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Study of Mechanical Properties of Moisture Absorbed Hybrid Composite Material

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Abstract— **The study of moisture effects on composite materials have been carried out in order to understand the behavior of materials subjected to moisture. Bi-directional (Kevlar/glass fiber) mechanical test samples were prepared by hand layup process and submerged in water at room temperature for different periods (35, 45, 65 days). As per the ASTM standards the mechanical tests like tensile and flexural were performed for the different level of moisture absorption. These series of tests are to run to directly measure the fiber/matrix bond strength and then the results will be compared with the dry specimens., simulation has been done for flexural and tensile test .when the specimen is immersed in water for 45 days; it has been observed that there is 30% degradation in tensile strength compared to dry specimen. Mechanical properties are found to decrease as moisture diffused into the material.**

Keywords — Moisture absorption, composite material, hybrid composites

I. INTRODUCTION

Composites are the most structural materials used in variety of sectors like Aerospace, sports, marine etc because of its high specific strength and high specific stiffness. Composites are of light weight that offers an enhanced strength than its individual constituents . Materials such as glass, carbon and Kevlar have high mechanical properties. In solid form, many random surface flaws present in such Materials, and the material will fail for small value of tensile stress. The crack propagation occurs rapidly for these materials. Whereas in a fiber form, the flaws can be reduced in the form of small number of fibers at any one point, and they are meant to carry the loads. The resin system is used to prevent flaws due to abrasion on the surface of the material or preventing existing flaws transformation, and so the fibers are need to be isolated. Composites are made up of two phases. First phase is the reinforcement phase like fibers, metals, polymers which are embedded in a matrix phase which binds up the fiber phase together.

II. LITERATURE SURVEY:

They hybridization of composite materials results in much improved strength than the pure composites that the composite made of single fabric. The tensile strength of KGFRP is 19.4% greater than GFRP [1]. The hybrid composite was made of Kevlar and glass fiber shown a higher flexural resistance [2]. The study of environmental effects on fiber-polymer composites revealed that the moisture absorption causes the degradation of strength and stiffness of the composite and it was found that the degradation is a function of fiber orientation [3]. In another study the laminates were made by oven cured and autoclave methods and it was found that the laminates made by oven cured contains more voids and acts as a moisture entrapper. After three weeks of immersion of the specimen ,it was found that the there was a decrease in stiffness of 50% for 5% moisture absorption and also decrease in compressive strength of 5-15%.young's modulus decreases by 14%and elongation to failure decreased by 27%. The increased level of moisture causes the deterioration of the specimen and it was due to resin plasticization, interface failure and also fiber degradation. For one year of moisture absorption there was only 12% decrease in compressive strength. It resulted as that the moisture conditioned Kevlar for long duration does not show much impact in strength [4]. Even when we are adding the additives / fillers like Al_2O_3 in the materials, upon water absorption, the mechanical properties of the Al_2O_3/epoxy nano composites decrease evidently, because of the damage of water on the epoxy resin. However, the ductility can be improved by the water absorption process. In addition, both dielectric constant and dielectric loss of the Al_2O_3/ epoxy nano composites increases greatly after water absorption treatment [5]. But conducting fracture toughness tests, The mode II fracture toughness, $G_{II}c$, decreased significantly after water absorption. The reduction of $G_{II}c$ is attributed to degradation of the matrix due to water absorption as observed in the scanning electron microscope [6]. Some reduction in fatigue life also appears to be brought about by absorbed water [7]. The amount of water absorption greatly influences the mechanical properties of the materials made.

III. MATERIALS USED

a.Kevlar fiber

Kevlar is a long, yellow, shiny para - aramid fiber that can be spun into strong threads. They have higher thermal expansion and corrosion resistance and low electrical conductivity. Kevlar fibers are used in bullet proof jacket to withstand high loads at a particular point. Kevlar fibers are composed primarily of the plant materials cellulose and lignin. Jute is a rainy season crop, growing best in warm, humid climates.

b. E-Glass

E-Glass contains low alkali content and stronger than A-Glass. It has good tensile and compressive strength. It is the most common reinforcing fiber used in polymer matrix composites.

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c. Epoxy resin

The epoxy resin used in our work is Araldite LY556. The various properties follow. Excellent adhesion to different materials, great strength , toughness resistance.

d. Hardener

The hardener used in our work is hardener (HY 951).Hardener is a curing agent for epoxy resin. The main purpose of hardener is to initiate curing of epoxy resin. It is the substance which hardens the adhesive when it is mixed with resin. The combination of epoxy resin and hardener are very important for the final characteristics and suitability of epoxy coating for a given environment.

e. properties

Table 3.1 Comparison of fiber material properties

Content	Kevlar	Carbon	Glass
Density(g/cm³)	1.45	1.4	2.6
Elongation (%)	4	1.4-1.8	4.9
Tensile strength (Mpa)	3620	4000	3330
Young´s modulus (Gpa)	130	230-240	76

IV. FABRICATION

The material used are Kevlar and glass $\{[\frac{0}{90}]_{12G}[\frac{0}{90}]_{4K}\}$.Composites laminates of size 30*30 cm^2 are made using hand layup process .The setting of laminate is done by compression molding for four hours at 20 bar pressure and 80^{o}c.The laminate of size 120*12mm for flexural test and 250*25mm for tensile test are cut. The Specimens are dipped in water for 35, 45, 65days.The flexural and tensile tests are carried out in universal testing machine (UTM).The results are plotted for both dry and wet specimen and the percentage decrease in strength is evaluated by comparing both wet and dry specimen.

V . TESTING

Table.5.1 Tensile test tabulation

S.No	Content	Dry Specimen	Wet Specimen		
			35 days	45 days	65days
1	Load at break(N)	86.906	416.406	348.548	417.882
2	Extension at maximum load(mm)	15.963	3.671	4.3	3.587
3	Maximum Load(N)	708.03	600.924	617.057	617.91
4	% Elongation	31.385	7.76	8.6	7.17
5	Max tensile strength (Mpa)	15.527	13.178	13.532	13.551
6	Extension at break(mm)	17.029	4.453	8.76	4.2
7	Tensile stress at Maxim um load (Mpa)	15.527	13.1665	13.532	13.55

TABLE 5.2 FLEXURAL TEST TABULATION

S.No	Content	Dry Specimen	Wet Specimen		
			35 days	45 days	65days
1	Max Force (kN)	30.36	22.2	20.36	20.6
2	Max Displacement(mm)	11.9	12.1	11.2	13.4
3	Tensile strength(MPa)	0.323	0.234	0.214	0.217
4	Elongation(%)	11.9	12.2	9.2	13.4
5	Young's Modulus(GPa)	23.003	22.08	19.062	18.13

VI.RESULTS AND DISCUSSIONS:

The tensile and flexural test are carried out in both dry and wet specimen which is immersed in 45 days .The following results are made for tensile and flexural test.

TENSILE TEST:

The influence of moisture absorption behavior in tensile properties can be shown in following figures 6.1, 6.2 ,6.3.It has been observed that there is a decrease in elongation for wet specimen .Dry specimen shows a higher elongation due to its elastic nature. The specimen immersed in water attains its plasticity due to the Kevlar fibers that is present in the top layer acts as a water ingress .The plastic nature of the plate minimizes its elongation. It has been observed that for wet specimen, the maximum force needed to break the specimen is higher compared to the dry specimen.

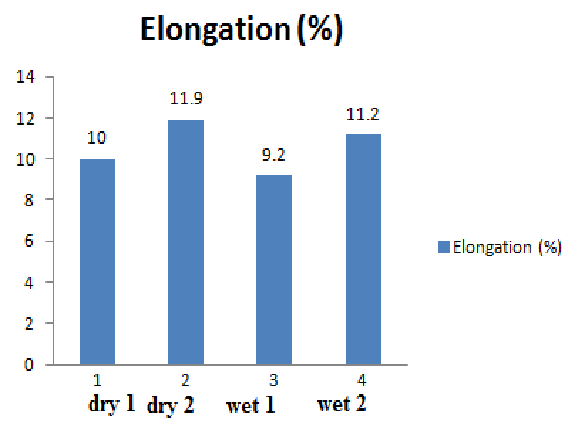

Fig 6.1 Elongation graph

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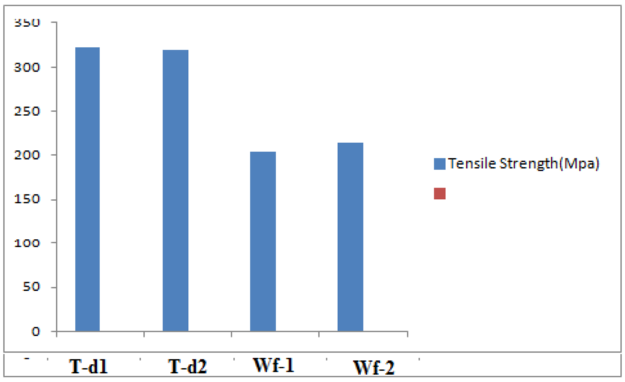

Fig 6.2 tensile strength graph

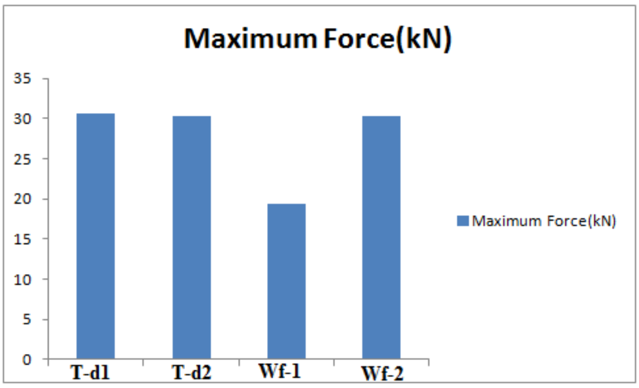

Fig 6.3 Maximum force graph

FLEXURAL TEST:

The load at which break happens for wet specimen is more compared to dry specimen.It shows that wet kevlar/glass reinforced composites is capable of withstanding more load in wet condition.

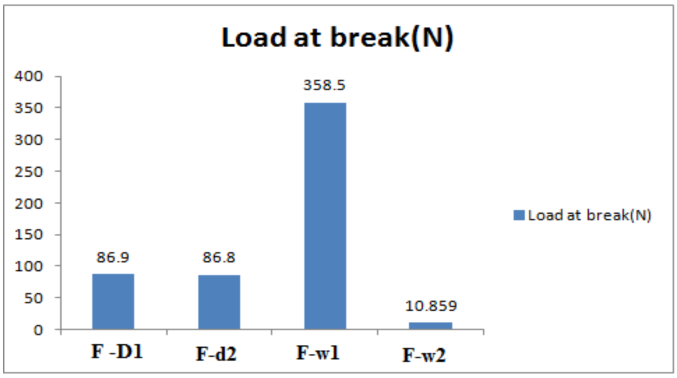

Fig 6.4 Load at break graph

STRESS VS STRAIN CURVE:

For dry specimen,from the graph 6.4, the maximum stress value of 0.0872MPa and stain value of 14.14 mm/mm are obtained. For wet specimen immersed in 45days,the maximum stress value attained is 0.3141Mpa and strain value of 15.51mm/mm.

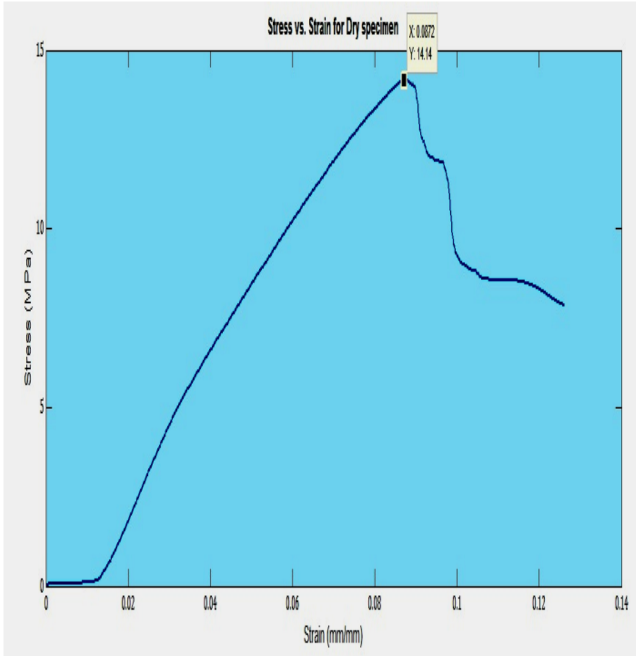

Fig 6.5 stress vs strain graph for dry specimen

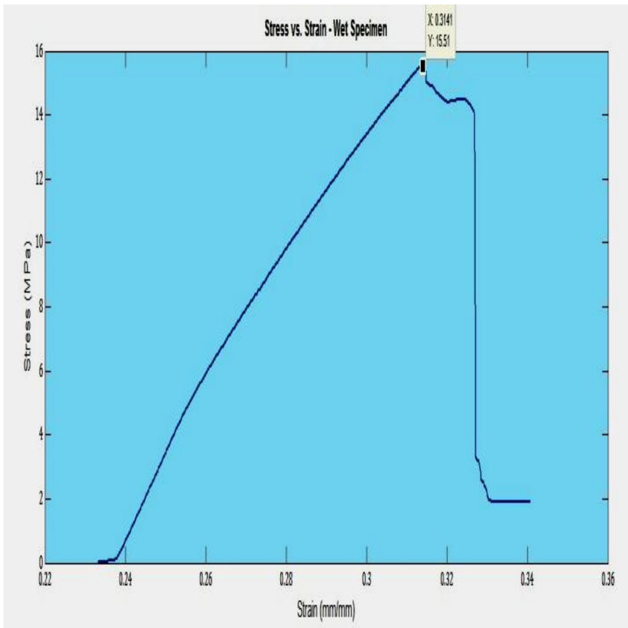

Fig 6.6 stress vs strain for wet specimen

LOAD VS DEFLECTION:

The wet specimen, at maximum load of 708N, the deflection undergone by it is 15.69mm and for dry specimen, the deflection undergone at maximum load of 645N is 4.34mm only. For dry specimen, the rupture occurs suddenly as it yield point is reached.

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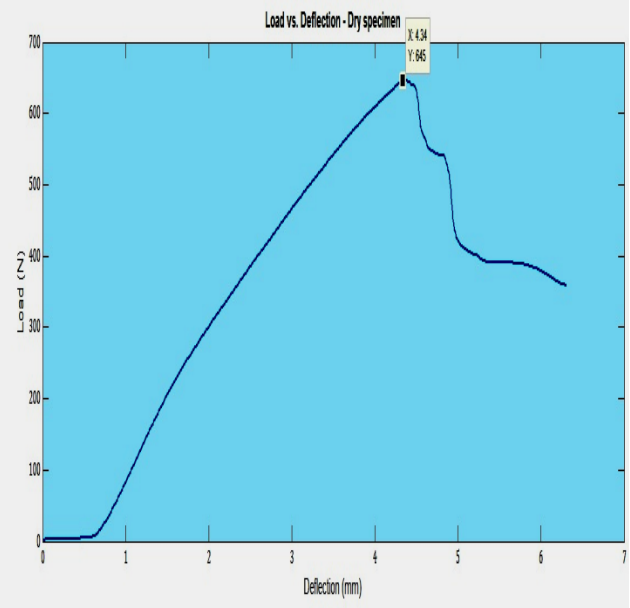

Fig 6.7 Load vs deflection for dry specimen

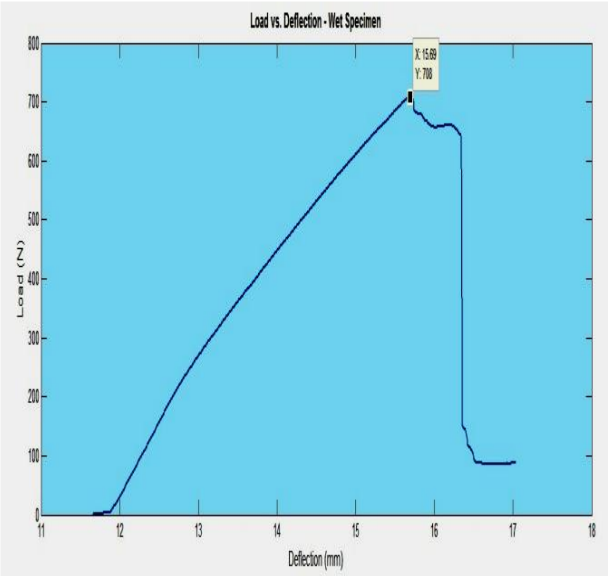

Fig 6.8 Load vs deflection for wet specimen

VII CONCLUSION

The tensile and flexural properties of Kevlar/glass fiber reinforced composites in both dry and wet conditions are made. The simulation works has been carried out for visualizing the stresses acting along x-axis when tensile and flexural loads are applied .The comparative charts for dry and wet specimen is made .It has been found that Kevlar/glass fiber reinforced composites is found to exhibit a high break point load and it undergoes less extension due to the attainment of plasticity. The Kevlar/glass reinforced composites is found to withstand more load compared to dry specimen.

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