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Cathodic Protection of Steel Reinforcement using Pure Magnesium Anode

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Abstract

Cathodic Protection to the embedded steel in concrete was established using sacrificial pure magnesium anode to prevent the corrosion of reinforcement. Two slabs were casted one containing 3.5% sodium chloride with respect to weight of cement and the other without NaCl. Both the slabs were provided with cathodic protection of pure Magnesium anode. Half cell potential measurements with Standard Calomel Electrode as reference electrode were taken at regular intervals and for a number of days. It could be observed that the potential of the slab decreased with increase in distance from the anode and reduced with time. Thus, magnesium anode was found to shift the potential of steel to more negative potential initially and later towards less negative potentials with respect to time. It could be concluded that use of Magnesium anode could prove to be an effective means of corrosion prevention.

Keywords: Corrosion Prevention, Cathodic Protection, Chloride Induced Corrosion, Mg Aanode

1. Introduction

Among the several methods available for protecting the embedded steel from corrosion, cathodic protection is the major technique adopted. It aims to shift the potential to least probable range of corrosion[1]. Cathodic Protection of the embedded steel in concrete was established using sacrificial pure magnesium anode to increase the durability and prevent the corrosion of the reinforcement[2]. The use of high purity magnesium anode is preferred due to its inherently higher active potential. These have several advantages such as they do not require any auxiliary power supply, do not increase weight of the structure, easier to install and replace lower installation and operating costs[2].

Pure Magnesium anode, designed for three years life, was installed at the centre of two reinforced concrete slabs, one containing 3.5% sodium chloride with respect to weight of cement and other without any chloride content. Potential of the embedded steel with respect to time and distance from anode was monitored, plotted and analysed at different points parallel to the embedded reinforcement. The results indicated that in both the slabs, the magnesium anode shifted the potential of steel to more negative potentials initially and later decrease in potential values was observed. The potential values decreased as the distance from anode increased, with increase in time.

Hence this paper concentrates on evaluating the performance of high purity magnesium sacrificial anode in the protection of steel embedded in concrete against corrosion.

2. Experimental Part

2.1 Concrete Slab

Pozzolana Portland cement was used for casting the slabs of size 1m x 1m x 0.10m. The sand, used as fine aggregate, and 0.01-.02m sized coarse aggregate was washed thoroughly prior to their usage. The mix ratio used was 1:1.5:3 with water/cement ratio of .45. In one of the slabs sodium chloride, equivalent to 3.5% by weight of cement was dis-

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solved in water used for casting[1]. 0.01m diameter and 0.95m long steel rods were cleaned with pickling solution and thoroughly washed and dried. The reinforcement assembly was placed in the formwork with Magnesium anode in the centre of both the slabs. Each steel rod was provided with wire connections, to extend outside the slabs. The assembly was embedded in concrete with cover thickness of 0.025m. Rows and columns of points, paralleling the embedded reinforcement, were marked on the both the slab surfaces, where the potential measurements were made.

2.2 Cathodic Protection

The potential of reinforcement bars was measured at points marked parallel to the embedded reinforcement after 7 days of casting of slabs. Saturated Calomel Electrode (SCE) was used as the reference electrode. The total surface area to be protected was estimated to be $0.179m^2$. A high purity magnesium anode was designed for three years life. The potential at different distances from anode was plotted against time of measurement to analyse the influence of magnesium anode on the protection offered to the embedded steel.

Figure 1. Reinforcement assembly with anode, slab without NaCl.

Figure 1 illustrates reinforcement assembly with anode placed in formwork, slab casted without NaCl, slab casted with NaCl and slab without NaCl ponded with 3.5% NaCl solution.

3. Results and Discussions

High purity magnesium anode was employed for cathodically protecting the embedded steel. It had a diameter of .02m and a length of 0.025m with a weight of 0.015kg. The potential readings were obtained with respect to time and distance from anode for the time period of 66 days.

Figure 2 illustrates the potential of embedded steel in slab which does not contain chloride and is cathodically protected. Here the potential of steel was initially around -1050mV near the anode and later shifts to less negative values as the time progresses and remains about -500±60 mV during the period of investigation[2].

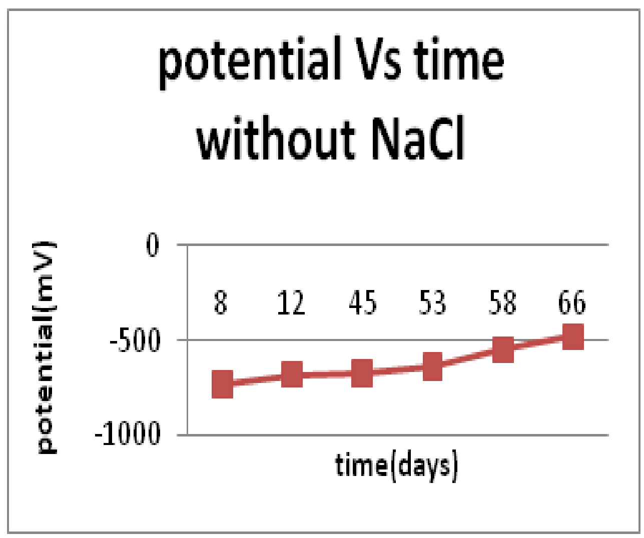

Figure 2. Potential with respect to time in slab without chloride.

Figure 3 illustrates the potential of embedded steel in slab containing 3.5% sodium chloride with respect to the weight of cement and is cathodically protected. Here the potential of steel was initially around -1350mV near the anode and later shifts to less negative values, remains about -700±80mV as the time progresses[3].

The high negative potentials attribute to negligible probability of corrosion as the steel is rendered as cathode. On comparing potentials of steel with and without chloride the potential values of the steel shifted by nearly

-150 mV in slab containing chloride which attributes to the increase in conductivity.

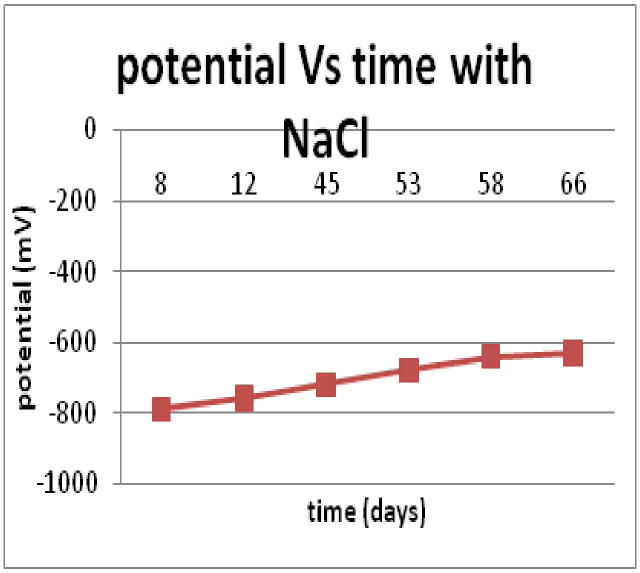

Figure 3. Potential with respect to time in slab with 3.5% chloride.

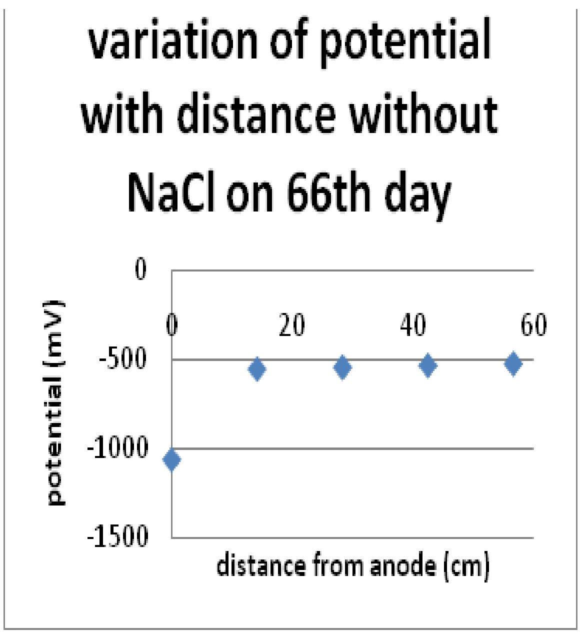

Figure 4. Potential with respect to distance from anode in slab without chloride.

Figure 4 illustrates the extent of polarisation as a function of distance from anode in the slab without chloride content becomes less and less as the distance from anode increases. The steel nearest to anode is polarized by -650mV ± 50mV while the farthest from anode is polarized by -400mV±20mV.

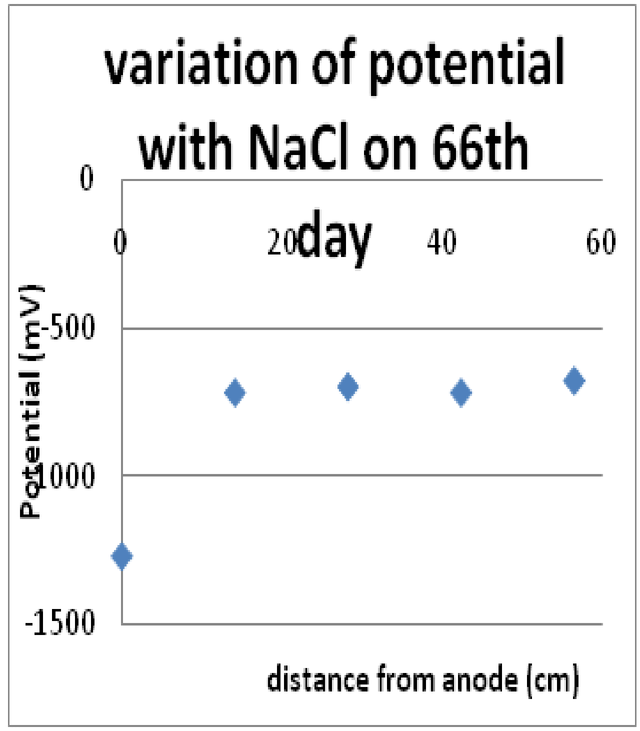

Figure 5. Potential with respect to distance from anode in slab with 3.5% chloride.

Figure 5 illustrates the extent of polarization as a function of distance from anode in the slab containing 3.5% chloride content becomes less and less as the distance from anode increases. The steel nearest to anode is polarised by -800mV±50mV while the farthest from anode is polarized by -600mV±50mV.

It is seen that that the extent of polarisation in steel containing chloride is nearly same when compared with steel which does not chloride. The decreasing potentials of steel as the distance from anode increases can be attributed to the flow of chloride ions in the direction of anode as the concrete slabs are rendered as cathode, hence repelling the negatively charged chloride ions[4]. The chloride ions are being attracted towards magnesium anode thus protecting the embedded steel from chloride attack.

Hence it can be inferred by shifts in the potentials achieved that the high purity magnesium anode can be used to protect the reinforcement effectively.

4. Conclusions

- Cathodic protection of embedded steel in concrete can be achieved using high purity magnesium anode.

- The potentials of embedded steel in concrete with and without chloride concentration shifted from more negative to less negative values as the time and distance from anode increased.
- The shift in potential values towards less negative values with time at any distance from anode ensured the protection offered to the embedded steel.

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