

BIO-DESIGN AND FABRICATION OF BIO COMPOSITE HELMET USING NATURAL FIBER

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in
Mechanical Engineering

By

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DEPARTMENT OF MECHANICAL ENGINEERING

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **VANIMISETTI SHANMUKHA VEERENDRA (Reg. No. 37150201)** and **VIKAS DHARMULA (Reg.No.37150214)** who carried out the project entitled **“BIO DESIGN AND FABRICATION OF BIO COMPOSITE HELMET USING NATURAL FIBER”** under my supervision from **AUGUST 2020 to MARCH 2021.**

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Submitted for Viva voce Examination held on_____

Internal Examiner

External Examiner

DECLARATION

I, **VANIMISSETTI SHANMUKHA VEERENDRA** (Register No.37150201) hereby declare that the Project Report entitled **“BIO-DESIGN AND FABRICATION OF BIO-COMPOSITE HELMET USING NATURAL FIBER”** done by under the guidance of **Mr. S.YUVARAJA, M.E., Department of Automobile Engineering** is submitted in partial fulfillment of the requirements for the award of **Bachelor of Engineering** Degree in **Mechanical Engineering**.

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PLACE: CHENNAI

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ABSTRACT

Recently, bio composite materials are synthesized utilizing characteristic cellulose fibers as fortifications in conjunction with matrix, which have pulled in the consideration of analysts due to their low density with high mechanical strengths, availability, renewability, degradability and being environmental-friendly. The present work concentrates on advancement within the current existing head protector fabricating technique and materials utilized to have way better mechanical properties as well as to improve the compatibility between fibers and the matrix. The bio-composite are arranged with the unsaturated polyester lattice and fibers such as jute, sisal, utilizing hand lay-up strategy with fitting extents to result in protective cap shell structure .The created protective shell is arranged to assess its mechanical properties such as tensile, hardness and impact strength quality.

TABLE OF CONTENTS

CHAPTER NO.	TITLE	PAGE NO
	ABSTRACT	v
	LIST OF FIGURES	viii
	LIST OF TABLES	ix
1	INTRODUCTION	
1.1	OVERVIEW OF COMPOSITES	1
1.2	DEFINITION OF COMPOSITE	3
1.3	TYPES OF COMPOSITES	4
1.3.1	METAL MATRIX COMPOSITES	4
1.3.2	CERAMIC MATRIX COMPOSITES	4
1.3.3	POLYMER MATRIX COMPOSITES	5
1.3.4	BASED ON REINFORCING MATERIAL STRUCTURE	7
1.4	INTRODUCTION TO REINFORCEMENTS	9
1.5	NATURAL FIBER REINFORCED COMPOSITES	10
1.5.1	ANIMAL FIBER	11
1.5.2	MINERAL FIBER	11
1.5.3	PLANT FIBER	11
1.6	SURFACE TREATMENT OF FIBERS	14
1.7	MANUFACTURING PROCESS OF COMPOSITES	14
2	LITERATURE SURVEY	15
3	AIM AND SCOPE	20
3.1	AIM	20
3.2	SCOPE	20
4	MATERIALS AND METHODS	22

4.1	MATERIALS USED	22
4.1.1	EPOXY RESIN (LY-556)	22
4.1.2	HARDENER (HY-951)	23
4.1.3	NATURAL FIBERS SUCH AS SISAL/JUTE	23
4.1.4	ADVANTAGE OF NATURAL FIBERS	23
4.1.5	NaOH SOLUTION	24
4.2	METHODOLOGY	24
4.2.1	SELECTION OF MATRIX MATERIAL	24
4.2.2	SELECTION OF REINFORCEMENT AND FIBERS	24
4.2.3	EXTRACTION OF FIBERS	24
4.2.4	SURFACE TREATMENT OF FIBERS	26
4.2.5	WET HAND LAY-UP TECHNIQUE	27
4.3	FABRICATION OF HELMET	29
4.3.1	MATERIALS USED FOR MOULD MAKING	29
4.3.2	PROCEDURE OF MOULD MAKING	29
4.3.3	HELMET MAKING	30
5	RESULTS AND CONCLUSION	31
5.1	SPECIMEN PREPARATION AS PER ASTM STANDARDS	31
5.2	MECHANICAL TESTING OF COMPOSITE LAMINATES	31
5.2.1	TENSILE TESTING OF COMPOSITES	32
5.2.2	IMPACT TESTING OF COMPOSITES	34
5.2.3	HARDNESS TESTING OF COMPOSITES	36
6	SUMMARY AND CONCLUSION	38
6.1	SUMMARY	38
6.2	CONCLUSION	38
	REFERENCES	39

TABLE OF FIGURES

FIGURE NO	LIST OF FIGURES	PAGE NO
1.1	THERMOSET RESIN	6
1.2	THERMOPLASTIC RESIN	7
1.3	TYPES IN COMPOSITE	8
1.4	TYPES OF REINFORCEMENT	9
1.5	CLASSIFICATION OF NATURAL FIBERS	10
4.1	SISAL FIBER	25
4.2	JUTE FIBER	25
4.3	SURFACE TREATMENT WITH NaOH	26
4.4(a)	HAND LAY-UP PROCESS	27
4.4(b)	ORIENTATION OF FIBER LAYERS	27
4.5	SAMPLES WITH VARYING FIBER COMPOSITION	28
4.6	HELMET MOULD FORMED	29
4.7	STICKING FIBER INTO THE MOULD	30
4.8	AFTER SEPERATING HELMET FROM MOULD	30
5.1	UNIVERSAL TESTING MACHINE	33
5.2	SPECIMEN DIMENSIONS	34
5.3	IMPACT TEST MACHINE	35
5.4	RESULTS CERTIFICATE	36

CONTENT OF TABLES

TABLE NO	LIST OF TABLES	PAGE NO
1.1	FIBERS AND COUNTRIES OF ORIGIN	13
4.1	PROPERTIES OF NATURAL FIBERS	24
5.1	ASTM STANDARDS FOR SAMPLES DIMENSIONS	31
5.2	SPECIFICATIONS OF UNIVERSAL TESTING MACHINE	31
5.3	TENSILE STRENGTH RESULTS	33
5.4	IMPACT STRENGTH RESULTS	35
5.5	HARDNESS TEST RESULTS	36

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW OF COMPOSITES

Over the past three decades composite materials, plastics and ceramics have been the overwhelming developing materials. The volume and number of applications of composite materials have developed relentlessly, entering and overcoming unused markets tirelessly. Cutting edge composite materials constitute a critical extent of the built materials advertise extending from ordinary items to advanced specialty applications. Whereas composites have as of now demonstrated their worth as weight-saving materials, the current challenge is to create them taking a toll compelling. The endeavors to create financially appealing composite components have brought about in a few imaginative manufacturing techniques right now being utilized within the composites industry. It is clear, particularly for composites, that the change in fabricating innovation alone isn't sufficient to overcome the taken a toll jump. It is essential that there be an integrated effort in design, material, process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals.

The composites industry has started to recognize that the commercial applications of composites guarantee to offer much bigger commerce openings than the aviation division due to the sheer estimate of the transportation industry. In this way the move of composite applications from airplane to other commercial employments has gotten to be noticeable in later a long time. Progressively empowered by the presentation of more current polymer gum framework materials and tall execution fortification strands of glass, carbon and aramid, the entrance of these progressed materials has seen a consistent development in employment and volume. The expanded volume has come about in an anticipated decrease in costs. High performance FRP can presently be found in such diverse applications as composite armoring planned to stand up to hazardous impacts, fuel barrels for normal gas vehicles, windmill edges, mechanical drive shafts, bolster pillars of thruway bridges and indeed paper making rollers. For

certain applications, the utilize of composites instead of metals has in truth brought about in reserve funds of both taken a toll and weight. A few cases are cascades for motors, bended fairing and filets, substitutions for welded metallic parts, barrels, tubes, conduits, edge control groups etc. Further, the require of composite for lighter construction material and more seismic safe structures has put tall accentuation on the utilize of unused and progressed materials that not as it were diminishes dead weight but too retains the stun & vibration through custom fitted microstructures. Composites are presently broadly being utilized for restoration/ fortifying of pre-existing structures that got to be retrofitted to form them seismic safe, or to repair harm caused by seismic movement. Not at all like routine materials (e.g., steel), the properties of the composite fabric can be outlined considering the structural aspects.

A composite material consists of two or more physically and/or chemically distinct, suitably arranged or distributed phases, with an interface separating them. It has characteristics that are not portrayed by any of the components in confinement. Most commonly, composite materials have a bulk stage, which is nonstop, called the framework, and one scattered, non-continuous, stage called the support, which is as a rule harder and stronger. The function of individual components has been portrayed as Matrix phase the primary stage, having a continuous character, is called network. Network is as a rule more pliable and less difficult stage. It holds the scattered stage and offers a stack with it. In Dispersed (reinforcing) phase the second phase (or phases) is embedded within the lattice in an irregular shape. This auxiliary stage is called scattered stage. Scattered stage is as a rule more grounded than the lattice, subsequently it is some of the time called strengthening phase.

Many of common materials(metal combinations, doped Ceramics and Polymers blended with added substances) moreover have a little sum of scattered stages in their structures, be that as it may they are not considered as composite materials since their properties are comparative to those of their base constituents (physical properties of steel are comparable to those of unadulterated press). There are two classification frameworks of composite materials. One of them is based on the network fabric (metal, ceramic, polymer) and the moment is based on the material structure.

1.2 DEFINITION OF COMPOSITE

The most widely utilized meaning is the taking after one, which has been expressed by Jartiz "Composites are multifunctional fabric frameworks that give characteristics not reachable from any discrete fabric. They are cohesive structures made by physically combining two or more consistent materials, diverse in composition and characteristics and some of the time in form". The shortcoming of this definition dwelled within the truth that it permits one to classify among the composites any blend of materials without demonstrating either its specificity or the laws which ought to give it which recognizes it from other exceptionally cliché, meaningless mixtures.

Kelly exceptionally clearly stresses that the composites ought to not be respected straightforwardly as a combination of two materials. Within the broader noteworthiness; the combination has its particular properties. In terms of quality to resistance to warmth or a few other alluring quality, it is superior than either of the components alone or drastically distinctive from either of them.

Beghezan characterizes as "The composites are compound materials which vary from amalgams by the truth that the person components hold their characteristics but are so consolidated into the composite as to require advantage as it were of their qualities and not of their brief comings", in arrange to get moved forward materials.

Van Suchetclan explains composite materials as heterogeneous materials comprising two or more strong stages, which are in hint contact with each other on a minuscule scale. They can be too considered as homogeneous materials on a minuscule scale within the sense that any parcel of it will have the same physical property.

1.3 TYPES OF COMPOSITES

For the sake of simplicity, however, composites can be grouped into categories based on the nature of the matrix each type possesses. Methods of fabrication also vary according to physical and chemical properties of the matrices and reinforcing fibers

1.3.1 Metal Matrix Composites (MMCs)

Metal lattice composites, as the title suggests, have a metal lattice.

Illustrations of lattices in such composites incorporate aluminum, magnesium and titanium. The normal fiber incorporates carbon and silicon carbide. Metals are primarily strengthened to suit desires of plan. For illustration, the versatile solidness and quality of metals can be expanded, whereas huge coefficient of warm development, and warm and electrical conductivities of metals can be decreased by the expansion of strands such as silicon carbide

1.3.2 Ceramic Matrix Composites (CMCs)

Ceramic matrix composites have ceramic lattice such as alumina, calcium, alumina silicate fortified by silicon carbide. The preferences of CMC incorporate tall quality, hardness, tall benefit temperature limits for ceramics, chemical idleness and moo thickness. Normally safe to tall temperature, ceramic materials have an inclination to end up fragile and to break. Composites effectively made with ceramic networks are strengthened with silicon carbide filaments. These composites offer the same tall temperature resilience of super combinations but without such a tall thickness. The fragile nature of ceramics makes composite creation troublesome. Ordinarily most CMC generation methods include beginning materials in powder shape. There are four classes of ceramics lattices: glass (simple to manufacture since of moo softening temperatures, incorporate borosilicate and alumino silicates), customary ceramics (silicon carbide, silicon nitride, aluminum oxide and zirconium oxide are completely crystalline), cement and concrete carbon component.

1.3.3 Polymer Matrix Composites (PMC)

Most commonly utilized lattice materials are polymeric. The reasons for this are two-fold. In common the mechanical properties of polymers are lacking for numerous basic purposes. In specific their quality and firmness are too compared to metals and ceramics. These troubles are overcome by fortifying other materials with polymers. Besides the preparation of polymer networks, composites do not include tall weight and do not require tall temperature. Moreover types of gear required for fabricating polymer lattice composites are less difficult. For this reason polymer composites created quickly and before long got to be prevalent for auxiliary applications. Polymer composites are utilized since by and large properties of the composites are predominant to those of the person polymers. They have a more prominent flexible modulus than the flawless polymer but are not as brittle as ceramics. Polymeric matrix composites are composed of a matrix from thermoset (unsaturated polyester, epoxy or thermoplastic polycarbonate, polyvinyl chloride, nylon, polystyrene and embedded glass, carbon, steel or Kevlar fibers (dispersed phase).

The potential applications of polymer composites incorporate shopper merchandise (sewing machines, entryways, baths, tables, chairs, computers, printers, etc), donning merchandise industry (golf shafts, tennis rackets, snow skis, angling bars, etc.), aviation industry (entryways, flat and vertical stabilizers, wing skins, blade boxes, folds, and different other auxiliary components), marine applications (traveler ships, control vessels, buoys, etc.), car industry (bumper pillar, seat/load floor, hood radiator bolster, roof board and arrive transport frameworks like cars, trucks and transport bodies, railroad coach components, holders and two and three wheelers), development and gracious structures (bridges, columns entryways, windows and segments and for translucent material sheets, pre-assembled measured houses and buildings etc.), industrial applications

Two main kinds of polymers are thermosets and thermoplastics. Thermosets have qualities such as a well-bonded three-dimensional atomic structure after curing. They break down rather than softening on hardening. Just changing the fundamental composition of the gum is sufficient to modify the conditions appropriately for curing

and determine its other prolonged periods of time, rendering Thermosets exceptionally adaptable. In this way, they are most suited as network bases for advanced. conditions fiber strengthened composites. Thermosets discover wide extending applications within the chopped fiber composites frame especially when a premixed or shaping compound with strands of particular quality and angle proportion happens to be beginning fabric as in epoxy, polymer and phenolic polyamide resins. Thermoplastics have one- or two-dimensional atomic structure and they tend to at an hoisted temperature and appear as an overstated softening point. Another advantage is that the method of softening at lifted temperatures can be turned around to recapture its properties amid cooling, facilitating applications of conventional compress techniques to mould the compounds.

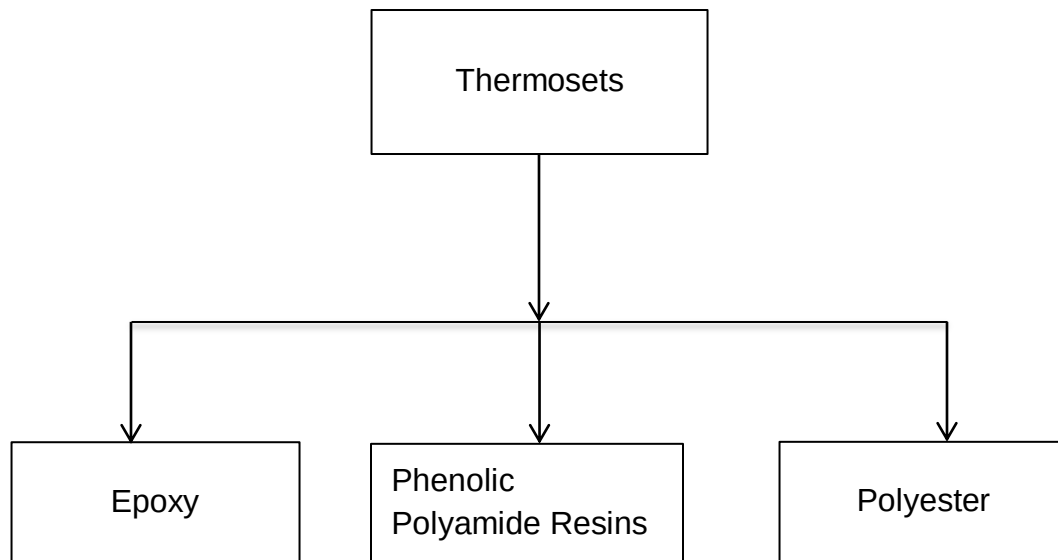


Fig 1.1: Thermoset resin

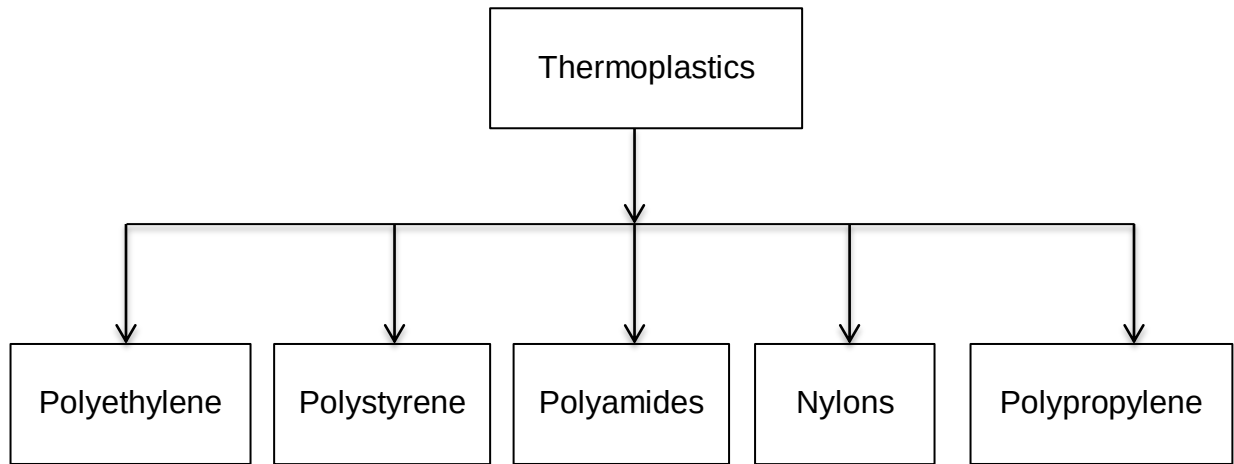


Fig 1.2: Thermoplastic resin

1.3.4 Based on reinforcing material structure

Classification of composites: three main categories

- particle-reinforced (large-particle and dispersion-strengthened)
- fiber-reinforced (continuous (aligned) and short fibers (aligned or random))
- structural (laminates and sandwich panels)

- *Particulate Composites*

Particulate Composites comprise of a matrix reinforced by a dispersed stage in frame of particles. These are the cheapest and most broadly utilized. They drop in two categories depending on the measure of the particles

- ☐ Composites with random orientation of particles.
- ☐ Composites with preferred orientation of particles.

Dispersed stage of these materials comprises 2-D level platelets (chips), laid parallel to each other's.

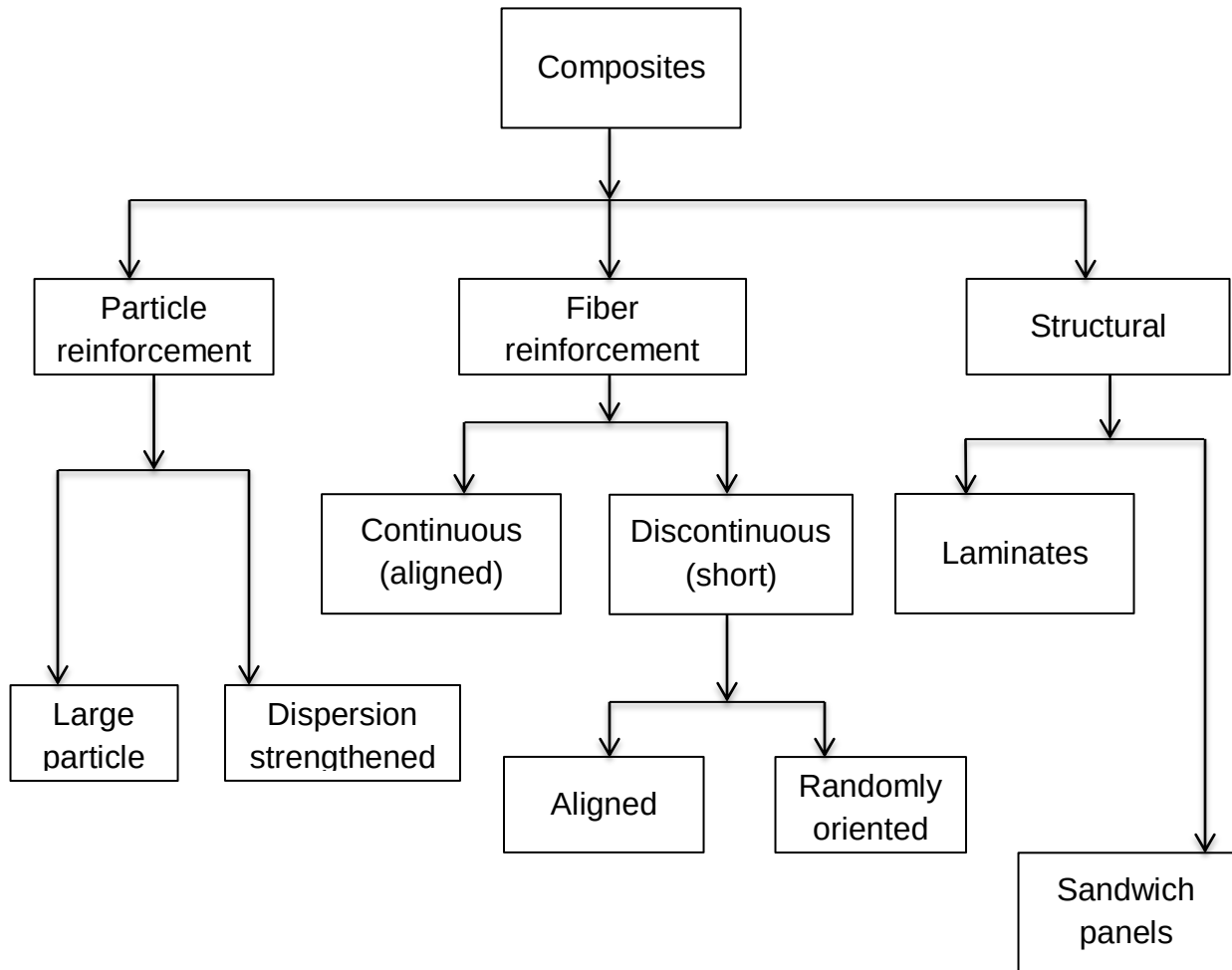


Fig 1.3: Types in composites

- *Short fiber reinforced composites:*

Short-fiber strengthened composites comprise of a framework fortified by a scattered stage in shape of irregular filaments (length < 100*diameter). They are classified as

- ☐ Composites with random orientation of fibers.
- ☐ Composites with preferred orientation of fibers.

- *Long-fiber reinforced composites:*

Long-fiber fortified composites consist of a framework fortified by a scattered stage in a frame of nonstop fibers.

- ☐ Unidirectional orientation of fibers.
- ☐ Bidirectional orientation of fibers (woven).

- *Laminate composite*

When a fiber reinforced composite comprises a few layers with diverse fiber

introductions, it is called a multilayer composite.

1.4 INTRODUCTION TO REINFORCEMENTS

Reinforcements for the composites can be fibers, textures particles or whiskers. Strands are basically characterized by one exceptionally long pivot with two other tomahawks either regularly circular or close circular. Particles have no favored introduction and so does their shape. Hairs have a favored shape but are little both in distance across and length as compared to strands. Figure.2.3 appears as a sort of reinforcements in composites.

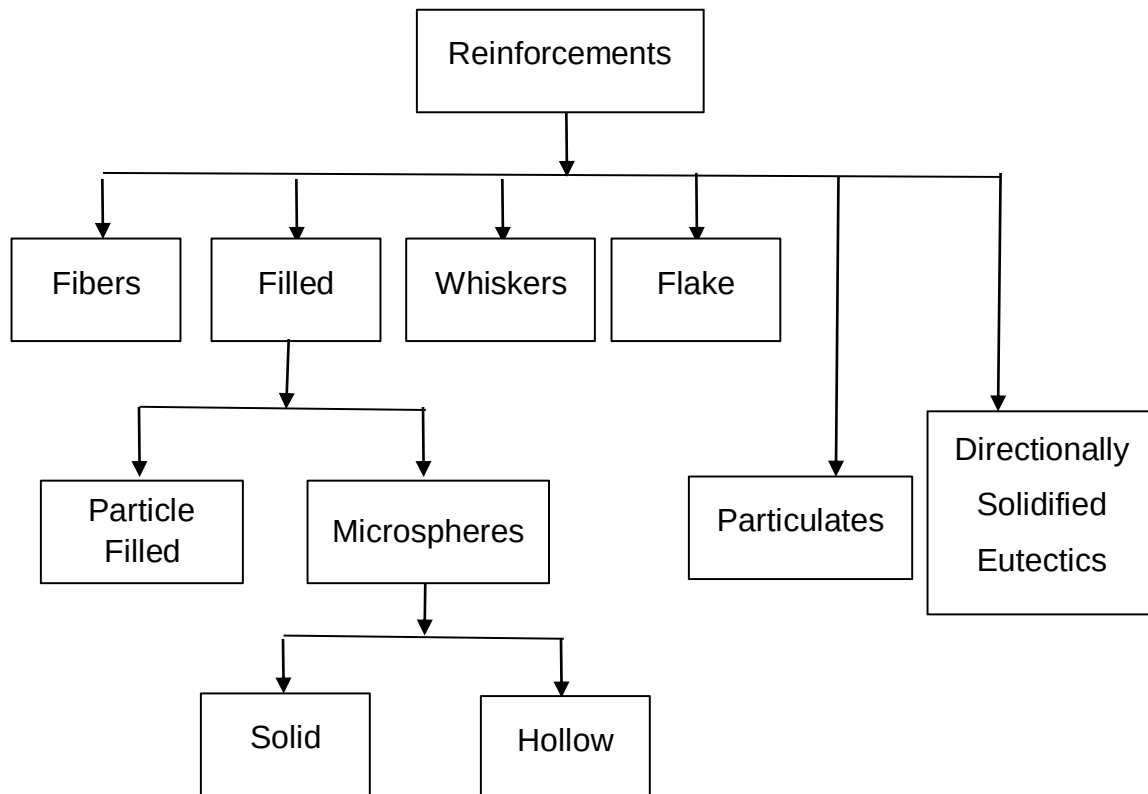


Fig 1.4: Types of reinforcement

Reinforcing constituents in composites, as the word demonstrates, give the quality that creates the composite what it is. But they too serve certain extra purposes of warm resistance or conduction, resistance to erosion and give rigidity. Fortification can be made to perform all or one of these capacities as per the requirements

1.5 NATURAL FIBER REINFORCED COMPOSITES

Fiber-reinforced polymer composites have played a prevailing part for a long time in an assortment of applications for their tall particular quality and modulus. The fabricate, utilize and evacuation of conventional fiber–reinforced plastic, ordinarily made of glass, carbon or aramid fibers–reinforced thermoplastic and thermoset tars are considered fundamentally since of natural issues. By common fiber composites we cruel a composite fabric that's fortified with strands, particles or platelets from characteristic or renewable assets, in contrast to for example.

carbon or aramid fibers that have to be synthesized. Normal filaments incorporate those made from plant, creature and mineral sources. Common filaments can be classified concurrent to their beginning. The point by point classification appears in Figure 1.1.

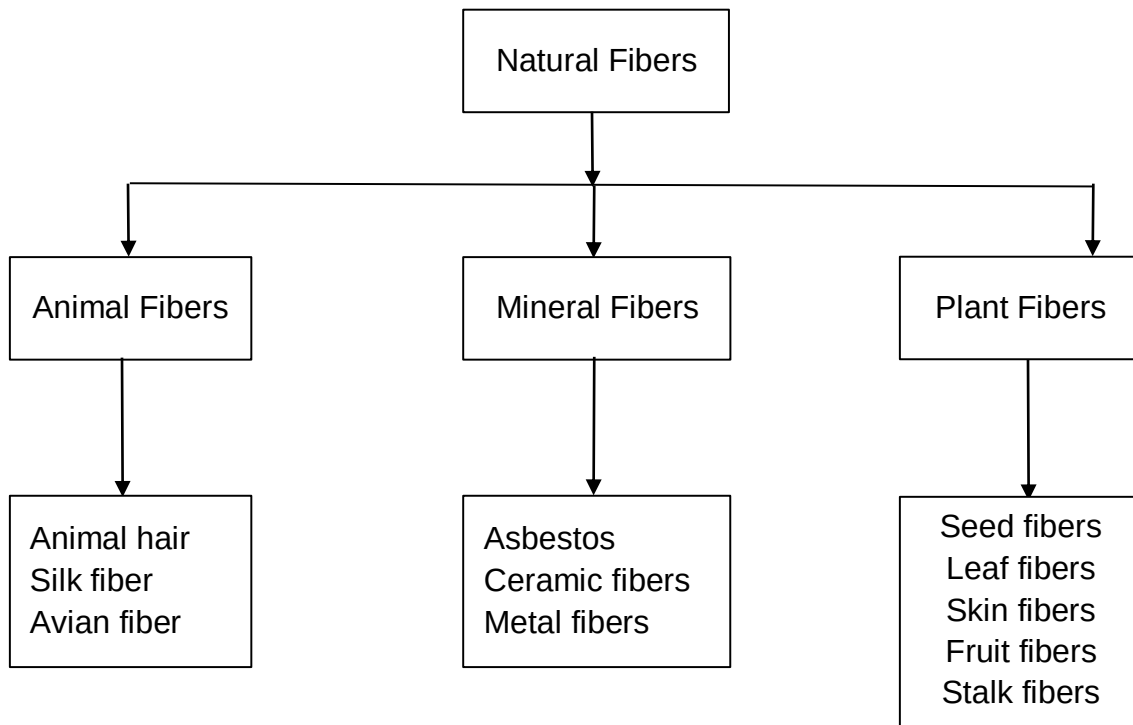


Fig 1.5: Classification of natural fiber

1.5.1 Animal Fiber

Animal fiber for the most part contains proteins; illustrations mohair, fleece, silk, alpaca, angora. Creature hair (fleece or hair) are the strands taken from creatures or bushy mammals. E.g. Sheep's fleece, goat hair (cashmere, mohair), alpaca hair, horse hair, etc. Silk fiber are the strands collected from dried spit of bugs or creepy crawlies amid the arrangement of cocoons. Cases incorporate silk from silkworms. Avian fiber are the filaments from birds, e.g. feathers and feather fiber.

1.5.2 Mineral fiber

Mineral fibers are naturally occurring fiber or slightly modified fiber generated from minerals. These can be categorized into the following categories: Asbestos is the only naturally occurring mineral fiber. Variations are serpentine and amphiboles, anthophyllite. Ceramic fibers includes glass fibers (Glass wool and Quartz), aluminum oxide, silicon carbide, and boron carbide. Metal fibers include aluminum fibers.

1.5.3 Plant fiber

Plant fibers are for the most part comprised basically of cellulose: illustrations incorporate cotton, jute, flax, ramie, sisal and hemp. Cellulose strands serve within the make of paper and cloth. This fiber can be categorized into taking after as Seed fiber are the strands collected from the seed and seed case e.g. cotton and kapok. Leaf fibers are the strands collected from the clears out e.g. sisal and agave. Skin fibers are the filaments collected from the skin or bast encompassing the stem of their individual plant. These strands have higher pliable quality than other strands. Hence, these strands are utilized for tough yarn, texture, bundling, and paper. A few cases are flax, jute, banana, hemp, and soybean. Natural product fibers are the strands that are collected from the natural product of the plant, e.g. coconut (coir) fiber.

Stalk fibers are really the stalks of the plant. Tree wood is additionally such a fiber. Normal fiber composites are by no implies modern to mankind. As of now the old

Egyptians utilized clay that was strengthened by straw to construct dividers. Within the starting of the 20th century wood- or cotton fiber fortified phenol- or melamine formaldehyde tars were created and utilized in electrical applications for their non-conductive and heat-resistant properties. At display day characteristic fiber composites are mainly found in the car and building industry and after that for the most part in applications where stack bearing capacity and dimensional solidness beneath wet and tall warm conditions are of second order significance. For case, flax fiber strengthened polyolefin are broadly utilized nowadays within the car industry, but the fiber acts basically as filler fabric in non-structural interior boards.

The natural fiber composites can be very cost effective material for following applications:

- Building and development industry: boards for segment and wrong ceiling, parcel sheets, divider, floor, window and entryway outlines, roof tiles, versatile or pre-fabricated buildings which can be utilized in times of characteristic calamities such as surges, violent winds, seismic tremors, etc.
- Storage gadgets: post-boxes, grain capacity silos, biogas holders, etc.
- Furniture: chair, table, shower, shower units, etc.
- Electric gadgets: electrical apparatuses, channels, etc.
- Everyday applications: lampshades, bags, protective caps, etc.
- Transportation: Aerospace, automobile and railway coach interior, boat, etc.

Natural fibers are by and large lignocellulose in nature, comprising of helically wound cellulose smaller scale fibrils in a network of lignin and hemicellulose. Concurring to a Nourishment and Agrarian Organization overview, Tanzania and Brazil create the biggest sum of sisal. Henequen is developed in Mexico. Abaca and hemp are developed within the Philippines. The biggest makers of jute are India, China, and Bangladesh. Directly, the yearly generation of common strands in India is almost 6 million tons as compared to around the world generation of almost 25 million tons. The detail data of strands and the nations of root are given in Table 1.1.

Table.1.1 Fibers and countries of origin

Flax	Borneo
Hemp	Yugoslavia, china
Sun hemp	Nigeria, Guyana, Sierra, Leone, India
Ramie	Honduras, Mauritius
Jute	India, Egypt, Guyana, Ghana, Malawi, Sudan, Tanzania
Kenaf	Iraq, Tanzania, Jamaica, South Africa, Cuba, Togo
Roselle	Borneo, Guyana, Malaysia, Sri Lanka, Togo, Indonesia, Tanzania
Sisal	East Africa, India, Bahamas, Antique, Kenya, Tanzania
Abaca	Malaysia, Philippines, Bolivia, Uganda
Coir	India, Sri Lanka, Philippines, Malaysia

Natural fibers such as jute, sisal, pineapple, abaca and coir have been studied as a reinforcement and filler in composites. Growing attention is nowadays being paid to coconut fiber due to its availability. The coconut husk is accessible in expansive amounts as buildup from coconut generation in numerous ranges, which is yielding the coarse coir fiber. Coir may be a lingo-cellulosic characteristic fiber. It could be a seed-hair fiber gotten from the external shell, or husk, of the coconut. It is a safe scraped area and can be colored. Add up to world coir fiber generation is 250,000 tons. The coir fiber industry is especially imperative in a few regions of the creating world. Over 50% of the coir fiber delivered every year all through the world is expended within the nations of root, primarily India. Since its difficult- wearing quality, strength and other focal points, it is utilized for making a wide assortment of floor outfitting materials, yarn, rope etc. In any case, these conventional coir items devour as it were a little rate of the potential to add up to the world generation of coconut husk. Consequently, inquire about and advancement endeavors have been underway to discover unused utilize regions for coir, including utilization of coir as reinforcement in polymer composites.

1.6 SURFACE TREATMENT OF FIBERS

The influence of fiber treatment on the properties of bio composites inferred from grass fiber and soy based bio plastic has been examined with natural checking electron microscopy, warm and mechanical properties estimations. Grass fibers were treated with an antacid arrangement that diminished the inter-fibrillar locale of the fiber by expelling hemicellulose and lignin, which decreased the cementing drive between fibrils. This led to a more homogenous scattering of the fiber within the framework as well as increment within the angle proportion of the fiber within the composite, coming about in advancement in fiber fortification efficiency. This led to improvement in mechanical properties counting pliable and flexural properties as well as affect quality. Furthermore, the antacid arrangement treatment increased the concentration of hydroxyl bunches on the surface, which drove much better interaction between the fibers and the matrix.

Against this background, the show investigate work has been attempted, with an objective to investigate the potential of coir fiber as a strengthening fabric in polymer composites and to explore its impact on the mechanical behavior of the coming composites. The present work hence points to create this modern course of common fiber based polymer composites with distinctive fiber lengths and to analyze their mechanical behavior by experimentation.

1.7 MANUFACTURING PROCESSES OF COMPOSITE MATERIAL

Manufacturing of a composite fabric is to combine the polymeric gum framework with the fiber fortification. Since the introduction of the filaments is basic to the conclusion properties of the composite, fabricating preparation is most extreme imperative to adjust the filaments in wanted heading. A great fabricating handle will deliver a better, uniform fiber volume division alongside a better generation of a huge volume of parts financially and have repeatable dimensional tolerances. The composite fabrication strategies can be classified into two categories:

A. Open mould process

- a) Hand lay-up process
- b) Spray up process
- c) Vacuum-bag autoclave process
- d) Filament winding process

B. Closed mould process

- a) Compression moulding
- b) Injection moulding
- c) Sheet moulding compound (SMC) process
- d) Continuous pultrusion process

CHAPTER 2

LITERATURE SURVEY

- Anuppatil, CkCheparge “Fabrication and Characterizations of Natural Fiber Reinforced Polyester Composites” on IOSR journal of mechanical and civil engineering e-ISSN: 2278-1684, p-ISSN: 2320-334X PP: 64-70 [1]

This paper proposed that uni-directionally arranged natural fibers possess less strength than the fibers arranged in the mat forms. It is a generally accepted fact that the toughness of the fiber reinforced composite mainly depends on the stress-strain behavior. The impact strength of the coconut fiber bio-composites decreases with increase in filler content. Adding coconut shell upto 30% leads to increase in tensile strength. Thermoset polymers showed a good result with a variety of natural fibers systems due to its good spreading efficiency and the resultant improved adhesion. On may 2018, Asankabasanyake, Juan hidalgo stated that epoxies can have a glass temperature of up to 220°C, meaning that they can be safely used up to these temperatures. Epoxy resins can be kept in an uncured state for a long duration. In the present study, both untreated and alkali treated short fibers were used as reinforcement in unsaturated polymer resin composites. The alkali treatment was found to be effective in improving the tensile and flexural properties of fiber reinforced polymer resin.

- Naheed Saba, Chandrasekar Muthukumar, Rajini N “Mechanical Properties Evaluation Of Sisal Fiber Reinforced Polymer Composites: A Review” in construction and building material from science direct ISSN:713-729.

This review stated that Sisal fibers are obtained from decortications of sisal plant. Natural fibers has a number of advantages such as low density, bio- degradability, non-abrasive, non-toxicity which enable them to use as filler or reinforcement in the polymer composites. Adding in thermo sets, thermoplastics and biopolymer improves mechanical strength. Some of the factors influencing their mechanical properties are,

- Type of fiber used
- Type of matrix used
- Fiber-matrix adhesion
- Fiber dispersion
- Fiber orientation

The composites consist of a bulk material and a reinforcement of some kind, added primarily to increase the strength and stiffness of matrix. Thermosetting polymers are resins which change irreversibility into an infusible and insoluble material by formation of covalent cross-linked bond. Epoxy resins has certain limitation they are, Low transverse strength, Low operational temperature limits.

- M.asim, khalina abdan, jawaid m on FEB 2018 International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 03 | June-2015 p-ISSN: 2395-0072 [5]

This paper explained that extraction of pineapple fiber is done by using mechanical method and retting method. The pineapple fibers are of high mechanical properties when compared to other natural fibers. Epoxy possesses higher mechanical properties and more thermal and chemical resistance than other types of resin. Therefore, it has exclusive use in making aircraft components. Epoxy resin is also called polypeoxides. The reinforcing phase is the distribution phase in the composite. Many reinforcing materials were available such as the natural fiber, synthetic fiber, particle etc. The matrix phase is the continuous phase in the composite. It may be a polymer, metal or ceramic. Among these polymer is consider to be best by its mechanical and thermal properties. It is low cost and easy fabrication hence it is economical.

- Mp Todor, Bueli C, Heput Hindawi “Researches on the development of new composite material partially biodegradable using natural textile fiber” Publishing Corporation Journal of Materials Volume2013, ArticleID 297213, [6] on Dec 2017

The paper says that by including biodegradability, composites have been in which the filler fibers are bio reinforcement, most often vegetable fibers. It has been studied that, these composites in addition to waste, by reducing their deposited quantity we can maintain or improve the properties of polymer matrix and they can be recycled more favorably. For the composite development a compression molding is used. The pineapple leaf fiber is used as reinforcing phase and epoxy resin LY556 as matrix phase is used. A hardener HY951 is used for the composite development.

- Asheesh kumar and Anushman srivastava “Preparation and mechanical properties of jute fiber reinforced epoxy composites” Ind Eng Manage, Volume 6, Issue 4, 1000234 ISSN: 2169-0316 by on Nov 2017 [7]

This article says that Natural fiber bundle, straight configuration shows linear behavior up to some portion of the curve and the becomes non-linear at higher loads. The modes of failure in case of composites are,

- By tension
 - a. Breaking of fibers.
 - b. De-lamination of lamina
 - c. De-bonding of fiber from matrix
 - d. Fiber pull out
 - By compression
 - e. Buckling of fiber.
 - f. Crushing of matrix
-
- Bino Prince Raja D, Stanly Jones Retnam B, Mohini Shuka “Tensile, flexural and impact properties of glass fiber reinforced polymer matrix composites” in `International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue 11, November 2017, pp. 467–475, Article ID: IJMET_08_11_050 ISSN Print: 0976-6340 and ISSN Online: 0976-6359 [8]

This article proposed that Mechanical properties of fiber reinforced composites are depending upon the properties of the constituent materials type, quantity, fiber distribution and orientation. Recently the efforts to reduce the weight of automobiles by the increased use of plastics and their composites

- Yogesh M, Hari Rao A N “Study on pineapple leaves fiber and its polymer based composites:” on Oct 2015 in International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 03 | June-2015 p-ISSN: 2395-0072 [8]

This review paper presents that Pineapple leaf fiber has a major problem related to adhesion with many polymer matrices. PALF contains waxy substance on surface causing low surface tension which negatively affects the bonding polymer matrix. Modification methods like alkali treatment, cyanoethylation, dewaxing are done to improve the surface properties.

- Tushar Sona, Shirish Patil “Natural Fiber Reinforced Polymer Composite Material”, in May 2015 at IOSR journal of mechanical and civil engineering e-ISSN: 2278-1684, P-ISSN: 2320-334X PP: 142-147[9].

This review states that the thermosetting polymers are cross linked polymers, formed by condensation polymerization. These polymers become permanently hard when heat is applied and do not softened upon subsequent heating. The mechanical and physical property of natural fiber depends on the chemical composition and structural composition, fiber type and growth condition. The properties of natural fibers are comparable to glass fibers due to their low density, the specific properties, strength and stiffness.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The natural fibers have to be successfully reinforced with the epoxy resin by simple wet hand lay-up technique. The aim of this project is to find the tensile, impact strength of natural fibers reinforced hybrid-composites. The fibers like sisal and jute are to be successfully used to fabricate hybrid composites with varying the fiber percentage. The obtained hybrid composite produced with natural fibers as reinforcements should give good mechanical properties as compared with pure matrix material. These hybrid-composite can be used in Aerospace and automobile applications. To prove the concept of using hybrid natural fibers is viable for helmet application. However, there is a scope to optimize the volume fraction of natural fibers as reinforcements to achieve enhanced mechanical properties of the helmet. So, aim is to indicate that reinforcement of hybrid natural fibers have good and comparable mechanical properties as conventional composite materials.

3.2 SCOPE

Presently, the most markets for bio composites are within the development and car segments. With assist improvements and enhancements in execution, be that as it may, unused openings and applications will likely arise. Noteworthy openings are likely to happen within the built environment as this segment is mindful for creating colossal volumes of squander at a time when the natural effect of businesses is coming beneath near examination.

For example, unused, 'environmentally friendly' materials are required for off- location development strategies, moving forward quality and ease of establishment and construct. In any case, these openings may be hampered by controls based on existing materials. A specific zone that gives significant potential for development is within the substitution of additive treated wood. The presentation of more tightly confinements on the utilize of certain additives most eminently those containing

arsenic, presents an opportunity for bio- composites items in applications where there's a tall hazard of biological attack. In expansion to this, advancements within the mechanical execution of existing biocomposites⁹⁰ through, for case, the presentation of modern fiber types, processing and added substances may result in an extension in their utilization into more differing, and in fact requesting, application regions. A zone of note in this regard is the continuous investigation into dissolvable turning of fluid crystalline cellulose, which looks promising for creating high-strength filaments. Biotechnology is being utilized to adjust and/or increment the surrender of particular triglycerides and oils in crops for producing resins. These tars will moreover be reasonable compared with those accessible nowadays and, in case appropriately adjusted, may be biodegradable. Investigate is additionally being conducted at different inquiries about research facilities to create modern pathways to synthesize reasonable biodegradable tars with superior mechanical properties. Once completely created, these tars and high-strength filaments hold incredible guarantee for supplanting numerous of the manufactured progressed composites right now in use. There are too openings for half breed materials and items by, for illustration, utilizing bio tars and bio plastics as cements input of current fossil-based adhesives. There are moreover great prospects for utilizing recovered fiber from items such as MDF (medium thickness fiberboard) or other squander streams from the mash and paper industry to fabricate a run of cost-effective and naturally successful materials and items. Whereas there's sufficient opportunity for these items to enter unused markets and discover unused application, it is fundamental that advantage in terms of fetched sparing be highlighted and a more grounded commercial case for these materials be made.

CHAPTER 4

MATERIALS AND METHODS

This chapter describes the subtle elements of preparing of the composites and the experimental procedures taken after for their mechanical characterization. The crude materials utilized in this work are

4.1 MATERIALS USED

- ❖ Epoxy resin (LY-556)
- ❖ Hardener(HY-951)
- ❖ Natural Fibers (Sisal and Jute mat)
- ❖ NaOH Solution

4.1.1 Epoxy resin (LY-556)

Features of Epoxy

- Light weight
- Resists most alkalis and acids
- Resists stress cracking
- Retains stiffness and flexibility
- Low moisture absorption
- Non-staining
- Easily fabricated

Applications of Epoxy

- Structural applications
- Industrial tooling and composites
- Electrical system and electronics

4.1.2. Hardener (HY-951)

Hardener is a curing operator for epoxy or fiberglass. Epoxy resin requires a hardener to start curing; it is additionally called a catalyst, the substance that solidifies the cement when blended with gum. It is the particular selection and combination of the epoxy and hardener components that decides the ultimate characteristics and reasonableness of the epoxy coating for a given environment.

4.1.3. Natural fibers such as Sisal/ Jute mat

Fiber-reinforced polymer composites have played a dominant part for a long time in an assortment of applications for their tall particular quality and modulus. The fabricate, utilize and removal of customary fiber–reinforced plastic, as a show made of glass, carbon or aramid fibers–reinforced thermoplastic and thermoset tars are considered fundamentally since of natural issues. By natural fiber composites we cruel a composite fabric that's fortified with filaments, particles or platelets from characteristic or renewable assets, in differentiate to for illustration carbon or aramid fibers that ought to be synthesized

4.1.4 Advantages of Natural Fibers

Comparing to conventional reinforcing strands like glass, carbon and Kevlar, normal natural fibers have the following advantages:

- Environmentally friendly
- Fully biodegradable
- Non toxic
- Easy to handle
- Nonabrasive during processing and use
- Low density/light weight
- Source of income for rural/agricultural community
- Renewable, abundant and continuous supply of raw materials
- Low cost

- Free from health hazard (cause no skin irritations)
- High toughness
- Good thermal properties

Properties of Natural Fiber:

Table 3.1: Properties of natural fiber

Plant Fibers	Density (Kg/m ³)	Tensile Strength (MPa)	Young's Modulus (GPa)
Jute Fiber	1300-1500	200-450	20-55
Sisal Fiber	1300-1500	80-840	9-22

4.1.5. NaOH Solution

Sodium Hydroxide (NaOH) is a alkaline solution used to enhance the surface morphology of natural fibers

4.2. METHODOLOGY

4.2.1. Selection of matrix material

Epoxy LY-556 having a place in the Epoxide family was taken as the framework. HY 951 was utilized as the hardener.

4.2.2 Selection of reinforcement and Natural fibers

Natural filaments such as Sisal, Coconut coir, Areca nut, Edge gourd and Tamarind were taken to fill as fortifications within the Polymer composite.

4.2.3 Extraction of fibers

Sisal Fiber:

- Sisal is commercially available.

- Sisal may be a characteristic fiber (Logical title is *Agave sisalana*) of Agavaceae (Agave) family yields a hardened fiber customarily utilized in making twine and rope.
- Sisal is completely biodegradable and exceedingly renewable resource.
- Sisal fiber is outstandingly tough and a moo upkeep with negligible wear and tear.



Fig 4.1: Sisal Fiber

Jute Mat Fiber:

- Jute may be a long, delicate, sparkly plant fiber that can be spun into coarse, strong threads. It is created from plants within the class *Corchorus*.
- Jute is one of the cheapest characteristic strands, and is moment as it were to cotton in sum created and assortment of uses.
- Jute strands are composed primarily of the plant materials cellulose and lignin. Jute may be a blustery season edit, developing best in warm, muggy climates.
- It is 100% biodegradable & recyclable and hence environment friendly.

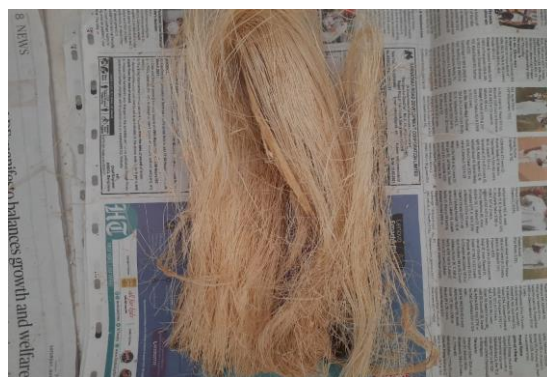


Fig 4.2: Jute Fiber

4.2.4 Surface treatment of fibers

Freshly drawn strands by and large incorporate parts of pollutions that can unfavorably influence the fiber lattice bonding. Thus the composite fabric made from such strands may not have palatable mechanical properties. Hence it is alluring to dispense with the pollution substance of the filaments and maybe improve the surface geology of the filaments to get a more grounded fiber-matrix holding. The filaments were cleared out to treat with 5% NaOH for 3-4 hrs. Later they were drawn and dried under sunlight for 1-2 hours.



(a) 5% NaOH solution



(b) Fibers in NaOH solution



(c) Water Treatment



d) Drying at room temperature

Fig 4.3: Surface Treatment with NaOH

4.2.5 Wet Hand lay-up technique

Hand lay-up procedure is the best strategy of composite handling. The infrastructural requirement for this strategy is additionally negligible. The preparing steps are very basic. To begin with, a discharge gel is showered on the shape surface to maintain a strategic distance from the staying of polymer to the surface. Lean plastic sheets are utilized at the beat and foot of the shape plate to urge great surface wrap up of the item. Support within the frame of woven mats or chopped strand mats are cut as per the form measure and put at the surface of shape after Perspex sheet. At that point thermosetting polymer in fluid frame is blended completely in suitable extent with a endorsed hardener (curing specialist) and poured onto the surface of mat already put within the mold.

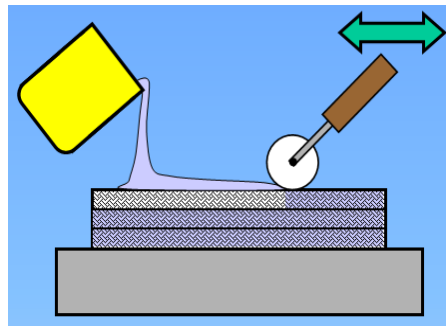


Fig 4.4: a) Schematic Diagram of hand lay-up process.

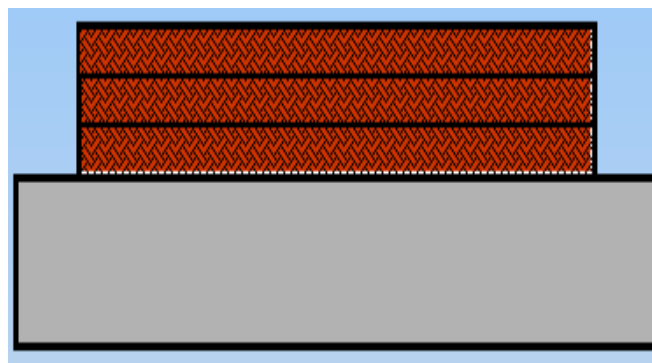


Fig 4.4: b) Orientation of fiber layers

The polymer is consistently spread with the assistance of brush. Moment layer of tangle is at that point set on the polymer surface and a roller is moved with a mellow weight on the mat-polymer layer to expel any discuss caught as well as the excess polymer display. The method is rehashed for each layer of polymer and tangle, till the specified layers are stacked. After setting the plastic sheet, discharge gel is splashed on the internal surface of the best form plate which is at that point kept on the stacked layers and the weight is connected. After curing either at room temperature or at a few particular temperatures, form is opened and the created composite portion is taken out and further processed. The schematic of hand lay-up is appeared in figure 1. The time of curing depends on sort of polymer utilized for composite handling. For illustration, for epoxy based framework, ordinary curing time at room temperature is 24-48 hours. This strategy is basically appropriate for thermosetting polymer based composites. Capital and infrastructural requirements less as compared to other strategies. Generation rate is less and tall volume division of support is troublesome to realize within the prepared composites. Hand lay-up strategy finds application in numerous zones like aircraft components, automotive parts, pontoon frames, diase board, deck etc.

SAMPLES 1 AND 2:

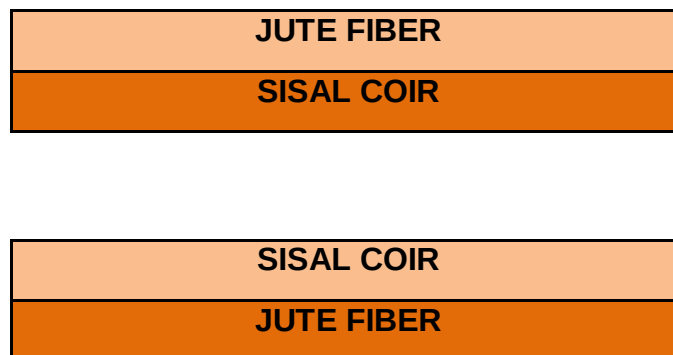


Fig 4.5: Samples with varying composition

4.3 FABRICATION OF HELMET

To get the composite material into shape we got to have a mould.so we took a helmet to perform mould making process on it.

4.3.1 Materials used for mould making

- Gelcoat
- Epoxy
- Mould release
- MEKP catalyst
- Glass fiber
- Brushes
- Steel roller

4.3.2 Procedure of mould making

- We applied mould release gel on the surface of a helmet so that the gelcoat won't stick to it.
- A mixture of 200g of gelcoat with 2 percent catalyst is applied on the helmet.
- And we added 200g of resin with 2 grams of catalyst.
- Now we stuck chopped glass fibers along with prepared resin on the surface of the helmet.
- After letting it treat for a few hours demoulding (removing the helmet from the mould formed) is done.



Fig 4.6: Helmet mould

4.3.3 Helmet making

By adopting hand layup technique we carried out the process of fabricating a helmet. Initially we applied release gel in the inner shell of the mould and applied some paint after. Now along with epoxy resin we laid out chopped fibers of sisal and jute. And once again applied epoxy on top of it for better surface finishing. After letting it cure for 5-6 hours mould is released, now on the formed well cured helmet, the extra projections are cut down and the irregularities are smoothed out by sandpaper.



Fig 4.7: Sticking fiber into the mould



Fig 4.8: After separating helmet from mould

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 SPECIMEN PREPARATION AS PER ASTM STANDARDS

Table 5.1: ASTM Standards for sample dimensions

Sl. No	ASTM Code	Mechanical Test	Sample Dimensions (mm)
1	ASTM-D638M	Tensile	65x19x3
2	ASTM-D256	Impact	65×12.5×3

5.2 MECHANICAL TESTING OF COMPOSITE LAMINATES

Mechanical Testing of Composite Laminates Mechanical properties such as Universal tensile strength(UTS), Young's modulus, Flexural strength (FS), Flexural modulus, Inter laminar shear quality (ILSS) of carbon and glass fiber fortified vinyl ester composites are computed from the test conducted utilizing all inclusive universal testing machine (UTM) (Fig 5.2) in understanding to ASTM guidelines for example arrangement. The 10 ton capacity UTM machine is from ordnance factory Hyderabad. UTM Details are appeared in **Table 5.2**.

Table 5.2: Specifications of Universal Testing Machine

Parameter	Specifications
Capacity	10 tones
Load frame	Mild steel C channel with double ball screw mechanism preloaded ball screw with zero backlash covered with bellow
Mounting	Free standing
Load range	1 kg-1000 kg using 1 ton load cell 1 kg-10000 kg using 10 ton load cell

Length measurements	Rotary encoder mounted on to the screw rod
Length resolution	0.01 mm
Cross head speed	0.1 to 100 mm/min
Controls	Emergency off, up and down key
Input power	220V $\pm$ 10% VAC,50 HZ,1500 VA
Net weight	225 kg
Grippers	Tensile, Compression, Three point Bending
Length accuracy	$\pm$ 0.1 mm

5.2.1 Tensile testing of composite

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the flat type. During the test a uniaxial load is applied through both the ends of the specimen. Dog bone shaped tensile test specimens were made in accordance with ASTM-D 638M to measure the tensile properties. Typical points of interest when testing a material include: ultimate tensile strength (UTS) or peak stress; offset yield strength (OYS) which represents a point just beyond the onset of permanent deformation; and the rupture (R) or fracture point where the specimen separates into pieces. The tensile test is performed in the universal testing machine (UTM) Instron 1195 and results are analyzed to calculate the tensile strength of composite samples. The tensile values of specimens with different fiber volume fraction are taken.



Fig 5.1: Universal testing machine

Table 5.3: Tensile strength results

Specimen	Tensile Strength (Mpa)
Sample1	7.2
Sample2	6.5

5.2.2 Impact Strength Testing of Composites

ASTM D 256: Standard test method for impact properties of polymer matrix composites. Izod affect quality of composite tests is assessed as per ASTM D256, utilizing Affect Testing Machine provided by Universal Types of gear, Mumbai, India

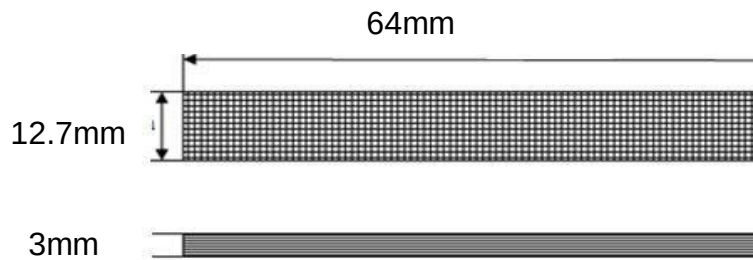


Fig 5.2: Specimen Dimensions

The test example geometry as indicated within the over standard for adjust symmetric glass and carbon fiber (0/90) composites are 64 mm long $\times$ 12.7 mm wide $\times$ 3 mm thick. The Izod test examples are clamped in an upright position so that the conclusion of the example confronted its striking edge and affect vitality ingested for breaking the example is straight forwardly.

The taking after tables gives the points of interest of the Affect test comes about gotten for different combinations of Normal strands reinforced bio-composites.

Izod impact test specimens were prepared in accordance with ASTM D256-97, to measure the impact strength. The specimens are prepared to dimensions of 64 x 12 x 9 mm width. A V-notch is provided having an included angle of 45° at the centre of the specimen and 90° to the sample axis. The depth of the notch is 2mm. the samples were fractured in plastic impact testing machine and the impact strength of the sample specimen have been evaluated. Table shows the impact values of two sample specimen with different fiber volume fraction.

Table 5.4 : Impact test result

Specimen	Impact Strength (Joules)
Sample1	8.7
Sample2	6.9



Fig 5.3: Impact testing machine

5.2.3 Hardness testing of composites

Abrasive wear or erosion and thermal deformation are caused by reduced hardness of the material therefore it is important to identify the sample with greater hardness. The two samples as per ASTM standard (ASTM D2240) are subjected to Hardness test using Shore D Micro hardness tester. Each sample was tested at three locations with the specimen being subjected to a load of 0.5 kg for a dwell time of 10 seconds for each location. The hardness values of two sample specimens with different fiber volume fraction are taken.

Table 5.5: Hardness test results

Specimen	Hardness (shore D scale)
Sample1	67.5
Sample2	63.4



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NO. OFMK/ML-11/20-21, Date: 03.03.2021.
Report No: 359 ULR-TC546721000000133F

TEST REPORT

Test requisition No. : 01/20-21, Dtd: 01.03.2021.
Description / Size: : Bio composite fiber laminated samples
Specification/ Grade : Bio Composite material
Date of Receipt : 01.03.2021
Test method : ASTM-D638M for Tensile testing, ASTM D256-97 for Impact testing and ASTM D2240 for Shore D hardness testing.

Test Results:

Sample ID	UTS Mpa	Impact (Joules)	Hardness (Shore D scale)
Sample-I	7.2	8.7	67.5
Sample-II	6.5	6.9	63.4

Remarks:

1. Above results relate to samples received at lab.
2. Samples will be retained for a period of six months from the date of issue of this report unless demanded back by the client.
3. This report shall not be re produced without written approval from the Laboratory except in full.
4. Date of test is between the date of receipt of indent & report.

Authorized Signatory



CHETAN VILAS CHAVAN
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Government of India
Ministry of Defence
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Yeddumailaram - 502 205
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Fig 5.4: Results certificate

By comparing our results with that of synthetic based fibers, we can say that we have achieved more or less the same results in terms of strength while having lower density along with the advantages like having greater stiffness and specific strength, more resistant to corrosion, better recyclability, more absorption capacity and environmental friendly. The energy consumed in processing the natural fibers is much lower than that of glass fibers .For example energy required to produce natural fiber from flax is about 17% of the energy required for the same quantity of glass fiber.

Natural fiber composites have higher fiber content for equivalent performance, reducing more polluting base polymer content. The light weight natural fiber composites improve fuel efficiency and reduce emissions in the use phase of the component, especially in auto applications.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

- The natural fibers have been effectively fortified with the epoxy gum by straightforward damp hand lay-up procedure. The point of this venture is to discover the tensile, hardness and impact affect quality of common fiber reinforced bio-composites.
- The fibers like jute fibers, sisal fibers were successfully used to fabricate bio-composites with varying the fiber percentage.
- The new hybrid composite created with characteristic filaments as fortifications gives great mechanical properties as compared with unadulterated lattice fabric. These hybrid bio-composite can be utilized in Aerospace and automobile applications.

6.2 CONCLUSION

In the present work, bio-composite with different normal strands such as jute strands, sisal strands have been effectively strengthened with the epoxy tar by basic and reasonable hand lay-up procedure. The mechanical testing of manufactured bio composite head protectors demonstrates that, concept of utilizing numerous characteristic filaments is reasonable for helmet application. Be that as it may, there's a scope to optimize the volume fraction of characteristic strands as fortifications to realize upgraded mechanical properties of the helmet.

So, it clearly demonstrates that support of characteristic strands have great and comparable mechanical properties as conventional composite materials.

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