International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 2, Issue 2 (January 2013) PP: 65-70

Investigation on Effect of Fiber and Orientation on the Properties of Bio-Fibre Reinforced Laminates

Sripathy Malaiah[1], Krishna Vinayak Sharma[1], M Krishna[2]
[1]Department of Mechanical Engineering, UVCE, Bangalore University, KR Circle, Bangalore560001, India
[2]Research and Development, R V College of Engineering, Mysore Road,Bangalore-560059, India

Abstract:- The objective of this work is to investigate the effect of fibre type and fibre orientation tensile and flexural shear properties of woven jute and bamboo fibre reinforced epoxy composites by experimentally. Laminates were fabricated by hand lay-up technique in a mould and cured under light pressure for 60 min followed by curing at room temperature for two days. Jute and bamboo laminates were made with a total of six piles by varying two orientation of fibre as to obtain four different samples. Specimen preparation and testing was carried out as per ASTM standards. The results shows the tensile strength and flexural strengths of the jute and bamboo laminates higher at 0/90° orientation and jute shows the highest in both tensile and bending strength.

Keywords:- Natural fibre, fibre orientation, tensile strength, SEM**.**

I. INTRODUCTION

The natural fibre reinforced composites (NFRC) are rapidly replacing petroleum based composites in different areas such as automotive, electrical construction and even building industries [1-3] due to low-density materials yielding relatively light weight composites with high specific properties[4-5]. One of the main important aspects of the behaviour of NFRC is their response to an bending load and the capacity of the composites to withstand it during their service life. Some of the reported work has suggested that NFRC are very sensitive to impact loading [7].

However the mechanical properties of natural fibre composites much lower than those of synthetic fibre composites [8]. The fibre type and fibre orientation also influence on mechanical properties of NFRC. The aim of this work was to study the influence of fibre type and fibre orientation on the mechanical properties of epoxy composites and also studied fibre breakage during the experimental studies.

II. EXPERIMENTAL STUDY

Calcium hypochlorite and hydrogen peroxide used as a oxidizing agent to remove dust and oil from natural fibre. Alkanline treatement with NaOH, known as mercerization, extracts lignin and hemicelluloses, increasing the tensile strength and the elongation at break of the composite. In this process the fibre are immersed in 10 wt.% solution of NaOH for two hours, followed by continuous washing and drying at 100 °C.

The composites used in the study were virtually identical in every aspect bamboo / jute used was plain-woven fabric type. The bamboo or jute was coated with an emulsion based sizing agent to promote good chemical adhesion with the resin matrix. The resin used in this study was epoxy (Ciba-Geigy, Araldite-LY 556 and Amine Hardener HY 951 – The resin hardener ratio- 100:10). The specimens were fabricated using wet hand layup process. Woven mat 2-D fibers [0/90] and [45/45] were used in the specimens. The number of fiber layers was derived based on the resin: fiber proportion 50: 50 wt % in all the cases. The specimens were cured at room temperature for two weeks as most of the materials for industrial applications are naturally cured, before exposing to experimental conditions. The edges of the panels were sealed using the matrix resin before exposing to the experimental conditioning. This was to prevent the moisture permeation through these sides.

Mechanical properties such as ultimate tensile strength (UTS), Young's modulus, Flexural strength (FS), Flexural modulus of fibre reinforced epoxy composites are computed from the test conducted using universal testing machine (UTM) in accordance to ASTM standards. The Test specimen geometry as specified in the above standard for balance symmetric glass are, width 12.7 mm, length 208 mm and thickness 3 mm. The test specimen is positioned vertically in the grips of the testing machine. The grips are tightened evenly and firmly to prevent any slippage. The samples are cut to the dimensions as per ASTM standards for flexural testing. The test specimen geometry as specified in the above standard for balanced symmetric glass fibre composites (0/90) are , width 12.7 mm, length 127 mm, thickness 6 mm. The test is conducted at a strain rate of 0.5mm/minute.

III. RESULTS AND DISCUSSION

3.1 Tensile Strength with fibre orientation

The strain–stress curves for jute and bamboo composites with fibre orientation of 0/90 and 45/45 °are plotted in Fig. 1. From this figure, an increase in maximum tensile strength and a reduction in strain is observed with an increase in jute reinforced plastic composites at 0/90° fibre orientation being prominent. This indicates that jute fibre is acts as reinforcement and also as an effective stress transfer constituent in the composite system. Composite with 0/90 ° fibre orientation has demonstrated a factor of improvement in tensile strength when compared with the 45/45 ° fibre orientation. The maximum tensile strength of jute fibre composites is 22.01 Mpa with a strain at ultimate strength of 2.1%. The same trend of higher tensile strength is observed in case of bamboo composites.

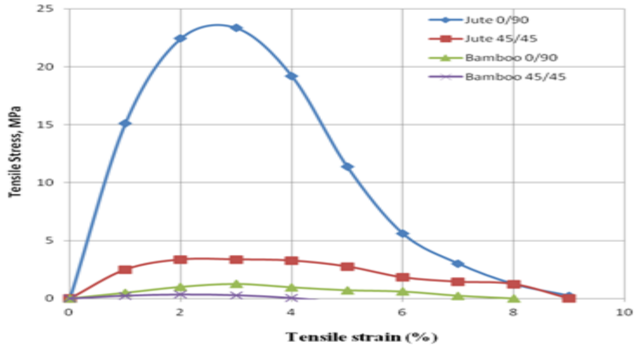


Fig. 1: Typical stress–strain curve of jute and bamboo epoxy composites for different fiber orientation

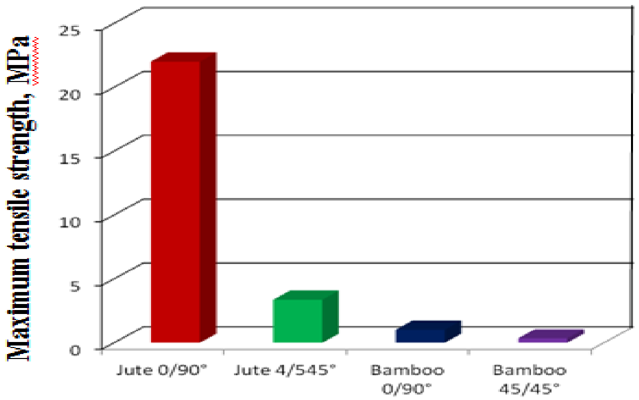


Fig. 2 Maximum tensile stress of Jute and bamboo composites at different fibre orientation

A comparison of tensile strength between jute and bamboo specimens with different fibre orientation is presented in Fig. 2, 3 and 4. It can be seen that the tensile properties of jute composites compares well with those of bamboo composites for 0/90 ° and 45/45 ° fibre orientation. The tensile strength of jute $0/90^0$ composites is 535% more than that of jute 45/45**,** while jute 45/45 is 230% more than that of bamboo 0/90 and bamboo 0/90 is 191 % more than that of bamboo 45/45.

The improved tensile strength in jute 0/90 ° could be attributed to several factors. Firstly, the density of jute 0.88 g/cc is marginally less than that of bamboo matrix at 0.96 g/cc, which suggests that the jute has less branching, therefore providing stronger intermolecular forces and tensile strength.

Secondly, during the recycling process the presence of additive compounds, such as cellouse, could improve the compatibility of jute fibre with epoxy matrix, which in turn will increase the tensile strength of jute composites. With the 0/90 ° fibre orientation the maximum strength can be observed, the fibre matrix compatibility plays more significant role in contributing mechanical properties of composites. As a consequence of this, the maximum tensile strength for jute composite with 0/90 ° fiber loading showed an improvement of nearly 6.53 times when compared to that of jute with 45°/45° orientation composites.

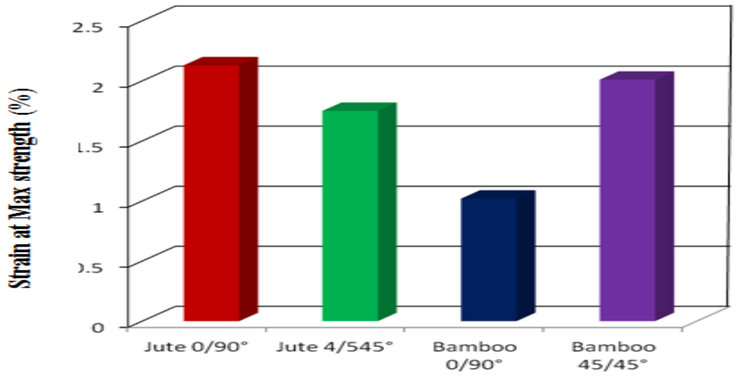


Fig.3: Strain (%) at maximum strength for jute and bamboo composites at different fibre orientation

Fig. 3 shows the values of strain at maximum strength and also as a function fibre orientation for composites containing both jute and bamboo composites. It can be observed here that there is improvement in composite stiffness with an increase in fibre orientation in case of jute composites. However, in the case of the bamboo the reverse is observed. That is, the strain in the case of bamboo 45/45 orientation is higher than bamboo with 0/90 orientation.

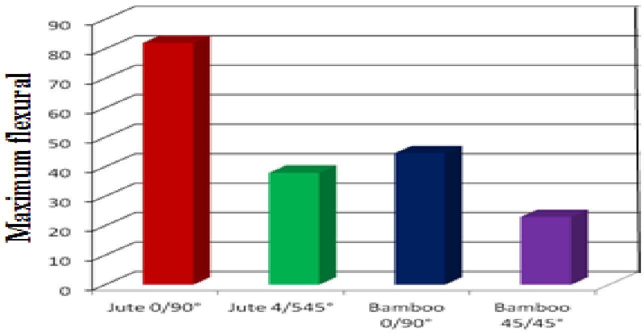


Fig 6: Variation of flexural strength of jute and bamboo epoxy composites for different fiber orientation

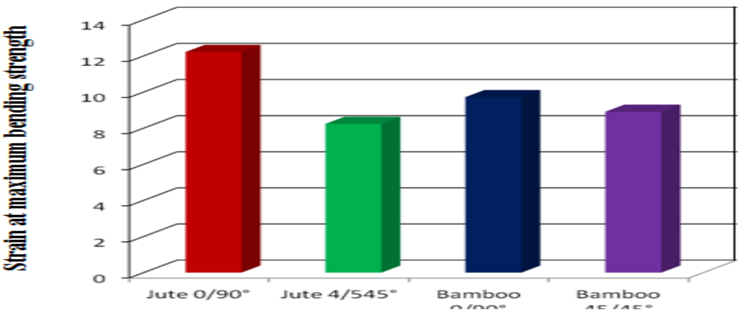


Fig 7: Variation in strain at maximum bending strength for jute and bamboo epoxy composites at different fiber orientation

Fig. 4 shows the results of the variation of Young's Modulus (E) within the elastic limit as a function of the fibre orientation for composites containing both jute and bamboo composites. As was observed in the case of tensile strength, the value of Young's Modulus can be seen to improve with an increase in fibre orientation. A significant improvement of the Young's Modulus in the case of jute composites was observed at 0/90 ° fiber orientation when compared to that of 45/45° fiber orientation.

3.2 Flexural Strength with fibre orientation

Flexural strength, the strain at maximum strength and the flexural modulus at 1% and 3% strain for jute and bamboo composites were tested on the UTM in accordance with ASTM D790 standard. The dimensions of the test specimen were maintained to be as per the standard. Three specimens were tested in each case to ensure repeatability of values.

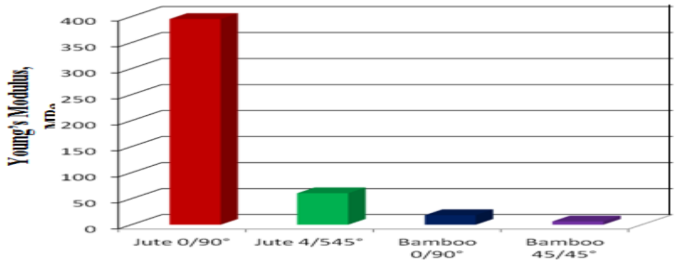
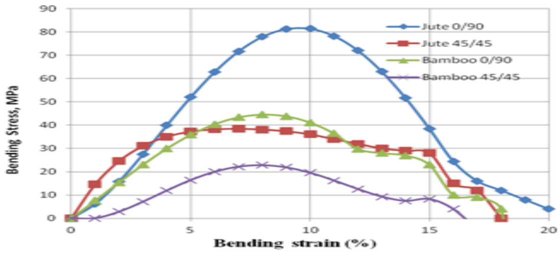


Fig.4: Young's modulus of jute and bamboo composites for different fibre orientation



The strain–stress curves for jute and bamboo composites with 45/45° and 0/90° fibre orientation are plotted and shown in Fig. 5. The figure shows an increase in maximum flexural strength and strain with an increase in the angle of fibre orientation. This indicates that the jute fibre acts as a reinforcing and also as an effective bending stress transfer constituent in the composite system.

The flexural strength in the case of for both jute and bamboo composites laminates with 45/45 ° and 0/90 ° fibre orientation are plotted and shown in Fig. 6. It can be observed that as the fibre orientation increases, there is an increase in the bending strength and stiffness. This is similar to the results obtained from tests conducted on tensile testing. The highest value of flexural strength and stiffness are seen in the case of jute composites laminates with 0/90 ° fiber orientation.

The percentage decrease in the maximum flexural strength between Jute 0/90 to Jute 45/45 is a 217% and from jute 45/45 to bamboo 0/90 shows an increase in flexural strength by 14.91%.However there is a decrease in the maximum flexural strength from bamboo 0/90 to bamboo 45 by a factor of 94.12%.

Thus the best orientation and composition is terms of the maximum flexural strength is 0/90 jute composite system with maximum flexural strength being 82.02 Mpa.

However, in the case of bamboo composites laminates at 0/90 orientation, the bending strength and the modulus at 1% strain are 44.59 MPa and 685 Mpa, respectively. This could be attributed to the insufficient interface bonding between fibers with epoxy matrix to transfer shear strength. In this study, the strain at maximum flexural strength and the flexural modulus of composites at 1% and 3% strain are presented in Figures 6.7, 6.8 and 6.9 respectively for the selected composite systems. This was done to specifically evaluate the low flexural strain behaviour and stiffness for possible structural applications.

The testing results indicate that jute/epoxy combination at 0/90 fiber orientation is the optimized combination for obtaining high flexural strength and modulus. The maximum bending strength and stiffness was observed for composites with 0/90 fiber orientation. This may be due to the higher compatibility and better interface bonding between the jute fibers and epoxy matrix. A summary of the flexural testing results are presented in grahps. Results from both tensile and flexural testing results indicate that under quasi-static loading condition, the mechanical properties of the jute composites with epoxy matrix are compatible with those of bamboo/epoxy matrix

IV. FIBER FRACTURE AND DAMAGE STUDIES

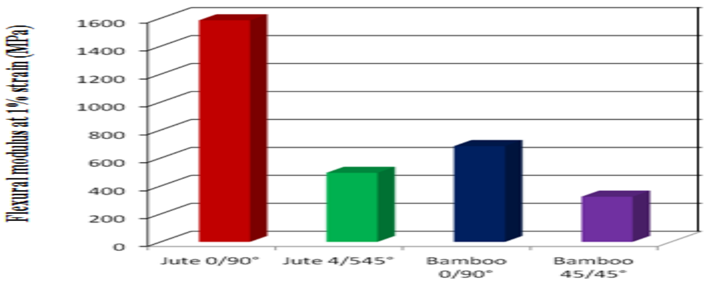


Fig. 8: Variation of flexural modulus at 1% strain for jute and bamboo epoxy composites at different fiber orientation

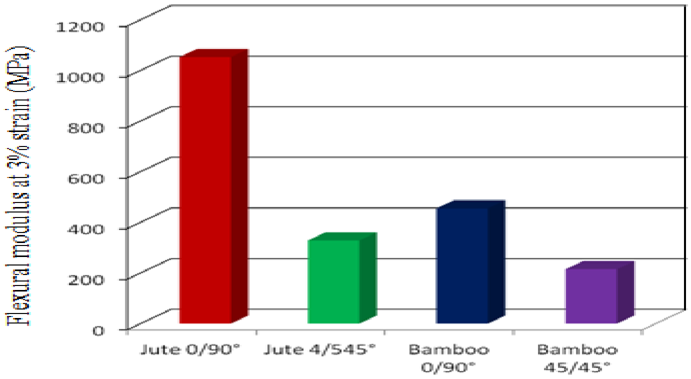


Fig. 9: Variations of flexural modulus at 3% strain for jute and bamboo epoxy composites at different fiber orientation

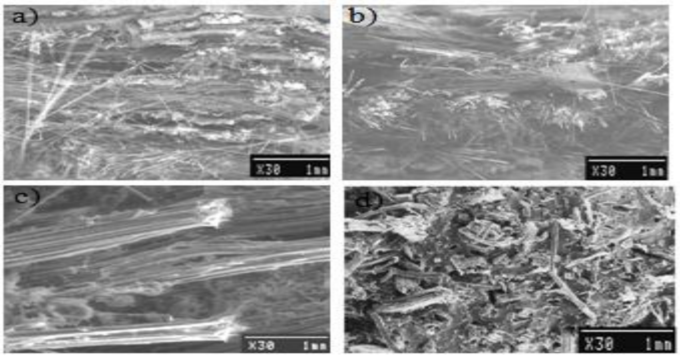


Fig. 10 SEM image of fracture surface of a) Jute / epoxy composites laminates (0/90° fiber orientation), b) Jute / epoxy composites laminates (45/45° fiber orientation) c) bamboo/ epoxy composites laminates (0/90° fiber orientation), b) bamboo / epoxy composites laminates (45/45° fiber orientation)

Fig. 10 shows an overview of the fractured surfaces of jute-epoxy (0/90 ° fibre orientation), jute-epoxy (45/45° fibre orientation), bamboo-epoxy (0/90 ° fibre orientation) and bamboo- epoxy (45/45 ° fibre orientation) composites. It shows many fibre pullouts in all composites and that bamboo fibres are coarser when compared to jute fibres. Jute fibres are the thinnest when compared with the other and are also more evenly distributed in the epoxy. The reason for this separation is expected to lie in the enzymatic retting process and the lower lignin content when compared with other fibres. Jute fibres are better dispersed and distributed in the epoxy matrix when compared with bamboo. Good dispersion and distribution of fibres is very important for mechanical properties. It is also possible to see that in all the composites the fibre surfaces are clean which indicates poor adhesion between the fibres and the matrix.

V. CONCLUSION

The objective of this study was to investigate effect of fibre and orientation affects the mechanical properties of NFRC. The tensile and bending strength were highest with jute fibre orientation of 0/90. This is believed to depend on fibre toughness along fibre pullouts. The electron microscopy study showed that bamboo fibres were several times coarser than jute after processing. Furthermore jute fibres were separated to single elementary fibres during the tested but bamboo fibres were still in the form of fibre bundles after processing.

REFERENCES

1) Karus M, Kaup M. Natural fibres in the European automotive industry. J Ind Hemp vol. 7 (2002), pp.117–29.
2) Hepworth DG, Hobson RN, Bruce DM, Farrent JW. The use of unretted hemp fibre in composite manufacture. Composites: Part A, vol. 31 (2000), pp1279–83.
3) Jacob M, Thomas S, Varughese KT. Mechanical properties of sisal/ oil palm hybrid fibre reinforced natural rubber composites. Compos Sci Technol, vol. 64 (2004), pp-955–65.
4) Munawar SS, Umemura K, Kawai S. Characterization of the morphological, physical, and mechanical properties of seven nonwood plant fiber bundles. J Wood Sci, vol 53 (2007) pp.108–13.
5) Brett S, William E. Natural fiber composites in automotive applications, in natural fiber composites in automotive applications. CRC Press; 2005.

6) Joshi SV, Drzal LT, Mohanty AK, Arora S. Are natural fiber composites environmentally superior to glass fiber reinforced composites? Compos A Appl Sci Manuf, vol. 35 (2004), pp.371–6.
7) Ganster Johannes, Fink Hans-Peter. Novel cellulose fibre reinforced thermoplastic materials. Cellulose, vol. 13 (2006), pp.271–80.
8) Maya JJ, Rajesh DA. Recent developments in chemical modification and characterization of natural fiber reinforces composites. Polym Compos vo. 29 (2008) pp.187–207.


M Sripathy, Obtained BE in Mechanical Engineering, ME in Manufacturing Science, and pursuing Ph.D in natural fiber sandwich structures, from UVCE, Bangalore University. His area of interest are natural fiber sandwich structures, FRP, ect. He is active member of ISTE, He published number of papers in Journals.


Krishna Vinayak Sharma obtained B.E, in Mech. Engg.,, ME in Design and Ph.D in Composites Materials form Bangalore University. At present he is Professor and Chairman of Mechanical Engineering, UVCE, Bangalore. He published 20 Journal publications in Journals. He successfully guided 2 research Scholars for Ph.D's. His research interest include: FEM, Composites, Sandwich etc.


M Krishna BE, MS, Ph.D, is working as professor and Director, Research and Development, R V College of Engineering, Bangalore. He has published more than 100 research article in National and International Journals and presented more than 150 papers in National and International Conferences. He executed more than 50 sponsored projects and consultancy.