Phase II: Field Load Testing of Shallow Foundations in Florida Limestone, FDOT BDV31-977-124

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Department of Civil and Coastal Engineering

August 2020

Presentation Outline

- **Project Objectives**
- **Project Background**
- **Deliverable 1 Site Investigations**
  - **Cemex SCL Quarry Site**
  - **Sawgrass Expy & W SR 84 (near I-75)**
- **Deliverable 2 Shallow Foundation Load Cemex SCL Quarry**
  - **Anchor Installation**

Project Objectives

I. Conduct load test (900 tons) on shallow foundations at three sites having different Florida Limestone formations and layering (Deliverables 2 to 4)
   I. Homogeneous – single rock layer
   II. Heterogenous - 2 layer – rock overlying sand

II. Measure and predict load vs. settlement and bearing capacity of shallow foundation on homogeneous & heterogeneous (rock over sand) Florida Limestone.

III. For I & II – Need to assess rock strength (q_u, q_{dt} and triaxial testing), modulii (G and E) and rock unit weight from laboratory tests and in-situ methods – a newer seismic method (Deliverable 5)

IV. Validate the New Bearing Capacity Equations derived in FDOT research project BDV31-977-51 (Deliverable 6 & 7)

V. The results of Phase I (FDOT BDV31-977-51) and current project (Phase II) will be used for implementation (Phase III) in FB-MultiPier for the design of shallow foundations beneath bridge piers.

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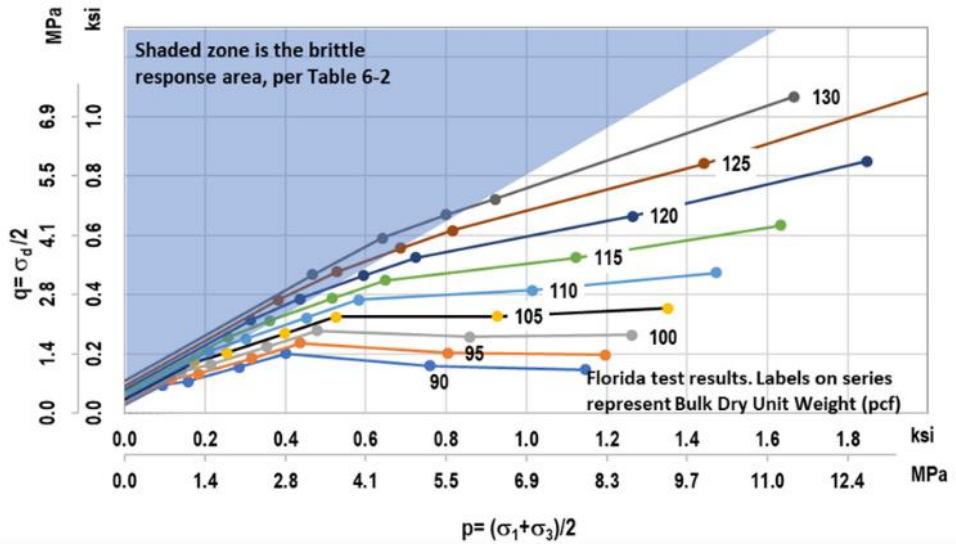
Project Background

- FDOT research project BDV31-977-51 investigated the strength envelope of several Florida limestone formations near the ground surface – function of dry unit weight of rock
- Developed Bearing Capacity Equation on Right, function of rock strength and modulii (homogenous or layered)
- Proposed load vs. settlement is linear [Settlement(G, E)] up to bearing capacity



Strength Envelope – Miami Formation (FDOT BDV31-977-51)

$$Q_u = \min(Q_{u1}, Q_{u2}) * \xi / N_R$$

$$Q_{u1} = n*c*N_c + q*N_q$$

$$Q_{u2} = n*[c*N'_c + p_p*N_\gamma] + q*N_q$$

$$N_c = \frac{1.8\ cos\varphi}{0.8 - sin\varphi}$$

$$N'_c = \frac{1.8\ cos\varphi}{0.8 - sin\omega}$$

$$N_\gamma = \frac{1.8\ [sin\varphi - sin\omega]}{0.8 - sin\omega}$$

$$N_q = (1.5 * \frac{p_p}{\sigma_a} - 10) * (3 * sin\varphi - 1)$$

$$n = \left(\frac{4}{B\ in\ meter}\right)^{-0.055} \text{ or } n = \left(\frac{4}{0.3B\ in\ ft}\right)^{-0.055}$$

$$\xi = \text{shape factor} = 1 + 0.245 \left(\frac{B}{L}\right)^{0.66}$$

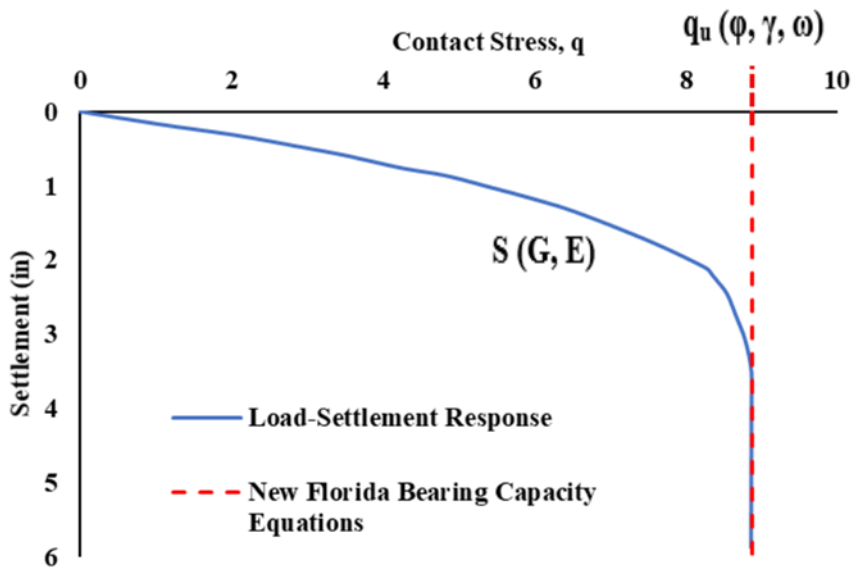
N_R = Rock thickness reduction factor

$$N_R = 0.86 * R^{-0.25} \text{ if } R < 0.3$$

$$N_R = 1.2 - 0.1 * R \text{ if } R \geq 0.3$$

$$R = .093\ T^2 * (E_{soil} / E_{rock})$$

New Florida Bearing Capacity Equations (FDOT BDV31-977-51)



Load vs. Settlement Response of Shallow Foundation

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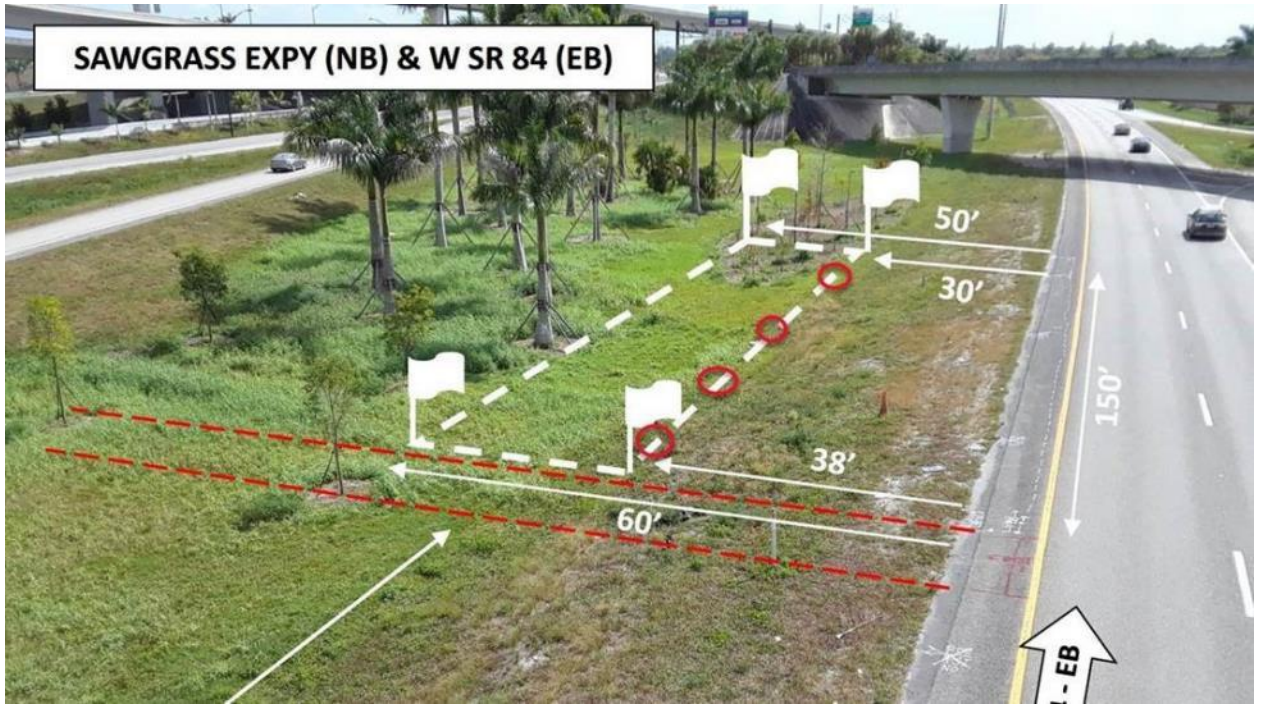
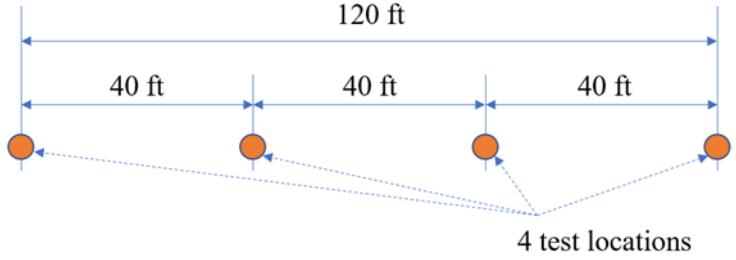
Deliverable 1: Investigation of Load Test Sites

Homogenous Cemex Site SCL Quarry Miami



Layered – Rock over Sand - near I-75 Site



Positions of Rock Cores and SPT tests

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Site 1, Cemex SCL Drilling Investigation

EXPLORATION PLAN
FDOT D6 Geotechnical Services Contract ■ Miami, FL
May 19, 2020 ■ Terracon Project No. H8195028 TWO-32

Terracon GeoReport

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Rock Cores: Cemex RC1

5’ to 10’

10’ to 15’

Run 1 and Run 2

20’ to 25’

30’ to 35’

Run 3 and Run 4

40’ to 45’

50’ to 55’

Run 5 and Run 6

Rock Cores: Cemex RC2

5’ to 10’

10’ to 15’

Run 1 and Run 2

15’ to 20’

28’ to 33’

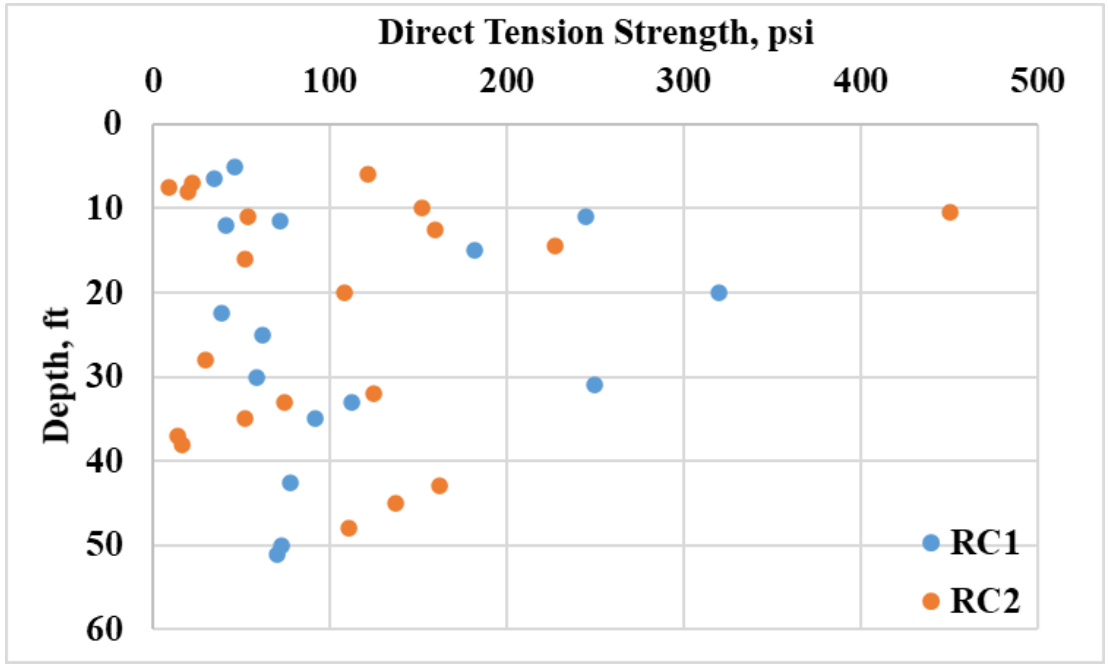
Run 3 and Run 4

33’ to 38’

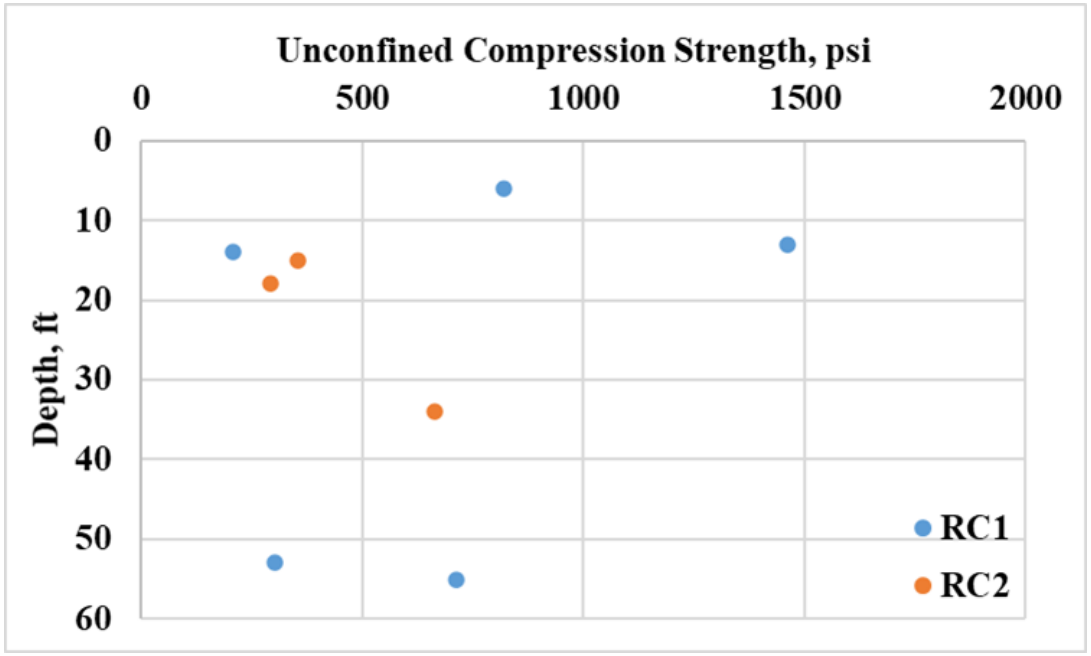
43’ to 48’

Run 5 and Run 6

Strength vs. Depth Cemex SCL Site



$q_{dt} = 0.7 * q_t$, *36 Split Tension Tests*



8 Unconfined Compression Tests

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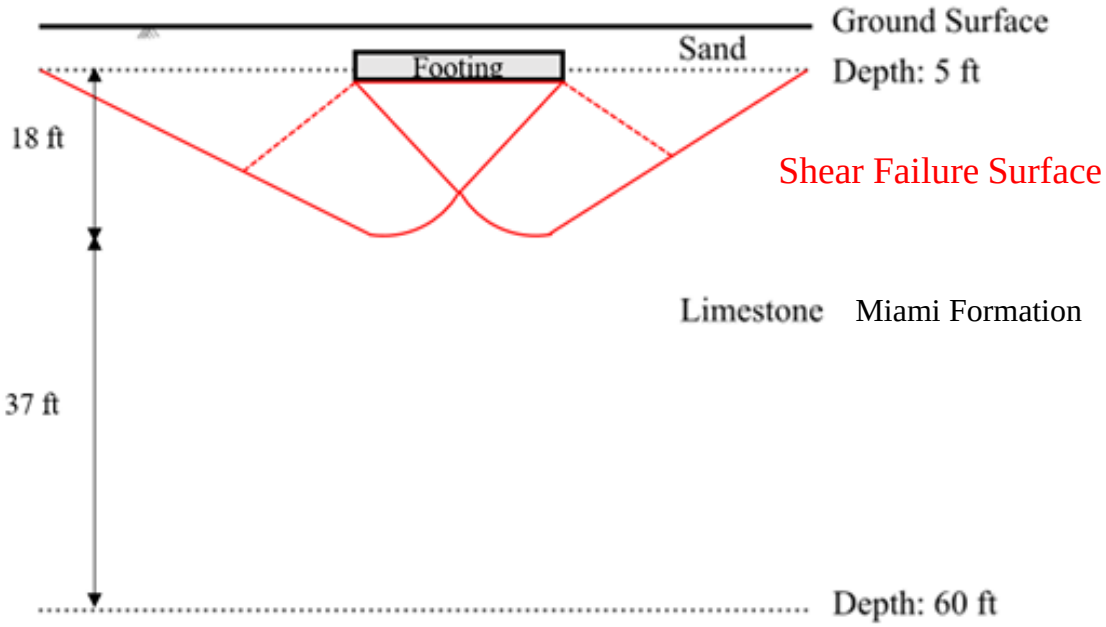
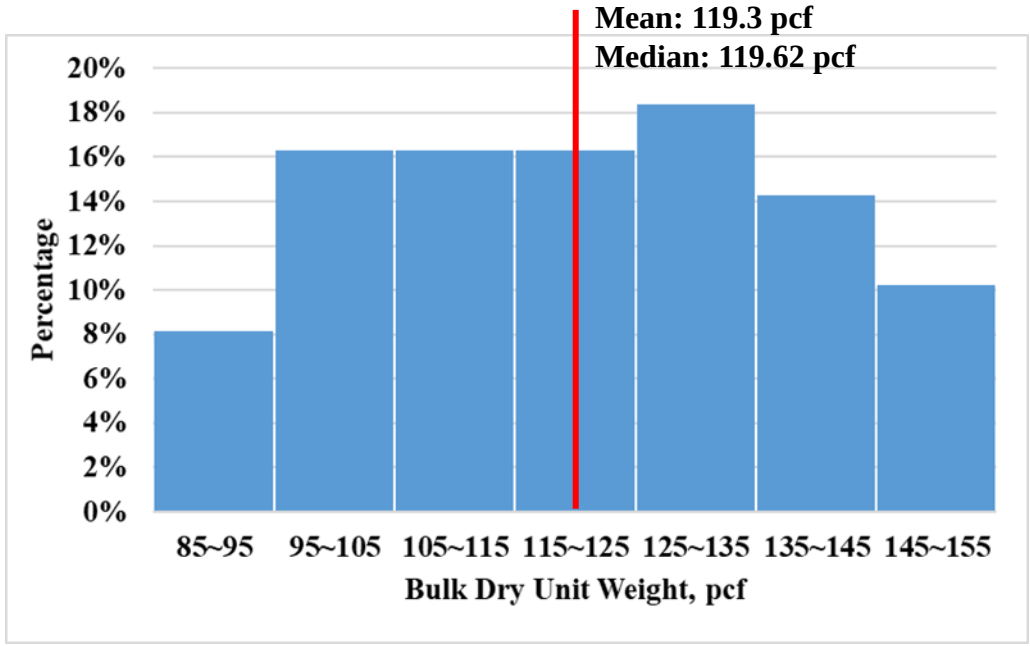
Cemex SCL Bearing Assessment

Cemex Water Table: Varies between 1 ft to 3.5 ft depth



Subsurface Stratigraphy of Cemex Site



Frequency Distribution of Bulk Dry Unit Weight at Cemex Site

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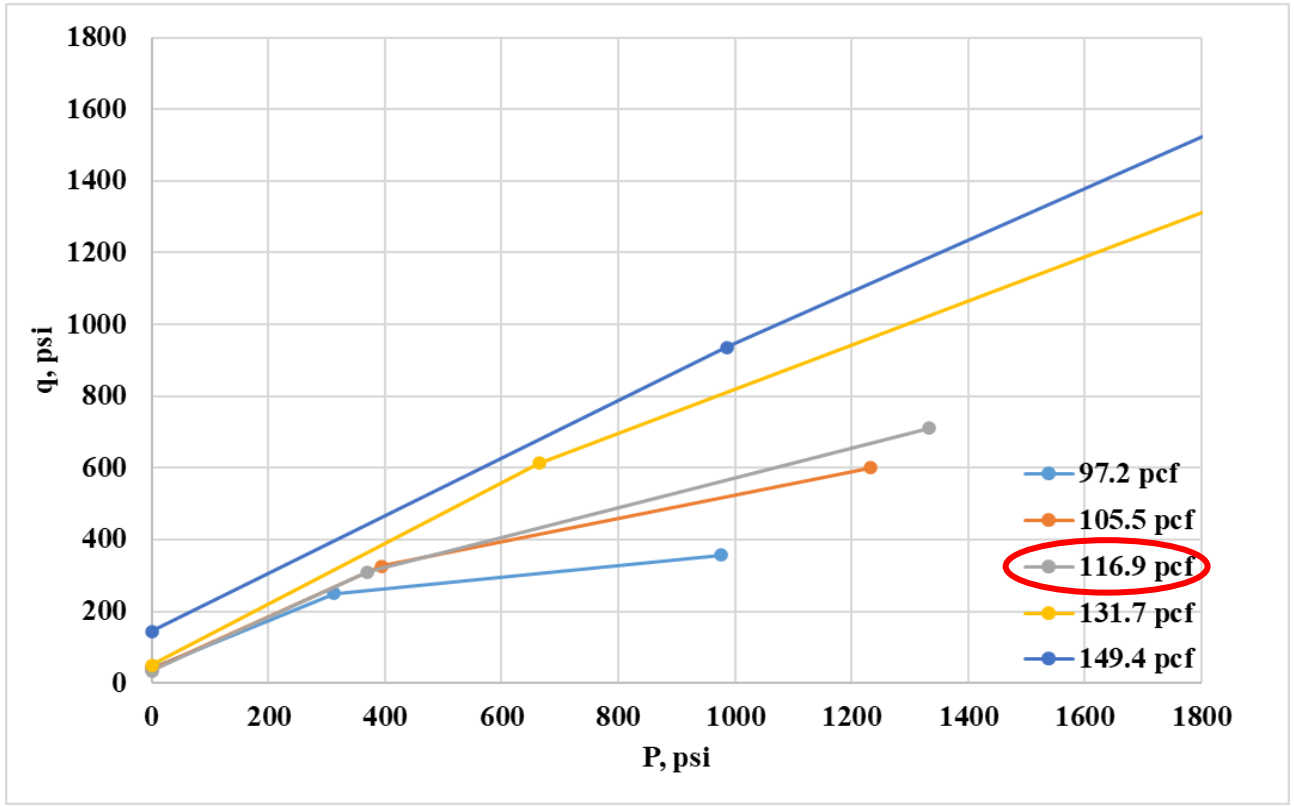
Cemex SCL Triaxial Strength Assessment



Strength Envelope – Miami Formation at Cemex Site

The Strength Envelope of 116.9 pcf (closest to average and median) was selected to size the footing:
A square footing with a dimension of 3 ft and an embedment depth of 5 ft will have a bearing capacity of 700 tons.

A square footing with a dimension of 42" will be used for load test at Cemex site

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Site 2, I-75 Drilling Investigation

BORING LOCATION PLAN

BORING	LATITUDE	LONGITUDE
B-01	26.118521°	-80.345339°
B-02	26.118501°	-80.345231°
B-03	26.118475°	-80.345161°
B-04	26.118434°	-80.345074°

Approximate SPT Boring Location

Approximate Rock Coring Location

FIGURE No.:	2
DRAWN BY:	CM
CHECKED BY:	AVL

GEOTECHNICAL ENGINEERING SERVICES
Sawgrass Expy & W SR 84
Broward County, Florida
PSI PROJECT No.: 03971517
DATE: 05/11/2020

intertek psi

Site 2, I-75 B1 Rock Cores

8’ to 13’

3’ to 8’

38’ to 43’

33’ to 38’

68’ to 73’

Site 2, I-75 B2 Rock Cores

5’ to 8’

8’ to 13’

33’ to 38’

38’ to 43’

43’ to 48’

48’ to 53’

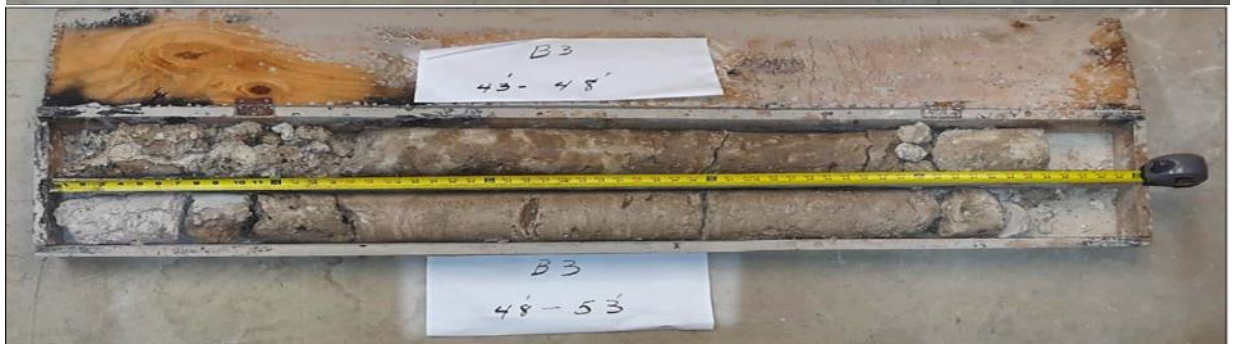
Site 2, I-75 B3 Rock Cores

8’ to 13’

3’ to 8’

38’ to 43’

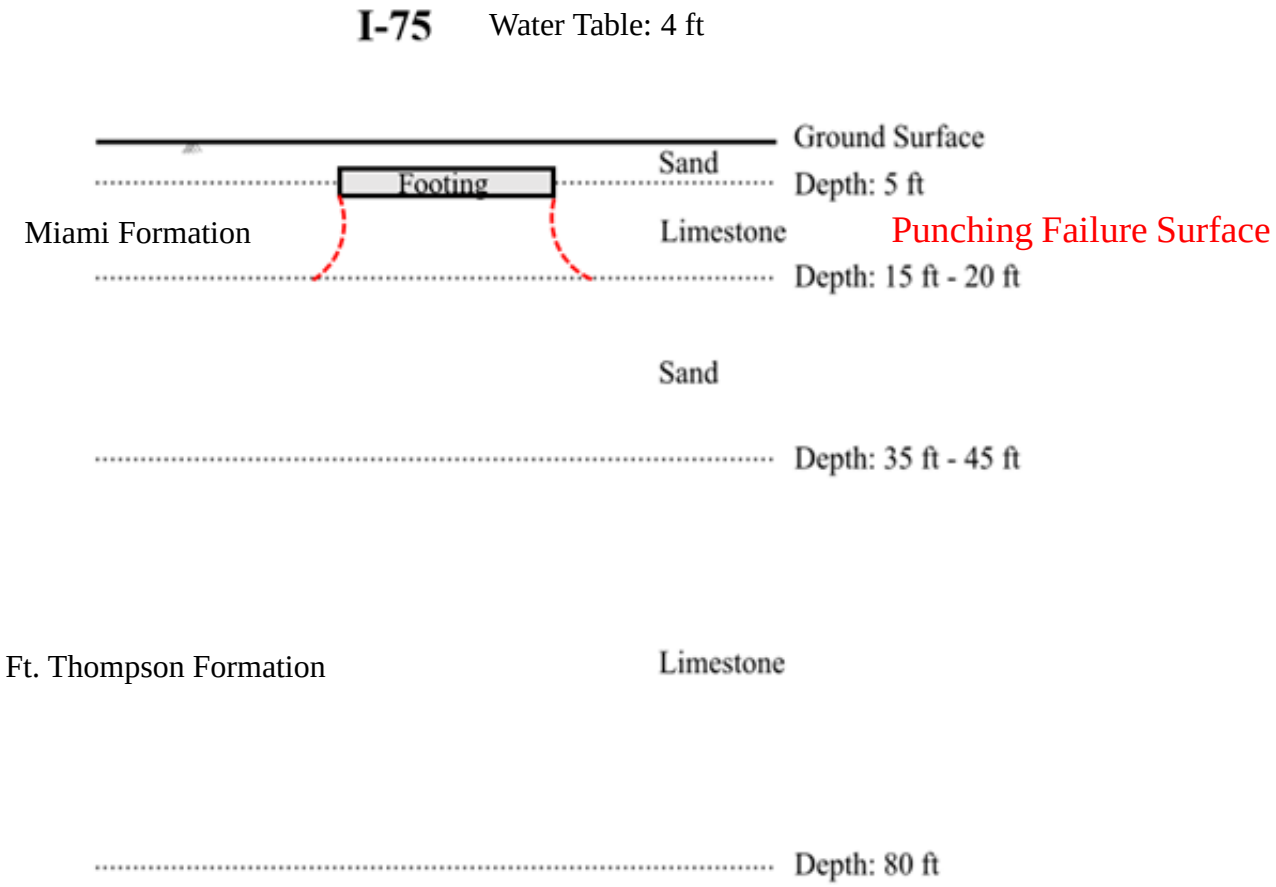
33’ to 38’



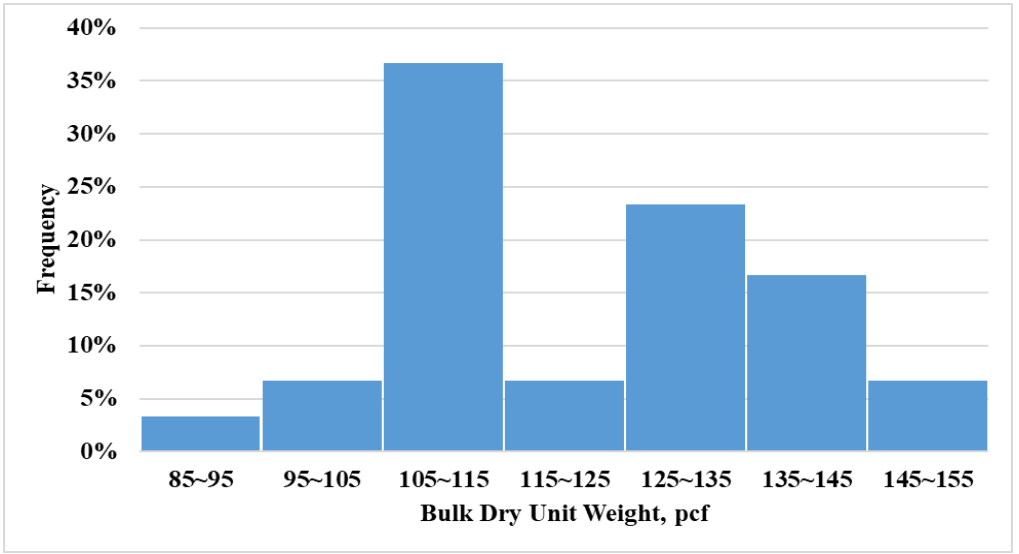
43’ to 48’

48’ to 53’

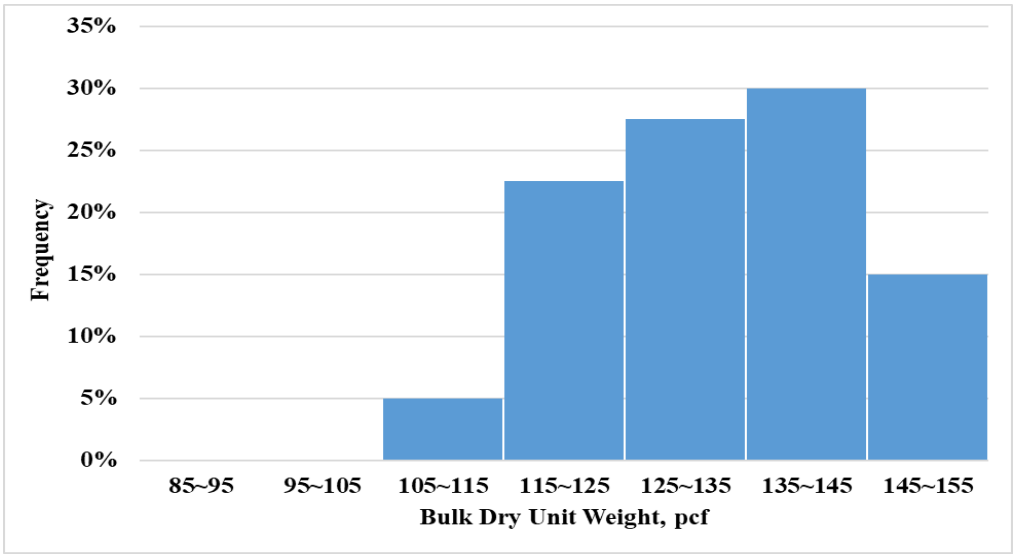
Site 2, I-75 Rock over Sand, Stratigraphy



Subsurface Stratigraphy of I-75 Site

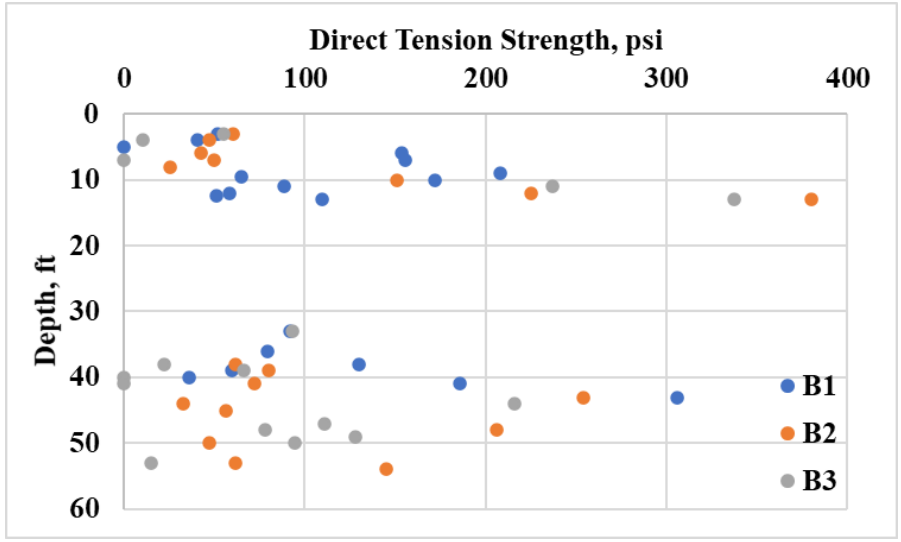


Frequency Distribution of Bulk Dry Unit Weight-Miami Formation

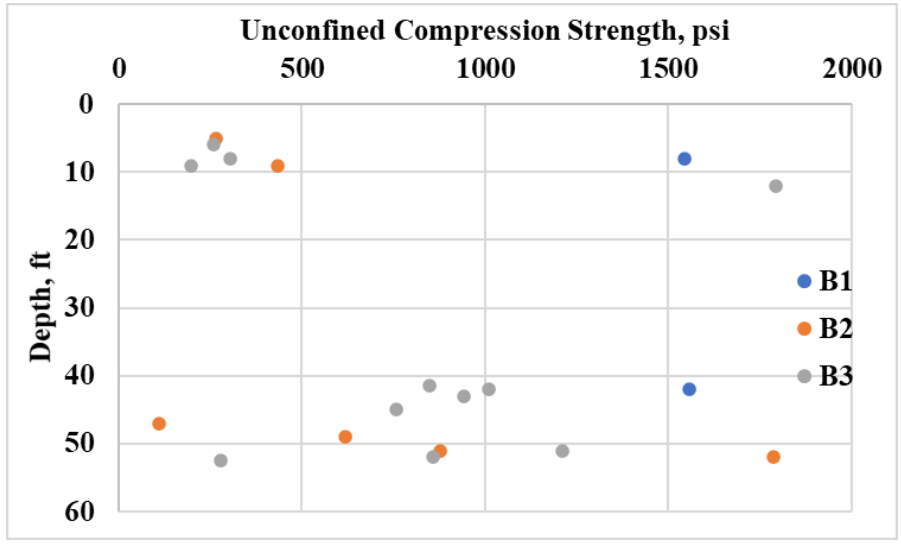


Frequency Distribution of Bulk Dry Unit Weight-Ft. Thompson Formation

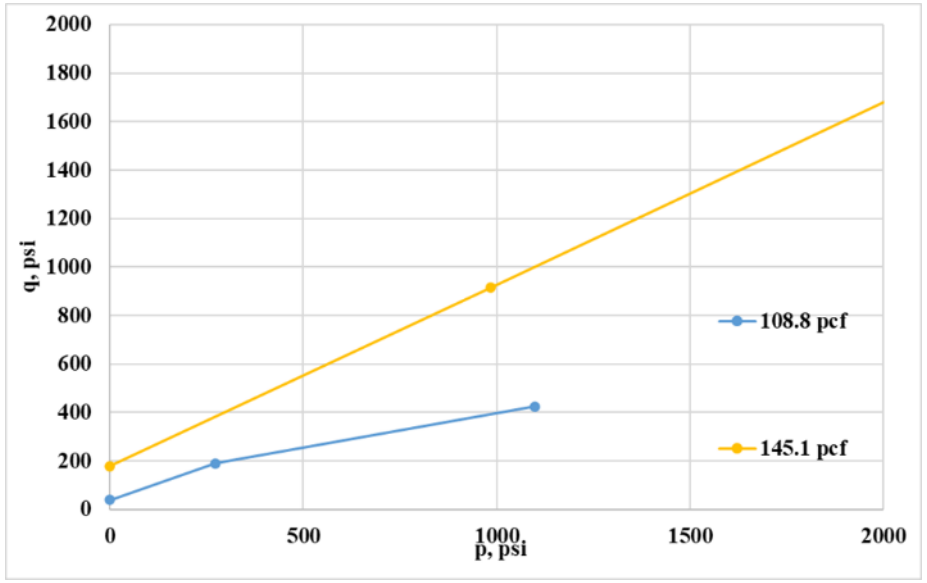
Site 2, I-75 Strength vs. Depth and Strength Envelopes



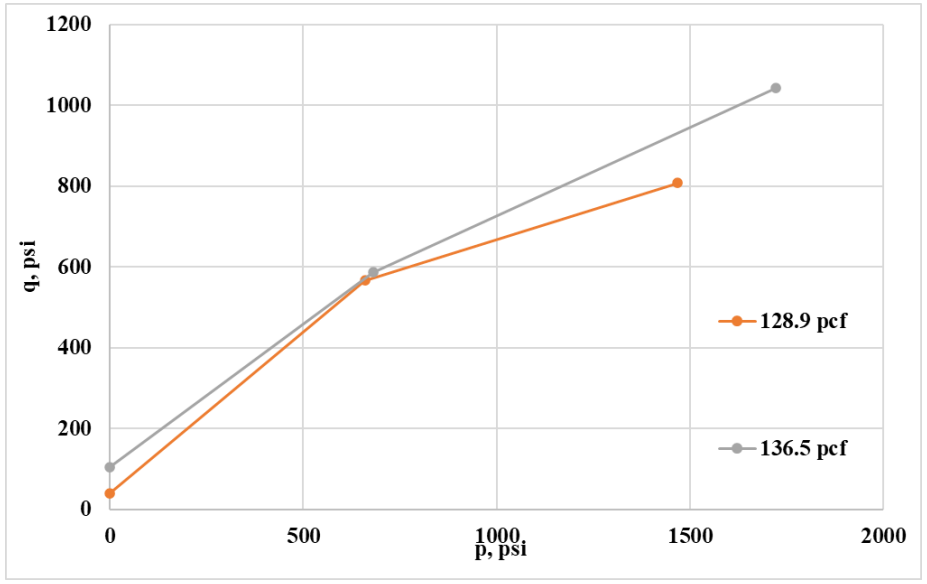
Direct Tension Strength versus Depth at I-75 Site



Unconfined Compressive Strength versus Depth at I-75 Site

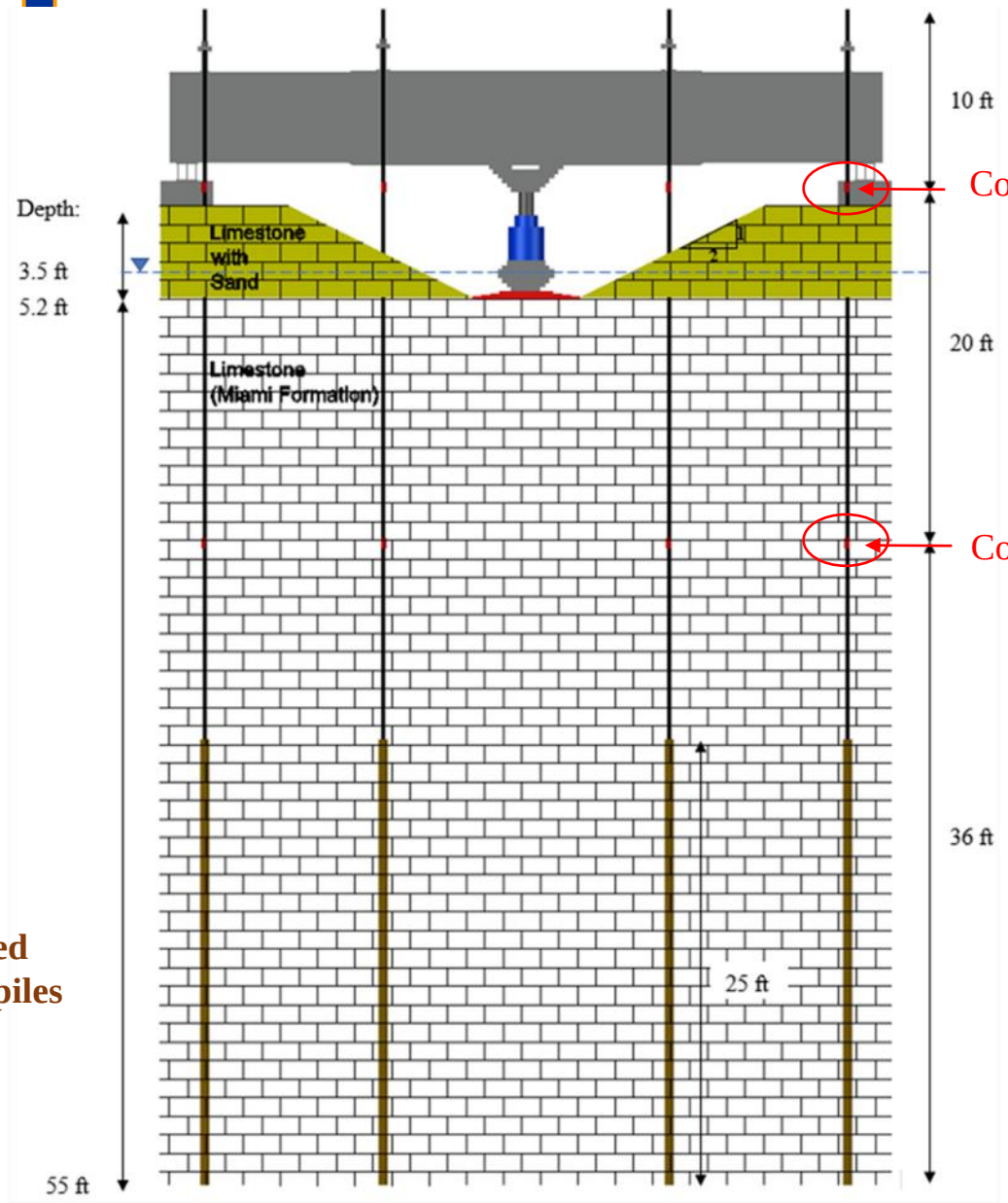


Strength Envelope – Miami Formation



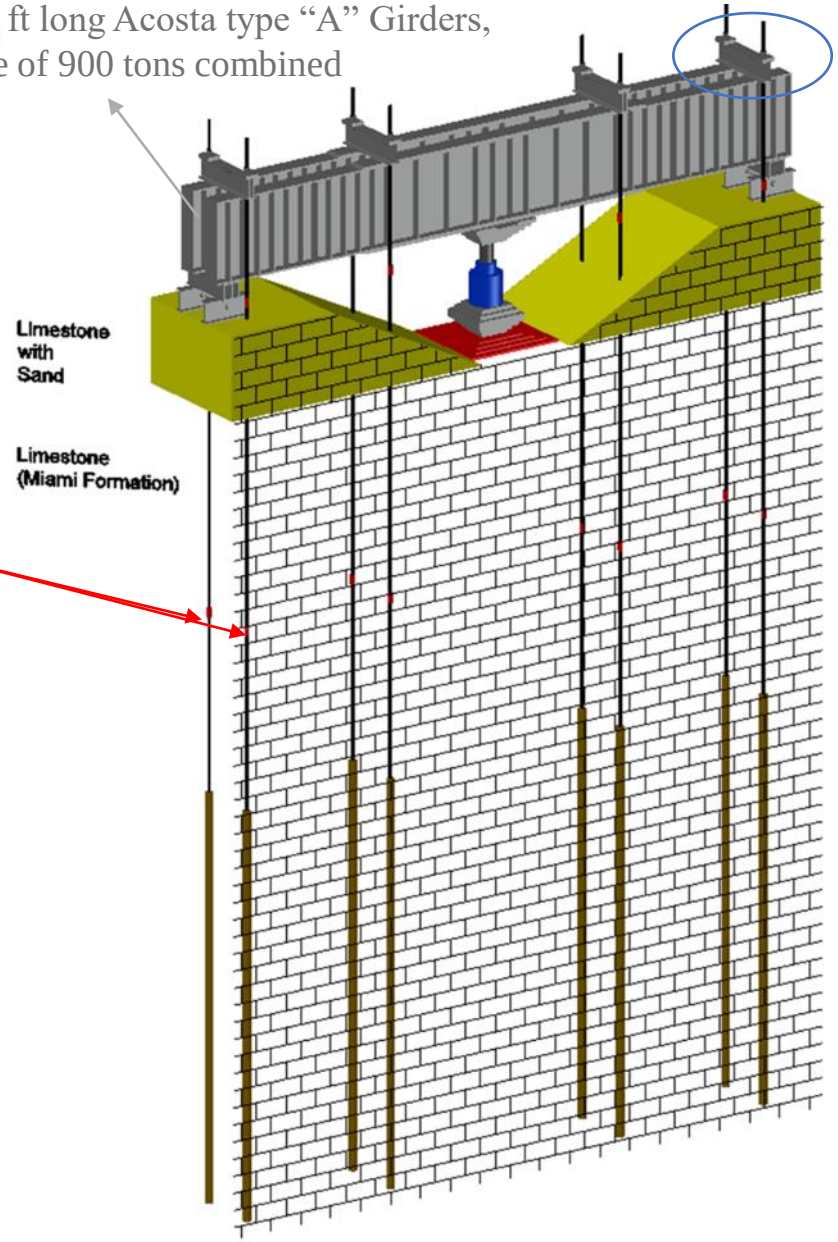
Strength Envelope – Ft. Thompson Formation

Deliverable 1 – Load Test Frame and Anchors



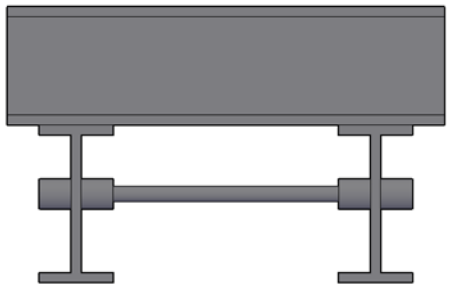
25 ft Grouted Micropiles

Two 40 ft long Acosta type "A" Girders, Capable of 900 tons combined

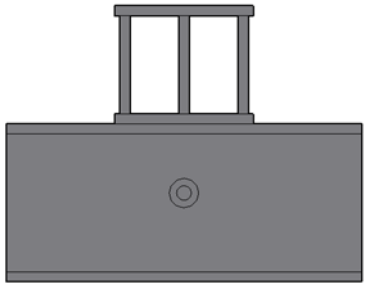


Two 2.5 in thickness steel plates
Two Grade 50 C15×40 C Channels

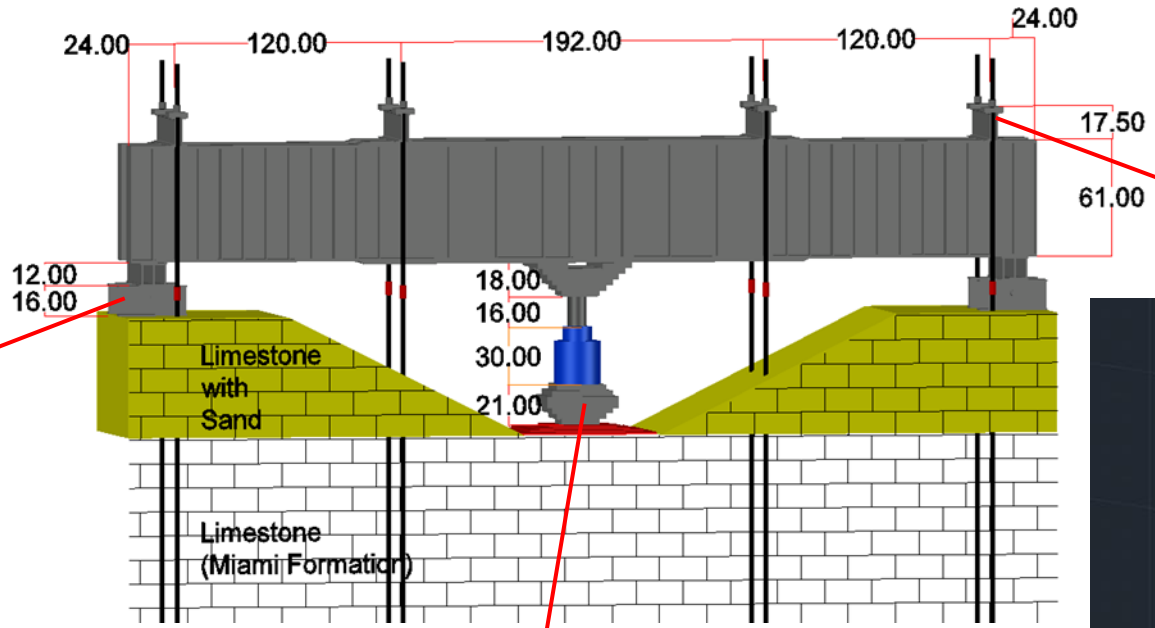
Deliverable 1 – Load Test Frame and Anchors

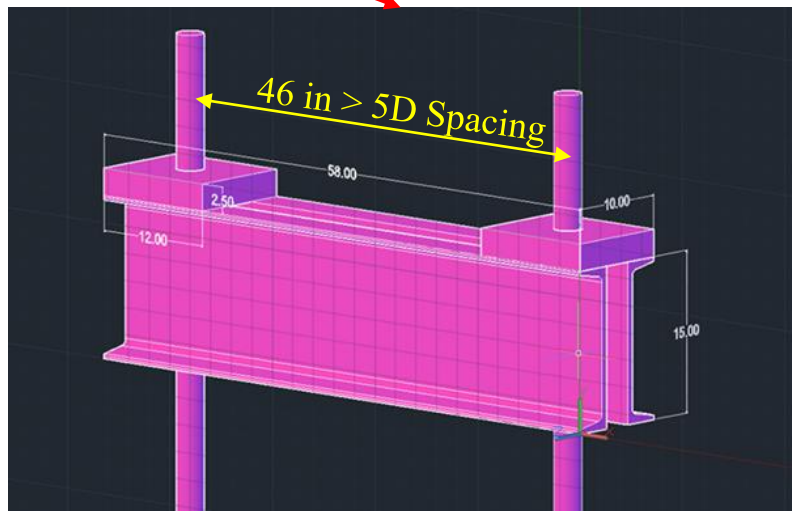


Left View of New Stand Support

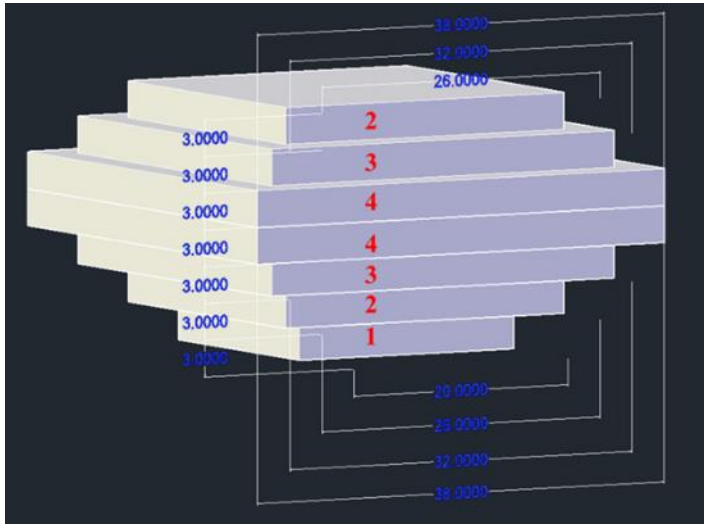


Front View of New Stand Support



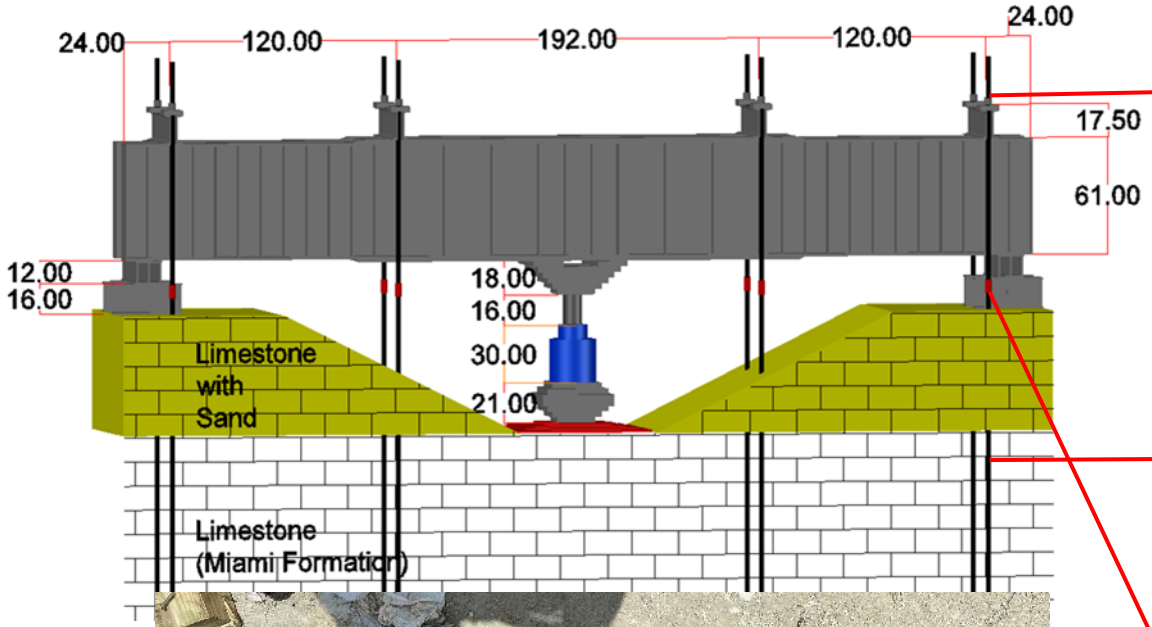


New Anchor System, capable of 225 kips reaction force



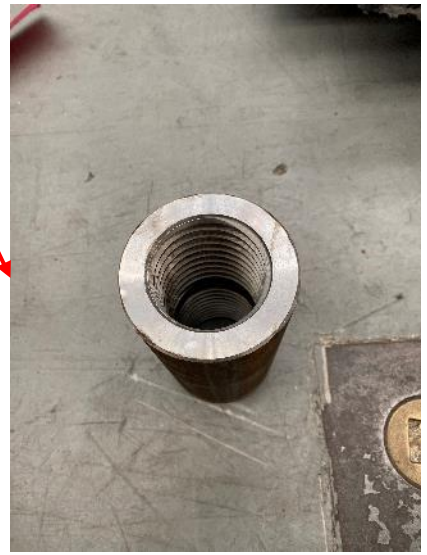
New Load Spreader to raise Hydraulic Jack above the Water Table

Deliverable 2 – Load Testing Cemex Site



Bolts on Couplers to prevent rotation of bottom threaded rebars when unscrewing

Hex Nut for #18 Grade 80 Threaded Rebars



Coupler for #18 Grade 80 Threaded Rebars

#18 Grade 80 Threaded Rebars, From left to right: 10 ft, 20 ft, 36 ft

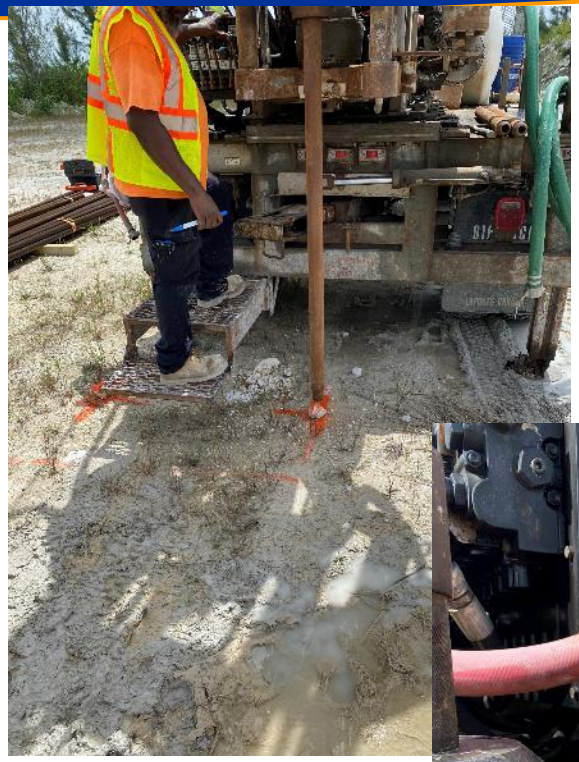
Deliverable 2 – Load Testing Cemex Site

#18 Grade 80 Threaded Rebars

Acosta Girders

Deliverable 2 – Installing Anchors Cemex Site (H2R)

Drill Rigs and Water Tank



Tricone Drill bit

Deliverable 2 – Drilling Anchors Cemex Site (H2R)

6 in Casing

Miami Limestone Cuttings

Drill with Clear Water – Loose Holes

Drill with Polymer Mud System – Tight Holes

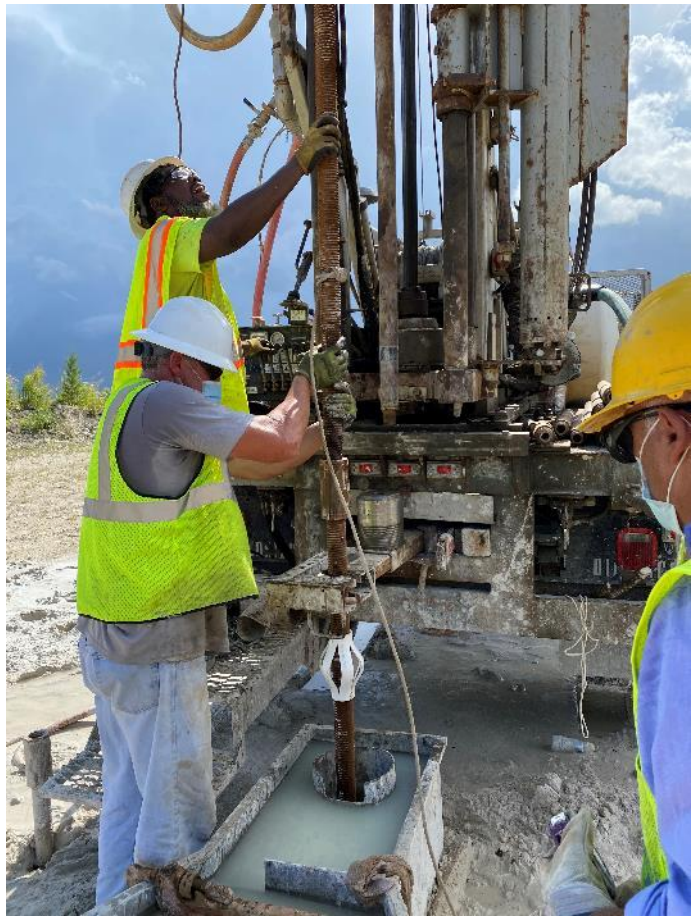
Deliverable 2 – Drilling Anchors Cemex Site (H2R)

Polymer Mud washed by Regular Bleach

Deliverable 2 – Installing Anchors Cemex Site (H2R)

Placement of 36 ft long #18 Grade 80 Threaded Rebars

Deliverable 2 – Installing Anchors Cemex Site (H2R)



Placement of 20 ft long #18 Grade 80 Threaded Rebars

Deliverable 2 – Grouting Anchors Cemex Site (H2R)

ASTM C845 Type K cement

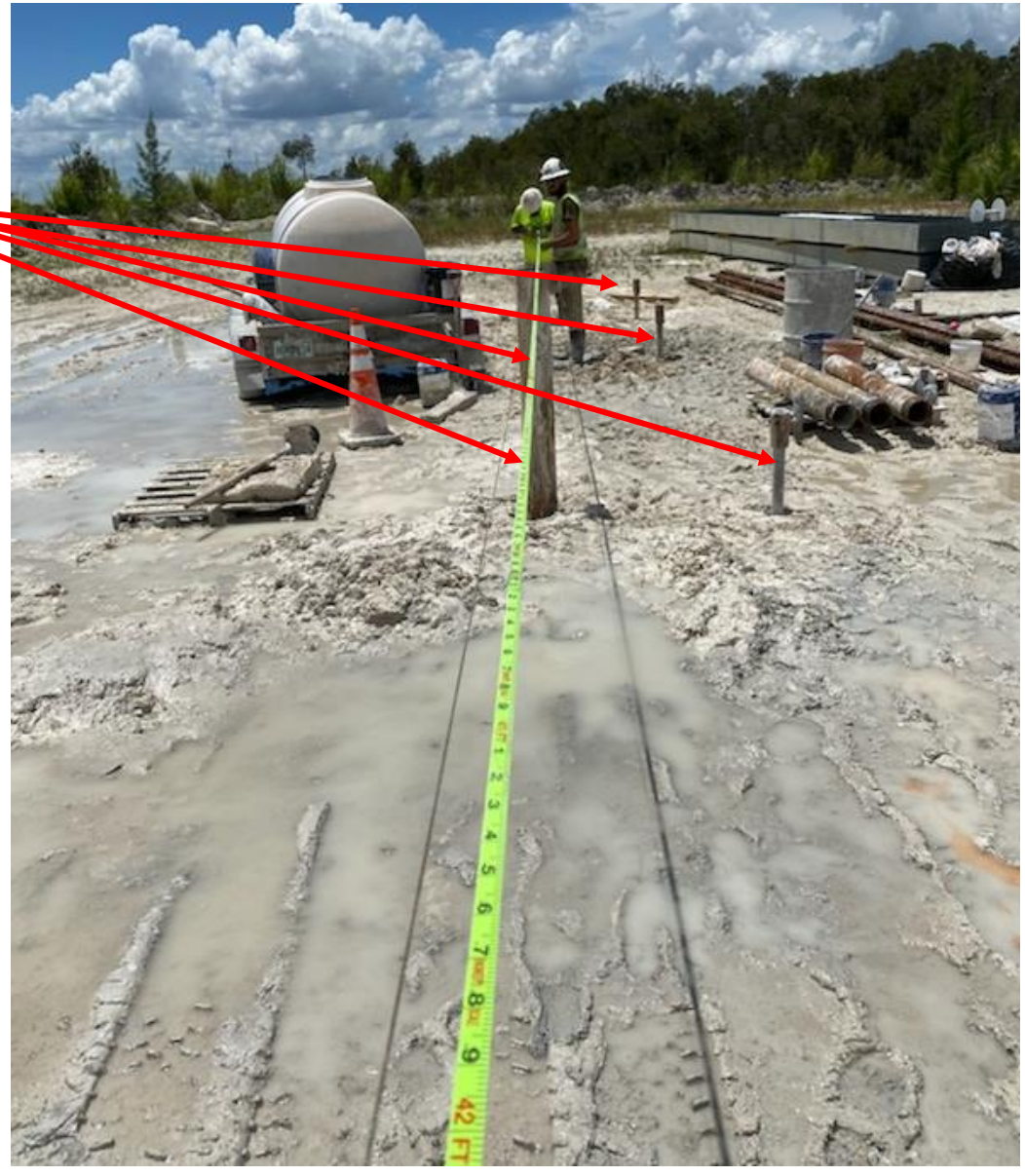
Cement Specimens

Mix with ASTM C494 Type D Retarding Admixtures

Grouting

Deliverable 2 – Cemex Site (Aug – Sept)

- Currently 6 anchors of 8 installed
- Seismic surface testing is next (Deliverable 5) – Assess in-situ density, shear (G) and Young's (E) modulii
- Excavate 5', place footing, place girders, jack, instrumentation
- Perform static load test
- Compare Measured vs. predicted bearing capacity



Thank You!

Questions & Answers