Analysis of Mechanical Behaviour of Banana Fiber Reinforced Composite Materials

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Abstract – In this work, Banana fibers (Musa acuminata) have been characterized for their physical, chemical, and tensile properties. Banana fibers have good length, strength, uniformity, fineness, and excellent moisture absorption. In this study the feasibility of applying banana (Musa acuminata) fibers, namely bark fibers as an alternative raw material for fiber-reinforced composite (FRC) is investigated. The chemical analysis of the bark fibers indicates that their main components are cellulose 76.69%, hemicelluloses 18.94%, lignin 1.87% and pectin 2.5% respectively. The bark fibers are long, with a thin wall relative to their diameter, and are therefore lightweight. The mechanical properties of the Banana fibers are: tensile strength 381 MPa, strain at break 2.27%. In general, Banana fibers have enough potential for replacing other fibrous raw materials as reinforcing agent.

Index Terms – Fiber, Banana Fibers, Fiber-Reinforced Composite.

1. INTRODUCTION

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry.

It is obvious, especially for composites, that the improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, material, process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals. The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry.

2. RELATED WORK

This chapter outlines some of the recent reports published in literature on mechanical behavior of natural fiber based epoxy composites with special emphasis on bast fiber reinforced epoxy composites.

- On natural fiber reinforced composites
- On bast fiber reinforced composites

2.1. On natural fiber reinforced composites

The mechanical properties of a natural fiber-reinforced composite depend on many parameters, such as fiber strength, modulus, fiber length and orientation, in addition to the fiber-matrix interfacial bond strength. A strong fiber-matrix interface bond is critical for high mechanical properties of composites. A good interfacial bond is required for effective stress transfer from the matrix to the fiber whereby maximum utilization of the fiber strength in the composite is achieved [16]. Modification to the fiber also improves resistance to moisture induced degradation of the interface and the composite properties [17]. In addition, factors like processing conditions/techniques have significant influence on the mechanical properties of fiber reinforced composites [18]. Mechanical properties of natural fibers, especially flax, hemp, jute and sisal, are very good and may compete with glass fiber in specific strength and modulus [19, 20]. A number of investigations have been conducted on several types of natural fibers such as kenaf, hemp, flax, bamboo, and jute to study the effect of these fibers on the mechanical properties of composite materials [21, 22].

2.2. On bast fiber reinforced composites

Bast fibers are defined as those obtained from the outer cell layers of the stems of various plants and comprises one-third of the weight. Bast fibers are made up of bundles of fibers. These bundles are broken down mechanically or chemically to achieve the fineness required. The filaments are made of cellulose and hemicellulose, bonded together by a matrix, which can be lignin or pectin. Natural Bast Fibers are strong, cellulosic fibers obtained from the phloem or outer bark of jute, kenaf, flax and hemp plants [23]. The fibers find use in textile applications and are increasingly being considered as reinforcements for polymer–matrix composites as they are perceived to be ''sustainable''. The fibers are composed primarily of cellulose which potentially has a Young's modulus of 140 GPa (being a value comparable with manmade aramid [Kevlar/Twaron] fibers). The plants which are currently attracting most interest are flax and hemp (in temperate climates) or jute and kenaf (in tropical climates).

3. PORPOSED MODELLING

This chapter describes the details of processing of the composites and the experimental procedures followed for their mechanical characterization.

The raw materials used in this work are as follows:

1. Banana fiber (Musa acuminata***)***
2. Epoxy resin
3. Hardener

Extraction of Fiber from the Plant

1. Musa acuminate

2.Outer Bark Skin of the Plant 3.Extraction of Individual Fibers

4. Bundle Fibers 5.Chopped Fibers

4. MOLD DESIGN FOR SPECIMEN PREPARATION

The dimension of the Banana fiber reinforced composite boards was 300 mm (L) x 150 mm (W) and the boards had 3 mm thickness. The mould was made up of steel. The required equipments for the mould that was used to lay the material down into mats were including glass, transparency plastic for the bottom layer and spacer frame.

5. RESULTS AND DISCUSSIONS

This chapter presents the various properties of Banana fibers and mechanical properties of the Banana fiber reinforced epoxy composites prepared for this present investigation. Details of processing of these composites and the tests conducted on them have been described in the previous chapter. The results of various characterization tests are reported here. These includes evaluation of tensile strength, flexural strength, impact strength and wear property, water absorption property has been studied and discussed.

Specimens

Specimen 1 = Fiber 20 % and Matrix 80 %

Specimen 2 = Fiber 30 % and Matrix 70 %

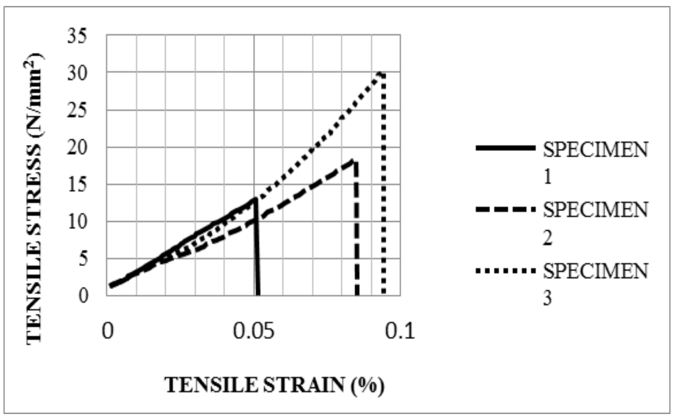
Specimen 3 = continuous fiber 20 % and Matrix 80 %

- 4.1 TENSILE PROPERTY

- 4.2 IMPACT PROPERTY
- 4.3 FLEXURAL PROPERTY
- 4.4 WATER ABSORPTION

4.1 TENSILE PROPERTY

Material	Maximum Stress (N/mm^2)	Maximum Strain	Maximum Load (N)	Maximum Displacement (mm)
Specimen 1	12.95	0.0514	647.26	2.5722
Specimen 2	18.24	0.0852	912.05	4.2615
Specimen 3	30.21	0.0944	1510.28	4.7199



4.2IMPACT PROPERTY

Specification Of The Composite Specimen

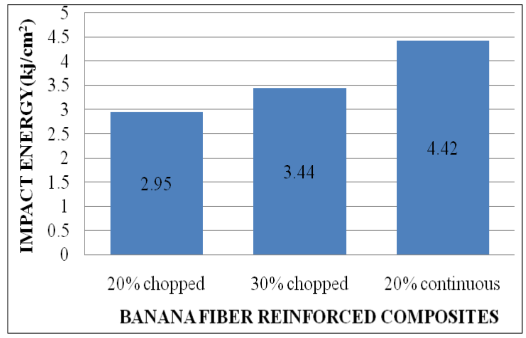
Length of the bar = 64mm

Breath of the bar = 12.7mm

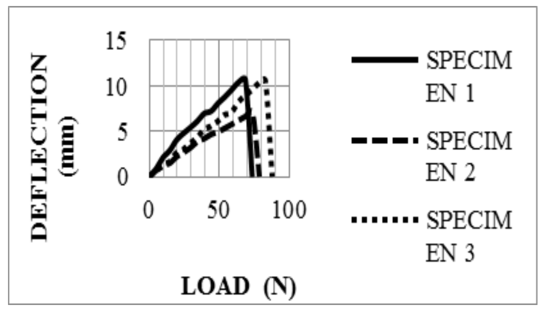
Thickness of the bar = 3 mm

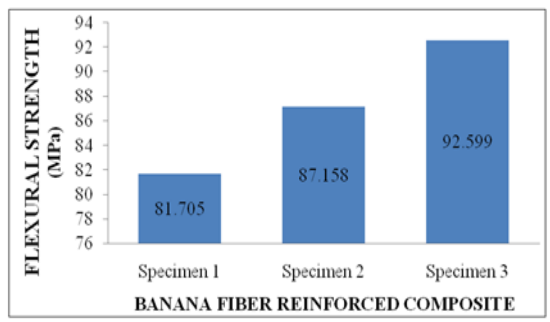
Area of the cross section of bar = 40.64 mm^2

S.no	Material	Energy absorbed force (a) Kj	Energy spend to break the specimen (b) Kj	Energy absorbed by the specimen (a-b) Kj	Impact strength Kj/cm^2
1	Specimen 1	16	14.8	1.2	2.95
2	Specimen 2	16	14.6	1.4	3.44
3	Specimen 3	16	14.2	1.8	4.42



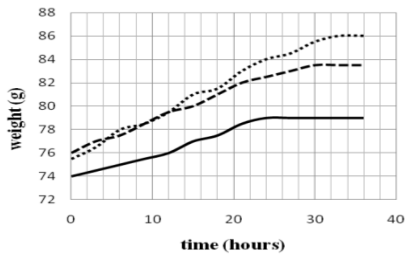
4.3 FLEXURAL PROPERTY





4.4 WATER ABSORPTION

Material	Amount of water absorbed (g)	Percentage of water absorbed (%)
Specimen 1	7.50	9.86
Specimen 2	10.5	13.90
Specimen 3	5	6.75



------- SPECIMEN 1
……… SPECIMEN 2
——— SPECIMEN 3

6. CONCLUSION

In this work, Banana fibers (Musa acuminata) have been characterized for their physical, chemical, and tensile properties. Banana fibers have good length, strength, uniformity, fineness, and excellent moisture absorption. In this study the feasibility of applying Banana (Musa acuminata) fibers, namely bark fibers as an alternative raw material for fiber-reinforced composite (FRC) is investigated. The chemical analysis of the bark fibers indicates that their main components are cellulose 76 and 69%, hemicellulose 19 and 17%, lignin 1.8 and 1.5%, and alkali soluble substances 10 and 15%, respectively. The bark fibers are long, with a thin wall relative to their diameter, and are therefore lightweight. The mechanical properties of the Banana bark fibers are: tensile strength 381 MPa, strain at break 2.1%.

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