Historic Perspective on Galvanic Anode Use for Corrosion Protection of Bridges

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Vector Corrosion Technologies

VECTOR CORROSION TECHNOLOGIES

Presentation Outline

- Corrosion Problems on Bridges
- Review of Corrosion of Steel in Concrete
- Solutions using Galvanic Anodes


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M.P.H.
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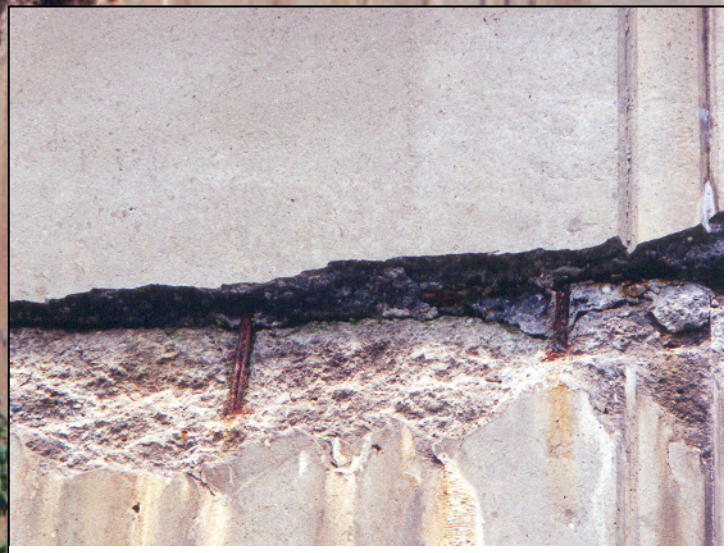
What could be
happening here?

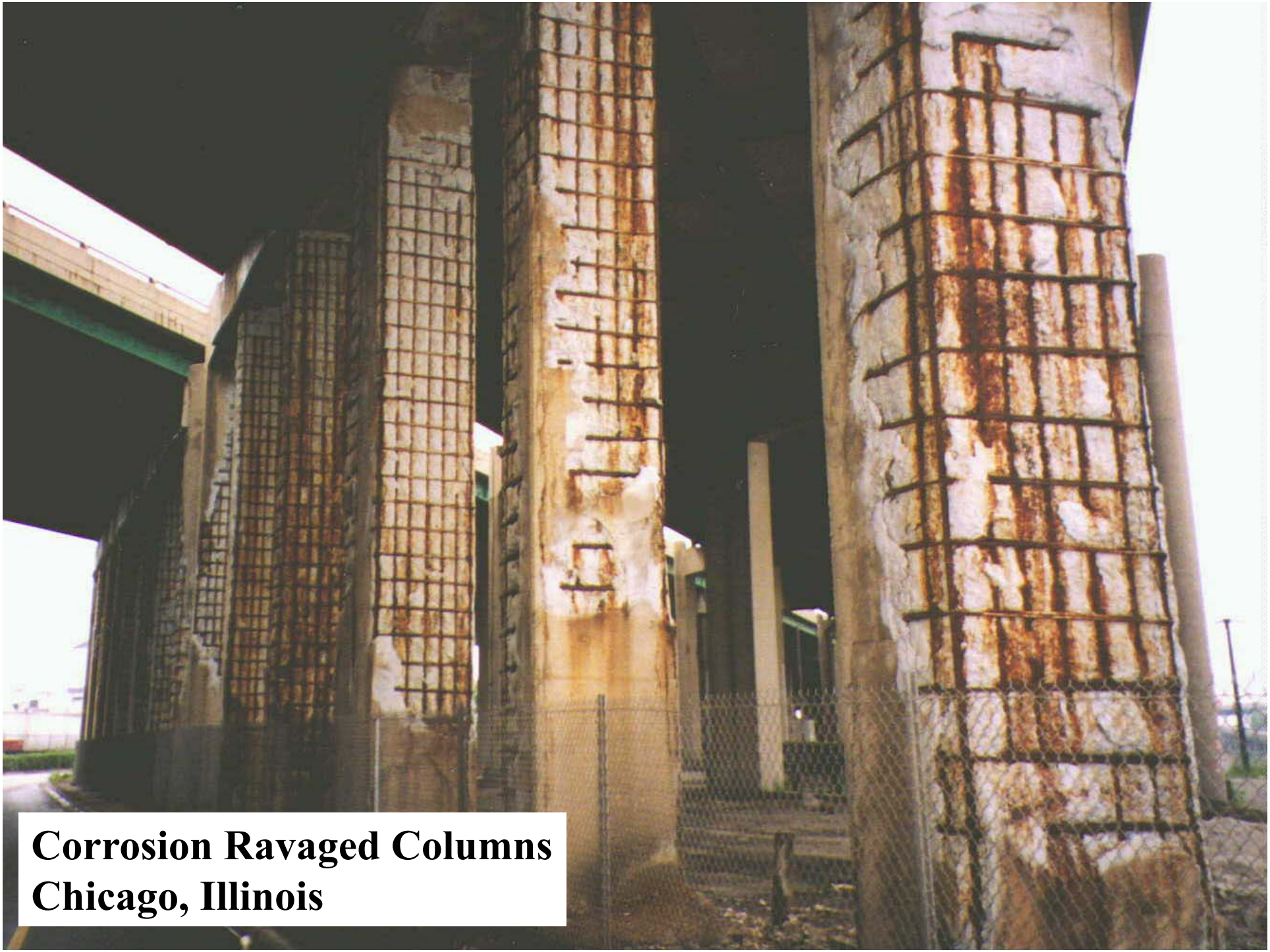
Corroded Joint
Pittsburgh, Pennsylvania

New Concrete Extension

Old Retaining Wall



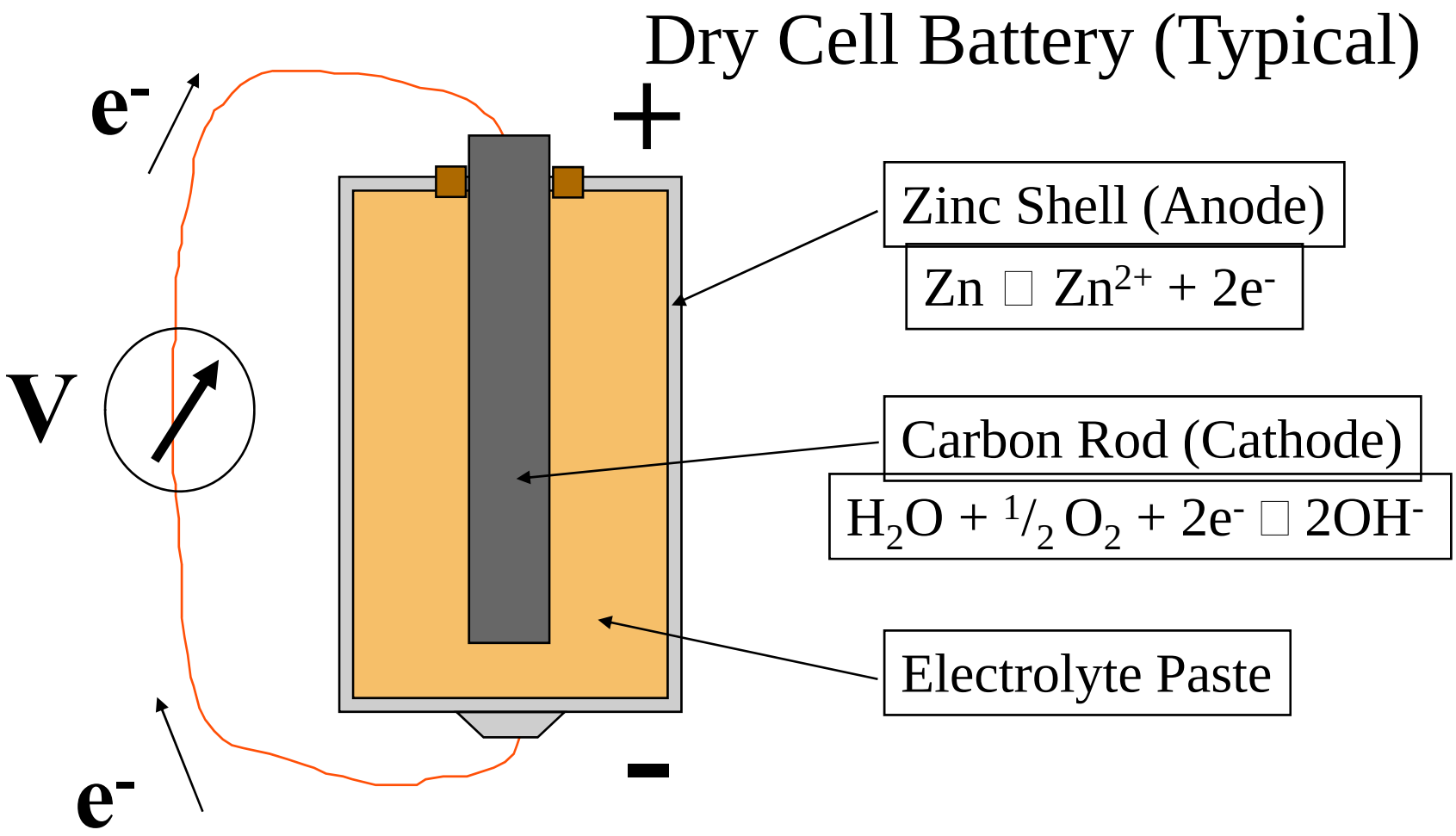
Failed Concrete Next to Joint Due to Corrosion



Corrosion Ravaged Columns
Chicago, Illinois

Corrosion Basics

A Battery is an Electrochemical Process

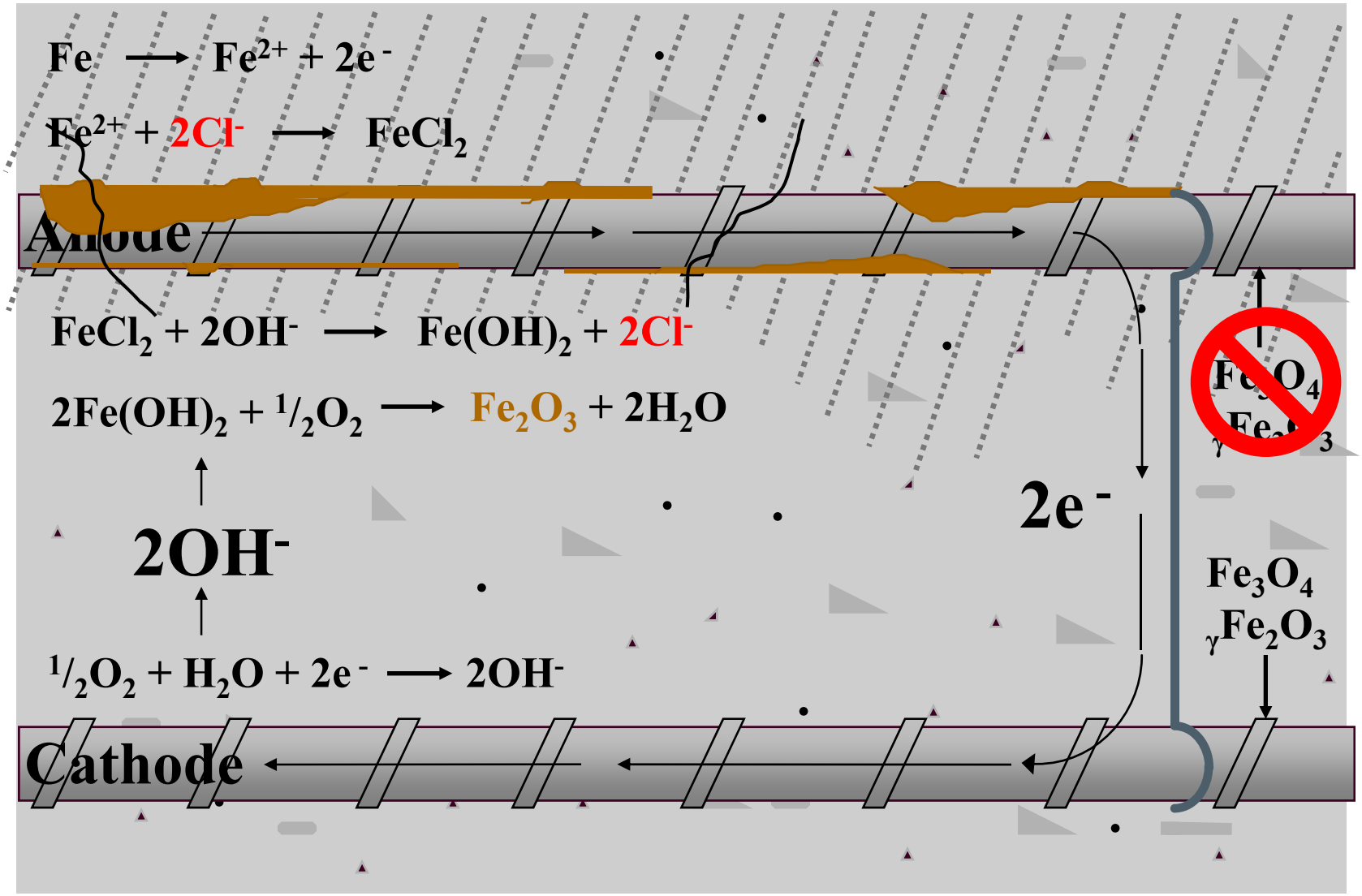


Causes of Corrosion

- Chlorides
- Carbonation
- Dissimilar Metals

Results in the Destruction of the Steel's Passive Oxide Layer

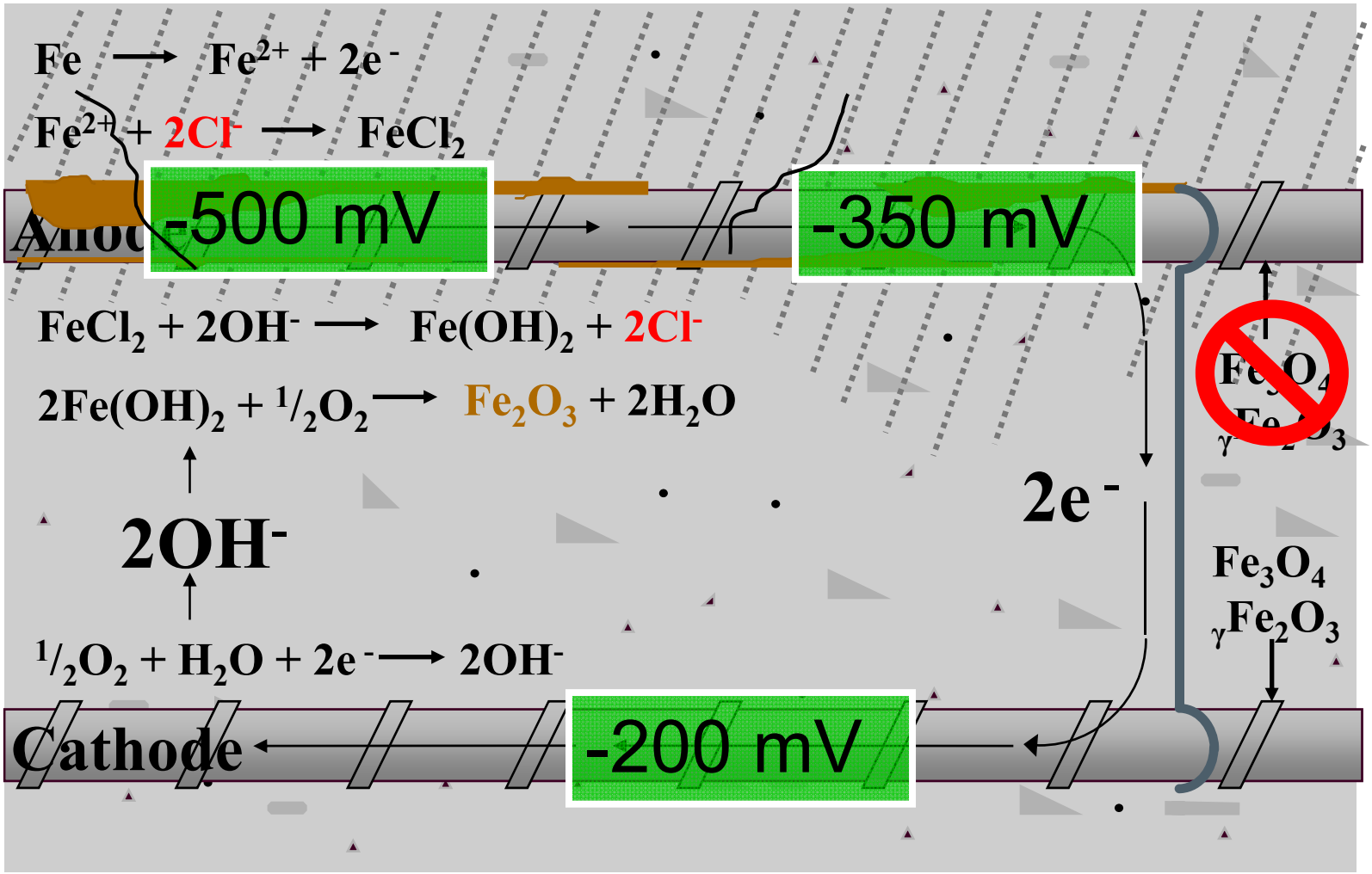
Corrosion Cell in Concrete



Why Does This Occur?

Corrosion Potential for Steel in Concrete	
Metal	Voltage
Steel in Chloride-Free Concrete	0 to -200 mV
Steel in Chloride-Contaminated Concrete	-350 to -500 mV
*Typical potentials measured with respect to copper-copper sulfate electrode	

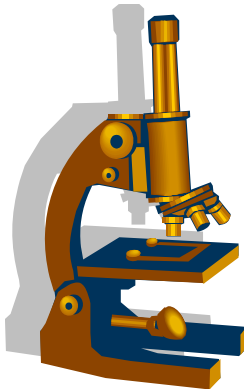
Corrosion Cell in Concrete



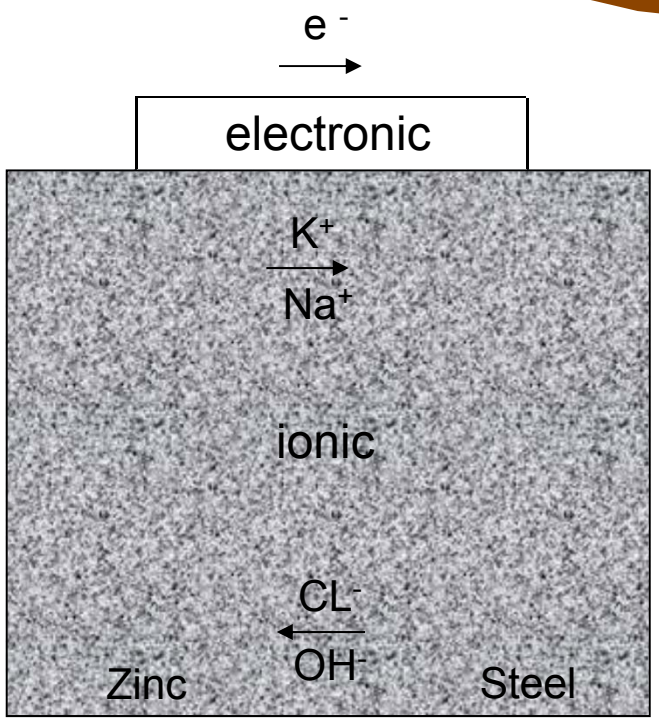
Galvanic Protection Systems

- Two different metals are connected in same electrolyte (concrete)
- More “active” metal = anode
- More “noble” metal = cathode
- Anode corrodes to protect cathode
- Natural reaction
  - no external power required
- Safe for prestressed concrete

Galvanic Protection



Partial Galvanic Series	
Metal	Voltage
Zinc	-1100 mV
Steel in concrete	-200 mV to -500 mV
*Typical potentials measured with respect to copper-copper sulfate electrode	



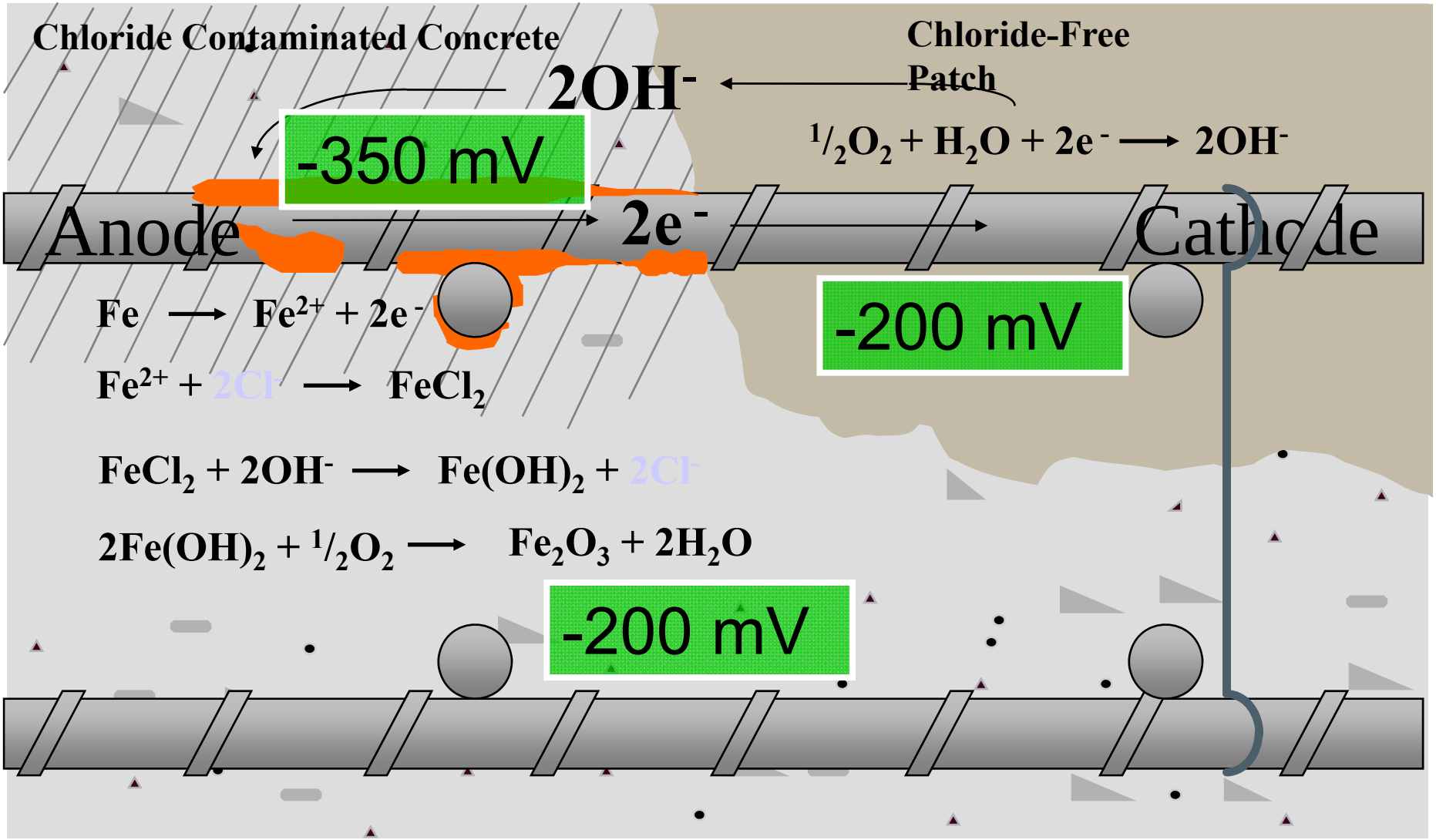
Galvanic anodes naturally operate based on the principle of dissimilar metals corrosion like commonly used batteries. Current flows from the anode (the metal with the most negative potential) to the cathode (steel).


Zinc Anode

Discrete Galvanic Anodes


“Chip and Patch” Repair Method

Patch Accelerated Corrosion



Typical Embedded Discrete Galvanic Anode for Corrosion Protection

Use began 25+ years ago

What is the purpose of the mortar shell around the anode?

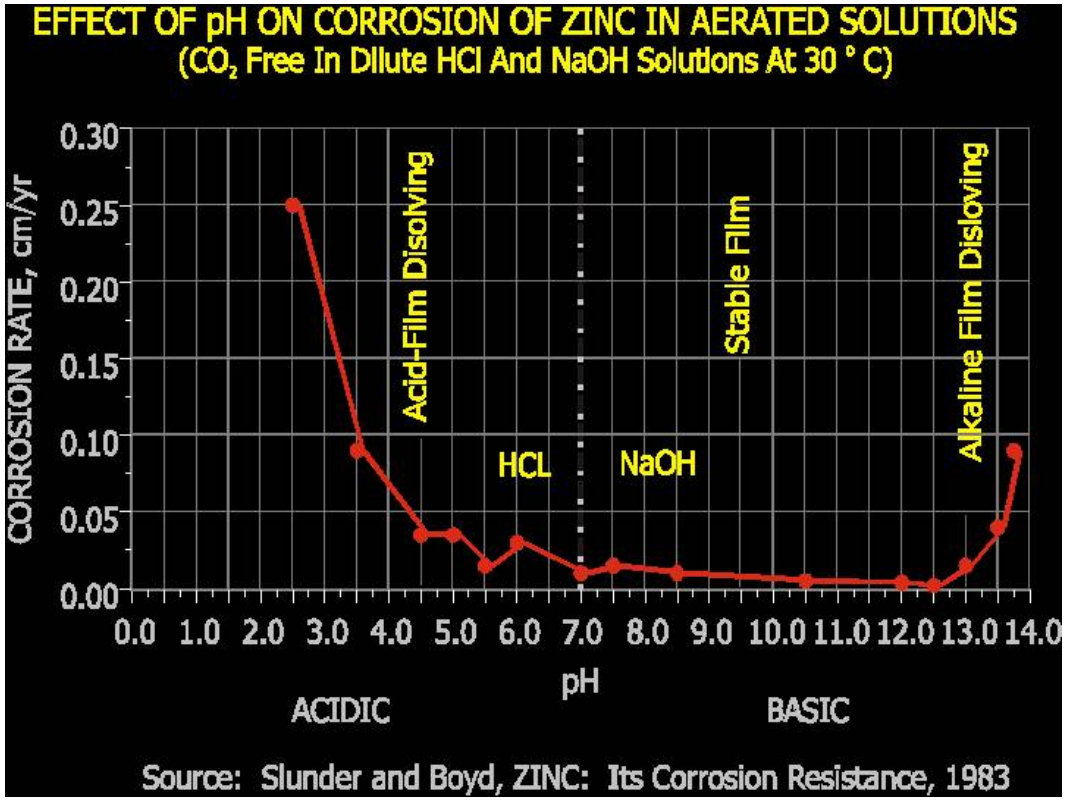
- Mortar is specially formulated to keep the zinc active over time.
  - High pH
  - Halides (Chlorides, Bromides, etc.)

- Mortar accepts corrosion by-products from the zinc core.

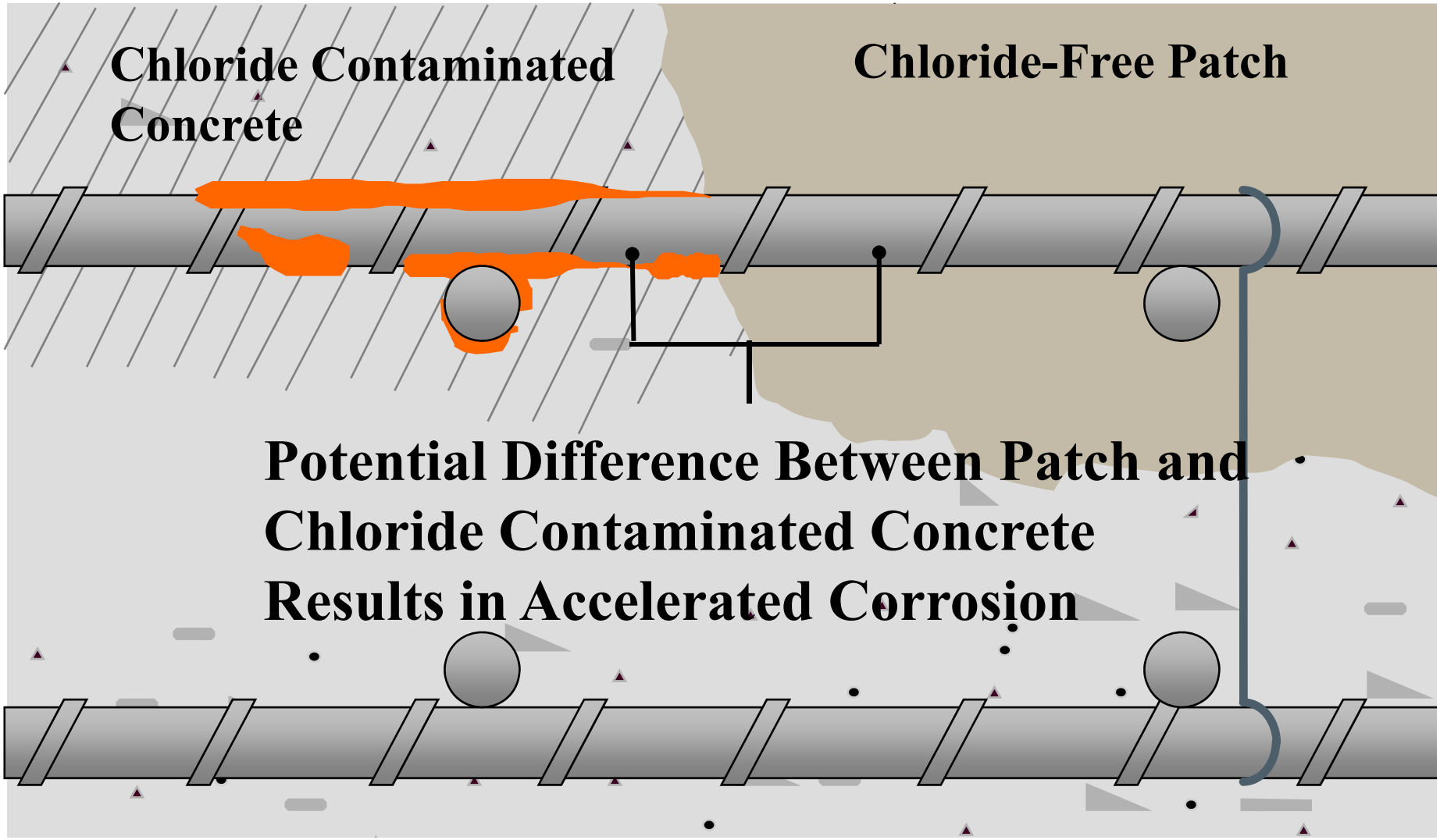
Activation Technology

Alkali Activated

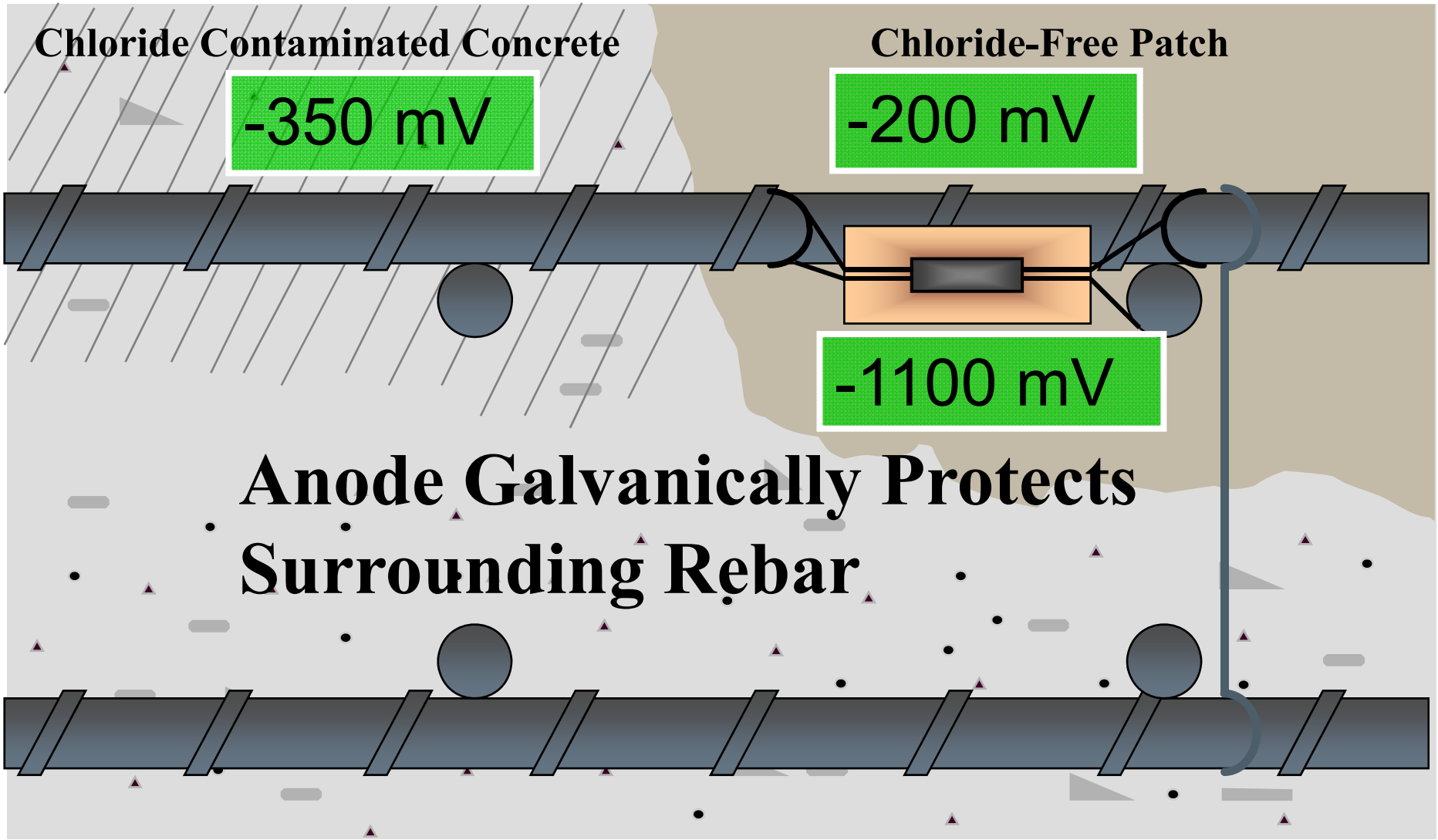
- High pH is corrosive to zinc but not to steel
- Allows zinc anodes to provide protection to reinforced concrete over time



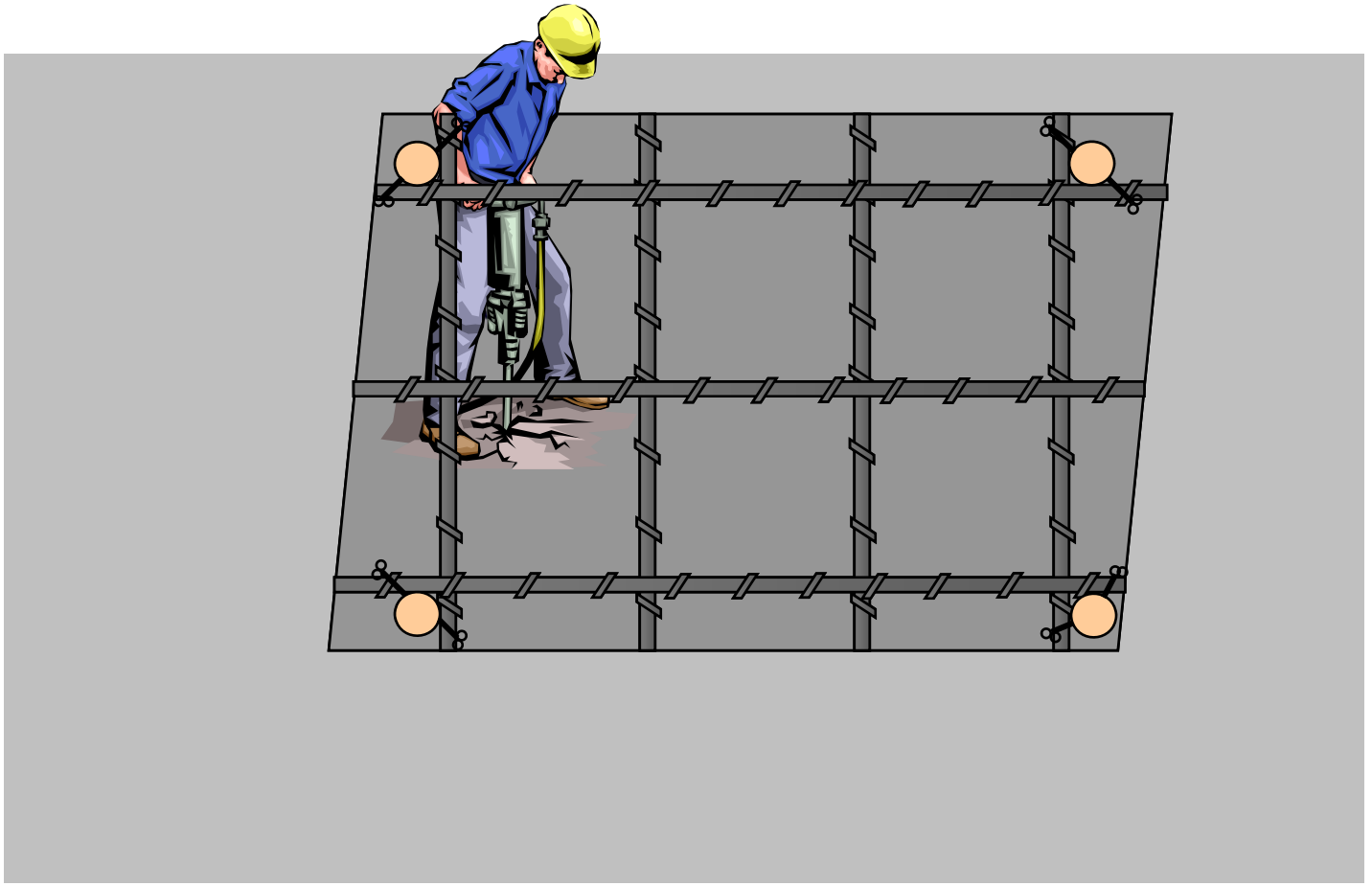
Patch Accelerated Corrosion



Installed Galvanic Anode



Installation of Galvanic Anodes



Anode Installation

Saw cut and cleaned repair area.

Anode Installation

Installing anodes around the perimeter of the repair.


Quick and Easy Installation

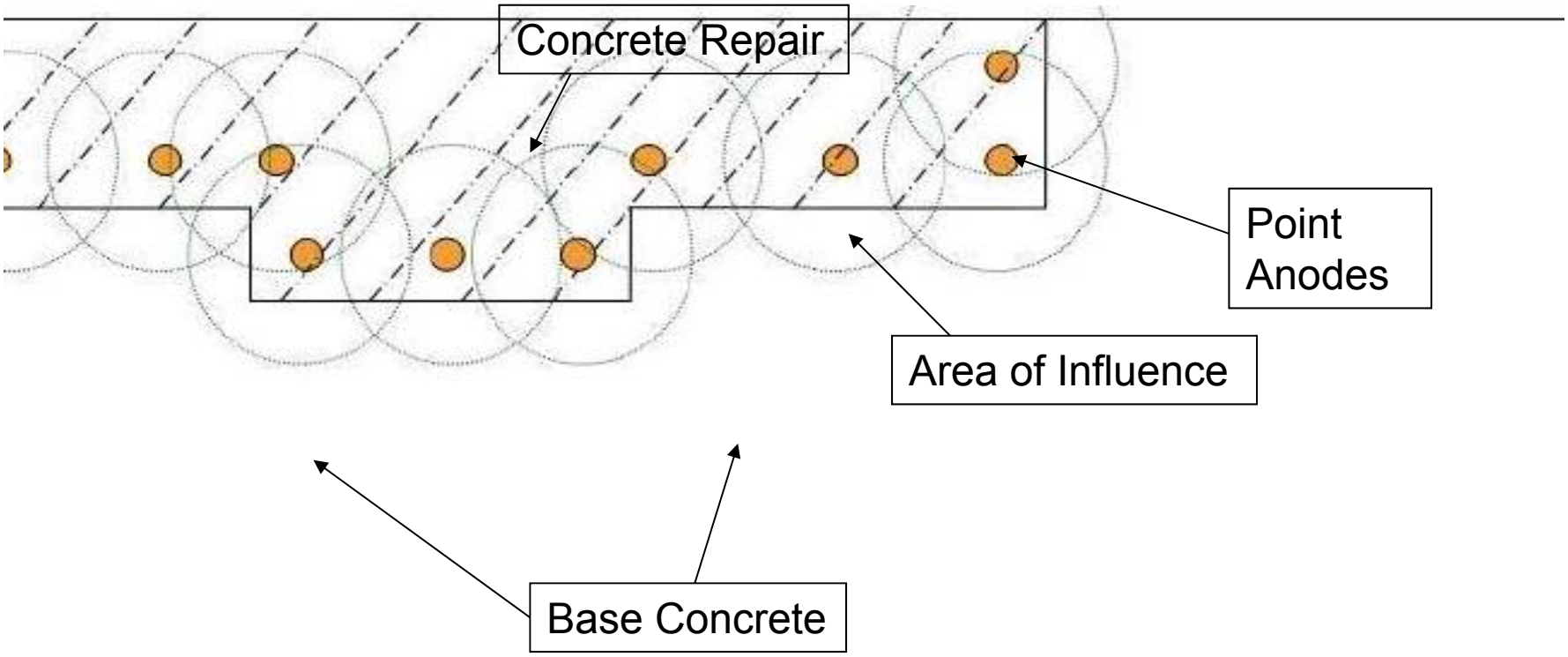
Anode Installation

Testing anode connection to reinforcing steel.

Anode Installation

Embedding anodes with repair material.

Point Anodes Protection

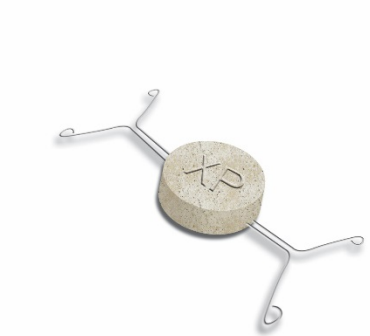


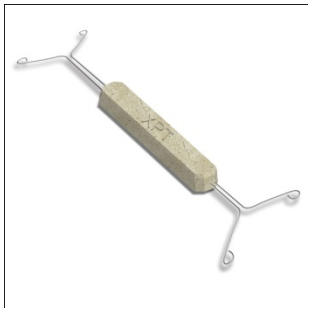
Prestressed Concrete Girders in Parking Garage
Southern Ontario, Canada

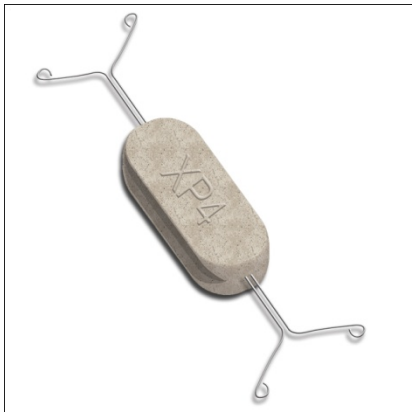
Prestressed Beam Ends

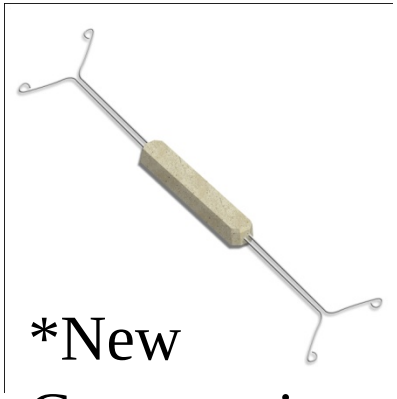
Type 1A Embedded Galvanic Anodes

Discrete Galvanic Type 1A Anodes for use in Patches comes in different sizes and shapes





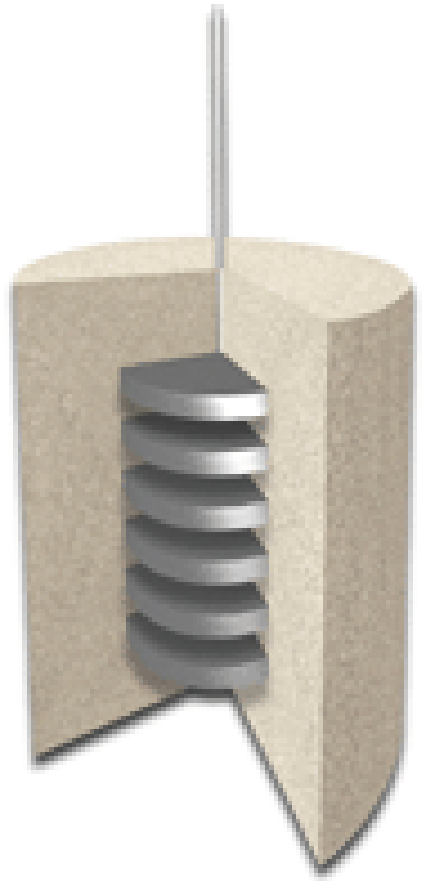




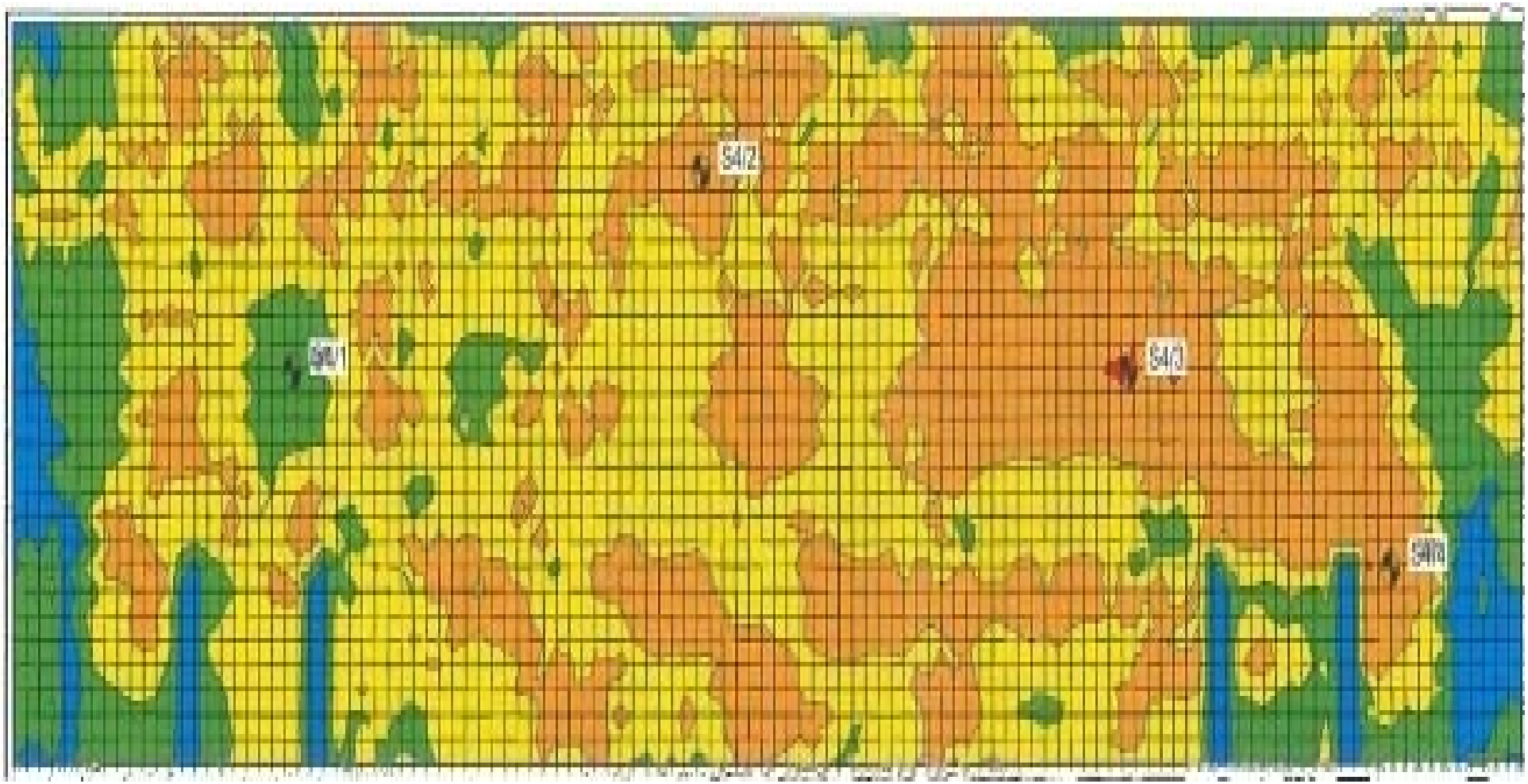
*New Construction


What do you do about corrosion that could be occurring outside a spall?

Drilled in Anodes for “Hot Spots”



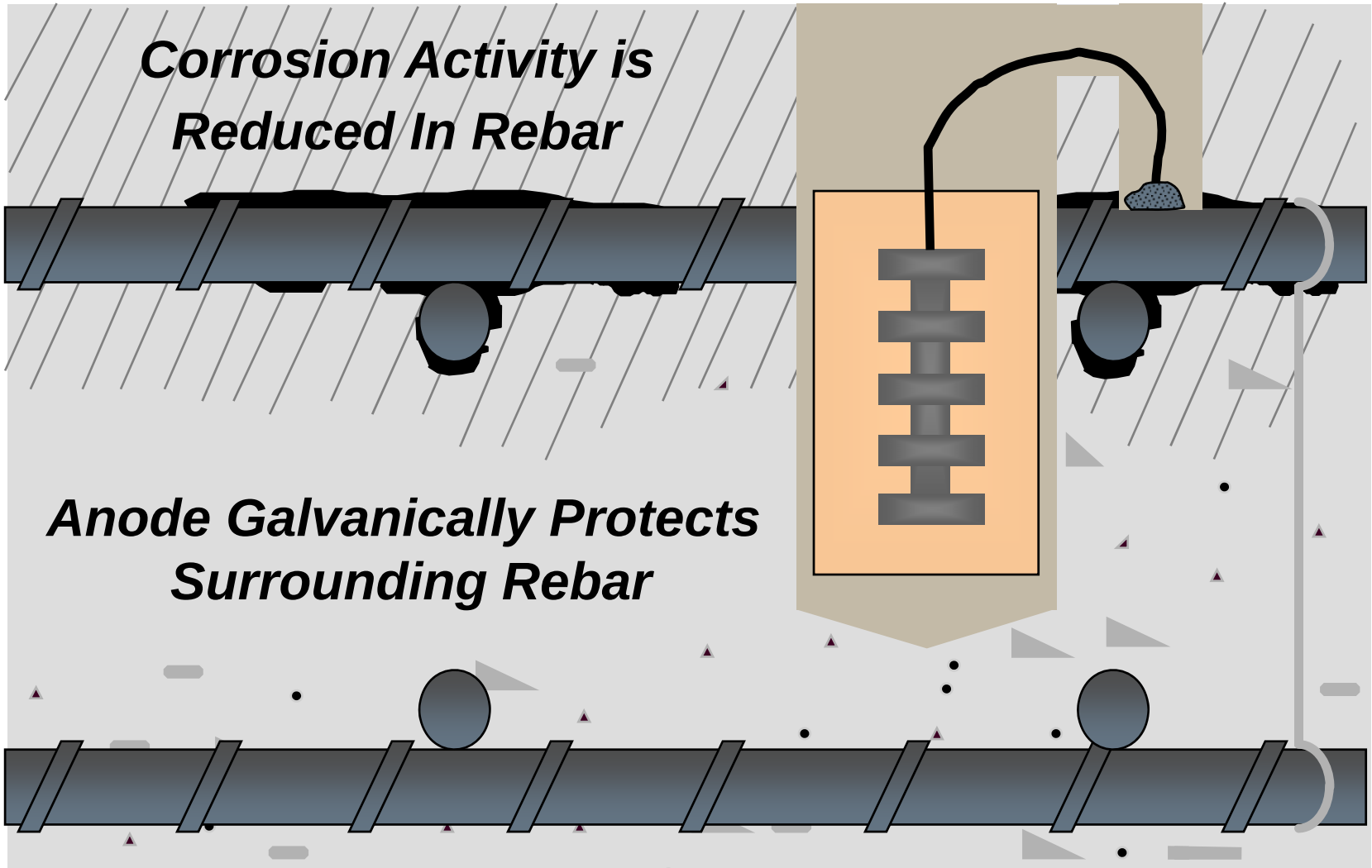
Half Cell Survey



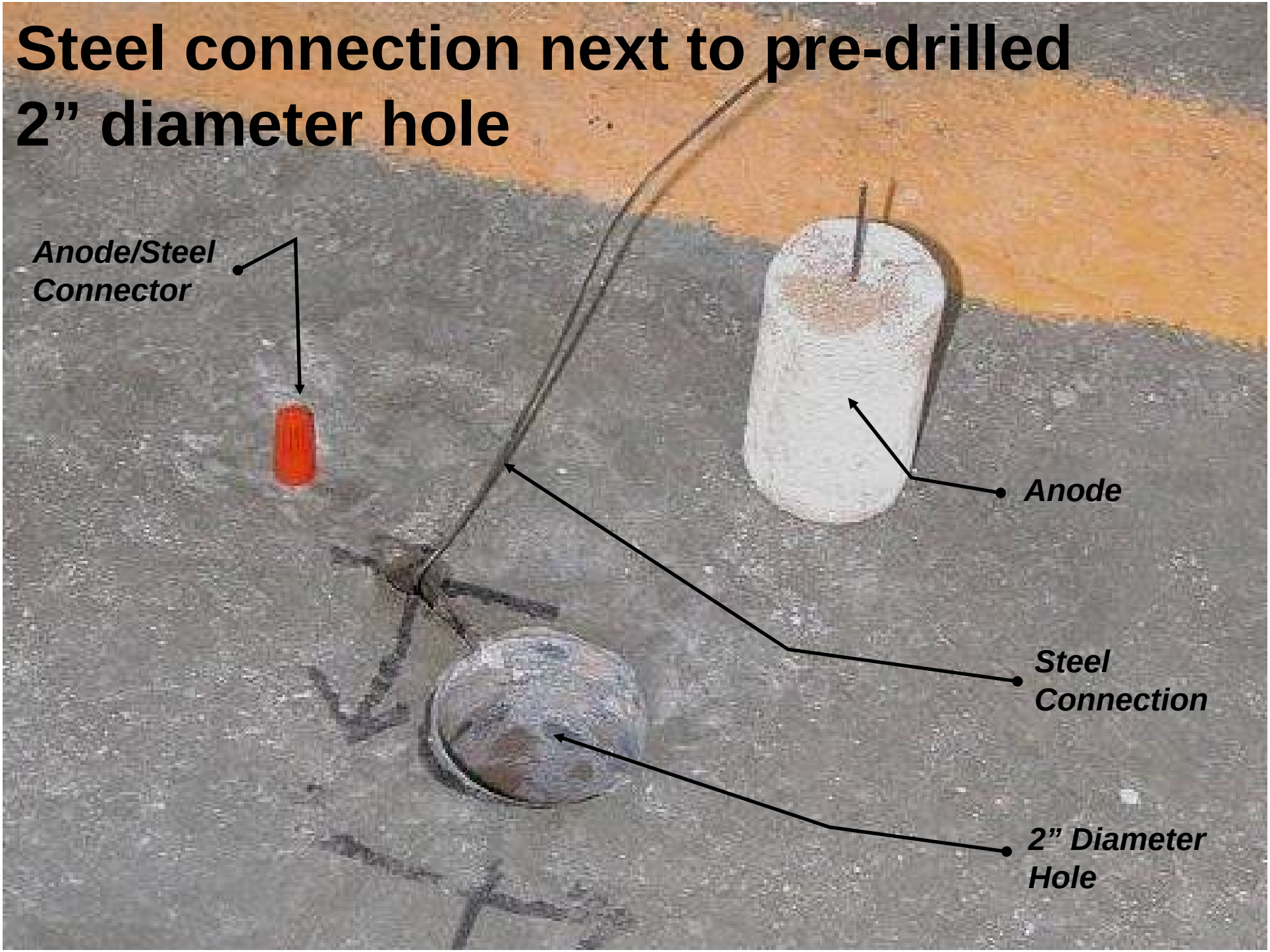
Preventative Medicine!

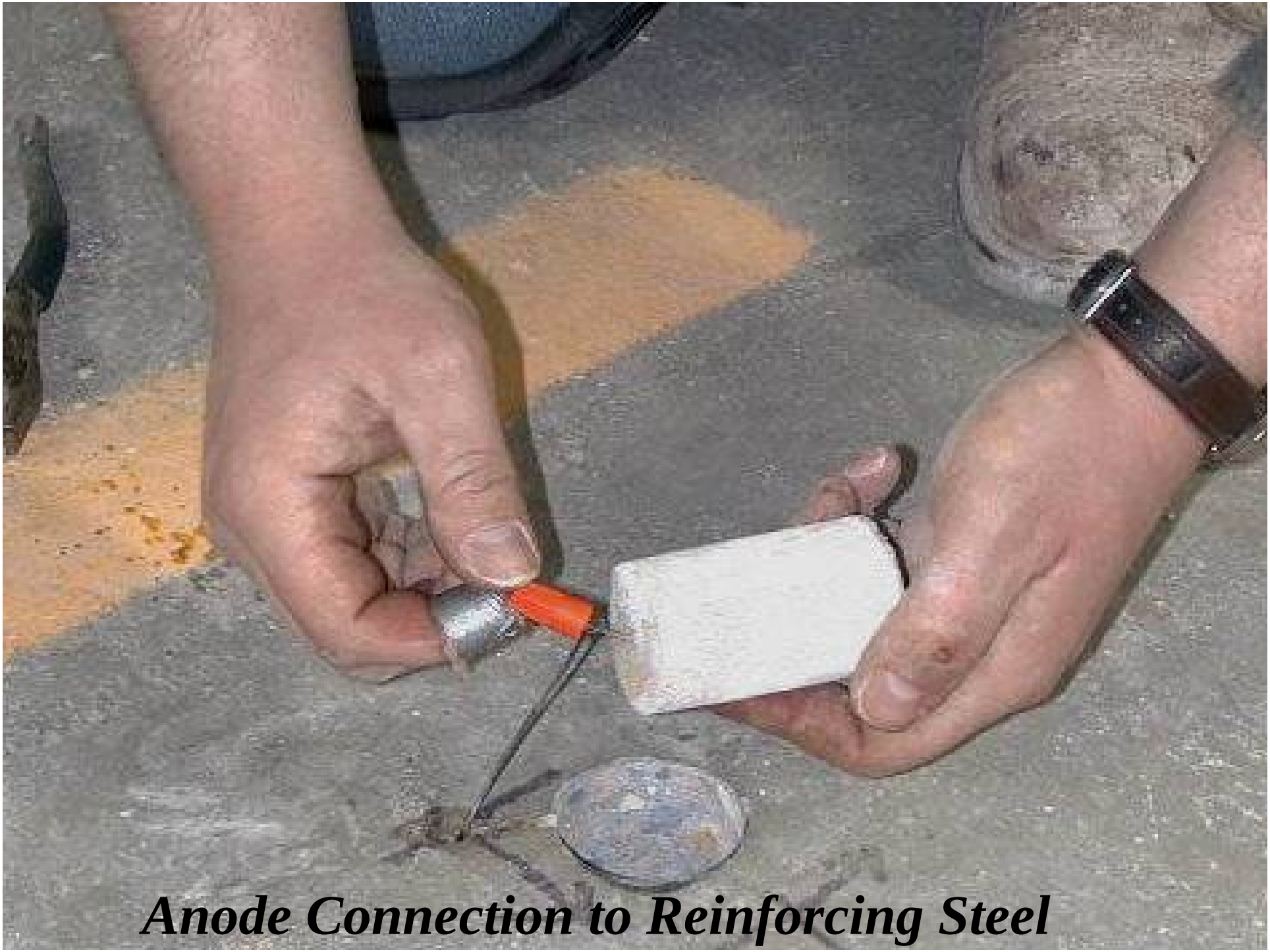
- **Discrete Type 2A Anodes drilled in sound concrete for “Localized” Protection**
- **Addresses on-going corrosion activity in “Hot Spots” identified by potential testing**
- **Pro-active solution for areas that are contaminated but have not yet spalled or delaminated**

Corrosion Control Anode Installation

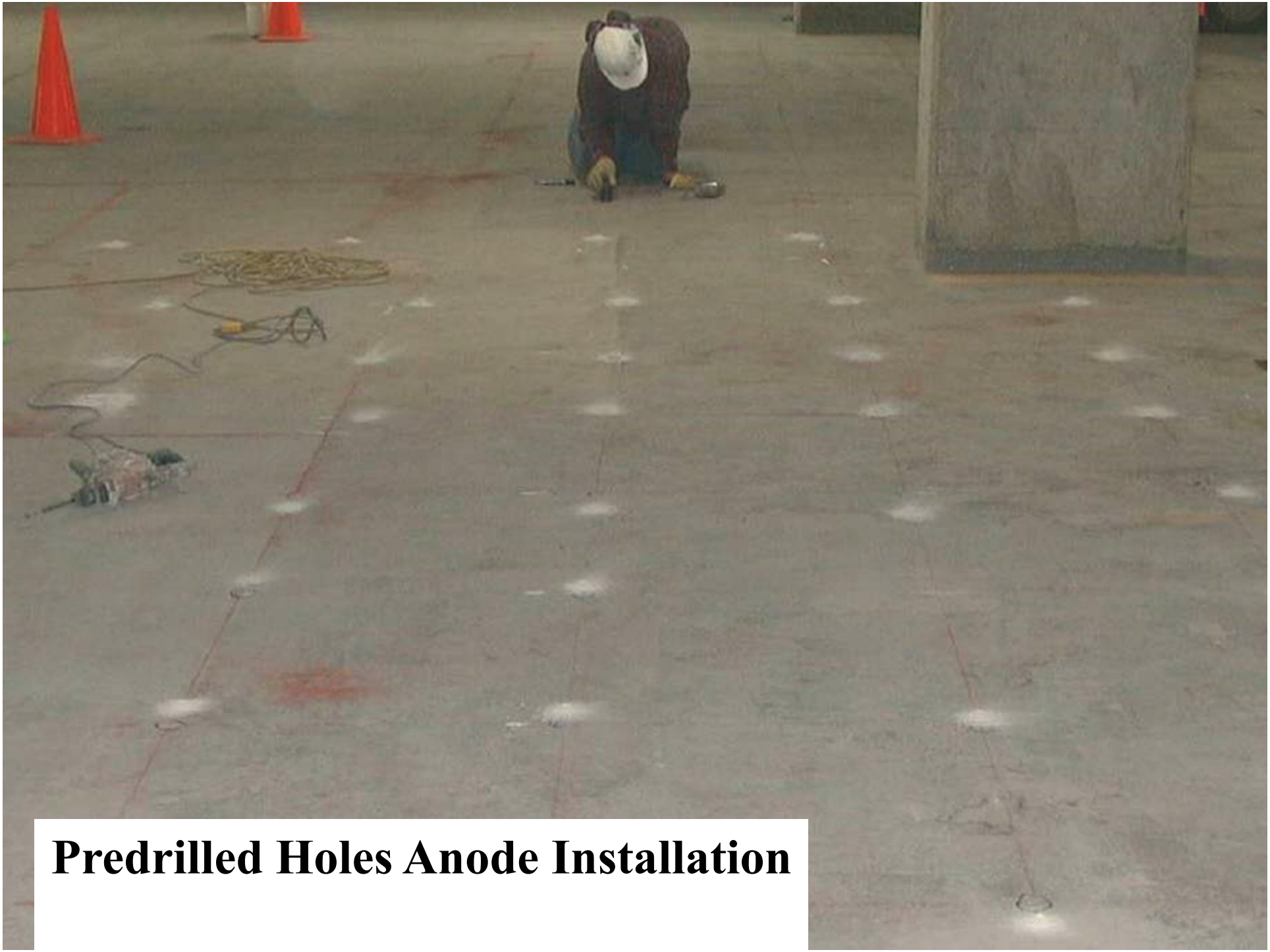


Steel connection next to pre-drilled 2” diameter hole



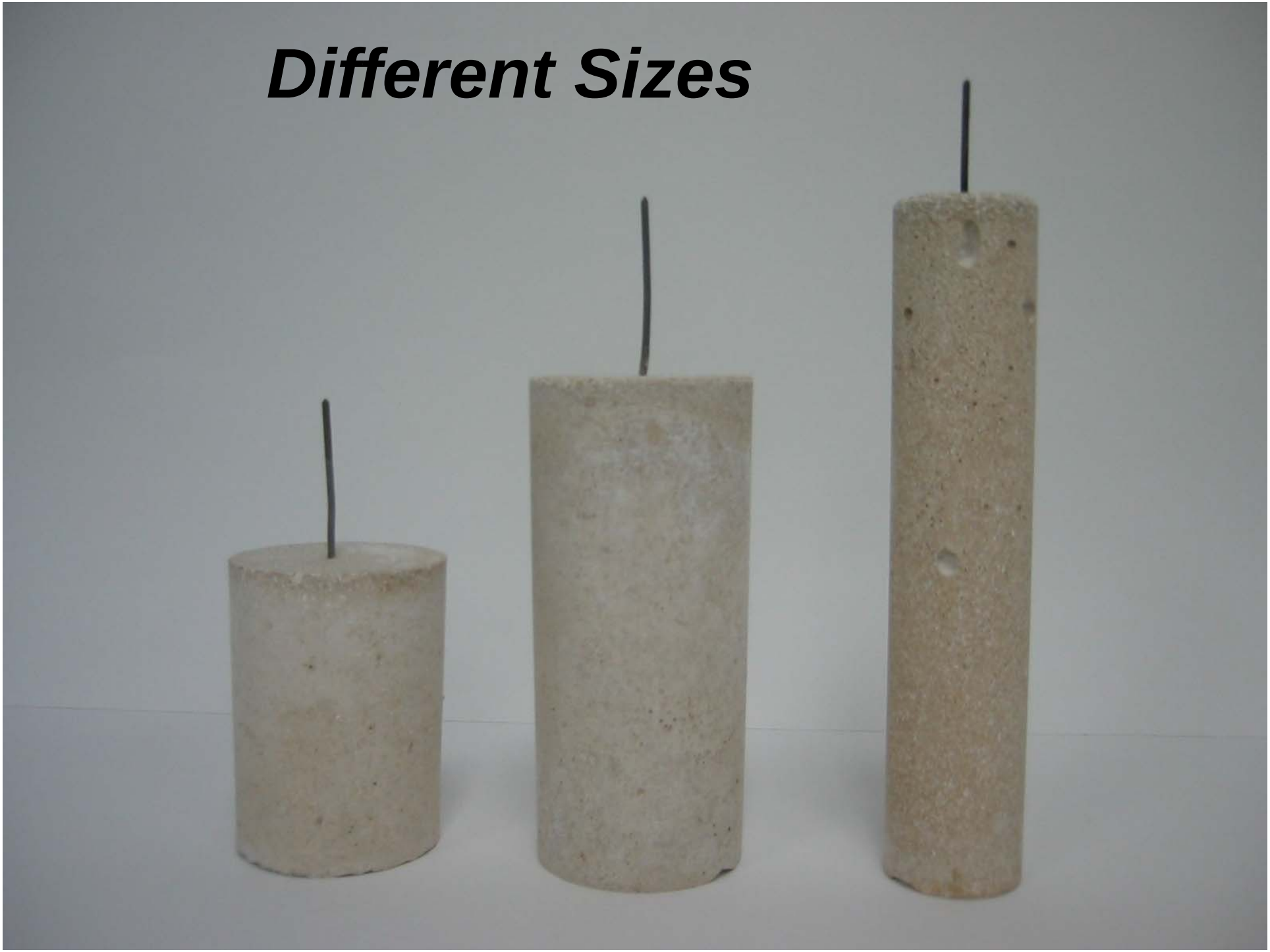


Anode Connection to Reinforcing Steel

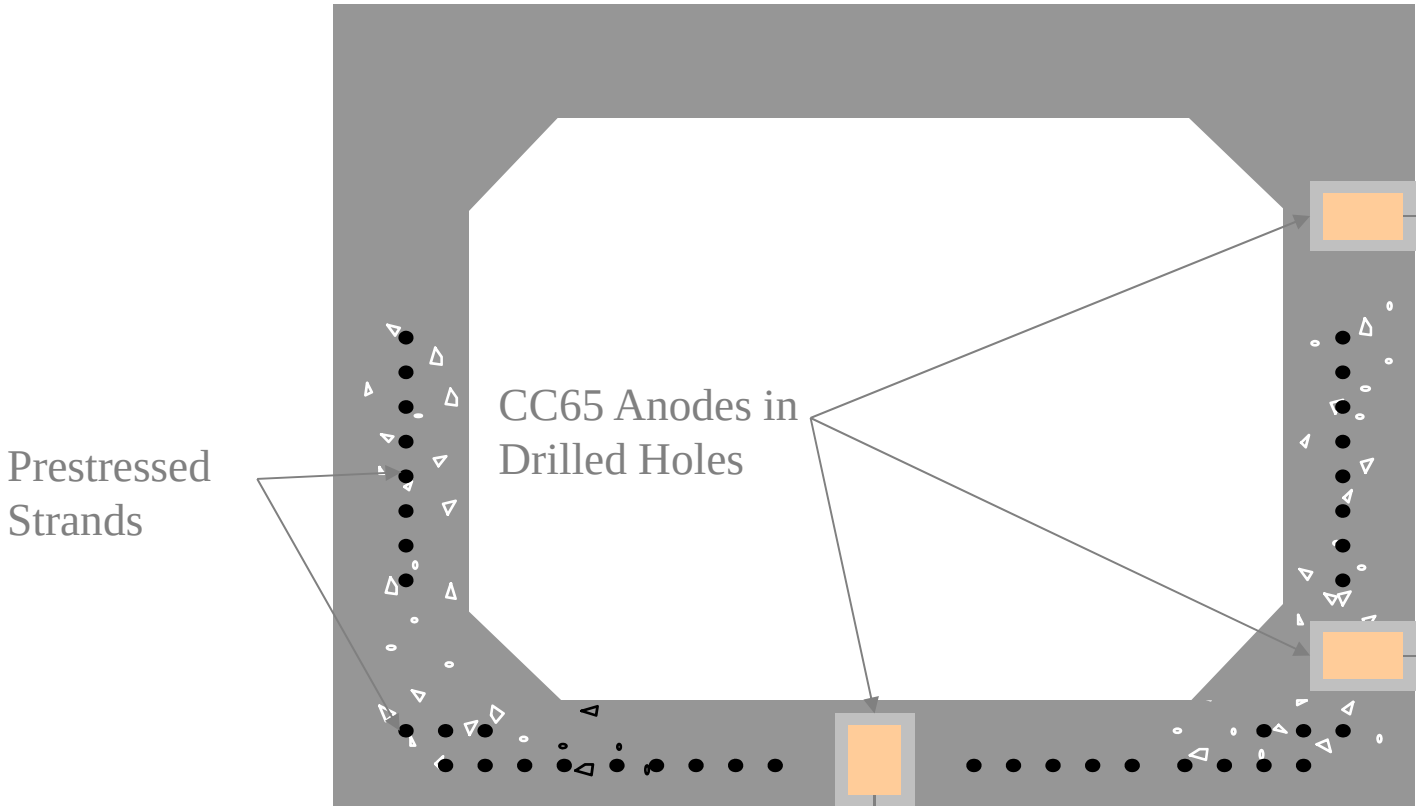


Predrilled Holes Anode Installation

Different Sizes



Galvanic Anodes in Prestressed Box Girder



Galvanic Anodes in Prestressed Box Girder

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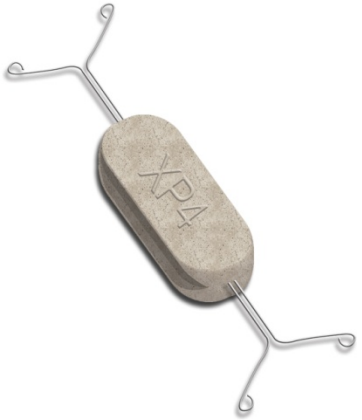
Galvanic Anodes in Prestressed Box Girder

Embedded Galvanic Anodes - Nomenclature

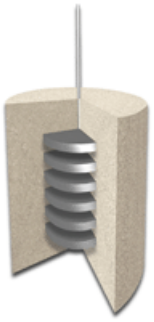
Type 1A and 1H

–Installed in Patch Repairs



Type 2A (No Type 2H available)

–Installed in Hot Spots in Sound Concrete

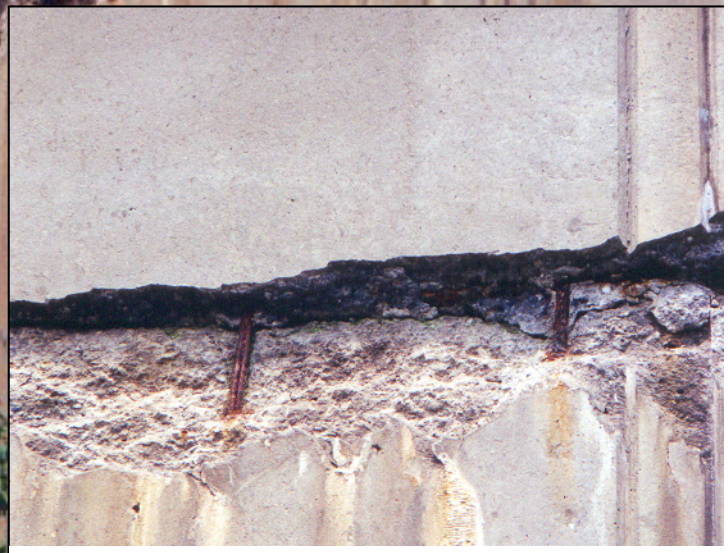


Joints and Interfaces

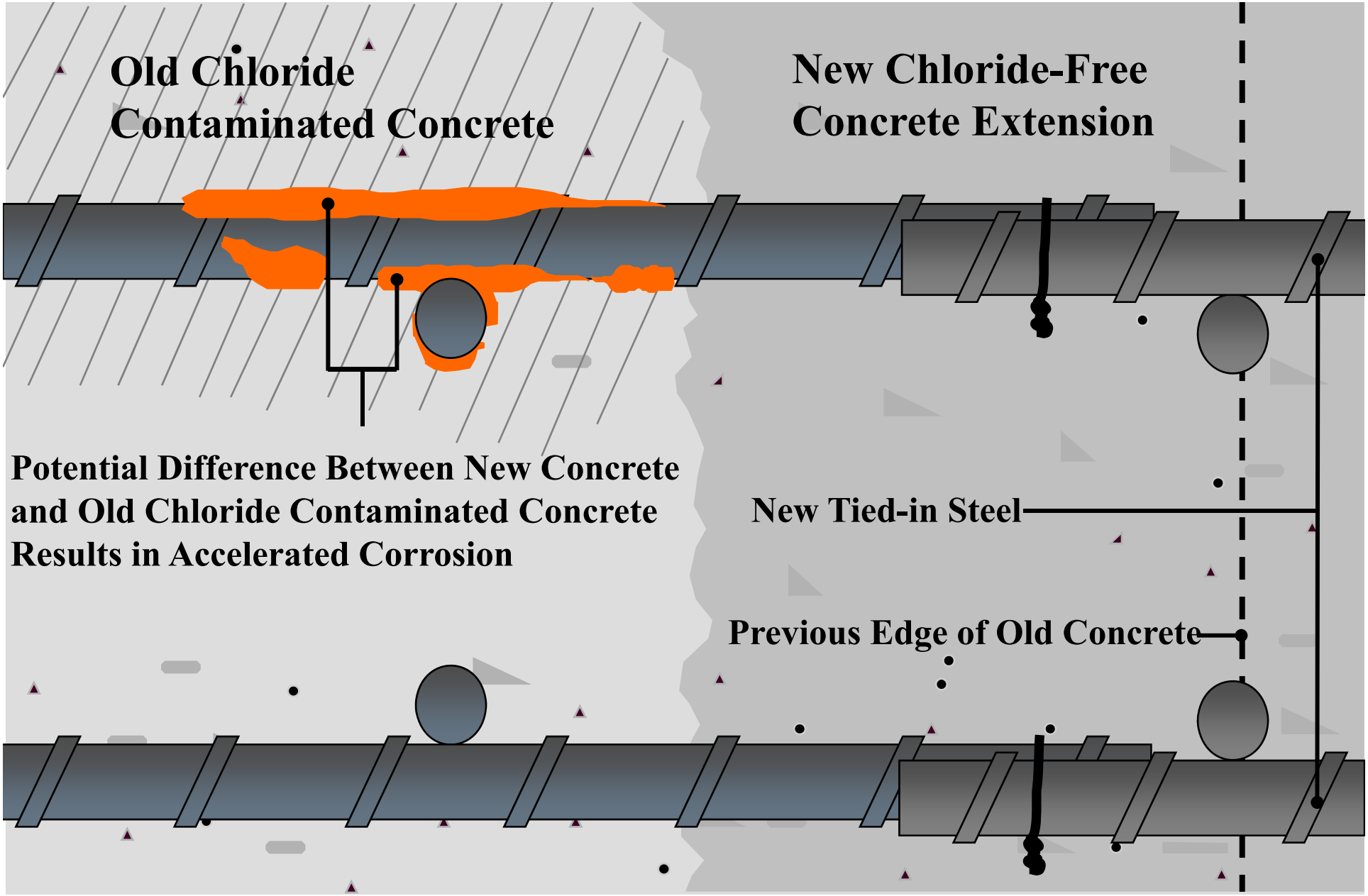
Corroded Joint
Pittsburgh, Pennsylvania

New Concrete Extension

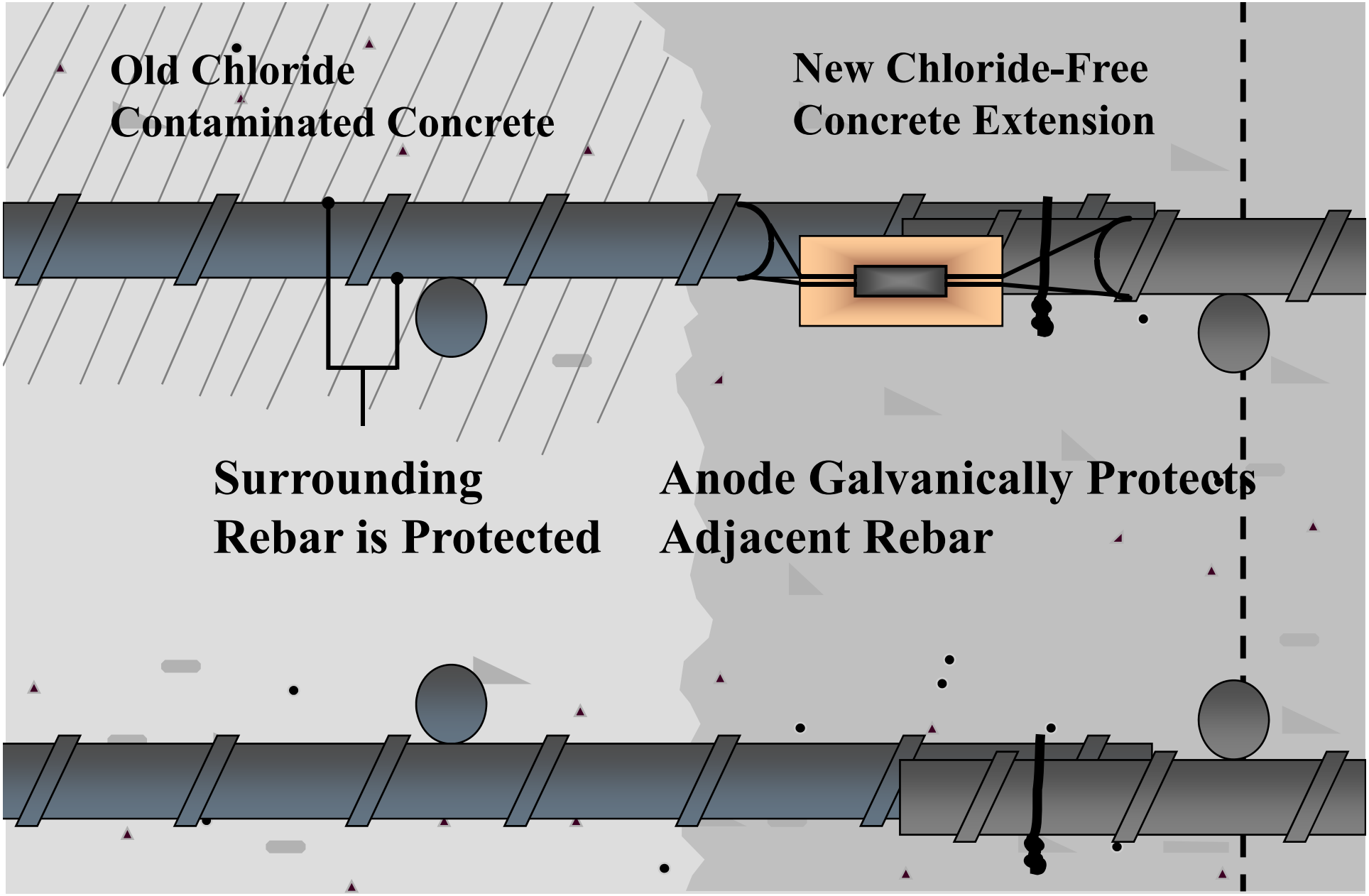
Old Retaining Wall



Failed Concrete Next to Joint Due to Corrosion



Accelerated Corrosion at Joint Interface

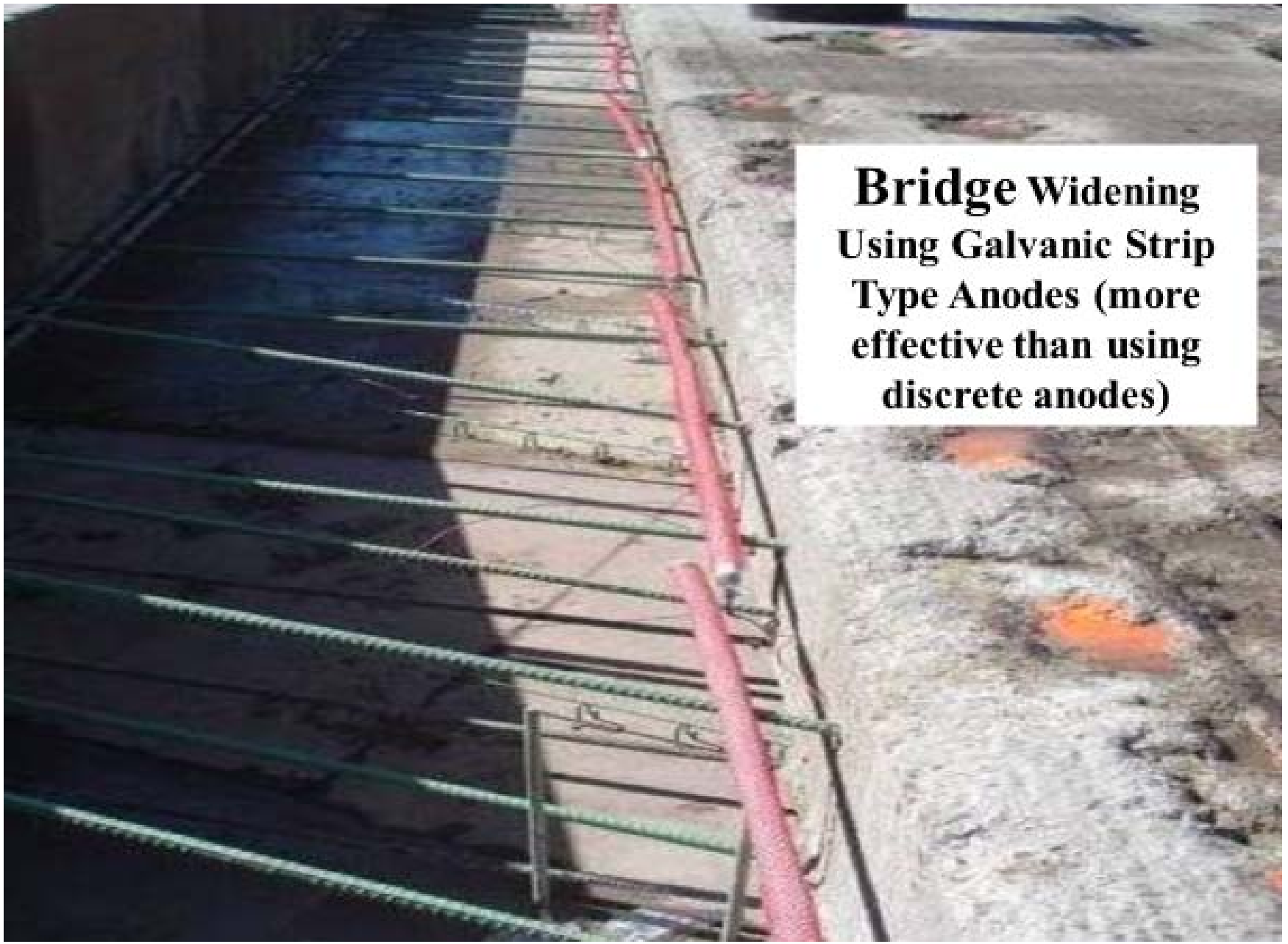


Anodes Prevent Accelerated Corrosion at Joint Interface

Distributed Anodes


VECTOR


VECTOR


Bridge Widening
Using Galvanic Strip
Type Anodes (more
effective than using
discrete anodes)

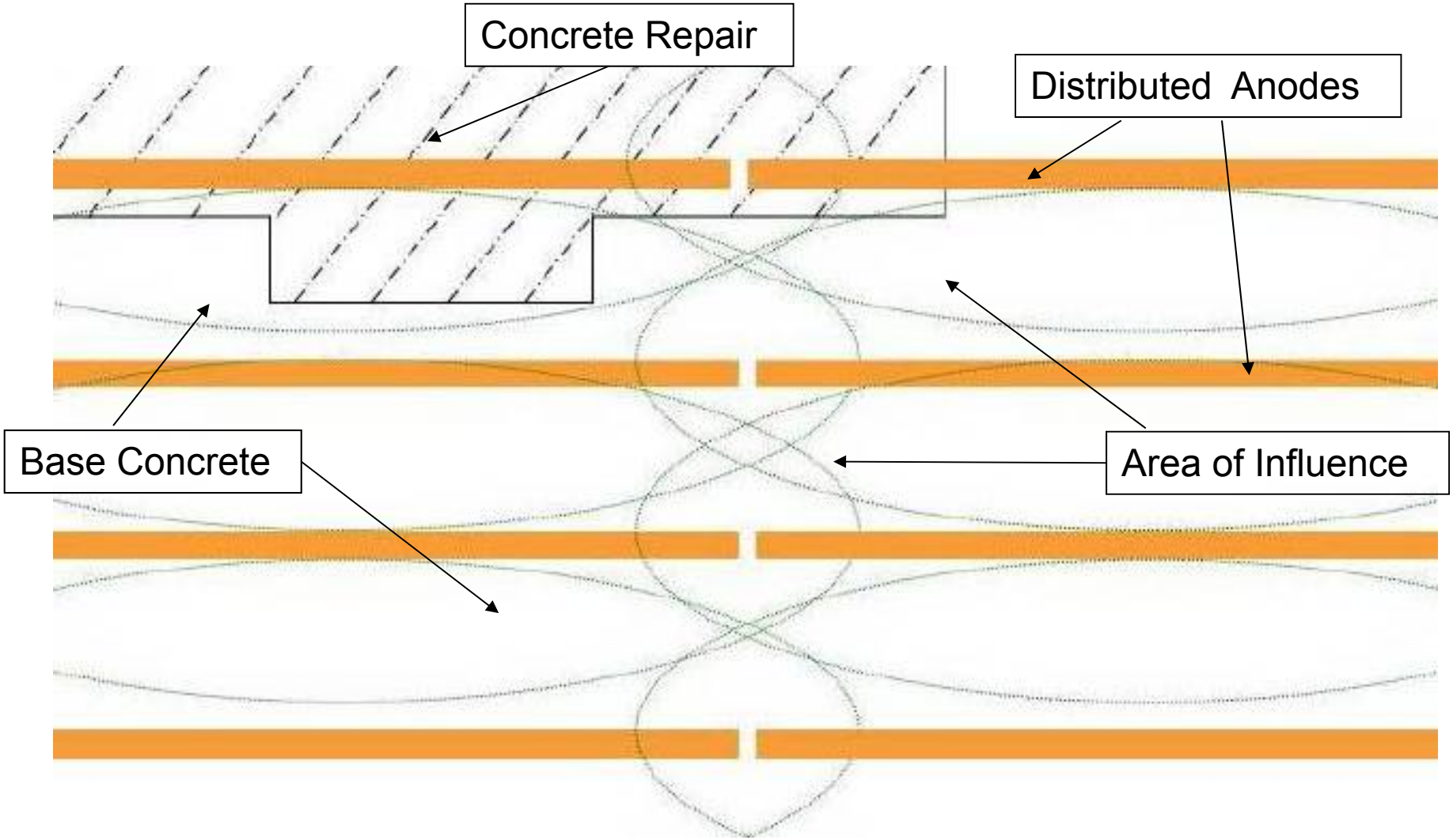

*Galvanic Strip
Anodes Used to
Protect Replaced
Expansion Joint

“Distributed” Galvanic Corrosion Protection Systems:

For Deck Overlays and Structural Members (Beams, Columns, Pier Caps, Etc.) overbuilds and Encasements or Jackets

(*When more than localized protection is required)

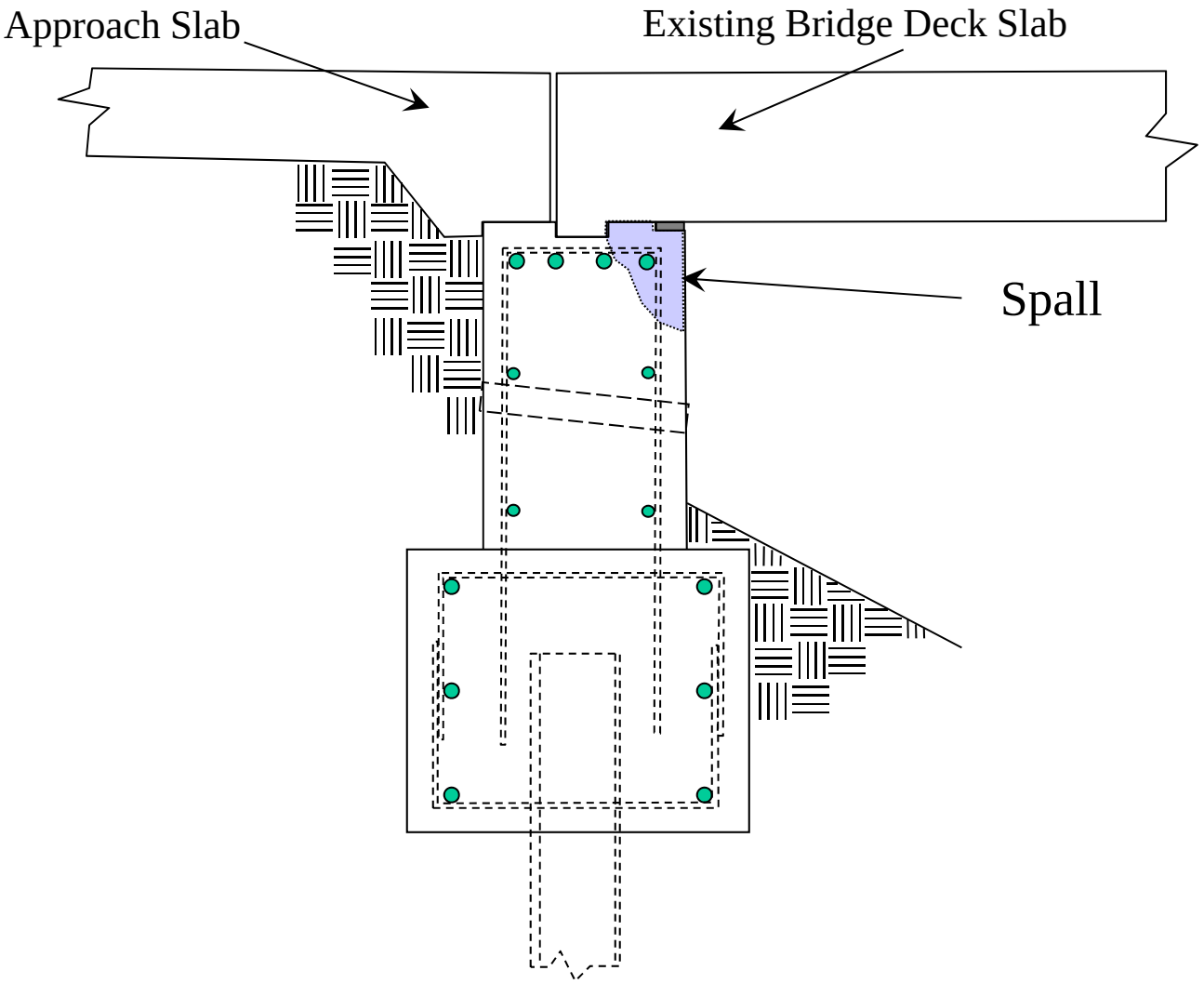
Distributed Strip Type Anode Protection in a Deck



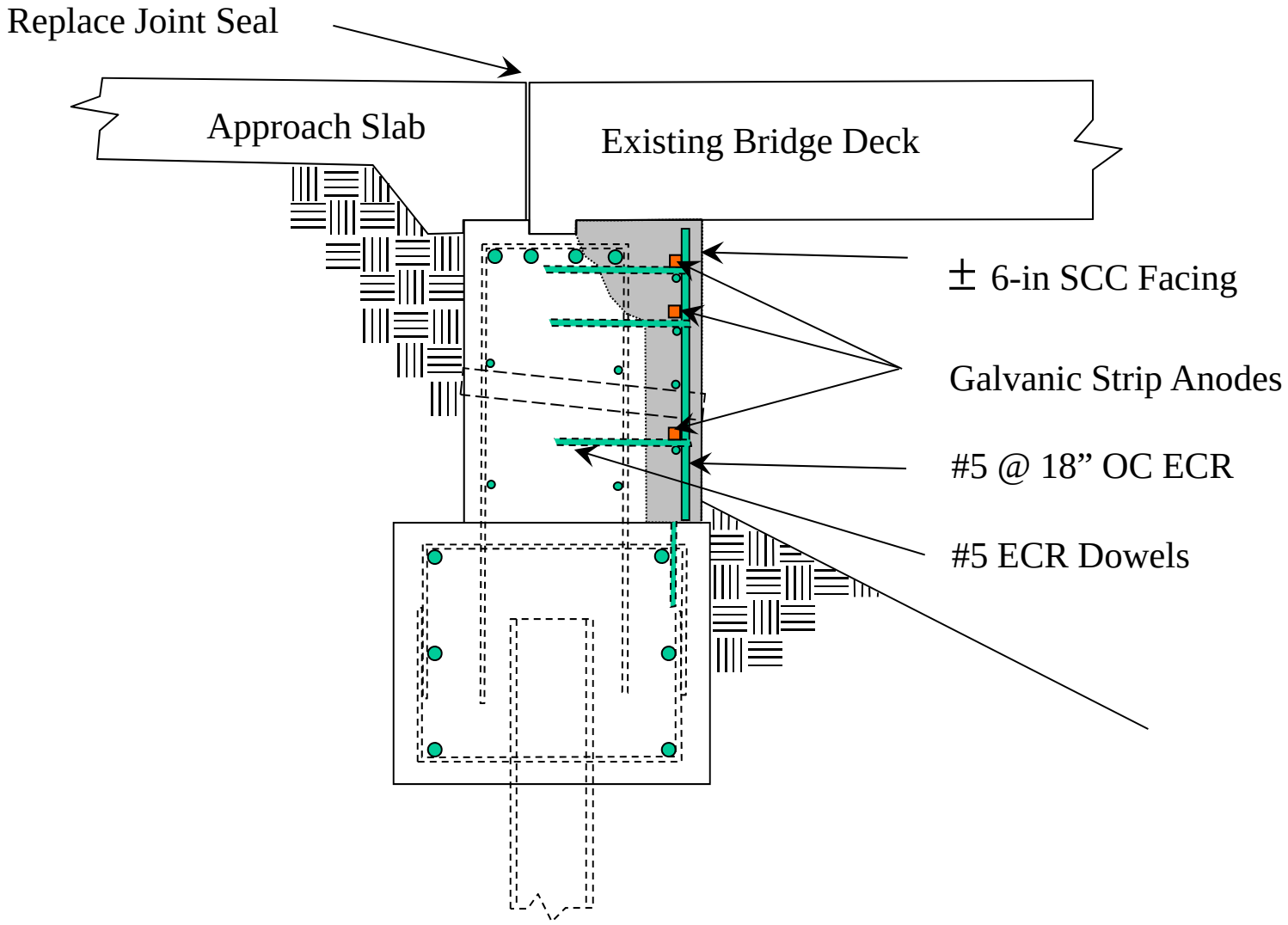
On Many Slab Bridges…

- Slabs are in good condition
- Deterioration at abutment around the key way

Typical Slab Bridge Abutment



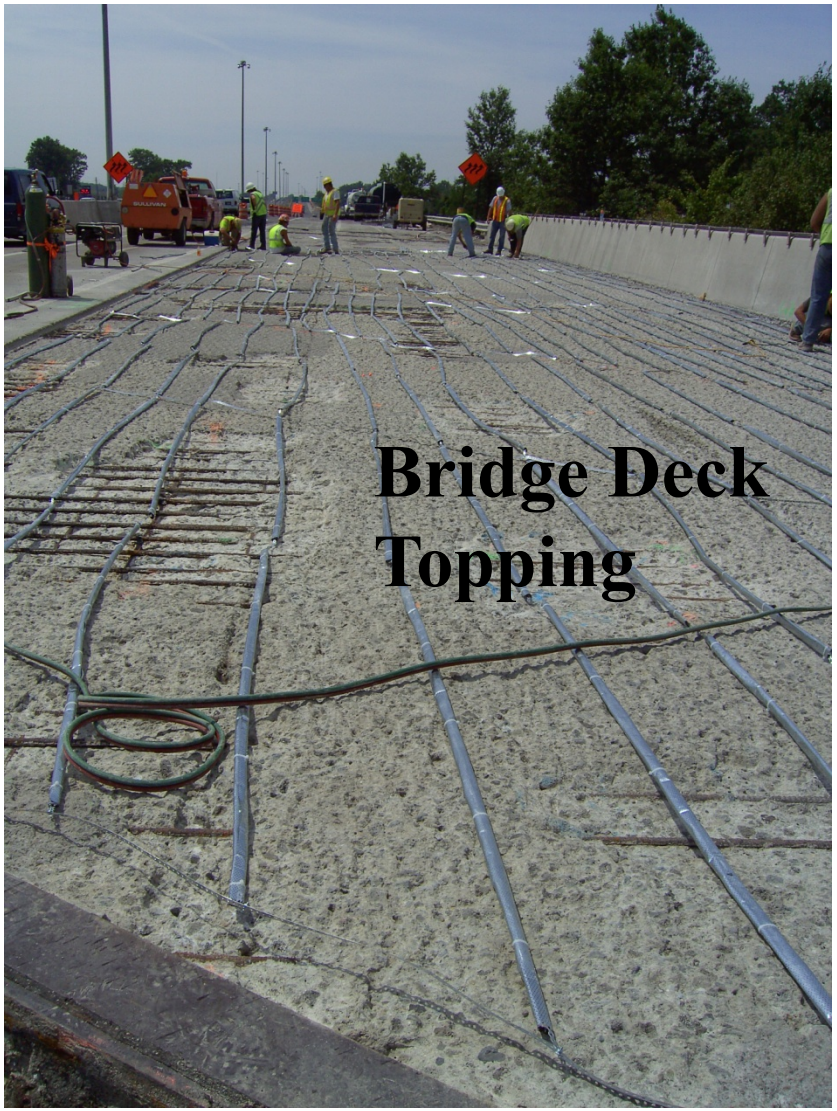
Abutment Repair Detail With Galvanic Protection

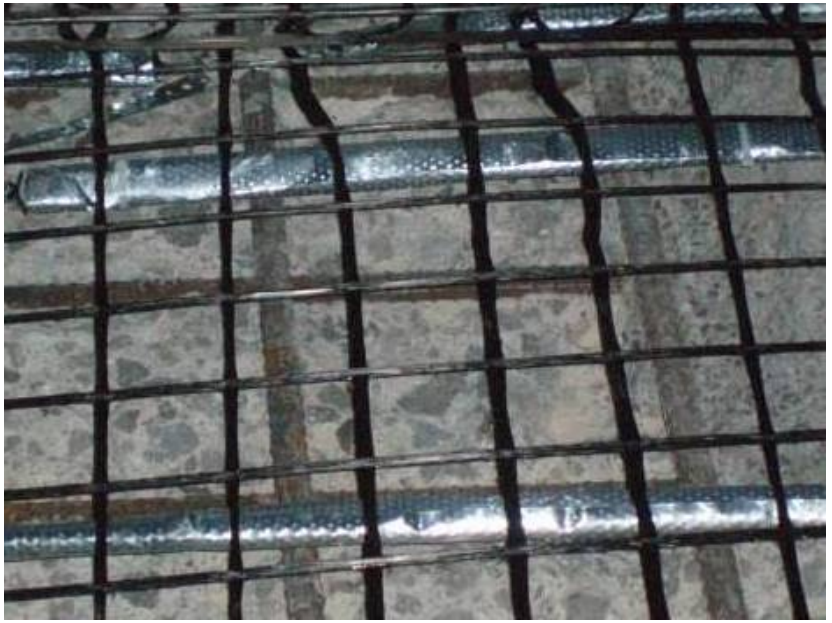



Completed repair

Distributed Galvanic Anodes in Large Area Repairs

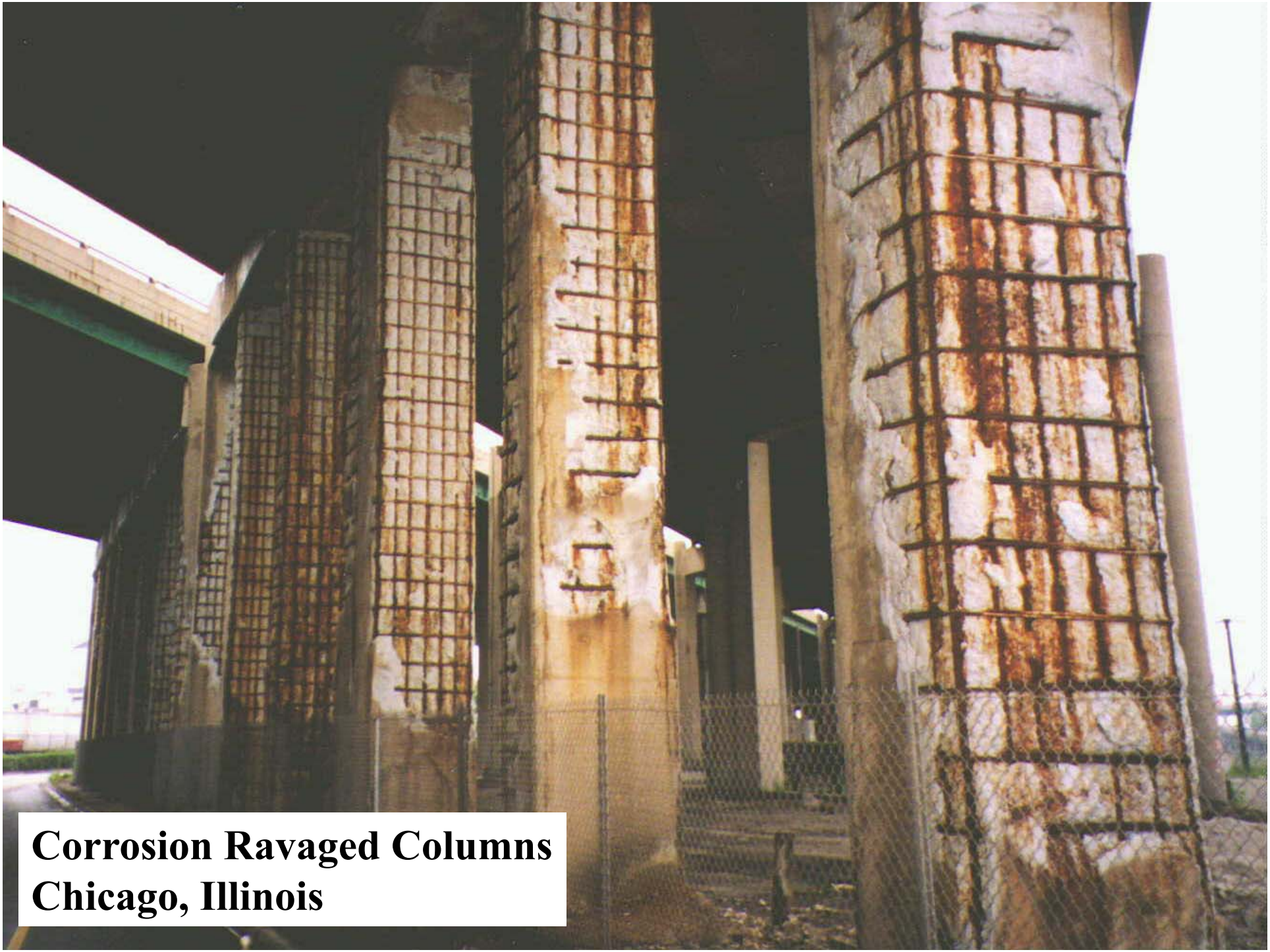
Custom galvanic anodes distributed throughout large repair areas provide a high level of protection and long service life.


Bridge Deck
Topping



Galvanic Distributed Anodes

Pier Cap Protection



Corrosion Ravaged Columns
Chicago, Illinois


BRIDGE PIER OVERBUILD WITH
GALVANIC PROTECTION WITH
STRIP TYPE ANODES

Monitoring and Verification of Corrosion Protection

- Substructure Restoration
- Galvanic Concrete Encasement
- Ohio DOT

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Galvanic Anodes used in New Concrete Structures:

Normally used to Protect and extend Life to Areas of Rehabilitated Structures

*Can also be used to Protect and extend life to “Targeted Areas” of New Concrete Construction

Corrosion Prevention

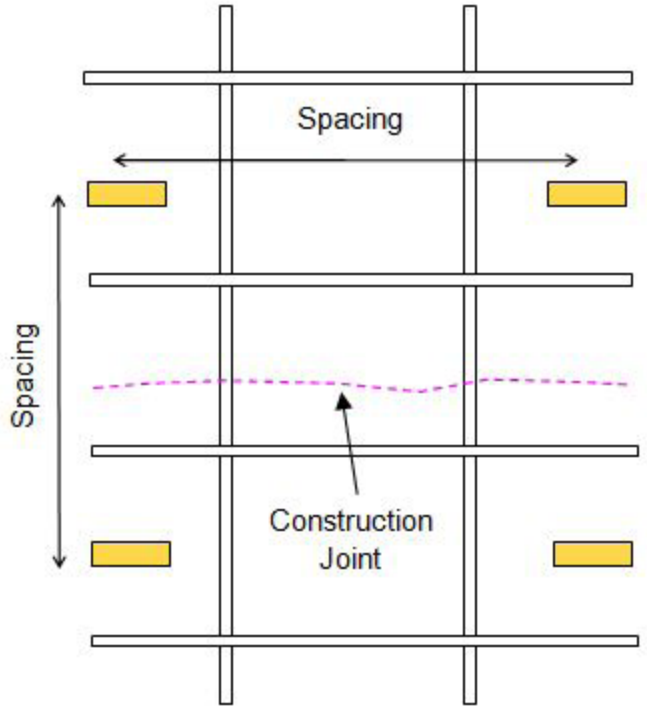
- Used for New Concrete to Prevent Corrosion and extend Service Life of New Structures (*Especially in Severe Environments)
- Galvanic anodes force the cathodic reaction to occur at steel surfaces in uncontaminated new concrete
- Preventing initiation of corrosion in new structures is substantially less than for actively corroding existing structures
  - Typically in the range of 0.025 to 0.2 mA / ft2 of steel surface area (versus 0.1 to 0.7 mA / ft2)

Anode Placed in New Concrete:

- Galvanic anodes
  - Anodes can be distributed over large areas
  - Or used as targeted projection for specific areas of concern

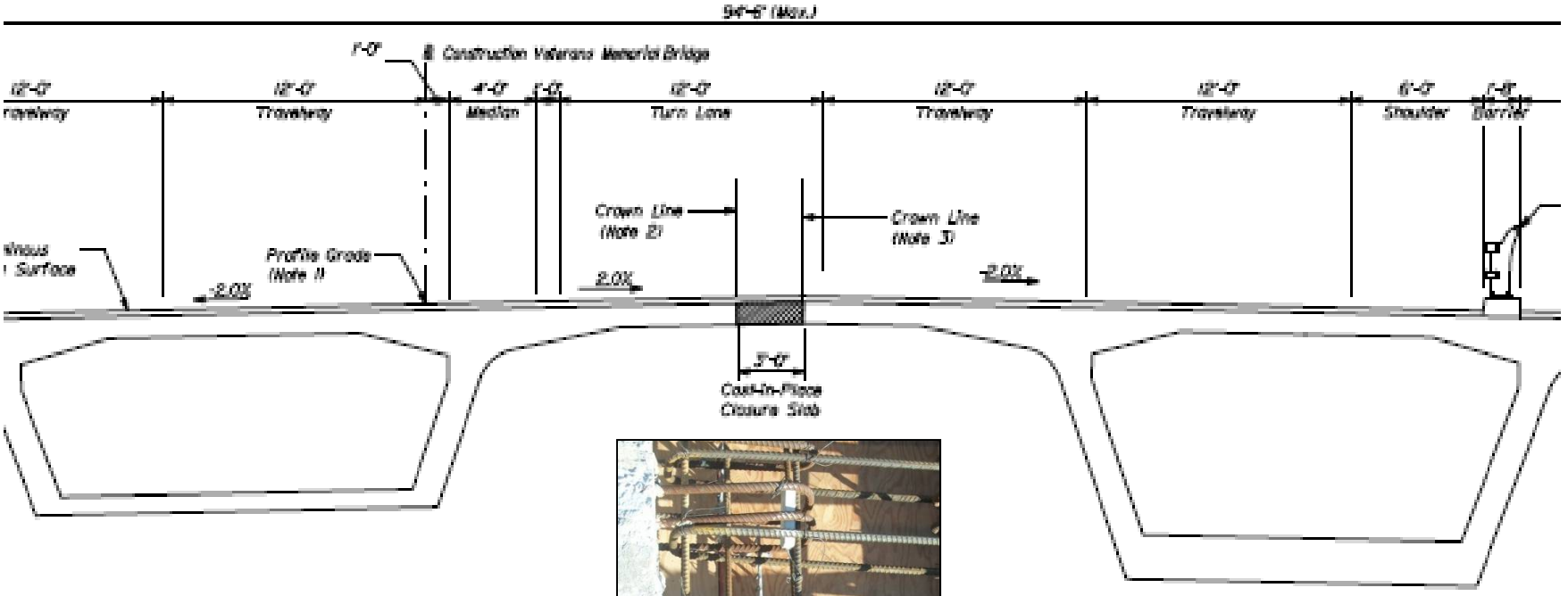
Galvanic Anodes in New Construction

- Targeted protection
  - Potential future high chloride exposure areas
  - Critical structural elements
  - Construction joints, etc.



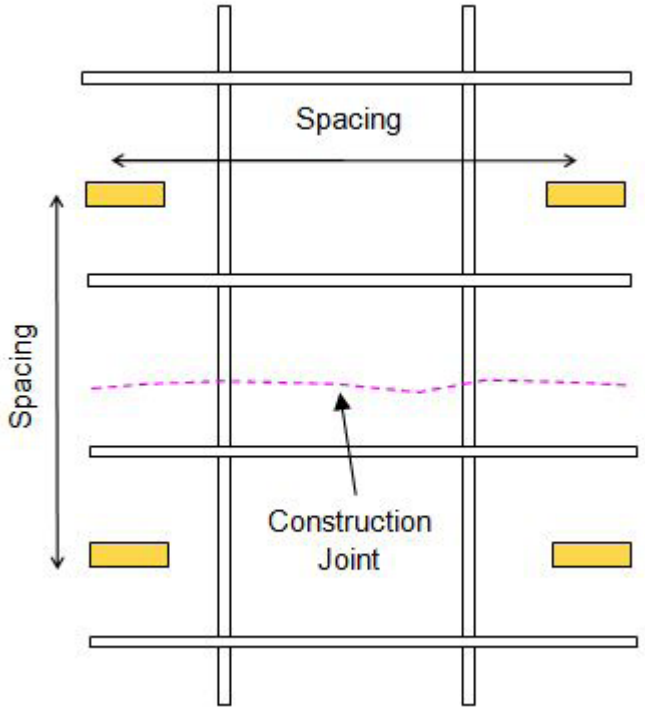
Marine Pile Protection

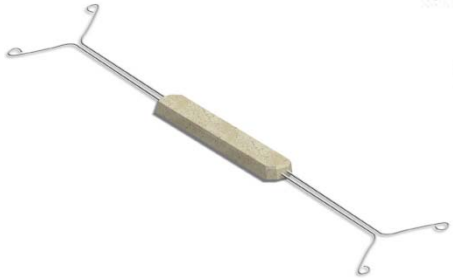
Precast Closure Strip



Discrete Anode for New Construction

- General Protection for New Construction
- Extra long tie wires
  - Allows anode to be tied in the center of the steel grid
  - More even current distribution
- Spacing:
  - a minimum of one anode per 2.7 sqf of steel surface area
  - maximum spacing of 30 inches between anodes.





Summary of New Construction Protection

- Anodes provide cathodic current to improve corrosion resistance of conventional reinforcing steel
  - establishes a strong passive layer
  - increases the tolerance to chlorides.
  - keep chlorides away from the steel.
- Global or targeted protection strategies can be utilized

Thank You

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