## Preserving port infrastructure for the future

#### J. Chris Ball Vector Corrosion Services



#### **Benefits of Preservation**

- Economic, Environmental, Disruption, etc.
- The construction industry is the single largest global consumer of resources and raw materials, almost 50% the total.
- Up to 40% of solid waste derives from construction and demolition.



Maintenance, Repair, Strengthening, Corrosion Mitigation, Reuse, Repurpose

Corrosion is one of the largest costs to the U.S. economy, estimated at over 6% of GDP











#### **Repair Process**



#### Visual & Delamination Survey



#### **IMPACT-ECHO MEASUREMENTS**

Concrete thickness Concrete delamination





#### PULSE-VELOCITY MEASUREMENTS

Concrete cracking Concrete strength



#### **Corrosion Potential Mapping**





of Uncoated Reinforcing Steel in Concrete

# Depth of Cover, Chloride Sampling and Analysis





#### Ground Penetrating Radar

GPR Data Indicative of Voiding/Subsidence



Depth in Inches

## **Concrete & Timber Pile Lengths**



**Parallel Seismic** 

## **Steel Pile Lengths**

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#### **Cathodic Protection**

#### **Cathodic Protection General Categories**

- **Cathodic Protection Systems** 
  - Galvanic
  - Impressed Current
- 2-stage ICCP and Galvanic (Fusion)





**Galvanic Systems** 



Cathodic Protection



#### **Galvanic Protection**

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#### **Steel Piles**

#### **Concrete Structures**

#### **Structure Expansion**





#### **Service Life Extension**

#### **Copper Plant, Chile**

- Copper concentrate filter plant and shipping
  - Built 1996 1999
- Corrosion due to cast-inchlorides
- Tanks, support structures, and ship loading pier
- ICCP with various anode types
  - Discrete ceramic anodes
  - Titanium mesh in concrete overlay
  - Impressed current and galvanic anodes in soil



#### **Impressed Current Cathodic Protection**



#### MMO Titanium Ribbon Mesh - ICCP



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#### Preservation of Bulk Materials Loading Berth

- Built in 1983 to export coal
- 830' x 44'
- Potash export 1997
- Preserve structure for 30 years





#### **Structure Evaluation**

- Deterioration survey
  - Over 3,000 ft2 of concrete damage
- Chloride penetration
   and diffusion rates
- Corrosion rate
- Cover depth over reinforcing steel
- Estimate remaining useful service life
- Repair and corrosion mitigation options



#### **Berth Condition**







# Conveyor Condition







#### **Chloride Levels**



#### Service Life Modelling



# **Galvanic Protection**

- Arc Spray Zinc Anode
  - Berth Beams and Girders (49,276 ft2)
  - Conveyor Legs & Struts (7,050 ft2)
- Discrete Galvanic Anode (Type 2A)
  - Top Side of Exposed Beams (890 ea.)
- Discrete Galvanic Anode (Type 1A)
  - Concrete repairs without ASZ





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#### Arc Sprayed Zinc Anode







## Pilot Installation During Design Process



#### **Embedded Galvanic Anodes**

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#### **Pile Protection**





## ZincMesh Jacket

- Tidal zone protected
  - Zinc mesh anode
  - Open bottomed FRP Jacket
  - Allows saltwater inside
- Bulk anode for underwater protection





#### ZincMesh Jacket

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Tidal Zone Protection



#### Wicking Anodes Jacket



# Stay-in-Place Forms Options



Fiberglass Reinforced Polymer (FRP)

**Modular PVC** 

# Self-Activated Anode Jacket

#### Saltwater **NOT** required!

- Alkali Activated Anodes used to protect piles and columns in:
  - Saltwater
  - Brackish water
  - Fresh water and
  - Dry land applications.
- Use appropriate bulk anode for underwater protection when required.







# Summary

- Preservation of infrastructure
- Understanding the cause and magnitude of the problem
- Corrosion mitigation extends the life of structures
- Many cathodic protection options including impressed current and galvanic anodes

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# Thank You!

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