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Study on behavior of SIFCON produced with low tensile strength steel fibre

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ABSTRACT

The acronym SIFCON stands for Slurry Infiltrated Fibre Concrete. SIFCON is a unique kind of fibre reinforced concrete (FRC) which has large volume percentages of fibre. In SIFCON we can use fibre from 5 to 20 % of the volume of the cube in comparison with FRC; which contains fiber only from 2% to 5% by volume of the cube because of clustering and balling problem. The SIFCON can also be used in wear & tear cases since it consists of high performance ductile layer of high fibre concrete. Although it does not perform any load bearing function since it is only used in very thin layers. In this research work we have used 6%, 12% and 18% of steel fibre by volume of 150 mm × 150 mm × 150 mm cube to find out the strength and compare it with SIFCON which is produced due to partial replacement of cement with the powder of glass.Glass is a non-crystalline brittle and hard, somewhat transparent material produced by fusion, usually consisting of mutually dissolved silicate and silica that also contains lime and soda. Waste glass contains high silica due to which when this waste glass is ground to a very fine powder which reacts with alkalis in cement and forms a cementitious product which helps in the contribution of strength. In this work 5%, 10%, 15% & 20% Glass powder is replaced by weight of cement.

Keywords—*SIFCON, Flexural strength, Glass powder, Compressive strength, Steel fibre, FRC*

1. INTRODUCTION

This technique of slurry infiltrated fibrous concrete was first proposed by Haynes (1968). Further Lankard (1979) modified the method used by Haynes and concluded that if the percentage of steel fibers in the cement matrix is increased high strength concrete can be obtained. The cementing composites having larger volume percentages of fibres known as slurry infiltrated concrete. As the volumes fraction of fibre increases; the fibre-reinforced concrete shows significant strength & toughness properties. The technique to gain a high volume of fibre consists of the strategy of pre-placement of fibres in the framework & then infiltrating the fibre bed with the cementing slurry.

In FRC the fibres are added dry or wet mix but in SIFCON cement slurry is poured over pre-placed fibres. In comparison with the usual concrete, the SIFCON does not contain any kind of coarse aggregates; however, it contains cement, water, steel fibre and sometimes admixtures such as super plasticizers, etc. Although it may contain fine sand and additives such as glass powder or fly ash. Super plasticizers can be used to improve flow characteristics.

In the manufacturing process of the Portland cement a large amount of the CO_2 and other greenhouse gases are emitted in the air, which further causes global warming. To produce 1000 kg cement, 900 kg of CO_2 emitted in the atmosphere. Thus it is important to partially replace the cement with some other binding material to curb the effects of pollution. The material in replacement having cementitious properties can be used. The material such as fly ash, glass powder, blast furnace slag, etc can be used.

The recent researches show that the glass powder can be used in the place of coarse aggregate or in place of cement. Waste glass is generated mainly from door and windows, glasses, bulbs, tube light, liquor bottles, wind-shields, glass containers etc. Everywhere, storage and safe disposal of waste glass creates a major problem for municipal corporations and to reduce this problem waste glass is recycled.

2. MATERIALS USED

2.1 Water

The potable water is used in the process of making of the cement slurry. Generally, cement requires about three-tenth of water for the hydration although some additional water is also required to lubricate the mix. The water used for curing and mixing should be free from impurities.

2.2 Cement

The OPC 43 grade of cement is used in this study. The physical properties of the cement is shown in table 1.

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Table 1: **Physical properties of cement**

S. No.	Characteristics	Standard Results (As per IS Code)	Test Results
1	Initial Setting Time	Minimum 30 Minutes	70
2	Final Setting Time	Maximum 600 Minutes	316
3	Consistency	30%	30%
4	Specific Gravity	3.15	3.157
5	F.M. (Fineness Modulus)	Maximum 10%	7%
6	Compressive Strength	Minimum 43 N/mm^2	44.5

2.3 Steel Fibre

Low tensile strength steel fiber of diameter 1mm is used in this study. For this purpose locally available binding wire is used. Length of the fiber is taken as 50mm. Steel fiber (binding wire) was purchased from Gorakhpur market. The type of fiber used in this study was made of steel and having a unit weight of $7850kg/m^3$. Low tensile strength steel fiber of diameter 1mm is used in this study. Steel fibers of the aspect ratio of 50 were cut into a required length of 50mm. The ultimate tensile strength was 410MPa. Black steel fibers are commercially available and are generally used for binding the steel reinforcement in RCC works.

2.4 Fine Aggregates

Sand conforming to grading zone II as per the specifications of IS 383:1970 is used.
Fineness modulus = 2.80
Specific gravity = 2.62

2.5 Admixtures

Super plasticizers enable the optimization of water cement ratio and workability. Super plasticizers (CICO Plast super HS) make possible to produce the mix with relatively lower cement content.

2.6 Glass Powder

The waste glass contain high silica (SiO2) due to which when this waste glass is ground to a very fine powder; it reacts with alkalis present in the cement and form a cementitious product that helps in the contribution of strength. In this study, very fine glass powder is used.

Table 2: Chemical composition of glass powder

S. No.	Chemical Compound	Percentage by Mass
1	SiO_2	67.33
2	Fe_2O_3	1.42
3	Al_2O_3	2.62
4	CaO	12.45
5	Na_2O	12.05
6	MgO	2.74
7	K_2O	0.638
8	SrO	0.016
9	ZnO	0.008
10	P_2O_5	0.05
11	CuO	0.009
12	NiO	0.014
13	Cr_2O_3	0.022
14	ZrO_2	0.019
15	TiO_2	0.157

3. TEST PROGRAMME

Firstly Twenty seven SIFCON cube specimen of 150*150*150mm with 6,12and 18% volume of fibers with 50aspect ratio was casted and tested. The proportion of cement to sand is taken as 1:2. Optimum strength of SIFCON was determined. The % of fibre at which SIFCON shows optimum strength was taken as optimum fibre content and at that % of fibre 45 cubes and 15 prism specimens were casted.

4. FABRICATION, CASTING AND TESTING

Steel fibres of 1mm diameter and aspect ratio of 50 were placed into the mould randomly up to the desired level. Then with sufficient shaking the cement based slurry was poured over the mould. Throughout the experiment, the water content is kept at 0.45. The initially required volume of fiber was placed in mould randomly and then cement sand slurry is infiltrated over the fibers. To increase the workability of cement sand slurry 1% super plasticizer by weight of cement was used. All the casted specimen were taken out from the mould after 24 hours and water-cured for 28 days.

4.1 Flexural Strength Test

For flexural test beams of 150×150×750 mm size were adopted. The load was applied without shock and was increased until the specimen failed, and the maximum load applied which is on the meter to the prism during the test was recorded. The appearances of the fractured faces of concrete failure were noted. Three-point load method was used to measure the flexural strength of SIFCON.

Table 3: Flexural strength test for SIFCON

S. No	Mix Designation	Flexural strength (7 Days)	Flexural strength (14 Days)	Flexural strength (28 Days)
1	S-6%	4.50	5.60	6.40
2	S-12%	6.25	7.80	9.26
3	S-18%	5.70	7	8.30

As the Flexural strength of SIFCON is recorded maximum at 12% of steel fibre; so it is considered as optimum fibre content.

Table 4: Flexural strength test for SIFCON with glass powder

S. No	Mix Designation	Flexural strength (7 Days)	Flexural strength (14 Days)	Flexural strength (28 Days)
1	S-0%	6.25	7.80	9.26
2	S-5%	6.45	7.90	9.45
3	S-10%	6.75	8.25	9.60
4	S-15%	7.15	8.60	10
5	S-20%	6.95	8.30	9.75

4.2 Compressive Strength Test

For compressive strength test cubes of size 150×150×150 mm made. The test was done on the hydraulic testing machine. Compressive strength is defined as the resistance of concrete to axial loading. Cubes are put in the machine and after tighten its wheel start button is pressed as pressure is beginning to apply. Reading of meter is note down when cracks are there on cubes. Compressive strength is calculated by the following formula:
Compressive Strength = P / A
Where P represents the load and A is an area of the cube.

Table 5: Compressive strength test for SIFCON

S. No	Mix Designation	Compressive strength (7 Days)	Compressive strength (14 Days)	Compressive strength (28 Days)
1	S-6%	26.34	32.9	40.3
2	S-12%	35.10	42.2	47.9
3	S-18%	33	38	44.2

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Also here due to the value obtained at 12% level is maximum; thus it is considered as the optimum fibre content value.

Table 6: Compressive strength test for SIFCON with glass powder

S. No	Mix Designation	Compressive strength (7 Days)	Compressive strength (14 Days)	Compressive strength (28 Days)
1	S-0%	35.10	42.2	47.9
2	S-5%	40.30	43	48.35
3	S-10%	41.65	44.80	49.20
4	S-15%	44	46.50	50.65
5	S-20%	40.5	42.55	48.60

5. CONCLUSION

Based on the study carried out on the strength behaviour of SIFCON the following conclusions are drawn:

5.1 Flexural Strength of SIFCON

It is evident from the results that, flexural strength increases with an increase in the percentage of steel fibre. It means that the addition of steel fibre enhances the flexural strength behaviour of SIFCON; although beyond 12 % it tends to decrease. The optimum strength thus is obtained at 12 % of steel fibre. When glass powder is partly replaced by cement, initially flexural strength increases and become maximum at 15% of glass powder beyond which flexural strength decreases. Maximum flexural strength value was recorded as 10 N/mm^2 after 28 days of curing.

5.2 Flexural Strength of SIFCON

From the result observation, it can be concluded that the compressive strength increases with increase in the volume percentages of fibre up to a certain limit and beyond which compressive strength decreases. This is also in conformity with results of previous investigations. Optimum compressive strength is achieved at 12% of steel fibre which is 47.9 N/mm^2 after 28 days curing. When glass powder is partly replaced by cement, initially compressive strength increases and become maximum at 15% of glass powder beyond which compressive strength decreases. Maximum compressive strength was recorded as 50.65
N/mm^2 after 28 days of curing.

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