CHARACTERIZATION OF NATURAL FIBERS IN COMPOSITE MATERIALS

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Abstract
A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The two constituents are one is reinforcement and the other is matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. After World War II synthetic fibers are used mostly than natural fibers. This is an interest on natural fibers use within the textile, building, plastic, and automotive industries for economic development and independence versus imported material. This experimental study aims fabrication and characterization of natural fibers in composite materials. The samples are several Natural Composites and those samples are pure epoxy mat, coconut coir mat, palm fiber mat, combination of coconut coir and palm fiber mat were manufactured by using hand layup method. The weight fraction of fiber and the matrix was kept 40% - 60%.Testing is done for treated and the untreated fibers thus properties will be studied and compared with previous mechanical properties. The tests were flexural test, tensile test, hardness test.

Index Terms: Composite material, Coconut Coir, Palm fiber mat, Epoxy resin

I. INTRODUCTION

DEFINITION OF COMPOSITE

A composite is combination of two materials in which one of the materials, called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. The matrix is more ductile than the fibers and thus acts as a source of composite toughness. The matrix also serves to protect the fibers from environmental damage before, during and after composite processing. When designed properly, the new combined material exhibits better strength than would each individual material. Composites are used not only for their structural properties, but also for electrical, thermal, tri-biological, and environmental applications.
The following are some of the reasons why composites are selected for certain applications:
High strength to weight ratio (low density high tensile strength)

- ✓ High creep resistance
- ✓ High tensile strength at elevated temperatures
- ✓ High toughness

NATURAL FIBER REINFORCED COMPOSITES

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc.

APPLICATIONS OF NATURAL FIBER COMPOSITES

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

Building and construction industry: panels for partition and false ceiling, partition boards, wall, floor, window and door frames, roof tiles, mobile or pre-fabricated buildings which can be used in times of natural calamities such as floods, cyclones, earthquakes, etc.

- ✓ Storage devices: post-boxes, grain storage silos, bio-gas containers, etc.
- ✓ Furniture: chair, table, shower, bath units, etc.
- ✓ Electric devices: electrical appliances, pipes, etc.
- ✓ Everyday applications: lampshades, suitcases, helmets, etc.
- ✓ Transportation: automobile and railway coach interior, boat, etc.

OBJECTIVE

- ✓ To manufacture natural fiber composite using coconut coir, palm fiber and epoxy resin.
- ✓ To determine the mechanical properties of natural fiber composites, Such as Tensile Test, Flexural Test, Micro Hardness Test and Impact Test.

II. MATERILAS AND METHODS

The following section will elaborate in detail the experimental procedure carried out during the course of our project work. The steps involved are:

1. Specimen Fabrication (Fabrication of FRP).
   - ✓ By Hand Lay-Up method.
   - ✓ Cutting of Laminates into samples of desired dimensions.
2. Tensile test
3. Flexural test (3-Point Bend test)

RAW MATERIALS

Raw materials used in this experimental work are:

1. Epoxy Resin
2. Hardener
3. Natural fiber
   a. Coconut coir
   b. Palm fiber

EPOXY RESIN

Epoxy resin (Araldite) LY 556 made by CIBA GUGYE Limited, having the following outstanding properties has been used.

- ✓ Excellent adhesion to different materials
- ✓ Great strength, toughness resistance
- ✓ Excellent resistance to chemical attack and to moisture
- ✓ Excellent mechanical and electrical properties.
- ✓ Odorless, tasteless and completely nontoxic.
- ✓ Negligible shrinkage.

HARDENER

In the present work Hardener (Ardor) HY 951 is used. This has a viscosity of 10-20 poise at 250C.

Fig-1: Hardener

Natural Fiber-Coconut coir

Coir is a natural fiber extracted from the husk of coconut technically. Coir is a fibrous material fount between the hard internal shell and he outer. Coat of a coconut and it's used for making products such as floor mats, doors, brushes, mattresses etc. Ropes and cordage made from coconut fiber have been in use from ancient times.

The individual fiber cells are narrow and hallow, with thick walls made of cellulose. Each cell is about 1mm (0.04in)long and 10to20µm (0.004 to 0.0008) diameter. Two types of fiber are taken in coconut coir white coir, Brown coir. Now we are using Brown coir in our project. The brown coir contains more lignin and less cellulose than the fiber such has flax and Cotton so they are stronger and less flexible.

Fig-2: Coconut Coir

Natural fiber-Palm fiber

Palm fiber is taken from the Leaves of the Palm tree so it's also known as the palm leaf fiber. Palm fiber has the poor spinning characteristics the fiber is naturally hard palm fiber behavior has been classified into two types they are Active behavior and the Passive behavior.

Fig-3: Palm fiber

Active behavior

Palm fiber has a slight pleasant straw like odors even slight moisture may impart a musty odor to palm fiber after a time. As Upholstery stuffing.

Passive behavior-

Palm fiber is sensitive to unpleasant (or) pungent odors. For example Fish meal stowed nearby may result in considerable depreciation of the palm fiber.

Moisture/RF Humidity

Palm fiber requires particular temperature, humidity/moisture and possible ventilation conditions they are given below

Table-1: Moisture/RF Humidity

Designation	Humidity/water conditions
Relative humidity	65%
Water content	12%
Maximum equilibrium content	65%

III FABRICATION OF COMPOSITE FIBER

The fiber piles were cut to size from the Palm fiber cloth. The appropriate numbers of fiber plies were taken: two for each. Then the fibers were weighed and accordingly the resin and hardeners were weighed. Epoxy and hardener were mixed by using glass rod in a bowl. Care was taken to avoid formation of bubbles. Because the air bubbles were trapped in matrix may result failure in the material. The subsequent fabrication process consisted of first putting a releasing film on the mould surface. Next a polymer coating was applied on the sheets. Then fiber ply of one kind was put and proper rolling was done. Then resin was again applied, next to it fiber ply of another kind was put and rolled. Rolling was done using cylindrical mild steel rod. This procedure was repeated until eight alternating fibers have been laid. On the top of the last ply a polymer coating is done which serves to ensure a god surface finish. Finally a releasing sheet was put on the top a light rolling was carried out. Then a 20 kg weight was applied on the composite. It was left for 72 hrs to allow sufficient time for curing and subsequent hardening.

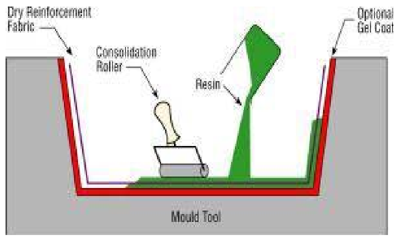


Fig-4: Hand Lay-up Technique

Procedure

- ✓ Bottom layer of the Die is covered with the Aluminum foil sheet.
- ✓ The Wax is applied on the Aluminum foil sheet it is used for easy removing of composites from foil sheet.
- ✓ Then the mixture of epoxy resin and hardener is placed on the sheet and palm leaf fibers mate is dipped.
- ✓ After that Male die is compressed for some times.
- ✓ This process is repeated for others also.

GENERAL OVERVIEW

The composites sheets were fabricated from Natural fiber, with (Coconut/Palm) and resin matrix. The resin used was epoxy resin. The weight fraction of composites was maintained at 40% fiber and 60% resin. Number of plies for each fiber taken was two i.e. total number of plies used in hybrid composite are four. Four natural hybrid composites are made i.e. pure epoxy mat, untreated short palm fiber, Treated Coconut long fiber and Treated Palm long fiber fabrication cutting of the specimen is done in the desired shape to test the mechanical properties of the natural hybrid composite fiber. The tensile and flexural testing of the samples was done by UTM (universal testing machine). The Micro Hardness and Impact test has been conducted.

MIXING RATIO'S

For the preparation of the composite we calculate the percentage of fibers, polymer and hardener required from the table we come to know about the amounts accurately.

Table-2: Mixing Ratios

Sample No	Natural Fiber (%)	Epoxy (%)	Hardener (%)
1	0	90	10
2	30	60	10
3	30	60	10
4	15+15	60	10

MOULD PREPARATION

First of all the mould for the composite is prepared. We have to prepare moulds of size 200x200x5 mm for the preparation of required composite. A clean smoothed surfaced M.S iron is taken and the Die is made of two plates one is male Die and another is female Die in female die the mixture composites are poured by the hand Lay-Up method and Male die is covered at the top for 72 hours. We give a cover to the iron die with a non-reactive thin Aluminum foil sheet. Then the wax is applied on it due to easy removal of the Natural fiber fabricated. According to the ASTM Standards the various Samples cutted and this conducted.

Fig-5: Mould Preparation

FIBER PREPARATION

Raw natural palm fiber and the coconut fiber where cut in the tree and them which are brought and cleaned with water and dried. Then the aggregations are gently dispersed with hand sitting patiently. Then its outer shell is removed by the knife and it is cut into required dimension. After that it is measured for proper weight and kept.

The two separate methods of natural fiber has been tested

- ✓ Chemically Untreated Natural fiber
- ✓ Chemically Treated Natural fiber

Fig-6: Fiber Preparation

POLYMER-HARDNER MIXTURE PREPARATION

For the making of good composite the measurement of the samples should be accurate and the mixture should be very uniform. We take accurate amount of polymer which we have calculated earlier and 10% of its hardener. Then this mixture is stirred thoroughly till it becomes a bit warm. Bit extra amount of hardener is taken for the wastage in the process. Hardener should taken very minutely because little extra amount of hardener can spoil the composite.

CASTING

First of all mould release was spread all over the die it is the mixture Short natural fiber chemically treated composites. This sample is then left for 72 hours. The composite gets dried up in 72 hours in which the silk fiber and the polymers adheres itself tightly in the presence of hardener. After a day we put out the weights. Then carefully the nailed bits are removed from the Iron Die. Now we have the composite attached with the Aluminum foil sheet. The hardener has so strong effect that it attachés the sheet with the composite. This attachment is slowly and gently hammered on the boundary of its attachment when the aluminum sheet and the composite separate out. Then we see whether any undesired voids are left behind. We fill the voids with polymer and the sample is prepared.

CASTING SAMPLES

Fig-7: Casting Samples

Table-3: Composition Ratio Table

Sample	Natural fiber	Natural Fiber (%)	Epoxy (%)	Hardener (%)
1	Pure Epoxy Resin + Hardener	0	90	10
2	Coconut coir + Epoxy Resin + Hardener	30	60	10
3	Palm Leaf Fiber+ Coconut Coir + Epoxy Resin + Hardener	30	60	10
4	Palm Leaf Fiber+ Epoxy Resin + Hardener	15+15	60	10

IV TESTING AND PERFORMANCE EXPERIMENTAL PROCEDURE

Cutting of Laminates into Samples of Desired Dimensions

A WIRE HACKSAW blade was used to cut each laminate into smaller pieces, for various experiments:

TENSILE TEST- Sample was cut into dog bone shape (150x10x5) mm.

FLEXURAL TEST- Sample was cut into flat shape (20x150x5) mm, in accordance with ASTM standards.

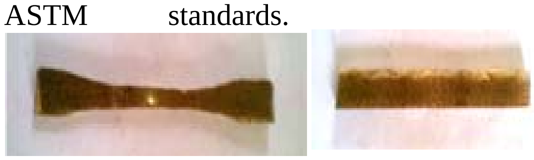


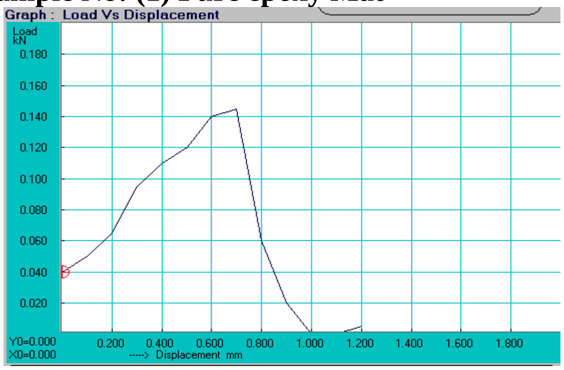
Fig-8: (a) Dog-bone shape (b) Flat bar shape

FLEXURAL TEST

Flexural strength is defined as a materials ability to resist deformation under load. The short beam shear (SBS) tests are performed on the composites samples to evaluate the value of inter-laminar shear strength (ILSS).

FLEXURAL TEST REPORT

Sample No: (1) Pure epoxy Mat



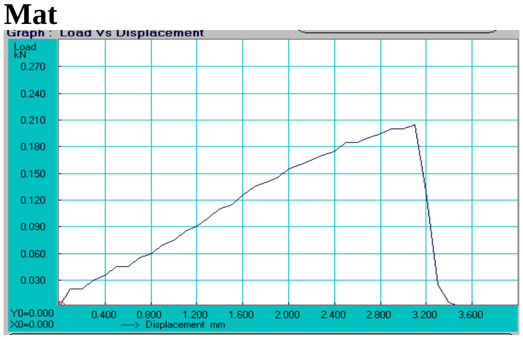
Graph-1: Pure Epoxy Mat

Sample No: (2) Untreated Palm and Coconut Coir Short Fiber Mat

Ult./Break Load	0.155 kN
Disp. at FMAX	0.700 mm
Max. Disp.	1.200 mm
Area	71.374 mm²
Ult. Stress	0.002 kN/mm²

Graph-2: Untreated Palm and Coconut Coir Short Fiber Mat

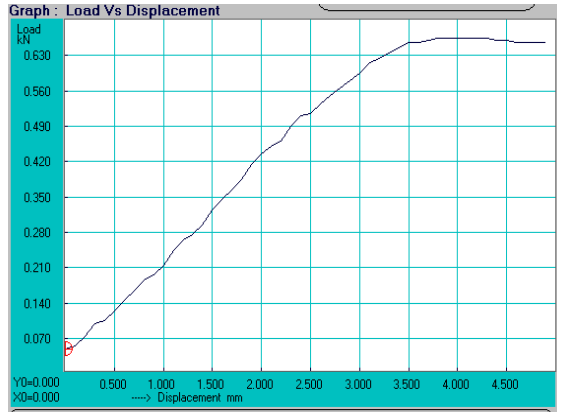
Sample No: (3) Treated Coconut long Fiber Mat



Ult./Break Load	0.205 kN
Disp. at FMAX	3.100 mm
Max. Disp.	3.700 mm
Area	63.500 mm²
Ult. Stress	0.003 kN/mm²

Graph-3: Treated Coconut Long Fiber Mat

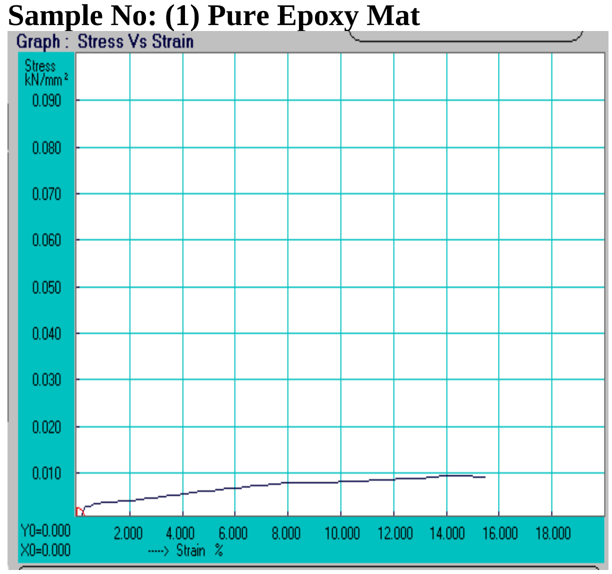
Sample No: 4 Treated Palm Long Fiber Mat



Graph-4: Treated palm long Fiber Mat

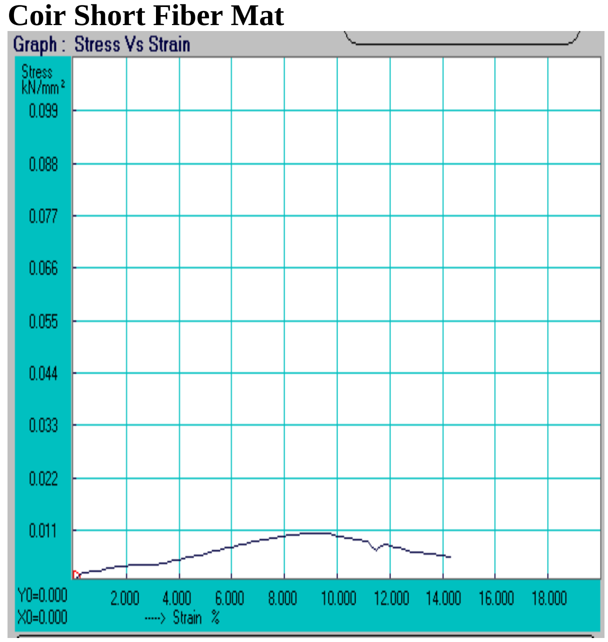
TENSILE TEST

Sample No: (1) Pure Epoxy Mat



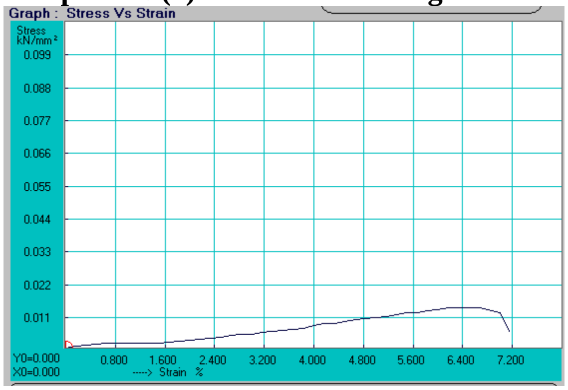
Graph-5: Pure Epoxy Mat

Sample No: (2) Untreated Palm And Coconut Coir Short Fiber Mat



Graph-6: Treated Coconut Long Fiber Mat

Sample No: (3) Treated Palm long Fiber Mat

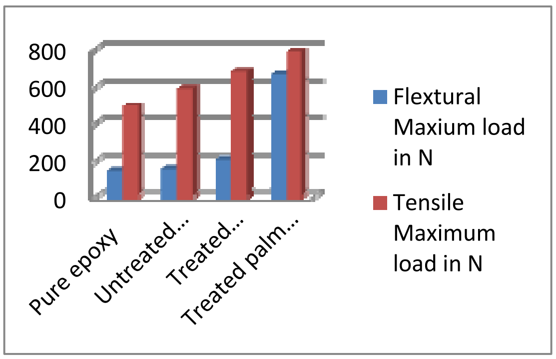


Graph-7: Treated Palm long Fiber Mat

V RESULTS AND DISCUSSIONS

The following bar diagram shows the maximum load capacity of the various type of the natural fiber composites. By comparing and seeing the **Chemically Treated Long Palm Fiber** is having good load with standing capacity in both the Tensile as well as Flexural test.

Flexural and Tensile Maximum load in N



Graph-8: Flexural and Tensile Maximum load

- ✓ The Maximum load Capacity in Flexural test is **665N**
- ✓ The Maximum load Capacity in Tensile test is **785N**

The Palm fiber is having good Mechanical properties if we use this natural fiber it will have the good load capacity.

FLEXURAL TEST

Three point bend test was carried out in an UTM machine in accordance with ASTM standard to measure the flexural strength of the composites. All the specimens (composites) were of rectangular shape having dimension of (150x20x5) mm. The span length was 75mm. The experiment was conducted on all the four samples. The results are tabulated.

Table-4: Flexural Test

SAMPLE NAME	GAUAGE LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	THICKNESS (mm)	MAXIMUM LOAD(N)
Plane Epoxy	50.8	12.7	5	1.2	145
Untreated palm and coconut coir short fiber	50.8	12.7	5	1.2	155
Treated coconut long fiber	50.8	12.7	5	3.7	205
Treated Palm long fiber	50.8	12.7	5	3.8	665

It is found that the flexural strength for long Coconut fiber 205N and Palm fiber 665N.Variation of force with extension in 3-point bend test.

TENSILE TEST

Tensile test was also carried out on UTM machine in accordance with ASTM standard. All the specimens were of dog bone shape of dimension (150x10x5)mm. The results are tabulated.

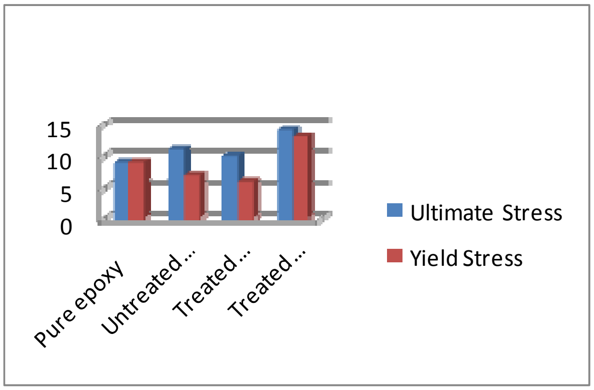
Table-5: Tensile Test

SAMPLE NAME	GAUAGE LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	EXTENSION (mm)	MAXIMUM LOAD(N)
Plane Epoxy	60	13	5	9.3	495
Untreated palm and coconut coir short fiber	60	13	5	13.1	590
Treated coconut long fiber	60	13	5	8.6	680
Treated Palm long fiber	60	13	5	4.3	785

ULTIMATE STRESS

AND YIELD STRESS

The following bar diagram shows the Ultimate stress value and Yield stress value of the various type of the natural fiber composites. By comparing and seeing the **Chemically Treated Long Palm Fiber** are having good stress values with both Ultimate stress and the Yield stress in the Tensile test.

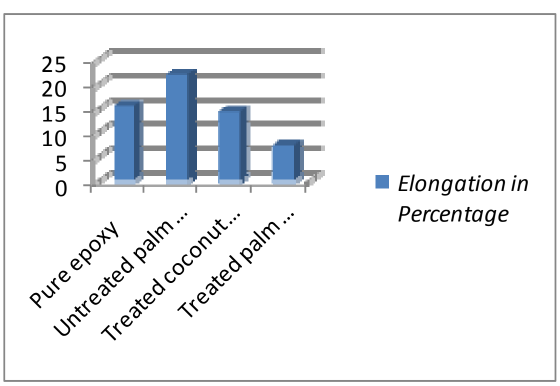


Graph-9: Ultimate stress and Yield stress

- ✓ The Maximum Ultimate stress value is **14N/mm^2**
- ✓ The Maximum Yield stress value is **13N/mm^2**

The Palm fiber is having good Mechanical properties if we use this natural fiber it will have the good Stress values.

The following Bar diagram shows the Elongation of the various type of the natural fiber composites. By comparing and seeing the **Chemically Treated Long Palm Fiber** is having less elongation percentage.



Graph-10: Elongation in Percentage

The Hardness value of Pure Epoxy mat is **15.500%**

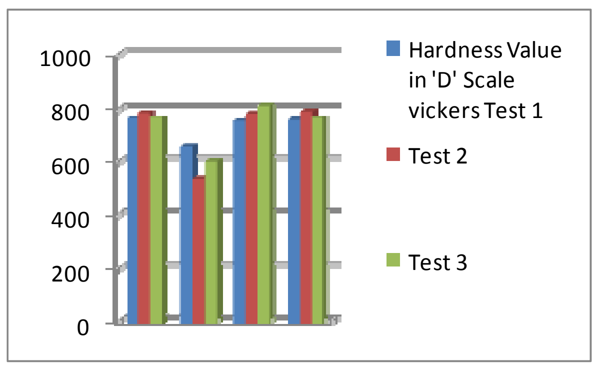
- ✓ The Hardness value of Untreated palm and coconut coir short fiber is **21.833%**
- ✓ The Hardness value of Treated Coconut long fiber is **14.333%**
- ✓ The Hardness value of Treated Palm long fiber is **7.167%**

The Palm fiber is having good Mechanical properties if we use this natural fiber it can able to with stand the good load capacity without elongation.

Micro Hardness Test

The following bar diagram shows the Hardness Value of the various type of the natural fiber composites. By comparing and seeing the **Pure Epoxy Mat** is having good Hardness value the Hardness value is directly proportional to the **ductility**.

Hardness value in 'D' Scale Vickers Test



Graph-11: Hardness value in 'D' Scale Vickers Test

- ✓ The Hardness value of Pure Epoxy mat is **760, 784 & 764**
- ✓ The Hardness value of Untreated palm and coconut coir short fiber is **654, 535 & 600**
- ✓ The Hardness value of Treated Coconut long fiber is**750, 780 & 810**
- ✓ The Hardness value of Treated Palm long fiber is**754, 789 & 762**

The Pure Epoxy mat is having good Hardness value if we use this natural fiber it will have the less ductility property.

Table-6: COST ANALYSIS

ELEMENT DISCRIPTION	C0ST(₹)
Fiber	200.00
Resin	2,500.00
Fabrication	4,000.00
Cutting	300.00
Testing	3,000.00
Total	10,000.00

VI CONCLUSION

1. The palm, coconut fibers was successfully used to fabricate natural composites with 40% fiber and 60% resin; these fibers are bio-degradable and highly crystalline with well aligned structure. So it has been known that they also have higher tensile strength than glass, good elasticity, and excellent resilience and in turn it would not induce a serious environmental problem liken others.
2. The flexural strength of pure epoxy resinis145N with15.5%elongation.With increase of fiber loading capacity by 20% (Untreated fiber), the flexural strength value increases to 155N with 21.833% elongation for untreated short palm fiber.
3. The tensile strength of epoxy is 495N with increase of fiber loading capacity by 20% the tensile strength increase will increases upon 590N for the untreated short fiber. So, it is clearly indicates that inclusion of natural fibers improves the load bearing capacity (Tensile strength) and the ability to withstand bending (flexural strength) of the composites.
4. In flexural test for the treated multidirectional discontinues coconut long fiber loading capacity is 205N less while comparing with the treated multidirectional discontinuous palm long fiber 655N.
5. In Tensile test for the treated multidirectional discontinues coconut long fiber loading capacity is 680N less while comparing with the treated multidirectional discontinuous palm long fiber 785N.
6. From the impact test and the Micro hardness test it is clearly studies the hardness and strength of the composites.
7. By comparing the Flexural strength, Tensile strength, Hardness number and Impact test of the composites with varying Natural fiber, the best mechanical property results are obtained with treated multidirectional discontinuous palm long fiber combination.

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