

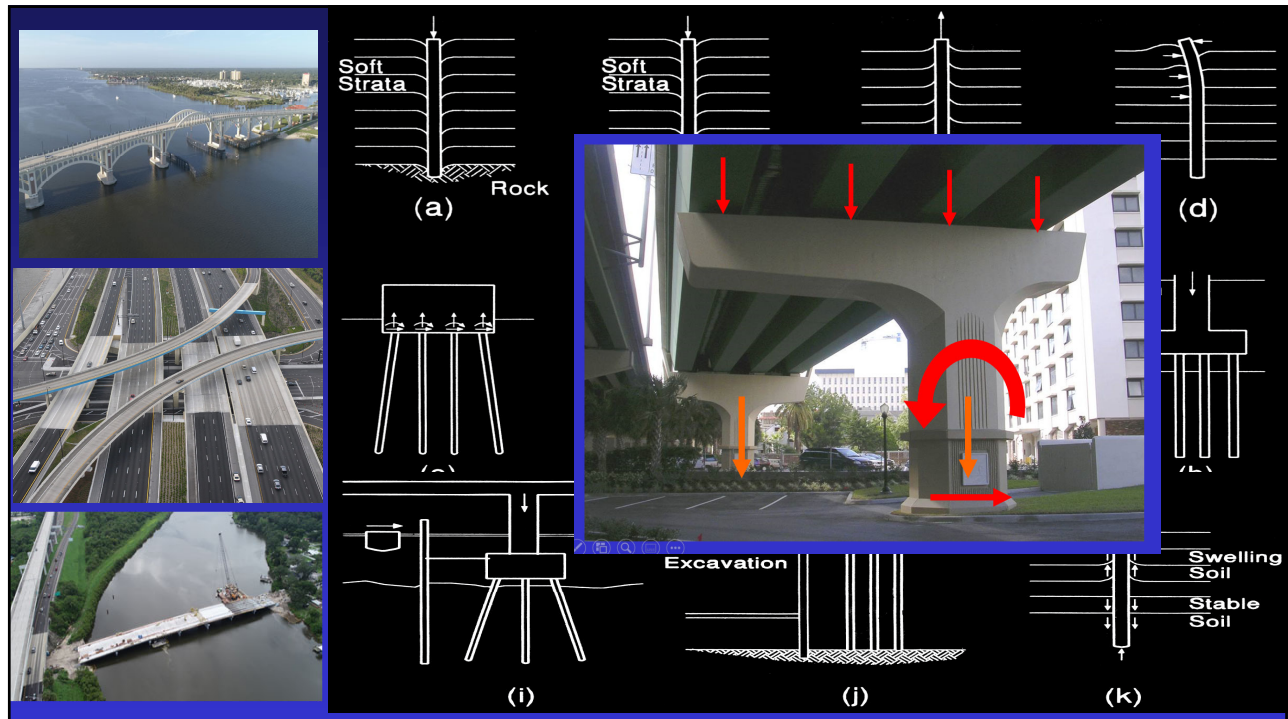
# Pile Driving Blow Counts Criteria or 100% Testing: Advantages, Disadvantages, and Best Practices

Mohamad Hussein, P.E.

[www.pile.com](http://www.pile.com)



1



2



3



4



5



6

# Driven Piles



U.S. Department of Transportation  
Federal Highway Administration

Publication No. FHWA-NHI-16-009  
FHWA GEC 012 – Volume I  
September 2016

NHI Courses No. 132021 and 132022

### Design and Construction of Driven Pile Foundations – Volume I

Developed following:  
AASHTO LRFD Bridge Design Specifications, 7<sup>th</sup> Edition, 2014, with 2015 Interim.

and

AASHTO LRFD Bridge Construction Specifications, 3<sup>rd</sup> Edition, 2010, with '11, '12, '13, '14, and '15 Interims.

NHI  
NATIONAL HIGHWAY INSTITUTE  
Funding Provided by: TRANSPORTATION BUDGET

U.S. Department of Transportation  
Federal Highway Administration

Publication No. FHWA-NHI-16-009  
FHWA GEC 012 – Volume II  
July 2016

NHI Courses No. 132021 and 132022

### Design and Construction of Driven Pile Foundations – Volume II

Developed following:  
AASHTO LRFD Bridge Design Specifications, 7<sup>th</sup> Edition, 2014, with 2015 Interim.

AASHTO LRFD Bridge Construction Specifications, 3<sup>rd</sup> Edition, 2010, with '11, '12, '13, '14, and '15 Interims.

NHI  
NATIONAL HIGHWAY INSTITUTE  
Funding Provided by: TRANSPORTATION BUDGET

7

**NCHRP**  
SYNTHESIS 418

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

**Developing Production Pile Driving Criteria from Test Pile Data**

*A Synthesis of Highway Practice*

TRANSPORTATION RESEARCH BOARD  
OF THE NATIONAL ACADEMIES

### Acceptance Procedures for Structural Foundations of Transportation Structures

FHWA Geotechnical Engineering Circular 015

April 18, 2022

U.S. Department of Transportation  
**Federal Highway Administration**

Office of Infrastructure  
FHWA-HIF-22-024  
April 2022

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The screenshot shows the PCI website page for 'Piles'. The header includes the PCI logo and navigation links like 'Design Resources', 'Projects', 'Certification', 'Education', 'Publications', 'Certified Plants', and 'News & Events'. The main content area features a title 'Piles' and 'Precast Piles', followed by a descriptive paragraph and two images: one showing precast piles stacked and another showing a pile being lifted by a crane. A sidebar on the right lists various resources under categories like 'Architectural Resources', 'Building Engineering Resources', and 'Transportation Engineering Resources'. At the bottom, there are sections for 'Design Resources' and 'Related Resources & Articles'.

The cover of the PDCA manual is red with black vertical stripes at the top and bottom. The PDCA logo is prominently displayed at the top. Below it, the title 'Recommended Design Specifications For Driven Bearing Piles' is written in a serif font. At the bottom, it indicates 'Third Edition September 2001' and 'The Pile Driving Contractors Association © 2001'.

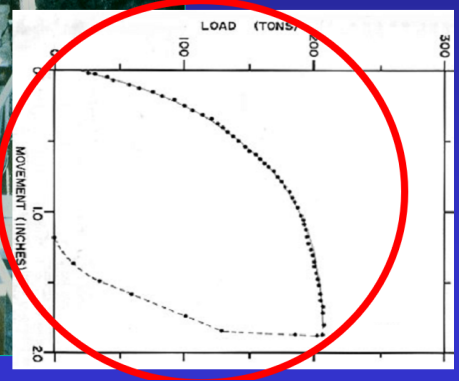
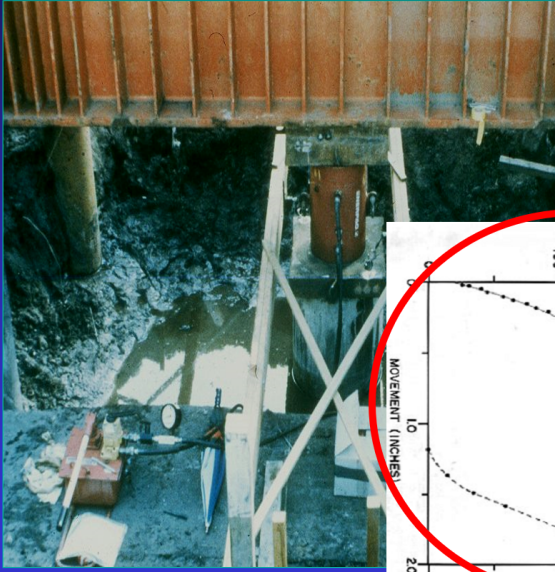
9

The collage includes four images: a close-up of a pile driving rig, a worker in a safety vest looking at a tablet, a full view of a pile driving rig in operation, and a worker writing on a clipboard next to a calculator.

## The pile/foundation design generally is not completely finished until the piles are successfully driven to the required depth and load bearing capacity.

10

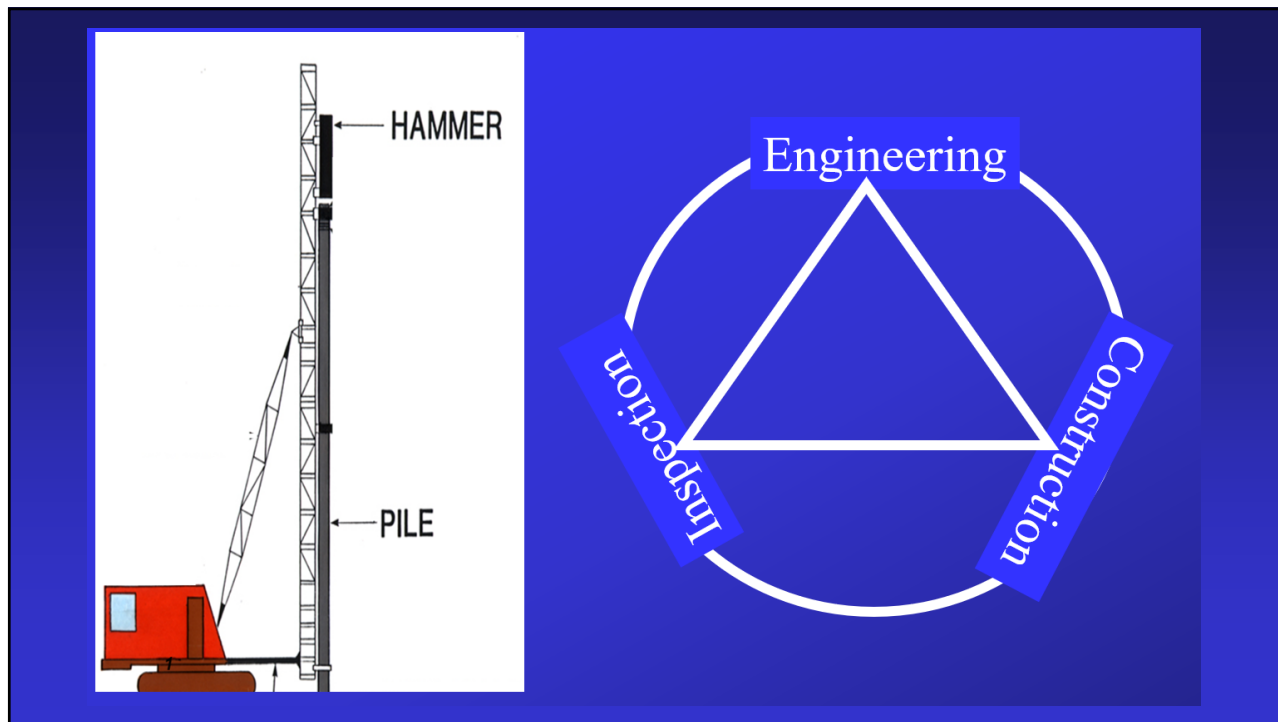
### Conventional Static Load Testing



11



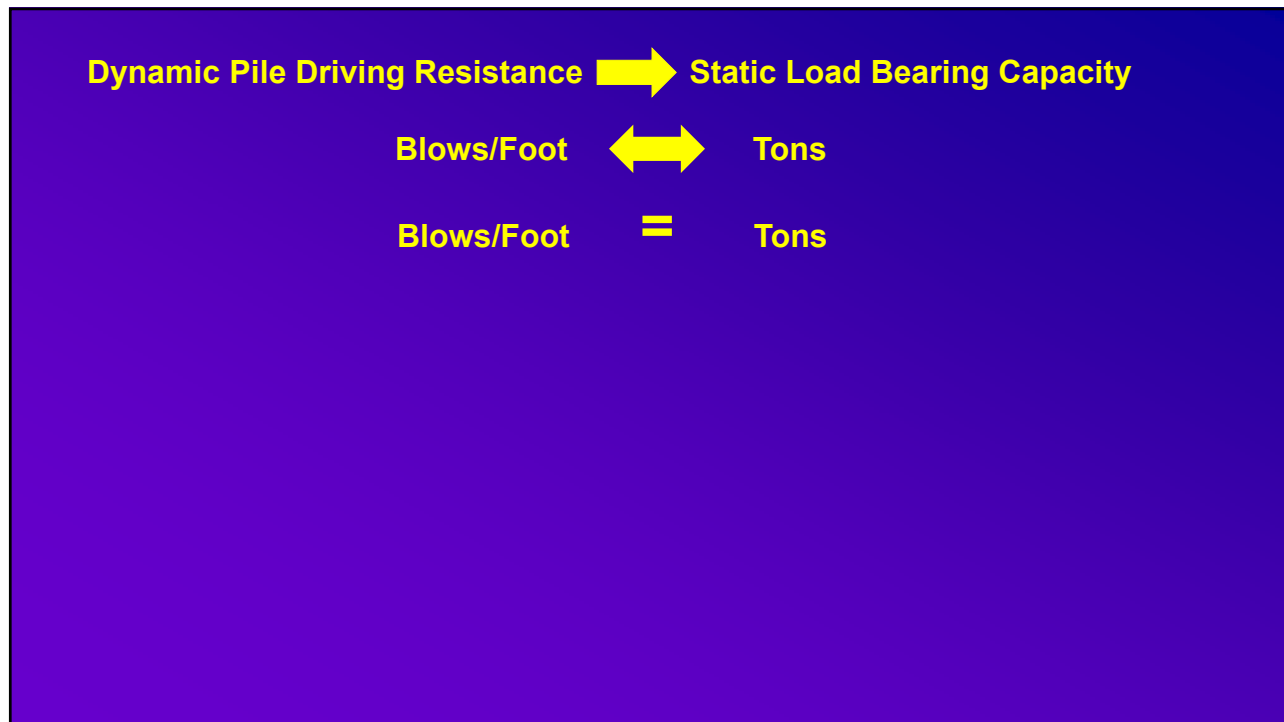
12



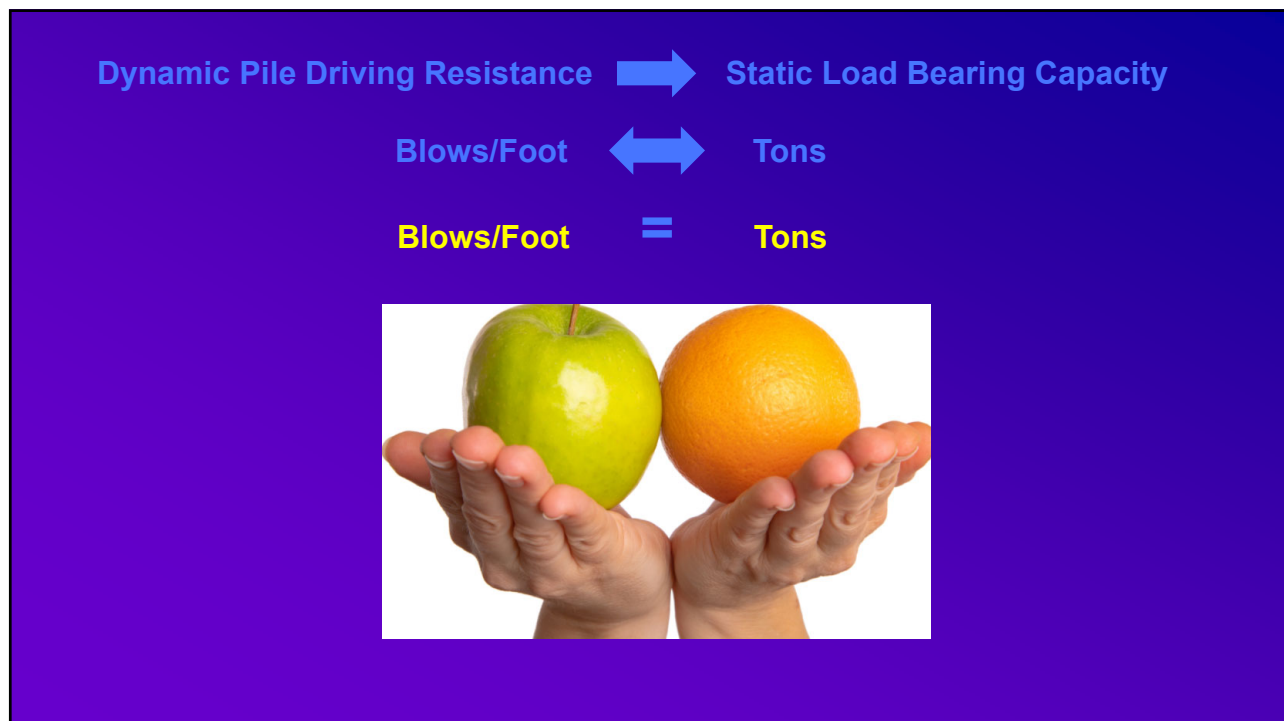
13



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16



**Dynamic Pile Driving Resistance** ➔ **Static Load Bearing Capacity**  
**Blows/Foot** ↔ **Tons**  
 $x$  **Blows/Foot** =  $y$  **Tons**

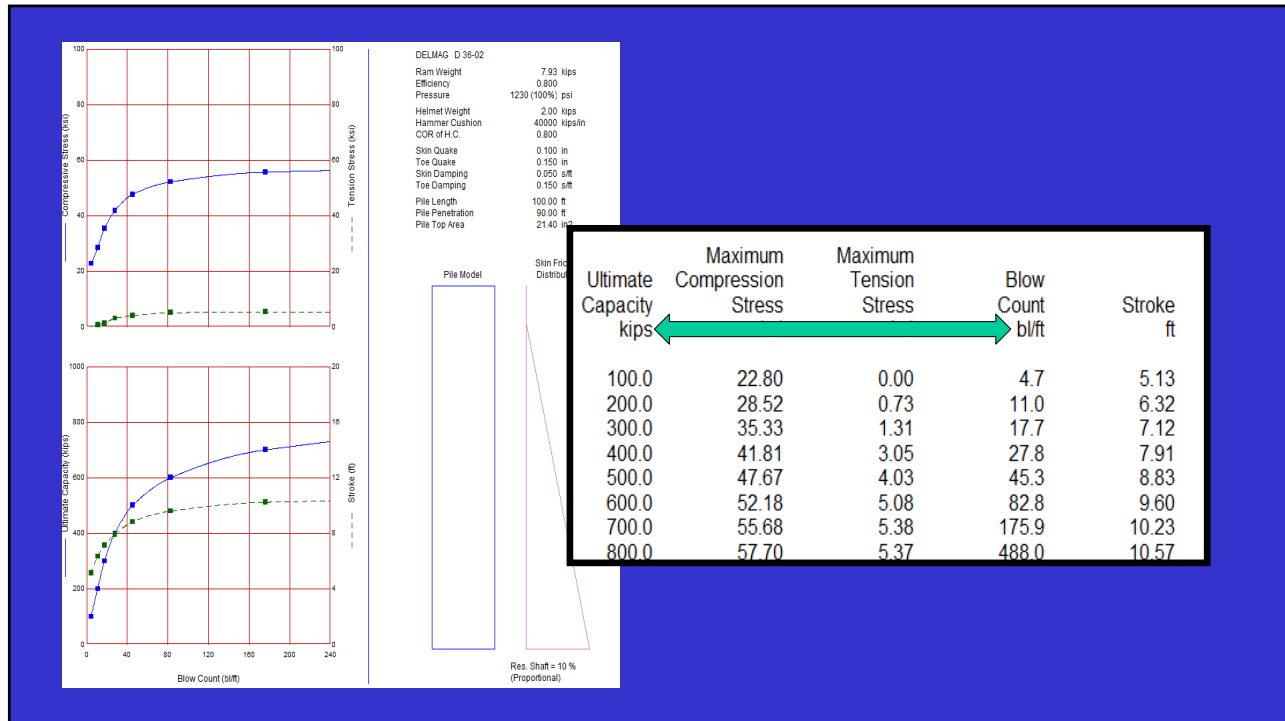
17

## Wave Equation Analysis

Hardware Information	
ID	Name
16	DELMAG 0.30
17	DELMAG 0.30-02
18	DELMAG 0.30-13

Pile Information	
Length	100.00
Perforation	0.00
Section Area	21.41
Elast Modulus	30000.00
Spec Weight	432.00
Top Area	152.19
Perimeter	4.020
Pile Type	14.00

18

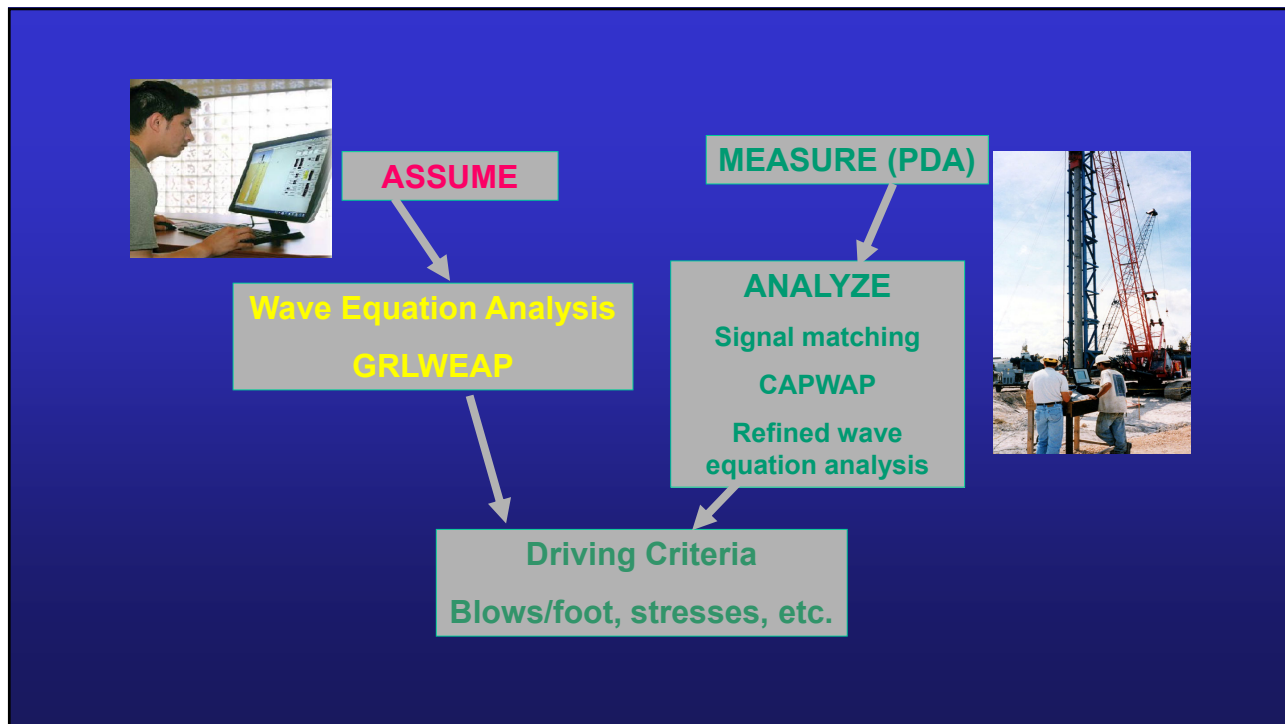


19

**Preliminary Wave Equation Analysis Potential Sources of Errors:**

- Hammer:** performance, efficiency
- Cushions:** stiffness, coefficient of restitution
- Soil:** static resistance to driving, resistance distribution, quake, damping, predrilling or jetting effects, open-ended pipe **pile** plug

20



21



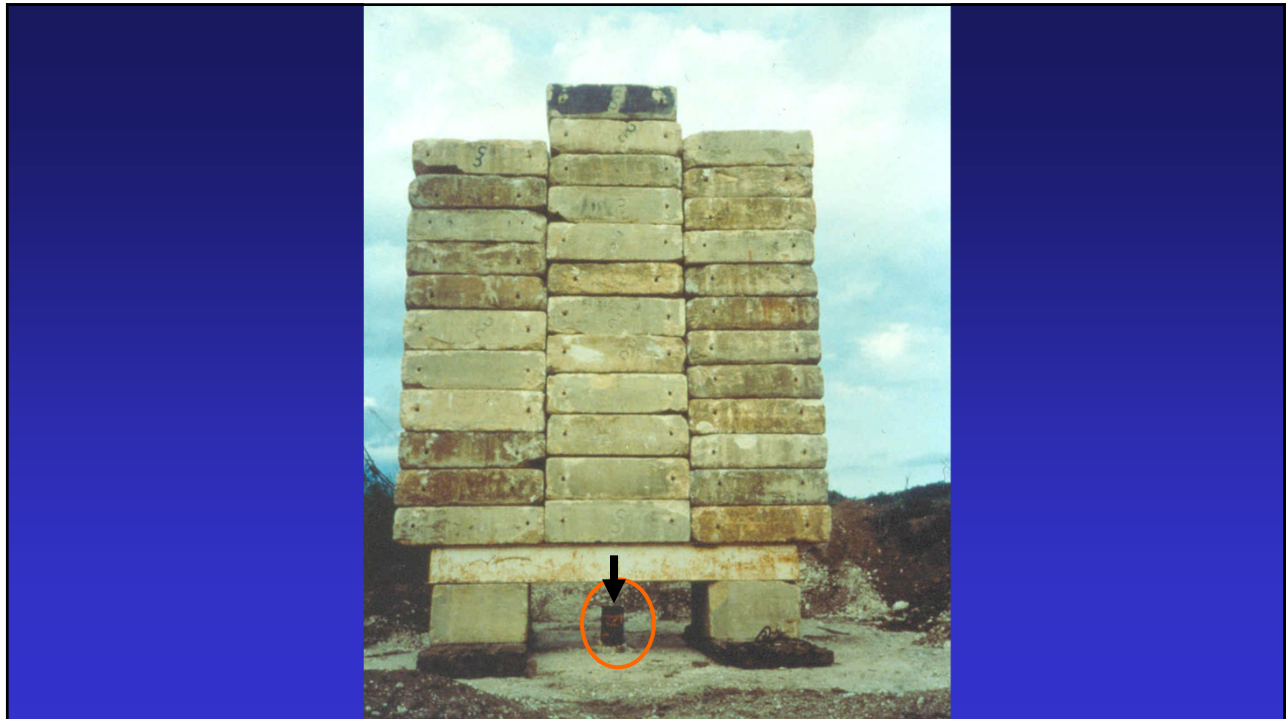
22

## The main goals of Test Piles are to establish:

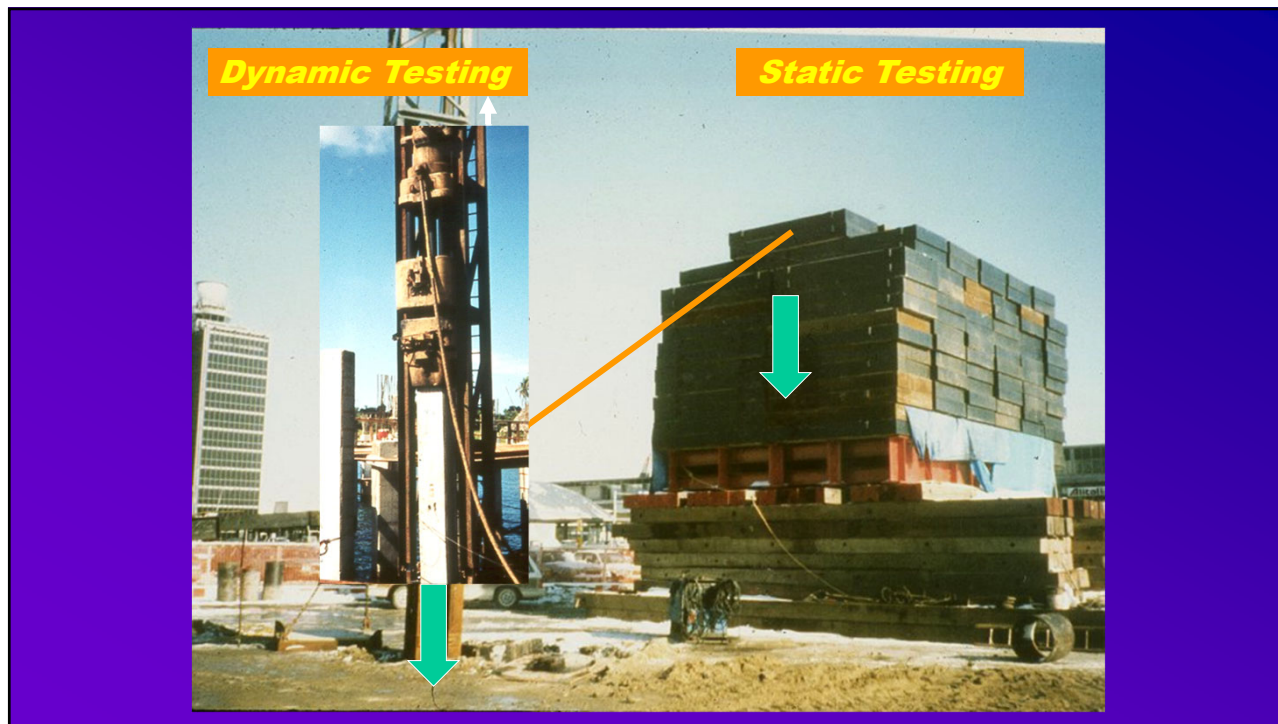
- **Production Piles Length**
- **Pile Driving Criteria**

... also to check the engineer's design assumptions, and the contractor's equipment, means and methods.

23



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26

**Dynamic Pile Testing is measuring Impact stress-wave traveling down the pile length and reflected waves**

MEASURING STRAIN AND ACCELERATION

Pile Top Reflection

27

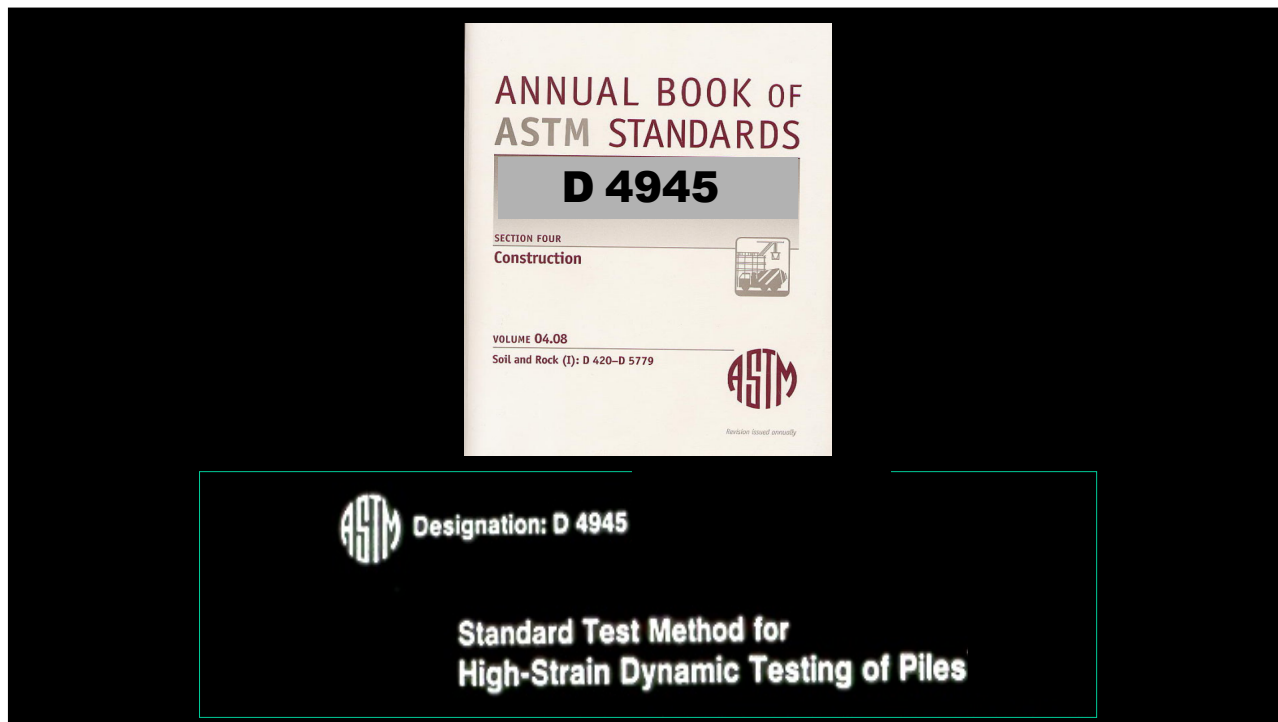
**PDA Wireless Gages & Remote Testing - SiteLink®**

Internet connection

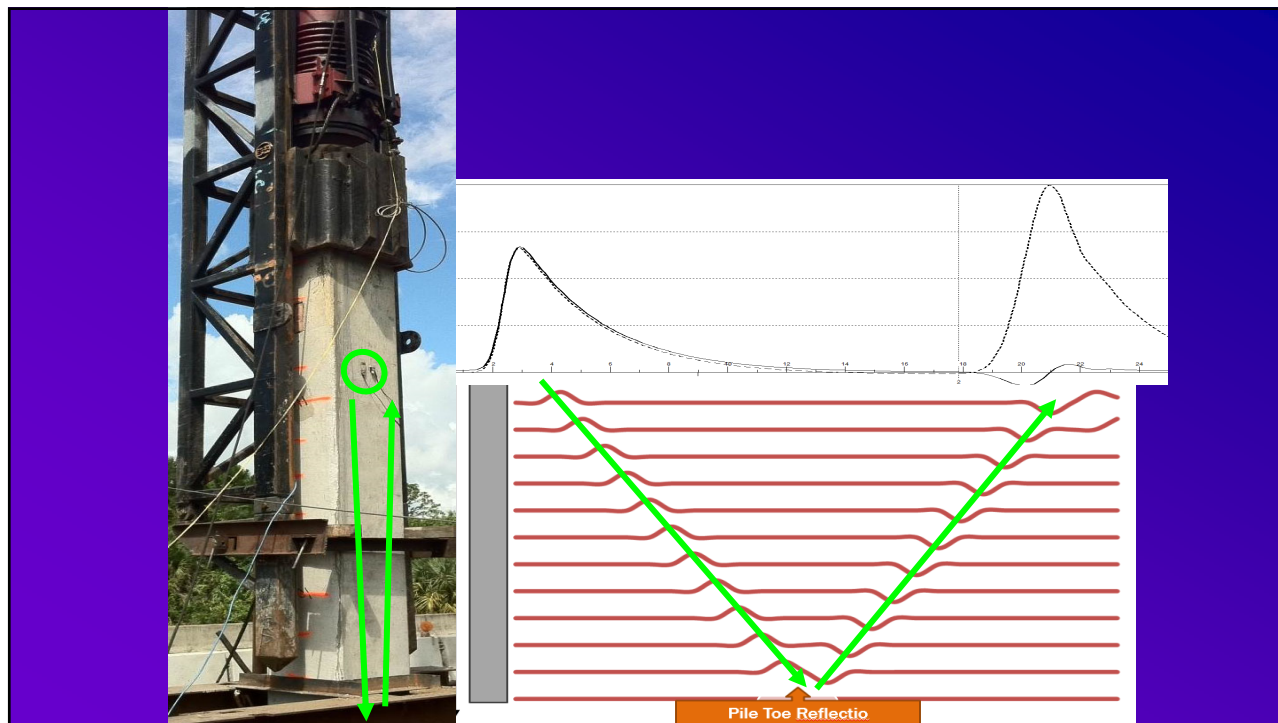
Engineer remotely monitors pile testing in real time.

1

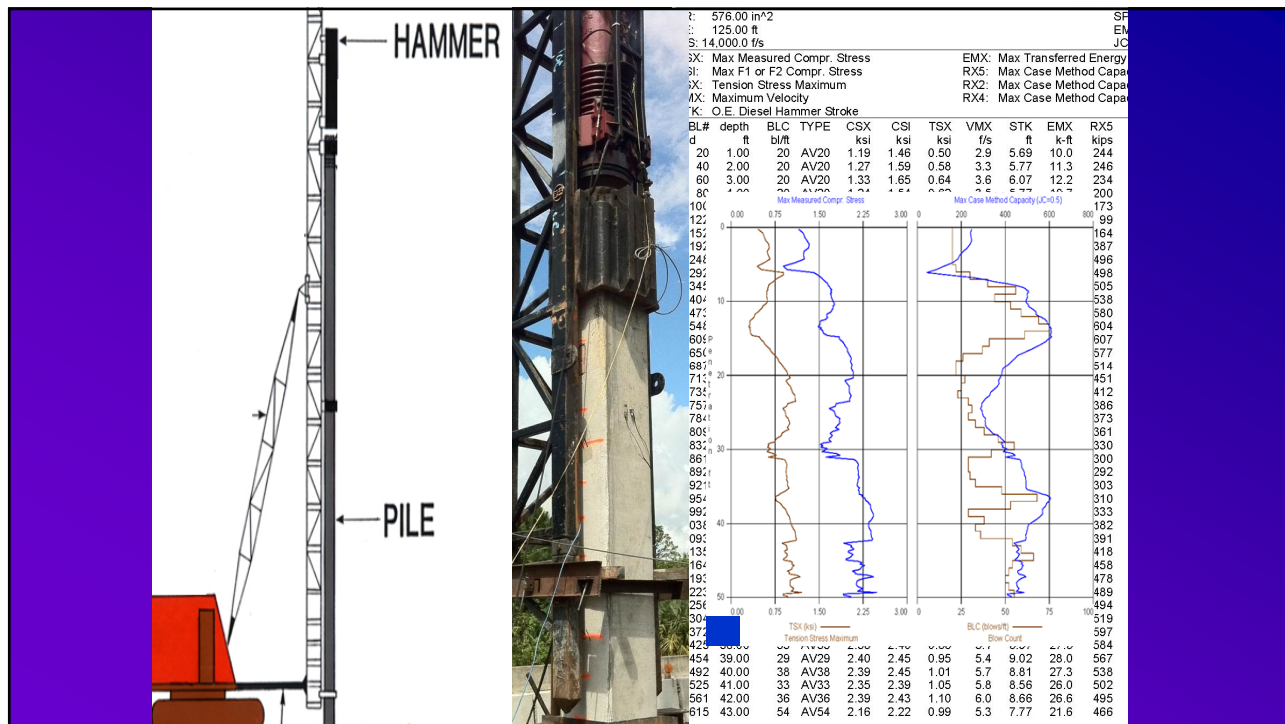
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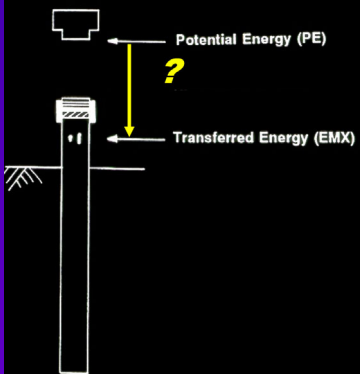
31

**Dynamic Pile Testing provides information for evaluating:**


- Hammer System Performance.**
- Pile Driving Stresses and Structural Integrity.**
- Soil Resistance and pile static load bearing capacity.**

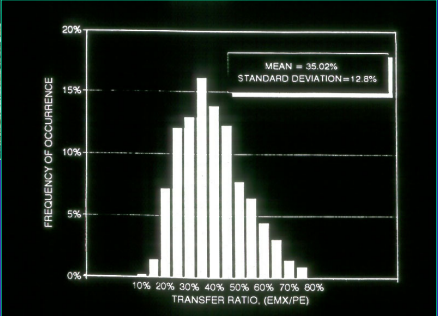
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Potential Energy (PE)  
?  
Transferred Energy (EMX)






**Work = Force x distance**  
 $= F \times$   
 $EMX = \int F d x$   
 $= \int F d x (dt/dt)$   
 $= \int F v dt$

33

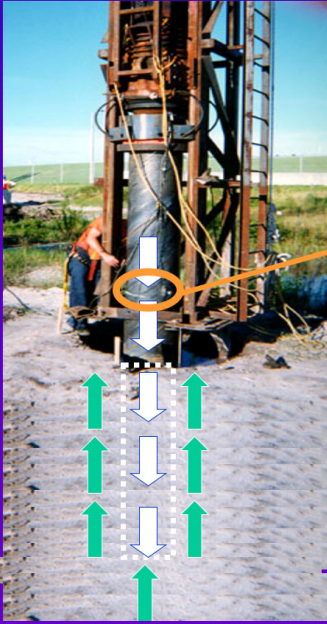
**Dynamic Pile Testing provides information for evaluating:**

**Pile Driving Stresses and Structural Integrity.**






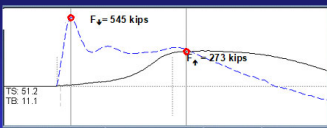
34



### Soil Resistance and Pile capacity

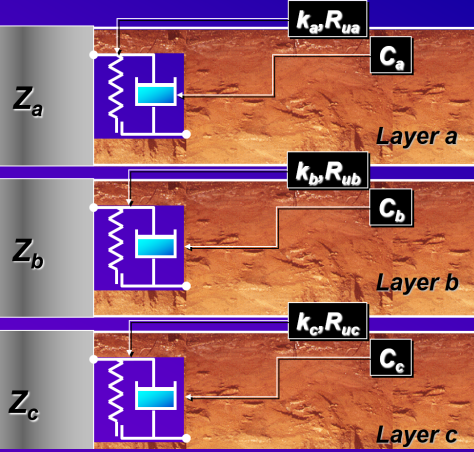


*R<sub>total</sub> using Wave down and Wave up*  
 $R_{total} = F_{u,1} + F_{u,2}$



$R_{total} = 545 + 273 = 818 \text{ kips}$

### CAPWAP Method




Layer a:  $k_{a1} R_{ua}$ ,  $C_a$

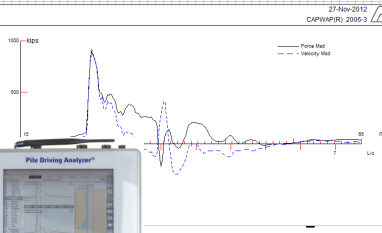
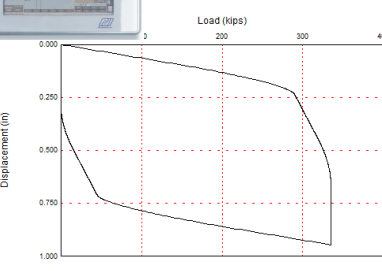
Layer b:  $k_{b1} R_{ub}$ ,  $C_b$


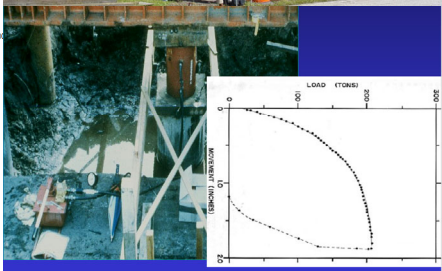
Layer c:  $k_{c1} R_{uc}$ ,  $C_c$

35


### PDA/CAPWAP Analysis Results



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Final Program

**ATLANTA**  
**GEOCONGRESS**  
2006

FEBRUARY 26 – MARCH 1

Geotechnical Engineering in the Information Technology Age

SENSING METHODS AND DEVICES

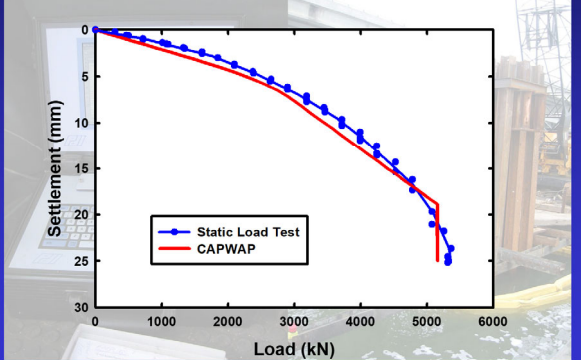
DATA SYNTHESIS AND MANAGEMENT

NUMERICAL MODELING AND ANALYSIS

SIMULATION AND VISUAL ANALYSIS

**Florida State Road 528 over  
Indian River Bridge**

**Class-A Correlation of Static Load Testing and PDA/CAPWAP Dynamic Testing Results**



Settlement (mm)

Load (kN)

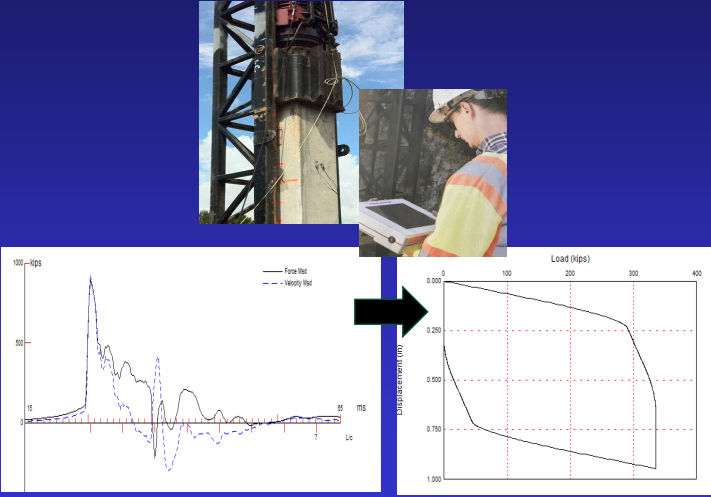
—•— Static Load Test  
— CAPWAP

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# iCAP

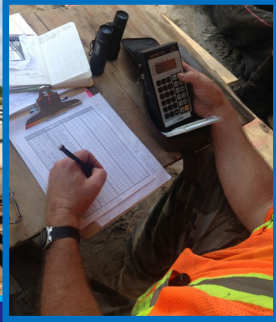
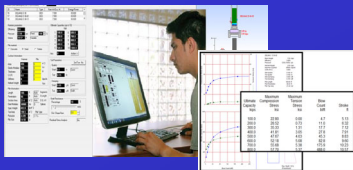
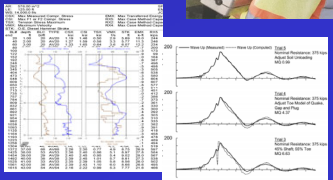
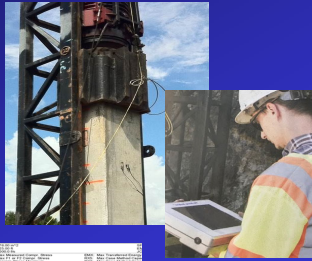
- iCAP is a quick signal matching program; it is based on the **automatic** routines of CAPWAP®
- The quickness of iCAP makes a **signal matching** result available as the data is being acquired, i.e., **during pile driving**
- The results are independent of user experience

PDA testing & iCAP



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**Pile Driving Criteria** - Test Pile, then production piles  
 PDA testing, CAPWAP analysis, refined GRLWEAP



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**Example: 96 ft long, 30-inch square voided PCP,  
APE D80, Required capacity 1030 kips**



PDA Dynamic testing of Test Pile.

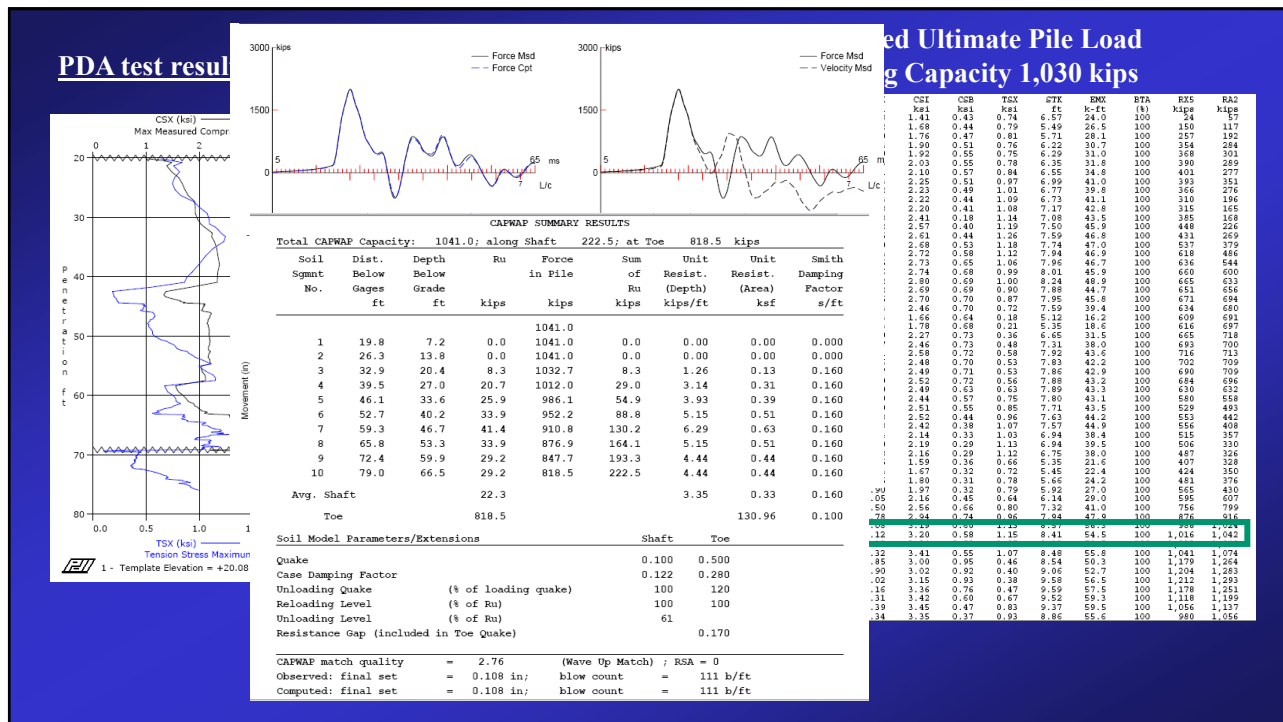


CAPWAP analysis

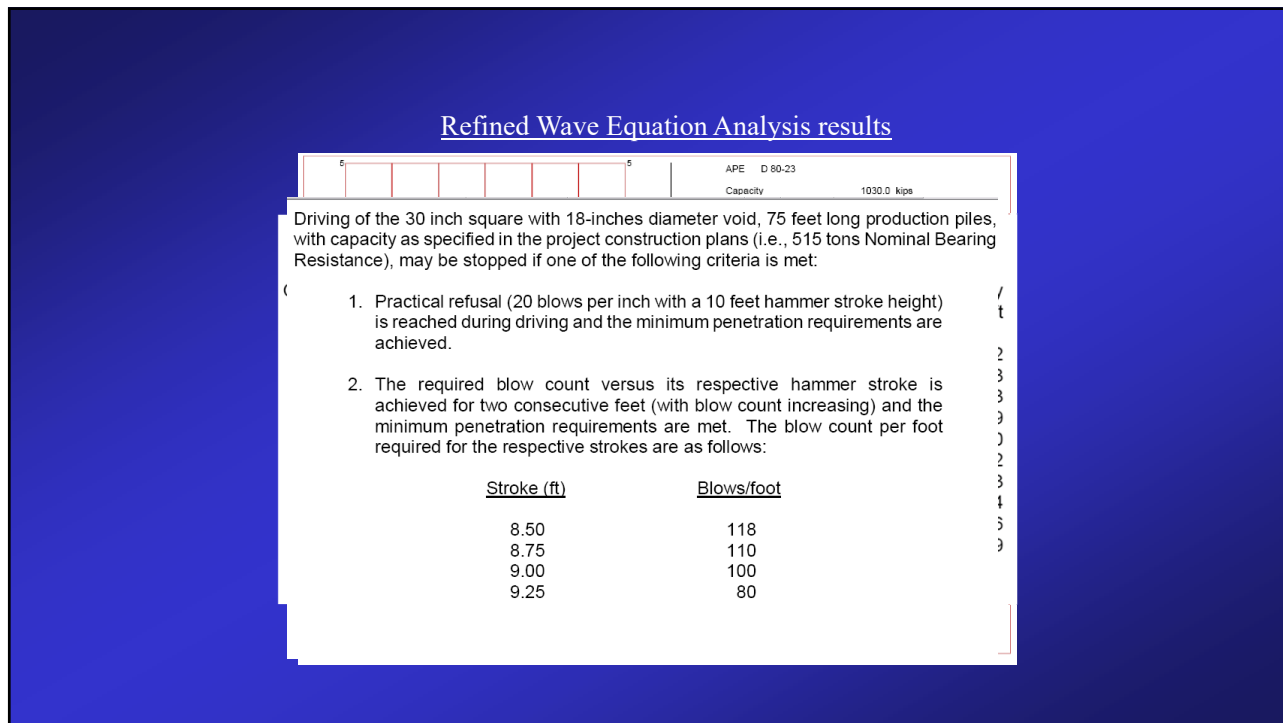


Refined Wave Equation  
 Analysis of Test Pile data,  
 Driving Criteria.

40



41



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Driving Criteria – page 2 of 2

Employ the same hammer equipment, means and methods used in the Test Pile program to install the production piles.


If there is a change in the hammer driving system, or installation methods, notify the project engineer to check/confirm the criteria.

Use a new 16-inch thick plywood cushion for each pile, change every 1700 blows, or as needed. Use it for 240 blows before applying criteria.


Start driving with hammer fuel pump setting #1, increase the setting to next higher at 50 blows/foot, and decrease to the lower at 25 blows/foot.

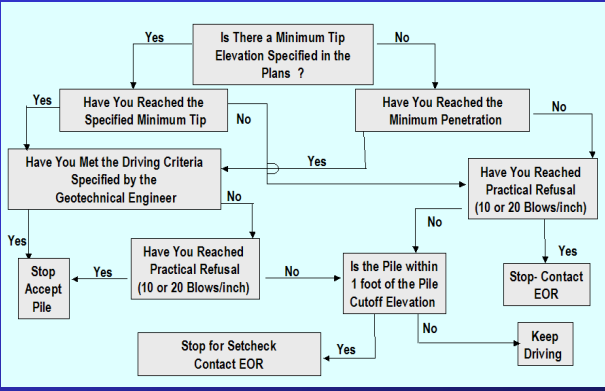
Stop pile driving if the pile top is one foot above cut-off elevation and notify the project engineer for a possible restrrike test.

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### Pile Acceptance Based on Inspection





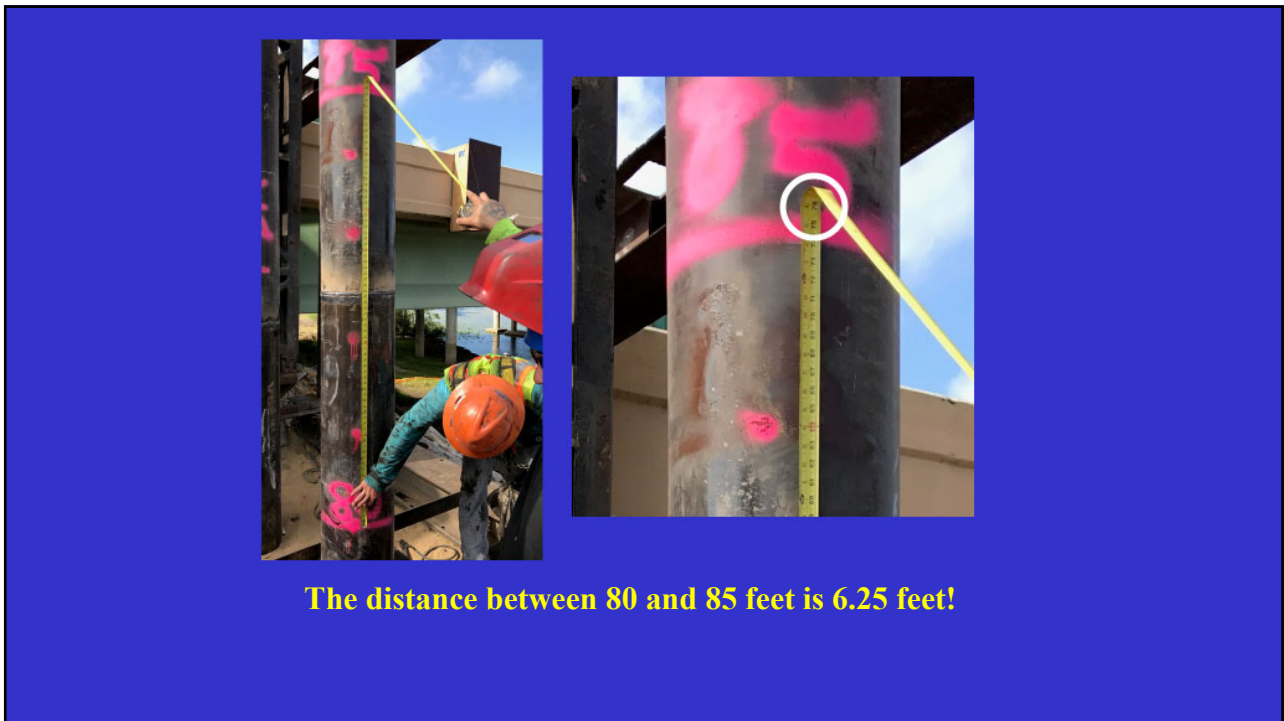
```

graph TD
    A[Is There a Minimum Tip Elevation Specified in the Plans?] -- Yes --> B[Have You Reached the Specified Minimum Tip?]
    A -- No --> C[Have You Reached the Minimum Penetration?]
    B -- Yes --> D[Have You Met the Driving Criteria Specified by the Geotechnical Engineer?]
    C -- Yes --> D
    C -- No --> E[Have You Reached Practical Refusal 10 or 20 Blows/Inch]
    D -- Yes --> F[Have You Reached Practical Refusal 10 or 20 Blows/Inch]
    D -- No --> G[Is the Pile within 1 foot of the Pile Cutoff Elevation]
    F -- Yes --> H[Stop - Contact EOR]
    F -- No --> G
    G -- Yes --> I[Stop - Contact EOR]
    G -- No --> J[Stop for Setcheck Contact EOR]
    E -- Yes --> H
    E -- No --> G
    
```

44



45



46

Inspector's pile driving blow count log

### PILE DRIVING INFORMATION

FIN PROJ ID # \_\_\_\_\_ DATE \_\_\_\_\_ NO. \_\_\_\_\_

PILE SIZE 36" LENGTH 76' BENTPIER NO. \_\_\_\_\_ PILE NO. 4

HAMMER TYPE \_\_\_\_\_ RATED ENERGY 175,000 OPERATING RATE 24-23

TEMPLATE ELEV. 230.00 MAIN TIP ELEV. 116' PILE CUTOFF ELEV. 120.00

DRIVING CRITERIA TEST Pile

PILE CUSHION THICKNESS AND MATERIAL 16" Plywood

HAMMER CUSHION THICKNESS AND MATERIAL 2" Plywood 1/2" Plywood

WEATHER \_\_\_\_\_ TEMP \_\_\_\_\_ START TIME 10:15 STOP TIME 11:15

**PILE DATA**

PAY ITEM NO. 505.113.6 WORK ORDER NO. 116

MANUFACTURED BY \_\_\_\_\_ B.M. ELEV. 234.00 GROUND ROD READ \_\_\_\_\_

DATE CAST \_\_\_\_\_ ROD HEAD 6.88 PILE HEAD ROD READ \_\_\_\_\_

MANUFACTURER'S PILE NO. H1.11.11 PILE HEAD ELEV. \_\_\_\_\_

PILE HEAD CHAMFER 3" x 3/4" PILE TIP ELEV. \_\_\_\_\_

PILE TIP CHAMFER 3/4" x 1/4" GROUND ELEV. \_\_\_\_\_

PILE DRIVING INSPECTOR H. F. F. Pile

BLow	Type	Time	Penetration	TOTAL PILE		BUMP UP	
				FURNISHED	DRIVEN	AUTHORIZED	ACTUAL
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
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99							
100							

NOTES: \* TEST Pile 10' Above 30' Steel @ 10' A Start Main on 10-2-23 Pile Driving Done Start up of Hammer

### PILE DRIVING LOG

TEST Pile 10' 10' 10'

Depth (ft)	Stroke (ft)	Blow Count	Penetration (ft)	Notes
1.00	1.20	19	5.81	
2.00	2.00	4	17.75	
3.00	2.60	3	56.00	
4.00	3.60	4	57.00	
5.00	3.80	5	55.50	
6.00	3.70	7	54.2	
7.00	3.60	8	53.35	
8.00	3.60	7	54.1	
9.00	3.60	10	54.2	
10.00	3.60	12	53.9	
11.00	3.60	13	53.9	
12.00	3.60	13	53.9	
13.00	3.60	13	53.9	
14.00	3.60	13	53.9	
15.00	3.60	13	53.9	
16.00	3.60	13	53.9	
17.00	3.60	13	53.9	
18.00	3.60	13	53.9	
19.00	3.60	13	53.9	
20.00	3.60	13	53.9	
21.00	3.60	13	53.9	
22.00	3.60	13	53.9	
23.00	3.60	13	53.9	
24.00	3.60	13	53.9	
25.00	3.60	13	53.9	
26.00	3.60	13	53.9	
27.00	3.60	13	53.9	
28.00	3.60	13	53.9	
29.00	3.60	13	53.9	
30.00	3.60	13	53.9	
31.00	3.60	13	53.9	
32.00	3.60	13	53.9	
33.00	3.60	13	53.9	
34.00	3.60	13	53.9	
35.00	3.60	13	53.9	
36.00	3.60	13	53.9	
37.00	3.60	13	53.9	
38.00	3.60	13	53.9	
39.00	3.60	13	53.9	
40.00	3.60	13	53.9	
41.00	3.60	13	53.9	
42.00	3.60	13	53.9	
43.00	3.60	13	53.9	
44.00	3.60	13	53.9	
45.00	3.60	13	53.9	
46.00	3.60	13	53.9	
47.00	3.60	13	53.9	
48.00	3.60	13	53.9	
49.00	3.60	13	53.9	
50.00	3.60	13	53.9	
51.00	3.60	13	53.9	
52.00	3.60	13	53.9	
53.00	3.60	13	53.9	
54.00	3.60	13	53.9	
55.00	3.60	13	53.9	
56.00	3.60	13	53.9	
57.00	3.60	13	53.9	
58.00	3.60	13	53.9	
59.00	3.60	13	53.9	
60.00	3.60	13	53.9	
61.00	3.60	13	53.9	
62.00	3.60	13	53.9	
63.00	3.60	13	53.9	
64.00	3.60	13	53.9	
65.00	3.60	13	53.9	
66.00	3.60	13	53.9	
67.00	3.60	13	53.9	
68.00	3.60	13	53.9	
69.00	3.60	13	53.9	
70.00	3.60	13	53.9	
71.00	3.60	13	53.9	
72.00	3.60	13	53.9	
73.00	3.60	13	53.9	
74.00	3.60	13	53.9	
75.00	3.60	13	53.9	
76.00	3.60	13	53.9	
77.00	3.60	13	53.9	
78.00	3.60	13	53.9	
79.00	3.60	13	53.9	
80.00	3.60	13	53.9	
81.00	3.60	13	53.9	
82.00	3.60	13	53.9	
83.00	3.60	13	53.9	
84.00	3.60	13	53.9	
85.00	3.60	13	53.9	
86.00	3.60	13	53.9	
87.00	3.60	13	53.9	
88.00	3.60	13	53.9	
89.00	3.60	13	53.9	
90.00	3.60	13	53.9	
91.00	3.60	13	53.9	
92.00	3.60	13	53.9	
93.00	3.60	13	53.9	
94.00	3.60	13	53.9	
95.00	3.60	13	53.9	
96.00	3.60	13	53.9	
97.00	3.60	13	53.9	
98.00	3.60	13	53.9	
99.00	3.60	13	53.9	
100.00	3.60	13	53.9	

The Good

### PILE DRIVING LOG

PROJECT NO. \_\_\_\_\_ Station No. \_\_\_\_\_ Page No. 1 of 4

PILE Size: 36" Length: 76' Bent Pier No. \_\_\_\_\_ Pile No. 14

HAMMER Model: \_\_\_\_\_ Rated Energy: 175,000 Operating Rate: 24-23

REF Elev: 230.00 MAIN TIP ELEV: 116' PILE CUTOFF Elev: 120.00

DRIVING CRITERIA: TWO FOOT INCREASING BLOWS WITH 81 BLOWS @ 7.5' 24 @ 8' OR 15 @ 8.5'

MAX STROKE: 9' (REVISED SEPT. 21 2017)

PILE CUSHION Thickness & Material: 16" PLYWOOD

HAMMER CUSHION Thickness & Material: 2" NYLON

Time	Stroke	Blow Count	Penetration	Notes
1:00	1.20	19	5.81	
2:00	2.00	4	17.75	
3:00	2.60	3	56.00	
4:00	3.60	4	57.00	
5:00	3.80	5	55.50	
6:00	3.70	7	54.2	
7:00	3.60	8	53.35	
8:00	3.60	7	54.1	
9:00	3.60	10	54.2	
10:00	3.60	12	53.9	
11:00	3.60	13	53.9	
12:00	3.60	13	53.9	
13:00	3.60	13	53.9	
14:00	3.60	13	53.9	
15:00	3.60	13	53.9	
16:00	3.60	13	53.9	
17:00	3.60	13	53.9	
18:00	3.60	13	53.9	
19:00	3.60	13	53.9	
20:00	3.60	13	53.9	
21:00	3.60	13	53.9	
22:00	3.60	13	53.9	
23:00	3.60	13	53.9	
24:00	3.60	13	53.9	
25:00	3.60	13	53.9	
26:00	3.60	13	53.9	
27:00	3.60	13	53.9	
28:00	3.60	13	53.9	
29:00	3.60	13	53.9	
30:00	3.60	13	53.9	
31:00	3.60	13	53.9	
32:00	3.60	13	53.9	
33:00	3.60	13	53.9	
34:00	3.60	13	53.9	
35:00	3.60	13	53.9	
36:00	3.60	13	53.9	
37:00	3.60	13	53.9	
38:00	3.60	13	53.9	
39:00	3.60	13	53.9	
40:00	3.60	13	53.9	
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43:00	3.60	13	53.9	
44:00	3.60	13	53.9	
45:00	3.60	13	53.9	
46:00	3.60	13	53.9	
47:00	3.60	13	53.9	
48:00	3.60	13	53.9	
49:00	3.60	13	53.9	
50:00	3.60	13	53.9	
51:00	3.60	13	53.9	
52:00	3.60	13	53.9	
53:00	3.60	13	53.9	
54:00	3.60	13	53.9	
55:00	3.60	13	53.9	
56:00	3.60	13	53.9	
57:00	3.60	13	53.9	
58:00	3.60	13	53.9	
59:00	3.60	13		



**The Bad**

Missing blow counts ?

Final blow count ?

Hammer Stroke ?

**Pile Driving Record**

CONTRACT NO. 14354  
 PILE NO. 1  
 SEQUENCE NO. 1

CUSTOMER: *AmbriCo* STRUCTURE: *1 made in D's cell also* LOCATION:  
 PILING CONTRACTOR: *N. Pile* FOUNDATION TYPE: DATE: *1-9-08*

HAMMER: *HP 12x28* PILE: *HP 12x28*  
 Head Energy (ft-lb) *26250 - 81125* Type  
 Head Wt (lb) *9475* Weight (lb)  
 Head Stroke (in) *30* Initial Length (ft)  
 Max. Pressure (psi)\*\* *30/50* Length Driven (ft)  
 Avg. Blowrate *30/50* Time Started  
 Time Finished

BL OF GRAVEL (ft)	BL OF SILL OFF (ft)	BL OF TIP (ft)	FINAL LENGTH (ft)		
77.8	25	52.8	28		
FT	Blow per Foot	Stroke (ft) or Pressure**	FT	Blow per Foot	Stroke (ft) or Pressure**
1	16	4			
2	17	4			
3	18	6			
4	19	6			
5	20	7			
6	21	8			
7	22	8			
8	23	6			
9	24	6			
10	25	11			
11	26	11			
12	27	30			
13	28	30			
14	29	30			
15	30	30			

\* Point of penetration of pile below working grade.  
 \*\* Indicate max. stress or pressure, and actual stroke or pressure for closed hammer.

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**And The Ugly**

Project # *0000* Location: \_\_\_\_\_ Date: *4-12-05*  
 Pile # *11/1* Pile Type: *HP12x28-05-C*  
 Hammer: *Chico D12-32 w/ BT70 Leads* Manufacturers Energy: *39,840*

Blow/ft	Blow	Stroke in Last Foot Driven
1	30	1"
2	39	2"
3	38	8"
4	30	4"
5	40	8"
6	41	8"
7	42	7"
8	43	8"
9	44	8"
10	45	10"
11	46	11"
12	47	12"
13	48	
14	49	Design Pile Capacity
15	50	80 tons
16	51	
17	52	Blow Count starts
18	53	blows
19	54	
20	55	
21	56	
22	57	
23	58	
24	59	
25	60	
26	61	
27	62	
28	63	
29	64	
30	65	
31	66	
32	67	
33	68	
34	69	
35	70	

*was told we had enough*

*214*

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STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION  
**PILE DRIVING LOG**

Structure No: \_\_\_\_\_ Page No: 1 of 4

PROJECT No: \_\_\_\_\_ Date: \_\_\_\_\_ Station No: \_\_\_\_\_

PILE Elev: \_\_\_\_\_ 24" Length (ft): 107.00 Bore/Pier No: 1 PILE No: 9 58

HAMMER Manufacturer: Aja D80-42 SN: 680531 Rated Energy: 80,776 ft-lbs Operating Rate: \_\_\_\_\_

REF Elev: +91.78 (REF 1) MIN TIP Elev: \_\_\_\_\_ PILE CUTOFF Elev: +104.30

DRIVING CRITERIA: Starting pile stroke height not to exceed 17'. When blow count exceeds 45 blows/ft increase stroke height to 0'. Change cushion after 1700 blows. Continue driving strokes until blowcount F and 8.75'. Stop driving at 20-blows/ft for two consecutive inches of stroke height.

SCOUR Elev (100 yd): \_\_\_\_\_

PILE CONDITION: Intact & Natural

PILE ACTIVITY:

Pile Activity	Date	Start Time
Pre-drilling	6/25/18	8:20 AM
Driving	6/26/18	10:08 AM
Driving	12/20/18	11:11 AM
Set check	7/2/19	12:33 PM

PILE DATA:

PAY ITEM No: 455-3

MANUFACTURED BY: Dura Steels, Inc.

TEMPERATURE Elev: +88.69

PRE-FORMED Elev: +71.89

PRE-FORMED Elev: Bottom

PILE HEAD Rise Read: -27.28

Top of SOIL PLUG Elev (for Open Ended Pipe Piles & 1/2" dia. Non-Open Ended): \_\_\_\_\_

DEPTH (FEET)	STROKES PER FOOT	BLOWS PER FOOT	STROKES PER FOOT	BLOWS PER FOOT	STROKES PER FOOT	BLOWS PER FOOT	STROKES PER FOOT	BLOWS PER FOOT
0.00 - 1.00	11	5.93	10.00	10.00	2.9	2.29	5.91	10.00
1.00 - 2.00	11	5.93	10.00	10.00	2.5	8.43	5.93	10.00
2.00 - 3.00	12	5.89	10.00	11.00	2.4	8.5	5.89	10.00
3.00 - 4.00	14	5.72	10.00	12.00	2.4	8.32	5.72	10.00
4.00 - 5.00	12	5.83	10.00	13.00	2.5	8.63	6.00	10.00
5.00 - 6.00	13	5.89	10.00	14.00	2.5	8.89	6.00	10.00
6.00 - 7.00	17	5.9	10.00	15.00	2.5	8.47	5.9	10.00
7.00 - 8.00	18	5.91	10.00	16.00	2.5	8.91	6.00	10.00

CTQP Trainer (supervised by the Qualified Inspector) Name: \_\_\_\_\_ TIN: \_\_\_\_\_

Qualified Inspector - I certify the Pile Driving Log content, and is applicable, for above CTQP. Name & TIN: \_\_\_\_\_

Trainer's participation during this pile installation: \_\_\_\_\_ Signature: \_\_\_\_\_

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION  
**PILE DRIVING**

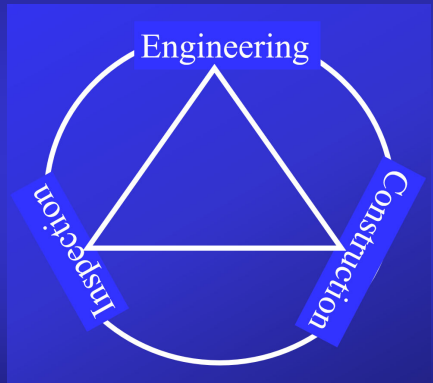
Page No: 2 of 4

DEPTH (FEET)	STROKES PER FOOT	BLOWS PER FOOT	STROKES PER FOOT	BLOWS PER FOOT	STROKES PER FOOT	BLOWS PER FOOT	STROKES PER FOOT	BLOWS PER FOOT
8.00 - 9.00	17	5.9	10.00	16.00	2.5	8.47	5.9	10.00
9.00 - 10.00	18	5.91	10.00	17.00	2.5	8.91	6.00	10.00
10.00 - 11.00	18	5.91	10.00	18.00	2.5	8.91	6.00	10.00
11.00 - 12.00	18	5.91	10.00	19.00	2.5	8.91	6.00	10.00
12.00 - 13.00	18	5.91	10.00	20.00	2.5	8.91	6.00	10.00
13.00 - 14.00	18	5.91	10.00	21.00	2.5	8.91	6.00	10.00
14.00 - 15.00	18	5.91	10.00	22.00	2.5	8.91	6.00	10.00
15.00 - 16.00	18	5.91	10.00	23.00	2.5	8.91	6.00	10.00
16.00 - 17.00	18	5.91	10.00	24.00	2.5	8.91	6.00	10.00
17.00 - 18.00	18	5.91	10.00	25.00	2.5	8.91	6.00	10.00
18.00 - 19.00	18	5.91	10.00	26.00	2.5	8.91	6.00	10.00
19.00 - 20.00	18	5.91	10.00	27.00	2.5	8.91	6.00	10.00
20.00 - 21.00	18	5.91	10.00	28.00	2.5	8.91	6.00	10.00
21.00 - 22.00	18	5.91	10.00	29.00	2.5	8.91	6.00	10.00
22.00 - 23.00	18	5.91	10.00	30.00	2.5	8.91	6.00	10.00
23.00 - 24.00	18	5.91	10.00	31.00	2.5	8.91	6.00	10.00
24.00 - 25.00	18	5.91	10.00	32.00	2.5	8.91	6.00	10.00
25.00 - 26.00	18	5.91	10.00	33.00	2.5	8.91	6.00	10.00
26.00 - 27.00	18	5.91	10.00	34.00	2.5	8.91	6.00	10.00
27.00 - 28.00	18	5.91	10.00	35.00	2.5	8.91	6.00	10.00
28.00 - 29.00	18	5.91	10.00	36.00	2.5	8.91	6.00	10.00
29.00 - 30.00	18	5.91	10.00	37.00	2.5	8.91	6.00	10.00
30.00 - 31.00	18	5.91	10.00	38.00	2.5	8.91	6.00	10.00
31.00 - 32.00	18	5.91	10.00	39.00	2.5	8.91	6.00	10.00
32.00 - 33.00	18	5.91	10.00	40.00	2.5	8.91	6.00	10.00
33.00 - 34.00	18	5.91	10.00	41.00	2.5	8.91	6.00	10.00
34.00 - 35.00	18	5.91	10.00	42.00	2.5	8.91	6.00	10.00
35.00 - 36.00	18	5.91	10.00	43.00	2.5	8.91	6.00	10.00
36.00 - 37.00	18	5.91	10.00	44.00	2.5	8.91	6.00	10.00
37.00 - 38.00	18	5.91	10.00	45.00	2.5	8.91	6.00	10.00
38.00 - 39.00	18	5.91	10.00	46.00	2.5	8.91	6.00	10.00
39.00 - 40.00	18	5.91	10.00	47.00	2.5	8.91	6.00	10.00
40.00 - 41.00	18	5.91	10.00	48.00	2.5	8.91	6.00	10.00
41.00 - 42.00	18	5.91	10.00	49.00	2.5	8.91	6.00	10.00
42.00 - 43.00	18	5.91	10.00	50.00	2.5	8.91	6.00	10.00
43.00 - 44.00	18	5.91	10.00	51.00	2.5	8.91	6.00	10.00
44.00 - 45.00	18	5.91	10.00	52.00	2.5	8.91	6.00	10.00
45.00 - 46.00	18	5.91	10.00	53.00	2.5	8.91	6.00	10.00
46.00 - 47.00	18	5.91	10.00	54.00	2.5	8.91	6.00	10.00
47.00 - 48.00	18	5.91	10.00	55.00	2.5	8.91	6.00	10.00
48.00 - 49.00	18	5.91	10.00	56.00	2.5	8.91	6.00	10.00
49.00 - 50.00	18	5.91	10.00	57.00	2.5	8.91	6.00	10.00
50.00 - 51.00	18	5.91	10.00	58.00	2.5	8.91	6.00	10.00
51.00 - 52.00	18	5.91	10.00	59.00	2.5	8.91	6.00	10.00
52.00 - 53.00	18	5.91	10.00	60.00	2.5	8.91	6.00	10.00
53.00 - 54.00	18	5.91	10.00	61.00	2.5	8.91	6.00	10.00
54.00 - 55.00	18	5.91	10.00	62.00	2.5	8.91	6.00	10.00
55.00 - 56.00	18	5.91	10.00	63.00	2.5	8.91	6.00	10.00
56.00 - 57.00	18	5.91	10.00	64.00	2.5	8.91	6.00	10.00
57.00 - 58.00	18	5.91	10.00	65.00	2.5	8.91	6.00	10.00
58.00 - 59.00	18	5.91	10.00	66.00	2.5	8.91	6.00	10.00
59.00 - 60.00	18	5.91	10.00	67.00	2.5	8.91	6.00	10.00
60.00 - 61.00	18	5.91	10.00	68.00	2.5	8.91	6.00	10.00
61.00 - 62.00	18	5.91	10.00	69.00	2.5	8.91	6.00	10.00
62.00 - 63.00	18	5.91	10.00	70.00	2.5	8.91	6.00	10.00
63.00 - 64.00	18	5.91	10.00	71.00	2.5	8.91	6.00	10.00
64.00 - 65.00	18	5.91	10.00	72.00	2.5	8.91	6.00	10.00
65.00 - 66.00	18	5.91	10.00	73.00	2.5	8.91	6.00	10.00
66.00 - 67.00	18	5.91	10.00	74.00	2.5	8.91	6.00	10.00
67.00 - 68.00	18	5.91	10.00	75.00	2.5	8.91	6.00	10.00
68.00 - 69.00	18	5.91	10.00	76.00	2.5	8.91	6.00	10.00
69.00 - 70.00	18	5.91	10.00	77.00	2.5	8.91	6.00	10.00
70.00 - 71.00	18	5.91	10.00	78.00	2.5	8.91	6.00	10.00
71.00 - 72.00	18	5.91	10.00	79.00	2.5	8.91	6.00	10.00
72.00 - 73.00	18	5.91	10.00	80.00	2.5	8.91	6.00	10.00
73.00 - 74.00	18	5.91	10.00	81.00	2.5	8.91	6.00	10.00
74.00 - 75.00	18	5.91	10.00	82.00	2.5	8.91	6.00	10.00
75.00 - 76.00	18	5.91	10.00	83.00	2.5	8.91	6.00	10.00
76.00 - 77.00	18	5.91	10.00	84.00	2.5	8.91	6.00	10.00
77.00 - 78.00	18	5.91	10.00	85.00	2.5	8.91	6.00	10.00
78.00 - 79.00	18	5.91	10.00	86.00	2.5	8.91	6.00	10.00
79.00 - 80.00	18	5.91	10.00	87.00	2.5	8.91	6.00	10.00
80.00 - 81.00	18	5.91	10.00	88.00	2.5	8.91	6.00	10.00
81.00 - 82.00	18	5.91	10.00	89.00	2.5	8.91	6.00	10.00
82.00 - 83.00	18	5.91	10.00	90.00	2.5	8.91	6.00	10.00
83.00 - 84.00	18	5.91	10.00	91.00	2.5	8.91	6.00	10.00
84.00 - 85.00	18	5.91	10.00	92.00	2.5	8.91	6.00	10.00
85.00 - 86.00	18	5.91	10.00	93.00	2.5	8.91	6.00	10.00
86.00 - 87.00	18	5.91	10.00	94.00	2.5	8.91	6.00	10.00
87.00 - 88.00	18	5.91	10.00	95.00	2.5	8.91	6.00	10.00
88.00 - 89.00	18	5.91	10.00	96.00	2.5	8.91	6.00	10.00
89.00 - 90.00	18	5.91	10.00	97.00	2.5	8.91	6.00	10.00
90.00 - 91.00	18	5.91	10.00	98.00	2.5	8.91	6.00	10.00
91.00 - 92.00	18	5.91	10.00	99.00	2.5	8.91	6.00	10.00
92.00 - 93.00	18	5.91	10.00	100.00	2.5	8.91	6.00	10.00

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Engineering, Construction, and Inspection must work together for a successful project.



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The two main (engineering) goals of Test Piles are to establish:

- Production Piles Length
- Pile Driving Criteria

**But ... it can be expensive, time consuming, not warranted, or ineffective..**

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... alternatively, some projects drive production piles without test piles and blow count criteria, but with 100% PDA dynamic pile testing.



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## 100% Pile Testing



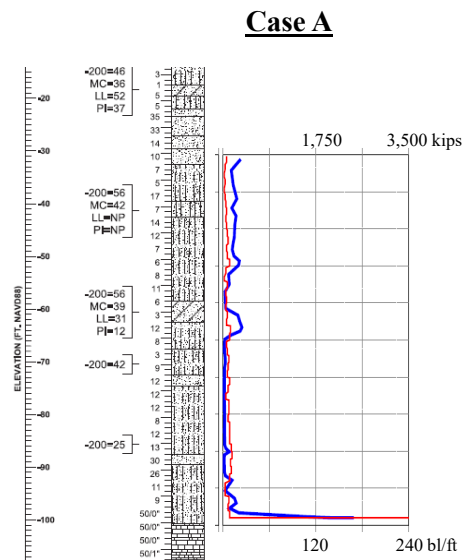
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**Must determine production piles length ahead of time ...**

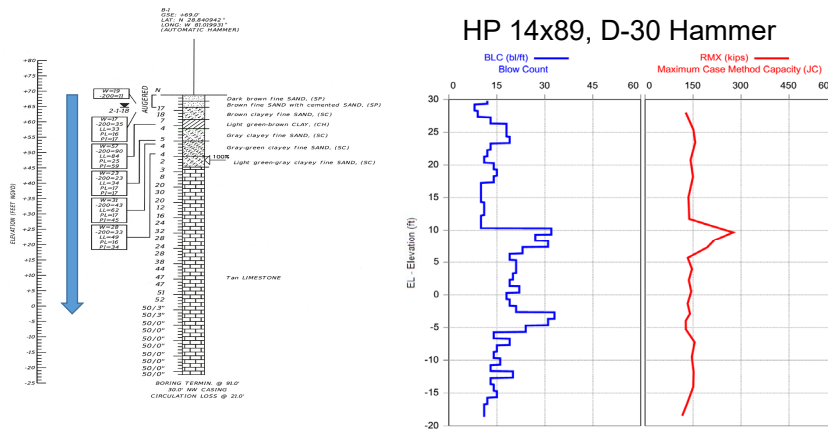
57

**Interesting cases:**



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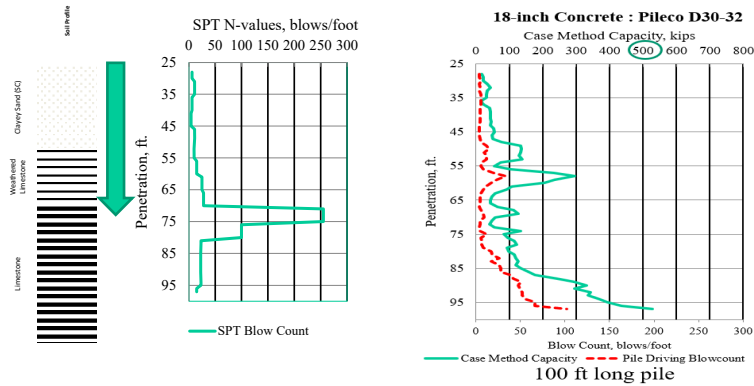
### Case B



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### Case C

#### Test Pile - SPT Boring



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**... some projects incorporate the best practices of both Test Piles and 100% production piles testing.**

SR 19 over Little Lake Harris Bridge Replacement



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