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Orlando, FL

TRANSPORTATION SYMPOSIUM

Foundation Engineering Innovations: Design, Construction, and Preservation

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Kelly Shishlova, State Materials Office
James Greene, State Materials Office

Transportation Symposium Website

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Outline

1. **Construction Specification Updates to Section 455**
   Rodrigo Herrera, Assistant State Structures Design Engineer, State Geotechnical Design Engineer

2. **Measuring While Drilling (MWD) for Geotechnical Applications**
   Kelly Shishlova, Geotechnical Operations and Research Engineer

3. **Cathodic Protection Program Preserving Florida's Bridges**
   James Greene, State Structural Materials Engineer

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Construction Specification Updates to Section 455: Driven Piles

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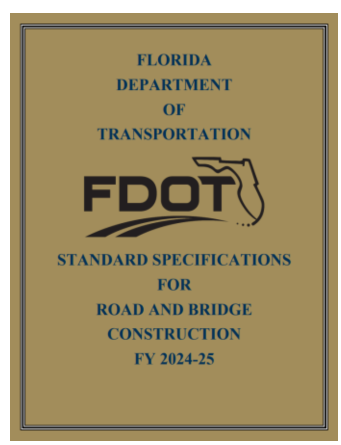
Section 455 – Driven Piles

- The Florida Department of Transportation working alongside with industry, implemented important updates to the 24-25 version of the construction Specifications book.
- This presentation will discuss the general outline of the changes made to the driven pile section of the Specification, including some of the upcoming revisions.



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Section 455 – Driven Piles

- Prior to these updates
  - Plans → Test Pile length (Engineer)
  - Construction → The Engineer monitored pile installation (CEI).
  - Authorized production pile length letter (Engineer).
- Current Specifications
  - Plans → Test Pile length (Engineer)
  - Construction → The Contractor's dynamic testing engineer (DTE) is responsible for pile installation.
  - DTE issues a recommended production pile length letter to the Department.
  - The Engineer provides authorized lengths to the Contractor.

Section 455 – Driven Piles

455-5.15.2 Production Pile Length:

455-5.15.2.1 Structures with Test Piles: When test pile lengths are shown in the Plans, the production pile bid quantity is based on information available during design and estimated pile lengths. Production pile lengths shall be recommended by the DTE for the Engineer's approval based on all information available before the driving of the permanent piles, including, but not limited to, information gained from the driving of test piles, dynamic load testing, static load testing, supplemental soil testing, etc. When authorized by the Department, soil freeze information obtained during set checks and pile redrives may be used to determine authorized pile lengths for sites with extreme soil conditions.

After completion of the test pile program, production pile lengths shall be recommended in a letter signed and sealed by the DTE. Submit the letter and load test reports to the Engineer including the following electronic files (Windows 10 compatible): dynamic testing data, signal matching data and results, and Wave Equation data and results.

Section 455 – Driven Piles

455-5.15.3 Authorized Pile Lengths: The authorized pile lengths are the lengths determined by the Engineer after reviewing the pile lengths recommended by the DTE. The Contractor may elect to provide piling with lengths longer than authorized to suit their method of installation or schedule. When the Contractor elects to provide longer than authorized pile lengths, the Department will pay for the furnished length as either the originally authorized length or the length between cut-off elevation and the final accepted pile tip elevation, whichever is the longer length.

The Engineer will provide an itemized list of authorized pile lengths within three working days after receipt of all test reports and the DTE's pile length recommendation letter. Use these lengths for furnishing the permanent piling for the structure. If

Section 455 – Driven Piles

455-11.9.1 Set Checks/Test Piles: There will be no separate payment for the initial four set-checks performed the day of and the working day following initial driving. Each additional set-check ordered by the Engineer will be paid as a redrive.

455-11.9.2 Set Checks/Production Piles: There will be no separate payment for the initial set-check performed the day of initial driving. Each additional set-check ordered by the Engineer will be paid as a redrive.

Section 455 – Driven Piles

455-11.9.3 Redrives: The quantity of redrives to be paid for, when shown in the Plans, will be the number of redrives, each, authorized by the Engineer. Redrives required by the Engineer, when not shown in the Plans, will be paid for as Unforeseeable Work.

Pay Item 455-155-AA (Does not include DLT)

Dynamic Load Test Pay Item: 455-137

Section 455 – Driven Piles

- Redrives
  - The number of anticipated redrives are now established during design. Be reasonable with the number selected. Some considerations for estimating redrive quantities:
    - Relaxation
    - High rebound
    - Punching shear
    - Set-up

Section 455 – Driven Piles

- Verification Testing (VT)

455-5.20 Verification: One working day, excluding weekends and Department observed holidays, after receipt of the Foundation Certification Package, the Engineer will determine whether a pile in that foundation unit will be selected for verification testing. Based on its review

The Department provides the dynamic load testing equipment and monitoring personnel. the Contractor provides the pile driving equipment and assists as usual under normal pile driving operations.

The Geotechnical EOR provides the number of anticipated VT tests during design
Currently under Pay Item for Redrive 455-115-AA

Section 455 – Driven Piles

- Be reasonable with the selection of the number of anticipated VT's
  - Is one VT per Pier really anticipated?
  - Coordinate with the District Geotechnical Engineer

Section 455 – Driven Piles

Set Checks	No addtn'l payment	There is a time limit!
Redrives	455-115-AA	455-137
Verification	Used to be in 455-137	Now in 455-115

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Section 455 – Driven Piles

- Certification Package

455-5.19 Foundation Certification Packages: Submit certification packages of pile foundations to the Engineer prior to Pile Verification Testing. A separate Foundation Certification Package must be submitted for each foundation unit. A foundation unit is defined as all the piles within one bent or pile footing for a specific bridge for each phase of construction. Each Foundation Certification Package shall contain an original certification letter signed and sealed by the DTE certifying the piles have the required minimum tip elevation, axial capacity including compression and uplift, pile integrity, and that the inspection and testing of the pile installation was performed under the supervision of the DTE. The package shall also include all pile driving logs, dynamic testing records, all supplemental dynamic testing raw data and

Signed and Sealed by the Dynamic Testing Engineer (DTE)

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Section 455 – Driven Piles

455-11.8 Pile Splices: The quantity to be paid for will be the number of authorized drivable splices and build-ups greater than 5 feet in length in concrete piling, and test piling, which are made for the purpose of obtaining authorized pile lengths longer than shown as the maximum length in the Standard Plans, for obtaining greater lengths than originally authorized by the Engineer, to incorporate test piling in the finished structure, for further driving of test piling, or for splices shown in the Plans.

The quantity to be paid for will be the number of authorized splices in steel piling and test piling, for the purpose of obtaining lengths longer than the lengths originally authorized by the Engineer.

Current

455-11.8 Pile Splices: The quantity to be paid for will be the number of authorized drivable splices and build-ups in concrete production and test piling, which are made for the purpose of obtaining authorized pile lengths longer than shown as the maximum length in the Standard Plans or shown in the plans. Unplanned splices and build-ups required to achieve pile resistance will be paid for as unforeseen work.

Include the cost of steel pile splices required to achieve pile resistance in the cost of steel production and test piles. Steel pile splices required for the purpose of obtaining lengths longer than the lengths originally authorized by the Engineer will be paid for as unforeseen work.

Next version

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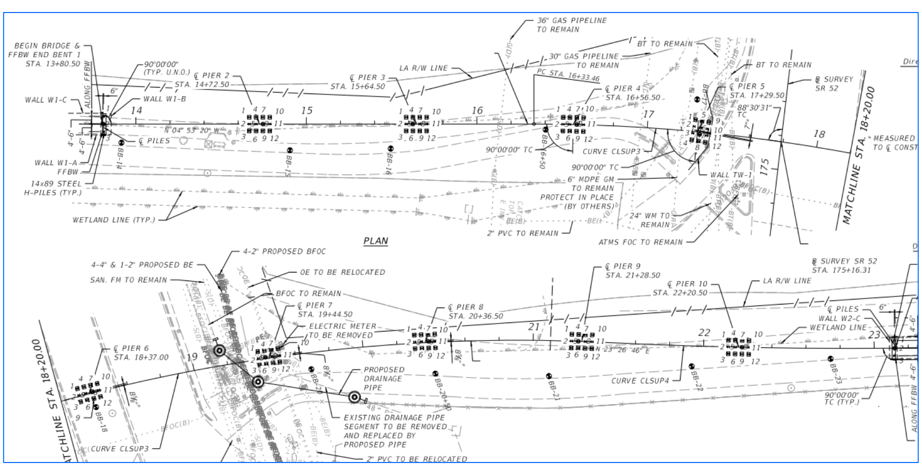
Section 455 – Driven Piles

2 EB's
9 Int. Piers

A total of 114 Steel Piles



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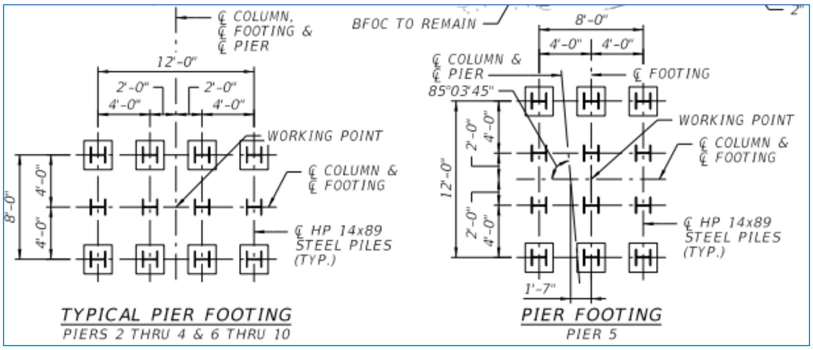
Section 455 – Driven Piles



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Section 455 – Driven Piles

Summary of Structure Quantities

Section	Pay Item Number	Pay Item Description	Units of Measure	Quantity		Total Quantity		Secondary Quantity			Location
				P	F	P	F	Units	P	F	Location Description
FOUNDATION	0455 35 6	STEEL PILING, HP14X89	LF	220.0		7133					END BENT 01
				742.0							PIER 02
				984.0							PIER 03
				1303.0							PIER 04
				375.0							PIER 05
				500.0							PIER 06
				973.0							PIER 07
				786.0							PIER 08
				489.0							PIER 09
				665.0							PIER 10
				96.0							END BENT 11
	0455 133 2	SHEET PILING STEEL, TEMPORARY-CRITICAL	SF	2050.0		2050					PIER 05
	0455 144 6	TEST PILES - STEEL, HP 14 x 89	LF	120.0		950					END BENT 01
				80.0							PIER 02
				105.0							PIER 03
				135.0							PIER 04
				60.0							PIER 05
				60.0							PIER 06
				105.0							PIER 07
				85.0							PIER 08
				60.0							PIER 09
				75.0							PIER 10
				65.0							END BENT 11

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Section 455 – Driven Piles

Summary of Structure Quantities											
Section	Pay Item Number	Pay Item Description	Units of Measure	Quantity		Total Quantity		Secondary Quantity			Location
				P	F	P	F	Units	P	F	Location Description
	~~0455 17 378~~	~~PRE-PLANNED PILE SPLICES~~	~~EA~~	~~20~~		~~20~~					~~PILES~~
	0455 115	PILE REDRIVE	EA	22		22					PILES
	455 137	LOAD TEST-DYNAMIC (DATA COLLECTION AND ANALYSIS)	EA	114		114					PILES
	0455 137 2	LOAD TEST-DYNAMIC (VERIFICATION TESTS)	EA	11		11					PILES

- No pre-planned splices for steel piles
- Add the number of anticipated redrives to the DLT pay item
- Add VT to 455-115

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Basis of Estimates

- 455-15-AB Preformed Pile Holes

A= Pile Hole Type	
1 (Preformed Pile Hole)	LF
2 (Casing for Preformed Pile Hole)	LF
3 (Grouting of Preformed Pile Hole)	LF
4 (Preformed Sheet Pile Hole)	SF
B= Drill/Punch Size	
0 (Sheet Pile)	
1 (15 to 17 inches)	
2 (18 to 20 inches)	
3 (22 to 26 inches)	
4 (24 to 29 inches)	
5 (30 to 34 inches)	
6 (36 to 43 inches)	

12 inch square piles .... 15 to 17 inches
14 inch square piles .... 18 to 20 inches
18 inch square piles .... 22 to 26 inches
20 inch square piles .... 24 to 29 inches
24 inch square piles .... 30 to 34 inches
30 inch square piles .... 36 to 43 inches

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Section 455 – Driven Piles

- Next version will address remote monitoring
- 105-8.13.4 will include requirements for Senior Geotechnical Technician for Pile Foundations.

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Measuring While Drilling for Geotechnical Applications

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What is Measuring While Drilling (MWD)?

- A series of sensors placed on the drill rig
- This application uses computerized systems for continuous recording of data during the drilling
- Produces high resolution profiles of **individual** and **compound** drilling parameters
- Data is monitored in real-time to optimize drilling process

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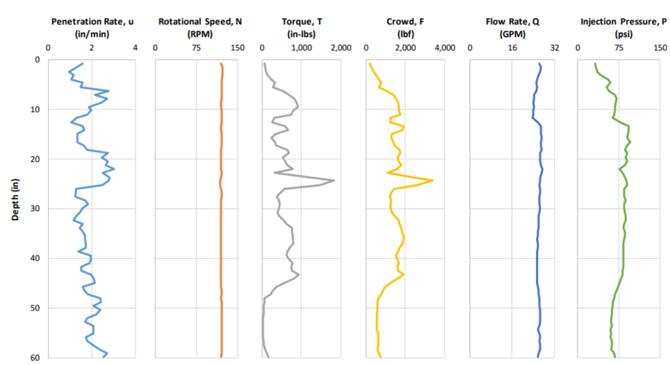
Monitored Parameters

- Fourteen (14) drilling parameters monitored
  - Torque
  - Crowd or downward thrust
  - Rotational speed
  - Penetration rate
  - Drilling fluid injection mass flow rate, volumetric flow rate, and pressure
  - Drilling fluid density, viscosity, and temperature
  - Vibration
  - Inclination
  - Eccentricity or eccentric rotation
  - Direction of drilling rotation (CW or CCW)



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Benefits of MWD

Optimization of Drilling

Ability to better quantify changes in subsurface conditions and site characterization

In situ Strength Assessment

QA/QC for Cast-in-Place Foundations

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Optimization of Drilling: Sample Recovery

- Florida limerock is soft and porous in nature
- With a high degree of variability and weathering
- Conventional drilling relies on expertise to minimize disturbance of the rock and maximize sample recovery
- Reduced core sample recovery (REC) and poor rock quality designation (RQD) are common leading to insufficient test samples (data) being collected from site investigations
- MWD has shown that these low RECs and RQDs are in large part due to coring techniques

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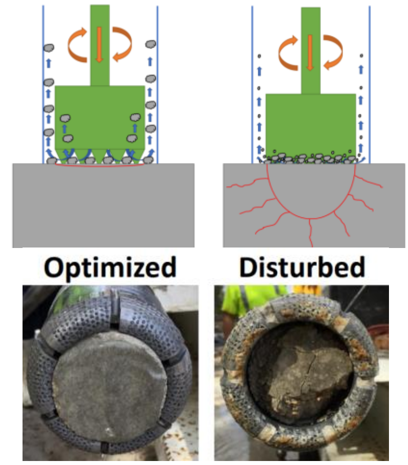
Optimization of Drilling: Sample Disturbance

- MWD has shown that over drilling can lead to disturbance of samples (low strength results)
- These lower values of strength can lead to unnecessary overconservatism in foundation designs
- By reducing drilling disturbance, MWD ensures the RQD is reflective of the in situ conditions and a more accurate assessment of the strength of the material
- MWD allows for an objective measure of drilling techniques that optimizes drilling
- This increases material recovery that gives more lab data for foundation design



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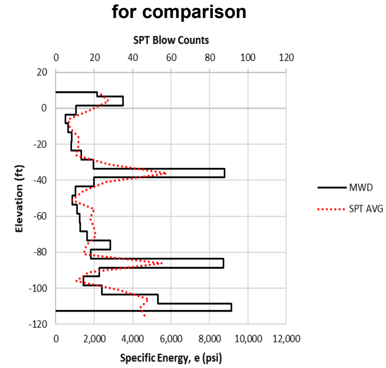
Quantifying Changes In Subsurface Conditions

- Driven piles are often designed using Standard Penetration Test (SPT) and/or Cone Penetration Test (CPT) data
  - SPT is typically performed at 2.5 feet intervals; this produces a low-resolution profile of the strata encountered
  - CPT provides a much higher resolution profile but is vulnerable to termination with rock or stiff strata layers
- MWD provides high-resolution profiling that surpasses CPT, with the added advantage of penetrating rock
- MWD as a new method of in situ soil assessment would combine the benefits of both conventional methods and greatly improve current practice

Combined MWD & SPT for comparison



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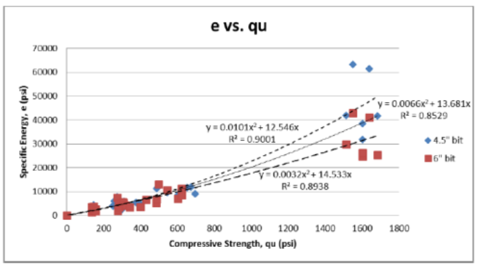
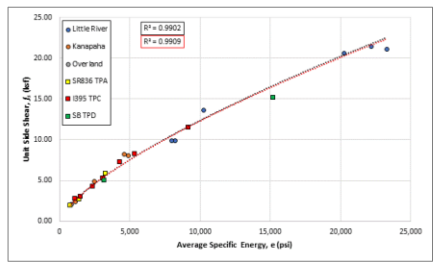
In situ Strength Assessment

- Specific energy, e, is a compound drilling parameter obtained from MWD
  - Defined as the energy required to remove/excavate a unit volume of rock
- Research shown as the unconfined compressive strength of rock, q_u, used for the design of deep foundations is directly correlated to specific energy
- Specific energy has also been correlated with mobilized side shear measured within cast-in-place (CIP) foundations





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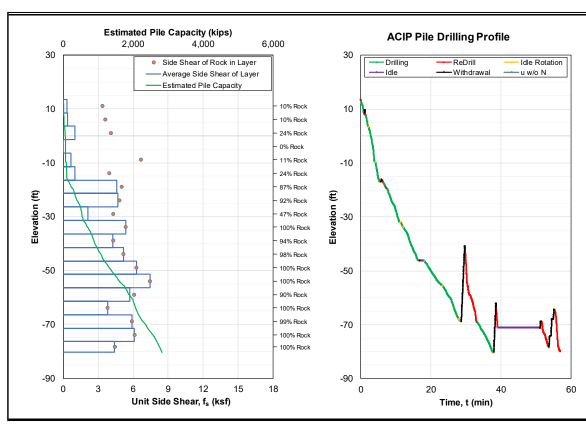
QA/QC for CIP (Cast-In-Place) Foundations

- MWD provides an assessment of the strength of Florida limestone during drilling
- MWD has been used to assess specific energy on planned instrumented load-tested piles
- The correlation between specific energy and CIP foundation side shear can be used for QA/QC of production piles
- MWD can be used to confirm the rock socket length of CIP foundations



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Case Study:
Auger Cast Piles for the I-395 Signature Bridge

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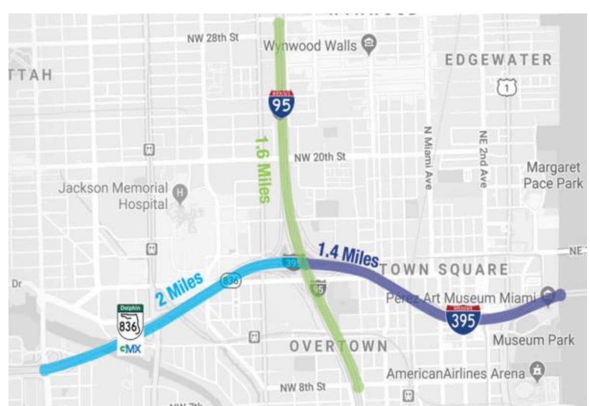
Case Study: Project Background

- The project is a partnership between FDOT and the Greater Miami Expressway Agency (GMX)
- The project connects various areas of Miami and helps reduce weaving movements
- Enhances pedestrian safety (crosswalks and new bike lanes)
- Increases the capacity of SR 836, I-95 and I-395



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Case Study: Use of ACIP Foundations

- Maximize the benefits of drilled-in-place foundations compared to driven piles
- The project required the calibration of resistance factors (LRFD)
  - Utilized SPT data, conventional rock coring data, and MWD data
- Reliability-based using existing database of full-scale static load tests and analysis using all LRFD methods
- Evaluated use of MWD for soil and rock properties
  - Assessment of rock socket length and rock strength
- First state to use MWD for Auger Cast Piles

Case Study: Construction of ACIP Foundations

Case Study: Construction of ACIP Foundations

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Case Study: Use of MWD

- Over 400 piles were installed
- Each pile was MWD monitored and validated during installation
- 5% of piles were proof tested using drop hammer load
- MWD detected zones of reduced cross-sectional area near the tip of the piles
  - Led to the selection of proof testing elements to confirm pile capacity (Bidirectional Static Load Testing)
- Resistance factors developed through research were validated using MWD ensuring the desired level of reliability
- MWD assisted in determining the proper strength distribution obtained from traditional rock core sampling

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Cathodic Protection Program
Preserving Florida's Bridges

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Outline

- Introduction
- Problems & Challenges with Corrosion
- What is Cathodic Protection (CP)?
- The Future

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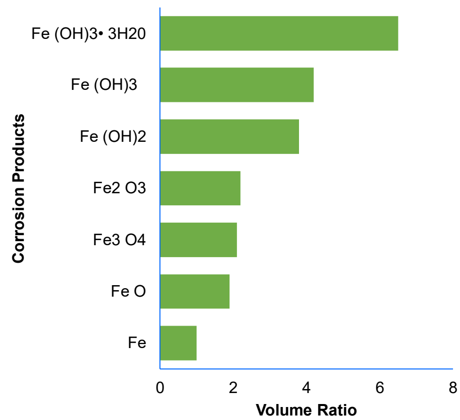
Introduction

- Florida's bridge infrastructure is vulnerable to corrosion
- Seawater, salt air, acidic soil & other factors accelerate corrosion
- Corrosion of reinforcing steel produces iron oxide which occupies 2 to 7 times more volume
- Proactive *preservation* extends the service life of bridges & reduces cost



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What are the Challenges?

- Problem
  - Corrosion damages concrete & steel components
  - Leads to cracking & spalling
  - High repair costs & safety risks
- Challenges
  - Marine environment
  - Soil resistivity/pH
  - Heat & humidity

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Corrosion Prevention

- Structure design
- Chemical inhibitors
- Corrosion-resistant materials
- Protective coatings
- **Cathodic Protection**





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What is Cathodic Protection (CP)?

- CP is a technology used to mitigate corrosion of metals by transforming the metal you want to protect into the cathode of an electrochemical cell
  - An anode gives up electrons – it corrodes or wears away
  - A cathode receives electrons – it stays protected & does not corrode
- The Federal Highway Administration concluded that CP is the only proven technology to stop corrosion in salt-contaminated bridge decks regardless of the chloride content of the concrete

FHWA-RD-01-096 Long-Term Effectiveness of Cathodic Protection Systems on Highway Structure, 2003
Stratfull, R.F., "Experimental Cathodic Protection of a Bridge Deck," Transportation Research Board No. 500, pp. 1-15, 1974, and Federal Highway Administration Report4 No. FHWA-RD-74-031, January 1974, Washington, DC.
Barnhart, R.A., Federal Highway Administrator, Memorandum entitled "FHWA Position on Cathodic Protection Systems," April 1982, Federal Highway Administration, Washington, DC.

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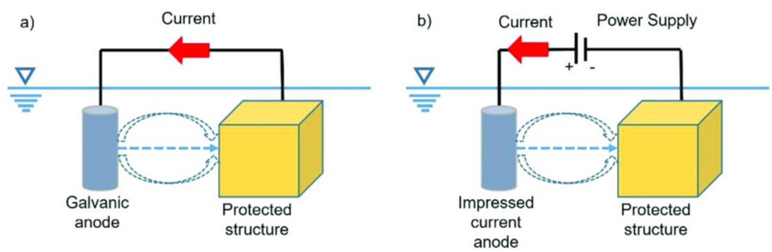
Cathodic Protection Types

- Galvanic (sacrificial anode) protection
  - A more reactive metal like zinc, magnesium, or aluminum is attached to the structure & corrodes instead of the steel reinforcement
- Impressed current protection
  - Uses an external power source to drive a current through an inert anode, offering more control and power



Galvanic Cathodic Protection

Impressed Current Cathodic Protection

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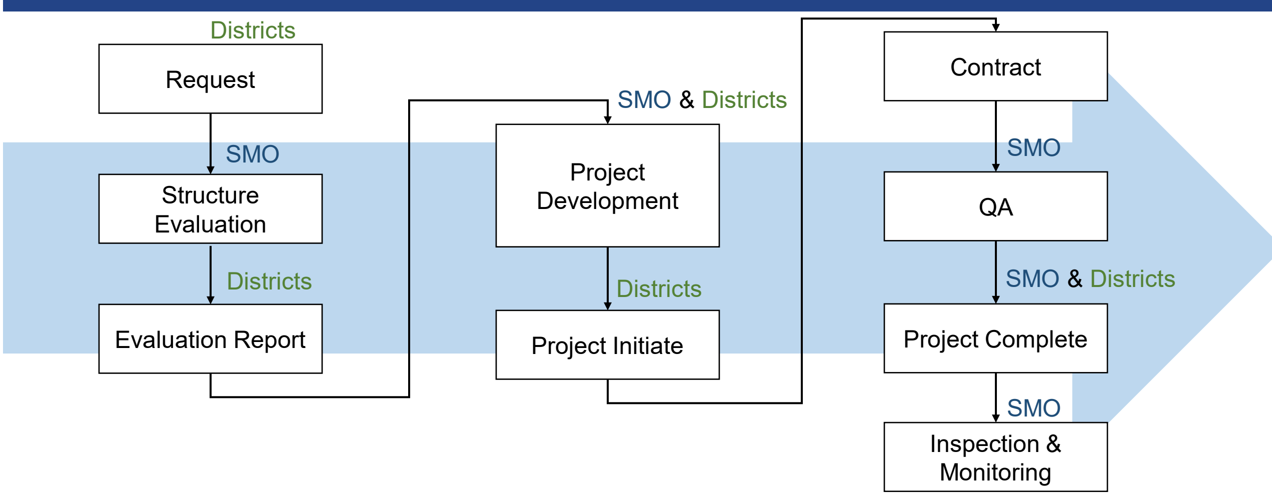
CP System Project Development



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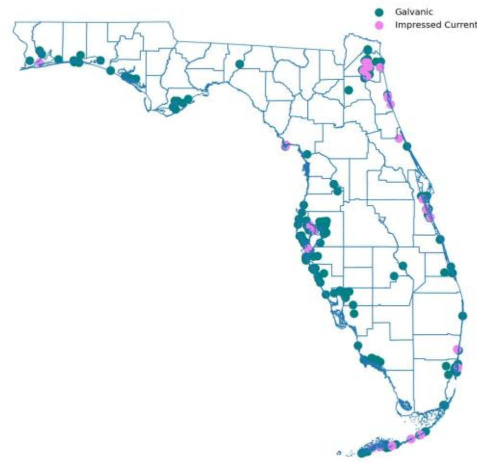
Cathodic Protection Systems in Florida

- There are currently 246 bridges that require the SMO team to monitor and inspect
  - 209 Galvanic CP systems
  - 37 Impressed Current CP systems
- For the past six years 5 bridges per year have been added to this list



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Inspection of Cathodic Protection Systems

- **Ensures Effective Corrosion Protection**
  - CP systems must maintain a certain voltage or current level to prevent corrosion
  - Inspection ensures the system is functioning as intended
- **Prevents System Failures Early**
  - Power supply failures (especially for impressed current systems), depleted sacrificial anodes, or damaged wiring can cause CP systems to stop working
  - Regular inspections help identify these failures before significant corrosion occurs
- **Extends the Life of CP System**
  - Routine inspections can be used to track the consumption rate of sacrificial anodes and the performance of rectifiers, allowing for timely maintenance and replacement
- **Improves Cost Efficiency**
  - Proactive inspection & monitoring reduces costly emergency repairs and unexpected infrastructure failures

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Current Inspection Practice

- **Impressed Current**
  - Average service life more than 20 years
  - 37 bridges with Impressed Current CP systems
  - ≈74 on-site inspections per year
  - On average, 1 ICCP system designed and built each year
- **Galvanic**
  - Service life max 20 years
  - 209 bridges with GCP
  - ≈100 on-site inspections per year
  - On average, 5 new galvanic systems designed and built each year

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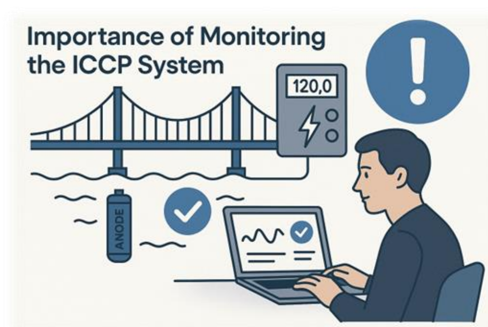
The Future

- **Impressed Current**
  - Effective for large, complex structures
  - Adjustable current for varying conditions
  - Long-term corrosion control
  - Retrofit and/or upgrade of Galvanic systems is possible
- **Remote Monitoring**
  - Improved safety
  - Optimized field inspections
  - Timely detection & response
  - Enhanced protection
- **Solar Powered**
  - Cost reduction of CP systems
  - Consistent protection



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Solar Power

- In the 1990s, the SMO began studying the use of solar panels installed on bridges to provide electrical current for cathodic protection systems
- Solar panel size & quantity optimized
- Direct sunlight exposure is critical
- Currently, 10 CP systems operate with solar power

Panels mounted on the underside of bridge

Suspended panels

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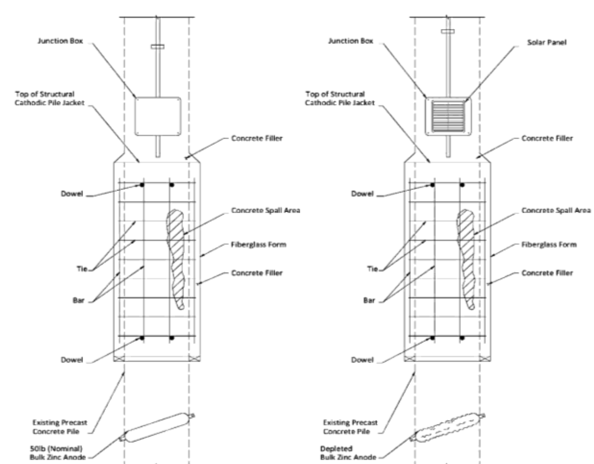
Upgrading Galvanic CP Systems

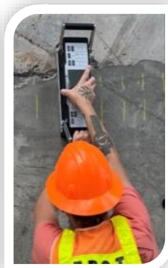
- With the standardization of solar power supply, a renewable energy platform is available for all CP systems
- Solar power improves the feasibility and reduces the cost of implementing CP systems
- SMO continues to explore alternative power sources to provide optimized and consistent power for CP systems

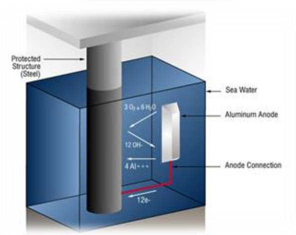


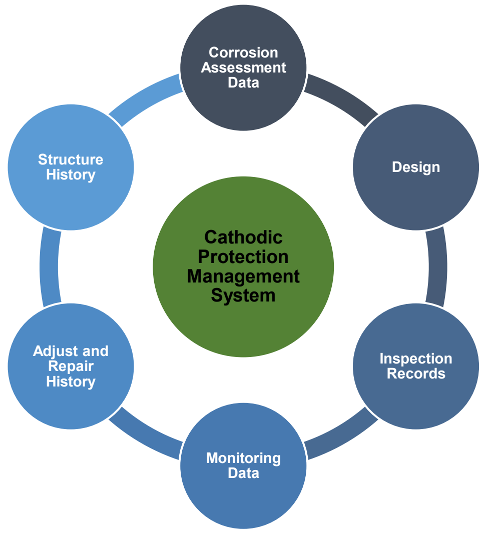
STRUCTURAL CATHODIC PROTECTION PILE JACKET

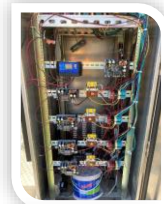
Cathodic protection details and wiring not shown for clarity

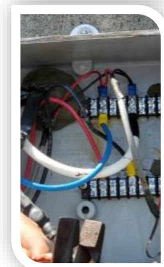
Cathodic Protection Management System











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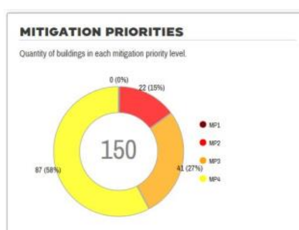
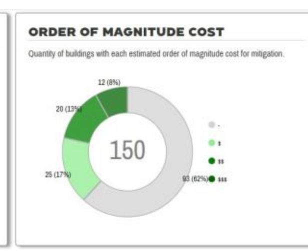
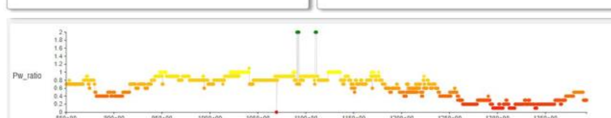
Cathodic Protection Management System

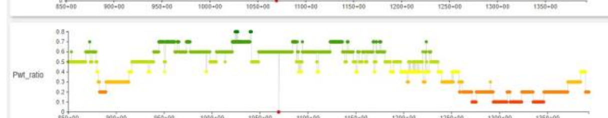
Vision

- Real-time monitoring and adjustment of CP system
- Inspection and maintenance scheduling
- Corrosion risk analysis
- User interface and accessibility
- Data logging and historical trends
- Standardized the reports and data
- Asset inventory and tracking
- Integration with Bridge Management Systems









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Summary

- Cathodic protection of critical structures is essential to *preserve* & maximize service life
- ≈250 bridges have cathodic protection with more added each year
- Research & experience has shown that Impressed Current CP systems coupled with solar power & remote monitoring are the most effective over the life of the structure

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Questions?

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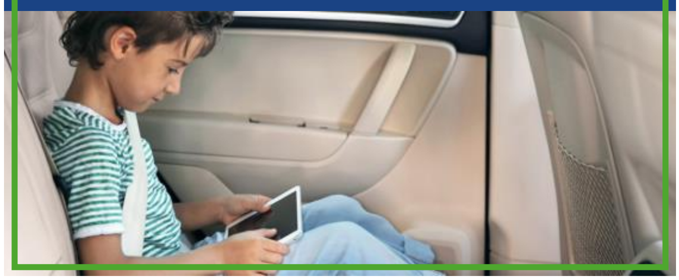
Safety Message

The next generation of great drivers begins with you!

Lead by example, Prioritize Safety - Every Trip, Every Time.



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Contact Us

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October 28-29, 2025
Orlando, FL

TRANSPORTATION SYMPOSIUM

DEADLINE

Please be sure to **certify your attendance** before leaving this event or no later than **November 30th**, in order to receive PDH/CEC. Detailed instructions are available on the Transportation Symposium website.

Transportation Symposium Website

SCAN ME

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