International Journal of Core Engineering & Management

ISSN: 2348 9510

International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

EXPERIMENTAL STUDY ON NATURAL FIBRE IN REINFORCED EPOXY HYBRID COMPOSITES

Padmaraj N H
Department of Automobile and Aeronautical Engineering
Manipal Institute of Technology
Manipal, India
padmaraj.nh@manipal.edu

Akshay Suresh
Department of Automobile and Aeronautical Engineering
Manipal Institute of Technology
Manipal, India
akshay.colsuresh@gmail.com

Vinod Nayak
Department of Automobile and Aeronautical Engineering
Manipal Institute of Technology
Manipal, India
nayak.vinod93@gmail.com

Onkar Anand
Department of Automobile and Aeronautical Engineering
Manipal Institute of Technology
Manipal, India
onkar.anand@learner.manipal.edu

Eril Joy Dsouza
Department of Mechanical Engineering
Manipal Institute of Technology
Manipal, India
eriljoy94@gmail.com

Pavan
Department of Automobile and Aeronautical Engineering
Manipal Institute of Technology
Manipal, India
pavankumar44429@gmail.com

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

ABSTRACT

In recent years natural fibres have appeared as one of the outstanding materials which come as viable and abundant substitute for costlier and non-renewable synthetic fibres. Natural fibres like sisal, banana, jute and coir is used as fibres in thermoset composite for applications in consumer goods, furniture, low cost housing and civil structures. The natural fibre chosen for this study are areca fibre and banana fibre. Mats were fabricated and layered up with [0-90^{o}areca; 0-90^{o} banana; 0-90^{0}-areca] arrangement with epoxy resin matrix. The laminate is manufactured using hand lay-up technique followed by compression moulding. Critical properties of the fabricated material such as flexure, tensile strength, hardness, izod impact energy are experimentally concluded and results are recorded. Maximum tensile strength for tested material is found to be 26.48 MPa. Flexure results showed a value of 135 N. Izod Impact Energy for the prepared material is found to be 2.5 Joules. Average hardness number of the specimen was found to be 11.4.

Keywords-Fleshy Areca leaves frond; banana fibre, hand lay-up, compression moulding, epoxy, bidirectional, flexural, running water.

I. INTRODUCTION

Innovations are carried out to develop the existing trends in the field of composites to obtain better results and apply these results for better application. Composites are playing an increasing role in replacing plastic, steel, aluminium, concrete etc. as building materials. They are prefabricated, portable and used in modular buildings and for exterior panels. Its applications are found in shuttering supports, ergonomics, special architectural structures imparting aesthetic appearance etc. Inspite of longer life, low maintenance, fire retardant properties etc. its advantages include corrosion resistance and light weight that has proved attractive for many low stress uses. Fibre reinforced polymer (FRP) in structural applications, is less accepted widely although much progress is been made towards this end. Composite based train panels & automobile body parts are under development to obtain high strength, long duration and other desirable properties. In composites, matrix as well as reinforcements are combined with varying compositions to produce varying properties. Fibres, either synthetic or natural are used as a reinforcement with varying weight compositions and orientation which may be randomly oriented, unidirectional or bidirectional woven with varying angle. Laying up methods commonly used are hand lay-up followed by compression moulding, vacuum bagging, resin transfer moulding, filament winding etc. The experimental analysis are being made to understand the strength of newly formed hybrid composite in order to get better results in the field of hybrid composite and imply it for various application. Both synthetic material and naturally abundant material was taken to study for such an experimental behaviour of newly formed material. Synthetic resins are constituents with property comparable to plant resins, which are viscous liquids and are capable of hardening permanently. They are chemically different from various resinous compounds secreted by plants. In this study, matrix used was epoxy Lapox L-12 resin. Among classic variety is epoxy resin, that are synthesized by polymerization-polyaddition reactions, applicable as thermoset polymer for adhesives and composites. Epoxy is twice stronger compared to concrete, seamless and waterproof. It is mainly in practise for industrial flooring, since 1960s. However, since 2000, epoxy and polyurethane resins are in practise for interiors as well. Fibres come under class of hair-like constituents which occur as discrete elongated pieces or as continuous filaments, comparable to pieces of thread which occur in two types: natural fibres and synthetic fibres.

Natural fibres are extracted from mineral sources, plants and animals. Plant sources comprise of cotton, flax, areca, sisal, jute, banana and coconut. Animal sources include silk, wool, and mohair. Mineral sources like asbestos and metal fibres. Natural fibre is acting as one of the abundant available material as reinforcement phase with varying properties. In this study bidirectional woven areca fibre mat were used on face side of laminate, whereas bidirectional woven banana fibre mat was used as core material in the form of sandwich composites.

Santosh et al.[1] in their research used treated and untreated banana fibre, for developing of hybrid composites. Fibres of banana were treated with 5% sodium hydroxide to rise its wettability. These fibres are used as reinforcements with both Epoxy resin and Vinyl ester resin. Difference in mechanical properties are studied and analysed. Tensile strength has been calculated by universal testing machine, impact strength, flexural strength of the sample was found out. Ashwani et al.[2] used hybridization of FRP at 20% weight reinforcement resulted for increase of tensile properties of HFREC(Hybrid fibre reinforced epoxy composite) by 1.24% than GFREC(Glass fibre reinforced epoxy composite) and by 71.2% than BFREC((Banana fibre reinforced epoxy composite). Hybridization of FRP at 30% fraction of weight of reinforcement showed rise in tensile value of HFREC by 2.5% compared to GFREC and by 63.4% compared to BFREC. Tensile strength showed highest value when 10% of banana fibre and 20% of glass fibre is used and an interleaving arrangement of glass and banana fibre is monitored. FRP at 20% fraction weight showed increased flexural value of HFREC by 6.9 % than GFREC and by 27.3 % than BFREC. FRP at 30% fraction weight hybridization showed rise in flexural strength of HFREC by an amount of 6% than GFREC and by 23 % than BFREC. Impact property revealed greater value .When banana fibres and glass fibres are reinforced in a ratio of 1:2, impact strength of HFREC increased by 5.1% compared to GFREC and by 91% compared to BFREC. Venkateshwaran et al.[3] in their study investigated effect of alkali and Sodium Lauryl Sulphate treatment on Banana/Kenaf hybrid and woven hybrids which treated with 10% of Sodium hydroxide and 10% Sodium Lauryl Sulphate for half an hour and fabrication was followed by moulding technique. Fibre content in composite was up to 40 %. Alteration in tensile, Flexure and Impact strength and morphological variations were investigated. Revati et al. [4] in her study, biodegradable matrix was combined with areca frond fibres for developing composites for low strength structural applications. Areca frond fibres were extracted and treated with sodium bicarbonate in order to improve surface properties. Hand lay-up and compression moulding techniques were used to fabricate material with unidirectional fibre orientation. Specimens fabricated were exposed to varied environments, namely, sunlight, OTG oven, steam oven, and hot air oven, for curing and results were analysed to best suit implicated requirements. Tensile and flexural strength of starch based/areca frond reinforced composites were evaluated according to ASTM standards. Test results revealed that composites cured in a steam oven resulted in improved tensile and flexural strength compared to other curing environments. Rishabh et al. [5] studied inter-laminar shear and flexural strength of E-Glass/Jute composites. Composite laminates with basket weave (BW) and twill weave (TW) patterns were fabricated using hand layup technique. Fibre weight fractions (FWF) of 10%, 15%, 20% and 25% were adopted. It was found that laminates with twill weave exhibited better flexural and inter-laminar shear strength.

Manjeshwar et al. [6] used biodegradable matrix composite by altering base material weight (95–170 g), binder (5–10 g), and plasticizer (5–20 g) with treated areca frond fibre. Tests were conducted on flexure and maximum flexure strength of 16.97MPa was found in arrangement with base (170 g), binder (10 g), plasticizer (5 g). Pramod et al. [7] in their research work investigated effect of compounding temperature and fibre loading on tensile properties of areca fibre in natural rubber composites. Fabrication is done by hot press machine with 60% fibre loading at different compounding temperatures, 130, 140, 150 and160^{0}C; and with 40, 50, 60 and 70% fibre loading were fabricated and analysed for tensile strength in accordance to ASTM standard. Areca fibre reinforced natural rubber composites with 60% loading of fibre at 130^{0}C had maximum tensile strength. Effect of compounding temperature on tensile properties of composites was insignificant. Ramadevi et al. [8] in her research work studied the influence of chemical treatment on flexural strength and impact strength of areca fibre reinforced natural rubber composites. Untreated, alkali treated, permanganate treated, benzoylated and acrylated areca fibre with natural rubber composites were fabricated under 40%, 50%, 60% and 70% fibre loadings at 130^{0}C. Evaluation of flexural strength and impact strength of untreated and all chemically treated areca-natural rubber composites was carried. Increase in fibre loading from 40% to 60%, flexural strength and impact strength of untreated and treated areca-natural rubber composites increased. Amongst untreated and all chemically treated areca-natural rubber composites, highest flexural strength and impact strength was exhibited by acrylated areca-natural rubber composites with 60% fibre loading.

Rodolfo et al. [9] in their work analysed effect of alkali treatment on mechanical behaviour of banana fibre. Extraction of fibres from pseudostem were done using defibring machine and treated using 5% NaOH. Morphological characterisation revealed, rougher surface was obtained in case of treated fibres compared to un-treated ones. Young's modulus, ultimate tensile strength and strain declined by increasing diameter of treated and untreated fibre. Sanjay et al. [10] used sisal/glass/Sic fibre with epoxy composites and tensile strength, flexural strength and impact energy were found. Better results were revealed for composites without filler than with silicon carbide as filler. Raghuraman et al. [11] in their study, fabricated Abaca-banana-glass composites with phenolic resin and mechanical characteristics were analyzed. Tensile, flexural and impact strength were found out during mechanical characterization. Composite are obtained by hand lay-up and fibre contents are altered through volume fraction of 0.4 to 0.5. Glass fibre was placed on top and bottom layer of laminate, where natural fibre is placed in between. Abaca-banana-glass hybrid showed good tensile result, Banana-glass composite showed best flexural value and Abaca-glass composite showed best impact property. Results revealed a substantial increase in mechanical properties. Madhusudhan et al. [12] made a study on development of impact strength of different polymer composites with glass fibre reinforcement, epoxy resin and different filler ranging from fibres, particulates and flakes. Results revealed that, epoxy resin with glass fibre and filler material showed better results than epoxy resin with any other type of reinforcement. Madhukiran et al. [13] investigated, tensile and hardness characteristics of material, by reinforcing Banana and Pineapple fibres with epoxy matrix. Extraction of fibres were done by retting and manual process. Hybrid

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

material were fabricated with banana/pineapple fibres of 0/40, 15/25, 20/20, 25/15, and 40/0 weight fraction. Results revealed, tensile characteristics showed growth in value with increase in fibre weight fraction. Hybridization of reinforcement showed greater tensile value compared to individual type of natural fibres. Similar observation were found for elongation, tensile modulus, hardness and break load.

II. METHODOLOGY

A. Extraction of fibres

Areca fibre and banana fibre were used as reinforcement material in the form of sandwich composite. A simpler methodology was implied for extracting areca fibres, from areca leaf frond. Selected areca leaf fronds were used as one of the reinforcement to prepare a hybrid composites. Fleshy areca frond was soaked in water for about five days. Soaking process loosens fibres from fleshy part of frond and fibres can be extracted out easily by combing with metallic brush. Finally, fibres are washed with running water and dried for about 48 hours. Dried fibres are designated as untreated fibres.

Figure 1:Untreated fibre after extraction

Figure 2: Treatment of areca fibres in 1N NaOH solution

Banana fibre was extracted from banana stems and the machine implied for extraction was agro based machine. The machine consists of blades of stainless steel arranged horizontally. The

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

machine reduces drudgery and increases fibre production at faster rate as compared to manual process. In this method banana stems are cut into sections of 120-160 cm in length. Stems are fed in through rotating blade of the machine, which crushes and removes the fleshy part and pulpy tissues of the stem, leaving behind fibres. Stem is fed multiple times, in order to get purely extracted fibres. Further fibres are combed and washed in running water to remove the tissues present on it. This machine reduces drudgery of manual extraction of fibre and provides a clean working environment. Extracted fibres are dried for 48 hours. Extracted fibres are designated as untreated fibres and are forwarded for alkali treatment.

Treatment of areca fibres are done in a solution of 1N NaOH for 6 hours and banana fibres were treated with 5% NaOH for 1 hour, both at room temperature. Finally, it washed against running water to wash away last traces of tissues and NaOH solution present on it. They are dried for 48 hrs at room temperature to get alkali treated fibres. Fibres were cut to equal size of about 250 mm length. Finally fibres were woven bidirectionally. 2 such mats were prepared with 1x1 weaving of 0-90^{o} orientation in case of areca fibres and 1 mat of 0-90^{o} orientation of banana mat was fabricated.

Figure 3: Fibre Extraction machine

Figure 4: Woven fibres

B. Matrix Material

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

Epoxy resin is selected as matrix material for this composite, of Atul grade which was procured from Bangalore. Epoxy resin is selected because of its high adhesive nature, overall bonding properties with fibres and very high load carrying capacity. K6 hardener was mixed in required proportion whose ratio with respect to resin was 1:10 to get a properly cured laminate.

C. Laminate preparation and sample testing

Hand lay-up technique was used to prepare the final laminate. The mould was made of wood of dimensions 250 mm^2. Mould was provided with holes underneath to remove the cured laminate. The first stage of fabrication is to apply a layer of wax in order to get pure surface finish as well as for easier removal of the laminate. In the next step, a layer of matrix was applied and spread throughout the mould uniformly. A layer of woven mat of areca is placed on the mould and matrix is again poured on it and the matrix is spread and compressed by roller. Core layer containing banana woven mat is now placed and resin is poured onto it and again rolling process is repeated. Finally, last layer of areca fibre is placed and remaining matrix material is poured and roller force is applied. After completion of this process the mould is closed and compressive load is applied on it, in order to maintain uniform thickness of the laminate.

After 24 hours the laminate is taken out and are cut according to standards. Tensile, flexure, izod impact, hardness tests were carried for 5 samples each cut from the laminate. The specimen was mounted on the machine and constant loading was given.

D. Testing of Samples

Table 1: ASTM Standards for testing samples

Sl no	Test	ASTM Standard
1	Tensile	D3039
2	Flexure	D780
3	Hardness	ISO (6507-1)
4	Impact	D256

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

Figure 5: Cured laminate

Figure 6: Tensile testing

Figure 7: Izod Impact testing

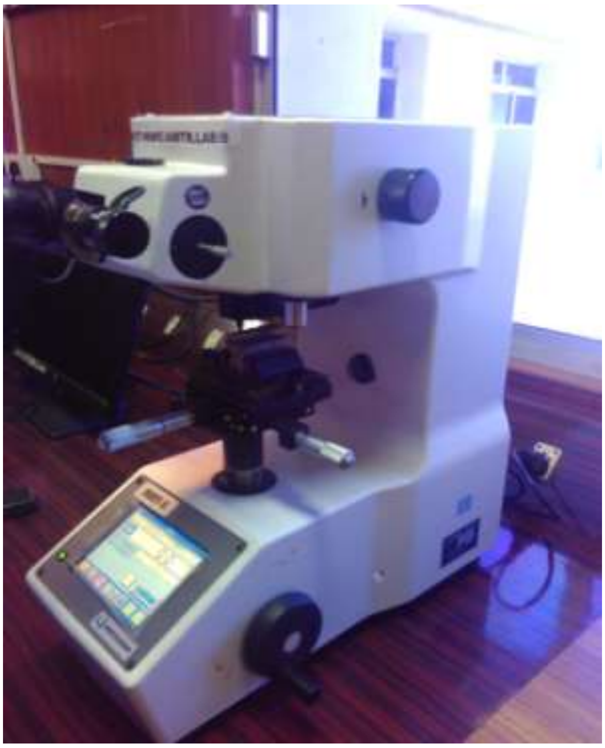

Figure 8: Matsuzawa microwickers hardness testing

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

III. RESULT

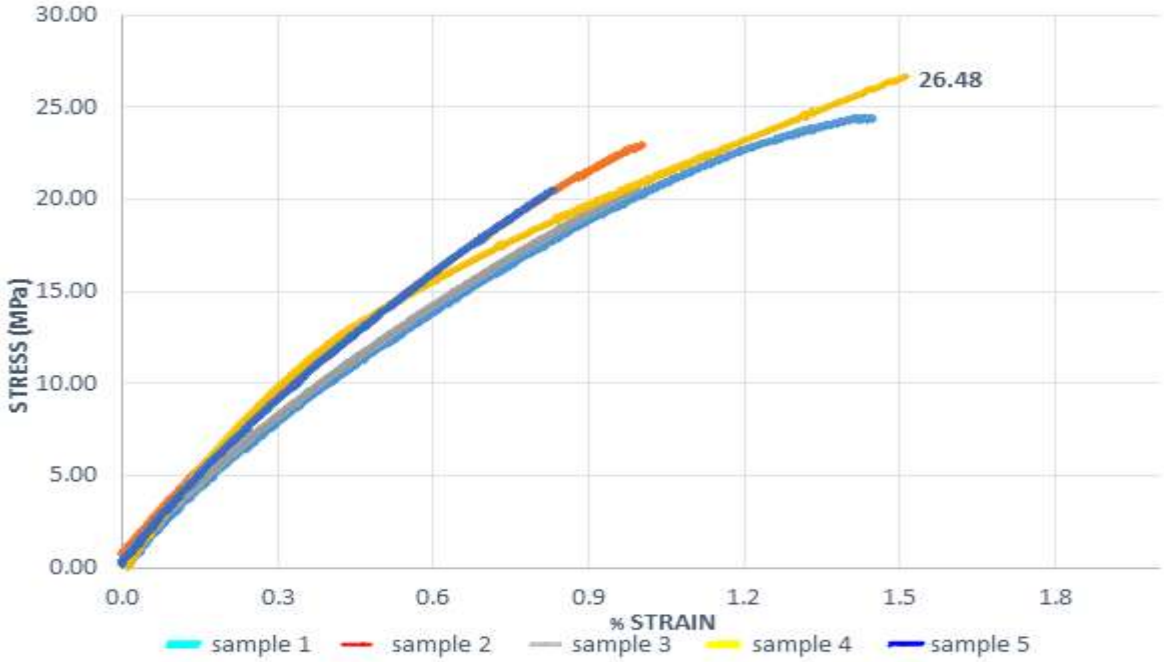

Figure 9: Stress vs strain graph for tensile samples

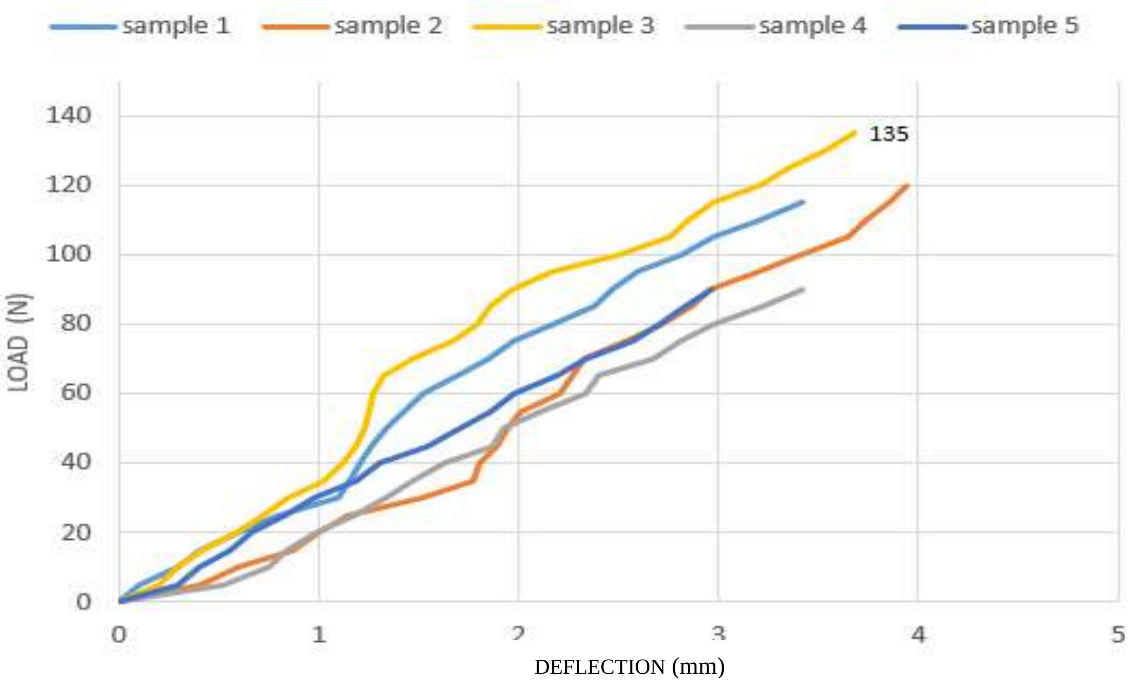

Figure 10: Load vs deflection for bending samples

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

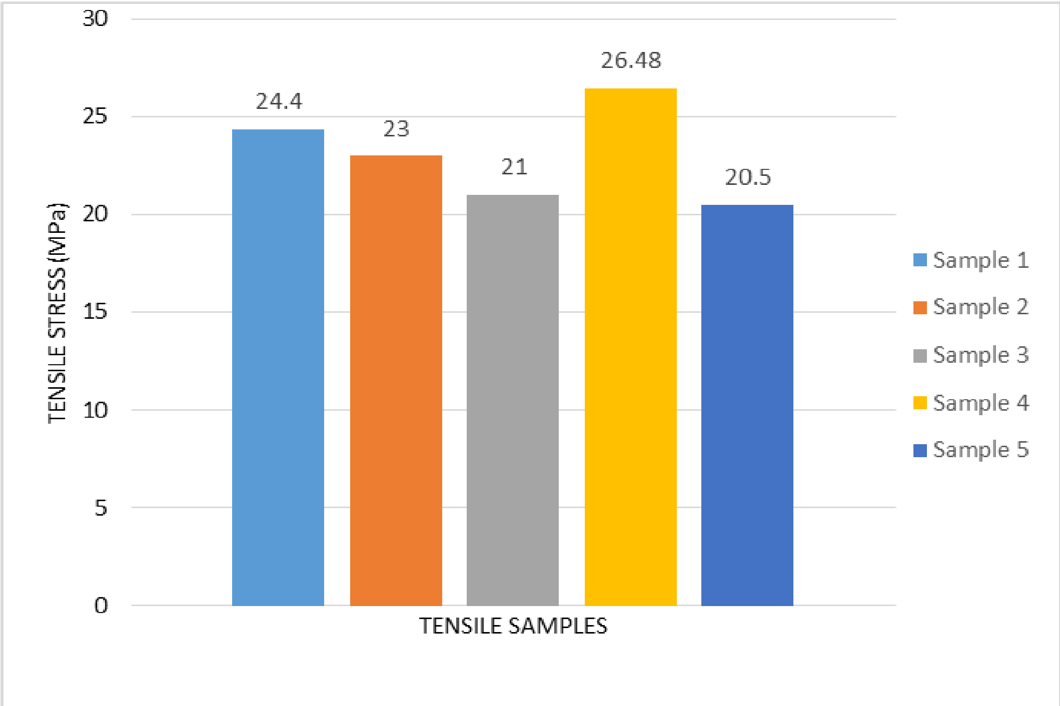

Figure 11: Variation in stress levels of hybrid samples

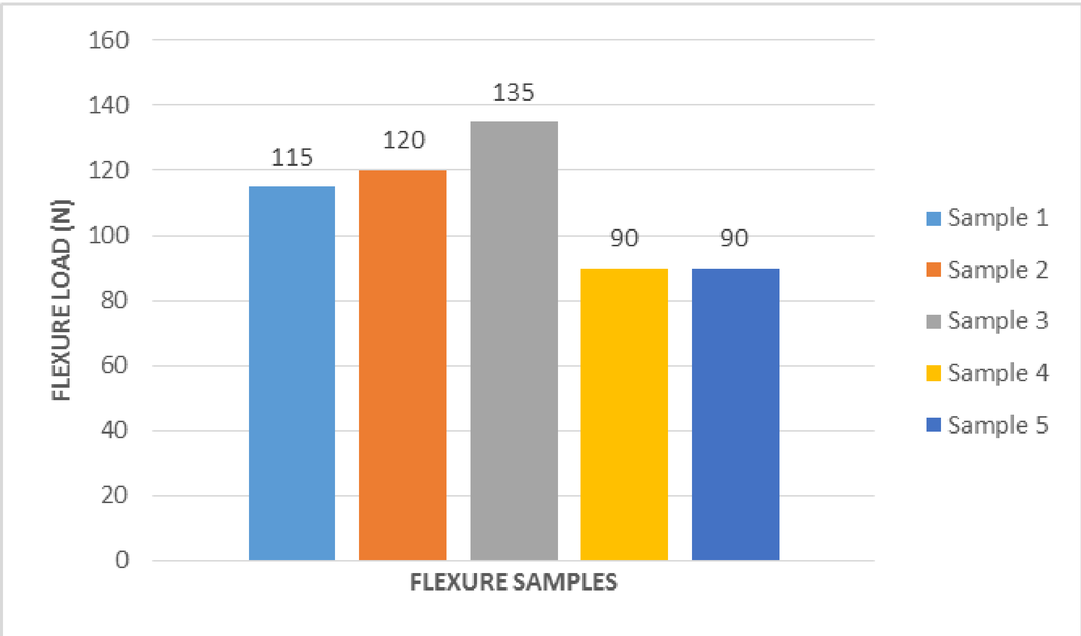

Figure 12: Variation in flexural loads levels of hybrid samples

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

Table 2: Flexure test results

Sample number	Flexure modulus	Maximum flexure load (N)	Maximum flexure deflection (mm)
1	6081	115	3.42
2	5507	120	3.94
3	6634	135	3.68
4	4759	90	3.42
5	5498	90	2.96

Out of 5 samples, maximum load carrying capacity was found to be 26.48 MPa for tensile. Average result was found to be 23.076 MPa. Young's modulus for the above specimen was found to be 1145 MPa. For bending maximum load capacity was 135 N. Average load capacity was 110 N. Izod Impact Energy for the sample is found to be 2.5 Joules. Average hardness number of the specimen was found to be 11.4.

IV. CONCLUSION

Increased need of composites in each field of engineering application, academic research is under great progress for altering properties to get improved results. An average value of load carrying results were obtained for the fabricated samples. Comparisons of the above prepared material can be made by fabricating another set of laminates with one bidirectional mat of areca on the core of the laminate and 1 layer each of banana bidirectional mats on the face side. To obtain better results samples may be fabricated with increase in number of layers of mat. The results obtained revealed good mechanical characteristics and hence hybrid composites can be used as alternative for synthetic fibres and be used for different industrial application.

V. ACKNOWLEDGEMENT

We make use of this great opportunity to express our gratitude to Mr. Padmaraj N.H for guiding us throughout the project on "Experimental study on natural fibre in reinforced epoxy sandwich composites" and his extending his support. We would also like to thank lab technicians of advanced composite lab and advanced material testing lab at Manipal Institute of Technology for helping us in all the work. We would also like to thank HOD of Aeronautical and automobile and department, MIT Manipal for extending his support.

REFERENCES

[1] J.Santhosh, N.Balanarasimman, R.Chandrasekar, S.Raja, "Study of properties of banana fibre reinforced composites", ISSN: 2321-7308, Volume: 03 Issue: 11 | Nov-2014, pp. 144-150.

[2] Ashwani Kumar,Deepak Choudhary, "Development of Glass/Banana Fibres Reinforced Epoxy Composite", ISSN : 2248-9622, Vol. 3, Issue 6, Nov-Dec 2013, pp.1230-1235.

[3] M. Thiruchitrambalam, A.Alavudeen, A.Athijayamani, N.Venkateshwaran and A.Elaya Perumal, "improving mechanical properties of banana/kenaf Polyester hybrid composites using sodium laulryl Sulfate treatment", Materials Physics and Mechanics 8 (2009) pp.165-173.

[4] Srinivas Shenoy Heckadka, Suhas Yeshwant Nayak, Manjeshwar Vijaya Kini, Revati Chowgule, and Pranay Jain, "Effect of Curing on the Tensile and Flexural Performance of Fully Biodegradable Corn Starch/Areca Frond Composites", Hindawi Publishing Corporation Journal of Composites Volume 2015, Article ID 358237.

[5] Srinivas Shenoy H., Suhas Y. Nayak, Ayush Prakash, Ankit Awasthi, Rishabh Singh Kochhar, "Interlaminar shear and flexural properties of e-glass/jute reinforced polymer matrix composites", Nov, 2015, Dubai, ISBN: 9788193137321, pp.26-31.

[6] Srinivas Shenoy Heckadka,1 Manjeshwar Vijaya Kini,1 Raghuvir Pai Ballambat,1 Satish Shenoy Beloor,2 Sathish Rao Udupi,1 and Ullal Achutha Kini, "Flexural Strength Analysis of Starch Based Biodegradable Composite Using Areca Frond Fibre Reinforcement", Volume 2014, Article ID 769012, 6 pages, 2014.

[7] Dhanalakshmi Sampathkumar, Ramadevi Punyamurthy, Raghu Patel G. Ranganagowda, Pramod B. Badyankal, and Basavaraju Bennehalli, "Tensile Behaviour of the Natural Areca Fibre Reinforced Rubber Composites", ISSN 2278-6783, Chemical Science Review and Letters, pp. 957 -961]

[8] Dhanalakshmi S, Ramadevi P and Basavaraju B, "A study of influence of chemical treatments on flexural strength and impact strength of areca fibre reinforced natural rubber composites", ISSN 0976-3031, Vol. 6, Issue, 6, pp.4833-4839, 2015

[9] Julio Cesar Mejia Osorio, Rodolfo Rodríguez Baracaldo, Jhon Jairo Olaya Florez, "The influence of alkali treatment on banana fibre's mechanical Properties", Ingenieria e Investigation Vol. 32 no. 1, pp.83-87, 2012.

[10] Arpitha G R, Sanjay M R, L Laxmana Naik, B Yogesha, 'Mechanical Properties of Epoxy Based Hybrid Composites Reinforced with Sisal/SIC/Glass Fibres', Volume 2, Issue 5, August-September, 2014 ISSN 2091-2730, pp.398-405.

[11] H. Venkatasubramanian, S. Raghuraman, 'Mechanical behaviour of abaca-glass-banana fibre reinforced hybrid composites' , Vol. 10, No. 8, 2015, pp.958 – 971.

[12] Bhanu praksh N, T. Madhusudhan, 'Investigative study on impact strength variation in different Combination of polymer composites', Volume 3, Issue 2, Part 2, March-April, 2015 ISSN 2091-2730, pp. 306-312.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

[13] Madhukiran. J, Dr. S. Srinivasa Rao, Madhusudan, 'Tensile and Hardness Properties of Banana/Pineapple Natural Fibre Reinforced Hybrid Composites', Vol. 2 Issue 7, July – 2013 ISSN: 2278-0181, pp.1260-1264.