JOURNAL OF SCIENTIFIC RESEARCH AND ADVANCES

*http://jsciresadv.com*

# Silica Fume for Partial Replacement of Cement

Fahad Iqbal Qureshi[1] and Narendra Kumar Sharma[1]

*[1]Department of Civil Engineering, IILM-College of Engineering and Technology,*
*Knowledge Park-II, Greater Noida-201306*
*E-mail address:* fahad.iqbal@iilmcet.ac.in

**Abstract-**The use of silicon oxide Fume (SF) briefly amount of your time had one among the foremost dramatic impacts on the industry's ability to habitually and commercially turn out SF changed concrete of flowable in nature however nonetheless stay cohesive, that successively would develop each high early and high later-age strengths as well as immune to aggressive environments. This paper options an experimental study on the character of SF and its influences on the compressive, flexural & Split lastingness of hardened concrete with flume. Within the gift study, an effort has been created to research the strength parameters of concrete created with partial replacement of cement by SF. Moreover, no such try has been created in subbing silicon oxide fume with cement for medium grade concretes.During this we have a tendency to come back to understand that it's possible to interchange the cement by silicon oxide fume for rising the strength characteristics of concrete.

**Keywords:** Compressive strength, flexural strength, normal concrete, silica fume (SF) concrete, split tensile strength

## 1. Introduction

### 1.1. Silica Fume

Silica fume (SF) could be a by-product of the smelting method within the element and ferrosilicon business. The reduction of high-purity quartz to element at temperatures up to 2000$^o$C produces a SiO2 vapour that oxidizes and condenses within the vasoconstrictive zone to small particles consisting of non-crystalline silicon oxide. By-products of the assembly of element metal and therefore the ferrosilicon alloys having element contents of 75 or a lot of contain 85–95% non-crystalline silicon oxide. The by-product of the assembly of ferrosilicon alloy having five hundredth element has abundant lower silicon oxide content and is a smaller amount pozzolanic. Therefore, $SiO_2$ content of the silicon oxide fume is said to the sort of alloy being created. ilicon oxide fume is additionally called small silicon oxide, condensed silicon oxide fume, volatilized silicon oxide or silicon oxide dirt. The American concrete institute (ACI) defines silicon oxide fume as a ''very fine non-crystalline silicon oxide created in electric discharge furnaces as a by-product of production of alloys containing silicon'. it's typically a gray colored powder, somewhat kind of like hydraulic cement or some fly ashes. It exhibits pozzolanic properties. Silicon oxide fume has been recognized as a pozzolanic admixture that's effective in enhancing the mechanical properties to an excellent extent. By victimization silicon oxide fume alongside super plasticizers, it's comparatively easier to get compressive strengths of the order of 100–150 MPa in laboratory. Additionally, of silicon oxide fume to concrete improves the sturdiness of concrete through reduction within the permeableness, refined pore structure, resulting in a discount within the diffusion of harmful ions, reduces calcium hydrate content which ends up during a higher resistance to salt attack. Improvement in sturdiness also will improve the power of silicon oxide fume concrete in protective the embedded steel from corrosion. With the extensively use of cement in concrete, there has been some environmental issues in terms of harm caused by the extraction of stuff and carbonic acid gas emission throughout cement manufacture. This has brought pressures to scale back the cement consumption within the business. At a similar time, there are becoming a lot of necessities for improvement in concrete sturdiness to sustain the dynamical atmosphere that is seemingly totally different from the previous days.

With the event in concrete technology, cement replacement materials (CRM) are introduced as substitutes for cement in concrete. Many sorts of materials area unit in common use, a number of that area unit by merchandise from different industrial processes, and thence their use could have economic benefits. However, the most reason for his or her use is that it will provide a form of helpful enhancements or modifications to the concrete Properties. All the materials have 2 common features:

1. Particle size vary is analogous to or smaller than that of hydraulic cement.
2. They are pozzolanic material.

## 2. EXPERIMENTAL METHOD

### 2.1Mix Design

A mix Design is done by using Indian Standard Method (IS 10262). The following basic data required to be specified for a design of concrete mix:

1- Characteristics Strength of Concrete at 28 days ($F_{ck}$) = 35N/mm$^2$
2- A Maximum Size of crushed aggregates = 20 mm.
3- A Degree of Workability (Compacting Factor) = 0.90
4- Value of Statistical Coefficient (K) = 1.65 (Refer IS: 456-2000 Clause 9.2.2)
5- Value of Standard Deviation (S) = 5.00 (Refer IS: 456-2000 Table 8)
6- Test data of materials:
**1-**Cement used= OPC 53 grade
**2-**Specific Gravity of Cement = 3.15
**3-**Specific Gravity of coarse aggregates = 2.82
**4-**Specific gravity of fine aggregates = 2.68

### 2.1.1. Target Strength for Mix Design: -

$F_t = f_{ck} + k\times S$

$K= 1.65, S= 5.00, f_{ck} = 35$ N/mm$^2$

$F_t = 35+1.65\times5.00=43.25$ N/mm$^2$

### 2.1.2. Selection of Water Binder Ratio:

Maximum water cement ratio specified for durability = 0.405 (Refer IS: 456-2000 Table 5). Therefore, the water/binder ratio adopted = 0.36

### 2.1.3. Selection of Water Content and Fine Aggregate to a total Aggregate Ratio:

For maximum size of coarse aggregate 20 mm based upon the following parameters of the water content and fine aggregate to the total aggregate ratio was selected from Table 2 given in IS: 10262-2009.

- Design mix M35 grade
- Sand zone II
- Workability = 0.90 CF
- Water/ Binder ratio = 0.36

Sand content as Wt. % of total aggregate by absolute volume =37%

Water content = 186 lit/m$^3$

Cement content = 186/0.36 = 516 kg/m$^3$

### 2.1.4. Calculation of aggregate content:

Volume of cement = 516/ (3.15×1000)
= 0.1638 m$^3$

Volume of water = 186/1000 = 0.186 m$^3$

Volume of all in aggregate = 1-0.1634-0.186
= 0.6506m$^3$

Coarse aggregate content= 2.82×0.78×0.650×1000
=1131.05 kg/m$^3$

Fine aggregate content= 2.68 × 0.22 ×0.650× 1000
= 383.82 kg/m$^3$

### 2.1.5. Super plasticizer Content:

\The super plasticizer is used as 0.65% weight of the binder

**Table 1. Mix proportions**

| Mixture | M0 | M1 | M2 | M3 | M4 |
|---|---|---|---|---|---|
| Cement (kg/m$^3$) | 516 | 490 | 464 | 439 | 413 |
| % of Silica fume | 0 | 5 | 10 | 15 | 20 |
| Silica fume (kg) | 0 | 26 | 52 | 77 | 103 |
| Coarse aggregate | 1131.05 | 1131.05 | 1131.05 | 1131.05 | 1131.05 |
| Fine aggregate | 383.82 | 383.82 | 383.82 | 383.82 | 382.82 |
| water | 186 | 186 | 186 | 186 | 186 |
| Sp | 3.35 | 3.35 | 3.35 | 3.35 | 3.35 |

## 3. RESULTS AND DISCUSSIONS

Compressive, Tensile and flexural strength of various Concrete mixes incorporating 0 %, 5%, 10%, 15% and 20 Wt. % of cement is replaced by silica fume is discussed. All the tests conducted were in accordance with the methods in IS code. Results were compared and checked for compressive, split tensile and flexural strength of concrete.

### 3.1. Compressive Strength Test (IS: 516 – 1999)

In order to review the result regarding compressive strength, the cubes containing totally different proportion of silicon oxide fume were ready and unbroken for hardening for seven and 28 days. The check was conducted on a compression testing machine of capability 2000 KN. The 7 and 28 days' compressive strength is listed in table a pair of and three severally it's obtained that 7 days strength of all mixes is invariably high. This can be thanks to continuous association of Cement with concrete. The water-binder was unbroken constant at zero.36. The check results indicated that, once five to fifteen Wt. % replacement of silicon oxide fume for cement is completed, a compressive strength will increase. When 20 Wt. a replacement of cement is completed by silicon oxide fume, strength starts decreasing. A Highest strength of 48.01 N/mm$^2$ was ascertained for 15 Wt. quartz glass fume concrete combine at twenty eight days.

**Table 2- Compressive Strength after 7 Days**

| Mix Designation | Percentage of Silica fume | Load (KN) | Compressive Strength (N/mm$^2$) | Average Compressive strength (N/mm$^2$) |
|---|---|---|---|---|
| M0 | 0 | 570<br>575<br>585 | 25.50<br>25.65<br>26.75 | 25.9 |
| M1 | 5 | 610<br>640<br>665 | 26.90<br>28.30<br>29..65 | 28.28 |
| M2 | 10 | 755<br>765<br>775 | 33.80<br>34.30<br>33.40 | 33.83 |
| M3 | 15 | 895<br>885<br>875 | 39.65<br>39.00<br>38.60 | 39.08 |
| M4 | 20 | 818<br>808<br>800 | 36.40<br>36.00<br>35.63 | 36.01 |

**Table 3- The Compressive Strength after 28 Days**

| Mix Designation | Percentage of Silica fume | Load (KN) | Compressive Strength (N/mm$^2$) | Average Compressive strength (N/mm$^2$) |
|---|---|---|---|---|
| M0 | 0 | 825<br>835<br>845 | 37.00<br>37.20<br>38.10 | 37.43 |
| M1 | 5 | 895<br>900<br>905 | 39.80<br>40.02<br>40.27 | 40.03 |
| M2 | 10 | 1010<br>1015<br>1045 | 45.00<br>45.55<br>46.75 | 45.76 |
| M3 | 15 | 1075<br>1085<br>1060 | 47.90<br>48.60<br>47.35 | 47.95 |
| M4 | 20 | 990<br>970<br>995 | 39.12<br>40.02<br>36.48 | 43.76 |

### 3.3. Split Tensile Strength Test

Splitting strength studies were dole out at the age of seven and 28 days. The result area units shown in Table four and five Fig. 2. The share of silicon dioxide fume replaced by cement is five-hitter, 10% and V-day and therefore the water binder magnitude relation is unbroken at 0.36. It is observed that by mass replacement of silicon dioxide fume for cement provided the very best strength. After we redoubled the replacement of silicon dioxide fume by V-day the strength attenuated. Ripping strength worth of five.06 N/mm$^2$ was obtained within the fifteen Wt. % replacement of silicon dioxide Fume at 28 days' strength.

**Table 4- Split Tensile Strength after 7 Days**

| Mix Designation | Percentage of silica fume | Load (KN) | Split Tensile Strength (N/mm$^2$) | Average strength (N/mm$^2$) |
|---|---|---|---|---|
| M0 | 0 | 215<br>250<br>185 | 3.10<br>3.60<br>2.65 | 3.12 |
| M1 | 5 | 240<br>215<br>290 | 3.35<br>3.10<br>4.08 | 3.51 |
| M2 | 10 | 315<br>275<br>265 | 4.50<br>3.90<br>3.85 | 4.08 |
| M3 | 15 | 220<br>235<br>320 | 3.15<br>3.35<br>4.60 | 3.70 |
| M4 | 20 | 245<br>265<br>255 | 3.50<br>3.80<br>3.65 | 3.65 |

**Table 5- Split Tensile Strength after 28 Days**

| Mix Designation | Percent age of silica fume | **Load (KN)** | Split Tensile Strength ($N/mm^2$) | Average strength ($N/mm^2$) |
|---|---|---|---|---|
| M0 | 0 | 260<br>305<br>415 | 2.80<br>3.00<br>3.20 | 3.00 |
| M1 | 5 | 335<br>280<br>400 | 4.70<br>4.00<br>5.67 | 4.79 |
| M2 | 10 | 350<br>315<br>370 | 4.98<br>4.50<br>5.25 | 4.91 |
| M3 | 15 | 293<br>350<br>355 | 4.15<br>4.98<br>5.06 | 4.73 |
| M4 | 20 | 280<br>270<br>235 | 4.00<br>3.80<br>3.30 | 3.72 |

### 3.4. Flexure Strength Test

Although the concrete isn't designed to resist tension, the information of strength of concrete is valuable in assessing the load at that the crack can begin showing in concrete. The absence of cracking is off to tidy importance in insuring the higher sturdiness of concrete structure and in several cases the interference of the corrosion of the reinforcement attributable to the partial difficulties sweet-faced in conducting a pure strength, it's desirable to live the strength of the concrete by subjecting an apparent concrete beam to flexure. The flexure takes a look at was conducted on varied mixes. The result obtained for varied mixes at the age of seven and 28 days. The result's shown Table 6 and 7.

**Table 6-Flexural Strength after 7 days:**

| Mix Designation | Percentage of Silica fume | **Load (KN)** | Split Tensile Strength ($N/mm^2$) | Average strength ($N/mm^2$) |
|---|---|---|---|---|
| M0 | 0 | 280<br>270<br>240 | 5.00<br>4.85<br>4.40 | 4.75 |
| M1 | 5 | 320<br>390<br>385 | 5.70<br>7.00<br>6.90 | 6.53 |
| M2 | 10 | 430<br>400<br>370 | 7.65<br>7.05<br>6.60 | 7.10 |
| M3 | 15 | 440<br>450<br>360 | 7.80<br>8.05<br>6.35 | 7 |
| M4 | 20 | 390<br>360<br>265 | 6.90<br>6.40<br>4.75 | 6.01 |

**Table 7-Flexural Strength after 28 Days:**

| Mix Designation | Percent age of Silica fume | Load (KN) | Split Tensile Strength ($N/mm^2$) | Average strength ($N/mm^2$) |
|---|---|---|---|---|
| M0 | 0 | 325<br>340<br>265 | 5.80<br>6.02<br>4.68 | 5.5 |
| M1 | 5 | 405<br>390<br>385 | 7.20<br>6.96<br>6.87 | 7.01 |
| M2 | 10 | 460<br>485<br>510 | 8.65<br>9.05<br>9.10 | 8.93 |
| M3 | 15 | 540<br>505<br>500 | 9.20<br>9.05<br>8.55 | 8.33 |
| M4 | 20 | 405<br>390<br>385 | 7.20<br>6.97<br>6.86 | 7.01 |

## 4. CONCLUSION

Based on the results obtained in the present investigation, the following conclusion can be drawn:

The results obtained in the present study indicate that it is feasible to replace the cement by silica fume for improving the strength characteristics of concrete. Thus, the silica fume can be used as an alternative material for the production of concrete to address the waste disposal problems and to minimize the cost of construction with usages of silica fume which is most freely available. Consistency of cement depends upon its fineness. Silica fume is having the greater fineness then cement and greater surface area so the consistency increases greatly when silica fume percentage increases. The normal consistency increases about 40% when silica fumes percentage from 0% to 20%. But finesse also creates high heat hydration. The optimum 7 and 28- day's compressive strength and flexural strength have been obtained in the range of 10-15% silica fume replacement level. Increase in split tensile strength beyond 10% silica fume replacement is almost insignificant whereas gains in flexural tensile strength have occurred even up to 15% replacement. The maximum compressive strength obtained at 15% replacement of silica fume is 47.95$N/mm^2$ at 28 days. The maximum tensile strength obtained at 10% replacement of silica fume is 4.91 $N/mm^2$ at 28 days. The maximum flexural strength obtained at 15% replacement of silica fume is 8.93$N/mm^2$at 28 days. There is a significant improvement in the compressive strength of concrete because a pozzolanic nature of the silica fumes and its void filling ability. Silica fume seems to have a pronounced effect on the flexural strength than the split tensile strength.

## 5. REFERENCE


[1]. H. H. Darweesh, "Effect of the combination of some pozzolanic wastes on the properties of Portland cement pastes" ii C Industrial italiana del Cemento, Italy, 808, 2005, 298-311.

[2]. H. El-Didamony, H. H. Darweesh and R. A. Mostafa, "Characteristics of pozzolanic cement pastes Part I: Physio-mechanical properties" Sil. Ind. (Cer. Sci. & Techn.), Belgium, 73, Nr. 11-12, 2008, 193-200.

[3]. Z. Kersener, H.H. M. Darweesh and L. Routil, "Mortar composites from waste materials" Cem. Hormigon, Spain, Vol. 2, No. 943, 2011, 12-19.

[4]. Ray, I, De, A and Chakraborty, Fifth Conference on Concrete Technology for High Slump Concrete, Vol 1, pp.86-93

[5]. Joshi, N. G. Bandra – Worli Sea Link: Evolution of HPC mixes containing Silica Fume, Indian Concrete Journal, (Oct. 2001), pp. 627-633

[6]. Saini, S, Dhuri, S. S, Kanhere, D. K, Momin, S. S. High Performances concrete for an urban viaduct in Mumbai, Indian Concrete Journal, (Oct. 2001). pp. 656-664.

[7]. Basu, P. C.: NPP containment structures Indian experience in Silica Fume –based HPC, Indian Concrete Journal, (Oct. 2001), pp. 656- 664.

[8]. Thomas, M D. A. Using Silica Fume to Combat ASR in Concrete, Indian Concrete Journal, (Oct. 2001), pp 656-664

[9]. Lewis, R. C. Hasbi, S. A.: Use of Silica Fume concrete: Selective case studies, Indian Concrete Journal, (Oct. 2001), pp. 645-652.

[10]. Roncero, J., Gettu, R., Agullo, L., Vazquez, E.: Flow behaviour of superplasticised cement pastes: Influence of Silica Fume, Indian Concrete Journal, (Jan. 2002), pp. 31-35.

[11]. Vishnoi, R. K., Gopalakrishnan, M: Tehri Dam Project: Silica Fume in High Performance Concrete for Ensuring Abrasion Erosion Resistance, Proceedings organised by Indian Society for Construction Materials and Structures, (February 2003), pp. 28-40.

[12]. Kanstad, T, Biontegaard, O, Sellevold, E. J, Hammer, T. A. and Fidjestol, P. Effect of Silica Fume on Crack Sensivity, Concrete International, (Dec. 2001), pp 53-59