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\textsubscript{2}CO\textsubscript{3} / K\textsubscript{2}CO\textsubscript{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

- Anode
- Electrolyte
- Reinforcement
- Concrete
Realkalization

Anode
Electrolyte

Concrete
Reinforcement
OH⁻
Realkalization

Anode

Electrolyte

+ve

-ve

Concrete

Reinforcement

OH⁻
Realkalization

Anode

Electrolyte

Na$_2$CO$_3$ & NaHCO$_3$

Reinforcement

Concrete
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
Ohio DOT
I-75 Substructure Restoration
Ohio DOT
- I-75 Substructure Restoration
Innovative Concrete Pumping Technique

- Ohio DOT
- I-75 Substructure Restoration
Completed repair
Kirkwood Road – Protective Current
# Kirkwood Road Performance

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Presentation Summary:

• Corrosion of Steel in Concrete
• Types of Corrosion Protection Systems
  – Re-alkalization
• Galvanic Protection
• Project Examples
Thank You

Vector Corrosion Technologies

www.vector-corrosion.com
Questions
THINK

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 m$^3$)
• Huge consumer of raw materials and energy
  – Cement
  – Aggregate
  – Concrete production and transport
  – Steel production is also energy intensive
Concrete in Society

- Overall Total CO$_2$ produced
  - Cement: 1 Billion tons CO$_2$ per year
  - Aggregate: ~ 50 Million tons CO$_2$ per year
  - Ready Mix: 150+ Million tons CO$_2$ per year
  - Rebar: 200 Million tons per year

- Total CO$_2$ 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.
50 Year Life Extension to a 75 Year Old Structure
Rainbow Bridge Rehabilitation

- 50 year service life extension.
- 1,809 yd$^3$ of concrete were maintained in service.
- Reduced CO$_2$ 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 yd$^3$ of concrete were maintained in service.
- Reduced CO$_2$ 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

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Questions