# EXPERIMENTAL INVESTIGATIONS FOR HIGH PERFORMANCE CONCRETE USING MICRO-SILICA AND FLY-ASH

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***Abstract:*** High Performance Concrete (HPC) presently is being utilized generally in the development business around the world today. To deliver HPC with ordinary fixings, mineral admixtures like Silica fume, fly ash and serviceable specialists Super-plasticizers are additionally utilized. The utilization of mineral admixtures in the solid improves its quality properties as well as sturdiness. The compressive quality are examine finding the ideal utilization of mineral admixture (Silica fume of levels 0, 2.3, 4.65, 7.14, 9.65 and 12.5 % at 7 days and 28 days of curing). The present examination intends to give configuration blend for HPC by utilizing silica fume and super-plasticizers.

**Keyword:** High Performance Concrete, Fly ash, Silica Fumes, flowability, Compressive Strength, Split Tensile Strength.

## I.INTRODUCTION

High performance concrete (HPC) exceeds the properties and constructability of normal concrete. Normal and special materials are used to make these specially designed concrete that must meet a combination of performance requirements. HPC are made with carefully selected high quality ingredients and optimized mixture designs. HPC will have a low water cement ratio of 0.2 to 0.45. Super Plasticizers are usually used to make these concretes fluid and workable. HPC almost always has a higher strength than normal conventional concrete. There are many methods of mix design for HPC. In this experiment, Indian Standard method IS 10262 : 2019 is used. In this method, the following data is required i.e. Grade of concrete, Maximum size of aggregate, Minimum cement content, Maximum w/c ratio, Workability in terms of slump, Exposure conditions, Maximum temperature at the pouring point, Grading zone of fine aggregate, Type of aggregate, Maximum cement content, Admixture kind, Specific gravity of all the materials used and doses. In this experiment, silica fume is used from 0 % to 12.5 % with addition of constant mass of fly-ash and super-plasticizer on high performance concrete with replacement of silica fume 0 – 12.5 % and the HPC mixes are tested experimentally for workability, compression, split tension and flexure and concluded that the performance of the design mixes are very good.

## II.RESEARCH SIGNIFICANCE

The main objective of this present investigation is to develop a mix design procedure, for HPC by varying the percentage of Silica fume (0 to 12.5%) as well as content of cement at constant dosage of super-plasticizers, fly-ash and other ingredients. Experiments were carried out on HPC using the IS 10262 : 2018 concrete mix procedure for M60 concrete to obtain good workability and achieve mechanical properties of the mix design and to find the optimum percentage of Silica Fume. Hence in the present investigation more emphasis is given to study strength characteristics of HPC using mineral and chemical admixtures like Silica fume and Super-plasticizer, fly-ash for achieving the better composite and also to increase use of Silica fume and fly-ash to maintain ecology and also encourage the use of silica fume and fly-ash.

## III.EXPERIMENTAL PROGRAM

### A. DESIGN STIPULATION

| | | |
|---|---|---|
| **1.** | Type of Mix | Design Mix |
| **2.** | Grade of Concrete | M 60 RCC |
| **3.** | Characteristic cube compressive strength @ 28 days | 60 Mpa |
| **4.** | Current Margin as per MORTH | 14 Mpa |
| **5.** | Target Mean Strength | 74 Mpa |
| **6.** | Nominal Maximum size of aggregate | 20 mm |
| **7.** | Workability in terms of Slump @ placement | 120 – 140 mm |
| **8.** | Degree of quality control | Good |
| **9.** | Mode of Pouring | Pump |

**10.** Cement content (Minimum) 400 Kg
**11.** Water Cement Ratio (0.28 Assumed)

**B. SOURCE / TEST DATA FOR MATERIALS**

**1.** Cement Type / Brand OPC-53 / Ultratech
**2.** Admixture Type / Brand BASF Master Glenium
**3.** Crushed Coarse Aggregates 100 % Natural
**4.** Natural sand as fine aggregate Khijrabad
**5.** Micro-silica Elkem
**6.** Specific Gravity / Water Absorption of Materials
- **a.** Cement 3.15
- **b.** Natural Sand 2.61 / 2 %
- **c.** Coarse Aggregates **20 mm** 2.62 / 0.8 %
  **10 mm** 2.64 / 1 %
- **d.** Fly-ash 2.2

**7.** Gradation of Combined graded coarse aggregates as per IS 383 has been enclosed
**20 mm down : 10 mm down = 60 % : 40 %**
**8.** Gradation of all in aggregates as per IS 383 has been enclosed
**Coarse Aggregate : Fine Aggregate = 65 % : 35 %**
**9.** Flakiness Index of Coarse Aggregate : 20 mm – 15.20 % & 10 MM – 11.5 %

**C. Optimum Mix Design Calculation For Unit Volume of Concrete**

**1.** Volume of concrete = 1.00 CUM
**2.** Total Cementitious Content = 540 Kg
**3.** Fly-ash = 90 Kg
**4.** Cement = 410 Kg
**5.** Microsilica (Elkem) = 40 Kg
**6.** Volume of Cement = 0.130 cum
**7.** Volume of Fly-ash = 0.04091 cum
**8.** Volume of Microsilica = 0.01136 cum
**9.** Volume of Water = 0.15 cum
**10.** Volume of Admixture = 0.00254
**11.** Volume of all in aggregates = (1-(0.13+0.04091+0.01136+0.15+0.00254))
= 0.667 cum

**12.** Mass of Fine aggregates (Natural Sand) = e X Vol of F.A. x Sp. Gr. of F.A. X 1000
= 0.667 X 0.35 X 2.61 X 1000
= 609 Kg

**13.** Mass of coarse aggregates M1 (20 mm) = e X Vol of C.A. x Sp. Gr. of C.A. X 1000
= 0.667 X 0.65 X 0.6 X 2.62 X 1000
= 681 Kg

**14.** Mass of coarse aggregates M2 (10 mm) = e X Vol of C.A. x Sp. Gr. of C.A. X 1000
= 0.667 X 0.65 X 0.4 X 2.64 X 1000
= 458 Kg

**Table.1 Properties of Fine Aggregate**

| Sieve Size | Weight Retained in Sieve (Grams) | % Retained | % Cumulative Retained | % Passing |
|---|---|---|---|---|
| 10 mm | - | - | - | 100 |
| 4.75 mm | 55 | 5.5 | 5.5 | 94.50 |
| 2.36 mm | 90 | 9.0 | 14.5 | 85.50 |
| 1.18 mm | 143 | 14.3 | 28.8 | 71.2 |
| 600 micron | 204 | 20.4 | 49.2 | 50.80 |
| 300 micron | 312 | 31.2 | 80.4 | 19.60 |
| 150 micron | 178 | 17.8 | 98.298.2 | 1.80 |
| Pan | 18 | 1.8 | 100 | 0 |

**Table.2 Properties of Coarse Aggregate**

| Coarse aggregate | Specific gravity | Bulk density (kg/m$^3$) | Water absorption (%) |
|---|---|---|---|
| CA | 2.64 | 1535 | 0.8 |

**Table.3 Properties of Cement**

| Property | Result |
|---|---|
| **Normal Consistency** | 30 % |
| **Setting Time**<br>**Initial**<br>**Final** | <br>130 min<br>375 min |
| **Specific Gravity** | 3.15 |
| **Fineness of Cement**<br><br>**(By 90 micron sieve)** | 2 % |
| **Compressive Strength**<br>**7 days**<br>**2 days** | <br>53 N/mm$^2$<br>60 N/mm$^2$ |

**D. Mix Proportions of HPC:** For HPC there is no specific method of design mix. In the present investigation Indian Standard method and as also the available literatures on HPC are used. In order to achieve high strength lower w/c ratio is adopted and to achieve good workability super-plasticizer and fly-ash are used. The trial mix proportions of the concrete are shown in **Table 4.** In the present investigation w/c ratio used is 0.28 and dosage of Super-plasticizer is 3.05 Kgs/Cum. The 28 days target mean strength for all mixes was 74 Mpa.

**Table 4 Mix proportions of concrete (kg/m3 )**

| Trial Mix | Cement (Kg) | Fine Aggregate (Kg) | Coarse Aggregate (20 mm) (Kg) | Coarse Aggregate (10 mm) (Kg) | Water (Kg) | Water cement ratio | Super Plasticizer (Kg) | Silica Fume (Kg) | Fly-ash (Kg) |
|---|---|---|---|---|---|---|---|---|---|
| **HPC Trial 1** | 450 | 606 | 681 | 458 | 150 | 0.28 | 3.05 | 0 | 90 |
| **HPC Trial 2** | 440 | 606 | 681 | 458 | 150 | 0.28 | 3.05 | 10 | 90 |
| **HPC Trial 3** | 430 | 606 | 681 | 458 | 150 | 0.28 | 3.05 | 20 | 90 |
| **HPC Trial 4** | 420 | 606 | 681 | 458 | 150 | 0.28 | 3.05 | 30 | 90 |
| **HPC Trial 5** | 410 | 606 | 681 | 458 | 150 | 0.28 | 3.05 | 40 | 90 |
| **HPC Trial 6** | 400 | 606 | 681 | 458 | 150 | 0.28 | 3.05 | 50 | 90 |

**E.** ***Preparation of Test Specimens:*** Six concrete mixes were cast with replacement of 0, 2.3, 4.65, 7.14, 9.65 and 12.5 % silica fume with cement, at a 0.28% w/c ratio. The slumps are measured and the slump values decreased when the silica fume increases. The cubes are casted and cured in curing pond. At 7 days and 28 days (cubes of size 150 mm x 150 mm x 150 mm) were tested for compressive strength of cubes and compressive strength of cylinders and the results are shown in Table 6. The compressive strength of cubes are shown in Fig.1

**Table. 6 Average value of Cube Strength of concrete (MPa)**

| Trial Mix | Cube compressive strength ($f_{cu}$) 7 days | Cube compressive strength ($f_{cu}$) 28 days |
|---|---|---|
| **HPC Trial 1** | 51.12 | 56.8 |
| **HPC Trial 2** | 55.98 | 62.2 |
| **HPC Trial 3** | 59.93 | 66.5 |
| **HPC Trial 4** | 61.09 | 72.4 |
| **HPC Trial 5** | 66.93 | 76.4 |
| **HPC Trial 6** | 65.12 | 73.6 |

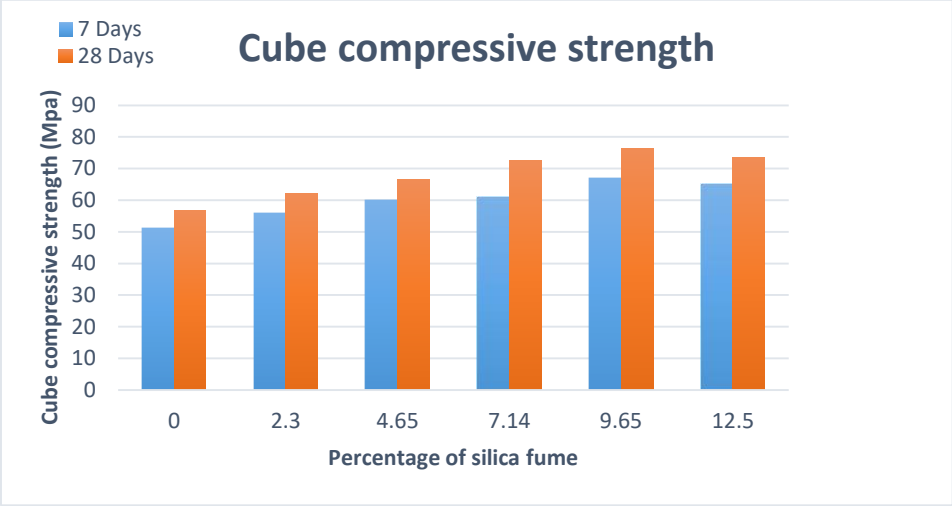


**Fig. 1 Percentage of silica fume replacement with cement Vs compressive strength**

## IV. DISCUSSION OF TEST RESULTS

Replacement of cement by silica fume in HPC improved compressive strength up to 9.65 % replacement and after that the strength were reduced both for 7 days and 28 days. This may be due to the fact that the decrease of strength is due to pozzolonic reaction and filler effect of Silica fume.

## V. CONCLUSION

**The following conclusions can be made on the basis of the current experimental results.**

**1.** A mix design procedure for HPC using silica fume and super plasticizer is formulated by Indian Standard method of mix design and available literature on HPC.
**2.** As the silica fume content increases the compressive strength increases up to 9.65 % [**HPC Trial 5**] and then decreases. Hence the optimum replacement is 9.65 %.

**3.** The 7 days and 28 days cube compressive strength ratio of HPC is 0.84 to 0.90.

## APPENDIX

Target Mean Strength

$$f_m = f_{min} + ks$$

**where**

$f_m$ = Target mean strength at 28 days
$f_{min}$ = Characteristics Compressive Strength at 28 days
**k** = A statical value depending upon the results and number of test
**s** = Standard deviation
$f_m$ = 60 + 1.65 X 5 = 68.25 Mpa (74 Mpa as per MORTH)

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