Study of behavior of SIFCON Produced by Partial Replacement of Cement with Glass Powder and Low Tensile Strength Steel fibre

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Abstract— Slurry Infiltrated Fibrous Concrete (SIFCON) is a special type of fiber reinforced concrete (FRC) which have large amount of fiber. FRC contain fiber only 2% to 5% by volume of cube because of balling and clustering problem but in SIFCON we can use fiber from 5 to 20 % of volume of cube. Since SIFCON is a ductile layer of high performance fibre concrete with significantly large amount of fibres, hence it can also be used to reduce the wear and tear. However, it is applied only in relative thin layers; hence SIFCON does not perform any load bearing function. Glass is a hard brittle, noncrystline more or less transparent substance produced by fusion, usually consisting of mutually dissolved silica and silicate that also contain soda and lime. Glass can be considered as an environmentally friendly material because it can be recycled several times and can be used in many applications. According to estimation several million tonne of waste glass are generated worldwide annually. Waste glass contain high silica (SiO2) due to which when these waste glass is ground to very fine powder react with alkalises in cement and form cementitious product that help in strength contribution. In this research work we are going to use 6%,12% and 18% of steel fiber by volume of 150mm× 150mm× 150mm cube to find out the optimum strength and compare it with the strength of SIFCON produced by partial replacement of cement with glass powder at the days of 7days,14days &28 days. This research therefore is an comparison of the performance of the control SIFCON concrete made of 6%,12% & 18% of steel fiber and SIFCON produced by partial replacement of cement with glass powder. In this work 5%, 10%, 15%, 20% and 25% Glass powder is replaced by weight of cement.

Key words: SIFCON, OPC, Glass Powder, Compressive Strength, Admixture

I. INTRODUCTION

SIFCON stands for slurry infiltrated fibrous concrete with higher amount of low tensile strength steel fibre. SIFCON is a new technique to increase the strength of concrete. It is an improvement over fiber reinforced concrete. Slurry infiltrated fibrous concrete is a relatively new high performance & advanced material which can be considered as a special type of Steel Fibrous Reinforced Concrete (SFRC). SIFCON is a type of fibre reinforced concrete (FRC) but it is produced by using a method which is very different from ordinary fibre reinforced concrete. To achieve uniform fiber distribution small length of fibre is used. These short discrete fibres are preplaced in the moulds to its full capacity or to the desired volume fraction thus forming a network. Then a fine liquid cement based slurry or mortar is allow to infiltrate over the fibre network. In FRC fibres are added dry or wet mix of concrete but in SIFCON cement slurry is poured over preplaced fibres. When compared to conventional concrete SIFCON contains relatively high cement and water content. SIFCON has no coarse aggregate but high cementous content. However it may contain fine sand and additive such as fly ash, fine glass powder. To improve the flow characteristics, controlled quantity of super plasticizer may be used. Vibration is necessary during placing the fibre and pouring slurry. 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 percentage of steel fibers in cement matrix is increased high strength concrete can be obtained.

Waste glass is generated mainly from waste containers, door and window glasses, bulbs, tube light, windshield, liquor bottles etc. Everywhere, storage and safe disposal of waste glass creates major problem for municipalities and to reduce this problem waste glass is recycled. Glass is recycled by melting a mixture containing material such as soda ash, silica, calcium carbonate and recycled glass piece. This blend is then heated to very high temperature where they melt followed by a rapid cooling process that effectively creates the crystallization glass it is often associated with. After the production the glass is used as a set of new glass. The problem in glass production comes from the industry inability to recycled 100% of glass produced. Most of the glass (76%) of this glass is disposed off in landfill. Glass recycling contains high cost for business point of view as well as transportation point of view. It is not very much cost effective. This pattern has influenced environmental organization to pressure the community to lower the amount of glass being discarded as well as find use to the non-recycled glass in new applications. The manufacturing of Portland cement which is an important part of concrete releases a large amount of CO_2 and other greenhouse gases which are responsible for Global warming. During cement manufacturing CO_2 releases both directly as well as indirectly. Directly when calcium carbonate is heated then it produce lime and CO_2 and indirectly through the use of energy if its production involves emission of CO_2. To produce 1000 kg cement, 900 kg of CO_2 emitted in atmosphere. Hence it is necessary to partially replace the cement with some binding material so that the use o cement can be reduced hence pollution can be reduced. Fly ash, silica flume, blast furnace slag etc can be used to replace the cement in concrete. Recently some research has shown that waste glass can be used either as a replacement of coarse aggregate or replacement of cement in form of fine glass powder. In this work glass powder is used as a partial replacement of cement and the behaviour of SIFCON is studied.

II. MATERIAL USED

A. Cement:

OPC 43 grade of cement is used in this study.

S.No	Characterstics	Test Result	Standard Result(As Per Is Code)
1	Consistency	32%	30%
2	Initial Setting Time	90 min	Not less than 30 min
3	Final Setting time	310 min	Not more than 600 min
4	Specific Gravity	3.157	3.15
5	Fineness Modulus	7%	Not more than 10%
6	Compressive Strength	44N/m m^2	Not less than 43 N/mm^2

Table 1:-Physical properties of cement

B. Fine Aggregates:

Sand conforms to zone II as per the specifications of IS 383:1970 is used as fine aggregate.

- Specific gravity = 2.62
- Fineness modulus = 2.81

C. Steel Fiber

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 unit weight of 7850kg/m³. Low tensile strength steel fiber of diameter 1mm is used in this study. Steel fibers of aspect ratio of 50 were cut into 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.

D. Glass Powder

Waste glass contain high silica (SiO_2) due to which when these waste glass is ground to very fine powder react with alkalises in cement and form cementitious product that help in strength contribution. Very fine crushed glass powder is used in this study.

S.NO.	Chemical Property of Glass Powder	% by mass
1.	Si_2	67.330
2.	Al_2O_3	2.620
3.	Fe_2O_3	1.420
4.	TiO_2	0.157
5.	CaO	12.450
6.	MgO	2.738
7.	Na_2O	12.050
8.	K_2O	0.638
9.	ZrO_2	0.019
10.	ZnO	0.008
11.	SrO	0.016
12.	P_2O_5	0.051
13.	NiO	0.014
14.	CuO	0.009
15.	Cr_2O_3	0.022

Table 2: Chemical composition of Glass Powder

E. Water:

Water plays a very important role in concrete. Hydration of concrete depends on water. Hence the quantity and quality of water is required to be looked into very carefully. In this work clean potable water is used.

F. Admixture:

Super plasticizers (CICO Plast super HS) are usually distinctive in their nature, and they make possible the production of concrete which, in its fresh and hardened state, is substantially different form of concrete made using the water reducing admixture.

III. 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.

IV. FABRICATION, CASTING AND TESTING

Steel fibres of 1mm diameter and 50aspect ratio were placed into the mould randomly up to desired level. Then Cement based slurry was poured over the mould with sufficient vibration. Water cement ratio was taken as 0.45 throughout the experiment. 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.

Fig 1 Placement of Steel Fibres in mould

A. Compressive Strength

For compressive strength test cubes of size 150×150×150 mm^3 made. Test was done on the hydraulic testing machine. Compressive strength is defined as resistance of concrete to axial loading. Cubes are put in the machine and after tighten its wheel start button is pressed as pressure is begin to apply. Reading of meter is note down when cracks are there on cubes. Compressive strength is calculated by following formula:

$$\text{Compressive Strength} = \frac{P}{A}$$

Where P is load and A is area of cube

Loading arrangement to test of the specimen for compressive strength is shown in the figure 2.

Fig. 2: Compressive Strength Testing Machine

S.No.	Designation Of Miix	Compressive Strength After 7 Days N/Mm^2	Compressive Strength After 7 Days N/Mm^2	Compressive Strength After 7 Days N/Mm^2
1.	**S-6%**	26.66	33	40
2.	**S-12%**	35.12	42.44	48
3.	**S-18%**	33	38.22	44.44

Table 3 compressive strength of SIFCON

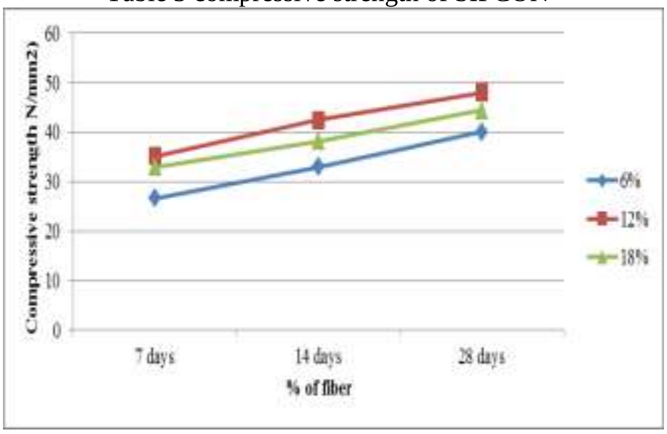

Fig. 3: Graph

As the compressive strength of SIFCON is recorded maximum at 12% of steel fibre. Hence 12% of steel volume is considered as optimum fibre content.

S.No	Designation of Mix	Compressive Strength of 7 Days N/Mm^2	Compressive Strength of 14 Days N/Mm^2	Compressive Strength of 28 Days N/Mm^2
1.	S-0%	35.12	42.44	48
2.	S-5%	40.45	43.11	48.50
3.	S-10%	41.77	45.00	49.30
4.	S-15%	44.22	46.67	51.11
5.	S-20%	40	42.67	48.88
6.	S-25%	35.55	40	44.44

Table 4 compressive strength of SIFCON with glass powder

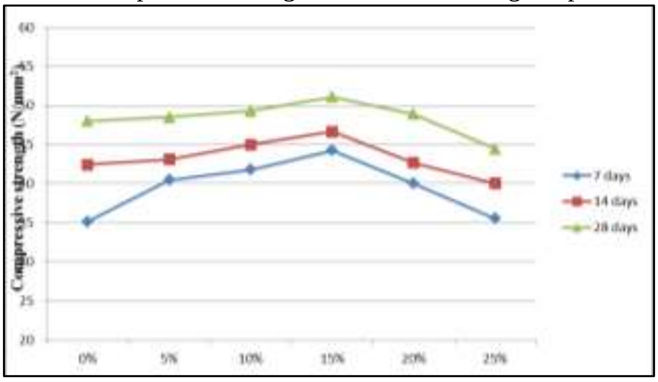

Fig. 4: Graph

B. Flexural Strength Test

For flexural test beams of 150×150×700 mm^3 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.

S.No.	Designation of Miix	Flexural Strength After 7 Days N/Mm^2	Flexural Strength After 14 Days N/Mm^2	Flexural Strength After 28 Days N/Mm^2
1.	**S-6%**	4.48	5.60	6.50
2.	**S-12%**	7.20	8.80	10.25
3.	**S-18%**	5.75	7.10	8.33

Table 5: Flexural Strength of SIFCON

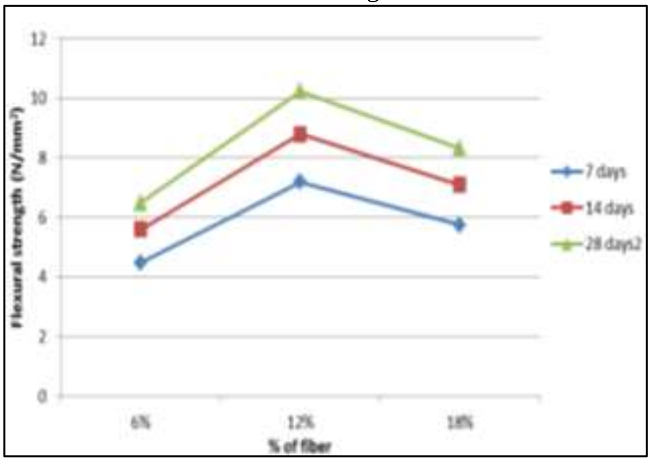

Fig. 5: Graph

As the Flexural strength of SIFCON is recorded maximum at 12% of steel fibre. Hence 12% of steel volume is considered as optimum fibre content.

S.No	Designation Of Mix	Flexural Strength Of 7 Days N/Mm^2	Flexural Strength Of 14 Days N/Mm^2	Flexural Strength Of 28 Days N/Mm^2

1.	S-0%	6.20	7.80	9.25
2.	S-5%	6.40	7.90	9.40
3.	S-10%	6.75	8.20	9.60
4.	S-15%	7.10	8.50	10.00
5.	S-20%	6.90	8.20	9.80
6.	S-25%	6.50	8.00	9.50

Table 6 flexural strength of SIFCON with glass powder

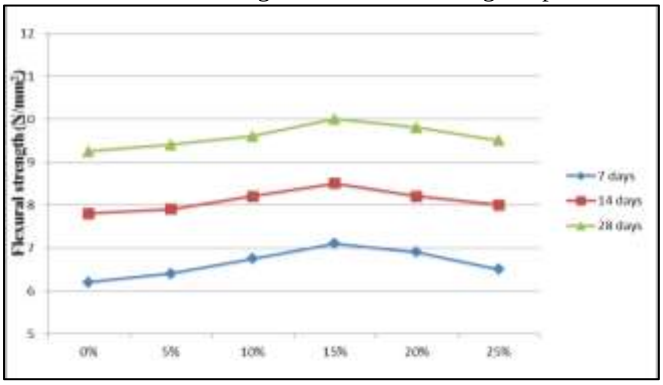

Fig. 6: Graph

V. CONCLUSIONS

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

A. *SIFCON in Compression*

It can be observed that the compressive strength increases with increasing volume percentages of fibre up to certain limit 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 48 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 51.11 N/mm^2 after 28 days of curing.

B. *Flexural Strength of SIFCON*

From the result it can be concluded that Flexural strength also increases with increases in percentage of steel fibre. It means addition of steel fibre definitely contribute the flexural strength up to a certain limit beyond 12% of steel fibre flexural strength decreases. Hence optimum strength is achieved 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 was recorded as 10 N/mm^2 after 28 days of curing.

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