Study on High Volume Fly Ash Concrete

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Abstract— Fly ash is finely divided residue resulting from the combustion of powered coal and transported by the flue gases and collected by electrostatic precipitator. There are multiple benefits for the sustainable development of the construction industry by using fly ash to increase the strength characteristics of structural members. The objective of the present investigation is to study the mechanical strength behavior of High Volume Fly ash concrete. In this study the mechanical properties are studied with various replacements with cement like 0%, 0%,40% and 50% of Fly ash. % saves the higher compressive strength. When compared with control mix the strength of HVFA concrete reduced % for 0%, 0%,40% and 50% at 7, 28 & 180 days respectively. Mineral admixtures generally used are raw fly ash, rice husk ash, silica fume etc. Addition of such materials improves the concrete property. Fly ash is finely divided residue resulting from the combustion of powered coal and transported by the flue gases and collected by electrostatic precipitator. There are multiple benefits for the sustainable development of the construction industry by using fly ash to increase the strength characteristics of structural members. Fly ash reacts with calcium hydroxide, a byproduct of the hydration of Portland cement.

Key words: Admixtures, Fly ash, Portland cement

I. INTRODUCTION

The World Bank has cautioned India that by 2015, disposal of coal ash would require 1000 sq. km. of land. Since coal currently accounts for 70% of power generation in the country, there is a need of 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, can become airborne. Currently more than 120 million tonnes of fly ash are being generated annually in India, with 65000 acres of land being occupied by ash ponds. Such a huge quantity does pose challenging problems, in the form of land use, health hazards and environmental damages. In commercial practice, the dosage of fly ash is limited to 15%-30% by mass of the total cementitious material, which has a beneficial effect on the workability and cost economy of concrete but for improved durability against sulfate attack, alkali-silica expansion, and thermal cracking, larger amounts of fly ash, are necessary. According to some researchers, more than 30% fly ash by mass (equivalent as 50% by volume) of the cementitious material may be considered enough to classify the mixtures as High-Volume Fly Ash (HVFA) concrete. It is possible to produce sustainable, high performance concrete mixtures with 50% or more cement replacement by fly ash.

II. EXPERIMENTAL INVESTIGATION

The materials used for the experimental programme are cement, river sand, coarse aggregate, fly ash, super plasticizer and water were locally available among the construction agencies and market delars. The succeeding subsections describes in detail about the materials used.

A. Cement

The Cement used was AMBUJA Ordinary Portland Cement (OPC) of grade 43 conforming to IS: 8112-1989. The various laboratory tests confirming to IS: 4031-1996 (PART 1 to 15) specification was carried out and the physical properties were found as such:

PROPERTY	AS PER IS CODE	EXPERIMENTAL INVESTION
Fineness	0.225 m^2/g	0.329 m^2/g
Consistency	30 %	32 %
Initial setting time	30 min	30 min
Final setting	600 min	600 min
Specific gravity	3.15	3.17

Table 1:

Fig. 1:

B. Fly Ash as Cementesious Material

Fly ash samples (fig 3.1) taken from Power Plant, NTPC were used in this study. Fly ash was not processed and, used as received.

Fig. 2:

Sl no.	Physical Properties	Observed values
1	Specific Gravity	2.2
2	Initial Setting	45 min
3	Final Setting	280 min
4	Consistency	35
5	Soundness (autoclave expansion %)	0.06
6	Fineness (m^2/Kg)	.489

Table 2:

C. Fine Aggregates

River sand from Sone river bed having the following characteristics has been used
Specific gravity - 2.66
Fineness modulus - 2.60
Water absorption - 1.35

D. Coarse Aggregates

Locally available crushed stone from Pakur with 16 mm graded size have been used as coarse aggregate. The physical properties for the coarse aggregate as found through laboratory test are
Aggregate crushing value = 24%
Aggregate impact value = 29%
Specific gravity = 2.713
Water absorption = 0.755

E. Mix Proportion

MIX NO	FLY ASH %	CEMENT %	Aggregate		W/C ratio	S.P L/m
			Coarse	Fine		
M-I	0	100	1217	745	0.5	3

Table 3: Conventional Concrete Mix Proportion (M20)

MIX NO	FLY ASH %	CEMENT %	Aggregate		W/C ratio	S.P L/m
			Coarse	Fine		
M-I	0	100	1183	800	0.4	5.5

Table 4: Conventional Concrete Mix Proportion (M25)

MIX NO	FLY ASH %	CEMENT %	Aggregate		W/C ratio	S.P L/m
			Coarse	Fine		
M-I	0	100	1125	625	0.32	9.6

Table 5: Conventional Concrete Mix Proportion (M60)

III. Results

A. Compressive Strength

Compressive strength tests were performed on cube samples of size 150mm X 150mm X 150mm using compression testing machine. Three samples per batch were tested with the average strength values reported

Table 4. Compressive Strength Test Results for M20

FLY ASH %	Compressive Strength		
	28 DAYS	91 DAYS	180 DAYS
30	46	54	57
40	44	55	67
50	38	41	53

Table 5:

FLY ASH %	Compressive Strength		
	28 DAYS	91 DAYS	180 DAYS
30	55	66	68
40	59	72	67
50	50	58	58

Table 6: Compressive Strength Test Results for M40

FLY ASH %	Compressive Strength		
	28 DAYS	91 DAYS	180 DAYS
30	68	77	64
40	60	72	75
50	70	72	76

Table 7: Compressive Strength Test Results for M60

B. Split Tensile Strength

Splitting tensile strength tests were performed on flexural testing machine using cylindrical samples of size 150 mm X 300 mm. Three samples per batch were tested with the average strength values reported.

FLY ASH %	split tensile	
	28 DAYS	91 DAYS
30	3.4	3.94
40	3.46	4.28
50	2.55	3.9

Table 8: Split Tensile Strength Test Results for M20

FLY ASH %	split tensile	
	28 DAYS	91 DAYS
30	3.67	3.76
40	4.28	4.87
50	3.94	5.08

Table 9: Split Tensile Strength Test Results for M40

FLY ASH %	split tensile	
	28 DAYS	91 DAYS
30	4.43	4.52
40	4.35	3.5
50	3.72	4.02

Table 10: Split Tensile Strength Test Results for M60

C. Flexural Strength

FLY ASH %	Flexure Strength	
	28 DAYS	91 DAYS
30	5.74	5.61
40	5.56	7.87
50	4.5	6.02

Table 11: Flexural Strength Test Results for M20

FLY ASH %	Flexure Strength	
	28 DAYS	91 DAYS
30	5.53	7.39
40	6.54	7.5
50	5.89	6.53

Table 12: Flexural Strength Test Results for M40

FLY ASH %	Flexure Strength	
	28 DAYS	91 DAYS
30	8.84	9.38
40	6.72	7.83
50	6.99	7.06

Table 12: Flexural Strength Test Results for M60

IV. CONCLUSION

- For similar cementitious material content and similar range of slump, the use of fly ash (0 to 50 %) decreased the water-to-cementitious-material ratio in general.
- The long term strength of the concrete containing fly ash is higher than that of control concrete without fly ash.
- Abrasion resistance of fly ash concrete is less than corresponding samples without fly ash both at early and longer ages, in general. The loss of thickness due to abrasion increases with percentage of fly ash in concrete.
- The fly ash concrete shows lower water permeability compared to that of control concrete.
- The depth of carbonation is increased with the increase in percentage replacement of fly ash in concrete.

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