



Re-alkalization and Galvanic Protection of Reinforced Concrete Structures

David Whitmore, P.Eng., FCSCE
Vector Corrosion Technologies





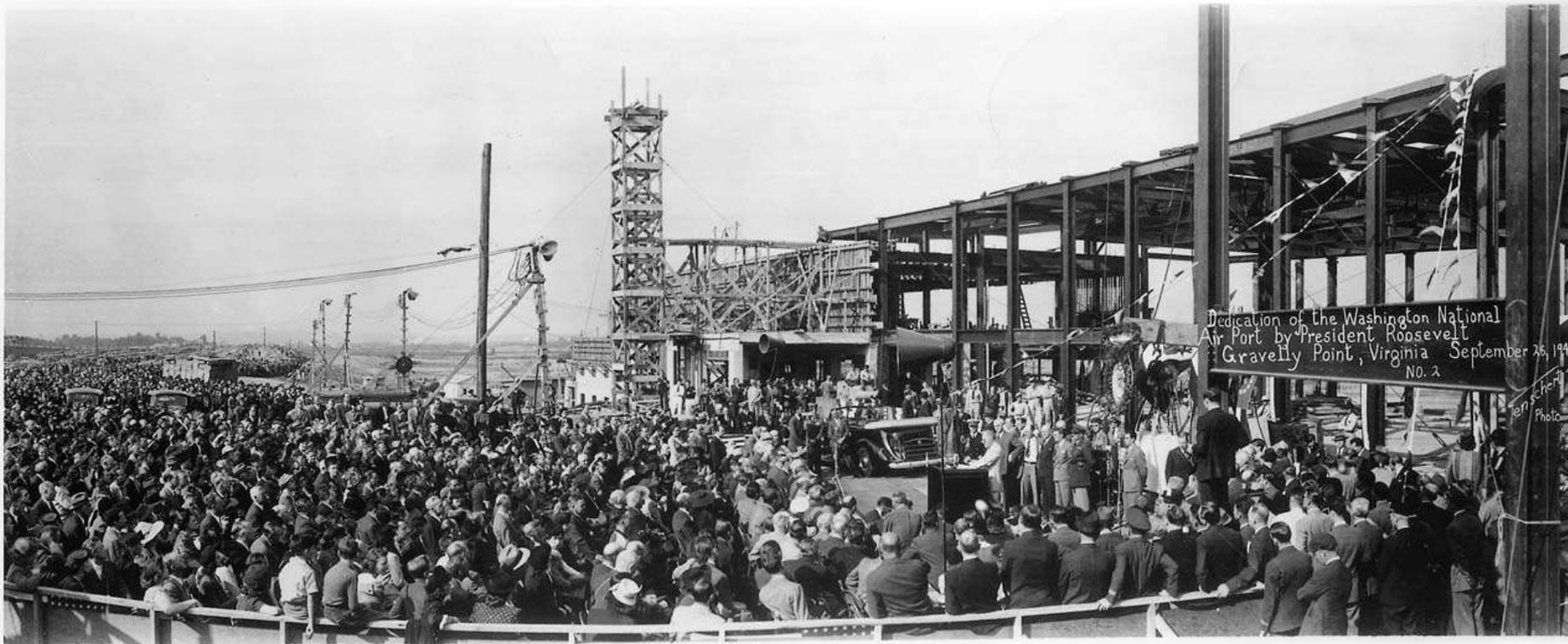








Washington National Airport Dedication; September 18, 1940









Evaluation Program

- Visual Inspection
- Delamination Survey
- Concrete Cover Survey (6 – 70mm)
- Cores (Strength + Depth of Cracks)
- Chloride Testing (High Cl⁻ 1 Location)
- Carbonation Testing (20 – 40mm)
- Corrosion Potential: Inconclusive

Evaluation Program



Rebar Issues



Corrosion Due to Carbonation and Low Concrete Cover over Rebar.



Corrosion Mitigation Options

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



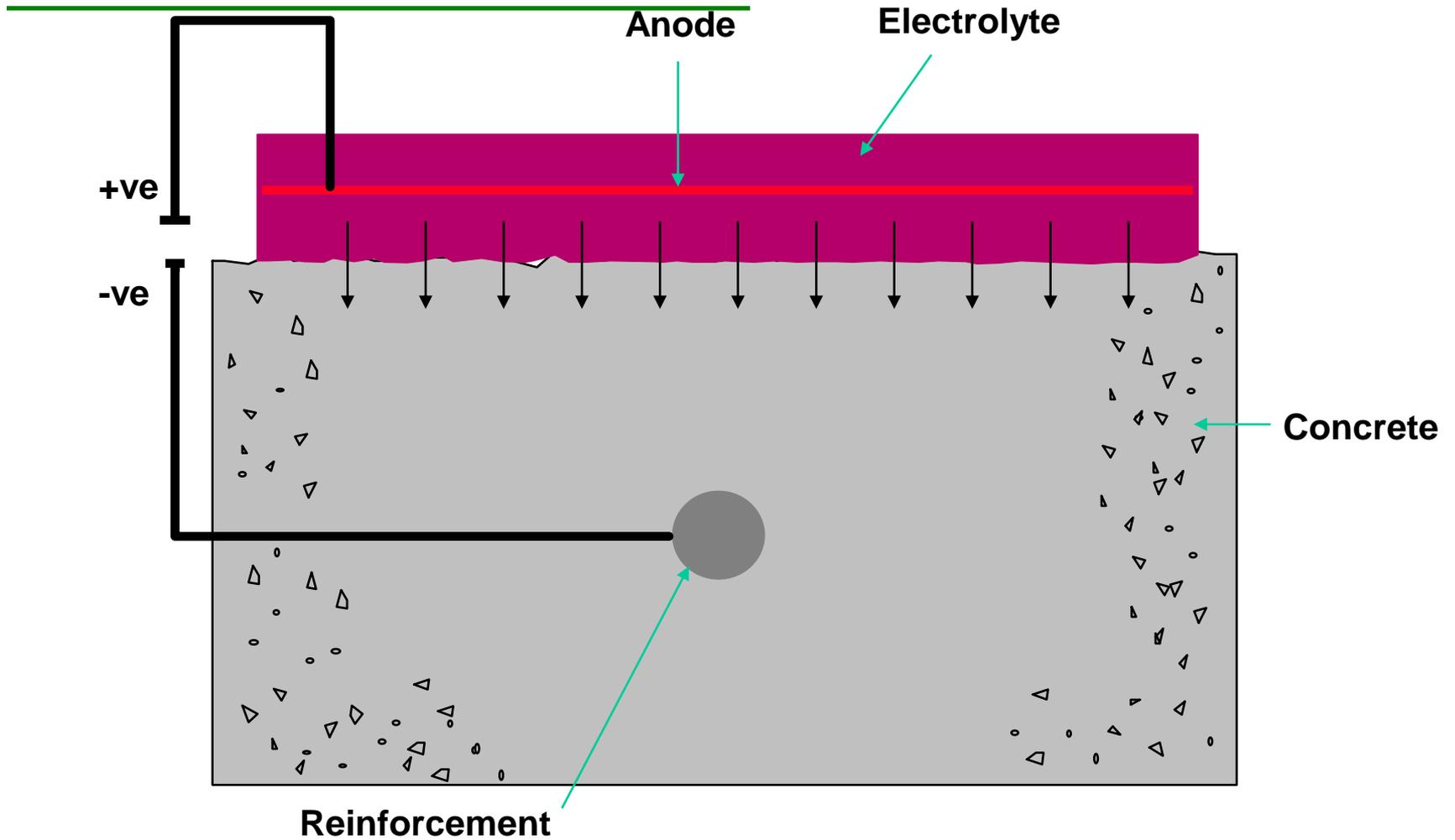
Washington National Airport Façade Repair Program

- Install access and protect windows
- Remove delaminated concrete
- Chemically strip paint
- Abrasive cleaning and surface preparation
- Replace corroded rebar and patch concrete
- Realkalisation of all exposed concrete
- Apply coating
- Perform all other work (roofing, railings, etc)

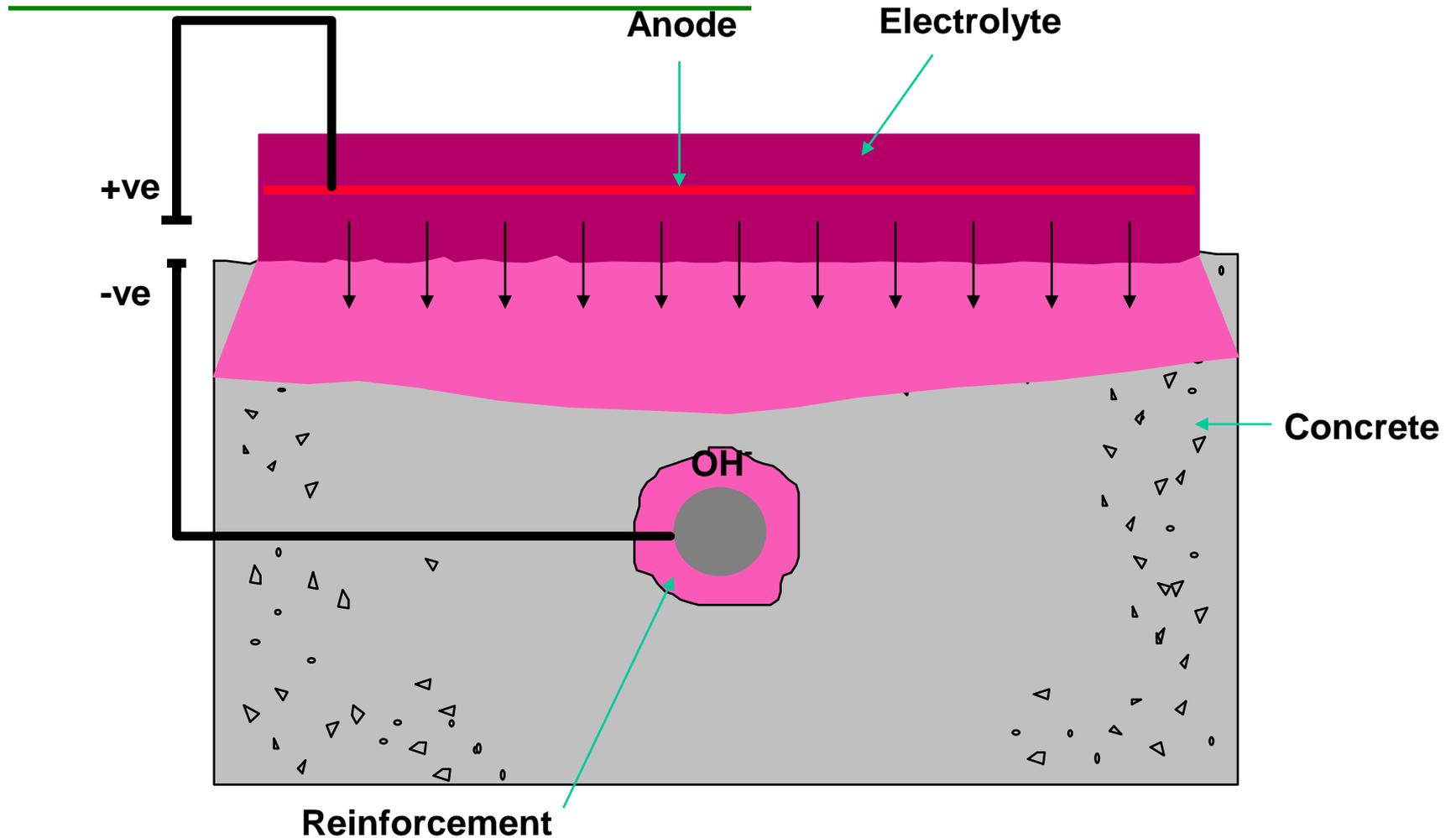
Realkalization

- Draws highly alkaline electrolyte sodium / potassium carbonate (Na_2CO_3 / K_2CO_3) to the reinforcing steel
- Restores lost alkalinity to carbonated concrete
- Alkalinity around reinforcing steel is maintained over time, will not re-carbonate
- Lower cost, less disruptive than mechanical removal and replacement of carbonated concrete

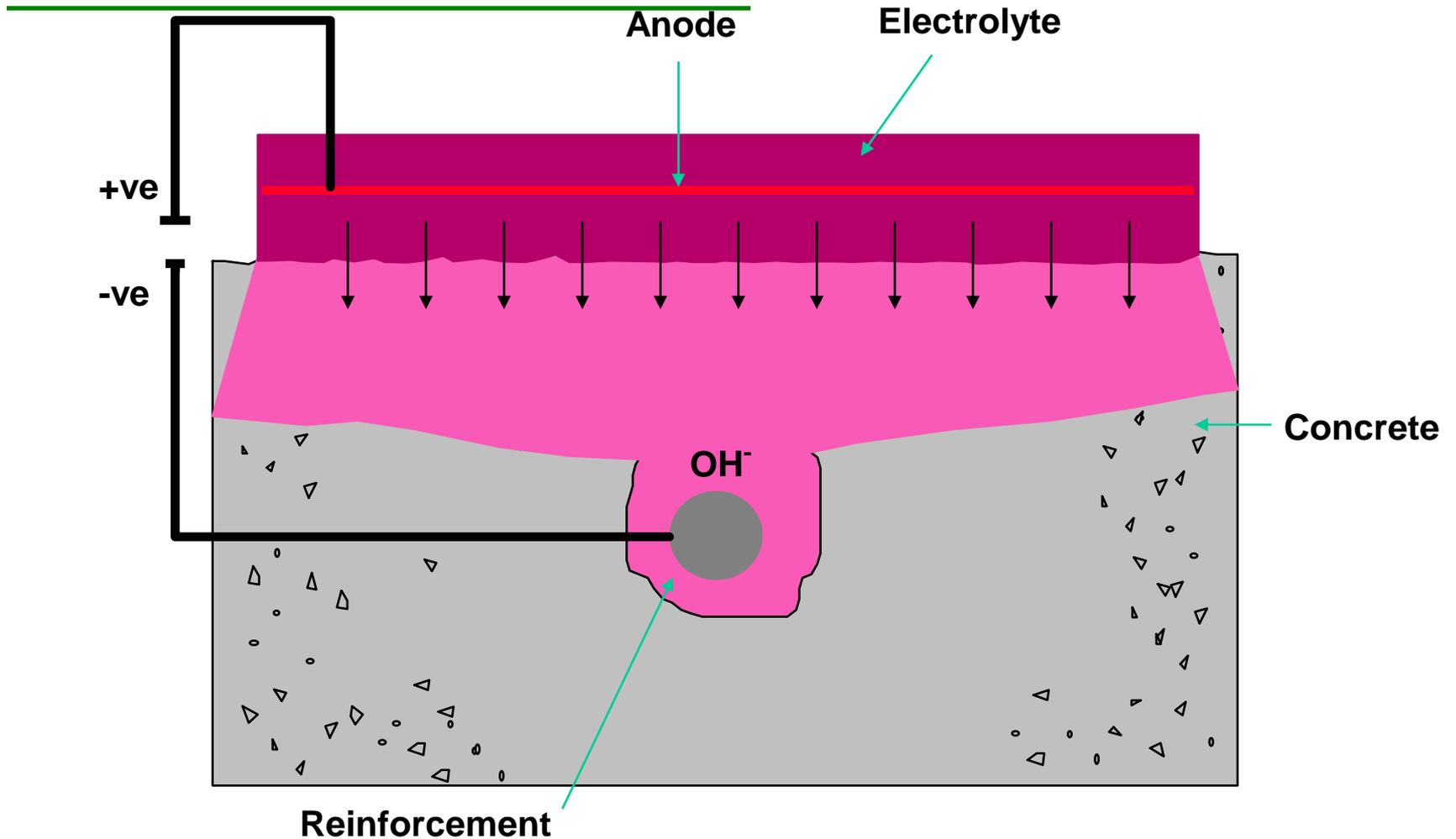
Realkalization



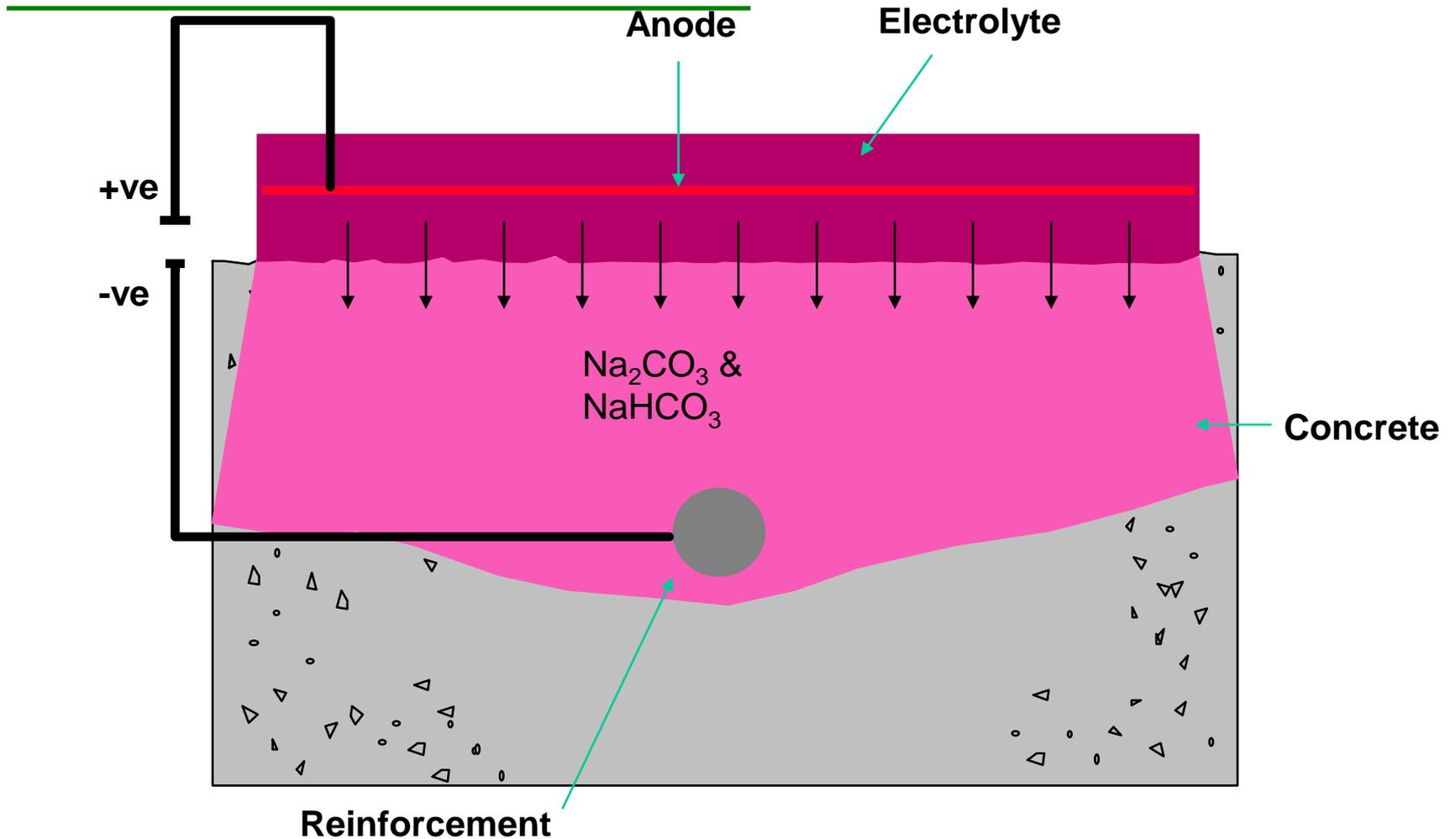
Realkalization



Realkalization



Realkalization



Access & Protection



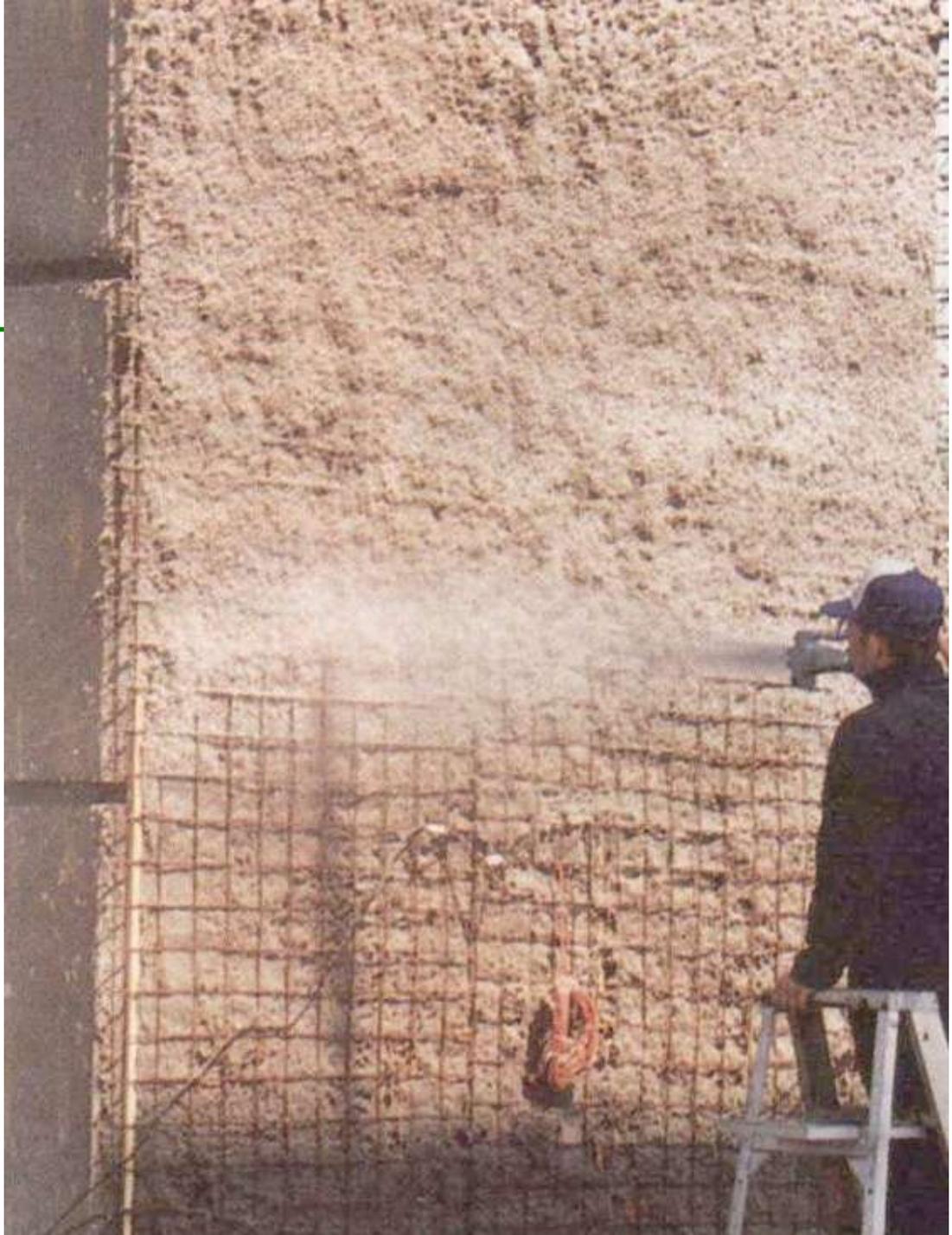
- Protection of windows installed.
- Scaffolding installed to access all walls.





**Norcure® Chloride Extraction and
Re-alkalization of Concrete Facade.**

**Reagan National Airport
Washington, DC**





Verification of Results

- Phenolphthalein (pH) Testing on Cores

Before



After Realkalization





Realkalization - Results

- Highly alkaline zone around steel
- Strong passivation occurs
- Cover zone impregnated with potassium carbonate, high final pH
- Low alkalinity problem is rectified
- Entire surface treated
- No further corrosion

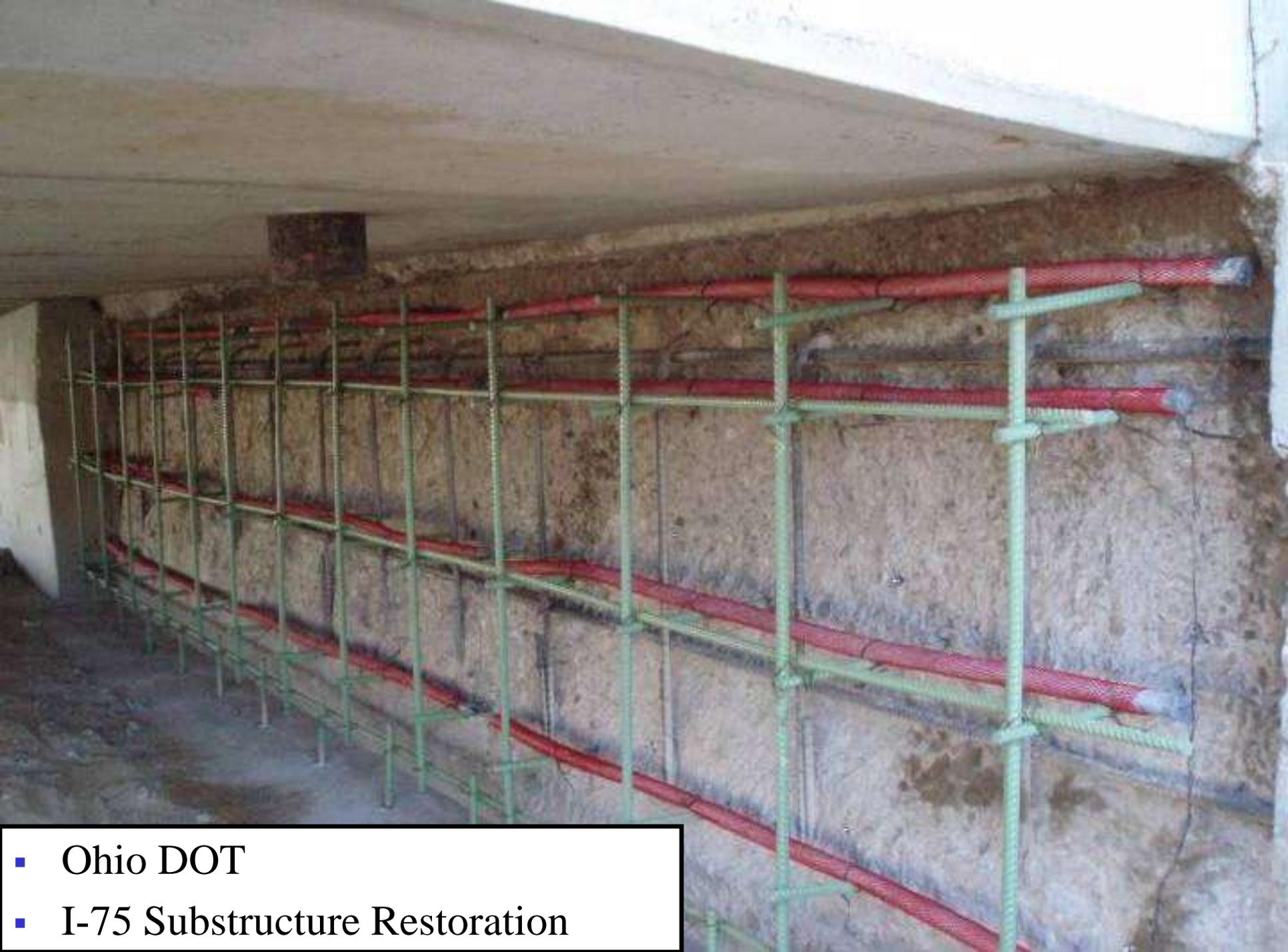




Image courtesy of Eric Taylor



- Ohio DOT
- I-75 Substructure Restoration



- Ohio DOT
- I-75 Substructure Restoration



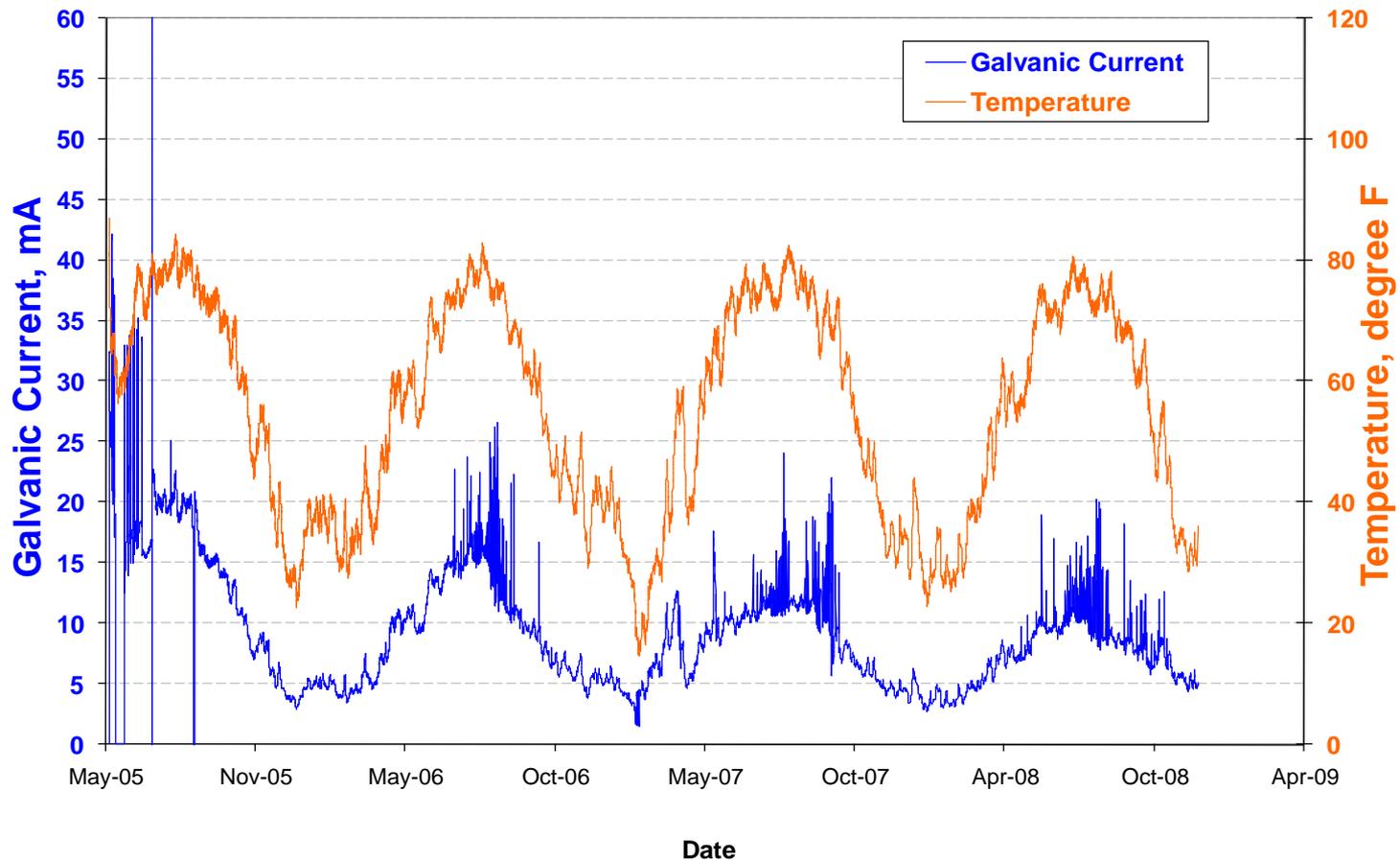
- Ohio DOT
- I-75 Substructure Restoration

7 19:51



Completed repair

Kirkwood Road – Protective Current



Kirkwood Road Performance

Date	Temperature (C)	Current (mA/m ²)	Polarization (mV)
5/6/05		37.7	
7/20/05		13.9	346
8/16/05	31	12.9	333
10/26/05	12	5.4	394
12/7/05	11	3.2	339
5/1/06	14	7.5	335
12/20/06	4	4.3	500
5/30/07	26	7.5	446
9/20/07	24	9.7	484
12/09/08	4	3.3	470
7/9/09	23	3.3	475



Presentation Summary:

- Corrosion of Steel in Concrete
- Types of Corrosion Protection Systems
- Electrochemical Treatments
 - Re-alkalization
- Galvanic Protection
- Project Examples



Thank You

Vector Corrosion Technologies

www.vector-corrosion.com



Questions

?



Compliments of Computer History Museum



Sustainability and the Environment



Concrete in Society

- Concrete is the most widely used man-made product in the world
- 6 Billion tons per year (~4 Billion m³)
- Huge consumer of raw materials and energy
 - Cement
 - Aggregate
 - Concrete production and transport
 - Steel production is also energy intensive



Concrete in Society

- Overall Total CO₂ produced
 - Cement: 1 Billion tons CO₂ per year
 - Aggregate: ~ 50 Million tons CO₂ per year
 - Ready Mix: 150+ Million tons CO₂ per year
 - Rebar: 200 Million tons per year
- Total CO₂ produced: ~ 1.5 Billion tons / yr



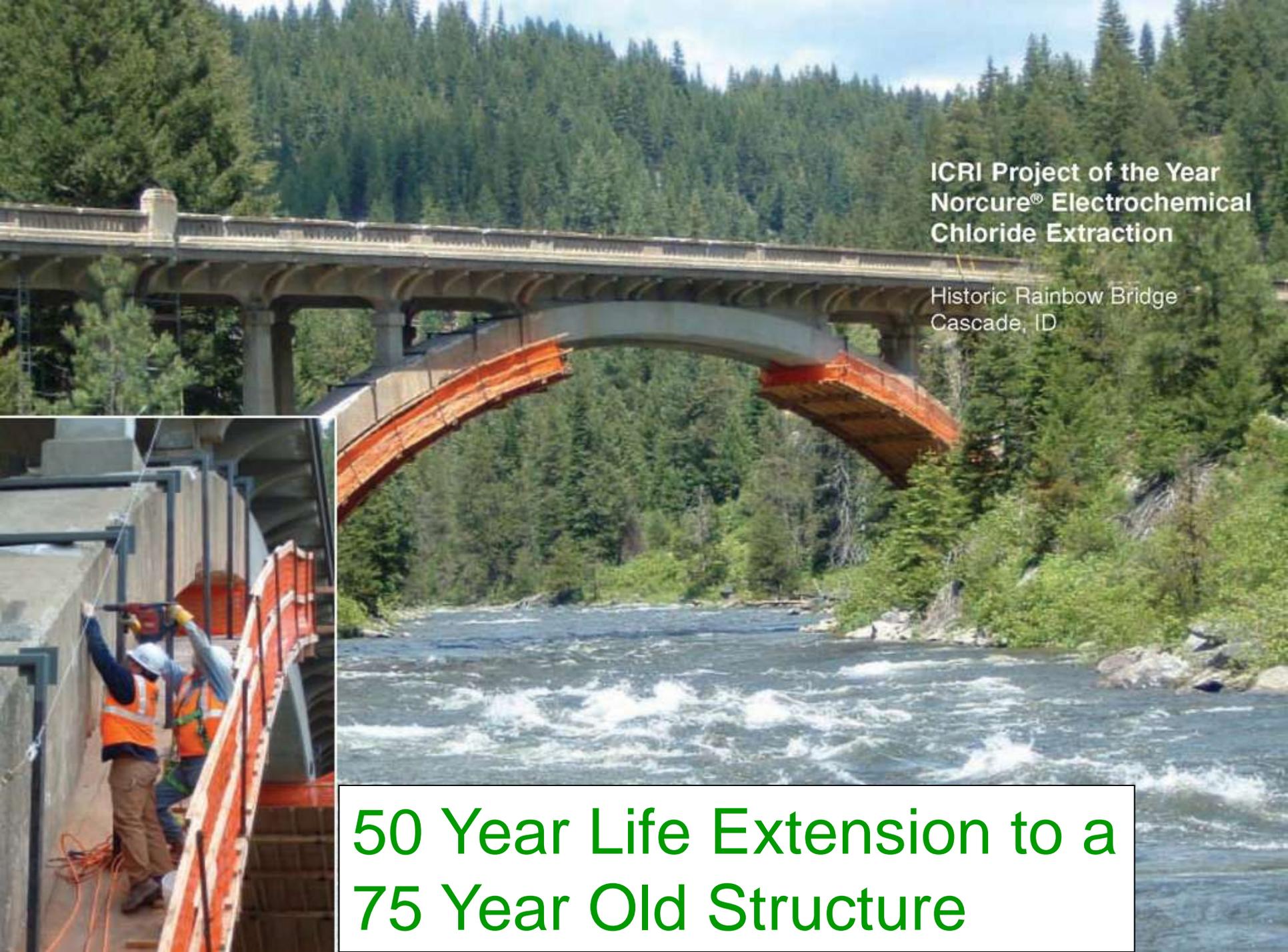
Concrete in Society

- Other Emissions
 - Carbon Monoxide: 10 Million tons per year
 - Nitrogen Oxides: 30 Million tons per year
 - Sulfur Dioxide: 29 Million tons per year
 - Volatile Organic Compounds: (VOC's)
2 Million tons per year
- Thermal pollution is also significant.



Concrete in Society

- Thermal pollution from concrete production is ~ 8 Billion GJ / yr.
- 1 GJ = A lot of Heat
- This is enough heat energy to raise the temperature of 1 million square kilometers of water (1 meter deep) by 1°C / year.



ICRI Project of the Year
Norcure® Electrochemical
Chloride Extraction

Historic Rainbow Bridge
Cascade, ID



50 Year Life Extension to a
75 Year Old Structure



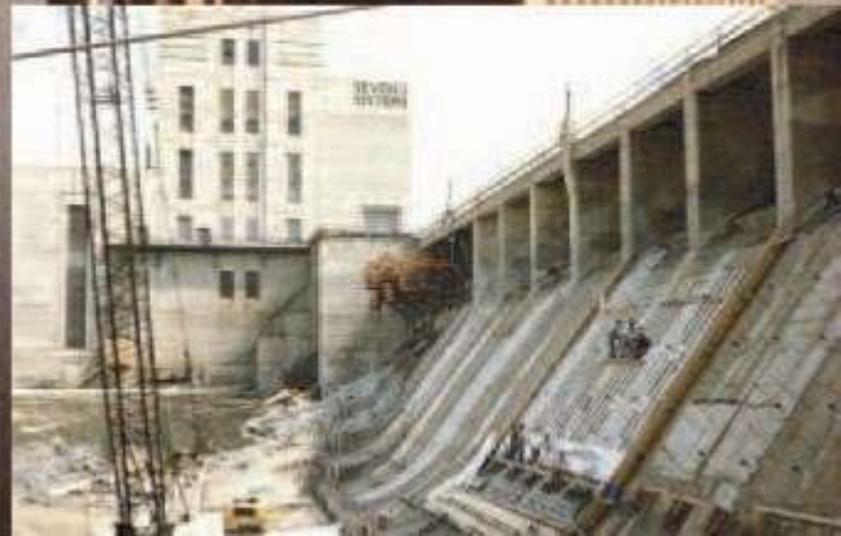
Rainbow Bridge Rehabilitation

- 50 year service life extension.
- 1,809 yd³ of concrete were maintained in service.
- Reduced CO₂ emissions by ~ 450 tons.
- Prevented the release of 4,800 GJ of heat.
(enough heat to boil 3 Olympic Pools)
- Equivalent to annual emissions of 90 people



**ICRI Award of Excellence
for Concrete Rehabilitation
Longevity.**

Seven Sister's Generating Station 1981
Manitoba, Canada





Seven Sisters Rehabilitation

- 40 - 50 year service life extension.
- 38,000 yd³ of concrete were maintained in service.
- Reduced CO₂ emissions by 9,500 tons.
- Equivalent to annual emissions of 1,900 people.



Call to Action

- This is an Important Issue,
- Think about the Reality,
- Accept Responsibility for the Situation, and
- Take Action



Thank You

Vector Corrosion Technologies

www.vector-corrosion.com



Questions

?