Effect of Alccofine and Fly Ash Addition on the Durability of High Performance Concrete

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Abstract

This project presents the results of an experimental investigation that was carried out to evaluate the effectiveness and performance of concrete with OPC cement in addition of Alccofine 1203. In this project we will replace the Alccofine with OPC cement and check the optimum dosage of Alccofine and Fly ash in mix design. Check the various dosage of Alccofine with 4% to 14%. And check the various dosage of Fly ash with 20% to 29%. We also find the different properties of cement, Alccofine, CA, FA, and chemical Admixture Glenium sky-874. Then we prepare the mix design with optimum dosage of Alccofine and Fly ash respectively 8% and 20% with OPC cement. The project results indicate that the performances of concrete using OPC cement and Pozzolanic material Alccofine 1203. Concrete is more durable due to pozzolanic action of Alccofine leading to pores refinement and denser concrete matrix. We were casted the concrete cube, cylinder and disk for the testing of Durability of concrete. Concrete cubes investigated and tested for Compressive strength for ages of 7, 28 and 56 days. This concrete cube, cylinder, and disk were tested with Durability test like RCPT test, Accelerated corrosion test, Sorptivity, Aci test like sea water test, sulphate test, chloride test, with respect to 28 Days strength, 56 Days strength with accelerated curing.

Key words : Conventional Cement Concretes, fly ash, alccofine,

1. Introduction

A pozzolan is siliceous or siliceous and aluminous material which, in itself, possesses little or no cementitious value but which will, in finely divided form and in the presence of water, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties (ASTM C618).[1]

Pozzolanic concretes are used extensively throughout the world where oil, gas, nuclear and power industries are among the major users. The applications of such concretes are increasing day by day due to their superior structural performance, environmental friendliness, and energy conserving implications.
The search for alternative binders, or cement replacement materials, has been carried out for decades. Research has been conducted on the use of fly ash, volcanic ash, volcanic pumice, pulverized-fuel ash; blast slag and silica fume as cement replacement material. Fly ash and others are pozzolanic materials because of their reaction with lime liberated during the hydration of cement. “High performance concrete” Concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing and curing practices.”

High-performance concrete has been primarily used in tunnels, bridges, and tall buildings for its strength, durability, and high modulus of elasticity it has also been used in shotcrete repair, poles, parking garages, and agricultural applications(By K. S. Kulkarni)[4]. The ingredients of HPCs are almost same as those of Conventional Cement Concretes (CCC). But, because of lower Water Cement Ratio, presence of Pozzolans and chemical admixtures. 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 from that of conventional cement concrete (CCC).

Alccofine with OPC cement and check the optimum dosage of Alccofine and Fly ash in mix design. Check the various dosage of Alccofine with 4% to 14%. And check the various dosage of Fly ash with 20% to 29%. We also find the different properties of cement, Alccofine, CA, FA, and chemical Admixture Glenium sky-874. Then we prepare the mix design with optimum dosage of Alccofine and Fly ash respectively 8% and 20% with OPC cement.

2. Objectives

The main objective of this project is to study the properties of fresh and hardened high performance concrete. It consists of following point –

1) To maximize the life span of concrete.
2) To find out the optimum content of alcofine to be mixed in concrete .
3) To economise the cost of concrete by mixing optimum content of fly ash.
4) To analyse the effect of alkali attack and sulphate attack test on concrete.
5) To analyze the effect of RCPT, Sorptivity ,
6) To analyze Chloride test and sea water test,

3. Materials

Physical and Chemical Properties of Fly ash and Alccofine shown in table – 2, table – 3, table – 4 and table – 5 respectively

Sr. No	Character	Results
1	Lime reactivity , N/mm^2	8 min
2	Retention On 25 Micron Sieve	>0.5
3	Drying Shrinkage, percentage	0.06
4	Soundness by Autoclave expansion, percent	0.05
5	Compressive Strength, as percent of strength of corresponding plain cement mortar cubes	80

Table - 1 Physical Composition of Fly Ash

Sr No	Type of test	Test Method	Result obtained
1	CaO%	IS-1727	0.50
2	SiO_2%	IS-1727	67.60
3	Al_2O_3%	IS-1727	11.30
4	MgO%	IS-1727	0.10
5	SO_3%	IS-1727	0.06
6	NaO_2%	IS-4032	0.035
7	K_2O%	IS-4032	0.005
8	Total Chloride%	IS-12423	0.008
9	Loss on Ignition%	IS-1727	2.60
10	Fe_2O_3%	IS-4031	1.15
11	TiO_2%	IS-4031	Nil
12	P_2O_3%	IS-4031	0.0002

Table -2 Chemical Composition of Fly Ash

Fineness (cm^2/gm)	Specific Gravity	Bulk Density (Kg/m^3)	Particle Size Distribution		
			D10	D50	D90
800	3.11	700-900	1	5	9

Table-3 Physical Composition of Alccofine

Cao	So_3	Sio_2	Al_2O_3	Fe_2O_3	MgO	Cl
61-64%	2-2.4%	21-23%	5-5.6%	3.8-4.4%	0.8-1.4%	0.03-0.05%

Table-4 Chemical Composition of Alccofine

pH	Relative Density	Chloride ion content
≥ 6	1.10 ± 1.01 at 25ºC	<0.2%

Table-5 Physical Properties of GLENIUM SKY 784

4. Durability Test and its Specimen Schedule

To find out harden properties of concrete following test were carried out.

1) Accelerated Corrosion test.
2) RCPT test.
3) Alkali attack test.
4) Sorptivity test,.
5) Sulphate Attack Test ,chloride attack test.
6) Sea water test.

Proportions of 5 groups and quantity of materials per m^3 are shown in table – 6.

M60	Quantity
Cement	432 Kg
20% of Fly-Ash	120 Kg
8% of Alccofine	48 Kg
Water	179 Liter
Fine Aggregate	752 Kg
C.A.(20 mm)	672 Kg
C.A.(10 mm)	448 Kg
Admixture	6 Litre
w/binder ratio	0.29

Table-6 Mix Proportions

4.1 Specimen Schedule.

Durability Test and its Specimen Schedule

Durability Test And its Specimen Schedule							
Specimen	Sulphate attack Test	Chloride Resistance Test	Alkali attack Test	Sea Water Test	Rapid Chloride Permeability Test (RCPT)	Sorptivity test	Accelerated Electrolytic Corrosion test
Cube 150*150*150	12	12	12	12			
Disk 100*50					6	6	
Cylinder 100*200							5

Table-7: Durability Test and its Specimen Schedule.

Schedule of Specimen

Schedule of Specimen			
Specimen	Total Quantity	ACC	Total Volume of Concrete in m^3
Cube 150*150*150	67	52	0.2345
Disk 100*50	12	4	0.00468
Cylinder 100*200	5	1	0.00785
Total	84	57	0.24703

Table-8: Schedule of Specimen

4.2 Rapid Chloride Permeability Test (RCPT)

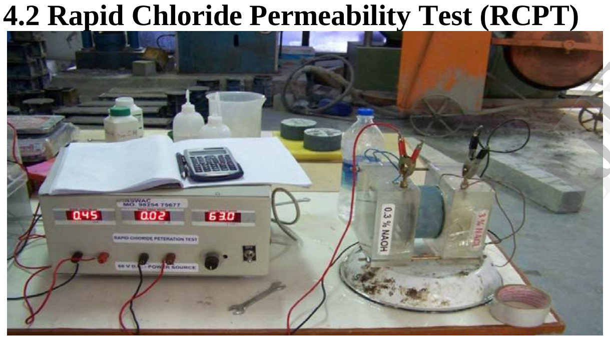

Figure 1 – RCPT

4.2.1 Test Procedure

The test method involves obtaining a 100 mm (4 in.) diameter core or cylinder sample from the concrete being tested. A 50 mm (2 in.) specimen is cut from the sample. The side of the cylindrical specimen is coated with epoxy, and after the epoxy is dried, it is put in a vacuum chamber for 3 hours. The specimen is vacuum saturated for 1 hour and allowed to soak for 18 hours. It is then placed in the test device (see test method for schematic of device). The left-hand side (–) of the test cell is filled with a 3% NaCl solution. The right-hand side (+) of the test cell is filled with 0.3N NaOH solution. The system is then connected and a 60-volt potential is applied for 6 hours. Readings are taken every 30 minutes. At the end of 6 hours the sample is removed from the cell and the amount of coulombs passed through the specimen is calculated(Rapid chloride permeability test of concrete (ASTM C1202, AASHTO T277)[3].

4.3 Accelerated Electrolytic Corrosion test.

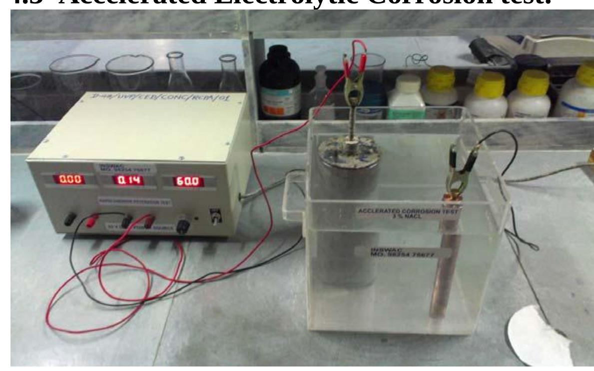

Figure **2** Accelerated Electrolytic Corrosion test

4.3.1 Test Procedure.

For corrosion test the cylindrical specimen of 100mm dia & 200mm height is taken. While casting, a 25mm rod is placed at the centre such that there is 25mm cover at bottom. The test setup that essentially measures resistivity of concrete consists of a constant DC supply providing constant voltage of 60V through a shunt in a constant voltage mode 80mA in constant current mode. The test was carried out in a 6% NaCl solution with an embedded reinforcement bar as a working electrode and a rectangular copper bar as a counter electrode. Set-ups used for inducing reinforcement corrosion through impressed current consist of a DC power source, a counter electrode, and an electrolyte. The positive terminal of the DC power source is connected to the steel bars (anode) and the negative terminal is connected to the counter electrode (cathode). The current is impressed from counter electrode to the rebar through concrete with the help of the electrolyte. The variable parameter voltage was recorded at every 15min interval for 6 hrs in constant current study. The specimens were then taken out, visually inspected and carefully split open to access the corroded steel bar. The reinforcement bar was then cleaned as per(ASTM G1 of 1981)[5] by dipping it in dark solution consisting of HCl of specific gravity 1.191 + antimony trioxide 20 gm + stannous chloride 50gm for 25 min. each bar was the weighed again to the accuracy of 0.1 mg to find out the change in wt.

4.4 Sorptivity.

Figure 3– Sorptivity.

4.4.1 Test Procedure

The Sorptivity can be determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used as the test fluid. The specimen were drowned as shown in figure with water level not more than 5mm above the base of specimen and the flow from the peripheral surface is prevented by sealing it properly with non absorbent coating. The quantity of water absorbed in a time period of 30 minutes was measured by weighing the specimen on a top pan balance weighing up to 0.1mg.Surface water on the specimen was wiped off with a dampened tissue and each weighing operation was completed within 30 seconds. Sorptivity(S) is a material property which characterizes the tendency of a porous material to absorb & transmit water by capillarity. The cumulative water absorption (per unit area of the inflow surface) increases as the square root of elapsed
time't'.

$I=S.t^{1/2}$ therefore $S = I/t^{1/2}$

Where: S = Sorptivity in $mm/min^{1/2}$

t = elapsed time in min.

$I = \Delta w/Ad$

A = surface area of the specimen through which water penetrated

d = density of water

4.5 Sulphate Attack Test

Test Procedure This test was carried out on the 150*150*150 mm Concrete cube. Total 12 cubes are casted and demoulded after 24 hours and at the ends of 28 days of normal curing period tested. The specimens were taken out from the curing tank and initial weight was taken. 5% of sodium sulphate (Na_2SO_4) and 5% magnesium sulphate ($MgSO_4$) by weight of water was added with water as per earlier investigators. The concentration of the solution was maintained throughout this period by changing the solution periodically. The specimens were taken out from the sulphate solution after 28 days of continuous soaking. The surface of the Cube were cleaned, weighed & then tested in the compressive testing machine under the uniform rate of loading of 120 kg/cm2/min. The changes in strength of the concrete cube were calculated as per (IS: 516-1959)[2].

4.6. Chloride resistance test.

This test was carried out on the 150*150*150 mm Concrete cube. Total 12 cubes are casted and demoulded after 24 hours and at the ends of 28 days of normal curing period tested. The specimens were taken out from the curing tank and initial weight was taken. 5% of sodium chloride by weight of water was added with water as per earlier investigators. The concentration of the solution was maintained throughout this period by changing the solution periodically. The specimens were taken out from the sulphate solution after 28 days of continuous soaking. The surface of the Cube were cleaned, weighed & then tested in the compressive testing machine under the uniform rate of loading of 120 kg/cm2/min. The changes in strength of the concrete cube were calculated as per IS: 516-1959[2].

4.7 Alkali Attack Test

This test was carried out on the 150*150*150 mm Concrete cube. Total 12 cubes are casted and demoulded after 24 hours and at the ends of 28 days of normal curing period tested. The specimens were taken out from the curing tank and initial weight was taken. 5% of sodium hydroxide by weight of water was added with water as per earlier investigators. The concentration of the solution was maintained throughout this period by changing the solution periodically. The specimens were taken out from the sulphate solution after 28 days of continuous soaking. The surface of the Cube were cleaned, weighed & then tested in the compressive testing machine under the uniform rate of loading of 120 kg/cm2/min. The changes in strength of the concrete cube were calculated as per IS: 516-1959[2].

4.8 Sea water Attack Test.

This test was carried out on the 150*150*150 mm Concrete cube. Total 12 cubes are casted and demoulded after 24 hours and at the ends of 28 days of normal curing period tested. The specimens were taken out from the curing tank and initial weight was taken. 5% of Sea Water by weight of water was added with water as per earlier investigators. The concentration of the solution was maintained throughout this period

ISSN: 2278-0181
Vol. 3 Issue 1, January - 2014

by changing the solution periodically. The specimens were taken out from the sulphate solution after 28 days of continuous soaking. The surface of the Cube were cleaned, weighed & then tested in the compressive testing machine under the uniform rate of loading of 120 kg/cm2/min. The changes in strength of the concrete cube were calculated as per IS: 516-1959[2].

5.RESULT AND DISCUSSION

5.1 rcpt test result

Rapid Chloride Permeability Test (RCPT)					
Mix Name	Batch Name	Coulombs	28 Days Result Chloride ion Permeability	Coulombs	56 Days Result Chloride ion Permeability
Alccofine	AL1	702	Very Low		
	AL2	621	Very Low		
	AL9			441	Very Low
	AL15			477	Very Low
Silica fume	SF 5	758	Very Low		
	SF 6	678	Very Low		
	SF 7			502	Very Low
	SF 8			544	Very Low

Table-9 rcpt test result

5.2 Accelerated Corrosion Test

Accelerated Corrosion Test						
Mix Name	Batch Name	Initial Weight of Rod in gm	Weight on 28 Days Test in gm	Weight loss at 28 days in gm	Weight on 56 Days Test in gm	Weight loss at 56 days in gm
Alccofine	AL4	811	806.8	4.2		
	AL6	801	797.1	3.9		
	AL1	794			792.2	1.8
	AL3	790			788.5	1.5
Silica fume	SF 1	806	801.6	4.4		
	SF 2	796	791.8	4.2		
	SF 3	806			803.9	2.1
	SF 4	810.3			808.3	2

Table -10 accelerated corrosion test result

5.3 Sorptivity Test Result

SORPTIVITY TEST RESULT					
Mix Name	Elapsed Time in min	28 Days Result in mm/min$^{0.5}$	Elapsed Time in min	56 Days Result in mm/min$^{0.5}$
Alccofine	15	0.0033	90	0.0013
	30	0.0047	180	0.0014
	45	0.0057	255	0.0016
	75	0.0059	330	0.002
Silica fume	15	0.004	90	0.00145
	30	0.00521	180	0.00151
	45	0.0058	255	0.00173
	75	0.0061	330	0.0018

Table-11 sorptivity test result

5.4 Acid Test result

Mix Name	Name of Test	Batch Name	Initial weight at 28 Days normal curing period in gm	loss of weight at 28 Days in Acid solution in gm	Loss of Weight in % at 28 Days	Strength Loss at 28 Days in Acid Solution in N/mm^2	Loss of Strength in % at 28 Days	loss of weight at 56 Days in Acid solution in gm	Loss of Weight in % at 56 Days	Strength Loss at 56 Days in Acid Solution in N/mm^2	Loss of Strength in % at 56 Days
Alccofine	Alkali attack Test	AL5, AL6, AL10, AL11	8408.25	165.4	1.97	5.27	9.60	188.2	2.24	9.28	12.57
	Sulphate attack Test	AL12, AL14, AL15, AL16	8559.25	187.2	2.19	4.69	8.55	208.7	2.44	8.37	11.34
	Chloride attack Test	AL3, AL9, AL10, AL14	8538	158.7	1.86	7.48	13.63	187.3	2.19	12.35	16.73
	Sea Water Test	AL1, AL4, AL6, AL9	8551.5	153.5	1.80	3.15	5.74	180.4	2.11	5.26	7.13
Silica fume	Alkali attack Test	MK1, MK3, MK8, MK4	8540	182.3	2.13	6.12	12.59	208.6	2.44	9.9	16.45
	Sulphate attack Test	MK2, MK5, MK10, MK6	8460	155.45	1.84	3.15	6.48	212.2	2.51	7.2	11.96
	Chloride attack Test	MK7, MK9, MK15, MK12	8539	181.5	2.13	9.85	20.27	202.7	2.37	12.86	21.36
	Sea Water Test	MK11, MK13, MK14, MK2	8651	160.5	1.86	4.62	9.51	187.3	2.17	5.97	9.92

Table -12 acid test result

6. Conclusion

- The average rate of increase of sorptivity at 28 days is 0.126% and 0.158% for Silica fume and Alccofine respectively and for 56 days it is 0.068% and 0.095% respectively.
- From the sorptivity results it can be concluded that the sorptivity in Silica- Fume is more than the sorptivity of Alccofine so the rate of capillarity rise in Silica-Fume is more than the rate of capillarity rise in Alccofine.
- The average rate of loss of weight at 28 days is 0.495% and 0.2% at 56 days for Alccofine and for Silica-Fume it is 0.53% and 0.25% at 28 days and 56 days respectively.
- From the Accelerated Corrosion Test Silica-Fume specimen is more affected to the corrosion than the Alccofine specimen.
- From the RCPT test results it can be concluded that the average coulomb passing rate is high in Silica-Fume specimens as compared to the Alccofine Specimens for both 28 days and 56 days results hence the Silica-Fume specimen possesses the high Chloride Ion Permeability Though the silica fume specimen possesses good resistant to chloride ion permeability.
- In alkali attack test the % weight loss of Alccofine and Silica-Fume specimen for 28 days and 56 days are 1.97, 2.13 and 2.24, 2.44 respectively.The % strength loss of Alccofine and Silica-Fume specimen for 28 days and 56 days are 9.60, 12.59 and 12.57, 16.45 respectively.
- From the Alkali Attack Test Results it can be concluded that the Alccofine possess the better resistant to the Alkali Attack than Silica-Fume.
- In the Sulphate Attack Test % weight loss of Alccofine and Silica-Fume specimen for 28 days and 56 days are 2.19, 1.84 and 2.44, 2.51 respectively.
- The % strength loss of Alccofine and Silica-Fume specimen for 28 days and 56 days are 8.55, 6.48 and 11.34, 11.96 respectively.
- In Chloride Attack Test % weight loss of Alccofine and Silica-Fume specimen for 28 days and 56 days are 1.86, 2.13 and 2.19, 2.37 respectively. The % strength loss of Alccofine and Silica-Fume specimen for 28 days and 56 days are 13.63, 20.27 and 16.73, 21.36 respectively.
- From the Chloride Attack Test Results it can be concluded that the Alccofine possess the better resistant to the Chloride Attack than Silica-Fume.
- In Sea Water Test % weight loss of Alccofine and Silica-Fume specimen for .28 days and 56 days are 1.80, 1.86 and 2.11, 2.17 respectively.The % strength loss of Alccofine and Silica-Fume specimen for 28 days and 56 days are 5.74, 9.51 and 7.13, 9.92 respectively .From the Sea Water Test Results it can be concluded that the Alccofine possess the better resistant to the Sea Water than Silica-Fume

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