An Experimental Study on Fly Ash Based Concrete with Aluminium as Partial Replacement of Cement

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Abstract— Concrete is one of the construction materials which is used on a large scale and it is generally includes Portland cement as the primary ingredient for making concrete. During concrete curing the heat generated is called heat of hydration. when water and cement react it will be an exothermic reaction. Keeping in view of the strength and durability of eco-friendly concrete, this investigation is mainly focused on the strength properties of M25 grade of concrete blended with fly ash and aluminum. In this study fly ash replacement level was kept at 25% and aluminium varied from 5% to 15% percentage. In this study, the parameters like unit weight, compressive strength and ultrasonic pulse velocity of concrete were studied after 7 and 28 days of curing. It is observed that the increase of aluminum increase the strength properties of concrete. It is due to the contribution of aluminum reaction in the concrete. The M25FA_AL15 attained almost strength properties of M25CC.

Keywords: Aluminum Powder, Flyash, Compressive Strength, Ultra Sonic Pulse Velocity

I. INTRODUCTION

Reducing carbon dioxide (CO_2) emissions is of prime importance for the industries, including the cement industries, as the major problem associated with these emissions is greenhouse effect which is considered to rise the global temperature and ultimately results in climate change. There's been 3% annual rise in production of cement. About one ton of CO_2 will be released into the atmosphere upon manufacturing one ton of cement, which finally leads to global warming.

About 1.35 billion tons annually or about 7% of the total greenhouse gas emissions were being contributed by the production of Portland cement worldwide. Furthermore, it was reported that the concrete structures built using ordinary Portland cement (OPC) in corrosive environments start to deteriorate after a period of 20 to 30 years, even though their designed service life is more than 50 years.

The Aluminum powder is of three types: atomized, flake and granules. In case of a atomized particle all dimensions like length, width and thickness are approximately the same order. In case of aluminium powder containing flaky paricle the length or width of a flake particle maybe several hundred times it thickness. Aluminium powder containing microscopic flake-shaped aluminum particles made out of foil scrap is available in the AAC industry. Highly flammable aero suspensions are prepared from aluminum powder with grain size less than 100µm and particularly with fractions less than 50µm.

II. LITERATURE REVIEW

Selvaraj. R (2015), Gas concrete falls under the category of light weight concrete. The change in volume and voids in concrete mortar is studied by adding aluminum powder to 1:3 proportion of cement mortar with and without alkali solutions. Properties of concrete like sorptivity, water absorption, micro structure, density etc. are examined for gas concrete.

Ahsan Habib, et.al., (2015), in this experiment, for aeration process, the generation method of hydrogen gas was used. Aluminum powder is added to the cement slurry for various percentages of OPC as per the gasification method. Density, water absorption and compressive strength tests were conducted on concrete to estimate the effect on aluminium powder on the mix proportion. In the case of aerated concrete, 0.15% aluminum powder helps in gaining strength.

The present investigation is mainly focused on the strength properties of M25 grade of concrete blended with fly ash and aluminum. In this study fly ash replacement level was kept at 25% and aluminum varied from 5 to 15% percentage.

III. EXPERIMENTAL PROGRAM

A. Fly ash

According to ASTM C 618 (2003), Class F fly ash produced from Rayalaseema Thermal Power Plant (RTPP), Muddanur, A.P was used. The chemical and physical properties are presented in the Table 3.1.

Particulars	Class F fly ash	ASTM C 618 Class F fly ash
Chemical composition		
% Silica(SiO_2)	65.8	
% Alumina($Al2O_3$)	29.0	
% Iron Oxide(Fe_2O_3)	3.2	SiO2+ Al2O3+ Fe2O3>70
% Lime(CaO)	1.1	
% Magnesia(MgO)	1.2	
% Titanium Oxide (TiO_2)	0.6	
% Sulphur Trioxide (SO_3)	0.3	Max. 5.0
Loss on Ignition	0.30	Max. 6.0
Physical properties		
Specific gravity	2.12	
Fineness (m^2/Kg)	360	Min.225 m2/kg

Table 3.1: Chemical and physical properties of Class F fly ash

B. Aluminium

In the present investigation, aluminium brought from Astrra chemicals, Chennai. Specific gravity of aluminium is 2.7

C. Mixture Proportions

In this study, M 25 grade of conventional concrete (M25CC) and M 25 grade of fly ash (FA) and aluminium (AL) blended concrete (M25FA_AL) were manufactured as per IS10262:2019. In M25FA_AL, fly ash was kept at 25% and AL varied from 5% to 15% replacement of cement.

Cement (Kg/m3)	Water (litre/m3)	20mm (Kg/m3)	10mm (Kg/m3)	Sand (Kg/m3)
384	192	655	438	675

Mix	Cement (Kg/ m3)	FA (Kg/ m3)	AL (Kg/ m^3)	Water (litre/ m3)	20mm (Kg/ m3)	10mm (Kg/ m^3)	Sand (Kg/ m3)
M25FA_ AL5	269	96	19.2	192	637	424	646
M25FA_ AL10	250	96	38.4	192	637	424	646
M25FA_ AL15	230	96	57.6	192	637	424	646

Table 3.2: M 25CC mix proportions

D. Test Methods

This section describes the procedure to determine the properties of concrete mixes and these include slump test, unit weight, compressive strength and ultrasonic pulse velocity (UPV) at different curing periods.

1) Slump test

Slump check of concrete is the check of measuring workability of concrete that's substantially utilized in creation site-paintings all around the world. As in keeping with IS 1199, every layer of concrete is laid about 1/four in peak of the mold and tamped every layer 25 instances with tamping rod. After tamping the pinnacle layer, the concrete is struck off stage with a trowel and any mortar leaked out among the mold and base plate is wiped clean away. The mildew is then eliminated from the concrete right away via way of means of elevating it slowly and thoroughly in a vertical direction. The droop is measured right away via way of means of figuring out the distinction among the peak of the mold and that of the best factor of specimen

Fig. 3.1: Slump cone test

2) Compressive strength test

Compressive power take a look at become performed at the cubical specimens for all of the mixes after 7 and 28 days of curing as in line with IS 516 (1991). Three cubical specimens of length one hundred fifty mm x one hundred fifty mm x one hundred fifty mm had been forged and examined for every age and every mix. Unit weight or density of hardened concrete (γc) become decided after 7 and 28 days of curing previous to compression take a look at

Fig. 3.2: Compressive strength test setup

3) Ultrasonic pulse velocity test

The check includes dedication of ultrasonic pulse speed (UPV) thru concrete as in line with manner provide in ASTM C 597-02. Battery operated Portable Ultrasonic Non-detrimental Digital Indicating Tester became used to degree the heartbeat speed thru concrete. Pulses of longitudinal pressure waves are generated with the aid of using an electro acoustical transducer held in touch with one face of concrete and are obtained with the aid of using every other transducer held in touch with different face of concrete specimen. The time (T) taken with the aid of using pulse to byskip thru specimen of period (L) is referred to as transit time. The pulse speed (V) is calculated with the aid of using dividing the period of specimen (L) with the aid of using transit time (T). Average fee of 3 specimens became taken into consideration because the pulse speed of concrete mix. Values of pulse speed for grading concrete as in line with BIS 13311-92 (Part-I) are given in Table 3.3

Pulse velocity (m/s)	Concrete quality grading
Above 4500	Excellent
3500-4500	Good
3000-3500	Medium
Less than 3000	Doubtful

Table 3.3: Concrete quality grading as per BIS 13311-92 (Part-I)

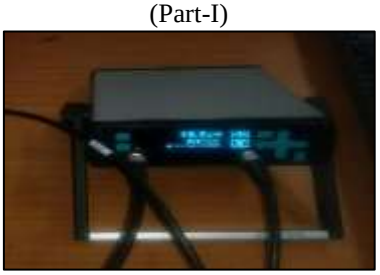

Fig. 3.3: Ultrasonic pulse velocity test setup

IV. RESULTS AND DISCUSSION

In this Chapter, the test results are presented and discussed. The properties viz. unit weight, compressive strength and ultrasonic pulse velocity of concrete mixes were measured after 7 and 28 days of curing.

A. Test Properties of Concrete

Table 4.1 shows the slump cone test values of concrete mixes.

Mix	Slump (mm)
M25	78
M25FA_AL5	85
M25FA_AL10	89
M25FA_AL15	94

Table 4.1: Slump cone test values of concrete

Table 4.2 shows the strength properties of concrete mixes after 7 days of curing.

Type of concrete	Compressive strength (N/mm^2)	UPV (m/s)	Unit weight (kg/m^3)
M25CC	33.2	4886	2424
M25FA_AL5	27.9	4514	2256
M25FA_AL10	29.8	4688	2354
M25FA_AL15	32.6	4734	2407

Table 4.2: Properties of concrete after 7 days of curing

Table 4.3 shows the strength properties of concrete mixes after 28 days of curing.

Type of concrete	Compressive strength (N/mm^2)	UPV (m/s)	Unit weight (kg/m^3)
M25CC	21.7	4732	2353
M25FA_AL5	15.6	4212	2134
M25FA_AL10	19.9	4477	2245
M25FA_AL15	20.8	4669	2306

Table 4.3 Properties of concrete after 28 days of curing

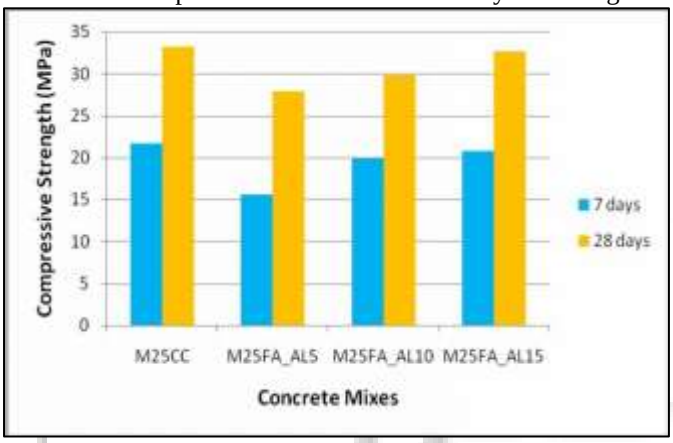

Fig. 4.1: Compressive strength of concrete at different ages

It is observed that the increase of aluminum increase the strength properties of concrete. It is due to the contribution of aluminum reaction in the concrete. The M25FA_AL15 attained almost strength properties of M25CC.

V. CONCLUSIONS

Based on the test results, the following conclusions are drawn:

- The increase of aluminium percentage increased the slump values.
- It is observed that the increase of aluminum increase the strength properties of concrete.
- It is due to the contribution of aluminum reaction in the concrete.
- The mix M25FA_AL15 attained almost strength properties of M25CC

A. Future work

Based on the investigation of this project, the future work includes:

- Monitoring pH and temperature of concrete for longer curing periods.
- Durability properties of fly ash and aluminium based M25 grade concrete

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