RESEARCH PAPER | Engineering | Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

Effect of Micro Steel Fiber on Compressive Strength of Concrete Containing Silica Fume

KEYWORDS: Micro Steel fibers, Silica Fume, Compressive strength of concrete.

Khelan Parikh
Research scholar, M.E Structure, SVIT, Vasad

Dhruti J Dhyani
Assistant Professor, M.E Structure, SVIT, Vasad

ABSTRACT *A widespread experimentation was performed to study the strength development of concrete containing steel fibers with Silica Fume. In present investigation series of cubes are casted with different percentage of Silica Fume with different percentage of volume of micro steel fibers. Cement is replaced with 6%, 8%, 10%, and 12% of Silica Fume. Micro steel fibers are used at 0.5%, 1%, 1.5%, 2% whose aspect ratio is 33.Compression test are conducted on several cubes to measure the effect of Micro steel fibers on compressive strength of concrete.*

1. Introduction :
Cement-based composites have long been used for civil structures such as highways, bridges and buildings. However, unexpected deterioration of reinforced or pre-stressed concrete structures has led to the improvement of durability of concrete. Traditionally, the constituents of cement-based composites include cementitious material, water, aggregate and/or admixtures.

Silica fume also known as micro silica is a by-product Ad of the reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. Because of its extreme fineness and high silica content, Silica Fume is a highly effective pozzolanic material. Silica Fume is used in concrete to improve its properties like compressive strength, bond strength, and abrasion resistance; reduces permeability; and therefore helps in protecting reinforcing steel from corrosion.

Fiber has been added in cement-based composites since 1960's to enhance concrete properties, particularly tensile strength, Flexural strength, abrasion resistance and energy absorbing capacity.

2.1Literature review:
A compressive review of literature related to Silica Fume and Steel Fiber concrete was presented by ACI Committee 544 (ACI Committee, 544, 2006), Balaguru and Shah (Balaguru P. N et al., 1992). It included guidelines for design, mixing, placing and finishing steel fiber reinforced concrete, reported that the addition of steel fibers in concrete matrix improves all mechanical properties of concrete.

Nguyen Van Chanh concludes that SFRC has superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading; and the fibres are able to hold the matrix together even after extensive cracking .The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied, shock or impact loading.

Kukreja, C.B. et al. (1980) carried out experimental investigations on the direct tensile strength, indirect tensile strength and flexural tensile strength of the fibrous concrete and compared with the various aspect ratios of the fibres as 100, 80 and 60 respectively. They observed that maximum increase in direct tensile strength obtained by fibres of aspect ratio 80 with 1% as volume fraction. Finally they concluded that indirect tensile cracking stress is an inverse function of fibre spacing and fibre reinforcement is more effective in improving the post cracking behaviours, than the first cracking.

Wei-Ting Lin, Ran Huang, Chin-Lai Lee, and Hui-Mi Hsu (2008) carried out experimental program to evaluate the mechanical properties of cement-based composites. Test variables included water to cementitious ratio, dosage of silica fume and volume fraction of steel fiber. Compressive strength test, direct tensile strength test, splitting tensile strength test, abrasion resistance test and drop weight test were performed and the results were analysed statistically. The found that Cement-based composites containing 10% silica fume demonstrates better compressive strength, splitting tensile strength, direct tensile strength and abrasion resistance, and worse impact resistance than composites containing 5% silica fume. The 10% silica fume specimens with w/cm ratios of 0.35 and 0.65 have 18% and 15% higher compressive strength, 3% and 8% higher direct tensile strength, 40% and 38% higher toughness, 32% and 42% lower abrasion coefficient and 83% and 62% lower impact toughness than the control specimen. The addition of steel fiber to silica fume composites achievesc10% and 9% increase in compressive strength, 68% and 59% increase in splitting tensile strength, 31% and 15% increase in direct tensile strength, 23% and 28% increase in toughness, 18% and 8% reduction in abrasion coefficient, and 4118% and 296% increase in impact toughness.

DasariVenkateswara Reddy, PrashantY.Pawade (2012) used concrete mixes with Silica Fume of 0%, 4%, 8%and 12%, with addition of crimped steel fibers of diameter 0.5 mm Ø with a aspect ratio of 60, at various percentages as 0%, 0.5 %, 1.0 % and 1.5 % by the volume of concrete on M35 grade of concrete. The effect of mineral admixture (silica fume) as cement replacement material with and without steel fibers on mechanical properties were analysed and compared with normal concrete. The weight density of concrete increase with increase in the steel fiber content. Super plasticizer with dosage range of 0.75 to 1.80% by weight of cementations materials (Cm = PPC + SF) has been used to maintain the adequate workability of silica fume concrete and silica fume with steel fiber concrete mixes. The compressive strength increases significantly due to addition of silica fume compared with normal concrete. The maximum increase in compressive strength was up to 15.84% and15.68% at 28 days and 90 days of curing for 8% of silica fume replaced by PPC cement.

Yu-Wen Liu, Chin-Chun Lee, K.S. Pann (2009) studied on Abrasion resistance of concrete containing different fibers with silica fume. Three different types of fibers, containing steel fiber, carbon fiber, and Polypropylene fiber, were added to repair concrete, also the abrasion resistance was measured with waterborne sand flow testing method and compared with plane silica fume concrete. Test results show

Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

that optimized fiber–silica fume combinations can better improve the abrasion resistance of repair concrete. At the silica fume–cement ratio of 20%, the fiber concrete can remarkably enhance the abrasion and impact resistance. When hit by waterborne sand flow, the abrasion resistance was better for silica fume concrete combine with carbon fibers, steel fiber and glass fiber than plain silica fume concrete. In addition, the carbon fiber and glass fiber concrete have rather high impact resistance than silica fume concrete.

3. Experimental Investigation:

3.1Cement:

Ordinary Portland Cement of Sanghi brand of 53 grade confirming to IS: 12269-1987 was used in present study. The property of cement is shown in Table 1.

Table 1: Properties of Cement

Properties	Obtained
Specific gravity	3.15
Initial setting time	65 min
Final setting time	175 min
Consistency	30%

3.2Fine aggregate:

Natural sand as per IS: 383-1987 was used.

Source: River Bhogavo, Limbdi
The properties of Fine aggregate are shown below in Table 2.

Table 2: Properties of Fine aggregate

Properties	Obtained
Specific gravity	2.67
Fineness modulus	2.544
Grading zone	II

3.3Coarse aggregate:

Crushed aggregate conforming to IS: 383-1987 was used.

Source: Vadagam
The properties of Coarse aggregate are shown below in Table 3.
20 mm Kapchi and 10 mm Grit were used.

Table 3: Properties of Coarse aggregate

Properties	Obtained
Specific gravity	2.85
Aggregate impact value	14%
Aggregate crushing value	17.5%

3.4Silica Fume:

Silica Fume used was confirming to ASTM C (1240-2000) and was supplied by Fortune minerals and abrasives, Ahmedabad. Silica Fume is used as partial replacement of cement. The properties of Silica Fume are shown in Table 4.

Table 4: Properties of Silica Fume

Property	Value
Colour	Dark to Light Gray
Bulk density	450-650 g/cm^3
Specific gravity	2.22
Moisture content	1%
Sio2	92%

***As per manufactures manual**

3.5Super plasticizer:

To improve the Workability Super plasticizer is used at 0.8% with Silica Fume. Yahska Super PRA 20 R used in present investigation.

The properties of Super plasticizer are shown in Table 5.

Table 5: Properties of Super plasticizer

Aspect	Dark Brown Liquid
Type	Napthalene Formaldehyde Sulphonate
Sp. Gravity	1.21
Ph	7-8

3.6Micro Steel Fiber:

Source: Fiber zone, Ahmedabad

The properties of fiber are shown below Table 6

Table 6: Properties of Fiber

Product name:	KrampHarex micro steel fiber
Material	Low carbon steel wire
Length	6mm ±10%
Diameter	0.17mm ±10%
Aspect ratio	33-35
Tensile strength (N/mm^2)	2100 ±15%

3.7Mix Proportioning:

Concrete mix design in this experiment was designed as per the guidelines specified in

ACI234R – 96 "Guide for the use of silica fume in concrete" by ACI committee 234(7).All the samples were prepared using design mix. M25 grade of concrete was used for the present investigation. Mix design was done based on I.S 10262-2009. The Table 7 shows mix proportion of concrete (Kg/m3).

Table 7: Mix Proportion

Material	Quantity(Kg/m3)
Cement	350
Fine Aggregate	744.53
Coarse Aggregate	1243.03
Water	175
W/C ratio	0.5

4. Test Results

4.1Effect of Micro steel fiber and Silica Fume on compressive strength of concrete:

Series of cubes are casted using different percentage of Silica Fume (i.e. 6%, 8%, 10%, 12%) with different percentage of fibers (i.e. 0.5%, 1%, 1.5%, 2%). Compression test are conducted and results are obtained shown below.

- Cement is replaced by 6% Silica Fume. Results shown below in table.

Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

Fiber (%)	3 days	7 days	28 days
0	20.24	28.54	38.85
0.5	13.5	23.14	38.87
1	14.15	24.48	39.9
1.5	14.95	26.3	41.3
2	17.66	29.16	44.63

Table 3.1 Compressive strength of concrete containing Silica Fume (6%) with Steel fiber

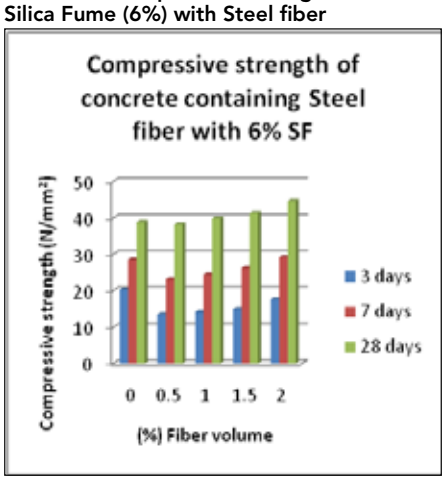

Fig 3.1 Compressive strength of concrete containing Silica Fume (6%) with Steel fiber

- Cement is replaced by 8% Silica Fume. Results shown below in table.

Fiber (%)	3 days	7 days	28 days
0	20.24	28.54	38.85
0.5	14.8	25.46	40.3
1	15.65	26.88	42.21
1.5	16.11	28.62	43.57
2	18.34	31.56	46.93

Table 3.2 Compressive strength of concrete containing Silica Fume (8%) with Steel fiber

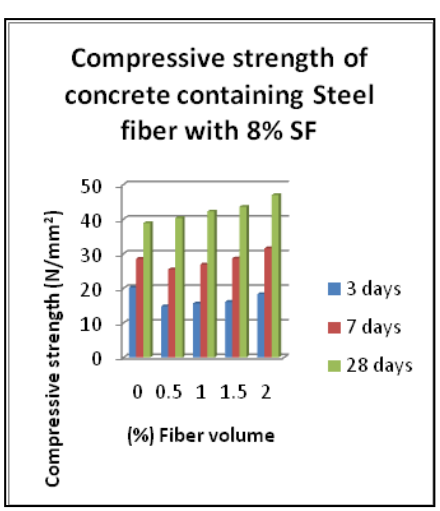

Fig 3.2 Compressive strength of concrete containing Silica Fume (8%) with Steel fiber

- Cement is replaced by 10% Silica Fume. Results shown below in table.

Fiber (%)	3 days	7 days	28 days
0	20.24	28.54	38.85
0.5	16.29	27.37	43.5
1	16.84	28.79	45.32
1.5	17.38	30.51	46.58
2	19.94	33.47	50.15

Table 3.3 Compressive strength of concrete containing Silica Fume (10%) with Steel fiber

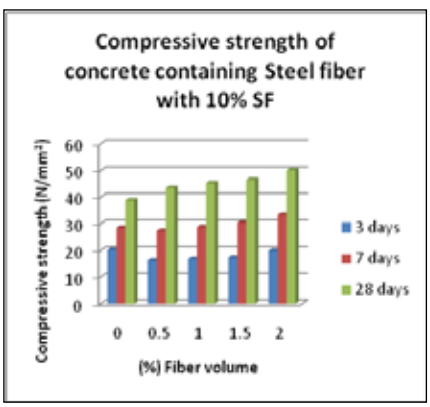

Fig 3.3 Compressive strength of concrete containing Silica Fume (10%) with Steel fiber

- Cement is replaced by 12% Silica Fume. Results shown below in table.

Fiber (%)	3 days	7 days	28 days
0	20.24	28.54	38.85
0.5	13.27	24.5	39.45
1	13.82	25.55	41.27
1.5	14.36	27.12	42.66
2	16.33	30.09	45.9

Table 3.4 Compressive strength of concrete containing Silica Fume (12%) with Steel fiber

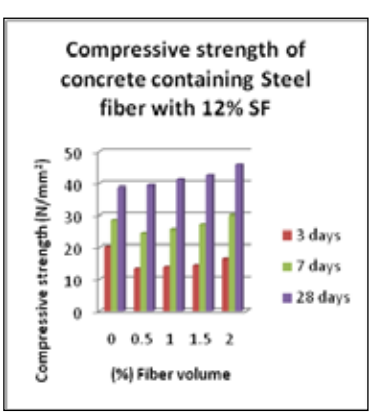

Fig 3.4 Compressive strength of concrete containing Silica Fume (12%) with Steel fiber

5. Discussion:

- Results shown that initially addition of fibers in concrete containing Silica Fume decrease the compressive strength compared with Plain concrete. But at age of 28 days curing it shows good results.
- Due to lower aspect ratio there is no problem of balling and handling is easily.

Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

- As increasing volume of fibers it is observed that there is increased in compressive strength.
- Thus addition of Micro Steel fibers and Silica Fume increases the compressive strength up to 30% with different combination.
- Among all replacement of Silica Fume with Micro steel fiber, 10 % Silica Fume with 2% volume of fiber is best combination.
- From the results it can be concluded that addition of micro fibers in concrete improves the mechanical properties of concrete.

REFERENCE | ACI 234R-96(2000): Guide for the Use of Silica Fume in Concrete. | SP 23 Handbook on Concrete mixes. | ACI 544.4R-88 (Reapproved 1999): Design considerations for Steel Fiber Reinforced Concrete. | Dasari Venkateswara Reddy, PrashantY.Pawade, "Combine effect of Silica Fume and Steel fiber on mechanical properties on standard grade of concrete and their interrelations", IJAET/Vol.III/ Issue I/January-March, 2012/361-366. | Er. Prashant Y.Pawade, Dr. P.B. Nagarnaik, Dr.A.M.Pande, "Critical studies on the influence of Silica Fume and Steel fibers in enhancing properties of concrete, JERS/Vol.II/ Issue IV/October-December, 2011/281-286. | Frank Papworth,"Use of steel fibre in concrete", The Concrete institute of Australia (1997). | K.C. Biswal and Suresh Chandra Sadangi, " Effect of superplasticizer and silica fume on properties of concrete", Conference on Effect of Superplasticizer and Silica Fume on Properties of Concrete, Trivandrum, Kerela, March 16th, 2011. | L. Cominoli, C. Failla, G.A. Plizzari, "Steel and synthetic fibres for enhancing concrete toughness and shrinkage behaviour". | Nguyen Van chanh, "Steel fiber reinforced concrete". | Pawade Prashant.Y, Nagarnaik P.B, Pande A.M, "Influence of Silica fume in enhancement of compressive strength, flexural strength of steel fibers concrete and their relationship", International Journal of Civil and Structural Engineering Volume 2 Issue 1 2011. | Prashant Y Pawade, Nagarnaik P.B, Pande A.M, "Performance of steel fiber on standard strength concrete in compression", International Journal of Civil and Structural Engineering Volume 2, Issue 2, 2011. | Shakir A. Salih, Saeed K. Rejeb, Khalid B. Najem, "The effect of Steel fibers on the mechanical properties of High performance concrete", Al-Rafidain Engineering Vol.13 No.4 2005. | Wei-Ting Lin, Ran Huang, Chin-Lai Lee, and Hui-Mi Hsu, "Effect of Steel Fiber on the Mechanical Proerties of Cement-Based Composites Containing Silica Fume", Journal of Marine Science and Technology, Vol. 16, No. 3, pp. 214-221 (2008). |