

# Strengthening of Concrete Using Jute with Polymer

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**ABSTRACT:** The design of a durable and low cost fiber reinforced cement concrete for building construction is a technological challenge in developing countries. The type of fibers currently been used include steel, glass, polymers, carbon and natural fibers. Economic considerations have restricted the use of carbon fibers in cementitious composites on a commercial level for their non-ecological performance. Natural fibers have the potential to be used as reinforcement to overcome the inherent deficiencies in cementitious materials. Use of natural fibers in a relatively brittle cement matrix has achieved considerable strength, and toughness of the composite. The durability of such fibers in a highly alkaline cement matrix must be taken into consideration by effective modifications. A specific chemical composition has to be chosen that can modify the fiber surface as well as strengthen the cement composite. In this study we replace the amount of cement in a certain percentage by using the latex modified jute in M30 concrete. We replace cement by juteas 1%, 2%, 3%.

**KEYWORDS:** Jute, Alkali Modification, Modification with polymer latex, Properties of material, Mix Design, Casting and moulding, Determine the properties of the concrete.

## I. INTRODUCTION

Cement concrete composite is the most important building material and its consumption is increasing in all countries. The only disadvantage of cement concrete is its brittleness, with relatively low tensile strength and poor resistance to crack opening and propagation and negligible elongation at break. To overcome these discrepancies reinforcement with dispersed fibers might play an important role. Steel is the conventional reinforcing material in concrete. Although steel enhances the strength and modulus of concrete but it lacks the ability to absorb mechanical impact. The steel makes the reinforced cement concrete (RCC) structure heavy and in due course of time as a result of water/moisture diffusion through micro crack developed in the RCC structure, steel starts corroding leading to failure of the concrete. On the contrary, if the micro crack formation and propagation can be minimized by dispersion of short fibers, the mechanical properties as well as the durability of the concrete can be improved. Such a system would be able to bear high level static as well as dynamic stress. Natural (cellulosic) fibers might offer the opportunity as a convenient reinforcing agent in concrete composite due to its low density and high tensile property. In recent years, considerable research efforts are found to develop high-strength; natural fibers reinforced concrete composites, mostly for using as building and construction materials.

Natural fibers, isolated from plants, are classified into three categories, depending on the part of the plant they are extracted from. The first category is the so called fruit fiber (e.g., coir, cotton, etc.) which are extracted from fruits of the plant. The second category of the fiber is found in the stems of the plant (e.g., jute, flax, ramie, hemp, etc.). Such fibers are known as bast fiber. The third category is the fibers extracted from the leaves (e.g., sisal, date palm, oil palm, etc.). Polymer modified jute fibers have been decided to be used as reinforcing element in cement concrete in which

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polymer will chemically bridge jute in one side and cement on the other side. Polymer modified jute fiber is expected to act as a flexible reinforcing agent in cement concrete enabling it to transmit both static and dynamic stresses to its surrounding bulk as well as absorb a portion of the stress by virtue of its flexible nature. An optimized weight fraction of polymer modified jute fiber in cement concrete may lead to excellent mechanical properties. It has been anticipated that modification of jute fiber with polymer will reduce degradation possibilities. Fiber reinforced concrete has been investigated extensively to make light weight corrosion free structural materials. There are global attempts to use natural fibers as reinforcing agent in cement concrete matrices. The advantages of natural fibers over the conventional reinforcing fibers like glass, synthetic (e.g., polypropylene, polyethylene and polyolefin, polyvinyl alcohol), carbon, steel etc., are: abundant availability, low cost, less abrasiveness, ability to absorb mechanical impact, easy to handle and process and environmental friendliness.

These composites can be used in various fields of applications such as permanent frameworks, paver blocks, wall panels, pipes, long span roofing elements, strengthening of existing structures and structural building members. The natural fiber reinforced concrete composites present enhanced strength and are likely to encounter a range of static overload and cyclic loading due to possible wind or earthquake loading. When concrete matrix cracks under load, the fibers bridge the cracks and transfer the loads to its surrounding bulk as well as absorb a portion of the load by virtue of its flexible nature. Several investigations have been carried out with different lingo cellulosic fibers like, wheat straw, rice straw, coir, hazelnut shell, bagasse, oil palm residues, etc., to find the potentiality of natural fibers as an effective reinforcement in concrete composites. But no report is found on the use of jute fiber as reinforcement in cement Concrete. Based on the present scenario it has been anticipated that the jute fiber reinforced cement concrete may find potential application as structural items in construction industry. Being a potential agricultural product, the use of jute as reinforcing fiber in cement concrete will promote jute farming industries as well as produce better advanced composites.

## II. RELATED WORK

**Danish Ansari., et.al (October 2016)** shows the experimental investigation has done by testing of cubes. Three different types of samples are prepared in laboratory; each sample has six specimens of cube. Three samples have different fiber content but each sample replace 10%, 20%, 30% & 0% cement by fly ash. Before going for the compression strength of specimens are tested for destructive test for each cube. Then out of these six specimens of each sample, three are tested for 7&28 days compressive strength of cube.

**PoojaWarke., et.al (Jun 2016)** this paper concludes the following results,

- 1) With the inclusion of jute fiber the compressive strength of concrete gradually increases up to a certain limit but the gradually decreases.
- 2) The addition of jute fibers increased compressive strength higher with the 0.2% fiber-cement ratio and little decreases compressive strength with 0.3% fiber-cement ratio and 0.4% fiber cement ratio of compressive strength little decreases as compared to 0.3% of fiber-cement ratio.
- 3) As the percentage of jute fiber cement ratio increases, sudden failure, brittle failure and cracking is avoided.
- 4) With increasing of fiber cement ratio is tending to no voids in concrete through thoroughly compacted and proper binding of fiber cement and aggregate.
- 5) By the ultra-pulse velocity it is obtained fiber has crack resisting properties after the crack grate bonding which gives the excellent grade quality of concrete.
- 6) Thus we found out by Ultra pulse velocity, higher percentage of jute fiber-cement ratio gives greater value of ultra-pulse velocity before and after compressive strength of concrete.
- 7) Fiber –cement ratio of 0.2% gives highest compressive strength and 0.4% fiber cement ratio gives highest ultra-pulse velocity value (km/sec).

**Rahul R. Kshatriya., et.al (March 2016)** it was observed that when the jute is chemically treated then its degradation decreases. When the raw jute is added in concrete by 1% weight of cement then the compressive strength of concrete cube increased by 17.5% and by adding modified jute compressive strength increase by 26.5%. It was observed that when the raw jute is added in concrete by 1% weight of cement then the split tensile strength of concrete cylinder

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increased by 7% and by adding modified jute split tensile strength increase by 9%. It was observed that when the raw jute is added in concrete by 1% weight of cement then the flexural strength of concrete cube increased by 1% and by adding modified jute flexural strength increase by 4%. Hence, it is proved that modified replacement proportion is beneficial to use in practice as it gives workable concrete with more compressive, flexural and tensile strength. It was observed that it is difficult to mix or spread jute in concrete also it is difficult to maintain water cement ratio.

**Jaspal Singh, et.al (October 2015)** In this paper they conclude that, natural fibers offer many benefits because of their low density, low cost and biodegradability. From the results discussed in this review it is clear that incorporation of the natural fibers in concrete enhanced the properties of concrete like flexural strength, toughness, impact resistance and durability. But due to high moisture absorption by the natural fibers, compressive strength does not gave desirable results. However, in future, the advanced chemical treatments to these fibers may help in modifying the natural fiber reinforced concrete performance.

**Vipul Kumar (August 2015)** The following conclusion could be drawn from above experimental investigation:-

1. With the increase of % of fiber-cement ratio the slump will decrease and increase the workability.
2. The compressive strength of experimental cubes comes out to be higher than that of plain concrete.
3. The difference in Initial setting and final setting time of mix will increased with increased ratio of fiber –cement.
4. There will be no need of increase of % steel reinforcement in RCC as we get enough strength and durability with the addition of Fiber in cement composites.
5. Jute fiber comes out to cheap and eco-friendly natural fiber and also effective for Low-Cost housing construction.
6. Durability of cement composites increases.

### III. MATERIALS AND THEIR PROPERTIES

**CEMENT:** The Cement used in the concrete is ordinary Portland cement 53 grade. The company name of the cement is JSW.

Specific gravity of cement for sample 1 is as follows,

Empty weight of Le-Chateliars flask (W1)	=25 gram.
Weight of flask with dry cement (W2)	= 75 gram.
Weight of kerosene and cement with flask (W3)	=113.2 gram.
Weight of kerosene with flask (W4)	=70 gram.
Specific Gravity of Cement G	= $\{[(W2-W1)] / [(W2-W1)-(W3-W4)0.79]\}$
Specific gravity of cement	=3.15

Initial Setting time of Cement

**Table 1. Initial Setting Time of Cement**

Sl.No	Penetration	Minutes
1.	0	0
2.	1	10
3.	1	15
4.	3	25
5.	5	35

Initial Setting time of cement = 35 minutes

Final setting time of cement = 9.15 hours.

**Fine Aggregate:** The fine aggregate which is taken from river is used to manufacture the concrete.

#### Specific Gravity

Specific Gravity of sample 1 is

Empty weight of pycnometer (W1)	= 660 Gram
Weight of fineaggregate+pycnometer (W2)	= 1180 Gram
Weight of pycnometer+fineaggregate+water (W3)	= 1760 Gram
Weight of pycnometer+water (W4)	= 1430 Gram
Specific Gravity of Fine Aggregate	$G = \{(W2-W1) / [(W2-W1)-(W3-W4)]\}=2.74$

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## Fineness Modulus of Fine Aggregate

**Table 2. Fineness Modulus of Fine Aggregate**

IS Sieves (mm)	Empty Weight of Sieve (Gms)	Retained Weight of Sieve (Gms)	Retained Weight of Soil (Gms)	Cumulative Weight Retained (Gms)	Cumulative % Weight Retained	% Finer
4.75	365	395	30	30	3	97
2.36	245	265	20	50	5	95
1.18	360	505	145	195	19.5	80.5
1	360	530	170	365	36.5	63.5
600	300	420	120	485	48.5	57.5
300	320	690	370	855	85.5	14.5
150	310	450	140	995	99.5	0.5
Pan	300	305	5	1000	100	0

Fineness modulus is an index number which represents the mean size of the particles in sand.  
It is equal to (Cumulative % sand retained / 100)

$$= 397.5/100 = 3.975$$

Confirming Zone

$$= \text{Zone 1 [As per IS 383-1970]}$$

**Coarse Aggregate:** Coarse aggregate is used which is passed in 20mm sieve and retained on 15mm sieve.

### Specific Gravity

Specific Gravity of sample is

$$\text{Empty weight of pycnometer (W1)} = 660 \text{ Gram}$$

$$\text{Weight of fine aggregate+pycnometer (W2)} = 1330 \text{ Gram}$$

$$\text{Weight of pycnometer+fine aggregate+water (W3)} = 1850 \text{ Gram}$$

$$\text{Weight of pycnometer+water (W4)} = 1430 \text{ Gram}$$

$$\text{Specific Gravity of Fine Aggregate G} = \frac{(W2-W1)}{[(W2-W1)-(W3-W4)]}$$

$$= 2.68$$

### Water Absorption

$$\text{Weight of saturated surface dry sample (A)} = 1009 \text{ g}$$

$$\text{Weight of oven dry sample (B)} = 1005 \text{ g}$$

$$\text{Water absorption of Coarse Aggregate} = \frac{[A-B]}{B} \times 100$$

$$= \frac{[1009-1005]}{1005} \times 100$$

$$= 0.49\%$$

**Jute:** Jute is the natural fiber which is drawn from the stem of the plant.

### Specific Gravity

$$\text{Empty weight of pycnometer (W1)} = 660 \text{ Gram}$$

$$\text{Weight of fine jute+pycnometer (W2)} = 726 \text{ Gram}$$

$$\text{Weight of pycnometer+jute+water (W3)} = 1451 \text{ Gram}$$

$$\text{Weight of pycnometer+water (W4)} = 1430 \text{ Gram}$$

$$\text{Specific Gravity of Fine Aggregate G} = \frac{(W2-W1)}{[(W2-W1)-(W3-W4)]}$$

$$= 1.47$$

### Fiber Aspect Ratio

The ratio between the lengths of the fiber to the diameter of the fiber is known as Fiber Aspect Ratio.

Fiber Aspect Ratio of the jute fiber is 10 to 12.

### Carboxylated Styrene Butadiene Co-Polymer

This SBR was bought from Perma Construction Aids Pvt. Ltd., Gujarat.

1. It reduces the cracking through increases the flexural strength.
2. It increases the wear resistance under rubber wheeled traffic.
3. It improves the bonding strength to harden concrete.

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**Table 3. Properties of Polymer Latex**

Physical properties	Typical Result
Color	Milky White
Ph	9 to 11
Specific gravity	1.0
Odour	Slight Sour
Form	Liquid



Fig. 1. Test Materials and their properties (a) Le-Chateliars flask (b) Vicat Apparatus (c) Sieve Shaker

(d) Specific Gravity of Jute using Pycnometer (e) Polymer latex (SBR)

### IV. EXPERIMENTAL RESULTS

**Concrete Mix Design:** 1:1.88:2.76 (M30 Grade Concrete)

**Problem Statement:** The properties of various fibers were identified and jute fiber is chosen as a natural fiber to replace by 1%, 2%, 3% weight of cement. And also it was treated with alkali and polymer latex such that the properties of jute fiber will change. And comparing in M30 grade plain cement concrete, raw jute cement concrete and modified jute cement concrete for compressive and split tensile strength.

**Mixing process:** The jute fiber reinforced concrete samples of mix design 1:1.88:2.76 (cement: sand: coarse aggregate, by weight) were fabricated by following process, for untreated and treated jute fiber reinforced concrete. Initially the chopped fibers of 6 cm length were immersed for 24 h in half of the total volume of water required for concrete preparation in a container. Next the half of the total amount of cement required was added to wet jute in that container with constant stirring to obtain jute-cement slurry. The jute cement slurry was then slowly poured into the pan for well mix. Sand and rest of cement was mixed with this jute-cement slurry. The remaining amount of water, sand and aggregate was then added and the pan and make it a well mix. The fresh cement concrete thus obtained was cast immediately in moulds and allowed to setting. All the specimens were demolded after 24 h of casting and water cured for 7 days respectively. At the specified date they were removed from water, surface dried and tested. Each test result represented the mean of at least three specimens.

#### Treatment on jute fiber:

**a) Treatment with alkali** The jute fibers were cut to ~6 cm of length and soaked in NaOH solution at ambient temperature maintaining a fiber to liquor ratio of 1:30. The fibers were kept immersed in the alkali solution for 24 h. The alkali treated fibers were then washed several times with distilled water to remove excess alkali from the fiber surface. The final pH was maintained at 7.0. The fibers were then air dried at room temperature for 24 h followed by oven drying at 55°C for 24 h.

**b) Treatment with polymer latex** commercially available aqueous emulsion of carboxylated styrene-butadiene copolymer based polymer latex (SBR) was used to modify the jute fibers. The solid content of undiluted polymer latex was found to be 41%. Alkali treated jute fibers were dipped into polymer latex for 24 h, maintaining a liquor ratio 1:30 at ambient condition. The fibers were then air dried at room temperature for 24 h followed by oven drying at 55°C for 24 h.

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**Slump Test:** Slump test is conducted to the freshly produced concrete. The main purpose of the Slump cone test was to determine the workability of that concrete. The slump value is varied with the addition of varied jute content is shown.

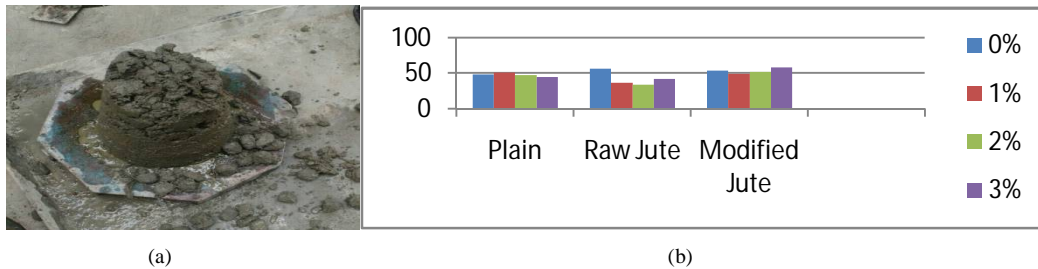


Fig.2. Experimental Results (a) Slump Cone Test (b) Slump Cone Test Result Analysis

## 7 days Compressive and Tensile Test Results:

After the 7 days curing period, the specimens are ready for test. The standard CTM (Compression Testing Machine) was used to test the specimen to determine the compression and its tensile properties.



Fig.3. Experimental Results (a) Treatment of jute with NaOH (b) Treatment of jute with polymer latex (c) Treated jute (d) Sample specimens (d) Oven Drying (e) Compression strength test (f) Split tensile test (h) Sample after testing

**Table 4. Seven days test results**

Sl.No	Fiber Cement Ratio	Compressive strength at Seven days (N/mm <sup>2</sup> )		Tensile strength at Seven days (N/mm <sup>2</sup> )	
		Raw jute	CM Jute	Raw jute	CM Jute
1.	1%	22.56	23.46	2.65	2.78
2.	2%	18.84	19.26	2.28	2.36
3.	3%	16.92	17.62	2.12	2.19

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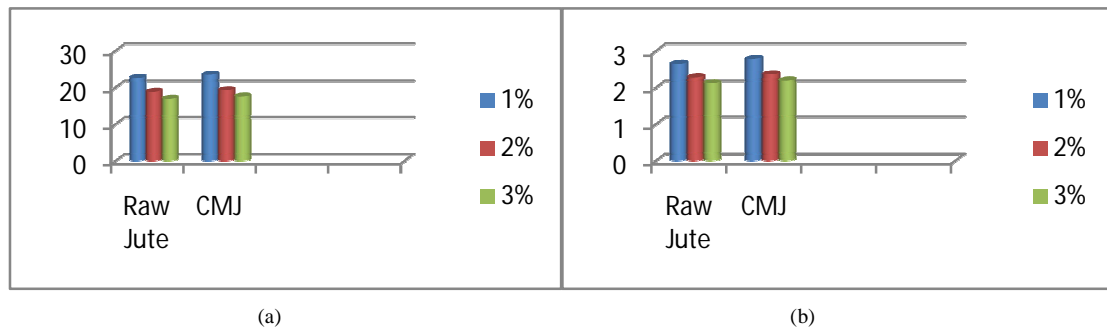


Fig.2. Experimental Results (a) 7 days compression test result (b) 7 days split tensile test result

### III CONCLUSION

- 1). It was observed that when the jute is chemically treated then its degradation decreases.
- 2). The main conclusion is when the cement is replaced by the jute it is not greater than 1%. After 1% it will degrade the strength of the concrete.
- 3). It was observed that when the raw jute is added in concrete by 1% weight of cement then the compressive strength of concrete cube increased by 15.7% and by adding modified jute compressive strength increase by 20.3%.
- 4). It was observed that when the raw jute is added in concrete by 1% weight of cement then the split tensile strength of concrete cylinder increased by 6.4% and by adding modified jute split tensile strength increase by 11.5%.
- 5). Hence, it is proved that modified replacement proportion is beneficial to use in practice as it gives workable concrete with more compressive and tensile strength.

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