North Carolina Experience with

Embedded Data Collectors

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July 25, 2013

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7/25/2013

Presentation Outline

- NCDOT History with Dynamic Testing
- NCDOT Familiarity with EDC
- Experience with EDC
- Current and Future Plans for EDC
- Benefits of Using EDC

NCDOT History with Dynamic Testing

Pile Dynamic Testing

- 1987 GC back PDA – Pile Driving
- 1997 PDA with DOS PAK version
- 2001 PDA with Window version

GC – Blue Box

PAK-DOS

PAK-Window

NCDOT History with Dynamic Testing

Pile Integrity Testing

- 1992 PDI (Pile Integrity Testing)
- 1993 TNO (Sonic Integrity Testing)
- 2001 PIT-W (Unknown Foundation)

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Pile Dynamic Testing Process

Dynamic Design – GRLWEAP (WEAP)

- Drivability analysis
- Select hammer size (assume hammer)
- Recommend specific range of hammer energy

During Construction

- Evaluate the specific hammer submitted by contractor
- Provide driving criteria
- If PDA is recommended, then CAPWAP will be used to refine WEAP analysis to generate driving criteria

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Our familiarity with Embedded Data Collectors (EDC)

- 2002 - FDOT and University of Florida research – Estimating pile capacity during construction was completed
- 2003 - Smart Structures got license agreement from University of Florida
- 2007 - FDOT mandated that all of their test piles must have EDC to collect enough data to conduct their own comparison with PDA and static load tests
- 2010 - FDOT adapted the use of EDC in their special provision
- AFT and Smart Structures communication with us

NCDOT Experience with EDC

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- 2007- NCDOT agreed with AFT to try the EDC in 2 piles
- B-1381 Sampson County 12” (305mm) Prestressed Concrete Pile –See Table 1

The pile driving template was used for determining the pile tip penetration and counting blows during pile driving. Pile size, length, gauge locations, and radio identification numbers are summarized in Table 1.

Table 1: Summary of Piles Tested
State Road 411 over the Black River
Sampson County, North Carolina

Pile Designation	Pile Size (inch)	Pile Length (feet)	Top Sensor Location Below Pile Top (inches)	Bottom Sensor Location Above Pile Toe (inches)	Radio Identification Number
End Bent 1, Pile 3	12	27.88	24	24	00.A0.96.10.8A.7E
End Bent 2, Pile 3	12	21.32	24	24	00.A0.96.10.8A.75

- NCDOT prepared the Pile detail and special provision

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This is a sample image. Similar documentation will be posted to the TIG Embedded Data Collectors website in the near future.

B-1381 **124**

EMBEDDED DATA COLLECTORS **(SPECIAL)**

1.0 GENERAL

This special provision governs the use of embedded data collectors (EDC) in accordance with the plans and as directed by the Engineer. EDC consist of strain gauges and accelerometers embedded in prestressed concrete piles to measure force and acceleration. For more information about EDC, contact the following:

Smart Structures, Inc.
324 2nd Street Pike, Unit #13
Southampton, PA 18966
(866) 640-2993
www.smart-structures-inc.com

EDC are required for the same prestressed concrete piles tested with the pile driving analyzer (PDA). The Department will retain the following EDC Consultant to perform the EDC testing and analysis.

Applied Foundation Testing, PLLC

201 Shannon Oaks Circle, Suite 200
Cary, NC 27511
(919) 654-7381

Do not use the EDC Consultant shown above for the PDA consultant on the prestressed concrete piles

2.0 NOTIFICATIONS

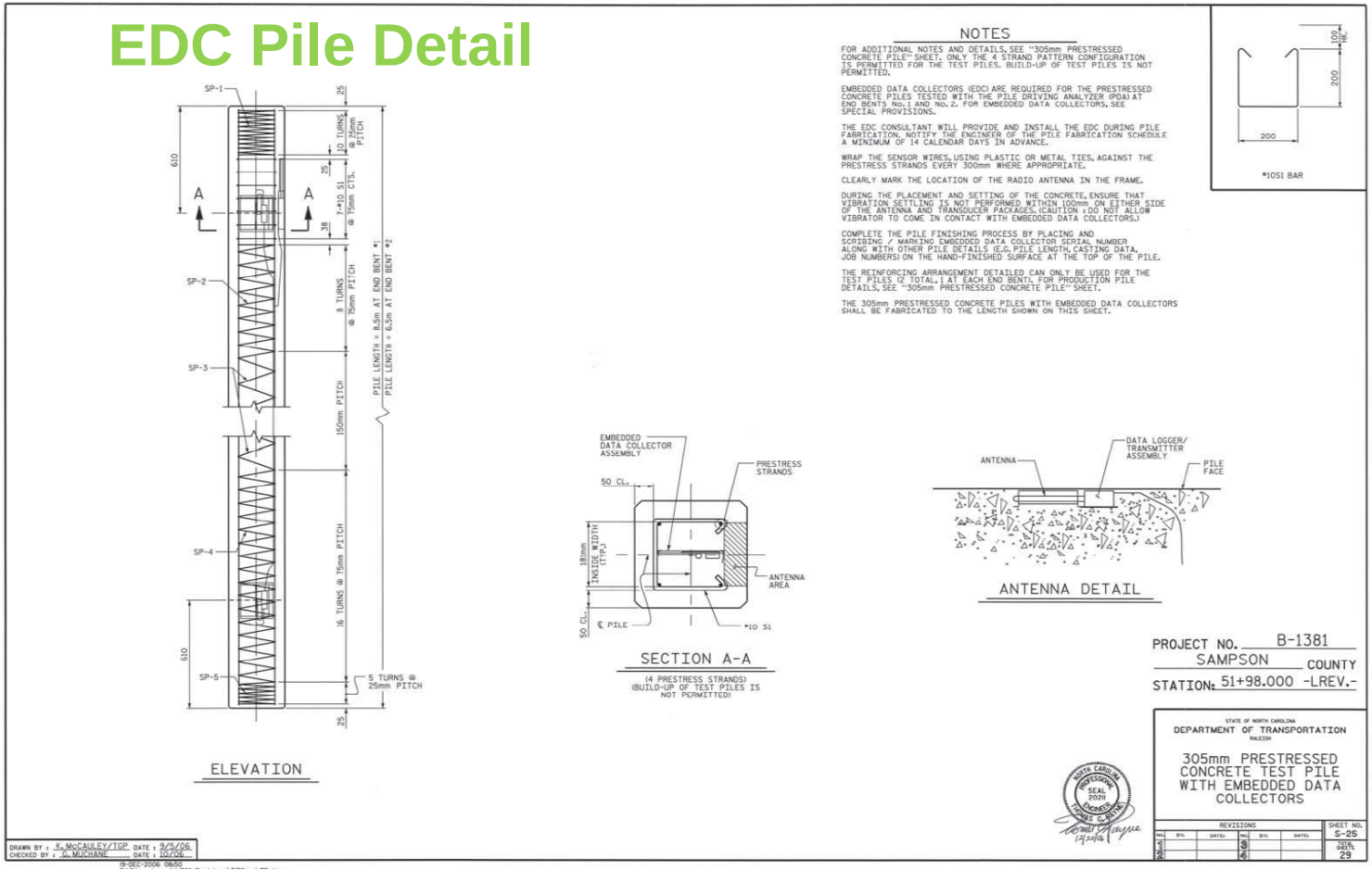
The EDC Consultant will provide and install the EDC during pile fabrication. Notify the Engineer of the pile fabrication schedule a minimum of 14 calendar days in advance. The EDC Consultant will record dynamic measurements during initial drive, restrikes and redrives. Notify the Engineer of the pile driving schedule in accordance with the Pile Driving Analyzer Special Provision.

3.0 MEASUREMENT AND PAYMENT

There will be no payment for the EDC. The Department will contract with the EDC Consultant directly to provide the EDC and associated installation, recording, analysis and reporting.

The cost of the PDA will be paid for separately in accordance with the Pile Driving Analyzer Special Provision (November 20, 2006). The cost of the pile and the installation including driving, restriking and redriving will be paid for separately in accordance with the Standard Specifications.

EDC Pile Detail



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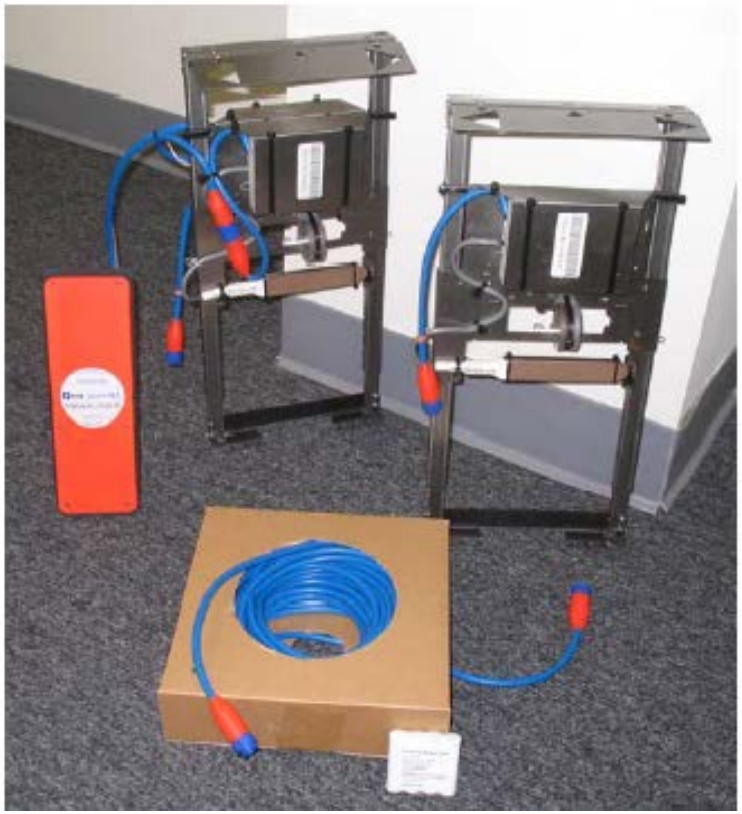
Radio and Antenna Assembly and Embedded Data Sensors



EDC Installation – P/S Concrete Pile

12” (305mm) PSC Concrete Pile with EDC

EDC and PDA

PDA Test

EDC Test

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EDC Communication Problem

PDA test
by different
consultant

PDA and EDC during driving

- Short Pile (28’)

- Suggest using longer pile for testing

EDC Tip and Skin Capacity Comparison to PDA

Table 5: *SmartPile*™ Tip Capacity Results / CAPWAP Tip Capacity
State Road 411 over the Black River
Sampson County, North Carolina

Pile Designation	Blow Number SSI/PDI	*SmartPile*™ Tip Capacity (kips)	MACTEC CAPWAP Tip Capacity (kips)	Automatic CAPWAP Tip Capacity (kips)
End Bent 1, Pile 3	357/192	72	75	31
End Bent 1, Pile 3	359/194 (RS 1)	86	78	11
End Bent 2, Pile 3	144/144	47	24	25
End Bent 2, Pile 3	176/176 (RS31)	161	113	127

Table 6: *SmartPile*™ Skin Capacity Results / CAPWAP Skin Capacity
State Road 411 over the Black River
Sampson County, North Carolina

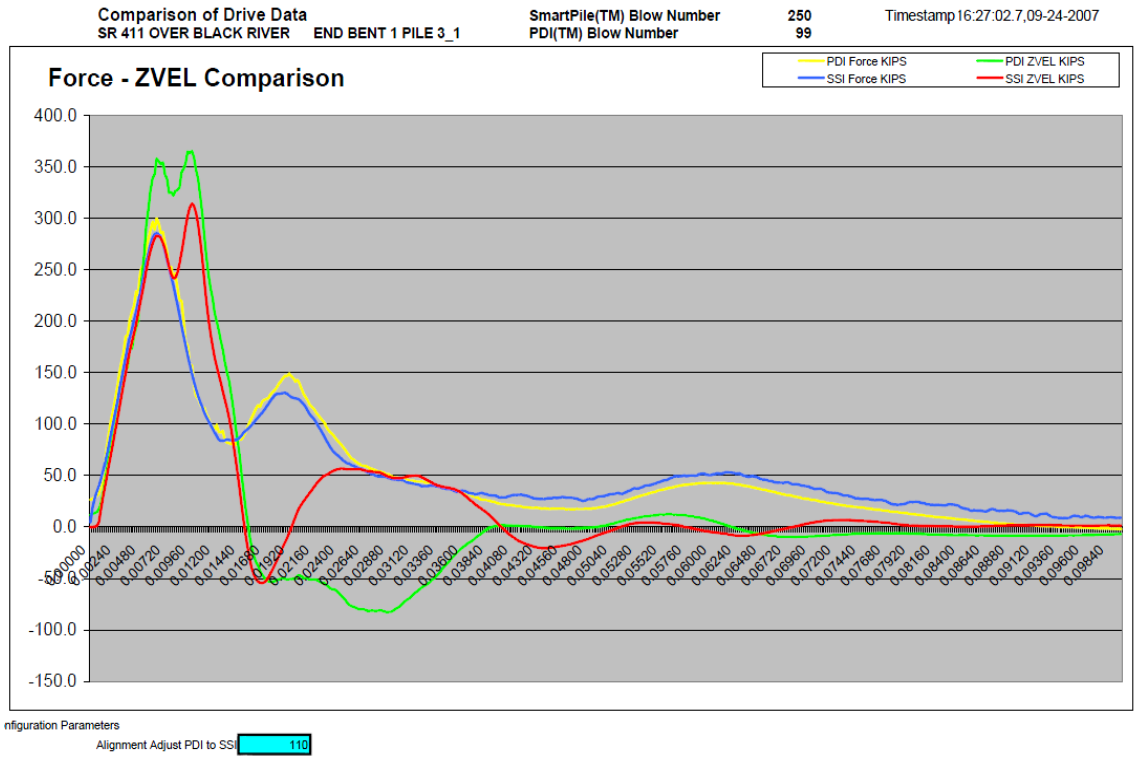
Pile Designation	Blow Number SSI/PDI	*SmartPile*™ Skin Capacity (kips)	MACTEC CAPWAP Skin Capacity (kips)	Automatic CAPWAP Skin Capacity (kips)
End Bent 1, Pile 3	357/192	128	124	164
End Bent 1, Pile 3	359/194 (RS 1)	153	142	174
End Bent 2, Pile 3	144/144	86	118	120
End Bent 2, Pile 3	176/176 (RS31)	133	130	116

EDC Total Capacity Comparison to PDA

Table 7: *SmartPile*™ Total Capacity Results / CAPWAP Total Capacity
State Road 411 over the Black River
Sampson County, North Carolina

Pile Designation	Blow Number SSI/PDI	*SmartPile*™ Total Capacity (kips)	MACTEC CAPWAP Total Capacity (kips)	Automatic CAPWAP Total Capacity (kips)
End Bent 1, Pile 3	357/192	200	199	195
End Bent 1, Pile 3	359/194 (RS 1)	226	219	185
End Bent 2, Pile 3	144/144	133	142	145
End Bent 2, Pile 3	176/176 (RS31)	294	243	243

EDC Force Comparison to PDA



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Cost: The EDC was more expensive than the PDA (probably twice the cost) and for that reason we did not pursue the EDC as another dynamic test method at that time.

Sole source: It was an issue to use and recommend a technology with sole source without proper justification.

Confidence: Without trying and confirming the results of the EDC with static load tests and PDA, it would be very hard for us to accept and implement such technology.

Smart Structures mentioned a few future changes that will enhance the results of the analysis.

FHWA Announces **Every Day Counts (EDC)** Initiative September 15, 2010

Every Day Counts (EDC) is an initiative by FHWA to accelerate the deployment of new, proven, under-utilized, market-ready technologies.

In other words, everyone is looking for better, faster, smarter project delivery.

We think Embedded Data Collectors (EDC) fit the **Every Day Counts (EDC)** initiative. They are ready to use and we are interested in the technology.

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Current and Future Plans for EDC

2011

NCDOT designated a couple of projects to use EDC, PDA, and Static Load tests.

2013

1. R-3307 New Bridge over Gallants Channel in Carteret County: Unfortunately, this project was delayed letting multiple times. Current letting date is January 2014

2. R-2633BB Dual Bridges on –L- (US17) over Cape Fear River in Brunswick and New Hanover Counties. Current letting date is September 2013

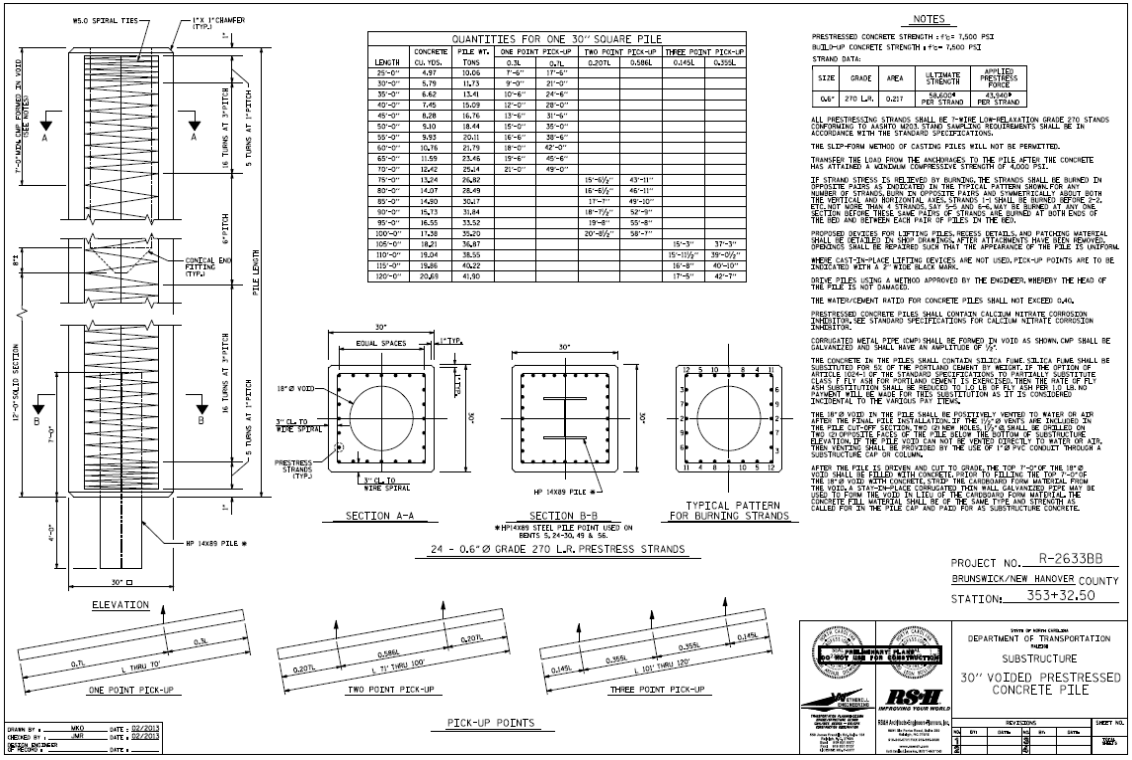
R-2633BB Dual Bridges on –L-(US 17) over Cape Fear River (Let September 2013)

# Interior Bents	# of Piles	Pile Type	Pile Sizes	Pile Length (Feet)	Total Pile Length (Feet)
57	1000	P/S Concrete	24" Solid 30"and 36"voided	35' to 105' Avg.=80'	78,000

# of EDC	Pile Type	Pile length	# Test Piles	# Production Piles	# of Bents
5	P/S Concrete	55' to 105'	1	4	4

Access by “Swamp Loggers”

R-2633BB 30” Voided P/S Concrete Pile Detail



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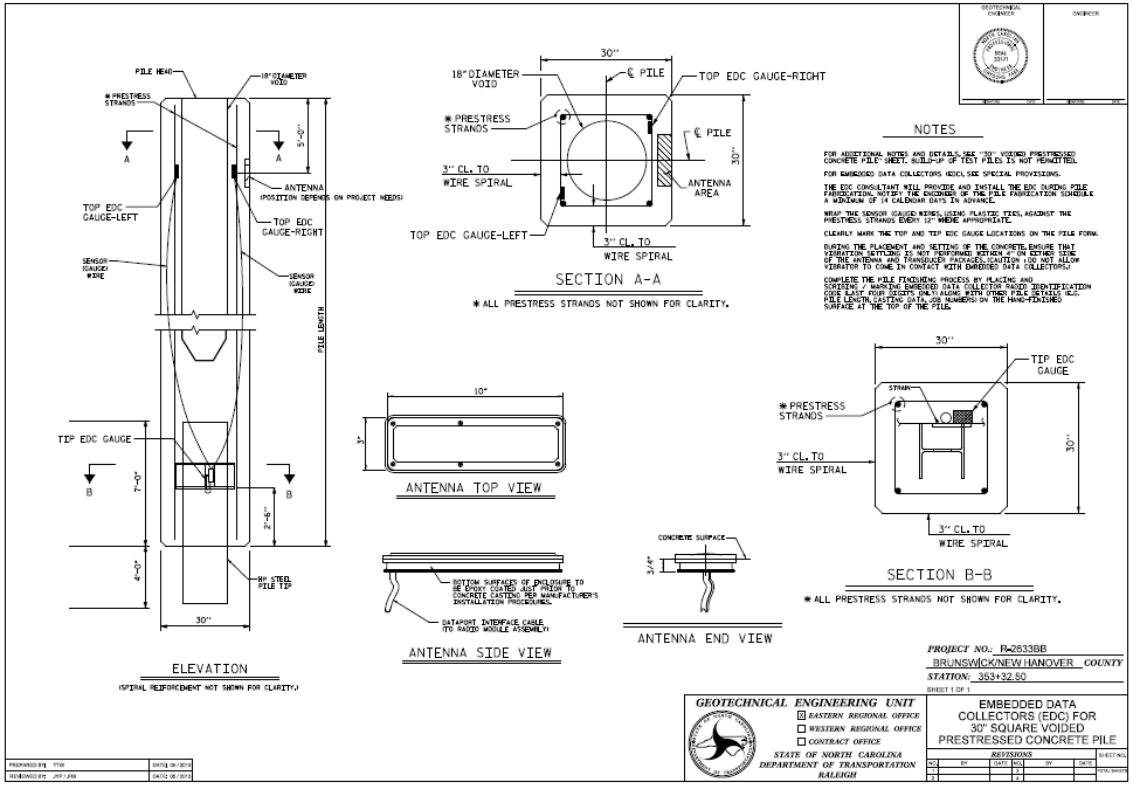
Concrete Piles with HP Steel Pile Stinger

EDC Installation Details – R2633BB



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R-3307 Bridge over Gallants Channel (Let January 2014)

# Interior Bents	# of Piles	Pile Type	Pile Sizes	Pile Length (Feet)	Total Pile Length (Feet)
28	471	P/S Concrete	30" Solid	35' to 130' Avg.=95'	46,000

# of EDC	Pile Type	Pile length	# Test Piles	# Production Piles	# of Bents
4	P/S Concrete	120'	1	3	3

- A total of four (4) EDC are required for the same prestressed concrete piles tested with the Pile Driving Analyzer (PDA)
- One (1) EDC on the Static Axial Compressive Load Test pile

Bridge Length = 3,395'

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NCDOT Current and Future Plans for EDC

- EDC is ready to use technology (FDOT success)
- NCDOT is pursuing this technology by taking the first step (two projects)
- The outcome from the two proposed projects will determine the implementation program
- The AASHTO TIG program

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Benefits

- Cost
- Eliminating over-driving piles
- Detecting pile tip damage
- Efficiency (time)
- Improving safety
- Reusing existing foundation

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Thank you very much.

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