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Mechanical and Durability Properties of Concrete Incorporating Flyash

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Abstract:- An attempt was made to replace cement by using mineral admixture Fly ash. As per Indian Government norms at-least 10% of fly ash should be used during cement production. The objective of this research work was to study the mechanical and durability properties of concrete by replacing maximum amount of cement by fly ash. M30 grade of concrete was used with w/c ration of 0.45. The results indicate that upto 35% of fly ash can be replaced for cement for effective compressive strength and flexural strength confirming to IS Standards. Also an attempt was made on the durability of concrete using fly ash as replacement material. 35% fly ash replacement showed better performance confirming to ASTM C1202. The sorptivity test also showed gradual increases in absorption when compared to control mix concrete.

Keywords:- Mineral admixture, Fly ash, Durability, Compressive strength, Flexural strength.

I. INTRODUCTION

For the civil engineering community, the concept of sustainable development involves the use of high-performance materials produced at a reasonable cost and with the lowest possible environmental impact [2]. Current trends show that infrastructure needs for our rapidly industrializing world will continue to require large amounts of low cost building materials, such as portland cement concrete [10]. The objective is to help engineers and concrete producers to more confidently use increased fly ash percentages in concrete [12]. The performance of concrete is adversely affected by the increase in size and number of micro cracks in the transition zone, which govern the strength and durability characteristics of the material [13]. India is the second largest producer of cement in the world. About 300 million Tons of cement and 175 million tons of Fly ash we produced. Fly ash is a by-product and therefore less expensive than Portland cement; it is also known to improve workability and reduce internal temperatures [11]. Fly ash also makes substantial contributions to workability, chemical resistance and the environment [1]. Fly ash is a group of materials that can vary significantly in composition. It is residue left from burning coal, which is collected on an electrostatic precipitator or in a bag house. Typically, fly ash is added to structural concrete at 15-35 percent by weight of the cement, but up to 70 percent is added for mass concrete used in dams, roller-compacted concrete pavements, and parking areas. Special care must be taken in selecting fly ash to ensure improved properties in concrete. The main benefit of fly ash in concrete is that it not only reduces the amount of non-durable calcium hydroxide (lime), but in the process converts it into calcium silicate hydrate (CSH), which is the strongest and most durable portion of the paste in concrete. If the calcium content of the fly ash is high enough, it is possible to make concrete with moderate strength using the fly ash as the sole cementing material [4]. The mechanical properties of the concrete made with the HVFA blended cements depend primarily on the type of fly ash used in the blended cements. In general, these properties are excellent due to the dense microstructure, and the low water content of the concrete made with this type of cement [3]. The improved workability is a result of the “ball bearing” action of the spherical fly ash particles. Fly ash improves the grading in the mixture by smoothing out the fine particle size distribution [9]. Also, fly ash has been shown to reduce the amount of water required [14]. Fly ash from modern power plants used in large volumes can reduce the water content by 15 to 20 percent [9]. However, research has shown that the properties of High Volume Fly Ash (HVFA) concrete are strongly dependent on the characteristics of the cement and fly ash used [1].Tensile and compressive strengths achieved are adequate for the proposed applications with drying shrinkage within acceptable limits [5].

II. MATERIALS

A. Fly ash

The fines of fly ash require a minimum of 66 percent passing the 0.044 mm (No. 325) sieve. The specific gravity of fly ash is 2.72.

B. Cement
The Ordinary Portland cement of 43-grade was used in this study conforming to IS:12269-1987 [6]. The specific gravity of cement is 3.15.

C. Coarse aggregate
Coarse aggregate obtained from local quarry units has been used for this study, conforming to IS: 383-1970 [7] is used. The specific gravity of coarse aggregate were 2.69 and 2.72 for 10 and 20 mm respectively.

D. Fine aggregates
The river sand is used as fine aggregate conforming to the requirements of IS: 383-1970 [7], having specific gravity of 2.52.

E. Water
The water used for experiments was potable water conforming as per IS: 456-2000 [8].

F. Admixtures
The admixture poly Carboxylic Ethane is used for tight concrete which makes to maintain slurry mode.

III. EXPERIMENTAL PROCEDURE

M30 grade concrete mix with w/c ratio of 0.45 was prepared. The mixes were designated in accordance with IS: 10262-2009. The mix proportion of the concrete with fly ash for the designated M30 grade of concrete is as shown in Table I. Fly ash is used as a replacement to cement by varying the percentage from 20 to 70. A chemical admixture of 0.6% was used to make the concrete workable. A total of 45 concrete cubes were casted for different percentages of replacement of cement. The specimens were demoulded after 24 hours and curing was done for different age of testing, i.e.,7, 28 and 56th day. Beam of 15 numbers was casted for determining the flexural strength of the concrete. The durability of concrete is also found out by observing the rapid chloride penetration by means of measuring the electrical conductance confirming to ASTM C1202 [15]. The sorptivity of concrete is measured for primary and secondary rate of water absorption.

Table I: Details of Mix Proportions of Concrete with Fly ash

Sl. No	Cement replacement %	W/C ratio	Cement Kg/m^3	Fly ash Kg/m^3	Water Kg/m^3	Admixture (PCE)	Coarse aggregate		Fine aggregate Kg/m^3
							20 mm	12 mm	
1	0%	0.45	380	0	171	0.6%	558.785	552.622	749.770
2	20%	0.45	304	76	171	0.6%	553.343	547.240	742.467
3	35%	0.45	247	133	171	0.6%	549.320	543.261	737.069
4	50%	0.45	190	190	171	0.6%	545.218	539.205	749.770
5	70%	0.45	114	266	171	0.6%	539.696	533.744	724.157

IV. RESULTS AND DISCUSSION

1. The compressive strength decrease from 45.37 MPa to 13.10 at the end of 28 days, when the fly ash is increased from 20% to 70% as shown in Fig.1.
2. A similar trend of reduction (i.e. from 53.3 MPa to 19.47 MPa) in compressive strength was observed for 56 days.
3. Flexural strength decreases from 5.47 MPa to 2.19 MPa at the end 28 days for fly ash replacement of cement from 20% to 70% as shown in Fig.2.
4. The Rapid Chloride Penetration Test **(**RCPT) values are very much on the lower side for the mixes with 20 % and 35 % replacement levels of fly ash as shown in Table II. However, the mixes incorporating higher levels of replacement, 50 % and 70 % show very low RCPT values lesser than 1000 coulombs and which fall under category of "Very Low" as per the requirements of ASTM C1202.
5. The initial rate of absorption for 20% and 35 % are almost the same as shown in Table III. However, for the mixes with higher volume of fly ash, the absorption values are on the higher side, indicating that water

cement ratios have to be accordingly adjusted to get equivalent compressive strengths as that of the control concrete at the age of 28 days.

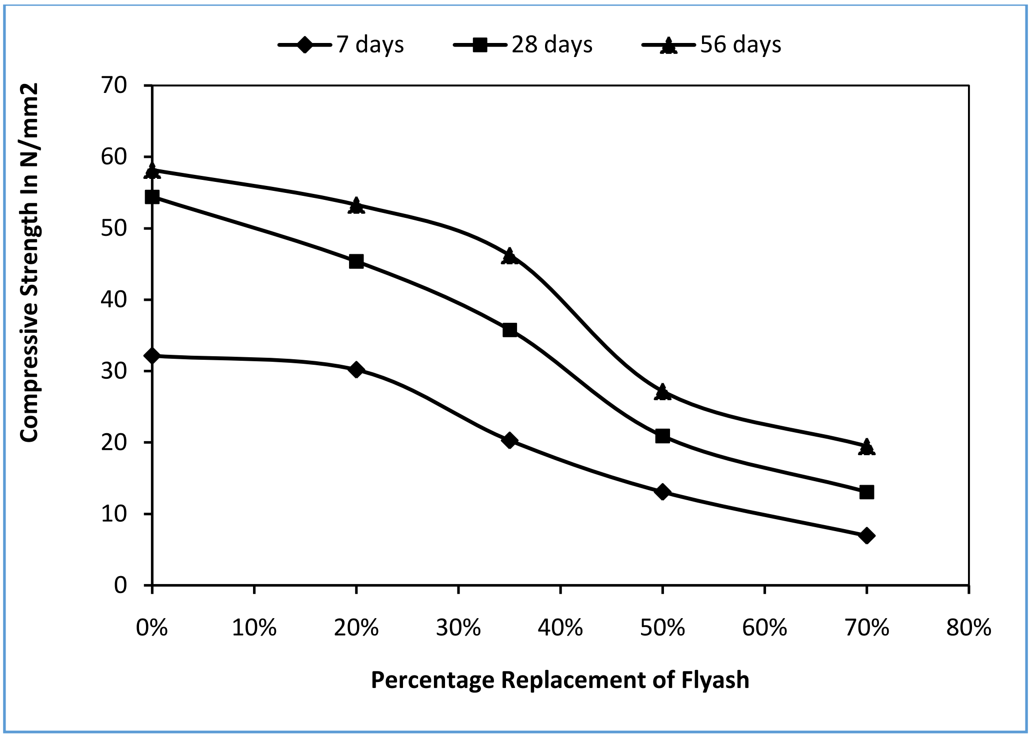

Fig.1: Compressive strength of concrete cubes

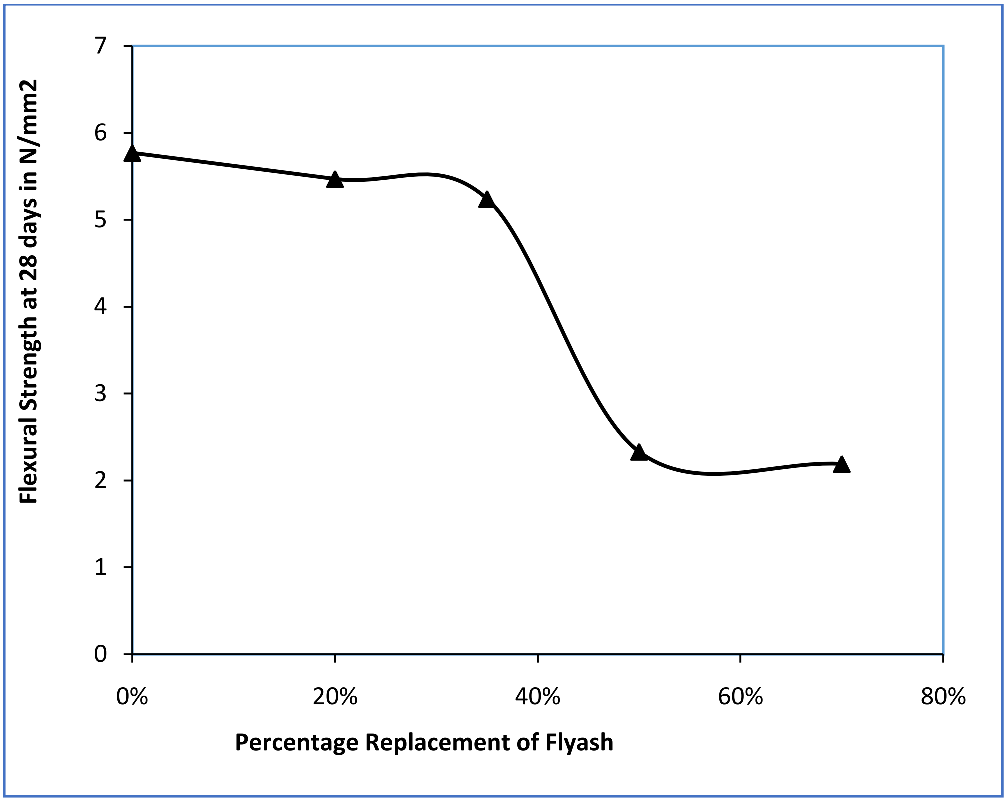

Fig.2: Flexural strength test of concrete beams at 28 days

Table II: Rapid chloride penetration test of concrete cylinder

Sl. No	Time (mins)	Control sample	20% sample	35% sample	50% sample	70% sample
1	0	140	84	60	32	36
2	30	164	96	71	35	40
3	60	180	107	75	36	43
4	90	188	112	79	39	44
5	120	199	120	80	40	44
6	150	204	128	81	40	42
7	180	207	131	84	40	40
8	210	208	136	87	43	44
9	240	210	139	88	44	48
10	270	212	143	92	44	51
11	300	211	143	92	44	52
12	330	208	144	95	44	52
13	360	203	144	92	44	51
		4252.5 (coulomb)	2723.4 (coulomb)	1800 (coulomb)	876.6 (coulomb)	978.3 (coulomb)

Table III: Sorptivity Test of concrete cylinder

Sec	Sec^2	Results				
		Control	20	35	50	70
0	8	0.082	0.081	0.094	0.175	0.220
60	17	0.102	0.113	0.131	0.209	0.281
300	24	0.107	0.120	0.136	0.223	0.307
600	35	0.113	0.127	0.142	0.258	0.328
1200	42	0.117	0.131	0.145	0.265	0.347
1800	60	0.136	0.141	0.160	0.289	0.410
3600	85	0.148	0.155	0.180	0.327	0.471
7200	104	0.283	0.167	0.191	0.354	0.535
10800	120	0.243	0.181	0.205	0.386	0.590
14400	134	0.255	0.194	0.216	0.415	0.634
18000	147	0.262	0.200	0.225	0.434	0.667

V. CONCLUSION

1. It is seen that 20 % replacement level of fly ash satisfy the target strength for M30 grade at the age of 28 and 56 days.
2. The concrete mixes incorporated with 35 %, 50 % and 70 % fly ash do not satisfy the target strength criteria at 28 and 56 days.
3. The above reduction might be due to the increase of fly ash, which will not hydrate in initial few days.
4. The higher replacement levels of fly ash result in enhanced durability characteristics as evident from the Sorptivity and RCPT test results, though they show reduced compressive strengths.
5. In the case of the mixes with 20 and 35 % replacement levels, there is a gradual increase in the secondary absorption.

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