EXPERIMENTAL STUDY ON BEHAVIOUR OF LIGNO-CELLULOSIC FIBERREINFORCED CONCRETE

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ABSTRACT- Concrete is the most widely used man made material on earth sought the attention of engineers worldwide. Researchers are focusing on the additive materials that could alter or increase the desired characteristics of a concrete. Various additives have been developed which turned out to be successful in the history of concrete. One such material which garnered the attention of various people is lingo-cellulosic fiber. It enables the concrete to provide good strength and reduced cracking.Jute fibers fall under the category of lingo-cellulosic fiber since they consist of 70% cellulose, 20% lignin and 10% of hemicellulose. They possess all the characteristics to be reinforced with concrete but not in their natural form since they possess hydrophilic character. Hence they need some pretreatment to be carried out to reinforce it with concrete. We are opting for a change in the composition of the concrete with some pretreatment to the fiber. In this study, the cubes and flexural beam specimens are cast using concrete grades M30 and M40. The varied percentage use of pretreatment jute fibreadded to concrete in the range of 2%and 4%. From the test results, the optimum amount of the jute fibre was found to be 2% that could be added to the concrete and as long as the content of jute fibers is increased, the strength of the concrete reduced.

KEY WORDS: Jute fibre, Compressive strength , Flexural strength, pretreatment,lingo-cellulosic

1.INTRODUCTION

The prime focus of this research is to develop a concrete with environment friendly material that could be used in most parts of the world using the abundant materials that exist in nature. There have been great ongoing researches which gave us few ideas to take up the research. There has been existence of various fibre materials that possessed the characteristics of a material that could be added to the concrete so that they increase the tensile strength of the concrete. Especially they helped in reducing the usage of the steel in concrete which resulted in drastic reduction in the price for developing the concrete. From the past, various works were carried out on these fiber reinforced concrete which led to the rise of glass fiber reinforced concrete, carbon fiber reinforced concrete etc. We opted for developing a concrete with a material that is environment friendly and finally zeroed upon the lingo-cellulosic fibers. These lingo-cellulosic fibers are the fibers that exist naturally and have the ability to be reinforced with concrete. There are different types of lingo-cellulosic fibers and some of them are coir fiber, cotton fiber, jute fiber, hemp fiber etc. Jute fibers are produced at larger volume in India especially in the northern part of our country. Due to

their abundance and natural existence jute fibers helped us to develop a good quality concrete. Various projects have been carried out on jute fibers and we would like to check for the stability and crack resistance of the concrete by changing the composition of jute fiber in the concrete. Since jute fibers are those which exist in nature they cannot be used directly for reinforcing in concrete and needed some pretreatment which could make it convenient to reinforce them to the concrete.

1.1 NEED FOR THE STUDY

Steel is one of the most important structural member that is irreplaceable though research has been carried out to reduce the content of steel by providing more tensile strength with the help of additional reinforcement. In this study jute fibers were taken as the reinforcing material. Being a natural fiber it is abundant in nature and has the abilities to be reinforced with concrete. Thus, jute fiber could definitely be used as an alternative material that could reduce the content of the concrete almost by 30% or even more. Successful reinforcement of the jute fiber has been carried out previously by reinforcing the jute fiber up to 1% by the weight of the concrete. While, we tried to provide some more jute content by changing the chemical composition of the concrete.Thus, the jute fiber could act as one of the best reinforcing materials that could increase the strength of the concrete with a good reduction in the content of steel. A concrete with even more durability and crack resistance could be developed with this jute fiber thereby producing revolutions in the industry.

2. LITERATURE REVIEW

J.Kimet al., carried out the investigation of mechanical properties of jute fiber reinforced concrete. It was observed that the addition of jute fibers in the normal strength concrete and high fluidity concrete increased the flexural strength by 17% and 20% comparing to normal conventional concrete. Additional treatment could be done. Finally the conclusion stated that the jute fibers do affect the workability of the concrete by the decreasing slump values.

Tara sen et al.,carried out the research work on the strengthening of RC beams in flexure using natural jute fiber textile reinforced composite system and its comparative study with CFRP and GFRP strengthening systems by suggested that jute fiber reinforced polymer displayed the highest deformability index which proved that jute fiber FRP possess huge potential to be used as a material for structural strengthening. They gave a conclusion that the jute fiber exhibited a tensile strength of 189.49 N/mm2, which was 21% of the tensile strength of the carbon FRP and 28% oftensilestrength of glass FRP. The jute textile FRP exhibited flexural strength of 208.705 N/mm2 which was 13% of flexural strength of carbon FRP and 32% of flexural strength of glass FRP.

Sumitchakraborty, et al, work accomplished by demonstrated effectiveness of short jute fiber as

reinforcement in cement mortar, the best mode of dispersion of the natural jute fiber in the concrete mix. The fiber was cut to 5mm approximately and then the reinforcement was carried out. The uniform and homogenous dispersion of the chopped jute fibers with the cement mortar is necessarily required which inhibits the crack propagation which results in improved mechanical properties of fiber reinforced mortar. On the contrary inhomogenous distribution of the jute fibers leads to surface and bulk flaws. Jute fiber is used as reinforcing agent to improve physical and mechanical properties of the cement mortar. The fiber content was varied from 0.0% to 4% in this research work. To use it as reinforcing agent in the cement mortar the length of the jute fibers were varied from 5mm to 20mm respectively. The project concluded that the optimal jute fiber content in the cement mortar would be 1% by weight of the cement for reinforcing with the cement mortar. The reinforcement of the jute fiber resists the crack propagation and shows failure gradually so that there would be ample time to determine and rectify the failure. The optimal addition of the jute fiber which is said to be 1% that of the weight of the cement was found to increase the crushing strength and the flexural strength approximately by 9% and 16% when compared to the control mortar without any jute reinforcement. This paper was concluded to have been provided the most plausible mechanism that could be carried out to add the jute fiber to the concrete to get the ighest mode of dispersion.

Xiangming Zhou et al.,carried out research to compared the fracture and impact properties of jute fiber reinforced cementitious composite (JFRCC). The report stated that there was a significant increase in the compressive strength, flexural strength and fracture toughness when combined with GGBS and PC as matrix and even PFA was also used for the combination. This work was initiated and developed by To improve the load bearing capacity of underground sewage pipe, we have formulated a concrete mixusing chemically-modified jute fibre (reinforcing agent), polymer latex (surface modifier both for fibreand matrix) and tannin (water reducing admixture). As compared to commercial non-pressure gradepipes (NP3 type), significant strength improvement, under three-edge-bearing test (_129.4%), is achievedin the pipes made using the modified concrete mix. NP3 pipes made using this modified concrete exhibitsimilar mechanical properties to that of NP4 pipes resulting an effective reduction of 31.6 wt% of steelused for reinforcement in NP4 pipes.In the present work we have studied the effect of chopped jutefibre as a reinforcing agent controlling the mechanical properties ofcement concrete. For homogeneous dispersion of jute fibre in cementmatrix, the alkali treated fibres were chemically modifiedby carboxylated styrene butadiene polymer latex. The nature ofthe chemical modification of the fibre surface was investigatedusing X-ray diffraction measurements in conjunction with FTIRanalyses. They have demonstrated that the chemical modificationmakes the fibre surface

hydrophobic for homogeneous dispersionin cement matrix. Also the polymer latex acts as a bridge betweenfibre and cement matrices to strengthen the interfacial bonding betweenthem. They have also demonstratedthat jute fibre reinforced NP3 sewage pipes can safely be used inapplication areas where heavy duty conventional NP4 type pipesare preferred; the superiority and commercial adaptability of thejute fibre reinforced concretes have been established. This work proved that jute fiber when chemically modified plays a mighty role in construction.

2.1. SCOPE AND OBJECTIVES

The research involves jute fibers that are to be added only after chopping them off to smaller sizes for proper mixing without agglomeration of the fiber when they are mixed with concrete. So, this studies will give a clear view of the optimized mix ratio and the best possible procedure that could be adopted for a proper mix. Sometimes even after the chopping the fiber fails to mix well with the concrete and hence they require some techniques that should be adopted. The fibers cannot mix well with the concrete due to their hydrophilic nature. Hydrophilicity refers to the inability of the fiber to mix with concrete and absorbs the water when they are used naturally. Using this research an evaluation over the usage of the short fibers in the concrete can be carried out. The most important aspect of the work is to modify the chemical characteristics of the jute fiber so that they could be well mixed with the concrete. The durability and strength of the jute fiber can be tested. Development of chemically modified jute fibers that could be reinforced with concrete can be produced. The optimized content of fiber that could be added to the concrete can be simulated. Moreover, the loading of the jute fiber with respect to the cement can be estimated. Thus, this project will definitely provide a proper set of details that are required by the researchers who carry out the project on the jute fibers. This works also describes about the various advantages of reinforcing jute fiber into the concrete over the other materials that could provide good results. This study will definitely make some changes in the research work that is carried out on jute fibers and also pave the path for the development of much more composite materials of the jute fiber and they even result in providing much more optimized loading results.

3. EXPERIMENTAL PROGRAM

3.1 MATERIALS USED

3.1.1.CEMENT:

Ordinary portland cement of grade 43 is used in this work.The properties are shown in table 1.

Table.1 Properties of cement

Specification	Values
Specific gravity	3.2
Fineness of the cement	4%
Expansion	3mm
Standard consistency	27 %
Initial setting time	45min
Final setting time	9 hours

3.1.2. FINE AGGREGATE

The naturally occurring river sand was used and the properties are shown in table 2.

Table .2 Properties of fine aggregate

Specification	Values
Specific gravity	2.4
Sum of cumulative % retained 150µ sieve	293.9 g
Fineness modulus	2.9
The water absorption	3 %

3.1.3.COARSE AGGREGATE:

Coarse aggregates which are less than 20 mm in size are used in the project and occupy almost 70 to 80% of the volume of the concrete thereby having a major influence on the properties of the composites. Angular aggregates are used in preparing the composite

3.1.4. WATER:

Water plays a crucial role in the construction due to its ability to infer the fluidic ability to the composite thus having a larger influence over the workability of the concrete. The water cement ratio is most important to avoid cracks in the concrete and even shrinkage could be avoided if optimum water cement ratio is maintained.

3.1.5. JUTE FIBER:

Jute is a natural fiber that is hydrophilic in nature which stops it to be reinforced with concrete but still it could provide good tensile strength to the concrete.

Fig.1 Jute fibre

3.1.6 MIX PROPORTION

Mix proportionas per IS10262for M 30:- 1: 1.5:3Mix and for M 40:- 1: 1.7:3

3.2. TESTS ON FRESH CONCRETE

3.2.1 SLUMP CONE TEST

The mould for the slump test is a frustum of a cone, 300mm (12 in) of height. The base is 200mm (8 in) in diameter and it has a smaller opening at the top of 100mm (4 in).The base is placed on a smooth surface and the container is filled with concrete in three layers, whose workability is to be tested.Each layer is tamped 25 times with a standard 16mm (5/8 in) diameter steel rod, rounded at the end.When the mold is completely filled with concrete, the top surface is struck off (leveled with mould top opening) by means of screening and rolling motion of the tamping rod.The mould must be firmly held against its base during the entire operation so that it could not move due to the pouring of concrete and this can be done by means of handles or foot-rests brazed to the mould.Immediately

after the filling is completed and the concrete is leveled, the cone isslowly and carefully lifted vertically, an unsupported concrete will now slump.The slump is measured by placing the cone just besides the slump concrete and tampingrod isplaced over the cone so that it should overcome the areas of slumped concrete.The decrease in height of concrete to that of mould is noted with scale (usually measured to the nearest 5mm (1/4 in)).

TYPES OF SLUMP

The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as,

1. Collapse slump
2. Shear slump
3. True slump

COLLAPSE SLUMP:

In a collapse slump the concrete collapses completely. A collapse slump will generate mean that the mix is too wet, for which slump test is not appropriate

SHEAR SLUMP:

In a shear slump, the top portion of the concrete shears off and slips side away (or)

If one half of the cone slides down an inclined plane, the slump is said to be a shear slump.

1. If a shear slump or collapse slump is achieved, a fresh sample is need to be taken and the test is repeated.
2. If the shear slump persists, as many the case with harsh mixes, this is an indication of lack of cohesion of the mix.

TRUE SLUMP:

In a true slump the concrete simply subsides, keeping more or less to shape.

1. This is an only slump which is used in various tests.
2. Mixes of stiff consistence have a zero slump, so that in the rather dry range no variation can be detected between mixes of different workability

Table 3. Slump values

DEGREE OF WORKABILITY	SLUMP mm	COMPACTION FACTOR
VERY LOW	0 – 25	0.78
LOW	25 – 50	0.85
MEDIUM	50 – 100	0.92
HIGH	100 – 175	0.95

3.3PREPARATION OF SPECIMENS

3.3.1 FORMWORK

For casting cubes and beam, standard moulds with smooth machined inner faces were used. The inner

dimensions of the cube mould were 150X150X150mm. The size of the flexure beam used was 500X100X100mm. The mould was completely watertight during concreting.

Fig. 2 Beam mould

3.3.2 COMPACTION

Compaction was done through using tamping rod. The compaction was done in 3 layers. The first layer was initially filled and compacted well while the second layer and the third layer were also filled and compacted well without disturbing the other layers. The compaction was carried out on alayer basis in order to obtain the concrete with less pores to avoid honey combs.

Fig. 3.Casting of beam

3.3.3 CASTING PROCEDURE AND CURING PROCESS

The form works are made ready and the casting of the cubes and beams are carried out. Initially, the mixing of the various aggregates, jute fiber and the cement were carried out in a pan mixer and the procedure followed for the proper mixing of these various aggregates involved certain variations from the normal mix to avoid the agglomeration of the jute fibers and the hydrophilic character of the jute fiber resists the jute fiber from mixing properly with the concrete to form the composites. So, before reinforcing the jute fiber with the concrete the jute fibers were pretreated by dipping them into NaOH solution for a period of 48 hours. The solution has the ability to provide the alkalic character that is needed by the jute fiber to be reinforced with the concrete. Then, the alkali treated fibers were taken out and were washed with water several times in order to remove the excess content of alkali that existed on the surface of the jute fibers. The fibers were then kept at a room temperature for a

period of 24 hours.Then, the fibers were kept for oven drying for a period of 24 hours at a temperature of about 50 degree Celsius. After the pretreatment of the jute fiber, a different procedure has been carried out for the mixing of the materials. Initially, the chopped jute fibers were dipped in water and the jute fibers were made wet that were required for mortar preparation. Half of the total amount of total cement required and half of the amount of total volume of water required were then added to the wet jute fibers and the jute cement slurry was prepared initially. The remaining amount of water and the aggregates were then added which allowed for the nominal and proper mixing of the aggregates and the jute fibers. The fresh concrete thus prepared were placed in the moulds made ready and allowed to set for 24 hours.The concrete composite from the cube moulds and beam moulds were then tested for compressive strength and flexural strength in an interval of 7 days, 14 days and 28 days respectively.

Fig. 4 Concrete specimens

4 TESTS ON HARDENED CONCRETE

4.1 CUBE COMPRESSION TEST

The compression test is carried out on cube specimens. For the determination of cube compressive strength of concrete. Specimens, of size 150X150X150mm size were cast and cured for 7 and 28 days in tap water. After the specimens are dried in open air, subjected to cube compression testing under digital compression testing machine.

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Fig.5 Experimental Setup for Compression Test.

4.2 FLEXURAL STRENGTH

Test specimens stored in water at a temperature of 24° to 30°C for 48 hours before testing shall be tested immediately on removal from the water whilst they are still in a wet condition. The dimensions of each specimen shall be noted before testing. No preparation of the surfaces is required.

Placing the Specimen in the Testing Machine

The bearing surfaces of the supporting and loading rollers shall be wiped clean, and any loose sand or other material removed from the surfaces of the

specimen where they are to make contact with the rollers. The specimen shall then be placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould, along two lines spaced 20.0 or 13.3 cm apart. The axis of the specimen shall be carefully aligned with the axis of the loading device. The load shall be applied without shock and increasing continuously at a rate such that the extreme fiber stress increases at approximately 7 kg/sqcm/min, that is, at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The appearance of the fractured faces of concrete and any unusual features in the type of failure shall be noted.

The flexural strength of the specimen shall be expressed as the modulus of rupture f_b.

$$f_b = \frac{p \times l}{b \times d^2}$$

5. RESULTS AND DISCUSSION:

5.1COMPRESSIVE STRENGTH OF JUTE FIBRE REINFORCED CONCRETE FOR M30

Table 4 Compressive strength of jute fiber for M30

Mix	% of Jute fiber	Load at failure (kN)	Compressive strength (N/ mm^2)	Avg compressive strength (N/ mm^2)
N	0	660	29.30	30.21
		700	31.11	
		680	30.22	
M-1	2%	850	37.77	38.60
		890	39.55	
		870	38.66	
M-2	4%	620	27.55	26.80
		610	27.33	
		575	25.55	

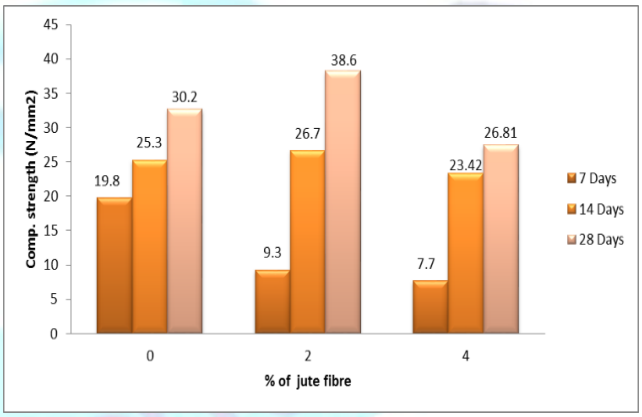

Table 5 Compressive strength of jute fiber for M40

Mix	% of Jute fiber	Load at failure (kN)	Compressive strength (N/ mm^2)	Avg compressive strength (N/ mm^2)
N	0	917	40.7	41.07
		925	41.11	
		933	41.4	
M-1	2%	100.9	44.8	45.12
		101.5	45.1	
		102.3	45.46	
M-2	4%	780	34.67	34.65
		765	34.06	
		793	35.24	

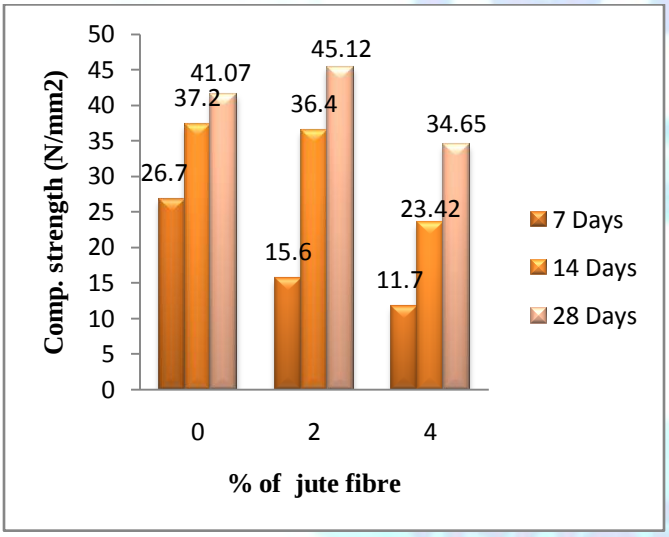

Fig3.2.Comparision of compressive strength

5.2 FLEXURAL STRENGTH FOR JUTE FIBRE REINFORCED CONCRETE FOR M30

Table 6 Flexural strength of jute fiber for M30

Mix	% of Jute fiber	Load at failure (N)	Flexural strength (N/ mm^2)	Avg flexural strength (N/ mm^2)
N	0	9.50	4.9	5.05
		10.45	5.15	
M-1	2%	12.1	6.05	6.1
		12.4	6.2	
M-2	4%	11.6	5.8	5.6
		10.8	5.4	

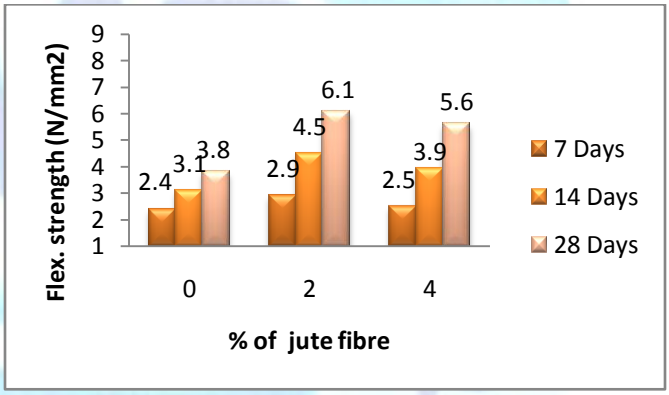

Table 7 Flexural strength of jute fiber for M40

Mix	% of Jute fiber	Load at failure (kN)	Flexural strength (N/ mm^2)	Average flexural strength (N/ mm^2)
N	0	10.16	5.08	5.2
		10.52	5.26	
M-1	2%	15.00	7.5	7.6
		15.46	7.73	
M-2	4%	10.92	5.46	5.5
		11.06	5.53	

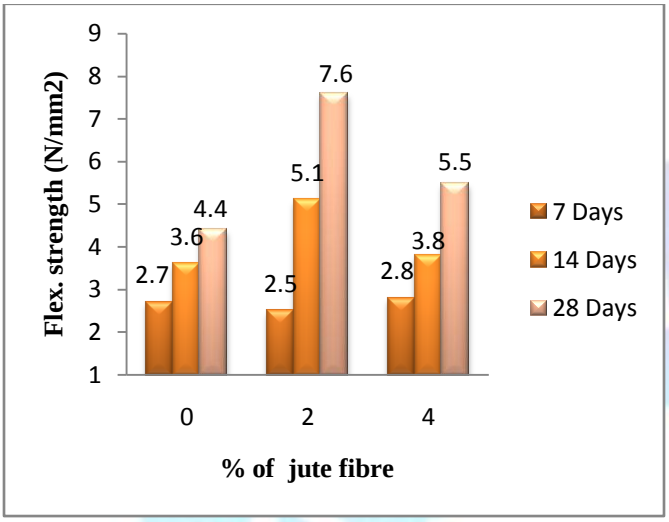

Fig 3.4 Comparison of Flexural strength of jute fiber for M40

6.CONCLUSION:

The development of the jute fibre reinforced concrete has been completed successfully and results were obtained for compressive strength and flexural strength of the concrete. Based on the results for the concrete mixes M30 and M40 the following conclusions are attained.

- The compressive and tensile strengths were identified to vary with the percentage of the jute fibres that is reinforced with the concrete.
- The compressive and tensile strengths are increased with the addition of the jute fibres.
- The mixes M30 and M40 showed variations with the addition of the jute fibres.
- The optimum amount of the jute fibre was found to be 2% that could be added to the concrete.
- As long as the content of jute fibres are increased, the strength of the concrete reduced.

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