Experimental and Analysis of different orientation Glass fiber Composite Laminates with moisture content

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***Abstract:** A composite material is a composition of two or more dissimilar materials composing of metals, non-metals, alloys, compounds or mixtures and so forth. These are differing in forms either liquid, solid or powder insoluble with each other, and physically distinct and chemically not homogeneous. These composite materials consist of two or more heterogeneous compounds which are combined together to produce desirable properties required for some sort of applications. Composite materials are recognized as a promising class of engineering materials demonstrating new prospects for structural, automobile, aviation and many more engineering applications from the recent past Laminated composite materials are applied to utilize the merit of low weight, high specific strength, stiffness and corrosion resistance. These materials are more appropriate to choose for weight-intensive applications as far as good rating of fatigue failure is concerned. . For the efficient structural design of composite laminate, right selection of ply orientation [±0°],[±30°] [±45°],[±60°],[±90°] is required the present work focuses on the analysis of various properties by conducting experimental tests*

***Keywords:** composite laminate, Glass fiber, epoxy matrix, Moister absorption, Tensile strength plasticization.*

1. INTRODUCTION

Most of the structural properties (stiffness, dimensional stability, and strength) of a composite laminate are dependent on the orientation sequence of stacking and thickness of the plies

The mechanical properties such as stiffness and strength of a composite laminate are decided by the orientation and sequence of the plies. For the efficient structural design of composite laminate, right selection of ply orientation is required. The composite laminate reacts to axial loads at [±0°] plies, it reacts to shear loads at [±45°] plies and react to side loads at [±90°] plies. In general for any type of composite laminate, the sequence of orientation of the ply is so selected based on the strength as a function of the load applied in any of the direction. When compared with conventional structural material, composites with unidirectional (UD) fiber orientation exhibit excellent fatigue performance [8]. The unidirectional fiber reinforced composite materials run in one direction and the stiffness and strength is also in similar direction. The fibers in a bidirectional (woven roving) material generally run in two directions, 90° apart, which posses the strength in both directions.

In structural applications, fiber reinforced composite materials are usually fabricated as thin layers known as lamina or ply. By stacking the number of layers in different orientations to attain required overall length and stiffness, the structural elements (bars, beams or plates) fashioned are called laminates. Hence composites are made up of two or more different types of materials, which are called hybrid composites.

2. EXPERIMENTAL MATERIALS AND METHODS

a. Specimen Fabrication

The material was taken as a woven glass fiber epoxy matrix composite laminates .The Fiber reinforcement was kept constant for each layer of glass fabric were used to fabricate composite laminates. The Identical woven glass fiber layers were selected depending on the thickness of the composite laminates and Specimen fabricated by hand lay-up process An epoxy matrix is LapoxL-12 resin and K-5 hardener was selected for making composite laminates. The volume fraction of glass fibers is approximately 60%.. The composite laminates were first cured at room temperature for 24 hrs under a pressure of 0.5MPa using a hydraulic press. The post-curing were carried out at 110^0C for 5 hrs and then cooled to room temperature.

Fig 1: Resin pouring on fiber

Fig 2: Brushing on fiber

Fig 3: Final Composite laminate

b. Experimental Procedure

Experimental setup is made to determine the effects of moisture content on the glass fiber composite laminates. The Specimens of different orientations 30°,45°, 60°, $0°/90^0$ are immersion in water. The properties of the composite samples taken before immersion in aqueous environments such as distilled water or saline water. Now, the Specimens are placed in water tub for a certain duration to determine the properties after immersion in the water

Fig 4: The Specimens before Flexural test

Fig 5: The Specimens before Tensile test

Fig6(a): The Specimens of 30° Orientation are immersion in the water

Fig 6(b): The Specimens of 45° Orientation are immersion in the water

Fig6(c): The Specimens of 60° Orientation are immersion in the water

Fig6 (d): The Specimens of $0°/90^0$ Orientation are immersion in the water

Fig 7: The Specimens after Tensile test

III RESULTS AND DISCUSSIONS

EVALUATION OF PROPERTIES OF GLASS FIBER LAMINATES

(a) Tensile Testing Results

1. Salt water Specimens

Table 1:-Tensile strength of Salt water Specimens

Sno	Sample thickness (mm)	No. of layers	Orientation	Cross sectional area	Ultimate tensile load(N)	Ultimate tensile strength (N/mm^2)
1	5.0	5	30°	34.90	3880	111.03
2	5.0	5	45°	47.80	4160	86.89
3	5.0	5	60°	48.92	3080	62.96
4	5.0	5	90°	58.11	8200	141.11

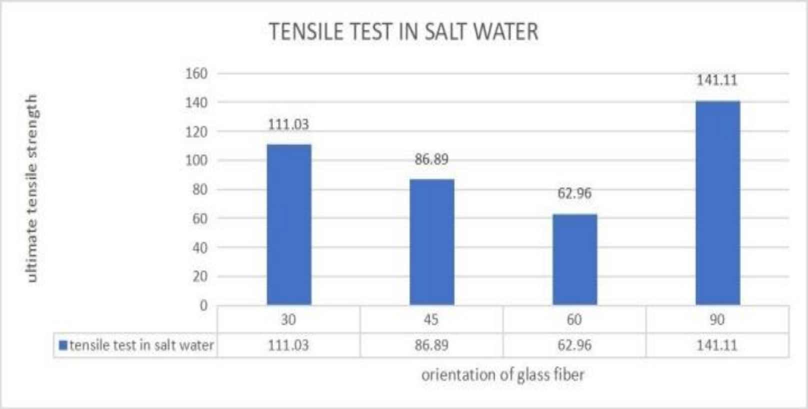

Fig8: Ultimate tensile strength vs. Orientation of glass fiber

2. Mud water Specimens

Table 2:- Tensile strength of Mud water Specimens

Sno	Sample thickness (mm)	No. of layers	Orientation	Cross sectional area	Ultimate tensile load(N)	Ultimate tensile strength (N/mm^2)
1	5.0	5	30°	39.30	3480	88.55
2	5.0	5	45°	50.53	4040	79.95
3	5.0	5	60°	43.32	3720	85.86
4	5.0	5	90°	57.07	7480	131.06

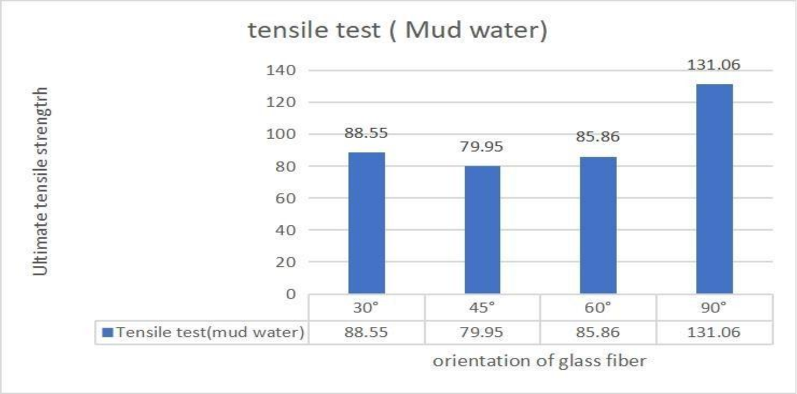

Fig 9: Ultimate tensile strength vs Orientation of glass fiber

(b) Flexural Strength Results

1. Salt water Specimens

Table 3: Flexural strength of Salt water Specimens

Sno	Sample thickness (mm)	No. of layers	Orientation	Length of Span(mm)	Flexural load(N)	flexural strength (N/mm^2)
1	5.0	5	30°	60	270	76.57
2	5.0	5	45°	65	300	64.85
3	5.0	5	60°	83	270	49.88
4	5.0	5	90°	69	390	75.80

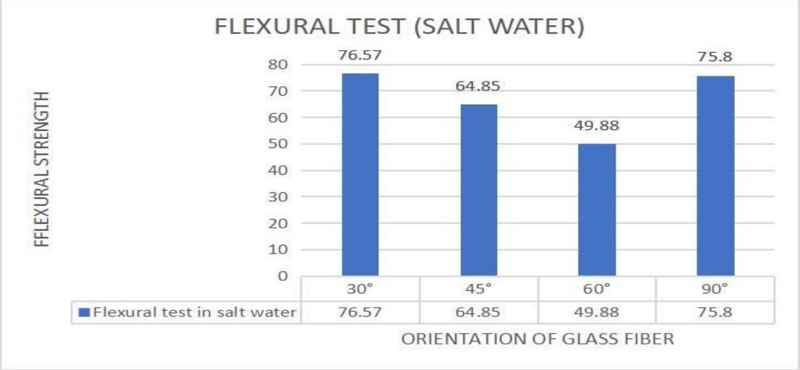

Fig 10: Flexural strength vs. Orientation of glass fiber

2 . Mud water Specimens

Table 4: Flexural strength of Mud water Specimens

Sno	Sample thickness (mm)	No. of layers	Orientation	Length of Span(mm)	flexural load(n)	flexural Strength(N/mm^2)
1	5.0	5	30°	60	320	103.20
2	5.0	5	45°	65	250	71.00
3	5.0	5	60°	83	270	58.60
4	5.0	5	90°	69	300	57.90

(c) Hardness Test Result :

1. Salt water Specimens

Table 5: Shore Hardness of Salt water Specimens

Shore Hardness in (30°)	79	80	80
Shore Hardness in(45°)	78	79	79
Shore Hardness in(60°)	78	79	80
Shore Hardness in(0°/90^0)	75	76	76

2. Mud water Specimens

Table 6: Shore Hardness of Mud water Specimens

Shore Hardness in (30°)	82	81	81
Shore Hardness in(45°)	81	80	81
Shore Hardness in(60°)	81	83	83
Shore Hardness in(0°/90^0)	76	78	78

(d) Moisture Testing Result:

Table 7

Fiber Orientation	Weight of specimen before immersion in water (kg) W1	Weight of specimen after immersion in water (kg) W2	% of water absorption
30°	6.1	6.1	0%
45°	6.7	6.7	0%
60°	6.7	6.7	0%
0°/90^0	9.0	9.1	1.11%

(e) Corrosion Testing Result:

Table 8

Fiber Orientation	Weight of specimen before immersion in water (kg) W1	Weight of specimen after immersion in water (kg) W2	% of water absorption
30°	5.7	5.7	0%
45°	6.4	6.5	1.56%
60°	5.6	5.7	1.78%
0°/90^0	8.2	8.3	1.21%

(f) SEM analysis:

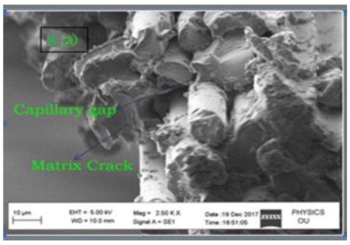

Fig11 (a): SEM graph of the micro capillary tubes and matrix crack

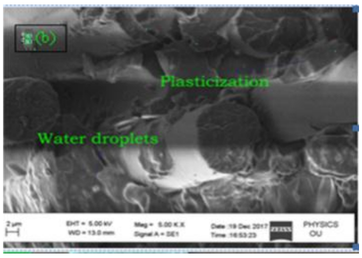

Fig11 (b): SEM graph of the water droplet sand plasticization

The failed samples are exposed to scan using SEM graphs. In the fig 11(a) the formations of micro capillary tubes in the form of gaps are observed along with a matrix crack. In the fig 11(b) water droplets are identified which caused the plasticization to occur in the matrix

4. CONCLUSIONS

Based on the results obtained, it can be concluded that the ultimate tensile strength values of glass fiber laminates varied depending on the angle of the fiber orientation as well as the type of water used. In saltwater, the highest ultimate tensile strength value was obtained for the fibers oriented at 90^0, with a value of 141.11 N/mm^2, while the lowest value was obtained for the fibers oriented at 60^0, with a value of 62.96 N/mm^2. Similarly, in mud water, the ultimate tensile strength value for fibers oriented at 90^0 was the highest with a value of 131.06 N/mm^2 and the lowest value was obtained for the fibers oriented at 45^0 with a value of 79.95 N/mm^2. Flexural strength in saltwater, the highest value was obtained for the fibers oriented at 30^0, with a value of 76.57 N/mm^2, while the lowest value was obtained for the fibers oriented at 60^0, with a value of 49.88 N/mm^2. Similarly, in mud water, the Flexural strength value for fibers oriented at 30^0 was the highest with a value of 103.2 N/mm^2 and the lowest value was obtained for the fibers oriented at $90^0$with a value of 57.90 N/mm^2. These results suggest that the orientation of the glass fibers and the type of water used have a significant impact on their ultimate tensile strength and Flexural strength values. Further research may be needed to better understand the underlying mechanisms and optimize the fiber and water combination for optimal strength performance.

Based on the results of the moisture testing of glass fiber reinforced with epoxy resin and hardener in pure water, it can be concluded that the water absorption for $0°/90^0$ is 1.11 percentage, while for 60^0, 45^0, and 30^0, the water absorption is 0 percentage. This suggests that the glass fibre reinforced with epoxy resin and hardener has a high resistance to moisture absorption, especially when the fibres are oriented at angles other than 90^0 degrees. These results can be useful in designing and manufacturing composite materials that require high moisture resistance

Based on the corrosion testing results in the saltwater, it can be concluded that the glass fiber reinforced with epoxy resin and hardener has relatively low water absorption rates. The water absorption percentage varies with the angle at which the fibre is placed, with the highest absorption observed at a 60^0 angle and the lowest at a 30^0 angle. Overall, the results indicate that the material is resistant to corrosion in salt water and can be considered suitable for applications in marine environments. However, further testing may be required to evaluate its long-term durability and performance under various conditions

Efforts were also made to study the effect of preform and number of reinforcement layers on water seepage in the laminate. The results appreciated that the preform and the fiber content also plays an important role in the interfacial behaviour of the material under aging. Plasticization of the matrix causes the degradation in the matrix strength causing a change in the interfacial properties of the fiber and matrix. Due to which fiber pull out phenomena was observed in the SEM analysis of the failed samples. Micro capillary tubes were also visible which cause the water drift in the interface of the sample. The fiber – matrix interface strength reduces due to the plasticization that occurs in the matrix phase due to the presence of moister. Thus when structure is designed for the environment which is moist an optimal required layer has to be used

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