Mechanical Properties of Bamboo Fiber Reinforced Plastics

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Abstract- *This paper describe mechanical properties and Design analysis of Bamboo Fiber Reinforced Biodegradable Plastics. Natural fiber has emerged as a renewable and cheaper substitute to synthetic materials such as glass, carbon. This increases tensile strength of composite. Compressive strength is not significantly increased. Bamboo fibers are ecofriendly and can be used in polymer composites.*

Keywords- Biocomposite, Bamboo fiber, Biodegradable Plastics

I. INTRODUCTION

Natural fibres have become popular reinforcement material for fibre reinforced polymer composite developments. These reinforcement can replace the conventional fibre, such as glass as an alternative material. Other than these natural fibers, bamboo is another interesting material considered as plant fibre and has a great potential to be used in polymer composite industry, ease of use.

The mechanical properties of different natural fibers such as sisal, vakka, banana, bamboo were compared and it was found that the bamboo fibers have much higher tensile and flexural properties than other fibers [1, 2].

Bamboo is one of the ecological materials for which it has many distinct characteristics such as [3, 4]:

- Bamboo fiber is a renewable biological resource
- Bamboo fiber is a low cost material improving economics of the end product
- Bamboo fiber is strong yet light weight - improving strength of composite
- Bamboo fiber is hydrophobic (repels water), rot proof, anti-bacterial, anti-allergic and fire resistant.
- Bamboo fiber provides an excellent resistance to compression and flexion.
- Due to its hollow structure bamboo fiber provides natural odour removal capacity
- Bamboo fiber is naturally bio-degradable

This study use the bamboo mixed with polymer in which to improve the bonding between fiber and matrix. Specifically, the reason of the study to use bamboo fiber is due to they havelow density and high mechanical strength as well as raw material cost makes it economically viable.

A. Bamboo

Bamboo is not grass neither wood, while it has two of their characteristics. It belongs to the family of the “Bambusoideae”. Bamboo mainly grows in tropical and sub-tropical regions of Asia, Latin America and Africa [5].

Bamboo, itself is very strong in its longitudinal direction due to strong fiber bundles penetration.

It is obvious that ecological materials satisfy fundamental requirements like pollution prevention and cost minimization. The use of agricultural by-products, which are environmentally friends, such as rice husk, coconut fibers, sisal and bamboo minimizing energy consumption, conserving non-renewable natural resources, reducing pollution and maintaining a healthy environment . Bamboo is the core of these materials that fulfills these advantages.

B. Bamboo Fiber

The bamboo fiber is often brittle compared with other natural fibers, because the fibers are covered with lignin. Therefore, a devised process should be adopted to extract the bamboo fibers for reinforcement of composite materials.

C. *Extraction Process of Bamboo fiber*

- Bamboo fibers can be extract in different ways. Some of them are explained below.
- Chemical Processing: It is basically hydrolysis alkalization. The crushed bamboo is "cooked"
- Hydrolysis alkalization is then done through carbon disulfide combined with multi-phase bleaching. Although chemical processing is not environmental friendly but it is preferred by many manufacturers as it is a less time consuming process [6].

- Mechanical Processing: In this method, the crushed bamboo is treated with biological enzymes. This breaks the bamboo into a mushy mass and individual fibers are then combed out. Although expensive, this process is eco-friendly [6].
- Steam-explosion processing: Raw bamboo was first cut into bamboo culms with 70-80cm in length by saw machine, and put into an autoclave with over-heated steam at 1750C and 0.7-0.8 MPa for 60 minutes. Then, the steam was suddenly released for 5 minutes and the cycles of sudden-steam release were continuously repeated for 9 times to assure the complete facture of cell walls. Finally, they were washed in hot water with addition of soap at 90-950C for 15 minutes to remove ash and dried in the oven for 24 hours at 1050C [6].

II. SAMPLE PREPARATION

Four different samples of standard dimensions as per ASTM are prepared. Two for tensile testing and two for compression testing.

Epoxy resin Araldite was kept in the furnace at a temperature of 90±10 °C for approximately one hour to remove or vaporize if any moisture or water in the resin and then cooled down to 45°C, after the temp reaches 45 °C, 15wt% hardener (HY-951) which acts as the curing agent is added to epoxy resin. Then bamboo fibers are added in ratio of 15 wt% as seen from past investigations and studies. The whole solution is then stirred manually or with the help of mechanical stirrer and then poured in the mould. Casting technique used will be simple hand layup technique followed by post curing by application of load. The whole mixture is poured in the mould is assembled together with the bolts and then held vertically in bench-wise for 24 hers after that it is post cured by pressing the mould with a 25kg weight for 2-3 days and then removed from the mould and left unloaded at normal room temperature for 2-3 days and then the samples of different sizes are cut from it.

III. TESTING

Tensile testing and Compression testing of Standard Specimen of Composite material and Non Composite material is carried out.

A. Tensile Test

Tensile test is used to measure the force required to break a material and the extent to which the specimen elongates to breaking point. Tensile test produces a stress-strain diagram which is used to specify a material or design parts to withstand applications of force and quality control check. Tensile test is used to determine the tensile strength of a material with unit as N/mm2 or MPa.

The specimens were prepared according to ASTM D3039-76, 150mm long x20mm wide x 3mm -14mm thickness this standard is recommended for tensile testing of reinforced thermosetting plastics. The sample was placed in the grips of the universal testing machine and pulled until deformation occurred. An extensometer was used to determine the elongation. The tensile strength was calculated using the following relation;

$$Tensile\ Strength = \frac{Maximum\ Tesnile\ Force}{Cross\ Sectional\ Area}$$

B. Compression Test

This test was carried out using ASTM D3410. The specimen was dimensioned 144mm long x 19mm width and 3.2 mm thickness. The sample was loaded into the machine and a force was gradually applied until the sample deformed.

Compressive test determines the behavior of materials under crushing loads. Compressive stress and strain was calculated and used to plot a stress-strain graph which can be used to determine elastic limit. The compressive properties that can also be determined from the data are; ultimate compressive strength, ultimate compressive strain, compressive Poisson's ratio etc.

$$Compressive\ Strength = \frac{Maximum\ Compressive\ Force}{Cross\ Sectional\ Area}$$

IV. OBSERVATIONS

A. Tensile Test

TABLE I TESNILE TEST

No.	*Type of Specimen*	*Maximum Tensile Force*
1	Reinforced Component	1900 N
2	Unreinforced Component	1100 N

B. Compression Test

TABLE II COMPRESSION TEST

No.	*Type of Specimen*	*Maximum Compression Force*
1	Reinforced Component	2900 N
2	Unreinforced Component	2870 N

V. CALCULATIONS

A. Tensile Test:-

Width =14mm and Thickness =3mm
Cross sectional area = Width x Thickness,
14mm x 3mm = 42 mm^2

i. For Reinforced Component-

$$Tensile\ Strength = \frac{1900}{42} = 45\ MPa$$

ii. For Unreinforced Component-

$$Tensile\ Strength = \frac{1100}{42} = 26\ MPa$$

B. Compression Test:-

Width =19mm and Thickness=3.2mm
Cross sectional area = length x Width
19mm x 3.2mm = 60.8mm^2

iii. For Reinforced Component-

$$Compressive\ Strength = \frac{2900}{60.8} = 47.7MPa$$

iv. For Unreinforced Component-

$$Compressive\ Strength = \frac{2870}{60.8} = 47.2\ MPa$$

VI. RESULT AND DISCUSSIONS

Following figures shows Elongation caused by tensile force.

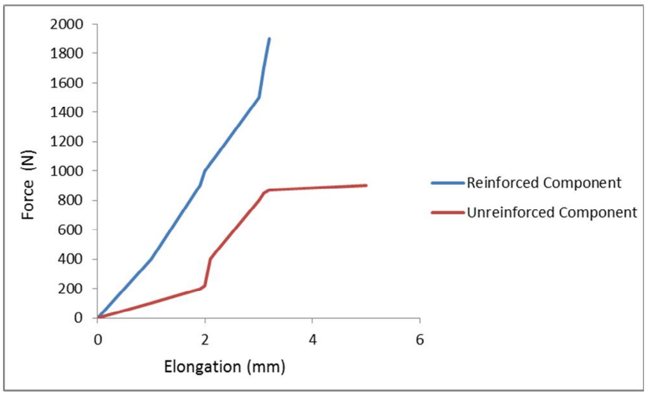

Fig. 1: Force Vs Elongation graph of Tensile Test developed composite material for reinforced and unreinforced composite

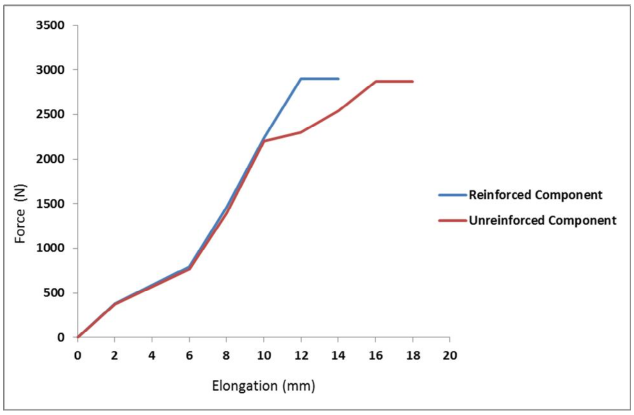

Fig. 2: Force Vs Elongation graph of Compression Test developed composite material for reinforced and unreinforced composite.

Tensile Strength and Compressive strengths of Reinforced and Unreinforced components are as follows:

TABLE III. TENSILE AND COMPRESSIVE STRENGTHS

No.	*Type of Specimen*	*Tensile Strength (MPa)*	*Compressive Strength (MPa)*
1	Reinforced Component	45	47.7
2	Unreinforced Component	26	47.2

VII. CONCLUSION

There is significant improvement in tensile strength of Plastic by reinforcement of Bamboo fibers; while there is not much improvement in Compressive strength of Plastic by reinforcement of Bamboo fibers.

Bamboo reinforcement is possible by simple techniques and also cost effective methods. They have lot of advantages like low density, low price, recyclable, biodegradable, low abrasive wear, CO2 neutral and environment friendly. Natural fiber composites are being used in a large number of applications in automotive, constructions, marine, electronic and aerospace.

Bamboo reinforcement can be widely used based on results obtained in this paper.

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