Engineering Considerations for the Proper Evaluation and Effective Use of Pile Static and Dynamic Testing Results - Lessons Learned from Case Studies

Mohamad Hussein, P.E.

STGEC-2025

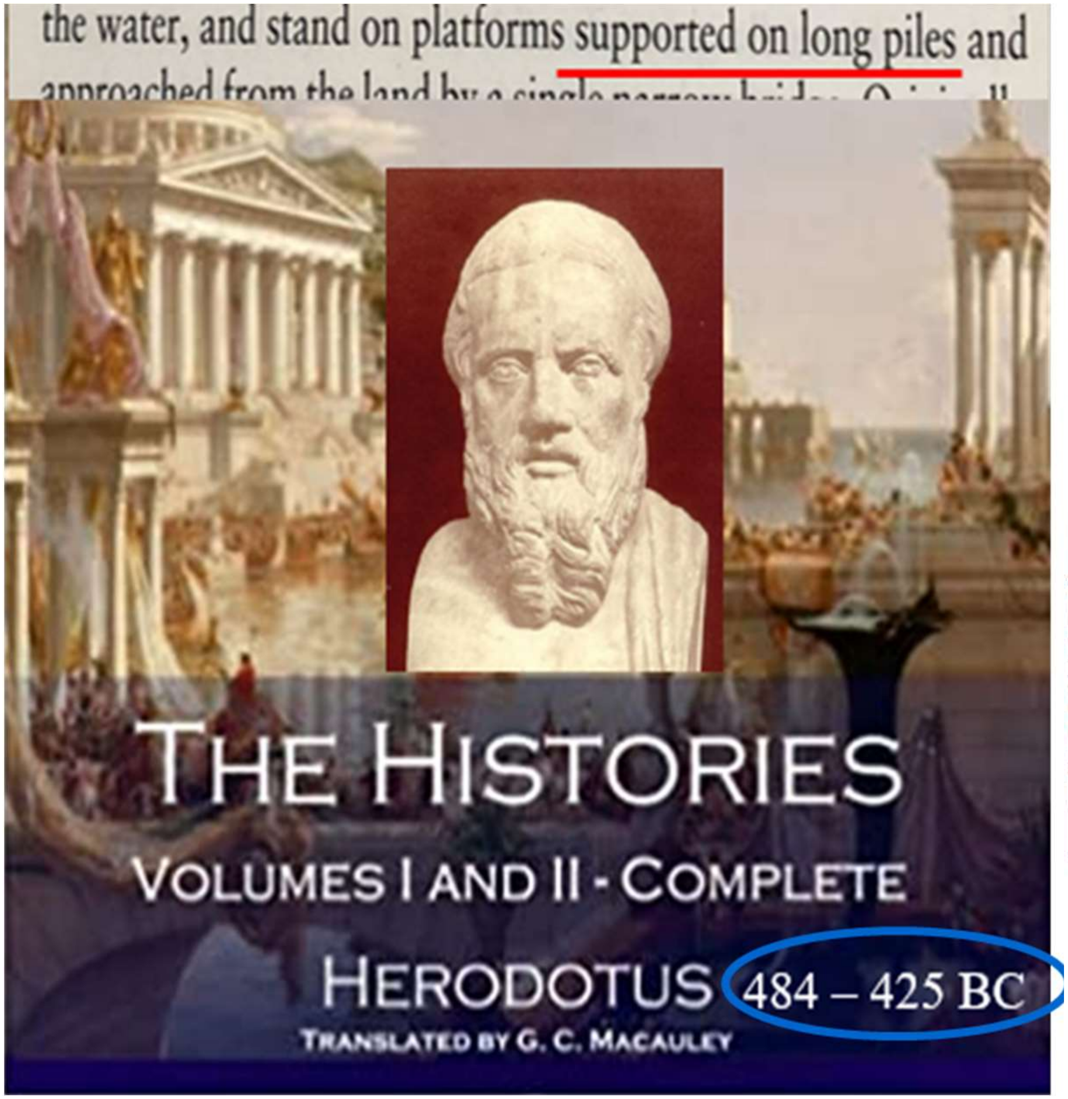
Southeastern Transportation Geotechnical Engineering Conference
September 15 to September 18, 2025
Williamsburg, Virginia

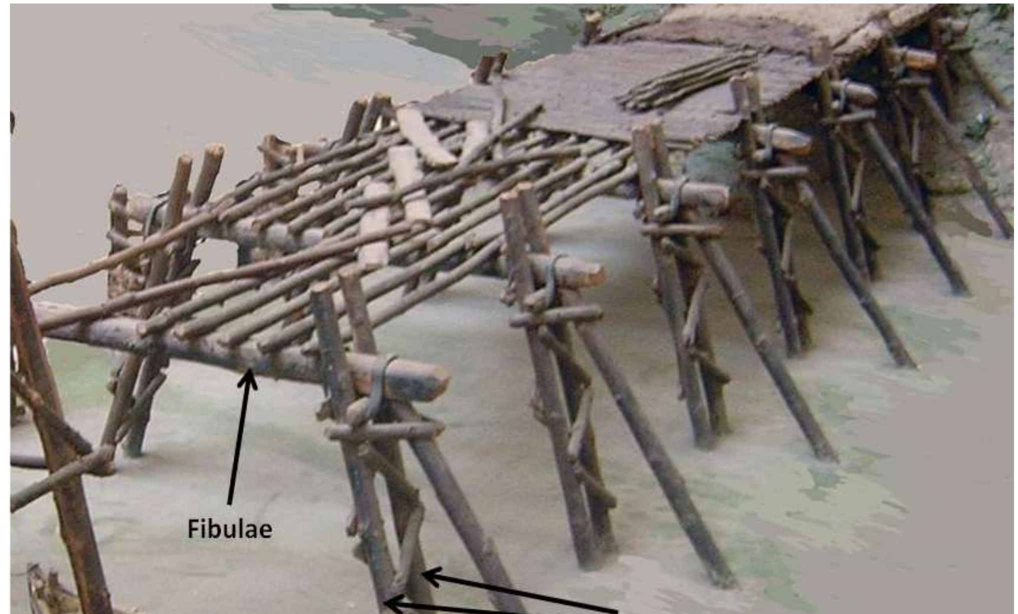
GRL Engineers, Inc.
GRLengineers.com

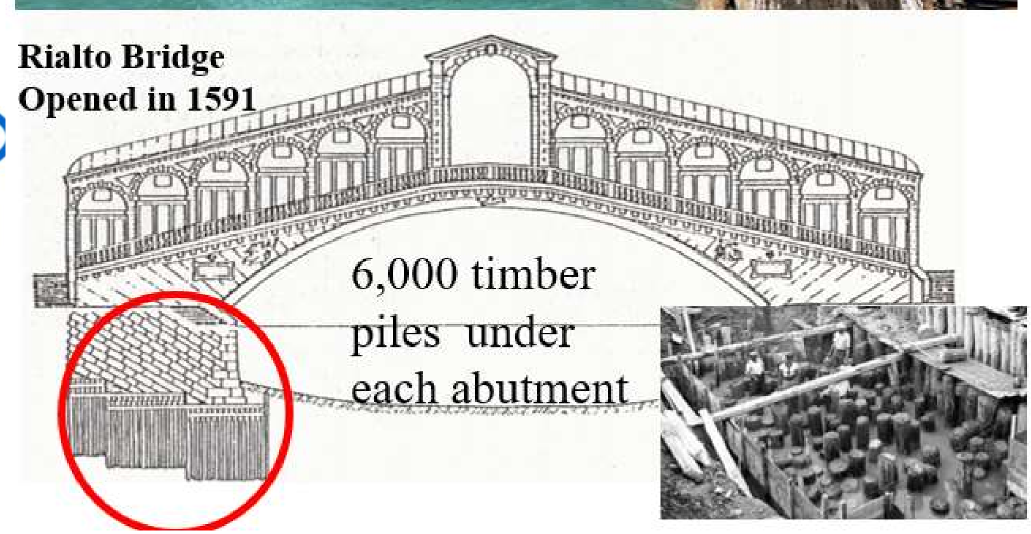
Southeastern
Transportation
Geotechnical
Engineering
Conference

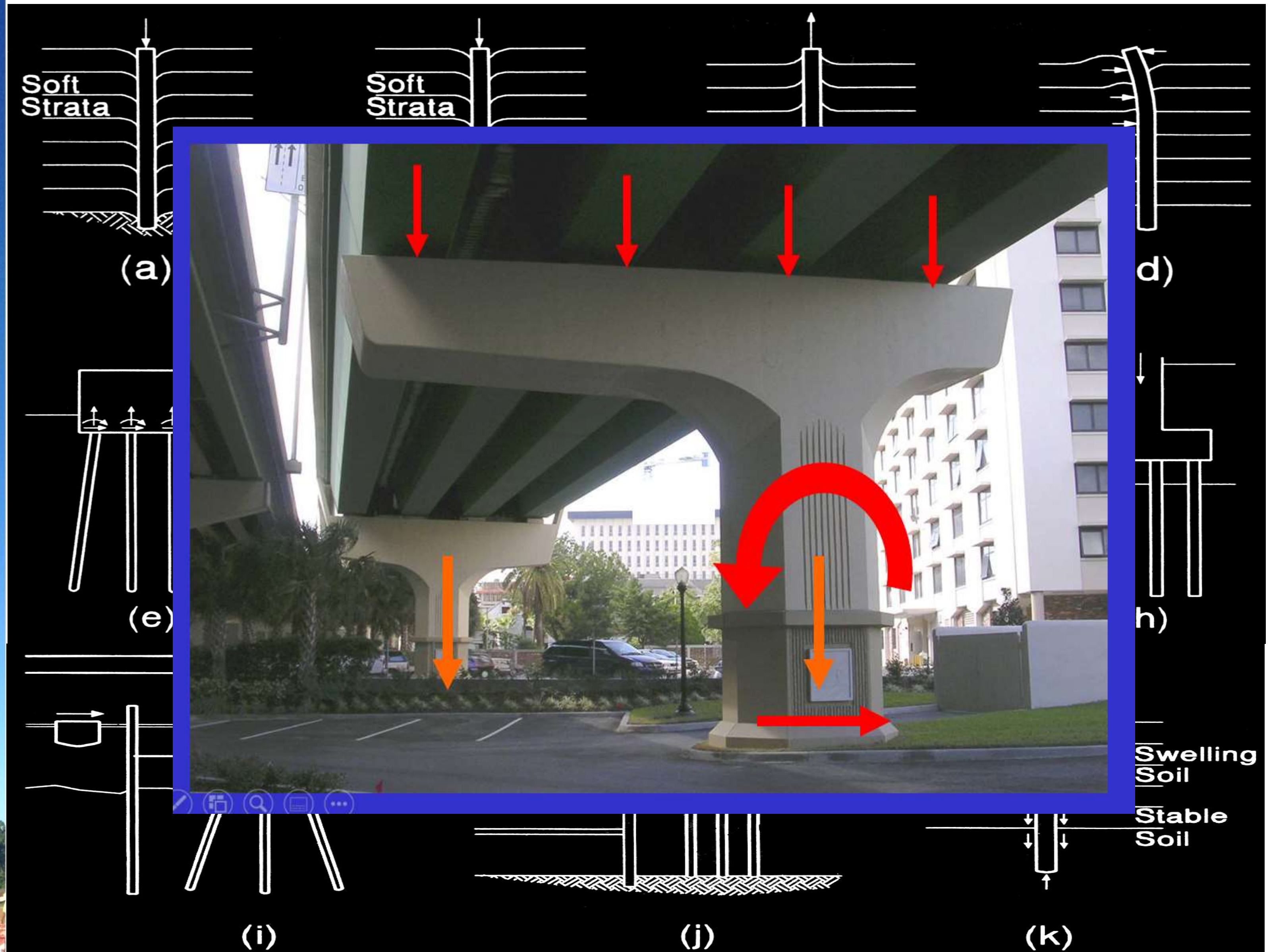
Pile Dynamics, Inc.
Pile.com

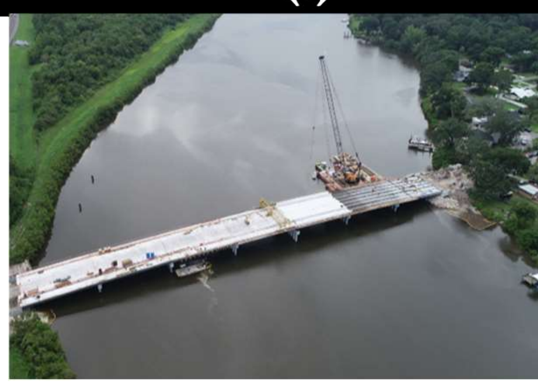
Caesar's Bridge across the Rhine, 55 BC

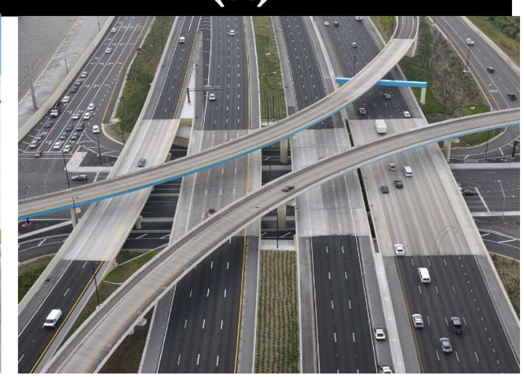


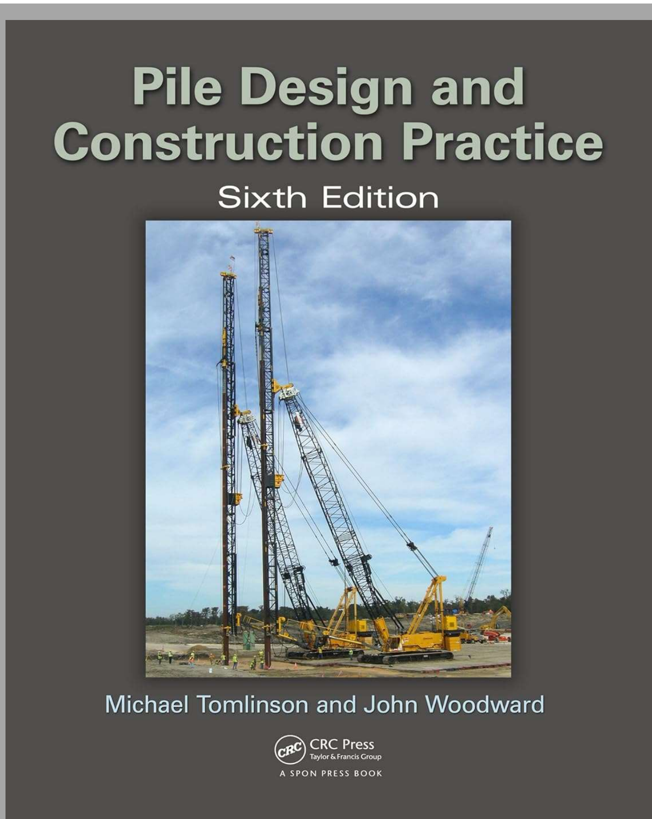


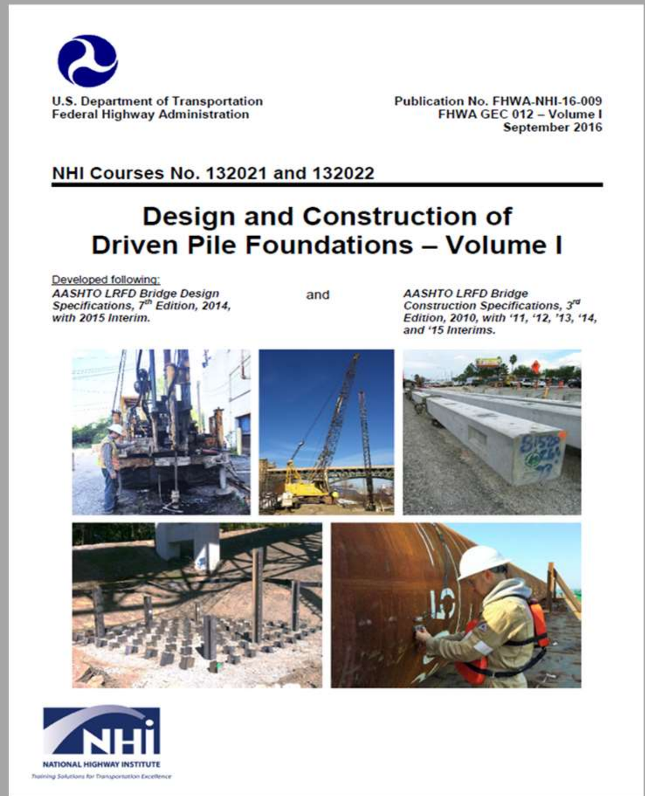


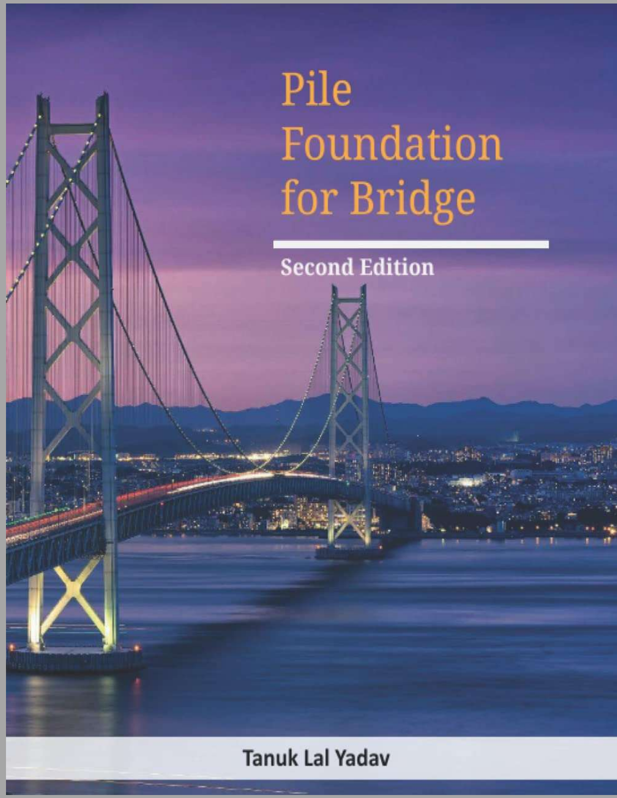

Soft Strata
Soft Strata
(a)
d)
(e)
h)
Swelling Soil
Stable Soil
(i)
(j)
(k)

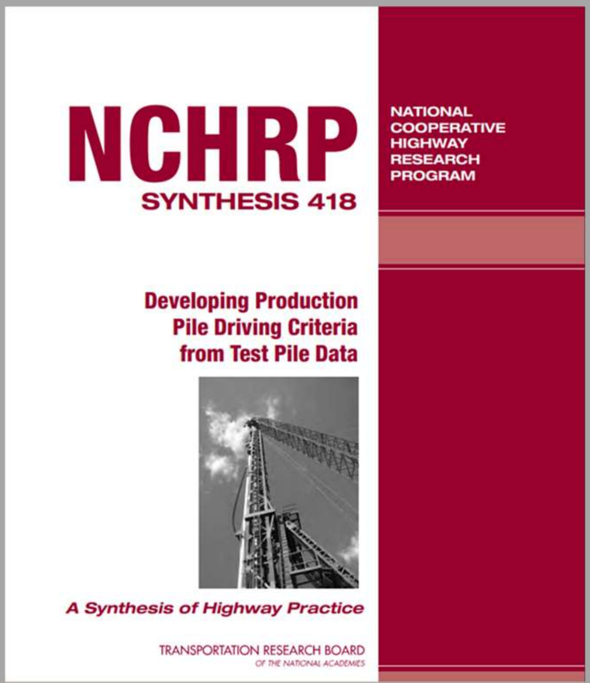


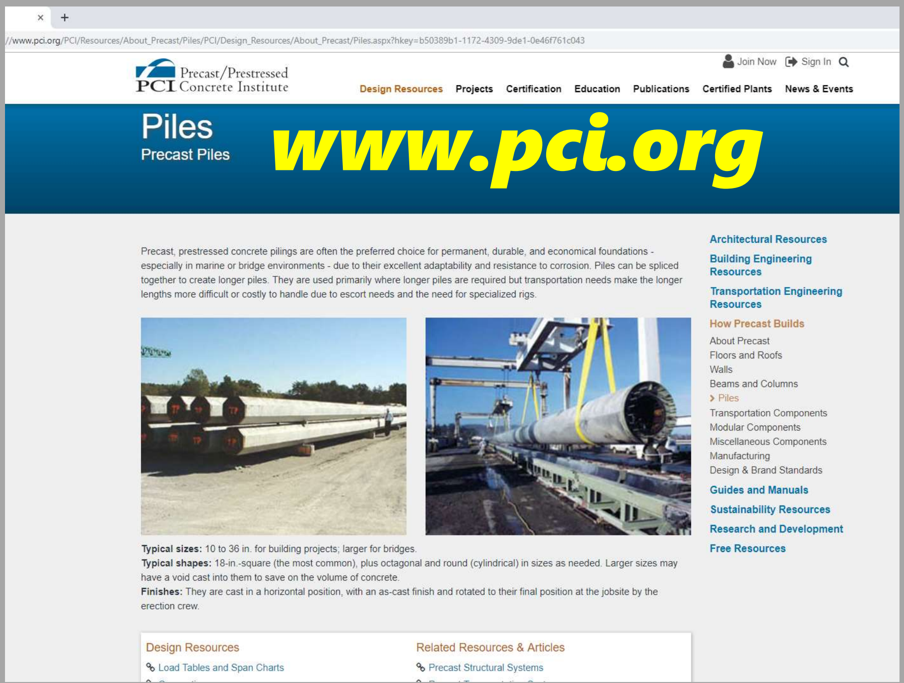


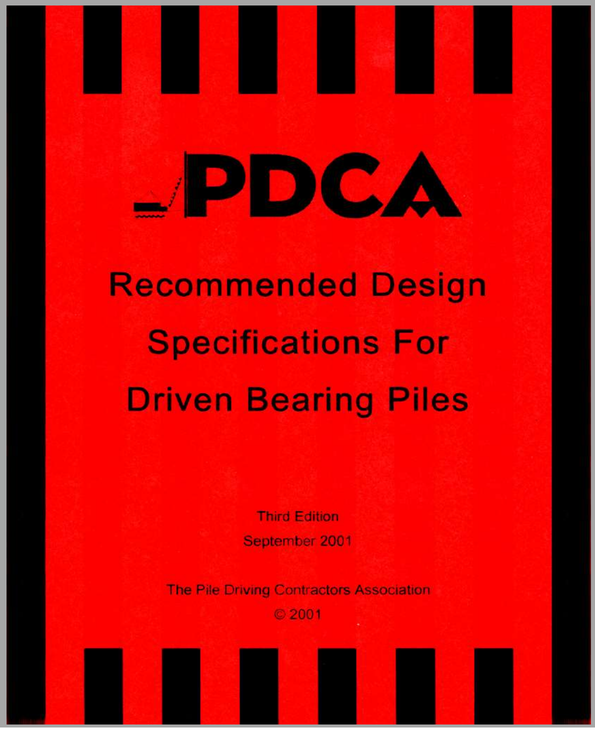

Pile Design and Construction Practice
Sixth Edition
Michael Tomlinson and John Woodward
CRC Press
Taylor & Francis Group
A SPON PRESS BOOK

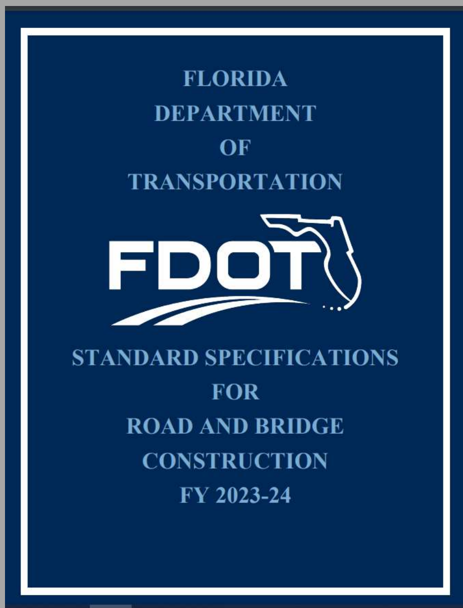

U.S. Department of Transportation
Federal Highway Administration
Publication No. FHWA-NHI-16-009
FHWA GEC 012 – Volume I
September 2016
NHI Courses No. 132021 and 132022
Design and Construction of
Driven Pile Foundations – Volume I
Developed following:
AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014, with 2015 Interim.
and
AASHTO LRFD Bridge Construction Specifications, 3rd Edition, 2010, with '11, '12, '13, '14, and '15 Interims.
NHI
NATIONAL HIGHWAY INSTITUTE


Pile
Foundation
for Bridge
Second Edition
Tanuk Lal Yadav


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


Precast/Prestressed
PCI Concrete Institute
Join Now
Sign In
Design Resources
Projects
Certification
Education
Publications
Certified Plants
News & Events
Piles
Precast Piles
www.pci.org
Precast, prestressed concrete pilings are often the preferred choice for permanent, durable, and economical foundations - especially in marine or bridge environments - due to their excellent adaptability and resistance to corrosion. Piles can be spliced together to create longer piles. They are used primarily where longer piles are required but transportation needs make the longer lengths more difficult or costly to handle due to escort needs and the need for specialized rigs.
Typical sizes: 10 to 36 in. for building projects; larger for bridges.
Typical shapes: 18-in.-square (the most common), plus octagonal and round (cylindrical) in sizes as needed. Larger sizes may have a void cast into them to save on the volume of concrete.
Finishes: They are cast in a horizontal position, with an as-cast finish and rotated to their final position at the jobsite by the erection crew.
Architectural Resources
Building Engineering Resources
Transportation Engineering Resources
How Precast Builds
About Precast
Floors and Roofs
Walls
Beams and Columns
Piles
Transportation Components
Modular Components
Miscellaneous Components
Manufacturing
Design & Brand Standards
Guides and Manuals
Sustainability Resources
Research and Development
Free Resources
Design Resources
Load Tables and Span Charts
Related Resources & Articles
Precast Structural Systems

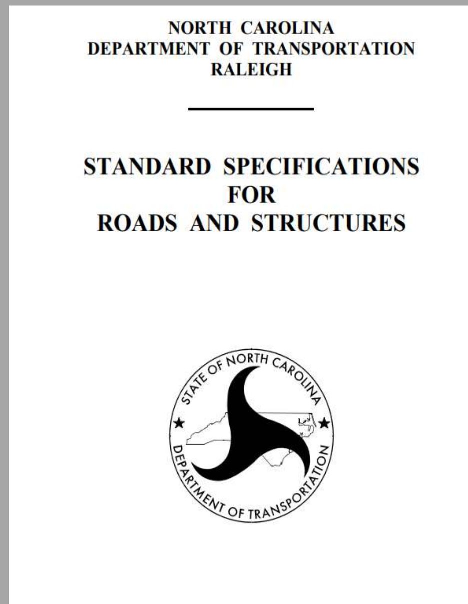

PDCA
Recommended Design
Specifications For
Driven Bearing Piles
Third Edition
September 2001
The Pile Driving Contractors Association
© 2001



FLORIDA
DEPARTMENT
OF
TRANSPORTATION

FDOT

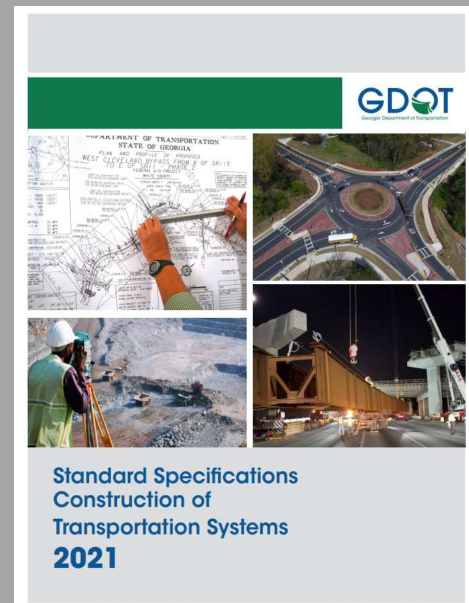
STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE
CONSTRUCTION
FY 2023-24



NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

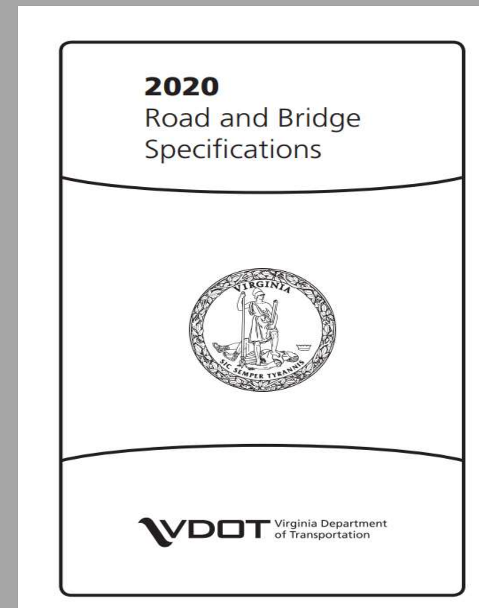
STANDARD SPECIFICATIONS
FOR
ROADS AND STRUCTURES

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION



GDOT

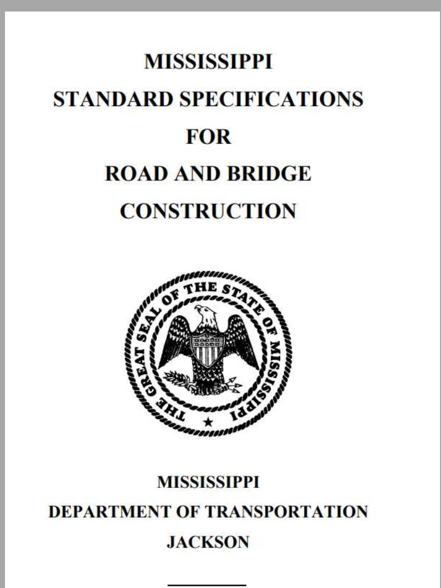
Standard Specifications
Construction of
Transportation Systems
2021



2020
Road and Bridge
Specifications

VIRGINIA
SIC SEMPER TYRANNIS

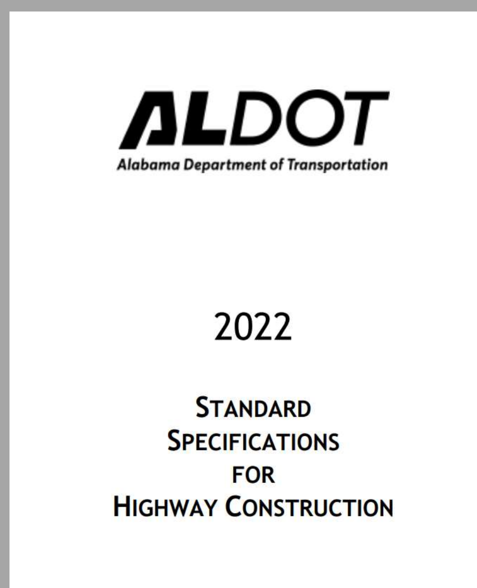
VDOT Virginia Department of Transportation



MISSISSIPPI
STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE
CONSTRUCTION

THE GREAT SEAL OF THE STATE OF MISSISSIPPI

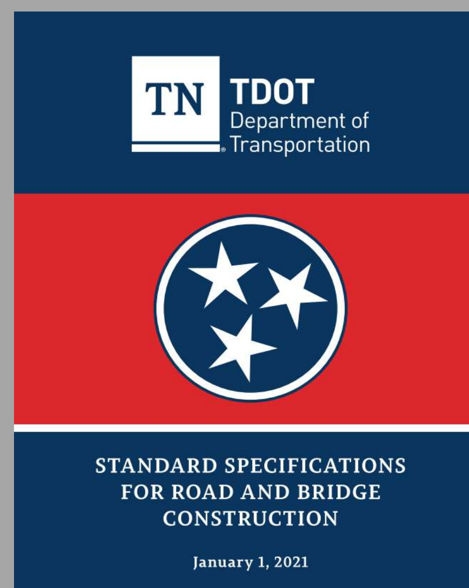
MISSISSIPPI
DEPARTMENT OF TRANSPORTATION
JACKSON



ALDOT
Alabama Department of Transportation

2022

STANDARD
SPECIFICATIONS
FOR
HIGHWAY CONSTRUCTION



TN TDOT
Department of
Transportation

STANDARD SPECIFICATIONS
FOR ROAD AND BRIDGE
CONSTRUCTION

January 1, 2021

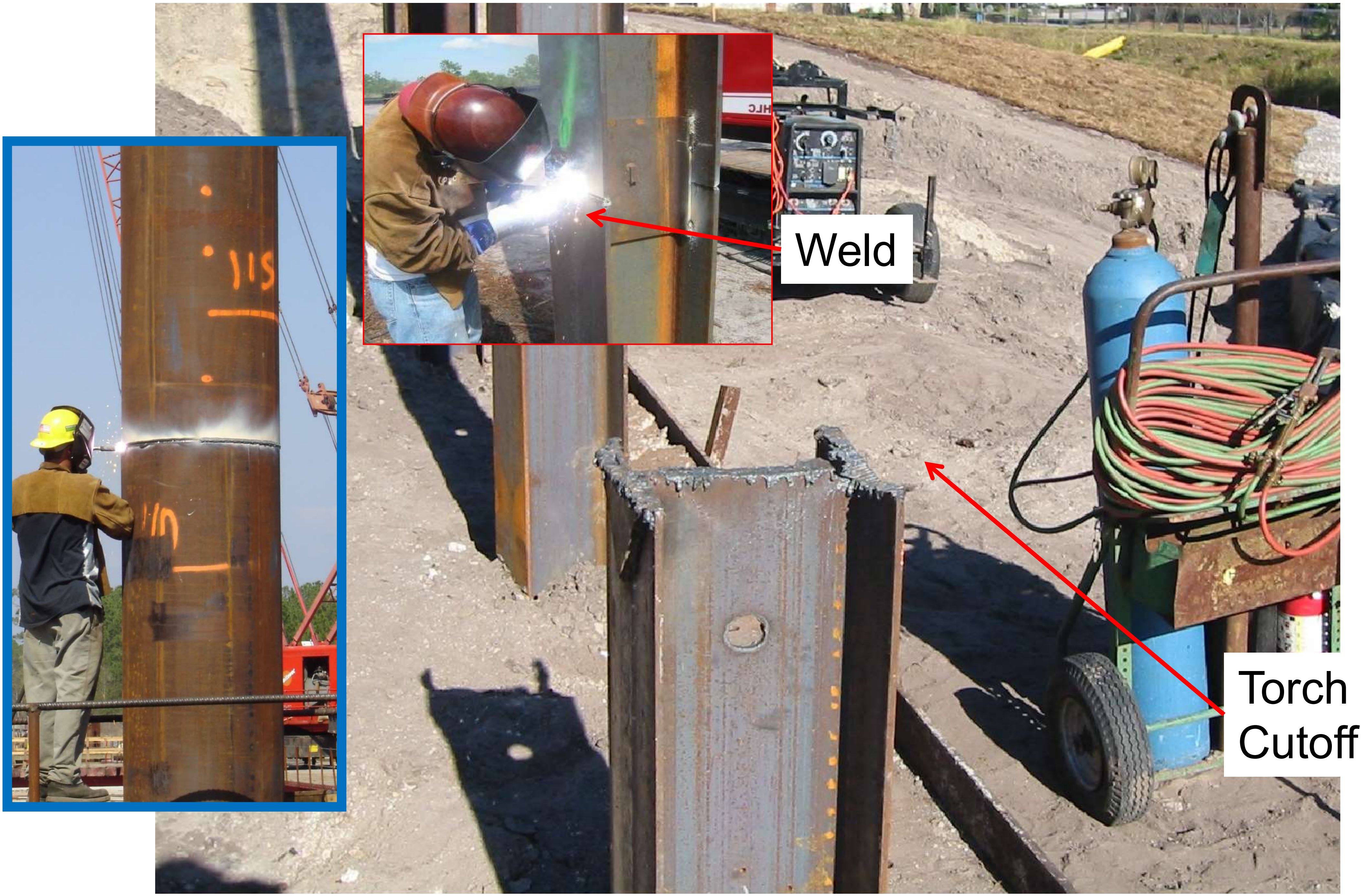
FLORIDA DEPARTMENT OF TRANSPORTATION

Image courtesy of BCC Engineering

STRUCTURES MANUAL

Introduction - General Introduction
Volume 1 - Structures Design Guidelines

Steel Piles



Concrete Piles

Composite and non-uniform Piles





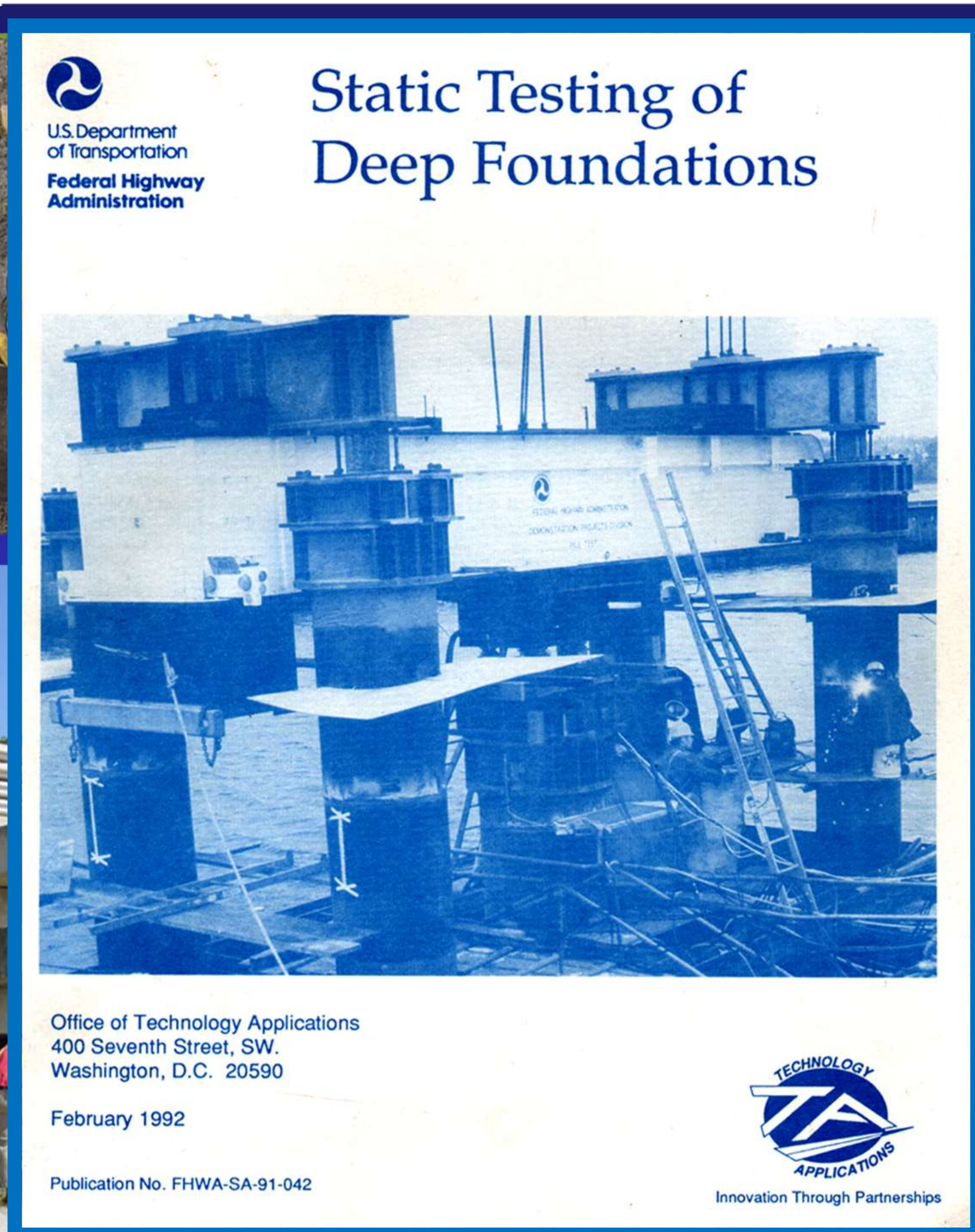
There are dozens of hammer manufacturers, and hundreds of hammer models.

Dynamic Pile Driving Resistance

Static Load Bearing Capacity

ASTM D1143/D1143M-20

Standard Test Methods for Deep Foundation Elements Under Static Axial Compressive Load



U.S. Department of Transportation
Federal Highway Administration

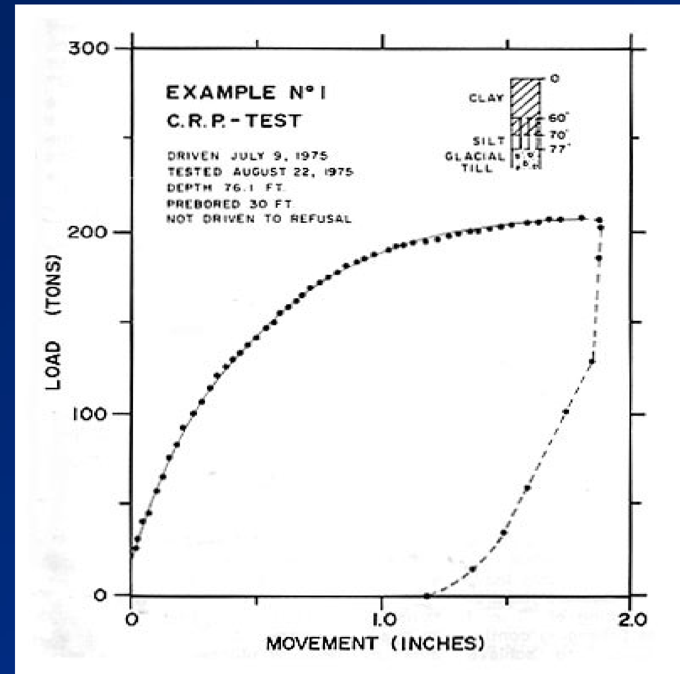
Static Testing of Deep Foundations

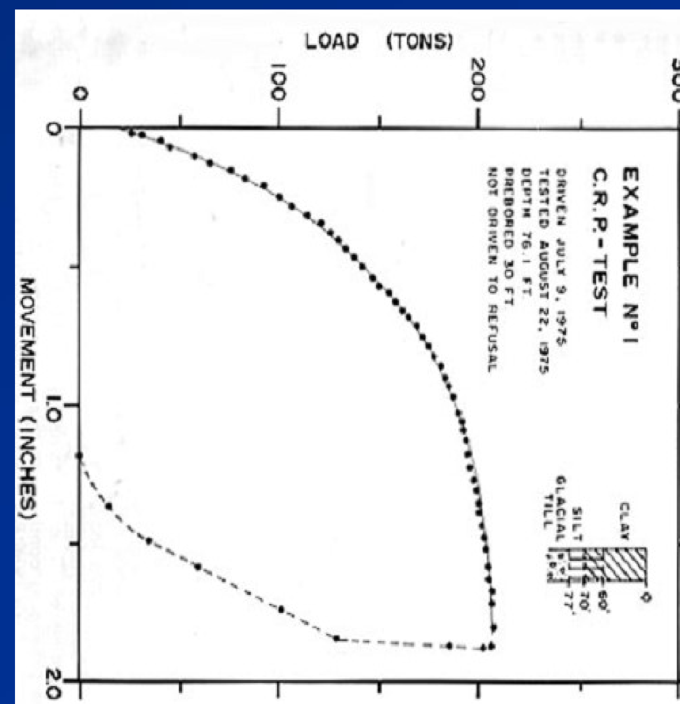
Office of Technology Applications
400 Seventh Street, SW.
Washington, D.C. 20590

February 1992

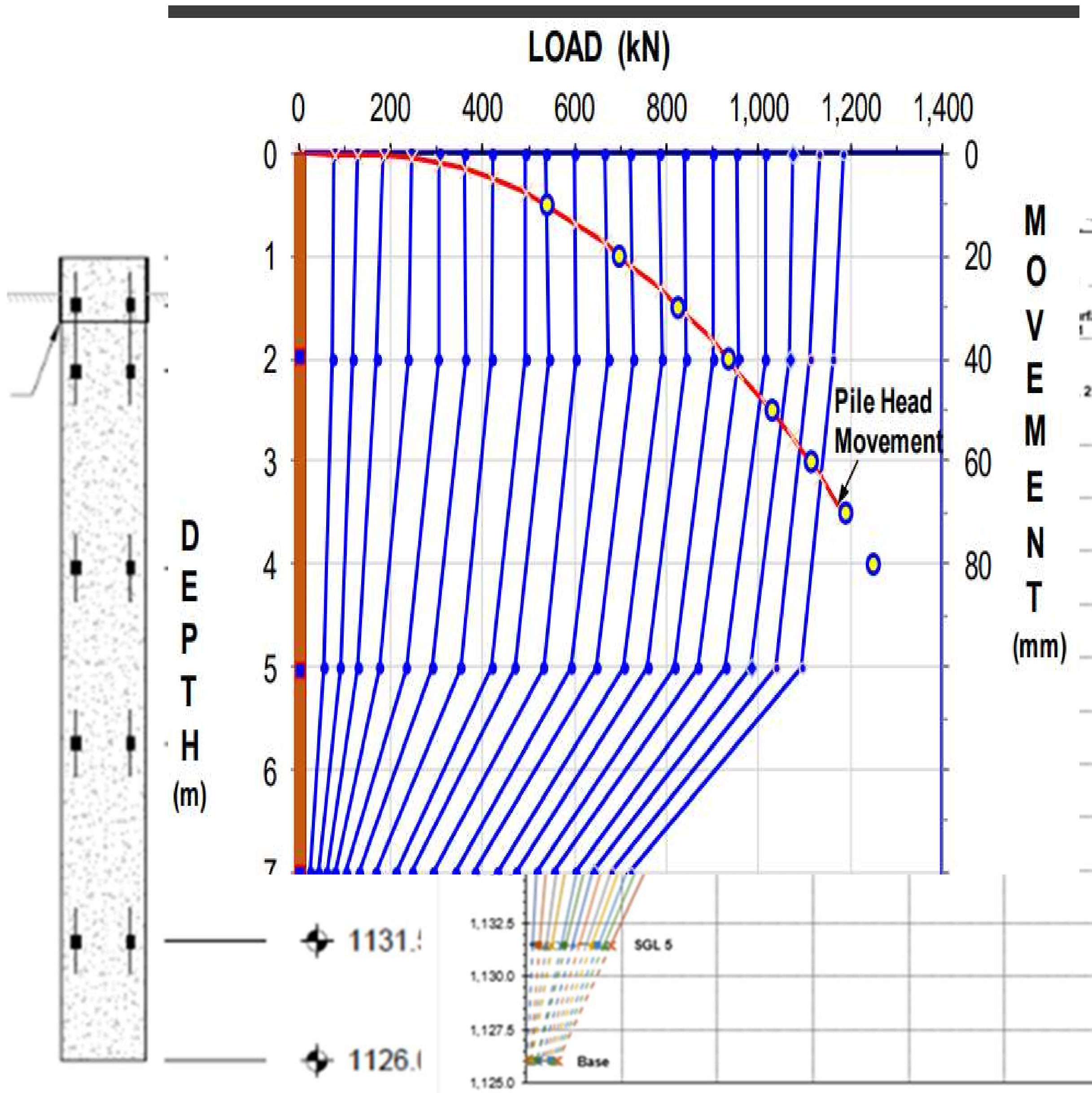
Publication No. FHWA-SA-91-042

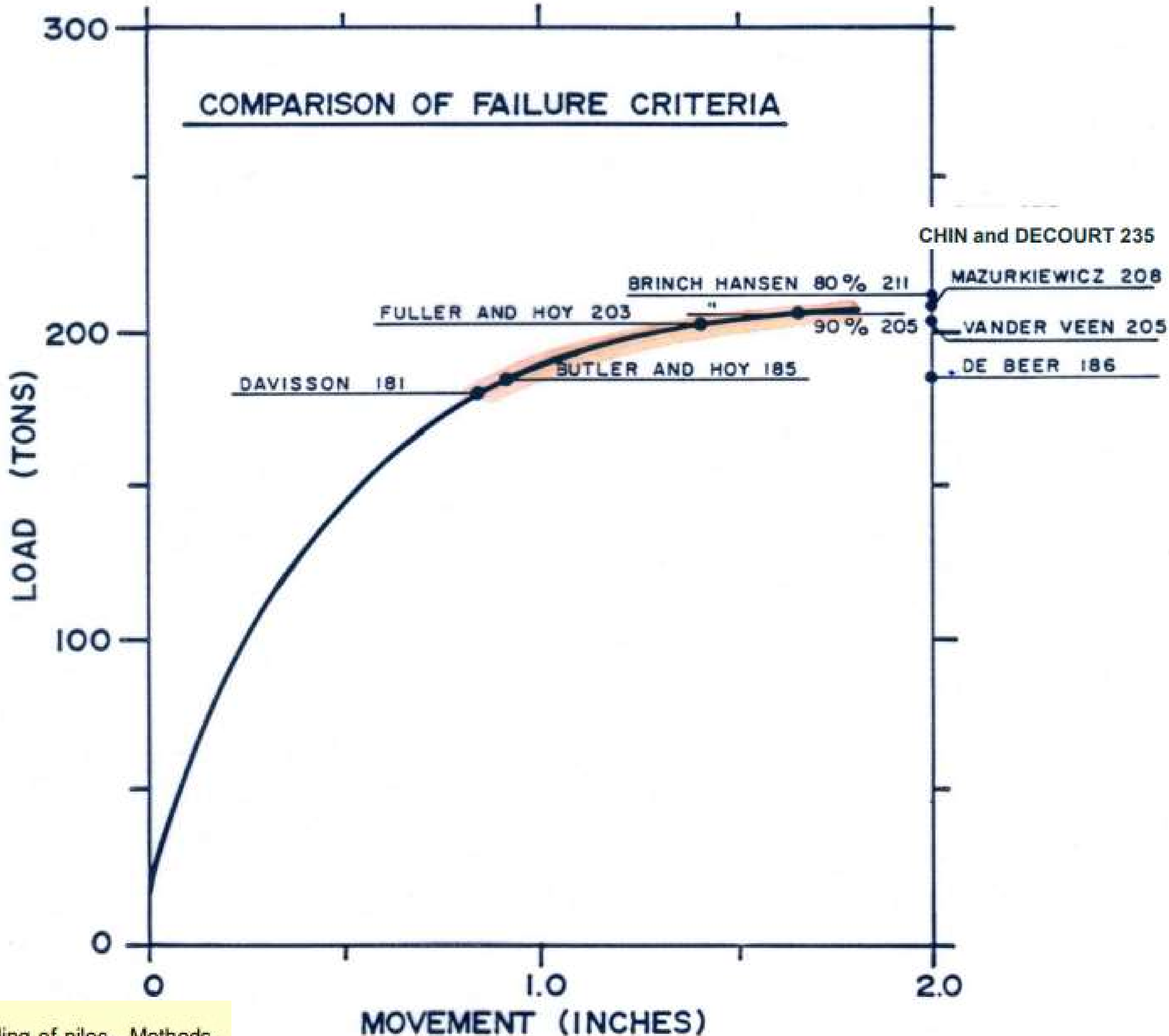
TECHNOLOGY APPLICATIONS
Innovation Through Partnerships


EXAMPLE N° I
C.R.P. - TEST
DRIVEN JULY 9, 1975
TESTED AUGUST 22, 1975
DEPTH 76.1 FT.
PREBORED 30 FT.
NOT DRIVEN TO REFUSAL
CLAY
SILT
GLACIAL TILL
0
60'
70'
77'
300
200
100
0
LOAD (TONS)
0
1.0
2.0
MOVEMENT (INCHES)

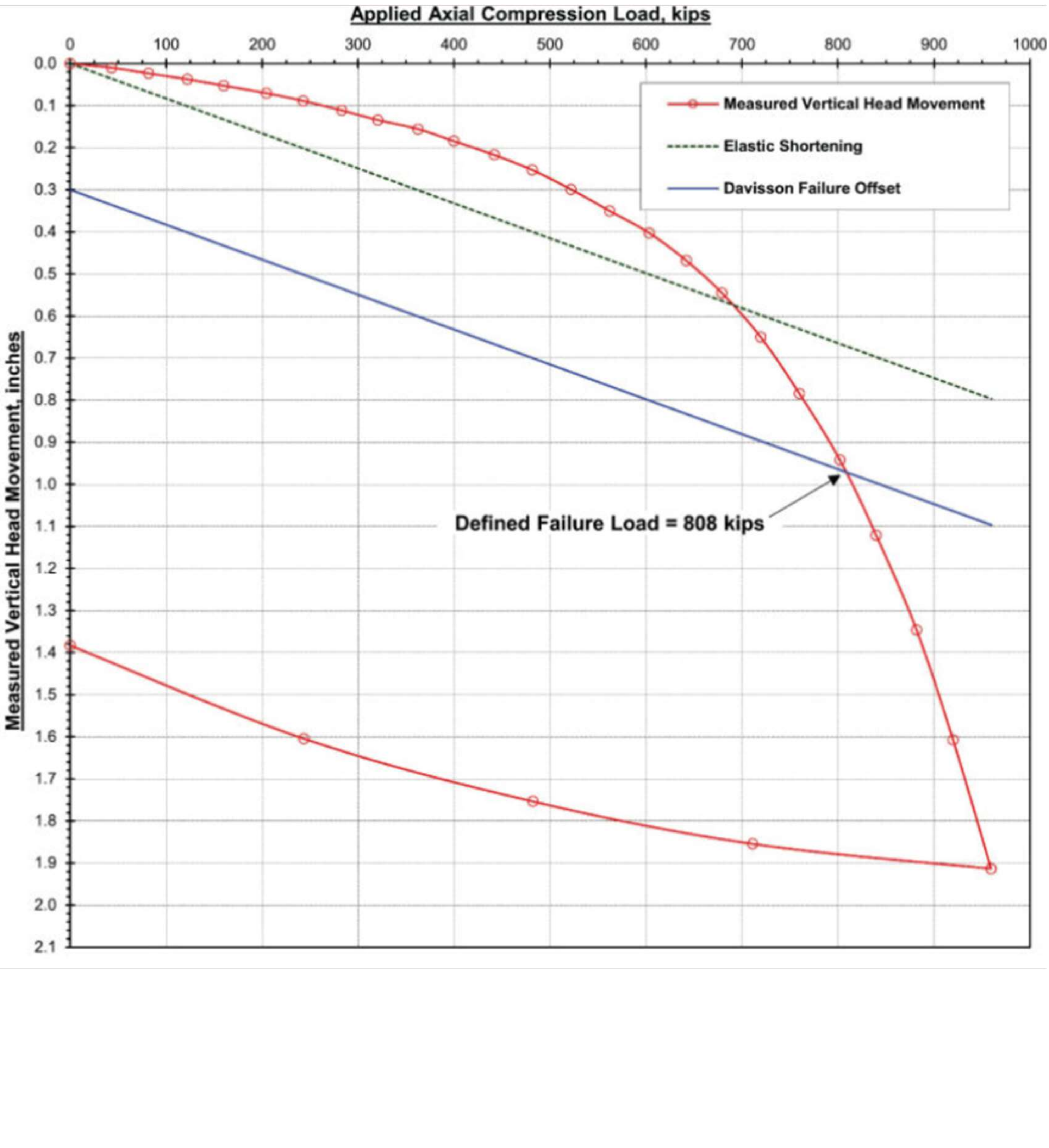



GRL

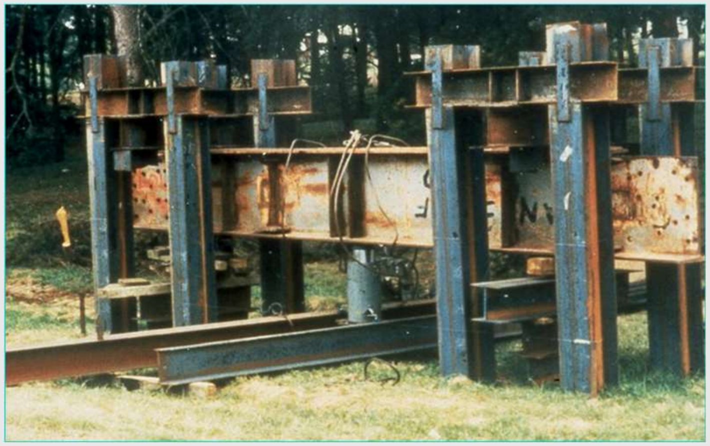

LOAD (kN)
0
200
400
600
800
1,000
1,200
1,400
DEPTH (m)
0
1
2
3
4
5
6
7
MOVEMENT (mm)
0
20
40
60
80
Pile Head Movement
1131.
1126.
1,132.5
1,130.0
1,127.5
1,125.0
SGL 5
Base



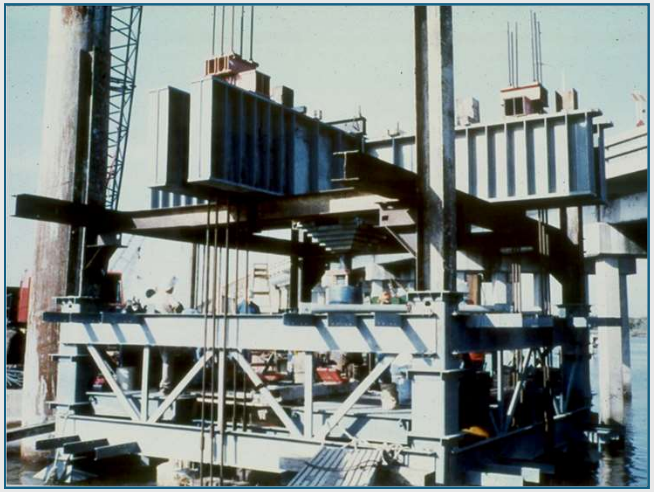
Fellenius, B.H., 1975. Test loading of piles—Methods, interpretation, and proof testing. ASCE Journal of the Geotechnical Engineering Division 101(GT9) 855-869.



Applied Axial Compression Load, kips
Measured Vertical Head Movement, inches
Measured Vertical Head Movement
Elastic Shortening
Davisson Failure Offset
Defined Failure Load = 808 kips








Dynamic Pile Driving Resistance ➡ Static Load Bearing Capacity

CASE WESTERN RESERVE UNIVERSITY PILING RESEARCH PROJECT 1964-1976

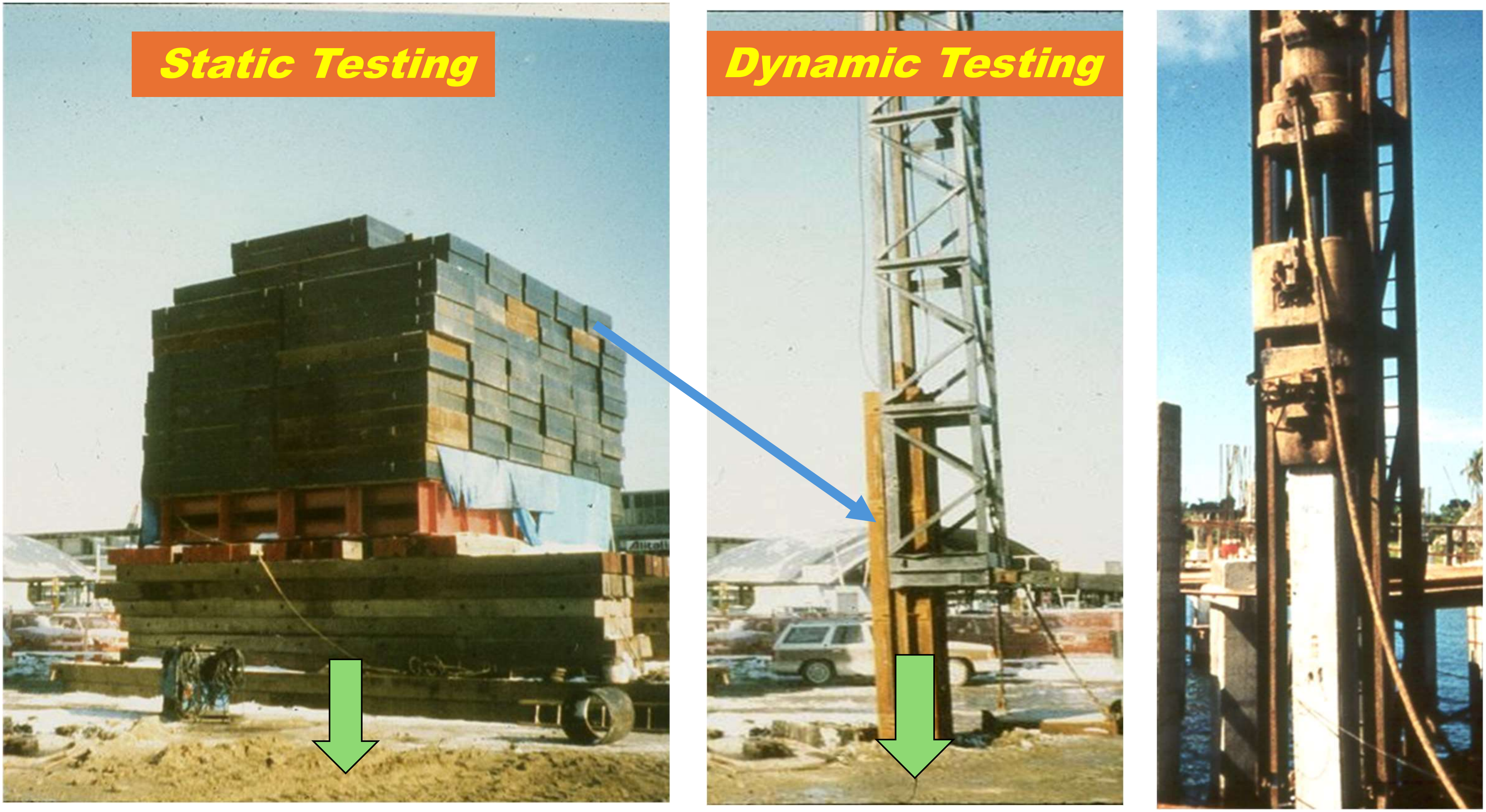
Funded by:

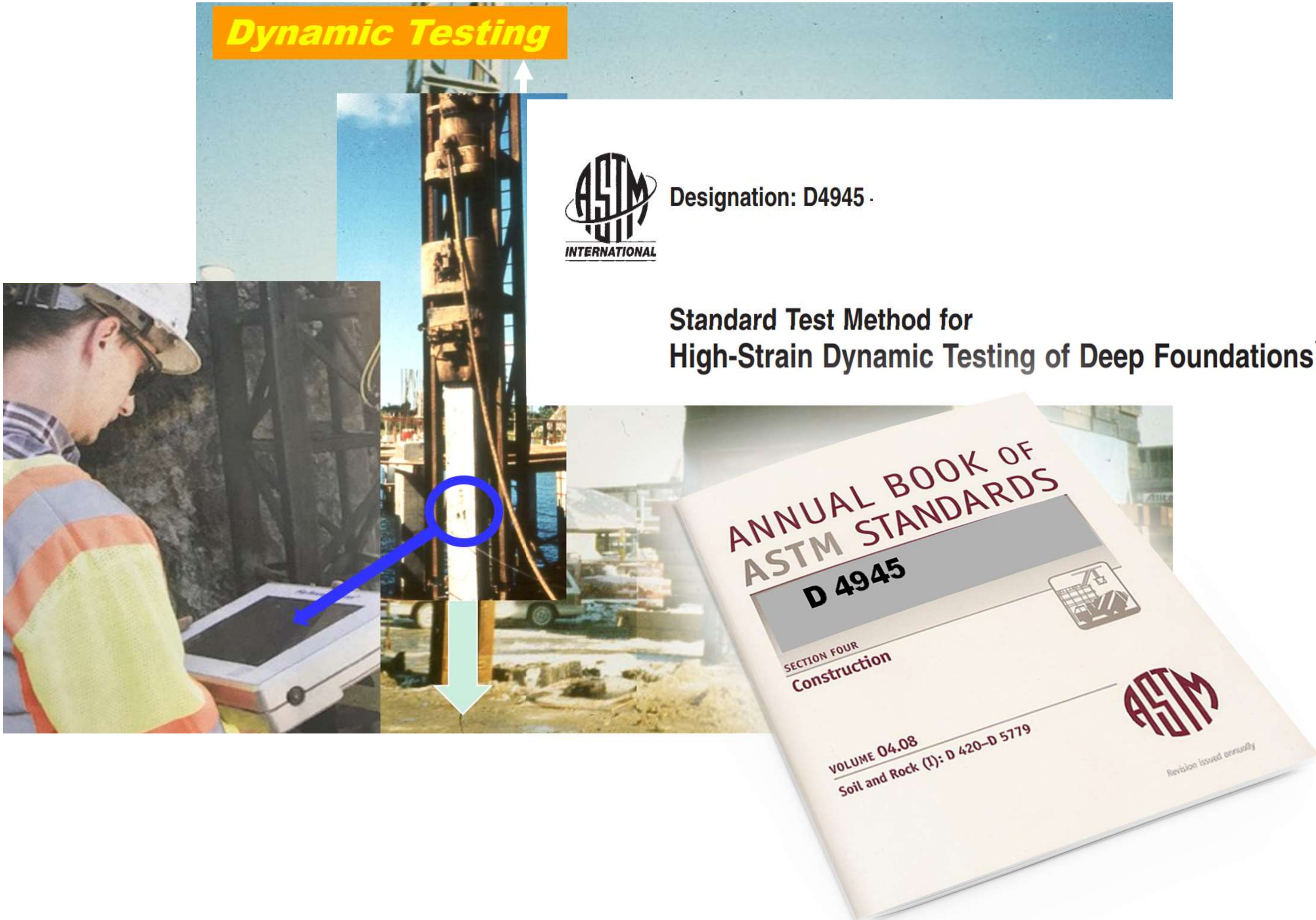
Ohio Department of Transportation
Federal Highway Administration

And

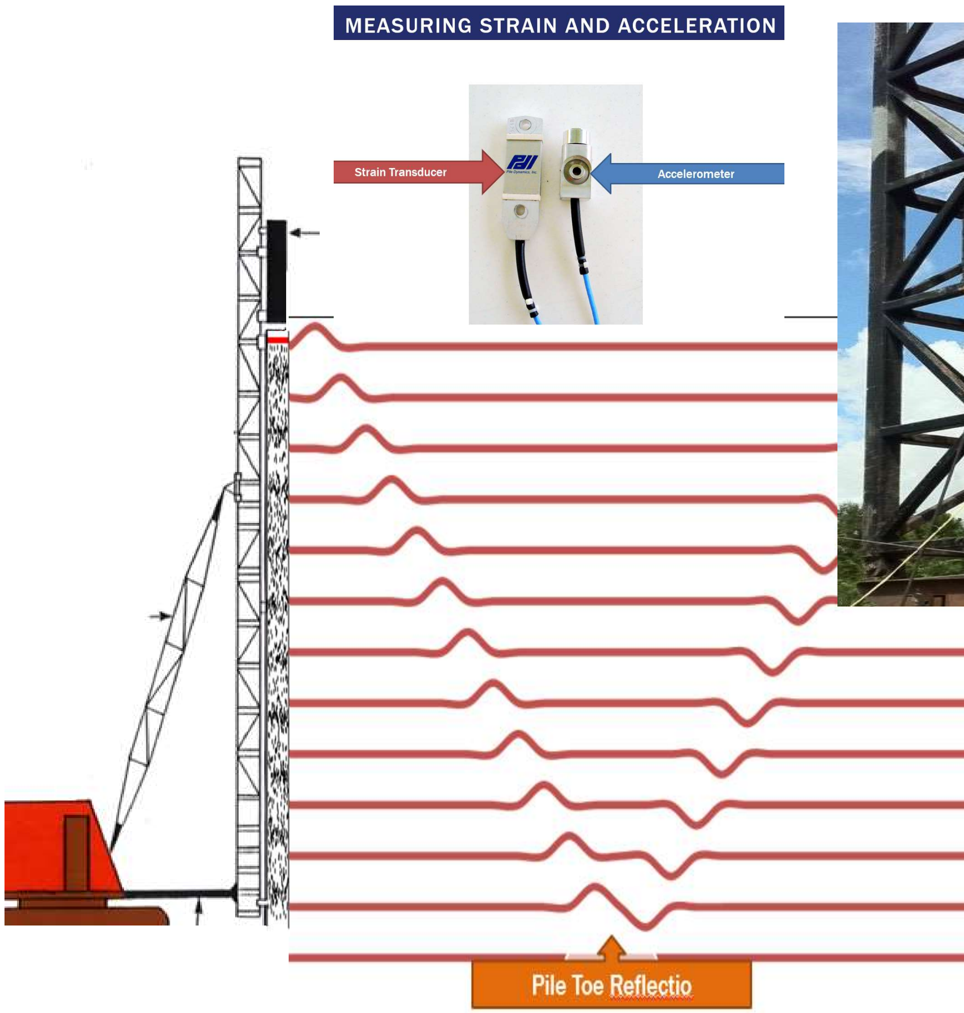
Highway Organizations of:

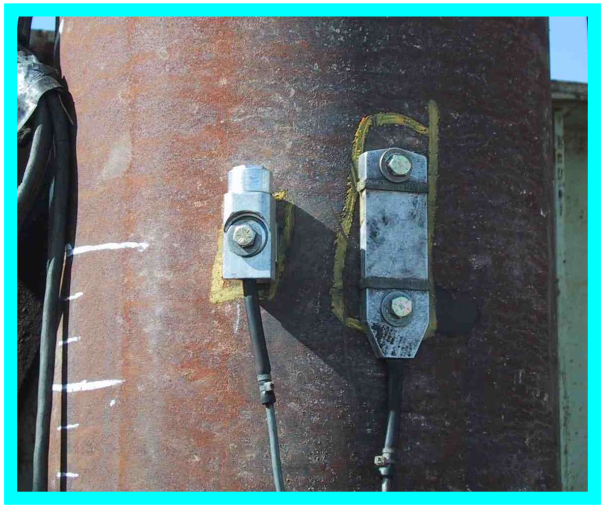
- Florida
- Georgia
- Idaho
- Minnesota
- New York
- Pennsylvania

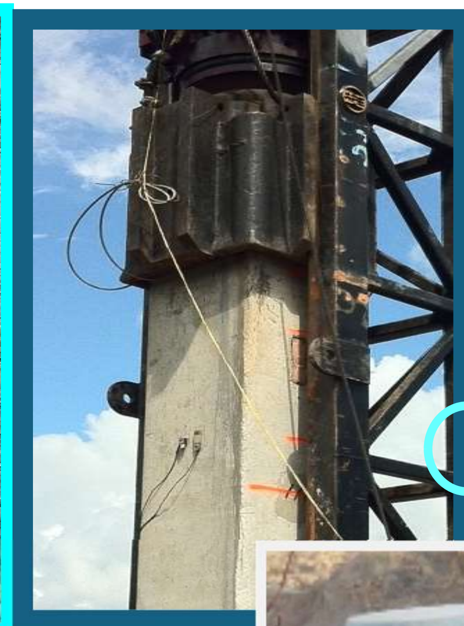
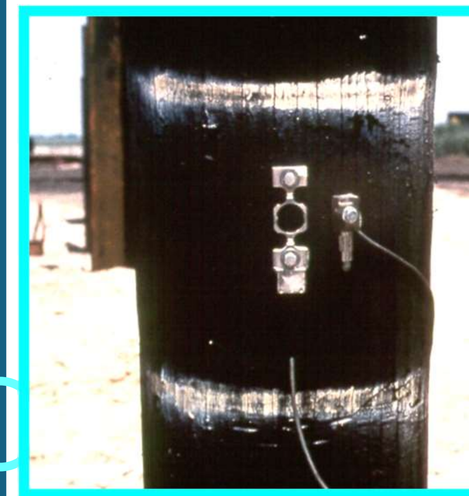

Static Testing
Dynamic Testing


Dynamic Testing
Designation: D4945
INTERNATIONAL
Standard Test Method for
High-Strain Dynamic Testing of Deep Foundations
ANNUAL BOOK OF ASTM STANDARDS
D 4945
SECTION FOUR
Construction
VOLUME 04.08
Soil and Rock (I): D 420–D 5779
Revision issued annually

DYNAMIC PILE TESTING (DLT)

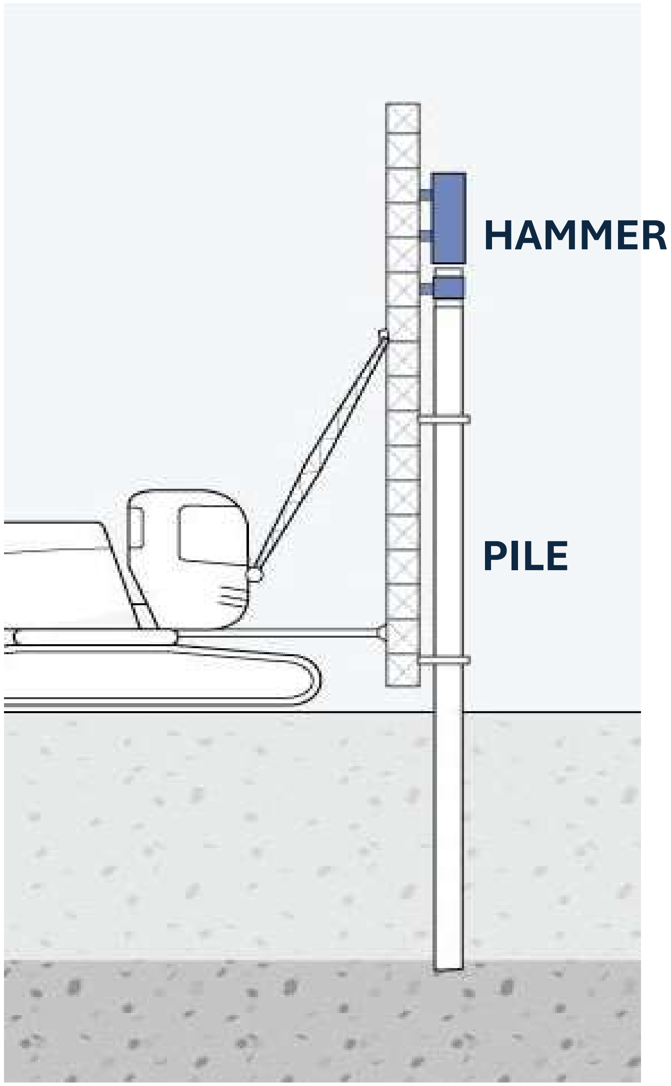


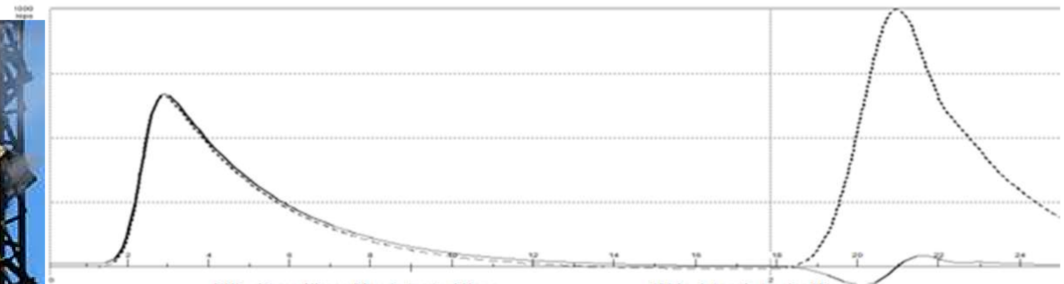




JUN 9 2005





CSI:	Comp Stress Max-Individual Sens
CSB:	Compression Stress at Bottom of Pile
TSX:	Tension Stress Max-Full Rec Search
STK:	Hammer Stroke
BTA:	Integrity Factor (1)
RA2:	Auto Capacity Friction Piles
RMX:	Maximum Case Method Capacity (JC)

BL#	Depth ft	BLC bl/ft	TYPE	CSX ksi	CSI ksi	CSB ksi	TSX ksi	STK ft	EMX k-ft	BTA (%)	RA2 kips	RMX kips
12	86.00	12	AV12	1.75	1.87	0.75	0.81	6.78	33.4	100.0	294	299
22	87.00	10	AV10	1.73	1.87	0.59	1.04	6.43	32.9	100.0	231	316
31	88.00	9	AV9	1.70	1.84	0.63	1.12	6.33	33.1	100.0	197	301
40	89.00	9	AV9	1.67	1.79	0.62	1.15	6.25	32.6	100.0	137	280
48	90.00	8	AV8	1.61	1.72	0.61	1.13	6.10	30.9	100.0	79	243
57	91.00	9	AV9	1.47	1.58	0.55	1.05	5.70	29.0	93.3	75	220
65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	224
75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	253
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98	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	237
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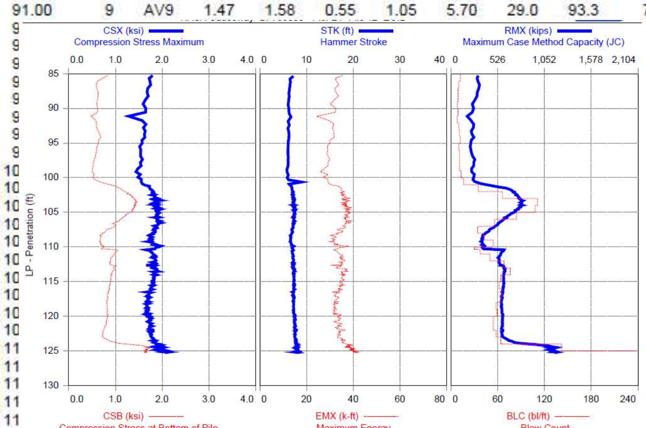
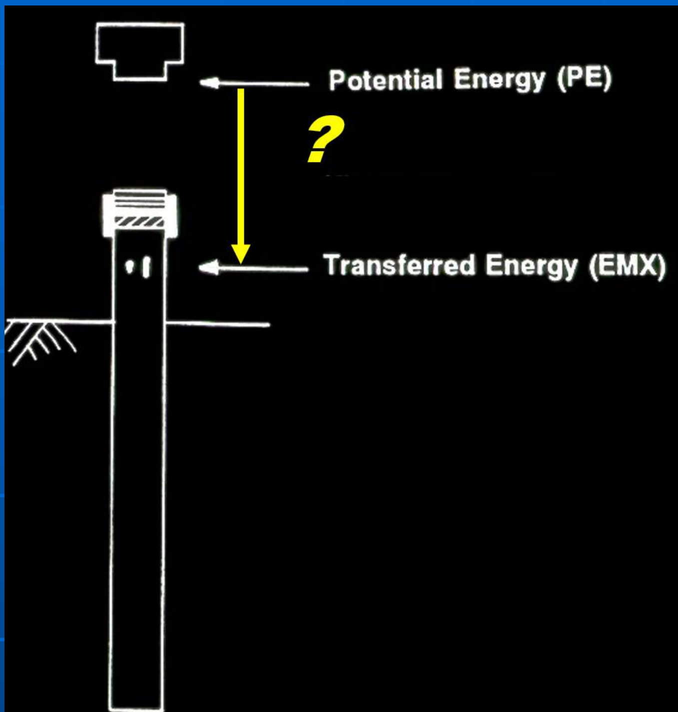
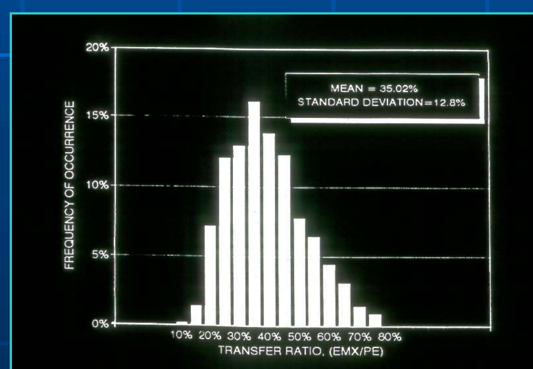
1053	115.00	64	AV64	1.82	1.89	0.90	0.51	7.29	35.4	100.0	657	592
1115	116.00	62	AV62	1.79	1.88	0.88	0.49	7.30	34.7	100.0	652	591
1180	117.00	65	AV65	1.73	1.85	0.85	0.46	7.20	33.2	100.0	646	579
1244	118.00	64	AV64	1.70	1.81	0.83	0.46	7.22	32.8	100.0	632	570
1302	119.00	58	AV58	1.68	1.78	0.82	0.45	7.21	32.1	100.0	627	568
1361	120.00	59	AV59	1.69	1.80	0.83	0.45	7.29	32.5	100.0	636	577
1415	121.00	54	AV54	1.73	1.82	0.82	0.50	7.44	33.5	100.0	643	578
1469	122.00	54	AV54	1.75	1.78	0.78	0.56	7.55	34.1	100.0	637	575
1527	123.00	58	AV58	1.76	1.81	0.73	0.63	7.53	34.1	100.0	632	576
1591	124.00	64	AV64	1.83	1.91	0.90	0.58	7.65	35.3	100.0	742	676
1733	125.00	142	AV142	1.96	2.07	1.61	0.52	7.94	38.7	100.0	1,172	1,107
1813	125.25	320	AV80	2.07	2.19	1.65	0.54	8.09	41.0	100.0	1,238	1,171



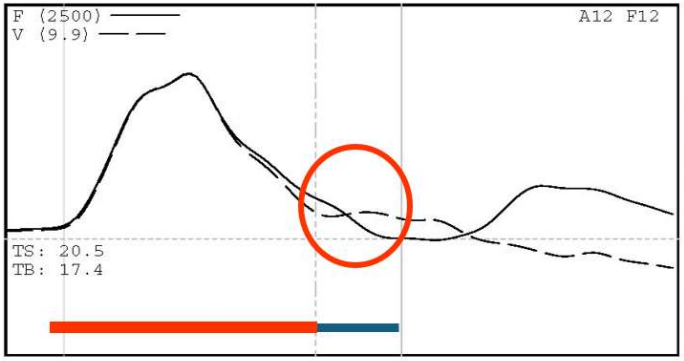


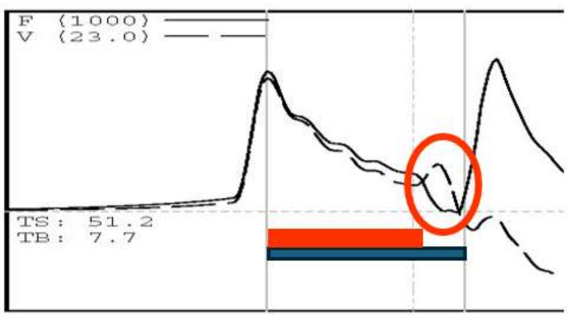
Hammer System Performance

$$EMX = \int F\, v\, dt$$

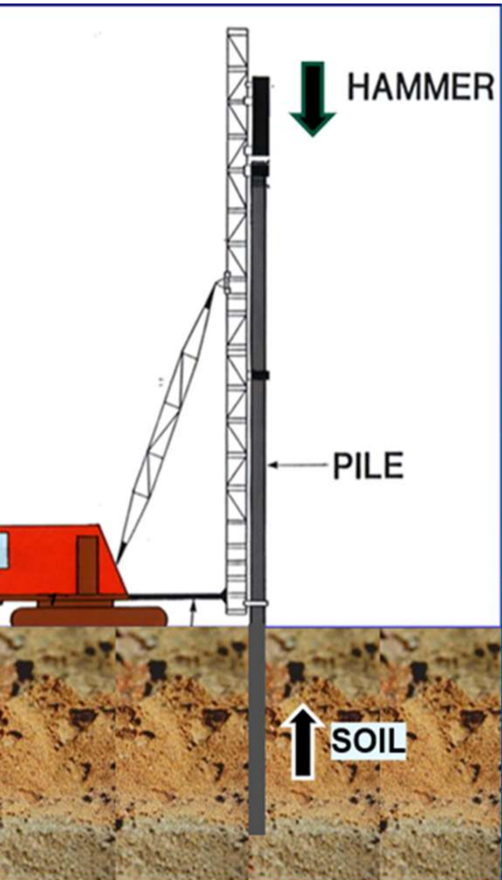


Pile Damage: BTA, LTD

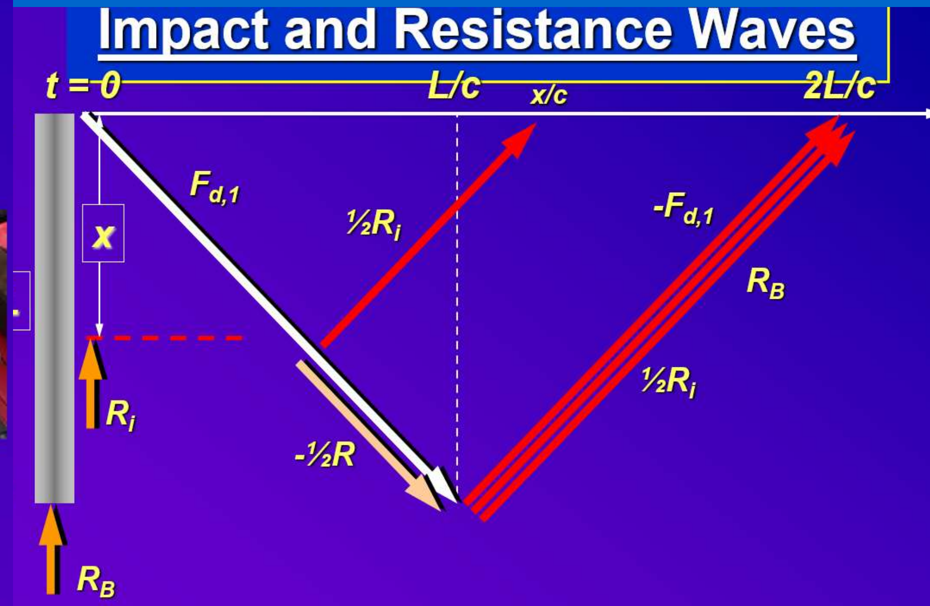


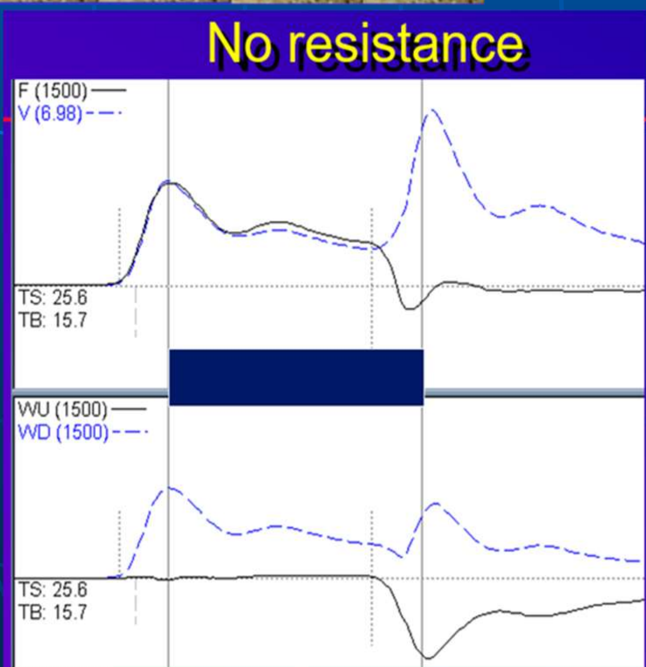


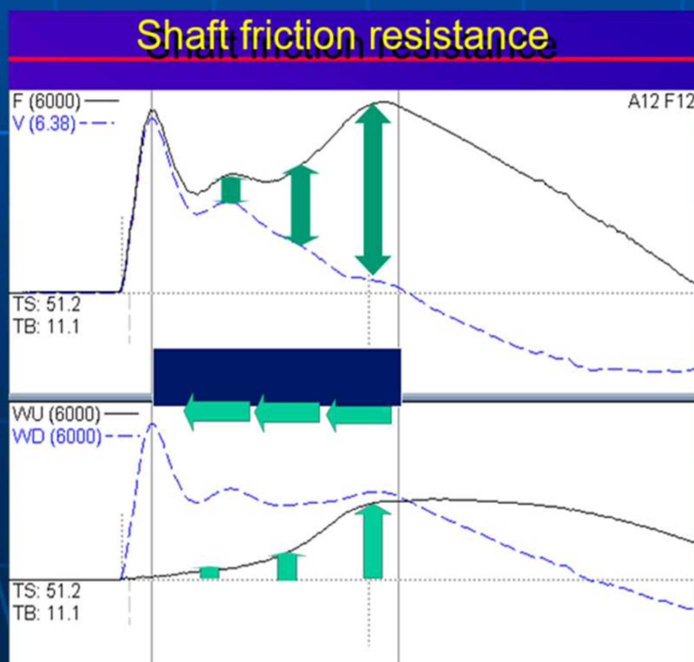
β	Condition
100	Uniform
80 - 100	Slight damage
60 - 80	Significant damage
<60	Broken

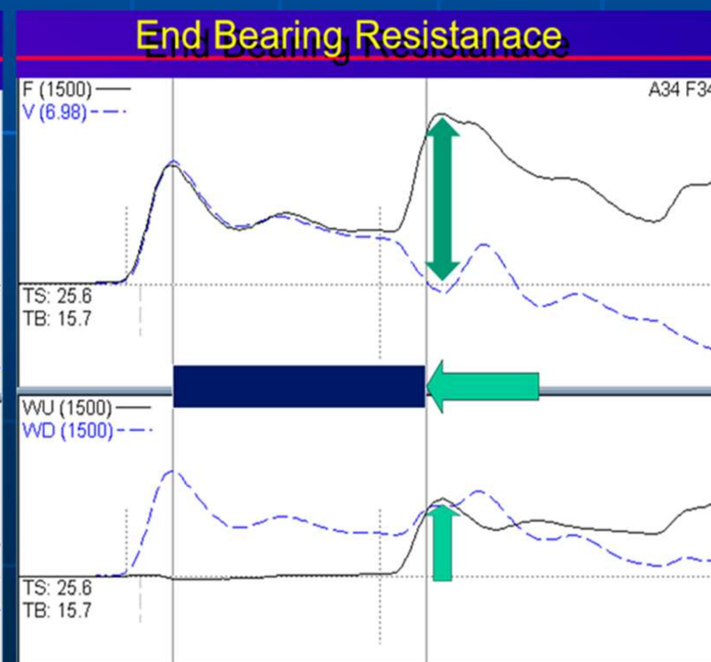

HAMMER
PILE
SOIL


Soil Resistance Effects

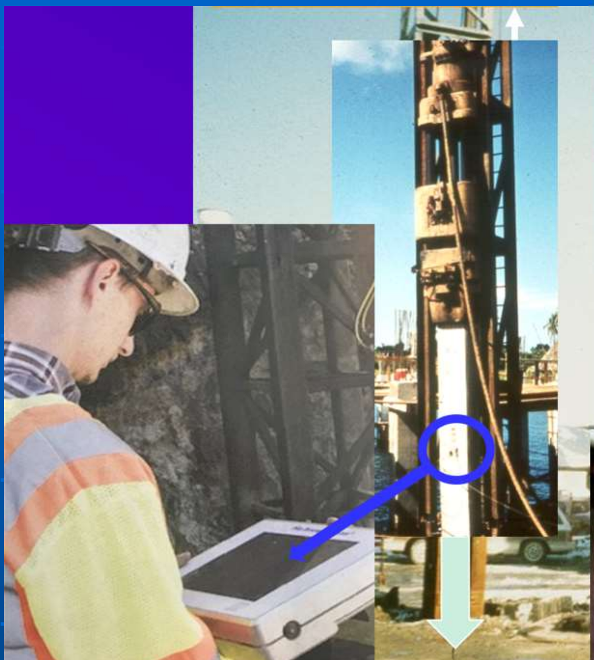

Impact and Resistance Waves
t = 0
L/c
x/c
2L/c
x
$F_{d,1}$
½R_i
$-F_{d,1}$
R_B
R_i
-½R
½R_i
R_B


No resistance
F (1500)
V (6.98)
TS: 25.6
TB: 15.7
WU (1500)
WD (1500)
TS: 25.6
TB: 15.7


Shaft friction resistance
F (6000)
V (6.38)
A12 F12
TS: 51.2
TB: 11.1
WU (6000)
WD (6000)
TS: 51.2
TB: 11.1


End Bearing Resistanace
F (1500)
V (6.98)
A34 F34
TS: 25.6
TB: 15.7
WU (1500)
WD (1500)
TS: 25.6
TB: 15.7

Dynamic Load Testing



STRESSWAVE '96

FIFTH INTERNATIONAL CONFERENCE ON THE APPLICATION OF STRESS-WAVE THEORY TO PILES

SELECTION OF A HAMMER FOR HIGH-STRAIN DYNAMIC TESTING OF CAST-IN-PLACE SHAFTS

Mohamad Hussein[1], Garland Likins[2], and Frank Rausche[3]

Abstract

Hammer details must be appropriately chosen for successful high-strain dynamic testing of cast-in-place foundation shafts (piles). This paper presents results of a wave equation analytical study performed to evaluate

CAPWAP®

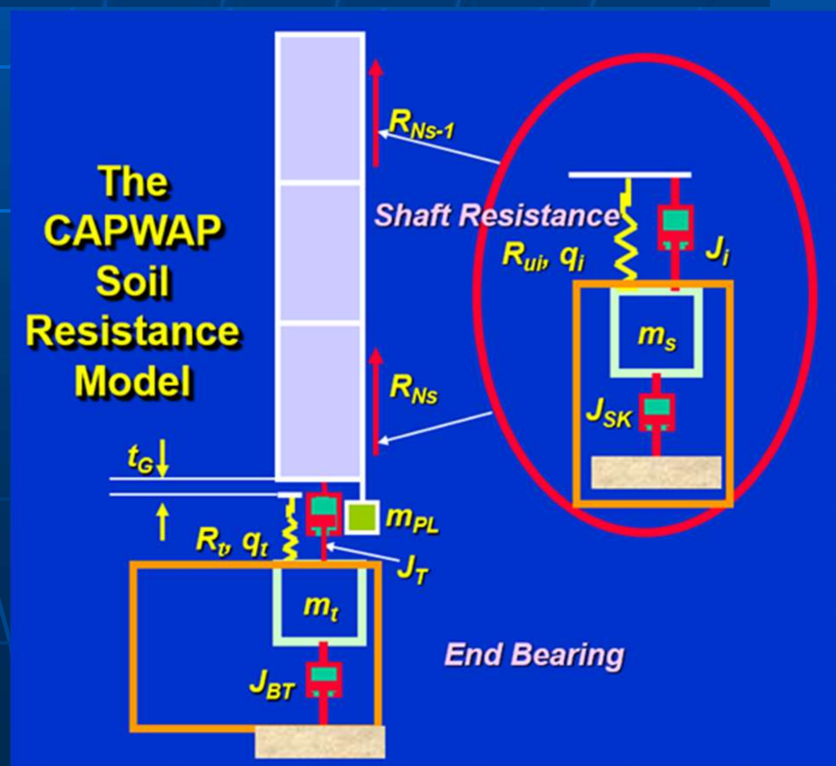
CAse Pile Wave Analysis Program

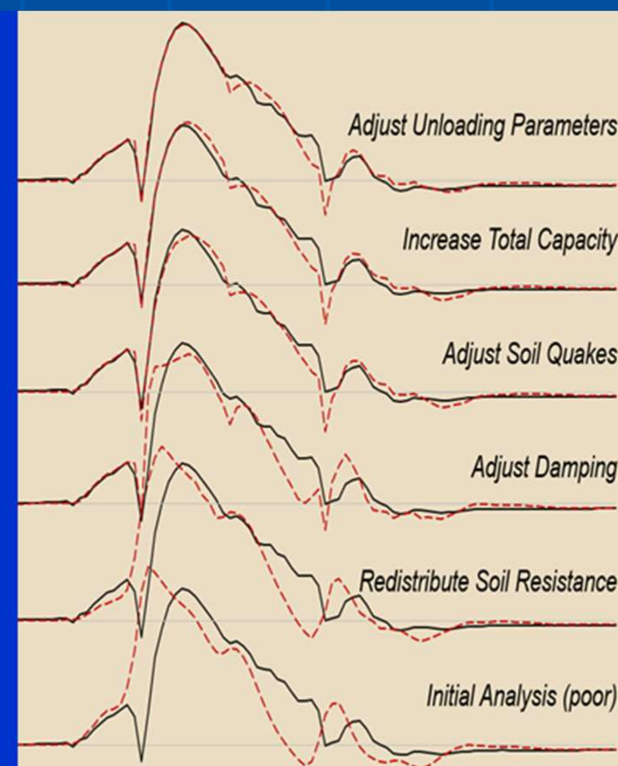
"Signal Matching" Program

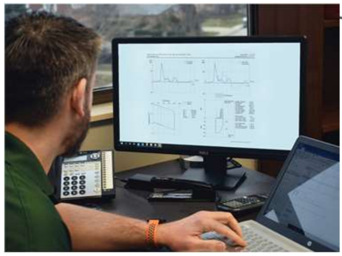
We know both Input and Response (wave down and wave up)

Find the "boundary conditions"

(static & dynamic soil resistance)







CAPWAP Analysis Results

CAPWAP SUMMARY RESULTS

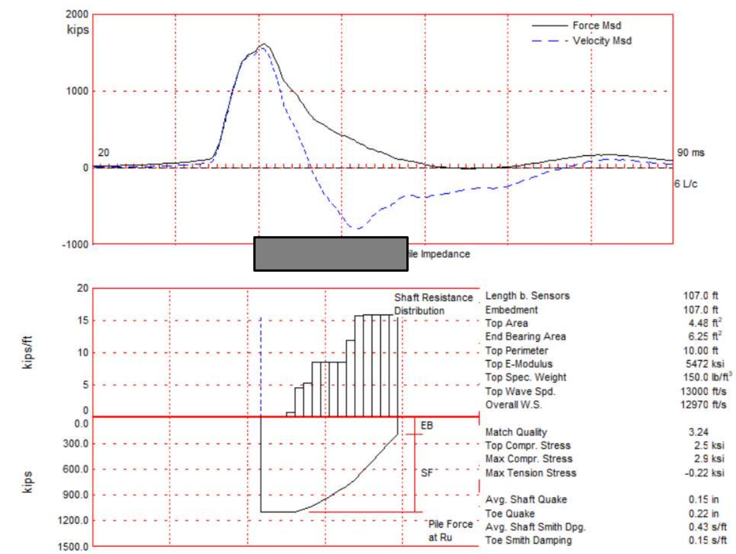
otal CAPWAP Capacity: 1100.0; along Shaft 906.0; at Toe 194.0 kips

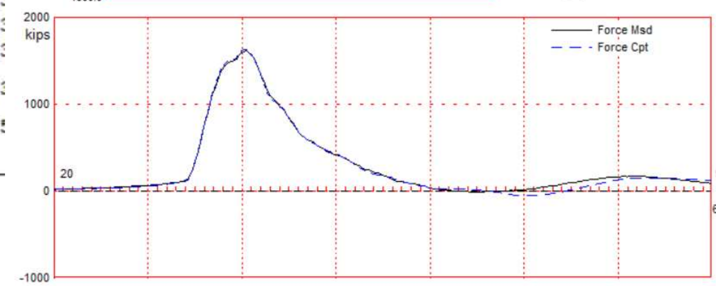
Soil Sgmnt No.	Dist. Below Gages ft	Depth Below Grade ft	Ru kips	Force in Pile kips	Sum of Ru kips	Unit Resist. (Depth) kips/ft	Unit Resist. (Area) ksf	Smith Damping Factor s/ft
				1100.0				
1	6.7	6.7	0.0	1100.0	0.0	0.00	0.00	0.00
2	13.4	13.4	0.0	1100.0	0.0	0.00	0.00	0.00
3	20.1	20.1	0.0	1100.0	0.0	0.00	0.00	0.00
4	26.8	26.8	4.9	1095.1	4.9	0.73	0.07	0.43
5	33.4	33.4	30.8	1064.3	35.7	4.61	0.46	0.43
6	40.1	40.1	35.2	1029.1	70.9	5.26	0.53	0.43
7	46.8	46.8	57.2	971.9	128.1	8.55	0.86	0.43
8	53.5	53.5	57.2	914.7	185.3	8.55	0.86	0.43
9	60.2	60.2	57.2	857.5	242.5	8.55	0.86	0.43
10	66.9	66.9	57.2	800.3	299.7	8.55	0.86	0.43
11	73.6	73.6	79.3	721.0	379.0	11.86	1.19	0.43
12	80.3	80.3	104.6	616.4	483.6	15.64	1.56	0.43
13	86.9	86.9	105.6	510.8	589.2	15.79	1.58	0.43
14	93.6	93.6	105.6	405.2	694.8	15.79	1.58	0.43
15	100.3	100.3	105.6	299.6	800.4	15.79	1.58	0.43
16	107.0	107.0	105.6	194.0	906.0	15.79	1.58	0.43
Avg. Shaft			56.6			8.47	0.85	0.43
Toe			194.0				31.04	0.15

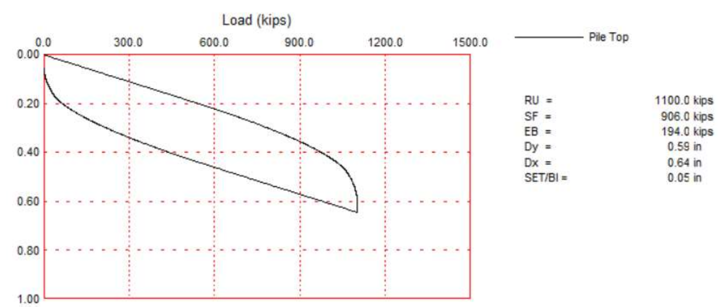
oil Model Parameters/Extensions		Shaft	Toe
uake	(in)	0.15	0.22
ase Damping Factor		1.43	0.11
amping Type		Viscous	Sm+Visc
eloading Level	(% of Ru)	100	100
nloading Level	(% of Ru)	1	
esistance Gap (included in Toe Quake) (in)			0.02

APWAP match quality = 3.24 (Wave Up Match) ; RSA = 0
bserved: Final Set = 0.05 in; Blow Count = 240 b/ft
omputed: Final Set = 0.05 in; Blow Count = 240 b/ft
ransducer F1 (E206) CAL: 92.0; RF: 0.98; F4 (I635) CAL: 95.9; RF: 0.98
A2 (K3680) CAL: 393; RF: 1.01; A3 (K4592) CAL: 369; RF: 1.01

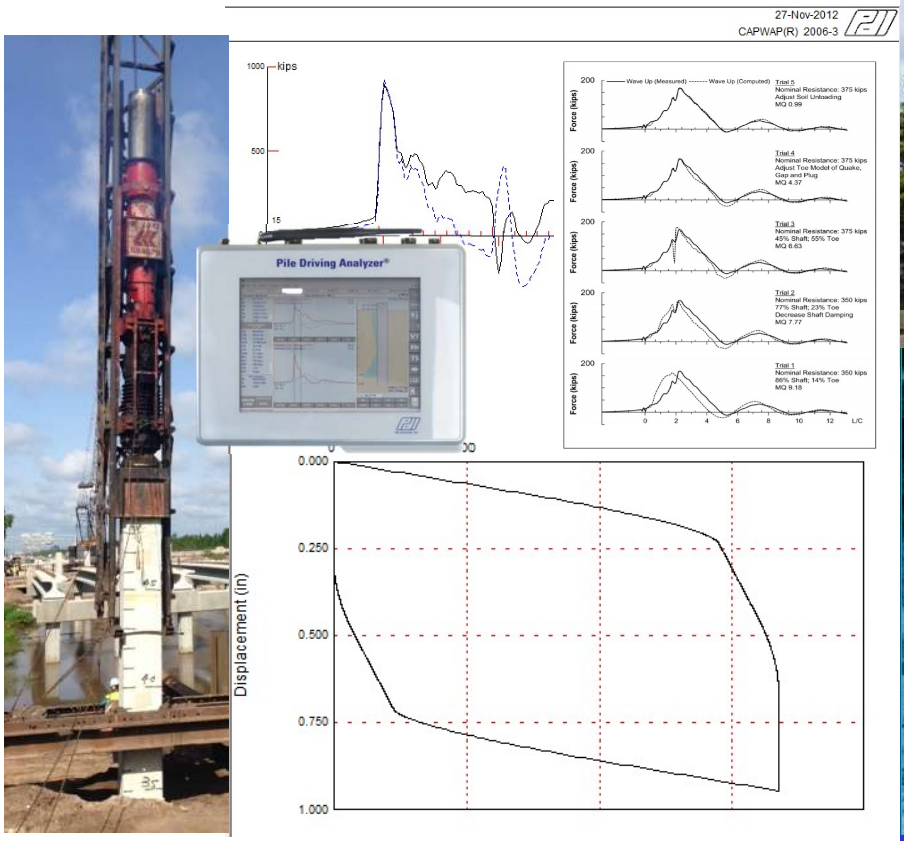
ax. Top Comp. Stress = 2.5 ksi (T= 41.0 ms, max= 1.147 x Top)
ax. Comp. Stress = 2.9 ksi (Z= 33.4 ft, T= 43.3 ms)
ax. Tens. Stress = -0.22 ksi (Z= 33.4 ft, T= 71.7 ms)
ax. Energy (EMX) = 52.1 kip-ft; max. Measured Top Displ. (DMX)= 0.50 in

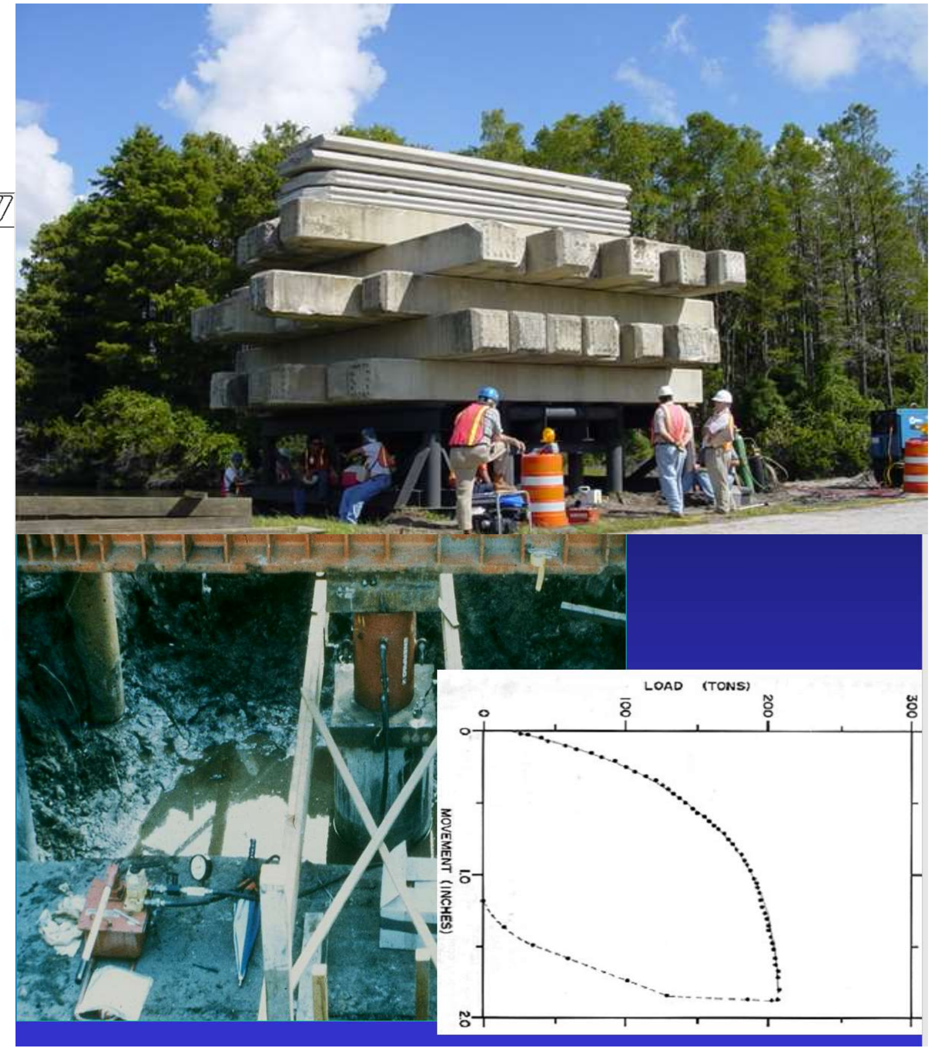




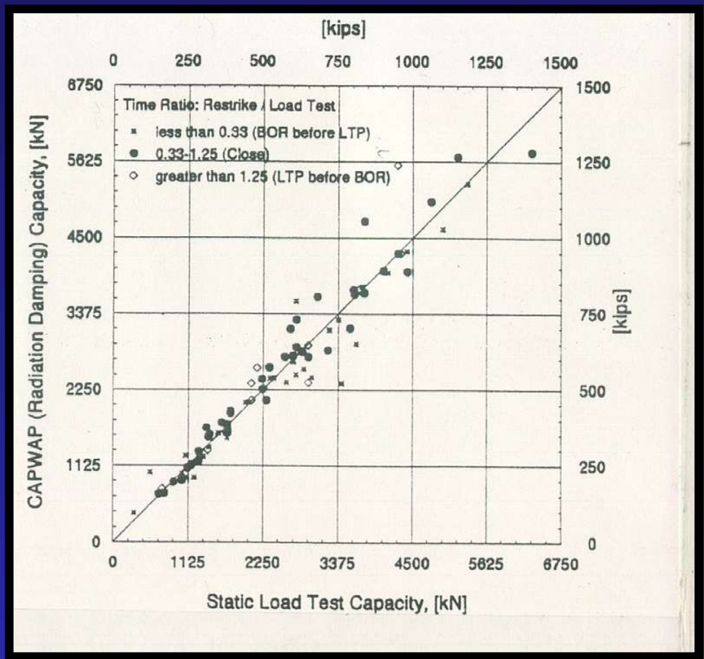


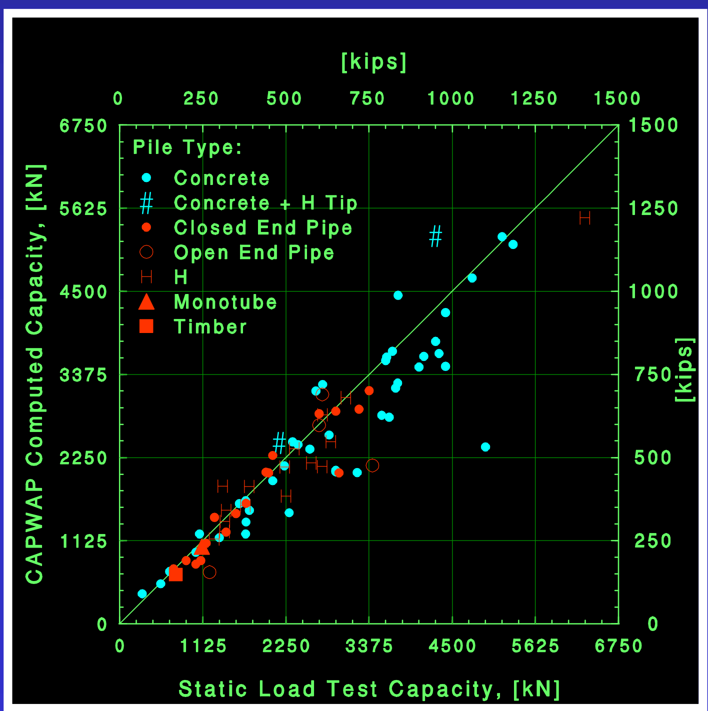
PDA/CAPWAP Analysis Results





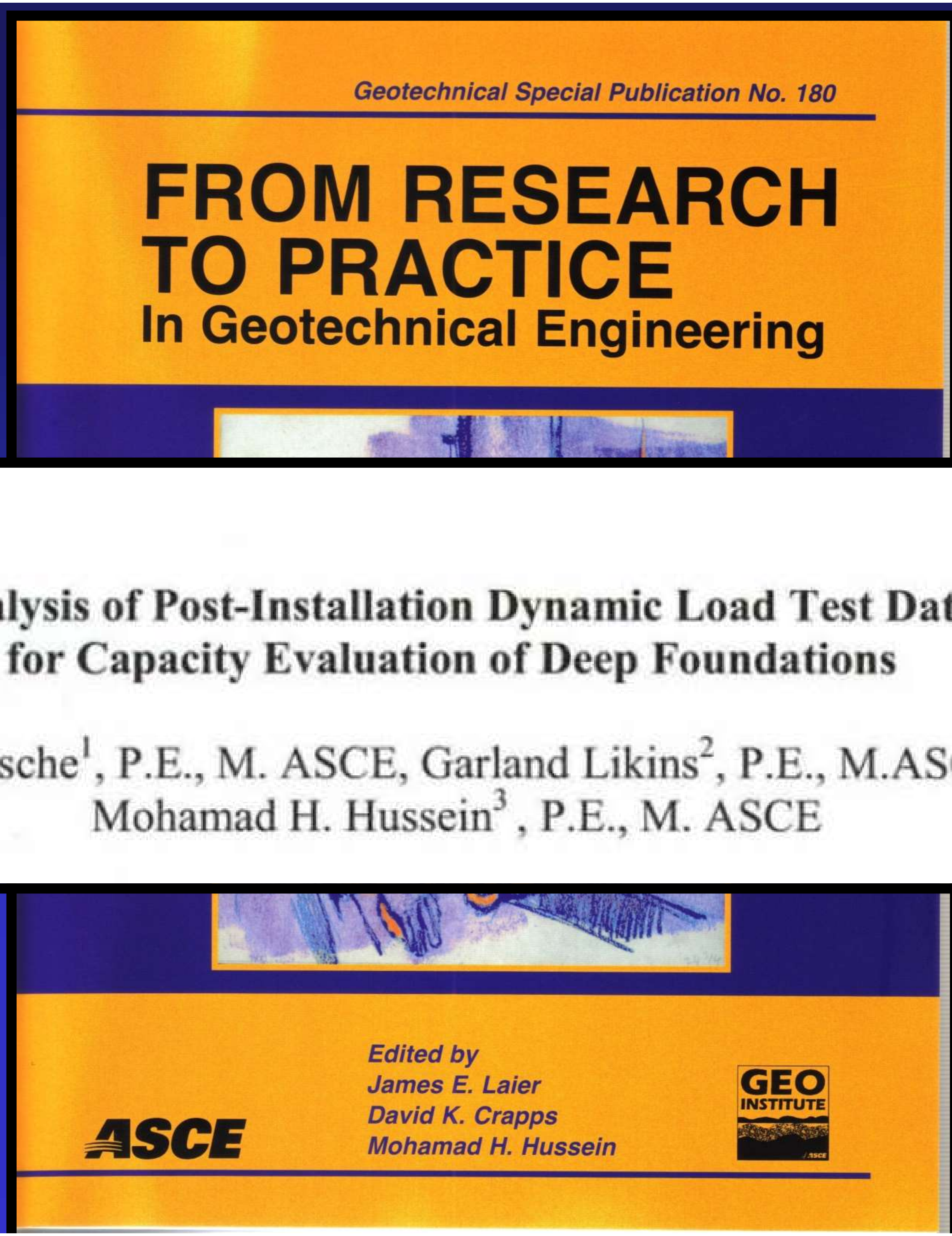
CAPWAP analyses and Static Load Test Results Correlations





Considerations for Pile Capacity Assessment:

- Which restrike blow data to analyze.
- Hammer energy insufficient to fully mobilize all soil/rock resistance.
- Pile capacity changes due to time-dependent soil strength changes.
- Questionable load test results
- Assessment of load bearing capacity of a damaged pile.

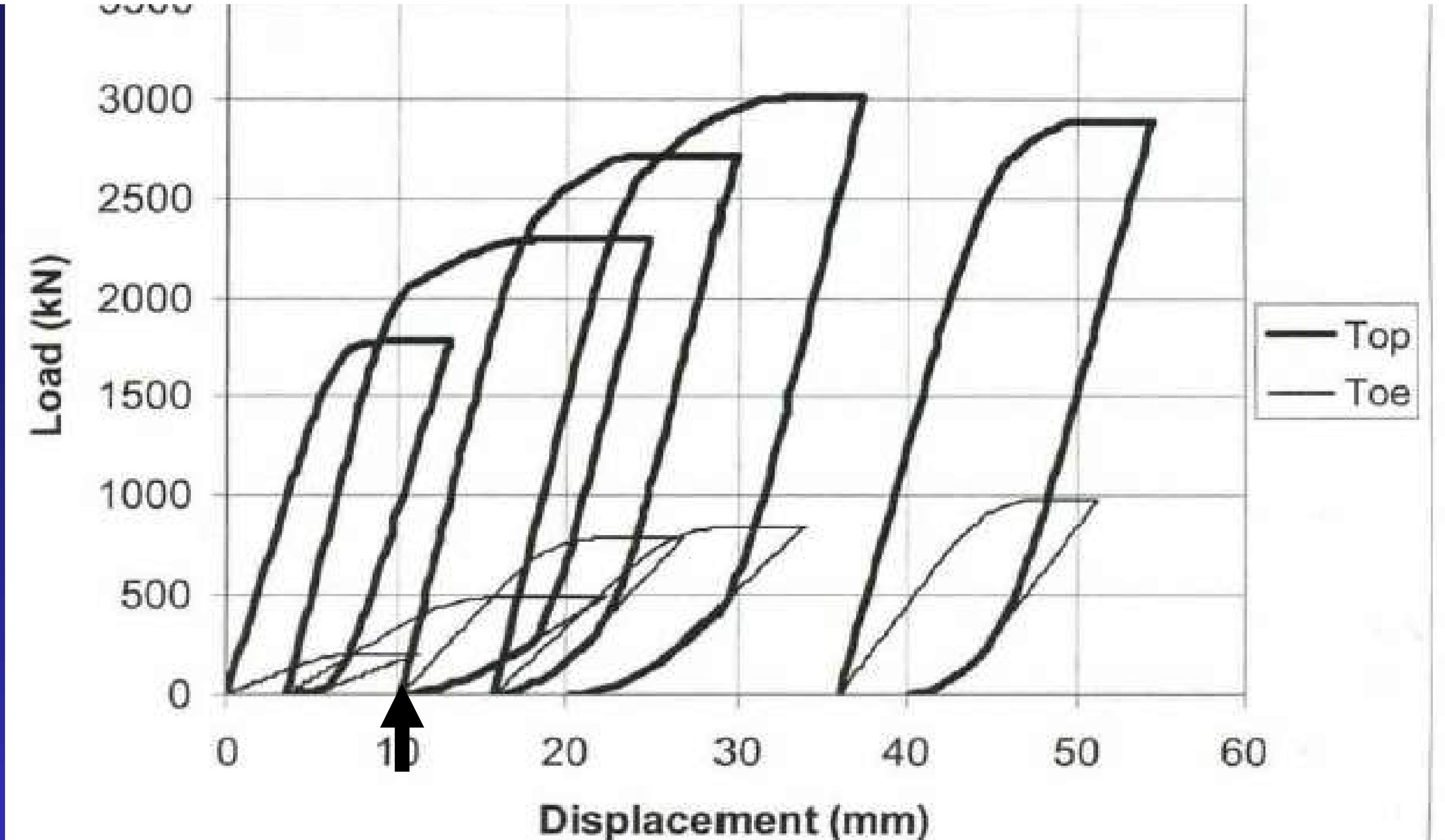


Analysis of Post-Installation Dynamic Load Test Data for Capacity Evaluation of Deep Foundations

Frank Rausche[1], P.E., M. ASCE, Garland Likins[2], P.E., M.ASCE, and Mohamad H. Hussein[3], P.E., M. ASCE

Criteria for Dynamic Load Test (DLT) data evaluation:

The toe should achieve a total displacement (elastic + cumulative permanent) of D/60.

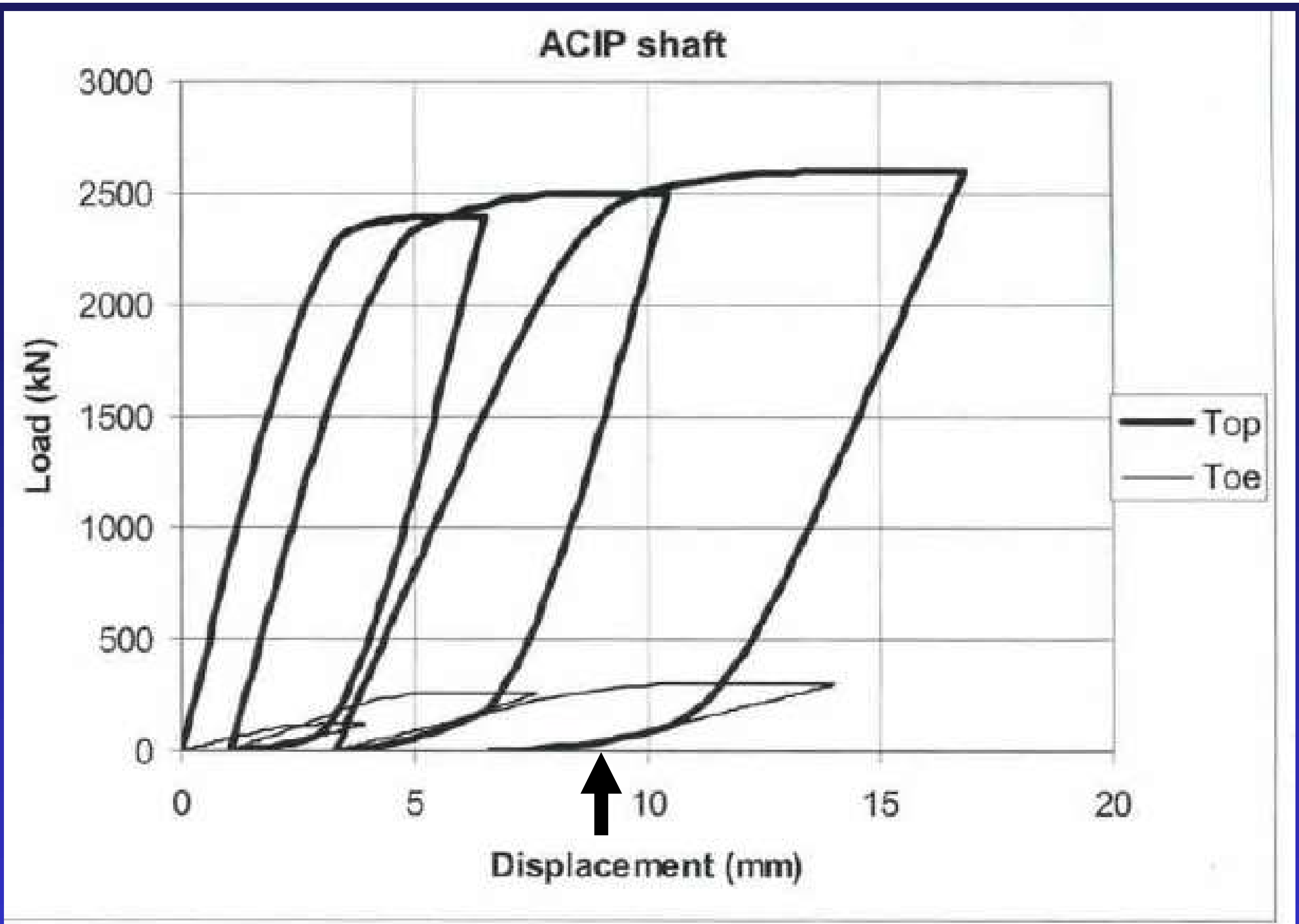


24-inch Prestressed Concrete Pile, 65 ft. 10 blows for 1.8 inches set.

The 10 mm (24/60 = 0.4") failure toe displacement was reached by the second blow (2200 kN).

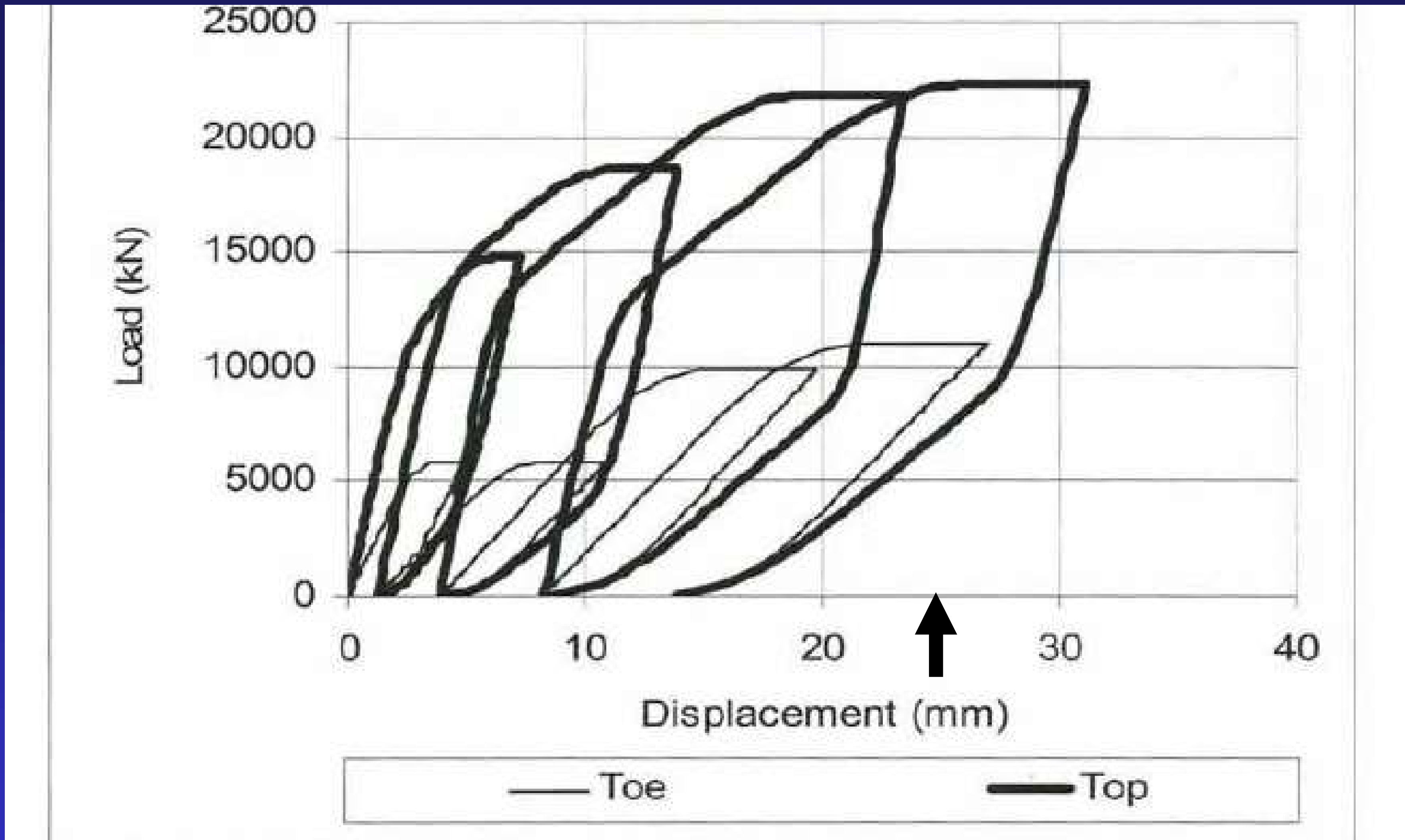
Increase of capacity due to more end bearing with successive blows.

Blows 1, 2, 3, 4, … and 10 shown.



20-inch diameter, 70 ft long auger-cast pile in clay. 13-kips hammer, three blows with sets of 1, 2, and 3 mm (0.04, 0.08, and 0.11 inch).

The 20/60 = 0.33 inch (9 mm) failure toe displacement was reached by the third blow.



5-ft diameter, 67 ft long drilled shaft. 60-ton hammer,

4 blows for 0.55 inch (14 mm).

End bearing not fully activated under blows 1 and 2, and failure toe displacement was reached by the fourth blow.

Considerations for Pile Capacity Assessment:

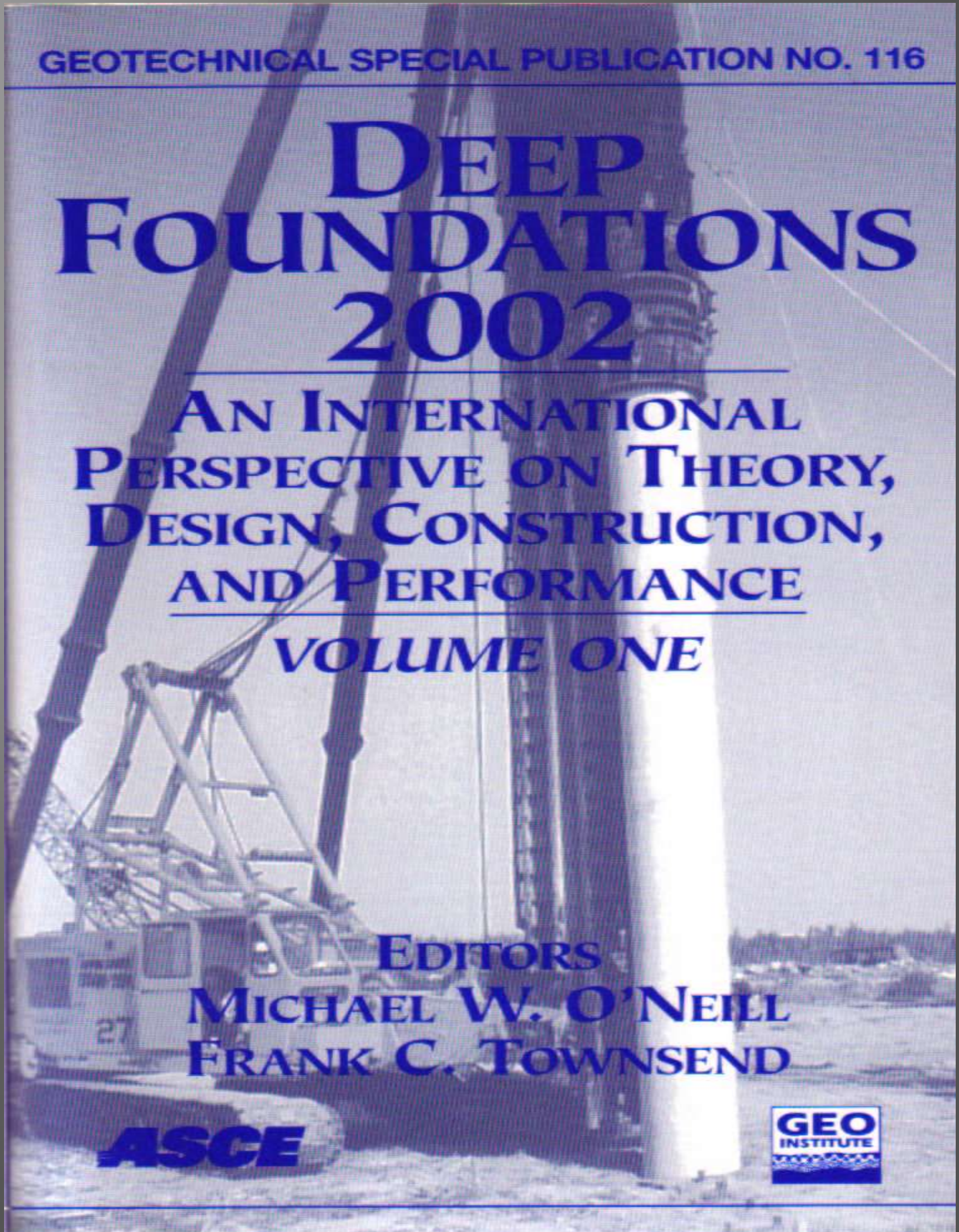
- Hammer energy insufficient to fully mobilize all soil/rock resistance (i.e., low pile displacement per blow).
- Pile capacity increases due to time-dependent soil strength changes effect (e.g., setup).

The Use of Superposition for Evaluating Pile Capacity

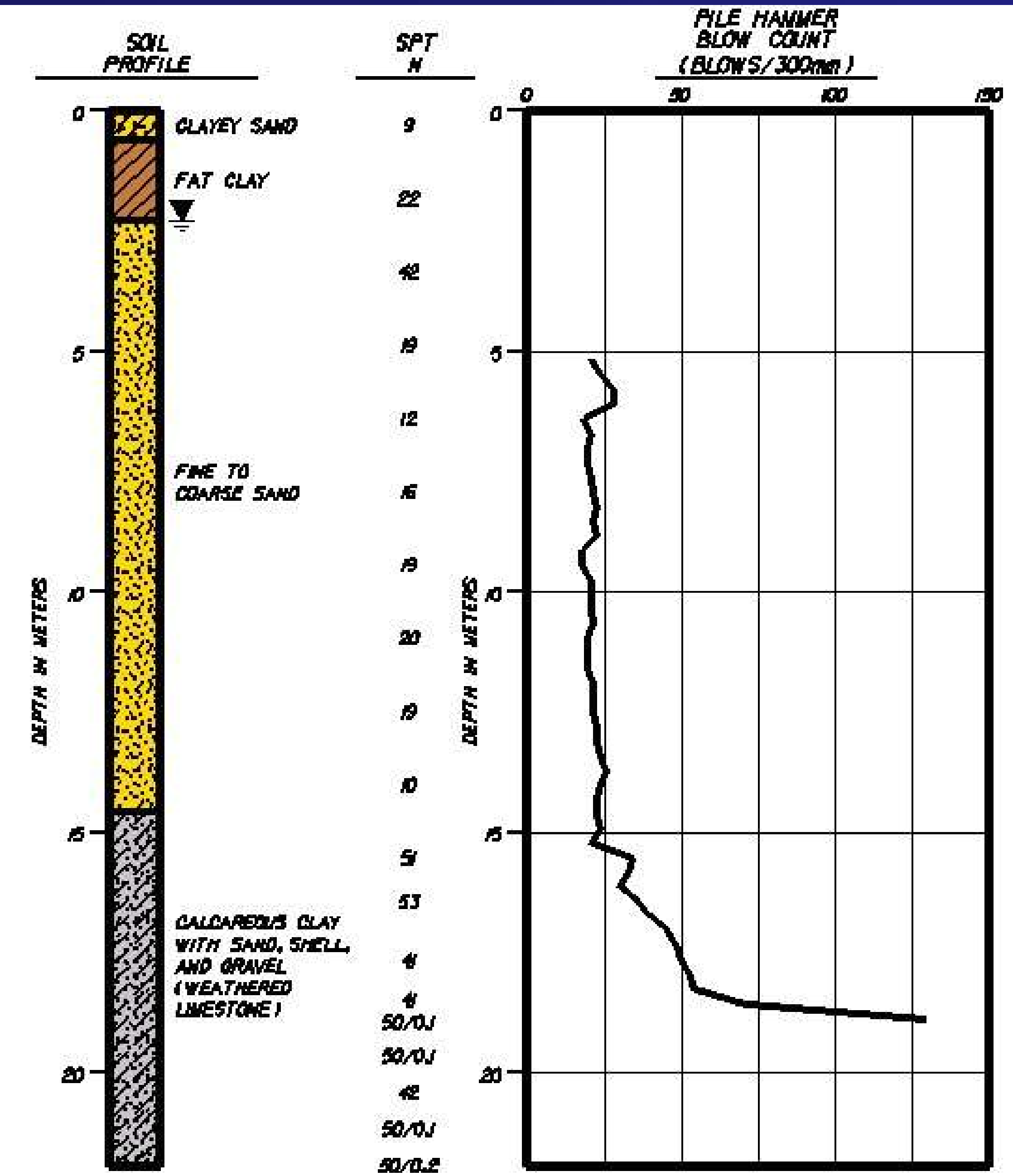
Mohamad H. Hussein
GRL Engineers

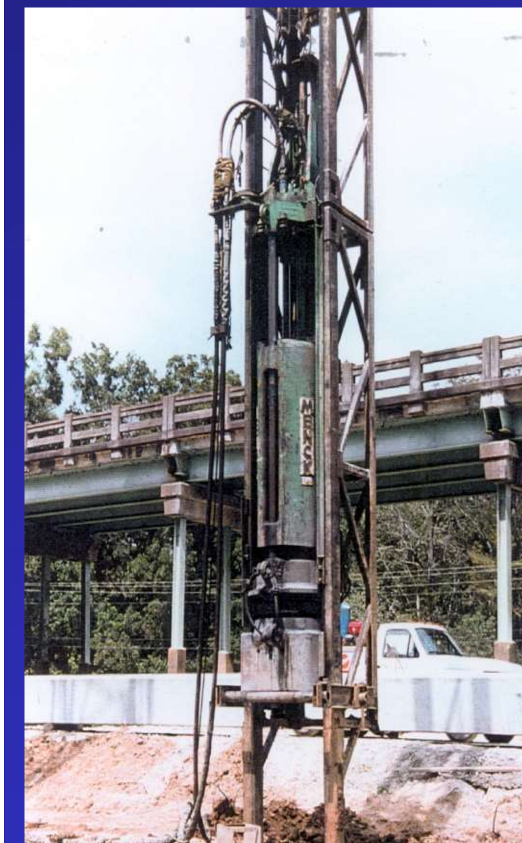
Michael R. Sharp
URS Corporation

William "Bubba" Knight
PSI (previously w/FDOT)



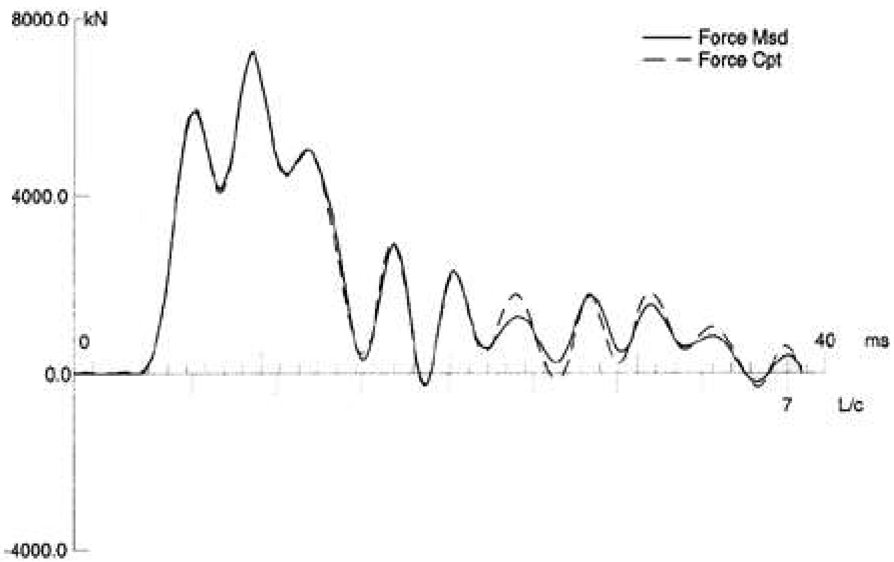
Test Pile Driving and Testing

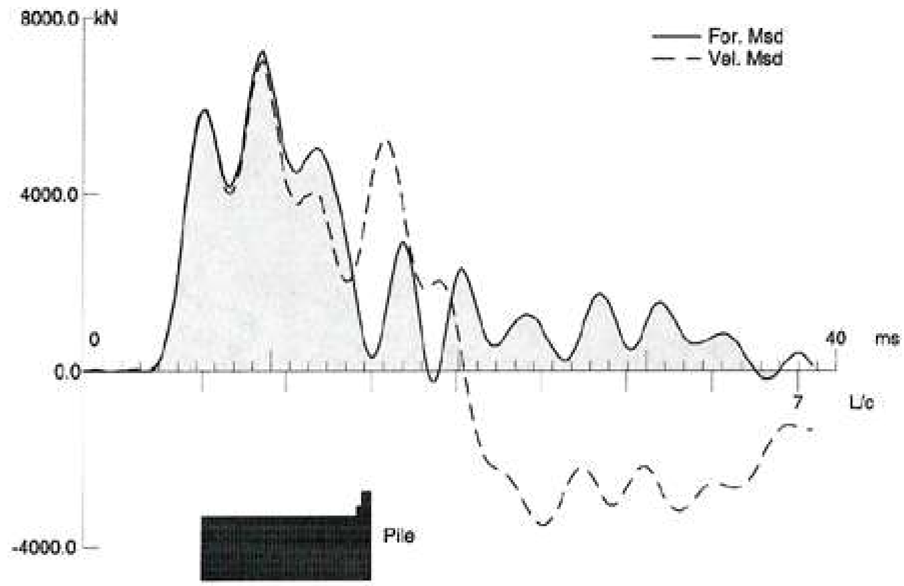


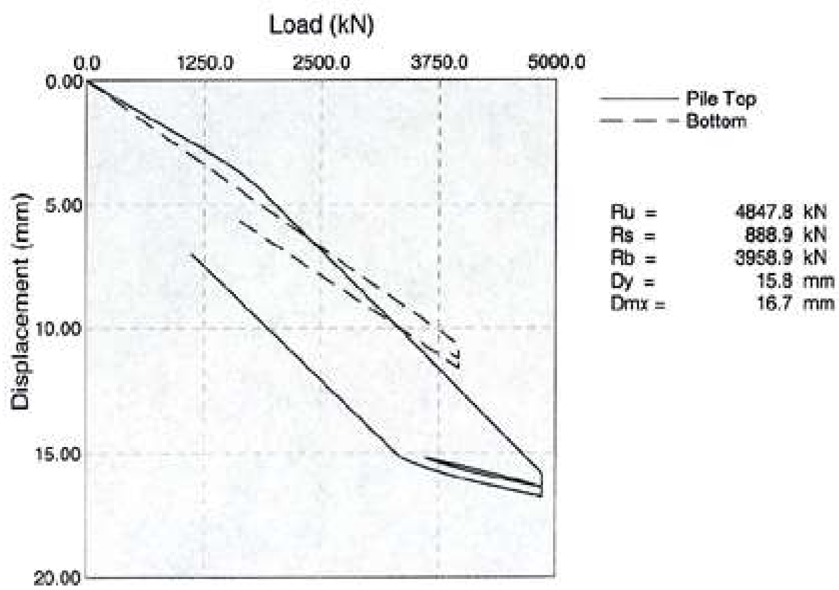


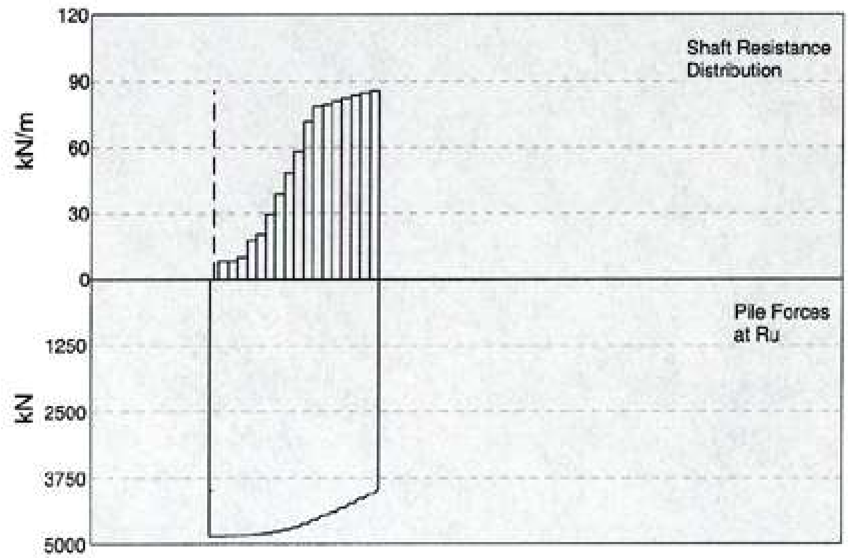
Menck MHF 5-12

Dynamic pile testing and data analysis results – end of initial drive









Summary of PDA/CAPWAP and Static Load Test Results

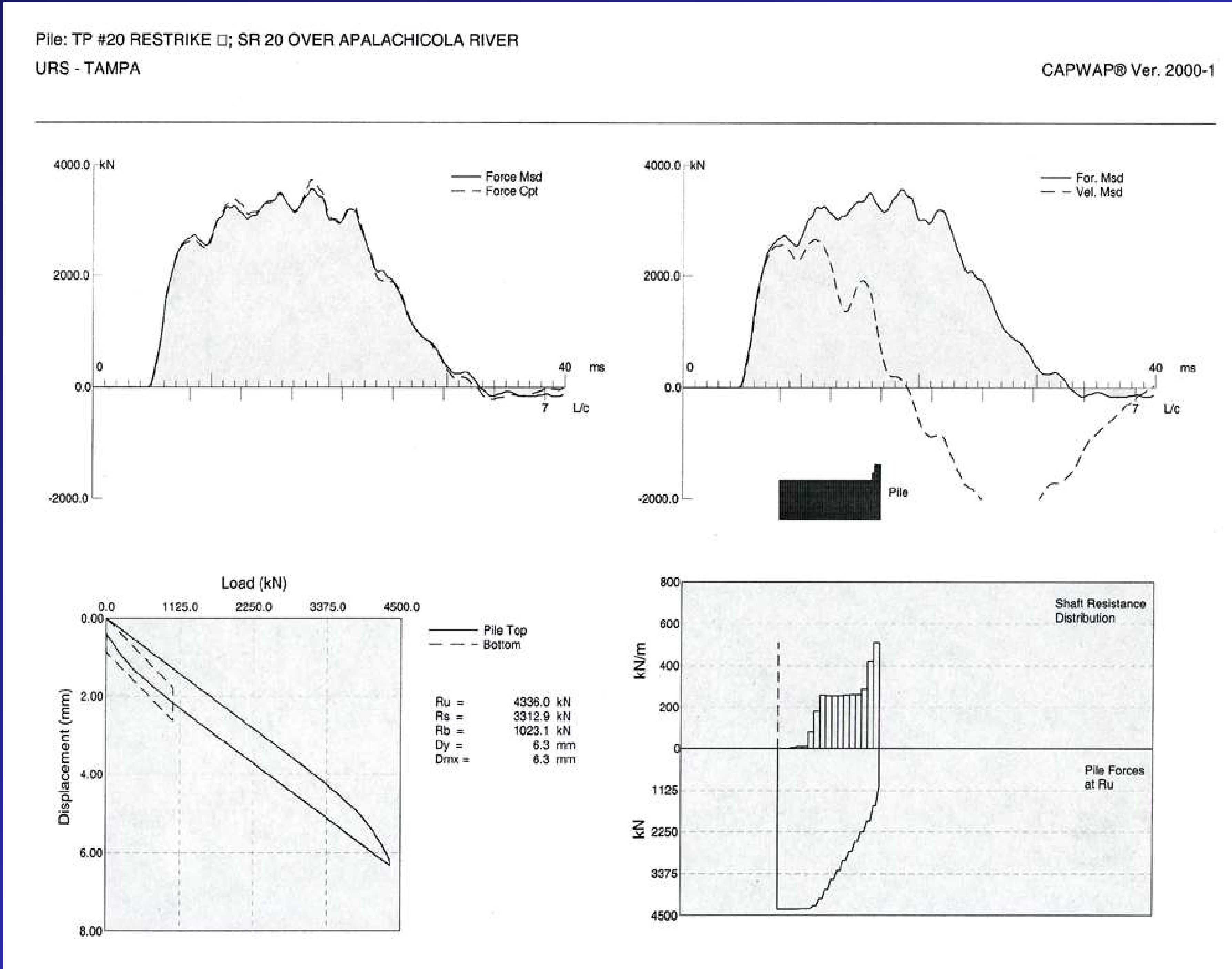
	Blow Count		Static Capacity, Kips		
			Skin Friction	End Bearing	Total Capacity
End of Driving	130 blows/foot		200	890	1090

Static Load Test

Summary of PDA/CAPWAP and Static Load Test Results

	Blow Count		Static Capacity, Kips		
			Skin Friction	End Bearing	Total Capacity
End of Driving	130 blows/foot		200	890	1090
Static Load Test					1630

Dynamic testing and data analysis results – restrike after static load test



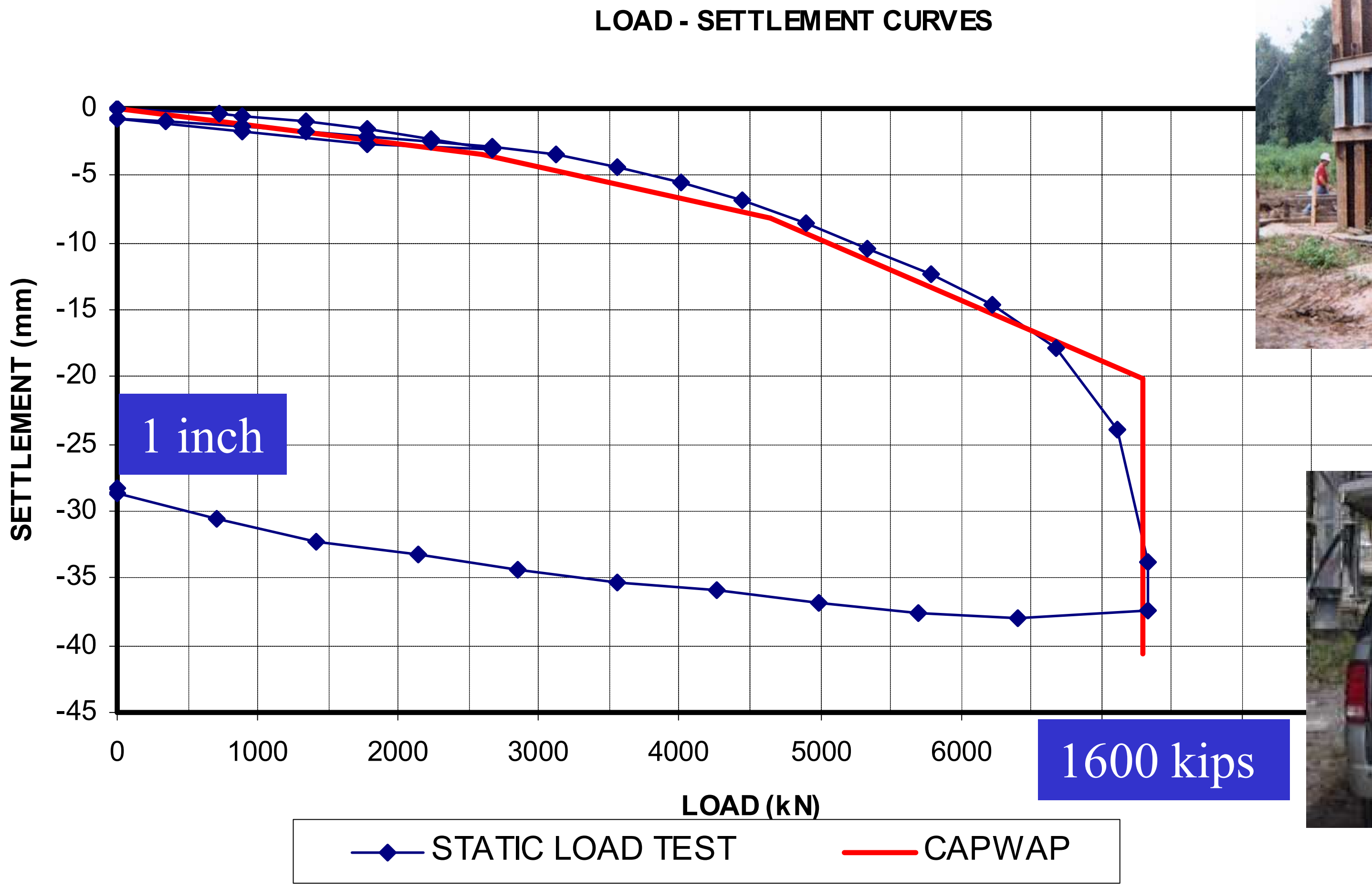
Summary of PDA/CAPWAP and Static Load Test Results

	Blow Count		Static Capacity, Kips		
			Skin Friction	End Bearing	Total Capacity
End of Driving	130 blows/foot		200	890	1090
Static Load Test					1630
Restrike	10 blows/inch		745	230	975

Summary of PDA/CAPWAP and Static Load Test Results

	Blow Count		Static Capacity, Kips		
			Skin Friction	End Bearing	Total Capacity
End of Driving	130 blows/foot		200	890	1090
Static Load Test					1630
Restrike	10 blows/inch		735	230	975
Superposition			735	890	1625

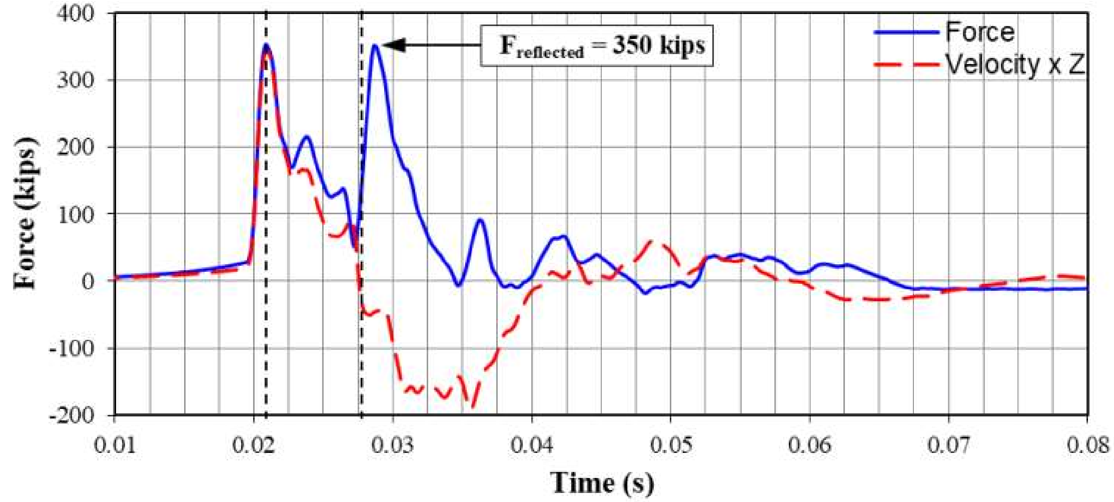
Comparison between Static Load test and CAPWAP results



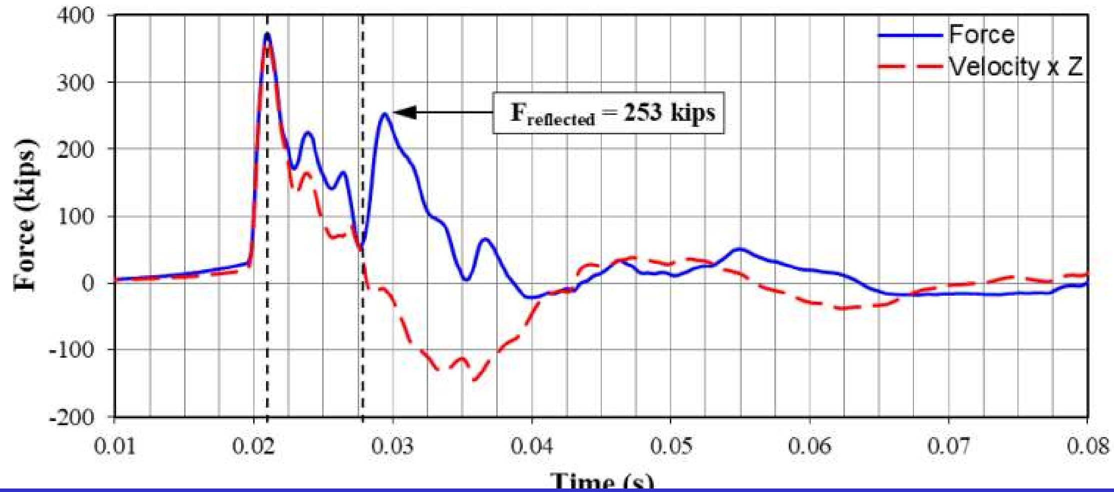
In cases of hammer energy limiting pile displacement/set, combining the pile end bearing from end of driving and skin friction from restrike testing provides best estimate for total, long-term pile capacity.

(if no relaxation)

End of Initial Driving		
FT1	353	kips
FMX	353	kips
RX9	400	kips
ROF	1.13	%
STK	7.03	ft
EMX	9.9	ft-kips
CSX	22.8	ksi
CSB	27.8	ksi



Beginning of Restrike		
FT1	372	kips
FMX	372	kips
RX9	271	kips
ROF	0.73	%
STK	7.31	ft
EMX	10.9	ft-kips
CSX	24.0	ksi
CSB	20.9	ksi



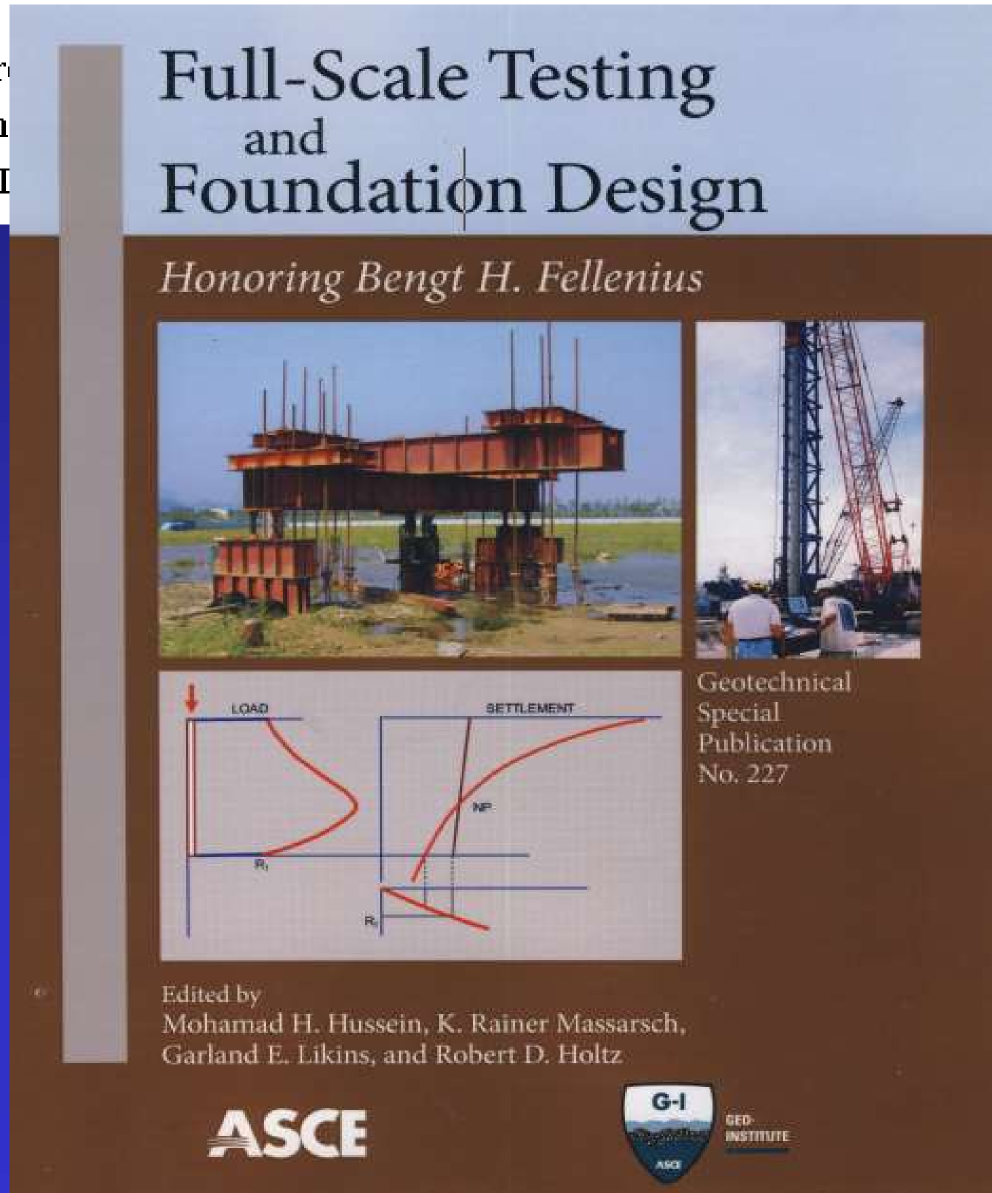
Considerations for Pile Capacity Assessment:

- Unexpected testing result.
- Combined dynamic and static testing.

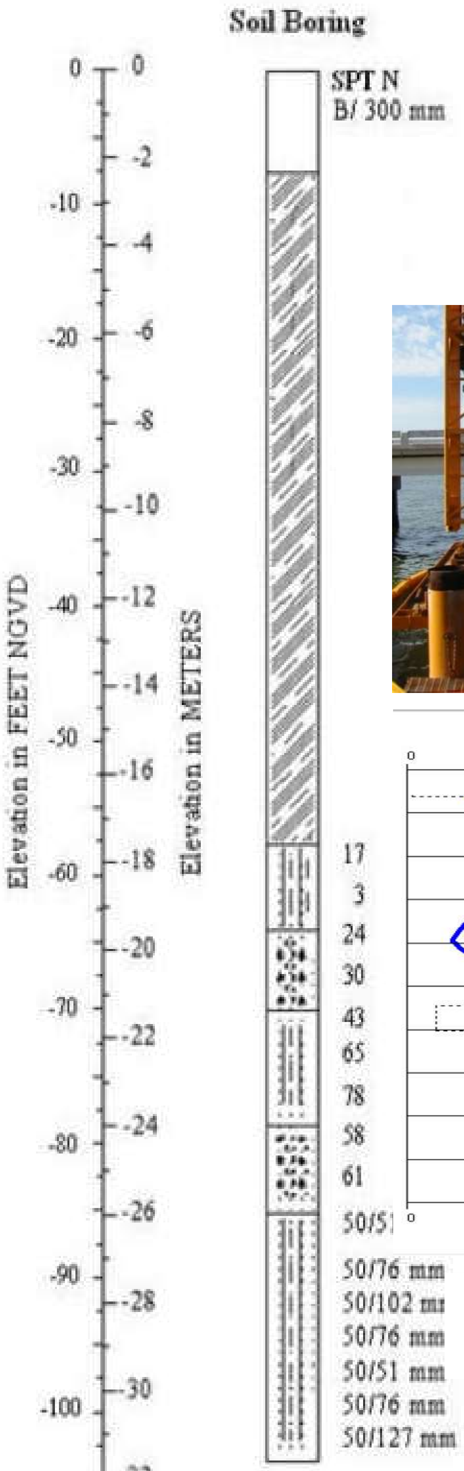
Knowledge is Bliss - A Case for Supplemental Pile Testing to Ascertain Fidelity

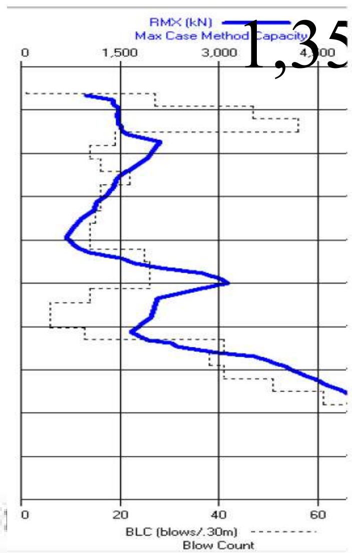
Mohamad H. Hussein[1], P.E., M.ASCE
Ross T. McGillivray[2], P.E., M.ASCE
Dan A. Brown[3], Ph.D., P.E., M.ASCE

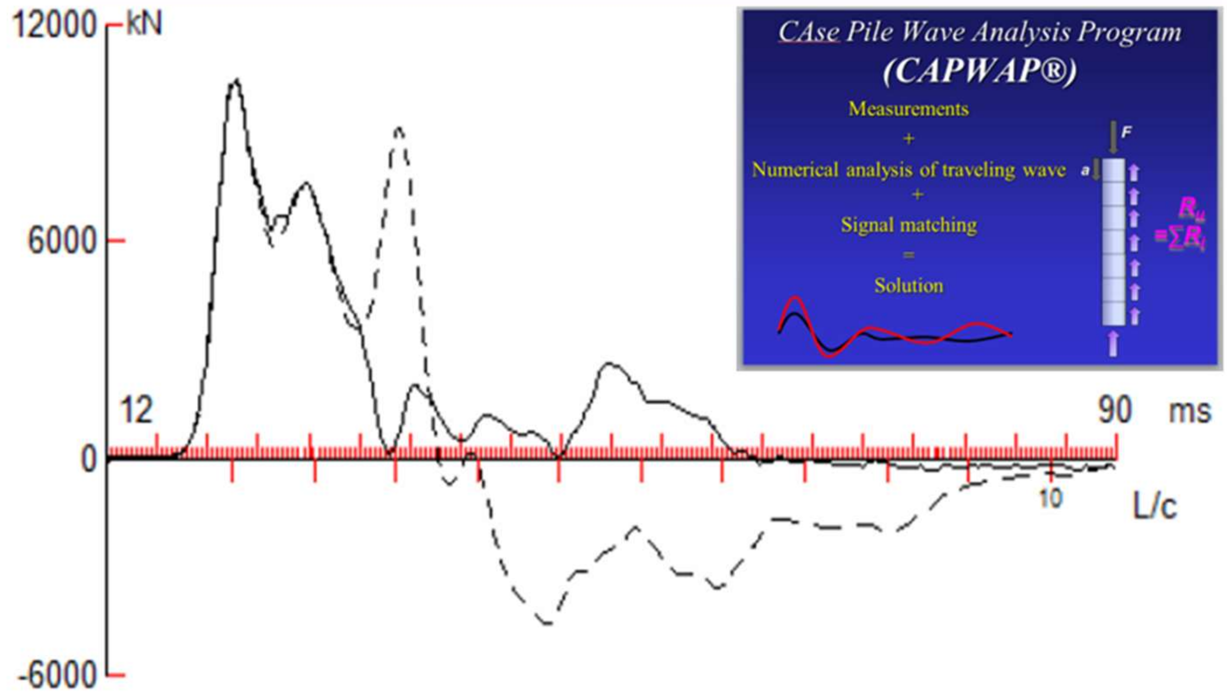
[1]Vice Pr ... ile.com>
[2]Senior Project En ... ay@ardaman.com>
[3] President, I ... sociates.com>

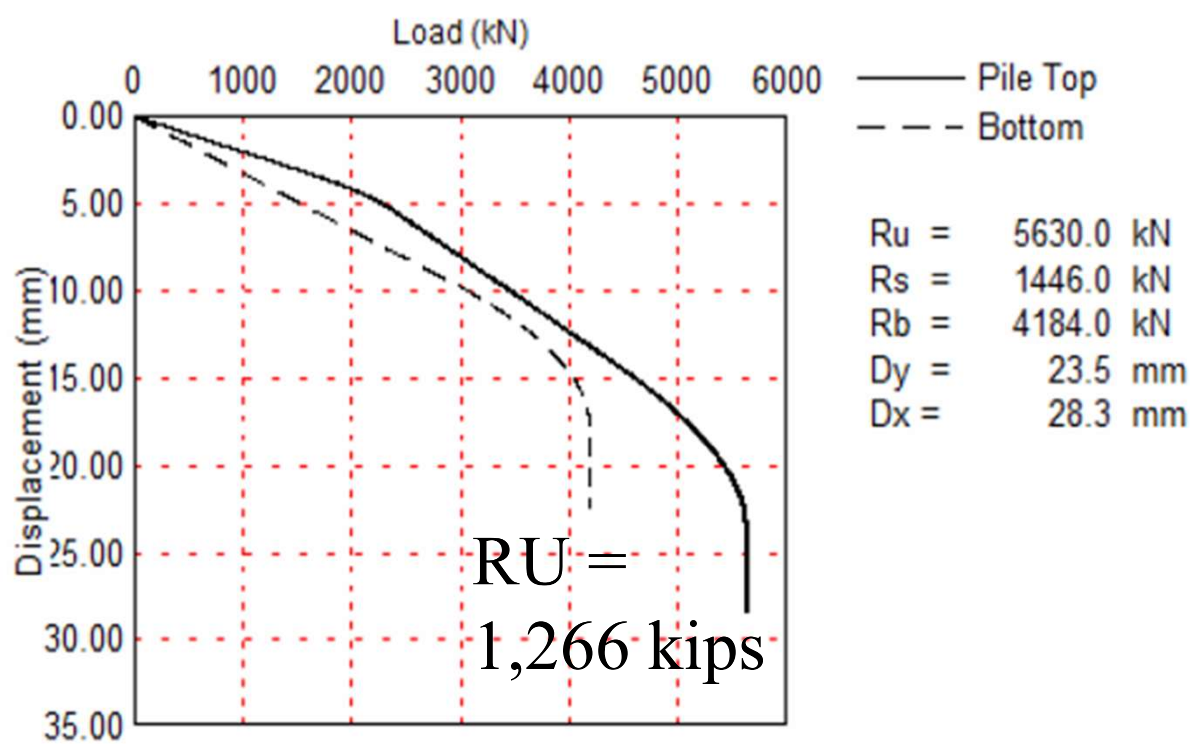


The 2.6-mile long, $243-million contract, twin bridges were supported on **36-inch square**, hollow with 23-inch circular void, prestressed concrete piles with lengths up to **140 feet** and the pile under consideration had a required capacity of 5760 kN (**1,295 kips**)

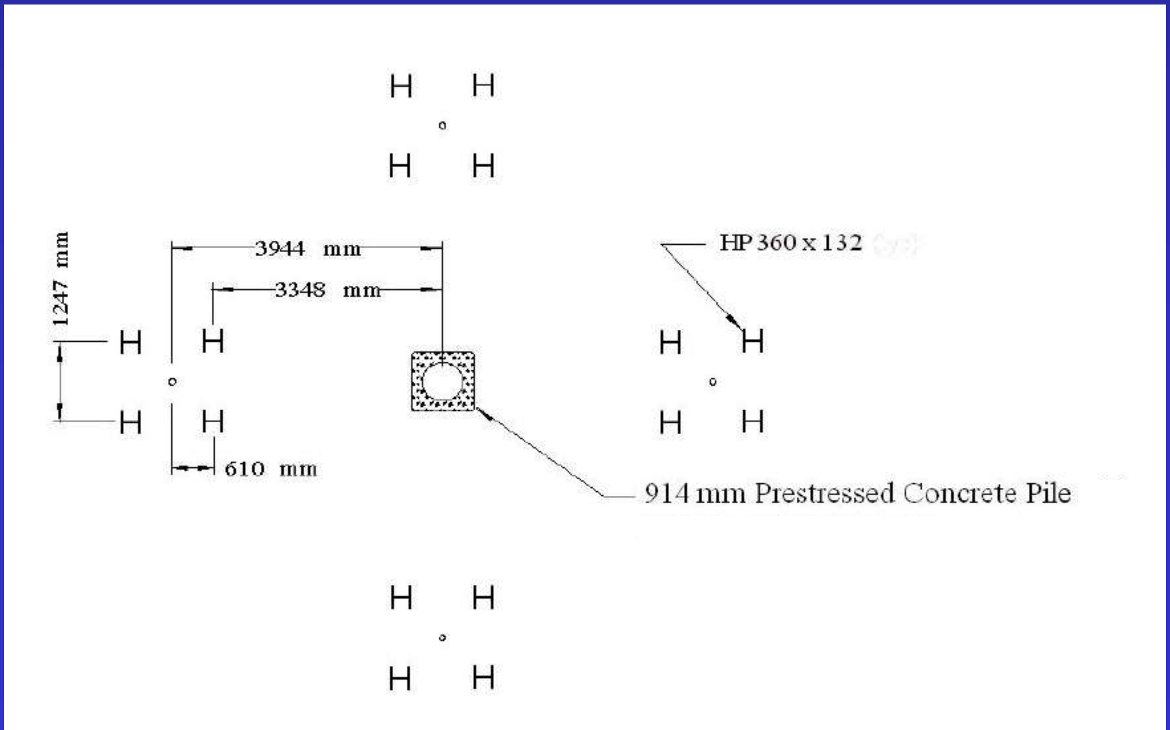

Soil Boring
SPT N
B/ 300 mm
Elevation in FEET NGVD
Elevation in METERS
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
17
3
24
30
43
65
78
58
61
50/51
50/76 mm
50/102 mm
50/76 mm
50/51 mm
50/76 mm
50/127 mm


RMX (kN)
Max Case Method Capacity
1,35
0
1,500
3,000
4,500
0
20
40
60
BLC (blows/.30m)
Blow Count

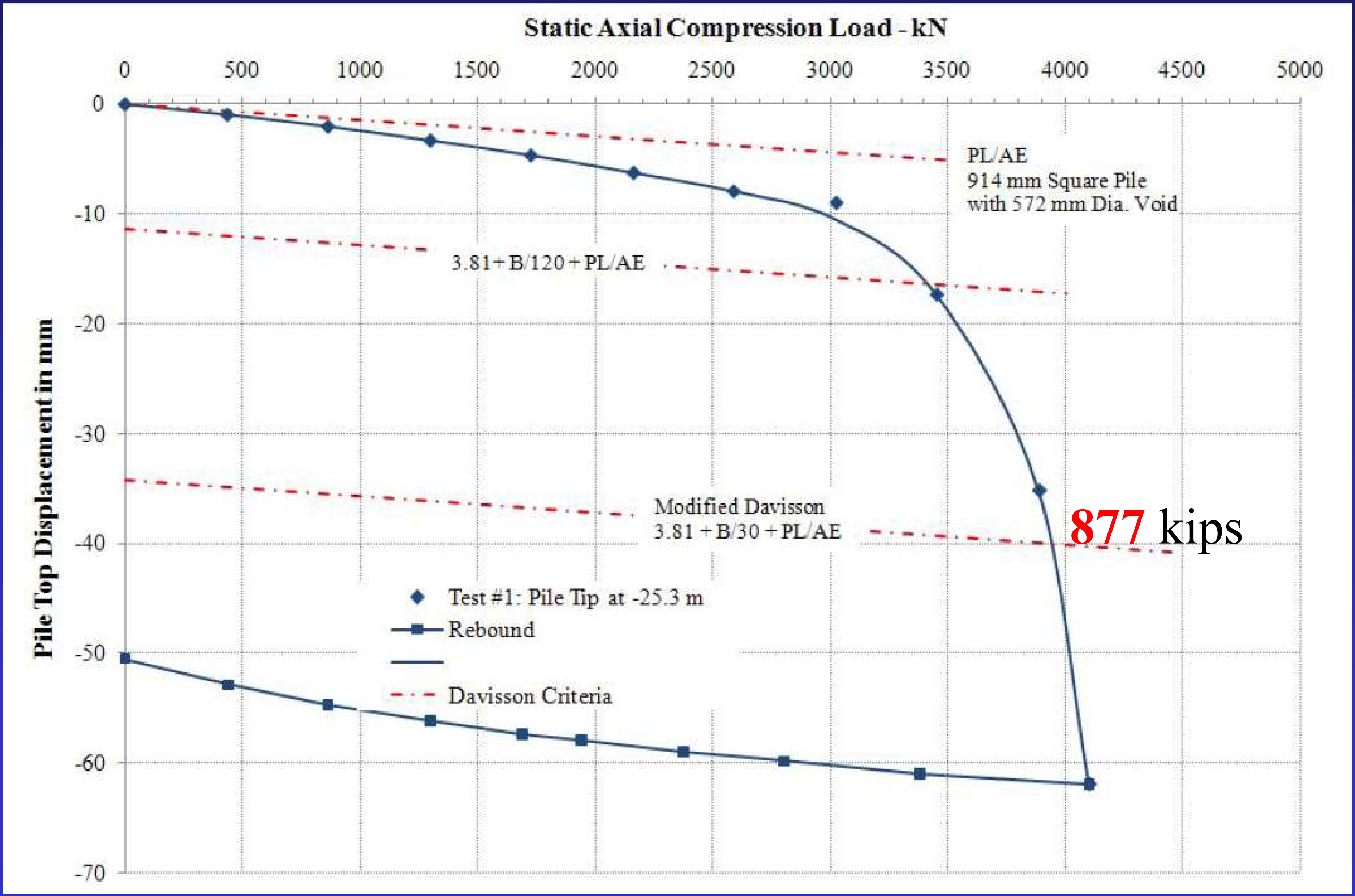

12000
kN
6000
0
-6000
12
90
ms
10
L/c
CAse Pile Wave Analysis Program
(CAPWAP®)
Measurements
+
Numerical analysis of traveling wave
+
Signal matching
=
Solution
F
a
$R_u = \sum R_i$


Load (kN)
0
1000
2000
3000
4000
5000
6000
Pile Top
Bottom
Displacement (mm)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
Ru = 5630.0 kN
Rs = 1446.0 kN
Rb = 4184.0 kN
Dy = 23.5 mm
Dx = 28.3 mm
RU =
1,266 kips

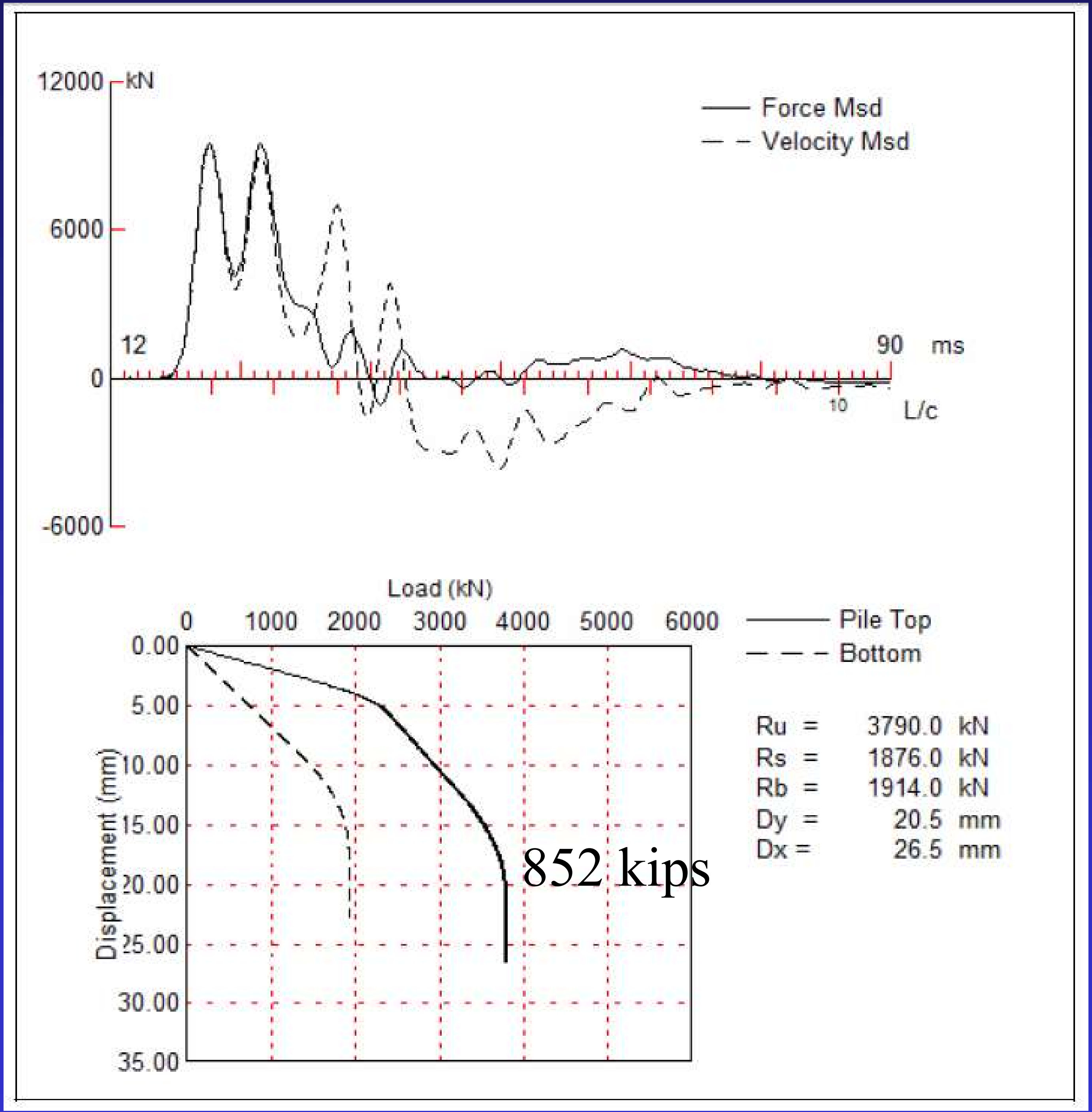

225


3944 mm
3348 mm
1247 mm
610 mm
HP 360 x 132
914 mm Prestressed Concrete Pile

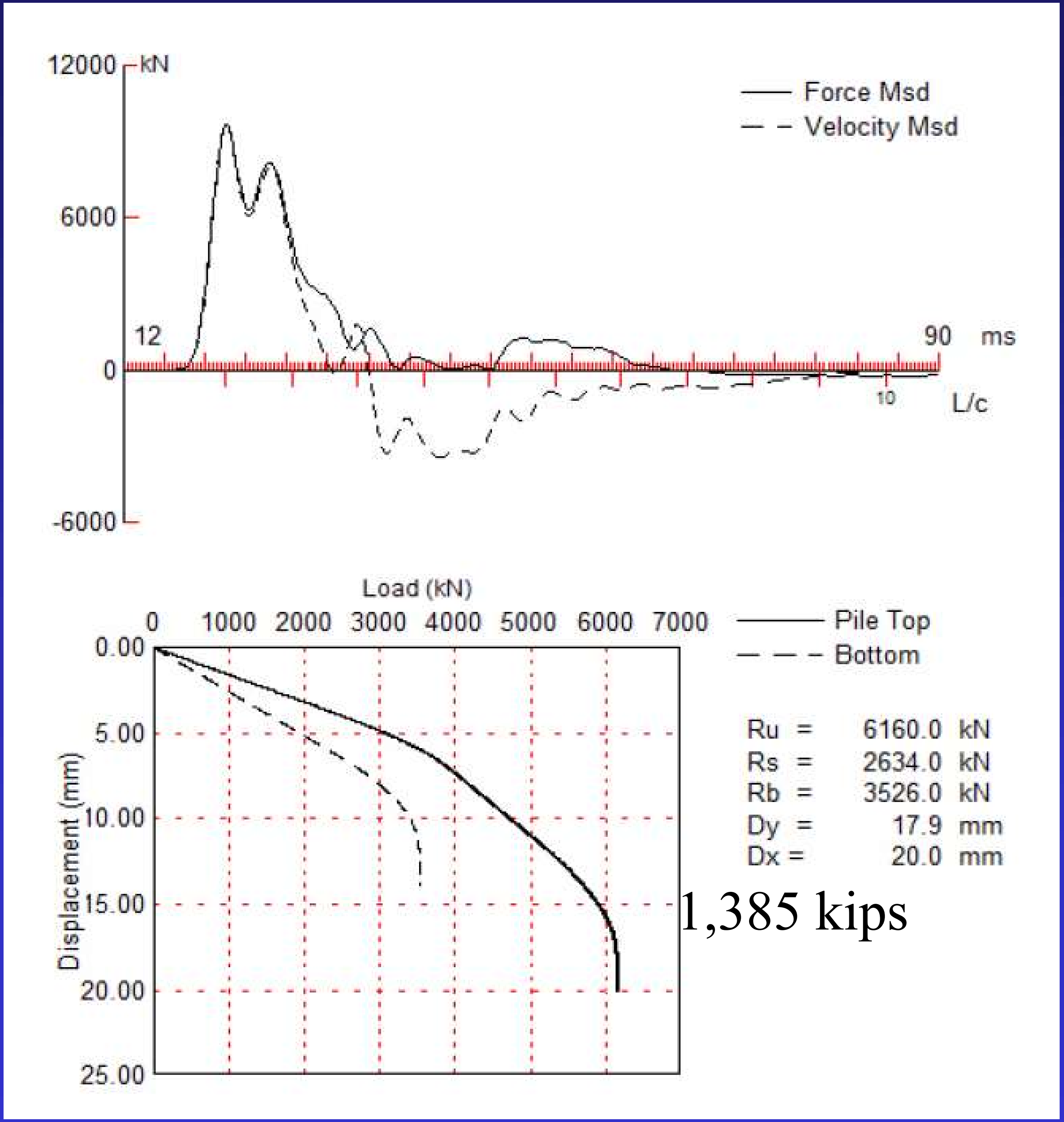
Static load testing result



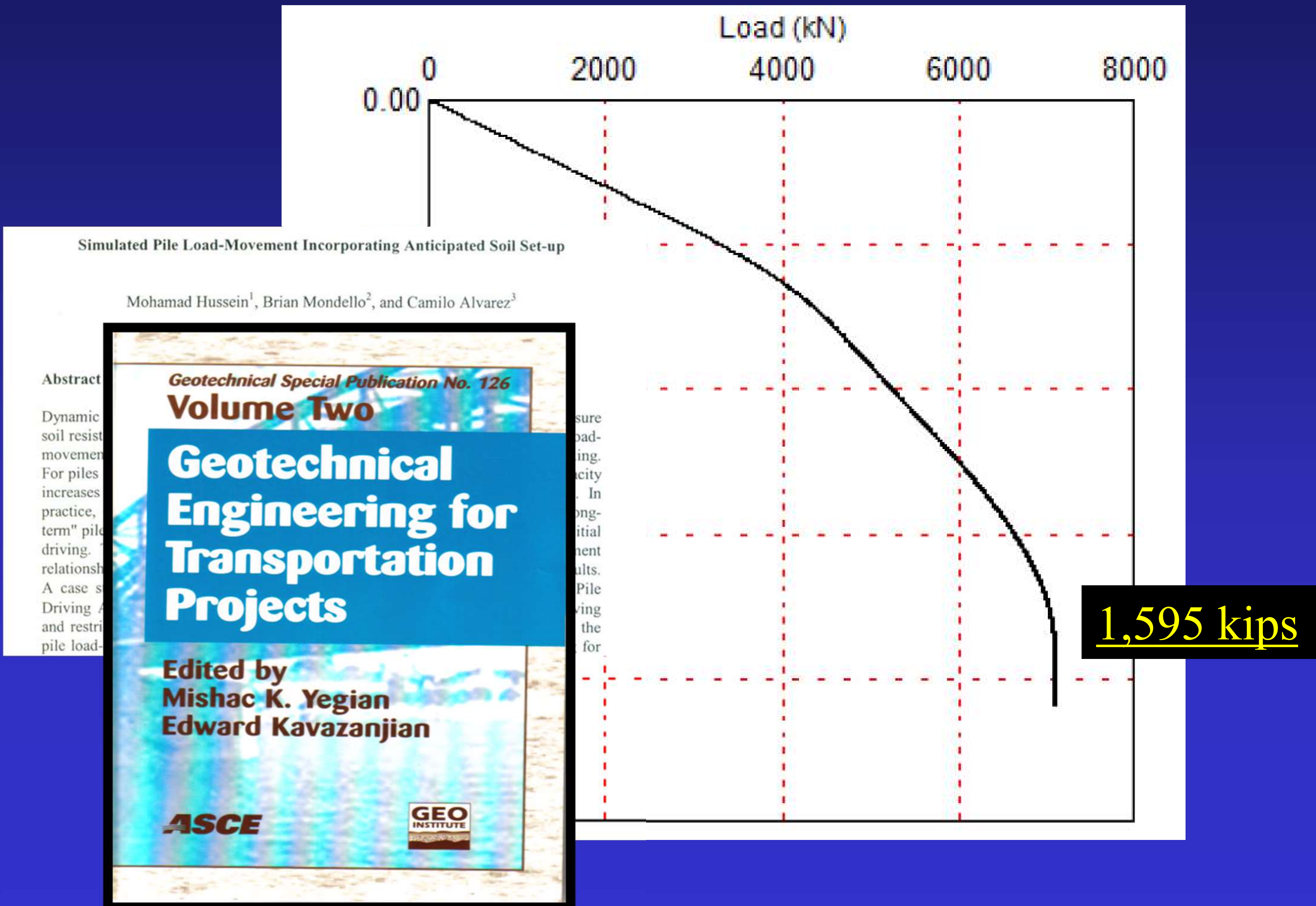
Results of dynamic testing performed after static load test



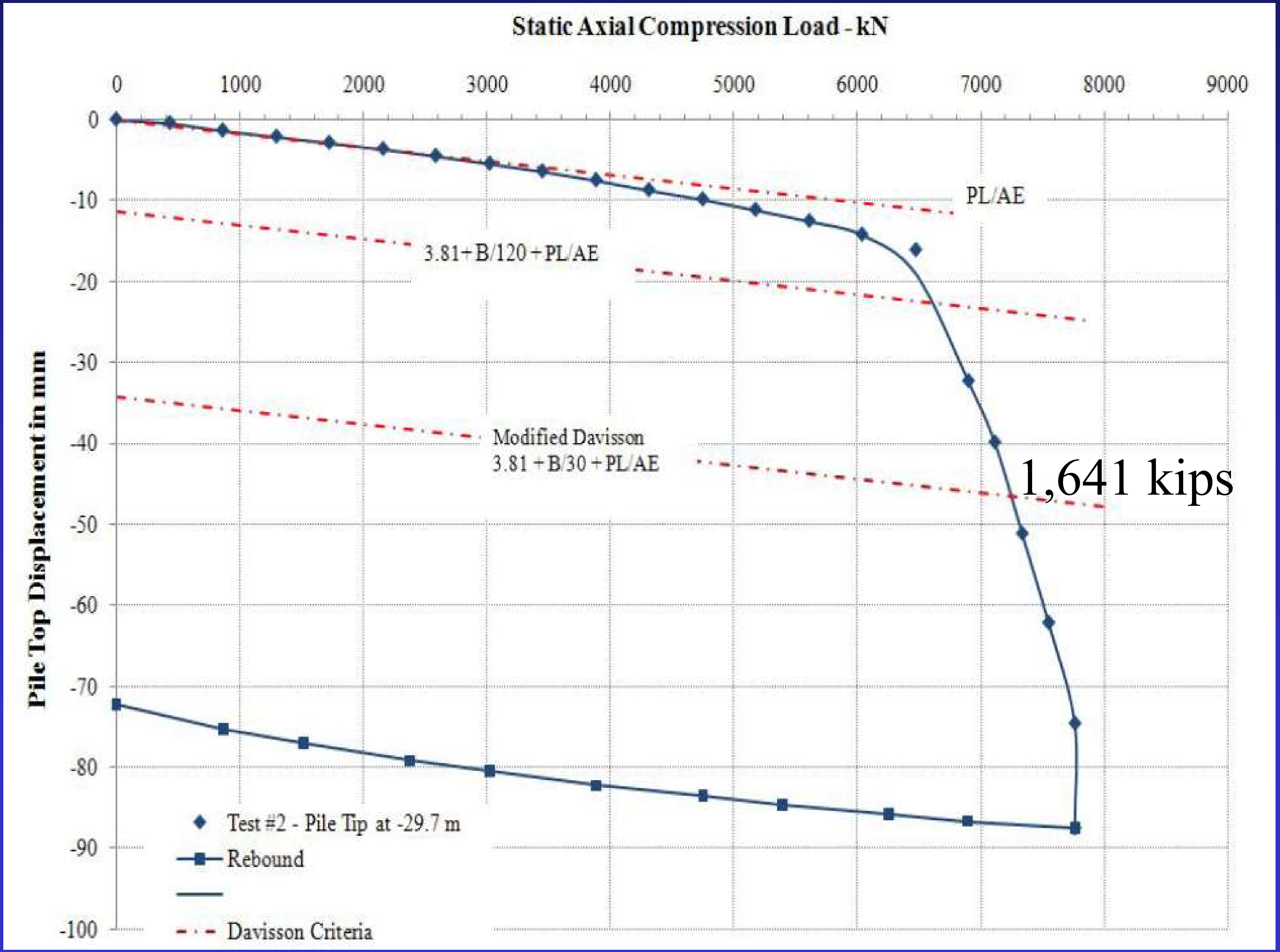
Results of dynamic testing at the end of 8.5 ft pile redrive



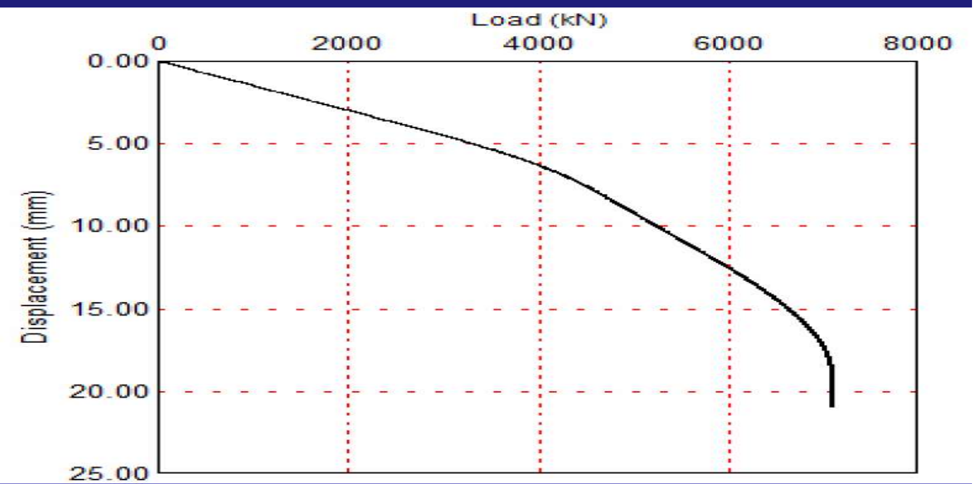
Combined dynamic testing results – end of redrive and setup effects
Predicted before the performance of the second static load test

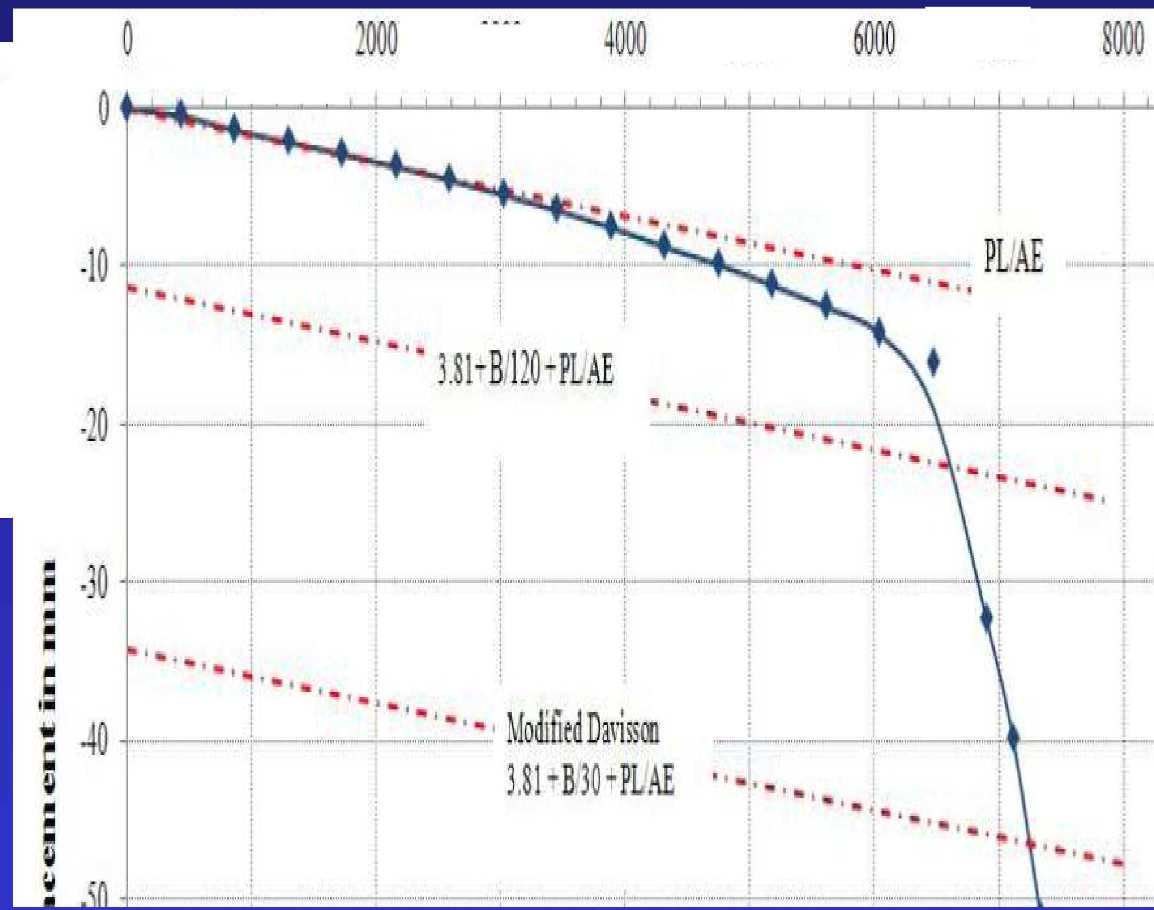


Second static load testing result



Predicted with dynamic testing Measured with static load test





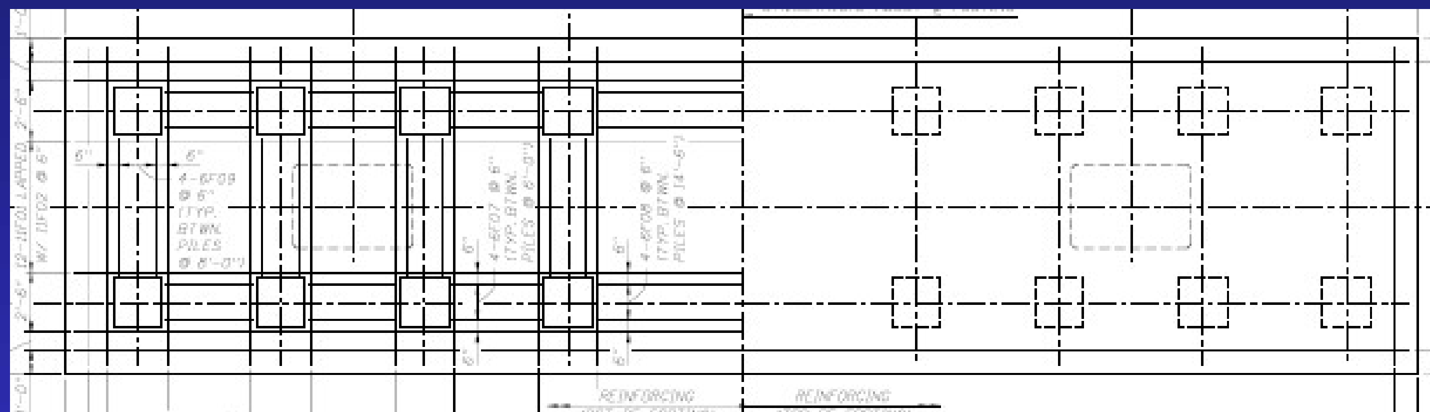
Combing dynamic testing with static load testing provided the means to explain curious results and for the proper assessment of pile load bearing capacity.

Considerations for Pile Capacity Assessment:

- Assessment of the load bearing capacity of a pile with damage.

<u>Prestressed Concrete Pile: 24” square, 130’ long.</u>

Nominal Bearing Resistance, NBR = 635 kips
(ultimate load bearing capacity).

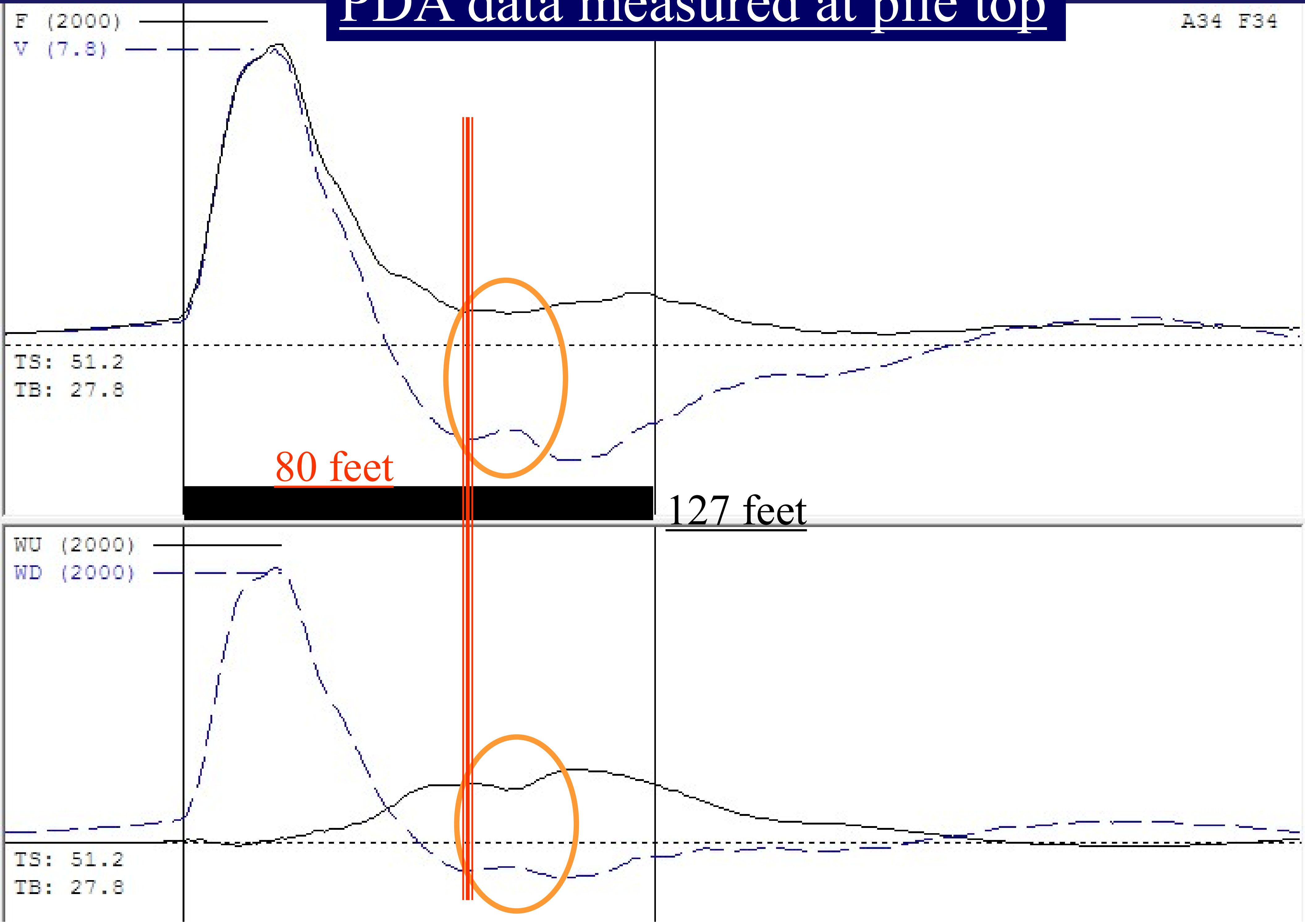


Pile driven with an open-end diesel D-62 hammer.

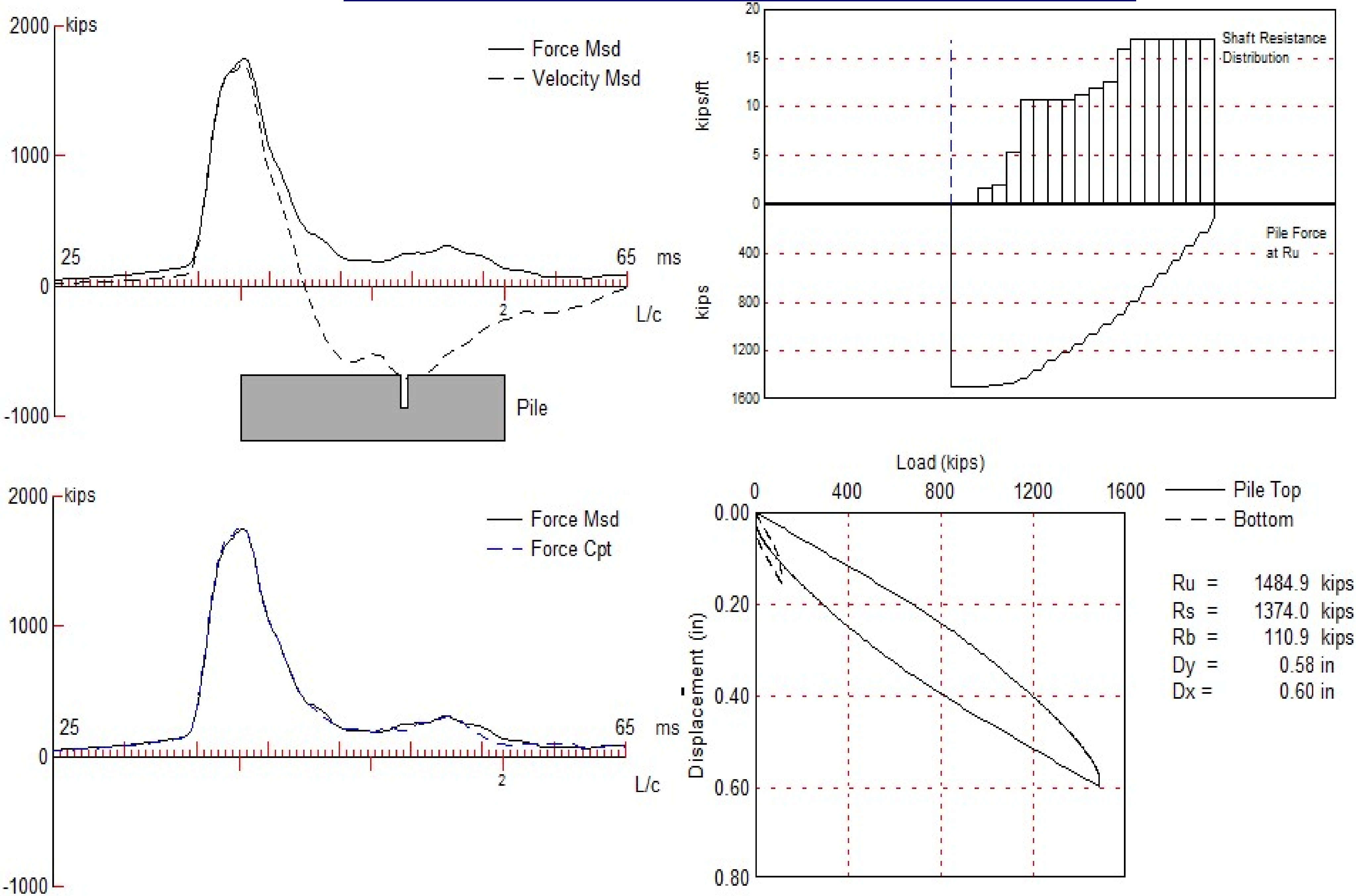
At final penetration of 125 feet, end of driving blow count was 61 blows/foot with 7.9 ft hammer stroke height.

Two weeks later, **PDA pile restrike test** had 13 blows for 1/16” pile set with 8.1 ft hammer stroke height.

PDA data measured at pile top



CAPWAP data analysis



PILE PROFILE AND PILE MODEL

Depth (ft)	Area (in²)	E-Modulus (ksi)	Spec. Weight (lb/ft³)	Perim. (ft)
0.00	576.00	6164.1	150.000	8.000
127.00	576.00	6164.1	150.000	8.000

Toe Area 4.000 ft²

Segmnt Number	Dist. B.G. ft	Impedance kips/ft/s	Imped. Change %	Tension Slack in	Tension Eff.	Compression Slack in	Compression Eff.	Perim. ft
1	3.34	257.35	0.00	0.000	0.000	-0.000	0.000	8.000
24	80.21	128.00	-50.26	0.000	0.000	-0.000	0.000	8.000
25	83.55	257.35	0.00	0.000	0.000	-0.000	0.000	8.000
38	127.00	257.35	0.00	0.000	0.000	-0.000	0.000	8.000

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CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 1484.9; along Shaft 1374.0; at Toe 110.9 kips

Soil Sgmnt No.	Dist. Below Gages ft	Depth Below Grade ft	Ru kips	Force in Pile kips	Sum of Ru kips	Unit Resist. (Depth) kips/ft	Unit Resist. (Area) ksf	Smith Damping Factor s/ft	Quak i
				1484.9					
1	6.7	4.7	0.0	1484.9	0.0	0.00	0.00	0.000	0.11
2	13.4	11.4	0.2	1484.7	0.2	0.03	0.00	0.300	0.11
3	20.1	18.1	10.9	1473.8	11.1	1.63	0.20	0.300	0.11
4	26.7	24.7	12.9	1460.9	24.0	1.93	0.24	0.300	0.11
5	33.4	31.4	35.5	1425.4	59.5	5.31	0.66	0.300	0.11
6	40.1	38.1	72.0	1353.4	131.5	10.77	1.35	0.300	0.11
7	46.8	44.8	72.0	1281.4	203.5	10.77	1.35	0.300	0.11
8	53.5	51.5	72.0	1209.4	275.5	10.77	1.35	0.300	0.11
9	60.2	58.2	72.0	1137.4	347.5	10.77	1.35	0.300	0.11
10	66.8	64.8	75.0	1062.4	422.5	11.22	1.40	0.300	0.11
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.89	1.49	0.300	0.11
12	80.2				586.0	12.57	1.57	0.300	0.11
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15.92	1.99	0.300	0.11
14	93.6	91.6	113.6	678.9	806.0	17.00	2.12	0.300	0.11
15	100.3	98.3	113.6	565.3	919.6	17.00	2.12	0.300	0.11
16	106.9	104.9	113.6	451.7	1033.2	17.00	2.12	0.300	0.11
17	113.6	111.6	113.6	338.1	1146.8	17.00	2.12	0.300	0.11
18	120.3	118.3	113.6	224.5	1260.4	17.00	2.12	0.300	0.10
19	127.0	125.0	113.6	110.9	1374.0	17.00	2.12	0.300	0.10
Avg. Shaft			72.3			10.99	1.37	0.300	0.11
Toe			110.9				27.72	0.384	0.10

Soil Model Parameters/Extensions Shaft Toe

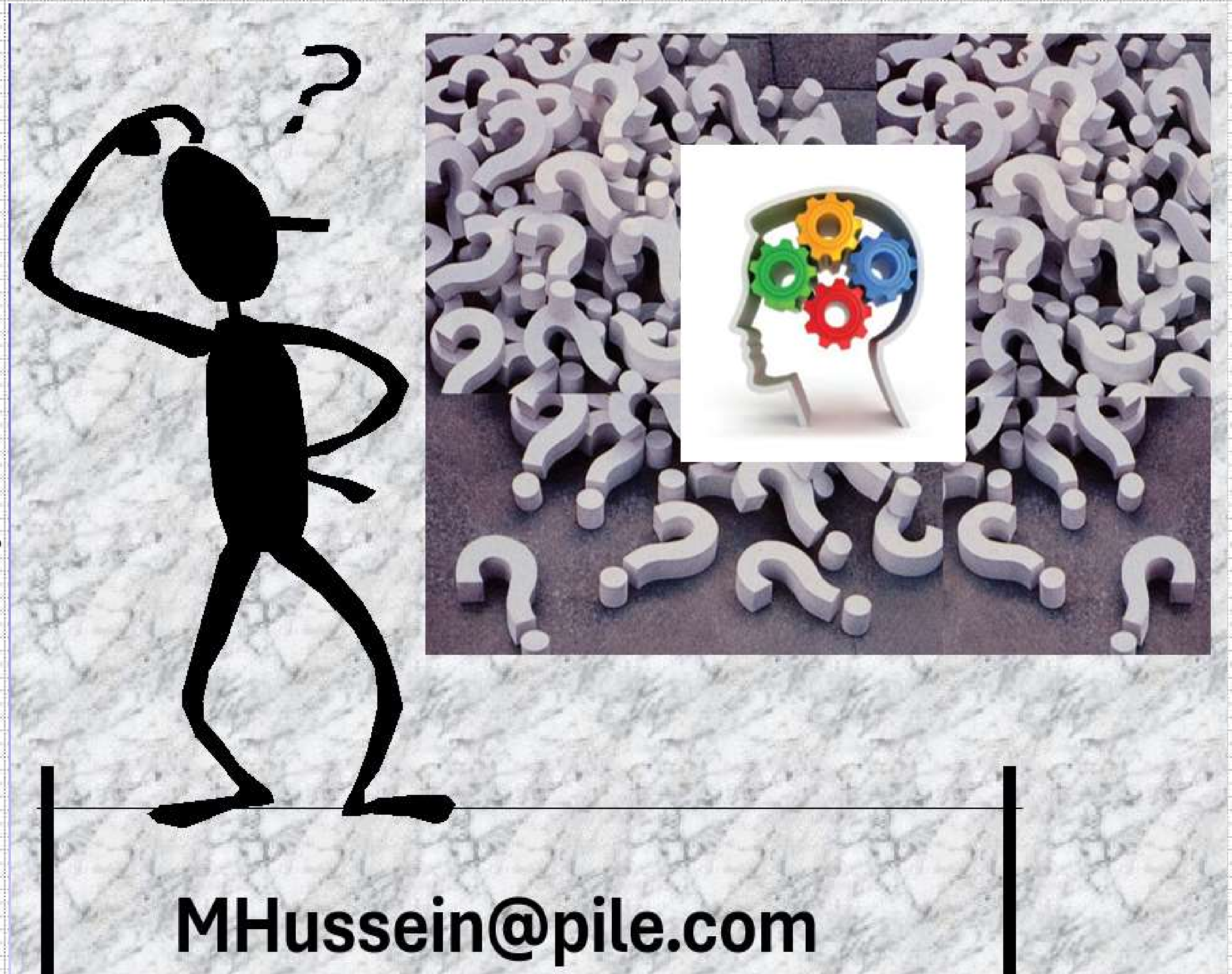
Testing results indicated the pile is partially damaged at 80 feet, and that it has skin friction resistance down to this location that meets 92% of the required pile ultimate load bearing capacity.

The pile was accepted in-place based on engineering considerations of the testing results and pile-specific design requirements.

CONCLUSION:

In addition to good data quality and competent analysis, engineering considerations are also needed for the proper and effective use of testing results for foundation evaluations.

Thank you.



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