International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 06, June-2015

An Investigation on Compressive Strength and Shrinkage af Concrete Containing Fly Ash Along with Alccofine

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***Abstract*- With the growing technology in concrete world and urbanisation there is lot of requirement of raw material. Due to scarcity of non renewable resources, concrete making materials are required to be preserved, so there is utmost necessity of using supplementary waste materials in concrete. The waste materials like fly ash, silica fume, lime stone quarry fine, blast furnace slag etc can be used as replacement of cement to address the issue of environmental pollution.**

In present study an attempt has been made to investigate the strength and shrinkage characteristics of concrete by partially replacing cement by fly ash in different proportions. To supplement the loss in strength of concrete due to addition of fly ash at higher percentage levels, another cementatious material alccofine as partial replacement of fly ash ha seen used to prepare binary and ternary mixes respectively.

The results obtained in present study showed that there is marked improvement in compressive strength and shrinkage properties of concrete with addition of fly ash and alccofine both.

Keywords: Compressive strength, Fly ash, Alccofine, Shrinkage, Concrete.

1. INTRODUCTION

With increase in industrialisation and waste material production which leads to problem of its management and removal from environment without harming it, emphasis is laid on use of waste material as a partial replacement of locally available materials used in concrete construction to effectively protect our environment from waste accumulation which in turn helps us to improve overall economy. Fly ash concrete is prepared by replacing cement partially by certain amount of Fly ash in concrete which will improve its engineering properties such as strength and durability. Thus the use of Fly ash for its pozzolanic properties and special particle size characters leads to quality up gradation at no effort and no extra cost or may be even as reduced cost.

Alccofine is a material of new generation, it is micro fine material of particle size finer than other materials like cement, fly ash etc. manufactured in India and Introduced by Ambuja Cement Ltd in march 2013. It has unique characteristic which has tendency to enhance performance of concrete in both fresh and hardened stages.

Reddy, V.G., Rao, K.N.V., Rao, A.R. (1994) investigated the effects of fly ash, obtained from Nellore Thermal Power Station, on six lean concrete mixes replacement levels of 10,20,30,40 and 50% and observed that though the rate of gain of compressive strength of fly ash concrete is less than that of reference concrete during the initial period of 28 days, it is more during the subsequent period reaching 90% of the reference mix at the age of 90 days.

Gopalakrishanan. S., Rajamane, N.P., Neelamegarn, M., Peter, LA., Dattatreya, JK. (2001) studied the strength characteristics and durability of fly ash concrete with different fly ash replacement levels and reported that fly ash concrete up to 25% replacement level would render the concrete more durable and corrosion resistant, beside the strength requirements.

Singh, N., Lal, R and Jha, N ., (2003) reported that due to low cement content in fly ash mixes there is less heat of hydration, therefore addition of fly ash leads to reduction in temperature rise and elimination thermal cracks. They have further reported that fly ash, being 30% lighter and finer than cement, it makes concrete more workable.

Kulkarni S. and Parekh V., (2013) investigated and evaluated the performance of high performance concretes (HPC) containing supplementary cementitious materials like slag waste, microsilica, alccofine and fly ash. The Alccofine and fly ash was added by weight of cement as a replacement and the concrete specimens were tested at different ages for Mechanical Properties of concrete, namely, Cube Compressive Strength, Flexural Strength. The results of the study showed the structureal response of concrete containing alccofine was better as compared to concrete containing slag material and microsilica. Out of mixes prepared using different percentages of fly ash and alccofine, the mix containing 8% alccofine and 16% of fly ash gave the better results.

Upadhyay S.P., and his co-workers (2014) has reported that flexural strength of concrete prepared by using slag materials and microsilica as binary and ternary replacements. They also conducted experiments on concrete containing waste glass powder and alccofine as supplementary cementitious materials. The results of the study showed that the performance of concrete containing 30% WGP and 10% alccofine were better as compared to the results obtained for concrete containing slag materials and micro silica.

2. NEED AND OBJECTIVE:

It is well established in literature that many studies have been carried out in past to investigate strength characteristics of concrete containing fly ash , blast furnace slag, rice husk and silica fume etc. However, very few studies are available on strength and durability characteristics of concrete containing fly ash and alccofine. Therefore, the following objectives were identified for present study.

1: To explore the suitability of use of fly ash procured from Thermal power plant, Bathinda as a partial replacement of cement.

2: To study the effect of partial replacement of cement with Fly ash (FA) in varying percentages (20%, 30% and 40%) on compressive strength and drying shrinkage characteristics of concrete at moist curing age of 7 and 28 days.

3: To investigate the effect of partial replacement of Fly ash with Alccofine (AF) in varying percentages (5%, 7.5% and 10%) on compressive strength and drying shrinkage characteristics of concrete at moist curing age of 7 and 28 days.

4: To compare the compressive strength and shrinkage characteristics of concrete without Fly ash, with fly ash and with fly ash and alccofine both.

3. MATERIALS USED:

3.1 CEMENT

Ordinary Portland cement (OPC) of 43 Grade (Ultratech) from a single batch was used for all the concrete mixes. Cement taken was fresh and without any lumps. The cement was tested as per IS: 8112- 1989 for its physical properties and results obtained are presented in table 1.

TABLE:1 PHYSICAL PROPERTIES OF CEMENT

S N	**Characteristics**	**Experimental Value**	**As per IS-8112-1989**
1	Normal consistency	29%	-
2	Specific Gravity	3.14	3.15
3	Initial setting time (minute)	53 minutes	> 30
4	Final setting time (minute)	293 minutes	< 600
5	Compressive strength (N/mm^2) 3 days 7 days 28 days	 24.95 N/mm^2 36.37N/mm^2 47.15 N/mm^2	 >23N/mm^2 >33N/mm^2 >43 N/mm^2

3.2 FINE AGGREGATES

In this study, locally procured natural sand from Ropar was used and it conformed to grading zone II. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75mm and then was washed to remove the lumps of clay and other foreign material. The Specific gravity of sand used was 2.62.

3.2.2 COARSE AGGREGATES

Locally available crushed stone aggregates of nominal size 20mm procured from Nangal were used in present study. The aggregates were washed to remove dust and dirt and dried to surface dry condition. The properties of aggregates were found to conform the requirements of IS: 383-1970. The specific gravity of aggregates used was 2.64. For preparation of concrete mixes the 20mm and 10mm aggregates were proportioned in the ratio 60:40.

3.3 FLY ASH (FA)

Fly ash procured from Bathinda and supplied by Ultratech Cement Ltd. in one lot was used in the present study. To assess suitability of fly ash for making concrete, the properties based on laboratory tests conducted by Central Soil and Material Research Station, New Delhi and CBRI, Roorkee were referred and it was found that fly ash was suitable to be used as partial replacement of cement in concrete as per IS code 3812-1999.

3.4 ALCCOFINE

It is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. It is grey in color. The computed blain value based on particle size distribution (PSD) is around 12000cm^2/gm and thus is ultra fine material. The alccofine used in present study was procured from Ambuja Cement Ltd. and the properties provided by the manufacturer are listed in table 2.

3.5 SUPER PLASTICIZER

The chemical “Conplast SP430G8” used for enhancing workability and to reduce water cement ratio was provided by Fosroc Pvt Ltd. It is sulphonated naphthalene formaldehyde which is brown in colour. Its specific gravity was 1.236.

Table 2: PROPERTIES OF ALCCOFINE

Chemical Analysis	Mass %	Physical analysis	Range
CaO	32-34	Bulk Density	600-700 kg/m^3
Al_2O_3	18-20	Surface Area	12000 cm^2/gm
Fe_2O_3	1.8-2	Particle shape	Irregular
SO_3	0.3-0.7	Particle Size, d10	< 2 µ
MgO	8-10	d50	< 5µ
SiO_3	33-35	d90	< 9 µ

4. EXPERIMENTAL PROGRAM

4.1 MIX PROPORTIONING AND CASTING

The concrete used in this study was proportioned as per IS: 10262-2009, three trial mixes were cast and mix proportions finally selected for control mkix are shown in table 3. The constant water- cement ratio adopted was 0.43.

Table 3: Detail of Mix Used As Per Is: 10262:2009

Mix	M35	
Water (Kg/m³)	165	0.43
Cement (Kg/m³)	385	1
Fine aggregates (Kg/m³)	719	1.86
Coarse aggregates (Kg/m³)	1149	2.98
Superplasticizer (Kg/m³)	1.925	0.005
Water cement ratio	0.43	-

5 RESULTS AND DISCUSSIONS

5.1 COMPRESSIVE STRENGTH TEST

The cubical specimens of size (150x150x150mm) were used for determining the compressive strength at moist curing ages of 7 and 28 days and tested immediately after removal from water and wiping off the surface water. The specimens were tested as per IS: 516-2008 on 100 tonne capacity compression testing machine. The results obtained are shown in table 4. From the table 4 and fig. 1 it can be seen that with increase in dosage of fly ash the compressive strength decreased at different ages. But with addition of dosage of alccofine the strength started increasing considerably as can be seen in mixes above M4. It can be seen from figure 2 and figure 3 that the mix which had higher dosage of fly ash did not show increase in strength in spite of addition of alccofine. The mix M10 which contained 10% fly ash and 10% alccofine showed better results among all mixes due to alccofine's unique chemistry and ultra fine particle size alccofine is very effective in improving the strength of concrete as shown in fig 4.

5.2 SHRINKAGE

The drying shrinkage was tested in the laboratory for the beam of size 75x75x300mm, which was measured with the help of digital vernier calliper of least count 0.001mm. The steel bars were embedded in the beam at the distance of 150mm to measure the shrinkage. Demoulding of specimen was done after 1 day and then moist curing was done for 6 days. Then specimens were stored in laboratory environment for rest of the days and readings were recorded at 7 and 28 days. The results obtained for various mixes are shown in table 5. It can be seen from this table that there is gradual decrease in shrinkage with increase in dosage of fly ash. With addition of alccofine along with fly ash further reduction in shrinkage was observed.

5.3 DENSITY

The density of cubes cast is found out by weighing them before testing for compressive strength test at 7 and 28 days each. The results obtained are shown in table 6.

Table 4: Test results of compressive strength at moist curing days of 7 and 28 days.

Sr No.	Mix	% replacement by Fly ash	% replacement by Alccofine	Compressive strength (N/mm^2)	
				7 Days	28 Days
1	M0	0	0	31.03	43.51
2	M1	20	0	21.06	34.00
3	M2	30	0	16.93	33.51
4	M3	40	0	12.28	25.58
5	M4	15	5	26.28	41.27
6	M5	25	5	20.07	37.14
7	M6	35	5	14.20	24.8
8	M7	12.5	7.5	23.14	39.70
9	M8	22.5	7.5	22.63	38.75
10	M9	32.5	7.5	18.75	29.30
11	M10	10	10	28.76	44.44
12	M11	20	10	20.93	36.4
13	M12	30	10	19.21	32.0

Table 5: Test results of shrinkage at moist curing days of 7 and 28 days.

Sr No.	Mix	% replacement by Fly ash	% replacement by Alccofine	Shrinkage ($x10^{-3}$)mm	
				7 Days	28 Days
1	M0	0	0	3.55	4.09
2	M1	20	0	3.49	3.98
3	M2	30	0	3.38	3.88
4	M3	40	0	3.20	3.58
5	M4	15	5	3.16	3.65
6	M5	25	5	3.09	3.47
7	M6	35	5	3.01	3.41
8	M7	12.5	7.5	2.88	3.45
9	M8	22.5	7.5	2.81	3.39
10	M9	32.5	7.5	2.79	3.32
11	M10	10	10	2.75	3.28
12	M11	20	10	2.62	3.21
13	M12	30	10	2.50	3.16

Table 6: Test results of density at moist curing days of 7 and 28 days.

Sr No.	Mix	% replacement by Fly ash	% replacement by Alccofine	Density (kN/m^3)	
				7 Days	28 Days
1	M0	0	0	24.71	24.55
2	M1	20	0	24.04	24.32
3	M2	30	0	25.03	24.87
4	M3	40	0	23.57	24.01
5	M4	15	5	24.29	23.99
6	M5	25	5	23.40	23.57
7	M6	35	5	24.19	24.32
8	M7	12.5	7.5	24.47	24.66
9	M8	22.5	7.5	23.25	23.51
10	M9	32.5	7.5	24.07	23.98
11	M10	10	10	24.00	23.81
12	M11	20	10	23.59	23.66
13	M12	30	10	23.71	23.91

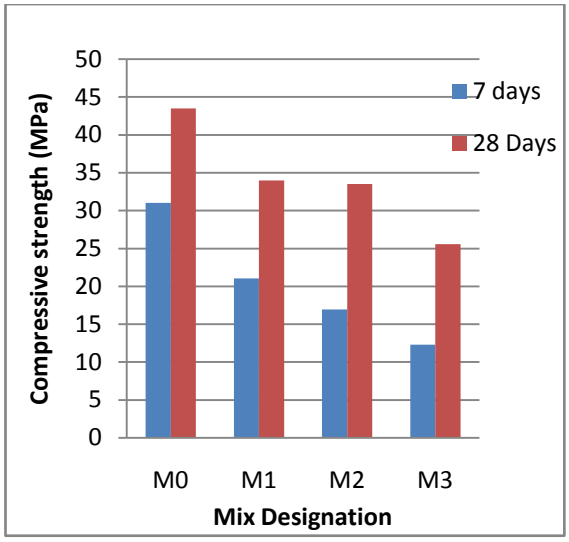

Fig1: Comparison of compressive strength of M0 to M3 mixes at 7days and 28 days. (0% replacement with alccofine)

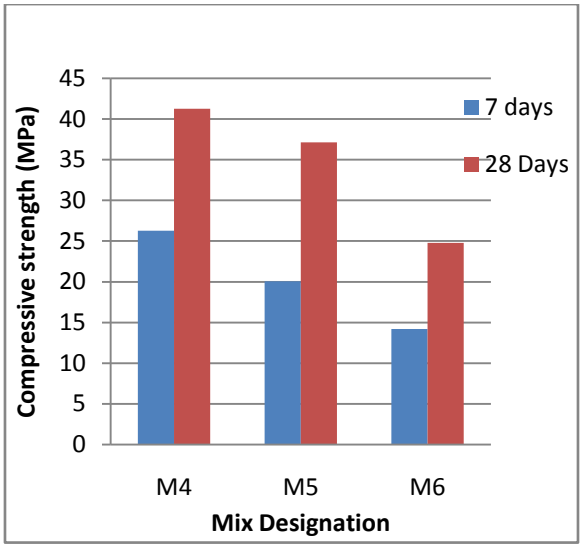

Fig 2: Comparison of compressive strength of M4 to M6 mixes at 7days and 28 days. (5% replacement with alccofine)

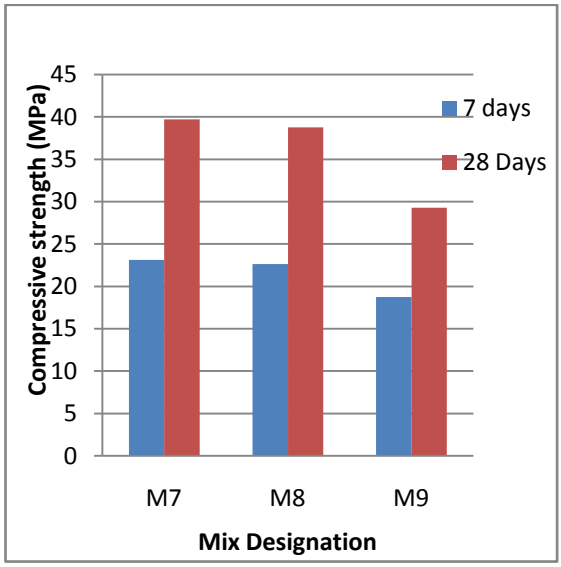

Fig 3: Comparison of compressive strength of M7 to M9 mixes at 7days and 28 days. (7.5% replacement with alccofine)

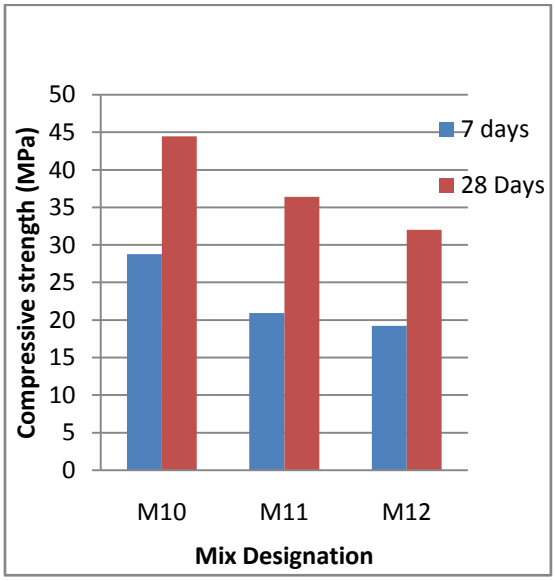

Fig 4: Comparison of compressive strength of M10 to M12 mixes at 7days and 28 days. (10% replacement with alccofine)

6. CONCLUSIONS:

On the basis of the results obtained in the present study, the following conclusions can be drawn.

1. Replacements of cement by fly ash in varying percentages of 20%, 30% and 40% and tested at 7 and 28 days showed that with addition of fly ash compressive strength of mixes decreased. Maximum decrease of 60 % was recorded at replacement level of fly ash by 40%. However, the percentage decrease in strength at 28 days was observed to be less as compared to decrease in strength at 7 days. This is due to the fact that Fly ash substitution generally results in favorable outcomes especially at later ages.

2. The replacement of fly ash by alccofine in varying percentages (5%, 7.5% and 10%) resulted in increase in compressive strength of the mixes for all replacement levels. The maximum increase in strength of 22 % was recorded for mix containing 10% fly ash and 10% alccofine.
3. With addition of fly ash shrinkage of mixes decreased. Maximum decrease was recorded at replacement level of fly ash by 40%. However, the percentage decrease in shrinkage at 28 days was observed to be less as compared to decrease in shrinkage at 7 days.
4. The replacement of fly ash by alccofine in varying percentages (5%, 7.5% and 10%) resulted in decrease in shrinkage of the mixes for all replacement levels. The maximum decrease in shrinkage was recorded for mix containing 30% fly ash and 10% alccofine.

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