Overview of Upcoming Full Scale Lateral Load Test of Group-Pile-Pier at I-10 Twin Span Bridge in New Orleans

88th TRB Annual Meeting
AFS30 Committee Meeting

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Louisiana Transportation Research Center (LTRC)

Acknowledgement

- **The project is financially supported by the FHWA-Innovative Bridge Research and Deployment (IBRD) Program and Louisiana DOTD.**

- **Ongoing research project on:**

  "*Structure Health Monitoring of the I-10 Twin Span Bridge*"

Structure Health Monitoring of the I-10 Twin Span Bridge: Objectives

Short-term Monitoring:

- Perform lateral load test for M19 eastbound pier,
- Validate the FB-MultiPier analysis for predicting the performance of battered pile group system under lateral loading,
- Develop (or back-calculate) the p-y multipliers for battered pile group system in similar soil conditions,

Long-term Monitoring:

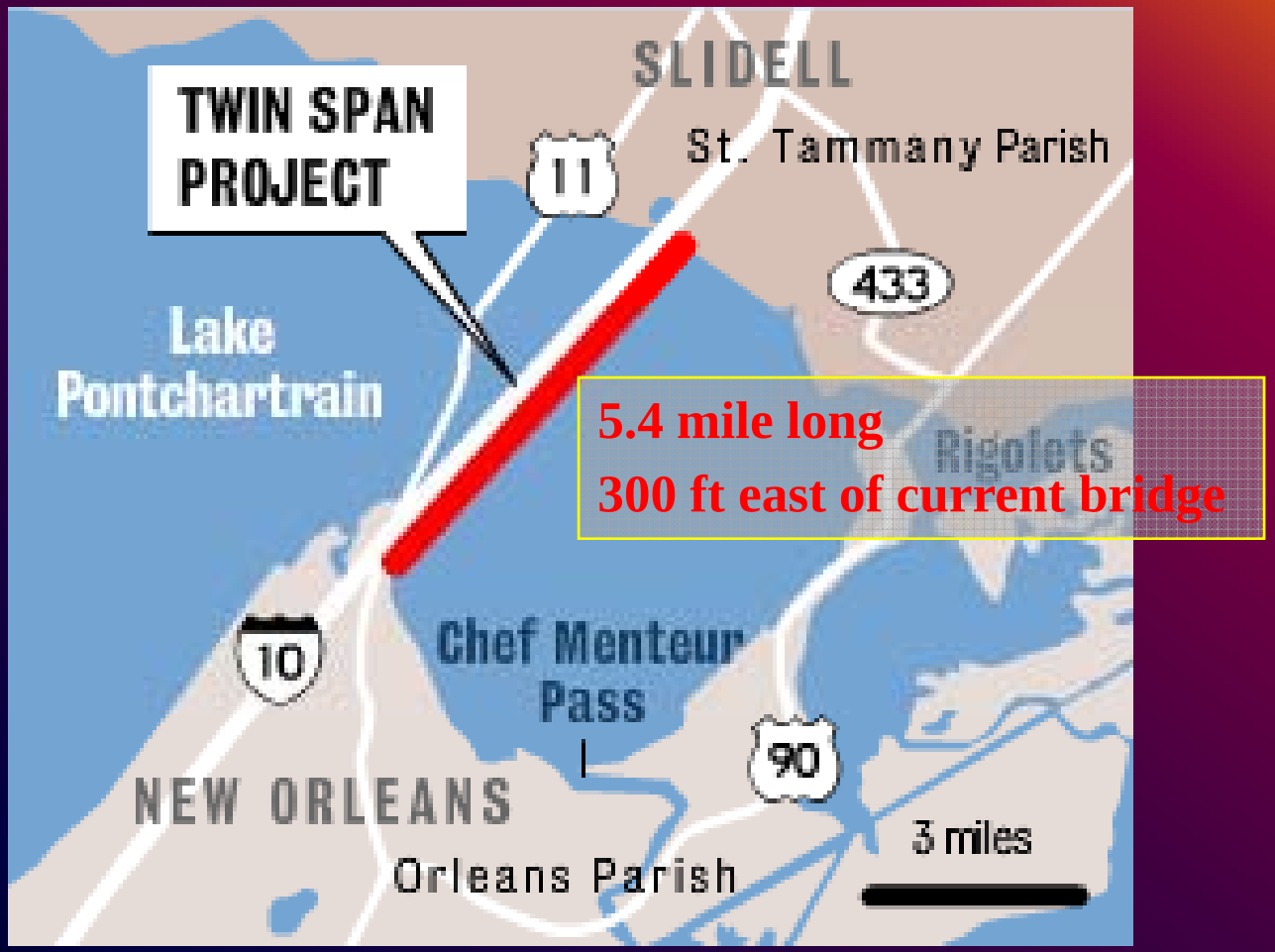
- Evaluate the behavior of pile group structure under dynamic loads (winds, waves and vessel collision)
- Includes both substructure and superstructure

Overview of the Project

- Interstate I-10 Twin Span Bridge across Lake Pontchartrain sustained serious damage from Hurricane Katrina, Aug. 2005,
- The construction of a new $800 million replacement bridge is underway,
- It consists of two parallel structures, with 3-12 ft travel lanes and 2-12ft shoulders on each side (60 ft wide).

Location of I-10 Twin Span Bridge

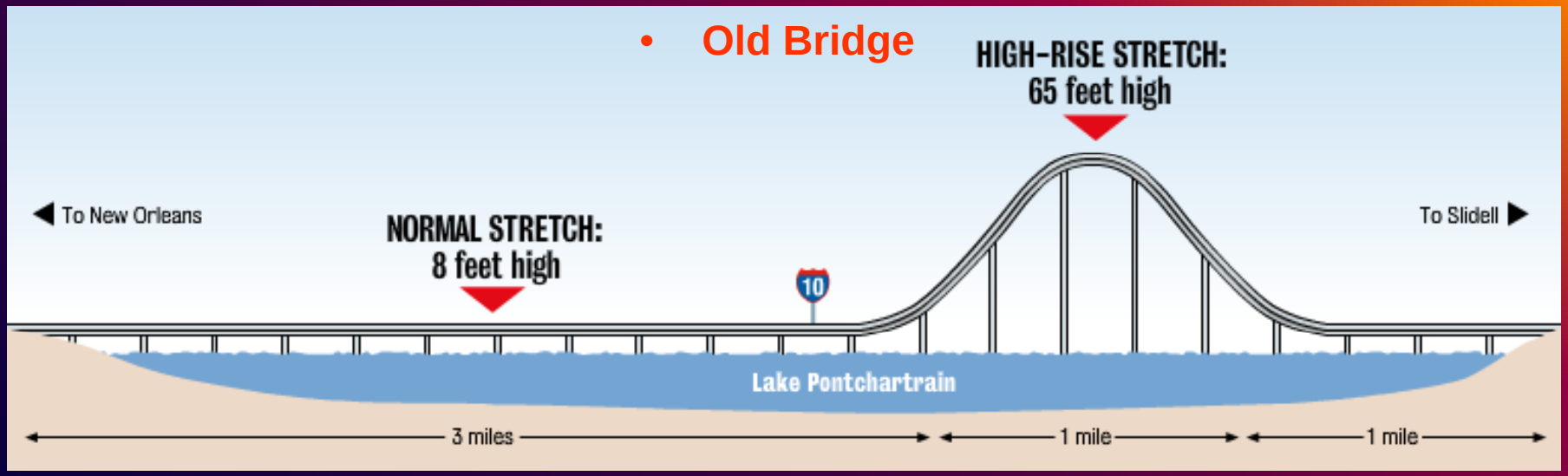
Location of I-10 Twin Span Bridge



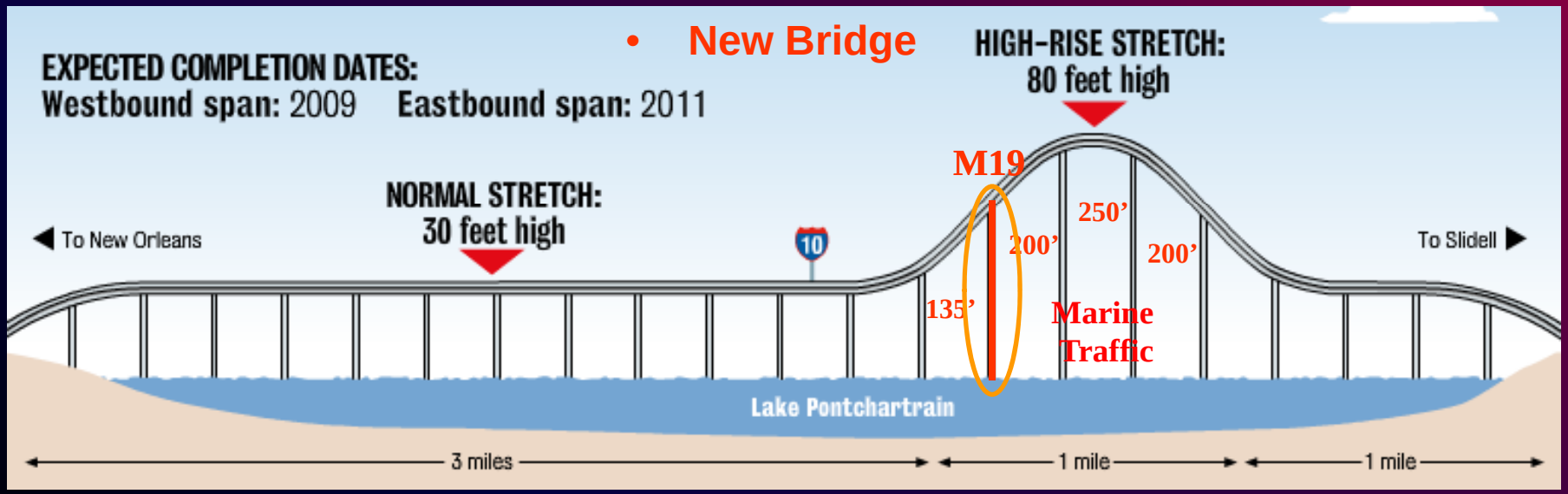
- Source: Volkert Construction, LA DOTD

Overview of Twin Span Bridge

- Old Bridge



- New Bridge

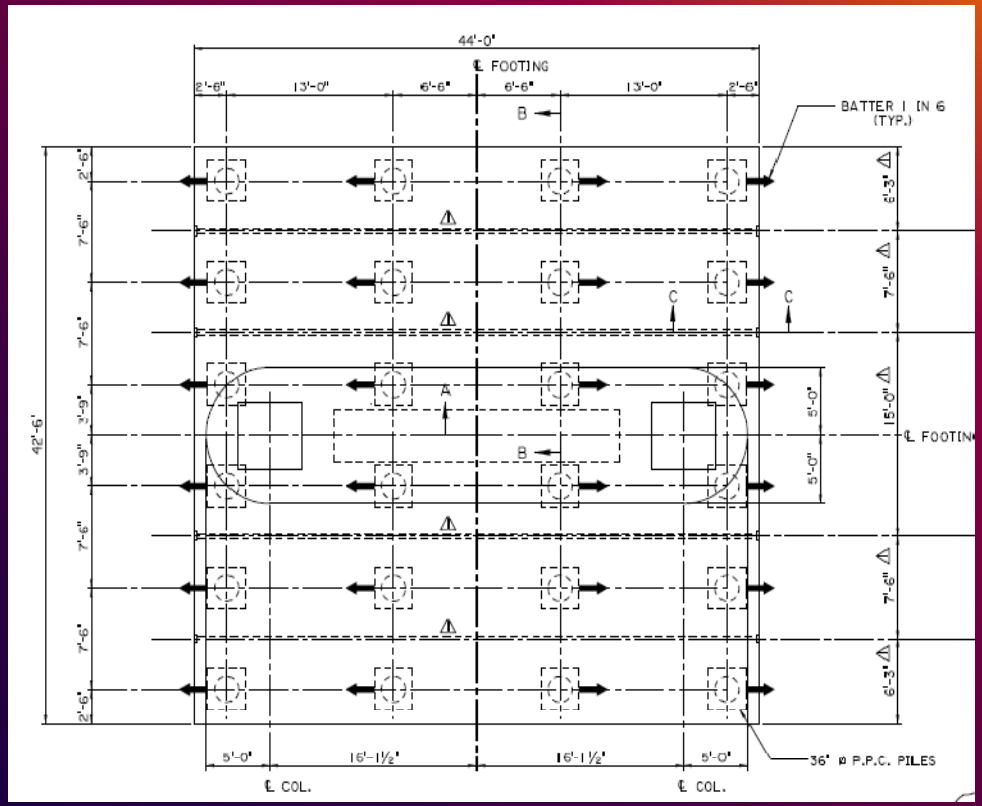


- Source: Volkert Construction, LA DOTD

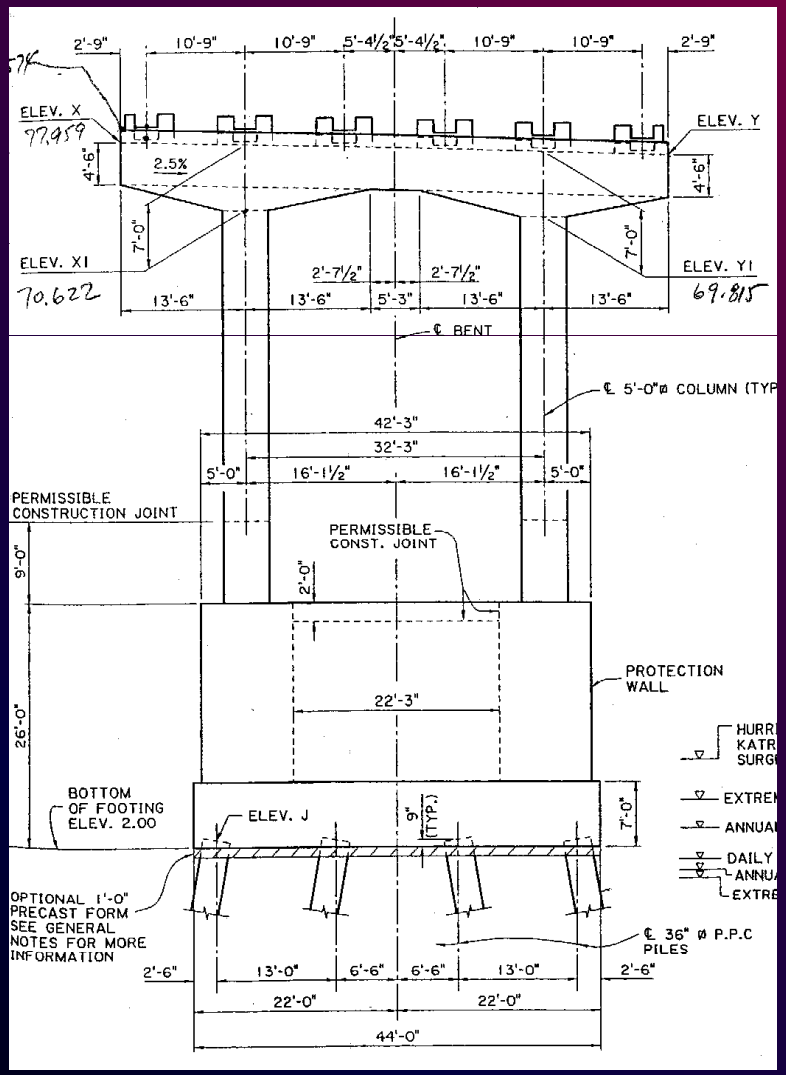
Overview of Twin Span Bridge

Overview of M19 Pier (Eastbound)

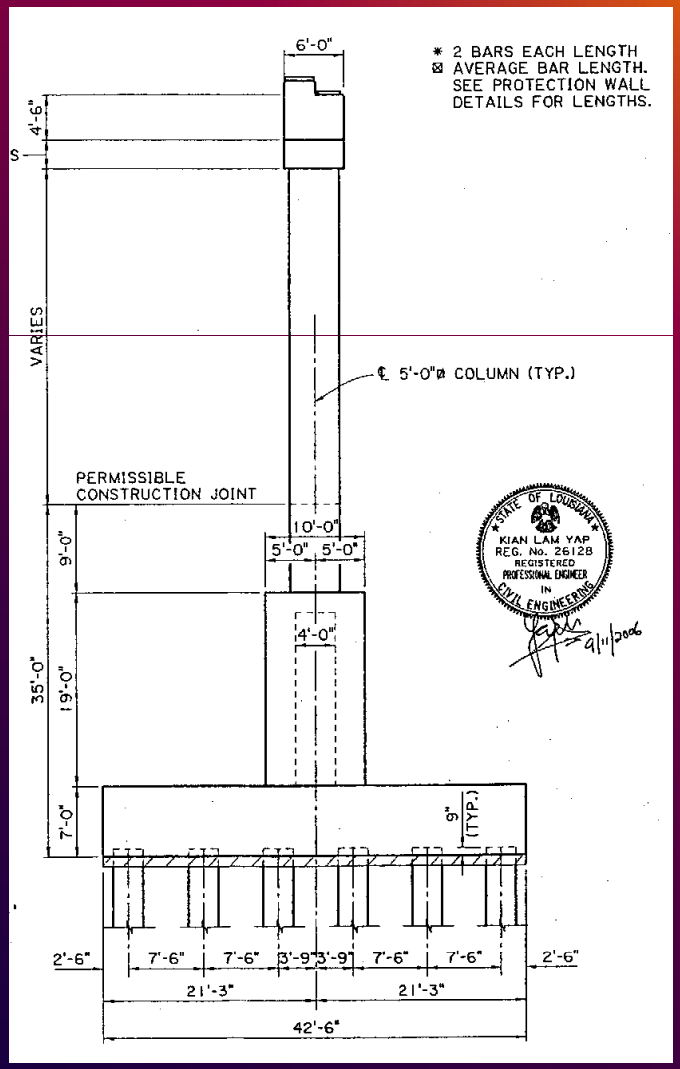
- **Footing size:**
  44 ft x 42.5 ft x 7 ft
- **Total: 24 battered pile (batter angle of 1:6)**
- **Size: 36” square PPC piles. 110 ft long**
- **Embedded pile length: ~87 ft**
- **Water depth: 11 ft**



Overview of M19 Pier (Eastbound)

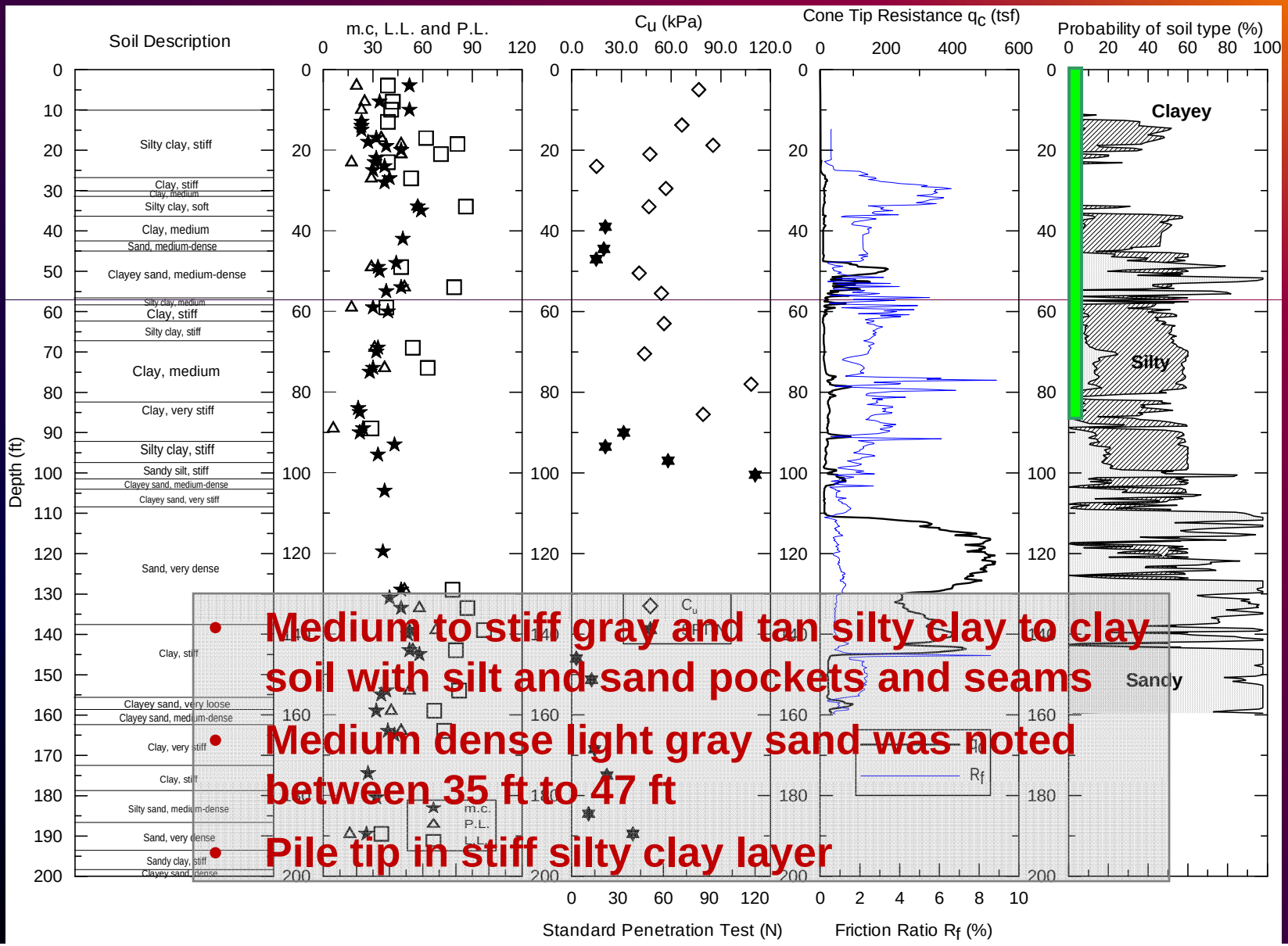


Elevation



Side View

Soil Profiles: Soil Boring & CPT



- **Medium to stiff gray and tan silty clay to clay soil with silt and sand pockets and seams**
- **Medium dense light gray sand was noted between 35 ft to 47 ft**
- **Pile tip in stiff silty clay layer**

Instrumentation of M19 Eastbound Pier

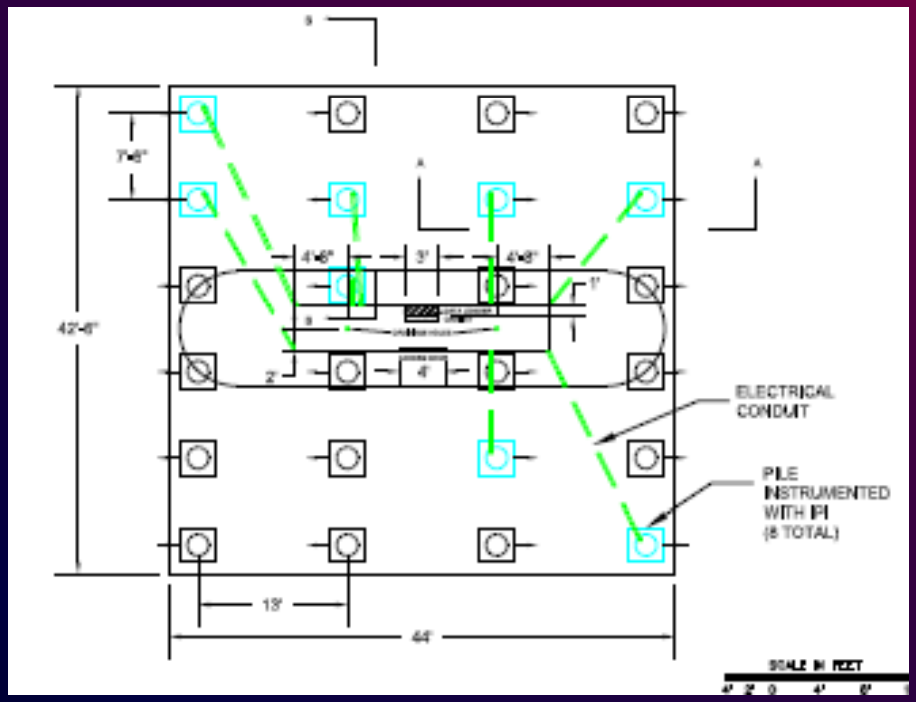
Substructure:

- **MEMS In-Place inclinometers for 8 piles**
- **Sister bar strain gauges for 12 piles,**
- **4 Uniaxial MEMS tiltmeters,**
- **2 Triaxial accelerometers,**
- **8 Water pressure cells.**

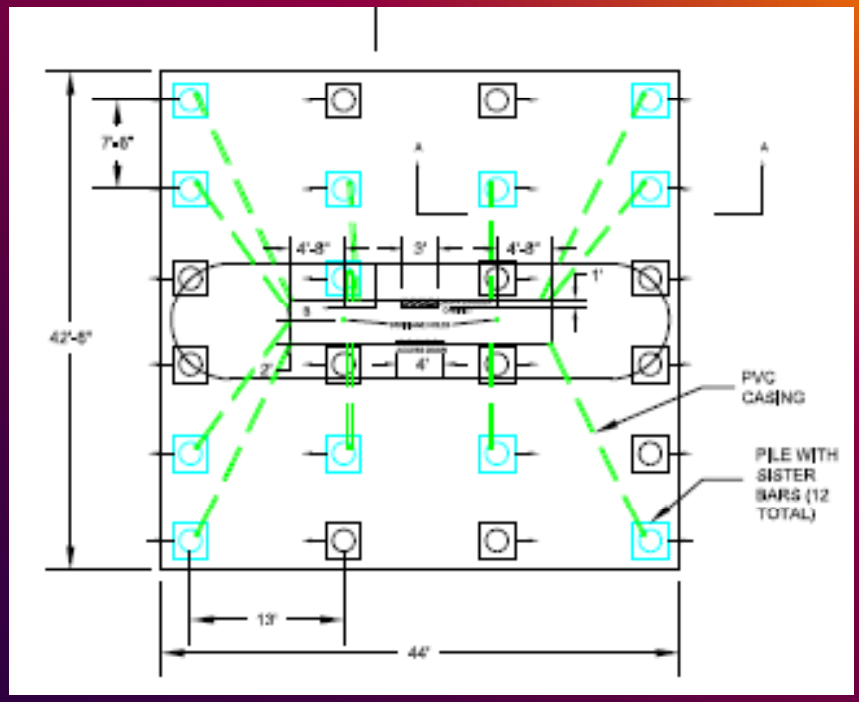
Superstructure:

- **Corrosion meters: footing, columns, & bridge deck,**
- **Strain gauges: columns, bent cap, girders, & diaphragms,**
- **Weigh In Motion: concrete bridge deck.**

Instrumentation of M19 Eastbound Pier



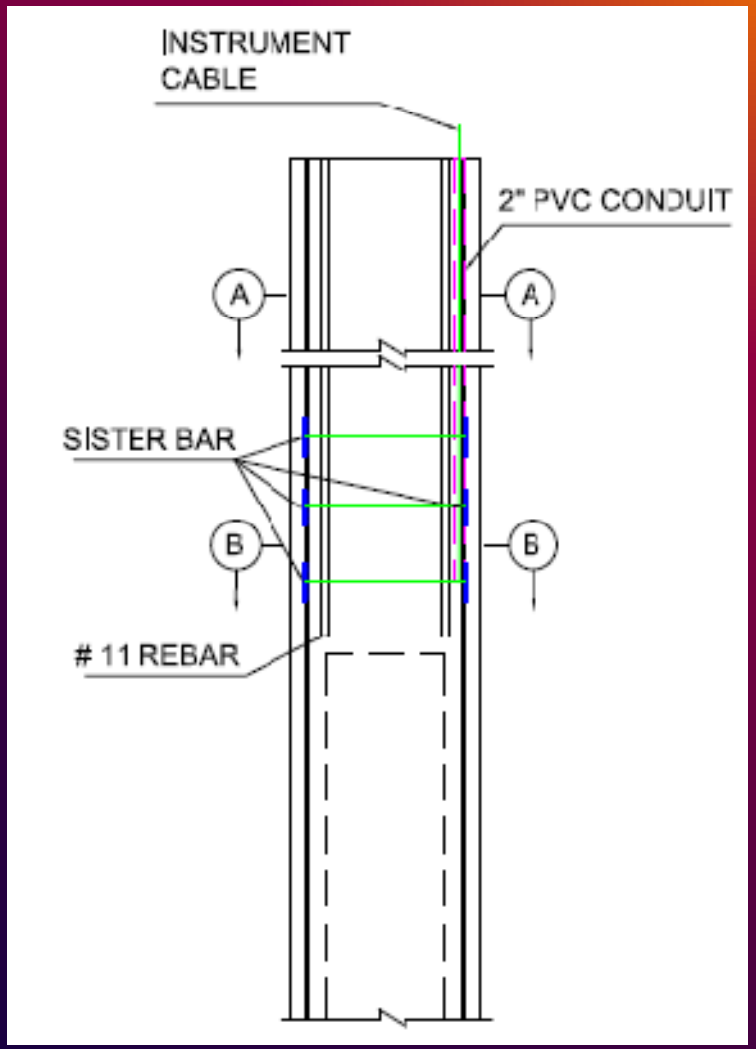
In-place Inclinometer



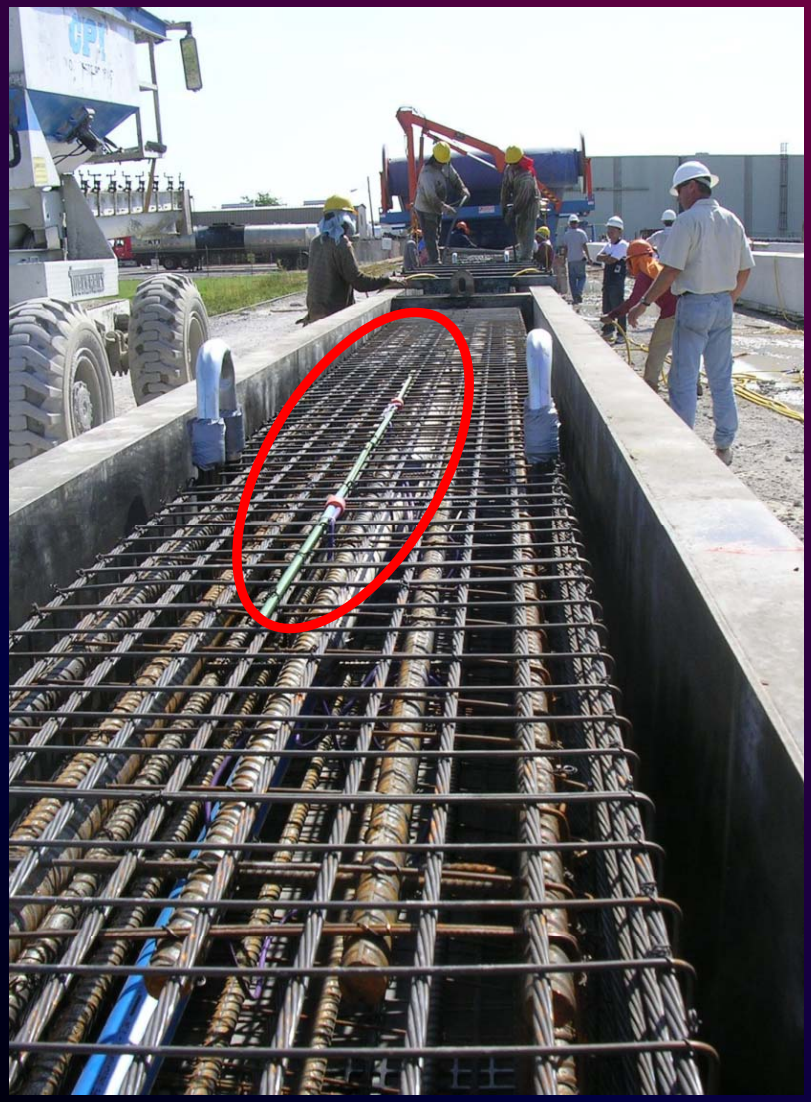
Sister Bar Strain Gauges

Installation of Sister Bar Strain Gages

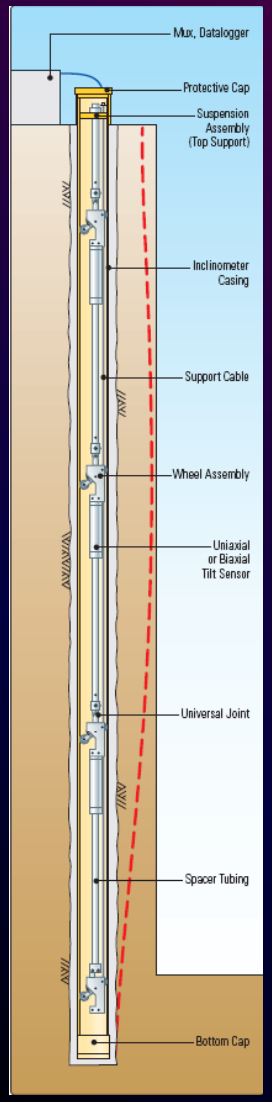
- For 12 piles
- at 11 ft and 21 ft from the top of pile (total 4 strain gauges / pile)

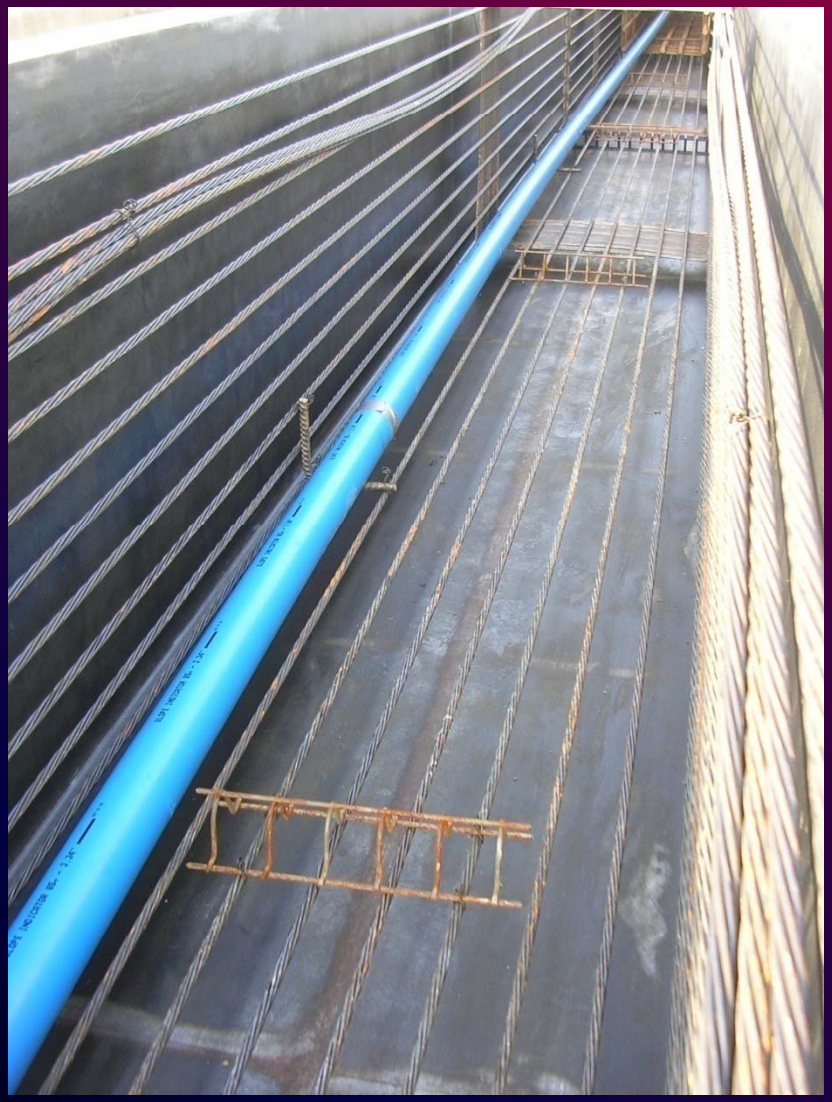


Installation of Sister Bar Strain Gages



Installation of IPI Casing





- Casing length = 100 ft
- To install 6 MEMS IPI sensors at depths of 5, 15, 25, 35, 45, and 65 ft from top.

Pile Driving & Footing Construction

Cutoff: 6’ – 7’

M20

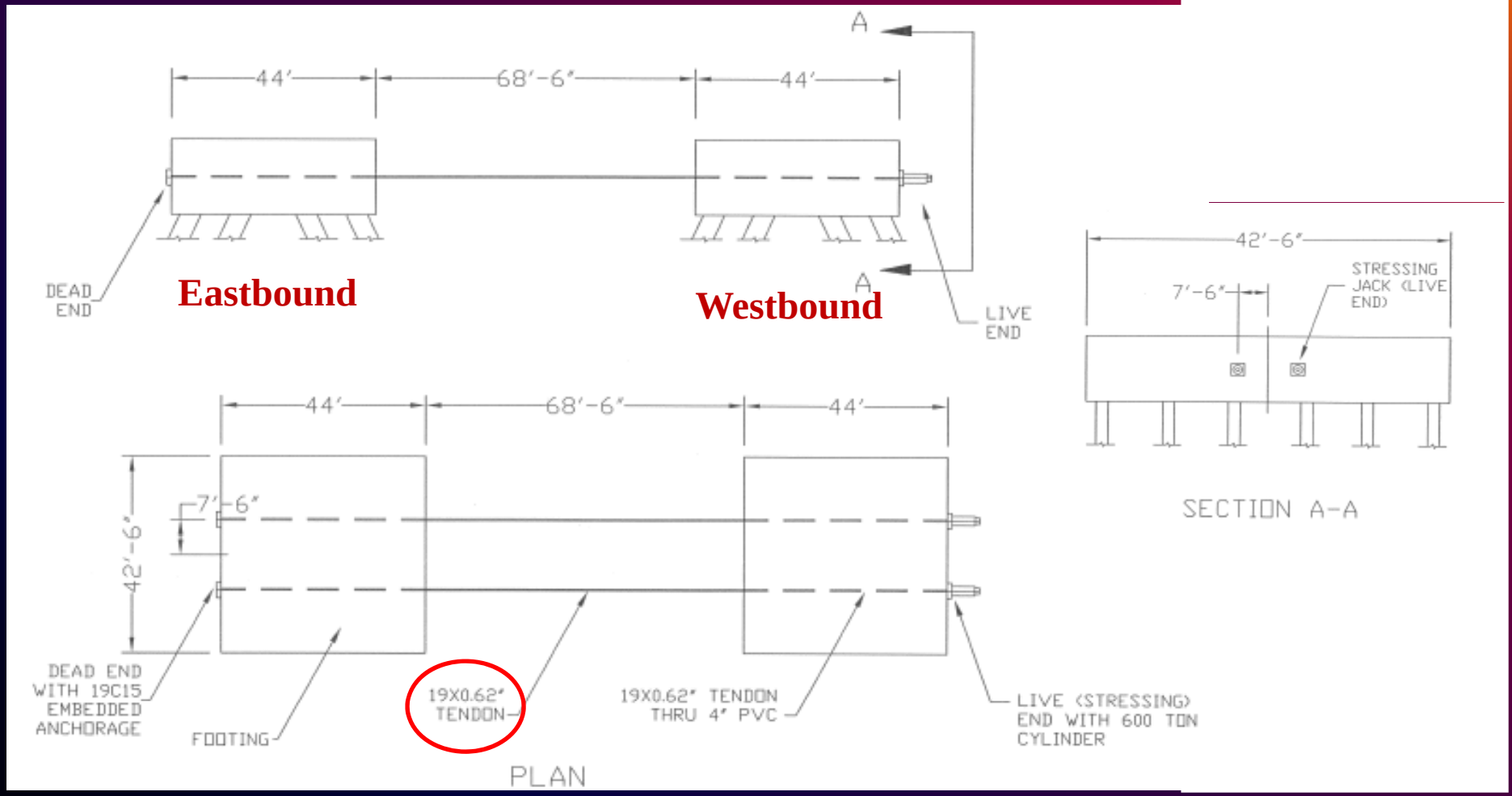
Lateral Load Test at M19 Pier

- **Maximum lateral load: 1600 kips**
- **Load applied using low relaxation two 19-strand tendons (0.62 in^2 each) run through the westbound and eastbound footings,**
- **The eastbound footing and westbound footing will be pushed towards each other using 600 ton hydraulic jacks,**

Setup Lateral Load Test at M19 Pier

- Install MEMS IPI sensors on selected 8 piles,
- Install dead-end anchorages, blockout plates, steel strand tendons, 600 ton jacks, hydraulic pump, manifold, laser survey, etc.
- Temporary assemble the data acquisition system,
- During Testing:
  - Apply load in increments of 100 kips (50k/tendon),
  - Record measurements from strain gauges and MEMS IPI sensors,
  - Deformations of east and west bound footings of M19 will be monitored using laser survey,

Setup of Lateral Load Test at M19



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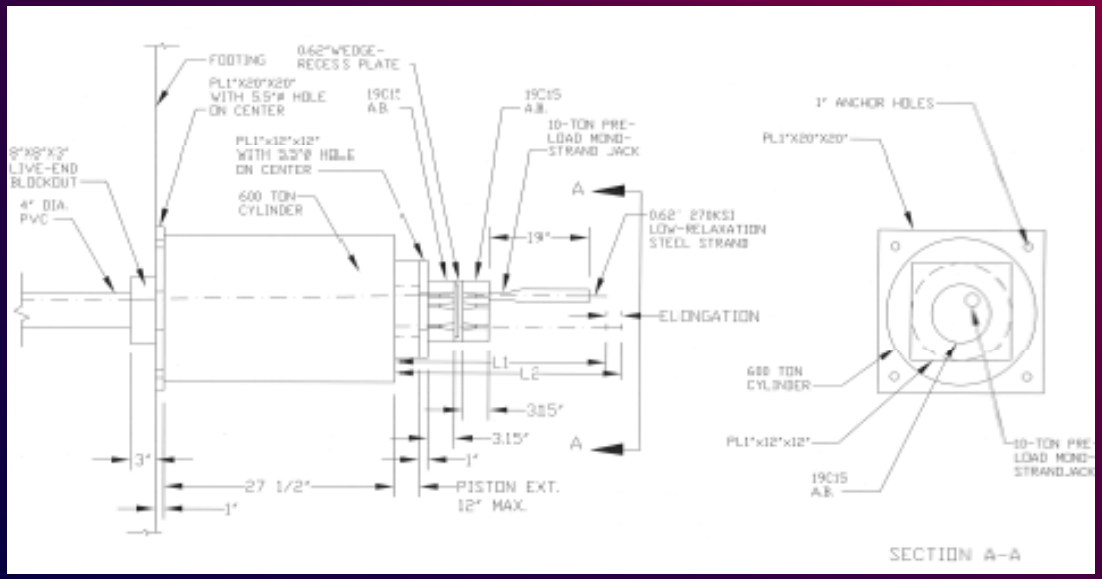
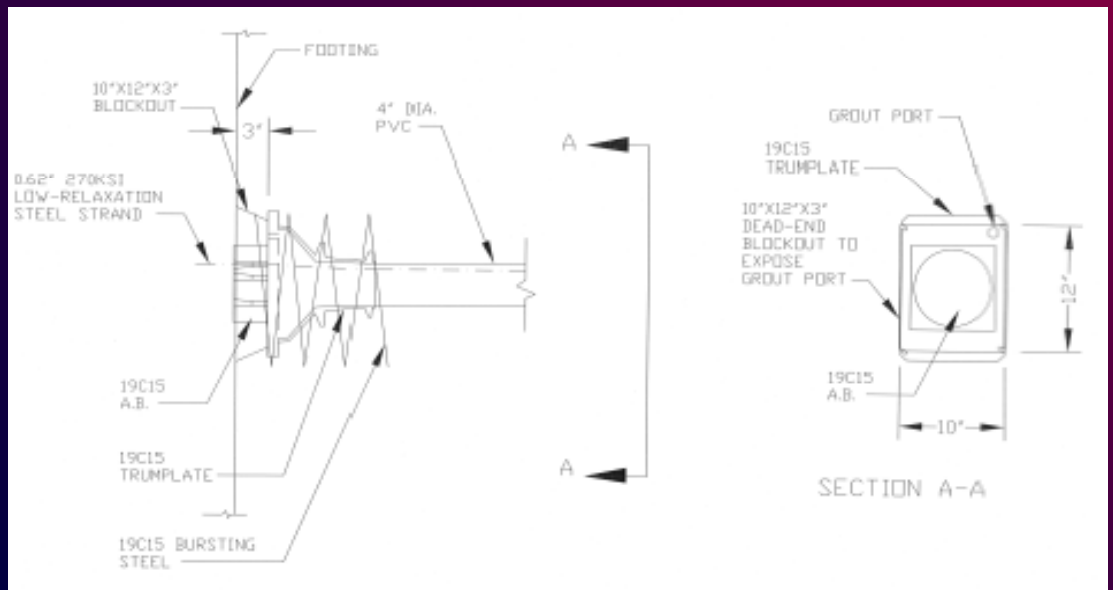
Setup of Lateral Load Test



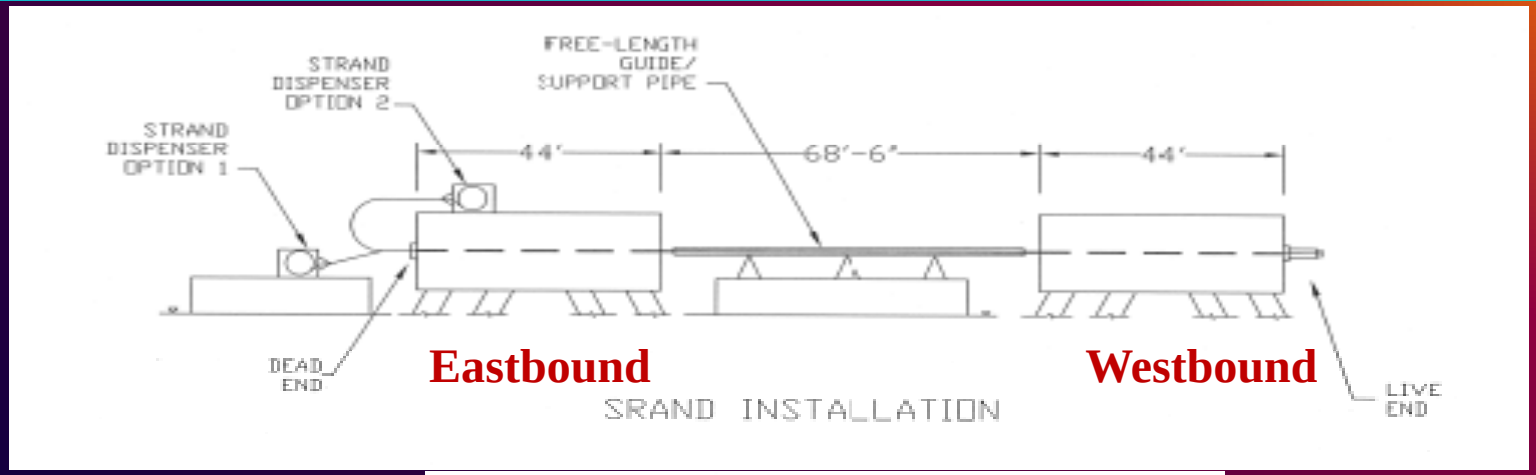
Details of Live End

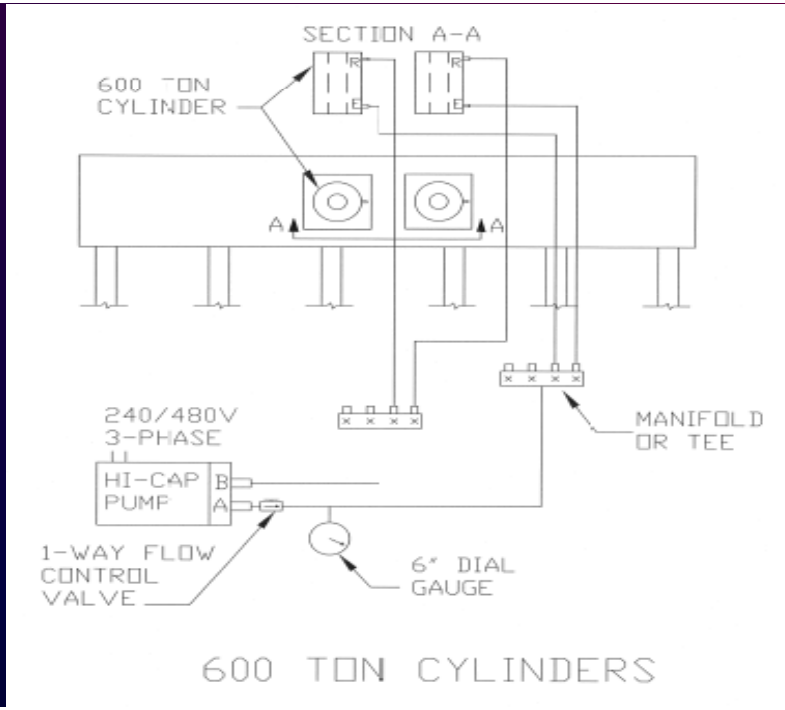


Details of Dead End

Volkert & Freyssinet, LLC

Setup of Lateral Load Test





Setup at Live End

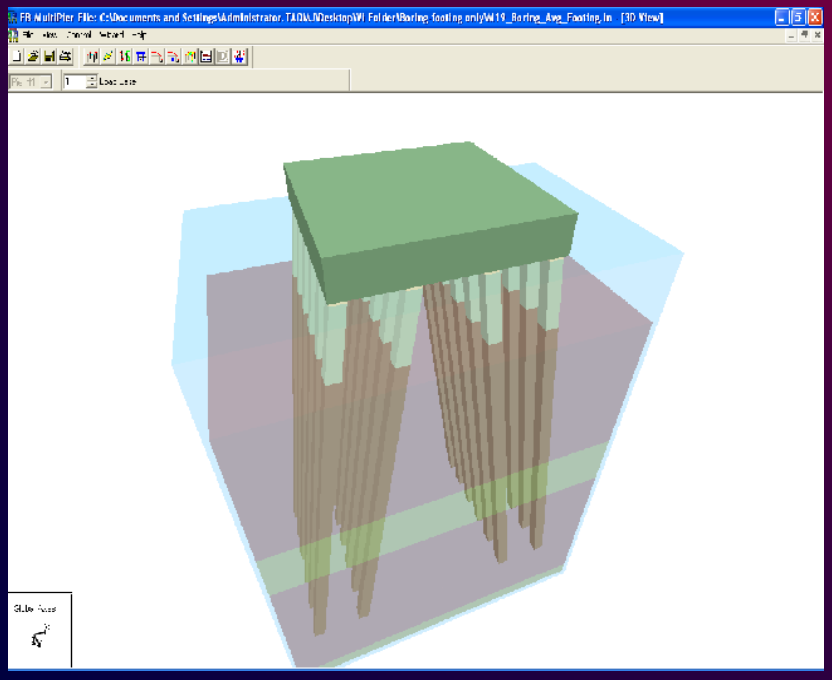
Volkert & Freyssinet, LLC

Loading-Unloading-Reloading Schedule

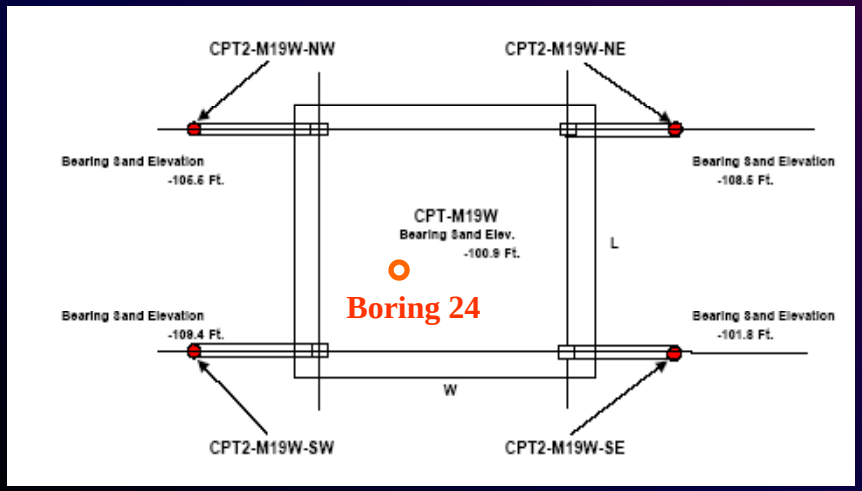
No.	Lateral Load (kips) per cable	Total Lateral Load (kips)	Load Duration (min)
1	0	0	-
2	50	100	10
3	100	200	10
4	150	300	10
5	200	400	10
6	250	500	10
7	300	600	10
8	350	700	10
9	400	800	20
10	300	600	10
11	200	400	10
12	100	200	10
13	0	0	20

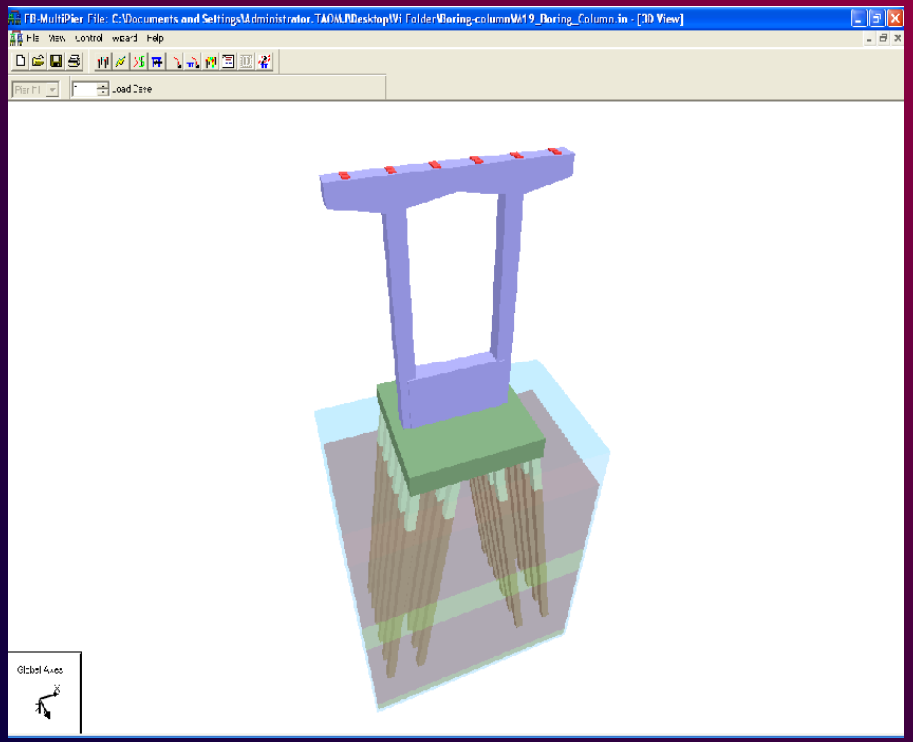
No.	Lateral Load (kips) per cable	Total Lateral Load (kips)	Load Duration (min)
14	100	200	10
15	200	400	10
16	300	600	10
17	400	800	10
18	500	1000	10
19	600	1200	10
20	700	1400	10
21	800	1600	20
22	600	1200	10
23	400	800	10
24	200	400	10
25	0	0	20

FB-MultiPier Analysis

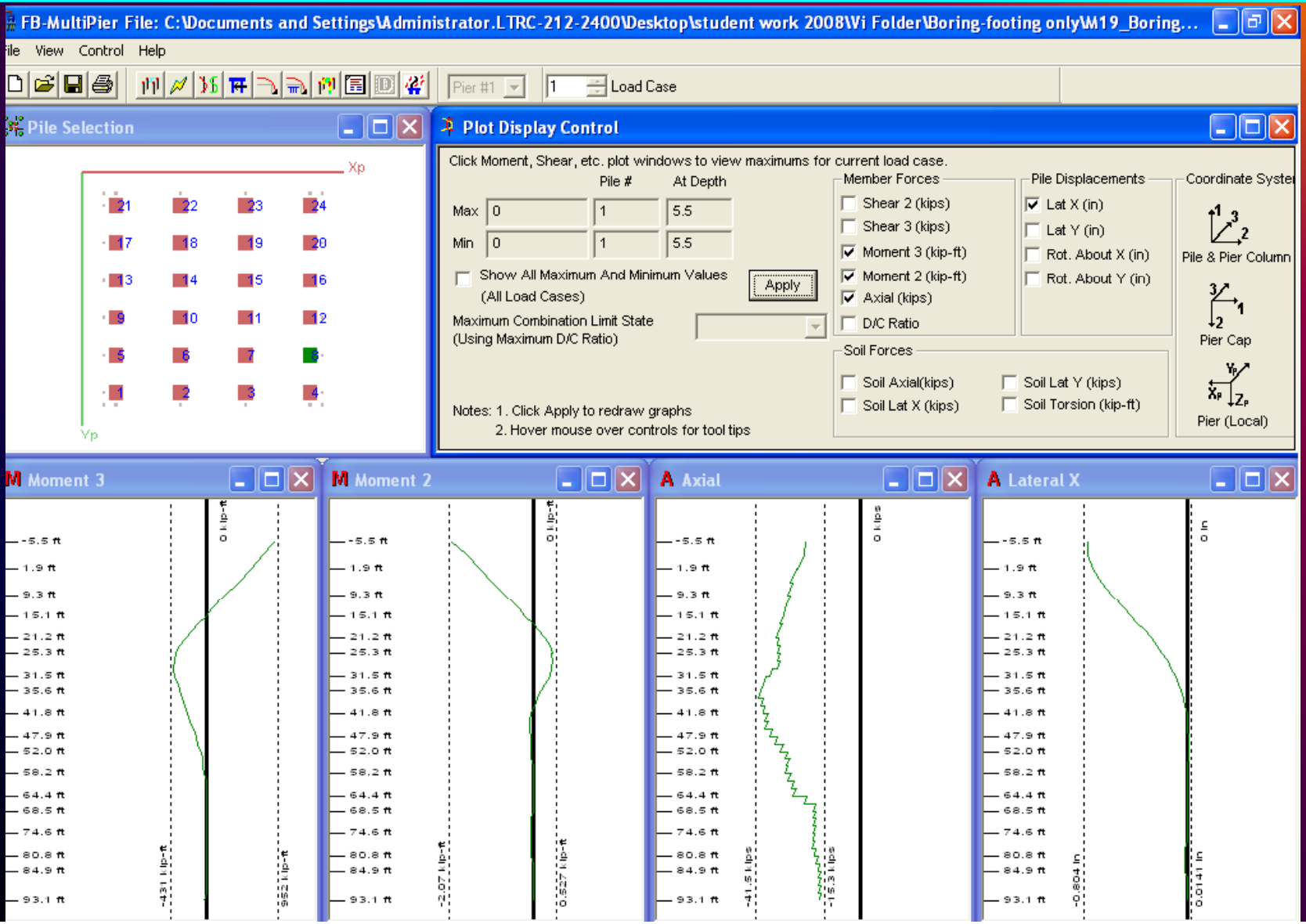


- P-Y method
- Analysis using soil boring and CPT data

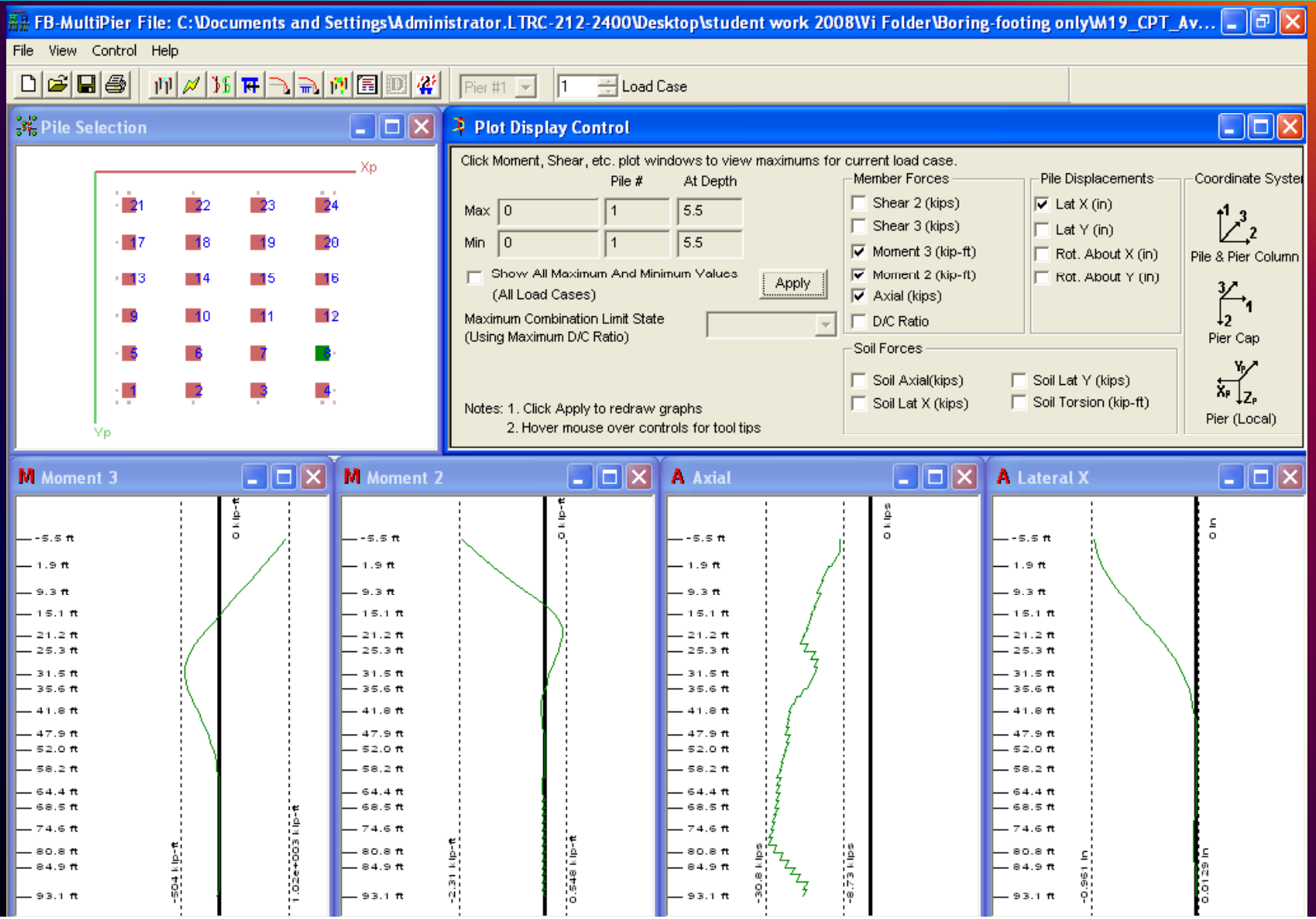




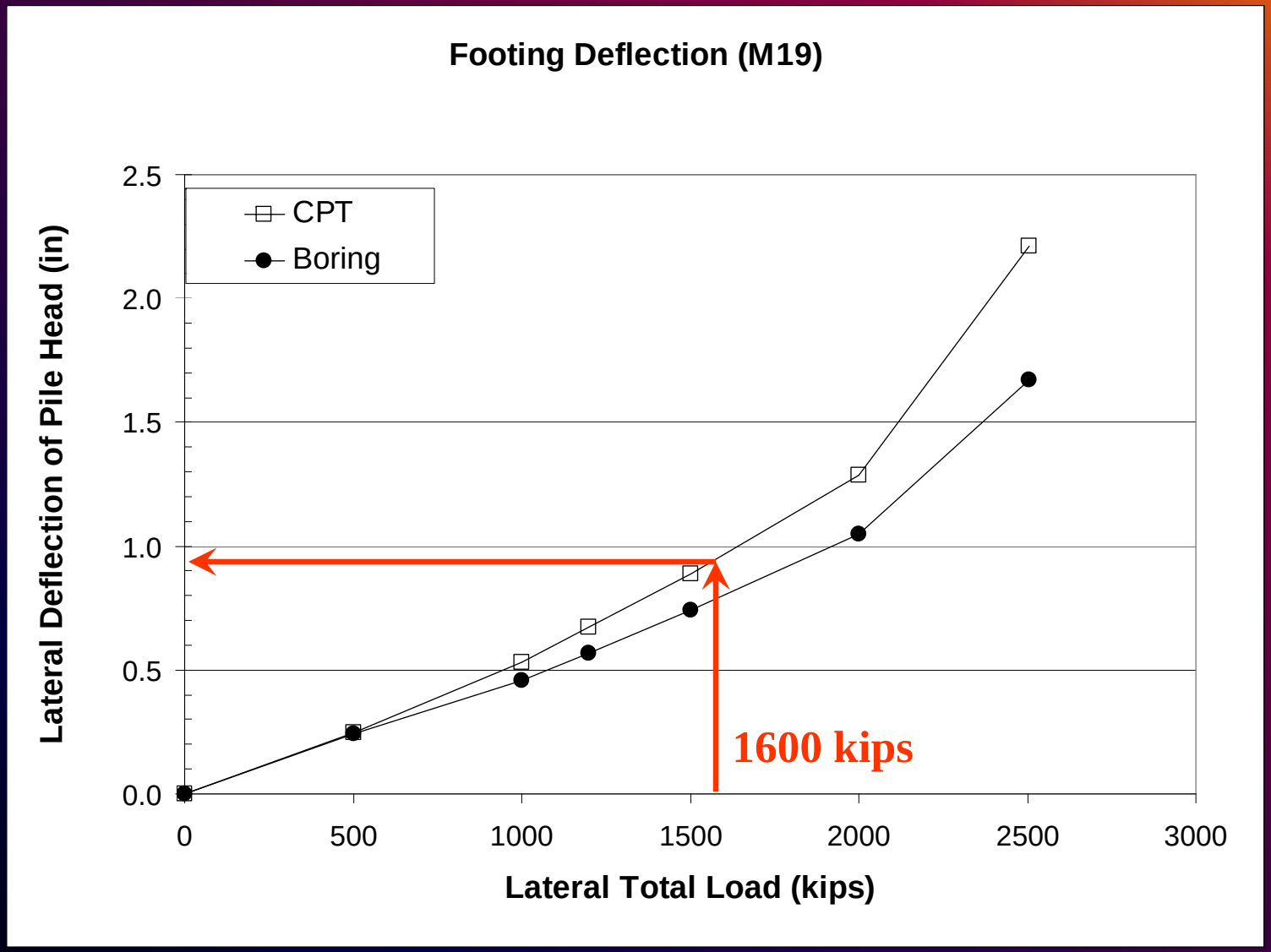
FB-MultiPier Analysis Using Boring Data at 1600 kips



FB-MultiPier Analysis Using CPT Data at 1600 kips



Results of FB-MultiPier Analysis

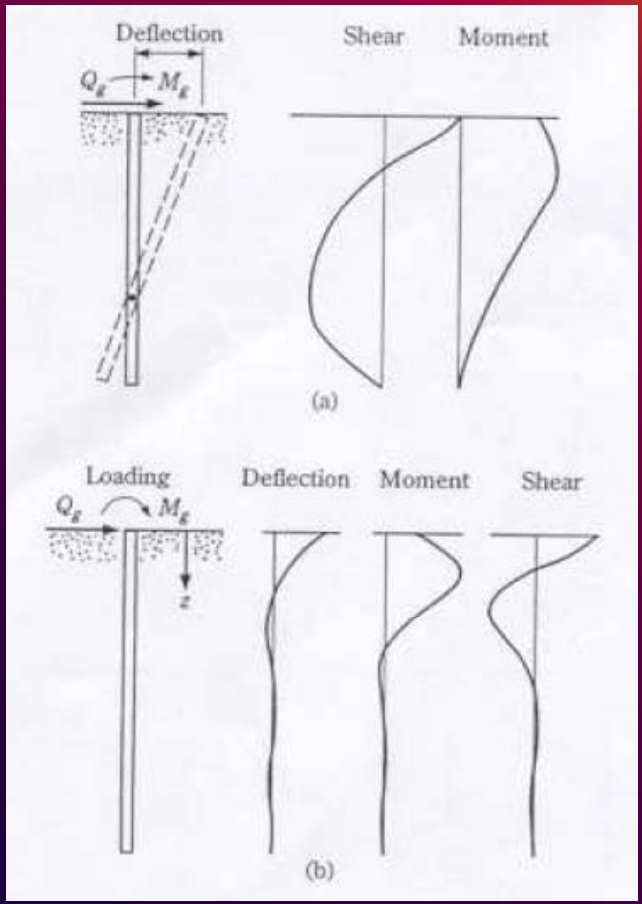


THANK YOU

Background of Laterally Loaded Pile Foundations Design

- **Types of Methods:**

1) **Broms' Method (1965)**
   - **Short pile: shear failure in the soil**
   - **Long pile: bending of the piles governed by plastic yield resistance of pile section**
2) **Meyerhof's Method (1995)**
   - **Another solutions for laterally loaded rigid (short) and flexible (long) piles**

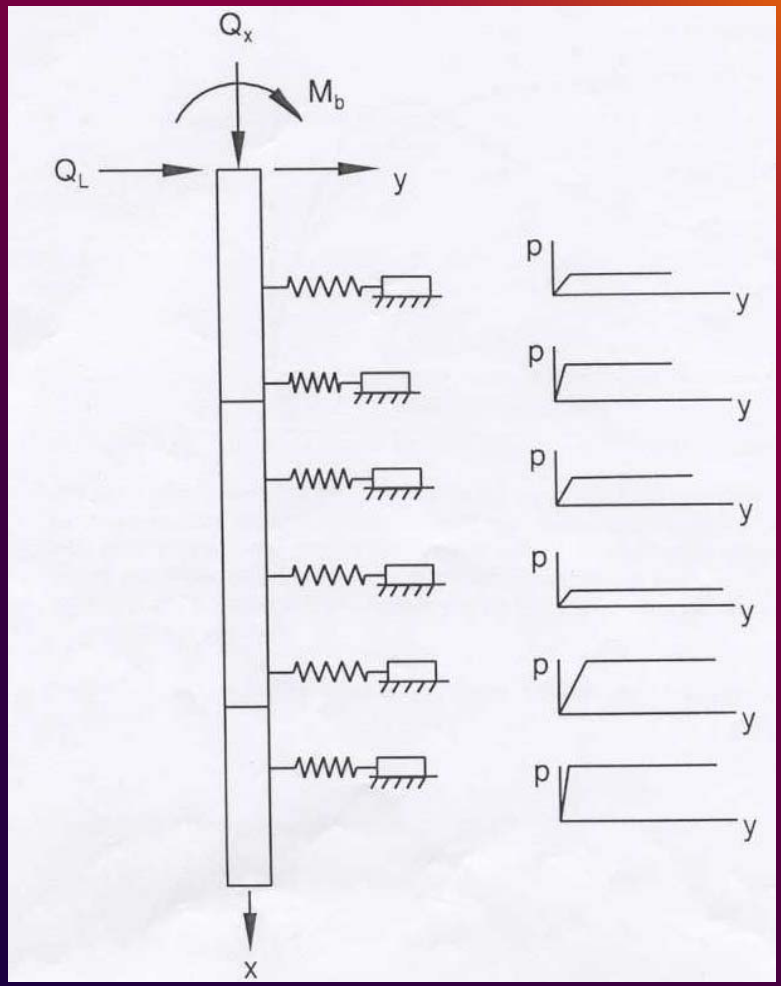


(a) Short Pile (b) Long Pile

3) The P-Y Method

$$k = p/y$$

k = subgrade modulus
(elastic springs)
p = soil resistance per unit
pile length
y = pile deflection



Pile-Soil Model

Average ε_{50} for Lateral Movement

ε_{50} for Clay							
Clay Consistency	Cu (kPa)		Avg.	Cu (psf)		Avg.	ε_{50}
soft clay	12	24	18	250.68	501.36	376.02	0.02
medium clay	24	48	36	501.36	1002.72	752.04	0.01
stiff clay	48	96	72	1002.72	2005.44	1504.08	0.007
very stiff clay	96	192	144	2005.44	4010.88	3008.16	0.005
hard clay	192	383	287.5	4010.88	8000.87	6005.875	0.004

Average κ for Lateral Movement

K Values for Clays and Sands								
Soil Type	Cu (kPa)		Avg.	Cu (psf)		Avg.	Soil Condition	K static (lb/in^3)	K static (kN/m^3)
soft clay	12	24	18	250.68	501.36	376.02		29.9552	8140
medium clay	24	48	36	501.36	1002.72	752.04		99.912	27150
stiff clay	48	96	72	1002.72	2005.44	1504.08		500.48	136000
very stiff clay	96	192	144	2005.44	4010.88	3008.16		997.28	271000
hard clay	192	383	287.5	4010.88	8000.87	6005.875		1998.24	543000
Loose sand							Submerged	19.9824	5430
Loose sand							Above WT	24.9872	6790
Med dense sand							Submerged	59.984	16300
Med dense sand							Above WT	89.9024	24430
Dense sand							Submerged	124.752	33900
Dense sand							Above WT	224.48	61000