Durability Study on Two Types of Fly Ash Concrete

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Abstract: The paper presents the durability study on two types of fly ash concrete. Fly ash replacement by various percentages of 20%, 30% and 40%. The conventional concrete M25 grade of concrete was made using OPC 53 grade. To be evaluated the optimize mix ratio, durability properties of fly ash based concrete and compared with test results.

Keywords: Acid resistance, Durability, Fly ash, Replacement, Sulphate attack,

INTRODUCTION

Concrete has been the basic building material ever seen the field of construction has come into existence. With the technological advancement the definition of concrete has undergone a few modifications but the prime goal has remained same. The reason behind the modification and evolution is the birth of additive materials like fly ash, silica fume, rice husk etc., which once being a residue has now found one of the important place in the manufacturing of high performanceconcrete.

Thermal power stations use pulverized coal as fuel generates large quantities of fly ash as by Product. There are about12 5thermal power plants in India, which form the major source of flash in the country. With the commissioning of super thermal Power plants and with the increasing use of low grade coal of high ash content, the current Production of fly ash is about120 Million tonnes per year and is expected to re acharound170Milliontonnesby 2012. This has posed serious disposal and ecological problem in addition to occupying a large tract of scarce cultivable land. Although the beneficial use of fly ash in concrete, brick making, soil stabilization treatment and other applications have been recognized, only a small quantity of the total fly ash is being utilized in our country currently in such applications.

SCOPEAND OBJECTIVES

To find the optimum replacement level of fly ash in replacement of cement. To study the impact of replacing cement with fly ash in conventional in durable properties of concrete. To practical guidelines for making conventional concrete incorporating fly ash as replacement for concrete. To compare the two types of fly ash with control specimen.

EXPERIMENTAL PROGRAMME

General

The experimental work carried out in this paper. The concrete were prepared with designed proportion. Then, casting and curing of the test specimens. This projects are included the optimization of fine aggregate using crushed sand in concrete for a grade M25.

TESTINGOFMATERIALS

The ingredient materials of concrete such as cement, fine aggregate and coarse aggregates are carried out.

Cement

Cement used in investigation was 53grade (zuari:OPC53) ordinary Portland cement conforming IS:12269:1987with specific gravity 3.14 is used.

ClassC FlyAsh

Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO).

Class F FlyAsh

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature and contains less than 10% lime (CaO). The glassy silica and alumina of Class F fly ash requires a cementing agent.

MIXPROPORTION

The M25 grade of concrete was used in the present work. The mix proportions ordinary grade concrete and standard grade concrete was designed using IS:10262- 2009. The slump of fresh concrete is found as 50 – 75 mm. The mix proportions for conventionalandvolumebasedpartialreplacementOPCbyclassCandclassFFly Ash.Table1presented the ratio for all mix proportion.

Table1RatioforAllMixes

Sl.No	Mix	Cement kg/m^3	FlyAsh kg/m^3	Fine Aggregate kg/m^3	Coarse Aggregate kg/m^3	W/C Ratio
1	Conventional	426.09	0	612.3	1181.1	0.45
2	CC20	340.87	62.96	612.3	1181.1	0.45
3	CC30	298.26	94.44	612.3	1181.1	0.45
4	CC40	255.65	125.92	612.3	1181.1	0.45
5	CF20	340.87	49.12	612.3	1181.1	0.45
6	CF30	298.26	73.68	612.3	1181.1	0.45
7	CF40	255.65	98.24	612.3	1181.1	0.45

CASTINGOFSPECIMENS

The test program was considered the cast and testing of concrete specimens of cube (150mm). The specimens were cast M25grade concrete using ordinary Portland cement, Natural River sand and aggregate of maximum size 20mm. Each three numbers of specimens were made to take the average value. The specimens were de-moulded after 24 hours. The specimens were allowed to the curing periods.

DURABILITY PROPERTIES

To study the properties concerning concrete durability, rapid chloride penetration test and sulphate attack to be conducted using 28-days cured concrete specimen.

Rapid Chloride Penetration Test

The test method consist of monitoring the amount of electrical currents that passed through 50 mm thick slice of 100 mm nominal diameter cores or cylinders during 6 h at 30min interval. A potential difference of 60 VDC is maintained across the ends of the specimen, one of which is immersed in a sodium chloride solution and the other in a sodium hydroxide solution. The total charge passed in coulombs was found to be related to the resistance of the specimen to chloride ion penetration. The left-hand side (-) of the test cell was filled with 3% NaCl. The right-hand side (+) of the test cell was filled with 0.3N NaOH solution. AASHTOT277 is the standard method of test for rapid determination of the chloride permeability of concrete. The test results are compared to the values in the standard table. This table was originally referenced in FHWA/RD-81/119 and also used in AASHTOT277-83 and ASTMC1202 Specification. The total charge passed on the specimen was calculated in Equation (1).

$$Q=900[I_0+2I_{30}+2I_{60}+\ldots\ldots+2I_{330}+2I_{360}] \qquad \ldots\ldots(1)$$

Where

Q=Charge passed (coulombs)

I_t=Current (amp) at t min after voltage is applied.

The total charge passed on 100 mm specimen was calculated: $Q_S=Q.(95/x)^2$

Where

Q_S=charge positive (coulombs) through a100 mm diameter specimen. x=diameter of the non-standard specimen.

Fig.1 shows the test setup for RCPT.

Sulphate Attack

Sulphate attack on concrete is a chemical break down mechanism where sulphate ions attack components of the cement paste. The compounds responsible for sulphate attack on concrete are water-soluble sulphate-containing salts, such as alkali- earth (calcium, magnesium) and alkali (sodium, potassium) sulphates that are capable of chemically reacting with components of concrete. The sulphate ion +hydrated calcium aluminate and/or the calcium hydroxide components of hardened cement paste+water= ettringite (calcium sulpho aluminate hydrate)

C3A.Cs.H18+2CH+2s+12H=C3A.3Cs.H32

Fig.1Test Setup RCPT

Water Absorption Test

Concrete cube specimens of size 100x 100x 100 mm were cast. After 28 days the specimens were taken out and placed in an oven at a temperature of 105°c to remove the moisture. The dry weight of the specimen was taken using an electronic weighing balance. The specimens were immersed in a curing tank, taken out, dried and the weights were recorded. The water absorption was calculated with reference to above weightsofthespecimen.Thisprocedurewasrepeatedforseveraltrialstillitobtains a saturation value. The specimen in water is shown in Fig.2.

Fig. 2 Water Absorption Test

Acid Resistance Test

Owing to the highly basic character of Portland cement, an acid cannot penetrate dense concrete without being neutralized as it travels inwards. Therefore, it cannot cause deterioration in the interior of the specimen without the cement paste on the outer portion being completely destroyed. The rate of penetration is thus inversely proportional to the quantity of acid neutralizing material, such as the calcium hydroxide, C-S-Hge land aggregates. Concrete is considered to be alkali resistivity in nature. The acid solution was prepared by mixing 3% sulphuric acid (H_2SO_4) and 2% hydro chloric acid (Hcl) in distilled water. At the end of 28 days of curing period, the specimens were air dried, cooled at room temperature, weigh educing an electronic balance and then immersed in to an acid bath. The initial weight of all the specimens were found and recorded before immersion. Then the weighed specimens were immersed in the acid solution for 15 days. After the specified period, the specimens were taken out from the acid bath and it was allowed to dry for 24 hours at room temperature. The specimens were brushed with a soft nylon brush and rinsed in tap water to remove loose surface material. The final weight and compressive strength of the cubes were found. The loss in weight and loss in strength were calculated. For determining the resistance of concrete specimens to aggressive environment like acid attack, durability factors are used based on relative compressive strength. Fig.3 shows the specimen immersed in Acid solution.

The results for conventional and replacement of fly ash in concrete cubes are presented.

$$\text{Loss in weight}(\%)=\frac{(W1-W2)}{W1}\times100$$

$$\text{Loss in compressive strength }(\%)=\frac{(\sigma1-\sigma2)}{\sigma1}\times100$$

Where

W1=Weight of concrete cube specimen before immersion in acid.

W2=Weight of concrete cube specimen after immersion in acid.

σ1=Compressivestrengthofconcretecubebeforeimmersioninacid.

σ2=Compressive strength of concrete cube after immersion in acid.

Fig.3 Specimens Immersed in Acid

RESULTS AND DISCUSSION

WATER ABSORPTION OF CONCRETE

The percentages of water absorption for conventional and fly ash concrete cubes were presented in Table 2. It was observed that there is significant difference between the conventional concrete specimens and fly ash concrete specimens. Water absorption increases with increases in percentage replacement of C and F fly ash replacement in cement.

ACID RESISTANCE OF CONCRETE

After immersion for 15 days in acid, the loss in weight and loss in compressive strength of conventional and fly ash concrete specimens obtained and presented in Table 3. It was observed that with the addition of fly ash there is some percentage of loss in weight. The loss in compressive strength was less in comparison with conventional concrete.

Weight loss of C fly ash mix CC20, CC30 and CC40 increases the 18%, 52% and 54% respectively when compared to the control specimen at 28^{th}day. Weight loss of F fly ash mix CF20, CF30 and CF40 reduces the loss 56%, 51% and 47% respectively when compared to the control specimen at 28^{th}day. Strength loss of C fly ash mix CC20, CC30 and CC40 increases the 9%, 17% and 23% respectively when compared to the control specimen at 28^{th}day. Strength loss of F fly ash mix CF20, CF30 and CF40 reduces the16%, 14% and 10% respectively when compared to the control specimen at 28^{th}day. It was found that the percentage of C fly ash increases correspondingly increases the strength loss. The percentage of F fly ash decreases correspondingly decreases the weight loss.

Table 2 Water Absorption of Concrete

S.No	MIX PROPORTION	Oven dried specimens mass (grams) W1	Mass of after immersion in water (grams) W2	Water absorption % (W2-1/W1)X100
1.	CC20	2593	2624	1.20
2.	CC30	2658	2707	1.64
3.	CC40	270	2760	1.86
4.	CF20	2729	2789	1.60
5.	CF30	2744	2808	1.83
6.	CF40	2756	2826	2.34

7	CONVENTIONAL	2708	2762	2.0

Table 3 Acid Resistance of Concrete

Sl. No	MIX PROPORTION	Weight loss(%)	Compressive strength before immersion in acid(N/mm^2)	Compressive strength after immersion in acid(N/mm^2)	Strength loss(%)
1.	CC20	1.25	26.35	24.93	5.57
2.	CC30	2.15	28.55	26.61	6.11
3.	CC40	2.26	25.36	23.80	6.58
4.	CF20	2.34	24.78	22.60	6.05
5.	CF30	2.12	26.65	24.60	5.92
6.	CF40	1.96	23.98	21.77	5.65
7	Conventional	1.02	34.75	32.86	5.05

SULPHATEATTACKTEST

After immersion for 15 days in sulphate, the loss of weight and loss of compressive strength of conventional and fly ash concrete specimens obtained and presented in Table 4. It was observed that the addition of fly ash there is some percentage of loss in weight. The loss in compressive strength was less in comparison with conventional concrete. Weight loss of C fly ash mix CC20, CC30 and CC40 increases the Weight loss 28%, 46% and 64% respectively when compared to the control specimen at 28thday. Weight loss of F fly ash mix CF20, CF30 and CF40 reduces the Weight loss 3 2%, 48% and 57% respectively when compared to the control specimen at 28thday. The percentage of fly ash increases correspondingly increases the weight loss. Strength loss of C fly ash mix CC20, CC30 and CC40 increases the strength loss 9%, 13% and 23% respectively when compared to the control specimen at 28thday. Strength loss of F fly ash mix CF20, CF30 and CF40 reduces the strength loss 26%, 18% and 12% respectively when compared to the control specimen at 28thday. The percentage of fly ash increases correspondingly increases the strength loss. Fig. 5 shows the before and after immersion of sulphate solution.

Table 4 Sulphate Attack of Concrete test values

Sl.No	MIXPROPORTION	Weight loss (%)	Compressive strength before immersion in Acid (N/mm^2)	Compressive strength after immersion in Acid (N/mm^2)	Strength loss (%)
	CC20	1.19	26.70	25.55	3.26
	CC30	1.6	28.00	27.33	3.62
3.	CC40	1.62	25.60	23.48	4.16
4.	CF20	1.84	24.70	22.09	3.63
5.	CF30	1.30	26.40	25.19	3.98
6.	CF40	1.05	23.20	22.33	4.22
7	CONVENTIONAL	0.95	34.75	32.22	3.16

RAPID CHLORIDE PENETRATION TEST

The chloride penetration on conventional and fly ash concrete slices at 28 days are given in Table 5. It was observed that with the addition of fly ash there is a significant decrease in chloride penetration which shows that the fly ash concrete is densely packed. The test result obtained shows that all the specimens up to 30 % in class C fly ash are under very low penetration but for class F fly ash CF20% is very low penetration.

Table 5 Rapid Chloride Penetration Test values

GRADEOF CONCRETE	SAMPLE	28DAYSCHLORIDE PERMEABILITY	
		COULOMBS	REMARKS
M25	CC20	893	VL
	CC30	981	VL
	CC40	1086	L
	CF20	941	VL
	CF30	1044	L
	CF40	1238	L

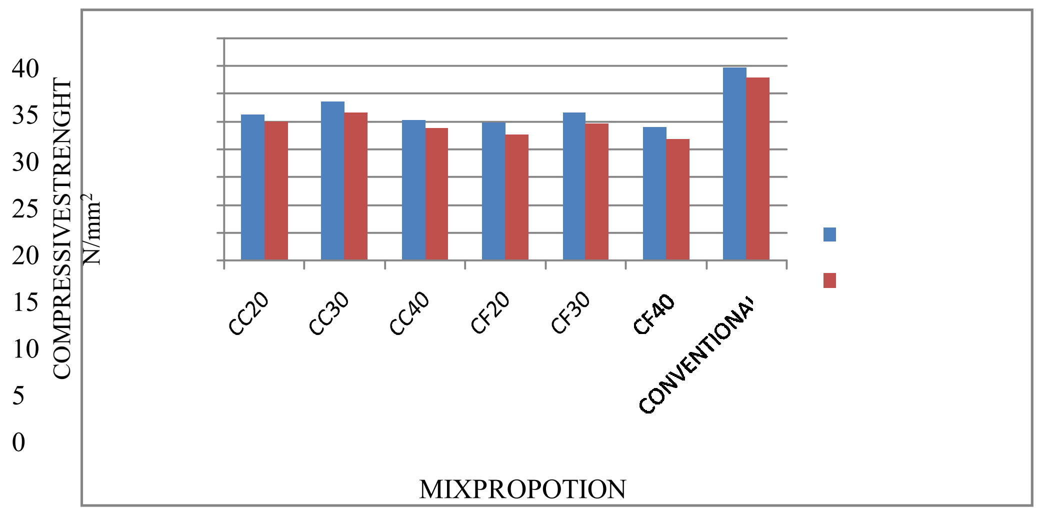

Fig. 5 Before and After Immersion of Sulphate Solution Test Values

CONCLUSIONS

a. Acid resistance test, the percentage of C fly ash increases correspondingly increases the strength loss. The percentage of F fly ash decreases correspondingly decreases the weight loss.

b. The average charge passed was found to be 893 coulombs for CC20% and for fly ash CC30 is 981 Coulombs and for CC40 is 1086 Coulombs. The maximum charged passed was 1238 coulombs for CF40% after 28 days compared to CF30 1044 Coulombs and CF40 is 1238 Coulombs. Conventional mixhas lowchloridepenetrationvaluecomparedtoother.

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