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ASSESSING MECHANICAL PROPERTIES OF COCONUT COIR - TAMARIND FRUIT FIBER REINFORCED EPOXY HYBRID COMPOSITES

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Abstract--- Matrix and reinforcement are the building blocks of composite materials, which exhibit combined qualities that outperform those of either component alone. Composite materials, which were invented and have since grown in popularity, have revolutionised several industries within the last 30 years. Weight reduction and improved mechanical characteristics are the primary goals of composite material. We achieved this by creating a hybrid composite material from the fibres of tamarind fruit and coconut coir. The next step is to use the experimental data to study the mechanical characteristics. In this study, we developed a hybrid composite material that incorporates coconut coir and tamarind fruit fibres as reinforcement. We then mixed this with LY556 epoxy resin and HY 951 hardener to form a matrix. The short fibres make up 30% of the material, while the remaining 70% is evenly distributed among the other components. After that, we cut the composites into ASTM standards and tested them for mechanical properties using tests such as tensile, compression, impact, and flexural. The results were used to learn more about the material's fabrication process. Additionally, we conducted a water absorption test on the composite materials. Scanning electron microscopy (SEM) study is used to examine the fractured surfaces' internal structure, interfacial characteristics, and internal fractures.

Keywords--- **Coconut Coir, Tamarind Fruit Fibers, Hand Lay-Up Method, Epoxy Resin LY556, Hardener HY 951.**

INTRODUCTION

A When two or more materials are combined to form a composite, the combined qualities of the components are superior than those of the materials used alone. Composites are made up of several materials, each with its own set of characteristics. When these components are mixed, they create a new material with a unique set of features. Compared to other mixed materials, composites have superior mechanical qualities. Composites are often lighter than metals, which means that using them makes the final product much lighter. To achieve these characteristics, we conducted an experiment to create a new composite material. We used Tamarind fruit fibre and Coconut coir with different compositions in three different configurations, and we tested the specimens according to ASTM standards to determine their mechanical properties. Composites obtain their special qualities by blending these two materials. These components do not dissolve or mix in with each other, thus we can readily recognise them in these composites. Composite materials are extensively used in a broad variety of engineering and non-engineering contexts. Because of its many useful properties, including as a high strength-to-weight ratio, low energy consumption, and excellent resistance to corrosion and weather, these materials have become an integral element of modern construction. The majority of the world's buildings, bridges, structures, ships, and car bodies are made from composite materials. Aircraft and spacecraft are mostly constructed using sophisticated composites in the aerospace industry. A review of the relevant literature reveals that many earlier studies focused on single-fiber composites rather than hybrids, with some studies combining several kinds of fibres and others focusing on specific combinations (e.g., jute, sisal, banana, etc.).

Alkali treatment increased the fiber's thermal stability, according to a study by C. Uma Maheswari et al. [1] Tensile Properties and Thermal Degradation Parameters of Tamarind Fruit Fibres. Furthermore, it was discovered that alkali treatment enhanced the tensile characteristics. The findings also show that thermoplastics with processing temperatures lower than 270o C may benefit from using alkali-treated tamarind fibres as reinforcements. The study by G. Ramachandra et al. [2] discusses the use of variable fibre lengths to create hybrid composites made of natural and synthetic fibres. The composites are based on tamarind fruit fibre and glass fibre reinforced polyester. Researchers have examined how the properties of polyester-based Tf / glass hybrid composites change with the length of the fibres, including hardness, chemical resistance, impact strength, and frictional coefficient. Results showed that hybrid composites with fibre lengths of 2 cm outperformed those with 1 and 3 cm in terms of hardness and impact strength. The mechanical properties of a banana-coir hybrid composite were studied using experimental and finite element methods [3] by T. HariPrasad et al. The paper concludes that compared to an untreated banana-coir epoxy hybrid composite, one that is alkali-treated has higher tensile and impact strengths. In contrast to the untreated banana-coir epoxy hybrid composite, the one treated with alkali shows lower flexural strength. In their study, Ram Krishna Adhikari et al. [4] detailed the mechanical characteristics of hybrid polyester composite materials made of banana and jute fibres. The mechanical characteristics of the hybrid polyester material are detailed.

MATERIALS

In this particular project, we are utilising coconut coir and tamarind fruit fibres, which have been precisely cut into uniform lengths and chemically treated with NaOH. These fibres are then prepared to be used as reinforcement in a composite with three distinct configurations, each with its own unique composition, mixed with epoxy resin LY556 and hardener HY951 in a ratio of 10:1. In order to prepare them for composites, these are moulded into a shape with dimensions of 160 mm x 160 mm x 10 mm (length x width x thickness). Then, specimens are cut into them according to ASTM standards for tensile, compressive, flexural, and impact (Izod) tests, and the results of these tests are used to investigate the mechanical properties of the materials. A weighing scale, roller, safety gloves, and release agent are additional tools needed.

I. MANUFACTURING METHOD

The Composite materials can be manufactured by using any of the following methods.

- Hand Lay-up Method
- Automated Lay-up Method
- Spray Up Method
- Filament winding
- Pultrusion

But for the current work we are going to prepare the composite materials by using Hand lay-up Method.

Hand lay-up encompasses the cutting of the reinforcement material to size by using a variety of hand and power- operated devices. These sized pieces are then impregnated with wet network material and laid over a shape surface that has been covered with a discharge operator and after that ordinarily a sap gel-coat. The impregnated fortification material is then hand-moved to guarantee uniform circulation and to expel caught air. Greater fortification material is included until the required part thickness has been developed. Manual lay-

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up can likewise be performed utilizing pre- impregnated support material, called 'prepreg'. The utilization of prepreg material disposes of independent treatment of the support and epoxy and can enhance part quality by giving more predictable control of fortification and sap substance. Prepreg must be kept refrigerated preceding use, be that as it may, to avert untimely curing.

II. PREPARATION OF MATERIALS

A. Preparation of Coconut coir fiber:

In this research work, we collected the dried coconut husks from the coconuts and then they are separated as husk and fiber by using the mechanical pounding and patiently each of the fiber strand are separated as the Fiber and the husk, then the fiber is thoroughly washed with water and then they are chemically treated with 5% NaOH solution and then it is dried it in the presence of sunlight, after the fibers are dried then the fibers are made into the uniform length which are selected for the preparation of the composites. Then the Collected fibers are finely cut into short uniform length fibers of the required form after which the fibers are segregated each fiber strand by sitting patiently, and then by using the weighing scale we can weighthe short fibers as per the required ratios to fabricate the required composite materials which is used in this research work.

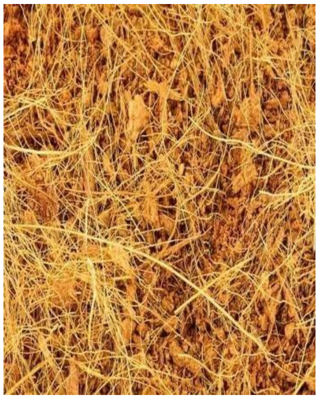

Fig: 1 Coconut Husk. **Fig: 2 Coir separated from Husk.** **Fig: 3 Coir dried after NaOH treatment.**

B. Preparation of Tamarind Fruit fiber:

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An evergreen shrub tree in the Fabaceae family, the tamarind tree (Tamarindus indica) has a lengthy life expectancy. The tropical belt, which includes South America, Southeast Asia, northern Australia, and Africa, is home to this plant. In India, tamarind trees may produce an estimated 300,000 tonnes of fruit per year, with yields ranging from 150 to 500 kg per tree. When mature fruits are dry, they are easy to crack; this releases the pulp and fibres from the fruit's shell, leaving behind a lot of fibres, kernels (seeds), and husk. The Mandy market in Hindupuram, Anantapur, Andhra Pradesh, India, was the source of the tamarind fruit fibres. The tamarind fruit fibres were extracted after a thorough rinsing in water. To get the most out of it, it was sun-dried for a few days. The fruit fibres of tamarind were placed in a bucket, then soaked for one hour in a solution of 5% sodium hydroxide. To get rid of any surplus NaOH solution that had stuck to the fibres, they were rinsed with water. After a last rinse in distilled water, the fibres were let to dry naturally in the sun. The collected fibres are next uniformly and finely chopped into small lengths, and then each fibre strand is separated by sitting patiently. These short fibres may then be utilised to make the composite materials needed for this study.

Fig: 4 Tamarind Fruits.

Fig: 5 Tamarind Fruit Fiber before Extraction.

Fig: 6 T/F Fiber dried after treatment.

III. PREPARATION OF SPECIMENS

The sample preparation of the composite is done by using varying weight percentages of ratios. We calculate the required weight percentage of short fibers, from the ratios table and then we calculate the weights accurately and are measured using them with a digital weighing machine. Percentages are taken based up on varying proportions and ratio of mixtures. The weight percentages are converted into grams by taking the epoxy and hardener mix as 220 grams, then the reinforcement material is also converting the weight percentages into grams by using the Digital weighing scale.

TABLE 1
SAMPLE PREPARATION IN RATIOS.

Specimens	**% wt. of Epoxy Resin + Hardener**	**% wt. of Tamarind fruit fiber**	**% wt. of Coconut coir fiber**
1	70	15	15
2	70	20	10
3	70	17	13

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The Fibers were arranged uniformly as per above ratios as mentioned in the table and the composites were prepared with epoxy resin (LY 556) and hardener (HY 951) as matrix in the ratio of 10:1 mixture in the fabricated mould of dimensions 1600 mm x 160 mm x 10 mm and the prepared composites are sized according to ASTM standards for testing of mechanical properties which as Tensile, Compressive, Impact, Flexural and Water Absorption Tests.

TESTING OF SPECIMENS

A. Tensile Testing of the Specimens:

At a cross-head speed of 5 mm/min, the composites' tensile strengths were tested using a computerised Universal Testing Machine technique. The specimens' average values were provided. Tensile specimens in a rectangular form of 140 mm X 15 mm X 10 mm were cut using a cutting machine. A material's tensile strength, or the amount of energy it absorbs during fracture, may be found out by doing this test. This test uses a universal testing apparatus to determine the tensile strength of specimens with dimensions of 140 mm in length and 10 mm in thickness. The following relation is used to compute the tensile strength.

Tensile stress = Tensile force / area

Fig: 7 Tensile Test Specimens.

Fig: 8 Tensile testing on UTM.

Fig: 9 Specimens after Tensile testing.

B. Impact Testing of the Specimens:

The impact strength of the samples was measured using an Izod impact test machine. All impact test samples were unnotched. The test specimen was supported as a vertical cantilever beam and broken by a single swing of a pendulum. Impact test is a solitary point test that measures the resistance of the material to impact from a swinging pendulum. Impact can be defined as the kinetic energy required inducing fracture and continuing the fracture until the specimen is failed. All the tests are conducted according to ASTM standards. Out of the composite specimen having more dimensions but in impact testing we required only 65 mm rectangular body specimen as per ASTM standards. So the specimens will be machined in to required length and thickness. The

Impact test specimens are carried out as per ASTM standards and are ready for the Impacttest. This test was carried out at ambient conditions and the average of impact strength was calculated

.

Fig: 10 Impact test specimens. Fig: 11 Specimen loaded for Impact test. Fig: 12 Specimens after Impact test.

*C. Compression Testing of the Specimens:*Compressive test is conducted at room temperature to determine the ultimate compressive strength of the given specimen under static loading conditions. The external faces of the specimen are perfectly plane. The specimen is placed between the heads of the Compression Test Machine (CTM), the loads are applied slowly onto the specimen and it undergoes compression. The specimen is tested and the equivalent readings are taken from the dial attached to the control unit. This testuncovers the measure of vitality consumed by a material amid break, which alludes to the materials pressure quality. The pressure quality test for samples of dimensions 10 mm X 10 mm was tested. The compression test is calculated from the following relation.

Compression stress = compression force / area

Flexural tests were performed on an Instron 3369 universal testing machine, using the three-point bending fixture according to ASTM standards and with a crosshead speed of 5 mm/min. The rectangular shape three-point bending specimens were prepared using a cutting machine with dimensions of 127 mm X 13 mm X 10 mm. Specimen deflection is measured by the crosshead position. Test results include flexural strength and displacement.

The testing process involves placing the test

specimen in the universal testing machine and applying force to it until it fractures and breaks. The specimen used for conducting the flexural test is presented in the below figures. The tests are carried out at ambient condition and the average values are reported.



Fig: 15 Flexural test Specimens. Fig: 16
Three point bending test for specimen. Fig: 17
Specimens after Flexural test.

D. Water Absorption test for the Specimens:

In this water absorption test, the composite specimen is subjected to the calculation of how much water absorbs the specimen. The specimen with 20 mm x 15 mm x 10 mm size has taken for water absorption test as per ASTM D 570 standard. Moisture absorption studied on treated Coconut Coir fiber and Tamarind Fruit fiber reinforced epoxy hybrid composites were carried out with the source of water.

E. SEM Analysis:

A Scanning Electron Microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The morphological characterization of the composite surface is observed in scanning electron microscope of Model JEOL JSM-IT 500.The composite samples are cleaned properly; air dried and are coated witha thick gold

IV. RESULTS

TABLE 2
Results for Tensile, Compression, Impact, Flexural and Water Absorption Tests.

Specimens	Tensile Strength (N/mm^2)	Impact Strength (J/m)	Compression strength (N/mm^2)	Flexural Strength (N/mm^2)	Water Absorption (%)
1	8.75	80	66.88	48.72	9.07
2	9.83	40	65.84	37.38	9.31
3	6.89	60	62.39	41.76	11.11

The Tensile Strength of the composite depends on the quantity and quality of Fiber used. The below Graph exhibits the variety of Tensile strength with various composite proportions for the greatest pinnacle loads. The specimen "2" has highest Tensile Strength of 9.83 N/mm^2 and specimen "3" has lowest tensile strength of .89 N/mm^2.

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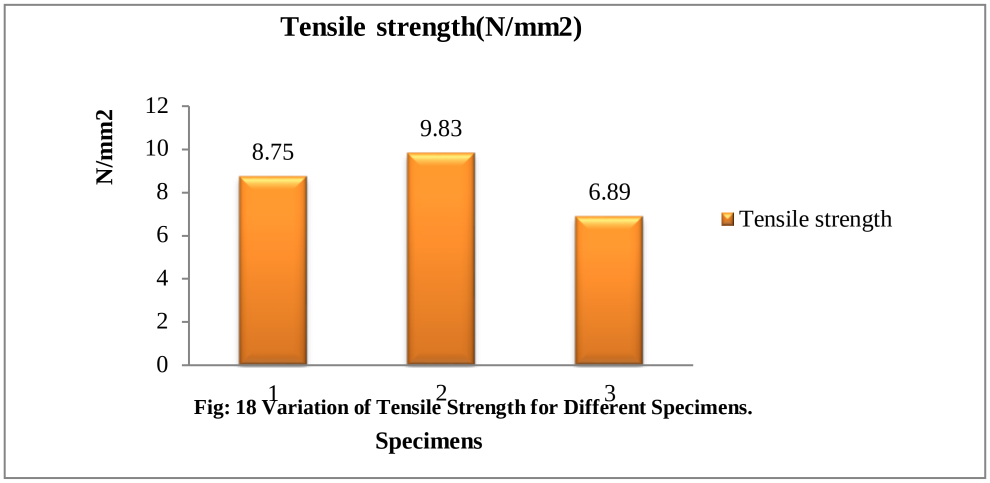

Fig: 18 Variation of Tensile Strength for Different Specimens.

A. Impact Test:

The Impact strength of different mixtures of composite material weight fractions are shown in below figure. From the figure the variation of impact strength with different composite specimen for the maximum impact loads. The specimen “2” has lowest impact strength of 40 J/m and the specimen “1” has highest impact strength of 80 J/m.

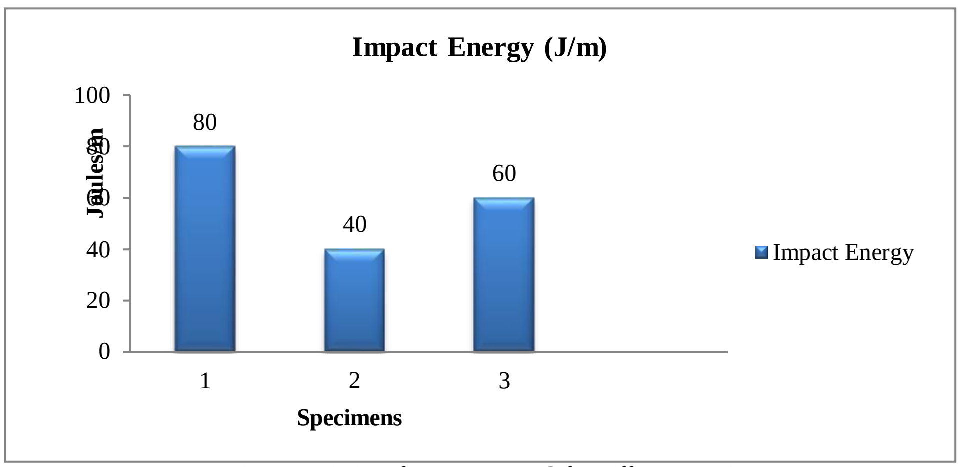

Fig: 19 Variation of Impact Strength for Different Specimens.

B. Compression Test:

In contrast to the tensile test direction, the planar area is used to determine the composite's compression strength in CTM. The figure below shows how the compressive strength varies as a function of the proportion of composite material. Specimen "1" of composite material clearly has a higher compressive strength, as seen in the graph. The Compressive Strength is reduced in specimens "1," "2," and "3" when the quantity of coconut coir fibre is reduced with the addition of tamarind fruit fibre. Specimen "1" has a Maximum Compressive Strength of 66.88 N/mm2, as shown in the figure. A minimum compressive strength of 62.39 N/mm2 was measured for specimen "3," whereas specimen "2" exhibited a value of 65.84 N/mm2.

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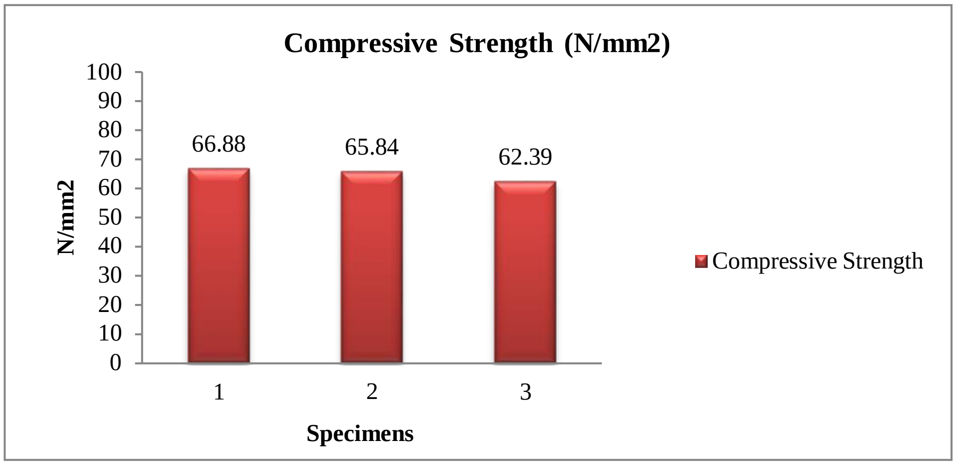

Fig: 20 Variation of Compressive Strength for Different Specimens.

C. Flexural Test:

The flexural properties for the different composites are displayed in following graph 5.4. Flexural stresses were increased with deflection, initial stage deflection & slope gradually follows until the failure point. The flexural stress & flexural modulus are tested for the specimens "1", "2" & "3". From the obtain values of three-point flexural tests the graph isplotted. In that the specimen "1" is having maximum flexural strength than the other two specimens.

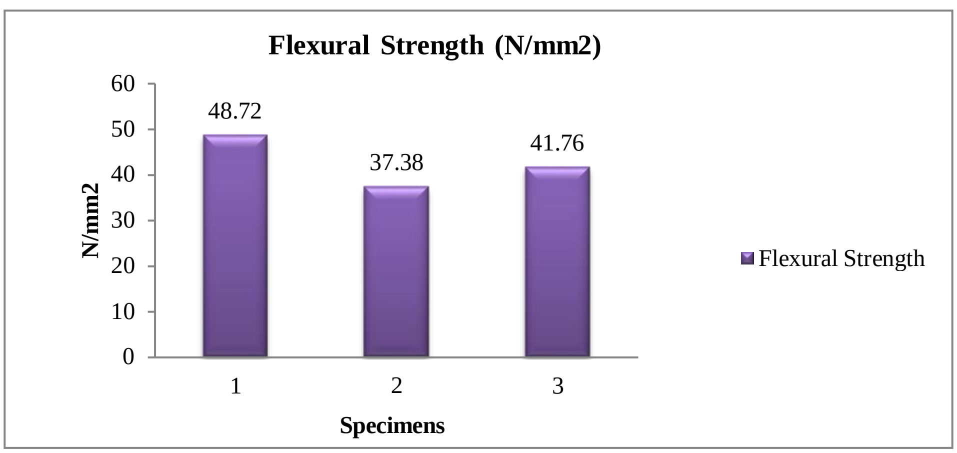

Fig: 21 Variation of Flexural Strength for Different Specimens.

D. Water Absorption Test:

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Examining how much water the specimens that were submerged in water for 120 hours at room temperature absorbed. As soon as the specimens were taken out of the water, they were dried and weighed. The table below displays the results of testing the water absorption percentage of each composite sample. See the figure below for the samples' moisture absorption % after 5 days. The water absorption rates of Specimen "1," Specimen "2," and Specimen "3" are 9.07%, 9.31%, and 11.11%, respectively. As a consequence, specimen "3" has a high moisture absorption rate, while specimen "1" has a low one.

TABLE 3

Percentage of Water Gain for different Specimens.

Specimens	**Immersion Time (Hrs)**	**Weight Before Immersion (Grams)**	**Weight After Immersion (Grams)**	**Percentage of Weight Gain (%)**
1	120	4.52	4.93	9.07
2	120	4.08	4.46	9.31
3	120	3.42	3.80	11.11

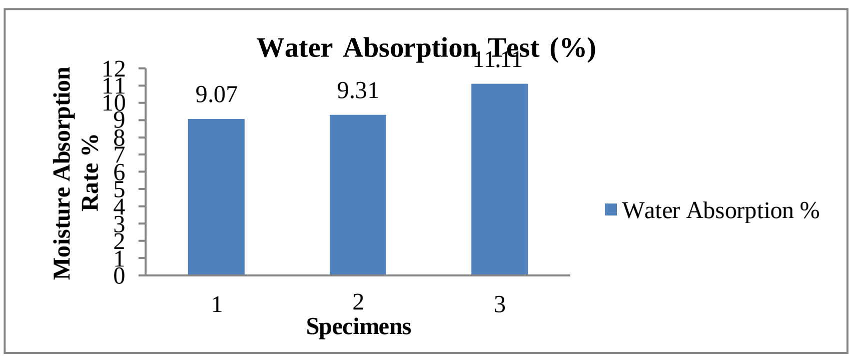

Fig: 22 Variation of Water Absorption test for Different Specimens.

E. SEM Analysis:

The composites' interfacial characteristics were examined using a scanning electron microscope (SEM). The next pictures show scanning electron micrographs of a cracked surface of the composites made with the treated coconut coir/tamarind fruit fibres. Using phase information, the topographical features of the manufactured composite surface reveal the mechanical property change. The fibre was totally saturated with the matrix, as shown in the image below. It's intriguing to see that the fibre was ripped and cracked. This proves that the fibres and epoxy resin matrix have an exceptionally strong bond at the interface. Better contact area between the matrix and the fibre was the result of an increase in the surface area of the fibre.

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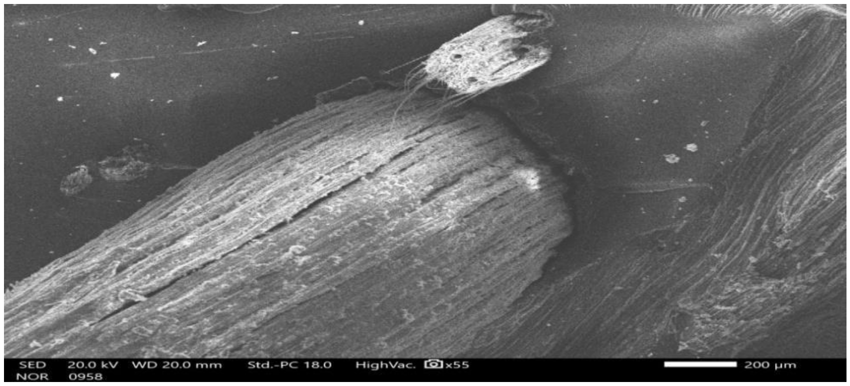

Fig: 23 SEM micrographs of fractured surface of Specimen 1.

Fiber pullout with a considerable length is clearly visible and a larger gap seen between the treated fiber and the matrix represents the fiber debonding as shown in the below figure. These indicate that the interaction between the fiber and the matrix in the composites of specimen “2” was moderate weak, due to poor fiber-matrix compatibility.

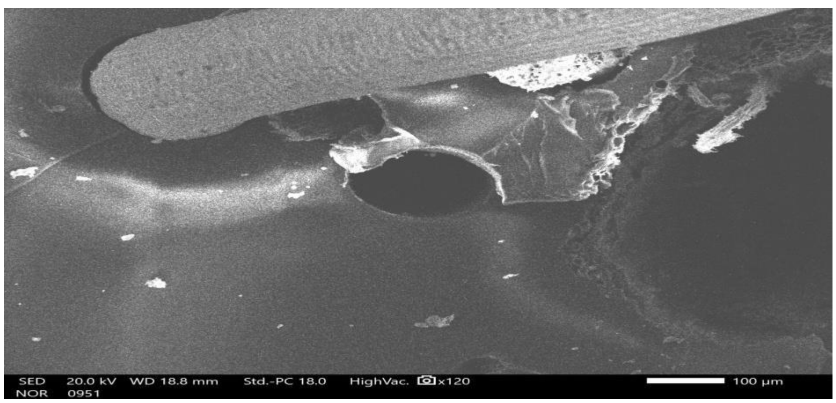

Fig: 24 SEM micrographs of fractured surface of Specimen 2.

In contrast, the fibers were covered (skin formation) with the matrix, resulting in considerable reduction in the gaps between them as shown in the below figure and then the fibers were found to break with a fiber pullout but which indicatesan improvement of interfacial adhesion between the fiber and the matrix.

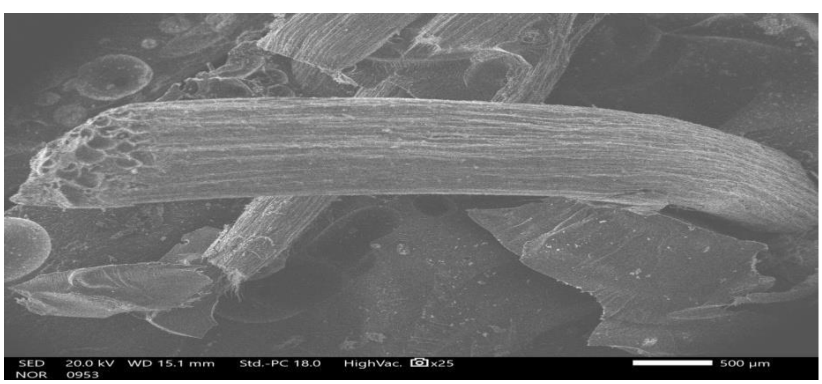

Fig: 25 SEM micrographs of fractured surface of Specimen 3.

V. CONCLUSIONS

The current study aimed to fabricate hybrid composites of coconut coir and tamarind fibres reinforced with epoxy using a simple hand lay-up approach. The composites were made with varying fibre weight ratios. Composites made using a mixture of 20% tamarind fibre and 10% coconut coir fibre exhibit an increase in tensile strength as shown by laboratory testing. Results from the Compression Test, Impact Test, and Flexural Test showed that the mechanical characteristics of the composites were significantly affected by the mix of 15% tamarind fibre and 15% coconut coir fibre.

To a certain extent, the flexural, impact, and compressive strengths of composites may be enhanced by increasing the proportion of coconut coir fibre. Specimen "1" has a much lower water absorption rate than other composite specimens. Using scanning electron microscopy, we can see that the reinforcing fibres are evenly distributed throughout the matrix. It follows that this chemical is homogeneous. The mechanical properties of the composite are enhanced due to the uniform distribution of reinforcement.

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