DEVELOPMENT OF MODIFIED JUTE REINFORCED CONCRETE: AN OVERVIEW

By

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ABSTRACT

The study is purely based on the tests carried out on jute mortar to observe the various changes and to know about its different properties. A result of 36 specimens (27cubes and 9 beams) with varying chemical modified ratios has been included in the experiment. A total 27 cube samples of 150mm x 150mm x 150mm size and 9 beams of 100mm x 100mm x 500mm were prepared to experiment. The result of specimens has been brought out in which compressive strength and flexural strength for each are evaluated for 7 and 28 days. The results were then compared with the conventional mortar specimens for each chemically modified jute at the respective ages. Results found shows that, the compressive strength increases by 48%, flexural strength increases by 55% and water absorption of chemically modified jute decreases by 50-60%. The investigation shows that, the chemically modified jute reinforced mortar is a very durable material and has higher strength than ordinary mortar and that too at very low cost when compared to new technological innovative materials.

Keywords: Jute, Compressive Strength, Flexural Strength, Durable, Water Absorption.

INTRODUCTION

Natural fibers have long served many useful purposes but the applications of materials for the utilization of natural fibers as the reinforcement in concrete have only taken place in comparatively recent years. Fiber reinforced concrete contains fibrous materials which increases its structural integrity. Considerable researches have been made for the use of reinforcing fibers in cement composites mostly in case of building materials. A research program was initiated to investigate some of the possible local uses of natural fibre cement composites (a collective term, including concrete) in mass housing applications by Stephens, (1993). This program has recently been given an even greater impetus and focus by the decision of the new Government of National Unity to make one of its major goals, the provision of 1 million new houses within the next five years. This could make natural fiber cement composites an immediate and important area for potential cost savings as the finance needed. Aziz et al. (1984) reported that, coconut coir, sisal, sugarcane bagasse, bamboo, jute and wood cement composites have already been investigated in more than 40 countries world-wide. Studies of other fibers such as pissava and henequey have since been reported by other authors including Agopyan (1988). Among the various natural fibres such as, sisal fibers, bamboo fibers, coir fibers and jute fibers are of particular interest as these composites have high impact strength besides having moderate tensile and flexural properties compared to other lignocellulosic fibres. (Tara Sen, and Jagannatha Reddy,2011). This study involves jute as the fiber for the fiber reinforced concrete. The jute fibers are extracted from the ribbon of the stem. When harvested, the plants are cut near the ground with a sickle shaped knife. The small fibers, 5 mm, are obtained by successively retting in the water, beating, stripping the fiber from the core and drying. A single jute fiber is a three dimensional composite composed mainly of cellulose, hemicelluloses, and lignin with minor amounts of protein, extractives and inorganics. According to Tara Sen, and Jagannatha Reddy, (2011), one of the most studied chemistries to interfere with the natures' recycling chemistry and to improve performance properties of jute fiber based composites involves reactions with acetic anhydride

(acetylation). Chemical modifications of this type react with accessible hydroxyl groups on the cell wall polymers. These are the same hydroxyl groups involved in the natural degradation chemistries. Jute fiber is a promising reinforcement for the use in composites on account of its low cost, low density, high specific strength and modulus, no health risk, easy availability, renewability and much a lower energy requirement for processing (Debiprasad Gon, et.al, 2012). Polymer modified jute fibers have been decided to be used as reinforcing element in cement concrete in which, the polymer will chemically bridge jute in one 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 the virtue of its flexible nature. An optimized weight fracture 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 lightweight corrosion free structural materials. Research in the late 1950s and early 1960s by Romualdi and Batson, (1963) and Romuladi and Mandal (1964) on closely spaced random fibers, primarily steel fibers, heralded the era of using the fiber composite concrete that we know today. Other developments using bundled fiber glass as the main composite reinforcement in concrete beams and slabs were introduced by Nawy et al. (1971) and Neuwirth (1989). Based on the present scenario, it has been anticipated that the jute fiber reinforced cement may find potential applications as structural items in the construction industry. Being a potential agricultural project, the use of jute as reinforcing fiber in cement concrete will promote jute farming industries as well as produce better advanced composites.

1. Objectives of the Study

The objective of the study was to prove the advantages of Jute Mortar over ordinary Mortar cement. The objectives which take into consideration to achieve the work are outlined as follows:

- Chemical modification of jute fiber.
- Characterization of unmodified and chemically modified jute fiber.
- Fabrication of jute reinforced cubic blocks & beams.
- Testing and characterization of jute fiber reinforced cement.
- To obtain the compressive and flexural strengths as well as the water absorption values of the jute mortar.

2. Aim of the Study

The aim of this work is to study about the mortar blocks which are easily, freely, abundantly available and even at low cost and have more strength than ordinary mortar blocks. The construction industry is revolutionized by new emerging trends and technology. Jute mortar is one of the new advanced technology, but with little knowledge and experimental data. Jute mortar can be used with traditional building techniques, thus using renewable resources at less cost that too with good strength. New technology methods in cement industry results in new machinery and expertise, jute mortar on other hand uses basis raw material easily available and at cheap cost. Natural 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. Based on the present scenario, it has been anticipated that the jute fiber reinforced cement concrete may find potential application as structural items in the 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.

3. Methodology

The study was based on the components like chemical modification of jute fiber, characterization of unmodified and chemically modified jute fiber, fabrication of jute reinforced cubic blocks and beams, and testing and characterization of jute fiber reinforcement. The calculated mix design to prepare 35M concrete was cemented:sand:stone chips 1:1.5:2.7, however, the stone

chips of two different sizes (20mm and 12.5mm) were used in 70:30 ratio. The water cement ratio for concrete preparation was 0.4-0.42 and the slump value was 25±5mm. For each set of concrete composites, 1% jute fiber was incorporated. The tests were performed to compare the chemically modified reinforced jute mortar with the normal mortar. The jute was soaked in NaOH and casting as well as built up of paver blocks has been taken into consideration as shown in Figure 1. To calculate the compressive strength of cement mortar cubes, the UTM of load carrying capacity 40 tons were used. The test for flexural strength of cement mortar and reinforced cement mortar beams were also studied in the present work.

There are various grades of Jute available in market each having its own characteristics and properties, but the authors have used Jute in threaded form available in the market as shown in Figure 2. This type of Jute is cheap, readily available and easy to handle. Approximate weight of each jute ball was 80 g. The Jute was cut in small required length so that, proper requirement may be fulfilled. The materials used in this study were ordinary OPC Khyber Cement (43 grade), fine sand, jute, sodium hydroxide (NaOH), carboxylated styrene-butadiene copolymer based polymer latex and tap water as shown in Figure 3.

The jute fibers were cut in to 6 cm of length and soaked in 0.25, 0.5 and 1.0% (w/v) NaOH solution at ambient temperature maintaining a fiber to liquor ratio of 1:30 as

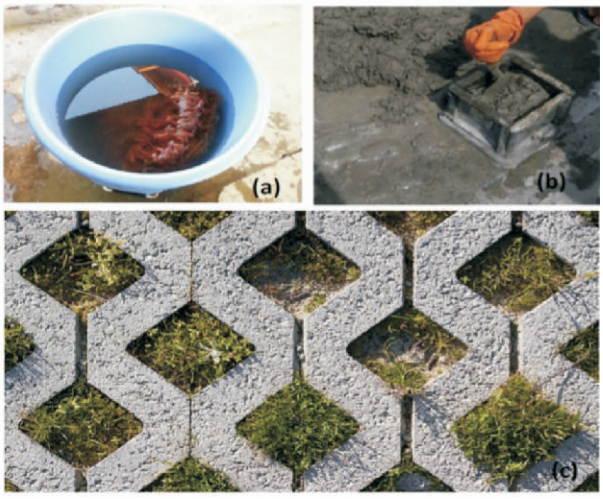

Figure 1 (a) Soaked Jute in NaOH, (b) Casting of Jute Mortar, (c) Jute Mortar Paver Blocks

Figure 2. Jute Threaded Balls

Figure 3. Material during Experimental Procedure

shown in Figure 4. The fibers were kept immersed in the alkali solution for 0.5, 1, 2, 4, 8, 16, 24, 36 and 48 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 hours as shown in Figure 5.

Commercially available aqueous emulsion of carboxylate styrene-butadiene copolymer based polymer latex 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 0.25, 0.5, and 1.0% (v/v) polymer latex for 24 h, maintaining a liquor ratio 1:30 at ambient condition Figure 5(c). The fibers were then air dried at room temperature for 24 hours followed by oven drying at 55 °C for 24 hours. The test moulds were kept ready before preparing the mix. Then moulds were cleaned and oiled on all contact surfaces of the moulds and then place the mould on the smooth and even surface. The modified jute cement mortar was filled into moulds with layers and then vibrated. The sample code (e.g. MS1, 11, 22, 0.8%, 33,

Figure 4. Preperation of Jute

Figure 5(a) Jute soaked in NaOH (b) Jute soaked in Polymer (c) Jute in Distilled Water (d) Oven Dried Jute

Figure 6. Pouring of modified Jute Cement slurry in Sand-cement Mix

etc.) and date of casting were put on the surface of the cubes, beams and moulds. The mixes were prepared by weight proportion of modified jute (i.e. jute treated with different sol. of NaOH & polymer) used as a cement mortar replacement material. The major problems encountered with jute fiber as a reinforcing agent in cement matrix are its non-uniform dispersion due to agglomeration of the fiber and its hydrophilic nature. Hence, to achieve a uniform dispersion of fibers in the cement matrix, jute was not directly mixed with sand & cement. A different technique was used in which, chemically modified jute was estimated which is to use in the cement mortar as reinforcement in the next day and then the chemically modified chopped fibers were immersed for 24 h in half of the total volume of water required for mortar preparation in a container. Next, 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 cement mortar mix as shown in Figure 6. The remaining amount of water was then added and the mixing was for further 5 min. The fresh cement mortar thus obtained was cast immediately in 150mm x 150mm x 150mm cubes and 100mm x 100mm x 500mm beams. After casting of cubes and beams, the vibrator was used for the proper compaction of the jute reinforced cement mortar as shown in Figure 7 and then all the moulds were allowed to set.

The moulds were opened after 24 h of casting as shown in Figure 8. The plain cement mortar samples were placed in the water bath tank for curing after writing the sample code on them. But for the chemically modified jute cement, mortar samples was placed in the open atmosphere for next 24 to 36 hours after writing the sample code and placed them in the water bath tank for curing. All samples were cured in the water bath tank to make sure that, maximum hydration process within the sample can take place as shown in Figure 9.

4. Results and Discussion

Jute fiber reinforced concrete blocks show very good results when compressive strength test and flexure strength test were done. Jute fiber reinforced precast concrete paver tiles achieves better properties than that of the control paver tiles without jute. The chemically modified

(a) (b)

Figure 7(a) Filling Mould with Jute Mortar, (b) Vibrator used for Compaction

Figure 8. Opening of Moulds

jute fiber reinforced concrete paver shows 54 % and 69 % higher compressive and flexural strengths respectively than that of the control concrete pavers block. Compressive strength and bending strength of cubes and beams have been obtained for both 7 and 28 days and have been plotted in Table 1. Flexural strength of cubes (150*150*150 mm) has also been obtained for both 7 and 28 days which have been plotted in Table 2.

Jute fiber reinforcement in concrete pipe leads to 3.4% increment in load required to produce 0.25mm crack. Jute reinforcement in concrete leads to 8.4% increment in ultimate load. Jute fiber reinforced concrete block show very good results when compressive strength test and flexural strength test are done. Jutefiber reinforced precast concrete pave tiles achieve better properties than that of the control pave tiles without jute. The chemically modified jute fiber reinforced concrete pave shows 54% and 69% higher compressive and flexural strengths respectively than that of the control concrete pave block. The study showed that, the chemical modification of jute fiber improves tensile strength and elongation at breakout 41% and 34% respectively. Water absorption of jute fiber was reduced to 108% from 210% after chemical and polymer treatment. The compressive strength of the samples for 7 days and 28 days has been plotted on the graph (Figure 10 and Figure 11). The samples Ms1', MS3' and MS4 on Figure 10 shows

(a) (b)

Figure 9 (a) Casted Samples (b) Curing of Samples

Sample	Date of Casting	Weight of sample (Kg)	Stage of strength (Days)	Code for sample	Failure load (kN)	Strength (Mpa)
Cubic Block 150*150*150 mm	06/05/2015	6.25	7 14 21 28	31	140	3.35
Cubic Block 150*150*150 mm	06/05/2015	6.25	7 14 21 28	31	220	9.82
Cubic Block 150*150*150 mm	06/05/2015	6.2	7 14 21 28	32	150	6.7
Cubic Block 150*150*150 mm	06/05/2015	6.2	7 14 21 28	32	230	10.26
Cubic Block 150*150*150 mm	06/05/2015	6.1	7 14 21 28	33	155	6.85
Cubic Block 150*150*150 mm	06/05/2015	6.2	7 14 21 28	33	235	10.56
Beam 100*100*500 mm	06/05/2015	9.5	7 14 21 28	0.8%	12	4.8
Beam 100*100*500 mm	06/05/2015	9.4	7 14 21 28	0.8%	14.5	5.8
Beam 100*100*500 mm	06/05/2015	9.4	7 14 21 28	1.0%	12.5	5
Beam 100*100*500 mm	06/05/2015	9.3	7 14 21 28	1.0%	15.5	6.2
Beam 100*100*500 mm	06/05/2015	9.4	7 14 21 28	1.2%	12	4.8
Beam 100*100*500 mm	06/05/2015	9.3	7 14 21 28	1.2%	15	6

Table 1. Compressive Strength and Bending Strength of Cubes and Beams

Sample	Date of Casting	Weight of sample (Kg)	Stage of strength (Days)	Code for sample	Failure load (kN)	Strength (Mpa)
Cubic Block 150*150*150 mm	05/05/2015	6.3	7 14 21 28	11	140	6.35
Cubic Block 150*150*150 mm	05/05/2015	6.25	7 14 21 28	11	210	9.3
Cubic Block 150*150*150 mm	05/05/2015	6.25	7 14 21 28	12	145	6.4
Cubic Block 150*150*150 mm	05/05/2015	6.25	7 14 21 28	12	230	10.12
Cubic Block 150*150*150 mm	05/05/2015	6.25	7 14 21 28	13	155	6.77
Cubic Block 150*150*150 mm	05/05/2015	6.2	7 14 21 28	13	235	10.41
Beam 100*100*500 mm	05/05/2015	6.3	7 14 21 28	21	150	6.57
Beam 100*100*500 mm	05/05/2015	6.25	7 14 21 28	21	230	10.1
Beam 100*100*500 mm	05/05/2015	6.3	7 14 21 28	22	150	6.65
Beam 100*100*500 mm	05/05/2015	6.3	7 14 21 28	22	235	10.26
Beam 100*100*500 mm	05/05/2015	6.2	7 14 21 28	23	155	6.9
Beam 100*100*500 mm	05/05/2015	6.2	7 14 21 28	23	240	10.71

Table 2. Compressive Strength and Flexural Strength of Cubes

low compressive strength as the composition of the samples were 1:3 cement mortar mix without the reinforcement chemically modified jute. The other samples in the graph show higher compressive strength according to the reinforcement of 1% jute with varying weights and volume solution of NaOH. The compressive strength for 28 days has been plotted in Figure 11. Degradation study of jute fiber in a cement matrix showed that the rate of degradation of treated jute fibers incorporated in cement paste was very slow, where in cases of untreated jute fibers incorporated in cement paste degraded rapidly with time. The scope of the study was to provide information of concrete with the inspiration and tools to implement green measures into concrete structures.

Conclusion

Jute reinforced mortar can be used in making fiber reinforced concrete pipe. These pipes can be used in many construction works and can prove their strength and work. Various tests have been conducted and have successfully come out with good results. In two tests which were conducted by a company hydrostatic test of concrete sewerage pipe and second one is the three edge bearing test. Concrete pipes with modified jute fiber reinforcement have performed much better than unmodified jute concrete pipes. The chemically modified jute reinforced concrete pipe achieves higher strength than that of conventional concrete pipe by incorporating only 20.5 kg of steel cage instead of 29.9 kg. Thus the chemically modified jute fiber reinforced concrete pipe is

Figure 10. Compressive Strength for 7 days

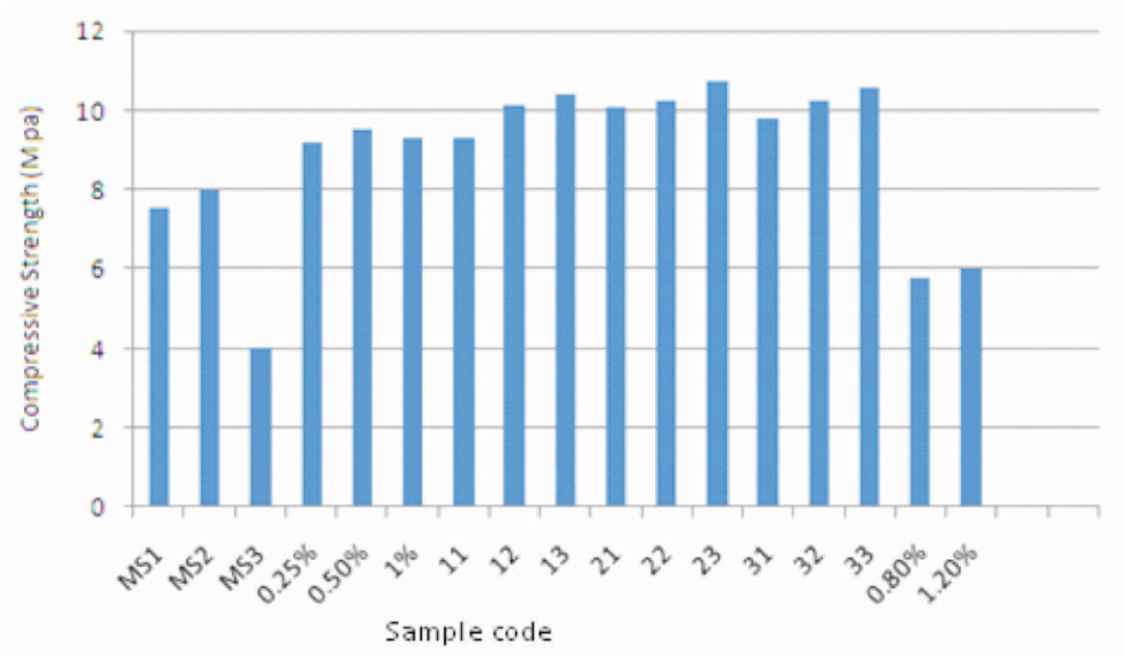

Figure 11. Compressive Strength for 28 days

cost effective as well as strong. Jute mortar blocks have more compressive strength than other ordinary mortar block and is available easily, freely, abundantly and at low cost. Due to tensile properties of fiber which get embed when jute is mixed with mortar, Jute mortar blocks have more tensile strength. Jute Mortar blocks are lightweight due to which, they can be a best alternative when roofing is considered. In spite of adding jute, there is no change in appearance and as such jute mortar block and ordinary mortar block look same. Jute mortar has very high shear strength as block and can be used in decorative moulds and block work. Jute mortar is very workable and thus can be formed into different shapes such as blocks, panels and sheets with ease.

Acknowledgement

The authors acknowledge the Department of Civil Engineering, NIT Srinagar, India for free dissemination of extensive data and free laboratory facility, which has been of great use for this research work.

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