APPENDIX C

SUPPORTING DOCUMENTATION

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS HIGHWAY BUILDING 1589 MAIL SERVICE CENTER RALEIGH, NORTH CAROLINA 27699-1589	SUBJECT: Bridge No. 111 on SR 2141 (Bizzell Grove Church Rd.) over I-95		
	PREPARED BY:	CW	TIP NO.:
	DATE:	5/17	I-5786
	CHECKED BY:	WPA	COUNTY: Johnston
	DATE:	5/17	

END BENTS SUMMARY

END BENT 1

Pile Type:	HP 12X53 Steel Piles	
Bottom of Cap Elevation:	196.8 ft	Provided by WEI
Anticipated Pile Length:	61 ft ± (Left)	Bottom of Cap - Anticipated Pile Refusal Depth
	48 ft ± (Right)	Bottom of Cap - Anticipated Pile Refusal Depth
Average Pile Length:	65 ft ± (Left)	Anticipated Pile Lengths Rounded Up to Nearest 5 ft
	50 ft ± (Right)	Anticipated Pile Lengths Rounded Up to Nearest 5 ft
Max Factored Load:	110 Tons/Pile	Provided by WEI, rounded up to nearest 5 tons
Required Ultimate Resistance:	245 Tons/Pile	AASHTO Resistance Factor = 0.45
Required Driving Resistance:	185 Tons/Pile	NCDOT Driving Resistance Factor = 0.6 for WEAP analysis with limited or no PDAs

END BENT 2

Pile Type:	HP 12X53 Steel Piles	
Bottom of Cap Elevation:	196.9 ft	Provided by WEI
Anticipated Pile Length:	49 ft ± (Left)	Bottom of Cap - Anticipated Pile Refusal Depth
	44 ft ± (Right)	Bottom of Cap - Anticipated Pile Refusal Depth
Average Pile Length:	50 ft ± (Left)	Anticipated Pile Lengths Rounded Up to Nearest 5 ft
	45 ft ± (Right)	Anticipated Pile Lengths Rounded Up to Nearest 5 ft
Max Factored Load:	110 Tons/Pile	Provided by WEI, rounded up to nearest 5 tons
Required Ultimate Resistance:	245 Tons/Pile	AASHTO Resistance Factor = 0.45
Required Driving Resistance:	185 Tons/Pile	NCDOT Driving Resistance Factor = 0.6 for WEAP analysis with limited or no PDAs

NOTES

See Notes on Sheet 2 of the Foundation Recommendations.

COMMENTS

See Comments on Sheet 3 of the Foundation Recommendations.

WETHERILL ENGINEERING
1223 Jones Franklin Road
Raleigh, North Carolina 27606
919-851-8077

SUBJECT FACTORED STRENGTH LOADS

PROJECT I-5786 JOHNSTON COUNTY

PREPARED BY BCH DATE 4-17 STATION 20+25.64 -Y4-

CHECKED BY GWH DATE 4/27/17 STR NO ____ SHEET ____ OF ____

END BENT #1
(END BENT #2 SIMILAR)

SINGLE ROW OF PILES

0 BATTERED PILES

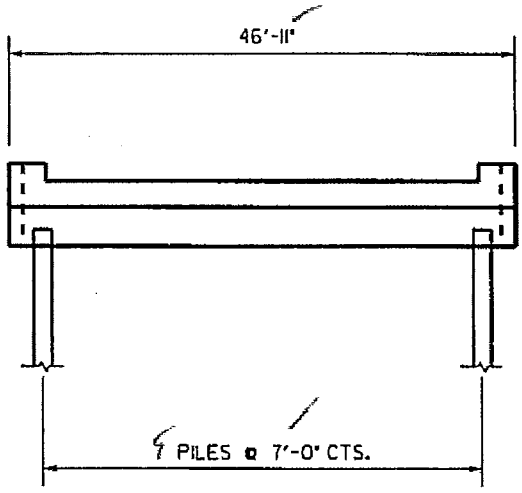
PILE TYPE : HP 12 X 53

BOC ELEV AT EB1 = 196.82
BOC ELEV AT EB2 = 196.85

MAX. FACTORED AXIAL PILE LOAD = 210.6 KIPS

= 105.3T

round up to 110T



END BENT SKETCH
NO SCALE

AASHTO Resistance Factor = 0.45

Req'd Ultimate Resistance $\frac{110T}{0.45}$ = 244.4T round up to 245T (490 kips)

WPA

GEOTECHNICAL BORING REPORT
BORE LOG

WBS N/A	**TIP** I-5786	**COUNTY** JOHNSTON	**GEOLOGIST** D. Racey	
SITE DESCRIPTION Bridge No. 111 on SR 2141 (Bizzell Grove Church Road) over I-95				**GROUND WTR (ft)**
BORING NO. EB1-A	**STATION** 19+04	**OFFSET** 5 ft LT	**ALIGNMENT** -Y4-	**0 HR.** NM
COLLAR ELEV. 200.8 ft	**TOTAL DEPTH** 63.9 ft	**NORTHING** 660,183	**EASTING** 2,241,576	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R4637 CME-75 81% 07/18/2015		**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER S. Sequist	**START DATE** 04/13/17	**COMP. DATE** 04/13/17	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft) / DEPTH (ft)
205										
200										200.8 GROUND SURFACE 0.0
	197.3	3.5	3	1	2			W		ASPHALT 0.3
195										ROADWAY EMBANKMENT 196.8 Tan-Orange-Red, Silty Fine Sandy CLAY (A-6) with Trace Gravel
	192.3	8.5	2	2	3			W		
190										
	187.3	13.5	WOH	2	2			W		
185										
	182.3	18.5	16	10	8			M		182.0 18.8 COASTAL PLAIN Gray, Silty Fine SAND (A-2-4)
180										178.8 22.0 Gray, Clayey Fine SAND (A-2-6)
	177.3	23.5	2	3	3			M		
175										173.8 27.0 Gray-Pink and Tan, Silty Fine SAND (A-2-4) with Trace Gravel
	172.3	28.5	1	1	1			W		
170										
	167.3	33.5	WOH	WOH	1			Sat.		163.8
165										
	162.3	38.5	3	3	5			Sat.		158.8 42.0 RESIDUAL Gray, Clayey SILT (A-5)
160										
	157.3	43.5	9	14	20			M		155.8
155										
	152.3	48.5	18	26	54			M		
150										
	147.3	53.5	20	29	51			M		
145										
	142.3	58.5	14	25	58			M		
140										
	137.3	63.5	100/0.4			100/0.4				137.3 63.5 136.9 63.9 WEATHERED ROCK Gray (META-ARGILLITE) Boring Terminated at Elevation 136.9 ft in Weathered Rock (META-ARGILLITE)

CDOT BORE SINGLE I5786_GEO_BH_BRDG111.GPJ NC_DOT.GDT 5/2/17

==========

APILE for Windows, Version 2014.6.8

Serial Number : 293783516

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

==========

This program is licensed to :

Froehling & Robertson, Inc.
Richmond, Virginia

Path to file locations : F:\Projects 66U\66U-0390 (WEI-I-5786 Bridges 108 & 111 Johnston Co)\NON_CADD\Foundation Recs\Bridge 111 Bizzel Grove\APILE\
Name of input data file : End Bent 1 LT.ap6d
Name of output file : End Bent 1 LT.ap6o
Name of plot output file : End Bent 1 LT.ap6p

Time and Date of Analysis

Date: May 17, 2017 Time: 16:20:57

1

****
* INPUT INFORMATION *
****

Bridge 111 End Bent 1 LT

DESIGNER : C Wang

JOB NUMBER : 66U-0390

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

TYPE OF LOADING :
- COMPRESSION

PILE TYPE :

H-Pile/Steel Pile

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.300E+08 PSI
- CROSS SECTION AREA = 15.50 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 62.00 FT.
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 IN.
- TIP AREA OF PILE = 15.50 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	53.00	0.00	0.00
14.80	CLAY	0.00	53.00	0.00	0.00
14.80	SAND	0.00	58.00	33.00	0.00
18.00	SAND	0.00	58.00	33.00	0.00
18.00	SAND	0.00	53.00	29.00	0.00
23.00	SAND	0.00	53.00	29.00	0.00
23.00	SAND	0.00	48.00	28.00	0.00
33.00	SAND	0.00	48.00	28.00	0.00
33.00	SAND	0.00	58.00	30.00	0.00
38.00	SAND	0.00	58.00	30.00	0.00
38.00	CLAY	0.00	63.00	0.00	0.00
41.00	CLAY	0.00	63.00	0.00	0.00
41.00	CLAY	0.00	63.00	0.00	0.00
59.50	CLAY	0.00	63.00	0.00	0.00
59.50	CLAY	0.00	63.00	0.00	0.00
65.00	CLAY	0.00	63.00	0.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.60	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.60	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
14.80	1.000	1.000
14.80	1.000	1.000
18.00	1.000	1.000
18.00	1.000	1.000
23.00	1.000	1.000
23.00	1.000	1.000
33.00	1.000	1.000
33.00	1.000	1.000
38.00	1.000	1.000
38.00	1.000	1.000
41.00	1.000	1.000
41.00	1.000	1.000
59.50	1.000	1.000
59.50	1.000	1.000
65.00	1.000	1.000

1

****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.2	0.2
1.00	0.0	0.2	0.2
2.00	0.5	0.5	1.0
3.00	1.5	0.5	2.0
4.00	2.6	0.5	3.1
5.00	3.6	0.5	4.1
6.00	4.6	0.5	5.1
7.00	5.7	0.5	6.2
8.00	6.7	0.5	7.2
9.00	7.7	0.5	8.2
10.00	8.8	0.5	9.2
11.00	9.8	0.5	10.3
12.00	10.8	0.5	11.3
13.00	11.8	0.5	12.3
14.00	12.9	1.0	13.9
15.00	14.1	1.6	15.7
16.00	15.3	2.3	17.6
17.00	16.7	2.6	19.2
18.00	18.1	2.2	20.3
19.00	19.4	1.8	21.2
20.00	20.6	1.4	22.0
21.00	21.8	1.4	23.2
22.00	23.1	1.4	24.5

23.00	24.4	1.4	25.9
24.00	25.8	1.4	27.2
25.00	27.1	1.4	28.6
26.00	28.6	1.4	30.0
27.00	30.0	1.4	31.4
28.00	31.5	1.4	33.0
29.00	33.1	1.4	34.5
30.00	34.7	1.4	36.1
31.00	36.3	1.4	37.8
32.00	38.1	1.4	39.5
33.00	39.8	1.4	41.2
34.00	41.8	1.4	43.2
35.00	43.9	1.4	45.3
36.00	46.1	1.4	47.5
37.00	48.4	1.9	50.3
38.00	50.7	2.5	53.2
39.00	58.7	3.0	61.7
40.00	72.4	3.8	76.2
41.00	85.7	4.2	89.8
42.00	101.0	4.5	105.5
43.00	118.8	4.8	123.7
44.00	136.7	4.8	141.5
45.00	154.5	4.8	159.3
46.00	172.3	4.8	177.2
47.00	190.2	4.8	195.0
48.00	208.0	4.8	212.8
49.00	225.8	4.8	230.7
50.00	243.6	4.8	248.5
51.00	261.5	4.8	266.3
52.00	279.3	4.8	284.1
53.00	297.1	4.8	302.0
54.00	314.9	4.8	319.8
55.00	332.8	4.8	337.6
56.00	350.6	4.8	355.4
57.00	368.4	4.8	373.3
58.00	386.3	4.8	391.1
~~59.00~~	401.1	4.8	405.9
60.00	413.0	4.8	417.8
~~61.00~~	424.8	4.8	429.7
62.00	436.7	4.8	441.5

Assume pile refusal ~1' into WR @ ±136.3'

Pile Length = Box – Tip

= 190.8' – 136.3' = 54.5'

∴ Anticipated Pile Length = 61' (LT)

Average Pile Length = 55' (RT)

Driving resistance req'd = 110T / 0.6 = 183.3T, round up to 185T (370kips)

At the depth of 60', where piles likely refuse

assume % skin = 95%

Check the available hammer in WEAP

AN ASTERISK WILL BE PLACED IN THE END-BEARING COLUMN
IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

WEAP Parameter Calculation

Bent #: Bridge 111 EB1-A

		Toe Quake	Shaft Quake
Pile Type:	HP 12X53	**0.10**	**0.10**

Subsurface Conditions: Loose/Soft or Submerged

Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping
1	196.8	182.0	5	Clay	0.30
2	182.0	178.8	22	Sand	0.15
3	178.8	173.8	8	Sand	0.20
4	173.8	163.8	3	Sand	0.20
5	163.8	158.8	11	Sand	0.18
6	158.8	155.8	45	Clay	0.10
7	155.8	137.3	80	Clay	0.10
8				WR	

	Toe Damping
0.18	**0.10**

Froehling & Robertson, Inc.
Birdge 111 End Bent 1 Lt

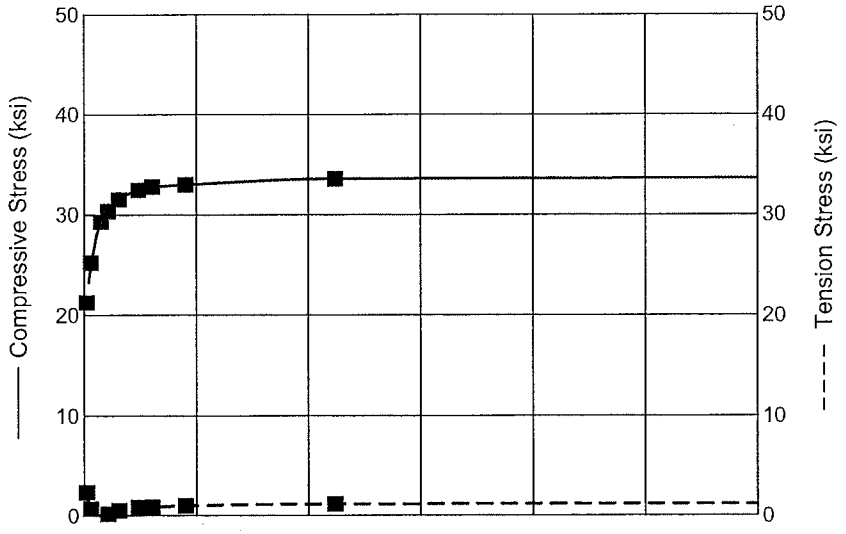
17-May-2017
GRLWEAP Version 2010

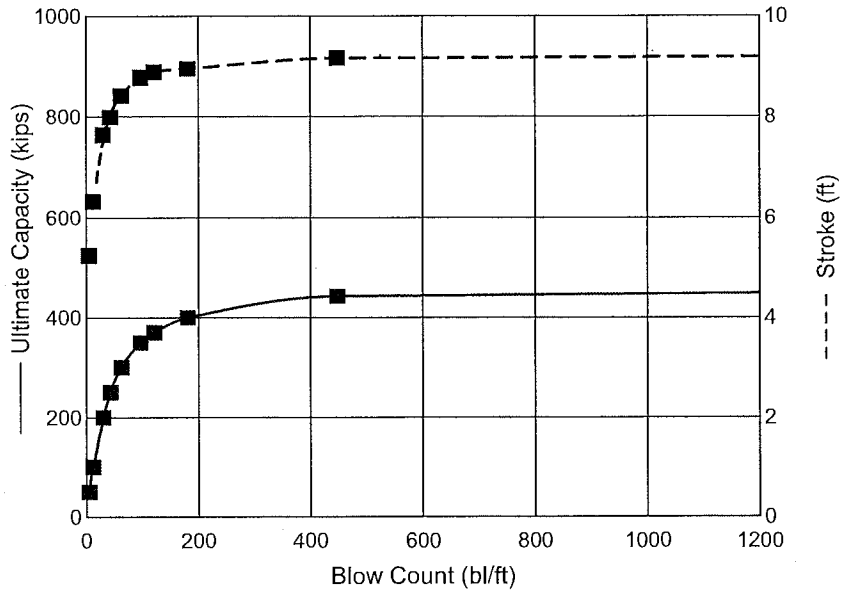
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
50.0	21.25	2.34	5.1	5.24	21.43
100.0	25.23	0.71	12.0	6.32	18.83
200.0	29.29	0.00	30.5	7.64	17.68
250.0	30.35	0.18	43.2	7.99	17.99
300.0	31.52	0.56	62.6	8.42	18.76
350.0	32.46	0.85	97.4	8.77	19.43
370.0	32.78 <45	0.90	30< 121.6	<18 8.89	19.54
400.0	33.00	1.03	181.6	8.95	19.70
442.4	33.55	1.18	448.2	9.16	20.01
500.0	34.20	1.32	9999.0	9.39	20.45

Delmag D19 or equivalent hammer should be able to drive the piles @ EB1 (Lt.)

Froehling & Robertson, Inc.
Birdge 111 End Bent 1 Lt

17-May-2017
GRLWEAP Version 2010

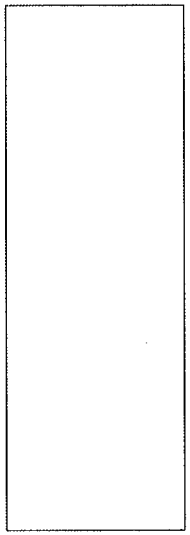




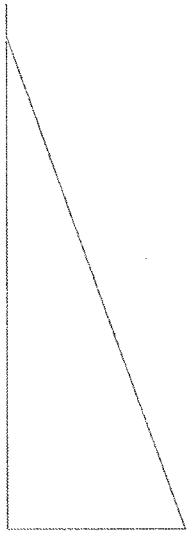
DELMAG D 19-32

Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1580 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.180	sec/ft
Toe Damping	0.100	sec/ft
Pile Length	65.00	ft
Pile Penetration	61.00	ft
Pile Top Area	15.50	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 95 %
(Proportional)

GEOTECHNICAL BORING REPORT
BORE LOG

WBS N/A	**TIP** I-5786	**COUNTY** JOHNSTON	**GEOLOGIST** P. Fahey
SITE DESCRIPTION Bridge No. 111 on SR 2141 (Bizzell Grove Church Road) over I-95			**GROUND WTR (ft)**
BORING NO. EB1-B	**STATION** 19+04	**OFFSET** 5 ft RT	**ALIGNMENT** -Y4-	**0 HR.** NM
COLLAR ELEV. 200.7 ft	**TOTAL DEPTH** 54.8 ft	**NORTHING** 660,177	**EASTING** 2,241,568	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R4637 CME-75 81% 07/18/2015		**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic
DRILLER S. Sequist	**START DATE** 04/10/17	**COMP. DATE** 04/10/17	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
										ELEV. (ft) DEPTH (ft)
205										
	200.7	0.0								GROUND SURFACE 0.0
200			3	6	3			M		**ASPHALT**
	197.2	3.5				BOC = 2'	Depth 0			**ROADWAY EMBANKMENT**
195			1	2	3			W		196.8 Yellowish Brown, Gray, and Red, Silty Fine Sandy CLAY (A-6)
	192.2	8.5				N=4				
190			2	2	2	N60=5 γ=53 c=500	1	W		
	187.2	13.5								
185			2	2	2			M		
							13.1			183.7
	182.2	18.5								
180			11	6	3	N=9		M		179.7 21.0
	177.2	23.5				N60=12 γ=58 c=1200	2			**COASTAL PLAIN** Gray and Yellow, Silty CLAY (A-7)
175			3	4	4			M		
							22.1			173.7 27.0
	172.2	28.5								Light Gray, Clayey Fine to Coarse SAND (A-2-6)
170			1	1	2	N=3	3	Sat.		
						N60=4 γ=53 Φ=29°	28.1			168.7 32.0
	167.2	33.5								Yellow, Silty Fine SAND (A-2-4)
165			WOH	WOH	1	N=1	4	Sat.		
						N60=1 γ=43 Φ=27°	32.1			163.7
	162.2	38.5								
160			2	3	3	N=1	5	Sat.		
						N60=8 γ=53 Φ=27°	38.1			158.7 42.0
	157.2	43.5								**RESIDUAL** Gray, Clayey SILT (A-5)
155			8	11	14	N=25	6	M		
						N60=34 γ=63 c=7100	44.1			153.7
	152.2	48.5								
150			23	33	65	γ=63 c=5300	7	M		150.7 50.0
							46.1			**WEATHERED ROCK** Gray (META-ARGILLITE)
	147.2	53.5								
			26	70	30/0.3	γ=63 c=5000	8			145.9 54.8
						100/0.8				Boring Terminated at Elevation 145.9 ft in Weathered Rock (META-ARGILLITE)

```
=============================================================================

                APILE for Windows, Version 2014.6.8

                 Serial Number :  293783516

                 A Program for Analyzing the Axial Capacity
                 and Short-term Settlement of Driven Piles
                           under Axial Loading.
               (c) Copyright ENSOFT, Inc., 1987-2014
                     All Rights Reserved

=============================================================================

This program is licensed to :

Froehling & Robertson, Inc.
Richmond, Virginia

Path to file locations      : F:\Projects 66U\66U-0390 (WEI-I-5786 Bridges 108 & 111 Johnston
Co)\NON_CADD\Foundation Recs\Bridge 111 Bizzel Grove\APILE\
Name of input data file     : End Bent 1 RT.ap6d
Name of output file         : End Bent 1 RT.ap6o
Name of plot output file    : End Bent 1 RT.ap6p

-----------------------------------------------------------------------------
                    Time and Date of Analysis
-----------------------------------------------------------------------------

          Date:  May 17, 2017     Time:  16:27:11


1
         ********************
         * INPUT INFORMATION *
         ********************


         Bridge 111 End Bent 1 RT

         DESIGNER   : C Wang

         JOB NUMBER : 66U-0390


         METHOD FOR UNIT LOAD TRANSFERS :

         - FHWA (Federal Highway Administration)
           Unfactored Unit Side Friction and Unit Side Resistance are used.



         COMPUTATION METHOD(S) FOR PILE CAPACITY :

         - FHWA (Federal Highway Administration)


         TYPE OF LOADING :
         - COMPRESSION


         PILE TYPE :

         H-Pile/Steel Pile
```

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.300E+08 PSI
- CROSS SECTION AREA = 15.50 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 48.00 FT.
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 IN.
- TIP AREA OF PILE = 15.50 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	53.00	0.00	0.00
13.10	CLAY	0.00	53.00	0.00	0.00
13.10	CLAY	0.00	58.00	0.00	0.00
23.10	CLAY	0.00	58.00	0.00	0.00
23.10	SAND	0.00	53.00	29.00	0.00
28.10	SAND	0.00	53.00	29.00	0.00
28.10	SAND	0.00	43.00	27.00	0.00
33.10	SAND	0.00	43.00	27.00	0.00
33.10	SAND	0.00	53.00	29.00	0.00
38.10	SAND	0.00	53.00	29.00	0.00
38.10	CLAY	0.00	63.00	0.00	0.00
44.10	CLAY	0.00	63.00	0.00	0.00
44.10	CLAY	0.00	63.00	0.00	0.00
46.10	CLAY	0.00	63.00	0.00	0.00
46.10	CLAY	0.00	63.00	0.00	0.00
56.10	CLAY	0.00	63.00	0.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.70	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.70	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
13.10	1.000	1.000
13.10	1.000	1.000
23.10	1.000	1.000
23.10	1.000	1.000
28.10	1.000	1.000
28.10	1.000	1.000
33.10	1.000	1.000
33.10	1.000	1.000
38.10	1.000	1.000
38.10	1.000	1.000
44.10	1.000	1.000
44.10	1.000	1.000
46.10	1.000	1.000
46.10	1.000	1.000
56.10	1.000	1.000

1

****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.2	0.2
1.00	0.0	0.2	0.2
2.00	0.5	0.5	1.0
3.00	1.5	0.5	2.0
4.00	2.6	0.5	3.1
5.00	3.6	0.5	4.1
6.00	4.6	0.5	5.1
7.00	5.7	0.5	6.2
8.00	6.7	0.5	7.2
9.00	7.7	0.5	8.2
10.00	8.8	0.5	9.2
11.00	9.8	0.5	10.3
12.00	10.8	0.5	11.3
13.00	11.9	0.6	12.5
14.00	12.9	0.8	13.7
15.00	14.4	1.0	15.4
16.00	16.2	1.2	17.4
17.00	18.0	1.2	19.2
18.00	19.9	1.2	21.0
19.00	21.7	1.2	22.9
20.00	23.5	1.2	24.7
21.00	25.4	1.2	26.5
22.00	27.2	1.2	28.4

23.00	29.7	1.2	30.9
24.00	32.9	1.3	34.2
25.00	35.2	1.4	36.6
26.00	36.8	1.4	38.2
27.00	38.4	1.4	39.8
28.00	40.1	1.4	41.5
29.00	41.8	1.4	43.2
30.00	43.5	1.4	44.9
31.00	45.1	1.4	46.5
32.00	46.7	1.4	48.2
33.00	48.4	1.4	49.9
34.00	50.1	1.4	51.6
35.00	52.0	1.4	53.5
36.00	54.1	1.4	55.6
37.00	56.3	1.4	57.7
38.00	58.5	1.7	60.2
39.00	60.8	2.0	62.8
40.00	66.5	2.3	68.8
41.00	75.7	2.6	78.3
42.00	84.8	2.6	87.5
43.00	94.0	2.6	96.6
44.00	102.7	3.1	105.9
45.00	111.0	3.7	114.7
46.00	121.8	4.3	126.1
47.00	135.1	4.8	139.9
48.00	148.4	4.8	153.2

AN ASTERISK WILL BE PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

Assume Pile refuses ~ 1' into WR @ EL 149.7'

Pile Length = Boc − Tip = 198.8' − 149.7' = 47.1'

∴ Anticipated Pile Length = 46.0' (Rt)

Average Pile Length = 50.5' (Lt)

Since pile likely refuse @ ~ 47'

% skin = 135 / 370 ≈ 36%

Run WEAP for driving then.

WEAP Parameter Calculation

Bent #: Bridge 111 EB1-B

		Toe Quake	Shaft Quake
Pile Type:	HP 12X53	**0.10**	**0.10**

Subsurface Conditions: Loose/Soft or Submerged

Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping	
1	196.8	183.7	5	Clay	0.30	
2	183.7	173.7	12	Clay	0.25	
3	173.7	168.7	4	Sand	0.20	
4	168.7	163.7	1	Sand	0.20	
5	163.7	158.7	8	Sand	0.20	
6	158.7	152.7	34	Clay	0.15	
7	152.7	150.7	98	Clay	0.10	
8						**Toe Damping**
					0.23	**0.10**

Froehling & Robertson, Inc.
Bridge 111 End Bent 1 Rt

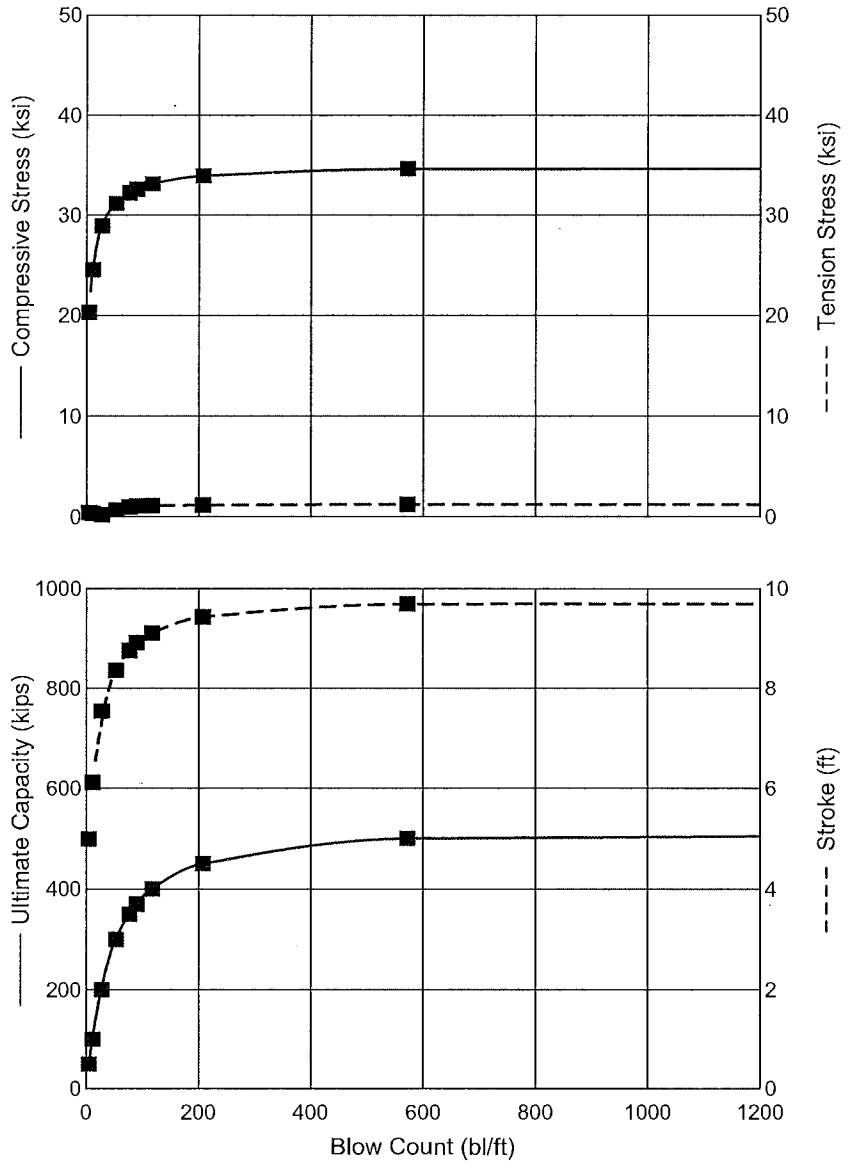
17-May-2017
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
50.0	20.28	0.45	4.7	4.99	22.04
100.0	24.53	0.34	11.2	6.11	19.38
200.0	28.91	0.24	27.9	7.54	18.11
300.0	31.17	0.71	53.2	8.36	18.83
350.0	32.24	1.00	77.4	8.76	19.62
370.0	32.63 <45	1.07	89.9 <180	8.92	19.99
400.0	33.14	1.13	117.7	9.11	20.34
450.0	33.95	1.19	208.3	9.43	20.96
500.0	34.66	1.26	572.5	9.69	21.41
550.0	34.98	1.27	9999.0	9.77	21.55

Delmag D19 or equivalent hammer should be able to drive the piles @ EB1 (Rt.)

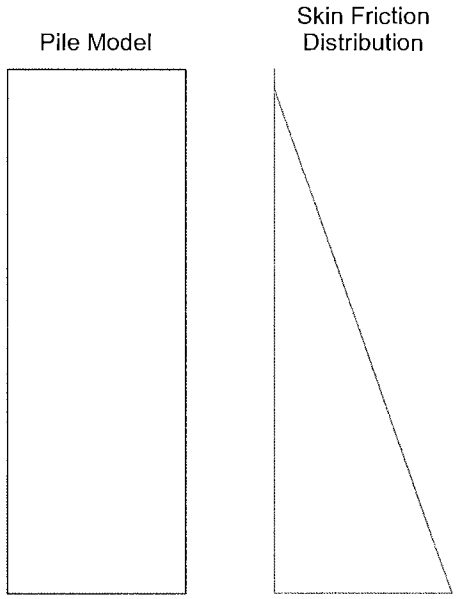
Froehling & Robertson, Inc.
Bridge 111 End Bent 1 Rt

17-May-2017
GRLWEAP Version 2010



DELMAG D 19-32

Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1580 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.230	sec/ft
Toe Damping	0.100	sec/ft
Pile Length	50.00	ft
Pile Penetration	48.00	ft
Pile Top Area	15.50	in2



Res. Shaft = 36 %
(Proportional)

GEOTECHNICAL BORING REPORT
BORE LOG

WBS N/A	**TIP** I-5786	**COUNTY** JOHNSTON	**GEOLOGIST** M. Arnold	
SITE DESCRIPTION Bridge No. 111 on SR 2141 (Bizzell Grove Church Road) over I-95				**GROUND WTR (ft)**
BORING NO. EB2-A	**STATION** 21+48	**OFFSET** 8 ft LT	**ALIGNMENT** -Y4-	**0 HR.** NM
COLLAR ELEV. 200.9 ft	**TOTAL DEPTH** 64.8 ft	**NORTHING** 659,992	**EASTING** 2,241,727	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R3495 CME-55 85% 01/30/2017		**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic	
DRILLER D. Tignor	**START DATE** 04/26/17	**COMP. DATE** 04/26/17	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
205						85/50=1.447					
200	200.5	0.4	9	5	5	10 BD=±196.4 pcf		M		200.9 GROUND SURFACE	0.0
	197.4	3.5	4	4	4	8		M		199.7 ASPHALT	1.2
195										ROADWAY EMBANKMENT Brown, Fine SAND (A-3)	
	192.4	8.5	2	3	4	N=7 7 N_{60}=10 γ=58 C=1,000	1	M		198.9 Gray-Orange-Brown, Fine Sandy CLAY (A-7) with Trace Organics (Wood Fragments)	
190							8			188.9	
	187.4	13.5	2	2	3	N=5 5 N_{60}=7 γ=53 C=700	2	M			
185							13			183.9	17.0
	182.4	18.5	WOH	1	2	N=3 3 N_{60}=4 γ=53 C=400	3	W		Brown, Silty Fine Sandy CLAY (A-6)	
180							18			178.9	22.0
	177.4	23.5	3	3	3	N=6 6 N_{60}=9 γ=53 C=900	4	W		COASTAL PLAIN Gray-Orange-Tan, Fine Sandy CLAY (A-7)	
175							23			173.9	27.0
	172.4	28.5	1	1	2	N_{60}=4 γ=53 c=300	5 25.4	W		171.5 Orange-White-Brown, Clayey Fine Sandy SILT (A-5)	29.4
170						3 N_{60}=4 γ=53 Φ=29°	6 28			168.9 Orange-Brown, Clayey Fine to Coarse SAND (A-2-6)	32.0
	167.4	33.5	2	1	2	3 N_{60}=4 γ=53 C=300	7	W		White-Orange-Brown, Fine Sandy Clayey SILT (A-5)	
165							33			163.9	37.0
	162.4	38.5	19	12	7	19 N_{60}=27 γ=63 Φ=35°	8	W		Orange-Brown, Clayey GRAVEL (A-1-b) with Trace Fine Sand	
160							38			158.9	42.0
	157.4	43.5	10	20	35	55 γ=63 C=4000	9	M		RESIDUAL Blue-Gray, Clayey SILT (A-5)	
155							43			153.9	
	152.4	48.5	6	10	23	33 γ=63 C=3800 N_{60}=47	10	M			
150							48			148.9	52.0
	147.4	53.5	66	34/0.1		γ=63 100/0.6				WEATHERED ROCK Brown-Gray (META-ARGILLITE)	
145											
	142.4	58.5	77	23/0.1		C=4000 100/0.6					
140											
	137.4	63.5	39	27	100/0.3	100/0.3				136.1	64.8
										Boring Terminated at Elevation 136.1 ft in Weathered Rock (META-ARGILLITE)	

APILE for Windows, Version 2014.6.8

Serial Number : 293783516

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

This program is licensed to :

Froehling & Robertson, Inc.
Richmond, Virginia

Path to file locations : F:\Projects 66U\66U-0390 (WEI-I-5786 Bridges 108 & 111 Johnston Co)\NON_CADD\Foundation Recs\Bridge 111 Bizzel Grove\APILE\
Name of input data file : End Bent 2 LT.ap6d
Name of output file : End Bent 2 LT.ap6o
Name of plot output file : End Bent 2 LT.ap6p

Time and Date of Analysis

Date: May 11, 2017 Time: 16:05:49

1

****
* INPUT INFORMATION *
****

Bridge 111 End Bent 2 LT

DESIGNER : C Wang

JOB NUMBER : 66U-0390

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

TYPE OF LOADING :
- COMPRESSION

PILE TYPE :

H-Pile/Steel Pile

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.300E+08 PSI
- CROSS SECTION AREA = 15.50 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 50.00 FT.
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 IN.
- TIP AREA OF PILE = 15.50 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	58.00	0.00	0.00
8.00	CLAY	0.00	58.00	0.00	0.00
8.00	CLAY	0.00	53.00	0.00	0.00
13.00	CLAY	0.00	53.00	0.00	0.00
13.00	CLAY	0.00	53.00	0.00	0.00
18.00	CLAY	0.00	53.00	0.00	0.00
18.00	CLAY	0.00	53.00	0.00	0.00
23.00	CLAY	0.00	53.00	0.00	0.00
23.00	CLAY	0.00	53.00	0.00	0.00
25.40	CLAY	0.00	53.00	0.00	0.00
25.40	SAND	0.00	53.00	29.00	0.00
28.00	SAND	0.00	53.00	29.00	0.00
28.00	CLAY	0.00	53.00	0.00	0.00
33.00	CLAY	0.00	53.00	0.00	0.00
33.00	SAND	0.00	63.00	35.00	0.00
38.00	SAND	0.00	63.00	35.00	0.00
38.00	CLAY	0.00	63.00	0.00	0.00
43.00	CLAY	0.00	63.00	0.00	0.00
43.00	CLAY	0.00	63.00	0.00	0.00
48.00	CLAY	0.00	63.00	0.00	0.00
48.00	CLAY	0.00	63.00	0.00	0.00
58.00	CLAY	0.00	63.00	0.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.70	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.70	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.40	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.40	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.90	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.90	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.30	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.30	0.00	0.00	0.00	0.00

0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.30	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.30	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	4.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	4.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.80	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.80	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
8.00	1.000	1.000
8.00	1.000	1.000
13.00	1.000	1.000
13.00	1.000	1.000
18.00	1.000	1.000
18.00	1.000	1.000
23.00	1.000	1.000
23.00	1.000	1.000
25.40	1.000	1.000
25.40	1.000	1.000
28.00	1.000	1.000
28.00	1.000	1.000
33.00	1.000	1.000
33.00	1.000	1.000
38.00	1.000	1.000
38.00	1.000	1.000
43.00	1.000	1.000
43.00	1.000	1.000
48.00	1.000	1.000
48.00	1.000	1.000
58.00	1.000	1.000

1

****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.5	0.5
1.00	0.0	0.5	0.5
2.00	1.8	1.0	2.8
3.00	5.5	1.0	6.5
4.00	9.2	1.0	10.1

5.00	12.8	1.0	13.8
6.00	16.5	1.0	17.5
7.00	20.2	0.9	21.1
8.00	23.8	0.8	24.6
9.00	27.0	0.7	27.7
10.00	29.7	0.7	30.3
11.00	32.3	0.7	33.0
12.00	35.0	0.6	35.6
13.00	37.7	0.5	38.2
14.00	39.8	0.5	40.2
15.00	41.3	0.4	41.7
16.00	42.9	0.4	43.3
17.00	44.5	0.5	45.0
18.00	46.1	0.6	46.7
19.00	48.5	0.8	49.3
20.00	51.9	0.9	52.8
21.00	55.3	0.9	56.1
22.00	58.6	0.7	59.4
23.00	62.0	0.6	62.6
24.00	64.3	0.4	64.8
25.00	65.5	0.6	66.1
26.00	66.7	0.9	67.6
27.00	68.1	0.9	69.0
28.00	69.8	0.9	70.6
29.00	71.2	0.6	71.8
30.00	72.4	0.3	72.7
31.00	73.6	0.3	73.9
32.00	74.8	2.2	77.0
33.00	76.0	4.5	80.5
34.00	78.2	6.8	85.0
35.00	81.6	9.0	90.6
36.00	85.1	9.3	94.3
37.00	88.7	8.1	96.8
38.00	92.4	6.7	99.1
39.00	99.7	5.3	104.9
40.00	110.4	3.9	114.3
41.00	121.2	3.9	125.1
42.00	132.0	3.8	135.8
43.00	142.3	3.8	146.0
44.00	151.7	3.7	155.4
45.00	160.9	3.7	164.6
46.00	170.1	3.7	173.8
47.00	179.3	4.0	183.3
48.00	188.0	4.3	192.2
49.00	197.4	4.6	202.0
50.00	208.2	4.8	213.0

AN ASTERISK WILL BE PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

Assume pile refusal ~ 1' into Lvl B
@ El 147.9'

Pile length = BOE − TIP

= 196.9 − 147.9' = 49'

∴ Anticipated Pile Length = 49'

Average Pile Length = 35'

check drawings and hammer at EB2-B since shorter piles @ EB2-B might have a higher stress

GEOTECHNICAL BORING REPORT
BORE LOG

WBS N/A	**TIP** I-5786	**COUNTY** JOHNSTON	**GEOLOGIST** P. Fahey
SITE DESCRIPTION Bridge No. 111 on SR 2141 (Bizzell Grove Church Road) over I-95			**GROUND WTR (ft)**
BORING NO. EB2-B	**STATION** 21+43	**OFFSET** 6 ft RT	**ALIGNMENT** -Y4-	**0 HR.** NM
COLLAR ELEV. 200.9 ft	**TOTAL DEPTH** 54.0 ft	**NORTHING** 659,987	**EASTING** 2,241,714	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R4637 CME-75 81% 07/18/2015		**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic
DRILLER S. Sequist	**START DATE** 04/10/17	**COMP. DATE** 04/10/17	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION	ELEV. (ft)	DEPTH (ft)
205												
200	200.9	0.0	7	4	3	7		M		GROUND SURFACE	200.9	0.0
	197.4	3.5	1	3	4	7		M		**ROADWAY EMBANKMENT** Reddish Brown and Light Gray, Fine to Coarse Sandy CLAY (A-6) with Petroleum Odor from 0.0'-1.5'	196.9	
195												
	192.4	8.5	3	4	3	7	①	M				
190												
	187.4	13.5	2	3	4	7		M				
185							13				183.9	17.0
	182.4	18.5	1	2	2	4	②	M		Brown, Fine Sandy SILT (A-4)		
180							18				178.9	22.0
	177.4	23.5	3	4	4	8	③	Sat.		**COASTAL PLAIN** Yellow, Brown, and Gray, Silty Fine SAND (A-2-4)		
175							23				173.9	
	172.4	28.5	1	1	2	3		Sat.				
170							④					
	167.4	33.5	3	2	3	5		Sat.				
165							33				163.9	37.0
	162.4	38.5	6	8	10	18	⑤	M		Brownish Yellow, Clayey GRAVEL (A-1-b)		
160							38				158.9	42.0
	157.4	43.5	10	12	19	31	⑥	M		**RESIDUAL** Greenish Gray, Clayey SILT (A-5)		
155							43				153.9	47.0
	152.4	48.5	44	56/0.4		100/0.9	⑦			**WEATHERED ROCK** Gray (META-ARGILLITE)		
150												
	147.4	53.5	100/0.5			100/0.5					146.9	54.0
										Boring Terminated at Elevation 146.9 ft in Weathered Rock (META-ARGILLITE)		

==========

APILE for Windows, Version 2014.6.8

Serial Number : 293783516

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

==========

This program is licensed to :

Froehling & Robertson, Inc.
Richmond, Virginia

Path to file locations : F:\Projects 66U\66U-0390 (WEI-I-5786 Bridges 108 & 111 Johnston Co)\NON_CADD\Foundation Recs\Bridge 111 Bizzel Grove\APILE\
Name of input data file : End Bent 2 RT.ap6d
Name of output file : End Bent 2 RT.ap6o
Name of plot output file : End Bent 2 RT.ap6p

Time and Date of Analysis

Date: May 11, 2017 Time: 16:08:35

1

****
* INPUT INFORMATION *
****

Bridge 111 End Bent 2 RT

DESIGNER : C Wang

JOB NUMBER : 66U-0390

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

TYPE OF LOADING :
- COMPRESSION

PILE TYPE :

H-Pile/Steel Pile

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.300E+08 PSI
- CROSS SECTION AREA = 15.50 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 45.00 FT.
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 IN.
- TIP AREA OF PILE = 15.50 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	53.00	0.00	0.00
13.00	CLAY	0.00	53.00	0.00	0.00
13.00	SAND	0.00	53.00	29.00	0.00
18.00	SAND	0.00	53.00	29.00	0.00
18.00	SAND	0.00	58.00	30.00	0.00
23.00	SAND	0.00	58.00	30.00	0.00
23.00	SAND	0.00	53.00	29.00	0.00
33.00	SAND	0.00	53.00	29.00	0.00
33.00	SAND	0.00	53.00	29.00	0.00
38.00	SAND	0.00	53.00	29.00	0.00
38.00	CLAY	0.00	63.00	0.00	0.00
43.00	CLAY	0.00	63.00	0.00	0.00
43.00	CLAY	0.00	63.00	0.00	0.00
53.00	CLAY	0.00	63.00	0.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.90	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.90	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.40	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.40	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	5.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
13.00	1.000	1.000
13.00	1.000	1.000
18.00	1.000	1.000
18.00	1.000	1.000
23.00	1.000	1.000
23.00	1.000	1.000
33.00	1.000	1.000
33.00	1.000	1.000
38.00	1.000	1.000
38.00	1.000	1.000
43.00	1.000	1.000
43.00	1.000	1.000
53.00	1.000	1.000

1

****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.4	0.4
1.00	0.0	0.4	0.4
2.00	1.7	0.9	2.5
3.00	5.0	0.9	5.9
4.00	8.4	0.9	9.2
5.00	11.7	0.9	12.6
6.00	15.0	0.9	15.9
7.00	18.4	0.9	19.3
8.00	21.7	0.9	22.6
9.00	25.1	0.9	25.9
10.00	28.4	0.9	29.3
11.00	31.8	0.9	32.6
12.00	35.1	0.9	36.0
13.00	38.4	1.0	39.5
14.00	40.5	1.1	41.7
15.00	41.4	1.3	42.6
16.00	42.3	1.3	43.6
17.00	43.3	1.4	44.7
18.00	44.3	1.4	45.7
19.00	45.4	1.4	46.9
20.00	46.7	1.4	48.1
21.00	48.0	1.4	49.4
22.00	49.3	1.4	50.8
23.00	50.8	1.4	52.2
24.00	52.2	1.4	53.7
25.00	53.7	1.4	55.1
26.00	55.2	1.4	56.7
27.00	56.8	1.4	58.3
28.00	58.5	1.4	59.9

29.00	60.2	1.4	61.6
30.00	61.9	1.4	63.4
31.00	63.8	1.4	65.2
32.00	65.7	1.4	67.1
33.00	67.6	1.4	69.0
34.00	69.6	1.4	71.0
35.00	71.7	1.4	73.1
36.00	73.8	1.4	75.2
37.00	76.0	1.9	77.8
38.00	78.2	2.4	80.6
39.00	86.0	2.9	88.9
40.00	99.4	3.3	102.7
41.00	112.8	3.3	116.1
42.00	126.3	3.7	129.9
43.00	139.0	4.1	143.1
44.00	153.9	4.5	158.4
45.00	171.6	4.8	176.5

AN ASTERISK WILL BE PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

Assume piles refuse ~ 1' into WR

⊗ EL 152.9

Pile Length = BOC − Tip

= 196.9' − 152.9' = 44'

∴ Anticipated Pile Length = 44'

Average Pile Length = 45'

⊗ depths of 44'

% skin = $\frac{153.9}{370} \approx 42\%$

WEAP Parameter Calculation

Bent #: Bridge 111 EB2-B

		Toe Quake	Shaft Quake
Pile Type:	HP 12X53	**0.10**	**0.10**

Subsurface Conditions: Loose/Soft or Submerged

Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping
1	196.9	183.9	9	Clay	0.25
2	183.9	178.9	5	Sand	0.20
3	178.9	173.9	11	Sand	0.18
4	173.9	163.9	5	Sand	0.20
5	163.9	158.9	7	Sand	0.20
6	158.9	153.9	42	Clay	0.10
7					
8					

	Toe Damping
0.20	**0.10**

Froehling & Robertson, Inc.
Bridge 111 End Bent 2 Rt

17-May-2017
GRLWEAP Version 2010

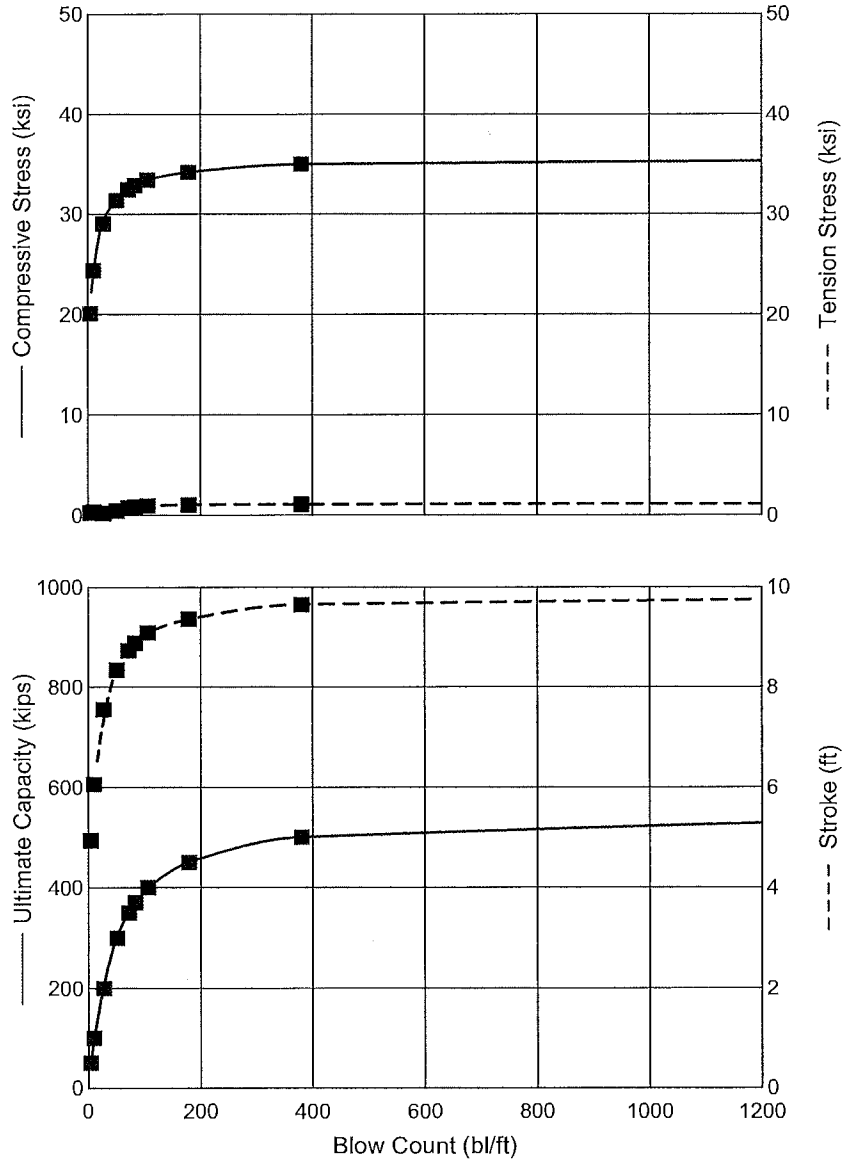
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
50.0	20.09	0.26	4.6	4.94	22.16
100.0	24.38	0.35	10.9	6.06	19.31
200.0	29.03	0.18	27.8	7.55	17.90
300.0	31.34	0.46	51.6	8.34	18.34
350.0	32.42	0.78	72.2	8.73	19.14
370.0	32.83	0.86	84.1	8.88	19.40
400.0	33.40	0.96	106.8	9.09	19.80
450.0	34.17	1.06	179.7	9.36	20.24
500.0	34.99	1.11	380.7	9.65	20.86
550.0	35.58	1.14	2154.3	9.83	21.16

Delmag D19 or equivalent hammer should be able to drive the piles

@ EB2 (Rt)

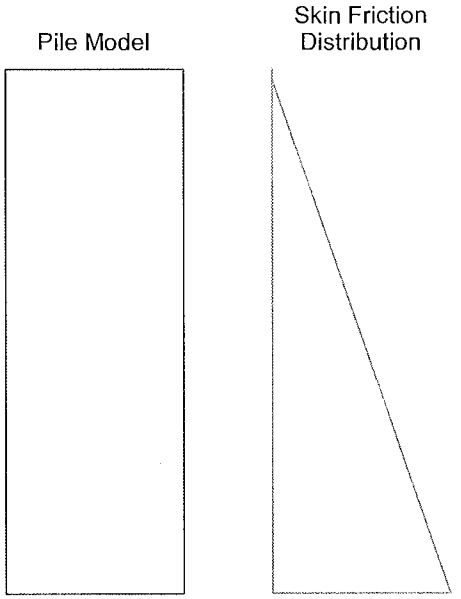
Froehling & Robertson, Inc.
Bridge 111 End Bent 2 Rt

17-May-2017
GRLWEAP Version 2010



DELMAG D 19-32

Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1580 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.100	sec/ft
Pile Length	45.00	ft
Pile Penetration	44.00	ft
Pile Top Area	15.50	in2



Res. Shaft = 42 %
(Proportional)

Slope ok!

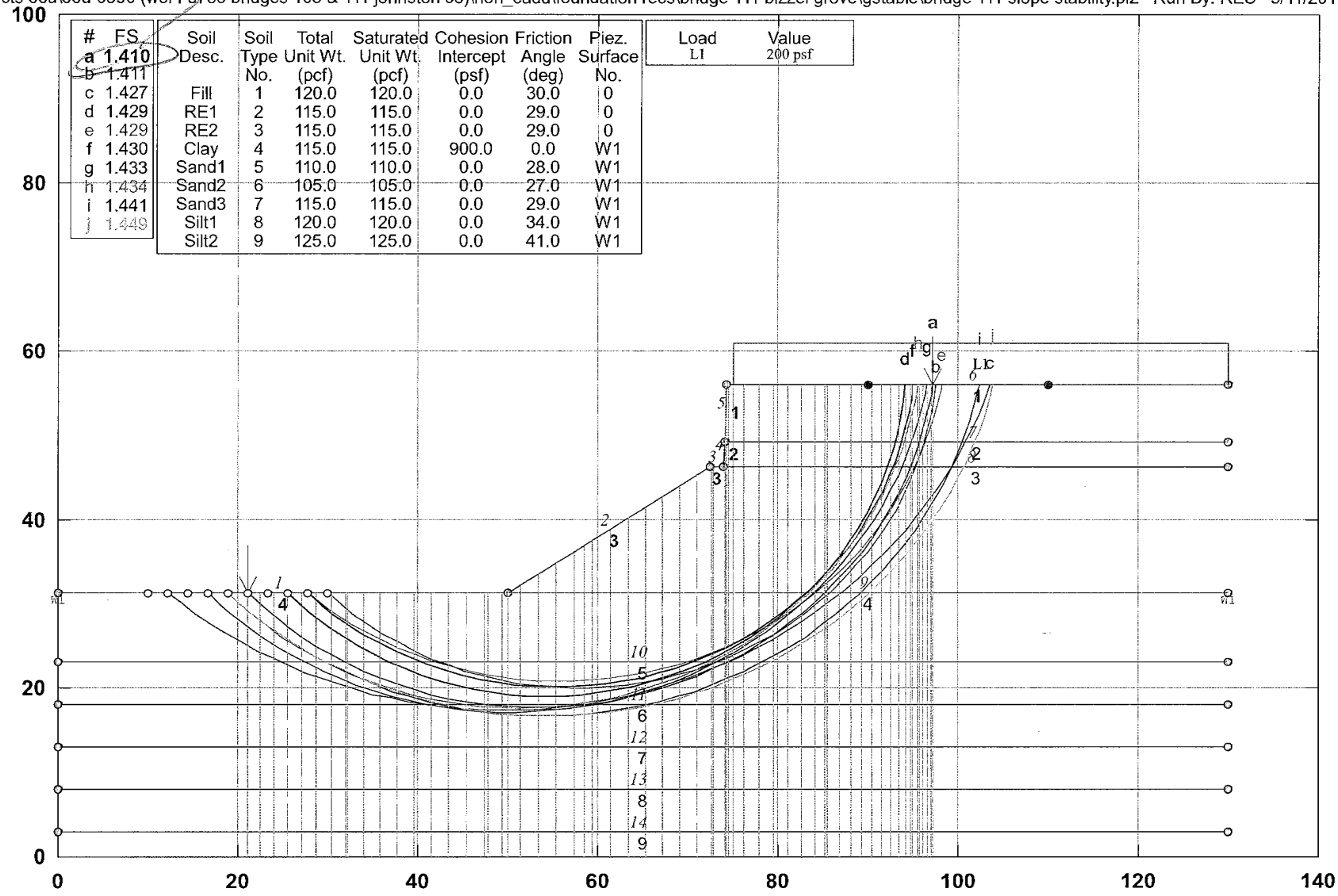
66U-0390 Brideg 111 Slope stability

f:\projects 66u\66u-0390 (wei-i-5786 bridges 108 & 111 johnston co)\non_cadd\foundation recs\bridge 111 bizzel grove\gstable\bridge 111 slope stability.pl2 Run By: RES 5/11/2017 08:20PM

#	FS
a	1.410
b	1.411
c	1.427
d	1.429
e	1.429
f	1.430
g	1.433
h	1.434
i	1.441
j	1.449

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Fill	1	120.0	120.0	0.0	30.0	0
RE1	2	115.0	115.0	0.0	29.0	0
RE2	3	115.0	115.0	0.0	29.0	0
Clay	4	115.0	115.0	900.0	0.0	W1
Sand1	5	110.0	110.0	0.0	28.0	W1
Sand2	6	105.0	105.0	0.0	27.0	W1
Sand3	7	115.0	115.0	0.0	29.0	W1
Silt1	8	120.0	120.0	0.0	34.0	W1
Silt2	9	125.0	125.0	0.0	41.0	W1

Load	Value
L1	200 psf



GSTABL7 v.2 FSmin=1.410

Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

SINCE 1881

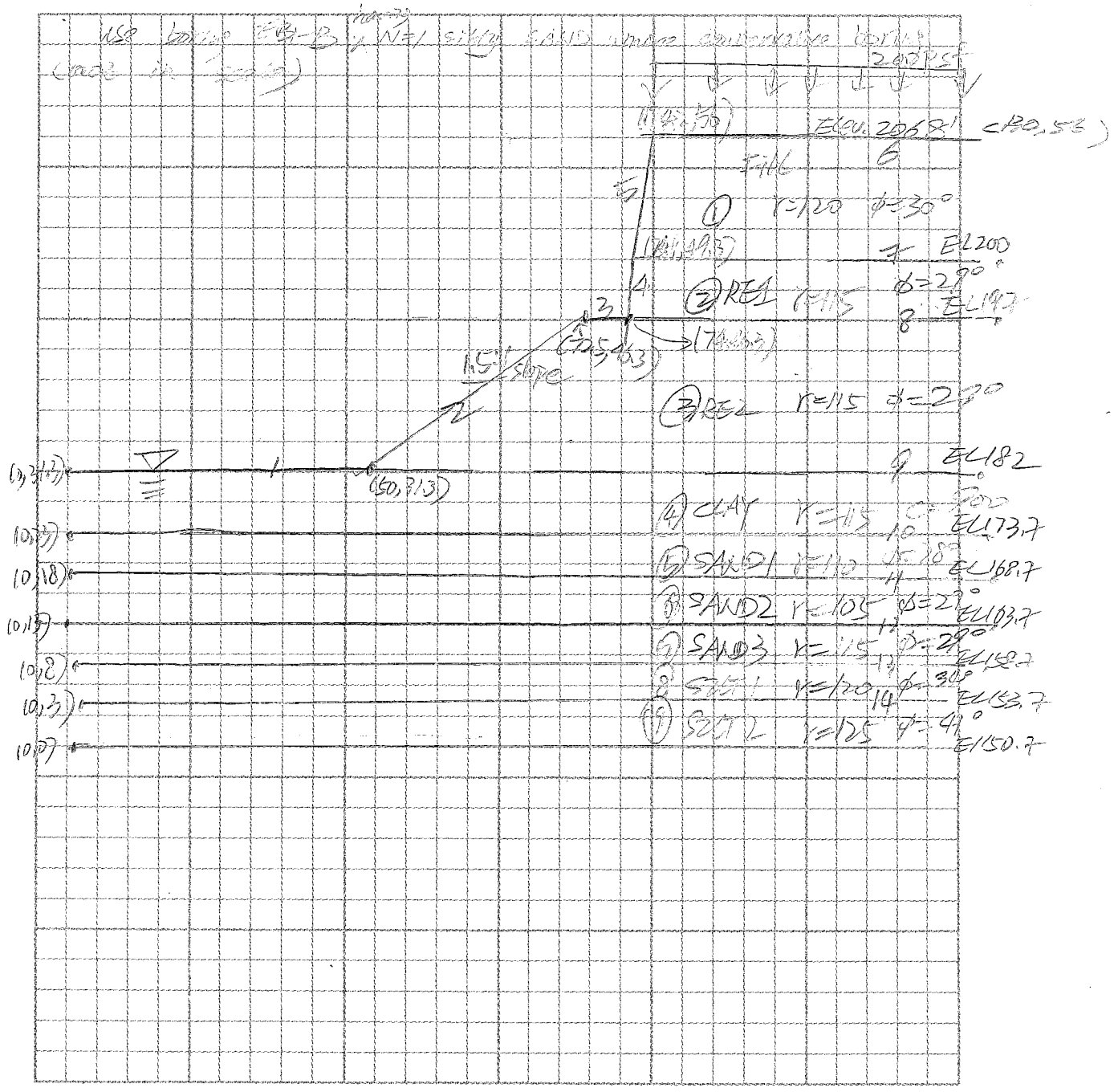
FROEHLING & ROBERTSON, INC.

Engineering • Environmental • Geotechnical

SHEET NO. 1 OF 1

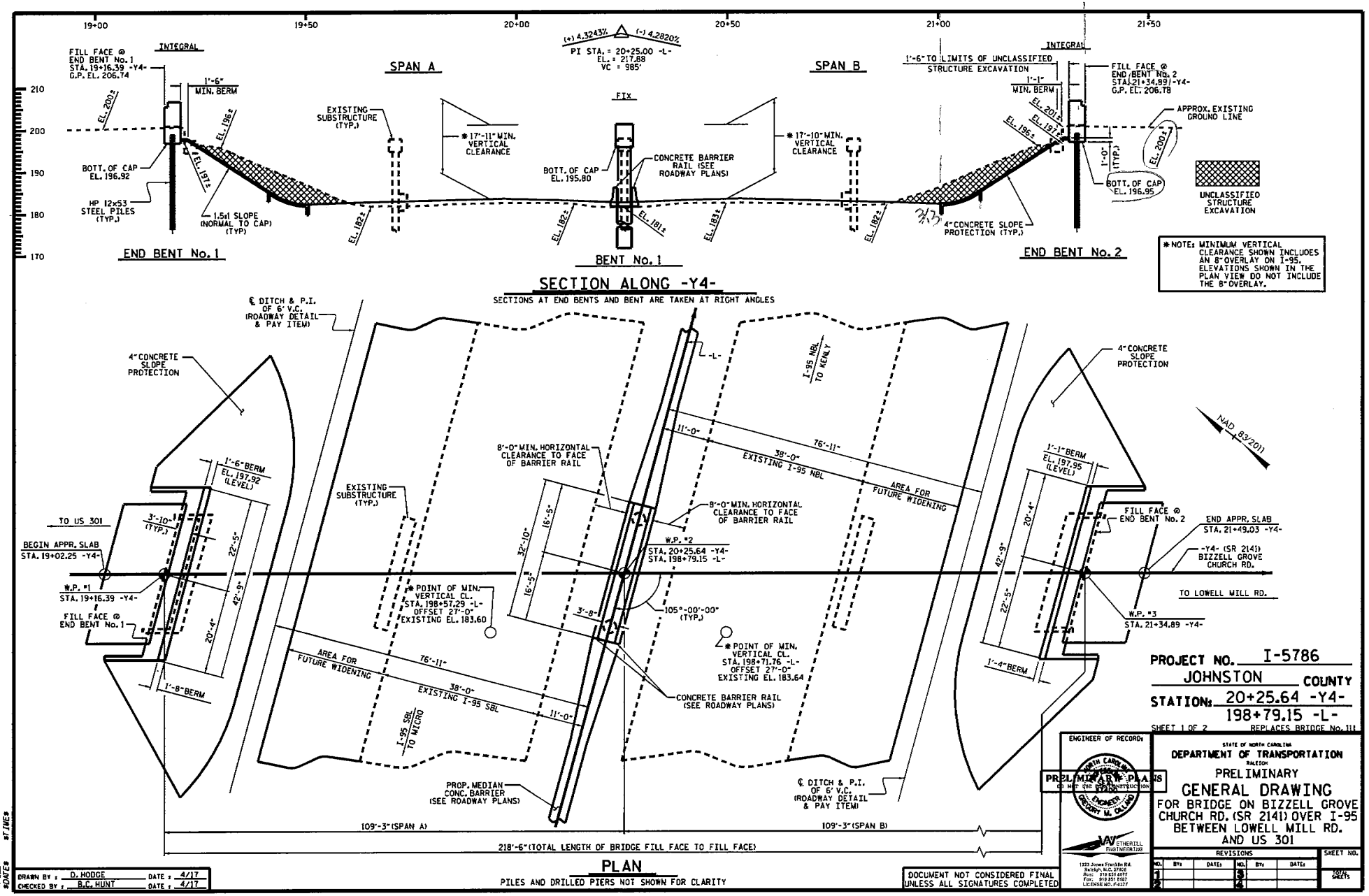
JOB I-5786 Bridge 11 DATE 5/11/17

COMPUTATIONS FOR Slope stability BY CWard CHKD



Form No. 502
Revised 05/2008

2H34.9



* NOTE: MINIMUM VERTICAL CLEARANCE SHOWN INCLUDES AN 8" OVERLAY ON I-95. ELEVATIONS SHOWN IN THE PLAN VIEW DO NOT INCLUDE THE 8" OVERLAY.

SECTION ALONG -Y4-

SECTIONS AT END BENTS AND BENT ARE TAKEN AT RIGHT ANGLES

PLAN

PILES AND DRILLED PIERS NOT SHOWN FOR CLARITY

PROJECT NO. I-5786

JOHNSTON COUNTY

STATION: 20+25.64 -Y4-
198+79.15 -L-

SHEET 1 OF 2 REPLACES BRIDGE No. 111

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

PRELIMINARY

GENERAL DRAWING

FOR BRIDGE ON BIZZELL GROVE CHURCH RD. (SR 2141) OVER I-95 BETWEEN LOWELL MILL RD. AND US 301

ENGINEER OF RECORD:

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

NORTH CAROLINA PROFESSIONAL ENGINEER GREGORY W. ORLAND

W ETHERILL ENGINEERING

1223 Jones Franklin Rd. Raleigh, N.C. 27606 Phone: 919 851 6072 Fax: 919 851 8167 LICENSE NO. F-0277

REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	
1			3			TOTAL SHEETS
2			4			

DRAWN BY : D. HODGE DATE : 4/17
CHECKED BY : B.C. HUNT DATE : 4/17

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

FILES
LINES
DATES

GEOTECHNICAL BORING REPORT
BORE LOG

WBS N/A	**TIP** I-5786	**COUNTY** JOHNSTON	**GEOLOGIST** P. Fahey	
SITE DESCRIPTION Bridge No. 111 on SR 2141 (Bizzell Grove Church Road) over I-95				**GROUND WTR (ft)**
BORING NO. EB1-B	**STATION** 19+04	**OFFSET** 5 ft RT	**ALIGNMENT** -Y4-	**0 HR.** NM
COLLAR ELEV. 200.7 ft	**TOTAL DEPTH** 54.8 ft	**NORTHING** 660,177	**EASTING** 2,241,568	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R4637 CME-75 81% 07/18/2015		**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER S. Sequist	**START DATE** 04/10/17	**COMP. DATE** 04/10/17	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
										ELEV. (ft) DEPTH (ft)
205										
200	200.7	0.0	3	6	3	9		M		GROUND SURFACE 0.0
	197.2	3.5								**ASPHALT**
			1	2	3	5		W		**ROADWAY EMBANKMENT** 197.0 Yellowish Brown, Gray, and Red, Silty Fine Sandy CLAY (A-6)
195										
	192.2	8.5	2	2	2	4		W		
190										
	187.2	13.5	2	2	2	4		M		
185										
	182.2	18.5	11	6	3	9		M		182
180										179.7 21.0
	177.2	23.5	3	4	4	8		M		**COASTAL PLAIN** Gray and Yellow, Silty CLAY (A-7)
175										173.7 27.0
	172.2	28.5	1	1	2	3		Sat.		Light Gray, Clayey Fine to Coarse SAND (A-2-6)
170										168.7 32.0
	167.2	33.5	WOH	WOH	1	1		Sat.		Yellow, Silty Fine SAND (A-2-4)
165										163.7
	162.2	38.5	2	3	3	6		Sat.		
160										158.7 42.0
	157.2	43.5	8	11	14	25		M		**RESIDUAL** Gray, Clayey SILT (A-5)
155										153.7
	152.2	48.5	23	33	65	98		M		150.7 50.0
150										**WEATHERED ROCK** Gray (META-ARGILLITE)
	147.2	53.5	26	70	30/0.3	100/0.8				145.9 54.8
										Boring Terminated at Elevation 145.9 ft in Weathered Rock (META-ARGILLITE)

NCDOT BORE SINGLE I5786_GEO_BH_BRDG111.GPJ NC_DOT.GDT 5/5/17

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS HIGHWAY BUILDING 1589 MAIL SERVICE CENTER RALEIGH, NORTH CAROLINA 27699-1589	SUBJECT: Bridge No. 111 on SR 2141 (Bizzell Grove Church Rd.) over I-95		
	PREPARED BY:	CW	TIP NO.:
	DATE:	5/17	I-5786
	CHECKED BY:	WPA	COUNTY: Johnston
	DATE:	5/17	

INTERIOR BENT SUMMARY

Foundation Type:	48-inch drilled piers	
Bottom of Cap Elevation:	195.46 ft	Provided by WEI
Top of Pier Elevation:	180.46 ft	Provided by WEI
Max Factored Load:	770 Tons/Pier	Provided by WEI, rounded up to nearest 5 tons
Required factored Resistance:	795 Tons/Pier	Per NCDOT axial spreadsheet rounded up to the nearest 5 tons
Required Tip Resistance:	20 tons/ft^2	For quality control purposes
Point of Fixity (POF) Elevation:	155.0 ft (Lt)	"LPILE" program calculations
	153.0 ft (Rt)	"LPILE" program calculations
Tip No Higher Than Elevation:	125.0 ft (Lt)	Axial Capacity Calculations
	130.0 ft (Rt)	Axial Capacity Calculations

NOTES

See Notes on Sheet 2 of the Foundation Recommendations

COMMENTS

See Comments on Sheet 3 of the Foundation Recommendations

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS HIGHWAY BUILDING PO BOX 25201 RALEIGH, NORTH CAROLINA 27611	SUBJECT: Bridge No. 111 on SR 2141 (Bizzell Grove Church Rd.) over I-95		WBS Element No.: N/A
	PREPARED BY:	CW	COUNTY:
	DATE:	May-17	Johnston
	CHECKED BY:	WPA	TIP #: I-5786
	DATE:	May-17	

QUANTITY OF DRILLED PIER IN SOIL & NOT IN SOIL CALCULATION SHEET

INTERIOR BENTS (Elevs. In feet)

	B1-A	B1-B
APPROX. TOP OF SHAFT ELEV. =	180.5	180.5
TOP OF WEATHERED ROCK (WR) ELEV. =	144.8	149.8
TOP OF CRYSTALLINE ROCK (CR) ELEV. =	123.3	128.3
TIP NO HIGHER THAN ELEV. =	125.0	130.0
NUMBER OF SHAFTS PER BORING:	**1.0**	**1.0**
QUANTITY OF PIERS BELOW TOP OF SHAFT:	55.5	50.5
QUANTITY OF PIERS IN WR - Total:	21.5	21.5
QUANTITY OF PIERS IN WR - Soil (1/2 of total):	10.8	10.8
QUANTITY OF PIERS IN WR - Not in Soil (1/2 of total):	10.8	10.8
QUANTITY OF PIERS IN CR - Not in Soil:	0.0	0.0
TOTAL QUANTITY OF PIERS NOT IN SOIL:	10.8	10.8
ROUND UP TO NEAREST WHOLE NUMBER:	11	11
TOTAL QTY OF PIERS NOT IN SOIL (lf)	**22**	
TOTAL QUANTITY OF PIERS IN SOIL:	44.7	39.7
ROUND UP TO NEAREST WHOLE NUMBER:	45.0	40.0
TOTAL QTY OF PIERS IN SOIL (lf)	**85**	

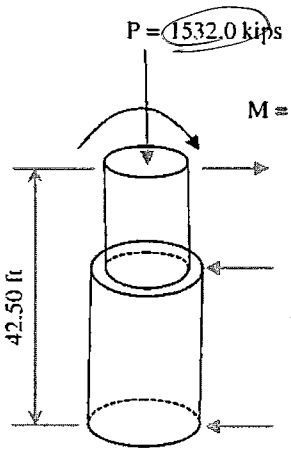
Due to piers extending primarily through weathered rock, use a single drilled pier pay item and enter "0" for the drilled pier not in soil quantity of the drilled pier pay items sheet

WETHERILL ENGINEERING, INC.
1223 JONES FRANKLIN RD.
RALEIGH, NC 27606
(919) 851-8077 * (919) 851-8107 (FAX)

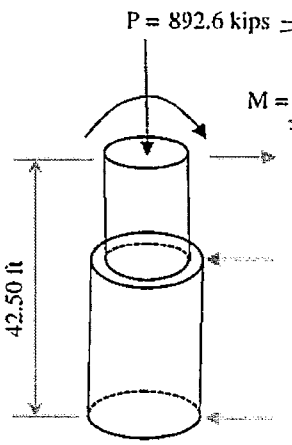
STR. NO.: 111 TIP NO.: I-5786 COUNTY: JOHNSTON
SUBJECT: CONTROLLING COLUMN LOADS (STRENGTH)
PREPARED BY: GMG DATE: 4/27/17 STATION: 20+25.64 -Y4-
CHECKED BY: BCH DATE: 4/27/17 SHEET 1 OF 2

Col #	1		2									
Node #	3	3a	6	6a								

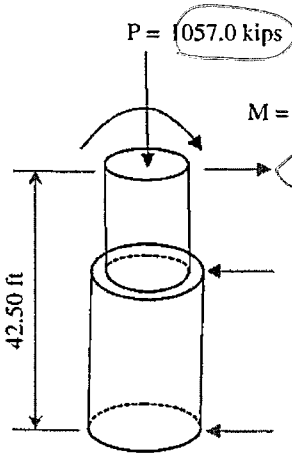
MAXIMUM AXIAL LOAD WITH LONGITUDINAL SHEAR AND MOMENT



MAXIMUM LONGITUDINAL SHEAR WITH AXIAL LOAD AND LONGITUDINAL MOMENT

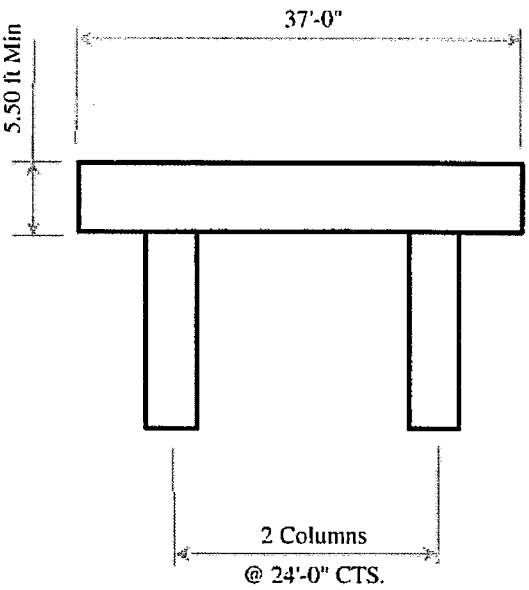


MAXIMUM TRANSVERSE SHEAR WITH AXIAL LOAD AND TRANSVERSE MOMENT



NOTES:

Column Φ = 42 in = 3' - 6"
Drilled Shaft Φ = 48 in = 4' - 0"

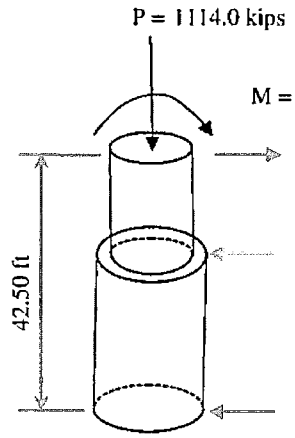


Bent No.	Bottom of Cap
1	195.46 ft

WETHERILL ENGINEERING, INC.
1223 JONES FRANKLIN RD.
RALEIGH, NC 27606
(919) 851-8077 * (919) 851-8107 (FAX)

STR. NO.: 111 TIP NO.: I-5786 COUNTY: JOHNSTON
SUBJECT: CONTROLLING COLUMN LOADS (SERVICE)
PREPARED BY: GMG DATE: 4/27/17 STATION: 20+25.64 -Y4-
CHECKED BY: BCH DATE: 4/27/17 SHEET 2 OF 2

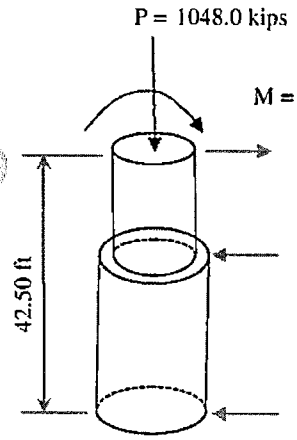
Col #	1		2									
Node #	3	3a	6	6a								



Bottom of Col. Elev. = 180.46 ft

Preliminary POF Elev. = 153.00 ft

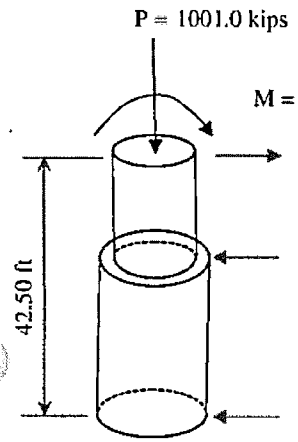
MAXIMUM AXIAL LOAD WITH
LONGITUDINAL SHEAR AND MOMENT



Bottom of Col. Elev. = 180.46 ft

Preliminary POF Elev. = 153.00 ft

MAXIMUM LONGITUDINAL SHEAR WITH
AXIAL LOAD AND LONGITUDINAL MOMENT



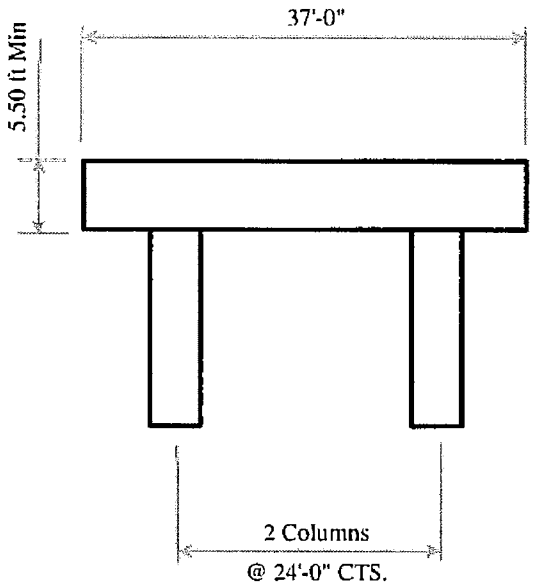
Bottom of Col. Elev. = 180.46 ft

Preliminary POF Elev. = 153.00 ft

MAXIMUM TRANSVERSE SHEAR WITH
AXIAL LOAD AND TRANSVERSE MOMENT

NOTES:

Column Φ = 42 in = 3' - 6 "
Drilled Shaft Φ = 48 in = 4' - 0 "



Bent No.	Bottom of Cap
1	195.46 ft

GEOTECHNICAL BORING REPORT
BORE LOG

WBS N/A	**TIP** I-5786	**COUNTY** JOHNSTON	**GEOLOGIST** P. Fahey	
SITE DESCRIPTION Bridge No. 111 on SR 2141 (Bizzell Grove Church Road) over I-95				**GROUND WTR (ft)**
BORING NO. B1-A	**STATION** 20+17	**OFFSET** 10 ft LT	**ALIGNMENT** -Y4-	**0 HR.** NM
COLLAR ELEV. 181.8 ft	**TOTAL DEPTH** 58.6 ft	**NORTHING** 660,097	**EASTING** 2,241,649	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R4637 CME-75 81% 07/18/2015		**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER S. Sequist	**START DATE** 04/12/17	**COMP. DATE** 04/12/17	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION	ELEV. (ft)	DEPTH (ft)
						BOC = ± 185.46 per WEI					185.46	
185												
										GROUND SURFACE	181.8	0.0
180						Bottom of column = ± 180.46				ROADWAY EMBANKMENT Orange and Gray, Fine Sandy CLAY (A-6)	180.46	
	178.3	3.5	3	3	6	9 N=9	1	M				
175											174.8	7.0
	173.3	8.5	1	1	2	3 N=1	2	Sat.		COASTAL PLAIN Brownish Gray and Tan-White, Clayey Fine SAND (A-2-6)		
170												
	168.3	13.5	WOH	WOH	WOH	0 Y=105pcf		Sat.				
165											164.8	17.0
	163.3	18.5	3	4	5	9 N=9 Y=115pcf	3	Sat.		Brownish Yellow, Silty Fine SAND (A-2-4)		
160											159.8	22.0
	158.3	23.5	6	9	13	22 N=22 Y=120pcf	4	Sat.		RESIDUAL Gray, Clayey SILT (A-5)		
155											154.8	
	153.3	28.5	13	12	23	35 N=35 Y=105	5	M				
150											149.8	
	148.3	33.5	10	23	48	N=150 Y=125 71	6	M				
145											144.8	37.0
	143.3	38.5	100/0.5			100/0.5				WEATHERED ROCK Gray (META-ARGILLITE)		
140							7					
	138.3	43.5	40	60/0.3		Y=130pcf 100/0.8						
135												
	133.3	48.5	100/0.3			100/0.3						
130												
	128.3	53.5	100/0.3			100/0.3						
125												
	123.3	58.5	60/0.1			60/0.1					123.3	58.5
										CRYSTALLINE ROCK (META-ARGILLITE)	123.2	58.6
										Boring Terminated with Standard Penetration Test Refusal at Elevation 123.2 ft in Crystalline Rock (META-ARGILLITE)		

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
Drilled Pier Axial Resistance Worksheet

PROJECT: I-5786 COUNTY: Johnston
DESCRIPTION: Bridge 111 Bizzell Grove Church, bent 1 left
DESIGNED BY: CW DATE: 05/09/17 STATION: Bent 1
CHECKED BY: DATE: STR. NO.: PAGE: 1 OF 8

Elevations

Bottom of Cap (BOC) Elevation =	195.46	ft
Top of Pier/Bottom of Column Elevation =	180.46	ft
Natural Ground / Finished Grade Elevation =	181.55	ft
Groundwater Table (GWT) Elevation =	0.00	ft
Design Scour (DSE) Elevation =	181.55	ft
Amount of Contraction Scour (from BSR) =	0.00	ft
Is Permanent Casing Required? ○ Yes / Maybe ◉ No		
Bottom of Permanent Casing Elevation =	N/A	ft
Drilled Pier Tip Elevation =	125.00	ft

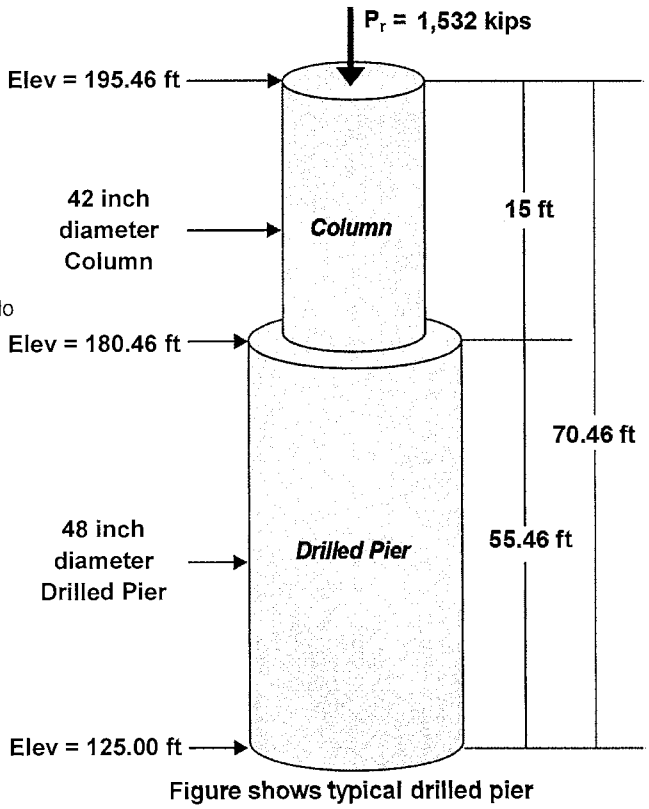


Figure shows typical drilled pier

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	1,532.0	kips
Number of Drilled Piers per Bent =	2	
Diameter of Column (d_{Column}) =	42	in
Diameter of Drilled Pier (d_{DP}) =	48	in
Unit Weight of Concrete (γ_c) =	0.150	kcf
Compressive Strength of Concrete (f'_c) =	4.500	ksi

Subsurface Information and Soil/Rock Layer Properties

internally calculate $N1_{60}$ values at midpoint of each layer ☑

Subsurface Boring Name / ID No. =	B1-A	
SPT Hammer Energy Efficiency Rating (ER) =	81	%
Top of Boring (Collar) Elevation =	181.80	ft
Depth to Groundwater Table (for actual boring) =	0.00	ft

Calculate GSI using RQD values : ☑
(Use if GSI is not shown on boring)

Layer No.	Material Description	Layer Elevations Top[1] (ft)	Layer Elevations Bottom (ft)	Total γ (kcf)	N (bpf)	N_{60} (bpf)	$N1_{60}$ (bpf)	RQD (%)	[2] GSI	q_u (ksf)	E_i (ksi)	v
1	Cohesive Soil (Clay)	180.46	174.80	0.115	9	12	21					
2	Cohesionless Soil (Silty Sand)	174.80	164.80	0.105	1	1	1					
3	Cohesionless Soil (Silty Sand)	164.80	159.80	0.115	9	12	15					
4	Cohesionless Soil (Silty Sand)	159.80	154.80	0.120	22	30	35					
5	Cohesionless Soil (Silty Sand)	154.80	149.80	0.125	35	47	52					
6	Cohesionless Soil (Silty Sand)	149.80	144.80	0.125	71	96	99					
7	Weathered Rock	144.80	125.00	0.130	100	135	123					
8												
TIP [3]	Weathered Rock	125.00	117.00	0.130	150	203	164					

Notes

1. Resistance from subsurface layers above the Bottom of Column Elevation, Drilled Pier Design Scour Elevation, and Permanent Casing Elevation will be ignored.
2. Hard rock layers with poor or very poor quality rock mass (GSI < 30) will be modeled as weathered rock.
3. Input the subsurface information for the soil / rock at the base of the drilled pier to a distance of 2 pier diameters below the base of the drilled pier.

Correcting SPT Values for Hammer Efficiency and Overburden Pressure

SPT-N Value Corrected for Hammer Efficiency, (N_{60})

$N_{60} = (ER/60\%)(N)$ *AASHTO Eqn. 10.4.6.2.4-2*

N_{60} = SPT blow count corrected for hammer efficiency (blows/ft)
ER = hammer efficiency expressed as percent of theoretical free fall energy delivered by the hammer system actually used. If ER is not known, use 80% for automatic hammers and 60% for drop hammers.
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for Overburden Pressure, (N1)

$N1 = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-1*

N1 = SPT blow count corrected for overburden pressure (blows/ft)
C_N = correction factor = $[0.77\log_{10}(40/\sigma'_v) < 2.0$
$\sigma'_v = \sigma_v - \mu$ = effective vertical stress at the depth of the SPT-N value (ksf)
σ_v = total vertical stress at the depth of the SPT-N value (ksf)
μ = total pore water pressure at the depth of the SPT-N value (ksf)
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for both Overburden Pressure and Hammer Efficiency, ($N1_{60}$)

$N1_{60} = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-3*

Summary of Corrected N Values for Boring

Top of Boring (Collar) Elevation = 181.8 ft
Hammer Efficiency (ER) = 81 %
Depth to Groundwater Table = 0.0 ft
Unit Weight of Water = 0.0624 kcf

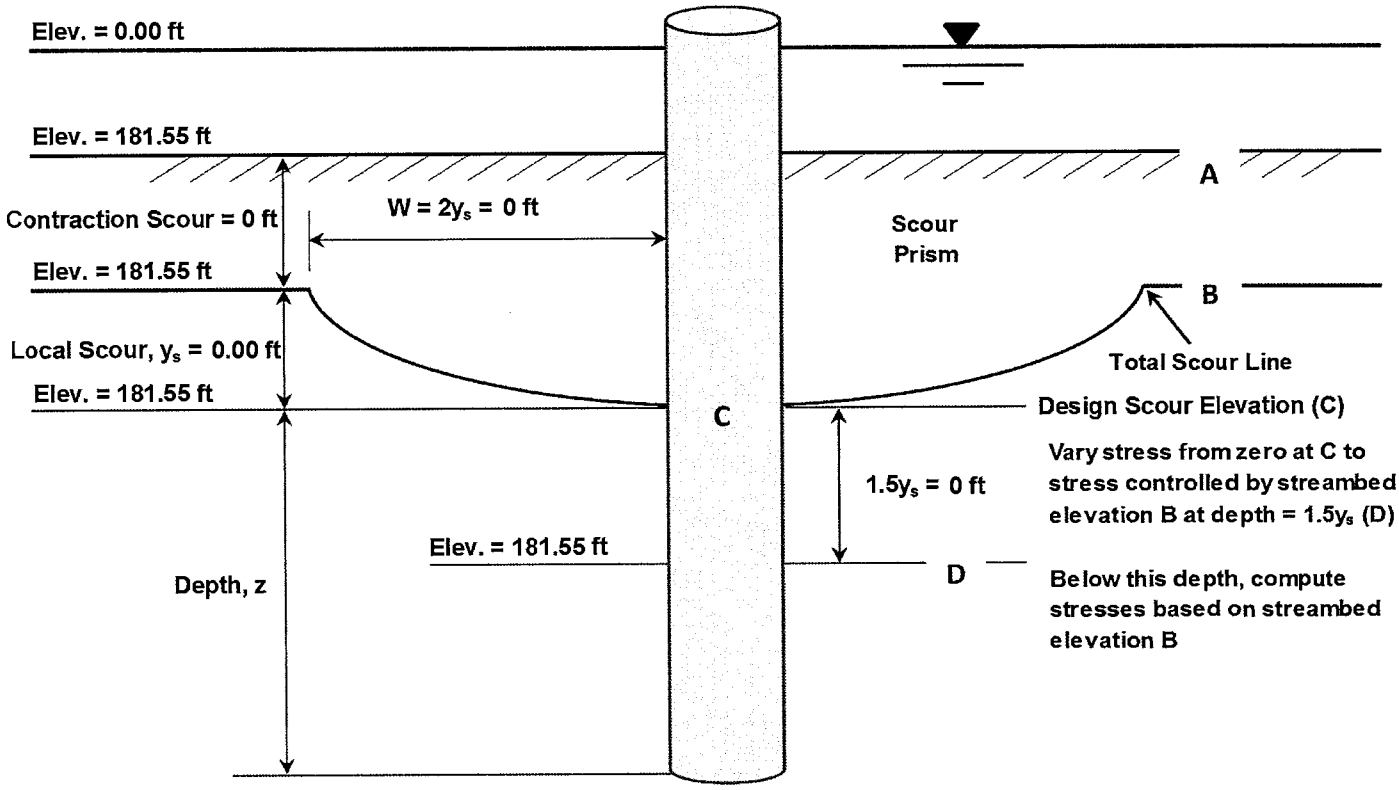
Layer No.	Layer Elevations		σ_v at top (ksf)	Δz (ft)	Total γ (kcf)	σ_v at bottom (ksf)	σ_v at midpoint (ksf)	z_{water} (ft)	μ at midpoint (ksf)	σ'_{vc} at midpoint (ksf)	N (bpf)	N_{60} (bpf)	C_N	$N1_{60}$ (bpf)
	Top (ft)	Bottom (ft)												
1	180.46	174.80	0.161	5.66	0.115	0.812	0.486	4.17	0.260	0.226	9	12	1.73	21
2	174.80	164.80	0.812	10.00	0.105	1.862	1.337	12.00	0.749	0.588	1	1	1.41	1
3	164.80	159.80	1.862	5.00	0.115	2.437	2.149	19.50	1.217	0.932	9	12	1.26	15
4	159.80	154.80	2.437	5.00	0.120	3.037	2.737	24.50	1.529	1.208	22	30	1.17	35
5	154.80	149.80	3.037	5.00	0.125	3.662	3.349	29.50	1.841	1.508	35	47	1.1	52
6	149.80	144.80	3.662	5.00	0.125	4.287	3.974	34.50	2.153	1.821	71	96	1.03	99
7	144.80	125.00	4.287	19.80	0.130	6.861	5.574	46.90	2.927	2.647	100	135	0.91	123
8														
TIP	125.00	117.00	6.861	8.00	0.130	7.901	7.381	60.80	3.794	3.587	150	203	0.81	164

Calculating Design Stresses for Drilled Piers based on Scour Prism used in FHWA GEC 010

For analysis purposes, lower ground line to the contraction scour elevation (CSE) to account for contraction scour reported in the bridge survey report.

- If the CSE is lower than or equal to the design scour elevation (DSE), consider all scour as contraction scour and lower th ground line to the design scour elevation (DSE).
- If the CSE is higher than the DSE, consider the difference between the CSE and the DSE as local scour.

Groundwater Elevation =	0.00	ft	
Original Pre-Scour Streambed Elevation (Point A) =	181.55	ft	= *Natural Ground / Finished Grade Elevation*
Amount of Contraction Scour =	0.00	ft	
Streambed Elevation after General Scour (Point B) =	181.55	ft	= *Point A - Contraction Scour ≥ Design Scour Elevation*
Amount of Local Scour (y_s) =	0.00	ft	
ıp of the embedded length of the drilled pier (Point C) =	181.55	ft	= *Design Scour Elevation*
$1.5(y_s)$ =	0.00	ft	
evation corresponding to a depth of $1.5(y_s)$, (Point D) =	181.55	ft	= *Point C - $1.5y_s$*



Adapted from FHWA GEC 010 Figure 13.18: Illustration of Scour Prism and Effects on Drilled Pier

Per FHWA GEC 010 page 13-46, vertical stress along any depth of the drilled pier can be estimated as follows;

1) At the top of the embedded drilled pier (Point C) the vertical stress is equal to zero.
2) At a depth of 1.5ys (Point D) or greater, assume the vertical stress is controlled by the streambed elevation (Point B).
3) Assume a linear variation in vertical stress from 0 at Point C to the vertical stress value controlled by the streambed at Point

Soil Layer Profile and Effective Vertical Stress controlled by the streambed elevation (Point B)

- Assume the streambed elevation is equal to the contraction scour elevation (Elevation 181.55 ft).

Layer No.	Top (ft)	Midpoint (ft)	Bottom (ft)	σ_{v_top} (ksf)	$\mu_{\_top}$ (ksf)	σ'_{v_top} (ksf)	Δz (ft)	γ (kcf)	σ_{v_bottom} (ksf)	$\mu_{\_bottom}$ (ksf)	σ'_{v_bottom} (ksf)
0	181.55	181.01	180.46	0.000	0.000	0.000	1.09	0.120	0.131	0.000	0.131
1	180.46	177.63	174.80	0.131	0.000	0.131	5.66	0.115	0.782	0.000	0.782
2	174.80	169.80	164.80	0.782	0.000	0.782	10.00	0.105	1.832	0.000	1.832
3	164.80	162.30	159.80	1.832	0.000	1.832	5.00	0.115	2.407	0.000	2.407
4	159.80	157.30	154.80	2.407	0.000	2.407	5.00	0.120	3.007	0.000	3.007
5	154.80	152.30	149.80	3.007	0.000	3.007	5.00	0.125	3.632	0.000	3.632
6	149.80	147.30	144.80	3.632	0.000	3.632	5.00	0.125	4.257	0.000	4.257
7	144.80	134.90	125.00	4.257	0.000	4.257	19.80	0.130	6.831	0.000	6.831
8											

Variation in Vertical Stress from Point C to Point D

- Assume the top of the embedded drilled pier is equal to the design scour elevation.
- Vertical stress at elevation 181.55 ft (Point C) = 0 ksf
- Assume a linear variation in vertical stress from 0 ksf at elevation 181.55 ft (Point C) to a stress value controlled by the elevation 181.55 ft (Point B) at the depth Point D, elevation 181.55 ft.
- PointD lies within Soil Layer No.0

Point D Elevation (ft)	Top of Layer 0 (ft)	σ_v at 181.55 ft	Depth below Layer 0 (ft)	γ for Layer 2	μ at Point D (ksf)	σ'_v at Point D (ksf)
181.55	181.55	0.000	0.00	0.120	0.000	0.000

Point	Elevation (ft)	z (ft)	σ'_v (ksf)	Equation for linear variation over a depth of $1.5y_s$
C	181.55	0.00	0.000	σ'_v (for z = 0 to 22.5 ft) = (0.0000)z
D	181.55	0.00	0.000	

- All stress calculations below elevation 181.55 ft (Point D) will be based on elevation 181.55 ft (Point B).

Summary of Design Stress at the Midpoint of each Soil Layer and at Tip of Drilled Pier

Layer	Top (ft)	Bottom (ft)	Midpoint (ft)	z (ft)	$\sigma_{v\_midpoint}$ (ksf)	μ (ksf)	$\sigma'_{v\_midpoint}$ (ksf)
1	180.46	174.80	177.63	3.92	0.456	0.000	0.456
2	174.80	164.80	169.80	11.75	1.307	0.000	1.307
3	164.80	159.80	162.30	19.25	2.119	0.000	2.119
4	159.80	154.80	157.30	24.25	2.707	0.000	2.707
5	154.80	149.80	152.30	29.25	3.319	0.000	3.319
6	149.80	144.80	147.30	34.25	3.944	0.000	3.944
7	144.80	125.00	134.90	46.65	5.544	0.000	5.544

Tip Elev. (ft)	z (ft)	σ_{v_bottom} (ksf)	μ (ksf)	σ'_{v_bottom} (ksf)
125.00	56.55	6.831	0.000	6.831

Side Resistance in Cohesive Soil (Clays with $S_U \leq 5$ ksf)

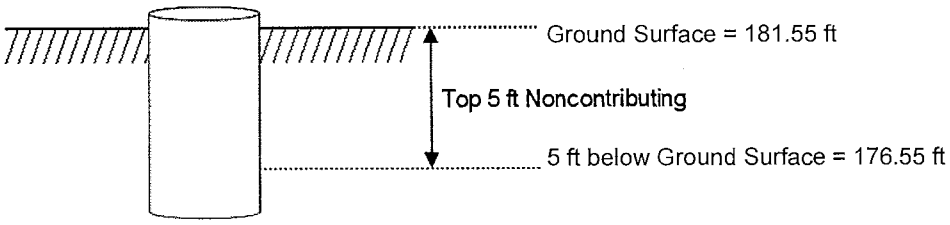
$R_s = (q_s)(A_s)$ *AASHTO Eqn. 10.8.3.5-3*

q_s = unit side resistance for soil layer (ksf)
= $(\alpha)(S_U)$ *AASHTO Eqn. 10.8.3.5.1b-1*

α = adhesion factor
= 0 between the ground surface and a depth of 5 ft
= 0.55 for $(S_U/p_a) \leq 1.5$ *AASHTO Eqn. 10.8.3.5.1b-2*
= $0.55 - 0.1(S_U/p_a - 1.5)$ for $1.5 \leq (S_U/p_a) \leq 2.5$ *AASHTO Eqn. 10.8.3.5.1b-3*

S_U = undrained shear strength (ksf)
= $100(N1_{60})/1000$ *NCDOT Empirical Formula*

p_a = atmospheric pressure (2.12 ksf)



Based on AASHTO Figure 10.8.3.5.1b-1

A_s = area of drilled pier side resistance (ft^2)
= $(\pi)(B)(\Delta z)$

B = diameter of drilled pier (4 ft)
Δz = effective thickness of the soil layer (ft)

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	$N1_{60}$	S_U (ksf)	S_U/p_a	α	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
1	180.46	174.80	21	2.100	0.99	0.55	1.155	1.75	21.99	25
Total Side Resistance in Cohesive Soil =										**25**

Side Resistance in Cohesionless Soil (Sand / Gravel with $N1_{60} \leq 100$)

$R_s = (q_s)(A_s)$ *AASHTO Eqn. 10.8.3.5-3*

q_s = unit side resistance for soil layer (ksf)

$= (\beta)(\sigma'_v)$ *AASHTO Eqn. 10.8.3.5.2b-1*

β = load transfer coefficient

$$= \left(1 - \sin \phi'_f\right)\left(\frac{\sigma'_p}{\sigma'_v}\right)^{\sin \phi'_f} \tan \phi'_f$$ *AASHTO Eqn. 10.8.3.5.2b-2*

ϕ'_f = effective friction angle

$= 27.5 + 9.2 \log(N1_{60}),\quad N1_{60} \leq 100$ *AASHTO Eqn. 10.8.3.5.2b-3*

$N1_{60}$ = SPT - N value corrected for hammer efficiency and overburden (limited to 100 bpf)

σ'_p = effective vertical preconsolidation stress

For Sands: $\frac{\sigma'_p}{\rho_a} \approx 0.47(N_{60})^m$ *AASHTO Eqn. 10.8.3.5.2b-4*

For Gravels: $\frac{\sigma'_p}{\rho_a} = 0.15(N_{60})$ *AASHTO Eqn. 10.8.3.5.2b-5*

m = 0.6 for clean sands; 0.8 for silty sands and sandy silts

N_{60} = SPT - N value corrected for hammer efficiency (limited to 100 bpf)

ρ_a = atmospheric pressure (2.12 ksf)

σ'_v = effective vertical stress at soil layer mid-depth as defined in FHWA GEC 010 pages 13-46

A_s = area of drilled pier side resistance (ft^2)

$= (\pi)(B)(\Delta z)$

B = diameter of drilled pier (4 ft)

Δz = effective thickness of the soil layer (ft)

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	Material Type	$N1_{60}$	ϕ' (deg)	m	N_{60}	σ'_p/ρ_a	σ'_v (ksf)	β	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
2	174.80	164.80	Sand	1	28	0.8	1	0.470	1.307	0.248	0.324	10.00	125.66	41
3	164.80	159.80	Sand	15	38	0.8	12	3.430	2.119	0.641	1.358	5.00	62.83	85
4	159.80	154.80	Sand	35	42	0.8	30	7.140	2.707	0.943	2.552	5.00	62.83	160
5	154.80	149.80	Sand	52	43	0.8	47	10.230	3.319	1.067	3.542	5.00	62.83	223
6	149.80	144.80	Sand	99	46	0.8	96	18.110	3.944	1.493	5.889	5.00	62.83	370

Total Side Resistance in Cohesionless Soil = 879

Side Resistance in Weathered and Hard Rock

$R_s = (A_s)(q_s)$ *AASHTO Eqn. 10.8.3.5-3*

q_s = unit side resistance for weathered or hard rock layer (ksf)

For weathered rock layers or hard rock layers with a GSI < 30

= 8 ksf *NCDOT Policy*

For drilled piers socketed into hard rock

$$= \left(C \sqrt{\frac{q_u}{p_a}} \right) p_a$$ *AASHTO Eqn. 10.8.3.5.4b-1*

C = regression coefficent taken as 1.0 for normal rock sockets (see AASHTO C10.8.3.5.4b-1 for details)

For fractured rock that caves and cannot be drilled without artificial support

$$= \left(0.65 \alpha_E \sqrt{\frac{q_u}{p_a}} \right) p_a$$ *AASHTO Eqn. 10.8.3.5.4b-2*

a_E = reduction factor to account for jointing in rock (from AASHTO Table 10.8.3.5.4b-1)

RQD (%)	Joint Modificaiton Factor, α_E	
	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

q_u = Uniaxial Compressive Strength of Intact Rock (ksf) $\leq f'_c$

f'_c = 28 day Compressive Strength of Concrete (4.5 ksi = 648 ksf)

p_a = atmospheric pressure (2.12 ksf)

A_s = area of drilled pier side resistance (ft^2)

= $(\pi)(B)(\Delta z)$

B = diameter of drilled pier (subtract 2 inches to account for possible reduction of drilled pier in rock)

= (48 inches - 2 inches) / 12 inches per ft = 3.83 ft

Δz = effective thickness of the soil layer (ft)

Layer No.	Rock Type	Layer Elevations		AASHTO Equation and Rock Joint Condition to use	RQD (%)	α_E	q_u (ksf)	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
		Top (ft)	Bottom (ft)								
7	Weathered Rock	144.80	125.00	N/A	N/A	N/A	N/A	8.000	19.80	238.45	1908

Total Side Resistance in Weathered and Hard Rock = 1,908

Note: *Hard Rock Layers with a poor surface quality (GSI < 30) will be modeled as weathered rock with an N_{60} = 600 blows/ft*

Tip Resistance in Weathered Rock

$R_p = (q_p)(A_p)$ *AASHTO Eqn. 10.8.3.5-2*

q_p = unit tip resistance (ksf)

$= (N_C)(S_U)$ *AASHTO Eqn. 10.8.3.5.1c-1*

N_C = cohesion bearing capacity factor *N_c = 9 for Weathered Rock per NCDOT Policy*

S_U = undrained shear strength of material below drilled pier tip (ksf)

$= 0.23(OCR)^{0.8}(\rho_a)$ *Mayne and Harris, 1993 (after Jamiolkowski, et al., 1985)*

$OCR = (\sigma'_p)/(\sigma'_{vo})$

$\sigma'_p = 0.47(N_{60})^{0.8}(\rho_a)$ *AASHTO Eqn. 10.8.3.5.2b-4*

N_{60} = SPT-N value corrected for hammer efficiency *N_{60} limited to 600 blows/ft*

ρ_a = atmospheric pressure (2.12 ksf)

σ'_{vo} = effective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46

A_p = area of drilled pier tip resistance (ft^2)

$= (\pi)(B^2)/4$

B = diameter of drilled pier (subtract 2 inches to account for possible reduction of drilled pier in rock)
(48 inches - 2 inches) / 12 inches per ft = 3.83 ft

Tip Elevation (ft)	N_C	N_{60}	σ'_p (ksf)	σ'_{vo} (ksf)	OCR	S_U (ksf)	q_p (ksf)	A_p (ft^2)	R_p (kips)
125.00	9	203	70	6.831	10.232	10.096	90.864	11.54	1,049

Summary of Nominal and Factored Side Resistance

Material Type	Nominal Side Resistance (kips)	Resistance Factor from AASHTO Table 10.5.5.2.4-1	Factored Side Resistance (kips)	Percentage of Side Resistance produced by Material Type
Cohesive Soil	25	0.45	11	0.9%
Cohesionless Soil	879	0.55	483	31.3%
CohesiveIGM	0	0.60	0	0.0%
Weathered Rock	1,908	0.60	1,145	67.9%
Hard Rock	0	0.55	0	0.0%
Total	**2,812**		**1,639**	**100%**

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance = 1,049 kips
Tip Resistance Factor = 0.55
Total Factored Tip Resistance = 577 kips

the drilled pier is bearing on Weathered Rock for Weathered Rock (use IGM), see AASHTO Table 10.5.5.2.4-1.

Required Factored Resistance

$R_{req} = P_r + \gamma_{DC}(W_{Column} + W_{Pier}) - \gamma_{WA}W_{Water} - \gamma_{DC}W_{Soil/Rock} \geq P_r$ *Required Factored Resistance*

P_r = 1,532 kips *Maximum Factored Axial Load Reported by Structure Design*
γ_{DC} = 1.25 *Factor for Permanent Dead Loads, from AASHTO Table 3.4.1-2*
γ_{WA} = 1.00 *Factor for Water Loads, from AASHTO Table 3.4.1-1*

$W_{Column} = (A_{Column})(L_{Column})(\gamma_c)$ *Unfactored Weight of Column*

A_{Column} = 9.62 ft^2 *Area of Column*
L_{Column} = 15 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 22 kips

$W_{Pier} = (A_{Pier})(L_{Pier})(\gamma_c)$ *Unfactored Weight of Drilled Pier*

A_{Pier} = 12.57 ft^2 *Area of Drilled Pier*
L_{Pier} = 55.46 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 105 kips

$W_{Water} = (A_{Pier})(z_w)(\gamma_w)$ *Unfactored Weight of Water Displaced by Drilled Pier*

A_{Pier} = 12.57 ft^2 *Area of Drilled Pier*
z_w = 0 ft *Depth from water surface to the drilled pier tip*
γ_w = 0.0624 kcf *Unit Weight of Water*

= 0 kips

$W_{Soil/Rock} = (A_{Pier})(\sigma'_{vo})$ *Unfactored Effective Weight of Soil / Rock that will be displaced*

A_{Pier} = 12.57 ft^2 *Area of Drilled Pier*
σ'_{vo} = 6.831 ksf *ffective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46*

$W_{Soil/Rock}$ = 86 kips

R_{req} = 1,532 kips + 1.25(22 kips + 105 kips) -1.00(0 kips) -1.25(86 kips) = 1,583 kips = 79.5T round up to 79T used for resistance

Load Transfer of Side and Tip Resistance

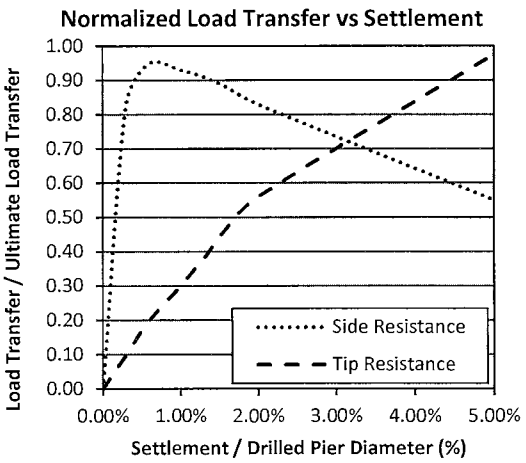
The majority of the side resistance is produced by Weathered Rock , which is treated as a cohesive material for Load transfer. Use AASHTO Figure 10.8.2.2.2.1 to predict the normalized load transfer for side resistance.

The drilled pier tip is bearing on Weathered Rock, which is treated as a cohesive material for load transfer. Use AASHTO Figure 10.8.2.2.2.2 to predict the normalized load transfer for tip resistance.

Load Transfer of Side and Tip Resistance (continued)

Δz / D (%)	Normalized Side Transfer R_{sd} / R_s AASHTO Figure 10.8.2.2.2.1	Normalized Tip Transfer R_{pd} / R_p AASHTO Figure 10.8.2.2.2.2
0.0	0.00	0.00
0.3	0.83	0.10
0.6	0.95	0.20
1.0	0.93	0.30
1.3	0.91	0.38
1.6	0.88	0.47
2.0	0.83	0.56
5.0	0.55	0.98

$\Delta z / D$ = total settlement / drilled pier diameter
R_{sd} / R_s = developed side resistance / total nominal side resistance
R_{pd} / R_p = developed tip resistance / total nominal tip resistance



Developed Factored Resistance, (R_{rd})

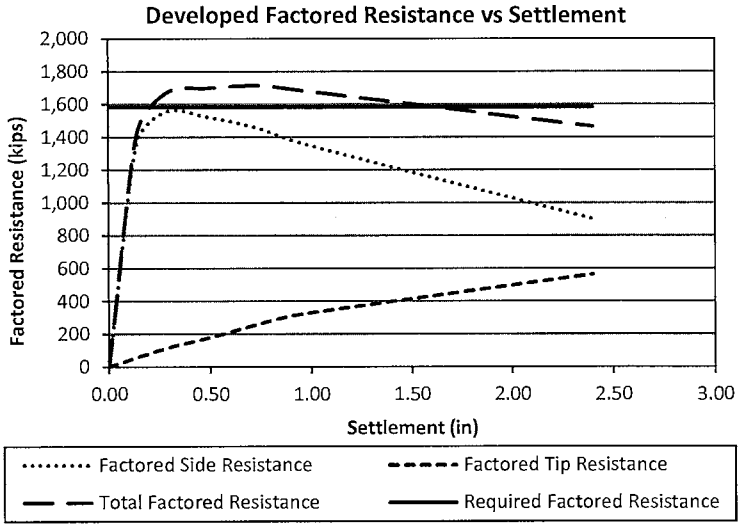
Use the normalized load transfer values along with the total factored side and tip resistance values to calculate the developed side and tip resistance at different vertical displacements. The developed factored resistance must be greater than or equal to the required axial resistance, ($R_{rd} \geq R_{req}$).

$\frac{\Delta z}{D}$	D (in)	Δz (in)	$\varphi_{qs}R_s$ (kips)	$\frac{R_{sd}}{R_s}$	$\varphi_{qs}R_{sd}$ (kips)	$\varphi_{qp}R_p$ (kips)	$\frac{R_{pd}}{R_p}$	$\varphi_{qp}R_{pd}$ (kips)	R_{rd} (kips)	R_{req} (kips)	Axial Resistance Requirement Satisfied
0.3%	48	0.14	1,639	0.83	1,360	577	0.10	58	1,418	1,583	NO
0.6%	**48**	**0.29**	**1,639**	**0.95**	**1,557**	**577**	**0.20**	**116**	**1,673**	**1,583**	**YES**
1.0%	48	0.48	1,639	0.93	1,524	577	0.30	173	1,697	1,583	YES
1.3%	48	0.62	1,639	0.91	1,491	577	0.38	219	1,710	1,583	YES
1.6%	48	0.77	1,639	0.88	1,442	577	0.47	271	1,713	1,583	YES
2.0%	48	0.96	1,639	0.83	1,360	577	0.56	323	1,683	1,583	YES
5.0%	48	2.40	1,639	0.55	901	577	0.98	563	1,464	1,583	NO

$\varphi_{qs}R_s$ = total factored side resistance
$\varphi_{qp}R_p$ = total factored tip resistance
$\varphi_{qs}R_{sd}$ = developed factored side resistance
= $(R_{sd}/R_s)(\varphi_{qs}R_s)$
$\varphi_{qp}R_{pd}$ = developed factored tip resistance
= $(R_{pd}/R_p)(\varphi_{qp}R_p)$

The axial resistance requirement is satisfied at an estimated vertical displacement of 0.29 inches.

Developed Factored Side Resistance = 1,557 kips
Developed Factored Tip Resistance = 116 kips
Developed Factored Total Resistance = 1,673 kips



Required Tip Resistance

q_{req} = required tip resistance (rounded up to the nearest 10 ksf or 5 tsf)

$$= \frac{\frac{R_{req} - \varphi_{qs} R_{sd}}{A_T}}{\varphi_{qp}} \leq q_p$$

NCDOT policy

R_r = required factored geotechnical resistance (kips)
$\varphi_{qs}R_{sd}$ = factored developed side resistance (kips)
A_T = area of drilled pier tip (ft^2)
φ_{qp} = tip resistance factor
q_p = unit tip resistance (ksf)

R_{req} (kips)	$\varphi_{qs}R_{sd}$ (kips)	A_{Tip} (ft^2)	φ_{qp}	q_p (ksf)	q_{req} (ksf)
1,583	1,557	11.54	0.55	91	10

10 ksf tip minimum
say 20 tsf tip resistance
req'd for Electric
control purpose

FROEHLING & ROBERTSON, INC.

Engineering • Environmental • Geotechnical

SINCE 1881

SHEET NO. 1 OF 1

JOB I-5786 Bridge 111 Bizzell Grove DATE 5/9/17

COMPUTATIONS FOR Lateral B1-A BY C. Wang CHKD

Use boring B1-A

Elev (ft)		Depth (ft)
195.5'	BOC = ±195.5' per WEI	0
	42" φ column	
180.5	Bottom of column = ±180.5 per WEI	15.0'
	48" φ pier ε = 0.003	
174.8'	① CLAY $\bar{N}$=9 N_{60}=12 γ=58 C=1200 K=500	20.7'
164.8	② SAND $\bar{N}$=1 N_{60}=1 γ=48 K=20 φ=27°	30.7
159.8'	③ SAND $\bar{N}$=9 N_{60}=12 γ=58 K=60 φ=30°	35.7
154.8'	④ SAND (SILT model as Sand) $\bar{N}$=22 N_{60}=30 γ=63 K=60 φ=36°	40.7'
149.8'	⑤ SAND $\bar{N}$=35 N_{60}=47 γ=63 K=125 φ=40°	45.7'
144.8	⑥ SAND $\bar{N}$=71 γ=63 K=125 φ=41°	50.7
134.8'	⑦ WR γ=100 ε=0.002 K=2000	60.7'

Model max long. shear case as free head condition
shear = 20,700 lbs, axial = 892,600 lbs, moment = 501,600 lbs·in
y = 0.46", 1st neg = 35.0' (EL 160.5'), max neg = 41.3' (EL 154.2')

Model max trans. shear case as fixed head condition
shear = 35,600 lbs, axial = 1,052,000 lbs, slope = 0
y = 0.24", 1st neg = 40.3' (EL 155.2'), max neg = 45.1' (EL 150.4')

Lateral {
say POF = EL 155.0'
Min tip: 1.5B below 1st neg = EL 154.3
1.0B below max neg = EL 152.2
}

POF EL = 155.0'
Min Tip EL = 125.0'

from axial, Min tip EL = 125.0'

GEOTECHNICAL BORING REPORT
BORE LOG

WBS N/A	**TIP** I-5786	**COUNTY** JOHNSTON	**GEOLOGIST** P. Fahey	
SITE DESCRIPTION Bridge No. 111 on SR 2141 (Bizzell Grove Church Road) over I-95				**GROUND WTR (ft)**
BORING NO. B1-A	**STATION** 20+17	**OFFSET** 10 ft LT	**ALIGNMENT** -Y4-	**0 HR.** NM
COLLAR ELEV. 181.8 ft	**TOTAL DEPTH** 58.6 ft	**NORTHING** 660,097	**EASTING** 2,241,649	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R4637 CME-75 81% 07/18/2015		**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic	
DRILLER S. Sequist	**START DATE** 04/12/17	**COMP. DATE** 04/12/17	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION	ELEV. (ft)	DEPTH (ft)
						Bottom of Col = ± 1955				1955		
185												
						Bottom of Column = ± 180.5 per MEZ	15			1805		
180											181.8	0.0
	178.3	3.5	3	3	6	9 N=9	1	M		ROADWAY EMBANKMENT Orange and Gray, Fine Sandy CLAY (A-6)		
175							20.7				174.8	7.0
	173.3	8.5	1	1	2	3 N=1		Sat.		COASTAL PLAIN Brownish Gray and Tan-White, Clayey Fine SAND (A-2-6)		
170							2					
	168.3	13.5	WOH	WOH	WOH	0.		Sat.				
165							30.7				164.8	17.0
	163.3	18.5	3	4	5	9 N=9	3	Sat.		Brownish Yellow, Silty Fine SAND (A-2-4)		
160							35.7				159.8	22.0
	158.3	23.5	6	9	13	22 N=22	4	Sat.		RESIDUAL Gray, Clayey SILT (A-5)		
155							40.7				154.8	
	153.3	28.5	13	12	23	35 N=35	5	M				
150							45.7				149.8	
	148.3	33.5	10	23	48	71 N=71	6	M				
145							50.7				144.8	37.0
	143.3	38.5	100/0.5			100/0.5				WEATHERED ROCK Gray (META-ARGILLITE)		
140							7					
	138.3	43.5	40	60/0.3		100/0.8						
135												
	133.3	48.5	100/0.3			100/0.3						
130												
	128.3	53.5	100/0.3			100/0.3						
125												
	123.3	58.5	60/0.1			60/0.1					123.3	58.5
											123.2	58.6
										CRYSTALLINE ROCK (META-ARGILLITE) Boring Terminated with Standard Penetration Test Refusal at Elevation 123.2 ft in Crystalline Rock (META-ARGILLITE)		

NCDOT BORE SINGLE 15786_GEO_BH_BRDG111.GPJ NC_DOT.GDT 5/5/17

LPile Plus for Windows, Version 2013-07.001

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

This copy of LPile is licensed to:

Branch User
Froehling & Robertson, Inc.

Serial Number of Security Device: 293783516
Company Name Stored in Security Device: Froehling & Robertson, Inc.

Files Used for Analysis

Path to file locations: F:\Projects 66U\66U-0390 (WEI-I-5786 Bridges 108 & 111 Johnston Co)\NON_CADD\Foundation Recs\Bridge 111 Bizzel Grove\LPILE\
Name of input data file: B1-A.lp7d
Name of output report file: B1-A.lp7o
Name of plot output file: B1-A.lp7p
Name of runtime messeage file: B1-A.lp7r

Date and Time of Analysis

Date: May 11, 2017 Time: 15:35:49

Problem Title

Project Name: Bridge 111 Bizzel Grove

Job Number: 66U-0390

Client: Wetherill Engineering

Engineer: C. Wang

Description: Bent 1 B1-A

Program Options

Engineering Units of Input Data and Computations:
- Engineering units are US Customary Units: pounds, inches, feet

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
- Static loading specified

Computational Options:
- Use unfactored loads in computations
- No computation of pile-head foundation stiffness matrix
- Compute pile response under loading and nonlinear bending properties of pile (if nonlinear properties are specified)
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Input Data Options:
- Analysis does not use p-y modification factors (individual pile or shaft only)
- Analysis assumes zero shear resistance at the pile tip
- Analysis assumes no loading by soil movements acting on pile

Output Options:
- No p-y curves to be computed and reported for user-specified depths
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1

Pile Structural Properties and Geometry

Total number of pile sections = 2

Total length of pile = 53.00 ft

Depth of ground surface below top of pile = 15.00 ft

Pile diameter values used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	42.0000000
2	15.000000	42.0000000
3	15.000000	48.0000000
4	53.000000	48.0000000

Input Structural Properties:

Pile Section No. 1:

- Section Type = Elastic Pile
- Cross-sectional Shape = Circular
- Section Length = 15.00000 ft
- Top Width = 42.00000 in
- Bottom Width = 42.00000 in
- Top Area = 1385.44236 Sq. in
- Bottom Area = 1385.44236 Sq. in

Moment of Inertia at Top	=	152745. in^4
Moment of Inertia at Bottom	=	152745. in^4
Elastic Modulus	=	3122019. lbs/in^2

Pile Section No. 2:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	38.00000 ft
Top Width	=	48.00000 in
Bottom Width	=	48.00000 in
Top Area	=	1809.55737 Sq. in
Bottom Area	=	1809.55737 Sq. in
Moment of Inertia at Top	=	260576. in^4
Moment of Inertia at Bottom	=	260576. in^4
Elastic Modulus	=	3823676. lbs/in^2

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 7 layers

Layer 1 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	15.00000 ft
Distance from top of pile to bottom of layer	=	20.70000 ft
Effective unit weight at top of layer	=	58.00000 pcf
Effective unit weight at bottom of layer	=	58.00000 pcf
Undrained cohesion at top of layer	=	1200.00000 psf
Undrained cohesion at bottom of layer	=	1200.00000 psf
Epsilon-50 at top of layer	=	0.00700
Epsilon-50 at bottom of layer	=	0.00700
Subgrade k at top of layer	=	500.00000 pci
Subgrade k at bottom of layer	=	500.00000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	20.70000 ft
Distance from top of pile to bottom of layer	=	30.70000 ft
Effective unit weight at top of layer	=	43.00000 pcf
Effective unit weight at bottom of layer	=	43.00000 pcf
Friction angle at top of layer	=	27.00000 deg.
Friction angle at bottom of layer	=	27.00000 deg.
Subgrade k at top of layer	=	20.00000 pci
Subgrade k at bottom of layer	=	20.00000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	30.70000 ft
Distance from top of pile to bottom of layer	=	35.70000 ft
Effective unit weight at top of layer	=	58.00000 pcf
Effective unit weight at bottom of layer	=	58.00000 pcf

Friction angle at top of layer	=	30.00000 deg.
Friction angle at bottom of layer	=	30.00000 deg.
Subgrade k at top of layer	=	60.00000 pci
Subgrade k at bottom of layer	=	60.00000 pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	35.70000 ft
Distance from top of pile to bottom of layer	=	40.70000 ft
Effective unit weight at top of layer	=	63.00000 pcf
Effective unit weight at bottom of layer	=	63.00000 pcf
Friction angle at top of layer	=	36.00000 deg.
Friction angle at bottom of layer	=	36.00000 deg.
Subgrade k at top of layer	=	60.00000 pci
Subgrade k at bottom of layer	=	60.00000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	40.70000 ft
Distance from top of pile to bottom of layer	=	45.70000 ft
Effective unit weight at top of layer	=	63.00000 pcf
Effective unit weight at bottom of layer	=	63.00000 pcf
Friction angle at top of layer	=	40.00000 deg.
Friction angle at bottom of layer	=	40.00000 deg.
Subgrade k at top of layer	=	125.00000 pci
Subgrade k at bottom of layer	=	125.00000 pci

Layer 6 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	45.70000 ft
Distance from top of pile to bottom of layer	=	50.70000 ft
Effective unit weight at top of layer	=	63.00000 pcf
Effective unit weight at bottom of layer	=	63.00000 pcf
Friction angle at top of layer	=	41.00000 deg.
Friction angle at bottom of layer	=	41.00000 deg.
Subgrade k at top of layer	=	125.00000 pci
Subgrade k at bottom of layer	=	125.00000 pci

Layer 7 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	50.70000 ft
Distance from top of pile to bottom of layer	=	60.70000 ft
Effective unit weight at top of layer	=	100.00000 pcf
Effective unit weight at bottom of layer	=	100.00000 pcf
Undrained cohesion at top of layer	=	5000.00000 psf
Undrained cohesion at bottom of layer	=	5000.00000 psf
Epsilon-50 at top of layer	=	0.00400
Epsilon-50 at bottom of layer	=	0.00400
Subgrade k at top of layer	=	2000.00000 pci
Subgrade k at bottom of layer	=	2000.00000 pci

(Depth of lowest soil layer extends 7.70 ft below pile tip)

Summary of Soil Properties

Layer	Soil Type	Layer Depth	Effective Unit Wt.	Undrained Cohesion	Angle of Friction	Strain Factor	kpy

Num.	(p-y Curve Criteria)	ft	pcf	psf	deg.	Epsilon 50	pci
1	Stiff Clay with Free Water	15.000	58.000	1200.000	--	0.00700	500.000
		20.700	58.000	1200.000	--	0.00700	500.000
2	Sand (Reese, et al.)	20.700	43.000	--	27.000	--	20.000
		30.700	43.000	--	27.000	--	20.000
3	Sand (Reese, et al.)	30.700	58.000	--	30.000	--	60.000
		35.700	58.000	--	30.000	--	60.000
4	Sand (Reese, et al.)	35.700	63.000	--	36.000	--	60.000
		40.700	63.000	--	36.000	--	60.000
5	Sand (Reese, et al.)	40.700	63.000	--	40.000	--	125.000
		45.700	63.000	--	40.000	--	125.000
6	Sand (Reese, et al.)	45.700	63.000	--	41.000	--	125.000
		50.700	63.000	--	41.000	--	125.000
7	Stiff Clay with Free Water	50.700	100.000	5000.000	--	0.00400	2000.000
		60.700	100.000	5000.000	--	0.00400	2000.000

Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 20700. lbs	M = 501600. in-lbs	892600.	No
2	2	V = 35600. lbs	S = 0.0000 in/in	1057000.	No

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

---

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 20700.0 lbs
Applied moment at pile head = 501600.0 in-lbs
Axial thrust load on pile head = 892600.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4554	501600.	20700.	-0.002103	713.2327	4.769E+11	0.000	0.000	0.000
0.530	0.4420	645170.	20700.	-0.002095	732.9714	4.769E+11	0.000	0.000	0.000
1.060	0.4287	788692.	20700.	-0.002086	752.7033	4.769E+11	0.000	0.000	0.000
1.590	0.4155	932154.	20700.	-0.002074	772.4270	4.769E+11	0.000	0.000	0.000
2.120	0.4023	1075545.	20700.	-0.002061	792.1411	4.769E+11	0.000	0.000	0.000
2.650	0.3893	1218855.	20700.	-0.002045	811.8439	4.769E+11	0.000	0.000	0.000
3.180	0.3763	1362073.	20700.	-0.002028	831.5340	4.769E+11	0.000	0.000	0.000
3.710	0.3635	1505187.	20700.	-0.002009	851.2100	4.769E+11	0.000	0.000	0.000
4.240	0.3508	1648188.	20700.	-0.001988	870.8703	4.769E+11	0.000	0.000	0.000
4.770	0.3382	1791064.	20700.	-0.001965	890.5134	4.769E+11	0.000	0.000	0.000
5.300	0.3258	1933804.	20700.	-0.001940	910.1379	4.769E+11	0.000	0.000	0.000
5.830	0.3135	2076397.	20700.	-0.001914	929.7422	4.769E+11	0.000	0.000	0.000
6.360	0.3014	2218834.	20700.	-0.001885	949.3250	4.769E+11	0.000	0.000	0.000
6.890	0.2895	2361102.	20700.	-0.001854	968.8846	4.769E+11	0.000	0.000	0.000
7.420	0.2778	2503192.	20700.	-0.001822	988.4197	4.769E+11	0.000	0.000	0.000
7.950	0.2664	2645092.	20700.	-0.001788	1007.9287	4.769E+11	0.000	0.000	0.000
8.480	0.2551	2786792.	20700.	-0.001751	1027.4102	4.769E+11	0.000	0.000	0.000
9.010	0.2441	2928281.	20700.	-0.001713	1046.8627	4.769E+11	0.000	0.000	0.000
9.540	0.2333	3069549.	20700.	-0.001673	1066.2847	4.769E+11	0.000	0.000	0.000
10.070	0.2228	3210583.	20700.	-0.001631	1085.6747	4.769E+11	0.000	0.000	0.000
10.600	0.2126	3351375.	20700.	-0.001588	1105.0313	4.769E+11	0.000	0.000	0.000
11.130	0.2026	3491913.	20700.	-0.001542	1124.3530	4.769E+11	0.000	0.000	0.000
11.660	0.1930	3632187.	20700.	-0.001494	1143.6384	4.769E+11	0.000	0.000	0.000
12.190	0.1836	3772186.	20700.	-0.001445	1162.8860	4.769E+11	0.000	0.000	0.000
12.720	0.1746	3911899.	20700.	-0.001394	1182.0943	4.769E+11	0.000	0.000	0.000
13.250	0.1659	4051315.	20700.	-0.001341	1201.2619	4.769E+11	0.000	0.000	0.000
13.780	0.1575	4190426.	20700.	-0.001286	1220.3873	4.769E+11	0.000	0.000	0.000
14.310	0.1495	4329218.	20700.	-0.001229	1239.4691	4.769E+11	0.000	0.000	0.000
14.840	0.1419	4467684.	20700.	-0.001170	1258.5059	4.769E+11	0.000	0.000	0.000
15.370	0.1346	4605810.	19855.	-0.001126	917.4813	9.964E+11	-265.7114	12552.	0.000
15.900	0.1276	4733022.	17998.	-0.001096	929.1980	9.964E+11	-318.4155	15876.	0.000
16.430	0.1207	4847183.	15821.	-0.001065	939.7126	9.964E+11	-366.1006	19293.	0.000
16.960	0.1140	4946360.	13367.	-0.001034	948.8471	9.964E+11	-405.5939	22626.	0.000
17.490	0.1075	5028951.	10680.	-0.001002	956.4540	9.964E+11	-439.2286	25978.	0.000
18.020	0.1013	5093593.	7788.2220	-0.000970	962.4078	9.964E+11	-470.2075	29533.	0.000

	18.550	0.0952	5139031.	4707.5718	-0.000937	966.5928	9.964E+11	-498.5504	33309.	0.000
	19.080	0.0893	5164116.	1454.9704	-0.000905	968.9033	9.964E+11	-524.2802	37325.	0.000
	19.610	0.0837	5167808.	-1953.0412	-0.000872	969.2433	9.964E+11	-547.4216	41603.	0.000
	20.140	0.0782	5149169.	-5500.0839	-0.000839	967.5266	9.964E+11	-568.0007	46167.	0.000
	20.670	0.0730	5107368.	-9169.9448	-0.000806	963.6766	9.964E+11	-586.0437	51044.	0.000
	21.200	0.0680	5041677.	-11212.	-0.000773	957.6262	9.964E+11	-56.0989	5247.0518	0.000
	21.730	0.0632	4973534.	-11582.	-0.000742	951.3500	9.964E+11	-60.1614	6056.0438	0.000
	22.260	0.0586	4902778.	-11974.	-0.000710	944.8331	9.964E+11	-63.2164	6865.0358	0.000
	22.790	0.0541	4829286.	-12383.	-0.000679	938.0642	9.964E+11	-65.3375	7674.0278	0.000
	23.320	0.0499	4752977.	-12802.	-0.000648	931.0359	9.964E+11	-66.5966	8483.0198	0.000
	23.850	0.0459	4673802.	-13227.	-0.000618	923.7435	9.964E+11	-67.0640	9292.0118	0.000
	24.380	0.0421	4591744.	-13653.	-0.000589	916.1858	9.964E+11	-66.8083	10101.	0.000
	24.910	0.0384	4506818.	-14075.	-0.000560	908.3638	9.964E+11	-65.8961	10910.	0.000
	25.440	0.0349	4419063.	-14489.	-0.000531	900.2812	9.964E+11	-64.3923	11719.	0.000
	25.970	0.0317	4328543.	-14893.	-0.000503	891.9440	9.964E+11	-62.3596	12528.	0.000
	26.500	0.0285	4235344.	-15281.	-0.000476	883.3601	9.964E+11	-59.8588	13337.	0.000
	27.030	0.0256	4139571.	-15653.	-0.000449	874.5390	9.964E+11	-56.9485	14146.	0.000
	27.560	0.0228	4041343.	-16004.	-0.000423	865.4919	9.964E+11	-53.6853	14955.	0.000
	28.090	0.0202	3940798.	-16335.	-0.000398	856.2313	9.964E+11	-50.1232	15764.	0.000
	28.620	0.0178	3838083.	-16641.	-0.000373	846.7708	9.964E+11	-46.3144	16573.	0.000
	29.150	0.0155	3733354.	-16923.	-0.000349	837.1250	9.964E+11	-42.3085	17382.	0.000
	29.680	0.0133	3626780.	-17179.	-0.000325	827.3091	9.964E+11	-38.1528	18191.	0.000
	30.210	0.0113	3518530.	-17408.	-0.000302	817.3390	9.964E+11	-33.8921	19000.	0.000
	30.740	0.009494	3408783.	-17771.	-0.000280	807.2308	9.964E+11	-80.3936	53857.	0.000
	31.270	0.007781	3295659.	-18246.	-0.000259	796.8117	9.964E+11	-68.8572	56284.	0.000
	31.800	0.006202	3179631.	-18647.	-0.000238	786.1252	9.964E+11	-57.2487	58711.	0.000
	32.330	0.004751	3061173.	-18974.	-0.000218	775.2147	9.964E+11	-45.6758	61138.	0.000
	32.860	0.003426	2940755.	-19228.	-0.000199	764.1238	9.964E+11	-34.2384	63565.	0.000
	33.390	0.002219	2818847.	-19411.	-0.000181	752.8956	9.964E+11	-23.0279	65992.	0.000
	33.920	0.001127	2695904.	-19522.	-0.000163	741.5722	9.964E+11	-12.1277	68419.	0.000
	34.450	0.000145	2572374.	-19566.	-0.000146	730.1945	9.964E+11	-1.6133	70846.	0.000
1st neg	34.980	-0.000733	2448684.	-19544.	-0.000130	718.8023	9.964E+11	8.4478	73273.	0.000
	35.510	-0.001512	2325248.	-19460.	-0.000115	707.4334	9.964E+11	17.9958	75700.	0.000
	36.040	-0.002196	2202456.	-19335.	-0.000101	696.1238	9.964E+11	21.3149	61726.	0.000
	36.570	-0.002791	2080446.	-19178.	-8.689E-05	684.8862	9.964E+11	28.1533	64153.	0.000
	37.100	-0.003301	1959499.	-18979.	-7.400E-05	673.7466	9.964E+11	34.5616	66580.	0.000
	37.630	-0.003732	1839879.	-18740.	-6.187E-05	662.7292	9.964E+11	40.4962	69007.	0.000
	38.160	-0.004088	1721831.	-18465.	-5.050E-05	651.8565	9.964E+11	45.9207	71434.	0.000
	38.690	-0.004375	1605578.	-18157.	-3.988E-05	641.1492	9.964E+11	50.8052	73861.	0.000
	39.220	-0.004596	1491321.	-17821.	-3.000E-05	630.6258	9.964E+11	55.1263	76288.	0.000
	39.750	-0.004756	1379241.	-17458.	-2.084E-05	620.3028	9.964E+11	58.8669	78715.	0.000
	40.280	-0.004861	1269491.	-17074.	-1.238E-05	610.1944	9.964E+11	62.0155	81142.	0.000
max neg	40.810	-0.004914	1162204.	-16517.	-4.623E-06	600.3129	9.964E+11	113.1880	146499.	0.000
	41.340	-0.004920	1059454.	-15784.	2.467E-06	590.8492	9.964E+11	117.2330	151555.	0.000
	41.870	-0.004882	961407.	-15029.	8.917E-06	581.8188	9.964E+11	120.2282	156612.	0.000
	42.400	-0.004806	868188.	-14258.	1.476E-05	573.2330	9.964E+11	122.1720	161668.	0.000
	42.930	-0.004695	779880.	-13478.	2.002E-05	565.0995	9.964E+11	123.0707	166724.	0.000
	43.460	-0.004552	696521.	-12696.	2.473E-05	557.4219	9.964E+11	122.9371	171780.	0.000
	43.990	-0.004380	618110.	-11917.	2.892E-05	550.2000	9.964E+11	121.7896	176836.	0.000
	44.520	-0.004184	544603.	-11150.	3.264E-05	543.4297	9.964E+11	119.6518	181893.	0.000
	45.050	-0.003965	475917.	-10398.	3.589E-05	537.1034	9.964E+11	116.5518	186949.	0.000
	45.580	-0.003727	411927.	-9670.0477	3.873E-05	531.2097	9.964E+11	112.5208	192005.	0.000
	46.110	-0.003472	352474.	-8985.8037	4.117E-05	525.7339	9.964E+11	102.6502	188008.	0.000
	46.640	-0.003204	297160.	-8350.1337	4.324E-05	520.6393	9.964E+11	97.2460	193064.	0.000
	47.170	-0.002922	245769.	-7751.3894	4.497E-05	515.9060	9.964E+11	91.0384	198120.	0.000
	47.700	-0.002631	198052.	-7194.5604	4.639E-05	511.5111	9.964E+11	84.0651	203176.	0.000
	48.230	-0.002332	153728.	-6684.3897	4.751E-05	507.4287	9.964E+11	76.3659	208232.	0.000
	48.760	-0.002027	112487.	-6225.3636	4.836E-05	503.6302	9.964E+11	67.9819	213289.	0.000
	49.290	-0.001717	73992.	-5821.7018	4.896E-05	500.0847	9.964E+11	58.9557	218345.	0.000
	49.820	-0.001404	37879.	-5477.3487	4.931E-05	496.7586	9.964E+11	49.3314	223401.	0.000
	50.350	-0.001090	3760.1975	-5195.9643	4.945E-05	493.6161	9.964E+11	39.1543	228457.	0.000
	50.880	-0.000775	-28775.	-3218.6414	4.937E-05	495.9201	9.964E+11	582.6453	4778615.	0.000
	51.410	-0.000462	-37741.	64.5710	4.915E-05	496.7459	9.964E+11	449.8114	6191207.	0.000
	51.940	-0.000150	-28512.	2311.0343	4.894E-05	495.8958	9.964E+11	256.6236	10864783.	0.000
	52.470	0.000160	-8900.7504	2285.0702	4.882E-05	494.0896	9.964E+11	-264.7884	10494260.	0.000
min Tip	53.000	0.000471	0.000	0.000	4.879E-05	493.2698	9.964E+11	-453.7872	3065035.	0.000

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection	=	0.4553796 inches
Computed slope at pile head	=	-0.0021028 radians
Maximum bending moment	=	5167808. inch-lbs
Maximum shear force	=	20700. lbs
Depth of maximum bending moment	=	19.6100000 feet below pile head
Depth of maximum shear force	=	0.000000 feet below pile head
Number of iterations	=	12
Number of zero deflection points	=	2

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head	=	35600.0 lbs
Rotation of pile head	=	0.000E+00 radians
Axial load at pile head	=	1057000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.2381	-5380620.	35600.	0.000	1502.6825	4.769E+11	0.000	0.000	0.000
0.530	0.2378	-5153962.	35600.	-7.025E-05	1471.5207	4.769E+11	0.000	0.000	0.000
1.060	0.2372	-4926843.	35600.	-0.000137	1440.2954	4.769E+11	0.000	0.000	0.000
1.590	0.2361	-4699282.	35600.	-0.000202	1409.0094	4.769E+11	0.000	0.000	0.000
2.120	0.2346	-4471300.	35600.	-0.000263	1377.6655	4.769E+11	0.000	0.000	0.000
2.650	0.2328	-4242917.	35600.	-0.000321	1346.2665	4.769E+11	0.000	0.000	0.000
3.180	0.2305	-4014153.	35600.	-0.000376	1314.8151	4.769E+11	0.000	0.000	0.000
3.710	0.2280	-3785029.	35600.	-0.000428	1283.3143	4.769E+11	0.000	0.000	0.000
4.240	0.2251	-3555566.	35600.	-0.000477	1251.7668	4.769E+11	0.000	0.000	0.000
4.770	0.2219	-3325785.	35600.	-0.000523	1220.1755	4.769E+11	0.000	0.000	0.000
5.300	0.2184	-3095705.	35600.	-0.000566	1188.5432	4.769E+11	0.000	0.000	0.000
5.830	0.2147	-2865347.	35600.	-0.000605	1156.8727	4.769E+11	0.000	0.000	0.000
6.360	0.2107	-2634733.	35600.	-0.000642	1125.1669	4.769E+11	0.000	0.000	0.000
6.890	0.2065	-2403883.	35600.	-0.000676	1093.4287	4.769E+11	0.000	0.000	0.000
7.420	0.2021	-2172817.	35600.	-0.000706	1061.6608	4.769E+11	0.000	0.000	0.000
7.950	0.1976	-1941556.	35600.	-0.000734	1029.8661	4.769E+11	0.000	0.000	0.000
8.480	0.1928	-1710121.	35600.	-0.000758	998.0475	4.769E+11	0.000	0.000	0.000
9.010	0.1879	-1478532.	35600.	-0.000779	966.2078	4.769E+11	0.000	0.000	0.000
9.540	0.1829	-1246812.	35600.	-0.000797	934.3499	4.769E+11	0.000	0.000	0.000
10.070	0.1778	-1014979.	35600.	-0.000813	902.4766	4.769E+11	0.000	0.000	0.000
10.600	0.1726	-783055.	35600.	-0.000825	870.5908	4.769E+11	0.000	0.000	0.000
11.130	0.1673	-551061.	35600.	-0.000833	838.6954	4.769E+11	0.000	0.000	0.000
11.660	0.1620	-319018.	35600.	-0.000839	806.7931	4.769E+11	0.000	0.000	0.000
12.190	0.1566	-86946.	35600.	-0.000842	774.8870	4.769E+11	0.000	0.000	0.000
12.720	0.1513	145133.	35600.	-0.000842	782.8867	4.769E+11	0.000	0.000	0.000
13.250	0.1459	377200.	35600.	-0.000838	814.7922	4.769E+11	0.000	0.000	0.000
13.780	0.1406	609233.	35600.	-0.000831	846.6930	4.769E+11	0.000	0.000	0.000
14.310	0.1353	841211.	35600.	-0.000822	878.5863	4.769E+11	0.000	0.000	0.000
14.840	0.1301	1073114.	35600.	-0.000809	910.4692	4.769E+11	0.000	0.000	0.000
15.370	0.1250	1304920.	34770.	-0.000798	704.3085	9.964E+11	-260.9473	13273.	0.000
15.900	0.1200	1526116.	32947.	-0.000789	724.6814	9.964E+11	-312.3805	16557.	0.000
16.430	0.1150	1734610.	30811.	-0.000778	743.8845	9.964E+11	-359.4575	19878.	0.000
16.960	0.1101	1928490.	28400.	-0.000767	761.7415	9.964E+11	-398.5776	23025.	0.000
17.490	0.1053	2106164.	25751.	-0.000754	778.1060	9.964E+11	-434.5690	26258.	0.000

18.020	0.1005	2266171.	22879.	-0.000740	792.8431	9.964E+11	-468.4693	29644.	0.000
18.550	0.0958	2407130.	19798.	-0.000725	805.8260	9.964E+11	-500.2762	33195.	0.000
19.080	0.0913	2527751.	16522.	-0.000709	816.9356	9.964E+11	-529.9906	36924.	0.000
19.610	0.0868	2626825.	13063.	-0.000693	826.0606	9.964E+11	-557.6165	40843.	0.000
20.140	0.0825	2703230.	9435.8222	-0.000676	833.0979	9.964E+11	-583.1597	44968.	0.000
20.670	0.0782	2755932.	5652.2995	-0.000658	837.9519	9.964E+11	-606.6273	49314.	0.000
21.200	0.0741	2783977.	3528.8043	-0.000641	840.5349	9.964E+11	-61.1385	5247.0518	0.000
21.730	0.0701	2809430.	3122.1513	-0.000623	842.8792	9.964E+11	-66.7398	6056.0438	0.000
22.260	0.0662	2832062.	2682.7324	-0.000605	844.9637	9.964E+11	-71.4422	6865.0358	0.000
22.790	0.0624	2851683.	2216.1225	-0.000587	846.7709	9.964E+11	-75.2905	7674.0278	0.000
23.320	0.0587	2868137.	1727.6112	-0.000568	848.2863	9.964E+11	-78.3294	8483.0198	0.000
23.850	0.0552	2881299.	1222.2019	-0.000550	849.4986	9.964E+11	-80.6043	9292.0118	0.000
24.380	0.0517	2891077.	704.6103	-0.000531	850.3992	9.964E+11	-82.1603	10101.	0.000
24.910	0.0484	2897407.	179.2641	-0.000513	850.9822	9.964E+11	-83.0429	10910.	0.000
25.440	0.0452	2900254.	-349.6972	-0.000494	851.2445	9.964E+11	-83.2972	11719.	0.000
25.970	0.0421	2899608.	-878.4214	-0.000476	851.1849	9.964E+11	-82.9683	12528.	0.000
26.500	0.0392	2895480.	-1403.3426	-0.000457	850.8048	9.964E+11	-82.1012	13337.	0.000
27.030	0.0363	2887908.	-1921.1789	-0.000439	850.1073	9.964E+11	-80.7404	14146.	0.000
27.560	0.0336	2876946.	-2428.9308	-0.000421	849.0977	9.964E+11	-78.9300	14955.	0.000
28.090	0.0310	2862667.	-2923.8778	-0.000402	847.7826	9.964E+11	-76.7137	15764.	0.000
28.620	0.0284	2845163.	-3403.5751	-0.000384	846.1704	9.964E+11	-74.1345	16573.	0.000
29.150	0.0261	2824538.	-3865.8495	-0.000366	844.2707	9.964E+11	-71.2348	17382.	0.000
29.680	0.0238	2800910.	-4308.7954	-0.000348	842.0945	9.964E+11	-68.0563	18191.	0.000
30.210	0.0216	2774410.	-4730.7697	-0.000330	839.6537	9.964E+11	-64.6400	19000.	0.000
30.740	0.0196	2745175.	-5463.9494	-0.000313	836.9611	9.964E+11	-165.9197	53857.	0.000
31.270	0.0177	2709112.	-6488.5864	-0.000295	833.6396	9.964E+11	-156.2932	56284.	0.000
31.800	0.0158	2666610.	-7450.5371	-0.000278	829.7250	9.964E+11	-146.2070	58711.	0.000
32.330	0.0141	2618079.	-8347.2257	-0.000261	825.2552	9.964E+11	-135.7705	61138.	0.000
32.860	0.0125	2563945.	-9176.7552	-0.000245	820.2692	9.964E+11	-125.0878	63565.	0.000
33.390	0.0110	2504641.	-9937.8747	-0.000228	814.8071	9.964E+11	-114.2579	65992.	0.000
33.920	0.009609	2440607.	-10630.	-0.000213	808.9093	9.964E+11	-103.3740	68419.	0.000
34.450	0.008306	2372288.	-11253.	-0.000197	802.6169	9.964E+11	-92.5235	70846.	0.000
34.980	0.007099	2300124.	-11807.	-0.000182	795.9703	9.964E+11	-81.7879	73273.	0.000
35.510	0.005986	2224553.	-12294.	-0.000168	789.0100	9.964E+11	-71.2427	75700.	0.000
36.040	0.004962	2146004.	-12674.	-0.000154	781.7754	9.964E+11	-48.1604	61726.	0.000
36.570	0.004026	2065416.	-12956.	-0.000141	774.3529	9.964E+11	-40.6113	64153.	0.000
37.100	0.003174	1983097.	-13191.	-0.000128	766.7710	9.964E+11	-33.2255	66580.	0.000
37.630	0.002402	1899348.	-13379.	-0.000115	759.0574	9.964E+11	-26.0628	69007.	0.000
38.160	0.001707	1814463.	-13523.	-0.000103	751.2393	9.964E+11	-19.1771	71434.	0.000
38.690	0.001086	1728725.	-13624.	-9.212E-05	743.3425	9.964E+11	-12.6168	73861.	0.000
39.220	0.000536	1642403.	-13685.	-8.136E-05	735.3919	9.964E+11	-6.4243	76288.	0.000
39.750	5.144E-05	1555750.	-13707.	-7.116E-05	727.4108	9.964E+11	-0.6366	78715.	0.000
40.280	-0.000370	1469005.	-13694.	-6.150E-05	719.4213	9.964E+11	4.7147	81142.	0.000
40.810	-0.000731	1382387.	-13626.	-5.240E-05	711.4435	9.964E+11	16.8356	146499.	0.000
41.340	-0.001036	1296391.	-13494.	-4.385E-05	703.5230	9.964E+11	24.6900	151555.	0.000
41.870	-0.001289	1211338.	-13314.	-3.585E-05	695.6893	9.964E+11	31.7337	156612.	0.000
42.400	-0.001492	1127517.	-13093.	-2.839E-05	687.9690	9.964E+11	37.9289	161668.	0.000
42.930	-0.001650	1045181.	-12835.	-2.145E-05	680.3856	9.964E+11	43.2477	166724.	0.000
43.460	-0.001765	964550.	-12545.	-1.504E-05	672.9592	9.964E+11	47.6710	171780.	0.000
43.990	-0.001841	885806.	-12231.	-9.131E-06	665.7066	9.964E+11	51.1888	176836.	0.000
44.520	-0.001881	809094.	-11897.	-3.721E-06	658.6412	9.964E+11	53.7989	181893.	0.000
45.050	-0.001888	734524.	-11550.	1.205E-06	651.7730	9.964E+11	55.5073	186949.	0.000
45.580	-0.001866	662168.	-11194.	5.663E-06	645.1088	9.964E+11	56.3270	192005.	0.000
46.110	-0.001816	592061.	-10844.	9.666E-06	638.6517	9.964E+11	53.6923	188008.	0.000
46.640	-0.001743	524101.	-10505.	1.323E-05	632.3923	9.964E+11	52.9053	193064.	0.000
47.170	-0.001648	458259.	-10174.	1.636E-05	626.3280	9.964E+11	51.3386	198120.	0.000
47.700	-0.001535	394473.	-9854.4230	1.909E-05	620.4531	9.964E+11	49.0269	203176.	0.000
48.230	-0.001405	332654.	-9552.2039	2.141E-05	614.7594	9.964E+11	46.0106	208232.	0.000
48.760	-0.001262	272682.	-9271.2629	2.334E-05	609.2357	9.964E+11	42.3357	213289.	0.000
49.290	-0.001108	214410.	-9015.6254	2.489E-05	603.8687	9.964E+11	38.0535	218345.	0.000
49.820	-0.000946	157668.	-8788.9735	2.608E-05	598.6425	9.964E+11	33.2207	223401.	0.000
50.350	-0.000777	102263.	-8594.6114	2.691E-05	593.5396	9.964E+11	27.8994	228457.	0.000
50.880	-0.000603	47983.	-6871.4678	2.739E-05	588.5401	9.964E+11	513.9696	5416779.	0.000
51.410	-0.000428	14490.	-3860.0503	2.759E-05	585.4553	9.964E+11	433.0170	6430100.	0.000
51.940	-0.000253	-1487.9229	-1425.5691	2.763E-05	584.2578	9.964E+11	332.5432	8374895.	0.000
52.470	-7.684E-05	-4014.6367	146.1617	2.761E-05	584.4905	9.964E+11	161.7118	13384968.	0.000
53.000	9.870E-05	0.000	0.000	2.760E-05	584.1207	9.964E+11	-207.6746	6691272.	0.000

1st neg

max neg

min Tip

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 2:

Pile-head deflection	=	0.2380746	inches
Computed slope at pile head	=	0.000000	radians
Maximum bending moment	=	-5380620.	inch-lbs
Maximum shear force	=	35600.	lbs
Depth of maximum bending moment	=	0.000000	feet below pile head
Depth of maximum shear force	=	8.4800000	feet below pile head
Number of iterations	=	10	
Number of zero deflection points	=	2	

Summary of Pile Response(s)

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 20700.	M = 501600.	892600.	0.45537959	5167808.	20700.	-0.00210280
2	2	V = 35600.	S = 0.000	1057000.	0.23807461	-5380620.	35600.	-0.00000000

The analysis ended normally.

GEOTECHNICAL BORING REPORT
BORE LOG

WBS N/A	**TIP** I-5786	**COUNTY** JOHNSTON	**GEOLOGIST** P. Fahey	
SITE DESCRIPTION Bridge No. 111 on SR 2141 (Bizzell Grove Church Road) over I-95				**GROUND WTR (ft)**
BORING NO. B1-B	**STATION** 20+14	**OFFSET** 7 ft RT	**ALIGNMENT** -Y4-	**0 HR.** NM
COLLAR ELEV. 181.8 ft	**TOTAL DEPTH** 53.5 ft	**NORTHING** 660,089	**EASTING** 2,241,634	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R4637 CME-75 81% 07/18/2015		**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER S. Sequist	**START DATE** 04/11/17	**COMP. DATE** 04/11/17	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION	ELEV. (ft)	DEPTH (ft)
									GROUND SURFACE	181.8	0.0
	181.8	0.0	4	9	9		M		**ROADWAY EMBANKMENT** Grayish Brown and Red, Silty CLAY (A-7)	178.3	3.5
	178.3	3.5	2	1	2		Sat.		**COASTAL PLAIN** Light Pink, Clayey Fine to Coarse SAND (A-2-6)		
	173.3	8.5	WOH	WOH	WOH		Sat.			169.8	12.0
	168.3	13.5	2	3	7		Sat.		Brownish Yellow, Silty Fine SAND (A-2-4)	164.8	17.0
	163.3	18.5	7	10	14		M		**RESIDUAL** Gray, Clayey SILT (A-5)		
	158.3	23.5	10	26	42		M				
	153.3	28.5	21	26	36		M			149.8	32.0
	148.3	33.5	100/0.5						**WEATHERED ROCK** Gray (META-ARGILLITE)		
	143.3	38.5	100/0.3								
	138.3	43.5	100/0.4								
	133.3	48.5	100/0.3								
	128.3	53.5	60/0.0						Boring Terminated with Standard Penetration Test Refusal at Elevation 128.3 ft on Crystalline Rock (META-ARGILLITE)	128.3	53.5

NCDOT BORE SINGLE I5786_GEO_BH_BRDG111.GPJ NC_DOT.GDT 5/5/17

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
Drilled Pier Axial Resistance Worksheet

PROJECT: I-5786 COUNTY: Johnston
DESCRIPTION: Bridge 111 Bizzell Grove Church, bent 1 right
DESIGNED BY: CW DATE: 05/10/17 STATION: Bent 1
CHECKED BY: DATE: STR. NO.: PAGE: 1 OF 7

Elevations

Bottom of Cap (BOC) Elevation =	195.46	ft
Top of Pier/Bottom of Column Elevation =	180.46	ft
Natural Ground / Finished Grade Elevation =	181.55	ft
Groundwater Table (GWT) Elevation =	0.00	ft
Design Scour (DSE) Elevation =	181.55	ft
Amount of Contraction Scour (from BSR) =	0.00	ft
Is Permanent Casing Required?	○ Yes / Maybe ◉ No	
Bottom of Permanent Casing Elevation =	N/A	ft
Drilled Pier Tip Elevation =	130.00	ft

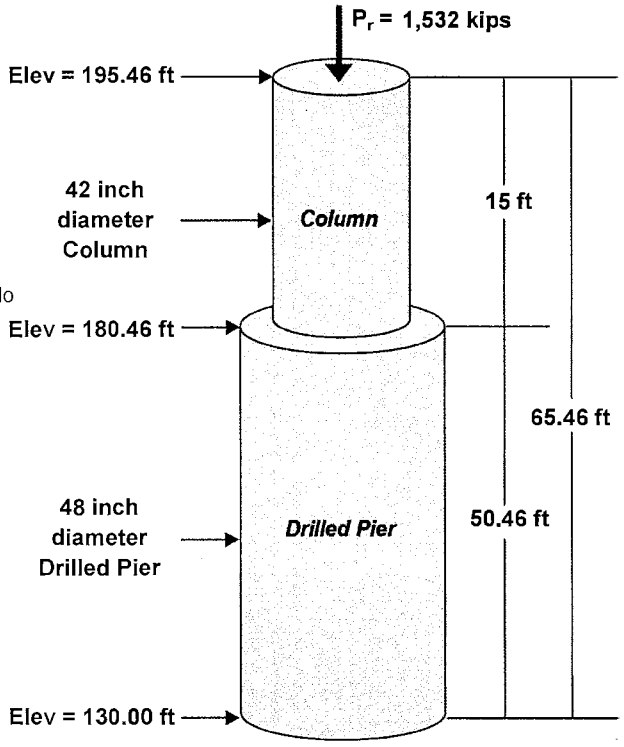


Figure shows typical drilled pier

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	1,532.0	kips
Number of Drilled Piers per Bent =	2	
Diameter of Column (d_{Column}) =	42	in
Diameter of Drilled Pier (d_{DP}) =	48	in
Unit Weight of Concrete (γ_c) =	0.150	kcf
Compressive Strength of Concrete (f'_c) =	4.500	ksi

Subsurface Information and Soil/Rock Layer Properties

internally calculate $N1_{60}$ values at midpoint of each layer ☑

Subsurface Boring Name / ID No. =	B1-B	
SPT Hammer Energy Efficiency Rating (ER) =	81	%
Top of Boring (Collar) Elevation =	181.80	ft
Depth to Groundwater Table (for actual boring) =	0.00	ft

Calculate GSI using RQD values : ☑
(Use if GSI is not shown on boring)

Layer No.	Material Description	Layer Elevations Top[1] (ft)	Layer Elevations Bottom (ft)	Total γ (kcf)	N (bpf)	N_{60} (bpf)	$N1_{60}$ (bpf)	RQD (%)	[2] GSI	q_u (ksf)	E_i (ksi)	v
1	Cohesionless Soil (Sand)	180.46	169.80	0.105	1	1	2					
2	Cohesionless Soil (Sand)	169.80	164.80	0.120	10	14	19					
3	Cohesionless Soil (Silty Sand)	164.80	159.80	0.125	24	32	40					
4	Cohesionless Soil (Silty Sand)	159.80	149.80	0.125	65	88	98					
5	Weathered Rock	149.80	130.00	0.130	100	135	127					
6												
7												
8												
TIP [3]	Weathered Rock	130.00	122.00	0.130	150	203	168					

Notes

1. Resistance from subsurface layers above the Bottom of Column Elevation, Drilled Pier Design Scour Elevation, and Permanent Casing Elevation will be ignored.
2. Hard rock layers with poor or very poor quality rock mass (GSI < 30) will be modeled as weathered rock.
3. Input the subsurface information for the soil / rock at the base of the drilled pier to a distance of 2 pier diameters below the base of the drilled pier.

Correcting SPT Values for Hammer Efficiency and Overburden Pressure

SPT-N Value Corrected for Hammer Efficiency, (N_{60})

$N_{60} = (ER/60\%)(N)$ *AASHTO Eqn. 10.4.6.2.4-2*

N_{60} = SPT blow count corrected for hammer efficiency (blows/ft)

ER = hammer efficiency expressed as percent of theoretical free fall energy delivered by the hammer system actually used. If ER is not known, use 80% for automatic hammers and 60% for drop hammers.

N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for Overburden Pressure, (N1)

$N1 = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-1*

N1 = SPT blow count corrected for overburden pressure (blows/ft)

C_N = correction factor = $[0.77\log_{10}(40/\sigma'_v) < 2.0$

$\sigma'_v = \sigma_v - \mu$ = effective vertical stress at the depth of the SPT-N value (ksf)

σ_v = total vertical stress at the depth of the SPT-N value (ksf)

μ = total pore water pressure at the depth of the SPT-N value (ksf)

N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for both Overburden Pressure and Hammer Efficiency, ($N1_{60}$)

$N1_{60} = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-3*

Summary of Corrected N Values for Boring

Top of Boring (Collar) Elevation = 181.8 ft Depth to Groundwater Table = 0.0 ft

Hammer Efficiency (ER) = 81 % Unit Weight of Water = 0.0624 kcf

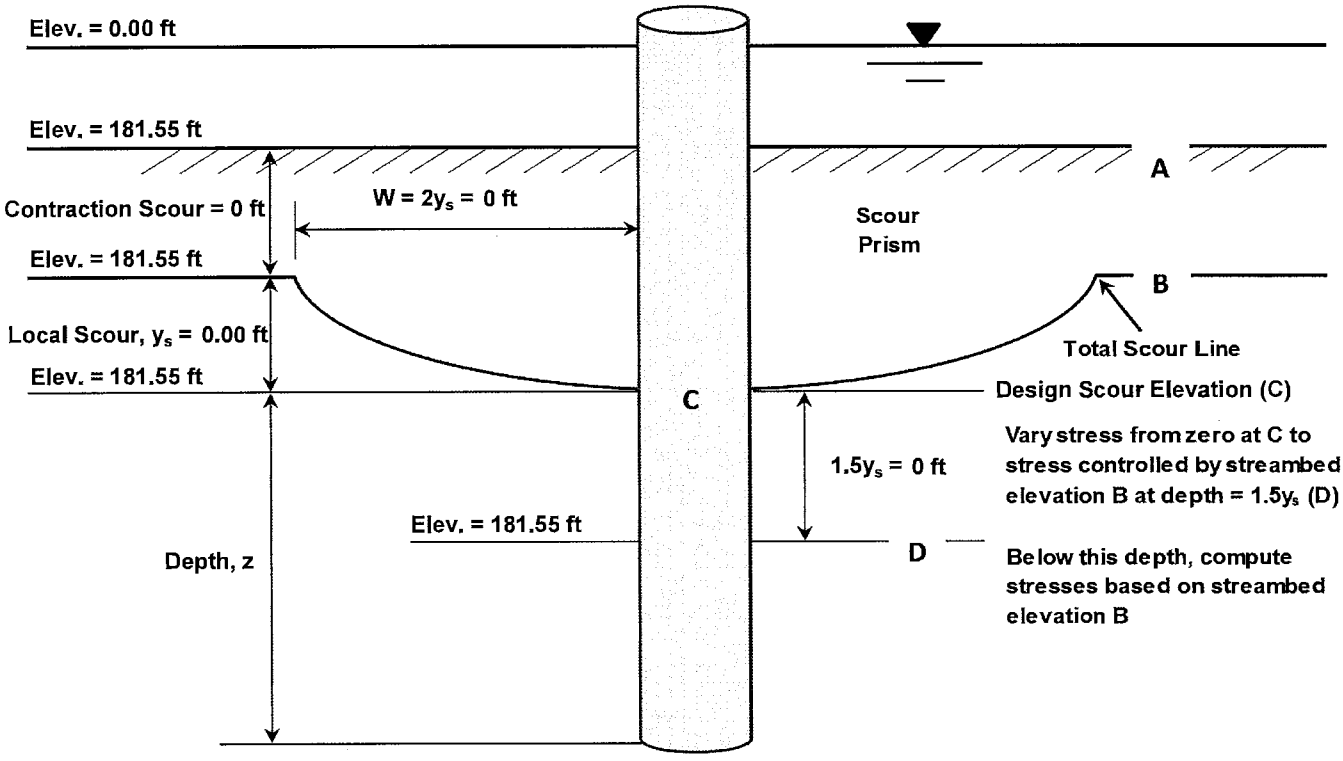
Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	σ_v at top (ksf)	Δz (ft)	Total γ (kcf)	σ_v at bottom (ksf)	σ_v at midpoint (ksf)	z_{water} (ft)	μ at midpoint (ksf)	σ'_{vo} at midpoint (ksf)	N (bpf)	N_{60} (bpf)	C_N	$N1_{60}$ (bpf)
1	180.46	169.80	0.161	10.66	0.105	1.280	0.720	6.67	0.416	0.304	1	1	1.63	2
2	169.80	164.80	1.280	5.00	0.120	1.880	1.580	14.50	0.905	0.675	10	14	1.37	19
3	164.80	159.80	1.880	5.00	0.125	2.505	2.193	19.50	1.217	0.976	24	32	1.24	40
4	159.80	149.80	2.505	10.00	0.125	3.755	3.130	27.00	1.685	1.445	65	88	1.11	98
5	149.80	130.00	3.755	19.80	0.130	6.329	5.042	41.90	2.615	2.428	100	135	0.94	127
6														
7														
8														
TIP	130.00	122.00	6.329	8.00	0.130	7.369	6.849	55.80	3.482	3.367	150	203	0.83	168

Calculating Design Stresses for Drilled Piers based on Scour Prism used in FHWA GEC 010

For analysis purposes, lower ground line to the contraction scour elevation (CSE) to account for contraction scour reported in the bridge survey report.

- If the CSE is lower than or equal to the design scour elevation (DSE), consider all scour as contraction scour and lower th ground line to the design scour elevation (DSE).
- If the CSE is higher than the DSE, consider the difference between the CSE and the DSE as local scour.

Groundwater Elevation =	0.00	ft	
Original Pre-Scour Streambed Elevation (Point A) =	181.55	ft	= *Natural Ground / Finished Grade Elevation*
Amount of Contraction Scour =	0.00	ft	
Streambed Elevation after General Scour (Point B) =	181.55	ft	= *Point A - Contraction Scour ≥ Design Scour Elevation*
Amount of Local Scour (y_s) =	0.00	ft	
ıp of the embedded length of the drilled pier (Point C) =	181.55	ft	= *Design Scour Elevation*
$1.5(y_s)$ =	0.00	ft	
evation corresponding to a depth of $1.5(y_s)$, (Point D) =	181.55	ft	= *Point C - 1.5y $_s$*



Adapted from FHWA GEC 010 Figure 13.18: Illustration of Scour Prism and Effects on Drilled Pier

Per FHWA GEC 010 page 13-46, vertical stress along any depth of the drilled pier can be estimated as follows;

1) At the top of the embedded drilled pier (Point C) the vertical stress is equal to zero.
2) At a depth of 1.5ys (Point D) or greater, assume the vertical stress is controlled by the streambed elevation (Point B).
3) Assume a linear variation in vertical stress from 0 at Point C to the vertical stress value controlled by the streambed at Point I

Soil Layer Profile and Effective Vertical Stress controlled by the streambed elevation (Point B)

- Assume the streambed elevation is equal to the contraction scour elevation (Elevation 181.55 ft).

Layer No.	Top (ft)	Midpoint (ft)	Bottom (ft)	σ_{v_top} (ksf)	$\mu_{\_top}$ (ksf)	σ'_{v_top} (ksf)	Δz (ft)	γ (kcf)	σ_{v_bottom} (ksf)	$\mu_{\_bottom}$ (ksf)	σ'_{v_bottom} (ksf)
0	181.55	181.01	180.46	0.000	0.000	0.000	1.09	0.120	0.131	0.000	0.131
1	180.46	175.13	169.80	0.131	0.000	0.131	10.66	0.105	1.250	0.000	1.250
2	169.80	167.30	164.80	1.250	0.000	1.250	5.00	0.120	1.850	0.000	1.850
3	164.80	162.30	159.80	1.850	0.000	1.850	5.00	0.125	2.475	0.000	2.475
4	159.80	154.80	149.80	2.475	0.000	2.475	10.00	0.125	3.725	0.000	3.725
5	149.80	139.90	130.00	3.725	0.000	3.725	19.80	0.130	6.299	0.000	6.299
6											
7											
8											

Variation in Vertical Stress from Point C to Point D

- Assume the top of the embedded drilled pier is equal to the design scour elevation.
- Vertical stress at elevation 181.55 ft (Point C) = 0 ksf
- Assume a linear variation in vertical stress from 0 ksf at elevation 181.55 ft (Point C) to a stress value controlled by the elevation 181.55 ft (Point B) at the depth Point D, elevation 181.55 ft.
- PointD lies within Soil Layer No.0

Point D Elevation (ft)	Top of Layer 0 (ft)	σ_v at 181.55 ft	Depth below Layer 0 (ft)	γ for Layer 2	μ at Point D (ksf)	σ'_v at Point D (ksf)
181.55	181.55	0.000	0.00	0.120	0.000	0.000

Point	Elevation (ft)	z (ft)	σ'_v (ksf)	Equation for linear variation over a depth of $1.5y_s$
C	181.55	0.00	0.000	σ'_v (for z = 0 to 22.5 ft) = (0.0000)z
D	181.55	0.00	0.000	

- All stress calculations below elevation 181.55 ft (Point D) will be based on elevation 181.55 ft (Point B).

Summary of Design Stress at the Midpoint of each Soil Layer and at Tip of Drilled Pier

Layer	Top (ft)	Bottom (ft)	Midpoint (ft)	z (ft)	$\sigma_{v\_midpoint}$ (ksf)	μ (ksf)	$\sigma'_{v\_midpoint}$ (ksf)
1	180.46	169.80	175.13	6.42	0.690	0.000	0.690
2	169.80	164.80	167.30	14.25	1.550	0.000	1.550
3	164.80	159.80	162.30	19.25	2.163	0.000	2.163
4	159.80	149.80	154.80	26.75	3.100	0.000	3.100
5	149.80	130.00	139.90	41.65	5.012	0.000	5.012

Tip Elev. (ft)	z (ft)	σ_{v_bottom} (ksf)	μ (ksf)	σ'_{v_bottom} (ksf)
130.00	51.55	6.299	0.000	6.299

Side Resistance in Cohesionless Soil (Sand / Gravel with $N1_{60} \leq 100$)

$R_s = (q_s)(A_s)$ *AASHTO Eqn. 10.8.3.5-3*

q_s = unit side resistance for soil layer (ksf)
$= (\beta)(\sigma'_v)$ *AASHTO Eqn. 10.8.3.5.2b-1*

β = load transfer coefficient

$$= \left(1 - \sin \phi'_f\right)\left(\frac{\sigma'_p}{\sigma'_v}\right)^{\sin \phi'_f} \tan \phi'_f$$ *AASHTO Eqn. 10.8.3.5.2b-2*

ϕ'_f = effective friction angle
$= 27.5 + 9.2 \log(N1_{60})$, $N1_{60} \leq 100$ *AASHTO Eqn. 10.8.3.5.2b-3*

$N1_{60}$ = SPT - N value corrected for hammer efficiency and overburden (limited to 100 bpf)

σ'_p = effective vertical preconsolidation stress

For Sands: $\frac{\sigma'_p}{\rho_a} \approx 0.47(N_{60})^m$ *AASHTO Eqn. 10.8.3.5.2b-4*

For Gravels: $\frac{\sigma'_p}{\rho_a} = 0.15(N_{60})$ *AASHTO Eqn. 10.8.3.5.2b-5*

m = 0.6 for clean sands; 0.8 for silty sands and sandy silts
N_{60} = SPT - N value corrected for hammer efficiency (limited to 100 bpf)
ρ_a = atmospheric pressure (2.12 ksf)

σ'_v = effective vertical stress at soil layer mid-depth as defined in FHWA GEC 010 pages 13-46

A_s = area of drilled pier side resistance (ft^2)
$= (\pi)(B)(\Delta z)$

B = diameter of drilled pier (4 ft)
Δz = effective thickness of the soil layer (ft)

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	Material Type	$N1_{60}$	ϕ' (deg)	m	N_{60}	σ'_p/ρ_a	σ'_v (ksf)	β	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
1	180.46	169.80	Sand	2	30	0.6	1	0.470	0.690	0.347	0.240	10.66	133.96	32
2	169.80	164.80	Sand	19	39	0.6	14	2.290	1.550	0.615	0.953	5.00	62.83	60
3	164.80	159.80	Sand	40	42	0.8	32	7.520	2.163	1.134	2.452	5.00	62.83	154
4	159.80	149.80	Sand	98	46	0.8	88	16.890	3.100	1.689	5.236	10.00	125.66	658

Total Side Resistance in Cohesionless Soil = 904

Side Resistance in Weathered and Hard Rock

$R_s = (A_s)(q_s)$ *AASHTO Eqn. 10.8.3.5-3*

q_s = unit side resistance for weathered or hard rock layer (ksf)

For weathered rock layers or hard rock layers with a GSI < 30

= 8 ksf *NCDOT Policy*

For drilled piers socketed into hard rock

$$= \left(C \sqrt{\frac{q_u}{p_a}} \right) p_a$$ *AASHTO Eqn. 10.8.3.5.4b-1*

C = regression coefficent taken as 1.0 for normal rock sockets (see AASHTO C10.8.3.5.4b-1 for details)

For fractured rock that caves and cannot be drilled without artificial support

$$= \left(0.65 \alpha_E \sqrt{\frac{q_u}{p_a}} \right) p_a$$ *AASHTO Eqn. 10.8.3.5.4b-2*

a_E = reduction factor to account for jointing in rock (from AASHTO Table 10.8.3.5.4b-1)

RQD (%)	Joint Modificaiton Factor, α_E	
	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

q_u = Uniaxial Compressive Strength of Intact Rock (ksf) $\leq f'_c$

f'_c = 28 day Compressive Strength of Concrete (4.5 ksi = 648 ksf)

p_a = atmospheric pressure (2.12 ksf)

A_s = area of drilled pier side resistance (ft^2)

= $(\pi)(B)(\Delta z)$

B = diameter of drilled pier (subtract 2 inches to account for possible reduction of drilled pier in rock)
= (48 inches - 2 inches) / 12 inches per ft = 3.83 ft

Δz = effective thickness of the soil layer (ft)

Layer No.	Rock Type	Layer Elevations		AASHTO Equation and Rock Joint Condition to use	RQD (%)	α_E	q_u (ksf)	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
		Top (ft)	Bottom (ft)								
5	Weathered Rock	149.80	130.00	N/A	N/A	N/A	N/A	8.000	19.80	238.45	1908

Total Side Resistance in Weathered and Hard Rock = 1,908

Note: *Hard Rock Layers with a poor surface quality (GSI < 30) will be modeled as weathered rock with an N_{60} = 600 blows/ft*

Tip Resistance in Weathered Rock

$R_p = (q_p)(A_p)$ *AASHTO Eqn. 10.8.3.5-2*

q_p = unit tip resistance (ksf)
$= (N_C)(S_U)$ *AASHTO Eqn. 10.8.3.5.1c-1*

N_C = cohesion bearing capacity factor *N_c = 9 for Weathered Rock per NCDOT Policy*

S_U = undrained shear strength of material below drilled pier tip (ksf)
$= 0.23(OCR)^{0.8}(\rho_a)$ *Mayne and Harris, 1993 (after Jamiolkowski, et al., 1985)*

$OCR = (\sigma'_p)/(\sigma'_{vo})$

$\sigma'_p = 0.47(N_{60})^{0.8}(\rho_a)$ *AASHTO Eqn. 10.8.3.5.2b-4*

N_{60} = SPT-N value corrected for hammer efficiency *N_{60} limited to 600 blows/ft*

ρ_a = atmospheric pressure (2.12 ksf)

σ'_{vo} = effective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46

A_p = area of drilled pier tip resistance (ft^2)
$= (\pi)(B^2)/4$

B = diameter of drilled pier (subtract 2 inches to account for possible reduction of drilled pier in rock)
(48 inches - 2 inches) / 12 inches per ft = 3.83 ft

Tip Elevation (ft)	N_C	N_{60}	σ'_p (ksf)	σ'_{vo} (ksf)	OCR	S_U (ksf)	q_p (ksf)	A_p (ft^2)	R_p (kips)
130.00	9	203	70	6.299	11.096	9.934	89.406	11.54	1,032

Summary of Nominal and Factored Side Resistance

Material Type	Nominal Side Resistance (kips)	Resistance Factor from AASHTO Table 10.5.5.2.4-1	Factored Side Resistance (kips)	Percentage of Side Resistance produced by Material Type
Cohesive Soil	0	0.45	0	0.0%
Cohesionless Soil	904	0.55	497	32.1%
CohesiveIGM	0	0.60	0	0.0%
Weathered Rock	1,908	0.60	1,145	67.9%
Hard Rock	0	0.55	0	0.0%
Total	**2,812**		**1,642**	**100%**

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance = 1,032 kips
Tip Resistance Factor = 0.55
Total Factored Tip Resistance = 568 kips

the drilled pier is bearing on Weathered Rock
for Weathered Rock (use IGM), see AASHTO Table 10.5.5.2.4-1.

Required Factored Resistance

$R_{req} = P_r + \gamma_{DC}(W_{Column} + W_{Pier}) - \gamma_{WA}W_{Water} - \gamma_{DC}W_{Soil/Rock} \geq P_r$ *Required Factored Resistance*

P_r = 1,532 kips *Maximum Factored Axial Load Reported by Structure Design*
γ_{DC} = 1.25 *Factor for Permanent Dead Loads, from AASHTO Table 3.4.1-2*
γ_{WA} = 1.00 *Factor for Water Loads, from AASHTO Table 3.4.1-1*

$W_{Column} = (A_{Column})(L_{Column})(\gamma_c)$ *Unfactored Weight of Column*

A_{Column} = 9.62 ft^2 *Area of Column*
L_{Column} = 15 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*
= 22 kips

$W_{Pier} = (A_{Pier})(L_{Pier})(\gamma_c)$ *Unfactored Weight of Drilled Pier*

A_{Pier} = 12.57 ft^2 *Area of Drilled Pier*
L_{Pier} = 50.46 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*
= 95 kips

$W_{Water} = (A_{Pier})(z_w)(\gamma_w)$ *Unfactored Weight of Water Displaced by Drilled Pier*

A_{Pier} = 12.57 ft^2 *Area of Drilled Pier*
z_w = 0 ft *Depth from water surface to the drilled pier tip*
γ_w = 0.0624 kcf *Unit Weight of Water*
= 0 kips

$W_{Soil/Rock} = (A_{Pier})(\sigma'_{vo})$ *Unfactored Effective Weight of Soil / Rock that will be displaced*

A_{Pier} = 12.57 ft^2 *Area of Drilled Pier*
σ'_{vo} = 6.299 ksf *ffective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46*

$W_{Soil/Rock}$ = 79 kips

R_{req} = 1,532 kips + 1.25(22 kips + 95 kips) -1.00(0 kips) -1.25(79 kips) = 1,580 kips

790T max factored resistance

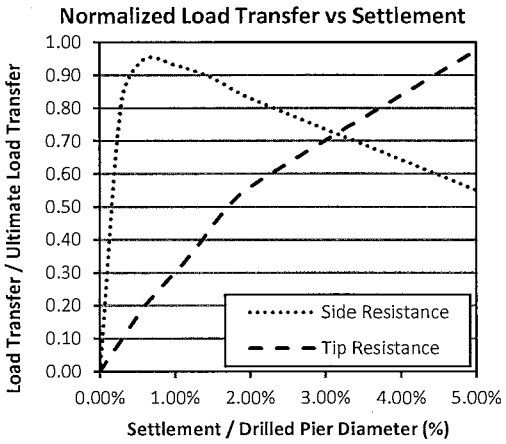
Load Transfer of Side and Tip Resistance

The majority of the side resistance is produced by Weathered Rock , which is treated as a cohesive material for Load transfer. Use AASHTO Figure 10.8.2.2.2.1 to predict the normalized load transfer for side resistance.

The drilled pier tip is bearing on Weathered Rock, which is treated as a cohesive material for load transfer. Use AASHTO Figure 10.8.2.2.2.2 to predict the normalized load transfer for tip resistance.

Load Transfer of Side and Tip Resistance (continued)

Δz / D (%)	Normalized Side Transfer R_{sd} / R_s AASHTO Figure 10.8.2.2.2.1	Normalized Tip Transfer R_{pd} / R_p AASHTO Figure 10.8.2.2.2.2
0.0	0.00	0.00
0.3	0.83	0.10
0.6	0.95	0.20
1.0	0.93	0.30
1.3	0.91	0.38
1.6	0.88	0.47
2.0	0.83	0.56
5.0	0.55	0.98



Δz / D = total settlement / drilled pier diameter
R_{sd} / R_s = developed side resistance / total nominal side resistance
R_{pd} / R_p = developed tip resistance / total nominal tip resistance

Developed Factored Resistance, (R_{rd})

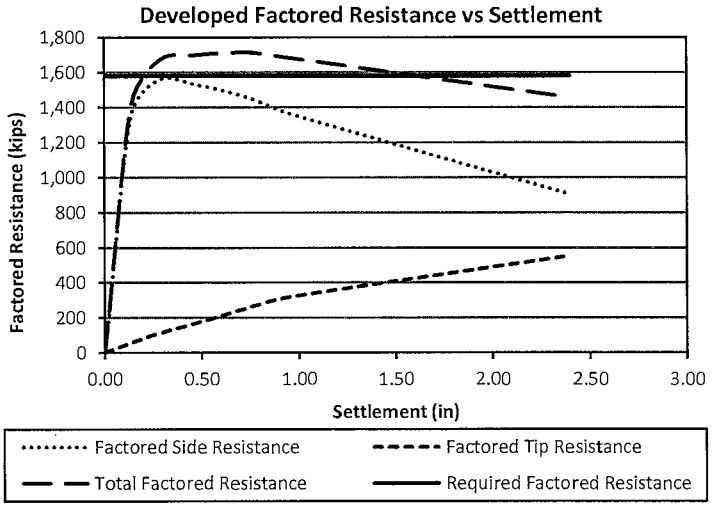
Use the normalized load transfer values along with the total factored side and tip resistance values to calculate the developed side and tip resistance at different vertical displacements. The developed factored resistance must be greater than or equal to the required axial resistance, ($R_{rd} \geq R_{req}$).

$\frac{\Delta z}{D}$	D (in)	Δz (in)	$\varphi_{qs}R_s$ (kips)	$\frac{R_{sd}}{R_s}$	$\varphi_{qs}R_{sd}$ (kips)	$\varphi_{qp}R_p$ (kips)	$\frac{R_{pd}}{R_p}$	$\varphi_{qp}R_{pd}$ (kips)	R_{rd} (kips)	R_{req} (kips)	Axial Resistance Requirement Satisfied
0.3%	48	0.14	1,642	0.83	1,363	568	0.10	57	1,420	1,580	NO
0.6%	**48**	**0.29**	**1,642**	**0.95**	**1,560**	**568**	**0.20**	**113**	**1,673**	**1,580**	**YES**
1.0%	48	0.48	1,642	0.93	1,527	568	0.30	171	1,698	1,580	YES
1.3%	48	0.62	1,642	0.91	1,494	568	0.38	216	1,710	1,580	YES
1.6%	48	0.77	1,642	0.88	1,445	568	0.47	267	1,712	1,580	YES
2.0%	48	0.96	1,642	0.83	1,363	568	0.56	318	1,681	1,580	YES
5.0%	48	2.40	1,642	0.55	903	568	0.98	553	1,456	1,580	NO

$\varphi_{qs}R_s$ = total factored side resistance
$\varphi_{qp}R_p$ = total factored tip resistance
$\varphi_{qs}R_{sd}$ = developed factored side resistance
= $(R_{sd}/R_s)(\varphi_{qs}R_s)$
$\varphi_{qp}R_{pd}$ = developed factored tip resistance
= $(R_{pd}/R_p)(\varphi_{qp}R_p)$

The axial resistance requirement is satisfied at an estimated vertical displacement of 0.29 inches.

Developed Factored Side Resistance = 1,560 kips
Developed Factored Tip Resistance = 113 kips
Developed Factored Total Resistance = 1,673 kips



Required Tip Resistance

q_{req} = required tip resistance (rounded up to the nearest 10 ksf or 5 tsf)

$$= \frac{\frac{R_{req} - \varphi_{qs} R_{sd}}{A_T}}{\varphi_{qp}} \leq q_p$$

NCDOT policy

R_r = required factored geotechnical resistance (kips)
$\varphi_{qs}R_{sd}$ = factored developed side resistance (kips)
A_T = area of drilled pier tip (ft^2)
φ_{qp} = tip resistance factor
q_p = unit tip resistance (ksf)

R_{req} (kips)	$\varphi_{qs}R_{sd}$ (kips)	A_{Tip} (ft^2)	φ_{qp}	q_p (ksf)	q_{req} (ksf)
1,580	1,560	11.54	0.55	89	10

5tsf
tip resistance
rqd
say 20tsf
for quality
control purposes

SINCE 1881

FROEHLING & ROBERTSON, INC.

Engineering • Environmental • Geotechnical

JOB I-5185 Bridge 111 Lateral SHEET NO. 1 OF 1

COMPUTATIONS FOR Bent 2 - 1 Pile DATE 5/10

BY C. Ward CHKD

Depth		Elev
0	BOC = EL 195.5'	195.5'
15'	Bottom of column = ± 180.5 say 180.5	180.5
25.2'	① SAND γ=63 k=20 Φ=27°	169.8
30.7'	② SAND γ=58 k=60 Φ=31°	164.8
35.2'	③ SAND (5.50' made as sand) γ=63 k=50 Φ=36°	159.8
45.2'	④ SAND " " " γ=63 k=125 Φ=41°	149.8
55.7'	⑤ CLAY (WiR model as clay) γc=100 c=5000 k=2000 ε50=0.04	139.8

① Model max long shear case as free head.
shear = 20,700 lbs, axial = 892,000 lbs, moment = 301,600 in-lbs
y = 0.65", 1st neg = ~~388~~ EL 150.7', max neg = 428 (EL 152.7')

② Model max trans. shear case as fixed head.
shear = 55,100 lbs, axial = 1051,000 lbs, slope = 0
y = 0.34", 1st neg = 423' (EL 153.2'), max neg = 454 EL 150.1')
say pot = EL 153.0'

MinTip: 15B (18') below 1st neg = EL 153.7' } MinTip = EL 148.0'
10B (10') below max neg = EL 148.7' }

MinTip from axial = EL 130.0'

pot = EL 153.0'
MinTip = EL 130.0'

LPile Plus for Windows, Version 2013-07.001

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

This copy of LPile is licensed to:

Branch User
Froehling & Robertson, Inc.

Serial Number of Security Device: 293783516
Company Name Stored in Security Device: Froehling & Robertson, Inc.

Files Used for Analysis

Path to file locations: F:\Projects 66U\66U-0390 (WEI-I-5786 Bridges 108 & 111 Johnston Co)\NON_CADD\Foundation Recs\Bridge 111 Bizzel Grove\LPILE\
Name of input data file: B1-B.lp7d
Name of output report file: B1-B.lp7o
Name of plot output file: B1-B.lp7p
Name of runtime messeage file: B1-B.lp7r

Date and Time of Analysis

Date: May 11, 2017 Time: 15:51:46

Problem Title

Project Name: Bridge 111 Bizzel Grove

Job Number: 66U-0390

Client: Wetherill Engineering

Engineer: C. Wang

Description: Bent 1 B1-B

Program Options

Engineering Units of Input Data and Computations:
- Engineering units are US Customary Units: pounds, inches, feet

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
- Static loading specified

Computational Options:
- Use unfactored loads in computations
- No computation of pile-head foundation stiffness matrix
- Compute pile response under loading and nonlinear bending properties of pile (if nonlinear properties are specified)
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Input Data Options:
- Analysis does not use p-y modification factors (individual pile or shaft only)
- Analysis assumes zero shear resistance at the pile tip
- Analysis assumes no loading by soil movements acting on pile

Output Options:
- No p-y curves to be computed and reported for user-specified depths
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1

Pile Structural Properties and Geometry

Total number of pile sections = 2

Total length of pile = 51.00 ft

Depth of ground surface below top of pile = 15.00 ft

Pile diameter values used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	42.0000000
2	15.000000	42.0000000
3	15.000000	48.0000000
4	51.000000	48.0000000

Input Structural Properties:

Pile Section No. 1:

Section Type	= Elastic Pile
Cross-sectional Shape	= Circular
Section Length	= 15.00000 ft
Top Width	= 42.00000 in
Bottom Width	= 42.00000 in
Top Area	= 1385.44236 Sq. in
Bottom Area	= 1385.44236 Sq. in

Moment of Inertia at Top	=	152745. in^4
Moment of Inertia at Bottom	=	152745. in^4
Elastic Modulus	=	3122019. lbs/in^2

Pile Section No. 2:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	36.00000 ft
Top Width	=	48.00000 in
Bottom Width	=	48.00000 in
Top Area	=	1809.55737 Sq. in
Bottom Area	=	1809.55737 Sq. in
Moment of Inertia at Top	=	260576. in^4
Moment of Inertia at Bottom	=	260576. in^4
Elastic Modulus	=	3823676. lbs/in^2

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 5 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	15.00000 ft
Distance from top of pile to bottom of layer	=	25.70000 ft
Effective unit weight at top of layer	=	43.00000 pcf
Effective unit weight at bottom of layer	=	43.00000 pcf
Friction angle at top of layer	=	27.00000 deg.
Friction angle at bottom of layer	=	27.00000 deg.
Subgrade k at top of layer	=	20.00000 pci
Subgrade k at bottom of layer	=	20.00000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	25.70000 ft
Distance from top of pile to bottom of layer	=	30.70000 ft
Effective unit weight at top of layer	=	58.00000 pcf
Effective unit weight at bottom of layer	=	58.00000 pcf
Friction angle at top of layer	=	31.00000 deg.
Friction angle at bottom of layer	=	31.00000 deg.
Subgrade k at top of layer	=	60.00000 pci
Subgrade k at bottom of layer	=	60.00000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	30.70000 ft
Distance from top of pile to bottom of layer	=	35.70000 ft
Effective unit weight at top of layer	=	63.00000 pcf
Effective unit weight at bottom of layer	=	63.00000 pcf
Friction angle at top of layer	=	36.00000 deg.
Friction angle at bottom of layer	=	36.00000 deg.

Subgrade k at top of layer	=	60.00000	pci
Subgrade k at bottom of layer	=	60.00000	pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	35.70000	ft
Distance from top of pile to bottom of layer	=	45.70000	ft
Effective unit weight at top of layer	=	63.00000	pcf
Effective unit weight at bottom of layer	=	63.00000	pcf
Friction angle at top of layer	=	41.00000	deg.
Friction angle at bottom of layer	=	41.00000	deg.
Subgrade k at top of layer	=	125.00000	pci
Subgrade k at bottom of layer	=	125.00000	pci

Layer 5 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	45.70000	ft
Distance from top of pile to bottom of layer	=	55.70000	ft
Effective unit weight at top of layer	=	100.00000	pcf
Effective unit weight at bottom of layer	=	100.00000	pcf
Undrained cohesion at top of layer	=	5000.00000	psf
Undrained cohesion at bottom of layer	=	5000.00000	psf
Epsilon-50 at top of layer	=	0.00400	
Epsilon-50 at bottom of layer	=	0.00400	
Subgrade k at top of layer	=	2000.00000	pci
Subgrade k at bottom of layer	=	2000.00000	pci

(Depth of lowest soil layer extends 4.70 ft below pile tip)

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Strain Factor Epsilon 50	kpy pci
1	Sand (Reese, et al.)	15.000	43.000	--	27.000	--	20.000
		25.700	43.000	--	27.000	--	20.000
2	Sand (Reese, et al.)	25.700	58.000	--	31.000	--	60.000
		30.700	58.000	--	31.000	--	60.000
3	Sand (Reese, et al.)	30.700	63.000	--	36.000	--	60.000
		35.700	63.000	--	36.000	--	60.000
4	Sand (Reese, et al.)	35.700	63.000	--	41.000	--	125.000
		45.700	63.000	--	41.000	--	125.000
5	Stiff Clay with Free Water	45.700	100.000	5000.000	--	0.00400	2000.000
		55.700	100.000	5000.000	--	0.00400	2000.000

Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 20700. lbs	M = 501600. in-lbs	892600.	No
2	2	V = 35600. lbs	S = 0.0000 in/in	1057000.	No

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

---

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 20700.0 lbs
Applied moment at pile head = 501600.0 in-lbs
Axial thrust load on pile head = 892600.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.6456	501600.	20700.	-0.002615	713.2327	4.769E+11	0.000	0.000	0.000
0.510	0.6296	642552.	20700.	-0.002608	732.6114	4.769E+11	0.000	0.000	0.000

1.020	0.6136	783460.	20700.	-0.002599	751.9839	4.769E+11	0.000	0.000	0.000
1.530	0.5978	924312.	20700.	-0.002588	771.3489	4.769E+11	0.000	0.000	0.000
2.040	0.5820	1065099.	20700.	-0.002575	790.7049	4.769E+11	0.000	0.000	0.000
2.550	0.5662	1205812.	20700.	-0.002560	810.0507	4.769E+11	0.000	0.000	0.000
3.060	0.5506	1346441.	20700.	-0.002544	829.3848	4.769E+11	0.000	0.000	0.000
3.570	0.5351	1486975.	20700.	-0.002526	848.7060	4.769E+11	0.000	0.000	0.000
4.080	0.5197	1627404.	20700.	-0.002506	868.0128	4.769E+11	0.000	0.000	0.000
4.590	0.5044	1767720.	20700.	-0.002484	887.3040	4.769E+11	0.000	0.000	0.000
5.100	0.4893	1907911.	20700.	-0.002460	906.5781	4.769E+11	0.000	0.000	0.000
5.610	0.4743	2047969.	20700.	-0.002435	925.8338	4.769E+11	0.000	0.000	0.000
6.120	0.4595	2187884.	20700.	-0.002408	945.0698	4.769E+11	0.000	0.000	0.000
6.630	0.4449	2327645.	20700.	-0.002379	964.2847	4.769E+11	0.000	0.000	0.000
7.140	0.4304	2467242.	20700.	-0.002348	983.4772	4.769E+11	0.000	0.000	0.000
7.650	0.4161	2606667.	20700.	-0.002316	1002.6459	4.769E+11	0.000	0.000	0.000
8.160	0.4020	2745909.	20700.	-0.002281	1021.7894	4.769E+11	0.000	0.000	0.000
8.670	0.3882	2884959.	20700.	-0.002245	1040.9065	4.769E+11	0.000	0.000	0.000
9.180	0.3746	3023806.	20700.	-0.002207	1059.9958	4.769E+11	0.000	0.000	0.000
9.690	0.3612	3162441.	20700.	-0.002168	1079.0559	4.769E+11	0.000	0.000	0.000
10.200	0.3480	3300855.	20700.	-0.002126	1098.0856	4.769E+11	0.000	0.000	0.000
10.710	0.3351	3439037.	20700.	-0.002083	1117.0834	4.769E+11	0.000	0.000	0.000
11.220	0.3225	3576978.	20700.	-0.002038	1136.0481	4.769E+11	0.000	0.000	0.000
11.730	0.3102	3714669.	20700.	-0.001991	1154.9783	4.769E+11	0.000	0.000	0.000
12.240	0.2982	3852099.	20700.	-0.001942	1173.8728	4.769E+11	0.000	0.000	0.000
12.750	0.2864	3989258.	20700.	-0.001892	1192.7300	4.769E+11	0.000	0.000	0.000
13.260	0.2750	4126139.	20700.	-0.001840	1211.5489	4.769E+11	0.000	0.000	0.000
13.770	0.2639	4262729.	20700.	-0.001786	1230.3280	4.769E+11	0.000	0.000	0.000
14.280	0.2531	4399021.	20700.	-0.001731	1249.0659	4.769E+11	0.000	0.000	0.000
14.790	0.2427	4535005.	20700.	-0.001673	1267.7615	4.769E+11	0.000	0.000	0.000
15.300	0.2327	4670671.	20652.	-0.001630	923.4552	9.964E+11	-15.6253	411.0078	0.000
15.810	0.2228	4805595.	20473.	-0.001601	935.8821	9.964E+11	-42.9160	1178.9620	0.000
16.320	0.2131	4938750.	20135.	-0.001571	948.1462	9.964E+11	-67.5008	1938.8160	0.000
16.830	0.2036	5069211.	19655.	-0.001540	960.1622	9.964E+11	-89.3993	2687.9040	0.000
17.340	0.1942	5196154.	19048.	-0.001509	971.8540	9.964E+11	-109.0741	3436.9920	0.000
17.850	0.1851	5318837.	18327.	-0.001476	983.1536	9.964E+11	-126.5986	4186.0800	0.000
18.360	0.1762	5436600.	17505.	-0.001443	994.0000	9.964E+11	-142.0481	4935.1680	0.000
18.870	0.1674	5548860.	16594.	-0.001409	1004.3395	9.964E+11	-155.5002	5684.2560	0.000
19.380	0.1589	5655110.	15607.	-0.001375	1014.1255	9.964E+11	-167.0344	6433.3440	0.000
19.890	0.1506	5754914.	14555.	-0.001340	1023.3178	9.964E+11	-176.7320	7182.4320	0.000
20.400	0.1425	5847905.	13449.	-0.001304	1031.8826	9.964E+11	-184.6758	7931.5200	0.000
20.910	0.1346	5933783.	12300.	-0.001268	1039.7923	9.964E+11	-190.9504	8680.6080	0.000
21.420	0.1270	6012310.	11117.	-0.001232	1047.0250	9.964E+11	-195.6412	9429.6960	0.000
21.930	0.1195	6083308.	9909.7425	-0.001194	1053.5641	9.964E+11	-198.8353	10179.	0.000
22.440	0.1124	6146655.	8687.4081	-0.001157	1059.3986	9.964E+11	-200.6204	10928.	0.000
22.950	0.1054	6202281.	7458.1901	-0.001119	1064.5219	9.964E+11	-201.0849	11677.	0.000
23.460	0.0987	6250167.	6229.8977	-0.001081	1068.9324	9.964E+11	-200.3179	12426.	0.000
23.970	0.0922	6290341.	5009.7934	-0.001042	1072.6326	9.964E+11	-198.4090	13175.	0.000
24.480	0.0859	6322873.	3804.5916	-0.001003	1075.6289	9.964E+11	-195.4478	13924.	0.000
24.990	0.0799	6347872.	2620.4573	-0.000964	1077.9314	9.964E+11	-191.5242	14673.	0.000
25.500	0.0741	6365485.	1463.0066	-0.000925	1079.5536	9.964E+11	-186.7277	15422.	0.000
26.010	0.0686	6375890.	-396.0846	-0.000886	1080.5120	9.964E+11	-420.8185	37567.	0.000
26.520	0.0632	6370320.	-2979.4357	-0.000847	1079.9989	9.964E+11	-423.4139	40969.	0.000
27.030	0.0582	6348678.	-5560.8511	-0.000808	1078.0056	9.964E+11	-420.1859	44196.	0.000
27.540	0.0534	6311084.	-8106.4627	-0.000769	1074.5431	9.964E+11	-411.7133	47222.	0.000
28.050	0.0488	6257859.	-10584.	-0.000731	1069.6408	9.964E+11	-398.0275	49948.	0.000
28.560	0.0444	6189515.	-12965.	-0.000692	1063.3461	9.964E+11	-380.0418	52365.	0.000
29.070	0.0403	6106730.	-15243.	-0.000655	1055.7213	9.964E+11	-364.3483	55337.	0.000
29.580	0.0364	6010093.	-17406.	-0.000617	1046.8207	9.964E+11	-342.5282	57585.	0.000
30.090	0.0327	5900425.	-19434.	-0.000581	1036.7199	9.964E+11	-320.0588	59832.	0.000
30.600	0.0293	5778572.	-21322.	-0.000545	1025.4968	9.964E+11	-297.1474	62079.	0.000
31.110	0.0261	5645395.	-22898.	-0.000510	1013.2308	9.964E+11	-217.7034	51112.	0.000
31.620	0.0231	5503875.	-24179.	-0.000476	1000.1963	9.964E+11	-200.9938	53359.	0.000
32.130	0.0202	5354643.	-25357.	-0.000442	986.4514	9.964E+11	-183.9503	55606.	0.000
32.640	0.0176	5198341.	-26430.	-0.000410	972.0554	9.964E+11	-166.7478	57853.	0.000
33.150	0.0152	5035619.	-27398.	-0.000378	957.0682	9.964E+11	-149.5504	60101.	0.000
33.660	0.0130	4867126.	-28261.	-0.000348	941.5494	9.964E+11	-132.5110	62348.	0.000
34.170	0.0110	4693507.	-29021.	-0.000319	925.5585	9.964E+11	-115.7712	64595.	0.000
34.680	0.009107	4515395.	-29679.	-0.000290	909.1537	9.964E+11	-99.4614	66842.	0.000

35.190	0.007414	4333406.	-30240.	-0.000263	892.3919	9.964E+11	-83.7003	69090.	0.000
35.700	0.005885	4148137.	-30879.	-0.000237	875.3279	9.964E+11	-125.0810	130081.	0.000
36.210	0.004511	3958043.	-31565.	-0.000212	857.8196	9.964E+11	-99.3384	134763.	0.000
36.720	0.003287	3764096.	-32098.	-0.000189	839.9564	9.964E+11	-74.8845	139444.	0.000
37.230	0.002203	3567218.	-32486.	-0.000166	821.8233	9.964E+11	-51.8890	144126.	0.000
37.740	0.001254	3368277.	-32738.	-0.000145	803.5001	9.964E+11	-30.4967	148808.	0.000
38.250	0.000432	3168080.	-32865.	-0.000125	785.0613	9.964E+11	-10.8279	153490.	0.000
38.760	-0.000272	2967372.	-32877.	-0.000106	766.5753	9.964E+11	7.0215	158172.	0.000
39.270	-0.000864	2766827.	-32785.	-8.821E-05	748.1044	9.964E+11	22.9787	162853.	0.000
39.780	-0.001351	2567050.	-32601.	-7.183E-05	729.7042	9.964E+11	36.9943	167535.	0.000
40.290	-0.001743	2368572.	-32338.	-5.667E-05	711.4237	9.964E+11	49.0408	172217.	0.000
40.800	-0.002045	2171852.	-32007.	-4.273E-05	693.3051	9.964E+11	59.1125	176899.	0.000
41.310	-0.002266	1977273.	-31620.	-2.999E-05	675.3837	9.964E+11	67.2244	181581.	0.000
41.820	-0.002412	1785145.	-31190.	-1.843E-05	657.6880	9.964E+11	73.4117	186262.	0.000
42.330	-0.002491	1595707.	-30728.	-8.047E-06	640.2401	9.964E+11	77.7292	190944.	0.000
42.840	-0.002511	1409127.	-30244.	1.181E-06	623.0554	9.964E+11	80.2505	195626.	0.000
43.350	-0.002477	1225506.	-29751.	9.273E-06	606.1432	9.964E+11	81.0676	200308.	0.000
43.860	-0.002397	1044879.	-29257.	1.625E-05	589.5069	9.964E+11	80.2900	204990.	0.000
44.370	-0.002278	867225.	-28772.	2.212E-05	573.1443	9.964E+11	78.0447	209671.	0.000
44.880	-0.002126	692464.	-28306.	2.691E-05	557.0482	9.964E+11	74.4754	214353.	0.000
45.390	-0.001949	520470.	-27864.	3.063E-05	541.2070	9.964E+11	69.7424	219035.	0.000
45.900	-0.001751	351071.	-24969.	3.331E-05	525.6047	9.964E+11	876.3322	3062216.	0.000
46.410	-0.001541	214482.	-19772.	3.505E-05	513.0244	9.964E+11	822.1057	3265075.	0.000
46.920	-0.001322	108678.	-14926.	3.604E-05	503.2794	9.964E+11	761.7221	3525152.	0.000
47.430	-0.001100	31399.	-10469.	3.647E-05	496.1618	9.964E+11	694.8290	3866413.	0.000
47.940	-0.000876	-19856.	-6444.0857	3.651E-05	495.0986	9.964E+11	620.3464	4333754.	0.000
48.450	-0.000653	-47875.	-2905.9632	3.630E-05	497.6793	9.964E+11	535.9028	5022570.	0.000
48.960	-0.000432	-55821.	68.9040	3.598E-05	498.4111	9.964E+11	436.2761	6184019.	0.000
49.470	-0.000213	-47425.	2344.0900	3.566E-05	497.6378	9.964E+11	307.2488	8843764.	0.000
49.980	4.737E-06	-27519.	3254.8946	3.543E-05	495.8044	9.964E+11	-9.6002	12404301.	0.000
50.490	0.000221	-7972.0208	2279.8213	3.532E-05	494.0041	9.964E+11	-309.0512	8556068.	0.000
51.000	0.000437	0.000	0.000	3.530E-05	493.2698	9.964E+11	-435.9884	3052349.	0.000

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection	=	0.6455598 inches
Computed slope at pile head	=	-0.0026152 radians
Maximum bending moment	=	6375890. inch-lbs
Maximum shear force	=	-32877. lbs
Depth of maximum bending moment	=	26.0100000 feet below pile head
Depth of maximum shear force	=	38.7600000 feet below pile head
Number of iterations	=	7
Number of zero deflection points	=	2

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head	=	35600.0 lbs
Rotation of pile head	=	0.000E+00 radians
Axial load at pile head	=	1057000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3361	-6177206.	35600.	0.000	1612.2004	4.769E+11	0.000	0.000	0.000

0.510	0.3359	-5959078.	35600.	-7.788E-05	1582.2112	4.769E+11	0.000	0.000	0.000
1.020	0.3352	-5740455.	35600.	-0.000153	1552.1541	4.769E+11	0.000	0.000	0.000
1.530	0.3340	-5521355.	35600.	-0.000225	1522.0314	4.769E+11	0.000	0.000	0.000
2.040	0.3324	-5301797.	35600.	-0.000295	1491.8456	4.769E+11	0.000	0.000	0.000
2.550	0.3304	-5081799.	35600.	-0.000361	1461.5994	4.769E+11	0.000	0.000	0.000
3.060	0.3280	-4861379.	35600.	-0.000425	1431.2951	4.769E+11	0.000	0.000	0.000
3.570	0.3252	-4640555.	35600.	-0.000486	1400.9354	4.769E+11	0.000	0.000	0.000
4.080	0.3221	-4419346.	35600.	-0.000544	1370.5227	4.769E+11	0.000	0.000	0.000
4.590	0.3186	-4197770.	35600.	-0.000599	1340.0596	4.769E+11	0.000	0.000	0.000
5.100	0.3147	-3975846.	35600.	-0.000652	1309.5485	4.769E+11	0.000	0.000	0.000
5.610	0.3106	-3753592.	35600.	-0.000702	1278.9921	4.769E+11	0.000	0.000	0.000
6.120	0.3061	-3531026.	35600.	-0.000748	1248.3928	4.769E+11	0.000	0.000	0.000
6.630	0.3014	-3308167.	35600.	-0.000792	1217.7533	4.769E+11	0.000	0.000	0.000
7.140	0.2964	-3085033.	35600.	-0.000833	1187.0759	4.769E+11	0.000	0.000	0.000
7.650	0.2912	-2861643.	35600.	-0.000871	1156.3634	4.769E+11	0.000	0.000	0.000
8.160	0.2858	-2638015.	35600.	-0.000907	1125.6182	4.769E+11	0.000	0.000	0.000
8.670	0.2801	-2414169.	35600.	-0.000939	1094.8429	4.769E+11	0.000	0.000	0.000
9.180	0.2743	-2190122.	35600.	-0.000969	1064.0400	4.769E+11	0.000	0.000	0.000
9.690	0.2683	-1965893.	35600.	-0.000995	1033.2122	4.769E+11	0.000	0.000	0.000
10.200	0.2621	-1741501.	35600.	-0.001019	1002.3618	4.769E+11	0.000	0.000	0.000
10.710	0.2558	-1516965.	35600.	-0.001040	971.4917	4.769E+11	0.000	0.000	0.000
11.220	0.2494	-1292303.	35600.	-0.001058	940.6042	4.769E+11	0.000	0.000	0.000
11.730	0.2428	-1067533.	35600.	-0.001073	909.7019	4.769E+11	0.000	0.000	0.000
12.240	0.2362	-842674.	35600.	-0.001085	878.7875	4.769E+11	0.000	0.000	0.000
12.750	0.2296	-617746.	35600.	-0.001095	847.8635	4.769E+11	0.000	0.000	0.000
13.260	0.2228	-392767.	35600.	-0.001101	816.9324	4.769E+11	0.000	0.000	0.000
13.770	0.2161	-167754.	35600.	-0.001105	785.9968	4.769E+11	0.000	0.000	0.000
14.280	0.2093	57272.	35600.	-0.001106	770.8072	4.769E+11	0.000	0.000	0.000
14.790	0.2025	282293.	35600.	-0.001103	801.7440	4.769E+11	0.000	0.000	0.000
15.300	0.1958	507291.	35557.	-0.001100	630.8440	9.964E+11	-14.0981	440.6400	0.000
15.810	0.1891	731741.	35401.	-0.001096	651.5167	9.964E+11	-36.7579	1189.7280	0.000
16.320	0.1824	954785.	35112.	-0.001091	672.0598	9.964E+11	-57.7807	1938.8160	0.000
16.830	0.1757	1175626.	34699.	-0.001084	692.4001	9.964E+11	-77.1804	2687.9040	0.000
17.340	0.1691	1393531.	34172.	-0.001077	712.4699	9.964E+11	-94.9747	3436.9920	0.000
17.850	0.1626	1607823.	33541.	-0.001067	732.2069	9.964E+11	-111.1855	4186.0800	0.000
18.360	0.1560	1817886.	32816.	-0.001057	751.5545	9.964E+11	-125.8385	4935.1680	0.000
18.870	0.1496	2023164.	32006.	-0.001045	770.4614	9.964E+11	-138.9633	5684.2560	0.000
19.380	0.1433	2223157.	31120.	-0.001032	788.8814	9.964E+11	-150.5930	6433.3440	0.000
19.890	0.1370	2417421.	30167.	-0.001018	806.7738	9.964E+11	-160.7644	7182.4320	0.000
20.400	0.1308	2605568.	29156.	-0.001002	824.1028	9.964E+11	-169.5176	7931.5200	0.000
20.910	0.1247	2787262.	28096.	-0.000986	840.8375	9.964E+11	-176.8961	8680.6080	0.000
21.420	0.1187	2962220.	26995.	-0.000968	856.9517	9.964E+11	-182.9464	9429.6960	0.000
21.930	0.1129	3130208.	25861.	-0.000949	872.4240	9.964E+11	-187.7177	10179.	0.000
22.440	0.1071	3291041.	24701.	-0.000930	887.2373	9.964E+11	-191.2624	10928.	0.000
22.950	0.1015	3444579.	23523.	-0.000909	901.3787	9.964E+11	-193.6352	11677.	0.000
23.460	0.0960	3590728.	22335.	-0.000887	914.8396	9.964E+11	-194.8932	12426.	0.000
23.970	0.0906	3729435.	21141.	-0.000865	927.6149	9.964E+11	-195.0957	13175.	0.000
24.480	0.0854	3860686.	19950.	-0.000842	939.7037	9.964E+11	-194.3042	13924.	0.000
24.990	0.0803	3984506.	18766.	-0.000818	951.1080	9.964E+11	-192.5821	14673.	0.000
25.500	0.0754	4100955.	17595.	-0.000793	961.8333	9.964E+11	-189.9943	15422.	0.000
26.010	0.0706	4210125.	15713.	-0.000767	971.8883	9.964E+11	-425.0819	36838.	0.000
26.520	0.0660	4303207.	13097.	-0.000741	980.4614	9.964E+11	-429.6765	39840.	0.000
27.030	0.0616	4380024.	10471.	-0.000714	987.5365	9.964E+11	-428.6688	42623.	0.000
27.540	0.0573	4440612.	7866.1398	-0.000687	993.1169	9.964E+11	-422.5352	45160.	0.000
28.050	0.0531	4485197.	5314.7508	-0.000660	997.2233	9.964E+11	-411.2520	47364.	0.000
28.560	0.0492	4514201.	2845.4866	-0.000632	999.8947	9.964E+11	-395.6971	49236.	0.000
29.070	0.0454	4528205.	461.5930	-0.000604	1001.1845	9.964E+11	-383.3531	51676.	0.000
29.580	0.0418	4527671.	-1834.9720	-0.000577	1001.1353	9.964E+11	-367.1583	53774.	0.000
30.090	0.0383	4513205.	-4021.4979	-0.000549	999.8030	9.964E+11	-347.3927	55449.	0.000
30.600	0.0351	4485549.	-6077.2671	-0.000521	997.2557	9.964E+11	-324.4273	56618.	0.000
31.110	0.0320	4445563.	-7886.8493	-0.000494	993.5729	9.964E+11	-266.9394	51112.	0.000
31.620	0.0290	4395402.	-9478.0372	-0.000467	988.9529	9.964E+11	-253.0567	53359.	0.000
32.130	0.0263	4335589.	-10982.	-0.000440	983.4439	9.964E+11	-238.5172	55606.	0.000
32.640	0.0236	4266670.	-12396.	-0.000413	977.0962	9.964E+11	-223.4818	57853.	0.000
33.150	0.0212	4189211.	-13717.	-0.000387	969.9619	9.964E+11	-208.1046	60101.	0.000
33.660	0.0189	4103791.	-14943.	-0.000362	962.0944	9.964E+11	-192.5325	62348.	0.000
34.170	0.0168	4010996.	-16073.	-0.000337	953.5478	9.964E+11	-176.9051	64595.	0.000

34.680	0.0148	3911417.	-17108.	-0.000313	944.3762	9.964E+11	-161.3544	66842.	0.000
35.190	0.0129	3805639.	-18049.	-0.000289	934.6336	9.964E+11	-146.0041	69090.	0.000
35.700	0.0112	3694241.	-19226.	-0.000266	924.3734	9.964E+11	-238.8191	130081.	0.000
36.210	0.009678	3573751.	-20609.	-0.000244	913.2759	9.964E+11	-213.1000	134763.	0.000
36.720	0.008254	3445138.	-21837.	-0.000222	901.4302	9.964E+11	-188.0575	139444.	0.000
37.230	0.006959	3309344.	-22914.	-0.000201	888.9231	9.964E+11	-163.8863	144126.	0.000
37.740	0.005789	3167281.	-23846.	-0.000181	875.8386	9.964E+11	-140.7593	148808.	0.000
38.250	0.004738	3019820.	-24640.	-0.000162	862.2569	9.964E+11	-118.8281	153490.	0.000
38.760	0.003800	2867788.	-25304.	-0.000144	848.2542	9.964E+11	-98.2228	158172.	0.000
39.270	0.002971	2711963.	-25847.	-0.000127	833.9022	9.964E+11	-79.0518	162853.	0.000
39.780	0.002243	2553070.	-26277.	-0.000111	819.2675	9.964E+11	-61.4021	167535.	0.000
40.290	0.001611	2391775.	-26603.	-9.589E-05	804.4117	9.964E+11	-45.3396	172217.	0.000
40.800	0.001069	2228687.	-26836.	-8.170E-05	789.3908	9.964E+11	-30.9094	176899.	0.000
41.310	0.000611	2064353.	-26987.	-6.851E-05	774.2550	9.964E+11	-18.1358	181581.	0.000
41.820	0.000231	1899258.	-27064.	-5.634E-05	759.0492	9.964E+11	-7.0231	186262.	0.000
42.330	-7.834E-05	1733824.	-27078.	-4.518E-05	743.8121	9.964E+11	2.4442	190944.	0.000
42.840	-0.000322	1568413.	-27039.	-3.504E-05	728.5772	9.964E+11	10.3010	195626.	0.000
43.350	-0.000507	1403326.	-26956.	-2.591E-05	713.3720	9.964E+11	16.6013	200308.	0.000
43.860	-0.000639	1238804.	-26840.	-1.780E-05	698.2190	9.964E+11	21.4177	204990.	0.000
44.370	-0.000725	1075035.	-26698.	-1.069E-05	683.1353	9.964E+11	24.8409	209671.	0.000
44.880	-0.000770	912154.	-26540.	-4.589E-06	668.1334	9.964E+11	26.9796	214353.	0.000
45.390	-0.000781	750248.	-26372.	5.167E-07	653.2212	9.964E+11	27.9604	219035.	0.000
45.900	-0.000764	589358.	-24510.	4.631E-06	638.4028	9.964E+11	580.3157	4648774.	0.000
46.410	-0.000725	450181.	-21005.	7.823E-06	625.5840	9.964E+11	565.2129	4774117.	0.000
46.920	-0.000668	332156.	-17614.	1.023E-05	614.7135	9.964E+11	542.8987	4972283.	0.000
47.430	-0.000599	234451.	-14379.	1.197E-05	605.7145	9.964E+11	514.3227	5251476.	0.000
47.940	-0.000522	156000.	-11336.	1.317E-05	598.4889	9.964E+11	480.0414	5630833.	0.000
48.450	-0.000438	95524.	-8520.4510	1.394E-05	592.9188	9.964E+11	440.1892	6147232.	0.000
48.960	-0.000351	51530.	-5966.7881	1.439E-05	588.8668	9.964E+11	394.3412	6872886.	0.000
49.470	-0.000262	22304.	-3716.1906	1.462E-05	586.1750	9.964E+11	341.1482	7965448.	0.000
49.980	-0.000172	5854.5782	-1823.8012	1.470E-05	584.6600	9.964E+11	277.2797	9852301.	0.000
50.490	-8.215E-05	-209.6397	-462.7560	1.472E-05	584.1401	9.964E+11	167.5063	12479210.	0.000
51.000	7.936E-06	0.000	0.000	1.472E-05	584.1207	9.964E+11	-16.2789	6277059.	0.000

1st neg

max neg

min tip

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 2:

Pile-head deflection	=	0.3361446 inches
Computed slope at pile head	=	0.000000 radians
Maximum bending moment	=	-6177206. inch-lbs
Maximum shear force	=	35600. lbs
Depth of maximum bending moment	=	0.000000 feet below pile head
Depth of maximum shear force	=	13.7700000 feet below pile head
Number of iterations	=	6
Number of zero deflection points	=	2

Summary of Pile Response(s)

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

	Pile-head	Pile-head				Maximum	Maximum

Load Case No.	Load Type No.	Condition 1 V(lbs) or y(inches)	Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Pile-head Deflection inches	Moment in Pile in-lbs	Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 20700.	M = 501600.	892600.	0.64555979	6375890.	-32877.	-0.00261516
2	2	V = 35600.	S = 0.000	1057000.	0.33614456	-6177206.	35600.	0.00000000

The analysis ended normally.

HQ: 3015 DUMBARTON ROAD RICHMOND, VIRGINIA 23228 T 804.264.2701 F 804.264.1202 www.fandr.com

VIRGINIA • NORTH CAROLINA • SOUTH CAROLINA • MARYLAND • DISTRICT OF COLUMBIA