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Evaluation of Mechanical Behaviour of Natural Fiber Hybrid Composite Material

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ABSTRACT: The polymer based natural fiber composites are mostly used in engineering applications because of their specific characteristics including light weight low density, easy availability and non abrasive natures Composite are one of the most widely used material because of their adaptability to different situation and the relative case of combination with other material to serve specific purposes and exhibit desirable The mechanical characteristics of coir and roysteniaregia-epoxy laminate is evaluated in this project work various fiber content(25%,20%,55%) and fiber orientation (Oº,45º,90º).

KEYWORDS:Coir, Roysteniaregia, Epoxy laminate, Polymer.

I. Introduction

India, endowed with an abundant availability of natural fiber such as jute, coir, sisal, pineapple, ramie, bamboo, banana etc., has focused on the development of natural fiber composites primarily to explore value- added application avenues. Growing environmental awareness throughout the world has triggered a paradigm shift towards designing materials compatible with the environment. The use of bonfires, derived from annually renewable resources, as reinforcing fibers in both thermoplastic and thermo set matrix composites provide Mathematical model [3]. In addition, other factors might be unpredictable, such as temperature, load dynamics, noise, and are poor compatibility between the fibers and the matrix, and the inherent high moisture absorption, which brings about dimensional changes in the lignocellulose"s based fibers. The efficiency of a fiber reinforced Composite depends on the fiber/matrix interface and the ability to transfer stress from the matrix to the fiber. This stress transfer efficiency plays a dominant role in determining the mechanical properties of the composite. In natural lignocelluloses fibers, cellulose is the main component. The elementary unit of a cellulose macro molecule is a hydro-d-glucose, 2 which contains three hydroxyls (_OH). These hydroxyls form hydrogen bonds inside the macromolecule itself (intra-molecular) and also with hydroxyl groups from moist airTherefore, all natural fibers are hydrophilic in nature and their moisture content can reach 3–13%. The internal adhesion can be improved by modifying the surface topology of fibers by a suitable pre-treatment or by selecting the proper components of the bonding system.

Natural fiber is a lignocelluloses fiber obtained from coconut trees which grow extensively in tropical countries. Because of its hard-wearing quality, durability and other advantages, it is used for making a wide variety of floor furnishing materials, yarn, rope etc. However, these traditional natural fiber products consume only a small percentage of the potential total world production of coconut husk. Hence, research and development efforts have been underway to find new use areas for natural fiber, including utilization of natural fiber as reinforcement in polymer composites. Unfortunately, the performance of natural fiber as a reinforcement in polymer composites is unsatisfactory and not comparable even with other natural fibers due to its low cellulose content (36–43%), high lignin content (41–45%) and high microfibrillar angle. Morphological studies of natural fiber fibers show the outer sheath of lignin that develops the cellulose ultimate. The removal of this surface layer of lignin usually results in a better and more stable bond. Keeping in view the above facts in our present investigation, we have chosen chemical cleaning and alkali treatment as surface treatments for natural fiber fibers in order to obtain better adhesion of these fibers with the polyester resin. The mechanical properties like tensile, wear and impact strength of natural fiber-polyester are determined and optimal values are calibrated.

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II. FIBER REINFORCED COMPOSITES

A fibrous composite is a compound between a polymer (such as polyester or PP) and a fibrous material (such as glass, carbon or natural fibers).

A. ROLE OF THE MATRIX

- Transmit force between fibers
- Arrest cracks from spreading between fibers
- Do not carry most of the load
- Hold fibers in proper orientation

B. DEMANDS ON MATRIX

- Interlaminar shear strength
- Toughness
- Moisture/environmental resistance
- Temperature properties

C .FEATURES OF COMPOSITES

The following features attract the manufacturing industries towards the invention of natural fiber reinforced composite materials.

- High strength-to-weight ratio
- High modulus-to-weight ratio
- Low specific gravity
- Good fatigue strength
- Good corrosion resistance, although are soluble in various chemicals
- Low thermal expansion, leading to good dimensional stability
- Significant anisotropy in properties

III CLASSIFICATION OF COMPOSITE MATERIALS

Composite materials can be classified into three groups on the basis of matrix material. They are:

- A.Metal Matrix Composites (MMC)
- B. Ceramic Matrix Composites (CMC)
- C. Polymer Matrix Composites (PMC)
- D. Carbon and graphic matrix composites (CMGC)

A. METAL MATRIX COMPOSITES

Metal Matrix Composites have many advantages over monolithic metals like higher specific modulus, higher specific strength, better properties at elevated temperatures, and lower coefficient of thermal expansion. Because of these attributes metal matrix composites are under consideration for wide range of applications viz. combustion chamber nozzle (in rocket, space shuttle), housings, tubing, cables, heat exchangers, structural members etc.

B. CERAMIC MATRIX COMPOSITES

One of the main objectives in producing ceramic matrix composites is to increase the toughness. Naturally it is hoped and indeed often found that there is a concomitant improvement in strength and stiffness of ceramic matrix composites.

C. POLYMER MATRIX COMPOSITES

Most commonly used matrix materials are polymeric. The reason for this are two fold. In general the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. These difficulties are overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites need not involve high pressure and doesn't require high temperature.

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- **D .CARBON AND GRAPHIC COMPOSITES**

Carbon and graphite have a special place in composite material options, both being highly superior, high temperature materials with strengths and rigidity that are not affected by temperature upto2300oC.

IV LITERATURE SURVEY

Review of the related literature, allows the researcher to acquaint himself with current knowledge in the field in which he is going to conduct his research, serves the following specific purposes. The review of related literature, enables the researcher to define limit in respective field. It helps the researcher to delimit and define his problem.

- **A. TENSILE BEHAVIOUR AND HARDNESS OF COCONUTFIBRE-ORTHO UNSATURATEDPOLYESTER COMPOSITES FIBRE REINFORCED POLYMER (FRP)**

A relatively newclass of composite material manufactured fromfibre and resin and has proven efficient and economical for use in variety of engineering applications in different field such as aerospace, oil, gas and process industries[1]. Composite materials exhibit good resistance to temperature extremes and wear, especially inindustrial settings. The tailorability of composites for a specific purpose has been one of its greatest advantages and also one of the more perplexing challenges for adopting them as alternative materials tometallic ones[2].thermoplastics or thermosets, can be used asmatrix and fibres of various types as reinforcement infibre reinforced polymer composite. Fibres provide increased stiffness and tensile capacity in the composites giving them their mechanical characteristics[3].The resin offers high compressive strength andbinds the fibres into a firm matrix. Many of ourtechnologies require materials with unusual combination metal alloys. The mechanical properties of fibrereinforced polymer composites make them ideal forwidespread applications in construction 10 worldwide [4].The use of natural fibre for the reinforcement ofthe composites has received increasing attention bothby the academic sector and the industry. Natural fibreshave many significant advantages over synthetic fibres.Currently, many types of natural fibres have beeninvestigated for use in plastics.These include flax, hemp, jute straw, wood, rice husk, wheat, barley, oats,rye, cane (sugar and bamboo), grass, reeds, kenaf,ramie, oil palm empty fruit bunch, sisal, coir, water,hyacinth, pennywort, kapok, paper mulberry, raphia,banana fibre, pineapple leaf fibre and papyrus[5].Thermoplastics reinforced with special wood fillers are enjoying rapid growth due to their many advantages; lightweight, reasonable strength and stiffness [6].Natural fibres, as reinforcement, have recentlyattracted the attention of researchers because of theiradvantages over other established materials. They are environmentally friendly, fully biodegradable, abundantlyavailable, renewable, cheap and have low density [7].Plant fibres are light compared to glass, carbon andaramid fibres [8]. The biodegradability of plant fibrescan contribute to a healthy ecosystem while their lowcost and high-performancefulfills the economic interest of industry.However, although natural fibres and theircomposites are environmental friendly and renewable(unlike traditional sources of energy, i.e., coal, oil and gas), they have several bottlenecks.These include: poorwetability, incompatibility with some polymeric matricesand high moisture absorption [9]. Composite materialsmade with the use of unmodified plant fibres frequentlyexhibit unsatisfactory mechanical properties. To overcomethis, in many cases, a surface treatment orcompatibilizing agents need to be used prior tocompositefabrication[10].Thepropertiescanbeimprovedbyphysicaltreatments(coldplasmatreatment,coronatreatment)andchemicaltreatments(maleicanhydrideorganosilanes,isocyanates,sodiumhydroxide,permanganateandperoxides)[11]. Mechanicalproperties of natural fibres are much lower thanthose of glass fibres but their specific properties,especially stiffness, are comparable to the glass fibres[12].Coconut fibre is one of the natural fibres .The common name, scientific name and plant family of coconut fibre is Coir, Cocos nucifera and Arecaceae (Palm), respectively [13]. The two types of coconut fibres include brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance while white fibres are smoother and finer but weaker. Coconut fibres are commercially available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres). These different types of fibres have different uses depending upon the requirement [14]. However, for the purpose of this study, the brown fibres were used.General advantages of coconut fibres are: they are moth-proof, resistant to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, flame-retardant,

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V DESIGN OF EXPERIMENTS

The coir-roysteniaregia composites were prepared as per 3 Level full factorial designs of fiber parameters namely; fiber content, fibre orientation. The composites were fabricated for the thickness of 3 mm and the mechanical property(tensile strength , flexural strength and impact strength) was tested as per ASTM D256, ASTM D 5963 standard. 3k factorial design is the most widely used factorial design having three levels for each of „k" factors. The three levels of factors are referred to as low (-1), intermediate (0) and high (+1). If there are three factors under study and each factor is at three levels arranged in a factorial experiment, then this constitutes a 33 30
factorial design. This study was designed as below

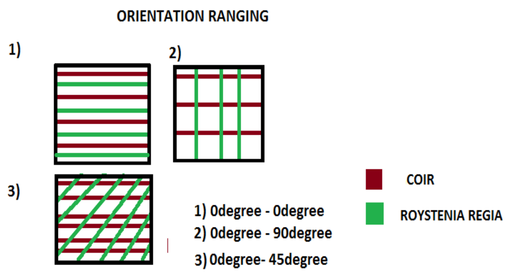

Figure.1Orientation Ranging

A. FABRICATION OF UNTREATED COMBINATION OF FIBRES/EPOXY COMPIOSITES

In this hand lay-up manufacturing process of fiber epoxy composites, the following steps are followed.
1. Woods are placed as base plate and border plates.
2. wax is applied as a releasing agent over the wood surfaces where the product surface is going to have the surface contacts.
3. Resin(10%), and Hardner(1%) are mixed together for sticking. Resin mixture is applied in base wood.
4. The fibre is placed over the base wood in a particular orientation angle (0o, 45o 90o)and a layer of resin is coated over the fiber layer(layer 1).
5. The above step is repeated again with a fibre placed in a different orientation angle and another layer (layer 2) is formed.
6. Pressure is applied at top for adjusting thickness of composites. After 7 hours, the pressure is released and fabric composite product is taken out. The preparation stages fabrication procedure and fabricated composite specimen of untreated fibers composites are in shown in below figure

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Figure. 2. Preparatory Stages for Composite Fabrication

Figure.3 .Fabrication Procedure

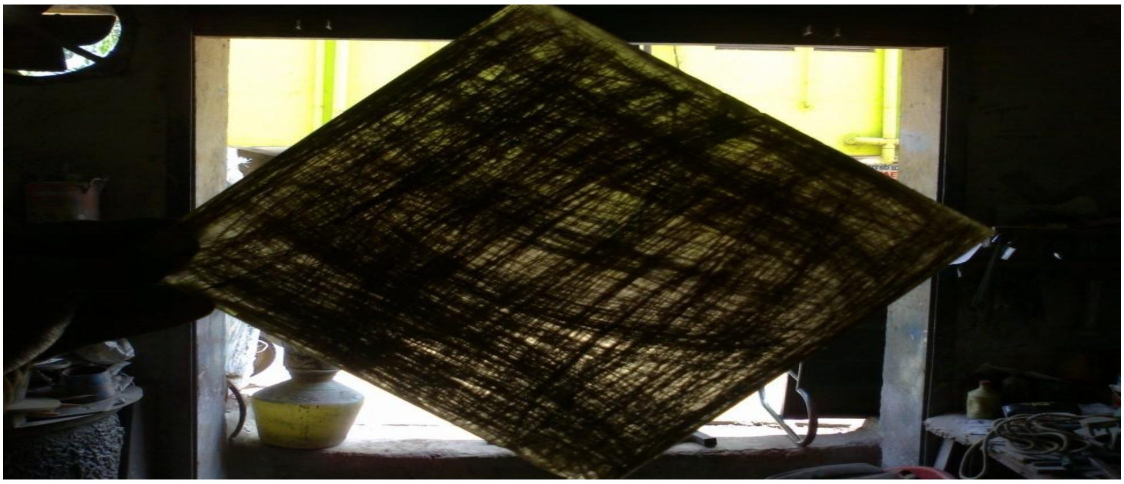

Figure.4. Fabricated Composite Specimen

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VI TESTING OF MECHANICAL PROPERTIES

A. TENSILE STRENGTH

The tensile test is generally performed on flat type specimens .The most commonly used specimen geometries are the dog-bone specimen and straight-sided specimen with end tabs. A uni-axial load is applied through the Gripping ends. The ASTM standard test recommends that the specimens with fibers parallel to the loading direction should be the wide of 11.5 mm. The tensile test specimen size in this work is 150mm x 20 mm x 3mmThe tensile tests are conducted for the coir fiber weight percentage of 15, 30 and 45 with orientation 0,45,90 in composites. The tensile tests are performed on the prepared composite samples as per the ASTM D 638 using UTN 40(SR NO : 11/98 – 2450) model, FIE make Universal Testing Machine shown in Figure 1.4 and one set of tested specimens are shown in Figure 6.

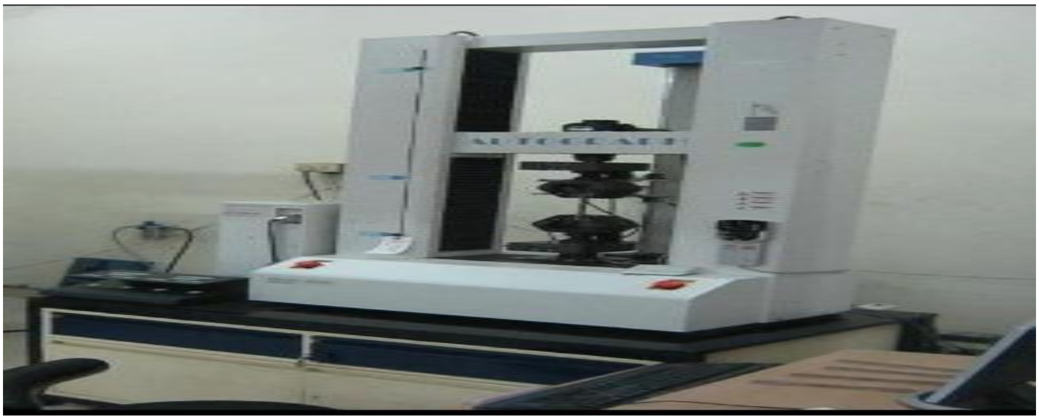

Figure.5.Loading of Specimen in UTN 40 Models UTM

Figure.6.Tensile Test Specimen

B. FLEXURAL TEST:

Flexural strength is defined as a materials‟s ability to resist deformation under load. The short beam shear (SBS) tests are performed on the composites samples to evaluate the value of inter-laminar shear strength (ILSS). It is a 3-point bend test, which generally promotes failure by inter-laminar shear. This test is conductedas per ASTM standard using UTM. The loading arrangement is shown in figure 8

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Figure.7.Flexural testing machine

Figure.8.Flexural Test Specimen

C. IMPACT STRENGTH

Impact test was done in Charpy Impact test bed. The v- notched specimen for impact test was 10cm X 1.5cm X 0.3cm thick. The specimen was placed horizontally in the test bed. The pendulum was lifted and made to hit the specimen from the standard height. Fig.10. depicts failed specimen of the impact test. It was observed that the adhesion between coir and polyester matrix was poor. Adhesion at fibre-matrix interface can be improved by chemical modification (sodium hydroxide treatment - mercirization) of the fibres 38 which reduces their hydrophilic nature . This makes them more porous leading to a rough surface texture. Consequently the fibres become thin and the surface becomes active that allows the coir fibres to reinforce strongly with polyester matrix .

Figure.10.Impact testing machine

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Figure.11.Impact Test Specimen

VII . EXPERIMENTAL RESULT OF COIR-ROYSTENIAREGIA EPOXY MECHANICAL PROPERTIES

The results of coir-roysteniaregia epoxy mechanical properties are shown in Table 1.

Run	Fiber weight	Fiber orientation (degree)	Fiber orientation (%)	Tensile strength (MPa)	Flexural strength (Mpa)	Impact strength (Mpa)
1	15	90	45	16.11	20.21	93.3
2	15	0	90	19.33	21.75	93.4
3	15	0	45	20.2	23.45	96.8
4	30	90	45	23.5	23.29	106.5
5	30	0	90	31.90	22.44	102.5
6	30	0	45	23.5	24.29	101.5
7	45	0	90	32.91	22.44	102.5
8	45	90	45	18.45	19.29	92.1
9	45	0	45	20.48	19.23	91.9

Table:1.The results of coir-roysteniaregia epoxy mechanical properties

VIII CONCLUSION

The mechanical properties of untreated coir-roysteniaregiafiber reinforced epoxy composites were evaluated as per ASTM standard in this investigation.

The following observations were made in evaluation of mechanical properties of untreated coir fiber reinforced epoxy composites.

- The untreated coir-roysteniaregia fiber-reinforced epoxy composites exhibited the maximum value of tensile strength of 32.91 MPa for the conditions of Fiber loading of 45% and fiber orientation of 90 degree,45degree)
- The untreated coir-roysteniaregiafiber reinforced composites exhibited the maximum value of flexural strength of 24.29 Mpa
- The untreated coir-roysteniaregiafiber reinforced composites exhibited the maximum value of impact strength of 106.5 Mpa

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