Cathodic Protection of Concrete in Harsh Saltwater Environments

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Overview

• Corrosion of Steel in Concrete
• What is Cathodic Protection
• Types of protection systems
  • Sacrificial (Galvanic) Cathodic Protection
  • Impressed Current Cathodic Protection
• Project Histories
Corrosion Cell
Reinforced Concrete
Corrosion Cell in Concrete

Anode

-500 mV

γFe₂O₃

γFe₂O₃

Fe₃O₄

2e⁻

-350 mV

-200 mV

Cathode
Anode Galvanically Protects Surrounding Rebar

-200 mV

-1100 mV

-350 mV
Types of Galvanic and Impressed Current Systems
Cathodic Protection Systems

• Work by applying current to reinforcing steel to overcome the corrosion process

• Galvanic Systems
  • Sacrificial metal corrodes to provide electrons

• Impressed Current Systems
  • D.C. power makes electrons flow from anode to reinforcement (cathode)
Galvanic Protection Systems

• Anode has higher “electronegativity”, corrodes in preference to steel
• No outside source of electricity needed
  • No electrical components to maintain
• Lower driving voltage avoids hydrogen embrittlement of prestressed steels
Impressed Current CP

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

Permanent DC Power Supply
Impressed Current CP
ICCP on Marine Bridge Footer
Copper Plant, Chile

- Copper concentrate filter plant and shipping built 1996 – 1999
- Corrosion due to cast in chlorides
- Tanks, support structures, and ship loading pier
- ICCP with various anode types
  - Ebonex conductive ceramic discrete anodes
  - Titanium mesh in concrete overlay
  - Impressed current and galvanic anodes in soil
Galvanic Systems

• Discrete Anodes
Discrete Anodes
Galvanic Systems

- Galvanic Jackets
Galvanic Jackets
Galvanic Systems

- Bulk Anodes
Bulk Anodes
Galvanic Systems

- Metalizing
Metalizing Spray
Port of Canaveral
North Cargo Pier Repairs
North Cargo Piers

• 700 - Galvanic Jackets, with bulk anodes
• 50,000sqft - Metalizing on Precast Deck Units
• 5000 ft - Strip Anodes in Pile Caps
Galvanic Jacket – Port Canveral
Galvanic Jacket – Port Canveral
Galvanic Jacket – Port Canveral
Bulk Zinc Anode - Port Canveral
Galvanic Jacket – Port Canveral
Galvanic Jacket – Port Canveral
Strip Anodes – Port Canveral
Strip Anodes – Port Canveral
Strip Anodes – Port Canveral
Metalizing Spray – Port Canveral
Metalizing – Port Canveral
Metalizing – Port Canveral
Metalizing – Port Canveral
Metalizing – Port Canveral
Strip Anodes - Deck

- Elevated Slab
- Near Gulf Coast
- Chloride Contamination
New Construction
Cataño Ferry Terminal
San Juan

• Old Terminal was 35 years old
• New - 240 feet x 312 feet wide
• 4600 passengers a day
• Completed in 2012
• Met U.S. Green Building Council Requirements
Discrete Anodes New Construction
Summary

• Galvanic or Impressed Current Systems
• Targeted or Global Protection
• Restoration and New Construction
• Service Life of system can be adjusted
QUESTIONS

Thank You
Jason Chodachek