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A Comparative Study of Hybrid Fibre Reinforced Concrete With Plain Cement Concrete

KEYWORDS: Compressive strength, Split tensile strength, flexural strength, Workability.

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ABSTRACT *The use of two or more types of fibers in a suitable combination may potentially improve the overall properties of concrete and also result in performance concrete.*

The combining of fibers, often called hybridization, is investigated in this paper for a M25 grade concrete. Control and two-fiber hybrid composites were cast using different fiber proportions of steel and coconut coir.

Compressive test, split tensile strength and flexural strength were performed and results were extensively analyzed to associate with above fiber combinations.

Based on experimental studies, the paper identifies fiber combinations that demonstrate maximum compressive, split tensile strength and flexural strength of concrete

I. INTRODUCTION

Concrete is characterized by quasi-brittle failure, the nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibers (steel, glass, synthetic and natural) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc (3, 4). Fiber reinforced concrete (FRC) is a fiber reinforcing cementitious concrete composite, and by adding discrete short fibers randomly in concrete it exhibits many substantially improved engineering properties in compressive strength, tensile strength, flexural strength etc. The fibers are able to prevent surface cracking through bridging action leading to an increased impact resistance of the concrete. The combination of two or more different types of fibres (different fibre types and/or geometries) is becoming more common, with the aim of optimizing overall system behaviour. The intent is that the performance of these hybrid systems would exceed that induced by each fibre type alone. That is, there would be a synergy. Vikrant S. Vairagade et al classified these synergies into three groups, depending on the mechanisms involved:

1. Hybrids based on the fibre constitutive response, in which one fibre is stronger and stiffer and provides strength, while the other is more ductile and provides toughness at high strains [13].

2. Hybrids based on fibre dimensions, where one fibre is very small and provides microcrack control at early stages of loading; the other fibre is larger, to provide a bridging mechanism across macrocracks.

3. Hybrids based on fibre function, where one type of fibre provides strength or toughness in the hardened composite, while the second type provides fresh mix properties suitable for processing.

The usefulness of fiber reinforced concrete in various Civil Engineering applications is thus indisputable. Hence this study explores the feasibility of hybrid fiber reinforcement; aim is to do parametric study on compressive strength, flexural strength, tensile strength study etc. with given grade of concrete, proportions and percentage of steel.

II. EXPERIMENTAL PROGRAMME

MATERIAL USED

In this experimental study, Cement, sand, coarse aggregate, water, steel fibers and coconut fibres were used.

Cement: Ordinary Portland cement of 53 grades was used in this experimentation conforming to I.S-12269: 1987

Coarse aggregates: Locally available, maximum size 20 mm, specific gravity 2.79

Sand: Locally available sand zone I with specific gravity 2.28, water absorption 2% and fineness modulus 2.92, conforming to I.S. – 383-1970.

Water: Potable water was used for the experimentation.

Steel Fibers: - In this experimentation, Hook end Steel fibers (L=30 mm, dia=0.5 mm) were used.

Coconut fibre:

Coconut fibres were collected from Salem shop that came from Salem.

It was obtained from oil extraction in the factory from the outer periphery of the coconut fruit.

The shell were than washed properly and air dried for five days and ambient temperature and later graded in accordance with the ASTM C330 (2009).

Fibres were shopped with sharp scissors maintaining a length from 15 to 35mm. shopped fibres were oven dried

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at 80°C for 5 hours and used desiccators for cooling (6).

Shopped fibres were used to determine the length, diameter, thickness, natural humidity, water absorption capacity and density of fibres (5).

Different proportions of steel and coconut fibers are shown below table

Table 1 Different proportions of fibers used:

Notation	Steel Fibers by Volume of Concrete (%)	Coconut Fibers by Weight of Cement (%)
HFRC SO.5C0.5	0.5	0.5
HFRC SO.6C0.4	0.6	0.4
HFRC SO.7C0.3	0.7	0.3
HFRC SO.8C0.2	0.8	0.2

Table 2: Concrete mix proportions

Concrete for M25 grade were prepared as per I.S 10262:2009 with w/c 0.44 (1, 2). Mix proportion for M25 grade concrete for tested material as follows:

Material	Quantity
Cement	428.01 Kg /m^3
Sand	516.30 Kg /m^3
Coarse Aggregates	1193.60 Kg /m^3
Water	188.32 Kg /m^3
Slump	75-100 mm

WORKABILITY

A shortcoming of using fibres in concrete is reduction in workability. Workability of FRC is affected by fibre aspect ratio and volume fraction as well the workability of plain concrete (13).

As fibre content increases, workability decreases. Most researchers limit volume of fibres to 4.0% and aspect ratio to 100 to avoid unworkable mixes. In addition, some researchers have limited the fibre reinforcement index [volume of fibres as % ×aspect ratio] to 1.5 for the same reason. To overcome the workability problems associated with FRC, modification of concrete mix design is recommended. Such modifications can include the use of additives.

III. EXPERIMENTAL METHODOLOGY

3.1 Compressive Strength Test:

For compressive strength test, both cube specimens of dimensions 150 x 150 x 150 mm were cast for M25 grade of concrete. The moulds were filled with 0% HFRC SO.5 C0.5, HFRC SO.6 C0.4, HFRC SO.7 C0.3 and HFRC SO.8 C0.2 fibers. Vibration was given to the moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where in they were allowed to cure for 7 days, 14 days and 28 days. After 7, 14 and 28 days curing, these cubes were tested on digital compression testing machine as per I.S. 516-1959. The failure load was noted. In each category, three cubes were tested and their average value is reported (14, 15).

The compressive strength was calculated as follows: Compressive strength (MPa) = Failure load / cross sectional area.

3.2 Tensile strength test:

For tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 7, 14 and 28 days. These specimens were tested under compression testing machine. In each category, three cylinders were tested and their average value is reported. Tensile strength was calculated as follows as split tensile strength:

Tensile strength (MPa) = $2P / \pi DL$,

Where, P = failure load,

D = diameter of cylinder,

L = length of cylinder.

3.3 Flexural Strength Test

The flexural strength is done in prism specimens of 150x150x750 mm size. The testing machine may be of any reliable type of sufficient capacity for the tests and capable of applying the load at the given specified rate.

The permissible errors shall be not greater than ± 0.5 percent of the applied load where a high degree of accuracy is required and not greater than ± 1.5 percent of the applied load for commercial type of use (7, 12).

The bed of the testing machine shall be provided with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from centre to centre is 60 cm for 15.0 cm specimens or 40 cm for 10.0 cm specimens.

The load shall be applied through two similar rollers mounted at the third points of the supporting span that is, spaced at 20 or 13.3 cm centre to centre.

The load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to torsional stresses or restraints. The load shall be applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 7 kg/sq cm/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 (8,11).

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, which, if 'a' equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/sq cm as follows:

Modulus of rupture, $f_b = fxl/bxd^2$

IV. EXPERIMENTAL RESULTS

4.1 Compressive Strength

Results of Compressive strength for M-25 grade of concrete on cube specimen with 0%, HFRC SO.5 C0.5, HFRC

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SO.6 C0.4, HFRC SO.7 C0.3 and HFRC SO.8 C0.2 fibers are shown in table and graph below:

Table 3: Results of Compressive strength using cubes specimen

Sr. No.	Specimen	No. of Days	Compressive Strength
1	Cubes for Conventional Concrete	7	20.20 N/mm^2
		14	23.25 N/mm^2
		28	27.03 N/mm^2
2	Cubes for HFRC S0.8P0.2	7	31.25 N/mm^2
		14	40.10 N/mm^2
		28	47.52 N/mm^2
3	Cubes for HFRC S0.7P0.3	7	28.34 N/mm^2
		14	37.50 N/mm^2
		28	43.60 N/mm^2
4	Cubes for HFRC S0.6P0.4	7	24.56 N/mm^2
		14	30.96 N/mm^2
		28	39.08 N/mm^2
5	Cubes for HFRC S0.5P0.5	7	22.82 N/mm^2
		14	28.19 N/mm^2
		28	35.00 N/mm^2

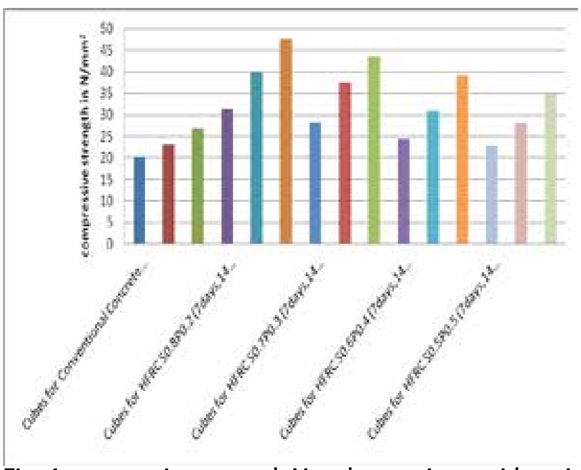

Fig. 1 compressive strength Vs cube specimen with various percentages

4.2 Tensile strength

Results of splitting tensile strength for M-25 grade of concrete with 0% %, HFRC SO.5P0.5, HFRC SO.6P0.4, HFRC SO.7P0.3 and HFRC SO.8P0.2 fibers are shown in table3 and graph below:

Table 4: Results of splitting tensile strength using cylinder

S. No.	Specimen	No. of Days	Splitting tensile Strength
1	Cubes for Conventional Concrete	7	4.3 N/mm^2
		14	4.58 N/mm^2
		28	5.11 N/mm^2
2	Cubes for HFRC S0.8P0.2	7	5.29 N/mm^2
		14	7.17 N/mm^2
		28	9.68 N/mm^2
3	Cubes for HFRC S0.7P0.3	7	4.92 N/mm^2
		14	6.43 N/mm^2
		28	9.23 N/mm^2
4	Cubes for HFRC S0.6P0.4	7	4.78 N/mm^2
		14	5.92 N/mm^2
		28	8.86 N/mm^2
5	Cubes for HFRC S0.5P0.5	7	4.62 N/mm^2
		14	5.18 N/mm^2
		28	8.12 N/mm^2

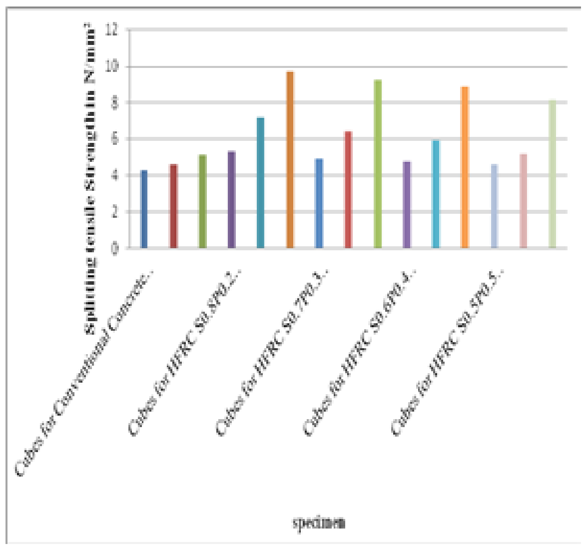

Fig. 2 splitting tensile strength Vs cube specimen with various percentages

4.3 Flexural strength

Results of flexural strength for M-25 grade of concrete with 0%, HFRC SO.5 C0.5, HFRC SO.6 C0.4, HFRC SO.7 C0.3 and HFRC SO.8 C0.2 fibers are shown in table3 and graph below:

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Table 5: Results of flexural strength using cylinder

S. No.	Specimen	No. of Days	Flexural Strength
1	Cubes for Conventional Concrete	7	5.96 N/mm^2
		14	8.04 N/mm^2
		28	7.47 N/mm^2
2	Cubes for HFRC S0.8P0.2	7	7.29 N/mm^2
		14	9.17 N/mm^2
		28	10.68 N/mm^2
3	Cubes for HFRC S0.7P0.3	7	6.92 N/mm^2
		14	7.43 N/mm^2
		28	9.23 N/mm^2
4	Cubes for HFRC S0.6P0.4	7	4.78 N/mm^2
		14	5.92 N/mm^2
		28	8.86 N/mm^2
5	Cubes for HFRC S0.5P0.5	7	4.5 N/mm^2
		14	5.2 N/mm^2
		28	8.1 N/mm^2

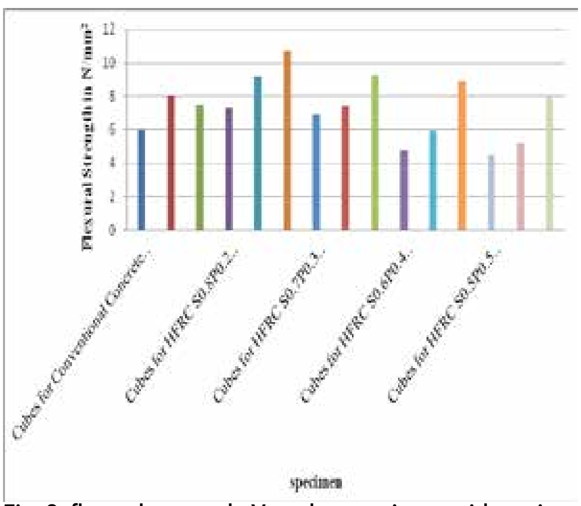

Fig 3 flexural strength Vs cube specimen with various percentages

V CONCLUSSION

The study on the effect of hybrid fibers with different proportions can still be a promising work as there is always a need to overcome the problem of brittleness of concrete (9,10).

The following conclusions could be drawn from the present investigation:

Compressive Strength

We conclude that the compressive strength between S0.6 C0.4 and S0.7 C0.3 is increase high as compare to other interval.

· S0.8 C0.2 Gives High Strength as Compare to other Combination

Split Tensile Strength

· S0.8 C0.2 Gives High Strength as Compare to other Combination

Flexural strength

· S0.8 C0.2 Gives High Strength as Compare to other Combination

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