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Fabrication, Testing and Analysis of Braided and Short fibre reinforced Jute Epoxy Bio-composite

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Abstract: The main objective of this paper is to fabricate and test the Jute-Epoxy braided as well as short fibre reinforced composite which is of low cost, low density, high specific strength, no health risks, renewable, environment friendly and lower energy requirement for processing. The jute fibres used have undergone alkali treatment to improve their properties and blended with epoxy resin and cured. The later stage of our work deals with the Tensile Test of both types of specimens ,Impact & Flexural test of Braided composite according to the ASTM standards for Plastics. Further an extensive comparison of braided & short fibre composite has been done along with finite element analysis to validate the results.
Keywords: Jute; Fiber; Epoxy; Composite; Tensile Strength; FEA; ANSYS.

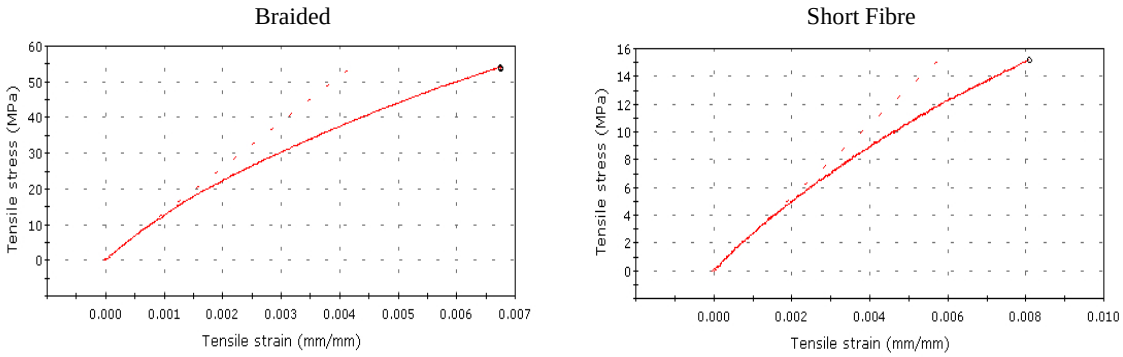
Introduction and Experimental:

An Important fact of increase in the use of bio composite has been its bio degradable property which gives it an edge over the existing synthetic material of which most are non-biodegradable. There is wide range of natural fibres are available which can be used as a substitute for the existing synthetic materials or metals without compromising its strength and durability. The most important type of composite fibre used is those made from jute, coir, bamboo, sisal, hemp etc [1][2]. Jute is available in abundance, eco friendly, high weight to strength ratio and has excellent moisture retaining capacity[3]. All this features of jute makes it the best suitable natural fibre to be reinforce with thermoplastic and thermosetting plastic both. The Epoxy Resin in our case adds to the existing mechanical strength of the jute fibre in particular stiffness and strength and that to at acceptable low price. Alkali treatment of natural fibres is one of the most common treatments of the natural fibres as it improves the adhesion between the different layers of fibre and combines them into a single unit [4].The fabrication of braided jute epoxy enriched composite was done by subjecting untreated double woven jute mat and jute short fibres to alkaline treatment in 5%NaOH solution for 4 hours at room temperature [4]. The alkaline treated jute fibres were then washed thoroughly in pure water. The cleaned jute fibres were subjected to drying in room Temperature for 24hrs and in an industrial furnace at 80 degree Celsius for 1 hour, thereupon the jute fibre was reinforced with Epoxy (LY556 + Hardener HY951) [2] using hand lay method, the same procedure was repeated for the fabrication of randomly oriented jute short fibres each of length $\approx 10mm$ in a wooden mold. The advantages of using epoxy resins as a binding agent are excellent mechanical strength, good electrical properties and chemical resistance [5]. Epoxy reinforced jute fibre was then left for curing for 48 hours [6]with an uniform weight distribution of 24 kg over the surface of the resin reinforced jute fibre [7].

Fig.1: Tensile Testing and Epoxy Enriched Jute Composite

Mechanical Testing

Both Specimens were tested according to the Tensile Standard from American Society for Testing and Materials "ASTM D3039" and Braided composites were subjected to Flexural Three point bending test "ASTM D790" using equipment INSTRON 8801 with cross head speed of 1mm/min [6].Later Braided Composites were further subjected to Charpy Impact test according to "ASTM D256" Standard [11].



Graph 1. Experimental Test Results f V/S δ

Results and Discussion

There is negligible or very small elongation present in the tensile test specimen. A comparative study was conducted between tensile strength of braided reinforced composite and short fibre reinforced jute composite [10]. Further Braided analysis is done using layup module present in the software Analysis System "ANSYS" & Short fibre reinforced composites are analyzed using Unit cell Concept [12]. Here the model was created in SOLIDWORKS 2010 and analyzed in ANSYS workbench maintaining the volume fraction. The reasons for low strength in short fibre composite may be due to presence of micro voids at the interfaces and based on Griffith Fracture theory strength of freshly drawn fibres is much greater than that of old or aged fibres.

Table 1. : Experimental Test Results

Specimen label	Strain at Max Load (Braided)	Strain at Max Load (Short Fibre)	Load at Break (Braided)	Load at Break (Short Fibre)	Stress at Break (Braided)	Stress at Break (Short Fibre)	Energy Absorbed (Braided)
	(%)	(%)	(kN)	(kN)	(MPa)	(MPa)	(Nm)
1	0.77214	0.50163	5.21	1.67	59.51	13.94	0.95
2	1.83267	0.29832	4.67	0.88	53.38	7.32	1.15
3	0.83373	0.78622	5.2	1.85	59.41	15.43	1.1
4	0.77849	0.8047	5.38	1.98	61.53	16.52	1.2
5	0.67473	0.80997	4.71	1.82	53.86	15.19	1.1
6	1.88349	0.47974	4.86	1	55.59	8.34	1
Mean	**0.80611**	**0.643925**	**5.03**	**1.745**	**57.5**	**14.565**	**1.1**

Analytical Calculations:

Calculation of Volume Fraction of Fibre [3] [8]

$$V_f = \frac{\rho_M w_F}{\rho_F w_M + \rho_M w_F}$$
$$= \frac{1.2 \times 50}{((1.29 \times 80) + (1.2 \times 50))}$$

V_f = Volume Fraction of Fibre V_m = Volume Fraction of Resin

$$V_f = 0.3676$$
$$V_m = 1 - V_f$$
$$V_m = 0.632$$

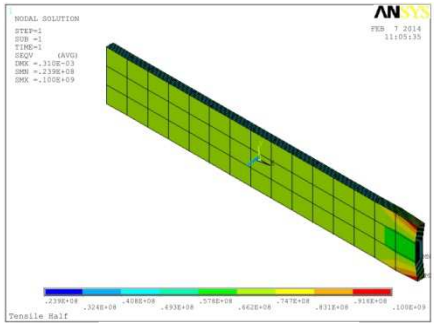
Calculation of Min Fibre Length [9]

$$l_c = \frac{\sigma_f \times d}{2 \times \tau_c}$$

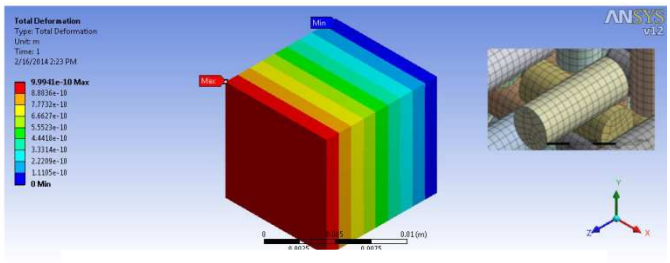
l_c = Critical length of Fibre to maintain strength.
σ_f = Tensile Strength of Fibre.
τ_c = Bond Strength .
d = Di

$$l_c = \frac{450 \times 10^6 \times 18 \times 10^{-6}}{8 \times 10^6}$$

$$l_c = 8mm$$



Tensile Braided



Tensile Short Fibre

Fig 2. FEA Results

Conclusion

In this study tensile strength of braided jute epoxy composite and short fibre reinforced jute composite was compared which resulted that braided composite's have higher strength & are comparatively easier to manufacture.FEA analysis results were compared with experimental results & were found to be within limits. Impact Strength of Jute epoxy Composite's whether braided or short fibre is low compared to synthetic fibres & can be increased if the duration of alkaline treatment of jute fibres are increased.

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