International Journal of Engineering Research
Volume No.5, Issue Special 1 pp : 60-62
ISSN:2319-6890(online),2347-5013(print)
8 & 9 Jan 2016

Cement Replacement by Fly Ash in Concrete

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Abstract: The potential for using fly ash as a supplementary cementitious material in concrete has been known almost since the start of the last century. Historically, fly ash has been used in concrete at levels ranging from 15% to 25% by mass of the cementitious material component. The actual amount used varies widely depending on the application, the properties of the fly ash, specification limits, and the geographic location and climate. There has been lot of research took place over using fly ash as additive in cement, admixture in concrete and cement replacement material in concrete. But most of the research has been limited to few percentages of cement replacement for concrete of fewer grades. An experimentation program is carried out to see the effect of fly-ash on compressive strength of different high grades concrete for different proportions of fly ash and different curing periods. Different grades of concrete mixes with varying percentage of fly ash content were prepared and the effects of fly ash on mechanical properties of fresh and hardened concrete have been investigated. The compressive strength of concrete was measured for 7, 28 and 45 days and compaction factor is taken as a measure of workability. A different comparative study is done consisting of rate and strength as parameters.Compressive strength of concrete at different proportions of cement being replaced by fly ash has been checked and results have been found effective and applicable. Hence, a comparative study is done and use of fly ash as a cement replacement in concrete can be analyzed and compared. The paper aims to study the effects of Fly ash as partial replacement of cement in concrete and ascertain the optimum proportion of fly ash for different grades of concrete which is acceptable, applicable and economical. This paper studies the variation in compressive strength of different grades of concrete at different percentages of fly ash and at different curing periods.

Keywords: ***Fly-ash, Additive, Admixture, Compaction factor***

I. Introduction

There has been a lot of research over using fly ash as additive in cement, admixture in concrete and cement replacement material in concrete. Compressive strength of concrete at different proportions of cement being replaced by fly ash has been checked and results have been found effective and applicable. But most of the research has been limited to few percentages of cement replacement or less grades of concrete. Hence, there borne a need to carry out an extensive research on compressive strength of different grades of concrete, different proportions of fly ash and different curing periods. Hence, a comparative study can be done and use of fly ash as a cement replacement in concrete can be analyzed and compared through various methods.

II. Methodology

Following materials were used in the experimental work:

Cement: Ordinary Portland cement (Ultra-Tech Cements of 53 grades) was used having specific gravity: 3.15, 32.5% Consistency and Compressive strength 54 MPa

Fly ash: Fly ash is finely divided residue resulting from the combustion of pulverized coal and transported by the flue gases of boilers by pulverized coal. It was obtained from thermal power station, dried and used.

Fine Aggregate: Natural sand with maximum size of 4.75 mm was used (zone II) with specific gravity 2.6 and fineness modulus 2.63.

Coarse Aggregate: Natural aggregates with maximum size of 40 mm were used with specific gravity of 2.7 and fine modulus 7.51.

Water: Drinking water from Walchand College of Engineering, Sangli was used for the preparation of concrete. The water samples are potable and of uniform quality.

The concrete mix was designed for M30, M40 and M50 grade and the mix design was done as per IS 10262-1982 and IS 456-2000. Mix design for concrete was made considering the properties of constituents of concrete. Different concrete mixes with varying fly ash content percentage were produced, replacing 0% (reference concrete), 10%, 20%, 30%, 40%, 50% and 60% cement in terms of weight. Cubic specimens of 150 mm size were casted for compressive strength test. The cubes were casted in stainless steel moulds and wet cured at standard temperature until the time of test. The cubes were cured for a time period of 7, 28 and 45 days.

III. Results and Tables

Figures 1 to 7 explain the variation in compressive strength of different mixes with respect to curing time for a particular percentage of fly ash. They show the behaviour of strength of concrete with time. Thus, it is observed that, increase in compressive strength with time is not same for all mixes. Some mixes have low early strength but achieve high strength

ISSN:2319-6890(online),2347-5013(print)
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later with time while some mixes have high early strength but achieve low strength at the end.

Table 1: Variation in Compressive Strength of Different Concrete Mixes for 7, 28 and 45 Days Curing and Different Percentages of Fly Ash.

% of fly ash	grade M30 compressive strength in N/mm²			grade M40 compressive strength in N/mm²			Grade M50 compressive strength in N/mm²		
	7	28	45	7	28	45	7	28	45
0	28.22	49.11	52.15	36.88	53.11	58.07	41.77	61	63.56
10	27.18	46.33	49.49	40.88	53.66	58.00	40.00	60.23	62.23
20	21.55	42.92	49.45	31.55	50.33	54.44	27.11	58.66	60.44
30	22.88	40.74	42.22	32.51	47.74	48.87	29.54	57.47	58.64
40	18.66	32.44	34.67	26.22	40.00	40.89	31.21	52.17	56.45
50	13.77	24.88	32.89	20.11	31.33	35.11	31.21	45.19	48.54
60	9.77	17.89	22.23	15.22	26.66	30.22	12.23	35.15	40.29

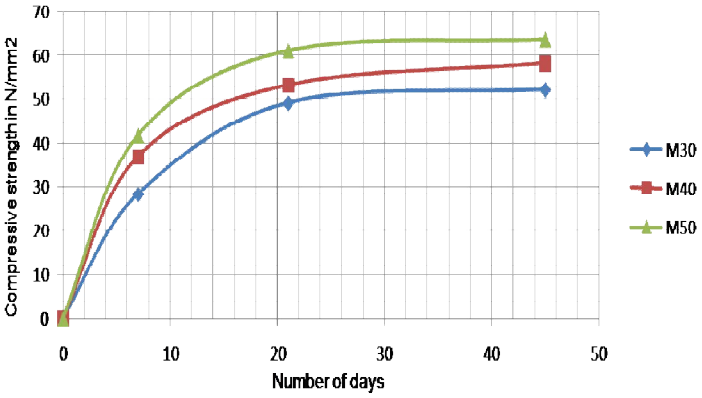

Figure 1: 0 % Fly Ash Replaced

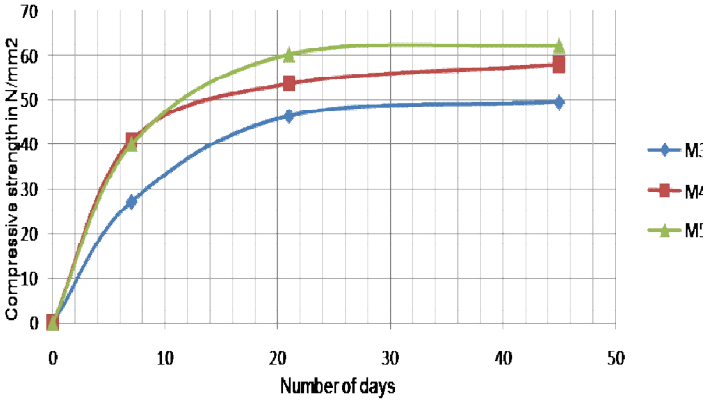

Figure 2: 10 % Fly Ash Replaced

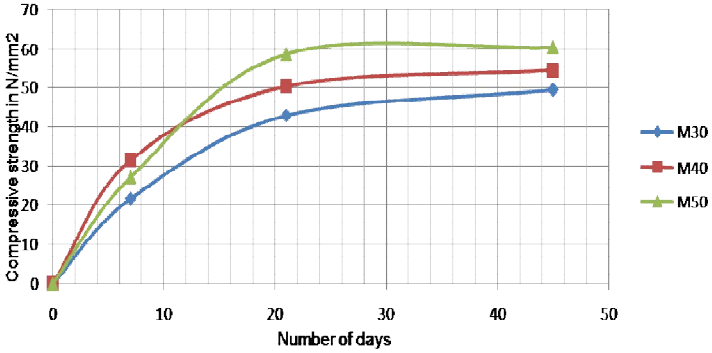

Figure 3: 20 % Fly Ash Replaced

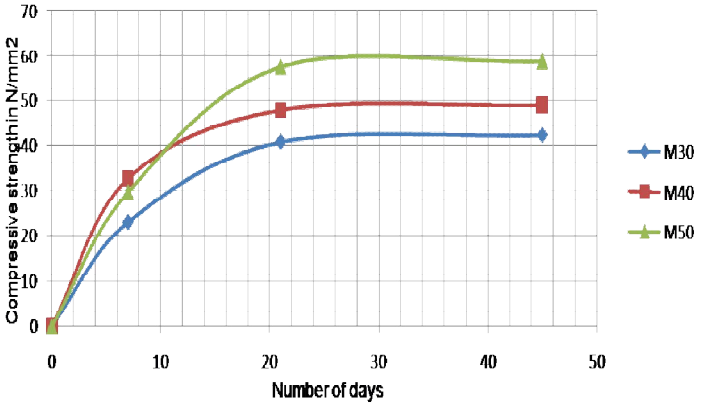

Figure 4: 30 % Fly Ash Replaced

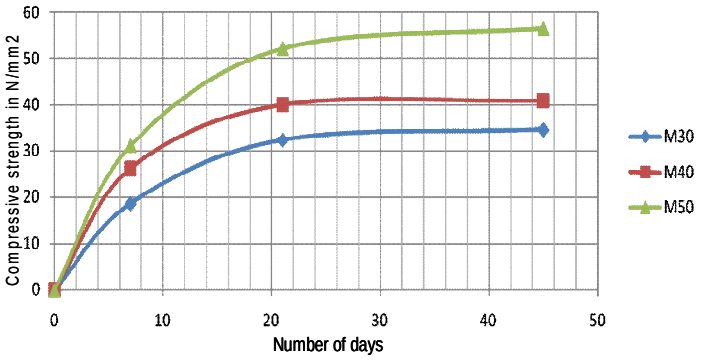

Figure 5: 40 % Fly Ash Replaced

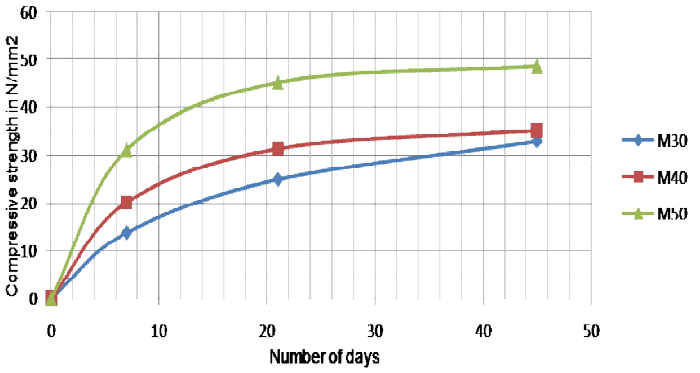

Figure 6: 50 % Fly Ash Replaced

doi : 10.17950/ijer/v5i1/014

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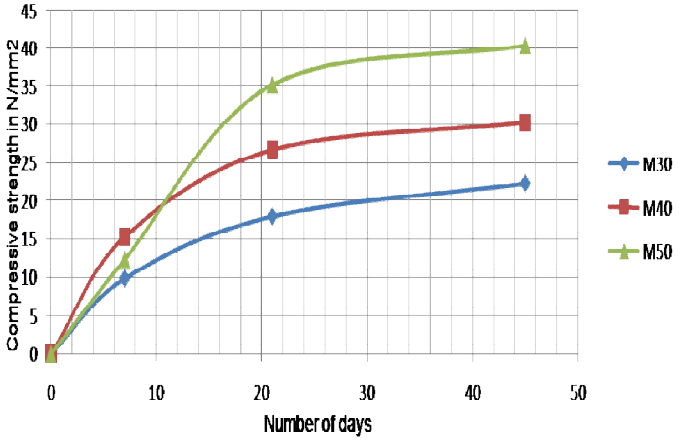

Figure 7: 60 % Fly Ash Replaced

Figure 8 explains the variation in rate of concrete of all mixes arranged in increasing order of compressive strength irrespective of fly ash proportion and types of mixes. Figure 8 is a very significant graph as rate of concrete is plotted against strength of concrete of all mixes and proportions. Figure 8 would be very useful for engineers and designers in choosing concrete mix out of the different fly ash proportions and different grades in order to have a most economic mix of particular strength.

For e.g. If concrete of 28 day compressive strength of around 30 to 35 N/mm^2 is to used, then the mix of strength 35.15 N/mm^2 (M50, 60% fly ash) gives more strength and economy than mix of strength 32.44 N/mm^2 (M30, 40% fly ash). Otherwise, M50 would have been selected considering that M30 is economical than M50. However, since percentage of fly ash and curing time comes into play, the compressive strength shows different behaviour. Hence, the graph shown in Figure 8 is very significant to choose an economic concrete mix of particular strength

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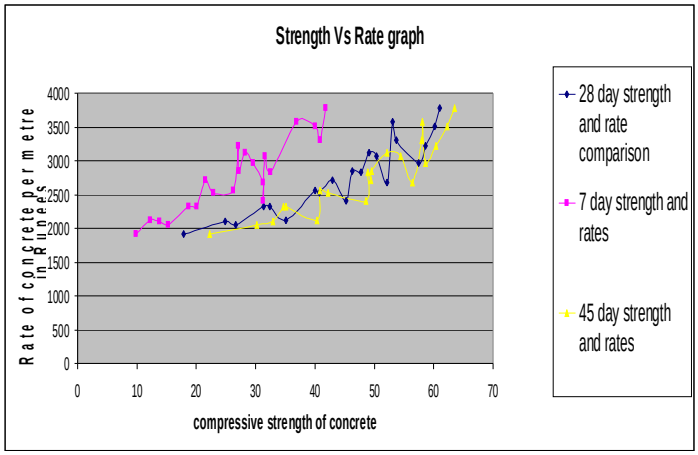

Figure 8: Compressive Strength Vs Rate of Concrete.

IV. Conclusion

1. The compressive strength of concrete mixes decrease with increase in fly ash. The fly ash can be replaced up to maximum of 40% and replacements above 40% may not be safe for different concrete mixes.
2. In general, with the increase of fly ash there is steep increase in strength from 7 to 28 days indicating that early strength of concrete is reduced with increase in fly ash. Also the variation in early strength is more than the variation in later strength. Thus, fly ash has an adverse effect on early strength of concrete.
3. Some mixes of higher strength can be economical than mix of lower strength which depends upon the percentage of fly ash and time of curing. Therefore, it is observed that the M50 with 60% fly ash gives more 28 day strength and is economical than M30 with 40% fly ash.

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