Memorandum

MIAMI-DADE COUNTY

Date: September 3, 2013

To: Honorable Xavier Suarez
Commissioner – District 7

From: Carlos A. Gimenez
Mayor

Subject: Kiewit - Bear Cut Bridge Existing Foundation Analysis Engineering Report

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In response to your memo of August 7, 2013 requesting a copy of the report regarding the Bear Cut Bridge structural integrity, attached please find a memo from Public Works and Waste Management (PWWM) Director Kathleen Woods-Richardson and the engineering analysis of the foundation prepared by the contractor's (Kiewit) engineer of record, Hardesty & Hanover.

If you have any questions, please contact PWWM Director Ms. Woods-Richardson at 305-514-6628 or me at 305-375-1880.

Attachments

c: Honorable Chairwoman Rebeca Sosa and Members, Board of County Commissioners
Honorable Franklin Caplan, Mayor, Village of Key Biscayne
Mayra Pena Lindsay, Vice Mayor, Village of Key Biscayne
John Gilbert, Village Manager, Village of Key Biscayne
R. A. Cuevas, Jr., County Attorney
Alina T. Hudak, Deputy Mayor
Kathleen Woods-Richardson, Director, Public Works and Waste Management

Memorandum

MIAMI-DADE COUNTY

Date: August 28, 2013

To: Honorable Carlos A. Gimenez
Mayor

Through Alina T. Hudak, Deputy Mayor
Office of the Mayor

From: Kathleen Woods-Richardson, Director
Public Works and Waste Management Department

Subject: Kiewit - Bear Cut Bridge Existing Foundation Analysis Engineering Report

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Background

The Design/Build Contractor for the rehabilitation of the Bear Cut and West bridges on the Rickenbacker Causeway, Kiewit Infrastructure South, Inc. (Kiewit), has submitted an existing foundation analysis engineering report to Miami-Dade County (County). This report was requested by the County in order to evaluate the load carrying capacity of the existing piles on the portion of the Bear Cut Bridge (Bridge) that was built in the mid 1940's and that are to remain in place following the rehabilitation of the Bridge. The report includes the results of:

- Hydrographic and Topographic surveys.
- Soil borings.
- Parallel Seismic Testing results.
- Calculations of the existing pile capacities.
- Calculation of actual loads on these existing piles.
- Resulting factors of safety of the existing bridge piles.

The report findings are based on the analysis of eight (8) piles on the Bridge. These piles are located on selected piers (numbers 5, 8, 13, 19, 24, 30, 35 and 40) along the full length of the bridge and are therefore representative of the total number of piles on the Bridge. The report contains the results of the field work (e.g., soil borings, parallel seismic testing results) as well as engineering calculations and analysis, and a summary of the findings and conclusions.

The report was initially received on August 16, 2013, and was discussed in a meeting between Kiewit and PWWM staff on August 20, 2013. A revised report that included a summary of findings, conclusions, additional calculations, and an additional table requested by PWWM staff, was provided on August 26, 2013.

Design Methods

A brief explanation of the design methods referenced in the report is as follows. The Allowable Stress Design (ASD) method also known as the Working Stress Method was used on the original Bridge's design, and its use was allowed until the implementation of the 1999 American Association of State Highway Transportation Officials (AASHTO) Interim Manual. The official manual was published in 2002. This method limits the stresses on a structural member below their capacity, therefore providing a safety factor. This method does not consider the statistical

variability of different loads such as live (i.e., traffic loads) and dead (i.e., weight of the concrete/steel members) loads.

The Load Factor Design Method (LFD), adopted by AASHTO in 1971, is also known as the Ultimate Strength Design method. It recognized that live loads (i.e., traffic loads) are more variable than dead loads (i.e., weight of the concrete/steel members) and thus it applies different factors to these loads in order to account for this variability. Although the Bridge was not designed with this method, it is used for evaluating older bridges and was used by the Florida Department of Transportation in its rating of the superstructure of both the West Bridge and Bear Cut Bridge in 2012.

Finally, in 2007 the Federal government issued a mandate that all new bridges be designed using a new Load and Resistance Factor Design method (LRFD). This method was not included in this analysis since it is not customary to refurbish older bridges to these new standards. To date, only a handful of the 209 County maintained bridges have been designed using this method. This also applies to thousands of bridges nationwide built prior to 2007. Therefore, it is the opinion of staff that this method is not applicable to the evaluation of bridges built prior to 2007.

Allowable Stress Design Method

The desired safety factor for the ASD, used for the design of the original Bridge, is 2.0. As referenced in the report, "a factor of safety of 2.0 for pile capacities is considered appropriate for a foundation that has exhibited its integrity for the past 67 years." The factor of safety was calculated for the estimated pile length as well as an upper and lower bound length based on a test variability of 5 % to 10% for each pile. The "estimated pile penetration", reflected in the Pile Capacity Evaluation Chart, is the result of the interpretation of test data by the subcontractor, Applied Foundation Testing (AFT), and is the likely existing penetration. The estimated penetration also corresponds to the depths of the sandy limestone indicated in the borings performed as part of the testing. The report indicates all piles meet the required ASD factor of safety for the estimated pile length. One (1) pile which shows an estimated pile penetration safety factor of 1.95 is considered as having met the criteria since it is reasonably close to the desired 2.0.

As mentioned above, the upper and lower bound lengths for each pile are included in the highly technical investigation conducted by AFT. Since this type of investigation is impacted by the effects of soil, water and the multiple piles in each foundation, an exact measurement of the pile lengths is subject to a 5% to 10% variability. This results in the "upper" and "lower" bound values for the estimated pile length. The use of the estimated or likely pile length is based on the latest techniques and currently accepted practices as noted in AFT's report.

The report notes that three (3) of the eight (8) piles (5, 24, and 30) have lower bound penetration ranges that do not meet the required factor of safety. However, since the average range for pile 5 is close to 2.0, and over 2.0 in the case of piles 24 and 30, they are deemed acceptable since the report findings reveal that all eight (8) existing piles have sufficient load carrying capacity using the "estimated pile penetration".

Load Factor Design Method

The report also provides the safety factors resulting from applying the LFD. The desired safety factor for the LFD method is 1.0, since there are already factors for safety introduced into the analysis itself. The report provides that the LFD range is from 0.79 to 2.37 using the estimated

pile penetration. The only pile under 1.0 is located at pier number 5, with a rating of 0.79. However, it is deemed acceptable since its ASD safety factor is 1.95 and there are no observable signs of distress, such as settlement or cracking of concrete on any pier.

The report also addresses the existing pile's capacity after an extreme event, such as a major hurricane. The LFD method shows that the safety factors for three (3) of the piers are less than 1.0 after an extreme event when including full traffic loads on the Bridge. However, provided traffic is routed off the 1940's portion of the bridge, the minimum LFD factor would be an acceptable 1.03. Furthermore, the report finds that the ASD safety factor ranges from 2.15 to 4.44 under similar circumstances. As is customary with all County maintained bridges, following an extreme event, the County would follow procedures limiting traffic loads until a full assessment of the actual impact to the Bridge was completed, and remedial actions were taken.

Conclusion

In summary, the foundation of the Bridge has exhibited its integrity and safely supported the loads imposed on it for the past 67 years. The report notes that "due to the fact that the new superstructure is not increasing the axial loads on the existing foundation the factors of safety which existed prior to the rehabilitation will remain consistent upon completion of the County's specified work".

Furthermore, as stated in the report's conclusion, "If the contract prescribed substructure improvements, as specified by Miami-Dade County, is all that is required and periodic maintenance of the substructure, which includes sealers, cathodic coatings, active cathodic protection and other maintenance methods is performed, this may allow this bridge to provide an additional 20-30 years of continued life, barring an extreme event such as coastal storm surges, extreme wind events (above 100 mph), and vessel collision."

Finally, based on the results of the report, the County will proceed with the planned demolition and replacement of the older portion of both the Bear Cut and West bridges in order to maintain the project's schedule of substantial completion by the end of February 2014. Upon completion of the work, the County will begin the process of identifying funding for a Project Development and Environmental Study for the complete replacement of the Bear Cut and West Bridges.

Should you require additional information, please contact my office at 305-375-2960.

Attachment

c: Honorable Harvey Ruvin, Clerk of the Board
Robert A. Cuevas, Jr., County Attorney
Hugo Benitez, Assistant County Attorney
Christopher Agrippa, Division Chief, Clerk of the Board
Antonio Cotarelo, P.E., Interim County Engineer, PWWM

Kiewit

August 16, 2013

KSE-MDC-028

Miami-Dade County
Public Works and Waste Management

Antonio Cotarelo, P.E.
Interim County Engineer
111 NW 1st Street, 16th Floor
Miami, Florida 33128

Subject: Bear Cut Bridge Existing Foundation Analysis Engineering Report

Mr. Cotarelo,

As requested by Miami-Dade County, Kiewit is submitting the engineering analysis of the foundation on the Bear Cut Bridge on Rickenbacker Causeway. The report was prepared by our engineer of record, Hardesty & Hanover. After Miami-Dade County personnel have reviewed our analysis, please direct us how to proceed.

If you have any questions or require additional information please feel free to contact me at your earliest convenience.

Sincerely,
Kiewit Infrastructure South Co.

David Johnson
Project Manager

CC: Marcos Redondo – Miami-Dade County
Luis Baldo – Miami-Dade County
Frank DiGilio – Kiewit
Correspondence File

Kiewit Infrastructure South Co.
Bear Cut Bridge Rehabilitation
13680 NW 5th Street, Suite 130 Sunrise, FL 33325
(954) 835-2228 (954) 835-2335 fax

EEO Employer

Hardesty &Hanover
engineering that moves you

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August 16, 2013

Frank DiGilio
KIEWIT INFRASTRUCTURE SOUTH CO.
13680 NW 5th Street Suite #130
Sunrise, Florida 33325

Re: Rickenbacker Causeway Bear Cut Bridge Existing Foundation Analysis

Dear Frank,

Please find attached the results of the engineering analysis of the existing unknown foundations (1947 Bridge) of the Bear Cut Bridge. The purpose of this investigation was to assess the capacity of the monotube pile foundations and assess their adequacy to support the new superstructure and live load based on the AASHTO Standard Specifications for Bridges 17th Edition as per the Design Criteria provided in RDBS Volume II page 19 of 29. The use of the 17th Edition is appropriate for structures designed prior to 1999 due to the additional loading requirements of the LRFD Specification introduced in 1999. The 1947 bridge substructure was not designed for extreme lateral load events such as coastal storm surges, extreme wind events (above 100 mph), and vessel collision. As such these loads were not applied in our analysis.

The 1947 Bridge consists of a multitude of identical 51'-4" spans which are supported by reinforced concrete piers of similar construction. Each concrete pier is supported by two waterline footings with an array of 5 tapered steel corrugated pipe piles for a total of 10 piles per pier. The outside perimeter piles are battered and the center pile is vertical (See Figure 1 in the calculations). The 18-inch diameter tapered steel corrugated piles, commonly known as monotube piles were manufactured by Union Metal, now known as the Monotube Pile Corporation. The Monotube Pile Corporation is still a supplier of tapered steel corrugated piles for the bridge construction market.

Each tapered pile is assumed to have been driven into the substrata with a pneumatic pile hammer until refusal and filled with concrete in order to safely support the bridge loads. Each pile protrudes above the bay bottom into the waterline footing at the water's surface of Biscayne Bay. Tapered piles have the advantage of developing larger capacitates than non-tapered piles with increased skin friction developed due to wedge action that is created when driven into the substrata.

At the time of construction, AASHO Standard Specifications for Highway Bridges 4th Edition required piles to be driven until a factor of safety of 2 was reached either by load test or using the appropriate pile driving formula as stated in Article 2.3.6 of AASHO. Since the piles are exposed from the bay bottom to the waterline (although many of the piles are jacketed with reinforced concrete) the geometric properties of the exposed piles were determined. However, there are no historical records of the existing bridge construction, and therefore insitu investigative techniques were necessary to determine pile lengths.

Hardesty &Hanover
engineering that moves you

In summary, the following information was gathered for this analysis in order to estimate the axial pile capacity of the eight referenced pile:

1. **Hydrographic and Topographic Survey** of the bay bottom and surrounding area in the vicinity of the bridge structures was performed in order to determine the mud line elevations of each pile tested for capacity.
2. **Soil Borings-** 8 soil borings were taken at 8 different piers at the Bear Cut Bridge (Piers 5,8,13,19,24,30,35,40). The soil borings were 100 feet deep taken adjacent to the existing straight pile (within 5 feet) in order to obtain soil samples of the underlying strata to determine their engineering properties. The only straight pile at each pier footing is the center pile of the 5 pile array. A foundation report is attached with this summary letter from Tierra South Florida providing Davisson Pile Capacities based on the geotechnical data gathered.
3. **Parallel Seismic Tests-** were performed to determine the penetration depth of the existing pile (Pile Tip Elevation) for each of the 8 selected piles. The casing used to extract the soil boring described in Step 2 was filled with sand and used as insulation for the 2-inch diameter PVC tube that was inserted inside the casing. The 2-inch tube was used to send an impulse created by a hammer down the tube to measure the seismic waves. The seismic waves were recorded and the data was analyzed with a Freedom Data NDT PC Parallel Seismic system to determine the location of the end of the pile. This test is used by FHWA and FDOT for unknown foundation studies. The pile lengths provided in the Summary of Parallel Seismic Results Table (on page 4 of the AFT Final Report of Parallel Seismic Testing Rehabilitation of Bear Cut Bridge dated August 5, 2013) were used to determine the individual pile capacities. Due to uncertainty in the individual pile lengths, the variability of the estimated pile length is provided for each pile. The report is included with this summary letter which also provides the data collected, and analysis performed to estimate the pile lengths.
4. **Pile Capacities-** Davisson Pile capacities for each pile were determined using the Nordlund Method. In discussion with Tierra South Florida and the Monotube Pile Corporation it was determined that the Nordlund Method best represents the actual capacity of a monutube tapered pile as it accounts for its taper in developing friction, and is the method recognized by the FHWA (Publication No. FHWA NHI-05-042 April 2006). As shown in the calculation table, the angle of the taper (0.95 degrees) is required to determine pile capacity. In conversations with Monotube Pile Corporation, the taper of the pile was confirmed by the known geometric properties of the pile (diameter, length, and required 8 inch tip diameter by 1944 AASHO). Axial pile capacities corresponding to the estimated range of pile lengths are provided in the Geotechnical Report by Tierra South Florida attached to this summary letter.
5. **Pile Loads, Service Factors, and Factor of Safety- are represented in the Pile Capacity Table.** The structural strength of the pile is used when the geotechnical capacity exceeds the structural strength of the pile. In these instances, the structural strength of the pile was calculated using the allowable compressive strength of the concrete only. The pile loads for each pier were calculated using the dead load of the new superstructure and existing substructure, and a live load of 3 lanes loaded with HS-20 trucks with a 0.9 multi-presence factor. Axial pile capacities corresponding to the estimated range of pile lengths was compared against Allowable Stress Design (ASD) Loads (Original Design Method) and factored loads (17th Edition of AASHTO Specification for Highway Bridges-LFD). The conclusions included rely on the ASD factors of safety, the LFD factors are provided for reference only.
6. **Scour Analysis.** Scour analysis was performed by OEA Inc. As stated in the Scour Report, a Reta Test was performed by FDOT Materials Office to determine the scourability of the bay bottom hard layer in order to provide more reliable analysis of the scour. A separate pile capacity table is provided for the scoured condition.

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Results & Discussion

A factor of safety of 2.0 for pile capacities is considered appropriate for a foundation that has exhibited its integrity for the past 67 years using unfactored or service loads. The factor of safety was calculated for the likely pile length as well as an upper and lower bound for each pile. As shown in the Pile Capacity Table (Non-Scoured condition) all piles meet the required ASD factor of safety for the likely pile length.

All of the piles meet the required factor of safety for the upper bound of pile lengths. Three pile do not meet the required factor of safety for the lower bound(see Pile Capacity Table).

The Pile Capacity Table (Scoured Condition) exhibit two piles in piers 5 and 30 with a Factor of Safety of 1.7 and 1.9 respectively. As per request of the County, an additional Scoured Condition Pile Capacity Table is provided showing the Factor of Safety with dead load only applied to the foundation. This Table is provided to show that the capacity of the substructure after a scour extreme event allows the bridge to be safely inspected with no vehicular traffic on the bridge.

Conclusion

Based on the analysis conducted for the eight referenced piles, our conclusions are limited to the axial capacities of the subject piles. Our analysis indicates that the eight piles provide satisfactory factors of safety for their likely embedment depths. However, our analysis indicates that piles 5, 24 and 30 may not provide the required factor of safety for the lower bound of the estimated pile lengths.

As concrete structures age in severe environments (sea spray and salt air contamination) more maintenance is required to ensure substructure integrity. If the contract prescribed substructure improvements, as specified by Miami-Dade County, is all that is required and periodic maintenance of the substructure, which includes sealers, cathodic coatings, active cathodic protection and other maintenance methods is performed, this may allow this bridge to provide an additional 20-30 years of continued life, barring an extreme event such as coastal storm surges, extreme wind events (above 100 mph), and vessel collision.

Prudent design of bridge rehabilitation is to minimize or prevent any additional load applied to the existing substructures to ensure settlement or distress of the existing foundation does not occur. The test of time of 67 years has shown this structure has safely supported the load applied. Due to the fact that the new superstructure is not increasing the axial loads on the existing foundation the factors of safety which existed prior to the rehabilitation will remain consistent upon completion of the County's specified work.

Very Truly Yours,

Timothy J. Noles

Timothy J. Noles, PE
Principal

Foundation Evaluation

of the

Existing Bear Cut Bridge Pier

Prepared for

Miami-Dade County

by

Hardesty & Hanover, LLC

August 16, 2013

Structural Foundation Analysis

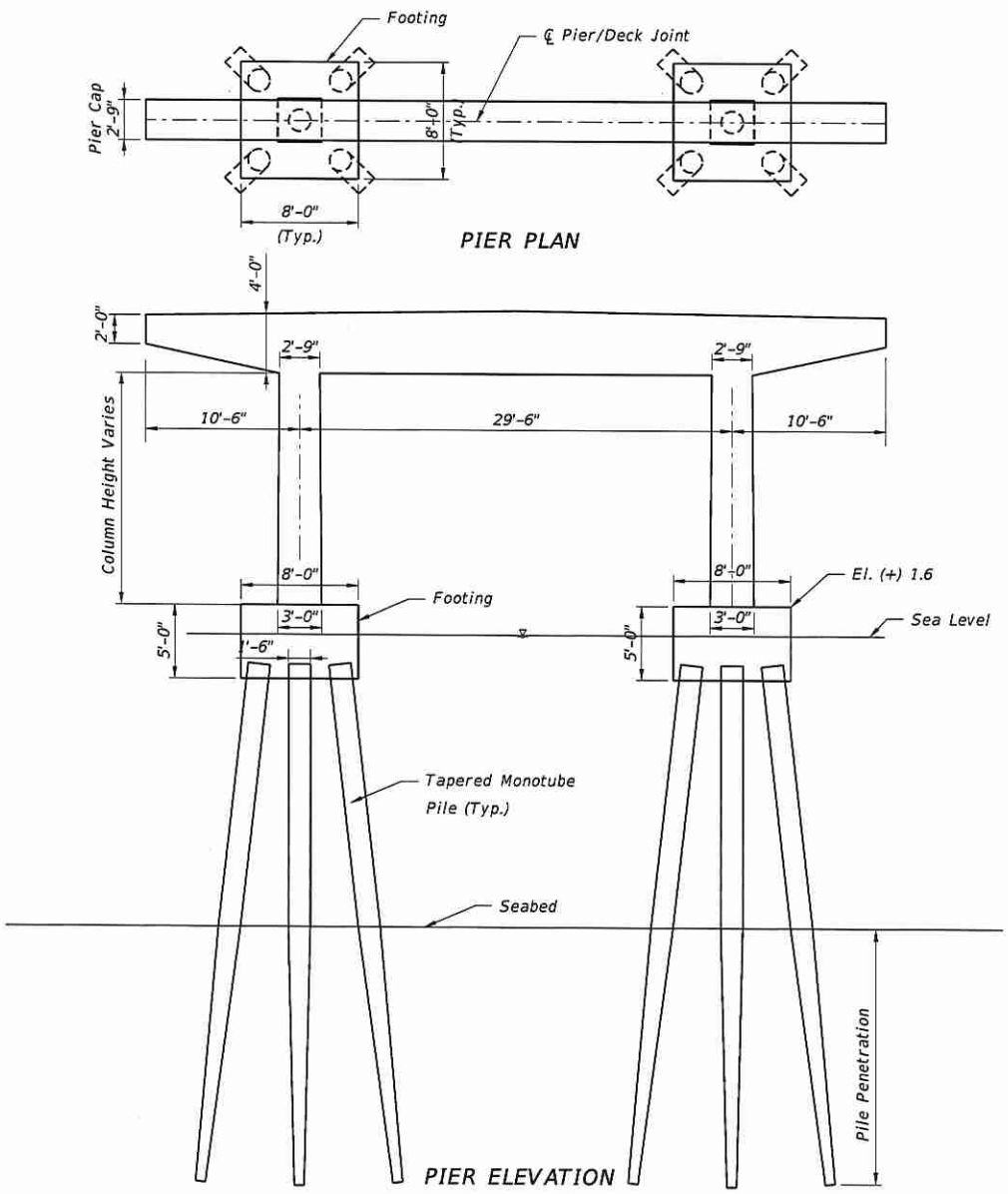


FIGURE 1. TYPICAL PIER GEOMETRY

PILE CAPACITY EVALUATION

(8" Tip Diameter with No Scour)

			Tapered Pile Axial Capacity by Nordlund's Method			Allowable Stress Design (ASD)			Load Factored Design (LFD)		
Pier	Pile Penetration Range	Pile Penetration	Davisson Pile Axial Capacity	Davisson Axial Capacity x 0.6	Structural Capacity of Monotube Pile	Maximum Allowable Pile Load (ASD)	Maximum Pile ASD Load	ASD Factor of Safety *	Maximum Allowable Pile Load (LFD)	Maximum Pile LFD Load	LFD Service Factor**
		ft	Kips	Kips	Kips	Kips	Kips		Kips	Kips	
5	Lower Bound	14.1	112	67.2	269	112	76.6	1.46	67.20	113.8	0.59
	Estimated Pile Penetration	19.1	149	89.4	269	149	76.6	1.95	89.40	113.8	0.79
	Higher Bound	24.1	206	123.6	269	206	76.6	2.69	123.60	113.8	1.09
8	Lower Bound	20.7	259	155.4	269	259	77	3.36	155.40	114.4	1.36
	Estimated Pile Penetration	25.7	468	280.8	269	269	77	3.49	269.00	114.4	2.35
	Higher Bound	30.7	493	295.8	269	269	77	3.49	269.00	114.4	2.35
13	Lower Bound	17.8	181	108.6	269	181	77.8	2.33	108.60	115.5	0.94
	Estimated Pile Penetration	22.8	284	170.4	269	269	77.8	3.46	170.40	115.5	1.48
	Higher Bound	27.8	511	306.6	269	269	77.8	3.46	269.00	115.5	2.33
19	Lower Bound	15.4	194	116.4	269	194	78.7	2.47	116.40	116.6	1.00
	Estimated Pile Penetration	20.4	364	218.4	269	269	78.7	3.42	218.40	116.6	1.87
	Higher Bound	25.4	565	339	269	269	78.7	3.42	269.00	116.6	2.31
24	Lower Bound	10.8	101	60.6	269	101	78.7	1.28	60.60	116.6	0.52
	Estimated Pile Penetration	15.8	228	136.8	269	228	78.7	2.90	136.80	116.6	1.17
	Higher Bound	20.8	423	253.8	269	269	78.7	3.42	253.80	116.6	2.18
30	Lower Bound	15	105	63	269	105	77.8	1.35	63.00	115.5	0.55
	Estimated Pile Penetration	20	190	114	269	190	77.8	2.44	114.00	115.5	0.99
	Higher Bound	25	276	165.6	269	269	77.8	3.46	165.60	115.5	1.43
35	Lower Bound	14.4	215	129	269	215	77	2.79	129.00	114.4	1.13
	Estimated Pile Penetration	19.4	290	174	269	269	77	3.49	174.00	114.4	1.52
	Higher Bound	24.4	402	241.2	269	269	77	3.49	241.20	114.4	2.11
40	Lower Bound	28.1	339	203.4	269	269	76.2	3.53	203.40	113.4	1.79
	Estimated Pile Penetration	33.1	493	295.8	269	269	76.2	3.53	269.00	113.4	2.37
	Higher Bound	38.1	764	458.4	269	269	76.2	3.53	269.00	113.4	2.37

* ASD Factor of Safety = (Minimum of Davisson Pile Axial Capacity or Structural Capacity of Pile) /Maximum Pile Service Load

** LFD Service Factor =(Minimum of Davisson Pile Axial Capacityx0.6 or Structural Capacity of Pile) /Maximum Pile LFD Load

PILE CAPACITY EVALUATION

(8" Tip Diameter with Scour)

		Tapered Pile Axial Capacity by Nordlund's Method			Allowable Stress Design (ASD)			Load Factored Design (LFD)		
Pier	Estimated Pile Penetration	Davisson Pile Axial Capacity	Davisson Axial Capacity x 0.6	Structural Capacity of Monotube Pile	Maximum Allowable Pile Load (ASD)	Maximum Pile ASD Load	ASD Factor of Safety *	Maximum Allowable Pile Load (LFD)	Maximum Pile LFD Load	LFD Service Factor**
	ft	Kips	Kips	Kips	Kips	Kips		Kips	Kips	
5	18.1	129	77.4	269	129	76.6	1.68	77.40	113.8	0.68
8	24.7	427	256.2	269	269	77	3.49	256.20	114.4	2.24
13	18.9	172	103.2	269	172	77.8	2.21	103.20	115.5	0.89
19	19.3	321	192.6	269	269	78.7	3.42	192.60	116.6	1.65
24	14.5	189	113.4	269	189	78.7	2.40	113.40	116.6	0.97
30	18.1	145	87	269	145	77.8	1.86	87.00	115.5	0.75
35	16.8	202	121.2	269	202	77	2.62	121.20	114.4	1.06
40	22.2	236	141.6	269	236	76.2	3.10	141.60	113.4	1.25

* ASD Factor of Safety = (Minimum of Davisson Pile Axial Capacity or Structural Capacity of Pile) /Maximum Pile Service Load

** LFD Service Factor =(Minimum of Davisson Pile Axial Capacityx0.6 or Structural Capacity of Pile) /Maximum Pile LFD Load

PILE CAPACITY EVALUATION

(8" Tip Diameter with Scour and No Live Load)

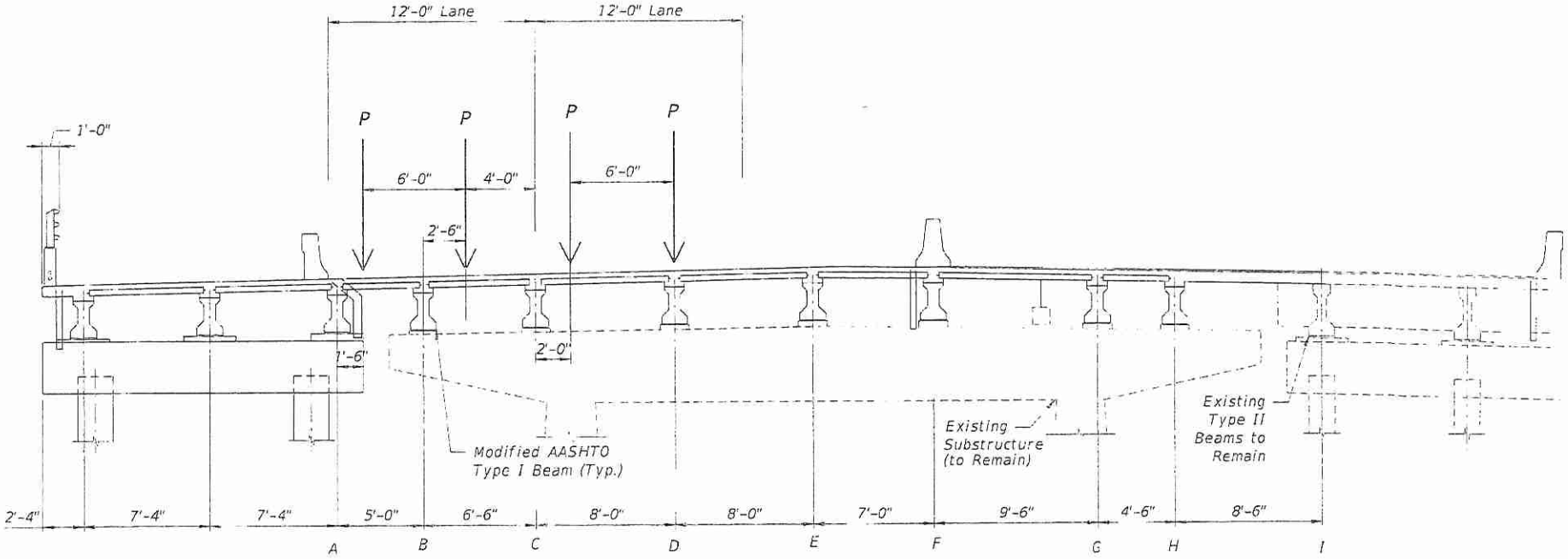
		Tapered Pile Axial Capacity by Nordlund's Method			Allowable Stress Design (ASD)			Load Factored Design (LFD)		
Pier	Estimated Pile Penetration	Davisson Pile Axial Capacity	Davisson Axial Capacity x 0.6	Structural Capacity of Monotube Pile	Maximum Allowable Pile Load (ASD)	Maximum Pile ASD Load	ASD Factor of Safety *	Maximum Allowable Pile Load (LFD)	Maximum Pile LFD Load	LFD Service Factor**
	ft	Kips	Kips	Kips	Kips	Kips		Kips	Kips	
5	18.1	129	77.4	269	129	60.05	2.15	77.40	74.86	1.03
8	24.7	427	256.2	269	269	60.52	4.44	256.20	75.48	3.39
13	18.9	172	103.2	269	172	61.32	2.80	103.20	76.51	1.35
19	19.3	321	192.6	269	269	62.19	4.33	192.60	77.65	2.48
24	14.5	189	113.4	269	189	62.19	3.04	113.40	77.65	1.46
30	18.1	145	87	269	145	61.32	2.36	87.00	76.51	1.14
35	16.8	202	121.2	269	202	60.52	3.34	121.20	75.48	1.61
40	22.2	236	141.6	269	236	59.72	3.95	141.60	74.44	1.90

* ASD Factor of Safety = (Minimum of Davisson Pile Axial Capacity or Structural Capacity of Pile) /Maximum Pile Service Load

** LFD Service Factor =(Minimum of Davisson Pile Axial Capacityx0.6 or Structural Capacity of Pile) /Maximum Pile LFD Load

Bear Cut New Dead Load

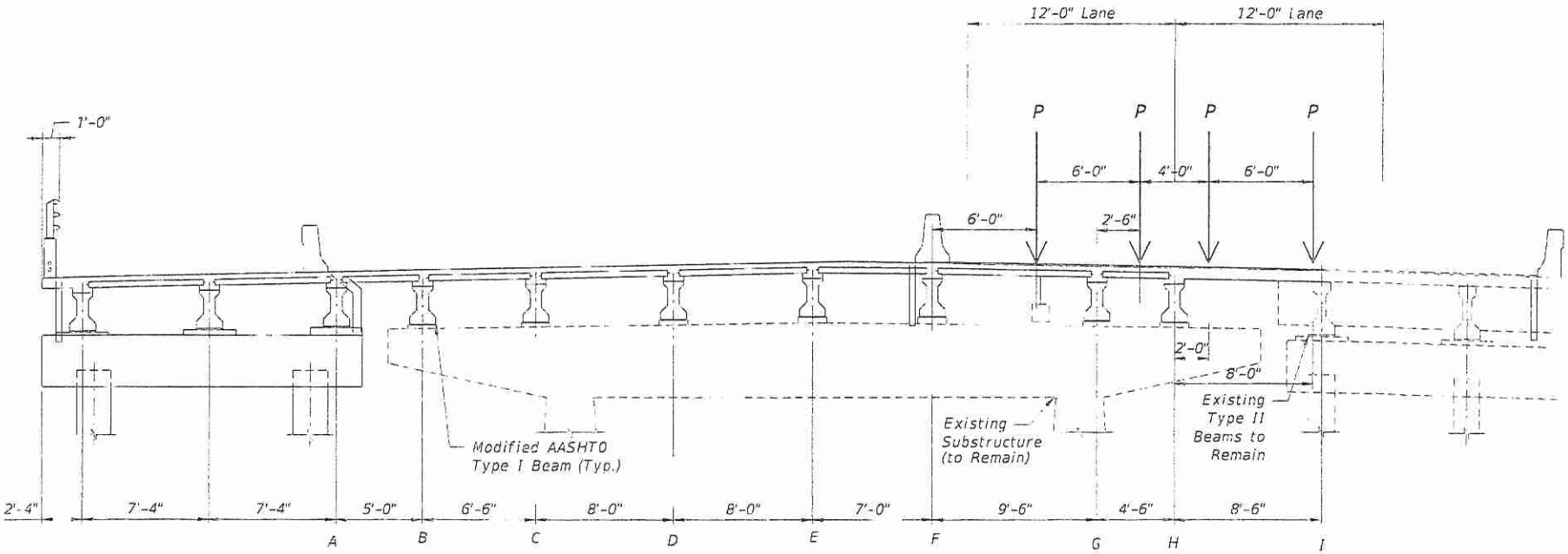
Beam	Slab Width ft	Slab Thickness ft	Beam Area ft^2	Buildup Area ft^2	Barrier Load k/ft	Contributary Length ft	Total Weight K
B	5.75	0.624	2.111	0.152	0.069	51.166	48.4362939
C	7.25	0.624	2.111	0.152	0.069	51.166	55.6200003
D	8	0.624	2.111	0.152	0.069	51.166	59.2118535
E	7.5	0.624	2.111	0.152	0.069	51.166	56.8172847
F	8.25	0.708	2.111	0.152	0.069	51.166	65.7278436
G	7	0.762	2.111	0.152	0.069	51.166	61.8366693
H	6.5	0.791	2.111	0.152	0.069	51.166	60.35925105
						Total	408.0091964


12'-0" Lane
12'-0" Lane
P
P
P
P
1'-0"
6'-0"
4'-0"
6'-0"
2'-6"
1'-6"
2'-0"
Modified AASHTO
Type I Beam (Typ.)
Existing
Substructure
(to Remain)
Existing
Type II
Beams to
Remain
2'-4"
7'-4"
7'-4"
5'-0"
6'-6"
8'-0"
8'-0"
7'-0"
9'-6"
4'-6"
8'-6"
A
B
C
D
E
F
G
H
I

CASE 1

Bear Cut Bridge CASE 1 NEW

	Beam Spacing	Wheel 1	Wheel 2	Cantilever	Sum	LLDF (Lane)	Truck Load (1 Lane)	MPF	Beam Load
A		0.7	0	0	0.7	0.35	61.1	1.00	
	5.00	1.5							
B1		0.3	0						
B2		0.615385	0		0.915385	0.457692308	61.1	1.00	27.97
	6.50	2.5							
C1		0.384615	0						
C2		0.75	0.0025		1.137115	0.568557692	61.1	1.00	34.74
	8.00	2	7.98						
D1		0.25	0.9975						
D2		0	0		1.2475	0.62375	61.1	1.00	38.11
	8.00	0	0						
E1		0	0						
E2		0	0		0	0	61.1	1.00	0.00
	7.00	0							
F1		0	0						
F2		0	0		0	0	61.1	1.00	0.00
	9.50								
G1		0	0						
G2		0	0		0	0	61.1	1.00	0.00
	4.50								
H1		0	0						
H2		0	0		0	0	61.1	1.00	0.00
	8.50								
I1		0	0						
								Sum	100.82



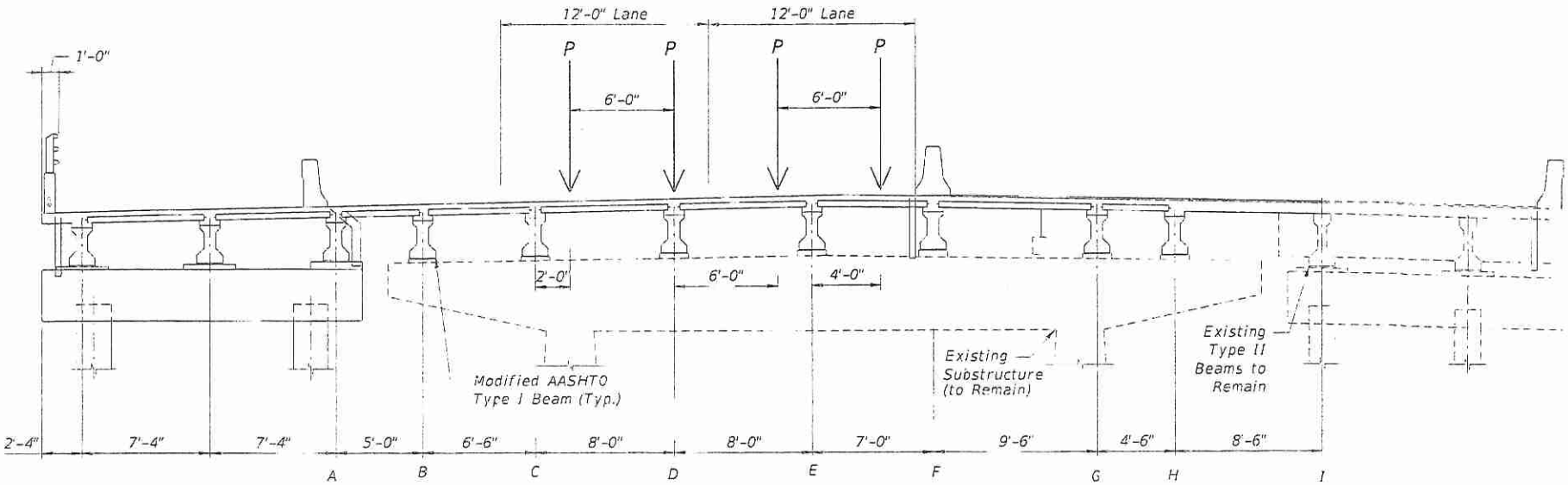
COMPLETED STRUCTURE

CASE 2

Bear Cut Bridge CASE 2 NEW

	Beam Spacing	Wheel 1	Wheel 2	Cantilever	Sum	LLDF (Lane)	Truck Load (1 Lane)	MPF	Beam Load
A		0	0	0	0	0	61.1	1.00	
	5.00								
B1		0	0						
B2		0	0		0	0	61.1	1.00	0.00
	6.50								
C1		0	0						
C2		0	0		0	0	61.1	1.00	0.00
	8.00								
D1		0	0						
D2		0	0		0	0	61.1	1.00	0.00
	8.00								
E1		0	0						
E2		0	0		0	0	61.1	1.00	0.00
	7.00								
F1		0	0						
F2		0.368421	0		0.368421	0.184210526	61.1	1.00	11.26
	9.50	6							
G1		0.631579	0						
G2		0.444444	0		1.076023	0.538011696	61.1	1.00	32.87
	4.50	2.5							
H1		0.555556	0						
H2		0.764706	0.058824		1.379085	0.689542484	61.1	1.00	42.13
	8.50	2	8						
I1		0.235294	0.941176						
					1.176471				

Sum 86.26

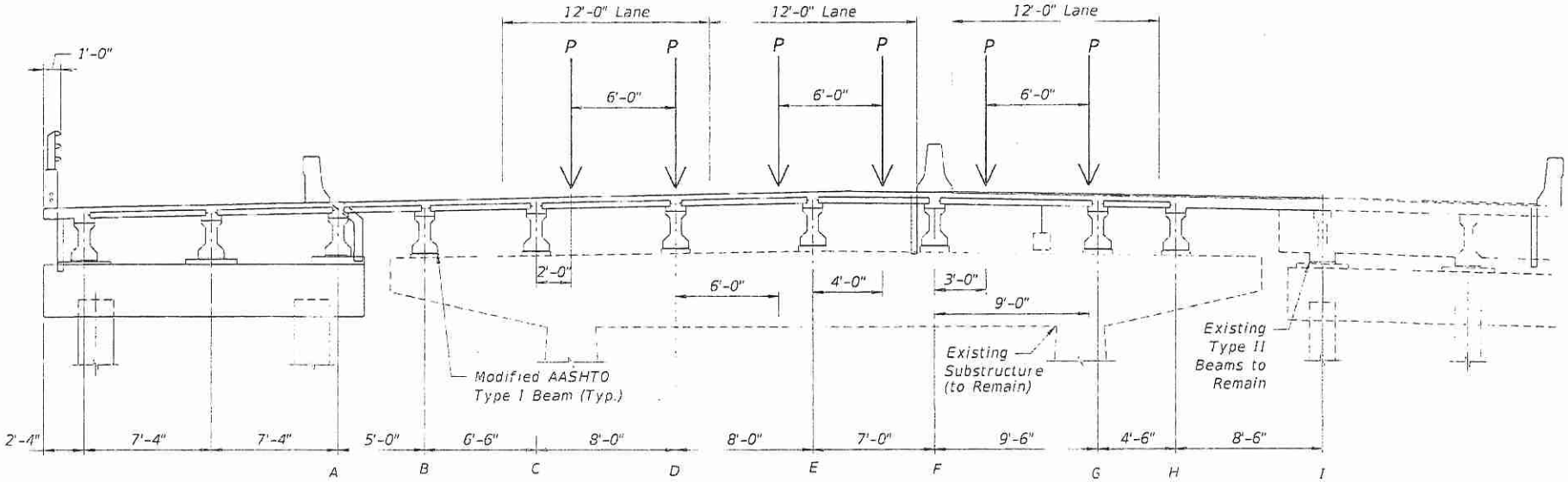


COMPLETED STRUCTURE

CASE 3

Bear Cut Bridge CASE 3 NEW

	Beam Spacing	Wheel 1	Wheel 2	Cantilever	Sum	LLDF (Lane)	Truck Load (1 Lane)		MPF	Beam Load
A		0	0	0	0	0	61.1	1.00		
	5.00	0								
B1		0	0							
B2		0	0		0	0	61.1	1.00		0.00
	6.50	0								
C1		0	0							
C2		0.75	0.0025		0.7525	0.37625	61.1	1.00		22.99
	8.00	2	7.98							
D1		0.25	0.9975							
D2		0.25	0		1.4975	0.74875	61.1	1.00		45.75
	8.00	6	0							
E1		0.75	0							
E2		0.428571	0		1.178571	0.589285714	61.1	1.00		36.01
	7.00	4								
F1		0.571429	0							
F2		0	0		0.571429	0.285714286	61.1	1.00		17.46
	9.50									
G1		0	0							
G2		0	0		0	0	61.1	1.00		0.00
	4.50									
H1		0	0							
H2		0	0		0	0	61.1	1.00		0.00
	8.50									
I1		0	0							
					0					
								Sum		122.20

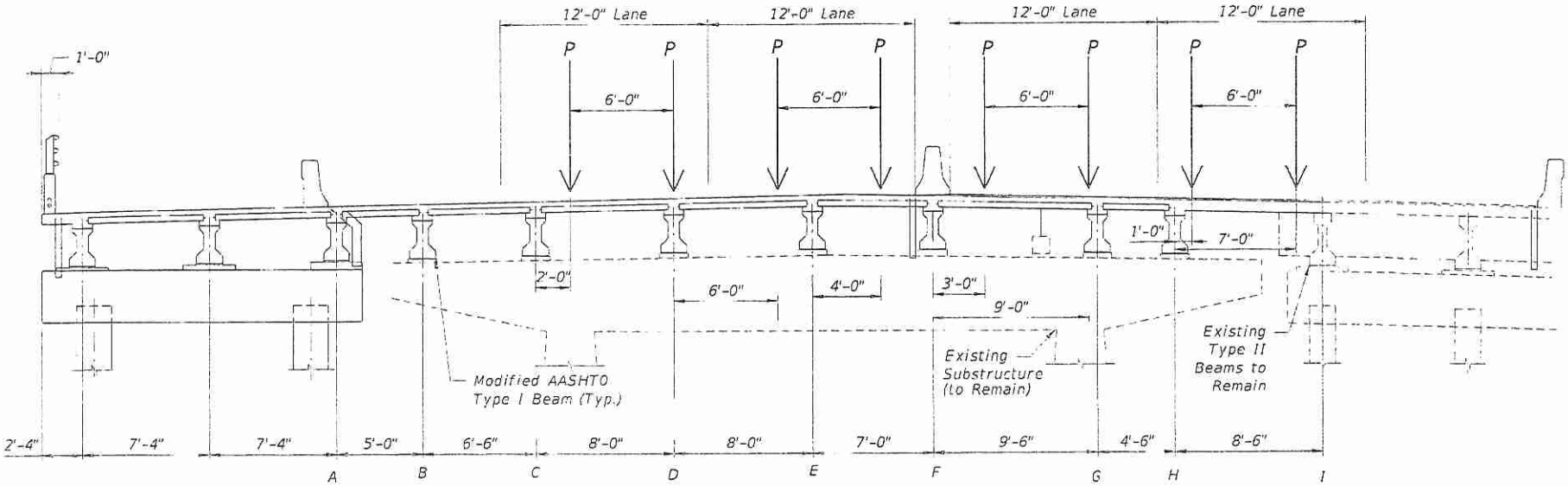


COMPLETED STRUCTURE

CASE 4

Bear Cut Bridge CASE 4 NEW

	Beam Spacing	Wheel 1	Wheel 2	Cantilever	LLDF (Wheels)	LLDF (Lane)	Truck Load (1 Lane)	MPF	Beam Load
A		0	0	0	0	0	61.1	0.90	
	5.00								
B1		0	0						
B2		0	0		0	0	61.1	0.90	0.00
	6.50								
C1		0	0						
C2		0.75	0.0025		0.7525	0.37625	61.1	0.90	20.69
	8.00	2	7.98						
D1		0.25	0.9975						
D2		0.25	0		1.4975	0.74875	61.1	0.90	41.17
	8.00	6	0						
E1		0.75	0						
E2		0.428571	0		1.178571429	0.589285714	61.1	0.90	32.40
	7.00	4							
F1		0.571429	0						
F2		0.684211	0.052632		1.308270677	0.654135338	61.1	0.90	35.97
	9.50	3	9						
G1		0.315789	0.947368						
G2		0	0		1.263157895	0.631578947	61.1	0.90	34.73
	4.50								
H1		0	0						
H2		0	0		0	0	61.1	0.90	0.00
	8.50								
I1		0	0						
					0				
				sum	6				
								Sum	164.97



COMPLETED STRUCTURE

CASE 5

Bear Cut Bridge CASE 5 NEW

	Beam Spacing	Wheel 1	Wheel 2	Cantilever	LLDF (Wheels)	LLDF (Lane)	Truck Load (1 Lane)	MPF	Beam Load
A		0	0	0	0	0	61.1	0.75	
	5.00								
B1		0	0						
B2		0	0		0	0	61.1	0.75	0.00
	6.50								
C1		0	0						
C2		0.75	0.0025		0.7525	0.37625	61.1	0.75	17.24
	8.00	2	7.98						
D1		0.25	0.9975						
D2		0.25	0		1.4975	0.74875	61.1	0.75	34.31
	8.00	6	0						
E1		0.75	0						
E2		0.428571	0		1.178571429	0.589285714	61.1	0.75	27.00
	7.00	4							
F1		0.571429	0						
F2		0.684211	0.052632		1.308270677	0.654135338	61.1	0.75	29.98
	9.50	3	9						
G1		0.315789	0.947368						
G2		0	0		1.263157895	0.631578947	61.1	0.75	28.94
	4.50								
H1		0	0						
H2		0.882353	0.176471		1.058823529	0.529411765	61.1	0.75	24.26
	8.50	1	7						
I1		0.117647	0.823529						
					0.941176471				
				sum	8				
								Sum	161.74

tierra
SOUTH FLORIDA
GEOTECHNICAL ENGINEERING · MATERIAL TESTING · INSPECTION SERVICES

August 15, 2013

Hardesty & Hanover, LLP
1000 Sawgrass Corporate Parkway, Suite 544
Sunrise, Florida 33323

Attn: John Low, P.E.
Project Manager

RE: **Engineering Services Report for Unknown Foundation**
Bear Cut Original Bridge
Miami-Dade County, Florida
TSF Project No.: 7111-13-118

Dear John:

Tierra South Florida, Inc. (TSF) has performed a Geotechnical Engineering Service for the subject project. The results of our field exploration program and subsequent Geotechnical evaluations are presented in this report.

TSF appreciates the opportunity to be of service to Hardesty & Hanover, LLP on this project and looks forward to working with you on future projects. If you have any questions or comments regarding this report, please contact our office at your earliest convenience.

Sincerely,

TIERRA SOUTH FLORIDA, INC.

for N. Krishnasamy
Raj Krishnasamy, P.E.
President
FL. Registration No.53567

Wenbin Zhao
Wenbin Zhao, Ph.D.
Staff Engineer

RAMAKUMAR V. VEDULA
LICENSE
No. 54873
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

8/16/13
Ramakumar Vedula, P.E.
Principal Engineer
FL. Registration No.54873

Table of Contents

1.0 PROJECT BACKGROUND AND DESCRIPTIONS 1
2.0 SCOPE OF SERVICES 1
3.0 FIELD EXPLORATIONS 2
3.1 Field Work 2
3.2 General Soil Condition 2
4.0 EXISTING PILE FOUNDATION 3
4.1 General 3
4.2 Pile Information 3
5.0 ENGINEERING EVALUATIONS AND DISCUSSIONS 4
5.1 Pile Axial Capacity - General 4
5.2 Axial Capacity Analysis Method 4
5.3 Analysis Results 5
5.4 Pile Lateral Load Analysis 7
6.0 CONCLUSIONS 7
7.0 REPORT LIMITATIONS 7

APPENDIX – A: Boring Location and Soil Profiles
APPENDIX – B: Existing Records with Pile Information
APPENDIX – C: Pile Axial Capacity Analysis Results
APPENDIX – D: Soil Parameters for FB-Pier Analysis
APPENDIX – E: Report of Parallel Seismic Testing by AFT

1.0 PROJECT BACKGROUND AND DESCRIPTIONS

The project, as we understand it, is to rehabilitate West Bridge (Bridge No. 874541) and Bear Cut Bridge (Bridge No. 874544) in Miami-Dade County, Florida. Additionally, Bear Cut Bridge will be widened on the north side to provide additional space for pedestrian and bicycle traffic.

The Bear Cut Bridge connects Virginia Key and Key Biscayne on Rickenbacker Causeway. The original Bear Cut Bridge was built in 1944 and widened later in 1984 on the south side of the bridge.

The rehabilitation plan of the original Bear Cut Bridge, based on the Miami-Dade County's Request For Proposal (RFP) of this project, calls for reuse of the existing bridge substructure (piles, pile caps, pier columns and girders), while the original bridge superstructure (bridge deck and beams) will be demolished and rebuilt. Additionally, some repair work, such as spall repairs, will be performed to the existing substructures. However, there are concerns about the capabilities of the 1944 bridge foundation among the County and bridge users. The Design-Build team was assigned with additional services on top of the ongoing bridge rehabilitation contract to evaluate the existing foundation of the original Bear Cut Bridge.

The purpose of this study was to provide Geotechnical (i.e. soils and groundwater) input to the design team and perform limited foundation axial capacity analysis to assist in evaluation of the existing pile foundations of the original Bear Cut Bridge.

2.0 SCOPE OF SERVICES

To fulfill the project objectives, the following services were provided:

- Drilled at 8 bridge pier locations and installed a 140-foot PVC casing for Parallel Seismic Testing (PST) at each location.
- Provided pontoon boat and a boat operator to assist in PST testing conducted by Applied Foundation Testing (AFT).
- Performed pile axial capacity analyses and prepared soil parameters for FB-pier analysis.
- Prepared this Geotechnical Service Report for the unknown foundations.

These Geotechnical Services were performed in general accordance with Miami-Dade County Standards and the FDOT "Soils and Foundations Handbook".

The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater, or surface water within or beyond the site studied. Any statements in this report regarding odors, staining of soils, or other unusual conditions observed are strictly for the information of our client.

3.0 FIELD EXPLORATIONS

3.1 Field Work

Since no pile driving records of the existing bridge are available, the team had to take efforts to determine the pile type and penetration depths. The method to determine pile length in this project is to conduct Parallel Seismic Testing (PST). The services were carried out in field by AFT.

To conduct PST tests, a hole has to be drilled into ground and PVC casing will be installed in the drilled hole and filled with water. A hydrophone, a PST instrument, will be lowered down into the PVC pipe to various depths during the testing. Also, the PVC casing needs to be close to the targeted pile; the closer the casing the more effective the test will be.

Eight locations across the bridge were selected to conduct PST tests in this study. They are at the north footings of Piers 5, 8, 13, 19, 24, 30, 35, and 40. The PVC casings were installed right off the pile caps (footings) at the center point on the east side. In this way, the PVC casings would be closest to the targeted piles, which are the plumb piles underneath the pile caps at the center. After the PVC casings were placed in position, the gap between the boreholes and casings were backfilled with sand.

The boreholes were created by conducting Standard Penetration Test (SPT) and SPT borings can provide subsurface soil information at the test locations that will be used further in the unknown foundation evaluation. The borings were performed from the existing ridge deck, drilled to depths of 80 and 100 feet below the seabed.

Approximate locations of the borings are presented on Report of Core Borings in Appendix A. The SPT borings were drilled using a D-50 (equipped with a safety hammer) drill rig and mud rotary procedures. In the borings, samples of the in-place materials were obtained continuously in the upper 10 feet and at a 2.5-foot interval thereafter.

The samples of the in-place soils were returned to our laboratory for classification by a geotechnical engineer. The samples were visually classified in general accordance with the ASTM Unified Soil Classification System. Approximate locations and Soil profiles of the borings are presented in the Appendix A.

3.2 General Soil Condition

The subsurface conditions encountered at the site below the top soil typically consisted of sand and sandy limestone. The SPT N values indicate that the sands are generally in loose to very dense conditions.

A Geotechnical engineer based soil stratification on a visual review of the recovered samples, laboratory testing, and interpretation of the field boring logs. The boring stratification lines represent the approximate boundaries between soil types of significantly different engineering

properties; however, the actual transition may be gradual. In some cases, small variations in properties not considered pertinent to our engineering evaluation may have been abbreviated or omitted for clarity. The boring profiles represent the conditions at the particular boring location and variations do occur among the borings.

4.0 EXISTING PILE FOUNDATION

4.1 General

The bridge substructure consists of two abutments and forty intermediate bridge piers. Each pier has 2 columns; each column is supported by a footing/ pile cap with a cluster of 5 piles underneath. Four piles are on the four corners of the pile cap; one pile is at the center. Previous construction plans (Appendix B) and field observations show the four corner piles are battered and the center pile is plumb. Also, some the piles were jacketed during 1980's.

4.2 Pile Information

There are no previous construction records for the piles. The field observation and information from the piling repair plan confirmed the piles are monotube piles. The monotube piles used on the original Bear Cut Bridge was manufactured by The Union Metal Manufacturing Co. Later, the company actually making this pile has gone through several corporate changes over the years. However, the Monotube pile products have not changed since.

A monotube always consists of a tapered lower section and constant-diameter upper section, and is cold-rolled and fluted for extra strength. The tip of monotube pile is closed with reinforced steel.

The document in Appendix B shows the monotube products used on the project were 45 feet long. We understand that, based on the conversation between structure engineers (H&H) and the Monotube manufacture, 8-inch tip diameter has been the standard since 1920 and occasionally, pile with tip diameters of 6 to 12 inches might have been produced. Based on the available information and the monotube product online catalog (www.monotube.com), the piles used on the bridge are believed to be Y Taper monotube and the geometric properties are provided in the following tables.

Taper Type	Taper Angle (degree), ω	Steel Shell Thickness (gauge)	Tip Diameter (in)	Tapered Section Length (ft)	Butt Diameter (in)	Constant Diameter Section Length (ft)
Y Taper (.40 Inch Per Foot)	0.95	7	8	25	18	20

The actual embedments of the piles were unknown to us. Eight piles were selected to determine their lengths by performing PST tests. The tests were conducted by AFT, and the results in Appendix D. A summary of the estimated pile penetration is presented in the following table.

Pier No.	Estimated Pile Penetration (ft)	Estimated Variability in Pile Length Estimate (ft)	Lower Bound Penetration (ft)	Higher Bound Penetration (ft)
5	19.1	± 2 to 4	15.1	23.1
8	25.7	± 3 to 5	20.7	26.4
13	22.8	± 3 to 5	17.8	25.4
19	20.4	± 3 to 5	15.4	24.8
24	15.8	± 3 to 5	10.8	20.8
30	20.0	± 3 to 5	15.0	23.1
35	19.4	± 2 to 4	15.4	23.4
40	33.1	± 3 to 5	28.1	38.1

Note that information regarding Estimated Pile Penetration and Estimated Variability in Pile Length Estimate is obtained from AFT report; Lower Bound Penetration and Higher Bound Penetration were inferred from AFT data and also take the total pile length into account.

5.0 ENGINEERING EVALUATIONS AND DISCUSSIONS

5.1 Pile Axial Capacity - General

Since a small fraction of the bridge piles were tested to estimate the pile penetration and subsurface soil properties change from location to location, only the piles with estimated length from PSTs were analyzed for axial capacity evaluation.

5.2 Axial Capacity Analysis Method

In Florida, geotechnical engineers typically used FB-Deep computer program to estimate pile axial capacities. The program can analyze cylindrical pipe piles. However, piles used for the existing bridge foundation are montube steel tapered piles. Therefore, the FB-deep program is not suited to estimate the capacities of the tapered piles on the bridge.

Nordlund did research on tapered piles' skin resistance and published the results in 1963 and 1979 (reference 1&2). Later, his method was introduced in the development of a Windows based computer program, Driven 1.0, sponsored by U.S. Department of Transportation Federal Highway Administration; the program has a component to calculate the capacities of Monotube piles. We used his method to estimate the skin resistance of the tapered piles in this study and used Thurman's method to estimate the tip resistance. Both of the methods can be found in the User's Manual for Driven 1.0 program (reference 3).

5.3 Analysis Results

In our analysis, we use the Estimated Pile Penetration along with 8" pile tip diameter and without considering scour to establish a Baseline situation, and from there to estimate as the Baseline pile axial capacities at the test locations. Due to the intrinsic uncertainty involved in the unknown foundation analysis, three variables were considered to evaluate the variability of the pile capacity: Pile Penetration, Pile Tip Diameter, and scour. The detailed analysis results using the variation in these three variables are presented in Appendix C.

Capacity with Pile Penetration Variation

The AFT report gives the Estimated Pile Penetration. However, due to variations in the test itself, the variability in pile penetration were estimated up to ±5 feet. The uncertainty in pile penetration may introduce most variation in pile axial capacity. Lower and Higher Bound Penetration (Table in Page 4) were used to estimate the axial capacity and the results were compared with the Baseline capacity; a summary table is shown below.

Pier No.	Estimated Pile Penetration (ft)	Pile Axial Capacity with Pile Penetration Variation (kips)			Variation Range (Compared to Baseline)
		Estimated Pile Penetration, Baseline	Lower Bound Penetration	Higher Bound Penetration	
5	19.1	149	112	206	-25.1% ~ 38.0%
8	25.7	468	259	493	-44.6% ~ 5.4%
13	22.8	284	181	511	-36.2% ~ 80.0%
19	20.4	364	194	565	-46.8% ~ 55.2%
24	15.8	228	101	423	-55.9% ~ 85.3%
30	20.0	190	105	276	-44.8% ~ 45.0%
35	19.4	290	215	402	-25.7% ~ 39.0%
40	33.1	493	339	764	-31.3% ~ 55.0%
Average		308	188	455	-39.0% ~ 47.6%

Note: 8-in tip diameter was used and no scour was considered in the axial capacity estimates.

Capacity with Pile Tip Diameter Variation

In addition to the Baseline case, 6 and 12-in tip diameters were used in our analysis to evaluate the variability of pile capacities. The results are summarized in the following table. The results show that using an 8-in tip diameter is more conservative than using a 12-in tip diameter.

Pier No.	Estimated Pile Length (ft)	Pile Axial Capacity with Tip Diameter Variation (kips)			Variation Range (Compared to Baseline)
		8-in tip, Baseline	6-in tip	12-in tip	
5	19.1	149	134	180	-10.2% ~ 20.7%
8	25.7	468	419	572	-10.5% ~ 22.4%
13	22.8	284	252	351	-11.0% ~ 23.7%
19	20.4	364	325	447	-10.7% ~ 22.7%
24	15.8	228	197	296	-13.8% ~ 29.5%
30	20.0	190	165	243	-13.1% ~ 27.9%
35	19.4	290	262	345	-9.7% ~ 19.2%
40	33.1	493	429	629	-13.0% ~ 27.5%
Average		308	273	383	-11.5% ~ 24.2%

Note: Estimated Pile Length was used and no scour was considered in the axial capacity estimates.

Capacity with Scour Consideration

The last factor we considered in our analysis is scour. 100-year scour depths were used and the values were obtained from the scour study for the Bear Cut Bridge Widening project. The results are presented in the following summary table.

Pier No.	Estimated Pile Length (ft)	Scour Depth (ft)	Penetration after Scour (ft)	Pile Axial Capacity with Scour Depth (kips)		
				Baseline (without scour)	100-Year Scour	Decrease (compared to Baseline)
5	19.1	1.0	18.1	149	129	-13.4%
8	25.7	1.0	24.7	468	427	-8.7%
13	22.8	3.9	18.9	284	172	-39.4%
19	20.4	1.1	19.3	364	321	-11.8%
24	15.8	1.3	14.5	228	189	-17.2%
30	20	1.9	18.1	190	145	-24.0%
35	19.4	2.6	16.8	290	202	-30.4%
40	33.1	10.9	22.2	493	236	-52.2%
Average				308	228	-26.2%

Note: Estimated Pile Length and 8-inch tip diameter were used in the axial capacity estimates.

5.4 Pile Lateral Load Analysis

We understand that FB-Pier analysis will be performed by the Structural Engineer to evaluate lateral stability of the bridge. Soil parameters that can be used for lateral stability analysis are presented in the Appendix D.

6.0 CONCLUSIONS

In this Bear Cut Bridge unknown foundation evaluation project, we conducted 8 SPT borings near the existing piles, installed PVC casing for PST tests, provided auxiliary assistance during field PST tests. Subsequently, we performed pile axial capacity analysis using Nordlund's method for skin resistance and Thurman's method for ultimate tip resistance estimates. The average ultimate capacity for a baseline situation (using Estimated Pile Penetration from AFT report, 8-inch tip diameter monotube piles, and no scour) is 308 kips. The variations in pile capacity were evaluated by considering the uncertainty in pile penetration, tip diameter, and scour.

It should be noted that our scope is limited to evaluating the axial pile capacity for the Estimated Pile Penetration of the existing piles. Evaluating the structural integrity of the existing piles is not included in our scope.

7.0 REPORT LIMITATIONS

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This company is not responsible for the conclusions, opinions, or recommendations made by others based on this data.

The scope of the investigation was intended to evaluate soil conditions within the influence zone of the foundations. The analysis and recommendations submitted in this report are based upon the data obtained from the soil borings performed at the locations indicated. If any subsoil variations become evident during the course of this project, a re-evaluation of the recommendations contained in this report will be necessary after we have had an opportunity to observe the characteristics of the condition encountered. The applicability of the report should also be reviewed in the event significant changes occur in the design, nature or location of the proposed structure.

The recommendations presented previously represent design and construction techniques that we feel are both applicable and feasible for the planned construction. We recommend, however, that we be provided the opportunity to review the final foundation plans to evaluate whether our recommendations have been properly interpreted and implemented.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted

professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

This preliminary Geotechnical report has been prepared for the exclusive use of Hardesty & Hanover, LLP. for the specific application to the original Bear Cut Bridge Evaluation over Biscayne Bay in Miami-Dade County, Florida.

Reference:

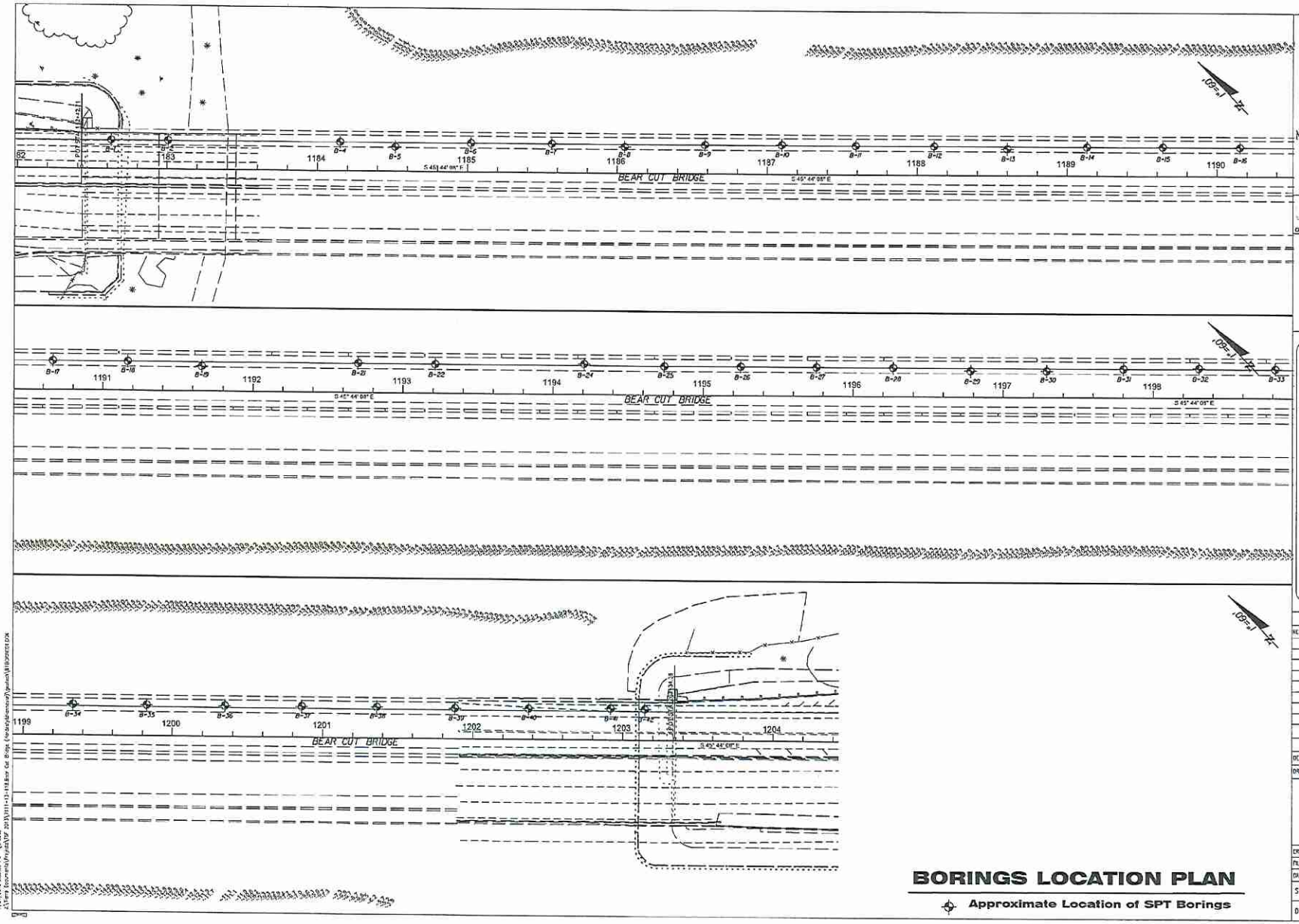
1. Nordlund, R.L. (1963), "Bearing Capacity of Piles in Cohesionless Soils," ASCE, SM&F Journal SM-3.

2. Nordlund, R.L. (1979), "Point Bearing and Shaft Friction of Piles in Sand," 5th Annual Fundamentals of Deep Foundation Design, University of Missouri-Rolla.

3. Mathias, D. and Cribbs, M (1998), "Driven 1.0: A Microsoft Windows™ Based Program for Determining Ultimate Vertical Static Pile Capacity", Report No. FHWA-SA-98-074.

Appendix – A

Boring Location and Soil Profiles



BORINGS LOCATION PLAN

Approximate Location of SPT Borings

MIAMI-DADE COUNTY
Delivering Excellence Every Day

PUBLIC WORKS AND WASTE MANAGEMENT

PUBLIC WORKS

STEPHEN CLARK CENTER
111 NW 1st STREET, 16th FLOOR
MIAMI, FLORIDA 33128
305-375-2900

RAJ KRISHNASAMY, P.E.
P.E. LICENSE NUMBER 53587
TERRA SOUTH FLORIDA
2965 VISTA PARKWAY, S-10
WEST PALM BEACH, FL 33411
CERTIFICATE OF AUTHORIZATION 28075

REHABILITATION OF BRIDGES NOS.
874541 (WEST BRIDGE) AND 874544 (BEAR CUT BRIDGE)
RICKENBACKER CAUSEWAY, MIAMI-DADE COUNTY

DRAWING ISSUED

REVISION No.	DESCRIPTION	DATE	BY
A			
B			
C			
D			

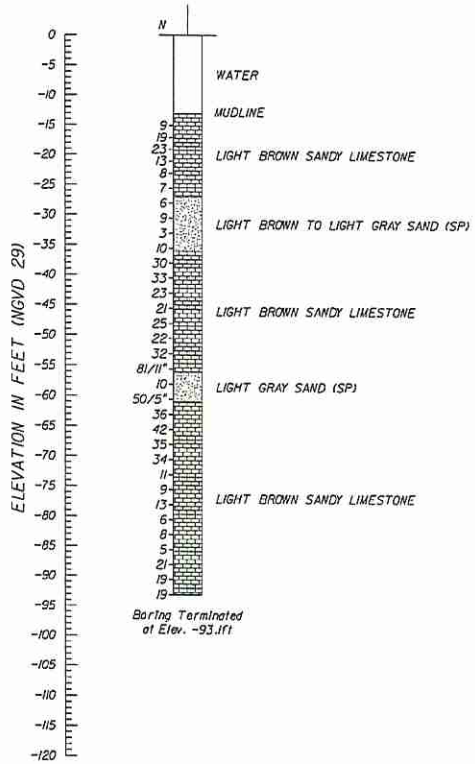
APPROVED

DESIGNED: NG CHECKED: JC
DRAWN: NG FINAL CHECK: RJ

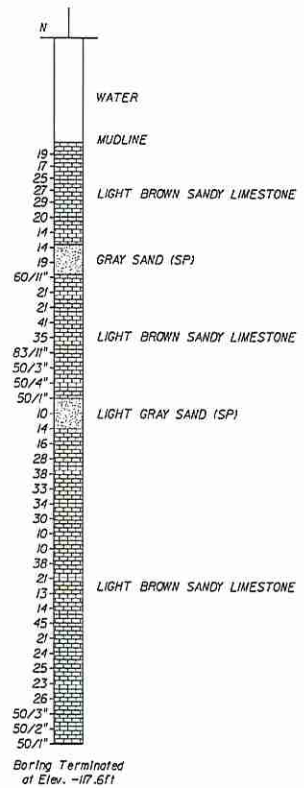
Date:

CR No. PCTS No.
FILE NAME:
DATE: SCALE:
SHEET:
DWG.:

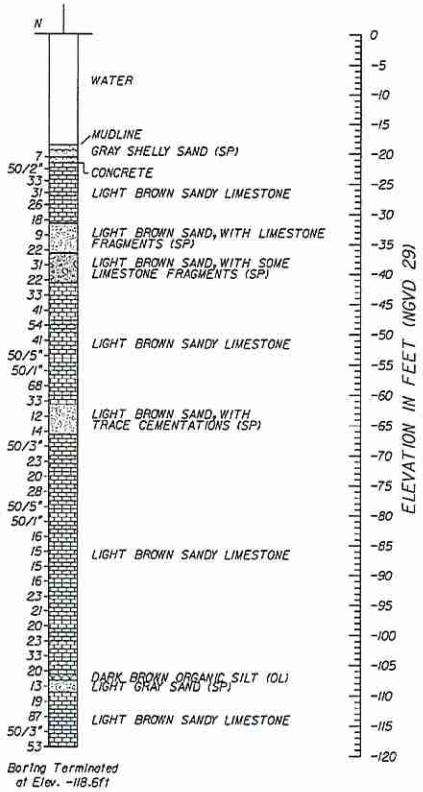
BOR # B-5
STA. 1184+52.3 CL_BEARCUT
OFF. 17.0' LT
ELEV. -13.1
DATE 7/9/2013
HAMMER Safety
RIG D-50
NORTHING 509199.91
EASTING 932511.12



BOR # B-8
STA. 1186+5.0 CL_BEARCUT
OFF. 17.0' LT
ELEV. -17.6
DATE 6/21/2013
HAMMER Safety
RIG D-50
NORTHING 509093.9096
EASTING 932621.5793



BOR # B-13
STA. 1188+60.2 CL_BEARCUT
OFF. 17.0' LT
ELEV. -18.6
DATE 6/21/2013
HAMMER Safety
RIG D-50
NORTHING 509891.5.971
EASTING 932804.3577



Shelly Sand
Limestone
Sand
Gravelly Sand
Concrete
Muck

NOTES:

▽ WATER TABLE

N NUMBERS TO THE LEFT OF BORINGS INDICATE SPT VALUE FOR 12" PENETRATION. (UNLESS OTHERWISE NOTED.)

MC=	NATURAL MOISTURE CONTENT (%)
-200=	FINES PASSING #200 SIEVE (%)
OC=	ORGANIC CONTENT (%)
LL=	LIQUID LIMIT (%)
PI=	PLASTICITY INDEX (%)
NP=	INDICATES NON-PLASTIC
WOH=	WEIGHT OF HAMMER

STRATA BOUNDARIES ARE APPROXIMATE AND MAY VARY BETWEEN OR AWAY FROM BORING LOCATIONS.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 Inches
SPOON OUTSIDE DIA.	2.0 Inches
AVG. HAMMER DROP	30.0 Inches
HAMMER WEIGHT	140.0 pounds

SPT CONSISTENCY CHART

SILTS AND CLAYS

CONSISTENCY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY SOFT	LESS THAN 2	LESS THAN 1
SOFT	2 - 4	1 - 3
FIRM	4 - 8	3 - 6
STIFF	8 - 15	6 - 12
VERY STIFF	15 - 30	12 - 24
HARD	GREATER THAN 30	GREATER THAN 24

SPT DENSITY CHART

GRANULAR MATERIALS

RELATIVE DENSITY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY LOOSE	LESS THAN 4	LESS THAN 3
LOOSE	4 - 10	3 - 8
MEDIUM	10 - 30	8 - 24
DENSE	30 - 50	24 - 40
VERY DENSE	GREATER THAN 50	GREATER THAN 40

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PUBLIC WORKS AND WASTE MANAGEMENT

PUBLIC WORKS

STEPHEN CLARK CENTER
111 NW 1st STREET, 16th FLOOR
MIAMI, FLORIDA 33128
305-375-2300

RAJ KRISHNASAMY, P.E.
P.E. LICENSE NUMBER 57567
TERRA SOUTH FLORIDA
2765 VISTA PARKWAY, S-10
WEST PALM BEACH, FL 33411
CERTIFICATE OF AUTHORIZATION 7005

REHABILITATION OF BRIDGES NOS. 874541 (WEST BRIDGE) AND 874544 (BEAR CUT BRIDGE) RICKENBACKER CAUSEWAY, MIAMI-DADE COUNTY

DRAWING ISSUED

REVISION	No.	DESCRIPTION	DATE	BY
	A			
	B			
	C			
	D			

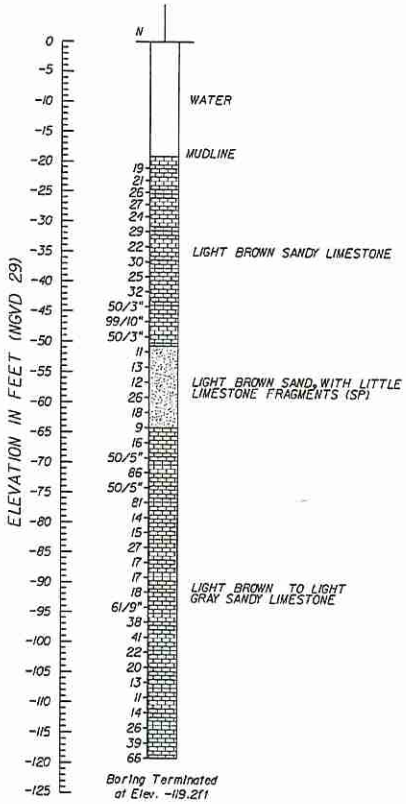
APPROVED

DESIGNED: WZ CHECKED: JD
DRAWN: HC FINAL CHECK: RJ

Refer:

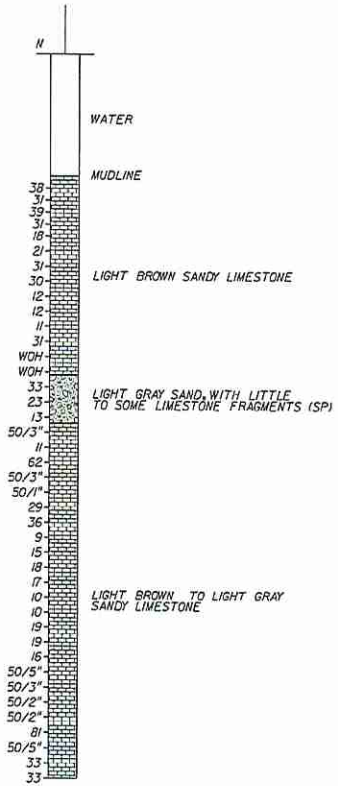
ER file: PCTS file:
FILE NAME:
DATE: SCALE:
SHEET:
DWG.:

BOR # B-19
STA. 1191+66.0 CL_BEARCUT
OFF. 16.24' LT
ELEV. -19.2
DATE 6/14/2013
HAMMER Safety
RIG D-50
NORTHING 933022.58
EASTING 508701.56



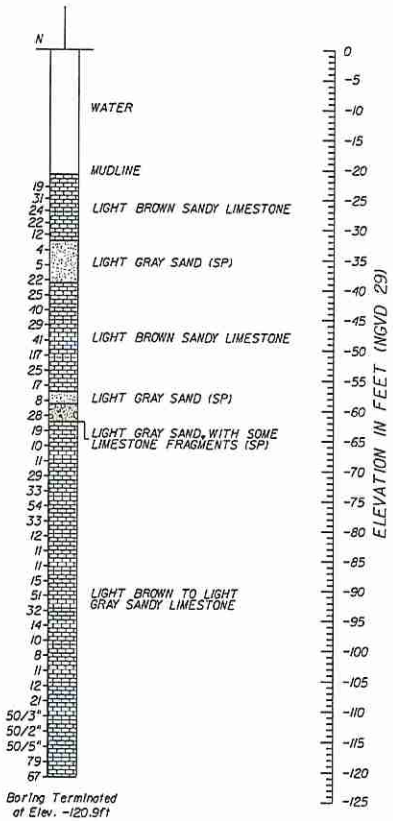
Boring Terminated at Elev. -119.2ft

BOR # B-24
STA. 1194+21.1 CL_BEARCUT
OFF. 17.0' LT
ELEV. -20.4
DATE 7/2/2013
HAMMER Safety
RIG D-50
NORTHING 508526.50
EASTING 933207.70



Boring Terminated at Elev. -120.4ft

BOR # B-30
STA. 1197+27.2 CL_BEARCUT
OFF. 17.0' LT
ELEV. -20.9
DATE 6/29/2013
HAMMER Safety
RIG D-50
NORTHING 508309.46
EASTING 933426.60



Boring Terminated at Elev. -120.9ft

SHELL
Silty Sand
Limestone
Sand
Gravelly Sand

NOTES:

▽ WATER TABLE

N NUMBERS TO THE LEFT OF BORINGS INDICATE SPT VALUE FOR 12" PENETRATION. (UNLESS OTHERWISE NOTED.)

MC=	NATURAL MOISTURE CONTENT (%)
-200=	FINES PASSING #200 SIEVE (%)
OC=	ORGANIC CONTENT (%)
LL=	LIQUID LIMIT (%)
PI=	PLASTICITY INDEX (%)
NP=	INDICATES NON-PLASTIC
WOH=	WEIGHT OF HAMMER

STRATA BOUNDARIES ARE APPROXIMATE AND MAY VARY BETWEEN OR AWAY FROM BORING LOCATIONS.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 Inches
SPOON OUTSIDE DIA.	2.0 Inches
AVG. HAMMER DROP	30.0 Inches
HAMMER WEIGHT	140.0 pounds

SPT CONSISTENCY CHART

SILTS AND CLAYS

CONSISTENCY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY SOFT	LESS THAN 2	LESS THAN 1
SOFT	2 - 4	1 - 3
FIRM	4 - 8	3 - 6
STIFF	8 - 15	6 - 12
VERY STIFF	15 - 30	12 - 24
HARD	GREATER THAN 30	GREATER THAN 24

SPT DENSITY CHART

GRANULAR MATERIALS

RELATIVE DENSITY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY LOOSE	LESS THAN 4	LESS THAN 3
LOOSE	4 - 10	3 - 8
MEDIUM	10 - 30	8 - 24
DENSE	30 - 50	24 - 40
VERY DENSE	GREATER THAN 50	GREATER THAN 40

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PUBLIC WORKS AND WASTE MANAGEMENT

PUBLIC WORKS
STEPHEN CLARK CENTER
111 NW 1st STREET, 16th FLOOR
MIAMI, FLORIDA 33128
305-375-2950

RAJ KRISHNASAMY, P.E.
P.E. LICENSE NUMBER 53560
TERRA SOUTH FLORIDA
2155 VISTA PARKWAY, S-D
WEST PALM BEACH, FL 33411
CERTIFICATE OF AUTHORIZATION 29673

REHABILITATION OF BRIDGES NOS. 874541 (WEST BRIDGE) AND 874544 (BEAR CUT BRIDGE)
RICKENBACKER CAUSEWAY, MIAMI-DADE COUNTY

DRAWING ISSUED

REVISION No.	DESCRIPTION	DATE	BY
A			
B			
C			
D			

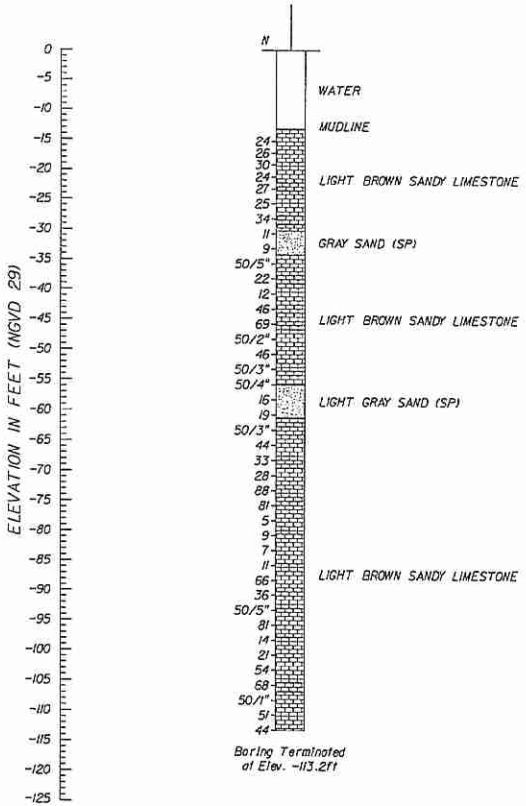
APPROVED

DESIGNED: NZ CHECKED: JS
DRAWN: BG FINAL CHECK: RJ

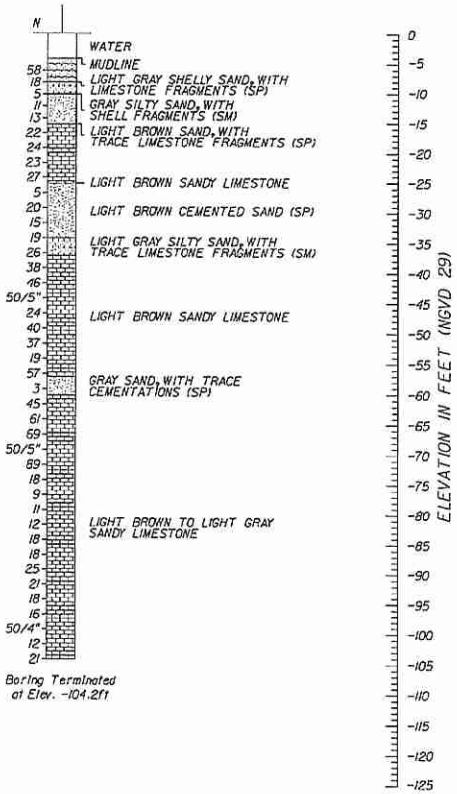
Date:

DR. No: PCTS No:
FILE NAME:
DATE: SCALE:
SHEET:
DWG.:

BOR # B-35
STA. 1199+82.1 CL_BEARCUT
OFF. 17.0' LT
ELEV. -13.22
DATE 6/25/2013
HAMMER Safety
RIG D-50
NORTHING 508134.0864
EASTING 933610.3507



BOR # B-40
STA. 1202+37.1 CL_BEARCUT
OFF. 17.0' LT
ELEV. -4.2
DATE 6/27/2013
HAMMER Safety
RIG D-50
NORTHING 507956.74
EASTING 933792.35



Limestone

Sand

Gravelly Sand

NOTES:

▽ WATER TABLE

N NUMBERS TO THE LEFT OF BORINGS INDICATE SPT VALUE FOR 12" PENETRATION. (UNLESS OTHERWISE NOTED.)

MC=	NATURAL MOISTURE CONTENT (%)
-200=	FINES PASSING #200 SIEVE (%)
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LL=	LIQUID LIMIT (%)
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WOH=	WEIGHT OF HAMMER

STRATA BOUNDARIES ARE APPROXIMATE AND MAY VARY BETWEEN OR AWAY FROM BORING LOCATIONS.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 Inches
SPOON OUTSIDE DIA.	2.0 Inches
AVG. HAMMER DROP	30.0 Inches
HAMMER WEIGHT	140.0 pounds

SPT CONSISTENCY CHART

SILTS AND CLAYS

CONSISTENCY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY SOFT	LESS THAN 2	LESS THAN 1
SOFT	2 - 4	1 - 3
FIRM	4 - 8	3 - 6
STIFF	8 - 15	6 - 12
VERY STIFF	15 - 30	12 - 24
HARD	GREATER THAN 30	GREATER THAN 24

SPT DENSITY CHART

GRANULAR MATERIALS

RELATIVE DENSITY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
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LOOSE	4 - 10	3 - 8
MEDIUM	10 - 30	8 - 24
DENSE	30 - 50	24 - 40
VERY DENSE	GREATER THAN 50	GREATER THAN 40

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PUBLIC WORKS

STEPHEN CLARK CENTER
111 NW 1st STREET, 14th FLOOR
MIAMI, FLORIDA 33128
305-375-2166

RAJ KRISHNASAMY, P.E.
P.E. LICENSE NUMBER 53507
TIERRA SOUTH FLORIDA
2765 VISTA PARKWAY, S-13
WEST PALM BEACH, FL 33411
CERTIFICATE OF AUTHORIZATION 8073

REHABILITATION OF BRIDGES NOS. 874541 (WEST BRIDGE) AND 874544 (BEAR CUT BRIDGE)
RICKENBACKER CAUSEWAY, MIAMI-DADE COUNTY

DRAWING ISSUED

REVISION No	DESCRIPTION	DATE	BY
A			
B			
C			
D			

APPROVED

DESIGNED: WZ CHECKED: JO
DRAWN: AG FINAL CHECK: RJ

Date:

ITI No: PCTS No:
FILE NAME:
DATE: SCALE:
SHEET:
DWG.:

APPENDIX – B

Existing Records with Pile Information:

Magazine Article of Monotube used in the bridge

Previous Piling Repair Plan (1980's)

Built by Board of County Commissioners, Dade Co., Fla., Earle M. Rader, County Engineer. J. E. Greiner Co., Consulting Engineers.

ON THE RICKENBACKER CAUSEWAY

AGAIN Monotubes play an important part in an engineering triumph—the Rickenbacker Causeway, Miami, Fla.

1260 7-gauge Monotube tapered steel piles, 45′ long, with 18″ butt diameter, were used in the piers of the fixed-beam bridges for this project. Piles were capped at the water line.

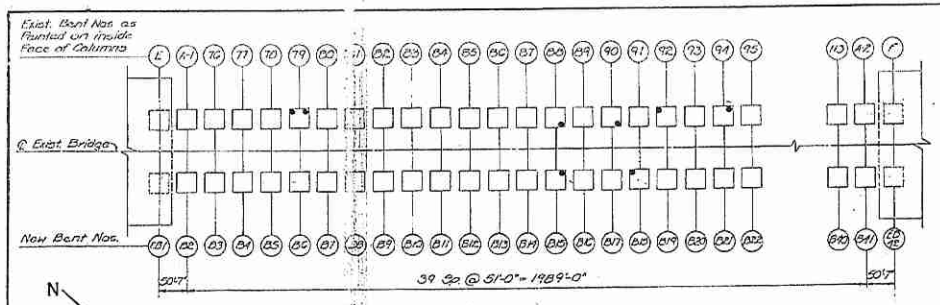
For this job, as on so many others, Monotubes were chosen because of their time-and-money-saving advantages. *They are cold-rolled and fluted for extra strength,* resist bending forces equally well from all directions. *They're light in weight, easily handled, extendible right on the job. Tapered design speeds driving—tubular construction makes inspection easy before concreting.*

For complete information, write The Union Metal Manufacturing Co., Canton 5, Ohio.

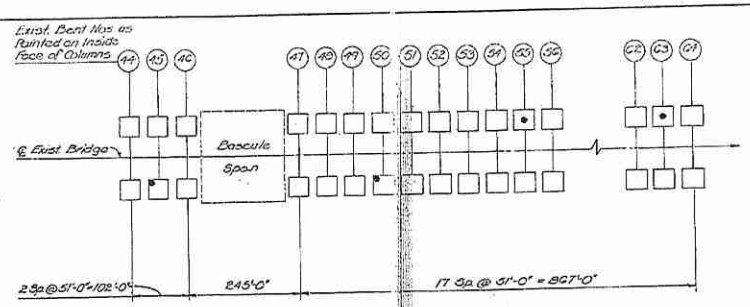
UNION METAL

Monotube Tapered Piles

For additional information, use postcard, pages 1077-1078



PLAN - BEAR CUT BRIDGE

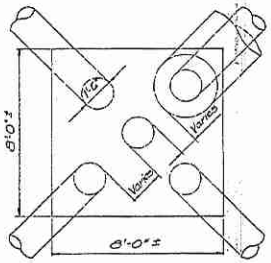


PLAN - BAY BRIDGE

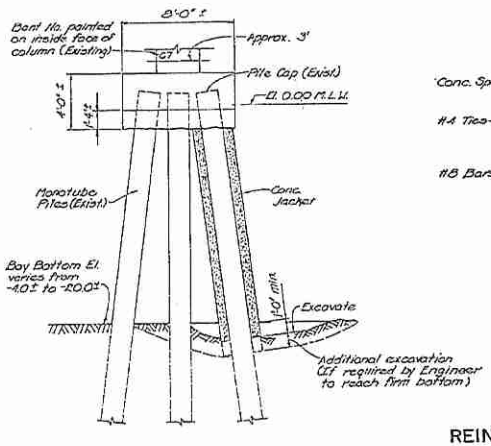
NOTE:
EB = End Bent
B = Bent
● = Piles to be repaired

N

NOTE: Piles battered 1½" per foot in direction shown.

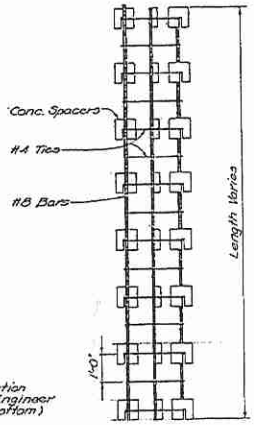


MONOTUBE PILE CAP (Existing)

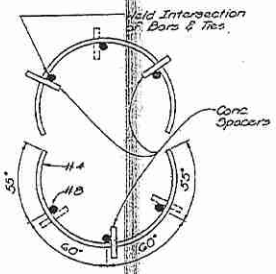


PILE BENT ELEVATION

NOTE: Exact dimensions of existing piles and pile cap to be determined in field

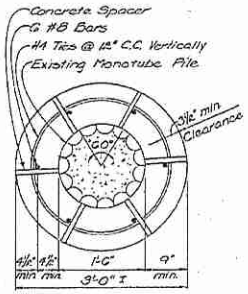


REINFORCING CAGE ELEVATION

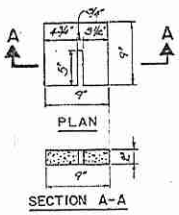


REINFORCING CAGE DETAIL

NOTE: The spacing of the concrete spacers shall be determined by the Engineer in the field. It shall be sufficient enough to maintain the clear cover over the reinforcing steel bars and the position of the forms.



CROSS SECTION THRU MONOTUBE PILE & JACKET



PRECAST CONCRETE SPACER

NOTES:

1.) Concrete shall be Class II and shall develop a minimum compression strength of 4000 p.s.i. at 28 days.
2.) Use A.S.T.M. Standards C-150 for Type II Portland cement.
3.) Reinforcing steel shall be new deformed bars in accordance with ASTM-A615, Grade 60 designation, Epoxy Coated.
4.) Length of forms and reinforcing cages to be determined in the field.
5.) All elevations are based on National Geodetic Vertical Datum.

PILING REPAIR

DRAWN BY: [illegible]
DESIGNED BY: [illegible]
CHECKED BY: [illegible]
DATE DRAWN: [illegible]
DATE APPROVED: [illegible]

KUNDE, DRIVER & ASSOCIATES INC.
ENGINEERS ARCHITECTS PLANNERS SURVEYORS

RICKENBACKER CAUSEWAY PROJECT
METRO-DADE COUNTY
PUBLIC WORKS DEPARTMENT

COUNTY PROJECT NO. 550220

EXISTING BRIDGE REPAIR

SHEET NO.
GB-37

APPENDIX – C

Pile Axial Capacity Analysis Results

Axial Capacity with Estimated Pile Penetration
(Constant Variables: 8" tip diameter without scour)

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 5

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-27	13.9	13.9	36	135	0.412
2	-27	-	-36	9	22.9	30	110	0.500
3	-36	-	-56	20	42.9	39	135	0.371
4	-56	-	-61	5	47.9	36	125	0.412

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 19.1 ft
Tip Elevation = -32.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.9	1	36	135	0.95	28.80	11.50	0.89	12.9	504.57	119.4
2	5.2	2	30	110	0.95	24.00	5.00	0.94	9.0	1132.9	27.7
											0.0
											0
Total Ultimate Skin Resistance (kips)											147.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											2.4
Total Ultimate Axial Capacity (kips)											149.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	8	19.1	28.65	0.55	30	7.2	20.9	1256.7	7.2

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 8

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-18	-	-34	16.4	16.4	38	135	0.384
2	-34	-	-39	5	21.4	32	115	0.470
3	-39	-	-49	10	31.4	40	135	0.357
4	-49	-	-60	11	42.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 25.7 ft
Tip Elevation = -43.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	0.7	1	38	135	0.95	30.40	14.50	0.87	18.0	25.41	0.5
2	15.7	1	38	135	0.95	30.40	14.50	0.87	14.9	620.73	248.3
3	5	2	32	115	0.95	25.60	7.00	0.92	10.7	1322.14	53.5
4	4.3	3	40	135	0.95	32.00	17.50	0.85	9.8	1609.73	143.6
Total Ultimate Skin Resistance (kips)											446.0
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											21.6
Total Ultimate Axial Capacity (kips)											467.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	3	8	25.7	38.55	0.75	140	64.7	417.7	1765.8	64.7

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 13

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-32	13.4	13.4	38	135	0.384
2	-32	-	-41	9	22.4	33	120	0.455
3	-41	-	-52	11	33.4	40	135	0.357
4	-52	-	-60	8	41.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 22.8 ft
Tip Elevation = -41.4 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.4	1	38	135	0.95	30.40	14.50	0.87	14.4	486.42	161.4
2	9	2	33	120	0.95	26.40	8.00	0.91	10.0	1232.04	97.1
3	0.4	3	40	135	0.95	32.00	17.50	0.85	8.1	1505.76	10.3
											0.0
Total Ultimate Skin Resistance (kips)											268.8
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											14.9
Total Ultimate Axial Capacity (kips)											283.6

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	40	3	8	22.8	34.2	0.6	140	44.6	417.7	1520.3	44.6

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 19

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-42	22.8	22.8	39	135	0.371
2	-42	-	-50	8	30.8	-	135	#VALUE!
3	-50	-	-67	17	47.8	31	110	0.485
4	-67	-	-77	10	57.8	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 20.4 ft
Tip Elevation = -39.6 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	20.4	1	39	135	0.95	31.20	16.00	0.86	12.1	740.52	349.5
					0.95						0.0
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											349.5
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											14.9
Total Ultimate Axial Capacity (kips)											364.4

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	39	1	8	20.4	30.6	0.72	120	44.7	348.1	1481.0	44.7

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 24

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-20	-	-48	27.6	27.6	40	135	0.357
2	-48	-	-53	5	32.6	30	110	0.500
3	-53	-	-61	8	40.6	33	120	0.455
4	-61	-	-73	12	52.6	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 15.8 ft
Tip Elevation = -36.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	15.8	1	40	135	0.95	32.00	17.50	0.85	11.2	573.54	214.3
					0.95						0.0
					0.95						0.0
					0.95						0.0
Total Ultimate Skin Resistance (kips)											214.3
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											14.0
Total Ultimate Axial Capacity (kips)											228.3

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	40	1	8	15.8	23.7	0.75	140	42.0	417.7	1147.1	42.0

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 30

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-21	-	-32	11.1	11.1	38	135	0.384
2	-32	-	-38	6	17.1	29	105	0.515
3	-38	-	-42	4	21.1	38	135	0.384
4	-42	-	-57	15	36.1	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 20 ft
Tip Elevation = -40.9 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	11.1	1	38	135	0.95	30.40	14.50	0.87	13.8	402.93	105.7
2	6	2	29	105	0.95	23.20	4.00	0.95	10.4	933.66	23.6
3	2.9	3	38	135	0.95	30.40	14.50	0.87	8.6	1166.73	49.8
					0.95						0.0
Total Ultimate Skin Resistance (kips)											179.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											11.1
Total Ultimate Axial Capacity (kips)											190.2

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	38	3	8	20	30	0.75	100	33.3	278.5	1272.0	33.3

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 35

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-30	16.9	16.9	40	135	0.357
2	-30	-	-34	4	20.9	30	110	0.500
3	-34	-	-41	7	27.9	38	135	0.384
4	-41	-	-56	15	42.9	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 19.4 ft
Tip Elevation = -32.5 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	16.9	1	40	135	0.95	32.00	17.50	0.85	12.4	613.47	271.9
2	2.5	2	30	110	0.95	24.00	5.00	0.94	8.5	1286.44	14.2
					0.95						0.0
					0.95						0.0
Total Ultimate Skin Resistance (kips)											286.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											3.4
Total Ultimate Axial Capacity (kips)											289.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	8	19.4	29.1	0.72	30	10.1	20.9	1345.9	10.1

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 40

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-4	-	-15	10.8	10.8	33	120	0.455
2	-15	-	-25	10	20.8	39	135	0.371
3	-25	-	-37	12	32.8	31	110	0.485
4	-37	-	-57	20	52.8	40	135	0.357

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 33.1 ft
Tip Elevation = -37.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	8.1	1	33	120	0.95	26.40	8.00	0.91	18.0	233.28	28.9
2	6.4	1	33	120	0.95	26.40	8.00	0.91	16.7	650.88	61.2
3	10	3	31	110	0.95	24.80	6.00	0.93	13.4	1073.2	91.7
4	8.6	4	40	135	0.95	32.00	17.50	0.85	9.7	1623.38	287.5
Total Ultimate Skin Resistance (kips)											469.3
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											23.6
Total Ultimate Axial Capacity (kips)											492.9

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	4	8	33.1	49.65	0.75	140	70.9	417.7	1935.6	70.9

Axial Capacity with Lower Bound Pile Penetration
(Constant Variables: 8" tip diameter without scour)

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 5

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-27	13.9	13.9	36	135	0.412
2	-27	-	-36	9	22.9	30	110	0.500
3	-36	-	-56	20	42.9	39	135	0.371
4	-56	-	-61	5	47.9	36	125	0.412

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 15.1 ft
Tip Elevation = -28.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.9	1	36	135	0.95	28.80	11.50	0.89	11.3	504.57	104.6
2	1.2	2	30	110	0.95	24.00	5.00	0.94	8.2	1037.7	5.3
											0.0
											0
Total Ultimate Skin Resistance (kips)											109.9
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											2.0
Total Ultimate Axial Capacity (kips)											111.9

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	8	15.1	22.65	0.55	30	6.1	20.9	1066.3	6.1

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 8

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-18	-	-34	16.4	16.4	38	135	0.384
2	-34	-	-39	5	21.4	32	115	0.470
3	-39	-	-49	10	31.4	40	135	0.357
4	-49	-	-60	11	42.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 20.7 ft
Tip Elevation = -38.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	16.4	1	38	135	0.95	30.40	14.50	0.87	13.0	595.32	217.6
2	4.3	2	32	115	0.95	25.60	7.00	0.92	8.9	1303.73	37.5
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											255.2
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											4.0
Total Ultimate Axial Capacity (kips)											259.1

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	32	2	8	20.7	31.05	0.6	40	11.9	36.5	1416.8	11.9

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 13

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-32	13.4	13.4	38	135	0.384
2	-32	-	-41	9	22.4	33	120	0.455
3	-41	-	-52	11	33.4	40	135	0.357
4	-52	-	-60	8	41.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 17.8 ft
Tip Elevation = -36.4 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.4	1	38	135	0.95	30.40	14.50	0.87	12.4	486.42	139.0
2	4.4	2	33	120	0.95	26.40	8.00	0.91	8.9	1099.56	37.8
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											176.8
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											4.0
Total Ultimate Axial Capacity (kips)											180.8

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	33	2	8	17.8	26.7	0.6	47	12.1	52.2	1226.3	12.1

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 19

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-42	22.8	22.8	39	135	0.371
2	-42	-	-50	8	30.8	-	135	#VALUE!
3	-50	-	-67	17	47.8	31	110	0.485
4	-67	-	-77	10	57.8	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 15.4 ft
Tip Elevation = -34.6 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	15.4	1	39	135	0.95	31.20	16.00	0.86	11.1	559.02	182.7
											0.0
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											182.7
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											11.2
Total Ultimate Axial Capacity (kips)											193.9

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	39	1	8	15.4	23.1	0.72	120	33.7	348.1	1118.0	33.7

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 24

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-20	-	-48	27.6	27.6	40	135	0.357
2	-48	-	-53	5	32.6	30	110	0.500
3	-53	-	-61	8	40.6	33	120	0.455
4	-61	-	-73	12	52.6	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 10.8 ft
Tip Elevation = -31.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	10.8	1	40	135	0.95	32.00	17.50	0.85	10.2	392.04	91.1
											0.0
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											91.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											9.6
Total Ultimate Axial Capacity (kips)											100.7

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	40	1	8	10.8	16.2	0.75	140	28.7	417.7	784.1	28.7

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 30

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-21	-	-32	11.1	11.1	38	135	0.384
2	-32	-	-38	6	17.1	29	105	0.515
3	-38	-	-42	4	21.1	38	135	0.384
4	-42	-	-57	15	36.1	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 15 ft
Tip Elevation = -35.9 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	11.1	1	38	135	0.95	30.40	14.50	0.87	11.8	402.93	90.3
2	3.9	2	29	105	0.95	23.20	4.00	0.95	8.8	888.93	12.4
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											102.7
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											2.2
Total Ultimate Axial Capacity (kips)											104.9

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	29	2	8	15	22.5	0.75	26	6.6	20.9	972.0	6.6

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 35

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-30	16.9	16.9	40	135	0.357
2	-30	-	-34	4	20.9	30	110	0.500
3	-34	-	-41	7	27.9	38	135	0.384
4	-41	-	-56	15	42.9	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 15.4 ft
Tip Elevation = -28.5 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	15.4	1	40	135	0.95	32.00	17.50	0.85	11.1	559.02	202.1
											0.0
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											202.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											13.1
Total Ultimate Axial Capacity (kips)											215.2

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	40	1	8	15.4	23.1	0.72	140	39.3	417.7	1118.0	39.3

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 40

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-4	-	-15	10.8	10.8	33	120	0.455
2	-15	-	-25	10	20.8	39	135	0.371
3	-25	-	-37	12	32.8	31	110	0.485
4	-37	-	-57	20	52.8	40	135	0.357

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 28.1 ft
Tip Elevation = -32.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	3.1	1	33	120	0.95	26.40	8.00	0.91	18.0	89.28	4.2
2	7.7	1	33	120	0.95	26.40	8.00	0.91	16.5	400.32	44.6
3	10	3	31	110	0.95	24.80	6.00	0.93	12.9	860.08	70.6
4	7.3	4	40	135	0.95	32.00	17.50	0.85	9.5	1363.07	199.4
Total Ultimate Skin Resistance (kips)											318.9
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											19.9
Total Ultimate Axial Capacity (kips)											338.8

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	4	8	28.1	42.15	0.75	140	59.7	417.7	1628.1	59.7

Axial Capacity with Higher Bound Pile Penetration
(Constant Variables: 8" tip diameter without scour)

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 5

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-27	13.9	13.9	36	135	0.412
2	-27	-	-36	9	22.9	30	110	0.500
3	-36	-	-56	20	42.9	39	135	0.371
4	-56	-	-61	5	47.9	36	125	0.412

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 23.1 ft
Tip Elevation = -36.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.9	1	36	135	0.95	28.80	11.50	0.89	14.5	504.57	134.3
2	9	2	30	110	0.95	24.00	5.00	0.94	9.9	1223.34	56.5
3	0.2	3	39	135	0.95	31.20	16.00	0.86	8.0	1444.8	4.4
											0
Total Ultimate Skin Resistance (kips)											195.2
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											11.2
Total Ultimate Axial Capacity (kips)											206.3

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	39	3	8	23.1	34.65	0.55	120	33.5	348.1	1452.1	33.5

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 8

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-18	-	-34	16.4	16.4	38	135	0.384
2	-34	-	-39	5	21.4	32	115	0.470
3	-39	-	-49	10	31.4	40	135	0.357
4	-49	-	-60	11	42.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 26.4 ft
Tip Elevation = -44 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	0.7	1	38	135	0.95	30.40	14.50	0.87	18.0	25.41	0.5
2	15.7	1	38	135	0.95	30.40	14.50	0.87	14.9	620.73	248.3
3	5	2	32	115	0.95	25.60	7.00	0.92	10.7	1322.14	53.5
4	5	3	40	135	0.95	32.00	17.50	0.85	9.7	1635.14	168.4
Total Ultimate Skin Resistance (kips)											470.8
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											22.2
Total Ultimate Axial Capacity (kips)											493.0

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	3	8	26.4	39.6	0.75	140	66.6	417.7	1816.6	66.6

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 13

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-32	13.4	13.4	38	135	0.384
2	-32	-	-41	9	22.4	33	120	0.455
3	-41	-	-52	11	33.4	40	135	0.357
4	-52	-	-60	8	41.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 25.4 ft
Tip Elevation = -44 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.4	1	38	135	0.95	30.40	14.50	0.87	18.0	486.42	195.6
2	9	2	33	120	0.95	26.40	8.00	0.91	16.2	1232.04	157.9
3	3	3	40	135	0.95	32.00	17.50	0.85	13.8	1600.14	140.4
											0.0
Total Ultimate Skin Resistance (kips)											493.8
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											16.7
Total Ultimate Axial Capacity (kips)											510.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	40	3	8	25.4	38.1	0.6	140	50.1	417.7	1709.0	50.1

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 19

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-42	22.8	22.8	39	135	0.371
2	-42	-	-50	8	30.8	-	135	#VALUE!
3	-50	-	-67	17	47.8	31	110	0.485
4	-67	-	-77	10	57.8	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 24.8 ft
Tip Elevation = -44 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	22.8	1	39	135	0.95	31.20	16.00	0.86	13.4	827.64	482.8
2	2	2	40	135	0.95	32.00	17.50	0.85	8.4	1727.88	61.5
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											544.3
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											21.1
Total Ultimate Axial Capacity (kips)											565.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	40	2	8	24.8	37.2	0.72	140	63.4	417.7	1800.5	63.4

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 24

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-20	-	-48	27.6	27.6	40	135	0.357
2	-48	-	-53	5	32.6	30	110	0.500
3	-53	-	-61	8	40.6	33	120	0.455
4	-61	-	-73	12	52.6	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 20.8 ft
Tip Elevation = -41.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	20.8	1	40	135	0.95	32.00	17.50	0.85	12.2	755.04	404.6
											0.0
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											404.6
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											18.4
Total Ultimate Axial Capacity (kips)											423.1

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	40	1	8	20.8	31.2	0.75	140	55.3	417.7	1510.1	55.3

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 30

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-21	-	-32	11.1	11.1	38	135	0.384
2	-32	-	-38	6	17.1	29	105	0.515
3	-38	-	-42	4	21.1	38	135	0.384
4	-42	-	-57	15	36.1	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 23.1 ft
Tip Elevation = -44 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	11.1	1	38	135	0.95	30.40	14.50	0.87	15.0	402.93	115.2
2	6	2	29	105	0.95	23.20	4.00	0.95	11.6	933.66	26.4
3	6	3	38	135	0.95	30.40	14.50	0.87	9.2	1279.26	121.1
											0.0
Total Ultimate Skin Resistance (kips)											262.7
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											13.1
Total Ultimate Axial Capacity (kips)											275.8

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	38	3	8	23.1	34.65	0.75	100	39.2	278.5	1497.1	39.2

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 35

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-30	16.9	16.9	40	135	0.357
2	-30	-	-34	4	20.9	30	110	0.500
3	-34	-	-41	7	27.9	38	135	0.384
4	-41	-	-56	15	42.9	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 23.4 ft
Tip Elevation = -36.5 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	16.9	1	40	135	0.95	32.00	17.50	0.85	14.0	613.47	307.1
2	4	2	30	110	0.95	24.00	5.00	0.94	9.8	1322.14	26.9
3	2.5	3	38	135	0.95	30.40	14.50	0.87	8.5	1508.09	54.9
											0.0
Total Ultimate Skin Resistance (kips)											388.9
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											13.4
Total Ultimate Axial Capacity (kips)											402.3

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	38	3	8	23.4	35.1	0.72	100	40.2	278.5	1598.8	40.2

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 40

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-4	-	-15	10.8	10.8	33	120	0.455
2	-15	-	-25	10	20.8	39	135	0.371
3	-25	-	-37	12	32.8	31	110	0.485
4	-37	-	-57	20	52.8	40	135	0.357

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 38.1 ft
Tip Elevation = -42.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	10.8	1	33	120	0.95	26.40	8.00	0.91	18.0	311.04	51.4
2	2.3	2	39	135	0.95	31.20	16.00	0.86	18.0	705.57	54.4
3	7.7	2	39	135	0.95	31.20	16.00	0.86	16.5	1068.57	259.4
4	12	3	31	110	0.95	24.80	6.00	0.93	12.5	1633.68	156.0
5	5.3	4	40	135	0.95	32.00	17.50	0.85	9.1	2111.67	214.8
Total Ultimate Skin Resistance (kips)											736.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											28.1
Total Ultimate Axial Capacity (kips)											764.2

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
5	40	4	8	38.1	57.15	0.75	140	84.4	417.7	2304.1	84.4

Axial Capacity with 6" Tip Diameter
(Constant Variables: Estimated Pile Penetration and without scour)

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 5

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-27	13.9	13.9	36	135	0.412
2	-27	-	-36	9	22.9	30	110	0.500
3	-36	-	-56	20	42.9	39	135	0.371
4	-56	-	-61	5	47.9	36	125	0.412

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 19.1 ft
Tip Elevation = -32.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.9	1	36	135	1.15	28.80	11.50	0.89	11.8	504.57	110.5
2	5.2	2	30	110	1.15	24.00	5.00	0.94	7.2	1132.9	22.3
											0.0
											0
Total Ultimate Skin Resistance (kips)											132.8
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											1.4
Total Ultimate Axial Capacity (kips)											134.2

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	6	19.1	38.2	0.55	30	4.1	20.9	1256.7	4.1

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 8

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-18	-	-34	16.4	16.4	38	135	0.384
2	-34	-	-39	5	21.4	32	115	0.470
3	-39	-	-49	10	31.4	40	135	0.357
4	-49	-	-60	11	42.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 25.7 ft
Tip Elevation = -43.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	0.7	1	38	135	1.15	30.40	14.50	0.87	18.0	25.41	0.5
2	15.7	1	38	135	1.15	30.40	14.50	0.87	14.2	620.73	239.1
3	5	2	32	115	1.15	25.60	7.00	0.92	9.3	1322.14	46.6
4	4.3	3	40	135	1.15	32.00	17.50	0.85	8.1	1609.73	120.1
Total Ultimate Skin Resistance (kips)											406.4
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											12.1
Total Ultimate Axial Capacity (kips)											418.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	3	6	25.7	51.4	0.75	140	36.4	417.7	1765.8	36.4

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 13

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-32	13.4	13.4	38	135	0.384
2	-32	-	-41	9	22.4	33	120	0.455
3	-41	-	-52	11	33.4	40	135	0.357
4	-52	-	-60	8	41.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 22.8 ft
Tip Elevation = -41.4 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.4	1	38	135	1.15	30.40	14.50	0.87	13.7	486.42	154.3
2	9	2	33	120	1.15	26.40	8.00	0.91	8.4	1232.04	81.9
3	0.4	3	40	135	1.15	32.00	17.50	0.85	6.1	1505.76	7.8
											0.0
Total Ultimate Skin Resistance (kips)											244.0
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											8.4
Total Ultimate Axial Capacity (kips)											252.4

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	40	3	6	22.8	45.6	0.6	140	25.1	417.7	1520.3	25.1

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 19

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-42	22.8	22.8	39	135	0.371
2	-42	-	-50	8	30.8	-	135	#VALUE!
3	-50	-	-67	17	47.8	31	110	0.485
4	-67	-	-77	10	57.8	-	135	#VALUE!

Pile Data: Pile Pentration = 20.4 ft
Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -39.6 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	20.4	1	39	135	1.15	31.20	16.00	0.86	10.9	740.52	316.9
					1.15						0.0
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											316.9
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											8.4
Total Ultimate Axial Capacity (kips)											325.3

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	39	1	6	20.4	40.8	0.72	120	25.1	348.1	1481.0	25.1

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 24

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_o
1	-20	-	-48	27.6	27.6	40	135	0.357
2	-48	-	-53	5	32.6	30	110	0.500
3	-53	-	-61	8	40.6	33	120	0.455
4	-61	-	-73	12	52.6	-	135	#VALUE!

Pile Data: Pile Pentration = 15.8 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -36.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	15.8	1	40	135	1.15	32.00	17.50	0.85	9.8	573.54	189.0
					1.15						0.0
					1.15						0.0
					1.15						0.0
Total Ultimate Skin Resistance (kips)											189.0
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											7.9
Total Ultimate Axial Capacity (kips)											196.9

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	40	1	6	15.8	31.6	0.75	140	23.6	417.7	1147.1	23.6

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 30

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-21	-	-32	11.1	11.1	38	135	0.384
2	-32	-	-38	6	17.1	29	105	0.515
3	-38	-	-42	4	21.1	38	135	0.384
4	-42	-	-57	15	36.1	-	135	#VALUE!

Pile Data: Pile Pentration = 20 ft
Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -40.9 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	11.1	1	38	135	1.15	30.40	14.50	0.87	12.9	402.93	99.8
2	6	2	29	105	1.15	23.20	4.00	0.95	8.8	933.66	20.3
3	2.9	3	38	135	1.15	30.40	14.50	0.87	6.7	1166.73	39.1
					1.15						0.0
Total Ultimate Skin Resistance (kips)											159.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											6.2
Total Ultimate Axial Capacity (kips)											165.3

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	38	3	6	20	40	0.75	100	18.7	278.5	1272.0	18.7

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 35

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-30	16.9	16.9	40	135	0.357
2	-30	-	-34	4	20.9	30	110	0.500
3	-34	-	-41	7	27.9	38	135	0.384
4	-41	-	-56	15	42.9	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 19.4 ft
Tip Elevation = -32.5 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	16.9	1	40	135	1.15	32.00	17.50	0.85	11.3	613.47	248.5
2	2.5	2	30	110	1.15	24.00	5.00	0.94	6.6	1286.44	11.1
					1.15						0.0
					1.15						0.0
Total Ultimate Skin Resistance (kips)											259.6
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											1.9
Total Ultimate Axial Capacity (kips)											261.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	6	19.4	38.8	0.72	30	5.7	20.9	1345.9	5.7

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 40

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-4	-	-15	10.8	10.8	33	120	0.455
2	-15	-	-25	10	20.8	39	135	0.371
3	-25	-	-37	12	32.8	31	110	0.485
4	-37	-	-57	20	52.8	40	135	0.357

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 33.1 ft
Tip Elevation = -37.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	8.1	1	33	120	1.15	26.40	8.00	0.91	18.0	233.28	28.9
2	6.4	1	33	120	1.15	26.40	8.00	0.91	16.5	650.88	60.7
3	10	3	31	110	1.15	24.80	6.00	0.93	12.5	1073.2	86.0
4	8.6	4	40	135	1.15	32.00	17.50	0.85	8.1	1623.38	239.8
Total Ultimate Skin Resistance (kips)											415.4
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											13.3
Total Ultimate Axial Capacity (kips)											428.7

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	4	6	33.1	66.2	0.75	140	39.9	417.7	1935.6	39.9

Axial Capacity with 12" Tip Diameter
(Constant Variables: Estimated Pile Penetration and without scour)

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 5

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-27	13.9	13.9	36	135	0.412
2	-27	-	-36	9	22.9	30	110	0.500
3	-36	-	-56	20	42.9	39	135	0.371
4	-56	-	-61	5	47.9	36	125	0.412

Pile Data: Pile Pentration = 19.1 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -32.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.9	1	36	135	0.57	28.80	11.50	0.89	14.9	504.57	136.9
2	5.2	2	30	110	0.57	24.00	5.00	0.94	12.6	1132.9	38.1
											0.0
											0
Total Ultimate Skin Resistance (kips)											174.9
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											5.4
Total Ultimate Axial Capacity (kips)											180.4

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	12	19.1	19.1	0.55	30	16.3	20.9	1256.7	16.3

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 8

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-18	-	-34	16.4	16.4	38	135	0.384
2	-34	-	-39	5	21.4	32	115	0.470
3	-39	-	-49	10	31.4	40	135	0.357
4	-49	-	-60	11	42.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 25.7 ft
Tip Elevation = -43.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	0.7	1	38	135	0.57	30.40	14.50	0.87	18.0	25.41	0.5
2	15.7	1	38	135	0.57	30.40	14.50	0.87	16.1	620.73	266.3
3	5	2	32	115	0.57	25.60	7.00	0.92	13.6	1322.14	67.2
4	4.3	3	40	135	0.57	32.00	17.50	0.85	13.1	1609.73	189.7
Total Ultimate Skin Resistance (kips)											523.8
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											48.5
Total Ultimate Axial Capacity (kips)											572.3

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	3	12	25.7	25.7	0.75	140	145.6	417.7	1765.8	145.6

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 13

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-32	13.4	13.4	38	135	0.384
2	-32	-	-41	9	22.4	33	120	0.455
3	-41	-	-52	11	33.4	40	135	0.357
4	-52	-	-60	8	41.4	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 22.8 ft
Tip Elevation = -41.4 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	13.4	1	38	135	0.57	30.40	14.50	0.87	15.9	486.42	175.3
2	9	2	33	120	0.57	26.40	8.00	0.91	13.2	1232.04	126.7
3	0.4	3	40	135	0.57	32.00	17.50	0.85	12.0	1505.76	15.2
											0.0
Total Ultimate Skin Resistance (kips)											317.3
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											33.4
Total Ultimate Axial Capacity (kips)											350.7

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	40	3	12	22.8	22.8	0.6	140	100.3	417.7	1520.3	100.3

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 19

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-42	22.8	22.8	39	135	0.371
2	-42	-	-50	8	30.8	-	135	#VALUE!
3	-50	-	-67	17	47.8	31	110	0.485
4	-67	-	-77	10	57.8	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 20.4 ft
Tip Elevation = -39.6 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	20.4	1	39	135	0.57	31.20	16.00	0.86	14.4	740.52	413.5
					0.57						0.0
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											413.5
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											33.5
Total Ultimate Axial Capacity (kips)											447.0

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	39	1	12	20.4	20.4	0.72	120	100.5	348.1	1481.0	100.5

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 24

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-20	-	-48	27.6	27.6	40	135	0.357
2	-48	-	-53	5	32.6	30	110	0.500
3	-53	-	-61	8	40.6	33	120	0.455
4	-61	-	-73	12	52.6	-	135	#VALUE!

Pile Data: Pile Pentration = 15.8 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -36.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	15.8	1	40	135	0.57	32.00	17.50	0.85	13.9	573.54	264.0
					0.57						0.0
					0.57						0.0
					0.57						0.0
Total Ultimate Skin Resistance (kips)											264.0
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											31.5
Total Ultimate Axial Capacity (kips)											295.6

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	40	1	12	15.8	15.8	0.75	140	94.6	417.7	1147.1	94.6

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 30

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-21	-	-32	11.1	11.1	38	135	0.384
2	-32	-	-38	6	17.1	29	105	0.515
3	-38	-	-42	4	21.1	38	135	0.384
4	-42	-	-57	15	36.1	-	135	#VALUE!

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 20 ft
Tip Elevation = -40.9 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	11.1	1	38	135	0.57	30.40	14.50	0.87	15.5	402.93	117.3
2	6	2	29	105	0.57	23.20	4.00	0.95	13.4	933.66	30.1
3	2.9	3	38	135	0.57	30.40	14.50	0.87	12.3	1166.73	70.9
					0.57						0.0
Total Ultimate Skin Resistance (kips)											218.3
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											25.0
Total Ultimate Axial Capacity (kips)											243.3

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	38	3	12	20	20	0.75	100	74.9	278.5	1272.0	74.9

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 35

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-30	16.9	16.9	40	135	0.357
2	-30	-	-34	4	20.9	30	110	0.500
3	-34	-	-41	7	27.9	38	135	0.384
4	-41	-	-56	15	42.9	-	135	#VALUE!

Pile Data: Pile Pentration = 19.4 ft
Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -32.5 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	16.9	1	40	135	0.57	32.00	17.50	0.85	14.6	613.47	318.0
2	2.5	2	30	110	0.57	24.00	5.00	0.94	12.3	1286.44	20.2
					0.57						0.0
					0.57						0.0
Total Ultimate Skin Resistance (kips)											338.2
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											7.0
Total Ultimate Axial Capacity (kips)											345.2

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	12	19.4	19.4	0.72	30	22.8	20.9	1345.9	20.9

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 40

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-4	-	-15	10.8	10.8	33	120	0.455
2	-15	-	-25	10	20.8	39	135	0.371
3	-25	-	-37	12	32.8	31	110	0.485
4	-37	-	-57	20	52.8	40	135	0.357

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration = 33.1 ft
Tip Elevation = -37.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	8.1	1	33	120	0.57	26.40	8.00	0.91	18.0	233.28	28.9
2	6.4	1	33	120	0.57	26.40	8.00	0.91	17.2	650.88	62.3
3	10	3	31	110	0.57	24.80	6.00	0.93	15.3	1073.2	102.7
4	8.6	4	40	135	0.57	32.00	17.50	0.85	13.0	1623.38	381.5
Total Ultimate Skin Resistance (kips)											575.3
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											53.2
Total Ultimate Axial Capacity (kips)											628.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	4	12	33.1	33.1	0.75	140	159.6	417.7	1935.6	159.6

Axial Capacity with 100-Year Scour
(Constant Variables: Estimated Pile Penetration & 8" tip diameter)

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 5

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-13	-	-27	13.9	13.9	36	135	0.412
2	-27	-	-36	9	22.9	30	110	0.500
3	-36	-	-56	20	42.9	39	135	0.371
4	-56	-	-61	5	47.9	36	125	0.412

Pile Data: Pile Pentration with Scour = 18.1 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -32.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	12.9	1	36	135	0.95	28.80	11.50	0.89	12.7	468.27	101.3
2	5.2	2	30	110	0.95	24.00	5.00	0.94	9.0	1060.3	25.9
											0.0
											0
Total Ultimate Skin Resistance (kips)											127.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											2.3
Total Ultimate Axial Capacity (kips)											129.4

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	8	18.1	27.15	0.55	30	6.8	20.9	1184.1	6.8

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 8

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-18	-	-34	16.4	16.4	38	135	0.384
2	-34	-	-39	5	21.4	32	115	0.470
3	-39	-	-49	10	31.4	40	135	0.357
4	-49	-	-60	11	42.4	-	135	#VALUE!

Pile Data: Pile Pentration with Scour = 24.7 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -43.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	0	1	38	135	0.95	30.40	14.50	0.87	17.9	0	0.0
2	15.4	1	38	135	0.95	30.40	14.50	0.87	14.8	559.02	218.5
3	5	2	32	115	0.95	25.60	7.00	0.92	10.7	1249.54	50.6
4	4.3	3	40	135	0.95	32.00	17.50	0.85	9.8	1537.13	137.1
Total Ultimate Skin Resistance (kips)											406.2
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											20.7
Total Ultimate Axial Capacity (kips)											426.9

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	3	8	24.7	37.05	0.75	140	62.1	417.7	1693.2	62.1

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 13

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-32	13.4	13.4	38	135	0.384
2	-32	-	-41	9	22.4	33	120	0.455
3	-41	-	-52	11	33.4	40	135	0.357
4	-52	-	-60	8	41.4	-	135	#VALUE!

Pile Data: Pile Pentration with Scour = 18.9 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -41.4 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	9.5	1	38	135	0.95	30.40	14.50	0.87	13.7	344.85	76.7
2	9	2	33	120	0.95	26.40	8.00	0.91	10.0	948.9	74.7
3	0.4	3	40	135	0.95	32.00	17.50	0.85	8.1	1222.62	8.4
											0.0
Total Ultimate Skin Resistance (kips)											159.9
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											12.1
Total Ultimate Axial Capacity (kips)											171.9

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	40	3	8	18.9	28.35	0.6	140	36.3	417.7	1237.1	36.3

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 19

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-19	-	-42	22.8	22.8	39	135	0.371
2	-42	-	-50	8	30.8	-	135	#VALUE!
3	-50	-	-67	17	47.8	31	110	0.485
4	-67	-	-77	10	57.8	-	135	#VALUE!

Pile Data: Pile Pentration with Scour = 19.3 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -39.6 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	19.3	1	39	135	0.95	31.20	16.00	0.86	11.9	700.59	307.1
					0.95						0.0
											0.0
											0.0
Total Ultimate Skin Resistance (kips)											307.1
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											14.1
Total Ultimate Axial Capacity (kips)											321.2

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	39	1	8	19.3	28.95	0.72	120	42.3	348.1	1401.2	42.3

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 24

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-20	-	-48	27.6	27.6	40	135	0.357
2	-48	-	-53	5	32.6	30	110	0.500
3	-53	-	-61	8	40.6	33	120	0.455
4	-61	-	-73	12	52.6	-	135	#VALUE!

Pile Data: Pile Pentration with Scour = 14.5 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -36.2 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	14.5	1	40	135	0.95	32.00	17.50	0.85	10.9	526.35	176.3
					0.95						0.0
					0.95						0.0
					0.95						0.0
Total Ultimate Skin Resistance (kips)											176.3
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											12.9
Total Ultimate Axial Capacity (kips)											189.1

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
1	40	1	8	14.5	21.75	0.75	140	38.6	417.7	1052.7	38.6

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 30

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-21	-	-32	11.1	11.1	38	135	0.384
2	-32	-	-38	6	17.1	29	105	0.515
3	-38	-	-42	4	21.1	38	135	0.384
4	-42	-	-57	15	36.1	-	135	#VALUE!

Pile Data: Pile Pentration with Scour = 18.1 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -40.9 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	9.2	1	38	135	0.95	30.40	14.50	0.87	13.4	333.96	70.6
2	6	2	29	105	0.95	23.20	4.00	0.95	10.4	795.72	20.1
3	2.9	3	38	135	0.95	30.40	14.50	0.87	8.6	1028.79	43.9
					0.95						0.0
Total Ultimate Skin Resistance (kips)											134.6
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											9.9
Total Ultimate Axial Capacity (kips)											144.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
3	38	3	8	18.1	27.15	0.75	100	29.7	278.5	1134.1	29.7

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 35

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_o
1	-13	-	-30	16.9	16.9	40	135	0.357
2	-30	-	-34	4	20.9	30	110	0.500
3	-34	-	-41	7	27.9	38	135	0.384
4	-41	-	-56	15	42.9	-	135	#VALUE!

Pile Data: Pile Pentration with Scour = 16.8 ft

Skin Resistance (after Nordlund 1963, 1979) Tip Elevation = -32.5 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	14.3	1	40	135	0.95	32.00	17.50	0.85	11.9	519.09	186.5
2	2.5	2	30	110	0.95	24.00	5.00	0.94	8.5	1097.68	12.1
					0.95						0.0
					0.95						0.0
Total Ultimate Skin Resistance (kips)											198.6
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											2.9
Total Ultimate Axial Capacity (kips)											201.5

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
2	30	2	8	16.8	25.2	0.72	30	8.7	20.9	1157.2	8.7

Existing Pile Axial Capacity Analysis

Bear Cut Original Bridge (Built in 1944)
Miami-Dade County, Florida
At Bent 40

Soil Data

Soil Layer #	Elevation (NGVD, 1929)			Layer Thickness (ft)	Depth of Layer Bottom (ft)	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Coeffient of Lateral Earth Pressure at Rest , K_0
1	-4	-	-15	10.8	10.8	33	120	0.455
2	-15	-	-25	10	20.8	39	135	0.371
3	-25	-	-37	12	32.8	31	110	0.485
4	-37	-	-57	20	52.8	40	135	0.357

Pile Data:
Skin Resistance (after Nordlund 1963, 1979)

Pile Pentration with Scour = 22.2 ft
Tip Elevation = -37.3 (NGVD, 1929)

Pile Section	Length (ft)	Soil Layer #	Internal Friction Angle (ϕ)	Total Unit Weight (pcf), γ	Taper Angle (degree), ω	δ	K_δ	C_f	Average Monotube Diameter (in)	Vertical Effective Overburden Stress (psf), σ'	Skin Resistance (kips)
1	0	1	33	120	0.95	26.40	8.00	0.91	18.0	0	0.0
2	3.6	1	33	120	0.95	26.40	8.00	0.91	16.2	103.68	5.3
3	10	3	31	110	0.95	24.80	6.00	0.93	13.4	445.36	38.0
4	8.6	4	40	135	0.95	32.00	17.50	0.85	9.7	995.54	176.3
Total Ultimate Skin Resistance (kips)											219.7
Tip Resistance (kips), taking 1/3 of the Ultimate Tip Resistance from the table below											16.0
Total Ultimate Axial Capacity (kips)											235.6

End Bearing (after Thurman 1964)

Pile Section	Internal Friction Angle (ϕ)	Soil Layer #	Tip Daimeter (in)	Pile Embedded Length (ft)	D/b	α_t	N_q	Q_{net} (kips)	Limiting Unit Toe Resistance, (kips)	Vertical Effective Overburden Stress (psf), σ'	Ultimate Tip Resistance (kips)
4	40	4	8	22.2	33.3	0.75	140	47.9	417.7	1307.7	47.9

APPENDIX – D

Soil Parameters for FB-Pier Analysis

Geotechnical Parameters for FB-MultiPier Input

Bear Cut Bridge
Miami-Dade County, Florida
At Bent 5

Piles (Steel Pipe Pile 18")

Reference Boring	B-5
Approximate Ground Elevation[1] (ft)	-13.10
Approximate Water Table Elevation[2] (ft)	0.00

Foundation Type	Driven Steel Pipe Pile
Size (inch)	18
Base Area (ft^2)	1.77

	Layer No.	1	2	3	4	5	6
	Soil Description	Sand/Limestone	Sand	Limestone/Gravel	Sand	Limestone	Limestone/Gravel
	Soil Type	Cohesionless	Cohesionless	Cohesionless	Cohesionless	Rock	Cohesionless
	Top Boundary Elevation (ft)	-13	-27	-36	-56	-61	-70
	Bottom boundary Elevation (ft)	-27	-36	-56	-61	-70	-93
	Average SPT N-Value[3] (Blows/ft)	13	7	26	50	36	12
LATERAL	Soil Model	Sand (Reese)	Sand (Reese)	Sand (Reese)	Sand (Reese)	Limestone (McVay)	Sand (Reese)
	Internal Friction Angle, ϕ	33	29	39	36	-	36
	Total Unit Weight (pcf), γ_t	120	105	135	125	135	135
	Subgrade Modulus (pci), k	35	25	96	154	-	36
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Major Principal Strain @ ε_{50}	-	-	-	-	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	12000	-
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Total Unit Weight (pcf), γ_t	120	105	135	125	135	135
	Shear Modulus (ksi), G	4.43	1.07	5.29	4.27	7.34	4.52
	Poisson's ratio, ν	0.30	0.30	0.26	0.30	0.23	0.26
	Vertical Failure Shear Stress (psf)	495	255	520	1367	720	240
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Ultimate Unit Skin Friction (psf)	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic
	Total Unit Weight (pcf), γ_t	120	105	135	125	135	135
	Internal Friction Angle, ϕ	33	29	39	36	-	36
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Shear Modulus (ksi), G	4.43	1.07	5.29	4.27	7.34	4.52
	Torsional Shear Stress (psf)	495	255	520	1367	720	240
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Shear Modulus (ksi), G	4.43	1.07	5.29	4.27	7.34	4.52
	Poisson's ratio, ν	0.30	0.30	0.26	0.30	0.23	0.26
	Axial Bearing Failure, kips	147	79	331	565	397	153
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-

(1) Ground Elevation of the Refrenced Boring (Borings).

(2) Approximate Water Table Elevation at the time the refrence boring was performed.

(3) Blow counts corrected to equivalent safety hammer if boring is conducted using automatic hammer.

Geotechnical Parameters for FB-MultiPier Input

Bear Cut Bridge
Miami-Dade County, Florida
At Bent 8

Piles (Steel Pipe Pile 18")

Reference Boring	B-8
Approximate Ground Elevation[1] (ft)	-17.60
Approximate Water Table Elevation[2] (ft)	0.00

Foundation Type	Driven Steel Pipe Pile
Size (inch)	18
Base Area (ft^2)	1.77

	Layer No.	1	2	3	4	5	6
	Soil Description	Limestone/Gravel	Sand	Limestone/Gravel	Limestone	Sand	Limestone/Gravel
	Soil Type	Cohesionless	Cohesionless	Cohesionless	Rock	Cohesionless	Cohesionless
	Top Boundary Elevation (ft)	-18	-34	-39	-49	-60	-68
	Bottom boundary Elevation (ft)	-34	-39	-49	-60	-68	-110
	Average SPT N-Value[3] (Blows/ft)	20	19	30	80	12	25
LATERAL	Soil Model	Sand (Reese)	Sand (Reese)	Sand (Reese)	Limestone (McVay)	Sand (Reese)	Sand (Reese)
	Internal Friction Angle, ϕ	38	32	40	-	31	39
	Total Unit Weight (pcf), γ_t	135	115	135	135	110	135
	Subgrade Modulus (pci), k	64	57	108	-	34	93
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Major Principal Strain @ ε_{50}	-	-	-	-	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	26000	-	-
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Total Unit Weight (pcf), γ_t	135	115	135	135	110	135
	Shear Modulus (ksi), G	4.96	2.08	5.51	19.76	1.71	5.24
	Poisson's ratio, ν	0.26	0.30	0.26	0.23	0.30	0.26
	Vertical Failure Shear Stress (psf)	400	709	600	1600	456	500
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Ultimate Unit Skin Friction (psf)	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic
	Total Unit Weight (pcf), γ_t	135	115	135	135	110	135
	Internal Friction Angle, ϕ	38	32	40	-	31	39
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Shear Modulus (ksi), G	4.96	2.08	5.51	19.76	1.71	5.24
	Torsional Shear Stress (psf)	400	709	600	1600	456	500
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Shear Modulus (ksi), G	4.96	2.08	5.51	19.76	1.71	5.24
	Poisson's ratio, ν	0.26	0.30	0.26	0.23	0.30	0.26
	Axial Bearing Failure, kips	254	215	382	505	136	318
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-

(1) Ground Elevation of the Refrenced Boring (Borings).

(2) Approximate Water Table Elevation at the time the refrence boring was performed.

(3) Blow counts corrected to equivalent safety hammer if boring is conducted using automatic hammer.

Geotechnical Parameters for FB-MultiPier Input

Bear Cut Bridge
Miami-Dade County, Florida
At Bent 13

Piles (Steel Pipe Pile 18")

Reference Boring	B-13
Approximate Ground Elevation[1] (ft)	-18.60
Approximate Water Table Elevation[2] (ft)	0.00

Foundation Type	Driven Steel Pipe Pile
Size (inch)	18
Base Area (ft^2)	1.77

	Layer No.	1	2	3	4	5	6
	Soil Description	Limestone/Gravel	Sand	Limestone	Limestone	Sand	Limestone/Gravel
	Soil Type	Cohesionless	Cohesionless	Rock	Rock	Cohesionless	Cohesionless
	Top Boundary Elevation (ft)	-19	-32	-41	-52	-60	-67
	Bottom boundary Elevation (ft)	-32	-41	-52	-60	-67	-112
	Average SPT N-Value[3] (Blows/ft)	23	21	42	70	13	23
LATERAL	Soil Model	Sand (Reese)	Sand (Reese)	Limestone (McVay)	Limestone (McVay)	Sand (Reese)	Sand (Reese)
	Internal Friction Angle, ϕ	38	33	-	-	31	38
	Total Unit Weight (pcf), γ_t	135	120	135	135	110	135
	Subgrade Modulus (pci), k	71	62	-	-	35	71
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Major Principal Strain @ ε_{50}	-	-	-	-	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	14000	22000	-	-
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Total Unit Weight (pcf), γ_t	135	120	135	135	110	135
	Shear Modulus (ksi), G	5.13	2.19	9.03	16.94	1.76	5.13
	Poisson's ratio, ν	0.26	0.30	0.23	0.23	0.30	0.26
	Vertical Failure Shear Stress (psf)	460	775	840	1400	495	460
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Ultimate Unit Skin Friction (psf)	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic
	Total Unit Weight (pcf), γ_t	135	120	135	135	110	135
	Internal Friction Angle, ϕ	38	33	-	-	31	38
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Shear Modulus (ksi), G	5.13	2.19	9.03	16.94	1.76	5.13
	Torsional Shear Stress (psf)	460	775	840	1400	495	460
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Shear Modulus (ksi), G	5.13	2.19	9.03	16.94	1.76	5.13
	Poisson's ratio, ν	0.26	0.30	0.23	0.23	0.30	0.26
	Axial Bearing Failure, kips	293	238	411	481	147	293
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-

(1) Ground Elevation of the Refrenced Boring (Borings).

(2) Approximate Water Table Elevation at the time the refrence boring was performed.

(3) Blow counts corrected to equivalent safety hammer if boring is conducted using automatic hammer.

Geotechnical Parameters for FB-MultiPier Input

Bear Cut Bridge
Miami-Dade County, Florida
At Bent 19

Piles (Steel Pipe Pile 18")

Reference Boring	B-19
Approximate Ground Elevation[1] (ft)	-19.20
Approximate Water Table Elevation[2] (ft)	0.00

Foundation Type	Driven Steel Pipe Pile
Size (inch)	18
Base Area (ft^2)	1.77

	Layer No.	1	2	3	4	5	6
	Soil Description	Limestone/Gravel	Limestone	Sand	Limestone	Limestone/Gravel	
	Soil Type	Cohesionless	Rock	Cohesionless	Rock	Cohesionless	
	Top Boundary Elevation (ft)	-19	-42	-50	-67	-77	
	Bottom boundary Elevation (ft)	-42	-50	-67	-77	-119	
	Average SPT N-Value[3] (Blows/ft)	25	80	15	80	22	
LATERAL	Soil Model	Sand (Reese)	Limestone (McVay)	Sand (Reese)	Limestone (McVay)	Sand (Reese)	
	Internal Friction Angle, ϕ	39	-	31	-	38	
	Total Unit Weight (pcf), γ_t	135	135	110	135	135	
	Subgrade Modulus (pci), k	93	-	48	-	69	
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	
	Major Principal Strain @ ε_{50}	-	-	-	-	-	
	Major Principal Strain @ ε_{100}	-	-	-	-	-	
	Average Undrained Shear Strength (psf)	-	-	-	-	-	
	Unconfined Compressive Strength (psf)	-	26000	-	26000	-	
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	
	Total Unit Weight (pcf), γ_t	135	135	110	135	135	
	Shear Modulus (ksi), G	5.24	19.76	1.87	19.76	5.07	
	Poisson's ratio, ν	0.26	0.23	0.30	0.23	0.26	
	Vertical Failure Shear Stress (psf)	500	1600	569	1600	440	
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	
	Ultimate Unit Skin Friction (psf)	-	-	-	-	-	
	Mass Modulus (ksi)	-	-	-	-	-	
	Modulus Ratio	-	-	-	-	-	
	Surface (Rough/Smooth)	-	-	-	-	-	
	Unconfined Compressive Strength (psf)	-	-	-	-	-	
	Split Tensile Strength (psf)	-	-	-	-	-	
	Concrete Unit Weight (pcf)	-	-	-	-	-	
	Slump (in)	-	-	-	-	-	
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	
	Total Unit Weight (pcf), γ_t	135	135	110	135	135	
	Internal Friction Angle, ϕ	39	-	31	-	38	
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	
	Shear Modulus (ksi), G	5.24	19.76	1.87	19.76	5.07	
	Torsional Shear Stress (psf)	500	1600	569	1600	440	
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	
	Shear Modulus (ksi), G	5.24	19.76	1.87	19.76	5.07	
	Poisson's ratio, ν	0.26	0.23	0.30	0.23	0.26	
	Axial Bearing Failure, kips	318	505	170	505	280	
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	

(1) Ground Elevation of the Refrenced Boring (Borings).

(2) Approximate Water Table Elevation at the time the refrence boring was performed.

(3) Blow counts corrected to equivalent safety hammer if boring is conducted using automatic hammer.

Geotechnical Parameters for FB-MultiPier Input

Bear Cut Bridge
Miami-Dade County, Florida
At Bent 24

Piles (Steel Pipe Pile 18")

Reference Boring	B-24
Approximate Ground Elevation[1] (ft)	-20.40
Approximate Water Table Elevation[2] (ft)	0.00

Foundation Type	Driven Steel Pipe Pile
Size (inch)	18
Base Area (ft^2)	1.77

	Layer No.	1	2	3	4	5	6
	Soil Description	Limestone/Gravel	Sand/Limestone	Sand	Limestone	Limestone/Gravel	Limestone
	Soil Type	Cohesionless	Cohesionless	Cohesionless	Rock	Cohesionless	Rock
	Top Boundary Elevation (ft)	-20	-48	-53	-61	-73	-100
	Bottom boundary Elevation (ft)	-48	-53	-61	-73	-100	-110
	Average SPT N-Value[3] (Blows/ft)	30	1	23	50	18	50
LATERAL	Soil Model	Sand (Reese)	Sand (Reese)	Sand (Reese)	Limestone (McVay)	Sand (Reese)	Limestone (McVay)
	Internal Friction Angle, ϕ	40	30	33	-	37	-
	Total Unit Weight (pcf), γ_t	135	110	120	135	135	135
	Subgrade Modulus (pci), k	108	14	66	-	59	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Major Principal Strain @ ε_{50}	-	-	-	-	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	16000	-	16000
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Total Unit Weight (pcf), γ_t	135	110	120	135	135	135
	Shear Modulus (ksi), G	5.51	3.79	2.30	11.29	4.85	11.29
	Poisson's ratio, ν	0.26	0.30	0.30	0.23	0.26	0.23
	Vertical Failure Shear Stress (psf)	600	-6	838	1000	360	1000
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Ultimate Unit Skin Friction (psf)	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic
	Total Unit Weight (pcf), γ_t	135	110	120	135	135	135
	Internal Friction Angle, ϕ	40	30	33	-	37	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Shear Modulus (ksi), G	5.51	3.79	2.30	11.29	4.85	11.29
	Torsional Shear Stress (psf)	600	-6	838	1000	360	1000
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Shear Modulus (ksi), G	5.51	3.79	2.30	11.29	4.85	11.29
	Poisson's ratio, ν	0.26	0.30	0.30	0.23	0.26	0.23
	Axial Bearing Failure, kips	382	11	260	431	229	431
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-

(1) Ground Elevation of the Refrenced Boring (Borings).

(2) Approximate Water Table Elevation at the time the refrence boring was performed.

(3) Blow counts corrected to equivalent safety hammer if boring is conducted using automatic hammer.

Geotechnical Parameters for FB-MultiPier Input

Bear Cut Bridge
Miami-Dade County, Florida
At Bent 30

Piles (Steel Pipe Pile 18")

Reference Boring	B-30
Approximate Ground Elevation[1] (ft)	-20.90
Approximate Water Table Elevation[2] (ft)	0.00

Foundation Type	Driven Steel Pipe Pile
Size (inch)	18
Base Area (ft^2)	1.77

	Layer No.	1	2	3	4	5	6
	Soil Description	Limestone/Gravel	Sand	Limestone/Gravel	Limestone	Sand	Limestone/Gravel
	Soil Type	Cohesionless	Cohesionless	Cohesionless	Rock	Cohesionless	Cohesionless
	Top Boundary Elevation (ft)	-21	-32	-38	-42	-57	-62
	Bottom boundary Elevation (ft)	-32	-38	-42	-57	-62	-70
	Average SPT N-Value[3] (Blows/ft)	22	5	23	38	10	13
LATERAL	Soil Model	Sand (Reese)	Sand (Reese)	Sand (Reese)	Limestone (McVay)	Sand (Reese)	Sand (Reese)
	Internal Friction Angle, ϕ	38	29	38	-	30	36
	Total Unit Weight (pcf), γ_t	135	105	135	135	110	135
	Subgrade Modulus (pci), k	69	21	71	-	30	38
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Major Principal Strain @ ε_{50}	-	-	-	-	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	14000	-	-
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Total Unit Weight (pcf), γ_t	135	105	135	135	110	135
	Shear Modulus (ksi), G	5.07	0.71	5.13	7.90	1.60	4.57
	Poisson's ratio, ν	0.26	0.30	0.26	0.23	0.30	0.26
	Vertical Failure Shear Stress (psf)	440	171	460	760	378	260
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Ultimate Unit Skin Friction (psf)	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic
	Total Unit Weight (pcf), γ_t	135	105	135	135	110	135
	Internal Friction Angle, ϕ	38	29	38	-	30	36
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Shear Modulus (ksi), G	5.07	0.71	5.13	7.90	1.60	4.57
	Torsional Shear Stress (psf)	440	171	460	760	378	260
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Shear Modulus (ksi), G	5.07	0.71	5.13	7.90	1.60	4.57
	Poisson's ratio, ν	0.26	0.30	0.26	0.23	0.30	0.26
	Axial Bearing Failure, kips	280	57	293	401	113	165
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-

(1) Ground Elevation of the Refrenced Boring (Borings).

(2) Approximate Water Table Elevation at the time the refrence boring was performed.

(3) Blow counts corrected to equivalent safety hammer if boring is conducted using automatic hammer.

Geotechnical Parameters for FB-MultiPier Input

Bear Cut Bridge
Miami-Dade County, Florida
At Bent 35

Piles (Steel Pipe Pile 18")

Reference Boring	B-35
Approximate Ground Elevation[1] (ft)	-13.10
Approximate Water Table Elevation[2] (ft)	0.00

Foundation Type	Driven Steel Pipe Pile
Size (inch)	18
Base Area (ft^2)	1.77

	Layer No.	1	2	3	4	5	6
	Soil Description	Limestone/Gravel	Sand	Limestone/Gravel	Limestone	Sand	Limestone
	Soil Type	Cohesionless	Cohesionless	Cohesionless	Rock	Cohesionless	Rock
	Top Boundary Elevation (ft)	-13	-30	-34	-41	-56	-61
	Bottom boundary Elevation (ft)	-30	-34	-41	-56	-61	-113
	Average SPT N-Value[3] (Blows/ft)	28	10	20	60	17	40
LATERAL	Soil Model	Sand (Reese)	Sand (Reese)	Sand (Reese)	Limestone (McVay)	Sand (Reese)	Limestone (McVay)
	Internal Friction Angle, ϕ	40	30	38	-	32	-
	Total Unit Weight (pcf), γ_t	135	110	135	135	115	135
	Subgrade Modulus (pci), k	102	30	64	-	53	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Major Principal Strain @ ε_{50}	-	-	-	-	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	20000	-	14000
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Total Unit Weight (pcf), γ_t	135	110	135	135	115	135
	Shear Modulus (ksi), G	5.40	1.60	4.96	14.12	1.98	8.47
	Poisson's ratio, ν	0.26	0.30	0.26	0.23	0.30	0.23
	Vertical Failure Shear Stress (psf)	560	378	400	1200	641	800
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Ultimate Unit Skin Friction (psf)	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic
	Total Unit Weight (pcf), γ_t	135	110	135	135	115	135
	Internal Friction Angle, ϕ	40	30	38	-	32	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Shear Modulus (ksi), G	5.40	1.60	4.96	14.12	1.98	8.47
	Torsional Shear Stress (psf)	560	378	400	1200	641	800
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Shear Modulus (ksi), G	5.40	1.60	4.96	14.12	1.98	8.47
	Poisson's ratio, ν	0.26	0.30	0.26	0.23	0.30	0.23
	Axial Bearing Failure, kips	356	113	254	456	192	406
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-

(1) Ground Elevation of the Refrenced Boring (Borings).
(2) Approximate Water Table Elevation at the time the refrence boring was performed.
(3) Blow counts corrected to equivalent safety hammer if boring is conducted using automatic hammer.

Geotechnical Parameters for FB-MultiPier Input

Bear Cut Bridge
Miami-Dade County, Florida
At Bent 40

Piles (Steel Pipe Pile 18")

Reference Boring	B-40
Approximate Ground Elevation[1] (ft)	-4.20
Approximate Water Table Elevation[2] (ft)	0.00

Foundation Type	Driven Steel Pipe Pile
Size (inch)	18
Base Area (ft^2)	1.77

	Layer No.	1	2	3	4	5	6
	Soil Description	Sand	Limestone/Gravel	Sand	Limestone	Sand	Limestone
	Soil Type	Cohesionless	Cohesionless	Cohesionless	Rock	Cohesionless	Rock
	Top Boundary Elevation (ft)	-4	-15	-25	-37	-57	-60
	Bottom boundary Elevation (ft)	-15	-25	-37	-57	-60	-73
	Average SPT N-Value[3] (Blows/ft)	21	24	15	37	3	66
LATERAL	Soil Model	Sand (Reese)	Sand (Reese)	Sand (Reese)	Limestone (McVay)	Sand (Reese)	Limestone (McVay)
	Internal Friction Angle, ϕ	33	39	31	-	28	-
	Total Unit Weight (pcf), γ_t	120	135	110	135	100	135
	Subgrade Modulus (pci), k	62	74	48	-	18	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Major Principal Strain @ ε_{50}	-	-	-	-	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	12000	-	22000
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Total Unit Weight (pcf), γ_t	120	135	110	135	100	135
	Shear Modulus (ksi), G	2.19	5.18	1.87	7.62	0.36	15.81
	Poisson's ratio, ν	0.30	0.26	0.30	0.23	0.30	0.23
	Vertical Failure Shear Stress (psf)	775	480	569	740	83	1320
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Ultimate Unit Skin Friction (psf)	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic
	Total Unit Weight (pcf), γ_t	120	135	110	135	100	135
	Internal Friction Angle, ϕ	33	39	31	-	28	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	Shear Modulus (ksi), G	2.19	5.18	1.87	7.62	0.36	15.81
	Torsional Shear Stress (psf)	775	480	569	740	83	1320
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile
	Shear Modulus (ksi), G	2.19	5.18	1.87	7.62	0.36	15.81
	Poisson's ratio, ν	0.30	0.26	0.30	0.23	0.30	0.23
	Axial Bearing Failure, kips	238	305	170	399	34	471
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-

(1) Ground Elevation of the Refrenced Boring (Borings).

(2) Approximate Water Table Elevation at the time the refrence boring was performed.

(3) Blow counts corrected to equivalent safety hammer if boring is conducted using automatic hammer.

APPENDIX – E

Report of Parallel Seismic Testing by AFT

Applied Foundation Testing

AFT Board of Professional Engineers Certificate of Authorization No. 7668

August 5, 2013

Final Report of
Parallel Seismic Testing
Rehabilitation of
Bear Cut Bridge
Miami-Dade County, Florida
AFT Project No.: 213060

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Applied Foundation Testing

AFT Board of Professional Engineers Certificate of Authorization No. 7668

August 5, 2013

Final Report of
Parallel Seismic Testing
Rehabilitation of
Bear Cut Bridge
Miami-Dade County, Florida
AFT Project No.: 213060

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For: **Mr. Wenbin Zhao,**
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Introduction

This report is provided to summarize the results of non-destructive testing (NDT) consisting of the Parallel Seismic Testing (PST) method to estimate unknown foundation lengths. This work was performed through a design build contract that has been awarded to Keiwit Infrastructure South to perform rehabilitation of the Bear Cut Bridge. As part of this rehabilitation we understand an interest exists in reusing the existing piles, pile caps, columns, and pier caps. Pile driving records were not available so field testing to estimate foundation length was undertaken. Applied Foundation Testing (AFT) was contracted through Tierra South Florida, Inc. (TSF) to perform the testing.

The Bear Cut Bridge carries the north and southbound traffic of Rickenbacker Causeway over Bear Cut to connect Virginia Key and Key Biscayne. The bridge is comprised of forty-one 51 ft spans over the waterway for a total length of 2,091 ft. Miami Dade County constructed the bridge (No. 874544) in 1944 and it was widened in 1984. The NDT work contained in this report was only performed on the original bridge built in 1944.

The bridge substructure consists of two abutments and forty intermediate bridge piers. Bridge piers were composed of two columns supporting the pier cap, beams, and deck. Each column sits centered atop a pile cap approximately 4.0 feet thick and approximately eight feet square. Each column is approximately four feet square at the top of the pile cap. Each pile cap is supported on a five pile cluster. The five pile cluster includes a center pile in the pile cap and four other piles at each corner of the pile cap. The four corner piles are double battered at an estimated batter angle of 1.5 inches horizontal to every 12 inches vertical. The piles are understood to be concrete filled monotube piles with an 18 inch butt diameter. Information provided to us on the existing pile type was limited and consisted of the attached Piling Repair plan sheet from 1983. The piling repair plan was apparently carried out as many of the piles observed during our work have jackets using concrete from the bottom of the pile cap to the mud line. The concrete pile jackets are approximately 36 inches in diameter.

The NDT testing efforts focused on the center plumb pile of eight (8) selected pile groups across the bridge. More specifically, the center pile of the seaward pile group at Piers 5, 8, 13, 19, 24, 30, 35, and 40 were tested using Parallel Seismic Testing (PST). Please note that Low Strain Integrity Testing (SIT) was also attempted but yielded inconclusive results. An example of these inconclusive results are provided in the appendix but is not discussed any further in this report. This report only includes the parallel seismic test results and our interpretations.

Parallel Seismic Test Set-up and Instrumentation

Within the scope of the SPT borings performed by TSF, borehole casings were installed at each of the eight piers to be tested. This was done prior to AFT being on site. These casings were composed of PVC with an approximate two inch inside diameter. The casings were installed to depths of approximately 120 to 125 feet below the top of the pile cap and filled with water. The casing was installed approximately four to five feet from the center of the pile cap (see photograph). The SPT borings are included within Appendix D.

Parallel seismic testing was accomplished using an Olson Instruments Parallel Seismic system and model Freedom Data PC. With necessary support from a diver, our general approach included impacting the center pile with a hammer and triggering the computer software (to start a time clock) via an accelerometer located near the hammer location. The subsequent

compression wave from the hammer impact was recorded by a hydrophone located within the borehole casing. The hydrophone was lowered in general to at least 80 feet below the top of the borehole casing prior to the first impact by the hammer to the pile. The pile was then impacted by the hammer. The hydrophone was then raised two feet and another hammer impact to the pile was provided. This process continued until the hydrophone was approximately two to six feet above the estimated mud line depth.

Keiwit Infrastructure South provided elevation survey measurements of the pile cap tops being at elevation $^{+}$1.6 feet (±0.02'), NGVD. All piles tested were accessed for testing using commercial divers. Industrial Divers Corporation provided the divers, support personnel, and equipment needed to attach a strike block to each tested pile to allow vertical hits with a small sledge hammer. The diver also secured or held a waterproofed accelerometer (for triggering purposes) against the pile during each hammer blow. Communication with the diver during the test was accomplished via a radio incorporated into the dive helmet.

Appendix A includes photographs of the typical test set up and equipment. Each photograph has a brief description or explanation.

Parallel Seismic Test Results

Parallel Seismic analysis is done in the time domain by stacking the test results from each test interval using Brigix software developed for Olson Instruments. Each test interval is defined as a vertical hammer blow creating a compression wave into the pile for each hydrophone depth below the top of the borehole casing. The results are shown graphically in the time domain with the signal captured by the hydrophone from each test interval stacked above the previous test depth. Estimation of the pile tip is based on interpretation of an inflection point showing a slowing of the first arrival from the compression wave energy traveling down the subject (center) pile and through the soil to the hydrophone. This inflection point is indicative of the pile tip.

Please refer to Figures 1 through 8 in Appendix B for the outputs showing the parallel seismic results and our interpretation. Data quality is acceptable for interpretation, but does appear to contain some noise due to potential wave energy traveling to the hydrophone through the water or through the nearby battered piles. Some of the poorer quality data sets were deleted from the waterfall plots during the interpretation process. These deletions are illustrated by gaps in the data in some of the figures. These deletions may slightly affect our interpretation of the inflection points when they occur in the vicinity of the inflection point.

For all test locations the top of the pile cap was established as $^{+}$1.6 feet elevation, NAVD. The top of the borehole casings ranged from approximately -16.4 feet to 5.0 feet, NAVD. Approximate measurements (using a weighted tape and/or depth finder) below the top of each pile cap were used to establish approximate mud line elevations. A summary of the results follows. A detailed summary of the results is included in Appendix C.

Summary of Parallel Seismic Results[1]

Pier	Estimated Top of Casing Elevation (ft)	Provided Mud Line Elevation (ft)	Estimated Inflection Point Elevation (ft)	Estimated Pile Penetration (ft)	Estimated Variability in Pile Length Estimate (ft)
5	6.1	-13.1	-32.2	19.1	± 2 to 4
8	6.3	-17.6	-43.3	25.7	± 3 to 5
13	5.0	-18.6	-41.4	22.8	± 3 to 5
19	5.6	-19.2	-39.6	20.4	± 3 to 5
24	6.4	-20.4	-36.2	15.8	± 3 to 5
30	-16.4[2]	-20.9	-40.9	20	± 3 to 5
35	6.4	-13.1	-32.5	19.4	± 2 to 4
40	6.1	-4.2	-37.3	33.1	± 3 to 5

1. Only the center pile of the seaward pile group was tested. Other pile penetrations within the pile group, within the landward pile group of the same pier, or in piers where no testing was completed likely vary from the results presented considering the geologic site conditions.
2. This borehole casing broke at approximately the mud line. Testing was accomplished by the diver placing the hydrophone into the borehole casing.

Summary and Conclusions

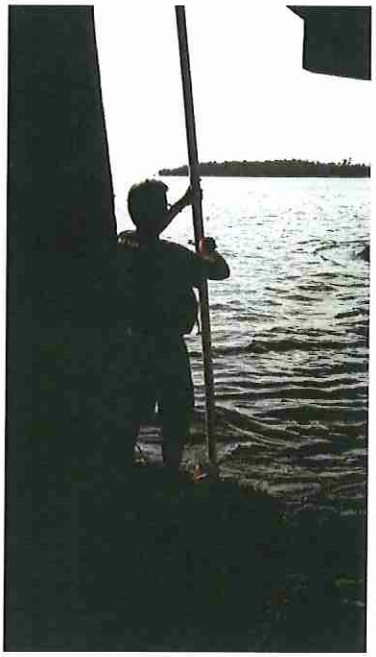
Non-destructive testing was performed using the Parallel Seismic test method to evaluate unknown foundation lengths of the original Bear Cut Bridge built in 1944. Testing was not performed on the adjacent bridge built in 1984. The parallel seismic testing was performed on eight (8) selected piers across the bridge. These were located at Piers 5, 8, 13, 19, 24, 30, 35, and 40. In each selected pier the testing focused on the center plumb pile. The parallel seismic data were collected, analyzed and interpreted by AFT. Our interpretations suggest the pile tip elevations for the tested piles range from approximately -32 to -43 feet. In general the estimated pile tip elevations correspond to depths within the sandy limestone indicated in the borings. Typical depth accuracy of the selected depth of the inflection point is estimated at plus or minus five to ten percent.

Limitations

This report presents test measurements made by AFT. Interpretations were made based upon the measurements made by AFT with the latest techniques available and currently accepted standards of care recognized by Geotechnical Engineering professionals.

Appendix A

Photographs of Parallel Seismic Test Set-Up and Equipment

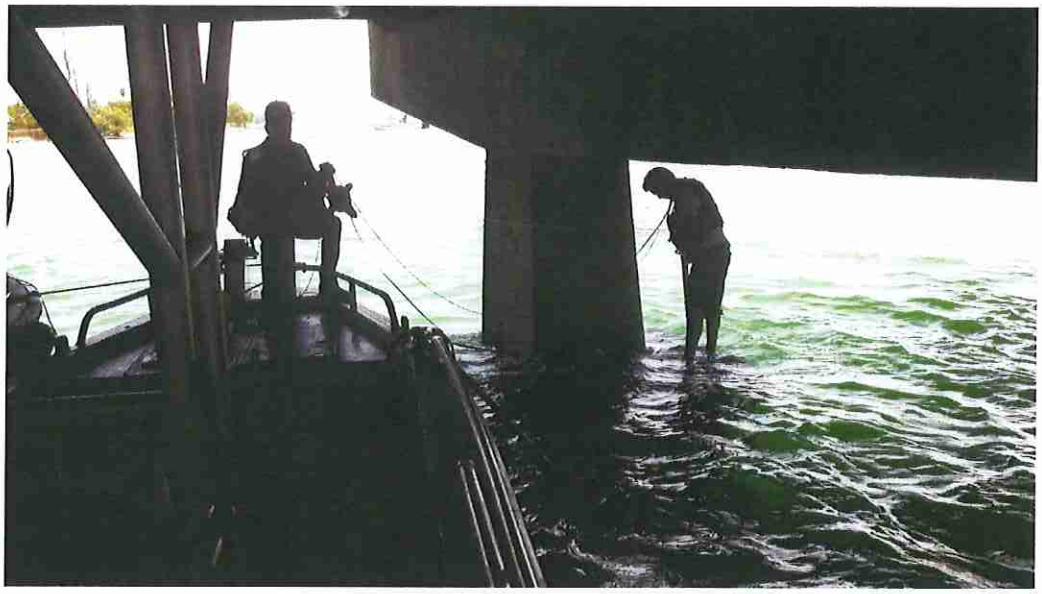


Photograph 1 - Preparing casing prior to testing (typical)

Photograph 2 - Location of casing relative to footing (typical)

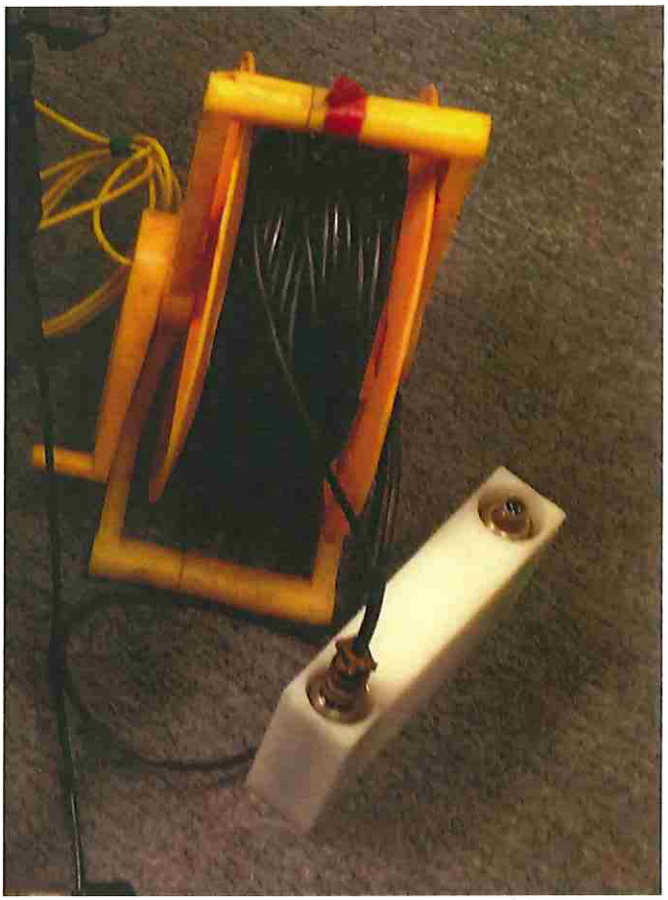
Photograph 3 - Typical configuration of boats during testing

Photograph 4 - Typical layout of radio and data acquisition computer



Photograph 5 - AFT and Tierra South Florida employees during testing

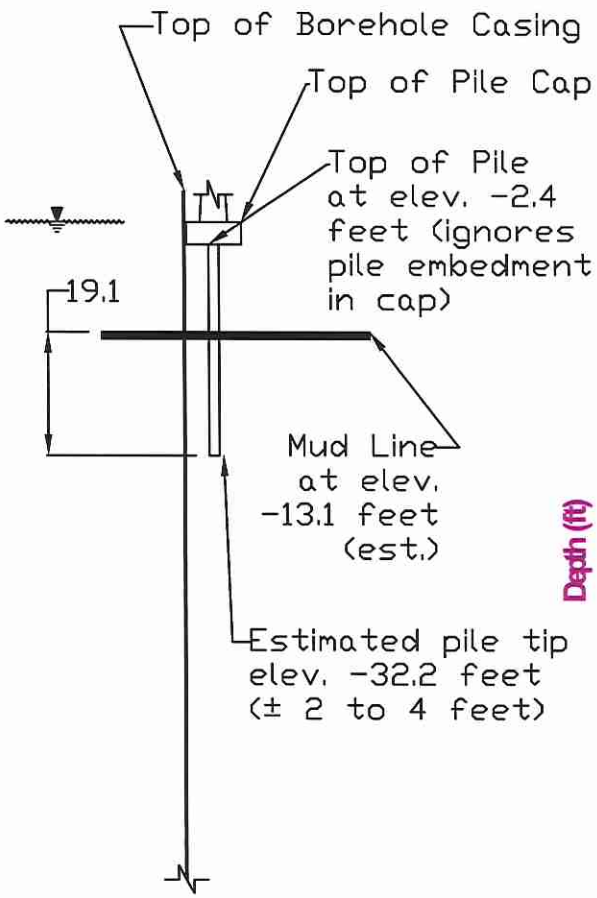
Photograph 6 – Waterproof accelerometers used for test

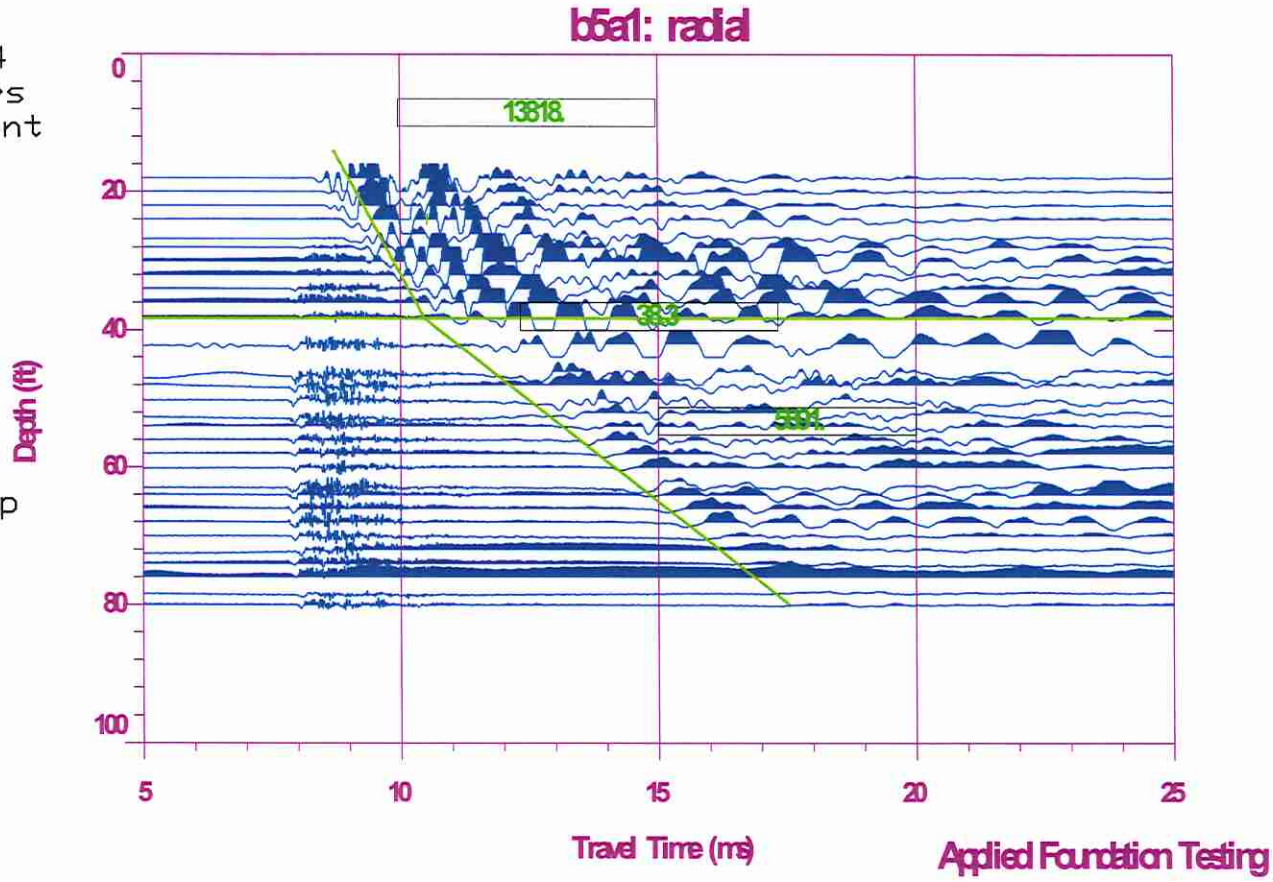


Photograph 7 – Hydrophone connected to cable

Appendix B

Parallel Seismic Results – Figures 1 through 8





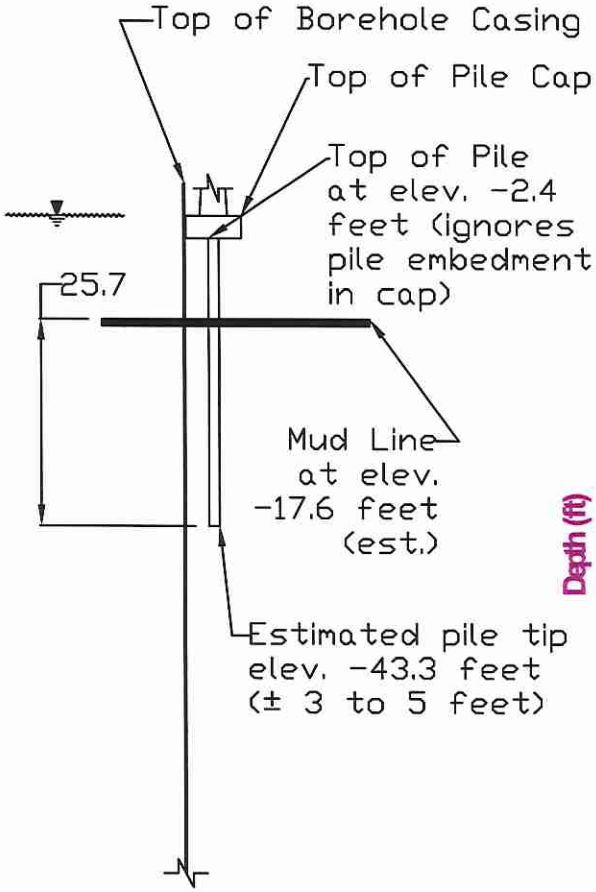
Notes:

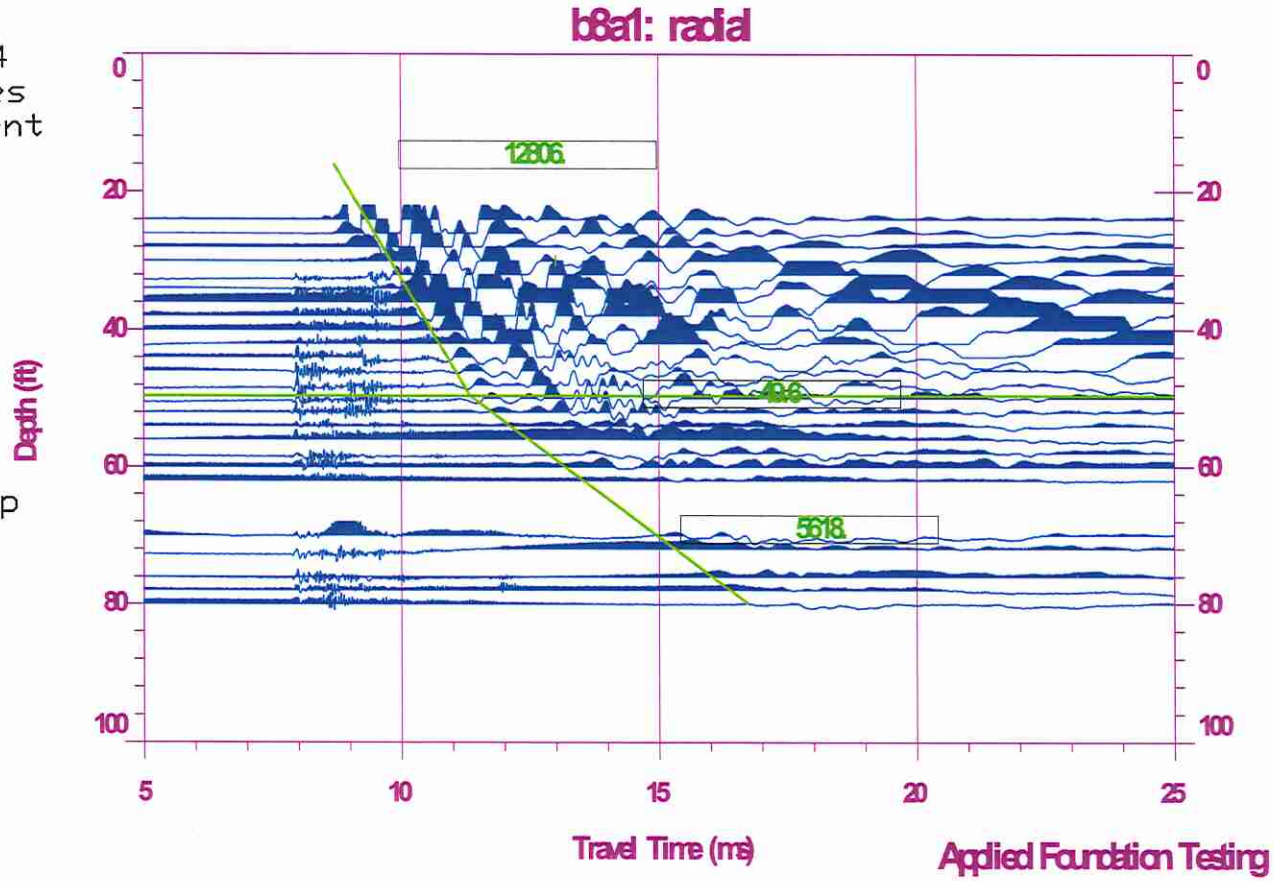
1. Pilejackets (if existing on pile) are not shown.
2. Only center pile shown in illustration (corner piles omitted).

Figure 1

Bent/Pier 5 Parallel Seismic Results

Rehabilitation of Bear Cut Bridge (874544), Rickenbacker Causeway, Miami-Dade County, FL





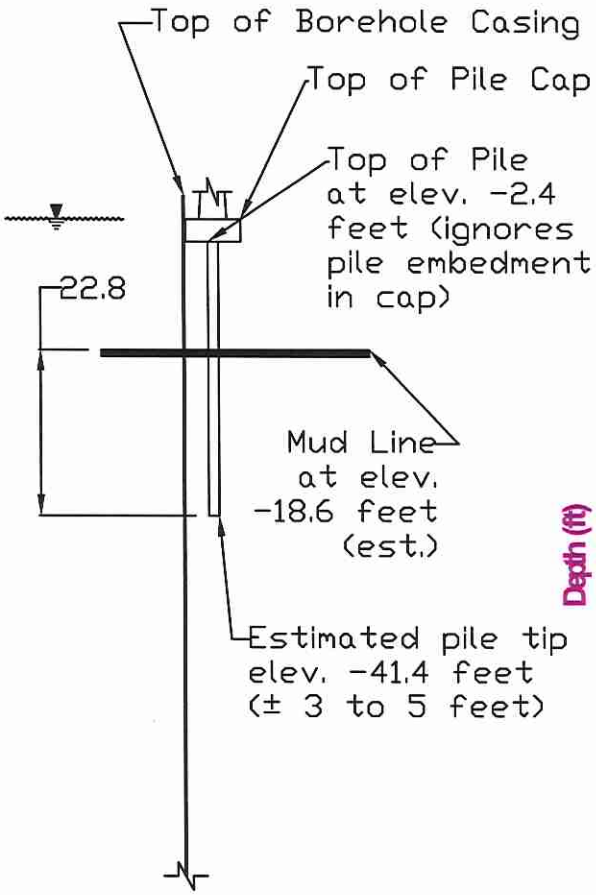
Notes:

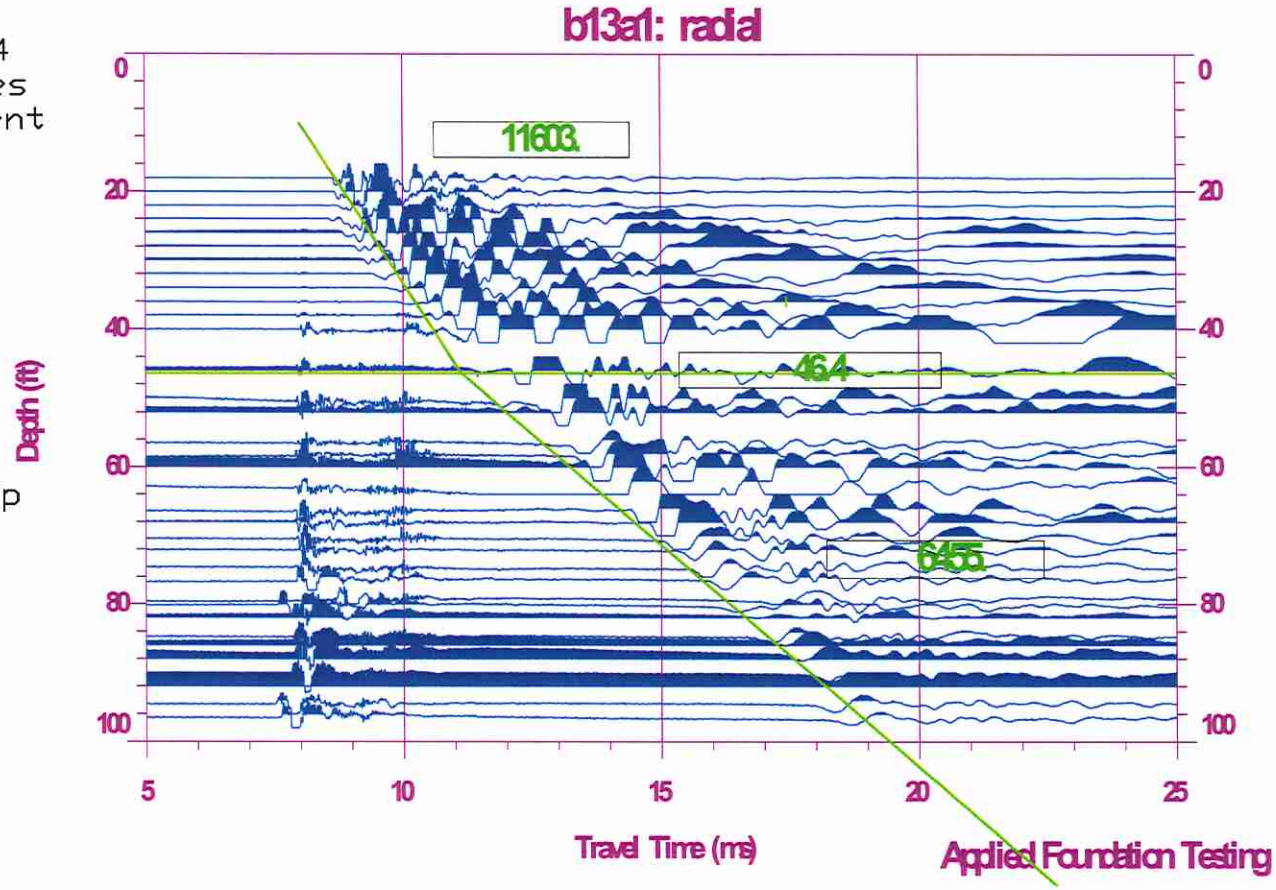
1. Pile jackets (if existing on pile) are not shown.
2. Only center pile shown in illustration (corner piles omitted).

Figure 2

Bent/Pier 8 Parallel Seismic Results

Rehabilitation of Bear Cut Bridge (874544), Rickenbacker Causeway, Miami-Dade County, FL

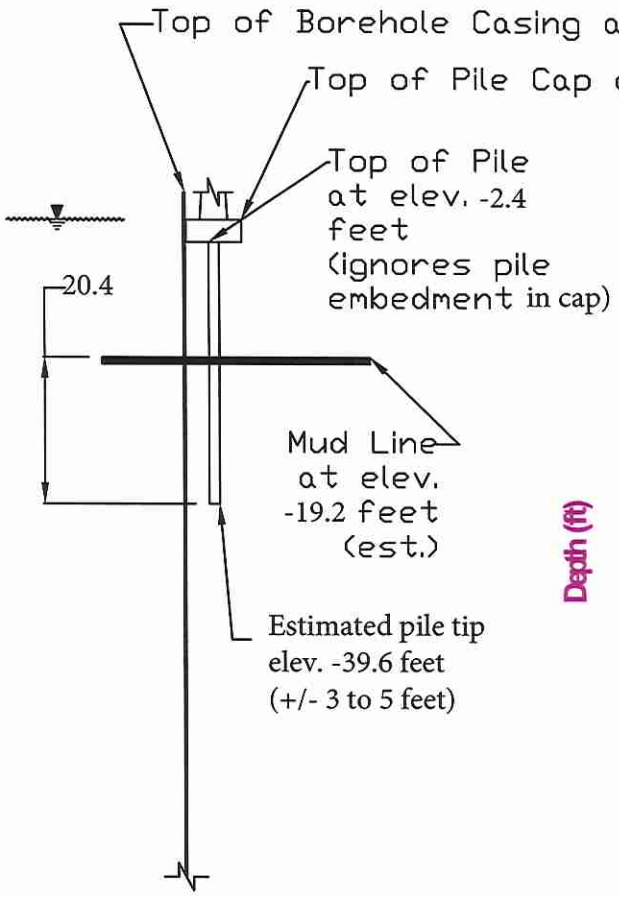


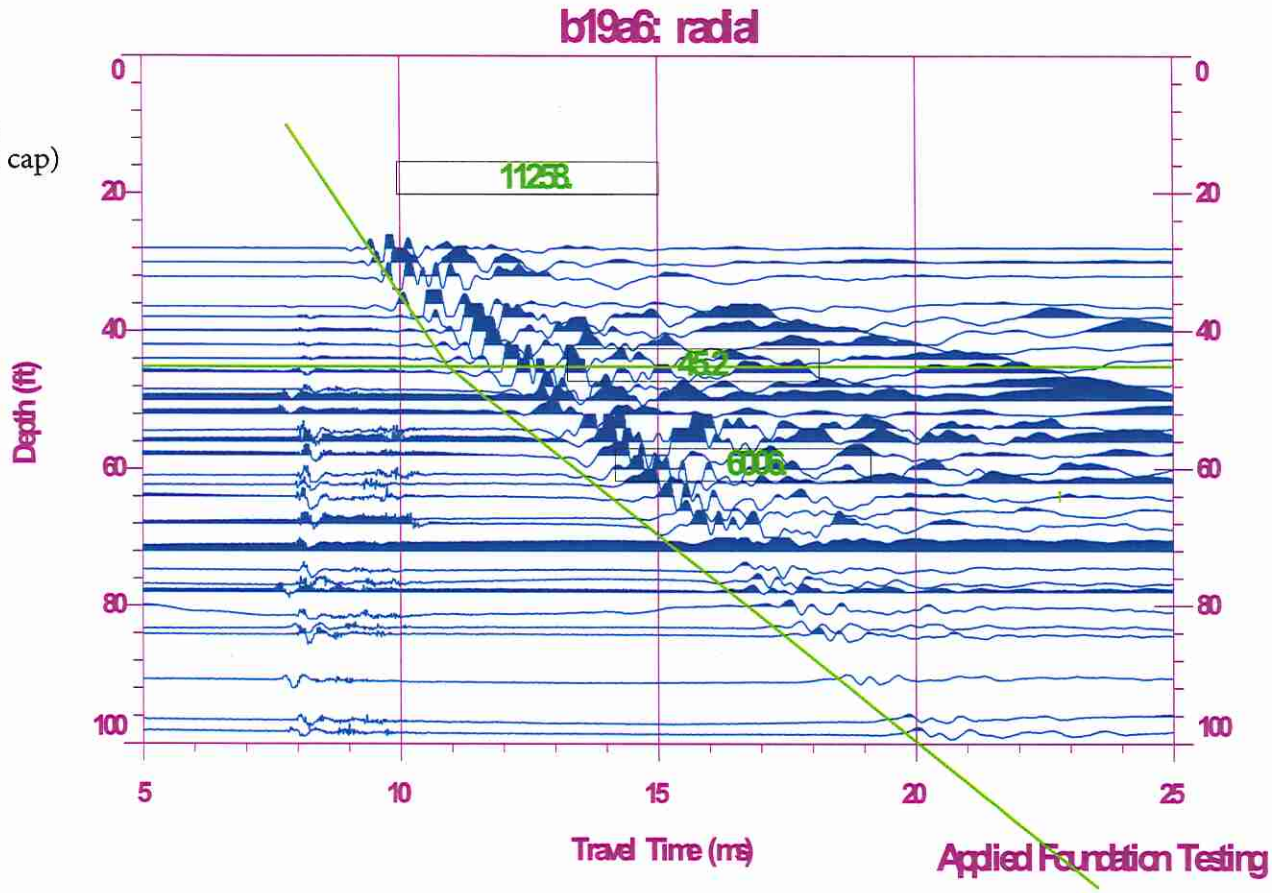


Notes:

1. Pile jackets (if existing on pile) are not shown.
2. Only center pile shown in illustration (corner piles omitted)..

Figure 3
Bent/Pier 13 Parallel Seismic Results
Rehabilitation of Bear Cut Bridge (874544), Rickenbacker Causeway, Miami-Dade County, FL

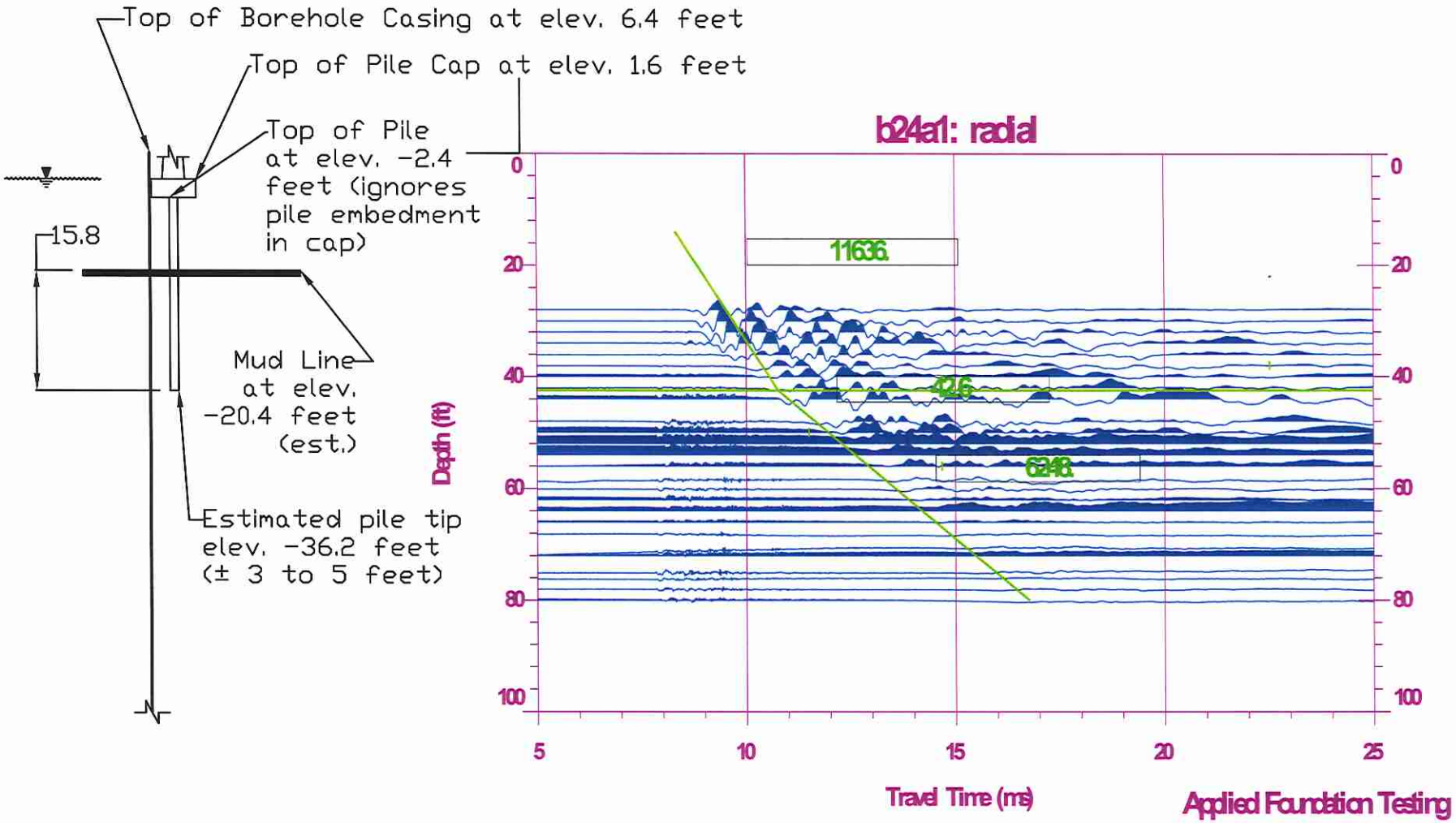




Notes:

1. Pile jackets (if existing on pile) are not shown.
2. Only center pile shown in illustration (corner piles omitted).

Figure 4
Bent/Pier 19 Parallel Seismic Results
Rehabilitation of Bear Cut Bridge (874544), Rickenbacker Causeway, Miami-Dade County, FL



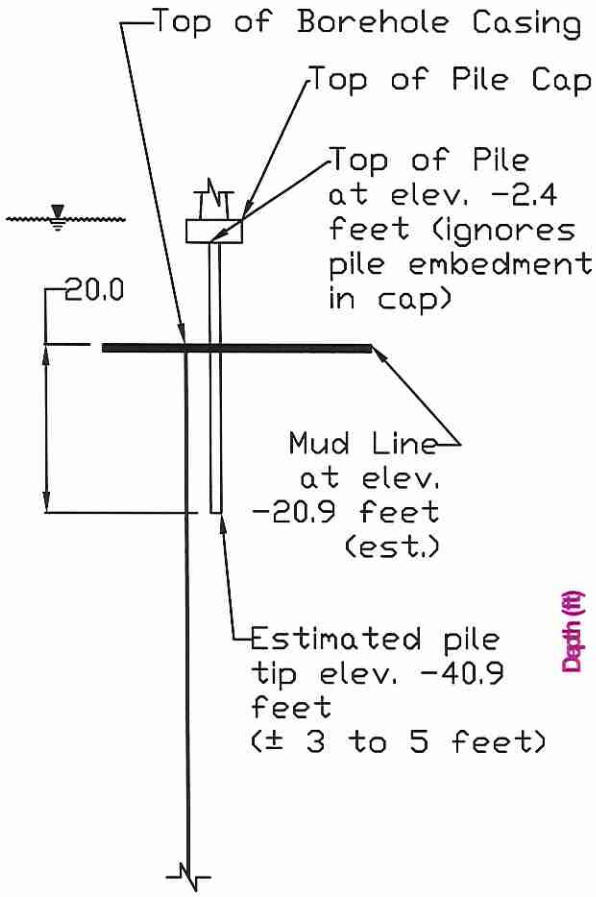
Notes:

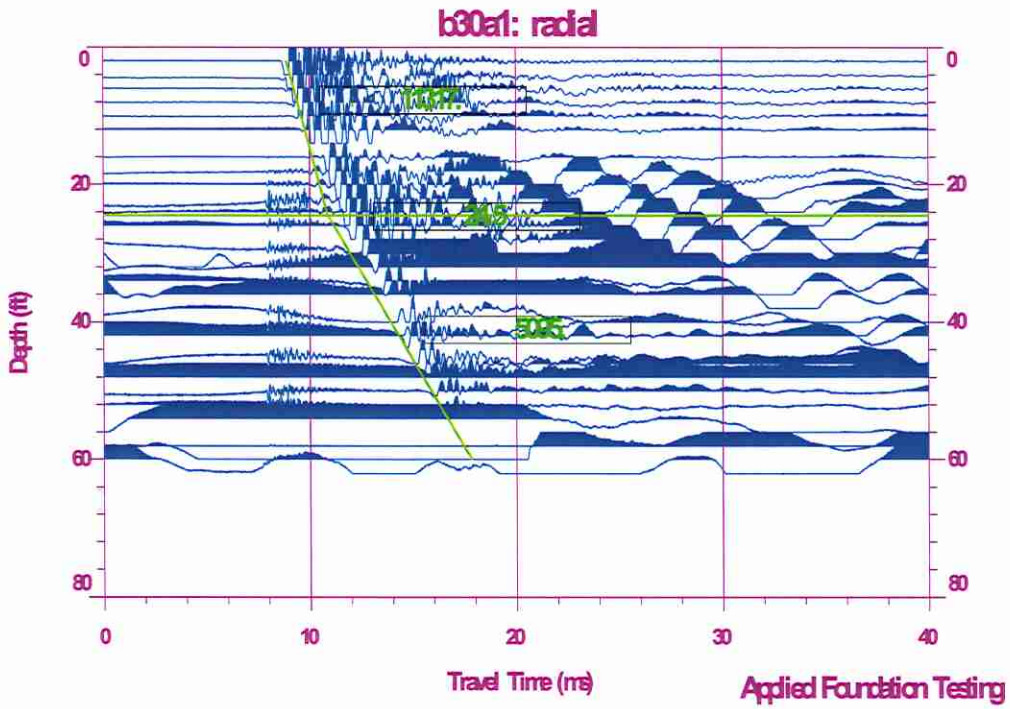
1. Pilejackets (if existing on pile) are not shown.
2. Only center pile shown in illustration (corner piles omitted).

Figure 5

Bent/Pier 24 Parallel Seismic Results

Rehabilitation of Bear Cut Bridge (874544), Rickenbacker Causeway, Miami-Dade County, FL





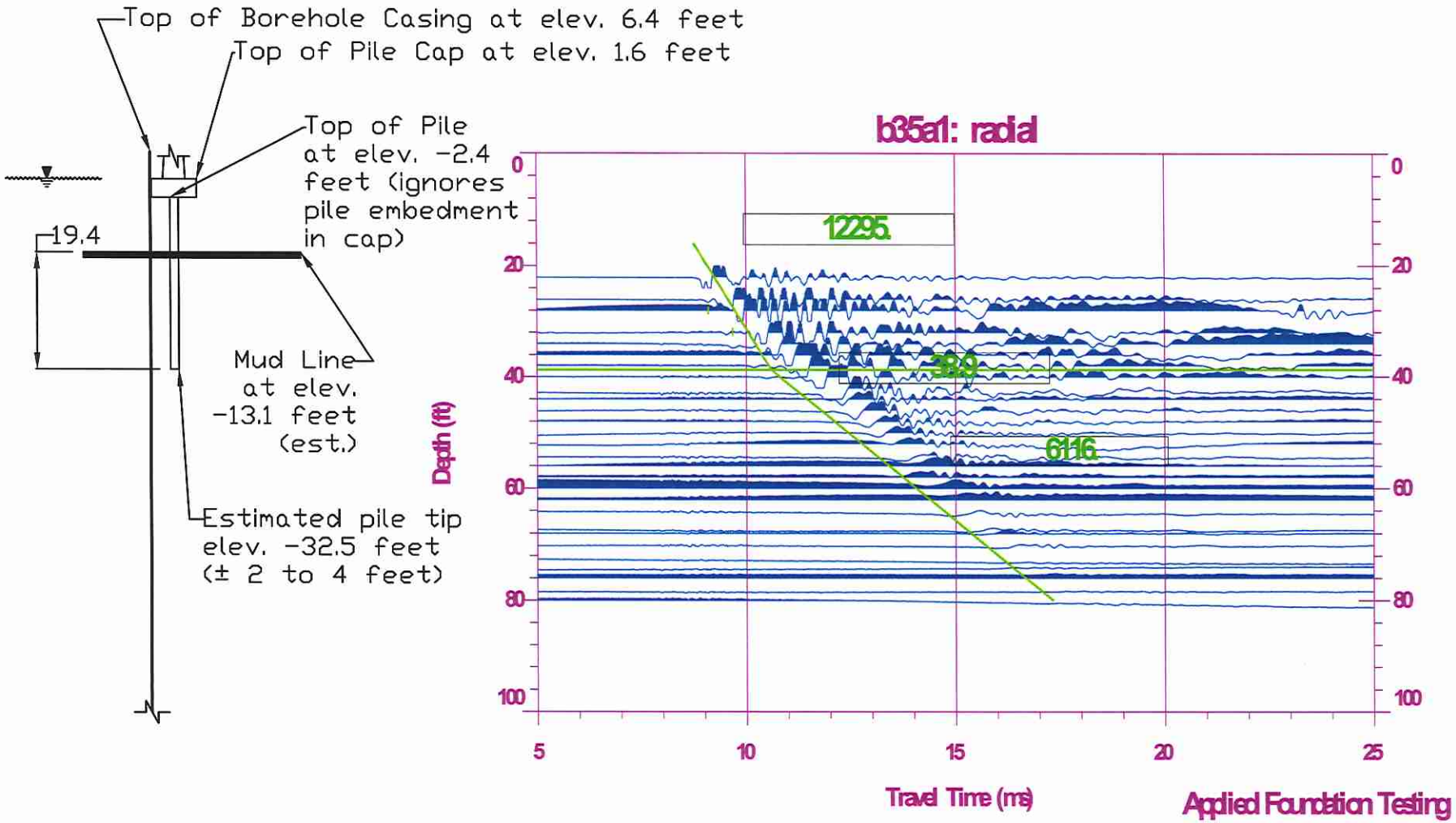
Notes:

1. Pilejackets (if existing on pile) are not shown.
2. Only center pile shown in illustration (corner piles omitted).

Figure 6

Bent/Pier 30 Parallel Seismic Results

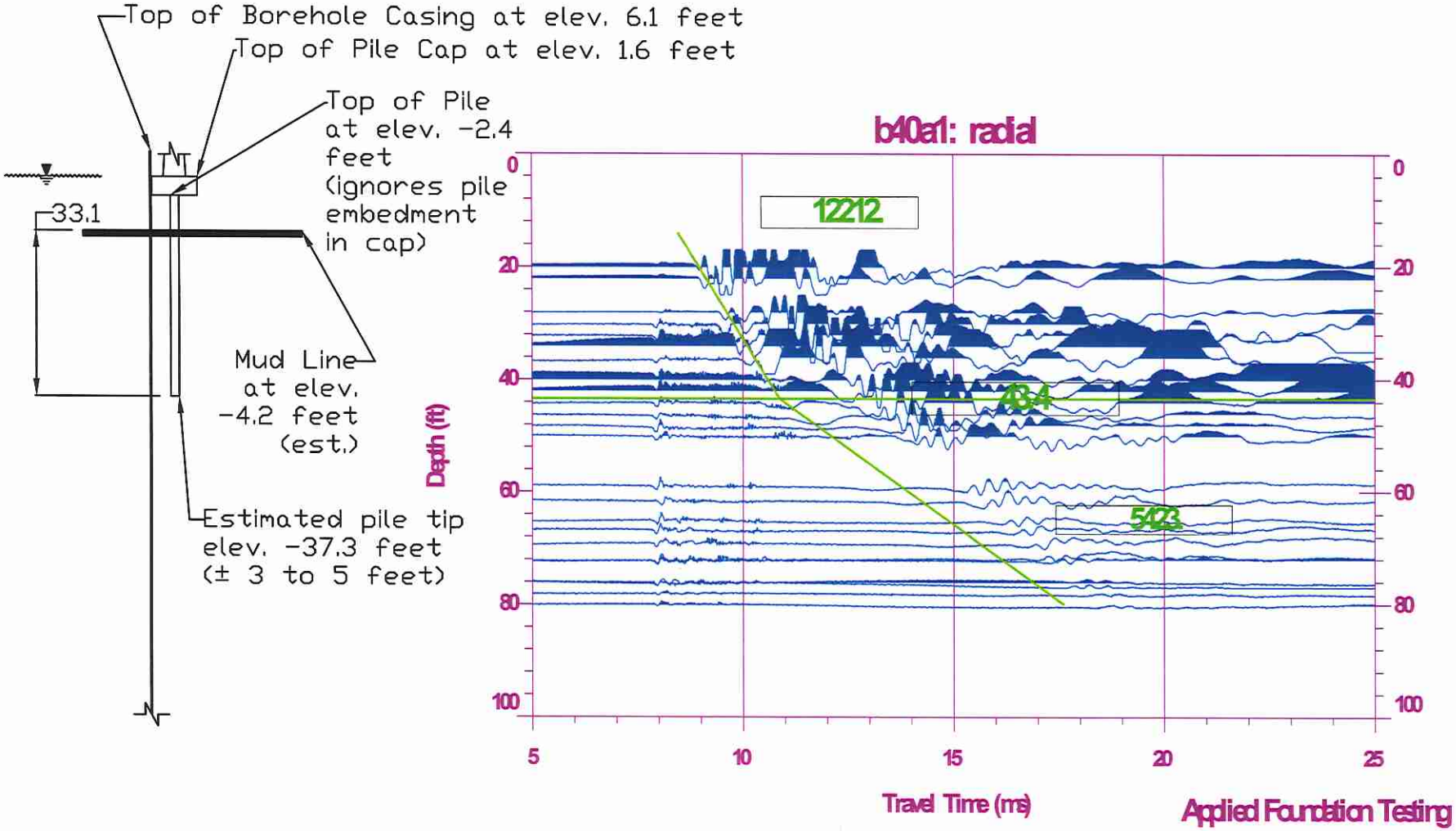
Rehabilitation of Bear Cut Bridge (874544), Rickenbacker Causeway, Miami-Dade County, FL



Notes:

1. Pilejackets (if existing on pile) are not shown.
2. Only center pile shown in illustration (corner piles omitted).

Figure 7
Bent/Pier 35 Parallel Seismic Results
Rehabilitation of Bear Cut Bridge (874544), Rickenbacker Causeway, Miami-Dade County, FL



Notes:

1. Pilejackets (if existing on pile) are not shown.
2. Only center pile shown in illustration (corner piles omitted).

Figure 8

Bent/Pier 40 Parallel Seismic Results

Rehabilitation of Bear Cut Bridge (874544), Rickenbacker Causeway, Miami-Dade County, FL

Appendix C

Parallel Seismic Results Summary

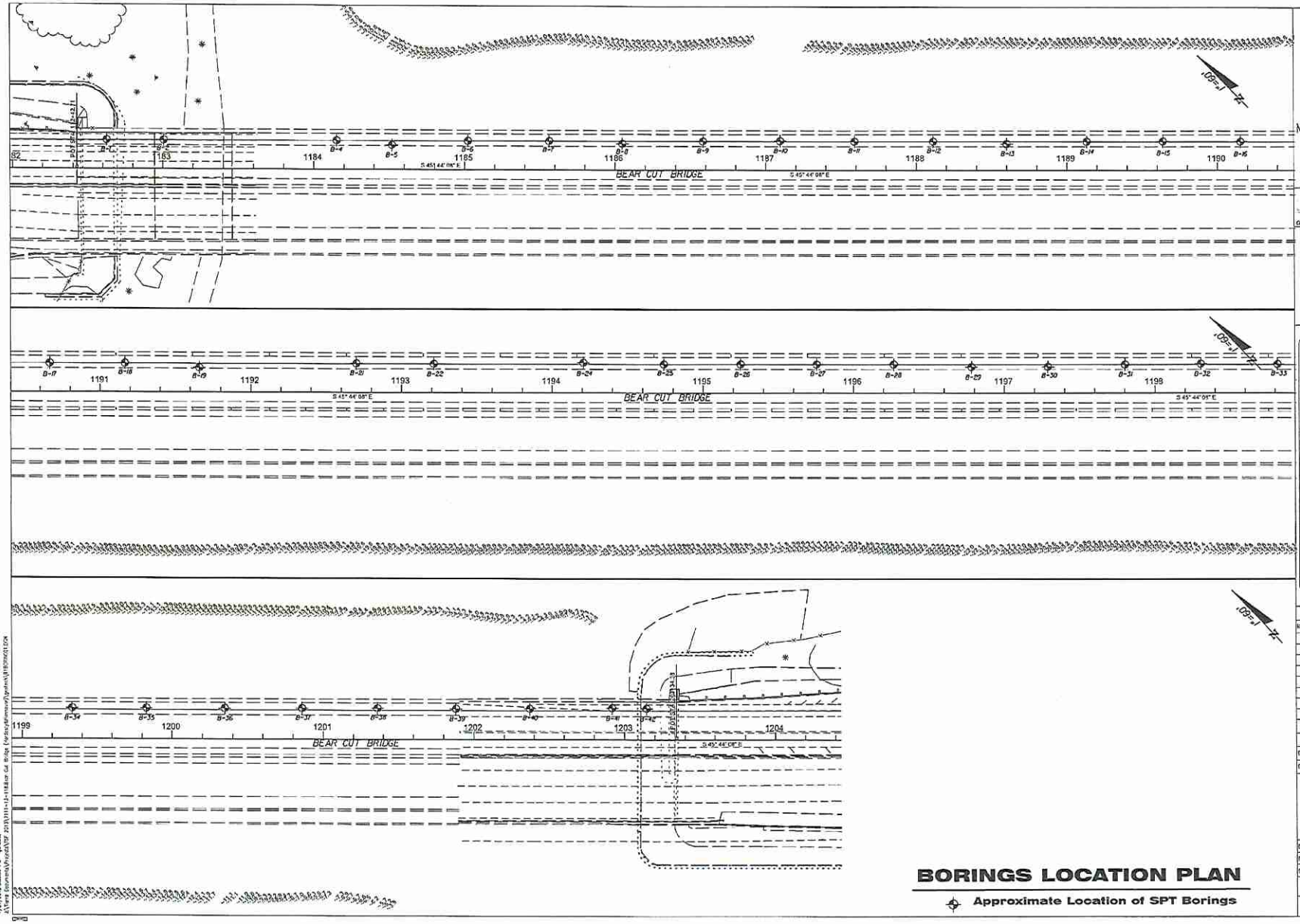
Summary of Parallel Seismic Test Results

Bear Cut Bridge
Miami-Dade County, Florida

Bent/Pier	Top of Footing Elev. (ft)	Distance to Top of Casing Above Top of Footing (ft)	Est. Depth to Inflection below Top of Casing (ft)	Pile Material Wavespeed via Slope (ft/s)	Soil Material Wavespeed via Slope (ft/s)	Top of Casing Elev. (ft)	Mud Line Elev. (ft)	Est. Inflection Point Elev. (ft)	Est. Pile Pene. (ft)	Estimated Variability in Pile Length Estimate (ft)
5	1.6	4.5	38.3	13818	5891	6.1	-13.1	-32.2	19.1	± 2 to 4
8	1.6	4.7	49.6	12806	5618	6.3	-17.6	-43.3	25.7	± 3 to 5
13	1.6	3.4	46.4	11603	6455	5	-18.6	-41.4	22.8	± 3 to 5
19	1.6	4	45.2	11258	6006	5.6	-19.2	-39.6	20.4	± 3 to 5
24	1.6	4.8	42.6	11636	6248	6.4	-20.4	-36.2	15.8	± 3 to 5
30	1.6	-18	24.5	11317	5095	-16.4	-20.9	-40.9	20	± 3 to 5
35	1.6	4.8	38.9	12295	6116	6.4	-13.1	-32.5	19.4	± 2 to 4
40	1.6	4.5	43.4	12212	5423	6.1	-4.2	-37.3	33.1	± 3 to 5

Appendix D

SPT Borings (by TSF) at Parallel Seismic Test Locations



BORINGS LOCATION PLAN

Approximate Location of SPT Borings

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PUBLIC WORKS AND WASTE MANAGEMENT

PUBLIC WORKS

STEPHEN CLARK CENTER
111 NW 1st STREET, 16th FLOOR
MIAMI, FLORIDA 33128
305-375-2900

RAJ KRISHNASAMY, P.E.
P.E. LICENSE NUMBER 53567
TERRA SOUTH FLORIDA
2765 VISTA PARKWAY, S-10
WEST PALM BEACH, FL 33411
CERTIFICATE OF AUTHORIZATION 29073

REHABILITATION OF BRIDGES NOS.
874541 (WEST BRIDGE) AND 874544 (BEAR CUT BRIDGE)
RICKENBACKER CAUSEWAY, MIAMI-DADE COUNTY

DRAWING ISSUED

REVISION No.	DESCRIPTION	DATE	BY
A			
B			
C			
D			

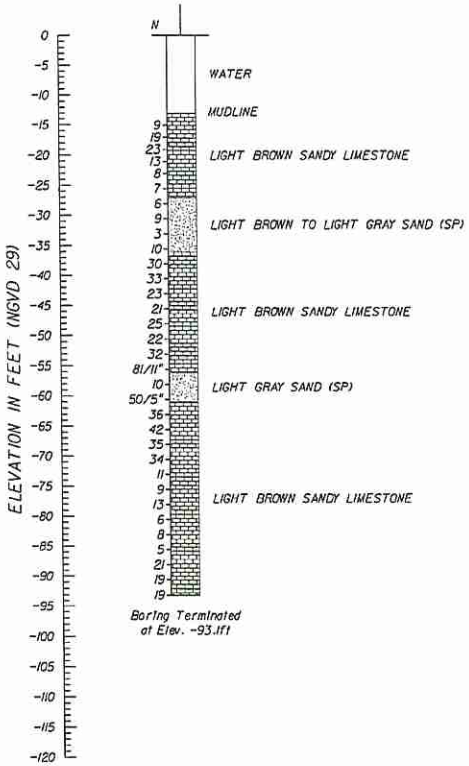
APPROVED

DESIGNED: WZ CHECKED: JC
DRAWN: HG FINAL CHECK: RJ

Date:

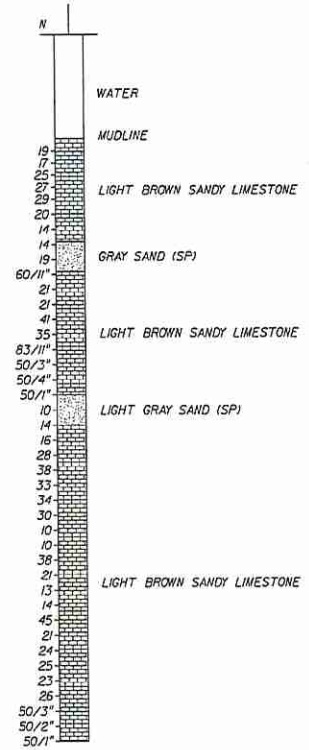
CM No. PCTS No.
FILE NAME:
DATE: SCALE:
SHEET:
DWG.:

BOR # B-5
STA. 1184+52.3 CL_BEARCUT
OFF. 17.0' LT
ELEV. -13.1
DATE 7/9/2013
HAMMER Safety
RIG D-50
NORTHING 509199.91
EASTING 932511.12



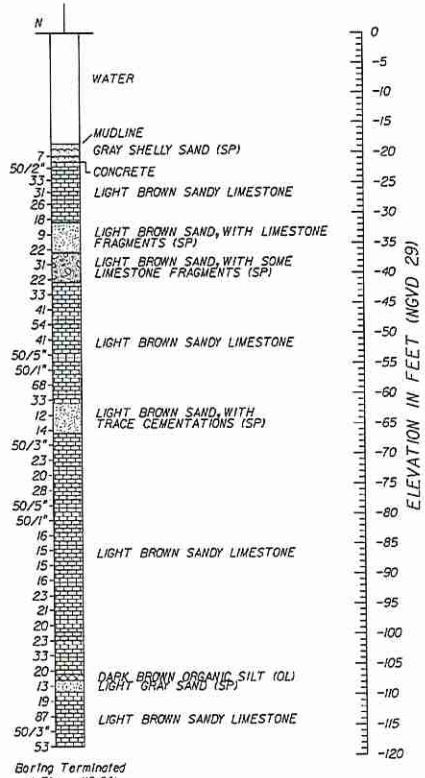
Boring Terminated at Elev. -93.1ft

BOR # B-8
STA. 1186+5.0 CL_BEARCUT
OFF. 17.0' LT
ELEV. -17.6
DATE 6/21/2013
HAMMER Safety
RIG D-50
NORTHING 509093.9096
EASTING 932621.5793



Boring Terminated at Elev. -117.6ft

BOR # B-13
STA. 1188+60.2 CL_BEARCUT
OFF. 17.0' LT
ELEV. -18.6
DATE 6/21/2013
HAMMER Safety
RIG D-50
NORTHING 509891.5.971
EASTING 932804.3577



Boring Terminated at Elev. -118.6ft

Shelly Sand
Limestone
Sand
Gravelly Sand
Concrete
Muck

NOTES:

▽ WATER TABLE

N NUMBERS TO THE LEFT OF BORINGS INDICATE SPT VALUE FOR 12" PENETRATION. (UNLESS OTHERWISE NOTED.)

MC=	NATURAL MOISTURE CONTENT (%)
-200=	FINES PASSING #200 SIEVE (%)
OC=	ORGANIC CONTENT (%)
LL=	LIQUID LIMIT (%)
PI=	PLASTICITY INDEX (%)
NP=	INDICATES NON-PLASTIC
WOH=	WEIGHT OF HAMMER

STRATA BOUNDARIES ARE APPROXIMATE AND MAY VARY BETWEEN OR AWAY FROM BORING LOCATIONS.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 Inches
SPOON OUTSIDE DIA.	2.0 Inches
AVG. HAMMER DROP	30.0 Inches
HAMMER WEIGHT	140.0 pounds

SPT CONSISTENCY CHART

SILTS AND CLAYS

CONSISTENCY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY SOFT	LESS THAN 2	LESS THAN 1
SOFT	2 - 4	1 - 3
FIRM	4 - 8	3 - 6
STIFF	8 - 15	6 - 12
VERY STIFF	15 - 30	12 - 24
HARD	GREATER THAN 30	GREATER THAN 24

SPT DENSITY CHART

GRANULAR MATERIALS

RELATIVE DENSITY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY LOOSE	LESS THAN 4	LESS THAN 3
LOOSE	4 - 10	3 - 8
MEDIUM	10 - 30	8 - 24
DENSE	30 - 50	24 - 40
VERY DENSE	GREATER THAN 50	GREATER THAN 40

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PUBLIC WORKS AND WASTE MANAGEMENT

PUBLIC WORKS

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MIAMI, FLORIDA 33128
305-375-2616

RAJ KRISHNASAMY, P.E.
P.E. LICENSE NUMBER 53507
TERRA SOUTH FLORIDA
2765 VISTA PARKWAY, S-18
WEST PALM BEACH, FL 3341
CERTIFICATE OF AUTHORIZATION 2207

REHABILITATION OF BRIDGES NOS. 874541 (WEST BRIDGE) AND 874544 (BEAR CUT BRIDGE)
RICKENBACKER CAUSEWAY, MIAMI-DADE COUNTY

DRAWING ISSUED

REVISION No.	DESCRIPTION	DATE	BY
A			
B			
C			
D			

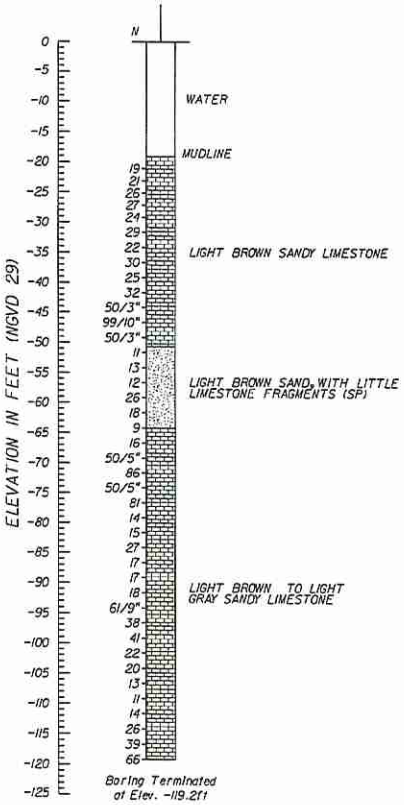
APPROVED

DESIGNED: WZ CHECKED: JO
DRAWN: MG FINAL CHECK: RJ

Date:

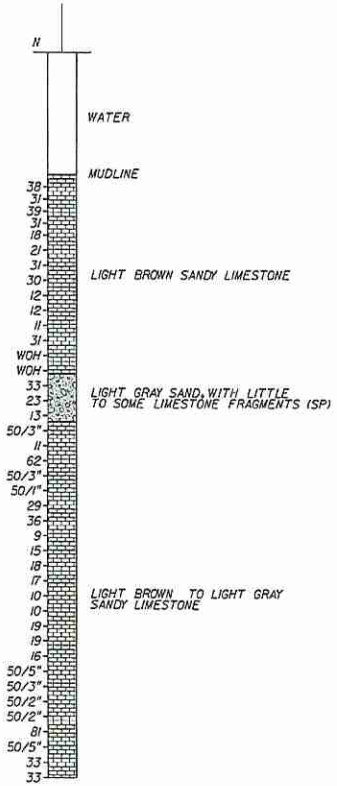
DR No: PCTS No:
FILE NAME:
DATE: SCALE:
SHEET:
DWG.:

BOR # B-19
STA. 1191+66.0 CL_BEARCUT
OFF. 16.24' LT
ELEV. -19.2
DATE 6/14/2013
HAMMER Safety
RIG D-50
NORTHING 933022.58
EASTING 508701.56



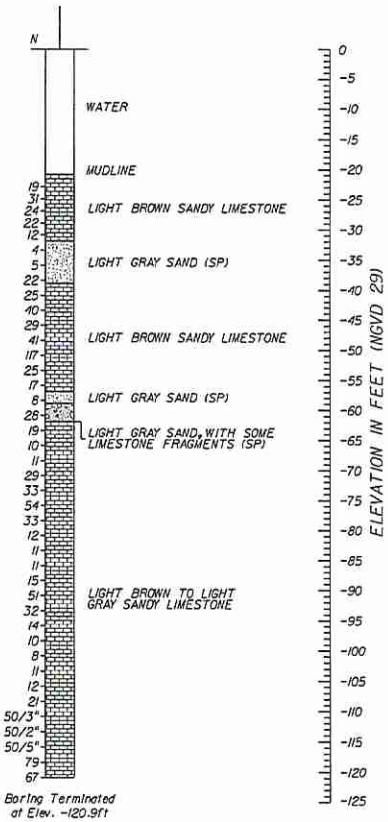
Boring Terminated at Elev. -119.2ft

BOR # B-24
STA. 1194+21.1 CL_BEARCUT
OFF. 17.0' LT
ELEV. -20.4
DATE 7/2/2013
HAMMER Safety
RIG D-50
NORTHING 508526.50
EASTING 933207.70



Boring Terminated at Elev. -120.4ft

BOR # B-30
STA. 1197+27.2 CL_BEARCUT
OFF. 17.0' LT
ELEV. -20.9
DATE 6/29/2013
HAMMER Safety
RIG D-50
NORTHING 508309.46
EASTING 933426.60



Boring Terminated at Elev. -120.9ft

SHELL
Silty Sand
Limestone
Sand
Gravelly Sand

NOTES:

▽ WATER TABLE

N NUMBERS TO THE LEFT OF BORINGS INDICATE SPT VALUE FOR 12" PENETRATION. (UNLESS OTHERWISE NOTED.)

MC=	NATURAL MOISTURE CONTENT (%)
-200=	FINES PASSING #200 SIEVE (%)
OC=	ORGANIC CONTENT (%)
LL=	LIQUID LIMIT (%)
PI=	PLASTICITY INDEX (%)
NP=	INDICATES NON-PLASTIC
WOH=	WEIGHT OF HAMMER

STRATA BOUNDARIES ARE APPROXIMATE AND MAY VARY BETWEEN OR AWAY FROM BORING LOCATIONS.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 Inches
SPOON OUTSIDE DIA.	2.0 Inches
AVG. HAMMER DROP	30.0 Inches
HAMMER WEIGHT	140.0 pounds

SPT CONSISTENCY CHART

SILTS AND CLAYS

CONSISTENCY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY SOFT	LESS THAN 2	LESS THAN 1
SOFT	2 - 4	1 - 3
FIRM	4 - 8	3 - 6
STIFF	8 - 15	6 - 12
VERY STIFF	15 - 30	12 - 24
HARD	GREATER THAN 30	GREATER THAN 24

SPT DENSITY CHART

GRANULAR MATERIALS

RELATIVE DENSITY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
VERY LOOSE	LESS THAN 4	LESS THAN 3
LOOSE	4 - 10	3 - 8
MEDIUM	10 - 30	8 - 24
DENSE	30 - 50	24 - 40
VERY DENSE	GREATER THAN 50	GREATER THAN 40

MIAMI-DADE COUNTY
Delivering Excellence Every Day

PUBLIC WORKS AND WASTE MANAGEMENT

PUBLIC WORKS

STEPHEN CLARK CENTER
111 NW 1st STREET, 18th FLOOR
MIAMI, FLORIDA 33128
305-375-2910

RAJ KRISHNASAMY, P.E.
P.E. LICENSE NUMBER 53507
TIERRA SOUTH FLORIDA
2765 VISTA PARKWAY, S-10
WEST PALM BEACH, FL 33411
CERTIFICATE OF AUTHORIZATION 29873

REHABILITATION OF BRIDGES NOS. 874541 (WEST BRIDGE) AND 874544 (BEAR CUT BRIDGE) RICKENBACKER CAUSEWAY, MIAMI-DADE COUNTY

DRAWING ISSUED

REVISION No.	DESCRIPTION	DATE	BY
A			
B			
C			
D			

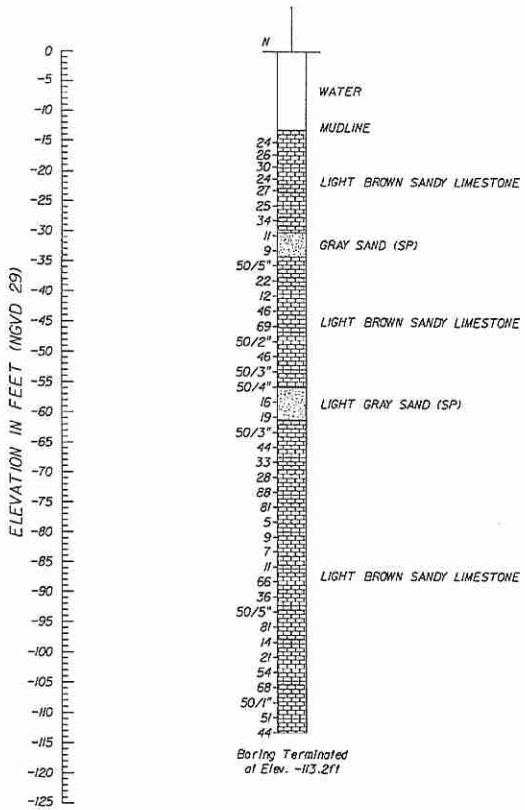
APPROVED

DESIGNED: WZ CHECKED: JS
DRAWN: MS FINAL CHECK: RJ

Bar:

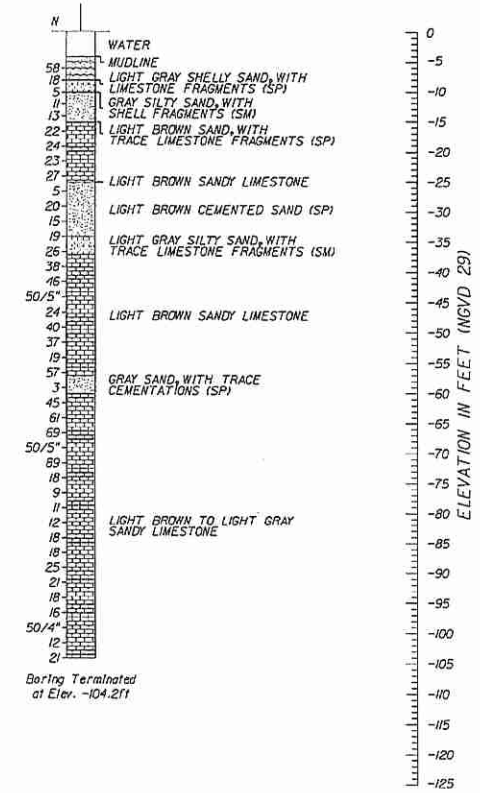
ER No: PCTS No:
FILE NAME:
DATE: SCALE:
SHEET:
DWG.:

BOR # B-35
STA. 1199+82.1 CL_BEARCUT
OFF. 17.0' LT
ELEV. -13.22
DATE 6/25/2013
HAMMER Safety
RIG D-50
NORTHING 508134.0864
EASTING 933610.3507



Boring Terminated at Elev. -113.2ft

BOR # B-40
STA. 1202+37.1 CL_BEARCUT
OFF. 17.0' LT
ELEV. -4.2
DATE 6/27/2013
HAMMER Safety
RIG D-50
NORTHING 507956.74
EASTING 933792.35



Boring Terminated at Elev. -104.2ft

Limestone

Sand

Gravelly Sand

NOTES:

▽ WATER TABLE

N NUMBERS TO THE LEFT OF BORINGS INDICATE SPT VALUE FOR 12" PENETRATION. (UNLESS OTHERWISE NOTED.)

MC=	NATURAL MOISTURE CONTENT (%)
-200=	FINES PASSING #200 SIEVE (%)
OC=	ORGANIC CONTENT (%)
LL=	LIQUID LIMIT (%)
PI=	PLASTICITY INDEX (%)
NP=	INDICATES NON-PLASTIC
WOH=	WEIGHT OF HAMMER

STRATA BOUNDARIES ARE APPROXIMATE AND MAY VARY BETWEEN OR AWAY FROM BORING LOCATIONS.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 Inches
SPOON OUTSIDE DIA.	2.0 Inches
AVG. HAMMER DROP	30.0 Inches
HAMMER WEIGHT	140.0 pounds

SPT CONSISTENCY CHART

SILTS AND CLAYS

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SOFT	2 - 4	1 - 3
FIRM	4 - 8	3 - 6
STIFF	8 - 15	6 - 12
VERY STIFF	15 - 30	12 - 24
HARD	GREATER THAN 30	GREATER THAN 24

SPT DENSITY CHART

GRANULAR MATERIALS

RELATIVE DENSITY	SAFETY HAMMER SPT N-VALUE (BLOW/FOOT)	AUTOMATIC HAMMER SPT N-VALUE (BLOW/FOOT)
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LOOSE	4 - 10	3 - 8
MEDIUM	10 - 30	8 - 24
DENSE	30 - 50	24 - 40
VERY DENSE	GREATER THAN 50	GREATER THAN 40

MIAMI-DADE COUNTY
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PUBLIC WORKS AND WASTE MANAGEMENT

PUBLIC WORKS
STEPHEN CLARK CENTER
111 NW 1st STREET, 14th FLOOR
MIAMI, FLORIDA 33128
305-375-2946

RAJ KONDAMUDI, P.E.
P.E. LICENSE NUMBER 63507
TIERRA SOUTH FLORIDA
2765 VISTA PARKWAY, S-15
WEST PALM BEACH, FL 33411
CERTIFICATE OF AUTHORIZATION 27073

REHABILITATION OF BRIDGES NOS. 874541 (WEST BRIDGE) AND 874544 (BEAR CUT BRIDGE) RICKENBACKER CAUSEWAY, MIAMI-DADE COUNTY

DRAWING ISSUED

REVISION No.	DESCRIPTION	DATE	BY
A			
B			
C			
D			

APPROVED

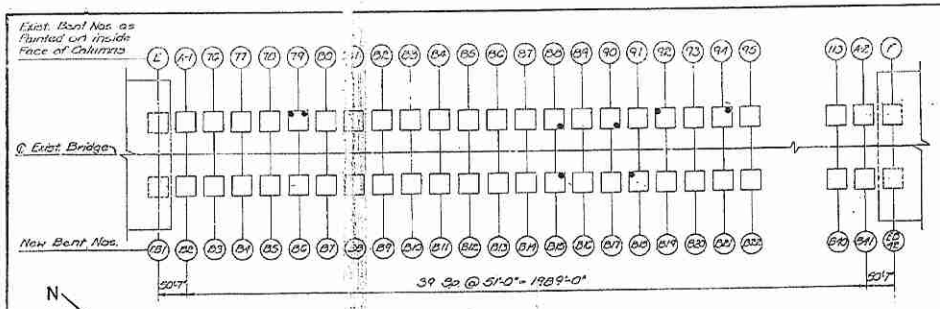
DESIGNED: RKZ CHECKED: JB
DRAWN: JLG FINAL CHECK: RJ

Date:

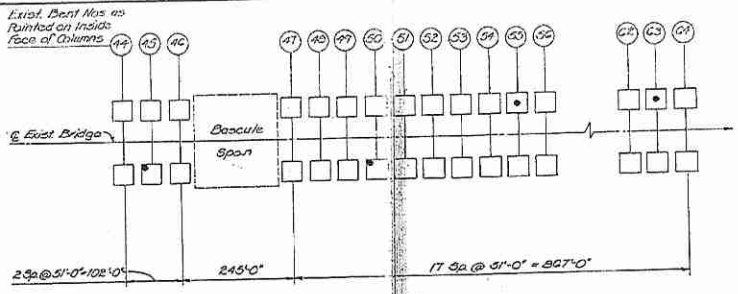
CTI No: PCTS No:
FILE NAME:
DATE: SCALE:
SHEET:
DWG.:

Appendix E

Existing Bridge Repair – Piling Repair Plan (from 1983)



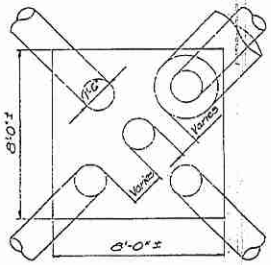
PLAN - BEAR CUT BRIDGE



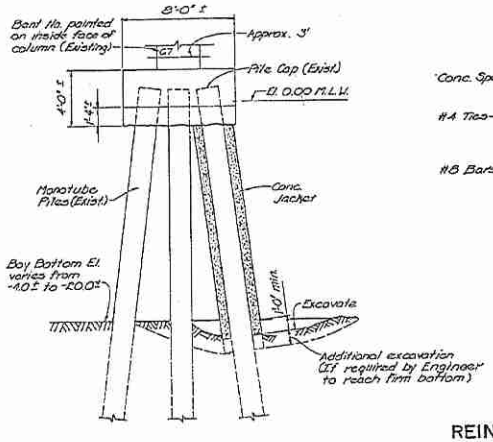
PLAN - BAY BRIDGE

NOTE:
EB = End Bent
B = Bent
● = Piles to be repaired

NOTE: Piles battered 1¼" per foot in direction shown.

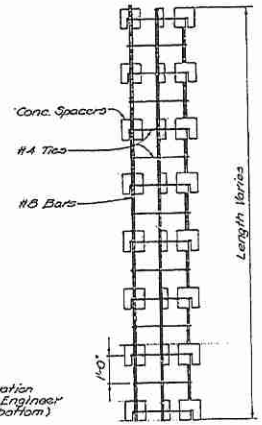


MONOTUBE PILE CAP (Existing)

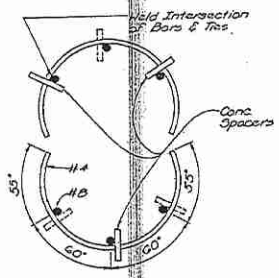


PILE BENT ELEVATION

NOTE: Exact dimensions of existing piles and pile cap to be determined in field.

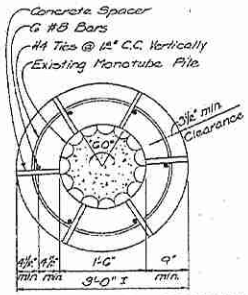


REINFORCING CAGE ELEVATION

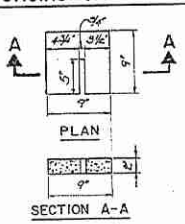


REINFORCING CAGE DETAIL

NOTE: The spacing of the concrete spacers shall be determined by the Engineer in the field. It shall be sufficient enough to maintain the clear cover over the reinforcing steel bars and the position of the forms.



CROSS SECTION THRU MONOTUBE PILE & JACKET



PRECAST CONCRETE SPACER

NOTES:

1.) Concrete shall be Class II and shall develop a minimum compression strength of 4000 p.s.i. at 28 days.
2.) Use A.S.T.M. Standards C-150 for Type II Portland cement.
3.) Reinforcing steel shall be new deformed bars in accordance with ASTM-A615, Grade 60 designation, Epoxy Coated.
4.) Length of forms and reinforcing cages to be determined in the field.
5.) All elevations are based on National Geodetic Vertical Datum.

PILING REPAIR

DRAWN BY: [illegible]
DESIGNED BY: [illegible]
CHECKED BY: [illegible]
DATE EXPIRES: [illegible]
DATE APPROVED: 7/20/83

KUNDE, DRIVER & ASSOCIATES INC.
ENGINEERS ARCHITECTS PLANNERS SURVEYORS

RICKENBACKER CAUSEWAY PROJECT
METRO-DADE COUNTY
PUBLIC WORKS DEPARTMENT

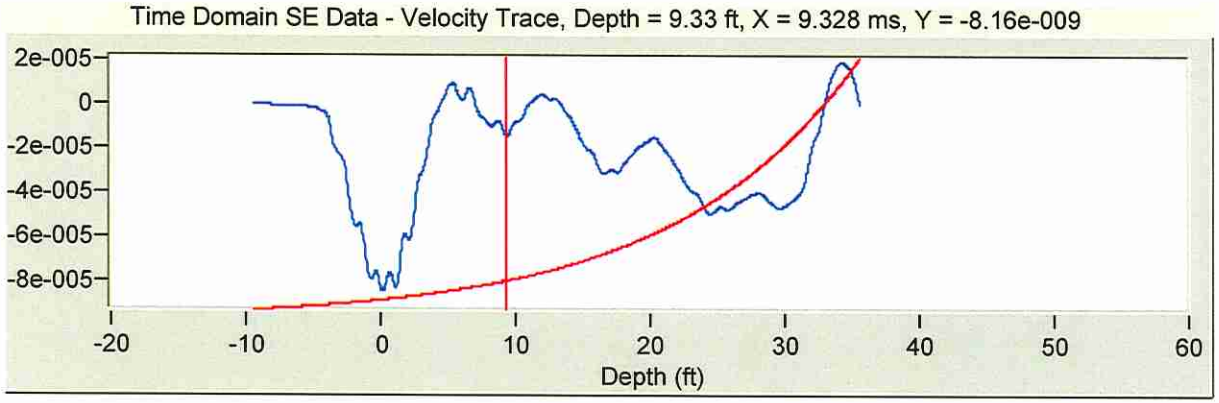
COUNTY PROJECT NO. 830230

EXISTING BRIDGE REPAIR

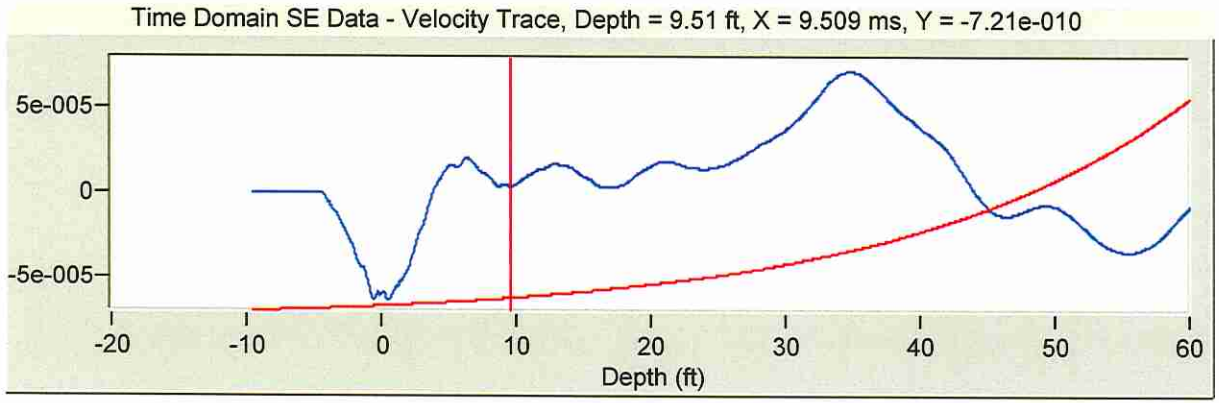
SHEET NO.
GB-37

Appendix F

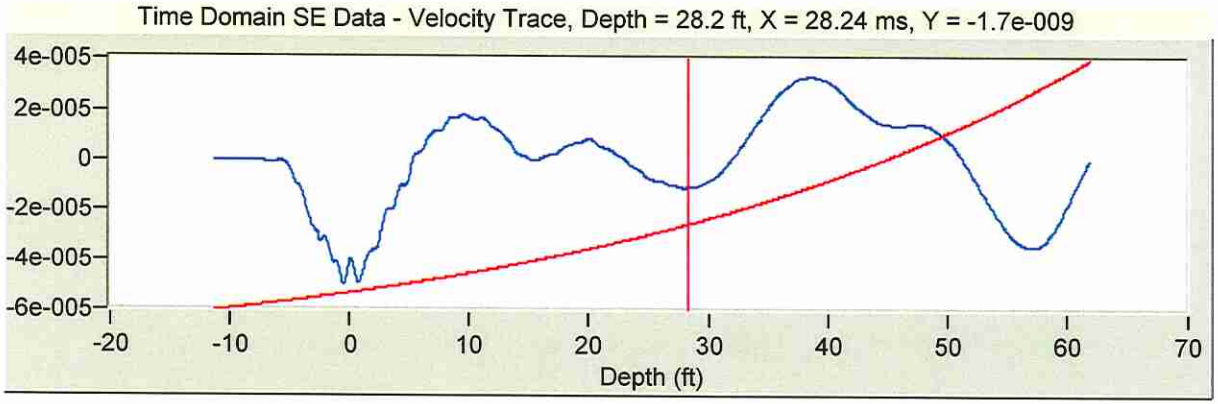
Representative Low Strain Integrity Test Data



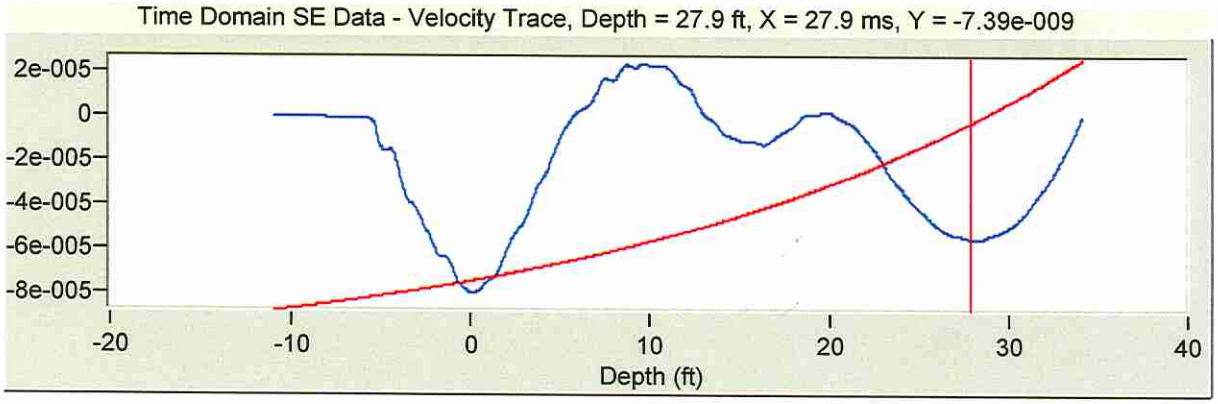
B13 (Pier 13) southwest pile shows velocity reduction at approximately 9 feet with probable multiple reflections below top of the pile cap (3.5 feet below top of PVC casing) using material compression wave velocity of 11,000 feet/second. Results appear inconclusive. Test was done at top of pile cap (hammer blow and accelerometer placement).



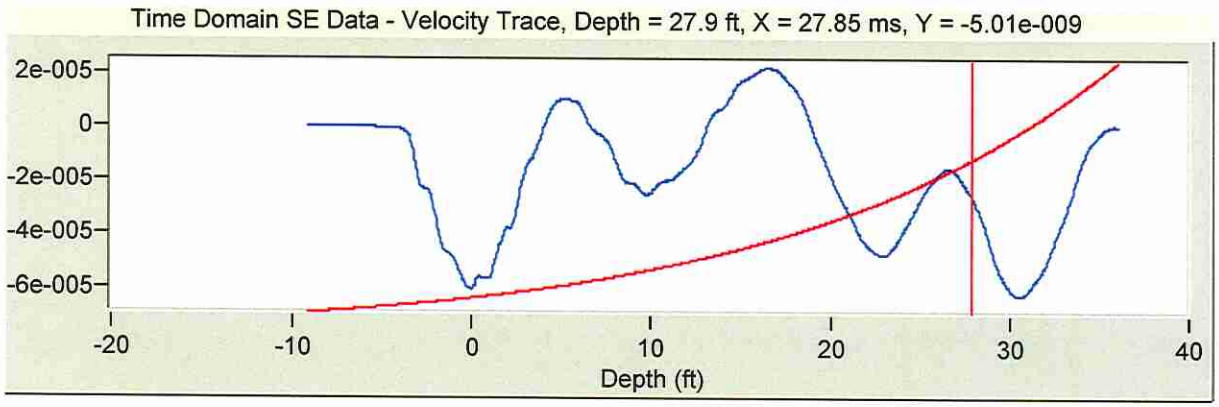
B13 (Pier 13) southwest pile with longer sampling rate shows similar results as above. This was done at same test location as above.



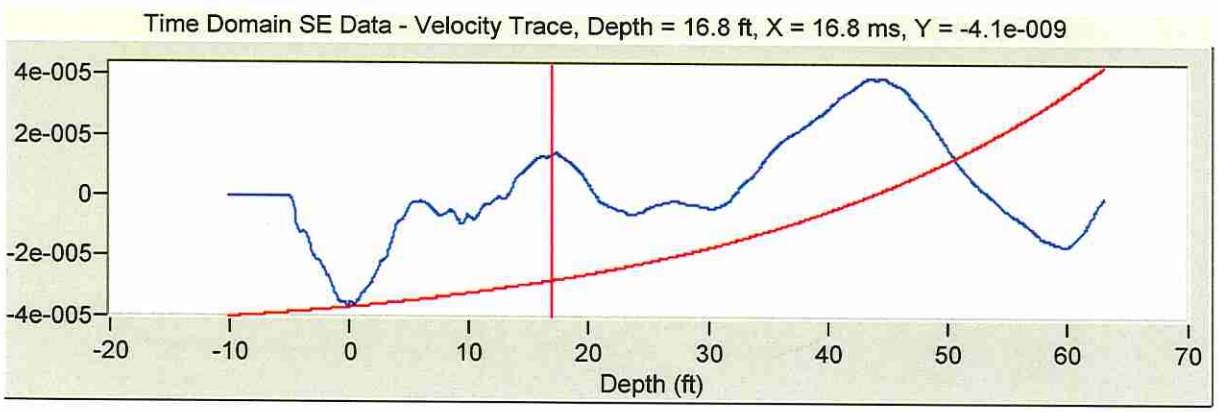
B19 (Pier 19) southeast pile shows velocity reduction at approximately 28 feet with probable multiple reflection at approximately 58 feet below top of the pile cap (4.0 feet below top of PVC casing) using material compression wave velocity of 11,000 feet/second. This equates to approximately 8 feet of pile penetration below mud line (mud line is approximately 20 feet below the top of footing). Casing top is at approximately elevation +4.0 feet, NAVD. Mud line is at approximately elevation -20 feet, NAVD. Top of footing assumed at approximately elevation +0.0 feet, NAVD. Test was done at top of pile cap (hammer blow and accelerometer placement).



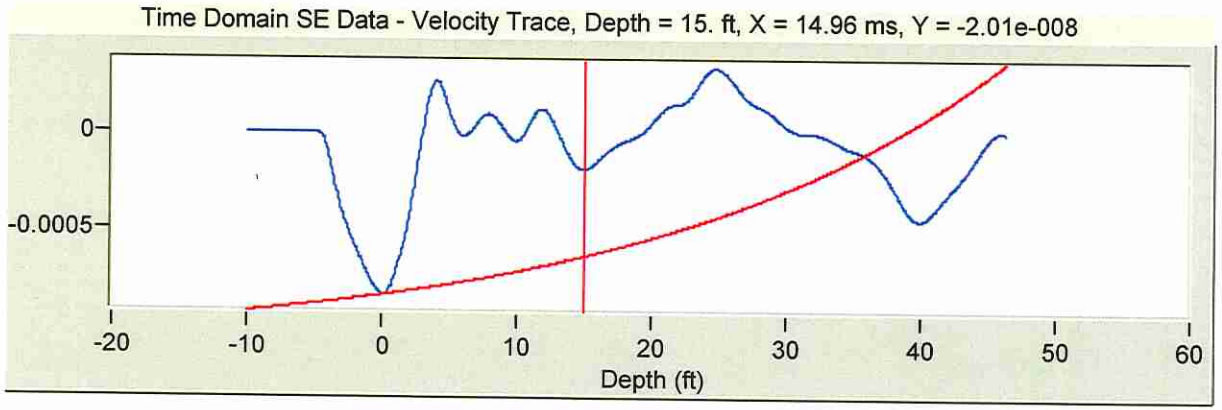
B19 (Pier 19) southeast pile shows velocity reduction at approximately 28 feet (lower sampling rate). See above for details of geometry, etc.



B19 (Pier 19) shows test result at pile cap top (hammer blow and accelerometer placement). No pile located beneath cap at this test location (between piles).



B19 (Pier 19) shows test result at pile cap top (hammer blow and accelerometer placement). No pile located beneath cap at this test location (between piles). Same location as the test above but done with higher sampling rate.



B19 (Pier 19) southwest pile shows velocity reduction at approximately 15 feet below test location (hammer blow and accelerometer placement approximately 5 feet above mud line) using material compression wave velocity of 11,000 feet/second. This equates to approximately 10 feet of pile penetration below mud line.

MEMORANDUM
COMMISSIONER XAVIER L. SUAREZ

111 NW First Street, Suite 220 Miami, Florida 33128 Tel. (305) 375-5680 Fax (305) 372-6103

TO: Carlos A. Gimenez
Miami-Dade County Mayor

DATE: August 7, 2013

RE: Bear Cut Bridge
Structural Integrity

FROM: Xavier Suarez
Commissioner
District 7

Mayor,

I noted in your above-captioned memo, dated July 17, 2013, that field testing "will be conducted for the portions of the piles that are underground, and thus not accessible for inspection." I understand that this study is being performed by the Contractor and should be ready by mid-August 2013.

As soon as the report is complete, I would appreciate receiving a copy.

Thank you.

Xavier L. Suarez
Commissioner
District 7

Cc: Franklin Caplan, Mayor, Key Biscayne
Mayra Pena Lindsay, Vice Mayor, Key Biscayne
John Gilbert, Village Manager, Key Biscayne