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RESEARCH ARTICLE

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AN EXPERIMENTAL INVESTIGATION ON SIFCON USING HYBRID FIBERS

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ABSTRACT

SIFCON stands for slurry infiltrated fiber concrete (SIFCON).SIFCON is relatively new special type of "High performance fiber reinforced concrete" (HPFRC), is a high strength material first invented by Haynes (1968), further Lankard (1979). SIFCON is new technique to increase the strength of concrete. It has no coarse aggregates but high cementitious content. Generally, fibre-reinforced concrete contains 1-5% of fibres by volume, but SIFCON contains 6-20% of fibres. SIFCON is new material, it has found applications in areas of Precast concrete products, Repair and retrofit of structural components, Explosive resistant structures, Security applications, Pavement and bridge deck overlay and Refractory applications.

In this project work the behaviour of SIFCON by adding 6% of HYBRID fibers with varying proportions is studied.The combination of steel fibers and Polypropylene fibers are used in different percentages to cast the specimens; the experimental study is basically focused to analyze the strength parameters of SIFCON using HYBRID fibers.

The SIFCON is prepared from, the cement and fine aggregate is taken in ratio of 1:1.The fibers are added in 6% by Volume of concrete are Flat Cribbed Steel fibers (FCSF) and Construction Polypropylene fibers (CPPF) with water cement ratio 0.45.This study showed that (5% SF+1% PPF) addition volume shows greater strength in flexure strength test and tensile strength test, (3% SF+3% PPF) addition volume shows greater strength in shear strength test, (4% SF+2% PPF) addition volume shows greater strength in compressive strength test compared to other combination of Hybrid fibers.

The result obtained indicated that different fiber combinationsbehave differently in compressive load, flexural load, tensile load and shear load. Because the bonding strength between the fiber matrix and concrete layer will varies for different combinations of Hybrid fibers.

Keywords: - SIFCON, HPFRC, HYBRID fibers, Slurry, Flat Cribbed Steel fibers, Construction Polypropylene fibers.

1) INTRODUCTION

Concrete is a composite materialcomposed mainly of water, aggregate, and cement. Often, additives and reinforcements (such as rebar) are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily moulded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses.

Fiber reinforced concrete (FRC) is Portland cement concrete or mortar reinforced with more-or less randomly distributed fibers. Many different types of fibers, both man-made and nature have been incorporated into concrete. These include not only steel, but also glass, carbon, and nature fibers. Use of nature fibers in concrete preceded the advent of conventional reinforced concrete in historical content. However, the technical aspect of FRC system remained essentially undeveloped for several centuries.

Over the past 35 years a significant amount of research has been performed in the FRC field. Today many different FRC composites have been commercialized around world.

SIFCON is unique construction material possessing high strength as well as large ductility and far excellent potential for structural applications when accidental (or) abnormal loads are encountered during services SIFCON also exhibit new behavioural phenomenon, that of “Fiber lock” which believed to be responsible for its outstanding stress-strain properties. The matrix in SIFCON has no coarse aggregates, but a high cementitious content. However, it may contain fine (or) coarse sand and additives such as fly ash, micro silica and latex emulsions. The matrix fineness must be designed so as to properly infiltrate the fiber network placed in moulds, since otherwise, large pores may form leading to substantial reduction in properties. A controlled quantity of high range water reducing admixtures (super plasticizer) may be used for improving flowing characteristics of SIFCON. All steel fiber types namely straight, hooked and crimped can be used. The fibers are subjected to frictional and mechanical interlock in addition to the bond with the matrix. The matrix plays the role of transferring the forces between fibers by shear, but also acts as bearing to keep fibers interlock.

EFFECT OF FIBERS IN CONCRETE: The fibers becomes dispersed during the mixing action of concrete, the result is a three dimensional, secondary reinforcement. Fibers are uniformly distributed throughout the concrete in all the directions, and provide effective secondary reinforcement for shrinkage crack control. As the concrete hardens and shrinks, microscopic cracks develop. When these micro cracks intersect a fiber, they are halted and prevented from developing into macro-cracks (visible shrinkage cracks) and further water tightness and durability of the concrete as well. This will also reduce the rate of evaporation and shrinkage and enables the concrete to gain strength without excessive moisture loss.

2) Materials and Methods:

Materials used for the experimentation:

Cement: Ordinary Portland cement of 43 grade was used in this experimentation conforming to IS8112-1989.

Sand: Locally available sand zone-II with specific gravity 2.46, conforming to IS – 383-1970.

Water: Potable water was used for the experimentation.

Flat cribbed steel fibers: 50mm length, 1mm thick and 2mm width, Aspect ratio = 50

Construction Polypropylene fibers :40mm length and 38 microns, Aspect ratio = 1000

Methodology used for the experimentation: The slurry mix investigated in this study is prepared with standard 43 grade Ordinary Portland cement which is conformed to Indian standards. The concrete mixed used for casting the cube, cylinder, beam, L-shape specimen is 1: 1 by weight and a water cement ratio as 0.45.

Tests on hardened concrete at 14 days and 28 days of normal water curing.

The following strength characteristic tests are conducted on hardened concrete.

- For compressive strength test, the cubes of size 150 x 150 x 150 mm were cast and tested under

compression testing machine of 2000 kN capacity as per IS: 516-1959.

- For splitting tensile strength test, the cylinders of 150 mm diameter and length 300 mm were cast and were tested under compression testing machine as per IS: 5816-1999
- For the flexural strength test, beams of dimension 100 x 100 x 500 mm were cast and were tested on an effective span of 400 mm with two-point loading as per IS: 516-1959
- For shear strength test L shaped specimens as shown in fig. 1 were used.

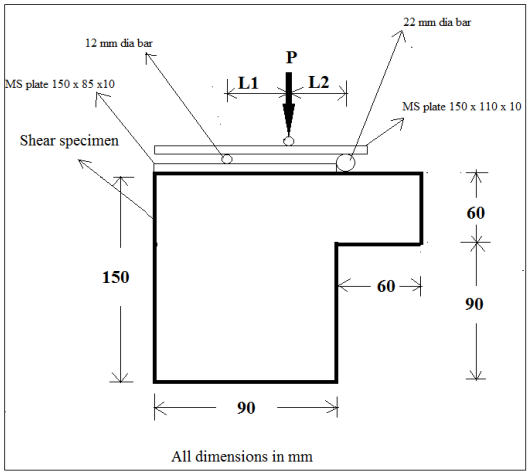

Fig. No. 1: Line diagram of shear test on L shape shear specimen

The specimen was centrally placed on the compression testing machine and load is applied continuously and uniformly. The load is increased until the specimen fails and record the maximum load carried by each specimen during the test. Computation of the shear strength was done as follows. Failure load = WL1/(L1+L2), Shear strength = (Failure load/A) × 1000 Where, W = Load in kN, A = Area of shear surface = 60 x 150 mm^2, L1 = 25mm and L2 = 25mm.

3) **Results and Discussion**

Table 2 and Plate 1 gives the overall results of Compressive strength of SIFCON for 6% of Hybrid fibers. The table also gives the percentage increase of compressive strength of SIFCON with Hybrid fibers as compared to the respective standard mix (Reference mix)

Table 3 and Plate 2 gives the overall results of Flexural strength of SIFCON for 6% of Hybrid fibers. The table also gives the percentage increase of flexural strength of SIFCON with Hybrid fibers as compared to the respective standard mix (Reference mix).

Table 4 and Plate 3 gives the overall results of Tensile strength of SIFCON for 6% of Hybrid fibers. The table also gives the percentage increase of tensile strength of SIFCON with Hybrid fibers as compared to the respective standard mix (Reference mix).

Table 5 and Plate 4 gives the overall results of Shear strength of SIFCON for 6% of Hybrid fibers. The table also gives the percentage increase of shear strength of SIFCON with Hybrid fibers as compared to the respective standard mix (Reference mix).

Table No. 2: Overall results of Compressive strength.

Fiber combination SF + PPF	Compressive strength test results		% increase or decrease in Compressive strength compared to reference mix	
	14 Days	**28 Days**	**14 Days**	**28 Days**
REFERENCE MIX 0%	39.56	42.62	--	--
1% + 5%	26.79	31.37	-32.28	-26.40
2% + 4%	30.09	34.22	-23.94	-19.71
3% + 3%	35.63	37.93	-9.93	-11.00
4% + 2%	**40.12**	**44.21**	**1.42**	**3.73**
5% + 1%	33.32	39.27	-15.77	-7.86

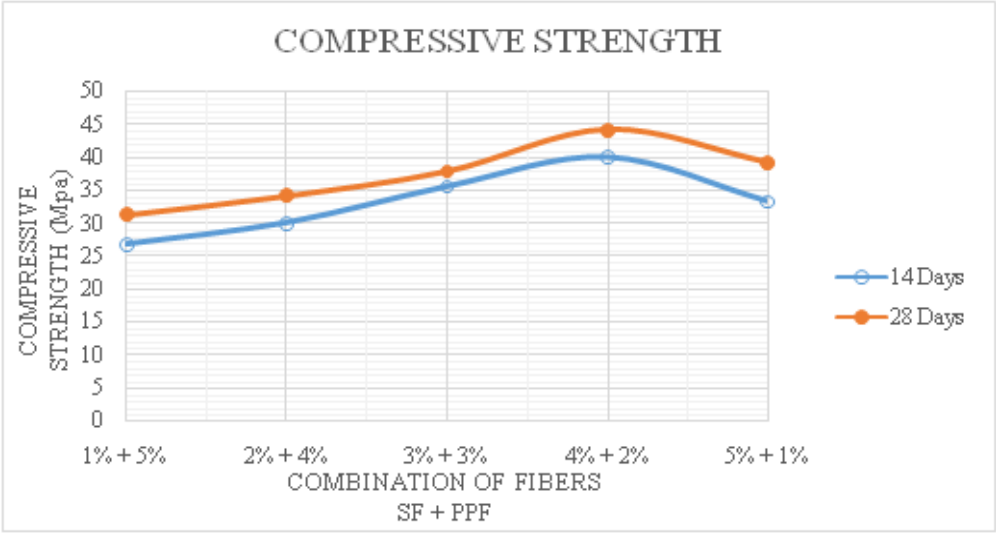

Plate. No. 1: Comparison of results of compressive strength for 14 days and 28 days of curing

Table No. 3: Overall results of flexural strength.

Fiber combination SF + PPF	Flexural strength test results		% increase or decrease in Flexural strength compared to reference mix	
	14 Days	**28 Days**	**14 Days**	**28 Days**
REFERENCE MIX	5.52	6.12	--	--
1% + 5%	6.83	8.28	23.73	35.29
2% + 4%	7.73	8.78	40.04	43.46
3% + 3%	8.11	9.99	46.92	63.24
4% + 2%	8.96	11.27	62.32	84.15
5% + 1%	**10.27**	**11.85**	**86.05**	**93.63**

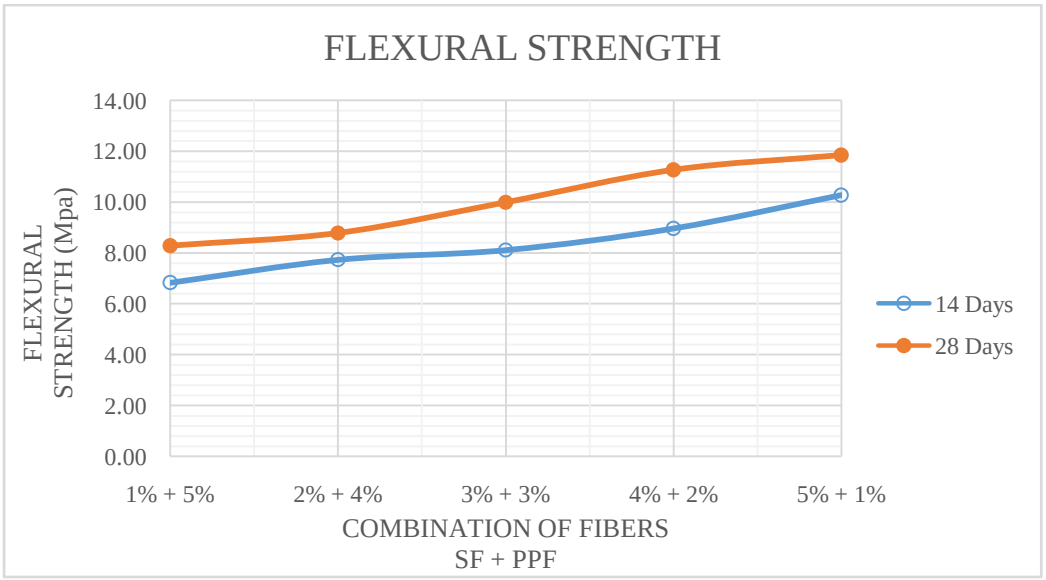

Plate. No. 2: Comparison of results of flexural strength for 14 days and 28 days of curing

Table No. 4: Overall results of tensile strength.

Fiber combination SF + PPF	Tensile strength test results		% increase or decrease in Tensile strength compared to reference mix	
	14 Days	**28 Days**	**14 Days**	**28 Days**
REFERENCE MIX	3.04	4.12	--	--
1% + 5%	2.90	4.43	-4.86	7.52
2% + 4%	3.13	5.28	2.66	28.16
3% + 3%	3.37	5.34	10.65	29.61
4% + 2%	5.16	7.03	69.33	70.63
5% + 1%	**5.54**	**7.65**	**81.88**	**85.68**

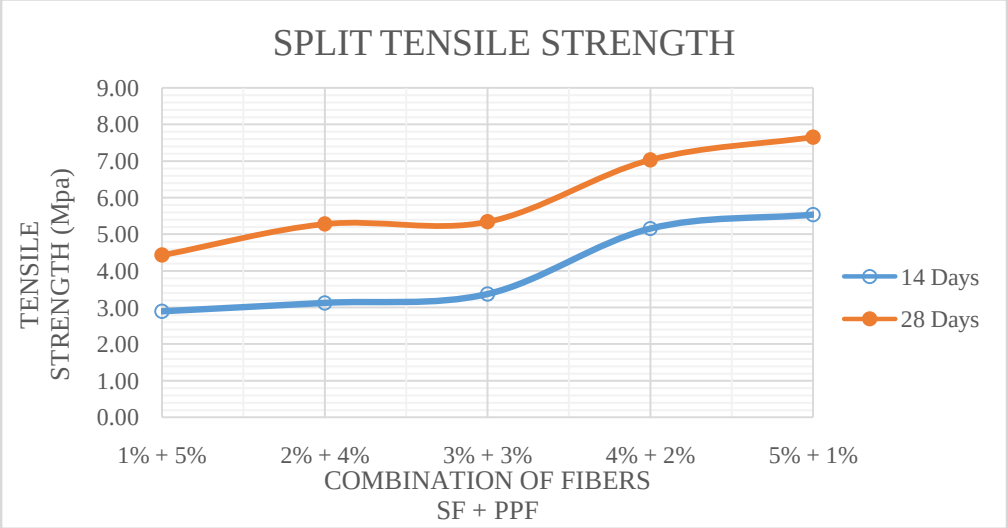

Plate. No. 3: Comparison of results of tensile strength for 14 days and 28 daysof curing

Table No. 5: Overall results of shear strength.

Fiber combination SF + PPF	Shear strength test results		% increase or decrease in Shear strength compared to reference mix	
	14 Days	**28 Days**	**14 Days**	**28 Days**
REFERENCE MIX	9.10	24.31	--	--
1% + 5%	10.27	29.29	12.86	20.49
2% + 4%	11.34	33.62	24.62	38.30
3% + 3%	**13.06**	**37.58**	**43.52**	**54.59**
4% + 2%	10.79	36.11	18.57	48.54
5% + 1%	8.86	32.73	-2.64	34.64

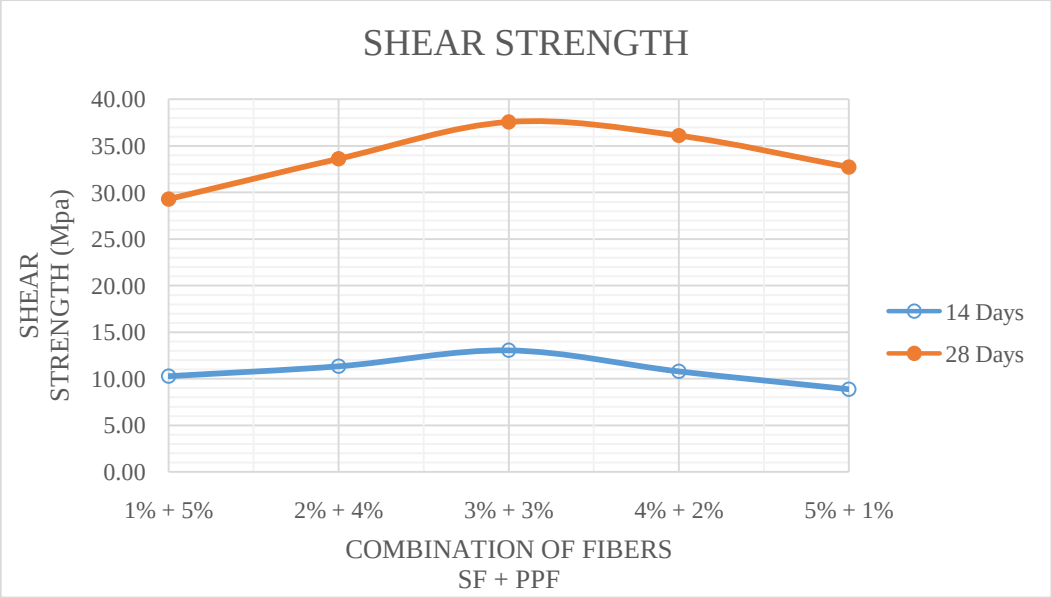

Plate. No. 4: Comparison of results of shear strength for 14 days and 28 days of curing

Discussion:

- It is observed that the compressive strength of SIFCON produced with 6% addition of hybrid fibers (4% SF+2% PPF) will gives optimum result, compare to reference mix addition of 4% SF and 2% PPF and cured for 14 days. The percentage increase in compressive strength is found to be 1.42 with respect to reference mix.

  It is observed that the compressive strength of SIFCON produced with 6% addition of hybrid fibers (4% SF+2% PPF) will gives optimum result, compare to reference mix addition of 4% SF and 2% PPF and cured for 28 days. The percentage increase in compressive strength is found to be 3.73 with respect to reference mix.

  This can be due to the fact that the variation of percentage hybrid fibers behaves differently in compressive load. The bonding strength between different hybrid fiber matrix and concrete layer will varies for different percentage of addition.
- It is observed that the flexural strength of SIFCON produced with 6% addition of hybrid fibers (5% SF+1% PPF) will gives optimum result, compare to reference mix addition of 5% SF and 1% PPF and cured for 14 days. The percentage increase in flexural strength is found to be 86.05 with respect to reference mix.

  It is observed that the flexural strength of SIFCON produced with 6% addition of hybrid fibers (5% SF+1% PPF) will gives optimum result, compare to reference mix addition of 5% SF and 1% PPF and cured for 28 days. The percentage increase in flexural strength is found to be 93.63 with respect to reference mix.

  This can be due to the fact that the variation of percentage hybrid fibers behaves differently in flexural load. The bonding strength between different hybrid fiber matrix and concrete layer will varies for different percentage of addition.
- It is observed that the tensile strength of SIFCON produced with 6% addition of hybrid fibers (5% SF+1% PPF) will gives optimum result, compare to reference mix addition of 5% SF and 1% PPF and cured for 14 days. The percentage increase in tensile strength is found to be 81.88 with respect to reference mix.

  It is observed that the tensile strength of SIFCON produced with 6% addition of hybrid fibers (5% SF+1% PPF) will gives optimum result, compare to reference mix addition of 5% SF and 1% PPF and cured for 28 days. The percentage

increase in tensile strength is found to be 84.32 with respect to reference mix.

This can be due to the fact that the variation of percentage hybrid fibers behaves differently in tensile load. The bonding strength between different hybrid fiber matrix and concrete layer will varies for different percentage of addition.

- It is observed that the shear strength of SIFCON produced with 6% addition of hybrid fibers (3% SF+3% PPF) will gives optimum result, compare to reference mix addition of 3% SF and 3% PPF and cured for 14 days. The percentage increase in shear strength is found to be 43.52 with respect to reference mix.

  It is observed that the shear strength of SIFCON produced with 6% addition of hybrid fibers (3% SF+3% PPF) will gives optimum result, compare to reference mix addition of 3% SF and 3% PPF and cured for 28 days. The percentage increase in shear strength is found to be 54.59 with respect to reference mix.

  This can be due to the fact that the variation of percentage hybrid fibers behaves differently in shear load. The bonding strength between different hybrid fiber matrix and concrete layer will varies for different percentage of addition.

4) **Conclusion:**

The following conclusions may be drawn based on the experimentations conducted on the behaviour of SIFCON produced with Hybrid fibers in varying proportions.

- The conclusion of (4% SF + 2% PPF) addition of fiber to the SIFCON gives higher compressive strength compared to (1% SF + 5% PPF), (2% SF + 4% PPF), (3% SF + 3% PPF), (5% SF + 1% PPF) addition of hybrid fibers.
- The conclusion of (5 % SF + 1% PPF) addition of fiber to the SIFCON gives higher flexural strength compared to (1% SF + 5% PPF), (2% SF + 4% PPF), (3% SF + 3% PPF), (4% SF + 2% PPF) addition of hybrid fibers.
- The conclusion of (5% SF + 1% PPF) addition of fiber to the SIFCON gives higher tensile strength compared to (1% SF + 5% PPF), (2% SF + 4% PPF), (3% SF + 3% PPF), (4% SF + 2% PPF) addition of hybrid fibers.
- The conclusion of (3 % SF + 3% PPF) addition of fiber to the SIFCON gives higher shear strength compared to (1% SF + 5% PPF), (2% SF + 4% PPF), (4% SF + 2% PPF), (5% SF + 1% PPF) addition of hybrid fibers.

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