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## Evaluation of Corrosion Inhibiting Systems Used in Reinforced Concrete

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Corrosion of reinforcing steel bars in concrete is a serious and significant problem. It costs tens of billions of dollars for repairing the corrosion-induced damage on bridges alone in USA (1). Corrosion inhibitors have been considered as one of the most cost-effective solutions to the reinforcement corrosion in concrete. They have been increasingly used as concrete admixtures for new structures and restorative applications for repairing existing reinforced concrete during the last fifteen years.

There are many corrosion-inhibiting systems commercially available (2) including rebar coatings, concrete admixtures and coatings applied to the concrete surface. Very little information is available on the effectiveness of these corrosion-inhibiting systems in field applications, especially on long-term performance. Engineers and bridge owners have difficulty selecting corrosion inhibiting systems that are more effective in the long-term for new concrete structures and restorative applications.

The effectiveness and performance of eight commercial corrosion-inhibiting systems were evaluated. A group of 10 consecutive spans of barrier wall of a highway bridge was selected as the test site for the application of the corrosion inhibiting systems. Each system has been given an arbitrary letter and a brief generic description as shown in Table 1.

Corrosion potential, corrosion current and concrete properties were measured on the 10 spans. The comparison laboratory tests were carried out to evaluate the effects of inhibiting admixtures on the carbon steel in saturated $Ca(OH)_2$ and simulated concrete pore solutions. This study was performed by measuring the polarisation resistance, $R_P$, on the carbon steel electrodes in solution with an increase in the chloride concentration in the presence of corrosion inhibiting admixtures.

The laboratory test of inhibiting admixtures in a saturated $Ca(OH)_2$ solution showed that inhibiting admixtures E and H were very effective in delaying the chloride induced corrosion and reducing the corrosion rate (Fig. 1). The on-site measurements on the special ladders embedded in the spans indicate that the high corrosion activity had occurred in the locations with thinner concrete cover. The inhibiting system H performed better for inhibiting the reinforcing steel corrosion than all other inhibiting systems as shown in Fig.2.

The tests of inhibiting admixtures in a simulated pore solution containing 0.002 M $Ca(OH)_2$ +0.45 M NaOH +0.26M KOH (pH = 13.5) showed no inhibiting effect. All tests failed at a concentration of 6% NaCl including the control solution without corrosion inhibiting admixture.

On-site corrosion measurements on the main spans show that the overall corrosion rates were still in the low category ($\leq 0.5\ \mu A\ cm^{-2}$) with regular thickness concrete covers. The results indicate that more time is needed to detect the significant corrosion activity and to evaluate the long-term effectiveness of the inhibiting systems in the main span.

### References

1. J. Broomfield, NACE Corrosion 92 Conference, Paper No. 204, 1 (1992).
2. N. S. Berke and T. G. Weil, Advances in Concrete Technology, editor V.M. Malhotra. CANMET, Canada, 899 (1992).

Table 1. Corrosion inhibiting systems tested

| System | Generic description |
|---|---|
| Control | Normal reinforcement and concrete |
| Epoxy | Epoxy-coated reinforcement |
| A | Cement-based rebar & concrete coating |
| B | Organic-based concrete admixture |
| C | Organic/inorganic-based concrete admixture |
| D | Cement-based rebar coating |
| E | Organic-based concrete admixture |
| F | Organic-based concrete admixture |
| G | Organic-based concrete admixture & sealer |
| H | Inorganic-based concrete admixture |

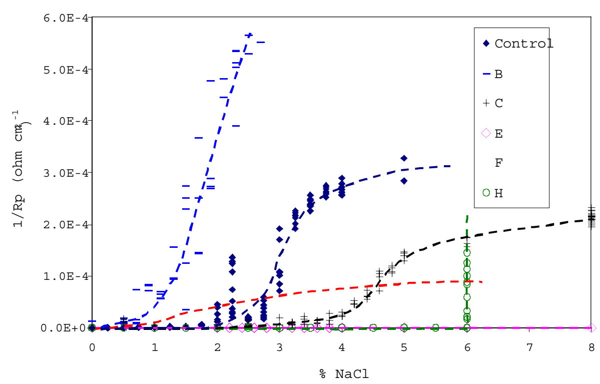


Fig. 1. Values of $1/R_p$ measured on carbon steel in saturated $Ca(OH)_2$ solution with increased chloride content in the presence of various inhibitors.

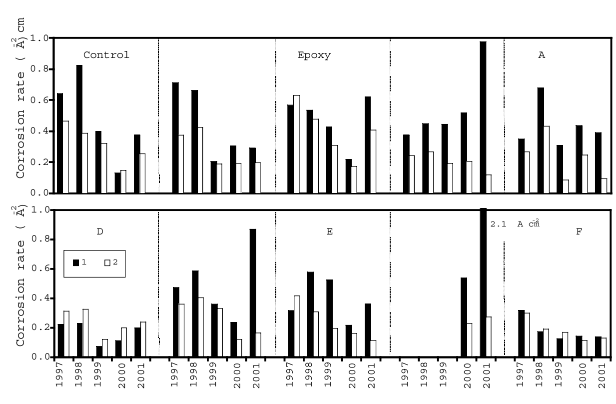


Fig. 2 Corrosion current density measured on the rebar ladders embedded in the barrier wall (concrete cover thickness: 13mm at bar 1 and 25mm at bar 2).