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Effect of Moisture Absorption on Tensile Properties of SiC_p filled Glass fiber reinforced epoxy composite material

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Abstract— Epoxy composites are widely used in marine applications where they constantly meet variety of water compositions which results in constant and gradual deterioration of its Mechanical strength due to moisture content. This strength can be kept constant to some extent by adding filler material. In this study, SiC_p is added to glass reinforced epoxy composite in different weight composition as a filler material and the effect of the service environment on tensile strength and moisture absorptive of these composites are evaluated experimentally. This study mainly focuses on the tensile strength of such composites which are soaked in sea water (SW) and normal water (NW).

Index Terms— Aluminoborosilicate glass fibers, ASTM D3039, FRP composites, Normal water, Sea water, Silicon Carbide Particle (SiCp).

1 Introduction

FRP composites with E-glass fibre used as the reinforcement are taken for experiments in this study. The E-glass fibers formed by calcium aluminoborosilicate have very good mechanical property with tensile strength and Young's modulus of 3450 MPa and 72.4 GPa respectively along with this it is also economically feasible [1]. Due to these benefits, this type of composites is mainly used in marine applications, hence it becomes important to test the quality of this composite when it meets various types of liquids. This paper mainly focuses on the experiments that are carried out to evaluate reinforcing fibres, characterize matrix materials, and determine lamina and laminated mechanical properties when soaked in different types of liquid. Apart from reinforcements, filler material also plays a major role when strength of composite is concerned. For this study, Silicon Carbide particle (SiC_p) is used as filler material and composite samples were prepared by hand layup technique as per ASTM standards to conduct tensile test, tensile tests for all samples were carried out using Universal Testing Machine with a capacity of 40 tonne

2 Experimentation

Tensile testing was performed in accordance with ASTM D3039, under displacement control using an UTM/E-40 with resolution of the piston movement of 0.01mm. Test specimens were well filed to attain overall length and gauge length of 250 and 140 mm respectively and an appropriate cross sectional area of 25 X 2.5 mm^2 and aluminum tabs with dimensions of 55 X25 X 2 mm with 45^0 filing is done at the one end is glued

2.1 Fabrication of test specimen

Fabrication of test specimens are done through the Hand-layup process. In which required volume fraction is attained by adding the constituents at required proportion. The constituent involves the E-Glass fibers, epoxy of L-12 grade, K6 hardener, SiCp of 400 mesh. Epoxy and hardener are added at a ratio by volume and required volume is directly measured in the measuring jar. Estimated density of Glass fiber, SiCp, and epoxy is 2.54 gm/cm^3, 3.3 gm/cm^3 and 1.2 gm/cm^3 respectively, and these values are used in the conversion of volume and weight.

Since it is difficult to fabricate the laminates with exact test standards at the initial stage itself, convenient dimensions are set during the fabrication. Laminates obtained after the fabrications are machined to reduce the set standards before sending for experimentations. Seven samples were prepared with different fraction of Epoxy resin, glass fiber and silicon carbide which is shown in table 1. Out of these seven samples, first four samples (i.e. sample no. 1-4) are without filler material and next three samples (i.e. sample no. 5-7) are with filler material. Two sets of samples were prepared as per the dimensions shown in table 1.

TABLE 1
TEST SPECIMEN COMPOSITION

Sample no.	Volume Fraction (%)	Volume of Constituents Added (cm^3)		
		E	GF	SiCp
1	E=55, GF=40	4	5.5	0
2	E=50, GF=45	5	4.5	0
3	E=40, GF=55	5.5	4	0
4	E=35, GF=60	3.5	6	0
5	E=40, GF=50 SiCp=5	4	5	0.5
6	E=35, GF=50 SiCp=10	3.5	5	1
7	E=30, GF=50 SiCp=15	3	5	1.5

2.2 Moisture absorption test procedure

Most resins will absorb much amount of moisture, compared to the fabrics [2][5]. Composites absorb moisture in humid atmospheres and when immersed in water and other environments. Remarkable changes were observed in the strength of the composites as a function of the absorbed moisture content. When moisture is absorbed by these composites, swelling of matrix relieves residual internal stresses [3][4].

(a) (b)

Fig. 1. Specimen immersed in (a) Normal water (b) Sea water.

To know the effect of moisture absorption, moisture absorption tests were performed on these composites for all the different compositions under different environmental conditions like, normal water and sea water. Each set of 7 specimens as shown in figure 1 (a) and (b) were treated in these environments for a time duration ranging from 4 days to 24 days in steps of 4 days.

The amount of moisture absorbed for each specimen were measured in digital electronic machine having an accuracy of 0.0001 gm. The corresponding weights of these specimens are noted. These specimens were immersed in these liquids till the saturation state is reached.

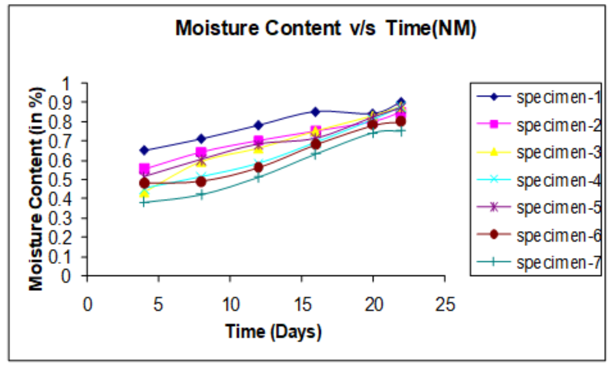
2.3 Tensile Test

The experiments were carried out on a computerized universal tensile testing machine, in order to obtain the load versus deflection data. Tensile testing specimens loaded in universal tensile testing machine with loading fixtures. The tests were performed in a displacement control mode at a rate of 1 mm/min. during the test, load displacement data were recorded for all the specimens under stated environmental conditions.

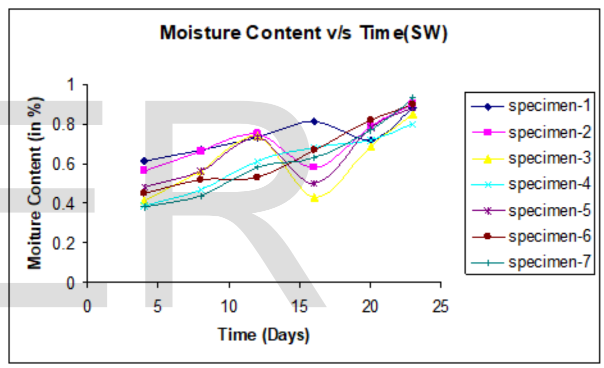
Fig. 2. Universal Testing Machine

3 Results and Discussion

From the experimentations, percentage moisture content of all the specimen were calculated. Also, graphs have been plotted for percentage moisture content v/s duration of immersion time in various environments like normal water & sea water and the results of which have been shown in Figure 3. (a) and (b) respectively.



(a)



(b)

Fig. 3. Effect of Moisture Absorptivity in GF-E and GF-E-SiCp Composites immersed in (a)Normal water; (b) sea water

It is clearly observed that saturation reaches early at a time period of 22 days [6] for specimen immersed in normal water. Then the immersion of specimen in sea water reaches saturation period next to normal water at a period of 23 days [7] as indicated in the Figure 3.

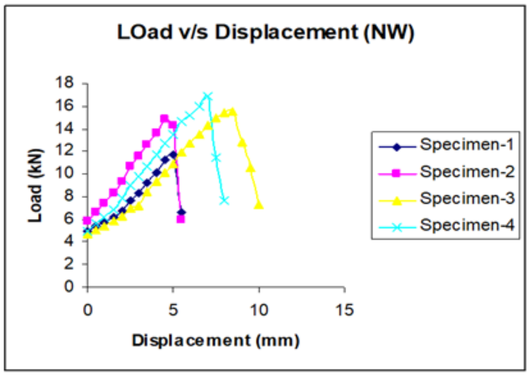
3.1 Evaluation of Tensile properties of specimens immersed in normal water

TABLE 2
DETAILS OF TEST RESULTS FOR SPECIMENS IMMERSED IN NORMAL WATER

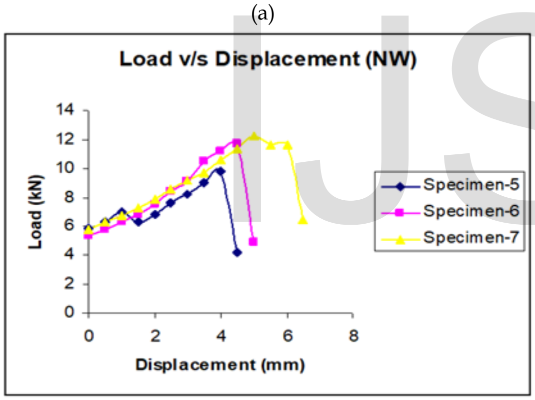
Speci men No.	Peak Load (kN)	Break Load(kN)	Max Displace-ment(mm)	Ultimate Stress (kN/mm^2)	Elonga-tion in %
1.	11.73	6.0	5.3	0.073	1.26
2.	14.60	6.64	5.6	0.266	6.0
3.	15.56	7.28	7.7	0.150	3.13
4.	16.90	7.48	9.9	0.175	7.6
With filler material (SiCp)					
5	10.12	4.2	4.5	0.057	3.66

6	11.76	4.88	5.5	0.135	3.0
7	12.22	6.48	6.6	0.163	4.4

It is clearly observed from the above Table 2. that the specimen-4 has highest peak load of 16.9 kN and having maximum displacement of 9.9 mm among specimens without filler which clearly indicates that by increasing glass fibre reinforcement, strength increases. It is also evident that the Specimen-7 has highest tensile strength of 12.22 kN at a maximum displacement of 6.6 mm among composites with filler material which shows that by increasing SiC_p filler material, the strength of composites increases.



(a)



(b)

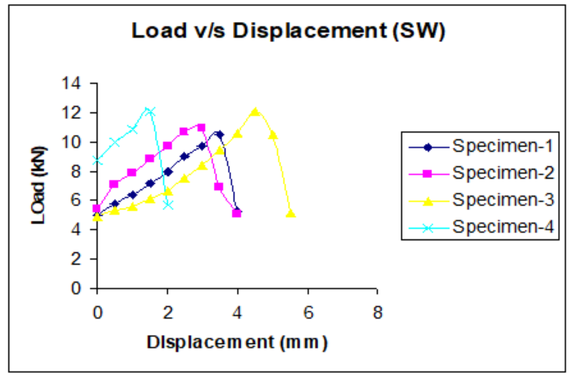
Fig. 4. Load v/s Displacement for specimens (a) without filler material (b) with filler material

3.1 Evaluation of Tensile properties of specimens immersed in Sea water

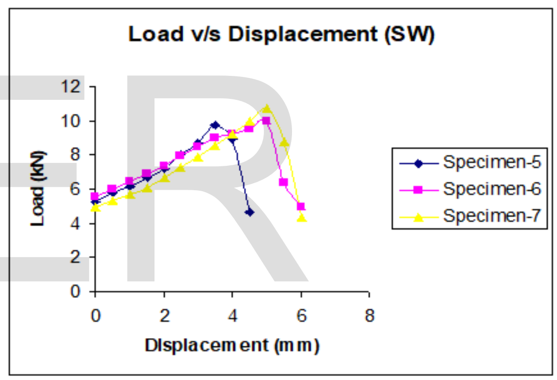
TABLE 3
DETAILS OF TEST RESULTS FOR SPECIMENS IMMERSED IN SEA WATER

Speci men No.	Peak Load (kN)	Break Load(kN)	Max Dis-place-ment(mm)	Ultimate Stress (kN/mm²)	Elonga-tion in %
1.	10.54	5.06	2.0	0.161	3.53
2.	10.94	5.16	3.6	0.41	2.6
3.	12.04	5.22	3.8	0.161	1.33
4.	12.84	5.72	5.3	0.146	2.4
With filler material (SiCp)					
5	9.76	4.32	4.3	0.165	3.8
6	9.94	4.66	5.7	0.154	3.2
7	10.74	4.96	6.0	0.15	4.53

As per the above Table 3, specimen-7 has highest ultimate tensile strength which is having highest percentage of SiCp (15%). Again, the strength is low when compared to the normal water which is because Salt water treatment causes micro-cracking of the matrix. When this occurs debonding takes place which reduces the strength of the specimen. The same is shown in graphs below



(a)



(b)

Fig. 5. Load v/s Displacement for specimens (a) without filler (b) with filler material

4 CONCLUSION

From the experimental results, it is very clear that specimen without filler material and highest composition of glass fibre immersed in normal water have highest tensile strength when compared to other specimens. When same specimen is used with filler material and immersed in normal water, its tensile strength is reduced which concludes that as glass fibre percentage is increased, the strength of specimen is also increased and when the percentage of matrix is reduced, the specimen breaks earlier which is due to debonding which is evident from percentage of elongation also when specimen with similar composition is immersed in sea water with filler material, it's tensile strength is further reduced as compared to normal water immersion since salt water immersion causes micro-cracking of matrix which degrades the tensile strength of composite. The tensile strength of normal water immersed specimens are more compared to sea water immersed specimens.

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