EFFECTS OF FLY ASH ON STRENGTHPROPERTIES OF HIGH STRENTH CONCRETE

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ABSTRACT

This research was undertaken to investigate the performance of high strength concrete incorporating fly ash and HRWRA. For modern construction, the use of new constituent materials is increasing to achieve economy and improved final results. For sustainable development, incorporating fly ash in the production of concrete can be one of the judicious uses of fly ash. Fly Ash is a pozzolan. A pozzolan is a siliceous or alumino siliceous material that, in finely divided form and in the presence of moisture, chemically reacts with the calcium hydroxide released by the hydration of Portland Cement to form additional calcium silicate hydrate and other cementitious compounds. The hydration reactions are similar to the reactions occurring during the hydration of Portland Cement. Thus, concrete containing Fly Ash pozzolan becomes denser, stronger and generally more durable long term as compared to straight Portland Cement concrete mixtures. Thus the main objectives of the research is to prepare high strength concrete using fly ash and also to find the effects of fly ash on the properties of concrete.

Keywords*: *High Strength Concrete, Fly ash, Construction, Hydration, Portland cement, Development,ACI

I.INTRODUCTION

Concrete is the most commonly used building material in construction today. In 2009 an estimated 70 billion tons of cement was produced in the United States alone. Everything related to construction is open for scrutiny in today's eco-conscience society. People today are more in tune and informed about the negative effects humankind leave behind for future generations. Builders today are under constant pressure to become more "earth friendly" and are constantly looking for more ways to incorporate recycled materials into their products.Thus construction and demolition industry has also started researching and adopting ways to reduce its carbon footprint. The production of Portland cement releases large amounts of carbon dioxide and other GHG into the atmosphere. For this reason, SCM are being used in concrete and its use would help achieve sustainable development. Two of these materials are fly ash, which is a by-product of thermal power generation, and silica fume, which is a by-product of silicon and ferro-silicon metal production. Both fly ash and silica fume possess pozzolanic activity, and, if not used, has to be disposed off in landfills at a considerable cost It represents the possibility of meeting the present needs without preventing future generations from meeting their needs. In other words, problems that arise due to present human actions should not to be passed on to future generations.

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1.1 HIGH STRENGTH CONCRETE AND FLY ASH

mechanical and durability properties than normal concrete. In general, the concrete which has 28 days strength greater than 55 MPa can be categorised into high strength concrete. It is characterised by low water-binder ratio and has rough workability. Its use is becoming increasingly popular in modern construction sector due to high structural requirements of concrete to be used in buildings so that they can withstand earthquakes, wind force at higher elevations and natural disasters.

1.2ADVANTAGES OF HIGH STRENGTH CONCRETE

Strength in concrete depends on many factors, the most important of which is the ratio of water to cement. Good quality fly ash generally improves workability or at least produces the same workability with less water. The reduction in water leads to improved strength. Because some fly ash contains larger or less reactive particles than Portland cement, significant hydration can continue for six months or longer, leading to much higher ultimate strength than concrete without fly ash.

II.OBJECTIVE OF THE STUDY

1. Literature review on High Strength Concrete.
2. Finding the optimum dosage of ***super plasticizer*** and ***admixtures***required.
3. Preparation of appropriate mix design as per codal specifications. (For the development of the mix design, the high strength concrete factors are also to be taken under consideration.)
4. Addition of different proportions of admixtures i.e. ***fly ash*** in replacement of cement in M60 grade of concrete to improve the strength and durability of concrete.

III. MIX DESIGN AS PER ACI - 211

Table -1: Details and Designation of Mix Design

Sr. No.	Mix Designation	Mix Proportion
1	Mix 1	100% Ordinary Portland Cement
2	Mix 2	90% OPC + 10% fly ash (by weight)
3	Mix 3	85% OPC + 15% fly ash (by weight)
4	Mix 4	80% OPC + 20% fly ash (by weight)
5	MIx 5	75% OPC + 25% fly ash (by weight)

Mix proportioning is the procedure of selecting constituents of concrete and determining their relative parts so that it will produce concrete with required workability, strength, durability with a minimum cost of production. The objective of the study is to create high strength concrete. So trials were done according to **ACI-211** to obtain high strength. However, the mix proportioning obtained according to **IS:10262** and was not used as the code does not suggests the mix design for high strength. Therefore, according to **ACI-211** M 60 grade concrete has been proportioned.

IV.PHYSICAL PROPERTIES OF THE MATERIAL USED

The different materials used in the present study were cement, fine aggregate, coarse aggregate, water, fly ash, superplasticizer. Laboratory tests were conducted on these materials and their properties have been reported as the following :

4.1 Cement

In the present investigation, Ordinary Portland cement (OPC) of 53 Grade (Ultratech) from a single batch was used for all the concrete mixes.. Cement taken was fresh and without any lumps with uniformity in its color. The cement was tested as per IS: 8112-1989 for its normal consistency, Initial and Finals setting time, Specific gravity and compressive strength for 3, 7 and 28 days, the results of various tests conducted are reported as

Table-2 : Properties cement used in present study

Sr. No.	Characteristics	units	Experimental value
1	Consistency of Cement	%	29.8
2	Soundness	mm	2
3	Specific gravity		3.12
4	Initial setting time	minute	110
5	Final setting time	minute	265

4.2 Fly Ash

Fly ash was procured from Guru Nanak Dev Thermal Power plant (GNDTP) Bathinda and supplied by the Ultratech Cement Pvt Ltd., Mohali in one lot. To assess the properties of fly ash, the properties based on laboratory tests conducted by Central Soil and Material Research Station, New Delhi and CBRI, Roorkee were used. The Chemical properties are presented in Table

Table - 3: Chemical Properties of fly ash used in study

S.N.	Characteristics	GNDTP, Bathinda fly ash value %
1	Loss on ignition	4.52
2	Silica (SiO_2)	56.32
3	Alumina (Al_2O_3)	30.87
4	Iron Oxide (Fe_2O_3)	4.94
5	Calcium oxide (CaO)	1.58
6	Magnesium oxide (MgO)	0.70

Table -4: Physical properties of fly ash used

S.N.	Characteristics	As per IS 3812-1981 (reaffirmed 1999) Grade of fly ash		Properties of GNDTP, Bathinda fly ash
		Grade I	Grade II	
1	Fineness specific surface in m^2/kg by Blain's permeability method	250 min	320 min	468
2	Lime reactivity - average compressive strength in MPaobtained by testing at least three mortar cubes at the age of 7days.	3min	4min	5.98
3	Compressive strength on 28 days in MPa	Nor less than 80% of the strength of plain cement mortar cubes		90.95%

4.3 Superplasticizer

The superplasticizer "Fosroc Conplast SP430G8" procured from M/s Fosroc Chemicals Pvt Ltd. Chandigarh was used in the present study. The properties of superplasticizer as supplied by the supplier are reported in Table. The optimum dosage is best determined by site trials with the concrete mix which enables the effects of workability, strength gain or cement reduction to be measured. It has been specially formulated to give high water reductions upto 25% without loss of workability or to produce high quality concrete of reduced permeability. It is mainly used for improving workability, increasing strength, increasing quality that is denser, close textured concrete with reduced porosity and hence enhanced durability.

Table - 4 :Properties of Superplasticizer used in study

S.N.	Test	Values obtained	Limit as per IS 9103:1999
1	Specific Gravity	1.236	0.02 of the value stated by manufacturer
2	pH	7.36	Min. 6.00
3	Dry Material Content	43.78	5% of the value stated by manufacturer (% by mass)
4	Chloride Content	0.029	Within 10% of the value or within 0.2% whichever is greater as stated by manufacturer (% by mass)

4.4 Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete and affects economy. The aggregate consist of inert and course materials. Fine aggregate in concrete assists in producing workability and uniformity in mixture. The fine aggregate also assists the cement paste to hold the coarse aggregate particles in suspension.he coarse aggregates are used primarily for the purpose of providing bulk to the concrete. IS: 383-1970 defines the fine aggregate as the aggregate most of which pass through 4.75 mm IS sieve. The coarse aggregates are defined as aggregates most of which are retained on 4.75 mm IS sieve

Table-5 : Physical Properties of Fine Aggregates

Characteristics	Results Obtained
Grading	Grading Zone II (IS: 383-1970)
Fineness Modulus	2.17
Specific Gravity	2.62
Water Absorption (%)	0.51 %
Free Moisture Content (%)	Nil

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Table - 6 : Physical properties of the Coarse aggregates used

Characteristics	Value
Colour	Grey
Type	Crushed
Shape	Angular
Specific gravity	2.65
Water absorption	1%
Fineness modulus	6.64
Moisture Content (%)	Nil

V. EXPERIMENTAL PROGRAMS

A total of 5 series of mixes was prepared in laboratory as per ACI-211. Compressive , Flexural tensile trength and other properties of high strength concrete are find out at 7 and 28 days of curing respectively

Table- 7: Proportioning of Material In Different Mix

Material	Quantity in M1 (Kg/m^3)	Quantity in M2 (Kg/m^3)	Quantity in M3 (Kg/m^3)	Quantity in M4 (Kg/m^3)	Quantity in M5 (Kg/m^3)
Cement	551.7	496.53	468.94	441.36	413.78
Fine Aggregate	766.48	766.48	766.48	766.48	766.48
CA	999.6	999.6	999.6	999.6	999.6
Water	185	185	185	185	185
HRWRA	1.1%of cement	1.1% of cement	1.1% of cement	1.1% of cement	1.1% of cement
Fly Ash	0	55.17	82.75	110.34	137.92

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VII. Results and Discussions

7.1 General

A series of experiments have been carried out in order to evaluate the compressive strength of different concrete mixes. Specimens of four different proportions of cementitious materials have been subjected to evaluate the influence of replacement of fly ash by cement. In this chapter the results obtained from the experiment described in the previous chapter have been discussed. The objective of the project is to develope high strength concrete using fly ash as a partial replacement of cement and study the effect of fly ash addition on compressive strength of high strength concrete. The objective involves the use of fly ash, and its properties are reported to be different in different areas also its properties vary with production process and source.

7.2 Workability

It was observed that the high strength concrete was very dry owing to the low water-cement ratio (0.30) and the presence of fly ash in the mix slightly improved the workability of the mix.

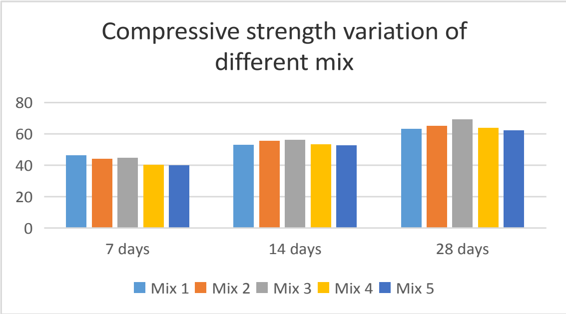
7.3 Compressive Strength Results

The results of compressive strength after 7, 14 and 28 days showed that the achievement of high strength concrete is possible by the mixed design proposed based on **ACI-211**.

Table -8: Compressive strength Results At 7 and 28 days respectively.

S.No.	**Mix Designation**	**7days Strength(MPa)**	**28days strength(MPa)**
1.	Mix 1	46.26	63.17
2.	Mix 2	44.11	65.51
3.	Mix 3	44.67	69.22
4.	Mix 4	40.20	63.84
5	Mix 5	40.11	62.20

Chart-1:Compressive strength of different mix at 7, 14 and 28 days respectively



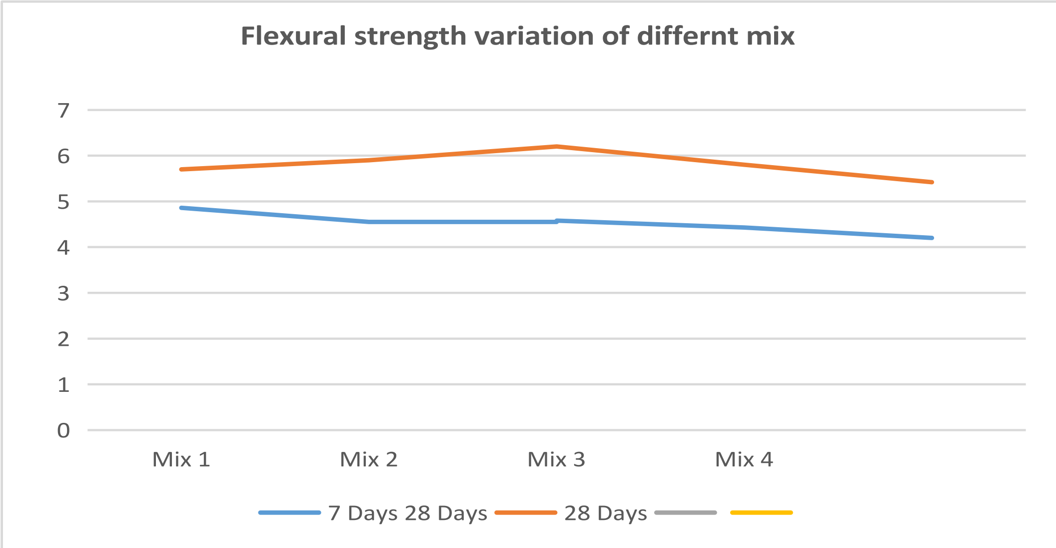
The specimens have been cast using standard size moulds. The interior surface of the assembled mould is coated with thin layer of oil to avoid adhesion of the concrete with mould surface. Concrete is filled in three layers and each layer is vibrated using vibration table. Fig. 3.6 shows the casting of specimens. The concrete was cast into cubes of size 150 mm x 150 mm x 150 mm for compressive strength testing.

Fig -1: C**rack Devloped After Casting Of Cubes**

7.5. Flexural strength results

The flexural strength of all the mixes was determined at the ages of 7 and 28 days for the various replacement levels of fly ash with cement. The value of average strength for different replacement levels of Fly ash with cement.At the end of different curing periods (7 days and 28 days) are shown in chart 2, which show the variation of flexural strength due to different percentages of fly ash.

Chart-2: Flexural strength variation of different mix



VIII. CONCLUSIONS

From the above results of the compressive strength testing of mixes with different Fly Ash replacement percentage with cement the following conclusions may be drawn:

[1.] By the addition of fly ash, the workability of the mix was improved slightly.

[2.] The target strength of 70.825 MPa could not be achieved but the required strength i.e. 60 MPa could be achieved at the end of 28 days

[3.] Compressive strength of Mix 3 with 15% fly ash at the end of 28 days is found to be maximum among all the mixes.

[4.] Compressive strength of Mix with 0% fly ash is found to be maximum among all at early age of 7 days curing.

[5.] Compressive strength of Mix with 0% fly ash is found to be 5% less than maximum strength mix at the end of 28 days curing.

[6.] 7days flexural strength of is maximum among all mix.

[7.] 28days flexural strength of mix 3 is highest among all.

[8.] As the fly ash content increses from otimum the strength of the concrete decreases where as workability of the concrete increases.

REFERENCES

[1]. IS: 456-2000; "Plain and Reinforced Concrete - Code of Practice"; Bureau of Indian Standards, New Delhi.

[2]. IS: 516-1959: "Method of Tests for Strength of Concrete"; Bureau of Indian Standards, New Delhi.

[3]. ACI-211.4R-08: "Guide for selecting Proportions for High-Strength Concrete Using Portland cement and other Cementitious Materials".

[4]. P. Nath and P. SARKAR (2011) "Effect of Fly Ash on durability Properties of concrete" *Curtin University Australia.*

[5]. B Muhit and S.S. Ahmed "Effects Of Silica Fume And Fly Ash As Partial Replacement Of Cement On Water Permeability And Strength Of High Performance Concrete" *AETACE*

[6]. Caroline Namagga and Rebecaa A. Atadero (2009) "OPTIMIZATION OF FLY ASH IN CONCRETE: High lime fly ash as a replacement for cement and filler material" *2009 World of Coal ash conference, KY, USA.*

[7]. Jayesh Kumar Pitroda, L.B. Zalia and Dr. F.S. Umrigar " Experimental Investigation on Partial Replacement of Cement with fly ash in design Mix Concrete" *Pitroda el al. International Journal of Advanced Engineering Technology.*

[8]. Lane, R.O. and Best,G.F.; 1982, Properties of use of fly ash in Portland cement*Concrete International*, vol. 4, pp 81-82

[9]. Berntsson, L., Chandra, S., and Kutti, T., "Principles and Factors Influencing HighStrength Concrete Production," Concrete International, December, pp.59-62, 1990.

[10]. Carrasquillo, R. L., "Production of High Strength Pastes, Mortars, and Concrete," Very High Strength Cement-Based Materials, Materials Research Society Symposia Proceedings, Vol. 42.

[11]. Mehta, P. K., and Aïtcin, P.C., "Principles Underlying Production of High-Performance Concrete," Cement, Concrete, and Aggregates, ASTM, Vol. 12, No. 2, winter

[12]. Gambhir.M.L.,"concrete technology" Tata McGraw-Hill Publishing company Ltd, New Delhi,2004.

[13]. Shetty. M.s,(2010) "concrete technology" S.Chand and company Ltd, Delhi