# MECHANICAL AND CORROSION PROPERTIES OF HYBRID SISAL FIBRE/ COTTON FIBRE/COCONUT SHEATH REINFORCED POLYMER COMPOSITES

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***Abstract*— Natural fibres seem to be a good alternative since they are readily available in fibrous form and can be extracted from plant leaves, fruit and stem at very low cost. Natural fibres have the potential to be used as reinforcement to overcome the inherent deficiencies in polymer materials. In recent years, there has been sustained interest in utilizing natural fibres in polymer composites and in manufacturing products based on them with a view to have alternative materials which are energy efficient, economical and eco-friendly.**

**Hybrid composite Materials have extensive engineering application where strength to weight ratio, low cost and ease of fabrication are required. Hybrid composites provide combination of properties such as tensile modulus, compressive strength and impact strength which cannot be realized in composite materials. In recent times hybrid composites have been established as highly efficient, high performance structural materials and their use is increasing rapidly. Hybrid composites are usually used when a combination of properties of different types of fibres have to be achieved, or when longitudinal as well as lateral mechanical performances are required. The investigation of the novel applications of hybrid composites has been of deep interest to the researchers for many years as evident from reports. The main objective of this project is to fabricate the hybird natural fibre reinforced polymer composites and analyzing the mechanical and corrosion properties of hybrid sisal fibre/coconut sheath/cotton fibre reinforced polymer composites.**

***Keywords: polyester composite, palmyra fiber .***

## I. INTRODUCTION

### 1.1.1 COMPOSITES

**Composite materials**, often shortened to **composites** or called **composition materials**, are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct at the macroscopic or microscopic scale within the finished structure.

The very common example would be disc brake pads, which consists of hard ceramic particles embedded in soft metal matrix. Those composites closest to our personal hygiene form our shower stalls and bathtubs made of fibre glass. Imitation granite and cultured marble sinks and countertops are widely used. The most advanced examples perform routinely on spacecraft in demanding environments.

A composite is created by combining different materials to create a new one. A rudimentary example would be mixing mud and straw and forming it into a brick shape to make adobe bricks. It takes two materials which, by themselves wouldn't usually be used for the same purpose as they are when combined into a composite material for building. In construction trades, concrete would be a slightly more complex composite of stone mixed with cement. If you add re-bar (strong steel rods), it becomes a three-phase composite that adds both strength and flexibility. In engineering, an engineer may design something that is under certain stresses that require the uses of a material that is a composite (either because conventional material can't meet the stress demands or could be too heavy for the purpose it has been designed)

### 1.1.2 Classification of Composites

Composite materials are commonly classified at following two distinct levels:

- The first level of classification is usually made with respect to the matrix constituent. The major composite classes include Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). The term organic matrix composite is generally assumed to include two classes of composites, namely Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon-carbon composites.
- The second level of classification refers to the reinforcement form - fibre **reinforced composites**, **laminar composites** and **particulate composites**. Fibre Reinforced composites (FRP) can be further divided into those containing discontinuous or continuous fibres.
- **Fibre Reinforced Composites** are composed of fibres embedded in matrix material. Such a composite is considered to be a discontinuous fibre or short fibre composite if its properties vary with fibre length. On the other hand, when

the length of the fibre is such that any further increase in length does not further increase, the elastic modulus of the composite, the composite is considered to be continuous fibre reinforced. Fibres are small in diameter and when pushed axially, they bend easily although they have very good tensile properties. These fibres must be supported to keep individual fibres from bending and buckling.

- **Laminar Composites** are composed of layers of materials held together by matrix. Sandwich structures fall under this category.
- **Particulate Composites** are composed of particles distributed or embedded in a matrix body. The particles may be flakes or in powder form. Concrete and wood particle boards are examples of this category.

- ***This project concentrate on Fibre Reinforced Polymer Matrix Composite***.

### 1.1.3 FIBRE REINFORCED COMPOSITES

Fibre-Reinforced composites materials consist of fibres of high strength and modulus embedded in or bonded to a matrix with distinct interfaces between them. In this form, both fibres and matrix retain their physical and chemical identities. Yet they produce a combination of properties that cannot be achieved with either of the constituents acting alone. In general, fibres are the principle load carrying members, while the surrounding matrix keeps them in the desired location, acts as a load transfer medium between them, and protects them from environmental damages due to elevated temperatures and humidity.

For example: The most common form in which composites are used in structural application is called as laminates. It is obtained by stacking a number of thin layers of fibres and matrix, and consolidating them into the desired thickness.

Fibres orientation in each layer as well as the stacking sequence of various layers can be controlled to generate a wide range of physical and mechanical properties for the composite laminates.

## 1.2 GENERAL CHARACTERISTICS

Many fibre–reinforced polymers offer a combination of strength and modulus that are either comparable to or better than many traditional metallic materials. Because of their low density, the strength-weight ratios and modulus-weight ratios of these composite materials are clearly superior to those of metallic materials. In addition, fatigue strength as well as fatigue damage tolerance of many composite laminates are excellent. For these reasons, fibre reinforced polymers have emerged as a major class of structured materials and are either used or being considered for use as substitution for metals in many weight–critical components in aerospace, automotive and other industries.

Traditional structure metals, such as steel and aluminium alloys are considered isotropic, since they exhibit equal or nearly equal properties irrespective of the direction of measurement. In general, the properties of a fibre -reinforced composite depend strongly on the direction of measurement, and therefore, they are not isotropic materials. For example, the tensile strength and modulus of a unidirectional oriented fibre-reinforced polymer are maximum when these properties are measured in the longitudinal direction of fibres. At any other angle of measurement, these properties are lower. The minimum value is observed when they are measured in the transverse direction of fibres, that is, at 90 degree to the longitudinal direction. Similar angular dependence is observed for other mechanical and thermal properties, such as impact strength, coefficient of thermal expansion (CTE), and thermal conductivity. Bi- or multidirectional reinforcement yields a more balanced set of properties. Although these properties are lower than the longitudinal properties of a unidirectional composite, they still represent a considerable advantage over common structural metals on a unit weight basis.

## 1.3 MATERIALS

Major constituents in a fibre-reinforced composite material are the reinforcing fibres and matrix, which act as a binder for the fibres. Other constituents that may also be found are coupling agents and coatings are applied on the fibres to improve their wetting with the matrix as well as to promote bonding across the fibre-matrix interface. Both in turn promote a better load transfer between the fibres and the matrix. Fillers are used with some polymeric matrices. Primarily to reduce cost and improve their dimensional stability. Manufacturing of a composite structure starts with the incorporation of a large number of fibres into a thin layer of matrix to form a lamina (ply). The thickness of a lamina is usually in the range of 0.1-1mm. If continuous (long) fibres are used making the lamina they may be arranged either in unidirectional orientation (i.e., all fibres in one direction), in a bidirectional orientation (i.e., fibres in two directions, usually normal to each other), or in a multidirectional orientation (i.e., fibres in more than two directions). The figure 1 shows different orientations of fibre. The bi-or multidirectional orientation of fibres is obtained by weaving or other process used in the textile industry. For a lamina containing unidirectional fibres, the composite material has the highest strength and modulus in the longitudinal direction of the fibres. However, in the transverse direction, its strength and modulus are very low. For a lamina containing bidirectional fibres, the strength and modulus can be varied using different amounts of fibres in the longitudinal and transverse directions. A lamina can also be constructed using discontinuous (short) fibres in a matrix. The discontinuous fibres can be arranged either in unidirectional orientation or in random orientation. Discontinuous fibre-reinforced composites have lower strength and modulus than continuous fibre composites. However, with random orientation of fibres it is possible to obtain equal mechanical and physical properties in all directions in the plane of the lamina. The thickness required to support a given load or to maintain a given deflection in a fibre reinforced composites structure is obtained by stacking several laminas in a specified sequence and then consolidating them to form a laminate. Various laminas in a laminate may contain fibres either all in one.

## 1.4 FIBRES

Fibres are the major constituent in a fibre reinforced composite material. They occupy the largest volume fraction in a composite laminate and share the major portion of the load acting on a composite structure. Proper selection of fibre type, amount and orientation of fibres is a very important. It influences the following characteristics of a composite laminate.

- Specific gravity
- Tensile strength and modules
- Fatigue strength and fatigue failure mechanism
- Compressive strength and modules
- Electrical and thermal conductivities
- Cost
- High strength and stiffness retention
- Light weight/parts consolidation
- Resistance to environmental factors
- Fire performance of composites

## 1.5 CLASSIFICATION OF FIBRES

In general, fibres are classified into two types.

1. Man-made fibres
2. Natural fibres

### 1.5.1 MAN-MADE FIBRES

Man-made fibres may come from natural raw materials or synthetic chemicals. Many types of fibres are manufactured from natural cellulose, including rayon; modal and the more recently developed Lyocell. Cellulose based fibres are of two types, regenerated or pure cellulose such as from the cupro-ammonium process and modified cellulose such as cellulose acetates.

Examples

1. Glass fibres
2. Carbon fibres
3. Kevlar 49 fibres
4. Boron fibres
5. Ceramic fibres

**Glass Fibres**

Glass fibres are the most common of all reinforcing fibres for polymeric matrix composites (PMC). Glass fibres are of two types. They are E-Glass and S-Glass .The principle advantages of glass fibres are low cost, high tensile strength, high chemical resistance, and excellent insulating properties. The disadvantages are relatively low tensile modulus and high density (among the commercial fibres), sensitivity to abrasion during handling (which frequently decreases its tensile strength), relatively low fatigue resistance, and high hardness (which causes excessive wear on molding dies and cutting tools).

**Carbon Fibres**

Carbon fibres are commercially available with a variety of tensile modulus ranging from 207 Gpa to 1035 Gpa. Their advantages are high tensile strength, very low coefficient of linear thermal expansion and high fatigue strength. Their disadvantages are of low impact resistance and high electrical conductivity. They are mainly used in the aerospace industries.

**Kelvar 49 Fibres**

A Kelvar 49 fibre belongs to highly crystalline aramid fibres that have the low specific gravity and the highest tensile strength to weight ratio among the current reinforced fibres. These are mainly used in the marine and aerospace industries. They also have negative coefficient of thermal expansion. This leads to the designing of composite printed circuit boards.

**Boron Fibres**

The most prominent feature of boron fibre is their extremely high tensile modulus, which is in the range of 379-414Gpa (55-603106psi).Coupled with their relatively large diameter, boron fibres offer excellent resistance to buckling, which is

even higher than of many forms of carbon fibres .For this reason, its use is at present restricted to a few aerospace applications.

**Ceramic Fibres**

Silicon carbide (sic) and aluminium oxide ($Al2O3$) fibre are examples of ceramic fibres notable for their high temperature applications in metal and ceramic matrix composites .Their melting points are 28308 c and 20458 c, respectively. Silicon carbide retains its strength retention up to about 13708 c. Both fibres are suitable for reinforcing metal matrices in which carbon and boron fibres exhibit adverse reactivity. Aluminium oxide fibres have lower thermal and electrical conductivities and have coefficient of thermal expansion than silicon carbide fibres.

### 1.5.2 NATURAL FIBRES

Examples of natural fibres are jute, flax, hemp, remi, sisal, coconut fibre (coir) and banana fibre (abaca).All these fibre are grown as agricultural plants in various parts of the world and are commercially used for making ropes, carpet backing ,bags and so on .The components of natural fibres are cellulose micro fibrils dispersed in an amorphous matrix of lignin and hemicellilise. Depending on the type of the natural fibre, the cellulose content is in 60-80wt% and the lignin content is in the range of 5-20 wt%.

**Coir (Coconut fibre)**

Coconut fibre is obtained from the husk of the fruit of the coconut palm. The trees can grow up to 20 m, making harvesting a difficult job. People or trained monkeys climb the tree to pick the nuts, or a pole with an attached knife is used. The fruits are dehusked with on a spike and after retting, the fibres are subtracted from the husk with beating and washing.

The fibres are strong, light and easily withstand heat and salt water. After nine months of growth, the nuts are still green and contain white fibre, which can be used for the production of yarn, rope and fishing nets. After twelve months of growth, the fibres are brown and can be used for brushes and mattresses.
Fig 2.shows the Coconut fibre.

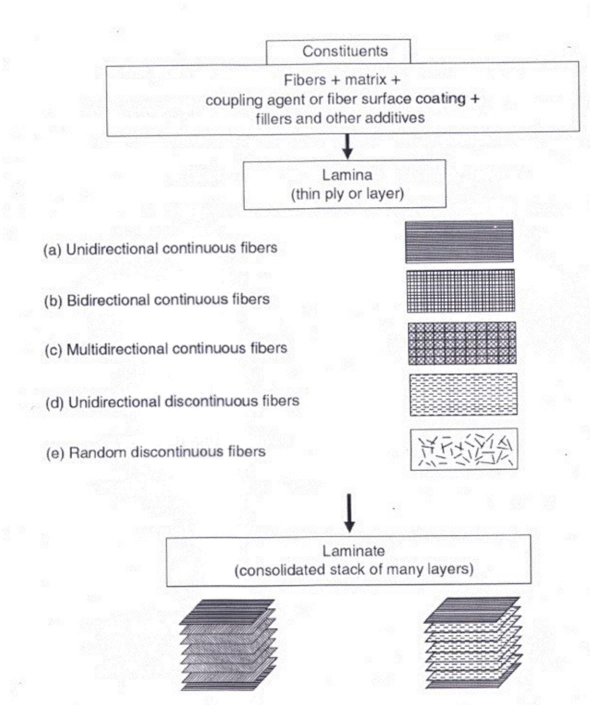



Fig:1 & 2 Basic building blocks in fibre Reinforced composites,

Coconut fibre

**Sisal**

The plants look like giant pineapples and during harvest the leaves are cut as close to the ground as possible. The soft tissue is scraped from the fibres by hand or machine. The fibres are dried and brushes remove the remaining dirt, resulting in a clean fibre.Sisal produces sturdy and strong fibres that are very well resistant against moist and heat. It is mainly used for ropes, mats, carpets and cement reinforcement.Fig:3 shows sisal Fibre

Fig:3 Sisal Fibre

**Jute**

The fibres are extracted from the ribbon of the stem. When harvested the plants are cut near the ground with a sickle shaped knife. The small fibres, 5 mm, are obtained by successively retting in water, beating, stripping the fibre from the core and drying. Due to its short fibre length, jute is the weakest stem fibre, although it withstands rotting very easily. It is used as packaging material (bags), carpet backing, ropes, yarns and wall decoration.Fig:4 shows Jute Fibre

Fig:4 Jute Fibre

**Cotton**

Cotton is world-wide one of the most important fibres used in the textile industry. Picking is highly labour-intensive, and on large scale is often carried out by machine. In many parts of the world, however, picking is carried out by hand. The picked cotton, so called ‘cotton wool’ is baled. The seeds, dead leaves and other debris are removed by ginning. The clean cotton is baled again and is ready to be spun. In comparison with other natural fibres, Cotton is rather weak. It can absorb moist up to 20% of its dry weight, without feeling wet and is also a good heat conductor. Cotton is applied for the manufacturing of clothes, carpets, blankets, mobs and medical cotton wool.Fig:8 shows Cotton Fibre

Fig:5 Cotton Fibre

**1.6 MATRIX**

The role of matrix in a fibre reinforced composites are

1. To transfer stresses between the fibres
2. To provide a barrier against an adverse environment
3. To provide the surface of the fibres from mechanical abrasion

The matrix plays a minor role in the tensile load carrying capacity of a composite structure. However, selection of a matrix has a major influence on the inter-laminar shear as well as in plane shear properties of the composite materials. The inter-laminar shear strength is an important design consideration for structure under bending loads, where as the plane-shear strength is important under torsion loads

The matrix provides lateral support against the possibility of fibre buckling under compression loading, thus influencing to some extent the compressive strength of the composite materials. The interaction between fibres and matrix is also important in designing damage tolerant structures.

**1.7 TYPES OF MATRIX**

The various types of matrices are as follows:

1. Polymeric Matrix
   - Thermoplastic polymers
   - Thermo set polymers
2. Ceramic Matrix
3. Metal Matrix

**1.7.1. Polymeric Matrix**

A polymer is defined as a long chain molecule containing one or more repeating units of atoms, joined by strong covalent bonds. A polymeric material is a collection of a large number of polymer molecules of similar chemical structure. In the solid state, these molecules are frozen in space either in a random fashion or in a mixture of random and orderly fashions.

However, on a sub microscopic scale, various segments in a polymer molecule may be in a state of random excitations. The frequency, intensity and number of these segmental monitors increase with increasing temperature, giving rise to the temperature dependant properties of a polymeric solid.

Materials used in polymeric matrix are;

1. Thermo set polymer (resins).
2. Epoxies principally used in aerospace and aircraft applications.
3. Polyester, vinyl ester: Commonly used in automobile, marine applications
4. Phenolic, used in bulk moulding compounds, polyamides, polyberzimidozoles (PBI), polphenol-quinoxialine (PPQ) for high temperature, used in aerospace applications.

**Thermo set and Thermoplastic Polymers**

Polymers are divided into broad categories, Thermoplastics and Thermo sets. In a thermo polymer, individual molecules are linear in structure with no chemical linking between them. They are held in a place by weak secondary bonds such as Vander walls bonds and hydrogen bonds, with the applications of heat and pressure.

These inter molecule bonds in a solid thermoplastic polymer can be temporarily broken and the molecules can be moved relative to each other to flow into new position, restoring the secondary bonds between them and resulting in a new solid shape. Thus the thermoplastic polymer can be heat softened, melted and reshaped as many times as desired.

In a thermo set polymers, the molecules are chemically joined together by cross links, forming a rigid and three dimensional network structure. Once these cross links are formed during the polymerization reaction the thermo set polymer cannot be melted and reshaped by the application of heat and pressure. However if the number of cross links are low it may still be possible to soften them at elevated temperature.

### 1.7.2 Ceramic Matrix

The most common ceramic fibres are silicon carbide and aluminium oxide. Silicon carbide retains its strength well above 650 degree Celsius and aluminium oxide has excellent strength extension up to 1370 degree Celsius both fibres are suitable for reinforcing metal matrices in which carbon and boron fibres exhibit adverse reactivates.

### 1.7.3 Metal Matrix

Metal matrix has the advantage over the polymeric matrix in application requiring a long-term resistance to serve environments, such as high temperature. The yield strength and modulus of most metal are higher than those polymers, which is an important consideration for application requiring high transverse strength and modulus as well as compressive strength for the composite.

Another advantage of using metals is that they can be plastically deformed and strengthened by a variety of thermal and mechanical treatments. However, metals have a number of disadvantages namely they have high specific gravity, high melting points and a tendency towards corrosion at the fibre/matrix interface. The two commonly used metal matrices are based on aluminium and titanium. Both of these metals have comparatively low specific gravities and are available in a variety of alloy form.

***This project concentrates on polymer matrix composites***

## 1.8 MANUFACTURING METHODS OF COMPOSITES

There are many methods available for manufacturing composite material. Some of the advanced methods are discussed in this chapter. The most common methods by which the composites of various types are explained below.

1. Pultrusion process
2. Resin transfer moulding process
3. Hand lay-up technique
4. Compression moulding process

### 1.8.1 Pultrusion Process

Fibres are pulled from a creel through a resin bath and then through a heated die. The die completes the impregnation of the resin content in the fibre and cures the material into its final shape as it passes through the die. This cured profile is then automatically cut down to required length. Fabrics may also be introduced into the die to provide fibre direction other than at zero degree. Although Pultrusion is a continuous process, producing a profile of constant cross section, a variant known as 'pulforming' allows for some variation to be introduced into the cross section. Epoxy, phenyl polyester and vinyl esters are some of the available resins to be used as matrix material.

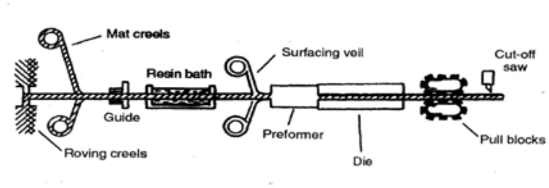



Fig: 6 Pultrusion process

**Advantages**

1. Very fast and economic way of impregnating and curing materials.
2. Resin content can be accurately controlled.
3. Fibre cost is minimized since the majority is taken from a creel.
4. Structural properties of laminates can be very good since the profiles have very straight fibres.
5. High fibre volume fractions can be obtained.

**Disadvantages**

1. Limited to constant or near constant cross section components.
2. Heated die costs can be high.

### 1.8.2 Resin Transfer Moulding Process

Fabrics are laid up as a dry stack of materials, these fabrics are sometimes pre-pressed to mould shape, and held together by a binder, these perform are then more easily laid into the mould tool is then clamped over the first, and resin is injected into the cavity. Vacuum can also be applied to the mould cavity to assist resin in being drawn into the fabrics. This is known as a vacuum Assisted Resin Injection (VARI). Once all the fabrics is wet out, the resin inlets are closed and the laminate is allowed to cure both injection and cure takes place at either ambient or elevated temperature. Generally epoxy, polyester, vinyl ester and phenolic resins are used. At elevated process temperature, resins such as bismaleimides can be used.

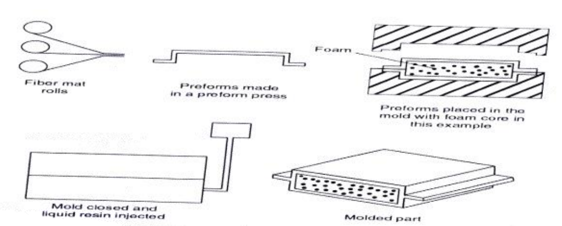



**Fig:7 Resin Transfer Moulding Process**

### 1.8.3 Compression Moulding Process

Compression moulding is used for transforming sheet compounds (SMC) into finished products in matched molds. The principle advantage of compression moulding is its ability to produce parts of complex geometry in short period of time. Non uniform thickness, ribs, bosses, flanges, holes, and shoulders, for example, can be incorporated during the compression molding process. Thus it allows the possibility of eliminating a number of secondary finishing operations, such as drilling, forming, and welding. The entire molding process, including mold preparation and placement of SMC in the mold, as well as part removal from the mold, can be automated. Thus, the compression molding process is suitable for the high volume production of composite parts. It is considered the primary method of manufacturing for many structural automotive components, including road wheels, bumpers, and leaf spring.

**Advantages**

1. High fibres volume laminates can be obtained with very low void contents
2. Safety and environmental control due to enclosure of resin.
3. Possible labour reductions.
4. Both sides of the component have a moulded surface.

## 1.9 MECHANICS OF COMPOSITES

The mechanics of composit**e** materials deals with stresses, strains and deformations when they are subjected to mechanical loads and thermal environments

A common assumption in the mechanics of conventional materials such as steels and aluminium is that they are homogeneous and isotropic. For a homogeneous material, properties will be uniform throughout the material, unless severely cold worked. The fibre- reinforced composites (FRC) on the other hand non-homogeneous and-isotropic (orthotropic). As a result, the mechanics of FRC are far more complex than that of conventional materials.

The mechanics of FRC material are studied at two levels.

1. The micro mechanics level, in which the interaction of the constituent material is examined on a microscopic scale. An understanding of the interacting between various constituents is also useful in delineating the failure modes in a fibre-reinforced composite material.

2. The macro mechanics level, in which the response of a fibre- reinforced composites material to mechanical and thermal load is examined on a macroscopic scale. The material is assumed homogeneous.

## 1.10 APPLICATIONS OF FRC

The fibre reinforced composites are used for the following applications now a day.

- Aerospace : wings, fuselages, landing gears, rudders/elevators, rotor blades, satellite structure
- Automobile: body panels and frames, bumpers, leaf springs, drive shafts, seat housing, tyres and other ground transportation vehicles (bullet train).
- Marine (eg.catamaran): boat hulls, decks, masts, propeller shafts, wind surfer
- Chemical plants: Process pipes, tanks, pressure vessels, oil field structures.
- Sporting goods: Tennis rackets, golf clubs, hockey sticks, fishing rods, base ball bats, bicycles, skis, canoes, bow, and swimming pools.
- Constructions: Bridge decks, repair of concrete decks, bridges, columns: FRP re-bars.

## 1.11 HYBRID COMPOSITES

Hybrid composite Materials have extensive engineering application where strength to weight ratio, low cost and ease of fabrication are required. Hybrid composites provide combination of properties such as tensile modulus, compressive strength and impact strength which cannot be realized in composite materials. In recent times hybrid composites have been established as highly efficient, high performance structural materials and their use is increasing rapidly. Hybrid composites are usually used when a combination of properties of different types of fibres have to be achieved, or when longitudinal as well as lateral mechanical performances are required. The investigation of the novel applications of hybrid composites has been of deep interest to the researchers for many years as evident from reports.

There is a steady increase both in the number of applications being found for fibre reinforced plastics and, concurrently, in the variety of fibre/resin systems that are available to designers. Some of these systems are useful, however, only in highly specialized situations where limitations such as high cost and brittle fracture behaviour are considered secondary to such qualities as low density, high rigidity and high strength. By mixing two or more types of fibre in a resin to form a hybrid composite it may be possible to create a material possessing the combined advantages of the individual components and simultaneously mitigating their less desirable qualities. It should, in addition, be possible to tailor the properties of such materials to suit specific requirements. There are many situations in which, for example, a high modulus material is required but in which the catastrophic brittle failure usually associated with such a material would be unacceptable. In the case of a strut member, a high initial modulus followed by limited yielding of the material and accompanied by the smallest possible reduction of load carrying capacity is usually desirable.

Hybrid fibre reinforced materials can be made in two separate ways either by intimately mingling the fibres shown in Fig 1 in a common matrix, or by laminating alternate layers of each type of composite. In this work the latter technique has been used and the following considerations apply to this type of hybrid material. In principle several different types of fibre can be incorporated into a hybrid system

## 1.12 APPLICATION AREAS OF HYBRID COMPOSITES

- Hybrid Smart Memory Composites

- Wind Power Generation
- Marine Applications
- Hybrid Thermoplastic Application
- Hybrid for Civil Construction
- Hybrid Composites for Telecom Applications
- Aeronautical Applications

**Advantages**

- Good wet-night visibility
- Can be applied at lower temperature
- Makes a mechanical bond with the road surface
- Good bead retention
- Low profile resists snowplow damage
- Epoxy does not contribute volatile organic compounds

**Disadvantages**

- Slow cure (no-track time)
- Mix proportions are critical

## 2.0. PROBLEM DESCRIPTION

The main objective of this project is

- ➢ To prepare the polyester composites reinforced with sisal/coconut sheath and cotton fiber.
- ➢ To analyze the mechanical properties in sisal /coconut sheath/cotton fibre reinforced polyester composites.
- ➢ To compare the mechanical properties with other natural fibers polyester composites.

**SCOPE:**

The scope of work is limited to

- ➢ Fabrication of composites by hand layup method
- ➢ Sisal fiber /coconut sheath/cotton fibre fibers are used as reinforcement
- ➢ Polyester is used as matrix.

## 3.0. EXPERIMENTAL WORKS

### 3.1. MATERIALS AND METHODOLOGY

Sisal fibre , coconut sheath and cotton fibre is one of the natural fiber which is used as reinforcement and the polyester resin is used as a matrix. The sisal fibre are extracted from the sisal leaf and coconut sheath fibre are extracted from the coconut trees ,cotton fibre extracted from the seeds, dead leaves and other debris are removed by ginning. The clean cotton is baled again and is ready to be spun.

The fabrication process consists of fabricating the sisal fibre and coconut sheath and cotton fibre hybrid natural fibre reinforced polyester composites by using hand-layup method. Using universal testing machine and with required attachment, the mechanical and corrosion properties like tensile strength and flexural strength and impact strength in addition to that and water absorption and chemical corrosion of the fabricated composites were tested.

Fig:8 sample of Coconut of sheath

### 3.2. Materials used in Sisal fibre /Coconut sheath/cotton fiber polyester composites

- General Purpose Resin (G.P.Resin polyester)
- Accelerator (Methyl Ethyl Ketone)
- Catalyst (Cobalt)
- Poly Vinyl Acetate
- Polythene sheets & Glass plates
- Mould
- Sisal /Coconut sheath/Cotton Fiber

### 3.3 FABRICATION PROCEDURE:

The following steps are followed during fabrication process:

1. The hand lay-up technique was used to fabricate the composite materials.
2. The 300 mm X 300 mm X 10 mm size rectangular closed mold is used for preparing the composites.
3. Prepare the binding mixture in a proper proportion. For 600ml of GP Resin, 8ml of Accelerator and 8ml of Catalyst are mixed together.
4. Cut the above said fibres with 30mm length.
5. Apply polyvinyl acetate on the mold cavity and top plate and allow it to dry.
6. Apply 100 ml of binding mixture inside the mold, which acts as polyester resin matrix.
7. 5 % of cotton fibre and 5 % of sisal fibre reinforced over the polyester resin matrix uniformly. Totally 10 % weight ratio of fibre maintained.
8. Again the step 5 and 6 repeated until the required size obtained.
9. After drying we obtain the composite plate with two side finishing.

10. Similar method used for other two fibre plates.

11. After that the required shape and size of the specimen for testing is prepared by cutting the composite plate using Zigzag cutting machine.
12. The required size of the specimen for testing is as follows:
    1) For tensile test - 165mm x 13mm x 3mm (I-SECTION) ASTM standard of ASTM D638in it.
    2) For flexural test - 30mm x 13mm x 3mm shows ASTM standard of ASTM D790-in it.
    3) For impact test - 66mm x13mmx3mm ASTM standard of ASTM D256
    4) For water absorption test-39mm x 10mmx 3mm ASTM D570-99
    5) For Chemical corrosion test-39mm x 10mmx 3mm ASTM D570-99

## 4.0.TESTING

The mechanical and corrosion properties of the composites are determined by using the following testing are.

1. Tensile test
2. Flexural test
3. Impact test
4. Water absorption
5. Chemical corrosion

### 4.1. Tensile test for Sisal /Cotton fibre, Cotton/Coconut sheath and cotton/ Coconut sheath fibers polyester composites

Tensile test is done on the composite specimen prepared with the size of 165mm x 13mm x 3mm by using tensile testing attachment in the universal testing machine shown in fig 17. Fig 18 which shows the composite specimen before testing. As the load increases, the deformation begins to increases. The composite deforms due to the breaking of fiber particles and the composite material breaks at the point of breaking load. .Fig 19 shows the composite specimen after testing.

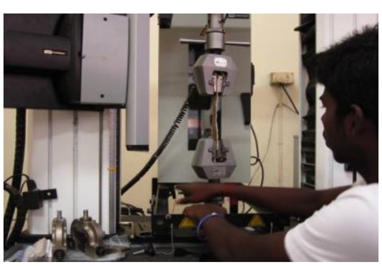


**Fig:9 Specimen With Tensile Test Attachment**

**Fig:10 before and after test specimen**

### 4.2. Flexural test for Sisal/Cotton fibre,Cotton/Coconut sheath and Sisal fibre/Coconut sheath polyester composites

Flexural test is also known as bending test and is done on the composite material with size 30mm x 13mm x 3mm by using flexural test attachment shown in fig 20 in the universal testing machine. Fig 21 shows the composite specimen before testing. In the flexural test three point flexural loads is applied at center of the material. When the point load is applied, the specimen bends and subjected to bending moments.. Fig 22 shows the composite specimen after testing.

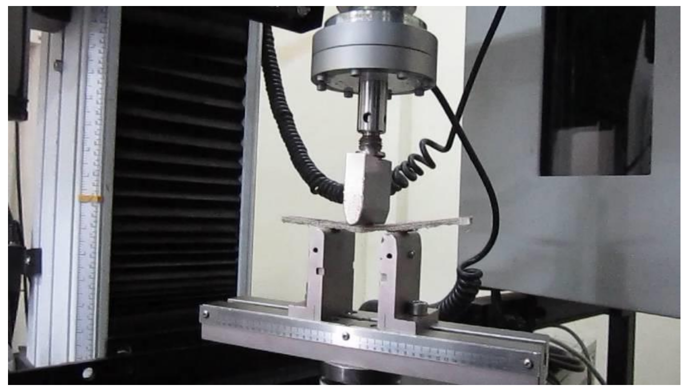


**Fig:11 Specimen With Flexural Test Attachment**

**Fig:12 before and after test specimen**

### 4.3. Impact test for Sisal/Cotton ,Sisal /coconut sheath and cotton/Coconut sheath polyester composites

Impact test is also known as sudden load test and is done on the natural hybrid fibre polyester composites with size 63.5mm x12.7 mm x 3mm by using impact test attachment shown in fig 23 in the Izod-charpy digital impact tester machine. Fig 24 shows the composite specimen before testing. In the Impact test, impact load is applied at center of the material. When the point load is applied, the specimen bends and subjected to bending moments.Fig 23 shows the composite specimen after testing.

**Fig:13 Izod-Charpy Digital Impact Testing Machine**

**Fig:14 before and after test specimen**

### 4.4. Water absorption test for Sisal/coconut sheath/cotton fibers polyester composites

In this experiment, three types of water were taken in beakers. initialy nine beakers are taken to test three samples of composite materials. After 24 hours the sample is taken, cleaned and checked for their weight and kept aside. This process was repeated for all the samples with three types of water in next 48 and 72 hours. After the tests were conducted it is observed that the weight of the composite material treated with salt water at room temperature is increased when compared with the other two types of water,when the water absorption rate is increased,the strength of the composite material decreases.

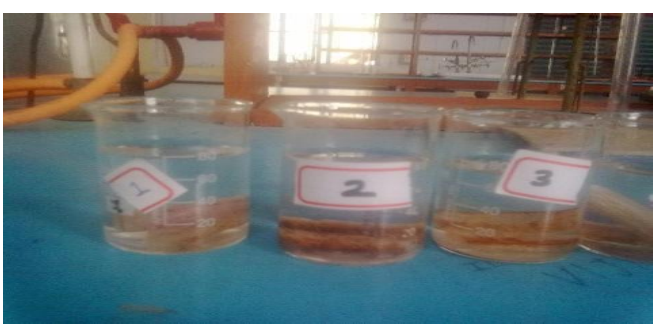



**Fig:15 Water absorption test**

**Fig:16 Specimen used for Water absorption and chemical corrosion test**

### 4.5. Chemical corrosion test for Sisal/coconut sheath/cotton fibers polyester composites

In this experiment, two types of acids are taken in beakers. Acids are prepared in 0.1Normality. Initially six beakers were taken to test three samples of composite materials. After the test were conducted 24 hours the sample is taken, cleaned and checked for their weight and kept acid. This process was repeated for all the samples with two types of acid in next 48 and 72 hours.


**Fig:17 Chemical corrosion test**

## RESULTS AND DISCUSSION

### 5.1. FOR TENSILE TEST

In this project, Sisal/cotton fibre, Sisal/Coconut sheath fibre and Cotton/Coconut fibre reinforced polyester composites are fabricated and analyzed the tensile properties of fabricated composites .Using UTM the tensile strength composite materials and determined. The tensile test report for Sisal/cotton fibre, Sisal/Coconut sheath fibre and cotton/Coconut fiber reinforced polyester composites are shown in Table 1,2,3. The maximum tensile strength attained for Sisal/Cotton composites is 25.98 Mpa, at 10% of Sisal fibre and Cotton fibre composites. The maximum tensile strength attained for Coconut sheath/Cotton fibre composites is 13.35 Mpa, at 10% of Coconut sheath fibre and Cotton fibre composites. The maximum tensile strength attained for Sisal/Coconut sheath composites is 15.94Mpa, at 10% of Sisal fibre and Coconut sheath fibre composites.

Table 1. Tensile test report For Sisal/Cotton fiber reinforced With Polyester composites

**Table 2. Tensile test report For Cotton/Coconut sheath fiber reinforced With Polyester composites**

| Sl No. | Ultimate/ Break Load (in N) | Ultimate tensile Strength (in Mpa ) | Elongation (%) |
|---|---|---|---|
| 1 | 1201.22 | 13.351 | 0.53 |
| 2 | 1150 | 12.77 | 0.63 |

| S.No | Break Load (in N) | Flexural modulus ( in Mpa) | Ultimate flexural Strength (in Mpa) |
|---|---|---|---|
| 1. | 270 | 52.83 | 54.86 |
| 2. | 252 | 48 | 50.23 |

**Table 3. Tensile test report For Sisal/Coconut sheath fiber reinforced With Polyester composites**

| S.No. | Break Load (in N) | Flexural modulus ( in Mpa) | Ultimate flexural Strength (in Mpa) |
|---|---|---|---|
| 1. | 141 | 14.0 | 28.40 |
| 2. | 120 | 12.3 | 22.23 |

| Sl No. | Ultimate/ Break Load (in N) | Ultimate tensile Strength (in Mpa ) | Elongation (%) |
|---|---|---|---|
| 1 | 2391 | 15.94 | 1.33 |
| 2 | 2350 | 15.66 | 1.55 |

**Fig-18 shows the tensile strength of hybrid natural fibre reinforced polyester composites**

| Sl No. | Ultimate/ Break Load (in N) | Ultimate tensile Strength (in Mpa ) | Elongation (%) |
|---|---|---|---|
| 1 | 272.84 2 | 25.98 | 1.18 |
| 2 | 691.89 | 25.71 | 1.10 |

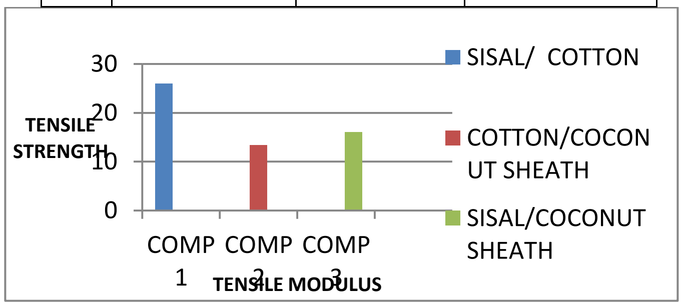



**Fig: 18-Tensile strength of composite specimen**

## 5.2. FOR FLEXURAL TEST

In this project, the Sisal/Coconut sheath /cotton fibre reinforced polyester composites are fabricated and analyzed the flexural properties of fabricated composites. Using universal testing machine, the flexural strength of the composite are determined. The flexural test report for Sisal/Coconut sheath/Cotton fiber reinforced polyester composites are shown in Tables 4, 5, 6. The maximum flexural strength attained for Sisal/Cotton composites is 52.83 Mpa at 10% of Sisal fibre and Cotton fibre composites. The maximum flexural strength attained for Coconut sheath/Cotton fibre composites is 14.00 Mpa at 10% of Coconut sheath fibre and Cotton fibre composites. The maximum flexural strength attained for Sisal/Coconut sheath composites is 13.39 Mpa at 10% of Sisal fibre and Coconut sheath fibre compositesFig.2 shows the variation of flexural strength with fibre for composites.

**Table 4. Flexural test report For Sisal/ Cotton Fiber Reinforced with Polyester composites**

**Table 5. Flexural test report For Cotton\Coconut sheath Fibre Reinforced with Polyester composites**

**Table 6. Flexural test report For Sisal/Coconut sheath Fiber Reinforced with Polyester composites**

| S.No. | Break Load (in N) | Flexural modulus ( in Mpa) | Ultimate flexural Strength (in Mpa) 0 |
|---|---|---|---|
| 1. | 404 | 13.36 | 29.37 |
| 2. | 350 | 12.26 | 25.86 |

**Fig:17 shows the flexural strength of hybrid natural fibre reinforced polyester composites**

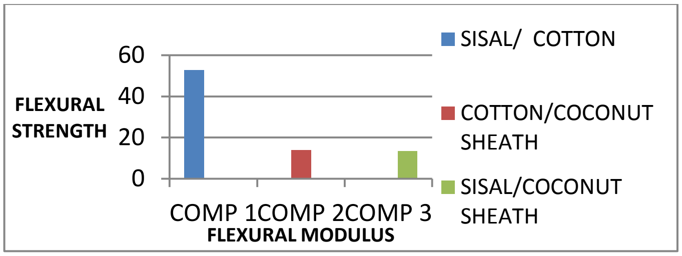



**Fig: 19 Flexural strength of composite specimen**

### 5.3. FOR IMPACT TEST

In this project, the Sisal/Coconut sheath/Cotton fibre reinforced polyester composites are fabricated and analyzed the impact properties of fabricated composites. Using Izod, charpy machine, the impact strength of the natural fiber Sisal/Coconut sheath/cotton fibre reinforced polyester composites is determined. The impact test report for Sisal/Coconut sheath fibre /Cotton Fibre reinforced polyester composites are shown in Table 7,8,9. The maximum impact strength attained for Cotton/Sisal fibre composites is 2.9137KJ/M$^3$. The maximum impact strength attained for Cotton/Coconut sheath composites is4.3706KJ/M$^3$. The maximum impact strength attained for Sisal/Coconut sheath composites is5.2447KJ/M$^3$ Fig.3 shows the variation of impact strength with fibre weight percent for polymer composites.

**Table 7. Impact test report For Sisal/Coconut sheath/Cotton Fiber Reinforced with Polyester composites**

| S.NO. | Energy (in Joules) | Impact strength (in kJ/m$^2$) |
|---|---|---|
| 1. | 0.75 | 2.9137 |
| 2. | 0.65 | 2.525 |

**Table 8. Impact test report For Cotton/Coconut sheath Fibre Reinforced with Polyester composites**

**Fig: 20 shows the impact strength of hybrid natural fibre reinforced polyester composites**

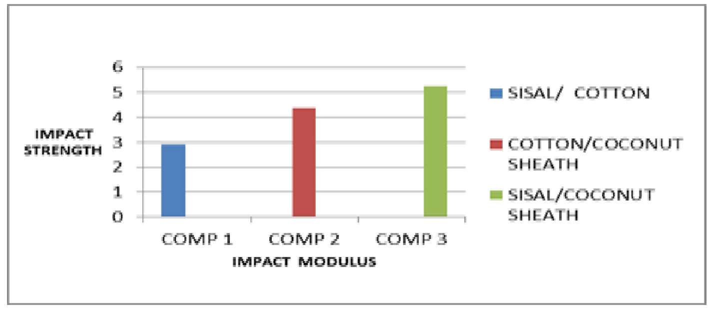



**Table 9. Impact test report For Sisal/Coconut sheath Fiber Reinforced with Polyester composites**

| S.NO. | Energy (in Joules) | Impact strength (in kJ/m$^2$) |
|---|---|---|
| 1. | 1.35 | 5.2447 |
| 2. | 1.31 | 5.089 |

### 5.4. WATER ABSORPTION TEST

Fig 21,22, 23, shows that the weight of the composite specimen after the water absorption test carried out

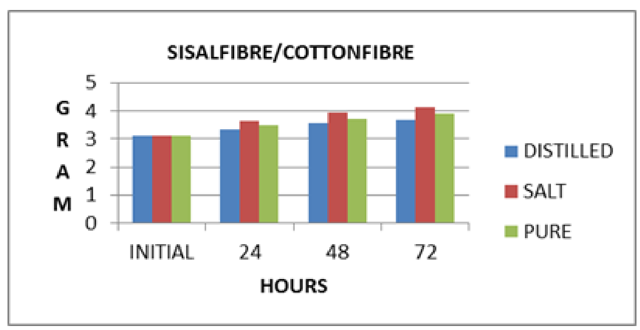



**Fig: 21-Water absorpation test of sisal/cotton composite specimen**

| S.NO. | Energy (in Joules) | Impact strength (in kJ/m$^2$) |
|---|---|---|
| 1. | 1.125 | 4.3706 |
| 2. | 1.25 | 4.8562 |

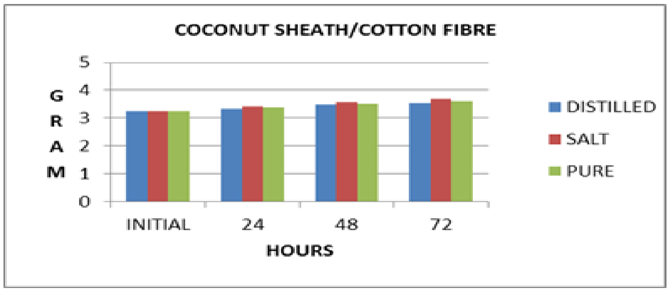



**Fig-22. Water absorpation test of coconut sheath/cotton composite specimen**

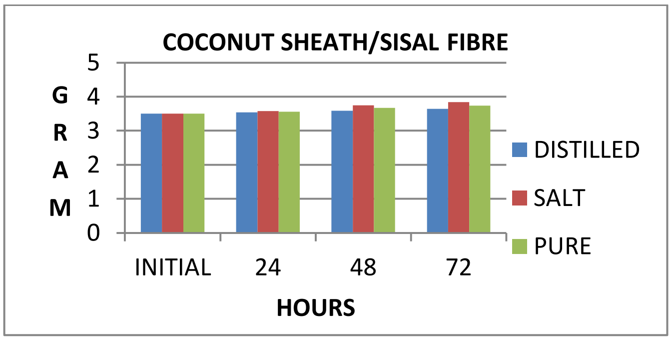



**Fig-23 Water absorpation test of coconut sheath/sisal fibre composite specimen**

From the fig 21, 22,23, it is observed that the weight of the Sisal/Cotton polyester composite treated with salt water at room temperature is increased compared with other two type of water.

### 5.5. CHEMICAL CORROSION TEST

Fig 24,25, 26,shows that the weight of the composite specimen after the chemical corrosion test carried out

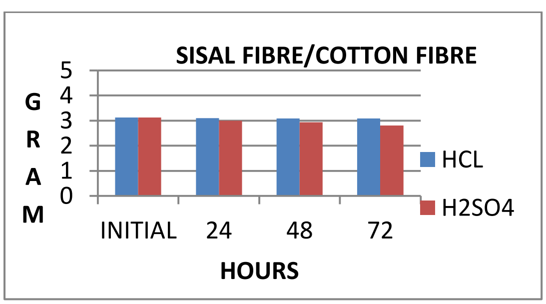
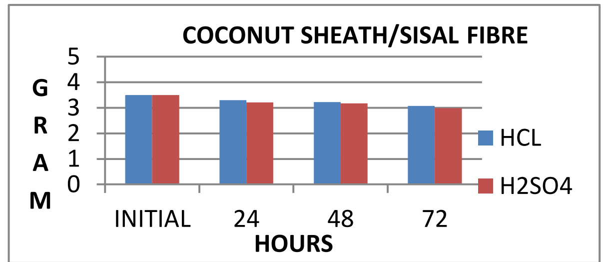



**Fig: 24 Chemical corrosion test of sisal/cotton composite specimen**



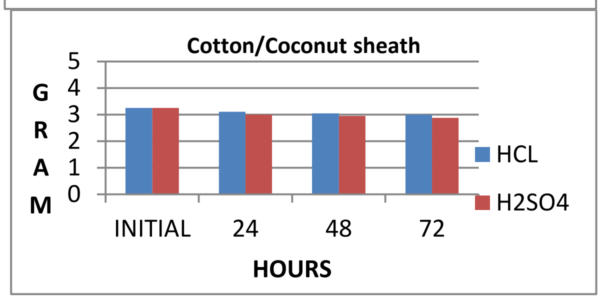




**Fig: 25 Chemical corrosion test of Coconut sheath/cotton composite specimen**

**Fig: 26 Chemical corrosion test of Coconut sheath/sisal fibre composite specimen**

From the fig 25, 26, 27 –it is observed that the weight of the Sisal/Cotton polyester composites treated with $H_2SO_4$ at room temperature weight is decreased Compared with HCL.

### 5.6. Scanning Electron Microscope analysis

The fractured specimen from the tensile, flexural and impact testing of the Sisal/cotton, Cotton/Coconut sheath and Sisal/Coconut sheath hybrid natural fiber reinforced polyester composite are considered for the cross section analysis using Scanning Electron Microscope. Fig 28 (a) ,(b) and, Fig 28 (c) SEM micrograph of the tensile ,flexural and impact fractured specimen.

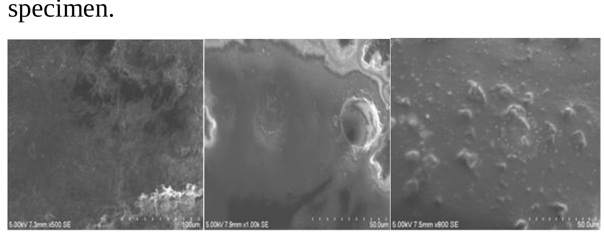


**Fig: 27 (a)** **Fig: 27 (b)** **Fig: 27 (c)**

**Fig- 27 (a)** shows the SEM fractographs of sisal/cotton, the strength of the material is good due to good orientation, between the fibre and matrix

**Fig-27 (b)** shows the SEM fractographs of cotton/coconut sheath specimens are given good flexural strength and by avoiding the voids, the strength can be increased than now.

**Fig-27 (c)** shows the SEM fractographs of cotton/coconut sheath specimens shows that due to high evidence of interfacial bonding the material exhibits high strength.

## CONCLUSION

Three types of combination of composite material such as Sisal/cotton, Cotton/Coconut sheath and Sisal/Coconut sheath reinforced with polyester are fabricated and tested the mechanical properties are tensile strength, flexural strength and impact strength using UTM and Izod testing machine. By testing it is found out that, the tensile strength and flexural strength is high in Sisal/Cotton fibre as 25.98Mpa and 52.83Mpa and be impact strength of Cotton/Coconut sheath is high as 5.2447kJ/$m^2$.Further these three combination were checked for water absorption test and it is observed that all the three combination of composite material tend to lose high amount of strength when treated with salt water compared with the other two types of water. Here the sisal/cotton mixture absorbs more amount of salt water and less amount of distilled and pure water when compared with the other two combinations of composite material. After the completion of the water absorption test the three combinations are further experimented for corrosion test. As a result of corrosion test it is found that the cotton/coconut sheath polymer composite material loses less amount of weight when compared with the other two combinations of polymer composites when treated with $H_2so_4$ and Hcl. It is found that the weight of the polymer is reduced when treated with $h_2so_4$ when compared with Hcl, high amount of corrosion takes place in sisal/cotton polymer composite. After the completion of all the tests it is found that the sisal/cotton polymer composite exhibits high amount of strength and corrosion resistance. So I conclude that the sisal/cotton polymer composite posses good characteristics when compared to the other two polymer composites.

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