EXPERIMENTAL INVESTIGATION OF IMPACT, SHORE HARDNESS AND SCANNING ELECTRON MICROSCOPE PROPERTIES OF LUFFACYLINDRICA, BANANA, SISAL AND GLASS REINFORCED EPOXY COMPOSITES

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Abstract—Natural cellulose fibers from plants are ideal choice for producing polymer composites. In this the experiments of impact ,shore hardness and scanning electron microscope tests were carried out on composites made by reinforcing luffa cylindrica, banana and sisal are now considered as a suitable alternative to glass fiber. Natural fiber reinforced composites are stiff, lightweight, recyclable low density, high strength-to-weight ratio and strength-to-weight characteristics, high mechanical properties, high electrical insulating properties are synthetic fiber reinforced composites. Application of composite materials presented the need for engineering analysis, the present work focuses on the fabrication of polymer matrix composites by using natural fibers like luffa cylindrica, banana and sisal, which are abundant in nature and calculating the material characteristics by conducting tests like impact test, shore hardness test and scanning electron microscope . By using scanning electron microscopy (SEM), the surface morphologies of the fracture surfaces and micro structure of the specimens can be recorded.

Index Terms— Natural fiber, luffa cylindrical, Banana, Sisal and glass reinforced epoxy composite, Mechanical Testing and SEM Analysis.

I. INTRODUCTION

Natural fibers are defined as substances produced by plants or artificial material that can be spun into filament, thread and further be woven, knitted, matted or bound. Fiber is obtained from the source. Natural fibers and artificial fibers are the most important type of fibers. Synthetic fibers or artificial fibers are the result of extensive research by scientists, while those which are not obtained from natural sources are called synthetic fibers. The development on naturally occurring animal and plant fibers, in this we are conducting experiments only on natural fibers. Fibers are mainly classified into natural fibers and man-made fibers.Natural Fibers: Natural fibers are hair-like materials that are continous filaments obtained directly from plants, animals, and mineral sources. Long length and negligible diameter can be obtained in natural fibres. . Natural fibre can be spun or twisted into yarn like cloth and can be converted into nonwoven fabrics, such as tea bags. An example of a commonly used natural fiber is cotton. Other examples include wool, jute, silk, hair, fur, hemp, and corn.While started a green revolution where historical resources for most advanced technologies are used.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 containers,clothing and to insulate, soften and decorate living spaces. Increasingly,traditional textiles are used for industrial purposes and in components of composite materials, in medical implants, and geo- and agro-textiles.

The natural fiber are becoming very cost effective material for following applications:

Building and Construction: partition boards and false ceiling, wall, door frames, window,floor and roof tiles which can be used in times of natural calamities such as cyclones, floods, earthquakes, etc. Industrial applications, providing sustainable solutions to support technical innovation from textiles and consumer products to the automotive and construction industries.

Storage devices: grain storage silos, post-boxes, bio-gas containers etc. Furniture: chair, bath units, shower,table, etc. Electric devices:electrical appliances, etc.Transportation: boat, automobile and railway coach interior, etc.Luffa cyllindrica as a natural fiber. Most of fibres comes from the agriculture and forest.The Luffa cylindrica plant with fruit (a), the inner fiber core (b) and the outer core open as a mat (c). Luffa cylindrica, generally called, as 'Sponge-gourds' is one such natural resource. When the fruit is fully ripened and very fibrous. The fully developed fruit is the source of the loofah scrubbing sponge. Luffa are not frost-hardy, and require 150 to 200 warm days to mature.It has fibrous cords are disposed in a multidirectional array forming a natural mat whichhas ligneous netting system, 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 (Luffa cylindrica) plant with fruit which is of the Curcubitacea family is shown in Fig. (a) which has a thick peel and the sponge-gourd, presents an inner fiber core Fig(b) and an outer matcore Fig(c).The main aim of this work is to prepare a PMC using luffa fiber as reinforcement and epoxy as matrix material and to study itsimpact,shore hardness and scanning electron microscope properties. Out of the available manufacturing processes and we havechoose hand-lay-up technique to prepare the composite.With single, double and triple layer fibers that the composites were manufactured by varying layers of fiber.

Fig (a)

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

II. MATERIALS AND METHODS

The materials used and methodologies adopted during the sample preparation, mechanical testing,fabrication 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

Banana fiber is complex in structure. They are generally lingo cellulosic, consisting of helically wound cellulose micro fibrils inamorphous matrix of lignin and hemi cellulose. The cellulose content serves as a deciding factor for mechanical properties alongwith micro fibril angle. A high cellulose content, low micro fibril angle impart desirable mechanical properties. Ligninsarecomposed of nine carbon units derived from substituted cinnamyl alcohol; that is, coumaryl, coniferyl, and syringyl alcohols.Lignins are associated with the hemicelluloses and play an important role in the natural decay resistance of the lingo cellulosic material. The composition of banana pseudostem obtained by elemental analysis.

Extraction of banana fiber from the pseudo stem Sheath of the plant. The extraction can be done mainly in three ways: Mechanical,Manual and chemical. In these, mechanical extraction is the best way to obtain fiber of 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 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.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. 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, lignin and cellulose. Cellulose and hemicellulose are present in the form of hollow cellulose in luffa which contributes to about 82 % of the total chemical constituents in it. 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 for it.

Fig 4 Luffa fiber

Sisal as a natural fiber

Sisal is a natural fiber is a stiff, yeild fiber traditionally used in making twine and rope. It is a biodegradable and eco-friendly crop all over the world. Moreover, sisal is a strong, stable and versatile material and it has been recognized as an important source of fiber for compositesin natural fibres. Sisal fiber made from the large spear shaped tropical leaves of the Agave Sisalana plant and sisal fiber is extracted by a process known as decortications.In which 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 eco 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 is widely 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.

Fig.1 Sisal plant

Fig.2 Sisal plant

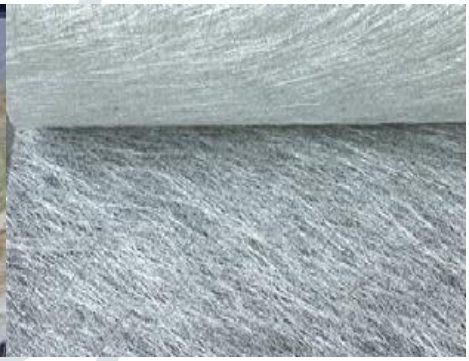

Fig.3 E-Glass fiber

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.

III COMPOSITE PREPARATION

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 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

IMPACT TEST- For impact testing, as per ASTM D 256-88 specifications, the specimen will be cut with a notch of 2.54mm and then using impact tester the test will be performed.

SHORE HARDNESS TEST- Ass per ASTM D 2240:2003 the specimen will be cutted.

Fig 3 a Rectangular shape sample with notch

Fig-3 b Testing sample

IV Mechanical Testing

Impact test

The impact strength of the matrix and the composite is measured by the Izod Impact Tester. The samples are made as per ASTM 256-88 specifications. The specimen that fits into the izod impact tester is rectangular with a notch cut in one side. The notch allows for a predetermined crack initiation location. Many composite izod impact tests are performed without the notch cut into the specimen.

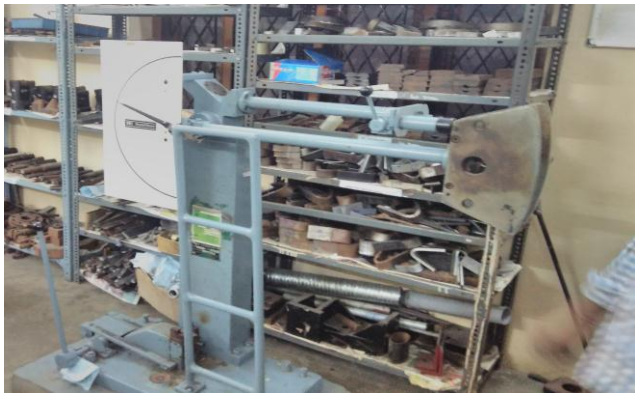

Fig 4 Impact machine Sample loaded condition

Shore Hardness Test

Shore hardness is tested with an instrument called Durometer.It utilizes an indenter loaded by a calibrated spring. The measured hardness is determined by the penetration depth of the indenter under the load. Shore hardness value may vary in the range from 0 to 100. Maximum penetration for each scale is 0.097-0.1 inch (2.5-2.54 mm). This value corresponds to minimum Shore hardness: 0. Maximum hardness value 100 corresponds to zero penetration.

Fig 5 Shore Hardness

V RESULTS AND DISCUSSION

Impact test

For impact testing, as per ASTM D 256-88 specifications, the specimen will be cut with a notch of 2.54mm and then using impact tester the test will be performed.The results single, double and triple layer samples are tabulated in the Table 4.

Table 4 Impact Test Data

Samples	Laminates	Observed values in joules
S1	GBLSG	2
S2	BLS	2
S3	GBSG	2
S4	GLBG	2
S5	GSLG	2

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 impact of all samples it was found is approximately equal.

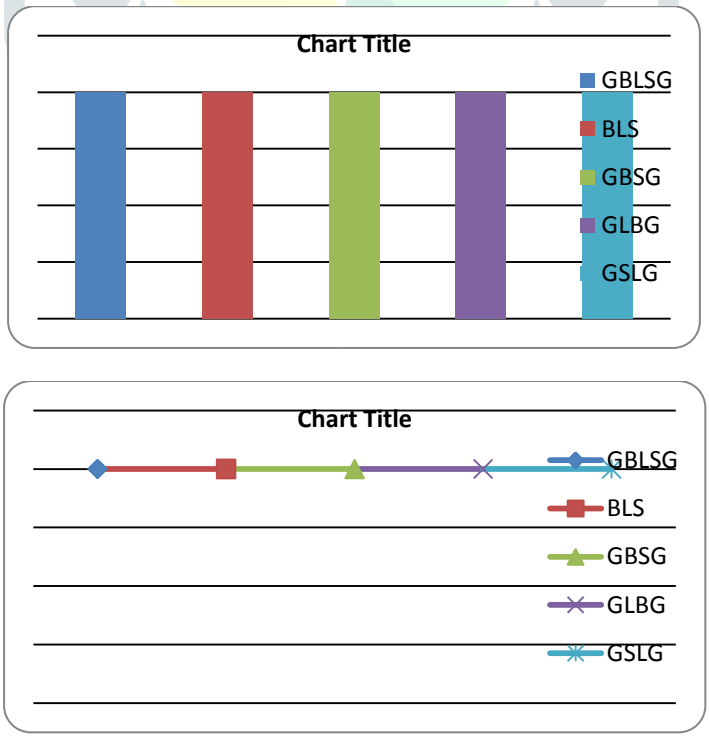

Fig 6 Impact test with different layers of sample

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

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

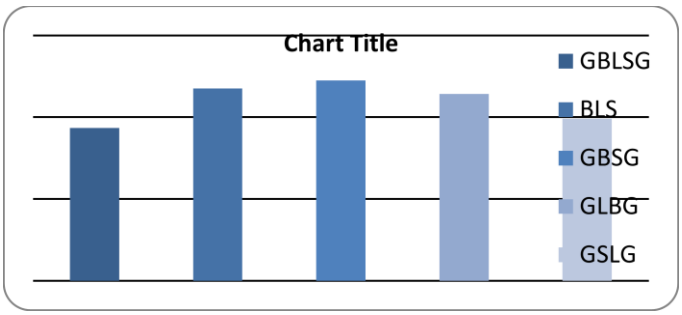

Fig 7 a Variation of Shore hardness with different layers of samples

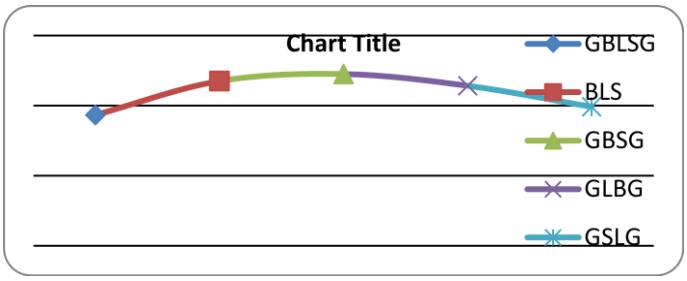

Fig 8 b Variation of Shore hardness with different volume fraction of fiber

Scanning electron microscopic test

To obtain the SEM images prepared specimens were cutted and subjected to sputter coating in order to obtain the conductive surface and also to avoid the splattering of electron beams while capturing the surface details. The SEM micrograph from the images it can be seen that fracture of the fiber and matrix due to the applied load are clearly observed and samples subjected to loading are presented in fig.6 indicated that the fiber pull out and voids on the resin in the specimen.

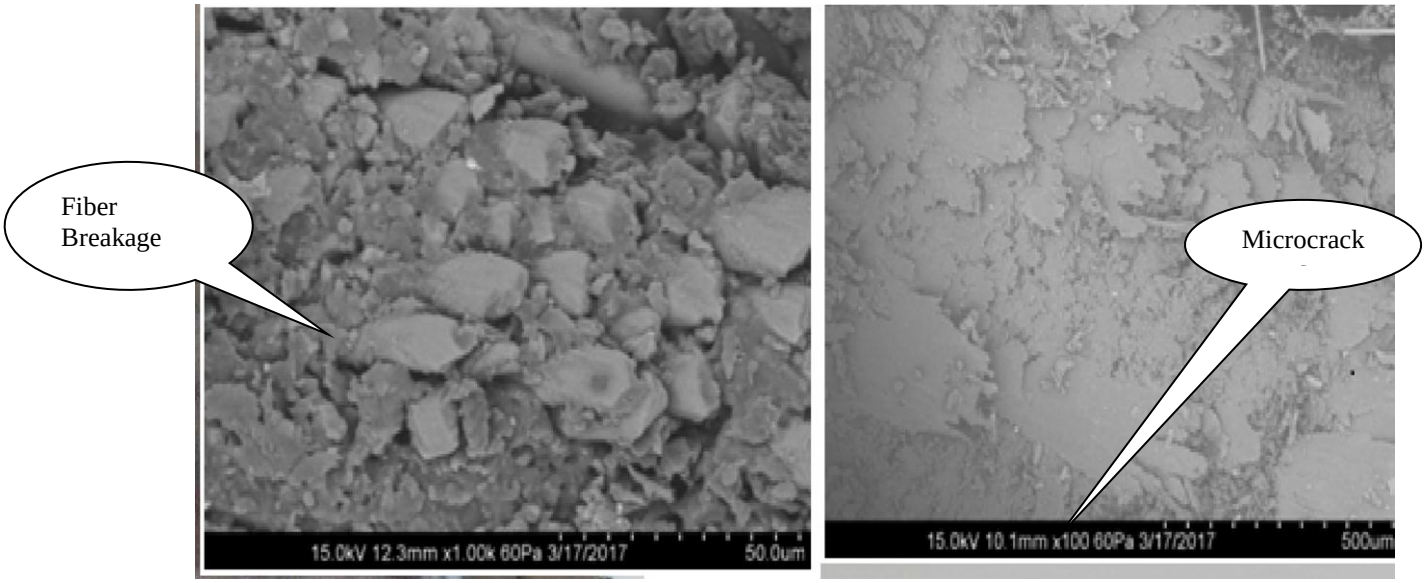

Fig 9 SEM micrographs of GBSG laminate

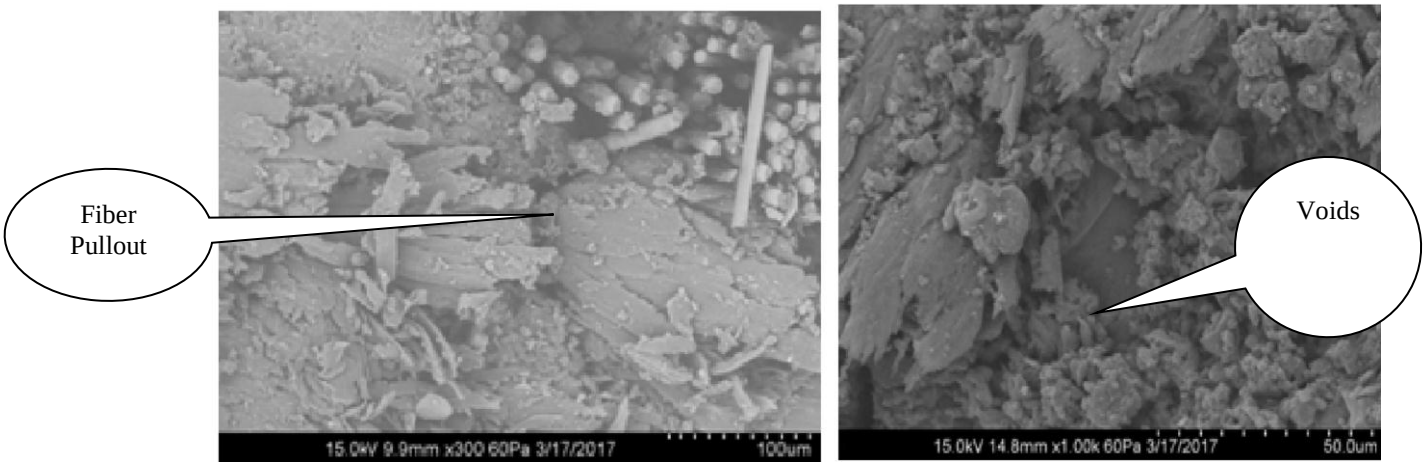

Fig 9 SEM micrographs of GBLSG laminate

VI 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. For impact testing, as per ASTM D 256-88 specifications, the specimen will be cut with a notch of 2.54mm and then using impact tester the test will be performed. It has been observed from this work that the impact strength is common for all samples i.e., 2Joules .However, the increase in shore hardness strength for GBSG layer composite (s3) may be due to the good fiber-matrix adhesion To obtain the SEM images prepared specimens were cutted and subjected to sputter coating in order to obtain the conductive surface and also to avoid the splattering of electron beams while capturing the surface details. The SEM micrograph from the images it can be seen that fracture of the fiber and matrix due to the applied load are clearly observed and samples subjected to loading are presented. By observing the SEM of the two laminates GBLSG,GBSG . It has large number of voids inside the. Laminates due to improper filling of resin and hardener due to which strength has been decreased. Proper mixing can increase strength.

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