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Effect of Fiber Content on Mechanical Properties of Glass Fiber Reinforced Polymer (GFRP) Composites

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Abstract—*Composite materials offer higher specific strength and stiffness than other conventional materials. The utilization of fiber glass is increase in recent years particularly in the aerospace industry due to its excellent properties such as light weight, high specific strength, high specific modulus of elasticity, good corrosion resistances. Glass fiber reinforced polymer (GFRP) composites are also used in passenger compartments, storage room doors due to their high mechanical properties. Composites were prepared with different wt% of chopped E-glass fiber mixed with epoxy resin. Tensile strength, bending test and impact test were conducted to find out the significant effect of glass percentage on mechanical characteristics of glass fiber reinforced composites. ASTM D638-10, ASTM D790-10 and ASTM D256 standards were used for tensile and bending and impact test respectively. Experimental results shown that addition of glass content increase the mechanical properties of composites.*

1. INTRODUCTION

The field of composite materials has progressed considerably over the last few decades .Properties like low density, high strength and stiffness, chemical and corrosion resistance, etc. make composite materials an attractive alternative to metals and alloys. Use of fibre glass is increase in recent years particularly in the aerospace industry Because of its excellent i.e light weight and high specific strength, high specific modulus of elasticity, good corrosion resistances etc [1]. Although strength properties of glass fibre are somewhat lower than carbon fibre and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are very favourable when compared to metals, and it can be easily formed using molding processes [2]. GFRP composites are also used in fairings, passenger compartments, storage room doors due to their high mechanical properties.

Fibreglass can be reinforced with both thermoplastic and thermoset polymer. The most common types of glass fibre used in fibreglass is E-glass, which is alumino-borosilicate glass with less than 1% w/w alkali oxides, mainly used for glass-reinforced plastics. With studies done over the year on composite it is concern that fibre volume fraction was have significant effects on mechanical properties of composite such as strength, stiffness and toughness. Composite mechanical properties were improved with the increase of fibre volume fraction. But when the fibre volume fraction was too large, the composite fibre bundle strength and hence ultimate strength degraded. also depend on the way in which the fibres alignment with matrix.[3][4] Hence objective of this project is to investigate the mechanical properties of GFRPC with different fibre volume fraction.

2. EXPERIMENTAL SET-UP

The composite Specimens used for the present investigation is fabricated by hand lay-up process. Raw material used in this fabrication process were epoxy thermoset polymer i.e Araldite LY 556 and chopped strands 3mm length E-glass fibre. E-glass fibre having fibre length approx 3mm and 11-13µm fibre diameter. Epoxy resin (LY 556) and corresponding hardener (HY951) are mixed in a ratio of 10:1 by weight. Specimen were prepared with different glass fibre contents(0wt%, 5wt%,7.5wt%,10wt% and 12.5wt%).for molding purpose Epoxy was first heated up to 45°C to decrease its viscosity and fibre and hardener was mixed properly and then pour the mold release agent was used to easy removal of material.

2.1. Measurement Techniques

ASTM D638-V standard and ASTM D256, standard were followed for tensile and impact test respectively [5]. Five specimen of GFR composite were prepared with different wt% of fibre separately for both tensile and impact test. The mass values of the specimens were measured by a precision balance weighting machine. Figure 1 and Figure 2 showing the various dimension of composite specimen

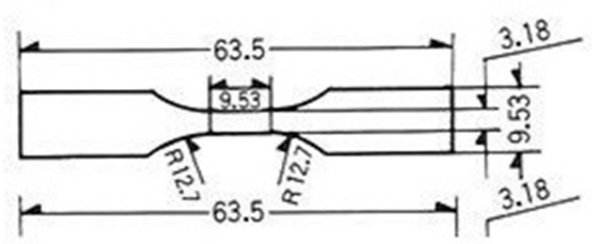

Fig. 1: ASTM D638-V standard tensile specimen

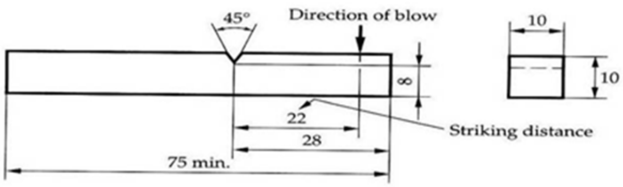

Fig. 2: and ASTM D256 impact specimen(izod)

3. MECHANICAL PROPERTIES TEST

3.1. Tensile testing

For finding the tensile properties of GFRP composite specimen a Electronic Tensometer, Model PC-2000 (Bench Model Horizontal Tensile Testing Machine Capacity: 20 KN) was used. Five different specimen with varying wt% was tested using tensometer with 2mm/min test speed i.e (0wt%,5wt%,7.5wt%,10wt% and 12.5wt%).

Fig. 3: PC-2000 Electronic Tensometer

Fig. 4: Tensile specimen before testing

Fig. 5: Tensile specimen after testing

3.2. Impact Testing

The TMI Impact Testing Machine is used to measure the impact resistance of polymer and composite materials in compliance with ASTM D256. A notching machine was used to create a precision notch in Izod-type specimen.

Fig. 6: Impact test machine

A standardized pendulum-type hammer breaks the sample, and the impact energy absorbed by the sample is automatically calculated. Different hammers may be installed for "low" and "high" ranges of impact-resistance.

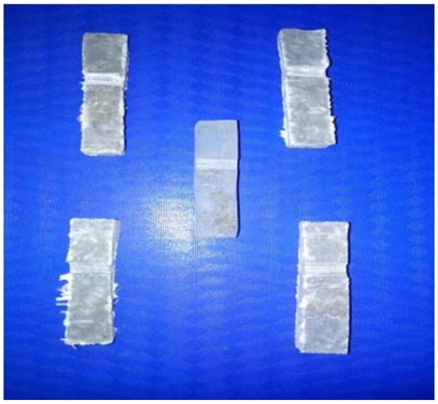

Fig. 7: Impact test specimen before testing

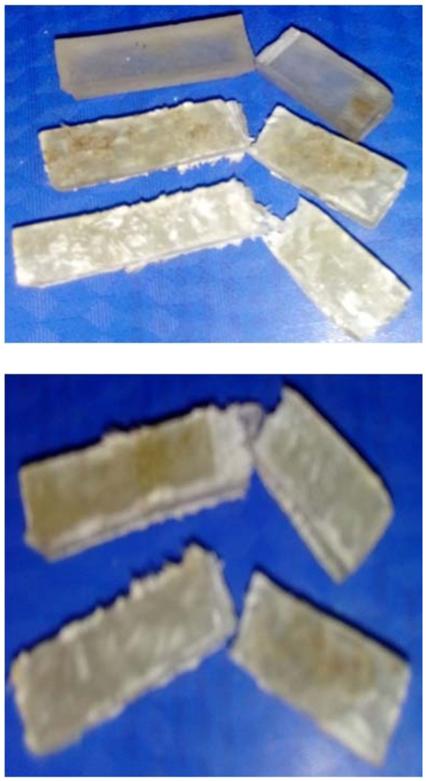

Fig. 8: Impact test specimen after testing

4. MECHANICAL ANALYSIS OF TEST RESULT

4.1. Tensile Test Behaviour of GFRP Composites

Table1: Tensile strength of GFRPC

Glass Fibre wt%	Ultimate Tensile Load (KN)	Ultimate Tensile strength (N/mm²)
0%	1040	19.3
5%	1680	48
7.5%	2720	63.9
10%	3760	78.2
12.5%	1569	21.8

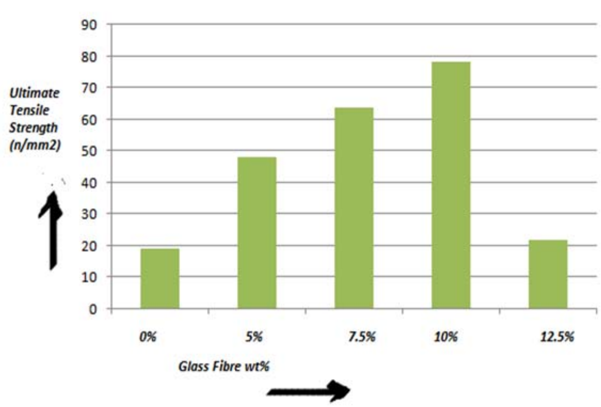

Fig. 9: Variation in Ultimate Strength with Variation of Fibre concentration

From above varying value of specimen relative to fibre volume fraction it i clearly visible that tensile strength of GFRC start increasing with increase of fibre reinforcement percentage. in this experiment highest value of tensile strength is given by the 10% glass fibre specimen is 78.2 N/mm².But when comes to 12.5% glass fibre component the tensile value start decreases up to 21.8 N/mm². This may due to the lack resin to bind the fibre as fibre volume fraction become significantly large. Also high fibre content increase void formation in material during fabrication. is one of the reason to low tensile strength.

4.2. Impact Test Behaviour of GFRPC

Table 2: Impact Strength of GFRPC

Glass Fibre wt%	Mean, kJ·m-2
0%	5.2153
5%	4.1129
7.5%	3.2537
10%	2.9661
12.5%	2.4476

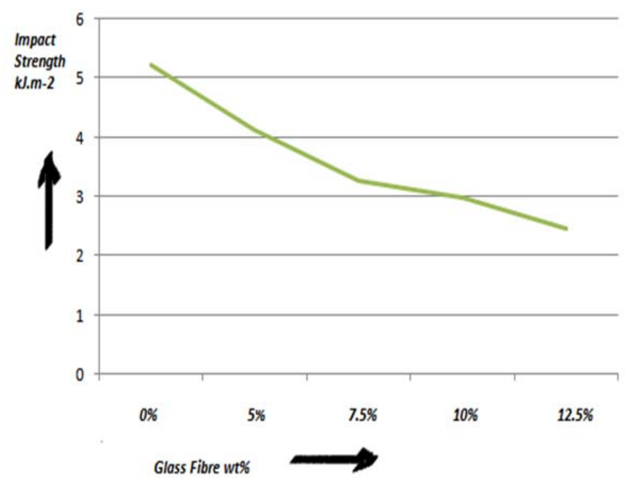

Fig. 10: Impact value with Respect to wt% of glass fibre

The values of the impact strength of the composites decreased significantly in comparison with the neat resin specimen (5.22 kJ·m-2), see Fig. 10 – statistically comparable with the values of the resin were only composite systems with 5% of filler in the matrix (4.11 kJ·m-2)

5. HARDNESS TESTING

Rockwell Hardness testing was perform in percentage different specimen with 0wt%,5wt%,7.5wt%,10wt% and 12.5wt% of glass fibre. Result Obtained are given below .Specimen Size were Length 30mm× width 30mm.

Fig. 11: Rockwell Hardness Testing Machine

Table 3: Hardness value

Glass Fibre %	Harness(HRB)
0%	24
5%	28
7.5%	42
10%	38
12.5%	29

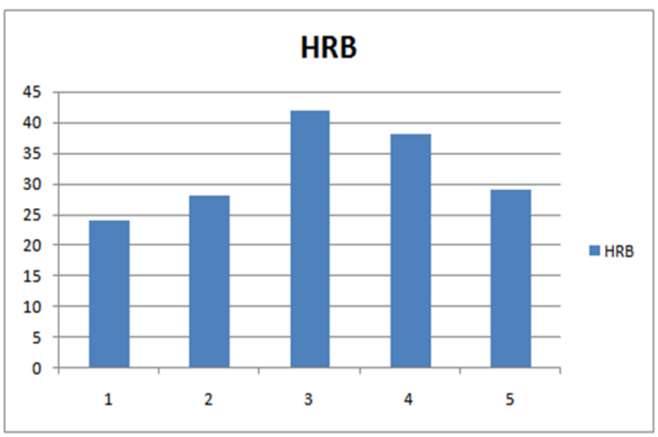

Fig. 12: Hardness value with respect to wt% of fibre

6. CONCLUSION

In this study, GFRP composite Specimen were firstly prepared from Glass fibre and epoxy polymer. Experimental investigations on if adding glass fibre (different content) into epoxy thermoset plastic can improve the mechanical properties of composite specimen have been conducted. Effects on tensile properties, impact strength and hardness property of specimens were investigated. The following conclusions were drawn from this study.

- Compared with pure plastic specimen, adding glass fibre into plastic materials could increase tensile strength and hardness.
- Specimen with 10 wt% glass fibre had largest ultimate tensile strength value 78.2 N/mm² and specimen with 12.5wt% glass fibre had smallest value of tensile strength compare to all reinforced specimen.
- Impact test specimen with fibre reinforced shown very less value than the pure epoxy specimen. only 5wt% glass fibre specimen had given neareast value 4.11 kJ.m² where pure specimen reading was 5.21 kJ.m²
- Highest Rockwell hardness reading was 42 HRB

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