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Engineering Properties of Cement CONTAINING POND ASH

Milind P. Bhamare[1], Yogesh N. Bafna[2], Arun K. Dwivedi[3]

Abstract: *A thermal power plants converts energy rich fuel into electricity and heat. Coal produced electricity takes about 80 % of the total power generated in India. The coal based power plant generates a huge amount of ash. The generated ash contains about 20 percent Pond ash and 80 percent fly ash of the total ash generated. Fly ash is been recycled as an alternative to cement while pond ash is being disposed off. Pond ash requires huge area , water and energy to dispose itself off so recycling of the pond ash is indeed required. This paper concentrates on utilization of pond ash as a cement replacement.*

I. Introduction

A thermal power plants converts energy rich fuel into electricity and heat. The fuel includes coal, natural gases, petroleum products, agriculture waste and domestic trash/waste, landfill gas and biogas etc. Coal and liginte accounts for about 57% of India's installed capacity of power generation. Coal produced electricity takes about 80 % of the total power generated in India. The Indian power plant uses coal like Gondwana coal; it has low calorific value and high ash content which requires 0.7 kg of coal to generate a 1 kwh of electricity.

The coal based power plant generates a huge amount of ash. In India, it is about 170 MT for the year 2011-12 and is expected to be above 600MT for the year 2031-32. The generated ash contains about 20 percent Pond ash and 80 percent fly ash of the total ash generated. Fly ash is been recycled as an alternative to cement while pond ash is being disposed off. The disposal of large quantity of pond ash requires huge area of land, water and energy. If not managed well becomes a health hazard and damages the environment. With increased power consumption the generation of coal ash has been growing annually and need for additional disposal sites has become urgent. So recycling pond ash might be able to sort out the above mentioned issues. This paper addresses the issues pertaining to the change in engineering properties of the cement containing pond ash.

II. Experimental Work

2.1 MATERIALS-

Experimentations have been on 53 grade OPC cement to find out its physical and chemical properties. The physical and chemical properties of OPC cement used for the research work are shown in the Table 1 and 2. Pond ash used for the cement replacement is collected from the thermal power plant situated at Deepnagar, Bhusawal, Maharashtra. Quartzanium TM Sand (standard sand) used as fine aggregate, for research work. Properties of pond ash and standard sand are given in Table 3 and 4. Figure 1 shows the grain size distribution of pond ash. It is observed that 66 percent of Total weight of the pond ash is smaller than 0.075mm. Fineness modulus is 1.656

Table 1. Chemical Characteristics of Cement.

Type of Cement	Lime Saturation Factor (%)	Alumina Iron Ratio (%) Min.	Insoluble Residue (%) Max.	Magnesia (%) Max.	Sulphuric Anhydride	Loss on Ignition (%) Max.
$OPC_{(53\ Grade)}$ (IS 12269-1987)	0.8 Min., 1.02 Max.	0.66	2	6	2.5% Max.	4

Table 2 "Physical Characteristics of Cement."

Type of Cement	Fineness %	Soundness (mm)	Setting Time		Compressive Strength	
			Initial (mins)	Final (mins)	3 Days N/mm^2	7 Days N/mm^2
$OPC_{(53\ Grade)}$ (IS 12269-1987)	2.7 %	2.5 mm	52	290	27.5	37.25

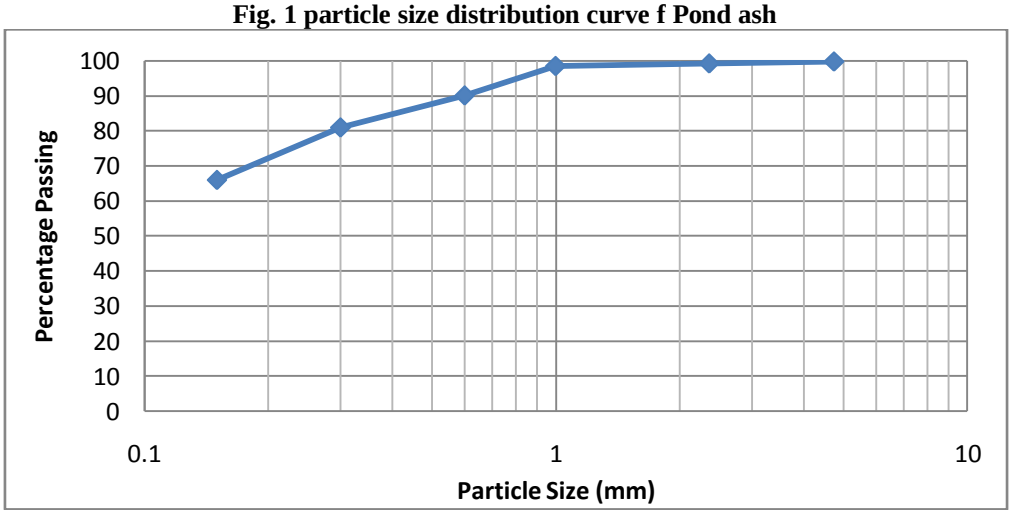
Table 3 "Physical and Chemical Characteristics of Standard sand."

Properties	Quartzanium TM Sand (Standard Sand)
Physical Properties	
Color	Whitish
Specific Gravity	2.65
W. Absorption in 24 hours	0.30%
Shape of Grains	Sub Angular
Chemical Properties	
SiO_2	99.42%
Al_2O_3	0.18%
Fe_2O_3	0.02%
CaO	-
Loss on Ignition	0.10%

Table 4 Physical Properties of Pond Ash

Properties	Pond Ash
Physical Properties	
Color	Whitish grey
Specific Gravity	2.153
W. Absorption in 24 hours	44.50%

Fig. 1 particle size distribution curve f Pond ash



2.2 Mix Proportions

As a replacement of cement, pond ash is mix in different percentage. The percentage and mix proportions are given in the Table 5.

Table 5 Cement labels and mix proportions

Sr. No	Description and Label	Mix proportion	Quantity of material (kg)		
		C:PA:S	Cement	Pond ash	Sand
1	OPC including 0.0% of pond ash by mass of cement as replacement of cement (OPC)	OPC 1:00:03	2.22	0	6.66
2	OPC including 2.5% of pond ash by mass of cement as replacement of cement (M 1)	M 1 0.975:0.025:3	2.165	0.051	6.66
3	OPC including 5.0% of pond ash by mass of	M 2	2.109	0.111	6.66

	cement as replacement of cement (M 2)	0.950:0.05:3			
4	OPC including 7.5% of pond ash by mass of cement as replacement of cement (M 3)	M 3 0.925:0.075:3	2.054	0.167	6.66
5	OPC including 10.0% of pond ash by mass of cement as replacement of cement (M 4)	M 4 0.90:0.1:3	1.998	0.222	6.66
6	OPC including 12.5% of pond ash by mass of cement as replacement of cement (M 5)	M 5 0.875:0.125:3	1.943	0.278	6.66
7	OPC including 15.0% of pond ash by mass of cement as replacement of cement ((M 6))	M 6 0.85:0.15:3	1.887	0.333	6.66
8	OPC including 17.5% of pond ash by mass of cement as replacement of cement ((M 7)	M 7 0.825:0.175:3	1.832	0.389	6.66
9	OPC including 20.0% of pond ash by mass of cement as replacement of cement (M 8)	M 8 0.8:0.2:3	1.776	0.444	6.66
10	OPC including 22.5% of pond ash by mass of cement as replacement of cement (M 9)	M 9 0.775:0.225:3	1.720	0.500	6.66

2.3 Test methods

Materials used in this research work are an OPC cement, pond ash and fine aggregate, Materials are tested as per Indian standard and mention in the Table 6 below.

Table 6 Standard utilized for testing

Test Method	**Related Standard**
Normal Consistency Setting Time La Chatelier	I.S.4031- (Part 4) 1988 I.S.4031-(Part 5) 1988 IS : 4031-(Part 3) 1988
Tests Performed on Cement Mortar	
Compressive Strength	IS : 4031-(Part 6) 1988

III. Test results and discussions

3.1 Analysis of the properties of cement

3.1.1 Normal consistency of cement- I.S.4031- (Part 4) 1988

The test results are shown in Table 7. Due to the porous nature of the pond ash particles, requires more water to make a plastic cement paste compare to ordinary Portland cement. It is observed that an amount of water required to make a plastic cement paste goes on increasing with the percentage content of the pond ash in cement.

Table 7. Normal Consistency Result of Cement Pastes

Cement	% of Pond Ash	Required Amount of water for Normal Consistency	
		%	gm
OPC	0.0	30.0	90.0
M1	2.5	31.8	95.4
M2	5.0	32.9	98.7
M3	7.5	33.6	100.8
M4	10.0	34.7	104.1
M5	12.5	35.8	107.4
M6	15.0	37.9	113.7
M7	17.5	39.4	118.2
M8	20.0	40.8	122.4
M9	22.5	42.1	126.3

3.1.2 Setting Time

For ease of construction the initial setting must not be too short and final setting must not be too long. Table 8 shows the initial and final setting time values for ordinary Portland cement containing different percentage of pond ash. Initial and final setting time increases with the increase in the percentage of pond ash content in the cement. Increased time seen due to the less pozzolanic properties of pond ash.

Table 8 Setting Time of Cement

Cement	Percentage of Pond Ash	Initial Setting Time (min.)	Final Setting Time (min.)
OPC	0	52	290
M1	2.5	55	302
M2	5	60	308
M3	7.5	68	319
M4	10	73	328
M5	12.5	78	345
M6	15	84	357
M7	17.5	88	373
M8	20	94	386
M9	22.5	102	395

3.1.3 Volume Expansion

The test was conducted on 10 samples containing 0 to 22.5% of pond ash using le Chateliers soundness test. This test only takes into account CaO. Hydration product has larger volume than that of free time and finally gives rise to cracks. Thus, partly replaced pond ash give advantages volume expansion results due to lower free time value in cement paste.

Table 9 Soundness test of Cement
(Values are near to 0.5 mm)

Cement	% of Pond Ash	Change in distance (mm)
OPC	0	2.5
M1	2.5	3.0
M2	5	2.5
M3	7.5	2.5
M4	10	2.0
M5	12.5	2.0
M6	15	2.0
M7	17.5	2.0
M8	20	1.5
M9	22.5	1.5

3.1.4 Compressive Strength of Cement

The compressive strength of cement decreases with increase by the content of percentage pond ash. The growing content of pond ash is responsible for decrease in the compressive strength of cement. A mix of cement & pond ash has less compressive strength as compared to the OPC as pond ash contains both fine as well as non reactive large particle due to which it has less pozzolanic property.

Graph 2 Compressive strength of cement

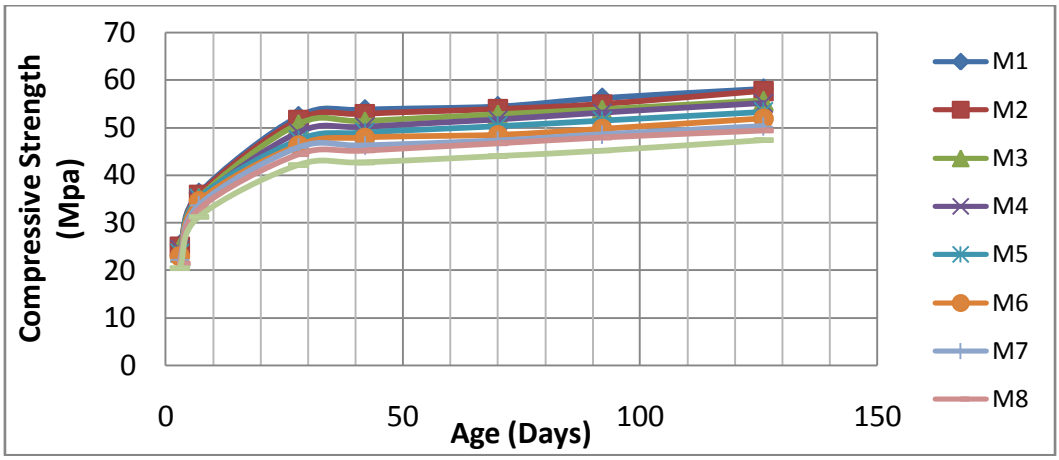


Table 10 percentage compressive strength of pond as incorporated cement w. r. t. OPC

Mix	% P.A.	Percentage compressive strength						
		3 Days	7 Days	28 Days	42 Days	70 Days	92 Days	126 Days
M1	2.5	93.889	97.919	98.755	97.745	95.491	96.914	98.525
M2	5.0	92.704	96.946	97.453	96.127	94.509	94.707	97.780
M3	7.5	92.074	95.216	95.774	93.400	92.596	92.810	94.373
M4	10.0	90.481	93.703	92.415	91.145	90.649	91.569	93.441
M5	12.5	87.667	94.946	89.377	88.964	88.193	88.707	90.288
M6	15.0	84.926	93.189	87.264	87.036	84.947	85.638	87.915
M7	17.5	81.904	91.000	86.358	84.000	82.877	83.690	85.186
M8	20.0	79.074	88.595	83.623	82.036	81.825	82.534	83.627
M9	22.5	75.741	84.351	79.509	77.582	77.193	77.810	80.254

IV. Conclusions

The results of the basic study to utilize pond ash as cement replacement and change in engineering properties of cement containing pond ash are as under.

1) Pond ash should be utilized by identifying its qualities which greatly depends on the particle sizes.
2) From the examination on pond ash used for cement replacement it can be inferred that the normal consistency of cement defer according to the percentage pond ash.
3) From the examination on the pond ash incorporated cement, it can be inferred that the pond ash acts as retarder & increases the initial setting time of the cement paste.
4) It is observed from the analysis of the compressive strength results that as the pond ash percentage increases in the cement paste the compressive strength decreases due to low pozzolanic property of the pond ash.

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