# Experimental Study on Sifcon with Glass Fiber

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*Abstract*— **Concrete is a composite material used in construction. Next to water, concrete is the most used material worldwide for construction of any desired shape or different structure. Concrete has low strength, low ductility and energy absorption. Different concrete require different degrees of durability depending on the exposure environment and properties desired. Concrete ingredients, their proportioning, placing and curing practices, and the service environment determine the ultimate durability and life of concrete. For this purpose to improve the concrete toughness and reduce the amount of defects by adding a some fibers to the concrete for this situation SIFCON type concrete is preferred and the fiber are uniformly distributed and it is different from fiber reinforced concrete (FRC). Slurry-infiltrated fibrous concrete (SIFCON) can be considered as a special type of fiber concrete with high fiber content. The fiber content of FRC generally varies from 1to3 percent by volume, but the Fiber content of SIFCON varies between 5 and 20 percent. The network is then infiltrated by a fine liquid cement-based slurry or mortar. It is not having coarse aggregate only have cement and sand or any cementitious material. In view of the above, the objectives of this study are to investigate and provide information about strength of SIFCON, mainly resistance to abnormal loads, impact loads and earthquake loads. Here straight stainless steel and E type glass fiber are used with different volume of fraction, i.e. 6%,8%,10%,12% and cement, sand, fly ash are used 1:1:0.5. The compressive strength of SIFCON is increased 26% when comparing to M30 concrete.**

***Keywords— Strength, Infiltated, Impact load, Durability, Slurry, Glass fiber, Toughness.***

## I. INTRODUCTION

SIFCON contains relatively high cement and water contents when compared to conventional concrete. Although it is still a relatively new construction product, SIFCON has been used successfully in a number of areas since the early 1980's. Some of those applications are explosive-resistant containers, security blast-resistance vaults, and repair of structural components, bridge decks, airfield pavements and abrasive-resistance surfaces. Most of previous research work on SIFCON found by literature survey has focused mainly upon studying the mechanical properties of this unique material. The research work in this area included, for example, behavior under different loading conditions, crack propagation, toughness, ductility or energy absorption, elasticity in tension and compression. On the other hand, the research work undertaken in the field of durability of High Performance Fiber Reinforced Concrete Composites (HPFRCC) in general is quite limited, and covers only few types not including SIFCON.

The main differences between FRC and SIFCON, in addition to the clear difference in fiber volume fraction, lie in the absence of coarse aggregates in SIFCON which, if used, will hinder the infiltration of the slurry through the dense fiber network.

### *A. Composition of Sifcon*

Proportions of cement and sand generally used for making SIFCON are 1:1, 1:1.5 (or) 1:2 cement slurry alone have some applications. Generally, fly ash (or) silica fume equal to 10 to 15% by weight of cement is used in mix. Water cement ratio varies between0.3 to 0.4. Percentage of super plasticizers varies from 2 to 5% by weight of cement. The percentage of fibers by volume can be anywhere from 4 to 20% even though the current practical ranges from 4 to 12%.

## II. PROCESS OF MAKING SIFCON

The process of making SIFCON is different, because of high steel fiber content. While in SFRC the steel fibers are mixed intimately with wet (or) dry mix of concrete, prior to mix being poured into forms. SIFCON is made by infiltrating low viscosity cement slurry in to a bed of steel fibers “pre packed” in forms (or) moulds.

The design methods for SIFCON members must take into account their application (or) end, the property that needs to be enhanced, minimum proportion, strength as well as its constructability and service life.

### *A. Factors Consideration*

There are four following factors consider when evaluating a SIFCON specimen. These are slurry strength, fiber alignment, fiber type, fiber volume.

### *B. Advantages*

- It has excellent durability, impact, abrasion and earthquake resistance.
- Young’s modulus (E) is compared to normal concrete and exhibits high ductility.
- Deflection is very less in compared to conventional concrete.

- The unit weight of SIFCON is varying from 2160 kg/m$^3$ to 3130 kg/m$^3$.

### C. *Application area*

- Pavement rehabilitation and pre cast concrete products.
- Overlays, bridge decks and protective revetments.
- Seismic and explosive resistant structures.
- Security concrete applications.(safety vaults, strong rooms)
- Refractory applications. (soak-pit covers, furnace lintels, saddle piers )
- Sea protective works

## III. MATERIALS USED

The making process of SIFCON consider different ingredients such as cement, fine aggregate, fly ash, high range water reducing admixture named conplast SP- 430. Here class F fly ash used.

### A. *Cement*

Ordinary Portland cement 53 grade is used with 3.15 specific gravity and fineness of cement is 4.8%. The initial and final setting time of this cement is 31 and 570 minutes.

### B. *Fine aggregate*

Natural River sand as used and it is passed through 600 µ to retain 300 µ sieves. The specific gravity of sand is 2.65.

### C. *Water*

Portable water is used. Then it have pH value of 6 to 8 range.

### D. *Superplasticizer*

Brown colored conplast SP- 430 superplasticizer used and reduce water content about 25%.

### E. *Fly ash, Steel & Glass fiber*

The class f fly ash used with fineness is 3200 cm$^2$/gm. Fly ash passing through 300 µ sieve taken. The stainless straight steel fibers are used. E type glass fiber used for achieving more strength. Table I gives the properties of steel and glass fiber. Figures 1 and 2 shows the shape of fibers.

TABLE I. PROPERIES OF STEEL AND GLASS FIBER

| Properties | Steel | Glass |
|---|---|---|
| Diameter (mm) | 0.33 | 0.33 |
| Length (mm) | 25 | 25 |
| Youngs modulus KN/mm$^2$ | 2.1 | 7.2 |
| Aspect ratio (L/D) | 75 | 75 |
| Unit weight kg/m$^3$ | 7850 | 2540 |

Fig. 1. Stainless Steel Fiber

Fig. 2. E type Glass Fiber

## IV. MIXPROPORTION AND CASTING OF SPECIMENS

The four SIFCON mixes are used with ratio of 1:1:0.5 such as cement, fine aggregate, and fly ash. The glass is kept 1% volume of fraction and steel fiber only having the various volume of fiber fraction i.e.5%,7%.9%.11%. Table 2 and 3 shows the mix proportion of SIFCON and M 30 concrete. In all four mix water-cement ratio (w/c) is 0.45 and 2% superplastizicer used.

TABLE II. SIFCON MIX PROPORTION

| Mix no | Cement | FA | Fly ash | Steel % | Glass% |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 0.5 | 5 | 1 |
| 2 | 1 | 1 | 0.5 | 7 | 1 |
| 3 | 1 | 1 | 0.5 | 9 | 1 |
| 4 | 1 | 1 | 0.5 | 11 | 1 |

TABLE III. M 30 CONCRETE MIX

| Cement | FA | w/c | CA |
|---|---|---|---|
| 1 | 1.54 | 0.45 | 2.62 |

### A. *Mould preparation*

150mmX150mmX150mm cube mould, 150mmX300mm cylinder and 400mmX100mmX100mm prism moulds are used to determining the mechanical properties of SIFCON and M30 concrete.

*B. Mix process*

- The moulds are free from dust and grease or waste oil applied to mould for easily demoulding purpose.
- First the steel and glass fibers are preplaced in the mould and it is different from normal FRC.
- After cement, fine aggregate, fly ash and water is prepared correct quantity and mixed with superplastizicer.
- The slurry or mortar is formed. This slurry is poured through pumps or directly poured into the mould.
- Hand compaction or vibrated for infiltration process and finally SIFCON specimens are casted.

*C. Demoulding and Curing*

- The test specimens are reached harden stage, it is demoulded after 24 hours from casting process.
- Specimens are named or marked with paints and cured 28 days.

## V. TEST RESULT AND DISCUSSIONS

An experimental investigation is carried out to determine or study the mechanical properties of SIFCON concrete and results are compared to nominal concrete. The mechanical properties of concrete are cube compressive, split tensile and flexural strength.

*A. Compression Strength Test*

The bearing surfaces of the testing machine are wiped clean and the cube are placed in the machine in such a manner that the load is applied to side face of the cube as cast. The load was continued the dial gauge needle reverse to its direction of motion.

The compressive strength of SIFCON is shown in figure 3.

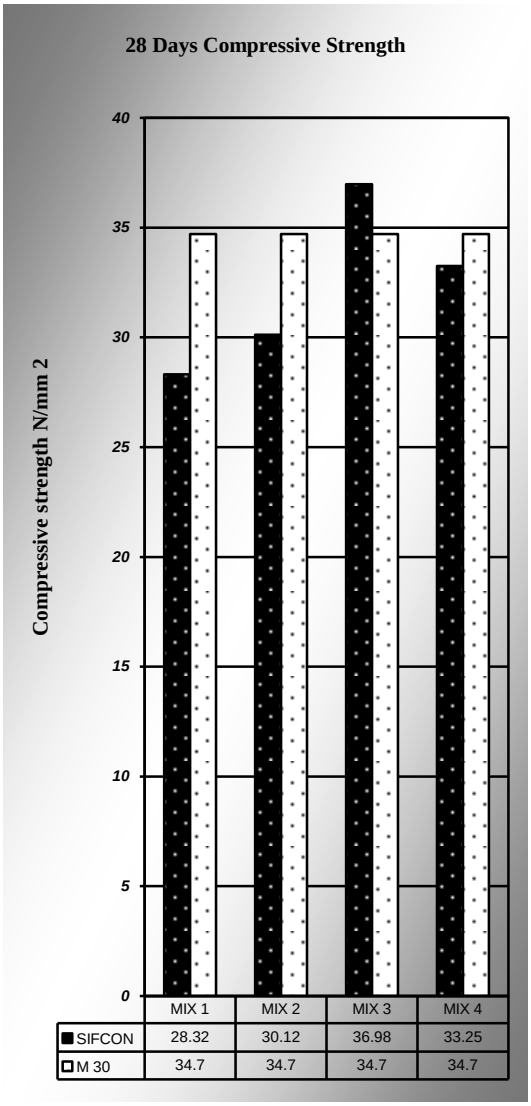


Fig. 3. 28 days Compressive strength

Compressive strength = load / area (N/mm$^2$)

*B. Split tensile Strength Test*

The split tensile strength of specimens was tested 28 days and the following graph shows the average split tensile strength of SIFCON and M30 concrete. The cylinder is placed in horizontally with its axis perpendicular to the loading direction.

Split tensile strength = $2P/\pi LD$

Where P is the applied load, or maximum load,

L is the length or height of cylinder,

D is the diameter of cylinder.

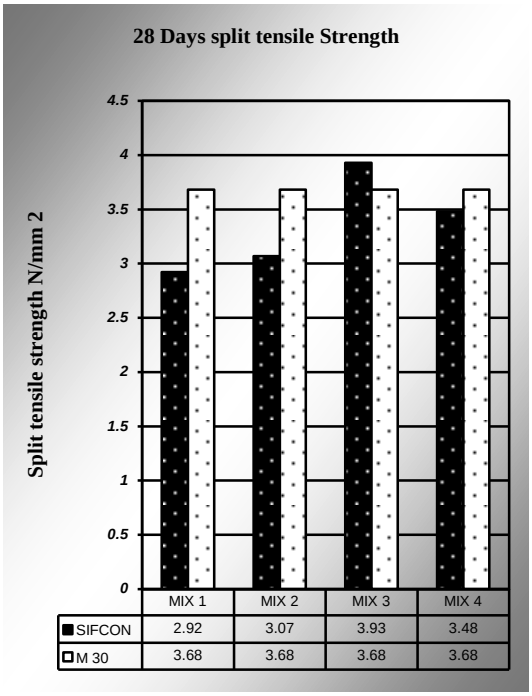


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Fig. 4. 28 days Split tensile strength

### C. *Flexural Strength Test*

The specimen is placed in UTM in such a manner that load shall be applied to the upper most surface, as cast in the mould, along two lines spaced 13.3cm apart. The load shall be applied without shock and increased at rate such that, the extreme fiber stress increases at approximately. The figure 5 gives the flexural strength of SIFCON and conventional concrete.

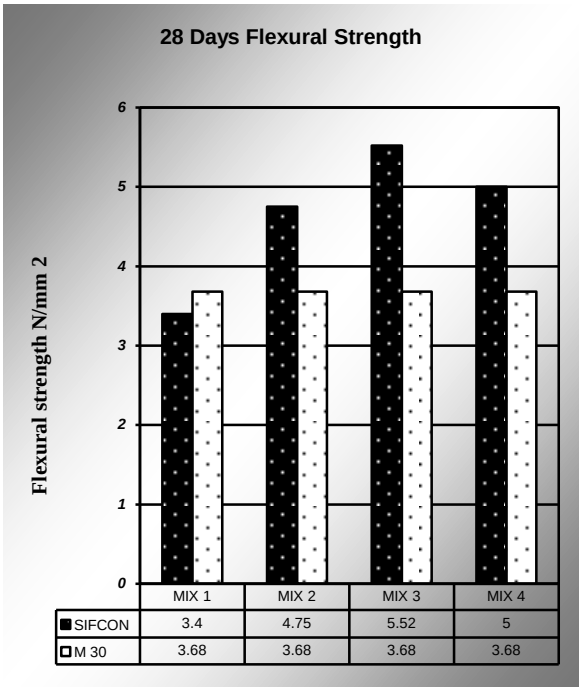


Fig. 5. 28 days Split tensile strength

## VI. CONCLUSION

- The results are observed that the using combination of steel and glass fiber the compressive strength is considerably higher than that of other SIFCON mixes and conventional concrete.
- In using steel and glass fiber the compressive strength of concrete is increased as 28.73 %. Also split tensile and flexural strength increased.
- Here fiber volume fraction, aspect ratio influences the strength of concrete and mostly this aspect ratio is will be best and effectively.
- The mix 3 was found to be optimum with increase in compressive strength more than conventional concrete with 10% volume of fiber usage.
- When the percentage of glass fiber is kept 1% a significant strength is noted.
- Similarly observation was made by earlier researchers using high tensile steel fibers. It can be observed that the 28 days cube strength also increases.

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