INFLUENCE OF SILICA FUME AND STEEL FIBER ON NORMAL CONCRETE

Manoj Kumar Poonia[1], Vinesh Kumar[2], Mukesh Kumar[3]
[1,2]M. Tech Scholar, [3]Asist. Professor, Department of Civil Engineering
Prannath Parnami Institute of Management & Technology, Hisar (Haryana)

ABSTRACT: Now a day, various investigations and study has been presently going on to prepare a durable concrete by the addition of different types of materials. This paper represents the Optimum use of the silica fume by replacing the cement with addition of steel fibers in the normal concrete mix and will also help in achieving the preferred results. This paper shows the investigation on M30 grade concrete due to incorporation of silica fume and stainless steel fibers. In this paper we used the silica fume by replacing the cement's weight 0%,3%,6%,9%,12% and stainless steel fibers of diameter 0.50 mm with aspect ratio 80 at various percentages 0%,0.7%,1.4%,2.1%,2.8% by the volume of concrete on M30 grade of mix proportion (1:1.53:2.82) with water cement ratio 0.44. Steel fiber reinforced concrete containing silica fume based specimens has been tested for the workability, compressive strength, flexural strength and split tensile strength.
Keywords: Silica fumes, Stainless steel fibers, compressive strength, flexural strength, split tensile strength and aspect ratio.

I. INTRODUCTION

The weak and endurable life of normal concrete under different types of climatic conditions has necessitate the researchers and engineers to look for new concrete composites and experiments. The pioneering use of concrete must contemplate explorations of areas, in use of new shapes, materials and technique of structures. Normal concrete is such a flexible material that such attempt of consideration is quite possible. In modern age no one cannot think of construction work without concrete. Normal concrete has major deficiencies like high permeability, low bond strength, low tensile strength and allow strain at the cracks. Silica fume is a result of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in normal concrete because of its chemical and physical properties; it is a very reactive pozzolona. Normal concrete contains silica fume can have very high strength and can be very long-lasting. Silica Fume is usually a greyish colour powder, fairly similar to Portland cement or some fly-ash. It exhibits both pozzolonic and cements nous properties. The function of silica fume is in High-strength concrete improved, silica-fume shortcrete, Oil well grouting and it also work as a packing material in concrete as its size is smaller than fine aggregate. To prevent shrinkage crack durability and compressive strength, thousands of small fibers are discrete and spread randomly in the concrete during mixing, and thus improve concrete properties in all directions. That's why the addition of steel fiber and silica fume in normal concrete improved the properties such as workability, brittleness, strength, corrosion resistance and ultimately increased life of the structure. Durability and the other mechanical properties of concrete are improved when pozzolonic materials are incorporated in concrete because of the reaction between silica present in pozzolonic and the free calcium hydroxide during the hydration of cement and consequently forms extra calcium silicate hydrate (C – S – H) and also there is major advantage of using fiber reinforced concrete besides reducing permeability and increasing fatigue strength is that fibers addition improves the toughness or residual load carrying ability after the first crack. Reinforce capability and proper functioning of steel fiber is based on length of fiber, diameter of fiber, the percentage of fiber and condition of mixing, orientation of fibers and aspect ratio. Aspect ratio is ratio of length of fiber to its diameter which plays an important role in the process of reinforcement. Normal concrete contains silica fume and steel fiber have only less than 3% of fibers and aspect ratio below 100.

II. LITERATURE REVIEW

As we know the properties of normal concrete gets enhanced due to the merging of silica fume and steel fiber. Many papers have being published which tells about the compressive strength, flexural strength and split tensile strength of concrete according to their view.

Pawade Parshant, Nagarnaik P B and Pande A M [1] have investigated the compressive strength increases with the increase in silica fume compared with ordinary concrete. The maximum increase in compressive strength was up to 8.01%, 11.92%, and 12.62% at 7 days, 28 days and 90 days of curing for 12% of silica fume replaced by PPC cement, also the weight density of concrete increases by addition of steel fibers. Both the properties of concrete, compressive strength and flexural strength increases by addition of 1.0 mm diameter steel fiber than 0.5 mm diameter.

Gurbir Kaur, S P Singh and S K Kaushik [2] represented the comparison based on actually applied fatigue stress, the trend differs. The two million cycles fatigue strength/endurance limits in terms of actually applied fatigue stress are 6.80 MPa and 4.75 MPa for ternary blended admixture concrete (CLS) and binary blended admixture concrete (CL) respectively. The most appropriate mix which results in maximum reduction of variability in the distribution of fatigue life and increase two million cycles fatigue strength is CLS, By replacing 30% cement and yet achieving properties of higher

potential makes CLS mix as most appropriate combination based upon the results of this investigation.

Khelan Parikh and Dhruti J Dhayani[3] has discussed the increased compressive strength performance of concrete with steel fibers containing silica fume at the age of 28 days. Also, due to lower aspect ratio there is no problem of balling and handling is easily. Among all replacement of silica fume with micro steel fiber, 10% silica fume with 2% volume of fiber is best combination.

Ahmed Fathi Mohamed, Nasir Shafiq, M F Nuruddin and Ali Elheber [4] investigated that steel fiber at early age did not increase the compressive strength due to the degree of reactivity of silica fume, the strength was less than that of control mix. The application of steel fiber reduced the workability properties but the silica fume will increase the ability of mixture to flow easily within short time due to it is fineness particles. 2.% of steel fiber by weight of cement was found as the optimum steel fiber for group one while the .0% and 1.5% was the optimum values for groups two and three respectively.

Dasari Venkateshwara Reddy and Parshant Y Pawade [5], investigated on the basis of regression analysis of large number of experimental results, the statically model showed in figures has been developed. The proposed model was found to have good accuracy in estimating the 28 days and 90 days compressive strength and flexural strength, with their inter relationship at 0%,4%,8%,12% silica fume & 0%,0.5%,1.0%,1.5% steel fibers of both diameters.

B H V Pai and Sujith Kumar C P [6], studied the effect of addition of steel strands has proven that it is possible to develop steel fiber reinforced self compacting concrete without any significant detrimental effects to its workability. The SFRSCC mix developed has satisfied all the requirements of self compact ability and has exhibited a maximum compressive strength of 80.44 MPa at 28 days, with a fiber content of 4%. SFRSCC is likely to experience some resistance to passing ability when used in structures having congested reinforcement.

III. MATERIAL USED

3.1Cement: Ordinary Portland cement (OPC) of ULTRATECH Company, 43-grade has been used in this investigational work. OPC 43-grade cement has been examine the strength of cement at 28 days as per IS 4031-1988.The various properties of the cement are described in Table 1.

3.2 Silica Fume: Silica fume having the fineness by residue on 45 micron sieve = 0.8%, specific gravity =2.2, moisture content =0.7% were used. The chemical analysis of silica fume (Grade 920-D): silicon dioxide =89.2%, LOI at 975* Celsius = 1.7% and carbon = 0.92%, are conforming to ASTM C 1240-1999 standards.

3.3 Fine Aggregates: nearby available river sand passed through 4.75mm IS sieve has been used in the preparation of SFRC containing silica fume. It confirms to IS 383-1970 which comes under Zone I. The physical Properties of sand like Fineness Modulus, Specific Gravity and water absorption are 3.49, 2.67 and 2.31%.

Coarse Aggregates: The Coarse aggregate are obtained from a local quarry has been used. The coarse aggregate with a maximum size 20mm having a specific gravity 2.89. In this experimental work coarse gravel of 20mm and crushed aggregate of 10mm are mixed in 60:40. The physical Properties of coarse aggregates like Fineness Modulus, Specific Gravity are 2.31, 2.89 respectively.

3.5 Steel Fibers: Stainless steel wire of 0.5 mm diameter has been used in the preparation of SFRC. The steel fiber of length 40 mm and of aspect ratio 80 has been used in this experimental work. All the steel fibers are straight in shape.

3.6 Water: Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete.

Table 1: Properties of cement

Sr. No.	Characteristics	Experimental value	Specified value as per IS:8112-1989
1	Consistency of cement (%)	33%	---
2	Specific gravity	2.98	3.15
3	Initial setting time (minutes)	37	>30 As Per IS 4031-1968
4	Final setting time (minutes)	286	<600 As per IS4031-1968
5	Compressive strength (N/mm^2) (i) 3 days (ii) 7 days (iii)28days	 27.56 40.57 48.96	 >23 >33 >43
6	Soundness (mm)	1.00	10
7	Fineness of Cement	5%	10% As Per IS 269-1976.

IV. EXPERIMENTAL SET-UP

In this section, Normal concrete contains silica fume and steel fibers; based specimens have been tested for the compressive strength, flexural strength and split tensile strength.

4.1 Compressive Strength Test: To examine the compressive strength of normal concrete contains silica fume and steel fibers; cube of 150mmX150mmX150mm has been used, in this experimental work 35-40 cube has been casted to determine the compressive strength. Firstly silica fume, cement and sand are mixed uniformly in dry condition. Secondly coarse aggregates are added in this mixture. Now steel fibers also added according to mix proportion to get the resulting mixture of M30 grade. Required dosage of water was added in the course of mixing. Through mixing was done until concrete appear to be homogeneous and of desired consistency. Now cube moulds were filled with concrete in

three layers and after every layer, concrete was compacted with tamping rod. The mould's surface level should be plane with trowel. The cube moulds were remolded after 24 hours then they were placed in water tank containing portable water and were left for curing. After that the specimen are tested at 7 days and 28 days at compression testing machine (CTM)

Figure 1 Cube under Compression Testing Machine (CTM)

4.2 Split Tensile Strength Test: To examine the tensile strength of normal concrete contains silica fume and steel fibers; cylinder of size 150mmX300mm has been used in this experimental work 35-40 cylinders has been casted to determine the tensile strength. The specimens are remolded after 24 hours and placed in the curing container for 28 days. After that, cylinders were tested horizontally under compression testing machine (CTM).

4.3 Flexural Strength Test: To examine the flexural strength of the normal concrete contains silica fume and steel fibers; cylinder of size 150mmX150mmX70mm has been used in this experimental work. 35-40 beams have been casted to determine the tensile strength. The beams specimen of different proportions was de-mold after 24 hours and transferred to the curing container for 28 days. After that, beams were placed to the two point loading machine on which we apply the load manually. Note down the load value at which cracks starts rising on the beam.

Figure 2 Test set-up for a Beam

4.4 Workability: Workability is one of the physical parameters of concrete which means how ease to work; it affects the strength and durability of concrete. Concrete is said to be workable when it is easily placed and compacted homogeneously without honeycombs, bleeding or Segregation. When we replace cement with silica fume and steel fiber then silica and calcium get react with cement and a strong bond formed which prevent the flow of concrete and workability get decreases, finally the quantity of water required get decrease also W/C ratio decreases and we get less slum value. This test works on the principal of measuring the behaviour of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the wetness of concrete

V. TEST RESULTS

5.1 Compressive Strength: Compressive strength of normal concrete contains silica fume and steel fibers; was measured at the ages of 7 and 28 days and shown in Table II. There was an increase in compressive strength of cube concrete specimens produced with silica fume and steel fibers.

Table II: Compressive Strength Results

Mix Designation	Percentage of Silica fume	Percentage of Steel Fiber	Compressive Strength after 7 days (N/mm^2)	Compressive Strength after 28days (N/mm^2)
MX0	0	0	18.78	29.65
MX1	3	0.7	23.19	35.19
MX2	6	1.4	24.37	37.9
MX3	9	2.1	23.41	36.59
MX4	12	2.8	20.19	30.74

Variation of compressive strength with different age is shown in figure 3.

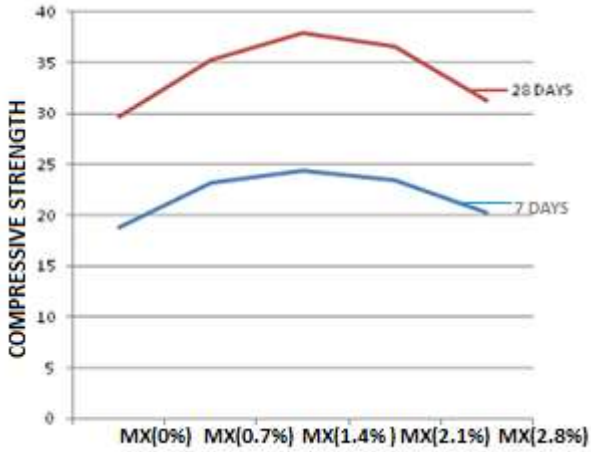

Figure 3 Compressive Test

From the above results, we observe that compressive strength of normal concrete increases due to incorporation of silica fume and steel fibers. From the plot we can say that compressive strength of normal concrete increases up to 43 % with 1.2% steel fibers and 12% silica fume.

5.2 Flexural Strength: Table shows the values of flexural strength of the normal concrete contains silica fume and steel fibers; beams at different mix proportions. Plot shows the variations of flexural strength at 7 and 28 days.

Table III: Flexural Strength Results

Mix Designation	Percentage of Silica fume	Percentage of Steel Fibers	flexural Strength after 7 days (N/mm^2)	flexural Strength after 28days (N/mm^2)
MX0	0	0	1.52	2.37
MX1	3	0.7	1.61	2.38
MX2	6	1.4	1.7	2.60
MX3	9	2.1	1.88	2.79
MX4	12	2.8	2.14	3.19

It shows Variation of flexural strength at different ages

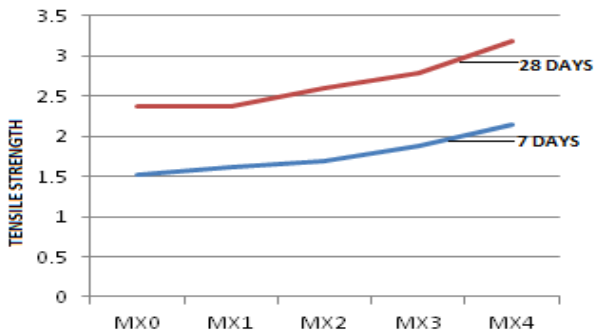

Figure 4 Flexural Strength test

The results obtained from the experiment showed that flexural strength increased up to 35 % as compared with normal concrete.

5.3. Split Tensile Strength

Split tensile strength of concrete mixtures was measured at the ages of 7 and 28 days as shown in Table 6. The results show that in general, there is an increase in splitting Tensile strength of cylinder concrete specimens up to 5% with the addition of silica fume and steel fibers to the concrete at 28 days age.

Mix Designation	Percentage of Silica Fume	Percentage of Steel Fibers	Split tensile Strength after 7 days (N/mm)	Split tensile Strength after 28days (N/mm²)
MX0	0	0	1.6	2.44
MX1	3	0.7	1.58	2.47
MX2	6	1.4	1.9	2.91
MX3	9	2.1	1.63	2.5
MX4	12	2.8	1.67	2.58

Table IV: Split Tensile Strength Results

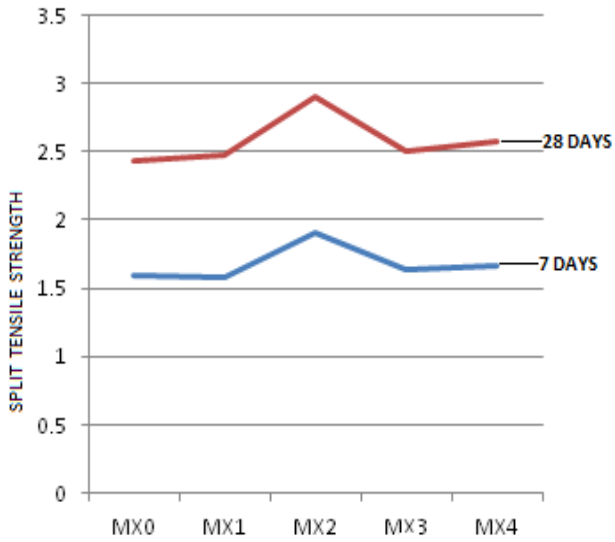

Figure 5 Split Tensile Strength Test

5.4. Workability

In this paper we will measure workability by the Slump test. Slump test apparatus is a cone of steel has a base width 10cm, top width 20 cm and height of 30 cm and a tamping road having standard 16 mm diameter steel rod, rounded at the end and 600 mm long is used. Slump value for 0.44 W/C ratios are shown in Table V.

Table V: Workability results

Mix Designation	Percentage of Silica fume	Percentage of Steel Fibers	Workability (mm)
MX0	0	0	70
MX1	3	0.7	64
MX2	6	1.4	60
MX3	9	2.1	51
MX4	12	2.8	40

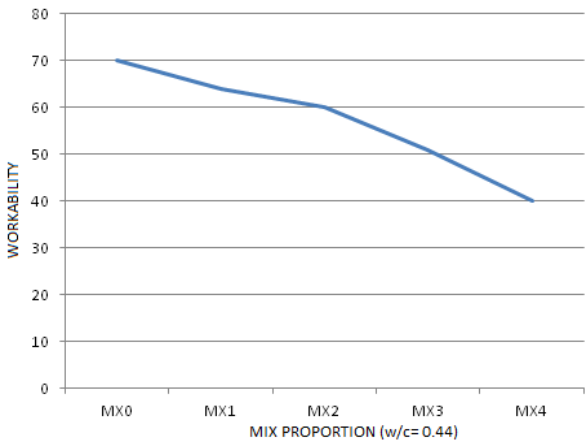

Figure 6 Workability

VI. CONCLUSIONS

Following studies can be drawn from this study:

1. When we added silica fume with steel fibers to the mixture it was seen that the weight density of the concrete is increased.
2. The compressive strength increases with the increase of silica fume as compared to the normal concrete.
3. Compressive strength was increase up to 34% at 7 days and 35% at28 days by addition of 6% of silica fume and 1.4% of steel fiber in normal concrete, Also seen that, the increase of 9% and 12% of silica fume to the replacement of cement has not much significant change on the development of compressive strength. So the maximum percentage of the silica fume on the replacement of cement should be 9%.
4. There is an increase in splitting Tensile strength of cylinder concrete specimens up to 5% with the addition of silica fume and steel fibers to the concrete the flexural strength increases also increases with the addition of steel fibers as compared to silica fume concrete.
5. The increases in flexural strength are directly proportional to the fiber content and also the flexural deflection decreases with increase in steel fiber as compared to the normal concrete.
6. The optimum replacement level of cement by silica fume is found to be 6% by weight, there is a significant improvement in the compressive strength of concrete using silica fume at both 7 and 28 days as compared to the normal concrete. The workability in case of silica fume concrete is slightly enhanced.
7. Workability of concrete decreases as increase with percentage of silica fume Beyond optimum silica fume level the strength decreases but the workability increases so The optimum replacement level of cement by 6% of silica fume and 1.4% of steel fiber by weight.
8. It is also notified that normal concrete specimens showing irregular cracks and breaks in two parts during testing but normal concrete specimens contains silica fume and steel fibers get closely packed which shows the ductility property.
9. The other properties of the concrete such as workability, ductility, fire resistance, acid resistance, corrosion resistance, chemical resistance are also improved on the addition of silica fume and steel fibers in normal concrete.

VII. ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation for providing steel fibers by Deepak iron store, Hisar and silica fume by Delhi building and chemical providers, Delhi.

REFERENCES

[1] Pawade Parshant, Y Nagarnail P B and Pande A M "Influence of silica fume in enhancement of compressive strength, flexural strength of steel fibers concrete and their relationship" volume 2, number 1, 2011 published in International Journal of Civil and Structural Engineering.

[2] Gurbir Kaur, S P Singh and S K Kaushik, "Flexural Fatigue Strength of Steel Fibers Reinforced Concrete Containing Blends of Limestone Powder and Silica Fume", volume 2, Issue 6, June 2012.

[3] Khelan Parikh and Dhruti J Dhyani, "Effect of Micro Steel Fiber on Compressive Strength of Concrete Containing Silica Fume", volume 2, Issue 4, April 2013.

[4] Ahmed Fathi Mohamed, Nasir Shafiq, M F Nuruddin and Ali Elheber, "Effect of Silica Fume on the Properties of Steel Fiber Reinforced Self-compacting Concrete", published in International Journal of Civil, Structural, Construction and Architectural Engineering Vol 7, No. 10, 2013.

[5] Dasari Venkateshwara Reddy and Parshant Y Pawade, "Combine effect of Silica Fume and Steel Fiber on Mechanical Properties on Standard Grade of Concrete and Their Interrelations", published in International Journal of Advanced Engineering Technology volume 3, Issue 1, January-March 2012.

[6] B H V Pai and Sujith Kumar C P, (2009), "Experimental Study on Steel Fiber Reinforced Self Compacting Concrete with Silica Fume as Filler Material", published in 34th Conference on OUR WORLD IN CONCRETE & STRUCTURES: 16-18 August, 2009.

[7] Partik Patel and Dr. Indrajit N Patel, (2013), "Effect of Partial Replacement of Cement with Silica Fume and Cellulose Fiber on Workability & Compressive Strength of High Performance Concrete".

[8] IS: 456:2000, "Plain and reinforced concrete-code of practice", Bureau of Indian Standards, New Delhi.

[9] IS: 2386-1963, "Indian Standard Code of practice for methods of test for Aggregate for Concrete", Indian Standard Institution, New Delhi.

[10] Is: 516-1959, "Methods of tests for Strength of Concrete", Bureau of Indian Standards, New Delhi.

[11] IS: 383-1970, "Indian Standards specification for coarse and fine aggregates from natural sources for concrete", Bureau of Indian Standards, New Delhi.

