Assessing Durability of Concrete with addition of low quality Fly Ash

Ali Ajwad, Usman Ilyas and Mudassar Ibne Shafiq
Department of Civil Engineering
University of Management and Technology
Lahore, Pakistan
Ali.ajwad@umt.edu.pk

Akhtar Abbas, M. Ali Khan and Tariq Ali
Department of Civil Engineering
The University of Lahore
Lahore, Pakistan

***Abstract*— Life of a structure is basically defined by its durability. Over coarse of time, concrete carbonation and corrosion of steel reinforcement leads to weakness in structural elements and hence reducing its useful life. Addition of fibers in concrete can act as a barrier and prolong the activation of this process. In this study, low quality fly ash was added to concrete to check it effect on durability of concrete. It was found out the addition of low quality fly ash with an activator does have positive impact on carbonation and reinforcement corrosion resistance.**

Keywords-Durability, fly ash, fibers, carbonation, corrosion

I. INTRODUCTION

Pulverized fuel ash or fly ash is a waste product of coal power stations. This waste is dumped to landfills and acts as a major threat to environment. Using it in concrete as replacement, can not only protect our environment but can also add to construction economy. In Past studies, fly ash has been used to improve the fresh and hardened properties of concrete but durability aspect has not been investigated properly. Qingxin Zhao et. Al [1] studied the effect of extended curing of 90 days on carbonation resistance and found out the extended curing did have positive effect of dense interfacial zone and negative effect of calcium hydroxide consumption.Bagheri et al. [2] compared the performance of fine fly ash and silica fume in enhancing the properties of concretes containing fly ash and found out that Silica fume is substantially more effective than fine fly ash in improving properties of conventional fly ash based ternary mixes. M.L. Berndt [3] studied the Properties of sustainable concrete containing fly ash, slag and recycled concrete aggregate. He found out that the mixes containing 50% slag gave the best overall performance. Cengiz Duran Atiş [4] studied the properties of Properties of steel fiber reinforced fly ash concrete and found out that addition of fly ash improved the durability of concrete by increasing its freeze-thaw resistance.

It can be noticed that most of the researches have been done using high-quality and well-refined fly ash whereas effects of use of low quality fly ash on durability is still not well studied. In this research low quality fly ash was added in concrete in large volumes and effects of doing so were studied.

II. EXPERIMENTAL PROGRAM

A. *Materials used*

Locally available Portland cement was used with brand name 'Maple Leaf'. The fly ash used for cement replacement was obtained from Maple leaf power plant located in city of Sahiwal, Pakistan. Table 1 shows the chemical analysis of fly ash used as cement replacement. The fineness of fly ash used was 27.3% (percentage retained on sieve size of 45 micrometer).

TABLE I. ELEMENT PROPERTIES OF ADDED FLY ASH

SiO_2	CaO	Fe_2O_3	Al_2O_3	MgO	Na_2O	TiO_2	SO_3	K_2O
53.6	3.5	3.9	34.3	1.0	0.8	0.9	0.9	1.1

Locally available Lawrencepur sand was used as fine aggregate and in place of coarse aggregate, waste crushed limestone was used. Water-reducing agent and activators were also added.

B. *Concrete specimens preparation*

For carbonation test, steel reinforcement corrosion test, and flexural strength, 100 x 100 x400 mm^3 specimens were cast whereas to test the compressive strength (corrosion resistance), cubes of 100 x 100 x 100 mm^3 were cast. A concrete cover of 30mm was provided to all specimens and minimum diameter steel i.e 6mm bar was used. Specimens were cured by keeping them dipped in water for 28 days.

III. RESULTS AND DISCUSSION

A. *Carbonation*

Two different concentrations of CO_2, 20% and 3%, were used to check the effect of addition of low quality fly ash in concrete. Table 2 shows the depth of carbonation at 28 days old concrete. M1 mix was normal concrete whereas M2 and M3 mixes were 35% cement replaced by low quality fly ash with addition of activator in M3.

TABLE II. DEPTH OF CARBONATION

Mix No.	Depth of Carbonation (mm)	
	20% CO_2 Concentration	*3% CO_2 Concentration*
M1	15.2	12.1
M2	23.1	17.3
M3	14.9	11.8

It can be seen from the results that depth of carbonation increases with addition of fly ash as cement replacement. This trend is similar for both types of carbon dioxide concentrations. Although this increased carbonation can be controlled with addition of activator in the mix.

B. Corrosion of steel reinforcement

The results of tests performed to check the corrosion of steel reinforcement were similar to that of carbonation tests. Addition of fly ash increased corrosion in carbonated concrete whereas addition of activators reduced the corrosion rate and the corrosion was even less than that in normal concrete. Whereas in the case where corrosion was checked in concrete that was not carbonated, the corrosion of reinforcement was less in M2 as compared to M1 specimen, and it was even less in M3 specimen.

C. Corrosion resistance

In order to check the corrosion resistance, specimens were cured for 120 days in 3 different solutions, normal curing, curing in 5% sodium sulphate solution and 5% hydrochloric acid solution. The results are shown in Table 3.

TABLE III. CORROSION RESISTANCE

Mix No.	Compressive Strength (MPa)			Flexural Strength (MPa)		
	Water	*5% Na_2SO_4*	*5% HCl*	*Water*	*5% Na_2SO_4*	*5% HCl*
M1	41.2	40.1	31.7	3.11	3.78	2.45
M2	43.6	44.2	34.2	3.34	3.9	3.56
M3	43.1	41.1	36.7	2.99	3.12	2.78

It can be seen from the table that addition of fly ash did improve the compressive and tensile strength of specimens. In addition to increased strength, resistance to corrosive environment also increased.

IV. CONCLUSIONS

1. After the text edit has been completed, the paper is ready Carbonation resistance can be increased with used of an activator in low quality fly ash reinforced concrete. This resistance is almost similar to that of control concrete.
2. The resistance to corrosion of steel reinforcement can be enhanced with use of activatorunder harsh environments.
3. With addition of low quality fly ash, the resistance to corrosive environments can be improved in concrete. Fibrous concrete shows more resistance and retains more strength over longer spans of time.

REFERENCES

[1] Qingxin Zhao, Xiaojun He, Jinrui Zhang, Jinyang Jiang. (2016). Long-age wet curing effect on performance of carbonation resistance of fly ash concrete. *Construction and building materials*. 127 (1), 577-587.

[2] Alireza Bagheri, Hamed Zanganeh, Hadi Alizadeh, Mohammad Shakerinia, Mohammad Ali SeifiMariand. (2013). Comparing the performance of fine fly ash and silica fume in enhancing the properties of concretes containing fly ash. *Construction and building materials*. 47 (1), 1402-1408.

[3] M.L. Berndt. (2009). Properties of sustainable concrete containing fly ash, slag and recycled concrete aggregate. *Construction and building materials*. 23 (7), 2606-2613.

[4] Cengiz Duran Atiş and OkanKarahan. (2009). Properties of steel fiber reinforced fly ash concrete. *Construction and building materials*. 23 (1), 392-399.