

## North Carolina Experience with Embedded Data Collectors

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## Presentation Outline

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

### Embedded Data Collectors

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# 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



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### 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

## 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

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## 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

- NCDOT prepared the Pile detail and special provision



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# 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.

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.



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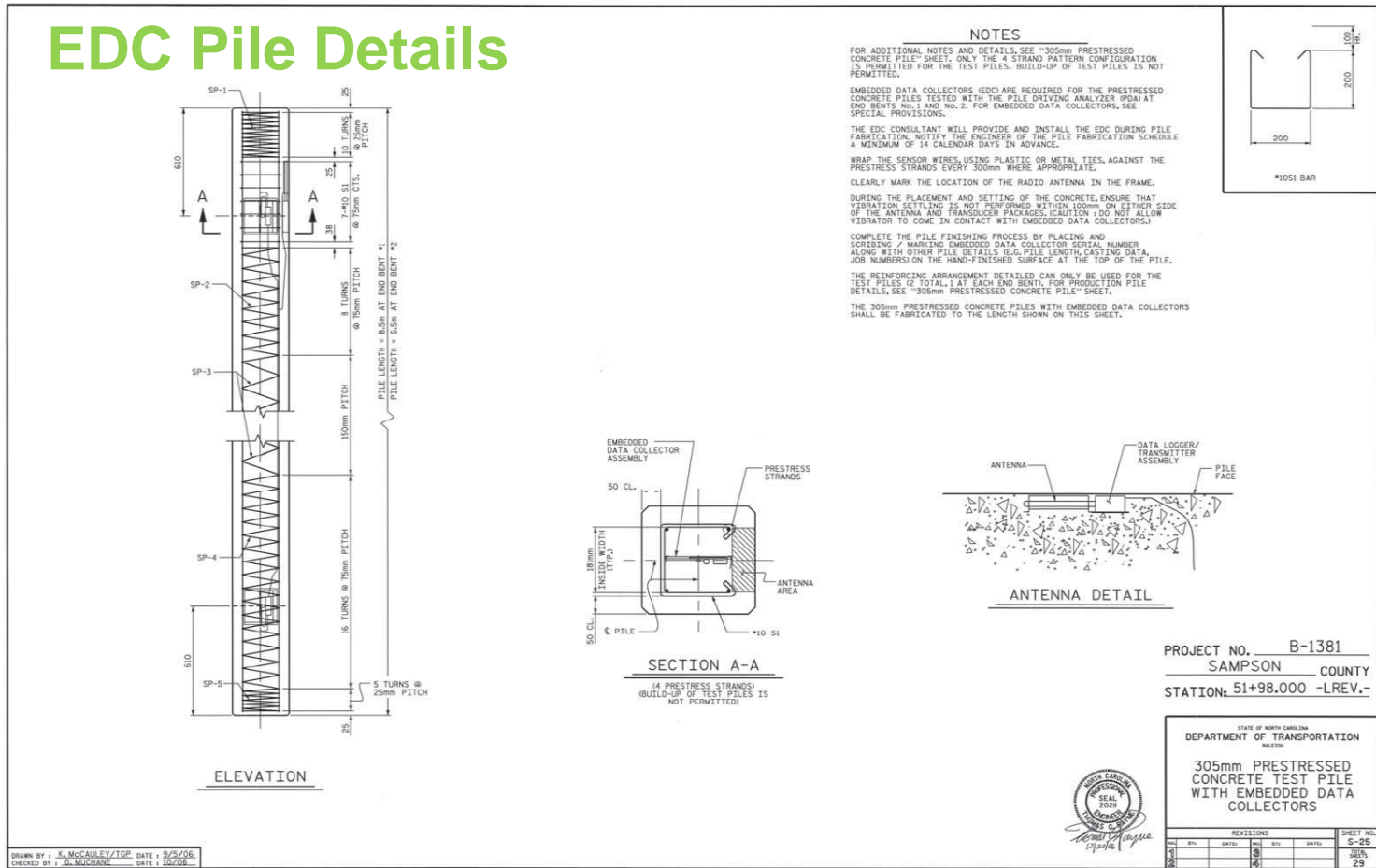
*This is a sample image. Similar documentation will be posted to the **All Embedded Data Collectors** website in the near future.*



# EDC

# EMBEDDED DATA COLLECTORS

## EDC Pile Details

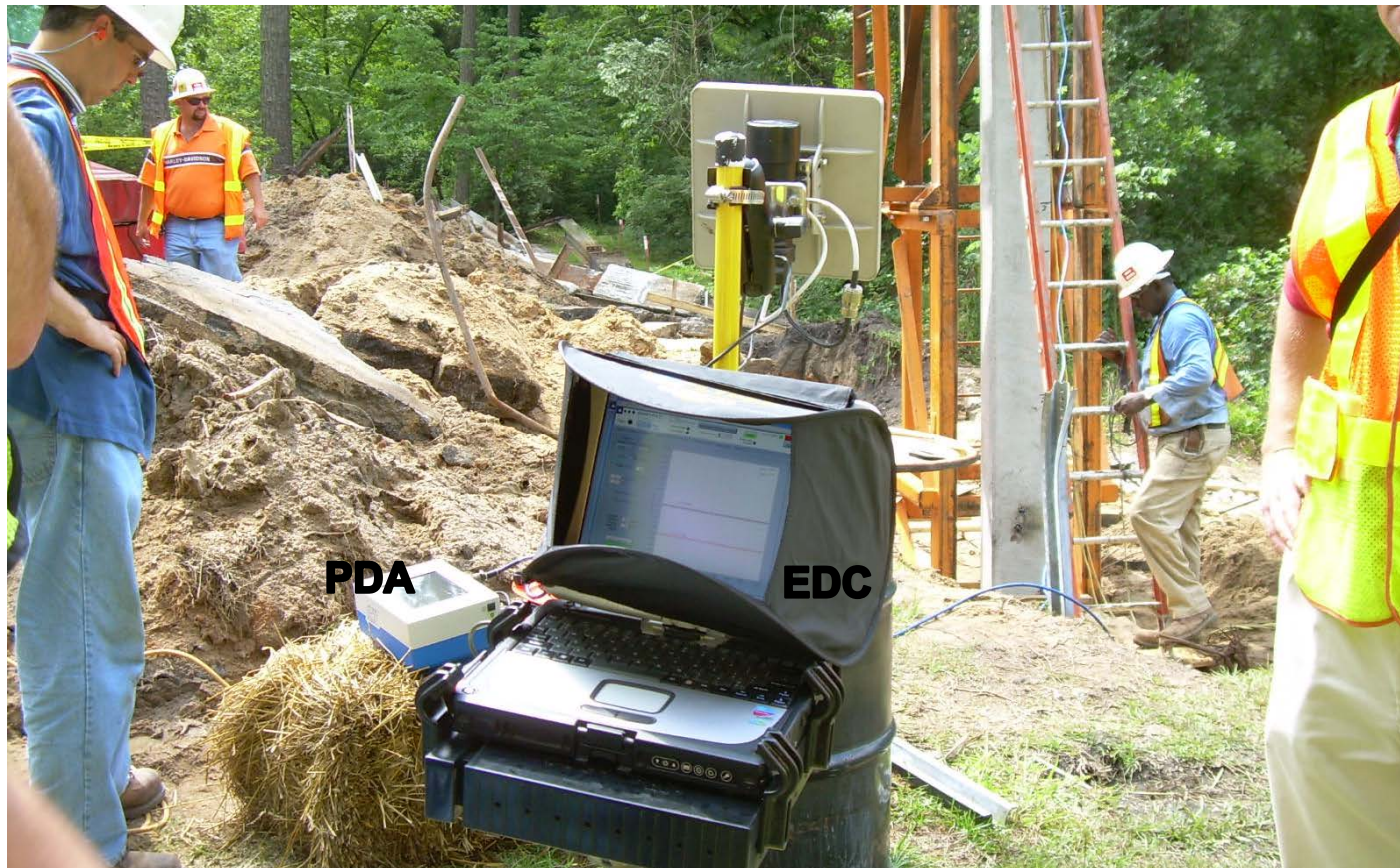


This is a sample image. Similar documentation will be posted to the **AII** Embedded Data Collectors website in the near future.

EDC

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## EDC and PDA





## EDC

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### EDC Communication Problem



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PDA test  
by different  
consultant

## PDA and EDC during driving



- Short Pile (28')

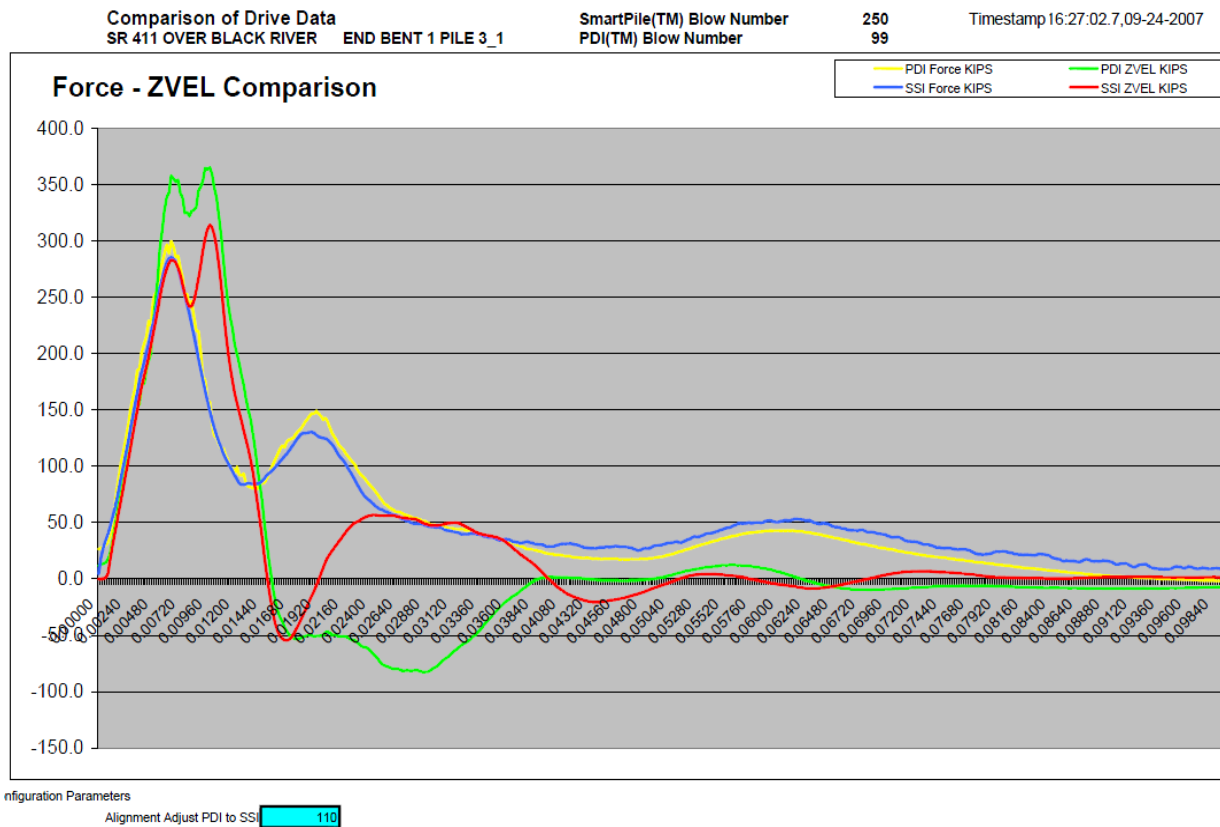
## EDC Total Capacity Comparison to PDA

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

Pile Designation	Blow Number SSI/PDI	<i>SmartPile</i> <sup>TM</sup> 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



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



## EDC

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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.

## 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



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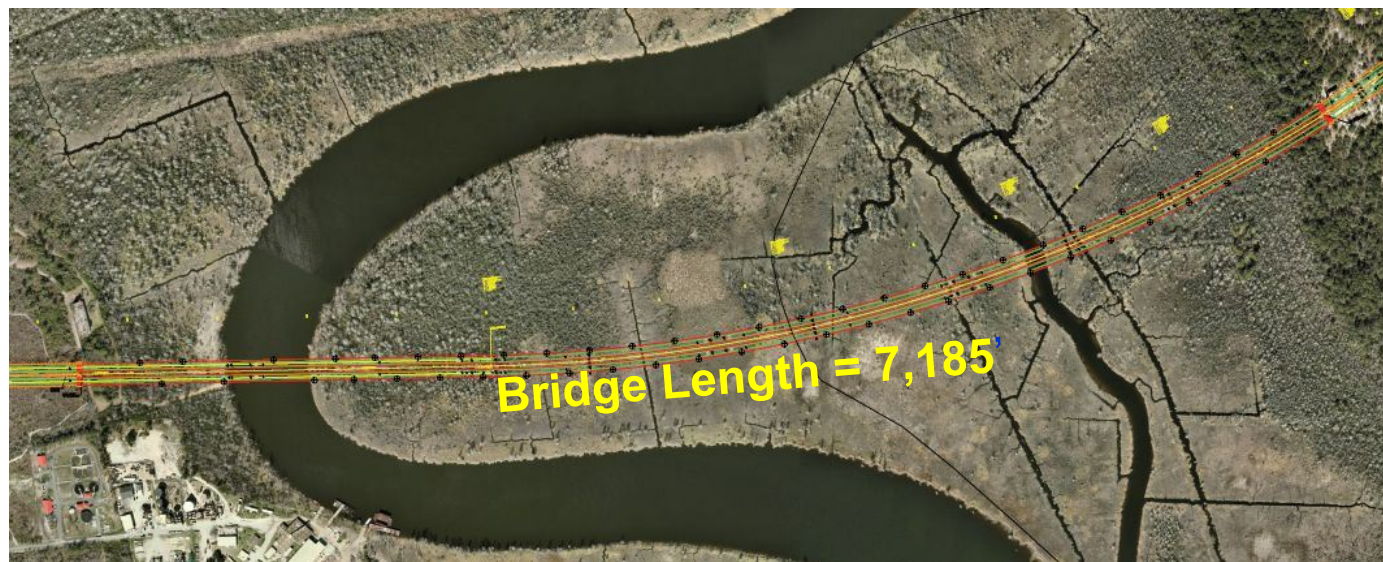
# EDC

# 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





## Access by “Swamp Loggers”



## Concrete Piles with HP Steel Pile Stinger Tip





EDC

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## 18" voided Concrete Piles







## EDC and PDA during Driving the concrete pile

**Wireless**



**EDC**



**PDA**



**After the restrike (4hrs., 12 hrs. and 72hrs.)**

**Static Axial Compressive Load Test**



## EDC

## EMBEDDED DATA COLLECTORS

### Premature Failure during Static Load Test



Design Load= 1,660 kips    Pile Cracked= 1,641 kips    Ultimate capacity = 4841 kips (7.5 ksi Conc.)

## R-3307 Bridge over Gallants Channel (Under Construction now)

# 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

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## R-3307 Bridge over Gallants Channel





EDC

## EMBEDDED DATA COLLECTORS



Pile  
Length

105'

EDC

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PDA

Install  
Gauges



## 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 pilot projects)
- The outcome from the two proposed pilot projects will determine the implementation program
- The AASHTO **AII** (TIG) program



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## Benefits

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



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## EDC

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# Thank You Very Much



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