



# Study and Analysis of High Performance Concrete and Estimation of Concrete Strength

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**Abstract** --The present day world is witnessing the construction of very challenging and difficult civil engineering structures. Concrete being the most important and widely used material is called upon to possess very high strength and sufficient workability properties. Researchers all over the world are attempting to develop high performance concretes by using fibres, silica fume, fly ash and other admixtures in concrete up to certain proportions. In the view of the global sustainable developments, it is imperative that fibres like Glass, and silica fume provides improvement in tensile and compressive strength. This paper features use of Fly Ash, Silica Fume and Glass Fibre and its influences on the properties of M60 grade of fresh and hardened concrete. In this study, High Performance Concrete mixes with fly ash of 20-30%, with addition of silica fume 10% and glass fibre 0-0.3% by volume of cement. An attempt has been made here to find the strength parameters of concrete made with partial replacement of cement by Fly Ash, Silica Fume and Glass Fibres.

**Index terms**—Fly Ash, Glass Fibre, High Performance Concrete, Silica Fume.

## I. INTRODUCTION

Concrete is the most widely used construction material in the world, mainly due to its favourable features such as durability, versatility, satisfactory compressive strength, cost effectiveness and availability. Concrete being the main construction material, it is being used in various applications and the strength of concrete varies below 60 MPa. Only for special application the concrete grade can be increased to 60 MPa and above. These special applications of HPC cannot be achieved only by ordinary Portland cement (OPC). It is achieved not only by reducing water cement ratio but also by replacement of cement by some mineral admixture like silica fume, fly ash, glass fibres and also with chemical admixtures. The term HPC is used for concrete mixture which possess high workability, high strength, high modulus of elasticity, low permeability etc. Substantial reduction of quantity of mixing water is the fundamental step for making HPC in the range below 0.3 (w/c ratio).

The initial interest in the use of silica fume was mainly caused by the strict enforcement of air pollution control measures in various countries to stop the release of material into the atmosphere. Silica fume is a pozzolanic

material which is a by-product of silicon smelting process. Silica fume is known to produce high strength concrete and is used in two different ways: as a cement replacement in order to reduce cement content and as an additive to improve concrete Properties. Therefore utilisation of silica fume together with Fly ash produces an interesting alternative and can be termed as high strength and high performance concrete. The use of glass fibres in concrete increases the mechanical properties such as compressive strength, tensile strength. Also flexural behaviour is increased to some extent. It also possesses the ability to reduce plastic shrinkage in concrete. The objective of this work is to study the behaviour of HPC with silica fume, fly ash and glass fibre. Hence in the present work the effect of silica fume & fly ash on development of HPC and the quantity of glass fibre required to control crack.

## II. LITERATURE REVIEW

[1] Bhanja and Sengupta (2003) worked on modified water cement ratio law for silica fume concrete. They reported modified relationships have been proposed to evaluate the strength of silica fume concrete. An extensive experiment was carried out to determine the isolated effect of silica fume on concrete and analysing the 28 day strength results of 32 Concrete mixes performed over a wide range of water-binder ratios and silica fume replacement percentages, simplified models serve as useful guides for proportioning concrete mixes incorporating silica fume.

[2] Bhanja and Sengupta (2005) worked on Influence of silica fume on the tensile strength of concrete. Extensive experimentation was carried out over water-binder ratios ranging from 0.26 to 0.42 and silica fume-binder ratios from 0.0 to 0.3. For all the mixes, compressive, flexural and split tensile strengths were determined at 28 days. The compressive, as well as the tensile, strengths increased with silica fume incorporation, and the results indicate that the optimum replacement percentage is not a constant one but depends on the water-cementitious material (w/cm) ratio of the mix. Compared with split tensile strengths, flexural strengths have exhibited greater improvements. Based on the test results, relationships between the 28-day flexural and split tensile strengths with the compressive strength of silica

fume concrete have been developed using statistical methods.

[3] Malathy. R. et al (2007) carried out an experimental work to study the effect of silica fume on plastic shrinkage cracking of HPC. Specimens were tested under hot dry environmental conditions. Finally, it was observed that optimum percentage of replacement were 0.3% volume fraction fibres were required for 10% silica fume replaced concrete with w/c ratio of 0.3. Silica fume increases strength and life of concrete especially durability, but it also requires glass fibres to arrest plastic shrinkage cracks.

[4] Hariharan, A.R. et al (2011) reported that strength development of High strength concrete containing fly ash and silica fumes. The mix with 40% fly ash showed the maximum Strength of 60.2MPa compared to all other fly ash replacement. The silica fume with 6% replacement showed maximum strength of 61.2MPa compared to 10% silica fumes. Silica fumes compensate the low early strength of concrete with high CaO fly ash.

[5] Vinayagam, p. (2012) formulated the specified mix design procedure for HPC by combining BIS and ACI code methods of mix design. The optimum % of cement replacement by silica fumes was 10% for the test conducted in M80 and M100 grades of concrete. It was observed that mixes containing silica fumes showed lesser value of pH and percentage of saturated water absorption also lower when compared to mixes containing silica fumes.

### III. EXPERIMENTAL WORK

The main objective of this paper is to compare the hardened properties of concrete made with Fly ash, silica fume and glass fibre.

#### A. Materials Used

##### 1. Cement:

The ordinary Portland cement of 53 grade conforming to IS 12269-2013 is used in this study. The specific gravity of OPC 53 grade with initial & final setting time is 3.15, 115 & 180.

##### 2. Fine aggregate:

Locally available cr. sand conforming to grading zone 2 of IS 383-1970. Sand passing through IS 4.75mm sieve is used with specific gravity of 2.73.

##### 3. Coarse aggregate:

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12mm as per IS 383-1970 with the specific gravity of 2.93.

##### 4. Fly Ash:

Fly ash conforming to IS: 3812 (Pt-1)-2013 is used in this study. The specific gravity of fly ash is 2.26.

##### 5. Water:

Casting and curing of specimens is with the potable water that is available in the college premises or on site.

##### 6. Silica Fume:

Silica fume is obtained from Elkem India (P) Ltd., conforming to ASTM C1240-05 as mineral admixture. Silica fume of grade 920-D is used here.

##### 7. Plasticizer:

“SUPAPLAST-SRC” is a newly developed unique concrete slump retainer and plasticizer for concrete. It improves the retention of workability to a great extent even for a long span of time.

##### 8. Glass Fibre:

Glass fibre available in the market is used in this experimentation. The length of the fibre is 12mm and diameter of 14micron with the specific gravity of 2.0. (Fig.1)

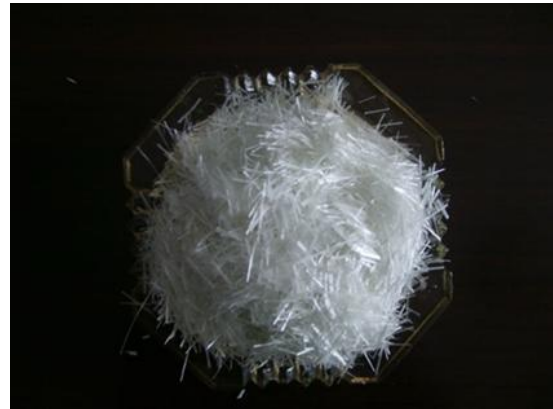


Fig.1. Glass fibre

##### 9. Super plasticizer(Optima K624):

Optima K624 is a new generation polycarboxylate based concrete super plasticizer developed for High to Ultra High Strength concrete is used in this work. The specific gravity is 1.055.

#### B. Mix Proportion

In this study, the mix proportion used is for M60 grade concrete. It is designed by referring IS 10262:2009 code specification. The mix proportion is given below in Table no.1

Table 1. MIX PROPORTION FOR HPC OF M60 GRADE

Particulars	Without SF & GF	With Silica Fume	With SF & GF
Cement	450 Kg/m <sup>3</sup>	450 Kg/m <sup>3</sup>	450 Kg/m <sup>3</sup>
Fly Ash	135 Kg/m <sup>3</sup>	135 Kg/m <sup>3</sup>	135 Kg/m <sup>3</sup>
Fine aggregate	820.4 Kg/m <sup>3</sup>	820.4 Kg/m <sup>3</sup>	820.4 Kg/m <sup>3</sup>
Coarse aggregate:			
20 mm	435.168 Kg/m <sup>3</sup>	435.168 Kg/m <sup>3</sup>	435.168 Kg/m <sup>3</sup>
10 mm	400.232 Kg/m <sup>3</sup>	400.232 Kg/m <sup>3</sup>	400.232 Kg/m <sup>3</sup>
Super plasticizer	6.949 Kg/m <sup>3</sup>	6.949 Kg/m <sup>3</sup>	6.949 Kg/m <sup>3</sup>

Water	230 lit	230 lit	230 lit
Silica Fume	-	45 Kg/m <sup>3</sup>	45 Kg/m <sup>3</sup>
Glass Fibre	-	-	1.845 Kg/m <sup>3</sup>

### C. Casting of Specimens

Casting of Specimens was done by batching of materials, preparation of moulds and placing of concrete in the moulds.

### D. Batching

A proper mix of concrete is essential for the strength of the concrete. Before the concreting, all the mix materials were weighed and kept for concreting as per design mix proportions.

### E. Preparation of Concrete Moulds

Concrete moulds of size 150mm x150mm x150mm were oiled for easy stripping. The moulds for conducting tests on fresh concrete were made ready and inner surfaces were oiled as shown in Fig.2



Fig.2.Oiled Mould

### F. Preparation of Concrete

Concrete were mixed in the pan mixer and dumped in a tray placed on a flat surface.

### G. Tests on Fresh Concrete

The concrete slump test is an empirical test that measures the workability of fresh concrete. More especially it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of fresh made concrete. Consistency is the term very closely related to workability.

### H. Preparation of Samples

During the placing of fresh concrete into mould, proper cares were taken to remove entrapped air by using a table vibrator to attain maximum strength.

### I. Demoulding

After leveling the fresh concrete in the mould, it was allowed to dry for 24 hrs. The identification marks of concrete specimens were done with permanent markers and the specimens were removed from the moulds. The moulds were cleaned and kept ready for next batch of concrete mix. The remoulded cube is shown in Fig.3.



Fig.3. Demoulded Cube

### J. Curing

Curing is an important process to prevent the concrete specimens from losing their moisture while they are gaining their required strength. All concrete specimens were cured in water at room temperature for 7, 14 and 28 days. After curing, concrete specimens were removed from the curing tank and air dried to conduct tests on hardened concrete.



Fig.4. Curing of Cubes

## IV. TESTS CONDUCTED ON HARDENED CONCRETE

### A. Compressive strength

Nine specimens of size 150 mm x 150 mm x 150 mm were casted for compression testing of 7,14,28 days of cubes. Clean and surface dried specimens were placed in the testing machine. The platen was lowered and touched the top surface of the specimen, the load was applied gradually and maximum load were recorded.

## V. RESULTS & DISCUSSIONS

The results obtained from the experimental investigations are tabulated in Table 2. The results have been analyzed. The effect of partial replacement of cement with fly ash, silica fumes and glass fibre is discussed herein.

### A. Slump Cone test:

It has been observed that the addition of silica fume and fly ash in concrete enhance the flow of concrete. It makes concrete flow able and addition of Retarder

slower the setting time of the concrete, and flow remains constant for specific period of time on site. (Fig.5)



Fig.5.Slump Cone Test

**B. Compressive Strength:**

1. The compressive strength of concrete cubes without silica fume & glass fibre were observed as, for

- 7 days average strength of cube is 39.81 N/mm<sup>2</sup>,
- 14 days average strength of cube is 49.63 N/mm<sup>2</sup> &
- 28 days average strength of cube is 60.78 N/mm<sup>2</sup>.

2. The compressive strength of concrete cubes with addition of 10% of silica fume & 30% of fly ash by the volume of cement were observed as, for

- 7 days average strength of cube is 43.67 N/mm<sup>2</sup>,
- 14 days average strength of cube is 57.48 N/mm<sup>2</sup> &
- 28 days average strength of cube is 72.85 N/mm<sup>2</sup>.

3. The compressive strength of concrete cubes with addition of 10% of silica fume & 30% of fly ash with 0.3% of glass fibre by the volume of cement were observed as, for

- 7 days average strength of cube is 49.59N/mm<sup>2</sup>,
- 14 days average strength of cube is 64.94 N/mm<sup>2</sup> &
- 28 days average strength of cube is 79.00 N/ mm<sup>2</sup>.

4. The compressive strength of the concrete cubes with silica fume & glass fiber gives very good compressive strength comparing with the concrete cubes without silica fume & glass fiber.

5. It is observed that by the addition of glass fibre prevents shrinkage crack.

Fig.6 & Fig.7 shows the compression test conduction on the cubes



Fig.6. Compression Test on cube without silica fume & glass fibre



Fig.7. Compression test on cube with silica fume & glass fibre

Table 2.M60 GRADE CONCRETE COMPRESSION TEST RESULT

Compression test results for M60 grade of concrete			
	7 Days (N/mm <sup>2</sup> )	14 Days (N/mm <sup>2</sup> )	28 Days (N/mm <sup>2</sup> )
Concrete Cubes without silica fume & glass fibre	39.89	51.59	60.00
	39.20	49.50	59.71
	40.34	47.80	62.64
Concrete cubes with silica fume	44.89	58.22	75.56
	41.33	58.22	75.11
	44.80	56.00	67.87
Concrete cubes with Silica fume & glass fibre	52.90	62.59	78.56
	50.85	61.89	80.44
	51.58	64.63	78.00

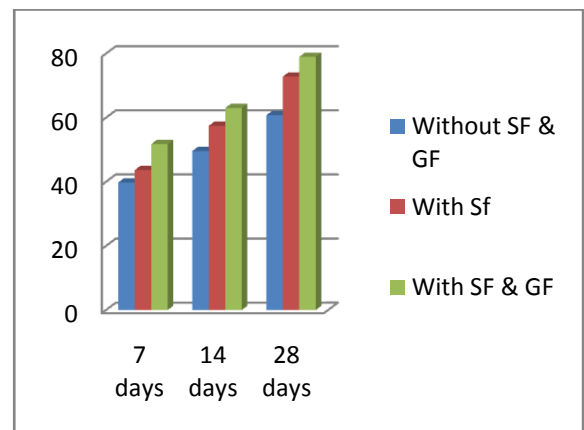


Fig. 8.Comparison of Compressive Strength

**C. Cost Estimation**

Table 3 Includes cost estimation of 1m<sup>3</sup> high performance concrete without silica fume (SF) & glass

fiber (GF), with silica fume, with silica fume (SF) & glass fiber (GF).

Table 3: Cost Estimation

Cost estimation of 1m <sup>3</sup> of concrete				
	Per kg (Rs)	Without SF & GF	With SF	With SF & GF
Cement	6	2700	2700	2700
Fly ash	2.75	371.25	371.25	371.25
Silica Fume	18	-	810	810
Glass fibre	240	-	-	324
20mm	1.419	617.50	617.50	617.50
10mm	1.419	567.929	567.929	567.929
Crush sand	1.00	836.808	836.808	836.808
Admixture OptimaK624	120	833.88	833.88	833.88
Total (Rs.)		5927.367	6737.367	7061.367

Cost for 1 m<sup>3</sup> of concrete:

- Without silica fume and glass fiber is Rs.5927.367 /-
- While with silica fume it costs Rs.6737.367/-,
- With both silica fume and glass fiber it costs Rs.7061.36/-

## VI. CONCLUSION

The experimental study shows that addition of fly ash,

silica fume, & glass fiber in the proportional quantity were placed in concrete. However the cost of the concrete is based on the actual cost of these ingredients & further needs analysis.

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