

Mechanical Performance on Slurry Infiltrated Fibre Concrete

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Abstract: Generally concrete has low cracking resistance, low tensile strength and low ductility. To improve the tensile properties of concrete members a conventional reinforced bars are used. These provide the tensile strength of concrete members and do not increase the inherent tensile strength of concrete. It has been known that the addition of small, closely placed and uniformly dispersed fibers to concrete would act as crack arrester and improve its static and dynamic properties. In this paper, the mechanical properties like compression strength, split tensile strength, flexural strength, flexural toughness and stress – strain characteristics of SIFCON specimens and then compared with conventional FRC and conventional concrete are investigated. The M30 grade of concrete is used for both fiber reinforced concrete and conventional concrete. The experimental program consists of investigation on the mechanical properties of SIFCON specimens with 8% fiber content and then compared with conventional SFRC with 0.5%, 0.75% and 1% fiber content and then compared with conventional concrete. Steel fibers with two types straight and crimped having 30 mm and 18 mm length have been investigated. The result shows that the compressive strength of SFRC is found to increase with increase in fiber content. SIFCON has higher Split tensile strength and Flexural strength than SFRC and control concrete.

Keywords: Slurry infiltrated Concrete, SIFCON, Steel fiber reinforced concrete, crimped steel fibers

I. INTRODUCTION

SIFCON (Slurry Infiltrated Fiber CONcrete) was invented in 1979 by Dr. David Lankard. A special type of fiber reinforced concrete is Slurry Infiltrated Fibrous Concrete. In two aspects it is different from normal fiber reinforced concrete. They are the production method and content of fiber. In FRC, the fiber content is less compare to SIFCON, usually in FRC, the fiber content varies from 0.5 to 2% by volume, whereas in SIFCON, the fiber content may vary between 5 and 12%. Due to high fiber content the process of making SIFCON is different. In FRC, the fibers are added to the wet or dry mix of the concrete during mixing, but SIFCON is prepared by infiltrating cement slurry into a bed of preplaced fibers. Alternatively, the fibers can also be implanted into the cement sand slurry. SIFCON has been successfully used in structures subjected to blast and dynamic loading. Because of high ductility and impact resistance, the composite has excellent potential for

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constructing structural components which need to resist high impact force and exhibit high ductility, such as explosive storage cabinets, blast resistant doors, high security vaults and missile silo structures. It is also very effective for precast applications, where standard modes of reinforcement are ineffective.

II. METHODOLOGY

SIFCON is cast a pre placing technique in which fibers are placed in the mould or on a substratum and infiltrated with cement-based slurry. The fibers can be sprinkled by hand or by using fiber-dispensing units. The amount of fiber that can be incorporated depends on fiber aspect ratio, fiber geometry and placement technique. Following are the materials used for the present investigation of Fiber Reinforced Reactive Powder Concrete.

The following are the steps involved in the preparation of SIFCON specimens.

- Preparation of forms i.e. substrates.
- Placement of the steel fibers.
- Preparation of the SIFCON slurry.
- Infiltration of the slurry through the packed steel fiber bed.
- Curing.

III. MATERIALS USED

The following materials have been used for the development of SIFCON and their properties have been presented in the following paragraphs.

- Cement
- Fine aggregate
- Coarse aggregate
- Chemical admixtures
- Water
- Steel fibers

A. Cement

In the present investigation, OPC of 53 grade was used and the cement sample was tested as per IS: 4031-1968 to obtain the following properties:

- Specific gravity (determined by Le – Chatelier flask) (IS: 1727-1967)
- Standard consistency (IS: 4031 – 1968 Part 4)
- Initial setting time (IS: 4031 – 1968 Part 4)
- Final setting time (IS: 4031 – 1968 Part 4)

The test results on cement sample are listed in Table 1.

Table-I: Physical Properties of Cement

Physical properties		IS 12269[8] specification for 53 grade OPC	Present study- OPC 53 grade
Specific gravity		-	3.15
Standard consistency (%)		-	28.0%
Initial setting time in min		> 30 minutes	110 minutes
Final setting time in min		< 600 minutes	260 minutes
Compressive strength (MPa)	3 days	27	27.5
	7 days	37	38.08
	28 days	53	54.32

B. Fine Aggregate

In the present investigation, the river sand available at Chennai was used and the following tests were carried out on the sample as per IS: 2386- 1968 (III):

- Specific gravity and Fineness modulus

The results of tests on sand are listed in the Table 2

Table- II: Properties of Fine Aggregate

Properties	Results
Specific gravity of sand	2.68
Fineness modulus	2.73
Sand Conforming	Zone II
Bulk density(kg/m ³)	1685

C. Coarse Aggregate

In the present investigation, locally available blue granite crushed stone aggregates of size 20 mm were used and the various tests carried out on the aggregates as per IS: 2386-1968 (III):

- Specific gravity, Bulk density and Fineness modulus

The results of the tests on coarse aggregate are listed in the Table 3.

Table-III: Properties of Coarse Aggregate

Property	Results
Specific gravity	2.69
Dry Rodded Weight (kg /m ³)	1550.0
Fineness modulus	7.15

D. Chemical Admixtures

In concrete, the water–binder ratio is generally kept as low as possible and hence to obtain the given degree of workability, chemical admixtures, such as, Super plasticizers were used. Poly-carboxylic group based superplasticizer, Structro 100 (a product of Fosroc chemicals), is used throughout the investigation. This group maintains the electrostatic charge on the cement particles and prevents flocculation by adsorption on the surface of cement particles. It is a light yellow colored liquid. The specific gravity of superplasticizer is 1.08-1.14 and solid content is 40 percent by mass.

E. Water

In the present investigation, potable water was used.

F. Steel Fibers

The steel fibers purchased from M/s Stewole and Co is used in the present investigation. Steel fiber used was

straight and crimped shaped fiber with a total length of 18mm and 30mm with diameters of 0.45 mm and aspect ratio of 67 and 40. The fibers used with the ultimate tensile strength of 800 MPa (from the data supplied by the manufacturers). From the results of the earlier investigations conducted at SERC, a fiber content of 640 kg/m³ (8 % by volume of concrete) for SIFCON and a fiber content of 40 kg/m³, 60 kg/m³ and 80 kg/m³ (0.5 %, 0.75% and 1% by volume of concrete) for SFRC (Steel Fiber Reinforced Concrete) was chosen and kept constant throughout the investigations.

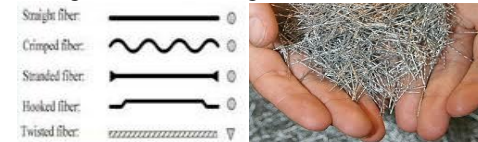


Fig. 1: Types of Steel Fiber Fig. 2: Crimped Steel Fiber

IV. MIX PROPORTION

Table- IV: Mix Proportion

Specimen ID	Mix Proportion (C:S:CA10mm:C A20mm: w/c: SP)	Type of fiber	Aspect ratio	Fiber volume
SIFCON S1	1 : 1 : 0 : 0 : 0.35 : 0.13%	Straight	67	8%
SIFCON S2	1 : 1 : 0 : 0 : 0.35 : 0.13%	Straight	40	8%
SIFCON C1	1 : 1 : 0 : 0 : 0.35 : 0.13%	Crimped	67	8%
SIFCON C2	1 : 1 : 0 : 0 : 0.35 : 0.13%	Crimped	40	8%
SFRC S1-1	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Straight	67	0.5%
SFRC S1-2	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Straight	67	0.75%
SFRC S1-3	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Straight	67	1%
SFRC S2-1	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Straight	40	0.5%
SFRC S2-2	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Straight	40	0.75%
SFRC S2-3	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Straight	40	1%
SFRC C1-1	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Crimped	67	0.5%
SFRC C1-2	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Crimped	67	0.75%
SFRC C1-3	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Crimped	67	1%
SFRC C2-1	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Crimped	40	0.5%
SFRC C2-2	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Crimped	40	0.75%
SFRC C2-3	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	Crimped	40	1%
Control	1 : 1.86 : 1.26 : 1.26 : 0.4 : 0.2%	No	No	No

The mix design is made as per ACI 211 method for M30 Grade.

V. RESULT AND DISCUSSION

A. Compressive Strength

The behaviour of SIFCON, Steel Fiber Reinforced Concretes (SFRC) and conventional concrete of M30 grade were tested under compression. Compressive strength test at 28 days were carried out and the results are given below. The fiber content used in this investigation are 640 Kg/m³ for SIFCON and 40 Kg/m³, 60 Kg/m³, and 80 Kg/m³ for SFRC of concrete. The cube size used for testing is 100x100x100mm cube, the test results are given below. Figure 3 and 4 shows the percentage increase in compressive strength for different fibers. From the results obtained the following inferences can be made,

- The compressive strength of SIFCON gets increased by more than 1.5 times than SFRC and control
- The compressive strength of SFRC increase/decrease with as the fiber volume increases from 0.5% to 1% depending on the fiber distribution.
- In SFRC, with different aspect ratio there is no change in compressive strength.
- In SIFCON, with different aspect ratio there is a change in compressive strength.

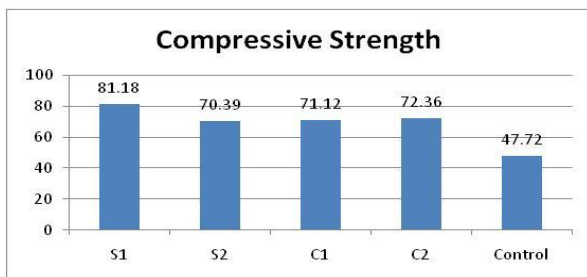


Fig. 3: Compressive Strength of SIFCON and Control Concrete

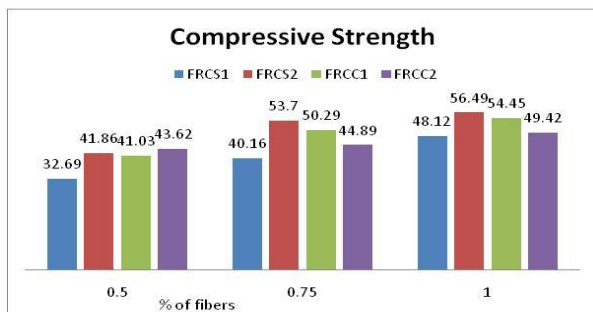


Fig. 4: Compressive Strength of SFRC

B. Split Tensile Strength

The behaviour of SIFCON, Steel Fiber Reinforced Concretes (SFRC) and conventional concrete of M30 grade were tested under compression. Split tensile strength test at 28 days were carried out and the results are given below. The cylinder size used for testing is 100mmx200mm, the test results are given below. Figure 5 and 6 shows the percentage increase in split tensile strength for different fibers. From the results obtained the following inferences can be made,

- Split tensile strength SIFCON gets increased by more than 3 times than SFRC and control concrete.
- In SIFCON when aspect ratio is varied the split tensile strength gets increased by 1.25 times.
- In SFRC there is no change in split tensile strength with different aspect ratio.

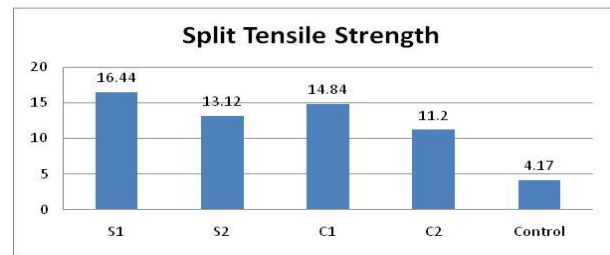


Fig. 5: Split Tensile Strength of SIFCON and Control Concrete

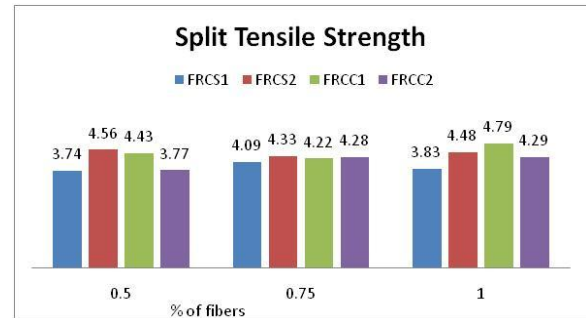


Fig.6: Split Tensile Strength of SFRC

C. Flexural Strength

The flexural test method followed was based on test method given in ASTM C 78-94. Mould size used was 100 x 100 x 400 mm prism. Four point loading is used for test. Force applied to the beam will be perpendicular to the face of the specimen and applied without eccentricity. Ratio of distance between point of applied load and nearest reaction to the depth of the beam shall not be less than one. Flexural strength test was carried out for 28 days. The test results are given below, Figure 7 and 8 shows the percentage increase in flexural strength for different fibers. From the results obtained the following inferences can be made,

- Flexural strength of SIFCON gets increased by more than 3.5 times than SFRC and control concrete
- In SIFCON when aspect ratio is varied the flexural strength gets increased by 1.8 times
- In SFRC when aspect ratio is varied the flexural strength gets increased by 1.2 times
- There is no change in the flexural strength when fiber volume is varied

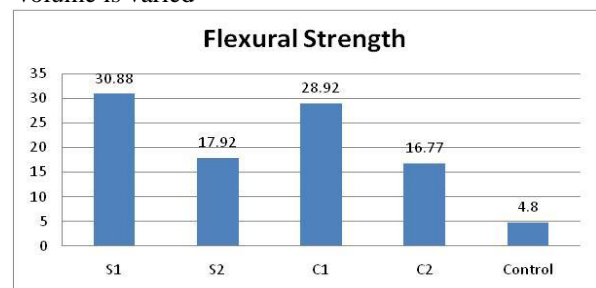


Fig. 7: Flexural Strength of SIFCON and Control Concrete

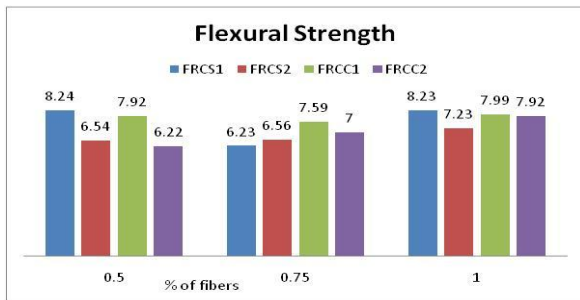


Fig. 8: Flexural Strength of SFRC

VI. CONCLUSION

Based on the experimental study the following conclusions can be drawn

- The fiber content is increased then the compressive strength of SFRC is also increased. The influence of aspect ratio is negligible in compressive strength. However, for SIFCON specimen the compressive strength depends on the aspect ratio, this is because the fiber content is kept constant which lead to the change in number of fibers per unit volume.
- Split tensile strength of SIFCON increased by 3 to 4 times than SFRC and control concrete.
- Flexural strength of SIFCON increased by 3 to 5 times than that of SFRC and 7 times than that of control concrete

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