

Fly Ash as Supplementary Cementitious Material in Portland Pozzolana Cement Concrete

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Abstract

Fly ash is a byproduct obtained from industries where coal or lignite is burnt like thermal power plant, steel, sugar, fertilizer industries etc. The Fly Ash is a class of artificial pozzolans, and generally comes in the category of non-conventional building material. It is particularly designed and processed as part supplement of cement in concrete to achieve improved performance. This work describes the utilization of this supplementary material (Fly ash) which is easily available, in the growth of new materials and technologies. It is considered that this material can be used as a supplementary material as partial replacement of cement in the construction industry in different areas. In the present study PPC cement was replaced by fly ash accordingly in the range of 0 to 60 % by weight of PPC cement at water cement ratio 0.48 for M-25 mix. Concrete mixtures were produced, tested and compared in terms of compressive strength.

1. INTRODUCTION

In recent years the major problem which India is struggling is disposal of waste material from. Leaving the waste materials in open land directly affect the environment. These wastes can be used to produce new products so that natural resources are used more efficiently and the environment is protected from pollutants resulting from waste deposits. Fly ash is the

widely available mineral residue produced in the thermal power plants of India resulting from the combustion of ground or powdered coal. Fly ash is an advantageous mineral admixture for concrete. Hence it is emphasized to the reuse of waste material like fly ash. Over a period of last ten years, the image of fly ash has completely been changed from a “Polluting Waste” to “Resource Material” Vimal Kumar et al.(2005). Addition of fly ash in concrete upto 50% gave most significant improvement in workability and required a shorter vibration time. It is also reported that addition of fly ash in concrete improves the workability Berndt et al. (2009). Combination of Silica fume and fly ash makes the concrete more cohesive and dense, thus reduces the permeability. This makes the concrete more durable. There will be a good reduction in the cost of concrete by the usage of fly ash. Replacement of even PPC cement with fly ash is possible up to 30% was suggested by Patel and Charkha(2012). The effect of fly ash on concrete workability, compressive strength, splitting tensile strength and bond strength was investigated by several researchers. The ordinary Portland cement was replaced with 5 to 50% fly ash, it was observed that 10 % fly ash showed the highest compressive strength at all ages, use of 15%-30% fly ash significantly increased the compressive strength at 90 and 180 days Hussein et al (2013).

S N	Properties	Experimental	Codal requirement (IS 1489 (Pt-1)-1991)
1	Normal Consistency%	31.5%	
2	Initial setting time	165min	(Not less than 30 min)
3	Final setting time	215min	(Not more than 600 min)
4	Soundness of Cement (Le chatelier expansion)	0.75mm	(Not more than 10 mm)
5	Fineness of Cement (%age retained on 90 micron IS sieve)	3.77%	10%
6	Specific gravity of Cement	2.67	3.15
Compressive Strength			
7	3 Days	23.0	16.0 N/mm ² (min)
8	7 Days	33.0	22 N/mm ² (min)
9	28 Days	43.2	33 N/mm ²
10	Declared % of Fly ash	26.0	10.0-25.0(min-max) The homogeneity of the mixture shall be guaranteed Within ± 3 percent in the same consignment.

2. MATERIALS AND METHOD

To study the effect of fly ash as supplementary material as replacement of cement on the strength of concrete 63 cubes were cast in the construction material laboratory. Cubes (100mm×100mm×100mm) were cast using a design mix of (1:2.08:3.86, where 3.86 is the proportion of 10mm and 20mm size aggregate), at water cement ratio. The strength of cubes made up with different

percentage of fly ash was checked to the respective strength of conventional concrete at the age of 7, 28 and 56 days in normal curing.

Cement- In this work, Pozzolana Portland Cement (P.P.C) of Prism brand obtained from single batches throughout the investigation was used. Table.1

Fine Aggregate- The fine aggregate was locally available river sand which was passed through 4.75 mm sieve. The specific gravity of fine aggregate and fineness modulus of fine aggregate result of sieve analysis is given in Table 2.

Coarse Aggregate- The coarse aggregate was locally available quarry having two different sizes; one fraction was passing through 20mm sieve and another fraction was passing through 10mm sieve. The specific gravity of coarse aggregate for both fractions and fineness modulus coarse aggregate of 10mm and 20mm size are given in Table 2.

Table 1: Properties of Cement
Method of test Refers to IS: 4032:1985

Table 2: Physical Properties of aggregate

S.No.	Material	Test	Result
1	Sand	Specific gravity	2.2
		Fineness Modulus	2.84
2	Aggregate	Specific gravity	2.66
		Fineness Modulus (10mm)	6.428
		Fineness Modulus (20mm)	6.006

Fly Ash- In the present work the fly ash was obtained from the NTPC. Unchahar Raibareli U.P. The Physical and Chemical Properties of fly ash along with PPC (Pozzolana Portland Cement) are given in Table 3.

Table 3: Physical and Chemical Properties of fly ash along with PPC

Physical Properties		
	PPC	Fly ash
Specific gravity	2.67	2.30
Mean grain size (µm)	21.5	20
Specific area (cm ² /gm)	3770	2680
Colour	Grey	Grey to black
Chemical Composition (%)		
	PPC	Fly ash
Silicon dioxide (SiO ₂) + Aluminium oxide (Al ₂ O ₃) + Iron oxide (Fe ₂ O ₃)	-	95.5
Silicon dioxide (SiO ₂)	-	60.5
Sulphur trioxide (SO ₃)	2.12 (3 % max)	0.2
Reactive Silica (SiO ₂)	-	33.4
Chlorides (Cl)	0.011(0.1 % max)	0.01
Magnesium oxide (MgO)	2.5 (6% max)	0.6
Loss on Ignition	1.74 (5% max)	1.1
Sodium oxide (Na ₂ O)	-	0.1
Insoluble Residue	24.28	

Water- Potable water was used for mixing and curing. The water cement ratio (w/c) of 0.48 has been used. Concrete- The concrete mix design is done in accordance with IS 10262(1982). The cement content used in the mix design is taken as 380 kg/m³ which satisfies minimum requirement of 300 kg/m³ in order to avoid the balling affect.

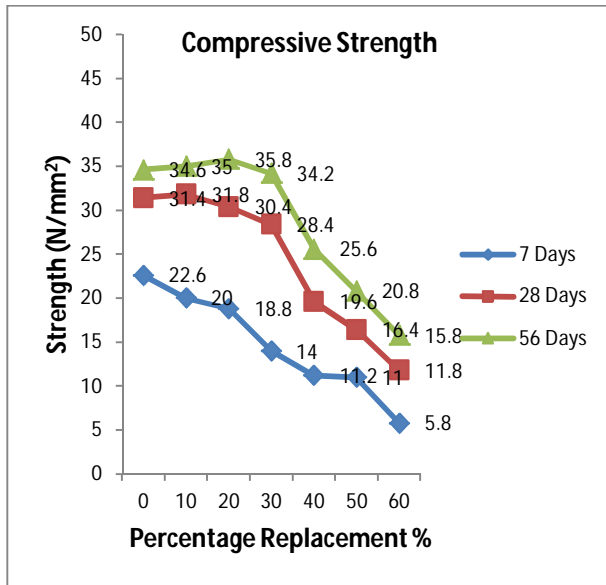
3. RESULTS AND DISCUSSIONS

The compressive strength of referral PPC concrete as well as fly ash PPC concrete at 7, 28 and 56 days are given in Table 4. It is evident from this Table 4 that the strength was increased with the addition of fly ash. Strength increases up-to 30 % fly ash content and after that it decreases. However increase in strength is more prominent at 20% replacement level. The compressive strength of PPC is 22.6 N/mm², 31.4 N/mm² and 34.6 N/mm² when water/cement ratio is 0.48 used at 7, 28 and 56 days respectively. Cement concrete normally

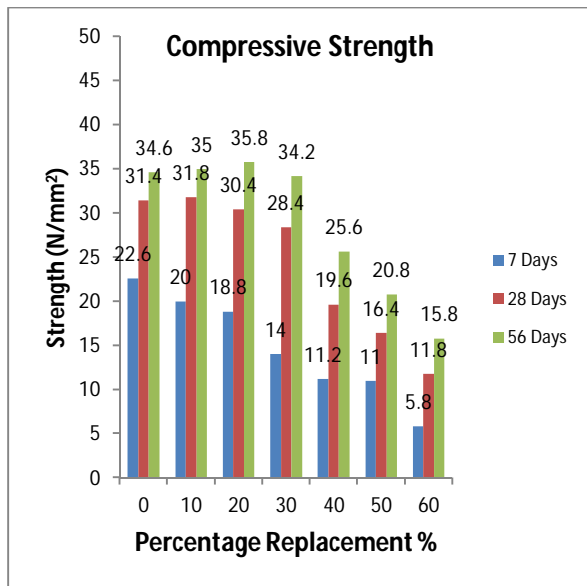
gains its maximum strength within 28 days, during the experimental process it was observed that slow hydration takes place with fly ash addition in Portland pozzolana cement (PPC) concrete and this phenomena decreases the strength of concrete mix at early age (7 days), because fly ash is a slow reactive pozzolans. Up to 30% replacement level strength is more and almost equal to the referral concrete, further increase in replacement of Portland pozzolana cement (PPC) by fly ash results in gradual decrease in the strength of concrete.

Table 4: Compressive strength of Fly ash concrete (W/C = 0.48)

S. N	Cube design-ation	Compressive strength (N/mm ²)			fly ash %
		7 days	28 days	56 days	
1	A1	22.6	31.4	34.6	0
2	A2	20.0	31.8	35.0	10
3	A3	18.8	30.4	35.8	20
4	A4	14.0	28.4	34.2	30
5	A5	11.2	19.6	25.6	40
6	A6	11.0	16.4	20.8	50
7	A7	5.8	11.8	15.8	60



Compressive Strength of Fly Ash Concrete (Line Chart)
Water/ Cement Ratio: 0.48



Compressive Strength of Fly Ash Concrete (Column Chart)
Water/ Cement Ratio: 0.48

4. CONCLUSIONS

From the above study following conclusions are drawn-

1. Up-to 30% replacement of Portland pozzolana cement (PPC) with fly ash compressive strength is comparable with referral concrete at 56 days.
2. Optimum replacement level of fly ash as partial replacement of Portland pozzolana cement (PPC) is 20%.
3. At 20% replacement strength 3.46% more than the referral concrete.
4. Addition of fly ash in Portland pozzolana cement (PPC) delays the strength gain at early ages of concrete.

5. REFERENCES

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