MECHANICAL PROPERTIES OF SHORT BAMBOO FIBER REINFORCED POLYESTER COMPOSITES FILLED WITH ALUMINA PARTICULATE

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***Abstract*— Uses of natural fibers as reinforcement have gained the importance in the recent years due to the eco-friendly nature. These natural fibers offer a number of advantages over traditional synthetic fibers. This paper deals with the evaluation of mechanical properties namely, Tensile strength (TS) and Flexural strength (FS), of short bamboo fiber reinforced polyester composites filled with alumina particulates. Specimens were prepared by hand lay-up technique and are cut as per ASTM standards to perform test. The experimental result reveals that the mechanical properties of the composite material were highly influenced by the fiber volume fraction (fiber loading). Addition of alumina (Al_2O_3) particulate at various proportions as filler material the mechanical properties viz,. Tensile strength and flexural strength are distinctly improved.**

Keywords- Bamboo fiber, Polyester matrix, Tensile strength, flexural strength, alumina particulate.

I. INTRODUCTION

Bamboo is a widespread plant family occurring in all countries. In Asia, it is used for constructing houses, in artificial handicrafts, pulp industry and paper manufacturing. Due to its importance, many studies have been aimed at the anatomical structure, chemical composition and various mechanical properties [1,2]. The use of natural fibers as reinforcement in the composites gives good opportunities for the effective utilization of agricultural by-products. Natural fibers can be molded in to flat plates and can be used as a substitute material [3]. Development of composite materials for buildings using natural fibers as bamboo with high tensile strength is an interesting alternative which would solve environmental issue and energy concern. Natural fibers have many advantages compared to synthetic fibers, for example low weight, low density, low cost, acceptable specific properties and they are recyclable and biodegradable. They are also renewable and have relatively high strength and stiffness and cause no skin irritations. On the other hand, there are also some disadvantages, for example moisture uptake, quality variations and low thermal stability. Many investigations have been made on the potential of the natural fibers as reinforcements for composites and in several cases the result have shown that the natural fiber composites own good stiffness but the composites do not reach the same level of strength as the glass fiber composite [4]. Mansur and Aziz [5] studied bamboo-mesh reinforced cement composites, and found that this reinforcing material could enhance the ductility and toughness of the cement matrix, and increase significantly its tensile, Flexural and impact strengths. Srinivasulu and Vijay kumar Reddy [6] have investigated the effect of fiber length on tensile properties and chemical resistance of short bamboo fiber reinforced polycarbonate toughened epoxy composites. Rajulu et al. [7] investigated the effect of fiber length on the tensile properties of short bamboo fiber epoxy composites. The term ‘filler’ is very broad and encompasses a variety of materials plays an important role for the improvement in performance of polymers and their composites. Filler materials are used to reduce the material costs, to improve mechanical properties to some extent and in some cases to improve process ability. In addition, it also increases properties like abrasion resistance, hardness and reduces shrinkage. So, although in fiber reinforced polymer composites, a judicious selection of matrix and the reinforcing phase can lead to a composite with a combination of strength and modulus comparable to or even better than those of conventional metallic materials, their physical and mechanical properties can further be modified by addition of a solid filler phase to the matrix body during the composite preparation.

The present work an attempt is made to develop a new class of natural (banana) fiber reinforced polymer composite filled with alumina particulate and to study their mechanical behavior.

II. MATERIALS AND METHODS

Short bamboo fiber is taken as reinforcement is collected from local sources. The unsaturated Polyester (Ecmas 4411) resin and hardener were supplied by Ciba Geigy India Ltd and Al_2O_3 powders is obtained from NICE Ltd India in a range of 80-100µm.

A. *Chemical treatment of Bamboo fibers:*

In this investigation, the bamboo fibers are chemically treated with mixture solution of two different types of chemicals namely Sodium Hydroxide (NaoH) and Potassium Hydroxide (KoH) each of 3 moles of concentration in100ml of distilled water, then the solution with fibers were boiled for few minutes and the fiber are dried in sun light for10-12days.The purpose of chemical treatment is to remove the moisture content present in the bamboo fiber and to increase the tensile strength of bamboo fiber.

B. *Composite fabrication*

A glass mould having dimensions of 150*150*3mm is used for composite fabrication. The short bamboo fiber and Al_2O_3 particulates are mixed with polyester resin by the simple mechanical stirring and the mixture is poured into various moulds. The composite samples of three different compositions PB-1to PB-3, in which no particulate filler is used. The other composite samples PBA-1 to PBA-3 are prepared in three different percentages of alumina particulates (5wt%, 10 wt% and 15wt% of alumina) is used keeping bamboo fiber at a fixed percentages (i.e. 45wt%). A releasing agent (Ethanol) is used to facilitate easy removal of the composite from the mould after curing. The entrapped air bubbles (if any) are removed carefully with a sliding roller and the mould is closed for curing at a temperature of 40°C for 24 h at a constant pressure of 10kg/cm^2. After curing, the specimens of suitable dimension are cut as per ASTM standards for mechanical tests. The compositions and designation of composites prepared for this study are listed in Table 1. Fig.1 shows the photo graph of the composites of different compositions.

Table 1. Designation of Composites

Samples	Compositions
PB-1	Polyester + Bamboo Fiber (15wt%)
PB-2	Polyester + Bamboo Fiber (30wt%)
PB-3	Polyester + Bamboo Fiber (45wt%)
PBA-1	Polyester + Bamboo Fiber (45wt %) + Alumina (5 wt%)
PBA-2	Polyester + Bamboo Fiber (45wt %) + Alumina (10 wt%)
PBA-3	Polyester + Bamboo Fiber (45wt%) + Alumina (15wt%)

Fig:1 Composites of different compositions.

C. *Tensile Test*

The tensile test is performed on specimens cut according to ASTM D638-03 test standards as shown in Fig.2, on a universal testing machine Instron 3369.The cross head speed was maintained 5mm/min, at a temperature 22^{o}C and humidity 50%. In each case three samples were tested and average value are recorded. Fig. 3 shows the specimen for tension test.

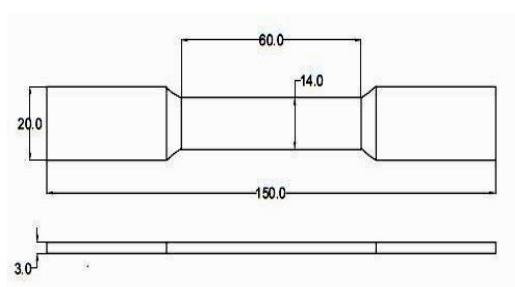

Fig: 2 Specifications of Tension test specimen

Fig: 3 Specimen for tension test

D. Flexural test

Flexural test were performed using 3-point bending method according to ASTM D790-03 procedure. Fig.4 shows the specifications of flexural test specimen and Fig. 5 shows the specimen for flexural strength test. The specimens were tested at a crosshead speed of 5 mm/min, at a temperature 22˚C and humidity 50%. In each case three samples were tested and average value is reported

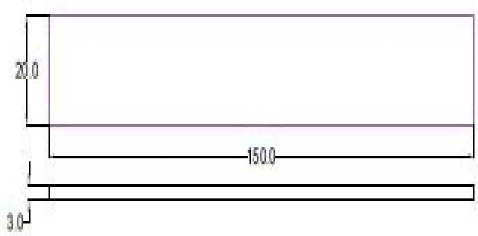

Fig: 4 Specifications of flexural test specimen

Fig: 5 Specimen for flexural test

III. RESULTS AND DISCUSSIONS

In this work short bamboo fiber reinforced polyester composites with and without the use of filler material alumina (Al_2O_3) were fabricated by hand lay-up technique. Then test specimens were prepared as per ASTM standards and were tested to evaluate mechanical properties like tensile strength (TS), and flexural strength (FS).

A. Effect of fiber volume fraction (V_f) on Tensile Strength of the composites

The effect of fiber volume fraction on the tensile strength of the composite is shown in Fig. 6. As the weight fraction of fiber increases, the tensile strength of the composite material increases gradually. The maximum value of tensile strength of 15.601MPa was observed at a fiber volume fraction of 45 wt. The tensile properties measured in the present work are in close agreement with the results sated by earlier investigators [8-10], though the method of extraction of bamboo fiber is different.

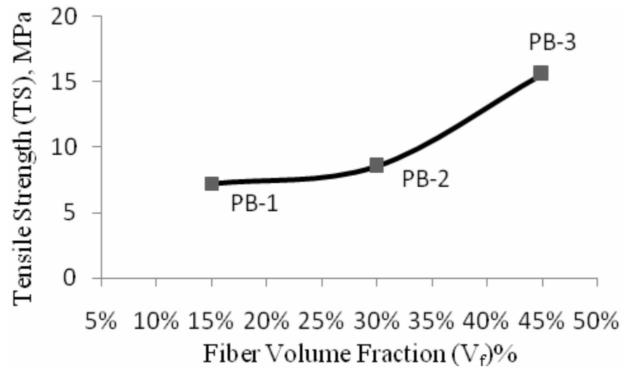

Fig: 6 Variation of tensile strength with respect to the fiber volume fraction

B. Effect of fiber volume fraction (V_f) on flexural strength of Composites

F

Fig.7 shows the effect of fiber volume fraction on flexural strength of composites. Adversely, as shown in Figure 7, the flexural strength is increased by the increase of fiber loading up to30wt%. For instance, flexural strength of bamboo-polyester composite is increased from 29.38Mpa to 38.98Mpa i.e., up to 30wt% and then decreased from 38.989MPa to 26.226Mpa i.e. up to 45wt% respectively. It is also observed from Fig.7 that a linearly increasing trend up to a certain value of fiber loading i.e., up to 30wt% and suddenly drops due to failure of specimens and the arrest points correspond to breakage end pull out of individual fibers from the matrix. This is due to higher flexural stiffness of bamboo composite and the improved adhesion between the matrix and the fiber. The effect of fiber volume fraction on mean flexural strength for other fiber reinforced composites in comparison to bamboo composites are more. The decrease in the flexural strength of the bamboo fiber reinforced is attributed to the inability of the fiber, irregular shape, and inability to support stresses transferred from the polymer matrix and poor interfacial bonding generates partially spaces between fiber and matrix material and as a result generates weak structure. A composite material to be used for the structural application must possess higher flexural strength.

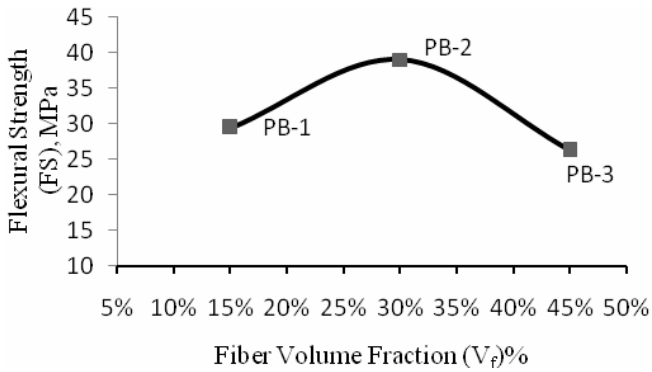

Fig: 7 Variation of flexural strength with respect to the fiber volume fraction

C. *Effect of filler content (V_f) on tensile strength of the Composites*

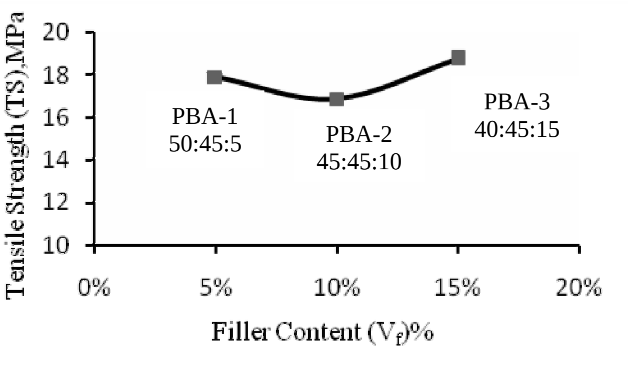

Fig: 8 Variation of tensile strength with respect to the filler content

The influence of filler content on tensile strength of composites is shown in Fig.8. In these composites the bamboo fiber reinforcement is maintained 45% and alumina is added as filler in different proportions. It can be seen from the graph that the tensile strength has distinctly improved with the incorporation of alumina particles (15wt %) in the matrix. The significant variation of tensile strength for different systems indicates that fiber alignment is not the only factor which affects mechanical performance, interfacial adhesion and the bamboo fiber influences polyester matrix properties also have a significant effect. Generally, modulus reflects the performance of both fiber and matrix interface material to transfer the elastic deformation in the case of small strains without interface fracture. The tensile strength of the composite is strongly associated with interfacial failure behavior. The increase in tensile strength is due to the cross linking network formation between the fibers and the filler filled polymer matrix.

D. *Effect of filler content (V_f) on flexural strength of the Composites*

The influence of filler content on flexural strength of composites is shown in Fig.9. In these composites the bamboo fiber reinforcement is maintained constant at 45% and alumina is added as filler at different proportions. It can be seen from the graph, that the flexural properties have become distinctly improved with the incorporation of alumina particles up to 10wt % in the matrix. The significant variation of flexural strength for different systems of composites indicates fiber alignment is not the only factor which affects mechanical performance interfacial bond between the matrix and reinforcement also has a significant effect.. The decrease in flexural strength of the composite is probably caused by an incompatibility of the alumina particles and the polyester matrix with bamboo fiber, leading to poor interfacial bonding. However, flexural strength also depends on other factors such as the size and shape of the filler taken in the composites.

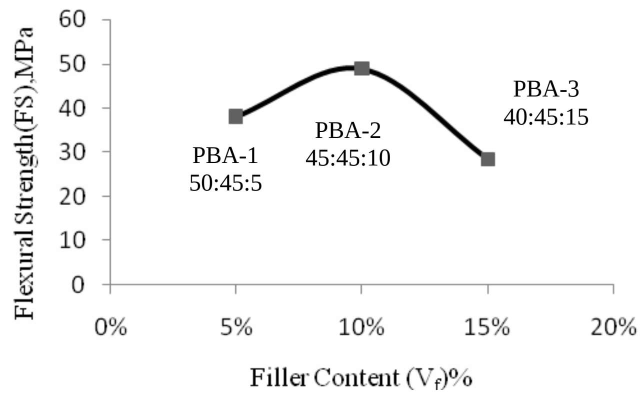

Fig: 9 Variation of flexural strength with respect to the filler content

IV. CONCLUSIONS

- The successful fabrication of new class of polyester based composites reinforced with short bamboo fiber and alumina particulates have been done.
- The present investigation reveals that 45% fiber loading shows the superior tensile strength. Whereas, better flexural strength was noticed at 30% of fiber loading.
- Inclusion of filler material in the bamboo- polyester composites, the observed mechanical properties are superior as compared with unfilled composites.
- Maximum tensile strength of 18.76Mpa was found for 15% filler loaded bamboo fiber reinforced polyester composite.
- Maximum flexural strength of 45.85Mpa was found for 10% filler loaded bamboo fiber reinforced polyester composite.

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