Development of E-Glass-Sisal Fiber Reinforced with Epoxy Composite for Automotive Body Panel

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ABSTRACT

Composite material is a material consisting of two or more physically or chemically distinct phase, suitably arranged or distributed. Recently car manufacturers have been interested in incorporating natural composite materials into both interior and exterior parts to lower overall weight of the vehicle thus decrease fuel consumption and to raise increase strength to weight ratio of the material for automotive body application.

The objective of this research project is to present the processing techniques of specimen preparation and conducting mechanical test which is aimed to propose a best material for automotive body panel.

In this research project, experimental characterization of the basic mechanical properties of natural (sisal) fibers and E-glass fiber composite was conducted. The important property such as tensile and flexural analysis of sisal and E-glass fiber composite has been carried out. Sisal fiber and glass fiber composite laminates were prepared by hand layup method by varying ratio of each material for tensile and flexural tests. Then samples were cut with standard size of 220mm X 4mm X 25mm and tested by using UTM both tensile and flexural tests.

The material property results which are obtained from tensile and flexural test results indicate that, pure glass fiber composite has a better mechanical property than sisal fiber.

Natural (sisal) fiber is also a promising material for vehicle body application by reinforcing it with E-glass fiber with epoxy adhesive. By increasing the thickness of the material it is possible to raise the overall strength of sisal-E-glass composite material for producing component of medium load applications such as; welding shield, light weight vehicle bumper and automobile body applications. Due to their low cost and availability, it is a better idea to substitute the metals with sisal -E-glass fiber composite which is aimed to reduce fuel consumption and overall weight of Automobile.

Key words*: Mechanical Properties, Tensile Strength, Flexural Strength*

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1. INTRODUCTION

1.1 Background of the Study

The use of composite materials has grown significantly in aeronautic, automotive, naval, and civil construction sectors by substituting conventional materials such as steel, aluminum and other alloy materials, due to their high modulus/weight and strength/weight ratios, excellent fatigue properties, and non-corroding behavior.

Ethiopian automotive industries import the parts of the vehicle from abroad since there is no a clear research activity on this areas, specially the characterization and use of available natural fibers with glass fibers.

Polymer composite materials have been widely used in various industries such as aircraft, automotive and submarine due to their great mechanical and thermal properties. However, the end of life disposal of polymer and synthetic materials is unknown and non-biodegradable. Therefore, the utilization and the manufacturing procedure of these materials will harm the nature. In contrast, natural fibers are renewable and environmentally friendly materials; they have low density, low price, and acceptable mechanical properties. Hence, many scientists are interested in replacing them with synthetic materials to conserve the environment.

Natural fibers based on their sources are divided into three categories: plant fibers (sisal, hemp, flax, bamboo, etc.), animal's parts involving protein (silk, hair, wool, etc.) and minerals [1]. The main parts of Plant fibers are cellulose, hemicellulose, lignin and pectin.

This research focuses on development of material from available sisal fiber and glass fiber as well as manufacturing & testing composite auto body panel.

1.2 Objectives

1.3 General Objectives

- The objective of this research is analysis mechanical property of natural (sisal) fiber with the imported fiber glass at a substitute for E-glass fiber by natural fiber.

1.4 Specific Objectives

The specific purposes of the study are:

- ✓ To study recent advances of glass fiber in automotive body application

- ✓ To study the effect of glass fiber and sisal fiber composition.
- ✓ To develop optimal composition
- ✓ To develop prototype of car body panel with the optimal composition.
- ✓ Give recommendation how to implement the developed material in Ethiopian automotive industries

1.5 Significance & Beneficiaries

The outcome of this research will generally contribute to industries which make use of composite materials as main components for product manufacturing, i.e. in the design of composite structures under different loading conditions. For example, applications of composite materials in automotive industries include some primary and secondary structures such as dashboard, roof, floor, front & back bumper, passenger safety cell, and rarely, A-pillar and B-pillar.

1.6 Beneficiaries of the Research

- Industries which produce composite products such as Dejen Aviation Industry, Bishoftu Automotive industry, Gafat Armament Industry and Ethio-plastic industry.
- Universities for knowledge transfer (University-industry linkages)
- Micro enterprises which produce composite material products like; water tank fabrication, different pipe, welding shield etc.
- Researchers and PG students, who are working on application of the composite materials for different automotive body panel.

1.7 Limitation of the study

Some of the challenges were encountered during the research project were the following:

- Absence of compression test machine limits our tests only to flexural and tensile strength.
- The manufacturing steps of the laminates used for the research project were through hand layup method, but vacuum bagging methods are better which we couldn't use it.
- The strength of pure sisal fibers is very low which may be affected by method of extraction and weather condition of the area where plants grow. This need to cultivate and extract the plants through scientific methods.

2. LITERATURE REVIEW

2.1 Introduction

The term composite can be defined as a material composed of two or more different materials, a material system composed of two or more physically distinct phases whose combination produces aggregate properties that are different from those of its constituents. Composites are hybrid materials made of a polymer resin reinforced by fibers, combining the high mechanical and physical performance of the fibers and the appearance, bonding and physical properties of polymers, the short and discontinuous fibers composites are responsible for the biggest share of successful applications, whether measured by number of parts or quantity of material used. A composite in this respect is a compound between a polymer (such as polyester or PP) and a fibrous material (such as glass, carbon or natural fibers). Composite products have good mechanical properties per unit weight, are durable and their technologies allow the manufacture of complex and large shapes. For these applications the substitution of industrial fibers with natural fibers could be considered. Many natural fibers traditionally employed in weaving, sacking and ropes; present various potentials to be used as reinforcement elements in composites. Retrofitting of flexural concrete elements is traditionally accomplished by externally bonding steel plates to concrete. Although this technique has proved to be effective in increasing strength and stiffness of reinforced concrete elements, it has the disadvantages of being susceptible to corrosion and difficult to install. In the last decade, the development of strong epoxy glue has led to a technique which has great potential in the field of upgrading structures.[12]

Natural fiber composites include coir, jute, baggase, cotton, bamboo, hemp. Natural fibers come from plants. These fibers contain lingo cellulose in nature. Natural fibers are eco-friendly; lightweight, strong, renewable, cheap and biodegradable [12]. The natural fibers can be used to reinforce both thermosetting and thermoplastic matrices. Thermosetting resins such as epoxy, polyester, polyurethane, phenolic are commonly used composites requiring higher performance applications. They provide sufficient mechanical properties in particular stiffness and strength at acceptably low price levels. Recent advances in natural fiber development are genetic engineering. The composites science offer significant opportunities for improved materials from renewable resources with enhanced support for global sustainability. Natural fiber composites are attractive to industry because of their low density and ecological advantages over conventional composites. These composites are gaining importance due to their non-carcinogenic and bio-degradable nature. Natural fiber composites are very cost effective material especially in building and construction, packaging, automobile and railway coach interiors and storage devices [7].These composites are potential candidates for replacement of high cost glass fiber for low load bearing applications [7].

Table 2-1 Properties of Glass and Natural Fibers [7].

Properties	Fibers								
	E-Glass	**Flax**	**Hemp**	**Jute**	**Ramie**	**Coir**	**Sisal**	**Abaca**	**Cotton**
Density g/cm3	2.55	1.4	1.48	1.46	1.5	1.25	1.33	1.5	1.51
Tensile strength* 10E6 N/m2	2400	800 - 1500	550 - 900	400 - 800	500	220	600-700	980	400
E-modulus (GPa)	73	60 - 80	70	10 - 30	44	6	38		12
Specific (E/density)	29	26 - 46	47	7 - 21	29	5	29		8
Elongation at failure (%)	3	1.2 - 1.6	1.6	1.8	2	15 - 25	2 - 3		3 - 10
Moisture absorption (%)	-	7	8	12	12 -17	10	11		8 - 25
price/Kg ($), raw (mat/fabric)	1.3 (1.7/3.8)	- 1.5 (2/4)	0.6 - 1.8 (2/4)	0.35 1.5/0.9 - 2	1.5 - 2.5	0.25 - 0.5	0.6 - 0.7	1.5 - 2.5	1.5 - 2.2

2.2 Natural Fiber Reinforced Composite

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lingo cellulosic fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites.

The natural fiber-containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc. The use of natural fiber for the reinforcement of the composites has received increasing attention both by the academic sector and the industry. Natural fibers have many significant advantages over synthetic fibers. Currently, many types of natural fibers have been investigated for use in plastics including flax, hemp, jute straw, wood, rice husk, barley, oats, cane (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm empty fruit bunch, sisal, coir, water, hyacinth, pennywort, kapok, paper mulberry, raphia, banana fiber, pineapple leaf fiber and papyrus. Thermoplastics reinforced with special wood fillers are enjoying Rapid growth due to their many advantages; lightweight reasonable strength and stiffness. Some plant proteins are interesting renewable materials, because of their thermoplastic properties. Natural fibers like (sisal and jute) reinforced polypropylene composites were processed by compression moulding using a film stacking method. The mechanical properties of the different natural fiber composites were tested and compared. Polypropylene composites were found to increase with increasing fiber weight fraction. Natural fiber (NF) reinforced composites, so called ecocomposites, is a subject of many scientific and research projects, as well as many commercial programs [1].

The growing global environmental and social concern, high rate of depletion of petroleum resources, and new environmental regulations have forced the search for new composites and green materials, compatible with the environment. Use of natural fiber as reinforcing material is the latest invention of polymer science in order to get higher strength with lower weight composite materials with low cost, low density, specific resistance, biological degradability, CO2 neutrality, renewability, good mechanical properties, non-toxicity and furthermore the fibers can be easily modified by a chemical agent improving their mechanical and thermal properties [3].

Advantages of Natural Fibers:

- ✓ Low specific weight, which results in a higher specific strength and stiffness than glass. This is a benefit especially in parts designed for bending stiffness.
- ✓ It is a renewable resource, the production requires little energy, CO_2 is used while oxygen is given back to the environment.
- ✓ Producible with low investment at low cost, which makes the material an interesting product for low-wage countries.
- ✓ Friendly processing, no wear of tooling, no skin irritation
- ✓ Thermal recycling is possible, where glass causes problems in combustion furnaces.
- ✓ Good thermal and acoustic insulating properties

Disadvantages of Natural fibers:

- ✓ Lower strength properties, particularly its impact strength
- ✓ Variable quality, depending on unpredictable influences such as weather.
- ✓ Moisture absorption, which causes swelling of the fibers
- ✓ Restricted maximum processing temperature.
- ✓ Lower durability, fibers treatments can improve this considerably.
- ✓ Poor fire resistance
- ✓ Price can fluctuate by harvest results or agricultural politics

2.3 Sisal Fiber

Sisal Fiber is one of the most widely used **natural fiber** and is very easily cultivated. It is obtain from sisal plant. The plant, known formally as Agave sisalana. These plants produce rosettes of sword-shaped leaves which start out toothed, and gradually lose their teeth with maturity. Each leaf contains a number of long, straight fibers which can be removed in a process known as decortication. During decortication, the leaves are beaten to remove the pulp and plant material, leaving the tough fibers behind. The fibers can be spun into thread for twine and textile production, or pulped to make paper products [23].

Sisal fiber is fully biodegradable, green composites were fabricated with soy protein resin modified with gelatin. Sisal fiber, modified soy protein resins, and composites were characterized for their mechanical and thermal properties. It is highly renewable resource of energy. Sisal fibers are exceptionally durable and a low maintenance with minimal wear and tear. Their fiber is too tough for textiles and fabrics. It is not suitable for a smooth wall finish and also not recommended for wet areas [23].

The fine texture of Sisal takes dyes easily and offers the largest range of dyed colors of all natural fibers. Zero pesticides or chemical fertilizers used in sisal agriculture. It is a stiff fiber traditionally used in making twine, rope and also dartboards Sisal fiber is manufactured from the vascular tissue from the sisal plant (Agavesisalana). It is used in automotive friction parts.

Figure 2-1 A, Sisal Plant (Agave Sisalana) [16]. B, Sisal Fibers

The important chemical components of the sisal fiber are shown in Table 2.2. Based on the composition, it can be inferred that the sisal fiber is harder (greater rigidity and lower flexibility) and coarser than other bast and leaf fibers because of the high lignin and pectin content.

(brakes, clutches), where it imparts green strength to performs, and for enhancing texture in coatings application[21].

Table 2-2 Chemical Composition of Sisal Fiber [16].

S.No.	**Chemical Components**	**% by weight**
1	Cellulose	55-65
2	Hemi-cellulose	10-15
3	Pectin	2-4
4	Lignin	10-20
5	Water soluble materials	1-4
6	Fat and wax	10.15-0.3
7	Ash	0.7-1.5

2.3.1 Sisal Fiber Plant Extraction

Sisal plants are more familiar with the tropics and sub tropics region as they can grow better at a temperature of more than 300K. These plants consist of sword shaped leaves of normally about 120cm length and a typical plant produces around 100 leaves during its life span of more than five years. It contains about 500-700 fibers, which are normally used to make ropes, carpets etc. The matured leaves standing at an angle of more than 50^0 to the upright of the plant are cut. The next stage in which the leaves are initially crushed by the rollers of rounded knife edges followed by repetitive beaten is called decortications. During this process, the fibers are extracted by squeezing out the pulpy content of the leaf. Finally the fibers are dried in sunlight for 2-3 days after washing them in clean water to remove the dusts and unwanted contents in it [22].

Table 2-3 Area harvested for sisal in Ethiopia [[24].

Years	Area harvested (Ha.)
2008	700
2009	901
2010	901
2011	901

2.3.2 Properties of Sisal Fiber [23].

1. Sisal Fiber is exceptionally durable with a low maintenance with minimal wear and tear.
2. It is Recyclable.
3. Sisal fibers are obtained from the outer leaf skin, removing the inner pulp.
4. It is available as plaid, herringbone and twill.
5. Sisal fibers are Anti static, does not attract or trap dust particles and does not absorb moisture or water easily.
6. The fine texture takes dyes easily and offers the largest range of dyed colours of all natural fibers.
7. It exhibits good sound and impact absorbing properties.
8. Its leaves can be treated with natural borax for fire resistance properties.

2.3.3 Uses/Application of Sisal Fiber

From ancient times sisal has been the leading material for agricultural twine because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in saltwater.

1. Sisal is used commonly in the shipping industry for mooring small craft, lashing, and handling cargo.
2. It is also surprisingly used as the fibers core of the steel wire cables of elevators, being used for lubrication and flexibility purposes. Traditionally sisal was the leading material

for agricultural twine or baler twine. Although this has now been overtaken by polypropylene.

3. It is used in automobile industry with fiberglass in composite materials.
4. Other products developed from sisal fiber include spa products, cat scratching posts, lumbar support belts, rugs, slippers, cloths and disc buffers.
5. Sisal is used by itself in carpets or in blends with wool and acrylic for a softer hand

Uses of Sisal;- Sisal has a wide variety of applications including:

Traditional - Twine, ropes, string, yarn and which can also be woven into carpets, mats, and various handicrafts.

Competition from synthetics has weakened demand for sisal in these traditional applications, however new consumer demands for natural fibers are expanding the markets for sisal in more high-value applications such as in paper, reinforcing composites and plastic composites.

Sisal pulp and paper – As sisal biomass contains a high proportion of cellulose its pulp is a substitute for wood fibers and adds bulk to paper and cardboard as well as being absorbent and having high fold endurance characteristics making it a high quality input for paper products. Given its porosity, it can be used in cigarette paper filters and things like tea bags [23].

Textile - A major use of the fibers is in buffing cloth – because sisal is strong enough to polish steel and soft enough not to scratch it.

Sisal reinforcing composites- Sisal can substitute or enhance fibers-glass used to reinforce plastic in automobiles, boats, furniture, water tanks and pipes. Sisal can also be used to add strength in cement mixtures for the development of low cost housing and to replace asbestos in roofing and brake-pads. In addition it is an insulation material and can be made into fibers-board as a wood substitute [23].

Plastic and rubber composites - Sisal has good potential as reinforcement in polymer (thermoplastics, thermosets and rubbers) composites due to the low density and good welding specific properties. The use of sisal composites in automotive components and other furniture is gaining popularity. Sisal also continues to make the best material for dart boards [23].

Sisal waste products - By-products from sisal extraction can be used for making biogas, pharmaceutical ingredients and building material. The biomass left after fibers have been removed represents as much as 98 percent of the plant and most is now flushed away as waste. To exploit the economic value of this material – amounting to some 15 million tonnes annually -

the Common Fund for Commodities, UNIDO and the Tanzanian sisal industry funded the first commercial plant to use sisal residues to produce biogas, electricity process heat and fertilizer. Ongoing evaluation of the plant indicates that 75% of the energy produced could be distributed to rural homes and 25 percent used in sisal processing [23].

2.4 Glass Fiber

Ancient Egyptians made containers of coarse fibers drawn from heat softened glass. The French scientist, Reaumur, considered the potential of forming fine glass fibers for woven glass articles as early as the 18th century. Continuous glass fibers were first manufactured in substantial quantities by Owens Corning Textile Products in the 1930's for high temperature electrical applications. Revolutionary and evolutionary technology continues to improve manufacturing processes for continuous glass fiber production. Raw materials such as silicates, soda, clay, limestone, boric acid, fluorspar or various metallic oxides are blended to form a glass batch which is melted in a furnace and refined during lateral flow to the forehearth. The molten glass flows to platinum/ rhodium alloy bushings and then through individual bushing tips and orifices ranging from 0.76 to 2.03 mm (0.030 to 0.080 in) and is rapidly quenched and attenuated in air (to prevent crystallization) into fine fibers ranging from 3 to 35 µm. Mechanical winders pull the fibers at lineal velocities up to 61 m/s over an applicator which coats the fibers with an appropriate chemical sizing to aid further processing and performance of the end products [11].
High strength glass fibers like S-2 Glass are compositions of aluminosilicates attenuated at higher temperatures into fine fibers ranging from 5 to 24 µm. Several other types of silicate glass fibers are manufactured for the textile and composite industry. Various glass chemical compositions described below from ASTM C 162 were developed to provide combinations of fiber properties directed at specific end use applications [8].

- **A Glass** – Soda lime silicate glasses used where the strength, durability, and good electrical resistivity of E Glass are not required.
- **C Glass –** Calcium borosilicate glasses used for their chemical stability in corrosive acid environments.
- **D Glass –** Borosilicate glasses with a low dielectric constant for electrical applications.
- **E Glass** – Alumina-calcium-borosilicate glasses with a maximum alkali content of 2 wt.% used as general purpose fibers where strength and high electrical resistivity are required.

- **ECR Glass** – Calcium aluminosilicate glasses with a maximum alkali content of 2 wt.% used where strength, electrical resistivity, and acid corrosion resistance are desired.
- **AR Glass** – Alkali resistant glasses composed of alkali zirconium silicates used in cement substrates and concrete.
- **R Glass** – Calcium aluminosilicate glasses used for reinforcement where added strength and acid corrosion resistance are required.
- **S-2 Glass** – Magnesium aluminosilicate glasses used for textile substrates or reinforcement in composite structural applications which require high strength, modulus, and stability under extreme temperature and corrosive environments. [8].

2.4.1 Glass Fiber Chemical Compositions

Chemical composition variation within a glass type is from differences in the available glass batch raw materials, or in the melting and forming processes, or from different environmental constraints at the manufacturing site. These compositional fluctuations do not significantly alter the physical or chemical properties of the glass type. Very tight control is maintained within a given production facility to achieve consistency in the glass composition for production capability and efficiency. Table 2.4 provides the oxide components and their weight ranges for eight types of commercial glass fibers [8].

Table 2-4 Composition Ranges for Glass Fibers [8].

	A GLASS	C GLASS	D GLASS	E GLASS	ECRGlas®	AR GLASS	R GLASS	S-2 GLASS®
Oxide	%	%	%	%	%	%	%	%
SiO_2	63-72	64-68	72-75	52-56	54-62	55-75	55-60	64-66
Al_2O_3	0-6	3-5	0-1	12-16	9-15	0-5	23-28	24-25
B_2O_3	0-6	4-6	21-24	5-10		0-8	0-0.35	
CaO	6-10	11-15	0-1	16-25	17-25	1-10	8-15	0-0.2
MgO	0-4	2-4		0-5	0-4		4-7	9.5-10
ZnO					2-5			
BaO		0-1						
Li_2O						0-1.5		
$Na_2O + K_2O$	14-16	7-10	0-4	0-2	0-2	11-21	0-1	0-0.2
TiO_2	0-0.6			0-1.5	0-4	0-12		
ZrO_2						1-18		
Fe_2O_3	0-0.5	0-0.8	0-0.3	0-0.8	0-0.8	0-5	0-0.5	0-0.1
F_2	0-0.4			0-1		0-5	0-0.3	

2.4.2 Glass Fiber Properties

Glass fiber properties, such as tensile strength, Young's modulus, and chemical durability, are measured on the fibers directly. Other properties, such as dielectric constant, dissipation factor, dielectric strength, volume/surface resistivity's, and thermal expansion, are measured on glass that has been formed into a bulk sample and annealed (heat treated) to relieve forming stresses. Properties such as density and refractive index are measured on both fibers and bulk samples, in annealed or unannealed form. The properties presented in Tables 2.5 and 2.6 are representative of the compositional ranges in Table 2.4 and correspond to the following overview of glass fiber properties [8].

A. Physical Properties

Density of glass fibers is measured and reported either as formed or as bulk annealed samples. ASTM C 693 is one of the test methods used for density determinations. The fiber density (in Table 2.4) is less than the bulk annealed value by approximately 0.04 g/cc at room temperature. The glass fiber densities used in composites range from approximately 2.11 g/cc for D Glass to 2.72 g/cc for ECRGLAS reinforcements [8].

B. Chemical Resistance

The chemical resistance of glass fibers to the corrosive and leaching actions of acids, bases, and water is expressed as a percent weight loss. The lower this value, the more resistant the glass is to the corrosive solution. The test procedure involves subjecting a given weight of 10 micron diameter glass fibers, without binders or sizes, to a known volume of corrosive solution held at 96°C. The fibers are held in the solution for the time desired and then are removed, washed, dried, and weighed to determine the weight loss. The results reported are for 24-hr (1 day) and 168-hr (1 week) exposures. As Table 2.6 shows, the chemical resistance of glass fibers depends on the composition of the fiber, the corrosive solution, and the exposure time[8].

C. Electrical Properties

The electrical properties in Table 2.6 were measured on annealed bulk glass samples the dielectric constant or relative permittivity is the ratio of the capacitance of a system with the specimen as the dielectric to the capacitance of the system with a vacuum as the dielectric. Capacitance is the ability of the material to store an electrical charge. Permittivity values are affected by test frequency, temperature, voltage, relative humidity, water immersion, and weathering[8].

D. Thermal Properties

The viscosity of a glass decreases as the temperature increases. Note that the S-2 Glass fibers' temperature at viscosity is 150-260°C higher than that of E Glass, which is why S-2 Glass fibers have higher use temperatures than E Glass[8].

E. Optical Properties

Refractive index is measured on either unannealed or annealed glass fibers. The standard oil immersion techniques are used with monochromatic sodium D light at 25°C. In general, the corresponding annealed glass will exhibit an index that will range from approximately 0.003 to 0.006 higher than the as-formed glass fibers given in Table 2.5 [8].

F. Radiation Properties

E Glass and S-2 Glass fibers have excellent resistance to all types of nuclear radiation. Alpha and beta radiation have almost no effect, while gamma radiation and neutron bombardment produce a 5 to 10% decrease in tensile strength, a less than 1% decrease in density, and a slight discoloration of fibers[8].

Table 2-5 Physical Properties of Glass Fibers [8].

	PHYSICAL PROPERTIES							
	A GLASS	C GLASS	D GLASS	E GLASS	ECRGlas®	AR GLASS	R GLASS	S-2 GLASS®
Density, gm/cc	2.44	2.52	2.11-2.14	2.58	2.72	2.70	2.54	2.46
Refractive Index	1.538	1.533	1.465	1.558	1.579	1.562	1.546	1.521
Softening Point, °C (°F)	705 (1300)	750 (1382)	771 (1420)	846 (1555)	882 (1619)	773 (1424)	952 (1745)	1056 (1932)
Annealing Point, °C (°F)		588 (1090)	521 (970)	657 (1215)				816 (1500)
Strain Point, °C (°F)		522 (1025)	477 (890)	615 (1140)			736 (1357)	766 (1410)
Tensile Strength, MPa								
-196°C		5380		5310	5310			8275
23°C	3310	3310	2415	3445	3445	3241	4135	4890
371°C				2620	2165		2930	4445
538°C				1725	1725		2140	2415
Young's Modulus, GPa								
23°C	68.9	68.9	51.7	72.3	80.3	73.1	85.5	86.9
538°C				81.3	81.3			88.9
Elongation %	4.8	4.8	4.6	4.8	4.8	4.4	4.8	5.7

Table 2-6 Properties of Glass Fibers [8].

	A GLASS	C GLASS	D GLASS	E GLASS	ECRGLAS®	AR GLASS	R GLASS	S-2 GLASS®
Durability (% weight loss)	CHEMICAL PROPERTIES							
H_2O: 24 hr	1.8	1.1	0.7	0.7	0.6	0.7	0.4	0.5
168 hr	4.7	2.9	5.7	0.9	0.7	1.4	0.6	0.7
10% HCl: 24 hr	1.4	4.1	21.6	42	5.4	2.5	9.5	3.8
168 hr		7.5	21.8	43	7.7	3.0	10.2	5.1
10% H_2SO_4: 24 hr	0.4	2.2	18.6	39	6.2	1.3	9.9	4.1
168 hr	2.3	4.9	19.5	42	10.4	5.4	10.9	5.7
10% Na_2CO_3 24 hr		24	13.6	2.1		1.3	3.0	2.0
168 hr		31	36.3	2.1	1.8	1.5		2.1
	ELECTRICAL PROPERTIES							
Dielectric Constant 1MHz	6.2	6.9	3.8	6.6	6.9	8.1	6.4	5.3
10 GHz			4.0	6.1	7.0			5.2
Dissipation Factor 1MHz		0.0085	0.0005	0.0025	0.0028		0.0034	0.0020
10 GHz			0.0026	0.0038	0.0031		0.0051	0.0068
Volume Resistivity (ohm-cm)	1.0E +10			4.02E +14	3.84E +14		2.03E +14	9.05E +12
Surface Resistivity (ohms)				4.20E +15	1.16E +16		6.74E +13	8.86E +12
Dielectric Strength (volts/mil)				262	250		274	330
	THERMAL PROPERTIES							
Specific Heat J/g°C (BTU/lb°F)								
23°C	0.796 (0.190)	0.787 (0.188)	0.733 (0.176)	0.810 (0.193)			0.732	0.737 (0.176)
200°C		0.900 (0.215)		1.03 (0.247)	0.97 (0.232)		0.938	
Thermal Expansion								
Coefficient (x 10^{-7})	°C (°F)	°C (°F)	°C (°F)	°C (°F)	°C (°F)	°C (°F)	°C (°F)	°C (°F)
-30°C to 250°C	73 (41)	63 (35)	25 (14)	54 (30)	59 (33)	65 (36)	33 (18)	16 (8.9)

2.5 Hand Lay-up Process

Resins are impregnated by hand into fibers which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions. Figure below shows the typical hand lay-up process [11].

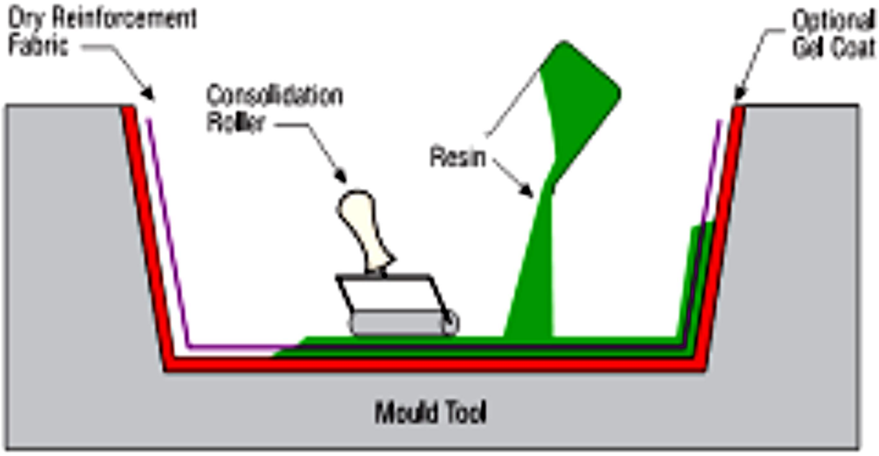

Figure 2-1 Hand lay-up techniques

2.6 Vacuum Bagging

This is basically an extension of the wet lay-up process described above where pressure is applied to the laminate once laid-up in order to improve its consolidation. This is achieved by sealing a plastic film over the wet laid-up laminate and on to the tool. The air under the bag is extracted by a vacuum pump and thus up to one atmosphere of pressure can be applied to the laminate to consolidate it [11].

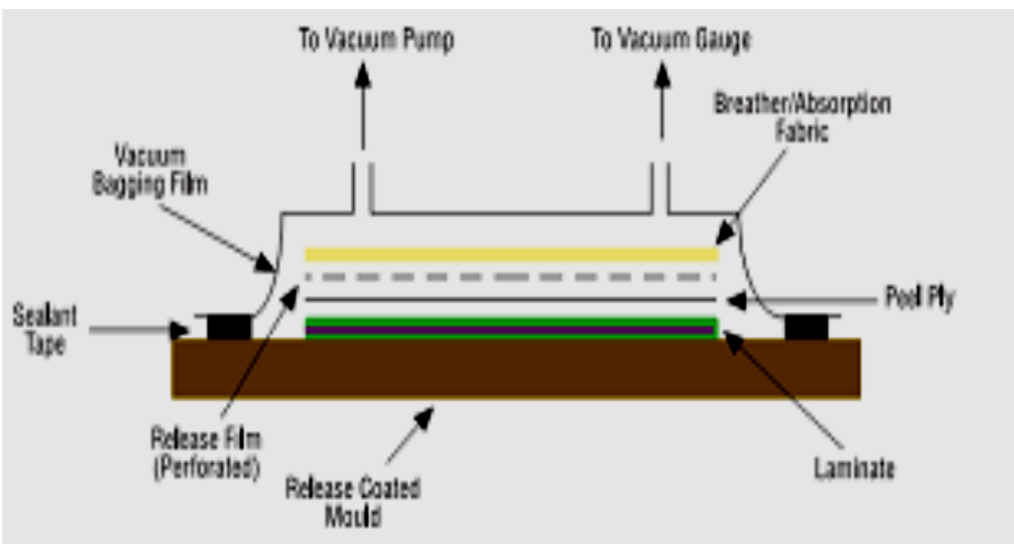

Figure 2-2 Vacuum bagging processes

According to [12] automobile body panels consist of a double structure with an outer panel and an inner panel. For the outer panels, higher strength materials are especially required to provide sufficient denting resistance. For the inner panels, higher deep drawing capacity materials are especially required to allow the manufacture of more complex shapes. In other words, different properties are required for the outer and inner panels.

Lightweight composite materials, such as glass-fiber reinforced polymers, have been used to replace traditional steel and aluminum components. This is because composites offer significant opportunities for enhancement of product performance in terms of strength, stiffness and energy absorption, combined with weight reduction and space saving. Today, design procedures of vehicles body that ensures reliability and road worthiness is well established [12].

3. MATERIALS AND METHODS

3.1 Materials

3.1.1 Sisal Fibers

Sisal fibers are used to conduct the experiments obtained from the leaves of the plant Agave Sisalana and are largely available in Ethiopia. In the specimen preparation the fiber is washed and dried by sun light. Once it is dried the fiber is mechanically double brushed. The lustrous strands, usually creamy white, average from 80 to 120 cm in length and 0.2 to 0.4mm in diameter. Sisal fiber is fairly coarse and inflexible. It is valued for cordage use because of its strength, durability, ability to stretch and affinity for certain dyestuffs.

Figure 3-1 Sisal Fiber

3.1.2 Glass Fiber

Glass fiber is a light in weight, extremely strong, and robust. Its bulk strength, stiffness and weight properties are also very favorable when compared to metals. The E-glass fiber with square (twill) orientation was used as a reinforcing material in the polyester resin matrix.

Figure 3-2 Glass Fiber

3.1.3 Resin and Hardener

The sisal and polyester were used as reinforcement and matrix respectively. The hardener was used as curing agent. In this work the sisal fiber, glass fiber, epoxy and hardener were purchased from local supplier.

3.1.4 Wax

Mold release provides the critical barrier between a tooling surface and the materials used to build up a part laminate, enabling separation of the cured part from the mold. Mold release agents serve two basic purposes:

i. Mold releases act as a parting agent between layers of resin and the mold surface, so that cured parts can be removed without damaging the part or the mold.
ii. When applied properly, mold releases help create a durable, high-gloss surface finish for finished parts.

Mold Releases help to preserve the integrity of your part and avoid damage to both the part and mold. The effort required to apply a quality release agent during preparation far outweighs the hours spent correcting damage later.

Figure 3-3 Mold releases (Wax)

Table 3-1 Materials used in the research work

S/No	Items/ Materials	Unit	Quantity
1	E-Glass Fiber	Roll	1
2	Natural Fiber (Sisal)	Kg	20
3	Resin	Lit	20
4	Wax	Can	1
5	Hardener(Catalyst)	lit	4
7	Thinner	lit	10
8	Body Paint	Kg	1

Table 3-2 Equipment and Tools Used for the Research

S/No	Items/ Materials	Unit	Quantity
1	Steel rule	pcs	1
2	Brush	pcs	10
3	V. caliper	Lit	1
4	Grinder	pcs	1
5	Grinder disc	Pcs	3
7	Hack saw	Pcs	1
8	Scissors	Pcs	1
9	Sheet metals	Pcs	1
10	Shear machine	Pcs	1
11	Bench tables	Pcs	3
12	Gloves	Pack	2
13	Masking Tape	Pcs	3
14	Compressor	Pcs	1
15	Universal Testing Machine	Pcs	1
16	Flexural Testing Machine	Pcs	1

3.2 Methods

The methods to be employed to achieve the objectives of the research are:

1. Literature review: A thorough literature review of current material characterization methods was conducted, the main focus of the review is on composite materials especially E-glass, natural fiber and Epoxy. However, characterization methods in other composite materials were also reviewed.
2. Conduct Experiment to know the tensile and flexural properties for the newly developed composite materials: The objective of this task is to collect experimental data of mechanical properties obtained from testing coupons of composite materials. This data was gathered by testing the coupons of natural (sisal) fiber-E glass/Epoxy composite materials under tensile and flexural strength.
3. Manufacturing and testing of the automotive body panel used for one of the car model.
4. Analysis and interpretation of the results: The findings of the research will have a long-term fundamental research value and will impact automotive industries in Ethiopia. On a larger scale, the knowledge generated from this research project will be disseminated and transferred to the research community and composite materials industry through publication of research.

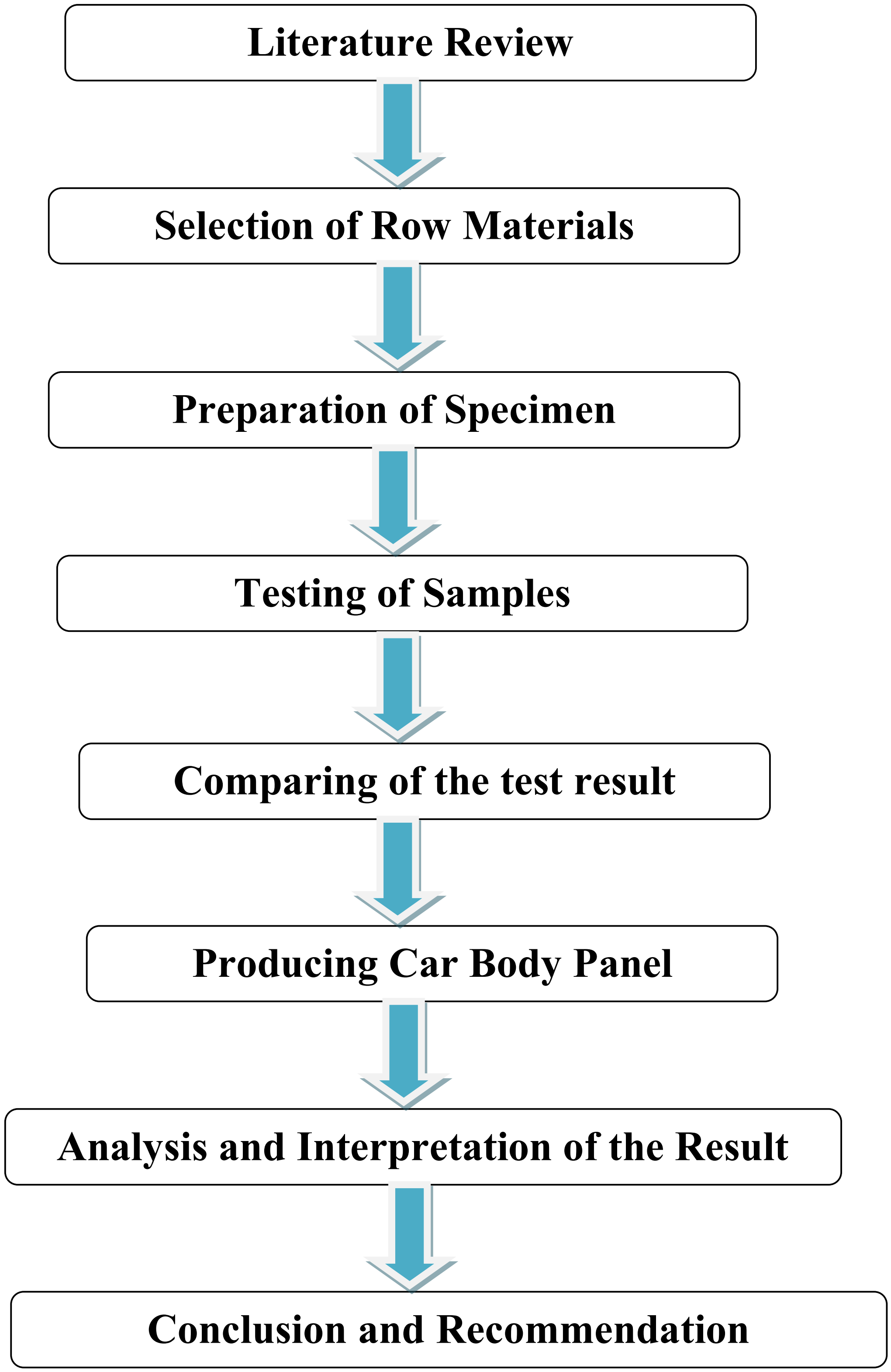

Figure 3-4 Work Flow Chart (Steps which were followed).

3.2.1 Steps to Preparation of Fiber Specimen and Products

- Cutting fibers to desired dimensions.
- Applying wax/gel on the fiber side of the lower mold for ease of removal.
- Preparing mixture of polyester and polyamine hardener with proper ratio.
- A coat of laminating resin (resin that being mixed with catalyst / hardener) is then being applied by brush or roller. Followed by the first layer of chopped strand.
- This process is done for all the layers, until desired thickness is achieved.
- Once finished, allow the resin to cure. You can feel the reaction taken place when your product is producing heat.
- Finally, remove your product from the mold (demould) and next step is trimming the specimen or the product.
- Cutting of the laminate was performed by grinder machine and samples are prepared according to ASTM standards i.e. (220mm X 4mm X 25mm) dimensions.
- Preparation of car body panel mold and composite panel based on high tensile strength results.

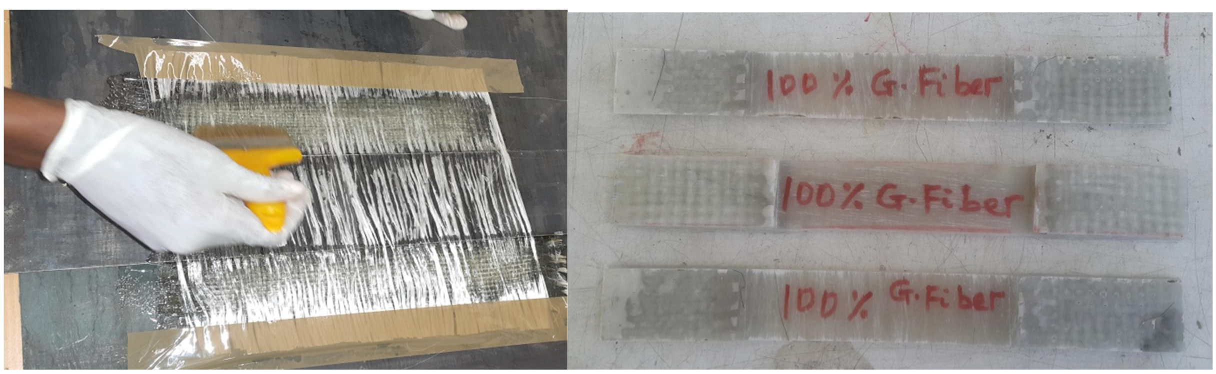

Figure 3-5 Preparation of Glass Fiber Laminate.

3.2.2 Specimens Fabrication

Through hand lay-up process followed by a cure process under pressure, four symmetrical laminates with a total of fifteen, three specimen for each were produced for tensile test. Another specimen, (nine in numbers) is also produced for flexural test. Hand lay-up is the simplest process in the low end composite products; require low investment, higher operating skill, and versa specimen shapes of product that need single high quality surface finish.

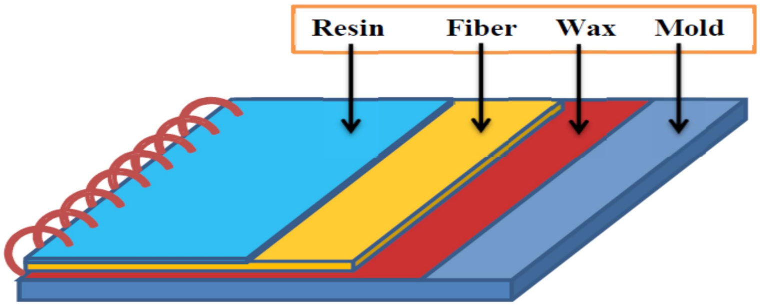

Figure 3-6 Hand Layup Manufacturing Technique

3.2.3 Standard Size for Manufacturing of Sample

The samples were prepared with the standard dimensions for the tensile testing, as per the ASTM standards. For high strain rate, the specimen dimension of length 220 mm, width 25mm and for holding 60 mm length at both ends of the specimen in both the cases as indicated in figure3.7.

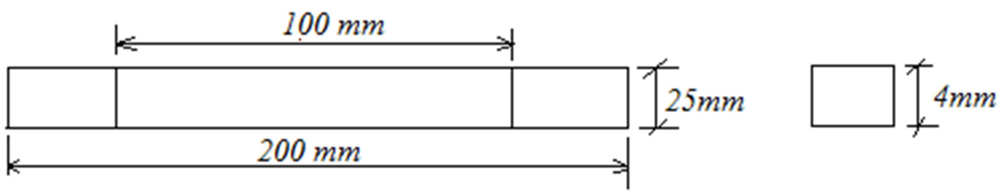

Figure 3-7 Standard Dimension of Specimen for Tensile Testing

- Fiber arrangement done for this study is Plain type with 0^0 and 90^0 angle of arrangement as shown in figure 3.8.

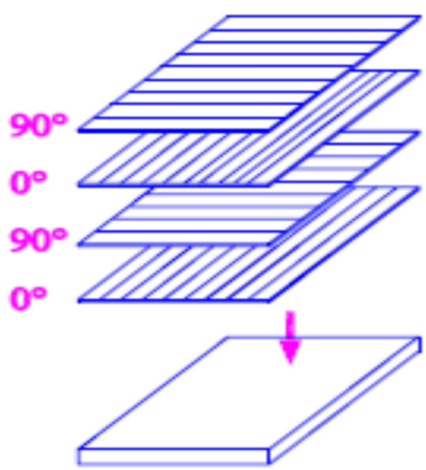

Figure 3-8 Fiber arrangement plain type with 0^0 and 90^0 angle

3.2.4 Manufacturing of Sisal-Glass Fiber Hybrid Composite

Three of the laminates were prepared from Sisal-Glass Fiber Hybrid Composite by varying a ratio of the two raw materials. Three of the laminates which composition of the synthetic and natural fiber is done with a ratio of;

A. **50% of Glass fiber and 50% of Sisal Fiber:** which was done with plain type of two layers of glass and sisal fiber plus resin are used as a matrix between each layer.

B. **25% of Glass Fiber and 75% of Sisal Fiber:** which was prepared with one layer of glass fiber and three layers of Sisal Fibers in which the resin is applied between individual layer.

C. **75% of Glass Fiber and 25% of Sisal Fiber:** is also among the hybrid composite in which three of the layers are Glass Fibers while one is Sisal Fiber and the resin is applied.

D. **100 % of Glass Fiber:-**which are all four layers is Glass Fibers and the resin is applied on it.

E. **100 % of Sisal Fiber**: which are all four layers is pure Sisal Fibers and the resin is applied on it as usual.

After preparing the laminates as procedures indicated above, cutting of the samples with a proper standard is made with help of grinder machine in manufacturing work shop of ASTU.

3.2.5 Preparation of Sisal Fiber

The manufacturing of sisal polyester composite is performed by the hand layup technique. The uni directional or plain type sisal fiber is used as reinforcement and polyester is taken as matrix material.

The steps which were followed during preparation of pure sisal fiber (100% Sisal fiber) are as follows:

- Arrangement of Sisal fiber is made by hand in our university workshop
- Individual fiber layer size was prepared by a dimension of 220mm length.

Figure 3-9 a) preparation of a sisal fibers   b) Sisal fiber after cut

- Mixing of polyester and hardener was performed with a ratio of 200ml: 1ml respectively.
- Four layers of sisal fiber was stacked one on the top of the other by hand
- Polyester were applied between each layers and laminate preparation was done

Figure 3-10 Preparation of Laminate by hand layup method

Cutting of the laminate was performed by hand grinder machine and samples are prepared according to ASTM standards i.e. (220mm X 4mm X 25mm) dimensions as figure 3.11.

Figure 3-11 Samples prepared with desired dimension

3.2.6 Preparation of Glass Fiber

Twill types of glass fiber are accessible (see figure 3.12). For making the same samples we were removed the one direction of fiber by hand which is used as reinforcement in the form plain type and polyester as matrix for the composite material.

Figure 3-12 Preparation and Cutting Fibers to Desired Dimensions.

4. RESULTS AND DISCUSSION

4.1 Description of Tensile Test Experiment

The ability of the material to stretch without breaking is termed as tensile strength. Tensile properties of the composites are mostly affected by the materials, method, specimen condition and preparation.The tensile strength of the laminate was measured by the ASTM standard (American Society for Testing and Materials) ASTM: D3039.

This experiment is done to get the property of the sample materials which are five in number and each of the five materials consists of three samples which makes a number for tensile test fifteen. One of the specimens is made from pure glass fiber (E-glass), the second specimen is manufactured from pure Sisal fiber, while the three sample materials are made from the composite hybrid of sisal and glass fiber materials.

The tension test is done at Ethiopian Conformity Assessment Enterprise, in their Mechanical Testing Laboratory. The sample material from the bulk material of the body panel is taken to be tested in aforementioned laboratory for tensile strength. The measurement is taken on the gauge section in which its length is 100 mm, 4mm thick and 25mm width. Special attention was paid in order to avoid stress concentration due to improper cutting.

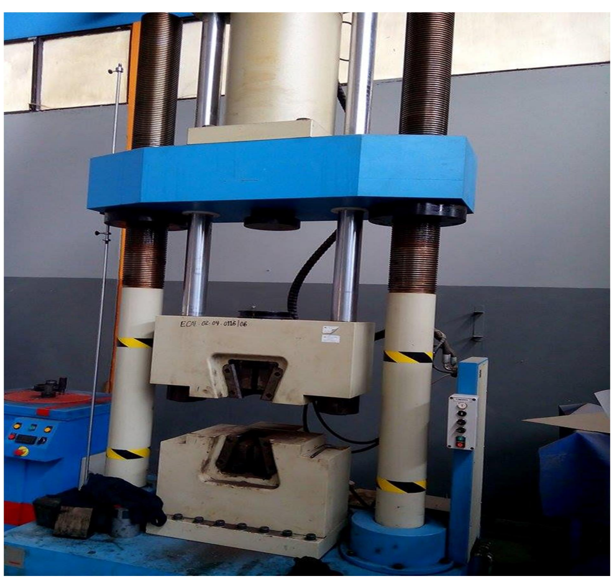

Figure 4-1 a) Universal Tensile Testing Machine b) Specimen While Tested In UTM

Also the load at failure is obtained from the chart and the ultimate tensile strength of the specimen is calculated as:

$$\boldsymbol{\sigma = \frac{F}{A}} \text{...}(1)$$

Where:-

- ✓ σ =Tensile Strength
- ✓ F = Load at failure
- ✓ A= = average cross-sectional area of the specimen in mm

A. 100% Glass Fiber Tensile Test

The test result indicates that, maximum tensile strength of 100% glass fiber composite is about 232Mpa and average tensile strength is 209Mpa. As shown in figure 4.3 glass fiber composite has highest tensile strength when compared to other two composites. The specimen weak section is around the center of span length where it has broken.

Figure 4-2 100% Glass Fiber Specimen for Tensile Test

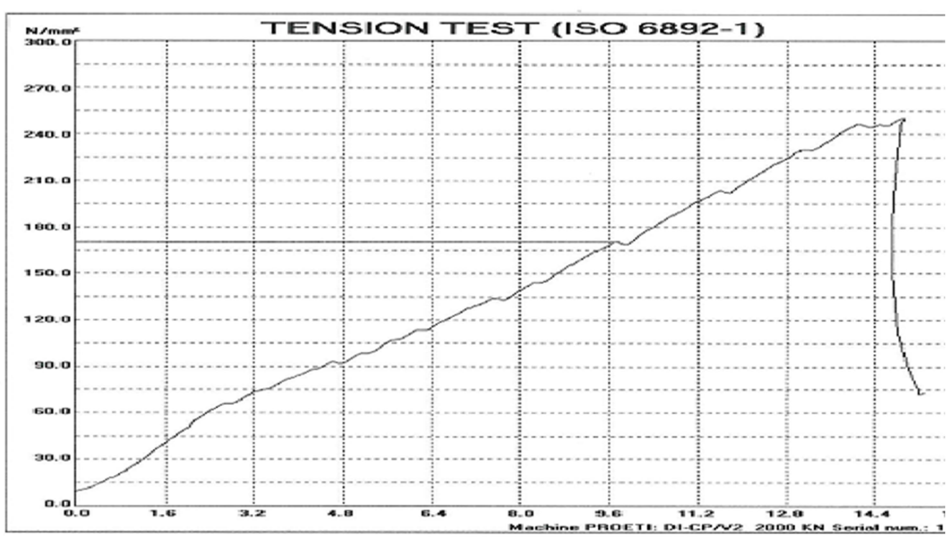

Figure 4-3 Test Result Of 100 % Glass Fiber

B. 100% Sisal Fiber

The second tensile test was done for pure sisal fiber, the test result indicates a maximum tensile strength of the material is about 59 Mpa and average tensile strength is 56 Mpa as shown in the figure 4.5. The specimen weak section is around the beginning of the span length where it has broken.

Figure 4-4 100% Sisal Fiber Specimen for Tensile Test

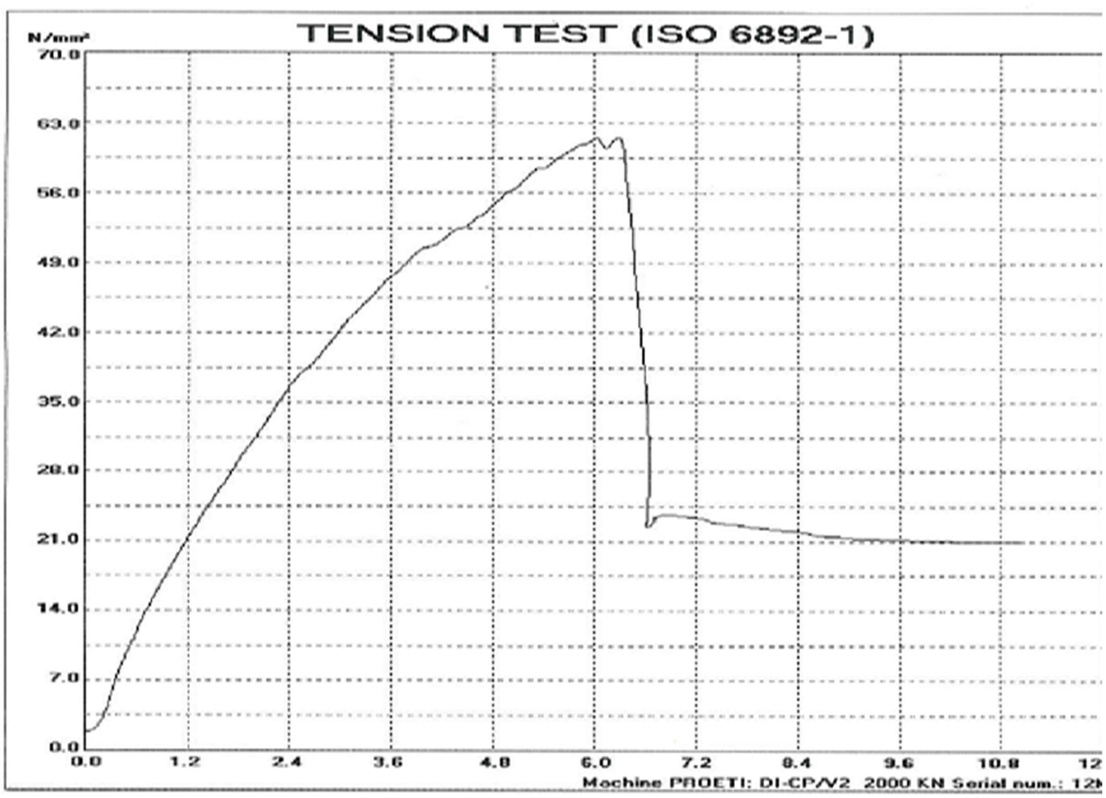

Figure 4-5 Tensile Test Result of 100% Sisal Fiber Composite

C. 75% Glass Fiber and 25% Sisal Fibers

The test result for 75% glass fiber composite indicates that, maximum tensile strength of the material is about 127Mpa and average tensile strength is 120Mpa as shown in the figure 4.7. The specimen weak section is around the center of span length where it has broken.

Figure 4-6 75 % Glass Fiber and 25% Sisal Fiber Specimen for Tensile Test

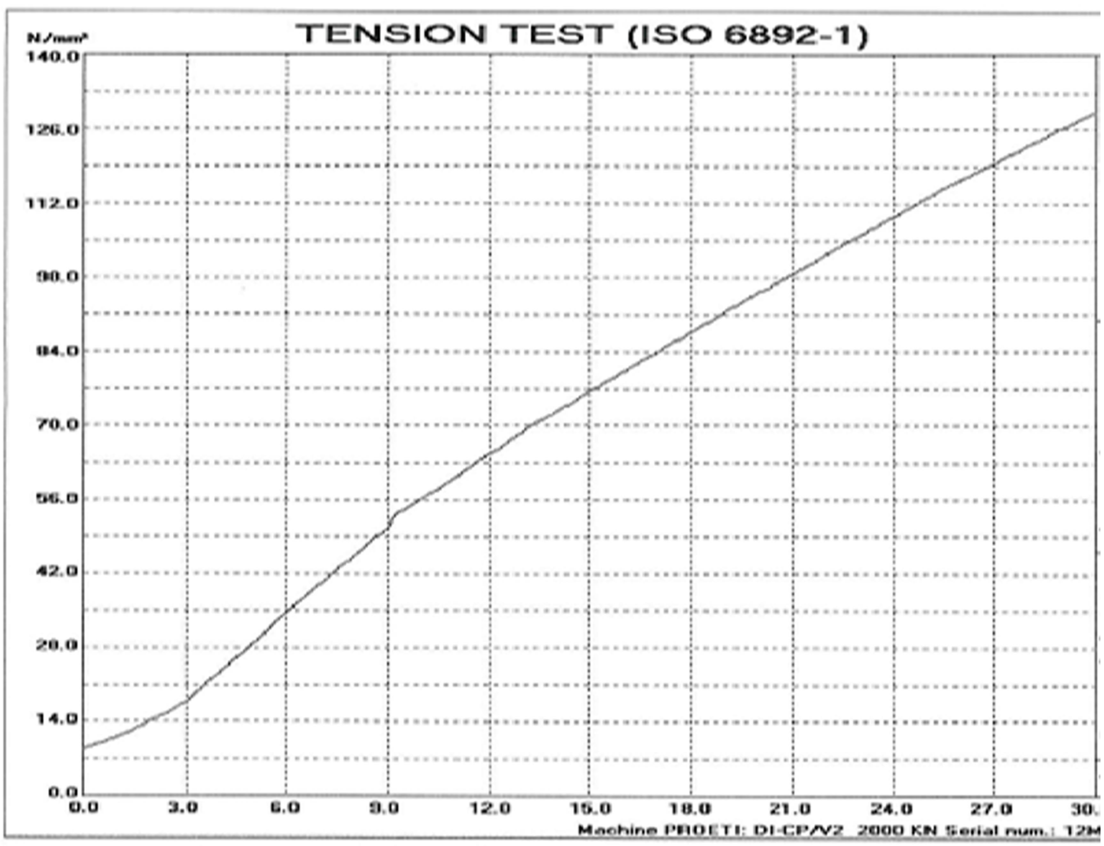

Figure 4-7 Tensile Test Result of 75% Glass Fiber Composite

D. 75% Sisal Fiber and 25% Glass Fiber

The tensile strength vs displacement curve for three specimens is as shown in figure 4.9. The maximum tensile strength of 75% sisal fiber and 25% glass fiber is 141Mpa and the average is 129Mpa tensile strength. The curve increases linearly with respect to displacement up to the maximum tensile load and then it gets failed.

Figure 4-8 75 % Sisal Fiber and 25% Glass fiber Specimen for Tensile Test

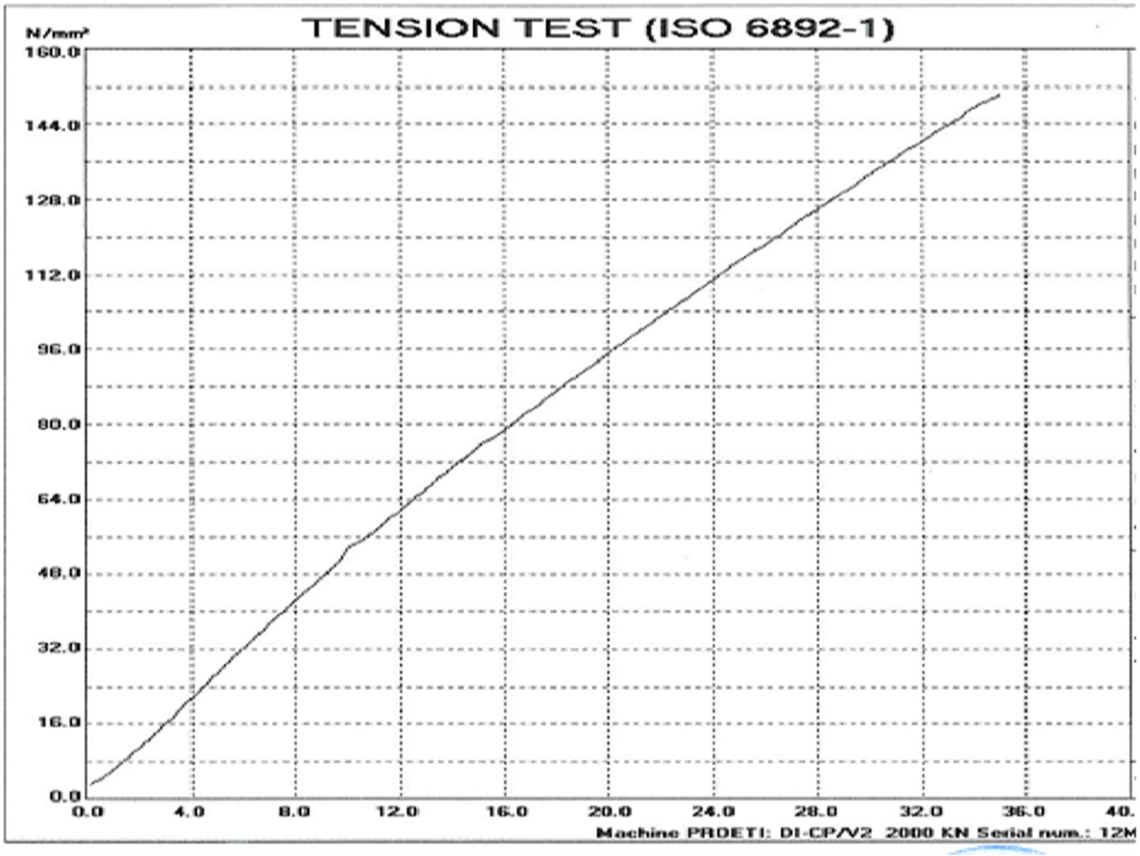

Figure 4-9 Tensile Test Result of 75% Sisal Fiber Composite

E. 50% Glass Fiber and 50% Sisal Fiber

Maximum tensile strength of 50/50 sisal-glass fiber composite is about 134Mpa and average tensile strength is 127Mpa as shown in the figure 4.11. The specimen weak section is around the center of span length where it has broken.

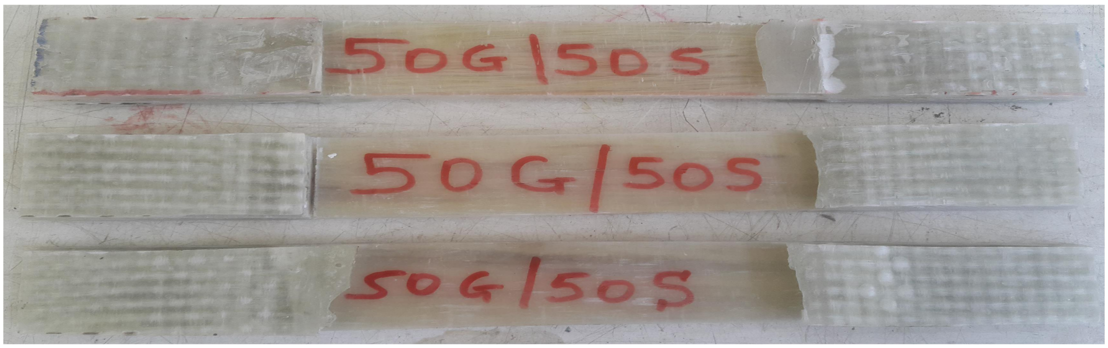

Figure 4-10 50 % Glass Fiber and 50% Sisal Fiber Specimen for Tensile Test

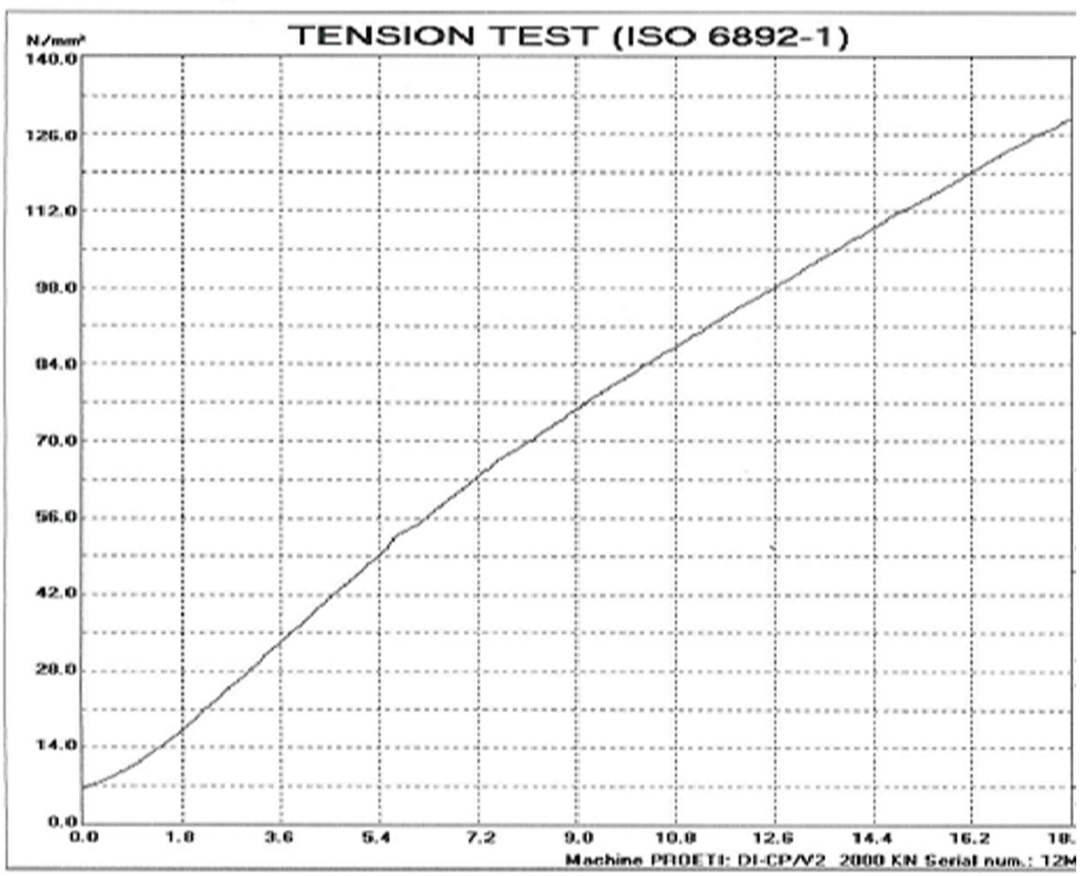

Figure 4-11 Tensile Test Result of 50% Sisal Fiber Composite

F. Summary of Tensile Test Result

The samples are tested on universal testing machine and the average value of the tensile test result is summarized in the following table:

Table 4-1 Summary of Tensile Test Result

S.No	Mechanical Test	Results (average of three samples)				
		Pure Glass Fiber	Pure Sisal Fiber	50/50 Glass-Sisal Fiber Respectively	25/75 Glass-Sisal Fiber Respectively	75/25 Glass-Sisal Fiber Respectively
1	Tensile Strength	209Mpa	56Mpa	127Mpa	129Mpa	120Mpa

The sisal fiber tensile strength is very low however, after reinforcing it by E-glass fiber, this property were highly increased as indicated in table 4.1. By raising a thickness of this hybrid composite material to some extent, it is possible to even achieve more strength than the one shown.

4.2 Description of Flexural Test Experiment

Fluxaral (Three Point Test) is one of very important test to check weather a material can achieve a desired strength or not. It is also an important parameter to test the ability of composite material to resist impact load.

For this test, the two ends of the rectangular specimen is supported and the load is applied at the center. The load will be gradually applied downward at the center point until the material breaks and the load is maximum at this point. three specimens of each composite were tested and average values are reported by using the following formulas:

$$f = \frac{3PS}{2bt^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where,

- F= Flexural Strength
- P= The Ultimate Failure Load in Newtons
- S= The Span Length (mm)

- B= The Width Specimen in (mm)
- T= The Thickness of Specimen in (mm)

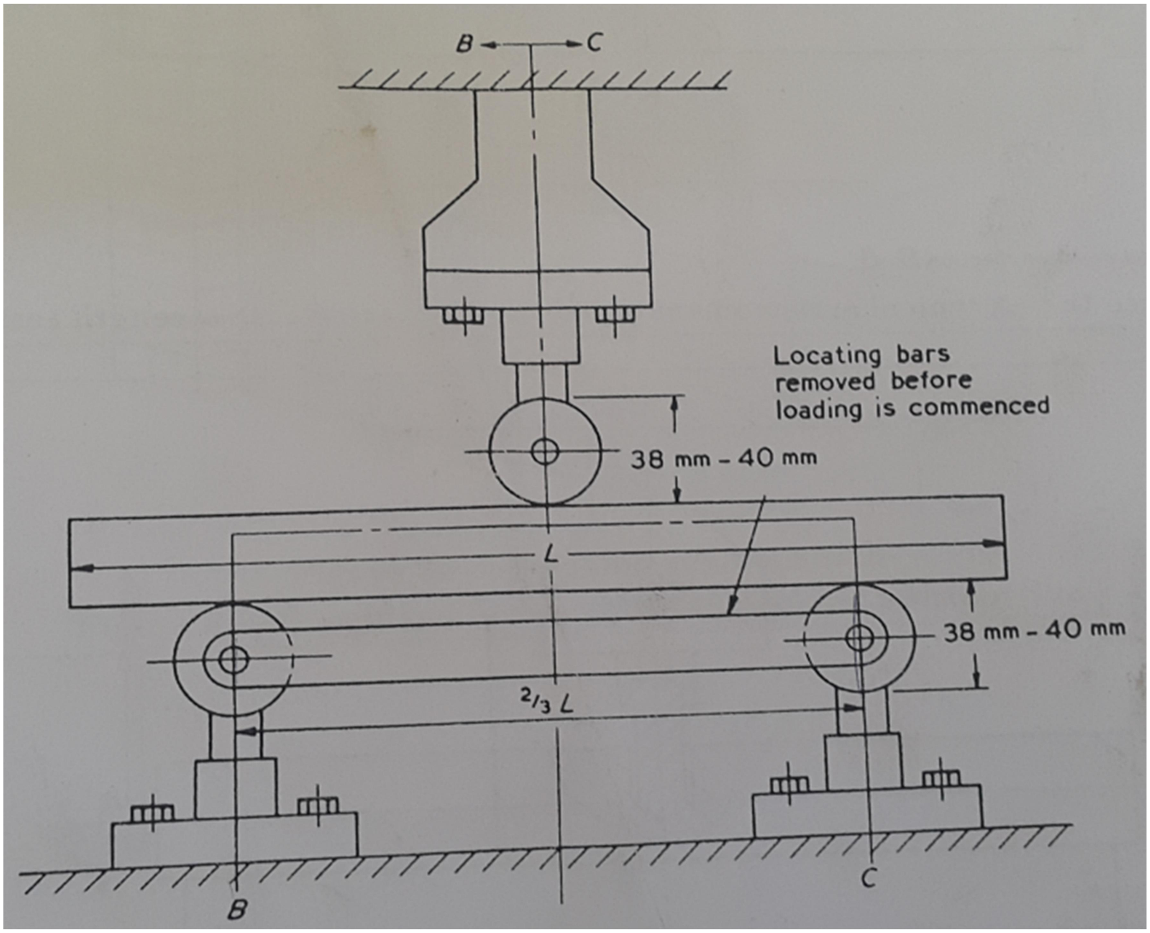

Figure 4-12 Flexural Test Mechanism

The flexural test was performed at Ethiopian Comfirmity and Assesment Enterprize. The three samples are prepared with a span length of 100mm, 0.4mm thikness and 80mm of span length. The three specimen with composition of 50/50 sisal/glass fiber composite, 100% glass fiber and 100% pure sisal (natural fiber) were prepared for the test. The spacemen are placed under a machine and the load is gradually applied at the center while the specimen is supported at the two ends. Then maximum load at which the sample broken is recorded from the screen which is connected to the machine.

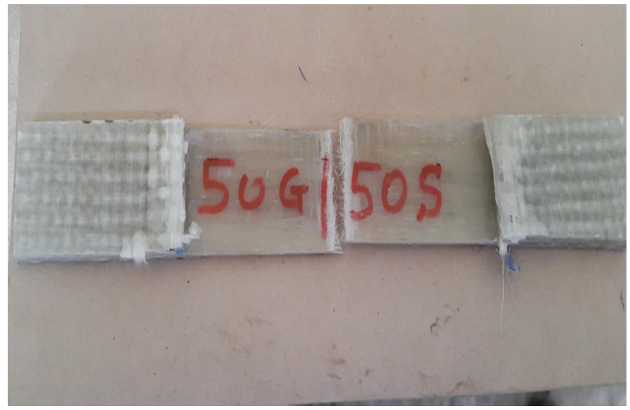

Figure 4-13 a). Specimen gripped for test b). Section of specimen broken

Table 4-2 Flexural Test Results of three Samples for each composition

Specimen Composition	Specimen No	Thicknes s(mm)	Breadth (mm)	Span Length(mm)	Breaking load(KN)	Flexural Strength (N/mm^2)
1. 50% Sisal and 50% Glass Fiber	1	3.0	28.8	80	0.253	117.13
	2	3.2	29.6	80	0.340	134.61
	3	2.8	28/5	80	0.336	180.45
2. 100% Glass Fiber	1	2.7	26.9	80	0.511	312.70
	2	2.2	26.5	80	0.365	341.49
	3	2.9	28.9	80	0.716	353.51
3. 100% Sisal Fiber	1	6.6	28.3	80	1.067	103.87
	2	5.2	29.6	80	0.595	89.21
	3	3.7	28.2	80	0.355	110.35

A. 50% Sisal Fiber and 50% Glass Fiber

The average and maximum flexural strength of 50% Sisal Fiber and 50% Glass Fiber is 180.45 and average is 144Mpa. this indicate the composite used for producing component of medium load applications such as welding shield, visor, window door, two wheeler bumper, and automobile body panel.

Figure 4-14 50% Glass Fiber and 50% of sisal fiber Specimen for Flexural Test

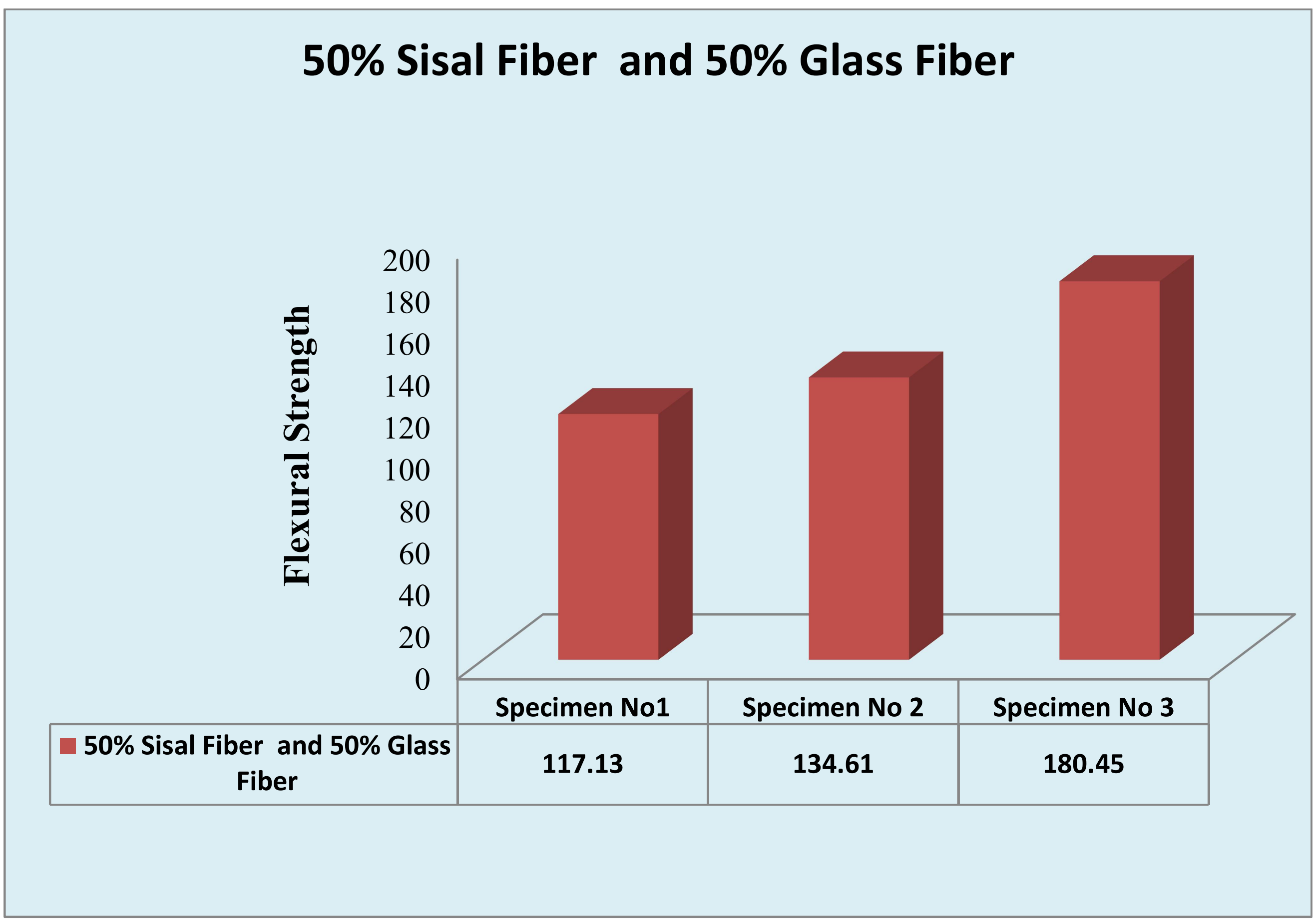

Figure 4-15 Flexural Strength of 50% Glass Fiber and 50% of Sisal Fiber

B. 100% Glass Fiber

The flexural property of pure glass fiber has high flexural strength. The maximum flexural strength of 100% glass fiber 353.51Mpa and average is 335.9MPa which shows glass fiber composite has highest flexural modulus when compared to other two composites.

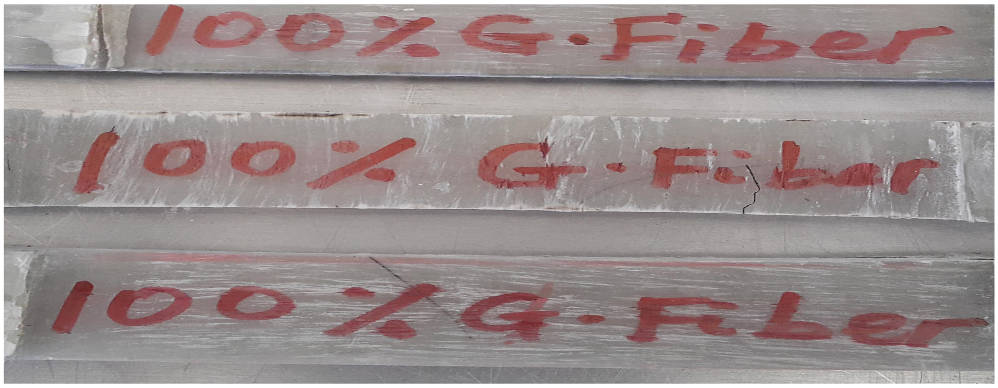

Figure 4-16 100% Glass Fiber Specimen for Flexural Test

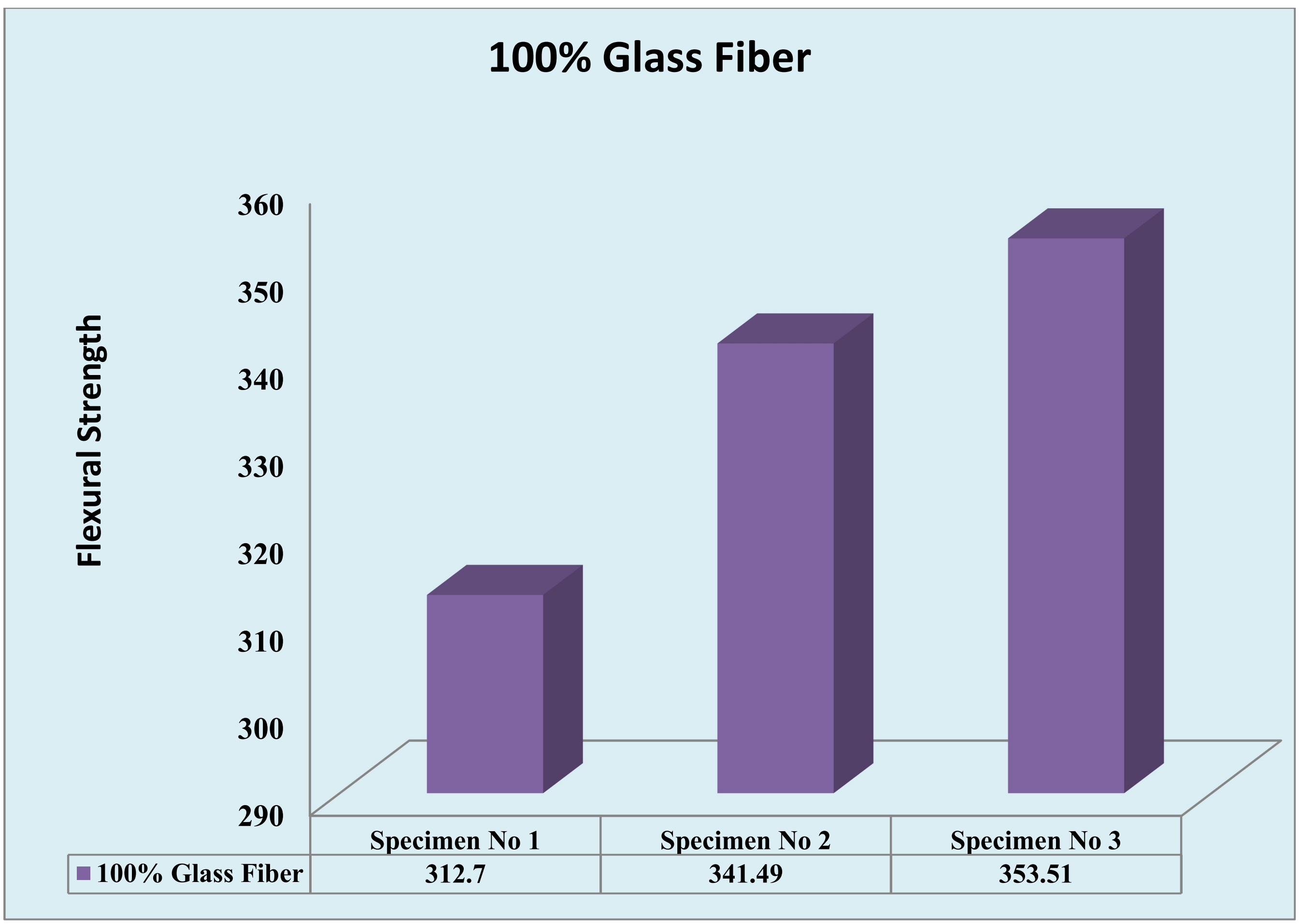

Figure 4-17 Flexural Strength of 100% Glass Fiber

C. 100% Sisal Fiber

The maximum and average flexural strength of 100% sisal fiber is 110.35Mpa and 101.14Mpa this figure shows sisal fiber can we used for materials which work on low flexural load.

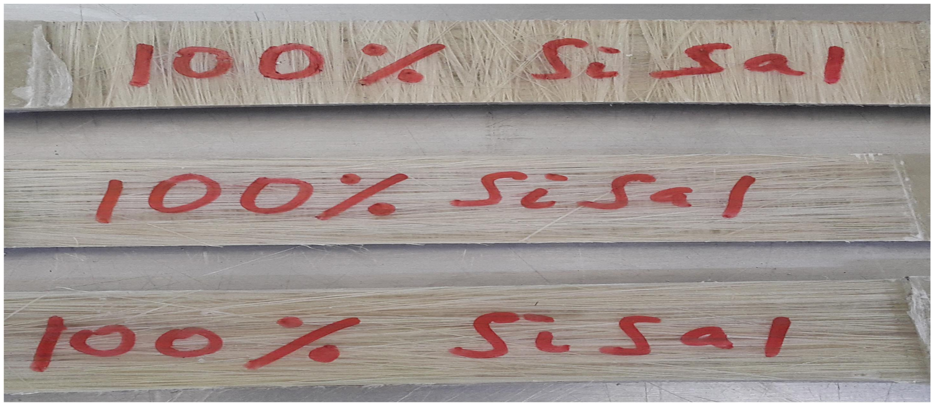

Figure 4-18 100% Sisal Fiber Specimen for Flexural Test

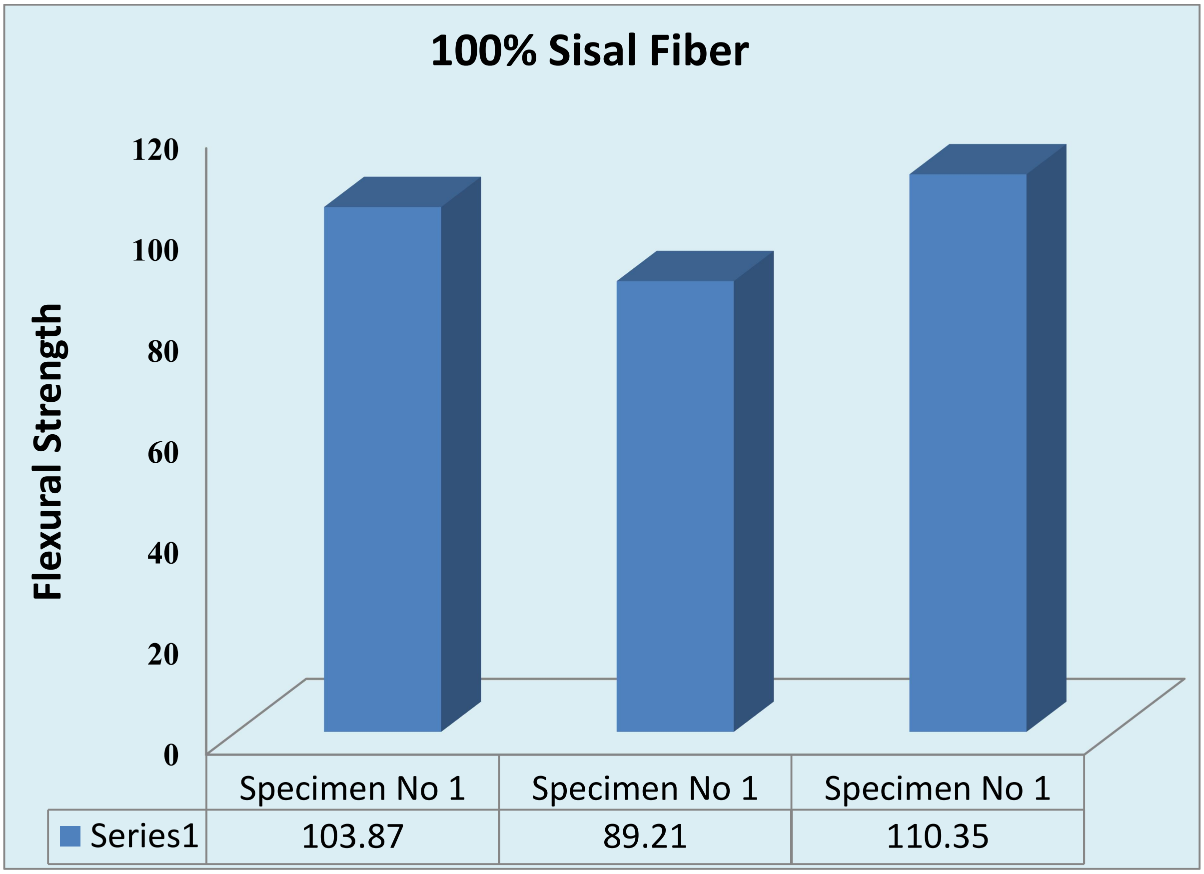

Figure 4-19 Flexural Strength of 100% Sisal Fiber.

D. Summary of Flexural Test Result

The samples are tested on universal testing machine and the average value of flexural test is summarized in the following table:

Table 4-3 Summary of Flexural Test Result

S.No	Mechanical Test	Results (average of three test result)		
		Pure Glass Fiber	Pure Sisal Fiber	50/50 Glass-Sisal Fiber Respectively
1	Breaking Load	716 N	1067 N	340 N
2	Flexural Strength	353.50 Mpa	103.86 Mpa	134.60 Mpa

Three specimens of each composite were tested and from the average values flexural strength can also be calculated by using the following formula:

$$\boldsymbol{f = \frac{3PS}{2bt^2}}$$

A. For Pure Glass Fiber:-

$$\boldsymbol{f = \frac{3 \times 716 \times 80}{2 \times 28.9 \times 2.9^2} = 353.50\ N/mm^2}$$

B. For Pure Sisal Fiber:-

$$\boldsymbol{f = \frac{3 \times 1067 \times 80}{2 \times 28.3 \times 6.6^2} = 103.86\ N/mm^2}$$

C. For 50/50 Glass-Sisal Fiber:-

$$\boldsymbol{f = \frac{3 \times 340 \times 80}{2 \times 28.5 \times 3.2^2} = 134.61 N/mm^2}$$

- The test result indicates that, the flexural strength of pure glass fiber is highest than other two composition. The flexural strength of 50/50 glass- sisal fiber is better than pure sisal fiber. This indicates reinforcing more amount of sisal fiber i.e. greater than 50% will raise the flexural strength of the materials.

4.3 Mold Manufacturing Process

The shape of the car body panel is determined by the shape of the mold, and the mold surface is typically in contact with the exterior of the part. Mold release is first applied to the mold to prevent the fiberglass part from adhering to the mold. Gel coat, which is pigmented resin, is applied to the mold to give the part color. Fiberglass and resin are then deposited onto the mold and the fiberglass is compressed by rollers, which evenly distributes the resin and removes air pockets. Multiple layers of fiberglass are deposited until the desired thickness is achieved. After the resin is dried, the part is removed from the mold. Excess material is trimmed off, and the part had painted.

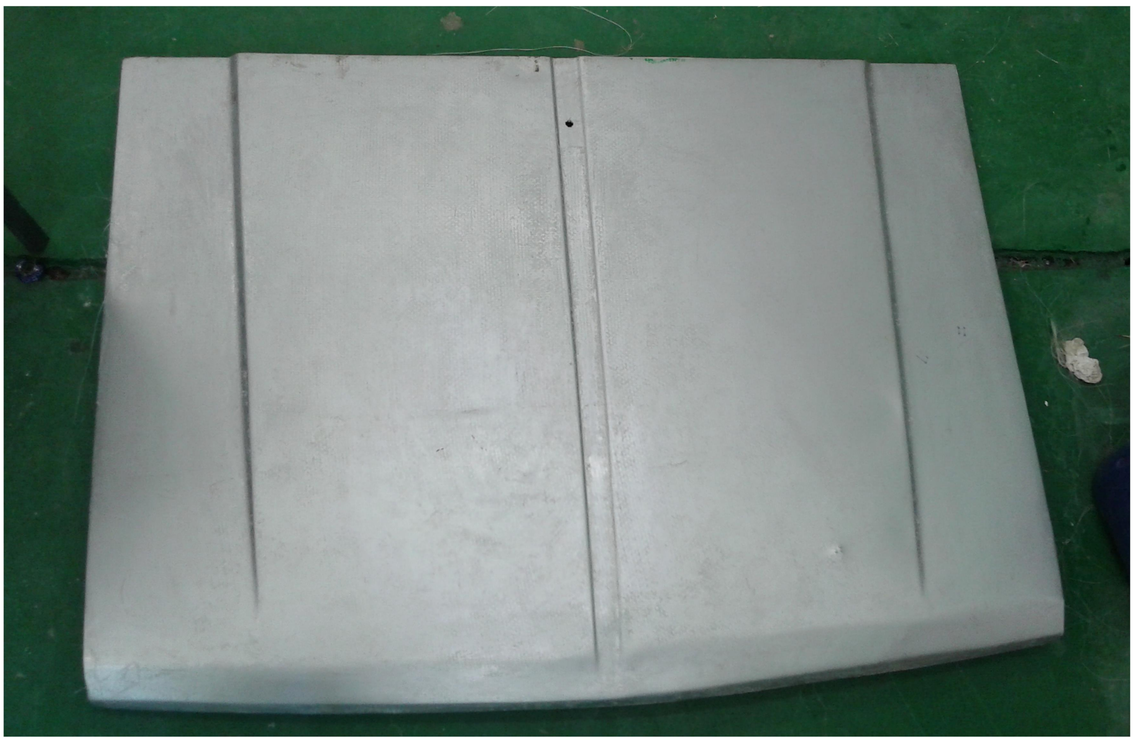

Figure 4-20 Car body panel used for mold preparation

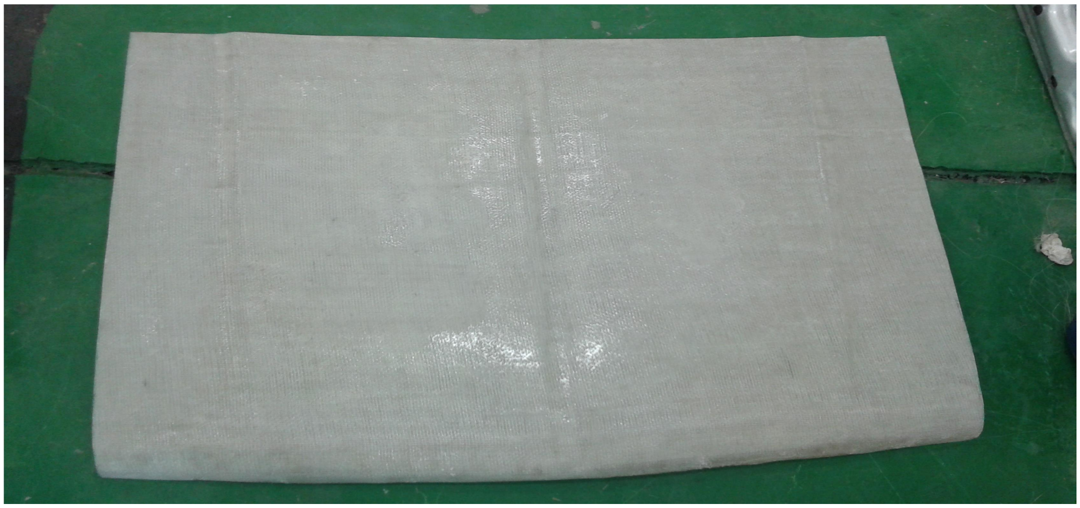

Figure 4-21 Mold for Manufacturing Auto Body panel

4.4 Manufacturing of Auto body panel

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. Even though there are several factors that influence the entire product development process to realize a lightweight vehicle, from the point of view of vehicle structural design, the main governing criteria for material selection are stiffness and strength properties that will determine the overall performance of vehicle during static and dynamic loading conditions.

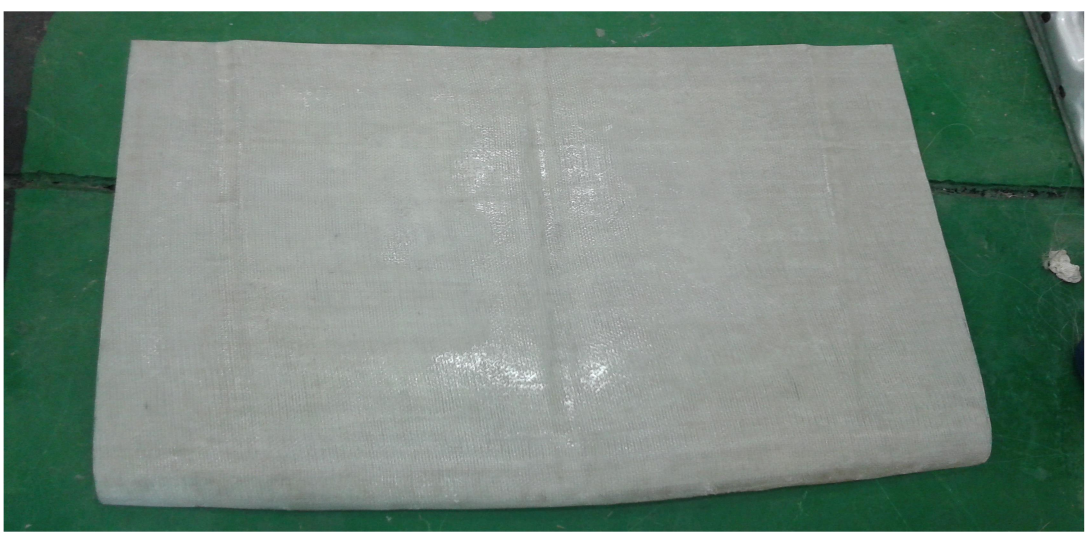

Figure 4-22 Manufactured Auto body panel.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Natural fiber reinforced thermoset composites are the best alternative materials for the synthetic fiber reinforced composites due to their properties such as low density, less expensive, high flexibility, abundant availability, and eco-friendly nature. Using natural fibers as reinforcement in the thermosets will introduce the positive effect on the mechanical properties of the thermosets. Composites with the higher mechanical properties are suitable chosen and used in automobile sector, industries, aerospace, sports, and also in medical fields for making the components required.

In this research project, composition of sisal fiber with glass fiber was made and important tests such tensile and flexural tests were performed. Natural (sisal) fibers are renewable and environmentally friendly materials as they have low density, low price and acceptable mechanical properties. The laminates were manufactured by the compression molding process and tested according to ASTM standards and obtained results. The following conclusion can be drawn from the analysis of composite materials:

1. The steel can be replaced by the composite materials since the composite materials such as glass fiber, sisal-glass hybrid has great advantages over steel in terms of lightweight.
2. These advantages are also conductive to the improvement of fuel consumption and the decrease of emission of harmful pollutants.
3. Through the analysis of lightweight materials, pure glass fiber (100% glass fiber) composite which has a tensile strength of 209 Mpa and transverse (flexural) strength of 353.5Mpa is selected as the material of the body panel which meets most of the requirements like high strength to weight ratio, crashworthiness and less body deformation instead of steel in order to achieve the lightweight design.
4. The hybrid composite material with 75% Sisal fiber and 25% glass fiber composite possess the second highest tensile strength and transverse (flexural) strength of 50/50 glass-sisal fiber composite is 134.60 Mpa, with lowest deformation and stress value which makes the material a promising option in replacing the conventional body materials such as steel and aluminum.
5. By incorporation of natural fibers into synthetic fibers, the mechanical properties almost enhanced to greater extent.

6. From the study it can be concluded that agriculture product like sisal fiber are able to be used for the fabrication of composite and able to make agricultural product into useful engineering applications.
7. Even though the property test result shows a pure glass fiber composite has highest strength of all other compositions, due to its cost, it is possible to use by incorporating 25% of sisal fiber with 75% of glass fiber, rigidity can be achieved by increasing thickness of body panel.

Therefore, from the observations, the hybrid composite laminates are showing moderate performance which is closer to the glass fiber composites. Hence it is suitable to use the material for the medium load applications such as welding shield, visor, window door, two wheeler bumper, and automobile body panel.

5.2 Recommendation

- ✓ The main economic advantage of natural fibers (Sisal fiber) is their local availability; therefore, it is feasible for local automotive industry such as Bishoftu Automotive Industry, Dejene Aviation Industry, Ethiopian Plastic Industry, etc. for automotive, railway and air craft body applications.
- ✓ Sisal fiber has a lower density than glass fiber, thus providing a good resin flow. There for using this natural fiber is easy for manufacturing regardless of the challenges during fiber arrangements.
- ✓ In this study variation of material composition is only considered and hence it's a good idea for other researchers to deal with the fiber orientation (variation of fiber direction) and comparing the results.
- ✓ Natural fibers prices are cheap and importing cost of glass fiber is very expensive. Therefore, import substitution and exporting sisal as a resource for composite components in a "value-added" form would be advantageous. This might be in the form of semi-finished materials.
- ✓ To come up with a good mechanical property sisal fiber it is recommended to cultivate and extract the fiber from the very beginning.

6. REFERENCE

[1] Abilash N. and Sivapragash M. [2013], "Environmental benefits of eco-friendly natural fiber reinforced polymeric composite materials", International Journal of application or innovation in Engineering and management (IJAIEM), ISSN 2319-4847, Vol.2 (1), 53-59.

[2] Agarwel, A., Garg, S., Rakesh, P. K., Singh, I. and Mishra, B. K. 2010. Tensile Behaviour of Glass Fiber Reinforced Plastics Subjected to Different Environmental Conditions. Indian journal of engineering & material sciences, 17: 471-476.

[3] ASTM D3039. 1995. 'Standard Test Method for Tensile Properties of Polymer MatrixComposite Materials'. Annual Book of ASTM Standards, American Society for Testing and Materials, Philadelphia.14 (2): 99-109.

[4] ASTM D3518. 1994. 'In-planeShearResponse of Polymer MatrixComposite Materials byTensile Test at ±45o Laminate'. Annual Book of ASTM Standards, Vol. 14.01, American Society for Testing and Materials, Philadelphia. pp. 139-145.

[5] Boustead I. Ecoprofiles of plastics and related intermediates, Association of Plastic manufacturers of Europe (APME) Brussels, Belgium; 2002

[6] Corbiere-Nicollier T, Laban BG, Lundquist L, Leterrier Y, Manson JAE, Jolliet O. Lifecycle assessment of biofibers replacing glass fibers as reinforcement in plastics. Resour Conservation Recycling 2001; 33: 267-87.

[7] Chand N. and P.K. Rohatgi, Natural fibers and their Composites, (Delhi ,Periodical experts book agency, 1994

[8] David Hartman, Mark E. Greenwood, and David M. Technical paper high strength glass fibers Pub. No. LIT-2006-111 R2 (02/06) Printed in USA.

[9] Diener J, Siehler U. Okologischer vergleich von NMT-und GMT Bauteilen. Angew Makromol Chem 1999; 272(Nr. 4744):1-4.

[10] Foulk JD, Akin DE, Dodd RB. New low cost flax fibers for composites. SAE Technical paper number 2000-01-1133, SAE 2000 World Congress, Detroit; March 6-9, 2000.

[11] Hinton, M. J., Soden, P. D., and Kaddour, A.-S. 2004. "Failure Criterion fibers-ReinforcedPolymer Composites: The World-Wide Failure Exercise". Elsevier Science

[12] International Journal of Innovation, Management and Technology, Vol. 2, No. 3, June 2011 Application of Sisal, Bamboo, Coir and Jute Natural Composites in Structural Upgradation

[13] Mohanty AK, Drazl LT, Misra M. Engineered natural fiber reinforced polypropylene composites: influence of surface modifications and novel powder impregnation processing. J Adhes Sci Technol 2002; 16(8):999-1015.

[14] Murali, B. Nagarani, J., "Design and fabrication of construction helmet by using hybrid composite material," Energy Efficient Technologies for Sustainability (ICEETS), 2013 International Conference on , vol., no., pp.145,147, 10-12 April 2013

[15] Prasad V R, Rao K M M, Rao K M & Kumar M A, Indian J fibers Text Res, 31 (2006) 335

[16] P.Srinivasakumar 1*, M.J.Nandan 2, Dr.C.Udaya Kiran1, Dr.K.Prahlada Rao3 *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 8, Issue 6 (Sep. - Oct. 2013), PP 01-08 www.iosrjournals.org*

[17] Schmidt WP, Beyer HM. Life cycle study on a natural fiber reinforced component. SAE Technical paper 982195. SAE Total Life-cycle Conf. Graz, Austria; December 1-3, 1998.

[18] Sen, T.; Reddy, H.N.J., "Finite element simulation of retrofitting of RCC beam using sisal fibers composite (natural fibers)," Electronics Computer Technology (ICECT), 2011 3rd International Conference on , vol.6, no., pp.29,33, 8-10 April 2011.

[19] Seviaryna, I. Bueno, H.G.Maeva, E. Tjong, J., "Characterization of natural fibers-reinforced composites with advanced ultrasonic techniques," Ultrasonic’s Symposium (IUS), 2014 IEEE International, vol., no., pp.1428, 1431, 3-6 Sept. 2014.

[20] Ticoalu A., Aravinthan T. and Cardona F. [2010], “A review of current development in natural fiber composites for structural and infrastructure applications”, Southern region engineering conference, 1-5.

[21] Varga, Cs., Miskolczi, N., Bartha, L., and Lipóczi, G. 2010. Improving the Mechanical Properties of Glass- fibers-Reinforced Polyester Composites by Modification of fibers Surface. Materials and Design, 31, 1: 185-193. doi: 10.1016/j.matdes.2009.06.034.

[22] Wotzel K, Wirth R, Flake R. Life cycle studies on hemp fiber reinforced components and ABS for automotive parts. Angew Makromol Chem 1999; 272(4673):121-7.
[23] http;//www.fao.org/economic/future fibers/fibers/sisal/en.
[24] http;//www.jute.org/wip/cp Ethiopia. html

7. APPENDIX