# Characterization of Kenaf Reinforced Bio-composite For Fabrication of FSAE Car Bodyworks

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***Abstract*- In manufacturing and fabrication industries composite material has wide use which shows impressive mechanical properties as strength and stiffness. Due to low density final product leads to decrement in weight. As per ecological based articles composites made up of petroleum product which liberate toxicity in atmosphere. Natural bio-composite has increasing attention due to availability and mechanical flexibility. Natural fibers as kenaf, jute, sisal etc. possess higher mechanical stability, thermal resistivity and low density compared to synthetic ones. Manufacturing process with unidirectional woven fiber effectively gives higher flexural and impact strength. Present work has results of flexural, impact and tensile testing of laminated unidirectional woven kenaf as fiber and epoxy as resin material. Fabrication of automotive part with same composite by Hand-layup technique.**

***Keywords— Bio-composite, epoxy, hand lay-up, kenaf, bi-directional***



## I. INTRODUCTION

A polymer has wide daily uses which replace heavy structure and comfort in flexibility and can be fabricated in a composite. A composite is fabricated by adding two or more dissimilar materials in such a way that enriched with properties superior to its original ones. A Natural fiber, has profound use due their availability, low density, ecological sustainability, and low cost as well as mechanical and physical stiffness and shows enhanced properties, are normally applied in different fields like aerospace, engineering applications, automotive, sports goods, etc. natural fibers have come a long way in replacing the synthetic material had been used conventionally which developed from petroleum products. This fiber material can be extracted from natural resources which resolve ecological terminology. Particular attractiveness showed by natural fibers due to their carbon dioxide neutrality[4]. Natural fibers are also much cheaper than synthetic fibers and could replace synthetics in many applications for which cost savings out weight high composite performance requirements [5]. The challenging task is adhesive bonding along the fiber need to be strong for better stiffness and sustainability. Epoxy resin material can do needful adhesion while fabrication of automotive components, construction, and other mechanical structures. Natural fiber reinforcement composite (NFRC) is comparatively lower cost to manufacture and there are comfortable manufacturing processes available for it. The use of NFRC more flexibility to design engineers in the existing design since NFRC's is easy to handle. Thereby natural fiber composite laminate has gained tremendous interest due to their flexible nature. More work has been carried out by researchers on these natural fibers. Naturally available fibers like kenaf, jute, sisal, silk, coir, etc. are cheap cost, renewable & with low density, light in weight, higher stiffness, and biodegradable. These fibers offer as a reinforcement material for composites [5]. According to researchers, the kenaf bast fibers possess impressive mechanical properties that make them as a replacement to glass fibers [8].

## II. EXPERIMENTAL DETAILS

Bidirectional woven kenaf fiber mat has been used. The matrix used for manufacturing the fiber specimen was epoxy HSC 7160 of density 1.05-1.25. g/cm$^3$ ,at room temperature mixed with hardener ARADHUR-HY951. The weight ratio of mixing epoxy and hardener was 10:1. The composites were laminate by hand lay-up technique with the help of a mould. A specific mould was used for the fabrication process so as to get superior mechanical properties as shown in below fig.1. Firstly wax coating was added on surface area of mould which helps in easy removal in case of epoxy adhesion to mould. Fiber reinforced layer by layer in between epoxy resin pour in it as sandwich pattern. Epoxy distribute over fiber and filled up the voids in between the reinforcement. The composite laminate were subjected to 24 hours curing at room temperature. The mould were kept away from open atmosphere as moisture content increases while curing. While packing nut and bolt were tightened diagonally so as to developed gradual stress over entire area of laminate

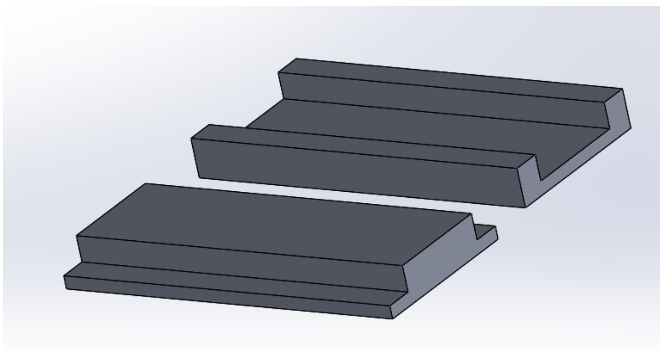

Fig 1 - CAD model of Mould

Fig 2 - Laminate Preparation

The theoretical density and of the laminate and void fraction percentage were determined in terms of weight fractions by following equation [14].

1.Theoretical density

$$\rho_{ct} = \frac{1}{\left[\frac{W_f}{\rho_f}\right] + \left[\frac{W_m}{\rho_m}\right]}$$

2. Void fraction ($V_v$) = $\frac{[\rho_{ct} - \rho_{ce}]}{\rho_{ct}}$

where W and ρ are weight fraction and density. The suffix m, f and ct represent the matrix, fiber and composite respectively. The manufactured laminates were subjected to charpy impact test, flexural test (3 point bending), tensile test were performed in UTM. Specimens were cut as per ASTMD 256 for impact testing as per ASTMD 790 for flexural and ASTMD 3039 for tensile testing also, water absorption test was conducted to evaluate the amount of water absorbed under given conditions as per standard ASTMD 570.

## III. RESULTS

The main factors that determine the properties of the composite laminate is density. Usually it is found that the theoretical values of density hardly matches with the measured values. This is may be due to the presence of air voids in the composite. Mechanical properties and the performance of the composite is dependent on density and void fraction in the actual case[12]. Larger void contents usually mean lower fatigue resistance, greater sensitivity to water and moisture absorption. Thus, the awareness of void content is desirable for the approximation of the quality of the composites. The experimental and theoretical densities of the fabricated laminate along with the void fraction are presented in fig 3.

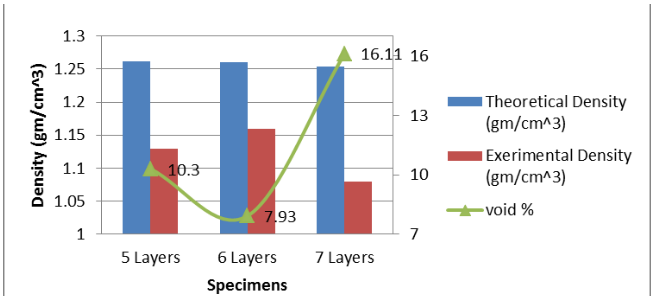


Fig.3 Graph of Density Comparison & Void Fraction%

Since moisture absorption of fibers plays a very important role in the reinforcement, the hydrophilic character of kenaf fiber was investigated. With the moisture absorption, the kenaf fibers swell laterally. Water absorption characteristic of laminate specimens was analyzed in terms of weight gain for the specimen immersed in distilled water for 48 hours. Kenaf reinforced epoxy composite specimen absorbed water aggressively in first 18hrs and it shows constant increment after that. In this experiment, it is seen that the water absorption content of the kenaf reinforced epoxy composite reaches an average value of wt.8.5% of original.

Table 1 - Percentage Increase in Weight of Kenaf Reinforced Epoxy composite

| Time Duration (hrs.) | Increase in weight % | | |
|---|---|---|---|
| | 5 layers | 6 layers | 7 layers |
| 6 | 3.36 | 3.12 | 3.95 |
| 12 | 3.36 | 5.20 | 3.95 |
| 18 | 3.46 | 6.77 | 6.21 |
| 24 | 3.89 | 6.77 | 6.77 |
| 30 | 5.19 | 7.29 | 6.77 |
| 36 | 5.6 | 8.85 | 7.90 |
| 42 | 6.06 | 9.37 | 8.47 |
| 48 | 6.49 | 9.37 | 8.47 |

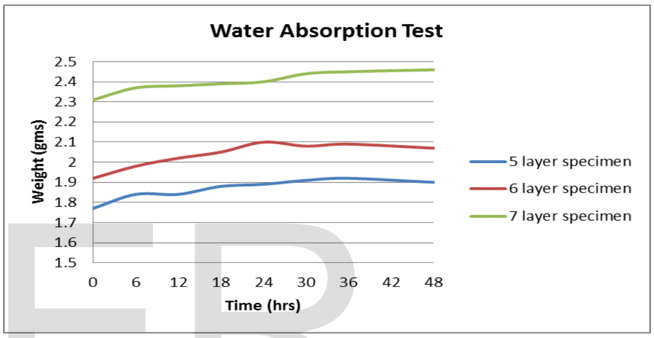




Fig.4 Water Absorption Test

Fabricated sample were tested under Charpy-Impact testing machine. Specimen was cut as per ASTM D 256 standards. Specimen mounted such that faces thickness to the hammer shank. Impact resistance increase with thickness of material. Each layer of three specimens was tested and it shows following results in Table3.

Table 2-Impact Testing Results

| Specimen (layers) | Thickness (mm) | Impact Energy (joules) | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| 5 layers | 2.5 | 48 | 47.7 | 48 |
| 6 layers | 3.4 | 50.5 | 53.5 | 52 |
| 7 layers | 4.2 | 58 | 56.3 | 57 |

Impact strength can obtained with above parameters as it would concluded from impact energy

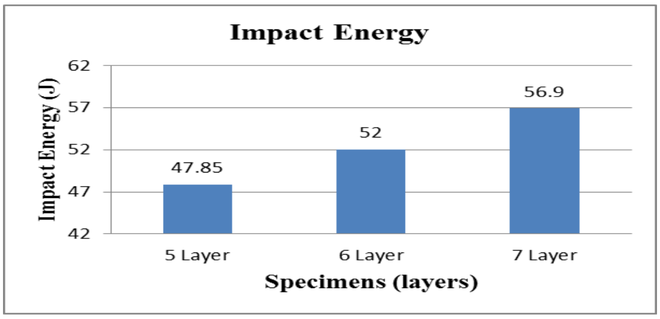


Fig.5 Graph of Impact Tested Specimens

Flexural or bend test effectively shows mechanical property and sustainability. It shows load bearing capacity up to which fatigue or crack may shown. Specimens were cut from laminate as per ASTM D790 standard. 3 point load method UTM machine was used. while testing specimen were placed at middle and span length was 60mm. The specimen with more fiber percentage shows better flexure as epoxy content behave brittle.

Table-3 Results of Flexural testing by 3 point load

| Specimen (layers) | Force (KN) | | | Deflection (mm) | | |
|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 1st | 2nd | 3rd |
| 5 | 3.92 | 3.86 | 3.88 | 9.2 | 8.4 | 9.3 |
| 6 | 3.84 | 3.88 | 3.98 | 4.7 | 4.6 | 4.4 |
| 7 | 3.96 | 3.98 | 3.82 | 3.9 | 4.3 | 4.2 |

1. Theoretical flexural stress:[11].

$\sigma = \frac{3FL}{2bd^2}$, for a rectangular cross section

2.flexural strain:

$\epsilon = 6Dd/L^2$

where,

σ = Stress in outer fibers at midpoint (MPa)

€ = strain in outer surface

F = load at a given point on the load deflection on curve(N)

L = support span (mm)

b = width of test beam (mm)

d = thickness of tested beam (mm)

D = maximum deflection of the center of the beam (mm)

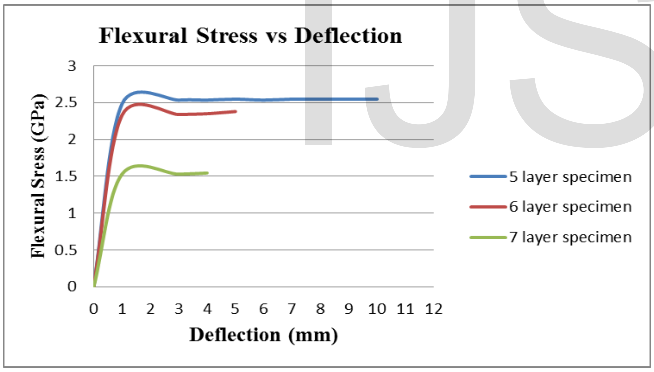


Fig.6 Graph of Flexural Stress vs Deflection

Specimen were cut from laminate as per ASTM D 3029 standard. UTM machine was used for testing purpose. specimen were mount in jaw of machine and emery cloth were wound around it which cease the slippage problem, specimen were mark upto jaw line. Then allow machine to elongate it till first crack has observe. Specimens with fiber percentage 33.3%, 38.12% & 46.32% were tested. Results were shown in table

Table 4- Summary of Tensile Testing

| Specimen (layers) | Maximum Load (KN) | | | Change in length (mm) | | |
|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 1st | 2nd | 3rd |
| 5 | 0.58 | 0.63 | 0.706 | 4.2 | 4.29 | 4.5 |
| 6 | 1.87 | 2.13 | 1.93 | 6.7 | 6.3 | 6.4 |
| 7 | 3.09 | 2.98 | 3.12 | 8.3 | 8.1 | 8.05 |

The force measurement is used to calculate the engineering stress, σ [11].

σ = F/A

F = tensile force

A = nominal cross section of the specimen.

strain, ε, using the following equation

$\varepsilon = (L-L_\circ)/(L_\circ)$

L = final length

$L_\circ$ = initial gauge length

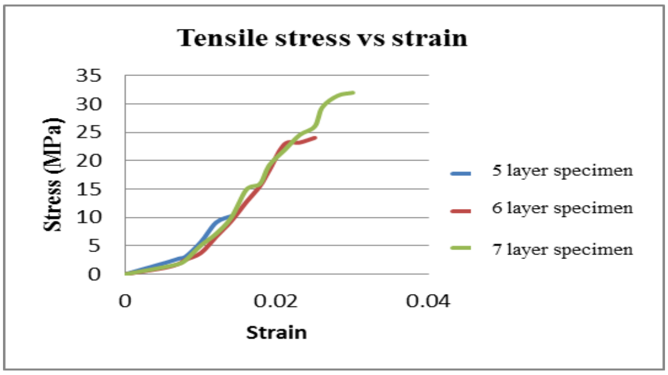


Fig.6 Graph of Tensile Stress vs Strain

## IV. CONCLUSION & FUTURE SCOPE

Lamination of unidirectional kenaf reinforce in epoxy matrix by hand layup technique has studied under physical as well as mechanical parameter. Composite showed effectively better physical sustainability. While laminating voids developed reason being poor adhesion and air trapped while fabricating. Such trouble can be resolve with modern fabricating techniques. Water absorption test was performed for 48 hrs which shows gradual and fewer increments in weight. For mechanical testing specimen was cut as per standards. and specimens were tested in Charpy impact testing machine . Impact test showed specimen with 5 layers fiber has better strength to resist impact force. 3 point flexural bending test was performed under UTM. In this we conclude specimen shows effective strength for bending . Specimen with fiber around 5 and 6 layers shows impactful results. Material can handle 3.8-4.0 KN force which can be effectively use in spare parts. Samples were tested for tensile test as per ASTM D3029 shows impressive results. Material with 6 and 7 layers can handle around 2500-3100 N load. Overall 6 layer specimen material has needful strength. Further research work needs to be carried out on fiber treatment so as to improve the adhesion properties. This is important if new improved materials are to be developed for safe usage against crack growth. Kenaf fiber composites, rather than glass fiber composite, may open up new applications for low load application.

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