# Experimental Study on Tensile Test and Three Point Bending Test of Jute Fiber Composite At Different Ply Orientations

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***Abstract-*** *In the field of composites various types of synthetic and natural fibers used as reinforcement purpose, but the synthetic fiber are non-biodegradable and non-recyclable material. In recent days as per environmental concern, biodegradable and renewable material used in industrial application as in the form natural fiber composites. Strength of different natural fiber composites material is main objective as per there use in different application. A composite is combination of reinforcing and matrix material. Various types of reinforcing natural fiber are available in the market, but as per cost concern, jute fiber is low cost material as compare to other natural fiber material. In this study jute fiber material are available in the form jute woven mat is taken. Various jute fiber composite specimens prepared with help of epoxy resin by hand lay-up technique. Jute fiber composite with ply orientations such as [900/00/900]s, [+450/00/-450]s and [+600/00/-600]s prepared as per standard methods. Mechanical characterization such as tensile and flexural (three point bending) strength at different ply orientations is studied. From the result it is observed that tensile strength in [900/00/900]s is higher than [+450/00/-450]s and [+600/00/-600]s and flexural strength in [+600/00/-600]s is higher than [+450/00/-450]s and [900/00/900]s. Results in longitudinal directions are higher than transverse directions.*

***Keywords***- jute fiber woven mat (JWM), EPOXY resin and EPOXY hardener, hand lay-up method, experimental setup, conclusion.

## I. INTRODUCTION

The term composite refers to the combination of a soft matrix and a strong reinforcement constituents that are joined together in order to manufacture easily. Matrix will be strengthen the properties and assist in transferring load between the strong and stiff reinforcements. A composite have combined constituents that are one constituent known as reinforcing and other known as the matrix at a macroscopic level. The reinforcing phase material is in the form of particles or flake, fibers etc. Composite materials are significant in mechanical, physical, thermal, corrosion resistance and dimensional stability properties thats why they are used in our day to day life. It is an important category of material properties for designing structural components in engineering applications such as biomechanical, automotive, and aerospace engineering application. Without being affected by the huge performance of synthetic fibers such as carbon and glass, drawbacks including non-recyclability, non-renewability and high-energy consumption requirements to manufacture, have shifted interests towards natural fibers in recent years. When compared to synthetic fibers, natural fibers have many advantages including mechanical properties, recycle, and require less energy to process. In addition, they are sustainable, cheaper and lighter in weight and minor toxic to human. Natural fibers have good mechanical properties depends on the purpose of the composite and by replacing the type of the fibrous reinforcements and their placement angle-ply orientations in composite structure. However, many factors like those lightweight, cost and failure nature lead the polymer epoxy resin used in composite because it gives well balance in a chemical properties and mechanical properties.

The awareness on health and environment concern the natural fiber (environment-friendly characteristics) provides opportunities to work on them for replacing the unhealthy material like synthetic fiber (manmade fiber) they are affecting the environment due to toxic, non-degradability and non-recyclability resulting waste products were increasing in the environment. By the classification of natural fiber, jute is coming into non-wood fiber it is produced from skin or bast of Corchorus capsularis plant. Jute has used from centuries as a packaging material. In recent time jute fiber found to be valuable a property, and thats why aid to composites material. Jute is eco-friendly, low cost, and has moderate mechanical properties, which is replaced several synthetic fibers in development of composite materials. Jute is available in many forms like raw jute, non-woven, woven and breaded in course threads by the use in different application. Jute fiber composites materials used in door panels, automobile headliners, in helmet, automobile dashboards, furniture materials, etc. Jute fiber has the valuable properties to

comparison with glass fiber, as reinforcing agents in plastics. Products made from jute-fiber reinforced composites have the advantage of low cost, low density, renewability and biodegradability. Applications of jute-fiber reinforced composites are significant positive effect on environment.

## II. LITERATURE REVIEW

**Vivek Mishra**

In this study, bidirectional (BD) jute mat taken as reinforcement and epoxy resin used as matrix. The jute fiber composites are manufacture by hand lay-up method and their physical & mechanical properties are investigated. Composite specimens are prepared for different fiber loading (0, 12, 24, 36 and 48 wt. %) and subjected to post curing at room temperature for 24 hours. It is found that pure epoxy composites specimens has the minimum void content, 12 wt. % fiber are adding to epoxy the void content increases immediately to 5.312 %. Further adding the fiber content by weight from 12 wt. % to 48 wt. % the voids contents in the composites samples decreases. Theoretical density of the composite is improved by adding Fiber contents to the composites. From the experimental results, observed that the formation of voids content in composites is affecting on the mechanical properties.

**M. Ramesh**

Studied this paper, the mechanical properties tensile and flexural strength (ASTM D 638 & ASTM D790) of hybrid glass fiber with sisal/jute epoxy composites was determined. The epoxy resin and hardener TETA used as matrix for specimen preparation. The results of tensile test the strength of the sisal-glass is better than the jute-glass composites. The sisal-glass fiber specimens possess good tensile strength up to 68.55 MPa. The flexural strength of jute-glass composites is more than sisal-glass fiber composites. The flexural strength of jute-glass specimen is higher than sisal-glass specimen.

Md. Rashnal Hossain

In this paper, natural fiber composite based jute fiber used for study of mechanical characterization by tensile and flexural test. UD (unidirectional) Jute fiber composites were fabricated by VARI technique. As resin epoxy Epikote 828Lvel and hardener used as matrix material. Jute Fiber are made by laminate sequences of ($0^0/90^0/90^0/0^0$), ($0^0/+45^0/-45^0/0^0$) and ($0^0/0^0/0^0/0^0$). In this paper, tensile properties characterized by ASTM D 3039 standard. After testing it is observed that laminate sequence of ($0^0/0^0/0^0/0^0$) and ($0^0/+45^0/-45^0/0^0$), tensile strength in longitudinal behavior was found to be higher than transverse direction. For the laminate of ($0^0/90^0/90^0/0^0$), tensile strength in longitudinal and transverse behavior found to close to each other.

**B. Vijaya Ramnath**

This paper deals with the hybrid natural fiber composites and compare with pure abaca and jute fiber used as reinforcement of composites. In this study epoxy resin LY 556 and hardener HY 951 used as curing agent and the mixture ratio of epoxy and hardener 10:1 used for fabrication of composites. The composites specimens are fabricated by most suitable hand lay-up technique and up to 40% of fiber, volume fraction is considered. From the results of tensile and shear test it is found that hybrid composites of abaca- jute fiber has higher strength than pure abaca fiber. However, the abaca composite is better to hybrid composites in impact and flexural strength.

**Ajith Gopinath**

This paper deals with natural plant fiber based jute fiber used for reinforced composites of length 5-6 mm. Two different types of matrix material used such as polyester with hardener methyl ethyl ketone peroxide (MEKPO) and epoxy resin with hardener triethylene tetramine (TETA). The jute fiber and resin composites fabricated at 18:82 by weight percentages. Jute fiber with epoxy composites shows better results of mechanical properties than Jute fiber with polyester composites.

**Himanshu Bisaria**

In this paper, short jute fiber with randomly oriented as reinforcement and the Epoxy resin AY-105 and Hardener HY-951 as matrix for fabrication of composites. Hand lay-up technique used for preparation of composites with 30% by weight of jute fiber in different lengths 5, 10, 15 and 20 mm. The results of tensile and flexural test it was found that strength is higher for 15 mm length of fiber and impact properties found maximum for 20 mm length of fiber.

**Subhankar Biswas**

This paper deals with study of unidirectional (UD) jute and bamboo fiber Epoxy resin (Prime$^{TM}$ 20LV) composites and fabricated by using vacuum technique. The stacking sequence of composites in such a manner that eight layers of jute and six layers of bamboo fiber. To prevent rough surface of the composite glass sheet aligned on the upper side of composites. Both longitudinal and transverse behavior of oriented composites was tested. The theoretical and experimental values calculated using rules of mixture. the

results of tensile testing and flexural testing it is observed that it shows good results for bamboo fiber, but values of tensile modulus for jute fiber composite higher than bamboo fiber in longitudinal distribution. On the other hand, flexural strength of jute fiber composites had better in transverse distribution.

**Sutanu Samanta**

In this paper, jute and bamboo fiber hybridized with glass fiber as polymer composites. The hybridization of composites like viz. jute/GFRP and bamboo/GFRP are prepared with 00 and 900 fiber alignment in a mat form. Epoxy resin 'LAPOX L12' and hardener 'LAPOX K-6' were used as matrix material. The fixed four number layers of laminate were prepared for composites laminate structure. Flexural modulus of jute hybrid and bamboo hybrid are maximum when bamboo fiber at bottom and glass fiber on top. Flexural strength of jute hybrid and bamboo hybrid are more when jute and bamboo fiber on top (under compression) and glass fiber at bottom (under tension).

**Radhika Londhe**

Studied this paper; effect of moisture absorption of natural fibers because they were hydrophilic in nature due to these poor water resistance properties, and results mechanical properties of composites was minimized. In this paper moisture absorption of natural fiber composites was reduced by providing different coatings to the composites. Natural fiber based jute fiber were used as reinforcement and Epoxy resin 520 and hardener PAM was used as matrix, composite laminates are fabricated by hand lay-up process.

**Problem statement**

Natural fibers produced from vegetable plant; they are non-toxic, biodegradable, fully or partially recyclable material. Now a day's environment friendly vegetable fibers are used in composites field for reinforcement purpose. Fibers were primary load carrying member for composites material, they are stiff and strong enough to sustain the load in the direction of fiber. Strength of unidirectional (UD) fiber composites in one direction because the fibers were run in one direction, but strength of the bidirectional (BD) fibers are in both directions ($0^0$ and $90^0$). The physical and mechanical properties of (UD and BD fibers) are varies with reference to axes of natural fiber direction. Woven mat is example of bidirectional (BD) ply orientation, strength of these fibers in both direction but not the same strength. In this project, jute fiber woven mat (JWM) (BD) used as a natural fiber reinforcing material for fabrication of composites at ply orientations was studied.

**Objectives**

1) To fabricate the jute fiber (JWM) composites at different ply orientations with symmetric type of laminates.
2) To investigate the effects of jute fiber (JWM) ply orientations on the performance of composites specimens.
3) Mechanical characterization of composites specimens by Tensile and three point bending test.

## III. METHODOLOGY

**Materials**

In the present study, for fabricating the composite laminates the jute fiber (JWM) used as the reinforcing material. The epoxy resin and epoxy hardener provided by K.S industries, Pune, Maharashtra, India.

**Jute Fiber**

From the classification of natural fiber, jute is non-wood natural fiber, and it collected from skin or bast of the plant, hence it is skin or bast fiber. Jute fiber shows the good material properties, inexpensiveness and commercially availability in the required form. Density of jute fiber is $1.46 g/cm^3$. Jute fabric mat (JWM) is used in the current research work is a shown in the given Fig.1

Fig.1 jute fiber woven mat (JWM)

**Matrix Material**

Epoxy resin 520 and Epoxy hardener-PAM they are purchased from the Electrocoating & Insulation Technology Pvt. Ltd Pune, Maharashtra, India. Density of matrix is 1.15 g/cc. The resin and hardener was mixed in the ratio of 10:1 by the weight as suggested.

**A) Hand lay-up procedure**

Hand lay-up method is convenient, best suitable, low cost and simple method to manufacturing the composites. Jute fiber woven mat used as reinforcement natural material to the

Composites. Jute fiber mat cut as per the required dimensions of ply orientation and placed at the surface of wooden mold plates. Then epoxy resin was mixed thoroughly with an epoxy hardener (as curing agent) in the proper proportion and poured on surface of first ply of jute mat already placed on the surface wooden mold plate. The resin applied to the all ply (laminates) with the help of brush. This lay-up process was repeated for all layers of ply (laminate) of jute fiber mat, until the required six layers of laminates were stacked. After placing, the wooden mold plate on the surface of top ply of jute fiber mat and the equal pressure applied from all side. At normal temperature, curing of composites was done for 12 to 48 hrs.

**a) Fabrications of jute fiber (JWM)/EPOXY Composites**

In this study, three different symmetric types of laminate with orientations of jute fiber woven mat (JWM) were developed with the help of hand lay-up technique in a closed of dimension 30cm x 30cm at the room temperature having the thickness of 0.4 cm. The Epoxy Resin 520 and epoxy hardener PAM mixed thoroughly in the ratio of 10:1 by weight. Each orientation consists of six layers of jute fiber (JWM).

Fig.2 Fabrications of Composites laminates.

**b) Fabricated jute fiber (JWM)/EPOXY Laminates**

The jute fiber (JWM)/EPOXY composites laminate fabricated with the help of hand-layup technique at room temperature. The orientation of the each ply in proposed laminate is given as ($90^0/0^0/90^0/90^0/0^0/90^0$), ($+45^0/0^0/-45^0/-45^0/0^0/+45^0$) and ($+60^0/0^0/-60^0/-60^0/0^0/+60^0$) respectively. Where is 's' denoted for symmetric laminates.

**B) Volume fraction of the jute fiber (JWM)/EPOXY composite laminate**

$Vjf = (Wjf/\rho jf)/ (Wm/\rho m+Wjf/\rho jf)$

Where, $Wjf$ = weight of jute fiber
$\rho jf$ = density of fiber
Wm = weight of matrix
$\rho m$ = density of matrix

In this study, total fiber volume fraction 24.79 ≈ 25% and matrix volume fraction 75%.

Table.1 Weight of jute fiber (JWM) and EPOXY resin (matrix)

| weight of jute fiber (g) | weight of epoxy resin (g) | Weight of composites (g) |
|---|---|---|
| 132 | 315.33 | 447.33 |

## IV. MECHANICAL CHARACTERIZATION OF JUTE FIBER (JWM)/EPOXY COMPOSITES

**Tensile Test**

Tensile test performed following the ASTM D3039 standard using the Universal Testing Machine (Model No-STS 248) with an accuracy of ± 1%. The crosshead speed was maintained as 5mm/min. The capacity of the machine is 100kN. The specimens were cut in to dimensions as 20mm x 250m x 4mm. Test process involves mounting the specimen on the (UTM) fixture and applying tensile force on specimen until it breaks. Tensile test specimen is placed in fixture and tensile force will be applied from both side in the application of tensile load, and after some time the specimen will break at its gauge section and simultaneously values of tensile strength are evaluated. The tensile test specimen of jute fiber composites and experimental setup for tensile test of composite specimen and UTM are shown in Fig.3 and fig.4

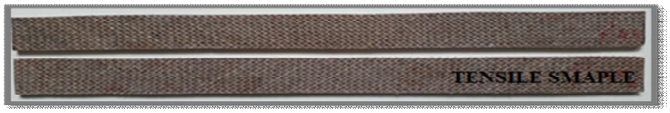


Fig.3 Tensile test SPECIMEN

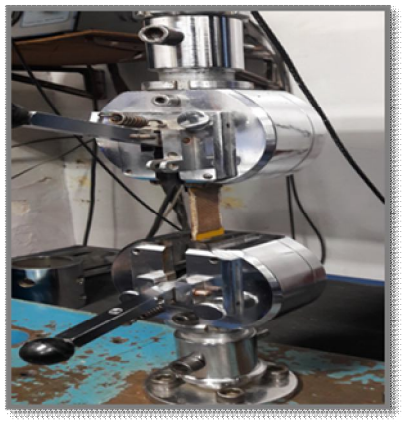

Fig.4 SPECIMEN loaded on (UTM)

**Flexural Test**

Three-point bending is also known as flexural bending. Flexural test was performed following the ASTM D790 standard using the Universal Testing Machine UTM (Model No-STS 248) with an accuracy of ± 1%. The specimens were cut in to dimensions as 13mm x 127m x 4mm. The specimens were placed on the fixture having overhang length of 65mm. The crosshead speed for flexural test was set at 5mm/min. The flexural test specimen of jute fiber composites and experimental setup for flexural testing of composite specimen and UTM are shown in Fig.5 and Fig.6

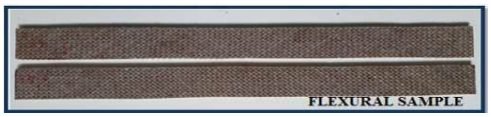


Fig.5 Flexural test SPECIMEN

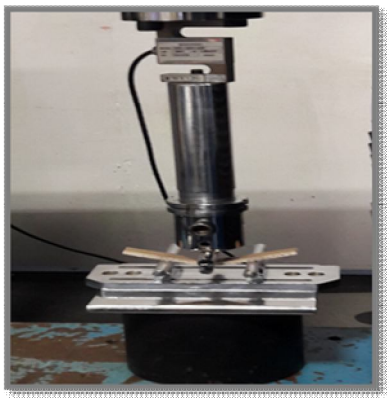

Fig.6 SPECIMEN loaded on (UTM)

## V. RESULTS AND DISCUSSION

### Tensile Strength Analysis of (JWM)/EPOXY Composite

The three different ply orientation (JWM)/EPOXY composite specimens like $[90^0/0^0/90^0]$s, $[+45^0/0^0/-45^0]$s and $[+60^0/0^0/-60^0]$s are tested in the universal testing machine to find the tensile properties. Tensile tested specimens shown in below fig.7. Stress vs. strain graph generated from UTM testing results.

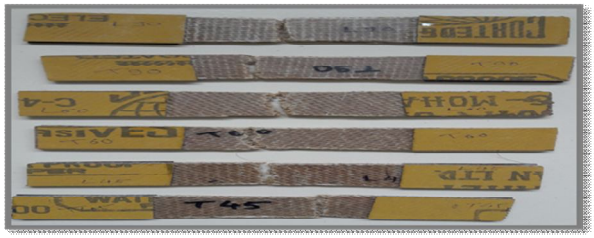

Fig.7 tested tensile specimens

A graph showing stress vs. strain of $[90^0/0^0/90^0]$s, $[+45^0/0^0/-45^0]$s and $[+60^0/0^0/-60^0]$s is shown in below Fig.8, 9 and 10. The stress increasing with respect to strain, after some time the specimen will break at ultimate stress. Tensile stress values in longitudinal higher than transverse directions.

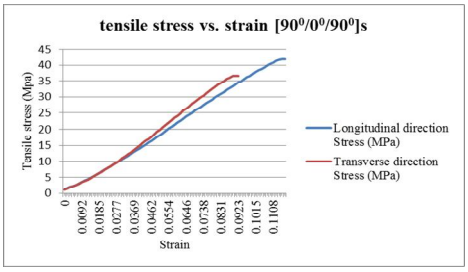


Fig.8 stress vs. strain graph

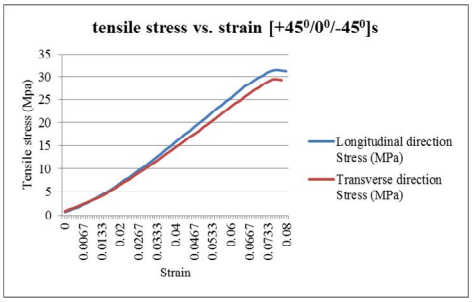


Fig.9 stress vs. strain graph

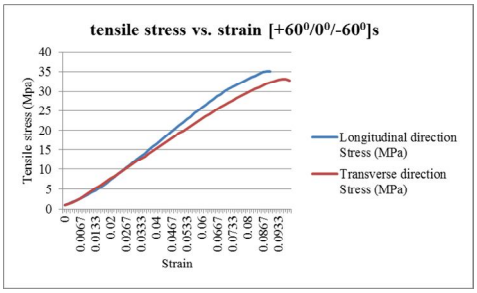


Fig.10 stress vs. strain graph

The comparison between different orientations of jute fiber (JWM)/EPOXY composites at tensile strength in directions are shown below in Fig.11 The tensile properties of the fabricated composite (at ply orientations) are summarized in the bar graph for better comparison. It is clearly seen that the tensile strength of Jute fiber (JWM)/EPOXY composite specimens having the highest in orientation of $[90^0/0^0/90^0]$s and it is observed 41.888MPa in longitudinal. Tensile strength in orientation of $[+45^0/0^0/-45^0]$s and $[+60^0/0^0/-60^0]$s are found slightly close to each other in both direction respectively for $[+45^0/0^0/-45^0]$s 31.488MPa in longitudinal and 29.455MPa in transverse and for $[+60^0/0^0/-60^0]$s 35.043MPa in longitudinal and 33.130MPa in transverse.

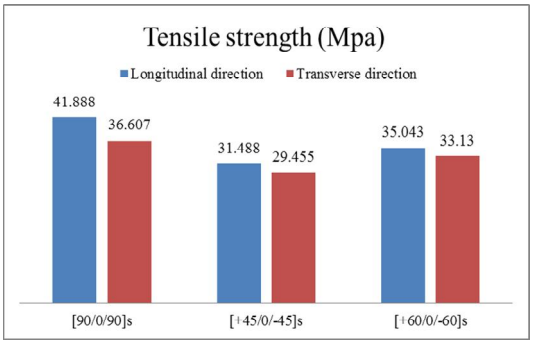


Fig.11 Bar graph of Tensile Strength

**Flexural Strength Analysis of (JWM)/EPOXY Composite:**

The three different ply orientation (JWM)/EPOXY composite specimens like $[90^0/0^0/90^0]$s, $[+45^0/0^0/-45^0]$s and $[+60^0/0^0/-60^0]$s are tested in the universal testing machine to find the flexural properties. Flexural tested specimens shown in below fig.12. Stress vs. strain graph generated from UTM testing results.

Fig.12 tested flexural specimens

A graph showing stress vs. strain of $[90^0/0^0/90^0]$s, $[+45^0/0^0/-45^0]$s and $[+60^0/0^0/-60^0]$s is shown in below Fig.13, 14 and 15. The stress increasing with respect to strain, after some time stress will decreasing linearly with strain. Flexural stress in longitudinal higher than transverse directions.

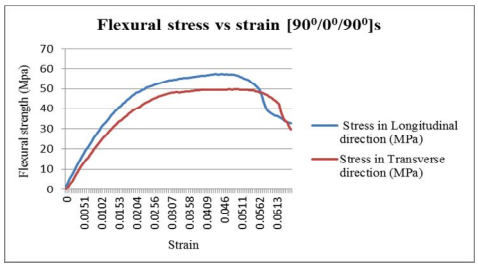


Fig.13 stress vs. strain graph

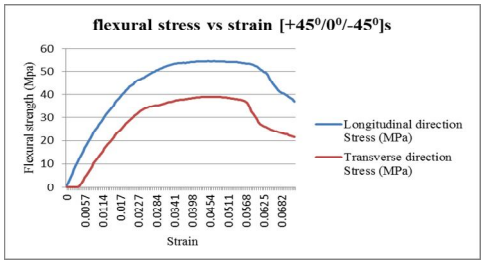


Fig.14 stress vs. strain graph

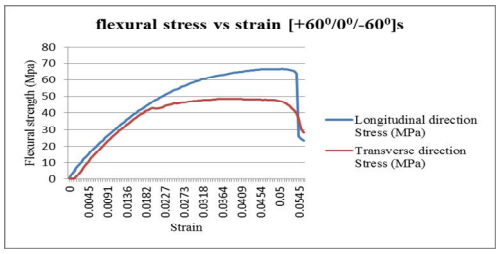


Fig.15 stress vs. strain graph

The comparison between different orientations of jute fiber (JWM)/EPOXY composites at flexural strength in directions (longitudinal and transverse) are shown below in Fig.16 The flexural properties of the fabricated composite (at ply orientations) are summarized in the bar graph for better comparison. Flexural strength of Jute fiber (JWM)/EPOXY composite specimens having the maximum in orientation of $[+60^0/0^0/-60^0]$s and it is observed 66.701MPa in longitudinal direction. And also Flexural strength in orientation of $[+45^0/0^0/-45^0]$s and $[90^0/0^0/90^0]$s are found higher in longitudinal direction respectively 54.436MPa and 57.284MPa.

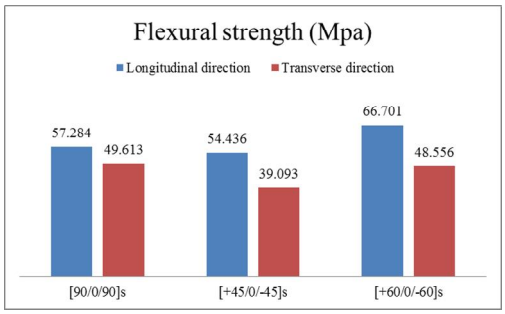


Fig.16 Bar graph of flexural Strength

## VI. CONCLUSION

Jute fiber (JWM)/EPOXY composites are fabricated by hand lay-up technique under the same operating pressure and temperature condition. The fabricated composites are mechanically characterized to get tensile strength and flexural strength. As the ply orientations changes strength also changes of composites. The following conclusions have been driven out from the experimental results.

1. Jute fiber (JWM)/EPOXY composite specimens having the highest tensile strength in orientation of $[90^0/0^0/90^0]$s and it is observed in longitudinal direction 41.888MPa.

2. 2. Jute fiber (JWM)/EPOXY composite specimens having the lowest tensile strength in orientation of $[+45^0/0^0/-45^0]$s and it is observed in transverse direction 29.455MPa.

3. Jute fiber (JWM)/EPOXY composite specimens having the highest flexural strength in orientation of [$+60^0/0^0/-60^0$]s and it is observed in longitudinal direction 66.701MPa

4. Jute fiber (JWM)/EPOXY composite specimens having the lowest flexural strength in orientation of [$+45^0/0^0/-45^0$]s and it is observed in transverse direction 39.093MPa.

## VII. ACKNOWLEDGMENT

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