PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH IN PPC CONCRETE

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Abstract: ***These days concrete is the most commonly used material in the field of construction. Due to the rapid growth of construction industry the demand for concrete is increasing considerably. Fly ash,a waste materialgenerated bythermal power plants during the combustion of crushed coal. Thus the use of fly ash would result in reduction of the cost of materials in construction and the reduction of greenhouse gas emission.In this present study fly ash are partially replaced for cement. PPC cement was replaced by fly ash in rang of 10% to 50% at an interval of 10% with 0.45% and .47% of water cement ratio respectively in mix design M25 (1:2.05:3.75).Concrete specimens at different replacement level of PPC were cast and tested for workability at fresh stage and for compressive strength after 7, 28 and 56 days curing. Result showed that PPC can be replaced up to 40% by fly ash without considerable change in compressive strength.***

Keywords: Fly ash, PPC Cement, Thermal Power plants, Compressive Strength, Concrete Mix Design

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1. INTRODUCTION

Fly ash can substitute up to 66% of cement in the construction of dams. It is also used as a Pozollanic substitute for cement in Roller Compacted Concrete dams-an innovative dam technology developed as a result of efforts to design more economical concrete dams that could be constructed rapidly with designed performance. Fly ash in R.C.C. is used not only for saving cement cost but also for enhancing strength and durability. Replacement levels of fly ash primarily Class f, range from 30-75% of total cement material. Fly ash can also be used in Portland cement concrete to enhance the performance of the concrete. Portland cement is manufactured with Calcium oxide, some of which is released in a free state during hydration. As much as 20 pounds of free lime is released during the hydration of 100 pounds of cement. This liberated lime forms the necessary ingredients for reaction with fly ash silicates to form strong and durable cementing compounds thus improving many of the properties of concrete. Typically 15-30% of the Portland cement is replaced with fly ash. This results in net reduction in energy use and green house gas and other emissions."As you are aware, Though there has been a steady progress in fly ash utilization from 1990, we have a long way to go to reach the target of 100 per cent fly ash utilization. It is reported that the agricultural increase of grains is around 15 per cent, green vegetables 35 per cent and root vegetables 50 per cent, when fly ash is mixed with soil. Toxicity tests have proved that there is no toxic element due to fly ash. But it has higher nutrients due to increased availability of iron and calcium. Fly ash can become a wealth generator by making use of it for producing 'green building' materials, roads, agriculture etc. Full utilization of the generating stock will provide employment potential for three hundred thousand people and result in a business volume of over Rs.4,000 crore."Concrete is a heterogeneous mix of binding material (mostly cement), fine aggregate, coarse aggregate and water. Some admixtures are also added in concrete to improve some of the properties as desired. Owing to modernization in all aspect of life andmake over of living standard energy requirement is increasing exponentially day by day. Thermal power plants are the major source of energy generated and used in India. The use of coal for power generation results in an increased quantum of fly ash production, which has reached about 400 MT per year. All out efforts are needed to utilize this fly ash not only from environmental considerations, but also to avoid land usage for fly ash dumping. The non-combustible minerals that naturally occur from burning coal form bottom ash and fly ash. Fly ash consists of fine, powdery particles that are mostly spherical in shape, either solid or hollow, and predominantly glassy in nature. The carbonaceous material in fly ash is composed of angular particles. The particle size distribution of most bituminous coal fly ashes is usually similar to that of silt (less than a 0.075mm). These particles consist of Silica, Alumina, Oxides of Iron, Calcium, and Magnesium and toxic heavy metals like Cobalt Arsenic, Lead and Copper. This poses problems in the form of land use, health hazards, and environmental impact. Thermal Power stations using crushed coal or lignite as fuel generate large quantities of ash as a by-product. With the commissioning of super thermal power plants and with increasing use low grade coal of high ash content, the current production of ash is about 190 million ton per year. Emission of large amount of Carbon dioxide gas into atmosphere during production of cement is a major contribute for green house effect and the global warming, hence it is inevitable either to search for another material or partially replace it by some other material. Disposal of large quantity of fly ash may cause pollution of land, water bodies and air. Disposal of used fly ash is a major problem in the present age, so effective ways to recycle & reuse of fly ash are being formulated. Recycling of fly ash to produce new materials like concrete or mortar appears as one of the best solution for disposing of fly ash, due to its economic and ecological advantages. **Siddique (2003)** found that the increase in strength with fly ash replacing fine aggregate, however, the rate of increase of strength decreases with increase in fly ash content. At 50% replacements of fine aggregate by fly ash, compressive strength of concrete increased by 51.5% and 67.1% at 28 and 365 d respectively. **Mohammed et al. (2009),**Strength development of concrete containing coal fly ash under different curing temperature condition' Fly ash concrete was experimental to be like to that of an equivalent Portland cement concrete at normal curing temperature(200 for 32 days) Their work indicates that fly ash concrete could be used in concrete when untimely strength required. **Mittal** investigated that the use of fly ash in mix concrete "result that, as fly ash content increase there is reduce the strength of concrete**.** "High early strength containing large quantities of fly ash" concluded that Fly ash improves the workability of concrete.**Bansal et al.(2015)**reported that the fly ash content increases there was increase as well as decrease in the strength of concrete. The 10% replacement of fly ash gives 20% and 50% decrease the compressive strength at the age of 7 and28days respectively. It was observed with replacement of 20% fly as concrete compressive strength was increased by 7% and 11% as compared to normal concrete cubes. It was observed that with increase in age the compressive strength also increased for fly ash replaced concrete.

2. MATERIALS AND METHOD

2.1.1 Cement:

Portland Pozzolana cement (PPC) of 53 grade confirming to specifications as per IS 12269–1987 was used throughout the investigation. The properties of PPC are Fineness of cement (3.77), Normal consistency (31.5%), Initial setting time (55 minutes), Final setting time (250 minutes) and Specific gravity (2.67).

2.1.2 Fine aggregates:

The Fine aggregate (sand) used for the experimental investigation is locally procured and was confirming to zone-II. The specific gravity of fine aggregate (2.44)and fineness (2.86)

2.1.3 Coarse aggregate:

In present experimental investigation "Bharatpur" stone aggregate passing through 20mm and 10mm sieve was used coarse aggregate. Share of 20mm and 10mm size aggregate kept as 60% and 40% respectively, for maintaining proper grading.

2.1.4Water:

Clean potable water available in the laboratory, is used for mixing and curing.It satisfying the requirements of IS 456:2000 is used for concrete mix. The water cement ratio is used in present investigation, are (0.45) and (0.47) respectively.

2.1.5 Fly ash:

Fly Ash obtained from Thermal Power Station (NTPC Unchahar Raibareli U.P. India) is used throughout investigation.

2.1.6 Chemical Admixture/ Supper Plasticizer:

The emceplast-SP430A1 super plasticizer is used. .0.5% supper plasticizer used throughout investigation.

2.2 Experimental design:

The cubes were cast in steel moulds of inner diameter of 100mm×100mm×100mm. All the materials are weighted as per mix proportion of (1:2.05:3.75)with different water cement ratio (0.45) and (0.47) corresponded to M25 grade of concrete. Cement is replaced by fly ash and each mix comprises of various percentages of cement replacement material in increasing order i.e. 10%,20% 30%, 40%, and 50% with water cement ratio 0.45 and 0.47 respectively in replacement. The specimens were cured at a room temperature in water tank for a period of 7, 28 and 56 days.

3. RESULT AND DISCUSSION

3.1 Compressive Strength:

Result of compressive strength of specimens cast for different percentage replacement levels of cement by fly ash in PPC concrete, varying water cement ratio (0.45 and 0.47) and constant dose of super plasticizer are discussed here in after.

3.2 Compressive strength of concrete with (0.45) water cement ratio

Compressive strength of referral concrete as well as fly ash concrete at 7, 28 &56 days are given in Table1 and Fig. 1. The result of compressive strength in respect of specimens cast for different replacement levels of PPC with fly ash and 0.45 water cement ratio is presented in Table 1. The results are produced in graphical form for visual observation in fig-1.It is obvious that beyond 28 days, the strength increased with the addition of fly ash. Strength was comparable up to 30% fly ash content andafter that it decreased. However, increase in strengthwas more prominent at 20% replacement level (Fig. 1).The compressive strength of Portland Pozzolana cement (PPC) was 24.30 N/mm^2,31.68 N/mm^2 and 36.28 N/mm^2 at 7, 28 and 56 daysrespectively for water cement ratio of 0.45. It was alsoobserved that on addition of fly ash, 7 days strength wasdecreased at all replacement level. It was observed that at 10% replacement of Portland Pozzolana cement (PPC) with fly ash compressive strength at 7days curing is decreased 17.68% than that of referral concretes. Decrease in strength at 7days curing was 23.00%, 31.92%, 80.53% and 103.57% at replacement level of 20%, 30%, 40% and 50% respectively. It showed that increase in fly ash content in concrete reduced the rate of strength gain at early ages due to slow hydration process. However, the tendency at 28days was not similar as the tendency of 7days. At 28days curing strength of fly ash PPC concrete was more than that of referral concrete at 10% and 20% replacement level. Beyond 20% replacement level decreased in strength was observed with increased in replacement level. At 30% replacement level strength of fly ash PPC concrete was marginally decreased. Decrease in strength at 28days curing was 50.90% and 64.57% at replacement level of 40% and 50% respectively. It showed that increase in fly ash content in concrete the rate of strength gain only up to 30% replacement level after that strength decreased. It was observed that at 56days curing, strength of fly ash PPC concrete increased up to 30% replacement with referral concrete and then strength decreased with increase in replacement level. It was observed that 10%, 20% and 30% replacement of Portland Pozzolana cement (PPC) with fly ash on the compressive strength at 56days curing is increased about 6.45%, 4.64% and 2.06% than that of referral concrete. Decrease in strength at 56days curing was 27.03% and 46.40% at replacement level of 40% and 50% respectively. It showed that increase in fly ash content in concrete the rate of strength gain only up to 30% replacement level.

Table 1: Average compressive strength of Fly ash concrete (W/C = 0.45)

S.No.	Cube Designation	Fly ash replacement level (%)	Average compressive strength (N/mm^2)		
			7 Days	28 Days	56 Days
1	A1	0	24.30	31.68	36.28
2	A2	10	20.65	31.90	37.95
3	A3	20	19.75	31.98	37.65
4	A4	30	18.42	29.73	36.88
5	A5	40	13.46	20.32	28.56
6	A6	50	11.94	19.25	24.78

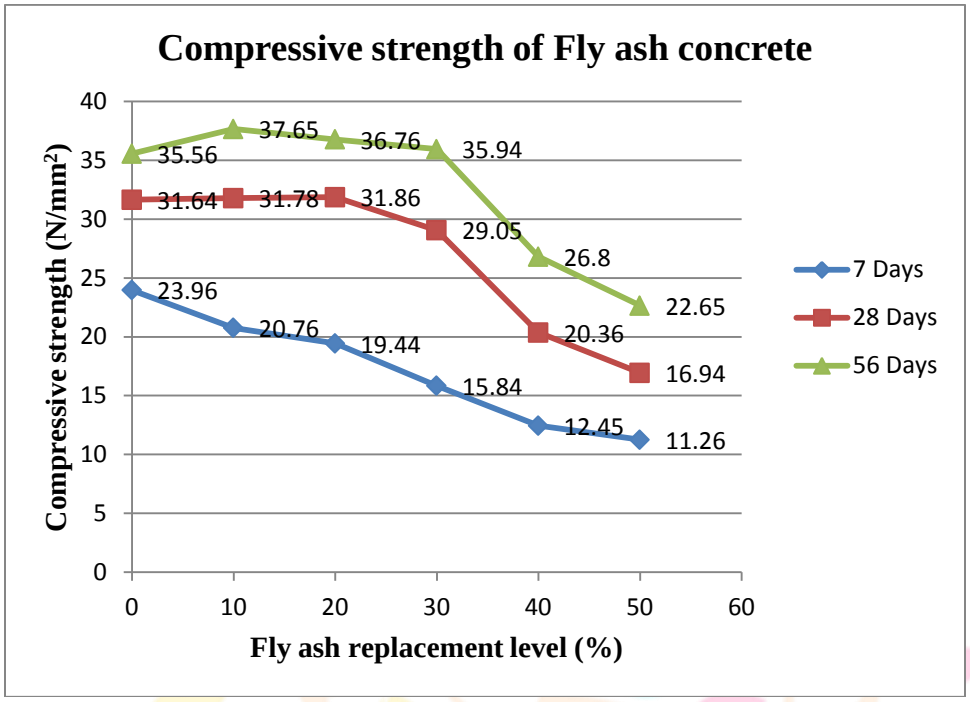

Figure-1 Compressive strength of fly ash concrete

3.3 Compressive strength of concrete with (0.47) water cement ratio:

Compressive strength of referral concrete as well as fly ash concrete at 7, 28 and 56 days are given in Table 2 and Fig. 2. The result of compressive strength in respect of specimens cast for different replacement levels of PPC with fly ash and 0.47 water cement ratio is presented in Table -1. The results are produced in graphical form for visual observation in fig-1.It is obvious that beyond 28 days, the strength increased with the addition of fly ash. Strength was comparable up to 30% fly ash content and after that it decreased. However, increase in strength was more prominent at 20% replacement level (Fig. 1). The compressive strength of Portland Pozzolana cement (PPC) was 23.96 N/mm^2, 31.64 N/mm^2 and 35.56 N/mm^2 at 7, 28 and 56 days respectively for water cement ratio of 0.47. It was also observed that on addition of fly ash, 7 days strength was decreased at all replacement level. It was observed that at 10% replacement of Portland Pozzolana cement (PPC) with fly ash compressive strength at 7days curing is decreased 15.41% than that of referral concretes. Decrease in strength at 7days curing was 23.25%, 54.78%, 92.45% and 112.78% at replacement level of 20, 30, 40 and 50% respectively. It showed that increase in fly ash content in concrete reduced the rate of strength gain at early ages due to slow hydration process. However, the tendency at 28days was not similar as the tendency of 7days. At 28days curing strength of fly ash PPC concrete was more than that of referral concrete at 10% and 20% replacement level. Beyond 20% replacement level decreased in strength was observed with increased in replacement level. At 30% replacement level strength of fly ash PPC (Portland Pozzolana cement) concrete was marginally decreased. Decrease in strength at 28days curing was 55.40% and 86.77% at replacement level of 40 and 50% respectively. It showed that increase in fly ash content in concrete the rate of strength gain only up to 30% replacement level after that strength decreased. It was observed that at 56days curing, strength of fly ash PPC concrete increased up to 30% replacement with referral concrete and then strength decreased with increase in replacement level. It was observed that 10%, 20% and 30% replacement of Portland Pozzolana cement (PPC) with fly ash on the compressive strength at 56days curing is increased about 5.95%, 4.26% and 2.03% than that of referral concrete. Decrease in strength at 56days curing was 32.60% and 57.05% at replacement level of 40% and 50% respectively. It showed that increase in fly ash content in concrete the rate of strength gain only up to 30% replacement level.

Table 2: Average Compressive strength of Fly ash concrete (W/C = 0.47)

S.No.	Cube Designation	Fly ash replacement level (%)	Average compressive strength (N/mm^2)		
			7 Days	28 Days	56 Days
1	B1	0	23.96	31.64	35.56
2	B2	10	20.76	31.78	37.65
3	B3	20	19.44	31.86	36.76
4	B4	30	15.84	29.05	35.94
5	B5	40	12.45	20.36	26.80
6	B6	50	11.26	16.94	22.65

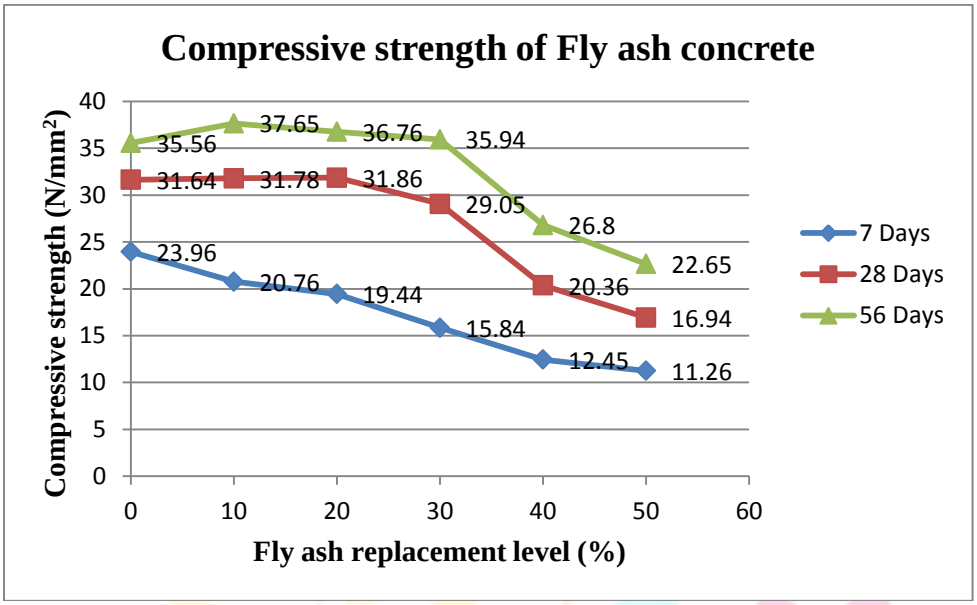

Figure 2: Compressive strength of fly ash concrete

4. CONCLUSION

The following conclusions were made based on the findings of this investigation.

1. The compressive strength of fly ash concrete up to 30% replacement level is slightly more than or equal to referral concrete at 28 and 56 days.
2. Optimum replacement level of fly ash is 20%.
3. It was observed that at 28 and 56 d in 20% replacement of Portland Pozzolana Cement (PPC) by fly ash, the strength at 28 and 56 days is marginally increased from 1.5% to 4.64% respectively with 0.45 W/C and, 1.44% and 4.26% respectively with 0.47 W/C.
4. It was also observed that up to 30% replacement of PPC by fly ash, the strength is almost equal to referral concrete at 56 days.
5. Portland Pozzolana Cement (PPC) gains strength after the 56 days curing because of slow hydration process.

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