IMPACT ON CONCRETE BY USING STEEL FIBRE AND SILICA FUME AS PARTIAL SUBSTITUTE OF CEMENT

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Abstract - *Now a days, many investigations and experiments are currently going on to prepare a high strengthed and durable concrete by the addition of different types of materials. This research represents the influence of silica fume and steel fibers on normal concrete and will also help in achieving the outstanding results. Hence in this research, Experimental investigations and analysis of results were conducted to study the compressive and flexural behavior of composite concrete with varying percentage of such silica fume and steel fibers added to it. The concrete mix adopted were M40 with varying percentage of the silica fume ranging from 0%, 5%, 10%, 15% & 20% in the partial replacement of cement weight and stainless steel fibers of diameter and length 0.50 mm and 40 mm respectively with the aspect ratio 80 at various percentages ranging from 0%, 0.4%, 1.4%, 2.4% & 3.4% by weight of the concrete. On the analysis of the test results the normal concrete with silica fume and straight steel fibers has enhanced the performance of composite mixture as compared to the ordinary concrete with conventional silica fume and steel fibers which were easily available in the market. These sustainable improvements or modifications could be easily adopted in the regular constructions.*

***Key Words*: Silica Fume, Straight Stainless Steel Fiber, Compressive Strength, Flexural Strength**

1.INTRODUCTION

The poor and unsatisfactory performance of conventional concrete under aggressive environmental conditions has necessitated the researchers and engineers to look for new concrete composites. The innovative use of concrete must contemplate explorations of area, in use of new shapes, materials and technique of construction. Concrete is such a versatile material that such attempts of contemplation are quite possible. In modern age one cannot think of construction work without concrete. It is the most widely used construction material which is available in variety of types and can be used in various types of construction works varying from small buildings to big multistoried buildings, bridges ,dams and other massive structures

1.1 SILICA FUME

Silica fume or Micro silica is co-product of the ferrosilicon and silicon alloy industry which is very rich in amorphous silicon dioxide nearly 90%. realizing the pozzolanic potential of the materials, this has been used successfully as an admixture in producing concrete. Initially, the use of micro silica was as a cement replacement, due to its very high pozzolanic reactivity, but as more data came from laboratory and field, the material becomes as additional cementitious component giving increased performance in both fresh and hardened states. For improved strength and durability, the use of silica fume as the replacement of cement has been tried with success

1.2 STEEL FIBRE

A number of steel fiber types are available as reinforcement. But generally round steel fibers are commonly used. These fibers found extensive engineering application. Most of the steel fibers are obtained by cutting drawn wires and fibers with different types of crimps, indentations and shapes to increase mechanical bond are also being produced steel fibers with low tensile strength (7141kg/cm^2) are also produced from low carbon flat rolled steel coils.

1.3 OBJECTIVES

i. To study the effect of silica fume and steel fibre in concrete when mix design.
ii. To investigate the behavior of steel fibre reinforced with silica fume concrete under various loading conditions
iii. To determine the effect of silica and steel fibre on the compressive and flexural strength of concrete.

2. LITERATURE REVIEW

The review deals with the significant developments regarding performance and applications of silica fume and steel fibre based concrete that have taken place in the recent past. An extensive literature review pertaining to different aspects of concrete containing silica fume with steel fibre has been carried out in order to identify the areas of future studies in concrete

2.1 REVIEW OF LITERATURE

(Bgiir Eren and Tahir CJeli, 1997) In this study the influence of silica fume on the properties of HSFRC were investigated by using silica fume of two different percentages and three different hooked-end fibers namely, 30/0.50, 60/0.80 and 50/0.60 length/diameter (mm/mm). Addition of 10% silica fume with fiber volume of 2% and aspect ratio of 60 to plain series

(Kayali, 2004) showed that the Steel fibers at the rate of 1% by volume of concrete resulted in the highest gains in the strength of high volume fly ash concrete reported in these tests. The strength of the concrete in compression was more than double that without fibers.

(Koksal et al. 2008) showed that the compressive strengths of concretes produced by additions of both steel fiber and silica fume had higher than the ones containing only silica fume. A considerable increase in the splitting and flexural tensile strengths of the concretes was obtained by using silica fume and steel fibers together.

3. METHODOLOGY AND EXPERIMENTAL STUDY

3.1 MATERIALS USED

Cement: Ordinary Portland cement (OPC) is by far the most important type of cement. The OPC was classified into three grades namely, 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988.

Fine aggregates : It should be passed through IS Sieve 4.75 mm. It should have fineness modulus 2.50-3.50 and silt contents should not be more than 4%. Coarse sand should be either river sand or pit sad; or combination of the two. In our region, fine aggregates can be found from bed of local river.

Coarse aggregates: It should be hard, strong, dense, durable and clean. It must be free from vein, adherent coatings and injurious amount of disintegrated pieces, alkalis, vegetable matters and other deleterious substances

Water: Water should be free from acids, oils, alkalies, vegetables or other organic impurities

Silica Fume :Silica fume or Micro silica is co-product of the ferrosilicon and silicon alloy industry which is very rich in amorphous silicon dioxide nearly 90%. realizing the pozzolanic potential of the materials

Steel Fibers: Normal unreinforced concrete is brittle with a low tensile strength and strain capacity. The function of the irregular fibers distributed randomly is to fill the cracks in the composite. Fibers are generally utilized in concrete to manage the plastic shrink cracking and drying shrink cracking.

3.2 TESTING OF MATERIALS

The objective of the present study is to obtain the properties of the different constituent materials to be used for making the specimens for the experimental studies. The data is useful to classify the cement, sand, coarse aggregate, silica fume and steel fiber. These values will be used for further studies for the calculation of mix design. These values also confirm the right type and quality of the materials used.

3.2.1 Test on Cement mix with SF and MS

The cement use for the experimental studies was Ambuja cement 43 grade OPC as per the specifications of Indian Standard Code IS: 8112-1989. It was fresh and without any lumps.

i. Consistency
ii. Setting Time
iii. Soundness
iv. Specific Gravity
v. Fineness

I. Consistency of Cement Pastes

The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. So we can say that standard consistency of cement is that consistency at which the Vicat plunger penetrates to a point 5-7mm from the bottom of Vicat mould. Normal consistency tests, for the silica fume and steel fibres with cement paste were conducted, by Vicat apparatus, to observe the changes in water requirement of pastes due to the addition of silica fume and steel fibre. As the nomenclature of silica fume and steel fibre is same so I choose MS (Micro Silica) for silica fume and SF for steel fibre with 5, 10, 15 and 20 % of silica fume and 0.4, 1.4, 2.4 and 3.4 % of steel fibre.

II. Soundness

When referring to Portland cement, "soundness" refers to the ability of a hardened cement paste to retain its volume after setting without delayed destructive expansion. This destructive expansion is caused by excessive amounts of free lime (CaO) or magnesia (MgO). Most Portland cement specifications limit magnesia content and expansion, Standard Specification for Portland cement specifies a maximum autoclave expansion of 0.80 percent for all Portland cement types.

According to the Ethiopian standard, the expansion of Portland cement shall not exceed 10mm . In the research Le-Chatlier expansion tests were conducted for soundness test.

3.3 MIX DESIGN

Mix Design by Indian Standard method (IS 10262)
Data:-

- The following basic data required to be specified for a design of concrete mix.
- Characteristics strength of concrete at 28 days (f_{ck}) = 40 N/mm^2
- Maximum size of crushed aggregate = 20mm
- Degree of workability (Compacting Factor) = 0.90
- Value of Statistical Coefficient (K) = 1.65
- Value of Standard Deviation (S) = 5.3

Test data of materials: -

- Cement used = OPC 43 grade
- Specific Gravity of Cement = 3.00
- Specific Gravity of coarse aggregates= 2.73
- Specific Gravity of fine aggregates = 2.69

(a) Target strength for mix design:-

- $F_t = f_{ck} + k \times S$
- K= 1.65, S= 5.3, f_{ck} = 40 N/mm^2
- F_t = **48.74 N/mm^2**

(b) Selection of water cement ratio:-

- Maximum water cement ratio specified for durability = **0.40** (Refer IS: 456-2000 Table 5)

(c) Selection of water content :-

- From Table 2 of IS 10262-2009, maximum water content is 186 litre for (25 to 50mm slump range) for 20mm aggregate
- Estimated water content for 75mm slump = 186+ $\frac{3}{100} \times 186$ = **191.58**

  Cement content = 191.58/0.40 = 478.95kg/m^3
  Hence, Adopt Cement content = **478.95 kg/m^3**

(d) Calculation of aggregate content:-

- Volume of cement = (478.95 / 3.00) ×1000 = **0.159 m^3**
- Volume of water = 191.58/1000 = **0.191 m^3**
- Volume of all in aggregate = 1- 0.159 - 0.191 = **0.65 m^3**
- Coarse aggregate content = 2.73 × 0.63 × 0.65 × 1000 = **1117.935 kg/m^3**
- Fine aggregate content = 2.67 × 0.37 × 0.65 × 1000 = **637.32 kg/m^3**

3.4 TESTING OF SPECIMENS

The following tests have been carried on various specimens:

- Workability Test
- Compressive strength test
- Flexure strength test

3.4.1 Workability Test

A very important characteristic of a concrete is its workability when it is wet (prior to setting into a hardened state). There are two reasons for this. The first is that placement becomes difficult if the concrete is too stiff and it may not be able to be pumped. The second reason is that the concrete may not be able to be compacted adequately thus leading to voids in the hardened concrete.
An increase in voids will lead to a decrease in the durability of the concrete. This is due mainly to lowered resistance to permeability of water and water borne ions. Also if the concrete is too stiff there is an increased likelihood of the concrete being watered down on site to make placement easier, reducing both the strength and the durability of the concrete.

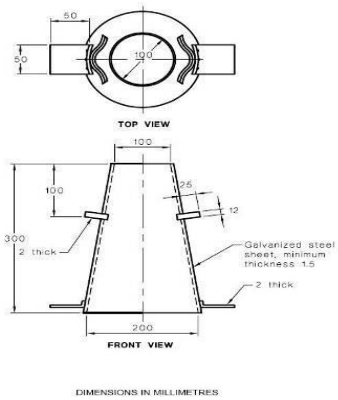

Fig -1: Mould for Slump Test

3.4.2 Flexure Strength Test

The test was conducted on beams according to IS code 516-1959. The bearing surfaces of the supporting and loading rollers was wiped clean, and any loose sand or other material removed from the surfaces of the specimen where they were to make contact with the rollers. The specimen was then placed in the machine in such a manner that the load was applied to the uppermost surface as cast in the mould, along two lines spaced 13.3 cm apart. The axis of the specimen was carefully aligned with the axis of the loading device. No packing was used between the bearing surfaces of the specimen and the rollers. The load was applied without shock and increasing continuously at a rate such that the extreme fibre stress increased at approximately 7 kg/sq cm/min, that is, at a rate 180 kg/min.

Fig -2: Test Set Up For Flexure Strength Test

4. ANALYSIS OF RESULTS AND DISCUSSION

An Experimental study on the behavior of silica fume and steel fibre reinforced concrete has been conducted for various loading conditions. The results of the present investigation are compared with the other investigation. A good agreement between the compressions, flexural strength has been obtained. The results of the present investigation are discussed under the following heads.

4.1 Slump Test

Overall, all the mixes did have a moderate workability level but at least this was consistent throughout. Average slump values are shown in Table 1. The slump was measured twice, once for each batch. Although IS (Standards India 1959) states that for high slumps exceeding 110 mm a tolerance of ± 30 mm is permitted., these high slumps value were a little too high for practical use in comparison with commercial concrete and would not be accepted in industry.
With such a high workability, special care was taken not to over tamping the concrete by the rod to avoid segregation of the concrete. Figure 3 shows the average, upper and lower slump values of the mixes.

Table -1: Workability Experienced of Concrete Mixes

Mix	M0	M1	M2	M3	M4
Average slump	80	75	70	60	55

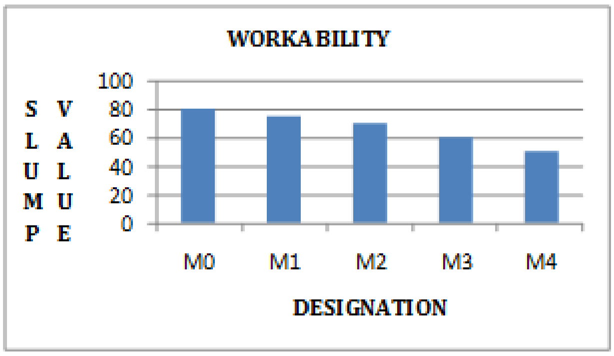

Fig -3: Workability of various mix

4.2 Flexural Strength

Flexural strength of plane mortar and SFRC has been investigated by testing beams of 150mm×150mm×700mm under two-point load because of small span between the supports. In this flexural strength, the effective length of the beam was 640 mm. The flexural strength of plane mortar and SFRC for various percentages of silica fume and fibre content has been illustrated in Table 2 and 3, which shows the flexural strength after 7 and 28 days respectively. concrete.

Table -2: Flexure Strength after 7Days

Mix Designation	% of Steel Fibre	% of Silica Fume	Flexural Strength (N/mm^2)	Average strength (N/mm^2)
M0	0	0	2.52 2.60 2.72	**2.61**
M1	0.4	5	2.55 2.80 3.00	**2.78**
M2	1.4	10	2.95 3.08 3.18	**3.07**
M3	2.4	15	2.68 2.55 2.41	**2.54**
M4	3.4	20	2.43 2.42 2.31	**2.38**

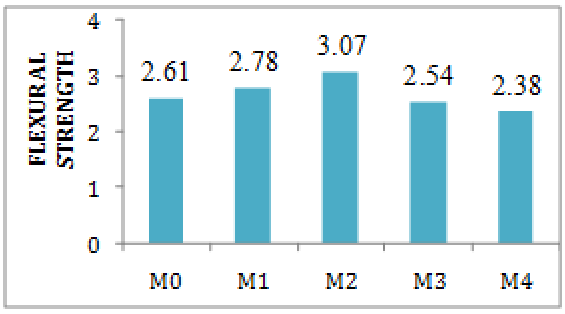

Fig -4: Flexural Strength after 7days

Table -3: Flexure Strength after 28 Days

Mix Designation	% of Steel Fibre	% of Silica Fume	Flexural Strength (N/mm²)	Average strength (N/mm²)
M0	0	0	4.59 4.78 4.65	**4.67**
M1	0.4	5	4.98 4.90 4.85	**4.91**
M2	1.4	10	5.19 5.20 5.12	**5.17**
M3	2.4	15	4.98 4.80 4.85	**4.87**
M4	3.4	20	4.52 4.40 4.38	**4.43**

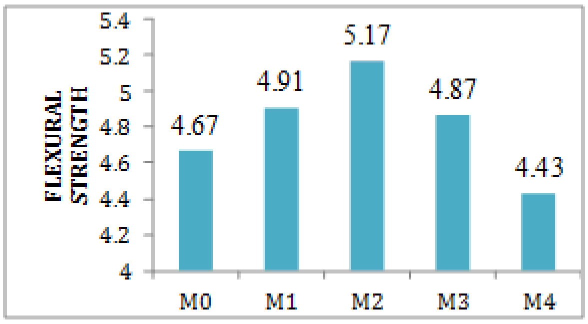

Fig -5: Flexural Strength after 28days

5. CONCLUSIONS

Steel Fibre Reinforced Concrete being a relatively new construction material is considered as a special type of fibre reinforced concrete and it posse good result when some silica fume added in it. Laboratory and field experiments have shown SFRC to be a unique construction material possessing high compressive, flexural strength. Because of it's higher strength and ductility, the composite has excellent potential for structural application in serve service situations where conventional concrete do not perform satisfactorily

5.1 CONCLUSIONS

From the results of the present investigation the following conclusion may be drawn:-

I. The Experimental work shows that properties of concrete M40 get improved due to incorporation of steel fibres with silica fume.
II. The Experimental work shows that workability of SFRC gets reduced as we increased the steel fibre percentage and silica content.
III. The consistency of cement paste increases as the percentage of silica fume increases, maximum value we get is at 10 % of silica fume.
IV. The soundness of the paste decreases with increasing % of silica fume in cement paste.
V. It can be concluded that the compressive strength after 7 days of SFRC gets increased up to 31.41 Mpa with 1.4 % addition steel fibres and 10 % of silica fume content as compared to plain concrete.
VI. It can be concluded that flexural strength after 7 days of the SFRC gets increased 3.07 Mpa after addition of 1.4 % of steel fibre and 10 % of silica content as compared to plain concrete.
VII. It can be concluded that the compressive strength after 28 days of SFRC gets increased up to 53.18 Mpa with 1.4 % addition steel fibres and 10 % addition of silica content as compared to plain concrete.

5.2 FUTURE SCOPE OF THE STUDY

The present investigation has been carried out to investigate the behavior of SFRC with silica fume under compression and flexure. It can be suggested that further study may be undertaken to investigate:

I. Effect of change in fibre length on the compressive, tensile, flexural and other structural properties of SFRC.
II. Effect of aspect ratio of fibres on the behavior of SFRC.
III. Effect of fibre contents from 3 to 12 % on the structural behavior of SFRC.

IV. Effect of use of Rice Husk and other type of material on the structural behavior of SFRC.
V. Effect of fibre content on the ductility and toughness of SFRC.
VI. Effect of change of W/C ratio on the structural behavior of SFRC.

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