EVALUATION OF MECHANICAL PROPERTIES OF HYBRID SISAL FIBER REINFORCED COMPOSITES

G.Sundaravadivel [1], Dr.M.Aruna [2], S.Anish[3]

[1,3]Assistant Professor, Department of Mechanical Engineering, St.Joseph College of Engineering, Sriperumbudur, Chennai, TamilNadu, (India)

[2] Professors, Department of Mechanical Engineering, Velammal College of Engineering and Technology, Madurai, TamilNadu, (India)

ABSTRACT

Now –a- days natural sisal fiber reinforced composites has been a growing interest in utilizing natural fibers as reinforcement in sisal composite for making low cost materials in recent years.Fibre reinforced Composite is one such material, which has revolutionized the concept of high strength. Sisal/Glass fibres are strong and have light weight. Hybrid Composites are fabricated using raw sisal/glass with varying fibre weight percents 1:1 to 1:4 wt. %. The hybrid composites are fabricated by using hand layup method. The fabricated specimens are made according to the ASTM standards for different mechanical testing such as flexural and tensile tests. The present work is to study the effect of fiber loading on mechanical behavior of sisal fiber reinforced epoxy composites. Finally, the sisal/glass specimen surface morphology of the composites of fractured surfaces has been studied using SEM analysis.

I. INTRODUCTION

Natural fibres are renewable resources in many developing countries of the world.The interest in natural fiber-reinforced composite materials are rapidly growing their industrial applications and fundamental research. However, they do not undergo biodegradation easily, no health hazards. Such composites are termed as green composites, by using sisal. Banana, bamboo, coir, pineapple leaf fibre, etc. Several green composites have already been developed and their properties have been studied.

Research revealed that the behaviour of hybrid composites appears to be simply a weighted sum of the individual components in which there is a more favourable balance between the advantages and disadvantages inherent in any composite material. It is generally accepted that the properties of hybrid composite are controlled by factors such as nature of matrix; nature, length and relative composition of the reinforcements; fibre–matrix interface; and hybrid design etc.

The hybridization of the reinforcement in the composite shows greater tensile strength when compared to individual type of natural fibres reinforced. For all the composites tested the tensile strength of the composite increased for approximately 25% of weight fraction of the fibres and further for the increase in the weight fraction of fibre the strength decreased, also it is found that for the hybrid combination of ridge guard and sisal fibres there is 65% increase in the tensile strength

Glass fibre reinforced composites due to their high specific strength and specific stiffness have become attractive structural materials not only in weight sensitive aerospace, automobile industries, but also in marine, armour, railways, civil engineering structures, sports goods etc. Epoxy resin is the most commonly use polymer matrix with reinforcing fibres for advanced composites applications.

Surface Treatment of the natural fibres was performed by rinsing the fibres in 10% NaOH solution for 24 hours and followed by washing with water. NaOH treatment removed wax and fatty substances and changed surface topography of the fibres.

II. RELATED WORK

Scanning electron micrographs obtained from fracture surfaces were used for a qualitative evaluation of the interfacial properties of coir /epoxy and compared with glass fibres. Length of the fibres was in the range between 8 and 337 mm.

The paper demonstrates the possibility of expressing each of the model parameters as a function of single variable that is stress ratio, maximum stress level, or a material-dependent constant. Glass fibre reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multiyear spring, was designed, fabricated (hand-layup technique) and tested. Computer algorithm using C-language has been used for the design of constant cross-section leaf spring. In this paper, only a mono-leaf composite leaf spring with varying width and varying thickness is designed and manufactured. Computer algorithm using C-language has been used for the design of constant cross-section leaf spring. The results showed that a spring width decreases hyperbolically and thickness increases linearly from the spring eyes towards the axle seat. The fabrication of composite leaf spring from unidirectional GERP. Composite leaf spring was fabricated using wet filament winding technique. In the present work, the hand lay-up process was employed. The templates (mould die) were made from wood and plywood according to the desired profile obtained from the computer algorithm.

The selected glass fibre is woven roving 360 GSM and epoxy resin is 520F with hardener 758. The fibres are cut into the required length of the leaf spring and are layered to get the final shape of the leaf spring. For every 100 parts by weight of Epoxy resin, 10 – 12 parts by weight of hardener 758 is mixed well at a temperature of 20 – 40 °C the fabricated composite leaf spring. Proposed an analytical micromechanical self-consistent approach dedicated to mechanical states prediction in both the fibre and the matrix of composite structures submitted to a transient hygroscopic load. The time and space dependent macroscopic stresses, at ply scale, are determined by using continuum mechanics formalism. The reliability of the new approach is checked, for carbon–epoxy composites, through a comparison between the local stress states calculated in both the resin and fibre according to the new closed-form solutions and the equivalent numerical model.

III. PROPOSED WORK

Sisal fiber is collected from rural area. The sisal leaves and leaf stem were removed and it was immersed in water retting tank for 4 weeks, followed by hand rubbing and rinsing in water till the unwanted greasy material was dissolved and fine fiber was extracted. Finally, the extracted fiber once again washed thoroughly in plenty of clean water to remove the surplus waste. Continuous fiber was obtained with length up to 1.7 m. The obtained fiber was dried under sun for 1 week. The average diameter of the fiber used for the composite preparation was between 0.2 and 0.3 mm.

Figure 1. Extracted Sisal Fibre

Alkali treatment improves the fibre-matrix adhesion due to the removal of natural and artificial impurities. This treatment increases surface roughness resulting in better mechanical interlocking and the amount of cellulose exposed on the fibre

Figure 2.Alkali Treated Sisal Fibre

Surface. The dry fiber was treated with distilled water 10% solution of NaOH for 24 h smoking to remove the unwanted soluble cellulose, hemi cellulose, pectin, lignin, etc. **(12 11)** from the fiber After 2 h the fiber was washed thoroughly in distilled water to remove excess of NaOH and dried at 60°C for 24 h.

The sisal fiber and E- Glass fibers are mixed with epoxy resin by simple mechanical stirring and the mixture was poured into various moulds, keeping in view the requirements of various testing conditions and characterization standards. The composite samples of nine different compositions (S 1 to S-4) are prepared. The composite samples S-1 to S-4 are prepared in three different percentages of Glass and sisal fibers (1:1wt %, 1:2wt % , 1:3wt % and 1:4wt%). This is done while keeping the epoxy content at a fixed percentage (i.e. 80 wt %). The composition and designation of the composites prepared for this study are listed in the following table. The samples have been prepared by varying the fiber percentages and fiber loading.

Composites	Compositions
S-1	Epoxy (70 wt%)+Glassfibre (15wt%)+Sisal fibre (15wt%)
S-2	Epoxy (70 wt%)+Glass fibre (10wt%)+Sisal fibre (20wt%)
S-3	Epoxy (70 wt%)+Glass fibre (7.5wt%)+Sisal fibre (22.5wt%)
S-4	Epoxy (70 wt%)+Glass fibre (16wt%)+Sisal fibre (24wt%)

For making the composite, a mol ding box (M.S) was prepared with dimensions of 250 x150 x3mm mould cavity. The mould box was coated with a thin layer of aqueous solution of poly vinyl alcohol (PVA) which acts as a good releasing agent. Further a thin coating of hard wax was laid over it and finally another thin layer of PVA was coated. Each coat was allowed to dry for 20 min. at room temperature. A 3 mm thick plate was made from the epoxy and hardener taken in the ratio of 100 and 10 parts by weight respectively. Then the moulding box was loaded with the matrix mixture and sisal & glass fibre with varying percentage was placed at 300C for 4 hours to complete the curing. After curing, the plate was removed from the moulding box with simple tapering and it was cut into samples.

A Hacksaw blade was used to cut each material into smaller pieces, for various experiments:

- TENSILE TEST- Sample was cut into dog bone shape (120x30x3) mm.
- FLEXURAL TEST- Sample was cut into flat shape (80x13x3) mm, in accordance with ASTM standards. Show the Fig 3.2

Fig 3. Flat Bar Shape

The tensile test was performed on all the three samples as per ASTM D3039-76 test standards. The tension test is generally performed on flat specimens. A uni-axial load is applied through the ends. The ASTM standard test recommends that the specimens with fibers parallel to the loading direction should be 11.5 mm wide. Length of the test section should be 120 mm. The test-piece used here was of dog-bone type and having dimensions according to the standards. The tension test was performed on all the three samples as per ASTM D3039-76 test standards.

Fig 4. UTM Machine Sample Unloaded Condition for Tensile Testing

All the specimens (composites) were of rectangular shape having length from 80 mm, breadth of 13 mm and thickness of 3 mm. A span of 50 mm was employed maintaining a cross head speed of 10mm/min. The strength of a material in bending is expressed as the stress on the outermost fibers of a bent test specimen, at the of failure. In a conventional test, flexural strength expressed in MPa is equal to

Flexural Strength = 3PL / 2bd2

Where P= applied central load (N)

L= test span of the sample (m)

b= width of the specimen (m)

d= thickness of specimen under test (m)

Scanning electron microscope was used for the morphological characterization of the composite surface. The samples are cleaned thoroughly, air-dried and are coated with 100 Å thick platinum in JEOL sputter ion coater and observed SEM at 20 kV. To enhance the conductivity of the composite samples a thin film of platinum is vacuum evaporated onto them before the micrographs are taken. The fracture morphology of the tensile fracture surface of the composites were also observed by means of SEM

Figure 5. SEM Set Up

IV. RESULTS & DISCUSSION

The composite specimens were tested as per ASTM standards. Tensile testing was done as per ASTM D 3039-76 with the help of TENSOMETER make KUDAL Instrument-20 KN model Universal Testing Machine at a crosshead speed of 5 mm/min. All the specimens (composites) were of rectangular shape having dimension of (120x30x3) mm3. The variation of the mean tensile strength at different fibre percentage is represented in (Fig no. 4) represent the variation of tensile strength of the composites **(**Fig no:1 **)** sisal fibre 10% and Glass fibre 10% with epoxy resin is used in this work. The graphs have been taking Displacement of fibre along the X-axis and Tensile strength Load N (MPa) along the Y-axis. Fig: 1; the combination of fibres used is Sisal and Glass. Show the Fig 4 tensile tested crack specimens.

Figure 6: Material Testing

In these Hybrid composites there is a considerable increase of tensile strength peak load 4236.6 N as the percentage of fibre increases to a maximum of 10% and then the strength increase. The experiment was conducted on both samples of sisal/glass combinations. The results are tabulated in the table 1.

COMPOSITES SAMPLE	LENGTH mm	BREADTH Mm	THICKNESS mm	EXTENSION Mm	MAXIMUM LOAD (N)
S-1	120	30	3	0.2	4236.6
S-2	120	30	3	0.5	313.8
S-3	120	30	3	0.3	715.9
S-4	120	30	3	0.1	2245.8

Shows combination of fibres used is Sisal and Glass fibre hybrid composites.The Sisal fiber increased 5wt% and Glass fiber 5wt% decreases tensile strength is decreases. The maximum peak load 313.8N and peak Displacement increase 12.22mm.

Shows the combination of fibres used is Sisal and Glass fibre composites. In these composites there is a considerable increase of tensile strength as the percentage of fibre increases to a maximum of 15% and then the strength decreases. The Sisal fibre increases 2% and then Glass fibre 1.5% decreases. The maximum Tensile strength of 715N MPa is obtained for 20% fibre reinforcement, there by sisal fibre 15% increase in the tensile strength decreases.

The combination of fibres used is Sisal and Glass hybrid composition. In these composites there is a considerable increase of tensile strength as the percentage of fibre increases to a maximum of 20% and then the strength increases. The Sisal fibre increases 1.5% and then Glass fibre 1.5% decreases. The maximum Tensile strength of 2245.8N Mpa

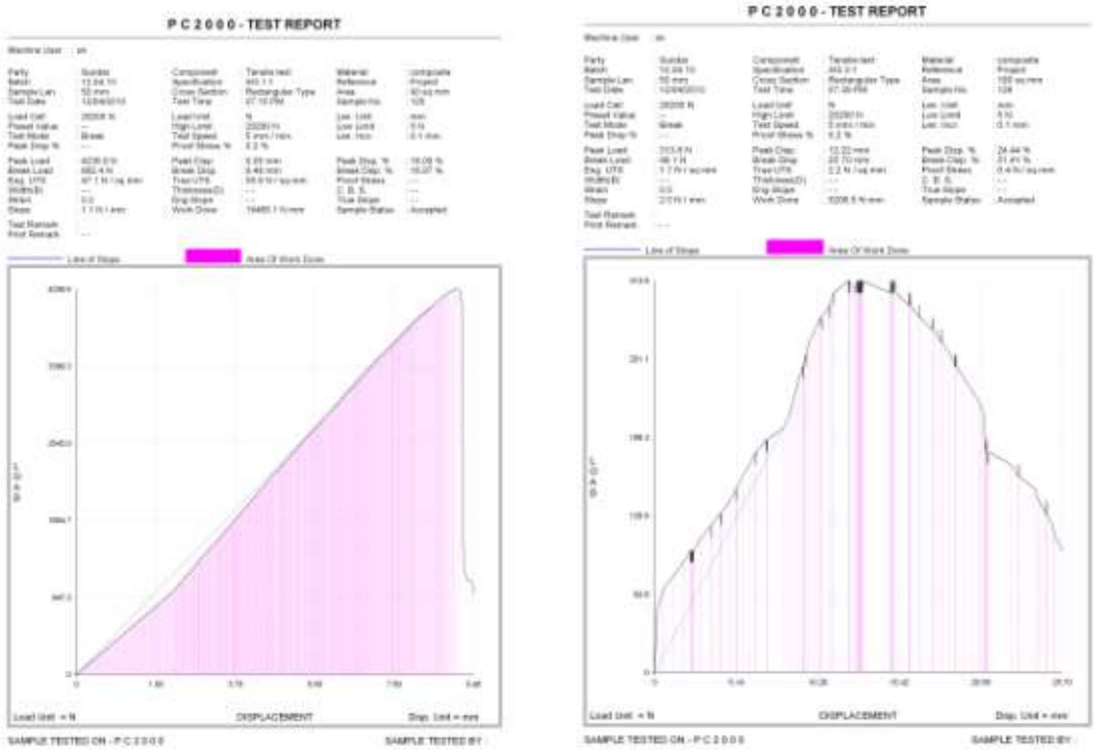

Figure 7. Effect of Fibre Loading on Tensile Strength of Composites

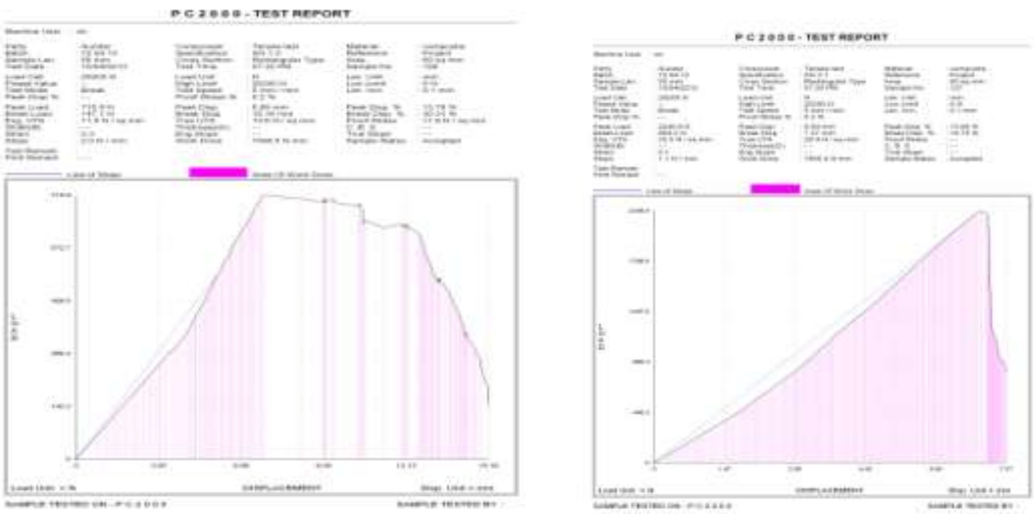

Figure 8. Effect of Fibre Loading on Tensile Strength of Composites.

To probe the bonding between the reinforcement and matrix, the scanning electron micrograms of fractured surfaces of Sisal/Glass reinforced epoxy hybrid composites were recorded. These micrograms were recorded at different magnifications and regions. The analysis of the micrograms of the composites prepared under different conditions is presented in the following paragraphs

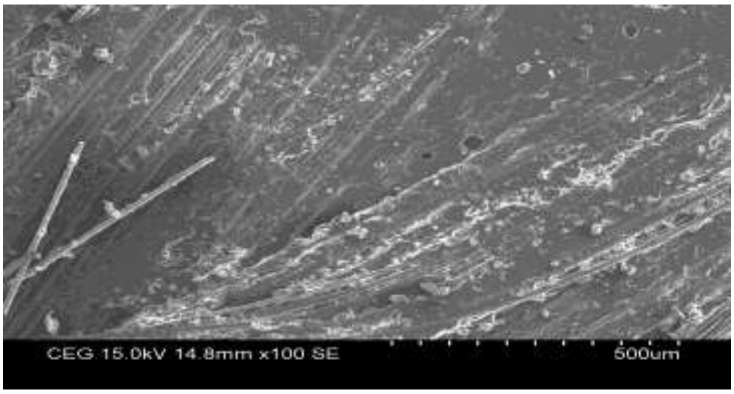

Figure 9. Scanning electron micrographs of bamboo fiber reinforced epoxy composite specimens

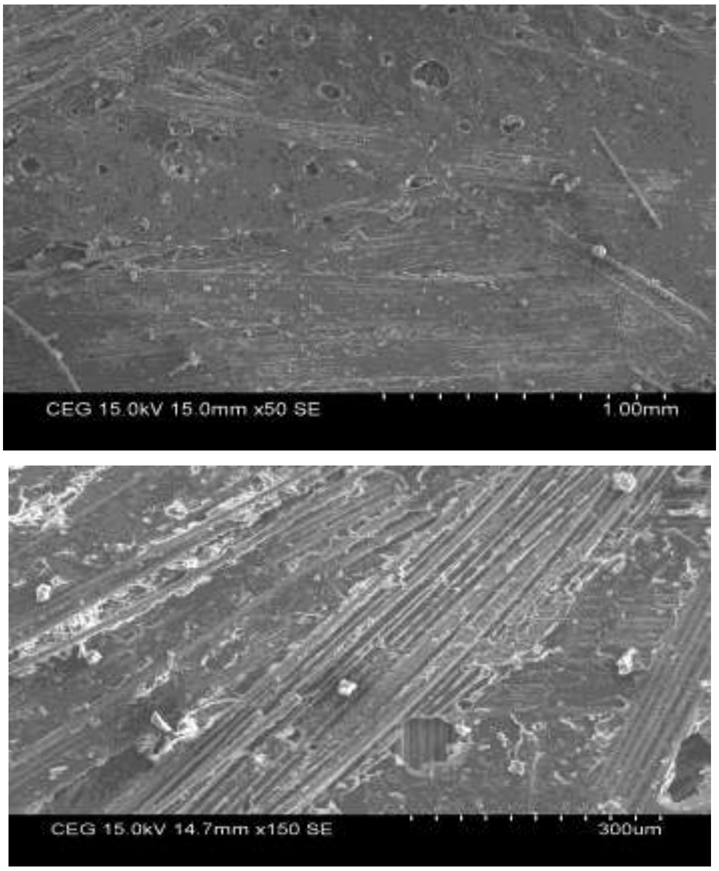

Figure 10. Scanning electron micrographs of bamboo fiber reinforced epoxy Composite specimens.

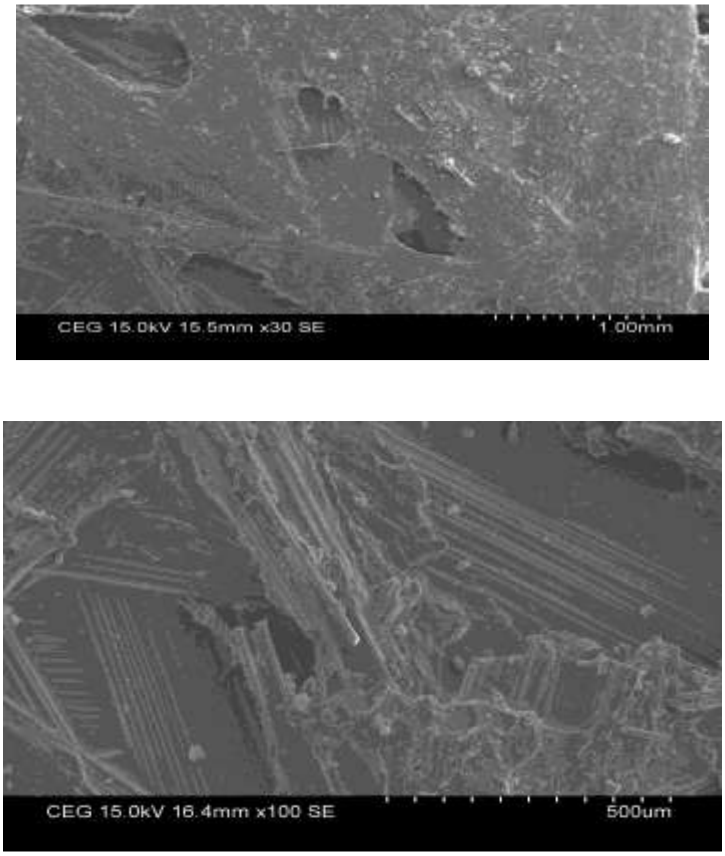

Figure 11. Scanning electron micrographs of sisal/glass fiber reinforced epoxy composite specimens

V.CONCLUSIONS

The experimental investigation on the effect of fiber loading on mechanical behavior of Hybrid sisal/glass fiber reinforced epoxy composites was conducted. Properties such as the Tensile strength, and flexural strength, were evaluated from various experiments. The experiments lead us to the following conclusions obtained from this study.

1. Successful fabrication of hybrid sisal/glass fiber reinforced epoxy composites is possible by simple hand lay-up technique.

2. Sisal fibres are effective reinforcement of polymers thus creating a range of technological applications beyond its traditional uses such as ropes, furniture, mats etc.

3. The tensile strength maximum loads of capacity 4236.6 N with 0.2mm elongation and sisal/glass both 15%wt of fibre content. The glass fibre increases tensile strength value increases but elongation degreases.

4. The load is applied on sisal/glass fibre hybrid composite, glass fibre increases to improve the tensile and flexural strength. At the same time the presence of sisal fibre in hybrid composite causes to decrease the tensile and flexural strength than the glass fibre composite.

5. The maximum flexural strength 166.7N, and sisal fibre percent increases and flexural strength decreases.

6. The fracture surfaces study of sisal/glass fiber reinforced epoxy composite after the tensile and flexural test has been done. From this study it has been concluded that the poor interfacial bonding is responsible for low mechanical properties.

REFERENCES

[1] Mwaikambo LY, Ansell MP. Chemical modification of hemp, sisal, jute, and kapok .bers by alkalisation. J Appl Polym Sci 2002; 84(12):2222–34.

[2] Van de Velde K, Kiekens P. Thermoplastic pultrusion of natural .bre reinforced composites. Comp Struct 2001; 54(2–3):355–60

[3]Gulur Siddaramanna Shiva Shankar, Sambagam Vijayarangan;Mono Composite Leaf Spring for Light Weight Vehicle – Design, End Joint Analysis and Testing (Accepted *07 April 2006)*.

[4] Kurumada akira, Nat inst for materials science, Toshiba denko ,Kurumada akira, Tanaka junzo, Suetsugu yasushi ;Carbon fibre reinforced composite material Molding containing calcium phosphate-based material, method of manufacturing the same, and artificial bone using the same.JP2004269333.

[5] V. Naga prasad naidu1, G.Ramachandra Reddy2, M.Ashok Kumar3, M.Mohan Reddy2, P. Noorunnisha Khanam2,S.Venkata Naidu2 " Compressive & impact properties of sisal/glass fibre reinforced hybrid composites" (11 July 2011).

[6]. Sreekala, M.S., M.G. Kumara, S. Joseph, M. Jacob and S. Thomas. 2000. Oil palm fibre reinforced phenol formaldehyde composites: influence of fibre Surface modifications on the mechanical performance. Applied Composite Materials 7:295-329.

[7] Vazquez A., Dominguez V. A., Kenny J. M.; Bagasse Fibre-Polypropylene Based Composites, *Journal of Thermoplastic Composite Materials*, 12 (1999) 477-497.

[8] Cao Y. Shibata S., Fokumoto I. "Mechanical properties of biodegradable composites reinforced with bagasse fibre before and after alkali treatment. Composites" Part A, *Applied Science and Manufacturing* 37 (2006) 423–429

[9] Govardhan Goud and R. N. Rao**; "**Effect of fibre content and alkali treatment on mechanical properties of Roystonea regia-reinforced epoxy partially biodegradable composites**"** [12 July 2010]

[10] Joseph, K. and S. Thomas. 1993. Dynamic mechanical properties of short Sisal fibre reinforced low density polyethylene composites. Journal of Reinforced Plastics and Composites 12(2):139-155.

[11]] L.M. Durão1a; Daniel J.S. Gonçalves2, João Manuel R.S. Tavares2, Victor H.C. de Albuquerque2,3, Túlio H. Panzera4, Leandro J. Silva4,A.A. Vieira2, A. M. Baptista2 the titled "Drilling Delimitation outcomes on glass and sisal reinforced plastics"

[12] Vemu.vara Prasad1 Tensile and Flexural Properties of Glass fibre-reinforced Polyester hybrid composites; (29 July 2011)

[13] Flávio de Andrade Silva1, Barzin Mobasher2, Romildo Dias de Toledo Filho3 titled "Advances in Natural Fibber Cement Composites: A Material for the Sustainable Construction Industry "

[14] Eichhorn SJ, Baillie CA, Zafeiropoulos N, Mwaikambo LY, Ansell MP, Dufresne A, et al."Current international research into cellulosic .bres and composites". the journal of J Mater Sci 2001;36(9):2107–31