IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
ISSN: 2278-1684 Volume 3, Issue 1 (Sep-Oct. 2012), PP 28-33
www.iosrjournals.org

Performance of High Volume Fly Ash in Concrete Structures

R. Thangaraj[1], R. Thenmozhi[2]
[1] *Dept of Civil Engg, CMS College of Engineering & Technology, Coimbatore – 641 032*
[2] *Dept of Civil Egg, Thanthai Periyar Govt, Institute of Technology, Vellore-638 002*

Abstract: *This paper presents the results of comparative study conducted to evaluate the strength properties of high volume flyash concrete(HVFAC) using a cement replacement level of 50%, 55% and 60% in M_{20} and M_{25} grades of concrete. In this investigation an attempt has been made to study the strength properties of HVFAC specimens in comparison with control OPC concrete specimens of same grade. It is observed that the compressive strength of HVFAC is improved by about 50% cement replacement by fly ash with 1.5% of plasticizer was equal to control concrete.*
Keywords: *Flyash, plasticizer, Compressive strength, Splitting Tensile strength, Flexural Strength*

I. Introduction

The fly ash has been used in concrete and identified such a product as Eco smart or green concrete. The HVFA concrete is one specific type of fly ash concrete with higher fly ash content that is above 50% with lower water cementitious material ratio (0.4) and lower cement contents. Fly ash used to improve the workability of fresh concrete to reduce the heat hydration, to improve economy, to decrease permeability, to increase durability and strength of concrete [1-3].

To produce workable concrete at such low water cementitious materials, the use of super plasticizer is most of the time is essential. The Civil Engineering community faces challenges to develop economic constructions materials with minimum environmental impacts. Portland cement concrete is a major construction material used in construction industry. In this investigation attempt has been made to search the effects of partial replacement of cement with fly ash, as it is a waste product. The properties of hardened concrete are studied by performing compressive strength, split tensile test and flexure test.

II. Materials Used

In order to study the properties of HVFA cement concrete, cubes, prism and cylinders were cast. Ordinary Portland Cement of 53 grade[4] of specific gravity 2.95, natural river sand with maximum size of 4.75 mm with specific gravity of 2.63 and fineness modulus 2.42 as per IS specifications, coarse aggregate of maximum size 20 mm of specific gravity 2.68 and fineness modulus of 6.90 were used. A water binder ratio of 0,4 and Class F Flyash[5] with a specific gravity of 2.37 for all mixes was maintained. The chemical composition of fly ash supplied by Mettur Thermal power plant is given in Table.1.

Table.1 Chemical properties of Fly ash

Oxide constitutions	Lime sludge	Fly ash	Fly ash after treatment
Sio_2	20.90	49 .00	60.00
Al_2o_3	10.70	18.40	21.90
Fe_2o_3	1.80	3.60	3.60
Cao	44.60	5.70	4.50
Mgo	1.00	1.00	1.10
LOI	21.00	22.30	8.90

Four different dosages of Super Plasticizer named Sulphonated Naphthalene Formaldehyde Condensate were tried in this investigation. The chemical admixture conplast Sp430 of specific gravity of 1.22-1.25 was used. Table-2 shows the properties of Plasticizer as mentioned by the manufacturer.

Table.2 Properties of Super Plasticizer (Conplast Sp 430)

Specific Gravity	1.22 – 1.25
Chloride Content	Nil
Recommended Dosage per 100 kg of cement	0.6 to 1.4 Litre
Approximate Additional Air Content at normal dosage	1%
Solid Content	40 %
Operating Temperature	10 to40 degree centigrade

III. Mix Design

Concrete grade M_{20} and M_{25} was proportioned by adopting I.S method of mix design[6]. The mix proportion arrived was 1:1.21:2.84 for M_{20} and 1 :1.16: 2.39 for M_{25} grade concrete respectively with a water binder ratio 0.4 by replacing 50%,55% and 60% of mass of cement concrete by fly ash. Concrete cube of size 150mmx150mmx150mm and cylinder 150mm in diameter and 300mm high were used for studying various properties like compressive strength, split tensile strength and flexural strength. All the test specimen were cast using steel moulds.

The test specimens were removed from the mould after 24hours and cured in water. The test specimens were divided into four series. Each series represents the addition of plasticizer 0%,1%,1.5% and 2% which consists of three groups made with partial replacement of cement by fly ash at 50%,55% and 60% respectively.

IV. Experimental Programme

Three specimen's represents same constituent materials were used for each test trough out this study and the average values were reported. The specimens were taken out of the curing tank one day prior to testing and kept outside to dry up the surface. The surface dried specimens were tested.

The compressive strength of concrete cube specimens was determined according to IS.516-1959 after 7,14,28,56, and 90 days of water curing [7]. The compressive load was applied in a compressive testing machine of 3000kN capacity, failure loads were recorded and the test results are shown in Table-3 for M_{20} grade HVFAC concrete and Table -5 for M_{25} grade HVFAC concrete.

Cylindrical concrete specimens were tested for split tensile strength according to IS standards after 28 days curing, the max diametrical load applied to specimen was recorded. Flexural strength determined according to IS standards using midpoint loading method utilizing 100x100x500mm prismatic concrete specimens after 28 days curing.

Similarly the splitting tensile strength (fsp) and flexural strength (ft) of HVFAC specimens at the age of 28 days is presented in Table-4 and 6. The results are compared with conventional concrete which further indicates the suitability for partial replacement of cement in concrete based construction.

V. Discussion on test results

High fly ash in concrete mix allows and lower water binder ratio and tends to an increase in compressive strength and rich in concrete mixes. Increase in substitutions of fly ash for OPC tends towards a reduction of compressive strength. The compressive strength of all the specimen is plotted in fig [1-8].

The compressive strength of specimens increased linearly with age and lagged behind OPC based concrete up to the age of 7 days due to delayed pazzolanic reactivity. This effective could be reached by aiming the higher 28 days strength.

Comparing all the series, it could be understand from the test results, better results could be achieved with 50% replacement of fly ash using 1.5% as dosage of plasticizer that is A1.5 specimens could reach the design strength. Also it has been observed that the strength is even more after 28 days and it indicates that the fly ash can be added as partial replacement for cement is concrete.

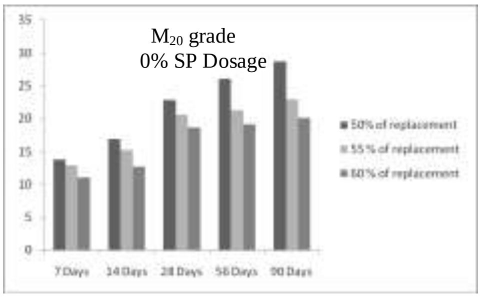

Fig.1 Effect of age and % replacement of cement on Compressive strength for 0% SP Dosage

Table.3 Strength Parameters Using Various Percentage Replacement of fly ash of M_{20} Grade Concrete

Cube ID	% of fly ash	Dosage of Plasti-cizer	Compressive Strength (MPa)				
			7 Days	14 Days	28 Days	56 Days	90 Days
A0	50	0	13.72	16.90	22.86	26.03	28.69
B0	55	0	12.90	15.20	20.54	21.23	22.87
C0	60	0	11.00	12.70	18.58	19.10	20.05

D	0	0	14.27	16.52	23.63	28.22	46.62
A1	50	1	13.82	16.01	21.90	26.13	27.97
B1	55	1	10.97	12.22	18.07	20.85	22.85
C1	60	1	6.85	8.04	12.69	13.65	14.36
A1.5	**50**	**1.5**	**15.00**	**17.60**	**22.90**	**27.00**	**29.76**
B1.5	55	1.5	10.35	12.00	16.57	19.10	21.27
C1.5	60	1.5	7.50	8.69	12.42	13.50	13.90
A2	50	2	11.76	13.91	19.05	21.95	25.20
B2	55	2	8.35	11.10	15.87	17.90	19.44
C2	60	2	6.00	6.79	11.80	12.10	12.48

Table.4 Splitting tensile strength (fsp) and flexural strength (ft) of HVFA Concrete Using Various Percentage Replacement of fly ash for

M_{20} Grade Concrete

Cube ID	% of flyash replaced	Dosage of plasticizer	f_{sp} (MPa)	f_t (MPa)
A0	50	0	5.70	3.96
B0	55	0	5.42	3.60
C0	60	0	-	-
D	0	0	5.65	3.65
A1	50	1	5.34	3.37
B1	55	1	5.10	3.19
C1	60	1	-	-
A1.5	**50**	**1.5**	**4.70**	**2.98**
B1.5	55	1.5	4.61	2.76
C1.5	60	1.5	-	-
A2	50	2	4.98	3.20
B2	55	2	4.82	3.02
C2	60	2	-	-

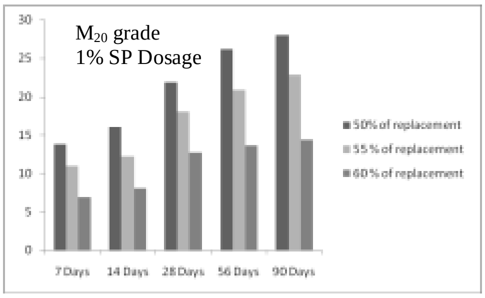

Fig.2 Effect of age and % replacement of cement on Compressive strength for 1% SP Dosage

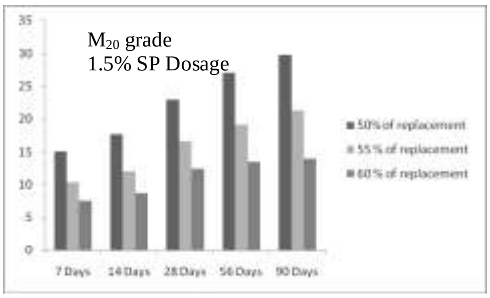

Fig.3 Effect of age and % replacement of cement on Compressive strength for 1.5% SP Dosage

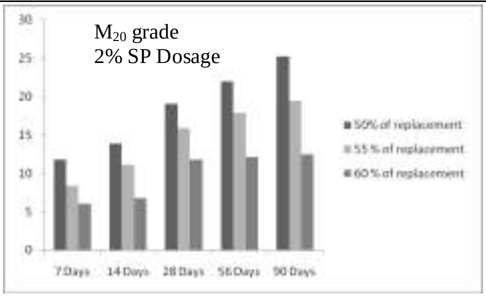

Fig.4 Effect of age and % replacement of cement on Compressive strength for 2% SP Dosage

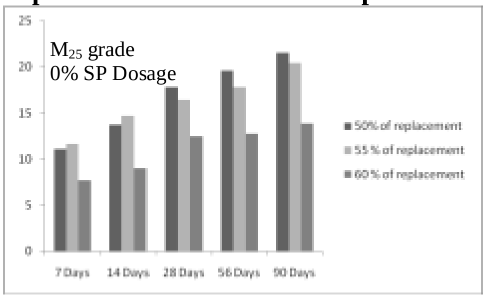

Fig.5 Effect of age and % replacement of cement on Compressive strength for 0% SP Dosage

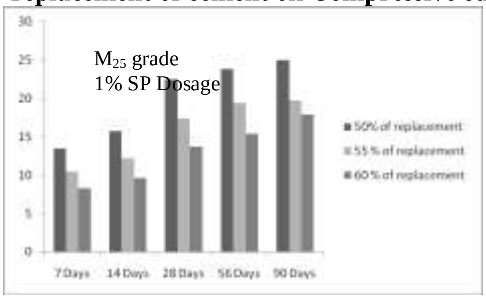

Fig.6 Effect of age and % replacement of cement on Compressive strength for 1% SP Dosage

Table.5 Strength parameters using various percentage replacement of fly ash of M$_{25}$ grade concrete

Cube ID	% of fly ash	Dosage of Plasti-cizer	Compressive Strength (MPa)				
			7 Days	14 Days	28 Days	56 Days	90 Days
A0	50	0	11.05	13.71	17.83	19.55	21.50
B0	55	0	11.64	14.67	16.45	17.80	20.40
C0	60	0	7.66	8.95	12.45	12.71	13.88
D	0	0	17.50	19.56	25.38	26.31	33.45
A1	50	1	13.46	15.70	22.44	23.80	24.97
B1	55	1	10.43	12.16	17.38	19.40	19.68
C1	60	1	8.30	9.59	13.70	15.37	17.90
A1.5	**50**	**1.5**	**14.53**	**17.95**	**24.22**	**25.20**	**25.94**
B1.5	55	1.5	10.66	12.00	16.88	18.60	19.10
C1.5	60	1.5	7.83	9.13	13.05	14.82	16.44
A2	50	2	11.85	13.95	19.85	21.35	23.44
B2	55	2	9.89	11.53	16.48	17.20	18.8
C2	60	2	7.10	8.30	11.82	13.24	14.88

Table.6 Splitting tensile strength (fsp) and flexural strength (ft) of HVFA Concrete Using Various Percentage Replacement of fly ash for M$_{25}$ Grade Concrete

Cube ID	% of flyash replaced	Dosage of plasticizer	f_{sp} (MPa)	f_t (MPa)
A0	50	0	2.70	1.85
B0	55	0	2.65	1.81
C0	60	0	-	-
D	0	0	2.80	1.91
A1	50	1	2.51	1.69
B1	55	1	2.24	1.51
C1	60	1	-	-
A1.5	**50**	**1.5**	**3.12**	**1.99**
B1.5	55	1.5	2.98	1.82
C1.5	60	1.5	-	-
A2	50	2	3.28	2.36
B2	55	2	3.05	2.52
C2	60	2	-	-

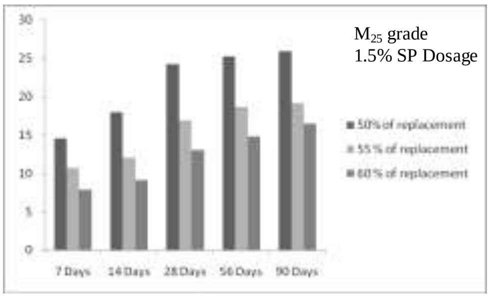

Fig.7 Effect of age and % replacement of cement on Compressive strength for 1.5% SP Dosage

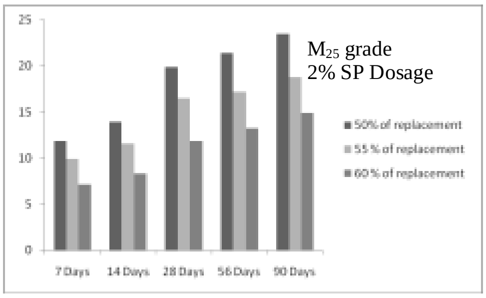

Fig.8 Effect of age and % replacement of cement on Compressive strength for 2% SP Dosage

VI. Conclusion

1) HVFAC mixtures are sustainable because they consume less Portland cement, large volume of an individual waste and produce a highly durable product.
2) The HVFAC offers a solution to the problem of meeting the increasing demands for concrete in the future in a sustainable manner and a reduce cost and at the same fine reducing the environmental impact.
3) The effective use of fly ash in concrete mix for present and future use minimizes the disposal of fly ash and free from pollution.
4) Superior environmental friendliness due to ecological disposal of large quantities of fly ash, reduced Co_2 emissions and enhancement of resource productivity of the concrete construction industry

VII. Acknowledgement

The present investigation was carried out at Structural Engineering Lab of Government College of Technology, Coimbatore. The authors would like to place on record wish to thank the Principal, Government College of Technology, Coimbatore and the authorities of the Civil Department for their assistance and infrastructure support for carrying out the research study.

References

[1] Dhir RK, Hubbard FH, Munday JGL, Jones MR, Duerden SL. Contribution of PFA to concrete workability and strength development. Cement Concrete Research 1988;18(2):277–89.
[2] Mark Reivier and Kevins Rens, high volume fly ash concrete; analysis and application, practice, periodical on structural design and construction @ ASCE, 2006.
[3] Ravina.D, Methta.P., "Properties of fresh concrete containing large amounts of fly ash" cement and concrete research, vol,16,PP227-238,1986.
[4] IS-12269-1987, "Specification for 53 grade OPC" BIS New Delhi.
[5] IS – 3812-1981, "Specification for fly ash for use as pozzolanic and admixture' BIS New Delhi.
[6] IS 10262:2009, "Concrete Mix Proportioning-Guidelines"
[7] IS:516 – 1959, Methods of tests for strength of concrete, edition 1.2(1991-07)