EDC | EMBEDDED DATA COLLECTORS

Embedded Data Collectors

Florida's Experience Presented by:
Rodrigo Herrera, PE
Florida Department of Transportation
Asst. State Geotechnical Engineer

August 27, 2013

INTRODUCTION

- Majority of Florida bridges are supported on deep foundations
- Most common deep foundation:
  Precast Prestressed Concrete piles
- Dynamic testing of all Test Piles required as per Specifications

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1995 FDOT PRACTICE

- – Pile Installation Plan (Contractor)
- – Pre-field wave equation analysis
- Test Pile program
  - – PDA
  - – CAPWAP
  - – Final wave equation
  - – Driving Criteria
- Install Production Piles

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DRIVING CRITERIA

- The Driving Criteria letter as a minimum addresses the following items;
  - Minimum number of blows per foot at various hammer stroke heights for the bearing layer
  - Maximum allowable stroke height
  - Minimum tip
  - Refusal conditions
  - Set-check requirements (when needed)

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In 1996 we were asking WHAT IF?

- What if piles could be instrumented without climbing the leads?
- What if pile testing did not impact construction operations?
- What if all foundations could be monitored instead of issuing blow count criteria?
- What if all of this was affordable?

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FDOT Sponsored Research

- Alternate dynamic testing method investigated by UF through FDOT sponsored research 1997-2002
- University of Florida's Final report issued August 2002
  - Proposed theory for the use of two levels of instruments
  - First generation hardware and software

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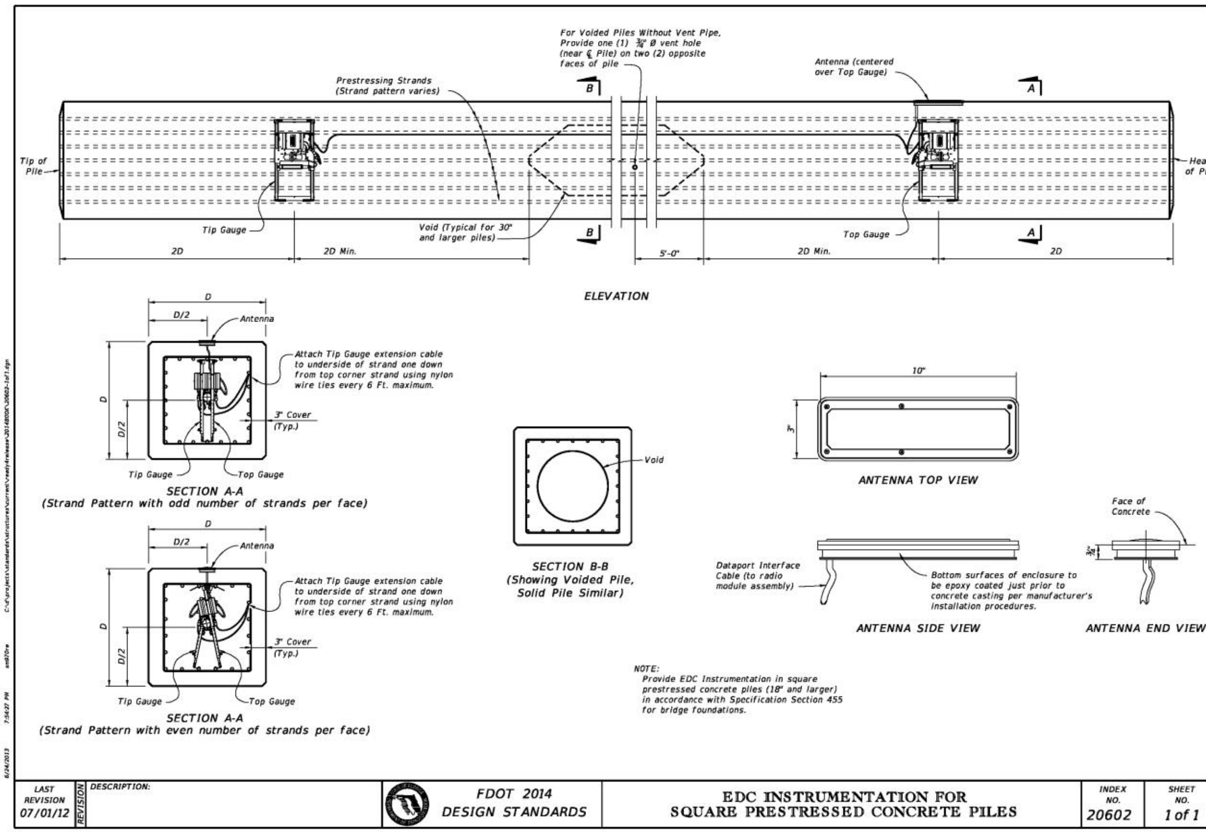
FDOT Sponsored Research

- In 2003 Smart Structures, Inc. acquired a license to the patented technology
- Advancements to the hardware and signal transmission aspects of the system

EMBEDDED DATA COLLECTOR

FDOT Design Standards Index 20602



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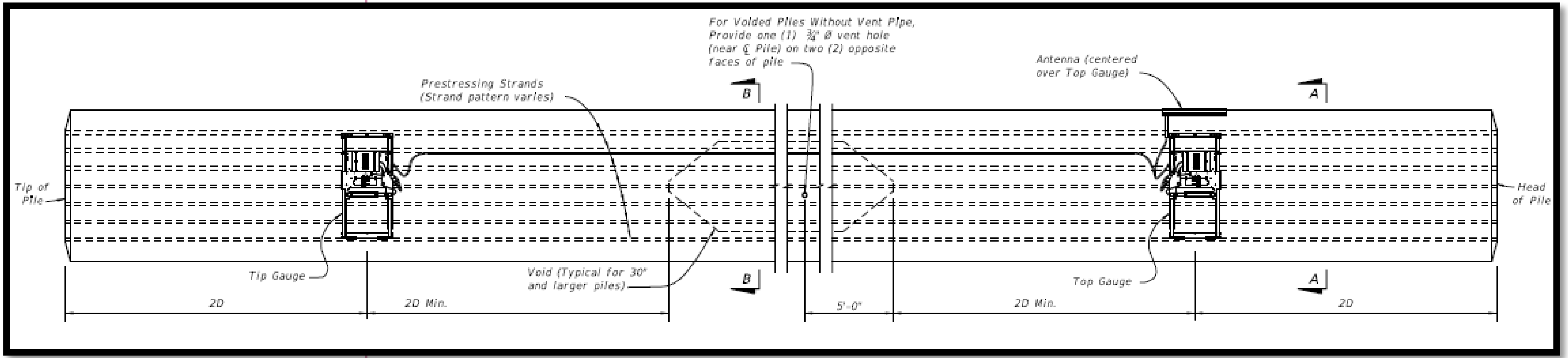
EMBEDDED DATA COLLECTOR



- Instruments cast into solid concrete piles;
- Two instrumentation levels, pile head and tip

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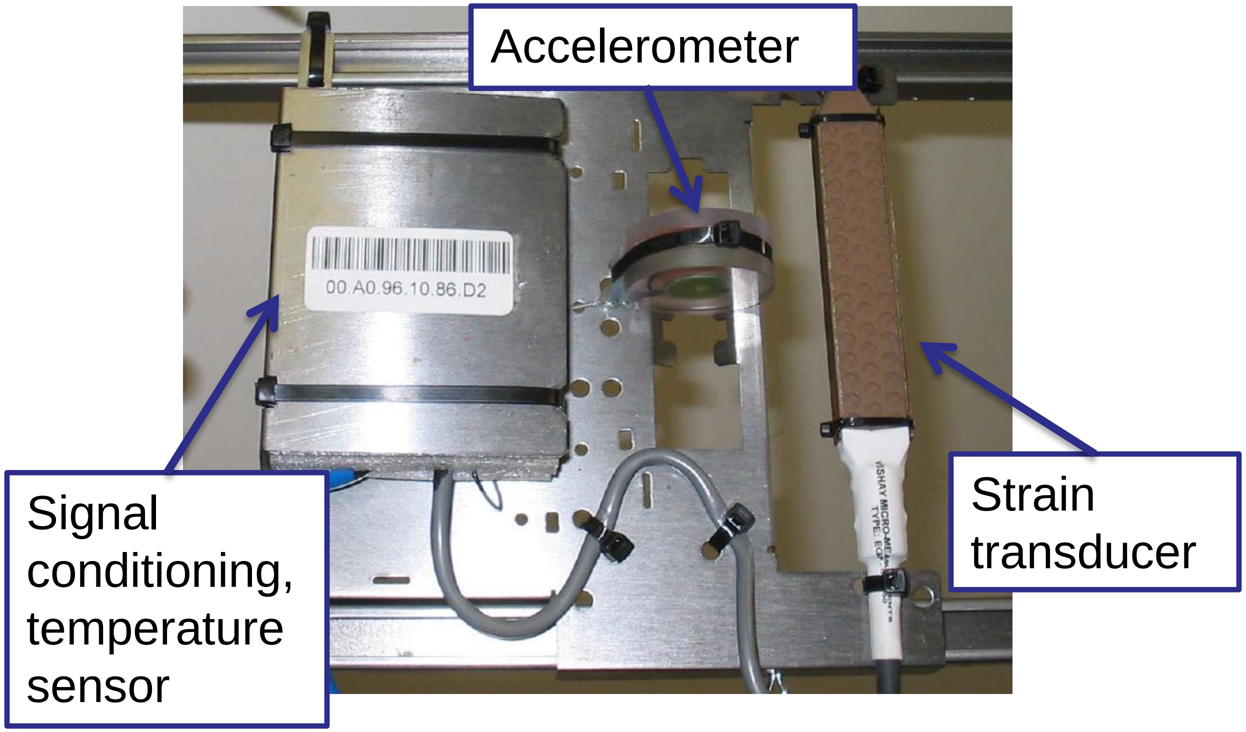
CASTING PROCESS

- Instrumentation
  - – Tip gages
  - – Connector cable (within the pile)
  - – Top gages and antenna

EMBEDDED DATA COLLECTOR



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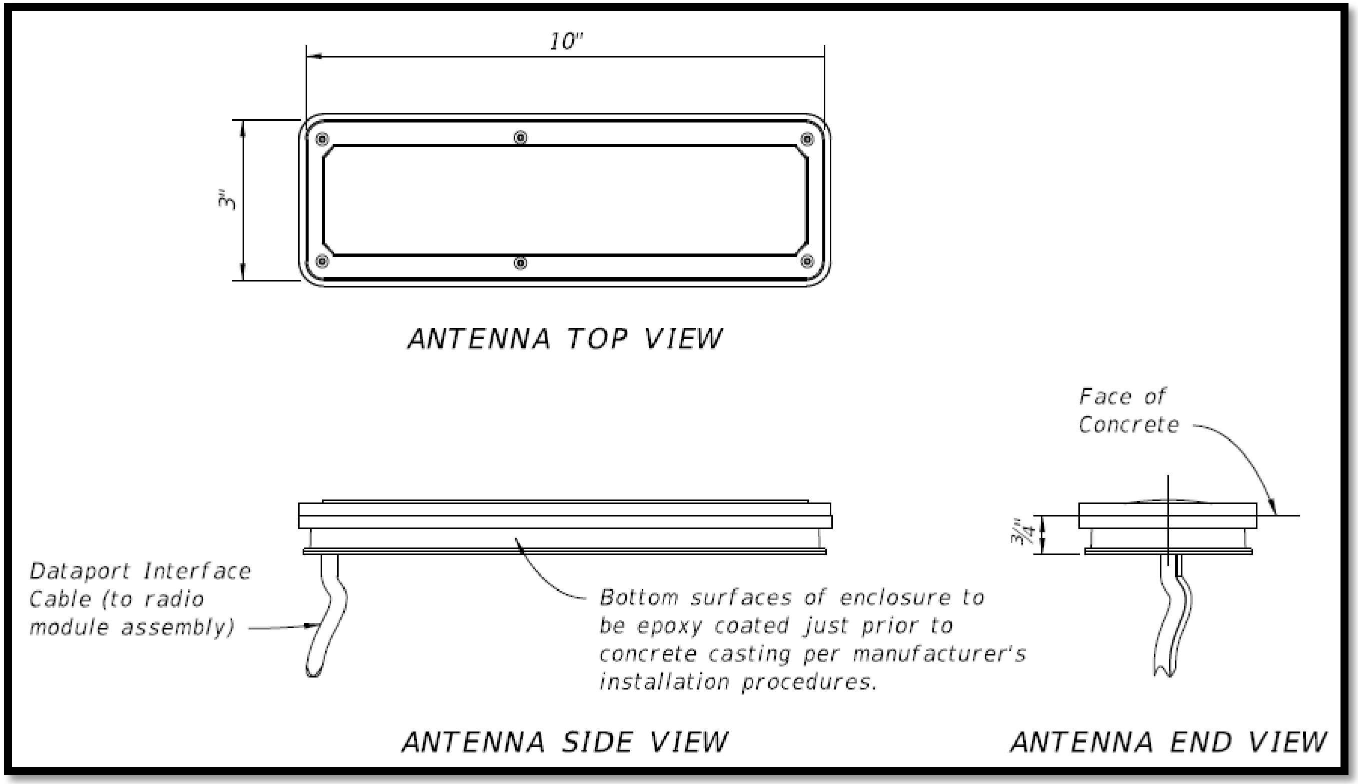
CASTING PROCESS



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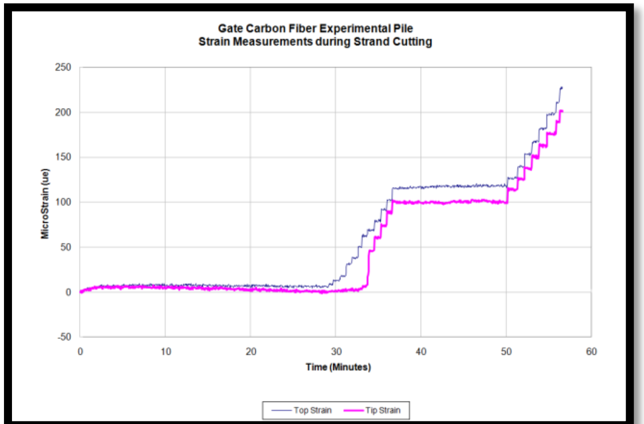

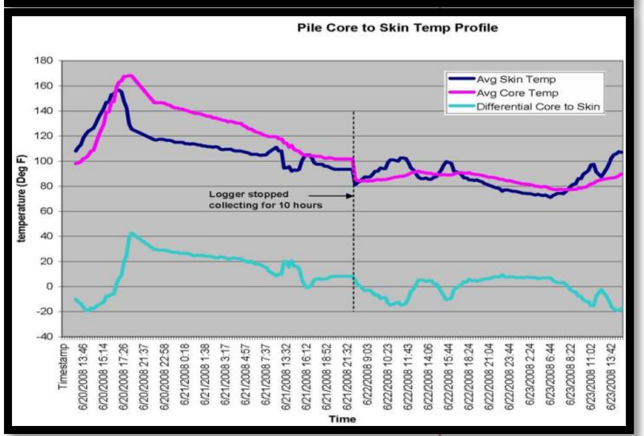

CASTING YARD MEASUREMENTS

- Install two levels of instruments prior to casting the pile
  - Get an initial measurement to confirm signal transmission
  - Cast the pile
  - Subsequent measurements
    - » Strain before and after cutting pre-stressing strands
    - » Temperature readings at pile core and antenna (ambient)

Casting Yard Battery

Pile Driving Battery

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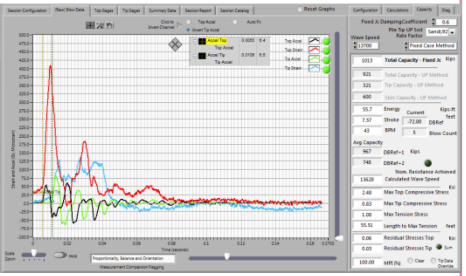
SOFTWARE INTERFACE



- Display of raw data;
  - Strain and acceleration
  - Qualitative assessment of data

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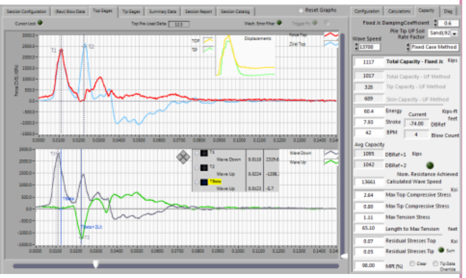
SOFTWARE INTERFACE



- Display of top level instrumentation;
  - Force-Velocity
  - Wave up / Wave down
  - Pile static capacity
  - Compression and tension stresses
  - Estimates of pile integrity (MPI)

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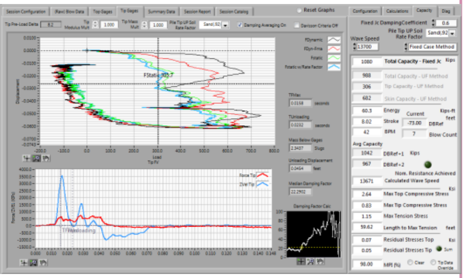
SOFTWARE INTERFACE



- Tip instrumentation readings;
  - Measured compressive stress near the pile tip
  - Total, dynamic, inertial and static components of the measured force
  - Force-velocity

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SOFTWARE OUTPUT

- Summary Table
  - Project information
  - Blows/ft
  - UF method (resistance)
  - Stresses
  - Energy
  - Stroke
  - Integrity
  - Other…

User Information

CEI Name Mitchell Foster
Company Name Applied Foundation Testing
City Odessa
State FL
Zip 33556
Certification ID 010FL0064-16
Phone Number 727-376-5040

Project Information

Project Name SW Florida Airport Interchange
City Ft Myers
State FL
County/District Lee
Project Number (DOT) AFT 913007
Project Description
Structure Bridge 120179
Description
Latitude
Longitude

Notes

Pile Information

Structure	Pier 4	
Pile Number	1	
Pile Length	90	Feet
Pile Marker Increment	1	Feet
Set Check Marker Increment	1	inches
Top Gage to Pile Top	48	inches
Tip Gage to Pile Tip	24	inches
d Dimension	24	inches
Mid Gage to Pile Tip	0	inches
Top Cross-Section Area	576	inches 2
Tip Cross-Section Area	576	inches 2
Modulus of Elasticity	5726.967212	KSI
Concrete Specific Weight	0.15	K/ft 3
Wave Speed	13300	Feet/sec
Fixed Jc Damping Coefficient	0.6	
Pile Tip UP Soil Rate Factor	0.96	
Air Hammer/Multipeak	FALSE	
Hammer	SPI D46-32	
Nominal Bearing Resistance	314	Tons
Tension Resistance	0	Tons
Minimum Tip Elevation	-30	Feet
Jet/PreForm Elevation	-10	Feet
Pile Cut-Off Elevation	16	Feet
Radio 1 ID	00.A0.96.36.70.F2	
Radio 1 FW Version	517	
Final Tip Elevation	-57.87	Feet

Drive Duration:From 06-19-2013 12:23:21 to 06-19-2013 12:35:34

***Average at identified displacement unless a single blow or indicated otherwise in header (e.g. Tension)*

Tip Elevation (Feet)	Blow Number	Blows per Foot to Disp	Stroke/BPM (Feet)	Energy (Kips-ft)	Fixed Jc Capacity (Kips)	UF Capacity (Kips)	Wave Speed (Feet/sec)	Top Compression (Ksi)	Tip Compression (Ksi)	Max Tension (Ksi)	MPI	Top Preload Delta (uStrain)	Tip Preload Delta (uStrain)
-11.87	3	4	2.6	12.3	54.5	45.0	13003.4	1.1	0.2	0.7	87.5	-28.5	-75.0
-13.87	10	3	4.7	12.8	26.7	39.7	13113.7	1.1	0.2	0.7	100.0	2.8	-2.4
-14.87	13	3	4.7	12.3	61.0	64.7	13125.1	1.1	0.1	0.8	100.0	1.5	-0.4
-15.87	16	3	4.7	12.2	64.3	62.7	13165.8	1.2	0.2	0.9	100.0	2.3	-3.0
-16.87	19	3	4.6	11.6	59.0	55.3	13188.0	1.1	0.2	0.8	100.0	2.0	-6.7
-17.87	22	3	4.5	11.0	42.3	37.3	13208.3	1.1	0.1	0.8	100.0	2.4	-4.7
-18.87	24	2	4.6	11.9	59.5	52.5	13223.7	1.1	0.1	0.8	100.0	1.9	-4.8
-19.87	27	3	4.5	11.6	45.3	42.0	13238.9	1.1	0.1	0.8	100.0	1.9	-5.0
-20.87	30	3	4.5	11.1	45.3	51.7	13258.3	1.1	0.1	0.9	100.0	2.4	-6.1
-21.87	32	2	4.5	11.5	95.0	97.5	13284.9	1.1	0.1	0.8	100.0	0.7	-5.0
-22.87	35	3	4.5	12.4	33.7	35.0	13291.7	1.1	0.1	0.9	100.0	0.9	-5.5
-23.87	38	3	4.6	12.1	31.7	32.7	13291.6	1.1	0.1	0.9	100.0	1.4	-1.6

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User Information

CEI Name
Company Name
City
State
Zip
Certification ID
Phone Number

Project Information

Project Name
City
State
County/District
Project Number (DOT)
Project Description
Structure
Description
Latitude
Longitude

Notes

Drive Duration:From 06-19-2013 12:23:21 to 06-19-2013 12:35:34

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Wave Speed	13300	Feet/sec
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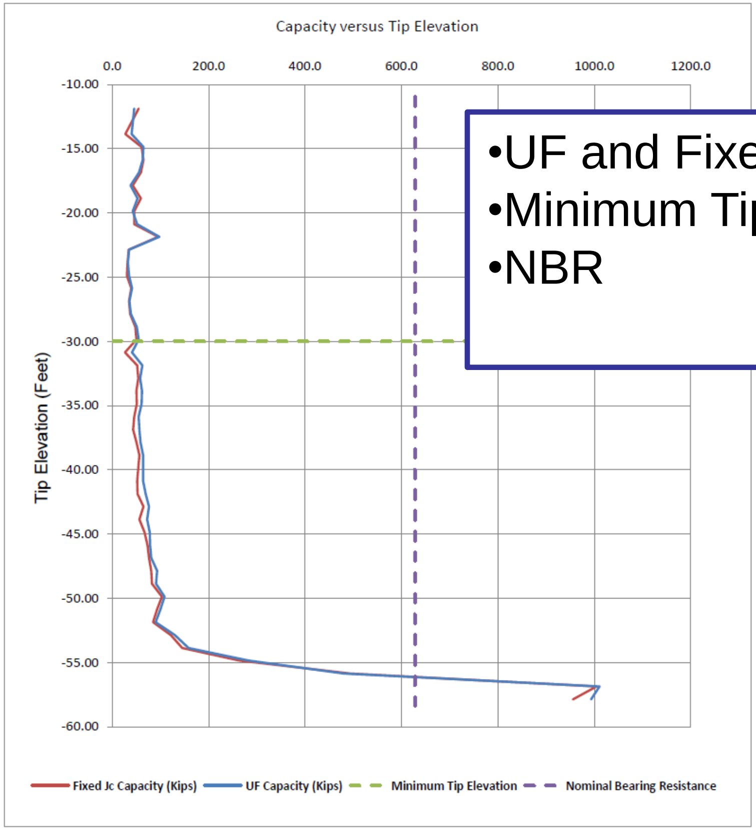
SOFTWARE OUTPUT



- UF and Fixed methods
- Minimum Tip
- NBR

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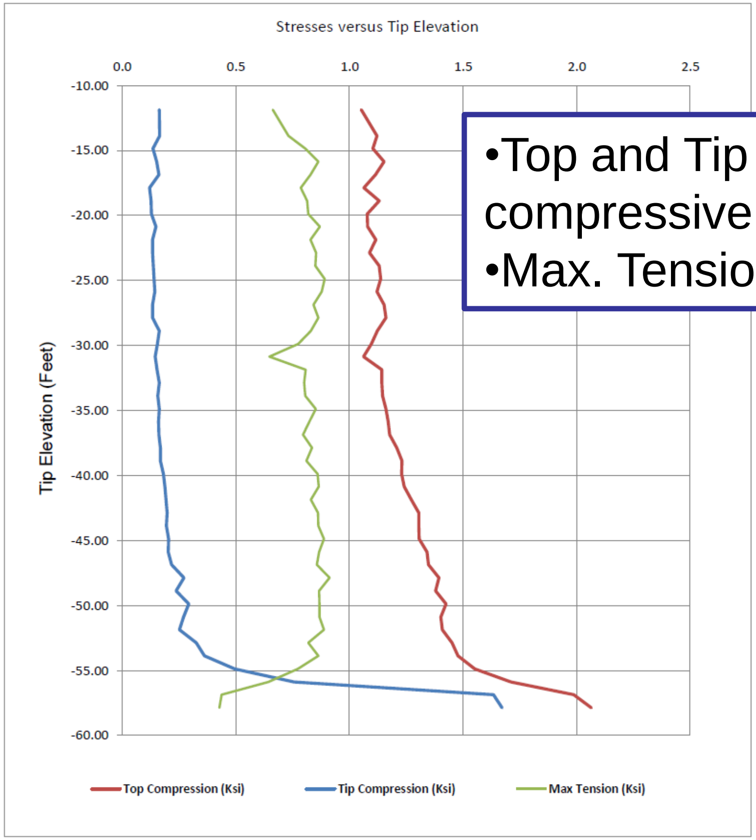
SOFTWARE OUTPUT



- Top and Tip compressive stresses
- Max. Tension

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CALCULATION METHODS

- Fixed Case Method
  - Constant damping factor for the entire drive, input by operator
  - Only top level of instruments
- UF Method
  - Damping factor is calculated for every hammer blow using pile top and tip measured data

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CALCULATION METHODS

- UF Method – Continued
  - Allows for the separation of static and dynamic resistance in real time, no signal match analysis required on an instrumented pile (top & tip)
  - Computes the contribution of end bearing and side friction to total resistance using both top and tip instrumentation.

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EVALUATING RESULTS

- Phase I, In-House evaluation (2006-2010)
  - Compare EDC estimates to PDA & CAPWAP;
- Phase II, UF (2009 – Present)
  - Collect results and generate a database of EDC vs. static load tests to develop a system-specific resistance factor for use in LRFD design

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EVALUATING RESULTS

- Phase 1: Compare EDC to PDA and CAPWAP
  - Database of piles monitored simultaneously with EDC and PDA
  - EDC data was collected and reported by different engineers than those collecting the PDA data.

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EVALUATING RESULTS

– Phase 1: Compare EDC to PDA and CAPWAP

- Neither engineer would see the other's data until test pile program was completed and both reports turned in.

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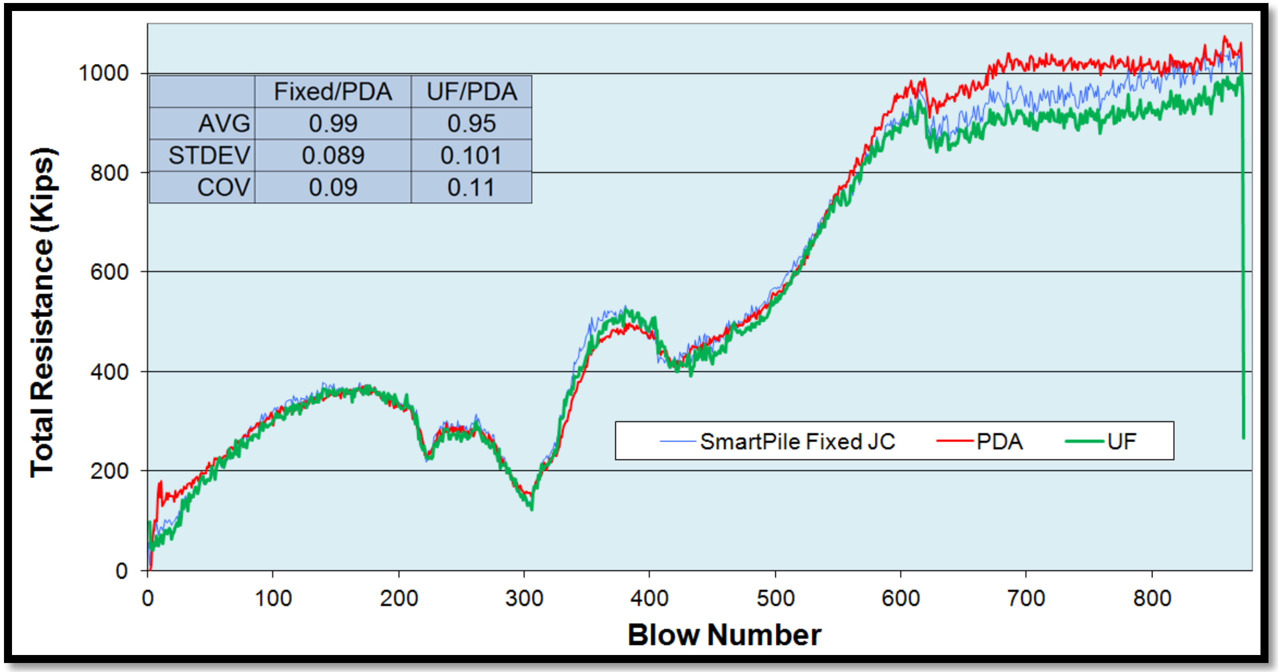
EDC EVALUATION – PHASE I



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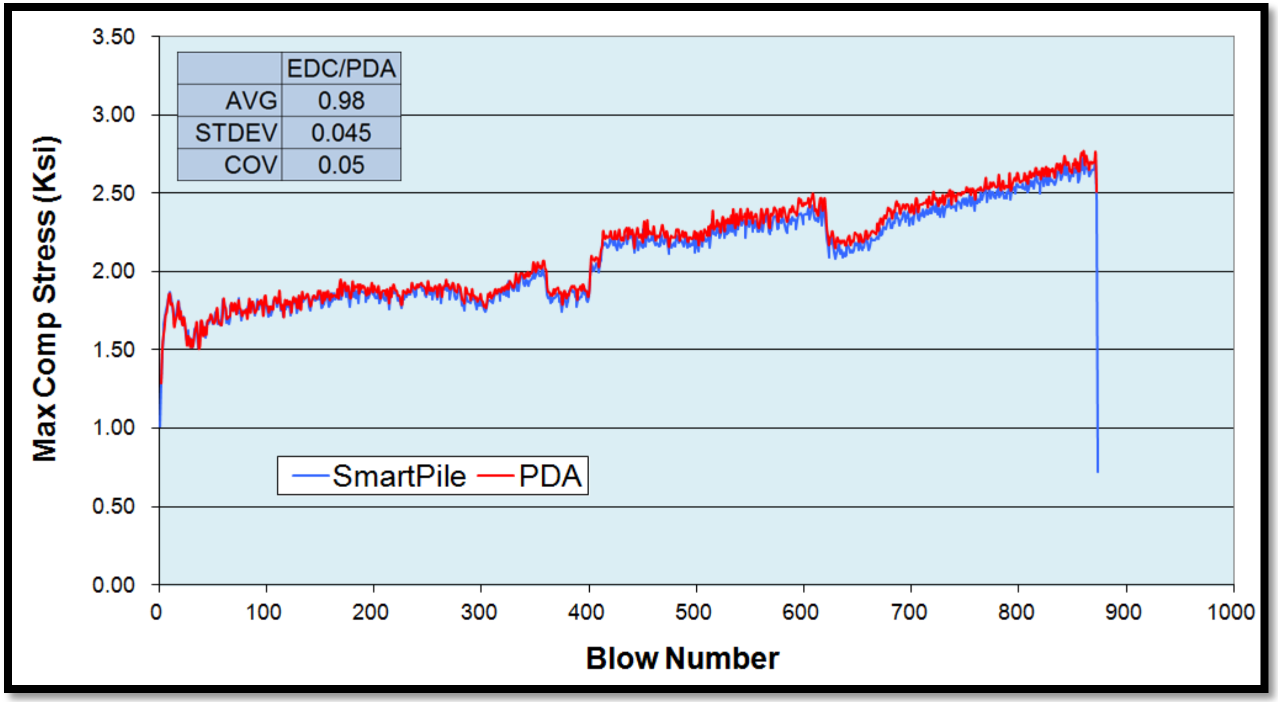
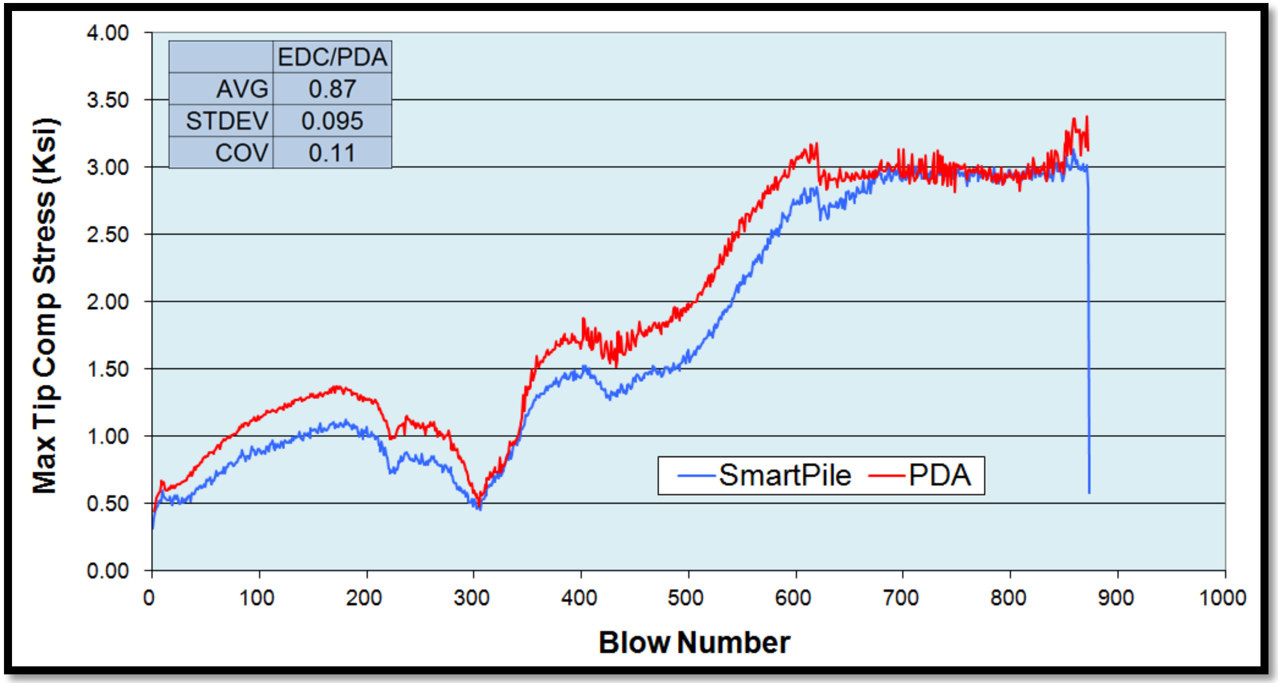
EDC EVALUATION – PHASE I

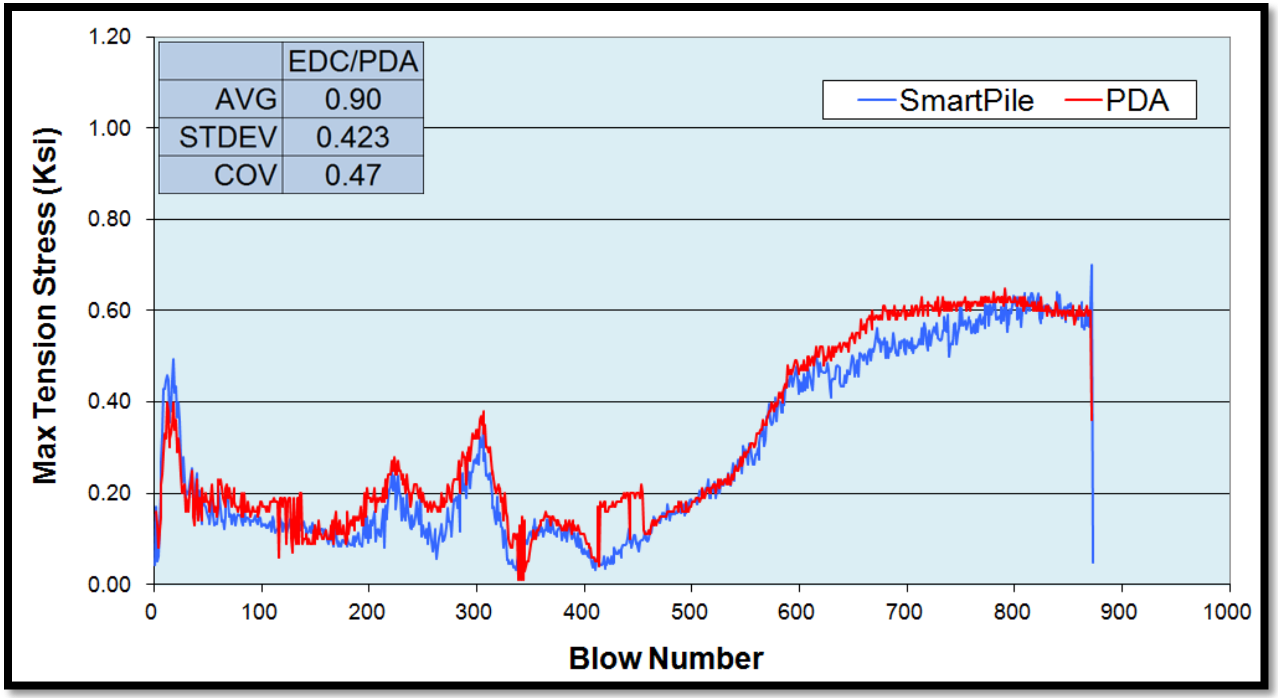


	EDC/PDA
AVG	0.98
STDEV	0.045
COV	0.05

EDC EVALUATION – PHASE I



EDC EVALUATION – PHASE I



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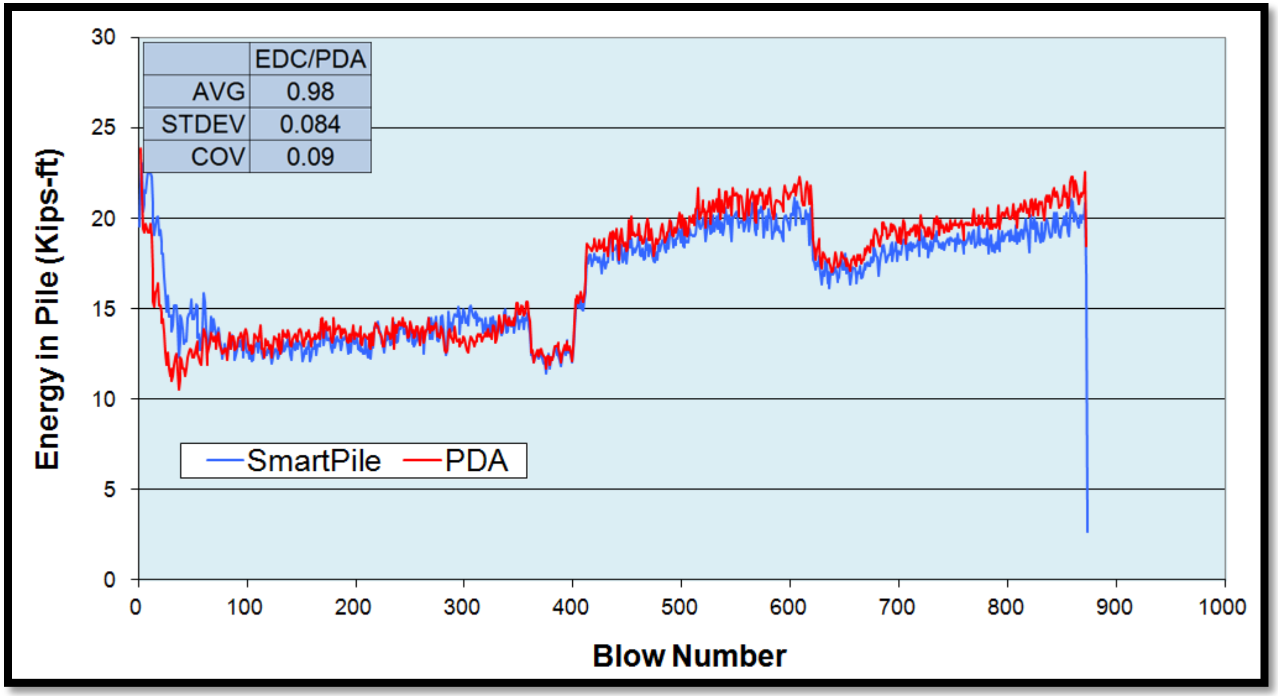
EDC EVALUATION – PHASE I



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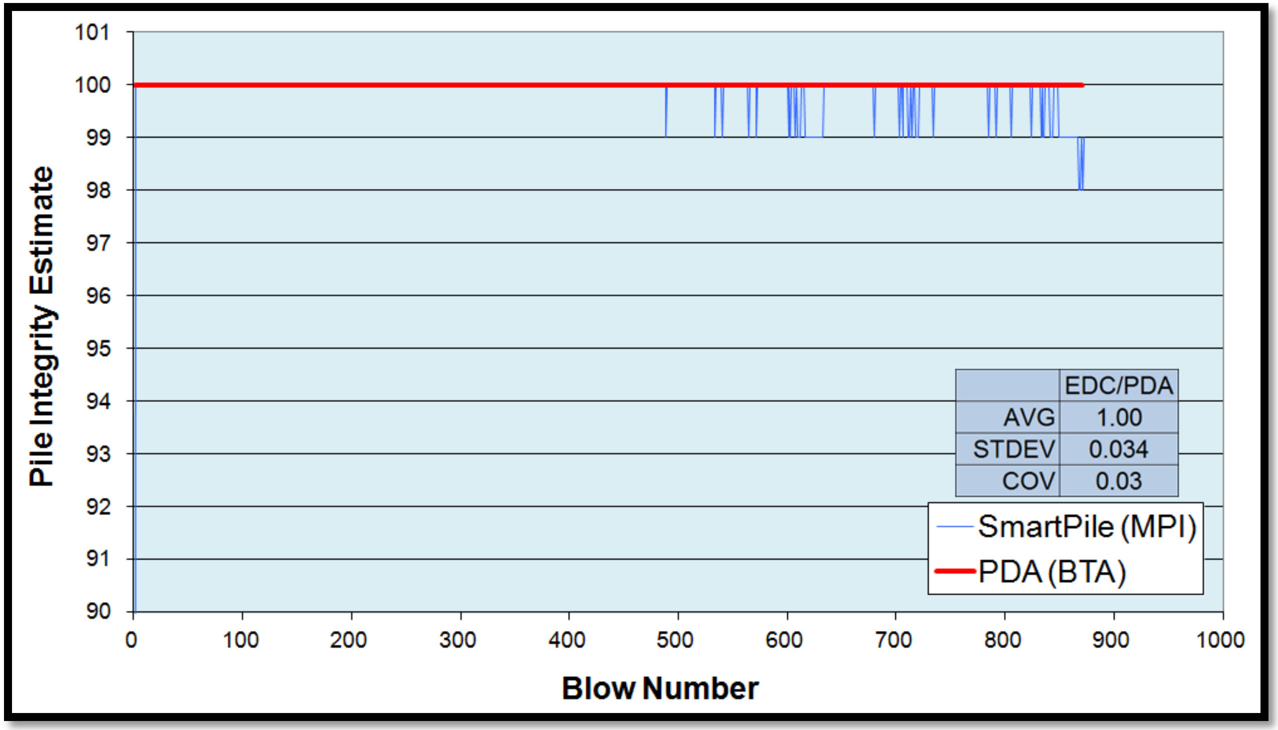
EDC EVALUATION – PHASE I



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EDC/PDA STATIC CAPACITY

Population "n" = 213,734 blows from 139 piles

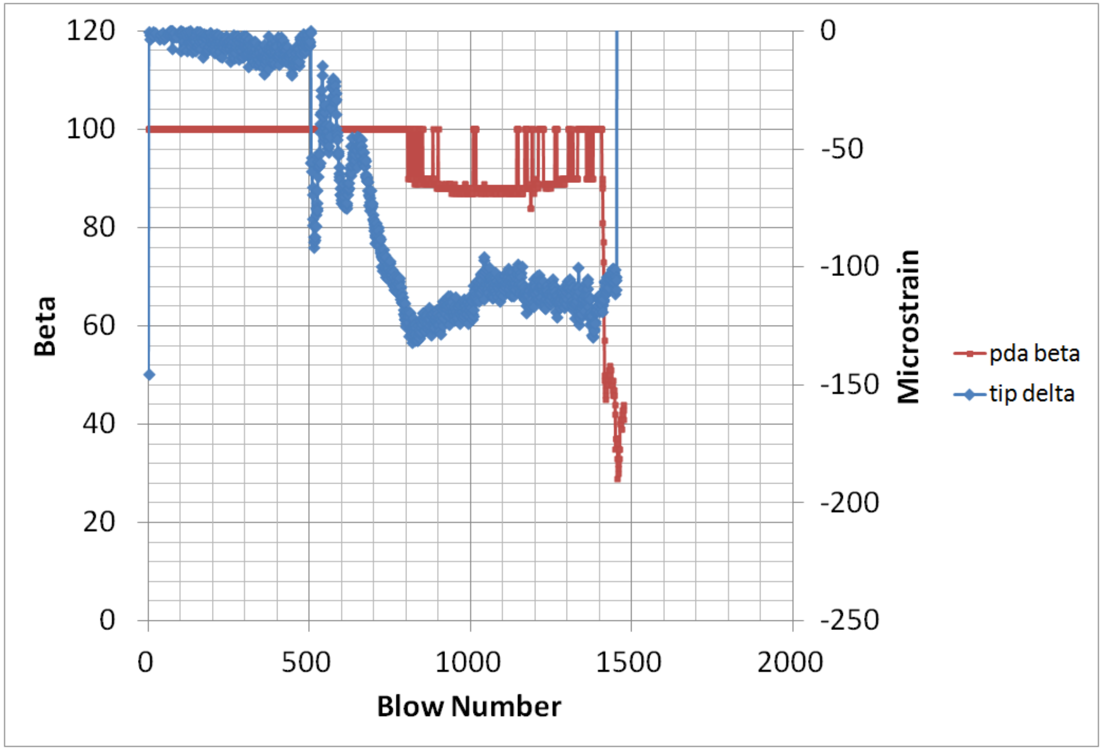
Ratio of Total Static Resistance		
Parameter	Fixed Method/PDA	UF Method/PDA
Mean	0.89	0.91
Median	0.93	0.91
Standard Deviation	0.15	0.16
Coefficient of Variation	0.17	0.18

EDC EVALUATION – PHASE I

Population “n” = 205,516 blows from 134 piles

STRESS, ENERGY AND INTEGRITY					
EDC/PDA					
	CSX	CSB	TSX	EMX	Beta
Mean	0.92	0.75	0.89	0.95	0.96
Median	0.93	0.75	0.90	0.93	0.99
Std. Deviation	0.09	0.18	0.26	0.24	0.12
Coefficient of Variation	0.1	0.24	0.29	0.25	0.12

TIP DAMAGE INDICATOR



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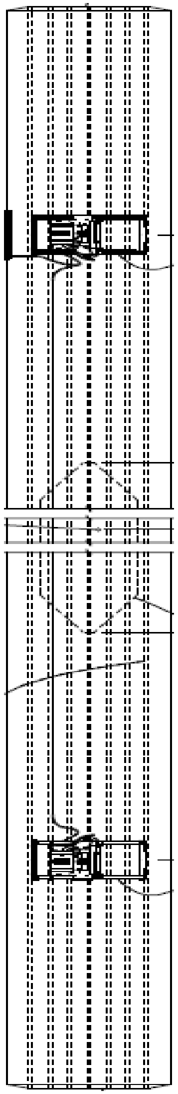
TIP DAMAGE INDICATOR

- Changes in measured strain;
  - Observed more often near the tip of the pile
  - Gradual loss of pre-stress as a precursor to damage

Measured state of stress during driving



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EDC/CAPWAP STATIC CAPACITY

Population “n” = 78 blows from 78 piles

Ratio of Total Static Resistance		
Parameter	Fixed Method/CAPWAP	UF Method/CAPWAP
Mean	0.88	0.86
Median	0.92	0.90
Standard Deviation	0.21	0.22
Coefficient of Variation	0.24	0.26

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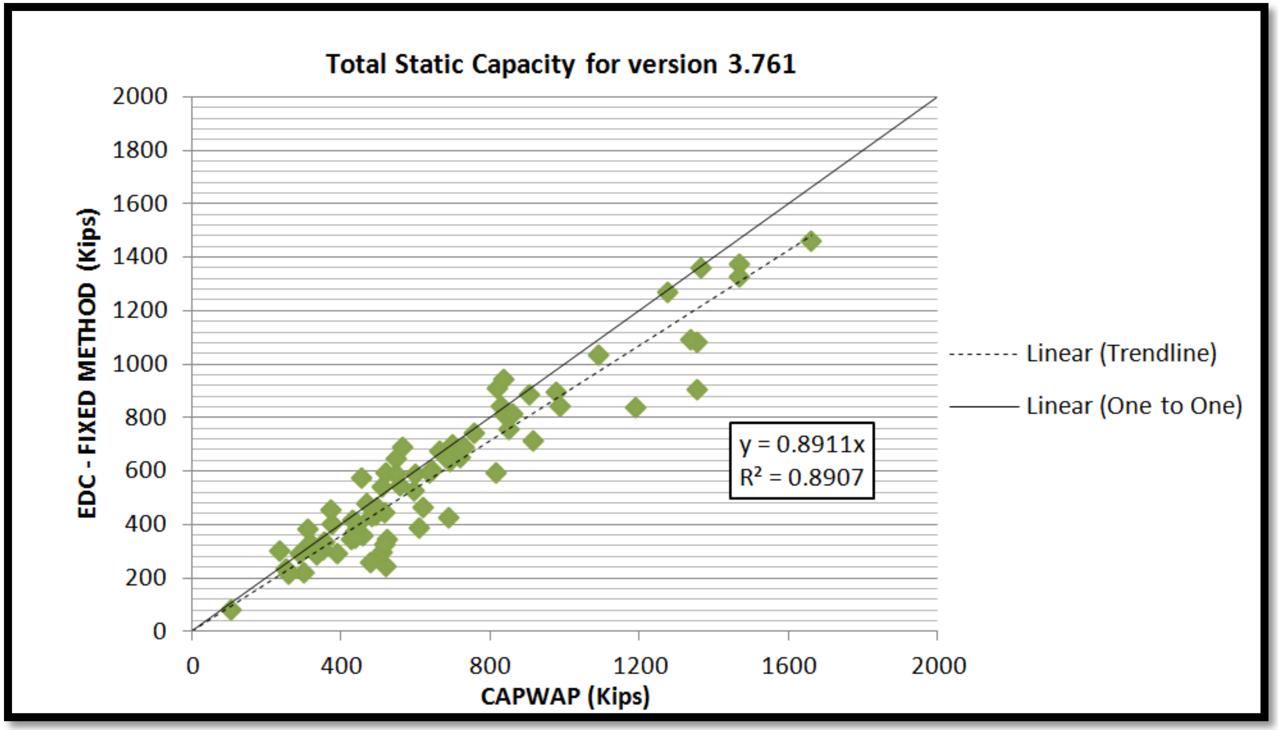
EDC EVALUATION - CAPWAP



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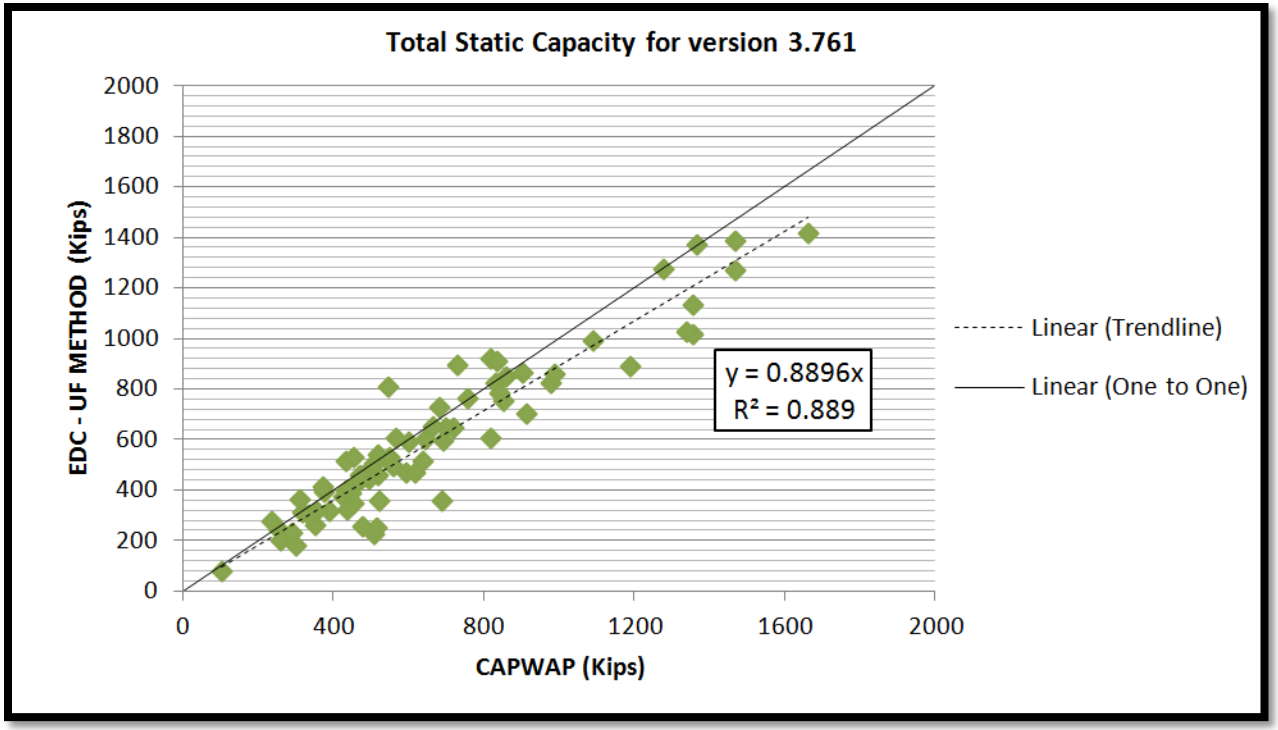
EDC EVALUATION - CAPWAP



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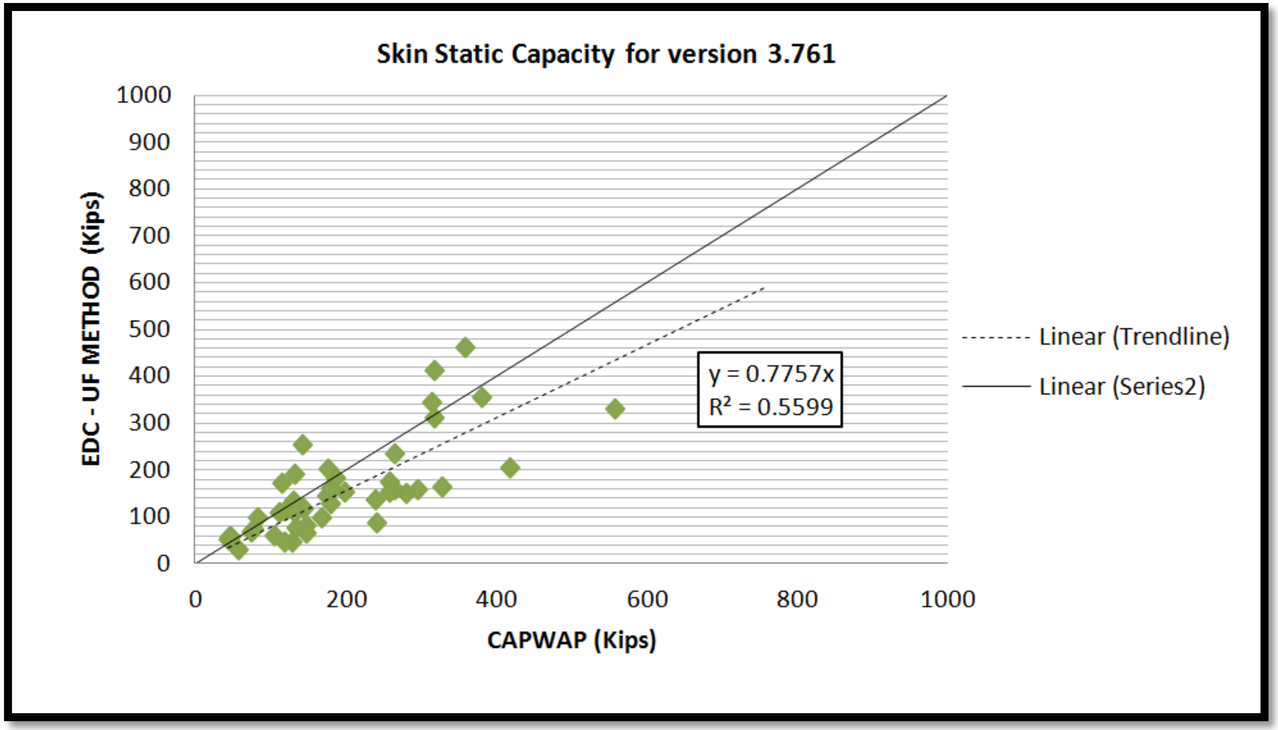
EDC EVALUATION - CAPWAP



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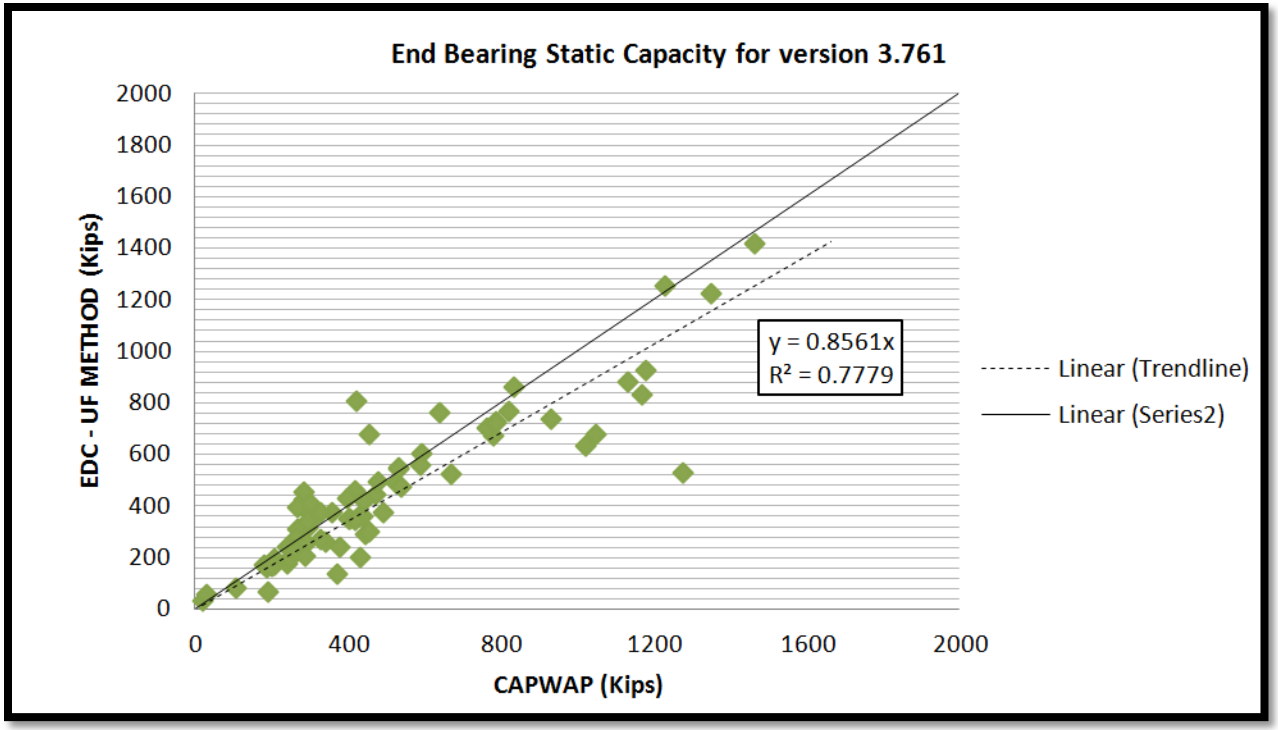
EDC EVALUATION - CAPWAP



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EDC EVALUATION – PHASE I

- Partial findings published in the proceedings of the 2009 International Foundation Congress and Equipment Expo
  - Blows with PDA estimate > 50 tons
  - Data within three standard deviations from the mean used in the development of statistical parameters

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EVALUATING RESULTS

- Phase 2: Compare EDC to Static Load Tests
  - 12 Load Tests (7 compression and 5 tension)
    - 8 in Florida
    - 4 in Louisiana
    - More to come…

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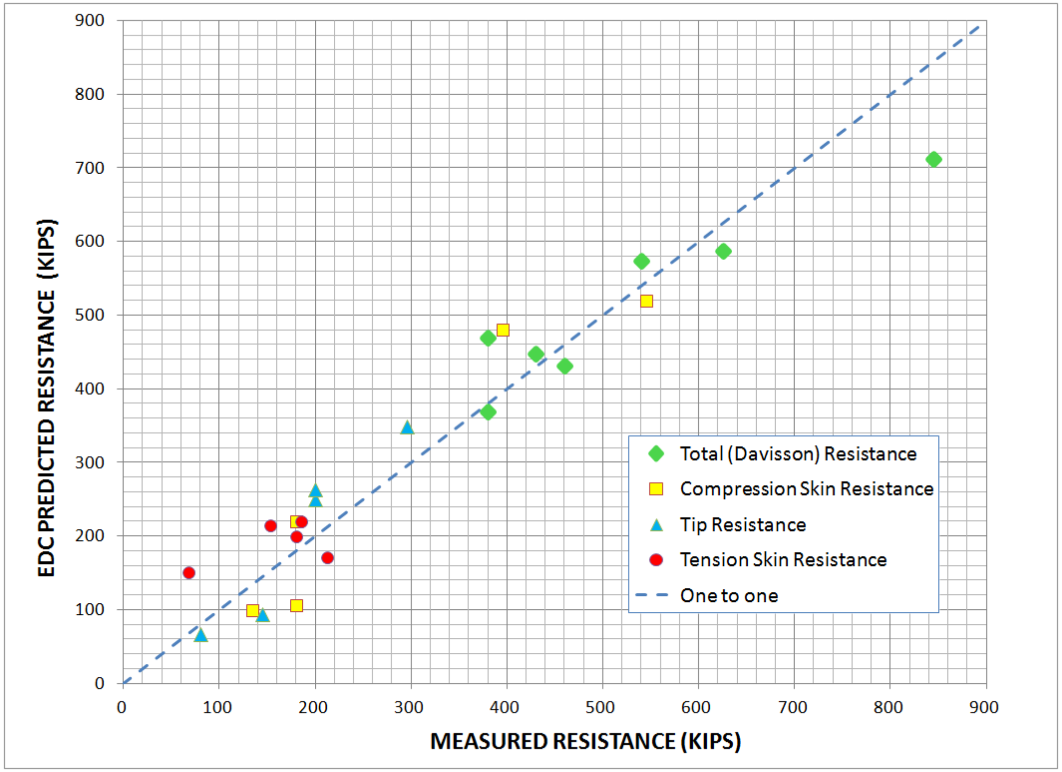
EVALUATING RESULTS



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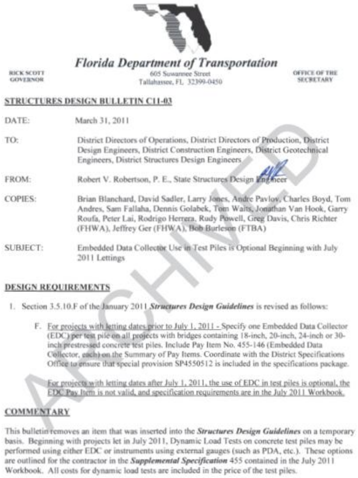
IMPLEMENTATION



Florida Department of Transportation

RICK SCOTT GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

OFFICE OF THE SECRETARY

STRUCTURES DESIGN BULLETIN C11-03

DATE: March 31, 2011

TO: District Directors of Operations, District Directors of Production, District Design Engineers, District Construction Engineers, District Geotechnical Engineers, District Structures Design Engineers

FROM: Robert V. Robertson, P. E., State Structures Design Engineer

COPIES: Brian Blanchard, David Sadler, Larry Jones, Andre Pavlov, Charles Boyd, Tom Andres, Sam Fallaha, Dennis Golabek, Tom Waits, Jonathan Van Hook, Garry Roufa, Peter Lai, Rodrigo Herrera, Rudy Powell, Greg Davis, Chris Richter (FHWA), Jeffrey Ger (FHWA), Bob Burleson (FTBA)

SUBJECT: Embedded Data Collector Use in Test Piles is Optional Beginning with July 2011 Lettings

DESIGN REQUIREMENTS

1. Section 3.5.10.F of the January 2011 ***Structures Design Guidelines*** is revised as follows:

   F. For projects with letting dates prior to July 1, 2011 - Specify one Embedded Data Collector (EDC) per test pile on all projects with bridges containing 18-inch, 20-inch, 24-inch or 30-inch prestressed concrete test piles. Include Pay Item No. 455-146 (Embedded Data Collector, each) on the Summary of Pay Items. Coordinate with the District Specifications Office to ensure that special provision SP4550512 is included in the specifications package.

   For projects with letting dates after July 1, 2011, the use of EDC in test piles is optional, the EDC Pay Item is not valid, and specification requirements are in the July 2011 Workbook.

COMMENTARY

This bulletin removes an item that was inserted into the ***Structures Design Guidelines*** on a temporary basis. Beginning with projects let in July 2011, Dynamic Load Tests on concrete test piles may be performed using either EDC or instruments using external gauges (such as PDA, etc.). These options are outlined for the contractor in the ***Supplemental Specification*** 455 contained in the July 2011 Workbook. All costs for dynamic load tests are included in the price of the test piles.

ARCHIVED

- – Design Bulletins issued on 2006, 2009 and 2010 addressing the use of EDC in test and production piles
- – Collect sufficient data to evaluate the system

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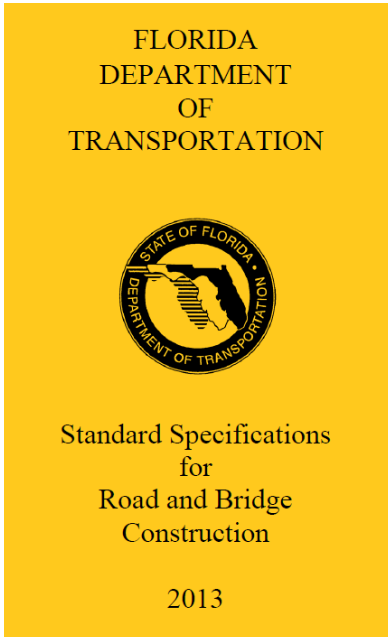
IMPLEMENTATION



- July 2011 Workbook
  - EDC introduced as a stand-alone system
- 2013 Standard Specifications

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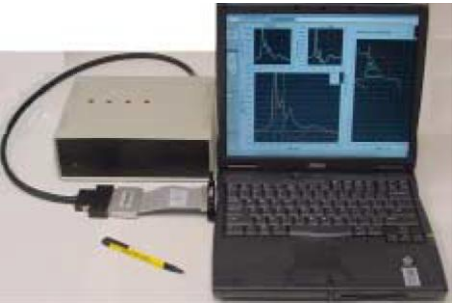

EDC EVALUATION

- Original Research
  - "Double wave up" for skin friction estimates

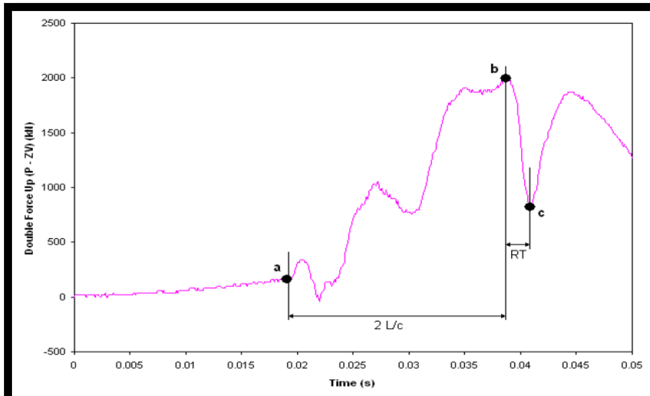

Figure 7-3. Procedure to Determine Tip to Skin Ratio for the Suggested Method

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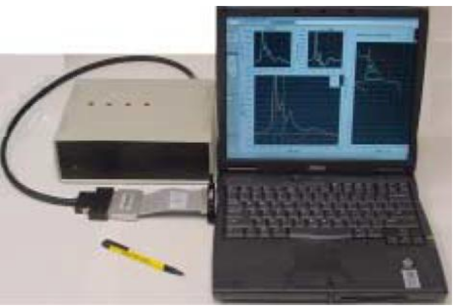

EDC EVALUATION

- Original Research
  - Tip to skin ratio

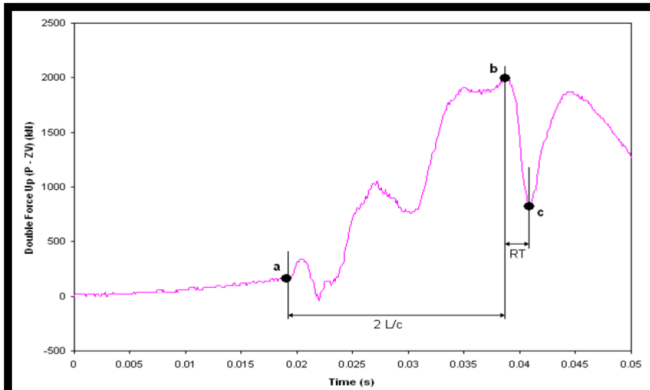

Figure 7-3. Procedure to Determine Tip to Skin Ratio for the Suggested Method

$$\frac{Tip}{Skin} = \frac{[(F_b - ZV_b) - (F_c - ZV_c)]}{[(F_b - ZV_b) - (F_a - ZV_a)]}$$

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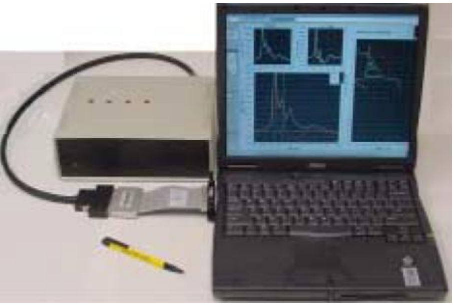

EDC EVALUATION

- Original Research
  - Case damping vs. tip/skin ratio

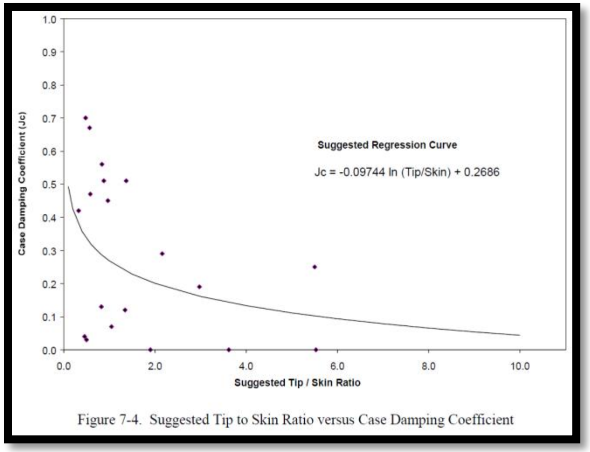

Figure 7-4. Suggested Tip to Skin Ratio versus Case Damping Coefficient

$$J_c = -0.09744 \ln\left(\frac{Tip}{Skin}\right) + 0.2686$$

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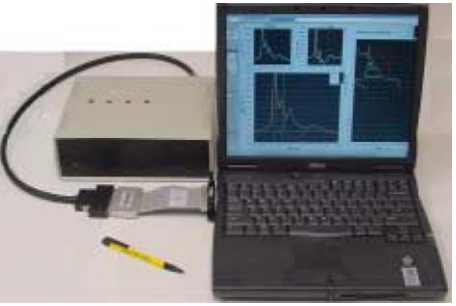

EDC EVALUATION

- Original Research
  - Case equation (Static resistance)

$$\overline{R} = \frac{1}{2}\left[\left(1-\overline{J}_c\right)\left(F_1 + ZV_1\right) + \left(1+\overline{J}_c\right)\left(F_2 - ZV_2\right)\right]$$

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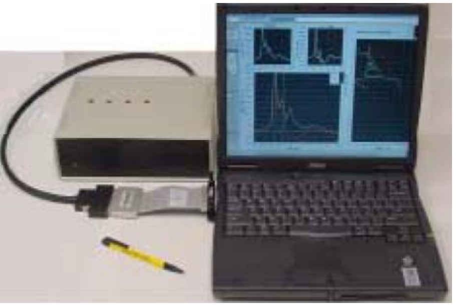

EDC EVALUATION

- Original Research
  - Proposed method vs. static load tests

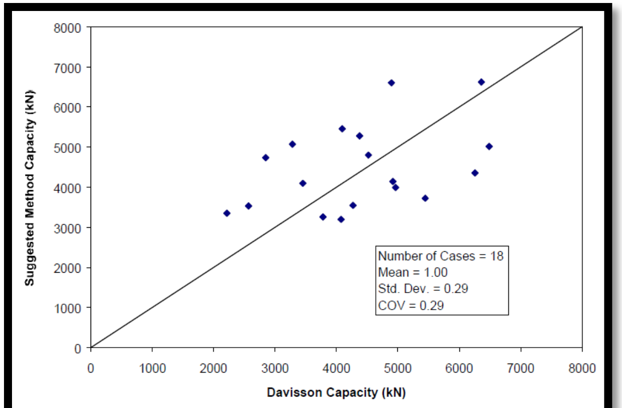

Figure 7-5. Davisson Capacity vs. Suggested Method II Capacity

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EDC EVALUATION

- Follow-up Research
  - Evaluate EDC’s measurements at the core of the pile vs. PDA and UF’s instrumentation measurements on the face of the pile under controlled laboratory conditions

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EDC EVALUATION

- Follow-up Research

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EDC EVALUATION

- Follow-up Research

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EDC EVALUATION

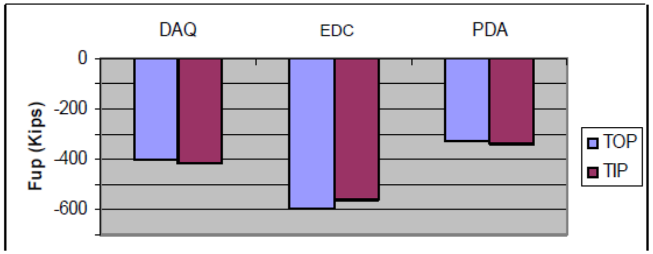

Figure 5-2. Comparison of peak F_{up} between tip and top of pile.

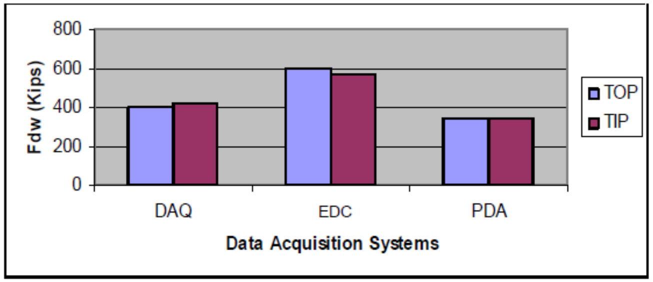

Figure 5-3. Comparison of peak F_{dw} between tip and top of pile.

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EDC EVALUATION

- Implementation of Findings and Smart Structures Updates
  - Revised Tip/Skin ratio

$$Tip/Skin = R_{D,tip} / R_{D,skin}$$

$$= [F_{down,tip} + F_{up,tip}] / [2*[F_{Down,top} - F_{Down,tip}]]$$

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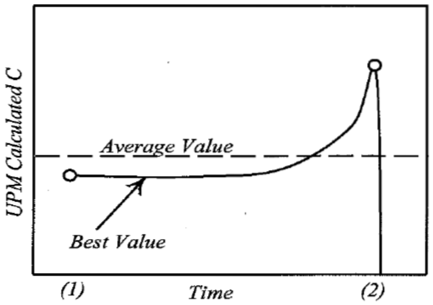

EDC EVALUATION

- Implementation of Findings and Smart Structures Updates
  – Unloading point method used for tip data analysis

$$F_{applied} = F_{static} + ma + cv$$

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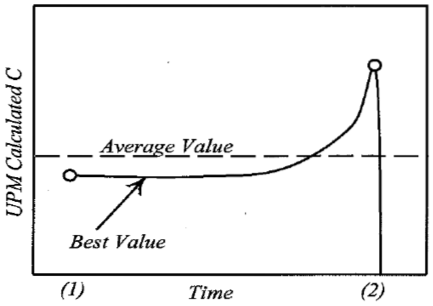

EDC EVALUATION

- Possibilities for the future
  - New methods for both tip and skin friction determination from UF (Tran & McVay)
  - Monitoring throughout the lifetime of the structure

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EDC EVALUATION

- Summary
  - Technology developed initially through FDOT funded research
    - UF - Dr. Michael McVay
  - Evaluation and stepped implementation of the system by FDOT between 2006 and 2011

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EDC EVALUATION

- Summary
  - Comparisons of total static capacity indicate that both UF and Fixed methods generally trend conservatively when compared to PDA and CAPWAP with averages near 86% and COV under 0.26

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AASHTO-TIG

- Thank you
- Rodrigo.Herrera@dot.state.fl.us

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Potential Future Benefits

Jc Determination without Signal Matching for the use of top gauges in production piles

INTRODUCTION

- The EDC's UF method uses information from top and bottom gauges to determine the capacity of the pile without the need for signal matching analysis.
- This has one potential benefit: Obtaining Jc, Case damping value directly from the output without matching analysis.

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INTRODUCTION

- Once Jc from top and tip instrumentation measurements is determined, it would be reasonable to use 100% EDC with top gauges only, similar to PDA.
- When we previously required 100% EDC on all projects, PDA and CAPWAP were used to determine Jc. Piles were then accepted based on the top gauge information.

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Determining Jc

- The procedure is similar, except the EDC data and UF method are the basis for determining Jc.
- This is easily done when the Session Reports are loaded into Excel.
- A Session Report for each Jc value will need to be created and the comparison with the UF method performed in Excel.

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EDC output

Here is a typical Session Report in Excel:

SMARTPILE

SmartPile™ EDC REPORT

SmartPile(TM) Review Version 4
Disabled Error Detection Levels: None

SW Florida Airport Interchange **End Bent 1** **Pile 3**

Print to PDF (Excel 2007)

User Information

CEI Name Mitchell Foster
Company Name Applied Foundation Testing
City Odessa
State FL
Zip 33556
Certification ID 010FL0064-16
Phone Number 727-376-5040

Project Information

Project Name SW Florida Airport Interchange
City Ft Meyers
State FL
County/District Lee
Project Number (DOT) FIN 416649-2-52-01
Project Description
Structure Bridge 120179
Description
Latitude
Longitude

Notes

Pile Information

Structure	End Bent 1	
Pile Number	3	
Pile Length	120	Feet
Pile Marker Increment	1	Feet
Set Check Marker Increment	1	inches
Top Gage to Pile Top	48	inches
Tip Gage to Pile Tip	24	inches
d Dimension	24	inches
Mid Gage to Pile Tip	1	inches
Top Cross-Section Area	576	inches 2
Tip Cross-Section Area	576	inches 2
Modulus of Elasticity	5900.501862	KSI
Concrete Specific Weight	0.15	K/ft 3
Wave Speed	13500	Feet/sec
Fixed Jc Damping Coefficient	0.6	
Pile Tip UP Soil Rate Factor	0.96	
Air/Hydraulic Hammer	FALSE	
Hammer	SPI D46-32	
Nominal Bearing Resistance	291	Tons
Tension Resistance	0	Tons
Minimum Tip Elevation	-30	Feet
Jet/PreForm Elevation	-6.5	Feet
Pile Cut-Off Elevation	48.7	Feet
Radio 1 ID	00.A0.96.36.70.DC	
Radio 1 FW Version	517	
Final Tip Elevation	-61.84	Feet

Drive Duration:From 04-15-2013 10:32:28 to 04-15-2013 10:58:47

*****Average at identified displacement unless a single blow or indicated otherwise in header (e.g. Tension)***

Tip Elevation (Feet)	Blow Number	Blows per Foot to Disp	Stroke/BPM (Feet)	Energy (Kips-ft)	Fixed Jc Capacity (Kips)	UF Capacity (Kips)	Wave Speed (Feet/sec)	Top Compression (Ksi)	Tip Compression (Ksi)	Max Tension (Ksi)	MPI	Top Preload Delta (uStrain)	Tip Preload Delta (uStrain)
-0.42	6	5	2.8	9.8	179.0	146.4	15015.0	1.1	0.2	0.8	90.0	10.8	-9.8
-1.42	13	6	5.2	12.3	196.0	189.0	14810.0	1.2	0.2	0.9	100.0	1.7	6.3
-2.42	22	9	5.8	15.7	238.9	285.0	14669.6	1.5	0.2	1.3	100.0	-0.7	-3.9
-2.42	22	1	5.3	5.1	97.0	107.0	14609.7	0.7	0.1	0.4	100.0	2.9	-1.1
-15.42	46	4	4.8	12.2	220.0	224.0	14558.7	1.3	0.2	1.0	100.0	-0.1	-1.9
-16.42	51	5	4.8	11.1	205.8	214.4	14503.3	1.3	0.2	0.9	100.0	-0.6	-0.1

Session Results | Session Graphs | Blow Distribution

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EDC output

The typical output includes “Fixed Jc Capacity” and “UF Capacity” columns:

Drive Duration:From 03-11-2013 12:07:07 to 03-11-2013 13:01:04

**Average at ide

Tip Elevation (Feet)	Blow Number	Blows per Foot to Disp	Stroke/BPM (Feet)	Energy (Kips-ft)	Fixed Jc Capacity (Kips)	UF Capacity (Kips)
0.67	19	6	5.8	22.9	134.0	127.4
-0.33	21	2	7.9	28.1	218.5	249.0
-1.33	24	3	7.6	24.9	174.3	216.7
-2.33	27	3	7.0	24.5	178.3	231.0
-3.33	30	3	6.6	27.8	224.7	292.3
-3.33	30	1	6.9	23.4	217.0	247.0
-5.33	34	2	7.7	27.6	250.5	273.0
-5.33	34	1	8.9	41.2	227.0	312.0
-8.33	37	2	8.0	31.7	285.5	370.5
-8.33	37	1	6.9	28.3	246.0	385.0
-9.33	38	1	7.1	26.9	197.0	271.0
-11.33	42	3	6.9	28.2	178.0	227.0
-11.33	42	1	6.7	31.2	194.0	223.0
-13.33	46	3	6.9	28.9	231.7	310.0
-13.33	46	1	6.7	29.2	227.0	297.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EDC output

A column can be added to perform statistical comparisons between Jc Cap and UF Cap:

added

***Average at identified displacement unless a single blow or indicated otherwise in header (e.g. Tension)*

UF Capacity (Kips)	Wave Speed (Feet/sec)	Top Compression (Ksi)	Tip Compression (Ksi)	Max Tension (Ksi)	MPI	Top Preload Delta (uStrain)	Tip Preload Delta (uStrain)	fixed Jc Cap/UF
853.0	14502.0	2.3	1.6	0.4	100.0	0.0	-0.6	0.964
847.0	14509.0	2.2	1.6	0.4	100.0	0.0	-5.0	0.959
844.0	14507.3	2.2	1.5	0.4	100.0	1.5	-4.4	0.944
845.0	14509.0	2.3	1.5	0.4	100.0	0.0	-5.1	0.981
863.0	14507.3	2.3	1.6	0.4	100.0	0.0	-7.0	0.943
843.0	14509.0	2.3	1.6	0.4	100.0	-1.9	-6.2	0.963
834.0	14512.9	2.2	1.5	0.4	100.0	0.0	-7.7	0.960
881.0	14502.9	2.3	1.5	0.4	100.0	0.0	-3.3	0.980
869.0	14496.1	2.3	1.6	0.4	100.0	0.0	-11.8	0.997
855.0	14497.2	2.3	1.5	0.4	100.0	1.3	-0.6	0.978
865.0	14485.3	2.2	1.5	0.4	100.0	0.0	-4.8	0.986
861.0	14486.0	2.3	1.5	0.4	100.0	0.0	-7.7	0.969
866.0	14490.9	2.3	1.5	0.4	100.0	0.0	-3.7	0.986
861.0	14491.9	2.3	1.5	0.4	100.0	0.0	-7.7	0.980
846.0	14503.8	2.3	1.5	0.4	100.0	-0.8	-3.7	0.989
848.0	14499.4	2.3	1.5	0.4	100.0	0.0	-4.0	0.988
860.0	14503.8	2.2	1.5	0.4	100.0	-1.0	-9.6	0.979
854.0	14488.1	2.2	1.5	0.4	100.0	0.0	-3.3	0.959
831.0	14487.3	2.1	1.5	0.4	100.0	0.0	-3.3	0.964
717.0	14487.3	1.5	1.2	0.2	100.0	-2.7	-7.3	0.987
504.0	14487.3	0.8	0.7	0.0	99.0	-1.8	-0.4	0.871
							Avg	0.962
							stdr. Dev	0.047
							correl	0.999
							max	1.103
							avg+ stdr	1.010

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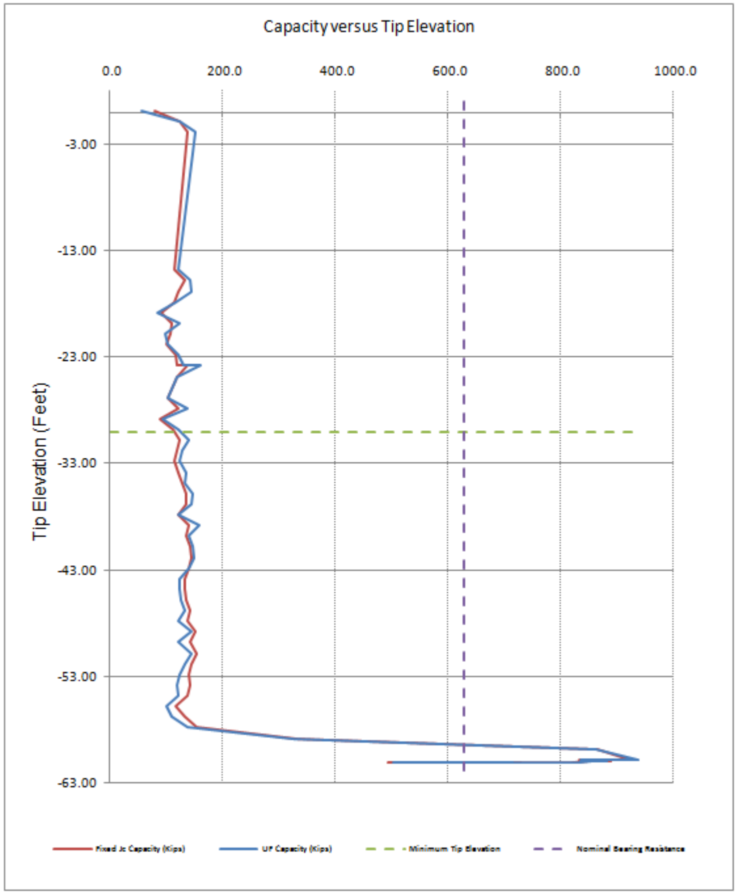
The graphical output includes a chart comparing the Fixed Case capacity with Jc and UF capacity



A typical output of an EDC session. In red, Jc capacity (at the JC value selected) compared with UF capacity (blue)

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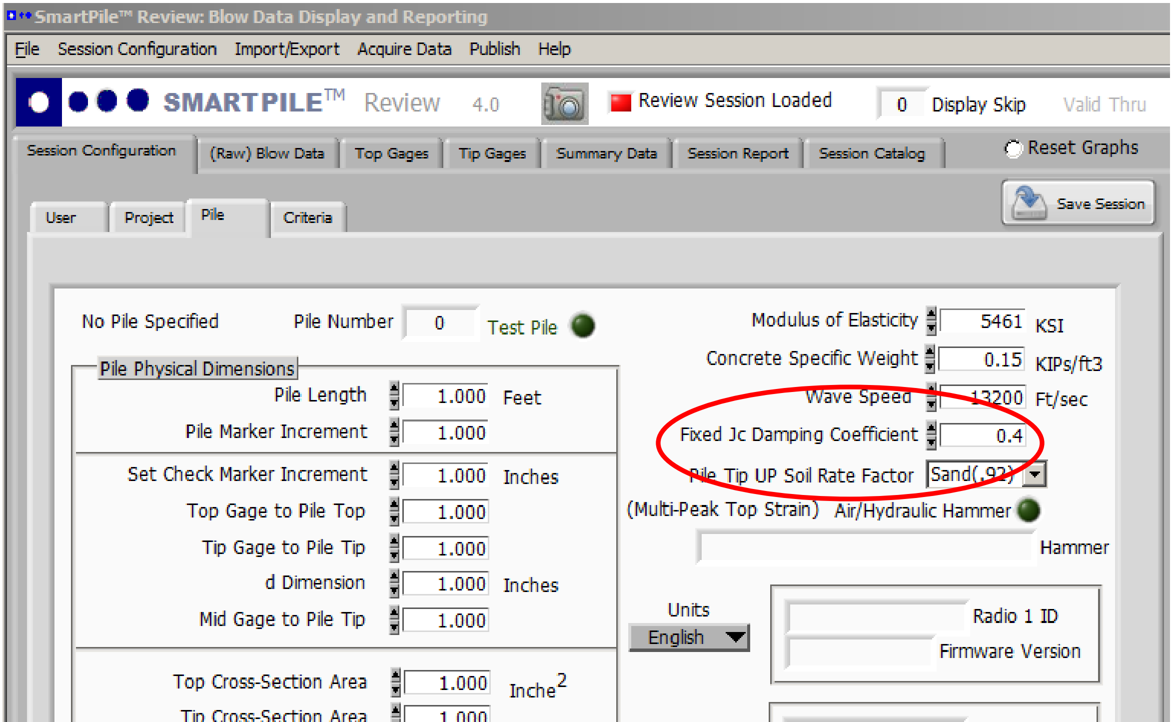
- The value of Jc used in the Fixed Method analysis is called the Fixed Jc Damping Coefficient in SmartPile Review and can be changed. The user then replays the EDC data for each different Jc value.



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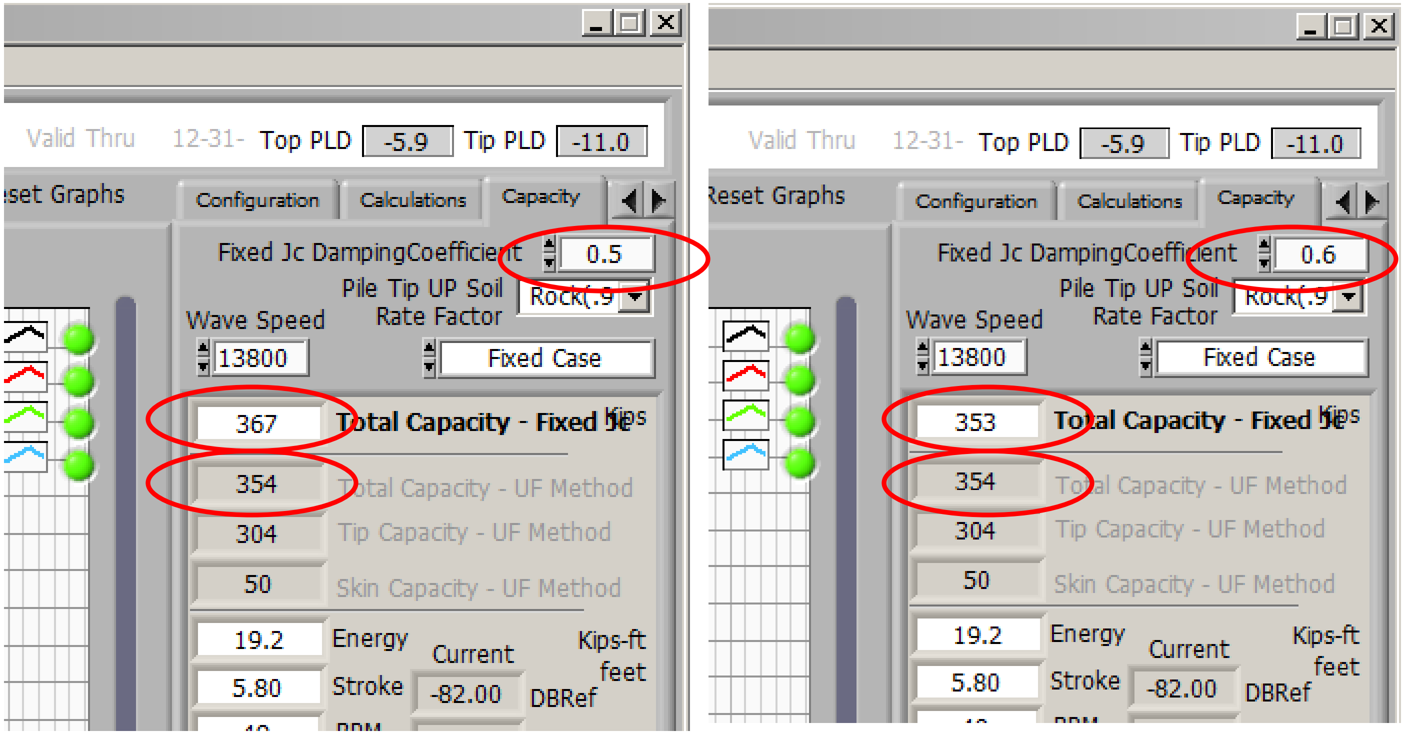
Capacity variability in individual blows can also be seen by changing the Jc value



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Suggested Procedure

The EDC outputs may be used to estimate the Jc value as follows:

- Produce output data for several Jc values.
- Compare the values and plots of Fixed Jc Capacity and UF Capacity.
- Focus on data collected below the minimum tip elevation.

- Select the Jc value at which the Fixed Jc Capacity is closest to, but does not exceed the UF capacity

Note: The Fixed Jc capacity will not necessarily be parallel to the UF Capacity for the entire drive.

Example follows:

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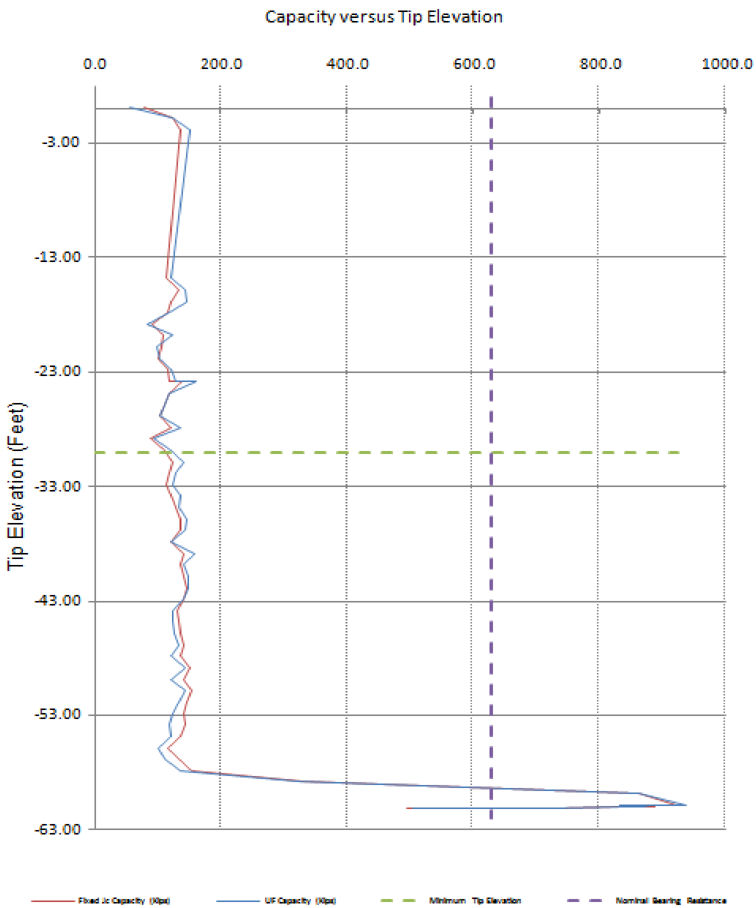
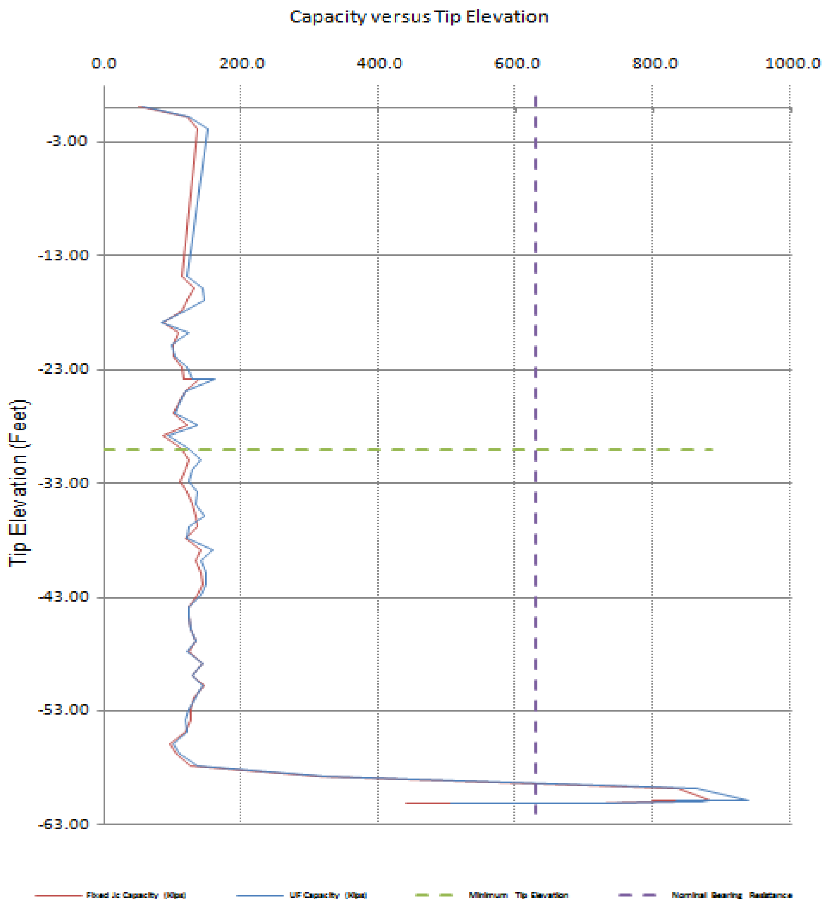
Jc=0.5 unconservative below El. -43.

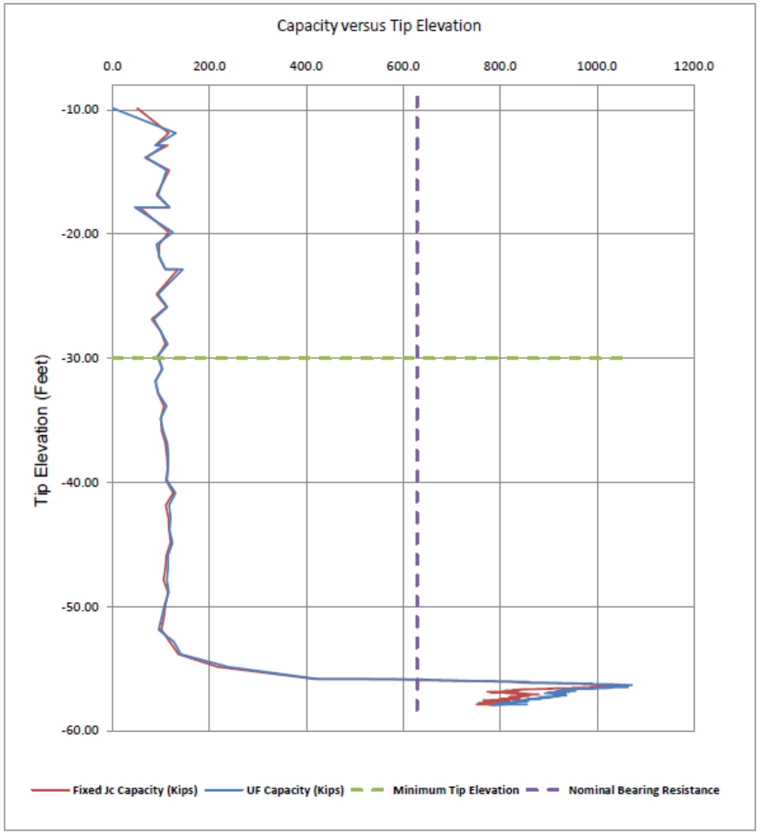
Jc=0.6 is a good value. Great match and even slightly conservative below El -57.





Example 2:

- In this case it can be seen how a Jc=0.6 gives a very good match with the UF Capacity, throughout the full drive.



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Notes on Set-Checks and re-drives

If the capacity is not achieved during initial drive, and we need a set-check (redrive) after a period of time, we may have a limitation because the Jc typically increases between initial drive and redrive, particularly in soils exhibiting set-up over time.

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