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A STUDY ON THE EFFICIENCY OF CURING COMPOUNDS IN FLY ASH BASED CONCRETE

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ABSTRACT

In the present study, replacement of fly ash with cement has been studied with cement at 10%, 20%, 30%, 40% and 50%. In this paper the effect of fly ash on workability, compressive strength and modulus of elasticity were studied. This study was also conducted to evaluate the compressive strength of concrete with different fly ash contents with different curing methods. The mix design was arrived for M30 concrete with w/c ratio of 0.4 and the super plasticizer was added for obtaining the required workability in the fly ash based concrete. The optimum compressive strength is to be finalized for preceding the work with adding internal and external curing compounds for determining the efficiency of curing compounds on fly ash based concrete. For the internal curing classic acryfix BS and for external curing cure c water based curing compounds were used in this study. These test were carried out to evaluate the mechanical properties at the age of 28, 56 days. The regression analysis was carried out and formulate regression equation for conventional and fly ash based concrete using origin pro software.

Keywords*: Fly ash, Compressive strength, Super plasticizer, Curing compounds.*

I. INTRODUCTION

In the view of global warming efforts are on to reduce the emission of CO2 to the environment. Cement Industry is major in contributor in the emission of CO2 as well as using up high levels of energy resources in the production of cement. By replacing cement with a material of pozzolanic characteristic, such as the fly ash, the cement and the concrete industry together can meet the growing demand in the construction industry as well as help in reducing the environmental pollution. India is a resourceful country for fly ash generation with an annual output of over 110 million tones, but utilization is still below 20% in spite of quantum jump in last three to four years. Availability of consistent quality fly ash across the country and awareness of positive effect of using fly ash in concrete are pre requisite for change of perception of fly ash from a waste material to a resource material. Technological efforts have been made to improve the quality of fly ash. At present most of the power plants are using Electro Static Precipitators (ESP) through which fly ash is collected in different chambers according to its particle size. Hence uniform good quality of fly ash can be collected from these power plants.And also covers the curing, types of curing and the uses of curing compounds with their advantages and disadvantages. The internal curing benefits and how the internal curing is used to improve the concrete properties are listed in the detailed manner.Internal curing can make up for some of the deficiencies of external curing, both human related and hydration related with in critical curing period between 12 to 72 hours because hydration products clog the passageways needed for the fluid curing water to travel to the cement particles thirsting for water.

II. METHOD & MATERIAL

The aim of the thesis was to determine the compressive strength, Flexural strength, Modulus of elasticity, and Rapid chloride penetration tests. The mix proportion was casted and cured. The specimens are tested to find compressive strength, Flexural strength, Modulus of elasticity, and Rapid chloride penetration tests for various mixes with various curing. And this chapter deals with the results obtained for compressive strength, Flexural strength, E for concrete, RCPT testes for different mixes with different curing periods by using different curing compounds.

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Cement
Cement with OPC 53 grade was used with confirming IS 12269-2013 specification with the specific gravity of cement is 3.03.

Fly Ash
The fly ash has the specific gravity of 2.25 with the source at NLC Lignite Corporation with confirming IS 3812-1981 codal provision.

Fine Aggregate
River sand is used as fine aggregate and specific gravity is 2.63and the zone of aggregates was zone III with confirming IS 383-1970 specification. The fineness modulus of fine aggregate is 2.31.

Coarse aggregate
The coarse aggregate used was crushed angular aggregate with 20 mm aggregates having specific gravity of 2.78with confirming IS 383-1970 specification. The fineness modulus of coarse aggregate was calculated as 6.80.

Water
Ordinary tap water is used for casting and conventional curing.

Super Plastizer
Super plastizer of conplast 430 was used in this study with the specific gravity of 1.23.

Curing compounds
For external curing the brand cure c was used and for the internal curing classic acryfix BS was used for curing purposes. The specific gravity of internal curing compound classic acryfix BS is 1.015 ± 0.005 and the pH value is 7 ± 0.5. And the specific gravity of external curing compound classic cure c was 1.100 ± 0.01 at 27ºC.

III. TRIAL MIX FOR CONVENTIONAL CONCRETE AND FLY ASH CONCRETE

Table 1 Trial mixes for Conventional Concrete

Trial mixes	Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	w/c Ratio	Water ($liters/m^3$)	SP (kg/m^3)	Slump
Mix 1	480	581.230	1156.480	0.4	192	Nil	0
Mix 2	384	690.112	1458.944	0.4	153.6	2.87	25
Mix 3	**432**	**645.718**	**1213.414**	**0.4**	**172.8**	**2.16**	**62**

Table 2 Trial mixes for Fly ash concrete

Trial mixes	Cement (kg/m^3)	Fly ash (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	SP (kg/m^3)	Slump
Mix 1	389.951	32.175	645.718	1213.414	2.160	62
Mix 2	346.632	64.350	645.718	1213.414	3.240	63

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Mix 3	303.303	96.525	645.718	1213.414	4.320	68
Mix 4	259.974	128.700	645.718	1213.414	5.400	69
Mix 5	216.645	160.875	645.718	1213.414	6.479	70

The specimen 150 x 150 x 150 mm cube specimen is used for casting. And the trial mixes were cured with the normal curing using curing tank and the test were carried out in compression testing machine and the readings were tabulated in table 4.2 to table 4.4. The mix designation CCN is the Conventional concrete in normal curing.

Table 3 Compressive strength for conventional concrete at 7 days

S. No	Mixes	Wt. of cube (kg)	Compressive load ($x10^3$) (N)	Compressive strength (N/mm2)
1	CCN	8.729	692	30.756
2	CCN	8.566	725	32.222
3	CCN	8.687	734	32.622

Table 4 Compressive Strength for Conventional Concrete at 28 days

S.N o	Mixes	Wt. of cube (kg)	Compressive load ($x10^3$) (N)	Compressive strength (N/mm2)
1	CCN	8.817	826	36.711
2	CCN	8.778	853	37.911
3	CCN	8.683	880	39.111

Table 5 Compressive Strength for Conventional Concrete at 56 days

S. No	Mixes	Wt. of cube (kg)	Compressive load ($x10^3$) (N)	Compressive strength (N/mm2)
1	CCN	8.725	858	38.133
2	CCN	8.568	866	38.489
3	CCN	8.256	877	38.978

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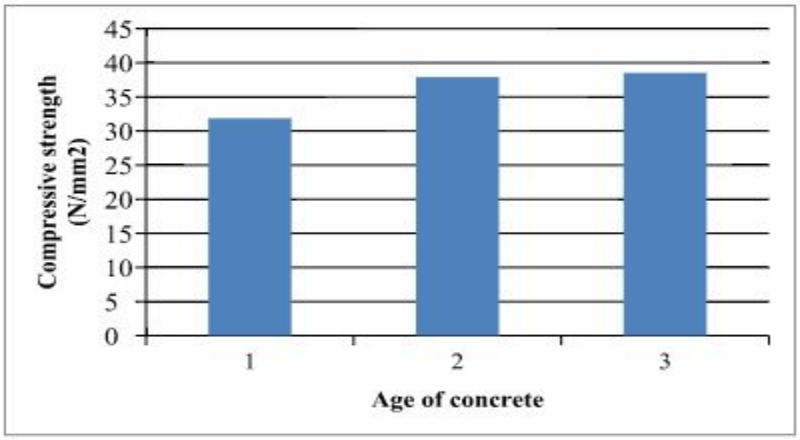

Fig. 1 Compressive strength for conventional concrete with normal curing

Compressive Strength for Conventional Concrete with External Curing

The conventional concrete mix proportions had taken for casting and the curing is done by using external curing compound cure and applying the external curing through spraying at the surface of the concrete cubes at once in a day up to the testing date arises. The compressive strength for the conventional concrete with external curing at 7 days, 28 days and 56 days is tabulated in the table 4.5 to table 4.7. The mix designation CCE is the Conventional concrete in external curing.

Table 6 Compressive Strength for Conventional Concrete with External Curing Compound at 7days

S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	CCE	8.172	511	22.711
2	CCE	8.170	527	23.422
3	CCE	8.165	530	23.556

Table 7 Compressive Strength for Conventional Concrete with External Curing Compound at 28days

S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	CCE	8.688	529	23.511
2	CCE	8.731	533	24.578
3	CCE	8.914	564	25.067

Table 8 Compressive Strength for Conventional Concrete with external curing compound at 56 days

S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	CCE	8.825	603	27.022
2	CCE	8.986	583	25.911
3	CCE	8.873	599	26.622

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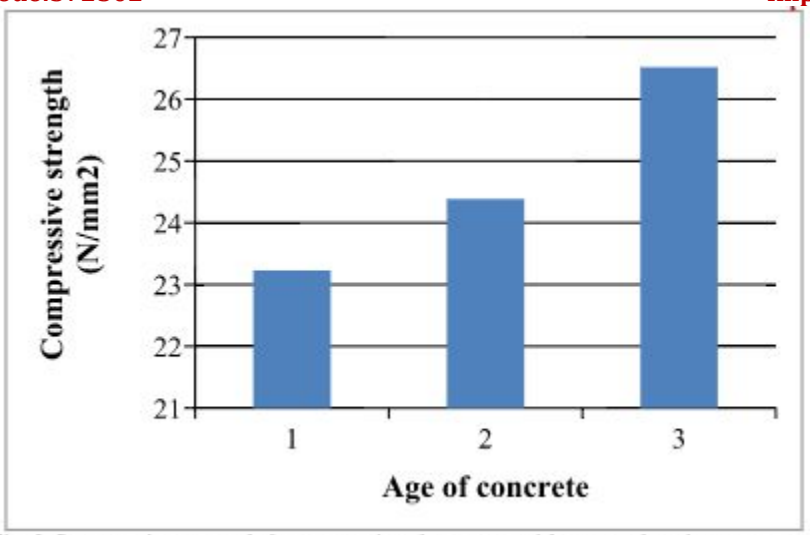

Fig. 2 Compressive strength for conventional concrete with external curing compound

Compressive Strength for Conventional Concrete with Internal Curing

The conventional concrete mix proportions had taken for casting and the curing is done by using internal curing compound. The internal curing compound classic acryfix BS is used for the curing purpose with the specific gravity of 1.015 ± 0.005 and it is replaced with the water, with the dosage of half of the weight of the cement is taken while casting of the concrete. The compressive strength of conventional concrete with internal curing at 7 days, 28 days and 56 days is tabulated in the table 4.8 to table 4.10. The mix designation CCI is the Conventional concrete in internal curing.

Table 9 Compressive Strength for Conventional Concrete with Internal Curing Compound at 7 days

S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	CCI	8.684	100	4.444
2	CCI	8.659	111	4.933
3	CCI	8.613	117	5.200

Table 10 Conventional Concrete Compressive Strength for Conventional Concrete with Internal Curing Compound at 28 days

S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	CCI	8.398	138	6.133
2	CCI	8.683	146	6.489
3	CCI	8.791	161	7.156

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Table 11 Compressive Strength for Conventional Concrete with internal curing compound at 56 days

S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	CCI	8.917	165	7.333
2	CCI	8.652	169	7.511
3	CCI	8.749	174	7.733

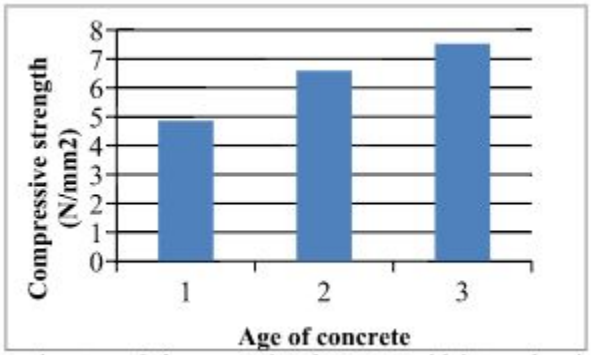

Fig. 3 Compressive strength for conventional concrete with internal curing compound

Table 12 Compressive strength for trial mix 1

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 1 10% fly ash	1	FAN	8.549	644	28.622
	2	FAN	8.433	604	26.844
	3	FAN	8.427	601	26.311

Table 13 Compressive strength for trial mix 2

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 2 20% fly ash	1	FAN	8.495	562	24.978
	2	FAN	8.475	558	24.800
	3	FAN	8.451	539	23.400

Table 14 Compressive strength for trial mix 3

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 3 30% fly ash	1	FAN	8.585	526	23.378
	2	FAN	8.315	512	22.756
	3	FAN	8.156	503	22.133

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Table 15 Compressive strength for trial mix 4

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 4 40% fly ash	1	FAN	8.015	436	19.378
	2	FAN	8.009	431	19.156
	3	FAN	7.992	416	18.622

Table 16 Compressive strength for trial mix 5

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 5 50% fly ash	1	FAN	7.766	151	6.711
	2	FAN	7.671	121	5.378
	3	FAN	7.627	117	4.975

Here the trial mix 1 is optimized because of the high strength while comparing to the other trial mixes. So the replacement of fly ash 10% with cement is finalized and the casting is done to find the compressive strength for 28 and 56 days. And the compressive strength is tested using the compression testing machine and tabulated in the table 4.17 and 4.18. Figure 4.5 shows the variation of the compressive strength for fly ash concrete with normal curing.

Table 17 Compressive Strength for Fly ash based Concrete at 28 days

S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	FAN	8.751	748	32.244
2	FAN	8.633	718	31.911
3	FAN	8.614	726	32.267

Table 18 Compressive Strength for Fly ash Concrete at 56 days

S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	FAN	8.717	725	32.222
2	FAN	8.840	752	33.422
3	FAN	8.692	764	33.956

Compressive Strength for Fly Ash Concrete with External Curing

The fly ash concrete is taken with the same mix proportion and casted. With that the external curing compound cure c is sprayed about 7, 28 and 56 days for curing the concrete. And the compressive strength for fly ash concrete with external curing compound at 7 days readings are tabulated in the table 4.19 to table 4.23. The mix designation FAE is the fly ash concrete in external curing.

Table 19 Compressive strength for trial mix 1

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 1 10% fly ash	1	FAE	8.084	437	19.422
	2	FAE	8.127	463	20.844
	3	FAE	8.151	490	21.778

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Table 20 Compressive strength for trial mix 2

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 2 20% fly ash	1	FAE	8.069	400	17.778
	2	FAE	8.116	447	18.622
	3	FAE	8.367	461	20.489

Table 21 Compressive strength for trial mix 3

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 3 30% fly ash	1	FAE	8.043	368	16.356
	2	FAE	8.178	391	17.200
	3	FAE	8.202	402	17.867

Table 22 Compressive strength for trial mix 4

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 4 40% fly ash	1	FAE	8.037	328	14.578
	2	FAE	8.061	337	14.756
	3	FAE	8.074	348	15.467

Table 23 Compressive strength for trial mix 5

Mix designation	S. No	Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
Mix 5 50% fly ash	1	FAE	7.857	85	3.778
	2	FAE	8.004	95	4.133
	3	FAE	8.021	108	4.800

The trial mix 1 is finalized for the further progress of casting and curing with external curing compound to get 28 and 56 days of compressive strength. The values are tabulated in table 24 and 25 as follows.

Table 24 Compressive Strength for Fly Ash based Concrete with External Curing Compound at 28 days

Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	FAE	504	22.400
2	FAE	521	23.156
3	FAE	530	23.556

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Table 25 Compressive Strength for Fly ash Concrete with external curing compound at 56 days

Mixes	Wt. of cube (kg)	Compressive load (x10^3) (N)	Compressive strength (N/mm2)
1	FAE	618	27.467
2	FAE	587	26.089
3	FAE	595	26.444

IV. CONCLUSION

From the experimental investigations the following conclusions were drawn.

- The compressive strength of cubes for conventional concrete with normal curing at 7, 28 and 56 days was 31.867, 37.911 and 38.533 N/mm2.
- The compressive strength of cubes for conventional concrete with external curing at 7, 28 and 56 days was 23.229, 24.385 and 26.518 N/mm2.
- The compressive strength of cubes for conventional concrete with internal curing at 7, 28 and 56 days was 4.859, 6.593 and 7.526 N/mm2.
- While comparing conventional concrete normal curing with conventional concrete external curing the compressive strength gets reduced about 27% at 7 days and 35% at 28 days and 31% at 56 days respectively for cubes.
- And while comparing conventional concrete normal curing with conventional concrete internal curing the compressive strength gets reduced about 84% at 7 days and 82% at 28 days and 80% at 56 days for cubes.
- By comparing fly ash based concrete normal curing with fly ash based concrete external curing the compressive strength gets reduced about 26% at 7 days and 28% at 28 days and 19% at 56 days respectively for cubes.
- In the comparison fly ash based concrete normal curing with fly ash based concrete internal curing the compressive strength gets reduced about 84% at 7 days and 85% at 28 days and 82% at 56 days respectively for cubes.
- While comparing conventional concrete normal curing with conventional concrete external curing the flexural strength gets reduced about 31% at 28 days for prism.
- While comparing conventional concrete normal curing with conventional concrete internal curing the flexural strength gets reduced about 53% at 28 days for prism.
- Then while comparing fly ash based concrete normal curing with fly ash based concrete external curing the flexural strength gets reduced about 34% at 28 days for prism.
- And while comparing fly ash based concrete normal curing with fly ash based concrete internal curing the flexural strength gets reduced about 42% at 28 days for prism.
- While comparing conventional concrete normal curing with conventional concrete external curing the experimental and theoretical value of modulus of elasticity gets reduced about 17% and 19% respectively at 28 days.
- While comparing conventional concrete normal curing with conventional concrete internal curing the experimental and theoretical value of modulus of elasticity gets reduced about 35% and 58% at 28 days.
- While comparing fly ash based concrete normal curing with fly ash based concrete external curing the experimental and theoretical value of modulus of elasticity gets reduced about 12% and 15% respectively at 28 days.
- While comparing fly ash based concrete normal curing with fly ash based concrete internal curing the experimental and theoretical value of modulus of elasticity gets reduced about 67% and 62% at 28 days.
- The compressive strength of cubes for fly ash based concrete of 10% replacement with cement in normal curing at 7, 28 and 56 days was 27.259, 32.141 and 33.200 N/mm2.
- The compressive strength of cubes for fly ash based concrete of 10% replacement the cement in external curing at 7, 28 and 56 days was 20.681, 23.037 and 26.667 N/mm2.

- The compressive strength of cubes for fly ash based concrete of 10% replacement with cement in normal curing at 7, 28 and 56 days was 27.259, 32.141 and 33.200 N/mm2.
- The compressive strength of cubes for fly ash based concrete of 10% replacement with cement in normal curing at 7, 28 and 56 days was 4.237, 4.622 and 5.911 N/mm2.

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