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Experimental Investigation on Hybrid Fiber Reinforced Concrete

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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 polypropylene. Compressive test and split tensile strength were performed and results were extensively analyzed to associated with above fiber combinations. Based on experimental studies, the paper identifies fiber combinations that demonstrate maximum compressive and split tensile strength of concrete.

Keywords **- Compressive strength, Compaction factor, hybrid composites, Split tensile strength, Workability.**

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. Fiber reinforced concrete (FRC) is a fiver reinforcing cementitious concrete composite, and by adding discrete short fibers randomly in concrete it exihibits many sustantially 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. Banthia and Gupta [2004] 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 [Banthia and Gupta 2004].
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 hybridl 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 and steel fibers were used.

Cement: Ordinary Portland cement of 53 grade 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.

Chemical Admixture Type: Super Plasticizer

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

Polypropylene Fibers: Fibrillated 20 mm cut length fibers were used.

Different proportions of steel and polypropylene fibers are shown below table

Table 1 Different proportions of fibers used:

Notation	Steel Fibers by Volume of Concrete (%)	Polypropylene Fibers by Weight of Cement (%)
HFRC SO.5P0.5	0.5	0.5
HFRC SO.6P0.4	0.6	0.4
HFRC SO.7P0.3	0.7	0.3
HFRC SO.8P0.2	0.8	0.2

Table 2: *Concrete mix proportions.*

Concrete for M25 grade were prepared as per I.S.10262:2009 with w/c 0.46.

Mix proportion for M25 grade concrete for tested material as follows

Material	*Quantity*
Cement	428.26 Kg/ m^3
Sand	608.3 Kg/ m^3
Coarse Aggregates	1116.56 Kg/ m^3
Water	197 Kg/ m^3
Slump	75-100 mm

III. WORKABILITY:

Slump tests were carried out to determine the workability and consistency of fresh concrete. The efficiency of all fiber reinforcement is dependent upon achievement of a uniform distribution of the fibers in the concrete, their interaction with the cement matrix, and the ability of the concrete to be successfully cast or sprayed. Essentially, each individual fiber needs to be coated with cement paste to provide any benefit in the concrete. Regular users of fiber reinforcement concrete will fully appreciate that adding more fibers into the concrete, particularly of a very small diameter, results in a greater negative effect on workability and the necessity for mix design changes. The slump changed due to the different type of fiber content and form. The reason of lower slump is that adding two different fibers can form a network structure in concrete, which restrain mixture from segregation and flow. Due to the high content and large surface area of fibers, fibers are sure to absorb more cement paste to wrap around and the increase of the viscosity of mixture makes the slump loss (Chen and Liu, 2000)

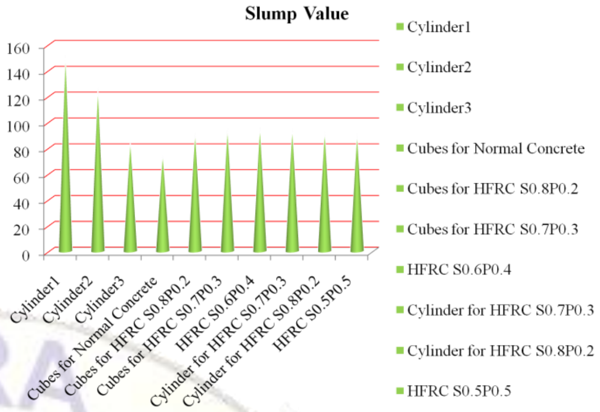

Figure 1: Workability of HRC using slump test

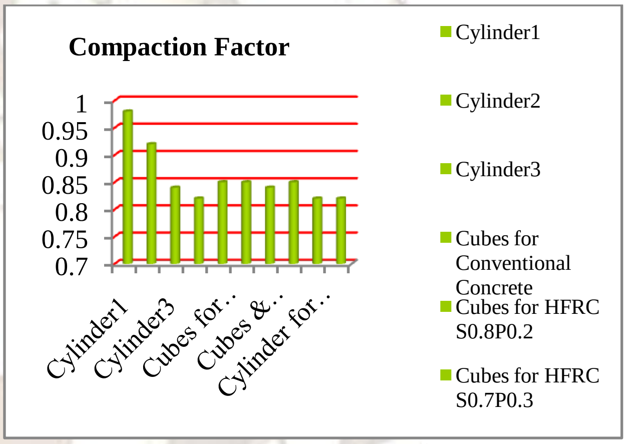

Figure 2: Workability of HRC by Compaction factor

IV. EXPERIMENTAL METHODOLOGY

4.1 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.5P0.5, HFRC SO.6P0.4, HFRC SO.7P0.3 and HFRC SO.8P0.2 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 cube 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.

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

4.2 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 / π DL,
Where, P = failure load, D = diameter of cylinder,
L = length of cylinder.

V. EXPERIMENTAL RESULTS

5.1 Compressive Strength

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

Table2: 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	40.40 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* N/mm^2

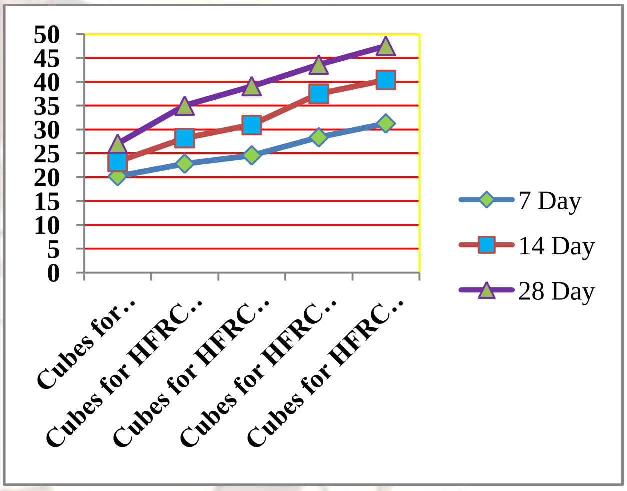

Figure 3: Graphical Results of Compression Test

Figure.3 indicates the comparison of result of compressive strength using cube specimen of M25 grade of concrete with and without fibers.

5.2 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:

Table3: Results of splitting tensile strength using cylinder.

Sr. No.	Specimen	No. of Days	Splitting tensile Strength
1	Conventional Concrete	7	4.3 N/mm^2
		14	4.58 N/mm^2

		28	5.11 N/mm^2
2	HFRC S0.8P0.2	7	5.29 N/mm^2
		14	7.17 N/mm^2
		28	9.68 N/mm^2
3	HFRC S0.7P0.3	7	4.92 N/mm^2
		14	6.43 N/mm^2
		28	9.23 N/mm^2
4	HFRC S0.6P0.4	7	4.78 N/mm^2
		14	5.92 N/mm^2
		28	8.86 N/mm^2
5	HFRC S0.5P0.5	7	4.62 N/mm^2
		14	5.18 N/mm^2
		28	8. 12 N/mm^2

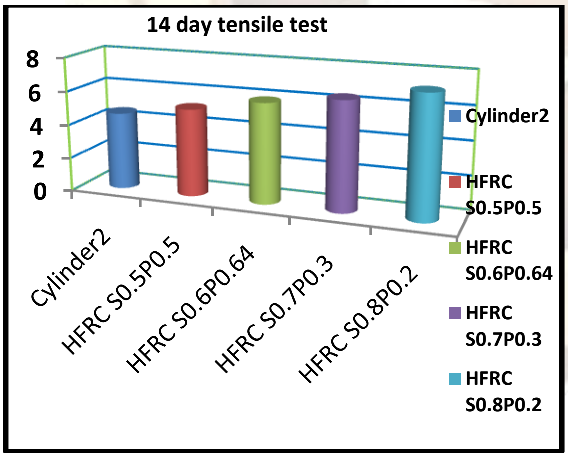

Figure 4: Comparison of Split tensile strength

VI 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.

The following conclusions could be drawn from the present investigation-

1. Compressive Strength

We conclude that the compressive strength between S0.6P0.4 and S0.7P0.3 is increase high as compare to other interval.

- S0.8P0.2 Gives High Strength as Compare to other Combination

2. Split Tensile Strength

- S0.8P0.2 Gives High Strength as Compare to other Combination

3. Slump Value

Increasing the percentage of steel fiber in Hybrid Combination reduces the slump value, to maintain the constant slump we have to increase the superplasticizers dose in concrete.

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