

## EDC

## EMBEDDED DATA COLLECTORS



# North Carolina Experience with Embedded Data Collectors

**Mohammed A. Mulla, P.E., CPM, MCE.**

North Carolina Department of Transportation  
Geotechnical Engineering Unit

August 27, 2013



## EDC

## EMBEDDED DATA COLLECTORS



### Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
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
- What can we do for you to start using the 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)
- 2007 PIT-W (Unknown Foundation)



## Pile Dynamic Testing Process

### During Design Process – GRLWEAP (WEAP)

- Driveability 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



Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

## EDC

## EMBEDDED DATA COLLECTORS

### 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

#### Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

## EDC

## EMBEDDED DATA COLLECTORS

# NCDOT Experience with EDC



- 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

### Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

- NCDOT prepared the Pile detail and special provision

# EDC

# EMBEDDED DATA COLLECTORS

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 2<sup>nd</sup> Street Pike, Unit #13  
Southampton, PA 18966  
(866) 640-2993  
[www.smart-structures-inc.com](http://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  
[www.testpile.com](http://www.testpile.com)

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

2.0

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.



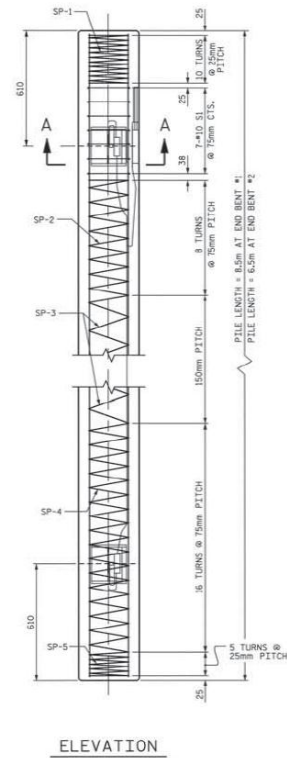
### Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

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

# EMBEDDED DATA COLLECTORS

## EDC Pile Detail



DRAWN BY : K. McCAULEY/TGP DATE : 9/5/06  
 CHECKED BY : G. MUCHANE DATE : 10/06  
 09-DEC-2006 09:50

## NOTES

FOR ADDITIONAL NOTES AND DETAILS, SEE "305mm PRESTRESSED CONCRETE PILE" SHEET. ONLY THE 4 STRAND PATTERN CONFIGURATION IS PERMITTED FOR THE TEST PILES. BUILD-UP OF TEST PILES IS NOT PERMITTED.

EMBEDDED DATA COLLECTORS (EDC) ARE REQUIRED FOR THE PRESTRESSED CONCRETE PILES TESTED WITH THE PILE DRIVING ANALYZER (PDA) AT END BENTS NO. 1 AND NO. 2. FOR EMBEDDED DATA COLLECTORS, SEE SPECIAL PROVISIONS.

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.

WRAP THE SENSOR WIRES, USING PLASTIC OR METAL TIES, AGAINST THE PRESTRESS STRANDS EVERY 300mm WHERE APPROPRIATE.

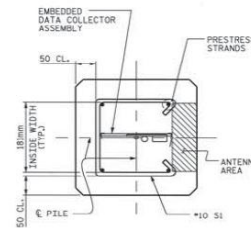
CLEARLY MARK THE LOCATION OF THE RADIO ANTENNA IN THE FRAME.

DURING THE PLACEMENT AND SETTING OF THE CONCRETE, ENSURE THAT VIBRATION SETTLING IS NOT PERFORMED WITHIN 100mm ON EITHER SIDE OF THE ANTENNA AND TRANSDUCER PACKAGES. (CAUTION: DO NOT ALLOW VIBRATOR TO COME IN CONTACT WITH EMBEDDED DATA COLLECTORS.)

COMPLETE THE PILE FINISHING PROCESS BY PLACING AND SCRIBING / MARKING EMBEDDED DATA COLLECTOR SERIAL NUMBER ALONG WITH OTHER PILE DETAILS (E.G. PILE LENGTH, CASTING DATA, JOB NUMBERS) ON THE HAND-FINISHED SURFACE AT THE TOP OF THE PILE.

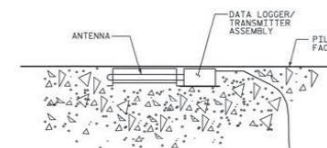
THE REINFORCING ARRANGEMENT DETAILED CAN ONLY BE USED FOR THE TEST PILES (2 TOTAL, 1 AT EACH END BENT). FOR PRODUCTION PILE DETAILS, SEE "305mm PRESTRESSED CONCRETE PILE" SHEET.

THE 305mm PRESTRESSED CONCRETE PILES WITH EMBEDDED DATA COLLECTORS SHALL BE FABRICATED TO THE LENGTH SHOWN ON THIS SHEET.



SECTION A-A

(4 PRESTRESS STRANDS)  
(BUILD-UP OF TEST PILES  
NOT PERMITTED)



### ANTENNA DETAIL

PROJECT NO. B-1381  
SAMPSON COUNTY  
 STATION: 51+98.000 -LREV.-

STATE OF NORTH CAROLINA  
DEPARTMENT OF TRANSPORTATION  
RALEIGH

305mm PRESTRESSED  
CONCRETE TEST PILE  
WITH EMBEDDED DATA  
COLLECTORS



REVISIONS						SHEET NO. S-25
NO.	BY	DATE	NO.	BY	DATE	
1			3			TOTAL SHEETS 29
2			4			

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

EDC

EMBEDDED DATA COLLECTORS

## Radio and Antenna Assembly and Embedded Data Sensors



EDC

EMBEDDED DATA COLLECTORS

## EDC Installation – P/S Concrete Pile



EDC

EMBEDDED DATA COLLECTORS

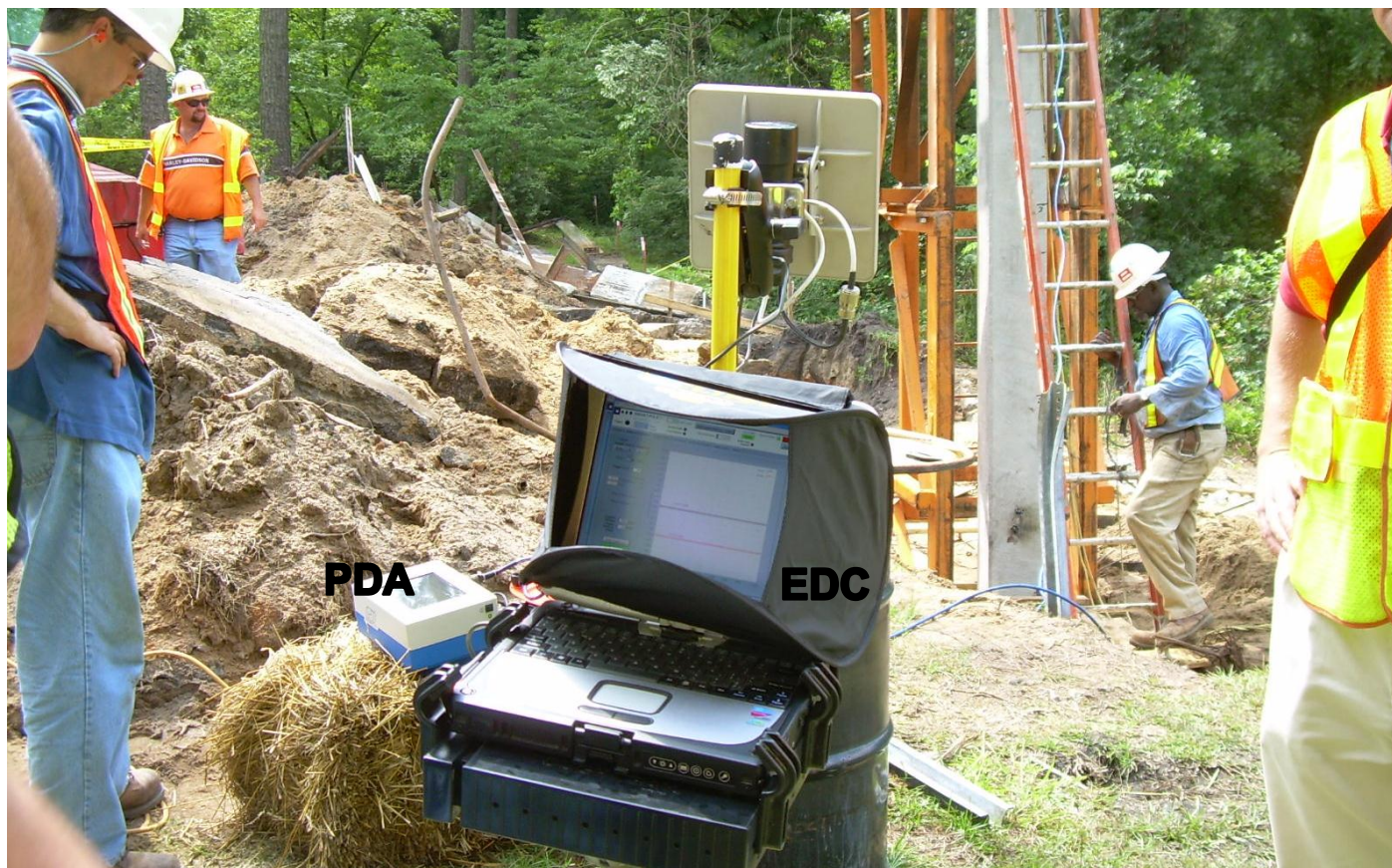
## 12" (305mm) PSC Concrete Pile with EDC



EDC

EMBEDDED DATA COLLECTORS

## EDC and PDA



## EDC

## EMBEDDED DATA COLLECTORS

### PDA Test



### EDC Test



## EDC

## EMBEDDED DATA COLLECTORS

### EDC Communication Problem



Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013



PDA test  
by different  
consultant

## EDC

## EMBEDDED DATA COLLECTORS

# PDA and EDC during driving



- Short Pile (28')

## EDC

## EMBEDDED DATA COLLECTORS



- Suggest using longer pile for testing

## EDC Tip and Skin Capacity Comparison to PDA

<b>Table 5: <i>SmartPile</i><sup>TM</sup> Tip Capacity Results / CAPWAP Tip Capacity</b> <b>State Road 411 over the Black River</b> <b>Sampson County, North Carolina</b>				
<b>Pile Designation</b>	<b>Blow Number SSI/PDI</b>	<b><i>SmartPile</i><sup>TM</sup> Tip Capacity (kips)</b>	<b>MACTEC CAPWAP Tip Capacity (kips)</b>	<b>Automatic CAPWAP Tip Capacity (kips)</b>
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

<b>Table 6: <i>SmartPile</i><sup>TM</sup> Skin Capacity Results / CAPWAP Skin Capacity</b> <b>State Road 411 over the Black River</b> <b>Sampson County, North Carolina</b>				
<b>Pile Designation</b>	<b>Blow Number SSI/PDI</b>	<b><i>SmartPile</i><sup>TM</sup> Skin Capacity (kips)</b>	<b>MACTEC CAPWAP Skin Capacity (kips)</b>	<b>Automatic CAPWAP Skin Capacity (kips)</b>
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

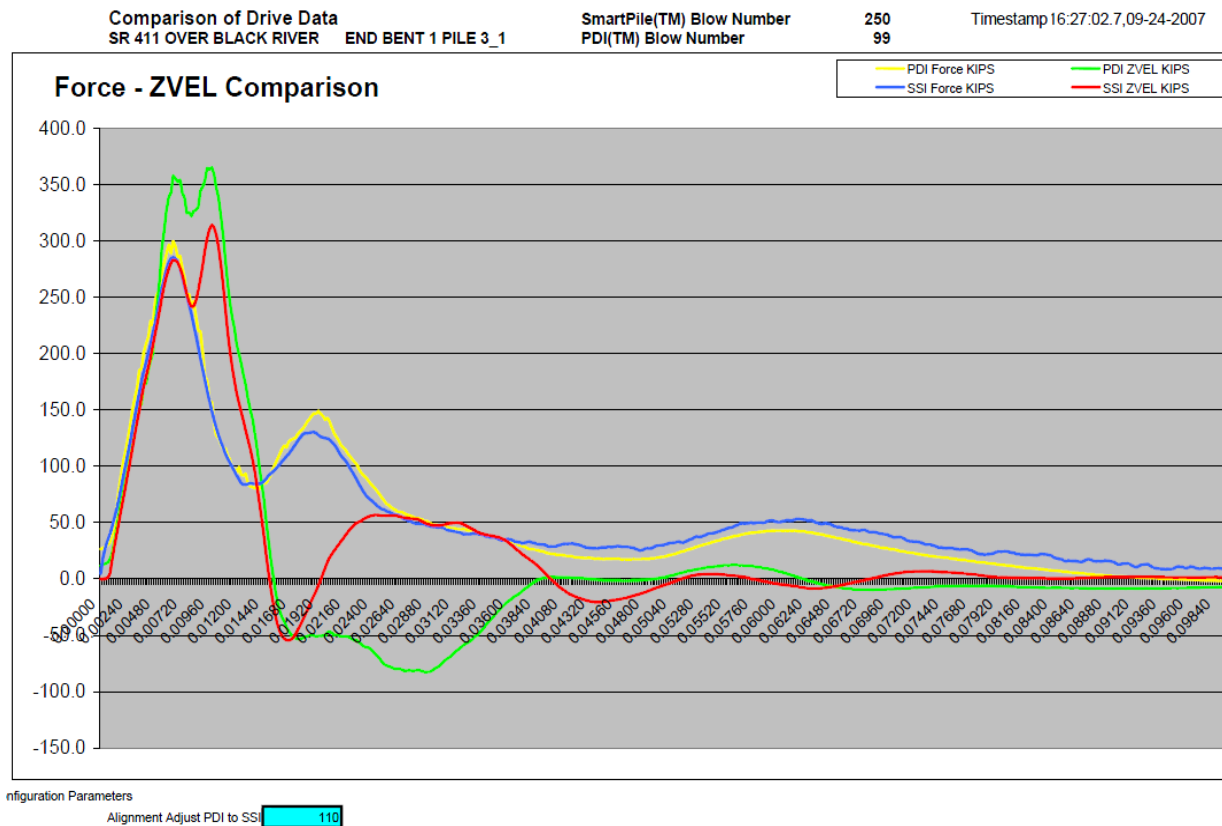
**Table 7: SmartPile™ Total Capacity Results / CAPWAP Total Capacity**  
State Road 411 over the Black River  
Sampson County, North Carolina

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

EMBEDDED DATA COLLECTORS

## EDC Force Comparison to PDA



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

## EDC

## EMBEDDED DATA COLLECTORS



- 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.

### Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

## EDC

## EMBEDDED DATA COLLECTORS



### 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.

## EDC

## EMBEDDED DATA COLLECTORS

### 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



Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

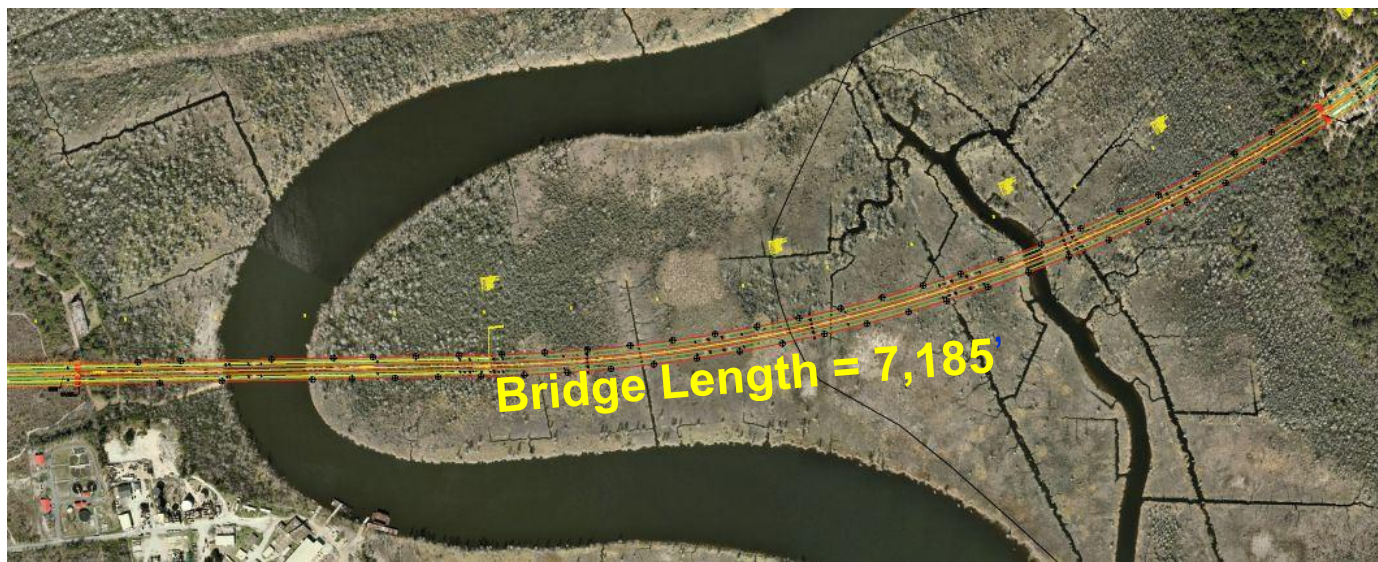
## EDC

## EMBEDDED DATA COLLECTORS

### 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



EDC

EMBEDDED DATA COLLECTORS

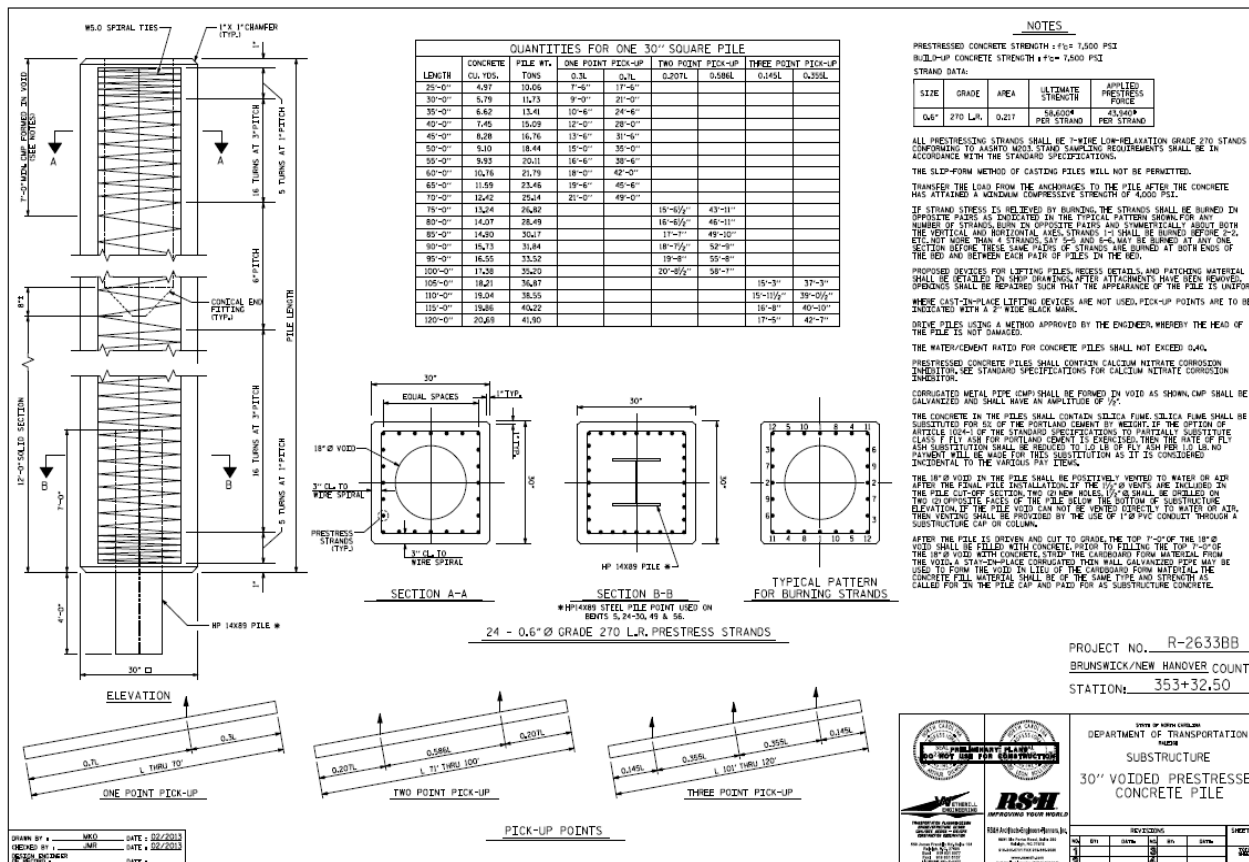
## Access by “Swamp Loggers”



EDC

# EMBEDDED DATA COLLECTORS

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



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

EDC

EMBEDDED DATA COLLECTORS

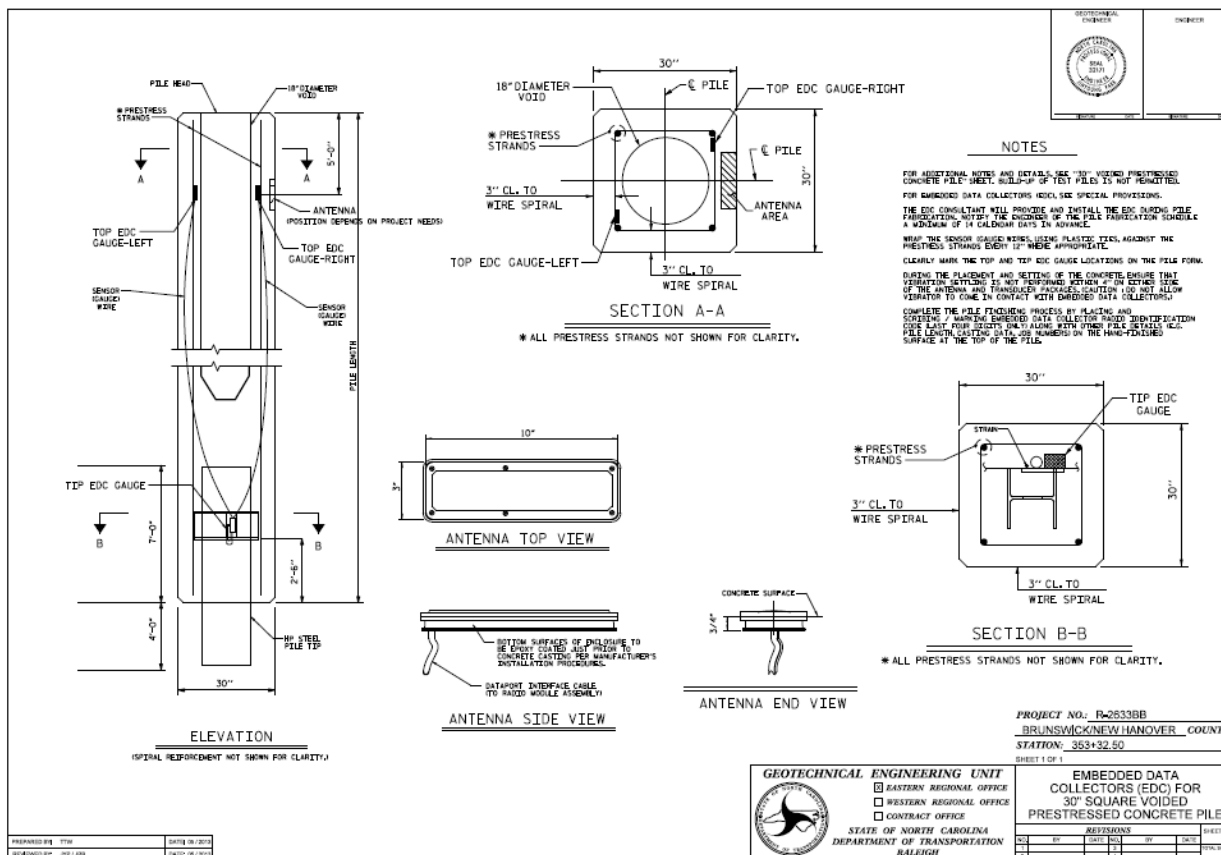
## Concrete Piles with HP Steel Pile Stinger



# EDC

# EMBEDDED DATA COLLECTORS

## EDC Installation Details – R2633BB



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

## EDC

## EMBEDDED DATA COLLECTORS

### 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'

## EDC

## EMBEDDED DATA COLLECTORS

### 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



Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

## EDC

## EMBEDDED DATA COLLECTORS

### Benefits

- Cost
- Eliminating over driving piles
- Detect pile tip damage
- Efficient (time)
- Improving safety
- Reuse existing foundation



Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

## EDC

## EMBEDDED DATA COLLECTORS

### What can we do for your State:

- Share our experience with EDC
- Share our special provisions
- Share our plan details
- We can provide technical assistance
- Share information and driving data with each other



Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

## EDC

## EMBEDDED DATA COLLECTORS

# Thank You Very Much



Embedded Data Collectors

Mohammed A. Mulla  
NCDOT  
7/25/2013

