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)

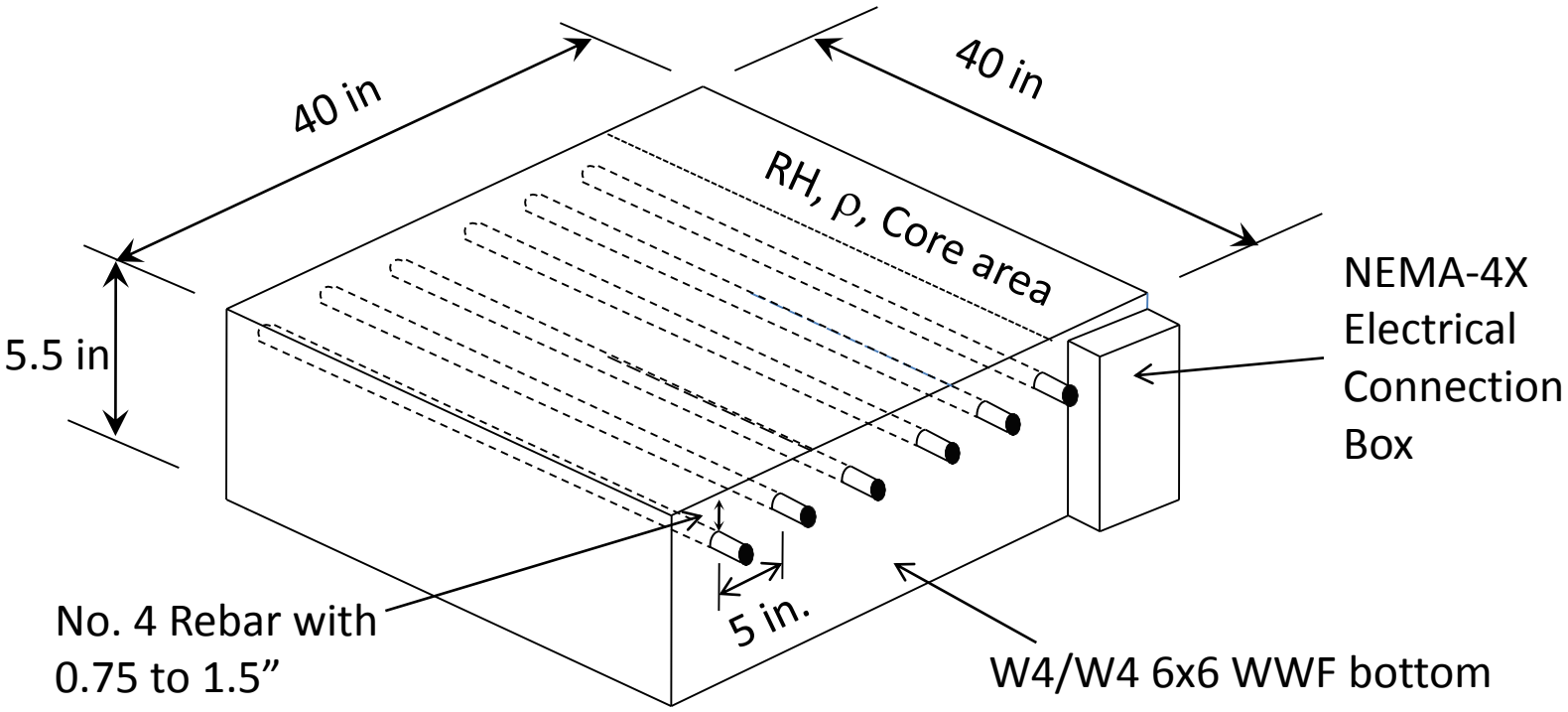
Corrosion Rate Measurements

Corrosion Potential Mapping

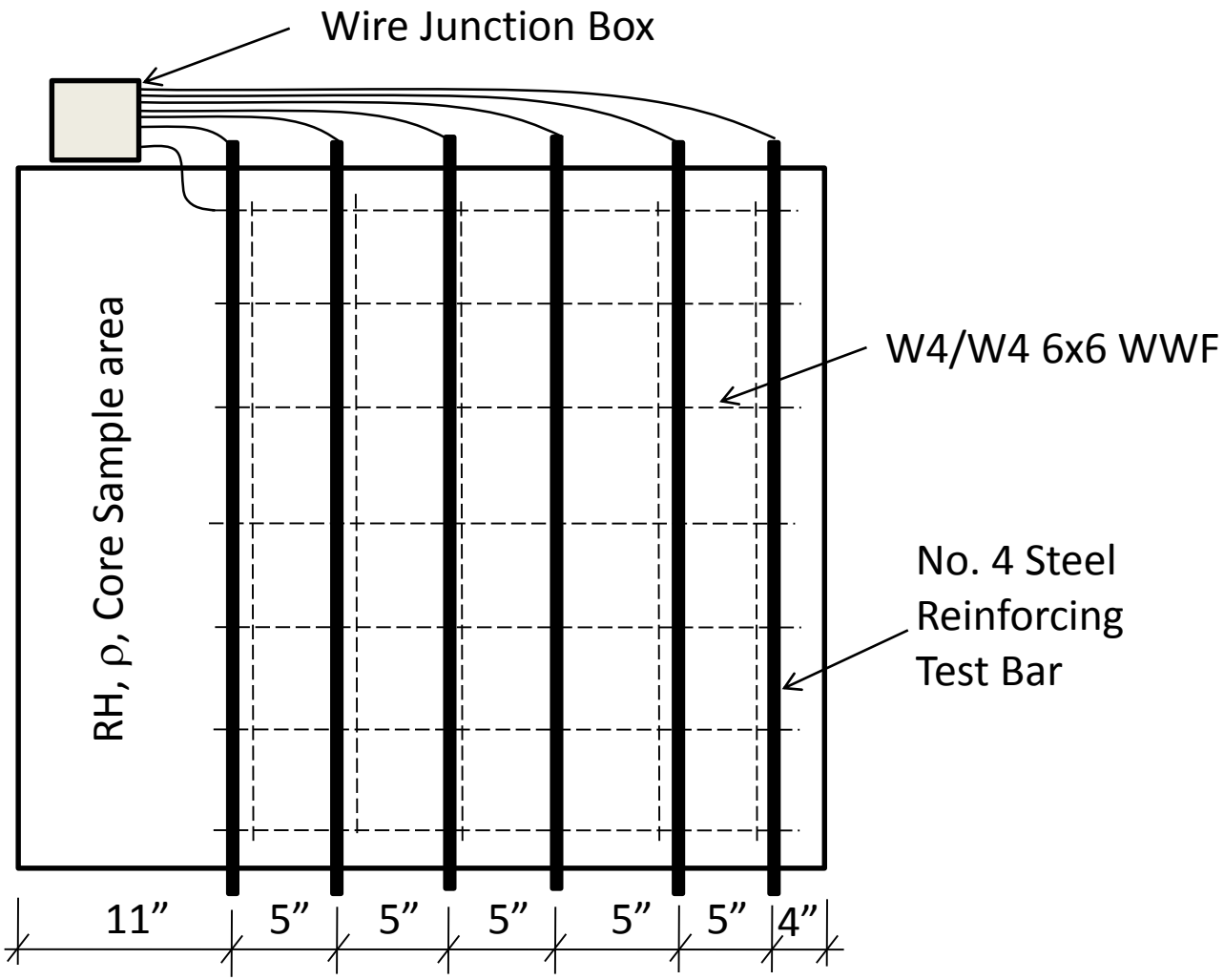
Large-Size Laboratory Specimens to Correlate Potential Mapping to Corrosion Activity

- 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



Electrical Wiring

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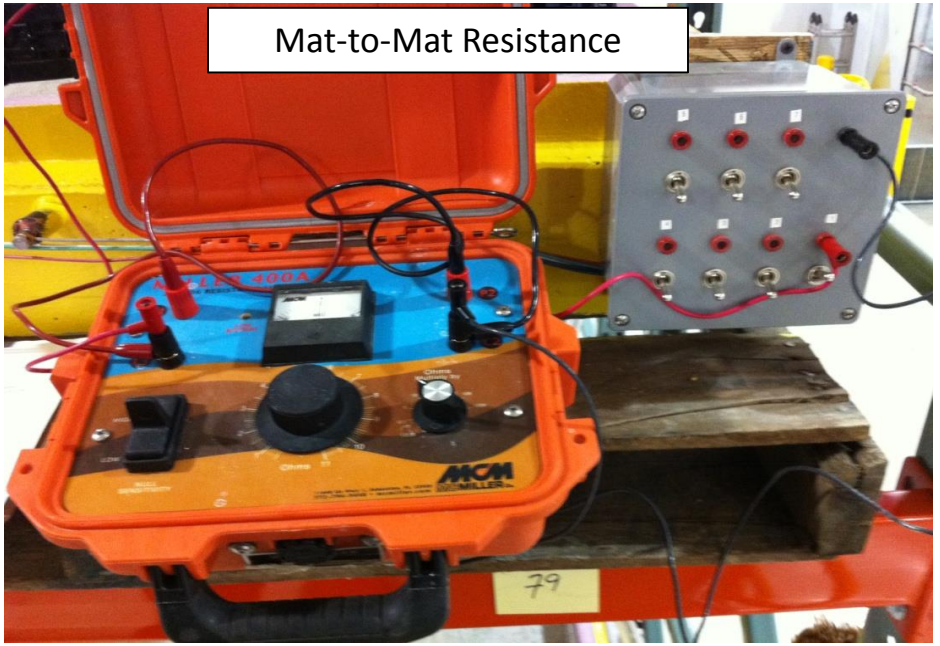
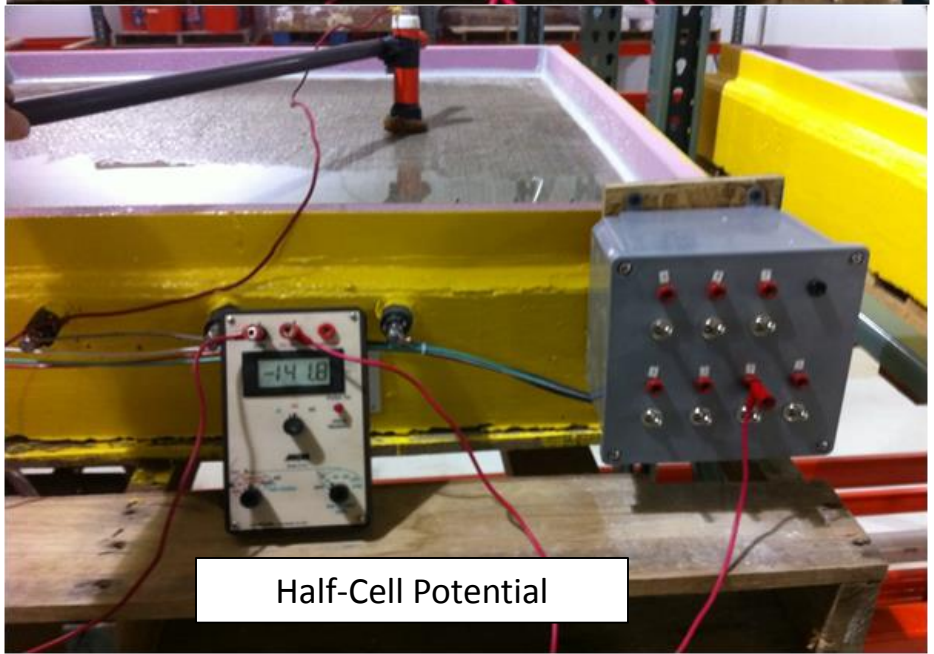
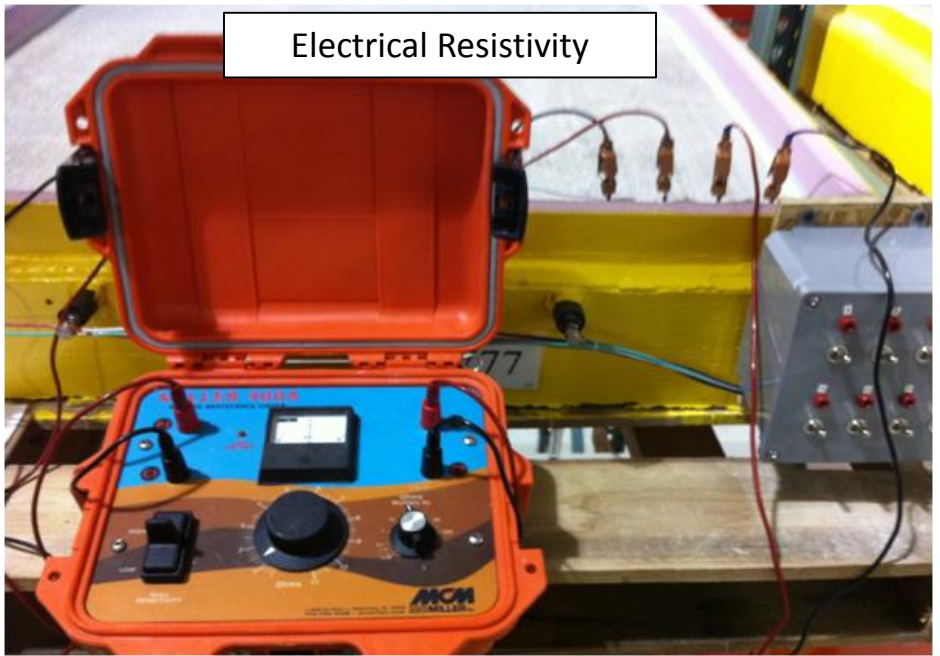
Corrosion Monitoring

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

Corrosion Monitoring

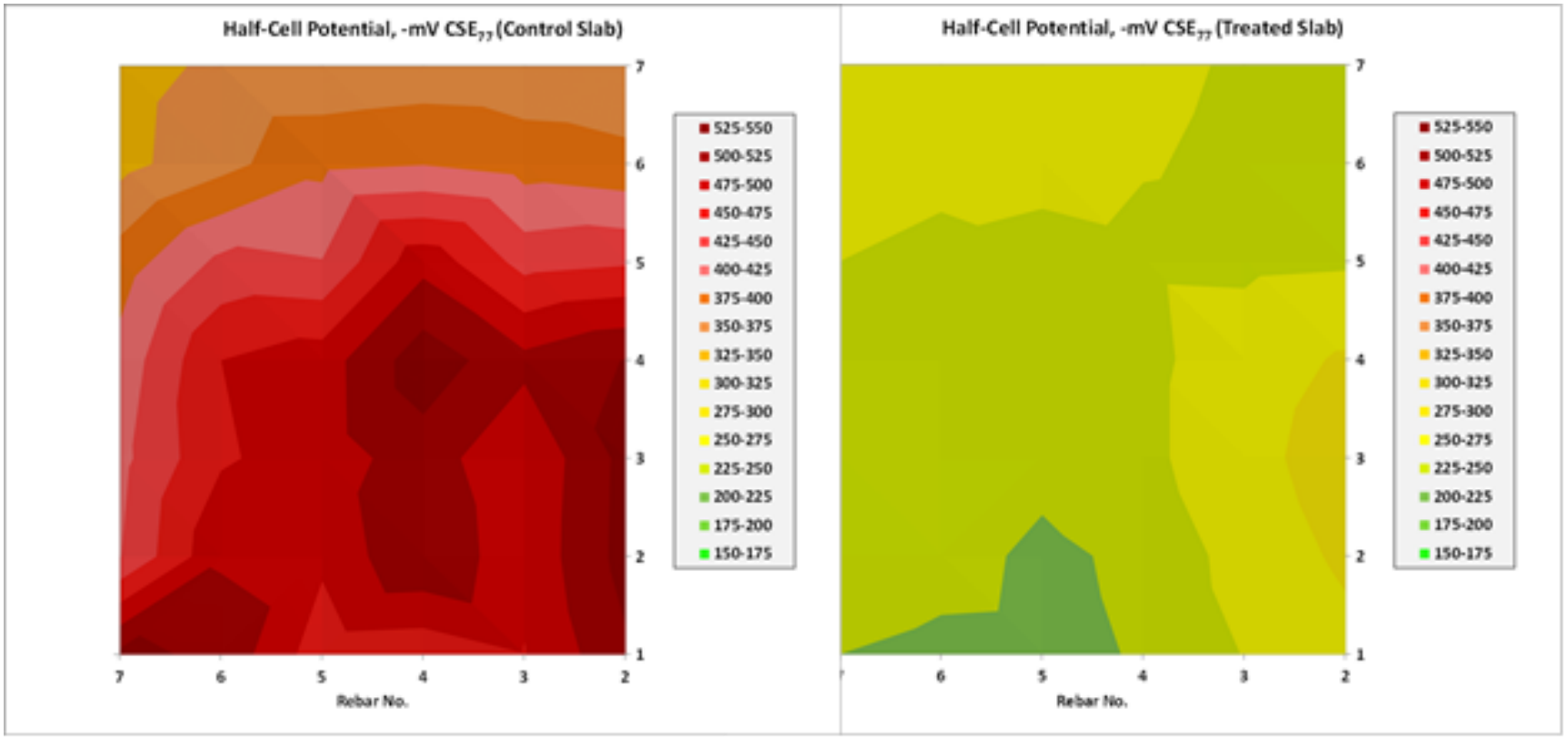







V34
V35

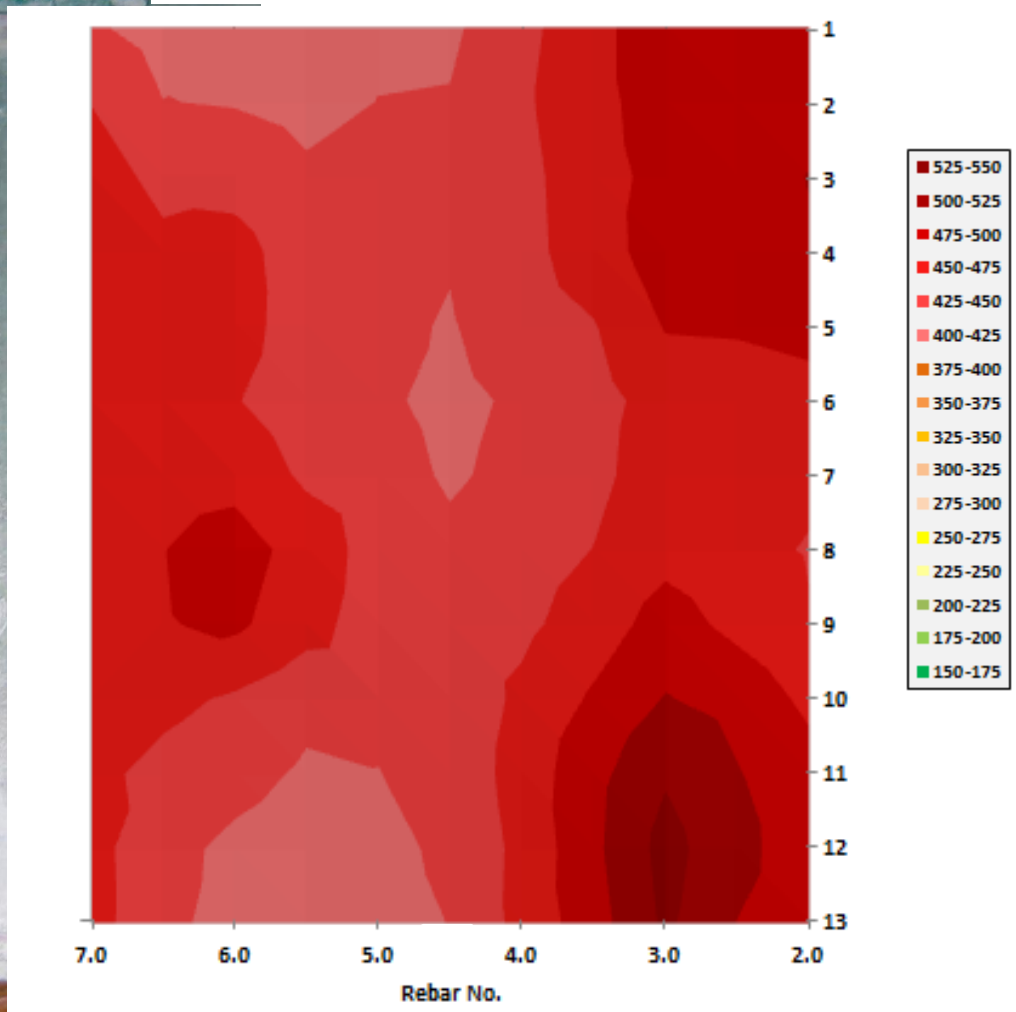
Half-Cell Potential Mapping, -mV CSE_{77}



Destructive Analysis

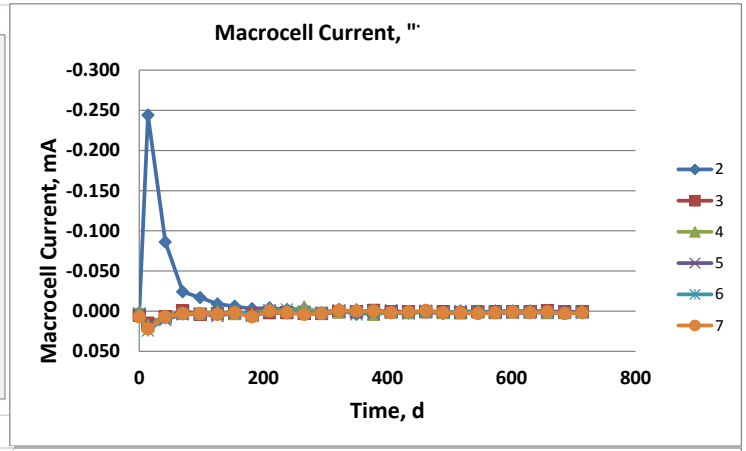
- 0.50 w/c
- 0.75” Cover

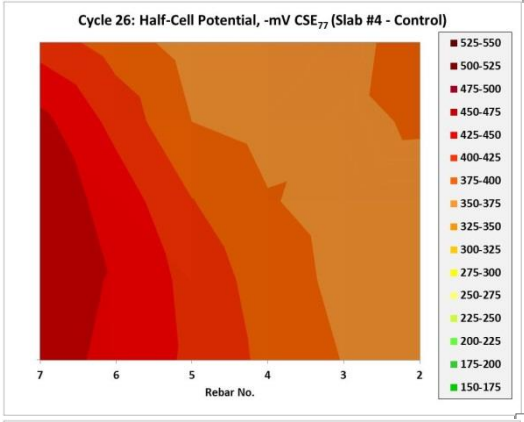
Half-Cell Potential, -mV CSE_{77}

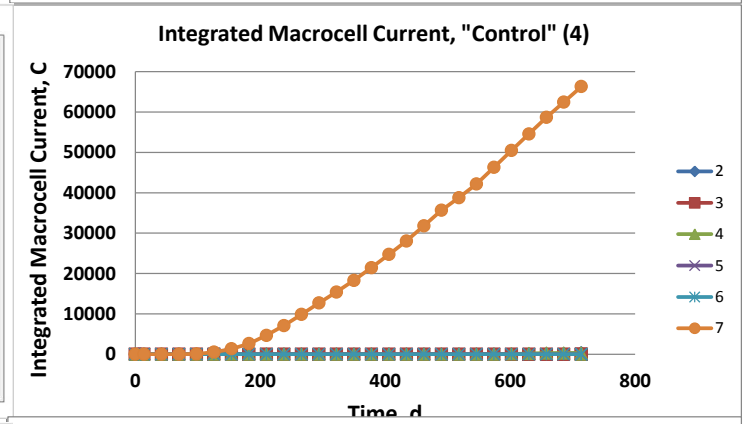


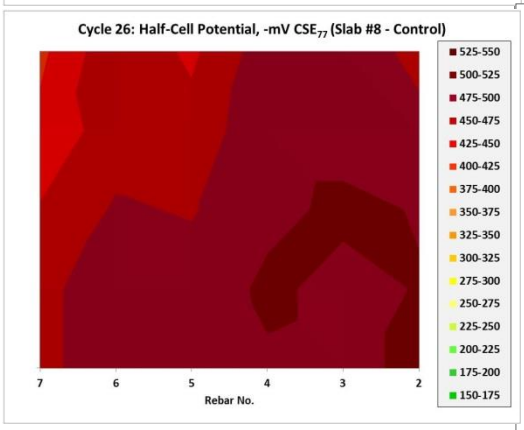
Slab #53								
Rebar	7	6	5	4	3	2	Average	Total
Integrated Current (Coulombs)	10128	34483	656	0	10669	35106	15174	91042
Half-Cell Potential (mV CSE_{77})	-514	-562	-428	-395	-529	-508	-489	-

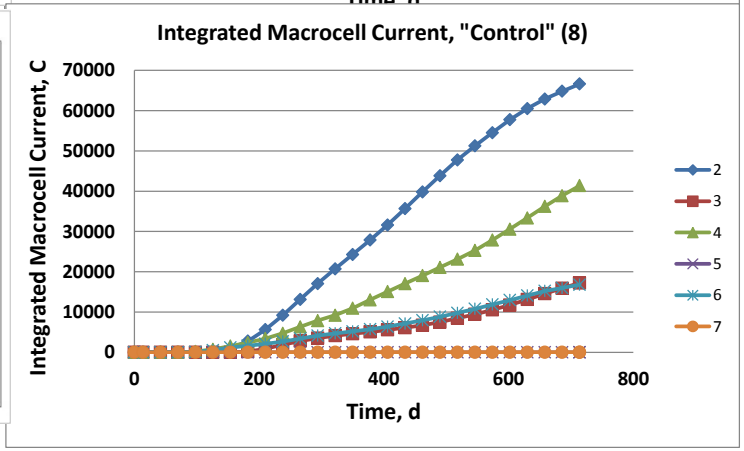

Cycle 1: Half-Cell Potential, -mV CSE77 (Slab #5 - Treated)
525-550
500-525
475-500
450-475
425-450
400-425
375-400
350-375
325-350
300-325
275-300
250-275
225-250
200-225
175-200
150-175
7 6 5 4 3 2
Rebar No.


Macrocell Current, "
-0.300
-0.250
-0.200
-0.150
-0.100
-0.050
0.000
0.050
Macrocell Current, mA
0 200 400 600 800
Time, d
2
3
4
5
6
7

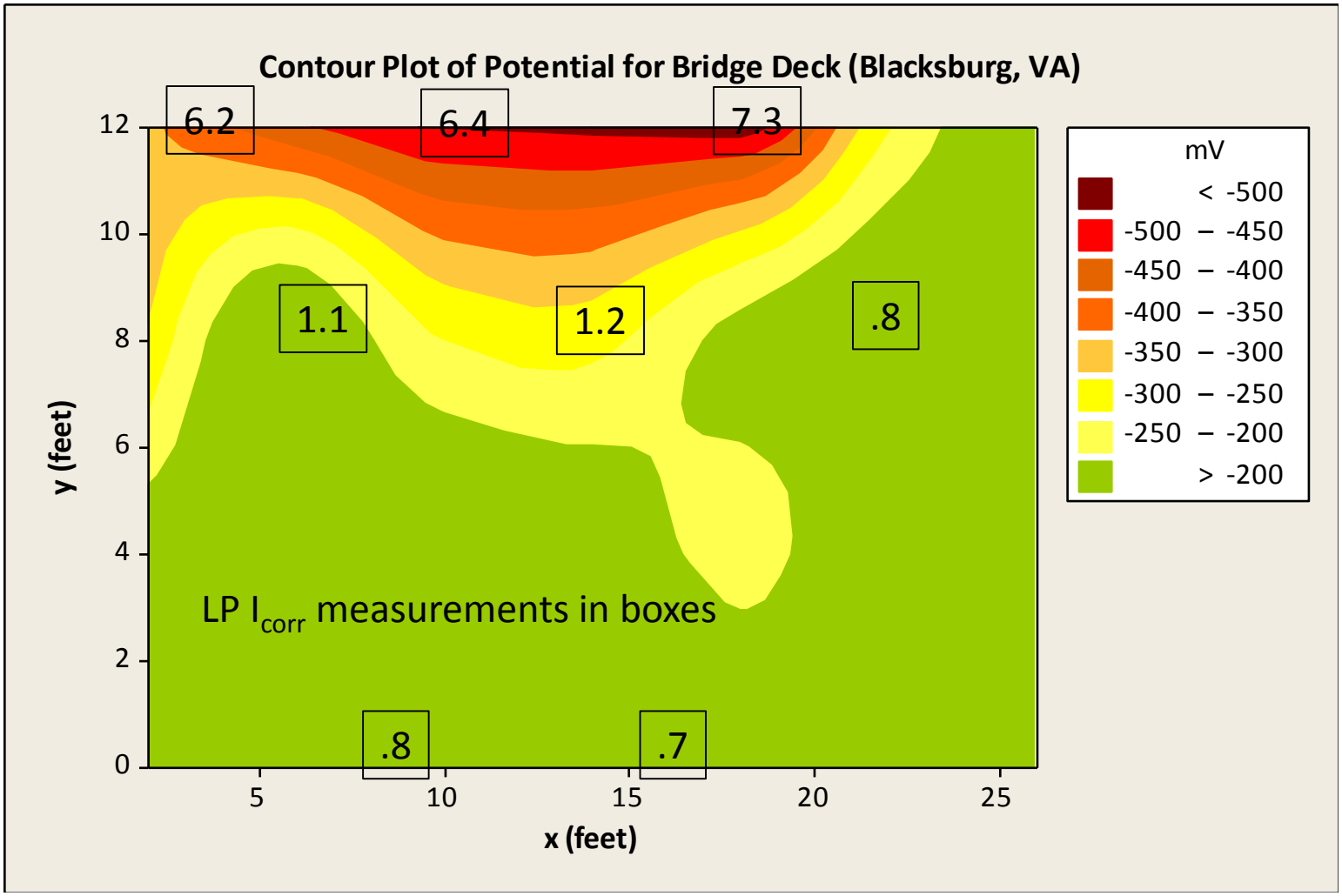

Cycle 26: Half-Cell Potential, -mV CSE77 (Slab #4 - Control)
525-550
500-525
475-500
450-475
425-450
400-425
375-400
350-375
325-350
300-325
275-300
250-275
225-250
200-225
175-200
150-175
7 6 5 4 3 2
Rebar No.


Integrated Macrocell Current, "Control" (4)
70000
60000
50000
40000
30000
20000
10000
0
Integrated Macrocell Current, C
0 200 400 600 800
2
3
4
5
6
7


Cycle 26: Half-Cell Potential, -mV CSE77 (Slab #8 - Control)
525-550
500-525
475-500
450-475
425-450
400-425
375-400
350-375
325-350
300-325
275-300
250-275
225-250
200-225
175-200
150-175
7 6 5 4 3 2
Rebar No.


Integrated Macrocell Current, "Control" (8)
70000
60000
50000
40000
30000
20000
10000
0
Integrated Macrocell Current, C
0 200 400 600 800
Time, d
2
3
4
5
6
7

Comparison of Potential Map to Corrosion Rates



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?