COMPARATIVE STUDY OF MECHANICAL PROPERTIES BETWEEN JUTE FIBER COMPOSITE AND LUFFA FIBER COMPOSITE

A Thesis

Submitted to the faculty in partial fulfillment of the requirements for the degree of B.Sc in Mechanical Engineering

Supervised By

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DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)
In partial fulfillment of the requirements for the award of the degree
Of
BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

FEBRUARY 2020

CERTIFICATE OF ACCEPTANCE

The thesis entitled as **“Comparative study of mechanical properties between jute fiber composite and luffa fiber composite”** submitted by the following students have been accepted for partial fulfillment of the requirement for the degree of B.Sc. in Mechanical Engineering on February, 2020.

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DECLARATION OF CANDIDATE

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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ACKNOWLEDGEMENT

It gives me immense pleasure to express my sincere gratitude to my supervisor, Kazi Tahmid Rahman, Lecturer, Department of Mechanical Engineering, Sonargaon University, for suggesting the topic for my thesis report and for his ready and able guidance throughout the course of my preparing the report. I am greatly obliged to him for his constructive suggestions and criticism from time to time during the course of progress of my work. I am extremely thankful to all my friends, well-wishers and classmates for their motivation and inspiration during this project work

ABSTRACT

In current years, composites have concerned considerable importance as a potential operational material. Low cost, lightweights, high specific modulus, renewability and biodegradability are the most basic & common attractive features of composites that make them useful for industrial applications. With low cost, high specific mechanical properties, natural fiber signifies a worthy renewable and biodegradable substitute to the most common synthetic reinforcement i.e. glass fiber. There are numerous potential natural resources in Bangladesh. Most grows from the forest and agriculture. Luffa-cylindrical locally called as "sponge-gourd" is one such natural resource whose potential as fiber reinforcement in polymer composite has not been explored till date for tribo logical applications. Against this background the present research work has been commenced with an objective to explore the use of natural fiber Luffa as a reinforcement material in epoxy base. In this study our goal is to fabricate glass and fiber reinforced polymer matrix composite materials and compare their tensile and flexural strength. Also, to determine whether adding synthetic fiber will increase its tensile and flexural strength with respect to the increase of cost. For better comparison six different laminar sequence of the composites are made with a weight fraction of 80:20. Flexural strength, Modulus of Elasticity, Young's Modulus and Tensile strength of the following composite materials have been investigated. Among these different laminar sequences, Luffa fiber composite holds the highest amount of flexural strength, 50.63 MPa and Jute fiber composite highest amount of modulus of elasticity, 3.82 GPa. On the other hand, maximum tensile strength i.e. 26.986 MPa has been found on Jute composite and maximum young's modulus i.e. .94 has been on Jute fiber composite material.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

In recent years, composites are becoming an essential material because they offer advantages such as low weight, high fatigue strength, corrosion resistance, faster assembly, etc. Composites are use as materials ranging from making aircraft structures to golf clubs, medical equipment to electronic packaging, and space vehicles to home building. Natural fiber composites have gained increasing interest due to their eco-friendly, low cost & easy availability properties [1]. Natural fibers such as jute, Luffa, sisal, silk and coir are inexpensive, abundant and renewable, lightweight, with low density, high toughness, and biodegradable. Among these, Jute has the potential to be used as a replacement for traditional reinforcement materials in composites for applications which requires high strength to weight ratio and further weight reduction**.** In this work, we have used two different types of fiber to produce two different types of composite. Firstly, we have used the jute fiber. Jute fiber is a natural fiber which is recycle able and 100% bio-degradable and thus environmentally friendly. It has high tensile strength, low extensibility, and ensures better breathability of fabrics. Therefore, Jute is very suitable in agricultural commodity bulk packaging. Secondly, we have used the Luffa fiber. Luffa fiber is also a natural fiber like jute fiber and it is also environmentally friendly. It is highly flammable. This fiber fineness varies between 50 and 300μm. Luffa is the fibrous material found between the soft, internal shell and the outer coat of a Luffa. Natural fiber such as bamboo fiber or Jute fiber also comes with a disadvantage of having high water intake due to the presence of hydroxyl and other polar groups in various constituents of natural fibers. Having high water intake due to the presence of hydroxyl and other polar groups in various constituents is its disadvantage. However, as the advantage of natural fiber composite is so great, huge amount of research time has been spent to improve this disadvantage with much success. For matrix resin, Polyester is used. It is unsaturated synthetic resin formed by the reaction of dibasic organic acids and polyhydric alcohols**.** The samples will be teste to find the tensile and flexural property using ASTM standard. Sometimes epoxy resin is also use which density and dynamic viscosity at 25 ºC are 1.109 g/cm3 and 11789 mPa.s respectively [2]. Epoxy resins were introduced to the paint industry in the late 1940's [3]. A three-point bending test fixture was designed and fabricated to conduct the flexural test and an already designed tensile module was used in order to determine its tensile strength.

1.2 OBJECTIVES

The main objectives of this study are as follows,

1. To development of flexural testing fixture (Three-Point bending fixture) for universal testing machine (UTM).
2. To fabrication of two layered jute fiber composite material
3. To fabrication of two layered luffa fiber composite material.
4. To determination and comparison of tensile and flexural strength of the composite material.

1.3 BACKGROUND THEORY

1.3.1 COMPOSITE

Composites, also known as fiber-reinforced polymer composites, are made from a polymer that is reinforced with man-made or natural fiber or other reinforcing materials. To make composites polyester resin and hardener is used. They are used as matrix material. Reinforcing material can be metal, ceramic or polymer. Reinforcing materials are strong with low density while the matrix is usually ductile or tough material. It is happened when fabrication is in good quality. Natural fiber composites are great competitors to the ceramics and metals because they are lighter and can be fabricated into different shapes at low temperature [4]. In composite material, strength and ductility is higher than any single conventional material. Some of the major advantages of composite materials are their high mechanical properties and low mass. Composite materials are designed and manufactured in different sectors, taking the place of metal. To make composite material, fiber and matrix are mixed with different ratio. For this reason, the strength and mechanical properties depends on mixture ratio. This ratio can be volumetric or weight. If volume or weight ratio is changed, the mechanical properties of composite will be change [5]. To make composite, natural fiber like banana, coconut, jute, sisal, bamboo is largely used. Reason behind to use those natural fibers is that they have low density, less pollutant emission, biodegradability. Again if we use of natural fibers reduces weight by 10% and lowers the energy needed for production by 80% [6].

1.3.2 TYPES OF COMPOSITE

Composite materials are usually classified according to the type of reinforcement they used. The reinforcement is used to strengthen the composite. Common composite types are random-fiber or short-fiber reinforcement, continuous-fiber or long-fiber reinforcement, particulate reinforcement, flake reinforcement, and filler reinforcement. Composite materials are classified into those categories (based on matrix material).

1.3.2.1 Metal Matrix Composites (MMCs)

Metal matrix composites are a unique class of man-made materials that integrate metals with ceramics. The most advanced and widely studied example of a metal matrix composite is that of silicon carbide reinforced aluminum (SiC/Al). Metal matrix composites are of interest largely because they combine the high thermal conductivity of metals with the low and tailorable coefficient of thermal expansion of ceramics.

Figure1.3.2.1: Metal Matrix Composite

1.3.2.2 Ceramic Matrix Composites (CMCs)

The development of CMCs is a promising means of achieving lightweight, structural materials combining high temperature strength with improved fracture toughness, damage tolerance and thermal shock resistance.

Figure 1.3.2.2: Ceramic Matrix Composite

1.3.2.3 Polymer Matrix Composites (PMCs)

Polymer matrix composites, and fiber-reinforced plastics (FRPs) in particular, are commonplace in the industrialized world; their applications range from primary structural aircraft components to tennis racquets and many household appliances incorporate some form of fiber reinforcement. The development of engineering FRPs began once significant quantities of glass fiber.

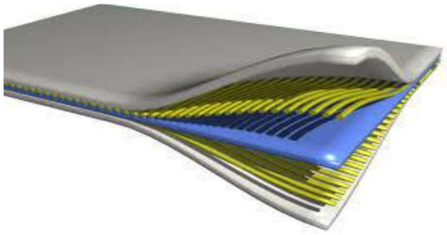
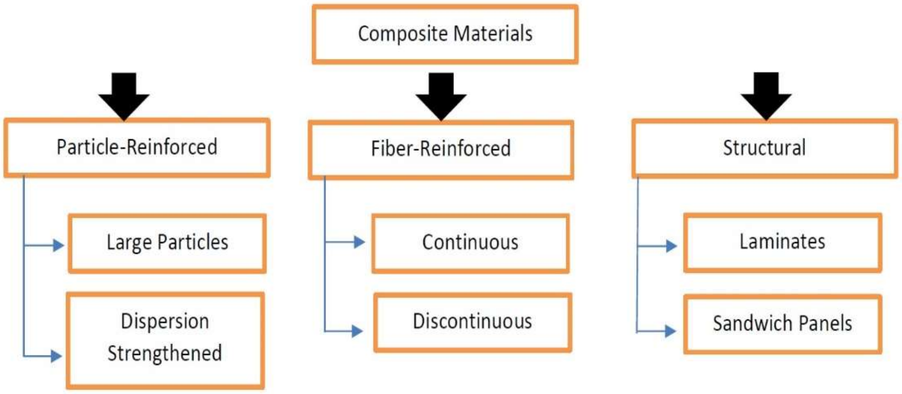


Figure 1.3.2.3: Polymer Matrix Composite

Again, composite materials are classified into those categories (based on reinforcement)



1.3.2.4 Particle Reinforced Composite

Particle reinforcing in composites is a fewer effective means of strengthening than fiber reinforcement. Particulate reinforced composites achieve gains in stiffness primarily, but also can achieve increases in strength and toughness. Particulate reinforced composites find applications where high levels of wear resistance are required such as road surfaces. The principal advantage of particle reinforce composites is their low cost and ease of production and forming.

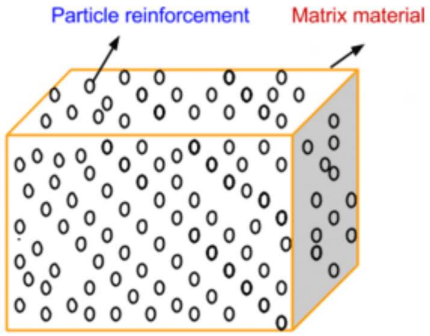


Figure 1.3.2.4: Particle Reinforced Composite

1.3.2.5 Fiber Reinforced Composite

Fiber-reinforced composite materials continue to be used in a large number of applications ranging from aerospace systems to automotive, industrial, and consumer products. In many other cases fiber-reinforced composite materials are being developed and used to replace metal components, particularly those used in corrosive environments.

Figure 1.3.2.5: Fiber Reinforced Composite

1.3.2.6 Structural Composite

Composite structural parts are subject to both cyclic mechanical loading and temperature variation.

Figure 1.3.2.6: Structural Composite

1.3.3 FIBER

In textile production, it is a raw material having suitable length, pliability, and strength for conversion into yarns and fabrics. A fiber of extreme length is a filament. Fibers can produce naturally or can be produced artificially.

Again, we can say that it is a natural or synthetic string or used as a component of composite materials. Fibers are often used in the manufacture of other materials. The strongest engineering materials often incorporate fibers, for example carbon fiber and ultra-high-molecular-weight polyethylene [7]. Synthetic fibers can be produced in large quantity with low cost than natural fiber. But significance of natural fiber is more than synthetic fiber.

1.3.3.1 Natural Fiber

Natural fibers are collected from plants and animals which are renewable resources [8]. In terms of utilization, there are two general classifications of plants producing natural fibers: primary and secondary. The primary plants are those grown for their fiber contents while secondary plants are those where the fibers come as a by-product from some other preliminary utilization. Jute, kenaf, hemp, sisal, and cotton are examples of primary plants while pineapple, cereal, stalks, agave, oil palm, and coir are examples of secondary plants. Natural fiber composites are being used highly so as to replace the commonly used synthetic composites [9]. Natural fibers derived from plants mainly consist of cellulose, hemicellulose, lignin, pectin. Cellulose is a highly crystalline structure which contains as much as 80% of crystalline regions Animals fiber are collected from Alpaca, Angora, Bison, Cashmere, Mohair, Sheep's wool. Availability and of being producible through recycling of plant materials are the advantages of natural fiber [10].

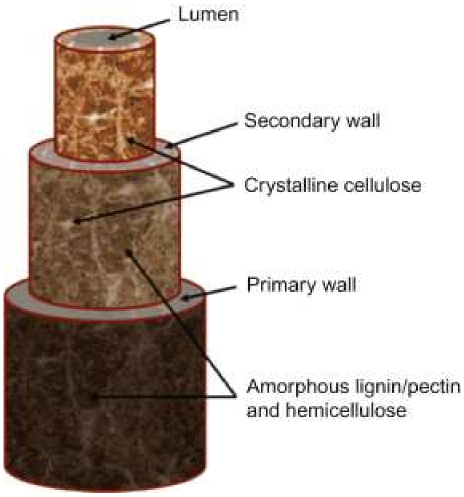


Figure 1.3.3.1: Natural fiber

1.3.3.2 Man-made fiber

Man-made fibers or chemical fibers are fibers whose chemical composition, structure, and properties are significantly modified during the manufacturing process. Man-made fibers consist of regenerated fibers synthetic fibers and in-organic fiber.

1.3.3.3 Regenerated Fibers

Regenerated cellulose fiber is a type of manufactured or man-made fiber that uses cellulose (mainly from wood or plant fibers) as a raw material. There are four major types of regenerated cellulose or cellulose-derived fiber:

1. Viscose
2. Lyocell
3. Cupro
4. Acetate

The classification of these different regenerated cellulose fibers is based on fiber production method.

.

Figure 1.3.3.3: Regenerated Fibers

1.3.3.4 Synthetic Fibers

Synthetic fibers are man-made fibers that derived from chemical resources. Synthetic fiber webs are made by using carding and air laid technologies. It is an important part of the textile industry, with the production of polyester alone surpassing that of cotton. Synthetic fibers such as nylon and polyester absorb less water.

Figure 1.3.3.4: Synthetic Fiber

1.3.3.5 In-Organic Fibers

Natural organic fibers are derived from either plant or animal sources. The majority of useful natural textile fibers are plant derived. The most widely used organic fibers that satisfy these requirements are known as aramid (aromatic polyamide) fibers. Synthetic organic fibers are used in polymer composites.

Figure 1.3.3.5: In-Organic Fibers

1.3.4 Resin Used

There are total of two types of resin we have used for fabricating the composite materials. These are,

1. Polyester Resin
2. PVC Resin

In most cases, Polyester resin were used for the fabrication process. PVC resin was used in some cases when there was a shortage of polyester resin at our disposal. It should be noted that, both of these resins didn’t show any drastic change in mechanical behavior of the composite materials.

1.3.4.1 Polyester Resin

Polyester resins are used in engineering applications for its economic condition. Its use is limited in high performance composites. They can be produced for a large variety of properties, from soft and ductile to hard and brittle. Polyester resin is too much viscous and highly absorbed water [11]. It is widely used in composite industries. 75% of total resin is polyester resin used in composite industries [12]. In organic chemistry, the reaction of an alcohol with an organic acid produces an ester and water. Through using alcohols such as a glycol, in a reaction with dibasic acids, a polyester and water will be produced. Figure 1.3.4.1.1 shows the idealized chemical structure of typical polyester.

Polyester resins are the least expensive of the resin options, providing the most economical way to incorporate resin, filler and reinforcement. They are the primary resin matrix used in SMC (sheet molding compounds) and BMC (bulk molding compounds). Thermoset Polyester resins are created by combining an alcohol like ethylene glycol with an organic acid like maleic anhydride.

Figure 1.3.4.1: Chemical structure of Polyester Resin

1.3.4.2 Polyvinyl Chloride (PVC) Resin

Polyvinyl chloride resin is a widely used polymer. Polyvinyl chloride (PVC) is a flexible or rigid material that is chemically nonreactive. Rigid PVC is easily machined, heat formed, welded, and even solvent cemented. Flexible PVC can be made into a low cost, transparent flexible film suitable for wraps. It has a high oxygen transmission rate**.** Pure polyvinyl chloride is a white, brittle solid generally delivered as powder or pellets. It is insoluble in alcohol but slightly soluble in tetrahydrofuran. PVC is manufactured from petroleum [13]. The production process also uses sodium chloride. Recycled PVC is broken down into powder or small chips with the impurities removed. The resulting product is refined to make pure white PVC. It can be recycled approximately seven times. Its lifespan is about 140 years.

Figure 1.3.4.2: Polyvinyl Chloride Resin

1.3.5 HARDENER (M.E.K.P)

Methyl ethyl ketone peroxide (MEKP) is organic peroxide. It is colorless which is used to catalyze polyester resins. MEKP is slightly less sensitive to shock and temperature, and more stable in storage. It reacts with the resin to turn it from liquid to solid. It is used in resin with different ratios, generally between 1%-3% according to the product being used [14]. MEKP is a severe skin irritant and can cause progressive corrosive damage or blindness.

CHAPTER 2
LITERATURE REVIEW

2.1 JUTE FIBER

Jute is produce primarily from plants in the genus *Corchorus*, which was once classified with the family Tiliaceae, and more recently with Malvaceae. There are mainly two types of jute are available: White jute (*Corchorus capsularis*) and Tossa jute (*Corchorus olitorius).* The primary source of the fiber is *Corchorus olitorius*, but it is considered inferior to *Corchorus capsularis*.

Jute fibers are composed primarily of the plant materials cellulose and lignin. It is a natural fiber so it seems to be a good alternative since they are readily available in fibrous form and can be extracte from plant leaves at very low costs. According to Kundu et al. jute fibers are about seven to eight times lighter than steel fibers and have proper tensile test [15]. It has high toughness, low extensibility, abundant [16] and ensures better breathability of fabrics. It is use chiefly to make cloth for wrapping bales of raw cotton, and to make sacks and coarse cloth. It can be used to create several fabrics such as Hessian cloth, sacking, scrim, carpet backing cloth (CBC), and canvas. White jute is being replace by synthetic materials in many of these uses, some uses take advantage of jute's biodegradable nature and nonabrasive [17], where synthetics would be unsuitable.

2.2 JUTE FIBER COMPOSITE

In this work we have studied the flexural properties of the composites made by reinforcing Jute fiber into polyester resin. We made jute fiber composite by using hand layup method. Hand layup is a molding process where fiber reinforcements are placed by hand then wet with resin. The manual nature of this process allows for almost any reinforcing material to be considered, chopped strand or mat.

2.3 Luffa Fiber

Luffa is a genus of tropical and subtropical vines in the cucumber family. In everyday non-technical usage, the luffa, also spelled loofah, usually refers to the fruit of the two species Luffa aegyptiaca and Luffa acutangula. The fruit of these species is cultivated and eaten as a vegetable.

K. Murali, Mohan Rao, K. Mohana Rao and A.V. Ratna Prasad [18] have investigated and compared the tensile, flexural and dielectric properties of some common natural fibers like vekka(Beatle nut), sisal and banana.

S.M. Sapuan, M.N.M. Zan, E.S. Zainudin and Prithvi Raj Arora [19] researched about the tensile and flexural strengths of coconut spathe fiber reinforced epoxy composites. Their result implied that the tensile strength of coconut spathe-fiber is less than other natural fibers such as cotton,coconut coir and banana fibers.

Mansour Rokbi, Hocine Osmani, Abdellatif Imad , Noureddine Benseddiq [20] published a paper which describes the optimum condition to treat the natural fibers with alkali (NaOH). The resultof their work showed that the bending behavior of a composite may increase for alkali treatednatural fiber reinforcement if the treatment is not long enough to reduce the lignin that binds thecellulose fibrils together.

Al-Mobarak, T., Gafur M. and Mina, M. [21] studied the properties of sponge gourd reinforced composite under different volume fraction and different pre preparation. The different chemical treatment of raw fiber showed different performance. The paper presented the surface morphological, structural, mechanical and thermal properties as well as antibacterial activities of raw and chemically modified sponge gourd fiber reinforced composite materials.

R.Panneerdhassa, A.Gnanavelbabub, K.Rajkumarc [22] presented their research about the tensile, compressive, flexural, impact energy and water absorption characteristics of the luffa fiber and Ground nut reinforced epoxy polymer hybrid composites.

Lassaad Ghali, Slah Msahli , Mondher Zidi , Faouzi Sakli [23] studied about the effect of chemical modification, fiber weight ratio and reinforcement structure on the flexural proprieties of Luffa-polyester composites. In their experiment, the fiber weight ratio influenced the flexural properties of composites and a maximum value of strength and strain is achieved over a 10% fiber weight ratio.

2.4 THREE POINT BENDING TEST:

A three-point bending test module was designed in SolidWorks to conduct flexural test of the samples in our UTM machine. As there is no available three-point bending test machine for the desired shape of composite sample to test three-point bending, the module was designed based on the standard. This test was performed in accordance with ASTM D790 to measure flexural properties.

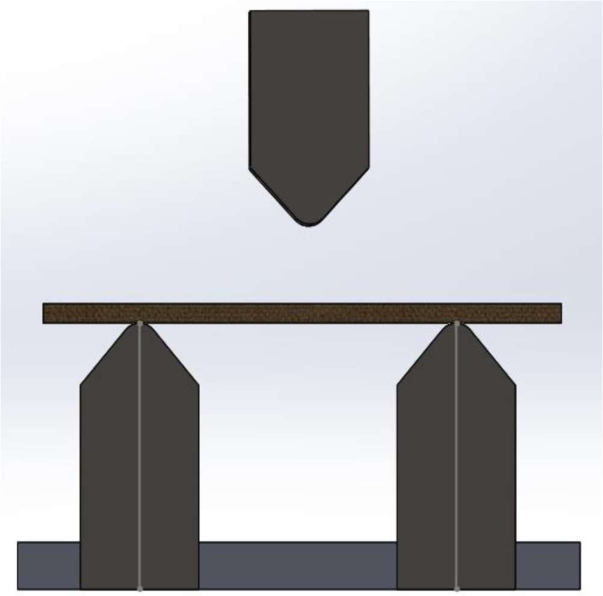


Figure 2.4: A typical Three-point bending setup

In a previous work, it was performed in accordance with ASTM D 790M to measure flexural properties [24]. The specimens were 125 mm long, 12.7 mm wide and 3 mm thick. In three-point bending test, the outer rollers were 64 mm apart and samples were tested at a strain rate of 0.2 mm/min. A three-point bend test was chosen because it requires less material for each test and eliminates the need to accurately determine center point deflections with test equipment. Flexural strength (σ) of the composite was calculated using the following relationship: $\sigma = 3PL/2bt2$. Where L is the support span (64mm), b is the width, t is the thickness and P is the maximum load. It was clearly evident that with increasing the fiber content in the polyester and epoxy matrix, the flexural strength is also increasing [25]. This is due to the fact that the polyester and epoxy resin transmits and distributes the applied stress to the Jute fiber resulting in higher strength. The flexural strength of Jute fiber reinforced epoxy composite better than Jute fiber polyester composite [26].

2.5 TENSILE TEST

Tensile test is also known as a tension test, which is one of the most elemental and common types of mechanical testing. A tensile test applies tensile force to a material and measures the specimen's response to the maximum stress. Tensile test is done to determine the effectiveness and behavior of a material when expanding force applies on it. The force is applied to its breaking point. These tests are done under optimum temperature and pressure conditions and determine the maximum load that the material can oppose [27]. Tensile test is done to recognize the strength of a material for that this material property will be used widely to ensure safety, high quality material and avoiding the major liabilities associated with providing non-compliant products.

Tensile test is also defined as a measurement of stress. In tensile test force, is measured in per unit area. By performing tensile test Young's Modulus can be determined. Because Young's Modulus appraises the elasticity of a material, which is the *relation* between the deformation of a material and the force needed to deform it.

In our study we opted for the minimum requirements part found in ASTM standard D3039. The specimen width was 27.03 mm and thickness were 6.5 mm. As a result, the minimum length was set at 140 mm. Each of the specimen that was used for tensile testing had a length between 150 to 160 mm which was above the required minimum length.

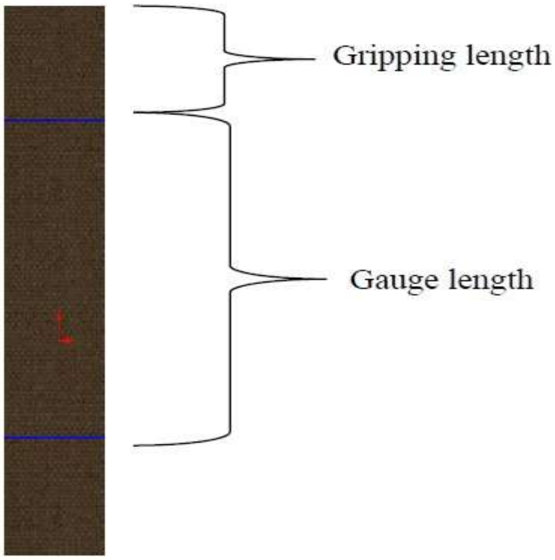


Figure 2.5: A typical specimen for tensile testing

CHAPTER 3

FABRICATION PROCESS

3.1 Fabrication of the composite materials

Since Luffa and jute fiber was bought and used, there was no need for chemical processing and mechanical processing as these were preprocessed. Furthermore, no fiber extraction was done. Luffa jute fiber was collected from a local market. Only the fabrication process was done. The steps are given bellow,

Step-1: At first the luffa fibers are cut into specific size to get the best use of natural fiber mat.

Figure 3.1a: Resized luffa fiber mat

Step-2: Weight of the fiber is measure in digital weight measuring machine in order to maintain the proportion of matrix and fiber.

Figure 3.1b: Digital weight measuring machine

Step-3: To make composite materials, 10 mm thickness glass was first placed on a flat surface.

Step-4: Then a transparent paper was placed on to the surface of the glass.

Step-5: Fiber and Matrix with a weight ratio of 20:80 (we will only be using this ratio throughout the study) was taken.

Figure 3.1c: Mixing of Polyester and hardener

Step-6: Weight of the fiber and resin was measure with the help of measuring device.

Step-7: A good amount of matrix mixture was put on to the transparent paper before placing the fiber.

Step-8: jute or Luffa fiber was placed on to the transparent paper and, again a good amount of mixture was placed on the top of the jute or Luffa mat fiber.

Figure 3.1d: Mixture is being poured on to the surface of the fiber and a cylindrical roller is used for the spreading

Step-9: A plastic cylindrical roller was used in order to spread out the matrix evenly on the surface of the fiber. That way the fiber can take in the matrix mixture evenly throughout its whole surface area.

Step-10: Then the step 6 and 7 was repeated for the next layer and this will go on until all the layers have been placed on the top of each other.

Step-11: After the final rolling action another transparent paper was placed on to the jute or Luffa fiber.

Figure 3.1e: Mixture is being poured on to the surface of the fiber and Polyester

Step-12: Then, another layer of glass was placed on to the transparent paper.

Figure 3.1f: Another layer of glass was placed

Step-13: Finally, a good amount of weight (say 2-3kg) was placed and kept in the room temperature for 24 hours.

Figure 3.1g: A regular notched 1+1+1= 3 kg weight placed on top of the fabricated composite material

Step-14: After completing the 24 hours wait, the composite is taken out from the open molding box and a manually operated grinding machine was used in order to cut the sample into requi red pieces (based on the ASTM standard).

Figure3.1h: Jute Fifer Composite

Figure 3.1i: Luffa Fiber Composite

Step-15: Composite after the grinding process for ready to sample.

Figure3.1j: Manual grinding operation

CHAPTER 4

METHODOLOGY

4.1 DESIGN & CONSTRUCTION

Total Two different types of testing were done. These were,

1. Three point bending test (Flexural testing)
2. Tensile Test

As a result, two different types of module have to be designed and constructed in order for the tests to be completed.

4.1.1 Three Point Bending Test

Machine used

Universal testing machine (UTM) was used so that, the designed flexural testing module can be attached to its compressive compartment section. UTM machine can apply load up 10 KN.

Material used

Mild Steel was used to make the parts of the flexural Strength testing module. The reason for selecting the mild steel was,

- Cost effective
- Can be machined easily
- Weldable

4.1.1.1 THREE POINT BENDING MODULE DESIGN

There are total of three main parts for Three-point bending module or Flexural module that need to be designed correctly. These parts are labelled as,

1. Base
2. Column
3. Indenter

4.1.1.1.1 Base Dimensions

A base was designed using SolidWorks software so that it can hold the other parts of the module in a specific place without any extra modification to the UTM machine. In order to design the base, first the dimensions of the compressive compartment of the UTM machine were measured. As the length between two columns of the compressive compartment of the UTM machine was 155 mm and the width were 85 mm, it was decided to design the base with a length of 152 mm and width of 50 mm. As the maximum height of the compartment was 270 mm, thickness of the base was primarily decided to 12 mm. Lath machining was not required for the base to fit itself to the UTM machine correctly as all it was needed to drill a hole of 7.83 mm, which was the diameter of the bolt that will be inserted in to the base to make it fit tightly to the UTM machine.

Figure 4.1.1.1.1a: Schematic view of Base V.01

Figure 4.1.1.1.1b: Base V.01

4.1.1.1.2 Problems Faced

Several problems were encountered after finishing the machining of the Base with a length of 152 mm, width of 50 mm and thickness of 10 mm. Problems are given bellow,

1. As the hole was exactly 7.83 mm, the bolt didn't fit correctly making it impossible to stay tightly to the UTM machine. So, the base was redesigned.
2. Due to the slight change of the final design of the column, the width of the base was changed.

4.1.1.1.3 Adjustment to the Base

It was decided to change the circular hole in to a capsule one. Vertical milling method was used to machine the capsule shaped hole. The main reason for selecting the capsule hole was that, it would enable adjustment of the base to accommodate the two bolts (Given with the UTM machine) should any adjustment of the placing of the base ever occurred. Capsule hole was done 10 mm from the edge of the and with a radius of 8 mm. With the length of 152 mm, width of 50 mm and thickness of 12 mm and with two capsule holes to fit the bolt tightly to the UTM machine base, these were the final dimension of the base which will be holding the other components of the flexural machine till no. 2 problem was faced while designing the column. More on that in the column section.

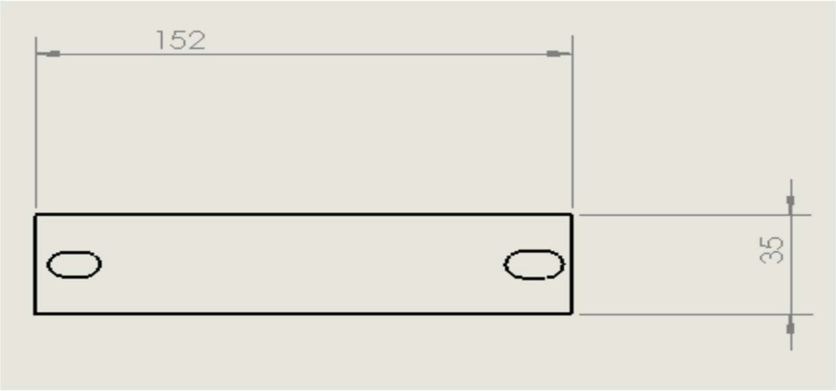


Figure 4.1.1.1.3a: Schematic view of Base Version Final

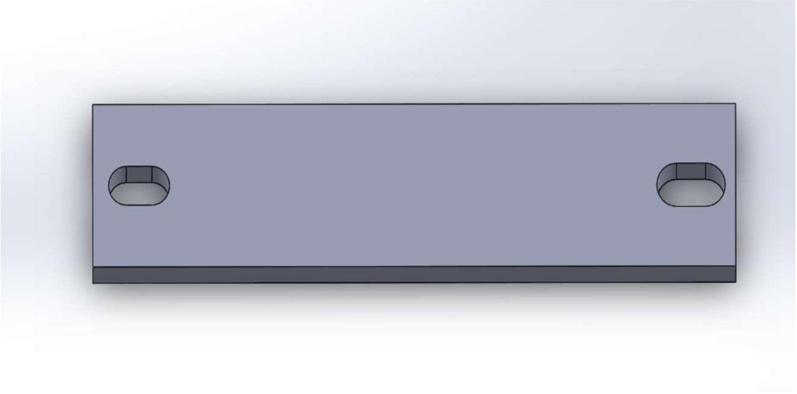


Figure 4.1.1.1.3b: 3D view of Base Version Final

4.1.1.2.1 Column dimensions

Total of two columns were decided to be made. A design was made before proceeding to the machining of the column. The main objective of the columns was to hold the composite material or sheet metal in one place and preventing it from sliding back and forth, thus enabling anyone to test the flexural test with ease. Primarily the length of the column was set to 45 mm. width was set to 32 mm and the height was set to 40+16=56 mm in total. The following figures are the early design of the column with the mentioned dimensions. First one, is the front side of the column and second is the top side of the column from a mechanical drawing as well as the 3D view.

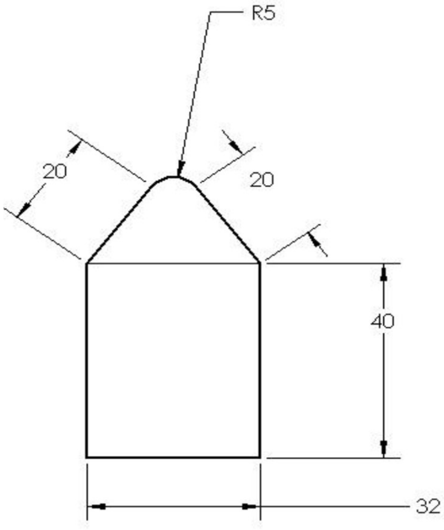


Figure 4.1.1.2.1a: Schematic view of Column V.01

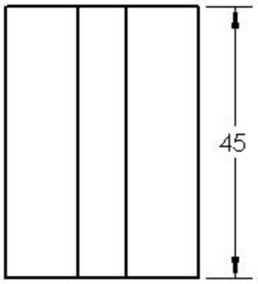


Figure 4.1.1.2.1b: Schematic view of Column V.01 (Top View)

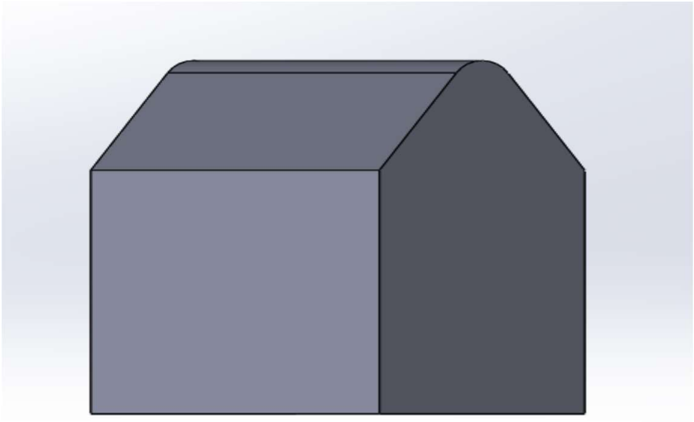


Figure 4.1.1.2.1c: 3D View of the Column V.01

4.1.1.2.2 Problems Faced

Several problems were encountered after reviewing the primary design before preceding to the machining phase. Problems are given bellow,

1. There were no hole or clamp was mentioned in the design, as clamp or hole could be used to tighten the column in a specific place on to the designed base.
2. Welding the columns to the designed base will make it difficult to produce composite materials or cutting sheet metals in to various shape, forcing anyone to make the materials using constant dimensions.

4.1.1.2.3 Adjustment to the Columns

In order to tighten the columns in to specific place to the base two main things were done at a same time.

- Base's width dimension was altered. The width of the base was changed from 50 mm to 35mm.
- Column's dimensions were also altered. The length was changed from 45 mm to 50 mm. The height of the column was changed from 40+16 mm to 40+16+12 mm (12 mm equals to the thickness of the base which will be holding the columns and indenters). Then, a portion of material was removed from the columns with a height of 12 mm and length of 35 mm from the center (17.5 mm on each side) so that it can slide through the base with ease.

After that, a hole was drilled both side of the column in its "leg" so that using Allen key, a screw can be inserted in to each leg to tighten the column to the base.

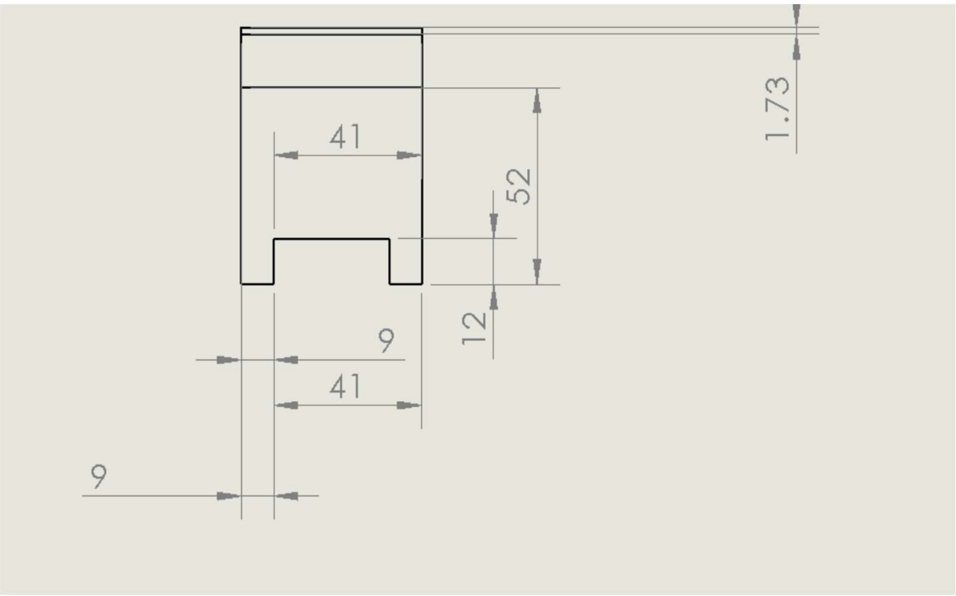


Figure 4.1.1.2.3a: Schematic view of Column Version Final

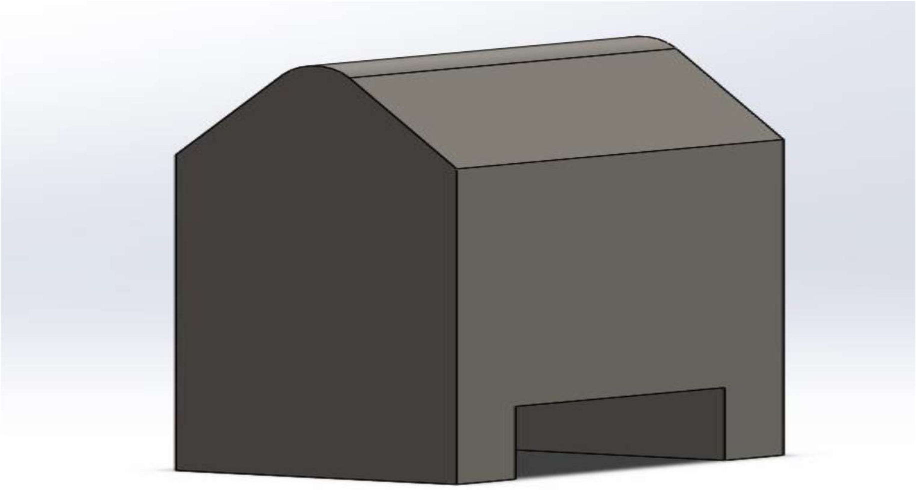


Figure 4.1.1.2.3b: 3D view of Column Version Final

Figure 4.1.1.2.3c: Allen Key is in action

4.1.1.3.1 Indenter Dimension

One indenter was needed for making a flexural module. Unlike other parts of the module this part didn’t need any ‘major’ alteration to its design. Indenter is primarily used to make a single bending possible in a three-point bending set up. An indenter was designed and made with a length of 50 mm, width of 32 mm and a height of 40+16 mm. The height’s edge was rounded with a radius of 5 mm (According to the ASTM D790 Standard). A screw was fitted on to the head of indenter with a diameter of 8 mm so that it can be used to tighten the indenter to the upper side of the UTM machine’s compressive compartment.

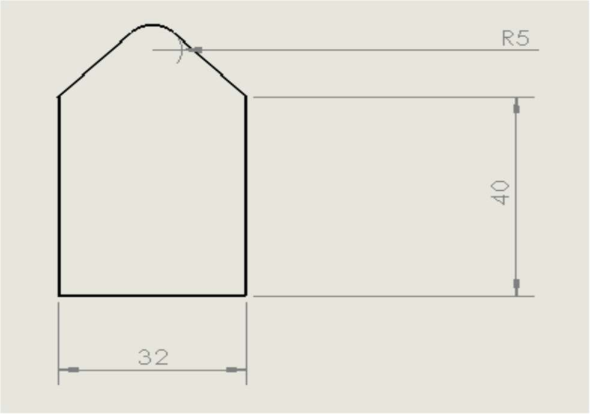


Figure 4.1.1.3.1a: Schematic view of Indenter Version Final

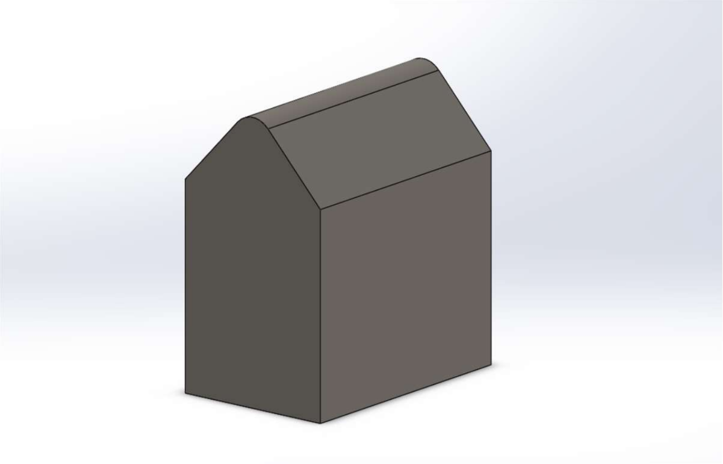


Figure 4.1.1.3.1b: 3D view of Indenter Version Final

4.1.1.3.2 Problems Faced

As it was proved to be rather difficult to find the exact match of the already provided screw attached with UTM machine's own indenter, an application was written to the authority to grant a permission for taking the UTM machine's own indenter with us and this way it took two hours to find the exact copy of the screw. The main reason for fining the exact copy of the screw in order to prevent the module to harm the surface of the UTM machine by any means and can be fitted without any external force.

4.1.1.3.3 Adjustment to the Indenter

No adjustment was made at first, to the indenter apart from drilling an 8 mm hole using lathe machine and fitting a screw in it using wrench. After it was decided to use a custom-made external sensor to measure the load from the machine with the help of an Arduino board, a custom-made screw was machined. The sensor that was ordered has two holes at each end. One hole was used to connect the indenter head to its one section of its head using the custom machined screw and another custom machined screw was used to connect the upper head of the screw to the UTM machine itself.

Figure 4.1.1.3.3: Indenter with sensor attached

4.1.2 Tensile Test

Module that was needed to perform tensile testing of laminated composite materials had already been constructed, So, no further designing and constructing was needed. The only problem that had been faced by us was that, tensile module was only suitable for materials with a thickness between 3 millimeters to 4 millimeters. Since the thickness of our composite materials was well above 4 millimeters a simple grinding operation was done in order to shed some metals from the module itself so that it could fit in to the compartment perfectly without any problem.

4.1.2.1 Adjustment done to the module

The gripper which was designed by our seniors had a diameter of above 42 millimeter but, the holder of the UTM machine's tensile compartment which is meant to hold the gripper in place in order for it ''hold'' on to the composite materials had a diameter of 41.8 mm (maximum) which made it impossible for the gripper to fit itself in to the holder. Therefore, an idea was made up and using a grinding machine a portion of its surface was removed in order to decrease its overall diameter from 42 mm to 41.5 mm (at minimum). That way, it became possible for us to fit it almost correctly to the holder as the thickness of material was above 4 millimeter and it was necessary to decrease the diameter of the gripper to compensate for the increase of composite material's thickness. As the gripper's locking hole was not aligned correctly with the holder's locking hole, instead of using the rod that had been provided with machine to lock the gripper with the holder tightly, an unused rod was used instead of the rod to lock the gripper to the holder. It should be noted that, the unused rod was not designed by us. It was happened to be there and we decided to incorporate this into our experiment.

4.2 TESTING PROCEDURE

This section is divided in to two subsections. These are -

1. Setup the testing Flexural strength module
2. Setup the testing Tensile testing module

4.2.1 Setup the flexural strength testing module

- Base is place on the compressive compartment of the Universal testing machine.
- Column is adjusted according to the span length of the standard as per the requirement of the user.
- Allen key is used to tighten the column to the base.
- The extensometer was calibrated to measure the deflection of the composite materials.
- Indenter then is attached to one end of the sensor using a custom-made screw.

- The other end of the sensor is attached to the head of the compressive compartment of the UTM using another custom-made screw.
- Washer is used in between the sensor’s one end and the indenter, so that the indenter can be aligned at 90-degree angle.

4.2.2 Setup the tensile testing module:

- There is total of two grippers that need to place on to the UTM machine opposite to each other.
- In order to attach the composite material to the gripper without any hassle, at first one of the grippers is connected to the lower end of the machine’s gripper holder.
- That way, when the other gripper is attached to the upper gripper holder, attaching the composite material with the gripper won’t be an issue.

The grippers are tightly attached to the gripper holder with the help of hard steel materials so that it won’t break in the event of tensile testing.

CHAPTER 5

CALCULATION AND ANALYSIS

5.1 SAMPLE INFORMATION

Table 5.1: Sample Information

Composite Type J=Jute fiber L= Luffa Fiber	Fiber wt. (gm)	Unsaturated Polyester/PVC Resin wt. (gm)	hardener wt. (gm)	Fiber orientation (Degree)
L+L	20+17	138	10	Natural Luffa fiber mat
J+J	18+17	133	7	Jute fiber Mat

5.2 VOLUME FRACTION AND DIMENSION

5.2.1a for L+L composite type

Total Specimen (wt%80-20):

Weight of jute mat fiber, wf = 37 gm

Weight of Polyester, wp = 138 gm

Weight of Hardener, wh = 10 gm

Total wt. of composite, wc = (37+138+10) gm = 185 gm

(Subject to change due to open molding process's inherent wastage problem)

Wt. fraction of fiber, Wf = 37/185 = 0.2 = 20%

Wt. fraction of polyester, Wp = 138/185 = 0.76 = 75%

Wt. fraction of hardener, Wh = 10/185=0.04=5%

Total wt. fraction of matrix, Wm = (75+5) % = 80%

Density of fiber, ρf = 0.54 g/cc

Density of Polyester, ρp = 1.95 g/cc

Density of Hardener, ρh = 1.17 g/cc

Volume of fiber, vf = 37/0.54 cc= 68.52 cc

Volume of polyester, vp = 138/1.95 cc= 70.77 cc

Volume of hardener, vh = 10/1.17 cc= 8.55 cc

Volume of composite, vc = (68.52+70.77+8.55) cc = 147.84 cc

Volume fraction of fiber, Vf = 68.52/147.84 = 0.4635 = 46.35%

Volume fraction of polyester, Vp = 70.77/147.84 = 0.4787 = 47.87%

Volume fraction of hardener, Vh = 8.55/147.84 = 0.0578 = 5.78%

Total volume fraction of matrix, Vm = (46.35+5.78) % = 52.13%

5.2.1b for L+L composite type

Total Specimen (wt%80-20):

Weight of jute mat fiber, wf = 42.10 gm

Weight of Polyester, wp = 154.78 gm

Weight of Hardener, wh = 15.12 gm

Total wt. of composite, wc = (42.10+154.78+15.12) gm = 212 gm

(Subject to change due to open molding process's inherent wastage problem)

Wt. fraction of fiber, Wf = 42.10/212 = 0.1990 = 19.9%

Wt. fraction of polyester, Wp = 154.78/212 = 0.73 = 73%

Wt. fraction of hardener, Wh = 15.12/154.78=0.0713= 7.13%

Total wt. fraction of matrix, Wm = (73+7.13) % = 80.13%

Density of fiber, ρf = 0.54 g/cc

Density of Polyester, ρp = 1.95 g/cc

Density of Hardener, ρh = 1.17 g/cc

Volume of fiber, vf = 42.1/0.54 cc= 77.963 cc

Volume of polyester, vp = 154.78/1.95 cc= 79.37 cc

Volume of hardener, vh = 15.12/1.17 cc= 12.92 cc

Volume of composite, vc = (77.963+79.37+12.92) cc = 170.253 cc

Volume fraction of fiber, Vf = 77.963/170.253 = 0.4579 = 45.79%

Volume fraction of polyester, Vp = 79.37/170.253 = 0.4661 = 46.61%

Volume fraction of hardener, Vh = 12.92/170.253 = 0.0759 = 7.59%

Total volume fraction of matrix, Vm = (45.79+7.59) % = 53.38%

5.2.1c for J+J composite type

Total Specimen (wt%80-20):

Weight of jute mat fiber, wf = 35 gm

Weight of Polyester, wp = 133 gm

Weight of Hardener, wh = 7 gm

Total wt. of composite, wc = (35+133+7) gm = 175 gm

(Subject to change due to open molding process's inherent wastage problem)

Wt. fraction of fiber, Wf = 35/175 = 0.2 = 20%

Wt. fraction of polyester, Wp = 209/175 = 0.76 = 76%

Wt. fraction of hardener, Wh = 11/175 =0.04=4%

Total wt. fraction of matrix, Wm = (76+4) % = 80%

Density of fiber, ρf = 1.293 g/cc

Density of Polyester, ρp = 1.95 g/cc

Density of Hardener, ρh = 1.17 g/cc

Volume of fiber, vf = 35/1.293 cc= 27.06888 cc

Volume of polyester, vp = 133/1.95 cc= 68.205128 cc

Volume of hardener, vh = 7/1.17 cc= 5.9829 cc

Volume of composite, vc = (27.0688+68.205+5.9829) cc = 101.2568 cc

Volume fraction of fiber, Vf = 13.0787/119.06164 = 0.109848 = 10.98%

Volume fraction of polyester, Vp = 97.43589/119.06164 = .818365155 = 81.836%

Volume fraction of hardener, Vh = 8.54700/119.06164 = 0.0728 = 7.28%

Total volume fraction of matrix, Vm = (81.836+7.28) % = 89.0151%

5.2.1d for J+J composite type

Total Specimen (wt%80-20):

Weight of jute mat fiber, wf = 35 gm

Weight of Polyester, wp = 133 gm

Weight of Hardener, wh = 7 gm

Total wt. of composite, wc = (35+133+7) gm = 175 gm

(Subject to change due to open molding process's inherent wastage problem)

Wt. fraction of fiber, Wf = 35/175 = 0.2 = 20%

Wt. fraction of polyester, Wp = 209/175 = 0.76 = 76%

Wt. fraction of hardener, Wh = 11/175 =0.04=4%

Total wt. fraction of matrix, Wm = (76+4) % = 80%

Density of fiber, ρf = 1.293 g/cc

Density of Polyester, ρp = 1.95 g/cc

Density of Hardener, ρh = 1.17 g/cc

Volume of fiber, vf = 35/1.293 cc= 27.06888 cc

Volume of polyester, vp = 133/1.95 cc= 68.205128 cc

Volume of hardener, vh = 7/1.17 cc= 5.9829 cc

Volume of composite, vc = (27.0688+68.205+5.9829) cc = 101.2568 cc

Volume fraction of fiber, Vf = 27.0688/101.2568 = 0.2673 = 26.73%

Volume fraction of polyester, Vp = 68.205/101.2568 = 0.6735 = 67.35%

Volume fraction of hardener, Vh = 5.9829/101.2568 = 0.05908 = 5.90%

Total volume fraction of matrix, Vm = (67.35+5.90) % = 73.267%

Table 5.2: Specimen Volume Fraction and Dimension

Composite Sample Type	Volume Fraction (%)		Dimension			Sample used for
	Fiber Vf	Matrix Vm	Length (mm)	Width (mm)	Thickness (mm)	
L+L	46.35	47.87	150	26	6.5	Tensile Test
L+L	46.35	47.87	150	27	6.53	Tensile Test
L+L	46.35	47.87	150	27	6.55	Flexural Strength Test
L+L	46.35	47.87	150	27	65	Flexural Strength Test
J/J	26.73	67.35	155	27	4.12	Tensile Test
J/J	26.73	67.35	156	26	4.11	Tensile Test
J/J	26.73	67.35	155	26	4.08	Flexural Strength Test
J/J	26.73	67.35	140	26	4.21	Flexural Strength Test

5.3 MECHANICAL PROPERTIES

The mechanical properties of materials characterize the response of a material to loading. The mechanical loading can be categorized as compression, shear, torsion, bending and tension. Thermal properties may also occur when subjected to loading. In our thesis, we have done tensile test.

5.3.1 TENSILE TEST

Tensile testing, is also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined Young's modulus.

Figure 5.3.1a: UTM Machine

The most common testing machine used in tensile & Bend testing is the Universal Testing Machine. This type of machine has two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test sample. There are two types: Hydraulic powered & Electro magnetically powered machines. The machine we have used here is Hydraulic powered. From the UTM machine we got the extension of the specimen with increase of tensile force. Now the nominal stress was calculate from the following equation,

Figure 5.3.1b: Tensile testing

σ= F/A Where,

F = Tensile Force

A = Cross sectional area

Cross sectional area, A= (W×t)

Where,

W= Width

t= Thickness

Nominal strain is calculated by, ε= ΔL/ L

ΔL = Extension

L_i = Gauge Length

Lf= Final Length

5.3.1.1 TENSILE TEST CALCUATIONS

Specimen 1: (L+L) (1)

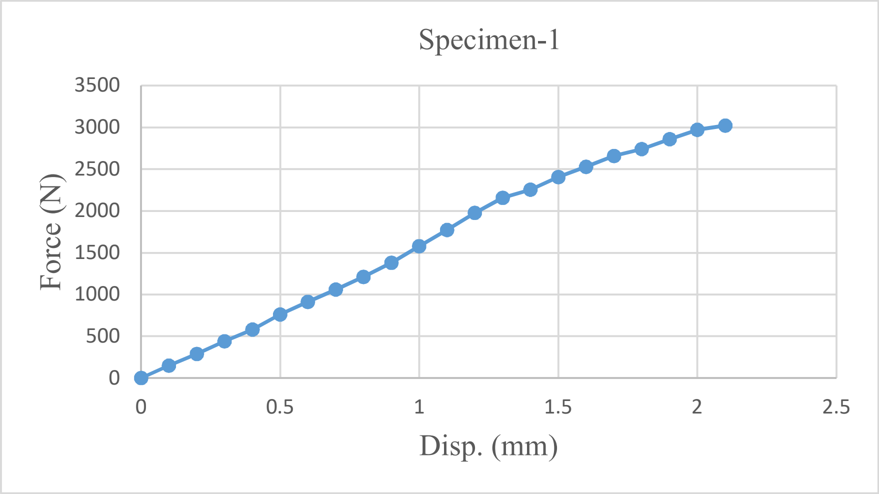


Figure 5.3.1.1a: Force vs Displacement graph for the luffa fiber composite materials

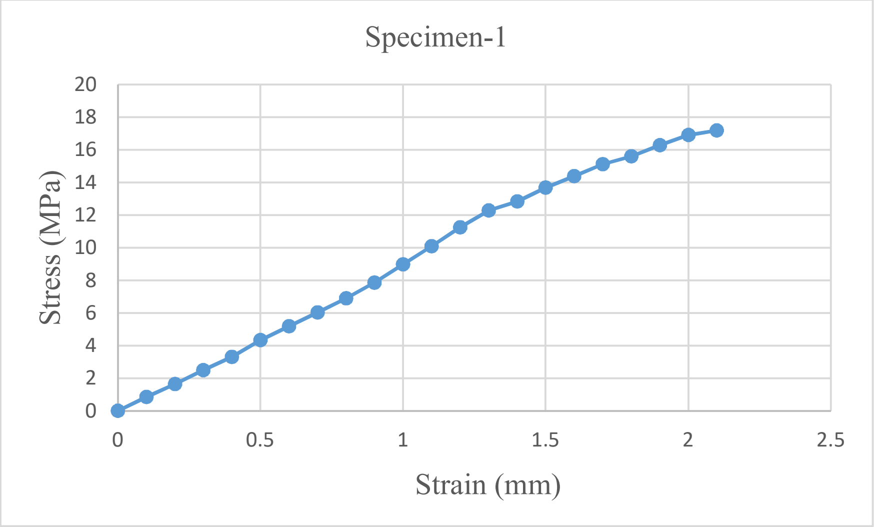


Figure 5.3.1.1b: Stress vs Strain graph for the luffa fiber composite materials

Maximum force F= 3020.73N

Width, W = 27.03 mm

Thickness, t = 6.5 mm

Area, A = 175.695 mm2

Ultimate Stress, σ = *F*/*A*

= 3020.73/175..695

= 17.1930 MPa

Gauge Length L_i= 100 mm

ΔL= 2.07 mm

Final Length Lf = (100+2.07) = 102.07 mm

Strain, Ɛ = *ΔL*/ L_i

= 2.07/100

= 0.0207

Young's Modulus: E= Stress/ Strain = σ/Ɛ

= 17.193/0.0207

= 830.58 MPa

Specimen 2: (L+L) (2)

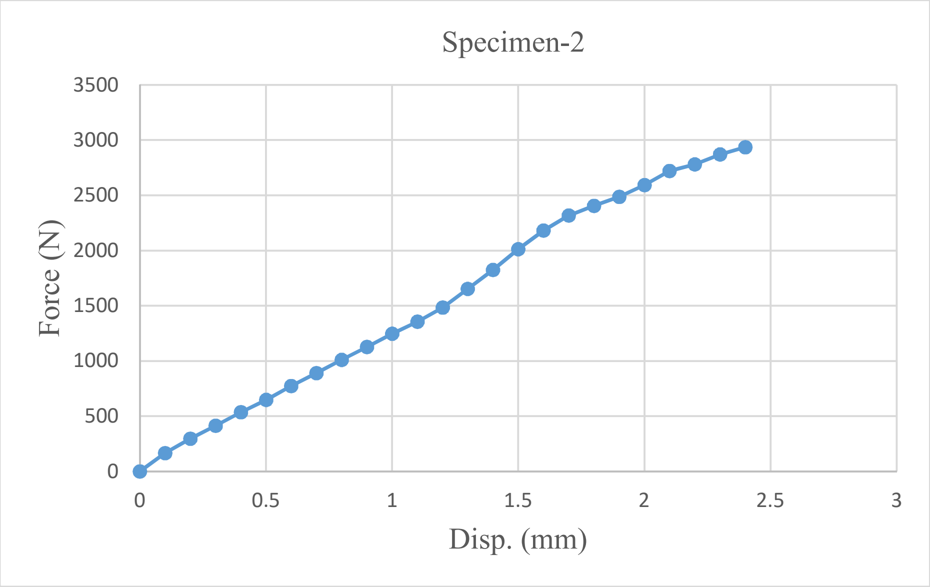


Figure 5.3.1.1c: Force vs Displacement graph for the luffa fiber composite materials

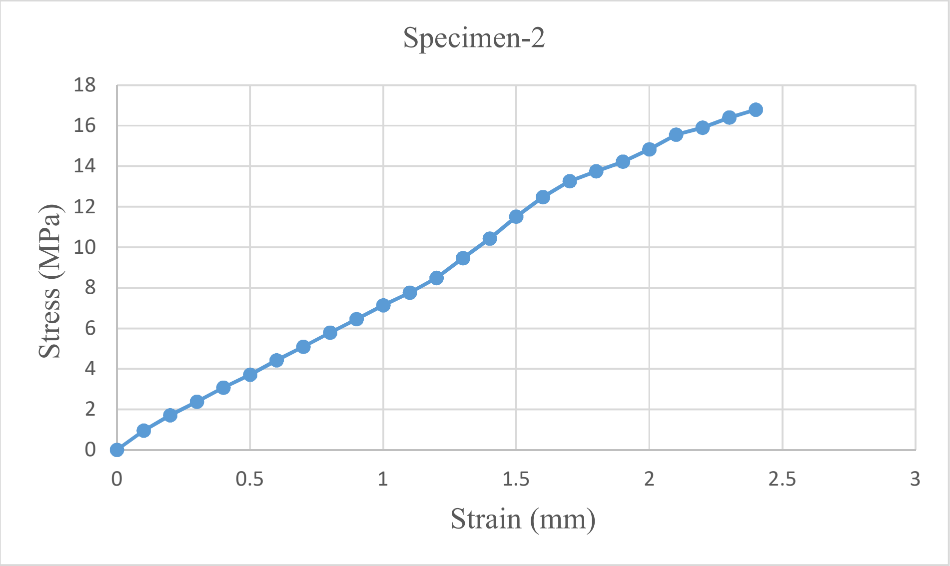


Figure 5.3.1.1d: Stress vs Strain graph for the luffa fiber composite materials

Maximum force F= 2935.84N

Width, W = 26.77 mm

Thickness, t = 6.53 mm

Area, A = 174.81 mm2

Ultimate Stress, σ = F/A

= 2935.84/174.81

= 16.79 MPa

Gauge Length L_i= 100 mm

ΔL= 2.4 mm

Final Length Lf = (100+2.4) = 102.4 mm

Strain, Ɛ = $\Delta L/ L_i$

= 2.4/100

= 0.024

Young's Modulus: E= Stress/ Strain = σ/Ɛ

= 16.79/0.024

= 699.78 MPa

Specimen 3: (J+J) (1)

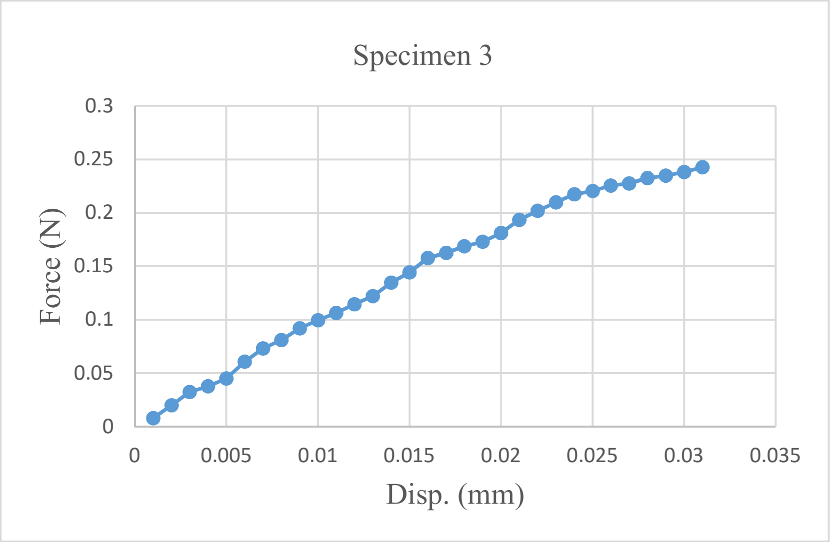


Figure 5.3.1.1e: Force vs Displacement graph for the jute fiber composite materials

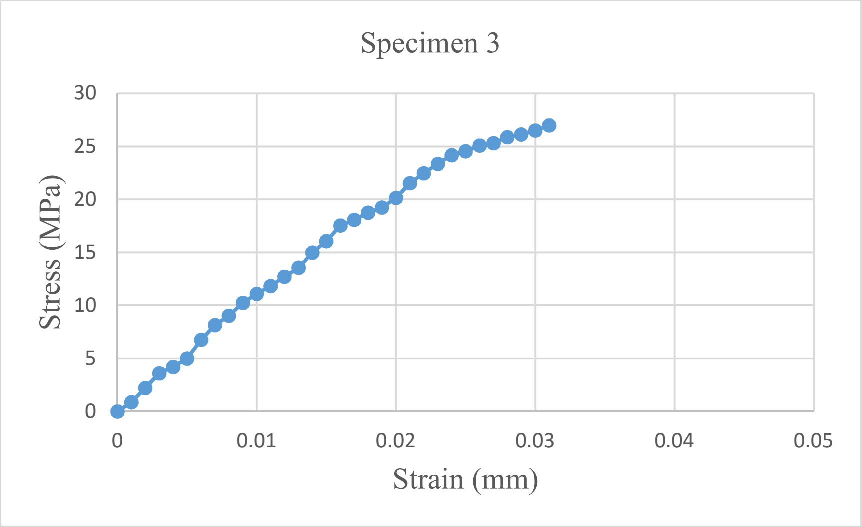


Figure 5.3.1.1f: Stress vs Strain graph for the jute fiber composite materials

Maximum force F= 3000N

Width, W = 27 mm

Thickness, t = 4.12 mm

Area, A = 111.24 mm2

Ultimate Stress, σ = F/A

= 3000/111.24

= 26.986 MPa

Gauge Length L_i= 80 mm

ΔL= 2.45 mm

Final Length Lf = (80+2.45) = 82.45 mm

Strain, Ɛ = $\Delta L/ L_i$

= 2.45/80

= 0.03063

Young's Modulus: E= Stress/ Strain = σ/Ɛ

= 26.986/0.03063

= 881.032 MPa

Specimen 4: (J+J) (2)

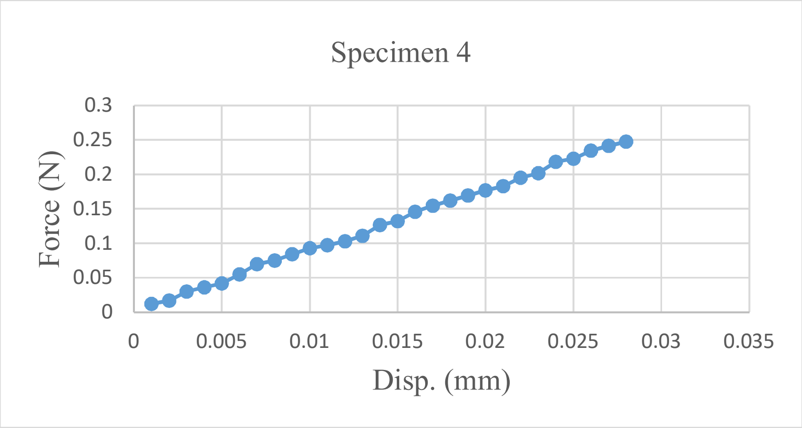


Figure 5.3.1.1g: Force vs Displacement graph for the jute fiber composite materials

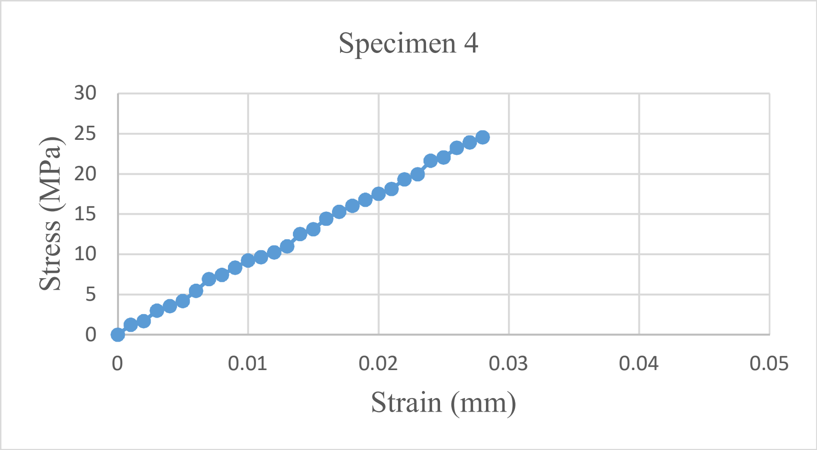


Figure 5.3.1.2h: Stress vs Strain graph for the jute fiber composite materials

Maximum force F= 2600N

Width, W = 26 mm

Thickness, t = 4.11 mm

Area, A = 106.86 mm2

Ultimate Stress, σ = *F*/*A*

= 2600/106.86

= 24.33 MPa

Gauge Length L_i= 85 mm

ΔL= 2.19 mm

Final Length Lf = (85+2.19) = 87.19 mm

Strain, Ɛ = *ΔL*/ L_i

= 2.19/85

= 0.02576

Young's Modulus: E= Stress/ Strain = σ/Ɛ

= 24.33 / 0.02576

= 944.488 MPa

5.3.1.2 Experimental Data Table for Tensile Strength

Table 5.3: Experimental Data for Tensile Test

Sample Name (J=Jute fiber mat, L= Luffa fiber)	Specimen name	Ultimate Stress (MPa)	Young's Modulus (GPa)
L+L	Specimen 1	17.1930	0.83
	Specimen 2	16.78	0.69
J+J	Specimen 3	26.986	0.81
	Specimen 4	24.33	.94

5.3.2 Flexural Testing

Flexural testing is use to determine the flex or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two points or supports and initiating a load using a third point or with two points which are respectively call 3-Point Bend and 4-Point Bend testing.

In this study, we will be conducting 3-point bending test for finding out the flexural strength and modulus of elasticity of our fabricated composite materials. In order to find the flexural strength and modulus of elastic two different types of equations need to be used. From the theory it can be easily deduced.

5.3.2.1 Theory of Flexural strength

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross- section is bent until fracture or yielding using a three-point flexural test technique.

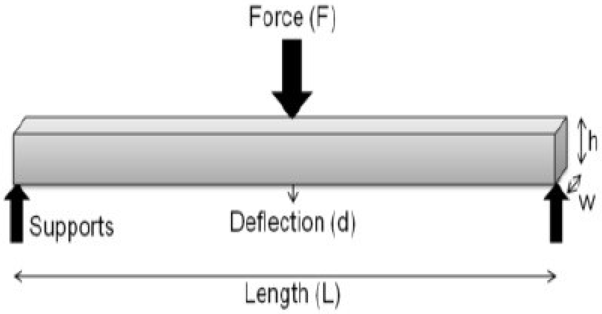


Figure 5.3.2.1: Flexural testing

Usually for three-point bending, the equation is, stress $\sigma = \frac{3FL}{2bd^2}$

5.3.2.2 Theory of modulus of elasticity

For a simply supported beam with central loading, deflection under the load is given by,

$\delta = PL^3/48EI$

So, from the above equation,
$E = (P/\delta) \times L^3/48I = (\Delta P/\Delta\delta) \times L^3/48I$ [Take $(\Delta P/\Delta\delta)$ from the graph.]

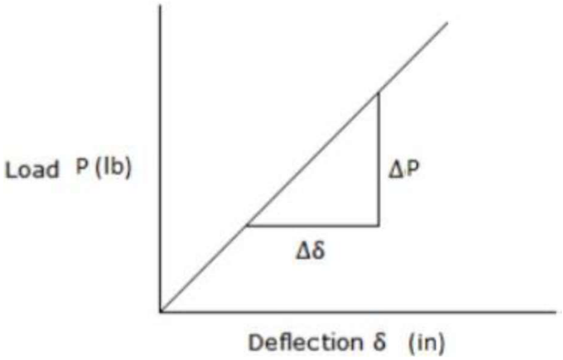


Figure 5.3.2.2a: Slope (load vs extension)

Again,

I= 0.0833*b*h*h*h

Where,

b = wide of the specimen

h = thickness of the specimen

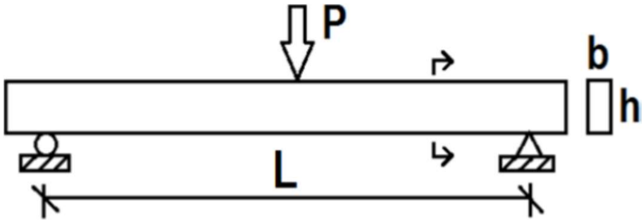


Figure: 5.3.2.2b: Simply supported beam for 3-point bending load

5.3.2.3 Flexural Strength Calculation (σ)

Here, L+L sample 1 data has been taken in order to complete the sample calculation. The calculation is given bellow,

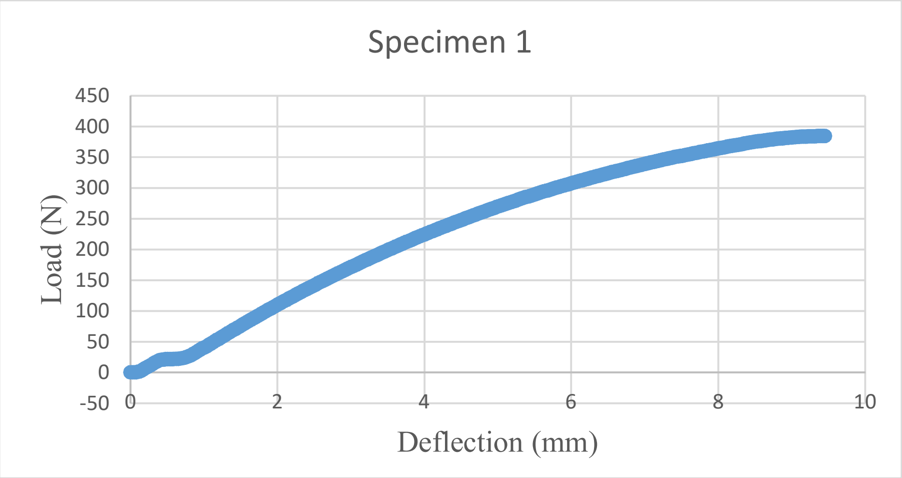


Figure 5.3.2.3: Luffa fiber flexural strength load vs deflection graph

Maximum Force F =384 N

Width, b= 27.17 mm = 0.02717 m

Thickness, d= 6.7 mm = 0.0067 m

Length of the support span, L= 16*0.0067= 0.1072 m

(We will be using 16:1 ratio due to machine inherent limitation)

Ultimate flexural stress $\sigma = \frac{3\mathrm{FL}}{2bd^2}$

$$= \frac{3*384*0.1072}{2*0.02717*(0.0067)^2}$$

= 50626514.1 Pa

= 50.63 MPa

So, the flexural strength of L+L Sample is, 50.63 MPa

5.3.2.4 Calculation for modulus of elasticity (E)

Here, L+L sample 1 data has been taken in order to complete the sample calculation. The calculation is given bellow,

For a simply supported beam with central loading, deflection under the load is,

$$\delta = \frac{FL^3}{48EI}$$

Where,

P= Applied load = 384 N

L=Effective span of the beam = 0.1072 m

E = modulus of Elasticity of the composite material

I = Moment of inertia

δ = Deflection under the load

Moment of inertia, $I = \frac{\mathrm{b}h^3}{12} = 6.80 * 10^{-10}\ m^4$

Now, $E = \frac{\Delta PL^2}{\Delta\delta 48\mathrm{I}}$ [$(\frac{\Delta P}{\Delta\delta})$ taken from the graph]

$$E = \frac{200 * 0.1072^2}{0.00375 * 48 * 6.80 * 10^{-10}}$$

$$= 2012949752\ Pa$$

So, the modulus of elasticity is, $E = 2.013\ GPa$

Here, J+J sample 1 data has been taken in order to complete the sample calculation. The calculation have been Completed similar L+L sample.

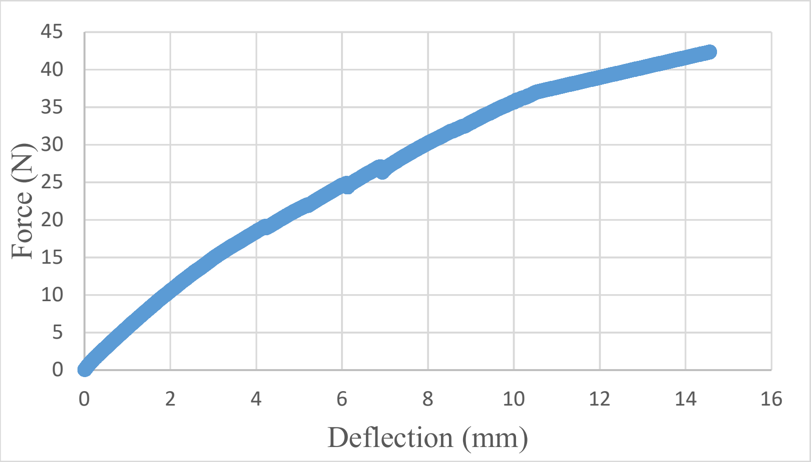


Figure 5.3.2.4: Jute fiber flexural strength load vs deflection graph

Maximum Force F =42.38 N

Width, b= 25 mm = 0.02735 m

Thickness, d= 5.7 mm = 0.0028 m

Length of the support span, L= 16*0.0057= 0.0448 m

So, the flexural strength of J+J Sample is, 13.3 MPa

So, the modulus of elasticity is, $E = 3.82\ GPa$

5.3.2.5 Experimental Data Table for flexural Strength

Table 5.4: Experimental Data for Flexural Test (Three-Point Bending)

Sample Name	Flexural Strength (MPa)	Modulus of Elasticity (GPa)
Luffa Fiber	50.63	2.013
Jute Fiber	13.3	3.82

CHAPTER 6
RESULTS AND DISCUSSION

6.1 TENSILE TEST

Tensile test results are divided into two sub sections. These are,

1. Comparison of Ultimate Stress among the samples.
2. Comparison of Young's Modulus among the samples.

6.1.1 Comparison of Ultimate Stress

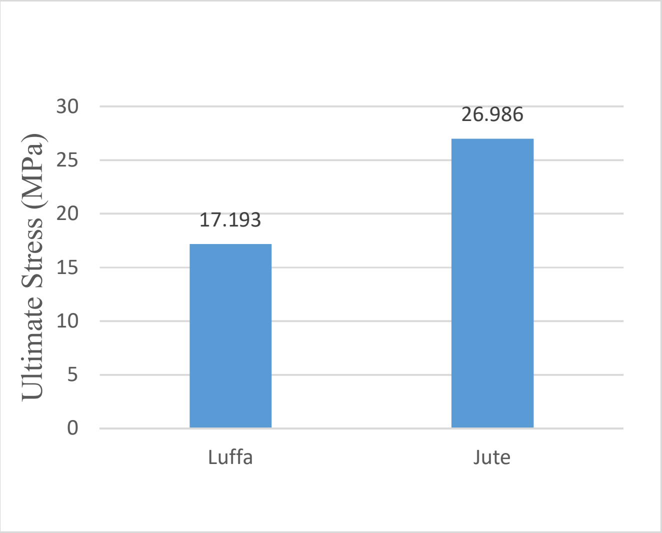


Figure 6.1.1: Bar chart representing specimen name vs respective ultimate stress

In the study, two types of composite materials were fabricate in order to perform tensile test and compare their ultimate stress data. From the bar chart above, it can be clearly said that, Luffa Fiber composite material has lower ultimate stress then the Jute Fiber composite material. It should be noted that, ultimate stress refers to ultimate stress (or simply, tensile strength) is the measurement of the maximum stress that an object can withstand without being fractured. So, if the scenery demands a material which can withstand more tensile load without breaking apart, between Luffa fiber and Jute Fiber, it is recommended to take Jute Fiber composite for the operation.

6.1.2 Comparison of Young’s Modulus

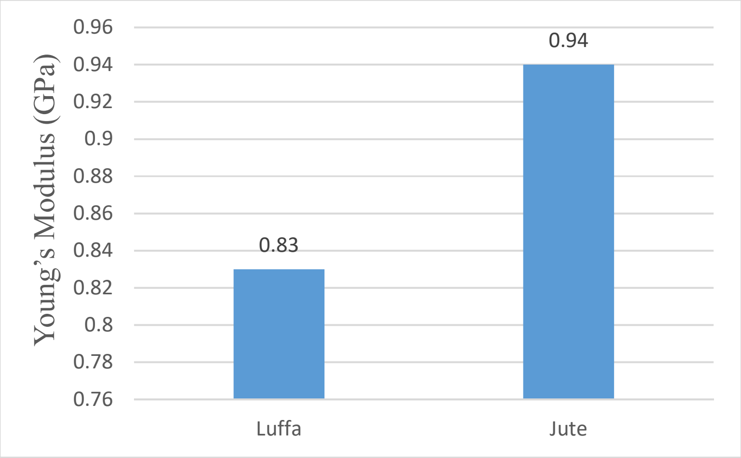


Figure 6.1.2: Bar chart representing specimen name vs young’s modulus

In the study, two types of composite materials were fabricated in order to perform tensile test and compare their Young’s modulus data. From the bar chart above, it can be clearly said that, Luffa fiber composite material has higher Young’s modulus then the Jute fiber composite material. It is basically a measurement of a solid’s stiffness or resistance to elastic deformation under load. That being said, if an operation demands a material which can be stretched easily with light weight than it is advisable to take the Luffa fiber composite instead of the Jute fiber composite material.

6.2 FLEXURAL TEST (3-POINT BENDING) RESULTS:

Flexural test results are divided into two sub sections. These are,

1. Comparison of Flexural Strength among the samples.
2. Comparison of Modulus of Elasticity among the samples

6.2.1 Comparison of Flexural Strength

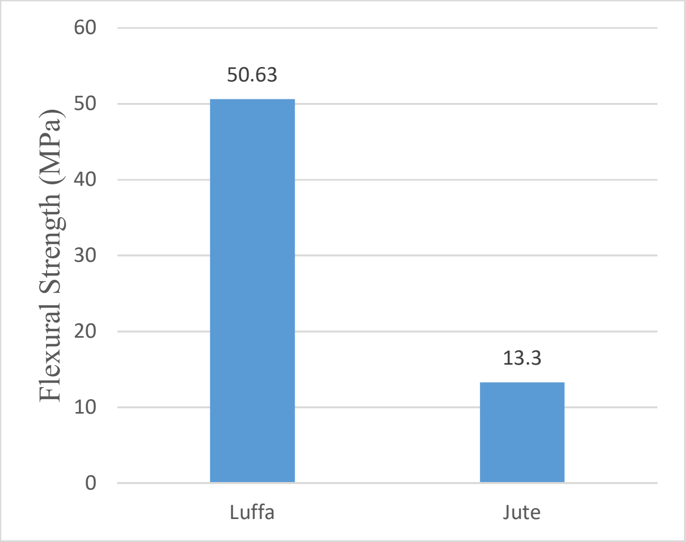


Figure 6.2.1: Bar chart representing specimen name vs flexural strength

In our study of two types of composite materials were fabricated. These were Luffa fiber and Jute fiber. Among these four types, Luffa fiber composite material has the highest amount of flexural strength. After this, the second is Jute fiber composite. Also, as only one piece of J/J was tested it was hard to determine the exact flexural modulus with this scenario. It should be noted that, flexural strength refers to a material how much force it can tolerate before it starts to break. In terms of definition it can be said, it is the amount of force an object can take without breaking or permanently deforming.

6.2.2 Comparison of Modulus of Elasticity

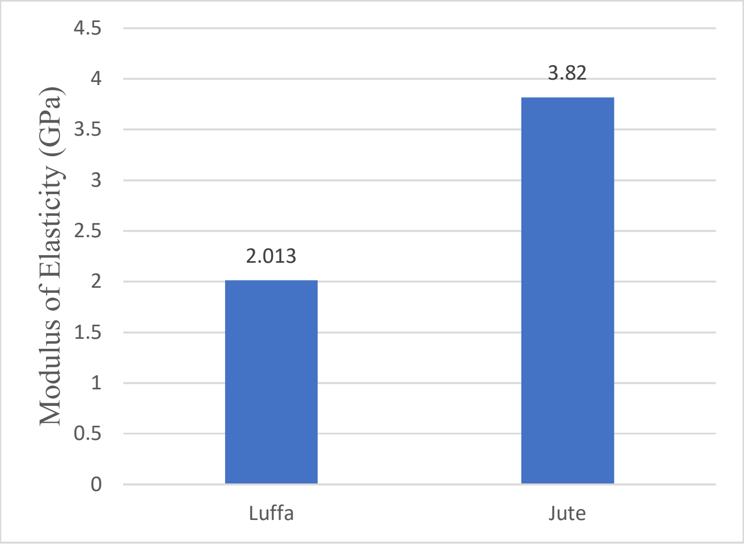


Figure 6.2.2: Bar chart representing specimen name vs modulus of elasticity

In our study of two types of composite materials were fabricated. These were Luffa fiber composite and Jute Fiber composite. Among these four types, Jute fiber composite material has the highest amount of modulus of elasticity. After this, the second is Luffa fiber composite. Though we later fabricated L+L and J+J composite materials. As the span length was too low while testing J+J composite, after a brief testing the J/J started to touch the column which also contributed to the flexural strength. Also, as only one piece of J/J was tested it was hard to determine the exact flexural modulus with this scenario.

CHAPTER 7
USES AND APPLICATIONS

7.1 APPLICATIONS

7.1.1 Aircraft

Since the invention of composite materials, aerospace industry has shown significant use of composite materials by making different parts of commercial and military aircrafts. Hybrid materials like fiber metal laminates are being widely used in aerospace [15]. In the body of Boeing 787, 50% of aluminum and 12% of composites by weight were used. But now 20% of aluminum and 50% of composites by weight are used [16].

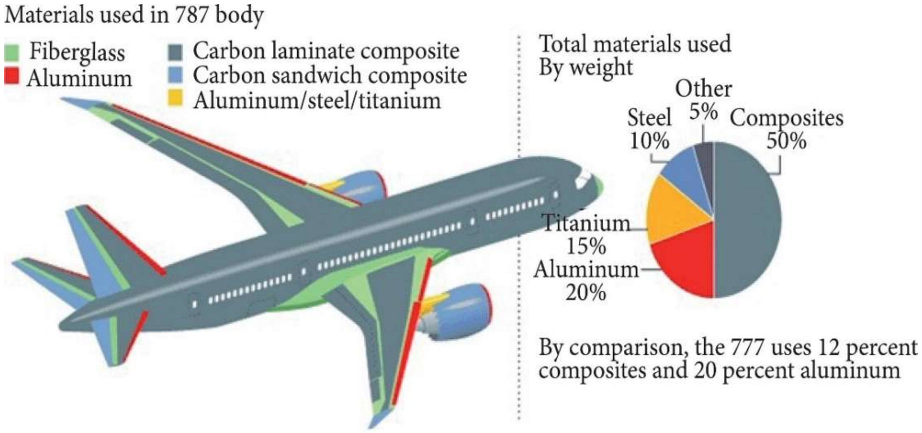


Figure 7.1.1: Composite materials in aircraft [28]

7.1.2 Automobile

In recent year, the use of composite materials in automotive industries is not a shocking news. In automobile sectors, the uses of composite materials are rapidly increasing day by day. They help make vehicles lighter and more fuel-efficient.

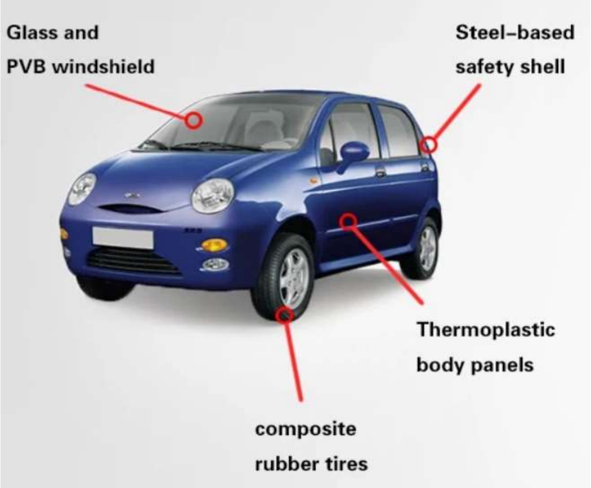


Figure 7.1.2: Composite materials in Automobile

7.1.3 Wind Turbine

The wind energy sector is one of the largest users of composite materials. Composites are primarily found in two components: the nacelle and the blades.

Figure 7.1.3: Composite materials in Wind Turbine

7.1.4 Civil Construction

Composite materials are hugely used in construction sectors. The building of homes, offices, and architectural components are composite material. The decoration components of construction building are also composite material.

Figure 7.1.4: Composite materials in Construction

7.1.5 Marine

The marine industry uses composites to help make hulls lighter and more damage-resistant. The interior components are also made from composite material for innovative designs

Figure 7.1.5: Composite materials in Marine

7.1.6 Electronics

Composite materials are used in electronics industries with rapid growth. Most of our house hold accessories are made from composite materials.

Figure 7.1.6: Composite materials in Electronics Component

7.1.7 Sports Equipment

There are many sports materials made of composite material such as tennis rackets, badminton rackets, softball bats, backboards of basketball stand, ski poles, ice hockey sticks, high jump goods etc. Composite materials are used because of it has light weight, high strength, high design and shaped freedom.

Figure 7.1.7: Composite materials in Sports Equipment

7.1.8 Power Transmission

Because of high dielectric strength, glass-fiber composites revolutionized the handling of electricity when they first replaced wood and metal in 1959. Today, many utility companies are working with composite suppliers to take advantage of composites for both power transmission towers and distribution poles, cables, cross-arms - traditionally the province of wood and steel - and the aluminum conductor cables they support.

Figure 7.1.8: Composite materials in Power Transmission

7.1.9 Oil and Gas Industry

From few decades ago, fiber-reinforced polymer composites have been widely used in oil and gas industries. In piping system glass-fiber reinforced polymer composites (GFRP) is used for environment offshore environment against highly corrosive fluids at various pressures, temperatures, adverse soil and weather conditions. One another reason is behind the use of glass-fiber reinforced polymer composites which is low cost and high strength than metal pipe.

Figure 7.1.9: Composite materials Oil and Gas Industry

7.1.10 Medical Sector

In medical sector, composite material is hugely used. In x-ray application, composite material is used for a wide range. The chemical inertness of carbon fiber has used in a number of surgical applications. The mechanical properties of bone repair materials, often a self-curing acrylic, can be enhanced by the addition of carbon fibers. Some medical testing equipment is also made by composite materials because of light weight, high stiffness and bio compatibility.

Figure 7.1.10: Composite materials in Medical Sector

7.1.11 Defense

In defense sector, many weapons, military aircraft naval vessels, bullet jackets are made by fiber-reinforced polymer composites. In this field importance of fiber- reinforced polymer composite material is increasing day by day.

Figure 7.1.11: Composite materials in defense

7.2 Possible application of jute fiber composite

Our manufactured composites can be used in these sectors:

- Automotive body
- Aircraft interior
- House interior
- Railway coach interior
- Sports equipment
- Industrial safety helmet [17].

CHAPTER 8

RECOMMENDATIONS

8.1 RECOMMENDATIONS

1. There is a very wide scope for future scholars to explore this area of research. This work can be further extended to study other tribological aspects like abrasion, wear, hardness behavior of this composite. We can also study other aspects of such composites like use of other potential fillers for development of hybrid composites and evaluation of their mechanical and erosion behavior and the resulting experimental findings can be similarly analyzed.
2. The fabrication was done using open molding process which is an ancient process and can cause a huge loss of resin because of its inherent problem. So proper measurements should be taken in to consideration in order get rid of this problem.
3. In the present investigation hand-lay-up technique is used to fabricate the composite. However there exists other manufacturing process for polymer matrix composite. They could be tried and analyzed, so that a final conclusion can be drawn there from. However the results provided in this thesis can act as a base for the utilization of this fiber.
4. Manually operated grinding machine was used. In future, we would recommend to use a automated grinding machine in order to precisely cut all the composite slabs in to their standardized pieces.
5. We would suggest to use SEM to examine the fracture surface.

CHAPTER 9

CONCLUSIONS

9.1 CONCLUSIONS

The present work deals with the preparation of luffa fiber reinforced epoxy composite. The mechanical behavior of the composite lead to the following conclusions.

1. The successful fabrications of a Polyester based composites reinforced with luffa fibers have been done.
2. It has been observed from this work that the tensile strength is maximum for double layer jute fiber 26.986 MPa and luffa fiber 17.193 MPa.
3. Flexural strength is found to be more than neat Polyester for double layers of jute fiber composites. Jute fiber maximum flexural strength is 13.3 MPa and luffa fiber is 50.63 MPa.

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