51st Annual Southeastern Transportation Geotechnical Engineering Conference (STGEC)

Top-Loaded Bi-Directional Test, a New Approach to Deep Foundation Load Testing

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www.rbmcgroup.com

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Outline

1) Conventional Bi-Directional Load Test (“BDLT”)
2) Top-Loaded Bi-Directional Test (“TLBT”)
3) TLBT Vs. BDLT - Comparison

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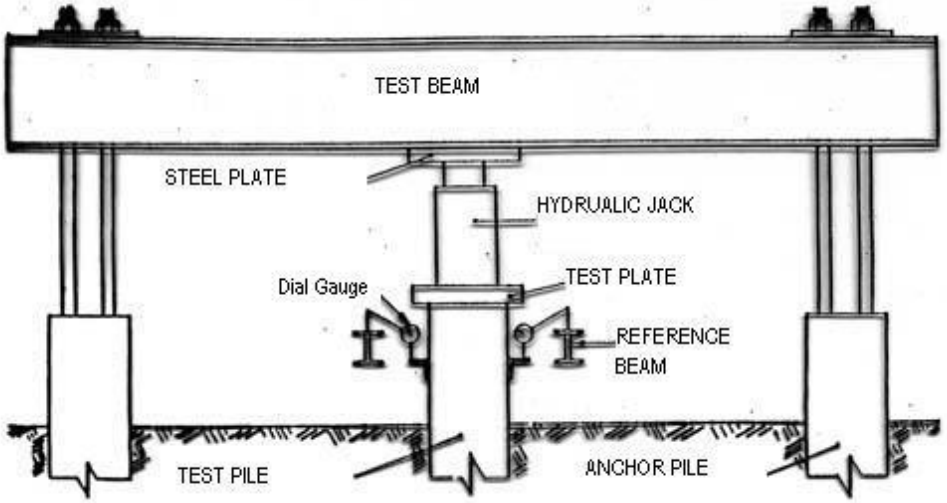
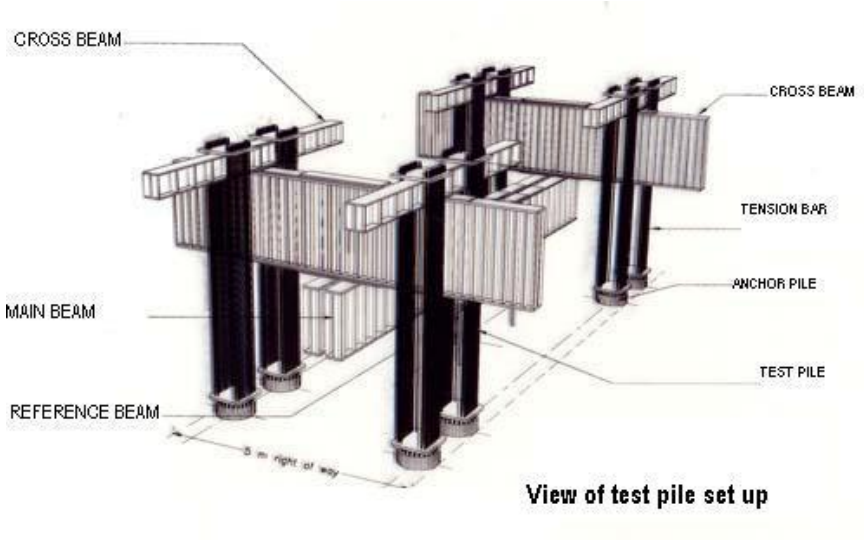
Introduction

- Full Scale Static load Tests to assess deep foundations geotechnical resistance
- All tests have Advantages and Limitations
- Selection and completion of a full-scale load test type
- Foundation optimization or alternate solutions
- In the LRFD case, resistance factors improvement

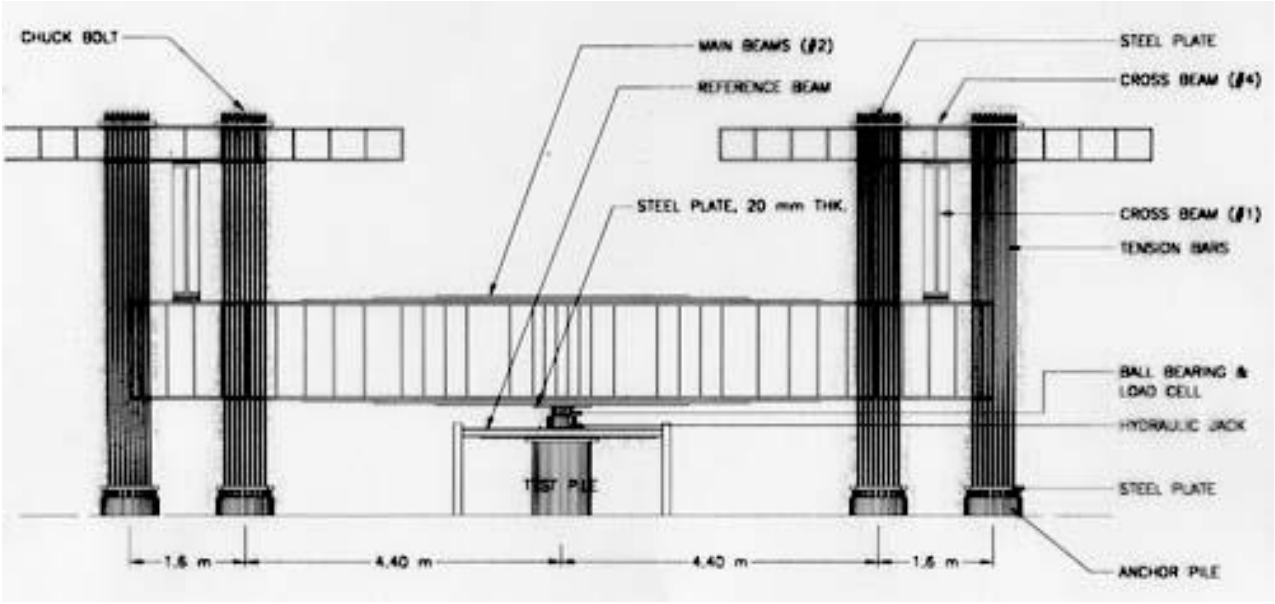
Full-Scale Static Load Tests

- Top-Down test, or Static Load Test
- Conventional Bi-Directional Static Load Test (“BDLT”)
  - Instrumented tests
  - Non-Instrumented tests





View of test pile set up



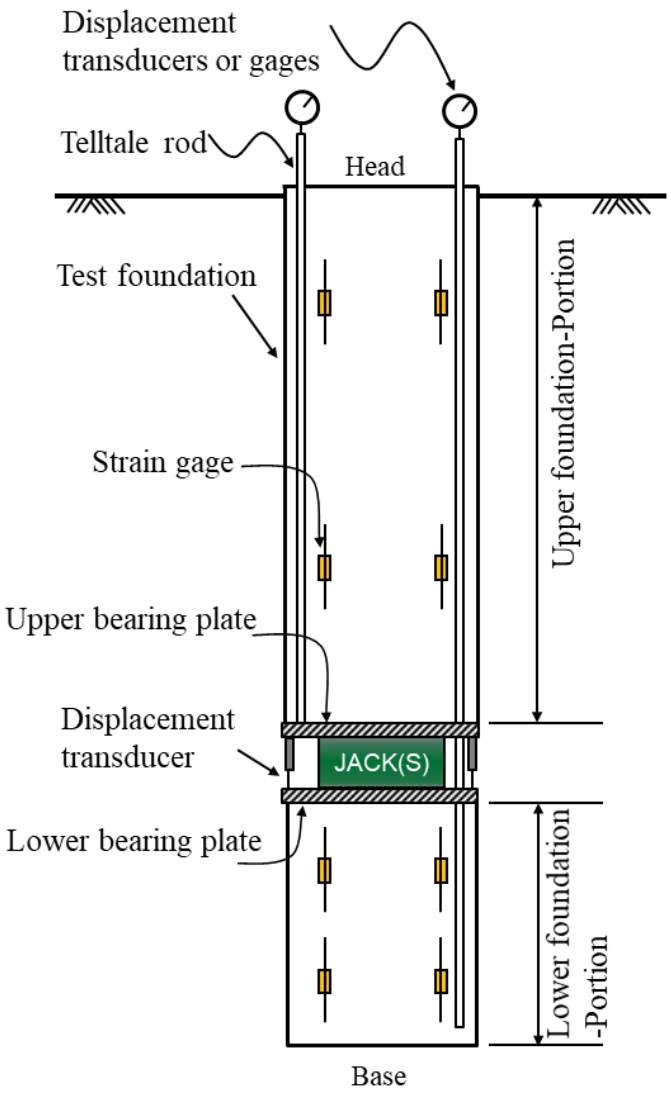
FHWA-HRT-05-159 (2006)

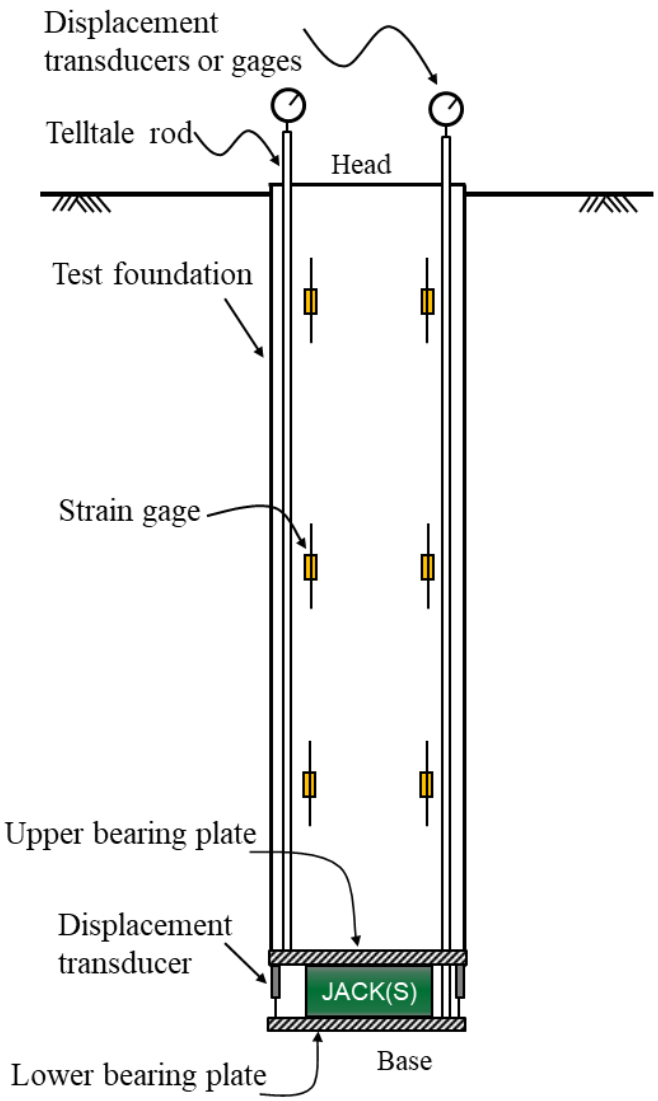
Conventional Bidirectional Load Test

Conventional Test

- Embedded single or multiple expandable jack assembly
- Jack assembly consists of one or multiple hydraulic jack
- As hydraulic pressure is applied, the jack assembly expands in both directions, Upward and Downward
- Jack assembly maybe located at the foundation base or at the geotechnical resistance balance elevation
- Instrumentation using Telltales, Strain Gages, Displacement Transducers

Conventional Bidirectional Load Test





Non-recoverable jacks


4x7.25 #

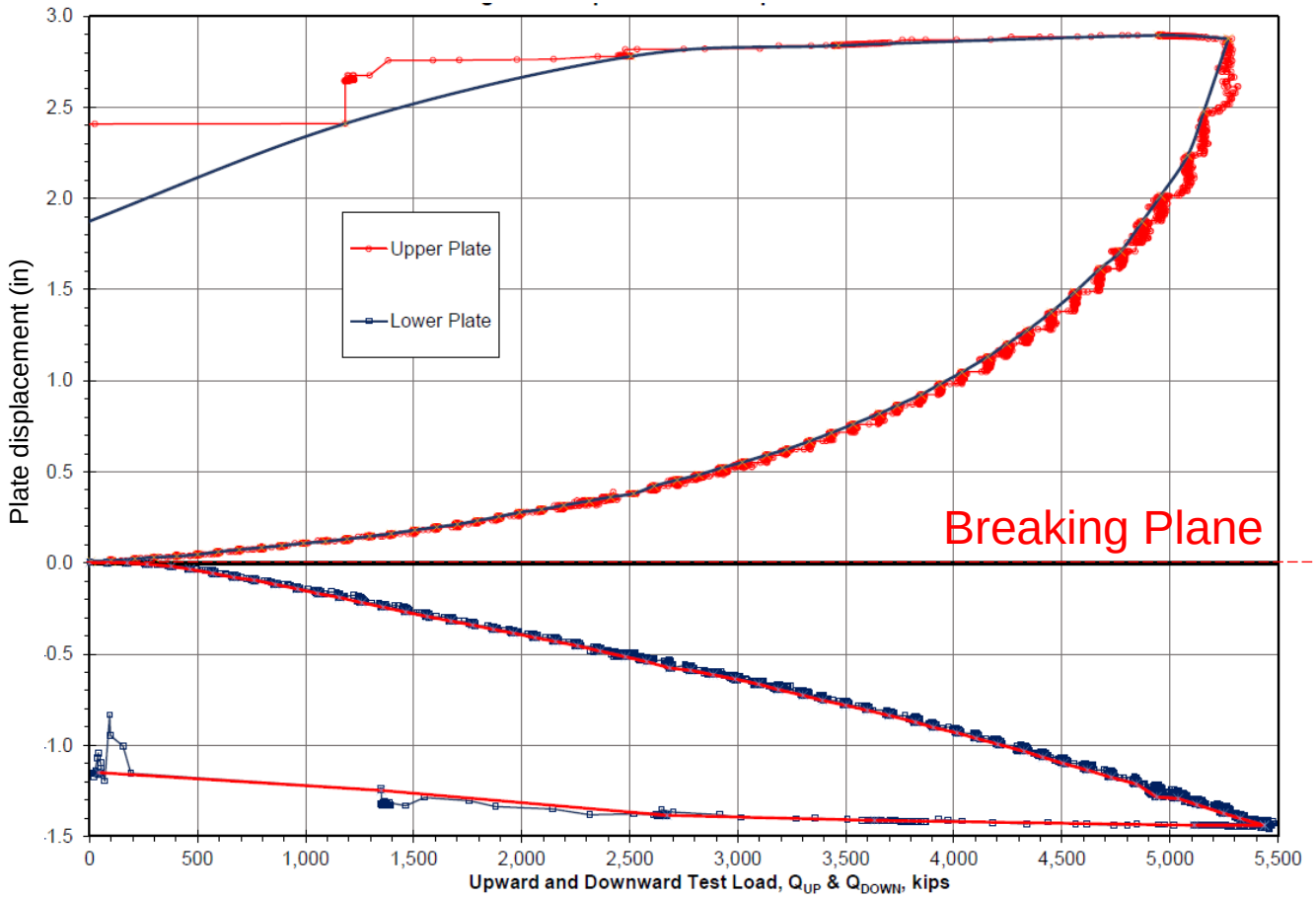
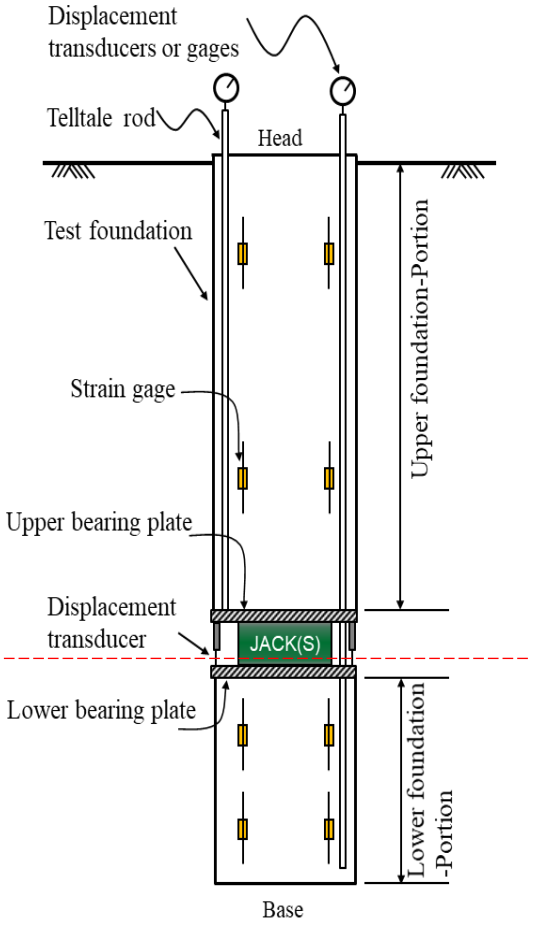
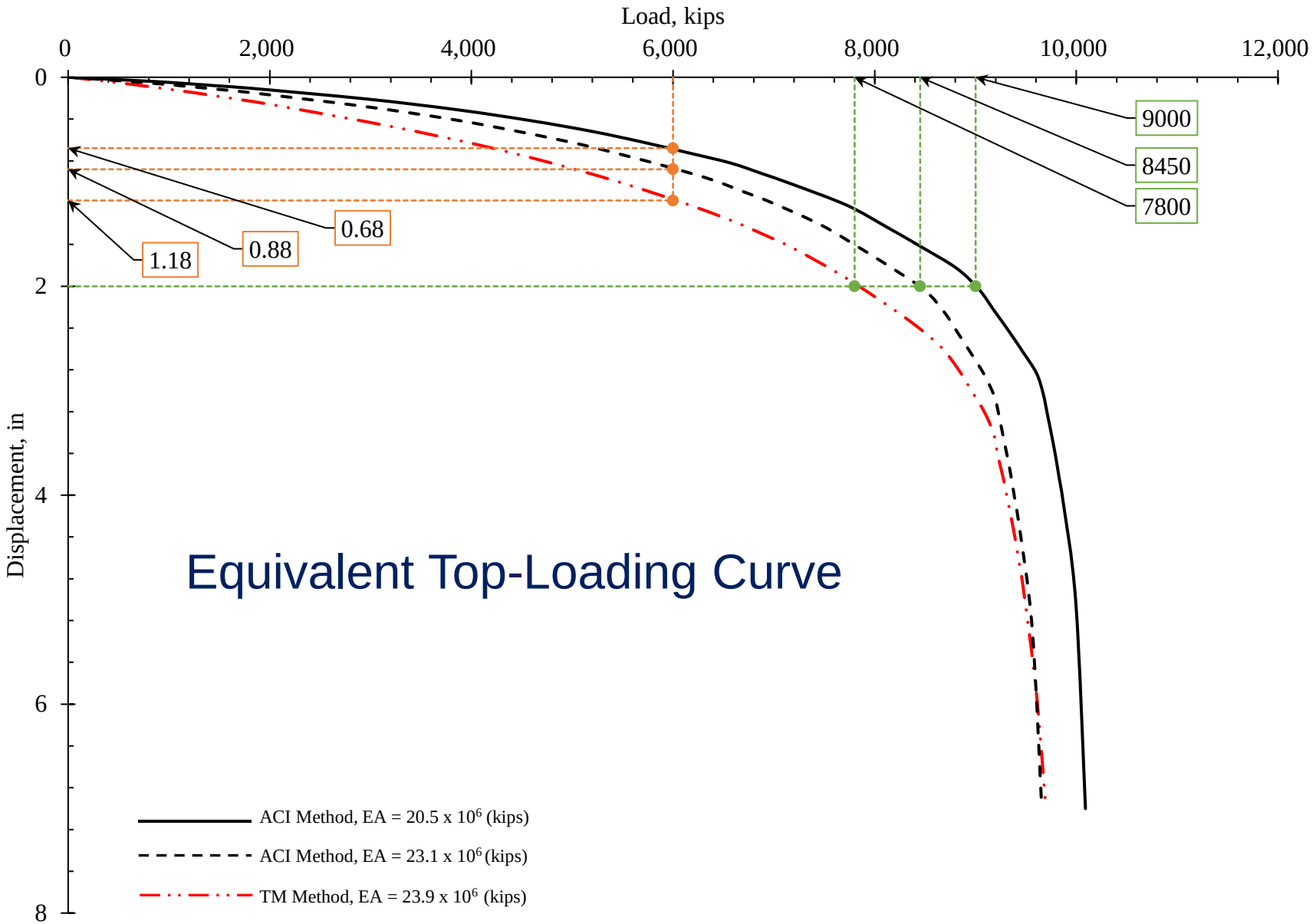


Plate displacement (in)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
Upward and Downward Test Load, Q_{UP} & Q_{DOWN}, kips
Upper Plate
Lower Plate
Breaking Plane


Displacement transducers or gages
Telltale rod
Head
Test foundation
Strain gage
Upper bearing plate
Displacement transducer
JACK(S)
Lower bearing plate
Base
Upper foundation-Portion
Lower foundation -Portion


Load, kips
0
2,000
4,000
6,000
8,000
10,000
12,000
Displacement, in
0
2
4
6
8
9000
8450
7800
0.68
0.88
1.18
Equivalent Top-Loading Curve
ACI Method, EA = 20.5 x 10^6 (kips)
ACI Method, EA = 23.1 x 10^6 (kips)
TM Method, EA = 23.9 x 10^6 (kips)

Conventional Bi-Directional Test Challenges

- Concrete placement and foundation integrity
- Tremie pipe location
  - No Center-hole Tremie
  - Slick line to the rebar cage side
- Concrete flow around the Bi-Directional Jack Assembly
- Hydraulic Jacks Mechanical Failures
- Possibility of running out of jack stroke (9 in. max.)
- Non-recoverable jack assembly

Slickline and pre-installed small-diameter Tremie Pipe

Slickline End

Slickline Pipe


SHAFTSPACER
SHAFTSPACER

Top-Loaded Bi-Directional Test (TLBT)

Deep Foundations Institute 2021

Las Verga, NV

Test Method Introduction

TOP-LOADED BIDIRECTIONAL TEST, A NEW APPROACH TO DEEP FOUNDATIONS LOAD TESTING

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ABSTRACT

The Top-Loaded Bi-Directional Test ("TLBT") is a new method to apply bi-directional loads to a deep foundation element with the loading source located above the foundation head. In the TLBT reusable load assembly, loads are applied to the foundation using the R-System which consists of two stacked steel plates located at the geotechnical resistance balance point or at the foundation base connected to the load assembly via vertical elements. The top plate or the Shaft Bearing Plate ("SBP") will transfer loads to the foundation upper portion, and the bottom plate or the Base Bearing Plate ("BBP") will transfer loads to the foundation lower portion as well as the foundation base. At the surface, above the foundation head, a hydraulic jack is located between a Top Load Assembly ("TLA"), and the Bottom Load Assembly ("BLA"). The TLA and BLA are connected to vertical elements which are consequently connected to the R-system. As the jack is pressurized and expanded at the surface, the R-System plates are separated, and the foundation is bi-directionally loaded. This paper presents a brief description of the conventional Bi-Directional Load Test ("BDLT") including benefits and limitations followed by the TLBT method introduction including its benefits and advantages over other testing methods.

Like the conventional BDLT, the TLBT includes instrumentation to measure strains within the foundation element, upward movement of the SBP and downward movement of the BBP, and the jack pressure. From these measured values, loads and displacements are calculated. Due to the test method practical constructability, the TLBT provides a foundation testing system with reduced risk associated with foundation construction as well as load testing challenges.

Deep Foundations Institute 2022

National Harbor, MD

Comparison to BDLT

TOP-LOADED BI-DIRECTIONAL TEST AND THE CONVENTIONAL BI-DIRECTIONAL LOAD TEST, A DIRECT COMPARISON

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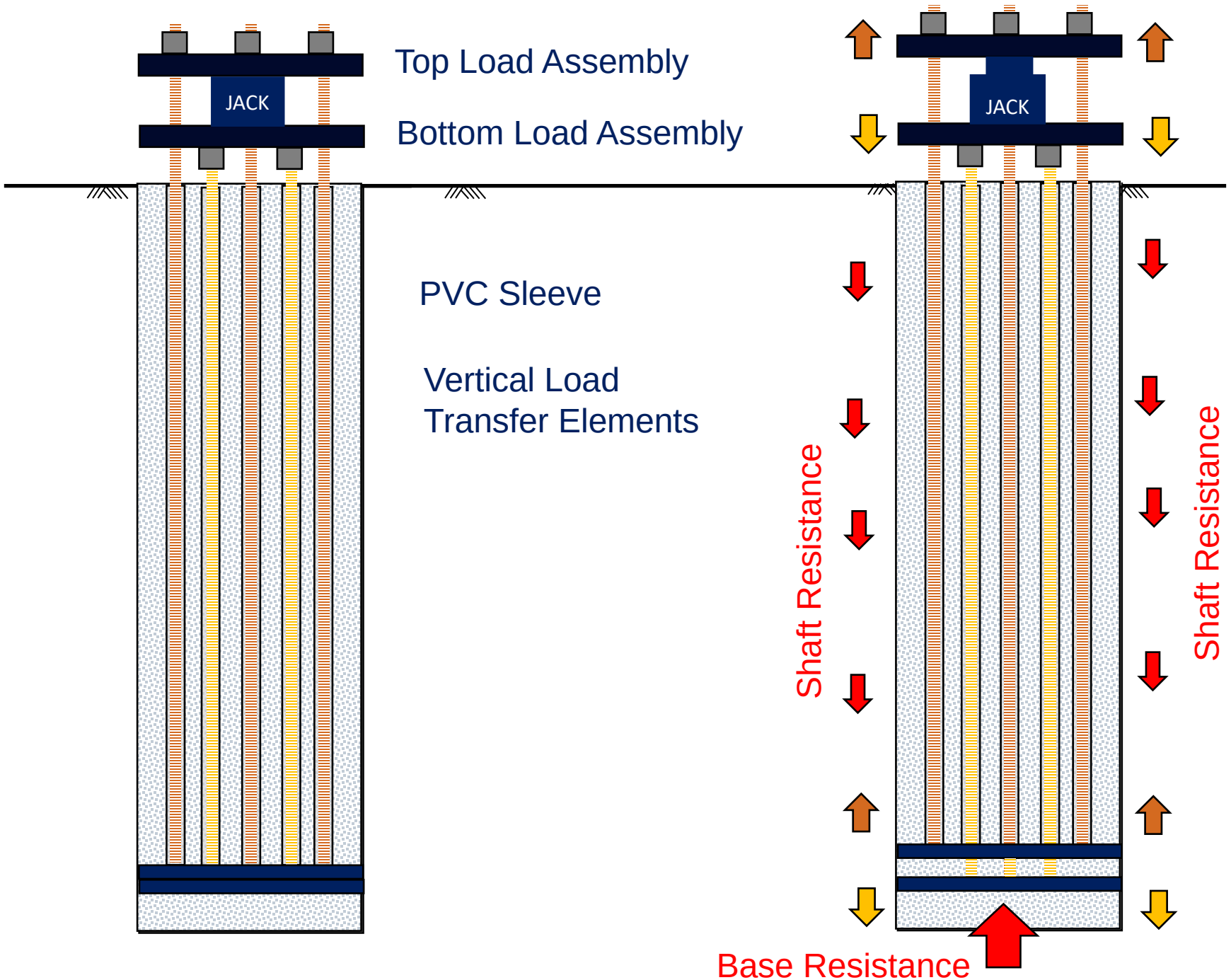
ABSTRACT

The Top-Loaded Bi-Directional Test ("TLBT") and the conventional Bi-Directional Load Test ("BDLT") are full-scale load tests where loads are applied bi-directionally to the foundation element. The BDLT uses an embedded loading source consisting of a jack assembly with one or multiple hydraulic jacks located between two steel bearing plates. As the jack(s) within the jack assembly is/are pressurized, the plates receive the load from the jack(s) and transfer these loads to the foundation element. In the case of the TLBT, the loads are also applied bi-directionally to the foundation element. However, in the TLBT case, the loading source is located above the foundation head. With the TLBT's non-embedded and reusable load assembly, the loads are applied to the foundation using the steel shaft bearing and base bearing plates cast within the foundation. These plates are connected to the load assembly at the foundation head via Grade 75 or Grade 150, threaded, steel bars.

This paper presents comparison results from a full-scale load test performed by both bi-directional load testing methods on adjacent test shafts. Details regarding subsurface conditions as well as test shaft construction and installation are included for the comparison tests. Test results and corresponding analyses are presented and discussed in detail.

Top-Loaded Bidirectional Test (TLBT)

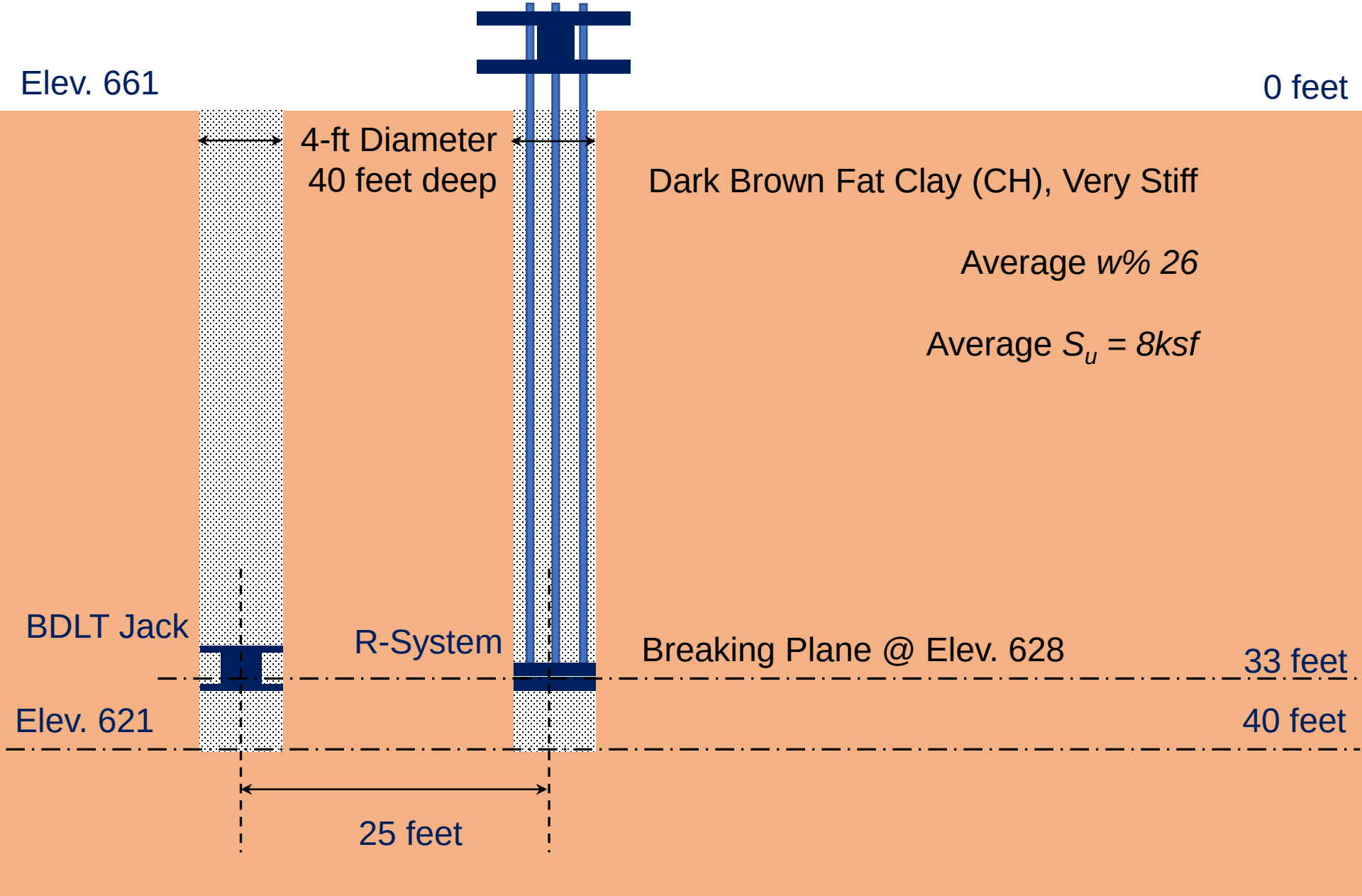
- All loads are applied from the top using a Load Transfer Assemblies, Vertical load transfer elements, and the /R-System
- The R-System Consists of Two Steel Plates, Connectors, and transfer bars
- The R-System will transfer the load Bidirectionally to the foundation
- No embedded hydraulic jack(s) is/are required for the test
- Instrumentation using Telltales and Strain Gages

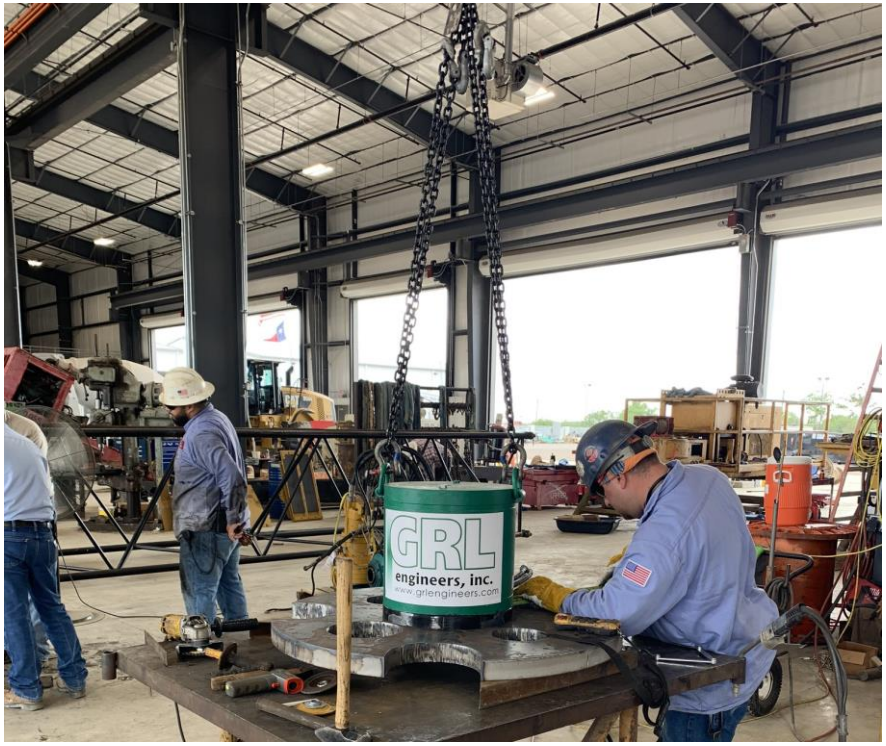

JACK
Top Load Assembly
Bottom Load Assembly
PVC Sleeve
Vertical Load
Transfer Elements
JACK
Shaft Resistance
Shaft Resistance
Base Resistance

Field Trial Test 1

TLBT First Full-Scale Test July 2020

Both Shafts fully instrumented with Strain Gages, CSL, TIP

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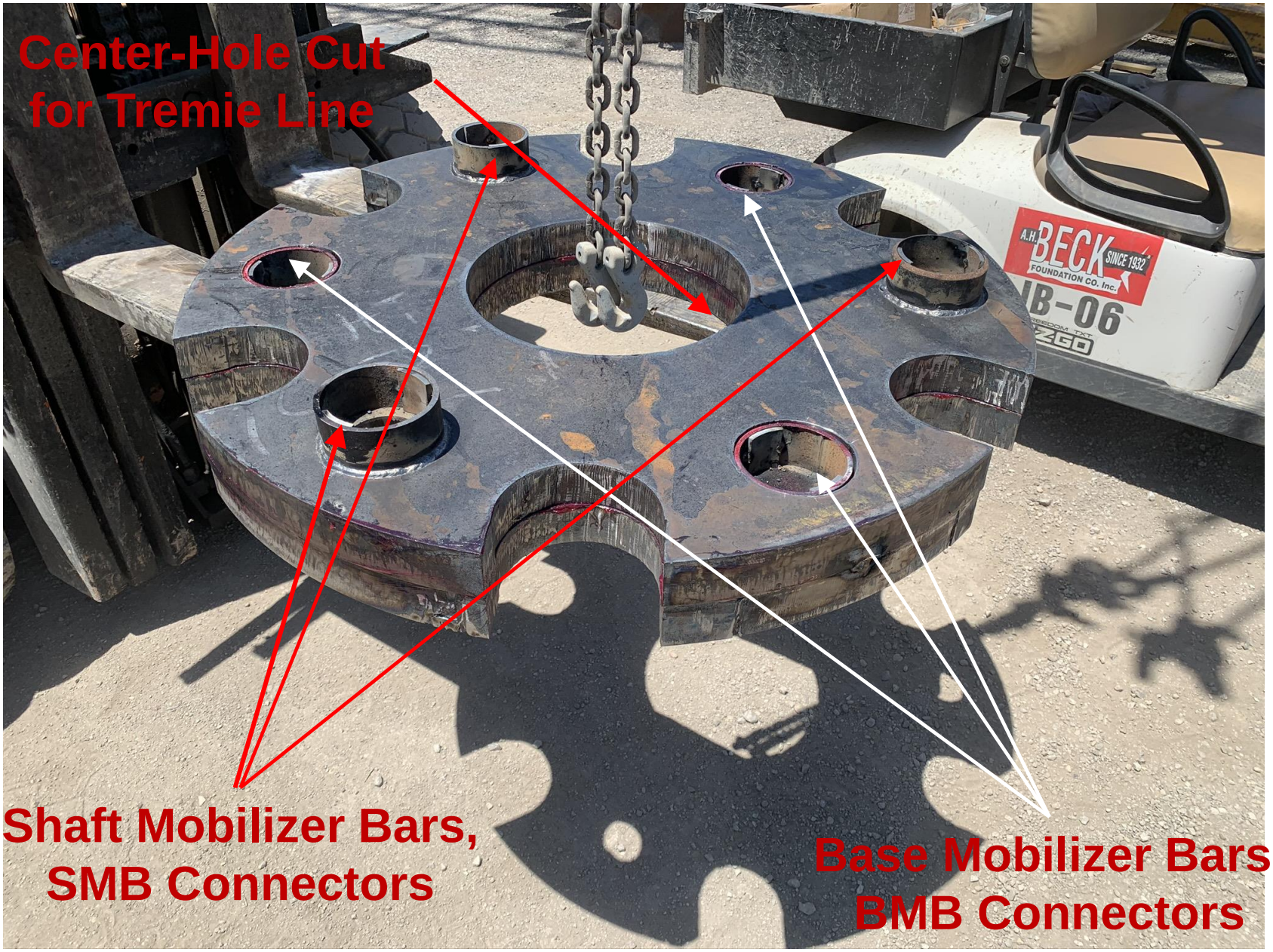
R-System- Plates and Connectors

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JB-06
E-Z-GO


HYSTER
SUPER DUTY

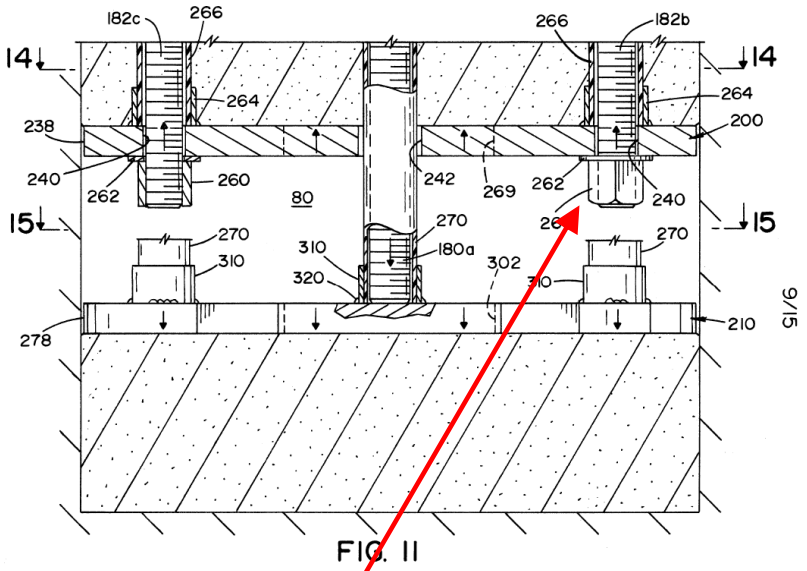
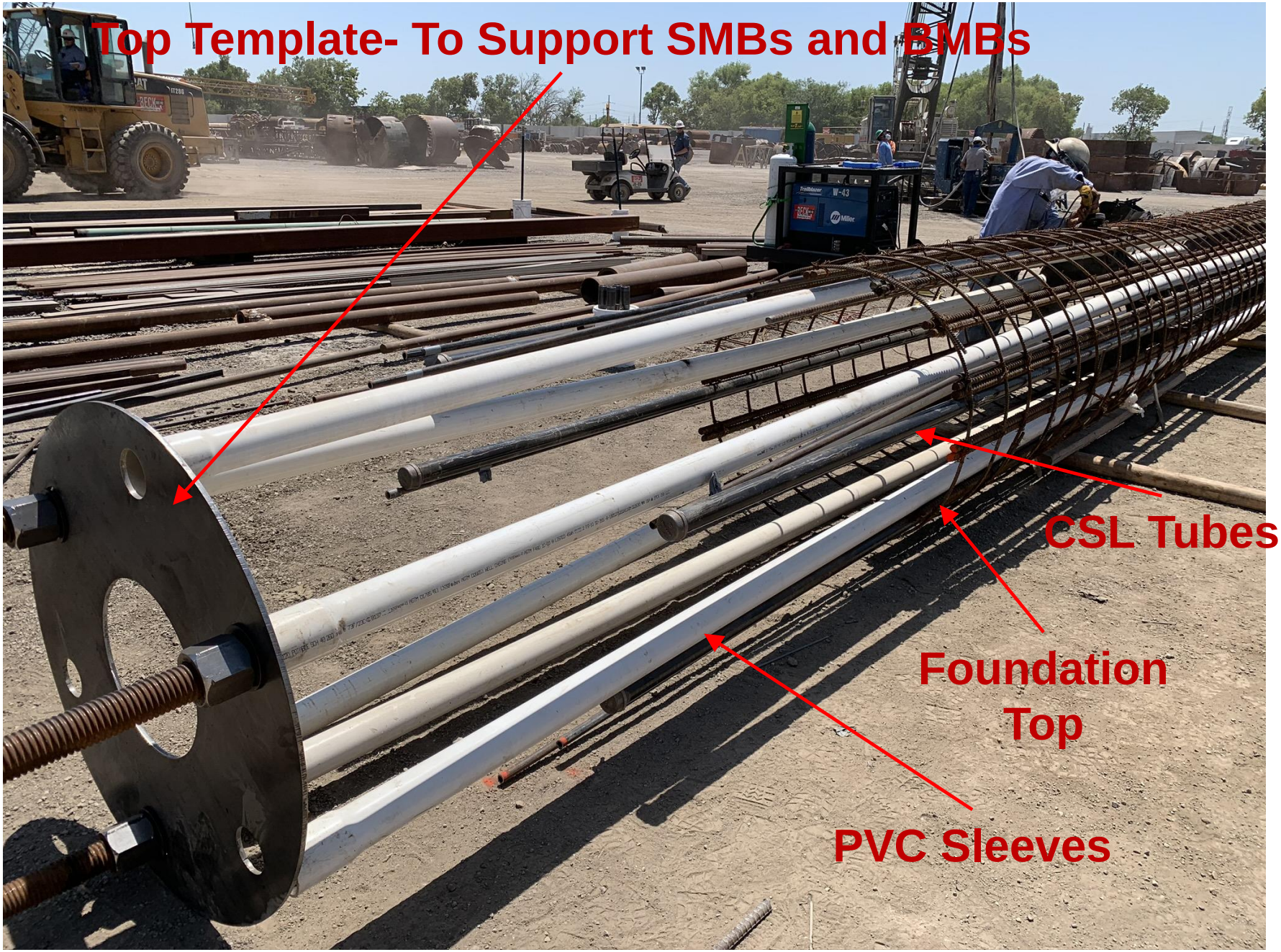


FIG. 11

Shaft Mobilizer Bars, SMB, Connectors

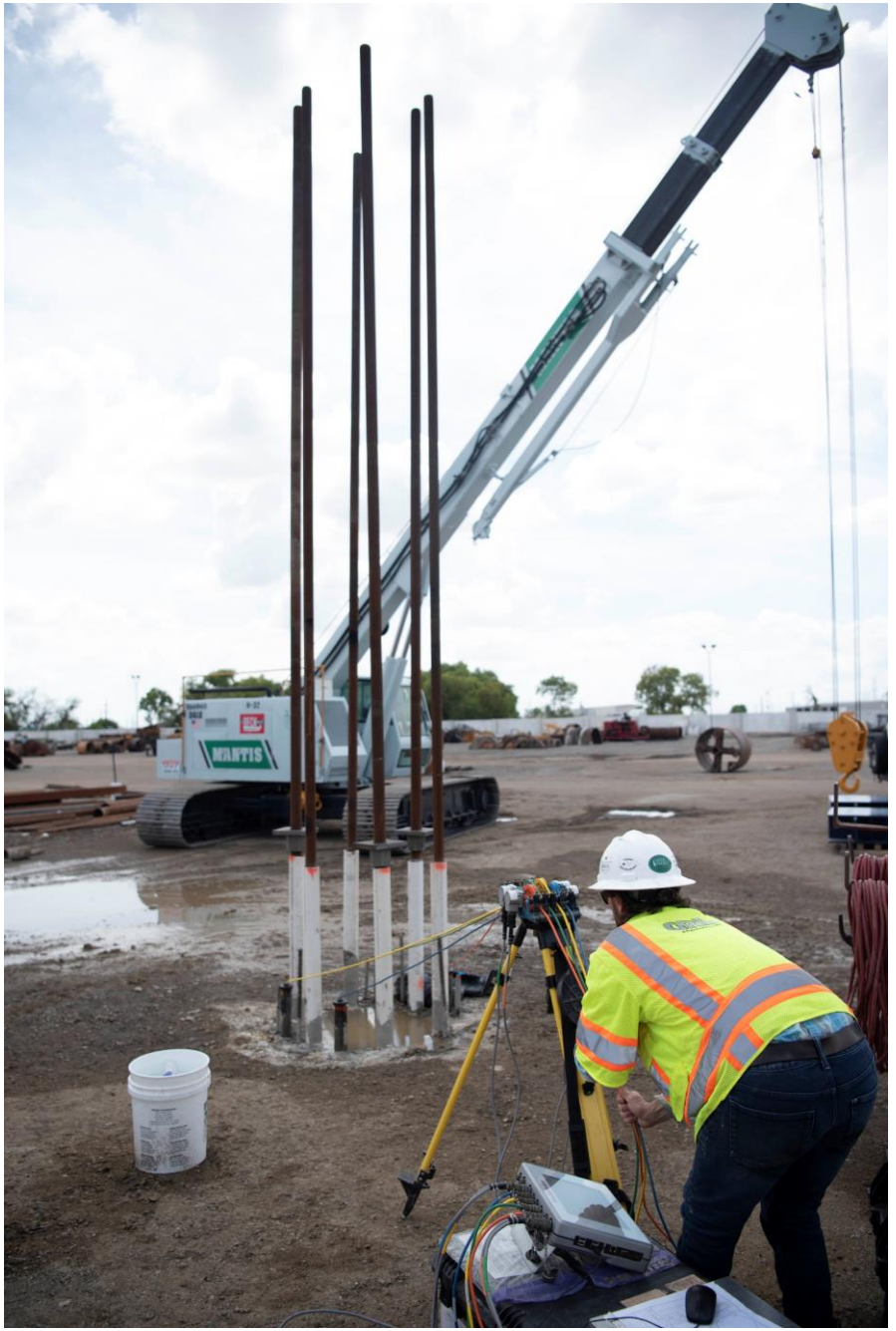
View: Foundation Base looking up


Top Template- To Support SMBs and BMBs
CSL Tubes
Foundation Top
PVC Sleeves


BDLT
TLBT


RBM


TAC


MARTIS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CAUTION CAUTION CAUTION CAUTION CAUTION CAUTION


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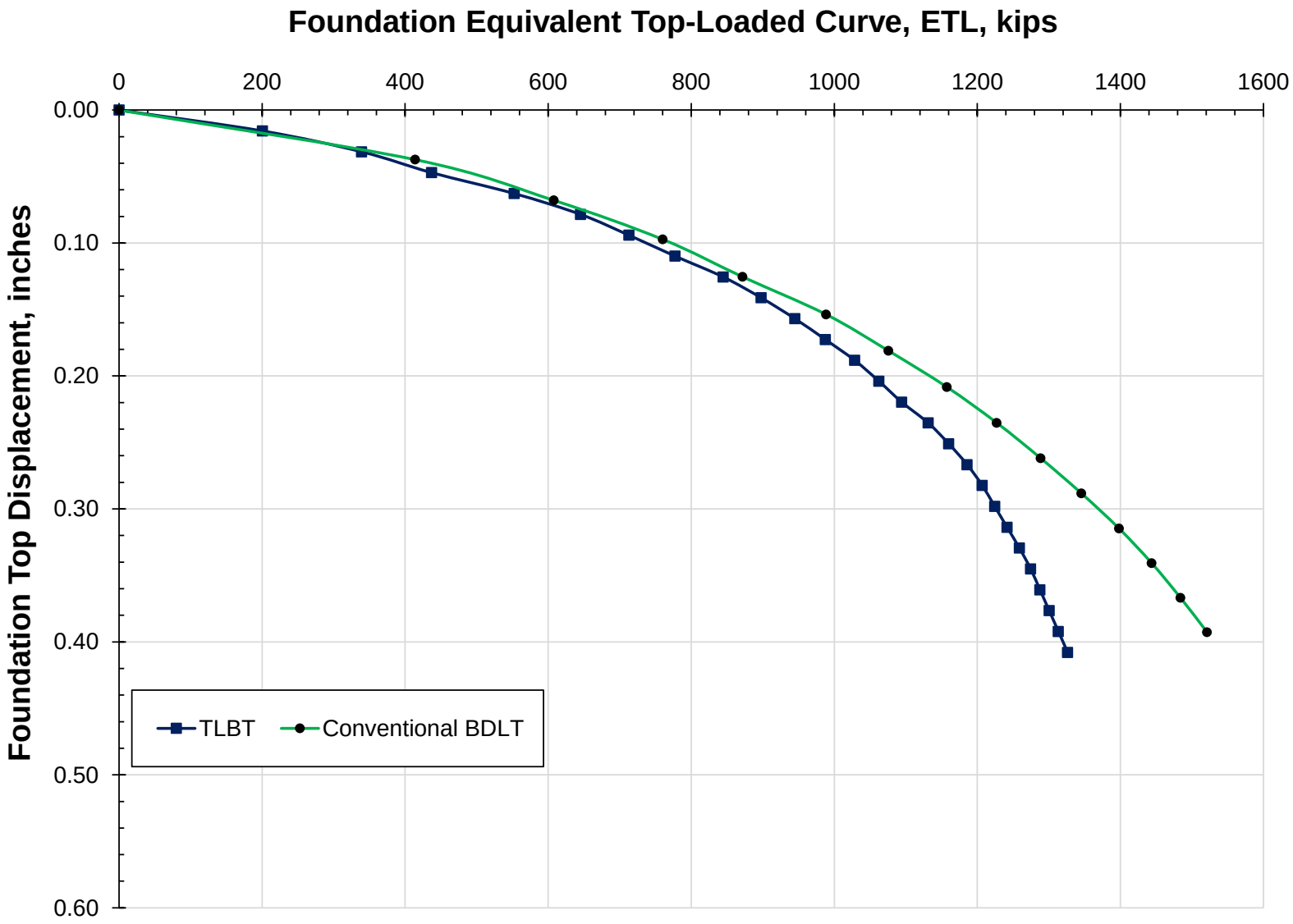
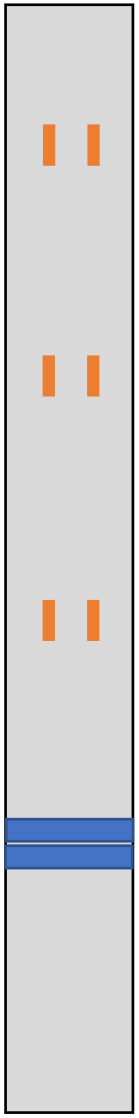
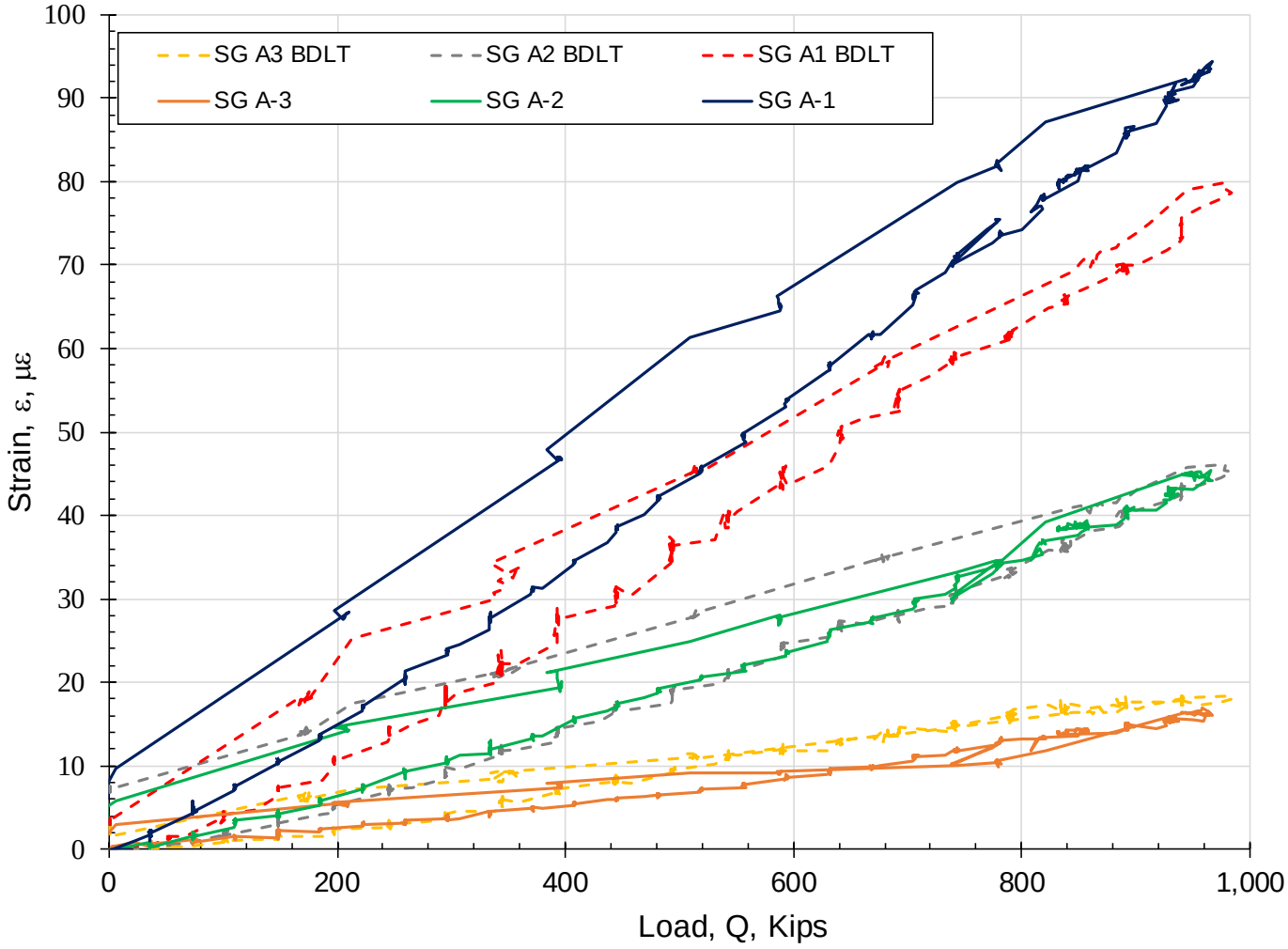
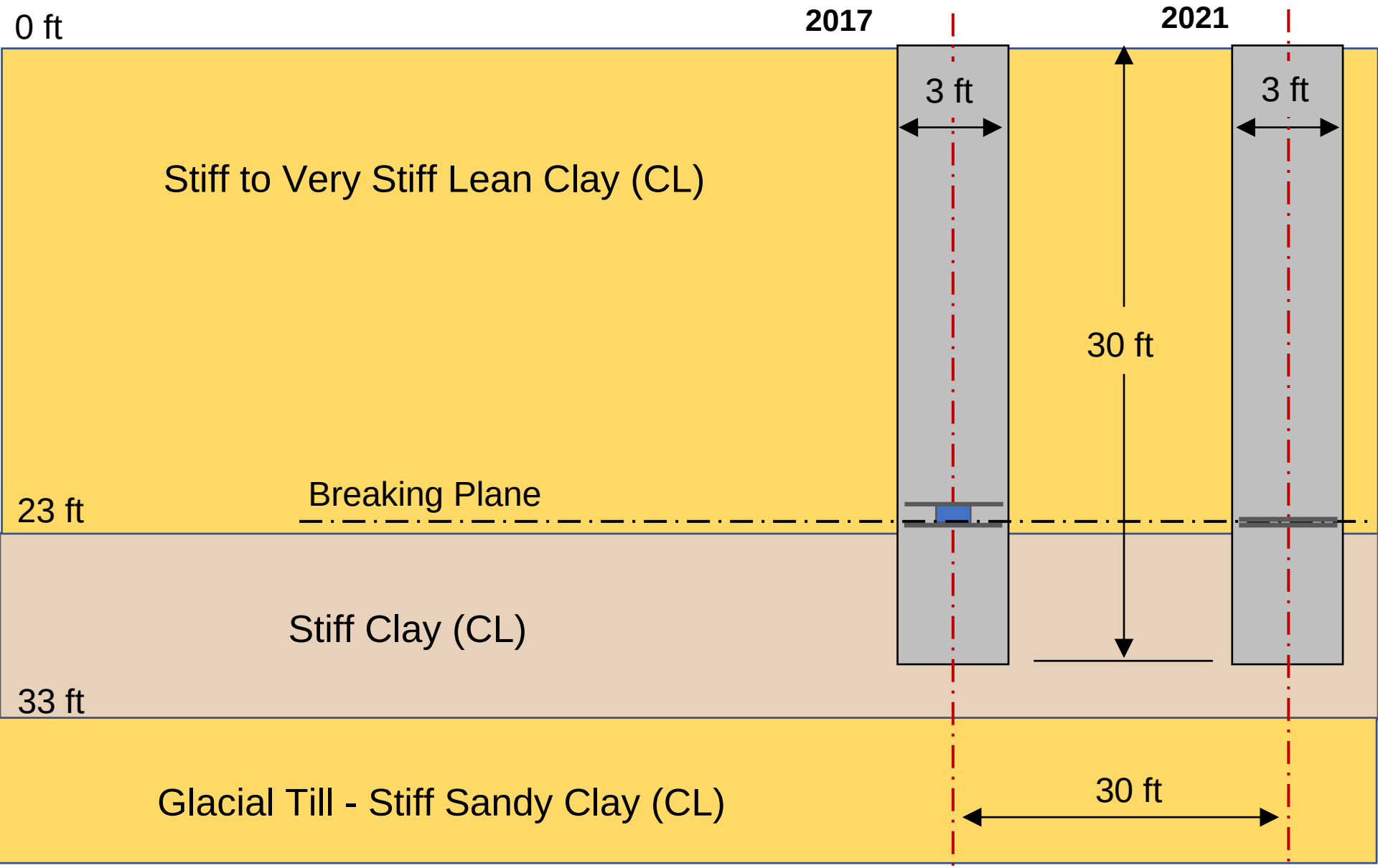
Load Test 1 Results


Foundation Equivalent Top-Loaded Curve, ETL, kips
0
200
400
600
800
1000
1200
1400
1600
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Foundation Top Displacement, inches
TLBT
Conventional BDLT


SG A-3
SG A-2
SG A-1


SG A3 BDLT
SG A2 BDLT
SG A1 BDLT
SG A-3
SG A-2
SG A-1
Strain, ε, με
Load, Q, Kips
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1,000

Field Trial Test 2


0 ft
2017
2021
3 ft
3 ft
Stiff to Very Stiff Lean Clay (CL)
30 ft
Breaking Plane
23 ft
Stiff Clay (CL)
33 ft
Glacial Till - Stiff Sandy Clay (CL)
30 ft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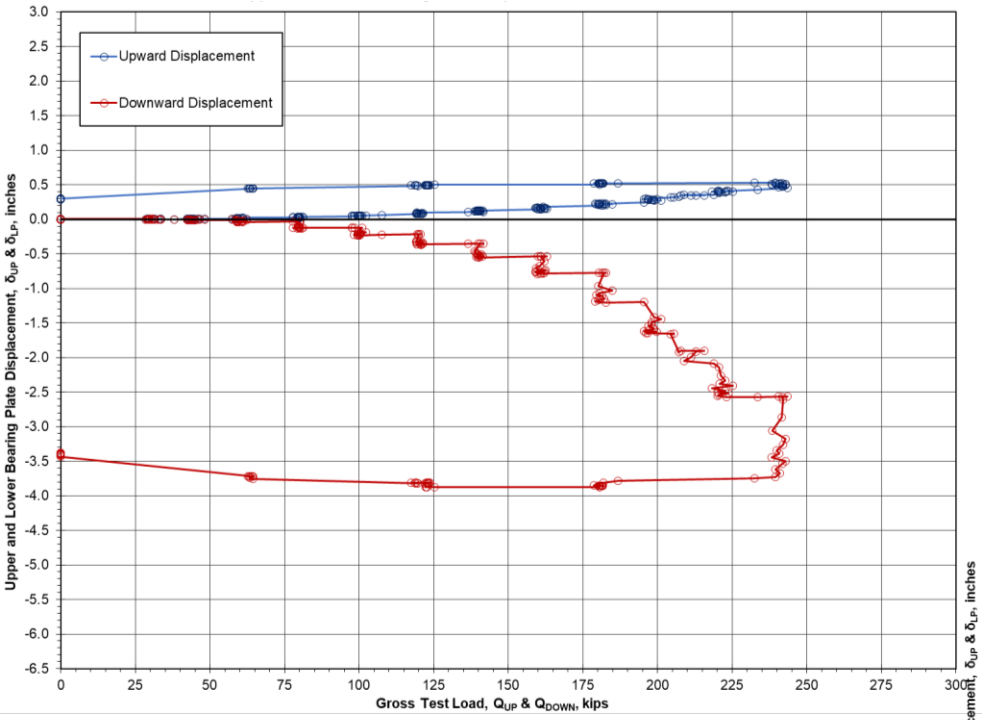
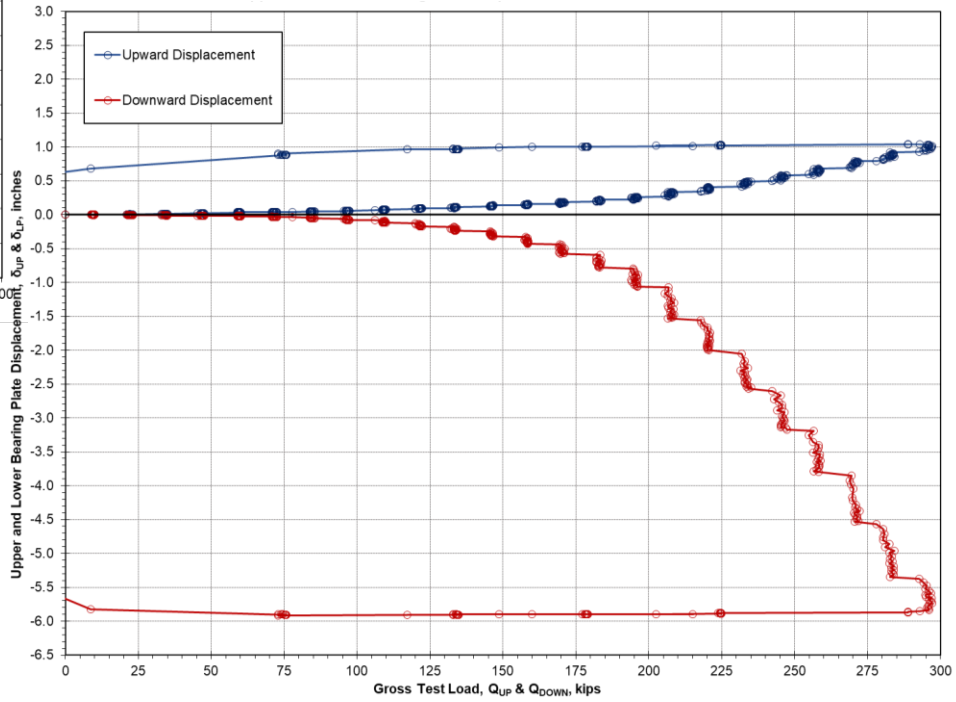
EQUIPMENT,INC.

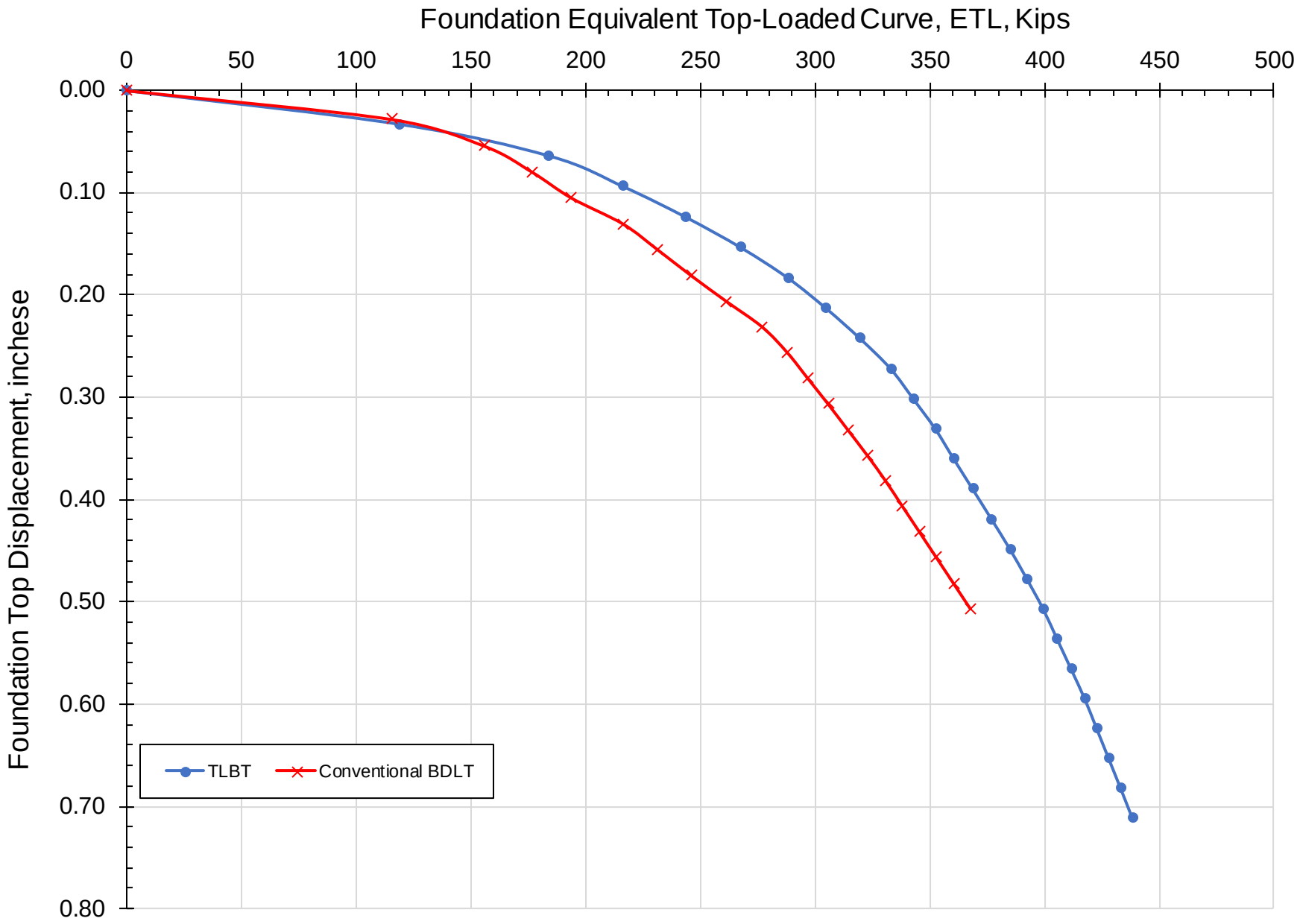

B160
XP

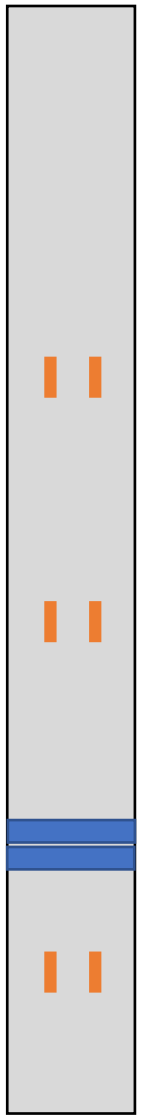


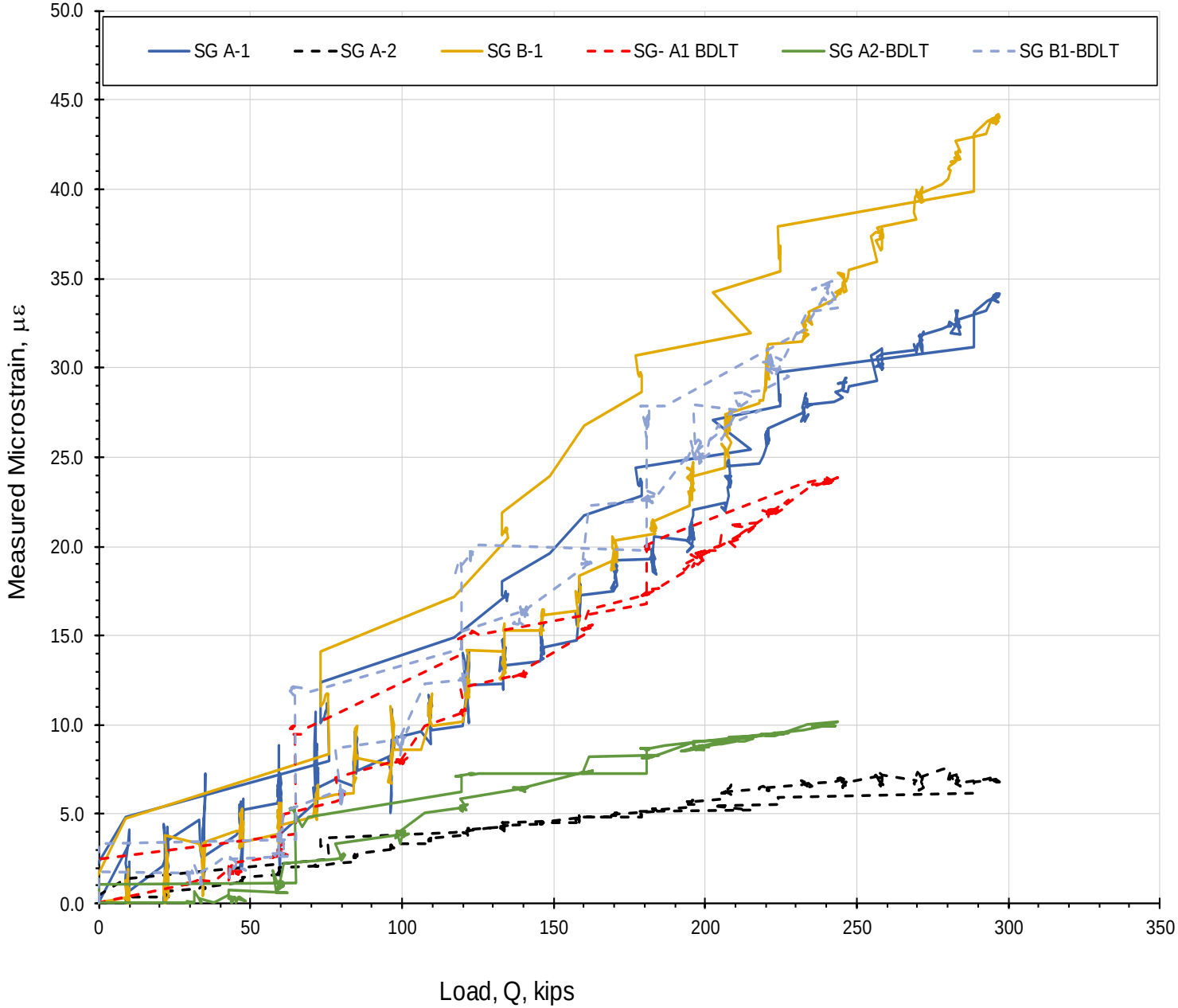
BDLT Results



TLBT Results


Foundation Equivalent Top-Loaded Curve, ETL, Kips
0
50
100
150
200
250
300
350
400
450
500
Foundation Top Displacement, inchese
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
TLBT
Conventional BDLT




SG A-1
SG A-2
SG B-1
SG- A1 BDLT
SG A2-BDLT
SG B1-BDLT
Measured Microstrain, με
Load, Q, kips
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
0
50
100
150
200
250
300
350

Findings:

- Reusable jack assembly
- No restrictions on Jack stroke
- Center-Line tremie pipe
- No damage risk to hydraulic lines
- In case of jack failure, it can be replaced at the top
- The system can be installed at the foundation base for base strengthening
- Financial advantages
- Base Strengthening

THANK YOU FOR YOUR INTEREST

QUESTIONS ARE WELCOME

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