

Water Absorption Behavior on Natural/Synthetic Fibre Reinforced Polymer Composites



Kalirasu S, Rajini N, Rajesh S, Jessy Michla J R.

Abstract: *This paper deals with the effect of moisture absorption on single coconut sheath fiber and single glass fibre. Additionally, the moisture effect in fibre reinforced unsaturated polyester composites like coconut sheath (CS) and Glass mat (GM) composite. Initially, CS and GM fibre reinforced polyester composite were produced through hand layup followed by compression moulding method. CSUPR and GMUPR composites were made through water treatment by dipping those composites in ordinary water for various time intervals at room temperature to study the water absorption effect. At different time periods, the absorption of water showed gradual increment. The effect of water gain in percentage for CS and GM was observed. From this experiment, it is concluded that the effect of water gain in CSUPR composite is higher than GMUPR composite.*

Keywords: *Coconut Sheath, Glass Mat, Water Absorption.*

I. INTRODUCTION

From the 20th century, researchers had a keen interest in composites mainly in the field of aviation, structural, automotive, marine and sports industries. Based on its consideration towards sustainability, durability, light-weight nature, endurance, etc. the composites are more likely to be used. Natural fibers which are the renewable source, bio-degradable and environment-friendly are utilized in polymer composites. Currently, top-rated automotive industries are using natural fibers as interiors, panel lining, soundproof, etc. especially coconut fiber is applicable as car seat cushions and interior panel design. The main drawbacks of these NFPCs were water absorption, poor fire resistance, and low-grade strength. H. N. Dhakal et al. [1] studied the percentage of moisture absorption is based on the volume fraction of fiber and more content of cellulose. Hemp fiber reinforced with unsaturated polyester composites (HFRUPE) showed poor tensile and flexural strength due to the water consumption of fiber.

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Hybrid composites namely kenaf/jute FRP composites and kenaf/hemp FRP composites were fabricated through infusion technique. Here epoxy resin is used as a polymer matrix. On water immersion experiment the fibers kenaf/jute and kenaf/hemp yarns absorbed water. When water penetrates via fiber/matrix interface for an increased period of time, the tensile and flexural modulus gets reduced [3]. H. Alamri et al. [4] revealed that the water suction rate and coefficient of diffusion depend on the fiber content. In recycled cellulose fibre (RCF) reinforced epoxy composites, the water intake, and diffusion rate get increased as the fiber content increased. The mechanical properties and toughness value get decreased on fibre

increment whereas the impact strength tends to increase slightly on such condition. The other work of him insisted that water intake reduced due to the increase in clay content

in a nanocomposite Epoxy-clay reinforced with recycled cellulose fibre (RCF). The flexural properties and the toughness ratio seemed to be decreased on water absorption. On SEM analysis the cellulose fibres, as well as fiber-matrix bonding interface, were greatly affected [5]. When unsaturated polyester composites reinforced with the

natural fiber jute is subjected to three various conditions likely to be in seawater treatment, distilled water treatment, and acid solution treatment. The samples were kept at room temperature over a period of three weeks. The results found a decline in flexural strength and compressive strength of the composites based on its amount of water intake [6]. The composite reinforced with synthetic fibre (glass fibre) was fabricated using the VARI (vacuum assisted resin infusion) technique. On dipping the laminate composites in simulated seawater for different time periods, the bending and tensile properties of the composites get decreased on increasing the time limit [7]. W. Z. W. Zahari et al. [2] proposed about polypropylene/juk fiber composite which was subjected to silane treatment. The composite once coated with silane showed better mechanical characteristics and improved water absorption resistance. Deposition of Polyaniline, a conductive and non-toxic polymer over the sisal fibre surface created a barrier for water and hence the mechanical properties get increased [8]. The hybridization of FRP composites improvised the water absorption limit whereas the polymer matrix reinforced with natural fibre made a loss in tensile strength to 27% and tensile modulus from 15 to 35% on immersed in water for a period of one month [9].

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The addition of nanoparticles in the composites also decreased the water absorption ratio. On influencing nano TiO₂ on epoxy composites reinforced with flax fibre, the mechanical properties, thermal properties and water resistance tend to increase. The diffusion coefficient of water gets decreased by 31.66% on account of nanoparticles insertion [10]. This research work focused on the water suction performance of coconut fibre and glass fibre by immersing in water for different time periods.

II. EXPERIMENTAL DETAILS

A. Materials Used

Coconut sheath which is a natural weave extracted from outer bask of the coconut tree from a rural region. Glass-mat fibre used is obtained from GVR enterprises, Madurai. The resin used in the matrix is unsaturated polyester resin. Methyl-ethyl-ketone peroxide (MEKP) and cobalt naphthenate are used as a catalyst and accelerator. It is obtained from vasavibala resins (P) Ltd, Chennai.

B. Equipment Details

Reinforced polyester composite is obtained by using compression molding. Initially, coconut sheath is taken and the fibre is cut down to our required shape 30×12.8cm. For a polished surface, the surface is treated with mansion wax and then the fibre is placed. The beaker contains 150ml of resin, 4.5ml of catalyst and 4.5ml of the accelerator and followed by stirring. Place the mat fibre on the mold surface and apply the resin mixture. Once completed the mold surface is closed and subjected to compression moulding. The maximum compression pressure is of 180kg/sq.cm over a period of 5 to 6 hours at room temperature for complete curing. Glass-mat fibre composite is also fabricated like this process only.

III. RESULT AND DISCUSSION

A. Water absorption test

The water absorption treatment was carried out as per ASTM D570 standard. Table 1. shows the initial weight and effect of immersion time on CS/UPR and GM/UPR composites. The initial weight of the CS/UPR composite is 1.34443 and GM/UPR composite is 2.3127. For each sample, minimum three specimens were used and the mean readings were noted. The water absorption percentage was estimated by the weight difference between samples after exposure to water and before exposed (dried samples). The equation is given by:

$$\text{Water Absorption (\%)} = \frac{W_t - W_o}{W_o} \times 100$$

Where,

W_t is the mass of the sample after immersion (g)

W_o is the mass of the sample before immersion (g).

Water absorption was estimated based on weighing on a balance with a precision of 0.0001 g.

Types of composites	CS/UPR		GM/UPR	
	After water Wt(g)	Water gain (%)	After water Wt(g)	Water gain (%)
0.5	1.4248	5.64	2.3175	0.21
1	1.4585	7.82	2.3195	0.29
1.5	1.4789	9.09	2.3204	0.33
2	1.4974	10.22	2.3220	0.40
2.5	1.5177	11.42	2.3196	0.30
3	1.5310	12.19	2.3187	0.26
3.5	1.5420	12.81	2.3201	0.32
4	1.5529	13.42	2.3248	0.52
4.5	1.5545	13.51	2.3224	0.42
5	1.5590	13.76	2.3233	0.46

Table – I: Water gain % of CS/UPR and GM/UPR composites

“Figure 1” shows the water absorption behavior of CS/PS composite. In this graph, it shows the relation between the immersion time (Hours) and water gain in percentage. The readings are noted according to half an hour from the initial immersion up to 5 hours. In the CS/PS composite, the absorption of water gradually increases in accordance with increase in immersion time (hours). Figure 2” shows the water absorption behavior of GM/PS composite.

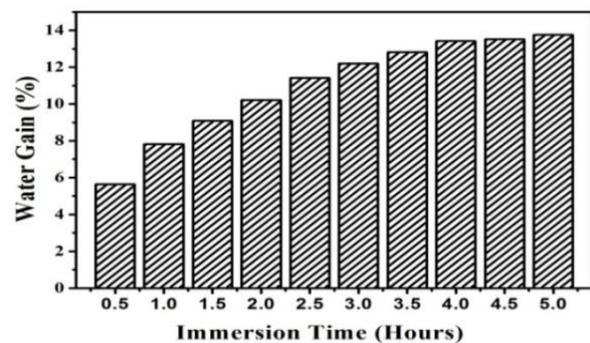
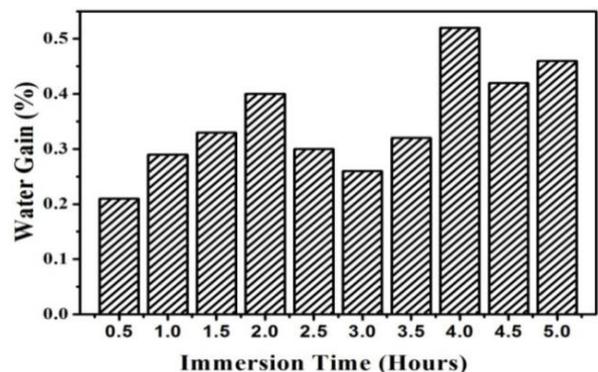


Fig.1. Water absorption behavior of CS/UPR composite
Fig.2: Water absorption behavior of GM/UPR composite

“This graph shows the relationship between the immersion time (hours) and the water gain in percentage. The readings are noted in half an hour from the initial immersion time up to 5 hours. In the GM/UPR composite, it is gradually increasing from 0.5 hours to 2 hours and from 2.5 to 3.5 hours the absorption becomes decreases and then it again increases after 3.5 hours when compared to the previous absorption of water.

TABLE – II: EFFECT OF IMMERSION TIME (DAY) ON CS/UPR AND GM/UPR COMPOSITES.

S.No	composites	BW	AW- Day1	%	AW- Day2	%
1	CS/PS	1.4206	1.702	19.81	1.7228	21.27
2	GM/PS	2.1994	2.2178	0.84	2.225	1.16

Table 2 shows the effect of immersion time (day) on CS/UPR and GM/UPR composite. In the CS/UPR composite, the absorption of water in day 2 is 1.46% which is greater than day 1. Likewise, in GM/UPR composite, the absorption of water in day 2 is 0.32% greater than day 1. Figure 3” shows the effect of water absorption behavior of CS/UPR and GM/UPR composite. It shows the effect of water absorption behavior in day 2 of CS/UPR and GM/UPR composite is higher than day 1.

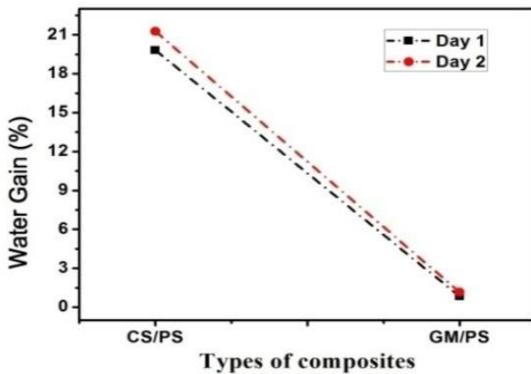


Fig. 3. Water absorption behavior of CS/PS and GM/PS composite

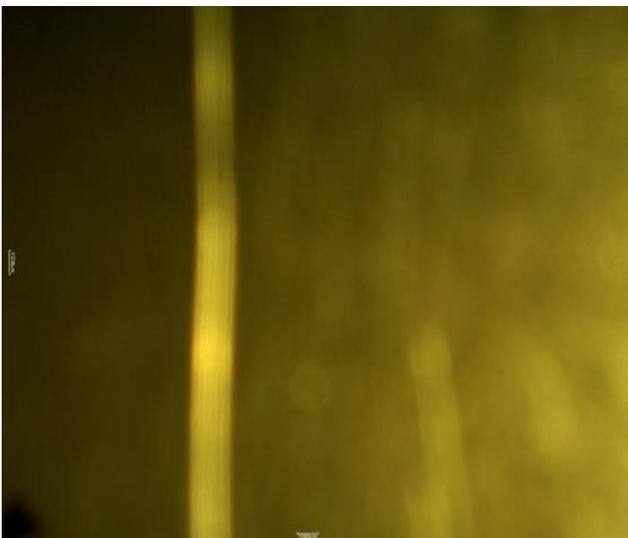


Fig 4.(a) optical image of immersions of Glass fibre before 48 hrs



Fig 4.(b) optical image of immersions of coconut fibre before 48 hrs

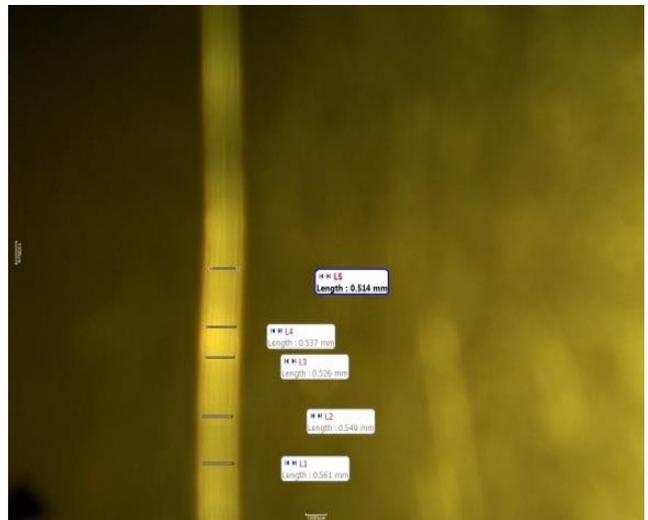


Fig 4.(c) optical image of immersions of single Glass fibre after 48 hrs



Fig 4.(d) optical image of immersions of single coconut fibre after 48 hrs

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From the above images, it is clearly visualized that Fig. 4 (a & b) showed the optical image of glass fibres and coconut fibres by immersing it a period of 48 hours without measurement. Fig. 4 (c & d) exposed the optical image of glass and coconut fibers with measurement

Table –III: Diameter Difference for Immersion of Single Coconut Sheath Fiber In 48 Hrs

S.No	The diameter of single coconut sheath fiber BW	The diameter of single coconut sheath fiber AW
1.	1.671	2.652
2.	1.647	2.652
3.	1.659	2.558
4.	1.6	2.465
5.	1.542	2.535
6.	1.881	2.185
7.	1.822	2.336
8.	1.857	2.266
9.	1.893	2.313
10.	1.893	2.336
11.	2.278	1.554
12.	2.395	1.612
13.	2.43	1.729
14.	2.535	1.682
15.	2.71	1.764
16.	2.593	2.664
17.	2.103	2.64
18.	2.033	2.71
19.	1.963	2.792
20.	2.056	2.967
Avg. Diameter	2.03	2.32
Difference in diameter		0.29

Table III discussed the diameter variation of coconut sheath fiber (single fiber) after water treatment for different time intervals. From this discussion, it is analyzed that the average diameter of CS fiber before water treatment is 2.03mm and after treatment, the average diameter changed to 2.32mm.

Table IV. Diameter Difference on Immersion of Single Glass Fiber in 48 Hrs

S.No	The diameter of single Glass fiber BW	The diameter of single Glass fiber AW
1.	0.397	0.404
2.	0.386	0.41
3.	0.386	0.413
4.	0.397	0.408
5.	0.397	0.413
6.	0.397	0.413
7.	0.386	0.408
8.	0.386	0.413
9.	0.386	0.413
10.	0.386	0.408
Avg. Diameter	0.39	0.41
Difference in diameter		0.02

The difference in average diameter before and after water treatment ranged to 0.29mm. Similarly, Table IV showed the diameter variation of single glass fiber before and after treating with water. The diameter difference is only 0.02 which is much lesser when compared to CS fiber.

IV. CONCLUSION

In this paper, the work proposed the water absorption of coconut fiber and synthetic fiber for varying time intervals. The experimental results and optical images revealed the absorption effect of CS/UPR and GM/UPR composite. There showed a bulging effect which means CS fiber absorbs more water than glass mat fiber. On comparing both fiber composites in terms of hours and days, the absorption behavior keeps on increasing. It is concluded that natural fiber absorbs more water than synthetic fiber and there are several possibilities for the entrapment of water consumption of natural fiber.

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Dr. S. Kalirasu obtained his Bachelor's degree in Automobile engineering from K.L.N.College of Engineering; Madurai affiliated to Anna University, Chennai in 2009. He was awarded his Master's degree in CAD/CAM from Kalasalingam University, Krishnankoil in 2012. Then he was awarded his PhD in Mechanical Engineering from Kalasalingam Academy of Research and Education, Krishnankoil in 2018. He has published 10 international journals and also published more than 10 papers in International Conference proceedings. His research interest is on the fabrication of natural fiber composites and machining studies.

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