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IJSRNSC

Volume-7, Issue-3, Jun 2019
Research Paper

www.ijsrnsc.org

Int. J. Sc. Res. in
Network Security
and Communication

ISSN: 2321-3256

Experimental Investigation on the use of Pond Ash in the Concrete

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Received: 03/Jun/2018, Accepted: 21/Jun/2018, Published: 30/Jun/2019

Abstract—The fly Ash generation in Indian thermal power stations is liable to shoot up to 365 Million tons. In India, about 200 million sq.m of land area is covered up with million tonnes of pond ash deposits. Although industry has claimed that fly ash is "neither toxic nor poisonous," this is disputed. To minimize the impact of such waste materials on environment proper management is required. Utilization of the waste materials in different purposes is an effective way of management. The utilization of the pond ash is studied as a construction material. Aim is to find out an effective way to use the pond ash as construction material so as to reduce the impact of the hazardous pond ash on environment and human health. Also finding the ways to efficiently use the pond ash waste in order to preserve our precious resources and reduce or eliminate the need for disposal of industrial waste in landfills. The use of pond ash in concrete and its properties such as compressive strength, particle size distribution, and cementitious nature of a pond ash is studied. The utilization of pond ash in different construction material effectively such that the strength and quality of construction increases but the cost of the construction decreases is studied.

Keywords— *Pond ash, compressive strength, concrete, admixture and fine aggregate*

I. INTRODUCTION

In India the power stations are mostly coal based which requires a huge amount of coal. As the combustion of coal it produces a large amount of ash. Coal ash is commonly divided into two subcategories based on particle size:

a) Fly ash- The most voluminous and well-known constituent is fly ash, which makes up more than half of the coal leftovers. Fly ash particles are the lightest kind of coal ash—so light that they "fly" up into the exhaust stacks of the power plant. Filters within the stacks capture about 99 percent of the ash, attracting it with opposing electrical charges. Fly ash is recyclable. The fine particles bind together and solidify, especially when mixed with water, making them an ideal ingredient in concrete and wallboard. The coal ash versions of these products are actually stronger than those made from virgin materials. The recycling process also renders the toxic materials within fly ash safe for use.

b) Bottom ash- Bottom ash is the coarser component of coal ash, comprising about 10 percent of the waste. Rather than floating into the exhaust stacks, it settles to the bottom of the power plant's boiler. Bottom ash not quite as useful as fly ash, although power plant owners have tried to develop "beneficial use" options, such as structural fill and road-base material. This isn't a good idea, because the bottom ash remains toxic when recycled.

c) Finally, there's boiler slag, the melted form of coal ash that can be found both in the filters of exhaust stacks and the boiler at the bottom. Even this foul sludge has its uses. Boiler slag can be included in roofing shingles and in structural fill.

Fly ash is the by product of thermal power station which requires a large area, suitable method for its disposal. Fly ash is collected by mechanical or electrostatic precipitators from the flue gases of power plant whereas; bottom ash is collected from the bottom of the boilers. (Aditya Verma, Abhishek Kumar et al, 2016)

The fly ash along with pond ash or bottom ash generated by the industries is generally disposed of in an engineered ash pond in a form of slurry in a ratio varying from 1 part ash and 6 to 10 parts of water which are situated within few kilometres distance from the power plant. This is why it is called pond ash. (Gourav Dhane, Arvind Agnihotri et al, 2014)

After the drying of that slurry clinkers are formed that can be collected as pond ash. In the pond ash the dissolvable alkalis present are washed with water. The metal oxides, sulphur, siliceous & aluminous materials with less pozzolonic properties than fly ash, are some main constituents of pond ash. (Prashant G. Sonawane, Dr. Arun Kumar Dwivedi, 2013)

Coal Ash Ponds: Impoundments created near the power plant to store or dispose of ash from combustion of coal. Ash solids settle, leaving water at the surface to be recycled or discharged.

An ash pond is an engineered structure for the disposal of bottom ash and fly ash. The wet disposal of ash into ash ponds is the most common ash disposal method, but other methods include dry disposal in landfills. Dry-handled ash is often recycled into useful building materials. Wet disposal has been preferred due to economic reasons, but increasing environmental concerns regarding leachate from ponds has decreased the popularity of wet disposal.

Fly ash affects the environment polluting soil, water, and air. This has detrimental effect on human health and the quality of life in the surrounding area. The over land disposal into ash ponds is responsible for leaching heavy metals into the ground water and possible transmission of trace metals into food chain, though as a whole fly ash is not included in the hazardous waste group. Fly ash collected through hoppers has been widely accepted as pozzolonic and is being used by the construction industry. Pond ash being coarser and less pozzolonic is not being used, or more importantly in places where the fine aggregate is pond ash accumulation posing contaminated with harmful chemicals such as sulphates and chlorides and environmental problems (P. P. Bhangale, P. M. Nemade 2013)

With rapid industrialization growth, the industrial activities are producing a large quantity of waste materials. Such wastes are hazardous for health and environment. The pond ash contents crystalline silica and lime along with toxic chemicals represent exposure risks to human health and the environment. Although industry has claimed that fly ash is "neither toxic nor poisonous," this is disputed. Exposure to fly ash through skin contact, inhalation of fine particulate dust and ingestion through drinking water may well present health risks. Fly ash contains crystalline silica which is known to cause lung disease, in particular silicosis. Crystalline silica is listed by the IARC and US National Toxicology Program as a known human carcinogen. Lime (cao) reacts with water (H_2O) to form calcium hydroxide [Ca $(OH)_2$], giving fly ash a ph somewhere between 10 and 12, a medium to strong base. This can also cause lung damage if present in sufficient quantities.

Material Safety Data Sheets recommend a number of safety precautions be taken when handling or working with fly ash. These include wearing protective goggles, respirators and disposable clothing and avoiding agitating the fly ash in order to minimize the amount which becomes airborne. The National Academy of Sciences noted in 2007 that "the presence of high contaminant levels in many CCR (coal combustion residue) leachates may create human health and ecological concerns." To minimize the impact of such waste materials, proper management is required. Utilization of the waste materials in different purposes is an effective way of management. The waste materials such as fly ash (FA), pond ash (PA), scrap tire, and rice husk ash (RHA) are generated in bulk and their utilization for general purposes becomes difficult and challenging. Such wastes can be used in large quantities for civil engineering construction.

In India 200 million sq.m. Of land area is covered up with million tonnes of PA deposits. The production of leachate compounds from the ash ponds leads to the contamination of the groundwater and surface water bodies as well as soil, because of the presence of toxic elements and heavy metallic substances within them. The engineering properties of PA can be improved using various techniques among which the incorporation of lime/cement in the PA by mechanical mixing has been found to be the most reliable approach.

The fly Ash generation in Indian thermal power stations is liable to shoot up to 365 Million tons. A small percentage i.e. 8% to 10% of fly ash is being used in India while in other countries the percentage of utilization is 30% to 80%. (Sofi & Phanikumar, 2015)

The use of technogenic waste in addition to saving material and natural resources protects the environment. Therefore, during the design phase of the construction of the object should be possible to use a man-made waste. At the same time, once made a focus on the environmental aspect, you need carefully to select building materials.

II. THEORETICAL ASPECT

A. Chemical Composition of Pond Ash

Since, pond ash is the residue after combustion of coal in thermal power plants, so its properties depends upon the coal used and may vary from one power plant to other power plant. It can be further seen in Table 1 that silica content in Pond ash is very high. Such high content of silica is reason for the pozzolonic activity up to some extent. (Ghosh et al. 2004, Sarkaret al. 2012, Sonawane and Dwivedi 2013)

Table No. 1: Chemical Property of Pond Ash

Constituent Value (%)	Value (%)
Silica (sio2)	50.5 – 67.4
Alumina (Al2O3)	1.38 – 25
Iron Oxide (Fe2O3)	0.71 – 9.81
Calcium Oxide (cao)	2.7 - 9.73
Magnesium Oxide (mgo)	0.45 – 4.18
Sulphur (SO3)	0.06 – 0.3
Loss on Ignition(LOI)	8.22 – 10.53

B. Physical Properties of Pond Ash

It can be observed from the Table 2(Ghosh et al. 2004, Sarkaret al. 2012, Sonawane and Dwivedi 2013, Kumar and Rajasekhar 2009) that specific gravity of pond ash is less as compared to the specific gravity of soil particles.

Table No.2: Physical property of Pond Ash

Property	Range of Values
Grain Size Distribution: Gravel (%)	0

Sand (%)	72-95
Fines (%): (a) Silt (%) (b) Clay (%)	 5-30 0-25
Consistency: Liquid limit (%) Plastic limit (%) IS Classification Specific Gravity	 Non Plastic Non Plastic SP-SM 2.0-2.4
Compaction Characteristics : Optimum moisture content (%) Maximum dry density (MDD) (g/cc) Angle of shearing resistance(deg) California bearing ratio (%) Coefficient of permeability (cm/s)	 14-37 1.3-1.4 28-36 1.3-12.2 2 x 10-6to 3.6 x 10-5

III. MATERIALS, METHODOLOGY AND RESULTS

A. Materials Used

For this project, various materials have been used, and all the materials have been tested. Test conducted are briefly discussed on all materials. The list of the materials is as follows:

a. Cement: Ambuja Ordinary Portland Cement (OPC) with grade -53
b. Course aggregate
c. Sand
d. Pond-ash: Pond ash collected from Rattan India Power Ltd, Nandgaonpeth, Amravati
e. Admixtures
f. Fiber: 100 % virgin fibrillated poly fibres were used.
g. Water

B. Methodology

Physical properties of the materials are determined as follows:

Physical properties of coarse aggregate were determined as follows:

i. Sieve analysis-

Table No.3: Sieve analysis of coarse aggregate

IS Sieve size (mm)	Weight retained (gm)	Percentage Weight retained (gm)	Cumulative percentage weight retained	Percentage passing
40	-	-	-	-
20	425	21.25	21.25	78.75
12.2	1340	67	88.25	11.75
10	200	10	98.25	1.75
4.75	35	1.75	100	0
Pan	-	-	-	-
Total	2000	-	-	-

ii. Specific gravity - 2.93

iii. Bulk density - 1.45 g/cc

iv. Water absorption - 2%

Physical properties of fine aggregate were studied as follows:

i. Sieve Analysis

Table No.4: Sieve analysis of fine aggregate

IS Sieve size	Weight retained (gm)	Percentage Weightretained (gm)	Cumulative percentage weight retained	Percentage passing
4.75 mm	39	7.8	7.8	92.2
2.36 mm	65	13	20.8	79.2
1.18 mm	90	18	38.8	61.2
600 mic	124	24.8	63.6	36.4
425 mic	132	26.4	90	10
300 mic	16	3.2	93.2	6.8
150 mic	18	3.6	96.8	3.2
75 mic	5	1	97.8	2.2
Pan	11	2.2	-	0
Total	500			

ii. Specific gravity - 2.66

iii. Bulk density - 1.70 g/cc

Physical properties of pond ash were studied as follows:

i. Sieve Analysis

Table No.5: Sieve Analysis of Pond Ash

IS Sieve size	Weight retained (gm)	Percentage Weight retained (gm)	Cumulative percentage weight retained	Percentage passing
4.75 mm	6	1.20	1.20	98.8
2.36 mm	35	7.00	8.2	91.8
1.18 mm	124	24.80	33	67
600 mic	239	47.80	80.8	19.2
425 mic	88	17.60	98.4	1.6
300 mic	0	0	98.4	1.6
150 mic	6	1.20	99.60	0.4
75 mic	1	0.2	99.80	0.2
Pan	1	0.2	100	0
Total	500	-	-	-

ii. Specific gravity - 2.3

iii. Bulk density - 1.01 g/cc

C. Mix Proportioning:

The mix proportion is designed according to the IS 10262-2009. The mix designing procedure was based upon above results of physical analysis of the materials cement, coarse aggregate and fine aggregate. Weigh batching was used for the entire casting. The mix proportion is designed as **1:1.5:3.12** and water cement ratio (W/C) is assumed as **0.5**

The quantity of material required for one cubic meter is as follows:
Cement = **385.5** kg
Fine aggregate = **578.5** kg
Coarse aggregate = **1203** kg

The pond ash was used as a replacement to the quantity of fine aggregate in the above mix proportion. Different proportions were used by replacing the fine aggregate by 0%, 15%, 20%, and 25% pond ash. This mix proportions are calculated as below and named as M0, M1, M2, and M3 respectively.

Table No.6: Concrete mix proportions with 15%, 20%, 25% pond ash

Mix Designation	Pond ash fraction of fine aggregate	Cement (kg)	Pond ash (kg)	Fine aggregate (kg)	Course aggregate (kg)	Water (ltr)
M0	0%	385.5	-	578.5	385.5	192.75
M1	15%	385.5	86.775	491.725	1203	192.75
M2	20%	385.5	115.7	462.8	1203	192.75
M3	25%	385.5	144.625	433.875	1203	192.75

D. Sampling:

Preparation of 150mmX150mmX150mm cubic moulds

1) Take 3 moulds of size 150mmX150mmX150mm
2) Apply grease or oil on the inner surface of the moulds for the easy removal of the cubes after 24 hours.
3) Fill the freshly prepared concrete mix in the empty moulds in three layers and after each layer, tamping should be done with the help of standard tamping rod by means of 35 blows.
4) Repeat the same procedure for the remaining two layers and level the concrete at the top of the mould by means of trowel and give proper identification mark of the specimen.
5) After this, keep the mould for 24 hours as it is for drying purpose and remove the cubes from the mould after 24 hours and put them for curing.

Preparation of 150mmX150mmX700mm beam specimen

1) Take 3 moulds of size 150mmX150mmX700mm
2) Apply grease or oil on the inner surface of the moulds for the easy removal of the cubes after 24 hours.
3) Fill the freshly prepared concrete mix in the empty moulds in three layers and after each layer, tamping should be done with the help of standard tamping rod by means of around 90 blows.
4) Repeat the same procedure for the remaining two layers and level the concrete at the top of the mould by means of trowel and give proper identification mark of the specimen.
5) After this, keep the mould for 24 hours as it is for drying purpose and remove the cubes from the mould after 24 hours and put them for curing.

IV. RESULTS

A. Partial Replacement Of Fine Aggregate By Pond Ash:

The 7 days compressive strengths of specimen M0, M1, M2, M3 were tested. Due to shortage of time 14 days and 28 days compressive strength could not be tested. Hence, 14 days and 28 days compressive strength were from the 7 days compressive strength. The compressive strength gained at 7 days is 65%, at 14 days is 90%, and at 28 days is 99%. The results are as follows:

Table No.7: Compressive testing results

Mix Designation	Pond ash fraction of fine aggregate	Cube no.	7 days compressive strength (N/mm^2)	Compressive strength in N/mm^2		
				Average7 days Strength	14 days Strength	28 days Strength
M0	0%	1st	33.53	28.97	40.11	44.12
		2nd	25.08			
		3rd	28.31			
M1	15%	1st	22.44	14.23	19.70	21.67
		2nd	6.028			
		3rd	14.22			
M2	20%	1st	24.33	22.32	30.90	33.99
		2nd	19.316			
		3rd	23.32			
M3	25%	1st	21.78	15.51	21.47	23.62
		2nd	18.612			
		3rd	6.16			

(A)

(B)

Fig No. 1: (a),(b) failure of blocks after testing

According to the above results average 7 days compressive strength of M2 mix designation is highest 22.32 N/mm2 is with 20% replacement of fine aggregate with pond ash. Also, for the same specimen the 14 days compressive strength is found to be 30.90 N/mm2 and 28 days compressive strength is found to be 33.99 N/mm2. This (M2) mix designation with 20% of replacement is used for the further study.

B. Use of Plasticizers In Pond Ash Replaced Concrete:

Different plasticizers were used with different doses along with 20% replacement of fine aggregate with pond ash. To determine the effect of different plasticizers on the strength and workability of pond ash replaced concrete.

i. PERMA PLAST SUPER 210

It is a super plasticizing, low dosage, naphthalene formaldehyde based product. The recommended dosages were 100 to 300 gm per 50 kg bag of a cement. The compressive strength and workability test results of pond ash replaced concrete with different dosage are as follows:

Table no.8: compressive strength and slump results

Dose (gm)	7 days compressive strength (N/mm^2)	Compressive strength in N/mm^2			Slump (mm)
		Average 7days Strength	14 days Strength	28 days Strength	
100	17.6	18.06	25.00	27.51	80
	18.52				
	18.06				
200	16.06	15.11	20.92	23.01	130
	14.168				
	15.10				
300	13.20	15.05	20.84	22.92	150
	16.89				
	15.06				

From the above results, the highest 7 days average compressive strength came out to be 18.06 N/mm^2, for dosage of 100gm per 50 kg bag of cement. Also, the 14 days compressive strength is found to be 25 N/mm^2 and 28 days compressive strength is found to be 27.51 N/mm^2 for the same. The slump is 80mm for the 100gm dose and increased to 130mm and 150mm when dose are increased but the strength decreased to 23.01 N/mm^2 and 22.92 N/mm^2 respectively.

ii. PERMA RHEO PLAST

Perma Rheo Plast is hyper plasticising sulphonated synthetic naphthalene polymer. Recommended dosages were 0.3 to 2% by Weight of a cement depending upon the type of cement required. The compressive strength results and workability for these dosages are found out as following:

Table No.9: compressive strength test and slump results

Dosage (%)	7 days compressive strength (N/mm^2)	Compressive strength in N/mm^2			Slump (mm)
		Average7days Strength	14 days Strength	14 days Strength	
0.2	20.37	17.38	24.06	26.47	80
	14.39				
	17.38				
1	13.33	14.39	19.92	21.91	130
	15.44				
	14.4				
2	12.58	13.07	18.09	19.90	150
	13.56				
	13.07				

From the above results, the highest average 7 days compressive strength came out to be 17.38 N/mm^2, for dosage of 0.2% . Also, the 14 days compressive strength is 24.06 N/mm^2 and 28 days compressive strength is 26.47 N/mm^2 for the same. The slump is 80mm for the 0.2% dose and increased to 130mm and 150mm when dose are increased but the strength decreased to 21.91 N/mm^2 and 19.90 N/mm^2 respectively.

iii. PERMA PLAST BP

It is hyper plasticising sulphonated synthetic polymers. Recommended dosages were 0.5 to 1.5% by Weight of cement depending upon the type of cement required. The results are as following:

Table No.10: compressive strength test and slump results

Dosage (%)	7 days compressive strength (N/mm^2)	Compressive strength in N/mm^2			Slump (mm)
		Average 7days Strength	14 days Strength	28 days Strength	
0.5	9.72	10.19	14.12	15.52	130
	10.65				
	10.02				
1	11.84	12.03	16.65	18.32	130
	12.19				
	12.06				
1.5	8.67	7.83	10.84	11.92	130
	7.10				
	7.72				

From the above results, the highest average 7 days compressive strength came out to be 12.03 N/mm², for dosage of 1%, the 14 days strength for the same is 16.65 N/mm² and 28 days strength is 18.32 N/mm². The slump found out to be 130mm for all doses.

iv. DYNAMON SR 500R-

This plasticizer was used in a single dosage of 0.8% by weight of a cement. The results are as following:

Table No. 11: compressive strength test

CUBE NO.	7 DAY COMPRESSIVE STRENGTH (N/MM²)	Compressive strength in N/mm²		
		Average 7days Strength	14 days Strength	28 days Strength
1st	25.696	26.237	36.33	39.96
2nd	28.500			
3rd	24.516			

The average 7 days compressive strength found out to be 26.237 N/mm². The 14 days and 28 days strength are 36.33 N/mm² and 39.96 N/mm² respectively. The slump was found out to be 150mm.

C. *Use of Fiber in Pond Ash Replaced Concrete:*

PERMA RE-CON FIBRES

100% virgin fibrillated poly fibres were used with 20% replacement of fine aggregate with pond ash. The recommended dosage is 150gm per 50 kg bag of cement. To determine the effect of fibres on the compressive strength of pond ash replaced concrete.

Table No. 12: compressive strength result

CUBE NO.	7 DAY COMPRESSIVE STRENGTH (N/MM²)	Compressive strength in N/mm²		
		Average 7days Strength	14 days Strength	28 days Strength
1st	19.04	18.45	25.55	28.10
2nd	18.67			
3rd	17.74			

The average 7 day compressive strength was found to be 18.45 N/mm². The 14 days and 28 days strength are 25.55 N/mm² and 28.10 N/mm² respectively.

D. *Combined Use of Plastisizer and Fibre in Pond Ash Replaced Concrete:*

100% virgin fibrillated poly fibres were used with 20% replacement of fine aggregate with pond ash. The recommended dosage is 150gm per 50 kg bag of cement. Dynamon SR 500R plasticizer was used in a dosage of 0.8% by weight of a cement. Compressive test was conducted , result are as follows:

Table No. 13: compressive strength result

CUBE NO.	7 DAY COMPRESSIVE STRENGTH (N/MM²)	Compressive strength in N/mm²		
		Average 7days Strength	14 days Strength	28 days Strength
1st	26.2	26.78	37.08	40.78
2nd	28.34			
3rd	25.8			

The average 7 day compressive strength was found to be 26.78 N/mm². The 14 days and 28 days strength are 37.08 N/mm² and 40.78 N/mm² respectively.

V. ESTIMATE:

The estimate of concrete required for the construction of residential building with 20% replacement of fine aggregate with pond ash.

A. *Rate Analysis:*

Rate analysis for R.C.C work in beam, slab (1:1:2) for 10 cu.m.

Calculation of material:

Assumed wet volume of RCC is 10 cu.m ;

Dry volume = 52% more of wet volume

Dry volume = 15.2 cu. m

i. Volume of cement = 2.8 cu. m
   Number of bags = 109 bags
ii. Volume of sand = 3.8 cu.m
iii. Volume of aggregate= 7.6 cu.m.
iv. Volume of steel reinforcement about 1% of wet volume of R.C.C
   Quantity of steel = 0.1 cu.m.
   Weight of steel = 0.1 x 7850 = 785 kg = 0.785 tonne
   Binding wire = 10kg per tonne = 10x 0.785 = 8 kg (approx)

Table No. 14: Rate Analysis of Materials

Sr. No.	Material	Quantity	Unit	Rate	Amount
1	Cement	109	Bags	320	34,880
2	Sand	3.8	M³	2400	9120
3	Aggregate	7.6	M³	1800	13,680
4	Steel	0.785	Tone	35000	27,475
5	Binding wire	8	Kg	70	560
				Total	**85,715**

Rate analysis for R.C.C work in beam, slab (1:1.5:3.12) for 10 cu.m. with 20% pond ash replaced concrete of M25 grade

Calculation of material:

Assumed wet volume of RCC is 10 cu.m ;

Dry volume = 52% more of wet volume

Dry volume = 15.2 cu. m

i. Volume of cement = 2.704 cu. m
   Number of bags = 78 bags
ii. Volume of sand = 4.056 cu.m

Volume of pond ash =0.811

iii. Volume of sand = 3.245

iv. Volume of aggregate= 8.438 cu.m.

v. Volume of steel reinforcement about 1% of wet volume of R.C.C

Weight of steel = 0.1 x 7850 = 785 kg = 0.785 tonne

Binding wire = 10kg per tonne = 10x 0.785 = 8 kg (approx)

Table No. 15: Rate Analysis of Materials

Sr. No.	Material	Quantity	Unit	Rate	Amount
1	Cement	78	Bags	320	24,960
2	Sand	3.245	M^3	2400	7,788
3	Pond Ash	-	M^3	-	-
4	Aggregate	8.438	M^3	1800	15,188
5	Steel	0.785	Tone	35000	27,475
6	Binding wire	8	Kg	70	560
				Total	**75,971**

From the above estimate, we save up to rs. 9,744 in material cost per 10 cu. m. of concrete work done with 20% replacement of fine aggregate with pond ash.

Now, the estimate of concrete required for the construction of residential building with 25% replacement of fine aggregate with pond ash,

Rate analysis for R.C.C work in beam, slab (1:1.5:3) for 10 cu.m.

Calculation of material:

Assumed wet volume of RCC is 10 cu.m ;

Dry volume = 15.2 cu. m

i. Volume of cement = 2.763 cu. m

Number of bags = 79 bags

ii. Volume of sand = 4.415 cu.m

iii. Volume of aggregate= 8.290 cu.m.

iv. Volume of steel reinforcement about 1% of wet volume of R.C.C

Quantity of steel = 0.1 cu.m.

Weight of steel = 0.1 x 7850 = 785 kg = 0.785 tonne

Binding wire = 10kg per tonne = 10x 0.785 = 8 kg (approx)

Table No. 16: Rate Analysis of Materials

Sr. No.	Material	Quantity	Unit	Rate	Amount
1	Cement	79	Bags	320	35.280
2	Sand	4.415	M^3	2400	10,596
3	Aggregate	8.290	M^3	1800	14,922
4	Steel	0.785	Tone	35000	27,475
5	Binding wire	8	Kg	70	560
				Total	**88,833**

Rate analysis for R.C.C work in beam, slab (1:1.5:3.12) for 10 cu.m. with 25% pond ash replaced concrete of M20 grade

Calculation of material:

Assumed wet volume of RCC is 10 cu.m ;

Dry volume = 15.2 cu. m

i. Volume of cement = 2.704 cu. m

Number of bags = 78 bags

ii. Volume of sand = 4.056 cu.m

Volume of pond ash =1.014

iii. Volume of sand = 3.042 cu. m

iv. Volume of aggregate= 8.438 cu.m.

v. Volume of steel reinforcement about 1% of wet volume of R.C.C

Weight of steel = 0.1 x 7850 = 785 kg = 0.785 tonne

Binding wire = 10kg per tonne = 10x 0.785 = 8 kg (approx)

Table No. 17: Rate Analysis of Materials

Sr. No.	Material	Quantity	Unit	Rate	Amount
1	Cement	78	Bags	320	24,960
2	Sand	3.245	M^3	2400	7,300
3	Pond Ash	-	M^3	-	-
4	Aggregate	8.438	M^3	1800	15,188
5	Steel	0.785	Tone	35000	27,475
6	Binding wire	8	Kg	70	560
				Total	**75,483**

From the above estimate, we save up to rs. 13,350 in material cost per 10 cu. m. of concrete work done with 25% replacement of cement.

From the sieve analysis performed on pond ash and fine aggregate, the particle size distribution of pond ash found out to be similar to the particle size distribution of fine aggregate. The particle size distribution curve is given below:

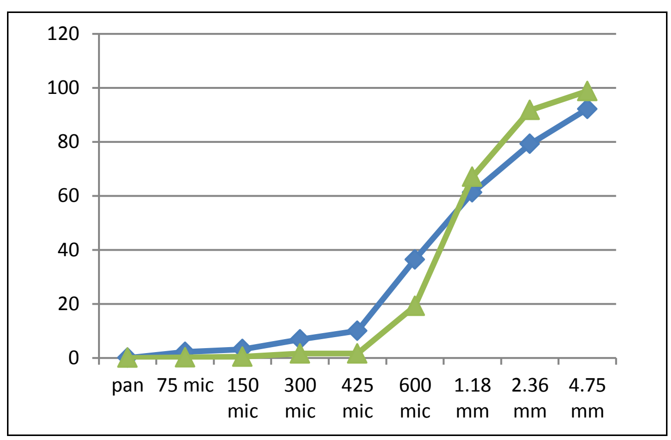

Figure No. 2: Particle size distribution of pond ash and fine aggregate

From the results, it can be seen that for 20% replacement of fine aggregate with pond ash, maximum compressive strength of 33.99 N/mm^2 for 28 days is achieved. The second highest strength we achieved for 25% replacement of fine aggregate which is 23.62 N/mm^2

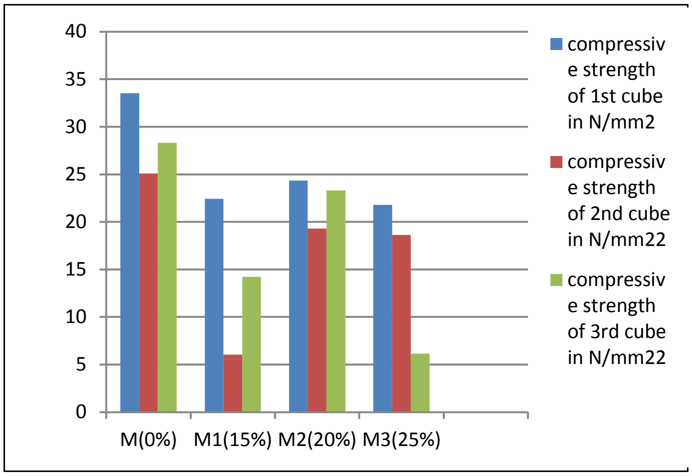

Figure No. 3: Bar graph of compressive strength in N/mm^2

M2 specimen with 20% pond ash replacement where targeted strength was 20 N/mm^2 gained 22.32 N/mm^2 of a compressive strength in only 7 days, and its 28 days strength was nearly of M30 grade concrete. Also, 25% replacement concrete has compressive strength nearly greater than M25 grade concrete.

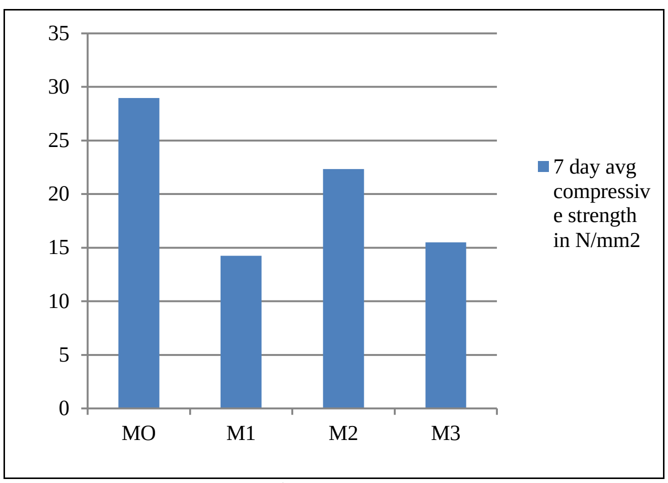

Figure No. 4: Bar Graph of average compressive strength

From the results, the super plasticizer Perma Plast Super 210 gives the highest compressive strength of 27.51 N/mm^2 among the three Perma Plasticizers. The dose of 100gm per bag of cement of Perma Plast Super 210 gives the highest compressive strength and medium workability for pond ash replaced concrete.

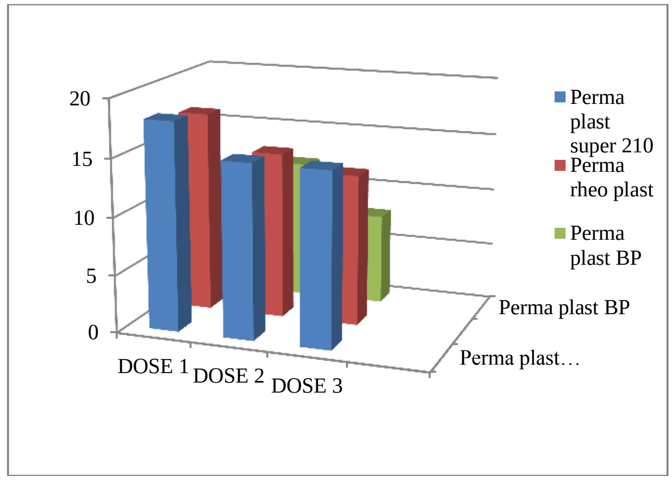

Figure No.5: Comparative bar graph of compressive strength using different plasticizers

VI. CONCLUSIONS

1) Pond ash can be used as replacement of fine aggregate in concrete.

2) If the percentage of pond ash increases, there is decrease in the compressive strength as well as workability of concrete decreases with the increase in percentage of pond ash , hence use of plasticizer is necessary.
3) To achieve the workability which was reduced when pond ash was added, we used plasticizer Dynamon SR 500R which increased the workability as well as the compressive strength of the concrete with 20% replacement from 33.99 N/mm^2 to 39.96 N/mm^2. Hence, we can use this as a M35 grade concrete and can be used in commercial construction.
4) For the construction of residential building having up to G+1 floor, replacement of up to 25 % can be done as it gives strength enough as M20 grade concrete, and the cost of materials required reduces considerable as 13,350 Rs. Per 10 m^3 .
5) For the construction of buildings higher than G+1 such as 3-4 story buildings, 20% replacement of pond ash can be done, to gain the strength of M 30 grade concrete, this is less economical than 25 % replacement but still saves up to 9,744 Rs. Per 10 m^3 of a material cost, which ultimately make the construction economical as quantity required for 4 story building is more.

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