Investigation of Mechanical Properties of Angle Ply Laminated Natural Hybrid Composite

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***Abstract*— The present work explains the fabrication of a new set of coir and banana based polymer composites consisting of treated coconut husk as reinforcement and epoxy resin through hand lay-up technique by various fiber orientation of unidirectional and Bidirectional. The physical and mechanical properties can be characterized by alkaline treatment and addition of ceramic filler Al_2O_3 to the matrix phase during the composite preparation. The newly developed laminated coir and banana based hybrid composite are analyzed for its mechanical properties, such as hardness, tensile, impact, shear and flexural strength as per ASTM standard. The investigation results reveal that coir and banana can be used as a potential reinforcing material for many structural and non-structural applications.**

Keywords—Coir, banana, epoxy resin, aluminium oxide (Al_2O_3)

I. INTRODUCTION

In a recent trend the technological development depends on advances in the field of materials. Composite materials in this regard represent a giant step in the ever constant endeavor of optimization in materials. The volume and number of applications of composite materials have grown steadily penetrating and conquering new markets relentlessly. Fiber reinforced polymer composites have played a dominant role for a long time in various applications for their high specific strength and modulus. Accordingly extensive studies on preparation and properties of polymer matrix composite replacing the synthetic fibers with natural fibers such as coir, jute and bamboo were carried out. These natural fibers have many advantages over glass fiber or carbon fiber such as renewable, bio-degradable, environmental friendly, low cost, light in weight, high specific mechanical strength.

II. MATERIAL SELECTION

Coconut fibre is obtained from the husk of the fruit of the coconut palm; the trees can grow up to 20 m, making nuts, or a pole with an attached knife is used. The fruits are dehusked with on a spike and after retting, the fibres are subtracted from the husk with beating and washing. The fibres are strong, light and easily withstand heat and saltwater. After nine months of growth, the nuts are still green and contain white fibre, which can be used for the production of yarn, rope and fishing nets. After twelve months of growth, the fibres are brown and can be used for brushes and mattresses. The combined use of coconut and sisal short fibres seem to delayed restrained plastic shrinkage controlling crack development at early ages. Many aspects of the use of coir fibres as forcement in polymer–matrix composites are described in the literature.

Coir is an abundant, versatile, renewable, cheap, and biodegradable lignocellulosic fibre used for making a wide variety of products. Furthermore, it represents an additional agro-industrial non food feedstock (agro industrial and food industry waste) that should be considered as feedstock for the formulation of eco compatible composite materials. Coconut coir is the most interesting products as it has the lowest thermal conductivity and bulk density. The addition of coconut coir reduced the thermal conductivity of the composite specimens and yielded a lightweight product.

Banana fiber, a ligno-cellulosic fiber, obtained from the pseudo-stem of banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties. The ‘‘pseudo-stem’’ is a clustered, cylindrical aggregation of leaf stalk bases. Banana fiber at present is a waste product of banana cultivation and either not properly utilized or partially done so. It is fully of bio-degradable, no environment hazards and eco-friendly materials. Development of composite materials for buildings using natural fibre as coconut coir and banana with low thermal conductivity is an interesting alternative which would solve environment and energy concern.

III. EXPERIMENTAL WORK

3.1 Fabrication of Composite

3.*1.1 Open mold Hand Lay-Up Technique*

Open Molding, also known as contact moulding, open laminating, and wet lay-up, is the method used longest in the polymer-matrix composites industry to make thermoset composite products, and it is still the selected production process for a wide range of composite products.

The molding method involves placing reinforcements and liquid resin onto the surface of an open mold (which may or may not be pre-coated with gel coat), or onto other substrates, when making a one-off sandwich construction, when making on-site repairs by applying a reinforcing vacuum-formed acrylic, corrosion-resistant lining on steel, or when making on-site repairs of tanks and pipes. The hand lay-up version involves applying the reinforcements and the resin by hand, while the spray-up version uses tailored spray equipment to deposit both reinforcements and resin on the mold or an alternative substrate.

Fig1.1 : A View of coir fiber

Fig 1.2 : 45^0 uni-directional lamina

fig 1.3: Random orientation

Fig 1.4: 0/90-Bi-directional laminate

3.2 Composition of samples

The following table indicates the various coir fiber orientations with percentage of weight for matrix phase and reinforcement phase.

Compositions of Samples

Sample no	Fiber orientation	coir	Al_2O_3	banana	epoxy
1	random	30	5	30	35
2	45° lamina	30	5	30	35
3	90°	30	5	30	35
4	45/45	30	5	30	35
5	0/90	30	5	30	35

IV. TESTING OF PHYSICAL PROPERTIES

4.1 Hardness test

Hardness is considered as one of the most important factors that govern the wear resistance of any material. Hardness is refers as the resist the indentation or scratch. The hardness is represented by RHN. Sample size: 30 × 15 × 3 mm.

Samples	Rockwell Hardness Number
Random orientation	35
45°lamina	42
90°lamina	26
45°⁄45° laminate	52
0 ⁄ 90° laminate	49

4.2 Tensile Test

Tensile testing provides tensile strength, tensile strength at break or ultimate tensile strength, tensile modulus or young′s modulus and elongation at yield and break.

Alkali treatment is a common method to clean and modify the fiber surface to lower surface tension and enhance interfacial adhesion between surface tension and enhance interfacial adhesion between a natural fiber and a polymer matrix. Alkali treatment improves the fiber-matrix adhesion due to the removal of natural and artificial impurities from the fiber surface as well as it changes the crystal structure of the cellulose. Moreover, alkali treatment improves the hydro thermal properties of the fiber and also reduces fiber diameter and thereby increases the aspect ratio. Therefore, the development of a rough surface topology and enhancement in aspect ratio offer better fiber-matrix interface adhesion and an increase in mechanical properties.

Natural fiber reinforced composites have several drawbacks such as poor wet ability, incompatibility with some polymeric matrices and high moisture absorption by the fibers, The main problem often encountered in its use is the fiber matrix adhesion problem due to the incompatibility between the hydrophilic natural fibers and the hydrophobic polymer matrix.

The hydrophilic nature of banana & jute fiber makes it difficult to adhere to hydrophilic epoxy and therefore posed the problem of interfacial bonding the fiber and matrix. This problem can be improved by chemically treating the fibers.

4.3 Treatment Procedure

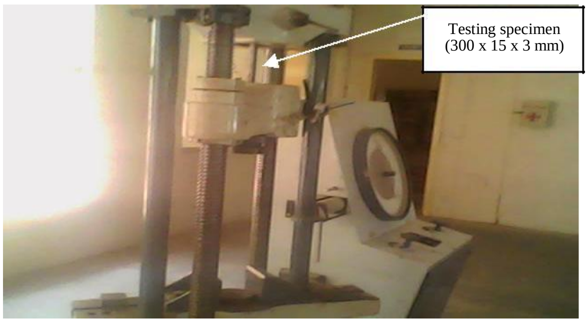
Step 1: The natural fibers are cut according to the ASTM standards. The natural fibers are to be clean with the distilled water and then dried in sunlight.

Step 2: The cleaned Banana & jute fibers (natural fibers) were to be in treatment with chemical process of NaOH contains 20% of sodium hydroxide and 80% of distilled water for about 30minutes at room temperature.

Step 3: The fibers were then washed many times by using the distilled water.

Step 4: The washed fibers were then immersed in distilled water with 2.5% HCL solution for about 30minutes at room temperature.

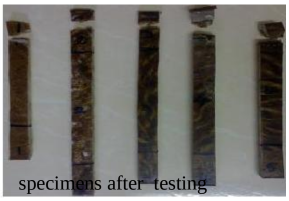
Step 5: The fibers were then washed again many times in distilled water and finally dried at room temperature.



Specimen size: 300 × 15 × 3 mm

Samples	Tensile Strength (N/mm^2)
Random orientation	13.09
45^0 lamina	1.58
90^0 lamina	2.92
45°/45° laminate	7.12
0/90° laminate	8.9

specimens before testing



specimens after testing

4.4 Flexural Test

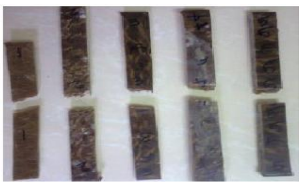
Composite materials used in structures are prone to fail in bending and therefore the development of new composites with improved flexural characteristics is essential. Bending test provides the modulus of elasticity and bending strength (σ_f)
The flexural strength (σ_f) is given by as follow relation

$$\sigma_f = 3PL / 2bh^2 \quad N/mm^2$$

Where,

P - Load in Newton (N)
L - Specimen length between two support point or span length (mm)
b - Width of specimen (mm)
h - Thickness of the specimen (mm)

Samples	Flexural strength (N/mm^2)
Random orientation	34.07
45^0 lamina	5.79
90^0 lamina	15.36
45°/45° laminate	13.38
0/90° laminate	12.77



4.5 Double shear Test

The force acting tangentially on body is called as shear stress. The shear strength (σ_s) is govern by the following relation

$$\sigma_s = W/2A \ N/mm^2$$

Where,

W- Maximum load (N),
A- Area of specimen
D - Diameter of specimen

Sample size: 65 × 15 × 3 mm.

Samples	Shear strength (N/mm^2)
Random orientation	9.4
45^0 lamina	8.8
90^0 lamina	18.23
45°/45° laminate	14.37
0/90° laminate	13.79

specimens before testing specimens after testing

4.6 Charpy Impact test

The impact strength of a material is its capacity to absorb and dissipate energies under impact or shock load. The impact strength (a_cU) is given by

$$a_cU = k/A \ (J/mm^2)$$

Where,

k – Impact energy observed by specimen in Joules, A – Area of specimen in mm^2,

Sample size: 65 × 15 × 3 mm.

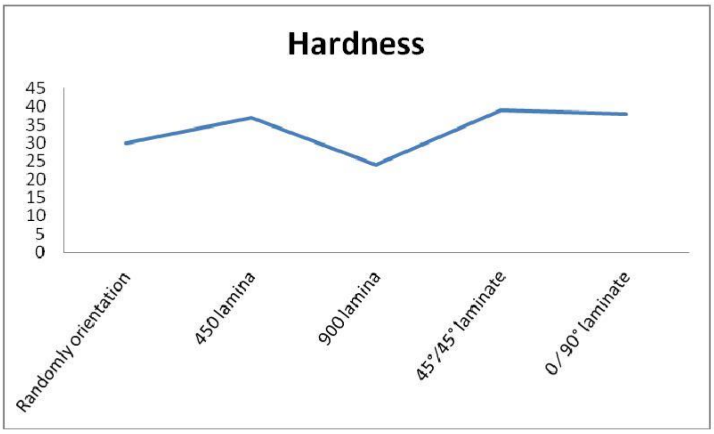
Samples	Impact Strength (J/mm^2)
Random orientation	0.19
45^0 lamina	0.25
90^0 lamina	0.098
45°/45° laminate	0.25
0/90° laminate	0.28

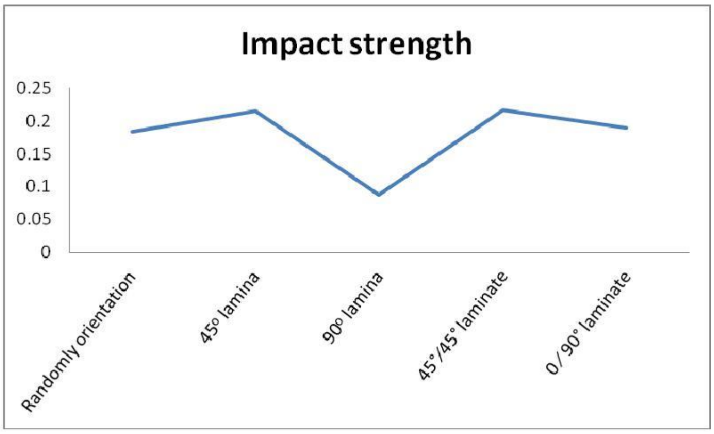
specimens before testing

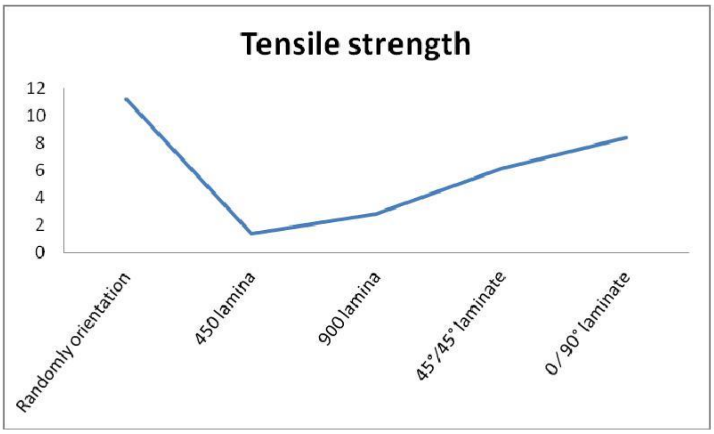
specimens after testing

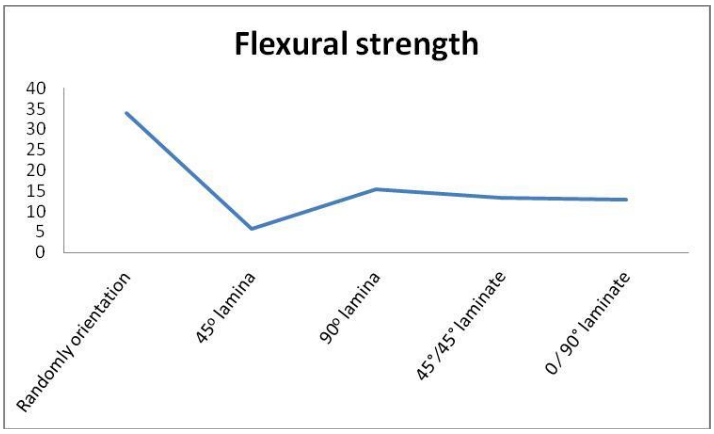
V. TABLES AND GRAPH

Performance characteristic curve of coir based hybrid composite









VI. CONCLUSION

The aforesaid coir and banana fibre can be successfully be used as reinforcing agent to fabricate composite by suitably bonding with epoxy resin and Al_2O_3 ceramic filler for value added product by simple hand lay-up technique. The optimum hardness is obtained at 45 / - 45 angle orientation of coir based hybrid composite.

This value proved that reaction between coir epoxy with Al_2O_3 gives more stiffness of the hybrid composite.The significant hardness difference shows the different configuration of fibre orientation of hybrid composite moderated comparing the 45° lamina.The tensile strength values were found to be higher peak for randomly orientation configuration of fibre. But in a various fibre orientation say 45° & 90° uni-directional lamina and 45 ⁄ -45 & 0 ⁄ 90 laminate steadly increasing the tensile strength.In the flexural test shows that the randomly orientation configuration of fibre has high flexural strength.

But in a 45°uni-directional lamina has least strength further orientation structure the strength will be slightly decrease from 90° lamina to 45 ⁄ -45 & 0 ⁄ 90 laminate respectively.In the shear test results gives the 90° uni-directional lamina has higher shear strength also the Bi- directional 45 ⁄ -45 & 0 ⁄ 90 laminate has significantly good for shear strength comparing of randomly orientation and 45° uni- directional lamina.In the impact testing results gives the 90° uni- directional lamina only least impact strength comparing the other orientation lamina and laminated structure.

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