

# Development and Testing Of Jute Fiber Epoxy Composites

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## Abstract

Nowadays environment factor grasps major attention in selection of materials. Natural fiber composite is one such material meeting those requirements due to its bio-degradable and sustainable properties. So, it is the need of the hour to work on the biodegradable materials like natural composites. This paper highlights the preparation and testing of a natural composite called Jute fiber-epoxy composite. Hand lay-up is the technique used in this work to develop the composites, by putting them on an open type mould made of plywood. Both single ply and double ply composites are prepared and compared under different mechanical loads. It is observed that the prepared composite showed better strength under different mechanical conditions.

**Keywords:** Epoxy resin, Hand layup technique, Jute fiber, and Mechanical testing. .

## I. INTRODUCTION

The natural composite is made up of naturally available fiber and matrix materials. The demand for the natural fiber reinforced composites is increased in recent years and also plays a vital role in economy. It is due to the fact that they are in abundance, cheaper, easily recyclable, and biodegradable. Further they also have lower environmental impact. Natural fibers like lingo-cellulosic fibers have low density but the stiffness can match with that of glass fibers. Therefore, the need for fiber reinforcement polymer composites is increasing drastically. The natural composites are very advantageous both technically and economically. However like other materials, the natural composites also have some disadvantages such it's prone to high moisture absorption and poor dimensional stability, low fire resistance which limits their ability in long term applications [1]. Further, the moisture absorption of the natural composites reduces mechanical properties. In the present work, among the various natural composites, jute fiber and

epoxy resin composite was selected due to its better strength and stability even in moisture conditions.

Epoxy resins are a type of polymers containing epoxide groups. The reactive poly epoxides often form a thermosetting polymer with or without hardener having better mechanical, thermal and chemical properties. The applications of Epoxy resins can be widely witnessed in metal coatings, electrical insulators, fiber-reinforced plastic materials and structural adhesives. It can be also used as a glue. The natural fibers like bamboo, jute find a tremendous growth in various applications due to their abundancy, low cost and excellent mechanical properties. Among the natural fibers jute is one of the most affordable natural fibers next to cotton in its productions and applications. Jute fibers are made of plant cellulose and lignin. They are very useful for the purpose of construction such as, wall, floor, windows, door frames, partition boards and roof tiles, mobile and pre-fabricated buildings. The sections of this paper are as follows, Literature review of the natural

composites, materials used, Development of epoxy resin jute fiber composites, mechanical testing, results and discussions and conclusion.

## II. LITERATURE REVIEW

Kabir et al. [2] gave an overview of advanced composites made from different surface treatments of natural fibres. It also highlighted the shortcomings of natural fibres such as poor dimensional stability and moisture absorption. John & Thomas [3] reviewed the cellulosic nano composites and its applications in construction and automotive industry. The classification of bio composites, their advantages and disadvantages were also discussed. Hapuarachchi & Peijs [4] developed a bio based Poly lactic acid composites having better heat resistance capacity and flame retardancy. Xin et al. [5] discussed the tribology and wear properties of sisal fiber reinforced resin brake composites and identified that it was a better substitute for asbestos pads in brakes. Srikala et al [6] examined the influence of physical ageing, surface alteration on the stress rate of oil palm empty fruit fiber and found that the relaxation rate of stress of fiber was improved due to that treatments.

Faruk et al. [7] studied the various works on bio-composites published between 2000 and 2010. It highlighted the most preferred biocomposites in industries, their properties and their methods of preparation. Shalwan & Yousif [8] explored the influence of orientation, surface treatments, volume fraction of natural fiber reinforced polymer composites on tribology and mechanical properties. Raghavendra et al.[9] pointed that the glass fiber composites were better than the jute fiber epoxy resin composites in terms of mechanical properties and the tribological properties of jute fiber were superior than the glass fiber composites. Ku et al. [10] highlighted from their studies that the interfacial adhesion between the matrix and fiber materials increases the tensile properties of natural fiber reinforced polymer composites. Gopinath et al. [11] developed jute fiber epoxy resin composites and jute polyester composites and compared their properties such as flexural strength, tensile strength, impact and hardness. It was

found that the properties of jute fiber epoxy composites showed the superior results than the polyester jute fiber composites.

## III. MATERIALS USED

The following items are required for the development of jute fiber epoxy resin composites. Table 1 shows the materials and their purpose of usage in the composite preparation.

Table 1 Material usage in composite preparation

Sl.no	Items	Purpose of usage
1	Epoxy resin	Matrix material
2	Jute	Fiber material
3	Hardener	Curing agent of epoxy resins
4	Plywood	Base material
5	Wax	Coating over the surface of plywood to prevent the adhesion of resins over the surface of the plywood

## IV. DEVELOPMENT OF NATURAL COMPOSITES

The jute fiber epoxy resin composite materials have varying material properties, when the number of plies is added. So in this work, both single ply and double ply composite materials were developed using hand layup technique to identify the difference in their mechanical properties. The details of development of composites were as follows.

### Single Ply

1. On the open type mould (ply wood material), wax was applied to avoid sticking of the jute fiber due to the application of resin.
2. A jute fiber of 170\*170\*1 mm material was kept on the wax coated plywood.
3. The epoxy resin and the hardener were mixed in 1:5 ratio to increase the adhesion and hardness property of the resin.
4. The mixture of resin and the hardener was used to make a coat over the surface of the jute fiber using a paint brush.
5. Similarly 3 layers of coating were given in the equal interval of 2 hours to increase the thickness upto 3mm.

6. The composite material was kept under the sunlight for 3 days to get cured.
7. The compression was given over the composite to increase the spread of the layer over the jute fiber.

#### Double Ply

1. On the open type mould (ply wood material), wax was applied to avoid sticking of the jute fiber due to the application of resin.
2. A jute fiber of 170 X 170 X 1 mm was set aside on the wax coated plywood.
3. The epoxy resin and the hardener were mixed in 1:5 ratio to increase the adhesion and hardness property of the resin.
4. The mixture of resin and the hardener was used to make a coat over the surface of the jute fiber using a paint brush.
5. Similarly 3 layers of coating were given in the equal interval of 2 hours to increase the thickness upto 3mm.
6. The second ply of jute fiber was kept over the mixture coating of the first ply.
7. Again a coating was given to increase the thickness upto 5 mm.
8. The composite material was kept under the sunlight for 3 days to get cured.
9. The compression was given over the composite to increase the spread of the layer over the jute fiber.

### V. MECHANICAL TESTING

The composite materials were cut into equal piece of dimensions 100 X 30X 3 for single ply and 100 X 30 X 5 for double ply. The following mechanical testings were carried out to evaluate the difference between the properties due to the applied loads.

#### VI. COMPRESSION TEST

A compression test is usually conducted to determine the resistance of the specimen against the perpendicular load. In this work, the compression tests were performed on the single ply and double ply natural composites. Table 2 indicates the results of the single ply and double ply specimens' compression test.

Table 2 Compression test on single and double ply

Compression Test	
Single ply	Double ply
850 KN	900 KN

### VII. HARDNESS TEST

The type of material and expected hardness will determine test method. Hardness number indicates the hardness of the material. Further the higher value of hardness number specifies the better material hardness. In the present work, the hardness tests such as Brinell and Rockwell are performed on the specimens. Table 3 shows the results of hardness test in those methods at 250 kg load on single ply and double ply.

Table 3 Hardness test on single ply and double ply

Hardness Testing of specimen	Load 250 kg	Load 250 kg
	<i>Single Ply</i>	<i>Double Ply</i>
Rockwell	C48	C48
Brinell Hardness	B78	B78

### VIII. CHARPY IMPACT TEST

The Charpy impact test is a high-rate test used to determine the absorption of strain energy by a material due to the application of external forces. Charpy impact tests were conducted on single ply and double ply to determine their impact strength as shown in Table 4.

Table 4 Charpy impact test on single ply and double ply

Charpy impact test	
Single ply	Double ply
44 joules	74 joules

### IX. BEAM DEFLECTION

The deformation of a beam is the deviation in dimension due the externally applied load. The deflection of the beam is usually measured using dial gauge from the neutral axis of the beam and this is point at which the load is applied. In this work, both single ply and double ply natural composite was placed over the two columns of the beam deflection testing setup. The load is applied as given in the table 5 to measure the deflection of the beam due to the

application of load. Figure 1 shows the deflection of beam due to varying loads.

Table 5 Beam deflection test on single ply and double ply

S no	Load (kg)	Single Ply	Double Ply
		Beam deflection	Beam deflection
1	0.500	0.2	0.1
2	1.000	0.4	0.2
3	1.500	0.5	0.3
4	2.000	0.6	0.4
5	2.500	0.8	0.5

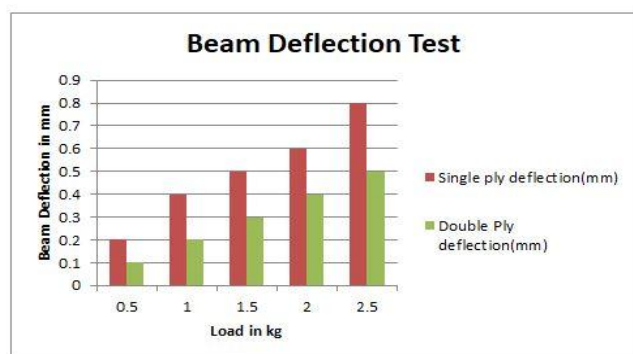


Figure 1 Beam Deflection Test

## X. ERICHSEN CUPPING TEST

The Erichsen cupping test is applied to calculate the ability of sheet material to undergo plastic deformation in stretch forming. In this test, the blank specimen is held between the two sides of clamp firmly and a spherical ball punch is used to penetrate

the mid-surface of the blank until it gets cracked. The depth of cupping due to penetration defines the formability of the sheet material. In the present work, Erichsen cupping tests were performed on both single and double ply to measure the depth of cup as shown in Table 6.

Table 6 The depth of cup

Single Ply	Double ply
20mm	15mm

## XI. RESULT AND DISCUSSION

The synthetic natural composites are bio degradable in nature so the demand for its application is vast in order to replace the plastic materials which are not bio degradable and polluting the environment for a long period of time. In the present work, jute fiber reinforced natural composite materials were prepared and tested under different mechanical conditions. The outcome of the ply was also analyzed. Due to the presence of more than one ply the natural composite has better result in all of the testing results. The percentages of variation between the plies are displayed in Table 7.

Table 7 The results of various mechanical tests

S.No	Testing methods	Percentage variation due to the addition of ply	Percentage of variation between the ply in %
1	Compression Test	Increase	5.56
2	Hardness Test	Increase	38.46
3	Charpy impact test	Increase	40.54
4	Beam deflection test due to min. load (0.5 kg)	Decrease	50
5	Beam deflection test due to max. load (2.5 kg)	Decrease	37.5
6	Erichsen cupping test	Decrease	25%

## XII. CONCLUSION

Investigation of prepared natural composites yielded the following inferences on its mechanical

properties. It revealed that the prepared composite exhibited better compressive strength in double ply than in single ply. The hardness of single and double ply showed no differences both in Rockwell and Brinell hardness testing methods. Double ply composite showed higher impact strength than the single ply. Moreover, double ply of the natural composite experienced lesser deflection due to the addition of loads than the single ply. Further the cupping of the composite decreased with increase in the number of ply. Overall, it was found that the double ply natural composite yielded better mechanical properties than the single ply.

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