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Tensile and Flexural properties of Jute, Pineapple leaf and Glass Fiber Reinforced Polymer Matrix Hybrid Composites

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Abstract

An experimental study has been carried out to investigate the tensile and flexural characterization of polymer hybrid composites made by reinforcing Jute, Pineapple leaf fiber and Glass fiber as 1:1:1 ratio into a epoxy resin. The fiber content in the composite was varied from 0.18 to 0.42 by volume fraction and the variation of mechanical properties such as tensile and flexural properties in each case were studied. The tensile strength increased with increase in fiber content. Further, the Flexural strength of the composite increased with increase in fiber content.

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1. Introduction

A fiber reinforced polymer (FRP) is a composite material consisting of a polymer matrix imbedded with high-strength fibers, such as glass, aramid and carbon [1]. Generally, polymer can be classified into two classes, thermoplastics and thermosetting. Thermoplastic materials currently dominate, as matrices for biofibers; the most

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commonly used thermoplastics for this purpose are polypropylene (PP), polyethylene, and poly vinyl chloride (PVC); while phenolic, epoxy and polyester resins are the most commonly used thermosetting matrices [2].

The natural fibers employed in this study are made of jute and were derived from Amazon region. Particularly, they were extracted from the steam of the plant Corchorus capsularis by a combination of processes comprising various steps, such as cutting, retting, shredding, drying, packing and classification [3].

Nowadays, the development of natural fiber reinforced composites is one of the high attractive research fields. Jute performs relatively better properties among the other natural fibers like banana, cotton, coir, sisal, etc., due to the inexpensive and commercial availability in a required form. It can also be substituted for conventional fibers in many applications and has been applied as reinforcement to eco-composites and bio-composites [4].

Despite the attractiveness of natural fiber reinforced polymer matrix composites, they suffer from lower modulus, lower strength, and relatively poor moisture resistance compared to synthetic fiber reinforced composites such as glass fiber reinforced plastics (GFRP). Natural fiber reinforced polymer matrix composites are very sensitive to influences from environmental agents such as water. Data on the effects of moisture on retention of mechanical properties of natural fiber reinforced composites during long-term service are crucial for them to be utilized in outdoor applications. However, only a few studies that dealt with durability issues for natural fiber reinforced composites are currently available [5]. Pineapple leaf fiber (PALF) which is rich in cellulose, relatively inexpensive, and abundantly available has the potential for polymer reinforcement [6].

Among various natural fibers, pineapple leaf fibers (PALFs) exhibit excellent mechanical properties. These fibers are multicellular and lignocellulosic. They are extracted from the leaves of the plant Ananus cosomus belonging to the Bromeliaceous family by retting [7]. The superior mechanical properties of pineapple fiber are associated with its high cellulose content and comparatively low microfibrillar angle. Among matrix resins, unsaturated polyesters have been commonly used for making thermoset composites, especially with glass fibers [8]. Tensile, flexural strengths and elastic moduli of the unidirectional kenaf/PLA composites increased linearly up to fiber content of 50% [9]. The tensile properties of sisal, hemp, coir, kenaf, and jute reinforced composites have been increased with increase of fiber volume fraction [10].

The objective of this research work is to study the mechanical properties of jute, Pineapple leaf and Glass fibers by incorporating them into epoxy resin matrix to prepare the composites at various volume fractions of fiber. The composites were tested and characterized to evaluate the tensile and flexural properties.

Nomenclature

FRP	Fiber Reinforced Plastics
GFRP	Glass Fiber Reinforced Plastics
PALF	Pineapple leaf fiber

2. Experimental Procedures

2.1 Materials

General purpose epoxy resin, methyl ethyl ketone peroxide and cobalt naphthenate were purchased from Subh Resins & Fuels Pvt Ltd, Hyderabad. Jute, Pineapple leaf and Glass Fibers were obtained from Agro World Bio Fibres, Kakinada, Andhra Pradesh, India and shown in figure 1.

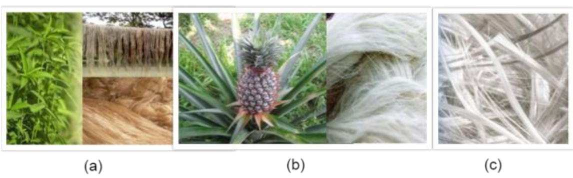


Fig. 1. (a) Jute fibe; (b) Pineapple leaf fiber; (c) Glass fiber.

2.2 Fabrication of composites

Polymer Hybrid Composites were prepared, using epoxy matrix to assess the reinforcing capacity of Jute, Pineapple leaf and Glass Fibers. These fibers were considered 1:1:1 by ratio at each volume fraction of a composite. The quantity of accelerator and catalyst added to resin at room temperature for curing was 1.5% by volume of resin each. Hand lay-up method was adopted to fill up the prepared mould with an appropriate amount of epoxy resin mixture and Jute, Pineapple leaf and Glass fibers, starting and ending with layers of resin. Fiber deformation and movement should be minimized to yield good quality, fiber reinforced hybrid composites. Therefore at the time of curing, a compressive pressure of 0.05 MPa was applied on the mould and the composite specimens were cured for 24 h. The specimens were also post cured at 70˚C for 2 h after removing from the mould. The specimens were prepared with five different percentage volumes of Jute, Pineapple leaf and Glass Fibers.

2.3 Tensile test

The tensile behaviour of the Jute, Pineapple leaf and Glass Fiber Reinforced hybrid composites were prepared as per the standard ASTM D 638M. The composite specimens with 165 mm long 12.7 mm wide and 3 min thick were prepared. The specimens were tested at a cross-head speed of 2.5 mm/min, using a Tensile testing machine supplied by Associated Scientific Engg. Works, New Delhi

2.4 Flexural test

Three point bend tests were performed in accordance with ASTM D 790M to measure flexural properties. The specimens were 125 mm long, 12.7 mm wide and 3 mm thick. In three point bending test, the outer rollers were 64 mm apart and samples were tested at a strain rate of 0.2 mm/min. A three point bend test was chosen because it requires less material for each test and eliminates the need to accurately determine center point deflections with test equipment. The specimens were tested using the same testing machine mentioned above at same crosshead speed. Flexural strength (σ) of the composite was calculated using the following relationship:

$$\sigma = 3PL/2bt^2$$

Where L is the support span (64mm): b, the width: t, the thickness; P, the maximum load.

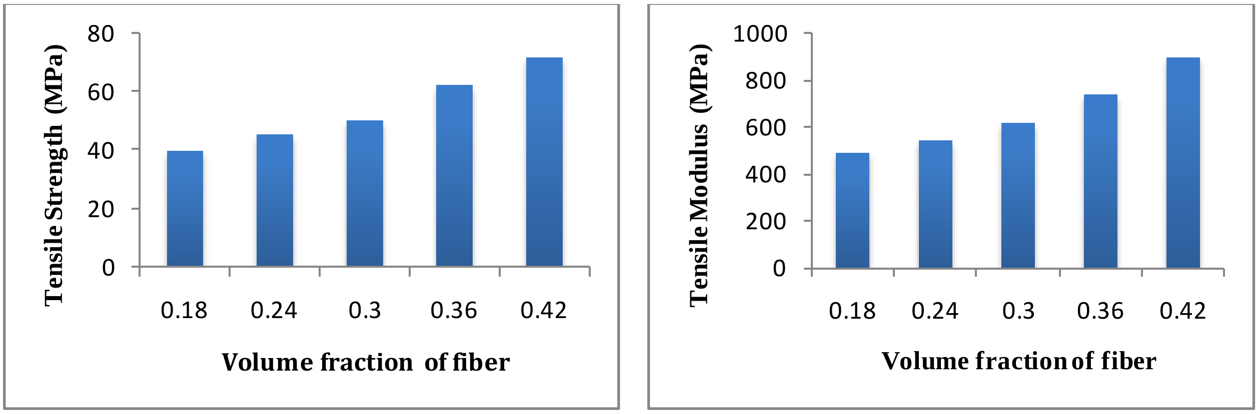
3. Results and Discussion:

3.1 Physical properties

The density of the Jute, Glass and Pineapple leaf Fiber was found to be 1.46, 2.55 and 1.52g/cm3 [10-11] respectively.

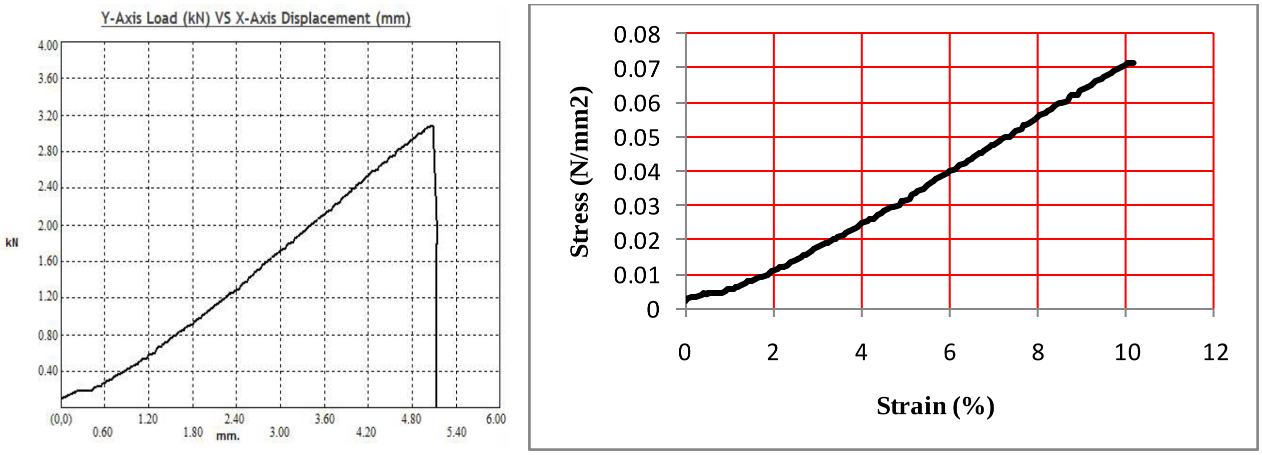
3.2 Tensile and Flexural Properties

The variation of mean tensile strength and tensile modules with varying fiber content is presented in Figure 2. It was clearly evident that with increasing the fiber content in the epoxy matrix, the tensile strength is also increasing. This is due to the fact that the epoxy resin transmits and distributes the applied stress to the Jute, Pineapple leaf fiber and Glass fiber resulting in higher strength. The percentage increment in tensile strength of the composites at the maximum fiber content (0.42 volume fraction of fiber) is found to be 71.66MPa. The tensile strength as well as tensile modulus of composite considered in this study is far better than that of other fiber reinforced composites [12-13]. The tensile modulus also increases as the volume fraction of fibre increases in the composites (Figure 2). The tensile test report of the composite at volume fraction (0.42) of fiber is shown in Figure 3.



(a) (b)

Fig. 2. Variation of (a) tensile strength (b) tensile modulus of composite with volume fraction of fibre.



(a) (b)

Fig. 3. (a) Load - Displacement curve (b) Stress - Strain curve of composite at volume fraction (0.42) of fiber.

The flexural behavior of Jute, Pineapple leaf fiber and Glass fiber reinforced hybrid composites is presented in Figure 4. These plots exhibit the similar trend observed for tensile properties and same cause is attributed as stated above. The flexural strength of the composite at maximum fiber content is about 239.37MPa.

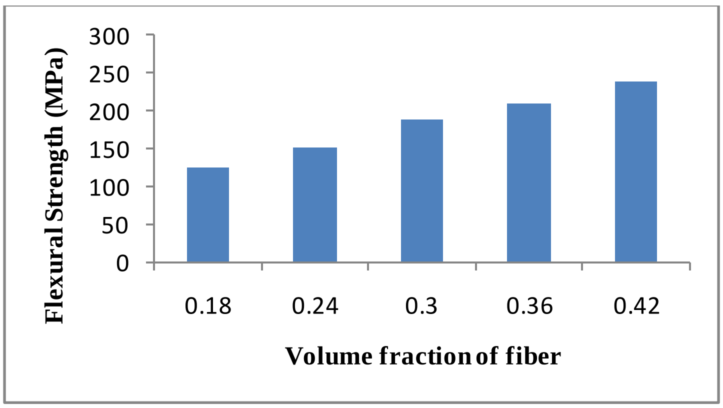


Fig. 4. Variation of flexural strength of composite with volume fraction of fibre.

4. Conclusions

In this work, Jute, Pineapple leaf fiber and Glass fiber reinforced hybrid composites were prepared. The tensile and flexural properties of the composites with these fibers were found to be increased with fiber content, conforming the reinforcing action of the fibers. Thus the composites of Jute, Pineapple leaf fiber and Glass fiber epoxy composites were found to be light in weight, possessed better mechanical properties. Hence these composite materials can be used for applications such as automobile parts, electronic packages, building construction etc.

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