

# Mechanical Characterization of Bagasse and Coconut Coir Reinforced with Vinylester Polymer Composite

Sachudhanandan.S<sup>1</sup>, Dr.N.Lakshmana Swamy<sup>2</sup>, Manoj Kumar<sup>3</sup>

Research Scholar , Department of Mechanical Engineering, UVCE, Bangalore, Karnataka, India<sup>1</sup>

Professor, Department of Mechanical Engineering, UVCE, Bangalore, Karnataka, India<sup>2</sup>

UG Student, Department of Mechanical Engineering, UVCE, Bangalore, Karnataka, India<sup>3</sup>

**ABSTRACT:** This Polymer Matrix Composites (PMC) are gaining more importance compared to the monolithically materials as being more reliable and economical. Polymer matrix composites are finding application from household to engineering approach. With the advancement of PMC's their properties can be increased by the addition of one more fiber made as hybrid composite which boost the property of PMC where a single fiber composite lags. In our project we have chosen bagasse as the major reinforcement and coconut coir as an additional fiber to improve the mechanical property of polymer composite with vinyl ester as the base material prepared by hand layup process according to ASTM standards Test specimens are prepared with different weight fractions of bagasse at the optimization point of tensile test a small percentage of coconut coir are added and tests were conducted and the enhancement in mechanical properties (tensile strength and flexural strength) of the hybrid composite material is observed.

**KEYWORDS:** Bagasse, coconut coir, matrix, reinforcement, vinylester.

## I. INTRODUCTION

Natural fibers reinforced with polymer composites have gained more attention because of their biodegradable, less expensive, light weight, easy processing, high specific modulus and also naturally appeal. The interest in long term sustainability of material resources has made advancements in bio-composites or polymer composites materials which made from natural fibers and resin. Polymeric composites may be understood as the combination of two or more materials, for example, reinforcement elements or filler involved by a polymeric matrix [1]. Natural fibers such as jute, sisal, pineapple, abaca and coir [1-11] have been studied as a reinforcement and filler in composites. Besides, Plant fibres from agricultural crops are renewable materials which have potential for creating green products and replacing synthetic materials which have potential for creating composites panel [12]. According to all the natural fibers listed, bagasse is biomass remaining after sugarcane stalks are crushed to extract their juice. A sugar factory produces nearly 30% of bagasse out of total crushing. Many research efforts have attempted to use bagasse as a renewable feedstock for power generation and for the production of bio-based material. However, the consumption of the bagasse is very low, especially in Asian country.

## II. MATERIALS AND METHODS

### A. Preparation of sample.

Bagasse and coconut coir were collected from local mill both material contain impurities like dust, small sand particle. Therefore it need to cleaned in order to get pure bagasse and coconut coir,. After cleaned with 10 % NaOH solution, the bagasse and coconut coir dried in direct sun light for 8 hours. The it were weighted according to the percentage needed (5%,10%,15%,20%). After that the unsaturated polymer resin and methyl ethyl ketone peroxide (MEPK)

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catalyst were mixed in a container and stirred well for 3 to 5 minutes. The bagasse was then added gradually and stirred to allow proper dispersion of fiber with in the gel like mixture. Before the mixture were poured inside the mould, the mould was initially polished with a release agent to prevent the composites from sticking to the mould upon removal finally, after the mixture has been poured in the mould, it was left at room temperature for 24 hours for fully cured and hardened. The materials used in the present are tabulated in table.1

Table. I Specification of material used in the research work

Materials	Specifications	Suppliers
Vinylester	Density: 1.05 g/cm <sup>3</sup> UTS: 60MPa	Nepatha resin , Bangalore
Bagasse	Density: 0.25 g/cm <sup>3</sup> Length : 2-10mm	Local market
Coconut coir	Bulk density :0.28 g/cm <sup>3</sup> length : 3- 6mm	Local market

Above materials used in the research work.vinylester is a resin it have low viscosity, higher corrosive resistant, water resistant. Bagasse and coconut coir are agriculture waste material, lighter in weight, low cost and biodegradable for this reason above materials selected for research work.

### B.Processing of bagasse and coconut coir.vinylester composite.

Bagasse Composite is prepared first to know at what percentage of weight fraction the composite gives the Ultimate Tensile Strength from that percentage some percentage of coconut coir is added to enhance its tensile property. First make some sample preparation calculation before preparing the composite as given below and start the fabrication by preparing the temporary mould using beadings arranged on the wooden base representing a rectangular mould of 300x200x5mm. Pour the calculated amount of resin with thoroughly mixed Promoters, Accelerators & Catalyst of 1%to the mould and wait for ten minutes so that it starts pre hardening then put a Mylar sheet on to it and then apply pressure by placing a concrete block over the setup for 24 hours to complete cure the laminate and once the laminate is completely cured then it is ready for machining according to ASTM standard for testing, repeat the procedure by adding 5, 10, 15, 20% wt. of bagasse to the resin. At optimum percentage then add 3, 5, and 7% of coconut coir and repeat the same procedure to get the Hybrid composite and is tested for mechanical properties.

### C.Sample preparation

Composite laminate of 300 mm X 200 mm X 5 mm were fabricated according to ASTM standards for mechanical tests.

$$\text{Density of Vinyl ester } (\delta) = 1.05 \text{ g/cm}^3$$

$$\begin{aligned} \text{Volume of the mold (V)} &= 300 \times 200 \times 5 \text{ mm} \\ &= 300000 \text{ mm}^3 \\ &= 300 \text{ cm}^3 \end{aligned}$$

$$\begin{aligned} \text{Mass of resin (m)} &= \text{Volume of mould} \times \text{Density of resin} \\ &= 300 \text{ cm}^3 \times 1.05 \text{ g/cm}^3 \\ &= 315 \text{ g} \end{aligned}$$

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Table II. Sample preparation calculations for bagasse / Vinylester composite

Samples	% wt of bagasse	% of Resin	Mass of bagasse	Mass of Resin	Total mass
A	0	100	0g	315g	315g
B	5	95	4g	300g	304g
C	10	90	8g	284g	292g
D	15	85	12g	268g	280g
E	20	80	16g	252g	268g

The above table II. Shows that sample preparation calculation for bagasse and vinylester composite .by considering 0%,5%,10%,15%and 20% weight of bagasse and 100%,95%,90%,85% and 80% weight of vinylester resin.

Table III. Sample preparation calculations for bagasse&coconut coir/ Vinyl ester composite.

Samples	% of resin	% wt of coconut coir	% wt of bagasse	mass of resin
F	85	3	12	281g
G	85	5	10	281g
H	85	7	8	281g

Table III. Shows sample preparation calculation for bagasse & coconut coir / vinylester.in this case % weight of resin is kept constant and by varying the % weight of bagasse and coconut coir. The samples are tested according to ASTM standards.

### III. TESTING

Ultimate tensile strength, often referred to tensile strength is the maximum stress that a material can withstand while being stretched or pulled before fracture. The tensile test for the specimens was conducted according to ASTM D3039. The specimens of size 250 mm x 25 mm x 10 mm were tested with a span length of 250 mm in tensile mode at a cross head speed of 1 mm / min. The fixtures used for the tensile testing is shown in Figure 1a and 1b



Fig. 1a Universal testing machine set



Fig. 1b Specimen loaded in tension

A Universal Testing Machine (UTM) is an instrument used for the measurement of loads and the associated test specimen deflections such as those encountered in tensile, compression or flexural modes. It is used to test the tensile, compression, flexural and Inter Laminar Shear Strength (ILSS) properties of materials.

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## A. Ultimate tensile strength

Ultimate tensile strength, often referred to tensile strength is the maximum stress that a material can withstand while being stretched or pulled before fracture. The tensile test for the specimens was conducted according to ASTM D3039. The specimens of size 250 mm x 25 mm x 5 mm were tested with a span length of 250 mm in tensile mode at a cross head speed of 1 mm / min. The fixtures used for the tensile testing is shown in Figure 1b.

Ultimate tensile strength was determined using the equation (1)

$$1) \text{ Ultimate tensile strength} = \frac{\text{Maximum load}}{\text{C/s area in mm}^2} \text{ in MPa}$$

$$2) \text{ Young's modulus (E)} = \frac{\text{Stress in GPa}}{\text{Strain}}$$

$$3) \text{ Stress} = \frac{\text{Load}}{\text{Area (bXd)}}$$

$$4) \text{ Strain} = \frac{\text{change in length}}{\text{Original length}}$$

Where,

P = maximum load in N

b = width of the specimen in mm

d = thickness of the specimen in mm

## B. Tensile test report

Table IV Ultimate tensile strength of Bagasse / Vinyl ester composite

Samples	Bagasse (%)	Ultimate Tensile Strength (Mpa)			Avg UTS (Mpa)
A	0	32.36	30.28	27.42	30.8
B	5	32	32.8	32.78	32.52
C	10	33.28	33.98	33.82	33.69
D	15	33.9	35.09	35.58	34.85
E	20	32.08	32.1	32.8	32.32

The above table shows that tensile strength of bagasse / Vinylester composite. The tensile strength increases from 30.80MPa to maximum 34.85 MPa and then decreases to 32.32 MPa.

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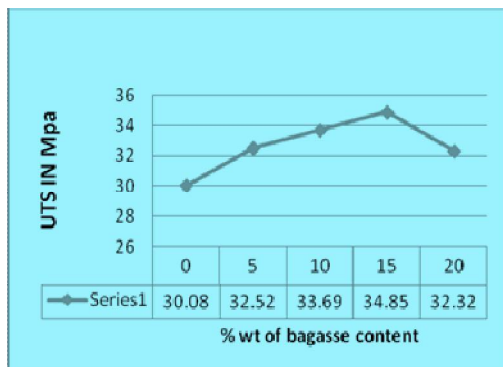
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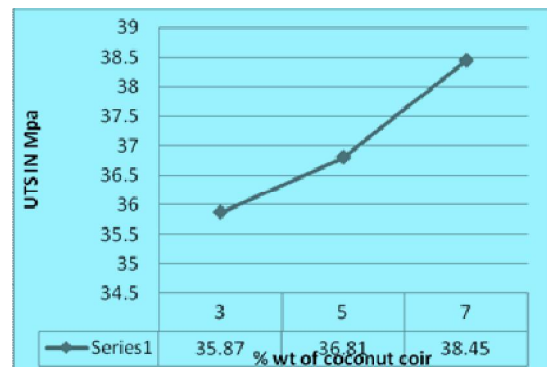
Table V. Ultimate tensile strength of Bagasse and coconut coir / Vinyl ester composite

Samples	Coconut coir (%)	bagasse(%)	Ultimate Tensile Strength (Mpa)			Avg UTS (Mpa)
F	3	12	35.7	35.63	36.26	35.87
G	5	10	36.5	36.96	37.02	36.81
H	7	8	38.4	38.5	38.46	38.45

The above table shows that tensile strength of bagasse and coconut coir/ Vinylester composite. The tensile strength increases from 35.87MPa to maximum 38.45 MPa.



Graph I. Variation of UTS values with bagasse loading.



Graph II. Variation of UTS values with bagasse and Coconut coir.

Graph I and II shows the variation of ultimate tensile strength of bagasse / vinylester composite and bagasse/coconut coir/vinylester composite respectively.

### C. Flexural strength

The use of flexural test to determine the mechanical properties of polymeric composite is widely prevalent because of the relative simplicity of the test method, instrumentation and testing equipment required. The flexural strength of the specimens were determined for specimen using the three-point bending test as per ASTM –D790. The specimen of dimensions 200mm x15mmx5mm.

The flexural strengths of the composites were determined using the formula using equation (1)

$$1) FS = \frac{3PL}{2BD^2} \text{ in MPa}$$

Where,

FS – Flexural Strength [N/mm<sup>2</sup>]

P – Peak Load [N]

L – Support Length [mm]

B – Breadth of the specimen [mm]

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### D.Flexural strength bagasse/ vinylester composite

The use of flexural tests to determine the mechanical properties of polymeric composites is widely prevalent because of the relative simplicity of the test method, instrumentation and testing equipment required .tables VI and VII list the flexural strength of bagasse & coconut coir / vinyl ester composite.

Table V. lists the flexural strength of Bagasse / Vinylester

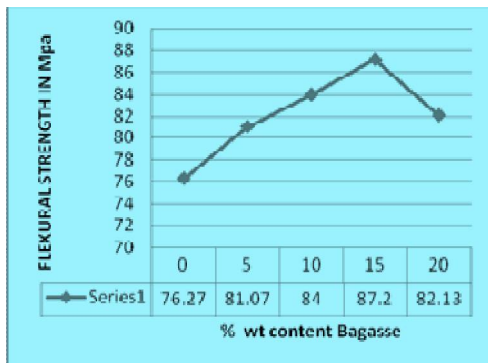
Sample	Bagasse %	Flexural strength( Mpa)			Avg FS (Mpa)
A	0	74	78.4	76.4	76.27
B	5	79.2	80	84	81.07
C	10	83.2	84	84.8	84
D	15	86.4	87.2	88	87.2
E	20	79.2	82.4	84.8	82.13

The above table shows that flexural strength of bagasse / Vinylester composite. The flexural strength increases from 76.27MPa to maximum 87.20 MPa and then decreases to 82.13 MPa.

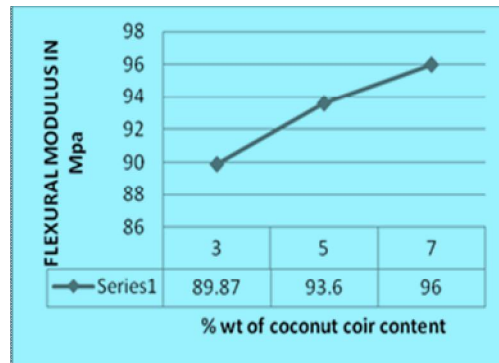
Table VI. Flexural strength of Bagasse and coconut coir / Vinyl ester composite

Sample	Coconut coir (%)	Bagasse (%)	Flexural strength MPa			Avg FS MPa
F	3	12	91.2	90.4	88	89.87
G	5	10	91.2	94.4	95.2	93.6
H	7	8	95.2	96	96.8	96

The above table shows that flexural strength of bagasse and coconut coir / Vinylester composite. The tensile strength increases from 89.87MPa to maximum 96.00 MPa.



Graph III



Graph IV

Graph III and IV Shows the Ultimate flexural Strength of Bagasse composite and Ultimate Flexural Strength of bagasse & coconut coir composite respectively at different percentage loading.

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## IV.SIMULATION AND RESULT

Table VIII Result of mechanical test

Samples	Tensile Strength in MPa	Flexural strength in MPa
A	30.08	76.27
B	32.52	81.07
C	33.69	84
D	34.85	87.2
E	32.32	82.13
F	35.87	89.87
G	36.81	93.6
H	38.45	96

Table VIII. Shows the result of mechanical test, in bagasse / vinylester composite tensile strength maximum at sample D is 34.85 MPa and in hybride composite the tensile strength maximum at sample H is 38.45 MPa. Flexural strength in case of single fiber is maximum at sample D is 87.2MPa and in hybride composite is maximum at sample H is 96 MPa.

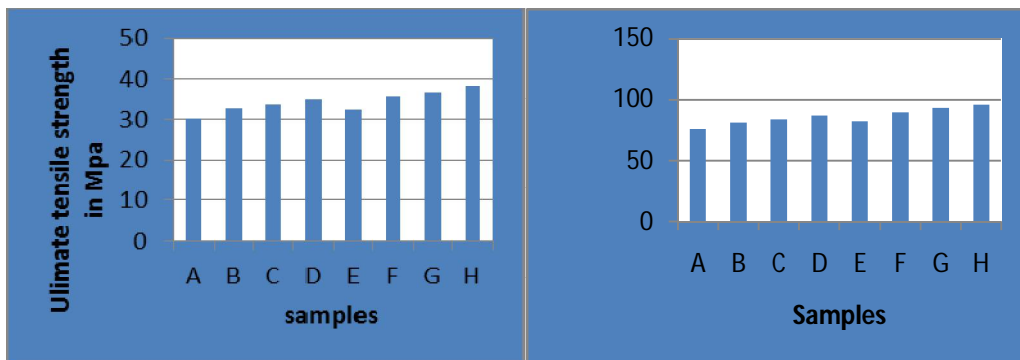


Fig (a)

Fig (b)

Fig.(a) and (b) shows ultimate tensile strength , ultimate flexural strength respectively.tensile strength maximum at sample H is 38.45MPa.and Flexural strength maximum at sample H is 96 MPa.

## V.CONCLUSION

The conclusion of the study of the study of Bagasse and coconut coir reinforced with vinylester composite is that there is significant increase in the tensile strength and flexural strength of the composite.

1. Tensile strength increased by 37.66% gradually with more percentage of loading of Bagasse composite and hybrid composite
2. The flexural Strength increased by 20.56%, gradually with the more percentage Bagasse .and hybrid composite

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3. Random oriented bagasse fiber –polyester composites are low-strength materials, but can be designed to have a set of flexural strengths that enable their use as non- structural building elements.
4. To have better mechanical properties at higher fiber content , The bonding between The bagasse and vinyl ester must improved
5. To increase the mechanical properties of the composite there must be homogenous mixture of the fiber and matrix to have the property of the composite.
6. Hybridization has been successfully found to be better option to have better mechanical property which alone a Bagasse fiber fails.

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