EXPERIMENTAL INVESTIGATION OF MECHANICAL BEHAVIOR OF BAMBOO-COTTON WOVEN FABRIC/EPOXY HYBRID COMPOSITES

R. Thilipkumar[1]
[1](Department of Mechanical Engineering, M.P.N.M.J Engineering College, Erode, India, rthilipkumar@gmail.com)

Abstract—*The objective of this paper is to study the effect of number of layers on mechanical behaviour of bamboo- cotton woven fabric/epoxy hybrid composite laminates. The bamboo-cotton woven fabric/epoxy composite laminates having layers in the range of 8, 10, 12 and 14 were prepared by a hand lay-up followed by compression moulding process. The specimens were prepared according to ASTM standards and the experiment has been carried out by Universal Testing Machine (UTM).The tensile, flexural, impact and water absorption tests have been performed on the fabricated composites. It was found that the addition of layers of the fibers resulted in increase in mechanical properties of the composites and decrease in water resistance.*

Keywords—Banana-cotton, Hybrid Composites, Woven Fabric, Mechanical properties, Epoxy resin

1. INTRODUCTION

The combination of two or more constituents is called as composites. One constituent is called as reinforcing phase. Another one in which it is embedded is called as matrix phase. Reinforcing phase may be in the form of fibers, particles, flakes etc. There are different fibers are used to make composites. They are natural fiber, glass fiber, carbon fiber, aramid fiber and etc. The natural fibers are renewable, non- abrasive, bio-degradable, possess a good calorific value, exhibit excellent mechanical properties. It is used in automotive industries in order to reduce the weight of the component. Natural fibers such as jute, flux, hemp, bamboo, cotton etc. can be used to reduce the cost of the composites. Bamboo is an important forest biomass resource. Bamboo textiles have many fantastic properties when used as textile materials such as high tenacity, excellent thermal conductivity, resistant to bacteria, and high water and perspiration adsorption. The bamboo is in its size, lightness and strength an extreme product of nature. It is stable and because of its cavities an extreme light and elastic building material. The reinforcement by diaphragms and its physical conditions cause its enormous superiority compare to other building materials.

Okubo et al. compared the mechanical properties of bamboo and glass fibers and concluded that the strength of the bamboo fiber is equal to that of glass fiber[1]. Gun et al. found that the property of bamboo/cotton fiber is good when compared with other combinations of bamboo fiber[2]. Kawahito et al concluded that when applying heavy load cotton fiber has high tenacity and it has good water absorbing capacity like bamboo fiber [3].

Karahan et al. reported that the cotton fiber is used for functional requirements in textile industries due to its good moisture absorption capacity and antibacterial properties [4]. Godbole and Lakkard investigated that the mechanical strength of bamboo fiber is affected by hot water.[5] Yakou and Sakamotu found that the abrasive properties of bamboo fiber are depending on friction surface so that the inner layer thickness is higher than the outer layer[6].

Bamboo is found in abundance in Asia and South America. In many Asian countries bamboo has not been explored fully to its extent although it is considered as natural engineering material. This sustainable material has evolved as backbone for socio-economical status of society as it takes several months to grow up. This property is due to the longitudinal alignment of fibers. In practice, it is mandatory to fabricate the bamboo based composites in addition to the extraction of bamboo fibers in controlled way from bamboo trees[7-10]. There are few studies examined the properties of bamboo and cotton fibers. They reported that the combination of bamboo/cotton fiber can be used in different applications due to its better mechanical properties. The purpose of this paper was to study the mechanical properties of bamboo/cotton fiber with different weight fractions.

2. MATERIALS

A. Preparation of Bamboo /cotton woven fabric

In this work, bamboo/cotton hybrid fabric (BCF) was produced with warp packed with cotton yarn and weft as bamboo yarn. The fabric particulars are given in Table 1.

TABLE 1: Particulars of Bamboo/Cotton woven fabric (BCF)

S.No	Fabric particulars	Values
1	Fabric GSM (g)	160
2	Thickness (mm)	0.20

B. *Epoxy Resin*

Epoxy LY556 resin, chemically belonging to the epoxide family is used as the matrix material. The epoxy resin and hardener HY 951 are mixed in a ratio of 10:1 by weight as recommended.

3. EXPERIMENTAL

A. *Composite Manufacturing*

The composite was made by compression moulding technique. The mould release agent (wax) was first applied on the inner surface of a three piece chromium plated tool steel mould with dimensions 270 mm x 270 mm x 3 mm, then the fabric layers (warp and weft way alternatively) and matrix (epoxy resin mixed in the ratio of 10:1 with hardener) were mutually laid in the mould to obtain a thickness of 3 mm. The mould was then closed and the setup was left to cure 45 min at temperature of 70°C under a load of 100kg/cm^2 in a compression moulding machine. The composite panels were fabricated with various the numbers layers varied from 8 to 14 with respective fabric weight in the range of 56 gms to 90 gms. Tests (3 point bend test) were carried in same machine as per ASTM D790 standard with specimen dimension (127x 13x 3) mm. The impact testing was done under the standard ASTM D 256 with specimen dimension of (66x13x3) mm using Izod method. Water absorption test was carried out as per ASTM D 570 with the specimen dimensions of 20x20x3 mm.

B. *Mechanical Testing*

Tensile measurements were carried out as per ASTM D3039 type IV testing in KALPAK UTM (Universal Testing Machine) with specimen dimension (250x25x3) mm. Flexural tests (3 point bend test) were carried in same machine as per ASTM D790 standard with specimen dimension(127x 13x 3) mm. The impact testing was done under the standard ASTM D 256 with specimen dimension of (66x13x3) mm using Izod method. Water absorption test was carried out as per ASTM D 570 with the specimen dimensions of 20x20x3 mm.

4. RESULTS AND DISCUSSION

A. Tensile Strength of Bamboo-Cotton hybrid composite laminate

The tensile test specimens are prepared and testing of the composite laminates was carried out as per ASTM D 3038. Average values of five specimens are used from each laminates for testing tensile behaviour of hybrid laminates. The tensile strength found to increase with increase in fiber content up to 12 layers and then decrease with increase layers. This may be due to the optimum level of fiber content to wet properly, beyond 12 layers, the resin may not penetrate in to the layers and it may be insufficient to wet the fibers.

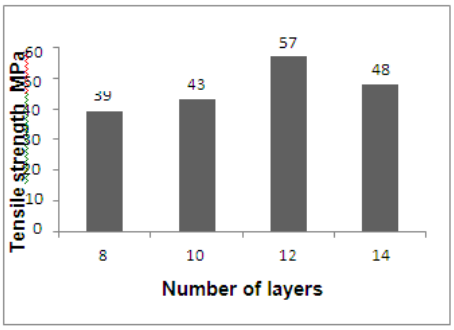

Fig.1. Tensile strength Vs Number of Layers

B. *Flexural Strength of Bamboo-Cotton hybrid composite laminate*

The fabricated specimens were tested for flexural strength in universal testing machine. Maximum displacement against load was recorded. The comparative results of different layers of bamboo-cotton hybrid epoxy are presented in figure 2. Flexural strength of 40 MPa, 44 MPa, 72MPa and 78 MPa for 8 layers, 10 layers, 12 layers and 14 layers of bamboo-cotton fabric composites were recorded respectively. The result indicated that 14 layers woven bamboo-cotton fabric yields more flexural strength.

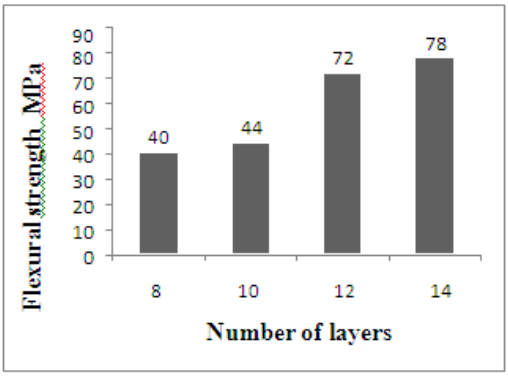

Fig. 2. Flexural strength Vs Number of Layers

C Impact test of Bamboo-Cotton hybrid composite laminate

The impact test is carried out for evaluating the impact load carrying capability of the different layers of hybrid composite specimens and the Izod impact test is used in the present investigation. The loss of energy is found out on the reading obtained from the impact testing machine. The impact strength comparison of different layers of hybrid composite samples is presented in Fig. 3.

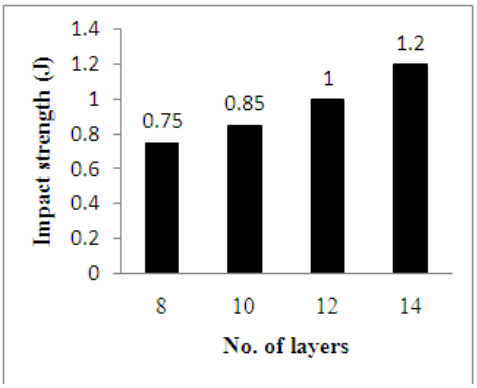

Fig.3. Impact strength Vs Number of Layers

D. Water absorption test

The water absorption characteristic is another significant property for natural fiber composites. The water absorption test is carried out as per ASTM D 570. For each laminates average of 5 samples used to find out the water absorption capacity of the bamboo-cotton/epoxy composites. Water absorption occurs mainly in the outer layer of the composite laminate. The water absorbing capacity increase with increase in layers, this is due to more amount of fiber present in the laminates. The values are plotted in the figure 4.

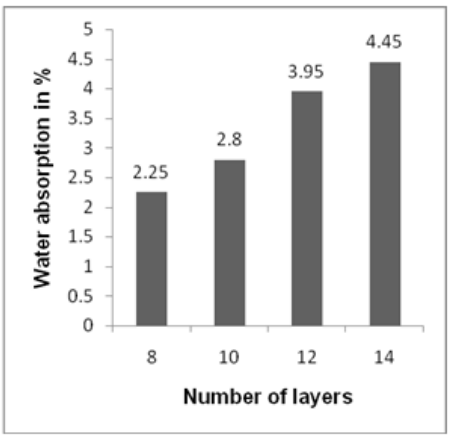

Fig.4. Water absorption percentage Vs Number of Layers

5. CONCLUSION

In this work, mechanical properties of woven bamboo-cotton fiber hybrid epoxy composites were investigated. The tensile, flexural, impact and water absorption properties of the composites as a function of fiber content were analyzed. The tensile strength of woven bamboo-cotton fiber hybrid epoxy composite improved by layers in the number range 12 and decreased by increasing the layers. The flexural strength, impact strength and water absorption characteristics of woven bamboo-cotton fiber hybrid epoxy composite improved by increasing the number of layers.

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