Design and characterization of E-Glass Fiber Reinforced Composite Material with use of sisal Fiber

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Abstract:- *The present work describes the development and mechanical characterization of new polymer composites consisting of E-glass fiber[1] reinforcement, Epoxy resin, and hardener, natural fiber (Sisal fiber).The newly developed composites are characterized by their mechanical properties. Experiments like Hardness test, tensile test, Compression test, Impact test were conducted to find the significant influence of natural fiber (sisal) on mechanical characteristics of Glass fiber Reinforcement composites. Composites are an important class of materials available to mankind. Studies of these composites play a very important role in material science, metallurgy, chemistry, solid mechanics and engineering applications. The E-glass fiber[1] reinforced polymer composite is more widely used in the automotive industry and other industrial applications, due to their advantages, like low cost, noise control, low weight and ease of processing. Natural fibers1 are cheap and environment-friendly materials. Glass Fiber[2] composites are considered to have potential use as a reinforcing material in epoxy polymer-based composites because of their good strength, stiffness etc., in the present study, mechanical properties[3] for glass fiber composites were evaluated. The present work focuses on mechanical characterization of new polymer composites consisting of glass fiber reinforcement, epoxy resin, and sisal fiber. The newly developed composites are characterized for their mechanical properties[3]. Experiments like the tensile test, compression test, hardness test and impact test were conducted to find the significant influence of sisal fiber on mechanical characteristics of GFRP3 (Glass Fiber Reinforced Polymer) composites.*

Keywords: *Epoxy hybrid composites, E-glass fiber, sisal fiber*

1. Introduction

1.1 Introduction to composite material

This is a new generation of reinforcements and supplements for polymer[2] based materials used as the reinforcement in polymer matrix composites[4]. Their availability, low density, and price as well as satisfactory mechanical properties, make them attractive alternative reinforcements to glass, carbon and other manmade fibers diameter. Continuous fibers1 have high aspect ratios, while discontinuous fibers have low aspect ratios, and the orientation of continuous fiber composites normally is perfect, while discontinuous fibers generally have a random orientation with fiber volume as high as 60 to 70%. Polymers[12] have low strength and stiffness, metals have intermediate strength and stiffness but high ductility, and ceramics have high strength and stiffness but are brittle is the main driver and strength and stiffness are less important.

Figure 1:Scanning Electron Micrograph of NaoH treated sisal fiber-epoxy composites showing better fiber-matrix adhesion

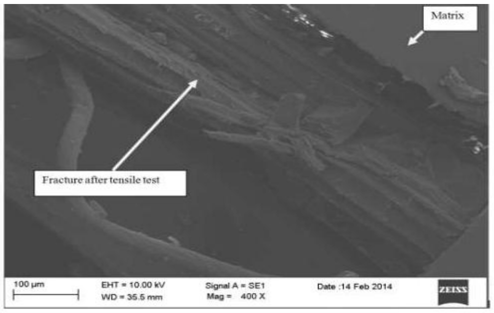

Figure 2:SEM image of tensile tested hybrid glass/sisal reinforced epoxy composites

1.1.1Classificationof composite materials
Composite materials are broadly classified into three categories as given Composites
Metal matrix composites (MMCs)
Ceramic matrix composites (CMCs)
Polymer matrix composites (PMCs)
1.2Introduction to glass fiber

Glass fiber10 also called fiberglass. It is a material made from extremely fine fibers of glass Fiberglass is a lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. The strength to weight ratio is better when compared to metals and can be easily formed by molding process. Glass is the oldest, and most familiar, performance fiber13. Fibers have been manufactured from glass since the 1930s.

Figure 3:Glass Fiber

1.2Types of glass fibers
1. A type glass fiber
2. AR type glass fiber
3. C type glass fiber
4. D type glass fiber
5. E type glass fiber
6. ECR type glass fiber
7. R type glass fiber
8. S type glass fiber

1. A Type glass fiber

Alkali glass made with soda lime silicate. Used where an electrical resistivity of E-glass is not needed. A-glass or soda lime glass is the predominate glass used for containers and windowpane.

• Fiber density of soda lime

Density	-	2.44 g/cm3
Tensile strength	-	3300MPa
Young's modulus	-	72 GPa
% of elongation	-	4.8

2. AR- type glass fiber

Alkali Resistant glass made with zirconium silicates. Used in Portland cement substrates.

• Properties of AR-type glass fiber

Density	-	2.7 g/cm3
Tensile strength	-	1700MPa
Young's modulus	-	72 GPa

% of elongation - 2.3

3. C – type glass fiber

Corrosive resistant glass made with calcium borosilicate. Used in acid corrosive environments.

- Properties of C- type glass fiber

Density - 2.56g/cm3
Tensile strength - 3300MPa
Young's modulus - 69 GPa
% of elongation - 4.8

4. D – type glass fiber

Low dielectric constant glass made with borosilicate. Used in electrical applications.

- Properties of D –type glass fiber

Density - 2.11 g/cm3
Tensile strength - 2500MPa
Young's modulus - 55 GPa
% of elongation - 4.5

5. E- type glass fiber

Alkali-free, highly electrically resistive glass[10] made with alumina-calcium borosilicate. E-glass is known in the industry as a general-purpose fiber for its strength and electrical resistance. It is the most commonly used fiber in the fiber reinforced polymer composite industry.

- Properties of E –type glass fiber

Density - 2.54g/cm3
Tensile strength - 3400MPa
Young's modulus - 72 GPa
% of elongation - 4.7

Physical properties

- Low cost.
- High production rates.
- High strength.
- High stiffness.
- Relatively low density.
- Non-flammable.
- Resistant to heat.
- Good chemical resistance.
- Relatively insensitive to moisture.
- Able to maintain strength at diverse conditions.
- Good electrical insulation.

Composition

SiO2 - 54%
Al2O3 - 14%
Cao + Mgo - 22%
B2O3 - 10%

6. ECR –type glass fiber

An E-glass with higher acid corrosion resistance made with calcium aluminosilicates. Used where strength, electrical conductivity, and acid corrosion resistance is needed.

- Properties of ECR –type glass fiber

Density - 2.72g/cm3
Tensile strength - 3400MPa
Young's modulus - 80 GPa
% of elongation - 4.3

7. R – Type glass fiber

A reinforcement glass made with calcium13 aluminosilicates used where higher strength and acid corrosion resistance is needed.

- Properties of R –type glass fiber

Density - 2.52g/cm3
Tensile strength - 4400MPa
Young's modulus - 86 GPa
% of elongation - 5.1
Composition
SiO2 - 58-60%
Al2O3 - 23.5-25.5%
Cao + MgO - 14-17%

8. S –Type glass fiber

High strength[13] glass made with magnesium aluminosilicates. Used where high strength, high stiffness, extreme temperature resistance, and corrosive resistance is needed.

- Properties of S–type glass fiber

Density - 2.523/cm3
Tensile strength - 4600MPa
Young's modulus - 89 GPa
% of elongation - 5.3

- Physical properties
- High production rates.
- Improved mechanical properties compared to E-glass.
- High strength.
- High stiffness.
- Relatively low density.
- Non-flammable.
- Resistant to heat.
- Good chemical resistance.
- Relatively insensitive to moisture.
- Able to maintain strength properties over a wide range of conditions.

Composition
Sio2 - 65%
Al2O3 - 25%
Mgo - 10%

1.3 Introduction to e-glass fiber

Fiberglass has a white color and is available as a dry fiber fabric as shown in Fig.1. Four major types of Glass Fiber used for composites: E-glass: have good strength & electrical resistivity. S-glass: have 40% higher strength, better retention of properties[10] at elevated temperatures. C-glass have corrosion resistant. Quartz: have low dielectric properties, good for antennae. Glass fiber exhibit two forms.-+*

- Unidirectional

Unidirectional tapes have been the standard within the aerospace industry for many years, and the fibre[10] is typically impregnated with thermosetting resins. Tape products have high strength in the fiber direction. The fibers are mixed with the resin.

- Bi-directional

Most fabric constructions offer more flexibility for the layup of complex shapes than straight unidirectional tapes offer. Fabrics offer the option for resin mixed either by hot melt or the solution process. Generally, fabrics used for structural applications use like fibers[13] or strands of the same weight or yield in both the warp (longitudinal) and fill (transverse) directions. For aerospace structures, tightly woven fabrics are usually to save weight, minimizing size, and maintaining during the fabrication process.

Figure 4:E-Glass Fiber Matt.

Figure 5: Epoxy resin and Hardener

In this research work, materials tested consist of E-glass fiber[10] reinforced composites with Epoxy resin as matrix reinforced composites. The E-glass fiber matt is used, supplied by GO GREEN PRODUCTS, CHENNAI

1.4 Introduction to epoxy resin

The resin is a generic term used to designate the polymer. The resin, its chemical composition, and physical properties[16] fundamentally affect the processing, material. Thermosetting resins are the most diverse and widely used of all man-made materials. They are easily poured or formed into any shape, are compatible with most other materials, and cure readily (by heat or catalyst) into an insoluble solid. Thermosetting resins are also excellent adhesives and bonding agents. Epoxy resin[6] is mostly used.

Epoxy resins are much more expensive than polyester resins[7] because of the high cost of the precursor chemicals most notably epichlorohydrin. However, the increased complexity of the 'epoxy' polymer chain and the potential for a greater degree of control of the cross-linking process gives a much-improved matrix in terms of strength and ductility. Most epoxies require the hardener and resin to be mixed in equal proportions.epoxies are used for full strength. It requires heating to complete the curing process. This can be advantageous as the resin can be applied directly to the fibres[5] and curing need only take place at the time of manufacture. And known as pre or pre-impregnated fiber.

Epoxy polymers [6] are made by reacting epichlorohydrin with biphenyl-A in an alkaline solution which absorbs the HCl released during the condensation polymerization reaction. Each chain has a molecular weight between 900 and 3000 with an epoxide grouping at each end of the chain but none within the polymer chain. The epoxy is adding by a hardener in equal amounts and it is heated to about 120°C. The hardeners are usually short chain diamines such as ethylene diamine. Heat is usually required since the cross-linking involves the condensation of water which must be removed in the vapor phase.

Hardener

A substance or mixture added to the plastic composition to promote or control the curing action by taking part in it. Also, a substance added to control the degree of hardness of the cured film.

1.5 Introduction to natural fiber (sisal fiber)

In the last ten years, there has been an increase in the use of natural fiber composites.There is tremendous potential for future growth in this area both in terms of their research aspects and industrial applications. So, the present focus of the work is to develop natural fiber composites which inhibits the form of renewable energy and the research material as green composites. This reinforcement will be a supplement for polymer-based materials.This is a new generation of reinforcements and supplements for polymer-based materials. Fibers develop from plants such as ramie, bamboo, banana, cotton, hemp, jute, sisal, pineapple, etc.Wood and seeds of flax are used as the reinforcement in polymer matrix composites. Their availability, low density, and price as well as satisfactory mechanical properties7, make them attractive alternative reinforcements to glass, carbon and other manmade fibers. Natural fibers are alike hair material that is continuous filaments[5]. It is similar to pieces of the thread and it can be converted into filaments. Natural fibers are classified depending on their origin, derivatives of plants and types of minerals.These sustainable and eco-efficient fibers have been applied as substitutions for glass and other synthetic fibers in diverse engineering applications. In view of environmental consciousness, the biodegradable natural waste can be reducedlandfills, if they are used for replacing other non-degradable materials for product development. Natural fibers are flexible for manufacturing with less tool damage.

Ecological risks demand the substantial growth of natural fibers over synthetic fibers thus focused to be a renewable resources. Factors like poor wet ability, poor bonding and degradation at the fiber/matrix interface, and damage of the fiber during the manufacturing process, are the main causes for the reduction of the composite's strength.

1.5.1 Sisal fiber

Sisal fiber is obtained from the leaves of the plant Agave Sisalana, which is grouped under the broad heading of "hard fibers", among which sisal[7] is placed second to Manila in durability and strength. The cell wall consists of several layers of febrile, and the primary wall has a reticulated fibrillate structure. In the outer secondary wall, which is located inside the primary wall, thefibrillate are arranged in spirals with a spiral angle of 4 0° in relation to the longitudinal axis of the cell.

Figure 6: Sisal Fiber Plants

Figure 7: Extraction of sisal from sisal plants

Figure 8: Dried Sisal fiber

The cell wall consists of several layers of febrile, and the primary wall has a reticulated fibrillate structure. In the outer secondary wall, which is located inside the primary wall, the fibrillate are arranged in spirals with a spiral angle of 40° in relation to the longitudinal axis of the cell. The fibrillate[7] in the inner secondary wall of the sisal fibers have a sharper slope of 18 to 25°. The thin, innermost, tertiary wall has a parallel fibrillate structure and encloses the lumen. The sisal leaf contains three types of fibers, such as mechanical fibers, ribbon fibers, and xylem fibers. The mechanical fibers are extracted mostly from the periphery of the leaf. They are the most commercially useful sisal fiber. Ribbon fibers occur in association with the conducting tissues in the median line of the leaf.The ribbon fibers are the longest fibers when compared to the mechanical fibers they can be easily split longitudinally during processing. Xylem fibers have an irregular shape and occur opposite to the ribbon fibers. The SEM micrographs of the sisal fibers are presented in which shows the surface features of the sisal fiber. In the case of micro fibrillated sisal fibers, the surface micro fibrils[7] and aggregates were well developed, providing a larger contact area and introducing micro or Nano-sized reinforcement to the fiber surface as shown.

1.6 Scope of the present study

Natural fibers are mostly available in many countries. It can be using locally available manpower and technology. The latest development in the use of composites is to protect man against fire, impact and a tendency to a more environment-friendly design, leading to the introduction of natural fibers[5] in composite technology. These include the process of extraction of fibers from the respective plants, then, the extracted fibers could be added alone with resin or in the hybrid composites by substituting industrial fibers.

1.7 Need for the present study

Now-a-days, natural fiber reinforced composite materials5 are replacing the conventional, synthetic and manmade fiber reinforced composites, due to their easy availability, biodegradability, Eco-friendliness, in-homogeneity, non-ductility, renewable nature and user-friendly characteristics. Glass fiber reinforced composites have excellent mechanical properties[13], but the process of disposal is very difficult due to severe environmental concerns, and the process of recycling these composites has been a serious problem. Though glass and other synthetic fiber reinforced composites[10] possess high strength, the field of their application is restricted, because of their higher cost of production and low biodegradability.The usage of natural fiber based composite materials is growing during recent years, due to their specific properties, positive environmental impact, economical production and processing, and their safe handling and working conditions. To take advantage of sisal fiber added with glass fiber conjointly to the matrix, so that an optimal, superior but economical composite can be obtained.

1.8 Properties of sisal fiber

Each leaf of a sisal plant has a composition of 4% fiber, 0.75% cuticle, 8% other dry matter and 87.5% of moisture. A normal leaf weighing about 600g yields about 3% by weight of fiber16. It has high tensile strength when compared to the other natural fibers. It has low specific weight resulting in a higher specific strength and stiffness.

1.9 Advantages of Sisal Fiber

- It is a renewable source, the production requires little energy and CO2 is consumed and O2 is given back to the atmosphere.
- It has good thermal and acoustic insulating properties7.
- The thickness of sisal fiber is high when compared to other natural fibers
- It is a short natural fiber when compared to jute, and this confers
- Very good impact strength.

1.10 Applications of Sisal Fiber

- Manufacturing of post-boxes, grain storage silos, bio-gas containers, etc.
- Manufacturing of chairs, tables, showers, bath units, etc.
- Making of electric devices, electrical appliances, pipes, etc.
- Used in everyday applications, such as lampshades, suitcases, helmets, etc.
- Used for making automobile interiors and panels.

1.11 Sisal fiber Properties

Tensile Strength (Mpa)	:	350 to 680
Elongation of Break (%)	:	6.8
Diameter (mm)	:	0.8 to 1.2mm
Density (g/cm3)	:	1.58
Young's Modulus (Gpa)	:	19.8

2. Basic design procedure

The following are the materials used to prepare e glass fiber composite material specimen with addition of natural fiber (sisal fiber)

2.1 Materials used

- E-Glass fiber
- Sisal fiber (Natural fiber)
- Epoxy and hardener

2.2 Preparation of specimen**:**

The following Specimen consists of three layers in which E-glass fiber mat is placed top and bottom of the specimen. A middle layer is filled with sisal fiber. The layers of fibers are fabricated by adding required amount of Epoxy resin. Initially, sisal fiber is soaked in alkaline solution NaoH for two hours and dried in hot oven for three hours to remove moisture. Epoxy6 and hardener are mixed in the ratio of 10:1.After mixing the epoxy resin is used to prepare a specimen. Before going to the making of specimen the glass fiber matt is cut into required dimensions. The following are the dimensions of glass fiber and sisal to prepare a required specimen.

2.2.1 Specimen -1

DIMENSIONS:Width=200mm
Length=300mm
Chopped sisal fiber length=300mm
Fabrication details:
Glass fiber to natural fiber = 1:1

E-glass fiber	= 40gms
Sisal fiber	= 40gms
Epoxy and hardener	= 220gms

Cut the glass fiber into required size. Initially, E-glass fiber is placed on an Aluminum foil and resin is coated on E-glass fiber using roller brush.

Chopped sisal fiber is placed on a glass fiber and resin is coated on sisal fiber. Another glass fiber layer is placed on the sisal fiber. After these three layers, aluminum foil is placed on the specimen. Weight is placed on the specimen and allowed to cure for three hours for the purpose of uniform shape.

- After fabrication the final weight of the specimen was almost 200gms


Figure 9: **E-glass Fiber composite specimen-1Figure 10:** E-glass Fiber composite Specimen-2(For Tensile Test)

2.2.2.Specimen 2:
Dimensions:
Width=50mm
Length=300mm
Fabrication details:
Glass fiber to natural fiber =1:1
E-glass fiber = 17gms
Sisal fiber = 17gms
Epoxy and hardener = 55gms

Cut the glass fiber into required size. First E-glass fiber is placed on an Aluminum foil and resin is coated on E-glass fiber using roller brush. Chopped sisal fiber is placed on a glass fiber and resin is coated on sisal fiber. Another glass fiber layer is placed on the sisal fiber. After these three layers, aluminum foil is placed on the specimen. Weight is placed on the specimen and allowed to cure for 3 hours for the purpose of uniform shape.

•Final weight of the specimen=55 grams

2.2.3 Specimen-3
OVAL SHAPE
Fabrication details:
Glass fiber to natural fiber = 1:1
E-glass fiber = 20gms
Sisal fiber = 20gms
Epoxy and resin = 220 gms

First, prepare the oval-shaped mold. Cut the glass fiber into an oval shape. Apply grease in the mould. After applying grease place aluminum foil in the mould .Place glass fiber on aluminum foil epoxy resin is coated on glass fiber using a brush. Sisal fiber is placed on glass fiber and epoxy resin coated on sisal fiber. Another glass fiber is placed on sisal fiber. After these three layers, aluminum foil is placed on the specimen. A weight is kept on specimen allowed to cure for few hours.

•Final weight of the specimen=75 gms

Figure 11: Pattern making for Oval shape E-glass fiber composite specimen

2.2.4 Specimen-4
Square plate Dimensions:
Width = 300mm
Length = 300mm
Fabrication details:
Glass fiber to natural fiber = 1:1
Glass fiber = 70gms

Sisal fiber = 70gms
Epoxy and hardener = 220gms

Cut the glass fiber into required size. First E-glass fiber is placed on an Aluminum foil and resin is coated on E-glass fiber using roller brush. Chopped sisal fiber is placed on a glass fiber and resin is coated on sisal fiber. Another glass fiber layer is placed on the sisal fiber. After these three layers, aluminum foil is placed on the specimen. Weight is placed on the specimen and allowed to cure for 3 hours.

•Final weight of the specimen =260gms

Figure 12: E-glass fiber composite Specimen-4(For Hardness Test)

3. Results and discussion

After fabrication of composite specimens, the specimens are being subjected to following tests to know the mechanical characterization.

3.1 Tests conducted

- Tensile test
- Compression test
- Rockwell hardness test
- Impact test

3.1.1 Tensile test meaning of tensile:

Tensile strength is the capacity of material or structure to withstand loads tending to elongate, as opposed to compressive strength, which withstands loads tending to reduce size.Tensile strength resists tension.

Tensile strength is the measurement of the force required to pull something such as rope, wire, or a structural beam to the point where it breaks.

The specimen-2 is tested in the universal testing machine (UTM) and the samples are left to break till the ultimate tensile strength occurs. The stress-strain curve is plotted for the determination of ultimate tensile strength and elastic modulus. Graph generated directly from the machine for the tensile test with respect to load and displacement for Glass Fiber /sisalReinforced Composite material.

Figure 13: Glass fiber/sisal Rectangular specimen 300x50 mm before testing (Tensile)

Figure 14: Composite Specimen under universal testing machine Fig.14: Specimen after tensile test

The testing process involves the test specimen in the testing machine and it is slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The data is manipulated. The elongation measurement is used to calculate the relations between stress and strain, stress and displacement and load and displacement.

The machine does these calculations as the force increases so that the data points can be graphed into a stress-strain curve, load-displacement curve and stress-displacement curve.

The following above figure represents the specimen obtained after testing. The following are the curves obtained by the universal testing machine as shown below.

The following graph shows the relationship between stress and displacement when the load on the specimen increases.

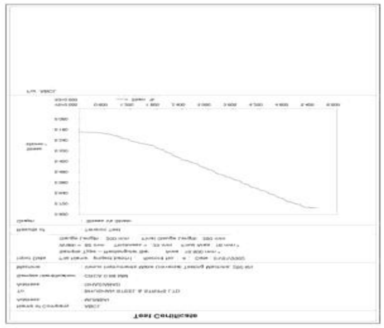

Figure15:Tensile Test Graph for Rectangular specimen (Stress vs Displacement)

- STRESS VS DISPLACEMENT
- LOAD VS DISPLACEMENT
- STRESS VS STRAIN

The sisal/glass fiber hybrid composites resembled to ductile material during testing as the sisal fibers are flexible. T The composites have exhibited 110% in breaking strength. The strength of these composites depend on loading geometry and strain rate.

The graph below shows the relationship between stress and displacement

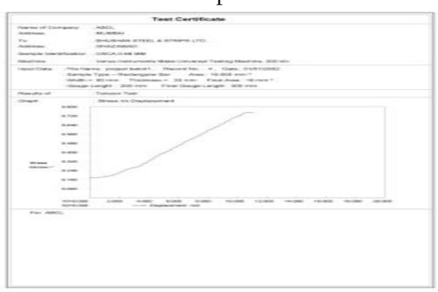

Figure 16: Tensile Test for Rectangular Specimen (Load vs Displacement)

The following graph shows the relation between stress and strain on the specimen.

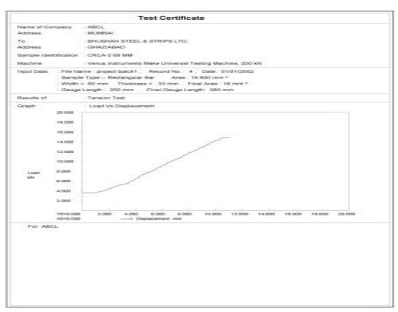

Figure 17: Tensile Test for Rectangular Specimen (Stress vs Strain)

3.1.1.1. Results from Tensile Test for rectangular specimen:

Sample Area: 19.8 mm^2

Final Area : 18 mm^2

Gauge length: 200 mm

Final gauge length: 300 mm

3.1.2 Compression test

Compressive strength is the capacity of a material to withstand loads tending to reduce the size, as opposed to tensile strength, which withstands loads tending to elongate.Compressive strength resists compression whereas tensile strength resists tension.

Compressive strength is so important in deriving the compressive load limit since, at times there might be a fracture in structure at this limit.

S.No	Stage	Stress v_s Displacement		Load v_s Displacement		Stress v_s Strain	
		Stress KN/mm^2	Displacement mm	Load KN	Displacement mm	Stress KN/mm^2	Strain
1.	Initial	0.18	0	3.5	0	0.19	0.75
2.	Final	0.75	11	15	11	0	5.4

TABLE:1 Tensile test results for Rectangular speciman

The specimen size for compression test is 300*300*3 mm cube. Compression test is conducted in the universal testing machine. Graphs are developed from the machine for compression test with respect to displacement and load for Glass fiber reinforced the composite material.

Figure 18:Specimen 200x300 mm before compression

Figure 19: Compression test in universal testing machine

After testing of compression test in universal testing machine, the following are the graphs obtained as the load increases. The graphs are followed as shown below.

- STRESS VS DISPLACEMENT
- LOAD VS DISPLACEMENT
- STRESS VS STRAIN

The following graph shows the relation between stress and displacement when the load on the specimen increases.

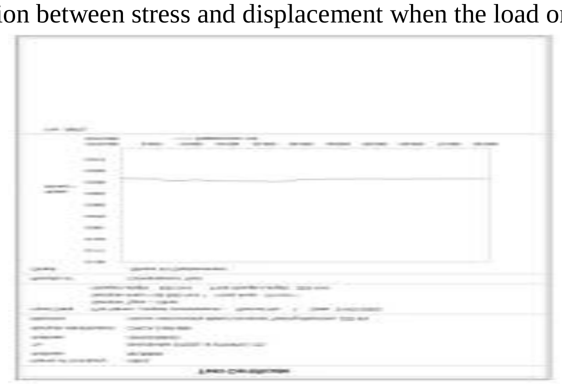

Fig.20: Compression Test for Rectangular specimen (Stress vs Displacement)

The following graph shows the relationship between load applied and displacement obtained on the specimen.

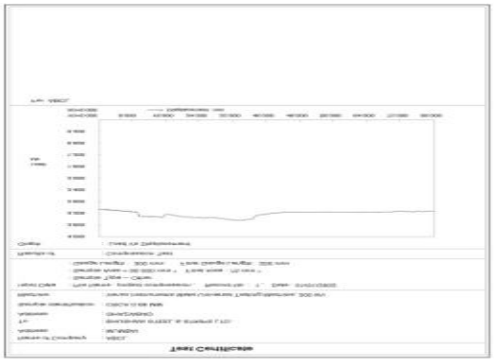

Figure 20: Compression Test for Rectangular specimen (Load vs Displacement)

The following graph shows the relation between stress and strain on the specimen.

Figure 21: Compression Test for Rectangular specimen (Stress vs Strain)

3.1.2.1. Results from Compression Test for Rectangular specimen:
Sample Area: 90 mm^2
Final Area : 75 mm^2
Gauge length: 300 mm
Final gauge length: 250 mm

S. No	**Stage**	**Stress v_s Displacement**		**Load v_s Displacement**		**Stressv_s Strain**	
		Stress KN/mm^2	Displacement mm	Load KN	Displacement mm	Stress KN/m^2	Strain
1.	Initial	0.035	0	3.10	0	0.035	0
2.	Final	0.03	80	3	80	0.03	29

TABLE:2 Compression test for Rectangular speciman

3.1.3 Hardness test

Hardness is a measure of how resistant solid matter. and is to various kinds of permanent shape change when a compressive force is applied. Some materials are harder than plastics. Macroscopic hardness is generally characterized by strong intermolecular bonds.

The measurements of hardness are classified into 3 types those are scratch hardness, indentation hardness, and rebound hardness. Hardness is dependent on ductility, strength, toughness, viscoelasticity, elastic stiffness, plasticity, strain, and viscosity.
The examples of hard matter are ceramics, certain metals, concrete and super hard materials. Thehardness measurements are classified into 3 types.Those are scratch, indentation, and rebound. These classes of measurement are individual measurement scales. These are used for practical reasons, conversion tables and those are used to convert between one scale and another.

Scratch Hardness

Scratch hardness is used for a measure of how resistant a sample is to fracture or deformation due to friction from a sharp object. The testing coatings and scratch hardness refer to the force necessary to cut through the film to the substrate. It is used in mineralogy.

Rebound hardness

Rebound hardness, also known as dynamic hardness.It measures the height of the "bounce" of a diamond-tipped hammer dropped from a fixed height onto a material.

Indentation hardness

Indentation hardness measures the resistance of a sample to material deformation due to a constant compression load from a sharp object. They are primarily used in engineering and metallurgy fields. The hardness tests process depends on the measuring the dimensions.Hardness of the material can be found from the test like Rockwell Hardness, Brinell hardness and Wicker hardness. The Rockwell hardness test carried out for the Glass fiber reinforced the composite material and obtained the result is applied 60kg for 1/4inch penetrator the B scale reading for all specimens.
These are the following results for hardness obtained by Rockwell hardness testing machine.

3.1.3.1 Results from Hardness Test for Rectangular 1 & 2, oval and square specimens:

SI.NO	POINT	SPECIMEN 1 HARDNESS	SPECIMEN 2 HARDNESS	SPECIMEN 3 HARDNESS	SPECIMEN 4 HARDNESS
1	1	B20	B45	B34	B45
2	2	B24	B33	B31	B32
3	3	B32	B28	B31.5	B30
4	4	B34	B32	B33	B26

TABLE:3 Hardness for Diffarent specimans

Figure 22: Rockwell hardness testing machine

Figure 23: Impact Testing Machine

3.1.4. Impact test

An impact is a high force over a short time period when two or more bodies collide. Such a force or acceleration usually has a greater effect than a lower force applied over a proportionally longer period. The effect depends on the relative velocity of the bodies to one another.

At normal speeds, during a perfectly inelastic collision, an object struck by a projectile will deform, and this deformation will absorb most or all of the force of the collision. The conservation of energy is changed into perspective, the kinetic energy of the projectile is changed into heat and sound energy, as a result of the deformations and vibrations induced in the struck object. Impact resistance decreases with an increase in the modulus of elasticity, which means that stiffer materials will have less impact resistance.

Resilient materials will have better impact resistance. The impact test is conducted on two specimens for one specimen Charpy impact test and for another specimen Izod impact test. The result indicated that maximum Charpy impact strength obtained is 516 Joules. Specimen size for the Charpy impact strength is 75x8x3 mm.

For Izod impact, test result indicates that maximum Izod impact strength obtained is 228 Joules. Specimen size for the Izod impact strength is 75x8x3 mm.

Figure 24: Specimens after impact test

3.1.4.1. Results from Impact Test for specimen.

SI.NO	READINGS	CHARPY IMPACT TEST (div)	IZOD IMPACT TEST (div)
1	Initial reading	300	168
2	Final reading	42	54
3	Final impact	258	114
4	In joules	258*2 =516	114*2=228

NOTE: 1div=2joules

CONCLUSION

In this project the design and fabrication of e glass fiber reinforced composite material performed with addition of sisal fiber and it is concluded that, the E-glass fiber reinforced composite material with adding of sisal fiber is more advantageous for aerospace and automobile applications. The following conclusions were made as follows:

- The Hardness, tensile, compression, impact characteristics of E-Glass fiber reinforced sisal composite material gives better results compare than Ordinary E-Glass fiber composite material.
- By conducting different types of mechanical tests we obtain better results compared than normal E-Glass fiber matrix composite material.
- The hardness, tension and compression values are better than normal E Glass fiber matrix material by adding natural fiber (Sisal fiber).

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