PERFORMANCE EVALUATION OF HPC USING MINERAL ADMIXTURES

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ABSTRACT

Replacement of cemtatious material with another material in concrete mixture can lead us to more economical structures. Also it will make use of unwanted waste such as fly ash in better use helping environment. In this study, the effect of mineral admixtures like limestone powder (LP), Silica Fume (SF), fly ash (FA) and Alccofine on fresh and hardened properties of HPC has been compared. This research is based on the measurement of early age characteristics of the High Performance Concrete (HPC), the study of the influence of water binder ratio and binder composition on setting, and the influence of strength, slump, and air content in the material. After a thorough study it was found out that Micro silica is a more effective mineral admixture when compared to other mineral admixtures, to obtain High Performance concrete with respect to Fresh and hardened properties of concrete . But in current industry scenario, rate of micro silica is higher as compared to other mineral admixtures. Hence considering results of all the trials it is suggested that using fly ash by replacing cement by 15% is better than replacing micro silica by 5% to obtain the desired strength but the durability is somewhat reduced is case of fly ash as compared to micro silica.

Keyword - *mineral admixtures, early age characteristics, water binder ratio and fly ash*

1. INTRODUCTION

Currently, high-performance concrete (HPC) is widely used due to their technical and economic advantages. The major difference between conventional cement concrete and High Performance Concrete is essentially the use of mineral admixtures and chemical admixtures in the latter.. In the modern concrete, active mineral additives, such as fly ash, silica fume and slag, etc., have been the important component that provides concrete with higher compressive strength, great fluidity, and higher durability. These Ultrafine materials are particles with a grain size finer than cement. These particles may be inert and improve the packing density of the fines in concrete, or they may be pozzolanic and react with hydration products of the cement. The hypothesis of this work is that substantial amounts of cement can be replaced by suitable very fine grained materials without affecting mechanical properties or durability negatively.

1.1 Literature review

It will be helpful to understand previous studies done on these minerals before commencement of actual study.

1. Micro silica: With the implementation of tougher environmental laws during the mid-1970s, silicon smelters began to collect the silica fume and search for its applications. The early work done in Norway received most of the attention, since it had shown that Portland cement-based-concretes containing silica fumes had very high strengths and low porosities. Since then the research and development of silica fume made it one of the world's most valuable and versatile admixtures for concrete and cementitous products.

2. Fly Ash: In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In the US, fly ash is generally stored at coal power

plants or placed in landfills. About 43% is recycled, often used as a pozzolan to produce hydraulic cement or hydraulic plaster or a partial replacement for Portland cementing concrete production.

3. Limestone: Limestone is very common in architecture, especially in Europe and North America. Many landmarks across the world, including the Great Pyramid and its associated complex in Giza, Egypt, are made of limestone. Limestone is readily available and relatively easy to cut into blocks or more elaborate carving. It is also long-lasting and stands up well to exposure. However, it is a very heavy material, making it impractical for tall buildings, and relatively expensive as a building material.

4. ALCCOFINE 1203 is a new generation, ultrafine, low calcium silicate product, manufactured in India. It has distinct characteristics to enhance 'performance of concrete' in fresh and hardened stages. It can be considered and used as practical substitute for Silica Fume as per the results obtained. If the advantages of ALCCOFINE 1203 are observed in the concrete mix design, the initial rate of strength development was found to be increased or similar as that of Silica Fume.

1.2 Properties of minerals used in this study

1. The use of fly ash is accepted in recent years primarily due to saving cement, consuming industrial waste and making durable materials, especially due to the improvement in the quality stabilization of fly ash. Average particle size of ultra-fine fly ash is 4-5 microns.

2. Silica fume is an ultrafine material with spherical particles less than 1 μm in diameter, the average being about 0.15 μm. This makes it approximately 100 times smaller than the average cement particle. The bulk density of silica fume depends on the degree of densification in the silo and varies from 130 (undensified) to 600 kg/m^3. The specific gravity of silica fume is generally in the range of 2.2 to 2.3. The specific surface area of silica fume can be measured with the BET method or nitrogen adsorption method. It typically ranges from 15,000 to 30,000 m^2/kg.

3. Lime stone powder was used to produce self-compacting concrete incorporating RHA. The T_{50cm} flow times increased in mixtures containing RHA or RHA and LS. Combinations of LS and RHA improved the workability of SCC mixtures. The hardened properties of the concretes were progressively improved with addition of LS.

4. Use of alccofine 1203 enhances the performance of concrete in terms of durability due to its superior particle size distribution. Alccofine is a well graded particle size smaller than cement and higher than micro silica. It is generally considered that fineness of cement or and cementitious materials have influence on strength. Besides fineness, the particle size distribution shape, surface nature, chemical composition etc. play significant role in strength and performance. Average particle size of alccofine

2. EXPERIMENTAL PROPERTIES OF ADMIXTURES USED IN STUDY

Following are the results obtained in laboratory with their individual testing as per representative I.S codes for cementitious materials.

Table 1: SUMMERIZED PHYSICAL PROPERTIES OF ULTRAFINE MATERIALS

Properties	Fly ash	Micro silica	Limestone Powder	Alccofine
Particle Size Distribution (μ)	4-5	0.15 – 0.5	1.5 – 2.5	4
Specific Gravity	2.37	2.22	2.79	2.91
Specific Surface (m^2/kg)	757	15000	2123	1118
45 μm Retention (%)	2.4	0.1	0.2	0.1
Dry loose bulk density (gm/cc)	0.59	0.578	0.425	0.535

3. EXPERIMENTAL BEHAVIOR OF CONCRETE WITH 5% REPLACEMENT OF ULTRAFINE MINERALS

3.1 FLOW TEST

This test was carried to check the required water/binder ratio and its consistency for the fixed flow i.e 120 ±10 mm when 25 blows were given. This test conducted to compare individual behavior of ultrafine materials with water when mixed with 0% cement or mixed with cement as a partial replacement. The flow for all mixes kept fixed i.e 120 ± 10 mm and water was adjusted to get the flow.

A. With Zero Cement Mix

This mixes consisting only mineral admixture, the properties of individual will affect highly in case of such mix.

TABLE 2: OBSERVATIONS FOR FLOW TEST WITH ZERO CEMENT

	Fly ash	Micro silica	Limestone Powder	Alccofine
Wt. of Sample (gm)	800	500	500	500
Water used	218.3	274.2	142.8	184.3
W/B ratio	0.272	0.548	0.285	0.36
Flow	121.42	119.14	114.28	129.71

B.With 5% replacement of Ultrafine

As it is well known that these ultrafine will not be used as fully replacement for the cement, therefore this has been partially replaced with cement and the water requirement and required consistency observation are found.

TABLE 3. OBSERVATIONS FOR FLOW TEST WITH 5% MINERAL REPLACEMENT

	Fly ash	Micro silica	Limestone Powder	Alccofine
Wt. of Cement (gm)	475	570	570	570
5% replacement	25	30	30	30
Water used	119	139.1	128	123
W/B ratio	0.238	0.232	0.213	0.205
Flow	128.58	126	127.72	129.43

3.2 MORTAR TEST

This test was carried to check the required water/binder ratio with fine aggregate for the fixed flow i.e. 120 ±10 mm when 25 blows were given. The ratio of Cement: Sand was adopted to be 1: 1. For the same ratio mineral admixture were replace by 5%, and 8% with cement. The mix was prepared without using chemical admixture, so that water requirement for concrete trial can be interpreted.

TABLE 4. OBSERVATIONS FOR MORTAR TEST

Material	w/c ratio	flow	7 day		28 days	
		(mm)	M.O.R	C.S	M.O.R	C.S

Control mix	0.258	120	6.03	56.5	7.48	72.49
5%	0.275	116	8.18	50.1	9.95	80.22
8%	0.277	115	9.37	51.48	10.88	80.71
Fly ash						
5%	0.302	117	8.53	58.11	8.84	73.52
8%	0.311	125.5	8.89	61.39	7.68	86.14
Micro silica						
5%	0.275	122	8.53	66.47	10.97	83.97
8%	0.285	124	8.89	61.39	10.22	84.98
Limestone Powder						
5%	0.263	116.5	6.87	56.38	10.8	78.34
8%	0.267	126	5.99	66.31	9.87	84.67
Alccofine						

4. TRIAL MIXES

Based on concrete mix design trial mixtures were prepared. Quantities found are summarized in following table.

TABLE NO 5. QUANTITIES FOR MIX DESIGN

Material	Cemen	Sand	10mm	Water	Water	Admixtu	Density	Temperatu
Control mix	562.50	837	1099	135	179	1%	2633.5	26
Lab trial mix(kg)	25.630	38.13	50.075	6.150	8.155	0.269	120	
Fly ash- 5% (28.125 kg/m^3)								
(Kg/m^3)	534.37	832.7	1089.1	135	179.19	0.50%	2619.39	28
Lab trial Mix(kg)	24.480	38.15	49.895	6.185	8.210	0.128	120	
Micro silica -5% (28.125 kg/m3)								
(Kg/m^3)	534.37	832.4	1096.2	135	179.26	1%	2626.11	27
Lab trial Mix(kg)	24.420	38.04	50.910	6.170	8.191	0.257	120	
Limestone -5% (28.125 kg/m3)								
(Kg/m^3)	534.37	834.8	1095.6	135	179.35	0.55%	2627.9	28
Lab trial Mix(kg)	24.400	38.12	50.030	6.164	8.189	0.141	120	
Alccofine-5% (28.125 kg/m3)								
(Kg/m^3)	534.37	836.1	1093.6	135	179.37	0.55%	2627.28	28
Lab trial Mix(kg)	24.410	38.19	49.950	6.166	8.192	0.141	120	

5. 4.3 STUDY OF HARDENED CONCRETE

High strength as well as Durability criteria is considered for HPC. The mineral admixtures which has been used as replacement of cement, found as effective inert fillers which contributes to increase the strength criteria of concrete and also helps to behave durably during its life span.

STRENGTH TEST

TABLE 6: COMPARISONS WITH RESPECT TO STRENGTH

Material	Compressive Strength (N/mm^2)			
	1day	3 day	7 day	28 day
Control mix	36.15	42.16	52.17	85.51

Fly ash- 5% (28.125 kg/m^3)				
	32.83	582.74	66.21	84.35
Micro silica -5% (28.125 kg/m3)				
	41.52	66.79	88.85	97.95
Limestone -5% (28.125 kg/m3)				
	38.01	53.18	67.51	83.35
Alccofine -5% (28.125 kg/m3)				
	33.86	60.97	69.24	86.85

7. CONCLUSION

Here we can conclude that Micro silica is a more effective mineral admixture when compared to other mineral admixtures, to obtain High Performance concrete with respect to Fresh and hardened properties of concrete . But in current industry scenario, rate of micro silica is higher as compared to other mineral admixtures.

This project has been conducted to get the better competitive mineral admixture which will be economical and give more durability and desired strength to make high performance concrete.

As economical point of view using fly ash by replacing cement by 15% is better than replacing micro silica by 5% to obtain the desired strength but the durability is somewhat reduced is case of fly ash as compared to micro silica.

Here we conclude from the results that alccofine has results which are near to micro silica. These results can be obtained same as micro silica if percentage of replacement is increased. But micro silica is costlier than other mineral admixtures. So alccofine can be good alternative to micro silica.

8. REFERENCE

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