Galvanic Cathodic Protection of Concrete Structures

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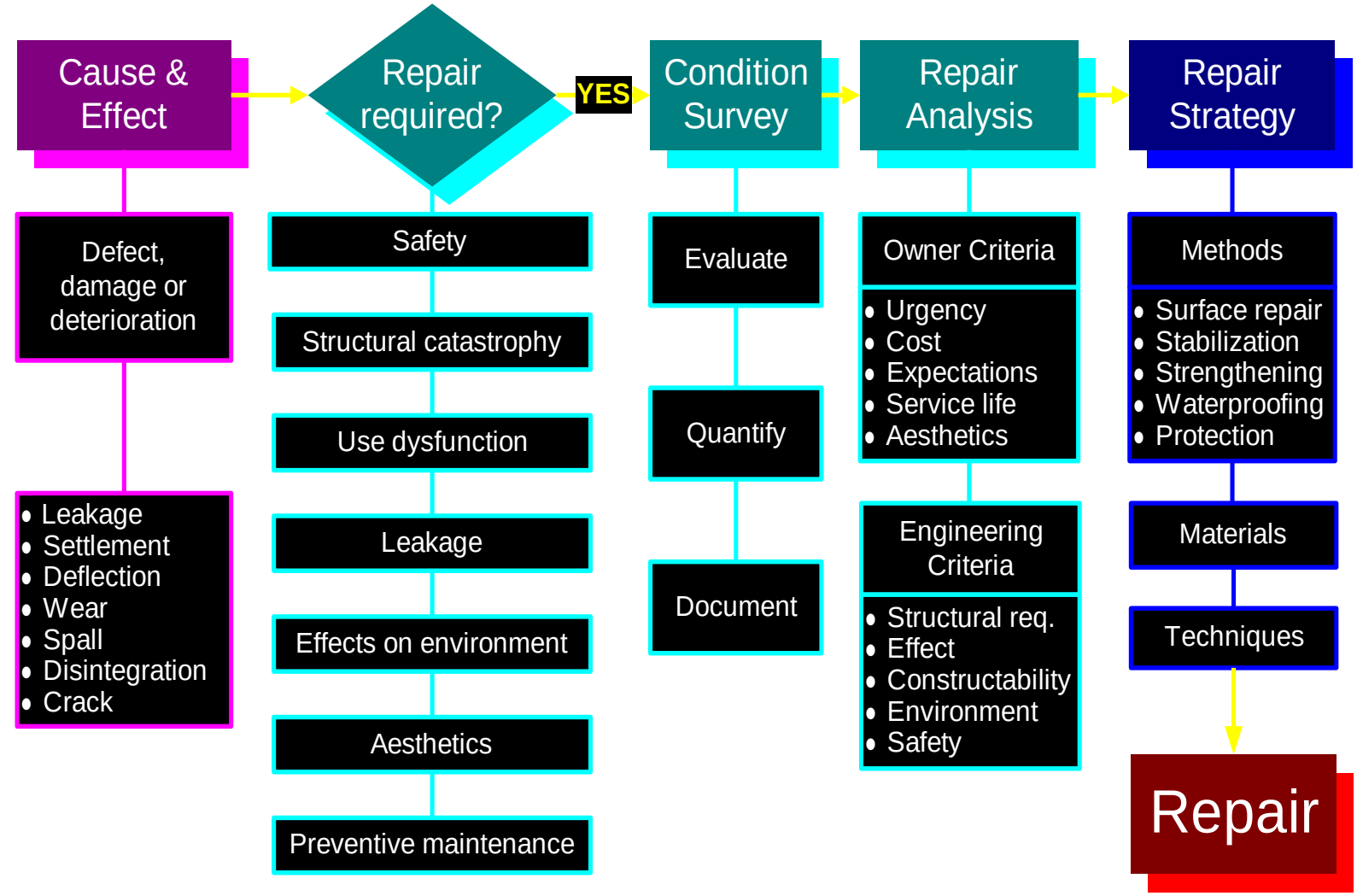
Vector Corrosion Technologies

VECTOR CORROSION TECHNOLOGIES

Concrete Repair Process



Corrosion Ravaged Bridge Columns

Halo Effect / Patch Accelerated Corrosion

Levels of Corrosion Protection

Cathodic Protection	Highest level of protection intended to stop on-going corrosion activity
Corrosion Control	Significantly reducing or stopping on-going corrosion activity
Corrosion Prevention (Cathodic Prevention)	Preventing new corrosion activity from initiating

Cathodic Protection

- Address active corrosion
- Reduce corrosion rate to approximately zero
- Typical applied current: 5 to 20 mA/m^2
- 100 mV+ potential shift

Corrosion Control

- Address Active Corrosion
- Significantly reduce corrosion rate
- Typical applied current: 1 to 7 mA/m^2
- Research has shown that as little as 1 mA/m^2 achieved 96% reduction in delamination growth

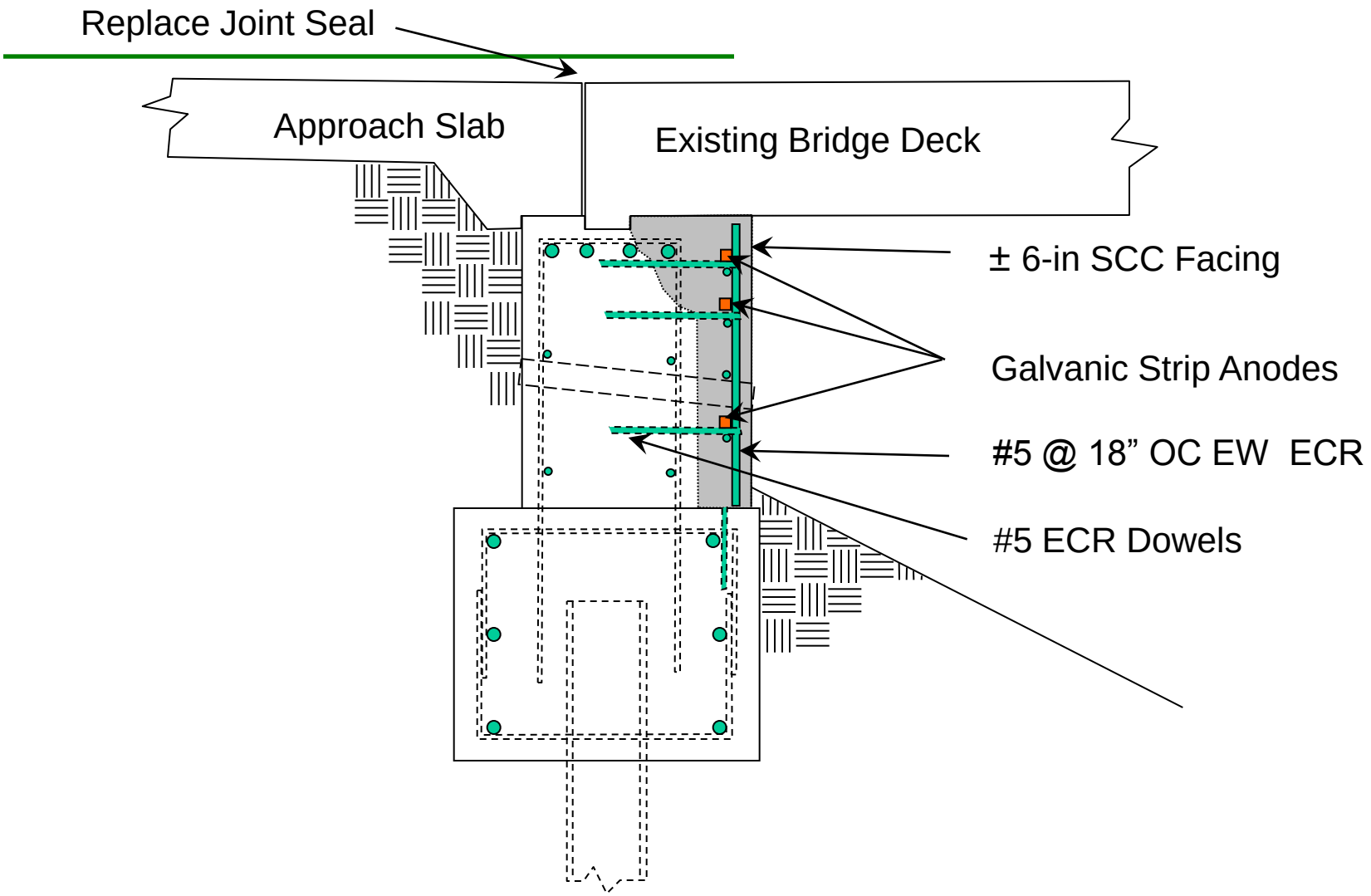
Corrosion (Cathodic) Prevention

- Mitigate the initiation of corrosion
- Current density required is lower than amount necessary to stop on-going corrosion activity
  - Research has shown that 0.25 to 2 mA/m^2 is sufficient to prevent corrosion initiation
- New Construction
- Repair

Corrosion Protection

- Current Provided to the Reinforcing Steel
  - Impressed Current Systems
  - Galvanic Systems
- Both Types of Systems can Provide Corrosion Protection to Steel in Concrete

Abutment Repair Detail With Galvanic Protection

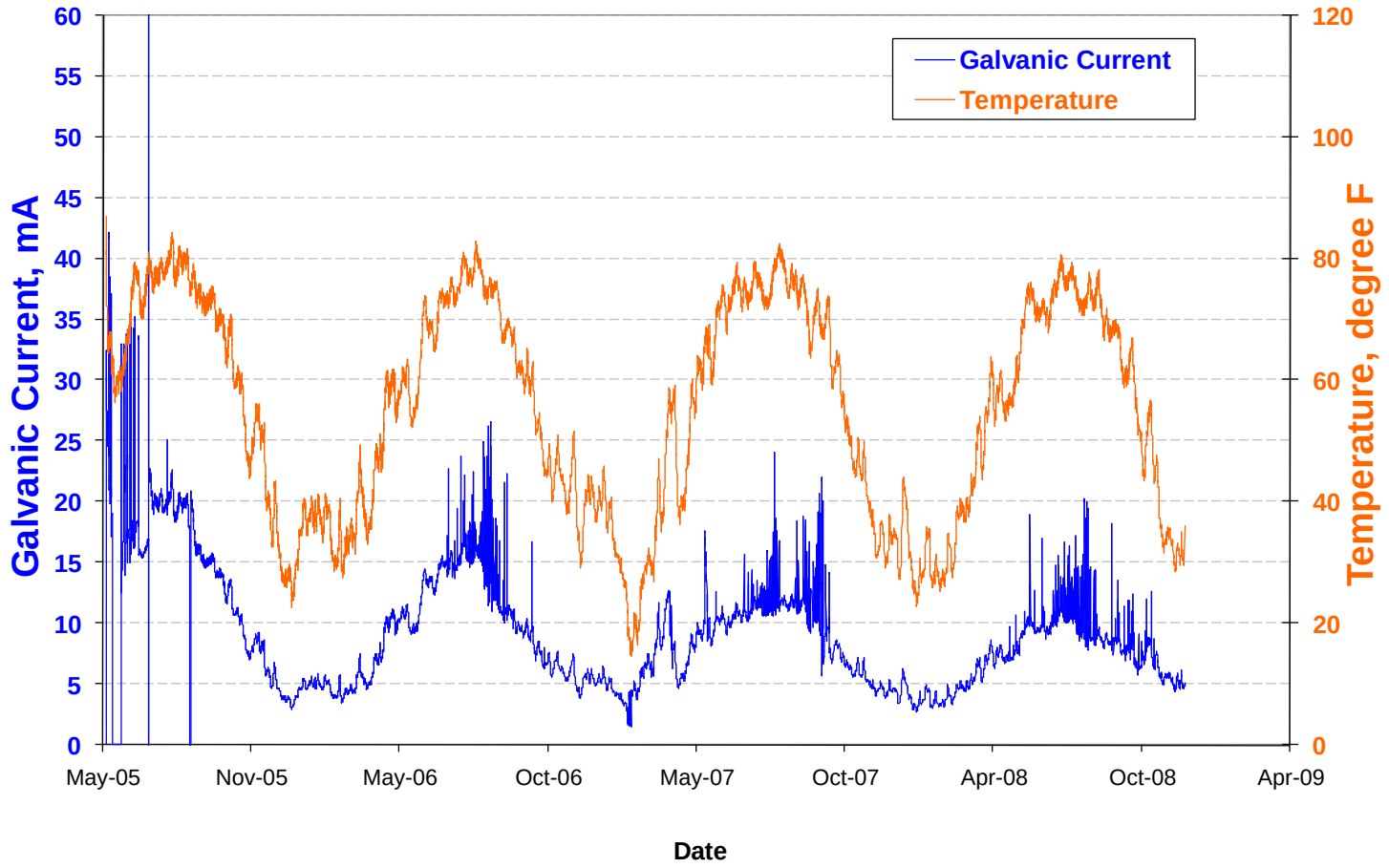


I-75 Ohio DOT


Forms installed


Completed repair

Kirkwood Road – Monitoring Protective Current and Temperature

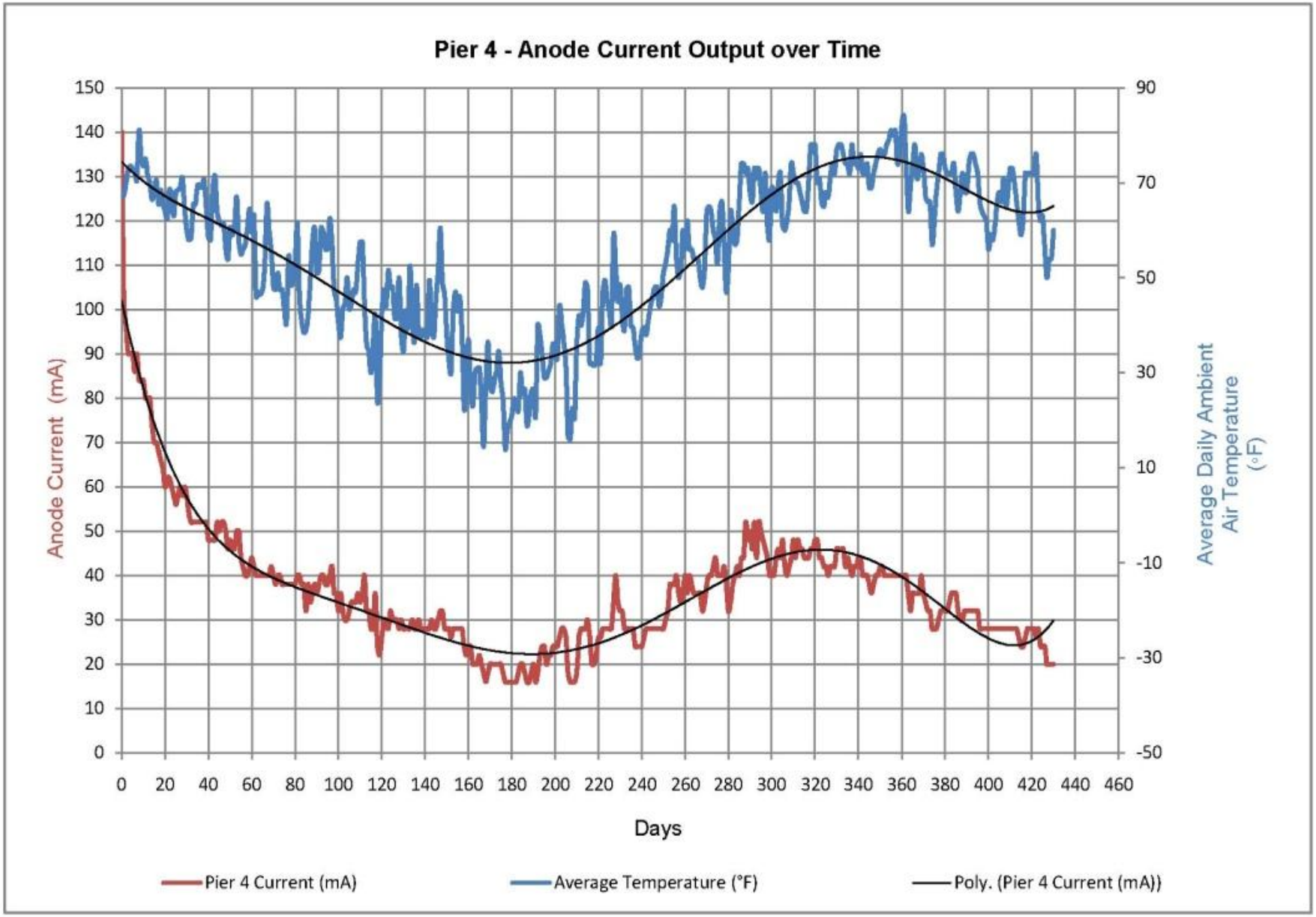


Kirkwood Road Monitoring

Date	Temp	mA/m2	Polarization	
5/6/05	(C)	37.7	(mA)	
7/20/05		13.9	346	
8/16/05	31	12.9	333	
10/26/05	12	5.4	394	
12/7/05	11	3.2	339	
5/1/06	14	7.5	335	
12/20/06	4	4.3	500	
5/30/07	26	7.5	446	
9/20/07	24	9.7	484	
12/09/08	4	3.3	470	
7/9/09	23	3.3	475	

Galvanode® Galvanic Protection System for Concrete Piles in Marine Environment

Robert Moses Causeway
Long Island, NY


Pier 4 - Anode Current Output over Time
Anode Current (mA)
Average Daily Ambient Air Temperature (°F)
Days
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
-50 -30 -10 10 30 50 70 90
Pier 4 Current (mA)
Average Temperature (°F)
Poly. (Pier 4 Current (mA))

Cathodic Protection: Robert Moses Causeway

- Contract Specified Monitoring for 1 Year
- Temperature has varied from -10C to 25C.
- Current has varied from 17 to 55 mA.
- Current Density: 4.0 to 12 mA/m^2.
- Polarization: 128 to 297 mV.
- System meets all CP Criteria.


YOU XUAN
PANAMA
RINKER

Pile Cap Repair

- 2,000 meters of pile cap repair
- Remove bottom 20 cm
- Install distributed strip anodes
  - 4 cm x 4 cm x 2.5 m
- Form and Pour Repair


20E


24.5X1

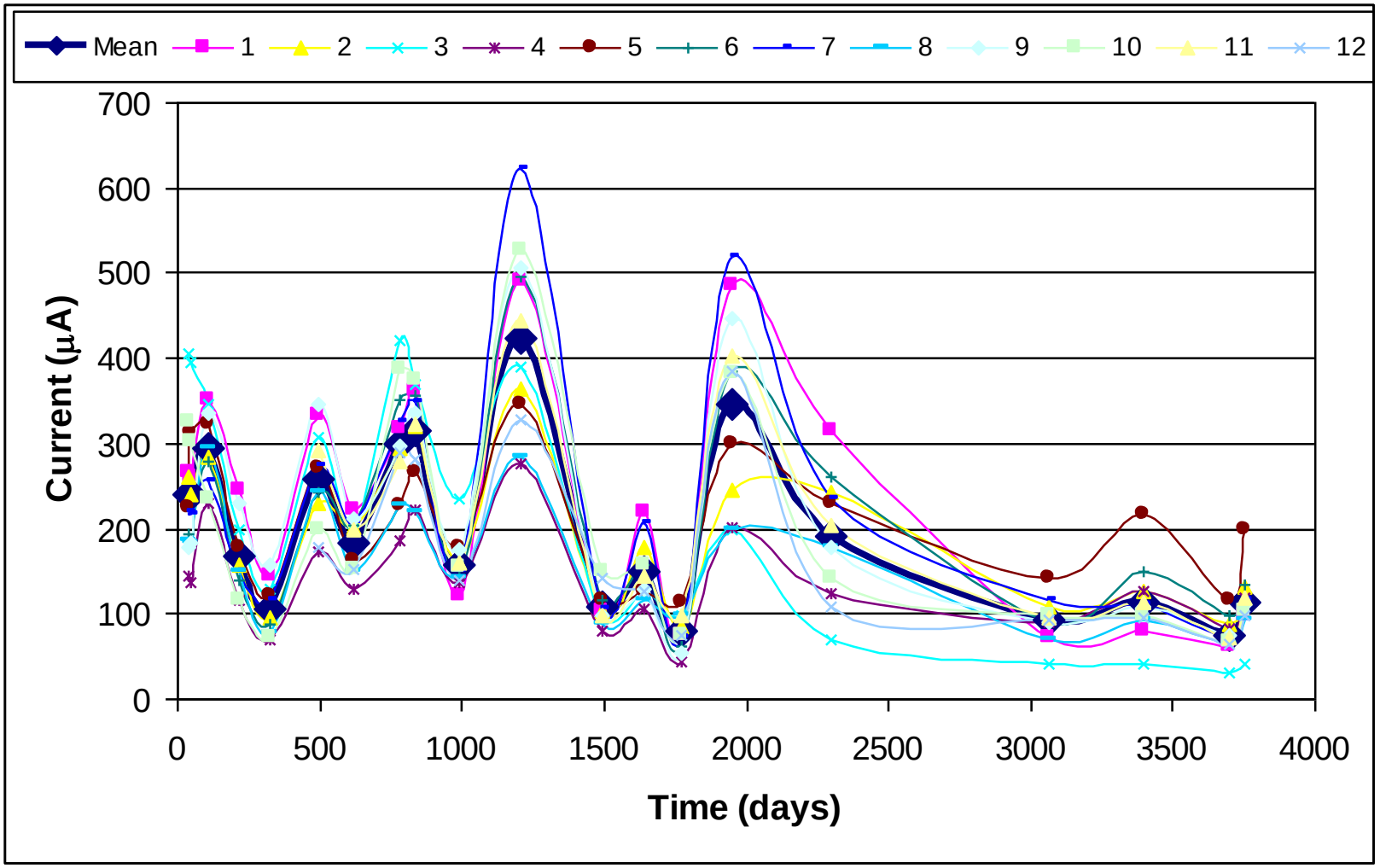
Parking Garage

Bridge Widening

Leister Bridge Cross Beam

- Completed in 1999
- Monitored for 10 years

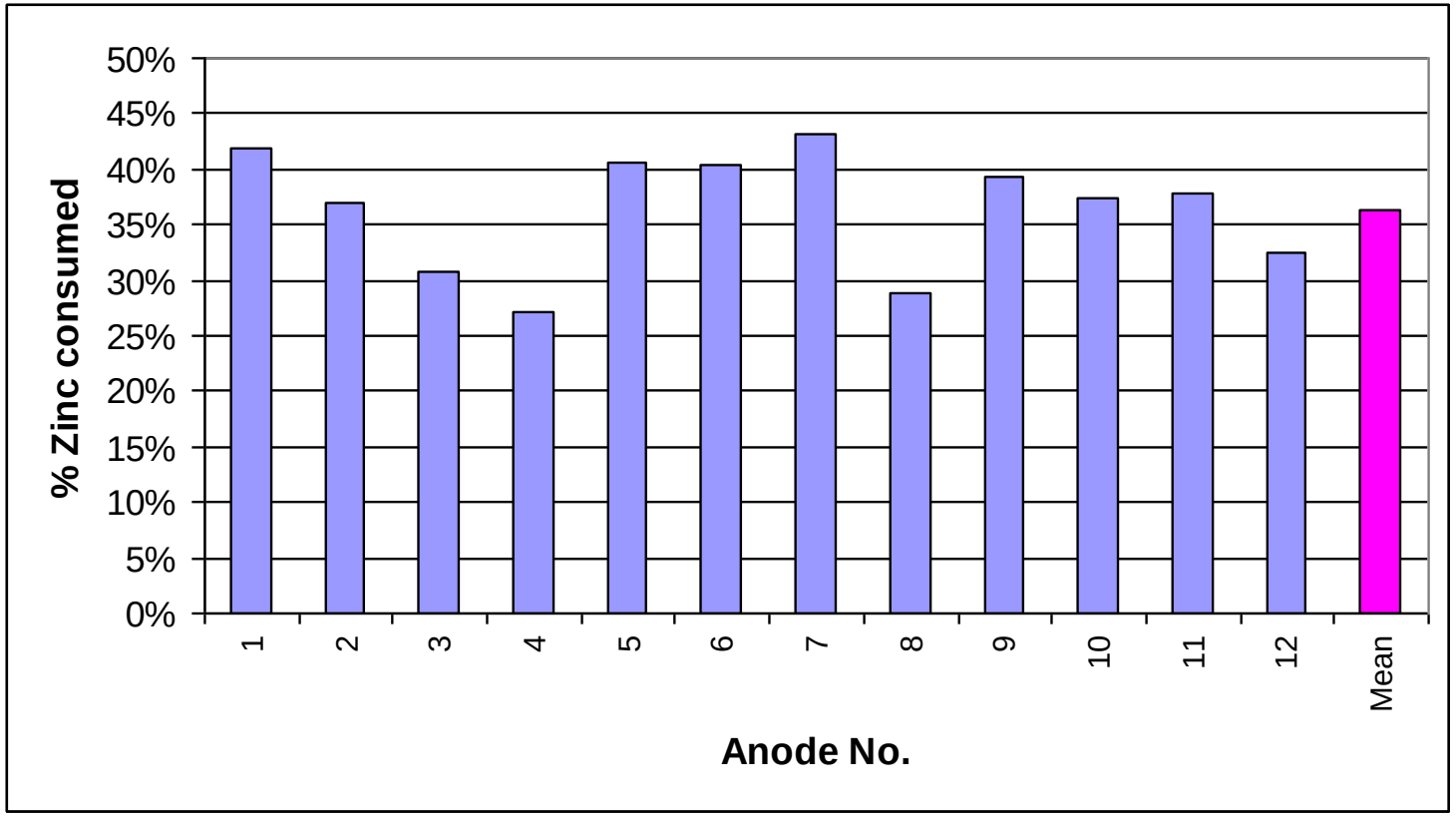
10 Year Monitoring - Current



Current Density

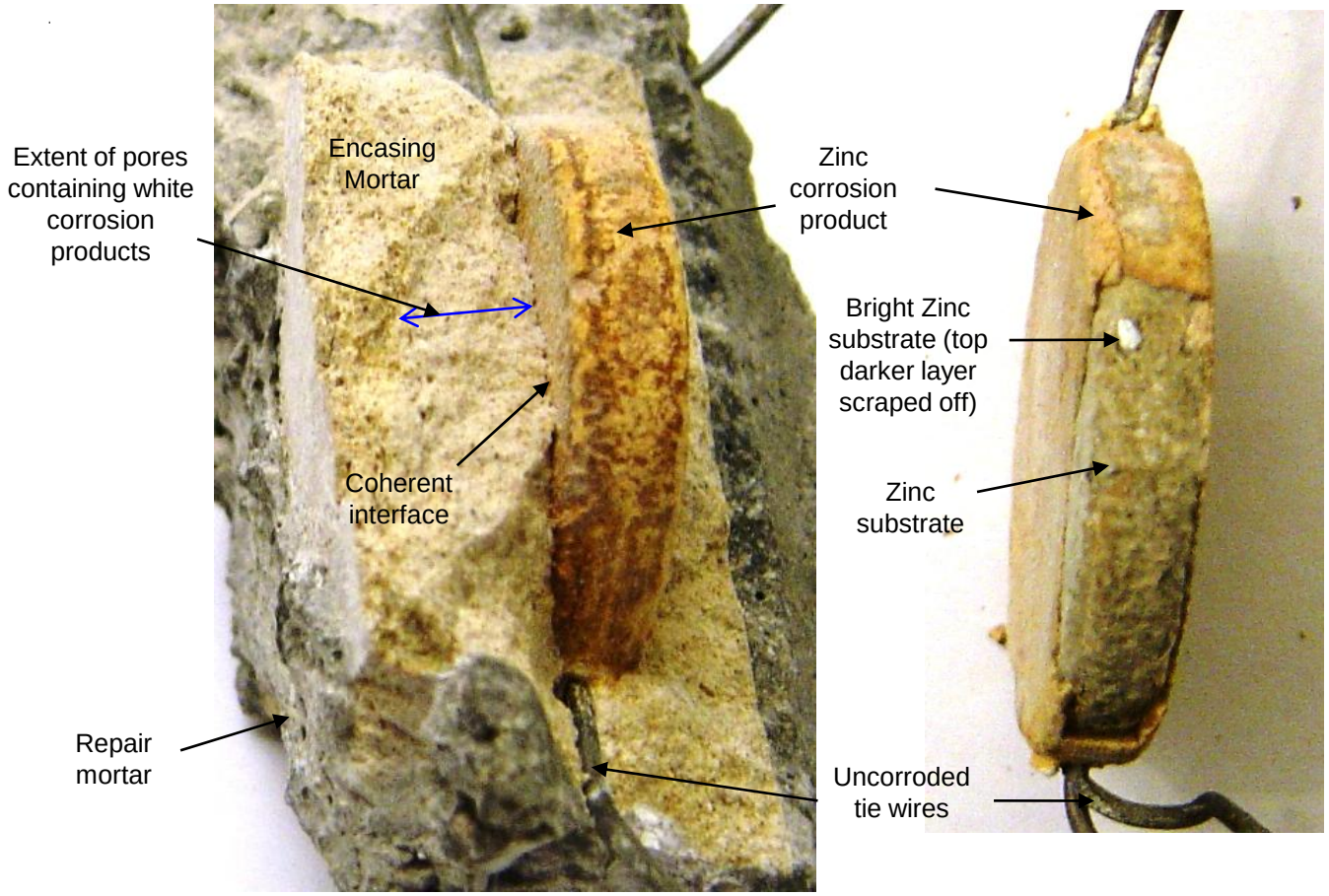
- Cathodic Prevention
  - European Standard EN 12696
  - Current Density 0.2-2mA/m^2
- Leister Bridge
  - Ranged 0.6 mA/m^2 and 3.0 mA/m^2
  - Overall mean of around 1.4 mA/m^2

Zinc Consumption



- Calculated based on current output and 85% utilization

Forensic Analysis after 10 yrs

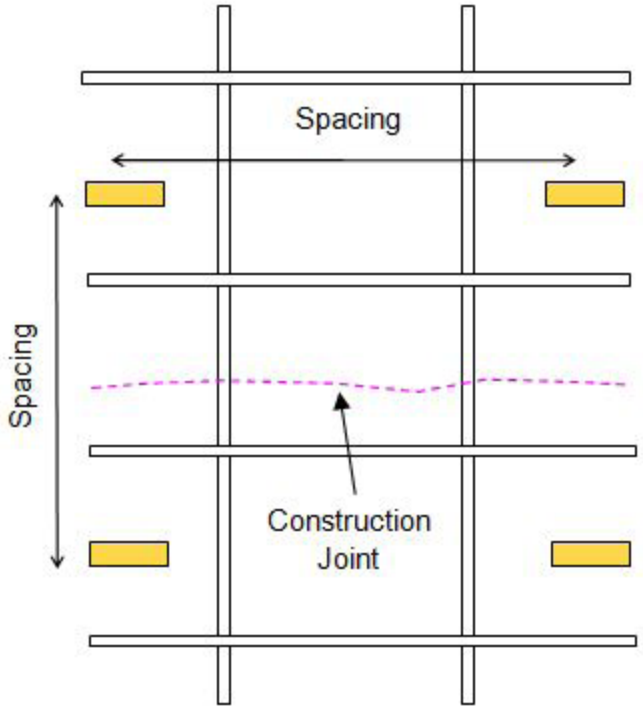


Anode Connection to Reinforcing Steel

Preventative Galvanic Protection with FRP Strengthening

Galvanic Anodes in New Construction

- General Protection
- Targeted protection
  - High chloride exposure
  - Critical structural elements
  - Construction joints



Catano Ferry Terminal

- First Green Building in Puerto Rico as certified by as LEED
- 2nd ferry terminal in the USA certified by LEED
- Construction Complete 2012

- $22.5 million ferry terminal in Catano
- Replace the existing 35 year old terminal
- 4,600 passengers daily

Catano Ferry Terminal

- Galvanic Anodes used for Cathodic Prevention
- Piles
- Beams
- Columns

Summary

- Large Range of Corrosion Mitigation Options Available
- Mitigation Strategies can be
  - Global, Targeted, or Localized
- System Selection
  - Existing Condition, Exposure Conditions, Service Life Required, Budget, and Maintenance Considerations

VECTOR CORROSION TECHNOLOGIES