Performance of High Volume Fly Ash Concrete

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Abstract

Fly ash is a waste-by-product which gives a challenge to the environment. Concrete technologists utilized High Volume Fly Ash Concrete in their research. Replacement of cement with 55%, 65%, 75%, and 85% Fly ash was carried out to evaluate the compressive strength of concrete. The results show that the 55% gives the best value on compressive strength after 90 days of curing. On 55% and 65% replacement level Flexural Strength, Impact strength and Rapid chloride penetration test were carried out. The results revealed that the high volume fly ash shows better performance when compared with conventional concrete.
Keywords: Concrete, High Volume Fly Ash, Compressive strength, Acid, Durability

I. INTRODUCTION

Fly Ash is obtained from combustion of coal. Fly Ash produced by burning anthracite or bituminous coal is referred as class F Fly Ash. Fly Ash produced by burning lignite or sub-bituminous coal is referred as class C Fly Ash. There has been an increase in using High Volume Fly Ash Concrete in recent years and a number of papers have been published. There are two ways that the fly ash can be used in cement and concrete. One way is by blending with cement clinker and gypsum in the manufacturing plant of ordinary Portland cement. Alternatively, at the construction site fly ash can be added to ordinary Portland cement. The ash that is disposed from the plant causes pollution. High Volume Fly ash is generally defined as that with at least 50% of the Portland cement replaced with fly ash. It is necessary to use superplacticizer because of very low water content in High Volume Fly Ash concrete. Setting time is longer than conventional concrete because of low cement content and lower rate of reaction. Up to 80% replacement of cement with fly ash is investigated [1]. Alternatively, at the constructionsite fly ash can be added to Ordinary Portland Cement. Nath.P and Sarker.P [4] reported that the fly ash reduced the sorptivity of concrete in early age and it decreased further at six months. High volume fly ash can be used in concrete structures such as mat foundations, large retaining walls, piles, large columns and dams. This type of concrete has high modulus of elasticity values when compared with that of ordinary Portland cement concrete [6].

II. EXPERIMENTAL DETAILS

A. Materials used:

The following materials were used in the investigation.

1) Cement: Ordinary Portland cement (43 Grade) with specific gravity of 3.12 confirms to IS: 12269:1987
2) Fine Aggregate: River sand of specific gravity 2.66 confirms to Zone III as per IS: 2386 (Part I)
3) Coarse Aggregate: Crushed coarse aggregate of 20 mm size with specific gravity of 2.68
4) Water: Potable water for mixing and curing of the specimens
5) Fly Ash: Class F fly ash obtained from Ennore Thermal Power Plant in Chennai with specific gravity of 2.21as per IS: 1727:1967
6) Chemical Admixture: Poly carboxylic ether based superplacticizer is used

III. CONCRETE MIXTURES

In this investigation totally five mixtures were made. Four high volume fly ash concrete mixes were made by replacing cement with 55%, 65%, 75% and 85% fly ash and one without fly ash. The mixture proportions of the concretes are given in Table 1. The water-cement ratio is kept constant for all mixes. Conventional concrete had cement content of 465 kg/m^3 and water-cement ratio of 0.40. The mixtures were made in a laboratory mixer machine.

Table – 1
Mixture proportions

Mix No	*Water-cement ratio*	*Quantities in kg/m^3*					
		Cement	*Fly Ash*	*Water*	*Coarse Aggregate*	*Fine Aggregate*	*Chemical Admixture*
CC	*0.40*	*465*	*-*	*186*	*1069*	*707*	*-*
HV55	*0.40*	*163*	*200*	*132*	*1277*	*653*	*3.63*
HV65	*0.40*	*127*	*236*	*132*	*1270*	*649*	*3.63*
HV75	*0.40*	*91*	*272*	*132*	*1259*	*644*	*3.63*
HV85	*0.40*	*55*	*308*	*132*	*1252*	*640*	*3.63*

IV. PREPARATION AND TESTING OF SPECIMENS

For compressive test cubes were cast with size of 150 mm x150 mm, 100 mm x50 mm cylinders were cast for rapid chloride penetration test, 200 mm x50 mm cylinders were cast for impact strength test and 50 mm x10 mm x10 mm prism were cast for flexural strength test. Compressive strength test at the ages of 7, 28, and 90 days were tested by using compressive testing machine. Flexural strength was tested by centre point loading at 28 days and 56 days. The rapid chloride permeability test is carried out at 28 and 56 days. Impact strength test was carried out at 28 and 56 days.

V. RESULTS AND DISCUSSIONS

The results of the tests conducted on the specimens are discussed below.
The results obtained show that the strength and many other properties of high volume fly ash concrete increases with time.

A. Compressive Strength:

Fig.1 shows the results obtained from the concrete cubes of 150 mm x 150 mm size. Compressive strength for specimens at 7 days, 28 days, 56 days, and 90 days are obtained. The results show that the compressive strength of high volume fly ash concrete at 28 days is lower when compared to the compressive strength of conventional concrete specimens. There is an increase of compressive strength to the specimens made of high volume fly ash concrete at 90 days of curing. Increase in compressive strength of high volume fly ash concrete is slower. At 90 days of curing, compressive strength of high volume fly ash concrete is higher than the conventional concrete. Cubes made of 55% replacement of cement with fly ash gives the best compressive strength value.

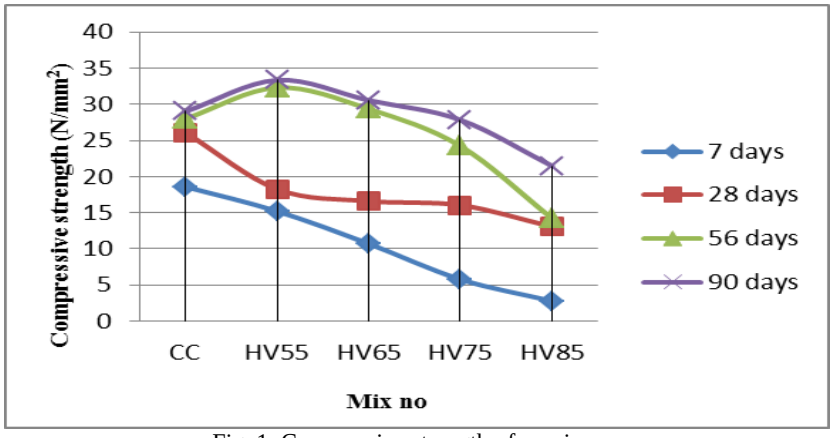

Fig. 1: Compressive strength of specimens

B. Flexure Strength:

Flexure strength test values are obtained at 28 days and 56 days of curing Table 2 shows the results obtained by centre point loading on prisms. Specimens made of 55% replacement of cement with fly ash concrete gives best values at 56 days of curing.

Table – 2
Flexure strength of concrete specimens

Mix No	*Specimen No*	*Flexural strength in N/mm^2*	
		28 days	*56 days*
CC	*1)*	*6*	*7*
	2)	*6*	*6*
HV55	*1)*	*4*	*8*
	2)	*4.5*	*8*
HV65	*1)*	*3*	*7*
	2)	*2.5*	*7*

C. Impact Strength:

Table 3 shows results obtained by impact strength on the specimens. Specimens made of 55% and 65% replacement of cement with fly ash shows good results when compared to conventional concrete at 56 days of curing.

Table – 3
Impact strength of concrete specimens

Mix No	*Sample No*	*Number of blows at 28 days of curing*		*Number of blows at 56 days of curing*	
		First visible crack	*Final failure*	*First visible crack*	*Final failure*
CC	*1)*	*85*	*87*	*91*	*95*
	2)	*84*	*85*	*92*	*94*
	3)	*85*	*87*	*90*	*94*
HV55	*1)*	*52*	*55*	*100*	*103*
	2)	*51*	*54*	*97*	*99*
	3)	*51*	*53*	*101*	*103*
HV65	*1)*	*45*	*46*	*96*	*98*
	2)	*43*	*44*	*97*	*99*
	3)	*42*	*44*	*94*	*97*

D. Rapid Chloride Permeability Test:

Table 4 shows results obtained by rapid chloride permeability test using RCPT apparatus. Chloride ion penetration is lower for the specimens of high volume fly ash concrete at later ages. This shows resistance of corrosion is higher for high volume fly ash concrete when compared to the specimens made of conventional concrete. Obada Kayali and Sharfuddin Ahmed.M [5] reported that the values of corrosion potentials and corrosion currents are less in high volume fly ash concrete up to 50% replacement.

Table – 4
Chloride ion penetration - charge passed in coulombs

Mix no	*28 days in Coulombs*	*56 days in Coulombs*
CC	*2568*	*2463*
HV55	*1046*	*704*
HV65	*1059*	*703*

VI. FURTHER RESEARCH

At 90 days of curing flexure strength test, impact strength test, and rapid chloride test has to be done to know its performances. Casting and testing of beams can be done for finding its bending properties with high volume fly ash concrete by two point loading method. This may show the ability of high volume fly ash concrete. Mahdi Arezoumandi and Jeffery S. Volz [3] reported that the beams made of high volume fly ash with 70% replacement of cement had higher shear capacity when compared with the beams made of Conventional Concrete and high volume fly ash with 50% replacement of cement beams tested in this investigation. Early-age and later-age compressive strength and durability properties can be improved by adding nano-CaCO3 as filler in High volume fly ash concrete [2].

VII. CONCLUSION

The long term compressive strength is higher than the conventional concrete which shows the quality of high volume fly ash concrete. Impact test shows good results. The optimum replacement level of cement with fly ash is 55%. Flexure strength test gives higher values for specimens with 55% replacement of cement with fly ash concrete. Chloride ion penetration is lower for high volume fly ash concrete which shows that it has greater resistance to corrosion.

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