ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 1, Issue 7, November 2016

Design, Fabrication and Testing of Sisal Fiber Filled Lapox L-12 Epoxy Resin Composites

[1] Abijeth K C [2] S.Venkataraju [3] Aruna Shanbhog [4] S Mahesh [5] Harishbabu L
[1] Student [2][3][4][5] Assistant Professor
[1][2][3]Department of Mechanical Engineering, Sri Sairam College of Engineering

Abstract:-- **Natural fibers are prospective reinforcement materials and their use until now has been more traditional then technical. They have served many useful purposes but the application of the material technology for the utilization of natural fibers as reinforcement in polymer matrix took place in comparatively recent years. Economic and other related factors in many developing countries where natural fibers are abundant demand that scientists apply appropriate technology to utilize these natural fibers as effectively and economically as possible to produce good quality fiber reinforced polymer composites for housing and other needs. Among various natural fibers, sisal is of particular interest in that its composites have high impact strength besides having moderate tensile and flexural properties compared to other lingo cellulosic fibers. The present project work is fabrication and mechanical characterization of sisal fiber reinforced epoxy polymer composites.**

Keywords: **Epoxy, LAPOX L -12, SISAL Leaf, Hardener K-6.**

Nomenclature	Unit
E Young's Modulus	GPa
Et Tangent Modulus	GPa
μ Poisson's Ratio	
σy Yield Strength	MPa
σut Ultimate Tensile Strength	MPa
Ɛy Yield Strain	

I. INTRODUCTION

Composite materials have generally considerable research interest during recent times. They are replacing many conventional engineering materials due to their specific properties of strength and stiffness. Composite materials were known to mankind in the Paleolithic age (also known as Old Stone age). The 300 ft high ziggurat or temple tower built in the city center of Babylon was made with clay mixed with finely chopped straw [1, 2].In recent years, polymeric based composite materials are being used in many applications, such as automotive, sporting goods, marine, electrical, industrial, construction, household appliances, etc.

Natural fibers from plants are beginning to find their way into commercial applications such as automotive industries, household applications, etc. [3]. A number of investigations have been conducted on several types of natural fibers such as kenaf, hemp, flax, bamboo, and jute to study the effect of these fibers on the mechanical properties of composite materials [4–7]. Mansur and Aziz [6] studied bamboo-mesh reinforced cement composites, and found that this reinforcing material could enhance the ductility and toughness of the cement matrix, and increase significantly its tensile, flexural, and impact strengths. On the other hand, jute fabric-reinforced polyester composites were tested for the evaluation of mechanical properties and compared with wood composite [7], and it was found that the jute fiber composite has better strengths than wood composites.

A pulp fiber reinforced thermoplastic composite was investigated and found to have a combination of stiffness increased by a factor of 5.2 and strength increased by a factor of 2.3 relative to the virgin polymer [8]. In dynamic mechanical analysis, Laly et al. [9] have investigated banana fiber reinforced polyester composites and found that the optimum content of banana fiber is 40%. Mechanical properties of banana–fiber–cement composites were investigated physically and mechanically by Corbiere-Nicollier et al. [10]. It was reported that kraft pulped banana fiber composite has good flexural strength. In addition, short banana fiber reinforced polyester composite was studied by Pothan et al. [11]; the study concentrated on the effect of fiber length and fiber content. The maximum tensile strength was observed at 30 mm fiber length while maximum impact strength was observed at 40 mm fiber length. Incorporation of 40% untreated fibers provides a 20% increase in the tensile strength and a 34% increase in impact strength. Joseph et al. [12] tested banana fiber and glass fiber with varying fiber length and fiber content as well. The analysis of tensile, flexural, and impact properties of these composites revealed that composites with good strength could be successfully developed using natural fiber as the reinforcing agent.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 1, Issue 7, November 2016

II. MATERIAL AND EXPERIMENTAL TECHNIQUES

2.1 Reinforcement

Conversion of sisal leaf into fibers and fiber mat available in dry lands. In this project we are using sisal leaf fibers to make reinforced composites. Initially the leaves are extracted from the sisal plant, which are normally long in length. These leaves are then fed in to fiber extracting machine, where these leaves are crushed by a set of cutters and bunch of fibers are extracted from the machine. This extracted fibers will have some moisture content, so these are kept to dry under sunlight for about 10- manually. Later these threads are weaved manually in bi-directional into fibre mats[4]

Stages of sisal fiber fabric preparation

Fig 1.0: Growing of sisal plants in mass

Fig 1.1(a): Leaves extracted from plant

Fig 1.1(b): Fiber extracting machine

Fig 1.2 (a): Harvested Sisal fiber

Fig 1.2(b): Prepared sisal fiber woven Fabric

Resin System

***Resin**: In this investigation LAPOX L-12 epoxy resin was used. LAPOX L-12 is a liquid, unmodified epoxy resin of medium viscosity which can be used with various hardeners for making fiberglass reinforced composites and laminates[5]. The choice of hardener depends upon the processing methods to be used and on the properties required.

***Hardener**: in* this investigation hardener K-6 is used. K-6 is a low viscosity room temperature curing aliphatic amine curing agent. It is commonly employed for civil engineering systems where low viscosity and fast setting at ambient temperature is desired.

2.2 Resin Preparation

In this LAPOX-12 is used as the resin and K-6 is used as the hardener. The mixing ratio of resin and hardener is 100:10.According to this ratio initially 350ml of resin and 35ml of hardener is taken in a clean and dry beaker separately. Then 35ml of hardener is mixed with the resin and stirred manually for about 5min.LAPOX L-12: Hardener k-6 = 100:10 Pot Life of mix @25oC 30 minutes.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 1, Issue 7, November 2016

The properties of 3mm resin caste sheet mentioned in the following table.

Properties	Units	Values
Tensile strength	N/mm2	50-60
Compression strength	N/mm2	110-120
Flexural strength	N/mm2	130- 150
Impact strength	N/mm2	17-20
Modulus of elasticity	N/mm2	4400-4600
Coefficient of linear thermal expansion	10-6/°C	64-68
Martens value	°C	75-80
Thermal conductivity	Kcal/mh°C	0.211

Table 2.1 Resin Properties

2.3 Fabrication Of Sisal Fiber Epoxy Composites

A die of 200X200 with two metal sheets has to been prepared. On a horizontal surface a metal sheet with an OHP film is placed on which the die is placed. A thin layer of resin is applied on the entire surface of the OHP film. Simultaneously a fiber mat of 12gm with dimension of 200x200mm is placed over it. Again a thin layer of resin is applied and the above step is continued until totally for 4 flies of fiber placed to obtain required thickness. After, the top face of the die is covered using an OHP film with a metal sheet, load is applied over it and kept for curing about 4-5hrs. Fig: 1.3(a) & 1.3(b) shows the short and long fiber reinforced epoxy composites.

Fig 1.3(a): Bidirectional waived

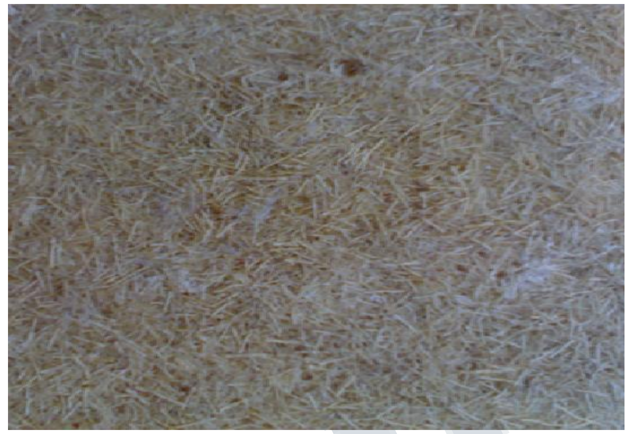


Fig 1.3(b): Short waived sisal fiber reinforced composite sisal fiber reinforced composite

2.4 Specimen Preparation

For preparing the specimen, initially the dimensions of each test are marked on the composite and then cutting is performed according to the dimensions. Dimensions of the bending test specimen according to the ASTM -D790 are as shown in the below mentioned fig: 1.4 Ref [13][14][15]

Fig 1.4: Bending test specimen

Dimensions of the tensile test specimen according to the ASTM- D638 are as shown in the fig: 1.5

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 1, Issue 7, November 2016

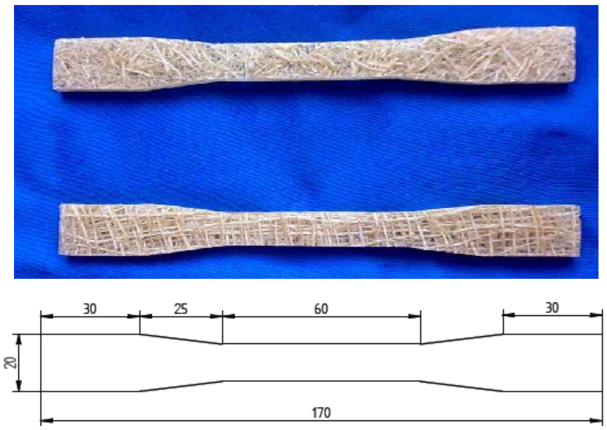


Fig 1.5: Tensile test specimen

Dimensions of the Impact test specimen according to the ASTM-D256 are as shown it the fig: 1.6

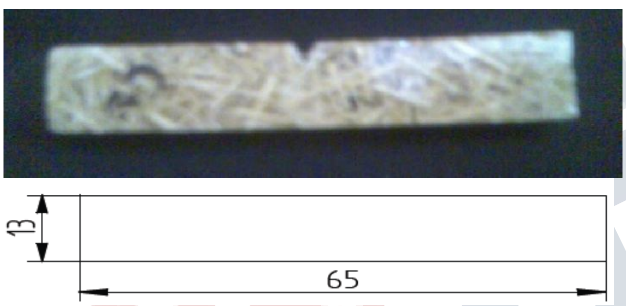


Fig 1.6: Impact test specimen

Dimensions of the Shore hardness test specimen according to the ASTM D785 are as shown in the fig: 1.7

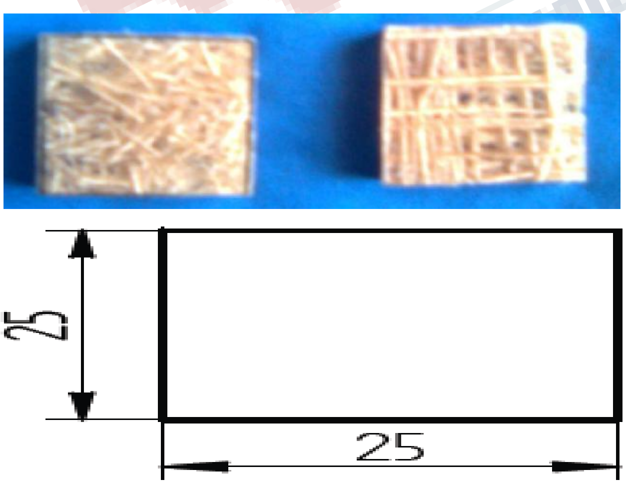


Fig 1.7: Surface hardness test specimen

Dimensions of the Water absorption test specimen according to the ASTM -D790 are as shown in the fig: 1.8

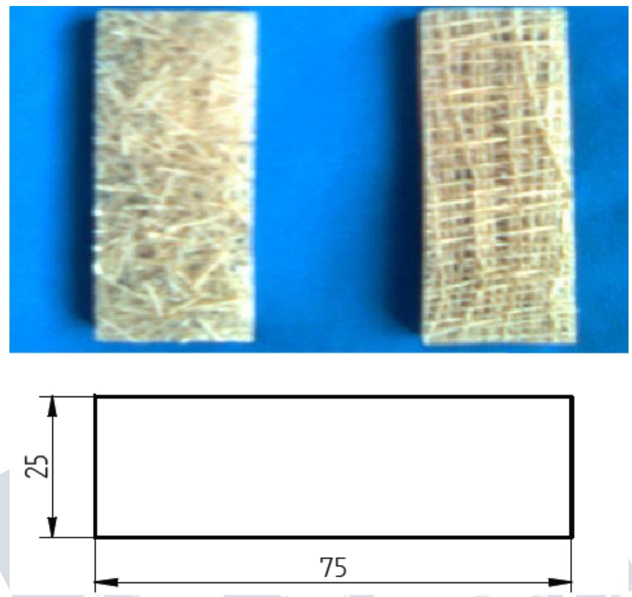


Fig 1.8: Water absorption test specimen

2.5 Experimental Techniques

This chapter deals with the theory and experimental techniques and methods used to investigate the physical, mechanical, thermodynamic, sliding wear and electrical properties of the prepared composites.

2.5.1 Theory And Techniques

The fabricated composites have been characterized by mechanical techniques [7]. The following paragraphs provide basic theory, techniques and experimental procedures adopted for measurements.

Density of Composites as per ASTM D792 – 86

Density of composites was measured according the ASTM D792–86 (displacement method) using Mettler electronic balance. Instrument was calibrated before use. This technique is applicable for solid samples such as film, sheet or powder. The accuracy of density obtained by this method is ± 0.0001g/cc.

Surface Hardness as Per ASTM D785

Hardness is the property of a material showing resistance to surface indentation. Surface hardness of composite was performed as per ASTM D785 on Rockwell hardness testing machine. In this investigation 1/16" diameter steel ball is used with a 150-kilogram load and the hardness is read on the "B" scale. The Rockwell test uses two loads, one applied directly after the other. The first load known as the "minor" load of 10 kilograms is applied to the specimen to seat the indenter and remove the effects in the test of any surface irregularities. The minor load creates a uniformly shaped surface for the application of major load. The difference in the depth of the indentation between the minor and major loads provides the Rockwell hardness number.

Tensile test as per ASTM- D638

Loyds LR 100K, Universal tensile testing machine was used to conduct tensile test on composite specimens. In this test, measurement of the tensile strength, percentage of elongation and young's modulus of the composite materials is measured.

$$\text{Tensile Strength(Mpa)} = \frac{\text{Load at break}}{\text{Cross sectionan area}}$$

% of Elongation = strain x 100 …………………….. (2)

The young's modulus of the material is calculated from the slope of the stress- strain curve.

Three-Point-Bending Test as per ASTM -D790

A three point bending technique is adopted for this test. Flexural test measures the Flexural strength, Flexural modulus of the composite materials. The Flexural tests for the specimens were carried out as per ASTM-D790 standard. The flexural strength is calculated by the equation

σf =3PL /2BD2 …………………………..(3)

The slope of load versus deformation curve generated by the computer which was interface with the machine gives the modulus.

σf = Bending strength in N/ mm2
p=load in N
L=Length between supports in mm
B=width of the specimen in mm
D=depth of the specimen in mm
E=L3m /4 B D3……………..(4)
E=Modulus in N/ mm2
m= slope of the curve

Impact Test as per ASTM-D256

Impact, in its physical context defined as the deformation and failure process during the collision of two or more objects. Impact is dynamic in nature. The impact properties of a material represent its capacity to absorb and dissipate energy under shock load. Fiber reinforced composites are highly strain rate sensitive and hence the static mechanical properties cannot be used in designing against impact failure. Impact testing is useful in comparing the failure modes and the energy absorption capabilities of different materials under impact loading. In this investigation the impact strength were determined using Izod impact tester, pendulum type (PSI make, India) confirming to ASTM-D256 specification. In each case, five samples were tested and the average valve reported.

Water Absorption

Short fiber reinforced sisal epoxy composite and long fiber reinforced sisal epoxy composite were subjected water absorption test as per ASTM standard for about 20 days and results are discussed in the next section.

2.6 Results And Discussions

2.6.1 Tensile Test & Young's Modulus of Long Fiber and Short Fiber Composite

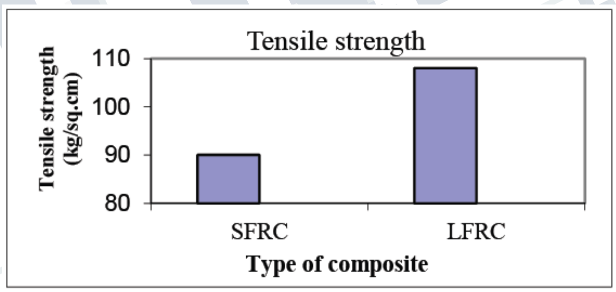


Fig 1.9: Plot of tensile strength v/s type of composite

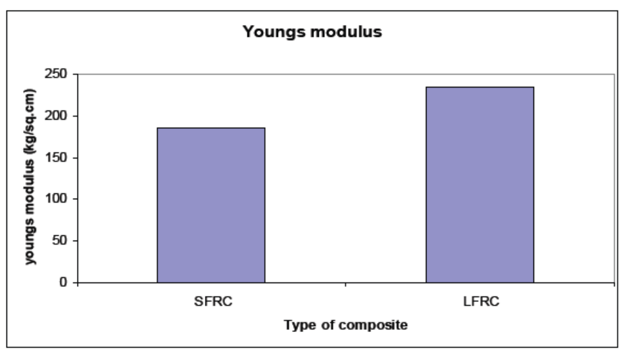


Fig 1.10: Plot of young's modulus v/s type of composite

From the above fig 1.9 & 1.10 it can be observed that the tensile strength & young's modulus of long fiber reinforced epoxy composite is more than short fiber reinforced epoxy composite.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 1, Issue 7, November 2016

2.6.2 Flexural Strength and Flexural Stress Test Of Long Fiber And Short Fiber Composite

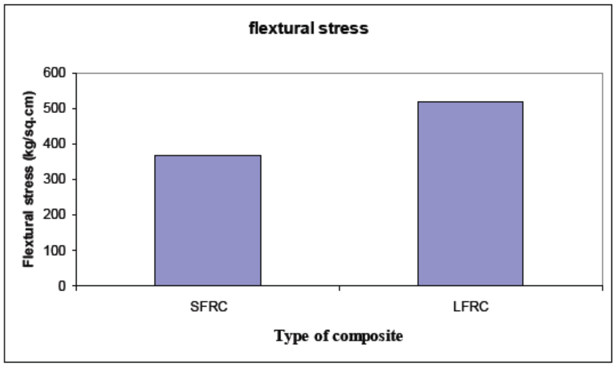


Fig 1.12: Plot of flexural stress v/s type of composite

From the above fig 1.11 & 1.12 we absorb that Flexural strength and Flexural stress of long fiber reinforced epoxy composite is more than short fiber reinforced epoxy composite.

2.6.3 Percentage Elongation at Peak Load and Percentage Elongation At Break Load Test Of Long Fiber And Short Fiber Composite

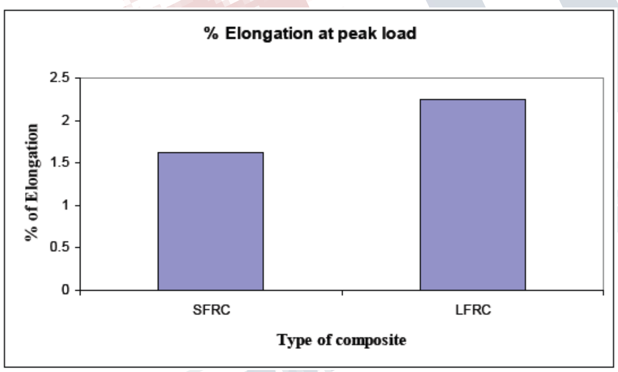


Fig 1.13: Plot of % elongation at peak load v/s type of composite

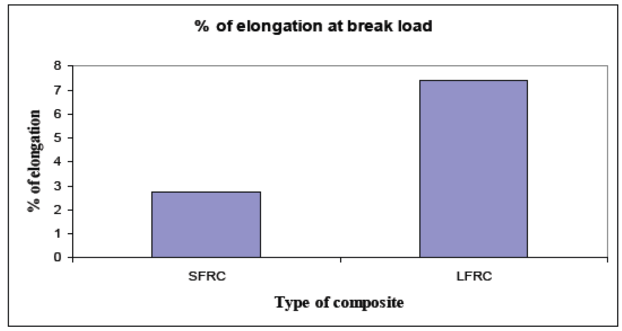


Fig 1.14: Plot of % elongation at break load v/s type of composite

From the above fig 1.13 & 1.14 we absorb that % elongation at peak load and % elongation at break load of long fiber reinforced epoxy composite is more than short fiber reinforced epoxy composite

2.6.4 Flexural Modulus Test of Long Fiber and Short Fiber Composite

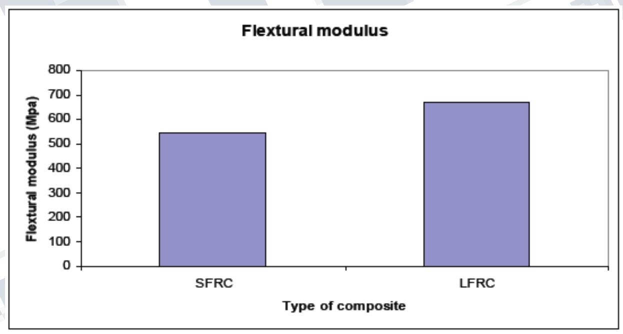


Fig. 1.15: Plot of flexural modulus v/s type of composite

From the above fig 1.15 we absorb that flexural modulus of long fiber reinforced epoxy composite is more than short fiber reinforced epoxy composite.

2.6.5 Impact Strength Test of Long Fiber and Short Fiber Composite

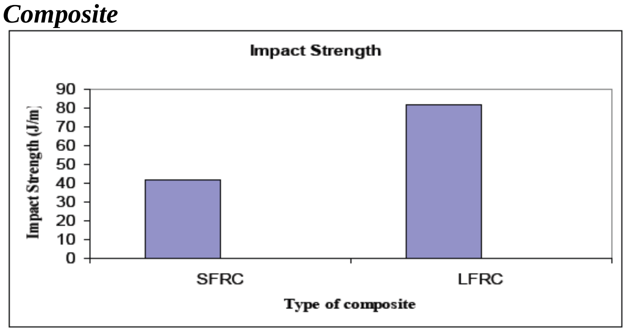


Fig 1.16: Plot of Impact strength v/s type of composite

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 1, Issue 7, November 2016

From the above fig 5.8 we absorb that Impact strength of long fiber reinforced epoxy composite is more than short fiber reinforced epoxy composite.

2.7 Water Absorption Test of Long Fiber and Short Fiber Composite

Table 2.2

Days	Long fiber (Weight in gm)	Short fiber (Weight in gm)
1st	20	20
5th	20	15.8
10th	20	15.8
15th	17	16
20th	17	16

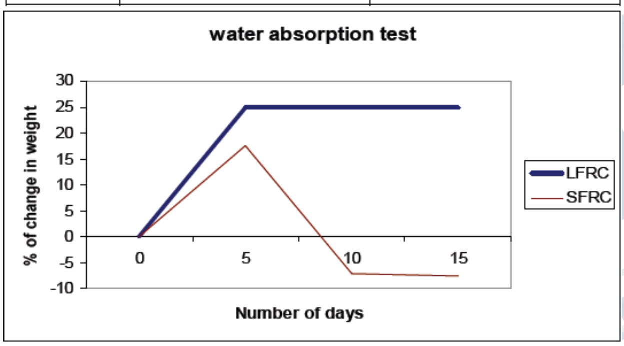


Fig 1.17: Plot of % change in weight v/s number of days

Fig 1.17 shows water absorption Short fiber reinforced sisal epoxy composite and long fiber reinforced sisal epoxy composite shows increase in water uptake with increase in duration till 5days of immersion. After it is observed that water absorption becomes constant in case of long fiber reinforced sisal composite (at 25% of water absorption) and in case of short fiber reinforced composite decreasing the total weight. This indicates that the material is dislodging from the surface due to poor of fiber and matrix in short fiber reinforced composite. Due to this the strength after water absorption decreases and degrades the performance of composite material.

III RESULTS OF TESTED SPECIMENS OF DEVELOPED SISAL FIBER REINFORCED COMPOSITES

Properties	Unit	Long fiber reinforced composite	Short fiber reinforced composite
Density	gm/cc	3.7	3.6
Tensile Strength	Kg/sq.cm	108	90
Young's Modulus	Kg/sq.cm	235	185
Flex. Strength at Peak Load	Kg/sq.cm	32.31	23
Flexural Stress	Kg/sq.cm	517.0196	368
% Elong. at Peak Load	%	2.25	1.62
% Elong. at Break Load	%	7.38	2.75
Flexural Modulus	Mpa	669.3379	546
Impact strength	J/m	82	42
Surface Hardness	Shore D	64	64
Water absorption after 5 days of immersion	% of change in weight	25	17.6

Table 2.3

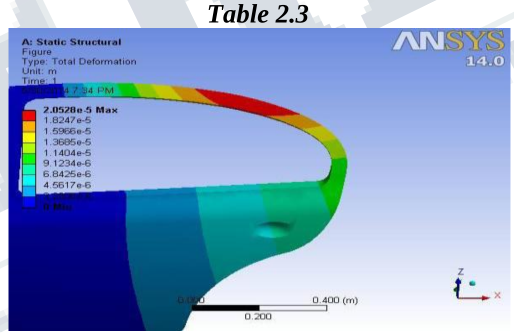


Fig 1.18 Car Door Total Deformation in Long fiber composite

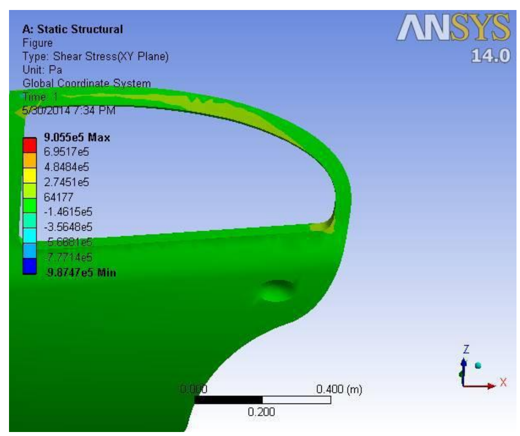


Fig 1.19 Car Door Shear stress in long fiber composite

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 1, Issue 7, November 2016

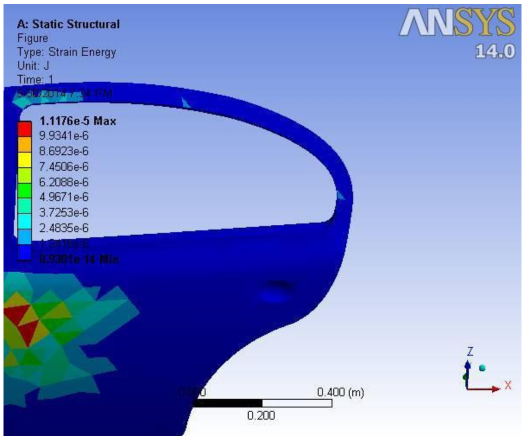
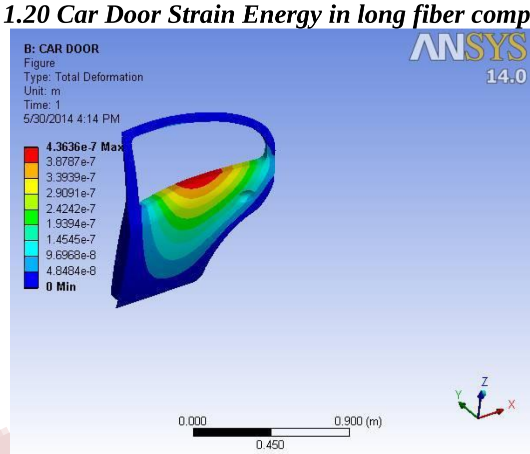
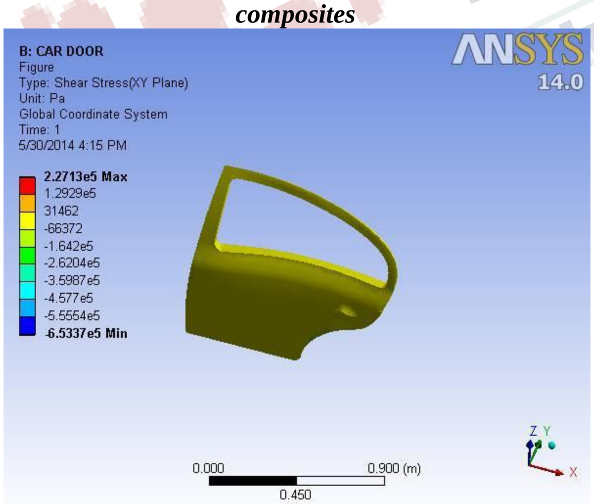


Fig 1.20 Car Door Strain Energy in long fiber composite



1.21 Car Door Total Deformation in short fiber composites



1.22 Car Door Shear Stress in short fiber Composites

IV. CONCLUSION

- ♣ Sisal fiber reinforcement increases the mechanical properties of resin
- ♣ Long Sisal fiber reinforcement epoxy composite exhibits higher strength than short Sisal fiber reinforced epoxy composite.
- ♣ Sisal fibers have good potential as reinforced in polymer composites.
- ♣ Due to low density and high specific properties these types of composites have lot of opportunities in automotive and transportation industries.
- ♣ Sisal fiber reinforced polymer composites reduce equipment abrasion and subsequent reduction of retooling cost will make those composites more attractive.
- ♣ Harvesting and supply of sisal fibers for composite manufacturing from rural area could generate a non-food source of economic development for farming and rural areas.

REFERENCES

1) F.T. Wallenberger and N. Weston, “Natural Fibers, Plastics and Composites Natural”, Materials Source Book from C.H.I.P.S. Texas, 2004.
2) K. G. Satyanarayana, K. Sukumaran, P. S. Mukherjee, C. Pavithran and S. G. K. Pillai. “Natural Fiber–Polymer Composites”, J Cement and Concrete Composites, 12(2)(1990), pp. 117–136.
3) K. G. Satyanarayana, K. Sukumaran, A. G. Kulkarni, S. G. K. Pillai, and P. K.Rohatgi, “Fabrication and Properties of Natural Fiber-Reinforced Polyester Composites”, J. Composites 17(4)(1986), pp. 329–333.
4) M. A. Mansur and M. A. Aziz, “Study of Bamboo-Mesh Reinforced Cement Composites” Int. Cement Composites and Lightweight Concrete, 5(3)(1983), pp. 165–171.
5) T. M. Gowda, A. C. B. Naidu, and R. Chhaya, “Some Mechanical Properties of Untreated Jute Fabric-Reinforced Polyester Composites”, J. Composites Part A: Applied Science and Manufacturing, 30(3)(1999), pp. 277–284.
6) L. Lundquist, B. Marque, P. –O. Hagstrand, Y. Leterrier and J. -A. E. Månson, “Novel Pulp Fiber Reinforced Thermoplastic Composites”,

Composites Science and Technology, 63(1)(2003), pp. 137–152