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*Research Paper*

# ROLE OF FLY ASH AND SILICA FUME ON COMPRESSIVE STRENGTH CHARACTERISTICS OF HIGH PERFORMANCE CONCRETE

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This paper focuses on studying the effect of fly ash silica fume and their combinations on compressive strength characteristics of high performance concrete. This work primarily deals with the compressive strength characteristics such as water absorption super plasticizer used in high performance concrete a set of 23 different concrete mixture were cast and tested with different cement replacement levels (0%, 2.5%, 5%, 7.5%, 10% and 12.5%) of Fly ash (FA) with silica fume (SF) as addition ( 0%,2.5%,5%,7.5% 10 % & 12.5% by wt of Cement and/or each trial super plasticizer has been added at constant values to achieve a constant range of slump for desired work ability with a constant water-binder (w/b) ratio of 0.30. Based on the test results the influence of such admixtures on compressive strength characteristics were critically analyzed and discussed.

***Keywords:*** High Performance Concrete, Fly Ash, Silica Fume, Compressive Strength, water absorption

## INTRODUCTION

High performance concrete has been used more widely in recent years due to the increasing demand for durable concrete in an attempt to extend in service life and reduce maintenance cost of concrete structures. The requirements may involve enhancements of characteristics such as placement and compaction without segregation, long-term mechanical properties, early age strength, toughness, volume stability, or service life in severe environments. High preference concrete incorporation silica and fly ash as pozzolanic mineral admixture is being increasingly used in the construction of structures for large projects.

High performance concrete each commonly available in metropolitan areas throughout the United States. Because of superior mechanical properties and the significant economic savings offered by high performance concrete.

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Mix design is a process of specifying the mixture of ingredients required to meet anticipated properties of fresh and hardened concrete mix design is a well established practice around the world. With which the use of chemical and mineral admixtures in concrete one would except that the concrete mix design procedure is given in IS 10262 will need changes. Mix design of high performance concrete is complex, because it includes more ingredients like supplementary, cementitious materials such as a fly ash (FA), micro silica (MS) ground granulated blast furnace slag (GGBFs), metakeoline and super plasticizers.

The use of mineral admixture such as a fly ash, silica fume and GGBF slag add strength and durability to concrete. High performance concrete provides enhanced properties in structural precast-concrete, including elevated tensile and compressive strength, and a boosted stiffness. The high performance concrete usually contains both pozzolanic and chemical admixtures. Hence, the rate of hydration of cement and the rate of strength development in HPC is quite different form that of conventional cement concrete (CCC).

## EXPERIMENTAL PROGRAM

To study the effect of fly ash and silica fume in the compressive strength characteristic of high performance concrete specimens were cast and for the combination mentioned in Table 3 Fly ash has been used as cement replacement material for ( 0%, 10%, 20% and 25% ) cement replacement level with different values of Silica fume ( 0%, 2.5%, 5%, 7.5%, 10% and 12.5%) by weight of cement ).

## MATERIALS

The properties of the selected material for this experimental study have been reported as given below.

### Cement

Ordinary Portland current 53 grade with physical and chemical properties as given in table has been used In this experimental study.

### Fly Ash

Fly ash supplied by dirk India pvt. Ltd. Nashik used in mineral admixture in day powder form the physical and chemical properties were given Table 1.

### Silica Fume

The Silica fume obtained from the M/s ELKEM Pvt Ltd, Bombay confirming to ASTM C1240 was used for this study, Its physical and chemical properties were given in Table 1.

### Fine Aggregate

Locally available river sand confirming to grading Zone II of IS: 383-1970 was used in this expermential work. Its physical properties were dealt with in Table 2.

### Course Aggregate

Locally available crushed stones confirming to graded aggregate of nominal size 12.5 mm as per IS: 383-1970 was used in this experimental work. Its physical properties were dealt with in Table 2.

### Super Plasticizer

Chemical admixture based on ( Glenium B276 Soretec ) Confirming to IS : 9103 -1999 used in this study.

| Table 1: Physical and Chemical Properties of Cement and Admixtures | | | |
|---|---|---|---|
| **Property/Composition** | **Cement** | **Fly Ash** | **Silica Fume** |
| Specific Gravity | 3.15 | 2.00 to 2.05 | 2.2 |
| Standard Consistency | 29.00% | – | – |
| Initial Setting time (Min) | 165 | – | – |
| Final Setting Time (Min) | 245 | – | – |
| Physical Form | – | Powder form | Powder form |
| Class | – | F | – |
| **Chemical Composition** | | | |
| Silicon Dioxide ($SIO_2$) | 20.78% | Min 35 | 90-96 % |
| Aluminium Oxide ( $Al_2O_3$ ) | 4.44% | 25-29% | 0.5-0.8% |
| Ferric Oxide ($Fe_2O_3$) | 2.88% | 4.5-4.8% | 0.2-0.8% |
| Calcium Oxide (CaO) | 63.78% | 0.5-1.2% | 0.1-0.5% |
| Magnesium Oxide (MgO) | 3.66% | 0.3-0.5% | 0.5-1.5% |

| Table 2: Basic Properties of Aggregates | | |
|---|---|---|
| **Property** | **Fine Aggregate** | **Coarse Aggregate** |
| Fineness Modulus | 3.04 | 4.03 |
| Specific Gravity | 2.35 | 2.88 |
| Water Absorption | 2.08 | 3.81 |

## Water

Portable water with PH value of 7.0 confirming to IS 456-2000 was used for making concrete and curing this specimen as well.

## Mix Proportions

A total of 23 Concrete Mixtures were designed as per IS 10262 -2009 having a constant water binder ratio of 0.30 and total binder content of 474 kg / $m^3$. The control Mixture of grade M70 included ordinary Portland cement alone as the binder, while remaining mixtures incorporated the fly ash as cement replacement material and silica fume as addition. The replacement levels for FA was 2.5%, 5%,7.5 %,10% and 12.5%. while those of SF were 2.5%, 5%,7.5 %,10%, and 12.5%.by weight of cement as addition. The mixture proportions were summarized in Table 3 in which the mixtures were designated according to the type and the amount of cementitious materials included.

## Casting and Testing

For the determination of compressive strength 150 mm x 150 mm cubes were used. All the specimens were moist cured under water until testing.

**Table 3: Proportion of Concrete Materials**

| S. No. | Mix Description | Cement (Kg) | Fly Ash (Kg) | Silica Fume (Kg) | Fine Aggregate (Kg) | Coarse Aggregate (Kg) |
|---|---|---|---|---|---|---|
| 1. | 0 | 5.55 | 0.00 | 0.00 | 5.24 Kg | 786 Kg |
| 2. | 2.5% MS + 2.5%FA | 5.275 | 0.137 | 0.137 | | |
| 3. | 5% MS + 5% FA | 5.00 | 0.275 | 0.275 | | |
| 4. | 7.5% MS + 7.5%FA | 4.71 | 0.416 | 0.416 | | |
| 5. | 10 % MS + 10 %FA | 4.44 | 0.55 | 0.55 | | |
| 6. | 12.5%MS+12.5%FA | 4.16 | 0.69 | 0.69 | | |
| 7. | 2.5% MS + 7.5%FA | 5.00 | 0.416 | 0.137 | | |
| 8. | 5% MS + 10%FA | 4.71 | 0.55 | 0.275 | | |
| 9. | 2.5% MS + 12.5%FA | 4.71 | 0.69 | 0.137 | | |
| 10. | 0.0% MS + 15%FA | 4.71 | 0.832 | 0.0 | | |
| 11. | 7.5% MS + 12.5%FA | 4.44 | 0.69 | 0.416 | | |
| 12. | 5% MS + 15%FA | 4.44 | 0.832 | 0.275 | | |
| 13. | 5% MS + 20%FA | 4.16 | 1.11 | 0..275 | | |
| 14. | 10% MS + 15%FA | 4.16 | 0.832 | 0.55 | | |
| 15. | 5% MS + 0.0%FA | 5.275 | 0 | 0.275 | | |
| 16. | 0.0% MS + 0.5%FA | 5.275 | 0.275 | 0 | | |
| 17. | 7.5% MS + 2.5%FA | 5.00 | 0.137 | 0.416 | | |
| 18. | 10% MS + 5%FA | 4.71 | 0.275 | 0.55 | | |
| 19. | 12.5% MS + 2.5%FA | 4.71 | 0.137 | 0.69 | | |
| 20. | 15% MS + 0.0%FA | 4.71 | 0 | 0.832 | | |
| 21. | 15% MS + 0.5%FA | 4.44 | 0.275 | 0.832 | | |
| 22. | 20%MS + 5%FA | 4.16 | 0.275 | 1.11 | | |
| 23. | 15% MS + 10%FA | 4.16 | 0.55 | 0.832 | | |

**Table 4: Test Results**

| S. No. | Mix Description | Replacement of Cement (%) | Graph | Compressive Strength (N/MM2) |
|---|---|---|---|---|
| 1. | CCM | 00 | 4.1 | 85.76 |
| 2. | MS 2.5%+FLA 2.5% | 5 | 4.1 | 96.22 |
| 3. | MS 5%+FLA 5% | 10 | 4.1 | 87.66 |
| 4. | MS 7.5%+FLA 7.5% | 15 | 4.1 | 84.74 |
| 5. | MS 10%+FLA 10% | 20 | 4.1 | 79.77 |
| 6. | MS 12.5%+FLA 12.5% | 25 | 4.1 | 76 |
| 7. | MS 2.5%+FLA 7.5% | 10 | 4.2 | 73.77 |
| 8. | MS 5%+FLA 10% | 15 | 4.2 | 85.11 |
| 9. | MS 2.5%+FLA 12.5% | 15 | 4.2 | 72.29 |
| 10. | MS 0%+FLA 15% | 15 | 4.2 | 71.11 |
| 11. | MS 7.5%+FLA 12.5% | 20 | 4.2 | 70.81 |
| 12. | MS 5%+FLA 15% | 20 | 4.2 | 77.77 |
| 13. | MS 5%+FLA 20% | 25 | 4.2 | 82.66 |
| 14. | MS 10%+FLA 15% | 25 | 4.2 | 92.88 |
| 15. | MS 5%+FLA 0% | 5 | 4.3 | 72.59 |
| 16. | MS 0%+FLA 5% | 5 | 4.3 | 76.88 |
| 17. | MS 7.5%+FLA 2.5% | 10 | 4.3 | 76.22 |
| 18. | MS 10%+FLA 5% | 15 | 4.3 | 83.11 |
| 19. | MS 12.5%+FLA 2.5% | 15 | 4.3 | 70.51 |
| 20. | MS 15%+FLA 0% | 15 | 4.3 | 72.51 |
| 21. | MS 15%+FLA 5% | 20 | 4.3 | 84.88 |
| 22. | MS 20%+FLA 5% | 25 | 4.3 | 75.11 |
| 23. | MS 15%+FLA 10% | 25 | 4.3 | 79.62 |

**Figure 1a: % of Replacement of Cement (with equal percentage of MS & FLA) - Comparison of Compressive Strengths of Cubes**

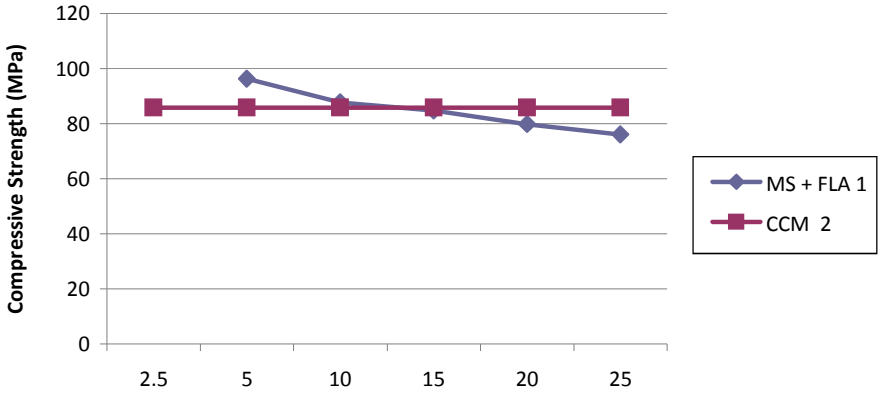



**Figure 1b: % of Replacement of Cement (with equal percentage of MS & FLA) - Comparison of Compressive Strengths of Cubes**

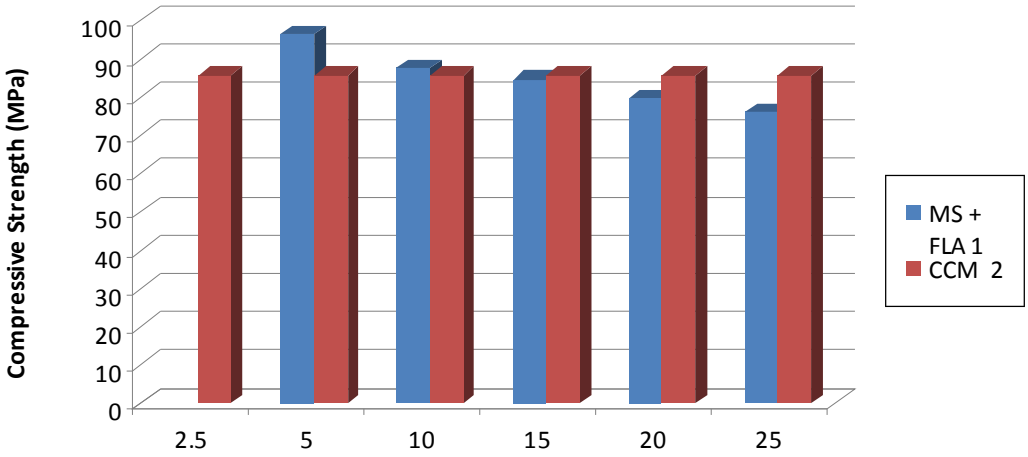



**Figure 2a: % of Replacement of Cement (with unequal percentage of MS & FLA) - Comparison of Compressive Strengths of Cubes**

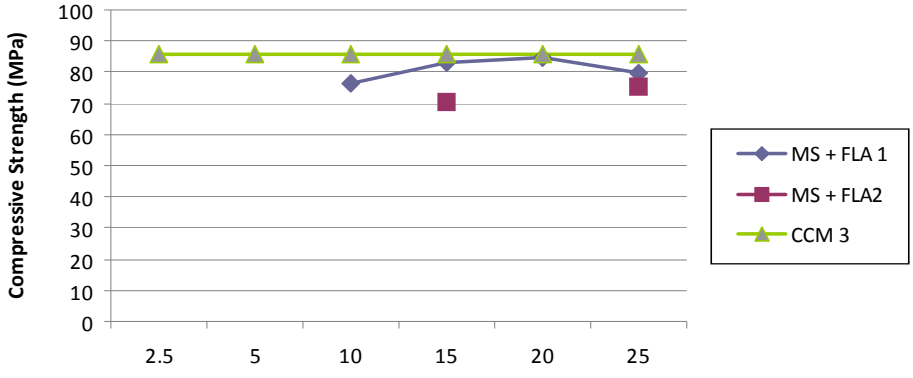


**Figure 2b: % of Replacement of Cement (with unequal percentage of MS & FLA) - Comparison of Compressive Strengths of Cubes**

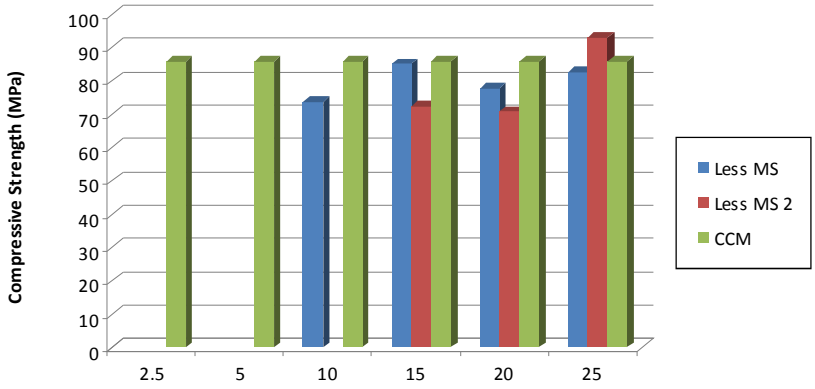



**Figure 3a: % of Replacement of Cement (with unequal percentage of MS & FLA) - Comparison of Compressive Strengths of Cubes**

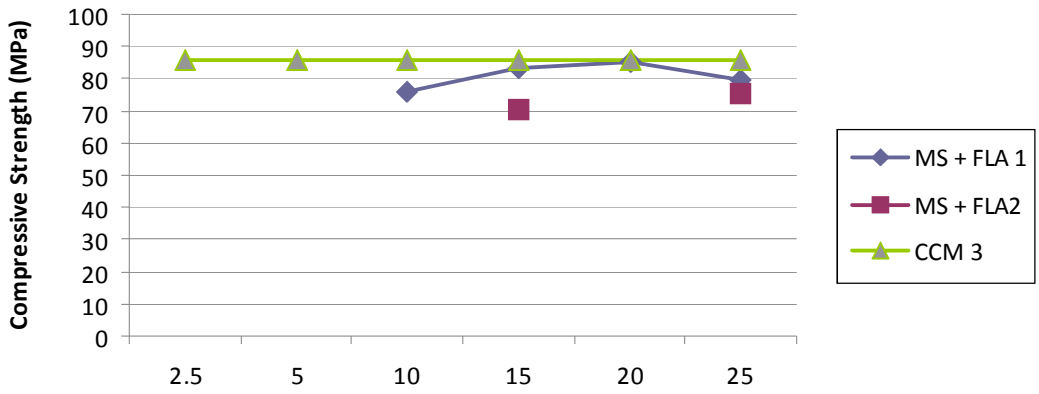
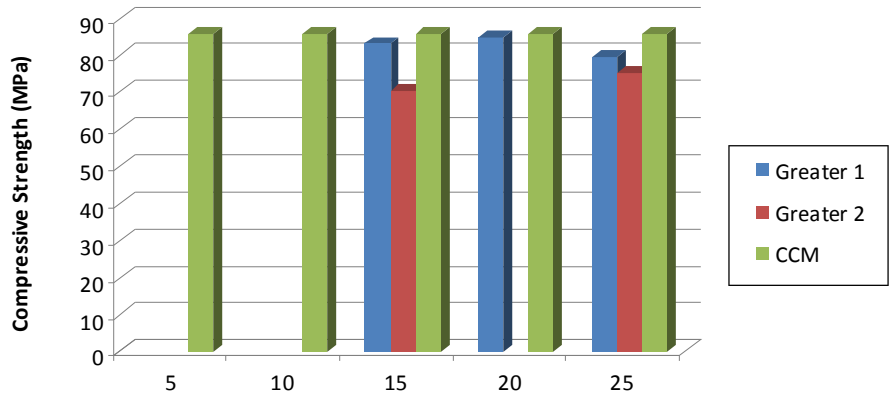



**Figure 3b: % of Replacement of Cement (with unequal percentage of MS & FLA) - Comparison of Compressive Strengths of Cubes**



## CONCLUSION

From the experimental study conclude that

1. The compressive strength of blend effect of fly ash and micro silica concrete (ms & fly) is comparatively greater than 12.19% that of control mix (ccm)
2. The compressive strength [96.22N/mm$^2$ ] is the optimum values 5% replacement of cement [2.5% fly ash + 2.5% microsilica].
3. There is no effect of activated blend effect of fly ash and micro silica for good $M_{70}$ grade concrete.
4. Alkali activation of fly ash is most considerable criteria from improving the pozzolanic properties of fly ash.

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