LRFD Resistance Factors for Auger Cast In-Place (ACIP) Piles

FDOT BDV31-977-12

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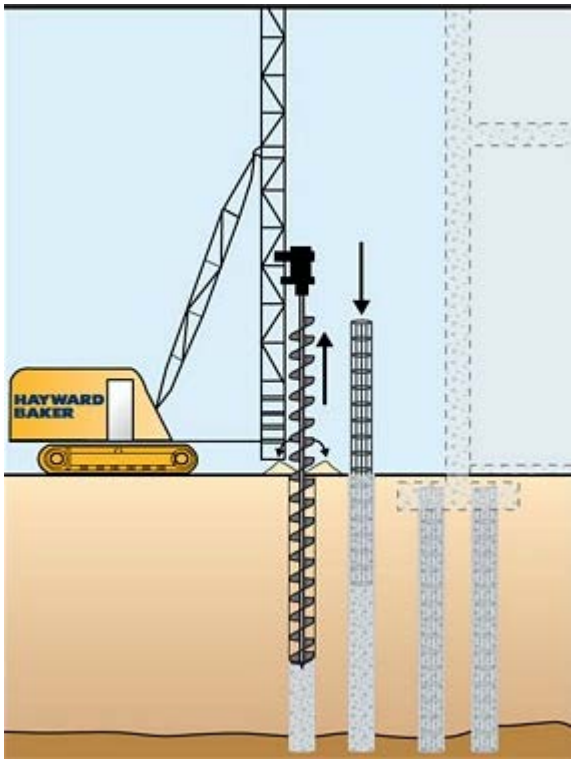
LRFD Resistance Factors for Design Methods for Auger Cast in Place (ACIP) Piles



- Current FDOT use - Sound Walls
- Used in Commercial Sector for High Rises, Condos, etc
- Other DOTs (e.g. Texas), FHWA (GEC No.8) Recommend for Bridge Foundations

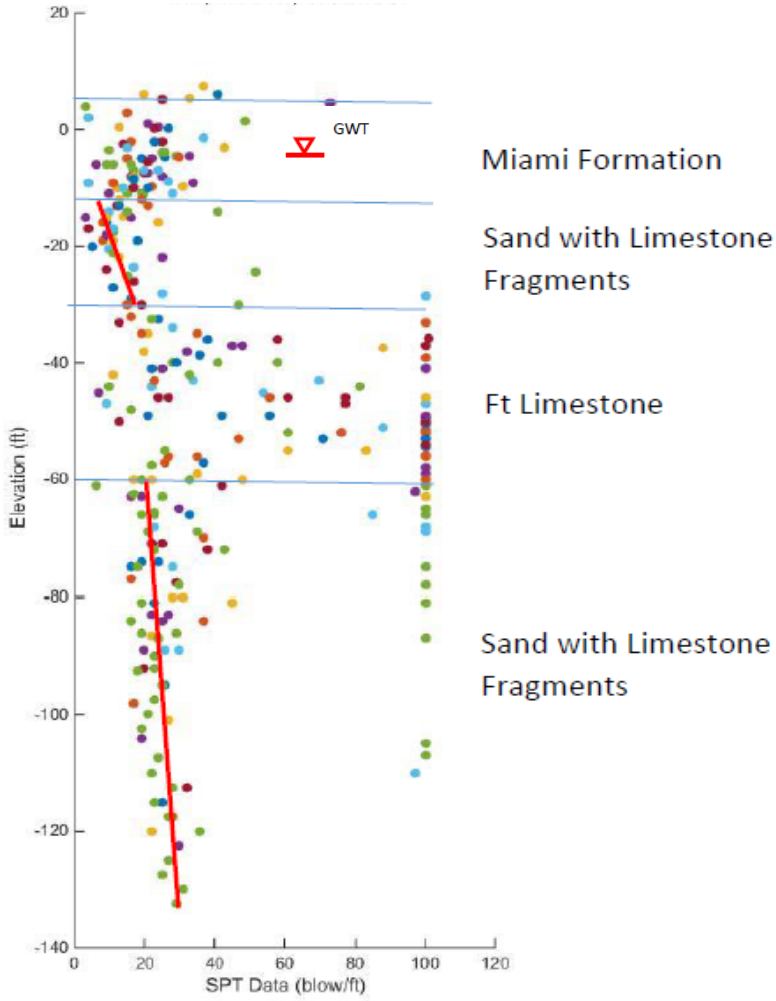
Benefits:

- Minimal Vibrations vs. Pile Driving for Urban Settings
- Much Higher Capacities in Limestone (e.g. South Florida)
- Number of Advances in Automated Monitoring

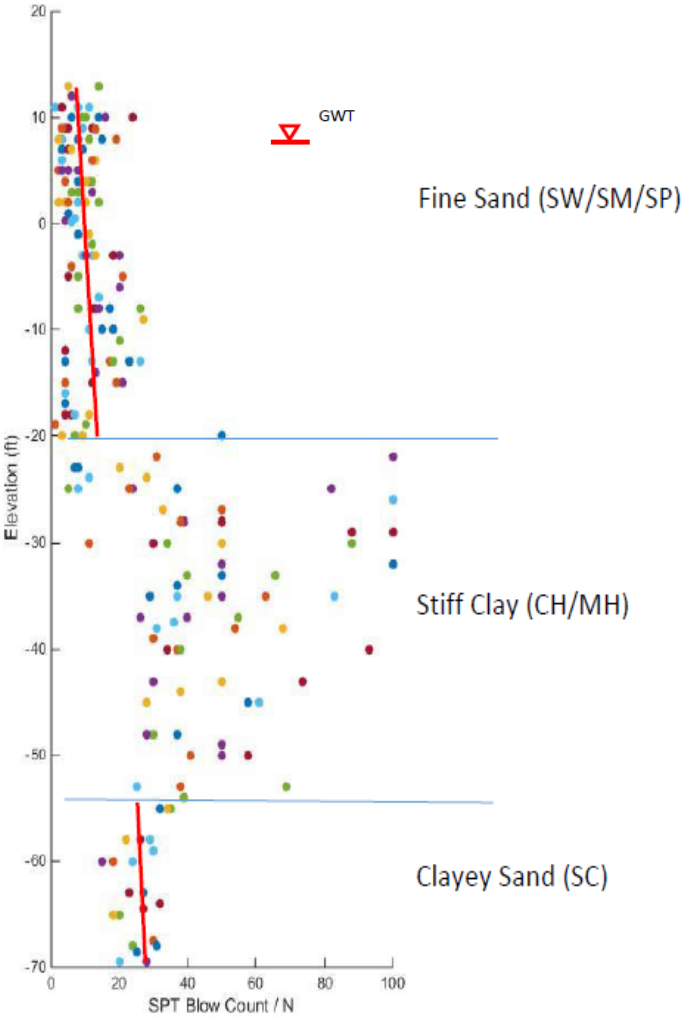
Location 3	Project Name	Soil Type	Diameter (in)	Embedded Length (ft)	Test Type	Number of Load Test	Water Table Depth (ft)	Instrumentation	Peak Displacement Load Test (in)	Data Provider
Alachua	Alachua-1 TP-2	Sand	16	64	Static	14	29	Load-Deflection	0.085	Universal Sciences Engineering, Inc.
	Alachua-1 TP-3	Clay, Sand & Limestone	16	64	Static		31	Load-Deflection	0.125	
	Alachua-1 TP-4	Sand	16	64	Static		26	Load-Deflection	0.183	
	Alachua-1 TP-5	Clay & Sand	16	64	Static		28	Load-Deflection	0.219	
	Alachua-2 TP-1	Clay, Silt & Sand	14	42	Static		4.5	Load-Deflection	0.288	
	Alachua-2 TP-2	Clay & Sand	14	42	Static		5	Load-Deflection	0.325	
	Alachua-2 TP-3	Sand	14	42	Static		6.5	Load-Deflection	0.295	
	Alachua-2 TP-5	Clay & Sand	14	42	Static		5	T-Z & Load-Defl.	0.341	
	Alachua-2 TP-XX-1	No Boring	14	42	Static		None	Load-Deflection	0.777	
	Alachua-2 TP-XX-2	No Boring	14	42	Static		None	Load-Deflection	0.460	
	Alachua-3 TP-1	Clay, Sand & Limestone	14	15	Static		12	Load-Deflection	0.549	
	Alachua-5 TP-1	Clay & Sand	14	65	Static		6	T-Z & Load-Defl.	0.600	
	Alachua-5 TP-2	Clay & Sand	14	65	Static		6	T-Z & Load-Defl.	1.000	
	Alachua-5 TP-3	Clay & Sand	14	65	Tension		6	T-Z & Load-Defl.	0.088	
Broward	Broward-1 TP-1	Sand & Limestone	18	102	Static	4	5.7	T-Z & Load-Defl.	0.344	Universal Sciences Engineering, Inc.
	Broward-1 TP-2	Sand & Limestone	18	102	Tension		5.7	T-Z & Load-Defl.	0.009	
	Broward-1 TP-5	Sand & Limestone	30	140	Osterberg		1	O-Cell	0.400	
	Broward-2 TP-1	Sand & Limestone	14	40	Static		None	Load-Deflection	0.350	
Duval	Duval-1 TP 1-2	Clay, Sand & Limestone	16	55	Static	4	4.5	Load-Deflection	0.289	Langan Engineering & Environmental Services
	Duval-1 TP 2-2	Clay, Sand & Limestone	16	54	Static		4.5	Load-Deflection	0.397	
	Duval-1 TP 3-2	Clay, Sand & Limestone	18	54	Tension		4.5	Load-Deflection	0.192	
	Duval-1 TP 3-3	Clay, Sand & Limestone	16	54	Static		4.5	Load-Deflection	0.267	
Hollywood	Hollywood-1 TP-1	No Boring	14	50	Static	3	No Boring	Load-Deflection	0.340	Universal Sciences Engineering, Inc.
	Hollywood-2 TP-1	No Boring	14	48	Static		No Boring	T-Z & Load-Defl.	0.200	
	Hollywood-2 TP-2	No Boring	14	48	Tension		No Boring	T-Z & Load-Defl.	0.032	
Hillsborough	Hillsborough-2 TP-1	No Boring	14	40	Static	6	None	Load-Deflection	0.079	Applied Foundation Test, Inc.
	Hillsborough-3 TP-1	Clay, Silt & Sand	16	60	Static		5.2	T-Z & Load-Defl.	0.548	
	Hillsborough-3 TP-2	Clay, Silt & Sand	16	60	Statnamic		5.2	T-Z & Load-Defl.	0.939	
	Hillsborough-3 TP-3	Clay, Silt & Sand	16	60	Statnamic		5	T-Z & Load-Defl.	1.176	
	Hillsborough-3 TP-4	Clay, Silt & Sand	16	60	Statnamic		5	T-Z & Load-Defl.	0.760	
	Hillsborough-3 TP-5	Clay, Sand & Limestone	16	67.4	Statnamic		4	T-Z & Load-Defl.	0.653	
Nassau	Nassau-1 TP14	Sand	14	60	Static	3	3.8	T-Z & Load-Defl.	0.385	Amec Foster Wheeler
	Nassau-2 TP-1	Clay, Silt & Sand	16	39	Static		3	Load-Deflection	0.300	
	Nassua-3 TP-1	Clay, Silt & Sand	14	65	Static		5	T-Z & Load-Defl.	0.200	
Palm Beach	Palm Beach-1 TP-9	No Boring	16	61	Static	2	None	T-Z & Load-Defl.	0.113	Universal Sciences Engineering, Inc.
	Palm Beach-2 TP-8	No Boring	16	61	Static		None	T-Z & Load-Defl.	0.188	
Polk	Polk-1	Clay, Silt & Sand	18	65	Static	1	8.5	Load-Deflection	0.360	Ardaman & Associates, Inc
Santa Rosa	Santa Rosa-1 TP-1	Clay, Silt & Sand	24	47	Static	1	2.5	T-Z & Load-Defl.	0.465	
West Palm	West Palm-1 T2B	Sand	14	40	Tension	3	9	Load-Deflection	0.250	DunkelBerger Engineering & Testing
	West Palm-1 T8	Sand	14	40	Tension		9	Load-Deflection	0.250	
	West Palm-1 T9B	Sand	14	40	Static		9	Load-Deflection	0.536	

Location **4**	Project Name	Soil Type	Diameter (in)	Embedded Length (ft)	Test Type	Number of Load Test	Water Table Depth (ft)	Instrumentation	Peak Displacement Load Test (in)	Data Provider
Miami Dade	Miami Dade-1 TP-1	Sand & Limestone	16	43	Static	37	5	Load-Deflection	0.343	Amec Foster Wheeler Environment & Infrastructure
	Miami Dade-1 TP-2	Sand & Limestone	16	43	Tension		5	Load-Deflection	0.208	
	Miami Dade-5 TP-1	Sand & Limestone	14	30	Static		(+) 2.5	Load-Deflection	0.148	
	Miami Dade-5 TP-2	Sand & Limestone	14	30	Tension		(+) 2.5	Load-Deflection	0.270	
	Miami Dade-6 TP-1	Sand & Limestone	14	25	Static		Not measured	Load-Deflection	0.183	
	Miami Dade-6 TP-2	Sand & Limestone	14	40	Static		8	Load-Deflection	0.182	
	Miami Dade-6 TP-3	Sand & Limestone	14	40	Static		8	Load-Deflection	0.303	
	Miami Dade-6 TP-5	Sand & Limestone	14	40	Static		8	Load-Deflection	0.090	
	Miami Dade-6 TP-6	Sand & Limestone	14	40	Static		4	Load-Deflection	0.206	
	Miami Dade-6 TP-7	Sand & Limestone	14	40	Static		Not measured	Load-Deflection	0.060	
	Miami Dade-6 TP-8	Sand & Limestone	14	40	Static		Not measured	Load-Deflection	0.093	
	Miami Dade-6 TP-9	Sand & Limestone	14	40	Static		Not measured	Load-Deflection	0.142	
	Miami Dade-6 TP-10	Sand & Limestone	14	40	Static		Not measured	Load-Deflection	0.572	
	Miami Dade-6 TP-11	Sand & Limestone	14	23	Static		5.5	Load-Deflection	0.073	
	Miami Dade-6 TP-12	Sand & Limestone	14	23	Static		5.5	Load-Deflection	0.346	
	Miami Dade-6 TP-13	Sand & Limestone	14	50	Static		Not measured	Load-Deflection	0.072	
	Miami Dade-6 TP-14	Sand & Limestone	14	58	Static		8	Load-Deflection	0.182	
	Miami Dade-6 TP-15	Sand & Limestone	14	45	Static		7.5	Load-Deflection	0.119	
	Miami Dade-6 TP-16	Sand & Limestone	14	25	Static		5.5	Load-Deflection	0.115	
	Miami Dade-6 TP-17	Sand & Limestone	14	25	Static		5.5	Load-Deflection	0.135	
	Miami Dade-6 TP-18	Sand & Limestone	14	20	Static		4	Load-Deflection	0.115	
	Miami Dade-6 TP-19	Sand & Limestone	14	55	Static		8	Load-Deflection	0.192	
	Miami Dade-6 TP-20	Sand & Limestone	14	30	Static		9	Load-Deflection	0.091	
	Miami Dade-6 TP-21	Sand & Limestone	14	46	Static		12	Load-Deflection	0.110	
	Miami Dade-6 TP-22	Sand & Limestone	14	41	Static		12	Load-Deflection	0.058	
	Miami Dade-6 TP-23	Sand & Limestone	14	58.5	Static		10.5	Load-Deflection	0.560	
	Miami Dade-6 TP-24	Sand & Limestone	14	47	Static		4	Load-Deflection	0.182	
	Miami Dade-6 TP-25	Sand & Limestone	14	56	Static		10	Load-Deflection	0.095	
	Miami Dade-6 TP-26	Sand & Limestone	14	57	Static		10	Load-Deflection	0.296	
	Miami Dade-6 TP-27	Sand & Limestone	14	47	Static		11	Load-Deflection	0.053	
	Miami Dade-6 TP-28	Sand & Limestone	14	65	Static		8	Load-Deflection	0.408	
	Miami Dade-6 TP-29	Sand	14	56	Static		9	Load-Deflection	0.107	
	Miami Dade-6 TP-30	Sand & Limestone	14	56	Static		9	Load-Deflection	0.107	
	Miami Dade-6 TP-31	No Boring	14	44	Static		None	Load-Deflection	0.432	
	Miami Dade-7 TP-1	Sand & Limestone	18	41	Static		4	Load-Deflection	0.064	
	Miami Dade-7 TP-2	Sand & Limestone	18	41	Static		4	Load-Deflection	0.069	
	Miami Dade-8 TP-1	Sand, Silt & Limestone	14	52	Static		1	Load-Deflection	0.300	
Total # of Test Piles						78	Total T-Z Curve	16		

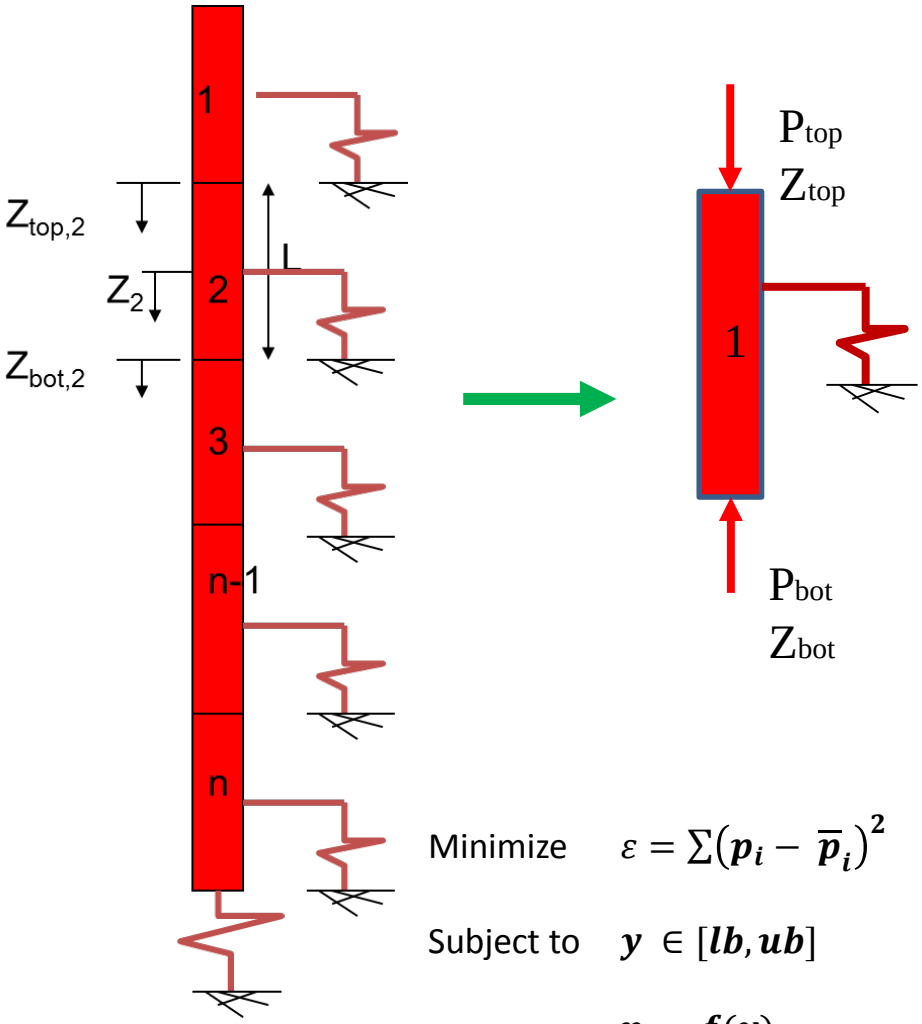
Miami-Dade Metrorail



Duval Court House



Pile-Soil Transfer



Minimize $\varepsilon = \sum(\boldsymbol{p_i} - \overline{\boldsymbol{p}}_{\boldsymbol{i}})^2$

Subject to $\boldsymbol{y} \in [\boldsymbol{lb}, \boldsymbol{ub}]$

$\boldsymbol{p} = \boldsymbol{f}(\boldsymbol{y})$

What's known:

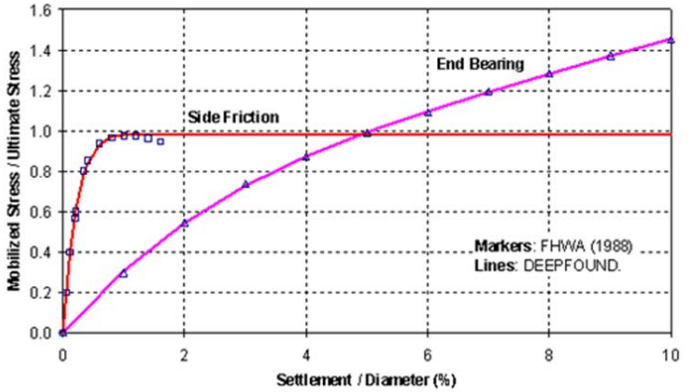
P_{top}; Z_{top}

What's unknown:

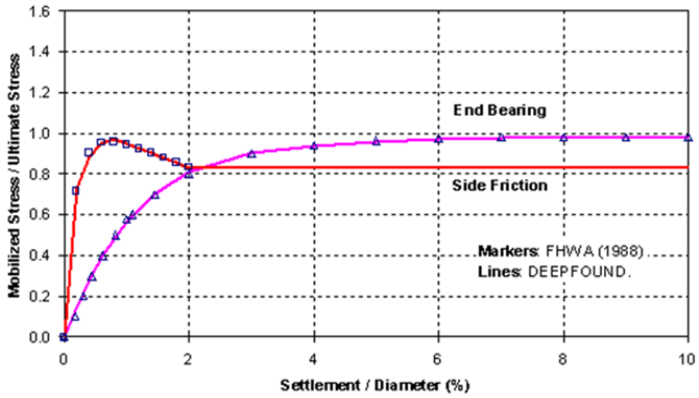
fs; P_{bottom}; Z_{bottom}

Assumption:

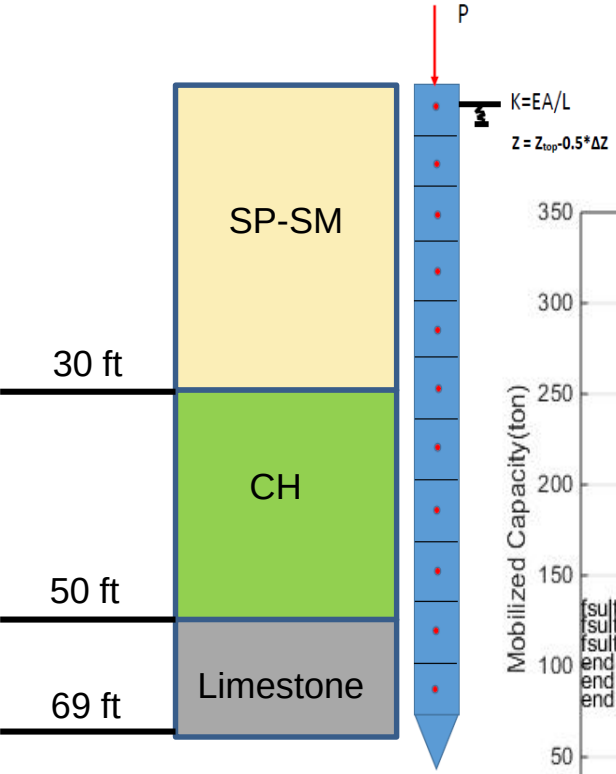
Sand:

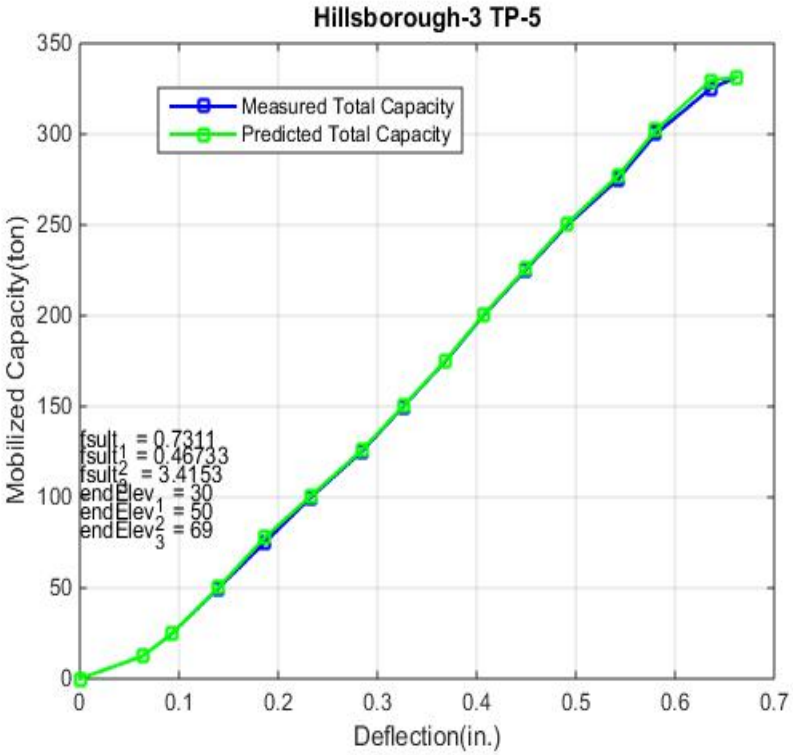


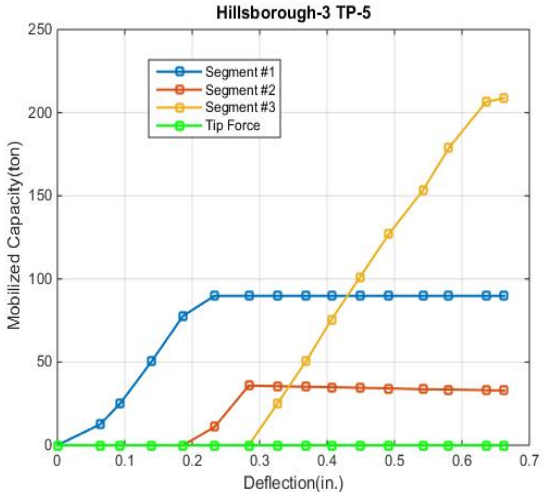
Clay:

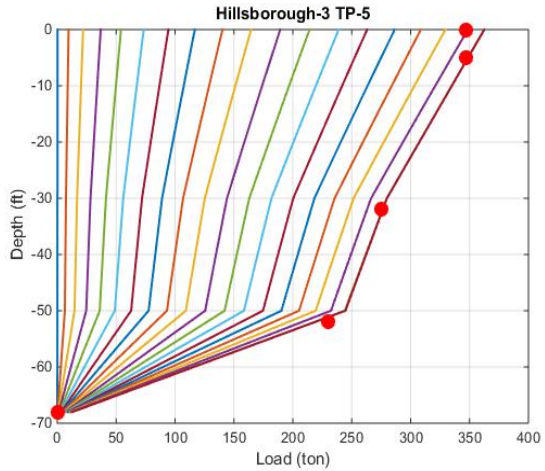


Assessment of Nominal Unit Resistance (Skin & Tip) From Load Tests

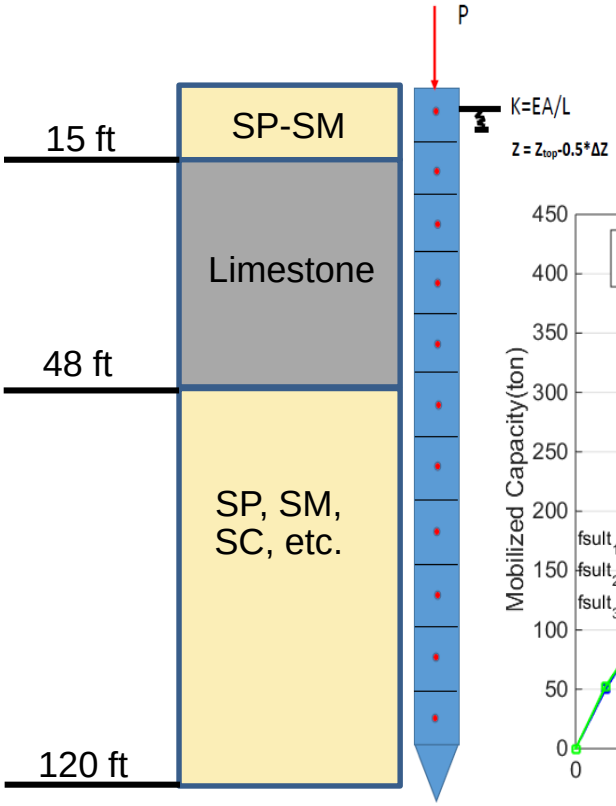


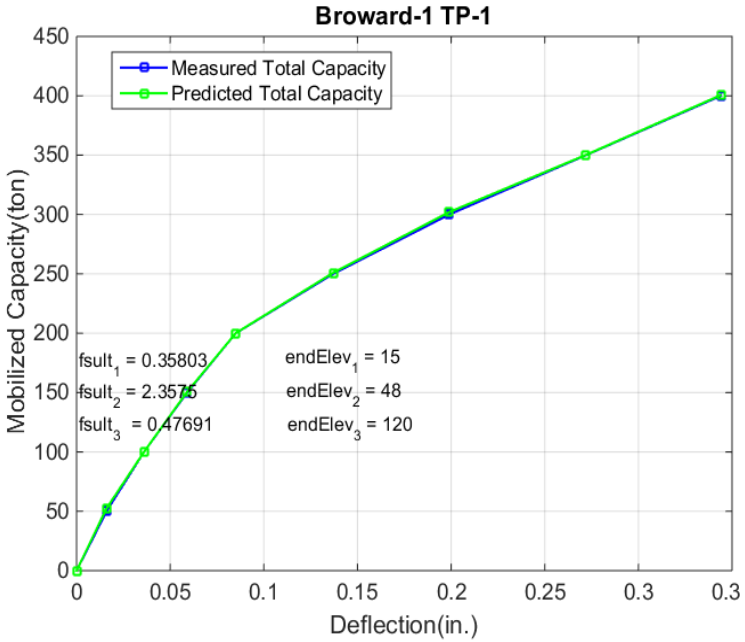


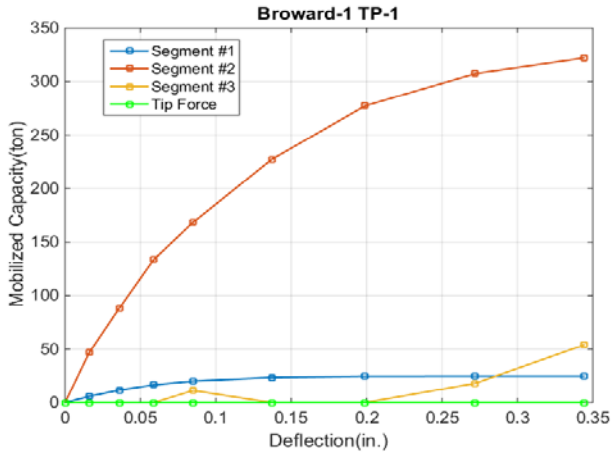


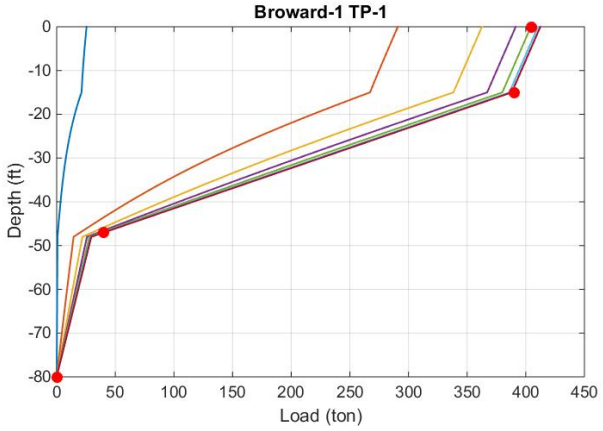


Assessment of Nominal Unit Resistance (Skin & Tip) From Load Tests



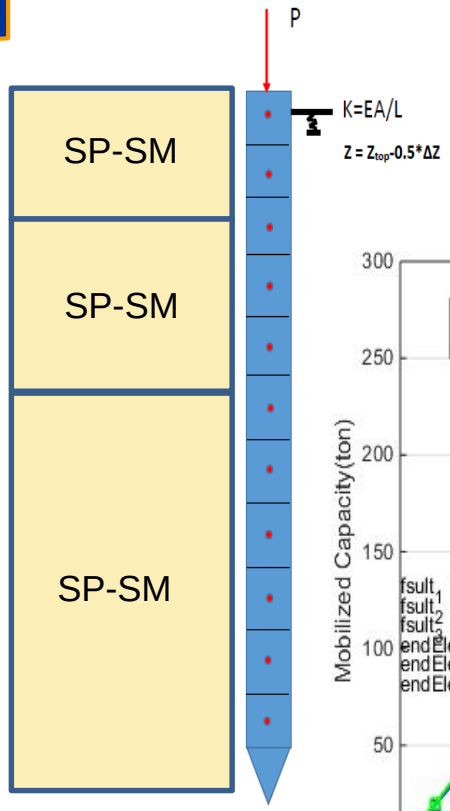


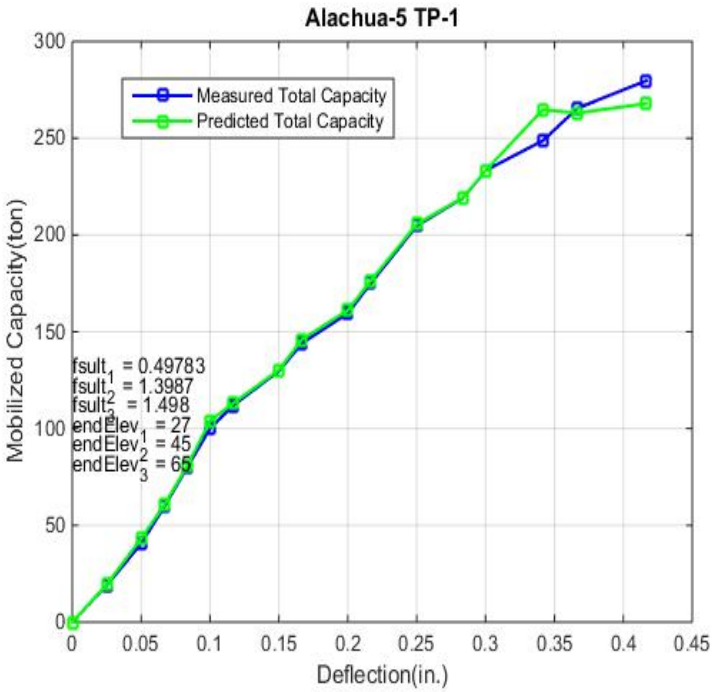


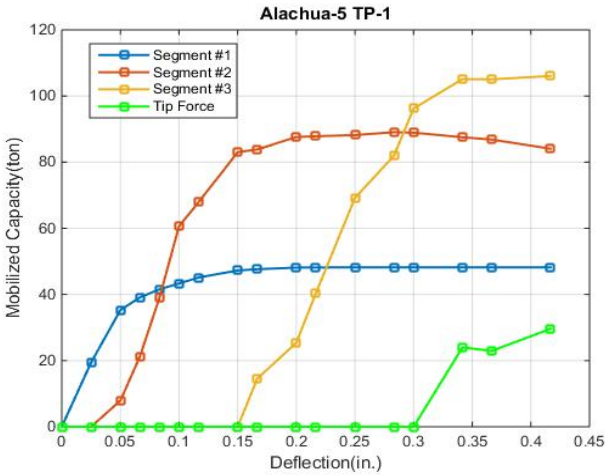


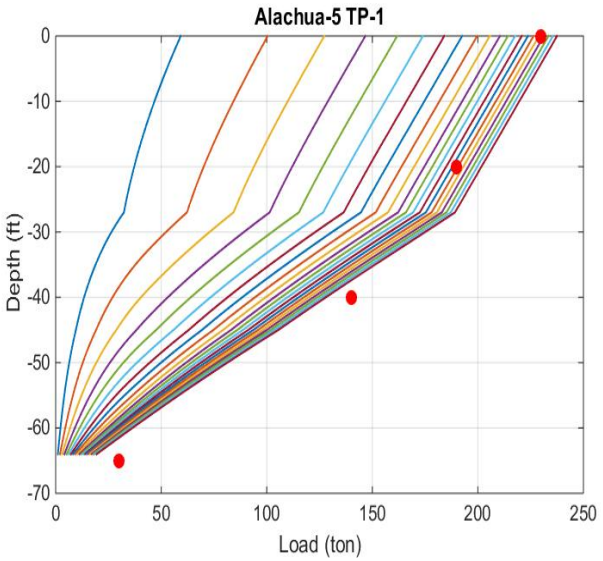
Assessment of Nominal Unit Resistance (Skin & Tip) From Load Tests

Depth
0-65 ft

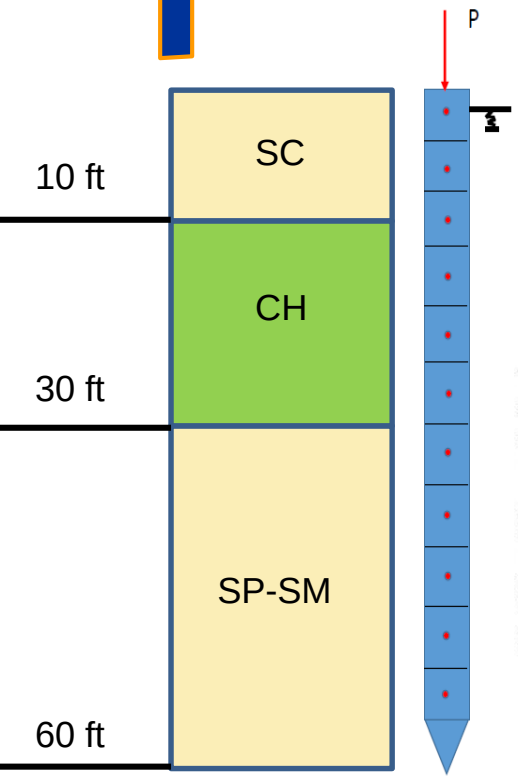


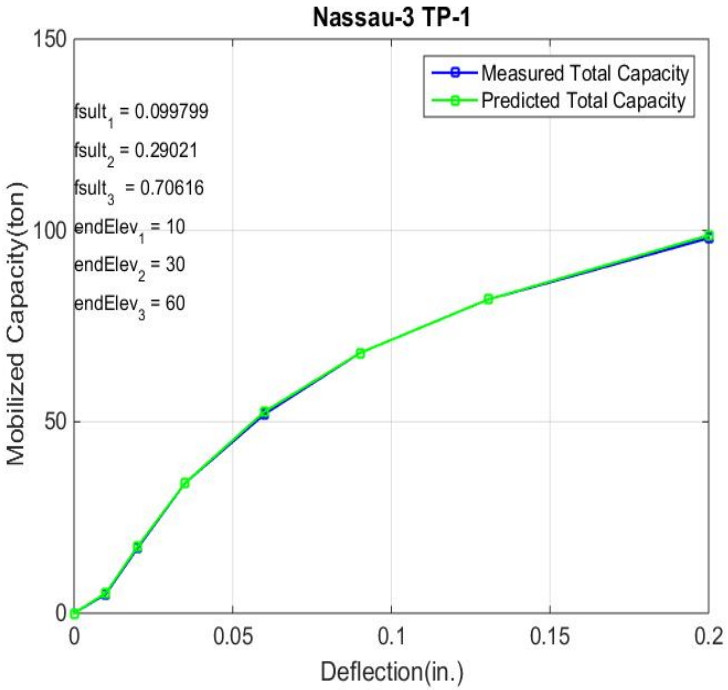


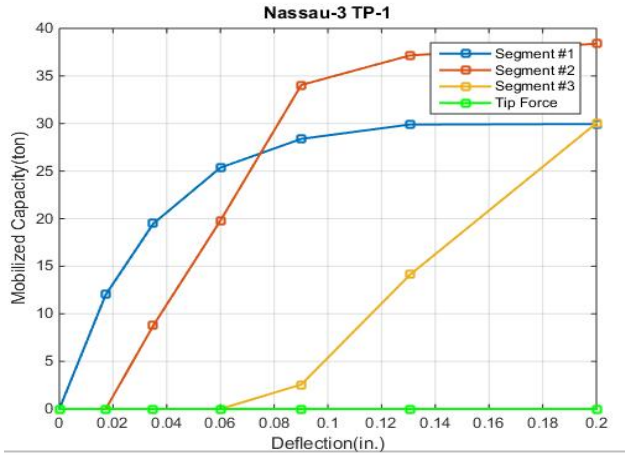


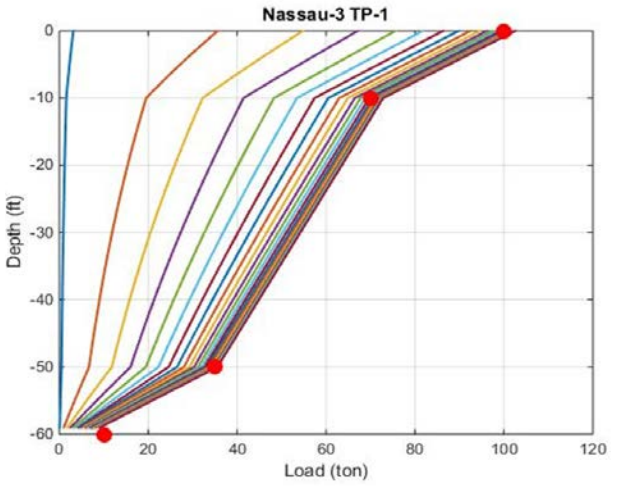


Assessment of Nominal Unit Resistance (Skin & Tip) From Load Tests









Measured Unit Skin Friction per Soil Layer

Location	Project Name	Soil Type	Diameter (in)	Embedded Length (ft)	Test Type	Water Table Depth (ft)	Instrumentation	Peak Displacement Load Test (in)	Segment #1 (tsf)	Elevation range (ft)	Segment #2 (tsf)	Elevation range (ft)	Segment #3 (tsf)	Elevation range (ft)
Alachua	Alachua-1 TP-2	Clay & IGM	16	64	Static	29	Load-Deflection	0.085	0.652	0~20	0.367	20~40	2.352	40~64
	Alachua-1 TP-3	Clay & IGM	16	64	Static	31	Load-Deflection	0.125	0.896	0~20	0.882	20~40	2.488	40~64
	Alachua-1 TP-4	Clay & IGM	16	64	Static	26	Load-Deflection	0.183	0.489	0~20	0.275	20~40	2.696	40~64
	Alachua-1 TP-5	Clay & IGM	16	64	Static	28	Load-Deflection	0.219	0.600	0~20	0.336	20~40	2.124	40~64
	Alachua-2 TP-1	Clay	14	42	Static	4.5	Load-Deflection	0.288	N/A		N/A		N/A	
	Alachua-2 TP-2	Clay	14	42	Static	5	Load-Deflection	0.325	0.461	0~15	1.609	15~30	1.496	30~42
	Alachua-2 TP-3	Clay	14	42	Static	6.5	Load-Deflection	0.295	0.555	0~15	1.498	15~30	1.493	30~42
	Alachua-2 TP-5	Clay	14	42	Static	5	T-Z & Load-Defl.	0.341	0.596	0~15	1.235	15~30	1.237	30~42
	Alachua-2 TP-XX-1	No Boring	14	42	Static	None	Load-Deflection	0.777	N/A		N/A		N/A	
	Alachua-2 TP-XX-2	No Boring	14	42	Static	None	Load-Deflection	0.460	N/A		N/A		N/A	
	Alachua-3 TP-1	Clay, Sand & IGM	14	15	Static	12	Load-Deflection	0.549	N/A		N/A		N/A	
	Alachua-5 TP-1	Sand & Clay	14	65	Static	6	T-Z & Load-Defl.	0.600	0.498	0~27	1.424	27~65		
	Alachua-5 TP-2	Sand & Clay	14	65	Static	6	T-Z & Load-Defl.	1.000	0.497	0~15	1.453	15~40	3.040	40~50
	Alachua-5 TP-3	Sand & Clay	14	65	Tension	6	T-Z & Load-Defl.	0.088						
Broward	Broward-1 TP-1	Sand & IGM	18	102	Static	5.7	T-Z & Load-Defl.	0.344	0.358	0~15	2.358	15~48	0.477	48~80
	Broward-1 TP-2	Sand & IGM	18	102	Tension	5.7	T-Z & Load-Defl.	0.009						
	Broward-1 TP-5	Sand & IGM	30	140	Osterberg	1	O-Cell	0.400	0.212	0~30	2.069	30~70	2.706	70~95
	Broward-2 TP-1	Sand & IGM	14	40	Static	None	Load-Deflection	0.350	0.331	0~10	0.536	10~32	4.633	32~40
Duval	Duval-1 TP 1-2	Sand, Marl & Clay	16	55	Static	4.5	Load-Deflection	0.289	0.341	0~30	3.197	30~45	0.967	45~55
	Duval-1 TP 2-2	Sand, Marl & Clay	16	54	Static	4.5	Load-Deflection	0.397	0.392	0~30	3.498	30~45	1.026	45~55
	Duval-1 TP 3-2	Sand, Marl & Clay	18	54	Tension	4.5	Load-Deflection	0.192						
	Duval-1 TP 3-3	Sand, Marl & Clay	16	54	Static	4.5	Load-Deflection	0.267	0.279	0~30	3.528	30~45	1.000	45~55
Hollywood	Hollywood-1 TP-1	No Boring	14	50	Static	No Boring	Load-Deflection	0.340	N/A		N/A		N/A	
	Hollywood-2 TP-1	No Boring	14	48	Static	No Boring	T-Z & Load-Defl.	0.200	N/A		N/A		N/A	
	Hollywood-2 TP-2	No Boring	14	48	Tension	No Boring	T-Z & Load-Defl.	0.032	N/A		N/A		N/A	
Hillsborough	Hillsborough-2 TP-1	No Boring	14	40	Static	None	Load-Deflection	0.079	N/A		N/A		N/A	
	Hillsborough-3 TP-1	Sand, and Clay	16	60	Static	5.2	Load-Deflection	0.548	0.543	0~43	0.570	43~55	4.650	55~60
	Hillsborough-3 TP-2	Sand, and Clay	16	60	Statnamic	5.2	T-Z & Load-Defl.	0.939	1.353	0~20	0.990	20~45	1.394	45~60
	Hillsborough-3 TP-3	Sand and Clay	16	60	Statnamic	5	T-Z & Load-Defl.	1.176	0.470	0~25	0.470	25~45	2.310	45~60
	Hillsborough-3 TP-4	Sand and Clay	16	60	Statnamic	5	T-Z & Load-Defl.	0.760	0.778	0~43	0.634	43~58	4.650	58~60
	Hillsborough-3 TP-5	Sand and Clay	16	69	Statnamic	4	T-Z & Load-Defl.	0.653	0.731	0~30	0.467	30~50	3.415	50~69
Nassau	Nassau-1 TP14	Sand	14	60	Static	3.8	T-Z & Load-Defl.	0.385	0.499	0~10	1.377	10~50	1.309	50~60
	Nassau-2 TP-1	Sand	16	39	Static	3	Load-Deflection	0.300	N/A		N/A		N/A	
	Nassua-3 TP-1	Sand	14	65	Static	5	T-Z & Load-Defl.	0.200	0.835	0~10	0.268	10~50	0.838	50~60
Palm Beach	Palm Beach-1 TP-9	No Boring	16	61	Static	None	T-Z & Load-Defl.	0.113	N/A		N/A		N/A	
	Palm Beach-2 TP-8	No Boring	16	61	Static	None	T-Z & Load-Defl.	0.188	N/A		N/A		N/A	
Polk	Polk-1	Clay, Silt & Sand	18	65	Static	8.5	Load-Deflection	0.360	N/A		N/A		N/A	
Santa Rosa	Santa Rosa-1 TP-1	Sand, Cayey Sand	24	47	Static	2.5	CPT Data	0.465	N/A		0.830	0~29	0.185	29~44
West Palm	West Palm-1 T2B	Sand	14	40	Tension	9	Load-Deflection	0.250						
	West Palm-1 T8	Sand	14	40	Tension	9	Load-Deflection	0.250						
	West Palm-1 T9B	Sand	14	40	Static	9	Load-Deflection	0.536	0.310	0~10	0.471	10~30	0.494	30~40

Measured Unit Skin Friction per Soil Layer

Location	Project Name	Soil Type	Diameter (in)	Embedded Length (ft)	Test Type	Water Table Depth (ft)	Instrumentation	Peak Displacement Load Test (in)	Segment #1	Elevation range	Segment #2	Elevation range	Segment #3	Elevation range
Miami Dade	Miami Dade-1 TP-1	IGM, Sand & FT Limestone	16	43	Static	5	Load-Deflection	0.343	2.100	0~18	0.441	18~35	3.910	35~43
	Miami Dade-1 TP-2	Sand & IGM	16	43	Tension	5	Load-Deflection	0.208						
	Miami Dade-5 TP-1	Sand & IGM	14	30	Static	(+) 2.5	Load-Deflection	0.148	N/A		N/A		N/A	
	Miami Dade-5 TP-2	Sand & IGM	14	30	Tension	(+) 2.5	Load-Deflection	0.270						
	Miami Dade-6 TP-1	IGM & Sand	14	25	Static	Not measured	Load-Deflection	0.183	6.425	5~14	1.500	14~25	N/A	
	Miami Dade-6 TP-2	IGM & Sand	14	40	Static	8	Load-Deflection	0.182	3.153	0~20	0.994	20~40	N/A	
	Miami Dade-6 TP-3	IGM & Sand	14	40	Static	8	Load-Deflection	0.303					N/A	
	Miami Dade-6 TP-5	IGM & Sand	14	40	Static	8	Load-Deflection	0.090	5.380	2~16	0.588	16~40	N/A	
	Miami Dade-6 TP-6	IGM, Sand & FT Limestone	14	40	Static	4	Load-Deflection	0.206	1.737	2~24	0.100	24~35	4.024	35~40
	Miami Dade-6 TP-7	IGM & Sand	14	40	Static	Not measured	Load-Deflection	0.060	N/A		N/A		N/A	
	Miami Dade-6 TP-8	IGM & Sand	14	40	Static	Not measured	Load-Deflection	0.093	N/A		N/A		N/A	
	Miami Dade-6 TP-9	IGM & Sand	14	40	Static	Not measured	Load-Deflection	0.142	3.005	1~24	0.478	24~40	N/A	
	Miami Dade-6 TP-10	IGM & Sand	14	40	Static	Not measured	Load-Deflection	0.572	3.431	5~22	0.404	22~40	N/A	
	Miami Dade-6 TP-11	IGM & Sand	14	23	Static	5.5	Load-Deflection	0.073	3.759	1~8	0.907	8~23	N/A	
	Miami Dade-6 TP-12	IGM & Sand	14	23	Static	5.5	Load-Deflection	0.346	N/A		N/A		N/A	
	Miami Dade-6 TP-13	IGM, Sand & FT Limestone	14	50	Static	Not measured	Load-Deflection	0.072	1.899	1~25	0.504	25~40	4.318	40~50
	Miami Dade-6 TP-14	IGM & Sand	14	58	Static	8	Load-Deflection	0.182	3.009	5~16	0.392	16~58	N/A	
	Miami Dade-6 TP-15	IGM & Sand	14	45	Static	7.5	Load-Deflection	0.119	3.199	3~11	0.616	11~45	N/A	
	Miami Dade-6 TP-16	IGM & Sand	14	25	Static	5.5	Load-Deflection	0.115	3.658	5~14	0.853	14~25	N/A	
	Miami Dade-6 TP-17	IGM & Sand	14	25	Static	5.5	Load-Deflection	0.135	3.315	4~21	0.159	21~25	N/A	
	Miami Dade-6 TP-18	Sand & IGM	14	20	Static	4	Load-Deflection	0.115	1.474	1~8	5.782	8~19	N/A	
	Miami Dade-6 TP-19	IGM, Sand & FT Limestone	14	55	Static	8	Load-Deflection	0.192	3.420	1~9	0.777	9~40	6.176	40~50
	Miami Dade-6 TP-20	IGM & Sand	14	30	Static	9	Load-Deflection	0.091	3.860	1~26	0.583	26~30	N/A	
	Miami Dade-6 TP-21	IGM & Sand	14	46	Static	12	Load-Deflection	0.110	3.008	4~17	0.612	17~46	N/A	
	Miami Dade-6 TP-22	IGM & Sand	14	41	Static	12	Load-Deflection	0.058	N/A		N/A		N/A	
	Miami Dade-6 TP-23	Sand	14	58.5	Static	10.5	Load-Deflection	0.560	0.275	0~58.5	N/A		N/A	
	Miami Dade-6 TP-24	IGM & Sand	14	47	Static	4	Load-Deflection	0.182	3.044	1~20	0.651	20~47	N/A	
	Miami Dade-6 TP-25	IGM & Sand	14	56	Static	10	Load-Deflection	0.095	N/A		N/A		N/A	
	Miami Dade-6 TP-26	IGM, Sand & FT Limestone	14	57	Static	10	Load-Deflection	0.296	2.755	20~32			4.634	32~57
	Miami Dade-6 TP-27	IGM, Sand & FT Limestone	14	47	Static	11	Load-Deflection	0.053	2.072	1~10	0.152	10~22	4.423	22~47
	Miami Dade-6 TP-28	IGM, Sand & FT Limestone	14	65	Static	8	Load-Deflection	0.408	1.564	1~9			7.230	60~65
	Miami Dade-6 TP-29	IGM, Sand & FT Limestone	14	56	Static	9	Load-Deflection	0.107	2.930	0~18	0.916	24~46	4.872	46~56
	Miami Dade-6 TP-30	IGM, Sand & FT Limestone	14	56	Static	9	Load-Deflection	0.107	3.490	1~15	0.659	15~45	4.248	45~56
	Miami Dade-6 TP-31	No Boring	14	44	Static	None	Load-Deflection	0.432	2.026	1~12	0.137	12~30	4.332	30~40
	Miami Dade-7 TP-1	Sand & IGM	18	41	Static	4	Load-Deflection	0.064	N/A		N/A		N/A	
	Miami Dade-7 TP-2	Sand & IGM	18	41	Static	4	Load-Deflection	0.069	N/A		N/A		N/A	
	Miami Dade-8 TP-1	Sand & IGM	14	52	Static	1	Load-Deflection	0.300	N/A		N/A		N/A	
				Total # of Test Piles		Total T-Z Curve	16							

Design Methods for Auger Cast in Place (ACIP) Piles using Lab Data

Examples of Design in Florida Limestone:

Authors	Design Methodology	Note	Comment
FDOT (1998)	Unit Skin Friction: $f_s = \frac{1}{2} \cdot \sqrt{q_u} \cdot \sqrt{q_t} \cdot REC$ (ksf)	$\boldsymbol{q_u}$= unconfined compressive strength (tsf); $\boldsymbol{q_t}$= split tensile strength (tsf); $\boldsymbol{REC}$ = average recovery of rock core.	Florida Limestone
Rodrigo−q_u (FDOT)	$f_s = C\sqrt{q_u(ksf)}\ x\ REC$ (ksf)	$\boldsymbol{q_t}$= split tensile strength (tsf); $\boldsymbol{REC}$ = average recovery of rock core. C = Correction factor	Florida Limestone
Ramos et al. (1994)	Unit Skin Friction: for $q_u \leq 1800\ kPa\ (36\ ksf)$ $f_s = 0.5 \cdot q_u$ (kPa or ksf) $f_s = 0.35 \cdot q_u$ (kPa or ksf)(lower bound) for $q_u > 1800\ kPa\ (36\ ksf)$ $f_s = 0.12 \cdot q_u$ (kPa or ksf)	q_u= unconfined compressive strength (kPa or ksf);	

Design Methods for Auger Cast in Place (ACIP) Piles using Lab Data

Examples of Design in Florida Limestone:

Authors	Design Methodology	Note	Comment
Horvath and Kenney (1979)	Unit Skin Friction: $f_s = 0.67 \cdot \sqrt{q_u}$ (tsf)	q_u= unconfined compressive strength (tsf).	
Williams et al. (1980)	Unit Skin Friction: $f_s = 1.842 \cdot q_u^{0.367}$ (tsf)	q_u= unconfined compressive strength (tsf).	
Reynolds and Kaderabek (1980)	Unit Skin Friction: $f_s = 0.3 \cdot q_u$ (tsf)	q_u= unconfined compressive strength (tsf).	Miami Limestone
Gupton and Logan (1984)	Unit Skin Friction: $f_s = 0.2 \cdot q_u$ (tsf)	q_u= unconfined compressive strength (tsf).	Key Large, Anastasia, Fort Thompson and Miami limestone formations

Design Methods for Auger Cast in Place (ACIP) Piles using Lab Data

Examples of Design in Florida Limestone:

Authors	Design Methodology	Note	Comment
Reese and O'Neill (1987)	Unit Skin Friction: $f_s = 0.15 \cdot q_u$ (tsf)	q_u= unconfined compressive strength (tsf).	
Rowe and Armitage (1987)	Unit Skin Friction: $f_s = 1.45 \cdot \sqrt{q_u}$ (tsf) (clean sockets) $f_s = 1.94 \cdot \sqrt{q_u}$ (tsf) (rough sockets)	q_u= unconfined compressive strength (tsf).	
Carter and Kulhawy (1988)	Unit Skin Friction: $f_s = 0.63 \cdot \sqrt{q_u}$ (tsf)	q_u= unconfined compressive strength (tsf).	

Design Methods for Auger Cast in Place (ACIP) Piles using In-situ data

Examples of Design in Florida Limestone:

Authors	Design Methodology	Note	Comment
Rodrigo-q_u (FDOT)	Unit Skin Friction: $f_s = C\left(\frac{N_{60}}{25}\right)^2$	N_{60} = SPT-*N* value at 60% of hammer efficiency (blows/ foot). C = Correction factor	Florida Limestone
Ramos et al. (1994)	Unit Skin Friction: for 5 ≤ N ≤ 60 blows/0.3 m (blows/ft) $f_s = 19.2 \cdot N + 192$ (kPa) $f_s = 0.4 \cdot N + 4$ (ksf) for N > 60 blows/0.3 m (blows/ft) $f_s = 9..6 \cdot N + 768$ (kPa) $f_s = 0.2 \cdot N + 16$ (ksf)	N = SPT value (blows/ 0.3 meter or blows/ft).	

Design Methods for Auger Cast in Place (ACIP) Piles using In-situ Data

Examples of Design in Florida Limestone:

Authors	Design Methodology	Note	Comment
Frizzi & Meyer (2000)	Unit Skin Friction: $f_s = 0.35 \cdot N_{60} - 1.5$ (tsf) (1) $f_s = 0.14 \cdot N_{60} + 1$ (tsf) (2)	$\mathbf{N_{60}}$ = SPT-*N* value at 60% of hammer efficiency (blows/ foot).	(1) Miami limestone formation; (2) Ft. Thompson limestone formation.
Crapps (IGM)	Unit Skin Friction: $f_s = \sigma_v' \cdot \left[e^{0.0646(N-13.6)}\right]$(ksf)	σ_v'= vertical effective stress (ksf) *N*= blow count (blows/ft).	

Design Methods for Auger Cast in Place (ACIP) Piles using In-situ Data

Examples of Design in Florida Cohesionless Soils:

Authors	Design Methodology	Note	Comment
FHWA 1999 (O'Neill and Reese,1999)	Unit Skin Friction: $f_s = \beta \cdot \sigma_v' < 2.0$ tsf $\beta = 1.5 - 0.135 \cdot Z^{0.5}$ N ≥ 15 $\beta = \frac{N_{60}}{15}(1.5 - 0.135 \cdot Z^{0.5})$ N < 15	σ_v' = vertical effective stress; β = friction factor; Z = depth in feet; N_{60}= SPT-N value at 60% of hammer efficiency; N = SPT value at the tip of the pile.	Cohesionless Soils (Sands & Silts)
Zelada and Stephenson (2000)	Unit Skin Friction: $f_s = \beta \cdot \sigma_v' < 1.6$ tsf $\beta = 1.2 - 0.11 \cdot Z^{0.5}$ N ≥ 15 $\beta = \frac{N_{60}}{15}(1.2 - 0.11 \cdot Z^{0.5})$ N < 15	σ_v' = vertical effective stress; β = friction factor; Z = depth in feet; N_{60}= SPT-N value at 60% of hammer efficiency; N = SPT value at the tip of the pile.	Cohesionless Soils (Sands & Silts)

Design Methods for Auger Cast in Place (ACIP) Piles

Examples of Design in Florida Cohesive Soils:

Authors	Design Methodology	Note	Comment
FHWA 1999 (O'Neill and Reese,1999)	Unit Skin Friction: $f_s = \propto \cdot S_u$ $\propto = 0.55\ for \frac{Su}{Pa} \leq 1.5$ $\propto = 0.55\ to\ 0.45\ for 1.5 \leq \frac{Su}{Pa} \leq 2.5$	S_u = undrained shear strength of the soil at the pile segment location; $\propto$ = reduction factor; P_a = standard atmospheric pressure.	Cohesive Soils

- Several design methods for cohesive soils use CPT data
- Santa Rosa site provided only source of CPT data

Geological Profile of Miami Stratigraphy

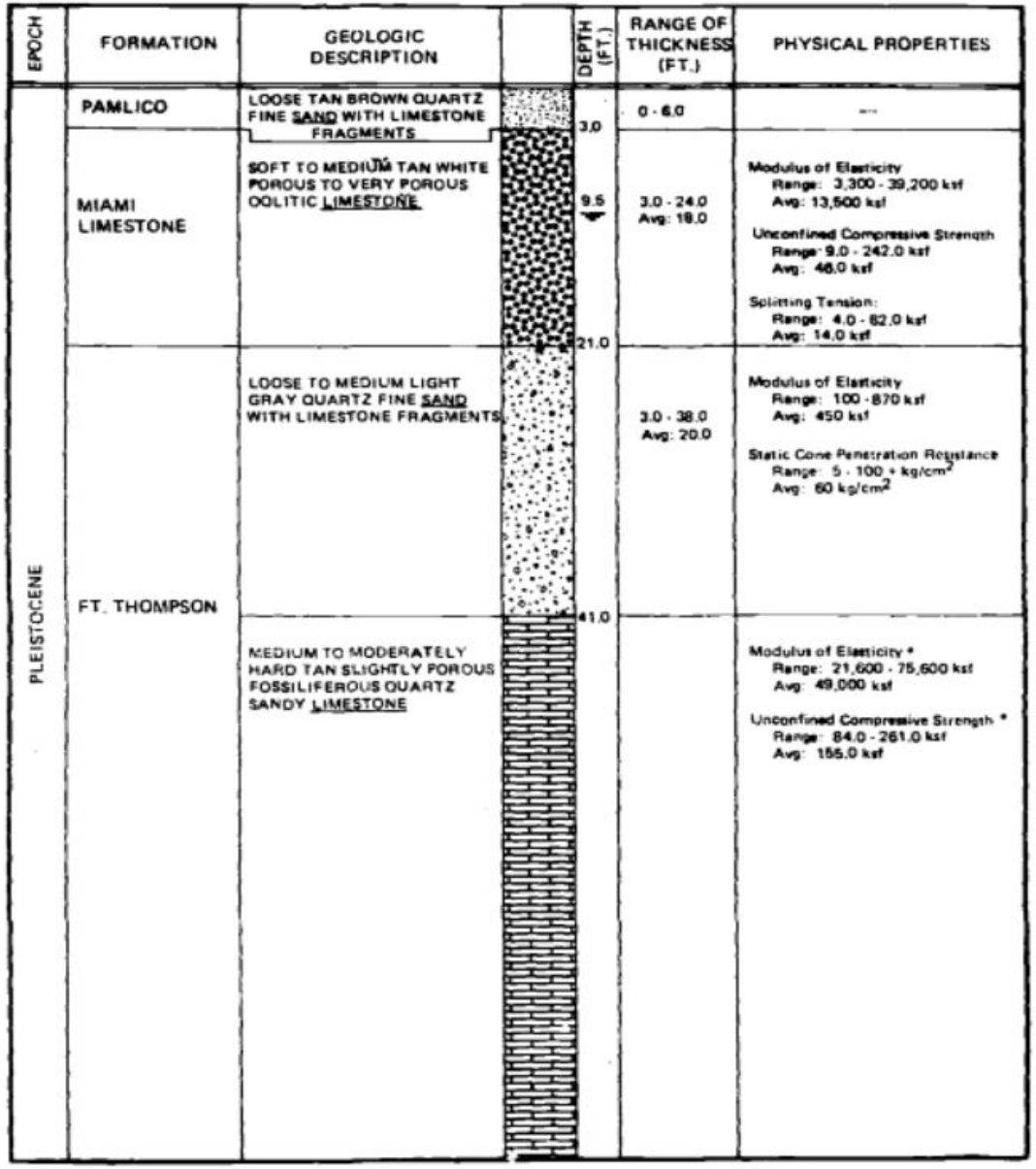
Prieto, 1981

Miami Limestone:

- Unconfined compressive strength
  - Range: 9 - 242 ksf
  - Avg: 46 ksf
- Split Tension
  - Range: 4 - 62 ksf
  - Avg: 14 ksf

Fort Thompson:

- Unconfined compressive strength
  - Range: 84 - 261 ksf
  - Avg: 155 ksf



Miami Limestone and Fort Thompson Unit Weight

Prieto, 1981

Miami Limestone:

- Unit Weight:
- Range: 60 - 115 pcf

Fort Thompson:

- Unit Weight:
- Range: 78 - 130 pcf

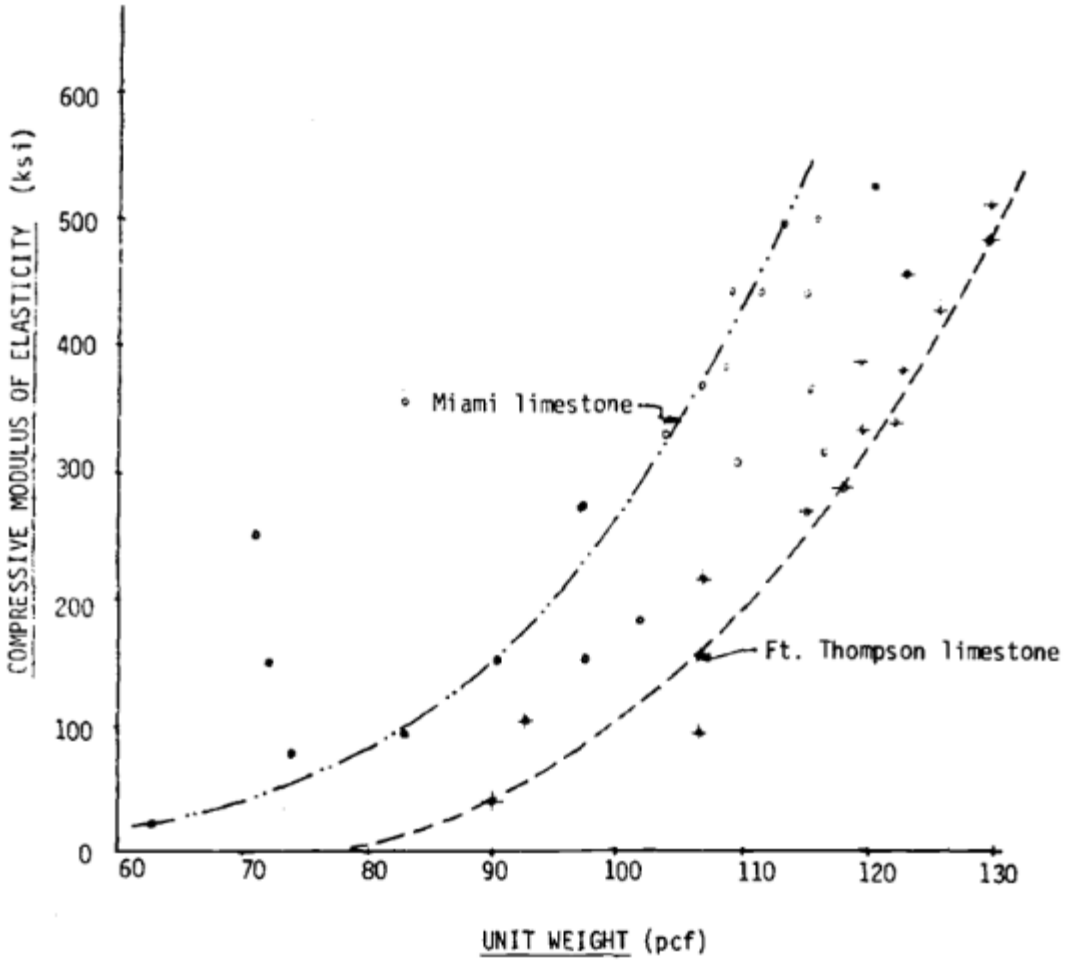
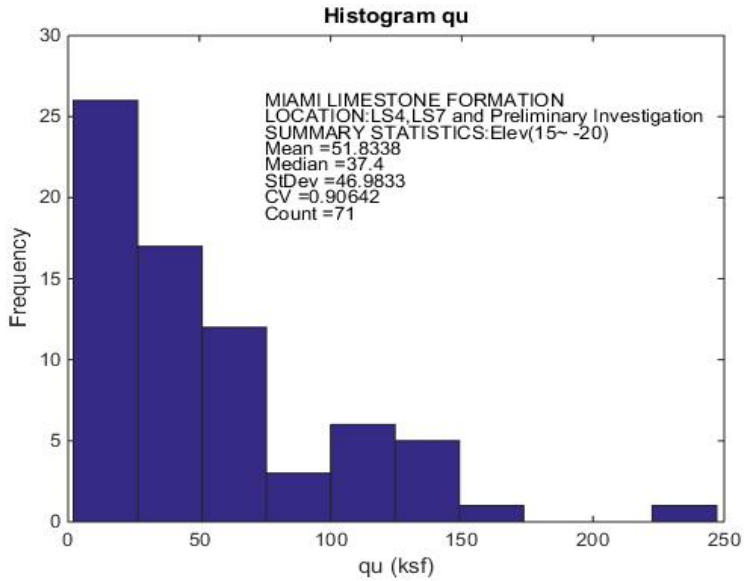
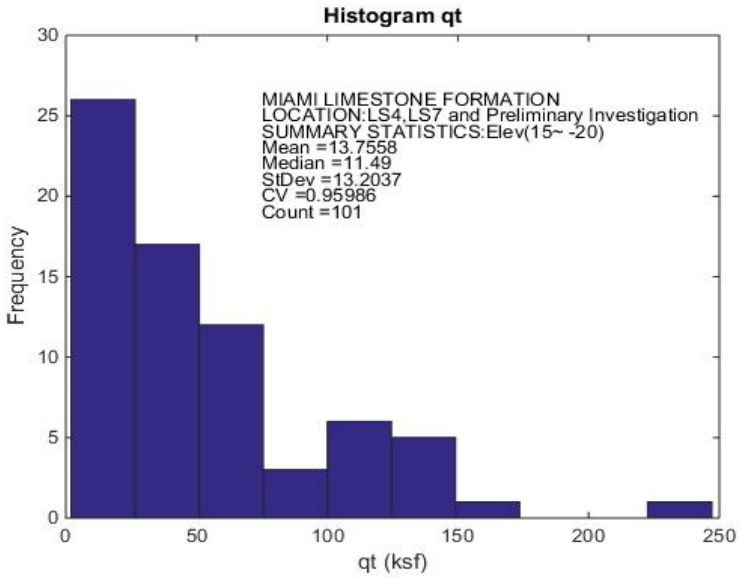


FIG. 19—*Correlation of compressive modulus of elasticity versus dry unit weights of Miami and Fort Thompson oolitic limestones.*

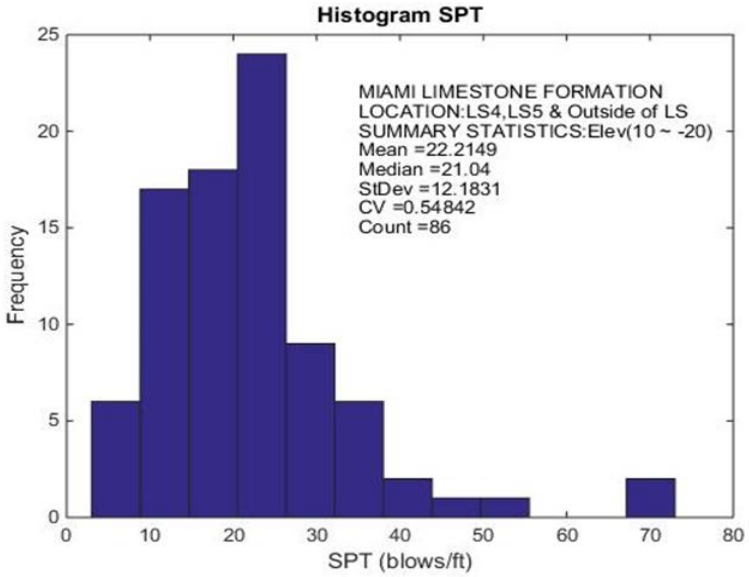
Mean Site Values of In Situ and Laboratory Data



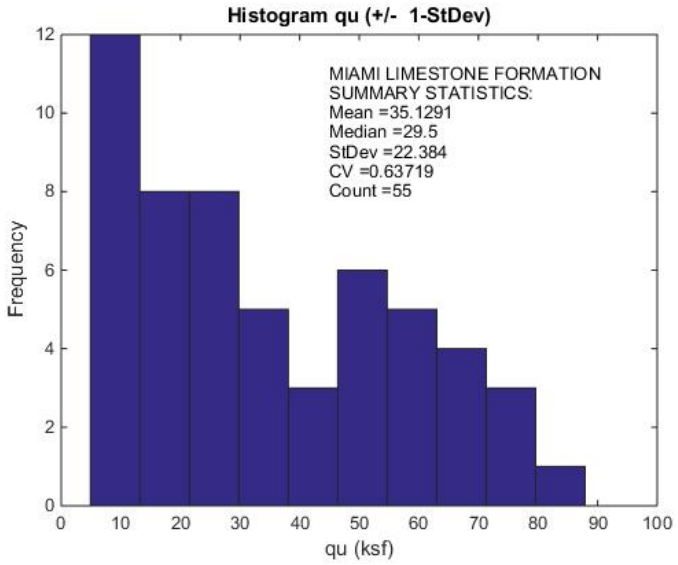


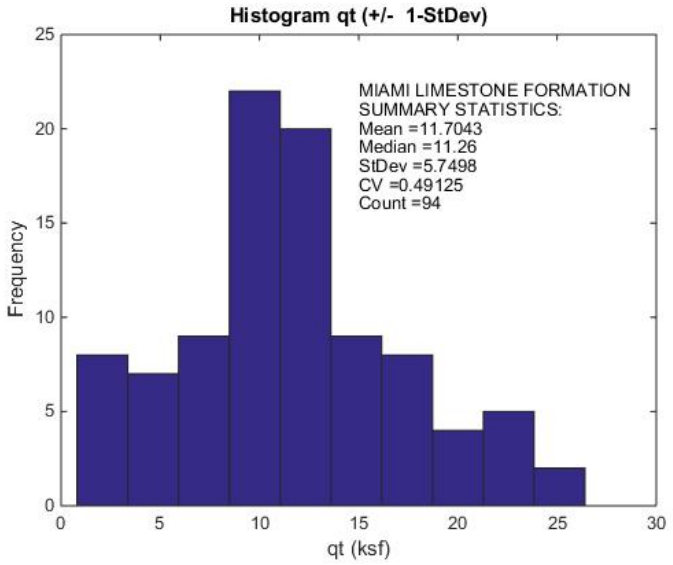
Miami Limestone

- Correlate q_u & SPT to unit weight
- Estimate unit weight
- Range of unit weights – Prieto, 1981

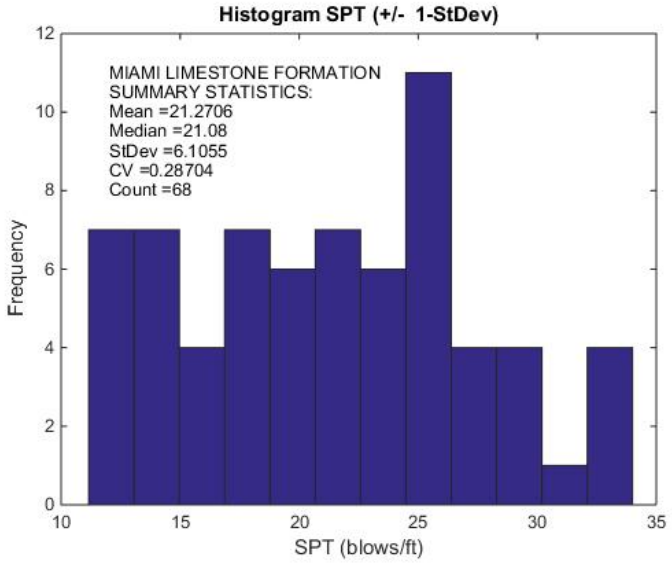


Mean Site Values ± 1-StDev of In Situ and Laboratory Data

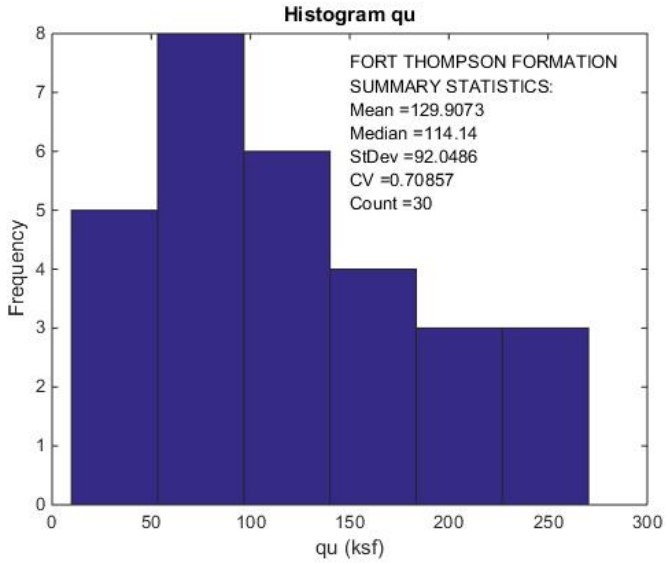


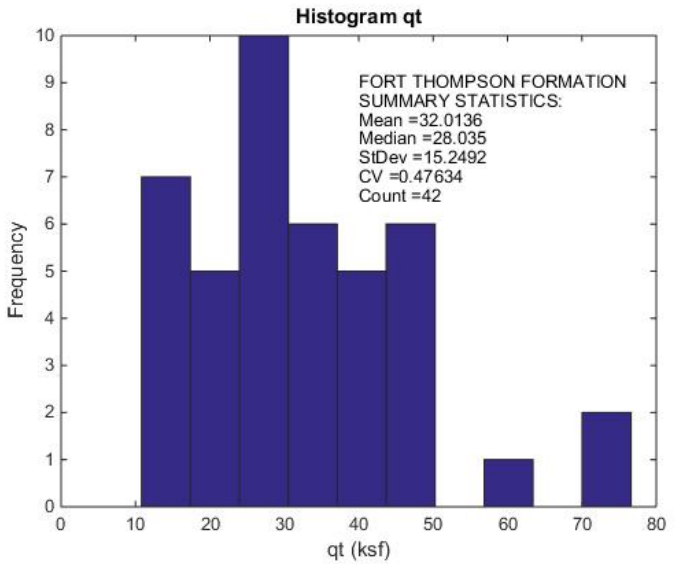


Miami Limestone
Site Mean ± 1-StDev



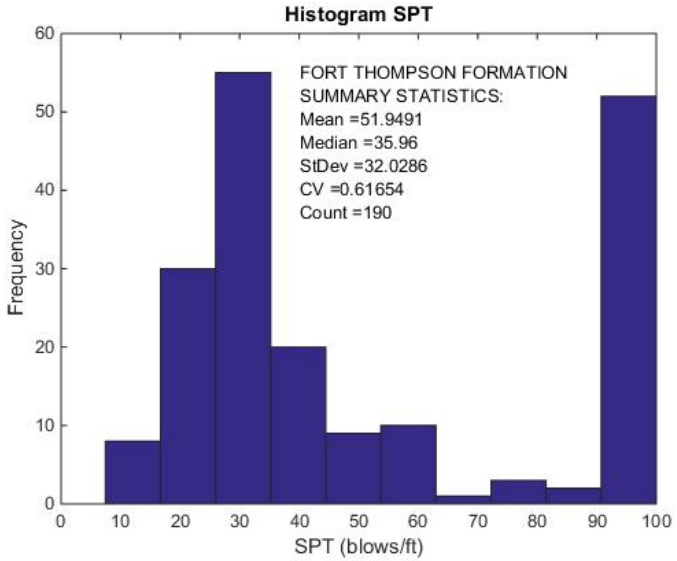
Mean Site Values of In Situ and Laboratory Data





Fort Thompson Limestone

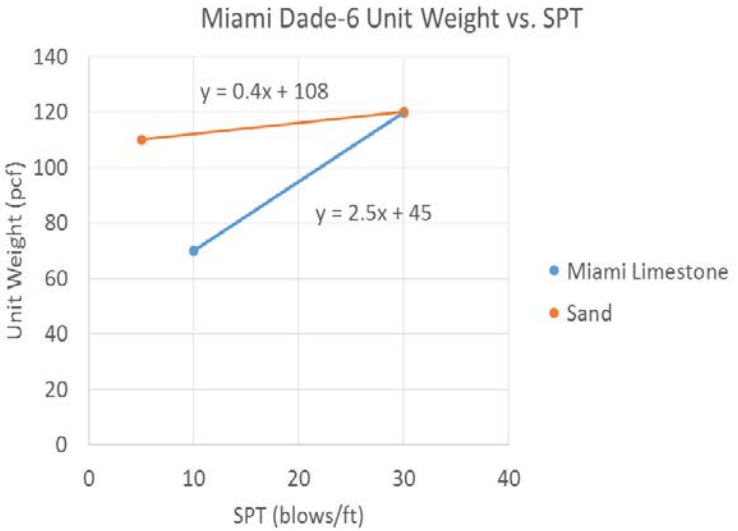
SPT refusal is determined by interval calculation
E.g. 50/4 = 150 => 100 (blows/ft)



Correlate Unit Weight to SPT to Calculate Vertical Stresses

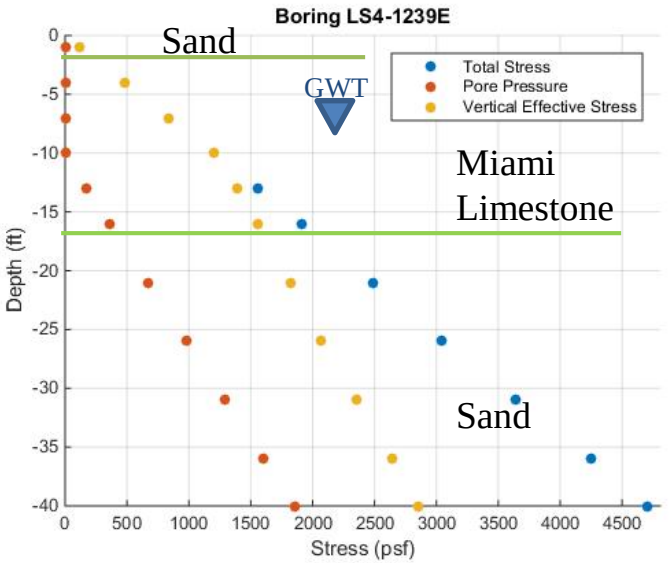
Cohesionless Soil

- Correlate SPT to unit weight
- All site borings are used to estimate unit weights
- Range of unit weights – AMEC, GeoSol, etc
- GWT from boring – site mean if not provided
- Calculate vertical stresses for each boring

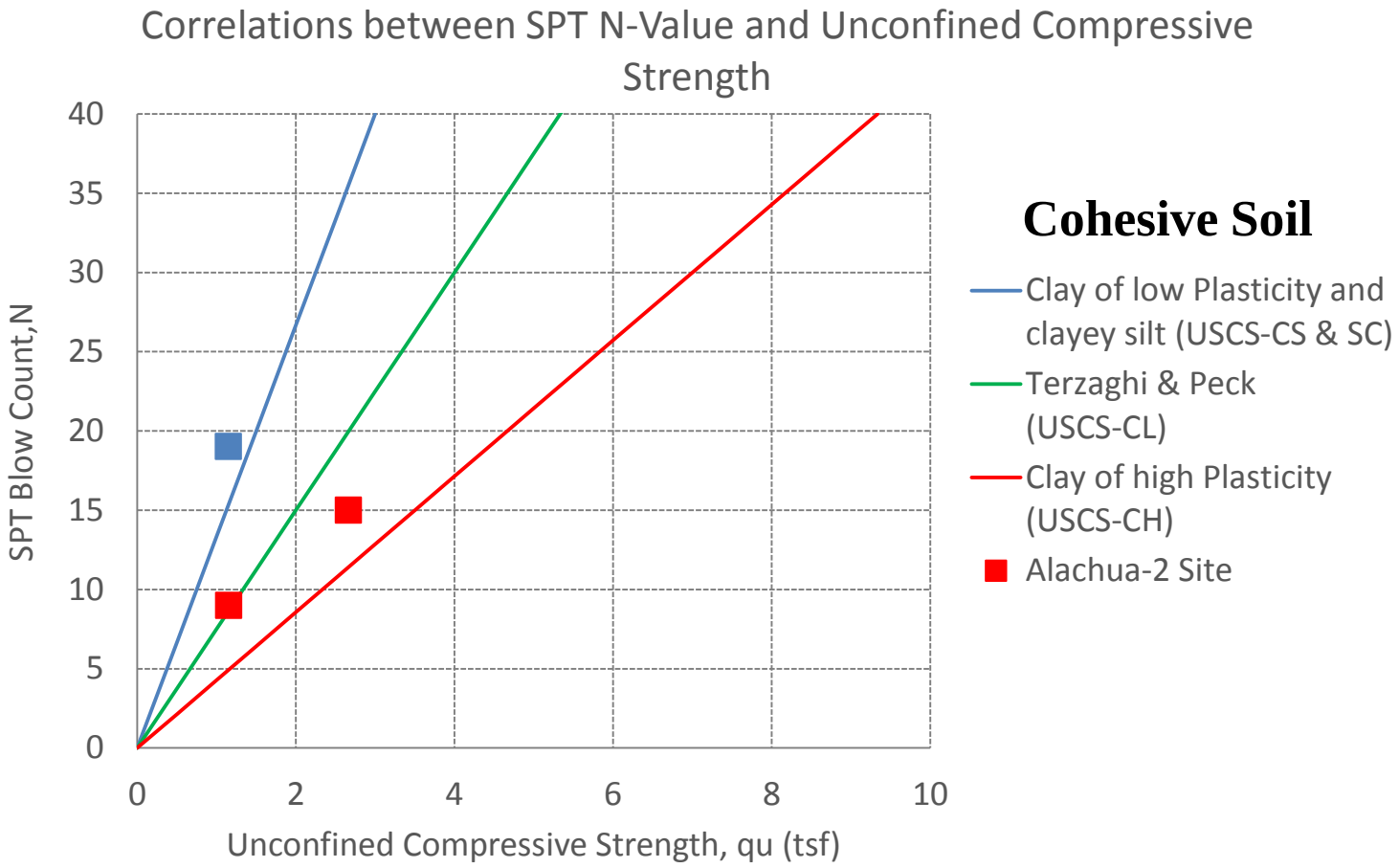


Miami-Dade-6

- Boring LS4-1239 E
- Total Stress
- Pore Pressure
- Vertical Effective Stress

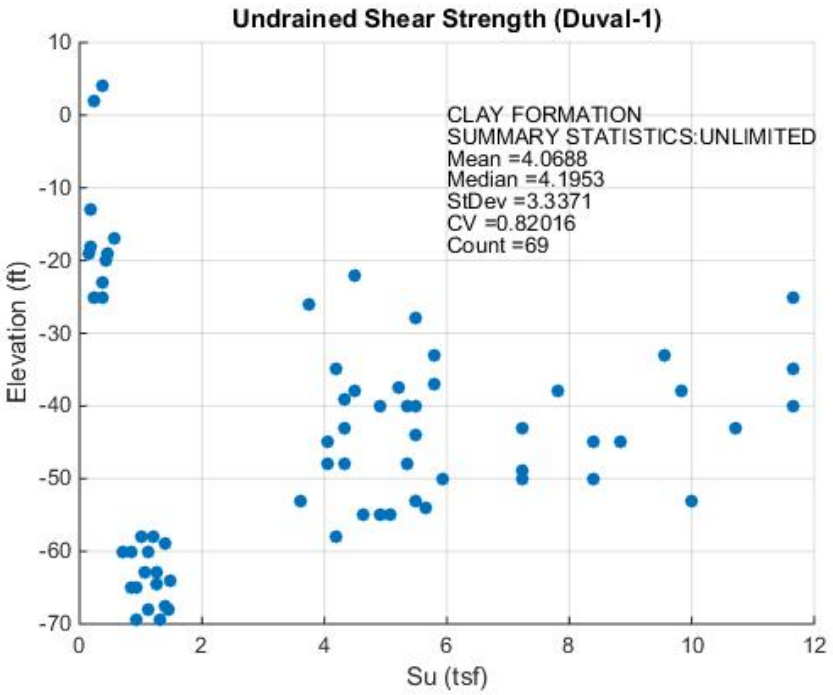


FB-MultiPier Method to Correlate SPT-N to Unconfined Compressive Strength

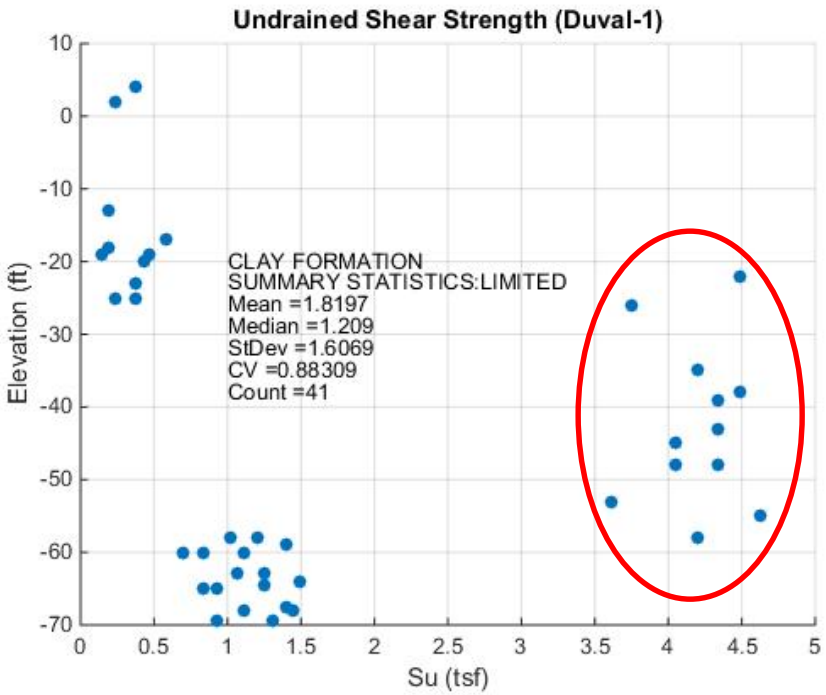


Limitations of SPT-N values in Cohesive Soils

Unlimited SPT



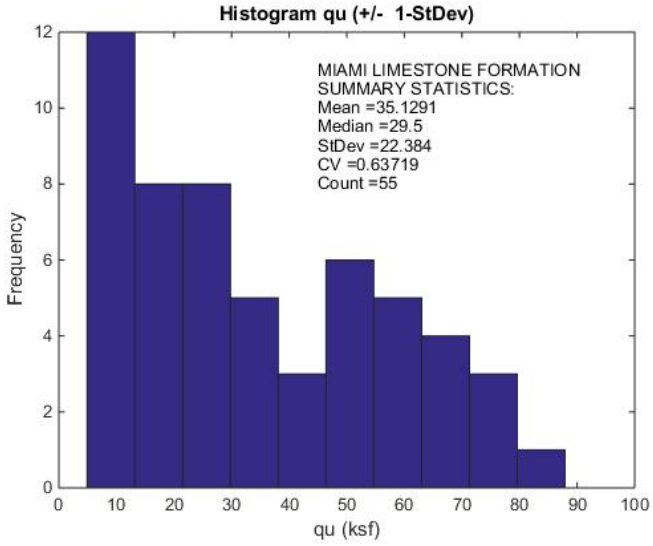
Limited SPT (40 blows/ft)

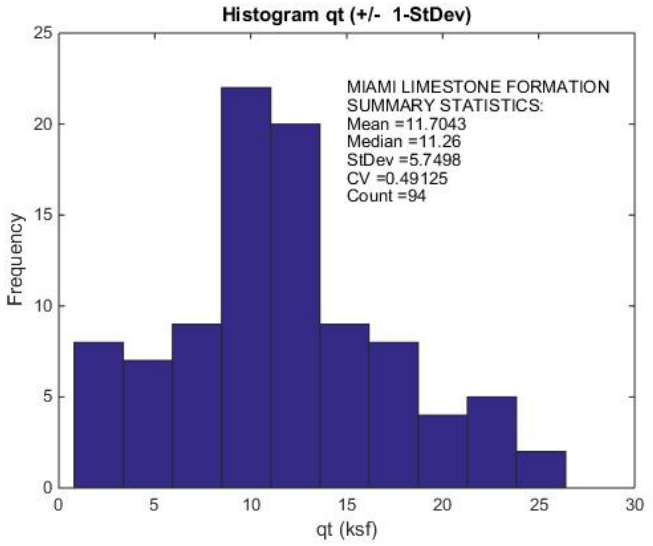


SPT-N limited to 40 blows/ft - (qu = 9.33 tsf from chart)

$$S_u = \frac{q_u}{2} = 4.665\ tsf$$

Measured vs. Predicted Miami Limestone

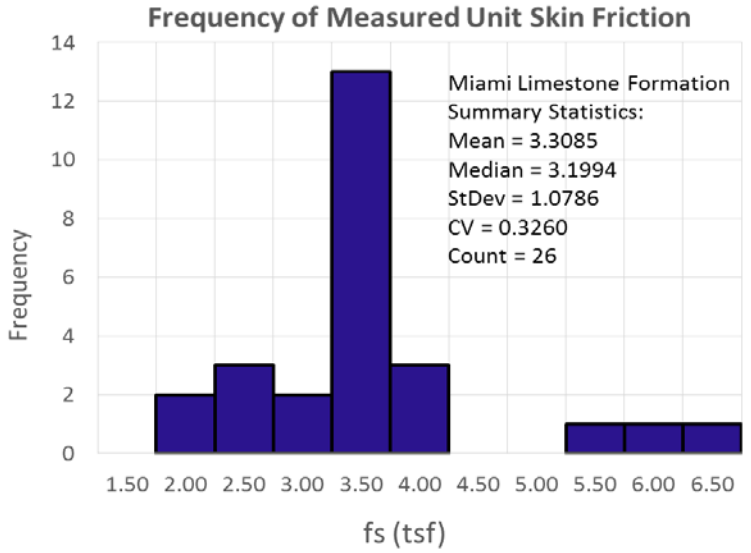


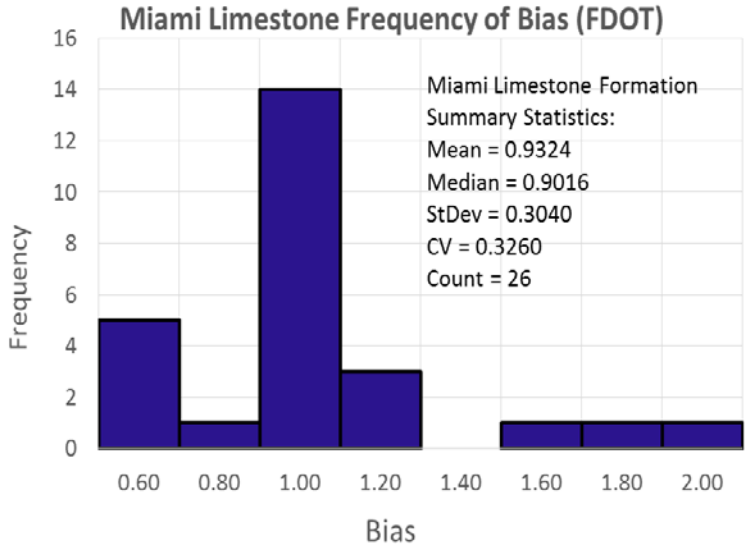


$$f_s = \frac{1}{2} \cdot \sqrt{q_u} \cdot \sqrt{q_t} \cdot REC \text{ (tsf)}$$

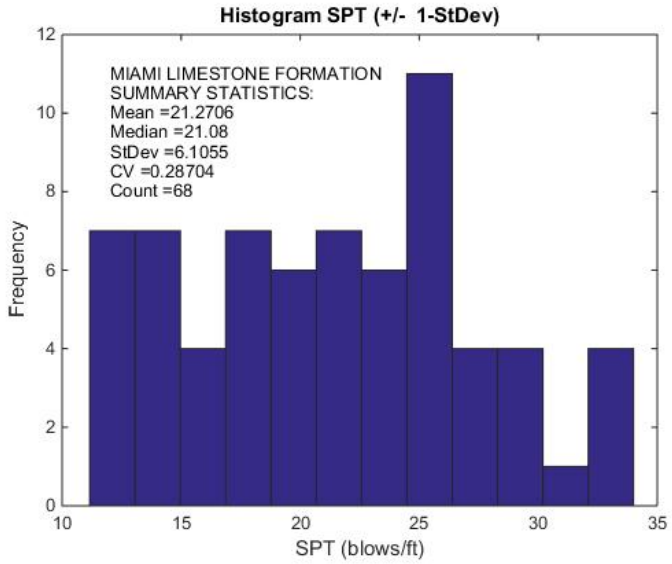
$$f_s = 3.55\ tsf$$

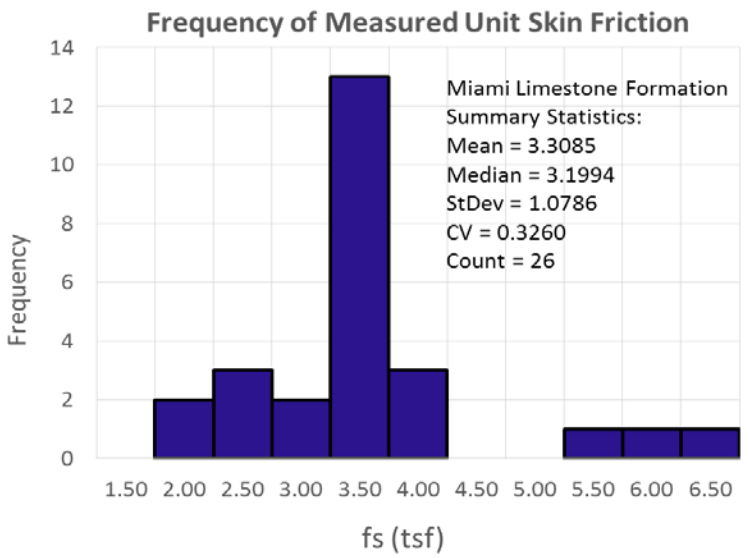
$$Bias = \frac{Measured}{Predicted}$$





Measured vs. Predicted Miami Limestone

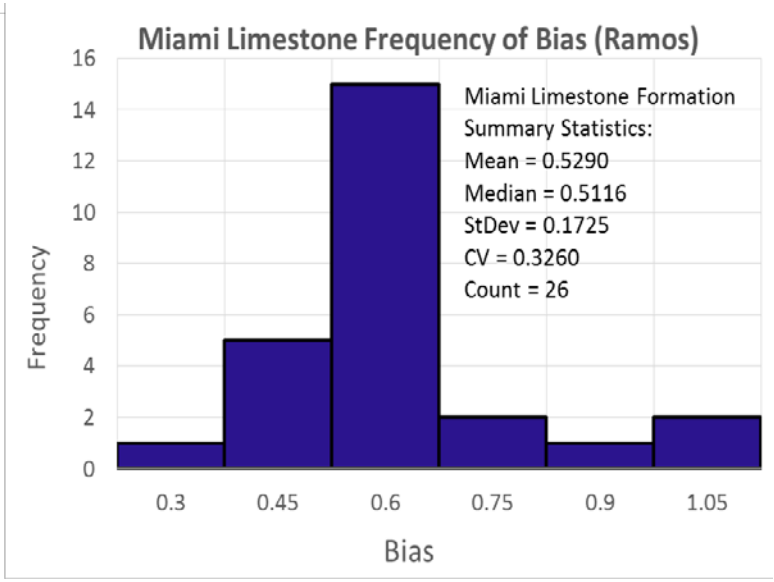




Frizzi and Meyer (2000) Method:

$$f_s = 0.35 \cdot 21.27 - 1.5 = 5.94 \text{ tsf}$$

$$Bias = \frac{Measured}{Predicted}$$

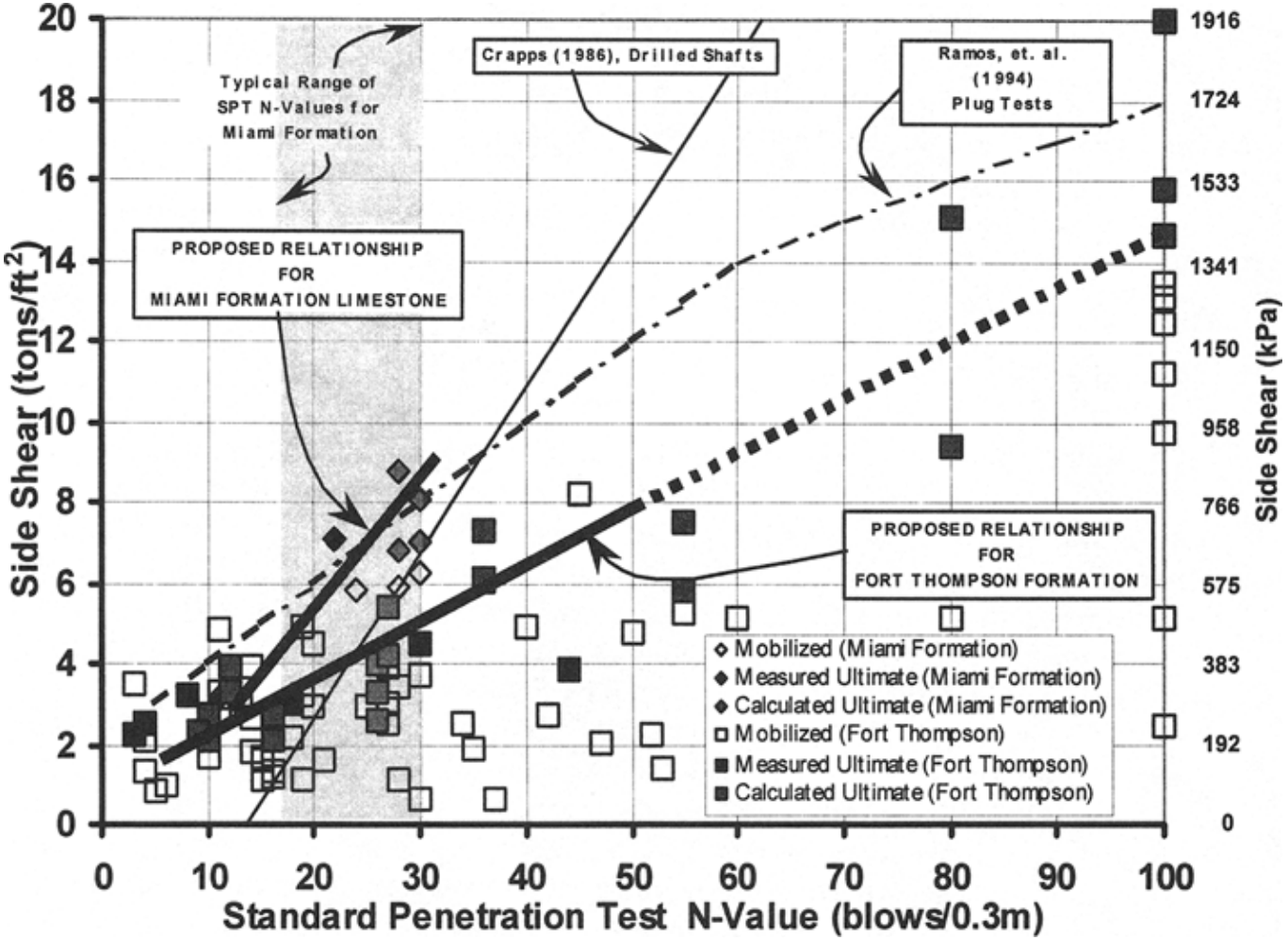


Frizzi and Meyer Unit Side friction to SPT Correlation

UF Measured:
SPT and f_s Range

Miami Limestone:
f_s – Range 2.0 – 6.5 tsf
SPT– Range 15 – 35

Fort Thompson:
f_s – Range 4.0 – 7.5 tsf
SPT– Range 20 – 75



Predicted Unit Skin friction and Measured Bias

Design Method (q_u & q_t)	Predicted Unit Skin Friction and Measured Bias (Miami Limestone Formation)				Predicted Unit Skin Friction and Measured Bias (Fort Thompson Formation)			
	Mean-qu (ksf)	51.85	Mean-qu (ksf) (+/-) 1-StDev	35.13	Mean-qu (ksf)	129.91*	Mean-qu (ksf) (+/-) 1-StDev	114.77*
	Mean-qt (ksf)	13.75	Mean-qt (ksf) (+/-) 1-StDev	11.70	Mean-qt (ksf)	32.01	Mean-qt (ksf) (+/-) 1-StDev	31.65
	fs (tsf)	Mean Bias	fs (tsf)	Mean Bias	fs (tsf)	Mean Bias	fs (tsf)	Mean Bias
Rodrigo_qu (C=1.572)	N/A	N/A	3.2610	1.0000	N/A	N/A	N/A	N/A
FDOT	N/A	N/A	3.5485	0.9324	N/A	N/A	6.0275	0.8245
Horvath and Kenney (1979)	3.4109	0.9700	2.8080	1.1782	5.3998	0.9204	5.0755	0.9792
Williams et al. (1980)	6.0824	0.5439	5.2732	0.6274	8.5215	0.5832	8.14278	0.6103
Reynolds and Kaderabek (1980)	7.7751	0.4255	5.2694	0.6279	19.4861	0.2550	17.2157	0.2887
Gupton and Logan (1984)	5.1834	0.6383	3.5129	0.9418	12.9907	0.3826	11.4771	0.433
Reese and O'Neill (1987)	3.8875	0.8511	2.6347	1.2557	9.743	0.5101	8.6078	0.5774
Rowe and Armitage (1987)	7.3818	0.4482	6.0770	0.5444	11.6861	0.4253	10.9842	0.4525
Carter and Kulhawy (1988)	3.2072	1.0316	2.6403	1.2531	5.0774	0.9788	4.7725	1.0413
Ramos et al. (1994)	3.11	1.0638	8.7823	0.3767	7.7944	0.6376	6.8863	0.7217
Kulhawy et al. (2005)	5.2367	0.6318	4.3111	0.7674	8.2903	0.5995	7.7923	0.6378
Design Method (SPT-N)	Mean-SPT (blows/ft)	22.21	Mean-SPT (blows/ft) (+/-) 1-StDev	21.27	Mean-SPT (blows/ft)	51.95	Mean-SPT (blows/ft) (+/-) 1-StDev	35.54
	fs (tsf)	Mean Bias	fs (tsf)	Mean Bias	fs (tsf)	Mean Bias	fs (tsf)	Mean Bias
Rodrigo_SPT (C=9.0)	N/A	N/A	3.2610	1.0000	N/A	N/A	N/A	N/A
Frizzi & Meyer (2000)	6.2752	0.5272	5.9447	0.5565	8.2729	0.6007	5.9756	0.8317
Ramos et al. (1994)-SPT (Blows/ft)	6.443	0.5135	6.2541	0.529	12.3898	0.4011	9.108	0.5456
Crapps (IGM)	1.7795	1.8592	1.6742	1.9761	19.8296	0.2506	6.8698	0.7234
*ACIP piles considered IGM with q_u between 10 ksf and 100 ksf.								

Measured vs. Predicted Miami-Dade-6 Cohesionless Soils

Cohesionless Soils: Zelda & Stephenson

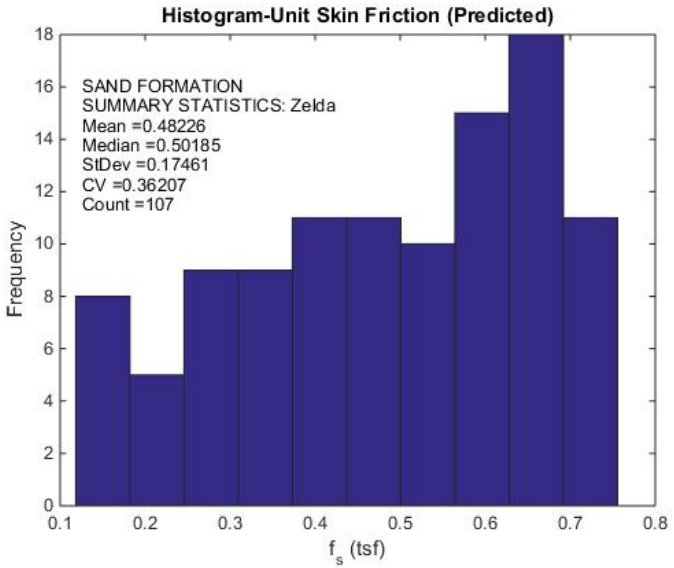
$$f_s = \beta \cdot \sigma'_v < 1.6 \text{ tsf}$$

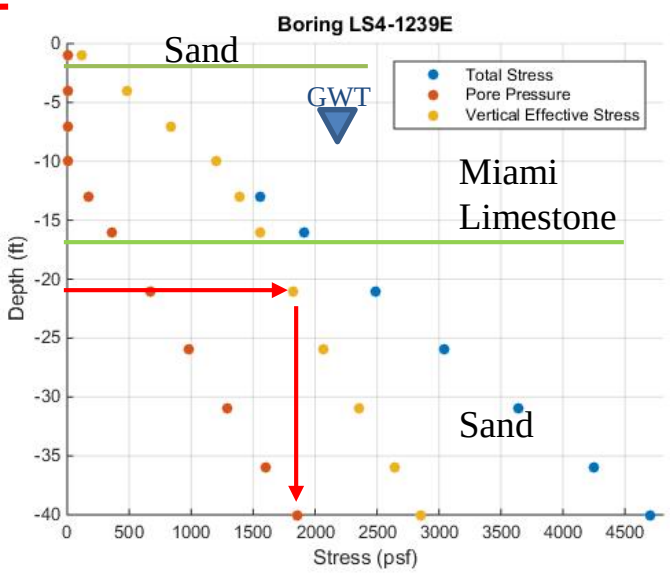
$$\beta = 1.2 - 0.11 \cdot Z^{0.5} \quad N \geq 15$$

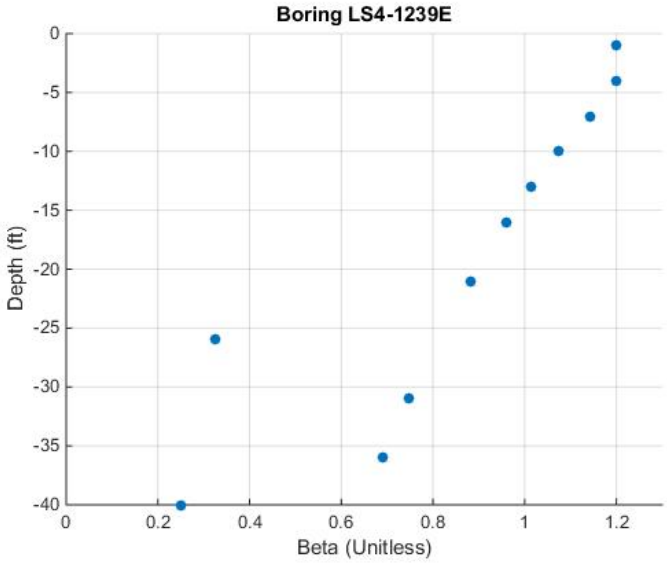
$$\beta = \frac{N_{60}}{15}(1.2 - 0.11 \cdot Z^{0.5}) \quad N < 15$$

$$0.20 \leq \beta \leq 0.96$$

Miami-Dade-6 site provided 55-Borings







Measured vs. Predicted Duval-1 Cohesionless Soils

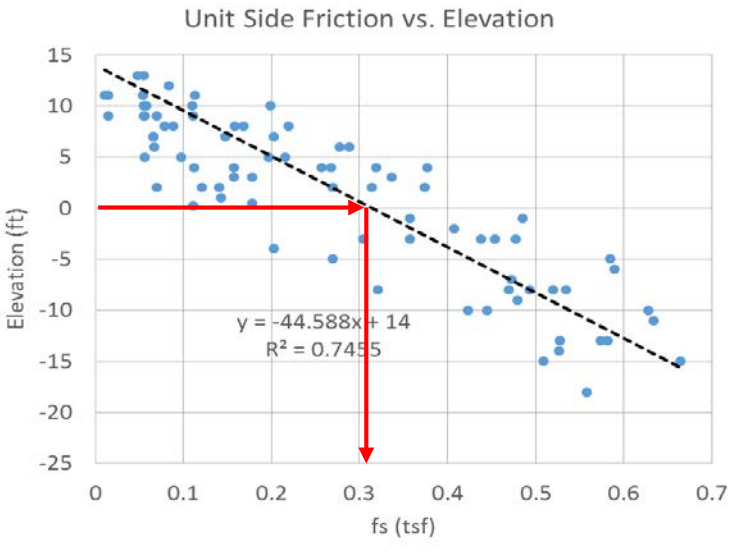
Duval-1 Site:
Cohesionless Soils: Zelda & Stephenson

Duval-1 Site provided 13-Borings

Unit Skin Friction: Duval-1 (Elev. 15~-15 ft)⇒ 0’

$f_s = \beta \cdot \sigma_v' < 1.6$ tsf

$f_s = 0.3140\ tsf$



$\beta = 1.2 - 0.11 \cdot Z^{0.5}$ N ≥ 15

$\beta = \frac{N_{60}}{15}(1.2 - 0.11 \cdot Z^{0.5})$ N < 15

$0.20 \leq \beta \leq 0.96$

Measured vs. Predicted Cohesive Soils

Cohesive Soils: FHWA

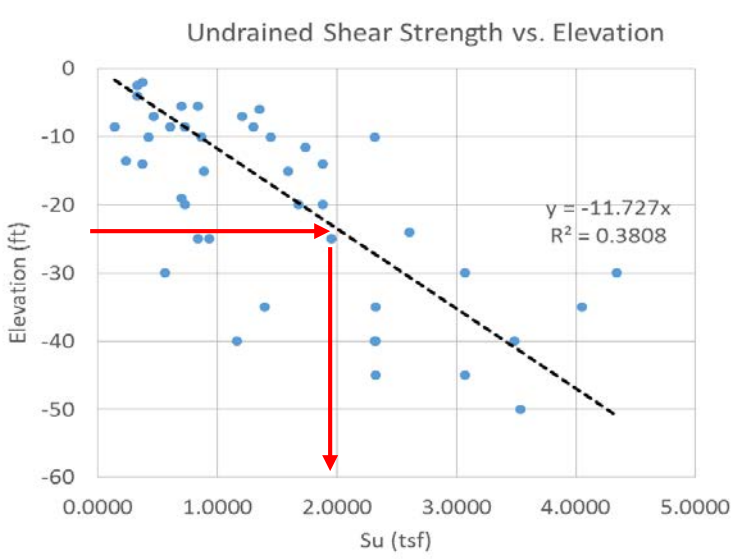
Alachua-2 Site provided 4-Borings

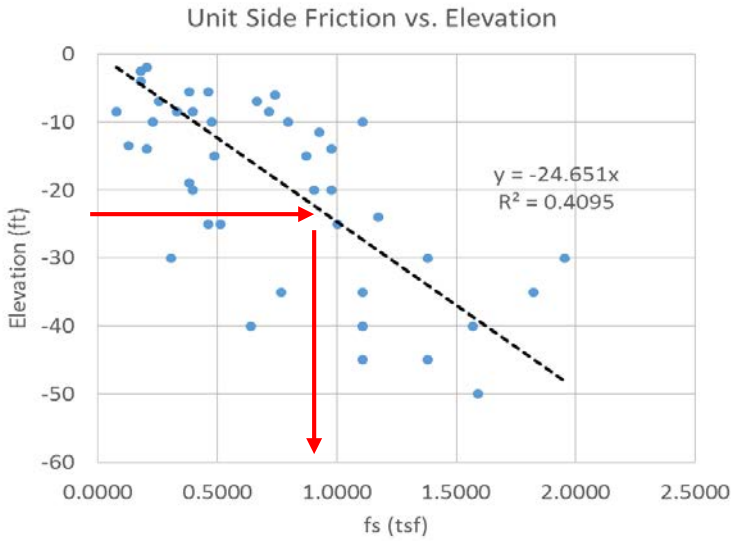
Unit Skin Friction: Alachua-2 (-15~-30 ft)⇒ -22.5’

$f_s = \propto \cdot S_u = 0.475 \cdot 1.92 =$ **0.9127 tsf**

$$\propto = 0.55 \; for \; \frac{Su}{Pa} \leq 1.5$$

$$\propto = \; 0.55 \; to \; 0.45 \; for 1.5 \leq \frac{Su}{Pa} \leq 2.5$$





Predicted Unit Skin Friction per Soil Layer (FHWA & FDOT Methods)

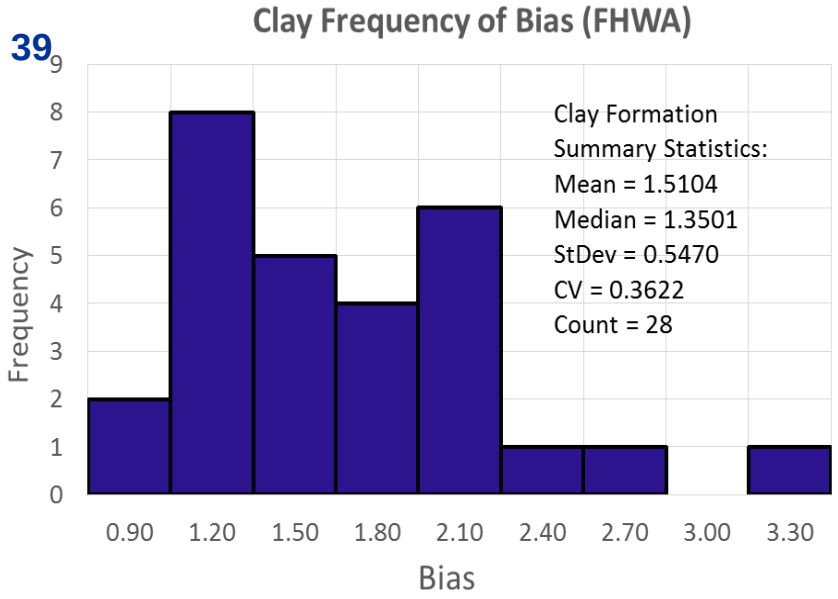
Location	Project Name	Soil Type	Diameter (in)	Embedded Length (ft)	Test Type	Water Table Depth (ft)	Instrumentation	Peak Displacement Load Test (in)	Segment #1 (tsf)	Elevation range (ft)	Segment #2 (tsf)	Elevation range (ft)	Segment #3 (tsf)	Elevation range (ft)
Alachua	Alachua-1 TP-2	Clay & IGM	16	64	Static	29	Load-Deflection	0.085	0.484	0~20	0.337	20~40	3.550	40~64
	Alachua-1 TP-3	Clay & IGM	16	64	Static	31	Load-Deflection	0.125	0.484	0~20	0.337	20~40	3.550	40~64
	Alachua-1 TP-4	Clay & IGM	16	64	Static	26	Load-Deflection	0.183	0.484	0~20	0.337	20~40	3.550	40~64
	Alachua-1 TP-5	Clay & IGM	16	64	Static	28	Load-Deflection	0.219	0.484	0~20	0.337	20~40	3.550	40~64
	Alachua-2 TP-1	Clay	14	42	Static	4.5	Load-Deflection	0.288	N/A		N/A		N/A	
	Alachua-2 TP-2	Clay	14	42	Static	5	Load-Deflection	0.325	0.304	0~15	0.913	15~30	1.460	30~42
	Alachua-2 TP-3	Clay	14	42	Static	6.5	Load-Deflection	0.295	0.304	0~15	0.913	15~30	1.460	30~42
	Alachua-2 TP-5	Clay	14	42	Static	5	T-Z & Load-Defl.	0.341	0.304	0~15	0.913	15~30	1.460	30~42
	Alachua-2 TP-XX-1	No Boring	14	42	Static	None	Load-Deflection	0.777	N/A		N/A		N/A	
	Alachua-2 TP-XX-2	No Boring	14	42	Static	None	Load-Deflection	0.460	N/A		N/A		N/A	
	Alachua-3 TP-1	Clay, Sand & IGM	14	15	Static	12	Load-Deflection	0.549	N/A		N/A		N/A	
	Alachua-5 TP-1	Sand & Clay	14	65	Static	6	T-Z & Load-Defl.	0.600	0.536	0~27	0.623	27~65		
	Alachua-5 TP-2	Sand & Clay	14	65	Static	6	T-Z & Load-Defl.	1.000	0.536	0~15	0.623	15~40	N/A	40~50
	Alachua-5 TP-3	Sand & Clay	14	65	Tension	6	T-Z & Load-Defl.	0.088						
Broward	Broward-1 TP-1	Sand & IGM	18	102	Static	5.7	T-Z & Load-Defl.	0.344	0.160	0~15	3.550	15~48	0.651	48~80
	Broward-1 TP-2	Sand & IGM	18	102	Tension	5.7	T-Z & Load-Defl.	0.009						
	Broward-1 TP-5	Sand & IGM	30	140	Osterberg	1	O-Cell	0.400	N/A	0~30	3.550	30~70	3.550	70~95
	Broward-2 TP-1	Sand & IGM	14	40	Static	None	Load-Deflection	0.350	0.400	0~10	1.075	10~32	3.550	32~40
Duval	Duval-1 TP 1-2	Sand, Marl & Clay	16	55	Static	4.5	Load-Deflection	0.289	0.392	0~30	1.902	30~45	0.970	45~55
	Duval-1 TP 2-2	Sand, Marl & Clay	16	54	Static	4.5	Load-Deflection	0.397	0.392	0~30	1.902	30~45	0.970	45~55
	Duval-1 TP 3-2	Sand, Marl & Clay	18	54	Tension	4.5	Load-Deflection	0.192						
	Duval-1 TP 3-3	Sand, Marl & Clay	16	54	Static	4.5	Load-Deflection	0.267	0.392	0~30	1.902	30~45	0.970	45~55
Hollywood	Hollywood-1 TP-1	No Boring	14	50	Static	No Boring	Load-Deflection	0.340	N/A		N/A		N/A	
	Hollywood-2 TP-1	No Boring	14	48	Static	No Boring	T-Z & Load-Defl.	0.200	N/A		N/A		N/A	
	Hollywood-2 TP-2	No Boring	14	48	Tension	No Boring	T-Z & Load-Defl.	0.032	N/A		N/A		N/A	
Hillsborough	Hillsborough-2 TP-1	No Boring	14	40	Static	None	Load-Deflection	0.079	N/A		N/A		N/A	
	Hillsborough-3 TP-1	Sand, and Clay	16	60	Static	5.2	Load-Deflection	0.548	0.724	0~43	0.570	43~55	1.135	55~60
	Hillsborough-3 TP-2	Sand, and Clay	16	60	Statnamic	5.2	T-Z & Load-Defl.	0.939	N/A	0~20	0.990	20~45	1.135	45~60
	Hillsborough-3 TP-3	Sand and Clay	16	60	Statnamic	5	T-Z & Load-Defl.	1.176	0.593	0~25	0.470	25~45	1.135	45~60
	Hillsborough-3 TP-4	Sand and Clay	16	60	Statnamic	5	T-Z & Load-Defl.	0.760	0.764	0~43	0.634	43~58	1.135	58~60
	Hillsborough-3 TP-5	Sand and Clay	16	69	Statnamic	4	T-Z & Load-Defl.	0.653	0.658	0~30	0.467	30~50	1.135	50~69
Nassau	Nassau-1 TP14	Sand	14	60	Static	3.8	T-Z & Load-Defl.	0.385	0.254	0~10	0.828	10~50	N/A	50~60
	Nassau-2 TP-1	Sand	16	39	Static	3	Load-Deflection	0.300	N/A		N/A		N/A	
	Nassua-3 TP-1	Sand	14	65	Static	5	T-Z & Load-Defl.	0.200	N/A	0~10	0.474	10~60	N/A	60~60
Palm Beach	Palm Beach-1 TP-9	No Boring	16	61	Static	None	T-Z & Load-Defl.	0.113	N/A		N/A		N/A	
	Palm Beach-2 TP-8	No Boring	16	61	Static	None	T-Z & Load-Defl.	0.188	N/A		N/A		N/A	
Polk	Polk-1	Clay, Silt & Sand	18	65	Static	8.5	Load-Deflection	0.360	N/A		N/A		N/A	
Santa Rosa	Santa Rosa-1 TP-1	Sand, Cayey Sand	24	47	Static	2.5	CPT Data	0.465	N/A		N/A	0~29	N/A	29~44
West Palm	West Palm-1 T2B	Sand	14	40	Tension	9	Load-Deflection	0.250						
	West Palm-1 T8	Sand	14	40	Tension	9	Load-Deflection	0.250						
	West Palm-1 T9B	Sand	14	40	Static	9	Load-Deflection	0.536	0.303	0~10	0.528	10~30	0.768	30~40

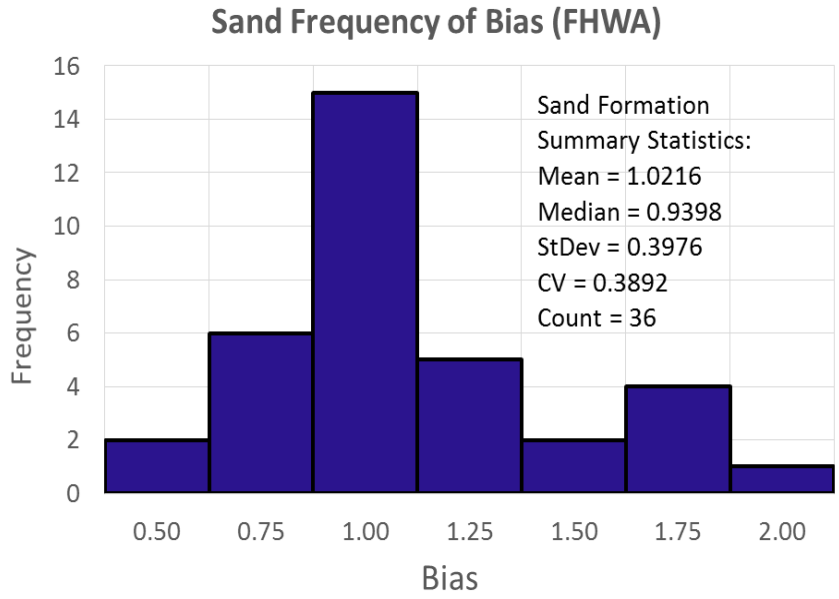
Predicted Unit Skin Friction per Soil Layer (FHWA & FDOT Methods)

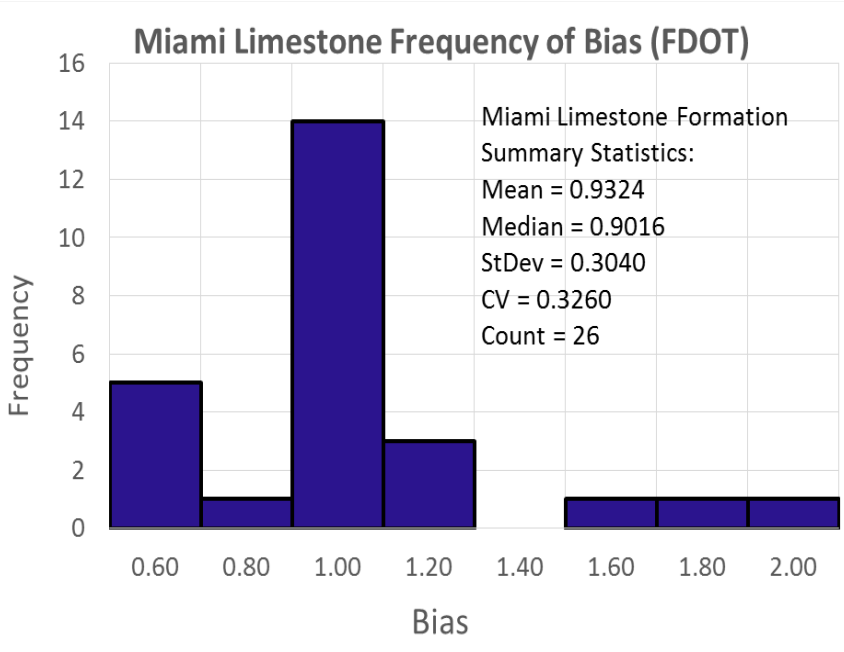
Location	Project Name	Soil Type	Diameter (in)	Embedded Length (ft)	Test Type	Water Table Depth (ft)	Instrumentation	Peak Displacement Load Test (in)	Segment #1	Elevation range	Segment #2	Elevation range	Segment #3	Elevation range
Miami Dade	Miami Dade-1 TP-1	IGM, Sand & FT Limestone	16	43	Static	5	Load-Deflection	0.343	3.550	0~18	0.603	18~35	6.028	35~43
	Miami Dade-1 TP-2	Sand & IGM	16	43	Tension	5	Load-Deflection	0.208						
	Miami Dade-5 TP-1	Sand & IGM	14	30	Static	(+) 2.5	Load-Deflection	0.148	N/A		N/A		N/A	
	Miami Dade-5 TP-2	Sand & IGM	14	30	Tension	(+) 2.5	Load-Deflection	0.270						
	Miami Dade-6 TP-1	IGM & Sand	14	25	Static	Not measured	Load-Deflection	0.183	3.550	5~14	0.603	14~25	N/A	
	Miami Dade-6 TP-2	IGM & Sand	14	40	Static	8	Load-Deflection	0.182	3.550	0~20	0.603	20~40	N/A	
	Miami Dade-6 TP-3	IGM & Sand	14	40	Static	8	Load-Deflection	0.303					N/A	
	Miami Dade-6 TP-5	IGM & Sand	14	40	Static	8	Load-Deflection	0.090	3.550	2~16	0.603	16~40	N/A	
	Miami Dade-6 TP-6	IGM, Sand & FT Limestone	14	40	Static	4	Load-Deflection	0.206	3.550	2~24	0.603	24~35	6.028	35~40
	Miami Dade-6 TP-7	IGM & Sand	14	40	Static	Not measured	Load-Deflection	0.060	N/A		N/A		N/A	
	Miami Dade-6 TP-8	IGM & Sand	14	40	Static	Not measured	Load-Deflection	0.093	N/A		N/A		N/A	
	Miami Dade-6 TP-9	IGM & Sand	14	40	Static	Not measured	Load-Deflection	0.142	3.550	1~24	0.603	24~40	N/A	
	Miami Dade-6 TP-10	IGM & Sand	14	40	Static	Not measured	Load-Deflection	0.572	3.550	5~22	0.603	22~40	N/A	
	Miami Dade-6 TP-11	IGM & Sand	14	23	Static	5.5	Load-Deflection	0.073	3.550	1~8	0.603	8~23	N/A	
	Miami Dade-6 TP-12	IGM & Sand	14	23	Static	5.5	Load-Deflection	0.346	N/A		N/A		N/A	
	Miami Dade-6 TP-13	IGM, Sand & FT Limestone	14	50	Static	Not measured	Load-Deflection	0.072	3.550	1~25	0.603	25~40	6.028	40~50
	Miami Dade-6 TP-14	IGM & Sand	14	58	Static	8	Load-Deflection	0.182	3.550	5~16	0.603	16~58	N/A	
	Miami Dade-6 TP-15	IGM & Sand	14	45	Static	7.5	Load-Deflection	0.119	3.550	3~11	0.603	11~45	N/A	
	Miami Dade-6 TP-16	IGM & Sand	14	25	Static	5.5	Load-Deflection	0.115	3.550	5~14	0.603	14~25	N/A	
	Miami Dade-6 TP-17	IGM & Sand	14	25	Static	5.5	Load-Deflection	0.135	3.550	4~21	0.603	21~25	N/A	
	Miami Dade-6 TP-18	Sand & IGM	14	20	Static	4	Load-Deflection	0.115	0.603	1~8	5.782	8~19	N/A	
	Miami Dade-6 TP-19	IGM, Sand & FT Limestone	14	55	Static	8	Load-Deflection	0.192	3.550	1~9	0.603	9~40	6.028	40~50
	Miami Dade-6 TP-20	IGM & Sand	14	30	Static	9	Load-Deflection	0.091	3.550	1~26	0.603	26~30	N/A	
	Miami Dade-6 TP-21	IGM & Sand	14	46	Static	12	Load-Deflection	0.110	3.550	4~17	0.603	17~46	N/A	
	Miami Dade-6 TP-22	IGM & Sand	14	41	Static	12	Load-Deflection	0.058	N/A		N/A		N/A	
	Miami Dade-6 TP-23	Sand	14	58.5	Static	10.5	Load-Deflection	0.560	0.603	0~58.5	N/A		N/A	
	Miami Dade-6 TP-24	IGM & Sand	14	47	Static	4	Load-Deflection	0.182	3.550	1~20	0.603	20~47	N/A	
	Miami Dade-6 TP-25	IGM & Sand	14	56	Static	10	Load-Deflection	0.095	N/A		N/A		N/A	
	Miami Dade-6 TP-26	IGM, Sand & FT Limestone	14	57	Static	10	Load-Deflection	0.296	3.550	20~32			6.028	32~57
	Miami Dade-6 TP-27	IGM, Sand & FT Limestone	14	47	Static	11	Load-Deflection	0.053	3.550	1~10	0.603	10~22	6.028	22~47
	Miami Dade-6 TP-28	IGM, Sand & FT Limestone	14	65	Static	8	Load-Deflection	0.408	3.550	1~9			6.028	60~65
	Miami Dade-6 TP-29	IGM, Sand & FT Limestone	14	56	Static	9	Load-Deflection	0.107	3.550	0~18	0.603	24~46	6.028	46~56
	Miami Dade-6 TP-30	IGM, Sand & FT Limestone	14	56	Static	9	Load-Deflection	0.107	3.550	1~15	0.603	15~45	6.028	45~56
	Miami Dade-6 TP-31	No Boring	14	44	Static	None	Load-Deflection	0.432	3.550	1~12	0.603	12~30	6.028	30~40
	Miami Dade-7 TP-1	Sand & IGM	18	41	Static	4	Load-Deflection	0.064	N/A		N/A		N/A	
	Miami Dade-7 TP-2	Sand & IGM	18	41	Static	4	Load-Deflection	0.069	N/A		N/A		N/A	
	Miami Dade-8 TP-1	Sand & IGM	14	52	Static	1	Load-Deflection	0.300	N/A		N/A		N/A	
				Total # of Test Piles		Total T-Z Curve	16							

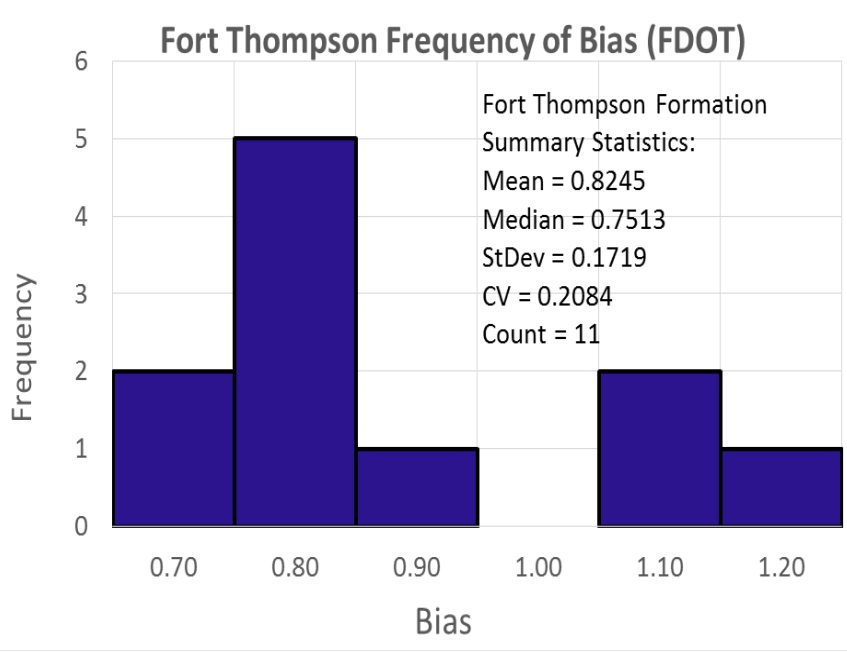
Predicted Cohesionless Unit Skin Friction (tsf)							
Site	Pile	Elev. Range (ft)	fs_{MEAS}(tsf)	$fs_{PRED-FHWA}$(tsf)	$Bias_{FHWA}$	$fs_{PRED-ZELDA}$(tsf)	$Bias_{ZELDA}$
Miami Dade	Miami Dade-1 TP-1	18~35	0.4413	0.6028	0.7321	0.4823	0.9151
	Miami Dade-6 TP-2	20~40	0.9938	0.6028	1.6486	0.4823	2.0605
	Miami Dade-6 TP-5	16~40	0.5885	0.6028	0.9762	0.4823	1.2202
	Miami Dade-6 TP-9	24~40	0.4783	0.6028	0.7934	0.4823	0.9917
	Miami Dade-6 TP-10	22~40	0.4040	0.6028	0.6702	0.4823	0.8377
	Miami Dade-6 TP-11	8~23	0.9067	0.6028	1.5041	0.4823	1.8798
	Miami Dade-6 TP-13	25~35	0.5040	0.6028	0.8361	0.4823	1.0450
	Miami Dade-6 TP-14	16~58	0.3923	0.6028	0.6508	0.4823	0.8134
	Miami Dade-6 TP-15	11~45	0.6156	0.6028	1.0212	0.4823	1.2763
	Miami Dade-6 TP-16	14~25	0.8525	0.6028	1.4143	0.4823	1.7677
	Miami Dade-6 TP-19	9~30	0.7771	0.6028	1.2891	0.4823	1.6112
	Miami Dade-6 TP-20	26~30	0.5832	0.6028	0.9675	0.4823	1.2092
	Miami Dade-6 TP-21	17~46	0.6123	0.6028	1.0158	0.4823	1.2696
	Miami Dade-6 TP-23	0~58.5	0.2750	0.6028	0.4562	0.4823	0.5702
	Miami Dade-6 TP-24	20~47	0.6508	0.6028	1.0796	0.4823	1.3494
	Miami Dade-6 TP-29	24~46	0.9164	0.6028	1.5203	0.4823	1.9001
	Miami Dade-6 TP-30	15~45	0.6590	0.6028	1.0932	0.4823	1.3664
Alachua	Alachua-5 TP-1	0~27	0.4980	0.5356	0.9298	0.4285	1.1622
	Alachua-5 TP-2	0~27	0.4510	0.5356	0.8420	0.4285	1.0525
Broward	Broward-1 TP-1	0~15	0.3580	0.1601	2.2362	0.1281	2.7953
	Broward-1 TP-1	48~80	0.4770	0.6513	0.7324	0.5210	0.9155
	Broward-2 TP-1	0~10	0.3311	0.4000	0.8278	0.3200	1.0347
	Broward-2 TP-1	10~32	0.5364	1.0750	0.4990	0.8604	0.6234
Duval	Duval-1 TP 1-2	0~30	0.3410	0.3924	0.8690	0.3140	1.0860
	Duval-1 TP 2-1	0~30	0.3920	0.3924	0.9990	0.3140	1.2484
	Duval-1 TP 3-3	0~30	0.2790	0.3924	0.7110	0.3140	0.8885
Hillsborough	Hillsborough-3 TP-1	0~55	0.5489	0.7242	0.7579	0.5793	0.9475
	Hillsborough-3 TP-3	0~45	0.4700	0.5925	0.7932	0.4740	0.9916
	Hillsborough-3 TP-4	0~58	0.7407	0.7637	0.9699	0.6109	1.2125
	Hillsborough-3 TP-5	0~50	0.6254	0.6584	0.9499	0.5267	1.1874
Nassua	Nassau-1 TP14	0~10	0.4990	0.2540	1.9646	0.2030	2.4581
	Nassau-1 TP14	10~50	1.3773	0.8280	1.6634	0.6620	2.0805
	Nassua-3 TP-1	10~60	0.3818	0.4736	0.8062	0.3789	1.0077
West Palm	West Palm-1 T9B	0~10	0.3100	0.3034	1.0218	0.2427	1.2773
	West Palm-1 T9B	10~30	0.4710	0.5282	0.8917	0.4226	1.1145
	West Palm-1 T9B	30~40	0.4936	0.7679	0.6428	0.6143	0.8035

Cohesive Unit Skin Friction Bias-All Sites					
Site	Pile	Elev. Range (ft)	fs_{MEAS}(tsf)	fs_{PRED} (tsf)	$Bias_{FHWA}$
Alachua	Alachua-1 TP-2	0~20	0.6520	0.4840	1.3471
	Alachua-1 TP-3	0~20	0.8960	0.4840	1.8512
	Alachua-1 TP-4	0~20	0.4890	0.4840	1.0103
	Alachua-1 TP-5	0~20	0.6000	0.4840	1.2397
	Alachua-1 TP-2	20~40	0.3670	0.3370	1.0890
	Alachua-1 TP-3	20~40	0.8820	0.3370	2.6172
	Alachua-1 TP-4	20~40	0.2750	0.3370	0.8160
	Alachua-1 TP-5	20~40	0.3360	0.3370	0.9970
	Alachua-2 TP-2	0~15	0.4610	0.3040	1.5164
	Alachua-2 TP-3	0~15	0.5550	0.3040	1.8257
	Alachua-2 TP-5	0~15	0.5960	0.3040	1.9605
	Alachua-2 TP-2	15~30	1.6090	0.9127	1.7629
	Alachua-2 TP-3	15~30	1.4980	0.9127	1.6413
	Alachua-2 TP-5	15~30	1.2350	0.9127	1.3531
	Alachua-2 TP-2	30~42	1.4960	1.4604	1.0244
	Alachua-2 TP-3	30~42	1.4930	1.4604	1.0223
	Alachua-2 TP-5	30~42	1.2370	1.4604	0.8470
	Alachua-5 TP-1	27~50	1.4240	0.6230	2.2857
	Alachua-5 TP-2	27~50	0.7050	0.6230	1.1316
Duval	Duval-1 TP 1-2	30~45	3.1970	1.9024	1.6805
	Duval-1 TP 2-2	30~45	3.4980	1.9024	1.8387
	Duval-1 TP 3-3	30~45	3.5280	1.9024	1.8545
	Duval-1 TP 1-2	45~55	0.9670	0.9700	0.9969
	Duval-1 TP 2-2	45~55	1.0260	0.9700	1.0577
	Duval-1 TP 3-3	45~55	1.2110	0.9700	1.2485
Hillsborough	Hillsborough-3 TP-2	45`60	1.394	1.1345	1.2287
	Hillsborough-3 TP-3	45~60	2.31	1.1345	2.0361
	Hillsborough-3 TP-5	50~69	3.415	1.1345	3.0101

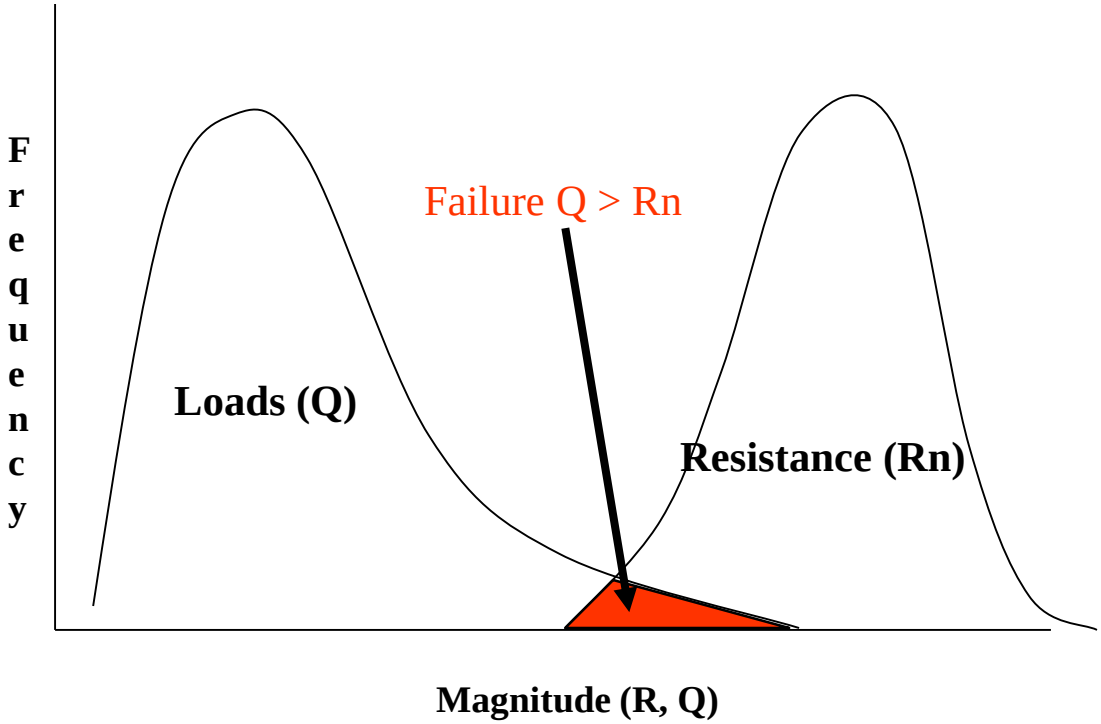

Clay Frequency of Bias (FHWA)
Clay Formation
Summary Statistics:
Mean = 1.5104
Median = 1.3501
StDev = 0.5470
CV = 0.3622
Count = 28
Frequency
Bias
0
1
2
3
4
5
6
7
8
9
0.90
1.20
1.50
1.80
2.10
2.40
2.70
3.00
3.30


Sand Frequency of Bias (FHWA)
Sand Formation
Summary Statistics:
Mean = 1.0216
Median = 0.9398
StDev = 0.3976
CV = 0.3892
Count = 36
Frequency
Bias
0
2
4
6
8
10
12
14
16
0.50
0.75
1.00
1.25
1.50
1.75
2.00


Miami Limestone Frequency of Bias (FDOT)
Miami Limestone Formation
Summary Statistics:
Mean = 0.9324
Median = 0.9016
StDev = 0.3040
CV = 0.3260
Count = 26
Frequency
Bias
0
2
4
6
8
10
12
14
16
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00


Fort Thompson Frequency of Bias (FDOT)
Fort Thompson Formation
Summary Statistics:
Mean = 0.8245
Median = 0.7513
StDev = 0.1719
CV = 0.2084
Count = 11
Frequency
Bias
0
1
2
3
4
5
6
0.70
0.80
0.90
1.00
1.10
1.20

Load and Resistance Factored Design – ϕ



AASHTO(2005) FOSM, LRFD Φ

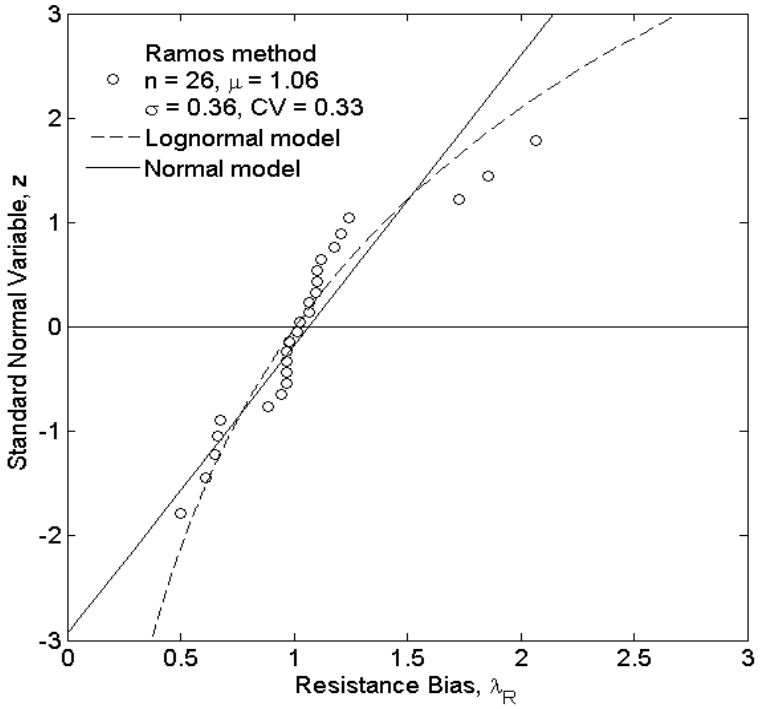
$$\phi\, Rn \geq \sum \gamma,\ Q_i$$

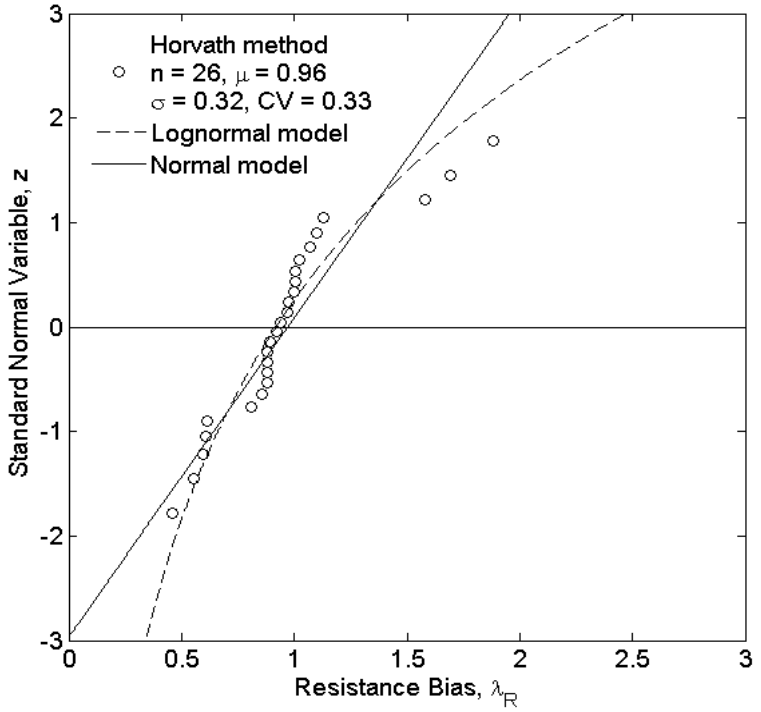
$$\Phi = \frac{\lambda_R \cdot \left(\gamma_D \cdot \frac{q_D}{q_L} + \gamma_L\right) \cdot \sqrt{\frac{\left(1 + CV_Q^2\right)}{\left(1 + CV_R^2\right)}}}{\left(\lambda_D \cdot \frac{q_D}{q_L} + \lambda_L\right) \cdot e^{\beta \sqrt{\ln\left[\left(1+CV_R^2\right)\left(1+CV_Q^2\right)\right]}}}$$

Both Load (Q) and Resistance (Rn) are Assumed lognormal distributions

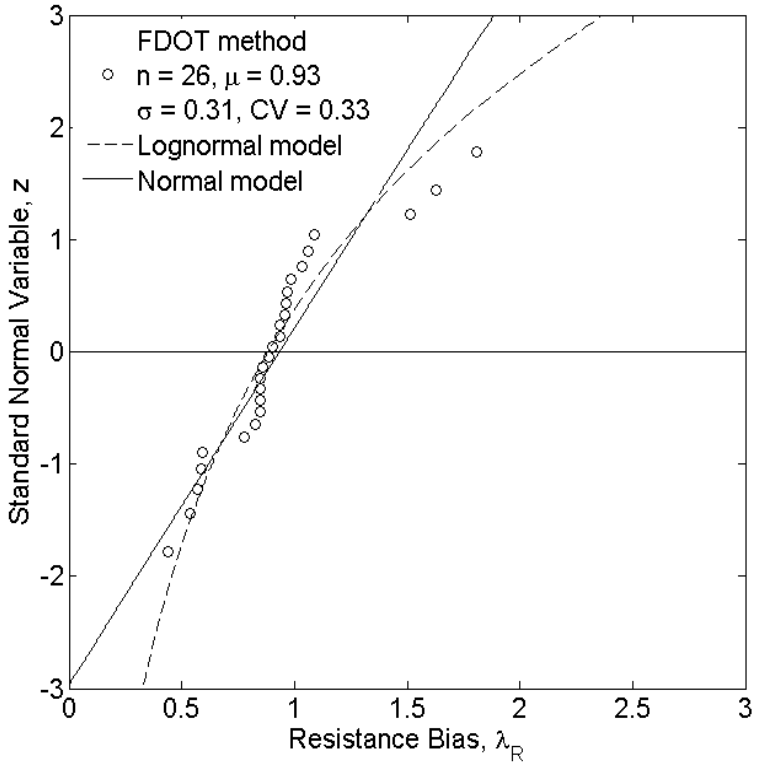
$$CV_Q^2 = \frac{\left(\frac{q_D}{q_L}\lambda_D CV_D\right)^2 + (\lambda_L CV_L)^2}{\left(\frac{q_D}{q_L}\lambda_D\right)^2 + 2\frac{q_D}{q_L}\lambda_D\lambda_L + {\lambda_L}^2}$$

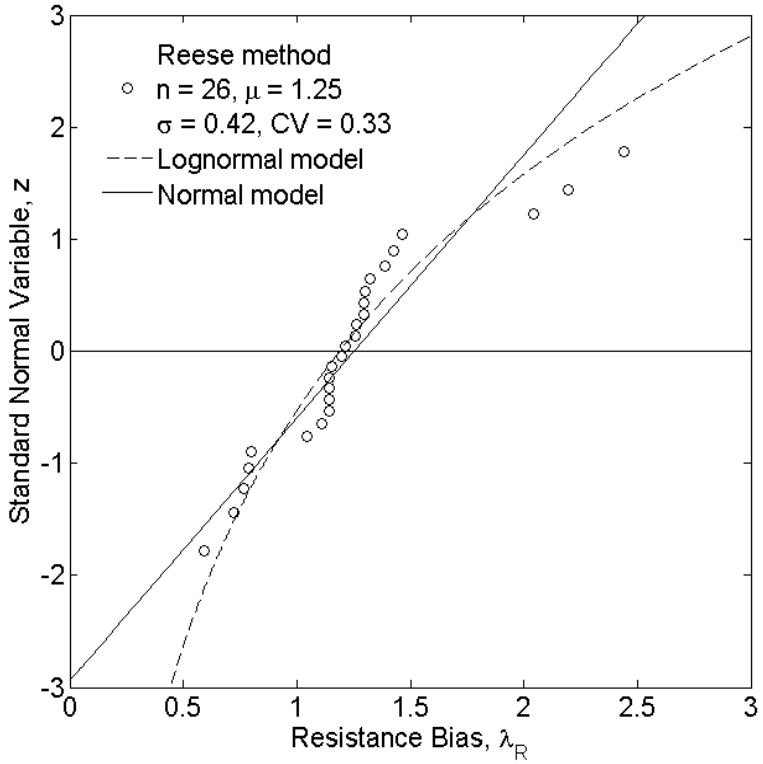
Ramos and Horvath method bias for Miami Limestone



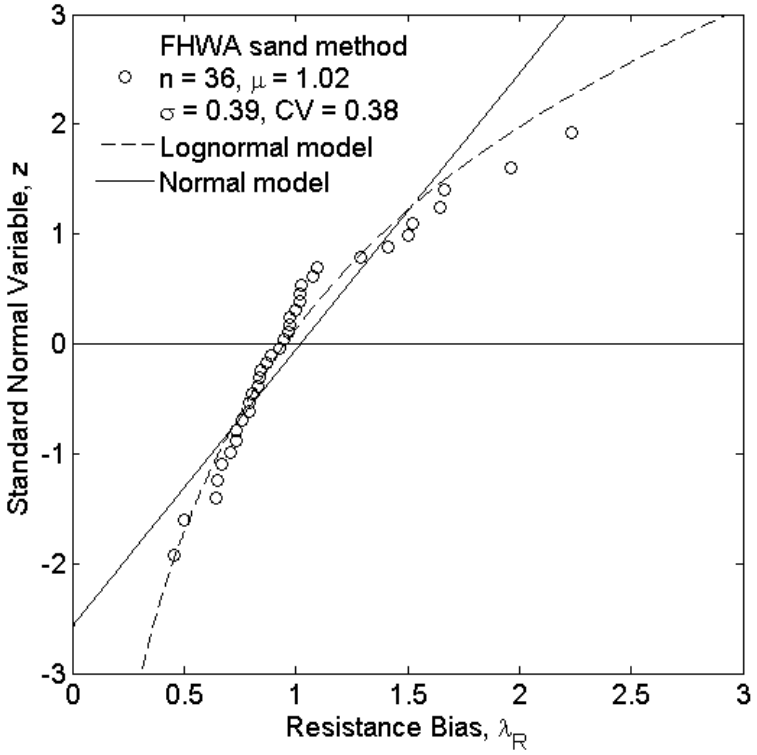


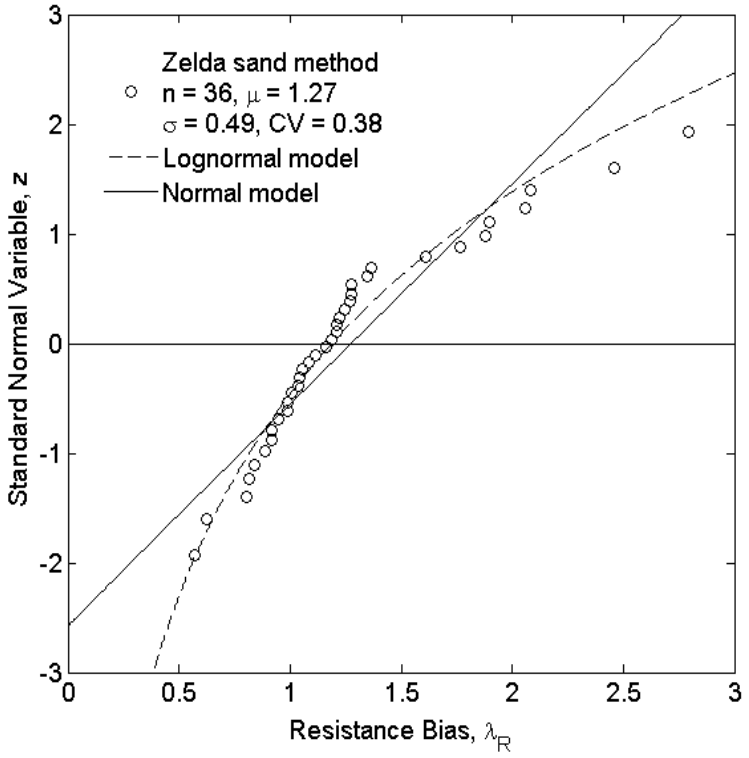
FDOT and Reese method bias for Miami Limestone ± 1-StDev





FHWA and Zelda sand method bias distributions





LRFD Resistance Factors for ACIP Design

Soil:

Method	Φ
Sand	
FHWA	0.52
Zelda	0.64
Clay	
FHWA	0.80

Miami Limestone:

Method	Φ
Miami Formation	
q_u	
Horvath	0.55
Williams	0.31
Reynolds	0.25
Gupton	0.37
Reese	0.49
Rowe	0.26
Carter	0.59
Ramos	0.61
Kulhawy	0.36
$\pm\sigma$ q_u	
FDOT ($\pm\sigma$ q_u and q_t)	0.54
Horvath	0.67
Williams	0.36
Reynolds	0.36
Gupton	0.54
Reese	0.72
Rowe	0.31
Carter	0.72
Ramos	0.22
Kulhawy	0.44

Fort Thompson Limestone:

Method	Φ
Fort Thompson	
q_u	
Horvath	0.68
Williams	0.42
Reynolds	0.19
Gupton	0.28
Reese	0.37
Rowe	0.31
Carter	0.72
Ramos	0.46
Kulhawy	0.44
$\pm\sigma$ q_u	
FDOT ($\pm\sigma$ q_u and q_t)	0.63
Horvath	0.75
Williams	0.46
Reynolds	0.22
Gupton	0.33
Reese	0.44
Rowe	0.34
Carter	0.80
Ramos	0.55
Kulhawy	0.48

LRFD Resistance Factors for ACIP Design

Miami Limestone: SPT

Method	Φ
Miami Formation	
SPT	
Frizzi	0.30
Ramos	0.30
Crapps	1.05
±σ SPT	
Frizzi	0.32
Ramos	0.30
Crapps	1.1

Fort Thompson Limestone: SPT

Method	Φ
Fort Thompson	
SPT	
Frizzi	0.44
Ramos	0.29
Crapps	0.18
±σ SPT	
Frizzi	0.64
Ramos	0.41
Crapps	0.55

Thank You