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Fabrication and Analysis of Natural Fiber Hybrid Composites

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Abstract: Natural fiber composites areA nowadays being used in various engineering applications to increase the strength and optimize the weight and the cost of the product. Hybridization is a process of incorporating synthetic fiber with natural fiber to get the better material properties. The use of natural or plant fiber reinforced composite is increasing with time. The important and exclusive properties of natural composite are its renewability and biodegradability. These properties with low cost fulfil the economic interest of industries. These materials are eco-friendly and use of green materials in these composites also provides an alternative way to deal with agricultural residue. The objective of the present work is to study the mechanical properties of banana and glass fiber reinforced epoxy and phenolic based hybrid composites. The effect of fiber loading and mechanical properties like hardness, density, flexural strength, and inter laminar shear stress of composites has to be calculated by using experimental analysis, and also comparing results for finding optimal composite material.
Keywords: Composites, Natural Fiber, Reinforced fiber

I. INTRODUCTION

The attraction in utilizing natural fiber, for example, distinctive wood fiber and plant fiber as support in plastics has expanded drastically throughout last few years. Concerning the ecological viewpoints if natural fibers might be utilized rather than glass fibers as fortification in some structural provisions it might be extremely intriguing. Natural fibers have numerous points of interest contrasted with glass fiber, for instance they have low thickness, and they are biodegradable and recyclable. Also, they are renewable crude materials and have generally great strength and stiffness.

A. Definition of Composite

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous.

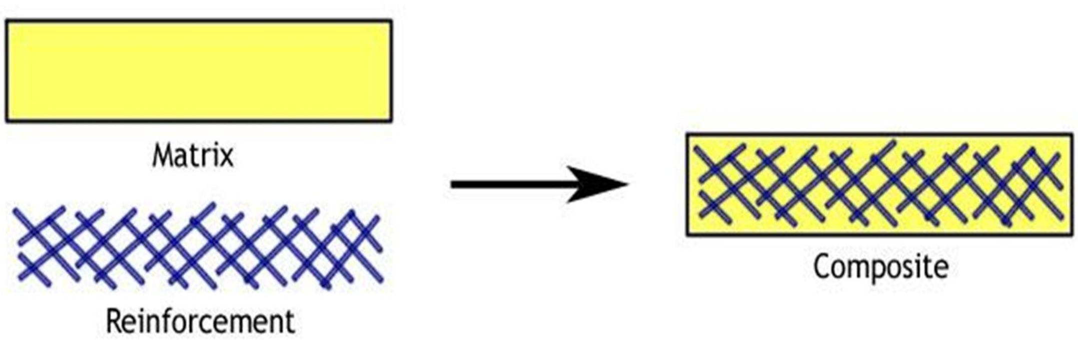

Fig.1: Structure of Composite

Examples of composite systems include concrete reinforced with steel and epoxy reinforced with graphite fibers etc.
Examples of naturally found composite**:** Examples include wood, where the lignin matrix is reinforced with cellulose fibers and bones in which the bone-salt plates made of calcium and phosphate ions reinforce soft collagen.

(a) (b)

Fig.2: Naturally Found Composite (a) Wood (b) Bones

B. Hybrid Laminate

Hybrid composites contain more than one fiber or one matrix system in a laminate.

The main four types of hybrid laminates follow

1) Interply hybrid laminates contain plies made of two or more different composite systems. Examples include car bumpers made of glass/ epoxy layers to provide torsional rigidity and graphite/epoxy to give stiffness. The combinations also lower the cost of the bumper.

2) Intraply hybrid composites consist of two or more different fibers used in the same ply. Examples include golf clubs that use graphite and aramid fibers. Graphite fibers provide the torsional rigidity and the aramid fibers provide tensile strength and toughness.

C. Natural Fiber Reinforced Composites

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc as well as wood, used from time immemorial as a source of lignocellulosic fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites.

D. Classification of Natural Fibers

Fibers are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be spun into filaments, thread, or rope. They can be used as a component of composites materials. They can also be matted into sheets to make products such as paper or felt. Fibers are of two types: natural fiber and man-made or synthetic fiber.

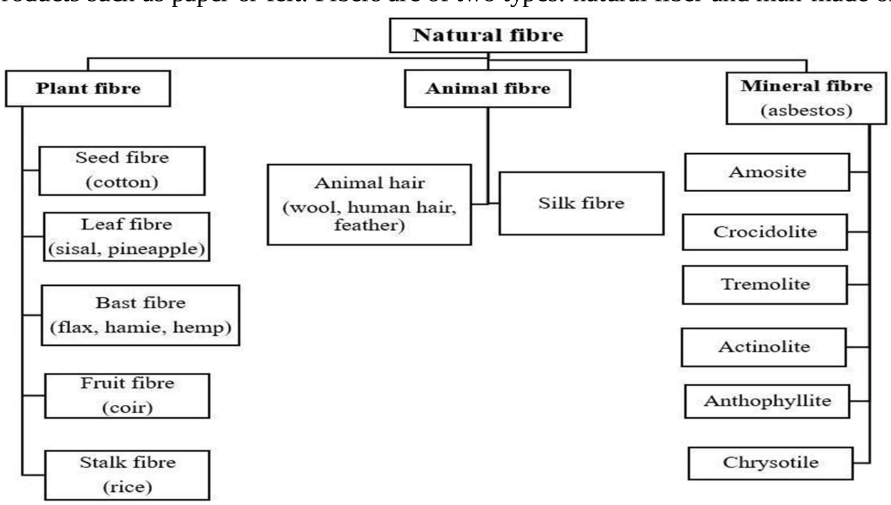

Fig.3 Classification of Natural Fibers

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Natural fibers are classified on the basis of the origin of source, into three types

1) Plant Fibers
2) Mineral Fibers
3) Animal Fibers.

a) *Plant Fibers:* Plant fibers are usually consisting of cellulose, examples include cotton, jute, bamboo, flax, ramie, hemp, coir and sisal. The category of these fibers is as following.

Seed fibers are those which obtain from the seed e.g. Kapok and cotton. These fibers having superior tensile properties than the other fibers. Because of these reasons these fibers are used in many applications such as packaging, paper and fabric.

Leaf fibers are the fibers those are obtained from the leaves (agave and sisal skin fibers are those fibers which are obtain from the bast or skin surrounding the stem of the plant).

Bast fibers are collected from the skin or bast surrounding the stem of their respective plant. These fibers have higher tensile strength than other fibers. Therefore, these fibers are used for durable yarn, fabric, packaging, and paper. Some examples are flax, jute, banana, hemp, and soybean.

Fruit fibers are the fibers generally are obtaining from the fruit of the plant, e.g. banana fiber and coconut fiber.

Stalk fiber are the fibers which are obtain from the stalks e.g. straws of wheat, rice, barley, and other crops including bamboo and grass.

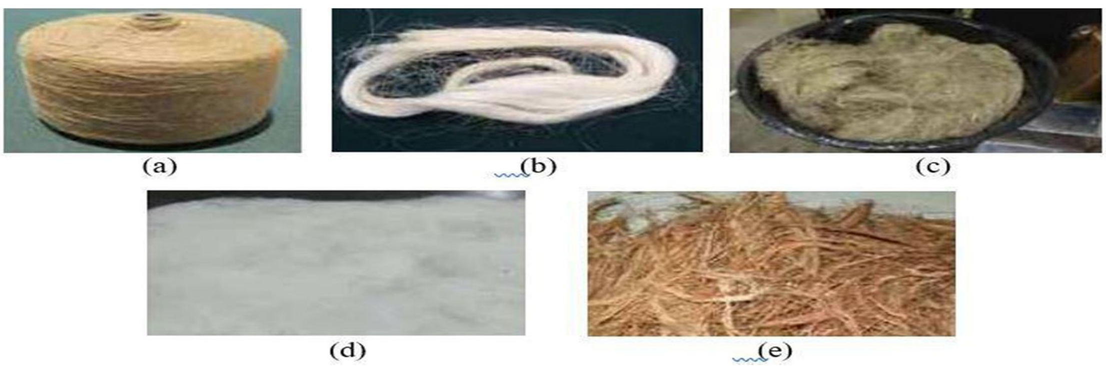

Fig.4(a) Jute Yarn (b) Sisal Fiber (c) Hemp Fiber (d) Cotton Fiber (e) Coir Fiber

Table.1 Composition of Few Commonly Used Natural Fibers

Fiber	Cellulose (wt.%)	Hemicellulose (wt.%)	Lignin (wt.%)	Pectin (wt.%)	Moisture (wt.%)
Cotton	85-90	5.7	-	0-1	7.85-8.5
Bamboo	60.8	0.5	32	-	-
Hemp	70-74	17.9-20.4	3.7-5.7	0.9	6.2-12
Jute	61.1-71.5	13.6-20.4	12-13	0.2	12.5-13.7
Kenaf	45-47	21.5	8-13	3-5	-
Sisal	66-78	10-14	10-14	10	10-22
Coir	32-43	0.15-0.25	40-45	3-4	8
Banana	63-64	19	5	-	10-12

II. MATERIALS AND METHODS

A. Materials Used

1) Reinforcements

a) E-glass fabric
b) Banana fabric

2) Matrix

a) Epoxy resin (LY 556)
b) Hardener (HY951)
c) Mix ratio (100:10)
d) Phenolic resin
e) Para toluene sulphonic acid (PTSA) (catalyst for phenolic resin)

3) Vacuum Bagging Materials

a) Polyester Breather fabric
b) Release film (PTFE coated glass fabric)
c) Vacuum bagging film (Nylon film)
d) Sealant tape (Butyl rubber)

4) Solvents

a) Acetone

5) Surface Preparation Materials

a) Emery paper
b) Wax polish
c) Banian cloth

6) Hand Lay-Up

a) Surgical gloves
b) Cutting blades
c) Measuring scale

III. METHODOLOGY

For this analysis we taken E-glass, Banana fiber and epoxy resin layers as shown in the table.

Table.2. Designation of Three Laminates

Laminates	Designation	Laminates Composition
L1	G+G+G+G+G+G	6 layers
L2	B	35grams
L3	G+B+G	1layer+20grams+1layer

Banana fiber a type of bast fiber, is extracted from the Pseudo-stem of banana tree.

Fig.5. Pseudo-Stem

Fig.6. Banana Fiber

Initially, banana fiber of about 120gm by weight is dipped in acetone for 48hrs and then heated in oven at 50^0c for 30min. This acetone treatment removes wax, hemicellulose, lignin and some other impurities hiding in the surface of the fiber.

Fig.7 Acetone Dipping

Fig.8 Oven Curing

After heating the fiber is made fine by using comb and cut in the length of 300mm.

Fig.9 Fine Banana Fiber

Table.3.Weight Loss of Banana Fiber of 300mm Length

S.no.	Banana fiber	Weight(grams)
1.	Initial weight	120
2.	After oven heating	100
3.	Fine facing	60
4.	Cut into 300mm length	55

Epoxy resin (LY 556) is a low temperature curing resin taken as matrix material. Epoxy resin (HY 556) and corresponding Hardener (HY 951) are mixed in a ratio of 10:1 by weight as recommended i.e. 1000gm of epoxy is mixed with 100gm of hardener by mechanical stirring.

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Fig.10 Epoxy Resin (LY 556)

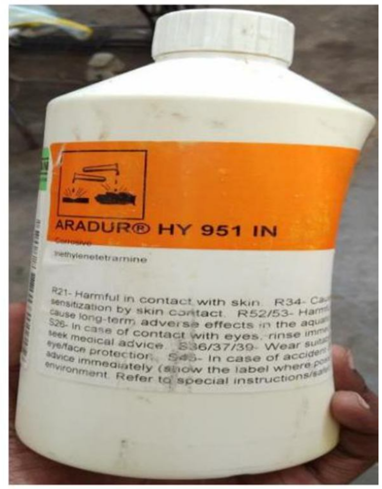

Fig.11 Hardener (HY 951)

Now, E-glass fabric (13mill grade) having diameter 0.4mm and 350gsm is taken of about 1m length and epoxy resin is coated by using hand layup method. Then, the E-glass is cut into dimension of 300×300mm2.

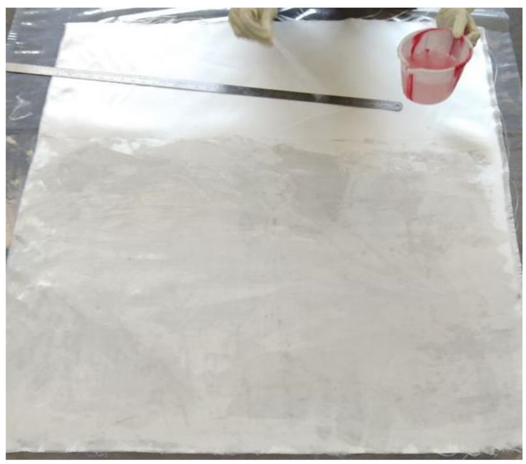

Fig.12. E-glass Fabric with Epoxy Resin Hand Layup

To prepare the composite a surface plate is used. The surface plate is cleaned with acetone to remove the impurities. Then a coat of wax layer is applied throughout the plate to facilitate easy removal of the laminate. This is followed by a dwell time of 5-10 minutes for the plate to get dried. Alternate layer of natural fiber is kept with a coat of resin over it. Consequent layers of glass and natural fiber are placed till the required thickness is obtained. Three laminates are prepared by using different designations.

Fig.13. Laminate1 (L1) Laminate2 (L2) Laminate3 (L3)

Then the laminates are covered by release film followed by Breather sheet to absorb excessive resin. Later the laminates are sealed with vacuum bag sheet over the wet laid-up laminate on to the tool. The air under the bag is extracted by a vacuum pump under atmospheric pressure in order for the compacting and hardening process to take place. The outer atmospheric pressure caused through the vacuum within the closed system will compress the laminate and excess resin is sucked out of the wet laminate.

Fig.14 Vacuum Bagging of Laminate

The curing process is allowed for 4 hrs in the vacuum bag at a pressure of 0.9bar. Finally, the laminates get cured.

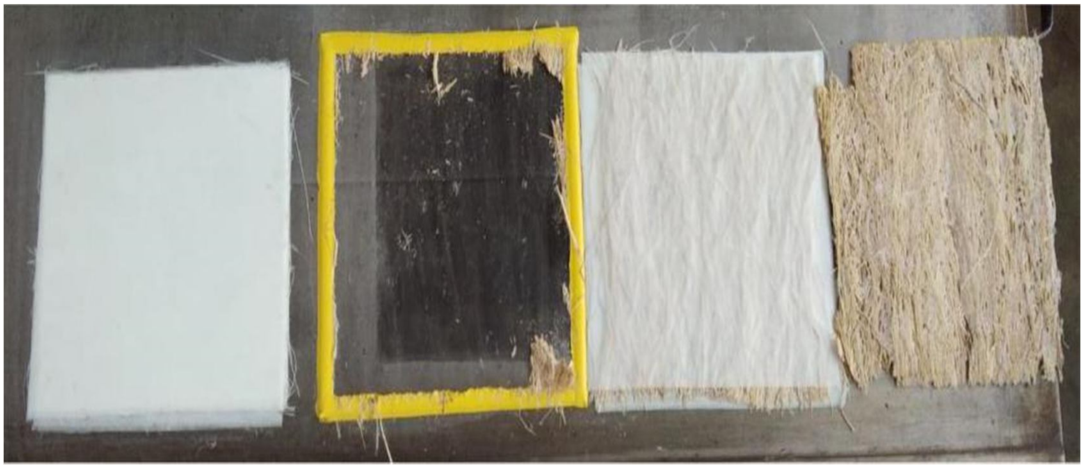

Fig.15. After Curing

IV. RESULTS

A. The L2 laminate did not got enough strength.
B. The L3 laminate had uneven surface finish in top layer.
C. Air gaps are present in the laminates.

V. CONCLUSIONS

The fabrication process and comparison of physical and mechanical properties of the hybridized natural fiber composites is successfully done i.e. banana/ E-glass fiber reinforced epoxy resin, banana/E-glass fiber reinforced epoxy/phenolic resin composites. Composites are fabricated by using hand layup technique. Due to some failures like voids, irregular surface finish, delamination six cases had been made and in case five and case six the failures were overcomed by making few modifications. Testing's like density, hardness, flexural strength and inter laminar shear strength are performed according to ASTM standards.

Recently, banana fiber reinforced composites are coming into in interest due to the innovative application of banana fiber in under-floor protection for passenger cars. Automobile parts such as rear-view mirror, visor in two-wheeler, billion seat covers, indicator cover, cover L-side, name plate was fabricated using fibers hybrid composites.

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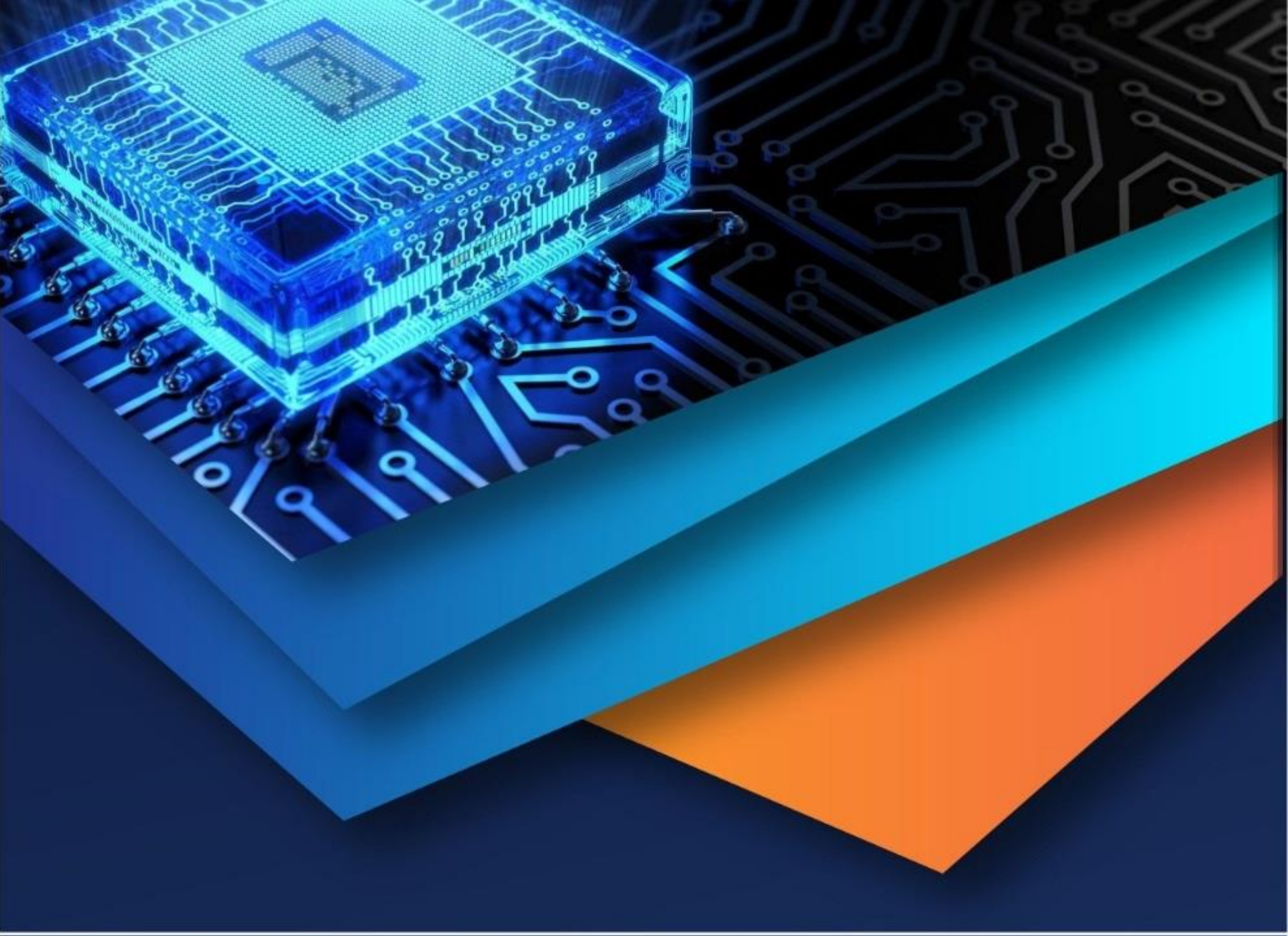

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