



## Optimizing Steel Design Life using High Capacity Pipe to Pipe Systems in Port Berthing Structures

Gerry McShane

## Durability of Steel



### Designing Steel for Durability

## Durability of Steel

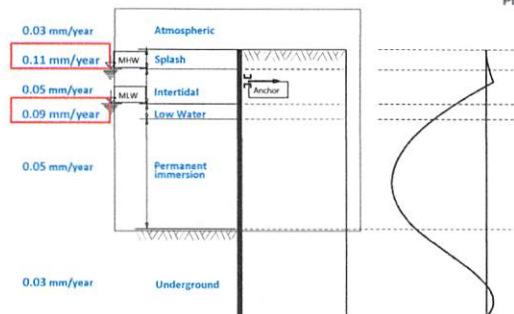


The number 1 option is Sacrificial thickness

### 1. Sacrificial Thickness

- b. Higher Grade Steel
- c. Coatings
- d. Marine Grade Steels
- e. Cathodic Protection

## Rate of Corrosion and Zones



Rates of corrosion are used to determine design life from sacrificial thickness

## Durability of Steel



### Options

- ✓ **Sacrificial Thickness** (if this is not sufficient additional measures are added)
  - ✓ **Higher Grade Steel** (small gain from designing to mild steel stresses but using high yield steel)
    - a) Coatings
    - b) Marine Grade Steels
    - c) Cathodic Protection

## Durability of Steel



### Options

- ✓ **Sacrificial Thickness** (if this is not sufficient additional measures are added)
  - ✓ **Higher Grade Steel** (small gain from designing to mild steel stresses but using high yield steel)
    - a) **Coatings**
    - b) Marine Grade Steels
    - c) Cathodic Protection

## Durability of Steel



### Coatings

Polyamide cured epoxy primer  
 Polyamide cured coal tar epoxy coating  
 Nominal dry film thickness of 400µm (16 mils)

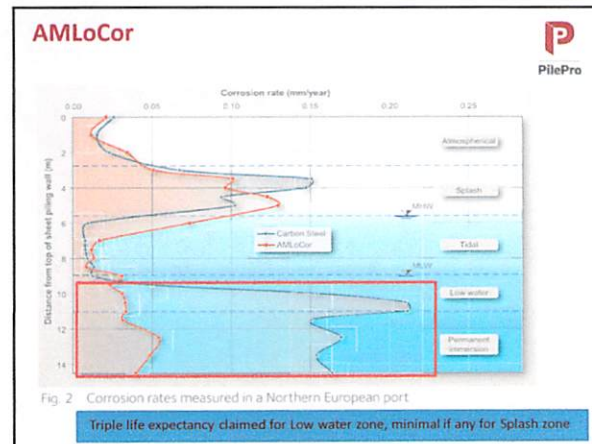
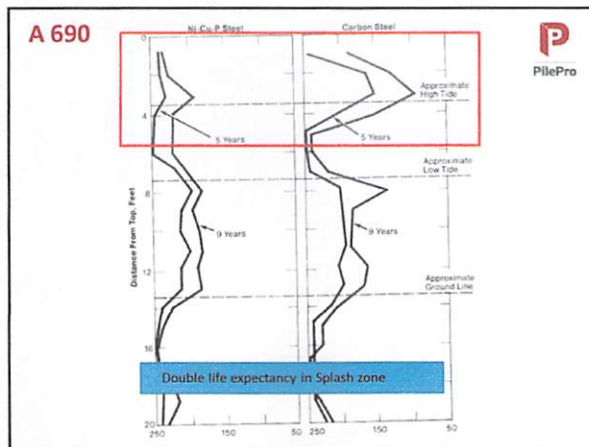
Adds approx. 15 years design life

## Durability of Steel



### Options

- ✓ **Sacrificial Thickness**
  - ✓ **Higher Grade Steel**
  - ✓ **Coatings**
    - a) **Marine Grade Steels**
    - b) Cathodic Protection



## Durability of Steel



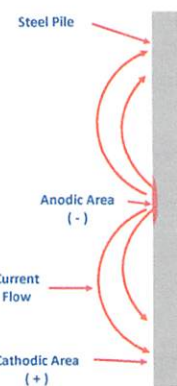
### Options

- ✓ Sacrificial Thickness
  - ✓ Higher Grade Steel
  - ✓ Coatings
  - ✓ Marine Grade Steels
- a) Cathodic Protection

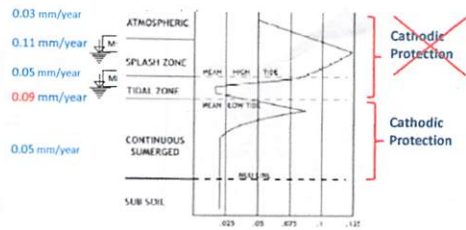
## Durability of Steel

### Cathodic Protection

- Design life: indefinite with scheduled program of maintenance.
- 5 year review of system. Maintenance or replacement of base metal anode (aluminum) or electrical continuity upgrade at 20 years.

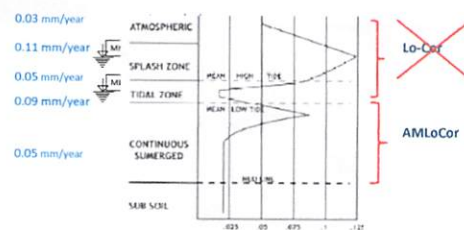


### Corrosion Options – Caution!



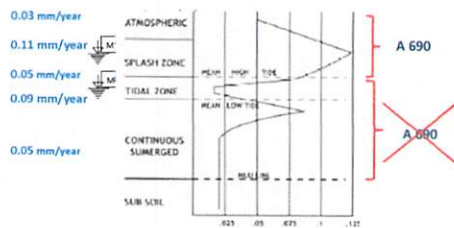
Cathodic Protection is NOT effective in SPLASH zone

### Corrosion Options - Summary



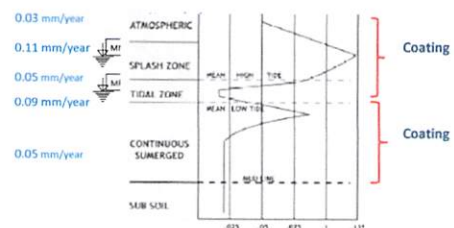
AMLoCor is NOT effective in SPLASH zone

### Corrosion Options - Summary

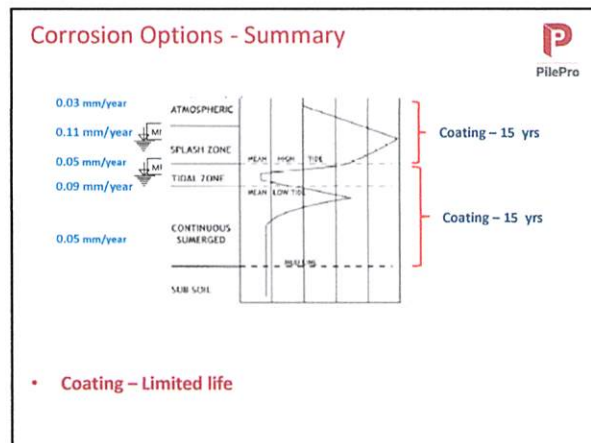
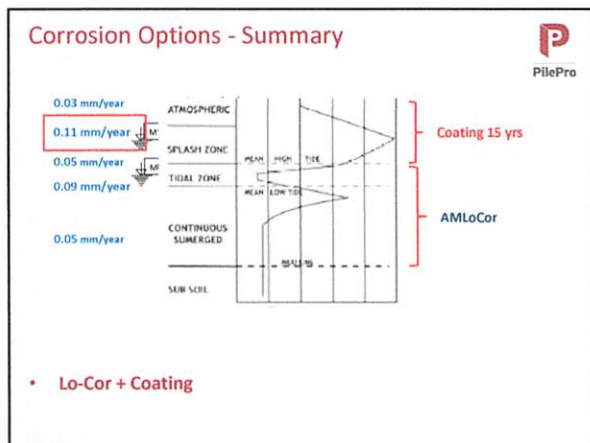
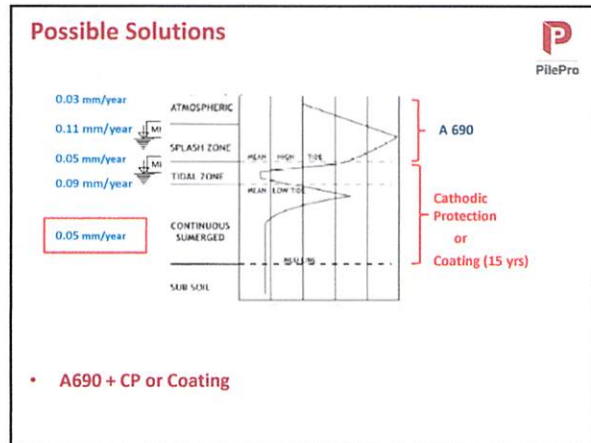
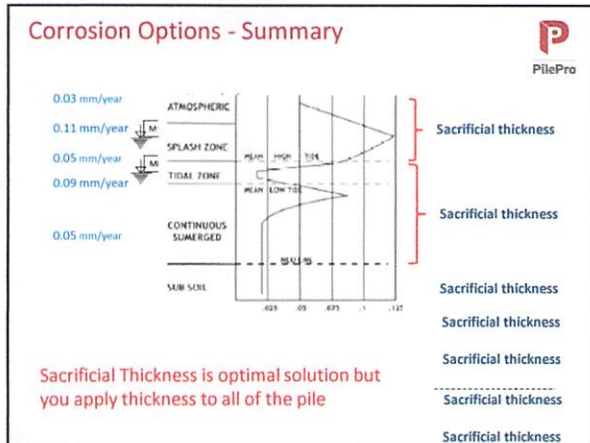


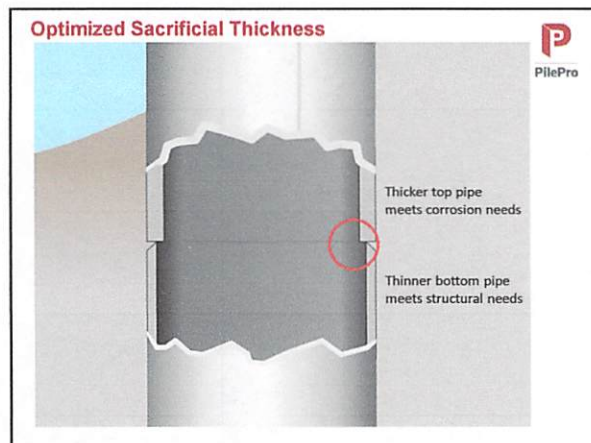
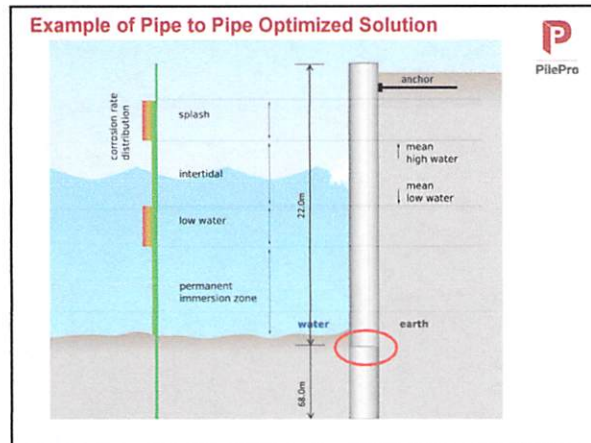
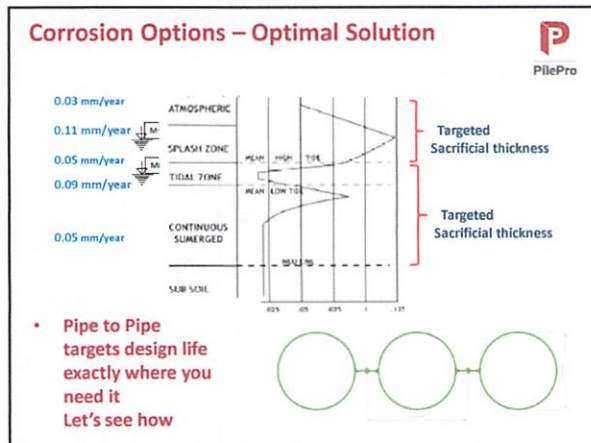
A690 is NOT effective in continuous submerged zone

### Corrosion Options - Summary

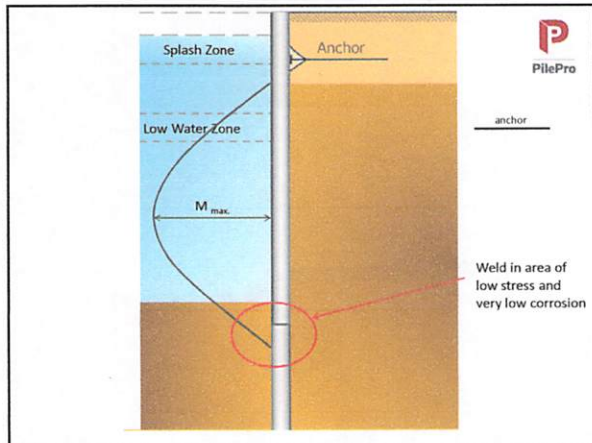


Coating Protection is effective but has limited life









### Sacrificial Thickness example

1. Requirement –  $S = 90 \text{ ins}^3/\text{ft}$  with 75 years life

Use ISheetPile to quickly find a sheet pile

The screenshot shows the PilePro software interface. The 'Find & Configure' tab is selected. Under 'Find PRODUCTS by Selection', the 'By name' dropdown is set to '90'. The 'BUILD A COMBINED SHEET PILE WALL' section is also visible, showing options for 'By Selection', 'By Intermediate Pile', and 'By End Pile'.

The screenshot shows the PilePro software interface. The 'Products' tab is selected. Under 'The system you selected', a list of products is shown. Under 'The Top Manufacturer listed solutions (matching section modulus + lowest weight)', a list of products is shown. A red arrow points to the 'AZ50' product.

### Sacrificial Thickness Example - ISheetPile

1. Requirement –  $S = 90 \text{ ins}^3/\text{ft}$  with 75 years life

AZ50 meets Structural needs

$S = 93.3 \text{ ins}^3/\text{ft}$   
 $MOI = 886.5 \text{ ins}^4/\text{ft}$

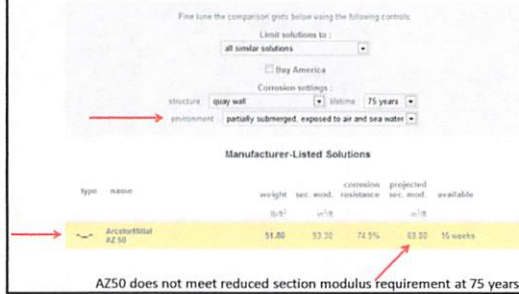
The screenshot shows the PilePro software interface. The 'Products' tab is selected. The 'AZ50' product is highlighted. The 'AZ 50' section shows the product details, including the section modulus  $S = 93.3 \text{ ins}^3/\text{ft}$  and the moment of inertia  $MOI = 886.5 \text{ ins}^4/\text{ft}$ .

## Sacrificial Thickness Example



1. Requirement –  $S = 90 \text{ ins}^3/\text{ft}$  with 75 years life

## Calculate Durability And Show Alternatives



## Now let's try this with a Pipe to Pipe solution



1. Requirement –  $S = 90 \text{ ins}^3/\text{ft}$  with 75 years life

Find & Configure

Limit solutions to: **all similar solutions**

Corrosion settings: **lifetime** **75 years**

Structure: **quay wall**

Environment: **partially submerged, exposed to air and sea water**

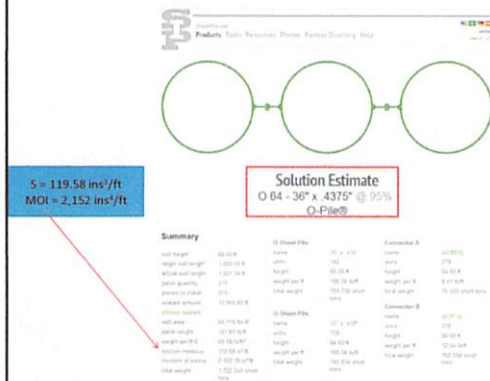
Manufacturer-Listed Solutions

type	name	weight	sec. mod.	corrosion resistance	projected sec. mod.	available
		lb/ft	in <sup>4</sup> /ft		in <sup>4</sup> /ft	
~	Architectural AZ 50	51.80	53.30	74.3%	63.00	16 weeks

AZ50 does not meet reduced section modulus requirement at 75 years

Use iSheetPile to quickly find a pipe system

## Now let's try this with a Pipe to Pipe solution



## Sacrificial Thickness Example



1. Requirement –  $S = 90 \text{ ins}^3/\text{ft}$  with 75 years life

## Calculate Durability And Show Alternatives





Now choose pipe size for the upper portion of pipe

**Solution Estimate**  
 $\phi 90 \times 36" \times 625" @ 100\%$   
 O-Pile®

**Summary**

Summary		O-Steel Pipe		Connector A	
wall height	21.00 ft	name	36" x 525"	name	10750-01
target wall length	1,000.00 ft	width	36"	width	270"
actual wall length	1,000.00 ft	height	21.00 ft	height	22.00 ft
panel quantity	179	weight per ft	256.16 lb/ft	weight per ft	8.41 lb/ft
panels to install	179	total weight	256,160 lb	total weight	20,719 lb (not used)
total weight	4,716.00 ft				
vertical spacing		O-Steel Pipe		Connector B	
wall area	21,000.00 ft²	name	36" x 525"	name	10750-01
panel weight	256.16 lb/ft	width	36"	width	270"
weight per ft	256.16 lb/ft	height	21.00 ft	height	22.00 ft
vertical modulus	100.00 lb/ft	weight per ft	256.16 lb/ft	weight per ft	8.41 lb/ft
moment of inertia	1,000.00 lb/ft²	total weight	256,160 lb	total weight	20,719 lb (not used)
total weight	100,000 lb				

**Sacrificial Thickness Example**

1. Requirement –  $S = 90 \text{ ins}^3/\text{ft}$  with 75 years life

Calculate Durability And Show Alternatives

Free tune the comparison grids below using the following controls:

Limit solutions to:

☐ Bay America

Corrosion settings:  75 years

structure:  environment:

36" x 0.625" exceeds reduced modulus for upper pipe at 75 years

type	name	weight	sec. mod.	corrosion resistance	projected sec. mod.	available
AccountTitle	AZ 50	18.88	53.35	74.9%	69.88	16 weeks
	O-Pile®	16.58	119.62	91.7%	129.63	4 weeks
	O-Pile®	95.95	163.16	63.2%	106.27	4 weeks

**Costing Out The Various Options**

1. AZ 50 1000' x 90' wall = 2,333t (Grade 50 steel)

Options

- AZ50 + A690 + Coating = \$4,544,000
- AZ50 + A690 + CP = \$4,522,000
- AZ50 + AMLoCor + Coating = \$4,614,000
- Pipe to Pipe

36" x 0.625" x 22.0 m  
 36" x 0.4375" x 68.0 m

Costs estimated based on known product rates April 2011

**Costing Out The Various Options**

1. AZ 50 1000' x 90' wall = 2,333t (Grade 50 steel)

Options

- AZ50 + A690 + Coating = \$4,544,000 +7.2%
- AZ50 + A690 + CP = \$4,522,000 +7.0%
- AZ50 + AMLoCor + Coating = \$4,614,000 +9.0%
- 36" x 0.625"  
 36" x 0.438"  
 + WOM/WOF-XL connector  
 = 2435t = \$4,237,000

The targeted sacrificial thickness option gives an economical solution without the need for coatings or special steel grades

Costs estimated based on known product rates April 2011