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An Experimental Investigation on SIFCON Using Mono Fibers

[1]Mr. Vinayaka N.M, [2] Sahana .N .S, [3]Sandeep.S.S, [4]Nagaraju.C, [5]Syed Shahbaz

[1]M. Tech. (Structural Engg.), Assistant Professor, [1, 2,3,4,5] Civil Engineering Department Jain Institute of Technology Davanagere-577005, India

Abstract: **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 the world. However, the technical aspect of FRC system remained essentially undeveloped for several centuries.**

Slurry infiltrated fibrous concrete (SIFCON) was first produced in 1979 in the USA, by incorporating large amounts of steel fiber in moulds to form very dense network of fibers. The network is then infiltrated by fine liquid cement-based slurry. Since it is not possible to use more than 2% of fiber in FRC (fiber reinforced concrete) because of workability and mixing issues, SIFCON is applied to contain fiber amount as high as 12%. Having higher mechanical properties in both strength and durability is one of the advantages of SIFCON in comparison with FRC. In view of the above, the objectives of this study are focused mainly on investigating the strength characteristic properties.

The study has been carried out on fibers having aspect ratio of 50 and The cement-sand slurry used is of the proportion 1:1 with a water cement ratio 0.45. The percentage of fibers (by volume fraction) used in the experimentation is 1% SF, 1%HDPEF & 1%WPF by the volume of concrete.

This study showed that 1% addition steel fiber volume shows greater strength in compressive and flexure strength test. Use of 1% WPF and HDPEF gives optimum result in the shear and tensile strength test respectively.

The result obtained indicated that different fibers behave differently in compressive load, flexural load, and tensile load and shear load. Because the bonding strength between the fiber matrix and concrete layer will varies for different fibers. However the SIFCON made with the highest possible fiber volume fractions shows the best results.

Keywords: **SIFCON, Steel fibers, HDPE fibers, WPF.**

1. INTRODUCTION

Concrete is a composite material composed 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 molded 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 behavioral 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.

2. 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.

3. 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-III with specific gravity 2.18, conforming to IS – 383-1970.

Water : Potable water was used for the experimentation.

Steel fiber : 50mm length, 1mm thick and 2mm width, Aspect ratio = 50

HDPE fiber : 50mm length and 4mm width, Aspect ratio = 50

WP fiber : 50mm length and 4mm width, Aspect ratio = 50

4. EXPERIMENTAL STUDY AND RESULTS

The slurry mix investigated in this study is prepared with standard 43 grade 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.

The 14 days and 28 days hardened concrete was tested for Compressive Strength, Tensile Strength, Flexural Strength and Shear Strength Parameters and revealing the following tables and graphs gives the overall results of compressive strength, tensile strength, flexural strength, and shear strength of concrete by 1% addition of reference mix, SF, HDPEF and WPF. Also it gives the percentage increase or decrease of compressive strength, tensile strength, flexural strength and shear strength with respect to reference mix.

Table 1 Overall results of compressive strength

Type of Fibers	Compressive strength test results		% increase or decrease in compressive strength compare to reference mix	
	14 Days	28 Days	14 Days	28 Days
Reference mix	26.66	29.16	-	-
SF	28.34	33.06	6.3	13.37
HDPEF	23.11	28.71	-13.32	-1.54
WPF	17.88	26.30	-32.93	-9.81

Table 2 Overall results of tensile strength

Type of fibers	Tensile strength of reference mix		% increase in tensile strength compare to reference mix	
	14 Days	28 Days	14 Days	28 Days
Reference mix	2.23	3.87	-	-
SF	2.65	4.15	18.83	7.24
HDPEF	3.00	4.22	34.53	9.04
WPF	2.55	3.71	14.35	-4.13

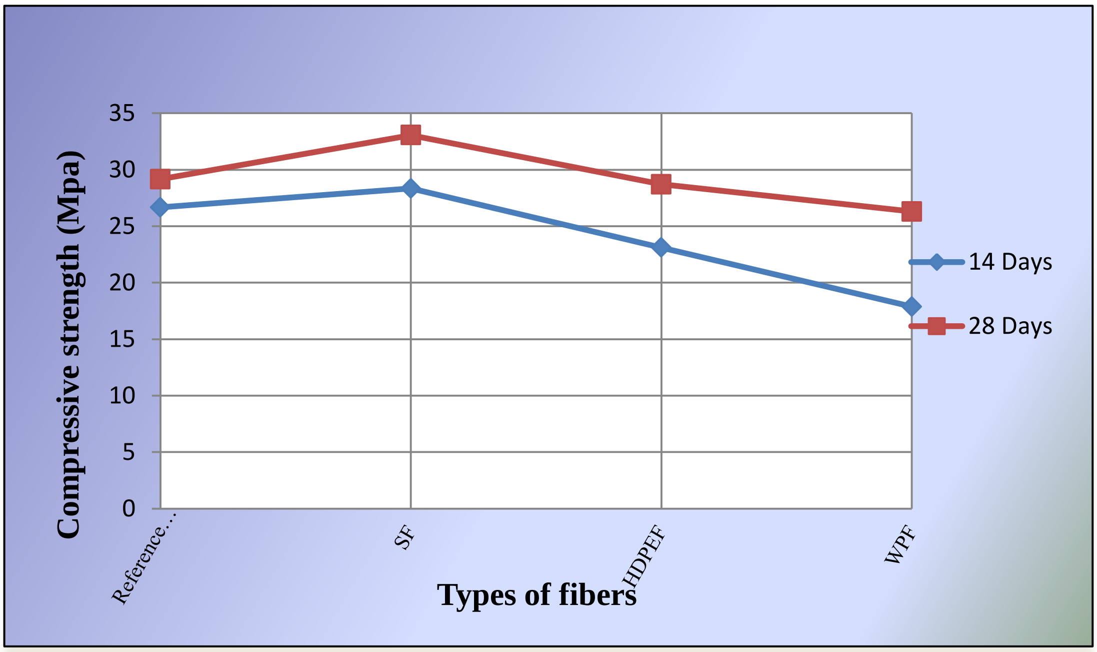
Table 3 Overall results of flexure strength

Type of fibers	Flexural strength test results		% increase or decrease in flexural strength compare to reference mix	
	14 Days	28 Days	14 Days	28 Days
Reference mix	6.23	11.35	-	-
SF	7.53	11.81	20.87	4.05
HDPEF	6.31	8.60	1.28	-24.23
WPF	4.43	8.22	-28.89	-27.58

Table 4 Overall results of Shear strength

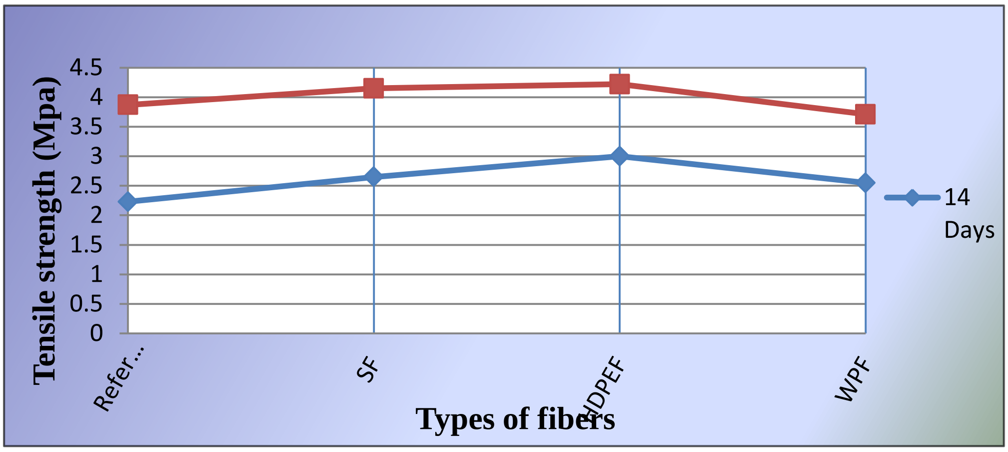
Type of fibers	Shear strength of reference mix		% increase in shear strength compare to reference mix	
	14 Days	28 Days	14 Days	28 Days
Reference mix	6.36	7.63	-	-
SF	7.34	8.76	15.41	14.81
HDPEF	8.55	9.50	34.43	24.51
WPF	9.44	12.71	48.43	66.58

Following Graph 1 shows the variation of compressive strength of concrete by 1% addition of reference mix, SF, HDPEF and WPF.



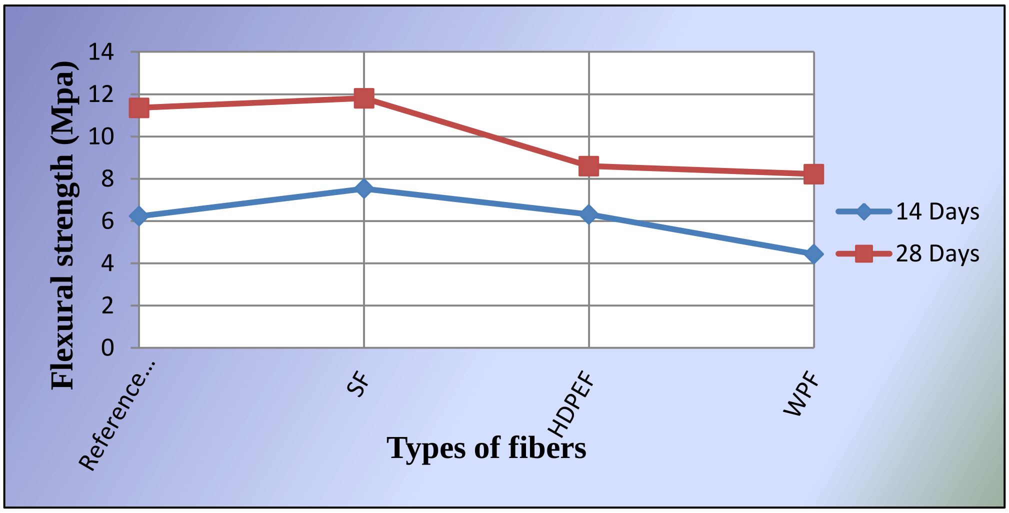
Graph 1 Variation of compressive strength

Following Graph 2 shows the variation of tensile strength of concrete by 1% addition of reference mix, SF, HDPEF and WPF.



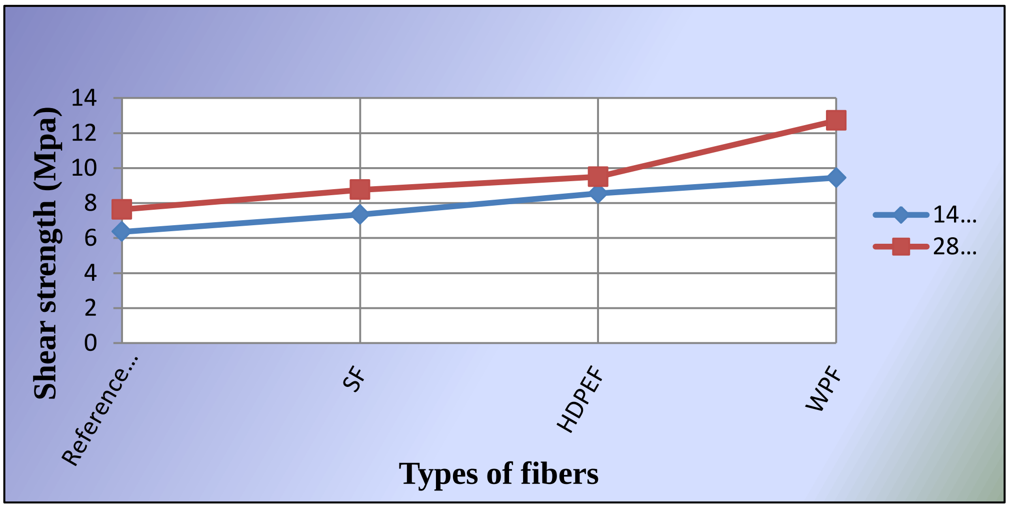
Graph 2 Variation of tensile strength

Following Graph 3 shows the variation of flexure strength of concrete by 1% addition of reference mix, SF, HDPEF and WPF.



Graph 3 Variation of flexural strength

Following Graph 4 shows the variation of shear strength of concrete by 1% addition of reference mix, SF, HDPEF and WPF.



Graph 4 Variation of Shear strength

5. CONCLUSIONS

Following conclusions may be drawn on the experimentations conducted on the behavior of fibers in concrete.

1. The 1% addition of steel fiber to the SIFCON gives higher compressive strength compare to 1% addition of HDPEF and WPF.
2. The 1% addition of steel fiber to the SIFCON gives higher flexural strength compare to 1% addition of HDPEF and WPF.
3. The 1% addition of HDPEF to the SIFCON gives higher tensile strength compare to 1% addition of steel fiber and WPF.
4. The 1% addition of WPF to the SIFCON gives higher shear strength compare to 1% addition of steel fiber and HDPEF

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APPENDIX - A

IS Codes:

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