Detailed investigation of properties of sisal - jute - kenaf yarn composites

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Abstract

The composite materials are replacing the conventional materials, owing to its better properties like high tensile strength, high strength to weight ratio and low thermal expansion. In the past few decades, research and engineering interest has been shifting from monolithic materials to fibre-reinforced polymeric materials. Composite materials (notably aramid, carbon and glass fibre reinforced plastics) now dominate the aerospace, leisure, automotive, construction and sporting industries. The advancement of new materials is on the anvil and is growing day by day. Natural fiber composites such as kenaf and jute polymer composites became more attractive due to their high specific strength, lightweight and biodegradability. Kenaf and jute Reinforced Polymers are finding increased applications. Various natural fibers namely, jute, sisal, kenaf, abaca, hemp and banana are widely used in industries for making composite which are fabricated by either hand layup method or by other mechanized methods .Over the last decade, polymer composites reinforced with natural fibers have received ever increasing attention, both from the academic world and from various industries. In this research work the sisal kenaf and jute fibres are used to make the fibre reinforced composite. The sisal jute and kenaf were used in the composite in the yarn form which are having identical count. The jute yarn is braided and used in the composite, The yarn were converted in to fabric and is used as reinforced material. Poly propylene is used as a matrix substrate. The fabric thus produced was used in two, three folds in the composite making. For making the composite board a uni polymer composite machine is used. The composite board were tested for its properties using universal tensile testing machine.

Key words: *fibre reinforced composite, Poly propylene matrix, uni polymer composite*

1. Introduction

The composite materials are replacing the conventional materials, owing to its better properties like high tensile strength, high strength to weight ratio and low thermal expansion. In the past few decades, research and engineering interest has been shifting from monolithic materials to fibre-reinforced polymeric materials. Mechanical behavior of a natural fiber based polymer composite depends on numerous factors, for example, fiber length and quality, matrix, fiber-matrix adhesion bond quality and so forth. The strong interface bond between fiber and matrix is paramount to show signs of improvement mechanical properties of composites [1-5]. Merlini et al. [6] have studied the effect surface treatment on the chemical properties of banana fiber and reported that treated banana fiber give higher shear interfacial stress and tensile strength when compared with the untreated fiber. Dhieb et al. [7] have studied about the surface and sub-surface degradation of unidirectional carbon fiber and have given many conclusions such as under sliding in demineralized water, the most simple degradation was detected on sliding in anti-parallel direction. Shankar et al. [8] have studied and reported that the ultimate tensile strength value maximum at 15% and then decreases with increasing in fiber starting from 15% to 20%. They also reported that the flexural strength value decreasing from 5% to 10% (87.31 MPa) and after that the value increased from fiber. Sumaila et al. [9] have investigated the influence of fiber length on the mechanical and physical properties of nonwoven short banana, random oriented fiber and epoxy composite and they described that the tensile properties and percentage elongation of the composite attained a maximum in composite fabricated from 15 mm fiber length. They have also reported that the impact energy whereas the compressive strength increases decreased with increasing fiber length, also the mean flexural properties of the composite increased with increasing in fiber length up to 25mm. The banana fibers characteristic depending on the variation of diameter, mechanical characteristic and the effects of the stresses performing on the fracture morphology. The stress-strain curves for changed strain rates were found and fractured surfaces were inspected by SEM [10]. Pothan et al. [11] have investigated on the influence of fiber content and length on short banana fiber reinforced polyester composite material. Laban et al. [12] has studied on the physical and mechanical behavior of banana fiber reinforced polymer composite and noticed that kraft mashed banana fiber material has better flexural strength. The tensile strength is detected maximum at 30 mm fiber length whereas the impact strength is noticed maximum at 40 mm length of fiber. Consolidation of 40% untreated banana fibers gives 20% rise in the tensile strength and 34% rise in impact strength. Prasanna and Subbaiah [13] reported that composites material having 20% treated fiber loading possess maximum values for above-mentioned properties than untreated composites, 10% and also 30% treated fibers composites. The interfacial area having main role in influential the strength of polymer material since fiber procedures a separate interface with the matrix. The effects of this study uncovered that short zig-zag fiber composites with great rigidity and element mechanical properties might be effectively ready utilizing banana fiber as reinforcement in a polyurethane matrix inferred from castor oil. The treated banana fiber demonstrated higher shear stress and tensile strength when contrasted with the untreated fiber, showing a solid association between the treated strands and the polyurethane matrix [6]. The hybridization of these reinforcement in the composite shows more terrific flexural quality when contrasted with singular kind of characteristic strands strengthened composites. All the composites shows expand in flexural quality in longitudinal heading. Comparable patterns have been watched for flexural modulus, entomb laminar shear quality and break burden values [14]. There are many researches who have evaluated the mechanical, chemical and physical behavior and banana fiber reinforced with epoxy composite. Many studied and compared of effect of treated and untreated banana fiber reinforced with thermoplastic and thermosetting polymer [15-19]. Joseph et al. [20] studied and compared the mechanical behavior of phenol formaldehyde composites which was reinforced with glass fiber and banana fiber. Selzer and Friedrich et al. [21] studied the carbon fiber reinforced polymer composites and reported that the brittle materials demonstrate a lot of delamination's also interlinear splitting throughout weariness. The disappointment of this material was dictated by a restriction of disappointment. This implies that in composites with a exceptionally intense grid and great fiber-network bond, various splitting, which ingests a higher measure of vitality, is anticipated, with the goal that at last confined disappointment happens at easier levels than anticipated. There is wide range of research in these fields; many researchers have investigated the natural fiber composite reinforced with various type of polymer [22-24]. Natural fibres (sisal, kenaf, hemp, jute and coir) reinforced polypropylene composites were processed by compression molding using a film stacking method. The mechanical properties of the different natural fibre composites were tested and compared [25]. Kenaf, hemp and sisal composites showed comparable tensile strength and modulus results but in impact properties hemp appears to out-perform kenaf. The tensile modulus, impact strength and the ultimate tensile stress of kenaf reinforced polypropylene composites were found to increase with increasing fibre weight fraction. Coir fibre composites displayed the lowest mechanical properties, but their impact strength was higher than that of jute and kenaf composites.

2. Materials and Methods

The following raw material were used to produce the composite

1. Sisal Yarn , 2. Jute Yarn , 3. Kenaf fibre, 4. Epoxy resin, 5. Polypropylene (PP) & 6. Hardener

Methodology

1. Sisal yarn, Braided jute yarn and kenaf are taken
2. Plain woven fabrics were produced by hand weaving using the following combination

Table 1

Fabric details	code
Sisal warp and -sisal weft	A
Sisal warp and jute (Braided yarn) weft	B
Sisal warp and kenaf weft	C

In all the cases the fabric structure GSM and warp yarn, EPI and PPI were kept constant.

3. Forming a composite board using the above said fabric by hot-molding"UNI POLYMER COMPOSITE MACHINE" by using different binders at different ratios.
4. Microscopic view and porosity of composite boards has been studied using microscopic
5. Tensile and Flexural strength testing of 100% sisal, Sisal-Kenaf, Sisal-Jute composite board is done by using Universal Testing machine.

The following chart will explain the methodology

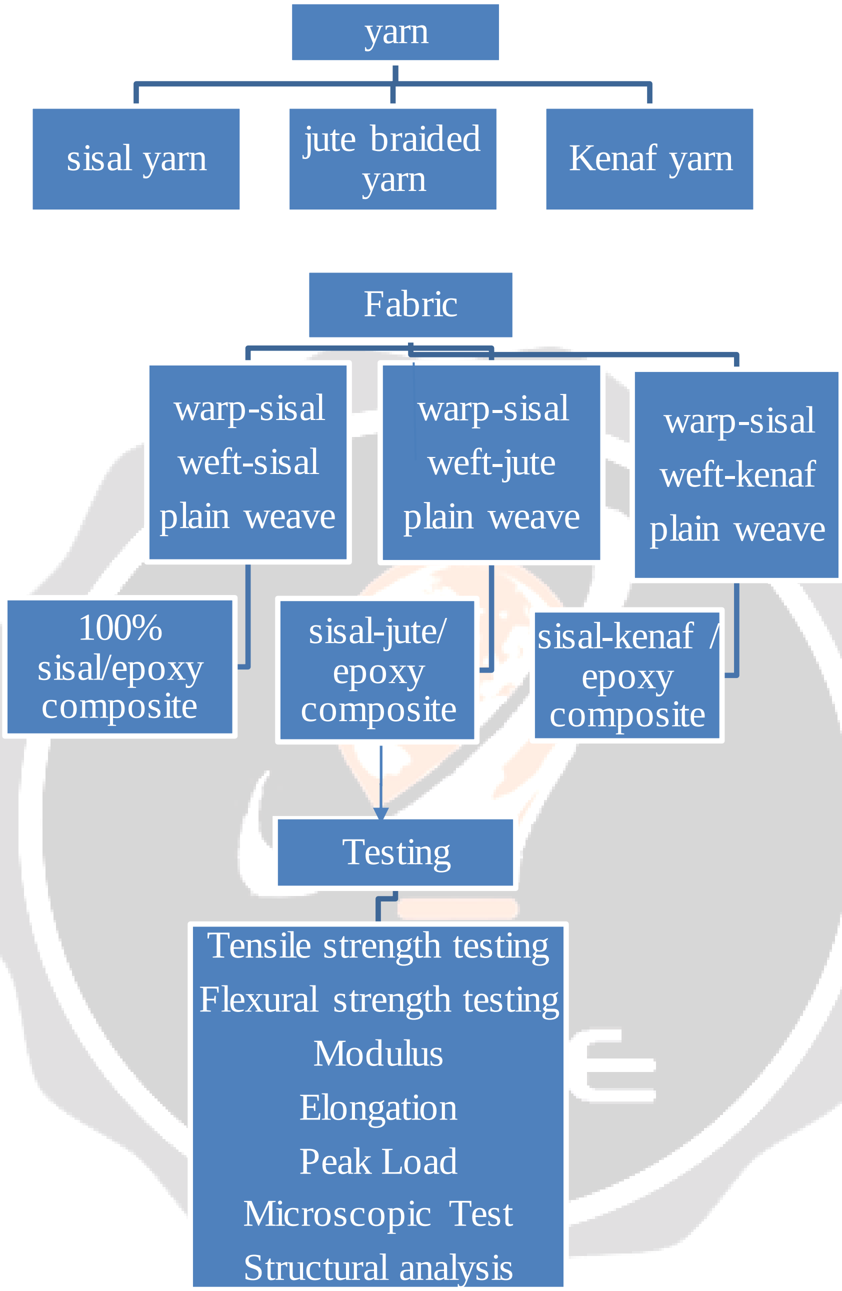


Figure-1

The compression molding machine is set to a pre-defined temperature of 120°C. The sample is prepared by placing a layer of jute fabric over a 0.1 mm thickness aluminium foil sheet where epoxy resin is coated on the inner surface of the foil sheet. The fabric is made in to two fold layers in which the resin was coated is placed in between the foil sheet. The material is placed in a frame and loaded into the machine after attaining the pre-defined temperature of 120°C for about 20 minutess at pressure of 35 kgs/cm². After that the pressure is released and allows it to cool at room temperature. The same procedure is repeated for all the samples.

3.Results and discussion

3.1: Tensile strength of yarn

The yarns were subjected to tensile strength tester to determine its tensile strength. Results of the study of strength properties of yarns as following

Table-2 Tensile Strength of Sisal Yarn

SPECIMEN	CSA (sq.cm)	PEAK LOAD(kg)	TS (kg/sq.cm)	Elng@brk (%)
1	0.0240	15.6881	652.9885	12.5872
2	0.0289	14.8007	512.1357	13.0265
3	0.0256	44.4022	1734.4603	17.0333
4	0.0324	36.8950	1138.7358	15.9332
5	0.0289	37.6860	1304.118	18.5867

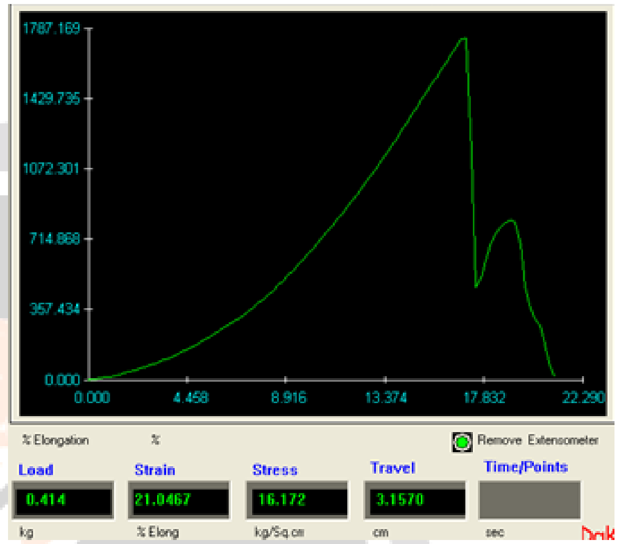


Table-3 Tensile Properties of Jute Yarn

SPECIMEN	CSA (sq.cm)	PEAK LOAD(kg)	TS (kg/sq.cm)	Elng@brk (%)
1	0.0256	18.9269	739.3311	14.3733
2	0.0225	18.0393	801.7443	17.2667
3	0.0144	15.8191	1098.5477	10.1465
4	0.0256	19.7411	771.1374	13.1065
5	0.0262	9.8376	374.8497	8.1132

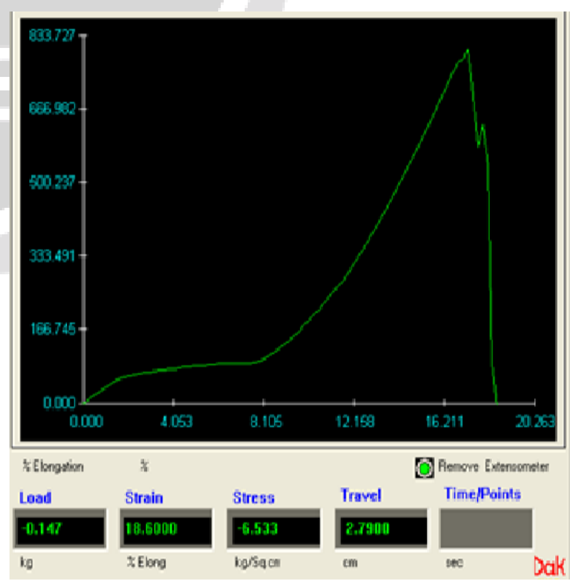
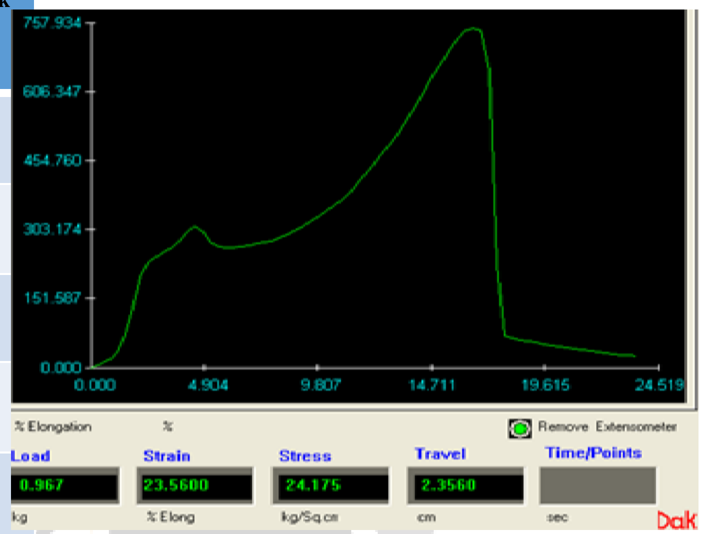


Table -4 Tensile Properties of Kenaf

SPECIMEN	CSA (sq.cm)	PEAK LOAD(kg)	TS (kg/sq.cm)	Elng@brk (%)
1	0.0400	25.3263	633.1547	13.8698
2	0.0400	29.4359	735.8962	33.9288
3	0.0400	29.7919	744.7963	16.8700
4	0.0400	19.7259	493.1473	15.5198
5	0.0324	14.3706	443.5371	8.5298



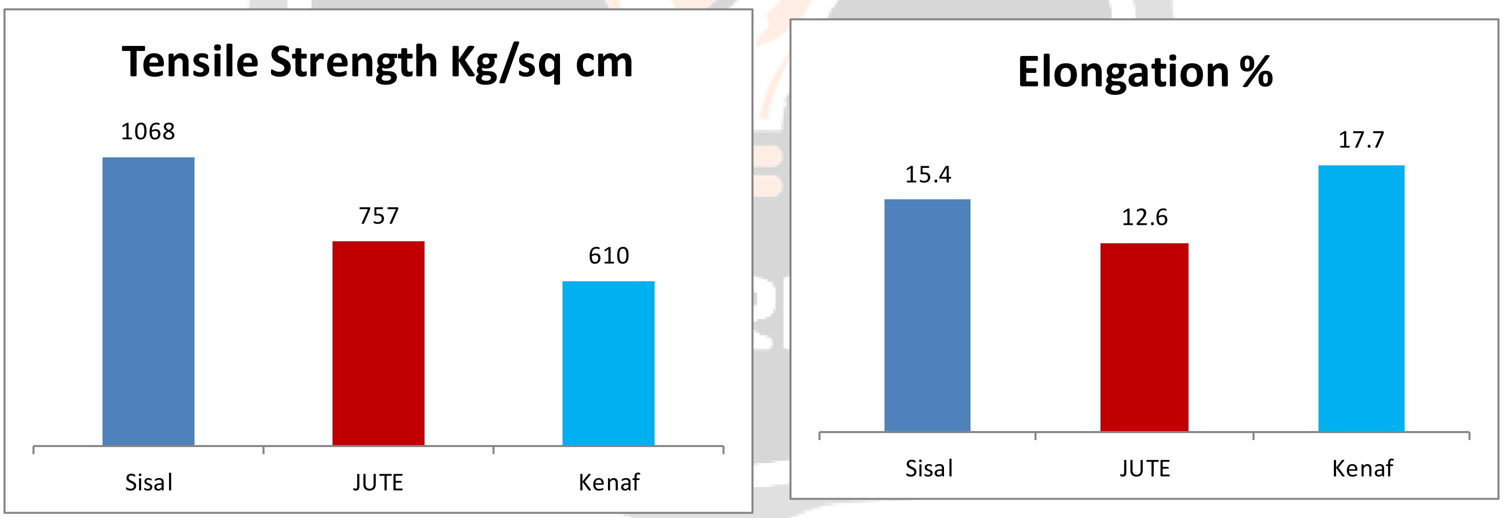


Figure 2 : Tensile and elongation details of yarn

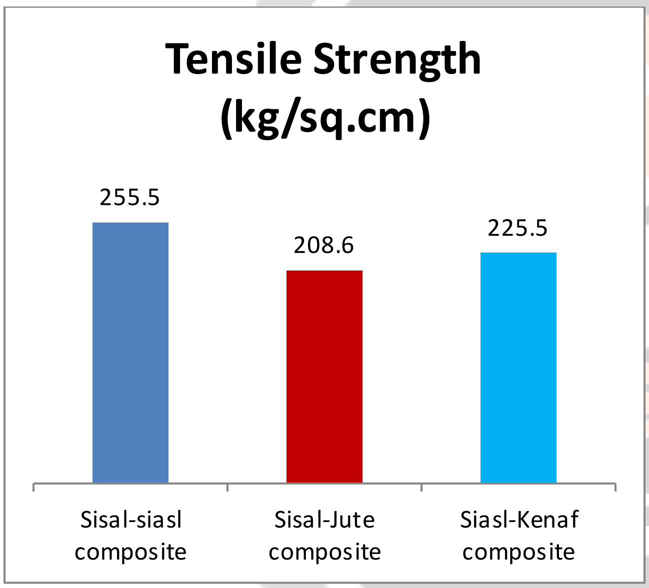
From the table 2,3,4 we can get an idea about the tensile properties of sisal, jute and kenaf yarn. From the figure 2 we can observe that the sisal yarn has got good tensile strength and elongation properties. So in the experimental set up the sisal yarn is used as warp yarn for all the samples.

3.2 Tensile Test for composite board

The composite boards were subjected to tensile strength tester to determine its tensile strength. Results of the study of strength properties of composite boards as following

Table 5 TENSILE properties of composite boards

SPECIMEN	CSA (sq.cm)	PEAK LOAD(kg)	Tensile Strength (kg/sq.cm)	Elongation@ break (%)
A	1.3375	321.5485	255.4508	6.0955
B	1.1000	229.3012	208.5764	8.0091
C	1.3375	301.5485	225.4508	7.0055



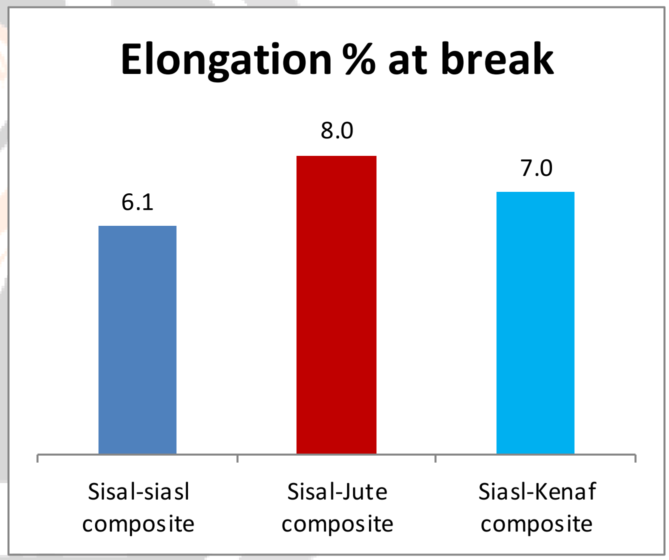


Figure 3 : Tensile and elongation details of composite boards

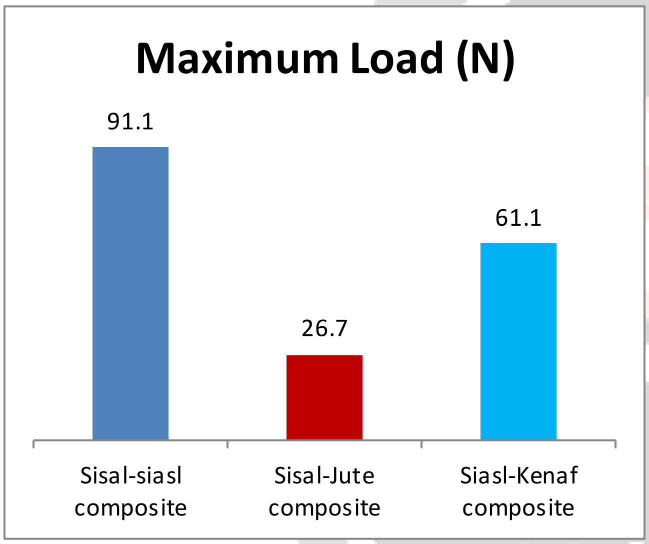
From the figure 3 it can be concluded that the sisal-sisal composite board has got highest strength and can with stand heavy load compared other fibre composite boards.

3.3 Flexural strength for composite board

The composite boards were subjected to flexural strength tester to determine its flexural strength. Results of the study of flexural strength properties of composite boards as following

Table -6 Flexural Strength of Composite Board

SPECIMEN	MAX LOAD(N)	F.STRESS (N.Sqmm)	WIDTH (mm)	DEPTH(mm)	SPAN(mm)
A	91.0518	13.3390	25	6.9	80
B	26.6744	9.1965	25.	4.4	100
C	61.051	10.3390	25	5.35	80



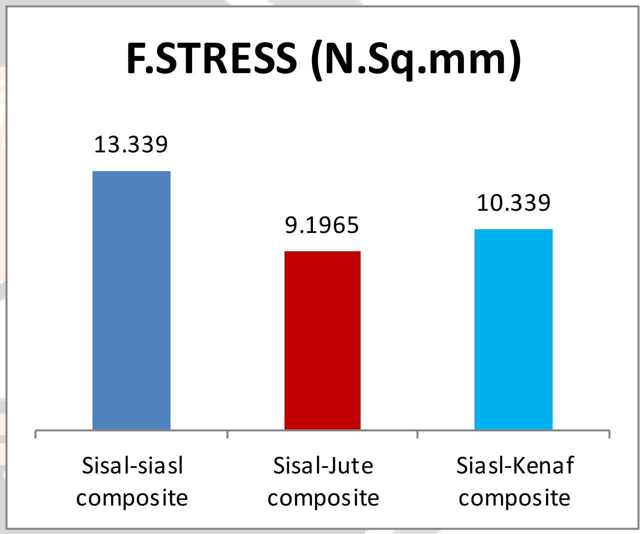


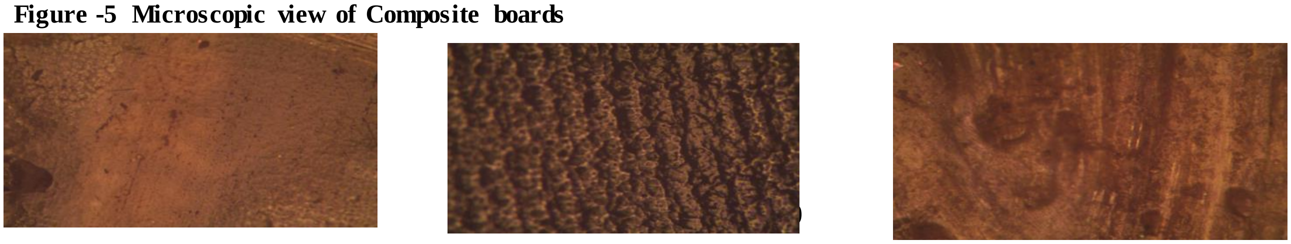
Figure – 4 Flexural Strength of Composite Board

From the figure 5 it can be concluded that the composite board made up of sisal yarn has got high flexural strength and high flexural stress compared to other boards

3.5 Microscopic view of Composites boards

Microscopic test is a technical test that involves identifying the fabric with the help of a microscope with a magnification of minimum 100 powers.

Figure -5 Microscopic view of Composite boards



The morphology of the composite samples used for the experiment is examined through metallurgical microscope. The image of the samples is presented in Fig 2 The fracture takes place in the specimen by the application of the load. The figures indicate the fiber fracture and pull out from the specimen and also the dislocation of fiber

Conclusion

The composite boards produced with braided yarn made up of 3 ply jute yarn blended with sisal, 100% sisal and sisal-kenaf blend are having higher mechanical properties in plain weave structure. Among the three 100% sisal is having higher mechanical properties.

These composite boards can be used as weather shield. It can be used in false ceilings. The strength of this composite makes it to use in automotive applications such as fuel tanks, pipe lines. Also it can be used in the structural materials of Aircraft engineering.

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