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International Journal of Recent Scientific Research
Vol. 8, Issue, 2, pp. 15634-15639, February, 2017

International Journal of Recent Scientific Research

ISSN: 0976-3031

Research Article

EXPERIMENTAL INVESTIGATION OF TENSILE AND FLEXURAL PROPERTIES OF LUFFACYLINDRICA, BANANA, SISAL AND GLASS REINFORCED EPOXY COMPOSITES

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ARTICLE INFO

Article History:

Received 17th November, 2016
Received in revised form 21st December, 2016
Accepted 05th January, 2017
Published online 28th February, 2017

Key Words:

Natural fiber, luffa cylindrical, Banana, Sisal and glass reinforced epoxy composite, Mechanical Testing.

ABSTRACT

Natural fibers like luffa cylindrica, banana and sisal are now considered as a suitable alternative to glass fiber, due to their advantages, which include low cost, high strength-to-weight ratio, and recyclability. Combining natural fibers with glass fiber also decreases the usage of glass fiber. Natural fibers are now regarded as a serious alternative to glass fiber for use as reinforcements in composite materials and having advantages like low cost, low density, high strength-to-weight ratio, resistance to breakage during processing, low energy content and recyclability. polymeric based composite materials are used in automotive, sports goods, marine, electrical, industrial, household appliances and many more applications more sustainable construction and packaging materials. Natural fiber reinforced composites are strong, stiff, lightweight, recyclable, and synthetic fiber reinforced composites are strength-to-weight characteristics, high mechanical properties, high electrical insulating properties, low susceptibility to moisture, corrosion resistance and have the potential to meet this need.

INTRODUCTION

Fibers are thread- like parts that form plant or artificial material and can be made into cloth There are two types of fibers natural fibers and artificial fibers. Natural fibers can be defined as substances produced by plants and animals that can be spun converted to filament, thread or rope and in a next step be woven, knitted, matted or bound. Synthetic fibers or artificial fibers are the result of extensive research by scientists in order to develop on naturally occurring animal and plant fibers in this we are conducting experiments only on natural fibers. Fibers are broadly classified into natural fibers and man-made fibers.Natural Fibers: Natural fibers are hair-like threads obtained directly from plants, animals, and mineral sources. Botanically, a natural fibre is a collection of cells having long length and negligible diameter. They are obtained as continuous filaments or discrete elongated pieces similar to thread. Natural fibre can be spun or twisted into yarn like cloth and can be converted into nonwoven fabrics, such as paper or felt. An example of a commonly used natural fiber is cotton. Other examples include wool, jute, silk, hair, fur, hemp, and linen.

While the methods used to make fabrics have changed greatly since then, their functionality have changed very less: today, most natural fibres are still used to make clothing and containers and to insulate, soften and decorate living spaces. Increasingly, however, traditional textiles are used for industrial purposes and in components of composite materials, in medical implants, and geo- and agro-textiles.

Application of Natural fibers reinforced composites

The natural fiber composites are very cost effective material for following applications: Construction and Building: partition boards, panels for partition and false ceiling, floor, wall, door frames, window and roof tiles, pre-fabricated buildings which can be used in times of natural calamities such as cyclones, floods, earthquakes, etc.

Storage devices: grain storage silos, bio-gas containers, post-boxes, etc. Furniture: table, chair, bath units, shower, etc. Electric devices: pipes, electrical appliances, etc. Everyday applications: suitcases, helmets, lampshades, etc. Transportation: boat, automobile and railway coach interior, etc.Luffa cyllindrica as a natural fiber There are many potential natural resources, which India has in large quantity. Most of it comes from the agriculture and forest.

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Fig (a)

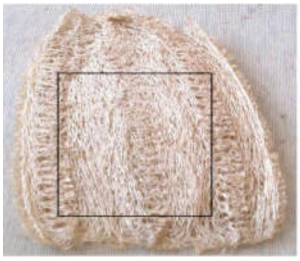

Fig (b) **Fig (c)**

The L. cylindrica plant with fruit (a), the inner fiber core (b) and the outer core open as a mat (c,). Luffa cylindrica, locally called, as ‘Sponge-gourds’ is one such natural resource whose potential as fiber reinforcement in polymer composite has not been explored to date. It has a ligneous netting system in which the fibrous cords are disposed in a multidirectional array forming a natural mat. This fibrous vascular system is composed of fibrils glued together with natural resinous materials of plant tissue. It contains 62% cellulose, 20% hemicellulose and 11.2% lignin [1]. The fruit of the sponge-gourd (L. cylindrica) plant with fruit which is of the Curcubitacea family is shown in Fig. (a) which has a thick peel and the sponge-gourd, which has a multidirectional array of fibers comprising a natural mat, presents an inner fiber core Fig(b) and an outer matcore Fig(c).

The main objective of this work is to prepare a PMC using luffa fiber as reinforcement and epoxy as matrix material and to study its tensile and flexural properties. Out of the available manufacturing processes, we have choose hand-lay-up technique to prepare the composite. Then the composites were manufactured by varying layers of fiber that is with single, double and triple layer fibers using these techniques.

MATERIALS AND METHODS

The materials used and methodologies adopted during the sample preparation, fabrication, mechanical testing and characterization of the composites.

Table 1 properties of fibers

Properties	Banana (B)	Sisal (S)	Luffa (L)	Glass (G)
Density (Kg/m^3)	1350	1450	920	2580
Flexural modulus(Gpa)	4	13.5	3.5	9.21
Tensile strength(Mpa)	529-914	500-855	1350	2000
Elongation at break (%)	2.6	2.4	1.4	2.5
Moisture content (%)	11	10	6.5-6.7	5-6

Banana Fiber

Global warming is a major threat to mankind .To stop and to reverse the effect of global warming, there is a need to replace non-reverse the effect of global warming, there is a need to replace non- renewable, non-degradable, and synthetic materials with renewable, bio-degradable, and natural material. The best way to bring about the change is to make use of or find innovative uses for agricultural waste which can be used is banana trunk. In India, approximately 5 lakhs tones of banana trunk is discarded as waste every year, after harvesting. Insted,we can extract fiber from hose trunks which has extensive uses in industries like textile, paper, and composite materials. Banana fiber is a very good replacement for synthetic fiber.

Banana fiber is extracted from the pseudo stem Sheath of the plant. The extraction can be done mainly in three ways: Manual, chemical and Mechanical. Of these, mechanical extraction is the best way to ontain fiber of both good quality and quantity in an eco-friendly way. In this process the fiber is extracted by inserting the pseudo stem sheaths one by one into a raspador machine. The raspador machine removes non-fibrous tissues and the coherent material (known as sctcher) from the fiber bundle present in the sheath and gives the fine fiber as output. After extraction, the fiber is shade dried for a day and packed in HDPE bags. Then extraction, then it is stored away from moisture and light to keep it in good condition until it is used

Fig 1

Fig 2

Fig 3

Luffa fiber

Luffa cyllindica, locally called, as 'Sponge-gourds' is one such natural resource whose potential as fiber reinforcement in polymer composite has not been explored to date. It has a ligneous netting system in which the fibrous cords are disposed in a multidirectional array forming a natural mat. This fibrous vascular system is composed of fibrils glued together with natural resinous materials of plant tissue. The main chemical constituents of luffa are Hemicellulose, cellulose and lignin. Cellulose and hemicellulose are present in the form of hollow cellulose in luffa which contributes to about 82 % of the total chemical constituents present in luffa. Another important chemical constituent present in luffa is lignin. Lignin acts as a binder for the cellulose fibers and also behaves as an energy storage system.

Fig 4

Sisal as a natural fiber

Sisal is a natural fiber is a yield, stiff fiber traditionally used in making twine and rope. It is a biodegradable and eco-friendly crop. Moreover, sisal is a strong, stable and versatile material and it has been recognized as an important source of fiber for composites. Sisal fiber made from the large spear shaped tropical leaves of the Agave Sisalana plant. Sisal fiber is extracted by a process known as decortications, where leaves are crushed and beaten by a rotating wheel set with blunt knives, so that only fibers remain. Now Sisal has been utilized as an environmentally friendly strengthening agent to replace asbestos and fiberglass in composite materials in various uses including the automobile industry.

This fibre is extracted from the leaves of the plant Agave sisalana which iswidely cultivated in the Western Hemisphere, Africa and Asia. It accounts for almost half of the total production of all textile fibres. Of the total world production of 0.6 million tons, India's share is only 3000 tons.33-35 In Kerala, about 50,000 kg of sisal fibres are extracted every year from the leaves. The agaves have rosettes of long and narrow fleshy leaves, which grow from a central bud. As the leaves mature, they gradually spread out horizontally and are 1-2 m long, 10-15 cm wide and about 6 mm thick at the centre. The fibres embedded longitudinally in the leaves are most abundant near the leaf surfaces. Though the leaves contain about 90 % moisture the fleshy pulp is very firm and the leaves are rigid. Generally by a mechanical decortication process, i.e, by scrapping away the pulpy material from the leaves the fibre is removed. In the decortication process, the leaves are fed through sets of crushing rollers. The crushed leaves are held firmly at their centres and both ends are passed between pairs of metal drums on which blades are mounted to scrape away the pulp, and the centers are scraped in the same way. The fibre strands are then washed and dried

Fig.1 Sisal plant

Fig2 Sisal fiber

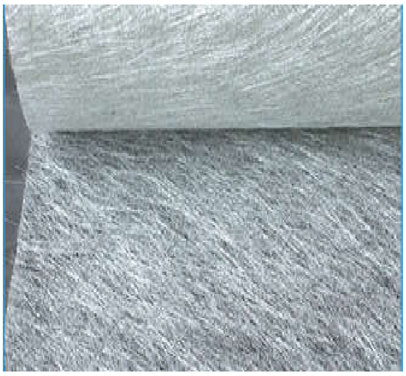

Fig.3 glass fiber

E-Glass fiber

E-Glass fiber is one of the most commonly used synthetic fibers, manufactured with the raw materials such as limestone, silica, clay, fluorspar, and dolomite. These ingredients are melted and extruded through bushings which have multiple small orifices to obtain filaments. The extruded filaments are coated with chemicals to obtain required size. The filaments are wounded together to form roving. The diameter of the filaments and the number of fila-ments in a roving determine its weight. The E-Glass fiber selected for this work is E-Glass woven roving of 400 gsm.

Epoxy

Epoxy resin is a member of the epoxy oligomer class. It forms a three dimensional structure when it reacts with the hardener or curing agent. It is possible to change the properties of the epoxy resins with different epoxy oligomers and by choosing various curing agents. The epoxy-LY556 i.e., diglycidyl ether of biphenyl-A (DGEBA) with the hardener HY951 i.e., triethylenetetramine (TETA) is used as matrix material. The blending ratio of the resin with the hardener is 10:1 by weight.

Composite preparation

The composite laminates for this work were fabricated by compression molding method. Initially, the qualified sunlight dried luffa(L),banana (B) and sisal (S) and Glass fibers are segregated and chopped. Five different kinds of laminates were prepared with stacking sequences GBLSG (Laminate 1), BLS (Laminate 2), GBSG (Laminate 3), GLBG (Laminate 4), GSLG (Laminate 5) as shown in Fig. 1. The weighted quantity of Luffa (L),banana, sisal, banana–sisal fibers and the epoxy resin were taken, the appropriate hardness also selected to fabricate the composites. The dimension of the mold used in the present work was 30x 30X 3 cm. This had to be placed over the fixed bottom jaw after placing a polythene sheet over it to avoid deposition of squeezing resin during the process. The mixture of epoxy resin with the hardener was applied to the mold, and then it was followed by the uniform deposition of the natural fiber premixed with a predetermined percentage of the resin mixture on the mold according to the laminates needed. Finally the resin was applied at the top before compressing the laminate with the hydraulic compression machine of 100 ton capacity. The pressure was applied gradually to ensure uniform distribution of resin throughout the laminate and also to remove the entrapped air. The laminate was kept under constant pressure for about nearly 24 h to guarantee absolute curing. The same pro-cess was repeated for the glass hybrid laminates with the e-glass woven fiber of 30x30x3 cm lamina placed agreeing to the stacking sequence. The weight percentage of natural fibers, E-glass fibers, epoxy resin mixture and the laminate was measured to calculate the weight and the volume fraction of the fibers listed in Table 2. After acquiring the compressed laminate from the compression molding machine, the burs on the rough edges were cut by using saw cutter and emery sheets were used to remove the rough edges.

Table 2 weight percentage of the fibers

LAMINATES	SISAL%	BANANA%	LUFFA%	GLASS%
GBLSG	20	20	20	40
BLS	37.5	37.5	25	0
GBSG	25	25	0	50
GBLG	0	25	25	50
GSLG	25	0	25	50

Fig 1

Fig 2

Experiments

TENSILE TEST- Sample Was Cut Into Dog Bone Shape (140x10x5) mm.

FLEXURAL TEST- Sample was cut into flat shape (15x140x5) mm, in accordance with ASTM standards

Fig 3 a Dog bone shape sample

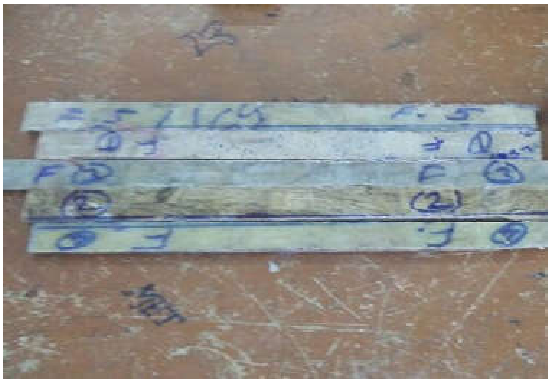

Fig-3 b Flat bar shape sample

Mechanical Testing

Tensile test

The tensile test is generally performed on flat specimens. The most commonly used specimen geometries are dog-bone and the straight side type with end tabs. The specimen used in present case is shown in fig 3(a). The tensile tests were conducted according to ASTM D 3039-76 standard on a computerized Universal Testing Machine INSTRON H10KS. The span length of the specimen was 42 mm. the tests were performed with constant strain rate of 2 mm/min.

Fig 4 UTM machine Sample loaded condition for tensile testing.

Flexural Test

Three point bend test was carried out in an UTM machine in accordance with ASTM D790-03 to measure the flexural strength of the composites. The loading arrangement for the specimen and the photograph of the machine used are shown in fig 4,fig 5. All the specimens (composites) were of rectangular shape having length varied from 100-125 mm, breadth of 100-110 mm and thickness of 4-8 mm. A span of 70 mm was employed maintaining a cross head speed of 0.5mm/min.

Fig 5 UTM machine Sample unloaded condition for Flexural testing.

RESULTS AND DISCUSSION

Tensile test

Tensile test was carried out on UTM machine in accordance with ASTM D 638 standard. All the specimens were of dog bone shape of dimension (140x10x5) mm. The results single, double and triple layer samples are tabulated in the Table 4.

Table 4 Tensile Test Data

Samples	Laminates	Ultimate Tensile Load(N)	Ultimate Tensile Strength (MPa)
S1	GBLSG	2460	28.400
S2	BLS	2460	22.784
S3	GBSG	1620	23.862
S4	GLBG	2220	31.097
S5	GSLG	4080	43.308

Where the samples G-Glass,B-Banana,L-Luffa,S-sisal stands for neat epoxy sample with different volume fraction of fiber, S1 stands for GBLSG layer reinforced sample with S-20%,B-20%,L-20%,G-40%volume fraction of fiber,S2 stands for BLS layer reinforced sample with S-37.5%,B-37.5%,L-25%,G-0%volume fraction of fiber content, S3 stands for GBSG layer reinforced sample with S-25%,B-25%,L-0%,G-50% volume fraction of fiber content. S4 stands for GLBG layer reinforced sample with S-0%,B-25%,L-25%,G-50%volume fraction of fiber content S5 stands for GSLG layer reinforced sample with S-25%,B-0%,L-25%,G-25% volume fraction of fiber content So by calculating the tensile strength of all samples it was found that S5 has the highest tensile strength i.e., 43.308MPa.

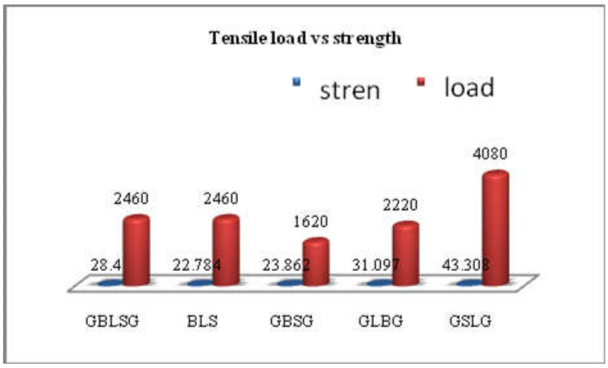

Fig 6 Variation of Tensile strength with different layers of sample

It is well known that fiber content and fiber strength are mainly responsible for strength properties of the composite. Therefore the variation in tensile strength of the samples are presented in fig3(a)and fig3(b) There is gradual increase in tensile strength for GSLG layer composite.

However, the decrease in tensile strength for GBSG layer composite (s3) may be due to the poor fiber-matrix adhesion.

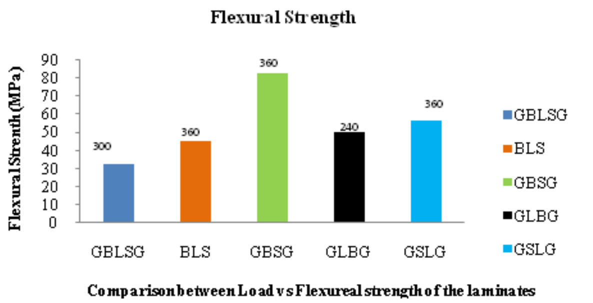

Fig 7 a Variation of Flexural strength with different layers of samples

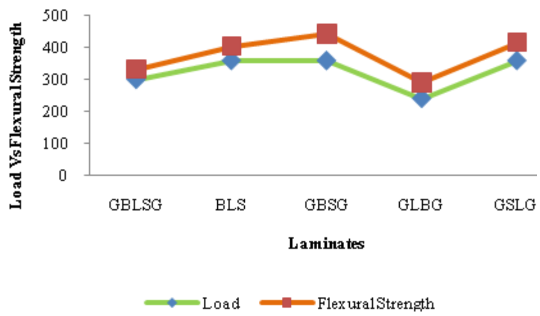

Fig 8 b Variation of Flexural strength with different volume fraction of fiber

CONCLUSION

The present work deals with the preparation of luffa fiber,sisal fiber and banana fiber reinforced epoxy composite. The mechanical behavior of the composite lead to the following conclusions:The successful fabrications of a new class of epoxy based composites reinforced with luffa, sisal and banana natural fibers have been done. It has been observed from this work that the tensile strength is maximum for GSLG layer (S5) sample i.e., 43.308MPa which is greater than neat epoxy i.e., 13.5 MPa.However, there is an abundant decrease in tensile strength observed for composite (S3). This decrease in strength is may be due to poor fiber-matrix adhesion.However, flexural strength is found to be more than neat epoxy for all layers of fiber reinforced composites. And it is found to be maximum for layer GBSG (S3) sample i.e., 82.47 MPa and second maximum in sample S5 is GSLG i.e.,56.35Mpa which is greater than neat epoxy i.e., 13.5 MPa. The lowest value of flexural strength is observed for GBLSG layer (S1) i.e., 32.24 MPa.This is may be due to insufficient matrix material compared to volume fraction of fibers which results in lower flexural strength of the various layer composites.

Possible use of these composites such as in Building and construction industry (partition boards, panels for partition and false ceiling, floor, wall, window and door frames etc.), Storage devices (grain storage silos, post-boxes, bio-gas containers etc.) is recommended. However, this study can be further extended in future to new types of composites using other potential natural fibers/fillers and the resulting experimental findings can be similarly analyzed.

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How to cite this article:

Sampathkumar M *et al*.2017, Experimental Investigation of Tensile And Flexural Properties of Luffacylindrica, Banana, Sisal and Glass Reinforced Epoxy Composites. *Int J Recent Sci Res.* 8(2), pp. 15634-15639.