Development & Comparison of Polymer Hybrid Composites Reinforced with Glass, Sisal, & Jute Fibers

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Abstract: In the present study, sisal-glass fiber reinforced polymer (SGFRP) hybrid composites replaced with jute-glass fiber reinforced polymer (JGFRP) hybrid composites have been fabricated by using the hand lay-up method, and pressure applied using the compression moulding machine. The mechanical properties such as tensile, flexural and impact strengths of these composites are evaluated with the help of the universal testing machine and Charpy impact testing machine. Experiments have been carried out for five samples in each case, and the average values are used for a detailed analysis.

Keywords: SGFRP, JGFRP, Mechanical properties, Polymer, Sisal fiber, Jute Fiber, Glass fiber

1.0 INTRODUCTION

A composite is usually made up of at least two materials out of which one is the binding material, also called matrix and the other is the reinforcement material (fiber, Kevlar and whiskers). By definition, composite materials consist of two or more constituents with physically separable phases. However, only when the composite phase materials have notably different physical properties it is recognized as being a composite material. Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix).Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder maintains the position and orientation of the reinforcement.

Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone. The reinforcement may be platelets, particles or fibers are usually added to improve mechanical properties such as stiffness, strength and toughness of the matrix material. A lot of research is being conducted in order to see which plants can provide raw material for composites and how to make them more environmental friendly. The use of composites have reduced the impacts on the environment as it has reduced the use of various toxic compounds and increased that of environment friendly products. It helps in various natural disasters such as earthquakes. Houses may be built in earthquake zones using lightweight composites and therefore may help in reducing the impact on human life when disaster strikes. Indeed most earthquake related deaths occur due to the fact that people are being buried under heavy concrete and metal beams. Lightweight structures have increased fuel efficiency in cars, buses, ships, etc., thus saving on fuel consumption and increased payload

1.1 Natural Fibers

Natural fibers have come into use after centuries. They have been around a decade that natural fibers have started to be used again. Now they are being highly recommended because of being naturally derived from plants and due to their characteristics of being lightweight compared to glass. These reinforcements are reusable, good insulator of heat and sound, degradable and have a low cost. It is being used widely for building purposes, in cars etc. The natural fibers used for composites are jute, hemp, flax, china grass etc. Natural fibers include those made from plant, animal and mineral sources.

Natural fibers can be classified according to their origin. The detailed classification is shown in Fig.1

The primary advantages of using fibers as fillers/reinforcements in composites are low densities, non-abrasive, high filling levels possible resulting in high stiffness properties, high specific properties, unlike brittle fibers, the fibers will not fractured when processing over sharp curvatures, biodegradable, wide variety of fibers available throughout the world, would generate rural jobs increases non-food agricultural/farm based economy, low energy consumption and low cost.

Figure 1 Picturous views of some natural fibers

The main drawback is the high moisture absorption of the natural fibers. Moisture absorption can result in swelling of the fibers. The absorption of moisture by the fibers is minimized in the composite due to encapsulation by the polymer. It is difficult to entirely eliminate the absorption of moisture without using expensive surface barriers on the composite surface. Good fiber-matrix bonding can also decrease the rate and amount of water absorbed by the composite. Natural fibers are generally lignocellulosic in nature, consisting of helically wound cellulose micro fibrils in a matrix of lignin and hemicelluloses. According to a Food and Agricultural Organization survey, Tanzania and Brazil produce the largest amount of sisal. Henequen is grown in Mexico. Abaca and hemp are grown in the Philippines. The largest producers of jute are India, China, and Bangladesh. Today with all the advancement in life, growing population and its increasing needs we have to consider how to meet those needs by producing the best and making it available for all. Fiber reinforced composites are helping to fulfil the needs of this growing population. They have been and are being studied in order to maximize their utilities in different fields. This part of the chapter will look into the various fields that fiber reinforced composites are being used and what are their environmental impacts. Application of fiber composites are represented by the following groups which are 70% of the total market value: automotive (23%), building and public works (21%), aeronautics (17%) and sports (11%) are shown in Fig.2.

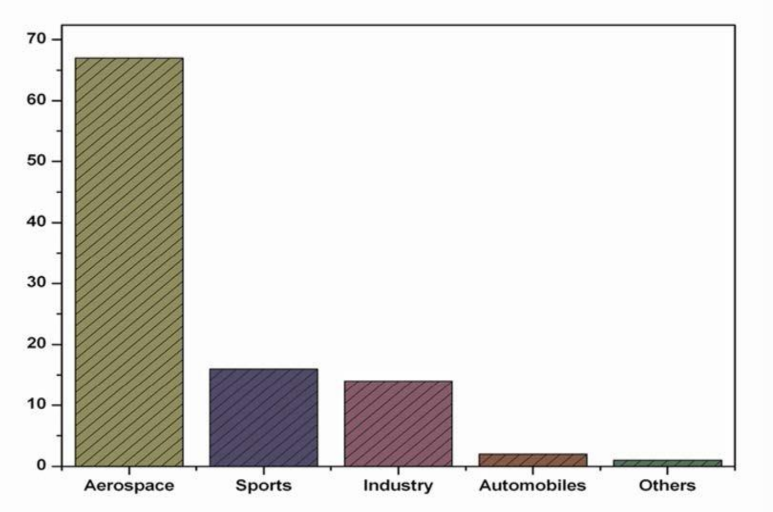

Figure 2 Field – wise distribution for the consumption of the advanced Composite materials.

The very first known application of fiber composites was in construction. Straw reinforced clay bricks were used by the Egyptian Pharaohs, Israelites and Chinese centuries ago. Nowadays the construction is the field of greatest application of fiber composites. The property of composites of being strong and resistant to environmental impacts makes them good building material. Its weight helps only in case of transportation of this material as they are lightweight and can easily be transported. Its light structure may help in earthquake prone region. Being lightweight and in case of collapse reduces threats to human life. In Gujarat India such fiber composite houses have been installed in an earthquake prone region in order to reduce the impacts of future earthquakes. Foldable structures have been introduced and are available due to the fiber composites otherwise making of foldable structures out of cement and a bricks is a difficult task. The first application of glass fiber reinforced composites was in a dome structure in Benghazi in 1968. Today glass fiber reinforced composites are used in footbridges as well as Highway Bridge in Bulgaria. Nearly four-year long continuous monitoring was carried out to demonstrate the performance of the bridge. This evaluation showed the level of confidence in the long-term field benefits of composite materials and technology. As mentioned before, the quality of fiber composites of being light weight and strong has been put into use in the aircraft, rockets, and other equipment used in aerospace. The use of fiber composites in the transport has provided 15-30% weight saving thus increasing fuel efficiency and lowering maintenance and operation costs. Fiber composites are easier to shape according to aerodynamic rules and are therefore being widely used in rockets and spaceships. First passenger carrying spaceship was made used fiber composites it has 24.8 m wingspan. Ballistic composites are materials with superior properties being lightweight and durable under environmental conditions, with high performance (high strength and impact). Lightweight ballistic composites are used in a wide range of lightweight vehicles and aircraft armor giving high performance and lightweight protection against bullets and fragments. They also have exceptional insulating properties in high temperature environments. They are being used in missiles, tanks and fighter planes. They can receive and send radar signals. And they are not magnetic thus help in wars from being not easily targeted. Fiber composites are being used is car industry. The reason for their increasing demand in this industry is because the strength and stiffness in combination with low weight decreases the fuel consumption. It is said to save up to 27% of the weight in most of the structures. All vehicles from train to cars as well as bicycles are now using fiber composites. They are not only being used in the exterior but a lot of car parts are also being made from composites which include radiators, ignition components, spoilers, door panels, hoods, hatchbacks, roof panels, bonnets, wing mirrors, rear light units, brake linings, Internal parts and trim where they are the solution to lightness, freedom of shape, freedom of design, matching internal decor and providing thermal and sound insulation. They are used to mold interior components for buses, seat squabs and bases, car door liners, back panel of seats, parcel shelves. Composite materials are increasingly being used in the train industry, which has resulted in high performance and lower costs. Weight savings of up to 50% for structural and 75% for non-structural applications brings associated benefits of high-speed, reduced power consumption, lower inertia, less track wear and the ability to carry greater pay-loads. Application of composites in transportation (Ex: Mercedes Benz E-Class) is shown in Fig.3

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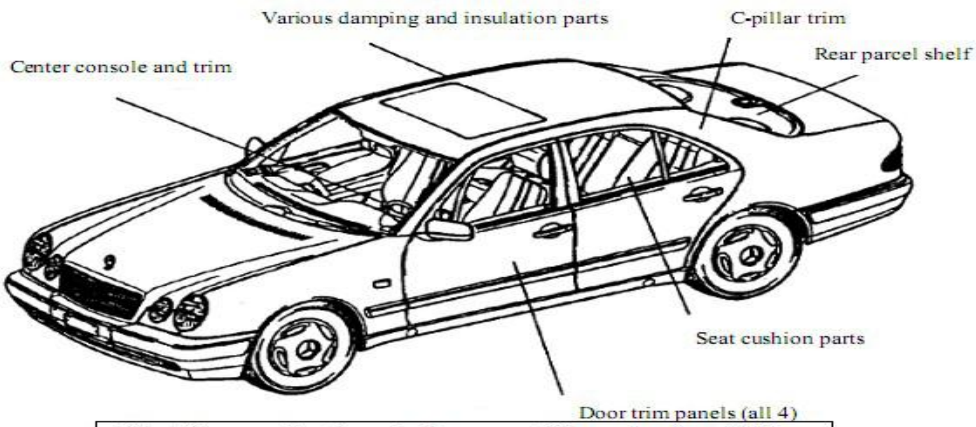

Plant fiber applications in the current Mercedes-Benz E-Class.

Figure 3 Application of composites in Mercedes Benz E-Class

Composites also provide greater versatility in train design and optimization of train performance (e.g. lowering the centre of gravity to enhance stability). High stiffness from structural materials reduces (even eliminates) supporting framework, increases passenger room, carries fittings readily. The construction of composites (interchangeable panels) is easy to handle and install and offers rapid fitting. Due to fire resistant characteristics, it also allows full safety to the entire system. Components of 25 coaches are generally made of glass fiber reinforced with polyesters/epoxies phenolic resins. Fiber composites are being used in Formula 1 cars as new and improved materials are being introduced that are fireproof. Fiber composites have found their way into medical sciences where they have provided new alternative in the field of science for other materials. Previously broken bones were supported with metal rods surgically, which in some cases would cause problem such as bending, corrosion etc thus causing a threat to the patient. Similarly in the case of amputees they had to use artificial limbs that were very heavy, thus making movement difficult and they were a cause of sores in diabetics. With the introduction of composites in this field it has been found to be a new and improved replacement for metal rod for bone surgery. Polysiloxane based composites with carbon fiber reinforcement have mechanical properties that are adequate from viewpoint of bone surgery requirement for load-bearing implants. They have also been studied to be more bio-compatible. In the case of artificial limbs new lightweight and cheaper artificial limbs have been introduced. This has made mobility for

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amputees easier. It has also benefited the diabetic patients. In 1896 there were no Olympics for those with prosthetic limbs but in 1992 they could not only participate but were considered to be equally good as that with full limbs. Application of fiber composite in the spinal surgery is also remarkable. Recently fiber reinforced composite have made their way into dentistry. Fiber Composites have also made their way in to our homes on the basis of their useful properties. Manufacturing of the fireproof core of fire resistant doors and screens, insulating and fire-resistant materials with different characteristics are being used, including a large number of materials comprised of insulators based on different silica compounds, e.g. fly ashes, which can be reinforced by fibers and produce fire resistant products with good thermal stability at high temperatures. Furniture is now being produced which is made of fiber composites. They are being used because they can easily be shaped into various beautiful and fashionable shapes. With the help of additives they can easily be colored according to our taste. Being lightweight it is preferred over heavy wooden and steel furniture. Various appliances in our homes are made from fiber composites such as vacuum cleaners, food processor etc. Bathtub swimming pools and other toiletries are also made from fiber composites. Children swings, joyride, water slide are another application of fiber composites. The application of fiber composites in household products is shown in Fig.4. Another application of fiber composites is in sports goods. Wood is rarely being used for sports goods. In sports where the time and strength is what is required fiber composites are playing a great role. When designing sport equipment most important things to consider are strength, ductility, density, toughness and cost. With introduction of new materials in sports new records have be set. Initially bamboo stem was used for pole vaulting then came the aluminum and now sophisticated fiber composites are being used.


GRP Cladding of buildings

Figure 4 Application of composites in Household Products

Figure 5 Application Of composites in Sports goods

Cycling is not limited to the Olympics or sports but has become one of the modes of transportation. China manufactures 10 million cycles per year. Since the first cycle that was built in 1817 a lot of advancements have taken place in the bicycle. One of the finest musical instruments is manufactured by fiber composites. They are lightweight and have astonishing sound properties. Carbon fiber and epoxy resin is being used to make guitars and violins, as it is lightweight and resistant to environmental impacts, and damage. It has resonating properties similar to that of wood and has lower construction time and cost. First fiber composite flute was made in Finland. It is a carbon fiber flute. Two factors make composites the material of choice in space applications: high specific modulus and strength, and dimensional stability during large changes in temperature in space. Examples include the Graphite/epoxy-honeycomb payload bay doors in the space shuttle. Weight savings over conventional metal alloys translate to higher payloads that cost as much as $1000/lb ($2208/kg). Also, for the space shuttles, graphite/epoxy was chosen primarily for weight savings and for small mechanical and thermal deflections concerning the remote manipulator arm, which deploys and retrieves payloads

2.0 MATERIAL AND METHODS

In order to study the performance of composites, it is necessary to test them for mechanical properties, such as tensile, flexural and impact. The performance of the composites depends on their properties. In this chapter, the materials used and the methods followed for the processing of composites are presented.

In the present work, two fibers were used as the reinforcements.

1. Jute fiber 2. Glass fiber

2.1 Jute Fiber

Fiber is the reinforcing phase of a composite material. In the present project work, jute is taken as the reinforcement to fabricate the composites. In general, jute is available and is abundant natural resource. It has been a conventional construction material since ancient times. The jute used for this work is collected from the local source. This is one of the predominant species of jute in Andhra Pradesh, west Bengal, Bihar, Assam, Kolkata, Tripura, Orissa, and Meghalaya in India. The structure of jute itself is a composite material, consisting of long and aligned cellulose fibers immersed in a ligneous matrix.

2.2 Glass Fiber

The glass fibers (chopped form) have been procured from company. Good tensile and compressive strength and stiffness, good electrical properties and relatively low cost, but impact resistance relatively poor. E-glass is the most common form of reinforcing fiber used to fabricate the composites. The density of the glass fiber is 1.7gm/cc.

2.3 Matrix

In the present work, Araldite LY 556 is used as the matrix. This resin was developed by ECMOS Corporation Ltd, and is bought at SREE COMPOSITES, Hyderabad, India. Its corresponding hardener is Aradur HY 951. Resin & Hardener should be mixed uniformly in the ratio 10:1 until they form a Homogenous mixture. Resin and hardener provides a low viscosity, solvent free room temperature curing laminating system. This inexpensive resin is mainly used in making parts of automobiles, domestic articles and sports goods.

2.4 Mould Releasing Agent

The bottom and side-walls of the mold were coated with aqueous solution of polyvinyl alcohol (PVA) and hard wax. Polyvinyl alcohol (PVA) acts as a good mold- releasing agent whereas the hard wax will give the good finish for the composite.

2.5 Chemical Treatment

The structure of jute itself is a composite material, consisting of long and aligned cellulose fibers immersed in a ligneous matrix. The jute fiber has the highest percentage of lignin which makes the fiber very stiffer when compared to the other natural fiber. This can be attributed to the fact that the lignin helps to provide the plant tissue and the individual cells with compressive strength and also stiffness to the cell wall of the fiber where it protect the carbohydrate from the chemical and physical damage.

In this investigation, the jute fibers were soaked in 1% NaOH solution for 30 min to remove any greasy material, hemi-cellulose etc., washed thoroughly in distilled water, and dried under the sun for 2 weeks. The purpose of chemical treatment is to increase the strength of jute fiber.

2.6 Fabrication

In order to make the specimens for mechanical strength testing, sheets are prepared by taking matrix and fiber in the open moulds. This system can be processed by different methods like injection, hand lay-up, winding and pressure moulding etc. Some of the fabrication techniques are as follows:

2.7 Hand layup method

- Resin injection technique
- Automatic injection moulding
- Hot press methods
- Filament winding
- Pultrusion

In the present work Hand lay-up technique is used for making test specimens.

2.8 Hand Layup Method

Hand lay-up technique is the simplest polymer-processing technique. Fibers can be laid onto a mould by hand and the resin is sprayed or brushed on. Frequently, the resin and fibers (chopped) are sprayed together onto the mould surface. The deposited layer is densified with roller as shown in the figure 6. Curing may be done at room temperature or at a moderately high temperature in an oven.

2.9 Preparation of Mould and Test Specimens

In the present work glass moulds are used to prepare glass fiber reinforced composites as well as jute fiber reinforced composites. A glass mould of 150mm x 100mm x 3 mm (length x width x thickness) is used to prepare sheets and specimens for tensile, flexural and impact test. The specimens for test were prepared as per ASTM specifications.

Figure 6 Hand lay-up technique

The specimen dimensions were presented in Table 1. The tensile test specimens with dimensions 150mm x 15mm x3mm are cut as described elsewhere. The flexural test specimens with dimensions 100mm x 10mm x 3mm are cut as per ASTMD5943-96 specifications from sheet 200mm x 200mmx 3mm. The impact test specimens with dimensions 122mm x 11mm x 3 mm are cut as per ASTM D 256-88 specifications from a sheet of 150mm x 100mm x 3mm.

Table 1 Specimen dimensions for different mechanical testing

Test	ASTM standard	Specimen Dimensions (mm)	Cross head Speed (mm/min)
Tensile	ASTM D 3039-76	150 X 15 X 3	5
Flexural	ASTM D5943-96	100 X10 X 3	2
Impact	ASTM 256-88	122 X 11 X 3	Sudden force

2.10 Composite Fabrication

In this study, the matrix material used for the fabrication of glass fiber reinforced composites and jute fiber reinforced composites is epoxy. The jute fiber is collected from the local sources. The jute fibers are chemically treated with NaOH solution at the concentration mentioned above as it will give the best strength at that particular concentration. The purpose of chemical treatment is to increase the strength of the fiber. As a result the bonding strength also increases. After the chemical treatment, the jute fibers are allowed to dry for 2 weeks under the sun. Then they are cut into 3, 5 and 7 mm lengths.

Now weigh the jute fiber of particular length & matrix of different volume fractions i.e. (30, 40 and 50%). After weighing the above raw materials they are reinforced in random orientation into the Epoxy and mixed uniformly and are poured in the glass mould. Before pouring the materials, the glass mould is to be prepared by applying white wax on it and allowed to dry for 20 minutes.

Later PVA is applied and is allowed to dry for 20 minutes at room temperature until a thin layer is formed on the surface of the glass mould. After pouring the mixture of jute fiber and epoxy on the mould, it is adjusted to distribute the material throughout the mould uniformly. A roller is taken and is rolled on the surface of the mould to level the surface and remove the excess content of the material by keeping an OHP sheet in between roller and mould.

After that the glass plate is kept on the OHP sheet to cover the mould completely and is kept under some weight so as not to disturb the arrangement as it should be kept for about 24 hours without disturbing the arrangement. After 24 hours, the upper glass plate is removed and the mould is kept in the oven for 20 minutes under 55-60°C to melt the releasing agent applied before pouring the material on the glass mould. The melting of the releasing agent helps to remove the composite material very easily. After getting the specimen, it is allowed to stay in oven at 65^{0}C up to 24 hours for curing. This is known as heat treatment for the specimens in order to increase their strength. Care should be taken to avoid the air gaps in the mould while preparing these specimens. This procedure is repeated for the other two fiber lengths of Bamboo fiber for different fiber volume fractions to form the following total number of specimens.

Table 2 Total number of jute composite Specimens with different combinations of V_f and L_f

Specimen No	Fiber volume fraction	Fiber length (L_f) in
1	30	3
2	30	5
3	30	7
4	40	3
5	40	5
6	40	7
7	50	3
8	50	5
9	50	7

The same procedure is repeated taking glass fiber as reinforcing material. Glass fiber does not require any chemical treatment as it is a synthetic fiber. The following are the total number of composite specimens shown in the table 3 in which glass fiber is taken as the reinforcement.

Table 3 Total no. of Glass composite Specimens with different combinations of V_f and L_f

Specimen No	Fiber volume fraction (V_f)%	Fiber length (L_f) in mm
1	30	3
2	30	5
3	30	7
4	40	3
5	40	5
6	40	7
7	50	3
8	50	5
9	50	7

2.11 Material Properties Testing

In order to know the performance of the composites made in the present work, the following tests are conducted.

- Tensile test
- Flexural test
- Impact test

The flexural test and tensile tests are conducted using Instron Universal Testing Machine (model 3369). Impact strength test was conducted using Izod Impact tester.

2.12 Tensile Test

Tensile strength is a measure of strength and ductility of the material. Ultimate tensile strength is the force required to fracture a material. The tensile properties of the composites are determined by employing an Instron make 3369 model Universal Testing Machine. Tensile testing provides useful data such as ultimate tensile strength and elongation at break. These properties indicate the materials behavior under loading in tension. The test is conducted as per ASTM D3039-76 specifications. The cross-head speed is maintained at 5mm/min. In each case, two specimens are tested and the average value is recorded.

2.13 Flexural Test

The strength of material in bending, expressed as the stress on the outer most fibers of a bent test specimen, at the instant of failure is defined as the flexural strength. The flexural properties of the matrix and the composites are determined using Universal Testing Machine. Here 3 Point bending method is conducted. In this method, a bar of rectangular cross-section rests on two supports and load is applied by means of a loading nose midway between the supports. The test is conducted as per the ASTMD 5943-96 specifications. The cross-head speed is maintained at 5mm/min. In each case, two specimens are tested and the average value is recorded.

2.14 Impact Test

The ability of material to withstand shock loading is defined as the impact strength. The impact strength of the composites is measured by the Izod Impact Tester. The samples are made as per ASTM 256-88 specifications. In each case three specimens were tested to obtain average value.

2.15 Design Of Experiments Via Taguchi Method

A Design of Experiment (DOE) is a structured, organized method for determining the relationship between factors affecting a process and the output of that process.

The Taguchi method involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintained that variation. Therefore, poor quality in a process affects not only the manufacturer but also society. It allows for the collection of the necessary data to determine which factors most affect product quality with a minimum amount of experimentation, thus saving time and resources. Analysis of variance on the collected data from the Taguchi design of experiments can be used to select new parameter values to optimize the performance characteristic.

The most important stage in the design of experiment lies in the selection of the control factors. The mechanical behavior of polymer composites reveals that parameters viz., fiber length and fiber volume fraction etc largely influence the mechanical behavior of polymer composites. The impact of two such parameters are studied using L9 (3^2) orthogonal design.

The control parameters used and their levels chosen are given in Table 4

Table 4 Control Parameters and Their Levels

Fiber volume fraction (V_f) %	Level 1	Level 2	Level 3
	30	40	50
Fiber length (L_f) in mm	3	5	7

Taguchi's orthogonal array of L9 (3^2) is most suitable for this experiment. This needs 9 runs (experiments). The L9 orthogonal array is presented in Table 5

Table 5 Orthogonal Array

Experiment No.	Fiber volume Fraction (V_f)%	Fiber length (L_f) in Mm
1	1	1
2	1	2
3	1	3
4	2	1
5	2	2
6	2	3
7	3	1
8	3	2
9	3	3

Table 6 Actual Setting Values for the Coded Values

Experiment No.	Fiber volume fraction (V_f)%	Fiber length (L_f) in mm
1	30	3
2	30	5
3	30	7
4	40	3
5	40	5
6	40	7
7	50	3

8	50	5
9	50	7

RESULTS AND DISCUSSION

Mechanical Properties

Comparison For Flexural Test Specimens

Table 7 Table Values for Flexural Test for 5 mm

specimen 1	5mm Glass	5mm Jute
max.load(KN)	0.08	0.09
max.stress(mpa)	65.22	79.04
flexural modulus(mpa)	10228.48	11781.2

From the results it is observed that the Flexural strengths for jute fiber reinforced composites are some much high when compared to glass fiber reinforced composites as shown in the Fig.7.

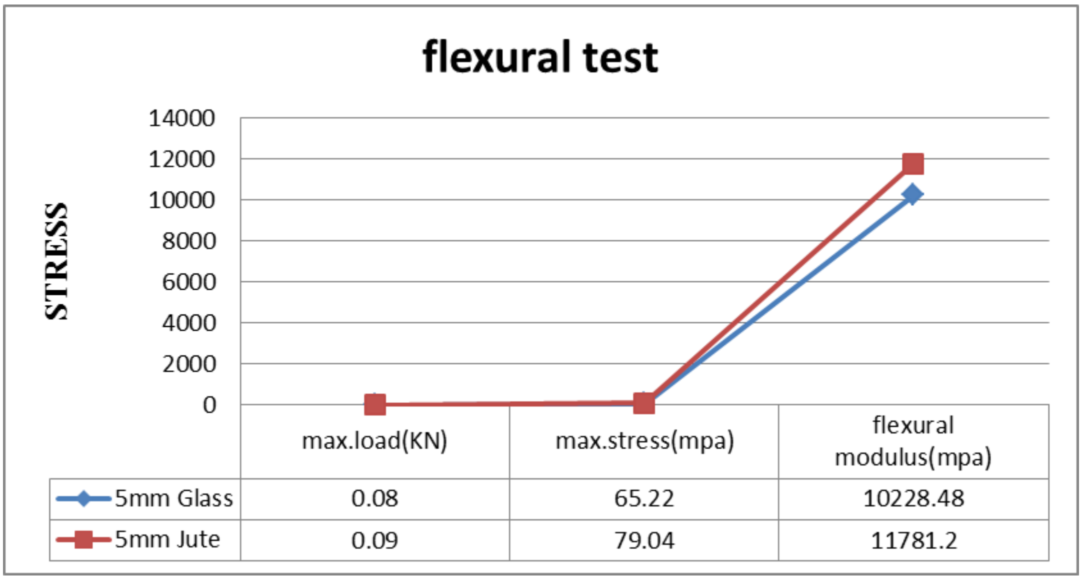

Figure 7 Graphs for Flexural Test for 5 mm

Table 8 Table Values for Flexural Test for 3 mm

Specimen 2	Jute 3mm	Glass 3mm
maximum load(KN)	0.13	0.13
maximum stress(MPa)	106.98	107.21

flexural modulus(MPa)	15925.32	15925

From the results it is observed that the Flexural strengths for jute fiber reinforced composites are very much closer when compared to glass fiber reinforced composites as shown in Fig.8.

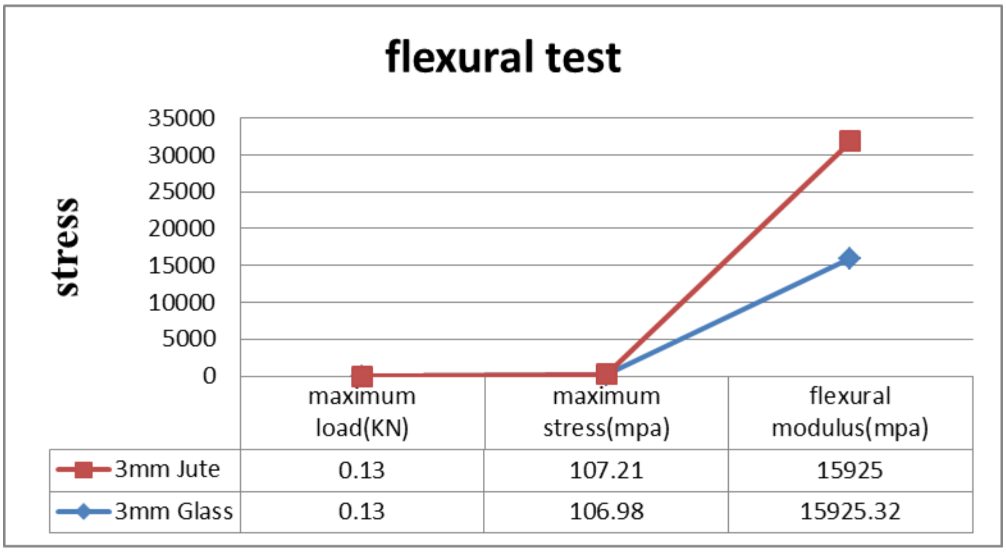

Figure 8 Variation of Flexural strength for 3 mm

2.16 Comparison For Tensile Test Specimens

Table 9 Table Values for Tensile Test for 5 mm

specimen 1	**5mm Glass**	**5mm Jute**
max. load(N)	1028.91	429.74
Tensile stress at max. load(mpa)	34.3	14.32
youngs modulus (mpa)	2877.66	1666.01
Tensile stress at break (mpa)	0.01383	0.00917

From the results it is observed that the Tensile strengths for Glass fiber reinforced composites are some much higher when compared to jute fiber reinforced composites as shown in fig.8.

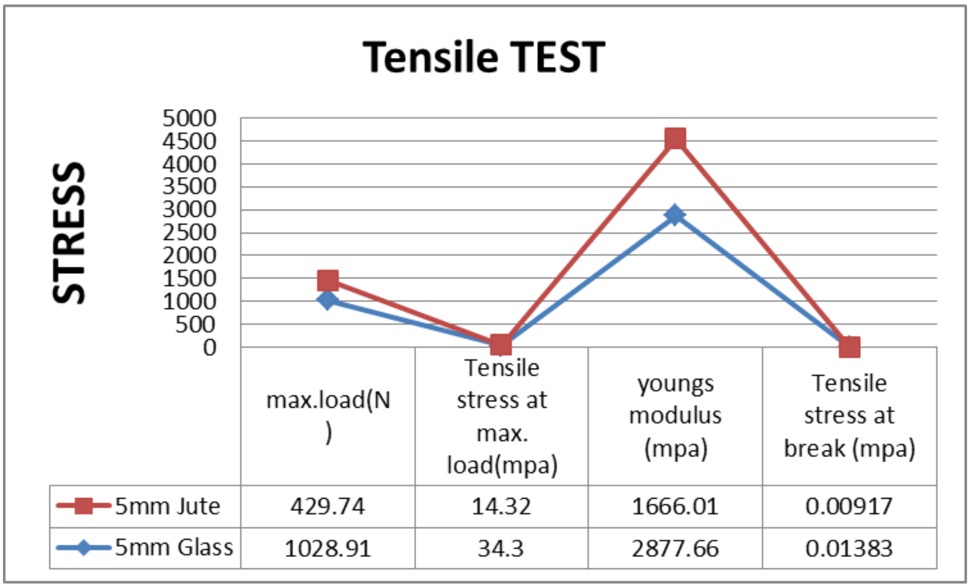

Figure 9 Graphs for Tensile Test for 5 mm

Table 10 Table Values for Tensile strength for 3 mm

specimen 2	**3mm Glass**	**3mm Jute**
Max. Load(N)	738.25	649.17
Tensile stress at max. load(MPa)	24.61	14.32
Young's modulus (MPa)	5266.46	3609.74
Tensile stress at break (MPa)	0.00567	0.00695

From the results it is observed that the Tensile strengths for jute fiber reinforced composites are very much higher when compared to glass fiber reinforced composites as shown in the Fig.10.

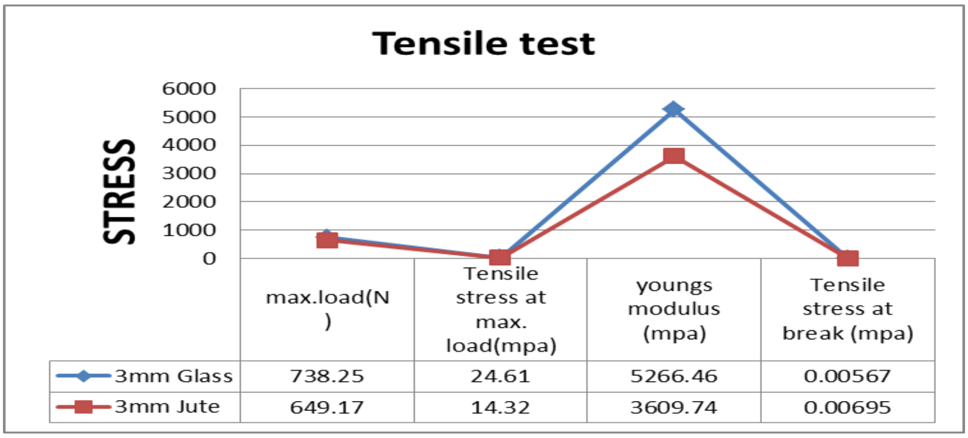

Figure 10 Graphs for Tensile Test for 3 mm

2.17 Comparison for Impact Test

Table 11 Table Values for Impact Test 3 mm

Specimen 1	Impact strength in j/m²
3mm Glass	0.3
3mm Jute	1.35

From the results it is observed that the Impact strengths for jute fiber reinforced composites are somewhat close when compared to glass fiber reinforced composites as shown in the Fig.11.

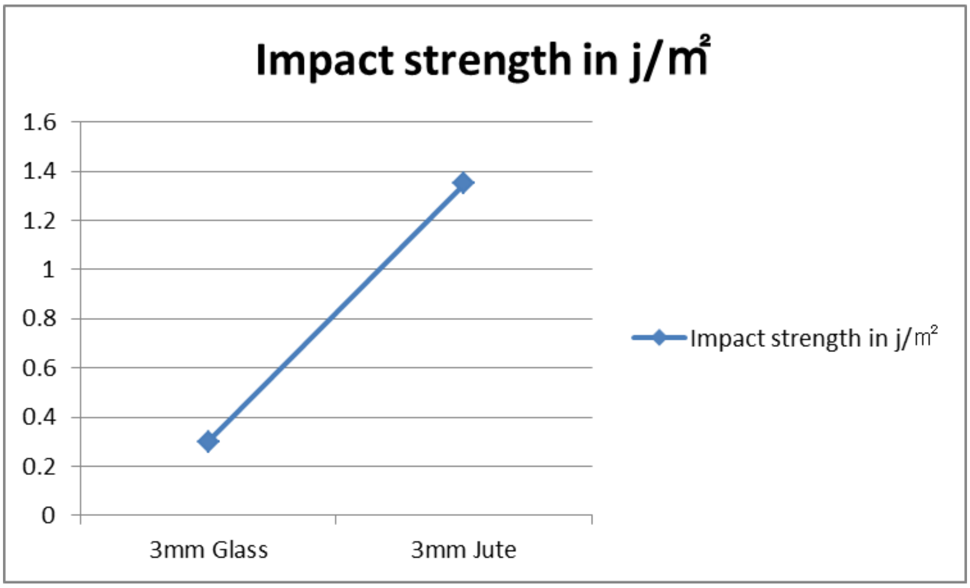

Figure 11 Graphs for Impact Test 3 mm2

Table 12 Comparison of Values for Impact Test for 5mm

Specimen 2	Impact strength in j/m²
5 mm Glass	0.2
5 mm Jute	1.08

From the results it is observed that the Impact strengths for jute fiber reinforced composites are somewhat close when compared to glass fiber reinforced composites as shown in fig.12.

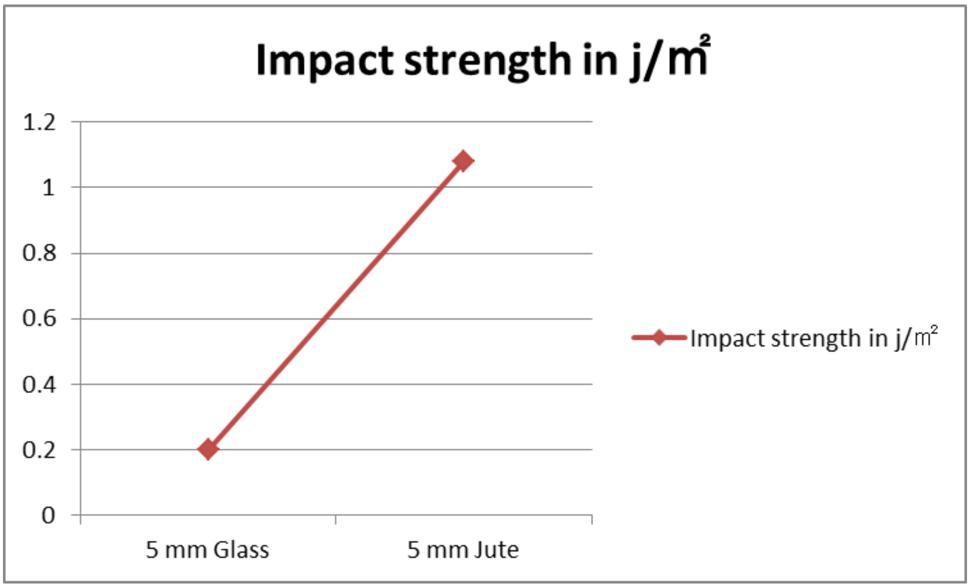

Figure 12 Graphs for Impact Test 5 mm

By comparing the results between glass fiber and jute fiber reinforced composites, and by observing the graphs and results in the previous chapters, it is concluded as follows:

The mechanical properties like Tensile strength (TS), Flexural Strength (FS) and Impact Strength (IT) for glass fiber reinforced composites are same equal to the jute fiber reinforced composites at particular fiber volume fraction and fiber length.

However for tensile and impact strengths, the values of jute fiber specimen1 (i.e., at V_f =40%, L_f = 3 mm) are same as that of the values of glass fiber specimen1. Also for Flexural strength, the value of jute fiber specimen number 1 (i.e., at V_f =40%, L_f = 3 mm) is very close to that of the value of glass fiber specimen number 1.

Therefore it is observed that the glass fiber can be replaced with the jute fiber at particular composition when the fiber volume fraction (V_f) =40% and fiber length (L_f) = 3 mm.

This suggests that the jute fiber composites have the potential to replace glass in some applications that do not require very high load bearing capabilities.

REFERENCES

[1] Rashed H.M.M.A., Islam M.A. and Rizvi F.B. (2006), 'Effects of Process Parameters on Tensile Strength of Jute Fiber Reinforced Thermoplastic Composites', Journal of Navel Architecture and

Marine Engineering, Vol. 3, pp. 1-6.

[2] Ray D. and Sarkar B.K. (2001), 'Characterization of alkali-treated jute fibers for physical and chemical properties', Journal of Applied Polymer Science, Vol. 80, pp. 1013-1020.

[3] Ray D., Sarkar B.K., Rana A.K. and Bose N.R. (2001a), 'Effect of Alkali Treated Jute Fibers on Composite Properties', Bulletin of Materials Science, Vol. 24, No. 2, pp. 129-135.

[4] Ray D., Sarkar B.K., Rana A.K. and Bose N.R. (2001b), 'Themechanical properties of vinylester resin matrix composites reinforced with alkali-treated jute fibers', Composites A, Vol. 32, pp. 119-128.

[5] Ray D., Sarkar B.K. and Bose N.R. (2002a), 'Impact fatigue behaviour of vinylester resin matrix composites reinforced with alkali treated jute fibers', Composites Part A, Vol. 33, pp. 233-241.

[6] Ray D., Sarkar B.K., Basak R.K. and Rana A.K. (2002b), 'Study of the thermal behaviour of alkali-treated jute fibers', Journal of Applied Polymer Science, Vol. 85, pp. 2594-2599.

[7] Razera I.A.T. and Frollini E. (2004), 'Composites Based on Jute Fibers and Phenolic Matrices: Properties of Fibers and Composites', Journal of Applied Polymer Science, Vol. 91, No. 2, pp. 1077-1085.

[8] Munikenche Gowda T., Naidu A.C.B. and Rajput Chhaya (1999), 'Some mechanical properties of untreated jute fabric-reinforced polyester composites', Composites Part A: Applied Science and Manufacturing, Vol. 30, No. 3, pp. 277-284.

[9] Mwaikambo L.Y. and Ansell M.P. (2002), 'Chemical modification of hemp, sisal, jute, and kapok fibers by alkalization', Journal of Applied Polymer Science, Vol. 84, pp. 2222-2234.

[10] Mohanty A.K., Misra M. and Hinrichsen G. (2000), 'Bio fibres, biodegradable polymers and bio composites: An overview', Macromolecular Material Engineering, Vols. 1-24, p. 277.

[11] Mohanty S., Verma S.K. and Nayak S.K. (2006), 'Dynamic mechanical and thermal properties

of MAPE treated jute/HDPE composites', Composites Science and Technology, Vol. 66, Nos. 3-4, pp. 538-547. Alsina O.L.S., de Carvalho L.H., Ramos Filho F.G. and d'Almeida J.R.M. (2005), 'Thermal properties of hybrid lingo cellulosic fabric reinforced polyester matrix composites', Polymer Testing, Vol. 24,No. 1, pp. 81-85.

[12] Attah F.I. (1995), 'Resignation and Crease resistance of polyester and cellulosic fabrics', B. Tech, Thesis, ATBU.

[13] Barkakaty B.C. (1976), 'Some structural aspects of sisal fibers', Journal of Applied Polymer Science, Vol. 20, pp. 2921-2940.

[14] Beckermann G.W., Pickering K.L. and Foreman N.J. (2004), 'The Processing, Production and Improvement of Hemp-Fiber Reinforced Polypropylene Composite Materials', Proceedings of SPPM, Dhaka, pp. 257-265.

[15] Bhagavan S.S., Thomas S. and Kuruvilla Joseph (2003), 'Mechanical properties and sortion behaviour of waste fabric reinforced polyester composite', Second ISAMPE National Conference on Composites at IISc Bangalore, pp. 26-29.

[16] Bisanda E.T.N. and Ansell M.P. (1991), 'The effect of silane treatment on the mechanical and physical properties of sisal-epoxy composites', Composites Science and Technology, Vol. 41, pp. 165-178.

[17] Bledzki A.K. and Gassan J. (1999), 'Composites reinforced with cellulose based fibers', Progress in Polymer Science, Vol. 24, and pp. 221-274.

[18] Carlo Santulli (2007), 'Impact properties of glass/plant fiber hybrid laminates', Journal of Material Science, Vol. 42, pp. 3699-3707.

[19] Chawla K.K. and Bastos A.C. (1979), 'The mechanical properties of jute fiber and polyester/jute composites', Mechanical Behaviour of Materials, Vol. 3, pp. 191-196.

[20] Chow C.P.L., Xing X.S. and Li R.K.Y. (2007), 'Moisture absorption studies of sisal fiber reinforced polypropylene composites', Composites Science and Technology, Vol. 67, No. 2, pp. 306-313.

[21] Curvelo A.A.S., De Cravalho A.J.F. and Agnelli J.A.M. (2001), 'Thermoplastic starch cellulosic fibers composites: Preliminary results', Carbohydrate Polymer, Vol. 45, pp. 183-188.

[22] Davies P., Morvan C., Sire O. and Baley C. (2007), 'Structure and properties of fibers from sea-grass (*Zostera marina*)', Journal of Materials Science, Vol. 42, No. 13, pp. 4850-4857.

[23] Davim J.P. and Reis P. (2003), 'Study of delamination in drilling carbon fiber reinforced plastics (CFRP) using design experiments', Composite Structure, Vol. 59, pp. 481-487.

[24] Davim J.P., Rubio J.C. and Abrão A.M. (2007), 'A novel approach based on digital image to evaluate the delamination factor after drilling composite laminates', Composite Science Technology, Vol. 67, pp. 1939-1945.

[25] de Medeiros E.S., Agnelli J.A.M., Kuruvilla Joseph, de Carvalho L.H. and Mattoso L.H.C. (2004), 'Mechanical properties of phenolic composites reinforced with jute/cotton hybrid fabrics', Polymer Composites, Vol. 26, No. 1, pp. 1-11.

[26] John K. and Venkata Naidu S. (2004), 'Tensile properties of unsaturated polyester-based sisal fiber-glass fiber hybrid composites', Journal of Reinforced Plastics and Composites, Vol. 23, No.17, pp. 1815-1819.

[27] Joseph P.V., Joseph K. and Thomas S. (1999), 'Effect of processing variables on the mechanical properties of sisal-fiber-reinforced polypropylene composites', Composites Science and Technology, Vol. 59, No. 11, pp. 1625-1640.

[28] Joseph P.V., Mathew G., Joseph K., Groeninckx G. and Thomas S.(2003), 'Dynamic mechanical properties of short sisal fiber reinforced polypropylene composites', Composite Part A: Applied Science and Manufacturing, Vol. 34, pp. 275-290.

[29] Joseph P.V., Rabello M.S., Mattoso L.H.C., Joseph K. and Thomas S. (2002a), 'Environmental effects on the degradation behaviour of sisal fiber reinforced polypropylene

composites', Composite Science and Technology, Vol. 62, pp. 1357 1372.

[30] Joseph S., Thomas S., Sreekala M.S., Oommen Z. and Koshy P. (2002b), 'A Comparison of the Mechanical Properties of Phenol Formaldehyde Composites Reinforced with Banana Fibers and Glass Fibers', Composites Science and Technology, Vol. 62, No. 14,pp. 1857-1868.