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# Investigation of Mechanical Properties of Jute-Betelnut Husk Fiber (BHF) Reinforced Epoxy Composite

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**ABSTRACT**
The importance of natural fiber reinforced composite material is increasing in the field of engineering and technology due to their outstanding promising properties. Here we investigate the mechanical properties of alkali treated jute betel-nut husk reinforced epoxy composite with respect to variation of BHF & epoxy .The composite sample was prepared by hand layup method. Different jute-betel nut reinforced epoxy composite was prepared in the ratio of fiber content 10:5, 10:10, 10:15 and 10:20 wt% with 85% epoxy , 80% epoxy, 75% epoxy and 70% respectively. The composite samples were prepared by hand layup process. Mechanical properties including tensile strength, yield strength, young modulus, elongation at break percentage and impact strength of the composites were investigated. The result showed that mechanical properties of 10:10 ratio of jute-betel nut and 80% epoxy was maximum. The effect of alkali treatment of fibers were verified by FTIR analysis.
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Keywords: BHF, alkali treatment, mechanical properties, UTM, FTIR.

## 1. Introduction

The researchers and scientists have been interested to find suitable alternative materials in order to replace traditional polymer composites made with synthetic fibers. Hence using natural fiber as reinforcement in composite preparation due to its environmental and economic concerns is called eco-friendly composite. Eco-friendly composites are natural fibers such as jute, hemp, betelnut, sisal, flax, kenaf, etc.[1-3].The main advantages of the eco-friendly composite materials are recyclable, biodegradable, sustainable and renewable. [4-7].There are many others reasons that make natural fibers superior to use instead of synthetic fibers i.e. lightweight, superior strength, good mechanical properties, low energy consumption and high specific modulus. They are naturally non-toxic, nonhazardous, recyclable, flexible in usage, low cost and that allow clean energy recovery, etc.[8-10].The properties of composite largely depends on adhesion of matrix and fiber. The adhesion of fiber and matrix are severely affected due to incompatibility of fiber and matrix. The degree of adhesion between the natural fiber and matrix determine the mechanical properties of natural fiber-reinforced composite [11]. The degree of adhesion depends on fiber surface. Naturally untreated natural fiber like betelnut [12], oil palm [13,14,15], banana [16], sugarcane [17,18] and coir [19] poses very weak interfacial adhesion strength with the matrix. Foreign substrate on the fiber surface of the natural fiber prevent the matrix to create strong bonding with the fiber. Hence some physical and chemical treatment were done to increase the adhesion between the fiber and matrix. Hence, it helps to increase the fiber properties, wettability and bondability between fiber and matrix. Physical process comprise treatments by laser, ionized gas (plasma or corona), steam explosion etc. [20].There are many chemical process to remove foreign material and impart hydroxyl properties of the natural fiber. The aim of these treatments to improve adhesion between fiber and matrix and hence increase the fiber strength and reducing water absorption [21].Here alkalization was done to remove the foreign material and increase bondability. There has difference in mechanical properties between the treated and untreated jute-betelnut composite .In the past the investigational results of researchers indicates that chemically treated jute-betelnut composites poses better mechanical properties than untreated composites[22].

From various natural fiber, betelnut husk fibers poses outstanding mechanical properties. BNHF is extracted from the leave of plant Aeraca Catechu. Another blessing natural fiber jute has better performance than other natural fiber. It is inexpensive and available in the Asian subcontinent .Jute exhibits better mechanical properties and a suitable replacement for wood [23]. Mechanical properties of jute-betelnut husk fiber composites are highly depends on the maturity of fiber.

The main objectives of the research work is to test the mechanical properties of the jute-betelnut husk reinforced epoxy composite at different content of betelnut husk fiber and epoxy resin. We focus on betelnut husk fiber as it is treated as wastage and sometimes it just use as fuel in some region of Bangladesh and Asian subcontinent. The jute-betelnut husk fiber reinforced epoxy composite can be a good replacement of wood hence it prevent the deforestation.

## 2. Materials and Methods

2.1 Materials

Epoxy resin (Araldite LY556) and Hardener (Aradur HY951) were purchased from Lucky Acrylic and Fiber from Dhaka, Bangladesh. Betelnut husk fiber was collected from Goripur, Noakhali Bangladesh and jute fiber (hessian cloth) was collected from Bangladesh Jute Research Institute Dhaka, Bangladesh.

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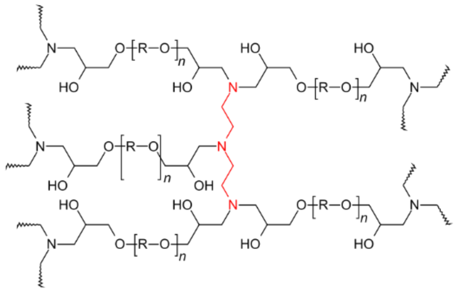

**Fig.1** Molecular structure of epoxy resin

2.2 Methods

Weight of the samples were recorded by electric balance. Betelnut fiber content were varied for each composite sample.

**Table 1** Sample Identification

| Sample Name | Jute | Betelnut Fiber | Epoxy |
|---|---|---|---|
| Sample A | 10 | 5 | 85 |
| Sample B | 10 | 10 | 80 |
| Sample C | 10 | 15 | 75 |
| Sample D | 10 | 20 | 70 |

## 3. Preparation of Composites

Composites were prepared by following steps

3.1 Fiber Extraction

Ripe betelnut husk was selected for fiber extraction. Selected betel nut husk was soaked in water for 20 days to rotten. Then the rotten husk was stripped manually by hand and rinsed in distilled water for several times. The extracted fiber was than dried for 15 days.

3.2 Alkali Treatment

The extracted betelnut was untreated. As it is natural fiber and its surface contain oil, wax and others foreign material so it was treated with coustic soda. 5% NaOH solution was prepared and betel nut husk fiber was immersed for 36 hr at 30oC.The fiber was than washed 10 times in distilled water and 2% acetic acid was used for neutralization. It was than washed again and the final Ph was near about to 7.Than they were dried at room temperature for 15 days.

3.3 Fabrication of Composite

Jute and betelnut husk fiber were taken for sample preparation according to sample identification. Butelnut husk fiber was in fiber stage. So the fiber was made in sheet like material and Jute hessian cloth was used for composite fabrication. Desired amount of betelnut husk fiber was measured in weight and 450KN was applied to make it a sheet like material. This force was applied by UTM machine in Strength of Material Lab, Department of Civil Engineering, KUET. Epoxy resin and epoxy hardener were mixed properly in 2:1 ratio. Jute-betelnut husk fiber reinforced epoxy composites were prepared by hand layup process. Jute and betelnut husk fiber sheet were cut in 22cm*22cm and placed on a 30cm*30cm metal plate. A mylot paper was placed on the metal plate with the same dimension of the metal plate. According to jute and betelnut fiber content epoxy resin and epoxy hardener were mixed in 2:1 ratio and agitate properly to mix up. Some of the matrix solution was spread over the mylot paper and a jute fabric sheet and betelnut husk fiber sheet were placed and rolled. By this process 3 jute fabric sheet and 2 betelnut husk fiber sheet were required for each composite sample. Than complete matrix solution was poured and rolled properly. A dead weight of 15 kg was given on the arrangement for 8 hr. Finally the load was removed and mylot papers were separated from composite sample. Thus our required composite samples were obtained.

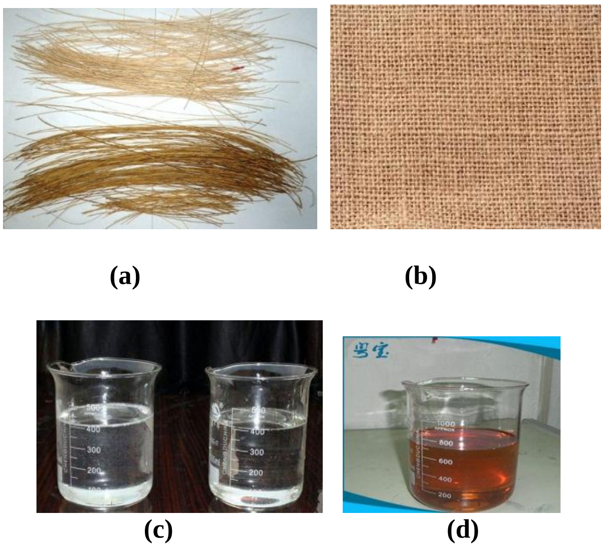

**Fig 2.** (a) Raw Betenut fiber,(b)Jute Fiber,(c)Epoxy Resin,(d)Epoxy Hardener

## 4. Testing of Composite Material

Mechanical properties such as Tensile properties (TS), Elongation at Break (EB), Young Modulus (YM), Yield Strength (YS), Impact Strength (IS) of the prepared composite sample were investigated by UTM at Bangladesh Atomic Energy Commission, Dhaka, Bangladesh. The samples were prepared for testing according to ASTM D638 standard. The specimen were cut in warp direction. The specimen size was 80mm*8mm*7mm. Here we maintained gauge length 35 mm and crosshead speed 10 mm/min. Three specimen were tested for each test from each sample A,B,C & D. Following equation 1, 2 and 3 were used for measuring the tensile strength, elongation at break percentage, Young's modulus respectively. Impact strength was measured from isode table.

Tensile strength (TS) = $\frac{F_{max}}{A}$ (1)

Where, *Fmax*= Load applied to the sample and,A= Cross-sectional area of the sample.

Percentage of elongation-at-break was obtained by the following relation:

Elongation at Break EB (%) = ( $\frac{\Delta L_0}{L_0}$ ) (2)

Where, $\Delta L_b$ = Extension at break point of the sample and L = Gage length or original length of the sample.

Yield modulus were measured by the following equation-

Yield Modulus (YM) = $\frac{d\sigma}{d\varepsilon}$ (3)

Where, d$\sigma$= Stress at yield point, d$\varepsilon$ = Strain at yield point.

Impact strength of the the composite samples were measured by Izod impact testing machine (HT8041B) according to the ASTM standard.

## 5. Result and Discussion

### 5.1 Tensile Strength

The tensile strength of epoxy and jute, Betelnut-husk & epoxy composite are given in Table 2 and its corresponding data are plotted in Fig. 3. It was observed that tensile strength increased from sample A to B, which means that with increasing percentage of Betelnut-husk tensile strength increased. In this case, due to 5% Betelnut-husk percentage increasing tensile strength increase. With further increasing percentage of Betelnut-husk from sample B to C and C to D Tensile strength of the composite is decreasing. This because of the decreasing percentage of Epoxy. Sample B having the most tensile strength 26.96 MPa and while sample C having the least 9.97 MPa.

**Table 2** Effect of fiber content on Tensile Strength of the composites

| Sample | Tensile Strength (Mpa) |
|---|---|
| A | 22.45 |
| B | 26.96 |
| C | 15.437 |
| D | 9.97 |

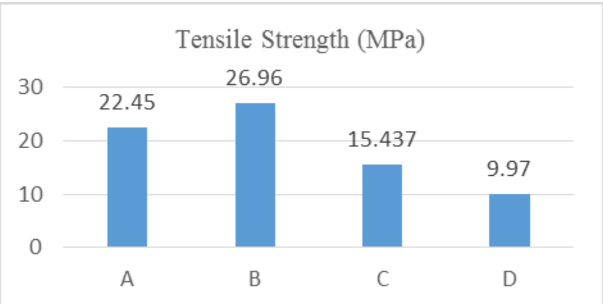


**Fig 3.** Effect of fiber content on Tensile Strength of the composites

### 5.2 Elongation at break (%)

Four samples were tested to observe their elongation behavior under tensile load. Elongation percentage are presented below in table 3 and fig 4. Elongation percentage of the four samples are not showing any proportional relation to the consisting materials of the composites. Sample B (10%betelnut-husk & 80% epoxy) having the least percentage of elongation and Sample C (15% Betelnut-husk & 75% epoxy) having the most amount of elongation percentage.

**Table 3** Effect of fiber content variation on Elongation at break (%) of the composites sample

| Sample | Elongation (%) |
|---|---|
| A | 8.06 |
| B | 6.9 |
| C | 10.617 |
| D | 7.47 |

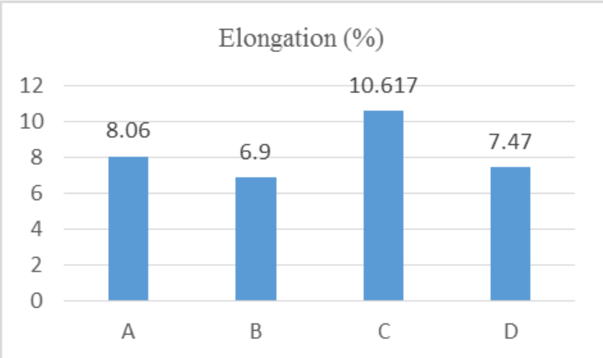


**Fig 4.** Effect of fiber content variation on Elongation at break (%) of the composites sample

### 5.3 Young's Modulus

Young's modulus means measure of the stiffness of a solid material. It shows the relationship between stress (force per unit area) and strain (proportional deformation) in a material. From table 4 it was observed that sample B exhibit most Young's Modulus 607 Mpa and sample C exhibit least Young's Modulus 309.2 Mpa. Epoxy resin has good bonding capacity with natural fiber. As the fibers were alkali treated hence there have strong covalent bonds between fiber and epoxy resin and made it strong.This due to the effect of strong bonding between matrix and resin material.

**Table 4** Effect of fiber content variation on Young's modulus of the composite sample

| Sample | Young's Modulus(Mpa) |
|---|---|
| A | 592.67 |
| B | 607 |
| C | 309.2 |
| D | 393.73 |

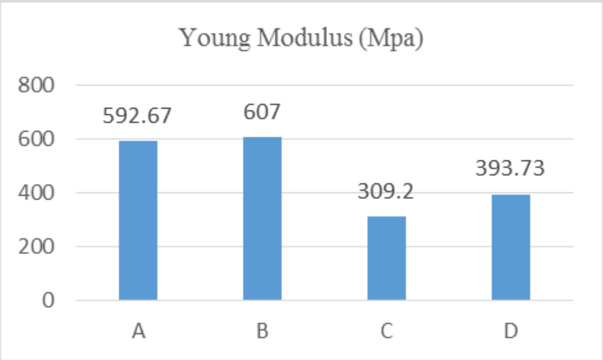


**Fig 5.** Effect of fiber content variation on Young's modulus of the composite sample.

### 5.4 Impact Strngth

The impact strength of jute-BHF reinforced epoxy composite are given in Table 5 and its corresponding data are plotted in Fig. 6. The impact properties of the composite sample were increased by the reinforcement of betelnut husk fiber. The maximum impact strength was found for sample D.

**Table 5** Effect of fiber content variation on impact strength of the composite sample

| Sample | Impact Strength($KJ/Cm^2$) |
|---|---|
| A | 13.848 |
| B | 12.842 |
| C | 16.968 |
| D | 22.485 |

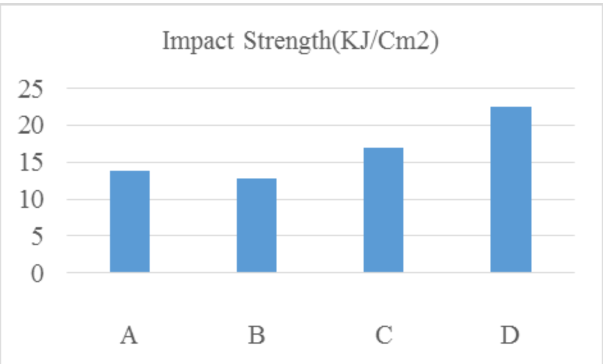


**Fig 6.** Effect of fiber content variation on impact strength of the composite sample

### 5.6 FTIR Spectra of Composite Sample

As the fibers were alkali treated, the peak 1722.43 cm-1 corresponding to C=O stretching vibration of hemicellulose disappeared owing to structural change [24]. In chemical solution this may be imposed to dissolution of hemicelluloses. The hydrogen of droxyl group was substituted by acetyl groups in chemical treatment, resulting in little hydroxyl groups able to carry through hydrogen bonds. OH band was decreased after alkali treatment and its displacement from 3400-3700 cm-1[25]. Most of the lignin and hemicellulose component were removed by the treatment and the changed the hydrophilic nature of the fibers to hydrophobic nature. FTIR spectra of composite samples are given below. They show that the bonding between the matrix and reinforcement. As the jute and betelnut husk fiber were alkali treated so the foreign material were removed .Hence the bonding were prime.

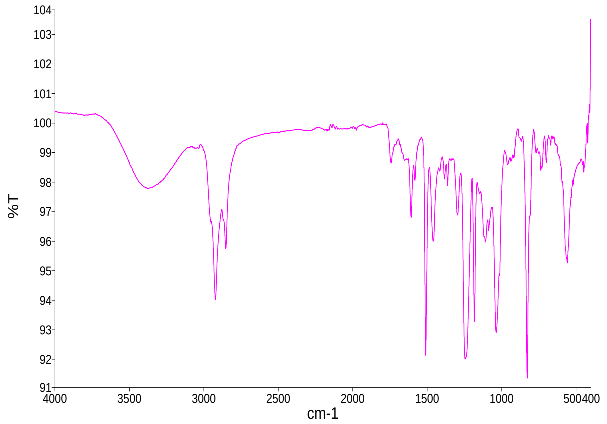


**Fig 7.** FTIR spectra of Jute-BHF reinforced epoxy composite sample A

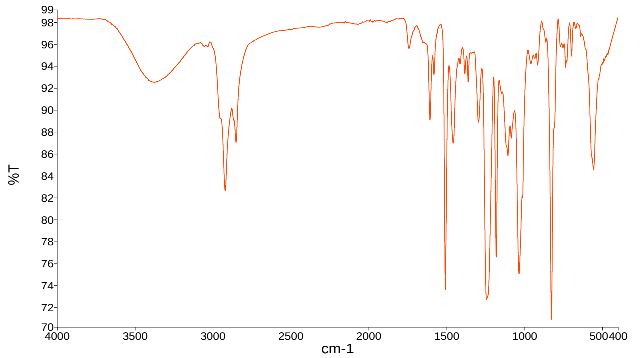


**Fig 8.** FTIR spectra of Jute-BHF reinforced epoxy composite sample B

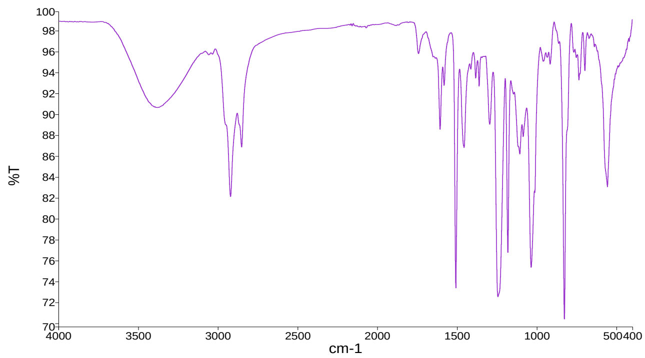


**Fig 9.** FTIR spectra of Jute-BHF reinforced epoxy composite sample C

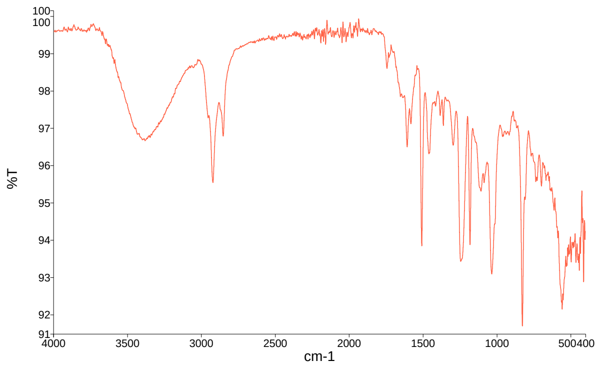


**Fig 10.** FTIR spectra of Jute-BHF reinforced epoxy composite sample D

### 5.7 Comparative Analysis

It was clearly evident that sample B exhibited better mechanical properties without impact strength. Tensile strength increased from sample A to sample B by 20.96%. But after that the tensile strength fall from sample C to sample D. This due to the strong interfacial bonding between matrix & reinforcement. Elongation at break percentage was better for sample B. It showed better elongation at break percentage property under tensile load. Sample B showed better Young's Modulus than sample A, C and D. Impact strength showed different phenomenon. Sample D showed better impact strength. As fiber content was more in sample D than sample A, B, and C so the capacity of withstand applied load was more and impact strength was more.

## 6. Conclusion

In this study mechanical properties of Jute-BHF reinforced epoxy composites were investigated. From above experiment we found that 10:10:80 ratio of jute, betelnut husk fiber and epoxy composition showed good mechanical properties. From the characterizations of the composites it can be suggested that jute-betelnut husk fiber reinforced epoxy composites can be used as engineering, automobile industry, building and construction materials and household utensils such as table, basket, shelve, partition board, ceiling etc. These are the potential application of this composite material as it has good mechanical properties. Further experiment will be done to improve processing to expand the application fields for jute and betelnut husk fiber reinforced epoxy composites.

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