Improving Design Phase Evaluations for High Pile Rebound Sites

The Mysterious Case of the Bouncing Piles

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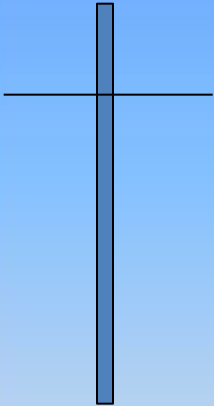
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Defining the Problem

- **Excessive Pile Rebound and/or Bouncing**
  - ❖ High Displacement Piles
  - ❖ Typically driven by Diesel Hammers
  - ❖ Cause Dilation of Very Dense Saturated Silty Sands to Sandy Silts
- **Capacities & Depths not achieved**

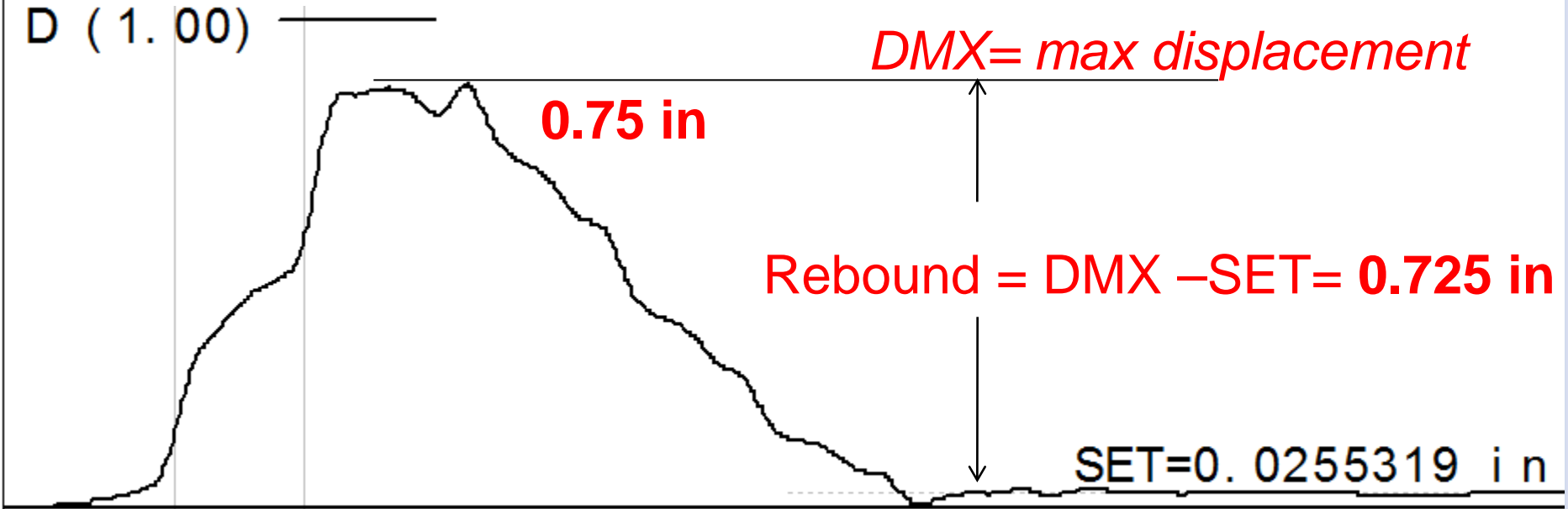Pile Rebound *Old School Recording*

Courtesy of GRL Library

Digital Record of Rebound from PDA sensors

Displacement (inches)

D (1. 00)

DMX= max displacement

0.75 in

Rebound = DMX –SET= **0.725 in**

SET=0. 0255319 i n
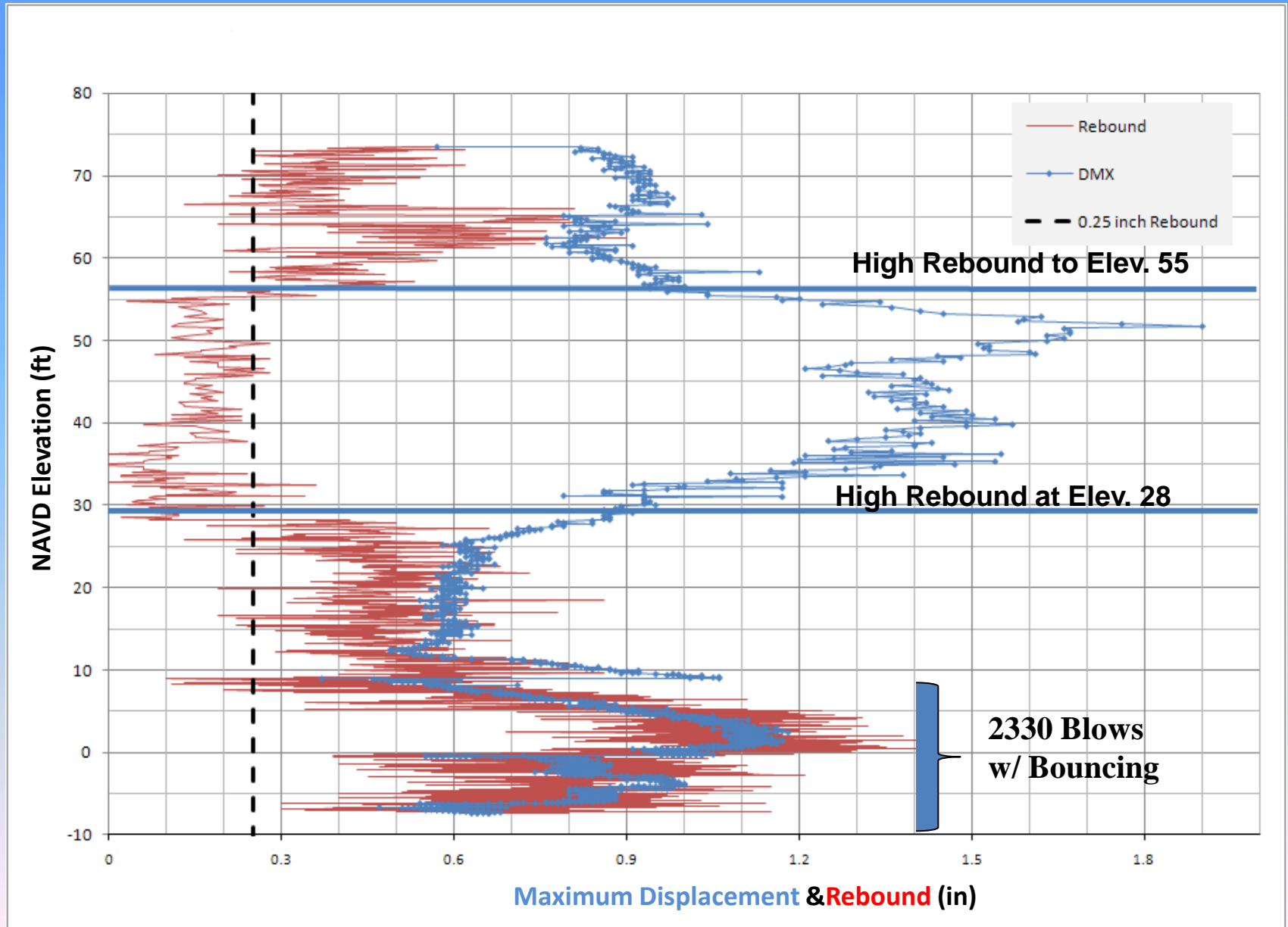
TS: 204. 8
TB: 0. 0

PDA Recording Time (milliseconds)

Phase I

🐾Retested Soils at 3 sites with PDA data

❖I-4/SR 408 Anderson Street Overpass

❖I-4/John Young Parkway

❖Ramsey Branch Bridge SR 83 US 331 over Choctawhatchee Bay: District 3

🐾 SPT, CPT, PMT, DMT, PocketPen

🐾 Shelby Tubes

❖CU Triaxial, Permeability etc.

Anderson Street PDA vs. Elevation

Silt Content Summary

Site Name	Rebound Soil Silt Content (%)	Increase in Silt Content (%)
Anderson Street	19	40
John Young	17	20
Ramsey Branch	20	100

N Values Summary

Site Name	N In Rebound Soil (blows/ft)	Increase in N In Rebound Soil (%)
Anderson St	27	290
John Young	16	220
Ramsey Branch	7	600

Pocket Penetrometer q_u, & CPT q_c, f_s Summary

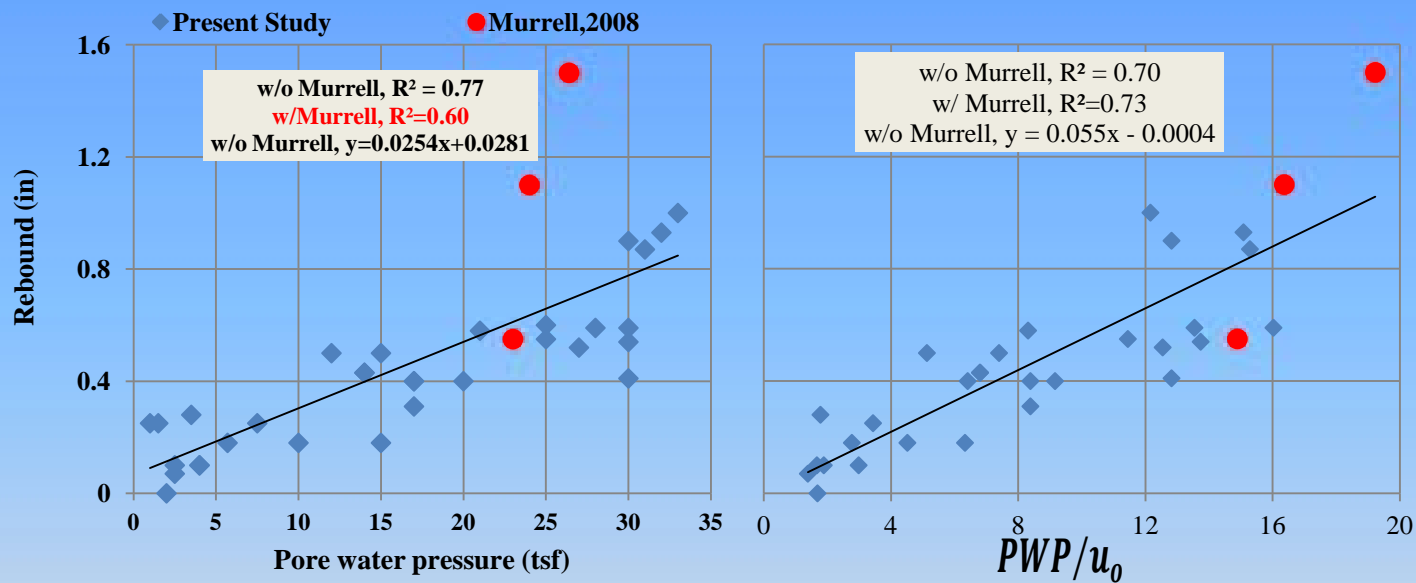| Site Name	Pocket Penetrometer Increase in q_u In Rebound Soil (%)	CPT Increase in q_c In Rebound Soil (%)	CPT Increase in f_s In Rebound Soil (%)
Anderson St	260	100	250
John Young	200	0*	-10*
Ramsey Branch	40	750	780

* John Young Site more layered

Conclusions

- Parameters that generally increased
    - ❖ Silt Content
    - ❖ SPT N values
    - ❖ Pocket Penetrometer q_u
    - ❖ CPT q_c and f_s
- PDA displacement vs. elevation shows rebound zones.
- Bouncing elevations match elevation of the dense or very dense to hard silty sands and clays (SM/SC/CH)
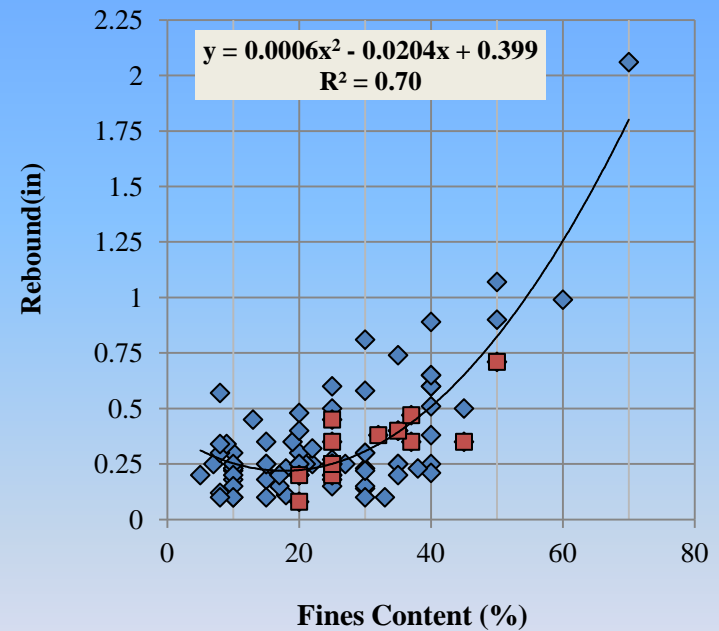
FIT Unfunded Findings
CPTu Pore Water Pressure Correlations

FIT Unfunded Findings
Rebound vs N and Fines Content

Left chart — Present Study (diamonds), Hussien et al. (2006) (squares); Rebound(in) vs N_{SPT} (blows/ft): $y = 0.0003x^2 - 0.0028x + 0.2274$, $R^2 = 0.80$

Right chart — Rebound(in) vs Fines Content (%): $y = 0.0006x^2 - 0.0204x + 0.399$, $R^2 = 0.70$
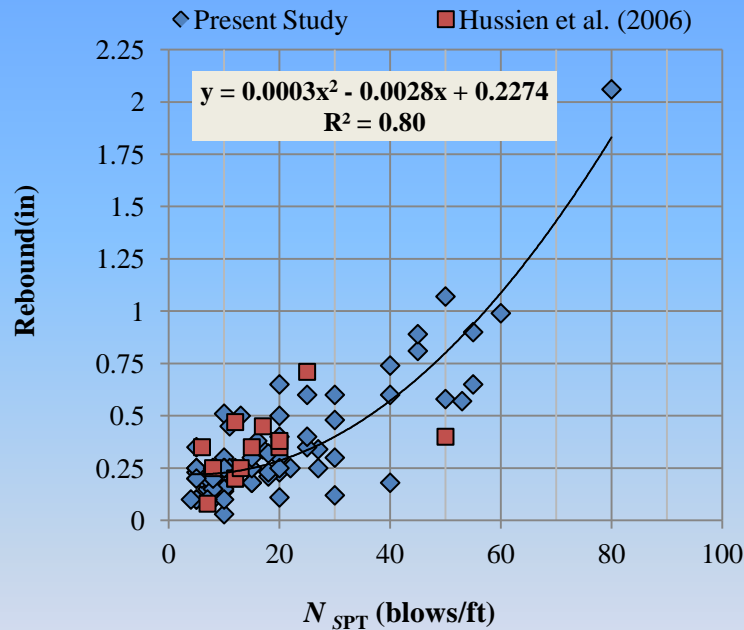
Phase II Research Objective

Prove these correlations are reliable

Project Schedule

RESEARCH TASK
Task 1 **Literature Search**
Task 2 **Develop Locations of New Testing Sites**
Task 3 **Test Program for New Field Testing Sites**
Task 4 **Field Data Reduction**
Task 5 **Laboratory Testing and Reduction of Disturbed Samples**
Task 6 **Laboratory Testing, Reduction and Analysis of Thin Walled Tube Samples**
Task 7 **Analyze Reduced Laboratory Data from Disturbed Testing**
Task 8 **Analyze Reduced Field Data**
Task 9 **Technology Transfer for Reporting and Presentations**

Cyclic Testing

Cyclic Objective

Determine and evaluate the variations in cyclic pore water pressure during cyclic triaxial testing for high pile rebound soils.

The study will focus on :

- ✓ Evaluation of pore water pressure generation during cyclic loading in and above rebound zone

- ✓ Influence of fines and silt content on pore water pressure generation during cyclic loading

Testing Program:

Identify Site Locations

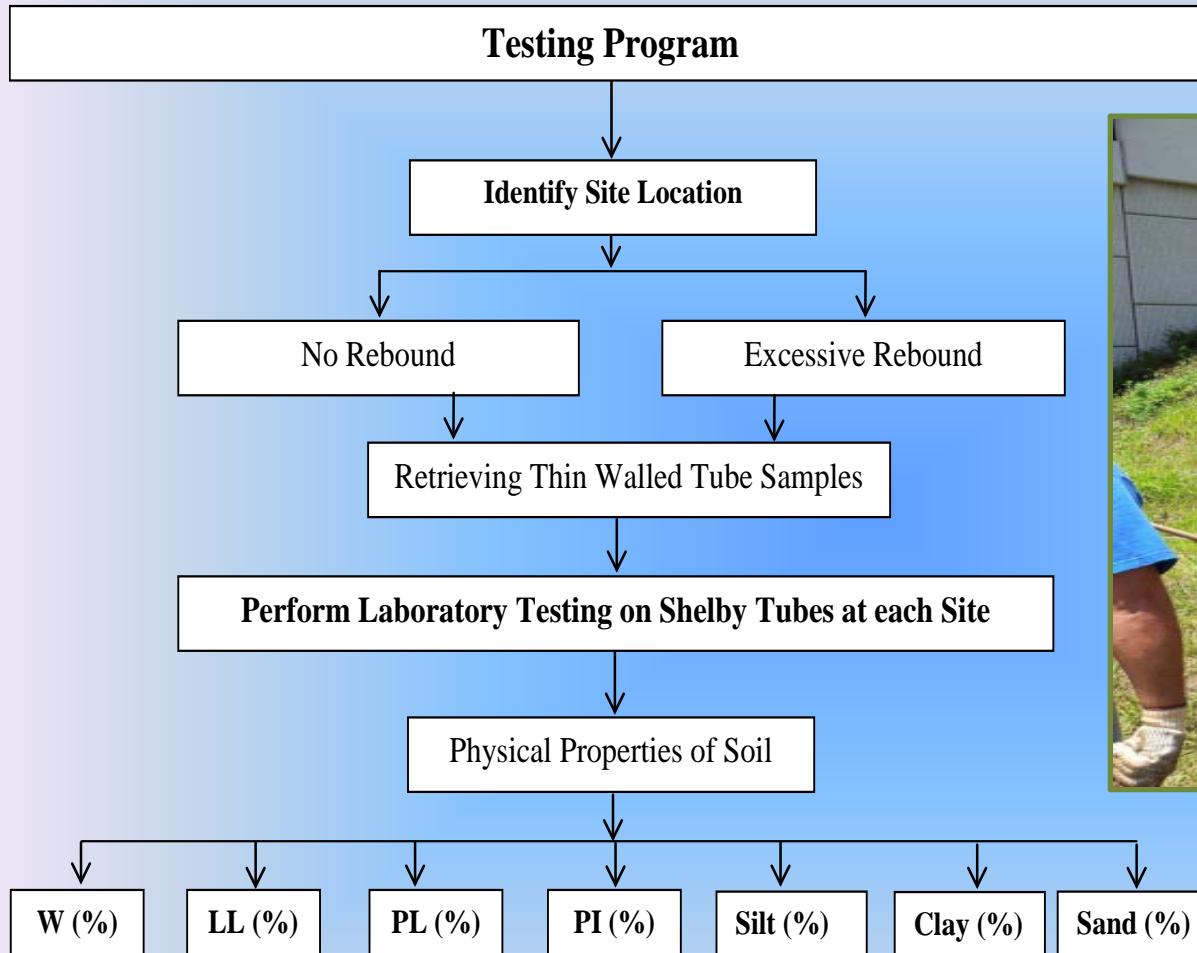| Case	Site Name	Rebound Observed?
1	I 4 and US 192, Orlando, Florida	Excessive Rebound
2	I-4/Osceola Parkway, Central Florida, Osceola County	
3	I 10 and Chaffee Road, Jacksonville, FL	
4	SR 417/International Parkway, Seminole County, FL	Non-Rebound
5	I-4/SR 408 (Ramp B), Orange County, Florida	

I 4 and US 192, Orlando, Florida

Westbound: End Bent 1

- Rebound Zone
- Shelby Tube Location

Elve.	Soil Profile	Pore Water Pressure (tsf)	Shelby Tube Sample	Rebound Zone
GSE + 144.31 ft				
88.3 ft	Brown Fine Sand with Silt (SP-SM)			
72 ft		Less than 3 tsf	1	No Rebound
67 ft				
57 ft	Brown Fine Sand with Silt (SP-SM)			
	Light Brown Fine sand (SP)	Less than 5 tsf	1	High Rebound (0.28 to 0.5 in)
53 ft	Light Brown Sand with Silt (SP-SM)			
	Light Brown Fine sand (SP)			
	Gray Fine Sand with Silt (SP-SM)			
	Gray Silty Fine Sand (SM)			
23 ft				
19 ft	Gray Silty Fine Sand (SM)	More than 9 tsf	1	High Rebound (0.26 to .82 in)
	Green Clayey Fine Sand (SC)			
0 ft	Green Sandy Silt (ML)			
	Green Clayey Fine Sand (SC)			
	Tan Highly Weathered Limestone			
	Bt at 193'			

Shelby Tube Location

Groundwater Elevation

BT   Boring Terminated

Testing Program

Identify Site Location

No Rebound

Excessive Rebound

Retrieving Thin Walled Tube Samples

Perform Laboratory Testing on Shelby Tubes at each Site

Physical Properties of Soil

W (%) | **LL (%)** | **PL (%)** | **PI (%)** | **Silt (%)** | **Clay (%)** | **Sand (%)**

Cyclic Testing

Consolidated Undrained (CU) Triaxial Test

Deviator stress at failure

Loading Stages

Applied Deviator Stresses

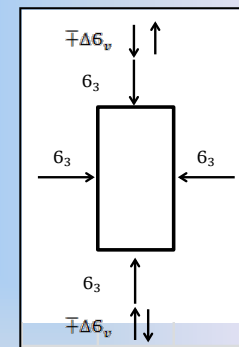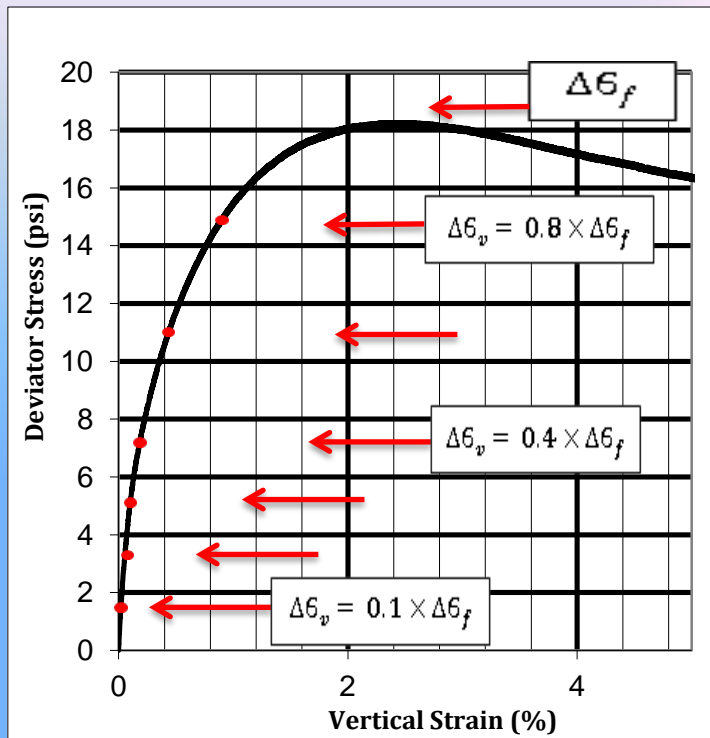| $\Delta\sigma_v = 0.1 \times \Delta\sigma_f$ | $\Delta\sigma_v = 0.2 \times \Delta\sigma_f$ | $\Delta\sigma_v = 0.3 \times \Delta\sigma_f$ | $\Delta\sigma_v = 0.4 \times \Delta\sigma_f$ | $\Delta\sigma_v = 0.6 \times \Delta\sigma_f$ | $\Delta\sigma_v = 0.8 \times \Delta\sigma_f$ |

1000 cycles at each loading stage

Deviator Stress (psi) vs Vertical Strain (%)

$\Delta\sigma_f$

$\Delta\sigma_v = 0.8 \times \Delta\sigma_f$

$\Delta\sigma_v = 0.4 \times \Delta\sigma_f$

$\Delta\sigma_v = 0.1 \times \Delta\sigma_f$

$\mp\Delta\sigma_v$

σ_3

σ_3 σ_3

σ_3

$\mp\Delta\sigma_v$

Questions