STUDY ON JUTE REINFORCED EPOXY COMPOSITES

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Abstract: Composite materials have experienced rapid development over the last three decades. From satellites to subsea, from automotive to artificial legs, there is likely to be some aspect of composite performance. Composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly.

The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. It is obvious, especially for composites that the improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, material, process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals.

This paper deals with preparation and investigation of composites of natural fibers in epoxy resin. Natural fibers used here are jute fibers which are mixed with in various volume fractions. This composite is manufactured using wooden pattern process. Mechanical properties of each composite are determined through tensile, bending, hardness tests.

Key words: Jute, Epoxy, natural fibers.

INTRODUCTION

A composite material is defined as the combination of two or more macro constituent materials, which are essentially insoluble into each other such that the properties of the combination are better than the sum of the properties of each constituent taken separately. The objective of this combination is to derive the best qualities of the constituent materials. These composites exhibit desirable qualities, which the constituents themselves may not possess.In recent years, the natural fibre reinforced composites have attracted substantial importance as a potential structural material. The attractive features of the natural fibres like jute, sisal, coir, hemp and banana have been their low cost, light weight, high specific modulus, renewability and biodegradability. Naturally, composites reinforced with such natural fibres have thus been a subject of intense study for low strength, low cost application in contrast to the synthetic fibre reinforced composites. Since the interfacial bond between the reinforcing fibres and the resin matrix is an important element to realize the mechanical properties of the composites.

Composite materials are amongst the earliest and also the latest of structural materials. Even though the basic concepts of composite materials were known from ancient times and some materials were used in the past, the development of advanced composite materials such as boron epoxy, Kevlar epoxy, glass epoxy, carbon epoxy, etc., suitable for modern engineering applications, received attention only in recent past. These fibre reinforced plastics (FRPs, here after referred to as conventional composites) are gaining popularity as primary and secondary structural materials in aerospace, marine, automobile, civil construction applications, sports industry, defence, renewable energy sectors, textile industries and other areas because of their inherent mechanical properties, such as low density, high strength-to-weight ratio, high stiffness-to-weight ratio, excellent durability, dimensional stability, non corrosive nature, good thermal and electrical insulation properties and ease of fabrication.

In addition, anisotropic nature of composites made them easy to adopt its properties depending upon design requirements. Furthermore, many FRPs posses better internal damping which leads to high impact energy absorption within the material and results in reduced transmission of noise and vibration to neighbouring structures. These are some of the main reasons for the popularity and success of conventional composites in structural and non-structural applications. The polymer

composites containing vegetable fibres have received considerable attention both in the literature and in industry. The interest in natural fibre reinforced polymer composites is growing rapidly due to the high performance in mechanical properties, significant processing advantages, low cost and low density. Natural fibres are renewable resources in many developing countries of the world. They are cheaper, poses no health hazards and finally provide a solution to environmental pollution by finding new uses for waste materials. Furthermore, natural fiber reinforced polymer composites form a new class of materials which seem to have good potential in the future as a substitute for scarce wood and wood based materials in structural applications.
Non-conventional fibres such as jute, hemp, sisal, coir, banana, palm fibres etc., are extracted from stem/leaf/fruit of plants. Among all these fibres, to suit the various applications optimistically a new composite material will be developed with enhanced mechanical properties by combining two natural fibers hemp and jute with epoxy matrix by the process, hand layout, which would be cost effective and eco-friendly.

EXPERIMENTAL SETUP

MATERIALS

For the investigation carried out natural fibers namely Jute has been used for fabricating the composite. Epoxy resin is used in different percentage.
Natural fiber: In the recent times use of natural fiber has found immense value in producing eco-friendly polymer composites. Natural fiber-reinforced polymer composites have attracted more and more research interests owing to their potential as an alternative for synthetic fiber composites. Due to increase in population, natural resources are being exploited substantially as an alternative to synthetic materials. Natural fiber composites possess the advantages such as easy availability, renewability of raw materials, low cost, light weight, high specific strength and stiffness. Mechanical properties of the composite are highly influenced by the hydrophilic nature of natural fibers that would result in porous materials. This can be controlled by reducing water absorption content in the natural fiber. Both natural fibers that are used in the experimental work were procured from the local source.
Jute fiber: Sisal plant belongs to the agave family. The composition of sisal fiber is 60–80% cellulose, 5–20% lignin and 5–20% moisture content. Sisal (Agave sisalana) looks like giant pineapple which can be extracted from its leaves by retting and mechanical extraction methods. Hand extraction machine is used to extract the fibers through serrated or non-serrated knives. The fiber extracted is dried under the sun until it turns white in colour and then it is made ready for knotting. Fiber is separated to various sizes and knotting is done on the other side to form long continuous strands. It is mainly used for mats, carpets and many other reinforcement materials.
Titanium Dioxide: Titanium Dioxide is produced from Ilmenite, a mineral found in rich abundance in beach sands and hard rock. This material is treated to produce the Titanium Dioxide which is then milled to produce fine particles. A white powder that makes it possible to render true-to-life colours.
Epoxy resin: Epoxy resin consists of long chain molecular structure carrying two aromatic rings at its centre and two epoxy groups at two ends.Epoxyresin can absorb better thermal and mechanical stresses, as it contains two aromatic rings at its centre. This eventually gives good stiffness, toughness and heat resistance properties to epoxy resin.Chemical structure of a typical epoxy is shown below:
Epoxy resins are usually amber or brown in colour.
Epoxy cured at any temperature 5° C - 150° C based on the curing agent.
Hardener (usually amine) is used to cure epoxy resin by addition reaction

FABRICATION DETAILS

Stage 1: Preparation of Reinforcements : Jutefiber is a hygroscopic fiber. The moisture regain is around 11.5%. So, the fiber can hold quite a large amount of water in it. In the fiber-matrix interface this water acts like a separating agent. Moreover, during for curing process of making fiber-reinforced composites, voids appear in the matrix due to evaporation of water.That is why, before making composite panels performs are heated in a pre-heated oven for 1hr at 105° C temperature.

Stage 2: Preparation of Mould Plate: The mould used for making laminates was made of steel with 50 cm × 25 cm dimension. The mould was cleaned by acetone first and then subsequently by mould cleaner (commercial name: Sika Mould Cleaner). Then the mould was coated by mould releasing agent (commercial name: LOCTITE 700NC Frekote) for three times with ten minutes interval between each coating. The purpose of applying this releasing agent was to make sure that the laminate will be separated from mould conveniently after curing.

Stage 3: Stacking of Reinforcement: The way of arranging the different layers of reinforcing material in a laminate is known as the stacking sequence.

Stage 4: Vacuum Bagging:A layer of nylon release fabric was placed on the coated mould. Then reinforcing materials were placed on this in a predetermined stacking sequence. On top of the reinforcing materials another layer of release fabric, then a layer of peel ply, a layer of mesh and on top most surface another steel plate of 28 cm × 18 cm were placed.

Stage 5: Resin Formulation: Epoxy resin "ARALDITE LY564" and hardener "ARADUR 3486" of Huntsman was used in resin infusion. For making 100 g of matrix for infusion, 66 g of resin and 34 g of hardener was weighed and mixed together. Then the mixture was stirred gently until it mixed well.

Stage 6: Infusion: For resin infusion, the outlet pipe of the vacuum bagged mould was connected to a suction pump, when inlet pipe was inserted into resin mixture. Controlling of the resin flow inside the moulding arrangement is important to ensure that all the fibers were wetted properly. When the infusion was completed, inlet and outlet were sealed with Dclamp. Then the mould assemble becomes ready for curing.

Stage 7: Curing: After infusion, the sealed mould assembly was placed inside a curing chamber (Figure 3-13). the curing time was 8hrs and temperature was 80° C. The programme was set to raise temperature from room temperature to 80° C, was an hour.

Stage 8: Removing cured laminate from oven and separation of manufacturing kits.After curing, the oven was allowed to cool. Then the mould assembly was removed from the curing chamber and manufacturing tools were carefully removed from the laminate. Thus the desired laminate was parallel.

(a) (b) (c)

Fig 1,(a)Vacuum Bagging,(b) Degassing machine,(c)Curing chamber

TESTING OF COMPOSITES

Tensile test: The tensile strength of a material is the maximum amount of longitudinal stress that it can take before failure. The commonly used specimen for tensile test is prepared as per ASTM D638-02a standard of specimen dimension are 165x19x5 mm.The testing process involves placing the test specimen in the testing machine and applying tension to it until it fractures. The tensile force is recorded as a function of the increase in gauge length. During the application of tension, the elongation of the gauge section is recorded against the applied force. The tensile test is performed in universal testing machine (UTM).

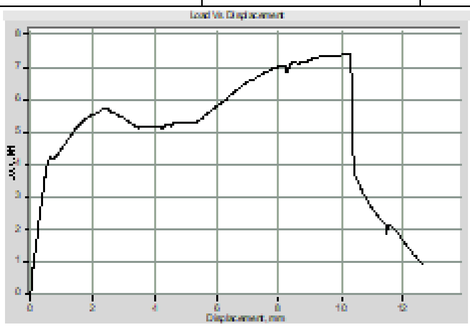
Compression Test: When conducting compression testing to ASTM D-1621 it is important to understand how system compliance and stiffness can impact results. Stiffness may vary considerably for the different frame capacities, as well as between manufacturers. When significantly high forces are expected, systems with inadequate frame stiffness are susceptible to absorbing energy from a specimen during testing and transferring it back into the specimen, resulting in a premature failure.

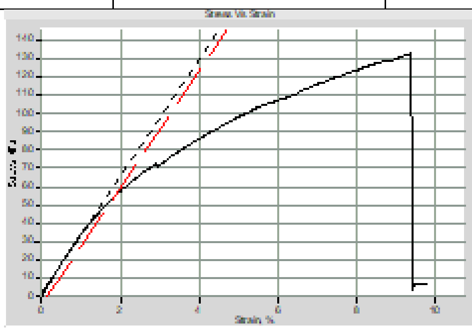
BENDING TEST: This is the most common test carried for composite materials. The standard used for bending test is ASTM D638-02a standard of specimen dimension are 165x19x5mm.The Universal Testing Machine is used to carry out the Bending test. Test determines the maximum stress induced in the outermost fiber. Testing is carried out at room temperature. In this test specimen is subjected to load at its midway between the supports until it fractures and breaks. The tests are repeated for all the specimens and values are used for the discussion.

RESULTS AND DISCUSSION

1. **Tensile properties:** The different composite specimen samples are tested in the universal testing machine to find tensile propertiesand the samples are left to break till the ultimate tensile strength occurs andtheir respective graphs are plotted below.

Specimen	Tensile Load (kN)	Stress (N/mm2)	Strain	Tensile strength (Mpa)	Young's modulus(Gpa)
Jute+ Titanium-Dioxide +Epoxy	7.398	99.631	0.0189	147.96	5.257

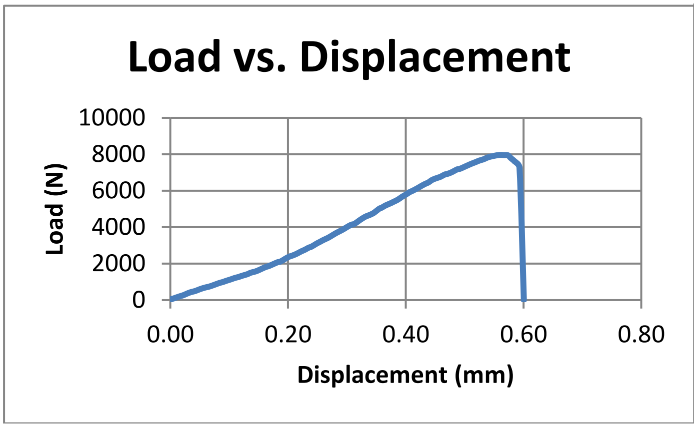


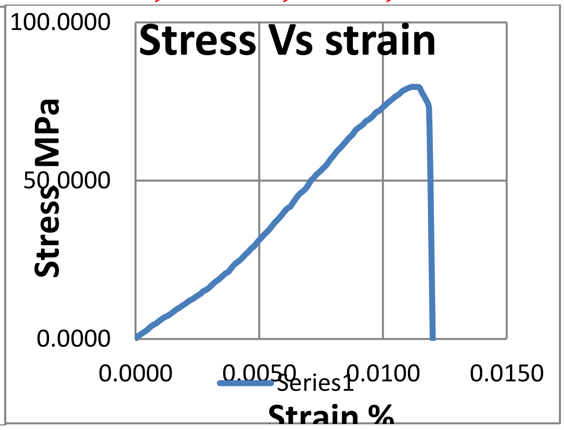


Load Vs Displacement for specimenStress Vs strain for specimen

2. **Compression Testing:** The different composite specimen samples are tested in the universal testing machine to find tensile properties and the samples are left to break till the ultimate compression strength occurs and their respective graphs are plotted below.

Specimen	Compressive load (N)	Compressive strength (Mpa)
Jute+ Titanium-Dioxid +Epoxy	7964.5227	79.64



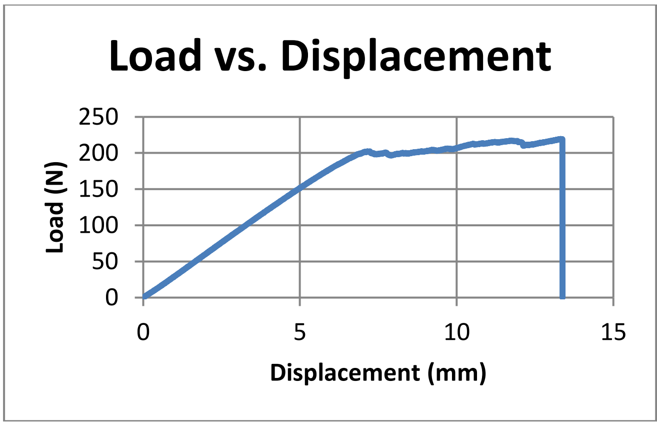


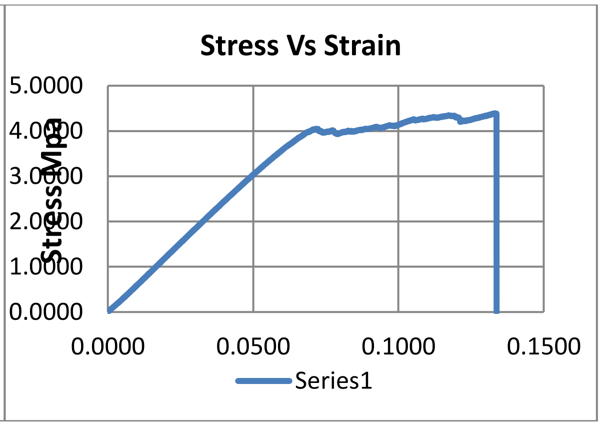
Load Vs Displacement for specimen

Stress Vs strain for specimen

3. Flexural properties: The different composite specimen samples are tested in a universal testing machine in accordance with ASTM standard to measure the bending/flexiural strength of the composites specimen. And their respective graphs are plotted below.

Specimen	Flexural load (N)	Flexural strength(Mpa)
Jute+ Titanium-Dioxide +Epoxy	219.5141	329.27





Load Vs Displacement for specimen

Stress Vs strain for specimen

CONCLUSION

The composite of jute-Titanium di oxide along with epoxyresin and hardener was successfully developed and the mechanical characteristics were tested and results were established.

- Tensile strength of the material is found to be 147.96Mpa.
- Compression strength of the material is found to be 79.64Mpa.
- Bending strength of base material is found to be 329.27Mpa.
- All mechanical properties of jute-titanium di-oxide reinforced epoxy resin composites are compared and found to be better than only jute reinforced epoxy composite material.

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