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Research Article

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A Study on Splitting Tensile and Compressive Behavior of DMA (N, N-Dimethyl aniline) and Khoyer (*Acacia catechu*) Modified JFRC

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Abstract JFRC (Jute Fiber Reinforced Concrete) is a composite which comprises Jute fiber as reinforcement in concrete matrix. The intention of this research work is to be investigated of mechanical properties of DMA (N, N-Dimethyl aniline) and khoyer (*Acacia catechu*) modified JFRC composite and also to be measured the hydrophilicity. Jute fiber is used as cementation element. Jute fibers have been modified by DMA and Khoyer. Samples of standard dimensions have been fabricated to induce jute fiber varying the mix ratio of the ingredients in concrete, water-cement ratio, and length and volume of jute fiber to know the effect of parameters as mentioned. This Experiment was driven on concrete samples vary with percentage of jute fiber i.e. 0%, 1%, 1.5%, etc. by weight of cement. Compressive and Tensile Splitting strength properties are compared by taking tests on plain and chemically modified JFRC cubes and cylinders after curing of 28 days. It can be deduced that the presence of modified jute fiber in concrete is enhanced the mechanical properties, i.e. concrete strength than plain concrete. It has extensive utilization of massive amount of jute produced in our country which is found at low cost.

Keywords Reinforcements; JFRC; Compressive Strength; Splitting Tensile Strength

Introduction

Concrete which takes compressive stress but weak in tension, has brittle behavior. It is impracticable to sustain the strength of concrete and to enhance its durability, so natural fiber addition like jute is economic approach to increase the strength of concrete [1-2]. Natural fiber is used in brittle cement concrete composite has attained considerable composite strength and toughness. In Bangladesh, Jute is enormously grown which is extracted from a woody plant which grows about 2 meters with stem 20 mm to 30 mm at diameter. Bark of jute comprises of bundles of fibers running longitudinally down the stem. It immersed under water for 20-30 days. Fibers of the stem are putrefied under action of bacteria. It washed away in water for removing dust, muddy like element. Then it dried under the sun. Jute fiber is lingo-cellulosic in nature and comprises mainly lignin, cellulose, hemicelluloses with minor quantity of others elements [3-5]. Cellulose exhibits hydrophilic nature which has hydrophilic glucan polymer being of a linear chain of 1, 4-β-bonded anhydroglucose units which contains alcoholic -OH groups (Fig.1).

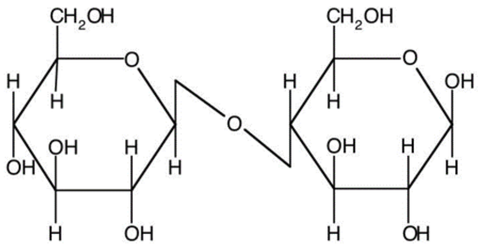

Figure 1: Structure of cellulose

Intramolecular H-bonds inside the macromolecule itself and intermolecular H-bonds among other cellulose macromolecules as well as with hydroxyl groups from the air are found these hydroxyl groups.

Therefore, all natural fibers in nature are hydrophilic and moisture content reaches 8–12.6% [6]. Such hydrophilicity might lead to depletion of water from the wet concrete mix as well as it might degrade in due course of time as a result of microbial attack. To overcome such shortcomings jute fibers need suitable physicochemical modification before incorporation in concrete matrix. It was anticipated that after modification with alkali and other chemical constituents, microbial degradation of jute fiber can be either delayed or prevented. Chemical modification of natural fibers also addressed at augmentation of the adhesion with matrix [7-10]. Jute fiber treated with Khoyer (*Acacia catechu*) and DMA (N, N- dimethylanliline) which is insoluble in water but freely soluble in alcohol, chloroform, ether [11].

Experimental Procedure

For evaluating Mechanical properties of chemically treated JFRC was schemed this experiment.

Materials

Jute fibers of TD4 grade were purveyed from local market at Rajshahi in Bangladesh. Jute fibers cut into 3 inches to 6 inches. Ordinary Portland cement of 53 grade with specific gravity 3.15 has been used. Locally available natural river sand with a fineness modulus of 2.74, and water absorption of 1.5% in saturated surface dry (SSD) condition was used. The specific gravity of the sand is found to be 2.63 and was confining to ZONE-III. The fineness modulus of Natural Coarse Aggregate (NCA) is 6.56 and its water absorption is 0.94% in SSD condition. The specific gravity of coarse aggregate is found to be 2.71. In this investigation Potable fresh water available from local sources free from deleterious materials was used for mixing and curing of all the mixes tried. *Acacia Catechu* (Khoyer) was collected from local market at Rajshahi in Bangladesh. Analytical grade of N, N- dimethylaniline (DMA), Merck, Germany and commercially available Methanol were used for surface modification of jute fibers.

(a) (b) (c) (d) (e) (f)

Figure 2: (a) Coarse Aggregates, (b) Fine Aggregates, (c) Cement, (d) Jute fiber, (e) DMA, (f) Khoyer

Chemical Modification of Jute Fiber

Chemically modification was done to improve the strength of jute fiber and also hindered the microbial attacked of jute fiber. Modification was performed by khoyer and DMA. Basically DMA was insoluble in water and freely soluble in methanol. So, methanol was used for reaction with DMA and jute fiber. Chopped Jute fibers were immerged into the prepared solution of DMA for 10 minutes at room temperature. The solution was prepared in methanol with DMA concentration (10% v/v). Also some were submerged into Khoyer solution which were prepared in distilled water with varying concentration. After soaking jute fibers were dried in an oven at 100^{o}C until the fiber reached a constant weight and kept in desiccators for concrete fabrication.

Fabrication of JFRC Sample Blocks

The JFRC sample blocks were fabricated by following mix design 1: 1.4: 2.5 (cement: sand: coarse aggregate) by weight. Jute fiber was chosen as a natural fiber which was used varying by (0%-1.5%) weight of cement. The mixture slurry of all ingredients were poured into desirable mold by which after consolidating the sample block could be suited for compressive strength and splitting tensile strength test.

(a) (b)

Figure 3: (a) After mixing the all ingredients (b) Making the sample block

Then the sample blocks were stored a place at a temperature of 27° +/- 2°C for 24 +/-0.5 hours for allowed to setting, from the time addition of water to the dry ingredients. All specimens were demolded after 24 hours of casting and submerged in clean fresh water. After 28 days they were removed from water, surface dried and tested.

(a) (b) (c)

Figure 4: (a) After molded the mixture, (b) demolded the sample block after 24 hrs. (c) After 28 days curing

Testing Procedure

Tests had been performed to determine the mechanical properties were compressive strength and splitting tensile strength of JFRC Specimens.

Compressive strength Test

Cubic specimens for compressive strength test were carried out in dimension 150 mm × 150 mm ×150 mm. Specimens were tested under the compression testing machine. The cross-sectional area of the cubes had been calculated from the measures dimensions. The compressive strength were in form of the maximum load the cube could carry before it ultimately fails. The compressive strength could be found by diving the maximum load by the area normal to it. Mathematically it's expressed as-

$$\sigma = P_a/A \quad (1)$$

Where P_a=Actual compressive load (N), A= characteristic area perpendicular to load P (mm^2), σ = compressive strength (N/mm^2). The actual load P_a was calculated by-

P_a=1.0106 Pm + 28.638(where P_m was machine load.)

(a) (b)

Figure 5: Measurement of (a) Compressive strength and (b) Splitting tensile strength

Splitting Tensile Strength Test

The cylindrical shape of specimens which were in dimension 75mm×150mm. The loading rate controlled at 1Mpa per minute. Specimens were tested under splitting tensile machine. Splitting tensile strength was calculated by using this formula-

$$T = 2P_a/\pi DL \quad (2)$$

Where P_a = Actual applied load, D = diameter of the specimen, L= length of the Specimen. The actual load P_a was calculated by- P_a=1.0106 Pm + 28.638 (where P_m was machine load).

Water Absorption Test

The absorption of water was measured percentage of water content absorbed in JFRC sample after submerging in fresh clean and malcontaminent water. It was calculated as following –

$$\text{Water absorption (\%)} = (W_2-W_1)/W_1 \times 100 \quad (3)$$

Where, $W_1$was the initial weight before water absorption, and W_2 was the weight after water absorption.

Results and Discussion

The consequence study on the effects of chemically modified jute fiber was done by evaluating the mechanical properties of JFRC sample. The mechanical properties of JFRC was accounted for nexus of jute fiber which were figured on many factor such as surface characteristic geometry, fiber length, fiber orientation and fiber distribution.One of the significant parameter was volume fraction which was affects the mechanical behavior of JFRC.The following test were account for evaluating the effect of jute fiber in concrete matrix.

According to Table-1, Chemically Modified JFRC Sample was enhanced the compressive strength rather than plain concrete (0% jute fiber). Using 1% modified Jute fiber, the khoyer modified JFRC Sample was increased by 3.33% and the DMA modified JFRC was increased by 5.24%.By adding 1.5% jute fiber by the weight of cement in khoyer modified JFRC sample blocks was increased by 4.55%, whereas 6.678% was DMA modified JFRC sample blocks. It was extrapolated that DMA and khoyer modified jute was nexus to concrete matrix that was improved the compressive strength of JFRC sample.

Table 1: Compressive Strength results of Khoyer and DMA modified JFRC Samples

Jute fiber (%wt.)	Khoyer modified JFRC (N/mm^2)	DMA modified JFRC (N/mm^2)
0	24.02	24.02
1	24.799	25.279
1.5	25.113	25.624

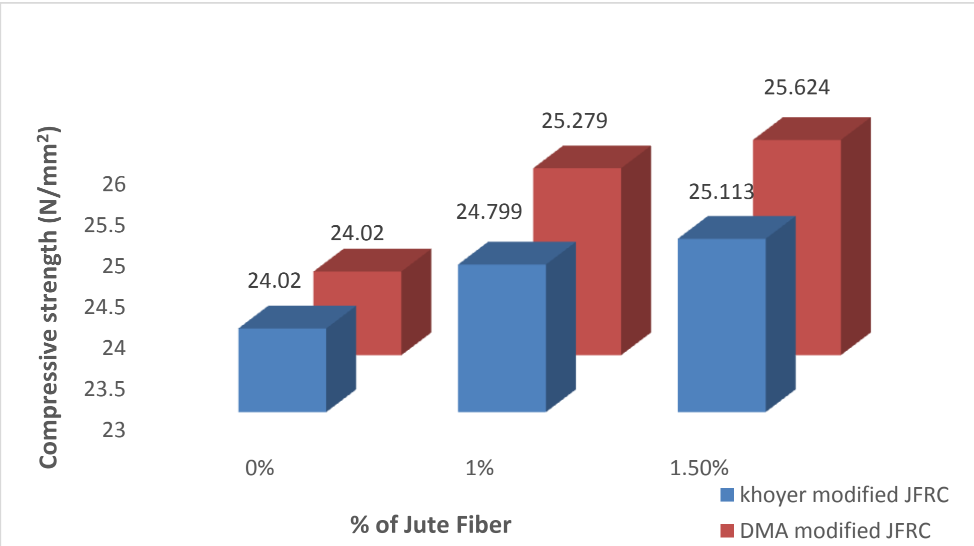

Figure 6: Compressive strength results for cubic samples after 28 days.

From Table-2, it was seen that splitting tensile strength of khoyer and DMA modified JFRC samples block was greater than plain concrete. Adding 1% jute fiber which was khoyer modified by the weight of cement in the JFRC was increased splitting tensile strength by 8.33%, whereas DMA modified was 19.99%. Adding 1.5% jute fiber by the weight of cement in khoyer modified JFRC sample blocks was increased the tensile strength by 30.79 %, whereas 45.16% was DMA modified JFRC sample blocks. It was that DMA and khoyer modified jute was enriched the bonding strength to concrete matrix that was improved the tensile strength of JFRC sample.

Table 2: Splitting tensile strength results of Khoyer and DMA modified JFRC Samples

Jute fiber (%wt.)	khoyer modified JFRC (N/mm^2)	DMA modified JFRC (N/mm^2)
0	2.221	2.221
1	2.406	2.665
1.5	2.905	3.224

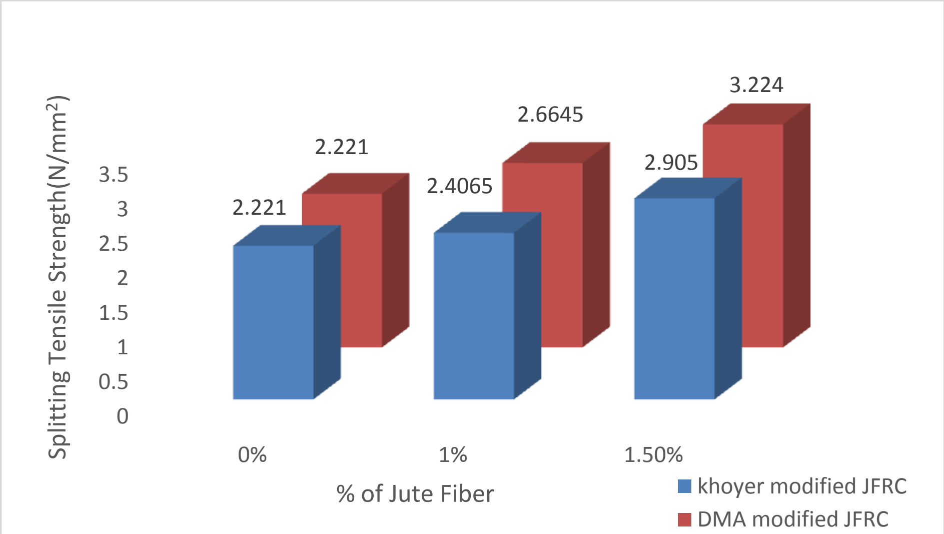

Figure 7: (b) Splitting tensile strength results for cylindrical samples after 28 days.

From the water absorption test result it was remarked that water absorption of plain concrete (0% Jute fiber), DMA modified JFRC and Khoyer modified JFRC was firstly high during 30 minutes submerged into clean and fresh water was about 8.7 %, 8.68% and 10.66% respectively. After that it was slightly decreased the percent of water absorption during 60 minutes immersion under water. But after 90 minutes the percentage of water absorption was constant in increased with time of every sample blocks. The water absorption of DMA modified and Plain concrete was almost similar but khoyer modified in absorbed water about 2% higher. Table-3 shows the percentage of water absorption varying time. From the figure-3, it was observed that the percentage of water absorption was not much differ from each other. It was remarkably observed that after 90 minutes it became saturated. It was inferred that the chemically modification was not only increased the strength of JFRC sample but also reduced the hydrophilicity. Because it is feasibility to absorbed much more plain concrete. In this experiment water absorption is nearly same.

Table 3: Water absorption test results of plain concrete and Khoyer and DMA modified JFRC Samples

Time(min.)	Plain concrete (%)	Khoyer modified JFRC (%)	DMA modified JFRC (%)
30	8.7	10.66	8.68
60	7.59	9.38	7.91
90	3.39	4.13	3.61
120	3.33	3.8	3.42
150	3.49	3.63	3.29

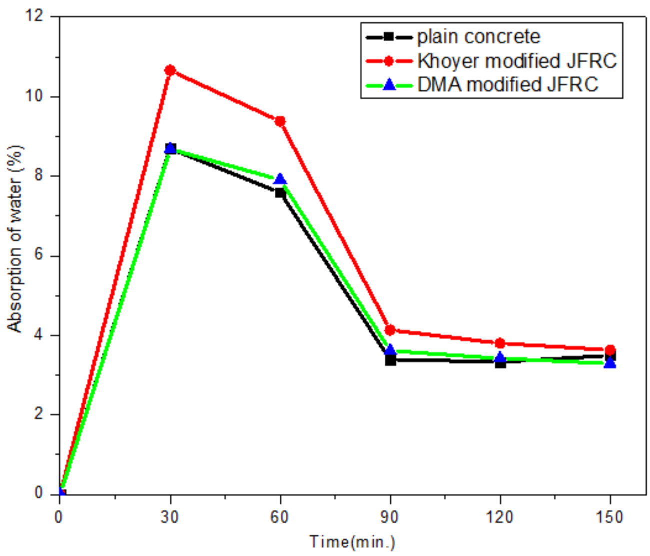

Figure 8: Result of water absorption of samples

Conclusion

According to this research work it was depicted that using DMA and Khoyer modified jute fiber effects on the splitting tensile and compressive strength. The compressive strength was increased by 6.678% at DMA modified JFRC and 5.24% at khoyer modified JFRC with respect to plain concrete. The splitting tensile strength was raised by maximum45.16% of DMA modified JFRC and 19.99% of khoyer modified JFRC samples with respect to Plain concrete. From water absorption it was found that DMA modified JFRC was assimilated to Plain concrete but the percentage of water was risen in Khoyer modified JFRC. Reduced hydrophilicity was lessen the microbial attack and degradation of jute fiber. It was deduced that Hydroxyl (–OH) groups were masked that was lessen adhesion of water to jute fiber. Jute was degraded by the microbial attack. Due to the presence of cement, concrete mix had high pH that was resisted the degradation of jute. It was extrapolated that Incorporation of jute fiber was one of the undertaking strategy to enhance the performance and workability of concrete composite. It was great opportunity to break out the way of using plethora quantity of jute fiber which was locally available and low cost.

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