Electrochemical Corrosion Mitigation for Reinforced Concrete Bridges

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Status of US Bridges

- About 1/4 of Bridges are classified as Structurally Deficient or Functionally Obsolete
- $140 billion required to repair all bridges
- Average age is 43 years


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Electrochemical Corrosion Mitigation Systems for Concrete

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

Viaduct Rehabilitation

- 1.5 miles long built in early 1970's
- 66 large hammerhead piers
- Assessment indicated various conditions along the structure
  - Wide spread chloride contamination to level of the steel
  - Localize spalling
- 40+ year life extension would not be achieved in current condition

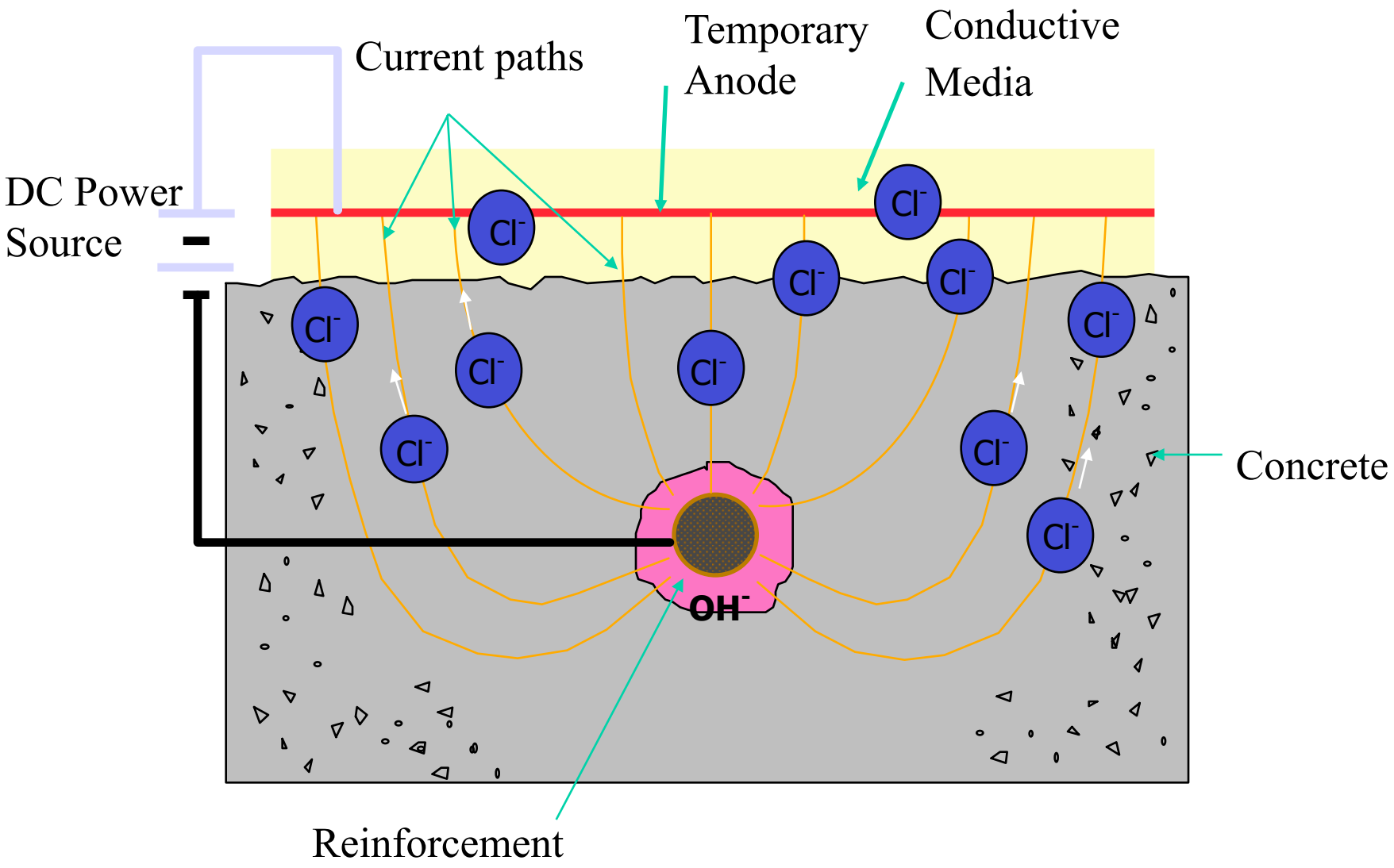
Solution

- Replace concrete deck
- Maintain steel box girders and supporting structures
- Piers with widespread chloride
  - 26 piers received Electrochemical Chloride Extraction
- Piers with localized concrete spalling
  - patch repairs with alkali-activated embedded galvanic anodes for local protection
- Application of acrylic coating for improved appearance and protection

Electrochemical Chloride Extraction

- Address the cause of the problem
- Passivates active corrosion
- Temporary treatment process
- No system left in place to maintain
- Miniminal aesthetic impact
- Long service life is achieved
  - 1989 - first application in North America

Electrochemical Chloride Extraction (ECE) From Salt Contaminated Concrete

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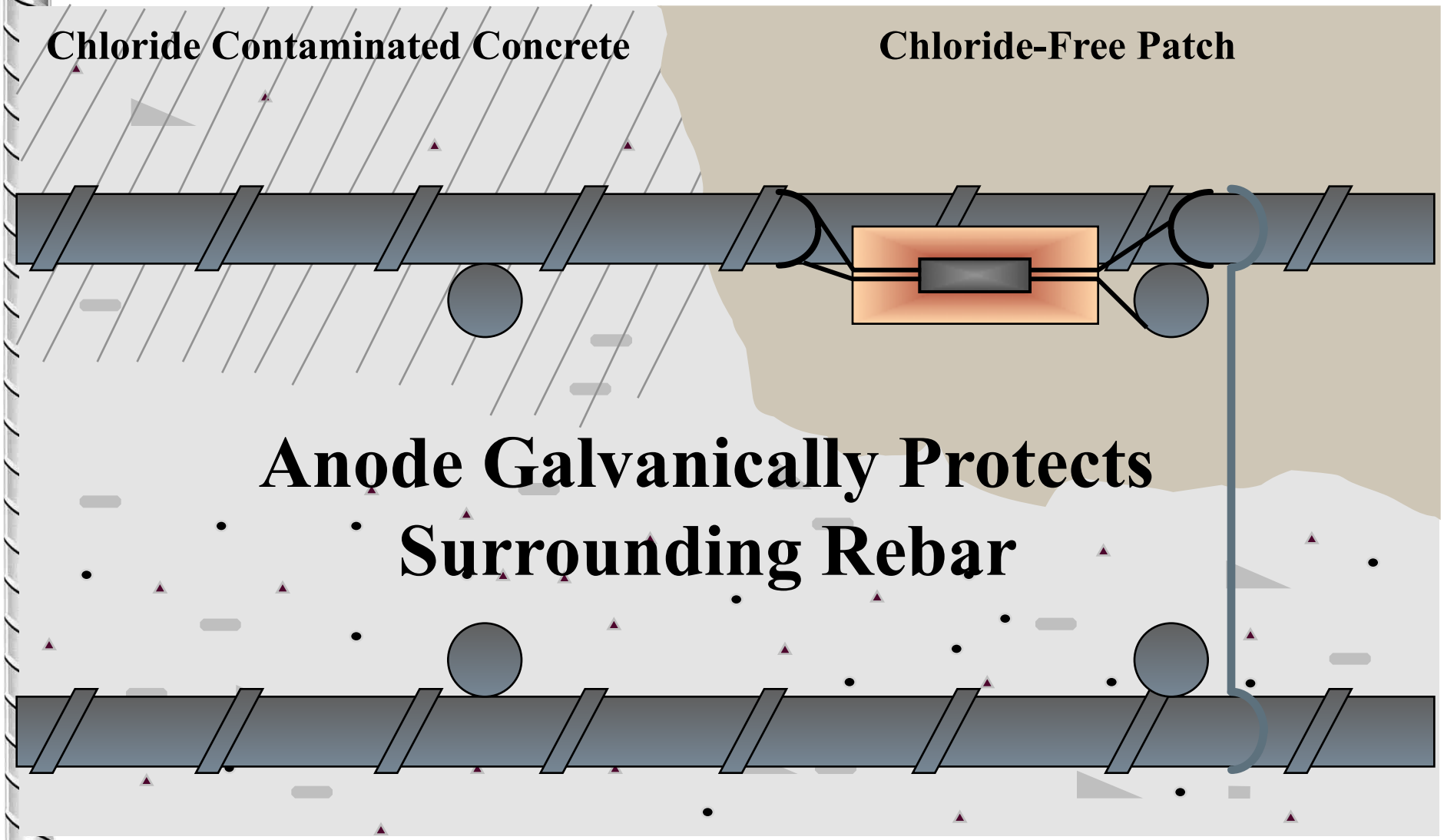
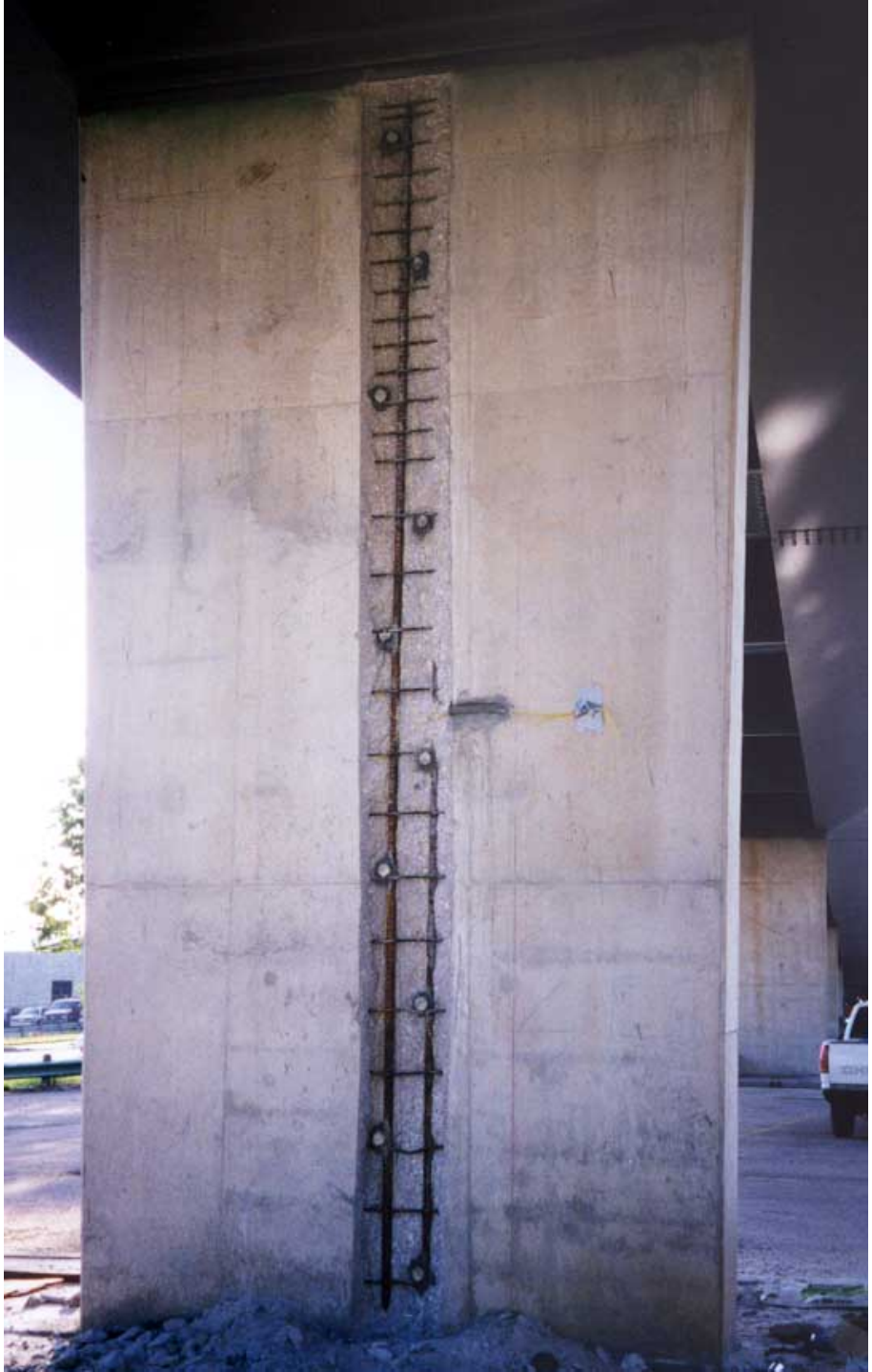
Embedded Galvanic Anode





Embedded Galvanic Anodes are tied to reinforcing steel at edge of repairs.

Substructure Repair

- Problem
  - Structure built in 1963
  - Previous repairs in early 2000's
  - Chloride content, concrete damage and corrosion potentials varied significantly among piers
  - Substructure rehabilitation to equal expected service life of new deck
  - Preference for galvanic protection due to resource availability for ICCP monitoring.

Solution

Area with Concrete Damage	Repair Method
Less than 20%	Concrete patching and sealer
Greater than 20%	Concrete removal and jacketing and sealer
< 20% concrete damage and > 20% of sound surface area with high corrosion potentials	Concrete patching and Galvanic Corrosion Control with Activated Arc Spray Zinc

Prestressed Concrete Girders

- Problem
  - Chloride-induced corrosion
  - Limited area (beam ends only)
  - Concrete damage
  - Section loss of steel
  - Repair, protection and strengthening required

Solution

- Concrete patch repair
- Strengthening with surface bonded fiber reinforced cement (PBO)
- Galvanic protection with surface applied zinc sheet anodes

Bridge Bent Protection

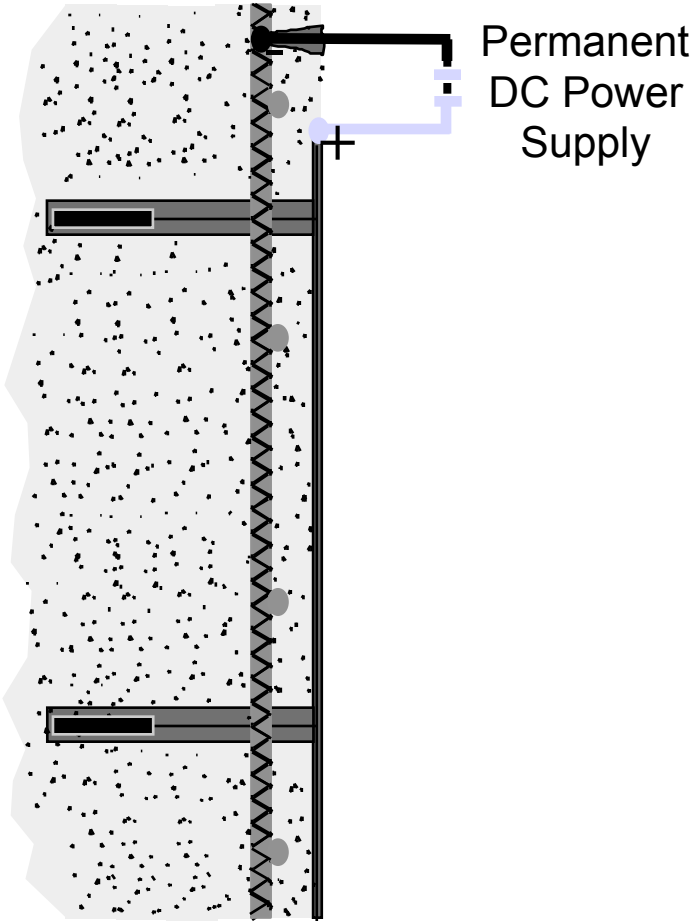
- Problem
  - Reinforced concrete columns and beams
  - Located under leaking joints
  - Chloride contamination and active corrosion
  - Long term protection required for critical structure

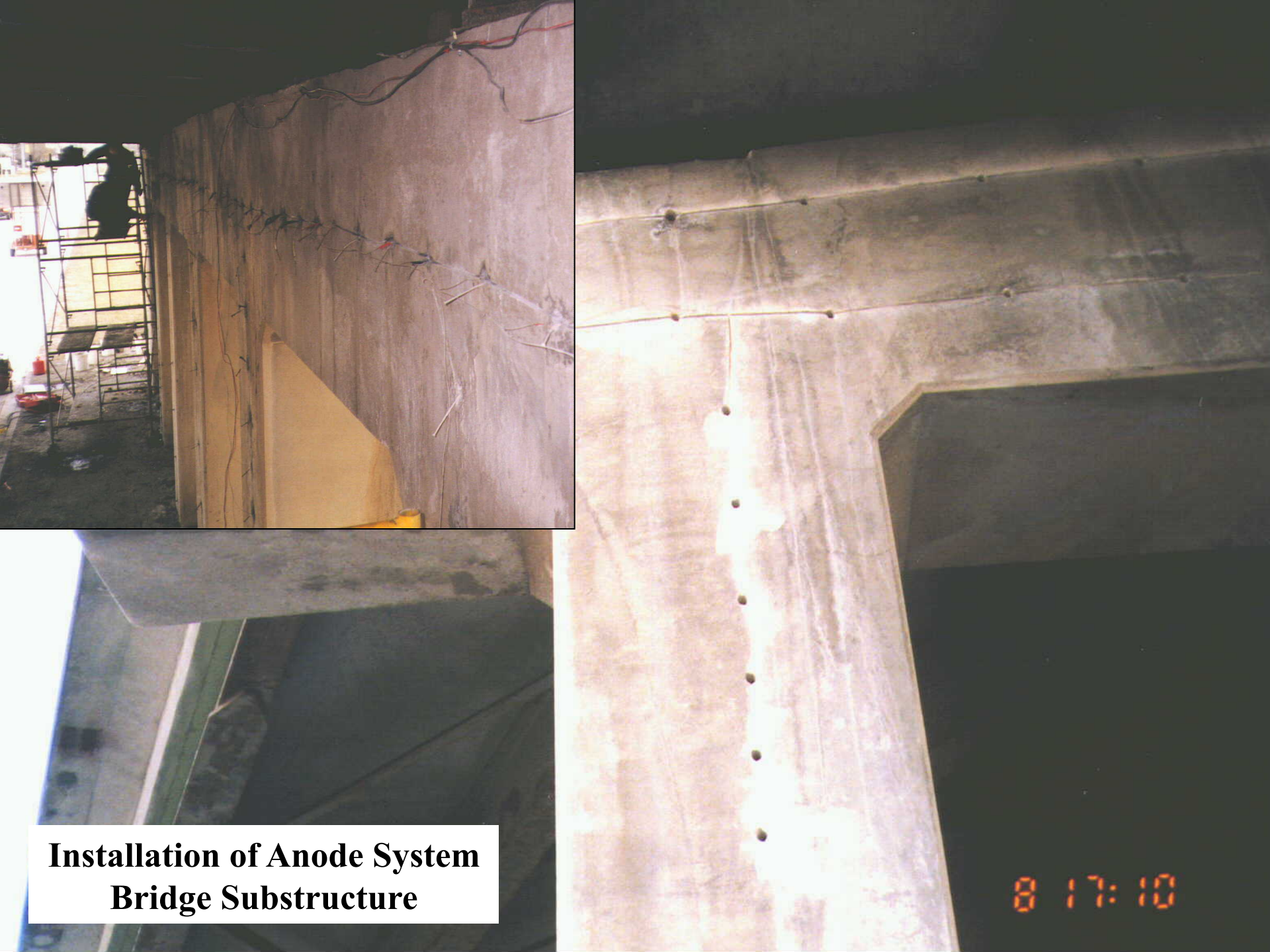
Solution

- Isolated concrete repairs
- Impressed current cathodic protection
  - Inert conductive ceramic point anodes for ICCP placed into drilled and grouted holes
  - AC Power, Transformer / Rectifier, associated wiring, conduit

Impressed Current CP

- Outside power source required
- High level of control
- Long term protection with regular system monitoring





Installation of Anode System
Bridge Substructure

Bridge in Marine Environment

- Problem
  - Prestressed concrete piles
    - Failed epoxy grouted FRP jackets
  - Chloride contamination from tidal and atmospheric exposure
  - Severe deterioration of reinforced concrete pier caps
  - High temperatures and high humidity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Solution

- Removal of epoxy grouted jackets
- Installation of galvanic protection for prestressed piles
- Repair and strengthening of pier footers incorporation impressed current cathodic protection
  - Associated power supplies, cabling and monitoring systems


03/29/2010

Pile Cap Repairs

- Problem
  - Small municipal roadway bridge over brackish water
  - Localized concrete damage on pile cap in low cover areas
  - Budgeted for maintenance repairs

Solution

- Concrete Patch Repair
- Embedded galvanic anodes to provide localized protection to repair areas

Summary

- Many bridges in the United States and other countries are in need of repair.
- Electrochemical corrosion mitigation technologies can be utilized to economically extend the life of reinforced concrete bridge structures.

Electrochemical Corrosion Mitigation for Reinforced Concrete Bridges

Thanks!

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