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EXPERIMENTAL INVESTIGATION ON TENSILE AND FLEXURAL PROPERTIES OF KENAF/PINEAPPLE HYBRID NATURAL FIBER COMPOSITES

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Abstract

The natural fiber composite fabrication has been a highly preferred field of research due to its unique properties like low mass density, stiffness, light in weight, low budget, easy obtainability and exceptional mechanical properties. These properties had found many applications in aircraft, space, automotive, sporting goods etc. The natural hybrid composites are the centre of attention for researchers as it serves in various engineering applications as asubstitute to commonly used synthetic fiber composites. The motive of this project is to study and enquire the tensile and flexural properties of Kenaf/Pineapple natural hybrid fiber with reinforced epoxy resin experimentally. The mechanical properties of Kenaf fiber are enhanced by incorporating the kenaf fiber with pineapple fiber. These hybridisations of fibres are made at different weight fractions and are incorporated with the mixture of resin epoxy LY556 and hardener HY951 by hand layup techniques. ASTM (American Society for Testing and Materials) standards were strictly followed for the preparation and testing of the tensile and flexural test specimens.

Keywords: *Composite, Kenaf fiber, Pineapple fiber, tensile properties, epoxy resin.*

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1. INTRODUCTION

Composites are flexible and practical materials that can be a solution to problems of various applications with a possibility of introducing new properties to the materials. Nowadays, there is a booming involvement in discovering new applications of natural fiber reinforced composites. Natural fibers seem to be the best materials which come as the feasible and suitable replacement for non renewable synthetic fiber. Natural fibers are highly preferred for use in composite materials since it has characteristics such as light in weight, less cost, high specific strength, high specific modulus, easy and safe to handle, eco-friendly, availability, easy to make, non-toxic nature. Natural composite fibers are studied mainly due to its eco-friendly character and unique properties such as ease of separation, improved energy recovery, carbon dioxide neutrality, ease of recycling.

Among the available natural fibers, Pineapple leaf fibers (PALF) possess exceptional mechanical properties. The leaves of the plant *Ananus cosmos*are the source of the PALF. They are composed of cellulose (70–82%), lignin (5–12%) and ash (1.1%). The high cellulose content with comparatively low micro-fibrillar angle of PALF is the major reasons for the exceptional mechanical properties of the fibers.

Another natural fiber, Kenaf performs relatively better among the rice straw fiber, bagasse, stramineous fiber, cocos fiber, hemp, flax, banana, cotton, coir, sisal, etc., due to the inexpensive and commercial availability of the fiber in a required form. Kenaf grows in warm season and it is used to make cordages, twine and sackcloth.Commonly used synthetic fibers can be replaced with the kenaf fibers in various applications, kenaf grows at a quicker rate compared to other natural fibers. The kenaf consists of 35-40% bast fiber and 60-65% core fibers by weight of the kenaf's stalk. Kenaf contains approximately 65.7% cellulose, 21.6% lignin and pectin and other composition. Therefore, kenaf composites may shows excellent mechanical properties and could be a best possible solution for wood substitution.

Many researches and studies have been conducted to study the mechanical, thermal and physical characteristics of kenaf and pineapple fiber reinforced composites. Different matrix materials were used in different research. Among the various researches, the normally used matrixes are polyester resin, natural rubber, polypropylene, polyethylene, polycarbonate, epoxy resin, phenol formaldehyde.

It has been determined that the different property of kenaf and pineapple composites varies randomly; and it depends mainly on environmental origin of fibers, growth atmosphere and processing methods.

In this study, the kenaf and pineapple fiber composites reinforced with polyester resin have been examined experimentally and the mechanical properties such as the tensile strength, flexural strength, stress-strain relations were evaluated.

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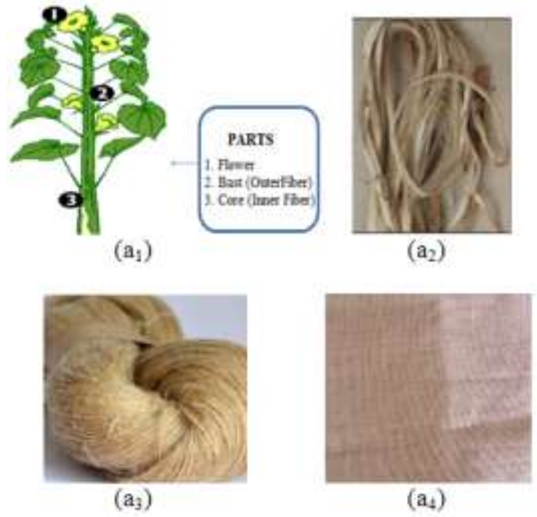

Figure 1. (a1) Kenaf Plant, (a2) Kenaf Fiber, (a3) Kenaf Yarn, (a4) Kenaf Fabric.

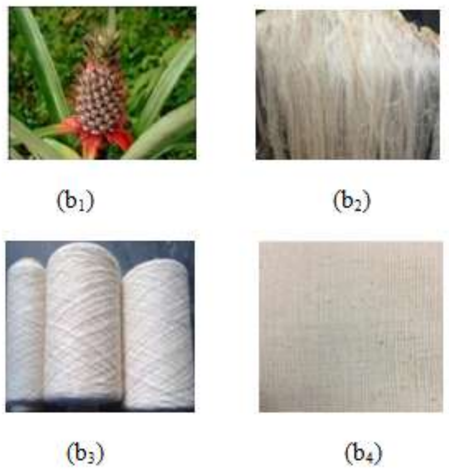

Figure 2. (b1). Pineapple Plant, (b2). Pineapple Fiber, (b3). Pineapple Yarn, (b4). Pineapple Fabric

2. MATERIALS

2.1 Fibers

Kenaf fiber is extracted from the stem part of Kenaf plant from the family Hibiscus cannabinus. Pineapple is lignocelluloses and multi-cellular material extracted from the leaf of plant Ananas cosomus of the family Bromeliaceous. The fiber is extracted by hand scraping after beating the leaves to break up the pulpy tissue. But here the fibers are purchased as bi-directional mat form.

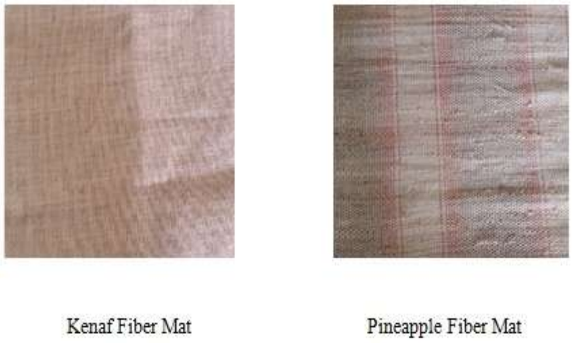

Fig 3: Fibers as Mat/Fabric form

2.2 Extraction of Fibers

The obtained fibers are cleaned with water and dried. Then the fibers are parted with hands patiently. Pineapple and Kenaf fibers are drenched in water and then crushed with a hammer. And finally, the fibers are removed out from the husks and comb. After drying the fibers under the normal room temperature, the fibers are parted further into individual states by combing the fibers with cotton carding frame for several times. Then weight and length of the fibers are measured.

2.3 Weight Fraction of the Fiber

The specific weight fraction of fibers was determined by evaluating the weight of the matrix taken. The matrix's weight was estimated by multiplying the density and volume of the matrix taken. In case of the hybrid combination, the specific weight fraction of fibers is shared between the kenaf and pineapple fibers.

2.4 Preparation of Epoxy and Hardener

The composite plates were prepared using a combination of epoxy LY556 and hardener HY951 at a weight ratio of 10:1. This mixture possesses a viscosity of 10-20 poise at a temperature of 25ºC.

2.5 Mould Preparation

Mould made of synthetic rubber of dimensions 300mm x 300mm x 4mm with four beadings is prepared. Hand layup method is employed throughout the preparation. The fiber mats are made at a size of 300mm x 300mm dimensions. The upper and lower surfaces of the mould and the side walls are layered with remover and are let to dry. During the curing process, the outer surfaces are covered with glass plates to compress the fibers from top and bottom to keep out the waste materials from entering the composites.

3. MANUFACTRUING METHOD

3.1 Hand Layup Technique

Firstly, the pineapple and kenaffiber fabrics were cut into the required size of 300mm x 300mm. The suitable numbers of fiber fabrics were taken as two or more. Then the fibers

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were weighted and accordingly the resin epoxy LY556 and hardener HY951 were weighted and mixed in a weight ratio of 10:1. Necessary steps were made to avoid the formation of air bubbles in the matrix, because the air bubbles may cause failure in the material. A releasing film and a polymer covering were applied to the sheets. After it was covered with a fiber plies and rolled using cylindrical rod as shown in Fig. 4. In the same manner, the required numbers of fiber layers were added to the composites. Finally, the composites are cured and hardened for a period of 48 hours. Hence the composite plates of size 300mm x 300mm x4mm were prepared as shown in Fig.5 (a) and Fig. 5 (b).

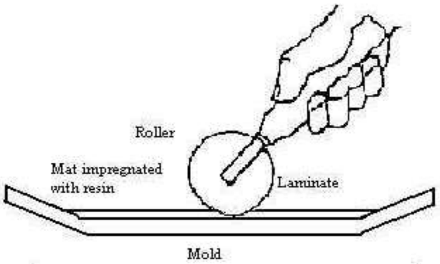


Fig 4: Hand Layup Technique

(a) (b)

Fig 5: (a) Pure Kenaf fiber Composites Plate, (b). Kenaf/Pineapple fiber hybrid Composite Plate.

3.2 Tensile Test Specimen Sampling

Tensile test specimens are cutted with proper dimensions from prepared composites plates as per ASTM D638 standards as shown in fig 6. Thicknesses of samples were evaluated by calculating the average of three readings measured at different points along the sample. Different samples are as mentioned in table1 and shown in fig 7.

Table 1: Sample Identification

Sample Types	Identifications
Pure Kenaf fiber Composites (4.12 mm thickness)	1TA, 1TB
Kenaf/Pineapple fiber Hybrid Composites (4.12 mm thickness)	2TA, 2TB

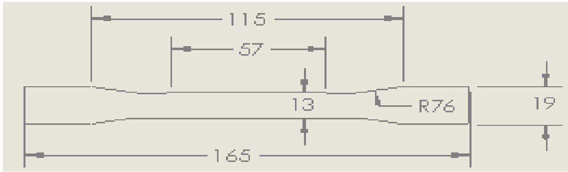
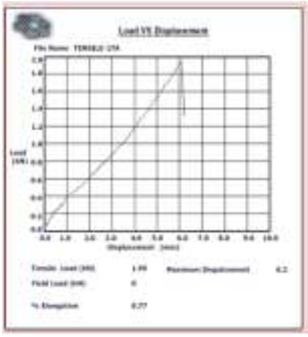


Fig 6: Tensile Test Specimen Diagram as per ASTM D638

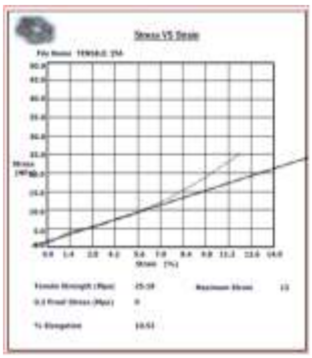
Fig 7: Tensile test specimen

3.3 Graphs



(a) (b)

(c) (d)



(e) (f)

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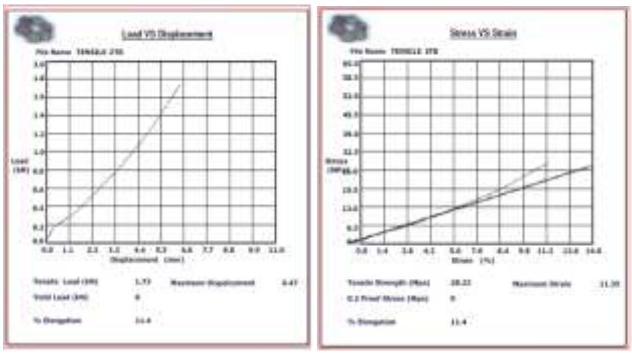


(g) (h)

Fig 8: (a, c, e, g) Load vs Displacement, (b. d, f, h) Stress vs Strain

3.4 Flexural Test

Flexural test specimens (2 pieces from each plate) are cutted with proper dimensions from prepared composites plates as per ASTM D790 standards. Thicknesses of samples were evaluated. The thickness for each specimen was calculated by averaging the thicknesses measured at different points of the specimens. Different samples are identified as mentioned table2.

Table 2: Sample Identification

Sample Types	Identifications
Pure Kenaf fiber composites (4.12 mm thickness)	1FA, 1FB
Kenaf/Pineapple fiber hybrid composites (4.12 mm thickness)	2FA, 2FB

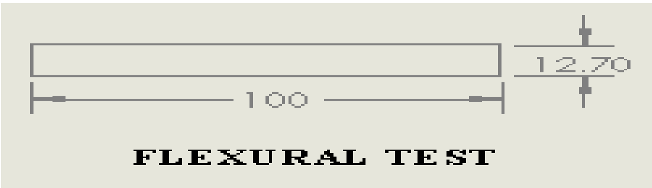
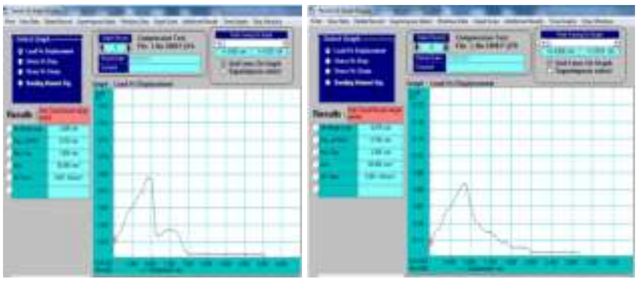
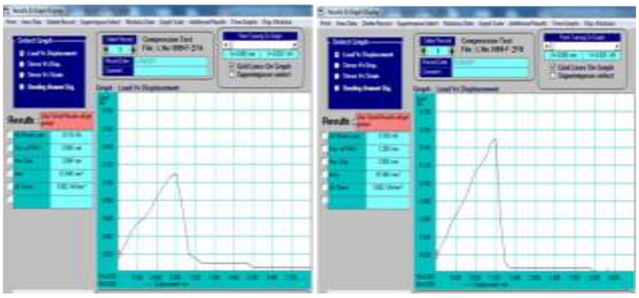


Fig 9: Flexural Test Specimen Diagram as per ASTM D790

Flexural Test Graphs



(i) (ii)



(iii) (iv)

Fig 10: Flexural Test (i, ii, iii, iv) – Load vsDisplacement

4. RESULTS AND DISCUSSION

4.1 Mechanical Properties

4.1.1 Tensile Strength

Fig.11shows the comparison of tensile strength of kenaf and pineapple fiber reinforced composite specimens in MPa. It is clear from the fig.7 (a to h) the tensile strength is increasing for both kenaf and pineapple fiber reinforced composites. Regarding kenaf composite, the tensile strength of sample 1B was increased which compared to the sample 1A (from fig.11).

The fig.11 also concludes that the kenaf fibers composite's tensile strength is higher than the hybrid kenaf/pineapple fiber composite. It is made evident that composite strength mainly depends on fiber loading, fiber strength and interfacial strength between fiber and matrix. Tensile properties of composite give some indirect information about interfacial bonding between fiber and matrix. In average, the result of pure kenaf fiber tensile strength was high.

4.1.2 Flexural Test

It is clear from the fig.9 (i to iv) that the flexural strength is increasing for kenaf and pineapple fiber reinforced composites. Regarding pineapple/kenaf hybrid composite from fig.13, the flexural strength of sample 2FB was high when compared to the sample 2FA. In average, the result of hybridised kenaf/pineapple flexural value was high.

4.1.3 ValueComparison

Table 3: Tensile Strength value comparison

Specimen ID	Specimen Details	Tensile Strength		
		T-A (Mpa)	T-B (Mpa)	Avg (Mpa)
1	Pure Kenaf (0/40)	33.40	37.68	35.54
2	Hybrid Pineapple/Kenaf (20/20)	25.18	28.23	26.70
Best Result	Pure Kenaf Composites			35.54

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Table 4: Flexural Strength value comparison

Specimen ID	Specimen Details	Flexural Test		
		F-A (KN)	F-B (KN)	Avg (KN)
1	Pure Kenaf (0/40)	0.085	0.075	0.08
2	Hybrid Pineapple/Kenaf (20/20)	0.110	0.150	0.13
Best Result	Hybrid Pineapple/Kenaf			0.13

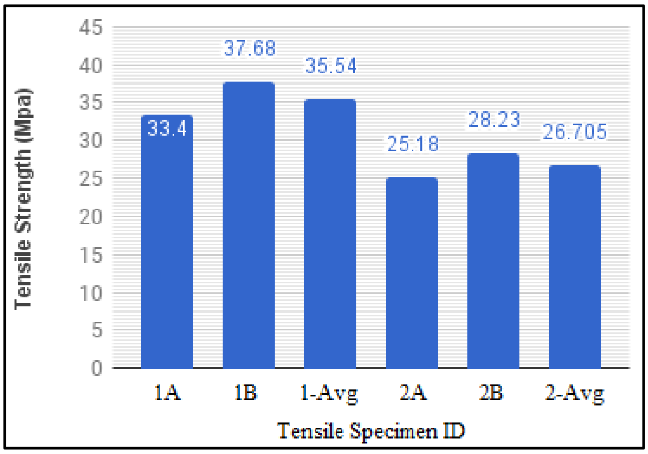

Fig 11: Tensile Strength

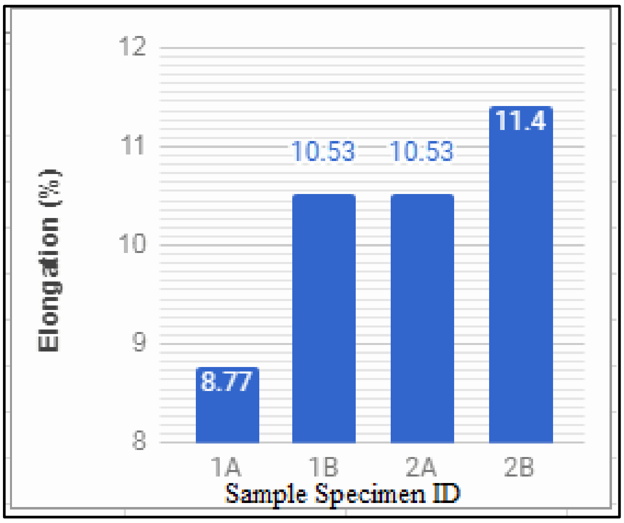

Fig 12: Elongation

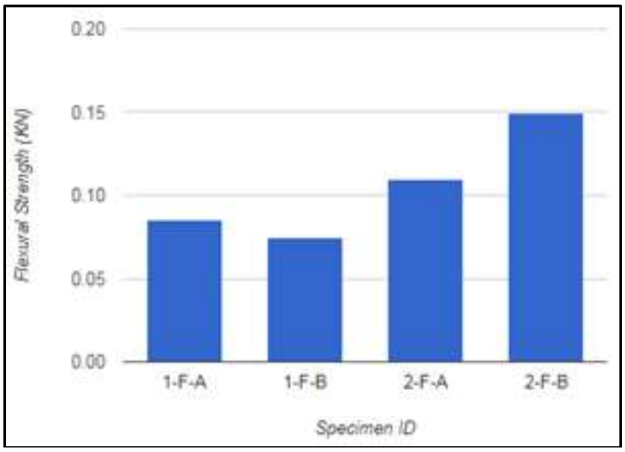

Fig 13: Flexural Test

5. CONCLUSION

In this study, tensile and flexural properties of kenaf and pineapple fabric reinforced composites were analysed and the pure kenaf composite exhibits better tensile strength results than that of the Pineapple/kenaf hybrid fabric reinforced composites. And the flexural strength of Pineapple/kenaf hybrid composites was exhibited better results than that of pure kenaf reinforced composites. The kenaf and pineapple fiber reinforced composites shown nature friendly characteristics. And more researches will be done in the future to enhance the manufacturing and processing of the fibers in a view to extend the scope of kenaf and pineapple fibers in the engineering field.

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