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Fabrication of Jute fibre reinforced PMC and evaluation of its mechanical Properties

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Abstract-The use of natural fibre composite has increased considered over the last decade to create hybrid products for replacing the essential components in an automobile such as the foot rest, bumpers, etc. Conventional uses of thermosetting plastics used in the economical, sturdy and also long lasting. In the present work an attempt is made in order to manufacture the PMC with natural fibre (jute) and subsequent evaluation of its mechanical properties such as tensile and flexural strength. The jute fibre chosen are varied in orientation (0^0,90,45^0) and the matrix composition is kept at 90% to its volume mixture with the hardener. The tests were carried out to ascertain the tensile and flexural strength of the PMC with 4 different orientations (45^0, 90^0,45^0), (90^0,45^0,90^0), (45^0,45^0,45^0), (90^0,90^0,90^0). The test reveal that (45^0,90^0,45^0) oriented fibre s have the highest peak loading tensile testing and flexural testing and can be used as the best substitute for varied automotive and other general use products.

Keywords—Jute Fiber, Polymer Matrix Composite, Hand Lay Up

1. INTRODUCTION

Fibre composites consist of matrices reinforced by short (discontinuous) or long(continuous) fibres. Fibres are generally anisotropic and examples include carbon and aramids. Examples of matrices are resins such as epoxy, metals such as aluminum, and ceramics such as calcium–aluminum silicate.

Fibres are hair-like materials that are continuous filaments or discrete elongated pieces. They are of two types: natural fibre (NF) and man-made or synthetic fibre. NFs are a class of hair-like materials that are obtained from vegetables, animals, or minerals. The development of bio composites has attracted great interest due to their environmental benefit (i.e., biodegradability) and improved properties. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such asflax, cotton, hemp, jute, sisal, pineapple, ramie, bamboo, banana, cactus, etc., as well as wood, used from time immemorial as a source of lignocellulosic fibres, 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 fibre s used for the manufacturing of composites. The natural fibre-containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc.

Plant fibres are generally comprised mainly of cellulose examples include cotton, jute, flax, ramie, sisal and hemp. The natural fibres can be used to reinforce both thermosetting and thermoplasticmatrices. Thermosetting resins, such as epoxy, polyester, polyurethane, phenolic, etc. arecommonly used today in natural fibre composites, in which composites requiring higherperformance applications. They provide sufficient mechanical properties, such as stiffness and strength, at an acceptably low price. Considering the ecological aspects of material selection, replacing synthetic fibre s with natural ones is only a first step

The tensile strength of sisal fibre improved when 0 º oriented fibre s were positioned at the extreme layers of the composites compared to 90 º oriented fibres. [1] The tensile, flexural and impact properties of epoxy and randomly oriented short jute fibre reinforced epoxy composite. The results showed that the tensile and flexural properties were found maximum for the composite with 15 mm length of fibre whereas the impact properties were found maximum for the composite with 20 mm length of fibre. [2] The hybrid reinforcement consists of two different fibres such as jute, gongura & hybrid polymer consists of polyster & cashew nut shell resins. The hybrid composites tensile strength is evaluated to study the influence of various fibre parameters on mechanical strength. The objectives of this study is to determine the possibility of weight and cost reduction of the composite by reinforcing it with jute fibre.[3]Usage of the bio-degradable reinforcement (jute fibre) helps in making this composite bio-friendly and to fabricate the specimens to the ASTM standards using the "Hand Layup" process with different orientation to get desired mechanical properties.[4]

2. MATERIALS AND EXPERIMENTAL PROCEDURE

A. Resin and hardener

LY–556 is used as matrix in the present investigation. The properties and curing details of epoxy resin shows the table 2.1.

PROPERTIES	VALUES
Density	1.15-1.20 gm/cm^3
Viscosity	50-100 mPa s
Flash point	>200 ^{o}C
Storage temperature	2-40 ^{o}C

Table 1: Some Important Properties of Epoxy Resin (LY-556)

HY-951 hardener is used as curing agent. The weight percentage of hardener used in the present investigation is in the ratio of 10:1.HY-951 low viscosity, aliphatic amine hardener for epoxies that offers incredible mechanical strength that cures at room temperature.

Fibre : Jute fibre s were used as reinforcement in the work.Jute fibre s are composed primarily of the plant materials cellulose, lignin, and pectin. Both the fibre and the plant from which it comes are commonly called jute. It belongs to the genus Corchorus in the basswood family, Tiliaceae. It is one of the cheapest natural fibre s. Jute is a best fibre used for sacking, burlap, and twine as a backing material for tufted carpets. It is a long, soft, shiny fibre that can be spun into coarse, strong threads.

Jute epoxy composite was prepared by mixing the epoxy resin (LY-556) and hardener (HY-951) in the ratio of10:1 by weight as recommended. The proposed work involves the use of hand layup method for fabrication

In the proposed work, specimens were prepared for three different compositions. Table gives the detailed information of all combinations of composite prepared and used.

Sl.no	Fibre with Orientation	Combination
1	Jute-0^0	90% LY-556+10% HY-951
2	Jute-45^0	90% LY-556+10% HY-951
3	Jute-90^0/45^0/90^0	90% LY-556+10% HY-951
4	Jute-45^0/90^0/45^0	45/90/45 degree = Jute+90% LY-556+10% HY-951

Table 2: Fibre orientation and combination

The composites which are prepared initially were marked for required dimensions of 250mm*25mm*2.5mm (lbh).The specimens are as per the standards of ASTM (D-3039).The specimens are prepared for both Tensile and Flexural test.

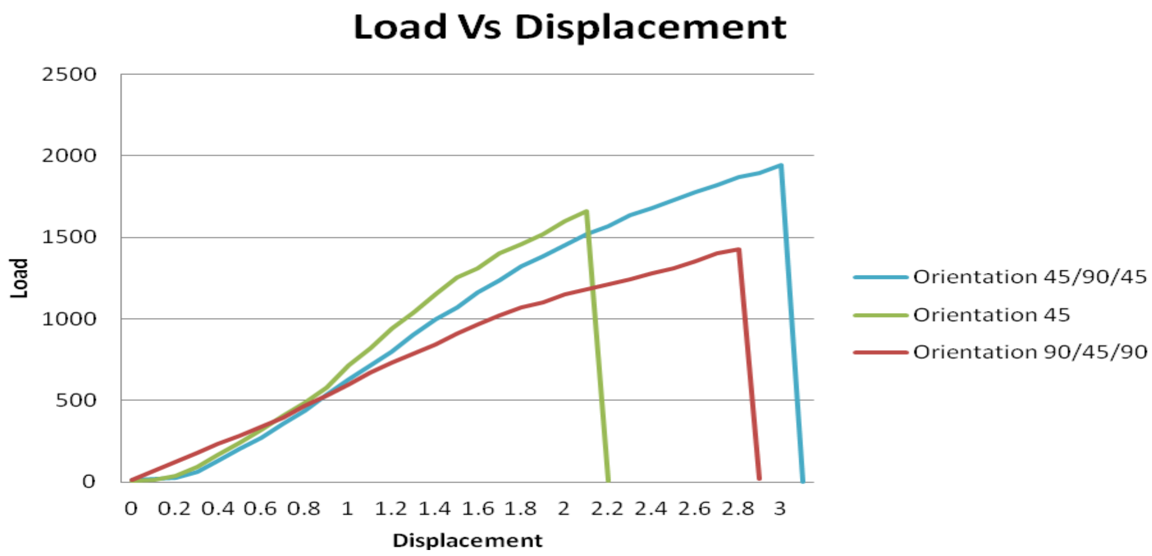
B. Test Procedure:

Specimens are placed in the grips of a Universal Test Machine at a specified grip separation and pulled until failure. For ASTM D3039 the test speed can be determined by the material specification or time to failure (1 to 10 minutes). A typical test speed for standard test specimens is 2 mm/min (0.05 in/min). An extensometer or strain gauge is used to determine elongation and tensile modulus.

The three-point bending flexural test provides values for the modulus of elasticity bending, flexural stress, flexural strain and the flexural stress-strain response of the material. The main advantage of a three-point flexural test is the ease of the specimen preparation and testing.

Tensile testing is used to measure the force required to break a polymer composite specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile tests produce a stress-strain diagram, which is used to determine tensile modulus. The data is often used to specify a material, to design parts to withstand application force and as a quality control check of materials.

3. RESULTS AND DISCUSSIONS

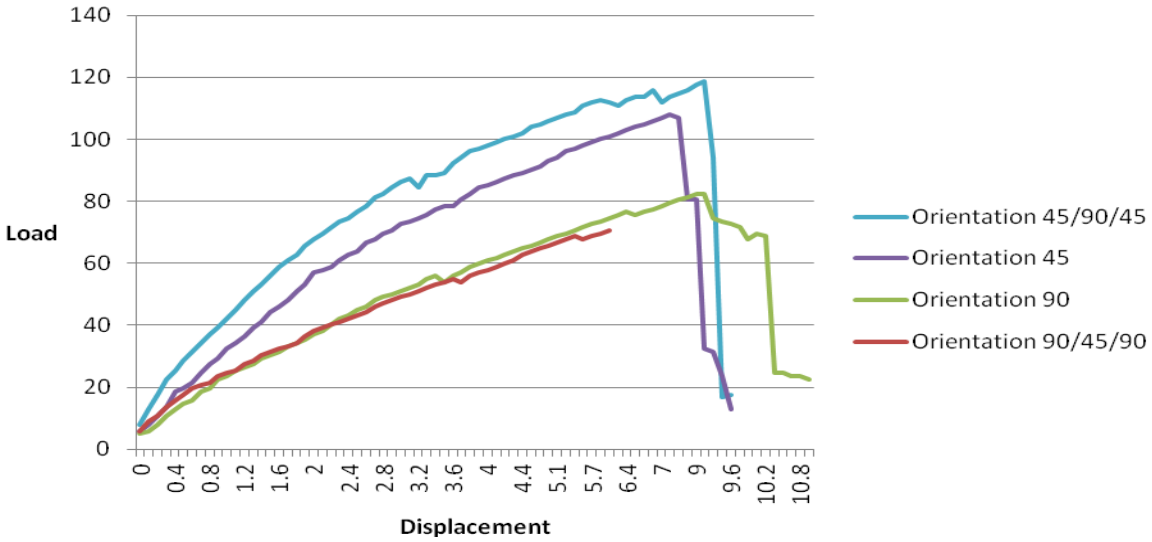


Tensile load v/s displacement for different fibre orientations

The jute fibre reinforced composites are found to have better strength at a particular orientation of the fibre s at 45/90/45 compared to other orientations. The strength of the fibre is higher in longitudinal direction than that of transverse. The laminate with 45 showed more creep strain than the other orientations. In the 45 sequence the epoxy had creep strain contributions from

- Tension in loading direction
- Shear in the 45/135 direction.
- Rotation of plies in scissor like action.
- Difference in the state of shear near the free edges.

The plastic constraint on the matrix owing to large difference in Poisson's ratio of matrix and fibre especially in the stage where fibre deforms elastically and the matrix plastically. The higher peak loads can also be reasoned out with the use of continuous fibre s which have flaws distributed along their length and resulted in fibre pullout. Also, the strength of the fibre is higher in longitudinal direction than that of transverse.



Flexural load v/s displacement for different fibre orientations

The following conclusions are drawn as a reason for highest peak load values for various orientations are

- 90/45/90°: The top and the bottom layer is 90⁰ and as weight is loaded on the top layer there is huge amount of deflection offered because of 45 sandwiched in between the top and bottom layer which in turn deflects the 90⁰ oriertated fibre .
- 45/90/45°: The top and bottom layer is 45 and both of them resist any load because of the 90⁰ sandwich which is already deflected along the top and bottom 45.
- 45°: Each laminar is at an angle of 45 and 135 and both aren't able to deflect because of the structure or resist any load and thus break at a lower load than others.

4. CONCLUSION:

In the present research effort, mechanical tests were conducted on randomly oriented short jute fibre reinforced epoxy based composites. Based on the experimental results, the following conclusions can be drawn:

1) The jute fibre reinforced composites are found to have better strength at a particular orientation of the fibres at 45/90/45 compared to other orientations.

2) From the results, it is understood that the role of reinforcement is very crucial. The orientation of reinforcements decides the mechanical properties of PMC. Current work shows that the properties of PMC with jute fibre, are comparable with the conventional PMCs.

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