Experimental Study on Compressive Strength of Concrete with Fly Ash as a Bonding Layer

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***Abstract*—** Detailed experimental work was carried out to study the effect of fly ash as a bonding layer in M20 and M30 grade of concrete. In this work, Fly ash is used in powder and paste form with horizontal profile to find out compressive strength of concrete. Specimens were tested with reference to IS: 516 for 7, 14 and 28 days of curing. The results of Fly Ash Concrete with control concrete were compared. The paper validated the positive effect of fly ash when use in powder form. Fly ash in powder form shows the maximum compressive strength as compared to fly ash in paste form. Paper concludes the fly ash used as bonding layer as it's useful in reduction of interfacial transition zone in the concrete. Experimental results obtained have been extensively analyzed to find out the optimum effect of Fly ash on the compressive strength of concrete.

***Keywords*- Fly** *Ash, Concrete, Compressive and flexural strength, Interfacial Transition Zone*

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I. INTRODUCTION

Concrete is one of the most widely used construction material in the world. We make more concrete than any other material in the world. It is used in our roads, dams, bridges, and buildings because of its versatility, strength, and durability. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cemetitious material, aggregate and water and by adding some special ingredients [8, 9]. Hence concrete is very well suited for a wide range of applications. However concrete has some deficiencies as low tensile strength, low post cracking capacity, brittleness and low ductility, limited fatigue life, not capable of accommodating large deformations, low impact strength. Fly ash is one of the numerous substances that cause air, water and soil pollution, disrupt ecological cycles and set off environmental hazards. The combustion of powdered coal in thermal power plants produces fly ash. The high temperature of burning coal turns the clay minerals present in the coal powder into fused fine particles mainly comprising aluminium silicate [2]. Fly ash produced thus possesses both ceramic and pozzolanic properties. When pulverised coal is burnt to generate heat, the residue contains 80 per cent fly ash and 20 per cent bottom ash. The ash is carried away by flue gas collected at economizer, air pre-heater and ESP hoppers. Clinker type ash collected in the water-impounded hopper below the boilers is called bottom ash [7].

The World Bank has cautioned India that by 2015, disposal of coal ash would require 1000 square kilometres or one square metre of land per person. Since coal currently accounts for 70 per cent of power production in the country, the Bank has highlighted the need for new and innovative methods for reducing impacts on the environment. The problem with fly ash lies in the fact that not only does its disposal require large quantities of land, water, and energy, its fine particles, if not managed well, by virtue of their weightlessness, can become airborne. Currently, 90 million tonnes of fly ash is being generated annually in India, with 65 000 acres of land being occupied by ash ponds. Such a huge quantity does pose challenging problems, in the form of land usage, health hazards, and environmental dangers. Both in disposal as well as in utilization, utmost care has to be taken, to safeguard the interest of human life, wild life, and environment [3]. Thus this paper deals with effect of compressive strength of fly ash in powder and paste form with horizontal profile as bonding layer was discussed.

II. EXPERIMENTAL PROGRAMM

A. Material Used

Cement, sand, coarse aggregate, water, and fly ash were used.
Cement: The cement used was Pozzolonic Portland cement (fly ash based) with a specific gravity of 2.86. Initial and final setting time of the cement was 20 min and 227 min, respectively.
Sand: Good quality river sand was used as a fine aggregate. Locally available sand, confirming to zone II with specific gravity 2.45, water absorption 2% and fineness modulus 3.18, conforming to I.S. – 383-1970 [12].
Coarse aggregate: Crushed granite stones of maximum 20 mm size having specific gravity of 2.67, fineness modulus of 7.10, conforming to IS 383-1970 [12]
Water: Potable water was used for the experimentation.
Fly ash: In whole work, low calcium (class F) fly ash obtains from KORADI thermal power plant (KTPS) near Nagpur was used as a bonding material. The chemical composition of the used fly ash is given in Table 1
.

TABLE 1 Physical and chemical properties of cement and fly ash

Material	Specific gravity	Comp.strength N/mm² (7days)	Na2O	MgO	Fe2O3	SiO2
Cement	2.86	38	0.35	0.72	3.22	17.25
F A	1.907	-	0.04	0.88	1.10	46.73

B. Concrete Mix Proportions

The mixture proportioning was done according the Indian Standard Recommended Method I.S. 10262- 2009 [11]

and with reference to IS 456-2000 [10]. The target mean strength was 26 MPa for the PPC control mixture, the total binder content was 450.625 Kg/m^3, fine aggregate was taken 469.29 Kg/ m^3 and coarse aggregate was taken 1114.81 Kg/m^3 with water to binder ratio was kept constant as 0.48 for M20 grade of concrete and target mean strength was 38Mpa for the PPC control mixture, the total binder content was 566.76 Kg/m^3, fine aggregate was taken 419.57 Kg/ m^3 and coarse aggregate was taken 1058.59 Kg/m^3 with water to binder ratio was kept constant as 0.38 for M30 grade of concrete . The total mixing time was 5 minutes, the samples were then casted and left for 24 hrs before demoulding. They were then placed in the curing tank until the day of testing cement, sand and coarse aggregate were properly mixed together in the ratio 1:1.04:2.7 & 1:0.75:1.87 by weight before water was added and properly mixed together to achieve homogenous material. Water absorption capacity and moisture content were taken into consideration. Cube moulds were used for casting. Compaction of concrete in three layers with 25 strokes of 16 mm rod was carried out for each layer. The concrete was left in the mould and allowed to set for 24 hours before the specimens were demoulded and placed in curing tank. The specimens with and without fly ash cured in the tank for 7, 14 and 28days.

III. METHODOLOGY

The tests have been performed to determine compressive strength of concrete mix with Fly ash is used in powder and paste form with horizontal profile as a bonding layer.

Compressive Strength Test

The strength of concrete is usually defined and determined by the crushing strength of 150mm x 150mmx150mm, at an age of 7, 14 and 28days. It is most common test conducted on hardened concrete as it is an easy test to perform and also most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. Steel mould made of cast iron dimension 150mm x 150mmx150mm used for casting of concrete cubes filled with Fly ash in powder and paste form with horizontal profile. The mould and its base rigidly damped together so as to reduce leakages during casting. The sides of the mould and base plates were oiled before casting to prevent bonding between the mould and concrete. The cube was then stored for 24 hours undisturbed at temperature of l8°C to 22°C and a relative humidity of not less than 90% (IS 516-1959) [13].

It also stated in IS 516-1959 [13] that the load was applied without shock and increased continuously at the rate of approximately 140 Kg/sq cm/ min until the resistance of specimen to the increasing loads breaks down and no greater load can be sustained. The maximum load applied to the specimen was then recorded as per IS: 516-1959. The testing of cube under compression was shown in figure 2.

The compressive strength was calculated as follows:

Compressive strength (MPa) = Failure load / cross sectional area.

Horizontal Profile:

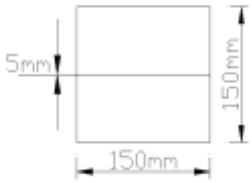

Figure..1 Cross Section of cube

In this work, 9 number of cubes were casted for each M20 and M30 grade of concrete and for control mix for compressive strength tests. According to different tests parameters, cubes (15x15x15cm) were divided into two groups first is fly ash in powder form and second is paste form. In between two layers of concrete fly ash in powder and paste form was applied uniformly about 5mm thin layer. In cubes, about 15gm of fly ash in powder form and 12gm of fly ash in paste form with horizontal profile.

Figure 2. a) Casting of Cubes b) Testing of Cubes

IV. EXPERIMENTAL RESULTS

Compressive Strength Test Results

The compressive strength test is consider the most suitable method of evaluating the behavior of concrete for underground construction at an early age, because in many cases such as in tunnels, concrete is mainly subjected to compression.

Results of compressive strength for M20 & M30 grade of concrete on cube specimens with Fly ash in powder and paste form with horizontal profile as a bonding layer was shown in Table 2, 3 and figure 3, 4 as below.

TABLE No.2 Compressive strength of M20 grade concrete with fly ash in powder and paste form.

Curing Period	Control Mix (Mpa)	Powder Form (Mpa)	Paste Form (Mpa)
7 days	17.20	19.51	18.81
14 days	18.33	21.67	20.39
28 days	22.61	25.98	25.62

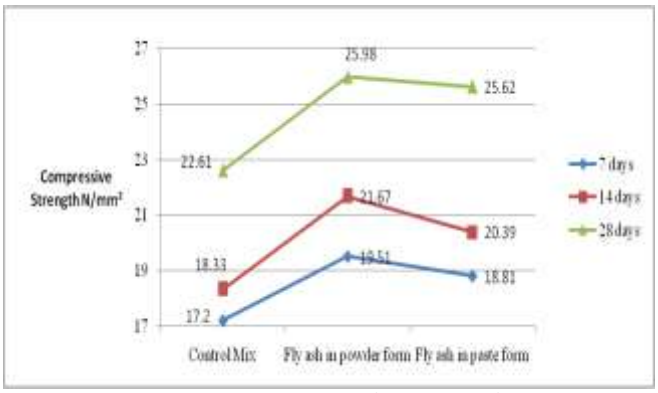

Figure. 3 Compressive strength of M20 grade of concrete

Table No. 3 Compressive strength of M30 grade concrete with fly ash in powder and paste form.

Curing Period	Control Mix (Mpa)	Powder Form (Mpa)	Paste Form (Mpa)
7 days	25.24	28.23	28.56
14 days	27.2	31.11	30.88
28 days	32.58	37.15	36

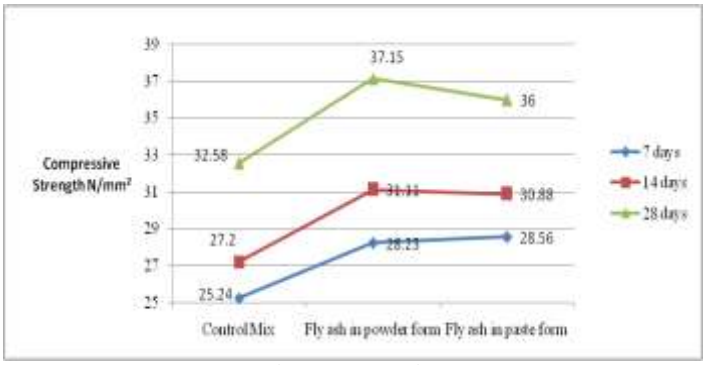

Figure 4 Compressive strength for M30 grade of concrete (Standard Concrete)

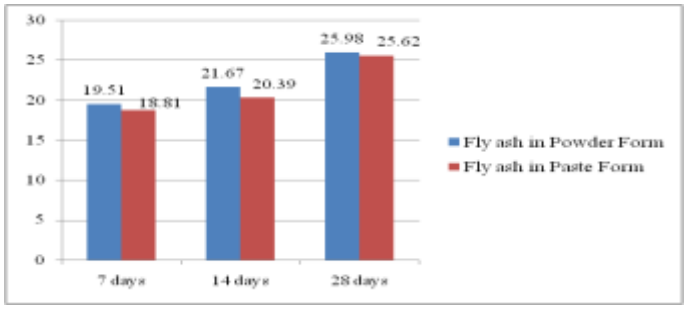

Fig. 5 Plain Comparison of Compressive strength of M20 grade of concrete with fly ash in powder and paste form

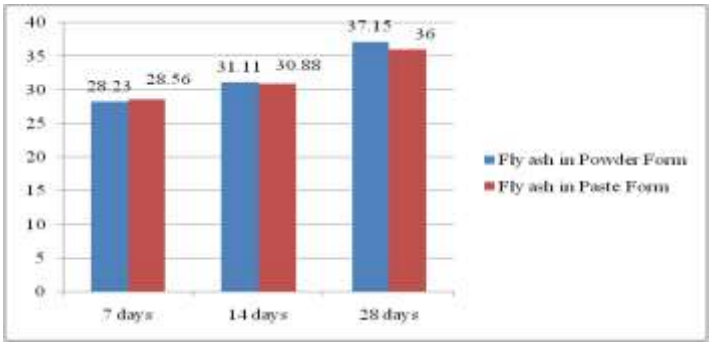

Figure 6 Plain Comparison of Compressive strength of M30 grade of concrete with fly ash in powder and paste form

As shown in Table 2, 3 and fig. 3, 4, 5, 6, the compressive strength of concrete with fly ash in powder form exceeded about 2 to 3% as compared to compressive strength of concrete with fly ash in paste form. There is an increase in the compressive of concrete of about 10 % to 15% when fly ash in powder form is used as bonding layer, as compared to strength of control mix.

There is an increase in the compressive of concrete about 10 % to 12% when fly ash in powder form is used as bonding layer, as compared to strength control mix.

V. CONCLUSIONS

Fly ash is one promising material which can be used as both supplementary cementitious materials as well as bonding layer in concrete. The use of fly ash as a bonding layer shows significant improvement in compressive strength of normal (M20) and standard (M30) concrete.

Based on the results presented above, the following conclusions can be drawn:-

- There is an increase in the compressive of concrete of about 10 % to 15% when fly ash in powder form is used as bonding layer, as compared to strength of control mix.
- There is an increase in the compressive of concrete about 10 % to 12% when fly ash in powder form is used as bonding layer, as compared to strength control mix.
- There is an increase in the compressive of concrete of about 2% to 5% when fly ash in powder form is used as bonding layer compared to fly ash in paste form.
- The reason of increment in strength is when fly ash used as bonding layer is improvement in transition zone or reduction the interfacial transition zone in the concrete.

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