A Critical Study of Composite Fibre Reinforced Concrete (CFRC) with the Partial Replacement of Cement by FlyAsh

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Abstract—Concrete is a most versatile material it can be used in typical environmental condition like extreme cold & hot weather, under any chemically surcharged and atomic reactor. Concrete possess very good compressive strength but have very low tensile strength, that cannot be neglected also limited ductility and little resistance to cracking. Internal microcracking is inherently present in concrete and the poor tensile strength of concrete is due to propagation of these microcracks and that leads to brittle fracture of concrete. In a Composite Fiber Reinforced Concrete (CFRC), two or more different types of fibers are rationally combined and added to the concrete produce a composite material that derives benefits from each of the individual fibers and show evidence of a synergistic response. The foremost aim of the present experimental investigation is to use different fractions of coconut coir and galvanized steel fibers to produce HFRC and thus to evaluate its performance under compression and flexure strength. Samples were prepared with 10 % replacement of ordinary Portland cement with fly ash and various proportions of these two fibers. The amount of fiber is kept upto 3% by the weight of cement. Six samples are prepared with the ratio of S0C0, S3C0, S2C1, S1.5C1.5, S1C2, & S0C3. The strength of each specimen is investigated to determine the optimum result of sample.

Key words: CFRC, FlyAsh

I. INTRODUCTION

Concrete is a mixture of binding material (cement), fine aggregate, coarse aggregate and water. Concrete is hard and strong like stone, this is caused by the chemically reaction take place between water and cement. The greatest advantage of concrete is its most versatile use in construction industry. Concrete is the material which can be mould in any shape and fit to cast from ordinary rectangular or circular structure to dome or hemispherical shape. The strength of concrete continuously increases with age up to a limit and it has minimum maintenance during the service period of structure as compare to other construction materials like steel, wood etc. But concrete is a brittle material and weak in tension therefore forming crack easily. For these reason reinforcement is required to strengthen and durability. To achieve objective concrete can be hybridized with fibre. Composite fibre reinforced concrete is an attempt for enhancing the inherent property of concrete to make it more valuable.. M30 grade concrete is prepared, Six samples are made with the fraction of steel is 3%, 2%, 1.5%, 1%, & 0% and respectively coconut coir in the same sample is 0%, 1%,2%, 1.5% & 3%, combined fraction of fibre in concrete is kept 3% by the weight of cement. Total 36 cube specimens and 18 beam specimens are prepared and tested respectively for compression and flexural strength.

II. METHODOLOGY

A. Introduction

The whole experimental methodology is composition of various stages. For the investigation of Hybrid Fibre Reinforced Concrete specimens are prepared with hybridization of two different kinds of fibres. During the execution of project, our work will pass through many stages so the whole methodology can be divided in following major stage.

- Concrete mix design
- Preparation of fresh concrete
- Casting of specimen
- Curing of specimen
- Testing and analysis

B. Concrete Mix Design

Mix design principle prescribed as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. So the first object of mix design to achieves the stipulated minimum compressive strength and durability. The second object is to make the concrete in economical manner. Trial mixes were prepared according to IS code method specified in IS: 10262 1982.

Ingredients	Water	Cement	FA	CA
Kg/m^3	189	450	545	1188
Simple ratio	0.42	1	1.22	2.64

Table 1: Ingredients of Concrete

1) Calculation for Quantity of Fibre:

In the following table quantity of fibre is determined by the weight of cement, Quantity of fibre is calculated for one cubic meter concrete given in following table

Sample	Ratio	For one cubic meter of concrete	
		Steel fibre (Kg)	Coconut coir fibre(Kg)
Sample I	S0C0	0	0
Sample II	S3C0	13.5	0
Sample III	S2C1	9	4.5
Sample IV	S1.5C1.5	6.75	6.75
Sample V	S1C2	4.5	9
Sample VI	S0C3	0	13.5

Table 2: Quantity of fibre

C. Preparation of Fresh Concrete

M30 grade of Concrete is manufactured in laboratory by specified method in IS: 10262-1982 and mentioned above. The ingredient of concrete is cement (OPC), coarse aggregate (C.A), Fine aggregate (F.A), galvanized steel fibre, coconut coir and water. Five different proportion of steel and coir fibre were tried for casting different types of

specimen. During the mixing of hybrid fibre concrete especially in coconut coir they lumps up and grouped together, assemblage of fibre creates void and decrease the efficiency harden concrete. It must be very careful at time of blending of fibres.

1) Preparation of sample

Six samples of different fibre fraction were prepared in each sample 10% cement is replaced by flyash. Samples are S0C0, S3C0, S2C1, S1.5C1.5, S1C2, & S0C3. The number indicates the percentage of fibre. Steel fibres are chopped in the length 40 mm and diameter is 0.5mm. aspect ratio is maintained at 80.The coir fibre has varying diameter from 0.1mm to 0.45mm and the aspect ratio of coir fibre is 100.

2) Preparation of mould and casting of specimen

- Cube mould of size 150mmX150mmX150mm
- Beam mould of size 100mmX100mmX500mm.

Cast iron mould of cube and beam is keep ready before filling with concrete; all bolts are tighten, clean inside mould properly and apply oil inside the plate. In the case of cube casting concrete is filled in half of the mould and vibrate for 30 second then fill the mould completely and vibrate for 60 second and finish the top surface of mould with trowel. For beam concrete is filled in two layers and each layer compacted by vibration 30 second & 60 second respectively and top finish the surface of concrete with trowel and moulds are kept in normal room temperature. There are six samples are prepared with different fraction of fibres. Each sample has six cube and three beam specimen. Total 36 number of cube and 15 number of beam specimens are prepared.

Fig. 1: Preparation of moulds

Fig. 2: Concrete filled mould

D. Curing of specimens

After casting of concrete specimens it is kept 24 hour in room temperature between 24^0C - 30^0C for set initially and then kept in water tank for curing. The age of curing for three cubes of each sample is 7 days and other three cubes are cured for 28 days. All three beam of each sample is cured for 28 days.

Fig. 3: Curing of specimens in tank

E. Testing of Concrete specimen

Following tests are conducted on harden concrete specimens.

- Compressive strength
- Flexural strength

1) Compressive Strength

This test is conducted for the cube after the completion of curing age cubes are taken out from the curing tank and wipe the water with dry cloth. Take the weight of specimen to determining the density of sample cube. Now keeps the specimen in the compression testing machine or universal testing machine. Measure the dimension of load bearing area. Load is applied gradually till the specimen fails to take further load and note down the maximum load taken up by the cube. Similarly other specimens are tested and load is taken down. Compressive Stress is calculated by load divided by load bearing area, similarly compressive stress is calculated for each specimen and average value is determined. Compressive strength is denoted by Greek letter sigma (σ).

Compressive strength (σ) =P/A

P = maximum applied load

A = bearing surface area

Fig. 4: Preparing for compression test.

Fig. 5: Specimen failed under load

F. Flexural strength

This test is conducted for beam after the age of 28 days of curing. Beams are taken out from the water tank and wiped it with dry cloth. Dimension of beam is measured and marked at 50mm from edge and marked centre is also marked in the beam. Beam is prepared for testing it kept in simply supported condition and load is applied through roller mounted at the centre of beam. The rate of loading is 18Kg/min, the load is increased until the specimen fails and maximum load applied to the specimen during the test is recorded. Appearance of fracture on the face of beam is the sign of failure. The flexure strength of the specimen is expressed in the term of modulus of rupture (f_b).

$$f_b = P*L/b*d^2$$

Fig. 6: Marking of beam

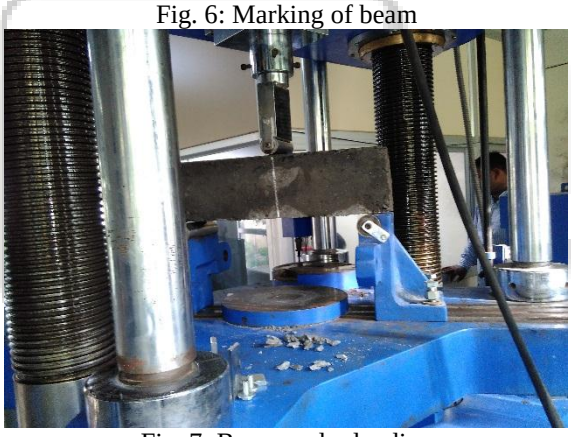

Fig. 7: Beam under loading

III. Result Analysis and Discussion

The experimental investigation has done by testing of cubes and beams. Six different samples are prepared in laboratory, each sample has six specimens of cube and three specimens of beam are prepared. Six samples have different fibre content but each sample replace 10% cement by flyash. Before going for the compression and flexural strength of specimens are tested for non-destructive test ultra-sonic pulse velocity and travelling velocity of pulse generated by electronics circuit through concrete is determined for each cube and beam. Then out of these six specimens of each sample, three are tested for 7 days compressive strength of cube and 28 days compressive and flexural strength of cube and beam respectively is determined.

A. Testing of Specimen

Total 36 numbers of cubes and 18 numbers of beams are casted for the experimental analysis of result. There are two type of specimen are prepared which undergo two different tests. Tests are conducted in two different period of time. At the age of seven days of curing, three cubes specimen of each sample are taken out from curing tank and compression test is conducted. All six samples undergo compression test at the age of 7 days and readings are recorded. Remaining specimens are kept in curing for 28 days, compression test of cubes and flexural strength test of beams are conducted to determining compressive strength and modulus of rupture respectively. Test sequence is similar for all the six samples, results are carefully recorded for each specimen and tabulated.

Sample	Specification	Mean Compressive strength (N/mm^2)		Mean Flexure Strength (N/mm^2)
		7 days	28 days	
Sample I	Fly ash(FA) 10%	23.28	35.49	6.24
Sample II	10% FA+S3C0	25.64	39.98	6.56
Sample III	10% FA +S2C1	26.42	41.22	7.24
Sample IV	10% FA +S1.5C1.5	24.90	37.08	6.58
Sample V	10% FA +S1C2	22.13	32.17	5.8
Sample VI	10% FA +S0C3	17.5	27.76	5.04

Table 1: Experimental result of specimens

B. Comparison of Results

Results are comparing to determine the optimum fraction of fibre in sample. Results are comparing as per testing of specimen compressive strength of each specimen for seven days and 28 days is compared and optimum result among the sample is emphasized. Similarly UPV test results are compared among the sample and modulus of rupture of each sample at the age of 28 days and results are compared among all samples. The optimum value of each sample is accentuated.

1) Comparison for Compressive Strength

It is observed that from the result of specimens of each sample the compressive strength of cube at the age of 28 days is increases with increasing in steel fibre content on the same time decreases by increasing the coir fibre. The optimum result of compressive strength is found in sample III which has 2% steel fibre content and 1% coconut coir.

Sample	**Sample I**	**Sample II**	**Sample III**	**Sample IV**	**Sample V**	**Sample VI**
Age of 7 days	23.28	25.64	26.42	23.93	22.13	17.50
Age of 28 days	35.49	39.98	41.22	37.08	32.17	27.76
Percentage changes(%) at age of 28 days	-----	+12.65	+16.14	+4.48	-9.35	-21.78

Table 2: Comparison

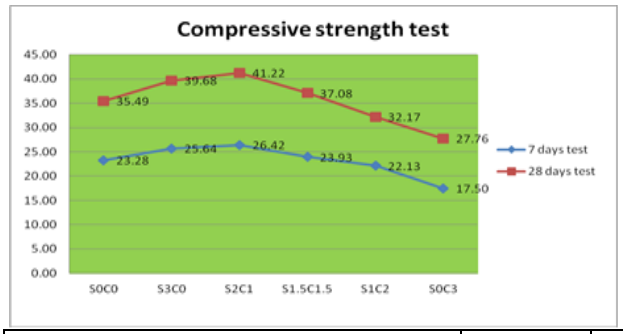

Fig. 8: Comparison for Compressive Strength

2) Comparison Of Flexural Strength Of Samples

It is observed from the below table the flexural strength of a beam is maximum in sample IV which has fibre composition is 1.5% steel and 1.5% coir fibre. There was 16.02% increment as compare to non fibre concrete beam. It also found in result analysis the flexural strength increases upto 1.5% increment in coir fibre further increment in coir fibre start decreases in flexural strength.

Samples	Sample I	Sample II	Sample III	Sample IV	Sample V	Sample VI
Modulus of rupture of beam (N/mm^2)	6.24	6.56	7.42	6.58	5.8	5.04
Percentage increase	----	+5.12	+18.91	+5.44	-7.05	-19.4

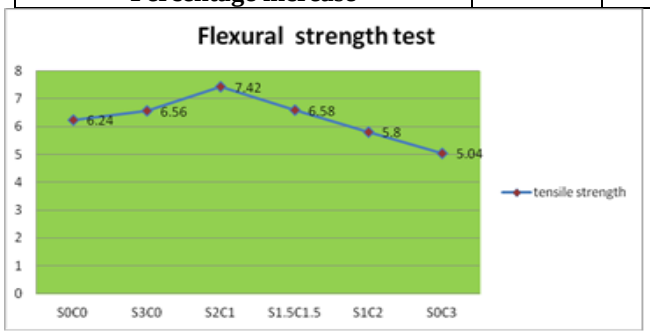

Fig. 9: Flexural Strength

Two other samples, S3C0 & S1.5C1.5 also shows the growth in flexural strength as compare to S0C0 this increment is 5.12% & 5.44% respectively. But further increment in coir fibre diminishes the flexural strength.

3) Comparison between flexural and compressive strength

The relation between flexural strength and compressive strength is established. Representation of graph shows straight line relationship between the compression and flexural strength. The sample has lower compressive strength also shows lower flexural strength and increases with the increasing the corresponding value.

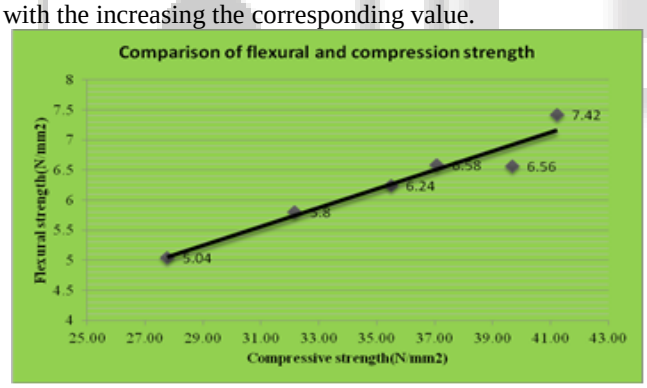

Fig. 9: Flexural Strength & Compressive Strength

IV. Conclusion

Experimental results revealed some significant outcomes, the compressive strength of the sample III S2C1 which has 2% steel fibre and 1% coir fibre content are mixed is found optimum result. The compressive strength of S2C1 is found 16.14% greater than sample without fibre S0C0. Inclusion of 1% coir fibre gives the good result but by increasing the coir fibre more than 1%, decreases the compressive strength and least compressive strength is found at the sample VI which contains maximum 3% coir fibre and 0% steel fibre. Only steel fibre also gives good result in compression. The sample contains 3% steel fibre has 12.65% greater compressive strength than sample S0C0.

In the case of flexural strength there is found sample III S2C1 contains 2% steel fibre and 1% coir fibre has 18.91% greater flexural strength than sample S0C0.

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