Effect of filler material in bamboo fiber reinforced polymer composites

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ABSTRACT

Natural fiber reinforced polymer composites have proved as an environmentally friendly and cost-effective alternative to synthetic fiber reinforced composites. A number of major industries such as the automotive and construction field has shown an interest in the progress of new natural fiber reinforced polymer composite materials. However, the uses of natural fibers are minimum. The primary objective of this research was to investigate the feasibility of using bamboo fiber mat with different filler like Graphene, Alumina, Silicon oxide materials as reinforcement for fiber reinforced composites (FRCs). It was observed that Graphene reinforced laminates has better mechanical properties over Alumina and Silicon oxide. Water repellent properties are better with silicon oxide reinforced laminates.

KEYWORDS: Bamboo Fiber Reinforced Composites, Epoxy Resin, Fiberglass Graphene, Alumina, Silicon oxide, Water Absorption.

1. INTRODUCTION

Natural fibers are from plants have great potentials for use in plastic, automotive, and packaging industries because of their characteristics such as eco-friendliness, low density, high specific stiffness, good mechanical properties, toxicologically harmless, biodegradability and acoustic insulation (Mohanty, 2004) and (Thakur, 2013). Bamboo has several advantages over other plant fibers such as its high growth rate, low cost, high mechanical strength, stiffness and low density (Jindal, 1986, Ray, 2004, Osorio, 2010, Riano, 2002). Bamboo has some disadvantages, high moisture content and thermal degradation during manufacturing (Li, 1994, Rajasekaran, 2016). Fiberglass mesh has tensile strength, not easy burn, small elongation, high elasticity, rigidity, low cost, shock resistance, chemical resistance, and forming glassy beads at high temperature.

2. MATERIALS AND METHODS

The process for BFRC (Bamboo Fiber Reinforced Composites) fabrication was studied first and evaluated to eliminate batch-to-batch variations in the final test specimens. The matrix plain woven glass fiber mat, glass fiber mesh, and flat knit bamboo fiber are proposed to be used as reinforcements. Use of hand molding, in a controlled temperature of 25° C approximately. The mold is allowed to stay under 15kg of weight for 24 hours at ambient temperature. Laminates of the epoxy and the select fibers are hand molded in room temperature. A total of six layers makes up one laminate.

Glass Fiber Woven Mat layer 1
Glass Fiber Woven Mat layer 2
Glass Fiber Mesh Layer 3
Hand weaved bamboo Fiber Layer 4
Glass Fiber Mesh Layer 5
Glass Fiber Woven Mat Layer 6

Fig.1.Layering of fibers

The laminates were prepared by hand moulding the chemicals and the filler materials were measured using a highly calibrated weighing scale. The epoxy was constantly stirred to prevent solidification. A transparent polythene sheet was placed. The sheet was coated with wax to prevent the moulds doesn't stick to sheet. The chemicals were measured using a high-precision weighing machine. The catalyst quantity was calculated to be 10% of the epoxy weight.

The epoxy was applied generously between all layers using a paint brush. A hand roller was used to flatten the layers to prevent air gaps. After layering was completed glass plate polythene sheet with wax was placed. Weight was placed on the very top finally to ensure flatness. The mould was allowed to rest for 24 hours at room temperature. After the resting period, the moulds are removed, the test specimens from each of the laminates are prepared for various testing. Using a rotating saw the laminate is cut to the required dimension.

Table.1.Laminate content

Laminate ID	Epoxy content in (gm)	Catalyst content in (gm)	Filler content in (gm)	Number Layer
Gra-1	200	20	5 gm of Graphene	6
Alu-2	200	20	5 gm of Alumina	6
Sil-3	200	20	5 gm of Silicon carbide	6
Pfc-4	200	20	No filler material	6

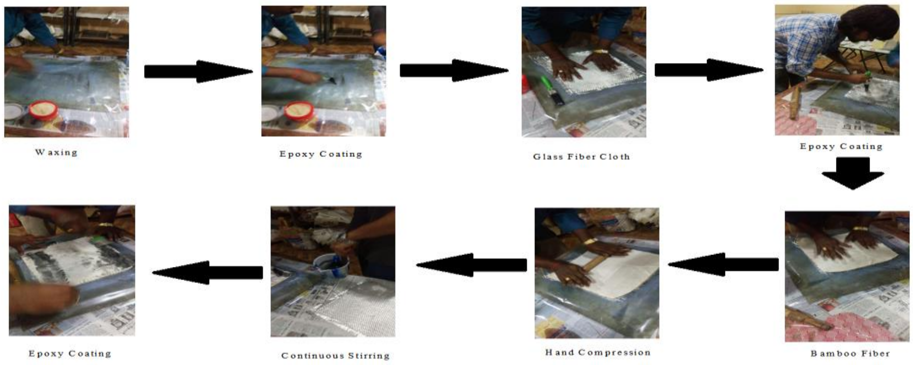

Fig.2.Process diagram for making laminate

The Tensile test and Bending test has been conducted in Electronic Universal Testing Machine/Electronic Te of model WDW 100 shown in figure.3 made by Jinan Test Machine Co. Ltd with a range of (0-100) KN.

Fig.3.Universal Testing Machine

Fig.4.Tensile test specimen Before& After

3. RESULTS AND DISCUSSION

Table.2.Tensile Test parameters

Tensile Test Parameters	Graphene	Alumina	Silica	Plain
Gauge Thickness(mm)	2.51	2.31	2.90	2.41
Gauge Width(mm)	23.75	23.84	23.80	23.70
Original Cross Section Area (mm×mm)	59.61	55.07	69.02	57.12
Ultimate Tensile Load(KN)	12.06	10.86	8.26	12.67
Ultimate Tensile Strength (MPa)	202	197	120	222

Table 3: Bending test Parameters

Test Parameters	Graphene	Alumina	Silica	Plain
Gauge Thickness(mm)	2.53	2.58	2.93	2.36
Gauge Width(mm)	23.46	24.83	24.68	24.36
Original Cross Section Area (mm×mm)	59.35	64.06	72.31	57049
Compressive Load (KN)	0.265	0.280	0.400	0.235
Compressive Strength(MPa)	4	4	6	4

The Tensile test shows in Fig.5, 6, 7, 8 and 9 that the plain fiber laminate has the maximum tensile load bearing capacity. Grpahene follows close behind with alumina and silicon oxide trailing behind.

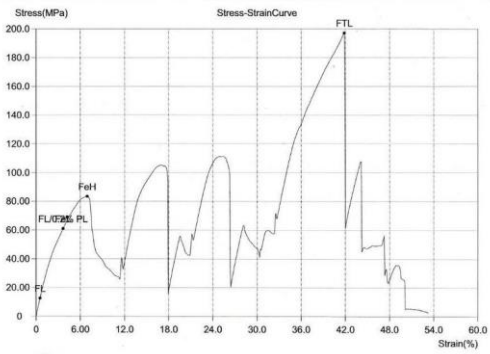

Fig.5.Graphene Specimen Size:23.75×2.51

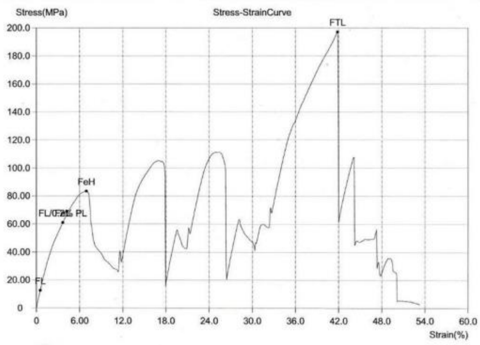

Fig.6.Alumina Specimen Size: 23.84×2.31

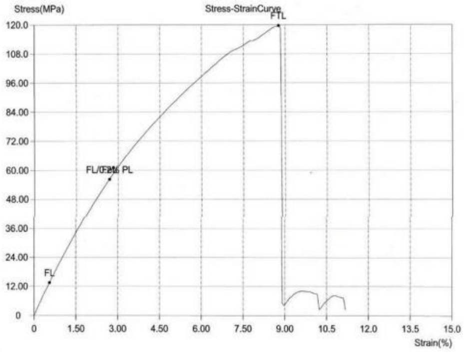

Fig.7.Silicon oxide Specimen Size: 23.80×2.90

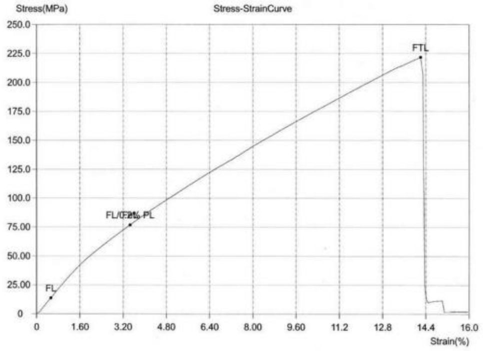

Fig.8.No Filler Specimen Size: 23.70×2.41

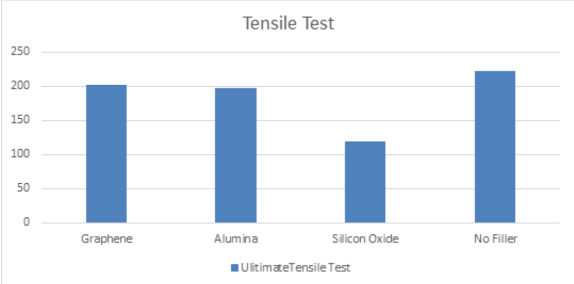

Fig.9.Tensile Test Results

The Bending test shows in Fig.10, 11, 12, 13, 14 that all laminates perform evenly. The 6 layer laminates have a very low Bending at an average load 2.35 Newton of force. Low Bending shows that the materials are capable of handling high compressive forces like floor boards, furniture etc.

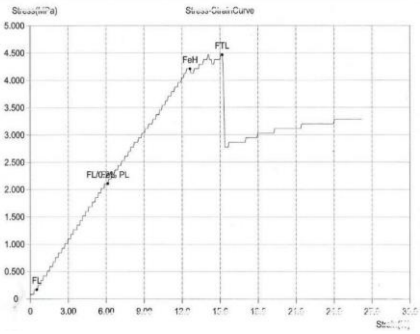

Fig.10.Grapheme Specimen Size: 23.46×2.53

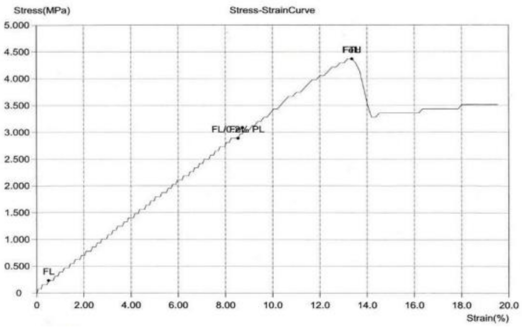

Fig.11.Alumina Specimen Size: 5.38×2.30

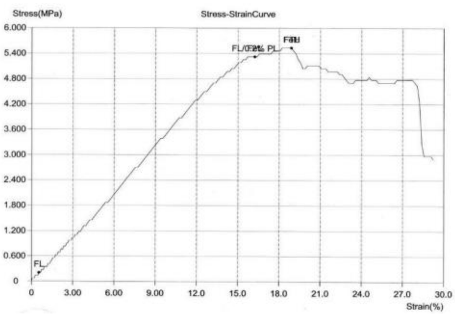

Fig.12.Silicon oxide Sp.Size: 24.68×2.93

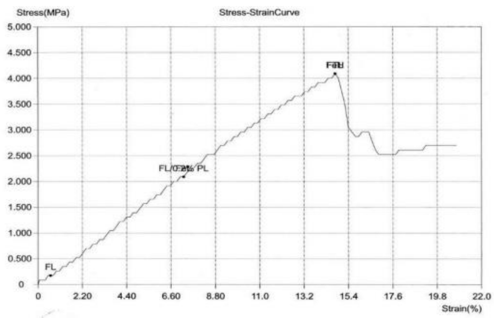

Fig.13.No filler material Sp.Size: 24.36×2.36

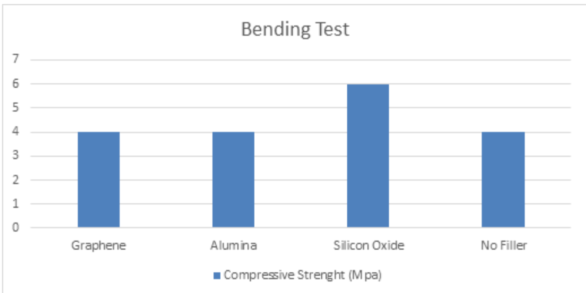

Fig.14.Bending test Results

In Charpy Impact Test as shown in Fig.15 Graphene is found to have the highest impact resistance and all the other filler materials show approximately the same results. Graphine is absorbed to have high energy absorption capabilities.

Table.4.Charpy test results for Specimen size (2.5×12×80)

Materials	Specimen1	Specimen2	Specimen3	Average
	Absorbed Energy in Joules			
Graphene laminate	08	06	08	7.33
Alumina laminate	06	06	02	4.67
Silicon oxide laminate	04	06	04	4.67
No Filler laminate	06	04	04	4.67

In water absorption test as shown in Fig.16 Alumina due to its water repellent properties has absorbed the least amount of water (0.28%) on the other hand Graphine shows to have (0.51%).A combination of both Alumina and Graphine is assumed to be the best combination to facilitate least water absorption.

Table.5.Water absorption percentage

Filler Material	Observation
Graphene	0.51%
Alumina	0.54%
Silicon Oxide	0.28%
No Filler	0.30%

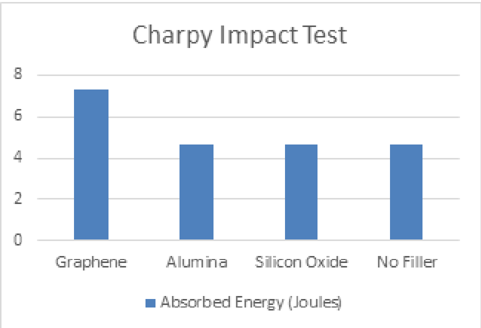

Fig.15.Charpy impact test results

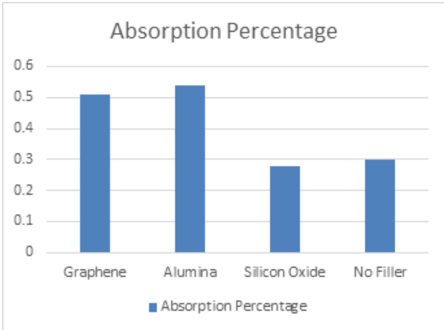

Fig.16.Water absorption test results

4. CONCLUSION

At the end of above testing results it was found that Graphene reinforced laminates have the maximum mechanical strength of 12.06KN compared with Alumina and Silicon oxide. Laminate without filler content shows high tensile bearing capabilities. Water repellent properties of silicon oxide give it the high resistance of 0.28% to water hence blending of different materials can lead to even better all-round performance.

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