

# Strength and Durability Properties of SIFCON with Silica Fume and Waste Binding Wire

P.Sampath, P.Asha

## HIGHLIGHTS

*The tensile performance of SIFCON subjected to high volume of 35% fibre was investigated.*

*Significant loss of strength in less fibre percentage was observed.*

*The fibre percentage is greater than 35% it results in non - accommodate (space) volume of specimen.*

*The fine aggregate was used between 0-1mm gives excellent strength.*

**ABSTRACT---** Slurry infiltrated fibrous concrete (SIFCON) is one of the starting late made movement material that can be considered as interesting kind of high performance fiber reinforced concrete (HPFRC) with higher fiber content. In this examination on SIFCON normal port land concrete is displaced by 15% by weight of Silica Fume (SF) and five explicit steel fiber volumes of Plain Mild Steel Fiber (PMSF) 0%, 5%, 15%, 25%, and 35% are used. The silica fume substitution is proceeded with persistent 15% by weight of concrete on the mechanical properties of SIFCON have been gotten some information about. As showed up by the results extending of fiber volumes makes apex weight. The compressive quality for PMSF35 at 28 days is 42.08MPa, the split inflexible nature for PMSF35 fiber of at 28 days is 5.7MPa, the brief versatility for PMSF35 at 28 days is 4.06MPa and ultrasonic heartbeat speed an assistance for 3D square for PMSF35 at 28day is 4.4 km/s and for PMSF35 fibered chamber at 28 days quality is 4.9km/s uninhibitedly.

**Key words:** SIFCON; Fiber reinforced materials; Silica fume; Admixtures; Mechanical properties; Composite; Steel fiber; Composites

## I. INTRODUCTION

Mental doing battling exchange offs human life and furthermore clobbers entire essential structures by shelling or rocket trap. One of promising materials which has a higher effect and impact check is explicit sort of high execution fiber reinforced cementitious composites[1,2,3]. Antonie E. Naaman and Joseph R. Homrich,[4] empowered high or ultra-high strength concrete with especially high compressive strength respects stays on an exceptionally essential dimension a tricky composite. The joining of adequate fibers improves rigid nature and thusly gives versatility [5,6,7]. SIFCON is a phenomenal sort high execution composite material which associations 5%-30% steel fiber volume by putting the steel fibers into a

formwork and after that ambushing fine total and concrete rich flowable slurry to coat the fibers [8,9]. The structure in SIFCON has no coarse aggregates regardless it might contain fine sand of 0-1mm and included substances, for example, silica rage. All steel fiber types unequivocally straight plain sensitive steel fiber can be utilized [9, 10]. The fibers are appeared to beating and mechanical interlock paying little personality to the bond with the framework [11]. The structure expect the movement of exchanging the powers between fibers by shear yet also goes about as bearing to keep fibers interlock. Slurry-trapped stringy concrete (SIFCON) is an all around new material that can be considered as a superb sort of fibers-reinforced concrete (FRC). In two of view explicitly fibers content and the structure for period of SIFCON isn't generally ascend to would be normal FRC. Slurry-struck solid concrete (SIFCON) has stunning mechanical properties united with coherently discernible centrality support characteristics [12, 13]. In SIFCON, the structure is made of spouting bond mortar slurry rather than full scale concrete in standard fiber-reinforced concrete. The hurling structure is in like way wonderful for SIFCON. If all else fails, SIFCON is made by assaulting a bed of pre-put fibers with bond slurry. There are four focal structure factors that ought to be considered in a SIFCON thing these are slurry strength, fiber volume, fiber approach and sort of fiber. The fiber volume relies upon the fiber type and the vibration exertion required for sound compaction. Intelligently minute or shorter fibers may pack denser than longer fibers and higher fiber volumes can be cleaned with wary and charming vibration. SIFCON has overwhelming mechanical properties, for example, compressive, versatile with phenomenal strength respects (Energy Absorption) [14]. Other than effect safe military structures, major sturdiness property demonstrates the cutoff of utilizing SIFCON in current floors and strengthening works [15, 16, 17, 18]. In addition, the impact of steel fiber morphology, type and improvement length on fiber-structure bond characteristics has been inspected [11, 19].

Despite their beginning and end contemplated high cost, high execution fiber reinforced bond based composites are utilized significantly more extensively wherever all through the world particularly in seismic retrofit plan and in the structures under dangerous and effect impacts. The fiber volume division of standard fiber reinforced concrete and ultra-high execution fiber reinforced concrete is routinely obliged to 1-3% Parameswaran et al [20], SIFCON is novel development material having high strength likewise as giant flexibility and far amazing potential for key applications when off the cuff loads are found out about the focal point of affiliations [13, 21]. It can in like way be utilized to the key methodology of parts appeared to endeavor and powers like breeze and tremor [16].

Manuscript published on 28 February 2019.

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Recorded as a printed structure chart of 2015 arranged research has been done to build up the high execution fiber reinforced in various nation under various climatic conditions, questions, and materials, and so on. The course of action of assaulted layers of steel fibers with Portland concrete based materials was first proposed by Haynes 1968. Lankard [22] 1979 adjusted the technique utilized by Haynes and demonstrated that if estimation of steel fibers in concrete structure could be expanded, one could get a material with strikingly high strength properties which he submitted as SIFCON. He demonstrated the focal properties of SIFCON, for example, load-redirecting curve and overly compressive strength. In any case, making study uncovers that a no work has been done on SIFCON to pick the strength attributes [14]. The central tests are Lambardi plate connection meter, J-Fiber entrance test [23]. Fibers are set in parallel, reverse and strange to chamber point of view and thought the break significance of SIFCON [24].

Because of the interlocking impact of high volume of steel fiber, making SIFCON with standard blending systems is past the locale of innovative noteworthiness. Managing this issue, the fibers are pre-put in the formwork molds to its full compel. By then coming about fiber structure is penetrated by security based slurry [9, 25, 26]. Interruption is dependably made by gravity stream together with light vibration or by weight grouting [9, 27].

As appeared by the piece survey, it has been esteemed that paying little character to the path that there are different examinations on the high strength concrete (HSC), and high strength fiber reinforced concrete (HSFRC) at any rate here spotlights research considers on SIFCON is inconceivably less. Which is driven in this examination, it is relied on to utilize steel fiber in the range 5-35% yet all examination paper which is restricted to 30% in past research works [7].

**II. EXPERIMENTAL PROGRAM**

*2.1 Research Significance (Objectives of the study)*

To pick the quality attributes of control blend (without steel fiber) and to pick the quality properties of SIFCON with a substitution of bond by silica fume and plain steel strands. The parameters concentrated are compressive quality, split firm nature, direct adaptability, strength and quality from Non Destructive Test (NDT) estimations of Ultrasonic Pulse Velocity (UPV) quality properties for 3D squares and chambers are concentrated to survey the quality [28].

*2.2 Physical and built properties of materials*

The physical, built and mechanical characteristics of Ordinary Portland Cement and Silica Fume (SF) utilized in this examination are displayed in Table 1 and 2. The various sizes (0 – 1 mm) of fine total of standard occupy sand were utilized in the blend plan. The specific gravities of fine total and silica fume were 2.60 and 2.33, respectively. A polycarboxylate ether type super plasticizer (SP) was utilized. Steel fiber with 0.5 mm separate over, 22.5 mm length, aspect degree 45 and 1100MPa flexibility was utilized. Blend degrees of specimen is given in Table 3. The water/folio (W/B) degree (0.33) was picked for this examination. The silica fume substitution is proceeded with

clear as 15% by weight of bond. Dry fixings were premixed for two minutes to accomplish homogeneous dry parts. By at that point, the blending water was being blended with the required level of super plasticizer and a brief span later, filled the blend.

**Table .1**  
**The physical characteristics of ordinary port land cement**

Initial setting time	32 min
Final setting time	568 min
Standard consistency	34%
Specific gravity	3.14
Fineness of cement	4.9%

**Table 2**  
**The characteristics of silica fume**

Constituents	Quantity (%)
SiO <sub>2</sub>	90.04
Al <sub>2</sub> O <sub>3</sub>	0.37
Fe <sub>2</sub> O <sub>3</sub>	2.11
CaO	1.5
LOI	4.05
Moisture content	0.8
Carbon	1.1

**Table 3**  
**Mortar mix Proportion.**

Description	Type	kg/m <sup>3</sup>
Cement	Portland (Type )	1000
Pozzolan	Silica fume	175
Fine Aggregate	Sand (0-1mm)	835
Water	Pure	388
w/cm	-	0.33
Super plasticizer	Polycarboxylate Ether	1.4% of cementitious materials by mass

**III. RESULTS AND DISCUSSION**

*3.1 Properties of SIFCON in fresh state*

(I) Standard Slump cone test (150mmD and 300mmH) Stream an awakening power for stream separate crosswise over 600+10mm and the hang respect is 282mm.

(ii) Mini hang cone test (Bottom D=100, Top D=70mm and H=50mm) Stream an assistant for stream breadth 175+10mm and the hang respect is 38mm. Consequently composite is lean and it is used for fix and changing of structures, self-compacted concrete in tenaciously propped region, precast part joints and SIFCON spread preparations.





Photograph 1- Mixing and Minislump cone test

### 3.2 Properties of SIFCON in hardened state

#### 3.2.1 Compression test

Weight test is the most clear test driven on set bond since it is an important test to perform and overwhelming characteristics properties of composites are outstandingly related to this compressive quality. The mortar of bond and sand is set up in the degree as 1:0.711. water to folio degree is 0.33. The mortar set in molds having sorts of 3D squares with side as 70mm [4]. zhe mortar, bouncing out at being set in molds, is compacted in vibrating machine for 2 minutes. The specimens are removed from the molds and they are submerged in clean water for engaging. The shapes are tested at 3 years of age days, 7 days, 14 days, 28 days, 56 days and 90 days The compressive quality at all fundamental stacks of PMSF35 fibered composites are higher than the specific fiber substitution composites and control mix. The most insane compressive quality for PMSF35 at 28 days respect is 42.08MPa.

The compressive strength variation at 28 days of curing of SIFCON cube specimens are for 0%, 5%, 15%, 25% and 35% are 22.85, 31.02, 36.42, 40.31, 42.08 (N/mm<sup>2</sup>) and the percentage of strength increments with respect to



Photograph 2 Curing of Specimens

Fig.1 Compressive strength control mix are 36%, 59%, 76% and 82%.

The compressive strength variation at 90 days of curing of SIFCON cube specimens are for 0%, 5%, 15%, 25% and 35% are 48.44, 48.98, 49.99, 55.51, 56.73 (N/mm<sup>2</sup>) and the percentage of strength increments with respect to control mix are 1.1%, 3.2%, 14.6% and 17.1%.

#### 3.2.2 Split tensile test

The mortar placed in molds having forms of cylinders with size as 75mm diameter and 150 mm height. The mortar, after being placed in moulds is compacted in vibrating machine for 2 minutes. The specimens are removed from the moulds and they are submerged in clean water for curing. The cubes are then tested in compression testing machine at the end of 3 days, 7 days, 14 days, 28 days, 56 days and 90 days.

The split tensile strengths at all days for the 35% fibered concrete are higher than all the other fiber replacement concrete and control mix. The maximum split tensile strength for PMSF35 fibered concrete at 28 days value is 5.7MPa.

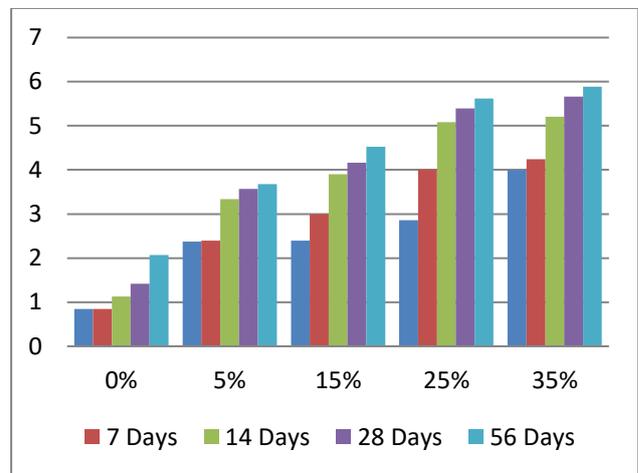


Fig.2 Split tensile strength

The Split tensile strength variation at 28 days of curing of SIFCON cube specimens are for 0%, 5%, 15%, 25% and 35% are 1.42, 3.57, 4.16, 5.39, 5.66 (N/mm<sup>2</sup>) and the percentage of strength increments with respect to control mix are 151%, 193%, 276% and 299%.

The Split tensile strength variation at 90 days of curing of SIFCON cube specimens are for 0%, 5%, 15%, 25% and 35% are 3.15, 4.75, 4.81, 5.82, 6.34 (N/mm<sup>2</sup>) and the percentage of strength increments with respect to control mix are 51%, 53%, 85% and 101%.



Photograph 3- Compressive Strength

3.2.3 Toughness

Quality test is enabled on canine bone specimen with size 330 x 50 x 20 mm. The mortar, in the wake of being set in molds, is compacted in vibrating machine for 2 minutes. The molds are set in a soaked cabin for 24 hrs. The specimens are ousted from the molds and they are submerged in clean water for reestablishing. The quality is created by zone under the bend in power keeps up a key partition from stroke outline.

Table 5

Toughness

Specimen ID	Toughness Value (Nm)
CM	1396
PMSF5	4937
PMSF15	5041
PMSF25	20971
PMSF35	48747

The quality is the condition of being acceptably masterminded to withstand negative conditions or grievous regulating and the capacity to control hardship or to change in dangerous conditions. The possibility of PMSF35 was the most essential of all point of view and saw to be 48747Nm. It is higher than CM, PMSF5, PMSF15 and PMSF25 by estimation of 0%, 5%, 15% and 25% independently. Quality respect is broadened concerning the high fiber volume utilize and most silly respect is obtained for 35% fiber substitution by the enormity of bond. High toughened SIFCON composites are utilized to seismic and sway safe structures, fix and changing of structures, high weight withstand structures, precast part joints, diminish top recovery, military applications, for example, adversarial to rocket holders, underground safe houses, flying driving stages, fortifying of bar region joints, and so on.,

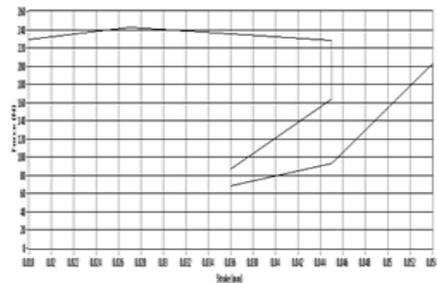


Fig. 3. Force vs Stroke of control mix (CM)

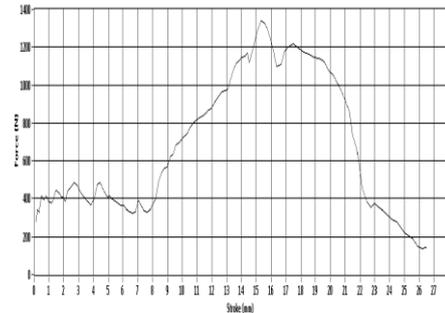


Fig. 4. Force vs stroke of PMSF5

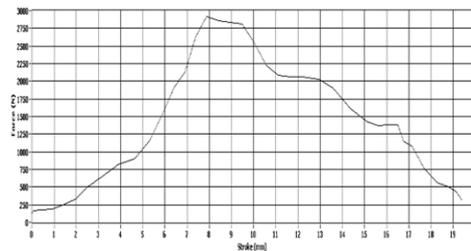


Fig. 5. Force vs Stoke of PMSF15

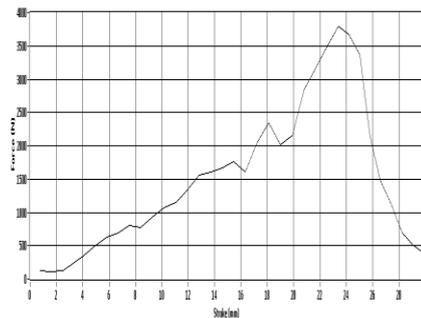


Fig. 6. Force vs Stoke of PMSF25

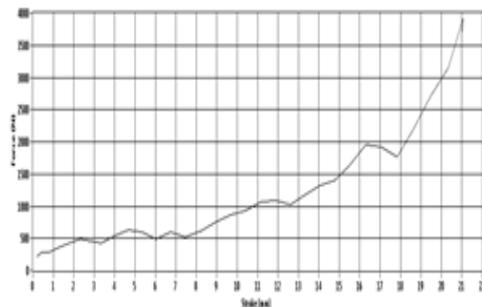


Fig.7. Force vs stoke of PMSF35

3.2.4 Direct tensile test

The mortar placed in moulds having forms of dog bone specimen with size as 330 x 50 x 20 mm.

Table 6

Direct tensile strength

Specimen ID	Ultimate tensile strength (MPa)
CM	0.23
PMSF5	1.37
PMSF15	2.75
PMSF25	3.77
PMSF35	4.06

The direct tensile strengths at 28 days for 35% fibered concrete is 4.06MPa are higher than all the other fiber replacement concrete and control mix.

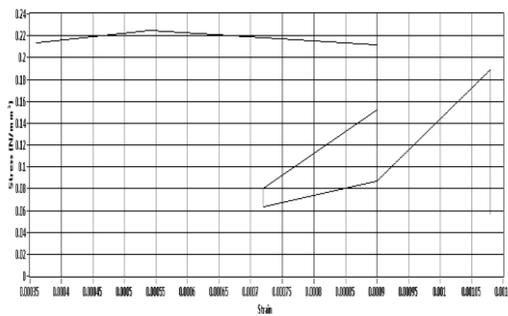


Fig.8. Stress vs Strain of control mix (CM)

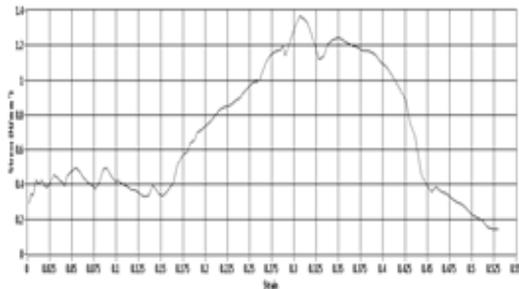


Fig. 9. 5% Plain steel fiber stress vs strain

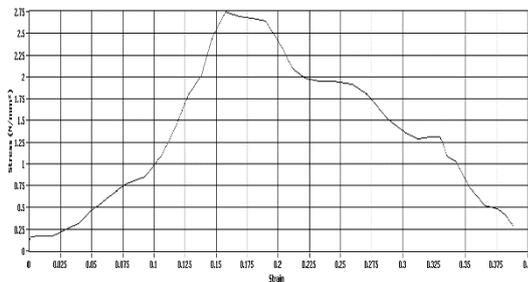


Fig.10. 15% Plain steel fiber stress vs strain

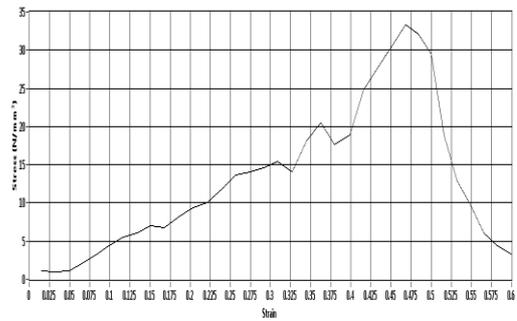


Fig. 11. Stress vs strain of PMSF25

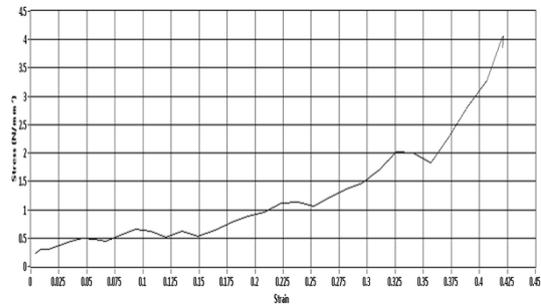


Fig.12. Stress vs Strain of PMSF35

IV. ULTRASONIC PULSE VELOCITY TEST

In this test structure, the ultrasonic heartbeat is made by the transducer which is held in contact with one surface of the strong part under a test. In the wake of examining a known way length (L) in the strong, the beat of vibrations is changed over into an electrical sign by second transducer held in contact with various surfaces of the strong part and an electronic sorting out circuit associates with the improvement time (T) of the beat to be evaluated. The beat speed (V) is given by  $V=L/T$  (km/s). Bond is term of consistency, rehash or nonattendance of inside blemishes, parts and partition, etc average for the fragment of workmanship used, would thusly have the decision to be assessed using the principles given in the table underneath which have been made for depicting concrete in structures the degree that the ultrasonic heartbeat speed.

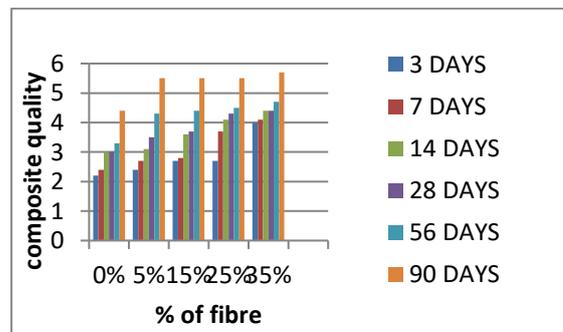


Fig.13 Ultrasonic pulse velocity value for cube specimens

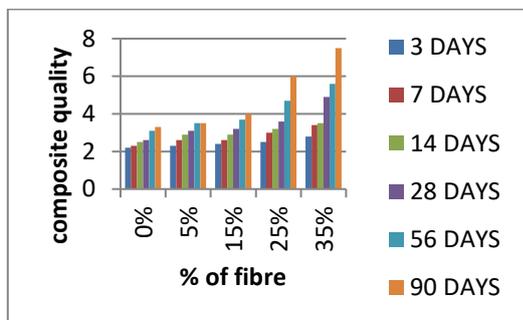


Fig.14 Ultrasonic Pulse velocity value for cylinder specimens

For all the piece of fiber at 28 days of restoring the astounding thought of solidarity was come to. In light of the no of broad stretches of restoring the UPV quality was extended. The apex respect was in PMSF35 of 3D square is 4.4km/s and for chamber is 4.9km/s. Along these lines the probability of PMSF35 obviously is amazing.

## V. CONCLUSION

By getting reasonable part of plain steel strands of 0%-35% with lacking substitution of bond by silica fume in various volumes, the mechanical properties can be improved.

Working up the piece of fiber in solid augmentations compressive quality, split adaptability, direct steady nature and nature of SIFCON wrapped up. The compressive quality at 28 days that displays the fiber results most inconceivable respect 42.08MPa with the extra substance of plain tricky steel fiber PMSF35.

The split flexibility at 90 days that demonstrates an estimation of 6.3MPa with PMSF 35% plain smooth steel fiber.

The short flexibility at 28 days that shows an estimation of 4.1MPa with PMSF 35% of steel fiber.

The quality estimation of ultrasonic heartbeat speed respect is 5.7km/s for square and 7.5km/s for chamber in the wake of including PMSF 35% of steel fiber, from this time forward the outcome is stunning for heartiness.

In setting on the examination did, the making in quality as for control blend is about 1.2 occasions for compressive quality, on different events for split flexibility, on various events for direct inflexible nature, 1.3times for ultrasonic heartbeat speed perfectly healthy, 2.3times for ultrasonic heartbeat speed in chamber.

Subsequently it is recognized that 35% usage of plain smooth steel fiber gives splendid quality in bond for all types of tests.

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