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Research Paper

Flow characteristics of slurry infiltrated fibrous concrete (SIFCON) with silicafume and steel fibres

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ABSTRACT

SIFCON is one of the newly established buildings substantial. The proportion of silica fume additional was 17.5% through mass of cement in slurry infiltrated fibrous concrete & four various bulk segments of plain mild steel fibres, crimped mild steel fibres and hooked ended mild steel fibers (0, 5, 15, 25 and 35) % were utilized. The examined belongings of fresh slurry infiltrated fibrous concrete were normal slump cone test, reversed slump cone test, mini slump cone trial, J- fibres penetration test and L-box test test which were agreed out on usual magnitude of slump cones, J-box and L-box respectively at fresh state of SIFCON slurry (mortar). The spread flow diameter for standard slump cone, inverted slump cone and mini slump cone values up to 670mm, 650mm and 175mm respectively were obtained at fresh state of SIFCON slurry (mortar).

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1. INTRODUCTION

The core goal of this study was to learning the flow properties of SIFCON slurry (mortar). The investigated flow characteristics were normal fall cone exam, Reversed fall cone trial, small fall cone trial, J- fibre infiltration examination and L-box test. Every slurry infiltrated fibrous concrete matrix was organized by means of three kinds of steel fibers plain, hooked end and crimped mild steel fibres & includes four fractions of fibres, 0%, 5 %, 15 %, 25 % and 35 %. The aspect ratios of steel fibers were 50 to 56. For entire research, relative clarifications were completed inside grout slurry infiltrated fibrous concrete control mix, among the three kinds of slurry infiltrated fibrous concretes utilized, as fine as by a control mix of SIFCON. Henceforth, the possessions of the subsequent constraints on slurry infiltrated fibrous concrete durability were studied [1].

1. Fiber Contents.
2. Types of Fibres.

SIFCON is comparatively an innovative high concert and progressive substantial that varies from normal FRC in relations of manufacture and arrangement. Fiber content in FRC usually differs from (1 to 3) % by capacity, although the fiber contented of SIFCON can be anyplace from (4 to 20) % even though the present exercise choices from (4 to 12%, and when consuming hooked ended steel fiber with span greater than 30 mm the fiber contented choice among (4 to10) %. SIFCON mix has no coarse aggregates but a huge cementitious volume. It may comprise fine sand and mineral mixture such as silica fume, fly ash and latex mixtures. So, the mix of SIFCON is flowing cement mortar as opposite to normal concrete used in FRC. Also, the manufacture of SIFCON faraway from FRC which is formed by addition of fiber to the damp or thirsty concrete mixture. Although SIFCON is formed by primary scattering fibers into a mold till it is fully occupied, then the fiber link of SIFCON is penetrated by cement slurry [2], [3].

2. RELATED WORK

[4] SIFCON is a superior kind of fiber reinforced concrete with a free fiber matrix that gives the complex mix significant stretchable belongings and, due to its large fiber volume, SIFCON also has distinguishing and sole ductileness and energy absorption characteristics. [5] Advanced temperature fighting is one of the greatest significant constraints upsetting the resilience and service period of the substantial. In this study, the solidity strength and modulus of elasticity of SIFCON were examined both earlier and later contact to high temperatures. Two fire contact periods of 2 and 3 hours are observed. In adding to room temperatures, three temperature choices of 400°C, 600°C and 900°C have been presented.

[6] Have proposed the flow properties of SIFCON. Once the slurry infiltrated fibrous concrete was infiltrated, its spread width was restrained as 38cm. It was examining that it kept its flow ability in 45-50 minutes & lastly, its spread width was restrained as 30cm in 2hours. [7] Conferring to this outcome, the grout can be utilized roughly aimed at 1 hour. Slurry infiltrated fibrous concrete wants a pozzolanic substantial that will block cracks of very smaller particulate matter in binder glue and that it will donate strong point by making minor hydrates through pozzolanic response through the lime, which outcomes since prime hydration [8].

[9] In this journal, few mechanical characteristics of SIFCON samples are considered and they are related with normal grout. The cement-based slurry used in this study is a structure of cement, silica fume. From the outcomes attained it was found that SIFCON samples are much improved than normal mortar. [10] The compressive, unbearable, flexural characteristics and impact fighting for normal mortar and SIFCON samples were examined and also plotted. Thus, this learning displays that SIFCON can be used as an effective substitute in superior building resolutions or wherever the concrete or normal steel fiber reinforce concrete cannot achieve as predicted/essential or in circumstances where such high strength is significant. [11] Have examined the performance of mini slump cone flow behavior. The small fall movement & V-funnel trial, giving to EFNARC, were utilized to find the flow ability, spreading capability & stickiness of slurry. The small slump cone bottom width, upper width and elevation of small fall movement

exam device utilized are 100, 70 and 60mm. A range among 240 to 260mm flow diameter. V-funnel trial movement period among 7-11s.

[12] The compressive strength of cube is used as a plan variable for reinforced concrete structures in design standards. However, as the performance-based project is being used with growing variabilities and strengths of sample and reinforcement bars, mechanical characteristics other than the compressive strength of cubes are occasionally used as main strategy variable star. In specific, the estimation of the mechanical characteristics of sample is vital when consuming fiber-reinforced concrete. Lessons of high-volume segments in recognized compressive performance forecast equations are inadequate related to lessons of normal fiber-reinforced sample. Additionally, existing forecast equations for the mechanical characteristics of high-performance fiber-reinforced cementitious compound and high-strength material have restrictions in relations of the strength and features of contained fibers (diameter, length, volume fraction) even though the stress-strain association is calculated by these features. So, this learning established a high-performance SIFCON composite that could stop the fiber ball formation, a difficulty of normal fiber-reinforced matrix, and exploit the fiber volume percentage. Then, the behavioral characteristics below compressive strength was examined for fiber volume percentages of 4%, 5%, and 6%. [13] This study goals to lean-to light on the result of steel fiber form, length, diameter, and aspect ratio on the mechanical characteristics of SIFCON. This research contained of molding and testing three assemblages of SIFCON samples with 6% fiber volume percentages. The first cluster was reinforced with micro steel fiber, further reinforced by hook end steel fibers, while the latter group of samples reinforced by mingling two form of steel fiber as hybrid fiber (3% micro steel fiber +3% hook end steel fiber). Silica fume was used as a part replacement (10%) by mass of cement. 3.7% super plasticizer was used to cast the slurry grout sufficient to infiltrate through the fiber system, while the w/c ratio kept constant at 0.33.

[14] Developed the flow properties of SIFCON. In this trial reversed slump cone is occupied with grout & raised to an elevation of 1.0 m. For enough spreading capability absence bleeding and isolation essential spread width should be among 350mm to 380mm. usually, the amount of cement and fine river sand utilized in slurry infiltrated fibrous concrete are 1:1, 1:1.5 or 1:2 with w/c of 0.4. The samples were cast with fibre content of 2%, 3% and 4% by bulk portion.

2.1 Research Significance (Aim of the Research)

The objective of the study work is to find the

2.1.1 Fresh SIFCON Properties

1. Normal fall cone trial
2. Reversed fall cone trial
3. Mini slump cone test
4. L box test
5. J fibre penetration test

2.1.2 Mix Proportions

The mortar mix proportion and mixture percentage as tabulated in Table 1.

Table 1. Mortar Mix Proportion

Description	Type	Quantity with Units
Cement	Type-OPC 53grade as per IS 12269-Maha Cement	1000 kg/m^3
Cementitious material	Silica fume	175.1 kg/m^3
Fine Aggregate	Fine Aggregate (0-1.18mm)	835kg/m^3
H_2O	Potable	387 kg/m^3
w/c ratio	-	0.329 kg/m^3
Admixtures-Super plasticizer	PC based	1.399% of cementitious materials by weight

Mini slump flow	Inverted slmp cone Bottom dia=100mm, Top dia = 70mm and Height = 50mm.	282mm
Fibres	PMSF, HEMSF, CMSF	0%, 5%, 15%, 25% &35%.

2.2 Constituents

Cement the cement used in entire mixes of this research was normal port-land cement 53Grade – Maha cement. The physical & mechanical characteristics of the cement utilized are itemized in Table 2 & its biochemical configuration is obtainable in Table 3.

Table 2. Physical and Mechanical Characteristics of the Cement

Density	**3.12 g/cm^3**
Fineness	4.9%
Standard consistency	34%
Soundness	0.7 mm
Setting time: Initial Final	 32 min 568 min
Cube strength: 3 days 7 days 28 days	 38MPa 48MPa 60 MPa
Specific gravity	4.9%
Specific Surface	327m^2/kg

Table 3. Chemical Investigation of the Cement Utilized in the Research

Oxides	**CaO**	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**MgO**	**K_2O**	**Na_2O**	**CaO (Free)**	**SO_3**
Content (%)	67.01	18.90	4.74	3.03	1.76	0.70	0.51	1.15	2.2

2.3 Silica Fume

The silica fume (SF) used in this study obeys to the ASTM C1240-15 rations, and the chemical structures of it are also specified in Table 4.

Table 4. The Characteristics of Silica Fume

Constituents	**Quantity (%)**
SiO_2	85.54
Al_2O_3	0.37
Fe_2O_3	1.91
CaO	1.4
LOI	3.40
Moisture content	1
Carbon	1
MgO	0.51
K_2O	0.49
Na_2O	0.21
SO_3	0.14

2.4 Fine Aggregates

Fine aggregate through a supreme magnitude of 1.18 milli meter is used as fine aggregate for SIFCON.

Table 5. Outcomes of Specific Gravity & Absorption of Fine Sand

Description	Fine Aggregate
whole specific gravity	2.60
Absorption volume (%)	2.51

Figure 1. Fine Aggregate

Table 6. Fine Aggregates Grading

Data	Passing (%)	Retained Weight (g)
4.75	97.3	26.5
2.36	90.9	65.4
1.18	69.8	210
0.6	31	388
0.3	5.9	251
0.15	1.3	46
0.075	0.5	8
pan	-	5

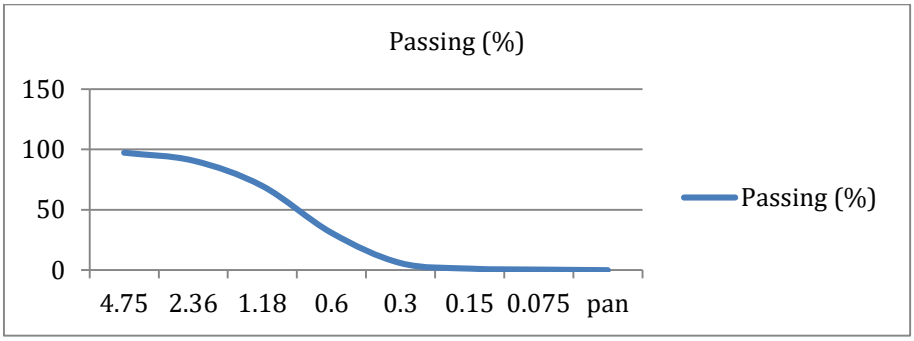

Figure 2. Grading curve of Fine Aggregate

2.5 Water

The SPIHER Site tap water was used as the mixing of SIFCON. It is potable, pure and outwardly fresh, and does not hold any constituents at extreme sums that can be harmful for production of SIFCON. But distilled water was utilized in mixing sodium chloride solution for chloride penetration tests.

2.6 Admixture

One of the best super-plasticizers was utilized in the research. It is a high choice water dropping super-plasticizing admixture called Polycarboxylate ether & collected from Astra Chemicals Ltd. Polycarboxylate ether is a ready-to-utilize, chloride free, liquid admixture which encounters ASTM C 494 necessities for kind A & F admixtures. This super plasticizer was utilized for grout slurry infiltrated fibrous mix blends wherever flowing characteristics were mandatory & for the control SIFCON blend since the minimum w/c ratio. The other hand, there remained no necessity to utilize any super-plasticizer in grout slurry infiltrated fibrous blends [15].

2.7 Steel Fibers

Table 7. Specifications of Steel Fibers Used in the Experimental Work (As Provided by the Manufactures)

Description	Length of Fibre, L (Milli Meter)	Diameter of Fibre, D (Milli Meter)	Aspect Ratio of Fibre, Length/Diameter	Tensile Stress of Fibre (N/Mm^2)
Plain Mild Steel Fibres (PMSF)	25	0.5	50	2585
Hooked End Mild Steel Fibres (HEMSF)	50	0.9	56	1345
Crimped Mild Steel Fibres (CMSF)	50	0.9	56	1100

3. METHODOLOGY

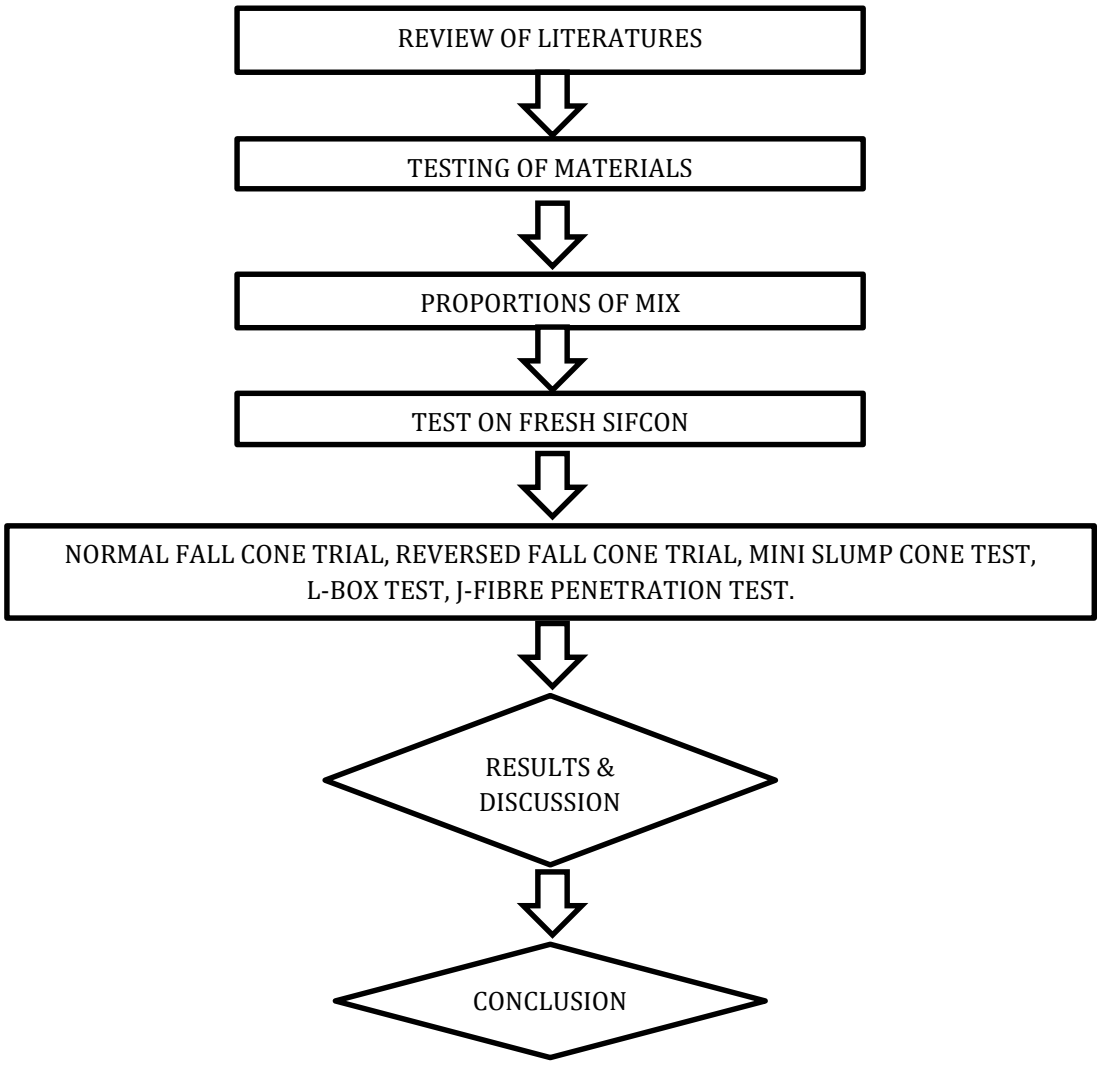

Figure 3. Flow Chart of SIFCON Experimental Program

4. RESULTS AND DISCUSSION

4.1 Standard and Inverted Slump Cone Test

To verify the Flexibility, stickiness & filling capability without flow and isolation of cement grout, slump movement exam was directed. In this trial reversed slump cone is occupied with grout slurry and

elevated to an elevation of 1.0 m. The width of flow grout engaged on plain outward is measured in 2 commonly perpendicular orders.

The middling of these 2 is booked as the width of slump flow. For enough filling capability without flowing and isolation essential flow width should be among 650 mm to 670 mm. Movement trial on new cement grout to be utilized in manufacturing slurry penetrated fibrous concrete samples were agreed out with changing proportions of steel fibres variations. Assessment of fresh mix is important to manufacture of SIFCON matrix. This matrix would be enough liquidness & consume sufficient quality to infiltrate the network fiber matrix. A slump funnel did it placed in a fair plate with thickness at least 2 milli meter. Slump trials were booked to locate the flexibility of all mixtures [16].

- Normal Slump cone test (D=150mm and H=300mm)
- Spread diameter was measured at least 3 to 4 places.

Spread diameter is 600+10mm and the slump value was 282mm

Table 8. Result of Standard Cone Slump Flow Test

Test Method	Result	EFNARK	ACI237R-07
Standard & Inverted Cone Slump flow in mm	660	650-800	450-760

4.2 L-Box Test

L-shape movement trial apparatus shall be prepared with an upward door to stop the movement of mix through the testing. The upward door shall be finished of a solid that is not bent or spoiled through the testing of mix or when raised up. Measure the extreme value of the L-shape and subsiding does the trial to the near (1 mm) and rounded off to the near 5 mm as shown in the table that shows the two procedures handled. These two-study conferring to references. Table 5 show investigated outputs [17].

Table 9. Investigated Outputs of Fall Movement and L-Shape Movement Assessment

Test Method	Result	EFNARK	ACI237R-07
L Box test (H1/H2)-PMSF	0.95	0.8-1	0.8-1
L Box test (H1/H2)-HEMSF	0.90	0.8-1	0.8-1
L Box test (H1/H2)-CMSF	0.85	0.8-1	0.8-1

4.3 J-Fibre Penetration Test

J-fibres infiltration test (J-FIT) is an innovative examination way it was technologically advanced to assessment the capability of cement grout to movement over the fibre build. The knowledge of this examination is to pattern the capability of a grout to movement over fibers and stabilize itsown at a flat near.

The opening of the device is locked and the segment for fibers is occupied with a casual transfer of 1.9 kg of fibers. Grout is prepared into the developed post of the apparatus, where no fibres are existing, to an elevation of 471 mm. Grouts with developed flexibility among 110 & 210 milli meter. The determined number of fibres and cement mortar stretches the similar exam state. Later manufacturing the cement slurry into the J-fiber infiltration examination the gate is raised and the cement slurry is permitted to permit over the fibers. The model is demolded succeeding daytime. The elevation of cement mortar which remnants in the developed post later raising the gate is measured & related [18].

4.4 V-Funnel Test

The test assesses the stickiness of grout was V-funnel trial, a movement period among (6-12) seconds is accounted proper.

5. CONCLUSION

Characteristics of SIFCON in new state in normal fall pinecone test (D=150mm & H=300mm) of Flow value for flow diameter 660+11mm and the slump value is 283mm. For small slump pinecone trial

(Bottom Diameter =100mm, Top Diameter =70mm and Height=50mm) the flow value for flow diameter 176+11mm & the slump value is 39mm. Hence mix is thin & it is utilized for repair & rehabilitation of constructions, self-compacted mix in closely reinforced area, prefabricated member intersections and slurry infiltrated fibrous concrete laminate preparations. L Type flow ranges are in between 0.8 to 1. Hence it was flow able concrete. J Fibre Penetration Test Slurries with higher fluidity between 110-210mm. V-funnel trials, a movement period among (6-12) s is measured proper. The addition of silica fume, fine sand and super-plasticizer was increased flow properties of SIFCON.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Dr. P Sampath	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	
Dr. P Asha		✓		✓		✓		✓	✓			✓		✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Informed Consent

All participants were informed about the purpose of the study, and their voluntary consent was obtained prior to data collection.

Ethical Approval

Not Applicable.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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