Experimental Study on High Performance Concrete by Using Alccofine and Fly Ash - Hard Concrete Properties

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Abstract

India is developing country and now days skyscrapers and other heavy structures are constructing and for that high performance concrete requires. 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. The main aim of this study is to get the economical and eco friendly High Strength Concrete(HSC). The fresh concrete test carried out for finding properties of this concrete at Harden stage.

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]

Concrete is mostly used artificial material all over the world and has played main role in development of all countries. For higher and higher requirements in last past few years many research has been done on concrete t make it more durable and higher strength. In 1970's compressive strength more than 40 N/mm2 known as high- strength concrete. Later 60-100 N/mm2 compressive strength classified as High-strength concrete

"High performance concrete" is used for concrete mixture which possess high workability, high strength, high modulus of elasticity, high density, high dimensional stability, low permeability and resistant to chemical attack.

	CEMENT (%)	FLY ASH (%)	ALCCOFINE (%)
M1	70	26	4
M2	70	24	6
M3	70	22	8
M4	70	20	10
M5	70	18	12

Table –1 Mix Proportion of Cement, Fly ash and Alccofine

As per M60 Mix design in this research the Alccofine and fine fly ash partially replaced with cement. Replacement of cement with fly ash and Alccofine of 5 proportions are shown in table -1

A. Pozzolonic Reactions

This is a chemical mechanism. Reactive silica (SiO_2) of pozzolan reacts with the calcium hydroxide (CH), which is liberated during process of hydration and produces calcium silicate hydrate (C-S-H). Due to pozzolonic reaction the larger size of crystal of Ca $(OH)_2$ converts to crystal of C-S-H, which is dense and leading to reduction of pore size.

Portland cement Reaction : $C_3S + H = C\text{-}S\text{-}H + CH$
Pozzolonic Reaction : $S + CH + H = C\text{-}S\text{-}H$

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 achieve desire strength of (M60).
2) To find out optimum dosage of alccofine.
3) To reduce the cost of concrete by finding out the optimum dosage of fly ash.
4) To find out compressive strength , flexural strength and split tensile strength of concrete.
5) To perform the non destructive test on concrete specimen.

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 - 2 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 -3 Chemical Composition of Fly Ash

Fineness (cm^2/gm)	Specific Gravity	Bulk Density (Kg/m^3)	Particle Size Distribution		
			D10	D50	D90
12000	3.11	700-900	1.5	5	9

Table-4 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-5 Chemical Composition of Alccofine

4. Experimental Program

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

1) Ultrasonic pulse velocity test.
2) Rebound hammer test.
3) Compressive strength of concrete cubes.
4) Split tensile strength of concrete cylinder.
5) Flexural strength of concrete beam.

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

M60	M1	M2	M3	M4	M5
CEMENT (kg)	414.4	414.4	414.4	414.4	414.4
FLY ASH(kg)	46.176	42.624	39.072	35.52	31.968
ALCCOFINE (kg)	7.104	10.656	14.208	17.76	21.312
WATER (kg)	258.5	258.5	258.5	258.5	258.5
C.A 1(kg)	755.5	755.5	755.5	755.5	755.5
C.A 2(kg)	752	752	752	752	752
Sand(kg)	173	173	173	173	173
Water(kg)	414.4	414.4	414.4	414.4	414.4

Table – 6 Mix Proportions

4.1 Ultrasonic pulse velocity

Figure – 1 UPV test

Direct Ultrasonic Pulse Velocity test were carried out as shown in figure – 1. For each proportion upv test carried out in 3 samples and average result shown in table -7

4.2 Rebound Hammer Test

Figure – 2 Rebound Hammer test

Rebound hammer test was carried out as shown in figure – 2. Results of Rebound hammer test are shown in table - 8

4.3 Compressive Strength

Figure – 3 Compression Test

The compressive strength was studied on different ages of concrete, with different proportion of Alccofine and Fly ash in the concrete mix. This is the long term strength study, thus we have selected different age of concrete such as 7 Days, 28 Days and 56 Days. The cube mould of 150mm x 150mm x 150mm size is taken as per IS: 516-1959 specification.

4.4 Split Tensile Strength

Figure – 4 Split Tensile Strength

The split tensile strength was made as per the IS: 5816-1999 specification, on the Grade M60 with different Alccofine and Fly ash percentage. For this study the concrete cylinders of diameter 150mm and height 300mm were prepared. Total 3 Nos. of cylinders were cast for each Alccofine proportion in the concrete mix, i.e. total 45 nos. of cylinders prepared for this test. Cylinders were cured for 28 Days time age.

4.5 Flexural Strength

Figure – 5 Flexural Test

The beam flexural strength was made as per the IS: 516-1959 specification, Concrete Grade M60 with different Alccofine and fly ash percentage. For this study the concrete beams of size 150mm x 150mm x 700mm were prepared. Beams were cured for 28 Days time age. The beams were tested on the Universal Testing Machine (UTM). The beams were placed normal to the casting and symmetrical two point system was adopted for the flexural tensile strength test.

5. Test Results

Proportion	M1	M2	M3	M4	M5
7 Days	4.52	4.63	4.60	4.53	**4.66**
28 Days	**4.66**	4.64	4.63	4.50	4.56
56 Days	4.64	4.59	4.62	4.59	**4.67**

Table – 7 UPV Test Results

Proportions	M1	M2	M3	M4	M5
7 Days	32.39	34.57	37.01	39.25	**40.47**
28 Days	57.18	52.73	**61.05**	52.91	59.79
56 Days	60.17	**62.34**	60.71	61.6	61.93

Table – 8 Rebound Hammer Test Results(N/mm^2)

Mix proportion	M1	M2	M3	M4	M5
7 Days	37.51	37.62	42.33	42.73	**46.52**
28Days	59.31	56.14	**66.64**	56.71	63.74
56Days	66.09	**70.51**	67.2	64.51	68.15

Table – 9 Compression Test Results(N/mm^2)

Mix proportion	M1	M2	M3	M4	M5
28 Days	3.73	4.01	**4.63**	4.19	4.3
56 Days	4.89	4.22	**5.08**	4.41	4.75

Table – 10 Split Tensile Test Results(MPa)

Mix proportion	M1	M2	M3	M4	M5
28 Days	6.03	4.91	5.57	**6.58**	6.37

Table – 11 Flexural Strength

6. Conclusion

6.1 Non-Destructive Test

By doing Non destructive test like Ultrasonic Pulse Velocity & Rebound Hammer we get excellent quality of concrete as per IS 1311(part- 1 & 2).

6.2 Compressive Strength

In all mix proportions strength gain up to 7 days is excellent, between 7 to 28 days strength gain is comparatively less, but between 28 to 56 days strength gain is high because of fly ash, in M3 proportion get acceptable strength at 28 days as per Table-7, clause 6.2.1 of IS 456-2000.

It concluded that initial compressive strength achieved by using Fly-Ash (22%) and Alccofine (8%) is 42.33 Mpa and 66.64 Mpa at 7 and 28 days respectively, but after 28 days strength gain is comparatively less than other.

6.3 Split Tensile Strength

After testing the split tensile strength of cylinder we concluded that cylinders are not getting tensile strength up to desired limits of 5.42 Mpa but in most of the cases the failure was in aggregates and not in transition zone of paste so it may be covered by using some different gradation or by using high strength aggregates.

Maximum split tensile strength of cylinder was achieved 5.08 Mpa in M3 mix (fly ash- 22% and alccofine-8%).

6.4 Flexural Strength

After testing flexural strength test of beam concluded that maximum flexural strength of 6.58 Mpa in M4 mix (fly ash-20% and alccofine-10%).

7. References

[1] Mehta, P.K. (1987). "Natural pozzolans : Supplementry cementing materials in concrete". CANMET Special Publication 86: 1-33.

[2] K.aniraj S.R. and Havangi V.J.(Aug 1999). 'Geotechnical Characteristics of Fly ash soil mixture' Geotechnical Engineering Journal, 30 pp 129147

[4] IS 456 -2000, 'Plain and Reinforced Concrete code for Practice.'

[5] IS 10262- 2009, 'Recommended Guidelines for Concrete Mix Design.'