Utilizing Large Laboratory Specimens to Develop Field Evaluation Techniques for Reinforced Concrete

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Structural Health Monitoring of Concrete Structures (Durability)—Tribute to Richard Weyers
Overview

• Introduction
• Review of Techniques Used to Determine Corrosion Rates in the Laboratory
• Need for Accurate Field Method
• Large-size Laboratory Specimens
  – Simulate larger field structures
  – Easier to confirm results using laboratory methods and autopsies
• Corrosion Potential Mapping
  – Quick technique that can evaluate large areas at a time
  – Large lab specimens potential mapping vs. other techniques
  – Example from the field from previous work with R. Weyers
• Conclusions
Introduction

• Assessing the corrosion activity in the field
  – Provides information on current condition
  – Can be used to predict future performance/time to repairs

• Problems in the field
  – Traffic Control and limited time at each location for measurements
  – Many laboratory techniques are not practical
    • Time constraints
    • Uncertainties in the area of steel affected

• Relatively quick, but accurate
  – Good qualitative assessment
  – Semi-quantitative or quantitative
  – Return to areas showing distress with more detailed analysis if required
Review of Lab Techniques

• Electrochemical Techniques (ND)
  – Corrosion Potential Measurements
  – Polarization Resistance
  – Electrochemical Impedance Spectroscopy (EIS)
  – Macrocell techniques

• Other Techniques
  – Mass Loss (D)
  – Visual appearance of surface (ND)
    • Surface Staining
    • Cracking
  – Detailed microscopic analysis (D)
Corrosion Rate Measurements
Corrosion Potential Mapping
Large-Size Laboratory Specimens to Correlate Potential Mapping to Corrosion Activity

- Need large specimen that can be used to evaluate corrosion potential measurements vs. other laboratory techniques.
- Design from USBR Standard Protocol to Evaluate the Performance of Corrosion Mitigation Technologies in Concrete Repairs-- M-82 (M08200000.714).
  - 40” x 40” x 5.5” slabs
  - 6-No. 4 reinforcing bars in top mat
  - Heavy wire mesh to provide cathode for macrocell corrosion
  - Cyclic Ponding with NaCl
Configuration of Slabs

- No. 4 Rebar with 0.75 to 1.5” Cover (M-82 is 1-inch, ½” aggregate)
- W4/W4 6x6 WWF bottom layer with 1-in. cover
- NEMA-4X Electrical Connection Box

- RH, ρ, Core area
- 40 in x 40 in x 5.5 in
Electrical Wiring

Wire Junction Box

W4/W4 6x6 WWF

No. 4 Steel Reinforcing Test Bar

RH, ρ, Core Sample area

11" 5" 5" 5" 5" 5" 4"
Corrosion Monitoring

- Corrosion Potential (ASTM C876)
- Macrocell Corrosion Current
- Mat-to-Mat Resistance
- Electrical Resistivity
- Chloride Profiles
- Internal Relative Humidity (Future)
Corrosion Monitoring

- Macrocell Corrosion Current
- Mat-to-Mat Resistance
- Electrical Resistivity
- Half-Cell Potential
Half-Cell Potential Mapping, -mV CSE$_{77}$
Destructive Analysis

- 0.50 w/c
- 0.75” Cover
Half-Cell Potential, -mV CSE$_{77}$

<table>
<thead>
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<th>Slab #53</th>
<th>Integrated Current (Coulombs)</th>
<th>Half-Cell Potential (mV CSE$_{77}$)</th>
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Comparison of Potential Map to Corrosion Rates

Contour Plot of Potential for Bridge Deck (Blacksburg, VA)

LP \( I_{\text{corr}} \) measurements in boxes

Replotted from Berke, Dallaire, WEYERS, Henry, Peterson, and Prowell, ASTM STP 1137, 1992
Conclusions

- Large Laboratory slabs demonstrate that corrosion potential mapping correlates to the corrosion activity as measured by electrochemical methods and autopsy of the specimens.
- Good correlation to the field was shown.
- A potential map can be performed with only a few seconds per measurement point, versus 10 minutes plus for polarization resistance or similar techniques.
- Thus, potential mapping is a practical means of evaluating corrosion performance in the field.
Questions/Comments?