

Fabrication and Mechanical Testing of Natural (Jute)Fibre Composite Material

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Abstract

Composite materials combine two dissimilar materials to attain better properties. Composite materials are as mature as jute natural fiber as reinforcement material by polymer materials matrix. A specimen product of such a composite is developed during layer by layer method at a certain temperature to go with the processes. The composite is tested for its mechanical properties using predictable testing machines and the results were recorded. The composite specimen is analyzed with ANSYS software for its mechanical properties.

Keywords: ANSYS, Composite Materials, Jute, Mechanical Properties, Natural Fibre

I. INTRODUCTION

A Composite material is a macroscopic mixture of two or extra dissimilar materials, having familiar interface between them. Composite materials have fatigue resistance and medium to low level impact resistance properties. Reinforcing phase is a composite of combination of two materials in which one of the materials which is in the form of fibres, sheets, or particles, and is embedded in the additional materials called the matrix phase. The matrix material and reinforcing matrix material may be metal, ceramic, or polymer. Composites normally have a fibre or particle stage that is stiffer and stronger than the nonstop matrix stage and dish up as the principal load hauling members. The matrix in addition serves to care for the fibres from environmental harm before, through and after composite processing. When designed properly, the new combined material displays enhanced power than would each individual material. Composites also have electrical, thermal, tri-biological, and environmental applications. The matrix acts as a load transfer medium between fibres and resin in less ideal cases where the loads are heavy, the matrix might yet have to bear loads transverse to the fibre axis. The matrix is extra ductile than the fibres and thus performs as a foundation of composite toughness.

II. LITERATURE REVIEW

Priyadarshini Tapas et al. [1] studied the physical and mechanical properties of Al₂O₃ filled jute fibre reinforced epoxy composites. The experiment was carried out to identify the effect of filler on properties of composites. Jute and Al₂O₃ taken as reinforcement and epoxy as matrix, they have observed that filler makes significant changes on different properties of composites. They have also observed that hardness, strength, flexural and tensile modulus increased with increase in the fibre and filler and inter laminar shear strength increased only by increasing fibre and decreased in addition of filler on composites.

Alavudeen et al. [2] studied the mechanical properties of woven banana fibre, kenaf fibre and banana/ kenaf hybrid fibre composites. The mechanical strength of woven banana/kenaf fibre hybrid composites increases due to the hybridization of kenaf with banana fibres. Tensile, flexural and impact strengths of the woven hybrid composite of banana/kenaf fibres are superior to those of the individual fibres. Sodium lauryl sulfate (SLS) treatments emerge to offer an extra improvement in mechanical strength through enhanced interfacial bonding. To know the de-bonding of fibre/matrix adhesion, morphological studies of cracked mechanical testing samples were performed by scanning electron microscopy (SEM)

M. Ramesh et al. [3] examined the mechanical properties of jute, sisal and glass fibre reinforced composites. In addition they observed maximum tensile strength of glass fibre into jute fibre composite. They have also noticed that sisal and jute mixture composites sample is capable having maximum flexural strength and maximum impact strength. The variation of flexural strength, tensile strength and compressive strength of epoxy based sisal-glass hybrid composites is also studied.

H. Ranganna et al. [4] observed that 2 cm fibre length hybrid composites showed maximum flexural tensile and compressive strength than 1 and 3 cm. They found that treated hybrid composites showed higher strength than untreated composites. The effect of alkali treatment on the tensile flexural and compressive properties has also been studied.

Gopinath et al. [5] studied experimentally the mechanical behaviour of jute fibre in polyester and epoxy matrices and their results showed that jute-polyester processing time is far minor as compared to jute-epoxy laminate.

A. Gowthami et al. [6] discussed the sisal natural fibre composites with and without silica by incorporating 100% bio-degradable sisal fibre as reinforcement in the polyester matrix. The results show that the tensile modulus and tensile strength of composites with silica are 1.08 and 1.5 times larger than that of composite without silica.

Amar Patnai et al. [7] studied abrasive wear behaviour of randomly oriented glass fibre (RGF) reinforced with epoxy resin filled with Al_2O_3 , SiC and pine bark dust. They considered the 3body abrasive wear and mechanical properties of particulate filled glass with epoxy resin. Dry sand/rubber wheel abrasion tests (RWAT) were carried out test at speed of 100 rpm. The experiment was carried out at 50 and 75 N loads by varying the abrading distance from 200 to 600 m. Experimental results of abrasive wear tests exposed that wear of composite was sentient to variations of abrading distance and less receptive to sliding velocity.

Hemalata Jena et al. [8] the effect of bamboo fibre composite packed with cenosphere were deliberated and described that the shock property of bio-fibre resistant composite is very much influenced by adding of cenosphere as filler and lamina. The results expose the sensitivity of the shock properties to the concentration of the fillers. Amid all 7 layers composite with 1.5 wt% of cenosphere has the maximum shock strength of 18.132 KJ/m². The impact strength is increased with addition of filler up to a certain limit and then it is reduced on additional adding for a given laminated composite.

Girisha, C. et al. [9] premeditated the mechanical properties of composites of chemically treated fibres from fruit of tamarind and fibres from the husk of areca nut. The treated fibres show better results when compared to untreated fibres. They also observed that the strength of the hybrid composites increases with increase in volume fraction of fibre in the hybrid composites. All the hybrid natural fibre composites shown maximum mechanical properties for 40% - 50% of the fibre reinforcements from the experiment initiated. Both fibres were reinforced with epoxy matrix and composites have been developed by manual hand layup technique in the investigation.

From [1]-[8] literature concluded that mechanical and physical characteristics of composites may be customized by adding up a filler phase to the matrix body at some stage in the composite preparation. The incorporation of filler in composite is to progress tri-biological and mechanical properties.

S. Raghuraman *et al.* [10] experienced that the composite with 50% resin and 50% sisal-glass fibre combination has higher tensile strength of 97.71MPa. The breaking load of sisal-glass fibre reinforced composite is found to be 10.285 KN. Breaking load of sisal-glass fibre reinforced composite is 1.33 times higher than coir-glass fibre reinforced composite and 1.10 times higher than sisal-coir-glass fibre reinforced composite. The hybrid with composite with 60% resin and 40% sisal coir- glass fibre combination has high flexural strength of 138.87MPa and high impact strength of 1.429 KJ/m². The % elongation of coir-glass fibre reinforced composite is found as higher than the other composites and hence it may have more ductile property in nature

III. FIBRES AND ITS PROPERTIES

Fibres fall little of ideal act due to several factors considered. The recital of a fiber composite is evaluated by its all aspects (length, shape, and orientation, composition of the fiber) and the mechanical properties of the matrix. Finest performance from longitudinal fibres maybe acquired if the load is applied along its direction (X, Y and Z Coordinates). Jute is the weakest stem fibre, due to its short fibre length although it withstands rotting very easily. It is used as carpet backing, ropes packaging material (bags), yarns and wall decoration. The least shift in the angle of loading may significantly ease the strength of the composite. Silica carbide and boron are besides exercising the scientific mind due to their wide applications. The orientation of the fibre in the matrix is an indication of the strength of the composite and the strength is most along the longitudinal directional of fibre.

A. Glass Fibres

More than 95% of the fibres used in reinforced plastics are glass fibres, because of reason as they are more expensive compared to natural fibre, simple to manufacture and acquires high strength and stiffness w.r.t the plastics which are reinforced. Glass fibre are low in density, resistance to chemicals, insulation capacity are other bonus characteristics. Major demerit of glass fibre is that they will prone to break when subjected to high tensile stress for continuous loading.

Glass fibres are offered in the form of tapes, cloth, mates continuous & chopped filaments, roving and yarns. By Adding chemicals to silica sand glasses fibres improve vastly in performance when a fine metal outline is included with refractory ceramics by improving their impact resistance and thermal fatigue properties which ensure high strength, light weight and good fatigue resistance. Better flexural properties are observed in some metal fibres reinforced plastic composites which also improve strength and weight, than glass fibres. Temperature, moisture and other factors also dictate the tolerance levels of glass fibers and the demerit further mixed by the fact that the brittleness of glass does not make room for earlier warning before the anamorphic failure. But this may be simply overlooked in sight of the fact the wide range of glass fibre variety lend themselves affably to fabrication processes like filament winding lay-up, matched die-moulding and so on. However, their poor tolerance of high temperature and the resultant steep variations of thermal coefficient of expansion with the resins are an obstacle that limits their application.

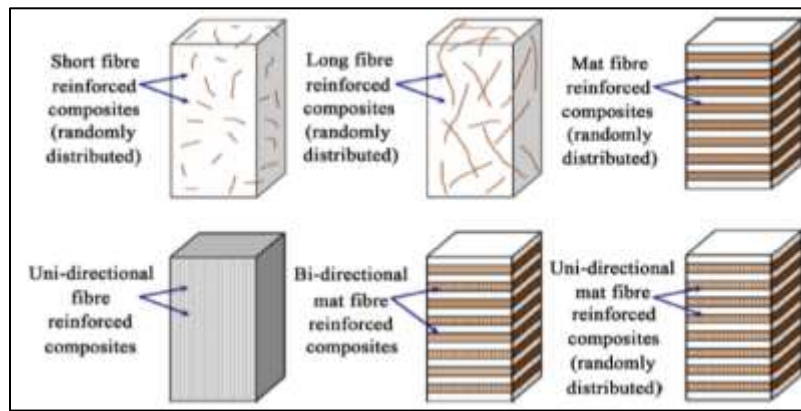


Fig. 1: Different type of fiber orientation used for the laminate manufacturing

B. Natural Fibres Properties

Natural fibres, often accessible to as vegetable fibres, are extracted from plants and they are further classified into 3 categories, depending on the part of the plant where they are extracted from. Fruit fibres are extracted from the fruits of the plant; they are light in weight and look hairy and permit the wind to carry the seeds. Bast fibres are established in the stems of the plant which usually, they run across the whole length of the stem and are thus very lengthy.

Leaf fibres are the one where the fibres are removed from the leaves are uneven and strong and form part of the plant's carrying system. When decide the properties of natural fibres, one has to know that, dealing with natural products with properties that are strongly prejudiced by their growing surroundings. Humidity, temperature, composition of the soil and air all affect the strength of its fibres, height of the plant and density etc. Natural (Jute) fibres are extracted from the ribbon of the stem.

Table – 1
Fibre Properties

Properties	Fibre								
	E-glass	flax	hemp	jute	ramie	coir	sisal	abaca	cotton
Density g/cm ³	2.55	1.40	1.48	1.47	1.50	1.25	1.33	1.50	1.51
Tensile strength 10E6 N/m ²	2400	800 - 1500	550 - 900	405 - 810	500	220	600- 700	980	400
E-modulus (GPa)	73	60 - 80	70	11 - 32	44	6	38	-	12
Specific (E/density)	29	26 - 46	47	7.2 - 22	29	5	29	-	8
Elongation at failure (%)	3	1.2 - 1.6	1.60	1.82	2	15 - 25	2 - 3	-	3 - 10
Moisture absorption (%)	-	7	8	13.1	12 - 17	10	11	-	8 - 25
price/Kg (\$), raw (mat/fabric)	1.30 (1.7/3.8)	- 1.5 (2/4)	0.6 - 1.8 (2/4)	0.35 1.5/0.9 - 2	1.5 - 2.5	0.25 - 0.5	0.6 - 0.7	1.5 - 2.5	1.5 - 2.2

Table – 2
Natural Fibre (Jute) Properties

Typical Properties	High Strength	High Modulus	Ultra-High Modulus
Density (g/cm ³)	1.80	1.90	2.0 - 2.1
Young's Modulus (GPa)	230	370	520 - 620
Tensile Strength (GPa)	2.48	1.79	1.03 - 1.31
Tensile Elongation (%)	1.10	0.50	0.20

C. Jute Fibre



Fig. 2: (a) Jute yarn (b) Jute yarn bundle (c) Jute ply

Jute is obtained from inner bast tissues of the plant stem. The fibers are bounce together by sticky materials (pectineous substances) which keep the fibre bunches cemented with non – fibrous tissues of jute bark. These encircling soft tissues are softened, dissolved and washed away so that the fibre may be obtained from the stem of the plant. Jute has low extensibility, high tensile strength, and makes sure better breathability of fabrics. Therefore, jute is very suitable in agricultural goods bulk packaging which helps to make most excellent quality industrial yarn, fabric, net, and sacks. Jute is one of the most versatile natural fibres that have been used in raw materials for agricultural, packaging, non-textile textiles and construction sectors. Jute is the cheapest vegetable fibre procured from the best or skin of the plant's stem. Jute fibre is 100% bio-degradable and recyclable and thus environmentally friendly.

IV. FABRICATION OF SPECIMEN

A. Specimen Preparation

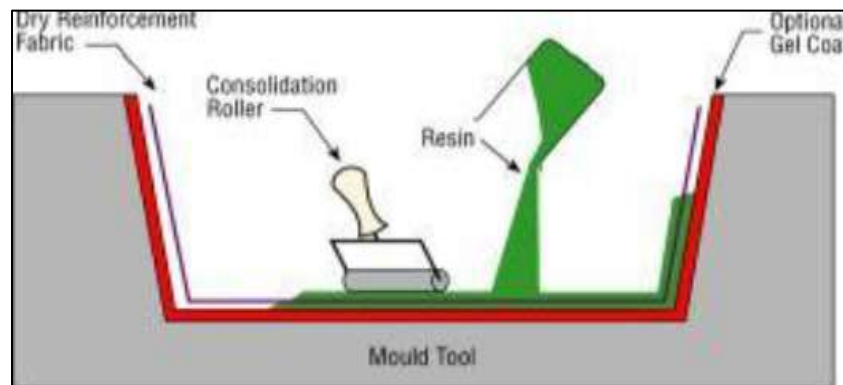


Fig. 3: Wet/hand lay-up method

The fiber plies were cut to size from the jute fiber cloth. The appropriate numbers of fiber ply were taken two for each. After then the fibers were evaluated and accordingly the resin and hardeners were evaluated. By glass rod in a bowl, Epoxy and hardener were mixed. Care is being taken to avoid formation of bubbles, since the air bubbles were fascinated in matrix may affect failure in the material. The subsequent fabrication procedure consists of primary putting a releasing film on the mould surface. Then resin was yet again applied, next to it fiber ply of another type was put and rolled. Rolling was done by cylindrical mild steel rod. This procedure was frequent until 8 alternating fibers have been laid. To ensure a good surface finish, on the top of the last ply a polythene paper was applied. Lastly a releasing sheet was put on the top to carry out a light rolling. Then a 10 kgf weight was applied on the composite and left for 3 days to allow sufficient time for curing and subsequent hardening. Raw materials used in this experimental work are Natural fibre Jute, Epoxy resin and Hardener. The hardener and softener resins are mixing uniformly with 1:3 ratio. Mould die was prepared for the size 300x25x10 mm. Die material is M.S which is suitable for this application. Improve the stiffness and strength of the composite beam. The composite specimen fabricated was tested for its mechanical properties using conventional testing machines and the values were recorded.

B. Fibre Material Preparation

Raw material Jute, lantana and Bagasse are cleaned with water and dried for sometimes. Then its outer shell is removed using knife and it is slice into necessary dimension. After that it is measured for proper blender ratio and kept in safe.

Table – 3

Blender (mixing) ratio

S.No	Jute (%)	Lantana (%)	Bagasse (%)	Epoxy (%)
I	20	----	20	60
II	30	20	-	50
III	50	-	-	50

C. Die Preparation Method

Die was prepared for moulds size of 300 x 25 x 10 mm. A clean smoothed surfaced M.S is taken and washed thoroughly. Then the glass of equal size of thickness= 3mm mould was taken. Square bits of 8 mm are cut in preferred dimension and are nailed surrounding the glass. The bits are carefully nailed so that the glass does not move sideways. Behind nailing the bits, the glass is easily taken out leaving after the mould.

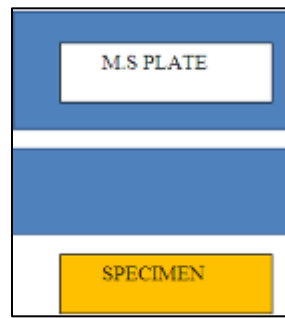


Fig. 4: Die Plates

V. MECHANICAL TESTING

A. Tensile Test

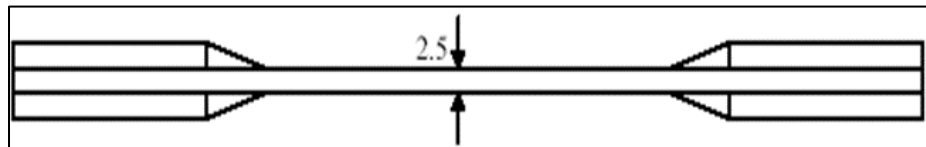


Fig. 5: Tensile test

The composite specimen was sized to the necessary dimension using a hacksaw blade. The test is carried out in Wick machine (Model; ASTM D3039) at room temperature conditions (303K) with a load cell of 250 KN and at a speed of 2mm/min. The specimen test rivets application of tension in the work piece until it cracks. The tensile stress observed according to tension. The test conducted for it blender ratio. The tests are frequent as a minimum 3-5 times and the average values are noted.

B. Compression Test

Compression tests are carried out on polyester resin and composite specimens to determine modulus of elasticity, compressive strength and Poisson's ratio. The specimens are and loaded, leaving an unsupported length as the test section.

C. Impact Test

Specimens 300x 25 mm have been used for the impact test for each energy level bounded with a clamping (ASTM D5628-96, ASTM D5428-98th). Impact test is carried out by computer – controlled closed – loop servo – hydraulic MTS – 810 having a maximum capacity of 10 metric ton to find the toughness and amount of energy required to break the material. The center of the specimen is made into a shape of V-notch and it is loaded for testing and repeatedly until it gets fractured. The effect of strain rate on fracture and ductility of the material can be determined by using the impact test. The tests are repeated minimum 3-5 times and the average values are noted.

Table – 4
Specimen Properties

Property	Value
Length (l)	300mm
Width (w)	25mm
Thickness (t)	10mm
Moment of inertia (I)	2083.33m ⁴

VI. RESULT

By ANSYS software, three samples composite specimen were analyzed and graph has been plotted. The results are tabulated below.

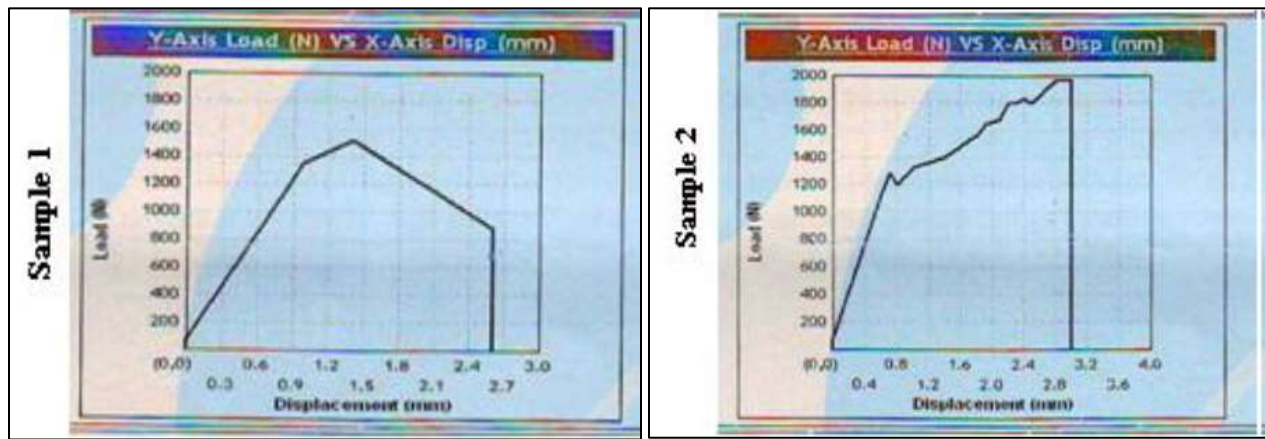


Fig. 6(a): Graphical representation of Sample 1 b) Sample 2

The below table V shows the comparison result of 3 samples

Table – 5

Comparison result of 3 samples

S. No.	Mechanical test	Sample I	Sample II	Sample III
1	Tensile strength	130.06Mpa	238.84Mpa	354.0Mpa
2	Compression test (Rockwell hardness Number)	91	91	91
3	Impact test	500N	600N	750N

VII. CONCLUSION

In the case I, composite with 20% jute fiber, 20% bagasse and 60% resin combination has minimum tensile strength of 130.6 MPa. In the case II, composite with 30% jute fiber, 20% lantana and 50% resin combination has tensile strength of 238.84 MPa. In the third case, the composite with 50% jute fiber and 50% epoxy resin combination has maximum tensile strength of 354 MPa. From this result, it is understood that jute and epoxy resin withstands maximum tensile strength for impact load. Comparing natural fiber and glass fiber reinforced composites found that natural fibers were advanced in industrial applications.

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