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Studies on Development of Ecofriendly Concrete by Utilization of Pond Ash and Lime

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Abstract:
Pond ash is a by-product of coal based thermal power plants. It has been generally considered a waste material in the past and disposal of which has posed numerous ecological and environmental problems. However, recent researches have shown that Pond ash has potential to act as invaluable ingredient in cement and concrete if used within the framework of prescribed specifications and quality systems. The Pond ash is now considered as a resource material rather than a waste in civil engineering.

Index Terms: Pond Ash, Lime, Compressive Strength, Flexural Strength.

I. INTRODUCTION

Coal based Thermal Power Generation has been the backbone of power capacity addition in the country. Indian coal is of low grade with ash content of the order of 30-45 % in comparison to imported coals which have low ash content of the order of 10-15%. Large quantity of ash is, thus being generated at coal based Thermal Power Stations in the country, which not only requires large area of precious land for its disposal but is also one of the sources of pollution of both air and water. The research for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Pond ash can is used in concrete as partial replacement of cement. The strength, durability and other characteristic of concrete depends on the properties of its ingredients, proportion of mix, method of compaction and other controls during placing and curing.

II.2 TYPE OF COAL ASH

Coal Ash is the residue of the coal combustion process involved in the thermal power plant. The types of coal ash from coal ash thermal power plant are:
(1) Fly ash,
(2). Bottom ash, and
(3). Pond ash

1.2.1 Fly Ash

Fly ash is the finely divided residue resulting from the combustion of ground or powdered coal. Fly ash is fine powder, the particles of which are generally spherical in shape and range in size from 0.5 to 100 micrometre. Fly ash is collected by mechanical or electrostatic precipitators from the flue gases of power plant.

1.2.2Bottom Ash

Ash is collected at the end of the grate in a Waste-to-Energy plant from the bottom, the particles of which are generally spherical in shape and size greater than 100 micrometre.

1.2.3Pond Ash

Fly ash and bottom ash when these two types of ash mixed together and transported in the form of slurry and stored in the lagoons, the deposit is called Pond ash. The total fly ash generated from the thermal power plant nearly 20% is the bottom ash and nearly 80% is the fly ash. The volume of Pond ash produced by thermal power plants is very large compared to that of the other two ashes, viz. fly ash and bottom ash.

III. METHODOLOGY

3.1 SAMPLE USED

Following are the samples which are used during the work:

3.1.1 CEMENT

Cement is a binder material which is grey in colour. It is a substance that sets and hardens and binds other materials together. It is created from different sorts of water with lime. It is a fine powder obtained by warming material in an oven to form what is called clinker. Grade 43 Jaypee cement has been used for complete test procedure. Cube has been made using same cement throughout the procedure of testing.

Properties of cement are mentioned in Table below.
Table 3.1 Chemical Properties Of cement

Contents	%
CaO (Lime)	60-70
SiO_2 (silica)	17-25
Al_2O_3 (Alumina)	3-8
Fe_2O_3(Iron Oxide)	0.5-0.6
MgO (Magnesia)	0.5-0.6
Alkalies	0.3-1.2

Table 3.2 physical properties of cement

Properties of cement	Experimental value	Codal requirement(IS8112-1989)
Normal consistency	30%	
Initial setting time	63 min	>30 min
Final setting time	250 min	<600 min
Specific gravity of cement	3.15	3.15
Fineness of cement	4%	<10%
Compressive strength of cement(N/mm^2)		
• 3 days	23.67	>23
• 7 days	33.33	>33
• 28 days	43.50	>43

3.1.2 AGGREGATE

Aggregates are inert granular materials such as sand, gravel or crushed stone that are end product in their own right. They are also the raw materials that are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete.
Aggregate properties greatly influence the behaviour of concrete, since they occupy about 80% of the total volume of concrete.

The aggregate are classified as

A) Fine aggregate
B) Coarse aggregate

3.1.2. A. Fine aggregate

Fine aggregate are material passing through an IS sieve which is less than 4.75mm.Fine aggregate are filler material between the coarse aggregate. The most important function of the fine aggregate is to provide workability and uniformity in the mixture.

Table 3.3 Properties of Fine Aggregate

Properties	Values
Bulking of sand	22.08%
Specific Gravity	2.52
Water Absorption	1.4%
Silt content	0.89
Fineness Modules	2.49

Table 3.4 Sieve Analysis of Fine Aggregate

Sieve Size	Weight (gm.)	% Wt.	Cumulative % Wt. Retained
10 mm	12	0.60	0.60
4.75 mm	92	4.60	5.20
2.36 mm	66	3.30	8.50
1.18 mm	294	14.70	23.20
600 micron	284	14.20	37.40
300 micron	844	42.20	79.60
150 micron	306	15.30	94.90
52	2.60	100	

3.1.2. B. Coarse Aggregate

Coarse aggregate are material retain through an IS sieve which is greater than 4.75mm. Coarse aggregate form the main matrix of the concrete. According to IS 383:1970 coarse aggregate, maximum 20 mm coarse aggregate is suitable for concrete work. But where there is no restriction 40 mm or large size may be permitted.

Table 3.5 Properties of Coarse Aggregate

Properties	Value
Specific Gravity	2.67
Water Absorption	0.43%
Los Angles Abrasion Value	23.2%
Crushing Value	25.3%
Impact Value	15.4%
Fineness Module	7.92

Table3.6- Sieve Analysis of Aggregate (20mm)

Sieve Size	Weight retained (gm.)	% wt. Retained	Cumulative % wt. retained
25mm	24	0.48	0.48
20 mm	1520	30.40	30.88
16 mm	1910	38.20	69.08
12.50 mm	1200	24.00	93.08
10 mm	296	5.92	99
4.75 mm	50	1.00	100
2.36 mm	-----	------	100
1.18 mm	-----	------	100
600 micron			100
300 micron			100

Table 3.7- Sieve Analysis of coarse Aggregate (10mm)

Sieve Size	Weight retained (gm.)	% wt. Retained	Cumulative % wt. retained
12.50 mm	128	12.80	12.80
10 mm	290	29.00	41.80
4.75 mm	562	56.20	98.00
2.36 mm	12	1.20	99.20
1.18 mm	8	.80	100
600 micron	---	---	100
300 micron	---	---	100
150 micron	---	---	100

3.1.3 POND ASH

Pond ash from Sipat Power Plant was utilized as a part of this examination. The other outcomes are indicated in Table below.

3.1.3.1chemical property of pond ash

The chemical properties of the pond ash greatly influence the environmental impacts that may arise out of its use/disposal as well as its engineering properties. The adverse impacts include contamination of surface and subsurface water with toxic heavy metals present in the pond ash, loss of soil fertility around the plant sites, etc.

Table 3.8 chemical properties of pond ash

S.No	Chemical Composition of Pond Ash	Compounds % in Pond Ash
1.	SiO_2	37.7-75.1
2.	Al_2O_3	11.7-53.3
3.	TiO_2	0.2-1.4
4.	Fe_2O_3	3.5-34.6
5.	MnO	*BD-0.6
6.	MgO	0.1-0.8
7.	CaO	0.2-0.6
8.	K_2O	0.1-0.7
9.	Na_2O	0.05-0.31
10.	LOI	0.01-20.9

Table 3.9 sieve analysis of pond ash

S. No	Size of Sieve	Wt. Of Retained Particles (gm.)
1.	2.00 mm	0
2.	1.00 mm	2.15
3.	425 micron	28.00
4.	212 micron	120.37
5.	150 micron	75.20
6.	75 micron	132.50
In pan		135.20
Total		= 493.50

Mass Loss During Sieve Analysis
=(500-493.5)/500
=1.3 % (OK if less than 2 %)

3.1.4 LIME

Hydrated Lime is a dry powder obtained by treating Quicklime with enough water to satisfy its chemical affinity for water. Lime is one of man's oldest and most vital chemicals and is often confused with limestone, from which it is derived. Quicklime is manufactured by calcining high quality limestone at elevated temperatures, which causes volatilizing nearly half of the stone's weight as carbon dioxide.

Hydrated Lime in turn is produced by reacting Quicklime with sufficient water to form a dry white powder. Reactions are as follows:
1. Limestone + Heat (800□C) = Calcium Oxide + Carbon Dioxide
$CaCO3 + Heat = CaO+CO2$
2. Quicklime + Water = Calcium Hydroxide + Heat
$CaO+H2O = Ca(OH)2$

Lime is used along with pond ash to increase the strength of concrete.

Table 3.10 Chemical properties of pond ash

Oxide	AS 1672.1-1997 Requirements	Typical analysis %
SiO_2	No requirement	1.8
Al_2O_3	No requirement	0.5
Fe_2O_3	No requirement	0.6
CaO	No requirement	72.0
MgO	No requirement	1.0
Loss on ignition	No requirement	24.0
CO_2	<5%	2.5

Table 3.11 Physical properties

Fineness	Typical fineness is 0.1% retained on a 75micron sieve size and less than 0.05% retained on a 250 micron sieve
Specific gravity	2.2
Bulk density	400-600 kg/m^3

3.1.5 WATER

Accordingly potable water was used for making concrete available in Material Testing laboratory. This was free from any detrimental contaminants and was good potable quality.

3.2 MIX PROPORTIONING FOR ALL SAMPLE

S.No	Sample	Cement%	Pond ash %	Lime%	Remark
1	A1	100	0	0	No Replacement
2	B1	95	5	0	Cement Replaced By 5% Pond Ash and 0% Lime
3	B2	93	5	2	Cement Replaced By 5% Pond Ash and 2% Lime
4	B3	91	5	4	Cement Replaced By 5% Pond Ash and 4% Lime
5	B4	89	5	6	Cement Replaced By 5% Pond Ash and 6% Lime
6	B5	87	5	8	Cement Replaced By 5% Pond Ash and 8% Lime
7	C1	90	10	0	Cement Replaced By 10% Pond Ash and 0% Lime
8	C2	88	10	2	Cement Replaced By 10% Pond Ash and 2% Lime
9	C3	86	10	4	Cement Replaced By 10% Pond Ash and 4% Lime
10	C4	84	10	6	Cement Replaced By 10% Pond Ash and 6% Lime
11	C5	82	10	8	Cement Replaced By 10% Pond Ash and 8% Lime
12	D1	85	15	0	Cement Replaced By 15% Pond Ash and 0% Lime
13	D2	83	15	2	Cement Replaced By 15% Pond Ash and 2% Lime
14	D3	81	15	4	Cement Replaced By 15% Pond Ash and 4% Lime
15	D4	79	15	6	Cement Replaced By 15% Pond Ash and 6% Lime
16	D5	77	15	8	Cement Replaced By 15% Pond Ash and 8% Lime
17	E1	80	20	0	Cement Replaced By 20% Pond Ash and 0% Lime
18	E2	78	20	2	Cement Replaced By 20% Pond Ash and 2% Lime
19	E3	76	20	4	Cement Replaced By 20% Pond Ash and 4% Lime
20	E4	74	20	6	Cement Replaced By 20% Pond Ash and 6% Lime
21	E5	72	20	8	Cement Replaced By 20% Pond Ash and 8% Lime

3.3 TESTS ON SAMPLE AND THEIR RESULT

These tests included determination of slump value, compressive strength at 7 and 28 Days and flexural strength at 7 and 28 Days. Test result has been shown in table below.

Table 3.12 Test results

Sample	Slump Value (mm)	Compressive Strength (N/mm^2) 7Days	Compressive Strength (N/mm^2) 28 Days	Flexural Strength (N/mm^2) 7 days	Flexural Strength (N/mm^2) 28 days
A1	110	22.28	32	6.59	9.58
B1	80	19.83	29.95	4.86	8.20
B2	84	20.30	30.15	5.01	8.85
B3	92	20.95	30.44	5.45	9.00
B4	96	20.10	30.22	5.95	9.40
B5	106	20	30	5.23	8.95
C1	105	18.73	28.77	4.00	7.45
C2	110	19.62	29	4.24	6.65
C3	96	20.13	30.10	4.85	7.35
C4	95	19.95	30	4.55	6.96
C5	115	19.65	29.90	4.10	6.20
D1	85	17.83	26.87	2.55	5.25
D2	95	18.35	27.32	2.85	5.95
D3	90	18.85	28.68	3.00	6.20
D4	115	18.50	28.43	2.64	5.95
D5	110	18.15	28.12	2.20	5.65
E1	105	16.9	24.85	1.5	4.25
E2	110	16.23	25.72	1.95	4.95
E3	95	16.00	25.10	2.80	5.10
E4	95	15.95	24.65	2.20	4.85
E5	115	15.30	24.20	1.90	4.45

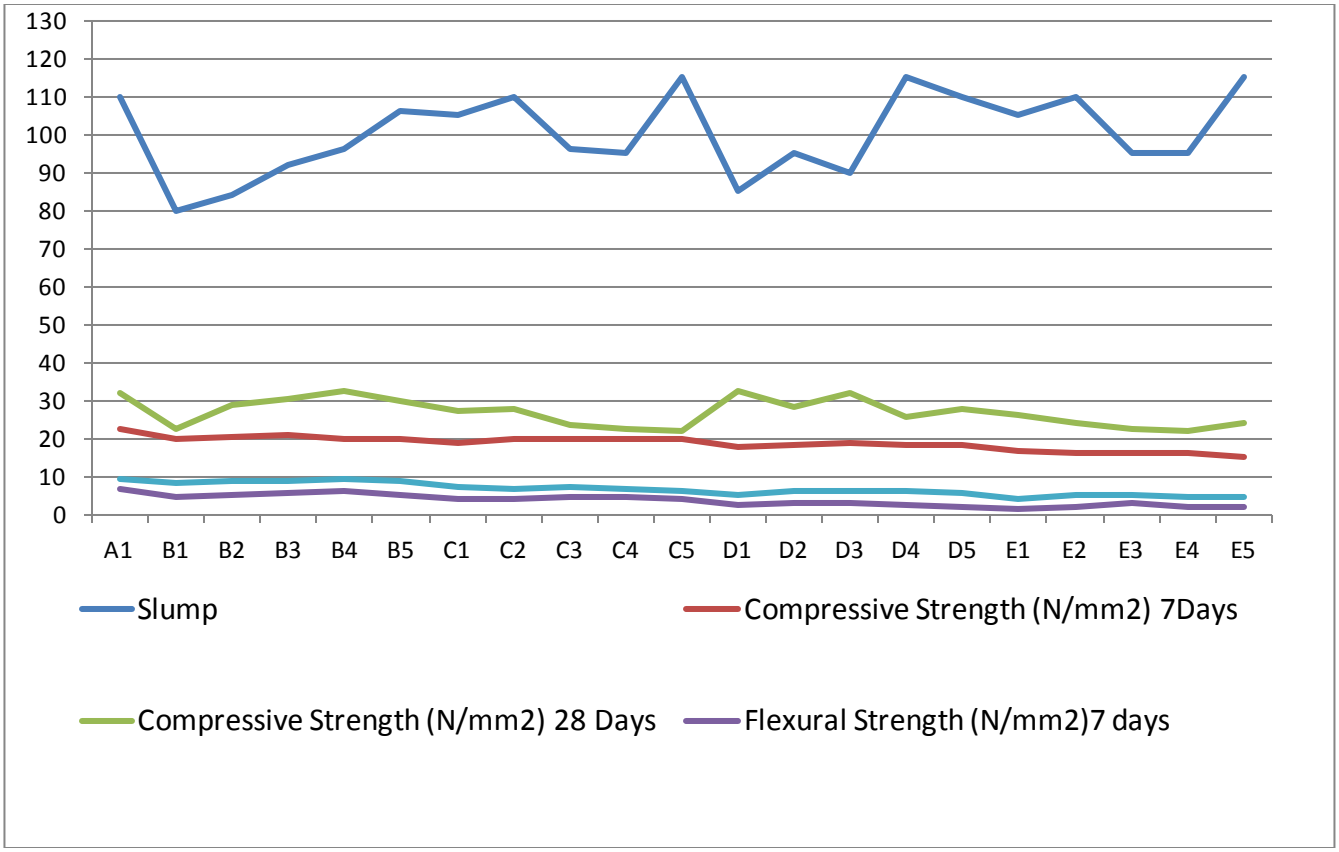

Figure 3.1 Test results

- Slump value war obtained in between 80 to 115 mm.
- No replacement of cement sample was taken as referral concrete taken, its compressive strength are 22.28 and 32 N/mm2 after 7 and 28 days, maximum flexural strength are 6.59 and 9.58 n/mm2 after 7 and 28 days, and slump value are 110mm.
- When cement are replaced by 5% pond ash with different proportion on lime the maximum compressive strength obtain on sample B3 i.e 20.95 N/mm2 and 30.44 N/mm2 after 7 and 28 days, Maximum flexural strength obtain on sample B4 i.e. 5.95 N/mm2 and 9.40 N/mm2 after 7 and 28 days and slump value is maximum on sample B5 i.e. 106.
- When cement are replaced by 10% pond ash with different proportion on lime the maximum compressive strength obtain on sample C3 i.e 20.13 N/mm2 and 30.10 N/mm2 after 7 and 28 days, Maximum flexural strength obtain on sample C3 i.e 4.85 N/mm2 and 7.35N/mm2 after 7 and 28 days and slump value is maximum on sample C5 i.e 115.
- When cement are replaced by 15% pond ash with different proportion on lime the maximum compressive strength obtain on sample D3 i.e. 18.85 N/mm2 and 28.68 N/mm2 after 7 and 28 days, Maximum flexural strength obtain on sample D3 i.e 3.00 N/mm2 and 6.20N/mm2 after 7 and 28 days and slump value is maximum on sample D4 i.e. 115.
- When cement are replaced by 20% pond ash with different proportion on lime the maximum compressive strength obtain on sample E2 i.e 16.23 N/mm2 and 25.72 N/mm2 after 7 and 28 days, Maximum flexural strength obtain on sample E3 i.e 2.80 N/mm2 and 5.10N/mm2 after 7 and 28 days and slump value is maximum on sample E5 i.e. 115.

IV. CONCLUSIONS

The polluting materials like pond ash are effectively used in concrete. Reduction in cost can be achieved due to the utilization of pond ash in concrete .concrete can be used for any structural applications with limitation.The characteristics strength of concrete such as Compressive strength, flexure Strength of concrete mixtures have been studied in the present work by replacing different percentage of cement by pond ash along with lime. Processes are On the basis of present study, following conclusions can be drawn.

Compressive strength

- Compressive strength of all grades of concrete change when different percentage of cement is replaced by a varying proportion of pond ash and lime as compared with referral concrete. But in some proportion there is sudden increase in strength which is nearer to the strength of referral concrete; this is because of the use of lime along with pond ash.
- We can replace 5 to 20 percent of cement by 2 to 8 percent of lime but 9 percent cement is replaced by 5 percent pond ash and 4 percent lime which give less bur nearer strength to referral concrete.
- Test was also carried out to replace 20 percent of cement by pond ash with 4 percent lime but its strength was very lower than referral concrete so it is of no use.
- There is variation in early strength of different sample of concrete when cement is replaced with 5% pond ash along with 0-8% lime up to 0-2% strength decreases than there is sudden increase in strength when lime is added 4-6% .

- There is a trend of increase in later age strength in all the concrete mixtures.

Flexural strength

- Flexural strength of all grades of concrete change when different percentage of cement is replaced by a varying proportion of pond ash and lime as compared with referral concrete. But in some proportion there is sudden increase in strength which is nearer to the strength of referral concrete; This is because of the use of lime along with pond ash.
- We can replace 5 to 20 percent of cement by 2 to 8 percent of lime but 9 percent cement is replaced by 5 percent pond ash and 6 percent lime which give less but nearer strength to referral concrete.
- Test was also carried out to replace 20 percent of cement by pond ash with 4 percent lime but its strength was very lower than referral concrete so it is of no use.
- There is variation in early strength of different sample of concrete when cement is replaced with 5% pond ash along with 0-8% lime up to 0-2% strength decreases than there is sudden increase in strength when lime is added 4-6% .
- There is a trend of increase in later age strength in all the concrete mixtures.

V. SCOPE FOR THE FUTURE WORK

- In the present study 5 to 20 percent replacement of cement has been considered. The other percentages i.e. 30, 40 & 50 percent need investigation with super plasticizer.
- Waste lime has been used for experimental work. This lime needs investigation after calcinations.
- Strength properties of concrete with partial replacement of cement with pond ash and lime need investigation for longer period i.e. 90, 180 and 360days.

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