Experimental Study on Effect of Fiber Volume and Aspect Ratio of Steel Fibers on the SIFCON Concrete Specimens

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Abstract— Slurry infiltrated fibrous concrete (SIFCON) is one of the starting late made movement material that can be considered as a kind of high performance fiber reinforced concrete with higher fiber content. The present investigation emphasizes on the impact of varying volume percentages and aspect ratio (L/D) of steel fiber in SIFCON specimen. Experiment was conducted on SIFCON mixtures containing different fiber percentages (7%, 8%, 9% and 10%) and different aspect ratio (50 and 60). Strength tests such as compression and split tensile strength were conducted to examine optimum fibre content and aspect ratio of SIFCON. From the test results it is observed that higher the fibre content, the better the results that are achieved in accordance with various strengths: compressive and split tensile strength.

Keywords: SIFCON, Steel Fibers, Compressive Strength, Split Tensile Strength

I. INTRODUCTION

SIFCON (Slurry Infiltrated Fibrous Concrete) is new construction material which has high strength as well as large ductility and excellent potential for structural applications when accidental (or) abnormal loads are encountered during services. SIFCON is a high-strength, high-performance material containing a relatively high volume percentage of steel fibres as compared to Fibre Reinforced Concrete. It is also sometimes termed as 'high-volume fibrous concrete.

The origin of SIFCON dates to 1979, when Prof. Lankard carried out extensive experiments in his laboratory and proved that, if the percentage of steel fibres in a cement matrix could be increased substantially, then a material of very high strength could be obtained.

SIFCON is made by preplacing short discrete filaments of steel (Steel Fibers) in to the moulds to full volume or to the desired part, consequently shaping an arrangement of network system. 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.

Proportions of cement and sand generally used for making SIFCON are 1: 1, 1:1.5, or 1:2. Cement slurry alone can also be used for some applications. Generally, fly ash or silica fume equal to 10 to 15% by weight of cement is used in the mix. The water-cement ratio varies between 0.3 and 0.4, while the percentage of the super plasticizer varies from 2 to 5% by weight of cement. The percentage of fibres by volume can be anywhere from 4 to 20%, even though the current practical range ranges only from 4 to 12%.

Even though, SIFCON is a recent construction material, it has found application in the areas of pavement repairs, repair of bridge structures, safe vaults and defense structures due its excellent absorption capacities

II. EXPERIMENTAL PROGRAM

The experimental work was carried out by casting cubes of size 150mm×150mm×150mm to find the compressive strength, cylinders of size 150 mm diameter and 300 mm height to find the split tensile strength.

The specimens were cast by using required size of moulds. A total of 48 SIFCON cube specimen and 48 SIFCON cylinder specimen with 7,8,9, 10% volume of fibers with 50 and 60 aspect ratio were casted. The proportion of cement to sand was taken as 1:1. Water cement ratio of 0.4 and super plasticizer about 0.6% was adopted. Optimum compressive strength and split tensile strength of SIFCON were determined.

A. Materials used

1) Steel Fiber

– Type of Steel fibre: straight fibre
– Diameter of steel fibre: 1 mm
– Aspect ratio. 50,60

2) Ordinary Portland cement of 53 grade.
3) M sand
4) Admixture

– Super plasticizer: CONPLAST SP – 430

B. Casting and Curing

Different test specimens such as Cubes and Cylinders were casted. Initially required volume of fiber was placed in mould randomly and then cement sand slurry was infiltrated over the fibers. To increase the workability of cement sand slurry 0.6% super plasticizer by weight of cement was used. The specimens were casted different fibre volume 7%, 8%, 9% and 10% and with two different aspect ratio. All the specimens were prepared in accordance with IS specifications. Moulds were allowed to dry for 24hrs and then hardened specimens were de-moulded and kept in water for curing for 7 days and 28 days.

III. RESULTS AND DISCUSSION

The tests were carried out at a uniform stress after the specimen has been centered in the testing machine. Loading was continued till the dial gauge needle just reverse its direction of motion. The test results for compressive strength and split tensile strength at 7 days and 28 days age were tabulated below:

A. Compressive Strength Test

Fig. 3.1: Compressive strength test

% steel fiber (Aspect ratio=50)	Compressive strength (N/mm^2)	
	7 day	28 day
7	26.22	38.22
8	28.89	41.33
9	33.22	46.22
10	32.11	43.89

Table 3.1: Compressive strength of SIFCON with L/D =50

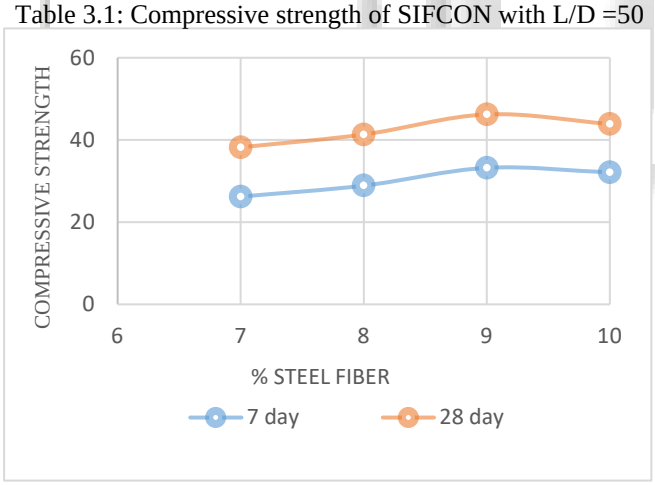

Fig. 3.2: Compressive strength test graph of L/D=50

% steel fiber (Aspect ratio=60)	Compressive strength (N/mm^2)	
	7 day	28 day
7	27.44	40.44
8	31.89	45.11
9	34.33	47.89
10	28.98	42.44

Table 3.2: Compressive strength of SIFCON with L/D =60

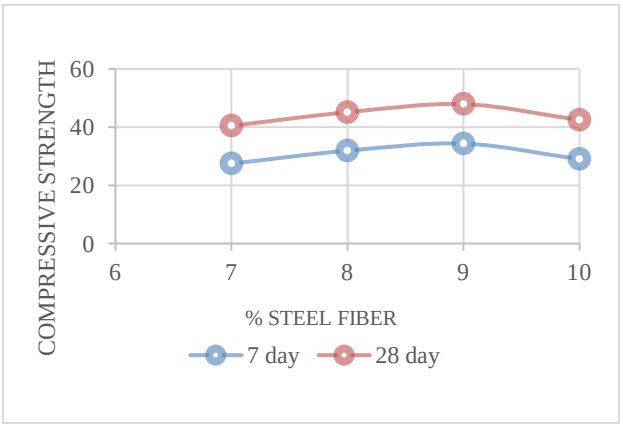

Fig. 3.3: Compressive strength test graph of L/D=60

From the above figure it is observed that by increasing volume of fibres from 7% to 9% the compressive strength has increased. But for 10% there was decrease in the compressive strength. This is due to the improper bonding between the materials due to the presence of higher amount of steel fibers in the specimen. Strength is highly influenced by the fiber volume and fiber alignment. 9% is considered as the optimum amount steel fiber volume that can be used. Also there was an increase in compressive strength when aspect ratio is also increased. Thus 9% steel fibre with 60 aspect ratio is considered as optimum.

B. Split Tensile Strength Test

Fig. 3.4: Split Tensile Strength Test

% steel fiber (Aspect ratio=50)	Split tensile strength (N/mm^2)	
	7 day	28 day
7	3.99	6.15
8	4.71	7.47
9	5.67	8.53
10	5.08	7.82

Table 3.3: Split Tensile Strength of SIFCON with L/D =50

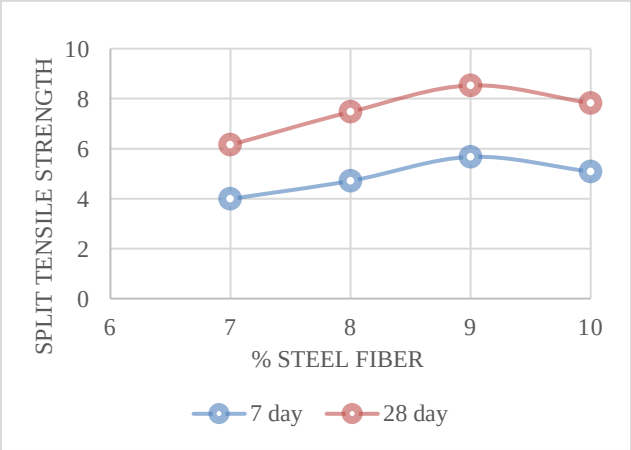

Fig. 3.5: Split Tensile Strength Test graph of L/D=50

% steel fiber (Aspect ratio=60)	Split tensile strength (N/mm^2)	
	7 day	28 day
7	4.41	6.48
8	4.97	7.89
9	5.89	8.67
10	4.97	8.03

Table 3.4: Split Tensile Strength of SIFCON with L/D =60

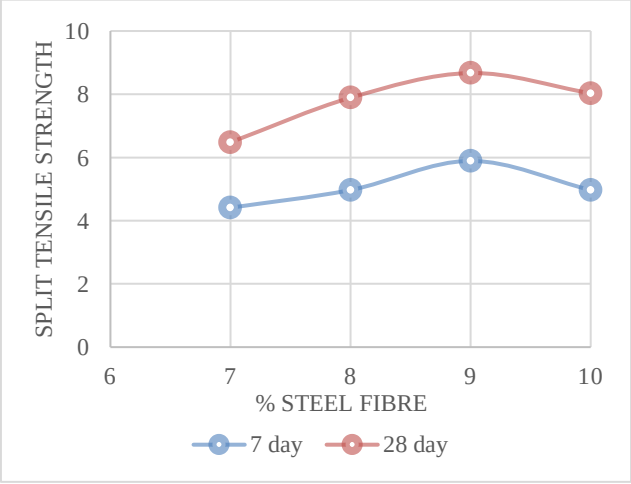

Fig. 3.6: Split Tensile Strength Test graph of L/D=60

Variations of tensile strength with respect to percentage of steel fibers utilized for the specimen can be observed from the above figure. It can be observed that there was good enhancement of tensile strength in SIFCON specimens, due to addition of steel fibers up to certain level. There is a reduction in the value of tensile strength for specimen with 10% steel fibers. It may be due to the presence of higher volume of steel fibers, which results in improper bonding. There was also an increase in tensile strength with increase in aspect ratio from 50 to 60. Thus 9% steel fibre with 60 aspect ratio is considered as optimum value for tensile strength.

IV. Conclusion

The experimental investigation of the strength characteristics of SIFCON with different volume of fibre and aspect ratio was carried out and the conclusions drawn are as given below:

- Addition of steel fibres in concrete significantly increased the Compressive strength and Split tensile strength of SIFCON.
- Aspect ratio also affect the strength and bonding properties of SIFCON.
- On comparing the strength of SIFCON, steel fibres with aspect ratio 60 performed better than steel fibres with aspect ratio 50 for all the tests.
- It is observed that both the compressive and tensile strength increases with increase in volume percentages of fibre up to certain limit beyond which it decreases.
- Optimum compressive strength is achieved at 9% of steel fibre with aspect ratio60 which is 47.89 N/mm^2 after 28 days curing.
- Similarly, optimum split tensile strength is achieved at 9% of steel fibre with aspect ratio 60 which is 8.67 N/mm^2 after 28 days curing.

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