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# Impact and Tensile Properties of Jute, Banana Fiber and Glass Fiber Reinforced Polymer Matrix Hybrid Composites for Fiber Boat

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**ABSTRACT:**The fabrication and experimental property study on jute/banana/glass fibers reinforced hybrid composites. The results of the mechanical properties such as tensile strength, impact strength and flexural strength are reported. Three different layers of the hybrid composites are fabricated by hand layup method. The test was carried out using the universal testing machining and Charpy impact machine as per the ASTM standard. It has been observed that the jute-glass-banana fibers reinforced hybrid composites shows superior properties and used as an alternate material for synthetic fiber reinforced composite materials.

# **I.INTRODUCTION**

They present the fabrication and experimental property study on jute/banana/glass fibers reinforced hybrid composites. The results of the mechanical properties such as tensile strength and impact strength are reported. Three different layers of the hybrid composites are fabricated by hand layup method. The test was carried out using the universal testing machining and Charpy impact machine as per the ASTM standard. It has been observed that the jute-glass-banana fibers reinforced hybrid composites shows superior properties and used as an alternate material for synthetic fiber reinforced composite materials.Composite substances are vital engineering substances due to their extraordinary mechanical properties. Composites are materials in which the desirable properties are obtained by separate materials. Fibers are combined by mechanically or metallurgical binding them together. Each of the components retains its structure and characteristic, but the composite generally possesses better properties. This project deals with the fabrication of a composite material in order to find out the strength of the material using the banana and the sisal fiber. The fabrication is done with the help of hand layup process. Also the various mechanical tests are conducted on the fabricated material. Finally the results of the tests and the strength of the material are discussed and reported.

Generally, all natural fibers have several attractive features that include low cost, light weight, moderate strength, high specific modulus, and renewability, and biodegradability, freedom from health hazards and amenability to chemical modification. Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker materials(known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position, orientation of the reinforcement and transfers the external load to the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties. Historical examples of composites are abundant in literature. Jute has been used since ancient times in Africa and Asia to provide cordage and weaving fiber from the stem and food from the leaves. In several historical documents during the era of the great Mughal Emperor Akbar (1542 –1605) states that the poor villagers of



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India used to wear clothes made of jute. Chinese papermakers from very ancient times have selected almost all the kinds of plants as hemp, silk, jute, cotton etc. for papermaking.

The East India Company which was the first Jute trader in India was the planet's biggest producer of bananas and Alexander the Great found them growing there in 327 BC, when he conquered India. Infantrymen of Alexander the Great returned to Greece and Persia with bulbs from banana plants, where they were distributed and planted. Antonius Musa, the private surgeon of Augustus Caesar, imported the first banana trees, although the banana is said to have originated in India, (Eastern East Asia), it was established in Africa and Europe as a basic food product many centuries back and came into North America through Spanish missionaries. The leaves of banana trees are used as wrappers for steaming other foods within, and the banana flower is also eatable.

Historical examples of composites are abundant in literature. Just has been used since ancient times in Africa and Asia to provide cordage and weaving fiber from the stem.

# **II.LITERATURE SURVEY**

#### 2.1 FRACTURE TOUGHNESS:

Kaleemulla etal (2009) studied that fracture toughness of a material has immense importance in the determination of the resistance of the material to crack propagation. The impact behavior and fracture toughness of the laminates were investigated as per ASTM standards with various specimen configuration includes selection of different notch depths, fiber proportion and orientations. The fracture toughness has been found to increase continuously ItThey increased volumes of glass fabric and significantly dependent on the notch size. The experimental investigations have shown that, as the glass volume increases, the fracture toughness will also increase but it is significantly dependent on the notch depth and fiber orientation. The impact strength of laminates with 45% glass content is superior as compared to other two specimen combinations, this is due to the fact that glass is tough in comparison to satin and epoxy. The higher notch depths have made the specimen to provide lesser fracture toughness, this behavior is true for all volumes of glass fabric and orientations.

#### 2.2 FATIGUE STRENGTH

Bernasconi and Cosmi (2007) investigated that fatigue strength of short fibre reinforced polymer components depends upon fibre orientation with reference to the acting stresses. In this work, the results of an experimental investigation on the combined effect of both notches and fiber orientation upon fatigue strength of injection moduled flat specimens are analyzed. Different fibre orientation patterns in notched specimens having the same geometry were obtained by changing size and position of the injection gate. These observations evidenced that mean fiber orientation alone is not sufficient to characterize the local properties of the material. Mechanical properties such as stiffness and strength also depend on the dispersion of the fiber orientations around the mean value.

#### 2.3 COMPOSITE MATERIALS:

Keshavamurthy et al (2012) studied that composite materials have characteristics of high modulus/weight and strength/weight ratios, excellent fatigue properties, and non-corroding behavior. For a transversely isotropic composite material, five elastic constants are necessary to describe the linear stress-strain relationship. If the geometry of the material could be considered as two-dimensional, four independent constants are necessary due to the assumption about the out-of-plane shear modulus or Poisson's ratio. The most common method to determine these constants is static testing. For composite materials, three types of specimens with different stacking sequences, i.e.,  $[0^0]$ ,  $[90^0]$ , and  $[\pm 45^0]$  are generally fabricated. In this work, specimens are prepared in the laboratory using vacuum bag technique with biwoven epoxy glass as fiber & with epoxy resin as an adhesive. The specimens are prepared for testing as per ASTM standards to estimate the tensile properties.

#### 2.4 SEMI-ANALYTICAL STRESS SOLUTION:

Ferjani et al (2003) investigated a semi-analytical stress solution suitable for notched axi-symmetrically tubes subjected to tension and bending loading. The proposed semi-analytical solution is based on an approximate elastic stress



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solution where the local balance condition is always satisfied by the use of a bi-harmonic stress function but the boundary conditions are not satisfied except at specific points. It is presented with the results for a notch geometry with an opening angle  $2\alpha$  of  $60^{\circ}$  and a notch root radius  $\rho$  of 1mm. The proposed semi-analytical solution has shown good agreements with respect to finite element solution in the case of an external notched tube. The match is less accurate with an internal notch on the radial and the circumferential stress component and this error has been reduced by changing the linear term in the expression of the radial stress component with a hyperbolic function.

#### 2.5 YIELDING:

Gregory et al (1999) investigated the issue of yielding in notched tensile specimens with a micro structural gradient by first gathering tensile data for un-notched and notched specimens in reference materials, then generating a strength gradient which is tailored to be expected loading gradient in notched specimens. It is suggested that the value of results generally available from a notch tensile test is to be found in comparing different materials rather than in generating data which can be used for engineering design purposes. From the demonstration of their previous work, the increase in local yield stress in the notch root of tensile specimen causes the macroscopically determined proportional limit to increase but this result is logical because plastic flow occurs first at the surface. On the other hand, the macroscopic yield stress of notched specimens of ductile materials is usually higher than that of un-notched specimens owing to constraint of plastic flow. From their experiments, he proposed that the local axial stress has its highest value at the surface and decreases to the applied stress intensity factors for cracks within the stress field of a notch. In this case, the local yielding rather than the crack propagation is considered. Hence the local equivalent stress was used as criterion for the local loading conditions

### 2.6 DAMAGES IN CONSTRUCTIONS:

Kreculj et al (2008) studied about Damages in constructions from composite materials have different causes. They can occur in the production process or during exploitation of these structures. Such damages may have negligible influence, but they may be critical for the integrity and service life of constructions from composites. Therefore, it is extremely important toassess the state of constructions because of damages. It is necessary to predict accurately where damages will appear, how they will spread and when they will eventually produce a fracture and failure of constructions. The development of modern military and civilian aircraft in the world and in our country requires a great amount of finance. As a result, there is a tendency to develop software packages, which could predict conditions on the aircraft constructions. These programs for structural analysis are mainly based on the finite element method (FEM). With these program packages on a formed model realistic conditions that construction was subjected to during service life can be simulated.

# **III. MODELING AND ANALYSIS**

3.1 SPECIMEN 1 WEIGHT OR MASS FRACTION (Ratio of composites is 50:50) Weight fraction of fibers  $W_f=50\%=0.5$ Where, Banana Fiber 16.67% Jute Fiber 16.67% Glass Fiber 16.67 1. BANANA FIBER: Volume of Banana Fiber V<sub>b</sub>=v<sub>b</sub>x0.1667 =0.18x0.1667 =0.030006m<sup>3</sup> Mass of Banana Fiber  $M_{c=}V_bxb$ 



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	$=0.030006 \times 1.35 \times 10^{3}$
	=40.58 g
2. JUTE FIBER:	-
Volume of Jute Fiber V	$i = v_c x 0.1667$
	=0.000108x0.1667
	$=0.030006 \text{ m}^3$
Mass of Jute Fiber M <sub>i</sub>	=V <sub>i</sub> xj
5	$= 0.030006 \times 1.46 \times 10^{3}$
=43.80 g	
3. GLASS FIBER:	
Volume of Glass Fiber	$V_{g} = v_{g} x 0.1667$
	=0.000108x0.1667
	$=0.030006 \text{ m}^3$
Mass of Glass Fiber Mg	<sub>z=</sub> V <sub>g</sub> xg
	$=0.030006 \times 2.55 \times 10^3$
	=76.653 gm
The before fabrication	process, the raw materials

The before fabrication process, the raw materials used in the fabrication process such fiber, resin are analysed in the following section

### **3.2 MATERIALS REQUIRED**

- 1. Epoxy Resin
- 2. Glass Fiber
- 3. Banana Fibre
- 4. Jute

### 3.3 Epoxy Resin

Epoxy resin systems are made up of an epoxy resin and a curing agent (also called a hardener orcatalyst). Many epoxy products also contain additives such as organic solvents, fillers such as fiberglass or sand, and pigments. See the box on page 2. When epoxy resin systems are used, single molecules (monomers) of the epoxy resin chemical and the curing agent combine to form long chains of molecules(polymers). As the mixture "cures," it becomes a hard polymer. Some epoxies cure in afew minutes at room temperature. Others need additional time or heat to harden. The characteristics of hardened epoxies (such as whether they are firm or flexible, or resistant to heat or chemicals) depend on which epoxy monomers, curing agents, solvents, and fillers are added. The hardened, finished polymers are almost non-toxic; it is exposure to the uncured resin components that can be harmful. In a two-component epoxy product, the epoxy resin and the curing agent are packaged separately and must be mixed together just before being used. Each component can be hazardous. In a single-component product, the resin and the curing agent are supplied in a pre-mixed form. Single-component systems are usually safer, because the hazardous chemicals are already partly combined into less toxic polymers and because they do not evaporate into the air as easily.

Epoxy resins are polyether resins containing more than one epoxy group capable of being converted into the thermoset form. These resins, on curing, do not create volatile products in spite of the presence of a volatile solvent. The epoxies may be named as oxides, such as ethylene oxides (epoxy ethane), or 1, 2-epoxide. The epoxy group also known as oxirane contains an oxygen atom bonded with two carbon atoms, which in their turn are bound by separate bonds



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#### 3.4 E-Glass fiber

E-Glass or Electrical grade glass was originally developed for stand-off insulators for electrical wiring. It was later found to have excellent fiber forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiberglass The advantageousproperties of E-glass generally outweigh the disadvantages which include Low modulus, self-abrasiveness if not treated appropriately leading to reduced strength, higher density compared to carbon fibers and organic fibers. The Figure 3.2 shows the E-Glass Fiber



Figure .3.1 Glass fiber

Properties:

Properties that have made E-glass so popular in fiberglass and other glass fiber reinforced composite include

- 1. Low cost and high production rates
- 2. High strength and high stiffness
- 3. Relatively low density
- 4. Resistant to heat and Non-flammable
- 5. Good chemical resistance
- 6. Relatively insensitive to moisture
- 7. Able to maintain strength properties over a wide range of conditions
- 8. Good electrical insulation.

### 3.5 BANANA FIBER

The natural fibers are renewable, non-abrasive, bio-degradable, possess a good calorific value, exhibit excellent mechanical properties and are inexpensive. • This good environmental friendly feature makes the materials very popular in engineering markets such as the automotive and construction industry. • The banana fibers are waste product of banana cultivation, therefore without any additional cost these fibers can be obtained for industrial purposes. The Figure 5.2 shows the Banana Fiber

# PROPERTIES OF BANANA FIBER

- 1. Banana fiber is similar to that of bamboo fiber, but its fineness and spin ability is better.
- 2. The chemical composition of banana fiber is cellulose, hemicellulose, and lignin.
- 3. It is highly strong fiber.
- 4. It has smaller elongation.



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5. It has got shiny appearance depending upon the extraction & spinning process.

6. It is light weight.

7. It absorbs as well as releases moisture very fast.

8. It is bio- degradable and has no negative effect on environment and thus can be categorized as eco- friendly fiber.

9. It can be spun through almost all the methods of spinning including ring spinning, open-end spinning, fast fiber spinning, and semi-worsted spinning among others.



# 3.6JUTE

Jute is a best fiber used for sacking, burlap, and twine as a backing material for tufted carpets. It is a long, soft, shiny fiber that can be spun into coarse, strong threads. It is one of the cheapest natural fibers, and is second only to cotton in amount produced and variety of uses. Jute fiber are composed primarily of the plant material cellulose, lignin, and pectin. Both the fiber and the plant from which it comes are commonly called jute. It belongs to the genus Workhours in the basswood family, Tiliaceae.

Figure 3.2 Banana fiber

Properties of jute fiber:

1. Jute fiber is 100% bio-degradable and recyclable and thus environmentally friendly.

2. Jute is a natural fiber with golden and silky shine and hence called The Golden Fiber.

3. Jute is the cheapest vegetable fiber procured from the bast or skin of the plant's stem.

4. It is the second most important vegetable fiber after cotton, in terms of usage, global consumption, production, and availability.

5. It has high tensile strength, low extensibility, and ensures better breathability of fabrics. Therefore, jute is very suitable in agricultural commodity bulk packaging.

### Uses of jute fiber:

Jute is the second most important vegetable fiber after cotton; not only for cultivation, but also for various uses. Jute is used chiefly to make cloth for wrapping bales of raw cotton, and to make sacks and coarse cloth. The fibers are also woven into curtains, chair coverings, carpets, area rugs, hessian cloth, and backing for linoleum. While jute is being replaced by synthetic materials in many of these uses, some uses take advantage of jute's biodegradable nature, where synthetics would be unsuitable. Jute butts, the coarse ends of the plants, are used to make inexpensive cloth. Traditionally jute was used in traditional textile machineries as textile fibers having cellulose (vegetable fiber



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content) and lignin (wood fiber content). But, the major breakthrough came when the automobile, pulp and paper, and the furniture and bedding industries started to use jute and its allied fibers with their non-woven and composite technology to manufacture nonwovens, technical textiles, and composites. The Figure 5.3 shows the diagram of Jute Fiber



Figure 3.3 Jute Fiber

# IV. STRUCTURE OF BANANA-JUTE GLASS FIBER REINFORCED

#### 4.1 COMPOSITE

Various tests are made on the fabricated composite to evaluate the mechanical properties of hybrid composite. There are two different type of test 1. Tensile test

### 2. Impact test

The size of composite sheet that is to be fabricated is 300\*150\*3 mm. The materials used for fabrication are:

- .Dye 300\*150\*3 mm (2).
- Unsaturated polyester Resin (4 kg).

1. Catalyst: - Methyl Ethyl Ketone Peroxide (100ml).

### 2. Accelerator: - cobalt naphthenate (50ml).Lamination sheet.

### 4.2 COMPRESSION MODULING:

Compression moduling normally uses a hydraulic press in which a moduling tool is fixed to top and bottom platens of the press. The moduling tool consists of a top cavity and bottom cavity, designed to produce the part to be manufactured and heated to the required moduling temperature. Once the materials of choice are placed into the open module, the press closes to apply an agreed pressure designed to force the material to flow within the cavities of the module. The moduling cycle continues to maintain heat and pressureuntil the polymer has cured and the part moduled. Once moduled it is removed from the tool and trimmed to provide a finished part.

A high-pressure moduling process, compression moduling produces high strength, lightweight and complex parts in a variety of sizes. The tooling utilizes matched metal modules which are mounted in a hydraulic or mechanical moduling press and the material of choice is placed by robotics or hand in the open module.

The heated modules once closed apply pressure between 7 and 20 MPa. This will be based on the materials chosen and the part to be produced. Cycle time, will also depend on part size design and thickness, and ranges from one to five minutes. Features such as ribs, bosses, inserts and attachments can also be moduled in using this process. Compression moduling technique is the most widely used method of manufacturing composite materials. It is used only for cross-linked polymers i.e. thermosetting polymers. In this method, upper part of the module is lowered and polymer is compressed. The module is opened after the completion of cross-linking reaction. This moduling technique flow over



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shorter distances, thus less frozen-in stresses. It is cheaper and easier in moduling design. The following Figures 4.1 shows the compression moduling process.



Figure 4.1 Compression moduling machine

Composite is fabricated using resin transfer moduling. The powdered bio char is weighed according to the required weight percentage and packed separately. Unsaturated polyester resin is mixed the catalyst MEKP and kept still for a while to remove air bubbles. For 1 litre of UP resin 5 ml of MEKP is added. The bio char is mixed with 150 ml of unsaturated polyester resin and stirred slowly in order to avoid the formation of air bubbles. A lamination sheet is placed inner side of the die for easy removal of specimen after curing. The dye is placed in a vise and a funnel is placed at the mouth of the dye.

Now 30-40 ml of cobalt naphthenate (accelerator) is added to the mixture and stirred slowly. Then the mixture is poured into the dye of size  $300 \times 150 \times 3$  mm and kept for curing. It should be cured for a period of 2-3 hours to set perfectly. After 3 hours the specimen is taken out of thedyeand cut in ASTM standard sizes for different testing. The prepared



Figure 4.2 Hybrid composite plates

# **4.3 TENSILE TEST**

A tensile test, also known as a tension test, is probably the most fundamental type of mechanicaltest performed on any material. Tensile tests are simple, relatively inexpensive, and fully standardized. As the material is being pulled, we can establish its strength together with how much it will elongate. The point of failure of the material is of significant interest and it is typically called its "Ultimate Tensile Strength".

For some materials (e.g., metals and plastics), the departure from the linear elastic region cannot be identified easily. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can



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also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. The Figure 4.3 shown in Universal testing machine



Fig 4.3Universal Testing Machine

This method of test covers the tensile properties of unreinforced plastics in the form of standard dumb-bell shaped.



Fig 4.4 TESTCASE SPECIMEN

method. Materials with a thickness greater than 14mm (0.55 in).the Figure 4.4 shows the Tested Specimen



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SI. NO	SPECIMEN NO	TENSILE
		STRENGTH (MPa)
1	SPECIMEN 1	2900
2	SPECIMEN 2	4400
3	SPECIMEN 3	3900
AVERAGE		3733

Fig 4.1Tensile test result

### **V CONCLUSION**

The fiber orientation and volume fraction plays a vital role in the manufacturing of GFRP composite as the strength of the GFRP varies with the fiber orientations as well as volume fractions. In this project the volume fraction of fiber is changed. It is also found from the tensile test that the strength of GFRP is maximum at the orientation of  $0^0$  (fiber orientation parallel to the axis of loading) and the composite is weak when the orientation is  $90^0$  (fiber direction is perpendicular to the axis of loading).

The volume fraction and the void content of the fibre have its own effect on the strength of the composite. Here the void content is found to be minimum for 40% volume fraction. Analysis of mean ratio is the factor which is determined by S/N ratio is used here to find the optimum parameter. The optimum parameters from the S/N ratio table are found to be for the composite of 50% volume fraction and  $0^0$  orientations.

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