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HALF CELL POTENTIAL DATA FOR CORROSION PROBABILITY OF FLY ASH CONCRETES

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ABSTRACT

Use of fly ash in concrete is an as partial replacement to cement in concrete is becoming indispensable as it is an eco-friendly and sustainable alternative to reduce the cement consumption in construction industry. Cement production involves lot of carbon dioxide emission into the atmosphere which in turn adds to the environmental pollution. As fly ash is acidic in nature addition or replacement of cement by fly ash reduces the pH of the end product fly ash concrete. Reduction in pH of concrete adversely affects the passivation layer formed around the reinforcement present in the concrete. Reduction in passivation layer promotes the corrosion of reinforcing bars. Thus it is necessary to study the affect of fly ash on the corrosion aspects of reinforced cement concrete. Half Cell Potential (HCP) meter is usually used to estimate the corrosion probability of a reinforced concrete element. In this investigation an attempt has been made to quantify the corrosion probability of different reinforced concrete members varying the different percentage replacement levels of cement by Fly ash. The Half Cell Potential data indicated that the probability of corrosion of fly ash concretes for higher levels of replacement of cement by fly ash. To impart corrosion resistance to the concrete fly ash is treated chemically and used in concrete. The Half Cell Potential Data of treated fly ash concrete shoed better response. It is concluded that the chemically treated fly ash needs to be used in fly ash concrete especially when the RC element is located in aggressive environment which promotes corrosion..

Keywords*: *Corrosion, Durability, Fly Ash Concrete, Half Cell Potential

I INTRODUCTION

Corrosion of re-bars in reinforced concrete structures is recognized as a major problem in the maintenance of the structural integrity. The most important causes for initiation of corrosion of reinforcing steel are the ingress of chloride ions and carbon dioxide to the steel surface and pH of concrete surrounding the rebar. Chloride ion causes local destruction of the passive film leading to localized corrosion. Carbon dioxide, on the other hand, reacts with the hydrated cement matrix, leading to a decrease in pH and subsequent loss of steel passivity and to corrosion initiation. Chemical protection is provided by the high pH (12.5-13.5) of the concrete interstitial solution, which causes passivation of the reinforcing steel. One of the several methods of estimating the corrosion probability of concrete is by Half Cell Potential method. Several researchers have pointed the use of

HCP data to assess the durability aspect of concrete with respect to its corrosion resistance. Fly ash is looked as an alternative to replace cement partially in concrete to make the concrete making eco friendly. Addition of fly ash to concrete has become common practice in recent years. Partial replacement of cement by fly ash in concreting has several advantages such as increased workability due to ball bearing action of smooth and rounded particles of fly ash and increased long term strength due to the pozzolanic action of fly ash. However the effect of fly ash addition/replacement to the cement on the corrosion aspects of the concrete needs careful consideration. In this investigation an attempt has been made to present the Half Cell Potential data of fly ash concretes.

II FLYASH

Fly ash is a finely divided residue with high specific surface area, obtained from thermal power plants as a waste product. The use of fly ash as replacement to cement has been reported by several researchers and its use in concrete construction is indispensable. Use of fly ash as partial replacement to cement in concrete improves the mechanical strength of the hardened concrete and the workability of the matrix when the matrix is in green state. Addition of fly ash in fly ash concrete may be as high as 60 percent of OPC content and because of the high replacement level; the fly ash concretes are characterized by their low early strength and high ultimate strength. The low early strength is attributed to the partial replacement of Portland cement, with a material that is not hydraulic. High dosage of fly ash in concrete may reduce the pH of the concrete and decrease corrosion resistance. A drop in the pH of concrete reduces the passive alkaline layer over the rebar, thereby promoting the favorable conditions of corrosion. Thus in the present study Fly ash concretes are tested for half cell potential. Half cell potential data of concrete with different percentage replacement levels of cement by fly ash as well as treated fly ash are presented in this paper.

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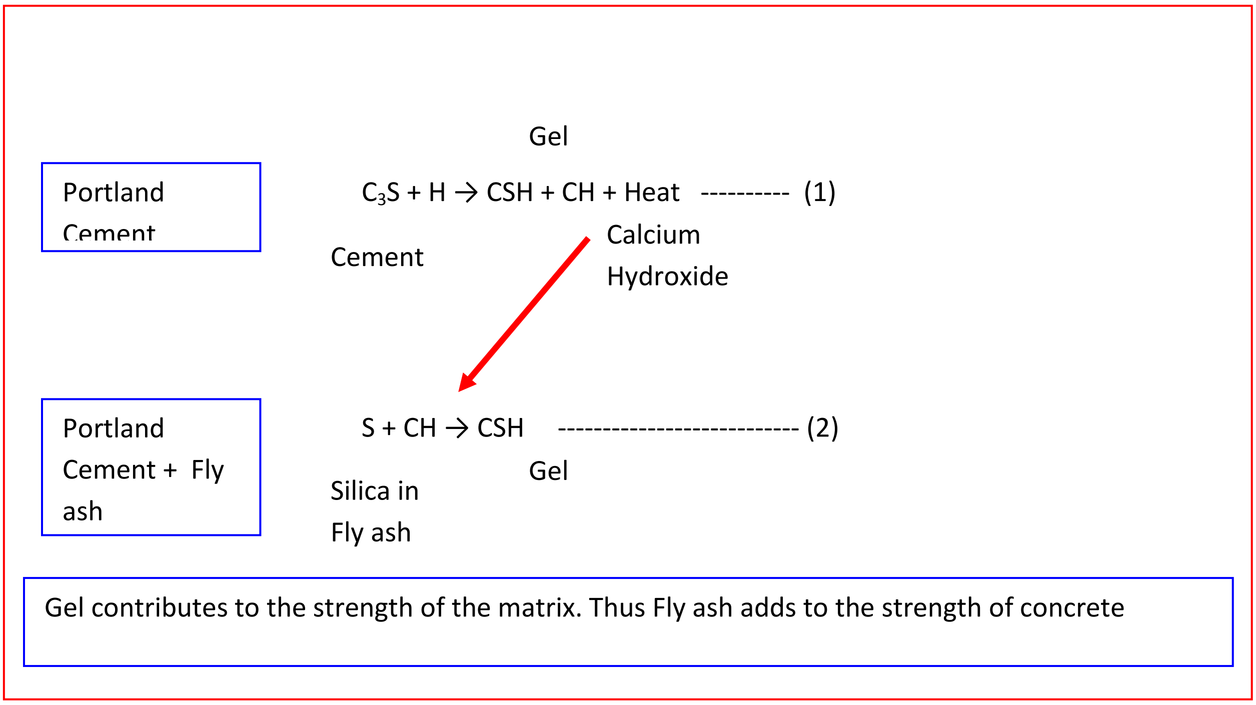

Figure 1 Schematic Representation of influence of Fly ash in Cement hydration

III CORROSION TESTING TECHNIQUES

There are several non-destructive techniques available for the investigation of corrosion in reinforced concrete. In order to get a reliable assessment of the corrosion of reinforcing steel, three corrosion evaluation techniques are available. They are half-cell potential, linear polarization and AC impedance methods. In the present investigation half cell potential technique has been adopted.

The half-cell potential method has been widely used because of its simplicity and cost effectiveness. This method allows the evaluation of the probability of corrosion activity through the measurement of the potential difference between a standard portable reference electrode and the reinforcing steel. The data analysis guidelines described in ASTM C876-99 provides general principles for the evaluation of the probability of corrosion of reinforcing steel in concrete structures. This method covers the estimation of the electrical half cell potential of reinforcing steel in concrete, for the purpose of determining the corrosion activity of the reinforcing steel.

This method may be used to indicate corrosion activity associated with steel embedded in field and laboratory concrete members.

This method is applicable to members regardless of their size or the depth of concrete cover over the reinforcing steel.

This method may be used at any time during the life of a concrete member.

Apparatus required

- Half Cell
- Electrical Junction Device
- Electrical Contact Solution
- Voltmeter
- Electrical Lead Wires

Interpretation of Results

Laboratory testing of reinforced concrete specimens indicates the following regarding the significance of the numerical value of the potentials measured. Voltages listed are referenced to the copper-copper sulfate (CSE) half cell.

If potentials over an area are numerically less than -0.20 V CSE, there is a greater than 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement.

If potentials over an area are in the range of -0.20 to-0.35 V CSE, corrosion activity of the reinforcing steel in that area is uncertain.

If potentials over an area is numerically greater than-0.35 V CSE it indicates that there is a greater than 90% probability that corrosion to occur in that area of reinforcement at the time of measurement.

Positive readings, if obtained, generally indicate insufficient moisture in the concrete and should not be considered valid.

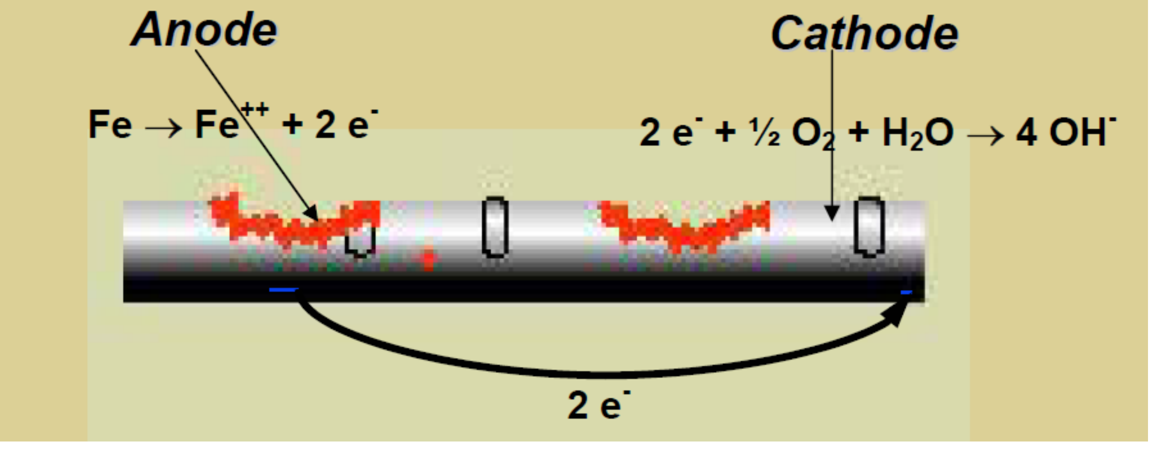

Figure 2. Corrosion activity in a Re-bar

Figure 3 (a) Half-cell potentiometer at a glance

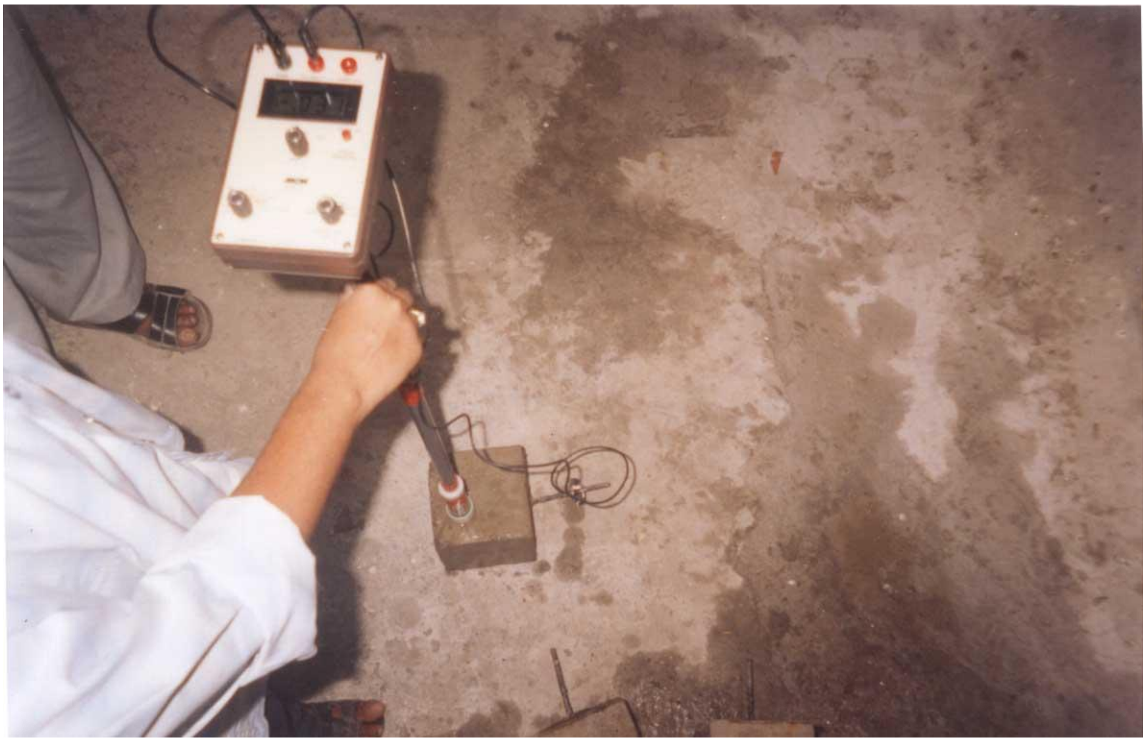

Figure 3 (b) Testing with Half-cell potentiometer

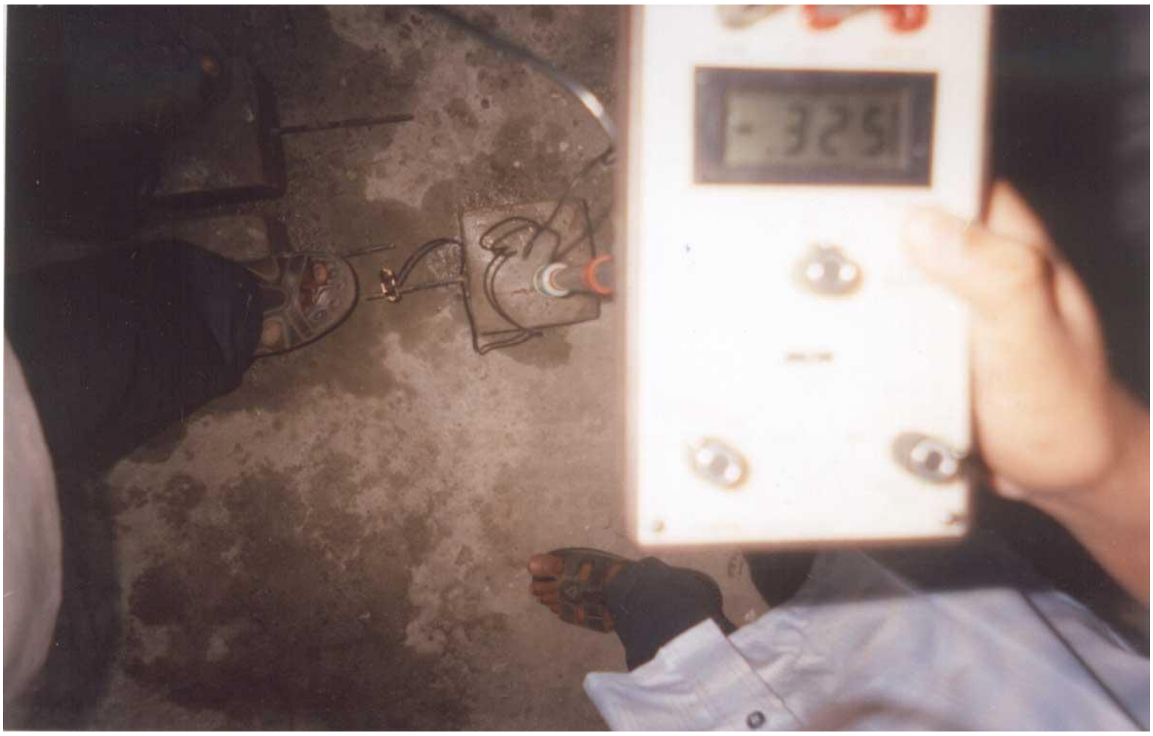

Figure 3(c) Picture showing the potential value being noted

IV TEST RESULTS AND DISCUSSION

Half cell potential data of Reinforced concrete blocks cast with different percentage replacements of cement by fly ash and immersed in 3% Sodium Chloride solution are presented in Table 1. The variation of the same data is presented in Fig.4. From these variations it is clear that the negative values of potential obtained from HCP found to increase with age of immersion. This indicates that the corrosion probability also increases with age of immersion of the RC element in the aggressive environment. It is also noted that increase in percentage replacement of cement by fly ash increased the negative potential value indicating that such replacement increase the probability of corrosion. Concrete having no fly ash showed better performance in respect of HCP values even at 28days immersion in aggressive environment. Fly ash concrete even with 5% replacement of cement by fly ash showed higher negative potential after 14 days of immersion in the 3% NaCl solution. When cement is replaced by fly ash to the tune of 70% increased the negative potential just 3days of immersion in NaCl environment. This clearly indicated that the replacement of cement by fly ash increase the probability of corrosion. This issue suggest for further examination of the concrete made with different replacement levels of cement by treated fly ash.

Treated fly ash concretes

Fly ash is to be treated with strong bases like Potassium hydroxide or Sodium hydroxide, so that the acidic activity of fly ash reduces to some extent. Half cell potential values were measured during curing periods.

Replacement levels of cement by fly ash considered in this phase of the investigation is 5%,10% and 15%. The half cell potential data of the tested specimens is presented in Table 2 and Fig.5. Comparing half cell potential data of treated fly ash concrete and untreated fly ash concrete presented in Fig.6 indicates that the treatment has a good impact on decreasing the negative potential making the concrete less susceptible for corrosion

V CONCLUSIONS

Based on the experimental investigation related to the half cell potential data of concretes with partial replacement of cement by fly ash and treated fly ash the following conclusion are drawn.

- The numerical potential values for different treated and untreated fly ash concrete specimens immersed in aggressive environments tested by using half-cell potential meter increased with age of immersion, which shows the active state of corrosion of steel bars embedded in concrete.
- The numerical potential value of treated fly ash concrete specimens immersed in aggressive environment is relatively low when compared to untreated fly ash concrete specimens. This indicates a reduction corrosion activity of rebars present in concrete with the use of treated fly ash.
- While using high volume fly ash concretes care needs to be exercised especially when the environment is aggressive.

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Table.1 Half Cell Potential data of Fly ash-Cement concrete for different ages of immersion in Aggressive Environment (3% Sodium Chloride Solution)

Percentage replacement of cement by fly ash	3rd day	7th day	14th day	28th day
0	-0.096	-0.265	-0.288	-0.302
5	-0.195	-0.284	-0.356	-0.360

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10	-0.250	-0.351	-0.410	-0.450
20	-0.168	-0.264	-0.345	-0.440
30	-0.121	-0.400	-0.470	-0.510
40	-0.291	-0.410	-0.505	-0.540
50	-0.333	-0.480	-0.550	-0.600
60	-0.345	-0.490	-0.580	-0.630
70	-0.350	-0.500	-0.600	-0.650
80	-0.389	-0.580	-0.625	-0.660
90	-0.421	-0.605	-0.635	-0.670

Table.2 Half Cell Potential data of Treated Fly ash-Cement concrete for different ages of immersion in Aggressive Environment (3% Sodium Chloride solution)

Percentage replacement of cement by treated fly ash	3rd day	7th day	14th day	28th day
5	-0.020	-0.096	-0.250	-0.300
10	-0.050	-0.142	-0.280	-0.350
15	-0.080	-0.260	-0.310	-0.410

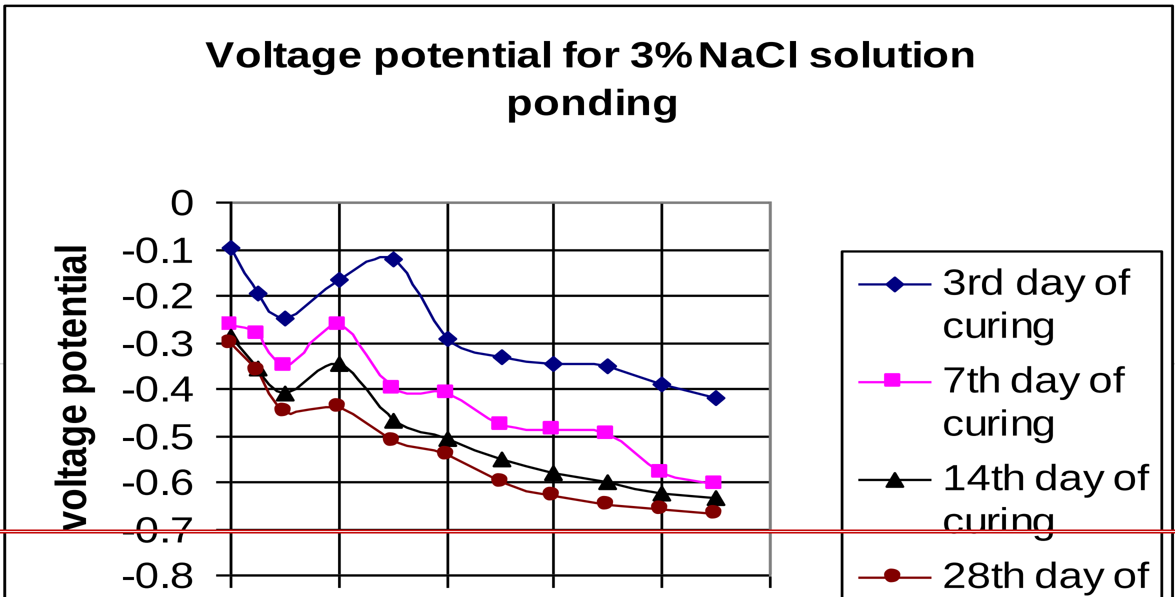

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Fig.4 Half Cell Potential data of Fly ash-Cement concrete for different ages of immersion in Aggressive Environment (3% Sodium Chloride solution)

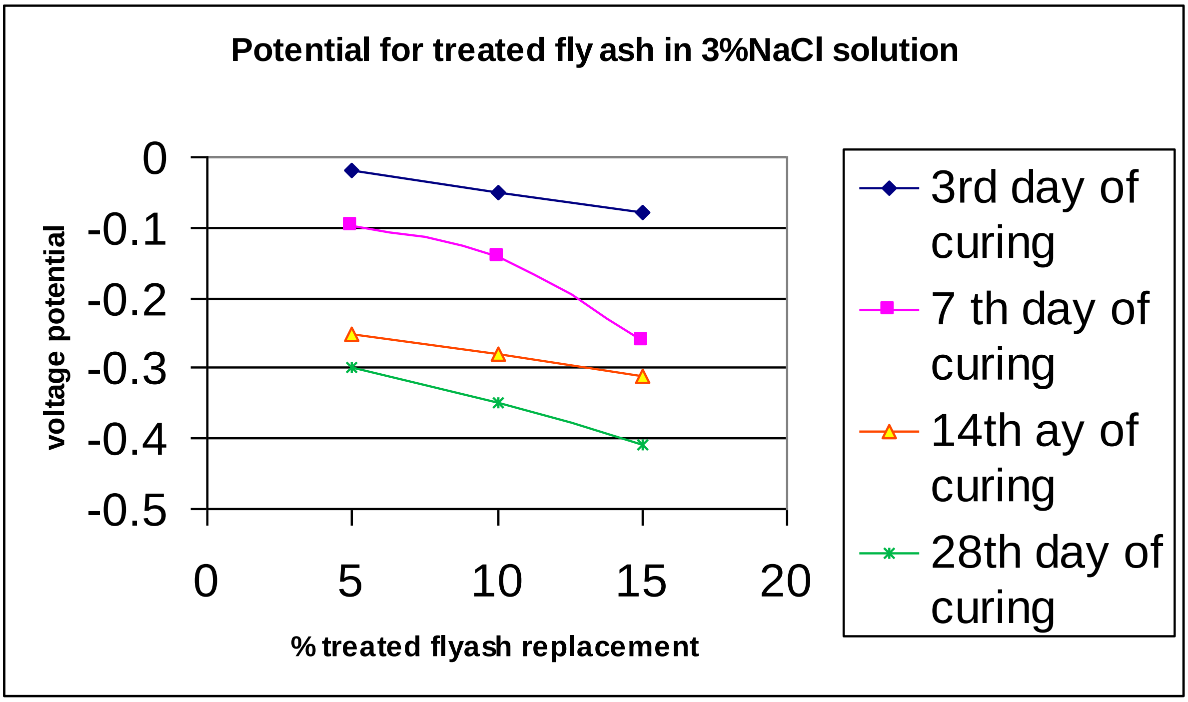

Fig.5 Half Cell Potential data of Fly ash-Cement concrete for different ages of immersion in Aggressive Environment (3% Sodium Chloride solution)

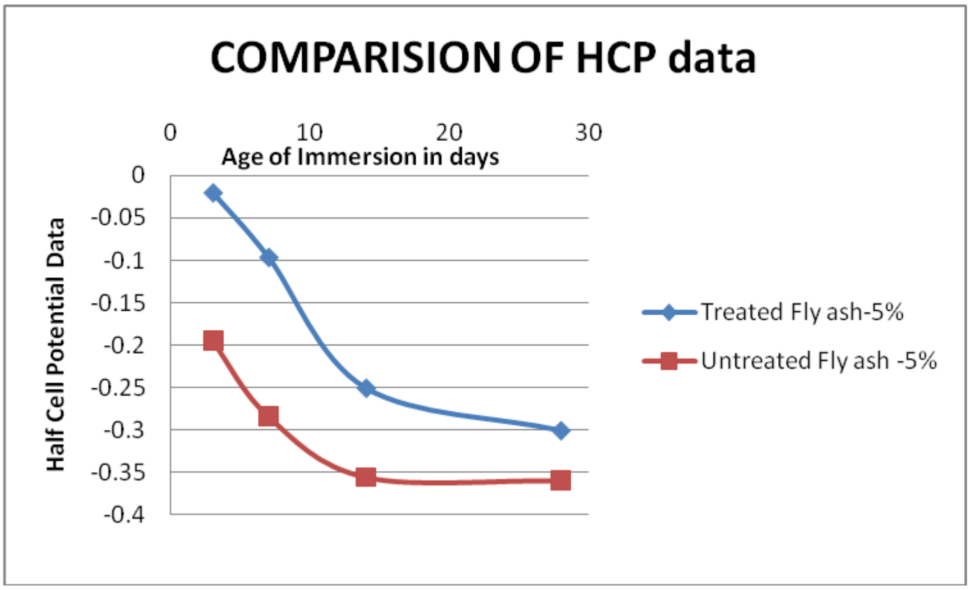

Fig.6 A comparison of Half Cell Potential data of concrete with and without treated fly ash for different ages of immersion in aggressive environment (3% Sodium Chloride solution).