Practical Corrosion Considerations for Small Boat Harbors

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Valdez Alaska

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How Important is Corrosion?

- FHWA 2002 In Depth Study
- Annual Direct Costs of Corrosion = $276 Billion
- 3.1% of GDP
What is Corrosion?

- Corrosion is the deterioration of a substance or its properties because of a reaction with the environment.
- Corrosion is an electro-chemical process. It includes the transfer of ions and electrons.
- Rust is a common form of corrosion.
A Corrosion Cell

- Anode and Cathode
- Electrolyte
- Metallic Path
FIGURE 2.4 — Sketch showing flow of current between an anode and a cathode in a corrosion cell.
Anode and Cathode

- Dissimilar Metals (Battery)
- Differing grain structure in same base metal (Heat Affected Zone)
FIGURE 2.10 — Formation of ions at an anodic area and release of hydrogen at a cathodic area in a local cell on an iron surface.
Electrolyte

- Sea Water
- Fresh Water
- Soil
Types of Corrosion

- General or Uniform
- Pitting
- Crevice
- Many Others
General Corrosion Rates

- Typical saltwater 5-10 mils per year. About $\frac{1}{4}$” in 25 years
- Cook Inlet 20 mils per year. About 1/2” in 25 years
- Pitting rates can be much higher!
Figure 2.6  Corrosion rate profile of steel sheet piling. [From Edwards, 1963]
What is so special about Cook Inlet?

- Cold water contains more oxygen
- Moving water brings fresh oxygenated water in contact with surface.
- Silt particles “sand blast” corrosion deposit film away
- Fresh water lens on surface forms oxygen concentration cell
Strategies to deal with corrosion

- Materials Selection
- Extra Thickness “Corrosion Allowance”
- Coating
- Galvanizing
- Anodes
- Design Considerations
Materials Selection

• Use Plastic
• Use Concrete
• Use Aluminum
• Use Stainless Steel, Bronze or Brass
• Use Weathering Steel (ASTM A690)
Corrosion Allowance

- Calculate corrosion rate and wastage at design life.
- Consider minimum plate thickness of \( \frac{1}{4} \) or 3/8 inch
Coating

- Perfect coating = no corrosion
- Key is surface prep and QC
- Many examples in automobiles and steel boats
- Many good new coating systems including epoxies and urethanes
Coated Sheet Piling
Coating Failure on Sheet Pile Cell
Sheet Pile Coating at Mud Line
Galvanizing

- Sacrificial Coating (3 to 6 mils typical)
- Good for 15 to 20 years
- Must be Hot Dip
- No zinc plated items in harbors
Pipe Piling
Pipe Pile With Some Galvanizing
Galvanizing Gone
Sacrificial Anodes

- Simplest system
- Can be zinc, aluminum, or magnesium.
- These have limited current output and will protect a limited area.
- Analogous to a handheld flashlight
Impressed Current Anodes

- High current output / can protect large areas
- Can be mounted on piles or on sleds. Need heavy wires and rectifiers above water.
- More complicated system requires regular maintenance
- Analogous to electric street lights
Anode Sled
Pile Mounted IC Anode
Design Considerations

• Consider minimum plate thickness
• Consider seal welding all fabrications
• Minimize or eliminate overlapping plates
• Eliminate H sections if possible
• Eliminate pile splices in high corrosion zones
• Don’t use thin stainless sections or banding
Think Systems and Service Life

- No one item will solve all problems
- Consider several measures,
  - Example corrosion allowance and hot dip galvanizing
  - Example coating and sacrificial anodes
- Put effort in up front: better to prevent cancer than to try and cure it.
### Service Life Example

**Durability by Design - Options**

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<th>Section</th>
<th>1 Sacrificial Thickness years</th>
<th>2 A 690 years</th>
<th>3 / 3a Steel Grade Gr 50 to Gr 55 / Gr 60</th>
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Don’t

- Put bare steel in salt water
- Use zinc plated fittings, (use hot dip)
- Use thin stainless steel sections
- Let bean counters remove corrosion control from your projects
Questions?