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Characterization and Investigation of Tensile Test on Kenaf Fiber Reinforced Polyester Composite Material

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***Abstract*— This paper constitutes the study of Mechanical Properties like Tensile Strength of 10%, 20%, 30% and 40% KFRPC material used as Bio-material. An attempt is made to develop the 10%, 20% 30% and 40% KFRPC material with low density, economical for tissue implant with respect to biocompatibility and the mechanical behavior of human tissues, such as Tendon, according to the ASTM D-3039 for Tensile test using the polyester resin as the matrix material with the 10%, 20% 30% and 40% of the KFRPC material with fiber weight fraction, random continuous long fiber orientation, by using the Hand Layup fabrication technique the specimens are prepared. The tensile tests are conducted by preparing varying percentage of standard. It is found that there is appreciable improvement in Tensile Properties of 10%, 20%, 30% and 40% KFRPC material. This Study suggests 40% of KFRPC material may be suitable for the different application in the replacement of human tissues. From the Experimental results it is found that by increasing the weight fraction of the fiber or percentage of fiber which will increase the Tensile strength and also increases the density and mass of composite of the specimen.**

This paper is concentrated on study of tensile strength of tendon and compared the experimental results of the 10%, 20% 30% and 40% KFRPC material with the Tendon. This study suggests that the KFRPC material is less cost, low density and high strength biocompatible material and may be suggested for implant, especially for Tendon. From the Experimental results the strengths of 10%, 20%, 30% and 40% KFRPC materials will match the Tendon Strength. Finally 40% KFRPC material can be suggested for Tendon. Further it can be tested for remaining mechanical tendon properties.

***Keywords*— Kenaf Fibre Reinforced Polyester Composite Materials (KFRPC), Tendon, Tensile test and Hand layup Technique.**

I. INTRODUCTION

Beghezan [1] defines as "The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings", in order to obtain improved materials.

A Biomaterial is defined as any systemically, pharmacologically inert substance or combination of substances utilized for implantation within or incorporation with a living system to supplement or replace functions of living tissues or organs. Or "A Biomaterial is a non-viable material used in medical device, so it's intended to interact with biological systems"[2].Requirements of Biomaterials are It must be inert or specifically interactive. It must be Biocompatible. Mechanically and chemically stable. Biodegradable. Process able (manufacturability): It must be machinable, and moldable. Sterilizable. Non-carcinogenic, non-pyrogenic, non-toxic, non-allergenic, blood compatible, non-inflammatory. Physical Characteristics Requirements: Strength, Toughness, Elasticity, Corrosion-resistance, Wear resistance, Long term stability [3] . Natural fibers represent an environmentally friendly alternative by virtue of several attractive attributes that include lower density, lower cost, non-toxicity, ease of processing, renewability and recyclability [4].

A Tendon is a tough band of fibrous connective tissue that connects muscle to bone, or muscle to muscle and is designed to withstand tension. Tendons are similar to ligaments except that ligaments join one bone to another. Tendons are muscles work to gather and can only exert a pulling force. Most of the strength of Tendon is due to the vertical, hierarchical arrangement of densely-packed collagen fibrils. Tendon length varies in all major groups and from monkey to person. Tendon length is practically the discerning factor where muscle size and potential muscle size is connected. The present work thus aims to develop this new class of natural fiber based polymer composites with fiber lengths and to analyze their mechanical behavior by experimentation and compare strength with tendon.

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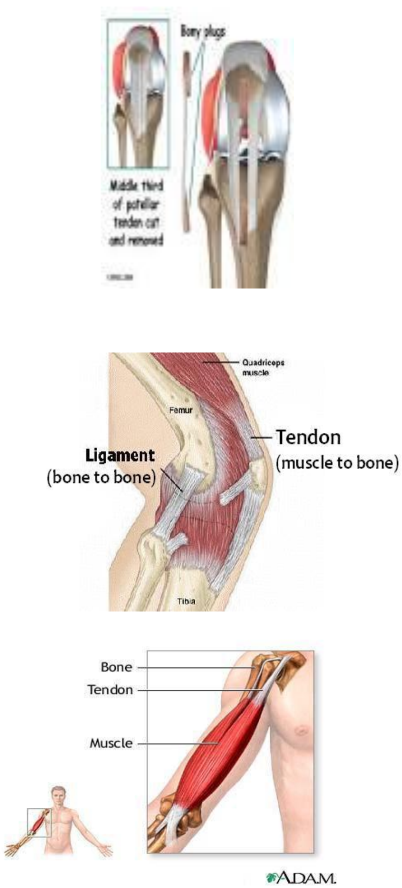

Fig – 1.1 Tendons in human body

Table 1.1: Tendon properties

TYPE	TENDON
Tensile strength	50-100 Mpa
Compressive strength	50-70 Mpa
Bending strength	70-110 Mpa

Objectives

- ❖ Fabrication of KENAF based composites.
- ❖ Study the effect of fiber on mechanical behavior of kenaf fiber reinforced polyester based composites
- ❖ Evaluation of mechanical properties of the composites such as tensile strength.
- ❖ Finally compare the results with tendon properties.

Besides all these the main objective is to develop a low cost, low weight, low density & high tensile strength natural fiber based composite that can be used for tendon & medical implant applications.

II. METHODOLOGY

Fiber Extraction : Kenaf fibers are collected from kenaf plant by extracting from kenaf plant using manual or mechanical extraction procedure

Fig – 2.1 Kenaf fiber extraction

Kenaf fiber preparation : Here continuous fibers are used to fabricate the natural fiber composites. First the natural fibers are cleaned in the distilled water. The cleaned natural fibers are dried in the sun light. The dried natural fibers are again cleaned by chemical cleaning process. In chemical cleaning process the 80% sodium hydroxide is mixed with 20% distilled water. The dried natural fibers dipped in the diluted sodium hydroxide solution. It's again dried in sun light .The dried natural fibers are cut to the length of 300 mm by manually. The cut natural fibers are used to fabricate the natural fiber composites.

Materials and pattern used for fabrication

The pattern is designed as per ASTM standard. The pattern is made up of mild steel. The pattern Size is 300 x 300 x 3 mm the pattern consist of three parts Base plate, frame and weight. The main purpose of the weights applied is for even distribution of load on mixture which is filled in the pattern.

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Fig – 2.2 Pattern

Materials used for fabrication work are polyester resin, Hardener, Kenaf, Sodium Hydroxide (NaOH), Weighing Machine, Roller, Bowl, Stirrer.

Mould preparation for tensile test

In mould preparation the resin is mixed with hardener in the ratio of 4:1. The mixer is strewed with stirrer for 15 minutes continuously.

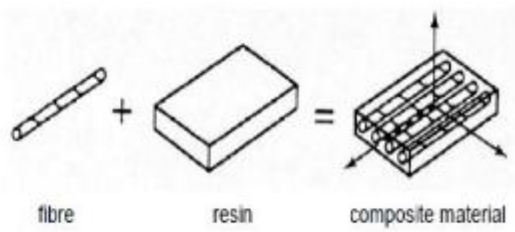

Fig -2.3 Mould Preparation

Take the Top mould or Die which is made up of Cast Iron of size 360mm* 300mm* 20mm in rectangular shape And similarly Take the Bottom mould or Die which is made up of Cast Iron of size 360mm *300mm *20mm mm in rectangular shape and place these moulds one above the other and tight these plates by means of 2" Clamps. Surrounding Die very thick rubber sheet is used to prevent the material and to avoid air or blow holes on the specimens and this rubber sheet is withstand up to temperature of 100 The working surface was cleaned with thinner to remove dirt and a thin coat of wax is applied on the surface to get smooth finish. Then a thin coat of polyvinyl alcohol (PVA) is applied for easy removal of mould.

Fabrication Process

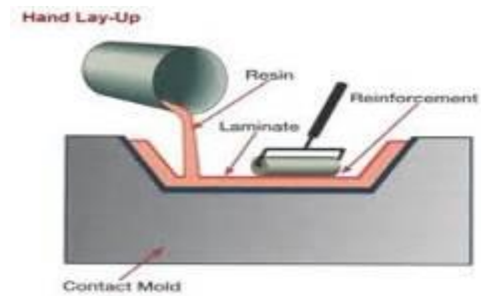

Fig -2. 4 Hand lay up method

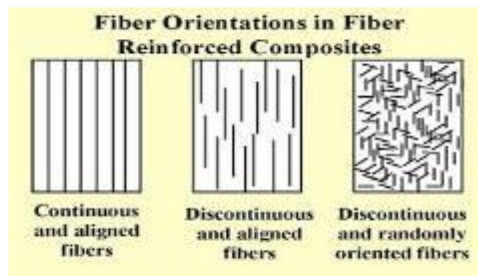

Fig -2.5 Fiber orientation

Here Hand Laminating Molding is used for fabricate the natural FIBER composites. The base plate is fixed inside the frame for fabricate the natural fiber composites 70% of rein hardener mixture and remaining natural fibers are used. The mixed resin and hardener is filled in the pattern. The prepared natural fibers are randomly poured in the resin hardener mixture without any gap. The roller is rolled in the mould. Again the mould is filled in pattern by next layer and fibers poured randomly .This process is simultaneously done till the height of the mould .The weights is fixed on the top of the frame for distribute the load evenly on the mould. The setup is kept in the dry place for 24 hours. After 24hours the mould is take away.

From the pattern, finally the natural fiber composite is fabricated.

The mould is prepared and loose the clamps and remove the fabricated material and for this material Zipsome coat is applied to fill the pits or blow holes after this go for annealing process for dry the material by maintaining the temperature of 82° c for an 15 minutes and take out the material Mould Preparation.

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Kenaf fibers are cut to the required dimensions for test specimen pre-impregnated with matrix material and placed one over the other in the mould. Casting was cured under light pressure for 2 hours before removal of mould. All test specimens were molded and prepared according to ASTM standards to avoid edge and cutting effect, thereby minimizing stress concentration effect. Fabrication steps showed in the figures.

Fig -2. 6 Fiber Cutting for required length

Fig -2.7 Fiber arrangement

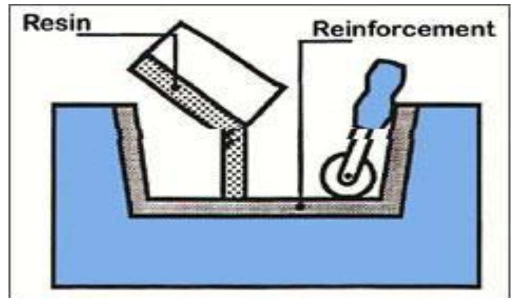

Fig – 2.8 Pouring resin in mould

Fig 2. 9 Furnace for annealing

Fabricated Composites

Polymer Kenaf matrix composites, The compositions of polymer composites with long fiber are given in the following table.

Table 2.1
Composites of fiber reinforced polymer

Composites	Orientation	Composition	
		Resin In Wt %	Fibers In Wt %
C1	Long fiber	90	10
C2	Long fiber	80	20
C3	Long fiber	70	30
C4	Long fiber	60	40

Fig 2.10 Specimens after fabrication

Experimental Testing

The main objective is to determine the mechanical properties of kenaf fiber reinforced polyester composite material by conducting Tensile Test .

Tensile tests were conducted using universal testing machine with a cross head speed of 2mm/min. In each case, three samples were tested and average value tabulated. Tensile test samples were cut as per ASTM D3039 test procedure. Tests were carried out at room temperature and each test was performed until tensile specimen fails. D 3039 should be utilized for highly oriented specimens and specifies straight-sided, rectangular test specimen geometry, with the standard primarily focusing upon the appropriate procedures for applying cyclic versus quasi-static loading. A compliant and strain-compatible material is used for making the end tabs to reduce the stress concentrations in the gripped area and thereby promote tensile failure in the gage section

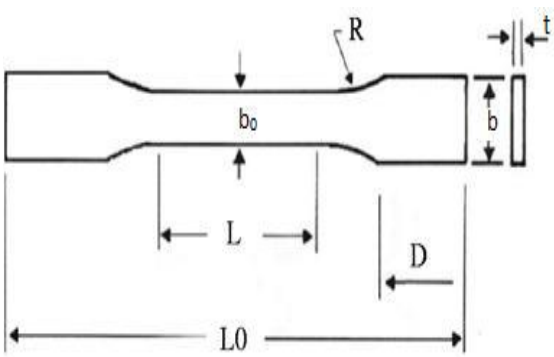

Fig 2.11 Tensile testing

III. CALCULATION

DENSITY: For a general composite, total volume V, containing masses of constituents Ma, Mb, Mc,... the composite density is

$$\rho = \frac{M_a + M_b + M_c + \dots}{V} = \frac{M_a}{V} + \frac{M_b}{V} + \dots$$

In terms of the densities and volumes of the constituents:

$$\rho = \frac{v_a \rho_a}{V} + \frac{v_b \rho_b}{V} + \frac{v_c \rho_c}{V} + \dots$$

But *va / V = Va* is the volume fraction of the constituent a, hence:

For $\rho = V_a \rho_a + V_b \rho_b + V_c \rho_c + \dots$ atrix

$$\rho = V_f \rho_f + V_m \rho_m = V_f \rho_f + (1 - V_f)\rho_m = V_f(\rho_f - \rho_m) + \rho_m$$

Since *Vf* + *Vm* = 1 ……(4)

Example (Kenaf And Polyester)

Polyester 90% and kenaf 10%

Volume of the die = 300x300x3 = 270000mm3

Density of polyester = 1.37x10-3 g/mm3

Density of kenaf = 1.13x10-3 g/mm3

Vc = Vpolyester + Vkenaf

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$m_c/\rho_c = m_{polyester}/\rho_{polyester} + m_{kenaf}/\rho_{kenaf}$

$1/\rho_c = 0.9/1.37e\text{-}3 + 0.1/1.13e\text{-}3$

$1/\rho_c = 742.9$ mm3/g

$\rho_c = 1.346e\text{-}3$ g/mm3

$m_c = \rho_c \times v_c$ (mc= mass of the composite material)

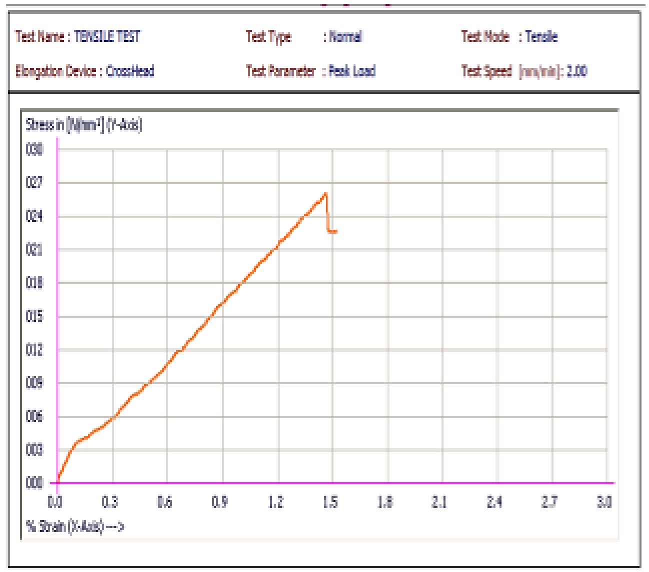
mc = 363.42 gm

For 90% Polyester = 332.91g

For 10% kenaf = 30.51g

IV. Results And Discussion

(a) Load verses length



(b) Stress verses strain

Graphs 4.1 : 10% KFRPC for Tensile test

a) Load verses length

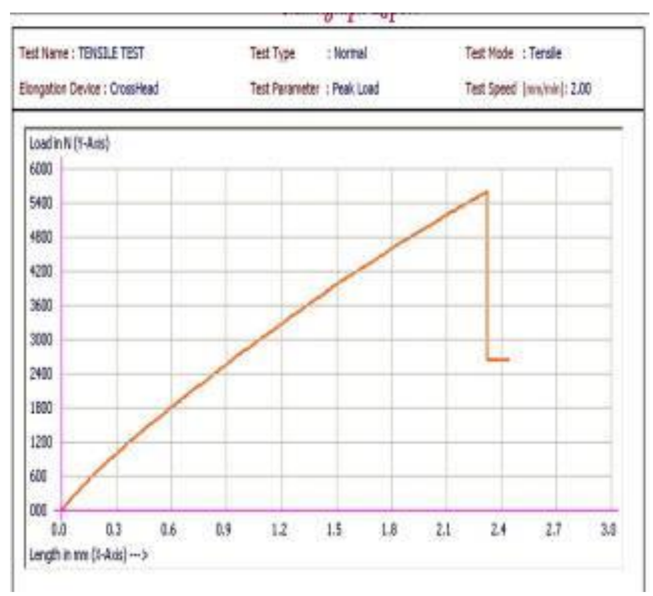
b) Stress verses strain

Graphs 4.2: 20% KFRPC for Tensile test

a) Load verses length

b) Stress verses strain

Graphs 4.3: 30% KFRPC for Tensile test



a) Load verses length

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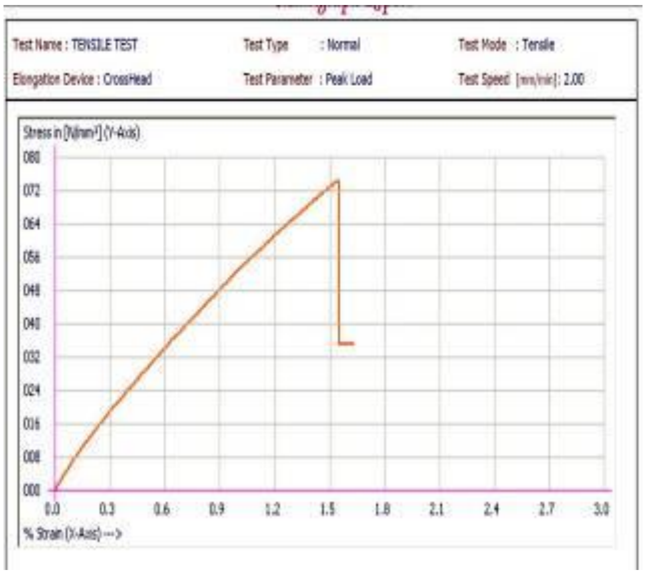


b) Stress verses strain

Fig4.4: 40% KFRPC for Tensile test

Table 4.1:
Tabular column shows graphs of tensile test of 10% KFRPC

Sl No	Peak Load(N)	Breaking load(N)	C/A area mm^2	UTS N/mm^2	Youngs modulus N/mm^2
1	1966	1812	75	26.21	2808.84
2	1951	1794	75	28.02	1707.23
3	2259	2161	75	30.12	2748.42

Table 4.2
Tabular column shows graphs oftensile test of 20% KFRPC

Sl No	Peak Load(N)	Breaking load(N)	C/A area mm^2	UTS N/mm^2	Youngs modulus N/mm^2
1	1347	1278	75	17.96	2719.85
2	2395	2113	75	31.93	2559.06
3	Before Testing Specimen Broken				

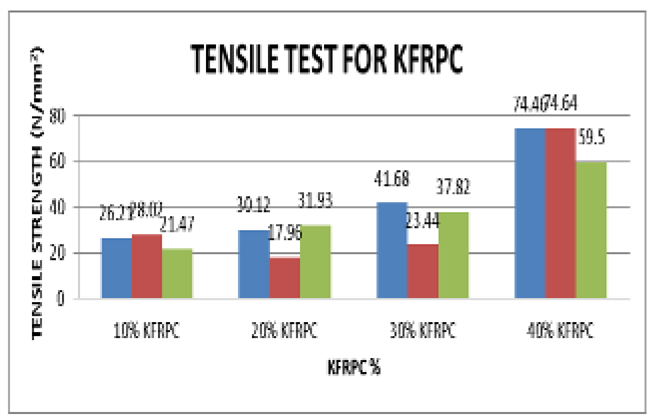
Table 4.3
Tabular column shows graphs of tensile test of 30% KFRPC

Sl No	Peak Load(N)	Breaking load(N)	C/A area mm^2	UTS N/mm^2	Youngs modulus N/mm^2
1	3126	2954	75	41.68	4136.91
2	1758	1622	75	23.44	3717.68
3	2836	2770	75	37.82	4331.62

Table 4.4
Tabular column shows graphs of tensile test of 40% KFRPC

Sl No	Peak Load(N)	Breaking load(N)	C/A area mm^2	UTS N/mm^2	Youngs modulus N/mm^2
1	5584	5189	75	74.46	4563.01
2	5598	5116	75	74.64	5506.58
3	4463	4276	75	59.50	7072.77

Comparison of tensile strength of KFRPC for Tensile test



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Tensile strength

From experimental results it is found that for 10% KFREC peak load=2259N, Ultimate stress=30.12(N/mm2), similarly for 20% KFREC peak load=2395N, Ultimate stress=31.93(N/mm2), similarly for 30% KFREC peak load=3126N, Ultimate stress=41.68(N/mm2) , similarly for 40% KFREC peak load=5598N, Ultimate stress=74.64(N/mm2) , from this conclude that by increasing the weight fraction of kenaf fiber it increases the strength of the specimen and from this experimental results the tensile strength of specimen will match the Tendon tensile strength.

Fig4.1: Tensile test specimen after testing

V. CONCLUSION

1. From experimental results it is found that KENAF fiber will have good tensile strength
2. From experimental results it is found 10%, 20%, 30% and 40% KFRPC, that out of 40% KFRPC is having good tensile strength and it is matching with Tendon Properties.
3. From the above experimental results it indicates that the Kenaf fiber reinforced polyester composites will have better mechanical properties like tensile properties by increasing the percentage of kenaf fiber.

VI. FUTURE SCOPE OF WORK

1. This work is carried out for tensile strength and tests can be carried out for other properties like Compression and Bending.
2. FEM analysis can be carried out and can be compared with experimental results.
3. Water absorption test can be conducted and reliable fiber composites are selected based on the results.
4. Wear test can be done under different operating conditions like varying time, track radius & speed.
5. Corrosion test can be conduct.
6. SEM analysis can be conduct.

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