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Experimental Investigation of Jute Fibre Reinforced Concrete Composites

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Abstract:- **An experimental investigation on jute fibre reinforced concrete (JFRC) is made for making a suitable material in terms of reinforcement. Jute fibre is economic and environment friendly. The slump value, compressive and splitting tensile strengths of specimens was investigated to six levels of jute fibre content by volume fraction. The results showed decrease in slump value with increase in fibre content which indicates that suitable limitation in fibre content must be made. Also presence of jute fibre has increased the compressive and splitting tensile strength to a great extent.**

I. INTRODUCTION

Concrete is the most widely used construction material in the world. It is durable, readily moulded into complicated shapes and has adequate compressive strength and stiffness. Plain cement concrete (PCC) possess high compressive strength but very low tensile strength. The poor tensile strength of PCC is due to the propagation of cracks, during the working condition which eventually leads to the brittle fracture of concrete. Improvements in tensile properties of concrete members are done by using conventional reinforced steel bars and also by applying restraining techniques.

Development of structural cracks may be reduced to a large extent by using Fibre reinforced concrete. Fibre reinforced concrete uses fine fibres distributed throughout the mix or other reinforcement elements to limit the size and extent of cracks. Addition of fibres in concrete improves its energy absorption capacity and apparent ductility to provide crack resistance and crack control.

II. EXPERIMENTAL INVESTIGATION

The experimental programme was done to study the mechanical properties of jute fibre reinforced concrete. The variable considered in this study include six different values of volume fraction of jute fibre
JFRC 0%,
JFRC-A 0.2%,
JFRC-B 0.4%,
JFRC-C 0.6% ,
JFRC-D 0.8%
&
JFRC-E 1%.

III. MATERIALS AND SPECIMENS

Ordinary Portland cement of 53 grade conforming to IS 12269:1987 was used for the study. M sand passing through 4.75 mm IS sieve conforming to grading zone II of IS 383:1970 was used as fine aggregate. Specific gravity of fine aggregate was 2.6 and fineness modulus was 2.67.Coarse Aggregate of maximum size 20 mm from local source was mixed and used. Jute fibre of good quality was cut into 6 cm length and was used. Mix design of JFRC is as follows: Cement 493 kg/m3, Fine Aggregate 795 kg/m3, coarse aggregate 1541 kg/m3,
Super plasticizer 9.86 kg was used.

IV. TESTING PROCEDURE

All the ingredients of the mix were weighed in an electronic balance and mixed properly in a standard type drum mixer. During mixing, placing and compaction, it is observed that the fibres were uniformly distributed. Mixing operation was continued till a good uniform and homogeneous concrete was obtained.

Fifty Four concrete cubes of size 150mm x 150mm x 150mm for compressive strength test, eighteen cylinders of 150mm diameter and 300mm height for splitting tensile strength test and twelve beams of size 500mm x 100mm x 100mm for flexural strength test were casted. For casting these specimens, required quantities of constituents were weighed and kept ready for mixing. For easy removal of the specimens, oil was applied to the inner surfaces of the moulds. At first, half of all the ingredients were mixed well in dry condition in the concrete mixer. Calculated amount of water was added to the dry mix and thoroughly mixed in the mixer. The concrete was placed in three layers and was internally compacted using mechanical vibrator. The specimens were de-moulded after 24 hours and were cured in a water curing tank. After 28 days, the specimens were kept ready for testing.

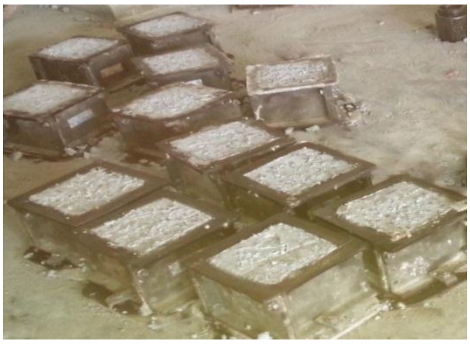

Fig 1.Casting of specimens

A. Compressive strength

Compressive strength test was performed in accordance with IS 516:1959. The cube tests was carried out on cubical specimen of size 150mm x 150mm x 150mm in a compression testing machine of 2000 KN. The specimens were taken out from the curing tank and the surface water was wiped off. The specimen was then placed on a compression testing machine in such a way that the load is applied to the opposite sides of the cubes. The load was applied gradually at the rate of 14 N/mm^2 per minute up to failure. The maximum load taken by the specimen was noted and the compressive strength was obtained by dividing maximum load by area of the cross section of specimen. The Fig. 2 shows the setup of cube compression test

Fig 2. Cube compression test

B. Splitting tensile strength

Splitting tensile strength test is an indirect method to determine the tensile strength of concrete. Cylindrical specimen of diameter 150mm and height 300mm were tested for determining the splitting tensile strength as per IS 5816:1999 specification.

The test was carried out by placing the cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load was applied continuously without shock at the rate of 1.2 N/mm^2 per minute to 2.4 N/mm^2 per minute. Specimen splits into two along the vertical diameter. The Fig.3 Setup for splitting tensile strength of cylinder.

Fig 3.splitting tensile strength test

C. Flexural Strength

Flexural Strength is used to measure the tensile strength of concrete. Although concrete is not normally designed to resist direct tension, the knowledge of tensile strength is important in estimating the load under which cracking will develop. Beam specimen of size 500mm x 100mm x 100mm was tested for determining the flexural strength as per IS 516:1959 specifications.

Center and one-third distance from either supports were marked on the specimen. The specimens were placed on the steel rollers resting on the bed of the testing machine. The load was then applied at the rate of 1.8 KN/min without shock. The breaking load and appearance of the fractured faces of concrete were noted. The Fig. 4 shows the test set up of flexural strength test on beam specimen.

Fig 4.Flexural strength test

V. RESULTS AND DISCUSSION

Fibre length was kept constant at 6mm while volume fraction was varied from 0 to 1%.

A. Slump and compacting factor.

The results of tests on the fresh concrete properties such as slump and compacting factor are presented in table 3.1. Slump and compacting factor was found to decrease with percentage addition of fibre.

TABLE 1 PROPERTIES OF FRESH CONCRETE

Sl.No	Mixes	Workability	
		Slump (mm)	Compacting factor
1	JFRC	30	0.85
2	JFRC-A	29	0.83
3	JFRC-B	28	0.81
4	JFRC-C	26	0.78
5	JFRC-D	25	0.75
6	JFRC-E	23	0.74

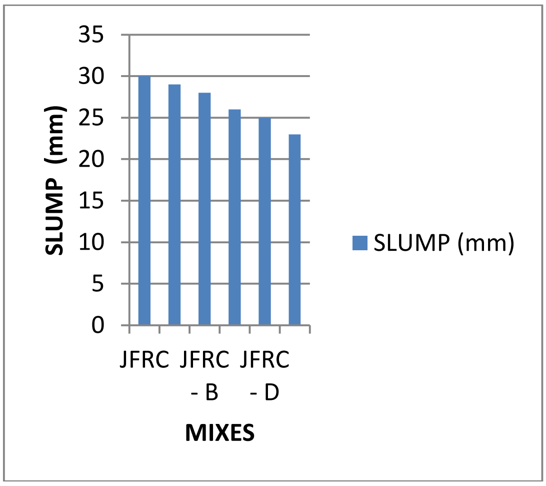

Fig 5 Variation of slump value for different mixes

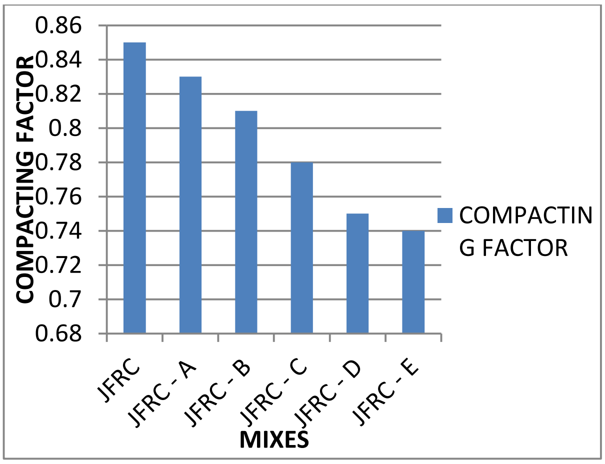

Fig 6 Variation of compacting factor for different mixes

B. Mechanical Properties

1. Cube compressive strength

Compressive strength of all concrete mixes was determined at 7, 14 and 28 days of curing. The compressive strength test results are given in Table 4.2. From these results, it was observed that compressive strength of all mixes was found to increase till 0.6% and that compressive strength of all mixes was greater than control mix JFRC. Compressive strength decreases for addition of fibres above 0.6%.Maximum strength at all ages occurs with 0.6% addition of fibre.

From test results it was concluded that there is an increase in the early age compressive strength due to the addition of fibre in concrete. Comparing to JFRC, JFRC-C has showed an increase in strength of 19 % at 7 days, 13% at 14 days and 20% at 28 days. From the compressive strength test, JFRC-C was obtained as the optimum percentage.

TABLE 2 COMPRESSIVE STRENGTH OF CONCRETE

Sl. No	Mixes	Average compressive strength (N/mm^2)		
		7 days	14 days	28 days
1	JFRC	26.15	30	33.40
2	JFRC-A	27.12	29.5	35.01
3	JFRC-B	29.10	31.40	37.12
4	JFRC-C	31.21	33.91	40.14
5	JFRC-D	28.43	32.34	38.25
6	JFRC-E	26.16	30.10	36.31

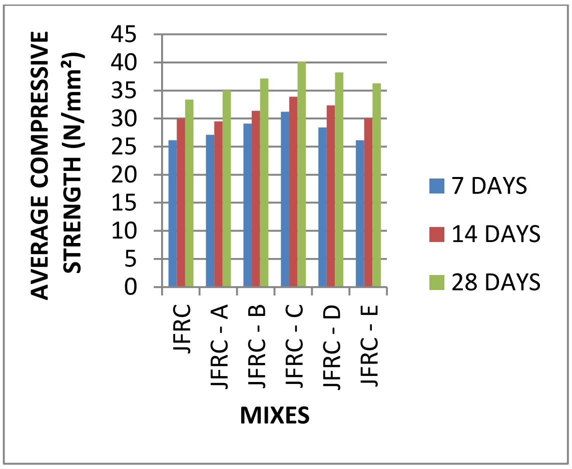

Fig 7 Variation of compressive strength for different mixes

2. Splitting tensile strength

Splitting tensile strength of cylinder was determined at 28 days of curing. The test results are given in Table 4.3. From these results it can be seen that splitting tensile strength of cylinder of JFRC-C was higher than JFRC. Percentage increase in strength of JFRC-C was higher than JFRC. Percentage increase in strength of JFRC-C was 68%.

TABLE 3 SPLITTING TENSILE STRENGTH OF CONCRETE

Sl No	Mixes	Average splitting tensile strength (N/mm^2)
1	JFRC	2.32
2	JFRC-A	2.81
3	JFRC-B	3.71
4	JFRC-C	3.90
5	JFRC-D	2.85
6	JFRC-E	2.80

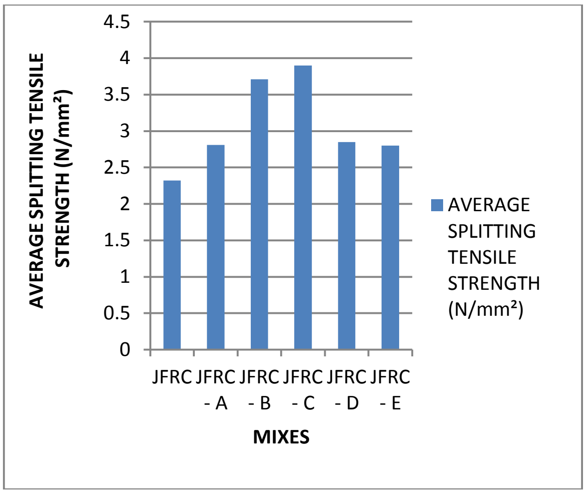

Fig 8 Variation of splitting tensile strength for different mixes

3. *Flexural strength*

Flexural strength was determined at 28 days of curing. The test results are given in Table 4.4.The variation of flexural strength of beams with different mixes is shown in Fig4.5. From these results, it can be seen that the flexural strength of JFRC-C was higher than JFRC-D and JFRC-E.

TABLE 4 FLEXURAL STRENGTH OF CONCRETE

Sl No	Mixes	Average Flexural Strength (N/mm^2)
1	JFRC	4.04
2	JFRC-A	4.16
3	JFRC-B	4.50
4	JFRC-C	5.60
5	JFRC-D	4.72
6	JFRC-E	4.70

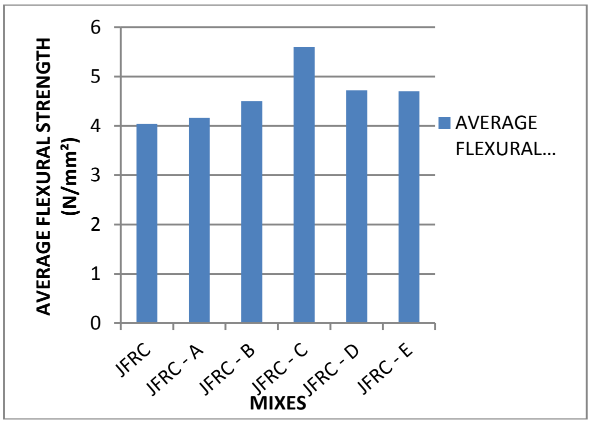

Fig 9 Variation of flexural strength for different mixes

VI. CONCLUSION

- When fibre is added to concrete, the mix becomes stiff. So the workability is decreased with addition of fibre. The workability can be improved by adding super plasticizer to some extent.
- The concrete mix starts clogging beyond the 0.6 % addition of fibre. So the mechanical properties are decreased above 0.6% by weight of concrete.
- The fibre distributes the strain more evenly in concrete and improves the tensile strength, thereby causing the increase in first crack load and ultimate load
- When fibres are added to concrete, crack propagation is arrested and this results in improving load carrying capacity and energy absorption capacity. So the toughness and ductility is improved with the addition of percentage of jute fibre
- Load deflection behavior curve shows that ductility of fibres increases and the stiffening effect occurred in the tension zone reducing widening of crack and diagonal crack are reduced to hairline crack
- In general jute fibres can be effectively used as a cost effective replacement for glass fibres and ordinary steel fibres. It improves the properties of concrete which are necessary in earthquake resistant structures.

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