

FDOT CATHODIC PROTECTION PRACTICES FOR BRIDGE PRESERVATION

**National Bridge Management, Inspection, and Preservation
Conference**

St Louis, Missouri - Oct 31 – Nov 3, 2011

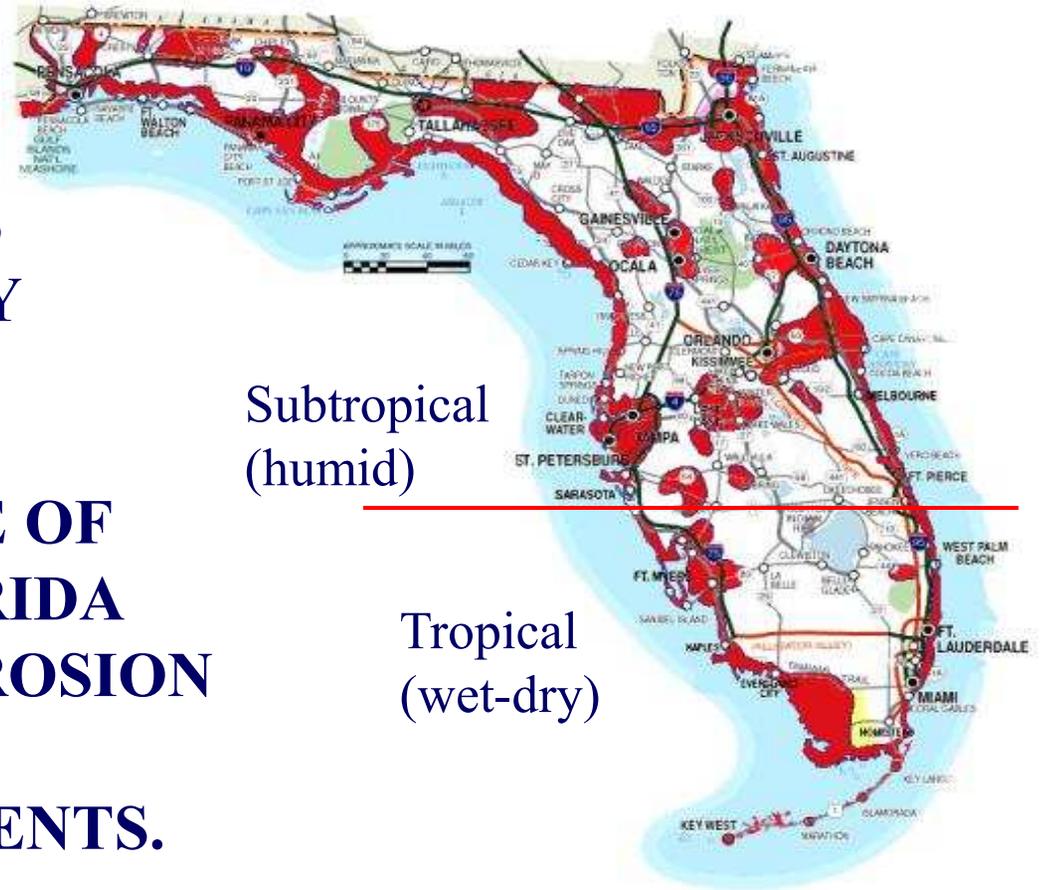
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- **OVER 8,000 MILES OF TIDAL COAST LINE ***
- **ENTIRE COASTAL AREA IS CONSIDERED EXTREMELY CORROSIVE.**
- **THE MOST COMMON TYPE OF DETERIORATION ON FLORIDA MARINE BRIDGES IS CORROSION INDUCED DAMAGE TO SUBSTRUCTURE COMPONENTS.**



* Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. <http://www.infoplease.com/ipa/A0001801.html>

***TYPICAL CORROSION DETERIORATION OF
FLORIDA BRIDGES***

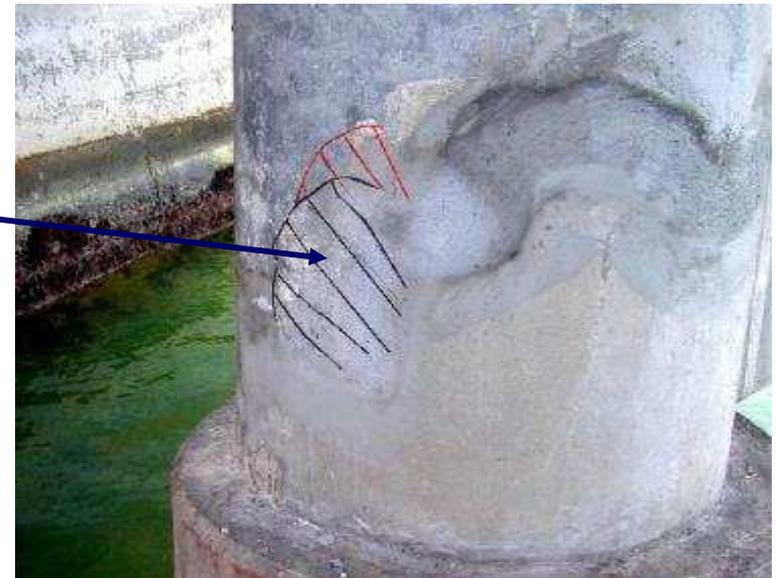


CONVENTIONAL REPAIRS ON CHLORIDE CONTAMINATED CONCRETE



- EVEN WHEN A GOOD ENCAPSULATION IS ACHIEVED, NEW CORROSION CELLS ARE DEVELOPED AND CORROSION CONTINUES

- CORROSION DEVELOPS AROUND REPAIR PATCHES DUE TO THE CHARACTERISTICS CHANGE OF THE REPAIRED REBAR. *



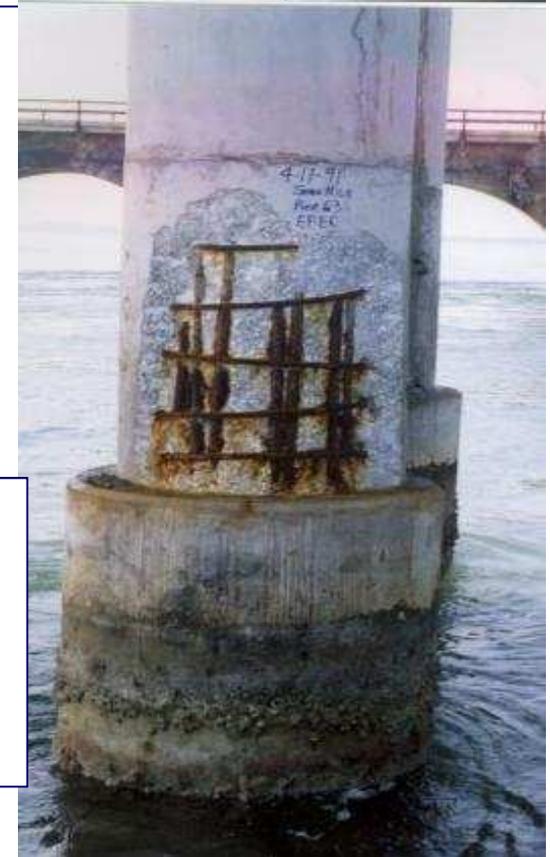
*** NCHRP D10-37C**

CONVENTIONAL REPAIR FAILURES



- REMOVAL OF STANDARD JACKETS SHOWED THAT CONVENTIONAL ENCAPSULATIONS ALLOW CONTINUED CORROSION.

- GOOD PATCHES PROMOTE ACCELERATED CORROSION IN THE CONCRETE SURROUNDING THE PATCH AND NEW SPALLS DEVELOP WITHIN A FEW YEARS.



CORROSION CONTROL PRACTICES

- **IN THE EARLY TO MID 1980'S FDOT CONCLUDES THAT CONVENTIONAL REPAIRS ARE NOT ADEQUATE FOR THE REHABILITATION OF CHLORIDE CONTAMINATED STRUCTURES.**
- **FDOT ESTABLISHES THAT THE APPROACH TO PRESERVE THESE CORROSION AFFECTED BRIDGES WOULD BE BASED ON THE CONCEPT OF CORROSION CONTROL USING CATHODIC PROTECTION AND CONCRETE REHABILITATION.**
- **GOAL: TO PROVIDE AN EXTENSION OF THE SERVICE LIFE OF THE STRUCTURE AS NEEDED.**

CATHODIC PROTECTION PRACTICES

- IMPLEMENTED IN A CASE BY CASE BASIS.**
 - a. No standard specifications have been developed.**
 - b. Cause and magnitude of corrosion activity determined prior to design of rehabilitation strategy.**
 - c. Type of cathodic protection determined based on needs.**

- FDOT HAS A WORKGROUP SOLELY DEDICATED TO CORROSION ISSUES TO ASSIST THE BRIDGE OFFICES.**
 - a. Provides corrosion condition assessment & recommendations.**
 - b. Provides technical support for design and construction.**
 - c. Monitors and maintains the cathodic protection systems.**
 - d. Districts have final decision on approach to take.**

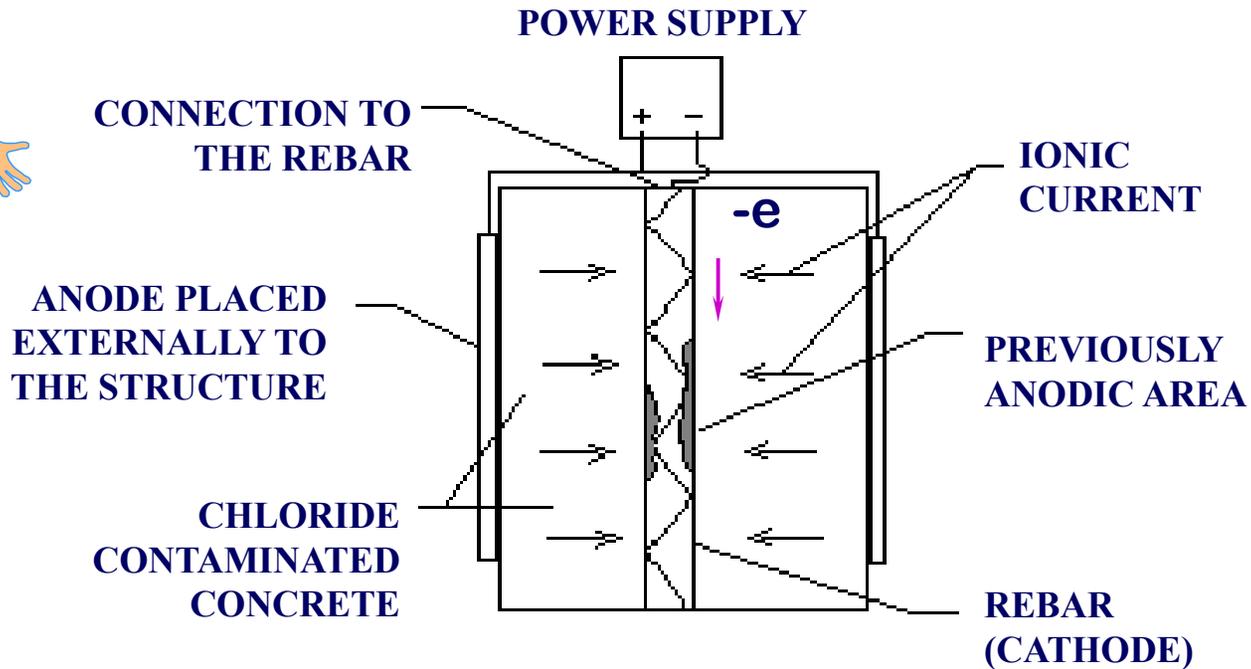
CATHODIC PROTECTION PRACTICES

Highlights of Implementation:

- A) Structural Analysis and Evaluation of Deterioration.**
- B) Rehabilitation of Concrete and Reinforcement is Provided as Needed.**
- C) Implementation of Corrosion Control Measures:
 - 1. Impressed Current Cathodic Protection.**
 - 2. Sacrificial (galvanic) Cathodic Protection.****
- D) Routine Biannual Inspection of Structure, and Monitoring the Performance of the Cathodic Protection Ensures the Preservation and the Extended Safe Use of the Structure.**

IMPRESSED CURRENT CATHODIC PROTECTION

Cathodic Protection?



- A CATHODIC PROTECTION CIRCUIT CONTAINS THE SAME FOUR BASIC COMPONENTS OF A TYPICAL CORROSION CELL.
- TRANSFER OF ELECTRONS FROM THE ANODE TO THE CATHODE IS ALSO SIMILAR TO A CORROSION CELL.

Cathodic Protection Systems Used by FDOT

- 1- Ti Mesh Anode Encapsulated in a Shotcrete/Mortar overlay**
- 2- Ti Mesh Anode Encapsulated in Structural Reinforced Concrete**
- 3- Ti Mesh Anode in Conventional Pile Jackets**
- 4- Thermal-Sprayed Zinc Anode in Sacrificial Mode**
- 5- Zinc Mesh Anode in Conventional Pile Jackets**
- 6- Submerged Bulk Anode Systems (Zn, Al or Mg)**

IMPRESSED CURRENT CATHODIC PROTECTION CIRCUIT

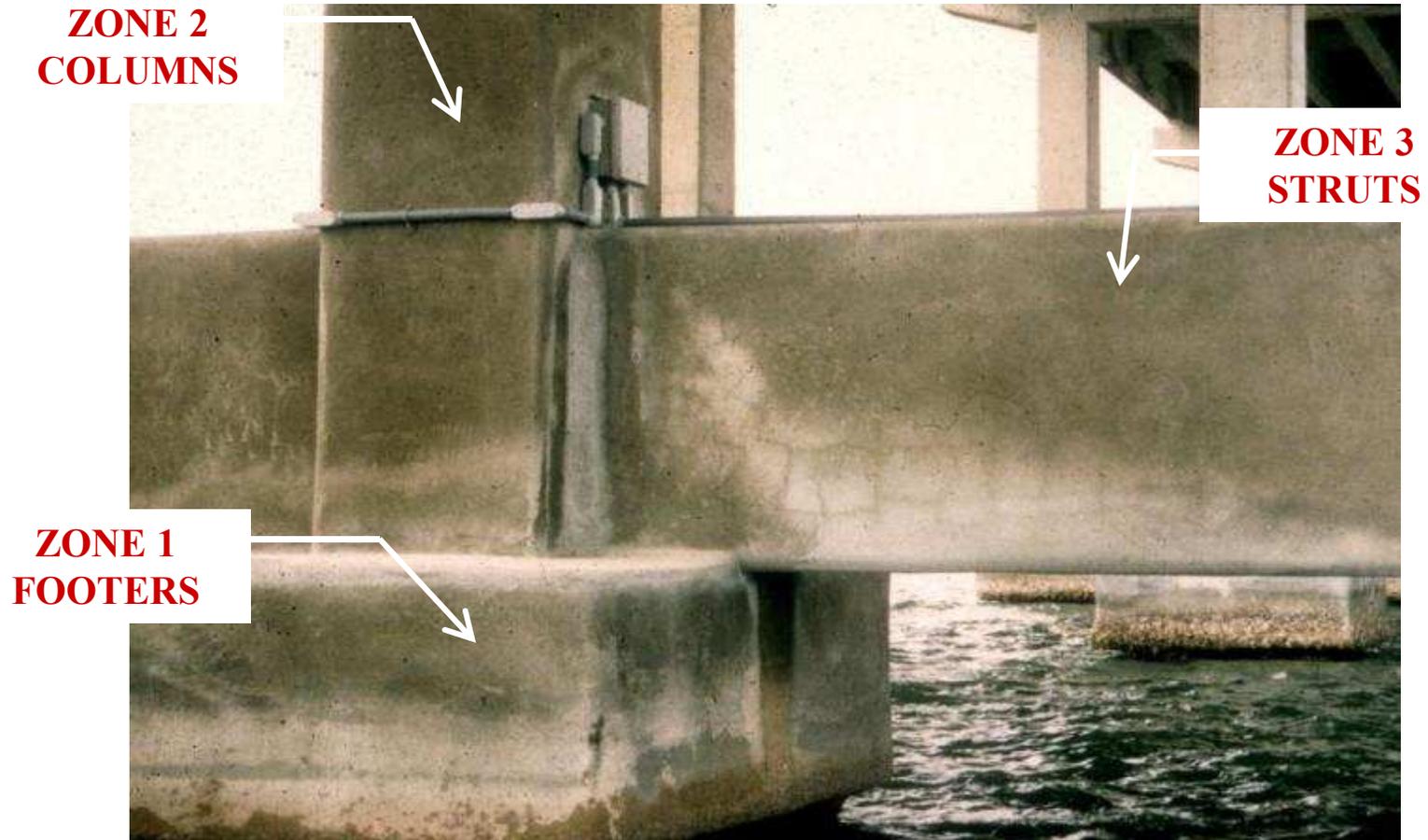
TITANIUM ANODE MESH



- TYPICALLY ATTACHED TO THE CONCRETE SURFACE AND THEN ENCAPSULATED IN CEMENTITIOUS OVERLAY.**
- EASILY CONFORMS TO THE STRUCTURE GEOMETRY.**
- MOST USED IMPRESSED CURRENT ANODE FOR CONCRETE.**

IMPRESSED CURRENT CATHODIC PROTECTION CIRCUIT

TITANIUM ANODE MESH



- ENCAPSULATION WITH MACHINE APPLIED MORTAR (SHOTCRETE).

IMPRESSED CURRENT CATHODIC PROTECTION CIRCUIT

TITANIUM ANODE MESH



- ENCAPSULATION IN STRUCTURAL CONCRETE**
- INCLUDES PLACEMENT OF ADDITIONAL REINFORCEMENT**
- C.P. PROVIDED FOR NEW AND EXISTING REINFORCEMENT**

IMPRESSED CURRENT CATHODIC PROTECTION CIRCUIT

TITANIUM ANODE MESH



- WIRES ARE ROUTED TO THE RECTIFIER IN CONDUIT.

IMPRESSED CURRENT CATHODIC PROTECTION CIRCUIT

TITANIUM ANODE MESH PILE JACKET

**ENCAPSULATION OF Ti ANODE
WITHIN A STANDARD PILE
JACKET.**

**A FIBERGLASS FORM IS PLACED
AROUND THE PILE LEAVING AN
ANNULAR SPACE BETWEEN PILE
AND FORM.**

**FORM IS FILLED WITH
MORTAR/CONCRETE.**

**SEVERAL PILES ARE COMBINED
INTO ONE C.P. CIRCUIT.**

**COMBINES SPALL REPAIRS AND
C.P. INTO ONE OPERATION.**



IMPRESSED CURRENT CATHODIC PROTECTION CIRCUIT

TITANIUM ANODE MESH JACKET



- **THE TITANIUM MESH ANODE IS PRE-INSTALLED INSIDE THE STAY-IN-PLACE FIBERGLASS FORM FOR SQUARE AND CIRCULAR COLUMNS (PILINGS)**

SACRIFICIAL CATHODIC PROTECTION

ARC-SPRAYED ZINC ANODE



- **ZINC ANODE IS APPLIED OVER CONCRETE SURFACE.**
- **NEEDS A DIRECT CONNECTION TO THE REINFORCEMENT.**

- **APPLICATION SIMILAR TO SPRAY PAINTING.**
- **CAN BE USED WITHOUT CONCRETE RESTORATION BY APPLICATION DIRECTLY TO THE REINFORCEMENT TO SERVE AS CONNECTION.**



SACRIFICIAL CATHODIC PROTECTION

ARC-SPRAYED ZINC

**THERMALLY APPLIED ANODES
ALSO USED ON STRUCTURAL
STEEL AS A PROTECTIVE COATING
WITH A PAINT OVERCOAT
SYSTEM.**



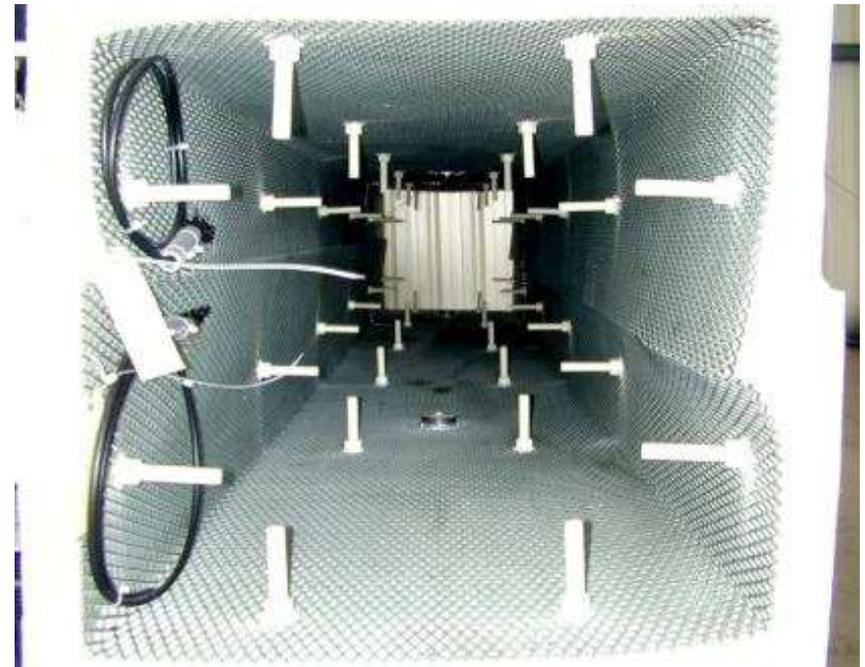
SACRIFICIAL CATHODIC PROTECTION

EXPANDED ZINC MESH ANODE PILE JACKET

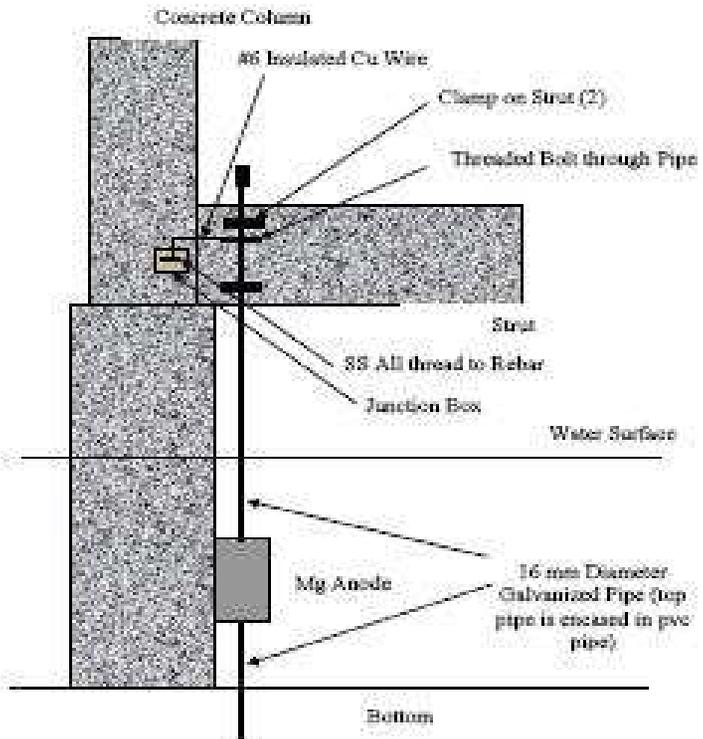


SACRIFICIAL C.P. JACKET IS PLACED AROUND THE PILE AND CONNECTED DIRECTLY TO THE REINFORCEMENT WITHOUT AN EXTERNAL POWER SUPPLY.

THE ZINC MESH ANODE IS PRE-INSTALLED INSIDE THE FORM TO PROVIDE AN ANNULAR SPACE OF 50 mm WHICH IS LATER FILLED WITH MORTAR.



SACRIFICIAL CATHODIC PROTECTION SUBMERGED BULK ANODES



THESE ANODES ARE MOSTLY USED TO PROVIDE CATHODIC PROTECTION TO STRUCTURES WITH UNDERWATER DAMAGE. SIMILAR ARE ALSO USED TO COMPLEMENT GALVANIC PILE JACKETS.

CONCLUSIONS

- FDOT CATHODIC PROTECTION PROGRAM HAS BEEN SUCCESSFUL IN EXTENDING THE SERVICE LIFE OF BRIDGES IN MARINE ENVIRONMENTS.**
- THE CATHODIC PROTECTION PROGRAM HAS PROVEN TO BE A COST EFFECTIVE MEANS FOR THE LONG TERM PRESERVATION OF CORROSION AFFECTED STRUCTURES.**
- THE PROGRAM IS MAINTAINED BY A WORK GROUP SOLELY DEDICATED TO CORROSION AND CATHODIC PROTECTION. CONTINUITY IN MONITORING AND MAINTENANCE IS PROVIDED TO ALL CP SYSTEMS.**



THANKS