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Experimental Study on Corrosion Prevention of Steel in Concrete by Using Zinc

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ABSTRACT
Reinforced concrete is used in numerous ways , some of the larger and better known uses including roadways, bridges, car parks, residential building and in industry. Damage caused by corrosion of concrete structure has been recognized as one of the major problem affecting service life of structure. But corrosion cannot be stopped completely. Permeability is the gateway of corrosion. Corrosion loss consumes considerable portion of the budget of the Owner, by the way of either restoration or reconstruction. This paper reviews the corrosion resistance in rebars by using Zinc as an anode and rebars act as a cathode. The electrochemical and Non-destructive techniques are used to analyses the corrosion in rebars.
Keywords**:** Corrosion, Prevention of steel, Zinc, Anode, Cathode.

I. INTRODUCTION

Reinforced concrete is a cost effective material used widely in our infrastructure durable combination of steel and concrete provides safety and serviceability. Normally physics and chemistry of concrete protects reinforcement steel against corrosion. Over time this protection can be lost due to aggressiveness from environment for example chloride ions from sea water,carbondioxide from atmosphere and water in moisture causing corrosion. Corrosion is the main cause of damage to concrete structure. For owners of structures corrosion is difficult to handle because there are no objective tools that inform them about the corrosion state with such information they could take repair action well before damage appears and spending on repair would be reduced.

The Europeans infrastructure has reached an aged where maintenance costs have increased to such an extent they construct the major part of total costs.In this paper Sacrificial anodic prevention method used to control the corrosion. In this SAP method the zinc is used as a more effective anode and rebar used as a cathode. The anode is get corrosion from cathodic area through the flow of electrons

The electro-chemical methods like as
1. Open circuit potential measurement
2. Surface potential measurement
is used for analyses the corrosion.

II. CORROSION REACTIONS

Corrosion is defined as the destruction or deterioration of a material because of its reaction with environment. Normally the metals are in the form of combined state that called as Ore. To given more energy the ore is converted to pure metal. The

Pure metal does not goes to corrosion. But the pure metals may be affect by Oxide, Alkali and Acids in atmosphere.

In reinforced concrete, steel react with an environment immediately get corrosion. The corrosion of steel is a chemical process where in steel oxidizes into more stable iron oxide. For the process to take place both moisture and air are required. The corrosion of steel can be understood as an electrochemical reaction between steel and environment.

The corrosion mechanism is like as a battery, which contains electrodes i.e. anode and cathode, which are connected in presence of an electrolyte.Depending upon the relative potential with respect to another material to which it is connected, it can serve as an anode and cathode. The Zinc and Magnesium are used as an anode for rebars, those are more effective than steel. The anodic material provides the electrons and in the process the anode get corrosion. The structural steel will not corrode until it is immersed in or wetted by an electrolytic solution and gets electrically connected to another metal like as zinc or magnesium those having a more positive electrical potential. Thus elimination of electrolyte itself can be effective for corrosion prevention.

The corrosion reaction in steel is below,

$Fe \rightarrow Fe^{2+} + 2e^-$

$2H_2O \rightarrow 2OH^- + H_2\uparrow$

$Fe + H_2O \rightarrow 2HO^- + Fe^{2+}$

$\rightarrow Fe(OH)_2$

$2Fe(OH)_2 + O_2 \rightarrow Fe_3O_4 + H$ (under acidic condition)

In initial attack, the ferrous leave the electrons and then to combine with oxygen and water to form hydroxyl ions. The hydroxyl ions react with ferrous ions to produce a ferrous hydroxide, which itself is further oxidized in air to produce hydrated iron oxide i.e. red rust.

Two important points for corrosion,

- For iron and steel to corrode, it is necessary to have the simultaneous presence of water and oxygen.
- All corrosion occurs at anode, no corrosion occurs at cathode.

Zinc Reaction With Ferrous Oxide

In emf series zinc is above than ferrous, so which is severely react with ferrous oxide.

The equation for zinc reaction is below,

$$Fe_2O_3 + 3Zn \rightarrow 2Fe + 3ZnO$$

25 gram of Fe_2O_3 would be react with 0.46965 mole of Zinc.

III. CORROSION MONITORING

The corrosion monitoring methods are also described well by the Ha-Won Song[1] and Velu Saraswathy[2]. Many of the strategic reinforced and pre-stressed concrete structures have started showing signs of distress within a short period usually the condition of the structures is monitored by visual inspection and remedial measures are resorted to only when the condition becomes very serious by way to heavy rusting of steel reinforcements followed by cracking and spalling on concrete. It is desirable to, monitor the condition of such strategic structures right from the construction stage by carrying out periodic corrosion surveys and maintaining a record of data. For measurement of the corrosion rate of reinforcing steel in concrete, many electrochemical and non-destructive techniques are available for monitoring corrosion of steel in concrete structures. Rebar corrosion on existing structures can be assessed by different methods such as:

1. Open circuit potential (OCP) measurements
2. Surface potential (SP) measurements
3. Concrete resistivity measurement
4. Linear polarization resistance (LPR) measurement
5. Tafel extrapolation
6. Galvanostatic pulse transient method
7. Electrochemical impedance spectroscopy (EIS)
8. Harmonic analysis
9. Noise Analysis
10. Embeddable corrosion monitoring sensor and
11. Cover thickness measurements
12. Ultrasonic pulse velocity technique
13. X-ray, Gamma radiography measurement
14. Infrared thermograph Electrochemical
15. Visual inspection

III. (A) Open Circuit Potential (OCP) Measurements

The tendency of any metal to react with an environment is indicated by the potential it develops in contact with the environment. In reinforced concrete structures, concrete acts, as an electrolyte and the reinforcement will develop a potential depending on the concrete environment, which may vary from place to place.

The principle involved in this technique is essentially measurement of corrosion potential of rebar with respect to a standard reference electrode, such as saturated calomel electrode (SCE), copper/copper sulfate electrode (CSE), silver/ silver chloride electrode etc. The detection and measurement of corrosion in concrete structures are essential. Although there are several methods for the diagnosis, detection and measurement of corrosion in reinforcing steel, there is no consensus regarding which method assesses corrosion levels in reinforced concrete structures most accurately. Various techniques for detecting and measuring corrosion will provide data on the causes, detection or rate of corrosion. The main method of detection of corrosion is the half-cell potential (HCP) measurements. The corrosion process of steel in concrete can be followed using several electrochemical techniques. Monitoring of open circuit potential (OCP) is the most typical procedure to the routine inspection of reinforced concrete structures. Its use and interpretation are described in the ASTM C876 Standard Test Method for Half-Cell Potential of Reinforcing Steel in Concrete. Potential readings, however, are not sufficient as criterion, since they are affected by a number of factors, which include polarization by limited diffusion of oxygen, concrete porosity and the presence of highly resistive layers. According to this method if the potential of steel in concrete becomes more negative than -276mV vs. SCE there is a 90% probability that corrosion will occur. It is a non-destructive test that collects an enormous quantity of data from a large structural area. Establishing structures potential map, according to ASTM C876-91, is the most commonly applied electrochemical technique for diagnosing the corrosion risk of reinforced concrete structures. However it is generally accepted that corrosion potential measurements must be complemented by other methods, because although reliable relationships between potential and corrosion rate can be found in the laboratory for well established conditions, these can in no way be generalized, since wide variations in the corrosion rate are possibly in very narrow range of potentials. Open circuit potential measurement is a useful technique in finding out the anodic and cathodic sites in reinforced concrete structures provided the reinforcing bars are exposed to the environments. Many authors have studied the effectiveness of the test and got useful results. OCP values only can provide information for corrosion probability and cannot indicate the rate of corrosion.

III. (B) Surface Potential (SP) Measurements

During corrosion process, an electric current flow between the cathodic and anodic sites through the concrete and this flow can be detected by measurement of potential drop in the concrete. Hence surface potential measurement is used as a non-destructive testing for identifying anodic and cathodic regions in concrete structure and indirectly detecting the probability of corrosion of rebar in concrete. No electrical connection to the rebar is necessary in this technique. In this measurement, one electrode is kept fixed on the structure on a symmetrical point. The other electrode called moving electrode is moved along the structure on the nodal points of the grid as mentioned in OCP measurements. The potential of movable electrode, when palced at nodal points, is measured against the fixed electrode using a high impedance voltmeter. A more positive potential reading represents anodic area where corrosion is possible. The greater the potential difference between anodic and cathodic areas greater is the probability of corrosion.

This is another useful non-destructive technique to know the condition of steel rebar embedded inside the concrete. Various condition survey assessments have been made using this technique.

IV. EXPERIMENTAL PART

Test were carried out on reinforced concrete of size 2'x9''x9'' were cast with PPC. Steel rebars are connected inside with copper wire. Mix design proportion of concrete is 1:1.5:3 and water cement ratio is 0.5 were used for casting the concrete. The PH value of water is 0.9. After the setting time, the anode like has a zinc is connected to the rebars, it is prevent the corrosion in bars by sacrificial anodic method. The anode and cathode are connected to volt meter for monitoring the corrosion range at rebars.

The varying parameter of concrete:

1. Not prevented by zinc anode.
2. Prevented by zinc anode.

V. RESULTS AND DISCUSSIONS

Corrosion of the embedded steels was monitored by measuring the potential of steel and concrete by using the corrosion is monitoring method which discussed above.

V. (A) Non Protective Concrete

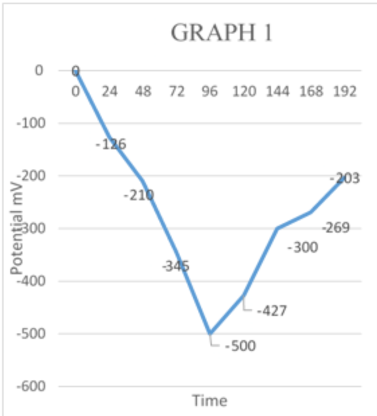
In open circuit potential method, the initial reading taken out after one day curing, the corrosion rate was in -126mv to -200mv. And then, the corrosion rate is found in steel with 24hours periodically. The second reading is taken out after 48hours, the corrosion rate is -329mV. It is high corrosion condition.

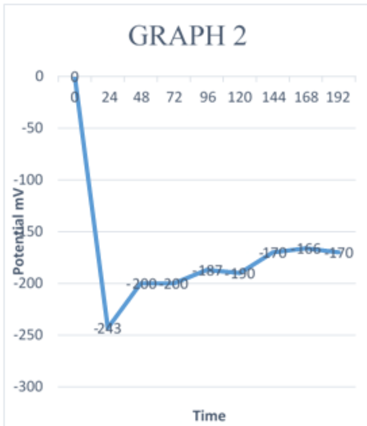
The graph 1 is below.

V. (B) Protective Concrete

The corrosion rate in protective concrete, initially the amount is -300 to -250mV. The second reading is as well as lower than initial reading (-200 to -150)mV.

The graph 2 is below.





The above results, the corrosion is occurs highly in non-protective concrete. The protective concrete, the rate of corrosion is low. The stable oxide layer is forming on rebars. The stable layer was reduced the corrosion rate in rebars. In anodic protected concrete, the corrosion is controlled by zinc.

VI. CONCLUSION

1. The corrosion resistance on steel bars in concrete is previewed.
2. The applicable and maintainable method is proposed.
3. In this method is proposed to curing time, so pure metal is taken an action against durability.
4. This method is favourable to pH value low or high water.
5. Using this method small cracks are not affect the structure.
6. It is periodically replacing technique.

REFERENCES

[1]. A.S.S.Sekar, V.Saraswathy and G.T.ParthibanCathodic protection of steel in concrete using conductive polymer overlays 2007.

[2]. Ha-Won Song and VeluSaraswathy corrosion monitoring of reinforced concrete structure –A Review 2006

[3]. P.C.S.HAYFIELD Corrosion Prevention in Concrete Birmingham 1986

[4]. S.K. CHAUDHARY, A.K. CHATURVEDI Preventive and protective solution for corrosion in concrete through chemistry 2001

[5]. Rengaswamy Srinivasan, periyagopalan, P. Ronald zarriello, Christina J. Myles-tochko, and james H. meyer Design of cathodic protection of rebars in concrete structures: an electrochemical engineering approach 1996

[6]. C. Andrade reinforcement corrosion: research needs 2009

[7]. C.L. Page and K.W.J. Treadaway, Nature 297 (1982) 109

[8]. H. Arup The Mechanisms of the Protection of Steel by Concrete, in Corrosion of Reinforcement in Concrete Construction, HellisHorwood, Chichester (1983) pp. 151–157 .