RESEARCH NOTES

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EVALUATION OF THE PERFORMANCE OF REFERENCE ELECTRODES EMBEDDED IN REINFORCED CONCRETE

The objectives of this work were to examine placement strategies for reference electrodes and to evaluate the suitability of graphite reference electrodes as imbedded reference electrodes in reinforced concrete structures that are cathodically protected. The evaluation was done on a system with a sprayed zinc anode. The reference electrodes will be used in tests to evaluate adequacy of the cathodic protection system operating parameters. The work was in two parts: computer simulation and laboratory experimentation.

Computer Simulation of Potential and Current Distributions in Cathodic Protection

A time-independent mathematical model for corrosion and cathodic protection of reinforcing steel in concrete structures was developed. In the report the processes are described qualitatively, and then the mathematical expressions that are used to quantify these processes are presented. Many of the issues involved in cathodic protection are introduced through consideration of a system with a one dimensional geometry. The additional complexities of potential distributions and transport processes in two-dimensional systems are then considered. Finally, a few comments on three-dimensional systems are presented.

As with any numerical modeling, many assumptions and simplifications are introduced. While the impact of critical assumptions are assessed, this model should be regarded as "a way of thinking about the concepts associated with cathodic protection" rather than "a direct basis for action." It is hoped that the direct basis for action will come out of the time dependent modeling that is currently underway.

A computer program of the model was developed to solve for the potential and current distributions in a simplified rectangular geometry. Input parameters were based on available experimental data. A sensitivity analysis was performed to evaluate the effects of pore saturation, concrete cover and applied potential.

The following recommendations resulted from the computer simulation completed for this study:

•Potential mapping of reinforced concrete structures is an effective method of locating actively corroding reinforcing steel.

•Reference electrodes should be placed at locations with the most negative potential and as close to the centerline of the reinforcing steel as possible.

•Care should be taken to account for the environmental conditions. In dry environments (low pore saturation), placement of the reference electrode has a large effect; in wet environments electrode placement is much less critical.

•In wet environments, the magnitude of the applied potential should be limited to prevent hydrogen evolution.

•Calculations of anode life should be based on the effective anode area (based on actual current density) rather than the total sprayed area. For thin concrete covers, lifetimes based on effective area could be 1/6 as long as lifetimes based on total area.

Experimental Study of Graphite Reference Electrodes

Reference electrodes mounted in a concrete block were evaluated under ambient laboratory conditions. The evaluation was based on a comparison of graphite electrodes to silver-silver chloride electrodes. Both commercially available and laboratory fabricated graphite electrodes were tested, as well as the effect of conditioning the graphite electrodes in $Ca(OH)_2$ solution. Conclusions were:

•Graphite electrodes appear to be suitable to monitor the 100-mV polarization decay.

•Graphite electrodes should be conditioned in saturated $Ca(OH)_2$ before installation.

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