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Feasibility Study of Some Corrosion Inhibitors for Cementitious Composites

Sabih Akhtar

Abstract - Use of chemical corrosion inhibitors has been recognized as one of the effective way of controlling rebar corrosion in cementitious composites. The effect of these chemicals on various physical properties of cement such as setting time, pH, and Compressive strength needs to be explored before use. In the present investigation the effect of some of the commercially available corrosion inhibitors on setting time, pH and compressive strength has been studied. In the next part of the study electrochemical test involving these chemical corrosion inhibitors were also conducted. Corrosion kinematic parameters have been estimated using potentio-dynamic polarization tests.

Key words **- Corrosion inhibitors, setting time, compressive strength, Tensile strength, corrosion rate**

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I. INTRODUCTION

The deterioration of cementitious composite due to the corrosion of the reinforcing steel has become a major problem. It has received worldwide attention and code of practices of different countries has suggested measures to control the steel corrosion but evidence of corrosion of steel in concrete continues to be reported in field situations. The corrosion of steel reinforcement in concrete structures leads to concrete fracture, loss of bond between steel and matrix and reduction in strength and ductility. As a result, safety, serviceability and durability of concrete structures are reduced.

During the last few decades the corrosion problem in reinforced concrete has been extensively investigated by many researchers. Corrosion inhibitors are one of the most cost-effective solutions to rebar corrosion problem in concrete. Corrosion inhibiting admixtures fall into the specialty admixture category and are used to slow down corrosion of reinforcing steel in concrete. In order to protect metallic materials against corrosion, certain

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inorganic and organic products, called corrosion inhibitors, are added in small concentration to the aggressive medium [1]. The addition of corrosion inhibitors to the mix, offers a viable corrosion protection measure [2-3]. There are generally three groups of inhibitors: anodic, cathodic and mixed inhibitors. Anodic inhibitors reduce the corrosion rate by reacting with the corrosion products and form a protective film. Cathodic inhibitors reduce the corrosion rate by reacting with the cathode sites (as an oxygen-barrier) on the steel. Passivating inhibitors like nitrites represent special types of anodic inhibitors and they are generally very effective if present in sufficient concentrations. Mixed inhibitors both influence the anodic and cathodic reaction sites, by forming an adsorption film on the metal surface. These adsorption type inhibitors are typically organic compounds [4-5].

In the present study, an attempt has been made to investigate the behaviour of two corrosion inhibitors *viz.* Calcium Nitrite and Calcium Hypophosphite. Physical properties tests of the cement and concrete in the presence of these inhibitors and potentio-dynamic polarization tests were conducted.

II. EXPERIMENTAL

The effect of chosen corrosion inhibitors on setting time, pH and compressive strength has been studied. In the next part of the study electrochemical test involving these chemical corrosion inhibitors were also conducted.

a. Setting Time Test

Setting time tests were carried out as per the recommendations of the IS: 4031(Part 5) [6] using 43-Grade Ordinary Portland cement. In Blank (control) specimen, no inhibitor was mixed. In the later two cases, 3% dose of inhibitor by weight of the cement was used.

b. Test for pH

pH is another important parameter governing the corrosion and its propagation. Six different mediums were taken for this part of the study. Tests were conducted for both potable and distilled water at a constant temperature of 28±2 °*C*.

c. Compressive Strength Test

To investigate the effect of corrosion inhibitors on the compressive strength of mortar, the mortar cubes of size

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70.6×70.6×70.6 *mm* were tested after 3, 7, 14, 28 and 90 *days* of curing as per the recommendations of IS: 4031(Part 6).

d. **Electrochemical Test**

Potentio-dynamic electrochemical studies (Tafel extrapolation tests) were also undertaken. Electrochemical System Model "Gill AC" (500 *mA*/ 100 *kHz*/ Guard Ring of ACM instruments, U.K.) was used for these experiments. The instrument had inbuilt software support to evaluate corrosion kinetic parameters. A platinum foil was used as the auxiliary electrode, a saturated calomel electrode was used as reference electrode and mild steel was used as working electrode. The experiments were carried out at a constant temperature of 28±2 °*C*. The result off the potentio-dynamic polarization tests are presented in Fig.1.

III. DISCUSSION ON TEST RESULTS

The results of the setting time of the cement after adding 3% dose of the inhibitors are given in Table 1. It has been observed that both the inhibitors reduce the initial and final setting time, however the values remains within the permissible limits of the codal provisions.

The effect of addition of inhibitors on pH has been tabulated in Table 2. 3% concentration of both the inhibitor increases the *pH* value marginally. It is interesting to note that when both the inhibitor were tested in cement slurry condition the value of *pH* rose to around 12, which is considered to be fairly alkaline.

The results of mortar cube compressive strength are given in Table 3. Due to the addition of 3% calcium nitrite inhibitors the early strength slightly slowed down, however at 28 *days*, the compressive strength almost matches with the control. With the calcium hypophosphite addition however values are even more than the control throughout the observation period.

The results of the electrochemical test are presented with the help of Tafel plots. Reasonably low corrosion current density and lower corrosion rates as compared to the blank specimen is clear indicator of the effectiveness of both the inhibitors at 3% dose of the inhibitors.

IV. CONCLUSIONS

Properties investigated viz. Setting time, *pH* and compressive strength tests clearly indicate that the addition of these

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inhibitors do not have any adverse effect. The low corrosion current density exhibited by both the inhibitors proves their potential in controlling Long term studies with variable dose are needed for making final recommendations with regard to the dose of these inhibitors for the protection of steel reinforcement in concrete.

V. REFERENCES

[1] Fontana, M.G., “Corrosion Engineering”, McGraw-Hill book Company, 1987.

[2] Berke, N.S., "A review of Corrosion Inhibitor in Concrete", Material Performance, 28(10), 41-44, 1989.

[3] West, J.M., "Electro-deposition and Corrosion Processes", Van Nostrand Reinhold Co., New York, U.S.A., 138-148, 1971.

[4] Harrop, D., "Chemical inhibitors for Corrosion Control", Proceedings of International Symposium at the University of Manchester, Royal Society of Chemistry, Special publication No.71, London, U.K., 4-20, 1988.

[5] El-Jazairi, B. and Berke, N.S., "The Use of Calcium Nitrite as a Corrosion Inhibiting Admixture to Steel Reinforcement in Concrete", Elsevier Applied Science, London and New York, U.S.A., 571-585, 1990.

[6] IS: 4031, Part 5 and 6, "Indian Standard Specification Methods of Physical Tests for Hydraulic Cement", BIS, New Delhi, India, 1988.

Table 1. Effect of Corrosion Inhibitors on Setting Time of Cement

System	Initial Setting Time (*minutes*)	Final Setting Time (*minutes*)
Blank	110	380
3% Calcium Nitrite	102	346
3% Calcium Hypophosphite	86	310

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Table 2. Effect of Corrosion Inhibitors on pH

System	*pH* in Potable water	*pH* in Distilled water
Blank	7.5	7.3
Cement (Slurry)	12.2	12.2
3% Calcium Nitrite	7.9	7.5
3% Calcium Nitrite + Cement (Slurry)	12.3	12.1
3% Calcium Hypophosphite	8.6	8.3
3% Calcium Hypophosphite + Cement (Slurry)	11.9	11.8

Table 3. Effect of Corrosion Inhibitors on Compressive Strength of Mortar Cube

Specimen Description	Compressive Strength of Mortar Cube N/mm^2			
	3 *days*	7 *days*	14 *days*	28 *days*
Blank	19.6	27.5	30.8	44.5
3% Calcium Nitrite	18.4	25.9	30.0	43.1
3% Calcium Hypophosphite	24.4	28.8	32.5	46.0

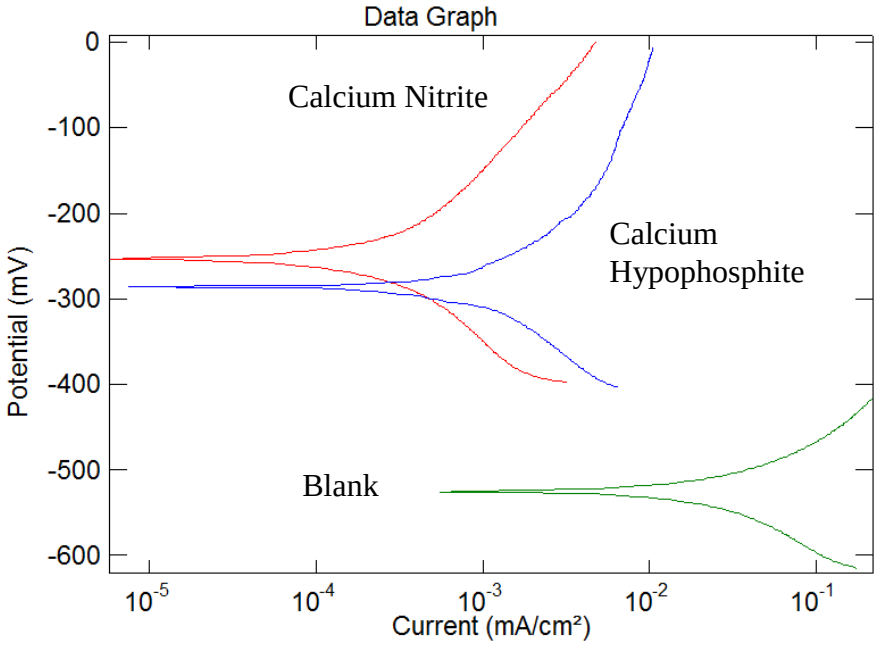

Fig. 1 Tafel Plot for the Control and the inhibited medium in saline water

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