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"Effect of Replacement of Cement by Silica Fume on the Strength Properties of SIFCON Produced From Waste Coiled Steel Fibres"

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Abstract: *A relatively new high performance and advanced material, 'Slurry-infiltrated fibrous concrete' (SIFCON) which is considered as a special type of fibre concrete with high fibre content Volume. The matrix usually consists of cement slurry. SIFCON is very good for application in areas where highly ductile and resistance to impact is needed. To improve the strength, wear resistance and durability of the concrete, a small fraction of short crimped fibres is used. In this paper, cement is partially replaced by SILICA FUME in SIFCON. SILICA FUME (SF) is a byproduct of producing silicon metal or ferro-silicon alloys, which blends with Portland cement to improve the durability and it reduces the porosity of concrete as the particle size of SF is very less. This experimental work focuses on strength development of SILICA FUME in SIFCON on partial replacement by 5%, 10%, 15% SF in cement with 8% fibre content by volume. To study influence of replacement of cement by silica flume and compare the compressive strength and flexural strength at different percentage of silica flume, is the basic objective of this project.*

Keywords: SIFCON, SILICA FUME, CEMENT, COMPRESSIVE STRENGTH, TENSILE STRENGTH, FLEXURAL STRENGTH.

I. Introduction

Cement shortages brought on by a continued housing boom and import constraints are spreading, delaying construction in some areas and sending prices as much as 20% above year-ago levels. Concrete is the most extensively used material in civil engineering and is the primary component in most infrastructures. In the future, there seems to be very less or no alternative to concrete as a construction material. Although strength of concrete is most important, it is also very much needed that the concrete is durable, workable and provide a good service life. For bridges, offshore structures, highway and airport pavements and machine foundations, concrete should possess high fatigue strength. For nuclear containers exposed to very high temperatures, the concrete must have high resistance to thermal cracking. All these requirements made the engineers to think seriously and to find out the appropriate technology for improving the performance of concrete. Increase in demand and decrease in supply of aggregates for the production of concrete results in the need to identify new sources of aggregates. SIFCON gains importance because eliminates the use of coarse aggregate. The principle of sustainable construction development requires prudent use of natural resources with best quality. SIFCON could be the one better solution.

Slurry Infiltrated Fibrous Concrete (SIFCON), is a high performance cement based composite which contains a high content of steel fibres. Fibres are preplaced in the form and then the fibre bed is infiltrated with cement-based slurry. SIFCON is a type of fibre concrete with high percent of steel fibres, the high amount of steel fibres makes SIFCON stronger in tension, though not strong enough to replace the steel and not economical to concrete, it enhances the cracking load considerably. Excellent energy absorption capacity, Highly ductile and Greater strength.

In recent years, there has been a great interest in the exploitation of silica fume (SF) as a supplementary cementitious material in concrete to improve its properties. Moreover, the use of SF in concrete in present form is a new concept. Recent researches have shown that the inclusion of SF greatly influenced the mechanical and ductility properties of concrete.

In this research, the strength development of Silica fume in SIFCON on partial replacement in cubes *for compressive strength, cylinders for split tensile strength and beams for flexure is being checked.*

II. Materials used:

- ***Cement - OPC 43:*** *Ordinary Portland cement of grade 43 was used in concrete. OP cement does not contain any pozzolanic material.*
- ***Steel Fibres*** *- Steel fibres are of different shaped namely straight ends, hooked ends, crimped fibre. In the experimental work 'crimped steel fibres with an aspect ratio of 50 is used (Section type = Circular; Length = 50mm; Diameter = 0.5 mm; Density = 6.8 gm/cm*^{3}*; Tensile Strength = 1100 MPa) because crimped fibres gives relatively good bending strength, strain, and takes up failure.*
- ***Silica fume*** *- Silica fume is a by-product of the manufacture of silicon metal and ferro-silicon alloys. The process involves the reduction of high purity quartz (SiO2) in electric arc furnaces at temperatures in excess of 2,000°C. Silica fume is a very fine powder consisting mainly of spherical particles or microspheres of mean diameter about 0.15 microns, with a very high specific surface area (15,000–25,000 m2/kg). Each microsphere is on average 100 times smaller than an average cement grain. At a typical dosage of 10% by mass of cement, there will be 50,000–100,000 silica fume particles per cement grain.*
- ***SIFCON*** *is a high performance cementitious composite material, which shows outstanding strength and ductility.*
- ***Water*** *- Normal tap water was used.*

III. Methodology:

SIFCON is done by pre-placing discontinuous steel fibres into the form, followed by infiltrating the fibres with cement-based slurry. So by this procedure content of steel fibre increases, therefore SIFCON is more expensive due to its high fibre content. The main difference between FRC (Fibre reinforced Concrete) and SIFCON is high fibre content and no coarse aggregate in SIFCON. In conventional FRC, the Fibre content is maximum 2% by volume; in SIFCON it varies from 3-20%.SIFCON has unique methodology of mix preparation.

Preparation of SIFCON:

- *Preparation of moulds and oil them.*
- *Fibres were dispersed in the mould.*
- *Preparation of cement slurry with water in mixer.*
- *Casting Specimen by infiltrating the Fibre with cement slurry.*

IV. Experimental Study:

The cement slurry was prepared proportion using w/c ratio 0.42.

To study the effect of replacement of cement by silica fume on SIFCON, slurry was prepared by replacing cement by silica fume at varying percentages like 5%, 10%, and 15% by weight of cement. The moulds were filled with 8% fibres, and slurry was poured into the moulds. Vibration was given to the moulds using table vibrator. The slurry was poured until no more bubbles were seen. This ensured a thorough infiltration of slurry into the fibres. The top surface of the specimen was leveled and finished.

After 24 hours, the specimens were demoulded and were transferred to curing tank where they were allowed to cure for 28 days. The effect of replacement of cement by silica fume on SIFCON was studied on compressive strength, tensile strength, flexural strength and impact strength. The cube specimens of dimension 150x150x150mm were cast, from which the compressive strength was calculated. The specimens of dimension 150mm diameter and 300mm length were cast for split tensile strength. The specimens of dimension 100x100x500mm were cast for flexural strength test.

1. **Flexural Strength:**

PERCENTAGE OF SILICA FUME (%)	LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)
0	9.5	3.8
5	11	4.4
10	13	5.2
15	14	5.6

Table 1: Flexural Strength on replacing % of Silica Fume

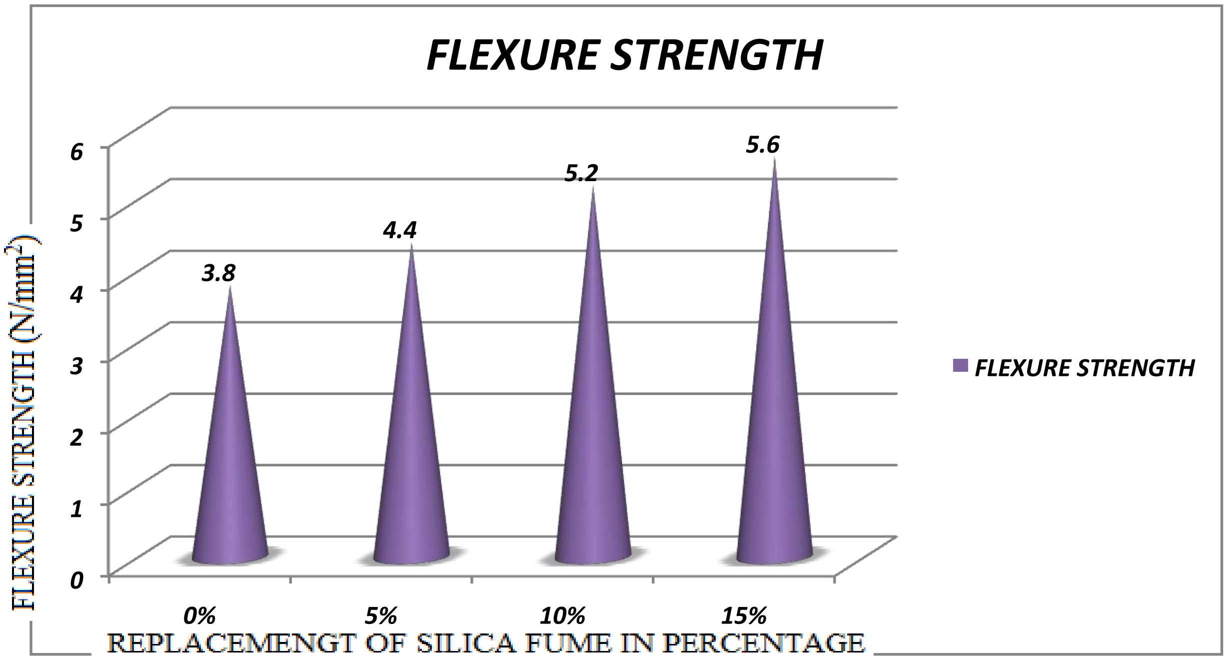

Fig 1: Flexural Strength v/s % of Silica Fume

2. **Tensile Strength:**

PERCENTAGE OF SILICA FUME (%)	LOAD (KN)	TENSILE STRENGTH (N/mm2)
0	200	1.41
5	210	1.48
10	240	1.69
15	220	1.55

Table 2: Tensile Strength on replacing % of Silica Fume

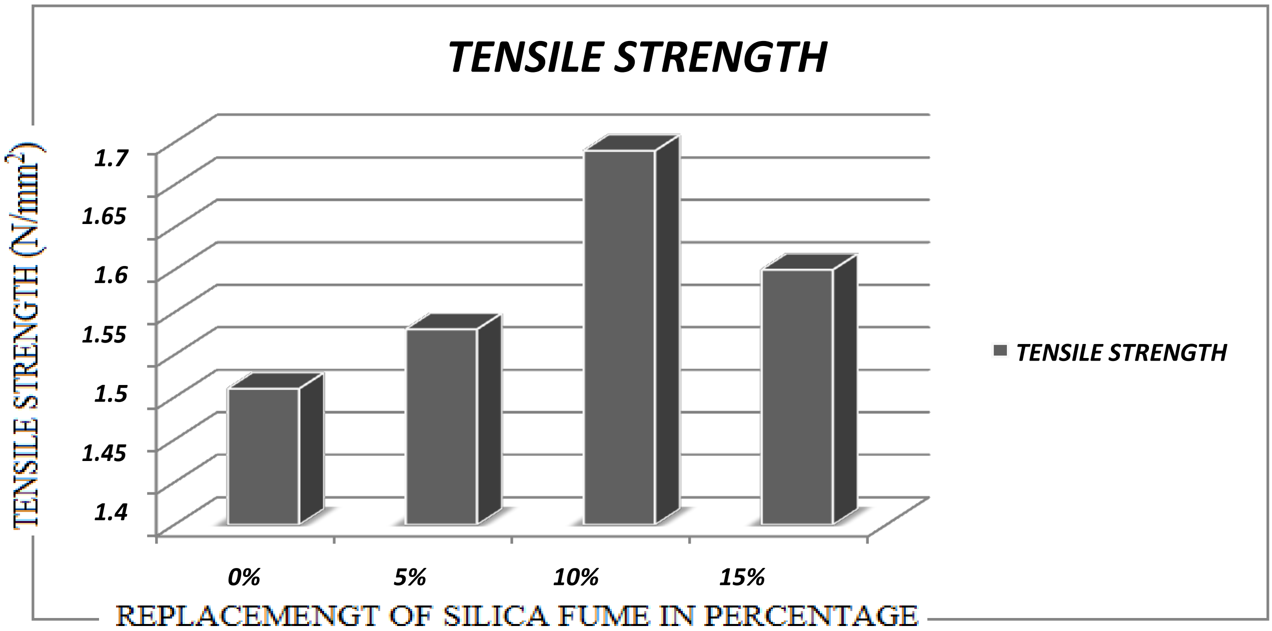

Fig 2: Tensile Strength v/s % of Silica Fume

3. Compressive Strength

PERCENTAGE OF SILICA FUME (%)	LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)
0	680	30.2
5	700	31.1
10	750	33.3
15	740	32.8

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Table 3: Compressive Strength v/s % of Silica Fume

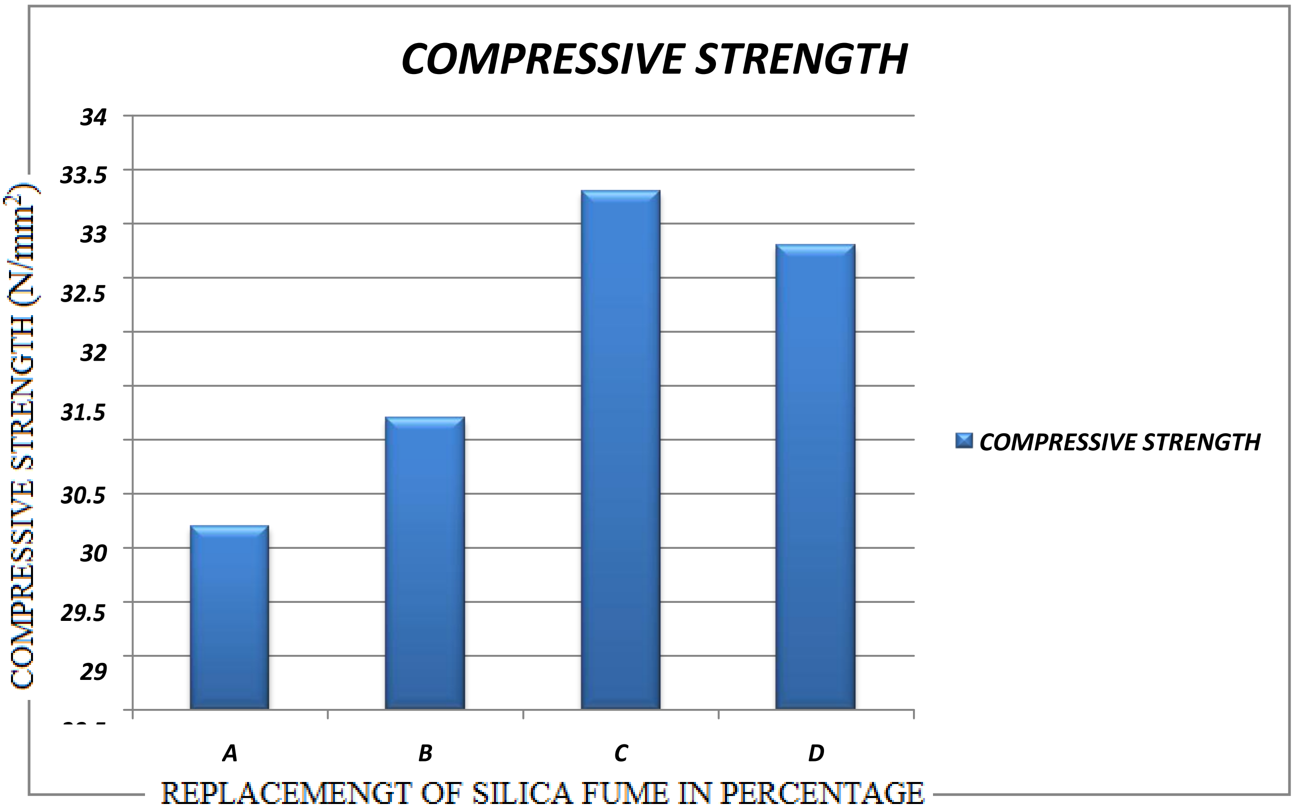

Fig 3: Compressive Strength v/s % of Silica Fume

V. Results and Discussions:

The results obtained from this experiment are described on the following points:

- *Compressive strength, initially increases when we add silica fume 5%, 10% (by weight) by replacement of cement but at 15% replacement, compressive strength slightly decrease.*
- *Tensile strength, initially increases when we add silica fume 5%, 10% (by weight) by replacement of cement but at 15% replacement, tensile strength also slightly decrease.*
- *Flexural strength increases as we replace cement by silica fume in the amount of 5%, 10%, and 15% (by weight).*

VI. Applications:

Some of the practical applications of SIFCON are:

- *Explosive-resistant bunkers*
- *Launching Aerospace Platform*
- *Security blast-resistance vaults*
- *Good absorption capacity*
- *Earthquake areas*
- *Seismic & explosive resistant structure*
- *Nuclear silos shielding*

VII. Conclusions:

From this research, we can conclude that:

- *By using silica fume to a significant extent, we can improve the properties (compressive, tensile, flexural strength) of cement.*
- *Availability of silica fume at large scale make our major construction projects, economical.*
- *It can be used as a control techniques and measure to mitigate greenhouse gas emissions from the manufacturing of cement.*
- *Because the primary GHG emitted by the cement industry is CO_2, the replacement by SIFCON can serve as a control technology and counter against this pollutant.*

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