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TENSILE PROPERTIES OF REINFORCED PLASTIC MATERIAL COMPOSITES WITH NATURAL FIBER AND FILLER MATERIAL

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ABSTRACT

Usage of natural fibers in reinforced plastic material with natural fibers as a composite had a positive approach for the development of green composites in our day today life. In this paper we are studying the tensile properties of woven bamboo bidirectional natural fiber with coconut shell powder in micro and nano size reinforced polymer composite with an angle of $0^o/90^o$ orientation. The tensile properties were studied before and after water absorption test on specimens. The water absorption test will shows the deviation in the tensile properties of the natural fiber reinforced composites before and after water absorption in material. More deviations can be reduced by various chemical treatment of the natural bamboo fiber. It is analyzed and proved that bamboo fiber absorbs less water when compared to all other natural fibers. Bonding between the matrix and the natural fibers are shown in the SEM analysis report.

Keywords: micro & nano filler material, tensile properties, water absorption, woven bamboo, FRP composite.

INTRODUCTION

Polymeric composites degradation behavior upon exposure to environment conditions such as humidity and temperature is one of the most important problems occurred. The natural fiber reinforced Plastic material composites are reasonably lightweight, strong, free from health hazards and biodegradable hence they have the potential to be used as building materials. Even though the natural fiber reinforced plastic material composite having more advantages, they are also having certain disadvantages like poor moisture resistance, lower modulus, high water absorption rate and low strength when compared with synthetic fibers such as carbon fiber and glass fiber (Velmurugan *et al.* 2007). However research works are conducted to replace artificial fibers with natural fibers. Bamboo fiber was natural grass like perennial fiber, which contains natural cellulosic lingo based fiber (McClure, 1966). The fiber which is made up of bamboo will have excellent property like high tensile strength and also having high strength to weight ratio, low cost when compare with synthetic fiber, easy availability and hazard less to environment due to ecofriendly nature, various researchers, scientists and engineers focused on bamboo fiber for using in reinforced plastic composites. In the fiber percentage moisture present with respect to weight varies from 9.16 to 10.14 at normal atmospheric condition (Murali Mohan Rao *et al.* 2007). The effect of silane coupling agent (Si69) on mechanical properties and curing characteristics of bamboo natural fiber filled natural rubber composites was highlighted in various aspects. It is proved that the addition of silane coupling agent in the bamboo fiber composites specimen will increase the adhesive property between the bamboo fiber and rubber matrix and also enhances the tensile strength, tensile modulus, shear strength, and hardness (Ismail *et al*., 2002) Generally water absorption increases with increasing fiber addition (George *et al* 1998, Ramachandran *et al.* 2014). Hence vol% of fiber is restricted to a maximum of 30 vol %. Coconut shell powder to micro and nano scale was used as filler along with polyester natural FRP composites increased the Young's modulus, water absorption property and tensile strength. In order to increase physical, mechanical and other properties, or to tailor a composite for a specific use or to facilitate processing and reducing the cost, coconut shell powder has been used as filler materials (SalmahHusseinsyah *et al.* 2011). Diffusion theory is the traditional method applied to find out the water absorption mechanism in composites (Sreekala *et al.* 2002; Pothan and Thomas, 2004; Bao and Yee, 2002; Bao *et al.*, 2001; Sahimi, 1994). The main objective of this research work is to make bamboo FRP composites suitable for outdoor use by modifying its properties by addition of filler materials and changing the orientation of filler materials. The tests such as water absorption and tensile test were conducted before and after water absorption. The water absorption test was conducted in collected rain water. Generally, the external applications composites were mainly affected because of rain water. SEM test was conducted in order to understand the fracture surface of the specimen.

MATERIALS AND SPECIMENS

Bamboo fibers of diameter 10-330 μm were procured from Coimbatore, India. Coconut shell powder was supplied by SIP India, Erode, India. The unsaturated polyester and other bamboo woven of 1000 X 1000 cm^2 size was purchased from scientific suppliers, India. The woven was cut in to a size of 100 X 100 cm^2 and soaked in 5 percentage of NaOH at normal room temperature for four hours. The treated woven was perfectly cleaned in water and excess water was dried at room temperature. Three types of FRP samples were prepared as given in Table-1. The coconut shell powder in the size of micron and nano were used as filler material. The sample A was fabricated by adding polyester resin with hardener in the ratio 10:1 by magnetic stirrer. This matrix solution was

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poured over the fiber woven evenly and the procedure continued for five layers of woven. In order to trap the air bubbles the specimen was pressed in the hydraulic press and followed by heating in a woven. The samples B and C were prepared by mixing the polyester and coconut shell powder (micron and nano) with hardener and the same procedure was adopted as sample A.

Table-1. FRP composite with different compositions.

Samples	Orientation	Compositions	Volume (%)
A	0°/90°	Polyester resin	70
		Bamboo fiber	30
B	0°/90°	Polyester resin	70
		Bamboo fiber	25
		micro powder	5
C	0°/90°	Polyester resin	70
		Bamboo fiber	25
		nano powder	5

WATER ABSORPTION TEST

Water absorption samples A, B and C was prepared as per ASTM D 5229. The initial weight of each specimen was taken before immersing into the water by electronic balance with an accuracy of 10^{-4}. Samples were then immersed in collected rain water of pH value 5.6 at room temperature of 31°C. After specific period of 24 hours interval the samples were taken out and wiped with tissue paper to remove the moisture. Then the weight of the specimens were taken and tabulated. The readings were taken for 21 days for an interval of 24 hours. The (water absorption) moisture content, M(t) absorbed by each specimen is calculated from its weight before, w (0) and after, w (t) absorption by using the following equation 1:

$$M(t) = 100\left(\frac{W_t - W_0}{W_0}\right) \text{-----------------} 1 \qquad (1)$$

Tensile specimens for with and without water absorption were prepared with respect to ASTM D 638 standards. The tests were conducted on six specimen containing two groups as before and after water absorption. Three prepared specimens were immersed in to collected rain water for 21 days. Then these specimens were taken out and wiped with tissue papers to remove the moisture. Every specimen was tested at a constant speed until fracture of the specimen by a computerized universal testing machine.

RESULTS AND DISCUSSIONS

Figure-1 shows the percentage of weight gain in the natural fiber reinforced plastic material composite specimen with respect to time with and without filler material after exposure to rain water at room temperature for all the samples A, B and C. In all the samples, the water absorption was high in the starting stage and then leads to steady level and this may happened due to hydrophilic characteristics of nature of natural fibers.

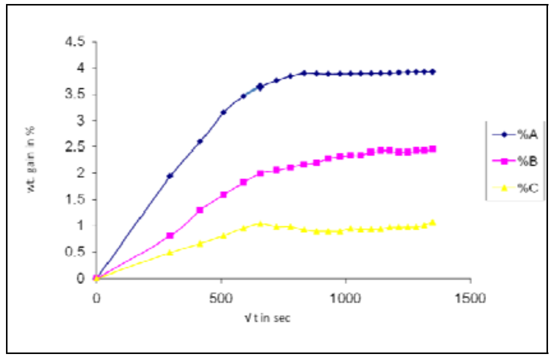

Figure-1. Weight gains in % Vs √time in sec. for tensile specimen.

From Figure-1, it was noticed that the addition of filler materials in micron and nano level reduces the rate of water absorption. All the specimens reinforced FRP composite with and without filler materials exhibited Pseudo Fickianbehavior, when moisture once gained never reaches equilibrium after initial change (Weitsman 2000). Moisture Content ($M_{m)}$ and diffusion coefficient (D) for all the three specimens were low when compared to other natural fibers like hemp (SuharaPanthapulakkal and MohiniSain, 2007; Mohd Hafiz *et al.* 2011).

TENSILE TEST

The Figure-2 shows the tensile strength of the specimens A, B and C before and after water absorption. The test results show that the specimens C with nano filler material inclusion show high tensile strength on both cases. This may be due to the better bonding strength between the matrix and reinforcement was good enough due to nano filler material addition. The specimen C showed a very less strength difference of 46.34 N/mm^2 and 46.082 N/mm^2 on before and after water absorption. The reduction in tensile strength was caused due to non uniform diameter of fibers, absorption of more water and poor dispersion of fibers with matrix. The water absorption of fibers promotes to decrease the stiffness of the fibers and formed shear stress in the interface; this creates debonding between fiber and matrix. Also, the rate of reduction in tensile strength was depends on duration of immersion, quantity of fiber and percentage of filler material. The addition of filler materials may fill the small void spaces resulted on minimizing the penetration of water. This may enhance the bonding between matrix and fibers. Among the micron and nano filler material addition, the nano filler material added samples show

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better results, this may be due to the occupying the very small voids of nano size by the nano material.

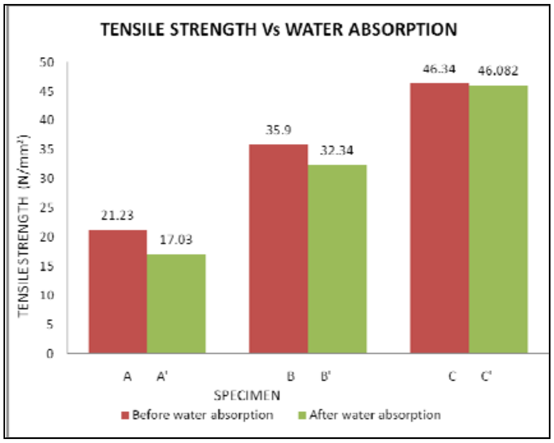

Figure-2. Tensile specimen before and after water absorption.

SCANNING ELECTRON MICROGRAPHS

In orders to study the type of fracture, the fracture surface of all tensile samples were examined by SEM. The Figure-3(a-c) shows the fracture surface of samples before water absorption. The images reveal that no cavity was present in the matrix and fiber interfacial bonding. Also failure mechanism shows higher degree of fiber pull out which indicates better interfacial adhesion between fibers and matrix. The Figure-3(d-f) shows the fracture surface of samples after water absorption. The images exhibit that no formation of cavity due to the water absorption, but the pull out of the fiber was sharp and no evidence of shear failure due to the water absorption. This may leads to reduce the mechanical properties like tensile strength of the sample after water absorption.

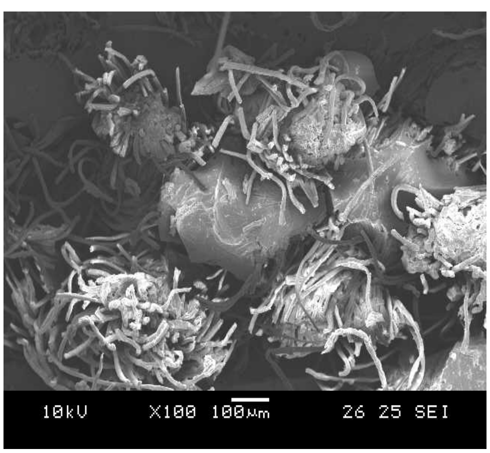

Figure-3(a). SEM image Pure Bamboo 0°/90° orientation.

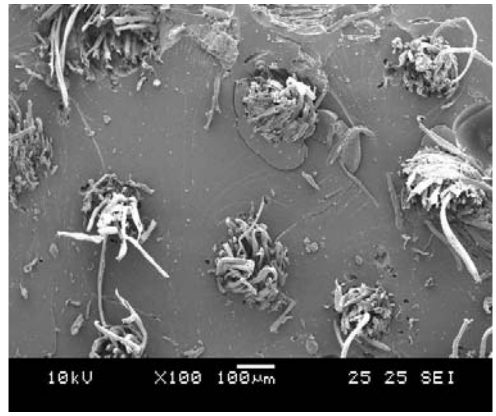

Figure-3(b). SEM image micro filler added Bamboo 0°/90° before water absorption orientation before water absorption.

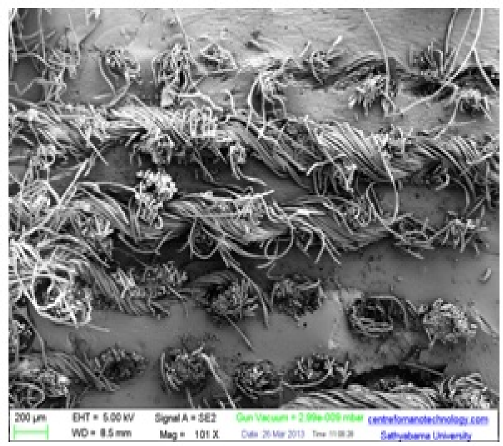

Figure-3(c). SEM image nano filler added Bamboo 0°/90°.

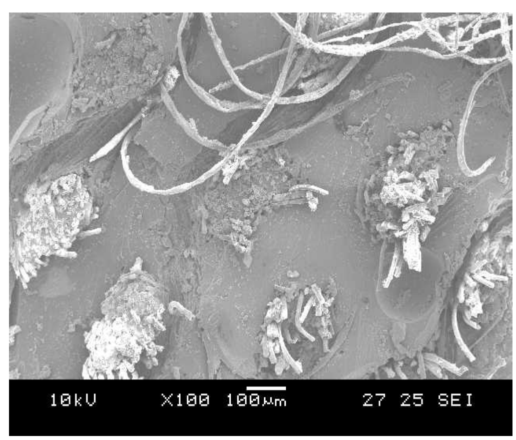

Figure-3(d). SEM image Pure Bamboo 0°/90° orientation after orientation before water absorption water absorption.

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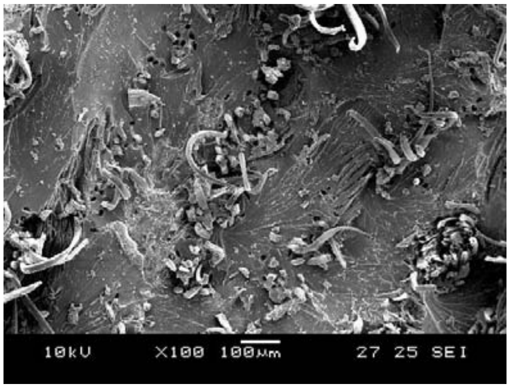

Figure-3(e). SEM image micro filler added Bamboo 0°/90°.

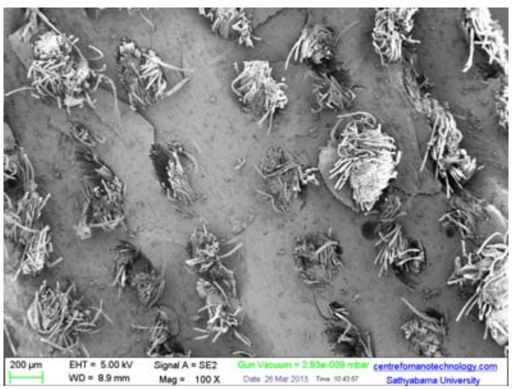

Figure-3(f). SEM image nano filler added Bamboo 0°/90°orientation after water absorption orientation after water absorption.

CONCLUSIONS

The above results show the effect of water absorption on tensile properties of natural fiber reinforced plastic material composite with added micro and nano tested at room temperature. The results found to follow pseudo-Fickian behavior with respect to time. The inclusion of fillers increases the bonding strength between the natural woven bamboo fiber and polyester resin. The coconut shell nano powder added FRP composites revealed better results when compared to pure bamboo and coconut shell micro powder added FRP composites. The images reveal that no cavity was present and failure mechanism shows higher degree of fiber pull out.

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