Assessment of Construction in Concrete by Mixing Activator Material

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Abstract – The utilization of fly ash in concrete as partial replacement of cement is gaining immense importance today, mainly on account the improvements in the long – term durability of concrete combine with ecological benefits. Technological improvements in thermal power plant operation and fly ash collection system have resulted in improving the consistency of fly ash. In this paper the effect of fly ash on compressive strength is studied. Today, fly ash is used in high-way bridges and has been used on regular basis to produce high performance concrete. High performance concrete can be defined as a concrete in which certain characteristics are developed for particular application and environment. Examples of these characteristics are ease of placement, compaction without segregation, early age strength, long-term mechanical properties, permeability, density, heat of hydration long life severe environments. Many concrete mixes are now available to produce high performance concrete for pre-cast. Bridge girders. Most of these mixes have been designed based primarily strength criteria. Durable concrete is usually archived because of low permeability associated with high strength concrete and use of combination of cementitious materials such as fly ash. To carry this project concrete cube were casted. The concrete cubes are placed in water tank for the curing for 7 days, 14 days and 28 days. Concrete cubes were then tested with compression strength test. These tests were conducted to insure the quality of material, to reduce the cost and the important thing is to reduce the parties involved from having the problem at the next stages. These investigation shows that by using fly ash as replacing material with cement is suitable and can be used in construction industries. In these we are using NaoH (Sodium hydroxide) as activator in concrete. It increases strength of concrete. It reduces settling time of concrete.

Index Terms – M25 Cement, Fly Ash, Sodium hydroxide, activator material, Compression strength.

1. INTRODUCTION

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled. Fly ash is the finely divided mineral residue resulting from the combustion of ground or powdered coal in electric power generating thermal plant. Fly ash is a beneficial mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state. Moreover, utilization of waste materials in cement and concrete industry reduces the environmental problems of power plants and decreases electricity generation costs. Cement with fly ash reduces the permeability of concrete and dense calcium silicate hydrate (C–S–H). Research shows that adding fly ash to concrete, as a partial replacement of cement (less than 35 percent), will benefit both the fresh and hardened states. While in the fresh state, the fly ash improves workability. This is due to the smooth, spherical shape of the fly ash particle. The tiny spheres act as a form of ball bearing that aids the flow of the concrete. . Concrete being the most important and widely used material is called upon to possess very high strength and sufficient. Workability properties. Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. In the present experimental investigation the fly ash has been used to study the effect on compressive and split strength on M25 and M40 grades of concrete. Present days construction industries needs faster development and also require high strength of concrete to facilitate the fast construction and economically construction. For that purpose we used high early strength of cement, to gain early strength of concrete. This demand of high early strength gain of concrete put forth the use of low w/c ratio. But when Use of fly ash in concrete imparts several environmental benefits and thus it is eco-friendly. It saves the cement requirement for the same strength thus saving of raw materials such as limestone, coal required for manufacture of cement. Fly ash is pozzolanic material & it improving the properties of concrete like compressive strength & Durability.

Figure 1 Material in use

2. RELATED WORK

The activators used for AAC are mainly sodium or potassium hydroxide and silicate and in some mixes sodium carbonate. "Fly ash concrete: a technical analysis for compressive strength". Fly ash is used as replacement as 5-25%. The optimum percentage is 10-20% provides higher strength [1]. Geopolymer concrete have been compared with ordinary Portland cement (OPC) concrete considering the same paste volume in the previous papers of Hebert et al. [2]. The Effect of class F-fly ash as partial replacement with cement and fine aggregate in mortar". Fly ash is used as 10%, 20%, 25% &30% by weight. 10 % replacement will give the maximum strength [3].

Other papers on environmental impact of AAC compares concrete with similar strength but that do not always have the same amount of aggregates, which induce a bias in the results. This lead for instance Yang et al. [4] to compare concrete with OPC, concrete with blended cement and concrete with alkali activated cement and to conclude that the concrete with blended cement is the worst. However, it comes mainly from the fact that more cement was used while keeping the same water/cement ratio. The Effect of fly ash on properties on concrete". In this work the percentage of concrete used was 10%, 20% and 30% by total weight and found that 10% - 20% gives the maximum strength after 30 days [5]. An Investigation on behavior of high performance reinforced concrete columns with met kaolin and fly ash as admixture was done, met kaolin: 5%, 7.5%, 10% and fly ash: 10% constant is used as replacement. 7.5 % is the optimum percentage where maximum strength is achieved [6].

3. MIXTURE DESIGN

2.1 Mixture Design;

- Concrete Mix Design Stipulation

Characteristic compressive strength required in the field at 28 days grade designation- M 25
Nominal maximum size of aggregate-20 mm
Shape of CA-Angular
Degree of workability required at site- 50-75 mm (slump)
Degree of quality control available at site- As per IS:456
Type of exposure the structure will be subjected to (as defined in IS: 456) –Mild
Type of cement: PSC conforming IS:455
Method of concrete placing: pump able concrete

- Test data of material (to be determined in the laboratory)

Specific gravity of cement- 3.15
Specific gravity of FA-2.64
Specific gravity of CA-2.84
Aggregate are assumed to be in saturated surface dry condition.
Fine aggregates confirm to Zone II of IS – 383

2.2 Steps involved in Concrete Mix Design of M25 Grade Concrete;

- Step 1 - Determination of Target Strength;

Hemsworth constant for 5% risk factor is 1.65. In this case standard deviation is taken from IS: 456 against M 20 is 4.0

$$F_{target} = f_{ck} + 1.65 \times S$$
$$= 25 + 1.65 \times 4.0$$
$$F_{target} = 31.6 \text{ N/mm}^2$$

Where,
S = standard deviation in N/mm2 = 4 (as per IS 10262- 2009)

- Step 2 - Selection of water / cement ratio;

From Table 5 of IS 456, Maximum water-cement ratio for Mild exposure condition = 0.55. Based on experience, adopt water-cement ratio as 0.5

$$0.5 < 0.55, \text{ hence OK}$$

- Step 3 - Selection of Water Content;

From Table 2 of IS 10262- 2009, Maximum water content = 186 Kg. (for Nominal maximum size of aggregate – 20 mm)
Estimated water content = 186+ (3/100) x 18 = 191.6 kg /m3

- Step 4 – Selection of Cement Contents;

Water Cement Ratio- 0.5
Corrected water content = 191.6 kg /m^3
Cement content = From Table 5 of IS 456,
Minimum cement Content for mild exposure condition = 300 kg/m^3, 383.2 kg/m^3 > 300 kg/m^3, hence OK
This value is to be check for durability requirement of IS: 456
In the present example against mild exposure and for the case of reinforced concrete the minimum cement content is 300 kg/m3 which is less than 383.2 kg/m^3. Hence cement content adopted = 383.2 kg/m^3
As per clause 8.2.4.2 of IS: 456
Maximum cement content = 450 kg/m^3

- Step 5 - Estimation of Coarse Aggregate proportion;

From Table 3 of IS 10262- 2009,
For Nominal maximum size of aggregate = 20 mm,
Zone of fine aggregate = Zone II and for w/c = 0.5
Vol. of coarse aggregate/unit volume of total aggregate= 0.62

- Step 6 - Estimation of the mix ingredients

a. Volume of concrete = 1 m^3
b. Volume of cement = (Mass of cement / Specific gravity of cement) x (1/100) = (383.2/3.15) x (1/1000) = 0.122 m^3
c. Volume of water = (Mass of water / Specific gravity of water) x (1/1000 = (191.6/1) x (1/1000) = 0.1916 m^3
d. Volume of total aggregates = a – (b + c)
= 1 – (0.122 + 0.1916) = 0.6864 m^3
e. Mass of coarse aggregates = 0.6864 x 0.558 x 2.84 x 1000
= 1087.75 kg/m^3
f. Mass of fine aggregates = 0.6864 x 0.442 x 2.64 x 1000
= 800.94 kg/m^3

- Step 7: Correction due to absorbing / moist aggregate;

Since the aggregate is saturated surface dry condition hence no correction is required.

- Step 8 - Concrete trial mixes;
- 2.2.1 Concrete trial mix 1

The mix proportion as calculated in Step 6 forms trial mix 1, with this proportion concrete is prepared, in this case,
Slump value = 25 mm & Compaction Factor = 0.844
So, from slump test we can say,
Mix is cohesive, workable and had a true slump of about 25 mm and it is free from segregation and bleeding.
Desired slump = 50-75 mm
So modifications are needed in trial mix 1 to arrive at the desired workability.

- 2.2.2 Concrete Trial Mix 2:

In case of trial mix 2 water cement ratio is varied by +10% keeping water content constant. In the present example water cement ratio is raised to 0.55 from 0.5 & W/c = 0.55
An increase of 0.05 in the w/c will entail a reduction in the coarse aggregate fraction by 0.01 aggregate fraction by 0.01.
Hence the coarse aggregate as percentage of total aggregate
= 0.558 – 0.01 = 0.548
Water content will be kept constant.
Cement content = (197.4/0.55) = 358.9 kg/m^3
Hence, volume of all in aggregate
= 1 – [{(358.9/(3.15 x 1000)} + (197.4/1000)] = 0.688 m^3
Mass of coarse aggregate = 0.688 x 0.548 x 2.84 x 1000
= 1070.75 kg/m^3
Mass of fine aggregate = 0.688 x 0.452 x 2.64 x 1000
= 821 kg/m3

- 2.2.5 Concrete Mix Proportions of Trial Mix 2

Cement = 358.9 kg/m^3 & Water = 197.4 kg/m^3
FA = 821 kg/m^3 & CA = 1070.75 kg/m^3
For casting trial -2, mass of ingredients required will be calculated for 4 no's cube assuming 25% wastage.
Volume of concrete required for 4 cubes = 4 x (0.153 x1.25)
= 0.016878 m^3
Cement = (358.9 x 0.016878) kg/m3 = 6.06 kg
Water = (197.4 x 0.016878) kg/m3 =3.33 kg
Coarse aggregate = (1070.75 x 0.016878) kg/m^3 =18.07 kg
Fine aggregates = (821 x 0.016878) kg/m3 = 13.85 kg
In this case,
Slump value = 75 mm
Compaction Factor = 0.89
So, from slump test we can say,
Mix is stable, cohesive, and workable and had a true slump of about 75 mm.
Desired slump = 50-75 mm
So, it has achieved desired workability by satisfying the requirement of 50-75 mm slump value.
Now, we need to go for trial mix - 3

- 2.2.6 Concrete Trial Mix 3:

In this case water / cement ratio is decreased by 10% keeping water content constant.
W/c = 0.45
A reduction of 0.05 in w/c will entail and increase of coarse aggregate fraction by 0.01.
Coarse aggregate fraction = 0.558 +.01 =.568
W/c = 0.45 and water content = 197.4 kg/m^3
Cement content = (197.4/0.45) = 438.7 kg/m^3
Volume of all in aggregate = 1 – [{438.7/(3.15 x 1000)} + (197.4/1000)] = 0.664 m^3
Mass of coarse aggregate = 0.664 x 0.568 x 2.84 x 1000
= 1071.11 kg/m^3
Mass of fine aggregate = 0.664 x 0.432 x 2.64 x 1000
= 757.28 kg/m^3

- 2.2.7 Concrete Mix Proportions of Trial Mix 3

Cement = 438.7 kg/m3
Water = 197.4 kg/m3
FA = 757.28 kg/m^3
CA = 1071.11 kg/m^3
For casting trial -3, mass of ingredients required will be calculated for 4 no's cube assuming 25% wastage.
Volume of concrete required for 4 cubes = 4 x (0.153 x1.25)
= 0.016878 m^3
Cement = (438.7 x 0.016878) kg/m3 = 7.4 kg
Water = (197.4 x 0.016878) kg/m3 =3.33 kg
Coarse aggregate = (1071.11 x 0.016878) kg/m3 =18.07 kg
Fine aggregates = (757.28 x 0.016878) kg/m3 = 12.78 kg

- **Concrete M25: Recommended mixture proportion**

Compressive Strength vs. c/w graph- target strength 31.6 MPa
We get,
W/c = 0.44 & Water content = 197.4 kg/m3
Cement content = (197.4/0.44) = 448.6 kg/m3
Volume of all in aggregate = 0.660 m3
Coarse aggregate fraction = 0.558 +.01 = 0.568
Volume of fine aggregate = 1 – 0.568 = 0.432
Mass of coarse aggregate = 1064.65 kg/m3
Mass of fine aggregate = 752.71 kg/m3

4. RESULTS AND DISCUSSIONS

The concrete cube made up of various combinations activator materials is tested using universal testing machine for determining compressive strength with reference to M25 concrete.

Figure 2 Compressive testing setup using universal testing machine

The detailed analysis of various samples with different combination of Ash & NaOH are given below;

% Fly Ash	Casting Date	Curing time (Days)	No. of Spec-imen	Weight of Sample (KG)	Compressive Strength (KN)	Avg. Compressive Strength (KN)	Concrete Grade
0		7	1	8.505	375		
0		7	2	8.857	430	395	M 17.55
0	06-03-2017	7	3	8.643	382		
0		14	1	8.741	475		
0		14	2	8.744	500	468.33	M 20.81
0		14	3	8.911	430		
0		28	1	8.93	610		
0	01-03-2017	28	2	8.907	650	628.33	M 27.92
0		28	3	9.123	625		

Figure 3 Compressive Strength of Concrete M25

% Fly Ash	Casting Date	Curing time (Days)	No. of Spec-imen	Weight of Sample (KG)	Compressive Strength (KN)	Avg. Compressive Strength (KN)	Concrete Grade
5%		7	1	8.505	340		
5%	13-03-2017	7	2	8.857	390	365	M 16.22
5%		7	3	8.643	365		
5%		14	1	8.741	425		
5%	06-03-2017	14	2	8.744	450	428.33	M 19.03
5%		14	3	8.911	410		
5%		28	1	8.93	550		
5%	06-03-2017	28	2	8.907	580	548.33	M 24.40
5%		28	3	9.123	540		

Figure 4 Compressive Strength of Concrete M25 (5% Fly Ash + NaOH)

% Fly Ash	Casting Date	Curing time (Days)	No. of Spec-imen	Weight of Sample (KG)	Compressive Strength (KN)	Avg. Compressive Strength (KN)	Concrete Grade
10		7	1	9.144	260		
10	06-02-2017	7	2	9.256	270	260	M 11.55
10		7	3	9.078	250		
10		14	1	8.98	370		
10	03-03-2017	14	2	9.194	350	366.67	M 16.29
10		14	3	9.235	380		
10		28	1	8.93	520		
10	27-03-2017	28	2	8.907	520	530	M 23.58
10		28	3	9.123	550		

Figure 5 Compressive Strength of Concrete M25 (10% Fly Ash + NaOH)

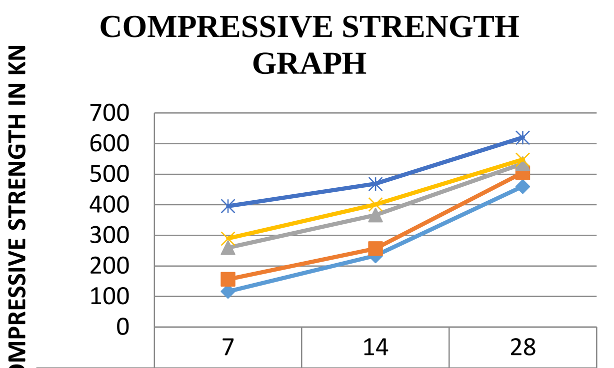
% Fly Ash	Casting Date	Curing time (Days)	No. of Spec-imen	Weight of Sample (KG)	Compressive Strength (KN)	Avg. Compressive Strength (KN)	Concrete Grade
20		7	1	8.547	160		
20	19-03-2017	7	2	8.58	160	156.67	M 6.96
20		7	3	8.638	150		
20		14	1	9.011	230		
20	06-03-2017	14	2	8.92	290	256.57	M 11.40
20		14	3	8.769	250		
20		28	1	8.868	450		
20	01-03-2017	28	2	8.71	440	450	M 20.25
20		28	3	8..690	460		

Figure 6 Compressive Strength of Concrete M25 (20% Fly Ash + NaOH)

% Fly Ash	Casting Date	Curing time (Days)	No. of Spec-imen	Weight of Sample (KG)	Compressive Strength (KN)	Avg. Compressive Strength (KN)	Concrete Grade
30		7	1	9	140		
30	11-03-2017	7	2	8.712	100	116.6	M 5.18
30		7	3	9.05	110		
30		14	1	8.65	240		
30	03-03-2017	14	2	8.645	230	233.33	M 10.37
30		14	3	8.791	230		
30		28	1	8.431	620		
30	02-03-2017	28	2	8.699	630	396	M 17.65
30		28	3	8.5	450		

Figure 7 Compressive Strength of Concrete M25 (30% Fly Ash + NaOH)

The combined analysis of 5%, 10%, 20% and 30% Ash + NaOH mixture is given below in graphical form. Various number of samples for different combination in M25 Cement were prepared and tested using Universal Testing Machine for determining compressive strength of the sample. The detailed analysis is carried for determining compressive strength of testing cube made up of different activator materials and is compiled in the graph showing below;



	7	14	28
30%	116.6	233.33	460
20%	156.67	256.67	505
10%	260	366.67	535
5%	290	401	548
0%	395.66	468.33	620

Figure 8 Combined graph showing compressive strength of various combinations

5. CONCLUSION

Compressive strength reduces when investigation replaced fly ash. As fly ash percentage increases compressive strength decreases. Use of fly ash in concrete can save the coal & thermal industry disposal cost and produce a ‘Greener’ concrete for construction. Concrete with 5% and 10% replacement of cement with Fly Ash show good compressive strength for 28 days than normal concrete 0.45 w/c ratio. But in case of 25% and 30% replacement of cement with Fly Ash ultimate compressive strength of concrete decrease. 10% Fly Ash is cost effective than 5%Fly Ash replaces as by cement in concrete. The cost analysis indicates that percentage cement reduction decreases cost of concrete but same time compressive strength of the concrete decreases.

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