# INFLUENCE OF SILICA FUME ON THE STRENGTH PROPERTIES OF CONCRETE

Pradeep Kuhar[1], V.S.Sagu[2]
[1]M. Tech Scholar, [2]Asst. Professor
Department of Civil Engineering, Prannath Parnami Institute of Management & Technology
Hisar (Haryana)

***Abstract: Many researches due to increased environmental awareness and its potential hazardous effects, utilization of industrial by products has become an attractive alternative to disposal. This paper represents the Optimum use of the silica fume with the concrete mixture and will also help in achieving the desired results. This paper shows the investigation on M35 grade due to incorporation of silica fume. In this paper we used silica fume at various percentages as 0%,4.5%.7%,9.5%,12% by the weight of cement on M35 grade of mix proportion with water cement ratio 0.49. Silica fume based specimens has been tested for the compressive strength, flexural strength and split tensile strength.***

***Keywords: Silica Fume, Compressive Strength, Flexural Strength and Split Tensile Strength.***

## I. INTRODUCTION

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The usage, behavior as well as the durability of concrete structures, built during the last first half of the century with ordinary Portland cement (opc) and plain round bars of mild steel, the ease of procuring the constituent materials (whatever may be their qualities) of concrete and the knowledge that almost any combination of the constituents leads to a mass of concrete have bred contempt. Strength was stressed without a thought on the durability of structures. As a consequence of the liberties taken, the durability of concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self– destruction. The innovative use of concrete must contemplate explorations of areas , in use of new shapes, materials and technique of construction. Concrete is such a versatile material that such attempts of contemplation are quite possible. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Substantial energy and cost savings can result when industrial by products are used as a partial replacement of cement. Fly ash, ground granulated blast furnace slag, rice husk ash, high reactive met kaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement. The ordinary Portland cement is one of the main ingredients used for the production of concrete involves emissions of large amounts of carbon dioxide gas into the atmosphere a major contributor for greenhouse effect and global warming hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material which can be used as an alternative or as a supplementary for cement should lead to sustainable development. Silica fume is the material which take place the cement replacing material.

## II. LITERATURE REVIEW

(Bhanja and Sengupta, 2002) represents a mathematical model developed using statistical methods to predict the 28-day compressive strength of silica fume concrete with water-to-cementitious material (w/cm) ratios ranging from 0.3 to 0.42 and silica fume replacement percentages from 5 to 30.. On examining the validity of the model with the results of previous researchers, it was observed that for results on both cubes and cylinders, predictions were obtained within 7.5% of the experimentally obtained values.

(Pawade.P et.al. 2011) In their study they used concrete mixes with Silica Fume of 0%, 4%, 8%and 12% with addition of crimped steel fibers of two diameters 0.5 mm Ø and 1.0 mm Ø with a constant aspect ratio of 60, at various percentages as 0%, 0.5 %, 1.0 % and 1.5 % by the volume of concrete on M30 grade of concrete. The effect of mineral admixture as cement replacement material with and without steel fibers on mechanical properties were analyzed and compared with normal concrete as well as silica fume concrete. In comparison, with control concrete the replacement of 4%,8%,12% and 16% cement by silica fume showed 7.46%, 11.17%, 11.91%and 9.83% increase in compressive strength at 28 days of curing. The optimum combined effect at 8% silica fume and 1.5% steel fiber with normal concrete the maximum compressive strength increase at 0.5 mm Ø and 1.0 mm Ø steel fiber at 28 days of curing were 15.38% and 18.69%, the maximum flexural strength increase were 17.13% and 24.02%.

(Heba A. Mohamed, 2011) presents an experimental study on self-compacting concrete (SCC) with two cement content. The work involves three types of mixes, the first consisted of different percentages of fly ash (FA), the second uses different percentages of silica fume (SF), and the third uses a mixture of FA and SF. After each mix preparation, nine cylinder specimens are cast and cured. Three specimens are cured in water for 28 days, three specimens are cured in water for 7 days, and three specimens are left in air for 28 days. The slump and V-funnel test are carried out on the fresh SCC and concrete compressive strength values are determined. The results show that SCC with 15% of SF gives

  

higher values of compressive strength than those with 30% of FA and water cured specimens for 28 days give the highest values of compressive strength.

(T. Shanmugapriya, Dr. R. N. Uma (2013) concluded that with increased environmental awareness and its potential hazardous effects, utilization of industrial byproducts has become an attractive alternative to disposal. Silica fume (SF), which is by product of the smelting process in the silicon and ferrosilicon industry. The water binder ratio (W/B) adopted was 0.32 and the Super Plasticizer used was CONPLAST SP 430.Specimens such as cubes, beams and cylinders were cast for various mix proportions and tested at the age of 7,14 and 28 days. The investigation revealed that. the partial replacement of cement by silica fume will develop compressive strength, flexure strength and split tensile strength sufficient for construction purposes

## III. MATERIALS USED

CEMENT: Ordinary Portland cement of 43 grade has been used in this experimental work. OPC 43 grade of ULTRATECH cement has been used after investigate the strength of cement at 28 days as per IS 4031-1988. The various properties of the cement are described in Table 1.

FINE AGGREGATES: Locally available river sand passed through 4.75mm IS sieve has been used in the preparation of SFRC. 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 2.86, 2.69 and 1.82% respectively.

COARSE AGGREGATES: The Coarse aggregate are obtained from a local quarry has been used. The coarse aggregate with a maximum size 20mm. 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, 2.87 respectively.

SILICA FUME: The physical properties of micro silica like Fineness Modulus, Specific Gravity and Specific Area are 2.40, 2.20 and 1800000 cm2/gm respectively, has been used in the preparation of silica fume based concrete.

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. Accordingly, potable tap water was used for the preparation of all concrete specimens.

Table 1: Properties of cement

| Sr.No. | Characteristics | Experimental value | Specified value as per IS:8112-1989 |
|---|---|---|---|
| 1 | Consistancy of cement (%) | 33% | — |
| 2 | Specific gravity | 2.98 | 3.15 |
| 3 | Initial setting time (minutes) | 35 | >30 As Per IS 4031-1968 |
| 4 | Final setting time (minutes) | 282 | <600 As per IS4031-1968 |
| 5 | Compressive strength (N/mm²) (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 PROGRAMME

In this section, Silica fume based specimens has been tested for the compressive strength, flexural strength and split tensile strength.

COMPRESSIVE STRENGTH TEST: To examine the compressive strength of silica fume based concrete, cube of 150mmX150mmX150mm has been used in this experimental work 30-40 cubes has been casted to determine the compressive strength. Firstly cement and sand are mixed uniformly in dry condition. Secondly coarse aggregates are added in this mixture. Now silica fume also added according to mix proportion to get the resultant mixture of M35 grade. Required dosage of water was added in the course of mixing. Through mixing was done until concrete appeared to be homogeneous and of desired consistency. Now cube moulds were filled with concrete in three layers and after each layer, concrete was compacted with temping rod. The moulds surface level should be plane with trowel. The cube moulds were demoulded 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) as per IS 516-1959


Fig. 1 Cube under Compression Testing Machine (CTM)

SPLIT TENSILE STRENGTH TEST:-

To examine the tensile strength of silica fume based concrete, cylinder of size 150mmX300mm has been used in this experimental work. 30-40 cylinders have been casted. The cylinder moulds were demoulded after 24 hours and transferred to curing tank for 28 days. After that cylinders were tested horizontally under compression testing machine (CTM).

Fig. 2 Cylinder Under CTM

  

FLEXURAL STRENGTH TEST:- To examine the flexural strength of silica fume based concrete, cylinder of size 150mmX150mmX70mm has been used in this experimental work. 30-40 beams has been casted to determine the tensile strength. The beams specimens of different proportions were demoulded after 24 hours and transferred to the curing tank 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 developing on the beam.

Fig. 3 Test Set Up for Beam

## V. TEST RESULTS

COMPRESSIVE STRENGTH: Compressive strength of Concrete mixtures was measured at the ages of 7 and 28 days and shown in Table 2. There was an increase in compressive strength of cube concrete specimens produced with silica fume.

TABLE 2: Compressive Strength Results

| Mix Designation | Percentage of Silica Fume | Compressive Strength After 7 Days ($N/mm^2$) | Compressive Strength After 28 Days ($N/mm^2$) |
|---|---|---|---|
| MX0 | 0 | 18.88 | 34.41 |
| MX1 | 4.5 | 19.74 | 36.05 |
| MX2 | 7 | 24.14 | 37.43 |
| MX3 | 9.5 | 27.33 | 39.43 |
| MX4 | 12 | 21.92 | 35.65 |

From the above results, we observe that compressive strength of concrete increases due to incorporation of silica fume. From the plot we can say that compressive strength of concrete increases upto 14 % with 9.5% silica fume.

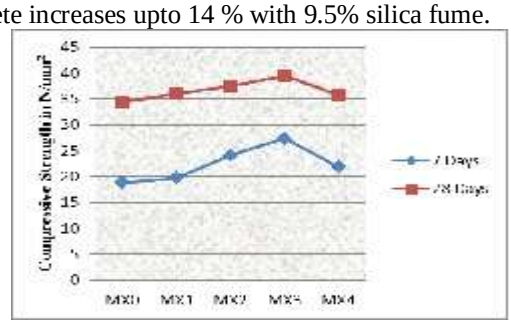


Fig. 4 Variation of Compressive Strength at Different Ages

FLEXURAL STRENGTH: Table 3 shows the values of flexural strength of silica fume based concrete beams at different mix proportions. Plot 5 shows the variations of flexural strength at 7 and 28 days.

TABLE 3: Flexural Strength Results

| Mix Designation | Percentage of Silica Fume | Flexural Strength After 7 Days ($N/mm^2$) | Flexural Strength After 28 Days ($N/mm^2$) |
|---|---|---|---|
| MX0 | 0 | 1.55 | 2.70 |
| MX1 | 4.5 | 1.48 | 2.36 |
| MX2 | 7 | 2.58 | 3.50 |
| MX3 | 9.5 | 2.56 | 3.44 |
| MX4 | 12 | 1.75 | 2.94 |

The results obtained from the experiment showed that flexural strength of the silica fume based concrete increased up to 30 % as compared with plain concrete.

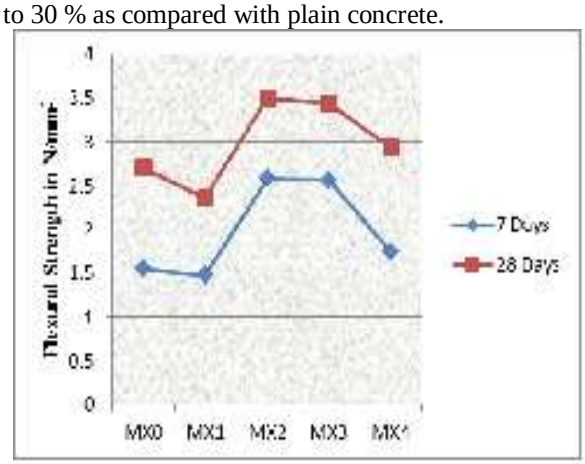


Fig. 5 Variation of Flexural Strength at Different Ages

SPLIT TENSILE STRENGTH: Split tensile strength of concrete mixtures was measured at the ages of 7 and 28 days as shown in Table 4. The result shows that in general, there is an increase in splitting tensile strength of cylinder concrete specimens with the addition of silica fume to the concrete at 28 days age.

TABLE 4: Split Tensile Strength Results

| Mix Designation | Percentage of Silica Fume | Split Tensile Strength After 7 Days (N/mm2) | Split Tensile Strength After 28 Days (N/mm2) |
|---|---|---|---|
| MX0 | 0 | 3.16 | 4.42 |
| MX1 | 4.5 | 3.52 | 5.52 |
| MX2 | 7 | 3.31 | 5.18 |
| MX3 | 9.5 | 2.71 | 4.58 |
| MX4 | 12 | 2.45 | 4.10 |

  

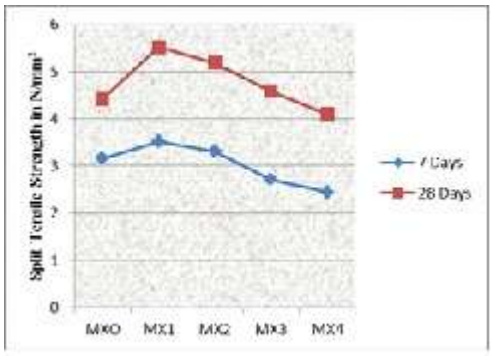


Fig. 6 Variation of Split Tensile Strength at Different Ages

From the above results, we observe that Split Tensile Strength of concrete increases due to incorporation of silica fume. From the plot we can say that Split Tensile strength of concrete increases up to 24 % as compared to plain concrete.

## VI. CONCLUSION

The following conclusions could be drawn from the present investigation.

- The results obtained in the present study indicates 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.
- M35 concrete produced from cement replacement up to 9.5% silica fume leads to increase in compressive strength of concrete at the end of 7 & 28 days respectively. Beyond 9.5 %there is a decrease in compressive strength of concrete.
- M35 concrete produced from cement replacement up to 7% silica fume leads to increase in flexural strength of concrete at the end of 7 & 28 days respectively. Beyond 7 %there is a decrease in flexural strength of concrete.
- M35 concrete produced from cement replacement up to 4.5% silica fume leads to increase in tensile strength of concrete at the end of 7 & 28 days respectively. Beyond 4.5 %there is a decrease in compressive strength of concrete.
- Silica fume seems to have a pronounced effect on the compressive and flexural strength than the split tensile strength.
- The results obtained in the present study indicates 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.

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