Experimental Investigation of Mechanical Properties of UNI Directional Jute and Banana Fiber Composites

Satish Pujari, A. Ramakrishna, K.T Balaram Padal

ABSTRACT- Natural fibers came into exposure from the research community like never before in the history, due to the number of advantages over traditional synthetic fibers, like low cost, low density, high specific strength and modulus, easy availability, renewability and much lower energy requirement for processing. This research deals about the mechanical properties of composites like Jute and Banana as reinforcing materials in epoxy resin based polymer matrix, for making partially green biodegradable material composite via hand lay-up technique. Jute is a rain fed crop, the fibers are extracted by retting. Banana fiber can be obtained easily from the plants, which are rendered as waste after the fruits have ripened. These fibers are exposed to NaOH treatment before reinforcement. The reinforcing of the resin with Jute and Banana fiber accomplished in four different orientations: 0°, 15°, 30° and 45° with reference to horizontal side of the sheet by employing optimized resin. Mechanical properties (Tensile, Impact) of both Jute fiber composites and Banana fiber composites were investigated as a function of fiber orientation. Results showed that the composite properties are strongly influenced by test direction and fabric characteristics. Comparatively, Composites tested along the Jute fabric 0° orientation obtained best overall mechanical properties.

Keywords: Mechanical Properties of Jute fibers, Mechanical Properties of Banana fibers, tensile properties of fibers, Impact properties of fibers, Fiber orientation

I. INTRODUCTION

There has been a growing pursuit for fibers from environmentally friendly, low cost, biodegradable and renewable resources in the recent years, whose feasibility in suiting their properties to a particular application can result in an easily tailored composite material. Fibers woven with natural fabrics partially fulfill those requirements and are finding ever increasing applications as reinforcement to polymer composites, especially in the furniture and automotive industries, due to additional advantages such as, their high strength to weight ratios, Drapability on multiple curved surfaces, and improved impact and tensile strengths to finished products, as well as cost reduction because of the partial replacement of the resin [1], [2]. The structure of fibers, cellulose content, angle of fibrils, cross section, and by the degree of polymerization, the physical properties of natural fibers and their physical and chemical composition are determined [3]. Natural fibers are hence considered as serious alternative to synthetic fibers for use in various fields [4], [5].

Manuscript Received on May 14, 2015.
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Positive environmental benefits can be built with respect to the ultimate disposability and best utilization of raw materials, by using the natural fibers as reinforcing materials in both thermo plastics and thermo set matrix composites [5], [6]. Studies on use of lignocelluloses bio fibers in place of synthetic fibers as reinforcing materials are currently being pursued vigorously [7], [8]. For the production of cost effective eco-friendly bio composites these bio fibers are extensively used [1], [9]. It has been observed that natural fiber reinforced composites have properties similar to traditional synthetic fiber reinforced composites. It is a globally accepted fact that natural fiber reinforced composites possesses relatively good mechanical properties and their inherent variability, poor wet ability and adhesion with many polymer matrices lead to composites whose properties are low if compared to synthetic fiber composites. However its drawbacks can be solved either by a combination of reinforcements, i.e., hybridization and/ or by physical and chemical treatments of the fibers as reported in literature. [2], [10]. As a function of fabric orientation, the present work displays the mechanical properties of epoxy composites reinforced with Jute and Banana. The effect of alkali treatments (1%, 3% and 5%) of bagasse fibers on the tensile strength was examined using a treated fiber (65%) composite. The tensile strength of the alkali treated fiber composites at 20% fiber content was 18.6 Mpa against 16.5 Mpa for the untreated fiber composites. For alkali treated bagasse fiber composites tensile strength at fiber 65 wt% is 26.77 Mpa which is higher than untreated fiber [11]. Nowadays, there is an increasing trend for the use of natural fibers as a result of government legislation on environmental issues. This is particularly important in those countries where products from agricultural sources offer an attractive and cheap alternative for developing degradable materials [12]. However their potential use as reinforcement is greatly reduced because of their hydrophilic nature [13], and lack of sufficient adhesion between untreated fibers and the polymer matrix resulting in poor impact resistance of the products. The issue of poor interfacial adhesion between fibers and matrix material is due to a mismatch in surface polarities - cellulose and polyolefins. These have been addressed by the development of effective surface treatments [7] for the fibers in both physical and chemical treatments.

Numerous researchers have exploited the reinforcement potential of kenaf, flax, hemp and Jute for developing thermoplastic and thermo set composites using several different techniques. These composites have been successful in semi structural as well as structural applications [14]-[16]. Previous studies have shown that with appropriate surface treatments the mechanical properties can be improved [17], [18]. Alkali treatments have been proven effective in removing impurities from the fiber, decreasing moisture absorption and enabling

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mechanical bonding and thereby improving matrix reinforcement interaction [19]. Mechanical properties of polymer composites depend on the fiber content, filler, compatibilizer, fiber orientation, and mode of testing [13]. Ranging from appliances to space crafts, Fiber reinforced polymers have better specific properties compared to the conventional materials and find applications in diverse fields. Many academic and industrial research activities are going to develop better fiber matrix adhesion characteristics of the composites by using different chemical treatment, orientation of fibers and manufacturing methods. The properties of fiber reinforced plastic composites depend on the fiber length, volume of the fiber content, fiber distribution and orientation. By controlling factors such as aspect ratio, the dispersion and orientation of fibers, considerable improvements in composite properties can be accomplished [19], [20].

II. EXPERIMENTAL

A. Materials

Local industries in Visakhapatnam, India supplied Jute and Banana fibers. These Collected fibers were treated with alkali and later process of neutralization was done by treating the fiber with 5% acetic acid solution, which is treated as raw sample in this study. Epoxy resin (Araldite LY 556) made by CIBA GUGYE Limited. Was used as matrix and its curing characteristics were enhanced by the use of 2% of hardener 0.5% of Accelerator. Hardener (araldite) HY 951 is used.

B. Alkali Treatment

The Jute and Banana fibers were cut to 60cm in length and were soaked in a 5% of NaOH solution separately at 30°C for 4 hours. The fibers were then washed several times with distilled water, neutralized with dilute acetic acid and washed again with distilled water to remove any NaOH sticking to the fiber surface. Final PH maintained was 7. The fibers were then dried at room temperature for 48h, followed by oven drying at 100°C for 6h for the removal of moisture content.

C. Composite Fabrication

Epoxy resin LY 556 was used to prepare the matrix materials, hardener and accelerator in a weight ratio of 1:0.02:0.005 respectively. The rows are layered by hand layup technique in parallel rows i.e. making an angle of 0°,15°,30°,45° with the reference horizontal side of the sheet respectively as shown in Fig:1. Placing one over the other in the mould each layer of the fiber was pre-impregnated with matrix materials, taken care to maintain practically achievable tolerances on fiber alignment. During curing at room temperature for minimum of 24 hours and post curing by oven heating at 60° for 8 hours both, to avoid the leakage of matrix material and to allow hot air to escape, arrangements were made by keeping the two opposite ends open. Similarly, any number of fiber layers can be layered as per required thickness for Jute and Banana fibers separately. Preparation of the composite with 39% of the weight fraction of fiber was maintained constant for all the specimens.

D. Tensile test specimen

Alkali treated Jute fiber reinforced epoxy composite and Banana fiber reinforced epoxy composite specimens of size 250 mm length X 25.4 mm of width X 4mm thickness as per ASTM D3039 standard were prepared in 0°,15°,30°,45° orientations. These specimens were tested by Electronic Universal Testing machine of model UTE-40 of Maximum Capacity 400KN supplied by Fuel Instruments & Engineers Pvt. Ltd.

E. Impact test specimen

Alkali treated Jute fiber reinforced epoxy composite and Banana fiber reinforced epoxy composite specimens of size 75 mm length, 10 mm width and 10 mm thickness as per ASTM D256 standard were prepared in 0°,15°,30°,45° orientations. These specimens were tested by Pendulum Impact testing machine of model IT-30 with maximum impact energy of pendulum 168 joules supplied by Fuel Instruments & Engineers Pvt.Ltd.

III. RESULTS & DISCUSSIONS

Static mechanical properties of fiber reinforced composites depend on the nature of the polymer matrix, distribution and orientation of the reinforcing fibers.

A. Tensile Strength

One of the most important and widely measured properties of materials used in structural applications is the ability of the material to resist breaking under tensile stress. The force per unit area (MPa) required to break a material in such a manner is the ultimate tensile strength or tensile strength at break.

Stress-strain curves for Jute fiber composite are as shown in Fig. 2 and for Banana fiber composites are as shown in Fig. 3 for different angle of orientations of the fibers. The figures indicate that as both stress and strain increases continuously till the break and no yield occurs, which indicates the materials are brittle in nature. The effect of different fabric angles on the tensile strength and percentage of elongation of the Jute fiber composites are as shown in Table I and Banana fiber composites are as shown in Table II. Results show that tensile properties are strongly dependent upon the fiber orientation. Jute at 0° orientation shows maximum tensile strength and Jute 45° fiber orientation shows least elongation at break compared to that of all other angles of orientations of Jute and Banana fiber composites. The comparison of tensile strength of Jute and Banana fiber composite are as shown in Fig. 4, and percentage of elongation are as shown in Fig. 5. The figures show from 0° to 45° orientation both Jute and Banana fiber composites follow same trend.

B. Impact Strength

There are many cases in which composite design can be optimized in terms of stiffness and strength alone, which can produce a material that is cannot support impact loading. Therefore an understanding of impact behavior is necessary, suitably to design composite material. Izod impact test was used to measure the impact strength, which may be defined as toughness or ability of material to absorb energy during plastic deformation. Impact strength of composite depends on the amount of fiber, type of testing and orientation of fiber. Results of notched Izod impact testing of Jute fiber composites are presented in Table III and for Banana fiber composites are shown in Table IV. Jute fiber composites along fiber orientation of 0° having maximum impact energy, Jute 45° orientation and Banana 30° fiber orientation

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have least impact energy compared to the remaining orientations of Jute and Banana fiber composites. The comparison of Izod impact energy properties of both Jute and Banana reinforced epoxy composites is plotted in Fig. 6, which shows both the curves followed same trend from 0° to 15° orientation. The Jute fiber composites have constant value of impact energy for 15° and 30° fiber orientations. But for Banana the trend is in decreasing order once again from 15° to 30°. After 30° the Jute fiber composite impact energy again decreases till 45°. But for Banana fiber the trend is reverse i.e. increases from 30° to 45°. Hence the impact strength is very sensitive to fiber orientation.

Fig. 1 – Preparation of unidirectional Jute and Banana fiber composites

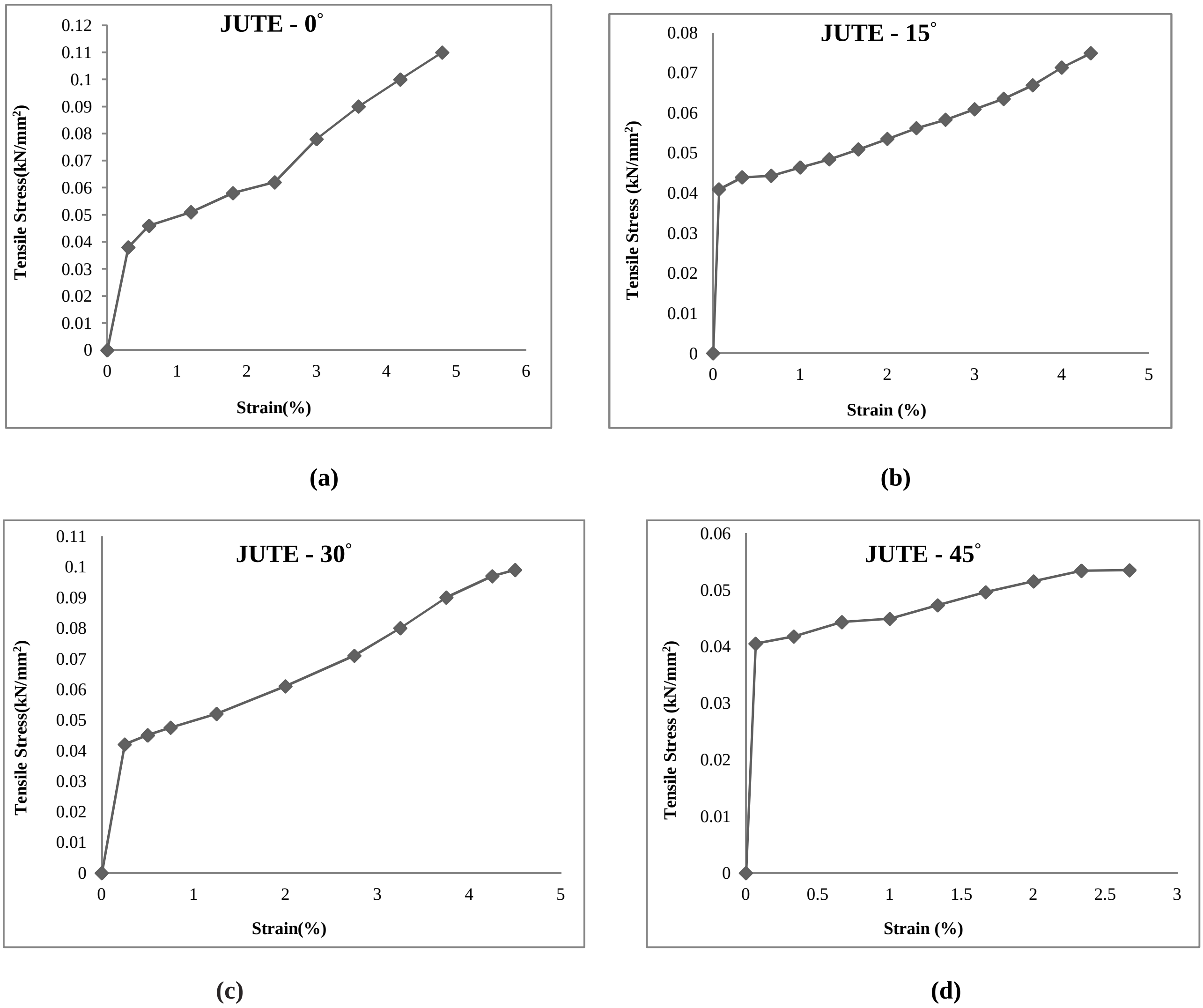

Fig. 2 – Tensile stress – Strain Curves of the composites reinforced with Jute fabric when tested at (a) 0° (b) 15° (c) 30° (d) 45°

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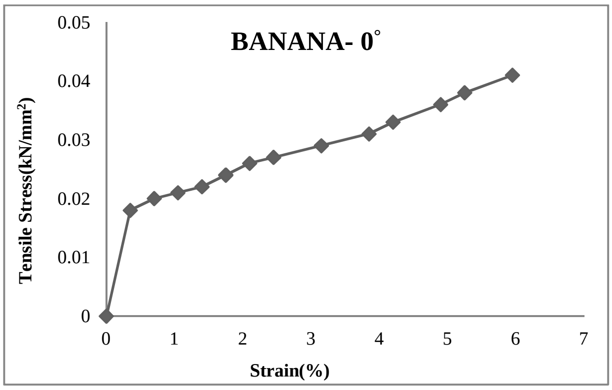
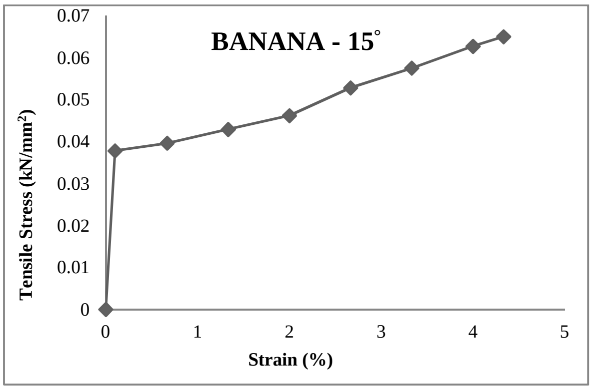
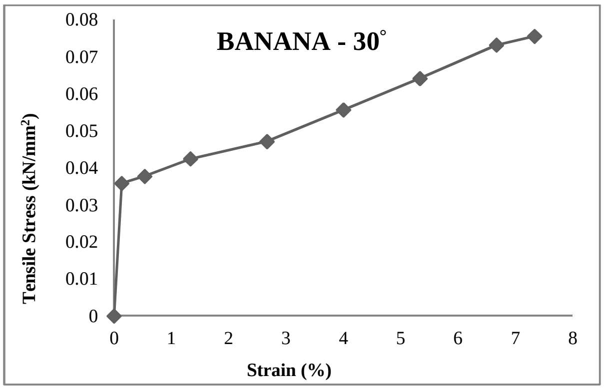
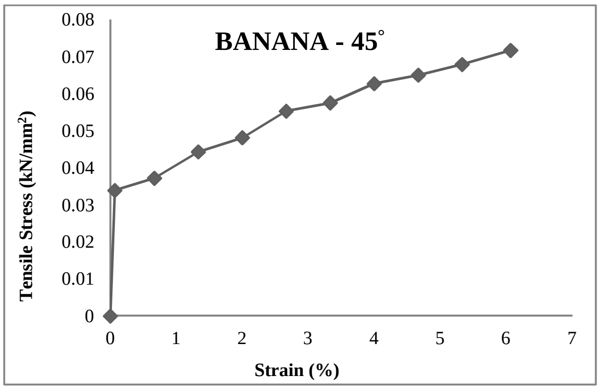




(a) (b)





(c) (d)

Fig. 3 –Tensile stress – Strain Curves of the composites reinforced with Banana fabric when tested at (a) 0˚ (b) 15 (c) 30˚ (d) 45˚

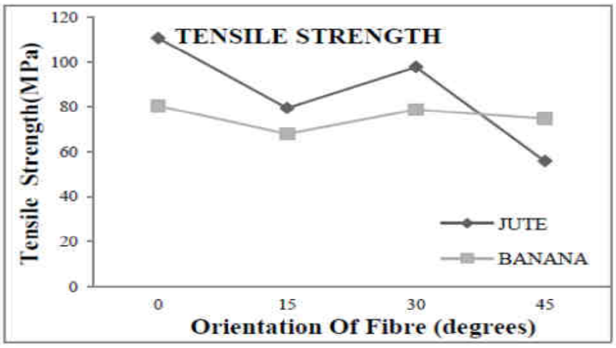


Fig. 4 – Effect of Test angle on Tensile strength of Jute and Banana composite

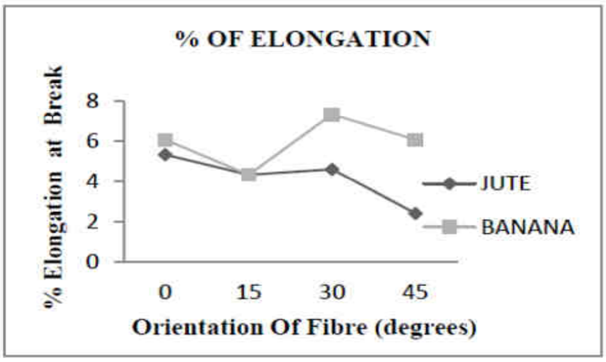


Fig. 5 – Effect of Test angle on % Elongation of Jute and Banana composite

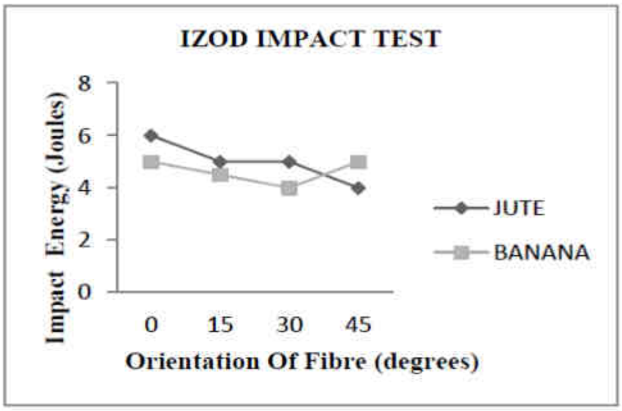


Fig. 6 – Effect of Test angle on Impact strength of Jute and Banana fiber composite

Table I: Tensile Properties of Jute fiber reinforced epoxy composite

Angle of orientation (degrees)	Tensile strength (Mpa)	Elongation at break (%)
0	110.8	5.33
15	79.5	4.33
30	97.8	4.6
45	55.9	2.4

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Table II: Tensile Properties of Banana fiber reinforced epoxy composite

Angle of orientation (degrees)	Tensile strength (Mpa)	Elongation at break (%)
0	80.5	6.067
15	67.9	4.33
30	78.83	7.33
45	74.8	6.06

Table III: Impact energy values of Jute fiber reinforced epoxy composite

Angle of orientation (degrees)	Izod impact test (joules)
0	6
15	5
30	5
45	4

Table IV: Impact energy values of Banana fiber reinforced epoxy composite

Angle of orientation (degrees)	Izod impact test (joules)
0	5
15	4.5
30	4
45	5

IV. CONCLUSIONS

Mechanical properties of Epoxy LY556 resin reinforced with Jute and Banana fibers are strongly dependent upon fiber orientation, adhesion and fabric characteristics. The best overall mechanical properties were found for composites tested along Jute 0° fiber orientations and least percentage of elongation found for composite tested along Jute 45° fiber orientation. Mechanical properties of these composites changes with change of fiber orientation. From these results we can conclude that Jute was found to promote a higher reinforcing effect compared to that of Banana fiber.

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