Effect Of Chloride Environment On PPC Concrete Made Using Fly Ash And Pond Ash

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***Abstract*—This paper presents the results of an experimental investigation carried out to explore the possibility of using fly ash and pond ash in concrete exposed in chloride environment. Specimens were cast and tested to determine their compressive strength replacing 10 percentage Portland Pozzolana Cement with fly ash and 15 percentage fine aggregate with pond ash individually. Specimens were cured in normal tap water as well as aggressive 5 percentage chloride solution up to 150 days. Test result showed that by addition of fly ash and ponded as partial replacement of PPC and fine aggregate respectively, improved compressive strength can be achieved as compared to referral conventional concrete both in tap water as well as in chloride environment at all the ages**

Keywords—Fly ash, pond ash, compressive strength, chloride effect.

I. INTRODUCTION

The history of using cement for making concrete is quite old. It is a binder which is used for the setting of other materials strength together for making concrete. The strength and durability of concrete is frequently experienced. It can be easily prepared from the readily available materials and its durability is quite remarkable. Hence it is widely used in construction field. Due to rapid advancement and increasing population, the demand of cement is increasing day by day. However there is emission of approximately same amount of CO_2 gas while production of cement. To meet this huge requirement and to control the emission of harmful gases, uses of several recycled products such as fly ash, pond ash etc have been initiated. Fly ash is the residual part left after combustion of coal in thermal power plants consisting of very fine particles, which are obtained and is collected by precipitators in dry form and possess good pozzolanic properties. Fly ash forms up to 3/4th of the total ash. Fly ash concrete has ability to moderate early setting time. Fly ash concrete is less permeable, has appreciable durability and is much economical and less susceptible than conventional concrete. Pond ash is the residue consisting of coarser particles and is obtained from the combustion of coal in large thermal power plants. Pond ash is composed of clustered ash particles which are too heavier, so they can't be carried along with flue gases and gets deposited at the bottom of the furnace. Pond ash forms up to 1/4th part of the total ash. It possess minimal or very little pozzolanic properties.

This study presents the performance of concrete in which cement was partially replaced by fly ash and fine aggregate was replaced partially by ponded ash individually. Addition of fly ash and pond ash was suitably done knowing the optimum content of replacement in the process of making concrete. The effect of chloride environment on PPC concrete using fly ash and pond ash was observed.

Mukherjee et al (2012) carried out an experimental investigation to study the physical and mechanical property of high volume fly ash cement paste. Ordinary Portland cement was replaced by 20, 30, 40, 50, 60 and 70 % class F fly ash (by weight) at w/b ratio of 0.30. Bulk density is reported to decrease with fly ash increment in the mixture. Apparent porosity and water absorption value increased with replacement of cement by fly ash. Results confirm the decrease in compressive strength at 3, 7 and 28 day with fly ash addition and it is more prominent in case of more than 30% fly ash content mixes. Mukherjee et al (2013) reported that the zero slump concrete shows higher compressive strength compare to workable concrete with super plasticizer up to 60% replacement with fly ash. The strength gain with time is higher compared to the OPC concrete at all replacement level of cement by fly ash and the optimum strength gain was noted at 70% replacement at 28 days. Kumar investigated the effect of addition of pond ash on the workability of concrete for 20, 40, 60 and 80% replacement of fine aggregate with ponded ash and with extra cement and water added to restore workability. (Ranganath et al), in their study on pond ash has shown that particles below 45um have a positive influence on the strength of cement concrete at 10% and 20% replacement of cement and concluded that pond ash contains both reactive small particles and non-reactive or poorly reactive large particles.

Horsakulthai and Paopongpaiboon (2013) reported that 7,28 and 90 days test results of chloride ion permeability of concrete by replacing 20, 40 and 60% of the cement content with coarse fly ash and found that in order to reduce the chloride ion permeability, 40% is the optimum replacement level of the cement. Siddqique et al (2003) studied the effects of furnace ponded ash on workability, compressive strength and chloride penetration of concrete were. The natural sand was replaced with furnace pond ash by 30, 50, 70 and 100% by mass at fixed free w/c ratio of 0.45

and 0.55 and cement content of 383kg/m^3. The result showed increase in workability of concrete and decreased compressive strength was observed. However the chloride transport coefficient decreased with the increase of replacement level up to 50%, beyond which it increases.

II. MATERIALS AND METHODOLOGY

A. Cement –

In this investigation, Birla Gold Portland Pozzolana cement was used, which is obtained from single batches and the test conducted on the cement are tabulated in table.1

Table1. *Properties of Cement*

Standard Consistency	31%
Initial Setting Time	240 minutes
Final Setting Time	315 minutes
7 days Compressive Strength	33 N/mm^2
28 days Compressive Strength	44 N/mm^2
Specific Gravity	2.72

B. Coarse aggregate –

Graded coarse aggregate from local available quarry of two different sizes were used in this investigation, one fraction was passing through 20mm sieve and another fraction was passing through 10mm sieve. The specific gravity of coarse aggregate was 2.66 for both fractions. The properties of coarse aggregate are given in table 2.

Table2. *Properties of Coarse Aggregate*

Fineness Modulus of 10 mm Aggregate	6.9
Fineness Modulus of 20 mm Aggregate	7.7
Water Absorption	0.8
Specific Gravity	2.6

C. Fine aggregate –

Local available river sand was used as fine aggregate, which was sieved for removing deleterious materials and over size particles. The properties of fine aggregate are given in table 3.

Table.3 *Physical properties of fine aggregate*

Specific gravity	2.2
Fineness modulus	2.84
Moisture content	2.2

D. Fly ash –

In the present study, the fly ash obtained from the NTPC, Tanda, U.P was used. The physical and chemical properties are shown in table 4

Table.4 *Properties of fly ash*

Color	Grey
% Passing	76 %
Size of particle	0.002-0.30 mm
Maximum dry density	1.183 g/cc
Optimum moisture content	22 %
Specific gravity	2.02 at 27^{0}c
Plastic limit	Non plastic
Classification	Class C and class F

E. Pond ash –

Pond ash obtained from NTPC, Tanda, U.P was used in this investigation. The specific gravity of ponded ash was found 1.65 and fineness modulus was 2.76.

F. Concrete –

The concrete mix design was done in accordance with IS 10262(1982). The cement content used in the mix design is taken as 380 kg/m^3 which satisfies minimum requirement of 300 kg/m^3 in order to avoid the balling affect. Good stone aggregate and Natural River sand of Zone-II were used as coarse and fine aggregate respectively. Maximum size of coarse aggregate was 20mm. A sieve analysis conforming to IS 383-1970 was carried out for both the fine and coarse aggregates. Potable water is used for mixing and curing. The water cement ratio (w/c) used was 0.42.

M 25 grade of concrete was used in this investigation and fine aggregate was kept as 50% of the total volume of aggregate. Slump test was done to check the workability of concrete

78 control specimens (78 cubes) of 100x100x100mm were casted to determine the compressive strength at 7, 28, 90 and 150 days interval respectively.

The resulting mix proportion of cement, fine aggregate and coarse aggregate was taken as 1:1.53:3 with water cement ratio of 0.42 and the quantity of cement is 380 kg/m^3. Compressive strength of cubes has been determined as per IS 516-1959 at a loading rate of about 140 kg/cm^2/min (about 30 tones per minute) on 2000 tons AIMIL. Two dial gauges in diametrically opposite direction were used to measure the deflection. Compression testing machine shown in fig 3.

III. RESULT AND DISCUSSION

A. Workability–

The strength and durability of concrete very much depends upon the workability of concrete. To measure the workability of concrete, slump test was done. Slump test is very popular and simple and used to measure the consistency of freshly made concrete under the action of gravity. By performing slump test, it was observed that the workability of concrete decrease as replacement level increases. Hence a dose of super plasticizer was added suitably as per the requirement. KEM SUPLAST 101 S super plasticizer was used in this study. It was an aqueous solution of sulphonated naphthalene and manufactured by Chembond Chemicals.

The slump value of concrete at the optimum replacement of cement with fly ash and fine aggregate with ponded ash at a constant dose of super plasticizer (i.e. at 0.8% by weight of cement and fine aggregate individually) is shown in table 5 .

Fig.1 *Workability measured by slump test*

Table.5. *Workability of concrete*

Sample Designation	Replacement (%)	Dose of Super Plasticizer (%)	Slump Value(mm)
W0	0	0.8	45
W1	10(cement with fly ash)	0.8	30
W2	15(fine aggregate with pond ash)	0.8	20

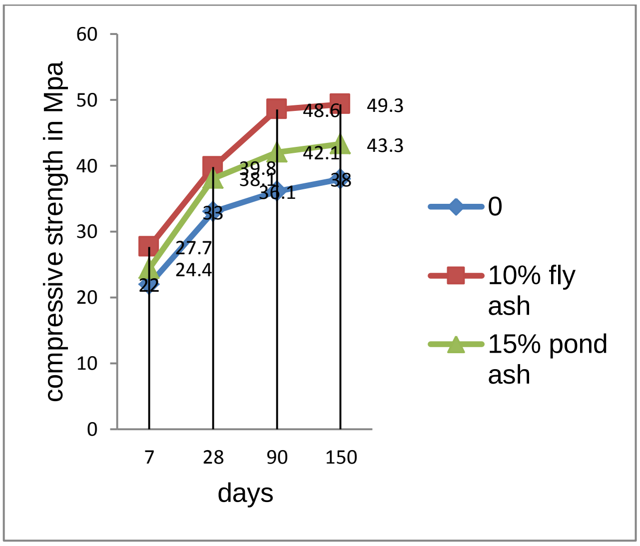
B. Compressive Strength

Compressive strength of referral concrete as well as concrete made using fly ash and ponded ash as partial replacement of PPC and fine aggregate respectively (replaced individually), cured in tap water and chloride environment are given in table 6.

Table.6 *Compressive strength of specimens cured in tap water*

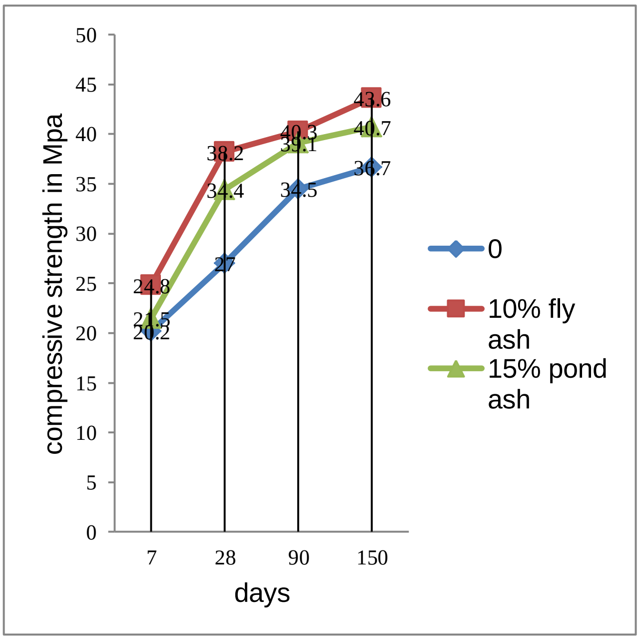
Sl. No	Specimen designation	Replacement level (%)	Compressive Strength (MPa)				Remark
			7 days	*28 days*	*90 days*	*150 days*	
1	A1	0%	22	33	36.1	38	Tap water
2	A2	10% fly ash	27.7	39.8	48.6	49.3	Tap water
3	A3	15% pond ash	24.4	38.1	42.1	43.3	Tap water
4	A4	0%	20.2	27	34.5	36.7	5% Cl
5	A5	10% fly ash	24.8	38.2	40.3	43.6	5% Cl
6	A6	15% pond ash	21.5	34.4	39.1	40.7	5% Cl

The results of the same are reproduced in graphical form in fig. 2 and 3 for visual observation.



Tap water

Fig.2 *Compressive Strength of specimen cured in tap water*



5% chloride

Fig.3 *Compressive Strength of specimen cured in 5% chloride solution.*

From table 6, it is seen that compressive strength of concrete made using fly ash and ponded ash as partial replacement of PPC and fine aggregate respectively (replaced individually) is substantially more than that of conventional concrete irrespective of curing period and curing environment.

The compressive strength of concrete made using 10% fly ash as partial replacement of PPC and cured in tap water is 25.9%, 20.6%, 34.6% and 29.7% more than that of referral conventional concrete at 7, 28, 90 and 150 days respectively. This increase in compressive strength may be due to pozzolanic action as well as filler action of fine particles of fly ash in concrete.

However, compressive strength of concrete made using 15% ponded ash as partial replacement of fine aggregate and cured in tap water is 10.9%, 15.5%, 16.6% and 13.9% more than that of referral conventional concrete at 7, 28, 90 and 150 days respectively.

The compressive strength of concrete made using 10% fly ash as partial replacement of PPC and cured in 5% chloride solution is 22.77%, 41.48%, 16.81% and 18.80% more than that of referral conventional concrete at 7, 28, 90 and 150 days respectively. However, compressive strength of concrete made .using 15% ponded ash as partial replacement of fine aggregate and cured in in 5% chloride solution is 6.4%, 27.4%, 13.33% and 10.9% % more than that of referral conventional concrete at 7, 28, 90 and 150 days respectively. This increase in compressive strength is due to increase in permeability as the percentage of replacement of PPC increases and hence contributes to the lesser chloride attack.

IV. CONCLUSION

From the above study following conclusions are drawn-

- By 10% replacement of Portland pozzolana cement (PPC) with fly ash compressive strength increases.
- At 15% replacement of fine aggregate with ponded ash compressive strength is more than the referral concrete.
- The workability of concrete specimen decreases with increase in replacement level of pozzolans due to the increase in water demand which can be maintained by increasing the dose of super plasticizer.
- Compressive strength of concrete cured in tap water and5% chloride solution increases as compared to referral conventional concrete at all ages.
- Compressive strength of concrete cured in 5% chloride solution decreases as compared to concrete cured in tap water at all the ages.

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