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EXPERIMENTAL INVESTIGATION ON EFFECT OF ALCCOFINE WITH FLYASH AND GGBS ON HIGH PERFORMANCE CONCRETE

JIGAR SAIYA[1], ANKIT TIWARI[2], SEEMA JAGTAP[3]

[1,2] BE Student, Dept. of Civil Engineering, Thakur College of Engineering and Technology, Mumbai, Maharashtra, India
[3]Professor and Head, Dept. of Civil Engineering, Thakur College of Engineering and Technology, Mumbai, Maharashtra, India

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Abstract - *The necessity of high performance concrete is increasing because of the increasing demand of the construction materials in the construction industry. Efforts for improving the performance of concrete over the past few years suggest that cement replacement materials along with Mineral & chemical admixtures can improve the strength and durability characteristics of concrete. This project is an attempt to study the behaviour of Alccofine 1203 (5%, 6%, 7%, 8% and 10% replacement by weight of cement) along with Fly Ash (15%) and GGBS (15%) replacement on fresh & hard property of concrete. As well as optimizing the percentage dosage of chemical admixture to achieve required retention period (up to 3hrs) and workability (Slump and Flow) to increase the productivity of concrete design. This paper also studies the effectiveness of applying value engineering to actual concrete mixtures. The application of value engineering to such concrete mixtures results in increase in performance, optimizing the mix by adding appropriate dosage of admixtures so as to work in different situation and increase its value, increase in durability of structure in which concrete will be used, reduction in cost of concrete and overall cost of construction projects, increasing the market share and competitiveness of concrete producers. This research shows that applying the methodology of value engineering to ready-mixed concrete is an effective way to save around 7.5-8.5 % of the total cost of concrete mixtures supplied to construction projects.*

Key Words: **High Performance Concrete (HPC), Fly Ash, GGBS, Alccofine 1203, Value Management, Quality Improvement.**

1. INTRODUCTION

High performance concrete is known as high technology construction material, proving to be very cost effective, reliable, and having long term durability in natural environment. Number of investigations are carried out to produce concrete with desired characteristics such as workability , strength and durability. With the advancement of technology the strength, workability, durability and other characteristics of the ordinary concrete are modified to make it more suitable for work in various situations.

So HPC technologies have used for the construction of numerous off-shore structures and long span bridges; repairs & rehabilitation works. The ingredients which are becoming scarce and expensive, has lead to the usage of economically alternative materials. Flyash and Ground granulated blast slag (GGBS) has been used as a replacement for OPC since this material has workability, strength and durability which enhance the characteristics of concrete. Alccofine is a specially processed product based on slag with high reactivity obtained through the process of controlled granulation. The development of High Performance concrete (HPC) has brought about the essential need for additives both chemical and mineral to improve the performance of concrete. Adding value engineering in our project and thus improving the overall quality of concrete will help in increasing value of the concrete mix and reducing the overall cost and thus increasing the durability of the structure in which concrete is used.

1.1 Admixture

Mineral Admixture: Mineral admixtures are fine powders mainly composed of silicate glasses or non crystalline silica which in the presence of moisture, calcium and hydroxyl ions, slowly hydrate to form cementing products. The most commonly used mineral admixtures in our country are Flyash and GGBS. For higher grade of mix, Alccofine 1203 is most accepted by various concrete producers. Mostly these admixtures are used in range of 5 – 50% replacement with cement.

Chemical Admixture: Besides using mineral admixture, certain chemicals are also used to enhance the performance of concrete like retarder, super-plasticizer. Retarder is used to increase the retention period of concrete (up to 3 hours) and Super-plasticizer is used to reduce water content simultaneously increasing flow of concrete (flow able to pump).

1.2 Role of Admixtures in High Performance Concrete [3]

- Engineering Performance
- Economic Performance
- Environmental Performance

1.3 Micro Ingredients

Fly-Ash: Pozzolans are mainly a type of siliceous or siliceous and aluminous material, which in a finely disintegrated form

and it reacts with calcium in the presence of water molecules. Indian standards for using fly ash are IS 3812 Part I and Part II. Flyash was used to replace 15% by weight of cement. [8]

GGBS: It is a by-product of the iron manufacturing industry. Its production requires less energy as compared with the energy needed for the production of the Portland cement. The replacement of the Portland cement will lead to significant reduction in carbon dioxide gas emission. Indian standards for using GGBS are IS 12089. GGBS was used to replace 15% by weight of cement. [9]

Alccofine1203: Alccofine-1203 is a new generation micro fine concrete producing material and which is important in respect of workability as well as strength. It lowers water binder ratio, improves packing density of concrete paste and also increases strength in compression and flexure. It possesses 10% strength as compared to cement and with addition to it improves strength of concrete to a great extent.

Retarder: TARD-SRC 80 was used as retarder. The dosage of retarder was 0.63 – 0.68% in 1m3 of concrete for retention period of 3 hours.

Super-Plasticizer: Sika K-5218 medium PC (Poly-Carboxylate) was used as super plasticizer. The dosage of it was 0.95% in 1m3 of concrete to achieve a flow of 500-550mm at 3 hours.

2. Literature Review

Some of the literature review on HPC using micro ingredients and to add Value Engineering in concrete mixes is as follows:

Abhijitsinh Parmar and Dhaval M Patel (2013):-

Had replaced cement with Alccofine (8%) and fly ash (15%) to investigate HPC. Various tests' was taken into consideration such as compressive strength test at the age of 3 days, 7 days and 28 days. The author concluded with results which shows that concrete incorporating with alccofine and fly ash have higher strength and also alccofine has increased the durability of concrete.

Adel Mohammed et. al. (2015):-

Studied the effectiveness of applying value engineering to actual concrete mixtures to increase quality, performance, company's market share and to reduce waste, cost and CO_2 emissions. This research also shows applying value engineering to ready mixed concrete is an effective way to save cost of concrete mixtures.

3. Concrete Mix Design

Parameters for mix design M60 grade of concrete

Table 1: Specification of materials for mix design, M60 grade of concrete [5]

Grade	M60
Condition of exposure	Severe
Required retention	3 hours
Required Flow in mm	500 -550 mm
Type of cement	OPC- 53grade
Brand of cement	Ambuja cement
Mineral admixture	Flyash, GGBS, Alccofine1203
Chemical admixture	SRC 80, K-5218
Fine aggregate Zone	Zone -1
Fines passing through 600 Mic. Sieve	25.4%
Maximum size of aggregate	20mm
Coarse aggregate passing through 20mm sieve	87.40%

Summary of materials required per m3 of concrete as per mix design

The total binder composition in $1m^3$ of concrete is 600 kg out of which fly ash and GGBS are replaced up to 15% and alccofine replacement varies as 5%, 6%, 7%, 8% and 10%. Overall 10 trials are listed down for analysis, 5 for OPC+FA+Alccofine and 5 for OPC+GGBS+Alccofine.

Table 2: Materials required per m^3 of concrete as per mix design [3]

Sr. No.	Materials per m3	Quantity in Kg.
1.	Binder	600
2.	C-Sand	747
3.	Coarse Aggregate	957
4.	Water	174
5.	Retarder	3.78 – 4.08
6.	Super-plasticizer	5.7

Composition of binder ingredients for each trial

Table 3: Trials performed for analysis

Trial Mix	Cement (Kg)	Fly Ash (Kg)	GGBS (Kg)	Alccofine (Kg)
TM-01	480	90	--	30
TM-02	474	90	--	36
TM-03	468	90	--	42
TM-04	462	90	--	48
TM-05	450	90	--	60
TM-06	480	--	90	30
TM-07	474	--	90	36
TM-08	468	--	90	42
TM-09	462	--	90	48
TM-10	450	--	90	60

4. Tests on Concrete

4.1 Workability Test results

Initially trial were performed and we have checked the retention period and flow of concrete for every 30 minutes interval and we have come to a conclusion that GGBS requires 0.63 – 0.65% and fly-ash requires 0.66 – 0.68% of retarder dosage to achieve 3 hours of retention period. Similarly for flow ability of concrete amount of super-plasticizer used was 0.95% to achieve a flow in the range of 500-550mm.
Depending upon the site location and distance from plant and site, dosage of retarder can be varied as per requirement [1].

Table 4: Retention time results on the basis of retarder dosage

Retarder Dosage (%)	Equivalent Weight(Kg)	Retention time(min)
0.20	1.2	30
0.45	2.7	60
0.5	3.0	90
0.58	3.48	120
0.61	3.66	150
0.64 (GGBS)	3.84	180
0.67(FA)	4.02	180

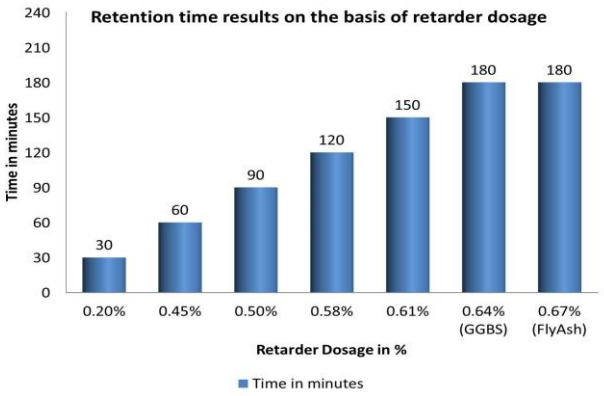

Chart-1: Retention time results on the basis of retarder dosage

4.2 Flow Table Test Results

Fig-1: Flow Table Test

Table 5: Flow Value in mm

Initial flow value of all trials were 660mm						
	Retention Period at every 30 min interval.					
Trial Mix	30	60	90	120	150	180
	OPC + Fly-Ash + Alccofine 1203					
TM-01	635	610	585	565	550	540
TM-02	635	610	590	570	555	540
TM-03	640	615	600	575	565	555
TM-04	640	620	605	585	570	565
TM-05	645	630	620	605	595	580
	OPC + GGBS + Alccofine 1203					
TM-06	630	605	585	555	540	530
TM-07	630	610	585	560	545	535
TM-08	635	610	590	570	550	540
TM-09	635	615	595	575	560	550
TM-10	645	630	610	590	570	560

To achieve required flow the water-binder ratio (0.29), super plasticizer (0.95%) and retarder dosage were kept constant in all trials.

Flow values are checked for every 30 minute interval so as to analyze the effect of Alccofine and chemicals admixture on various mixes.[1]

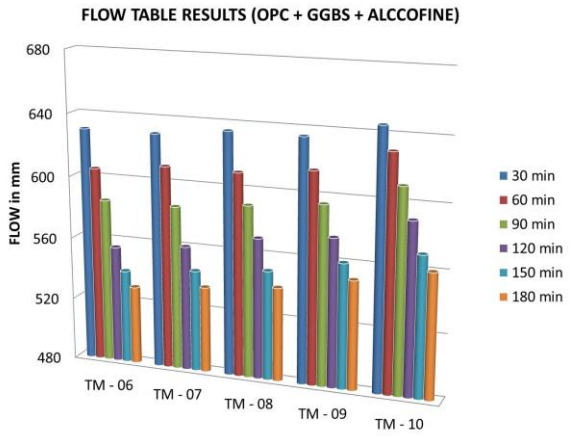

Chart-2: Flow Table Results (OPC + Fly ash + Alccofine)

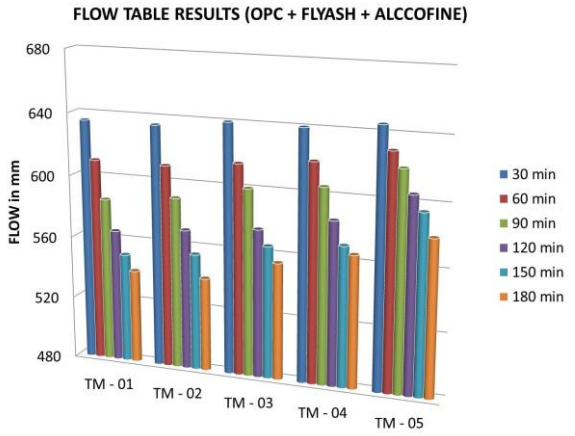

Chart-3: Flow Table Results (OPC + GGBS + Alccofine)

4.3. Compression Test:

Fig-2: Compression Testing Machine

Quality Improvement

Compression test was conducted for cubesize150x150x150 mm and 100x100x100mm. The main focus behind using two different sizes of cubes for testing is to check the homogeneity of mix.

HPC concrete also focuses on homogeneity, and it also enhances the quality of concreting work when it is use for application purpose.

Another aim was to minimize the size effect in case of RCC structures. 100mm size cube will give 5% more load value as compare to 150mm size cube.

But 100mm size cube proves efficient when high grade of concrete is design especially when compression testing machine is of lower load capacity.

Table 6: Compressive Test Results- M60

Compressive Strength in N/mm^2			
Trial Mix	3 Days	7 Days	28 Days
TM-00	42.33	64.77	76.66
	OPC + Fly-Ash + Alccofine1203		
TM-01	32.44	47.33	66
TM-02	35.77	51.77	69.77
TM-03	39.11	57.33	72.66
TM-04	41.77	61.77	74.66
TM-05	46	65.55	79.55
	OPC + GGBS + Alccofine1203		
TM-06	44.44	64.44	72.67
TM-07	47.33	67.55	74.88
TM-08	50.88	70.88	76.66
TM-09	53.11	72.66	78.66
TM-10	55.33	75.11	84.33

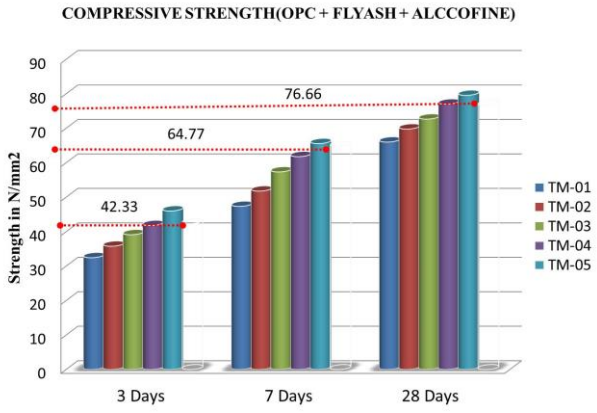

Chart-4: Compressive Strength Analysis (Fly Ash Mixes)

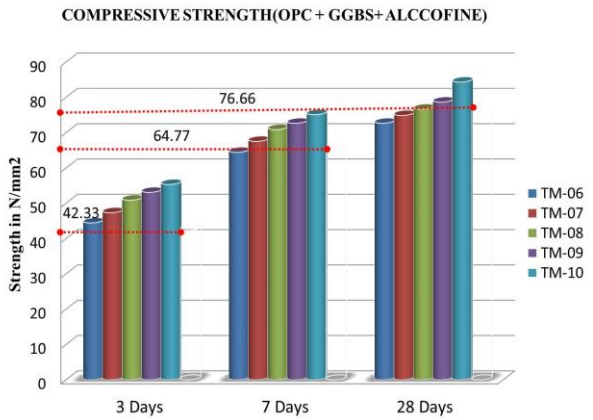

Chart-5: Compressive Strength Analysis (GGBS mixes)

5. Value Engineering

The application of value engineering methodology is of great importance to the owners of ready-mixed concrete plants.

This methodology can achieve an actual reduction in cost of concrete mixtures, while maintaining the quality at the least.

Initially in our project only single admixture which can serve for both retention and flow of concrete. The admixture is CAC and it was used at a dosage of 1.5% to achieve required workability.

Instead of using a single admixture which serves both function, using separate admixture for retention and flow at a dosage of 1.6% will not only increase the performance ,also it will reduce cost of concrete. If this is used for mass concrete production then overall performance and cost of structure in which concrete will be used will be optimised.[4]

Table 7: Various combination of Chemical Admixture

Type of Admixture	ADMIX 1	ADMIX 2	
Product Name	CAC	SRC 80	SIKA 5218
Cost /lit (Rs)	72	16	44
Overall Cost /lit (Rs)	72	60	

Table 8: Cost comparison analysis as per current price of material (Nov.2017)

*Cost Saved of trials TM-01 to TM-10 is compared with OPC mix cost value

	Type of admixture			
Trial Mix	Admix 1 (a) Rs.	Admix2 (b) Rs.	Cost Saved (a-b) Rs.	*Cost Saved (%)
	Only OPC			
TM-00	5287.54	4977.94	309.6	--
	OPC + Fly Ash + Alccofine1203			
TM-01	5106.94	4774.06	332.88	7.519
TM-02	5150.74	4817.86	332.88	
TM-03	5194.54	4861.66	332.88	
TM-04	5238.34	4905.46	332.88	
TM-05	5325.94	4993.06	332.88	
	OPC +GGBS+ Alccofine1203			
TM-06	5214.94	4879.18	335.76	8.449
TM-07	5258.74	4922.98	335.76	
TM-08	5302.54	4966.78	335.76	
TM-09	5346.34	5010.58	335.76	
TM-10	5433.94	5098.18	335.76	

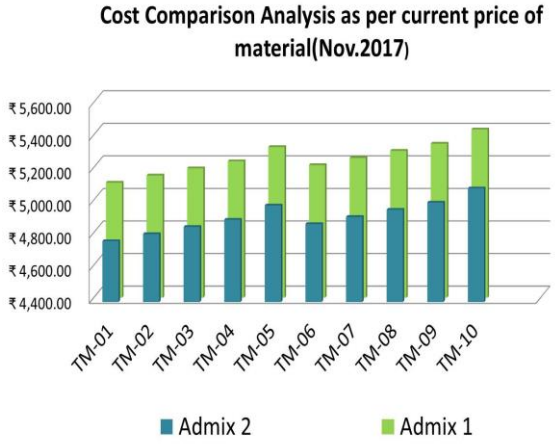

Chart-6: Cost comparison analysis

6. CONCLUSIONS

Using appropriate dosage of admixture will make the concrete to work in different situation. From the results obtained it can be analysed that Fly ash has better flow ability as compare to GGBS while Fly-Ash based mixes has lesser compressive strength as compared with GGBS based mixes.

It can also be concluded that using two separate admixtures in concrete mixes will not only optimize the performance but will also prove out to be more valuable.

Alccofine is most costly item than other ingredients but overall it increases the performance of concrete to a great extent. When certain quality measures are taken and concrete is developed for mass concreting work this method can prove out to be economically viable.

The application of above mixes can be made to implement on Cable bridges, Infrastructure sector, tall buildings, metro rail elevated section, tunnel work and many different sectors when made as per design requirements.

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