Effect of Fiber Volume and Partial Replacement of Cement by GGBS on Flexural Strength of SIFCON

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***Abstract*—The present investigation emphasizes on the impact of varying percentages of steel fiber and GGBS slag in slurry infiltrated fiber reinforced concrete (SIFCON). Experiment was conducted on SIFCON mixtures containing different fiber percentages (3%, 6%, and 9%) and cement being partially replaced with ground granulated blast furnace slag (0%, 10%, 20%, and 30%). Also the fine aggregate was taken as a mixture of river sand (60%) and stone dust (40%) and optimum percentages of steel fiber and GGBS for obtaining maximum flexural strength of SIFCON were determined. 24 Prism specimen of size 500 x 100 x 100 mm were used in the study. The results indicate an optimum fiber content of 6% and that cement can be partially replaced by GGBS up to 20% without much decrease in the flexural strength of SIFCON.**

Keywords— GGBS; Flexural Strength; SIFCON; Steel Fiber; Stone Dust

I. INTRODUCTION

It is known that Concrete is strong in compression and weak in tension and thus using plain concrete is limited to places where tensile stresses hardly develop. To enhance the tensile stress in concrete fiber reinforced concrete is used in place of plain concrete. The presence of fiber in the concrete helps improve resistance to cracking or deflection.

Slurry infiltrated fiber concrete (SIFCON) was first produced in 1979 in USA. In SIFCON, fibers up to 20% by volume can be added which is very difficult in FRC [1].

Various investigations on the tensile and compressive strength of SIFCON have been performed in the past and the results show a very high increase in these properties as compared to FRC or plain concrete. FRC composite beams with SIFCON in the tension zone show an increase of up to 45% in the flexural strength [2]. Another research on the flexural behavior of SIFCON using steel fibers of aspect ratio equal to 50 showed a flexural strength of up to 19 MPa which is very high as compared to FRC [3]. The optimum steel fiber content for the maximum flexural strength of SIFCON was found to be 5% in a previous research conducted on hooked steel fibers of aspect ratio 50 [4].

Ground Granulated Blast Furnace Slag (GGBS) is a by-product from blast furnace obtained by quenching molten iron slag. Its chemical composition mainly consists of Calcium Oxide, Silica, Alumina, and Magnesia. It is a waste product and hence using it as a replacement for cement is both cost effective and environment friendly. Studies suggest that partial replacement of cement by GGBS from 15-25% result in nearly the same strength of as pure cement concrete [5]. For 53 grade OPC, 20% replacement of cement by GGBS is possible without compromising with the strength of plain concrete [6].

With river sand becoming scarce there is a need to find alternatives for river sand in concrete. One such replacement for river sand is stone dust. It also provides more strength to concrete [7]. Investigations show that replacement of river sand by stone dust up to 40% result in higher flexural and compressive strength of concrete [8].

II. EXPERIMENTAL METHODOLOGY

A. Material Used

Ordinary Portland cement, 53 grade conforming to IS 12269-1987 was used to prepare SIFCON. Other materials used were Steel Fibers, River Sand, Stone Dust and GGBS. Fig. 1, shows crimped steel fibers with aspect ratio of 50 and 1mm diameter used in the study. The density of steel fibers was taken to be 7800 Kg/m^3. Locally available stone dust and River sand passing through 1.18mm sieve were taken.

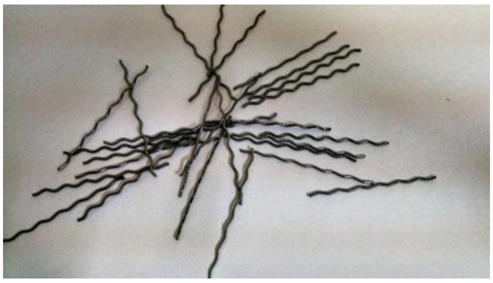

Fig. 1. Steel Fibers used in preparation of SIFCON.

B. Concrete Mix Preparations

The slurry was prepared by using cement to sand ratio of 1:2 and the water content being 0.35 which was determined on the basis of flow ability of the slurry. Steel fibers were preplaced in the mold with different proportions of 3%, 6%, and 9%. Sand was a mixture of river sand (60%) and stone dust (40%). Each proportion of steel fiber consisted of cement being partially replaced with GGBS in different proportions of 0%, 10%, 20%, and 30%. An accelerating chemical admixture containing calcium nitrate was used to obtain the early age strength of SIFCON.

C. Casting of Specimen

The fiber was preplaced in a mold of size 100 x 100 x 500 mm as shown in Fig. 2, and slurry was infiltrated into the mold. The prepared specimen was allowed to dry for 24 hours and then it was taken out from the mold as in Fig. 3, and cured in water for 28 days.

Fig. 3. Steel Fibers preplaced in mold

Fig. 2. Prepared specimen after 24 hours

III. RESULTS

The Flexural Strength Test carried out for various volume fractions are listed in Table I. The flexural strength for 3%, 6%, and 9% steel fiber are 12.7, 19.9, and 21.3 MPa respectively. There is only 5-7% decrease in the flexural strength of SIFCON for up to 20% replacement of cement with GGBS while the Flexural Strength decrease up to 13-15% for 30% replacement. The Bar Graph for flexural strength variation is shown in Fig. 4.

TABLE I. FLEXURAL STRENGTH OF SIFCON

No.	Flexural Strength (MPa)		
	Steel Fiber	***GGBS***	***Flexural Strength***
1.	3%	0%	12.7
2.	3%	10%	12.3
3.	3%	20%	11.8
4.	3%	30%	10.7
5.	6%	0%	17.9
6.	6%	10%	17.5
7.	6%	20%	16.9
8.	6%	30%	15.6
9.	9%	0%	21.3
10.	9%	10%	19.9
11.	9%	20%	19.7
12.	9%	30%	18.2

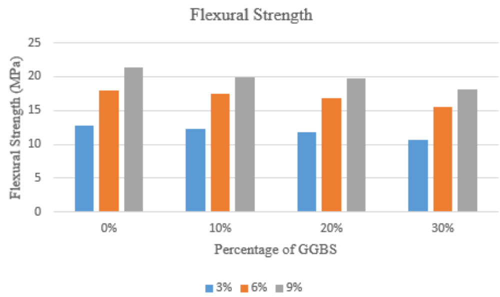

Fig. 4. Flexural Strength Results

IV. CONCLUSIONS

The following conclusions are drawn from the experimental tests:

a) SIFCON provides a very high flexural strength as compared to plane concrete or FRC.

b) The Flexural Strength for SIFCON increases with increase in percentage of steel fiber. The specimen fills completely for 9% steel fiber content without vibration and thus SIFCON can be prepared for 9% steel fiber for obtaining high flexural strength with good workability.

c) There is only a 5-7% decrease in the flexural strength of SIFCON up to 20% replacement of cement with GGBS and thus cement can be replaced with GGBS up to 20%.

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