Asian Journal of Chemistry; Vol. 24, No. 11 (2012), 5142-5144

ASIAN JOURNAL OF CHEMISTRY

www.asianjournalofchemistry.co.in

Study on Corrosion of Activated Fly Ash Concrete Beams

SUNILAA GEORGE[1,*], R. THENMOZHI[1] and P.N. MAGUDESWARAN[2]

[1]Department of Civil Engineering, Thanthai Periyar Government Institute of Technology, Bagayam, Vellore-632 002, India
[2]Department of Science and Humanities, Sri Krishna College of Engineering and Technology, Coimbatore-641 008, India

*Corresponding author: E-mail: sunilaageorge@rediffmail.com

(*Received*: 24 September 2011; *Accepted*: 12 June 2012) AJC-11581

Corrosion of main steel reinforcement is one of the major factors in flexural capacity reduction of reinforced concrete beam. Steel corrosion reduces the cross section area as well as the continuity of the surface of steel. Such reductions lower the tension strength of steel, bond strength due to a slip between steel and the surrounding concrete and, consequently deteriorate the member strength. Mineral admixture like fly ash can be used for enhancing passivity of concrete. The properties of fly ash can be improved by activation. The objective of the present investigation is to improve the quality of fly ash by chemical treatment and to study the corrosion resistance capacity of activated fly ash concrete. In this study, half cell potential of beams and weight loss due to corrosion are determined for activated fly ash concrete.

Key Words: Corrosion, Half cell potential. Activated fly ash, Fly ash, Supplementary cementitious materials.

INTRODUCTION

Corrosion of reinforcing steel is a major cause of failure in concrete structures. There are many methods for protection against corrosion of steel in concrete, including addition of inhibitors, cathodic protection, metallic coatings for steel reinforcement or the addition of supplementary cementing materials (SCM) such as, fly ash to concrete. The use of supplementary cementing materials in concrete not only improves the mechanical properties and durability but also uses industry by-products and has, therefore, significant environmental and economic benefits. The properties of fly ash are modified by activation.

A new method of chemical activation with addition of $Ca(OH)_2$ and a small quantity of Na_2SiO_3 was reported by Fan *et al.*[1]. Alkali activation showed improved accelerated setting and hardening[2-7]. Activated fly ash with CaO and Na_2SiO_3 improves the properties of RCC[8]. Although many studies are available with different activation methods, studies of reinforced concrete with activated fly ash(AFA) using CaO and Na_2SiO_3 are not available. Therefore a realistic assessment of activated fly ash concrete is essentially needed that can be adopted easily. More over research on the corrosion effects of these supplementary materials on chloride ion diffusivity and corrosion of the reinforcing steel in concrete is limited and needs further investigation. In this paper, an experimental investigation of the corrosion of reinforcing steel bars embedded in concrete beams containing activated fly ash was undertaken. The performance of these beams is then compared to a control mix made of normal Portland cement concrete and fly ash beams with the same w/b ratio.

EXPERIMENTAL

Ordinary pozzolanic cement (OPC) of 43 grade confirming to IS: 1489-1991 (Part II) was used in this study. River sand passing through 4.75 mm sieve with specific gravity of 2.67 fineness modulus of 2.87 was used. Coarse aggregates collected from approved quarry and aggregates having size ranging from 10-20 mm are used. Concrete specimens for testing were done in accordance with IS 516:1959. After 24 h of casting, the specimens were de-moulded and kept under wet gunny bags for curing. The beams are cast in triplicate from the same batch of concrete. Potable water was used for mixing and curing. The mix proportion of concrete 1:1.64:3.61 and water to binder ratio of 0.55 was taken for the study.

Half cell potential study of beams: The most common method to determine the corrosion potential of steel in reinforced concrete without having to destroy the structure or the specimen is to take half-cell measurements. Half-cell measurements compare the potential of the reinforcement with that of a reference electrode exposed to the same environment. In the field, half-cell measurements are usually taken using a copper-copper sulfate (CSE) electrode and are fairly accurate when proper presetting of the concrete is used (ACI 222 1996).

At a measured half-cell potential more negative than -0.350 V (CSE) there is a very high probability that active corrosion is present. At measured half-cell potentials more positive than -0.200 V (CSE), there is a very high probability that corrosion is not occurring. In the range of -0.200 to -0.350 V (CSE), the degree of corrosion is uncertain (ACI 222 1996).

Thirteen sets of concrete beams of size 100 mm × 200 mm × 1000 mm are cast in triplicate and the diagram for study is given in Fig. 1. All rods used for the study are cleaned and weighed accurately before casting. Beams after 28 days of curing are used for corrosion study.In order to accelerate corrosion, immersion of the specimens in 3.5 % NaCl solution was done for two months in an open tank outside the laboratory. Beams under unstressed conditions were subjected to the accelerated corrosion process. Beams were immersed in a tank to a depth of 150 mm in a 3.5 % sodium chloride solution. This study was carried out for a period of 90 days. Fig. 2 shows the beams under study and Fig. 3 shows the schematic diagram for measurement of open circuit potential. Open circuit potential was measured using a multi meter in mV for every 10 days. After the process of accelerated corrosion was over, all the specimens were disconnected and removed from the tank and tested to find the flexural strength in two point loading in a loading frame with a load cell of 500 kN capacity. After the load tests beams are broken and reinforcement removed cleaned again to remove rust and weighed again to find the weight loss due to corrosion.

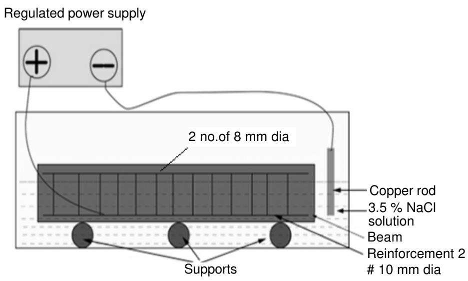


Fig. 1. Schematic diagram for half cell potential study

Fig. 2. Beams under study

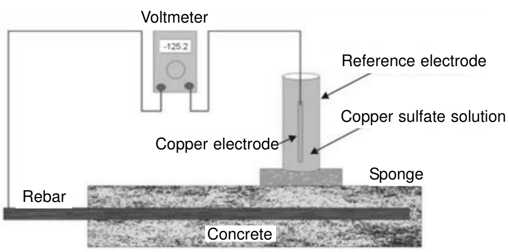
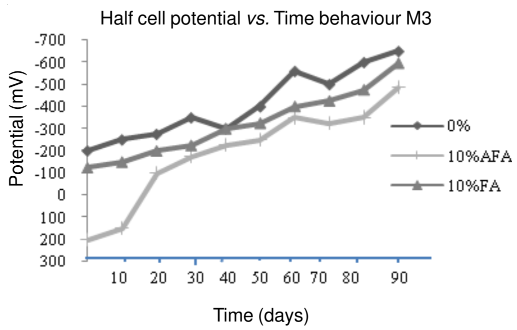
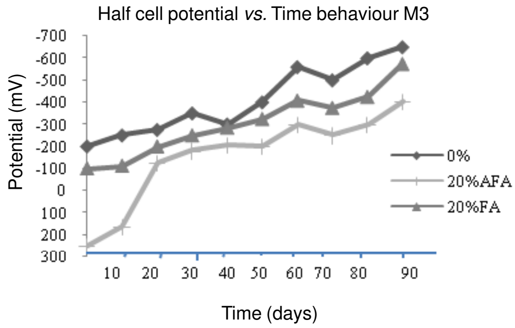


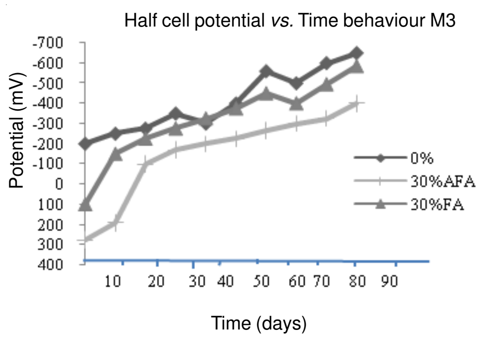
Fig. 3. Schematic diagram for measurement



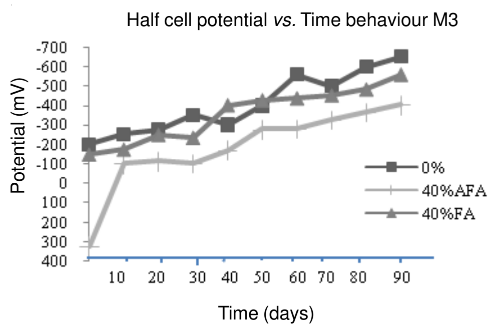
(a)



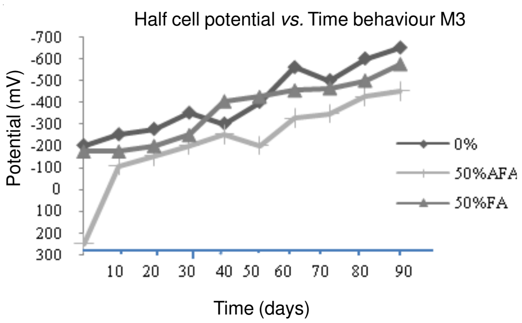
(b)



(c)



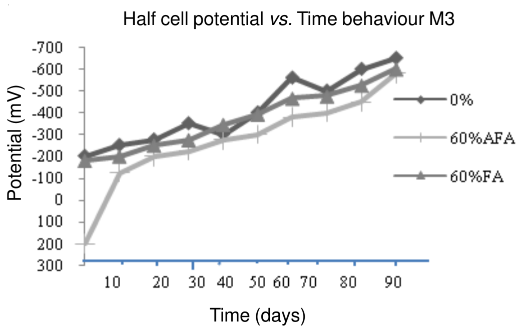
(d)



(e)

TABLE-1
OPEN CIRCUIT POTENTIAL IN mV

No of days	C1	F1	AFA1	F2	AFA2	F3	AFA3	F4	AFA4	F5	AFA5	F6	AFA6
0	-200	-125	200	-100	250	100	275	-150	323	-175	250	-180	200
10	-250	-150	150	-112	165	-150	190	-175	-100	-175	-105	-200	-125
20	-275	-200	-98	-210	-125	-225	-100	-250	-112	-240	-150	-250	-200
30	-350	-225	-175	-250	-180	-275	-170	-235	-101	-250	-200	-275	-225
40	-350	-300	-225	-285	-205	-325	-200	-400	-170	-405	-250	-345	-275
50	-400	-325	-250	-330	-202	-375	-225	-425	-275	-425	-230	-392	-300
60	-560	-400	-350	-408	-300	-450	-265	-435	-280	-455	-325	-465	-380
70	-500	-425	-325	-375	-250	-400	-300	-450	-325	-465	-345	-475	-400
80	-600	-475	-350	-425	-300	-495	-325	-480	-365	-500	-425	-525	-450
90	-650	-595	-485	-575	-402	-585	-400	-555	-402	-575	-450	-600	-580



(f)

Fig. 5(a-f). Comparison potential for activated fly ash And fly ash series eams

RESULTS AND DISCUSSION

From Table-1 and Fig. 4(a-f) it can be seen that the potential of ordinary pozzolanic cement beams the shift from -200 mV to -225 occurred in 10 days and it shows the probability of corrosion and there is 90 % probability in corrosion after 30 days.

In the case of fly ash concrete there is considerable improvement in the system due to the addition of fly ash which act as filler and prevents ingress of chloride ions. It is found that the change op potential moved to - 200 mV after 30 days and probability of corrosion is confirmed by the shift of potential than -350 occurred at a later stage in case of fly ash replacement of 10 % is from F1 beams and F2 beams. In case of activated fly ash beams there is more resistance when compared to fly ash concrete[9]. This is due to the filler effect along with formation of CSH gel in comparison to fly ash systems. Probability of corrosion is observed in case of activated fly ash system after 60-90 days. The test results are confirmed by the weight loss measurements. In case of fly ash weight loss is less in case of 10 and 20 % where as in case of activated fly ash it is 30 and 40 %.

TABLE-2
WEIGHT LOSS

S. No.	Replacement (%)	Weight loss (%)	
		Fly ash	Activated fly ash
1	0	8.5	8.5
2	10	2.15	6.48
3	20	2.35	5.79
4	30	3.96	1.83
5	40	4.35	2.43
6	50	4.75	3.25
7	60	5.55	4.35

Conclusion

From the above investigations it is inferred that the fly ash systems are having good corrosion resistance properties. Among the six replacements, 10 % fly ash and 30 % activated fly ash is showing better performance than the other systems with water binder ratio of 0.55 in concrete.From the above investigations it is further inferred that the activated fly ash is applicable for structural members in corrosive environments[10]. Apart from the waste disposal, use of activated fly ash in concrete can result in improved resistance to corrosion against aggressive environments.

ACKNOWLEDGEMENTS

The authors thank the Management and Civil Department of V.L.B. Janakiammal College for providing the necessary research facilities.

REFERENCES

1. Y.M. Fan, S.H. Yin, Z.Y. Wen and J.Y. Zhong, *Cem. Concr. Res.*, **29**, 467 (1999).
2. C.J. Shi and R.L. Day, *Cem. Concr. Res.*, **31**, 813 (2001).
3. A.R. Brough and A. Atkinson, *Cem. Concr. Res.*, **32**, 865 (2002).
4. Z.H. Xie and Y.P. Xi, *Cem. Concr. Res.*, **31**, 1245 (2001).
5. A. Palomo, A. Fernandez-Jimenez, G. Kovalchuk, L.M. Ordonez and M.C. Naranjo, *J. Mater. Sci.*, **42**, 2958 (2007).
6. F. Puertas, T. Amat, A. Fernández-Jiménez and T. Vázquez, *Cem. Concr. Comp.*, **33**, 2031 (2003).
7. C. Shi and J. Qian, *Energy Sources*, **25**, 617 (2003).
8. S. George, R. Thenmozhi and P.N. Magudeswaran, *J. Struct. Eng.*, **37**, 379 (2011).
9. V. Saraswathy and H.-W. Song, *Portug. Electrochim. Acta*, **26**, 417 (2008).
10. P.N. Magudeswaran, M. Malathi and S. George, *Asian J. Chem.*, **20**, 21 (2008).