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Experimental Investigation on Coir Fibre As A Concrete Composite

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Abstract:

Investigations to overcome the brittle response and limited post – yield energy absorption of concrete led to the development of Fibre Reinforced Concrete using discrete fibres within the concrete mass. A wide variety of fibres have been proposed by the researchers such as steel, glass, polypropylene, carbon, polyester, and acrylic etc., In this project work an attempt has been made to investigate the possibility of using locally available coir fibres as concrete composites.

Keywords **—Coir, Coir fibre reinforced concrete (CFRC),Volume fraction, Ultimate load carrying capacity, Ductility..**

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I. INTRODUCTION

The application of composites in civil infra-structural activities mostly concentrated on the mechanical strength on composites and not on its usage in structural system. Also, Solid waste disposal has become one of the major problems in modern cities. At present there are two major methods in practice to dispose wastes. One is land filling and the other is burning. First one requires more valuable land and second one pollutes the environment. So, alternate methods to dispose solid waste should be found. By considering these requirements, here an attempt is made to study the possibilities of using the coir fibre materials as fibre composites in concrete flexural members which not only tries to solve the ductility problem but also the problem of waste disposal at least to a small extent.

II.EXPERIMENTAL INVESTIGATION

This investigation is divided into three phases. Initially coir fibres with three different lengths (50mm, 75 mm & 100mm) and three volume fractions (0.5%, 1.0% and 1.5%) were taken and the influence of different fibre length on workability of concrete were studied.

Whilst the slump test is commonly used to assess the workability of conventional concretes, it is not generally suitable for natural fibre reinforced concrete. Hence in this investigation, both slump tests as well as Vee-bee test were conducted to assess the workability of fibre reinforced concretes.

The second phase was to obtain the optimum fibre length and volume fractions of fibres for structural studies for mechanical strength properties such as compressive strength, split tensile strength, Flexural strength and Ultrasonic pulse velocity of CFRC.

In the third phase, Flexural behaviour of reinforced concrete beams with coir fibres of optimum length and three different volume fractions (0.5%, 1.0% & 1.5%) have been studied under static loading.

MATERIALS, MIX AND CASTING

Materials used include ordinary Portland cement 43 grade, coarse aggregate of crushed rock (Max. size, 20 mm), fine aggregate of clean river sand (Zone II of IS: 383-1970) and potable water. Locally available rural coir fibre was taken from waste stream and converted into fibres of required length. Diameter of fibres was measured through profile projector. Uniform length of fibres was obtained by using a cutting machine. A mix was designed as per IS 10262-2009 to achieve a concrete grade of **M20**.

In order to avoid balling of fibres, aggregates and cement were mixed for 1 minute and water was being added and mixed for 2 minutes. Then fibres were manually added and dispersed throughout the mass in small quantities. Then, materials were allowed to mix thoroughly for 3 minutes. Fibrous concrete was manually placed in respective moulds. All specimens were well compacted using a tamping rod. Specimens were remoulded after 24 hours.

PRELIMINARY INVESTIGATION

CEMENT

Ordinary Portland cement of 43 grade conforming to IS 8112-1989 was used. Tests were carried out on various physical properties of cement and the results are shown in Table.I.

TABLE.I.PHYSICAL PROERTIES OF 43 GRADE ORDINARY PORTLAND CEMENT

Physical Properties	Values of OPC used
Standard Consistency	29.2%
Initial Setting Time	45 Minutes
Final Setting Time	265 Minutes
Specific gravity	3.12

FINE AGGREGATE

The properties of sand were determined by conducting tests as per IS: 2386 (Part- I).

TABLE.II

PHYSICAL PROPERTIES OF FINE AGGREGATE

(TESTS AS PER IS: 2386 – 1968: PART III)

Physical properties	Values
Specific gravity	2.64
Fineness Modulus	2.68
Water Absorption	1 %
Bulk density (kg/m3)	1654

COARSE AGGREGATE

The maximum size of coarse aggregate used was 20 mm. The properties of coarse aggregate were determined by conducting tests as per IS: 2386 (Part – III).The results are tabulated in Table.III

TABLE.III.PHYSICAL PROPERTIES OF COARSE AGGREGATE.

(TESTS AS PER IS: 2386 – 1968 PART III)

Physical properties	Values
Specific gravity	2.79
Fineness Modulus	7.53
Water Absorption	0.75%
Bulk density (kg/m3)	1590

WATER

Potable water free from salts was used for casting and curing of concrete.

FIBRES

Locally available coir waste materials were collected and properly shaped in the form of fibres. Uniform length of fibres was obtained by using cutting machine. The diameter of the fibres was found using optical projector. A random sample of 100 fibres has been chosen for tests as shown in Figure.1.

Fig.1 Coir Fibres

REINFORCEMENTS

Fe 415 steel bars of diameter 10 mm were used as main reinforcements for beams and 8 mm diameter rods were used as stirrups.

CONCRETE MIX DESIGN

M-20 Mix Design as per IS-10262-2009

Stipulations for Proportioning

1. **Grade Designation - M20**
2 .Type of Cement OPC - 43 grade confirming to IS-12269-1987
3. Maximum Nominal Aggregate Size - 20 mm
4. Minimum Cement Content - 300 kg/m3
5. Maximum Water Cement Ratio - 0.5
6 .Workability Compaction factor - 0.9
7. Exposure Condition - Mild
8 .Degree of Supervision - Good
9 .Type of Aggregate - Crushed Angular Aggregate

Test Data for Materials

1 .Cement Used - Chettinad OPC 43 grade
2 .Sp. Gravity of Cement- 3.12
3 .Sp. Gravity of Water - 1.00
4 .Chemical Admixture -Not Used
5. Sp. Gravity of Coarse Aggregate - 2.79
6 .Sp. Gravity of Sand - 2.64
7. Water Absorption of coarse aggregate - 0.75 %
8 .Water Absorption of Fine aggregate - 1 %

Target Strength for Mix Proportioning

1. Characteristic Strength @ 28 days =20N/mm2
2. Target Mean Strength for Mix Design

$$\overline{f}ck = fck + tS$$

$$\overline{f}ck = 20 + 1.65 \times 4$$

$$= 26.6 \text{ N/mm}^2$$

MIX PROPORTION

WATER	CEMENT	FINE	COARSE
186 litres	372 Kg	562 Kg	1260 Kg
0.50	1.00	1.51	3.38

The design is progressively corrected by trial mixes and the final mix proportion of **0.50:1:1.60:3.60** has been adopted.

ADOPTED MIX PROPORTION

WATER	CEMENT	FINE	COARSE
170 litres	340 Kg	544 Kg	1224 Kg
0.50	1.00	1.60	3.60

It gives 28 days compressive strength of **28.15 Mpa.**

TESTS CARRIED OUT

This section deals about the specimen details and testing procedure of each test.

WORKABILITY

SLUMP TEST

The slump test was conducted as per IS: 7320 – 1974. The slump value was measured in mm.

VEE-BEE TEST

By using this method, consistency is being found by determining the time required for transforming by vibration, a concrete specimen in the shape of a conical frustum into a cylinder. The test was conducted as per Indian Standards.

COMPRESSIVE STRENGTH

Compression test on cubes (150 mm x150 mm 150 mm) were conducted as per IS:516-1959.

SPLIT TENSILE STRENGTH

The Split tensile strength test was carried out on the compression testing machine. The casting and testing of the specimens has been carried out as per IS 5816: 1999. Load was applied continuously without shock.

FLEXURE TEST

SPECIMEN DETAILS

The specimens are beams of size 1000mm x 200mm x 150mm, reinforced with 2 Nos.of 10mm diameter HYSD bars in tension and 2 Nos. of 10mm diameter HYSD bars in compression zone as hanger rods. The specimen is also provided with shear reinforcements in the form of 8mm diameter mild steel bar two legged stirrups at 150 mm centers. The proportions of ingredient of the concrete of grade M20 had been determined by mix design as per IS code. Four number of beam specimens were cast and subjected to two points loading to study their flexure behaviour and other salient parameters.

III.RESULTS AND DISCUSSIONS

RESULTS

FRESH CONCRETE PROPERTIES

Slump, Vee Bee Time and unit weight test results of 10 different concrete mixes of **M20** grade with mix proportion **0.5: 1:1.60:3.60** are shown in Table IV.

TABLE IV WORKABILITY STUDIES

Mixture	Volume Fraction (*Vf*) in %	Fibre length(*l*) in mm	Slump in mm	Vee Bee Time in Secs	Unit Weight of concrete in Kg/m³
CC	-	-	128	1.50	2470
CFRC1	0.5	50	95	2.00	2735
CFRC2	0.5	75	87	2.50	2737
CFRC3	0.5	100	79	3.25	2744
CFRC4	1.00	50	63	3.20	2674
CFRC5	1.00	75	68	3.75	2527
CFRC6	1.00	100	46	4.25	2650
CFRC7	1.50	50	42	4.00	2530
CFRC8	1.50	75	23	5.00	2557
CFRC9	1.50	100	5	5.25	2688

MECHANICAL STRENGTH STUDIES

The 28-day compressive, Split, Flexural, Ultrasonic Pulse velocity values of CFRCs are given in Table.V

TABLE.V.MECHANICAL STRENGTH PROPERTIES OF CONCRETE MIXTURES

Mixture Designation	Volume Fraction (*Vf*) in %	Fibre length(*l*) in mm	Compressive Strength (*fc*) Mpa	Split Tensile Strength (*fst*) Mpa	Felxural Strength (*ff*) Mpa	Ultrasonic Pulse Velocity (*Upv*) m/s
CC	-	-	28.15	2.59	4.33	5.37
CFRC1	0.5	50	34.67	3.91	6.02	5.77
CFRC2	0.5	75	33.78	3.77	5.45	5.09
CFRC3	0.5	100	32.30	4.15	5.42	4.87
CFRC4	1.00	50	32.00	3.82	4.85	4.18
CFRC5	1.00	75	31.26	3.21	4.75	3.27
CFRC6	1.00	100	26.52	3.35	4.60	3.68
CFRC7	1.50	50	24.07	3.25	4.42	3.04
CFRC8	1.50	75	31.85	2.83	4.62	2.91
CFRC9	1.50	100	27.85	2.64	4.05	2.90

FLEXURE TEST RESULTS

CONTROL CONCRETE BEAM (CC)

First Crack Load = 9.5 KN

Ultimate Load = 56.81 KN

Mid Span Deflection at Ultimate Load = 23.78 mm

COIR FIBRE REINFORCED CONCRETE BEAM (CFRC -0.5% *Vf*)

First Crack Load = 13.50 KN

Ultimate Load = 61.465 KN

Mid Span Deflection at Ultimate Load = 26.71 mm

COIR FIBRE REINFORCED CONCRETE BEAM (CFRC -1% *Vf*)

First Crack Load = 12.00 KN

Ultimate Load = 60.61 KN

Mid Span Deflection at Ultimate Load = 25.62 mm

COIR FIBRE REINFORCED CONCRETE BEAM (CFRC -1.5% *Vf*)

First Crack Load = 8.50 KN

Ultimate Load = 48.018 KN

Mid Span Deflection at Ultimate Load = 20.15 mm

DISCUSSIONS

SLUMP TEST

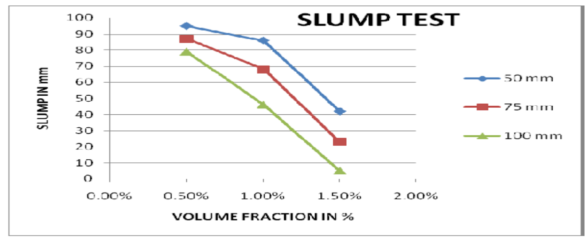

Fig.2 Volume fraction Vs Slump

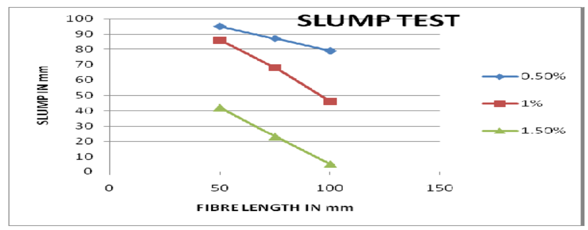

Fig.3 Fibre Length Vs Slump

VEE-BEE TEST

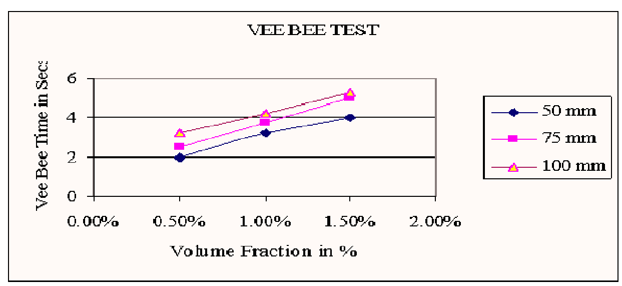

Fig.4 Volume Fraction Vs Vee bee time

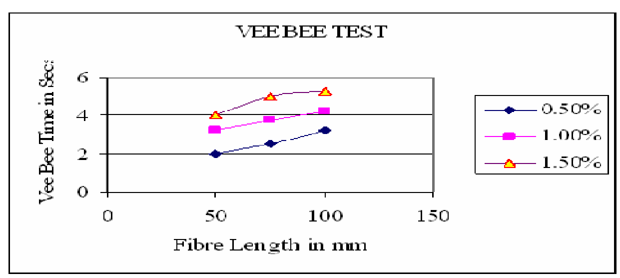

Fig.5. Fibre Length Vs Vee bee time

MECHANICAL STRENGTH STUDIES

COMPRESSIVE STRENGTH

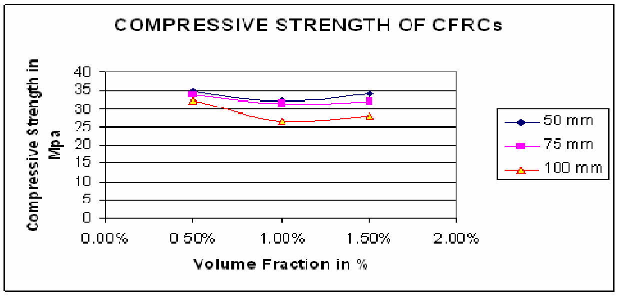

Fig.6 Volume fraction Vs Compressive strength

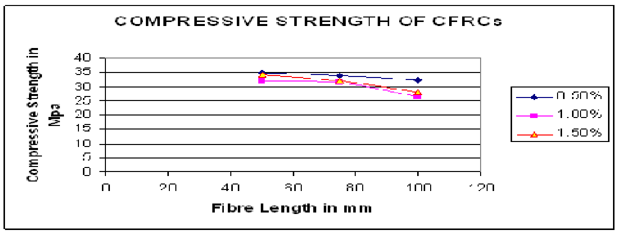

Fig.7 Fibre Length Vs Compressive strength

SPLIT TENSILE STRENGTH

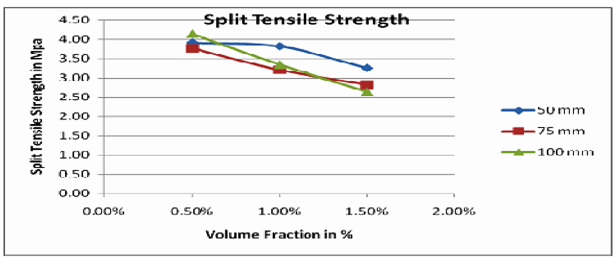

Fig.8 Volume Fraction Vs Split Tensile strength

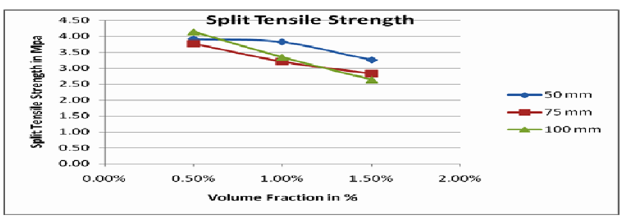

Fig.9 Fibre Length Vs Split Tensile strength

FLEXURAL STRENGTH

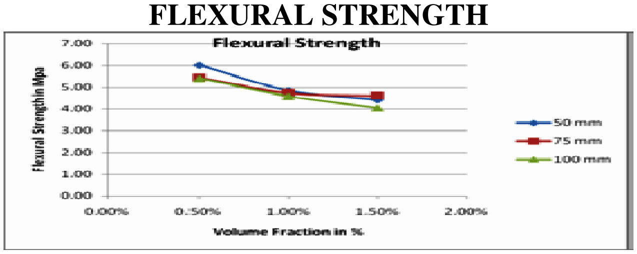

Fig.10 Volume Fraction Vs Flexural strength

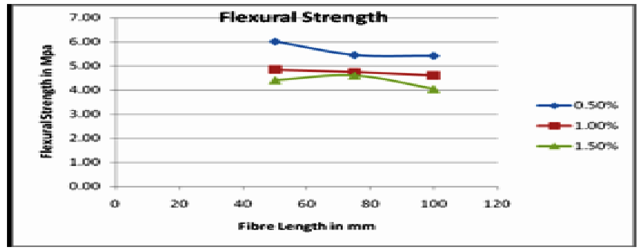

Fig.11 Fibre Length Vs Flexural strength

ULTRASONIC PULSE VELOCITY

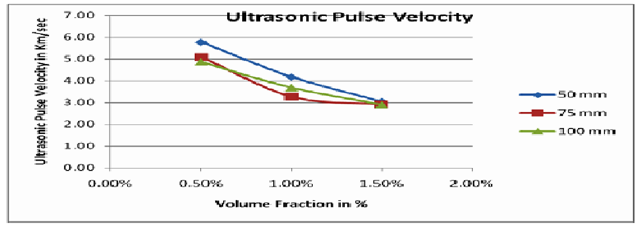

Fig.12 Volume Fraction Vs Ultrasonic Pulse Velocity

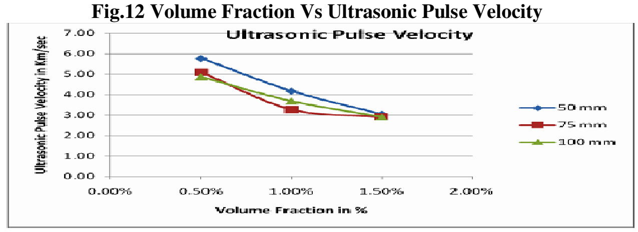

Fig.13 Fibre Length Vs Ultrasonic Pulse Velocity

IV. CONCLUSIONS

Extensive experimental investigations were carried out to study mechanical properties and flexural behavior of Coir fibre reinforcement system. From the study, the following conclusions are drawn.

1) Increase in fibre lengths and volume fractions decreased the workability of concrete mixtures. Especially, workability of coir fibre reinforced concrete mixture dramatically decreases for fibres of length 100 mm and volume fraction of 1.50 %.
2) Unit weight of concrete increases with increase in fibre content.
3) Coir fibre in concrete increases the compressive strength of concrete by about 11-23%.
4) Coir fibre in concrete significantly increases the split tensile and flexural strength of concrete. Split tensile strength of CFRCs are higher about 2- 60% than the control mixture and flexural strengths of CFRCs are 2-39% higher than control mixture.

5) Ultrasonic pulse velocity of CRFCs decreased with increase in fiber content.
6) The ultimate load carrying capacity of Coir fibre reinforced concrete beam are higher than that of controlled concrete beams up to 1% *Vf* whereas that for CFRC beam with1.5% *Vf* is 5.64% less than the controlled reinforced concrete beam.
7) The coir fibre reinforcement proved its capacity as a crack arrester.
8) Addition of fibres reduces the crack widths at service load in the CFRCs as compared to Controlled reinforced concrete beams. CFRCs exhibit fine cracks at ultimate load.
9) The presence of coir fibre in reinforced concrete improves the ductility performance of concrete because of higher bond and anchorage. The ductility indexes of the CFRCs are higher than that of controlled reinforced concrete beam. Increase in *Vf* increases ductility of the reinforced concrete.
10) The stiffness of CFRCs decreases as the fibre volume (*Vf*) increases.
11) From the above said conclusions it is clear that the presence of Coir fibre in concrete significantly improves the ultimate load carrying capacity and ductility of the beams.

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