An Experimental Study on Tensile Property of Glass Fibre Reinforced SiCp Filled Epoxy Composite Materials Subjected To Moisture Absorption

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***Abstract*—FRP composites are widely used in marine applications because of their good mechanical properties, resistance against weathering and higher resistance to atmospheric deterioration as compared to conventional metals. FRP composites can be prepared by variety of manufacturing techniques and hand layup process is the most economical technique among them. This study mainly focuses on the effect of aqueous environment like normal, distilled and sea water on tensile property of GFRP composites which consists epoxy of L-12 grade as matrix material reinforced with E-glass fibre manufactured by hand layup process. This experimental study focuses on the effect of silicon carbide particles of 400 mesh size. Also, tensile test was conducted on GFRP composite with and without filler material subjected to aqueous environment for 24 days.**

***Keywords*— Glass Fibre Reinforced Polymer (GFRP), Silicon carbide particles (SiCp), tensile property, ASTM D3039 standards, normal water, distilled water and sea water.**

I. INTRODUCTION

Composites are the heterogeneous combination of two or more materials insoluble in each other to gain properties which are better as compared to conventional materials [1]. Due to various advantages of composites like light weight, high strength, resistance to corrosion, high impact strength, heat resistant, superior thermal stability, durability etc. these are used in wide applications. The ingredients used to manufacture glass fiber are silicon dioxide, lime and aluminum oxide. Epoxy resins are better than other resin type in terms of mechanical properties, low shrinkage on curing and resistant to environmental degradation hence these properties makes epoxy widely used in construction of boats and marine parts. Addition of fiber as reinforcement makes a composite more suitable for aqueous environment as it gains more capacity to absorb moisture [2], but this affects the mechanical properties of composite. This phenomenon is called as diffusion or debonding. The rate of diffusion increases with increase in temperature [3]. This study mainly focuses on tensile property of E-glass fiber reinforced polymer (GFRP) composites filled with SiC particles subjected to moisture environment [4] and constant room temperature is maintained throughout the experimentation.

Epoxy L-12 is a liquid of medium viscosity which can be used with various hardeners for making FRP composites. Epoxy curing is done by hardener K6 which is anhydride hardener, helps in curing of the composite.

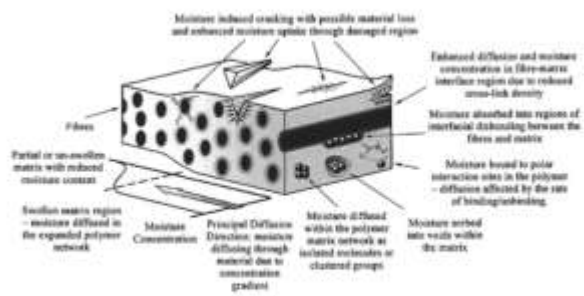


Fig. 1 Effects of moisture diffusion on composites [5]

TABLEI. NOTATIONS USED

Sl. No.	Terms used	Abbreviations
1	Normal Water	NW
2	Distilled Water	DW
3	Sea Water	SW

II. EXPERIMENTATION

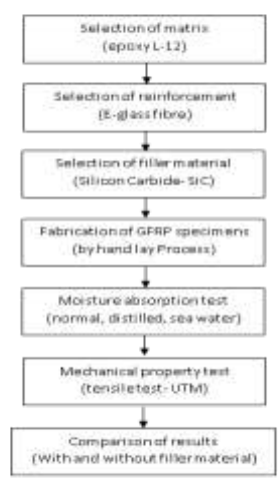


Fig. 2 Steps involved for experimentation

Methodology followed for experimentation is as shown in figure 2. For this study, epoxy of L-12 grade is selected as matrix material reinforced with E- glass fiber and silicon carbide particles are used as filler material.

The density and viscosity at 25°C of epoxy L-12 grade used for this study is 1.120 gm/cm^3 and 9000-12000 MPa.s respectively. This epoxy is mixed with K6 hardener which has a density of 0.954 gm/cm^3. Woven fabric E-glass fiber made up of calcium aluminaborosilicate is used as reinforcement which has a density of 2.54 gm/cm^3. Samples were fabricated using low budget manufacturing technique i.e. hand layup process as per ASTM D3039 standards for tensile test as shown in figure 3.

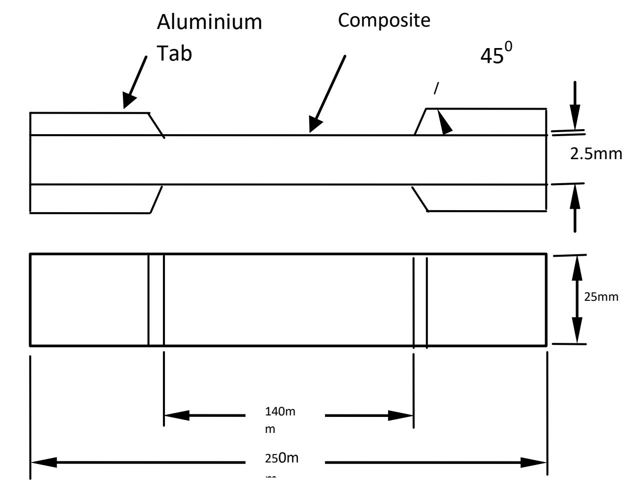


Fig. 3 Test sample as per ASTM D3039 standards.

Specifications of tensile test specimens are as follows,

Length of test specimen = 250 mm

Breadth of test specimen = 25 mm

Thickness of test specimen = 2.5 mm

Gauge length = 140 mm

A. Volume Fraction

Since the volume fraction of fiber and matrix play a vital role in enhancement of mechanical properties of FRP composites [4], following rule of mixture is adopted for fabrication of GFRP composites.

$$V_c = V_f + V_m$$

Where,

V_c= volume of composite material

V_f= volume of fibre

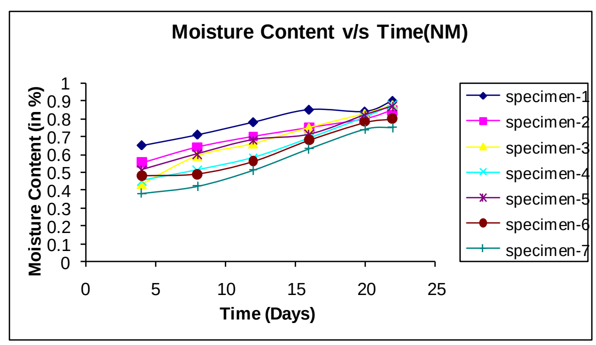
V_m= volume of matrix

TABLE II. VOLUME FRACTION OF TENSILE TEST SPECIMENS

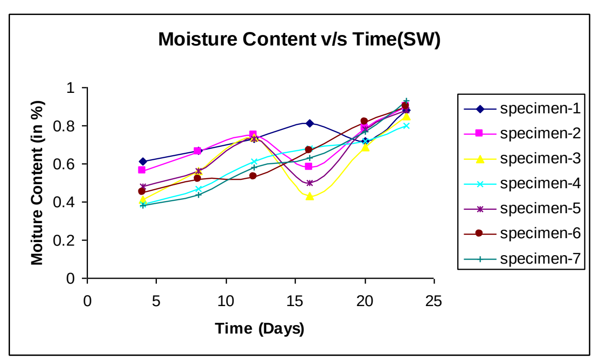
Specimen no.	Volume fraction (%)	Total Volume (cm^3)	Volume of Constituents added (cm^3)		
			E	GF	SiCp
1.	E= 55, GF= 40	15.625	6.25	8.59	0
2.	E= 50, GF= 45	15.625	5.47	9.37	0
3.	E= 40, GF= 55	15.625	7.81	7.03	0
4.	E= 35, GF= 60	15.625	8.61	6.25	0
5.	E= 40, GF= 50, SiCp= 5	15.625	6.25	7.81	0.78
6.	E= 35, GF= 50, SiCp= 10	15.625	5.47	7.81	1.56
7.	E= 30, GF= 50, SiCp= 15	15.625	4.69	7.81	2.34

B. Moisture Absorption Test

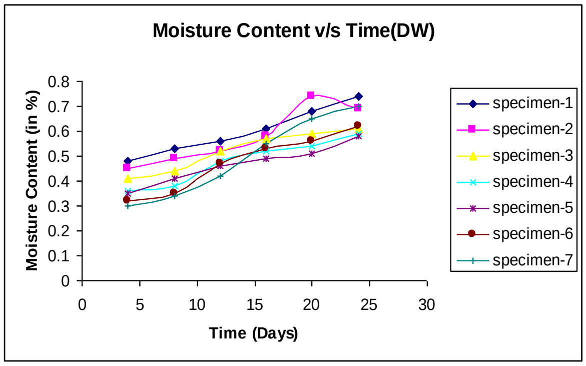
Each set of 7 samples prepared as per ASTM D3039 standards were immersed in normal water, distilled water and sea water till the saturation state is reached [6]. The moisture content is measured with the help of digital electronic weigh machine with an accuracy of 0.0001 gm. These samples were kept in normal, sea and distilled water for a period of 24 days and the moisture content of each sample is shown in figure 4.



(a)



(b)



(c)

Fig. 4 Effect of Moisture Absorptivity of GFRP with SiCp immersed in (a) normal water (b) sea water (c) distilled water

Figure 4. clearly indicates that saturation for sample immersed in normal water is reached at a time period of 22 days whereas sample immersed in sea and distilled water took 23 and 24 days respectively to reach saturation.

C. Tensile Test

Each set of seven saturated samples with and without filler material immersed in normal, distilled and sea water were subjected to tensile test using digital UTM with a resolution of 0.01 mm movement. Tensile test was conducted at a rate of 1mm/min.

III. RESULT AND DISCUSSION

At first stage, samples saturated in normal water were subjected to tensile test. In second and third stage, samples immersed in sea water and distilled water were subjected to tensile test at room temperature.

A. Tensile Test for Samples Immersed in Normal Water

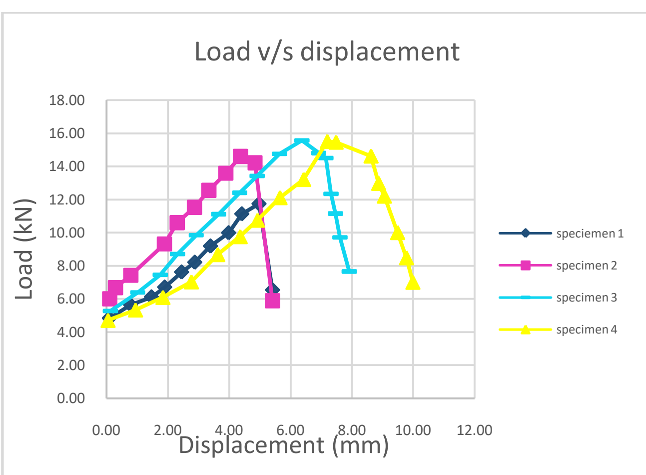


Fig. 5 Load v/s displacement for samples without filler material immersed in normal water.

It is evident from the figure 5 that specimen 4 (without filler) attained highest peak load of 15.5 kN and have maximum displacement of 9.9 mm. This behavior is observed due to highest percentage of glass fiber reinforcement i.e 60% in epoxy matrix.

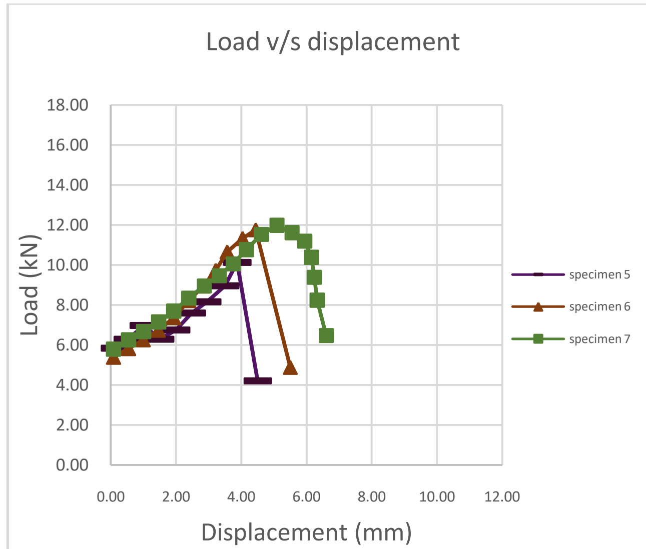


Fig. 6 Load v/s displacement for samples with filler material immersed in normal water.

Figure 6 represents the tensile test results for different composition of filler material in composite. It is clear from figure 6 that specimen no. 7 has the highest peak load of 11.98 kN and maximum displacement of 6.6 mm. This indicates that as percentage of SiC particle increases, an increment in strength of composite material is observed.

B. Tensile Test for Samples Immersed in Sea Water

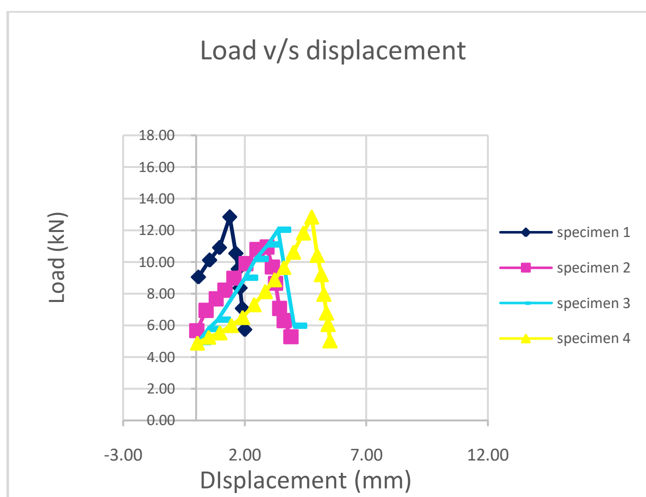


Fig. 7 Load v/s displacement for samples without filler material immersed in sea water.

Figure 7 shows the tensile properties of samples without SiC particle immersed in sea water. It can be concluded from figure 7 that specimen no. 4 has the highest peak load of 12.84 kN and maximum displacement of 5.51 mm. As sea water contains chloride and other salts which degrades the strength of glass fiber, these values are less compared to the samples immersed in normal water.

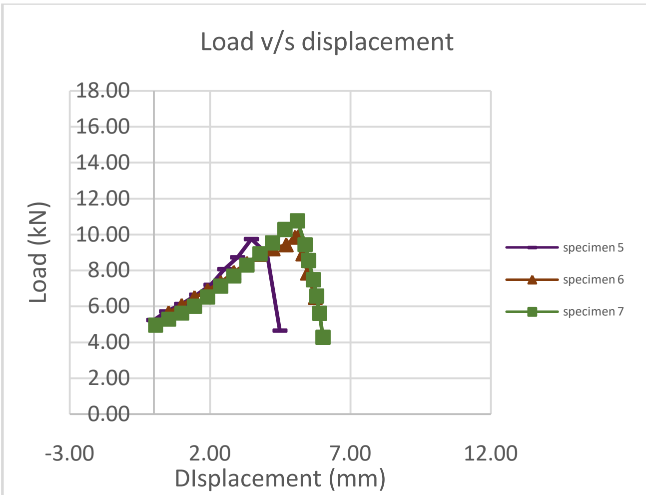


Fig. 8 Load v/s displacement for samples with filler material immersed in sea water.

From figure 8, specimen no. 7 shows the highest peak load value of 10.75 kN and displacement of 6.02 mm, but this value is less compared to the sample immersed in normal water as salt water causes micro cracking of matrix.

B. Tensile Test for Samples Immersed in Distilled Water

From figure 9, specimen no. 4 has highest peak load of 15.96 kN among other specimens. This value is more than the value obtained by sample immersed in normal water and sea water. Since, distilled water does not contain any minerals or salts, the strength of composite is not affected.

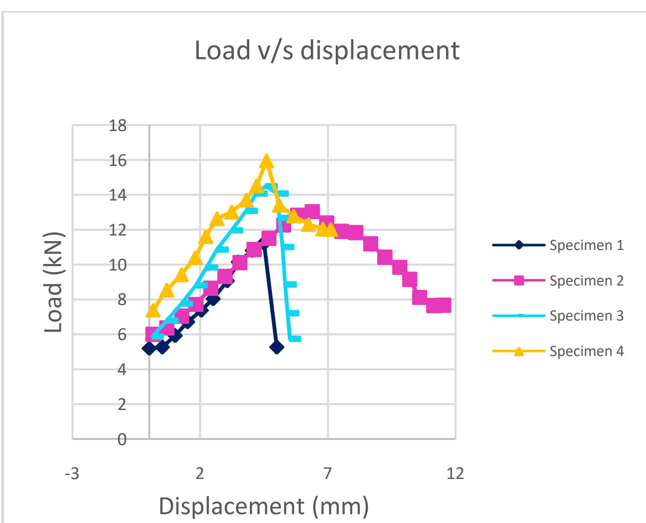


Fig. 9 Load v/s displacement for samples without filler material immersed in distilled water.

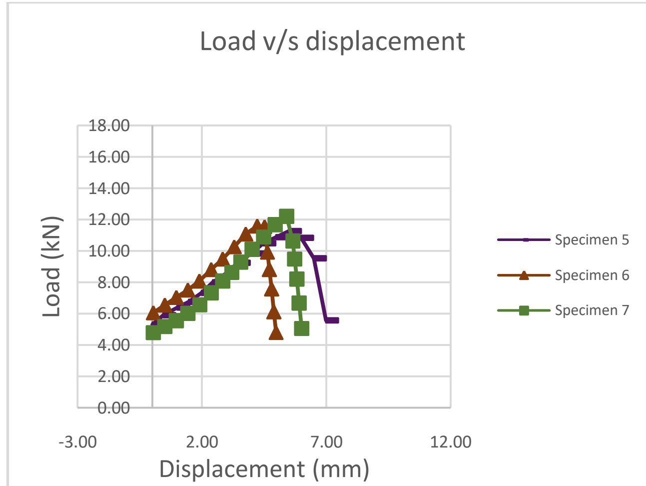


Fig. 10 Load v/s displacement for samples with filler material immersed in distilled water.

As evident from figure 10, specimen no. 7 bears highest peak load of 12.21 kN. With increase in percentage of filler material, an increment in strength is observed.

IV. CONCLUSIONS

From results of tensile tests on various samples subjected to moisture absorption, it can be concluded that as E-glass fiber reinforcement percentage in composite without filler material is increased, the tensile strength of GFRP composite is increased. In GFRP composites with filler material, as SiCp percentage increases, an increment in tensile strength is observed.

Among all specimens, those immersed in distilled water shows highest peak load and specimens immersed in sea water shows minimum peak load. This is because distilled water immersion increases glass transition properties whereas chloride/Fluoride present in sea water readily reacts with matrix and causes degradation in bonding between matrix material and reinforcement.

Further study on this composite can be made on other mechanical properties using different filler material.

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