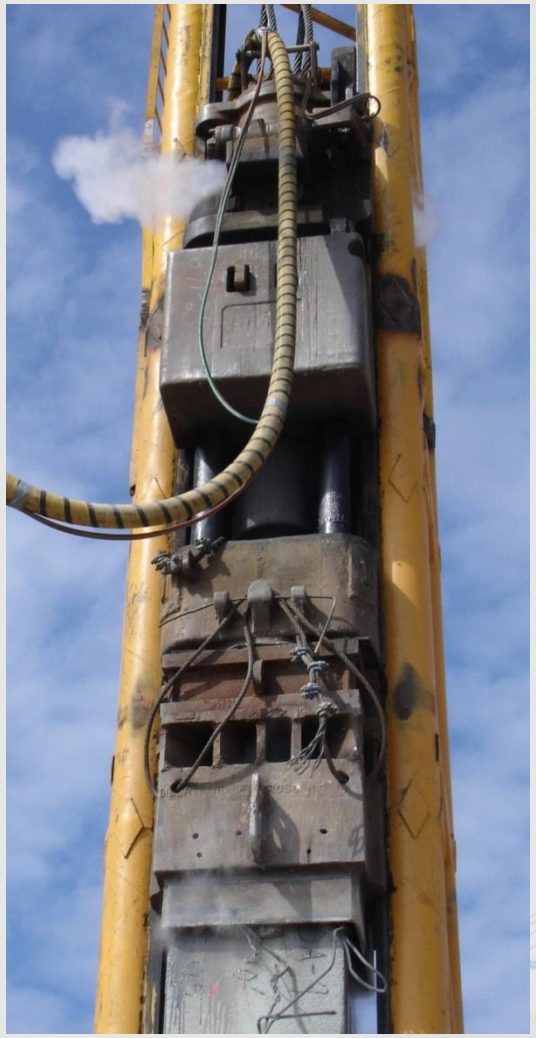
Drilled Shaft Testing

Pile Dynamics, Inc. Representative Days

September 27 – 29, 2017

For driven piles we usually have a dynamic loading system



Dynamic Testing of cast-in-situ piles

- need large drop weight
  - Approx 2% or more of ultimate capacity
    - e.g. 20 ton weight to assess 1000 tons capacity
    - GRLWEAP to assess weight and cushion
- prepare pile top
  - top transducer
  - excavate or build up pile top - 4 strains
  - flat top protected by cushion
- analysis method (CAPWAP®)

DLT on Bored Pile and CFA Piles

CAPWAP must also model non-uniform pile

- ***Know the area at sensor location***
  - *measure circumference*
  - *Consider casing (composite), if applicable*
- ***Know the total concrete volume !***
  - ***Shape from calipers or TIP – recommended***
- ***Use soil profile information***
- ***Add impedance increases or shaft plug***

DLT on Drilled Shafts and CFA Piles

Can assess "system" with wave equation for given pile geometry, soil condition, and req'd ult capacity.

Drop Weight

Typically between 1% and 2% of required test load

1% rock socket

1.5% friction pile

2% end bearing in granular soils

(test to 1000 ton by 20 ton ram)

More is generally better (up to 5%)

DLT on Drilled Shafts and CFA Piles

Standard procedure:

Blows of increasing drop height, until either:

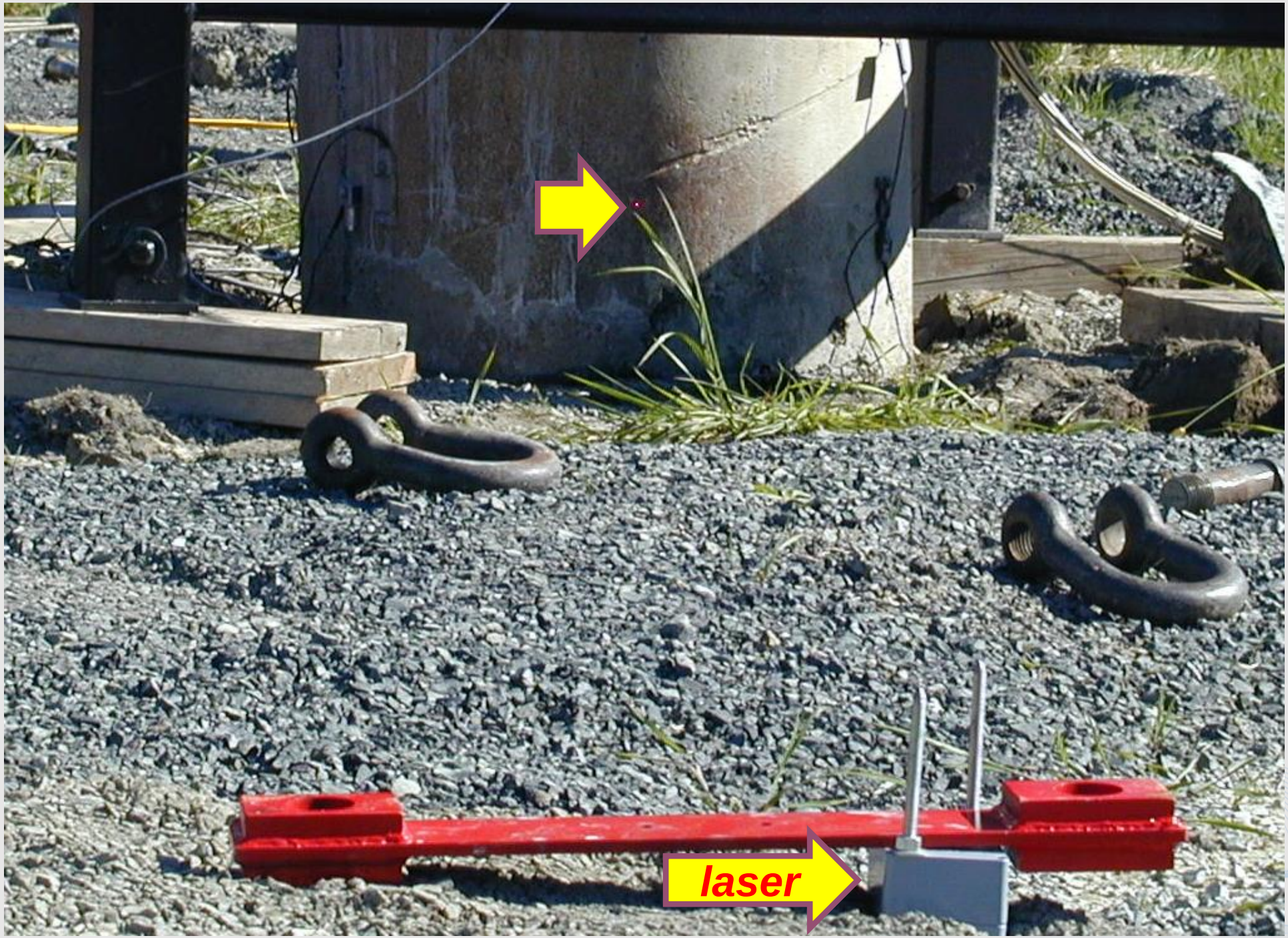
1. ***Permanent set > 3 ~ 4 mm (0.12 ~ 0.16 inches)***
   stop if > 5 mm (0.2 inch) or more set, or
2. ***Stresses reach the limit, or***
3. ***Capacity prediction > Required test load***

Pile Set

Measured Independently by

1. laser
2. piano wire / mirror setup
3. survey equipment
4. PDM

Set ideally between 1/4” and 1/8”
(6 to 3 mm)


laser

Information of Performed High Strain Dynamic Tests

E-mail: HSDT4 *Sheet 2/2*

Test #	Date	File Name	Top of pile Elevation	Existing Ground Elevation	CR (m)	L total (m)	Lp (m)	LE (m)	Indlinometer Depth * (m)	Blow #	Drop Height (m)	Set/Blow (mm)	Hammer cushion #	Pile cushion #
1	January 23, 2001	ENP1	98.65	96.85	2.15	23.65	21.85	22.00	16.15	1	0.50	1.44	5	8
										2	1.00	3.36	5	8
										3	1.50	4.15	5	8
2	January 23, 2001	ENP2 **	98.65	96.95	2.11	21.15	19.45	19.60	16.15	1	0.50	2.16	4	3
										2	1.00	4.05	4	3
										3	1.25	4.50	4	3
										4	1.25	5.50	4	3
3	January 23, 2001	ENP3 ***	98.65	96.90	1.60	21.15	19.40	19.60	16.15	1	0.25	0.92	3	4
										2	0.50	2.10	3	4
										3	0.75	3.30	3	4

Cushion #	Pile Diameter (cm)	Initial Thickness (mm)	Current Thickness (mm)
1	60	60	46
2	60	60	42
3	60	60	45
4	60	12	8
5	60	12	7
6	60	60	44.6
8	60	60	45
1	45	60	43.6
2	45	12	9.6
3	45	12	9
4	45	60	46

Increase drop heights until either stresses too large, or until achieve at least 3 mm (0.12”) set.

Stop test if 5 mm (0.2”) or more set.

DLT on Drilled Shafts and CFA Piles

Preparation of the top

System generally used in the USA

Build up pile top with steel casing

- *Reduces excavation*
- *Protects reinforcing*

4 strain transducers recommended

(2 or 4 accelerometers)

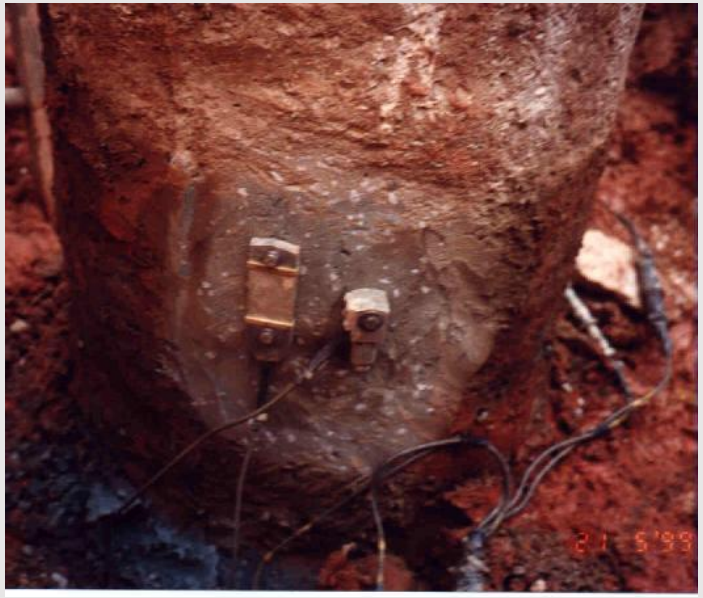
DLT on Drilled Shafts and CFA Piles

Preparation of the top

Another system

Reinforced cap executed after casting and cut-off

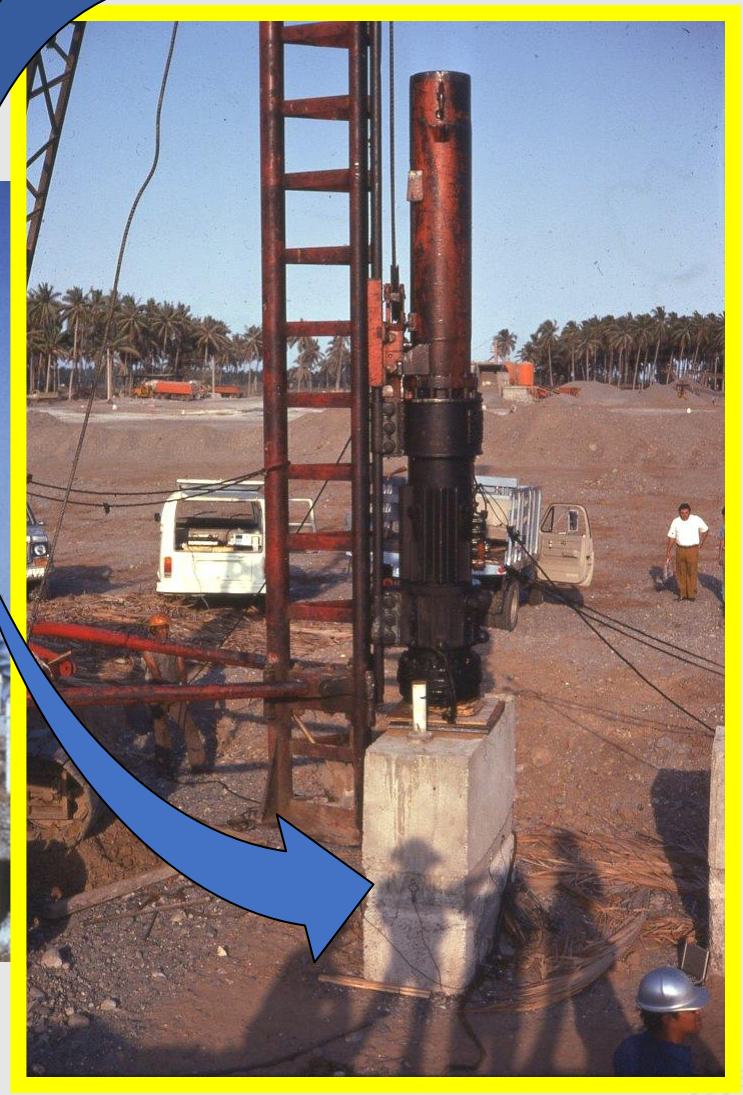
Sensors preferably installed on pile shaft surface smoothened with an electric grinder

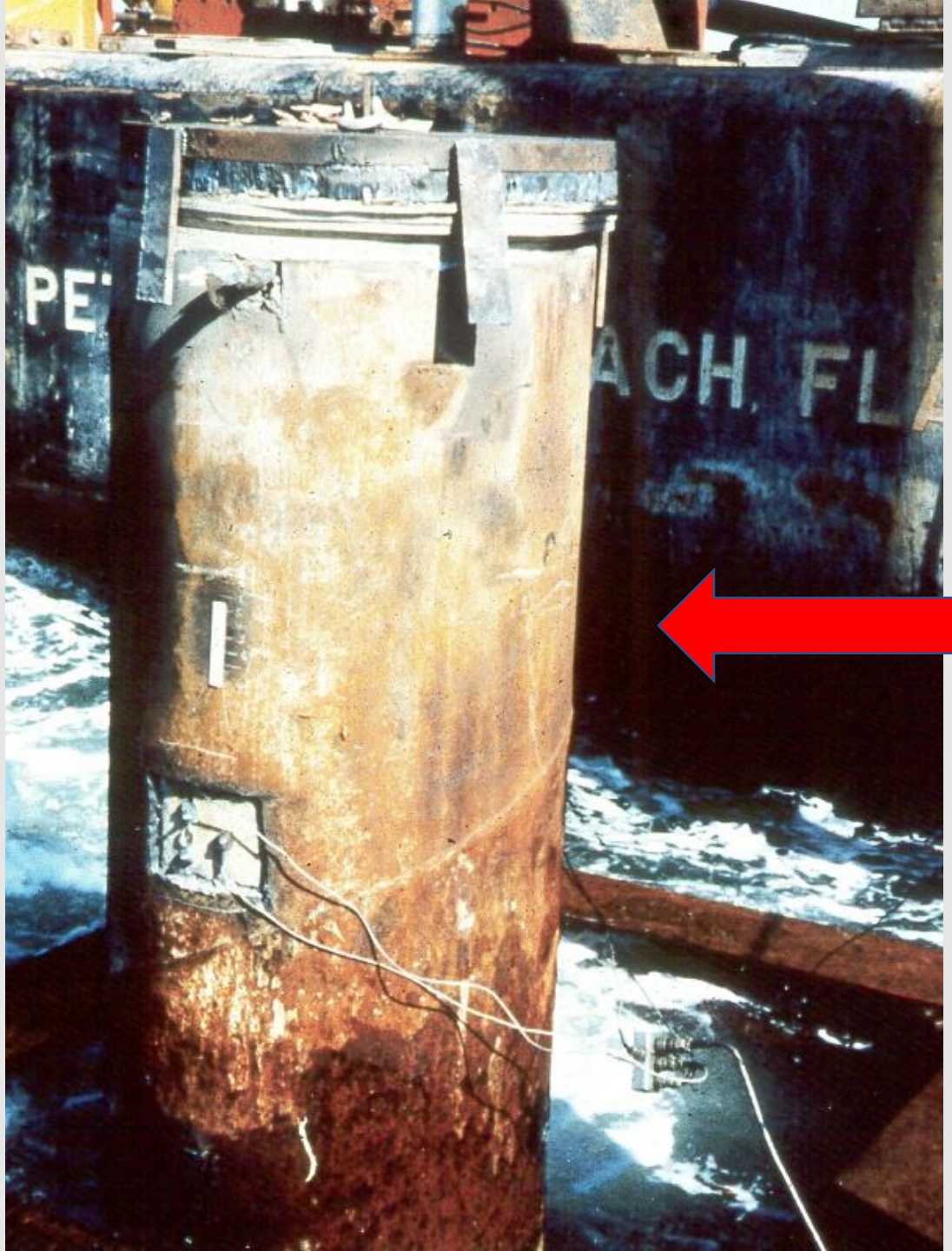


Photos provided by PDI Engenharia, RJ, Brazil

Las Truchas Mexico – June 1974

Testing barrette





Arbor Housing

Charleston WV

1977 CFA tests

Tampa, Florida

(early 1982)

"Sunshine Skyway"

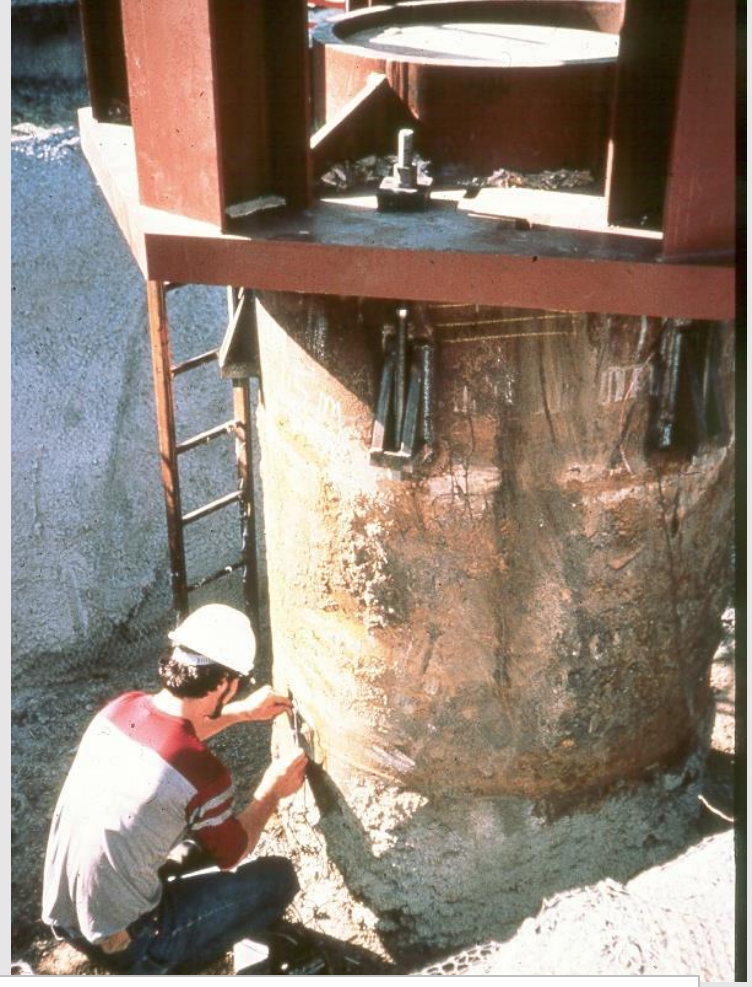
Melbourne, Australia

1982

Westgate Freeway

Tested 100 shafts
(1.5 m dia - 60 m long)

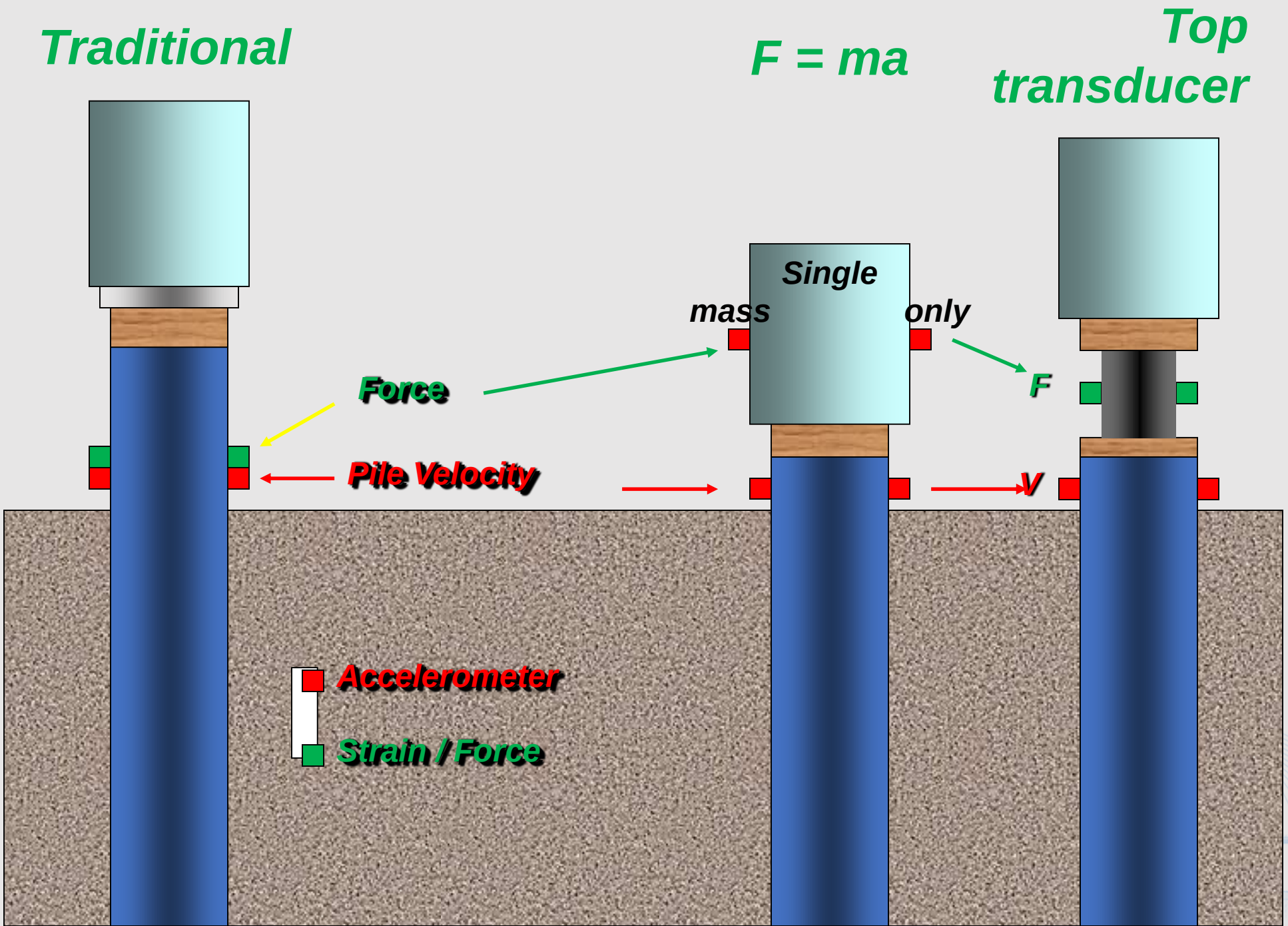
Socketed in Claystone
R_u = 2000 tons



Design and Performance of Dynamic Tests of Large Diameter Drilled Shafts, by: Rausche, F., Seidel, J.

Correlation of Static and Dynamic Pile Tests on Large Diameter Drilled Shafts; by: Seidel, J., Rausche, F.

Both papers presented at: **Second Int'l Conference on Application of Stress Wave Theory on Piles**: Stockholm, Sweden, **May 1984**.


Traditional
F = ma
Top transducer
Single mass only
Force
F
Pile Velocity
v
Accelerometer
Strain / Force


Use 4 strains


Force
Transducer


F = ma
Accelerometer
always on pile

Traditional - Pile Top Preparation

Remove steel casing for small diameter shafts

Tampa

$120 million repair cost

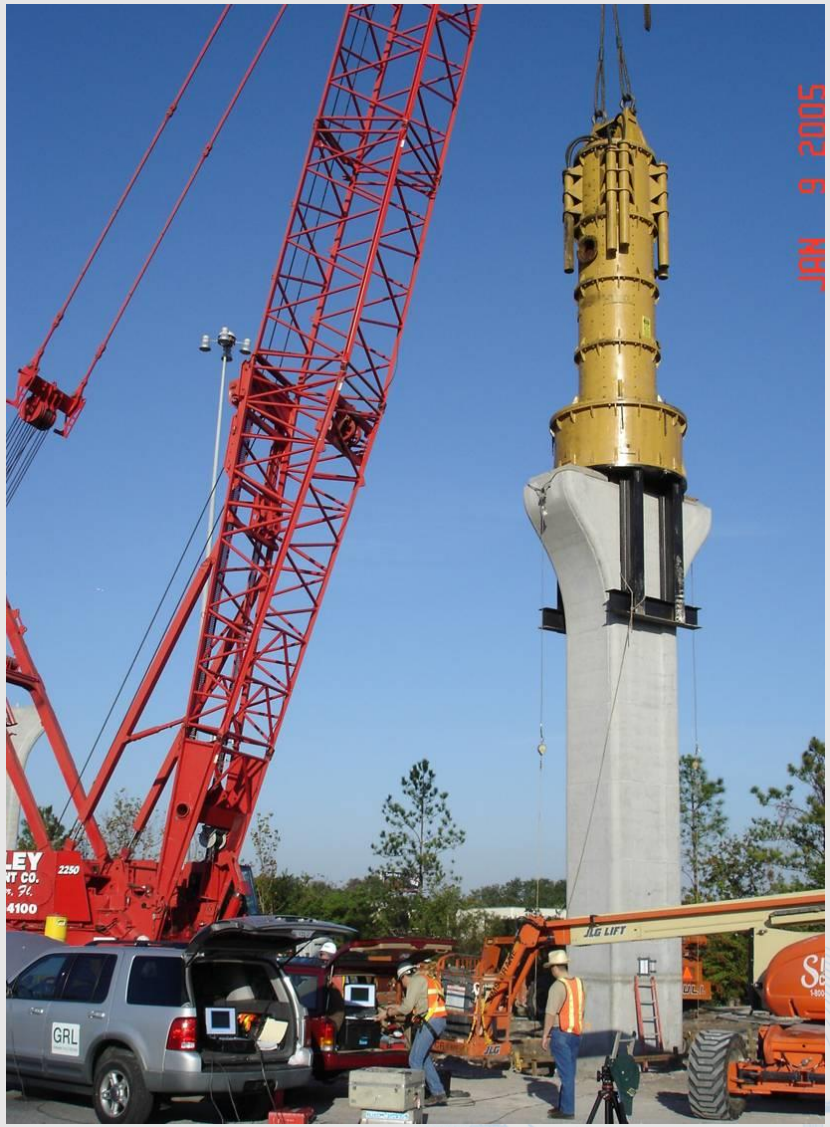
1 year delay

Tampa

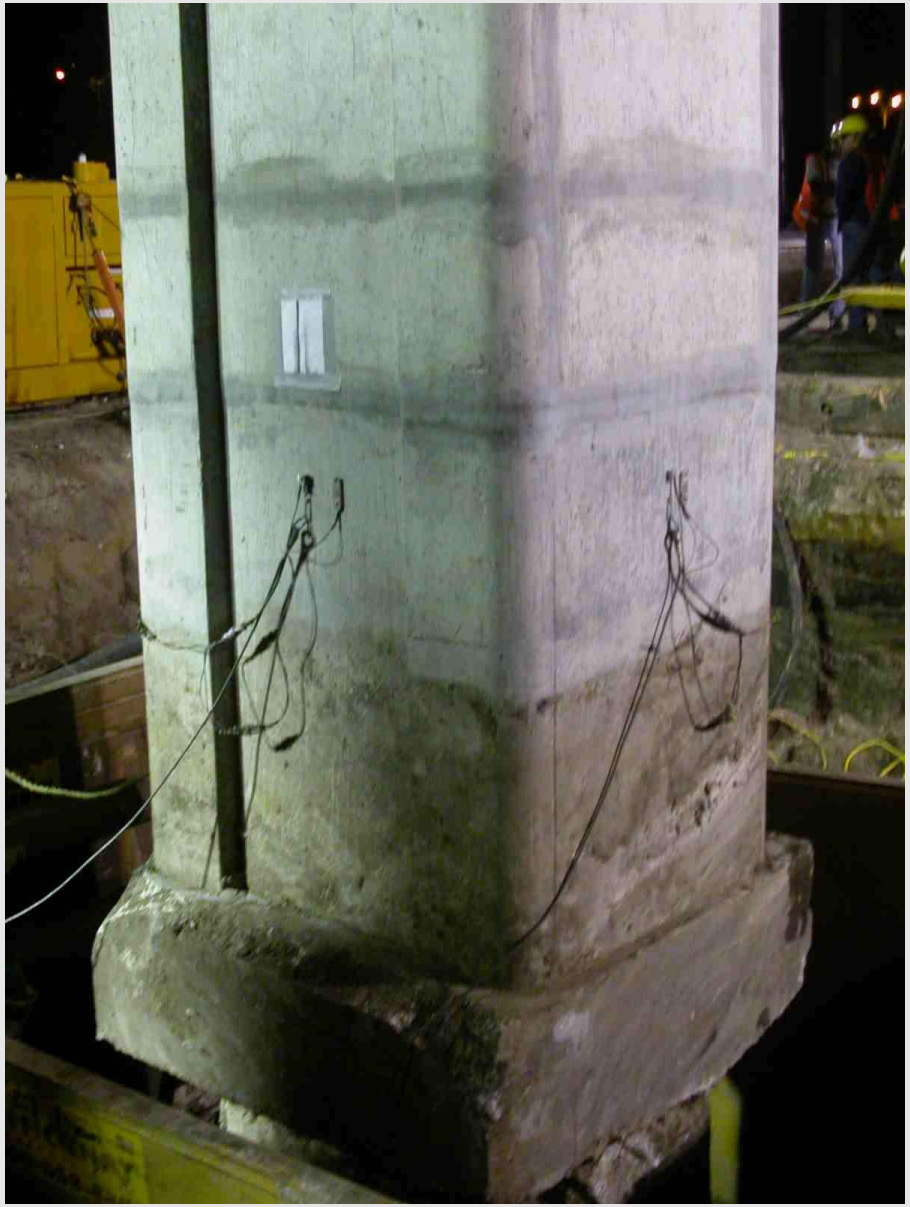
APE 750 hammer

- 60 ton ram
- 4.5 ft drop
- 6 ft dia. Shafts (under pier)

DAY and NIGHT: DRILLED SHAFT TESTING

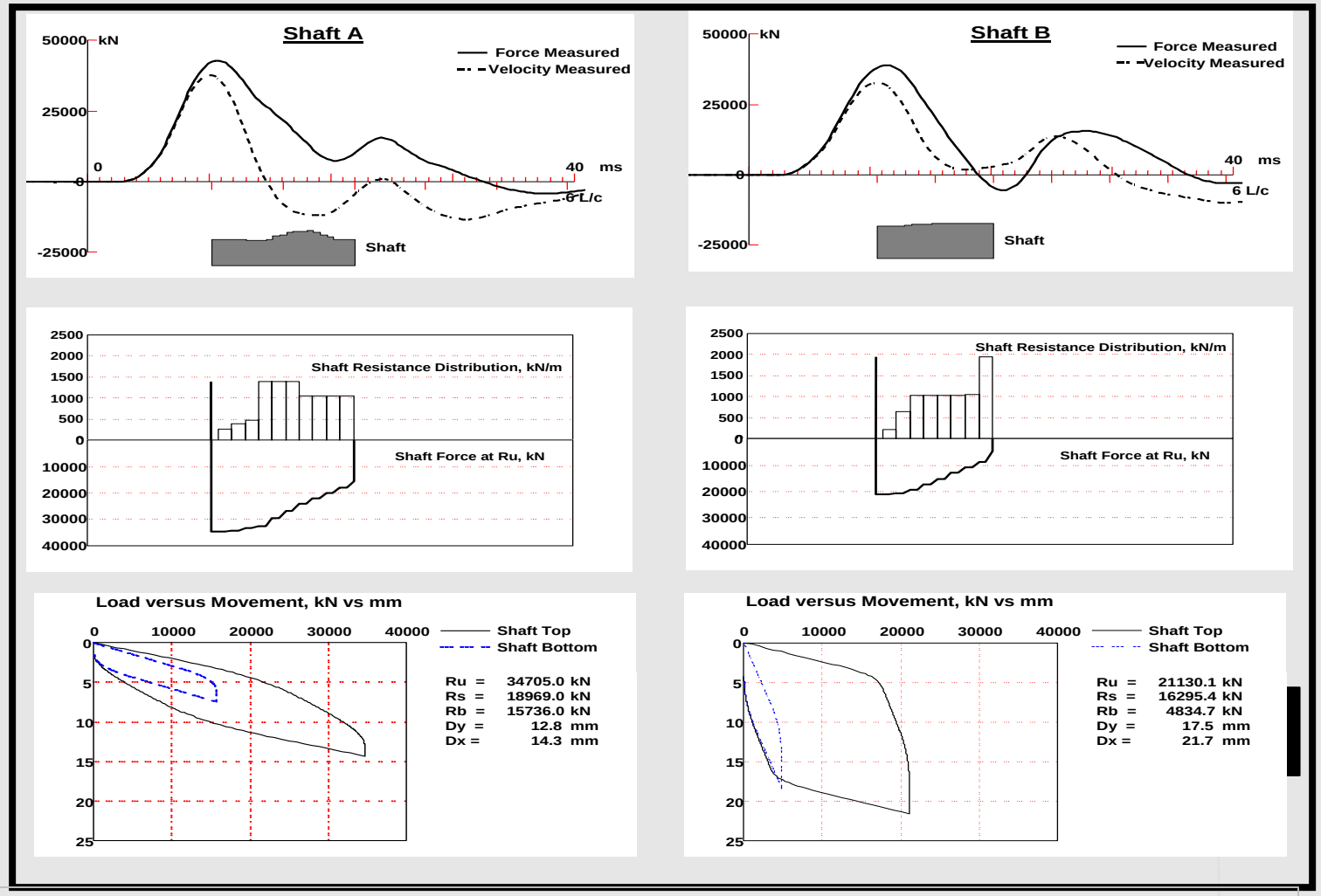


DRILLED SHAFT DESIGN



- XX

Tampa Results for two 72” dia shafts

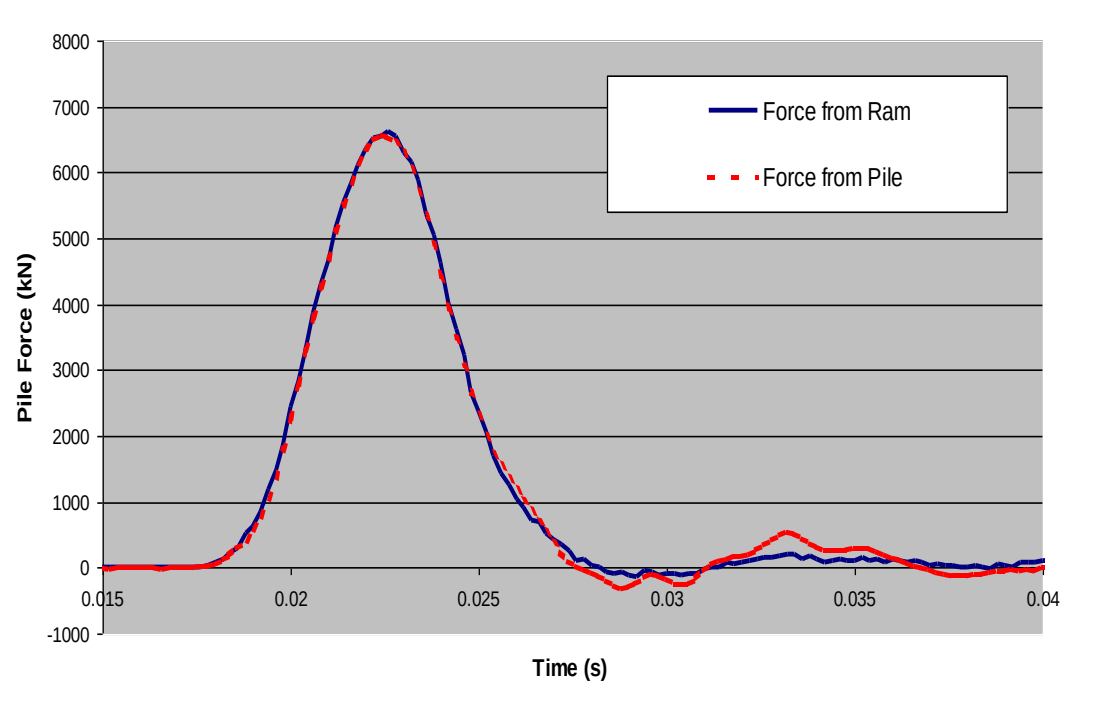


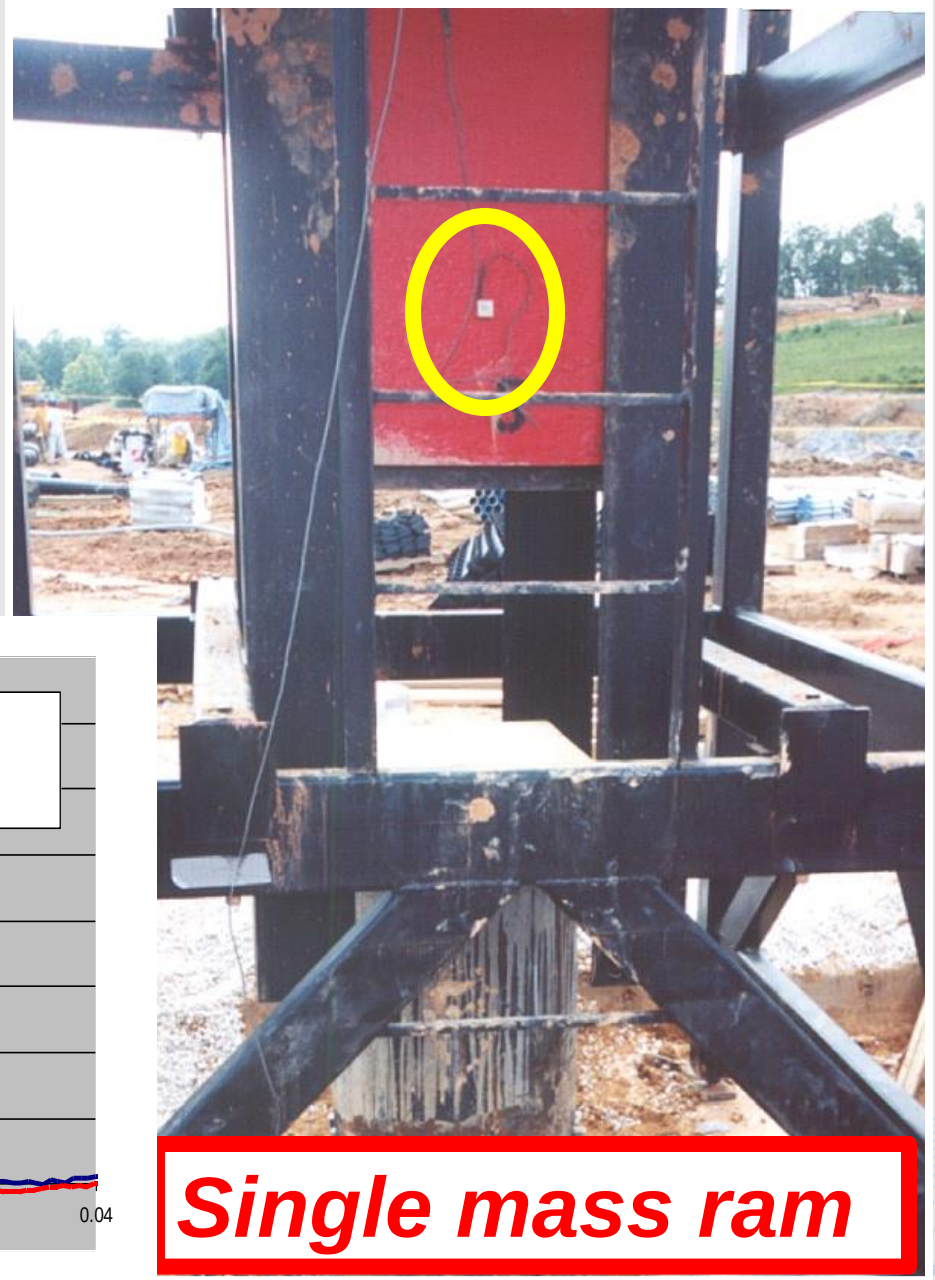
Large-scale Dynamic High-Strain Load Testing of a Bridge Pier Foundations.
Hussein, M.H., Bullock, P.J., Rausche, F., McGillivray, R., Eighth Int’l Conf. on Application of Stress Wave Theory to Piles
Lisbon, Portugal 2008

F=ma

Attach accelerometer to ram; instead of strain for force.

attach accelerometers to the pile for velocity.



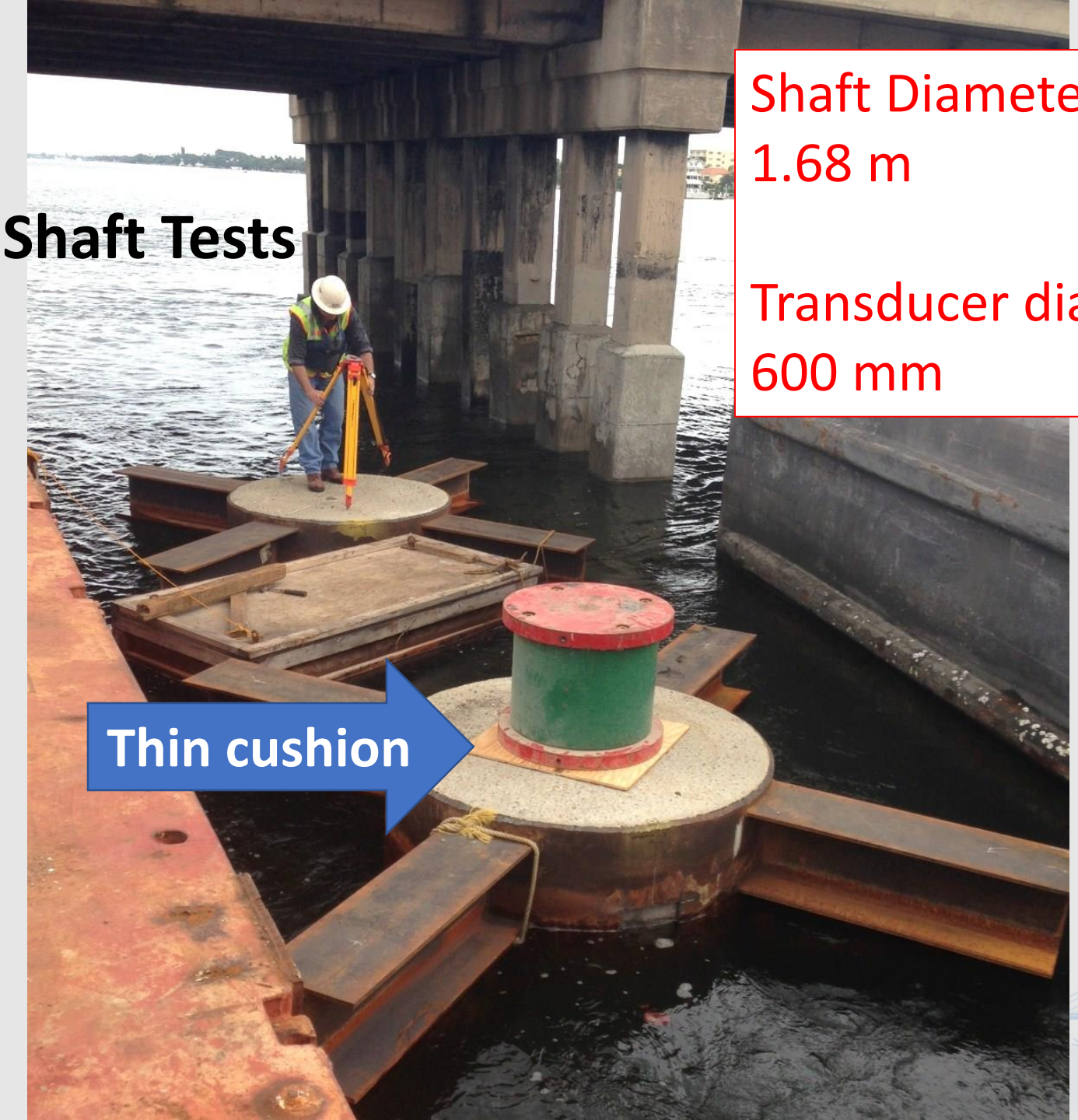


Single mass ram

F=ma or Top Transducer - Preparation

TOP TRANSDUCER

Drilled Shaft Tests



Shaft Diameter
1.68 m

Transducer diameter
600 mm

Testing bored piles

“APPLE” drop weight with 28 tons

20 – 80 tons available

FORCE *TRANSDUCER*

- ***Force is more accurate***
  - ***No "windows" in casing***
  - ***<u>Area and Modulus known</u>***
- ***Less pile preparation***
- ***Eliminate excavations***
- ***8 strains (4 pairs: in/out)***
- ***Accelerometer on pile***

Alternate Analysis

Transducer Force = Pile Top Force

$\varepsilon_{trans} \times EA_{trans} = \varepsilon_{pile} \times EA_{pile}$

$\varepsilon_{pile} = \varepsilon_{trans} \times EA_{trans} / EA_{pile}$

(EA_{trans} / EA_{pile}) ← input as "replay factor"

input → E and A of the pile

Testing Pile Through Slab

The PDA is, and has been designed for the Driven Pile Market

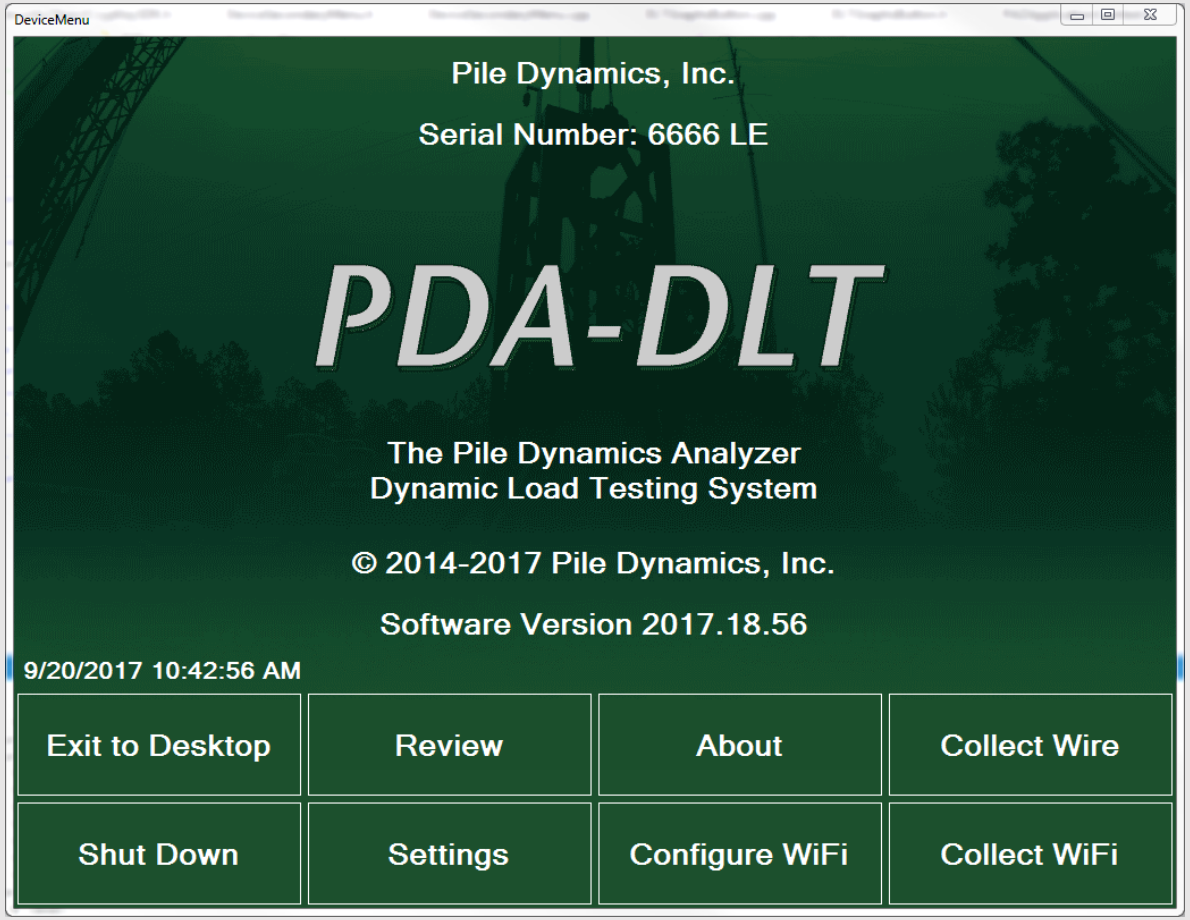
Driven Piles

- Continuous monitoring of hundreds if not thousands of blows
- Entry of driving resistance often entered in #blows / m (ft)
- Force measurement taken from the pile top

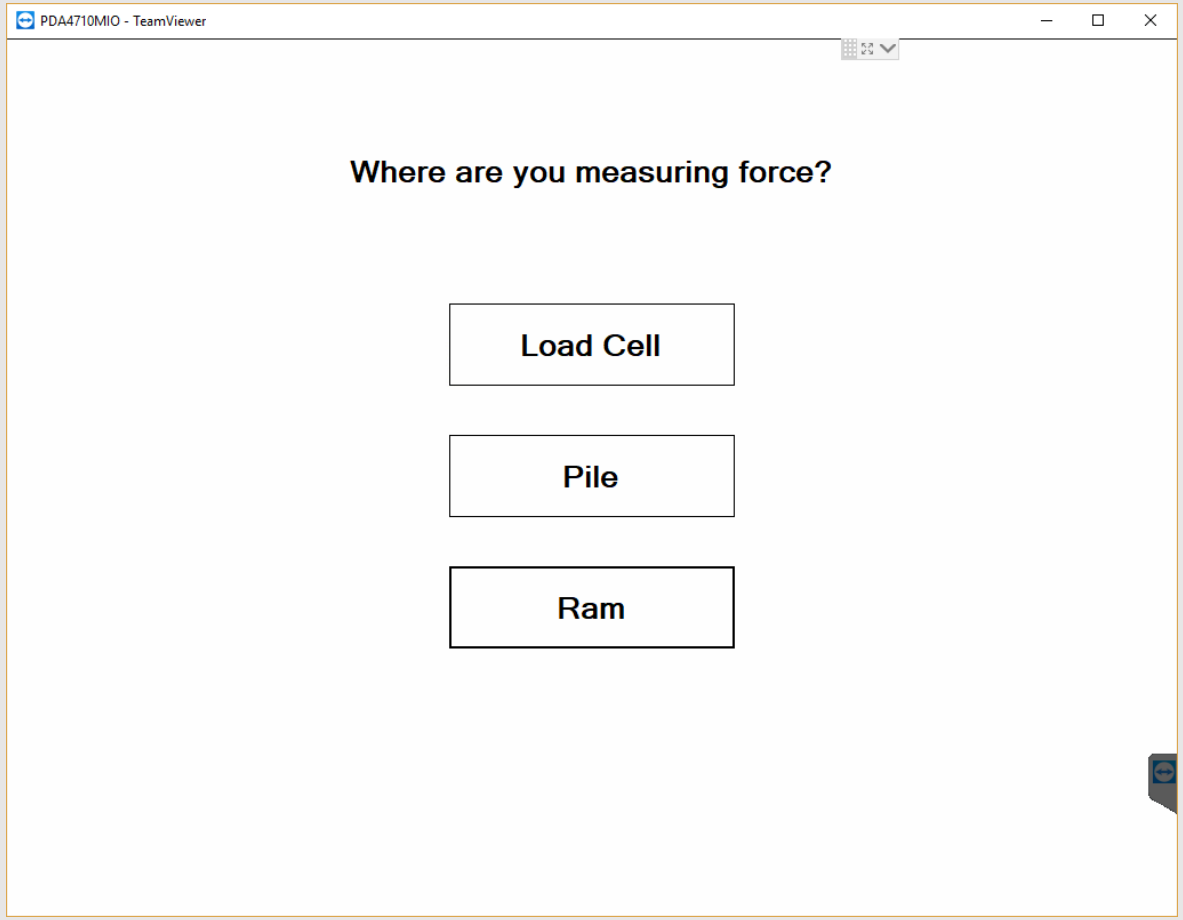
Bore Piles

- Require as few blows as possible
- Set measured after each blow
- Force measurement may be taken various ways
  - By load cell / Dolly
  - Traditionally
  - From ram measurements

Designed for the Bored Pile Industry

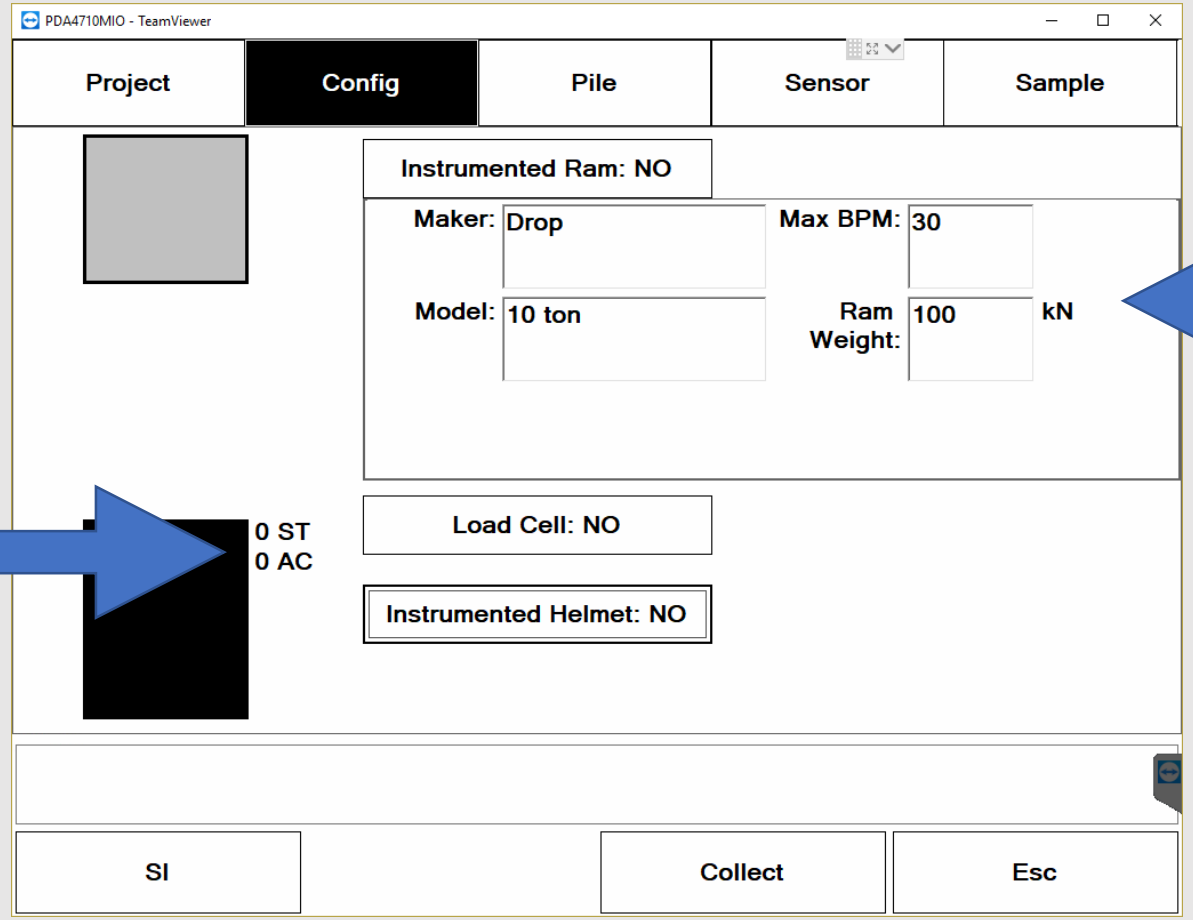


Allows for multiple configurations of force measurement



Proceeding to Data Collection

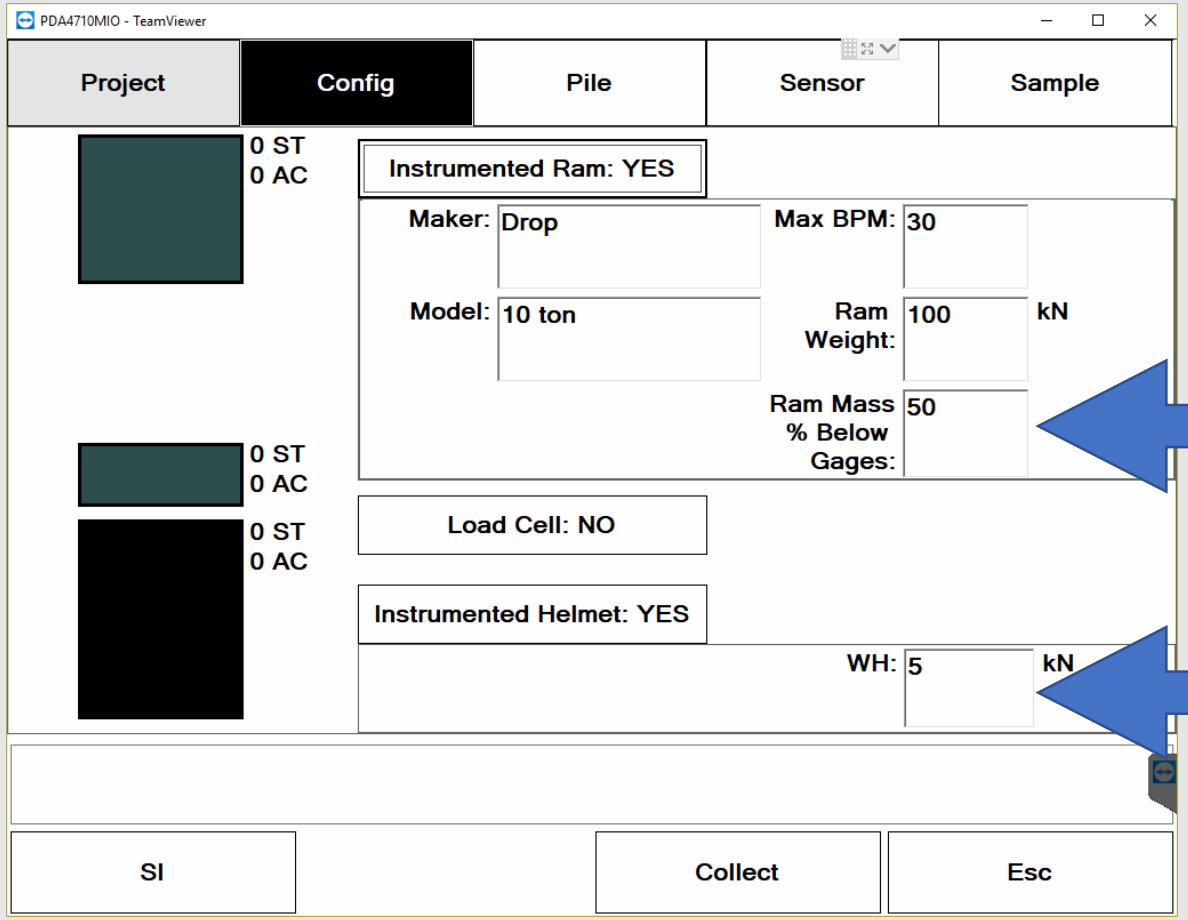
Standard configuration where measurements are made on the pile



Hammer is custom defined for the user's drop weight

Display confirms Measurement location

F=ma Configuration

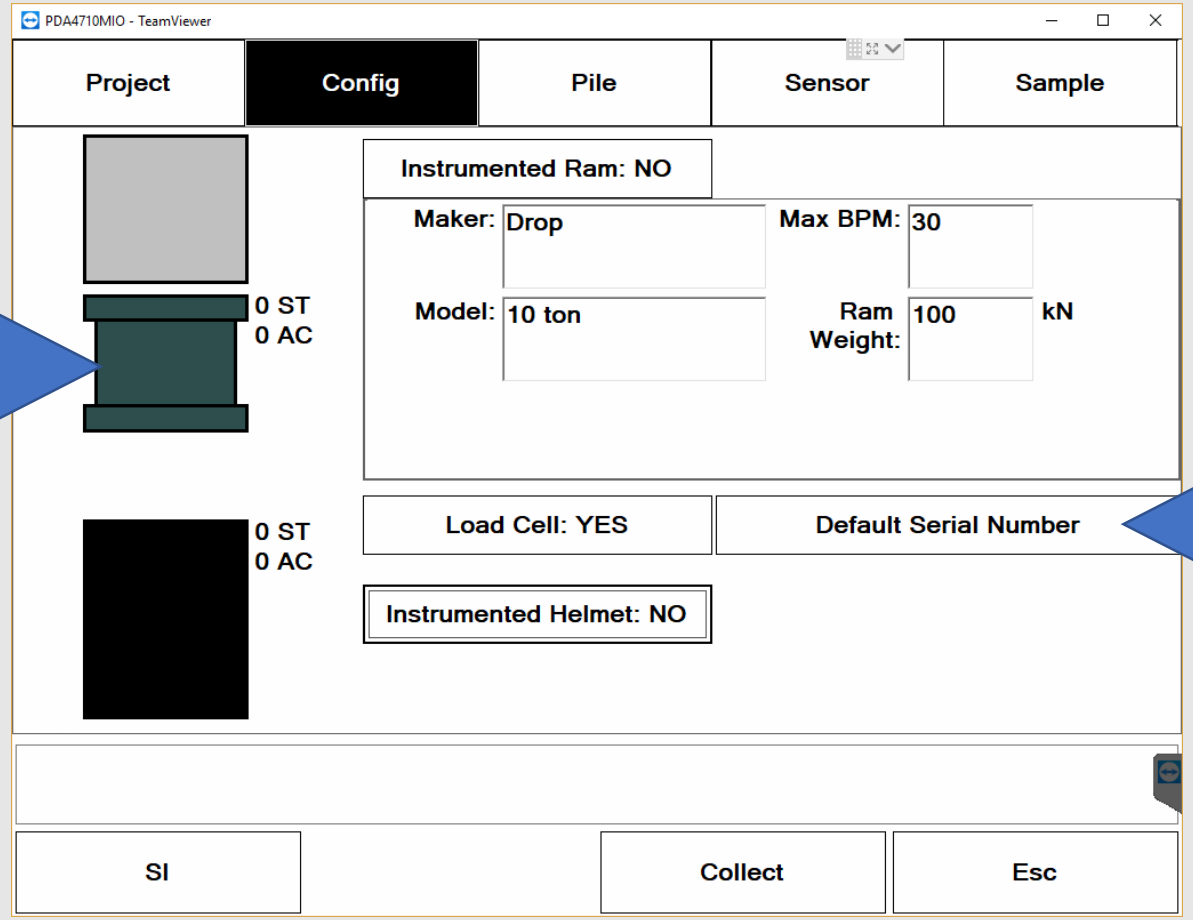


%Ram Mass below the sensors allows for inertial correction

Helmet Mass allows for inertial correction

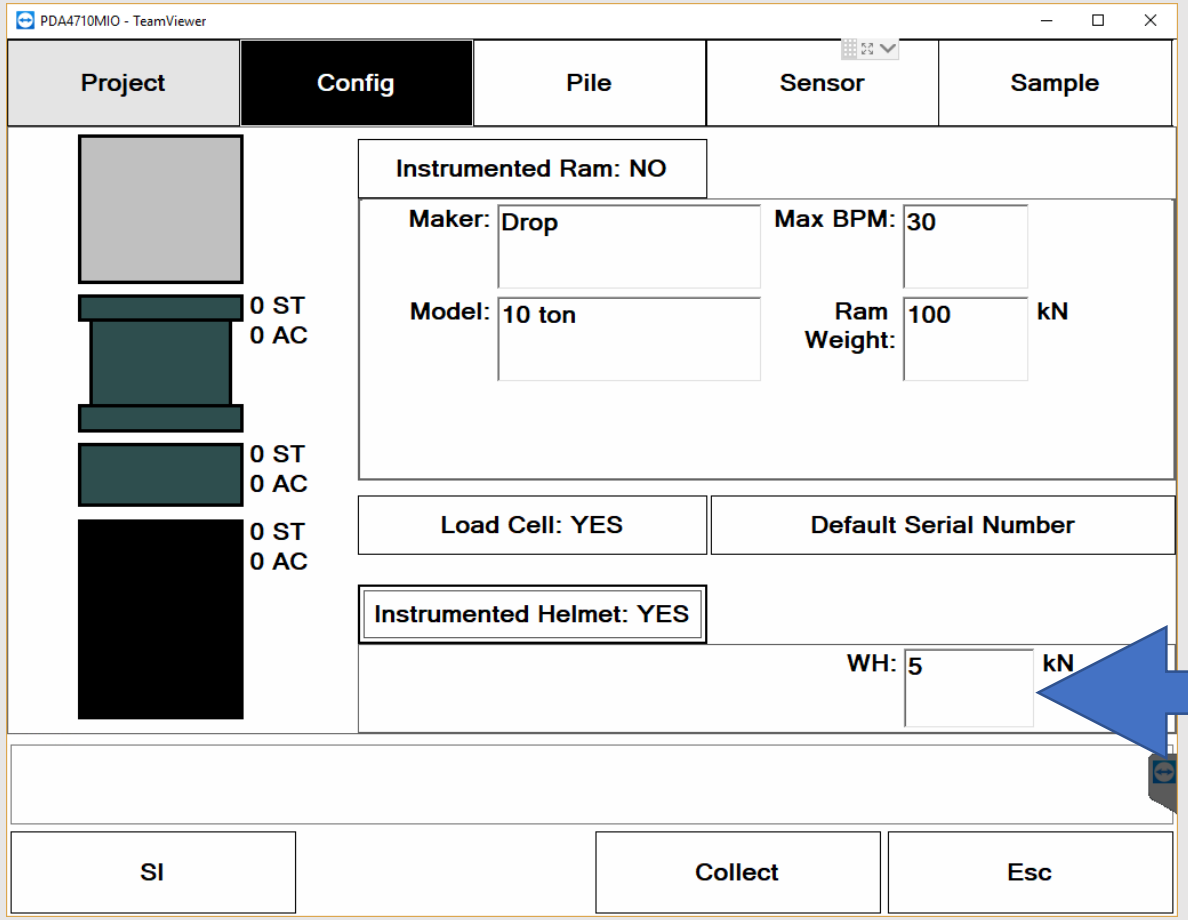
Load Cell Instrumentation

Load Cell Appears when activated



User fabricated load cell may be recalled

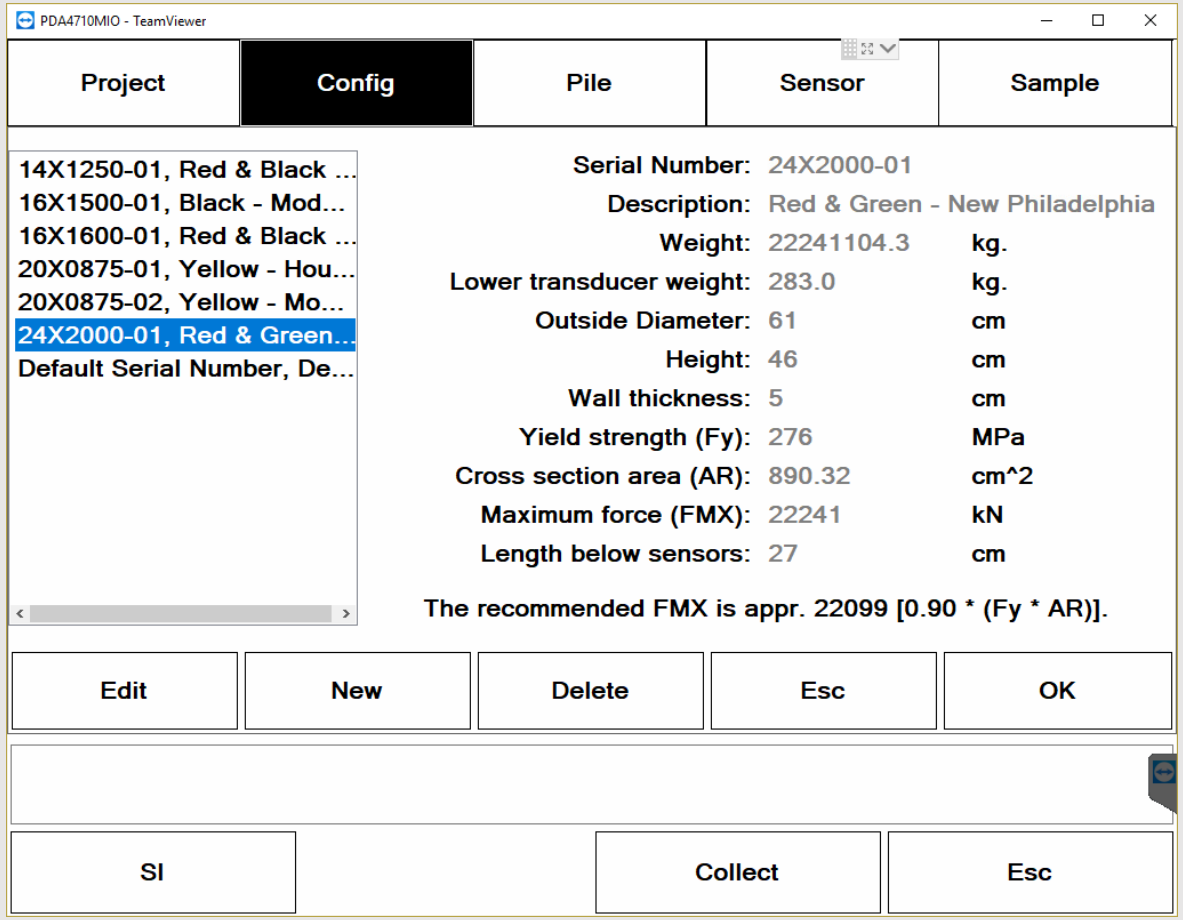
Stress values on the pile can be calculated from measurements made on the Load Cell



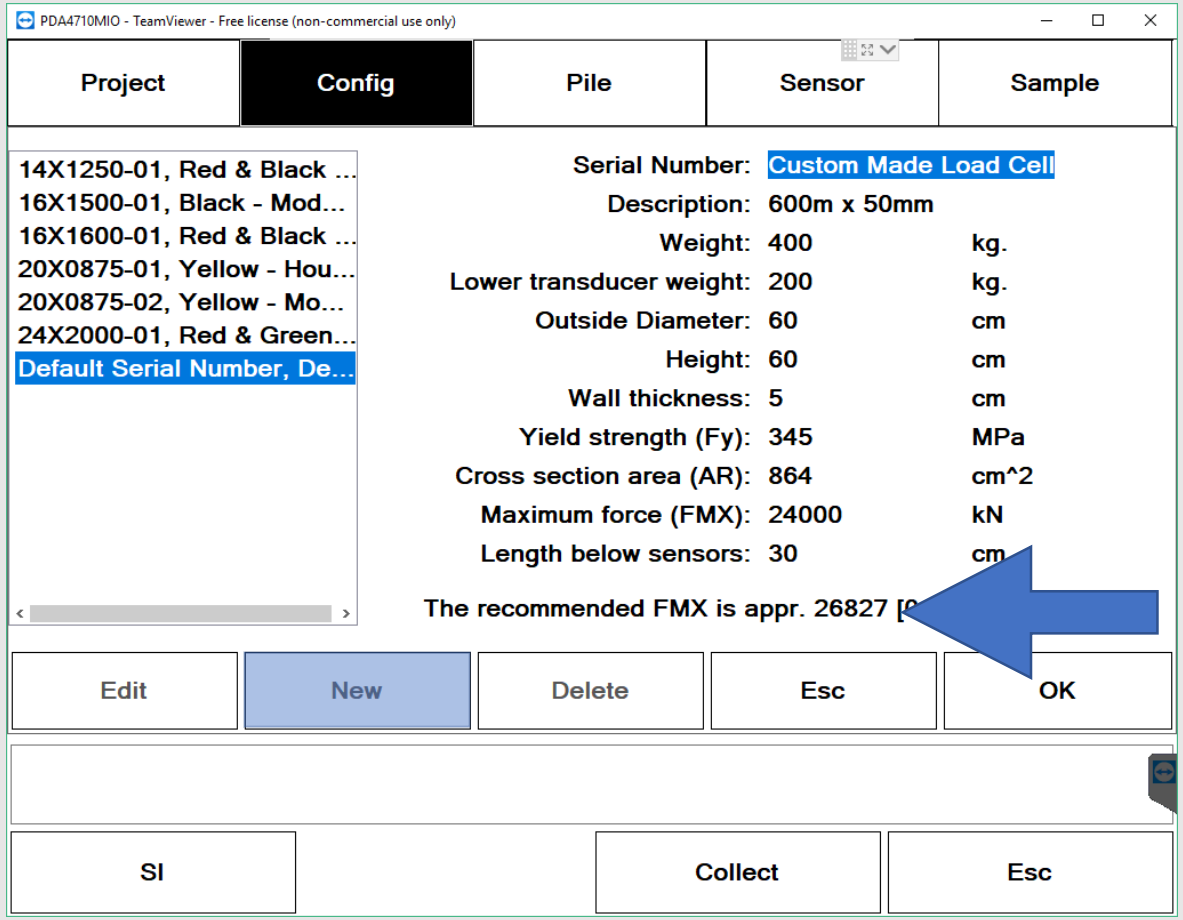
Helmet Mass allows for inertial correction

Database of Load Cells are stored in system

Users often require load cells of various sizes to appropriately match the Load Cell to the pile size and required load



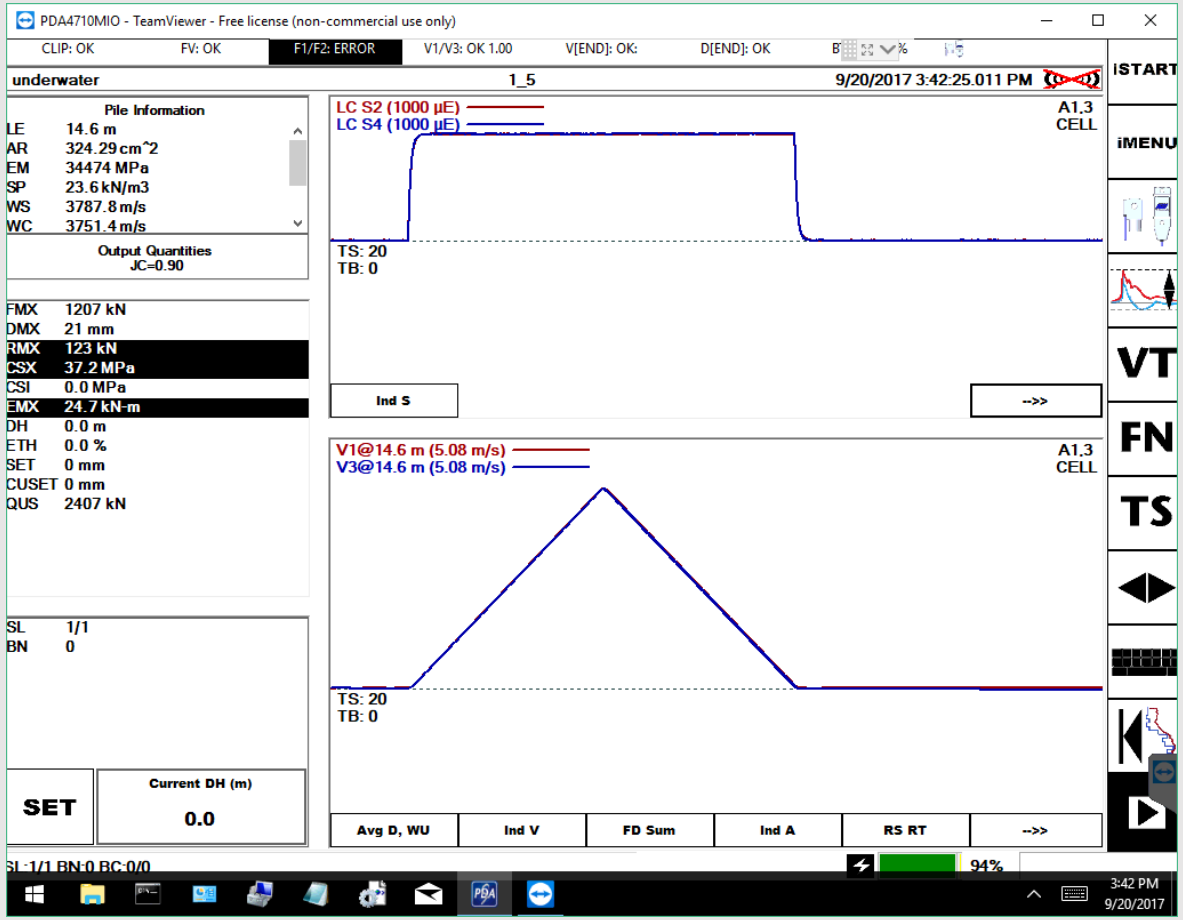
Enter Properties of your own Load Cell



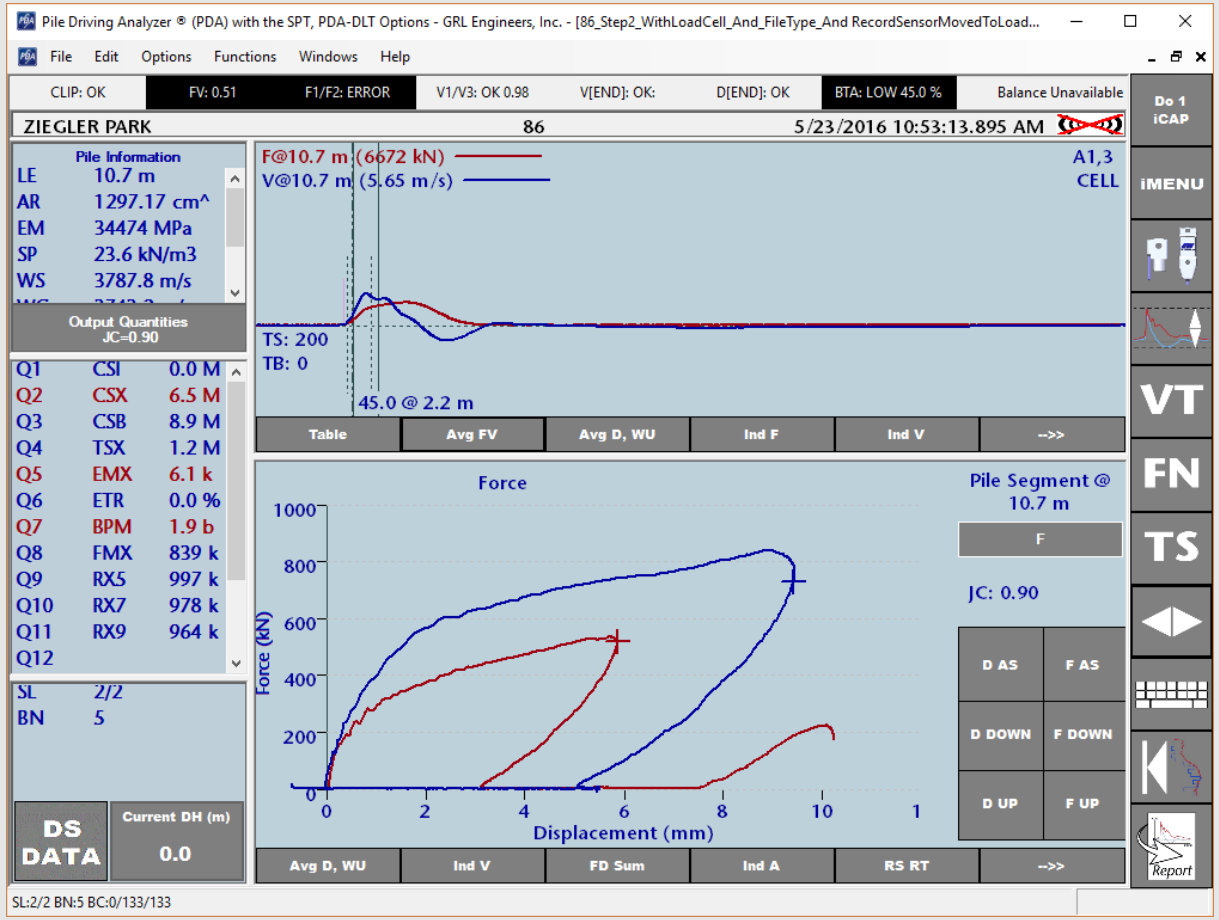
Calculated FMX valued is based on the entered area and the yield strength of the load cell

This can be used to verify the appropriate size of the Load cell for the Loads required

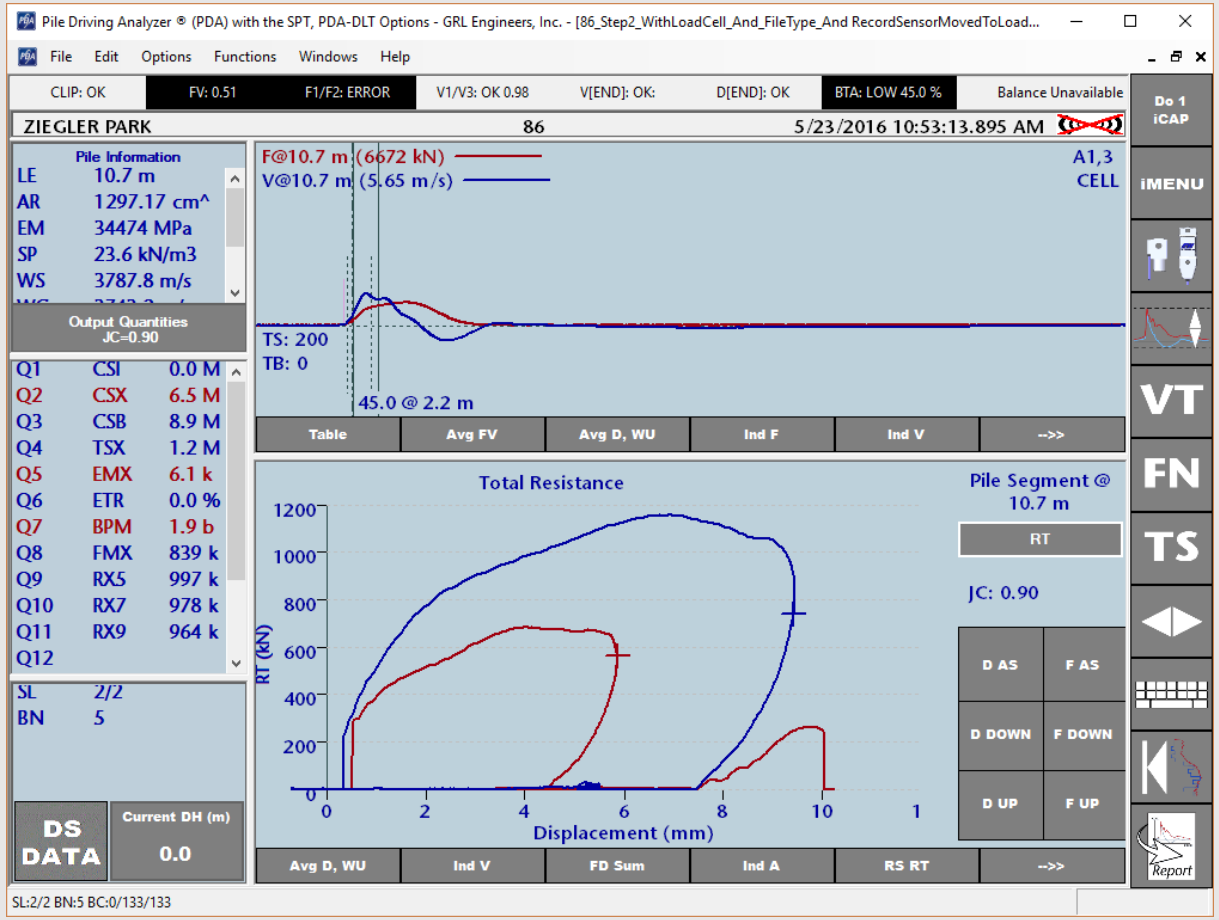
Cal Pulse will Display the Active Channels



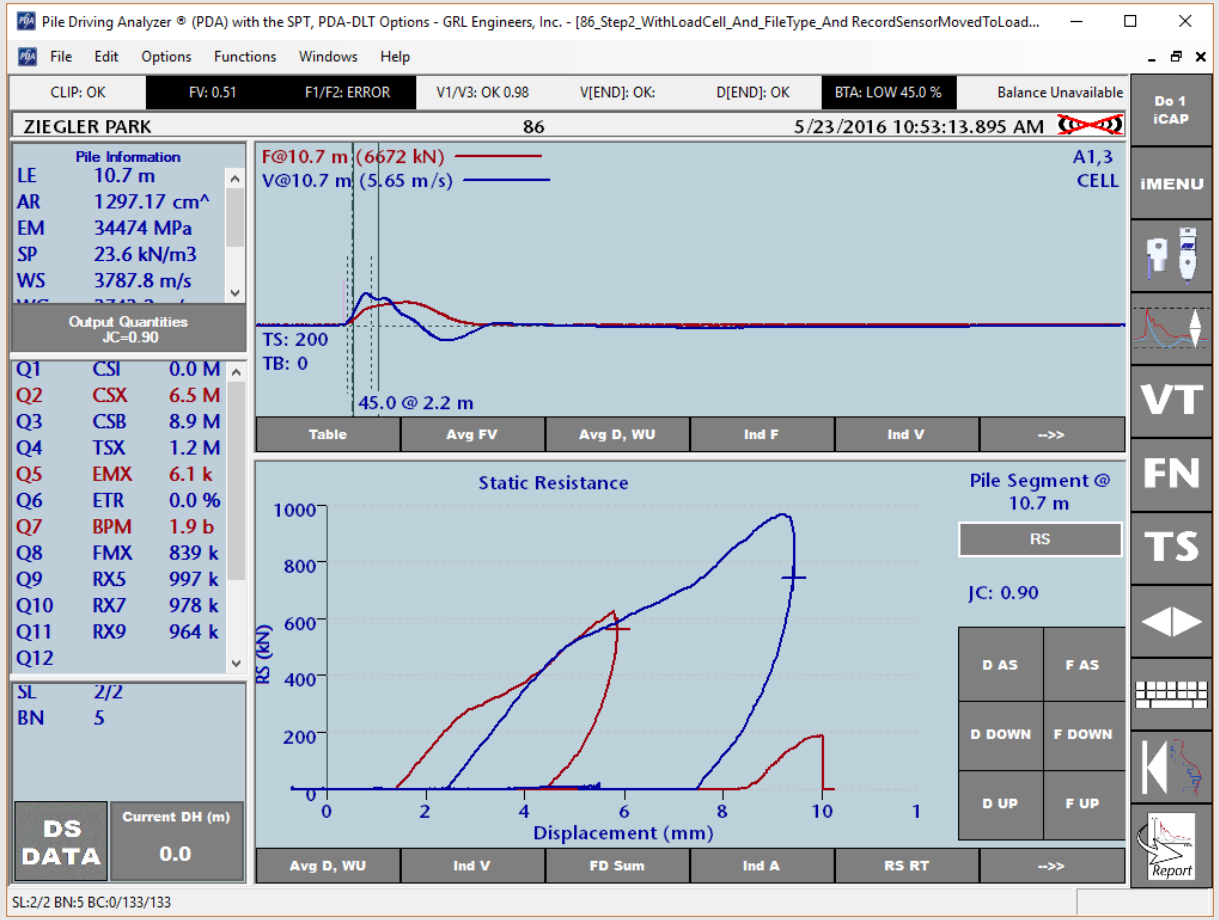
Force vs. Displacement Plot



Total Resistance (Case) vs. Displacement



Static Resistance (Case) vs. Displacement



Set and Drop Height Entry
Auto Populated Summary Graph