The Use of Zinc Anodes to Extend the Life of Concrete Patch Repair

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CONCRETE

The Ideal Environment For Steel

Steel Passivated in Concrete

By Film of  - Fe_2O_3

(Gamma Ferric Oxide)

Corrosion Rate of Steel vs. pH

pH 4 - 10 ~ 10 mils/yr.

pH 12 - 13 < 0.1 mils/yr.

pH 14 > .2-.5 mils/yr.

NO PROBLEM ? ? ?


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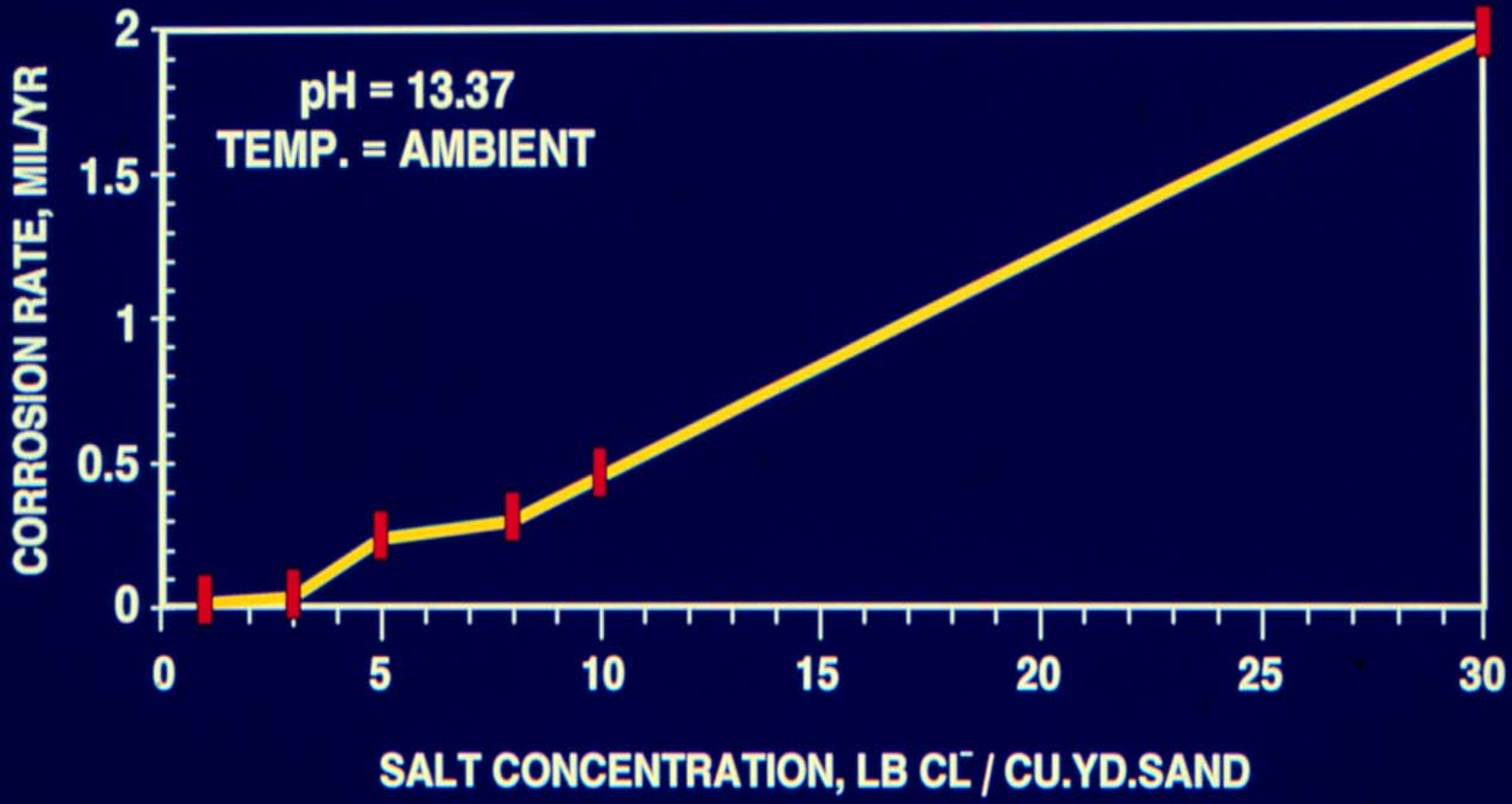
SALT !

- Destroys passivity of steel in concrete.
- Corrosion threshold @ 1.1 lb Cl^-/yd^3 (0.04%).
- Expansion due to rust causes cracks.
- Only 2 mils of corrosion needed to cause crack.
- Once contaminated, corrosion is never ending.

SALT CONC. VS. CORROSION RATE



New Construction

1. High quality concrete.
2. Increased cover.
3. Surface sealers.
4. Waterproof membranes.
5. Coated reinforcing steel.
6. Specialty concretes.
7. Corrosion inhibiting admixture.
8. Improved construction products.

Existing Structures in Trouble

REPAIR

↓

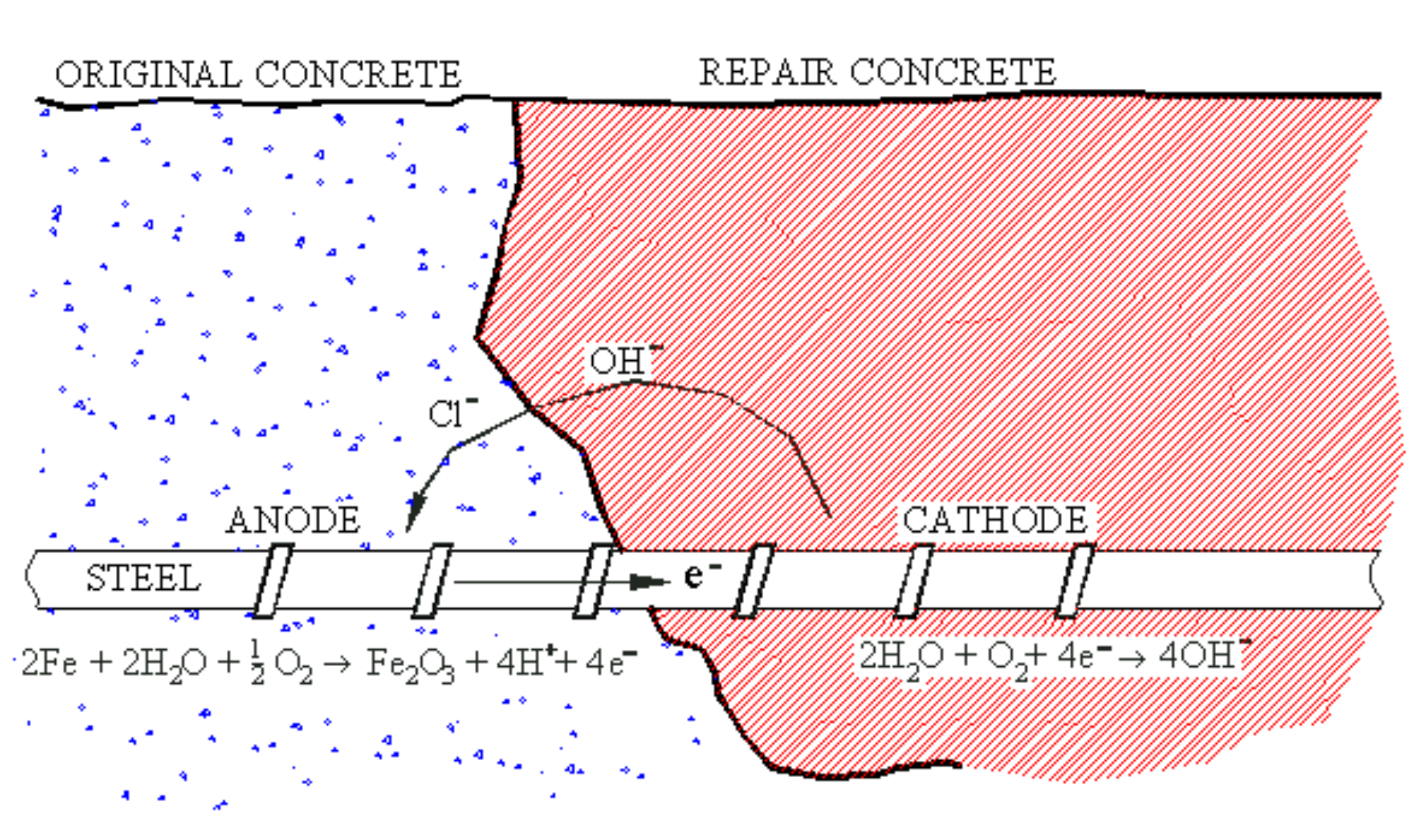
REPAIR

↓

REPAIR

↓

A Never-Ending Process



Conventional Patch Repair

Existing Structures in Trouble

1. Chloride Removal

   Effective, but Complex and Expensive.

2. Cathodic Protection

   Impressed Current Cathodic Protection (ICCP) Now Used on About 15 Million Square Feet Worldwide.

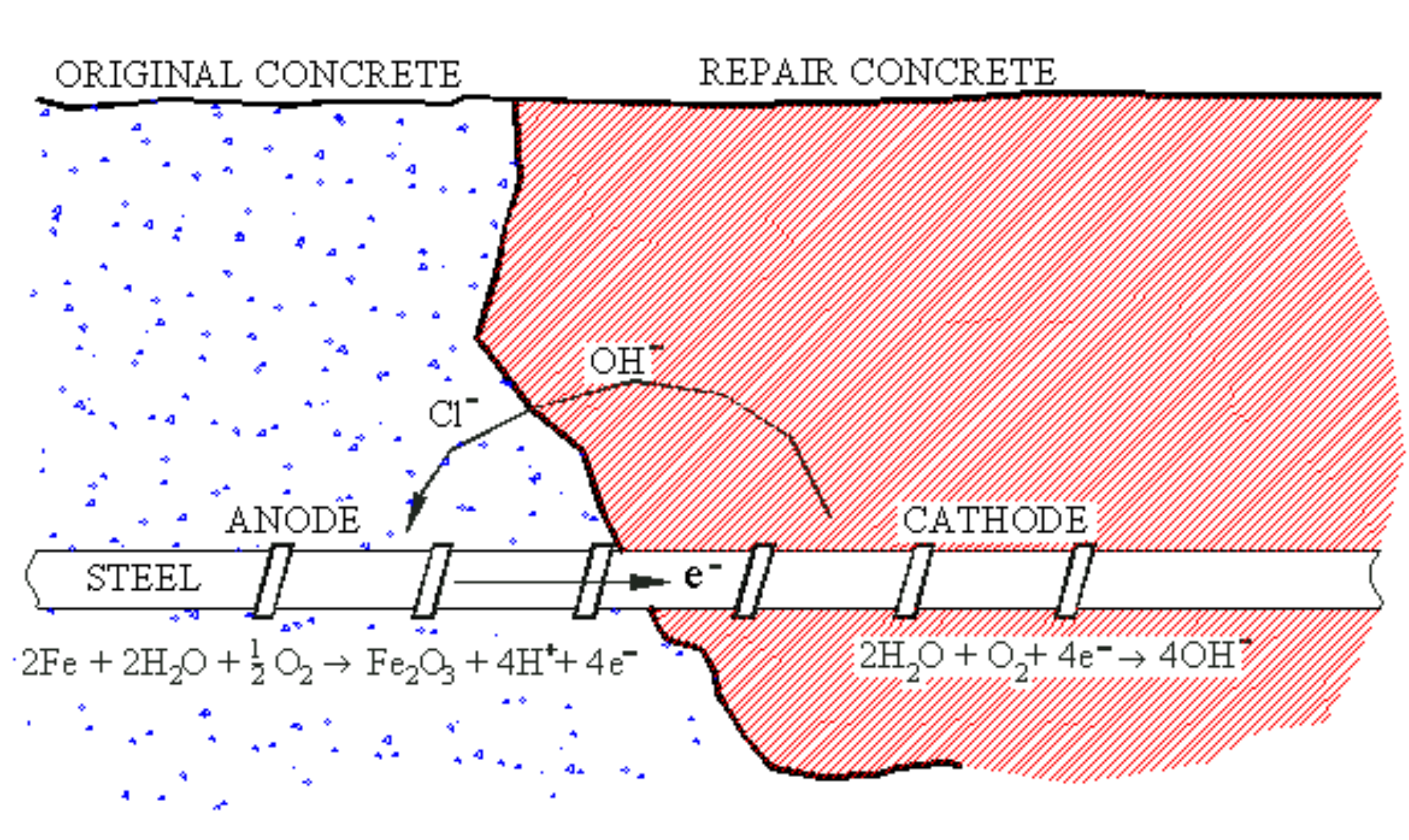
ICCP Does Work !

But issues of complexity, reliability, monitoring and maintenance still cause concern.

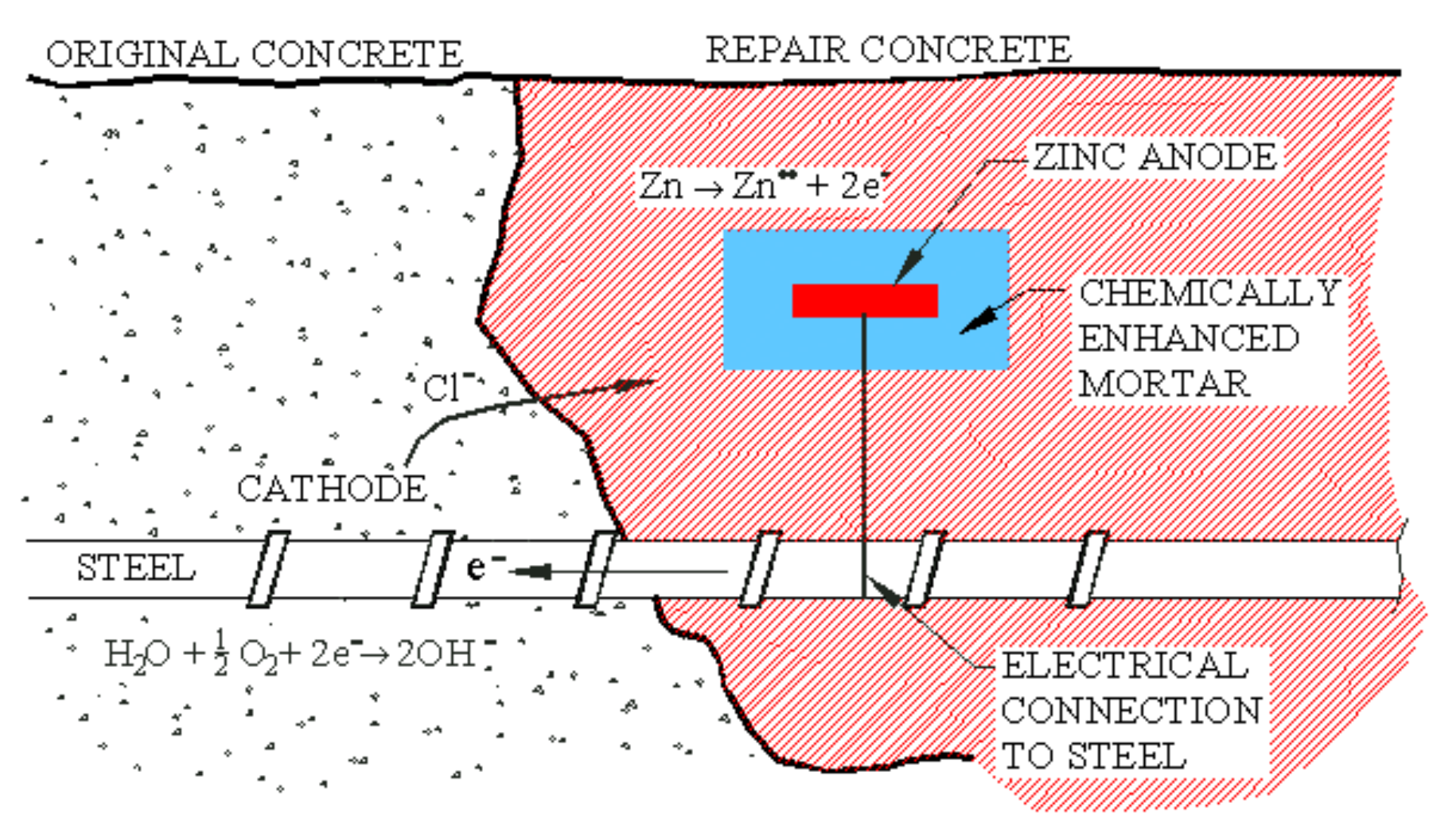
FHWA encouraged development and application of Galvanic Cathodic Protection (GCP) beginning in 1993.

Zinc Anodes Used to Extend the Life of Concrete Patch Repairs

1. Simple to Install.
2. No Power Supply Needed.
3. No Wiring or Conduit.
4. No Long-Term Monitoring or Maintenance.



Conventional Patch Repair



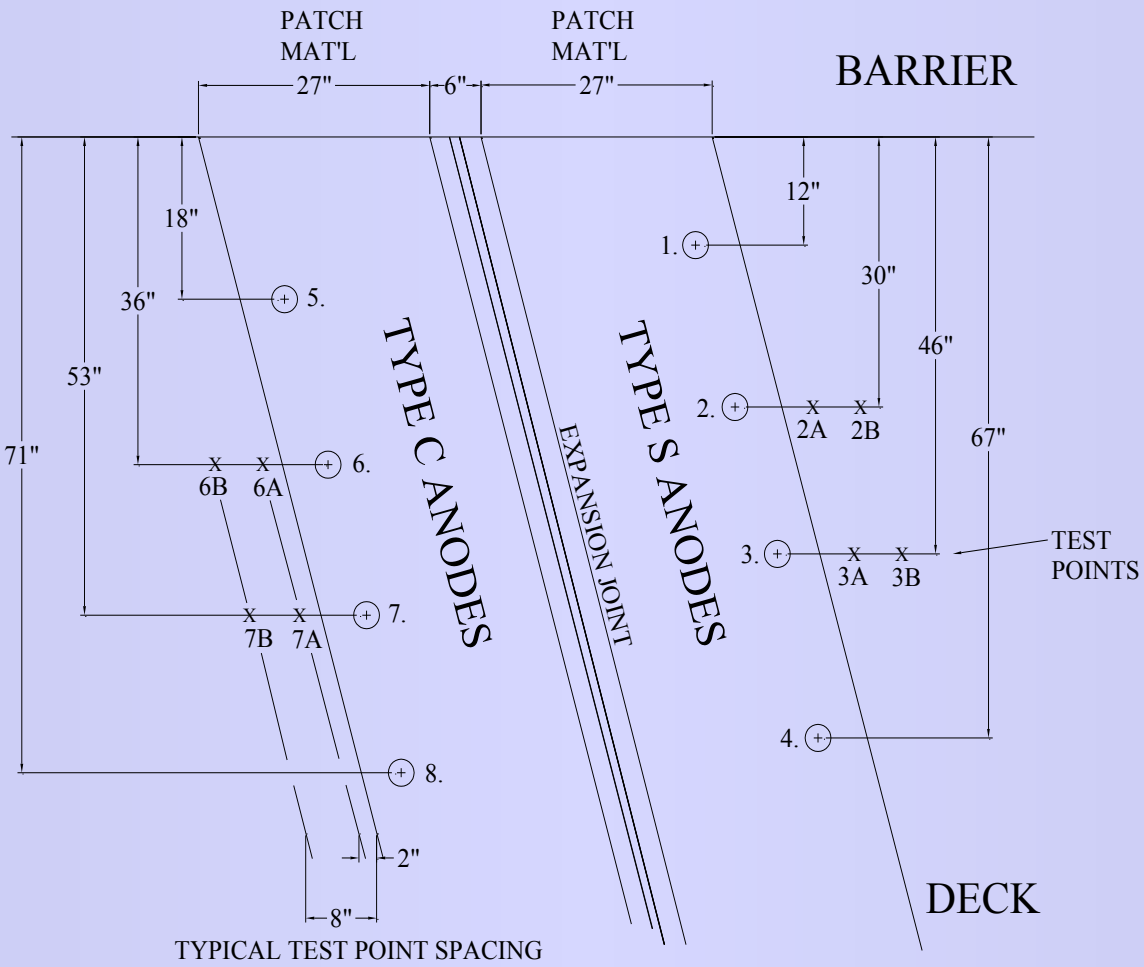
Embedded Zinc Anode for Patch Repair

Anode Trial on PA SR 220, Lock Haven, PA

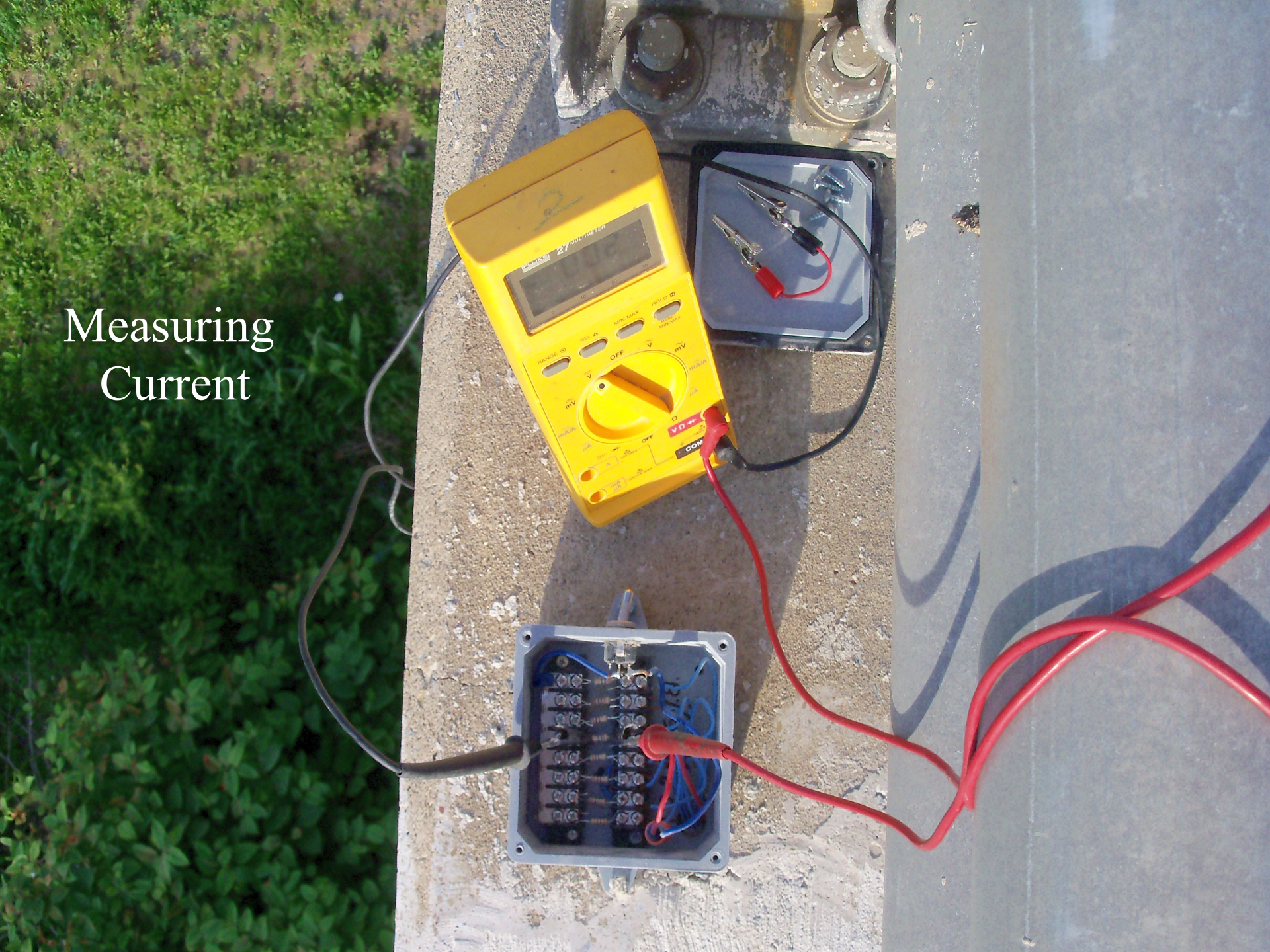
- Bridge Deck, Structure S-26218.
- Expansion Joint Repair.
- 4 Anodes, Type “S.”
- 4 Anodes, Type “C.”
- Installed by Penn DOT July 6, 2009.


PA DOT SR 220 Bridge

SR-220 ANODE TEST SITE



TYPICAL TEST POINT SPACING


Measuring
Current

Protective Current on PA SR 220 Anode Type S

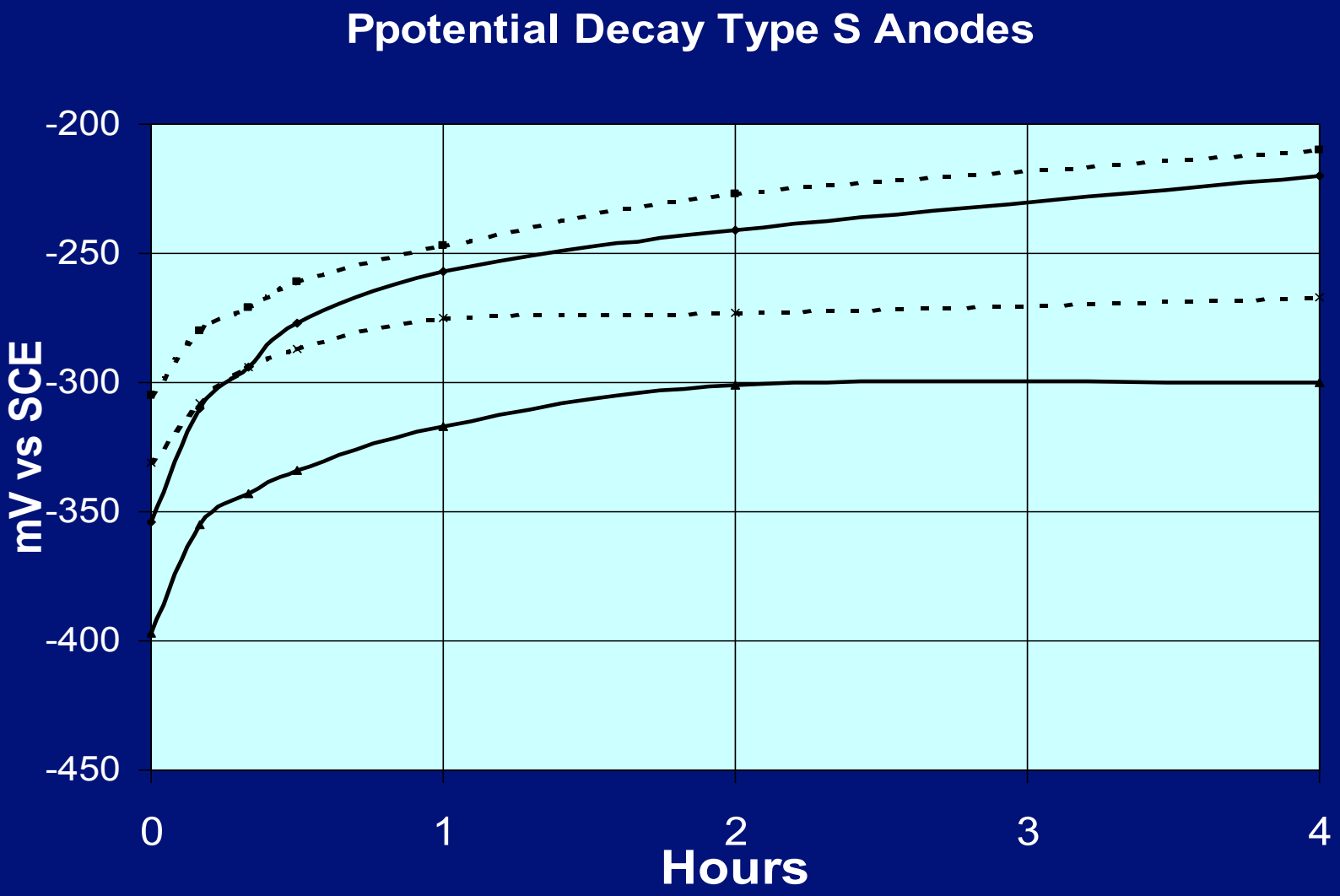
Anode	9/15/09	10/6/09	5/20/10	9/24/10
1.	0.95 mA	0.73 mA	0.98 mA	0.76 mA
2.	0.78 mA	0.65 mA	0.99 mA	0.85 mA
3.	0.73 mA	0.68 mA	0.89 mA	0.80 mA
4.	0.75 mA	0.71 mA	1.06 mA	0.85 mA
Avg.	**0.80 mA**	**0.69 mA**	**0.98 mA**	**0.81 mA**

Protective Current on PA SR 220

Date	Average, 4 Type S Anodes	Average, 4 Type C Anodes
Sept. 15, 2009	0.80 mA	0.69 mA
Oct. 6, 2009	0.69 mA	0.27 mA
May 20, 2010	0.98 mA	0.40 mA
July 13, 2010	0.93 mA	0.34 mA
Sept. 24, 2010	0.81 mA	0.36 mA
Average	**0.84 mA**	**0.41 mA**

Measuring Steel Potential

4-hr Potential Shift on PA SR 220



Polarization on PA SR 220 Anode Type S

Test Pt.	Polarization 10/6/09	Polarization 5/20/10	Polarization 9/24/10
1. (2”)	104 mV	150 mV	136 mV
2. (8”)	70 mV	136 mV	119 mV
3. (2”)	95 mV	164 mV	140 mV
4. (8”)	60 mV	117 mV	106 mV
Avg.	**82 mV**	**142 mV**	**125 mV**

Polarization on PA SR 220

	10/6/09	5/20/10	9/24/10	**Average**
Type S Anodes, 2” from Patch	100 mV	157 mV	138 mV	**132 mV**
Type S Anodes, 8” from Patch	65 mV	127 mV	113 mV	**102 mV**
Type C Anodes, 2” from Patch	12 mV	1 mV	17 mV	**10 mV**
Type C Anodes, 8” from Patch	18 mV	-1 mV	20 mV	**12 mV**

CONCLUSIONS

1. Corrosion can be mitigated by galvanic cathodic protection (CP).
2. Zinc anodes can be effectively used to provide CP in reinforced concrete.
3. Results from tests on a PA bridge show some zinc anodes provide excellent protective current and steel polarization.

The author thanks Penn DOT for installation and monitoring of the SR 220 anode trial.