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A study on characterization and use of Pond Ash as fine aggregate in Concrete

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ABSTRACT

This experimental study is to investigate the possibility of using pond ash in varying percentage as fine aggregate substitute in cement concrete. During the combustion of pulverized coal at the thermal power station the product formed are bottom ash, fly ash and vapours. There bottom ash is that part of residue which is fused into particles and is collected at the bottom of the furnace. The distribution between bottom ash and fly ash fraction is a function of burner type, type of coal and the type of boiler bottom (wet or dry). In India most of the thermal power plants adopt wet method of ash disposal. The fly ash collected from Electrostatic precipitator and the bottom ashes are with water and disposed in a slurry form in large ponds and dykes. Fly ash acts both as a fine aggregate and as a cement. Pond ash differs from fly ash collected from Electrostatic precipitators in a dry form in that it contains significant amount of relatively coarser particles (greater than 45 µm and up to 150 µ m). The above study is to be discussed with the workability and compressive strength of concrete and is to be compared with standard concrete.

Keywords: Bottom ash, fly ash, Electrostatic precipitator, pond ash, wet disposal.

1. Introduction

Use of waste and by-products in concrete will lead to green environment and such concrete can be called as “Green Concrete”. There are various types of waste materials that can be considered for usage in concrete. The most commonly used waste materials to replace sand and cement in concrete are Fly Ash, Rice Husk Ash, Blast Furnace Slag, Red Mud and Phosphor, gypsum, Silica Fume, Fumed silica, Crushed glass, Eggshells. The waste products used to replace coarse aggregate in concrete are Palm Oil Shell Aggregate for Lightweight Aggregate Concrete, Crushed Ceramic, glass, waste wood, crushed concrete aggregate. India depends upon primarily on coal for the requirement of power and its power generation is likely to go up from 1, 12, 090 MW to 2,12,000 MW in the year 2012. The fly ash generation in Indian Thermal Stations is likely to shoot up to 200 million tones in 2012 from the present level of 120 million tones. The current annual production of coal ash worldwide is estimated around 600 million tones. The disposal of fly ash will be a big challenge to environment, especially when the quantum increases from the present level. Hence worldwide research work was focused to find alternative use of this waste material and its use in concrete industry is one of the effective methods of utilization. Increase in demand and decrease in natural resource of fine aggregate for the production of concrete has resulted in the need of identifying a new source of fine aggregate. The possibility of utilization of thermal power plant by-product pond ash as replacement to fine aggregate in concrete is taken into consideration.

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2. Material used and Methods

2.1. Materials used

Thermal Power Plant By-Products

Products formed during combustion of pulverized coal in thermal power plant stations are:-

(i)	Bottom ash	-	fused particles collected at the Bottom of furnace.
(ii)	Fly ash	-	Collected in electrostatic Precipitators
(iii)	Vapours		

The distribution of bottom ash and fly ash is a function of burner type, type of coal, type of boiler bottom (Wet or dry).

Properties of fly ash

1. Fly ash in the presence of moisture and at ordinary temperature chemically react with calcium hydroxide forms components possessing cementitious properties.
2. Fly ash act both as cement and as fine aggregate.
3. Fly ash lowers heat of hydration.
4. Improves resistance to chloride inducing corrosion.

Methods of Disposal

In India most of thermal power stations adopt wet method of ash disposal and storage of ash in large ponds and dykes.

In wet method fly ash collected from ESP's and the bottom ash are with water and transported in a slurry form to this ponds.

Fly ash and pond ash

Pond ash differ from fly ash collected from ESP's in a dry form in that it contains significant amount of relatively coarse particles (greater than 45 µm and upto 50 µm).

Utilization

A. Pond ash and residue of integrated steel plant were mixed for manufacture of bricks and found.

1. Superior in aesthetic and structural qualities.
2. Saving in manufacturing cost.
3. Better consumer response

B. High volume of pond ash up to 55% replacement of cement has been used for making dry lean concrete as base course in four /six lane highways

2.2. Methods

Physical analysis

The physical properties of aggregate and pond ash

1. Specific gravity
2. Bulk density
3. Fineness Modulus
4. Water absorption

The physical properties of cement:-

1. Fineness
2. Consistency
3. Setting time

Chemical analysis

The chemical compound in pond ash and percentage of composition.

Test

1. Workability Test
2. Test for Compressive strength
3. Tension Test
   a. Flexure test
   b. Split tension test.

3. Experimental Investigation

3.1. Concrete Constituents

Cement	-	Portland Cement
Fine aggregate	-	River sand
Coarse aggregate	-	broken stone
Pond ash	-	Thermal Power Plant, Tuticorin

3.2. Specimen

(i)	cube	-	150mm x 150mm x 150mm

Figure 1: Cube and Cylinder

\ (ii) Cylinder - 150mm Φ and 300mm length

Figure 2: Cylinder

3.3. Mix proportions

Table 1: Concrete mix proportions with 0%, 20%, 40% and 60% pond ash

Mix Designation	Pond ash fraction of fine agg.	Cement Kg	Pond ash Kg	FA Kg	CA Kg	Water Ltr	Slump mm
M0	0%	385.5	-	578.5	1203.00	192.75	150
M1	20%	385.5	116	462.5	1203.00	192.75	120
M2	40%	385.5	232	346.5	1203.00	192.75	50
M3	60%	385.5	348	230.5	1203.00	192.75	30

3.4. Properties of Constituents

3.4.1. Physical properties

Cement

1. Fineness - 6%
2. Consistency - 34%
3. Initial setting time - 32 minutes

Fine Aggregate

1. Specific gravity - 2.65
2. Bulk density - 1.3 g/cc

Coarse aggregate

1. Specific gravity - 2.7
2. Bulk density - 1.13 g/cc
3. Water absorption - 2%

Pond ash

(i) Sieve Analysis

Table 2: Sieve Analysis

IS sieve size	Weight retained gm	Cumulative weight retained gm	Cumulative percentage weight retained	Cumulative percentage passing
40	0	0	0	100
20	0	0	0	100
10	10	10	2	98
4.75	40	50	10	90
2.36	30	80	16	84
1.18	105	185	37	63
600 mic	160	345	69	31
300 mic	100	445	89	11
150	10	455	91	9
Residue	45	500	-	-
Total	500		314	-

Fineness Modulus $FM = \frac{314}{100}$

$= 3.14$

(ii) Bulk density - 1.01 g/cc

(iii) Specific gravity - 2.3

3.4.2 Chemical Properties

Pond Ash

Table 3: Chemical composition

Sl. No	**Compounds**	**% composition**
1.	Silican di oxide (SiO2) plus, Aluminium oxide (A12O3) Plus, Iron Oxide (Fe 2O3) percent by mass	79.97
2.	Silican di oxide (SiO2) percent by mass	36.22
3.	Magnesium oxide (Mgo) percent by mass	2.73

4.	Total sulphur as sulpur Tri oxide (SO3) percent by mass	0.69
5.	Available alkalis as sodium oxide (Na203) percent by mass	2.12
6.	Loss on ignition percent by mass	6.84
7.	Moisture content percent by mass	1.78

3.5. Test results

Table 4: Compressive strength

Mix	Avg. Unit Wt. of conc kg/m^3	Cube							Cylinder	
		7 days comp strength N/mm^2	28 days comp strength N/mm^2	56 days comp strength N/mm^2	Rebound hammer (7 days)		Rebound hammer (28 days)		7 days comp strength N/mm^2	28 days comp strength N/mm^2
					R.H.No	Strength N/mm^2	R.H.No	Strength N/mm^2		
M0	2442	14.2	31	32.5	11	9	20	22	9	19
M1	2412	16.5	36	42.7	12	10	24	26	12	23
M2	2353	14	28.5	30.9	10	8	22	24	9.6	20
M3	2265	11	26.5	28.6	8	5	18	20	8.5	16.5

3.5.2. Tension Test

(i) Flexure test

Table 5: Modulus of Rupture

MIX	**Modulus of rupture (7 days) N/mm^2**
M0	6.67
M1	9.3
M2	6
M3	3.3

(ii) split tension test

Table 6: Tensile stress

Mix	**Tensile stress (7 days) N/mm^2**
M0	2.12
M1	2.8
M2	2
M3	2

4. Discussion on Test results

1. With the addition of pond ash there is reduction in slump value of fresh concrete.
2. The unit weight of concrete gets reduced through the addition of pond ash as replacement of fine aggregate since it has lesser specific gravity than fine aggregate.
3. The 7 days, 28 days and 56 days strength shows that the strength increases from standard concrete up to the addition of 20% replacement of fine aggregate with pond ash.
4. The 7 days, 28 days and 56 days strength get reduced on further additions of pond ash as sand replacement from 20%
5. The strength of concrete when fine aggregate is replaced with pond ash also improves with age of concrete.

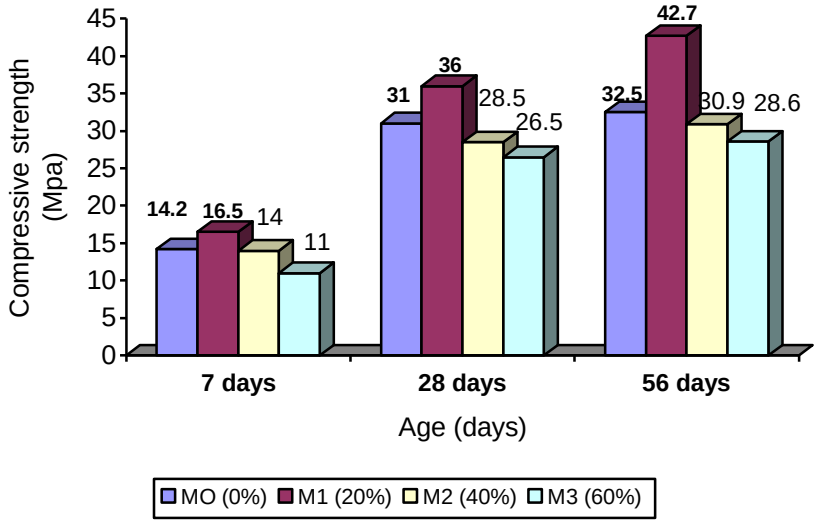

Figure 6: Compressive strength of concrete with addition of pond ash in varying percentage and age

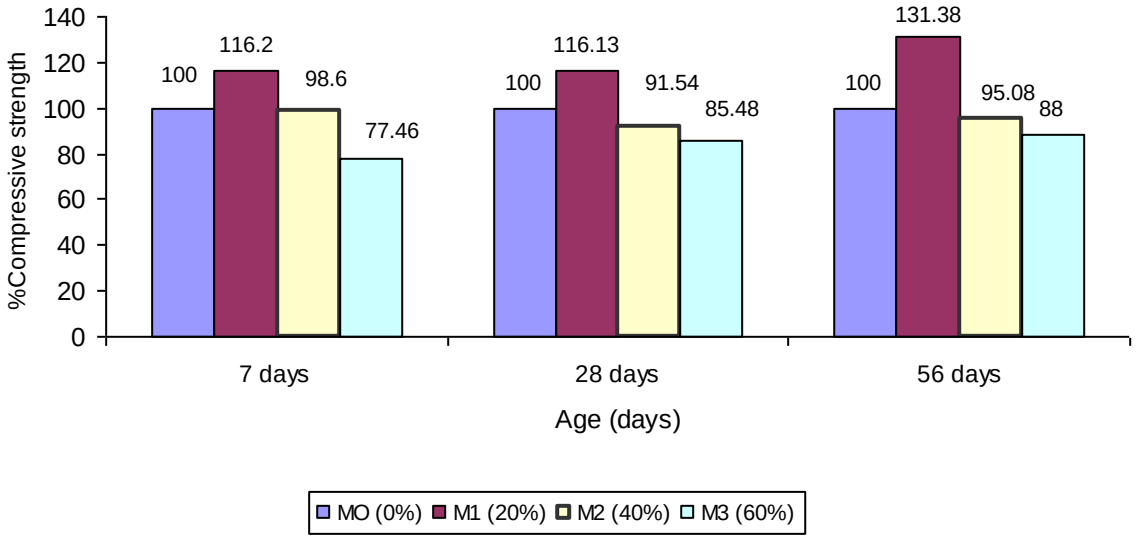

Figure 7: Relative compressive strength of concrete in percentage

5. Conclusion

The following conclusions are drawn from the observation of test in concrete with pond ash as partial replacement for fine aggregate.

1. The density of concrete reduces with the increase in percentage of pond ash.
2. The compressive strength of concrete with pond ash increases with increased curing period.
3. The split tensile strength of concrete with pond ash increases up to the addition of 20% ash sand replacement.
4. The flexural strength of concrete with pond ash increases upto the addition of 20% ash sand replacement.
5. While the pond ash is used the workability is reduced. For obtaining the required workability, super plasticizers are added while preparing the concrete. The more pond ash to be added the more super plasticizers are required to be added for obtaining the required workability.
6. With increasing replacement of fine aggregate with pond ash the average density of concrete shows linear reduction due to lower specific gravity.

5.1. Suggestions for Further Work

1. The part replacement of fine aggregate with pond ash gives the required strength values for the concrete construction purposes and the cost of the pond ash becomes very cheap.
2. In future the flexural strength of beams may be observed by increasing the sizes of beams.
3. The part replacement of fine aggregate with pond ash for casting the slabs with different end conditions may be required for the required strength values.
4. Also by providing different types of increased reinforcements the flexural strength of beams may be oberserved.

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