table .3 Flexural test results

No	% of fiber by weight	Flexural stress σf (MPa)	
		Glass Fiber	Carbon Fiber
1	20	329.09	606.70
2	30	330.01	706.06
3	40	417.37	794.10

The impact strength test is conducted on the notched specimens with dimensions 63.5mm × 12.7mm × 4 mm according to ASTM D256-56. The results are shown in table 4.

Fig. 4. Specimen of Impact strength test on carbon composite

(a)

(b)

Fig. 4. Specimen of Impact strength after test (a) carbon composite (b) glass composite

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Table .4 Impact Test Results

No	% of fiber by weight	Impact strength	
		Glass Fiber	Carbon Fiber
1	20	10.06	35.81
2	30	14.33	52.31
3	40	19.26	69.21

30mm x 30mm x 4 mm specimens are prepared as per ASTM D2583 and tested for hardness. The results are shown in table 5.

(a)

(b)

Fig. 5. Hardness test using BARCOAL instrument.

Table .5 Hardness test results

No	% of fiber by weight	Hardness Number(BHN)	
		Glass Fiber	Carbon Fiber
1	20	49.3	45
2	30	55	65.33
3	40	52	69

3 RESULTS & DISCUSSION

3.1 Tensile Properties

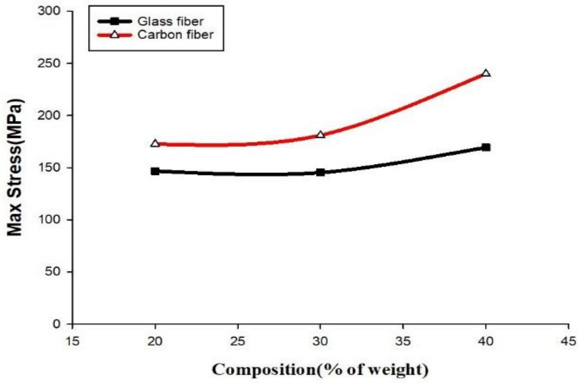

Fig. 6. Graph generated for max stress vs composition for tensile test of CFRP–GFRP composite

From the table 1, it has been observed that as the fiber load increases, the tensile strength of GFRP decreased initially and then increased whereas in the case of CFRP it is increasing. The same is presented in Fig.6.

3.2 Compression Properties

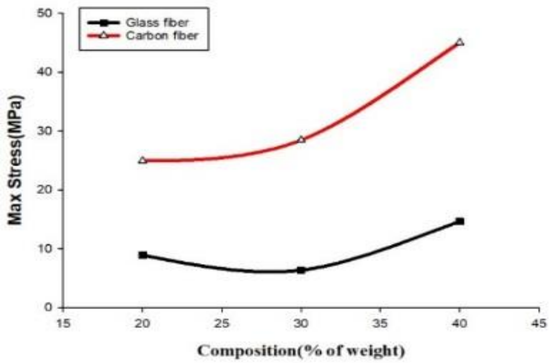

Fig. 7. Graph generated for max stress vs composition for compression test of CFRP–GFRP composite

From the table 2, it has been observed that as the fiber load increases, the compression strength of GFRP decreased initially and then increased whereas in the case of CFRP it is increasing. The same is presented in Fig.7.

3.3 Flexural Properties

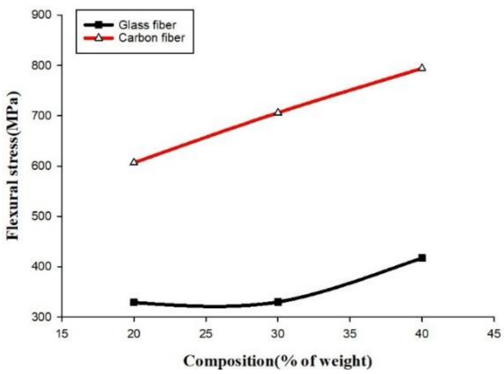

Fig. 8. Graph generated from the machine for Flexural stress vs composition for Flexural test of CFRP–GFRP composite

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From the table 3, it has been observed that as the fiber load increases, the Flexural strength of GFRP increased from 329.09 MPa to 417.37 MPa and in the case of CFRP it increased from 606.70 MPa to 794.10 MPa. The same is presented in Fig.8.

3.4 Impact Properties

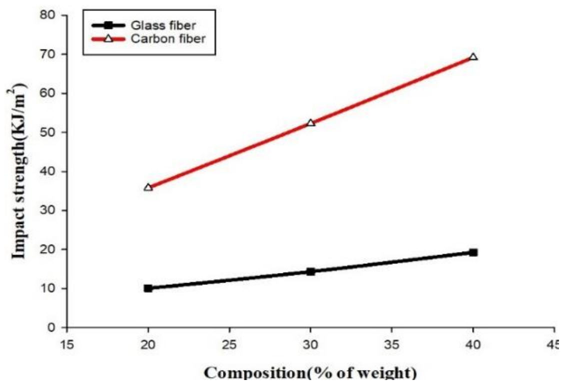

Fig. 9. Sample graph generated from the machine for Impact strength vs composition for Impact test of CFRP–GFRP composite

From the table 4, it has been observed that as the fiber load increases, the Impact strength of GFRP increased from 10.06 KJ/m^2 to 19.26 KJ/m^2 and in the case of CFRP it increased from 35.81 KJ/m^2 to 69.21 KJ/m^2. The same is presented in Fig.9.

3.5 Hardness Properties

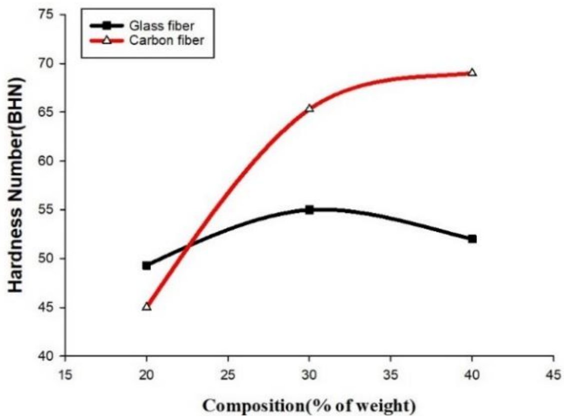

Fig. 10. Graph generated from the machine for Hardness number vs composition for Hardness of CFRP–GFRP composite

From the table 5, it has been observed that as the fiber load increases, the Hardness of GFRP increased initially and then decreased whereas in the case of CFRP it is increasing. The same is presented in Fig.10.

5 CONCLUSION

In this work, a comparative study of mechanical behavior of GFRP and CFRP composites is done by varying the percentage of fiber by weight and the concluded that

- CFRP composite material shows maximum tensile strength and can hold the strength up to 240 MPa.
- The CFRP composite is capable of having maximum compression strength with an 8.02 mm displacement and 45 MPa load.
- The CFRP composite is capable of having maximum flexural strength and holding the strength up to 794 MPa load
- The maximum impact strength is obtained for the CFRP composite and has a value of 69.21 KJ/m^2
- The maximum hardness number is obtained for the CFRP composite and has the value of 69 BHN.
- Finally it is concluded that at 40% of fiber load, both CFRP and GFRP shows maximum values. However CFRP is having overall strength better than GFRP.

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