BED Two 28 977-01
Using the PENCEL PMT to Evaluate Shallow Foundations at Florida's Fine Sand Sites

PM: David Horhota Ph.D., P.E. State Geotechnical Engineer

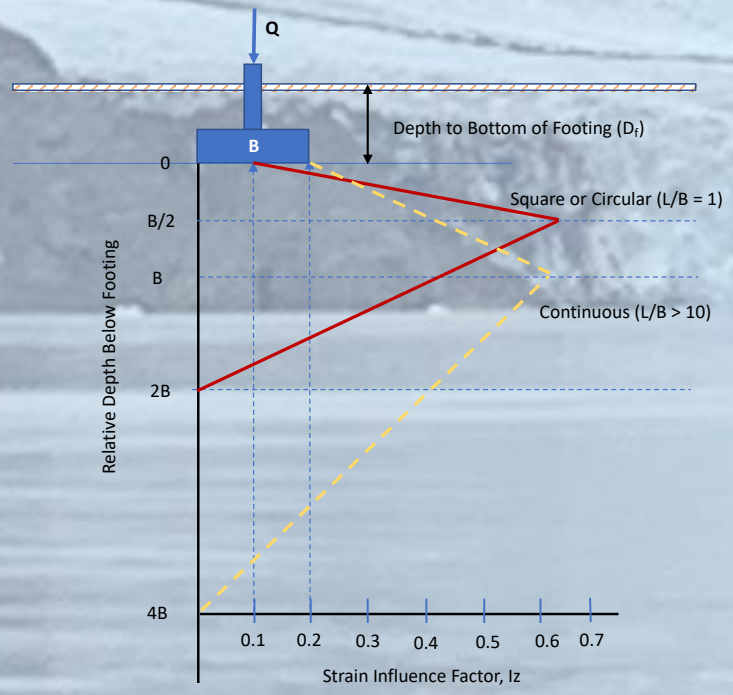
PI: Paul J Cosentino Ph.D., P.E.
Florida Institute of Technology
150 West University Boulevard
Civil Engineering and Construction
Olin Engineering Room 205
Melbourne FL 32901-6975
cosentin@fit.edu
321-674-7555

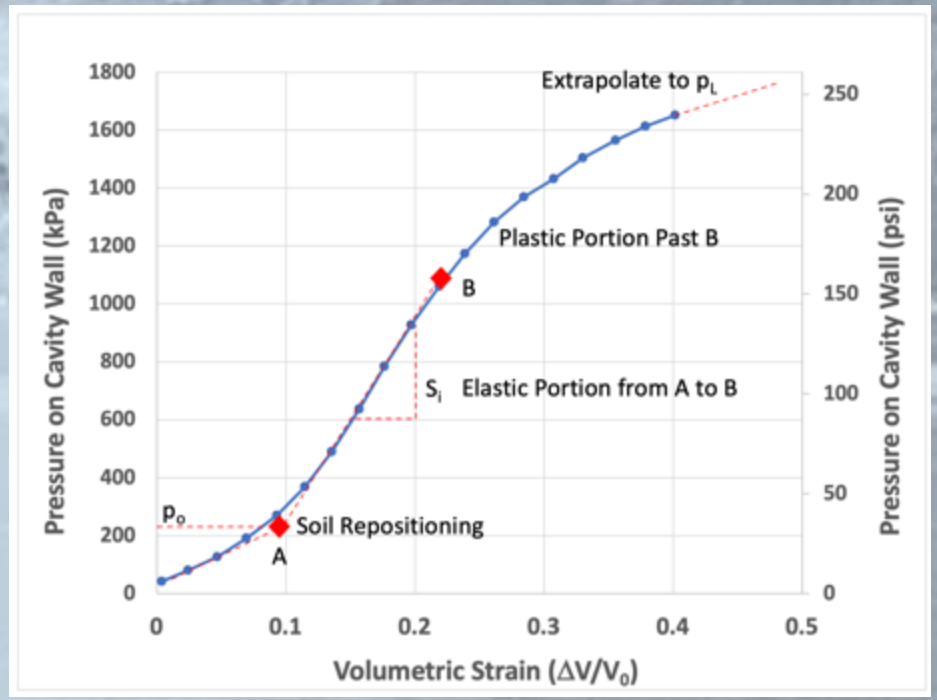
FDOT GRIP 2023 Meeting Outline

1. Introduction & Overview
2. Objective
3. Task Results to Date
    1. **Literature- Completed**
    2. **SMO Testing – Completed**
    3. ***Site Selection, Site Visits, and Procurement of Site Data – In Progress***
    4. ***PPMT, CPT, DMT, SPT, and Field Plate Load Testing – In Progress***
    5. ***Analyzing the Modulus Effects on Foundation Settlement and Bearing Capacity – In Progress***
    6. Extrapolation of Design Procedure Data with Design Flow Chart using Florida Site Conditions
    7. Draft Final Report and Closeout Teleconference
    8. Final Report
4. Project Timeline
5. Closing Slide

Introduction

- When Shallow Foundations are used, the zone of soil affected is typically within the top 25 to 25 feet.
- PENCEL PMT stress-strain curve components are easy to interpret and use in footing designs





Introduction (Cont.)

- **FHWA reports a 50 to 65 % cost savings when shallow footings replace deep foundations.**
- **Geotechnical Engineering Consultants using PENCEL Pressuremeter data saved clients *hundreds of thousands of dollars*.**
- **$4.5 million dollars saved during the construction of a 15-story hospital in Jacksonville, Florida.**
- **The instrumentation and software developed from *BD-658 Standardizing the Pressuremeter Test for Determining p-y Curves for Laterally Loaded Piles* has resulted in the significant increase in its use and has resulted in an estimated *½ billion dollars in savings*.**
- **Results will be incorporated into FDOT's Soils and Foundations Handbook.**

Overview

- Data from this work will be added to the existing data used in Briaud's 2007 Settlement of Sands prediction method.
  - New PPMT data will be compared to existing PMT data and determine its affect on the Briaud 2007 settlement prediction method.
  - Potential pile foundation sites will be re-evaluated using digital PENCEL PMT data to determine if they would enable shallow footings to be used.
- The research report will contain specific guidelines/ recommendations for consulting engineers to follow when using PMT data to design shallow footings.

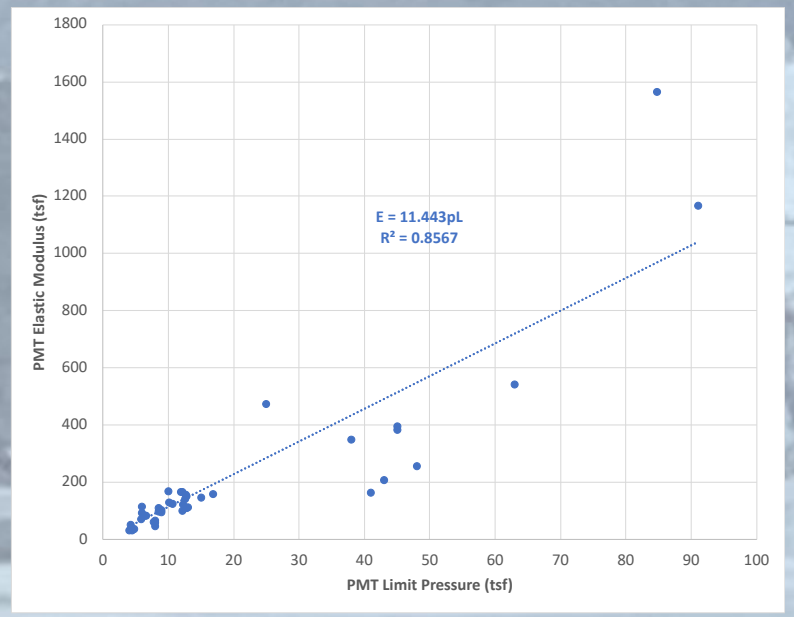
Objective

- To improve the confidence that geotechnical engineers would have in using PENCEL PMT data to safely design shallow footings placed on Florida fine sands.

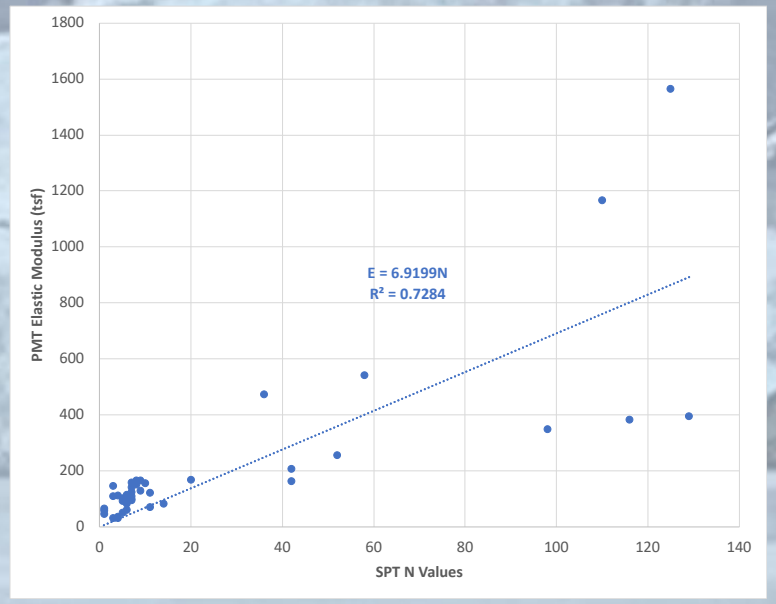
Overview of Literature and Historical Review

- Engineers now use pressuremeter testing for more applications
  - Traditional uses were for lateral loads on structures
  - High-quality PMT stress-strain data gives engineers confidence to use it in other areas especially for shallow footings
- Methods to predict elastic moduli and settlement of sands were reviewed indicating
  - Several PMT elastic moduli approaches are available
  - DMT elastic moduli approaches to predict both bearing capacity and settlement are available
  - CPT correlations between qc and elastic moduli are used
  - SPT Correlation to elastic moduli are available
- Case Histories from Chicago, Virginia and Florida were reviewed
- Several Correlations were reviewed

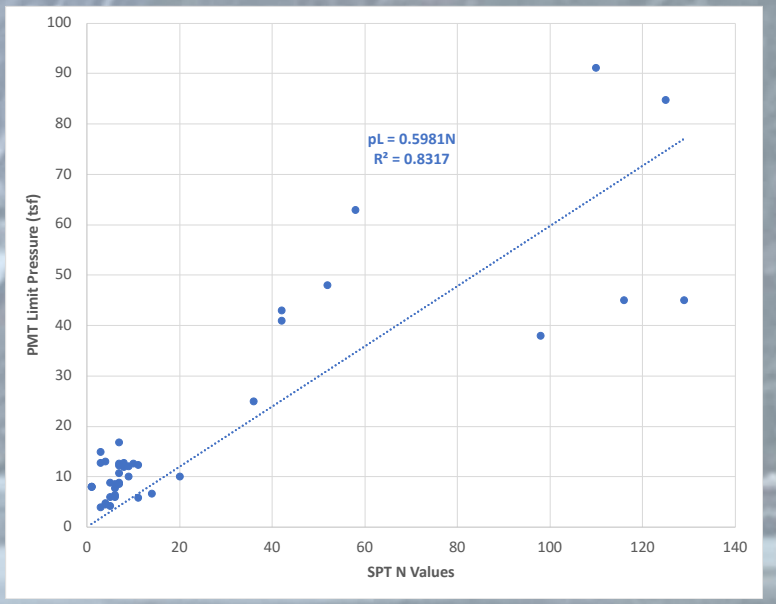
Overview of Literature and Historical Review (cont.)



Comparing PMT Elastic Moduli and Limit Pressures in Overconsolidated Residual Soils



Comparing N Values to PMT Elastic Moduli in Overconsolidated Residual Soils



Comparing N Values to PMT Limit Pressures in Overconsolidated Residual Soils

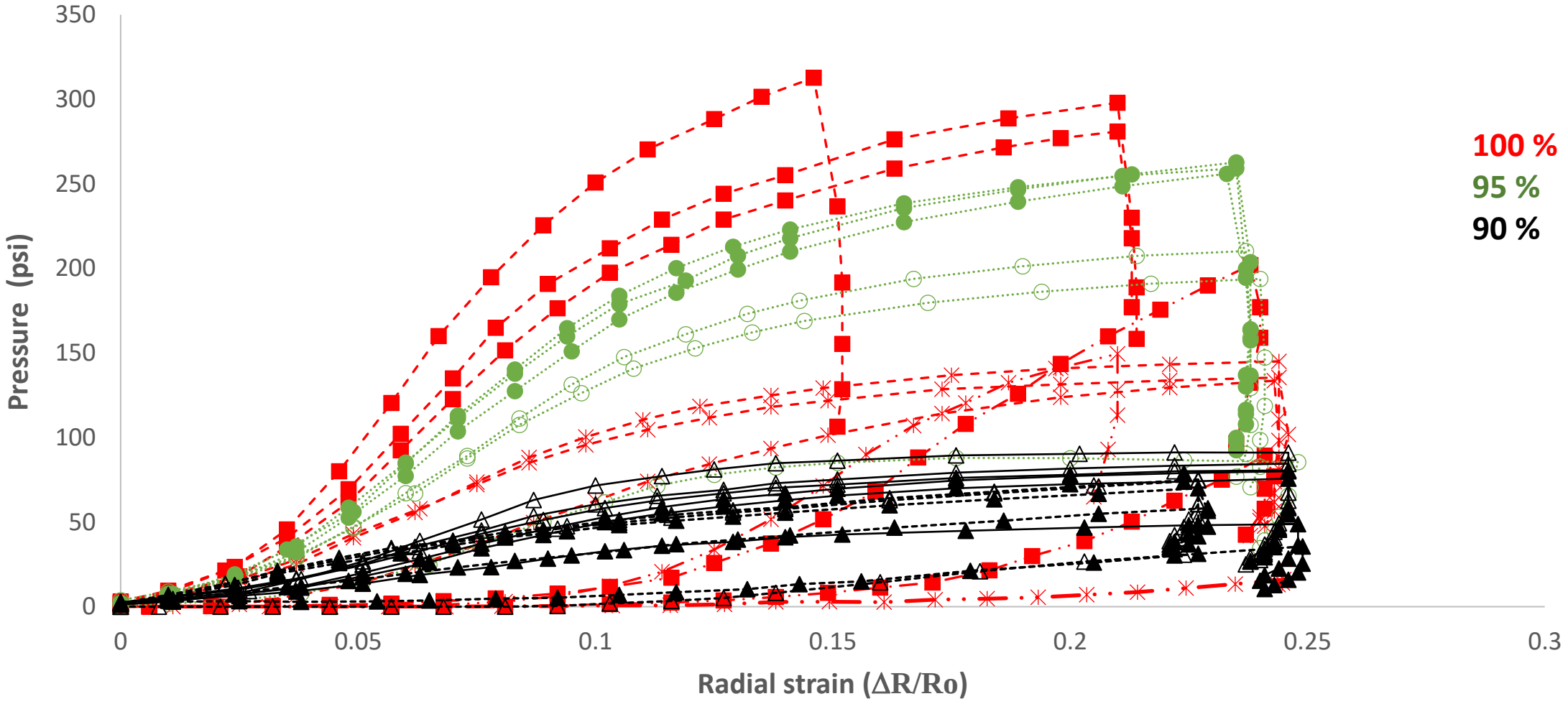
SMO Testing- In situ tests to determine E

- Both Indoor SMO Pits used
  - Compacted to about 5 ½ feet
- Two SP sands
  - *Starvation Hill Pit- LBR =32*
  - *Osteen Pit- LBR= 20*
- NDG-to ensure uniform compaction
  - 90, 95, 100 % Modified Proctor Densities
- PPMT-mostly pushed
- CPT
- DMT
- Plate Loading

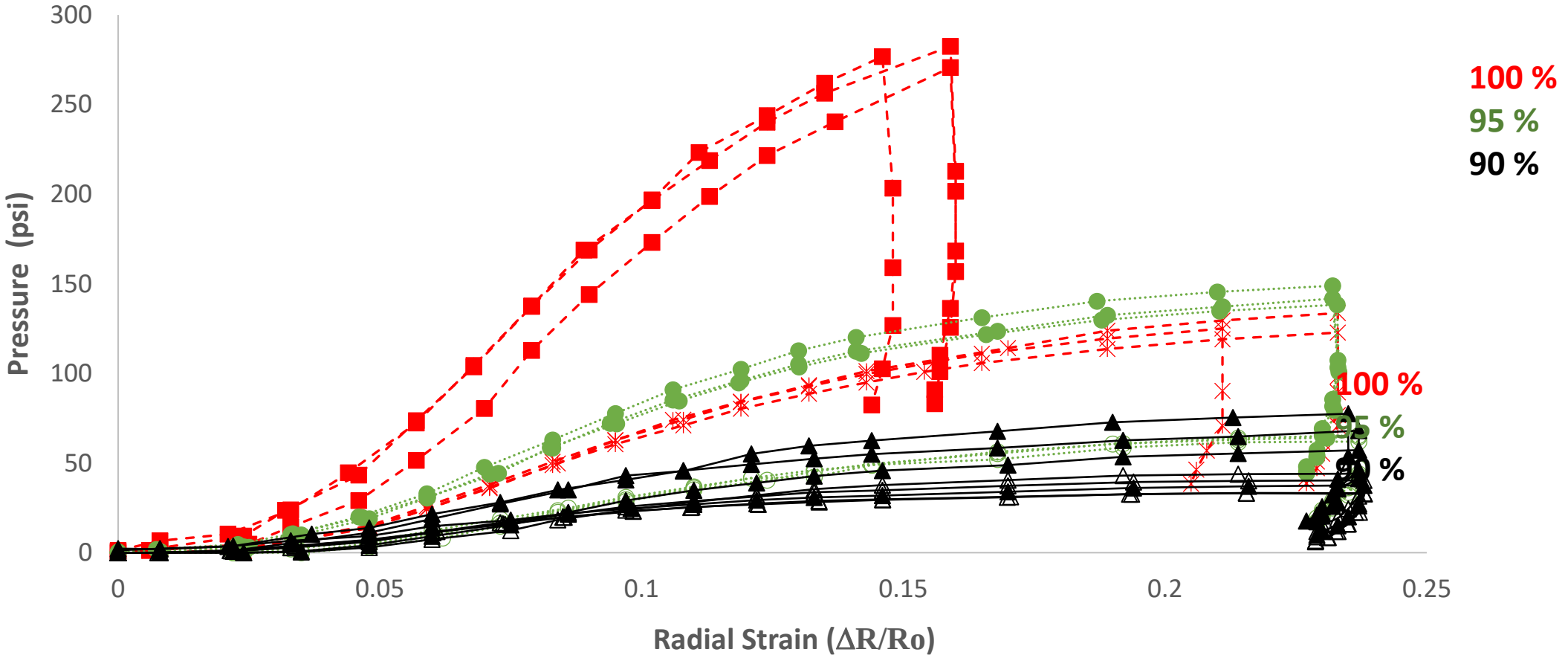
Summary of SMO Test Pit Testing

Site	PPMT Tests	CPT Soundings	DMT Tests	Plate Tests
SMO Starvation Hill 90 %	18	3	12	3
SMO Starvation Hill 95 %	6	3	12	3
SMO Starvation Hill 100 %	10	3	12	3
Subtotal	*34*	*9*	*36*	*9*
SMO Osteen 90 %	8	3	9	4
SMO Osteen 95 %	6	3	9	5
SMO Osteen 100 %	6	3	9	3
Subtotal	*20*	*9*	*27*	*12*
Total	**54**	**18**	**63**	**21**

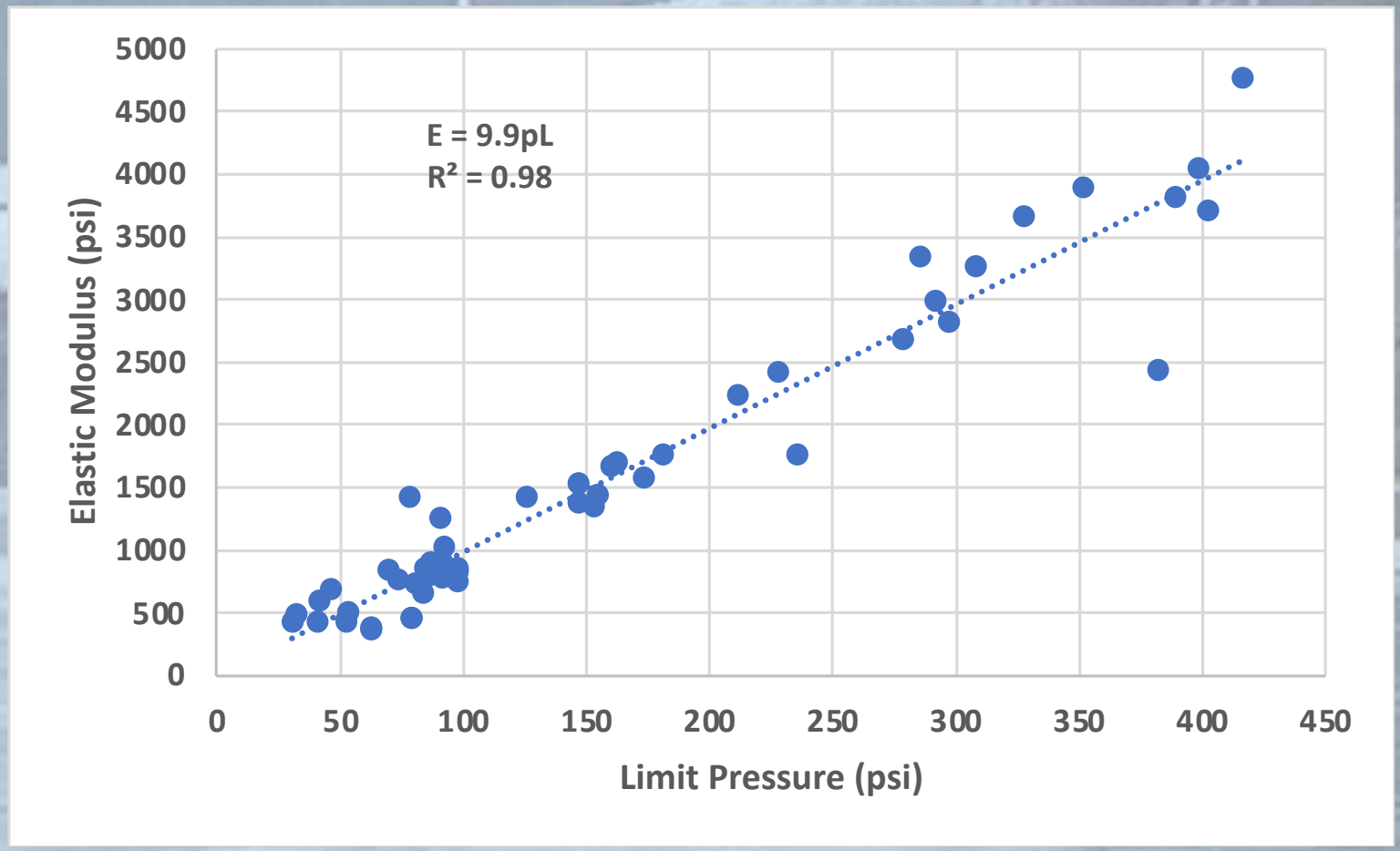
Starvation Hill PPMT Results



Osteen PPMT Results



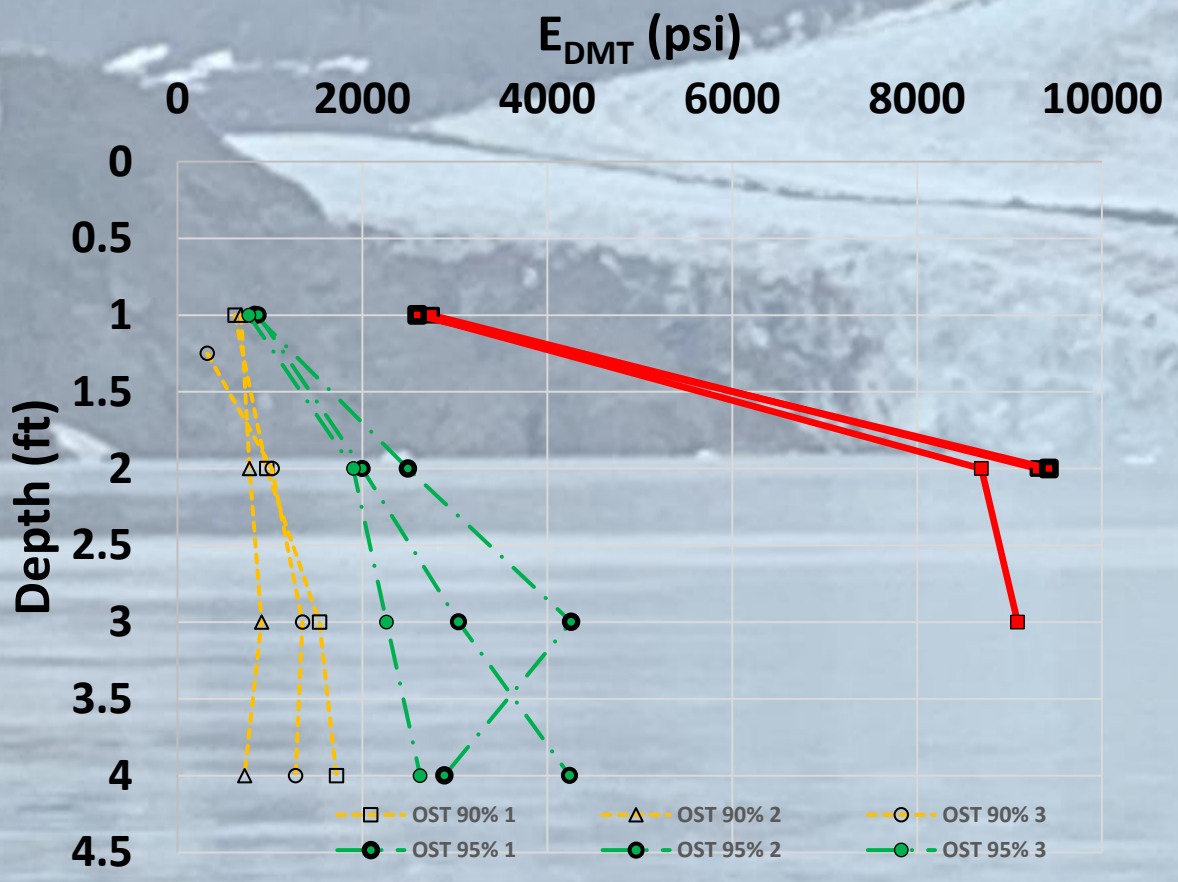
Both Pits SMO PPMT Results
54 tests
SP Sands



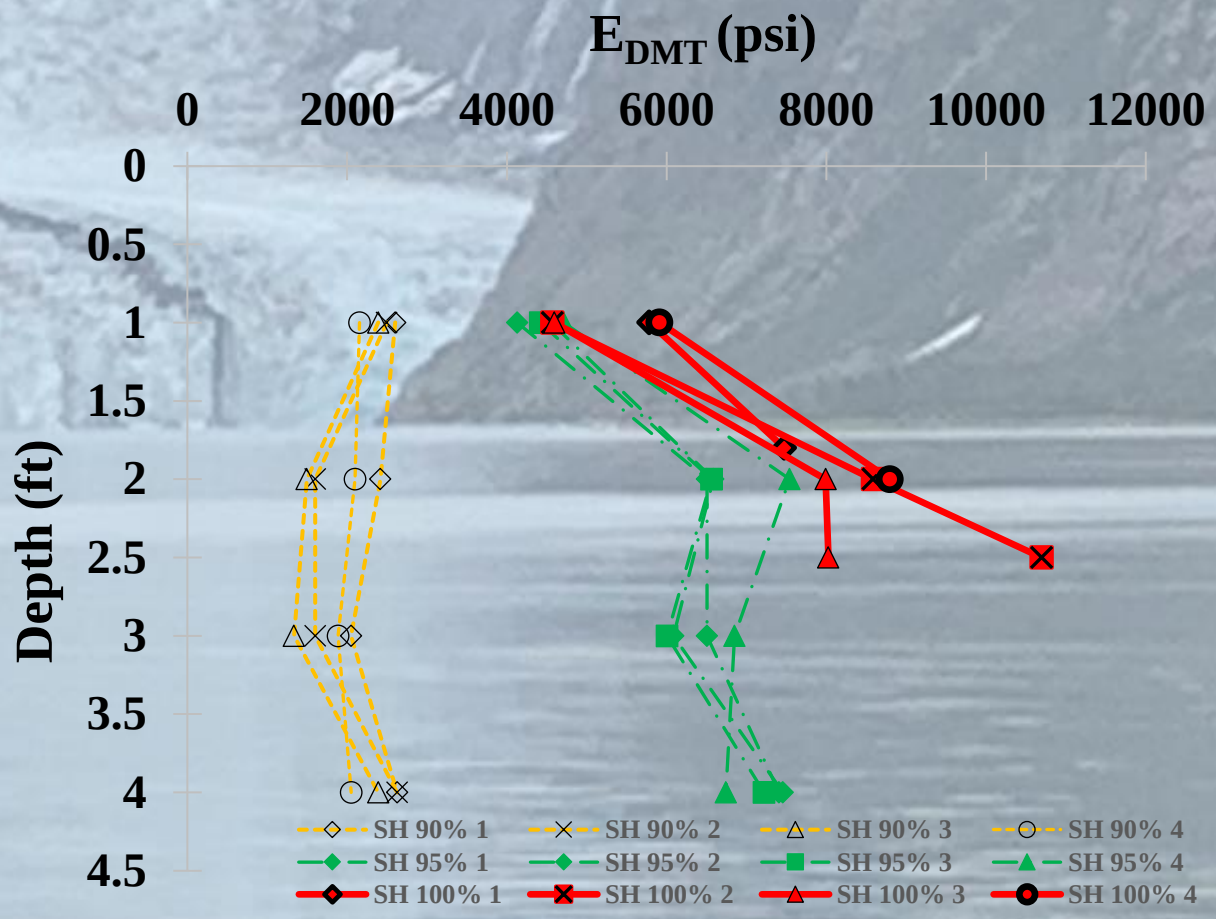
Results indicate PPMT tests produce reliable data!

DMT Results

Osteen Pit

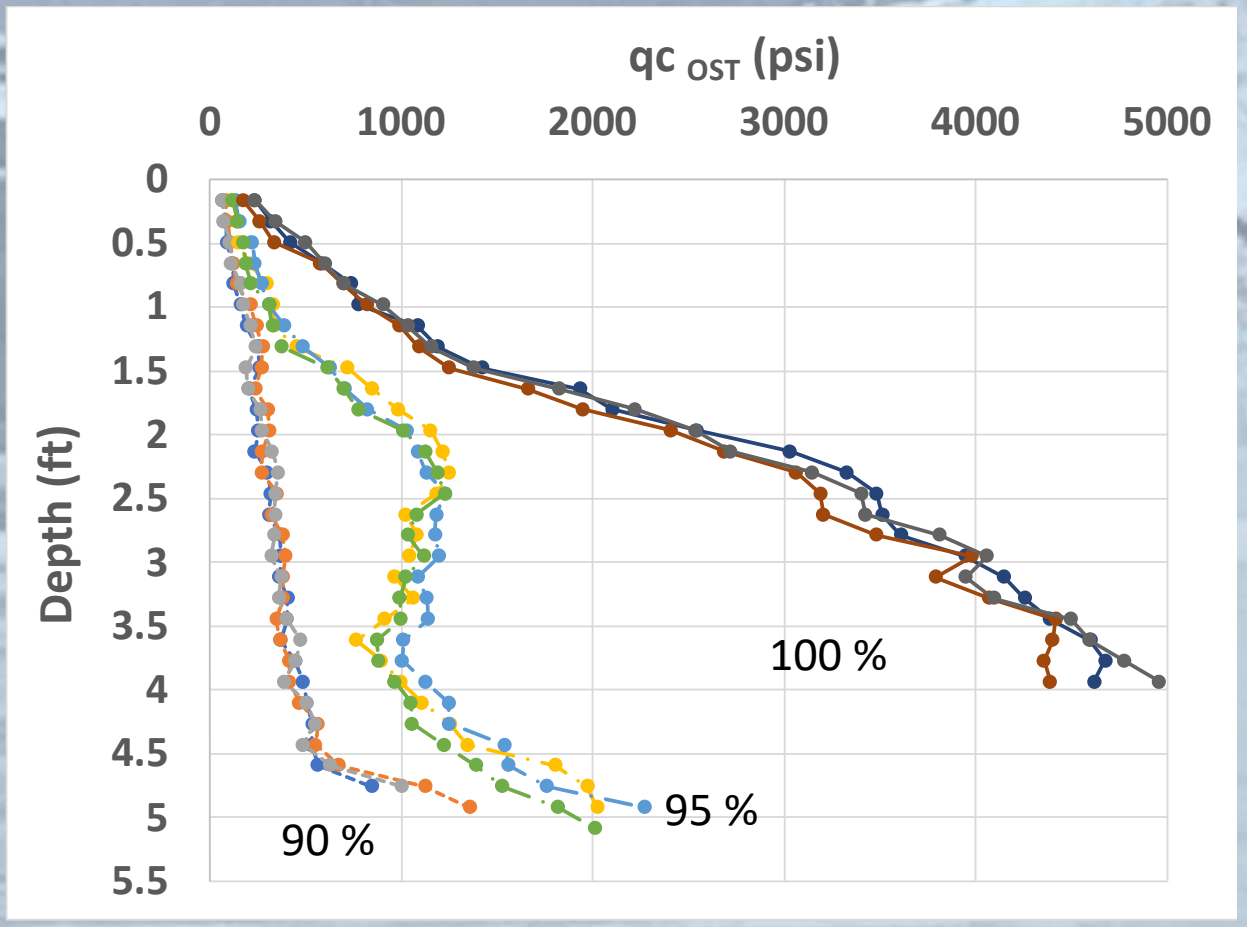


Starvation Hill Pit



CPT Results

Osteen Pit



Starvation Hill Pit

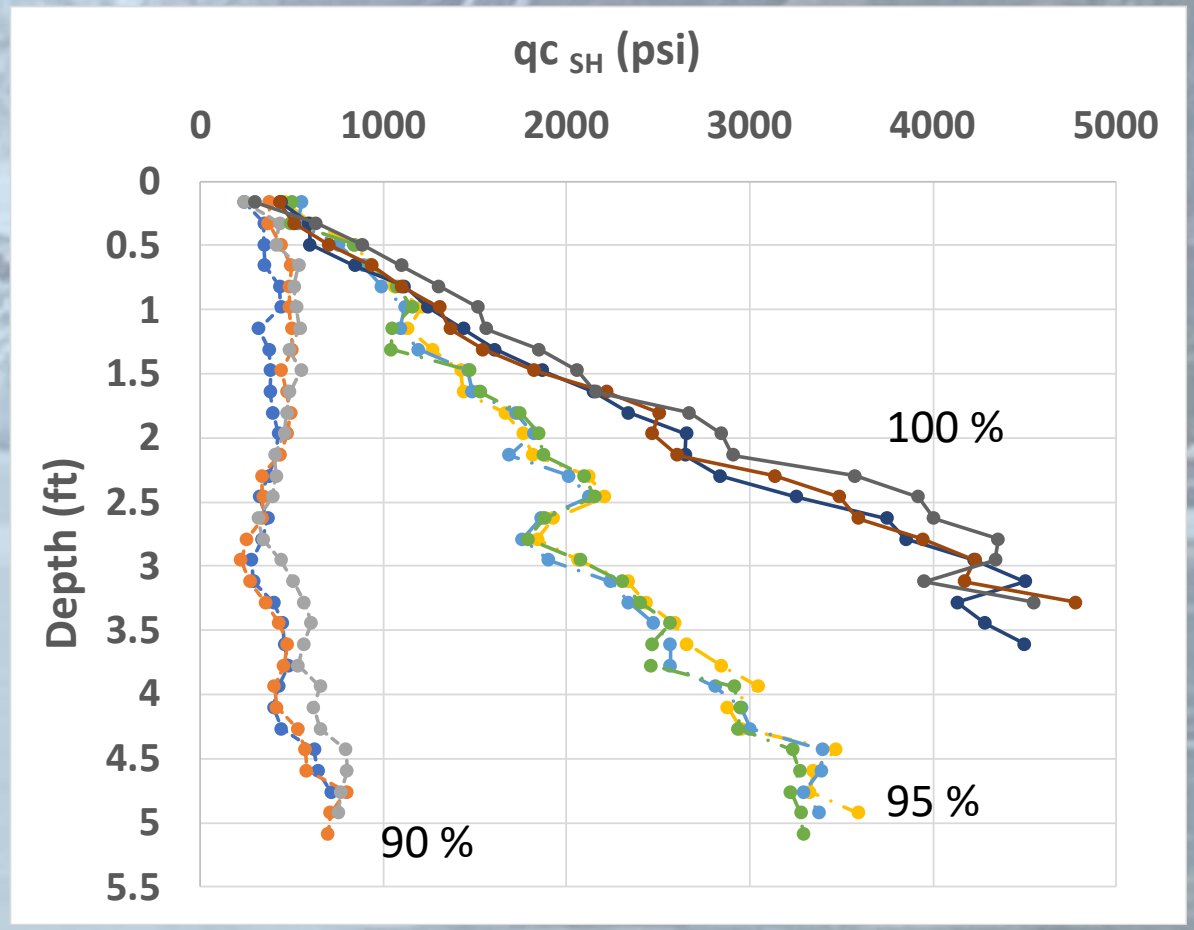
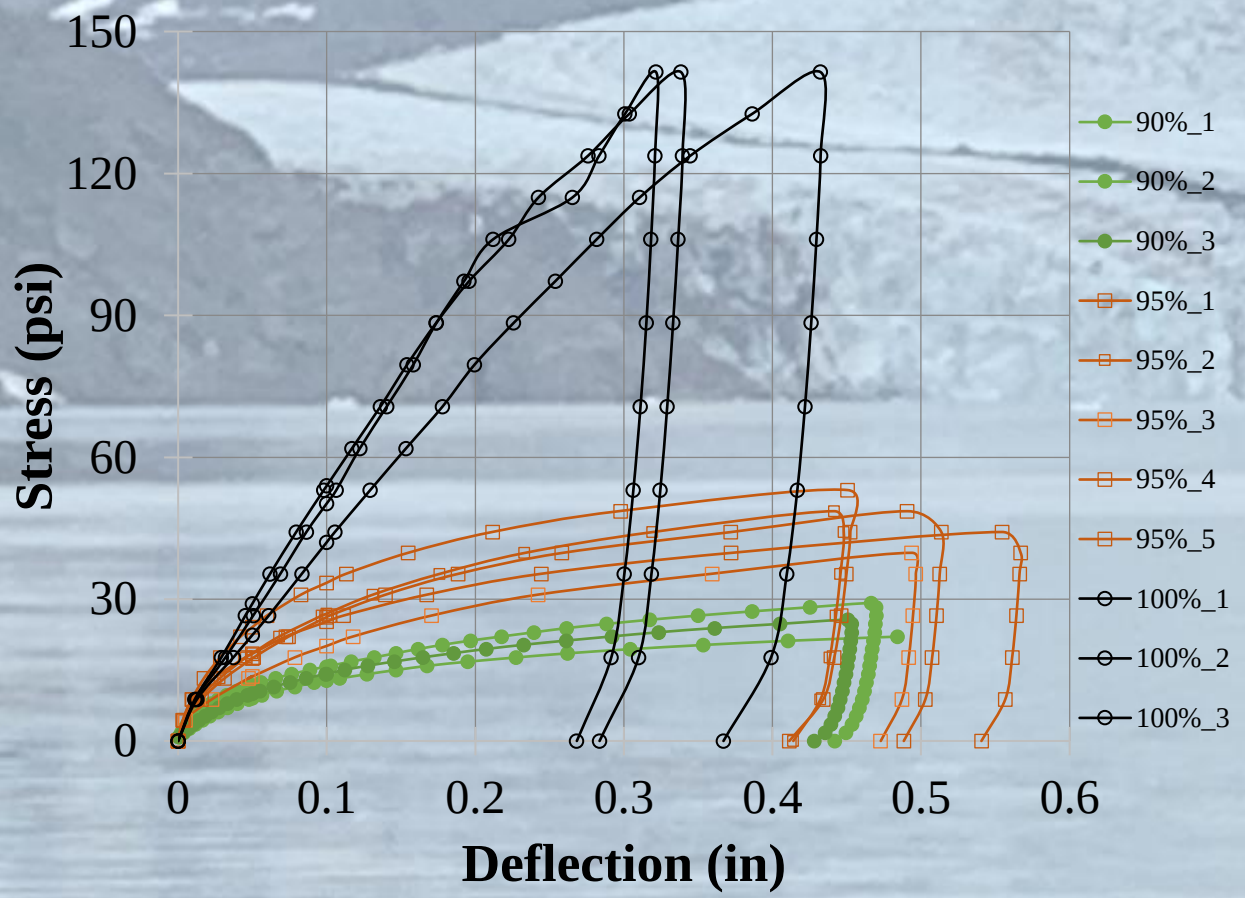
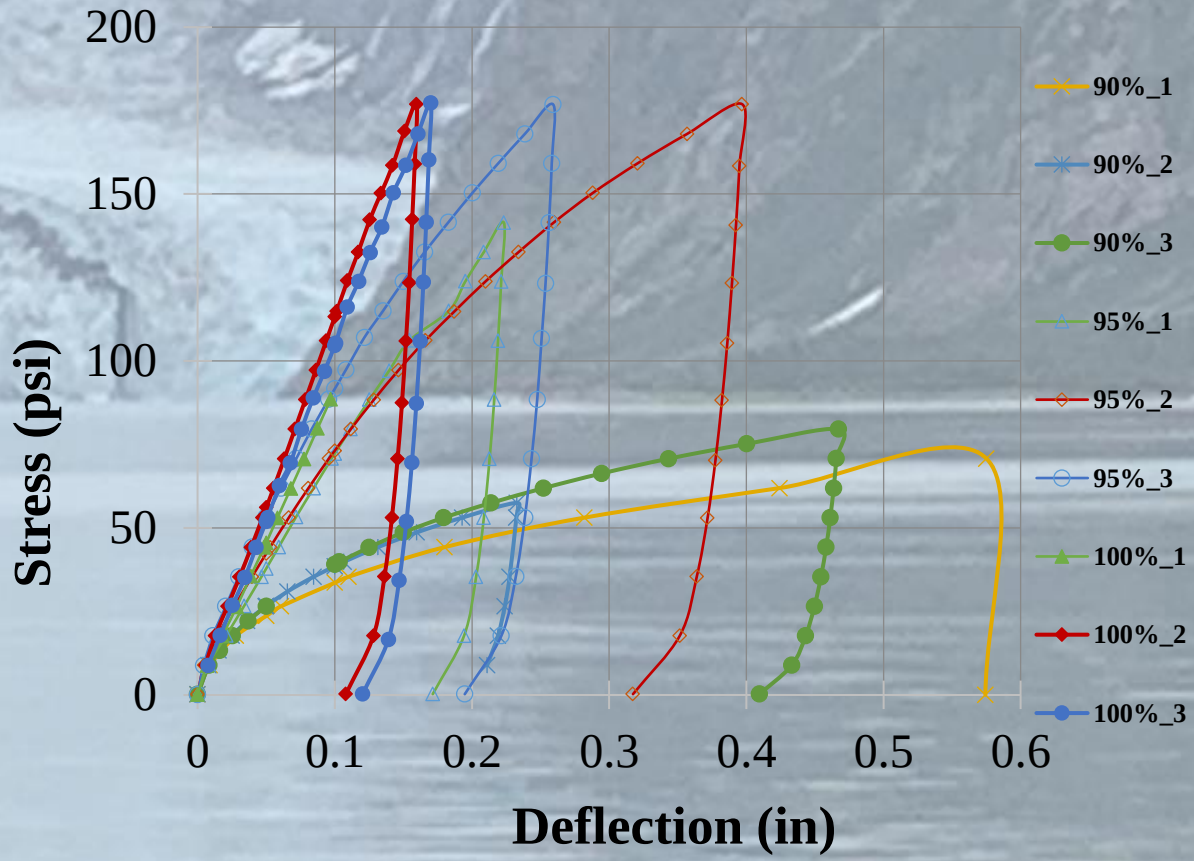


Plate Testing Results

Osteen Pit



You're Starvation Pit



Test Pits Correlations

Starvation Hill

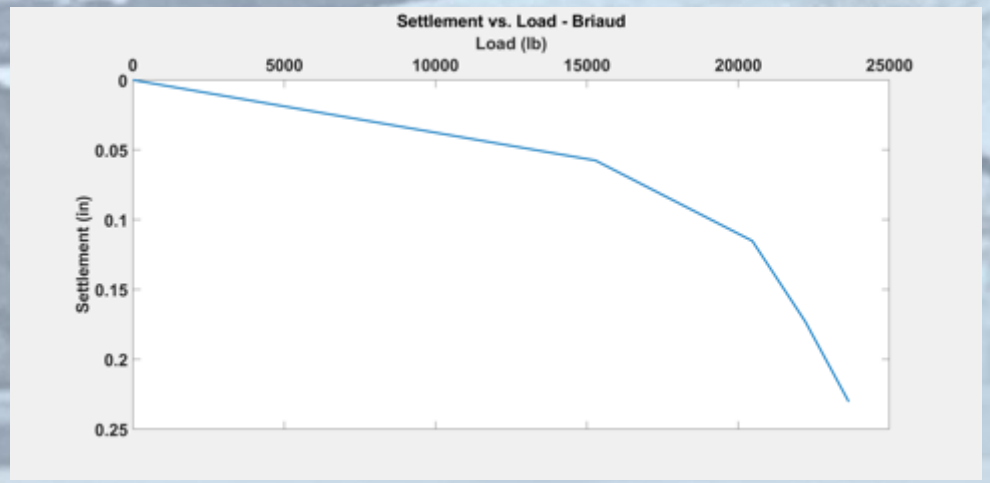
% Compaction	Ratios	Depth (ft) 0 - 0.5	0.5 - 1	1 - 1.5	1.5 - 2	2 - 2.5	2.5 - 3	3 - 3.5	3.5 - 4	4 - 4.5	4.5 - 5
90%	E_{PMT}/qc	2	2	2	2	2	2	2	2	1	1
	E_{DMT}/qc	6	5	4	5	5	6	5	4	4	3
	qc/pL	4	5	6	6	5	4	5	6	7	9
95%	E_{PMT}/qc	4	3	2	2	1	1	1	1	1	1
	E_{DMT}/qc	9	6	5	4	3	3	3	2	2	2
	qc/pL	3	5	6	8	10	10	11	13	15	16
100%	E_{PMT}/qc	5	3	2	1	1	1	1			
	E_{DMT}/qc	13	7	4	3	2	2	2			
	qc/pL	2	4	6	8	11	14	16			

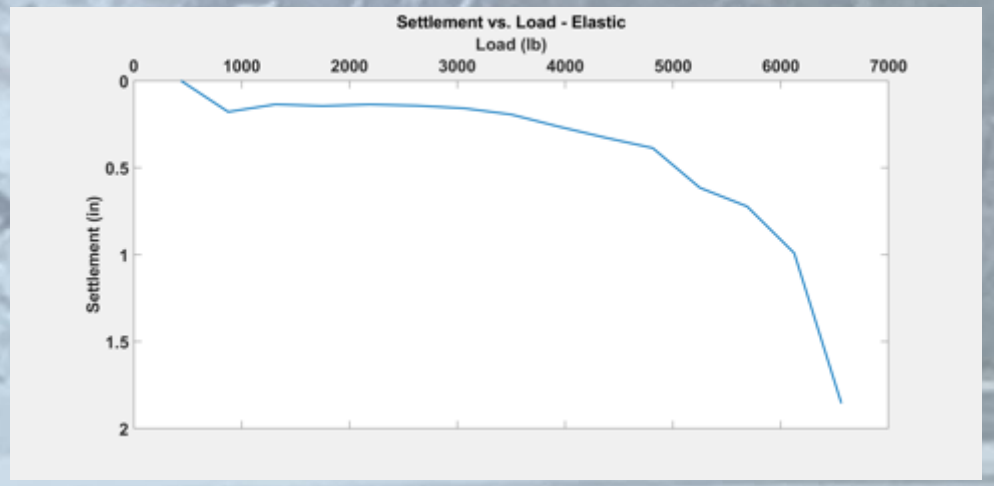
Osteen

% Compaction	Ratios	Depth (ft) 0 - 0.5	0.5 - 1	1 - 1.5	1.5 - 2	2 - 2.5	2.5 - 3	3 - 3.5	3.5 - 4	4 - 4.5	4.5 - 5
90%	E_{PMT}/qc	8	5	3	3	2	2	2	2	1	1
	E_{DMT}/qc	12	7	5	4	3	3	3	2	2	1
	qc/pL	2	3	4	5	6	6	7	8	9	15
95%	E_{PMT}/qc	8	5	2	1	1	1	1	1	1	1
	E_{DMT}/qc	16	10	5	3	2	2	2	2	2	1
	qc/pL	1	2	4	7	9	9	8	8	10	14
100%	E_{PMT}/qc	8	4	2	1	1	1	1			
	E_{DMT}/qc	20	10	6	3	2	2	2			
	qc/pL	1	2	4	7	11	13	16			

Comparing Settlements based on plate loading tests

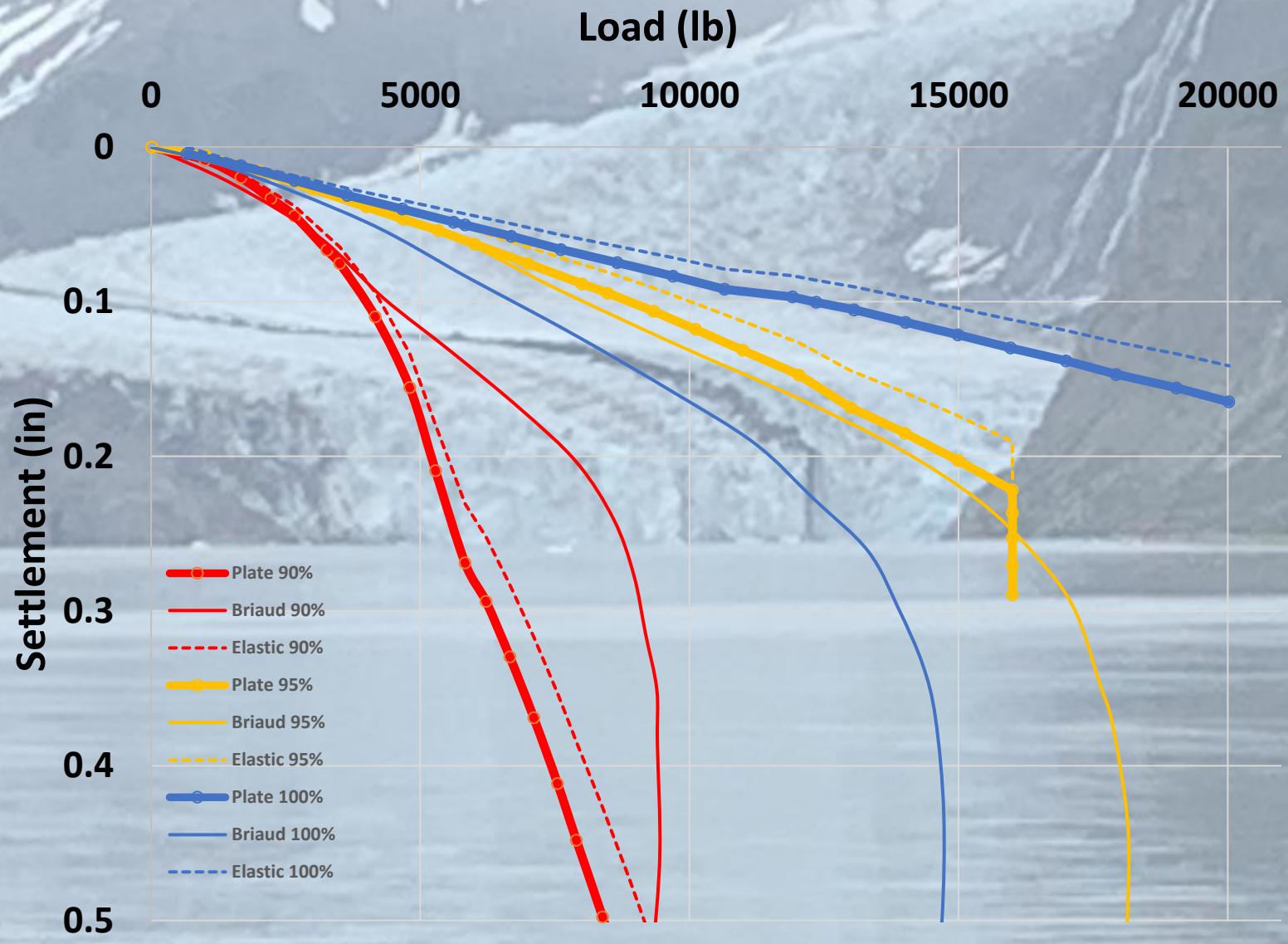
- Predicted settlements – Briaud 2007, Elastic settlement eq. using PMT data



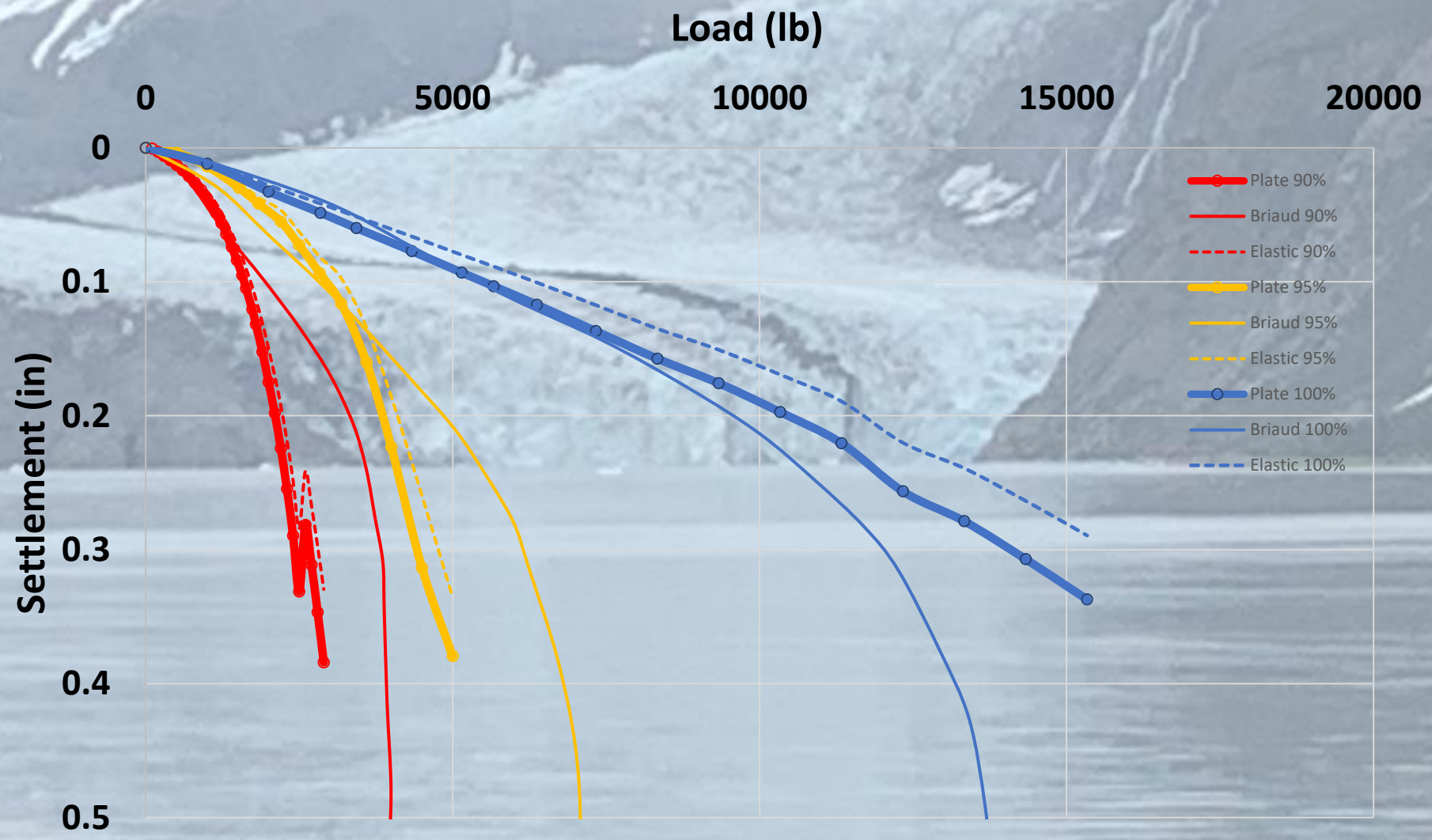


- Actual settlement – plate data

You're Starving Settlement – Ave. Plate vs. PPMT



Osteen Settlement – Ave. Plate vs. PPMT



Kingsley-Outdoor Testing

Type of Test		Depth (ft)	No of tests Conducted	Remark
PMT		3 to 21	21	Tests @ 3’ intervals
SSMini PMT	12”	0.6	1	Additional tests to be conducted
	10”	0.52	1	Additional tests to be conducted
	8”	0.44	0	Tests will be conducted
	6”	0.35	0	Tests will be conducted
Plate Load		Surface	3	12-inch plates
DMT		1 to 21	63	Three Soundings with tests @ 1’ interval
CPT		1 to 21	3	Three Soundings with Continuous Testing

Schedule of Tasks

Task No	Description	Months																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
N/A	Project Kick-off Meeting	4 2022																							
1	Literature Review and Historical Evaluations Concerning Settlement of Sands	4 2022	5 2022	6 2022	7 2022	8 2022	9 2022																		
2	PPMT and Plate Bearing Test Pit Evaluations of Fine Sands		5 2022	6 2022	7 2022	8 2022	9 2022	10 2022	11 2022	12 2022	1 2023	2 2023	3 2023	4 2023											
3	Site Selection, Site Visits, and Procurement of Site Data:		5 2022	6 2022	7 2022	8 2022	9 2022	10 2022																	
4	PPMT, CPT, DMT, SPT, and Field Plate Load Testing						9 2022	10 2022	11 2022	12 2022	1 2023	2 2023	3 2023	4 2023	5 2023	6 2023	7 2023	8 2023	9 2023						
5	Analyzing the Modulus Effects on Foundation Settlement and Bearing Capacity												3 2023	4 2023	5 2023	6 2023	7 2023	8 2023	9 2023	10 2023	11 2023	12 2023			
6	Extrapolation of Design Procedure Data with Design Flow Chart using Florida Site Conditions											2 2023	3 2023	4 2023	5 2023	6 2023	7 2023	8 2023	9 2023	10 2023	11 2023				
7	Draft Final Report and Closeout Teleconference														5 2023	6 2023	7 2023	8 2023	9 2023	10 2023	11 2023	12 2023			
8	Final Report																					12 2023	1 2024	2 2024	3 2024

Summary

- Both SP Sands were prepared to very high QC standards
- PPMT, DMT, CPT and Plate Testing successfully completed
- PPMT Moduli and Limit Pressures are related in SP sands
- PPMT and DMT Moduli relate to CPT Tip Resistance
- PPMT limit pressures relate to CPT Tip Resistance
- E_{PMT} and E_{DMT} to q_c ratios consistent with depth
- q_c to p_L ratios increased with depth

Closing Time

The lives we touch are our most important gift!


Questions?