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Research Paper

Study on Effect of Mineral Admixtures in High Performance Concrete

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ABSTRACT

High - performance concrete (HPC) is fast getting acceptability for a wide range of applications in the construction of concrete structures. It is a tailor made material for specific applications and having advantageous properties like high strength, high durability and high constructability as compared to the conventional type of normal strength concrete. To produce such a high performance concrete, mineral admixtures like silica fume, metakolin and fly ash on the one hand and super plasticizer on the other hand used along with normal ingredients. The use of mineral admixtures in concrete enhances its properties regarding strength, durability, workability and economy. They act as pozzolanic materials as well as micro fillers; thereby the microstructure of hardened concrete becomes denser and stronger. Superplasticizers being surfactant in nature, help to disperse the cement particles in the mix and thus enhance the fluidity of the mixes at low water binder ratio.

The scope of the present study is to investigate the effect of mineral admixtures such as silica fume, metakolin and fly ash towards the performance of HPC. An effort has been made to focus on the mineral admixtures towards their pozzolanic reaction, contribution towards strength properties, mix proportioning, and self-compactability.

The strength characteristics such as compressive strength and tensile strength are investigated with different water binder ratios (w/b) at different ages to find the optimum replacement of mineral admixtures. The compressive strength of HPC with mineral admixtures at the replacement levels of 0%, 5%, 10% and 15% were studied at 7 days, 28 days, 56 days and 90 days of curing. The strengths were compared and the optimum replacement level of each mineral admixture was arrived at. The tensile strength and flexural strength of HPC were obtained at the same replacement levels of mineral admixtures at 28 days curing.

Keywords: HPC, silica fume, Metakaolin, fly ash.

I. INTRODUCTION

High-performance concrete (HPC) is a recent development in concrete technology. High strength concrete having more than 60 MPa compressive strength with improved properties when designed to fulfill specific performance requirements is normally termed as HPC. In many field applications concrete is required to meet certain specific performance requirements besides high strength. For prestressed concrete bridges, offshore structures, highway and airport pavements and in machine foundations, concrete should possess high fatigue strength. For nuclear containers exposed to very high temperatures, the concrete must have high resistance to thermal cracking. All these needs have made the researchers to think seriously to find out an appropriate technology through research and HPC was the outcome.

II. REVIEW OF LITERATURE

In high performance concrete with a very low water/binder ratio, hydration stops within the concrete long before 28 days due to lack of water or when the partial pressure of water vapour within the pores has reached the 80% limit below which hydration is slowed down very significantly (Powers and Brownyard (1948)).

Aitcin, Sarkar and Laplante(1990) found that there is some small retrogression in strength due to the drying of a very thin layer of the skin of the high performance concrete. This strength retrogression of HPC is due to severe drying conditions. Hence it is emphasized that proper early water curing is much more important for HPC, especially when most of the hydration reactions are taking place.

Larrard and Aitcin (1993) found that some high performance concrete laboratory specimens experienced a slight decrease in compressive strength after a long period of curing in air, particularly those containing silica fumes.

Rougeron and Aitcin (1994) reported that one of the highlighted properties of high performance concrete is early age strength which can be achieved by decreasing water content and increasing binder content with superplasticizer. The effect of silica fume, metakaolin and fly ash on the strength characteristics of HPC is discussed from the previous literature.

III. EXPERIMENTAL STUDY

Materials:

Cement: The cement used in this experimental investigation is ordinary Portland Cement of 53 grade confirming to IS:12269: 1987

Fine aggregate: In the present investigations fine aggregate is natural sand obtained from local marked is used

Coarse aggregate: The coarse Aggregate used in this experimental investigation is crushed granite of 12.5 mm maximum size, which was obtained from the local crushing plant.

Water: Potable tap water available in the laboratory with pH value of 7.0±1 and confirming to the requirements of IS: 456 - 2000 was used for mixing concrete.

Fly Ash: The fly ash used in this investigation was obtained from V.T.P.S. located at Ibrahimpatnam, Vijayawada, Andhrapradesh.

Silicafume: Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. The Silica Fume used in this investigation was obtained from Pragathinagar, Hyderabad.

Metakaolin: Metakaolin is a dehydroxylated form of the clay mineral kaolinite.

Super plasticizer: Conplast SP43 complies with IS:9103:1999 and BS:5075 Part 3 and ASTM-C-494 Type 'F' as a high range water reducing admixture and Type G at high dosage

Mix proportioning:

Concrete mixes were designed for M60 to study the compressive strength at different w/b ratios. The w/b ratios of 0.3, 0.35 and 0.4 were adopted. At each w/b ratio, silica fume, metakaolin and fly ash content were varied as 0%, 5%, 10% and 15% by weight of cement. The cementitious material was taken as 450 kg/m3 and Sand content was650kg/m3. The quantity of coarse aggregate was calculated by allowing 2% airentrainment. Concrete with different w/b ratios with different content of silica fume, metakaolin and fly ash was studied at different ages, namely 3, 7, 28, 56 and 90 days. A concrete mixer machine was used for mixing the dry as well as wet concrete for sufficient time till a uniform mix was achieved.

IV. EXPERIMENTAL TEST RESULTS

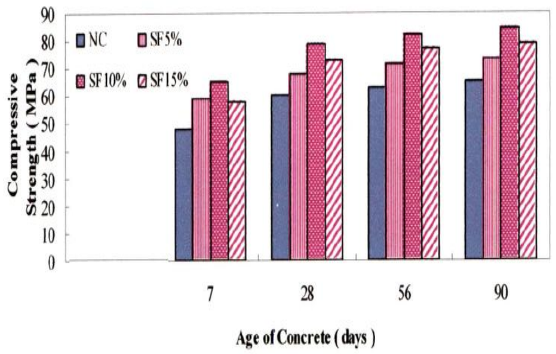

Figure 4.1 (a) Silica fume

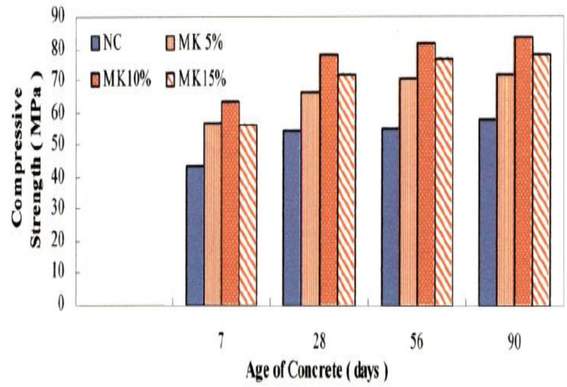

Figure 4.1 (b) Metakaolin

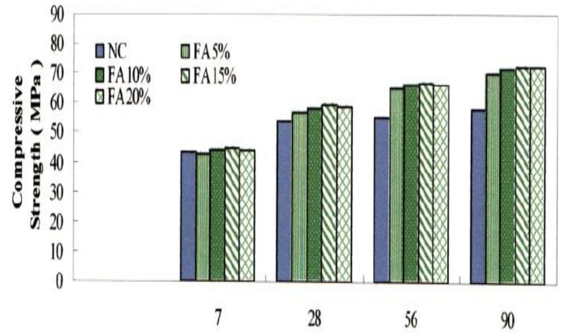

Figure 4.1 (c) Flyash

Figure 4.1 Compressive strength of concrete mixes with w/b ratio of 0.3

Table 4.4 Rate of compressive strength development of concrete mixes correspond to their respective 28 days strength (w/b = 0.3)

Mix	Strength gain (%)			
	7days	28 days	56 days	90 days
NC	79.40	100	103.70	107.40
SF5%	87.50	100	105.90	108.50
SF10%	82.50	100	104.50	107.33
SF15%	79.00	100	105.50	108.53
MK5%	85.33	100	106.00	108.00
MK10%	81.72	100	104.56	106.85
MK15%	78.39	100	106.17	108.64
FA5%	75.20	100	113.68	122.48
FA10%	75.58	100	113.74	123.67
FA15%	75.35	100	112.68	121.63
FA20%	74.44	100	112.03	122.55

V. DISCUSSIONS ON RESULTS

- From the test results it was observed that the maximum compressive strength is obtained for mixes with 10% silica fume at all ages and for all water binder ratios
- When comparing5% replacement levels at of 0.4, the metakaolin gave the better result than silica fume at all ages.
- In all w/b ratios, upto 28 days, fly ash attained least strength even less than normal concrete, but at 56 and 90 days the strength of fly ash concrete was increased significantly.
- Due to the slow pozzolanic reaction, the initial strength of fly ash concrete was lower than that of concrete without fly ash.
- Due to continued pozzolanic reactivity fly ash might have developed greater strength at later age, which was more than that of the concrete without fly ash.
- For all w/b ratios, at all ages, the optimum replacement level of silica fume and metakaolin was found to be 10%.

VI. CONCLUSIONS

- Concrete with 10% of silica fume gives better strength at all water binder ratios and at all ages.
- Metakaolin also performs well and the strength improvement is almost close to the strength development in silica fume concrete.
- The main aim of silica fume and metakaolin replacement is to increase strength whereas the aim of addition of fly ash was for economy and for improving the strength of hardened concrete.
- The early age strength can be achieved by adding silica fume and metakaolin
- At all ages of 7, 28, 56 and 90 days, the compressive strength of HPC with silica fume and metakaolin is more than that of normal concrete.
- It may be noted that addition of silica fume and metakaolin causes an increase

in strength at all ages. But fly ash gains strength at 56 and 90 days.

- From the results, it was found that the optimum replacement of silica fume, metakaolin and fly ash are 10%, 10% and 15%, respectively.

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