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# Experimental Investigation on Durability Properties of Slurry Infiltrated Fiber Concrete

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**Abstract:** Slurry infiltrated fibrous concrete (SIFCON) can be considered as a special and advanced type of steel fiber reinforced concrete composite. SIFCON is produced by infiltrating rich flow able cement slurry into the bed of preplaced fibers in the mold. In this paper, an attempt has been made to investigate the durability study of SIFCON. An ordinary Portland cement is used with fiber contents of (5%, 7.5%, 10%, and 12%). This study also presents the effect of incorporating Metakaolin (MK) on the mechanical and durability properties of SIFCON for a constant water/cement ratio of 0.5. The physical properties include the specific gravity, density, fineness modulus, water absorption, consistency. The above properties are studied for materials used like cement, fly ash, coarse aggregate, ceramic, sand and laterite. Mechanical properties of the hardened concrete such as compressive strength, tensile strength, flexural strength, and durability properties like water absorption, sorptivity, acid test, marine environment are tested and the values are validated. Metakaolin is a waste/non-conventional material which can be utilized beneficially in the construction industry. From the literature survey, Metakaolin inclusion increases the compressive, tensile, flexural and bend strength and modulus of elasticity of mortar considerably; however, the workability is slightly compromised.
**Keywords:** SIFCON, Metakaolin, Ordinary Portland cement, Mortar.

## I. INTRODUCTION

Slurry infiltrated fiber concrete (SIFCON) was first produced in 1979 in the USA, by incorporating large amounts of steel fiber in molds to form very dense network of fibers. The network is then infiltrated by a fine liquid cement-based slurry or mortar. The steel fiber content can be as high as 30%by volume. This percentage usually does not exceed 2% in normal fiber reinforced concrete (FRC) forreasons related to mixing and workability. Due to its high fiber content, SIFCON demonstrates unique and superior mechanical properties in the areas of both strength and ductility. Most of previous research work on SIFCON has focused mainly on investigating the mechanical properties of this material. On the other hand, the studies carried out in the field of durability of SIFCON are quite limited. Because of its high fiber content, SIFCON has unique and superior mechanical properties in the areas of both strength and ductility. 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. Furthermore, SIFCON contains relatively high cement and water contents when compared to conventional concrete.

## OBJECTIVES

- To Investigate the Strength and Durability properties of the various mixes of the SIFCON.
- To evaluate the SIFCON properties by adding various percentage of steel fiber and replacement of mineral admixtures.
- To investigate and provide information about various aspects of SIFCON strength and durability, mainly acid tests like Chemical resistance test (HCl and $H_2SO_4$), sulphate resistance test ($Na_2SO_4$), water absorption test, SEM analysis and UPV test.

- This information will help in providing the necessary database and knowledge about the ability of SIFCON to withstand the conditions for which it has been designed without deterioration.
- Especially when it is intended to be used in aggressive environments like the cases of marine structures or bridges.

## 2. METHODOLOGY

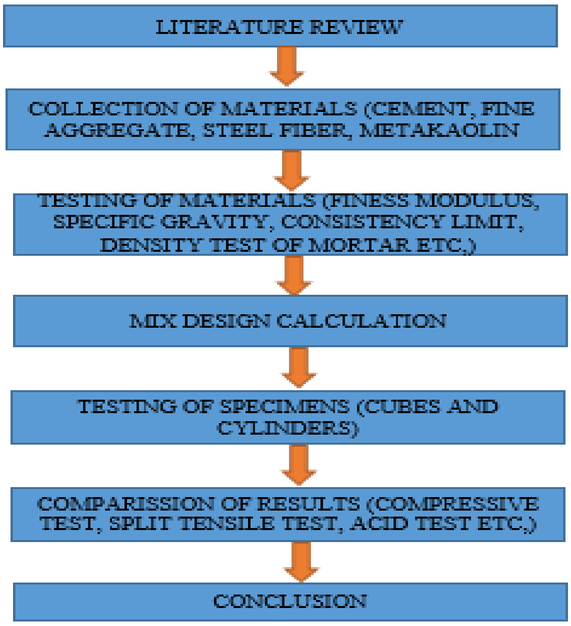


Fig. 1 Methodology

## 3. MATERIALS

### Cement

IS mark 53 grade cement was used for all concrete mixes. The cement used was fresh and without any lumps. Testing of cement was done as per IS: 8112-1989.

Fig. 2 Cement

### Fine Aggregate

Sand should not contain any noticeable amount of clay and should be firm, long-lasting, clean, and free of organic materials and sticky coatings. Hazardous impurities such as iron, pyrites, coal particles, lignite, mica shale, or other laminated material, alkali, and organic impurities in amounts or forms that compromise the durability or strength of mortar or concrete are not allowed in sand.

Fig. 3 Fine Aggregate

**Steel Fiber**

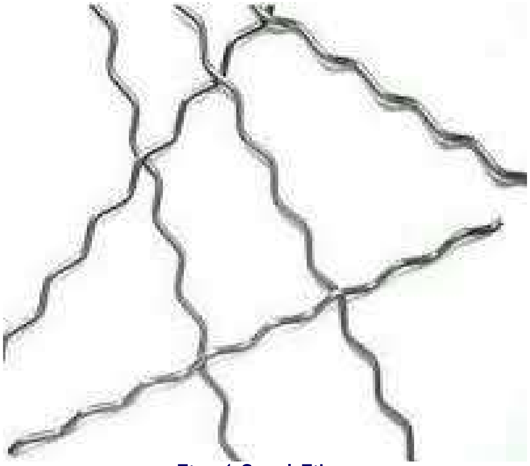

Fig. 4 Steel Fiber

Crimped steel fibers are low in carbon, cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, flexural reinforcement, improved shear strength and increase the crack resistance of concrete. Crimped steel fibers are used in the percentage of (5%, 7.5%, 10%, and 12% by volume).

**Metakaolin**

Among pozzolanic materials for use in concrete, metakaolin is arguably the most effective. It is created when China clay, a mineral known as kaolin, is heated to a temperature of 600–800 degrees Celsius. It is a product that is intended for use rather than a by-product. Metakaolin is kaolin clay that has been subjected to control heating to produce an amorphous aluminosilicate that reacts with concrete in a manner akin to that of other pozzalans. Calcium hydroxide interacts with metakaolin. and mixes with it to create more cementing chemicals, which give concrete its strength.

Fig. 5 Metakaolin

## 4. MIX DESIGN

**Density Test for Mortar (1:4)**

Cement = 2kgs

Fine aggregate = 8 kgs

Empty weight of 3 lit cylinder = 3.718 kgs

Without compaction = 8.852 kgs

With compaction = 9.10 kgs

Un compacted $= \dfrac{\text{Slurry} - \text{Empty weight of cyl}}{\text{Volume of cylinder}}$

$$= \frac{8.852 - 3.718}{3 \times 10^{-3}}$$

$$= 1711.33 \text{ kg / m}^3$$

Compacted $= \dfrac{\text{Slurry} - \text{Empty weight of cylinder}}{\text{Volume of cylinder}}$

$$= \frac{9.1 - 3.718}{3 \times 10^{-3}}$$

$$= 1794 \text{ kg / m}^3$$

Table. 1 Mix Proportion

| S. No | Type of Mix | % of Steel Fiber | % of Metakaolin |
|---|---|---|---|
| 1 | Control | - | - |
| 2 | M1 | 5% | 5% |
| 3 | M2 | 7.5% | 5% |
| 4 | M3 | 10% | 5% |
| 5 | M4 | 12% | 5% |

## 5. RESULT & DISCUSSION

### Compressive Strength

The ability of a material or structure to resist pressing pressures directed axially is known as its compressive strength. 150 x 150 x 150 mm cubes were cast, and specimens were subjected to compressive strength tests after 7, 14, and 28 days. The specimens are put in a compression testing apparatus, the cube is loaded, and the load at failure is recorded as the failure load.

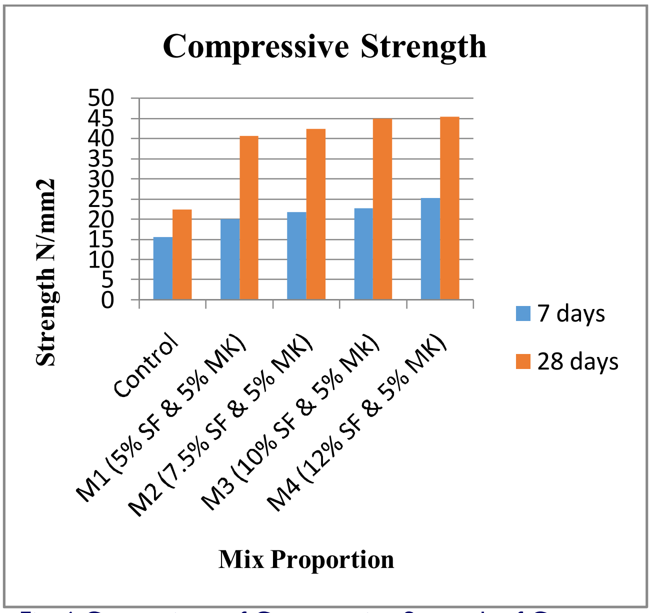


Fig. 6 Comparison of Compressive Strength of Concrete

### Split Tensile Strength

One of the fundamental and significant characteristics of concrete that has a significant impact on the degree and amount of cracking in structures is its tensile strength. Furthermore, because of its brittle character, the concrete is exceedingly weak under tension. It is therefore not anticipated to withstand the direct tension. In other words, when tensile pressures are greater than tensile strength, concrete fractures. Therefore, in order to ascertain the load at which the concrete members may break, it is imperative to ascertain the tensile strength of concrete. Additionally, one way to ascertain the tensile strength of concrete is to conduct a splitting tensile strength test on a concrete cylinder. A 150 mm by 300 mm concrete cylinder's tensile strength was measured using split tensile strength according to code IS 5816:1999 technique. The specimens are cured under ambient temperatures.

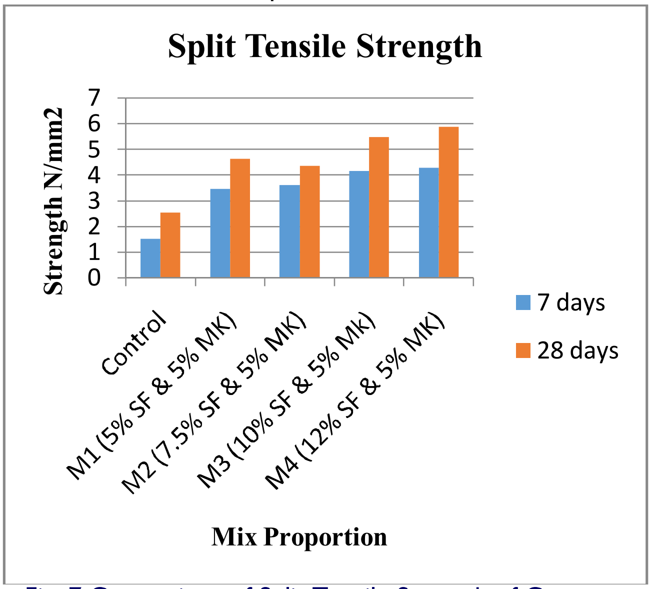


Fig. 7 Comparison of Split Tensile Strength of Concrete

**Flexural Strength**

The tensile strength of concrete slabs or beams is measured by their flexural strength. The amount of stress and force that an unreinforced concrete slab, beam, or other structure can sustain before bending or failing is known as its flexural strength. Bend strength modulus of rupture and fracture strength are other names for flexural strength. The flexural test provides an indirect assessment of the tensile strength of concrete. It evaluates the capacity of unreinforced concrete slabs or beams to tolerate bending failure. The modulus of rupture (MR), which stands for MPa or psi, is the outcome of the flexural test on concrete. One of two methods may be used for the concrete flexural test: the center-point load test (ASTM C293) or the three-point load test (ASTM C78).

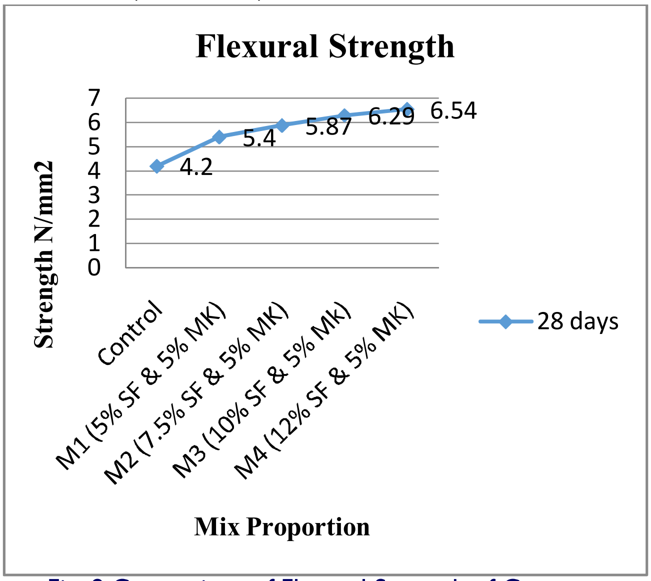


Fig. 8 Comparison of Flexural Strength of Concrete

**Durability Studies**

**Sorpitivity Test**

The Sorpitivity can be determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used of the test fluid. The cubes after casting were immersed in water for 28 days curing. The specimen size 150mm x 150mm x 150mm was drying in oven at temperature of 100 + 10ºC with water level not more than 5 mm above the base of specimen and the flow from the peripheral surface is prevented by sealing it properly with non-absorbent coating.The quantity of the water absorbed in time period of 30 minutes to 240 minutes was measured by weighting the specimen on a top pan balance. Surface water on the specimen was wiped off with a dampened tissue and each weighting operation was completed within 30 seconds. Sorpitivity coefficient (K) is a material property which characterizes the tendency of a porous material to absorb and transmit water by capillarity. The cumulative water absorption (per unit area of the inflow surface) increases as the square root of elapsed time (t).

Fig. 9 Sorpitivity Test

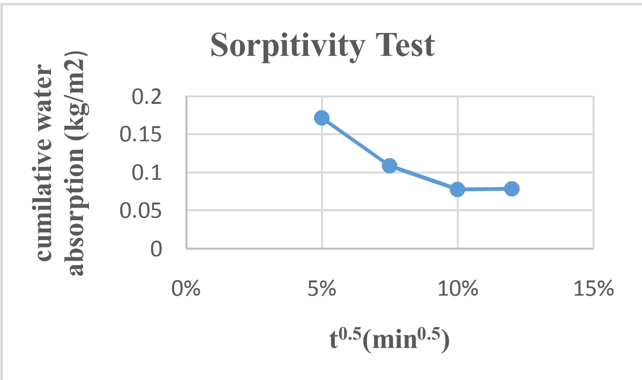


Fig. 10 Sorpitivity Test Result

### Chemical Resistance Test – HCl

Test specimen of size 150mm x 150mm x 150mm were cast and kept under 28 days curing. Then the specimens were dried and weighted. For chemical resistance – HCl the solution was prepared and the specimens were immersed in it. The test was carried out for 28 days. The solution was prepared in the proportion of 1:5. The pH concentration of the solution was maintained. After the completion of curing time period the specimens were taken out and the surface of the specimens were scraped and surface deposits were removed, washed and dried for 2 to 3 hours and weighed again. The chemical resistance test – HCl.

Fig. 11 Chemical Resistance Test HCl

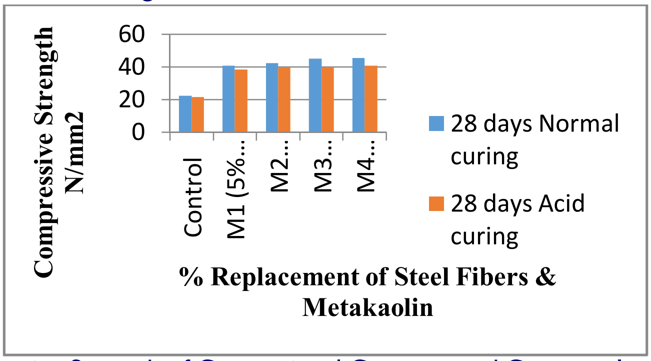


Fig. 12Compressive Strength of Conventional Concrete and Concrete Immersed in HCl

### Chemical resistance test – $H_2SO_4$

Test specimens of size 150mm x 150mm x 150mm were casted and kept under 28 days curing. Then the specimens were dried and weighted. For chemical resistance –$H_2SO_4$ the solution was prepared and the specimens were immersed in it. The test was carried out for 28 days. The solution was prepared in the proportion of 1:5. The pH concentration of the solution was maintained. After the completion of curing time period the specimens were taken out and the surface of the specimens were scraped and surface deposits were removed, washed and dried for 2 to 3 hours and weighed again. The chemical resistance test – $H_2SO_4$

Fig. 13 Chemical Resistance Test $H_2SO_4$

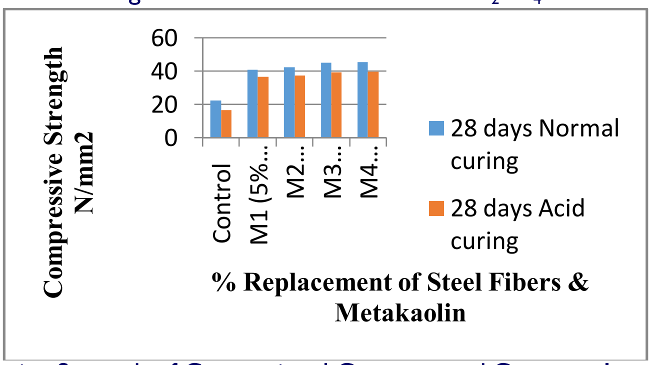


Fig. 14Compressive Strength of Conventional Concrete and Concrete Immersed in $H_2SO_4$

### Sulphate Resistance test – $Na_2SO_4$

Test specimens of size 150mm x 150mm x 150mm were casted and kept under 28 days curing. Then the specimens were dried andweighted. For chemical resistance – $Na_2SO_4$ the solution was prepared and the specimens were immersed in it. The test was carried out for 28 days. The solution was prepared in the proportion of 1:5. The pH concentration of the solution was maintained. After the completion of curing time period the specimens were taken out and the surface of the specimens were scraped and surface deposits were removed, washed and dried for 2 to 3 hours and weighed again.

Fig. 15 Sulphate Resistance test – $Na_2SO_4$

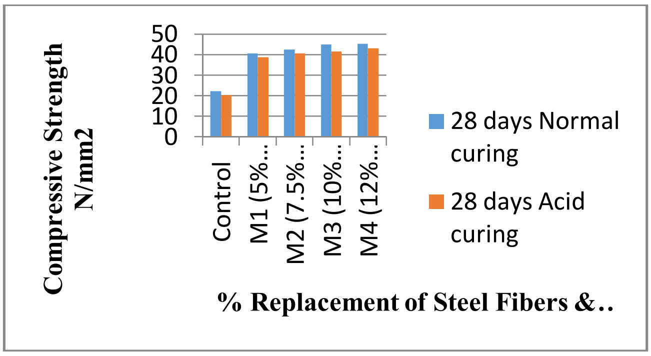


Fig. 16Compressive Strength of Conventional Concrete and Concrete Immersed in $Na_2SO_4$

### Water Absorption

For determination of water absorption of the cured samples, specimens of size 150mm x 150mm x 150mm cube were used. These specimens were then oven dried for 24 hours at the temperature of 85°C until the mass became constant and again weighed. This weight was noted as the dry weight ($w_1$) of the cube. After that the specimen was kept in water for 24 hours. Then this weight was noted as the wet weight ($w_2$) of the cube. The mass of water absorbed by the dry mass of specimen gives the capacity of water absorption. It is normally expressed in percentage.

Fig. 17 Water Absorption Test

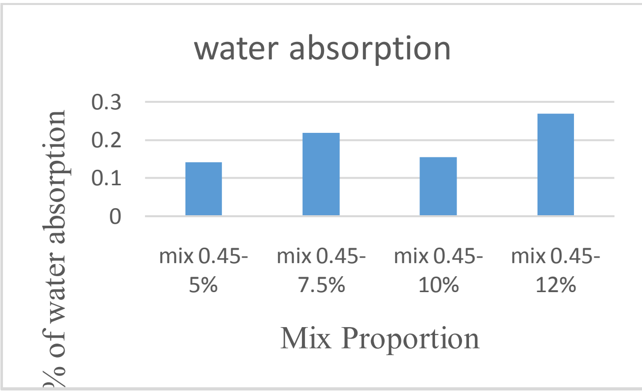


Fig. 18 Water Absorption Test Result

## 6. CONCLUSION

- The incorporation of steel fiber content in the matrix developed the marginal increase in compressive strength.
- 12% of Steel Fiber and 5% of Metakaolin gives high compression strength compared to other mix.
- It also concluded that SIFCON, especially when prepared using mortar not slurry, has shown good durability characteristics in spite of its apparent high water absorption.
- Metakaolin causes decrease of workability of suspension in time.Metakaolin increases resistance to chemical attack and prevention of Alkali Silica Reaction.
- The test results indicated that the SIFCON specimen with 12% of SF and5% of MK is found to be optimum both in normal and aggressive environmental conditions.
- Mechanical properties of Steel Fiber concrete specimens are slightly decreases compared to conventional Specimens.
- In HCl acid test and Sulphate resistance test results shows that 12% of steel fiber in concrete gives lesser value of compressive strength compared to 5%, 7.5% and 10% steel fiber concrete.
- From water absorption test, the percentage of water absorption increase in steel fiber concrete specimens when compared with control specimens.

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