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Evaluation of Tensile Properties of Jute Natural Fiber Reinforced PU Polymer Matrix Composite Material

M.G.Suresh, R.Suresh

Abstract: ***The objective of this Research work is to evaluate & analyze the Tensile properties of developed composite specimen with polyurethane foam as matrix material & jute fiber as Reinforcement material. The first research experimentation shall be the tensile test is done as per the ASTM D3039 standard to investigate the tensile properties of this combination of composite materials The main aim of this experimentation tests done are to investigate mechanical properties & strengths of newly developed jute reinforced composites to resist against the subjected tensile & bending loads under various conditions.***

Keywords : Composites, fiber, jute, polyurethane, tensile test.

I. INTRODUCTION

This research work is basically focusing on the development of natural fibers composites using jute fibers [12] reinforcement is to explore in low load condition applications and analyze its mechanical properties. Composites, the wonder material [13] with light weight, high strength to weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals, woods etc. The replacement of steel with composites can save a 60% - 80% of component weight and 20% - 50% weight of aluminium components. Thus jute fiber reinforced PU foam composites is a latest & new combination of composite materials with its combined properties & characteristics have wide scope and can be introduced for several salient applications such as Railway coach interiors, sleepers for railway girder bridges, modular toilet units in railway, railway coaches main doors for passengers, for automobile seats & accessories, boat hulls, Modular house construction & domestic furnitures.

M.G.Suresh, Associate Professor, Department of Mechanical Engineering, Holy Mary Institute of Technology & Science, Bogaran (V), Keesara (M), Medchal District, Hyderabad – 501301, Telangana State, India

Dr. R .Suresh, Professor & Co-ordinator, Bio-Fuel Information and Demonstration Centre, Dept. of Mech. Engg., Siddaganga Institute of Technology, B.H.Road, Tumkur-572103, Karnataka State, India

II. OBJECTIVE

In this research work proceedings, firstly, the jute fiber reinforced composites were prepared by Resin Transfer Mold (RTM) [11] process using mild steel moulds. The proportions of jute fiber – PU foam [1] are mixed as per the rule of mixture ratio in composites.

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* Correspondence Author

Prof. M.G.Suresh, Associate Professor in Holy Mary Institute of Technology & Science, Hyderabad

R Suresh, Professor in Department of Mechanical Engineering in SIT,

The developed composite specimens of :

(a) 50% PU & 50% Jute fibers ratio

(b) 60% PU & 40% Jute fibers ratio

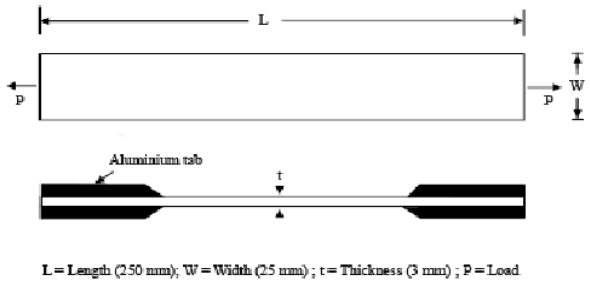
In this research work, the development of Jute reinforced PU foam composite material[2] is composed of the following Matrix & reinforced materials as mentioned in table (1.0).

Table I : Matrix & Reinforcement details

Reinforcing fiber	Bi-directional , woven Jute fiber mat (Stiched into a fabric form) of 500gsm
Matrix system	Polyurethane foam (140 HRC)
Moulding process	Resin Transfer Mould (RTM) process followed by room temperature molding
Reinforcements :	Matrix ratio : (a) 50:50 (b) 40:60

III. SPECIMEN SIZE FOR TENSILE TEST

The most common specimen for ASTM D 3039 is a constant Rectangular cross section, 25 mm (1 in) wide and 250 mm long.



L = Length (250 mm); W = Width (25 mm) ; t = Thickness (3 mm) ; P = Load

Fig. (1) Specimen dimension for tensile test as per ASTM D 3039 standards

IV. ABOUT ASTM D 3039 FOR TENSILE TEST

Fig.. (2) Tensile test setup in Tensometer machine

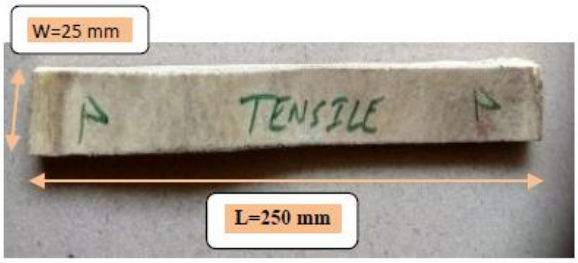
ASTM D 3039 Tensile testing [3] is used to measure the forces that required to break a polymer matrix composite [4] specimen and extent to which specimen stretches or elongates to that braking point.

The Tensile tests produce a Stress-Strain diagram, which is used to determine tensile modulus [5]. This data is often used to specify a material, to design parts to withstand application forces and as a quality control check of materials. Since the physical properties of many materials can vary depending on ambient temperature, it is sometimes appropriate to test materials [6] at temperatures that stimulate the intended end us of environment.

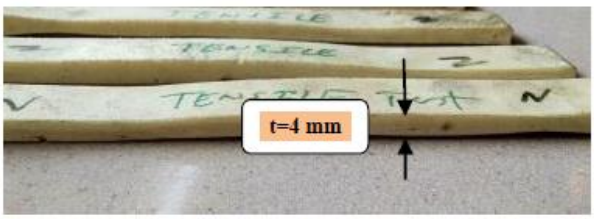
A. Experimental Procedure :

1. The developed specimens are placed in between the grips of a Tensometer at a specified grip separation and pulled until failure occurs. For ASTM D 3039 the test speed can be determined by the material specifications or the time to failure (1 to 10 minutes). A typical test speed for standard test specimens is 2 mm/min.
2. Specimens are placed in the grips of a Universal Test Machine at a specified grip separation and pulled until failure. For ASTM D3039 the test speed can be determined by the material specification or time to failure (1 to 10 minutes). A typical test speed for standard test specimens is 2 mm/min. A extensometer or a strain gauge is used to determine elongation and tensile modulus of the subjected specimen.
3. The load this specimen into tensile grips of tensometer as shown in Fig. (4a).
4. Then begin the test by separating the tensile grips at a constant rate of speed. The speed depends on the shape and in this the test speed is 10mm/min and the target time from start of test to break should be from 30 seconds to 5 minutes.
5. The specimen gauge length is 60mm.
6. The cross section of the subjected specimen is Rectangular type.
7. Finally, end the test after sample break or ruptures and tabulate the results.

B. TEST SPECIMEN DIMENSIONS :



(a)

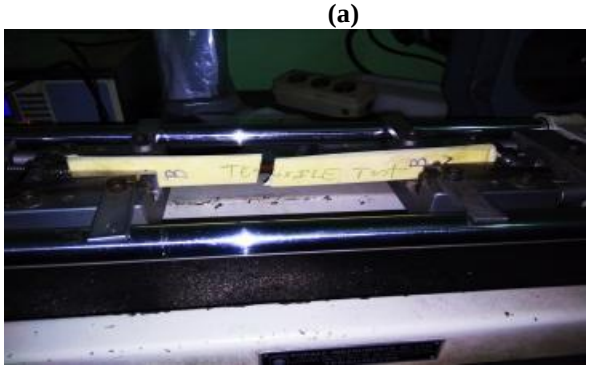


(b)

Fig. (3) Developed composite test specimen dimensions for tensile test

C. Tensile Test Conducted On Developed Specimen In Certified Test Centre :

(a)



(b)

Fig. (4-a&b) Tensile test conducted on Tensometer

D. EQUIPMENT USED:

1. The testing machine used is Tensometer (With UTM attachment setup) for conducting tensile test.
2. The testing machine equipped with servo Controlled for keeping a constant rate of speed.
3. The capacity needs to be enough for the testing materials. Usually a 2,000 Kgs dual column system is very commonly used. A high capacity of 10,000 Kgs model is sometimes needed for larger samples and / or stronger materials such as reinforced composites or plastics.
4. The extensometer or strain gauges are interfaced and integrated within the testing equipment.
5. Obtaining Data : The testing software has built-in support for ASTM D 3039 and suitable mechatronics are essential to operate this machine and to carryout the measurements. The basic systems will provide the raw data and Stress-Strain characteristics charts. Using these sources of data, we can determine and all of required calculations & analysis are provided immediately after performing the test.

V. RESULTS AND DISCUSSIONS

A. Jute Reinforced Composites for 60% PU & 40% Jute after Rupture :

Specimen after fracture on Tensometer subjected to Tensilel Test

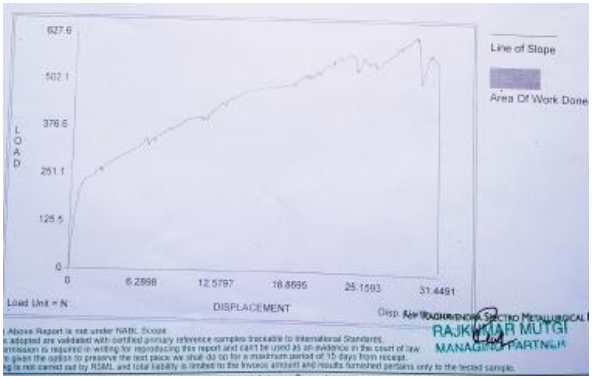
Fig. (5) Fractured specimens when subjected to Tensile test

Table Ii:Tabulation For Tensile Test Conducted As Per Astm D 3039 Standards For 60% Pu & 40% Jute :

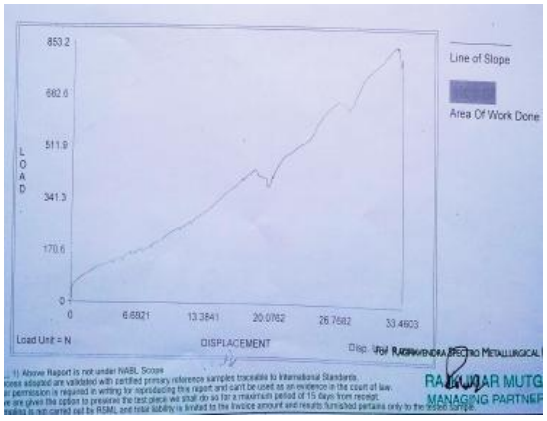
Trial No.	Peak Load (N)	Break Load (N)	Break Displacement (mm)	Ultimate Tensile Strength (N/mm^2)
1	627.6	431.5	31.415	97.69
2	853.2	402.08	33.426	132.8
3	892.4	637.45	41.87	138.6
Average	**791.07**	**490.34**	**35.57**	**123.03**

Specimen cross section: Rectangular type

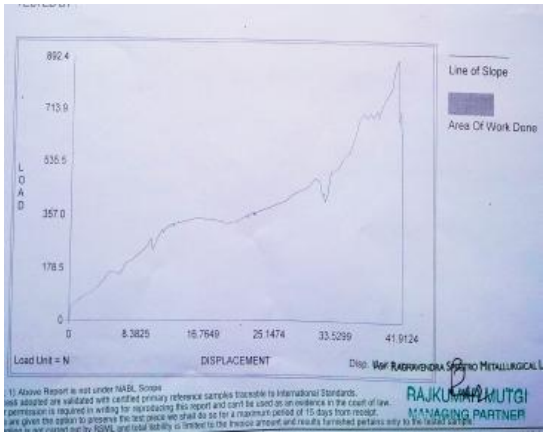
B. Jute Reinforced Composites For 60% Pu & 40% Jute For Tensile Test



(a)



(b)



(c)

Fig.(6) Characteristics of Tensile Test for jute Composites of 60%PU & 40% Jute specimens (a,b,c)

C. JUTE REINFORCED COMPOSITES FOR 50% PU & 50% JUTE AFTER RUPTURE :

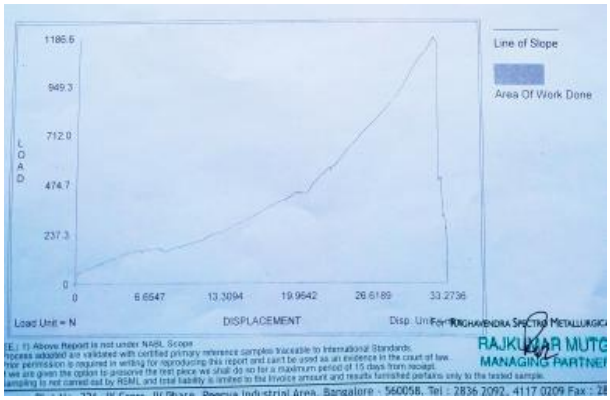
Fig. (7) Fractured specimens when subjected to Tensile test

Table Iii : Tabulation For Tensile Test Conducted As Per Astm D 3039 Standards For 50% Pu & 50% Jute :

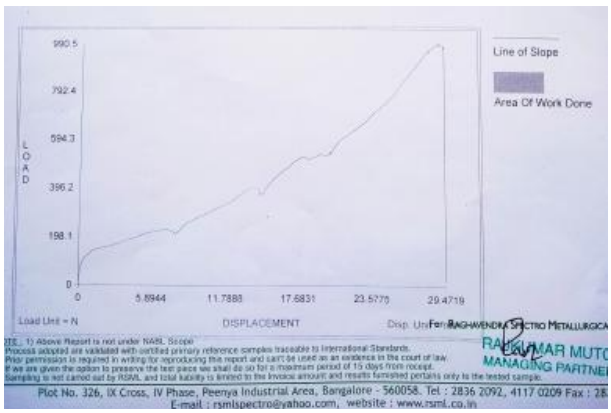
Specimen cross section : Rectangular type

Trial No.	Peak Load (N)	Break Load (N)	Break Displacement (mm)	Ultimate Tensile Strength (N/mm^2)
1	1186.60	264.78	33.18	230.88
2	990.50	180.70	29.43	192.72
3	1206.30	186.33	85.42	234.71
Average	***1127.8***	***210.6***	***49.34***	***219.43***

D. JUTE REINFORCED COMPOSITES FOR 50% PU & 50% JUTE FOR TENSILE TEST



(a)



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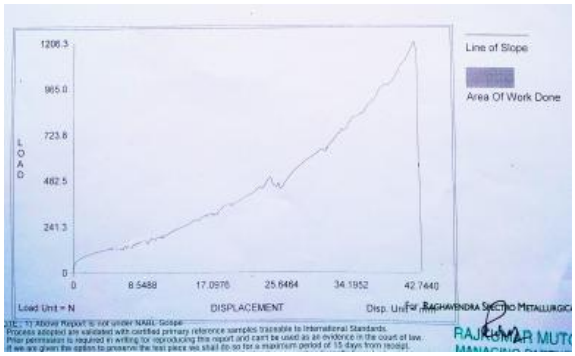


(c)

Fig. (8) Characteristics of Tensile Test for jute Composites of 50%PU & 50% Jute specimens (a,b,c)

E. 100% PU SPECIMENS AFTER RUPTURE :

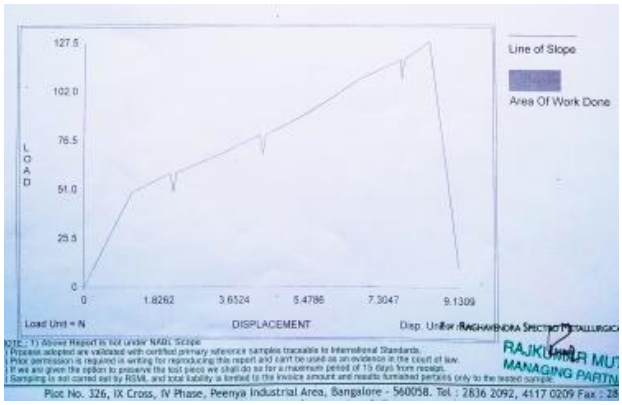
Fig. (9) Fractured specimens when subjected to Tensile test

Table Iv : Tabulation For TensileTest Conducted As Per Astm D 3039Standards For Pu Specimen Only :

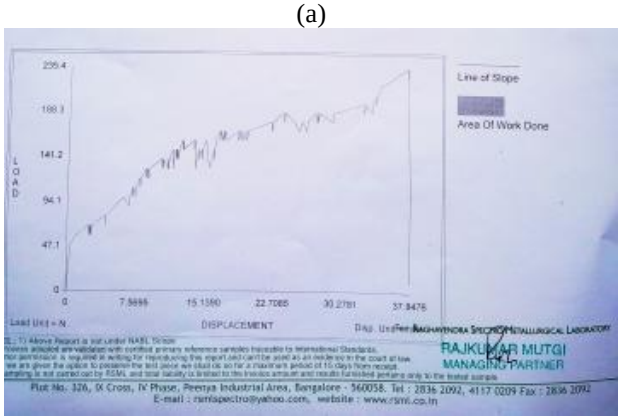
Specimen cross section : Rectangular type

Trial No.	Peak Load (N)	Break Load (N)	Break Displacement (mm)	Ultimate Tensile Strength (N/mm^2)
1	127.50	127.49	8.45	13.89
2	235.40	107.87	37.80	25.64
3	313.80	313.82	24.58	34.18
Average	***225.57***	***183.06***	***23.61***	***24.57***

F. FOR 100% PU SUBJECTED TO TENSILE TEST



(a)



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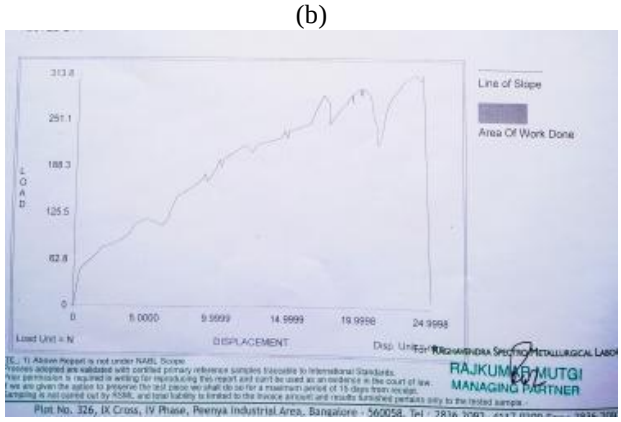

(c)

Fig. (10) : Characteristics of Tensile Test for 100% PU specimens (a,b,c)

G. DISCUSSIONS - TENSILE STRENGTH

From the tensile test, the following are the observations were made :

From the tensile test, the following are the observations were made :

- The Jute natural fiber reinforcement have effect on the tensile strength of polyurethane foam matrix is as demonstrated in Fig. (6,8,10) respectively.
- As depicted in Fig.(6), the Tensile strength is increased linearly up to certain weight % [7], then after that it tends to decrease despite of the further rise in Wt % of the natural fiber reinforcement. The reason may be the fact that, as the Wt% of the reinforcement fiber increased, the weak interfacial area [8][9] and the micro spaces increased between the fibers and matrix, accordingly bringing down the tensile strength.
- It is also fact that at high % reinforcement, is more difficult to completely impregnate the fibers, resulting to poor interfacial bonding and subsequently lower mechanical properties. So as a result, chances are there of decreasing trend in tensile strength with the increasing fiber content in the composites.
- From Fig's (6 & 8) & Table (II&III), It is noticed from the test characteristics that tensile strength for 50% jute & 50% PU mixture has increased than that 40% jute & 60% PU, as the jute fiber density increases. So the breaking load also has increased with this increase in Jute%.
- Also it is seen that the breaking load is higher & have increased for 50% jute & 50% PU with enhanced jute fiber reinforcement comparably with 40% jute & 60% PU mixture ratio.
- From fig. (10), with only PU material which has a lower breaking load signifies that introduction of jute fiber will definitely a suitable reinforcement which will drastically increases the tensile strength of this composite material.
- Hence Jute reinforcement can be increased with PU matrix upto certain mixture ratio beyond which there could arise poor bonding between the two materials.

VI. CONCLUSIONS

In this research & experimental investigation, Jute fiber reinforced PU matrix composites were fabricated & developed. The tensile behavior of the developed composites were analyzed. As a result the tensile test of the developed composites substantiate their mechanical behavior. Thus the following conclusions can be drawn.

1. In this investigation it has been found that the reinforcement of jute fibers with PU polymer matrix have drastically increased its respective tensile strength, increasing its sustainability against the subjected loads.
2. Thus the developed composite specimens with mixture ratio of 50% Jute & 50% PU have Shown an increased its breaking strength or breaking loads than that of 40% Jute & 60% PU when subjected to tensile test.
3. In the overall study, the strength of 50% Jute & 50% PU foam laminates has higher value than that of 40% Jute & 60% PU foam laminates in Tension.
4. Hence reinforcement of jute fibers with PU foam matrix is one of the favorable Composite materials which can play a prominent vital role in future for many industrial & other applications.
5. So it is concluded that further investigation on future experimental tests will definitely assure the use of this newer composite materials in coming future for our society.

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AUTHORS PROFILE

First Author : Prof. M.G.Suresh, Completed B.E. in Mechanical Engineering from PES College of Engineering, Mandya in 1997 and M.E. from UVCE. Bangalore in 2011. Now pursuing my Ph.D & Research work from VTU, Belgaum from 2012 onwards especially on polymer Composites. Presently working as Associate Professor in Holy Mary Institute of Technology & Science, Hyderabad from past 3 years. Having work experience over 20 years in both Teaching & Industry. Participated in many National conferences & presented many technical papers. The following are the technical papers published ; (a) Technical paper on " Graphene: A New Evolution In Material Science & Technology", Journal of Science &Technology, April 2014, Vol3,. (b) Published technical paper on "Natural Fiber Composites : Technology & Applications" in Technical Research Organisation, 2018, Pg. 69-74.

Second Author : R Suresh, working as Professor in Department of Mechanical Engineering in SIT, Tumkur from 1986. Carrying out research work on Metal & Polymer matrix composites from past 10 years. Also additional incharge as coordinator in Bio-fuel Information and Demonstration Centre, Dept.of Mech. Engg., SIT, Tumkur. Published more than 20 papers in various technical journals on Composites & Bio fuels.