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Experimental Investigation on Mechanical Properties of Rice Husk Filled Jute Reinforced Composites

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***Abstract*—** This paper describes the development of new class of epoxy based rice husk filled jute reinforced composites. Rice husk flour is added in 0%, 1%, 3%, 5% by weight. Epoxy resin and triethylenetetramine (T.E.T.A) is used as matrix and hardener respectively. It investigates the mechanical properties of the composites and a comparison is done for monolithic jute composite and the filled ones. The specimens are prepared according to the ASTM standards and experimentation is carried out using INSTRON 8801. The result shows that with the increase of filler percentage the tensile properties increases but compressive and flexural properties decreases.

***Keywords*—** Jute, mechanical characterization, natural fiber, rice husk.

I. Introduction

THE recent years have witnessed a great thrust for use of eco-friendly materials like natural fiber based composite. Basically, natural fiber reinforced composites are prepared by using fibers derived from natural sources like plants; minerals etc. which can be a viable source. These materials have made great strides in replacing most of the conventional materials and are penetrating deeply in various segments. This is evident from a recent report on "Global Natural Fiber Composites Market 2014-2019: Trends, Forecast, and Opportunity Analysis". It has been analyzed that the market size for natural fiber composites and it projected that it will reach $5.83 billion by 2019, at a compound annual gross rate(CAGR) of 12.31% between 2014 and 2019 [1].

Jute is one of the most promising materials among all the natural fiber-reinforcing materials. This can be attributed because it is comparatively inexpensive and commercially available in tropical countries. The benefits of agricultural fibers are that the end properties can be tailored by selection of fibers with a given chemical or morphological composition. Jute is ranked the second most common natural fiber, cultivated in the world and India happens to be the largest producer. Jute, in polymer composites would be appropriate for the primary structural applications, temporary outdoor applications like low-cost housing for defense and rehabilitation and transportation. Jute has high insulating properties and hence it can be used in automotive door/ceiling panels and panel separating the engine and passenger compartments [2].

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Abdellaoui et al. [3] have established the evaluation of the use of jute fibres as natural reinforcement in thermosetting matrix. The results show that the mechanical properties increase as the number of layers goes on increasing. Thus, a careful selection of matrix and the reinforcing phase can results in a composite with a combination of strength and modulus. However, modification of the composites for enhanced physical and mechanical characteristics can be done by adding a solid filler phase to the matrix body during the composite preparation. The fillers can have significant part in determining the properties and behaviour of particulate reinforced composites. The term 'filler' includes wide range of materials. New avenues in industrial and structural applications by the addition of particulate fillers are gaining importance among the researchers.

Among all the fillers use of lignocellulosic filler in place of synthetic fillers is limited and holds good prospects for its better use. This is because the production of composites by using natural substances as reinforcing fillers is not only inexpensive but it also minimizes the environmental pollution caused by the characteristic biodegradability. Thus new research have found to be more concentrated on utilizing recycled waste especially in developing composites using most agro-wastes as reinforcing fillers in polymers. The benefits offered by lignocellulosic materials include making the final product light decreasing the wear of the machinery used, low cost, biodegradability [4], and absence of residues or toxic byproducts.

Shalwan et al. [5] have studied mechanical and tribological behaviour of epoxy composites based on graphite content fillers and /or natural fibre reinforcement. The results discovered that interfacial adhesion of the date palm fibre plays with the epoxy plays a pivotal role for better mechanical and tribological results Addition of graphite fillers help in improving the wear characteristics of the polymer composites; however, mechanical properties shows a marginal improvement to a certain percentage.

Biswas and Satapathy [6] have studied red mud as filler in glass–epoxy and bamboo epoxy composites. The results shows that addition of these fillers modifies the tensile, flexural, impact and interlaminar shear strengths of the composites both for bamboo as well as for glass fiber reinforcement

Rice husk is one of the most promising agricultural wastes that can be found around the world. It is easily available and is cheap in rice producing states of India like Assam. It contains 75-90% organic matter. These includes cellulose, lignin etc. The rest of it contains mineral components such as silica,

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alkalis and trace elements [7].The contents vary depending on rice variety, soil chemistry, climatic conditions, and even the geographic localization of the culture. The applications of rice husk can be found in light weight concrete [8], an insulating material, fillers in plastics, building materials, panel boards, electricity generation, husk-fueled steam engines [9]. Thus, an attempt has been made to fabricate and characterize a new class of epoxy based composite wherein rice husk flour is added in 0%, 1%, 3%, and 5% and reinforced with jute. This will also serves a database for further research.

II. Material Preparation and Experimental Procedure

A. Material Preparation

1. Matrix Material

Epoxy resins have excellent adhesion to wide variety of fibers, superior mechanical and electrical properties, and good performance at elevated temperatures. These resins come in viscous liquid form, and have low molecular weight. The viscosity of these resins is dependent on the extent of polymerization of its molecules. Hence, these factors have contributed to choice of epoxy resin over other thermoset polymers, as the matrix material for the present research work. The common name for it is Bisphenol-A-Diglycidyl-Ether and it chemically belongs to the 'epoxide' family. Its commercial name is LB011 EPOXY RESIN LAPOX B-11 and procured from Haripa India Ltd.

Hardener is a catalyst which accelerates the polymerization of the resin at different rate with respect to the temperature. It is commonly employed for the hand layup process. Commercial name is triethylenetetramine T.E.T.A and obtained from the same manufacturer.

2. Reinforcement Material

In this present work Jute plain fabric (GSM 200+/-20) was provided by BABA AGENCY. The material provided was further heat treated in an oven at105°C for 5hrs in order to remove its moisture.

3. Filler Material: Rice husk

Rice husk Flour was procured from a local mill. The collected rice husk flour was dried in an oven at a temperature of 105°C for nearly 5hrs to remove moisture. It is then sieved properly to obtained coarse free finer particles.

B. Preparation of the Laminate

Eight layers of jute fabric are reinforced in epoxy resin wherein four different weight proportions of rice husk (0%, 1%, 3%, 5%) as filler material are added to fabricate the composites JJ, J-1, J-2, J-3 respectively. Hardener is added in the ration of 10:1 as per the recommendation. The mixture of epoxy resin, rice husk, and hardener is stirred vigorously for nearly 10mins approximately at 30-40 rpm so as to achieve proper dispersion of the fillers in the matrix. The composites are prepared by conventional hand layup technique because it caters the different layers easily. A mold-releasing agent (silicon spray) is used for easy removal of the composite laminate from the mold after curing. The cast of the composite is cured under a uniform load of 30kg for a period of 24hrs. Specimens are prepared from the laminates according to various ASTM standards desired for the mechanical characterization. The designations and details of the composites are tabulated in Table I.

TABLE I
Designations and Detailed Compositions of the Composites

Sl. No	Reinforcement	Fiber Orientation	Matrix	Filler (wt%)	Designation	Type of Composite
1.	Jute Fabric	0/90	Epoxy Resin	Rice Husk (0%)	JJ	Monolithic Composite
2.	Jute Fabric	0/90	Epoxy Resin	Rice Husk (1wt%)	J-1	Hybrid Composite
3.	Jute Fabric	0/90	Epoxy Resin	Rice Husk (3wt%)	J-2	Hybrid Composite
4.	Jute Fabric	0/90	Epoxy Resin	Rice Husk (5wt%)	J-3	Hybrid Composite

III. Mechanical Test Details

A. Tensile Test

The purpose of the tensile testing is to measure the ultimate tensile strength and modulus of the composite. The ASTM D3039 / D3039M – 14 Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials is followed for the test. The tensile test is generally performed on flat specimens. The length and breadth of the specimen are 250 mm ×25 mm respectively. Thickness varies from composites to composites and a uniaxial load is applied through both the ends. The gauge length set for the specimens is 140mm. The tab length is kept at 55mm from both ends of the specimen. A sharp toothed hand hacksaw was used to cut the specimens from the plate. Here, the test is repeated five times on each composite type and the mean value is reported as the tensile property of that composite. The coupons are held properly in the grips of the machine. The maximum length of the gripper is 54mm.The cross head speed of the machine was moved at a speed of 1.5mm/min. The direction of the applied load is along the direction of the fiber, in axis loading. Load is being applied until failure. The failure of all the coupons happened before 10 min, as mentioned in the standard.

B. Compressive Test

ASTM D3410 / D3410M - 03(2008) is followed during compression testing of the composite materials. These specimens are smaller in size as compared to the tensile testing specimens. The compressive test is also generally performed on flat specimens. The length and breadth of the specimen are 155 mm ×25 mm respectively. Thickness varies from composites to composites and a uniaxial load is applied through both the ends. The specimen has constant rectangular cross section throughout the length. The gauge length set for

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the specimens is 25mm. The tab length is kept at 65mm from both ends of the specimen. A sharp-toothed hand hacksaw was used to cut the specimens from the plate.

C. Flexural Test

The flexural tests are conducted to determine the mechanical properties of resin and laminated fiber composite materials. These tests are used to determine flexural strength and moduli. Here three points bending flexural test is carried accordingly to ASTM D790 – 10 standards. The length and breadth of each specimen is 125 mm and 12.7 mm respectively. The crosshead speed of 1.5 mm/min is maintained. The test is repeated five times for each composite type and the mean value is reported. The specimen is kept long enough to allow for overhanging on each end but in no case less than 6.4 mm on each end. Overhang shall be sufficient to prevent the specimen from slipping through the supports.

IV. Results and Discussion

A. Tensile Properties

Tensile properties of jute/filler composites we can observe that there is an increase of 2.6%, 4.43%, and 7.06% in the values of tensile modulus when filler addition is of 1%, 3% and 5% by weight of resin. Tensile properties of jute/filler clearly show that there is an gradual increase of tensile strength properties. The percentage increase is 5.65%, 13.99% and 19.62% for the filled composites when compared to the unfilled jute composite. The results are plotted in bar chart as shown in Figs. 1 and 2. The increase in tensile modulus and tensile strength values with the addition of filler can be observed for nylon 6 composites containing talc and kaolin fillers found by [10]. The tensile strength goes on increasing with the increase of filler up to 10%. Mahapatra et al. [11] and Findik et al. [12] found that tensile strength increases as the fiber loading increases for glass–polyester composites. This probably may because the fibers are the load carrying members in a polymer matrix. The small increase in tensile properties may be due to better filler characteristic and better interfacial adhesion between the filler particles and the matrix body. With the increase in filler, percentage due to sharp corners of irregular shaped filler particles may results in stress concentration zones in the matrix body during tensile loading. Presence of void percentage in the composites with increase in filler content also may be the reason.

B. Compressive Properties

The compressive modulus values are compared for filled composites with unfilled one. The compressive modulus for monolithic jute is found to be 11162.8 MPa. Its value decreases with the increase of filler percentage as shown in Fig. 3. The compressive strength values for 0%,1%,3%,5% filler addition are 55.68 MPa, 39.37MPa, 32.17MPa, 30.42MPa respectively as shown in Fig. 4.

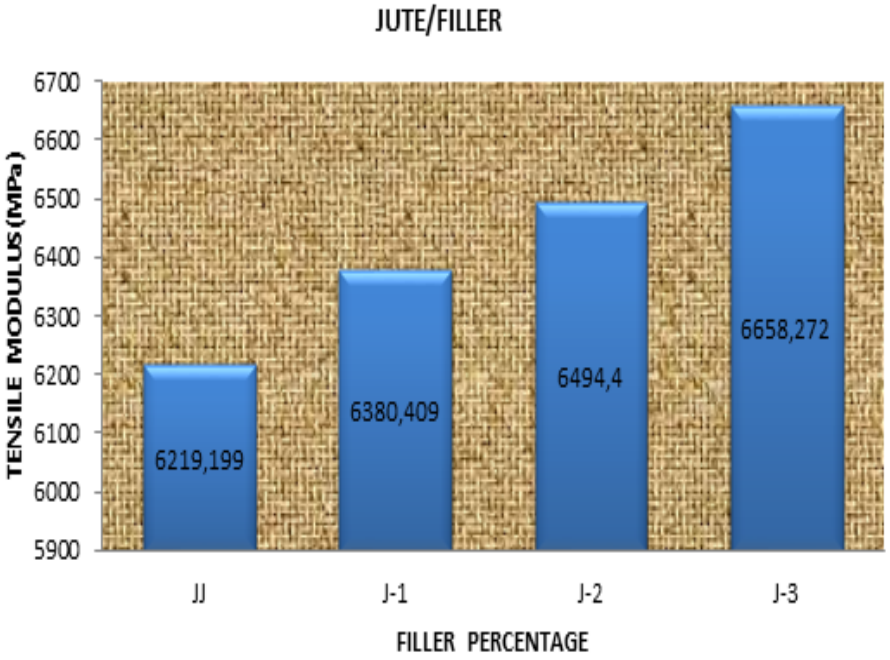


Fig. 1 Tensile Modulus of Composites in various stages of filler addition

C. Flexural Properties

Flexural modulus and flexural strength values are analyzed to measure the flexural properties of the hybrid composites. From every fabricated hybrid composite laminate five samples are tested and average value are reported here the composites were tested from both sides. Both flexural modulus values and flexural strength values are compared in percentage change in values with unfilled jute composites. The flexural properties show a decreasing trend as the filler percentage increases as shown in the Figs. 5 and 6. Flexural strength values also show

a small decrease in the strength values as we co increasing the filler percentage.

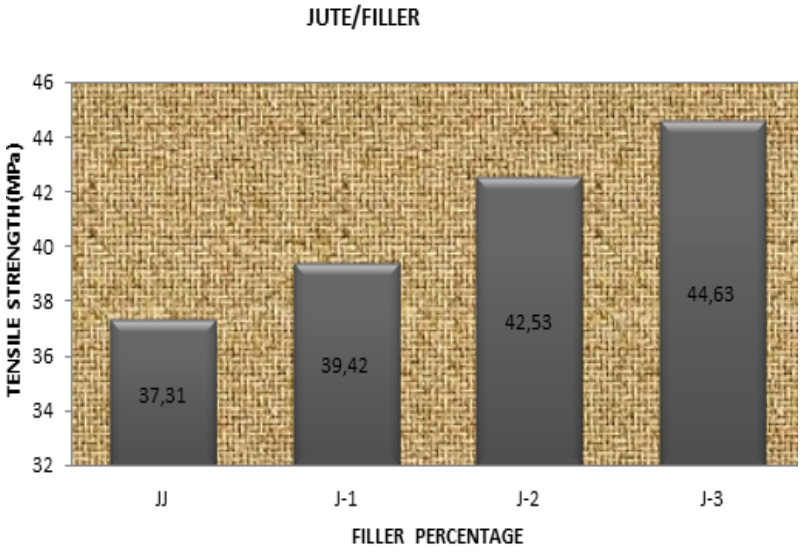


Fig. 2 Tensile Strength of Composites in various stages of filler addition

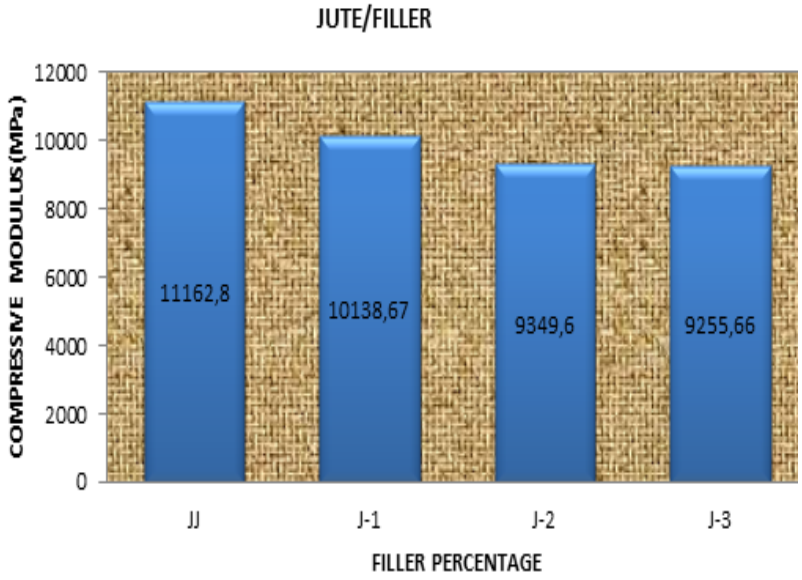


Fig. 3 Compressive Modulus of Composites in various stages of filler addition

V. Conclusion

A new class of epoxy-based jute filled with rice husk has been prepared. Here, tensile modulus and tensile strength of jute with rice husk filler shows a marginal rise. It clears that jute when hybridized with basalt and rice husk enhances it load bearing capacity (tensile strength). A decrease in compressive properties in case of hybrid composites of jute-rice husk composites can be observed Jute when filled with rice husk flour also does not show such improvements in flexural properties. The probable reason may be due to the presence of pores at the interface between filler and the matrix which results in poor adhesion between the two.

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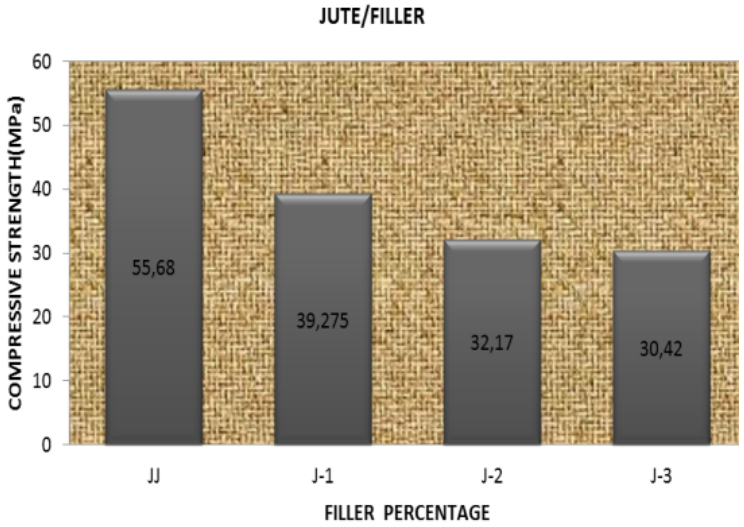


Fig. 4 Compressive Strength of Composites in various stages of filler addition

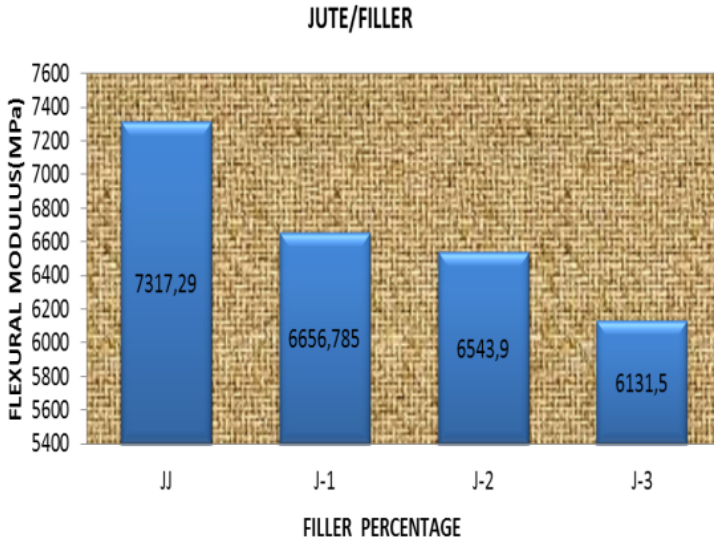


Fig. 5 Flexural Modulus of Composites in various stages of filler addition

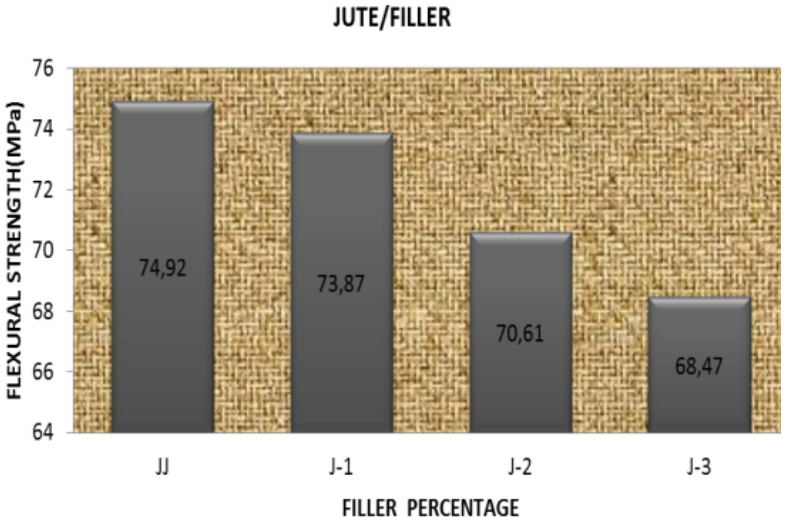


Fig. 6 Flexural Strength of Composites in various stages of filler addition

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