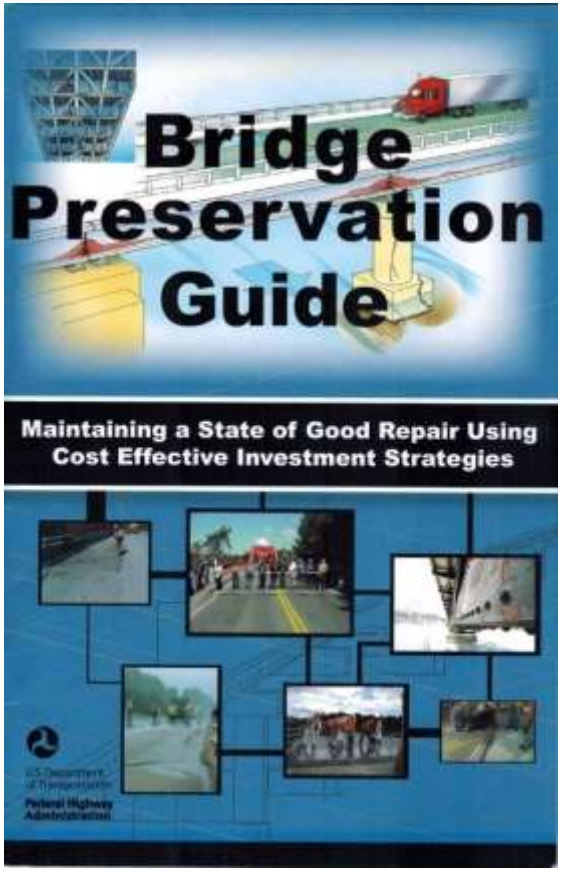
Bridge Preservation

Corrosion Mitigation of Existing Concrete Structures

Vector Corrosion Technologies

FHWA Bridge Preservation Guide



FHWA-HIF-11042, August, 2011

- In US, 25% of 600,000 bridges are Structurally Deficient or Functionally Obsolete
- 30% of bridges have exceeded their 50 year design life
  - Need repair, rehabilitation or replacement
- A need exists to develop adopt and implement systematic process for bridge preservation
- Since 2008, Systematic Preventive Maintenance (SPM) is eligible activity under the Highway Bridge Program

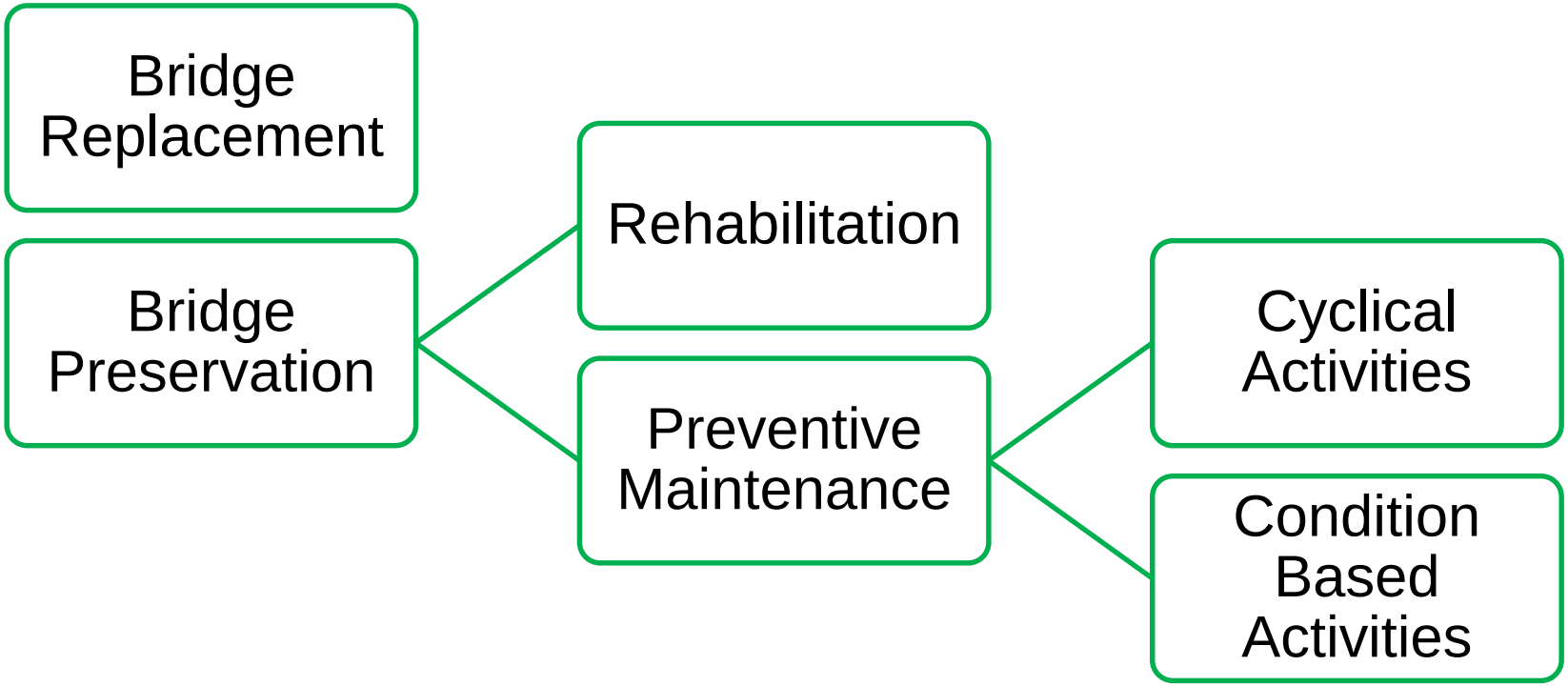
Bridge Definitions

- Bridge Rehabilitation – major work required to restore the structural integrity of a bridge as well as work necessary to correct major safety defects.
- Bridge Preservation - Actions that prevent delay or reduce deterioration or bridges or bridge elements, restore the function of existing bridges, keep bridges in good condition and extend their life. Preservation may be preventive or condition-driven.

Bridge Definitions

- Preventive Maintenance – planned strategy of cost-effective treatments to preserve, retard future deterioration, and maintains or improves the function condition of the system.
- Cyclical Preventive Maintenance – activities performed on pre-determined interval to delay deterioration
- Condition Based Preventive Maintenance – Activities performed as needed

Bridge Actions



Examples of Preventive Maintenance Activities

- Cathodic Protection
  - Decks, Superstructures, Substructures
  - With or without concrete repairs
- Electrochemical Chloride Extraction
  - Decks, Substructures
  - With or without concrete repairs
- Cathodic Protection Jackets
  - Substructure

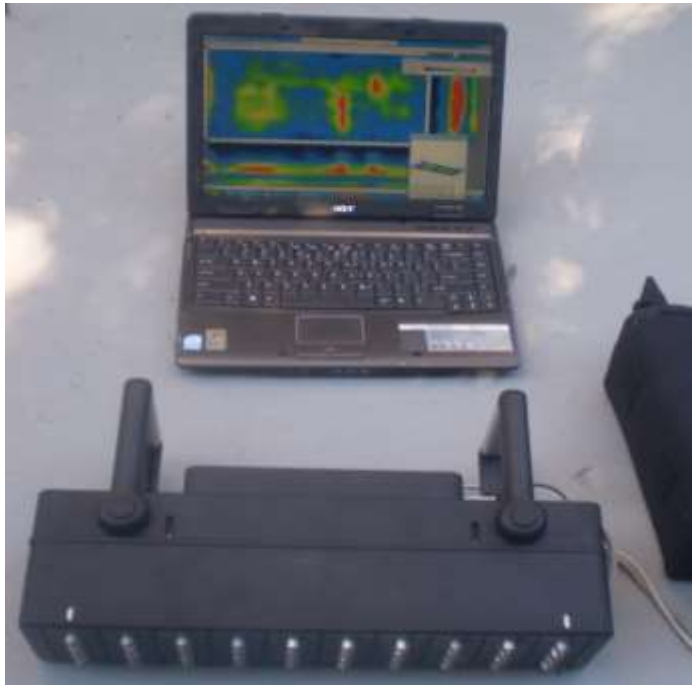
FHWA Bridge Preservation Guide (p. 21-23)

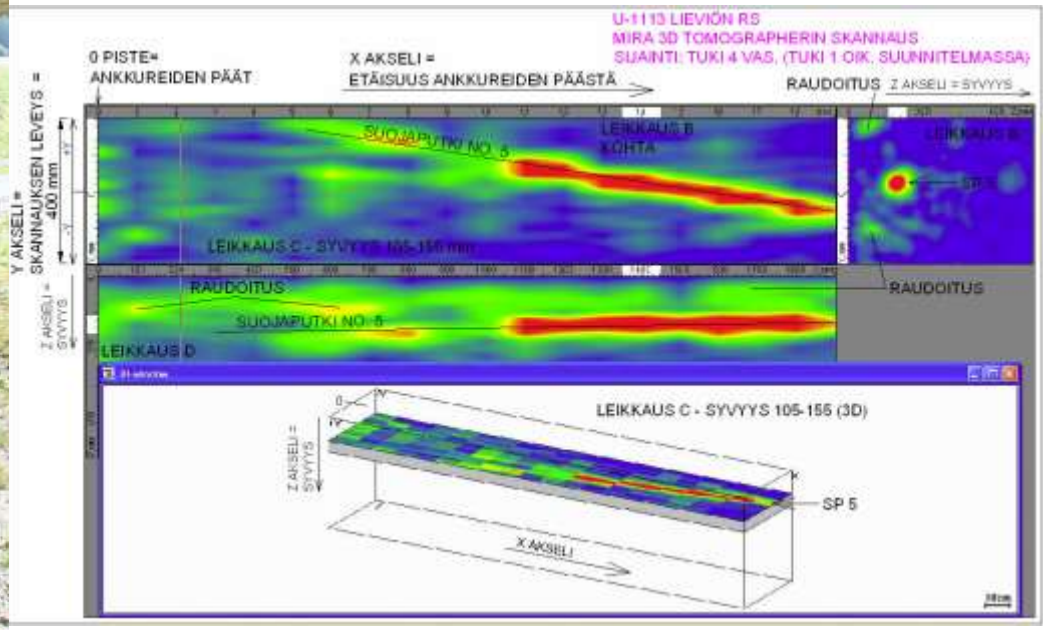
Corrosion Mitigation and Testing of Existing Concrete Bridge Structures

Corrosion Services

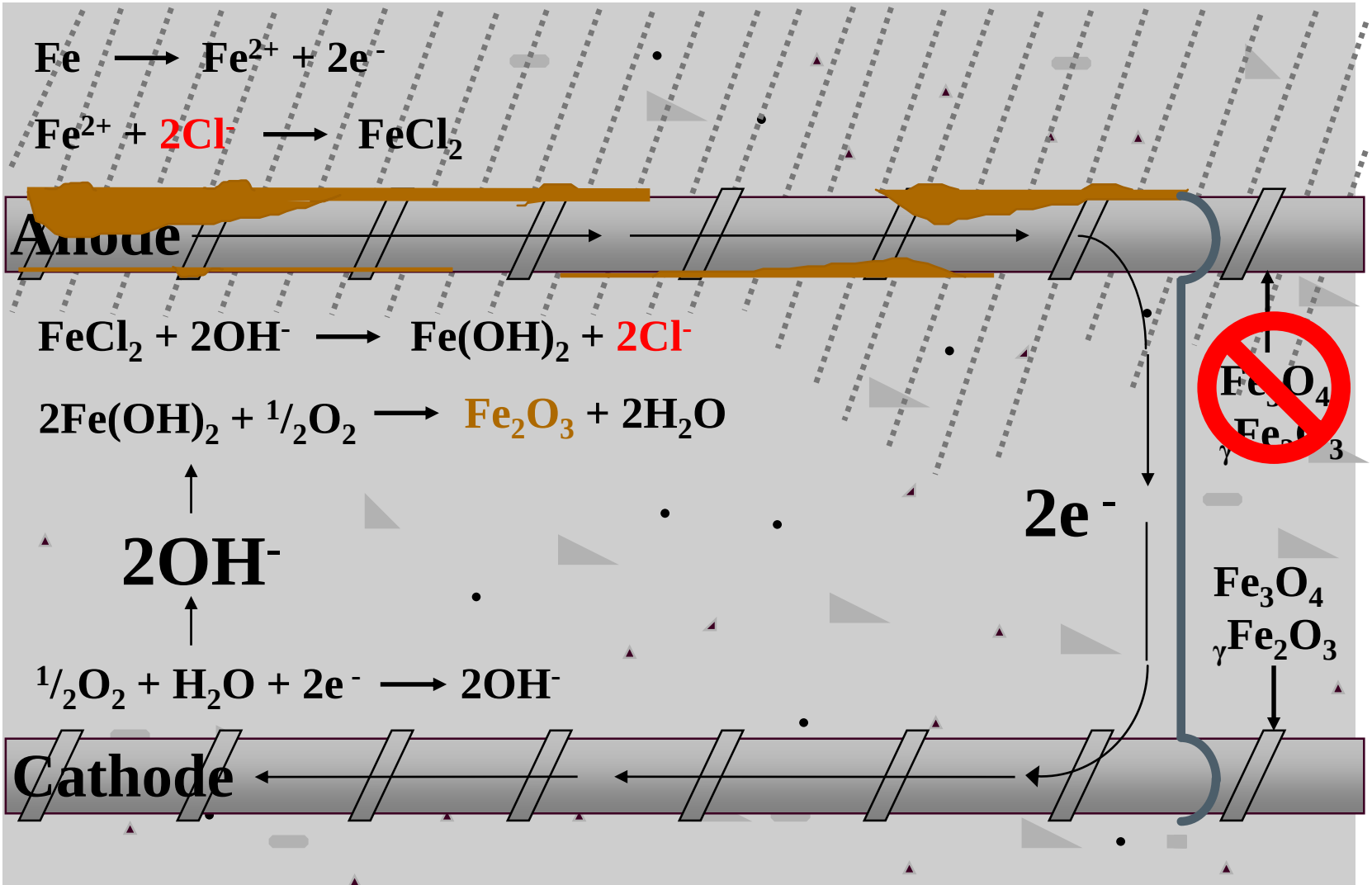
- Evaluation and Testing
- Monitoring
- Technical Site Services
- CP System Design
- System Installation
- Specialty Repair Services

3D Tomographer detecting voids in PT grout





Corrosion Cell in Concrete

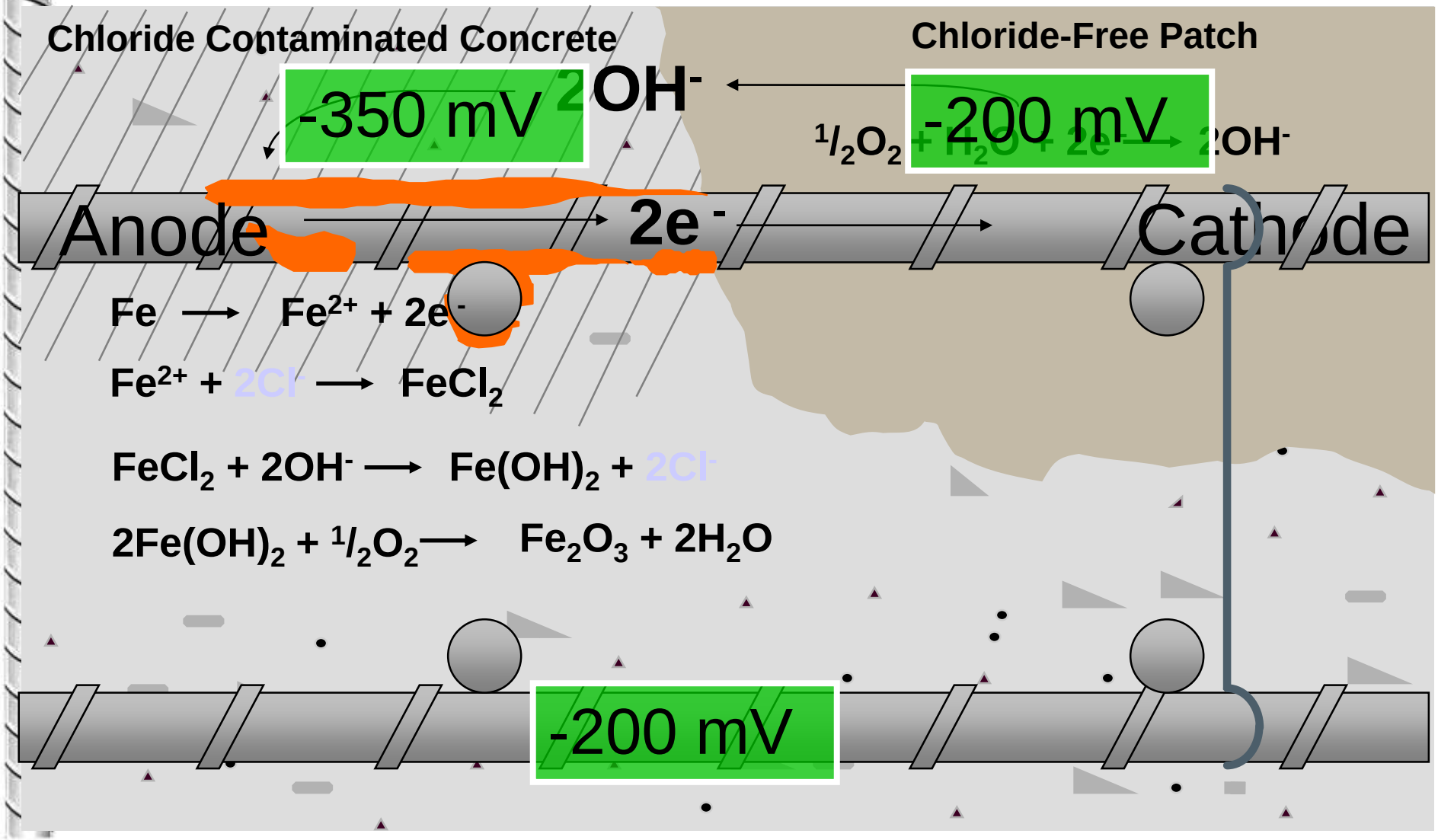


ICRI No. 310.1R–2008 Guideline for Surface Preparation for Repair of Concrete Deterioration Resulting from Reinforcing Steel Corrosion

Key Issues Re Corrosion

- Remove concrete from full circumference of all reinforcing steel.
- Remove corrosion by-products from steel
- Expand area of patch outside area of active corrosion (clean steel).

Patch Accelerated Corrosion



New Corrosion Sites

Bridge Pier

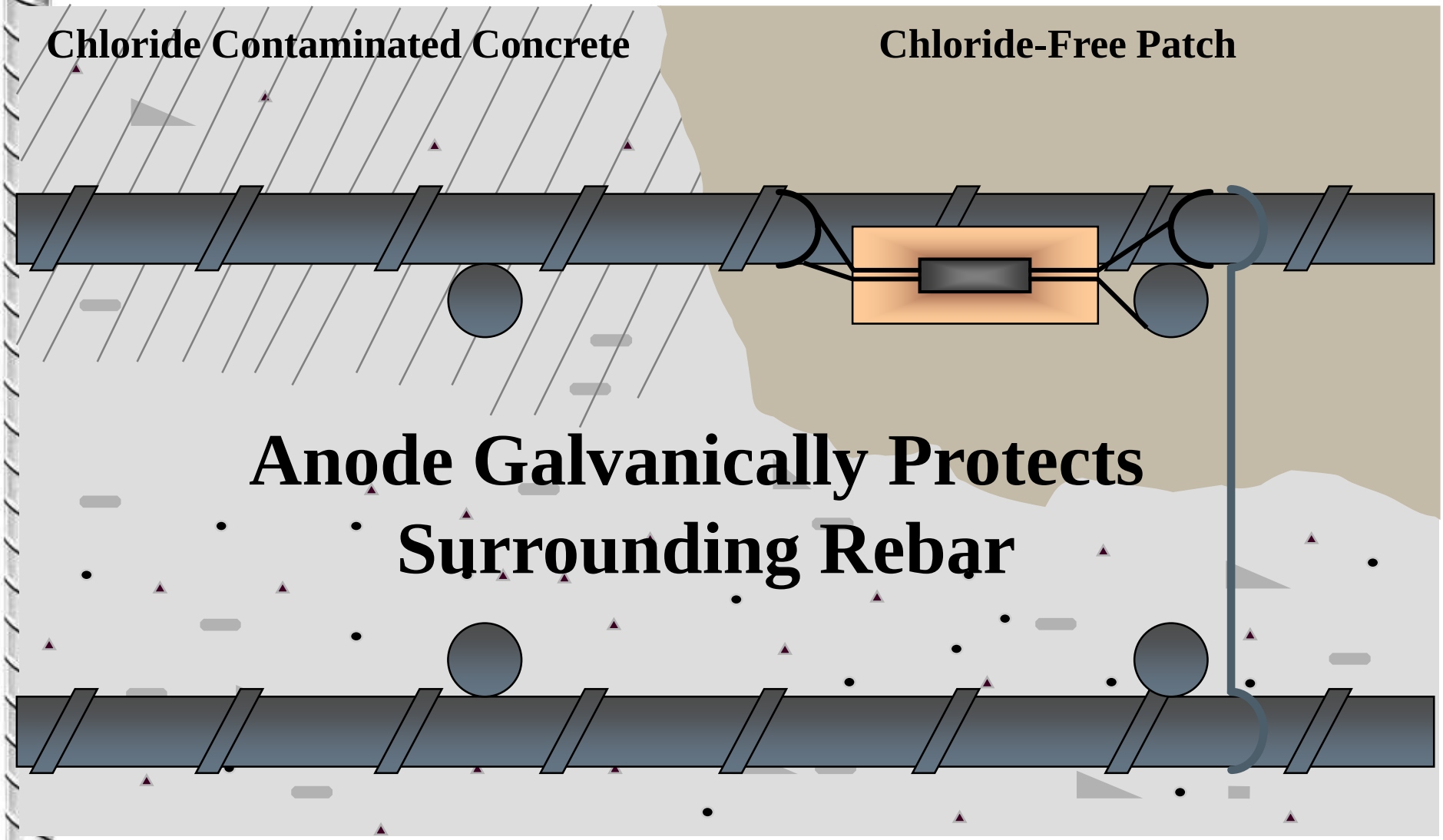
Bridge Deck

Electrochemical Corrosion Mitigation Systems for Concrete

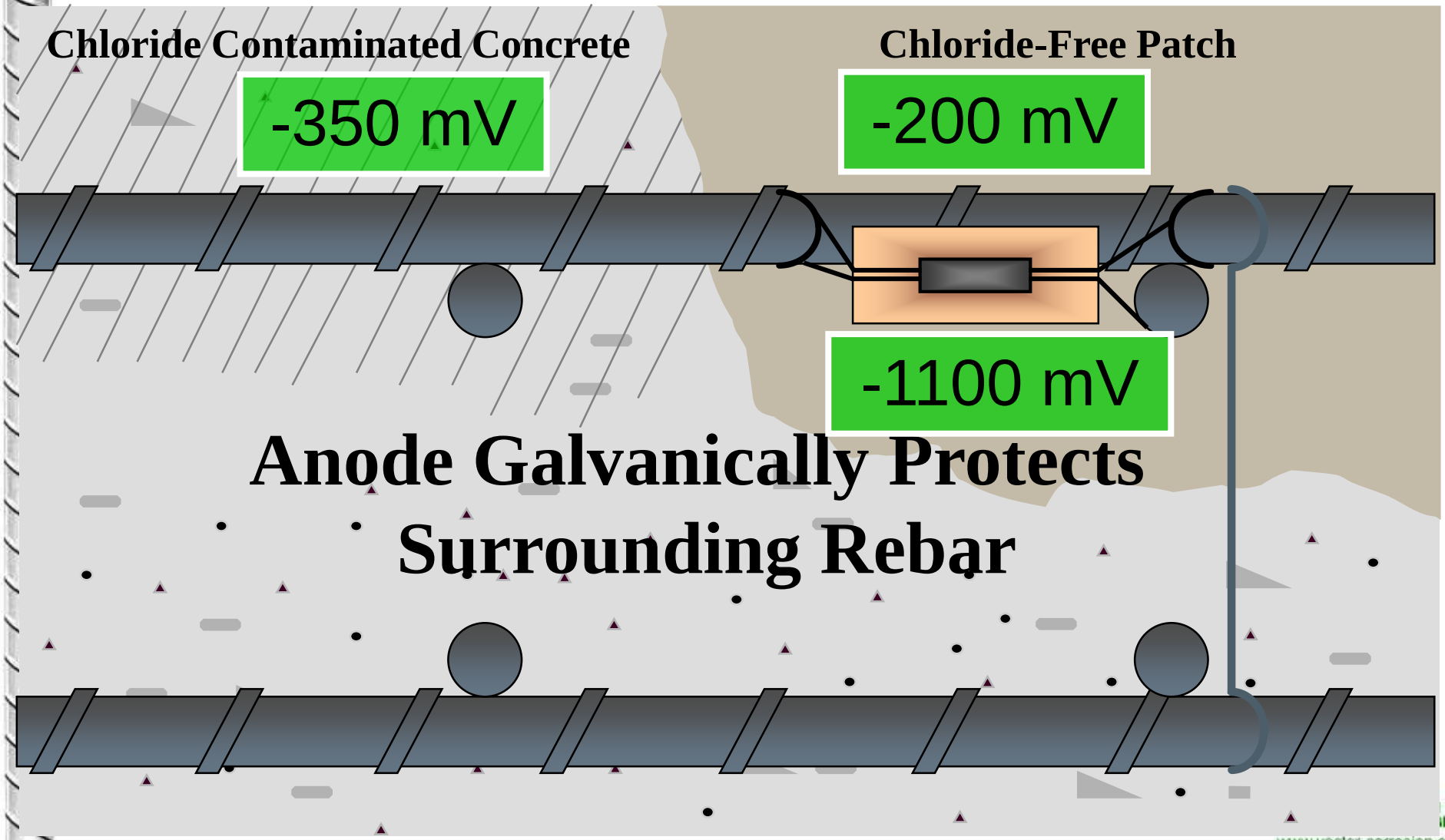
- Galvanic Protection
- Impressed Current Cathodic Protection
- Corrosion Passivation using Electrochemical Treatments
  - Chloride Extraction
  - Re-alkalization

Targeted Protection with Point Anodes

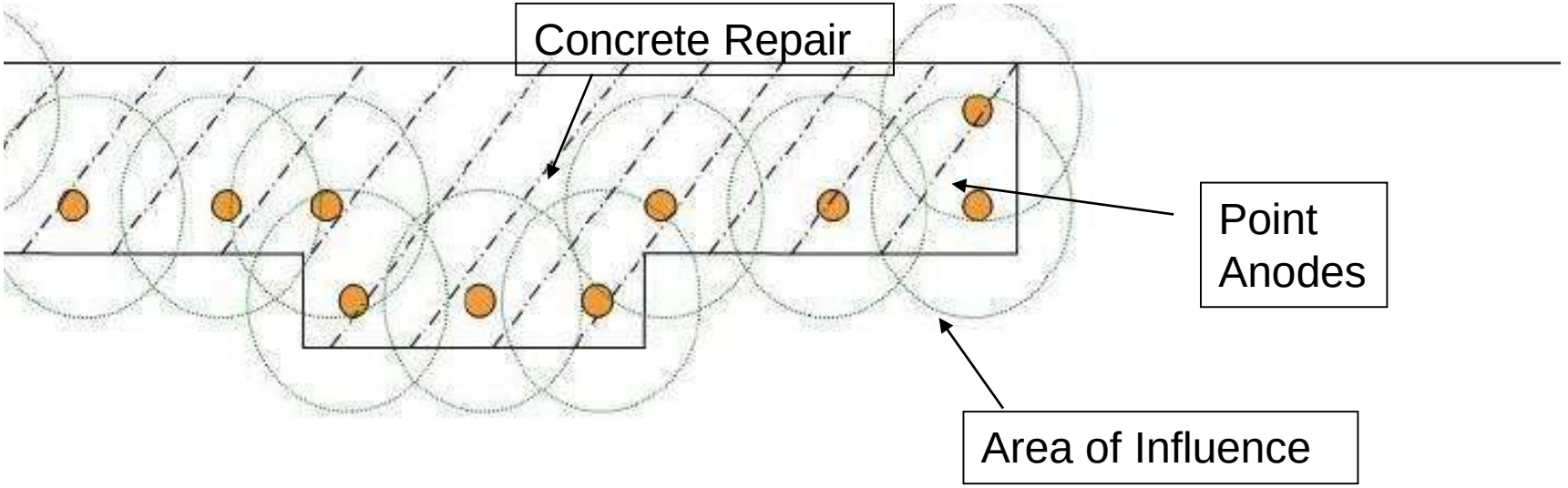
Installed Galvanic Anode



Installed Galvanic Anode



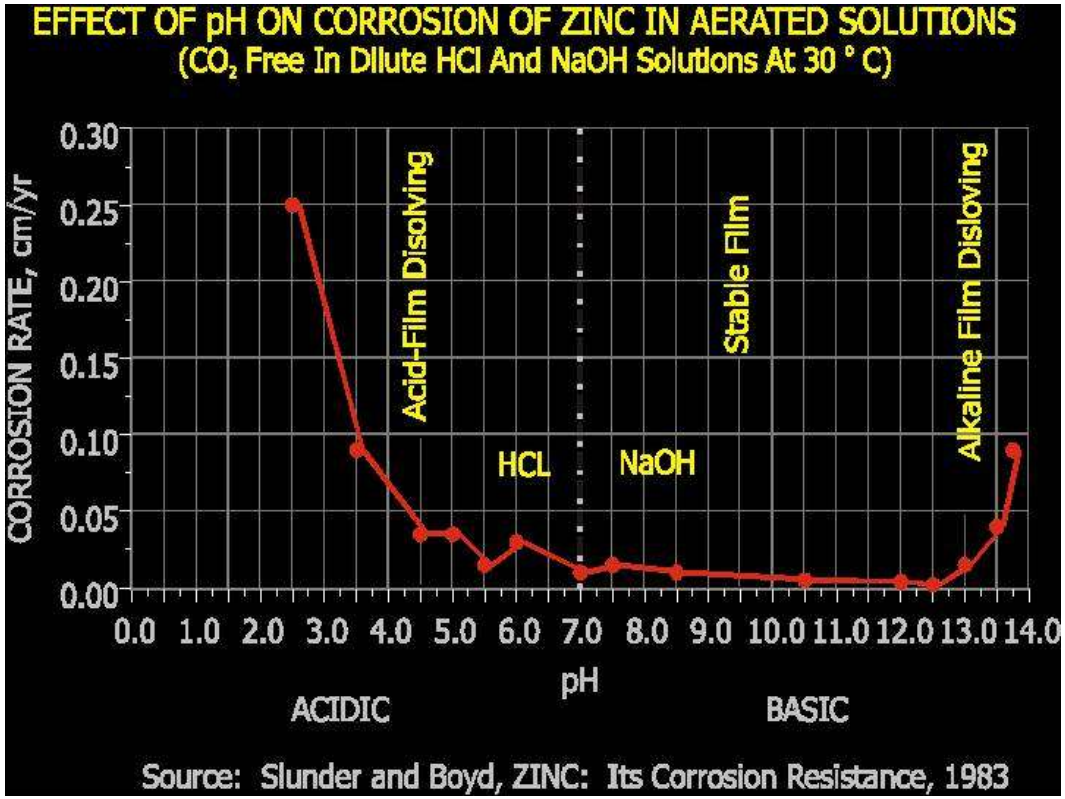
Point Anodes Protection



Activation Technology

Alkali Activated

- High pH is corrosive to zinc but not to steel
- Allows zinc anodes to provide protection to reinforced concrete over time



Anode Installation

Anode Installation

Testing anode connection to reinforcing steel.

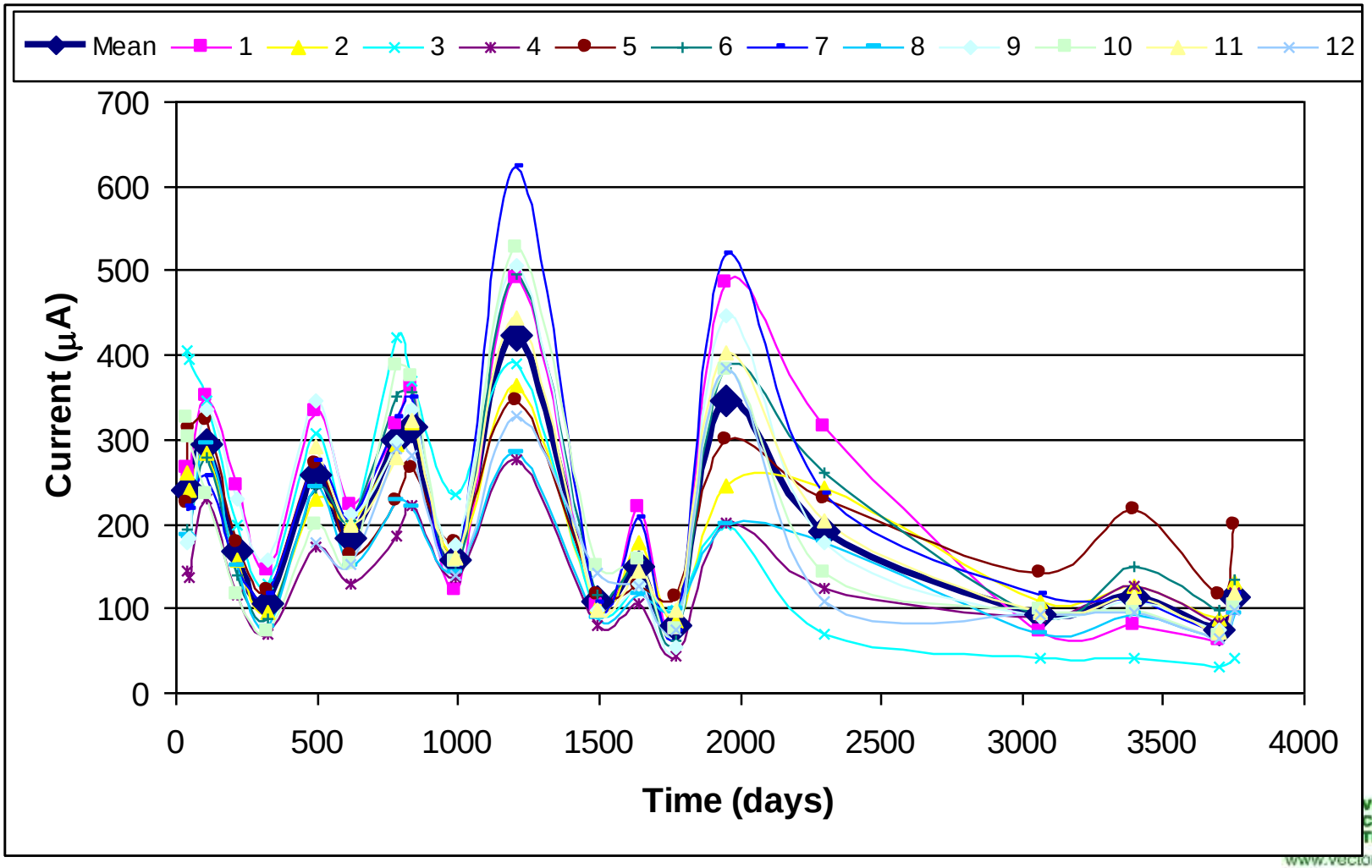
Anode Installation

Embedding anodes with repair material.

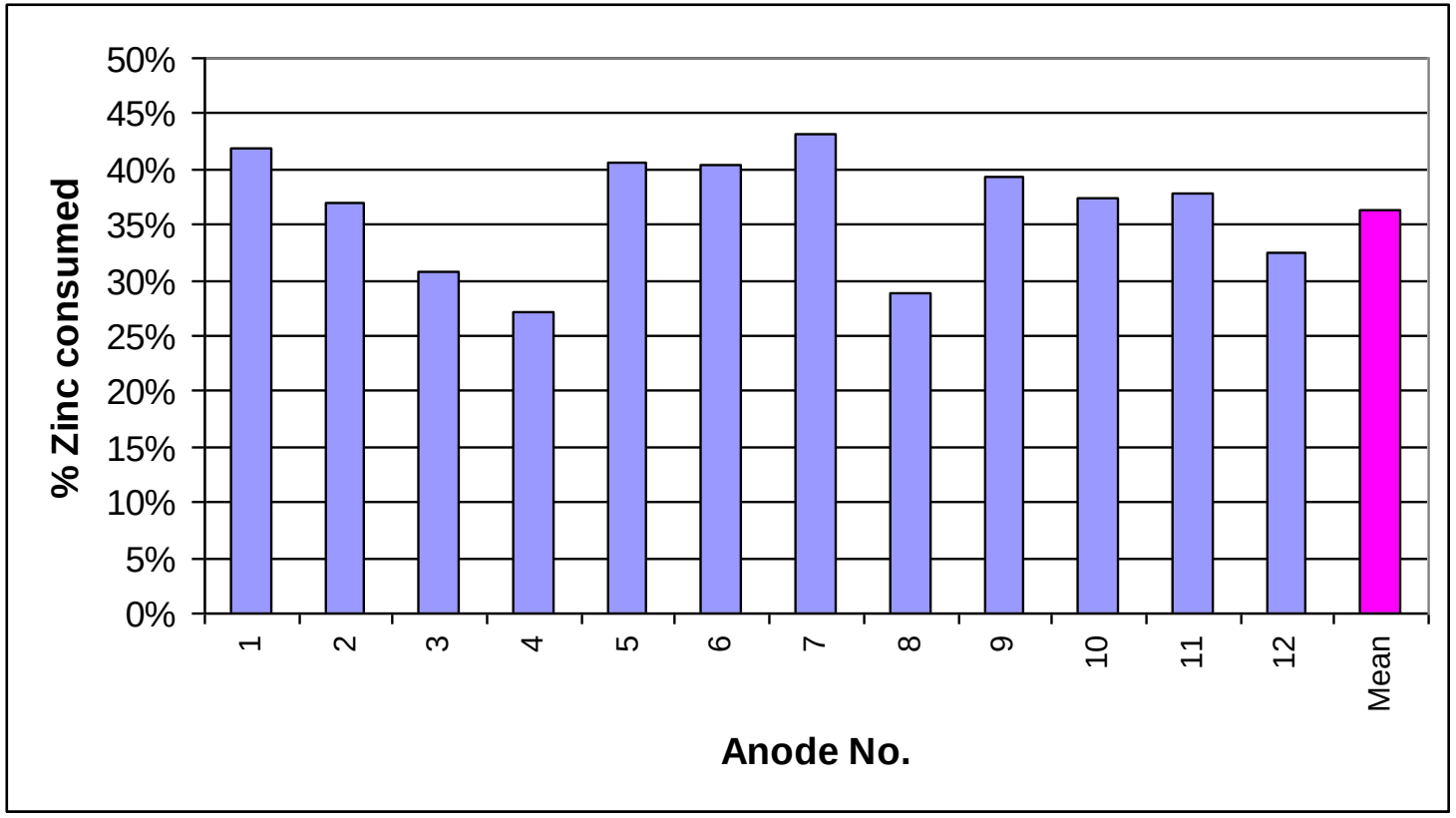
Leister Bridge Cross Beam

- Completed in 1999
- Monitored for 10 years

10 Year Monitoring - Current

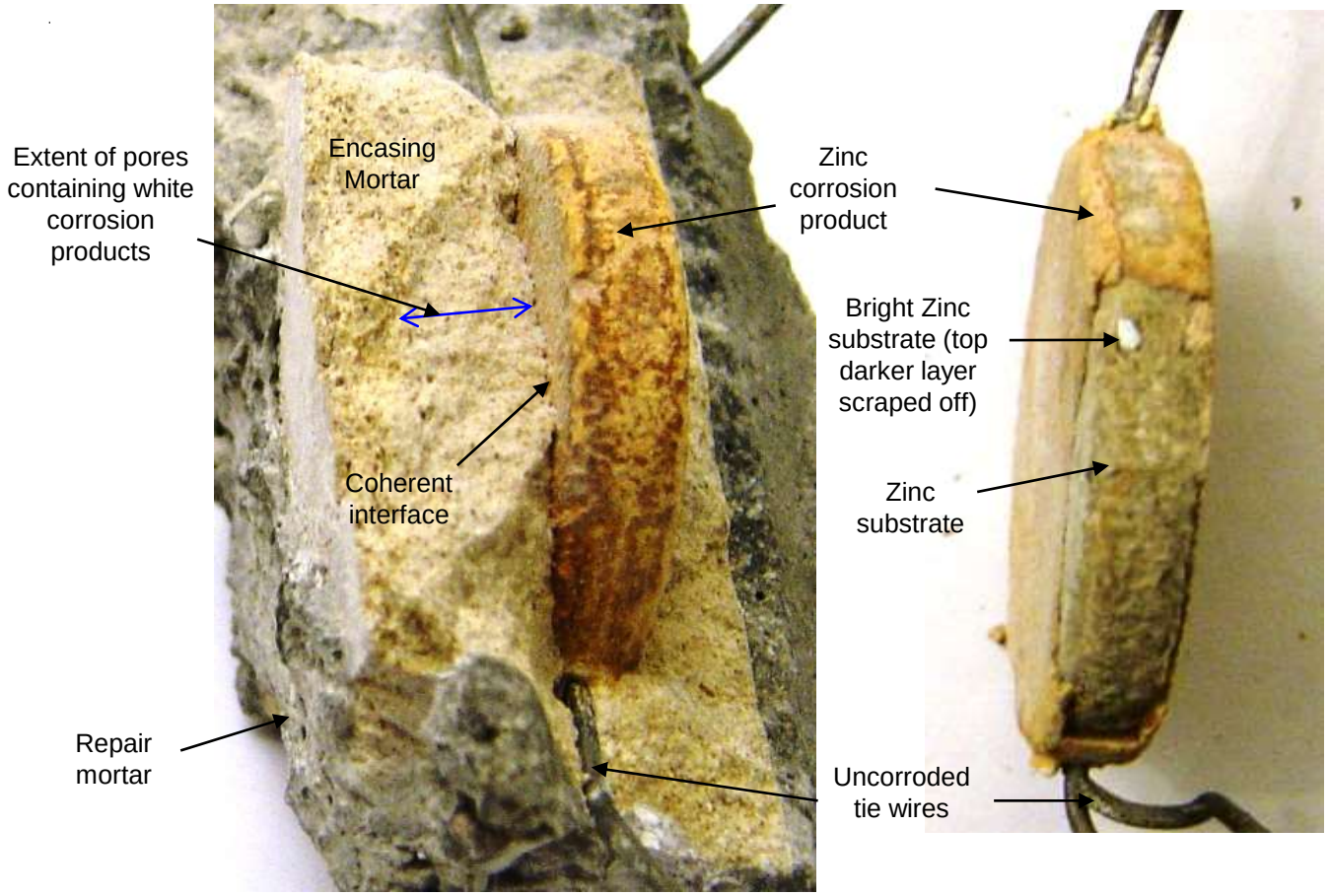


Approximate Zinc Consumption



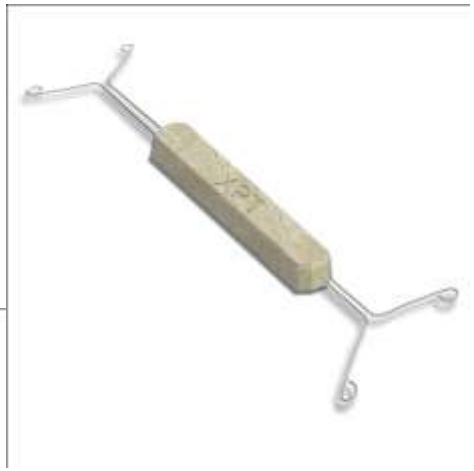
- Calculated based on current output and 85% utilization

Forensic Analysis after 10 yrs

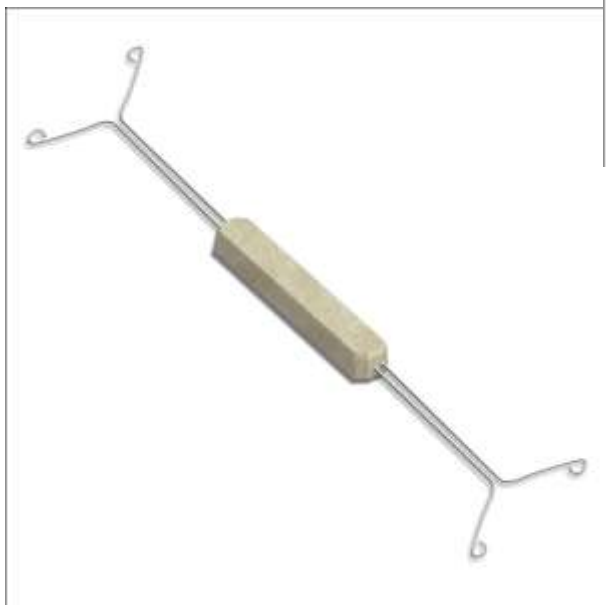


Galvanic Anodes for Corrosion Prevention

Galvashield XP



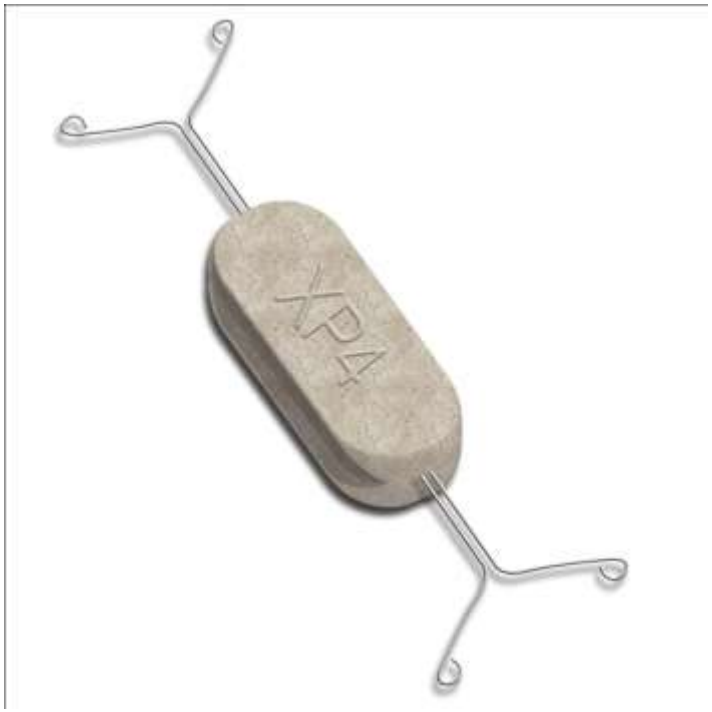
Galvashield XPT



Galvashield N

Galvanic Anodes for Corrosion Control

Galvashield XP2



Galvashield XP4

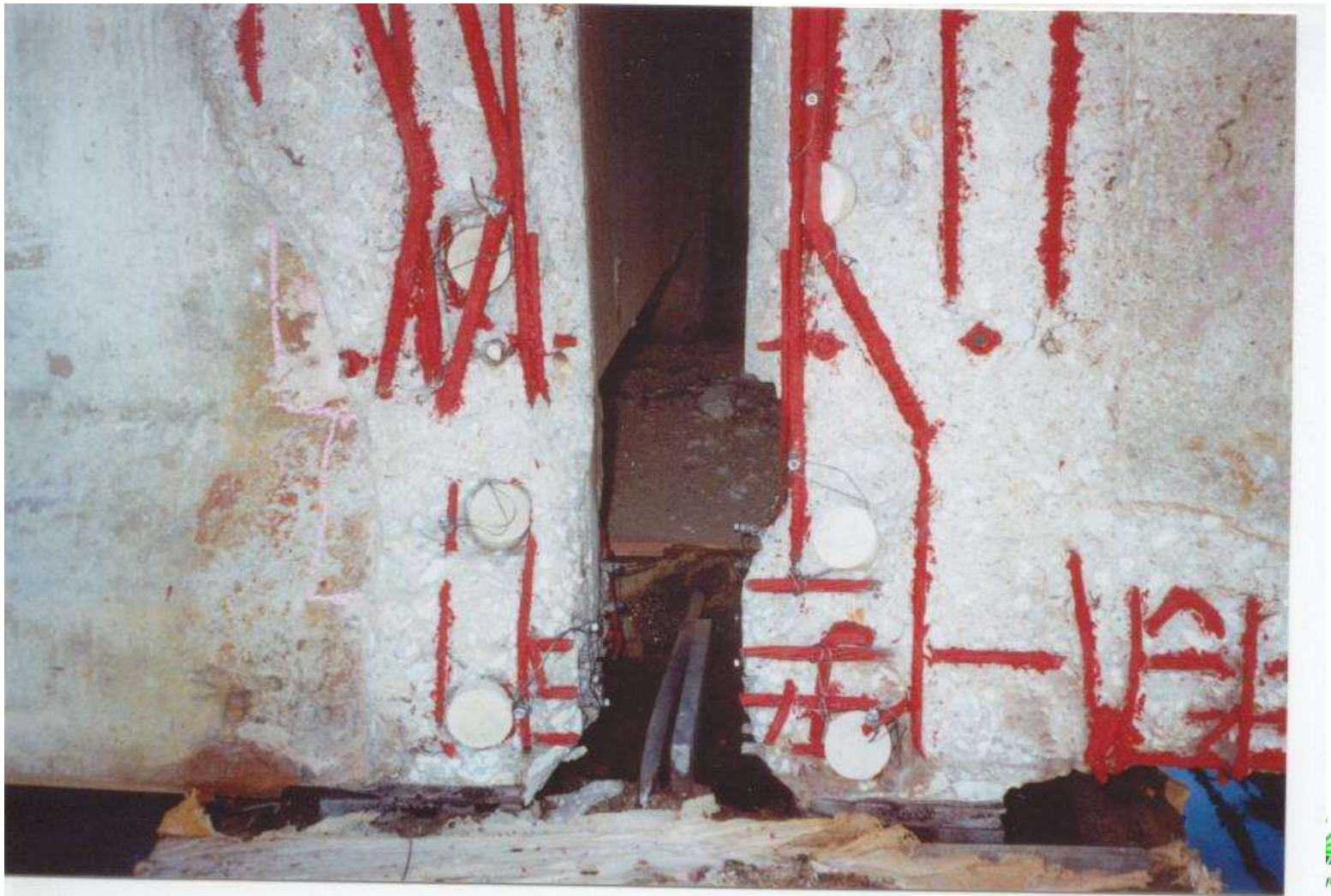
Localized Galvanic Anode Applications

Bridge Deck - Chip and Patch Repairs.
Colorado DOT – Greeley, CO

Bridge Beam Repair


20 07 2004

Prestressed Beam Ends



Grid versus Point / Line Installation

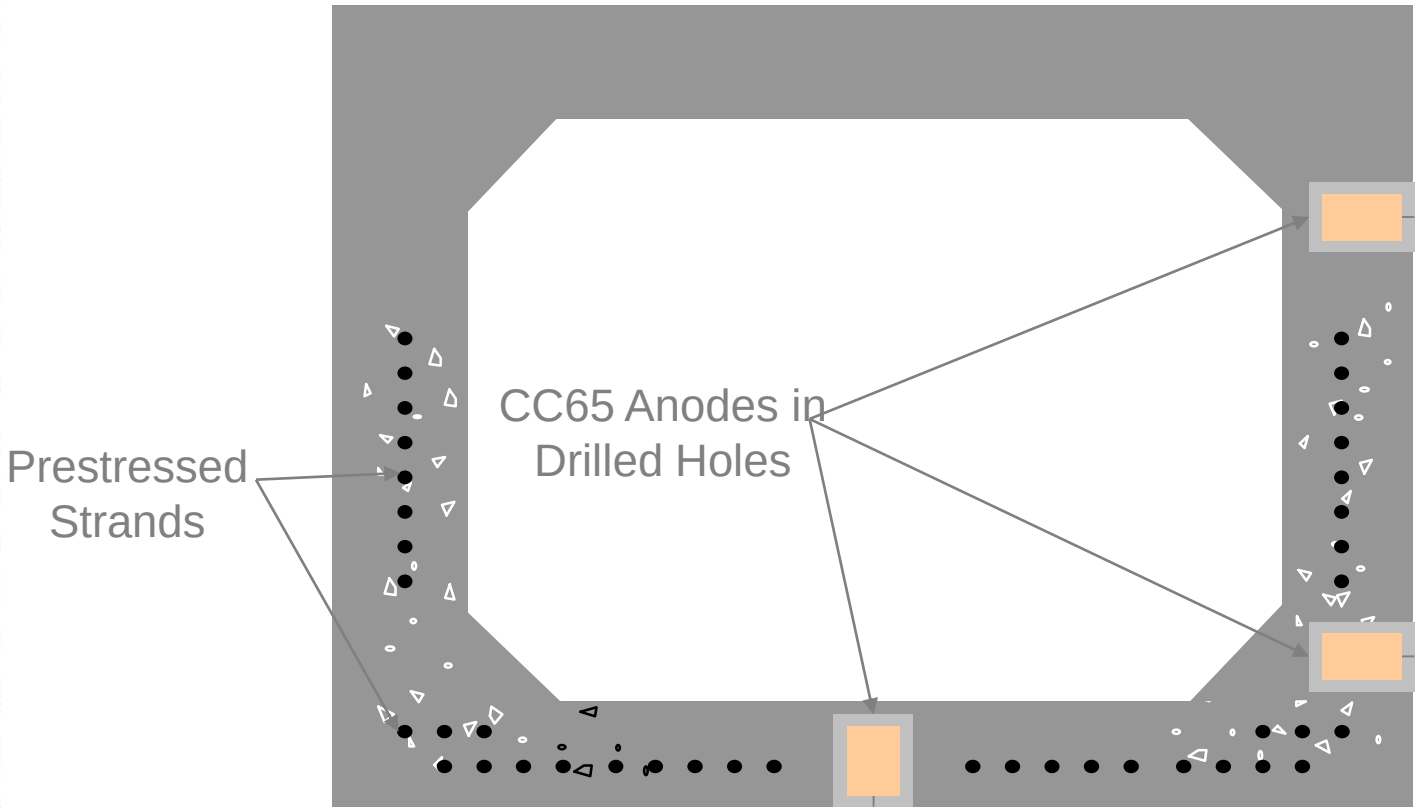
Jubilee Overpass, Winnipeg, Manitoba

Bridge Widening Corrosion Prevention

Embedded Galvanic Anodes

- Embedded anode for corrosion control
- Installed into drilled holes
- Protect sound but contaminated areas
- Corrosion “hot spots”

Galvanic Anodes in Prestressed Box Girder



Galvanic Anodes in Prestressed Box Girder

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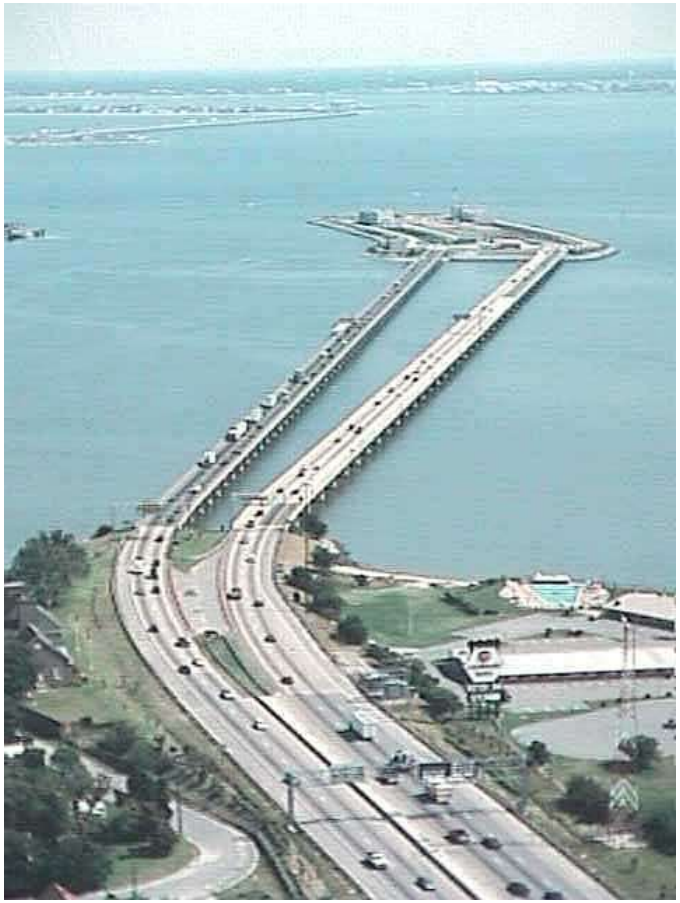
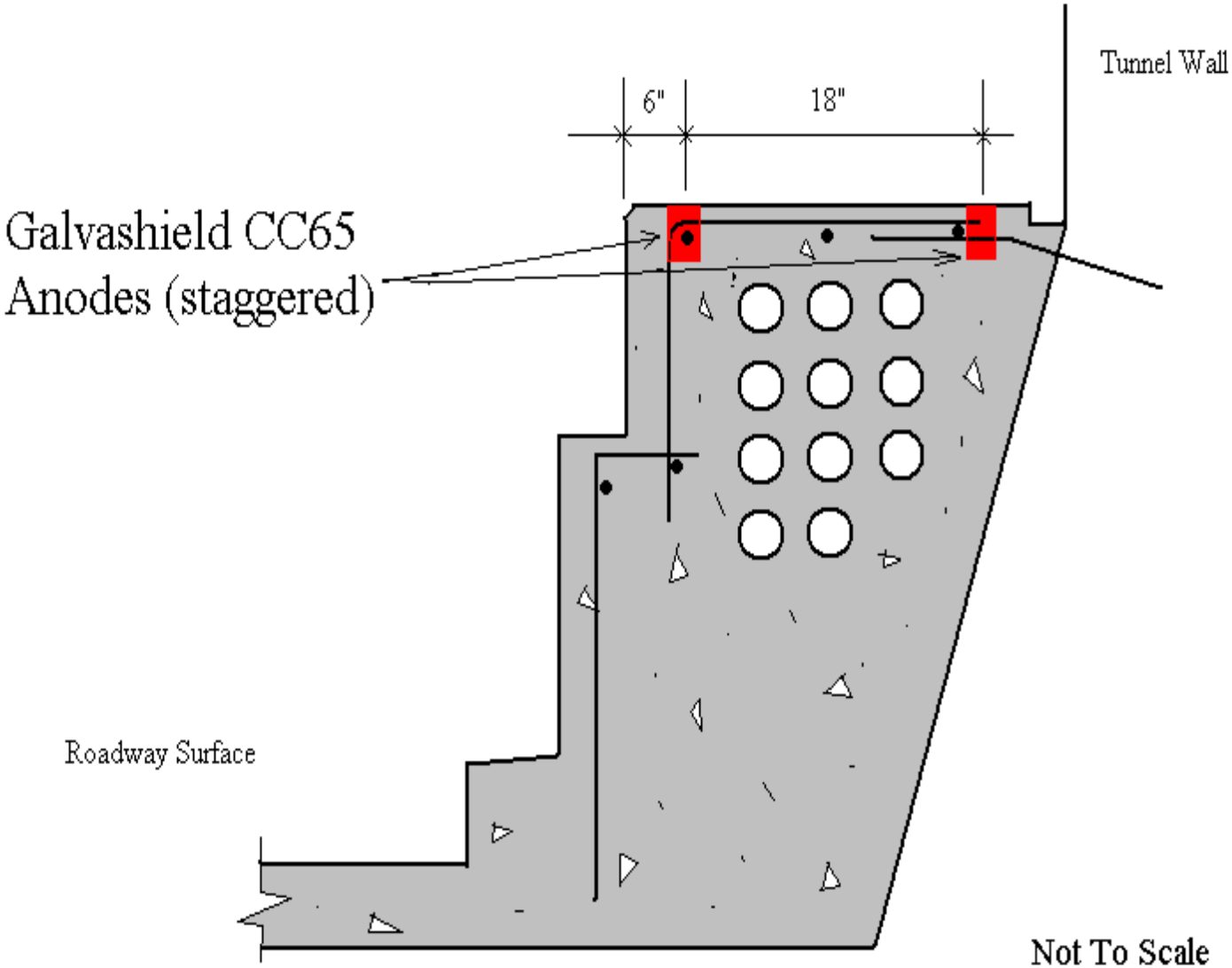
Galvanic Anodes in Prestressed Box Girder

Hampton Roads Tunnel



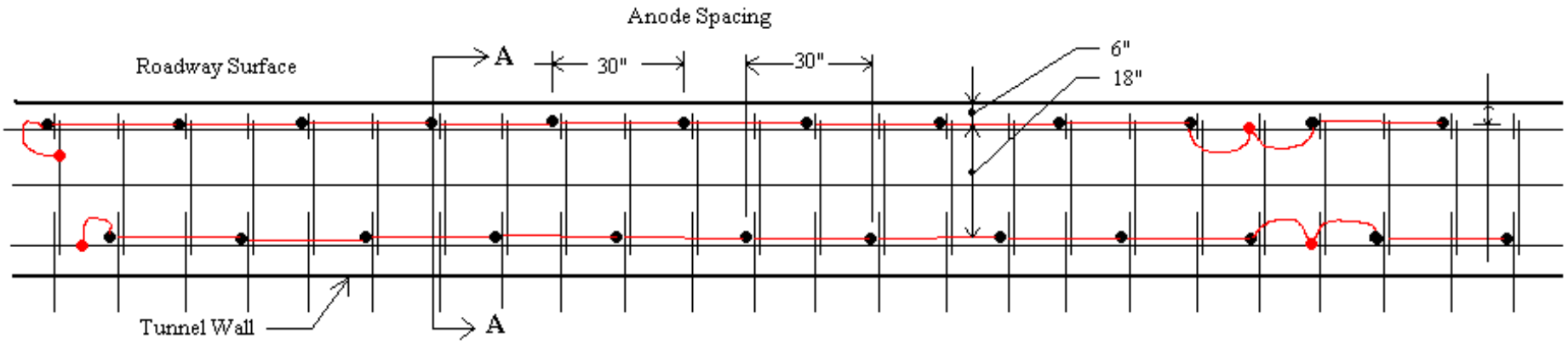


Not To Scale

Section A-A

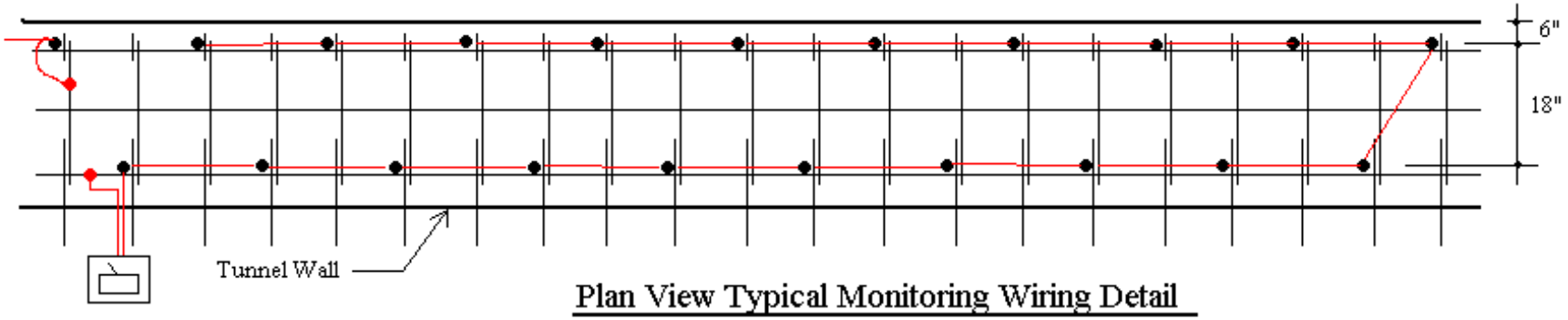
Galvashield CC65 Spacing Detail

Virginia DOT Hampton Roads Tunnel
Sidewalk Corrosion Mitigation
Proposed CC65 Spacing Detail NTS.
Vector Corrosion Technology Apr. 2004



Plan View Typical String Wiring Detail

Not to scale



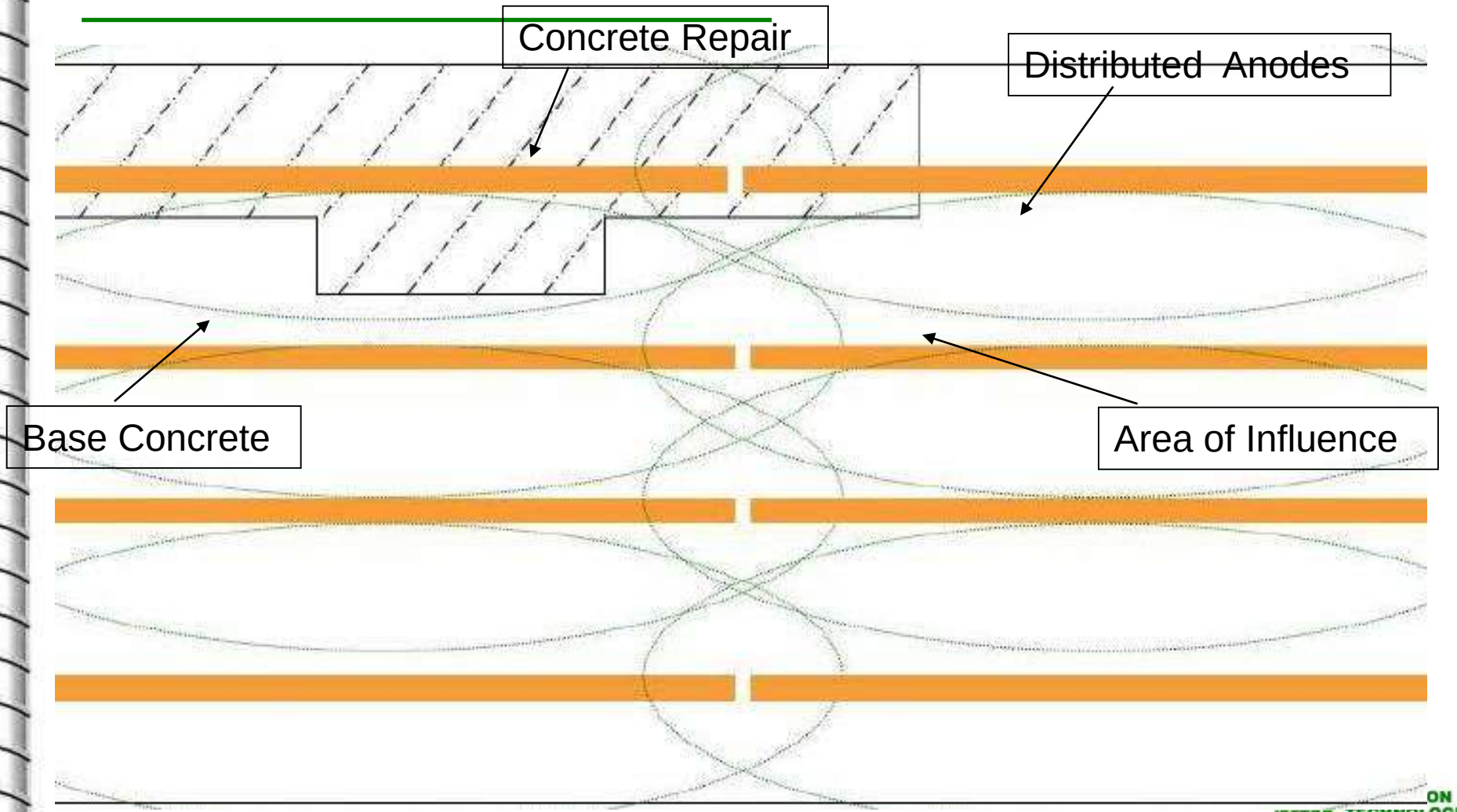
Plan View Typical Monitoring Wiring Detail

Not to scale

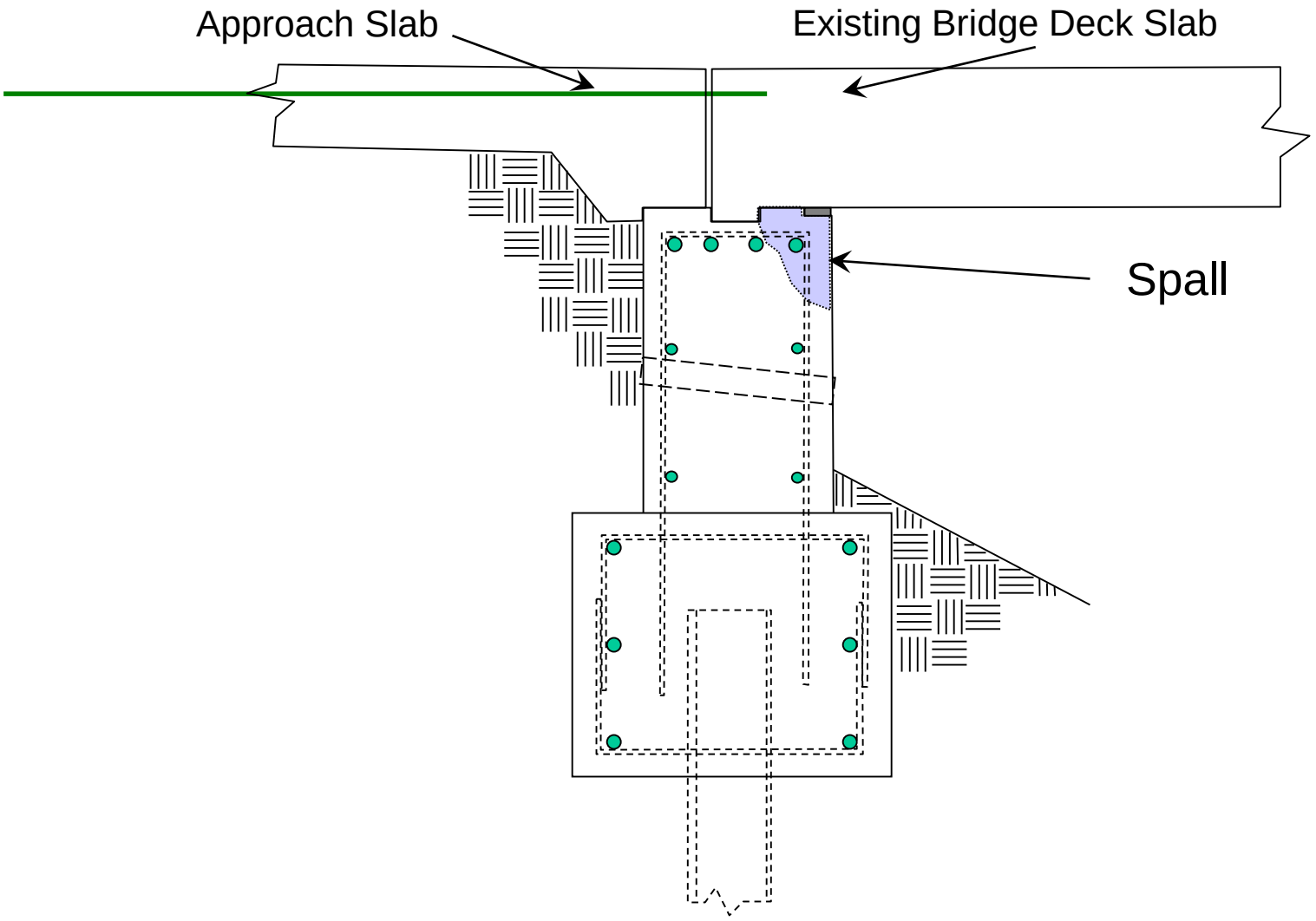
- — CC65 Anodes
- — rebar connection points
- — interconnecting wires
- — monitoring box

Virginia DOT Hampton Roads Tunnel
Sidewalk Corrosion Mitigation
Proposed CC65 Spacing Detail
Vector Corrosion Technology Apr. 2004

Distributed Anodes Protection



Typical Slab Bridge Abutment



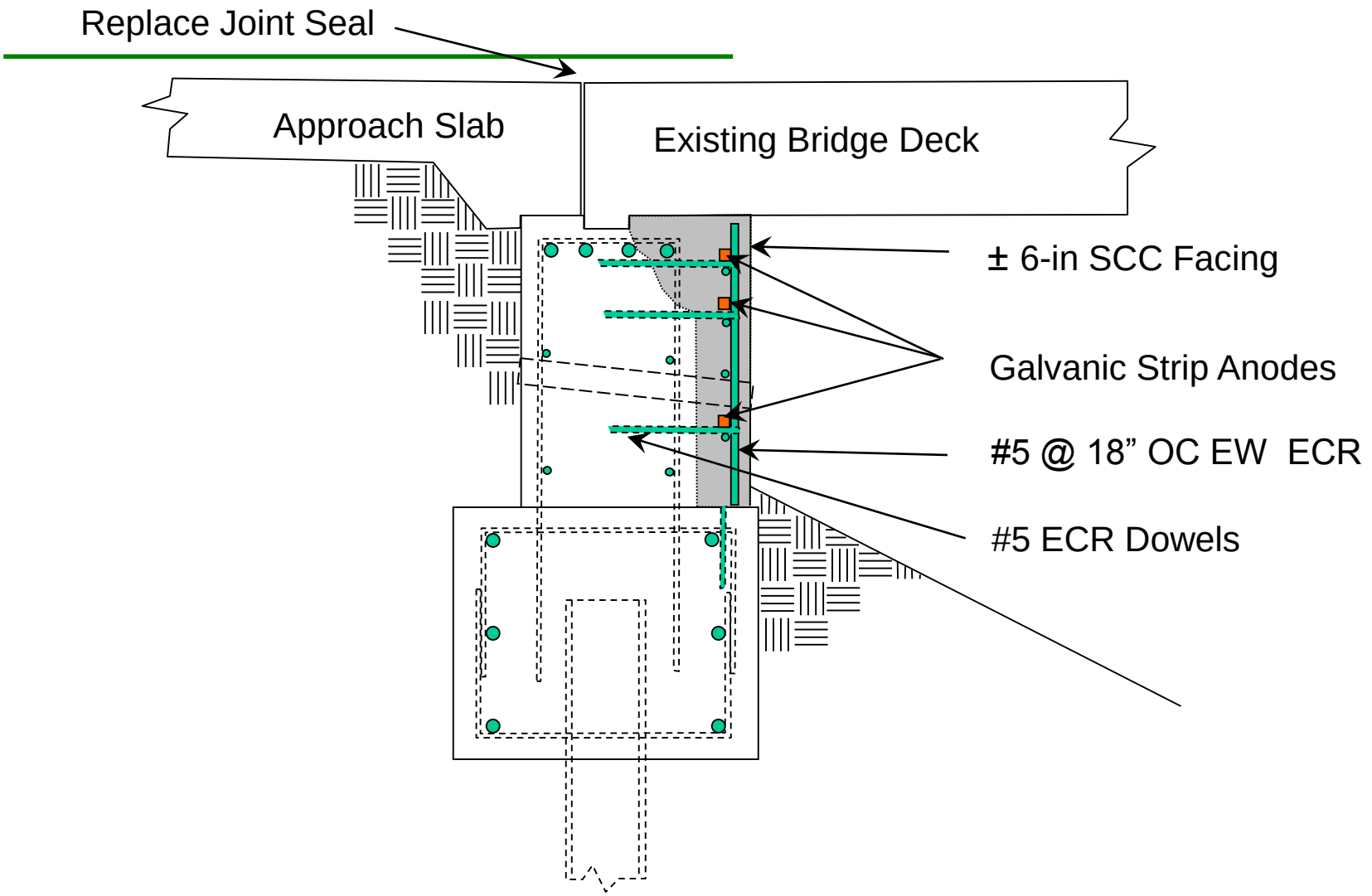
Options

- Do Nothing
  - Not a feasible alternative for deficient bridges on the interstate system
- Repair bridge
  - With appropriate repair, most of these bridges have remaining service life
- Replace bridge
  - Not cost-effective to remove a good slab

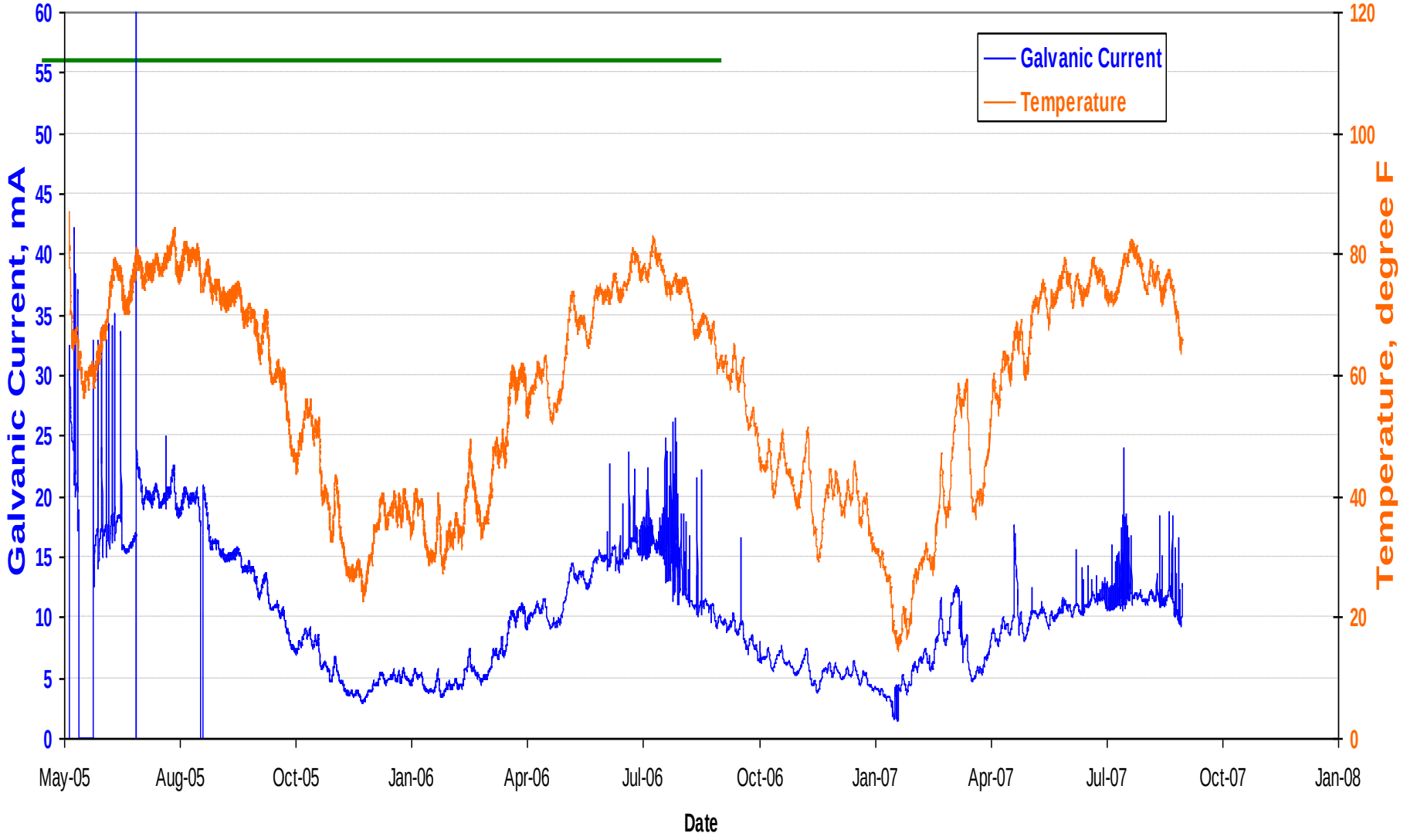
Past Practice for Repairs

- Slab would be temporarily supported
- Abutments would be replaced
- Requires closure or part-width construction

Abutment Repair Detail With Galvanic Protection



Kirkwood Road – Protective Current



Project Evaluation

- Project had minimal impact on interstate traffic
- One step repair with galvanic protection
- Cost Comparison
  - Rehabilitation with anodes - $319K
  - Abutment Replacement / Temporary Shoring - $427K
  - Replacement of structures - $4.5M
- Success continues to be tracked through monitoring

Bridge Column Repair

Bridge Pier Cap Repair

Galvanic Anodes Bridge Deck Overlays

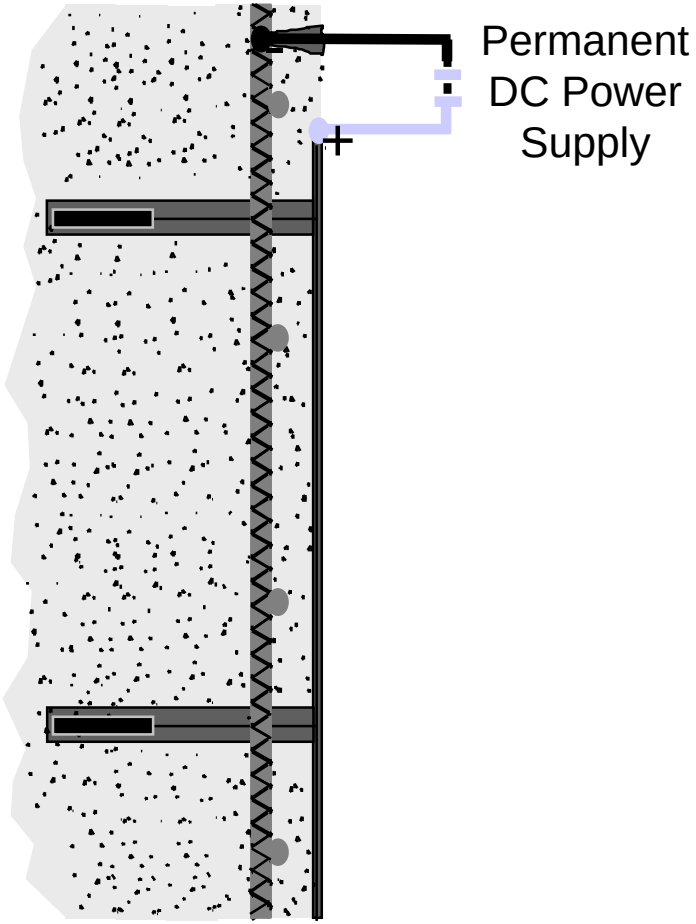
Galvanode® Galvanic Protection System for Concrete Piles in Marine Environment

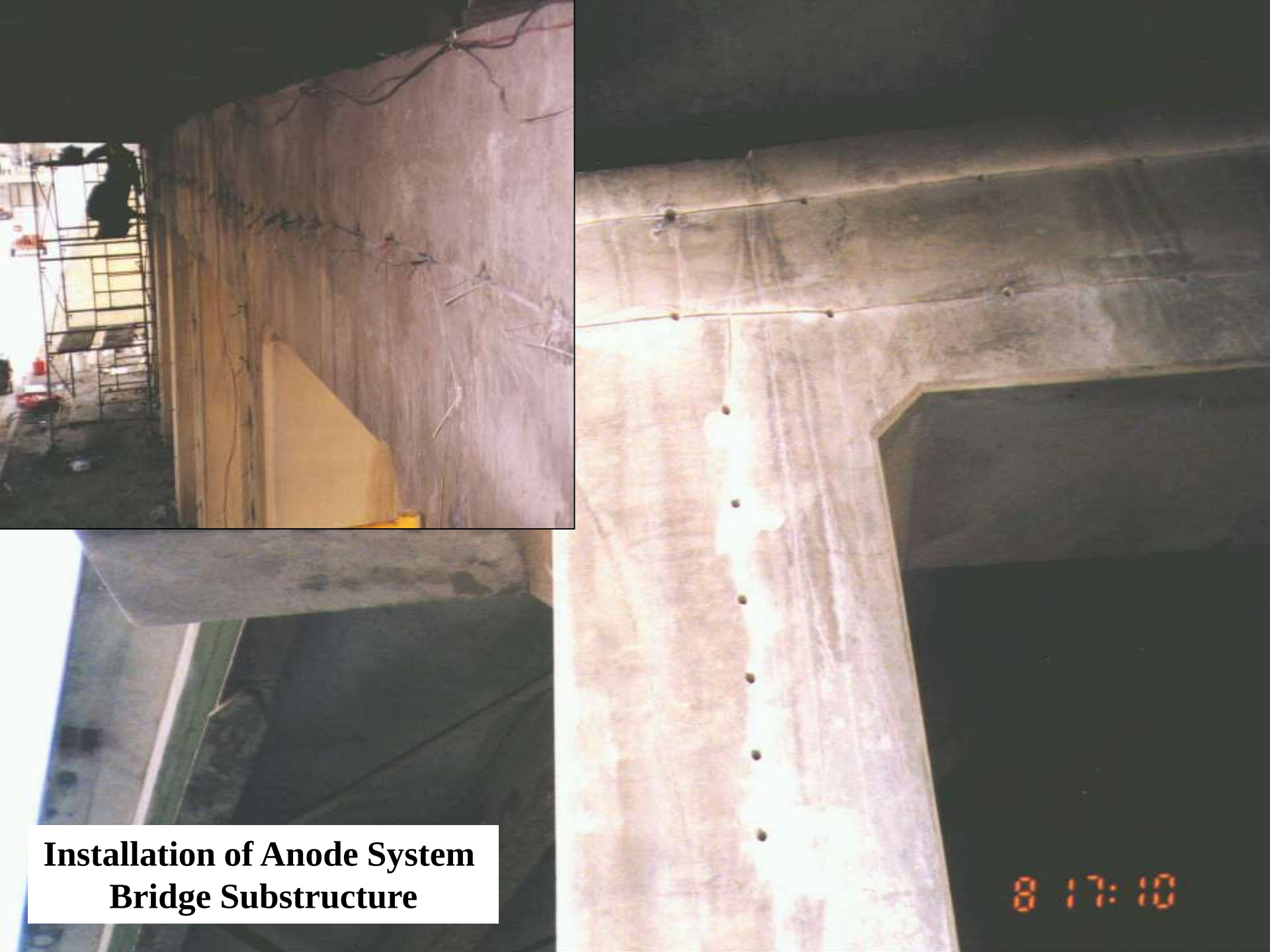
Robert Moses Causeway
Long Island, NY


JLG

Impressed Current CP

- Outside power source required
- High level of control
- System monitoring and maintenance required





Installation of Anode System
Bridge Substructure

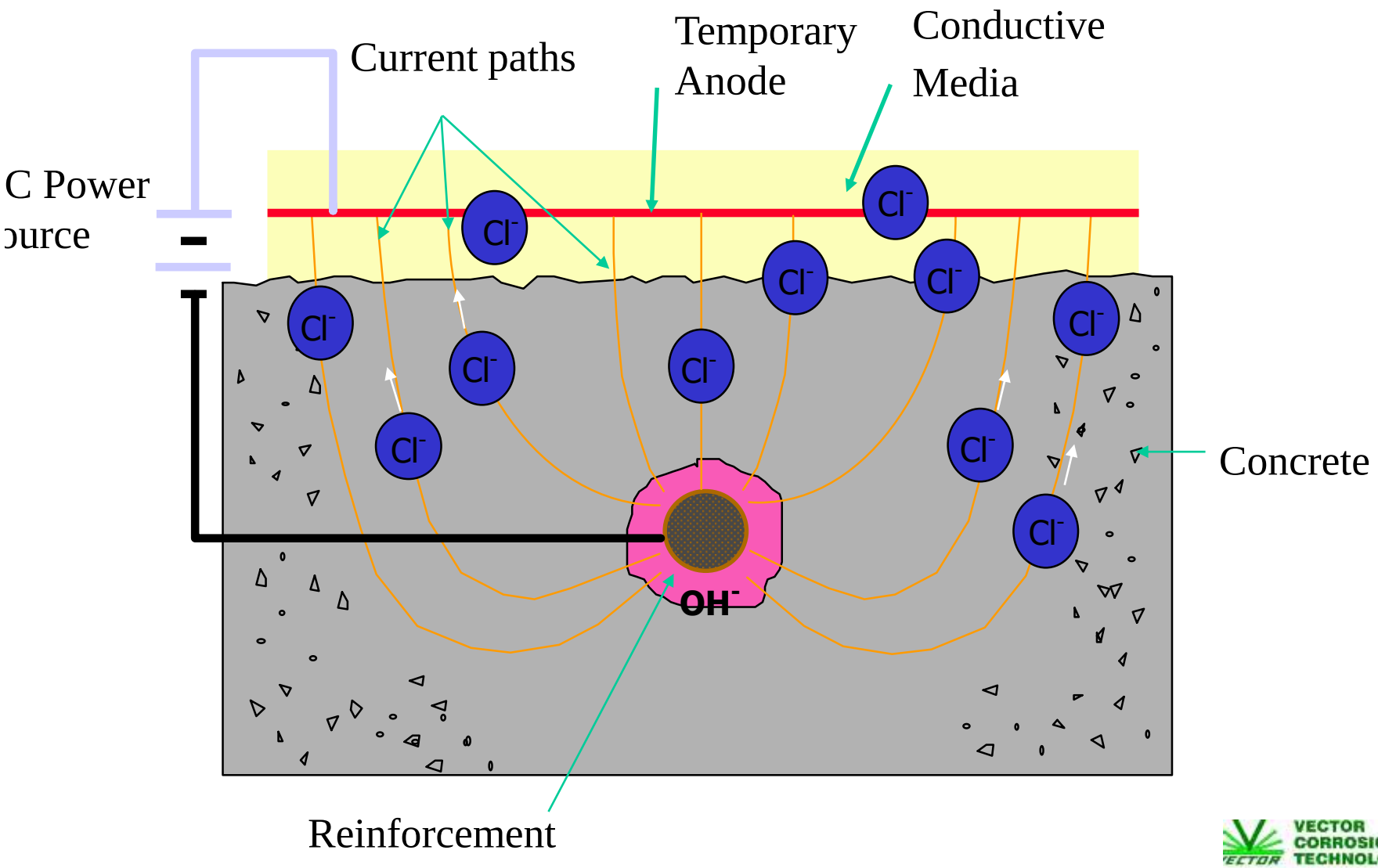
Electrochemical Treatments

- Electrochemical Chloride Extraction
- Re-alkalization

Chloride Extraction (ECE)

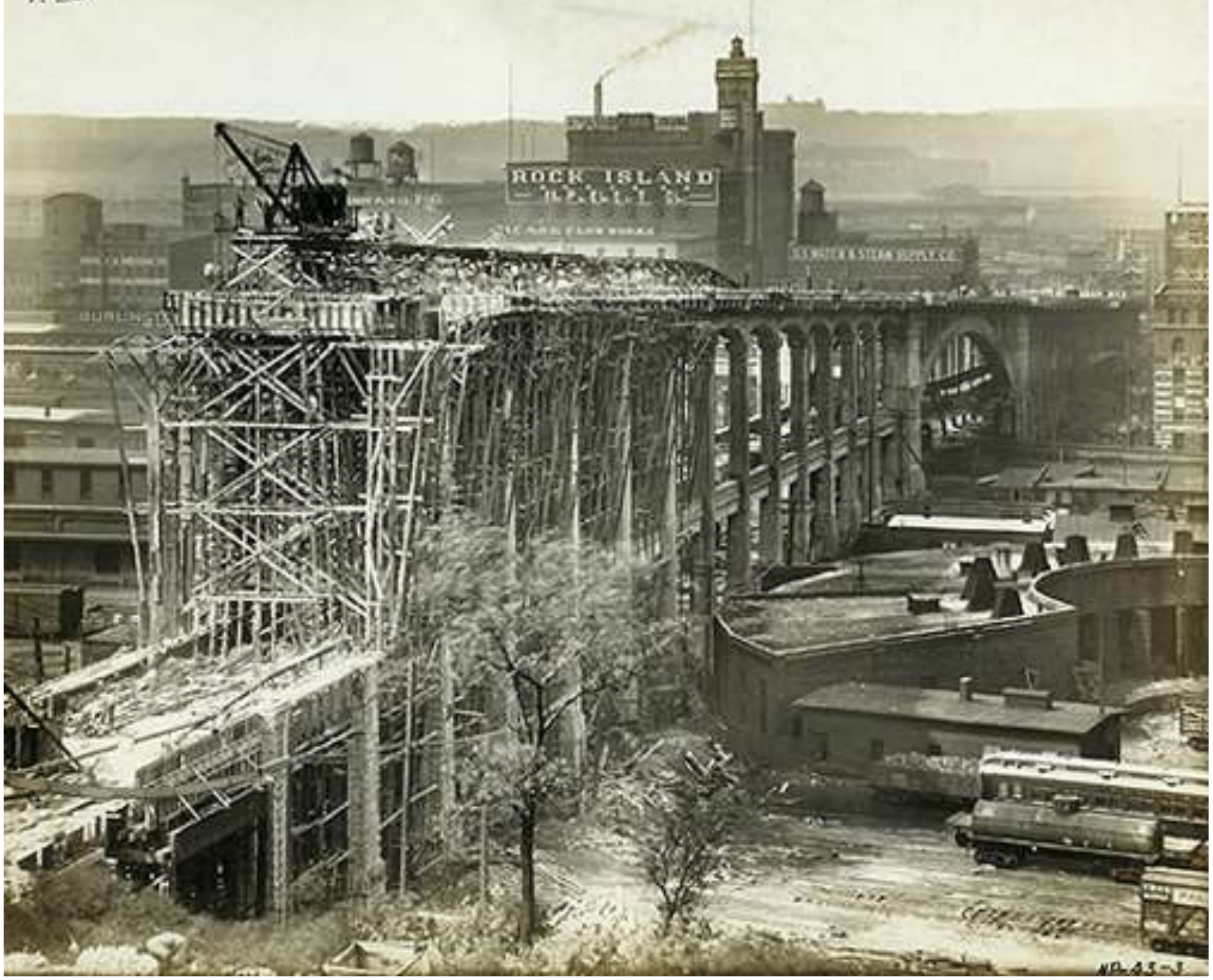
- Addresses the cause of corrosion
- Chloride levels are significantly reduced
- Alkalinity is increased at the level of the steel
- Reinforcing steel is returned to a passive, non-corroding state

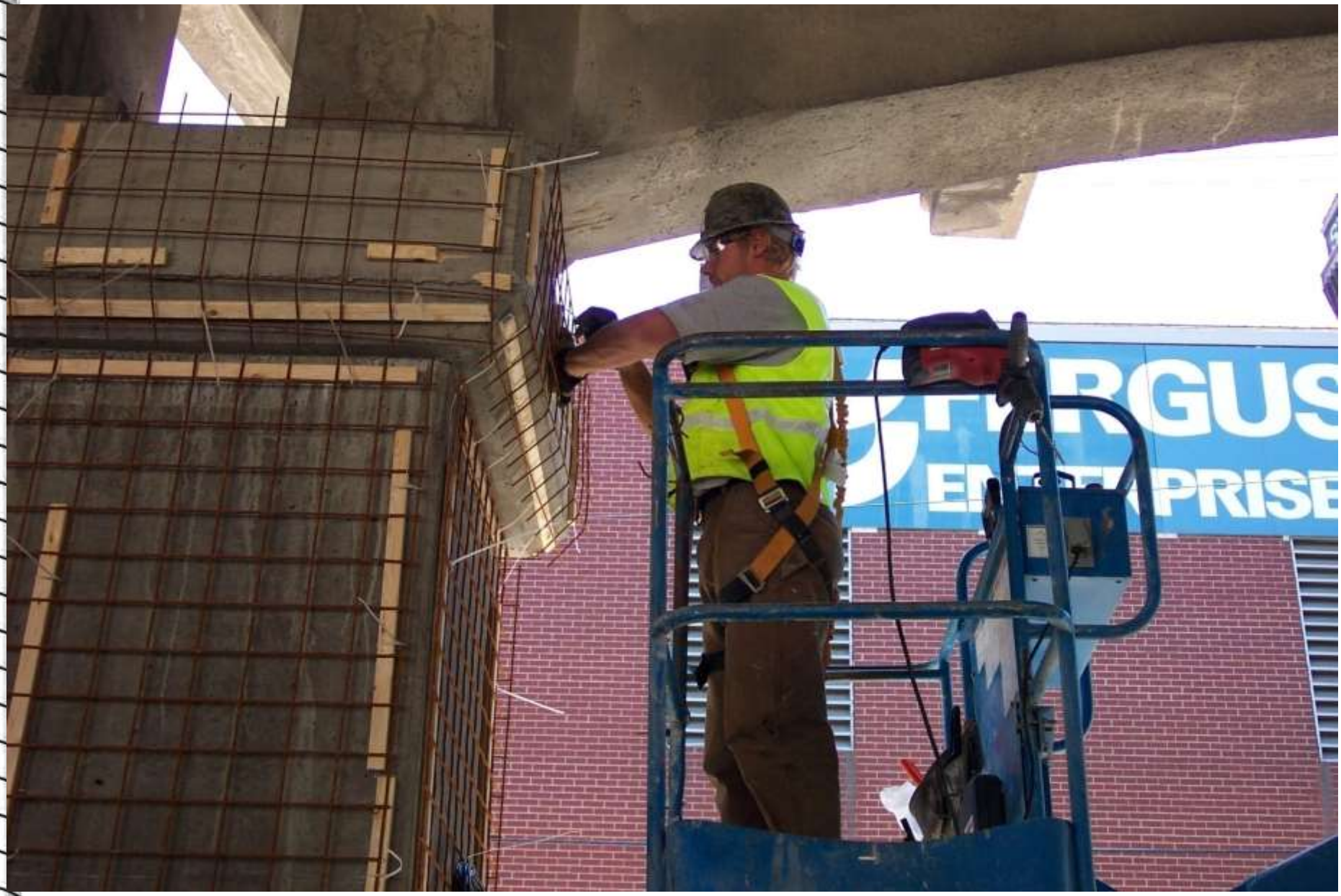
Electrochemical Chloride Extraction (ECE) From Salt Contaminated Concrete



12th Street Viaduct, Kansas City

- Bridge Completed in 1915
- 2,300 ft long reinforced concrete bowstring arch structure
- Links the industrial district in the bottom land along the confluence of the Missouri and Kansas rivers to the commercial district along the bluffs 200 feet above.

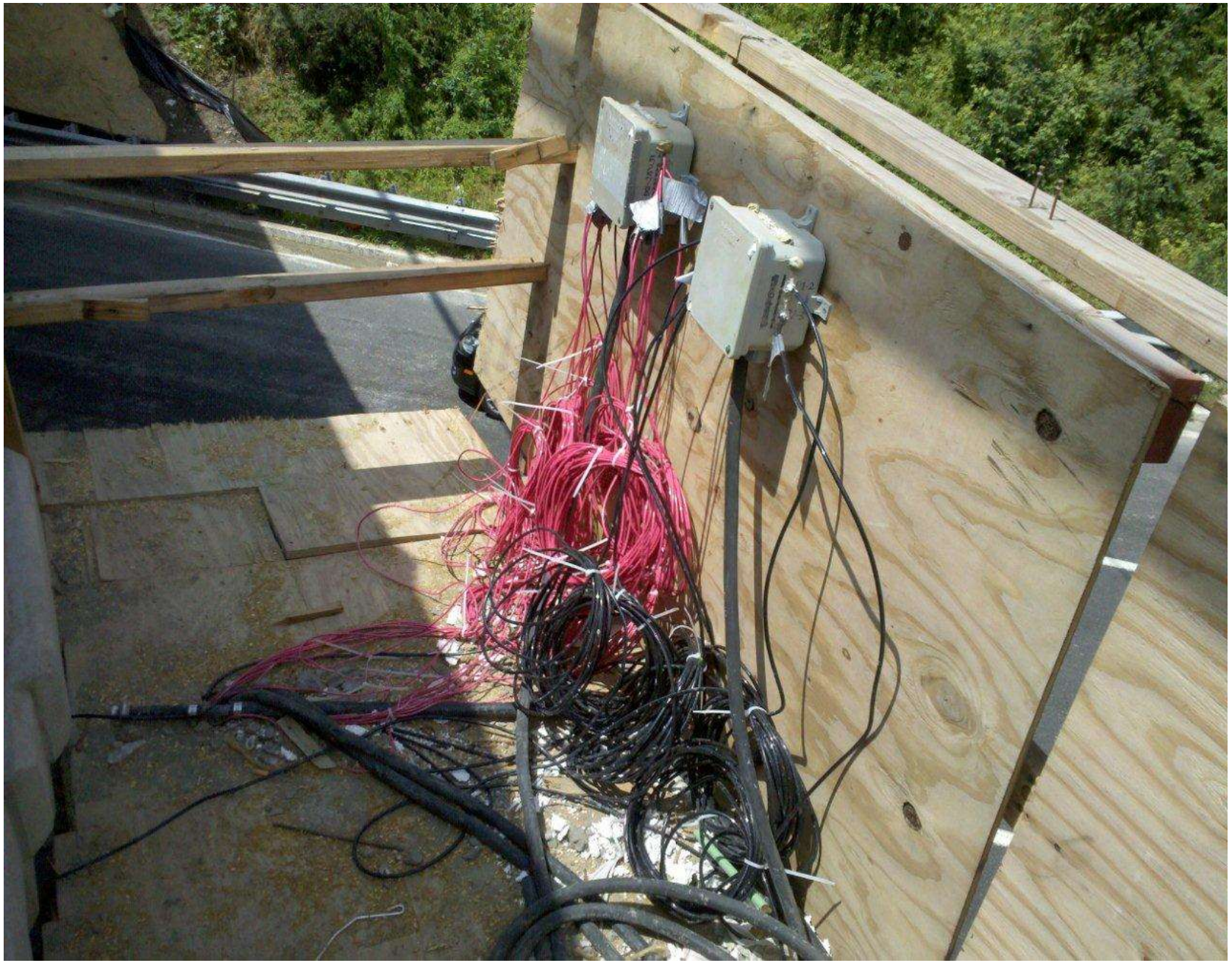

ROCK ISLAND


RGUS
PRISE


3-8

ECE Average Results

- Treatment Days
  - 60.9
- Current Passed
  - 623.6 A-hrs/m2
- Chloride at Level of Steel
  - Less than 0.03% by weight of concrete
  - 64.4% reduction



Summary
A Range of Corrosion Solutions

- Localized Galvanic Protection
- Global Galvanic Protection
- Impressed Current Cathodic Protection
- Electrochemical Chloride Removal
- Realkalization

Questions