Use of Pond Ash as a Partial Replacement of Fine Aggregate in Concrete

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Abstract

About 70-75% of total power generated in India is produced by coal-based thermal power plants.When combustion of Coal happens within the power station, Ash is produced as a by-product which is an Industrial waste. This ash is of different forms such as Fly ash, Bottom ash and Pond ash. A major drawback arises on the disposal of this industrial waste. As days go on more coal is utilized and a lot of ash is created prepared for the disposal, thus this becomes a heavy drawback. These industrial wastes are to be utilized in different fields such as construction, to minimize its disposal problems. In this study Pond ash is utilized as a partial replacement of fine aggregate (Natural sand) in concrete. In this investigation fine aggregate are replaced by pond ash by 0%, 10%, 20% and 30% by weight of fine aggregate to determine the strength properties. The Casting of cubes and cylinders were done to determine the compressive strength and split tensile strength respectively, for 7, 28 56 days and 90 days of curing. It is found by the study that it is possible to use pond ash upto 20% replacement of FA for M30 grade of concrete without compromising strength

1. Introduction

The present study investigate the effect of using Pond Ash (PA) as a fine aggregate in M30 grade of concrete. The design of concrete (M30) was done as per BIS 10262:2009 and IS 456:2000 and the quantities of ingredient have been estimated and accordingly concrete cubes and cylinders as per standard procedure are casted and tested and the results for compressive strength and split tensile strength are obtained and analysed. In this study fine aggregate is replaced by pond ash in varying percentage such as 0%, 10%,20% and 30%. 12 cubes and 12 cylinders are casted for each percentage which are designated as Mix1, Mix2, Mix 3 and Mix 4 respectively. All the specimen of each mix are tested for compressive strength and split tensile strength after 7 days, 28 days, 56 days and 90 days. It is found by the study that it is possible to use pond ash upto 20% replacement of FA for M30 grade of concrete without compromising strength. It is evident from study that the replacement of sand by pond ash can be increased from 10% to 20% if 20% artificial sand is replaced however there is reduction in corresponding compressive strength by 4.74 % for 10% PA replacement, 8.73% for 20% PA replacement as compared to concrete mix without pond ash.

1.1 Fly ash and pond ash:

FA and PA is an end product (waste) of thermal power plants, FA is a very finer as compared to PA, a Coarser and porous material which falls to bottom of furnace is called as bottom or PA then it is transported to ash pond by mix with water, for an easy flow and it will not fly, so it is also known as wet bottom ash. The FA and PA has pozzolanic properties

that‟s why **this kind** of **solfa syllable** and PA has **junction rectifier** to a **larger analysis** in utilization in replacement to a cement and fine aggregate by FA and PA.

1.2 Properties of Pond Ash / Fly Ash:

Coal ash is a by-product generated from the process of coal combustion at high temperature over 1600°c at the coal-fired power plants. Coal ash thus produced can be divided into fly ash and bottom ash. The 20 percent of total ash produced is dry bottom ash , a dark gray, granular, porous, material **that's** collected **in an exceedingly** water-filled hopper at **rock bottom** of the **chamber**.

1.3 Chemical Properties of Pond Ash:

Chemical properties of pond ash are shown in Table 1.2 below.

Table No.1 Chemical Properties of Pond Ash

Sr. No	Compounds	% Composition
1	Silicon di oxide (SiO2) plus, Aluminium oxide (Al2O3) Plus, Iron Oxid	79.97
2	Silicon di oxide (SiO2) percent by mass	36.22
3	Magnesium oxide (MgO) percent by mass	2.73
4	Total sulphur as Tri-oxide (SO3) percent by mass	0.69
5	Available alkalis as Sodium oxide (Na2O3) percent by mass	2.12
6	Loss on ignition percent by mass	6.84
7	Moisture content percent by mass	1.78

2. Objectives of Work:

i. To find economical solution for high cost construction material.

ii. To establish alternative for FA with partial use of Pond Ash in concrete

iii. To make a productive use of waste pond ash which has harmful effect on environment.

iv. To study properties of wet concrete using pond ash as partial replacement of fine aggregates.

v. To study strength properties after partially replacing fine aggregate with Pond ash for M30 grade of concrete.

vi. To compare the compressive and tensile strength of PA replaced concrete mix with concrete mix without pond ash.

3. Methodology

Following laboratory test were conducted to achieve the objective of study

i. Fineness test

ii. Setting time test

iii. Strength test

iv. Soundness test

v. Standard Consistency Test

The suitability of pond ash in concrete as partial replacement of sand is tested by using four different mix proportions for M30 grade concrete. The mix design is done as per BIS 10262:2009 and IS 456:2000 and the quantities of ingredient have been estimated and accordingly concrete cubes and cylinders and as per standard procedure are prepared and tested and the results for compressive strength and split tensile strength are obtained and analysed. In this experiment fine aggregate is replaced by pond ash in varying percentage such as 0%, 10%, 20% and 30%. 12 cubes and 12 cylinders are casted for each percentage which are designated as Mix1, Mix2 , Mix3 and Mix4 respectively. All the specimen of each mix were tested for compressive strength and split tensile strength after 7 days, 28 days, 56 days and 90 days.

4. Determination of Physical Properties of Materials

Physical properties of all materials are given below

Table No. **1** Physical Properties of Cement

Test	Result	Remark (standard range)
Normal Consistency	32%	26-33%
Initial Setting time	38 min.	Minimum 30-Maximum 130 min
Final Setting time	294min.	Minimum 195-Maximum 600 min.
Fineness of Cement	361 m2/kg	Minimum Should be 225m2/kg
Soundness	2.00mm	Should not exceed 10 mm.
Compressive strength for 7 days	38.6 N/mm2	Should not be less than 27 N/mm2
Compressive strength for 28 days	58.6 N/mm2	37 N/mm2

Table No. 2 Physical Properties of Fine Aggregate

Test	Result	Remark
Specific gravity	2.65	Should be range 2.4-3
Silt Content	1.1%	Should not exceed 6%
Fineness Modulus	2.66	Should be in range 2.2-2.6

Table No. 3 Physical Properties of Coarse Aggregate

Test	Result for 20 mm	Result for 12mm	Remark
Specific gravity	2.67	2.66	Should be range 2.4-3
Water absorption value	0.87%	0.86%	Should not exceed 3-4%
Aggregate crushing value	18%	19%	Should not exceed 30%
Aggregate impact value	15%	17%	Should not exceed 45%

Table No. 4 Physical Properties of Pond Ash:

SR No.	Properties	Value
1	Specific gravity	2.4
2	Water absorption	21%
3	Fineness modulus	2.79

5. Concrete Mix Design of M30 Grade :

1	Grade designation	M30
2	Type of cement	OPC 53 grade
3	Maximum nominal aggregate size	20mm
4	workability	25-50 mm (slump)
5	Exposure condition	Normal
6	Degree of supervision	Good
7	Type of aggregate	Crushed Angular Aggregate

5.1 Test Data For Materials

1	Sp. Gravity of cement	3.15
2	Sp. Gravity of water	1
3	Sp. Gravity of CA	2.7
4	Sp. Gravity of FA	2.65
5	Water absorption of CA	0.86%

5.2 Summary of Mix Design Calculation

Water	Cement	FA	CA
175	388.88	668.7	1160.08
0.45	1	1.72	2.98

So mix proportion for M30 grade is 1:1.72:2.98

6. Estimation of Quantity of Materials:

Actual Quantities Of Material Required For 48 No. of Cubes and 48 No. Of Cylinders:

Table No. 6 Actual Quantities Of Material Required For 48 No. Of Cubes And 48 No. of Cylinder

Material	Quantity required for 48 cubes (kg)	Quantity required for 48 cylinders (kg)
Cement	74.11	117.46
FA	127.47	202.03
CA	220.85	350.03
Water	33.35 lit	52.86 lit
PA	19.13	30.3
AS	19.14	30.3

6.1 Actual Quantities Of Material Required For Different Proportions Mix-1, Mix-2, Mix-3, Mix-4 For 12 No. Of Cubes:

Table No. 7 Actual Quantities Of Material Required For Different Proportions Mix-1, Mix-2, Mix-3, Mix-4 For 12 No. Of Cubes

Mix Designation	Cement (kg)	PA (kg)	AS (kg)	NS (kg)	CA-I (12mm)(20%) (kg)	CAII (20mm)(80%) (kg)	Water
Mix-1 PA:AS:NS 0:0:100	18.53	-	-	31.88	11.04	44.18	8.34
Mix-2 PA:AS:NS 10:20:70	18.53	3.19	6.38	22.31	11.04	44.18	8.34
Mix-3 PA:AS:NS 20:20:60	18.53	6.38	6.38	19.13	11.04	44.18	8.34
Mix-4 PA:AS:NS 30:20:50	18.53	9.56	6.38	15.94	11.04	44.18	8.34

6.3 Actual Quantities of Material Required for Different Proportions Mix-1, Mix-2, Mix-3, Mix-4 For 12 No. Of Cylinders:

Table No. 8 Actual Quantities Of Material Required For Different Proportions Mix-1, Mix-2, Mix-3, Mix-4 For 12 No. Of Cylinders

Mix Designation	Cement (kg)	PA (kg)	AS (kg)	NS (kg)	CA-I (12mm)(20%) (kg)	CAII (20mm)(80%) (kg)	Water
Mix-1 PA:AS:NS	29.36	-	-	50.49	17.5	70	13.21
Mix-2 PA:AS:NS	29.36	5.05	10.1	35.34	17.5	70	13.21
Mix-3 PA:AS:NS 20:20:60	29.36	10.1	10.1	30.29	17.5	70	13.21
Mix-4 PA:AS:NS	29.36	15.15	10.1	25.24	17.5	70	13.21

7.0 Results and Discussion

7.1 Results of Workability

Table 9 Results of Workability Test

Type of mix	Slump value
Mix-1	300mm
Mix-2	290mm
Mix-3	280mm
Mix-4	260mm

7.2 Result of Compressive Strength of Pond Ash Replacement in Concrete at All Ages :

Table No. 10 Result of Compressive Strength Of Pond Ash Replacement In Concrete at 7 Days & 28days

Sr. No	Mix Designation	% of PA in concrete	7 days Compressive strength (N/mm2)			28 days Compressive strength (N/mm2)		
			Load (T)	CS (N/mm2)	Avg	Load	CS	Avg
1	Mix-1 PA:AS:NS 0:0:100	0%	50	22.22	22.22	75	33.33	33.33
			51	22.67		74	32.89	
			49	21.78		76	33.78	
2	Mix-2 PA:AS:NS 10:20:70	10%	48	21.33	21.18	72	32	32.15
			46	20.44		74	32.89	
			49	21.78		71	31.56	
3	Mix-3 PA:AS:NS 20:20:60	20%	47	20.89	20.89	67	29.78	30.52
			45	20		68	30.22	

			49	21.78		71	31.56	
4	Mix-4 PA:AS:NS 30:20:50	30%	42	18.67	19.11	65	28.89	29.33
			44	19.56		67	29.78	
			43	19.11		66	29.33	

Table No. 11 Result Of Compressive Strength Of Pond Ash Replacement In Concrete At 56 Days & 90 days :

Sr.No	Mix designation	% of PA in concrete	56 days Compressive strength (N/mm2)			90 days Compressive strength (N/mm2)		
			Load (T)	CS (N/mm2)	Avg	Load	CS (N/mm2)	Avg
1	Mix-1 PA:AS:NS 0:0:100	0%	79	35.11	35	85	37.78	37.33
			78	34.67		83	36.89	
			79	35.11		84	37.33	
2	Mix-2 PA:AS:NS 10:20:70	10%	74	32.89	33.33	79	35.11	35.56
			75	33.33		80	35.56	
			76	33.78		81	36	
3	Mix-3 PA:AS:NS 20:20:60	20%	74	32.89	32.44	75	33.33	34.56
			72	32		77	34.22	
			73	32.44		78	34.67	
4	Mix-4 PA:AS:NS 30:20:50	30%	66	29.33	30.07	69	30.67	31.4
			68	30.22		71	31.56	
			69	30.67		72	32	

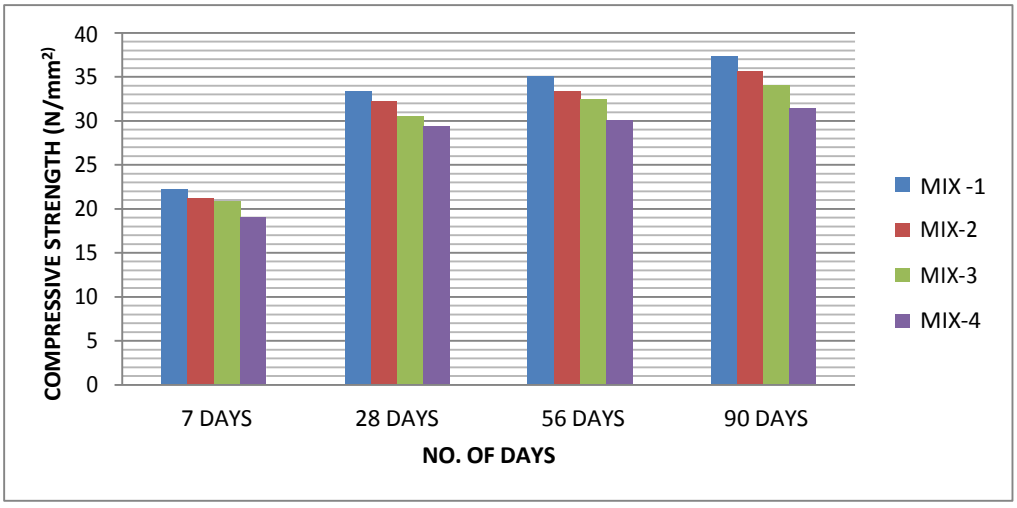

Fig.1 Compressive Strength of Pond Ash Replacement In Concrete At 90 Days of Curing

From the above study it can be concluded that compressive strength increases at all ages but lower than control concrete mix. However there is reduction in compressive strength by 4.74

% for 10% PA replacement, 8.73% for 20% PA replacement and 15% for 30% PA replacement as compared to concrete mix without pond ash.

7.3 Result of split tensile strength of pond ash replacement in concrete

Table No.12 Result of split tensile strength of pond ash replacement in concrete at 7 days & 28 day

Sr.No	Mix designation	% of PA in concrete	7 days Split tensile strength (N/mm2)			28 days Split tensile strength (N/mm2)		
			Load (T)	STS (N/mm2)	Avg	Load	STS (N/mm2)	Avg
1	Mix-1 PA:AS:NS 0:0:100	0%	17	2.38	2.24	17	2.38	2.43
			16	2.24		18	2.52	
			15	2.1		17	2.38	
2	Mix-2 PA:AS:NS 10:20:70	10%	15	2.1	2.15	18	2.52	2.29
			17	2.38		15	2.1	
			14	1.96		16	2.24	
3	Mix-3 PA:AS:NS 20:20:60	20%	14	1.96	2.01	16	2.24	2.24
			15	2.1		15	2.1	
			14	1.96		17	2.38	
4	Mix-4 PA:AS:NS 30:20:50	30%	13	1.82	1.82	15	2.1	2.1
			12	1.68		14	1.96	
			14	1.96		16	2.24	

Table No. 13 Result of split tensile strength of pond ash replacement in concrete at 56 days & 90 days :

Sr. No	Mix designation	% of PA in concrete	56 days Split tensile strength (N/mm2)			90 days Split tensile strength (N/mm2)		
			Load (T)	STS(N/mm2)	Avg	Load	STS(N/mm2)	Avg
1	Mix-1 PA:AS:NS 0:0:100	0%	22	3.08	3.08	24	3.36	3.22
			21	2.94		23	3.22	
			23	3.22		22	3.08	
2	Mix-2 PA:AS:NS 10:20:70	10%	20	2.8	2.67	24	3.36	3.12
			19	2.67		21	2.94	
			18	2.52		22	3.08	
3	Mix-3 PA:AS:NS 20:20:60	20%	17	2.38	2.57	20	2.8	3.03
			18	2.52		23	3.22	
			20	2.8		22	3.08	
4	Mix-4 PA:AS:NS 30:20:50	30%	16	2.24	2.24	18	2.52	2.67
			17	2.38		19	2.67	
			15	2.1		20	2.8	

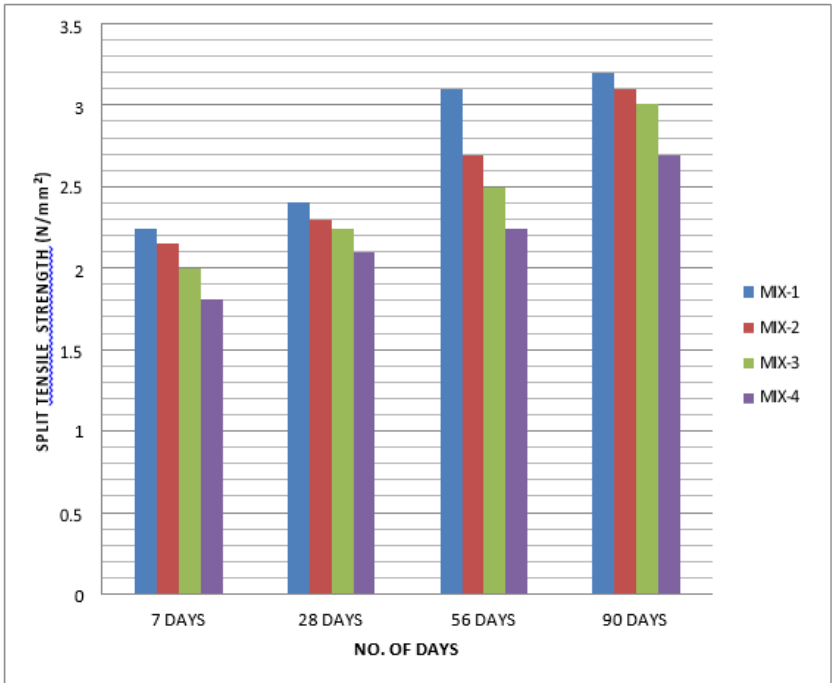

Fig.2 Split Tensile Strength of Pond Ash Replacement in Concrete At 90 Days of Curing

From the above study it can be concluded that tensile strength increases at all ages but lower than control concrete mix. However there is reduction in tensile strength by 3.10 % for 10% PA replacement, 5.9% for 20% PA replacement as compared to concrete mix without pond ash

8. Cost Comparison:

Table No 5.5 Cost Comparison Table for 1m^3 Quantity With PA And AS

Material	Rate per kg	PA 0%		10% PA+20%AS		20%PA+20%AS	30% PA+20%AS		
		Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Cement	6	388	2328	388	2328	388	2328	388	2328
Fine Aggregate	1.28	6668.7	855.93	468.1	600	401.22	513.56	33435	428

Coarse Aggregate	1.45	1160.08	1682.11	1160.08	1682.1	1160	1682.12	1160.08	1682.12
Pond Ash	1	-	-	66.87	66.87	133.74	133.74	200.61	200.61
Artifitial Sand	1	-	-	133.74	133.74	133.74	133.74	133.74	133.74
Total Cost		4866		4810			4791	4772	
Percentage Difference		-		1.16%			1.57%	2%	

The table above explains the cost comparison with basic sample M30

9. Conclusions

From the above study following conclusions are drawn:

i. It is found by the study that it is possible to use pond ash up to 20% replacement of FA for M30 grade of concrete without compromising strength.
ii. The workability of pond ash concrete decreases with the increase in pond ash content due to increase in water demand.
iii. It is found by the study that compressive strength of PA replaced concrete increases at all stages, however there is reduction in corresponding compressive strength by 4.74 % for 10% PA replacement, 8.73% for 20% PA replacement as compared to concrete mix without pond ash.
iv. Splitting tensile strength of concrete improved on use of pond ash as partial replacement of sand.
v. Use of pond ash as partial replacement of FA can reduces the cost of construction .For 10% replacement of pond ash and artificial sand, saving in cost is 1.16% and that for 20% and 30% PA replacement is 1.57% and 2% respectively.

10. Future Scope:

i. Further studies must be carried on chemical properties of pond ash.
ii. The future study can be done for high strength concrete to check suitability.
iii. The detailed study on pond ash samples from different thermal power plant is needed to ascertain its suitability.
iv. The further study can be done by varying percentage from 20-30% for same or different mix proportions of pond ash replacement in concrete as well as it can be performed by varying grades of concrete.

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