GEOTECHNICAL CALCULATION PACKAGE
EASTPORT BREAKWATER FACILITY
MAINE DOT PIN 18436.00
EASTPORT, MAINE

PREPARED FOR:
Childs Engineering Corporation, Inc.
Bellingham, Massachusetts

PREPARED BY:
GZA GeoEnvironmental, Inc.
Providence, Rhode Island

July 2014
File No. 33940.00

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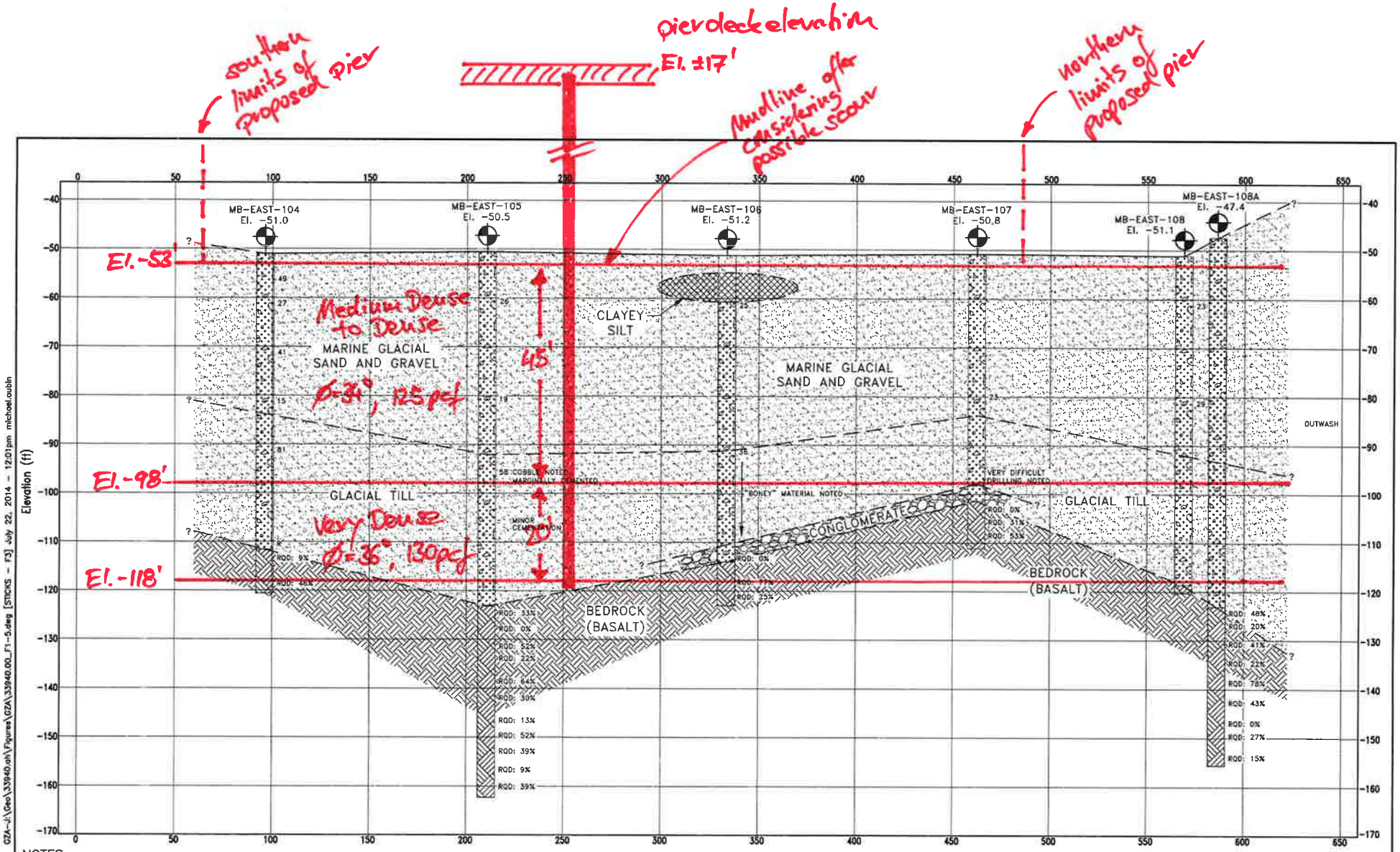
FIGURES

DESIGN SOIL PROFILE
PILE DESIGN LOADS



NOTES:

1) THIS GENERALIZED INTERPRETIVE SOIL PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDRIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED, AND HAVE BEEN DEVELOPED BY INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS AND SAMPLES. ACTUAL SOIL TRANSACTIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO THE EXPLORATION LOGS.

2) THE LOCATION AND ELEVATION OF THE BORINGS WERE LOCATED USING OPTICAL SURVEY METHODS AND SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHODS USED.

3) BORINGS WERE PERFORMED BY MAINE TEST BORINGS, INC OF HERMON, MAINE BETWEEN MAY 28, 2013 AND JUNE 17, 2013 AND OBSERVED BY SCHONEWALD ENGINEERING ASSOCIATES.

4) UNLESS SPECIFICALLY STATED BY WRITTEN AGREEMENT, THIS DRAWING IS THE SOLE PROPERTY OF GZA GEOENVIRONMENTAL, INC. (GZA). THE INFORMATION SHOWN ON THE DRAWING IS SOLELY FOR USE BY GZA'S CLIENT OR THE CLIENT'S DESIGNATED REPRESENTATIVE FOR THE SPECIFIC PROJECT AND LOCATION IDENTIFIED ON THE DRAWING. THE DRAWING SHALL NOT BE TRANSFERRED, REUSED, COPIED, OR ALTERED IN ANY MANNER FOR USE AT ANY OTHER LOCATION OR FOR ANY OTHER PURPOSE WITHOUT THE PRIOR WRITTEN CONSENT OF GZA. ANY TRANSFER, REUSE, OR MODIFICATION TO THE DRAWING BY THE CLIENT OR OTHERS, WITHOUT THE PRIOR WRITTEN EXPRESS CONSENT OF GZA, WILL BE AT THE USER'S SOLE RISK AND WITHOUT ANY RISK OR LIABILITY TO GZA.

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LEGEND:

MB-EAST-109 — INDICATES BOREHOLE DESIGNATION
El. -38.8 — INDICATES APPROXIMATE GROUND SURFACE ELEVATION (NAVD88)

OUTWASH — 23 — INDICATES STANDARD PENETRATION TEST VALUE (SPT)

BEDROCK — RQD: 27% — INDICATES ROCK QUALITY DESIGNATION (RQD)

Prepared By: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com	Eastport Breakwater Replacement Eastport, Maine Maine Department of Transportation	Project No.: 33940.00 File Name: 33940.00_F1-5_R0.dwg	
Project Mgr.: AH Designed By: SMF Reviewed By: CLS Drawn By: SBB Revision No.: 1 Date: 7/21/14	Title: INTERPRETIVE SUBSURFACE - PROFILE A-A'	Figure No.: 3	

SOIL DESIGN PROFILE AH 7/22/14

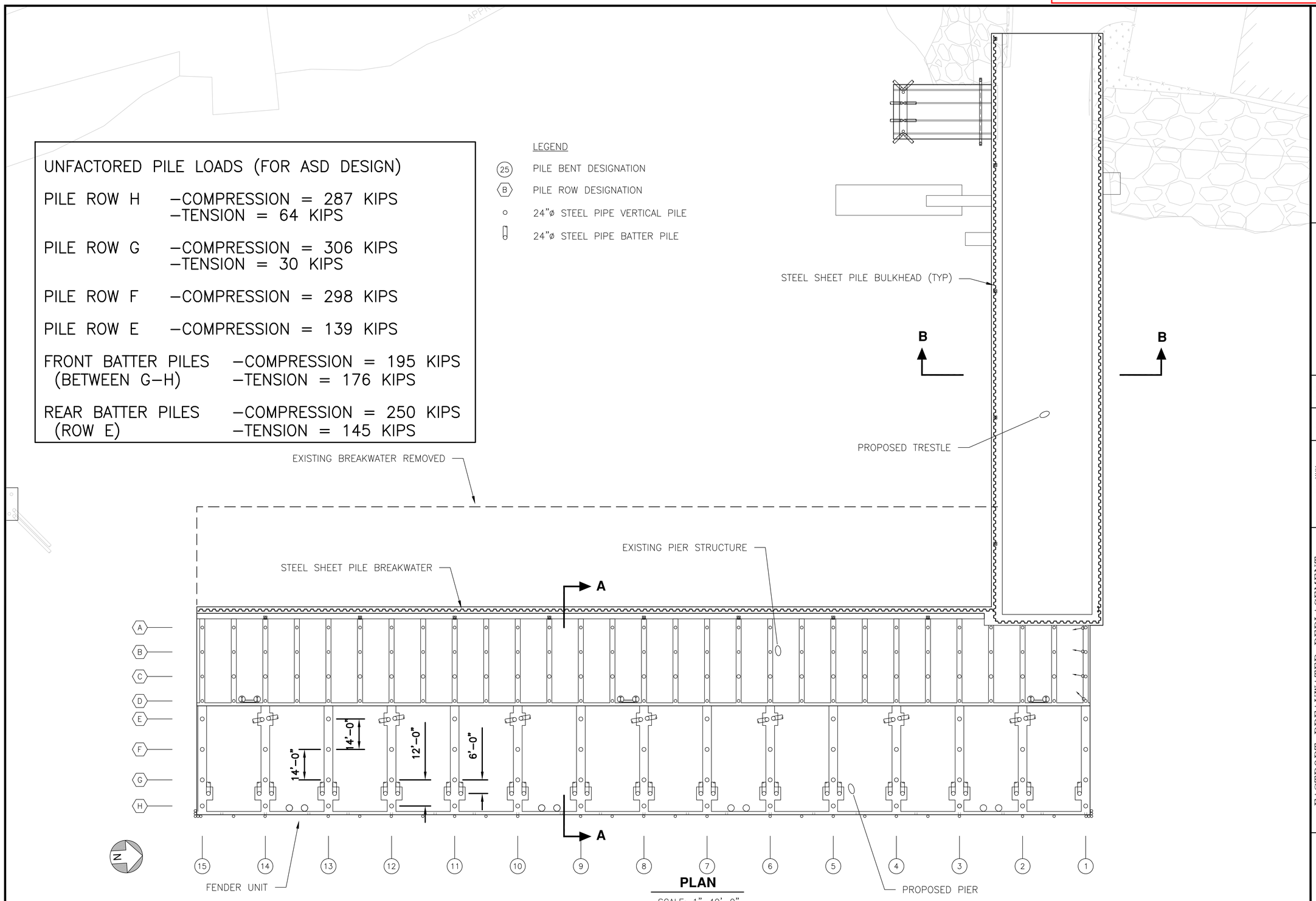
UNFACTORED PILE LOADS
PROVIDED BY CEC 11/06/2013

UNFACTORED PILE LOADS (FOR ASD DESIGN)

PILE ROW H	–COMPRESSION = 287 KIPS –TENSION = 64 KIPS	
PILE ROW G	–COMPRESSION = 306 KIPS –TENSION = 30 KIPS	
PILE ROW F	–COMPRESSION = 298 KIPS	
PILE ROW E	–COMPRESSION = 139 KIPS	
FRONT BATTER PILES (BETWEEN G–H)	–COMPRESSION = 195 KIPS –TENSION = 176 KIPS	
REAR BATTER PILES (ROW E)	–COMPRESSION = 250 KIPS –TENSION = 145 KIPS	

LEGEND

- (25) PILE BENT DESIGNATION
- (B) PILE ROW DESIGNATION
- ○ 24"ø STEEL PIPE VERTICAL PILE
- 24"ø STEEL PIPE BATTER PILE



PLAN
SCALE: 1"=40'–0"

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BR-1669(600)S

PIN 16696.00

BRIDGE NO. 3257

BRIDGE PLANS

PROJ. MANAGER	XXX		
DESIGN-DETAILED	ECL	XXX	5-09
CHECKED-REVIEWED			5-09
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

EASTPORT BREAKWATER REPLACEMENT
EASTPORT, ME
WASHINGTON COUNTY

CONCEPT DESIGN #4
PILE/PILE CAP PLAN

SHEET NUMBER

Sk-10

APPENDIX A

SOIL-SPRING CONSTANTS

GZA
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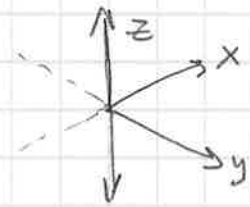
Engineers and Scientists

JOB EASTPORT 33940
SHEET NO. 1 OF 7
CALCULATED BY JJM DATE 8/20/13
CHECKED BY MJP DATE 7/23/14
SCALE

CALCULATION OF SOIL-SPRING CONSTANTS

↳ CALCULATE K FOR CBC INPUT INTO STADD USING "LOCAL" COORDINATES → LENGTH ALONG PILE NOT DEPTH

TWO K VALUES NEEDED (x-y) (LATERAL) & (z) (VERTICAL)



① LATERAL K ⇒ L-PILE MODEL: FIXED HEAD, BATTER INPUT, NO LOAD USED, P-y CURVE GENERATED FOR SOIL PROFILE PER FOOT OF PILE FOR 20" x 0.625" VERTICAL AND 1/4 BATTER

$$K = \frac{\Delta x P}{y} \Rightarrow \Delta x = 12''$$

P = load

② VERTICAL K ⇒ A-PILE MODEL: PILE DIA (20") INPUT SKIN FRICTION & END BEARING LIMITED AT 20B (See other calc), t-z CURVE GENERATED per length of pile

$$K = \frac{t(\pi D \Delta x)}{z} \Rightarrow \Delta x = 12''$$

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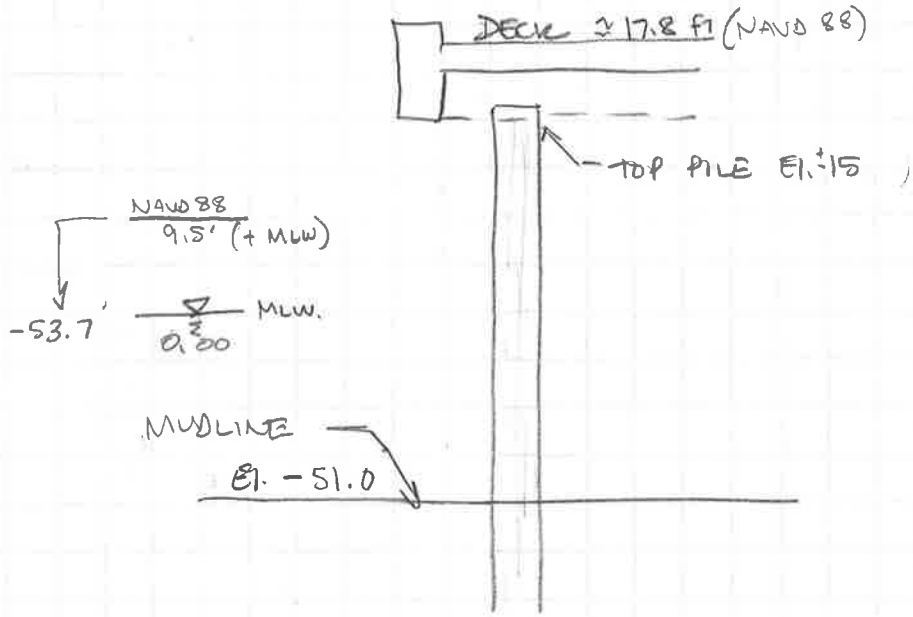
SOIL SPRING CONSTANT CALCULATIONS - SOIL PROFILE

1. 24" OD PIPE PILE, 0.625" WALL, 50 ksi, CONCRETE FILL, 4000 psi

2. SOIL PROPERTIES
   - STG 1 (M. DENSE - DENSE)
     $\gamma_b = 125 - 64$ pcf $= 61$ pcf, $\phi = 34°$
   - STG 2 (DENSE - V. DENSE)
     $\gamma_b = 130 - 64$ pcf $= 66$ pcf $\phi = 36°$
   - BEDROCK $\gamma_b = 160 - 64 = 96$ pcf $q_u = 20$ ksi

3. DATUM
   - ORIGINAL BORINGS & PLANS M.L.W
   - NEW BORINGS NAVD 88



±68 FT TO MUDLINE
+ 2 FT SCOUR
70 FT TO MUD

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4. SOIL PROFILES

A-A' (DEEP)

-51 MUDLINE

(2) -53 SCOUR

45' M. DENSE – DENSE SAND & GRAVEL $\gamma' = 125 - 64 = 61$ pcf, $\phi = 34°$

-98

20' DENSE – V. DENSE S+G $\gamma' = 130 - 64 = 66$ pcf, $\phi = 36°$

-118

20' ROCK

-138

5. LOADING CONDITIONS

↳ FIXED HEAD

PIER PILES: 20" OD x 0.625" VERTICAL
20" OD x 0.625" 3/12

610 kip ↓
210 kips ↑ VERTICAL

400 kip ↓
320 kip ↑ BATTER

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SOIL SPRING CONSTANTS

DEVELOP SOIL-SPRING CONSTANTS FOR 20 x 0.625" PILES

↳ WORST CASE CONDITIONS — VERTICAL: 305 kips COMPRESSION
65 kips TENSION

BATER (3:12): 245 kips COMPRESSION
180 kips TENSION

↳ MODEL IN L-PILE (P-y)

- FIXED HEAD, VERTICAL OR BATTER, SOIL SPRING CONSTANT GENERATED PER FOOT OF PILE (# of INCREMENTS = LENGTH)
- ADJUST LENGTH OF BATTER TO MEET ROCK

$$K = \frac{P}{y(\Delta x)} \Rightarrow \Delta x = 12'' \rightarrow \text{LPILE OUTPUT REPORT}$$

↳ MODEL IN A-PILE

- 20" DIA PILE → LIMIT SKIN FRICTION & END BEARING AT 20B
- FOLLOW NAVFAC DM 7.02 FOR INPUT

$$\sigma'_{v_0} \text{ AT } 20B = (125\,pcf - 64\,pcf)\left(20 \times 20''/12''/ft\right) = 2033\,psf$$

LIMITING END BEARING (t-z CURVES)

SAND 1: $\phi = 34°$, $N_q = 42$

$$Q_{END_1} = 2033\,psf\,(42)\,\frac{\pi\left(\frac{20}{12}\right)^2}{4} = 186.2\,kips \Rightarrow 85386\,psf$$

SAND 2: $\phi = 36°$, $N_q = 62$

$$Q_{END_2} = 2033\,psf\,(62)\,\frac{\pi\left(\frac{20}{12}\right)^2}{4} = 274.9\,kips \Rightarrow 126046\,psf$$

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SHEET NO. 5 OF 7
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SCALE

SAND 3 (ROCK) $\phi = 45°$, $N_q = 145$

↳ $Q_{SAND_3} = 2033 \text{ psf} \times 145 = 294785 \text{ psf}$

LIMITING SKIN FRICTION (t-z CURVES)

$K_{HC} = 1.0$ FOR DRIVEN DISPLACEMENT PILES

$\delta = 20°$ FOR STEEL PIPE PILES

$Q_s = (1.0)(2033 \text{ psf}) \tan(20°)(\pi \times \frac{20}{12} \times 65' \text{ INTO GROUND})$

$Q_s = 251.8 \text{ kips} = 739 \text{ lbs/ft}^2$ FOR SAND 1, 2, & 3

↳ A-PILE t-z CURVES

↳ $K = \frac{t(\pi D \Delta x)}{z}$ $\Delta x = 12''$, $t = \text{psi}$

↳ $A_s = \frac{\pi(\frac{20}{12})^2}{4} - \frac{\pi(\frac{18.75}{12})^2}{4} = 0.264 \text{ ft}^2 = 38 \text{ in}^2$

↳ TAKE POINT ON t-z CURVE WHERE IT LEVELS OFF (ie third from bottom in APILE REPORT)
USE API RP 2A METHOD

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END BEARING / TIP RESISTANCE (Q-W CURVES)

↳ ASSUME ALL PILES DRIVEN TO ROCK, N_q ROCK = 145 for $\phi = 40°$

↳ $\gamma_{BUOYANT} = 66$ pcf (ROCK)

↳ PILE TIP AT 65' FOR DEEP PROFILE

$$q_{max} = \gamma'_b N_q z = (66\,pcf)(145)(65') = 193{,}050\ psf$$
(1.34 ksi)

$$Q = (4 \cdot z)^{1/3}\, q_{max}$$

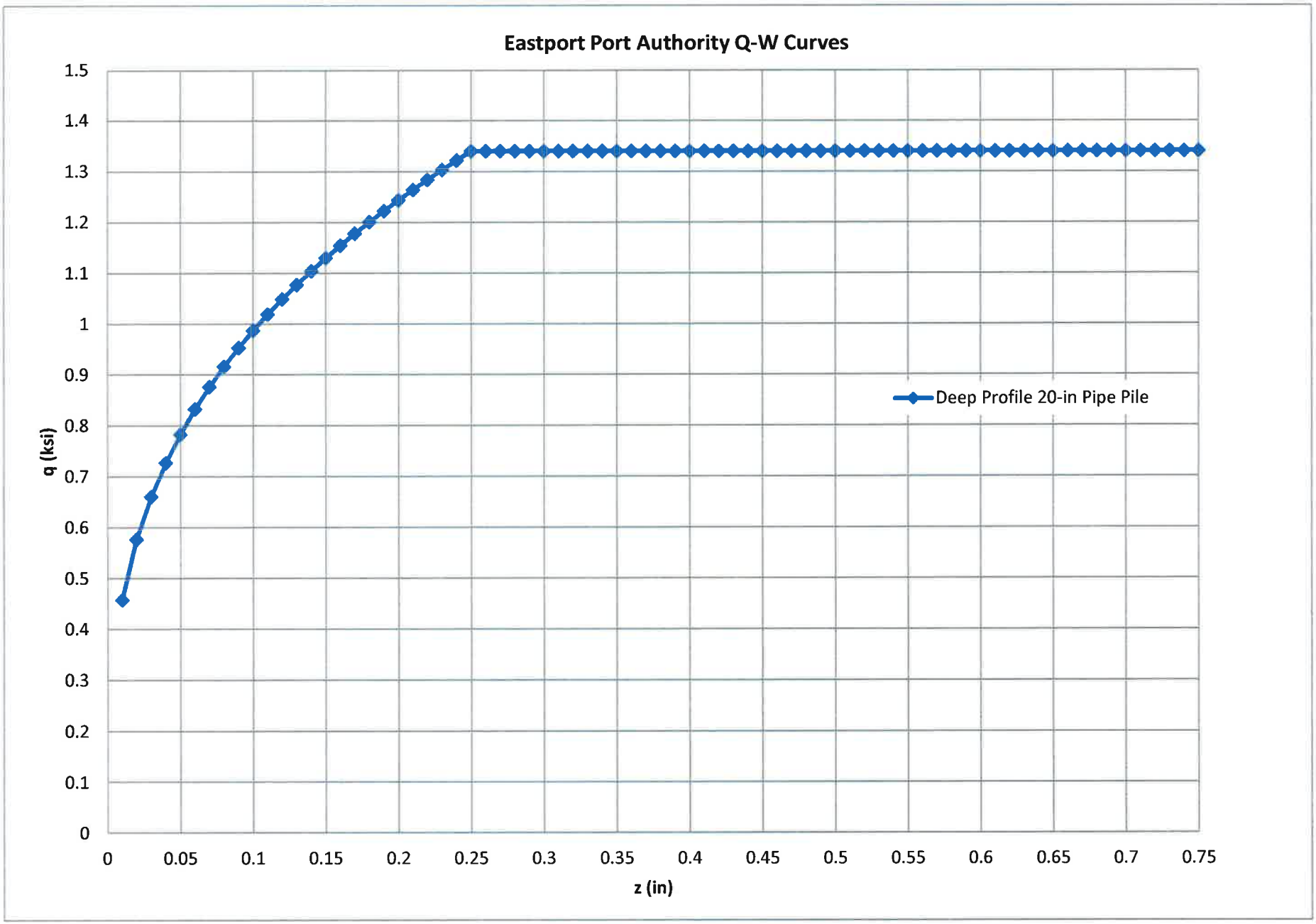
$$Q = (4 \cdot z)^{1/3}(1.34)$$

FOR $z = 0.01 - 0.75''$
(PLUG INTO EXCEL, FIND Q AND K)

SOIL SPRING CONSTANTS (CHECK)

$$K = \frac{Q\left(\frac{\pi d^2}{4}\right)}{z} \Rightarrow K = \frac{1.34\left(\frac{\pi(20)^2}{4}\right)}{0.25''} = 1683\ kips/in$$

AT PILE TIP


Eastport Port Authority Q-W Curves
q (ksi)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
z (in)
Deep Profile 20-in Pipe Pile

SOIL SPRING CONSTANT
TABLES

SOIL SPRING CONSTANTS - 20-inch PIPE PILE
LATERAL (p-y)

Length Along Pile (ft)	Profile A-A (deep)	
	Soil-Spring Constant, k (kips/in)	
	20 in vert	20 in 1:4 batter
20	0	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0
26	0	0
27	0	0
28	0	0
29	0	0
30	0	0
31	0	0
32	0	0
33	0	0
34	0	0
35	0	0
36	0	0
37	0	0
38	0	0
39	0	0
40	0	0
41	0	0
42	0	0
43	0	0
44	0	0
45	0	0
46	0	0
47	0	0
48	0	0
49	0	0
50	0	0
51	0	0
52	0	0
53	0	0
54	0	0
55	0	0
56	0	0
57	0	0
58	0	0
59	0	0
60	0	0
61	0	0

SOIL SPRING CONSTANTS - 20-inch PIPE PILE
LATERAL (p-y)

Length Along Pile (ft)	Profile A-A (deep)	
	Soil-Spring Constant, k (kips/in)	
	20 in vert	20 in 1:4 batter
62	0	0
63	0	0
64	0	0
65	0	0
66	0	0
67	0	0
68	0	0
69	0	0
70	0	0
71	163	0
72	18326	0
73	27489	4650
74	36653	12083
75	45816	20701
76	54979	29854
77	64142	37421
78	73305	41586
79	82468	39013
80	91631	52204
81	100795	73611
82	109958	87639
83	119121	96529
84	128284	105420
85	137447	114311
86	146610	123202
87	155773	132093
88	164936	140984
89	174100	149875
90	183263	158766
91	192426	167657
92	201589	176548
93	210752	185439
94	219915	194330
95	229078	203221
96	238242	212112
97	247405	221003
98	256568	229894
99	265731	238785
100	274894	247676
101	284057	256567
102	293220	265458
103	302384	274349

SOIL SPRING CONSTANTS - 20-inch PIPE PILE
LATERAL (p-y)

Length Along Pile (ft)	Profile A-A (deep)	
	Soil-Spring Constant, k (kips/in)	
	20 in vert	20 in 1:4 batter
104	311547	283240
105	320710	292130
106	329873	301021
107	339036	309912
108	348199	318803
109	357362	327694
110	366526	336585
111	375689	345476
112	384852	354367
113	394015	363258
114	403178	372149
115	429465	381040
116	516881	389931
117	529569	398822
118	542258	407713
119	554946	447810
120	567634	460121
121	580322	472432
122	593011	484744
123	605699	497055
124	618387	509366
125	631075	521678
126	643763	533989
127	656452	546300
128	669140	558612
129	681828	570923
130	694516	583234
131	707205	595546
132	719893	607857
133	732581	620168
134	745269	632480
135	378979	644791
136		657102
137		669414
138		681725
139		347018

SOIL SPRING CONSTANTS - 20-inch PIPE PILE
VERTICAL (t-z)

Length Along Pile (ft)	Profile A-A (deep)	
	Soil-Spring Constant, k (kips/in)	
	20 in vert	20 in 1:4 batter
20	0	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0
26	0	0
27	0	0
28	0	0
29	0	0
30	0	0
31	0	0
32	0	0
33	0	0
34	0	0
35	0	0
36	0	0
37	0	0
38	0	0
39	0	0
40	0	0
41	0	0
42	0	0
43	0	0
44	0	0
45	0	0
46	0	0
47	0	0
48	0	0
49	0	0
50	0	0
51	0	0
52	0	0
53	0	0
54	0	0
55	0	0
56	0	0
57	0	0
58	0	0
59	0	0
60	0	0
61	0	0

SOIL SPRING CONSTANTS - 20-inch PIPE PILE
VERTICAL (t-z)

Length Along Pile (ft)	Profile A-A (deep)	
	Soil-Spring Constant, k (kips/in)	
	20 in vert	20 in 1:4 batter
62	0	0
63	0	0
64	0	0
65	0	0
66	0	0
67	0	0
68	0	0
69	0	0
70	0	0
71	1.3	0
72	3.5	0
73	5.3	1.3
74	7.1	3.5
75	8.9	5.3
76	10.6	7.1
77	12.4	8.9
78	14.2	10.6
79	15.9	12.4
80	17.7	14.2
81	19.5	15.9
82	21.2	17.7
83	23.0	19.5
84	24.8	21.2
85	26.6	23.0
86	28.3	24.8
87	30.1	26.6
88	31.9	28.3
89	33.6	30.1
90	35.4	31.9
91	37.2	33.6
92	38.4	35.4
93	38.7	37.2
94	38.7	38.4
95	38.7	38.7
96	38.7	38.7
97	38.7	38.7
98	38.7	38.7
99	38.7	38.7
100	38.7	38.7
101	38.7	38.7
102	38.7	38.7
103	38.7	38.7

SOIL SPRING CONSTANTS - 20-inch PIPE PILE
VERTICAL (t-z)

Length Along Pile (ft)	Profile A-A (deep)	
	Soil-Spring Constant, k (kips/in)	
	20 in vert	20 in 1:4 batter
104	38.7	38.7
105	38.7	38.7
106	38.7	38.7
107	38.7	38.7
108	38.7	38.7
109	38.7	38.7
110	38.7	38.7
111	38.7	38.7
112	38.7	38.7
113	38.7	38.7
114	38.7	38.7
115	38.7	38.7
116	38.7	38.7
117	38.7	38.7
118	38.7	38.7
119	38.7	38.7
120	38.7	38.7
121	38.7	38.7
122	38.7	38.7
123	38.7	38.7
124	38.7	38.7
125	38.7	38.7
126	38.7	38.7
127	38.7	38.7
128	38.7	38.7
129	38.7	38.7
130	38.7	38.7
131	38.7	38.7
132	38.7	38.7
133	38.7	38.7
134	38.7	38.7
135	38.7	38.7
136		38.7
137		38.7
138		38.7
139		38.7
140		
141		
142		
143		
144		
145		

SOIL SPRING CONSTANTS - 20-inch PIPE PILE
TIP (Q-w)

Length Along Pile (ft)	Profile A-A (deep)	
	Soil-Spring Constant, k (kips/in)	
	20 in vert	20 in 1:4 batter
61	0	0
62	0	0
63	0	0
64	0	0
65	0	0
66	0	0
67	0	0
68	0	0
69	0	0
70	0	0
71	0	0
72	0	0
73	0	0
74	0	0
75	0	0
76	0	0
77	0	0
78	0	0
79	0	0
80	0	0
81	0	0
82	0	0
83	0	0
84	0	0
85	0	0
86	0	0
87	0	0
88	0	0
89	0	0
90	0	0
91	0	0
92	0	0
93	0	0
94	0	0
95	0	0
96	0	0
97	0	0
98	0	0
99	0	0
100	0	0
101	0	0
102	0	0

SOIL SPRING CONSTANTS - 20-inch PIPE PILE
TIP (Q-w)

Length Along Pile (ft)	Profile A-A (deep)	
	Soil-Spring Constant, k (kips/in)	
	20 in vert	20 in 1:4 batter
103	0	0
104	0	0
105	0	0
106	0	0
107	0	0
108	0	0
109	0	0
110	0	0
111	0	0
112	0	0
113	0	0
114	0	0
115	0	0
116	0	0
117	0	0
118	0	0
119	0	0
120	0	0
121	0	0
122	0	0
123	0	0
124	0	0
125	0	0
126	0	0
127	0	0
128	0	0
129	0	0
130	0	0
131	0	0
132	0	0
133	0	0
134	0	0
135	0	0
136	1683	0
137		0
138		0
139		1683

L-PILE OUTPUT

20-INCH PIPE PILE

VERTICAL

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

                    LPile Plus for Windows, Version 6 (6.0.28)

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

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

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James Marsland
GZA GeoEnvironmental, Inc.

Serial Number of Security Device:        361883089
Company Name Stored in Security Device:  GZA GeoEnvironmental, Inc.

------------------------------------------------------------------------------
                            Files Used for Analysis
------------------------------------------------------------------------------

Path to file locations:        J:\Geo\33940.ah\Work\Calcs\LPile\
Name of input data file:       33940.00_PROFILE_A-A_20-inch_vert.lp6d
Name of output report file:    33940.00_PROFILE_A-A_20-inch_vert.lp6o
Name of plot output file:      33940.00_PROFILE_A-A_20-inch_vert.lp6p
Name of runtime messeage file: 33940.00_PROFILE_A-A_20-inch_vert.lp6r

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

               Date:  October 31, 2013     Time:  16:40:43

------------------------------------------------------------------------------
                                Problem Title
------------------------------------------------------------------------------

Project Name: Eastport Breakwater

Job Number: 33940.00

Client: CEC

Engineer: JJM

Description: 24" vertical pile


------------------------------------------------------------------------------
                              Program Options
------------------------------------------------------------------------------

Engineering units are US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes pile response to lateral loading and will compute nonlinear
moment-curvature and nominal moment capacity for selected section types.

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output pile response for full length of pile
- Analysis assumes no soil movements acting on pile
- No p-y curves to be computed and output for user-specified depths

Solution Control Parameters:
- Number of pile increments                          =          135
- Maximum number of iterations allowed               =          100
- Deflection tolerance for convergence               =   1.0000E-05  in
- Maximum allowable deflection                       =     100.0000  in

Pile Response Output Options:
- 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 Sections                                =          1

Total Pile Length                                       =     135.00 ft

Depth of ground surface below top of pile               =      70.00 ft

Pile dimensions used for p-y curve computations defined using 2 points.
p-y curves are computed using values of pile diameter interpolated over
the length of the pile.

Point         Depth              Pile
                X              Diameter
                ft               in
-----       ---------        -----------
  1          0.00000         20.0000000
  2        135.000000         20.0000000
```

Input Structural Properties:

Pile Section No. 1:

```
   Section Type = Drilled Shaft with Permanent Casing
   Section Length                                        =         135.000 ft
   Pile Width                                            =          20.000 in
```

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 3 layers

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

```
Distance from top of pile to top of layer                =       70.000 ft
Distance from top of pile to bottom of layer             =      115.000 ft
NOTE:  Internal default values for p-y subgrade modulus will be computed for
the above soil layer.
```

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

```
Distance from top of pile to top of layer                =      115.000 ft
Distance from top of pile to bottom of layer             =      135.000 ft
NOTE:  Internal default values for p-y subgrade modulus will be computed for
the above soil layer.
```

Layer 3 is strong rock (vuggy limestone)

```
Distance from top of pile to top of layer                =      135.000 ft
Distance from top of pile to bottom of layer             =      155.000 ft
```

(Depth of lowest layer extends   20.00 ft below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 6 points

Point No.	Depth X ft	Eff. Unit Weight pcf
1	70.00	61.00000
2	115.00	61.00000
3	115.00	66.00000
4	135.00	66.00000
5	135.00	96.00000
6	155.00	96.00000

Summary of Soil Properties

Layer J Num.	Soil Type (p-y Curve Criteria)	kpy pci	krm psi	Depth Test Type ft	Eff. Unit Wt., pcf	Cohesion Elas. Subgr. psf pci	Friction Ang., deg.	qu psi	RQD percent	Epsilon 50
1	Sand (Reese, et al.)	default	--	70.000	61.000	--	34.000	--	--	--
		default	--	115.000	61.000	--	34.000	--	--	--
2	Sand (Reese, et al.)	default	--	115.000	66.000	--	36.000	--	--	--
		default	--	135.000	66.000	--	36.000	--	--	--
3	Vuggy Limestone	--	--	135.000	96.000	--	--	20000.	--	--
		--	--	155.000	96.000	--	--	20000.	--	--

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 = 1

Load    Load         Condition               Condition            Axial Thrust
 No.    Type             1                       2                 Force, lbs
-----   ----   --------------------   -----------------------   ----------------
   1     2     V =   1000.00000 lbs   S =       0.0000 in/in            305000.

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 = 1

Pile Section No. 1:


Dimensions and Properties of Drilled Shaft with Permanent Casing:
-----------------------------------------------------------------

Length of Section                                    =    135.00000000 ft
Outer Diameter of Casing                             =     20.00000000 in
Concrete Cover Thickness Inside Casing               =      0.0000000 in
Casing Wall Thickness                                =      0.62500000 in
Yield Stress of Casing                               =     45.00000000 ksi
Elastic Modulus of Casing                            =          29000. ksi
Number of Reinforcing Bars                           =              0 bars
Area of Single Reinforcing Bar                       =      0.0000000 sq. in.
Edge-to-Edge Bar Spacing                             =      0.0000000 in
Rebar Offset                                         =      0.0000000 in
Yield Stress of Reinforcing Bars                     =      0.0000000 ksi
Elastic Modulus of Reinforcing Bars                  =          29000. ksi
Area of Concrete                                     =    276.11654182 sq. in.
Cross-sectional Area of Steel Casing                 =     38.04272354 sq. in.
Area of All Steel (Casing and Bars)                  =     38.04272354 sq. in.
Area Ratio of All Steel                              =           13.78 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =        2650.719 kips
Tensile Load for Cracking of Concrete                  =        -114.840 kips
Nominal Axial Tensile Capacity                         =       -1711.923 kips


Reinforcing Bar Dimensions and Positions Used in Computations:

     Bar          Bar Diam.      Bar Area          X              Y
    Number         inches         sq. in.        inches         inches
  ----------     ----------     ----------     ----------     ----------



Concrete Properties:
--------------------

Compressive Strength of Concrete                       =      4.0000000 ksi
Modulus of Elasticity of Concrete                      =   3604.9965326 ksi
Modulus of Rupture of Concrete                         =     -0.4743416 ksi
Compression Strain at Peak Stress                      =      0.0018863
Tensile Strain at Fracture of Concrete                 =     -0.0001154
Maximum Coarse Aggregate Size                          =       0.000000 in


Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                     kips
   ------     ------------------
      1             305.000


Definitions of Run Messages and Notes:
--------------------------------------

   C = concrete in section has cracked in tension.
   Y = stress in reinforcing steel has reached yield stress.
   T = ACI 318-08 criteria for tension-controlled section met, tensile strain in
       reinforcement exceeds 0.005 while simultaneously compressive strain in
       concrete more than than 0.003. See ACI 318-08, Section 10.3.4.
   Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.


Axial Thrust Force =    305.000 kips

    Bending       Bending       Bending       Depth to      Max Comp      Max Tens    Max Concrete   Max Steel     Max Casing   Run
   Curvature      Moment       Stiffness       N Axis        Strain        Strain        Stress        Stress        Stress     Msg
    rad/in.       in-kip        kip-in2          in          in/in         in/in          ksi           ksi           ksi
```

0.000001250	94.6158902	75692712.	119.3289410	0.0001492	0.0001242	0.6071171	0.000000	4.3220491	
0.000002500	189.2312823	75692513.	64.6703125	0.0001617	0.0001117	0.6553393	0.000000	4.6813477	
0.000003750	283.8456780	75692181.	46.4533661	0.0001742	0.0000992	0.7032537	0.000000	5.0409286	
0.000005000	378.4585792	75691716.	37.3468404	0.0001867	0.0000867	0.7508598	0.000000	5.4007919	
0.000006250	473.0694878	75691118.	31.8844828	0.0001993	0.0000743	0.7981565	0.000000	5.7609375	
0.000007500	567.6779054	75690387.	28.2442095	0.0002118	0.0000618	0.8451431	0.000000	6.1213656	
0.000008750	662.2833338	75689524.	25.6451272	0.0002244	0.0000494	0.8918189	0.000000	6.4820761	
0.0000100	756.8852748	75688527.	23.6967893	0.0002370	0.0000370	0.9381829	0.000000	6.8430689	
0.0000113	851.4832299	75687398.	22.1822811	0.0002496	0.0000246	0.9842344	0.000000	7.2043443	
0.0000125	946.0767011	75686136.	20.9714538	0.0002621	0.0000121	1.0299725	0.000000	7.5659020	
0.0000138	1040.6651893	75684741.	19.9814853	0.0002747	-0.000000255	1.0753964	0.000000	7.9277422	
0.0000150	1135.2481560	75683210.	19.1571608	0.0002874	-0.0000126	1.1205054	0.000000	8.2898650	
0.0000163	1229.8200294	75681233.	18.4602390	0.0003000	-0.0000250	1.1652976	0.000000	8.6522627	
0.0000175	1324.3621767	75677839.	17.8633643	0.0003126	-0.0000374	1.2097689	0.000000	9.0149074	
0.0000188	1418.8543662	75672233.	17.3464674	0.0003252	-0.0000498	1.2539146	0.000000	9.3777667	
0.0000200	1513.2796588	75663983.	16.8945021	0.0003379	-0.0000621	1.2977305	0.000000	9.7408113	
0.0000213	1607.6244773	75652917.	16.4959691	0.0003505	-0.0000745	1.3412132	0.000000	10.1040160	
0.0000225	1701.8781820	75639030.	16.1419311	0.0003632	-0.0000868	1.3843596	0.000000	10.4673601	
0.0000238	1796.0324798	75622420.	15.8253375	0.0003759	-0.0000991	1.4271674	0.000000	10.8308263	
0.0000250	1890.0807237	75603229.	15.5405515	0.0003885	-0.0001115	1.4696345	0.000000	11.1943999	
0.0000263	1917.5351945	73048960.	15.1270104	0.0003971	-0.0001279	1.4980422	0.000000	11.4393117	C
0.0000275	1998.7392856	72681429.	14.8690208	0.0004089	-0.0001411	1.5370966	0.000000	11.7782942	C
0.0000288	2079.2654707	72322277.	14.6315975	0.0004207	-0.0001543	1.5756665	0.000000	12.1157195	C
0.0000300	2159.2252713	71974176.	14.4124345	0.0004324	-0.0001676	1.6137822	0.000000	12.4518181	C
0.0000313	2238.6760050	71637632.	14.2094528	0.0004440	-0.0001810	1.6514586	0.000000	12.7866917	C
0.0000325	2317.6737362	71313038.	14.0209032	0.0004557	-0.0001943	1.6887114	0.000000	13.1204514	C
0.0000338	2396.2728058	71000676.	13.8453056	0.0004673	-0.0002077	1.7255568	0.000000	13.4532179	C
0.0000350	2474.5253867	70700725.	13.6814003	0.0004788	-0.0002212	1.7620117	0.000000	13.7851214	C
0.0000363	2552.4169078	70411501.	13.5278892	0.0004904	-0.0002346	1.7980684	0.000000	14.1160686	C
0.0000375	2629.9932562	70133153.	13.3838344	0.0005019	-0.0002481	1.8337412	0.000000	14.4461701	C
0.0000388	2707.3430723	69866918.	13.2485855	0.0005134	-0.0002616	1.8690642	0.000000	14.7757230	C
0.0000400	2784.4587759	69611469.	13.1212799	0.0005249	-0.0002751	1.9040342	0.000000	15.1046848	C
0.0000413	2861.2929512	69364678.	13.0010028	0.0005363	-0.0002887	1.9386286	0.000000	15.4328247	C
0.0000425	2938.0058097	69129548.	12.8876489	0.0005477	-0.0003023	1.9729156	0.000000	15.7607774	C
0.0000438	3014.4395891	68901476.	12.7800878	0.0005591	-0.0003159	2.0068254	0.000000	16.0878615	C
0.0000450	3090.7794719	68683988.	12.6784274	0.0005705	-0.0003295	2.0404392	0.000000	16.4148479	C
0.0000463	3166.8861535	68473214.	12.5817219	0.0005819	-0.0003431	2.0736936	0.000000	16.7411096	C
0.0000475	3242.9273416	68272155.	12.4901213	0.0005933	-0.0003567	2.1066655	0.000000	17.0673923	C
0.0000488	3318.7292432	68076497.	12.4026457	0.0006046	-0.0003704	2.1392721	0.000000	17.3928656	C
0.0000513	3470.0580758	67708450.	12.2402495	0.0006273	-0.0003977	2.2035997	0.000000	18.0434460	C
0.0000538	3620.9537110	67366581.	12.0924217	0.0006500	-0.0004250	2.2667149	0.000000	18.6931875	C
0.0000563	3771.3448933	67046131.	11.9569242	0.0006726	-0.0004524	2.3285766	0.000000	19.3416077	C
0.0000588	3921.3965152	66747175.	11.8326656	0.0006952	-0.0004798	2.3892678	0.000000	19.9895292	C
0.0000613	4071.1411806	66467611.	11.7183748	0.0007178	-0.0005072	2.4488083	0.000000	20.6371384	C
0.0000638	4220.4896070	66203759.	11.6125358	0.0007403	-0.0005347	2.5071429	0.000000	21.2838008	C
0.0000663	4369.6271181	65956636.	11.5148018	0.0007629	-0.0005621	2.5643793	0.000000	21.9306881	C
0.0000688	4518.3970315	65722139.	11.4237332	0.0007854	-0.0005896	2.6204211	0.000000	22.5766933	C
0.0000713	4666.9648968	65501262.	11.3391805	0.0008079	-0.0006171	2.6753689	0.000000	23.2229570	C
0.0000738	4815.2633022	65291706.	11.2602323	0.0008304	-0.0006446	2.7291775	0.000000	23.8689470	C
0.0000763	4963.2968742	65092418.	11.1863515	0.0008530	-0.0006720	2.7818510	0.000000	24.5146950	C
0.0000788	5111.1661884	64903698.	11.1173918	0.0008755	-0.0006995	2.8334511	0.000000	25.1609688	C
0.0000813	5258.7438327	64723001.	11.0524456	0.0008980	-0.0007270	2.8838927	0.000000	25.8067002	C
0.0000838	5406.1117740	64550588.	10.9914365	0.0009205	-0.0007545	2.9332304	0.000000	26.4525767	C
0.0000863	5553.3148190	64386259.	10.9341758	0.0009431	-0.0007819	2.9814919	0.000000	27.0989825	C
0.0000888	5700.3000632	64228733.	10.8801550	0.0009656	-0.0008094	3.0286389	0.000000	27.7454243	C
0.0000913	5847.0318554	64077061.	10.8289797	0.0009881	-0.0008369	3.0746474	0.000000	28.3915628	C
0.0000938	5993.5980736	63931713.	10.7807301	0.0010107	-0.0008643	3.1195763	0.000000	29.0382353	C
0.0000963	6139.9980586	63792188.	10.7351791	0.0010333	-0.0008917	3.1634230	0.000000	29.6854440	C
0.0000988	6286.2104354	63657827.	10.6920440	0.0010558	-0.0009192	3.2061702	0.000000	30.3329663	C
0.0001013	6432.1660339	63527566.	10.6508906	0.0010784	-0.0009466	3.2477689	0.000000	30.9800528	C
0.0001038	6577.9546388	63401972.	10.6119007	0.0011010	-0.0009740	3.2882815	0.000000	31.6276817	C
0.0001063	6723.5755806	63280711.	10.5749224	0.0011236	-0.0010014	3.3277055	0.000000	32.2758551	C
0.0001088	6869.0281850	63163478.	10.5398177	0.0011462	-0.0010288	3.3660381	0.000000	32.9245754	C
0.0001113	7014.3117729	63049993.	10.5064610	0.0011688	-0.0010562	3.4032765	0.000000	33.5738450	C
0.0001138	7159.3595403	62939425.	10.4744808	0.0011915	-0.0010835	3.4393718	0.000000	34.2228188	C
0.0001163	7304.2214659	62832013.	10.4439779	0.0012141	-0.0011109	3.4743592	0.000000	34.8721357	C
0.0001188	7448.9134715	62727692.	10.4149210	0.0012368	-0.0011382	3.5082480	0.000000	35.5220096	C
0.0001213	7593.4348638	62626267.	10.3872215	0.0012595	-0.0011655	3.5410354	0.000000	36.1724430	C
0.0001238	7737.7849442	62527555.	10.3607978	0.0012821	-0.0011929	3.5727185	0.000000	36.8234384	C
0.0001263	7881.9630088	62431390.	10.3355747	0.0013049	-0.0012201	3.6032947	0.000000	37.4749983	C
0.0001288	8025.9683486	62337618.	10.3114831	0.0013276	-0.0012474	3.6327609	0.000000	38.1271254	C
0.0001313	8169.7712043	62245876.	10.2883390	0.0013503	-0.0012747	3.6610951	0.000000	38.7793657	C
0.0001338	8313.3724307	62156056.	10.2660935	0.0013731	-0.0013019	3.6882971	0.000000	39.4317356	C
0.0001363	8456.7998167	62068256.	10.2448103	0.0013959	-0.0013291	3.7143839	0.000000	40.0846822	C
0.0001388	8600.0526345	61982361.	10.2244381	0.0014186	-0.0013564	3.7393524	0.000000	40.7382082	C
0.0001413	8743.1301504	61898267.	10.2049291	0.0014414	-0.0013836	3.7631998	0.000000	41.3923162	C
0.0001438	8886.0316249	61815872.	10.1862390	0.0014643	-0.0014107	3.7859231	0.000000	42.0470091	C
0.0001463	9028.7563127	61735086.	10.1683264	0.0014871	-0.0014379	3.8075194	0.000000	42.7022896	C
0.0001488	9171.3034628	61655822.	10.1511527	0.0015100	-0.0014650	3.8279855	0.000000	43.3581605	C
0.0001588	9733.3123754	61312204.	10.0912503	0.0016020	-0.0015730	3.8987122	0.000000	45.0000000	CY
0.0001688	10178.	60316075.	10.0420727	0.0016946	-0.0016804	3.9511059	0.000000	45.0000000	CY
0.0001788	10494.	58707550.	9.9876213	0.0017853	-0.0017897	3.9841177	0.000000	45.0000000	CY
0.0001888	10741.	56905289.	9.9338906	0.0018750	-0.0019000	3.9989798	0.000000	45.0000000	CY
0.0001988	10943.	55058576.	9.8825556	0.0019642	-0.0020108	3.9994809	0.000000	45.0000000	CY
0.0002088	11111.	53225118.	9.8334553	0.0020527	-0.0021223	3.9994846	0.000000	45.0000000	CY
0.0002188	11253.	51444201.	9.7873654	0.0021410	-0.0022340	3.9990110	0.000000	45.0000000	CY
0.0002288	11375.	49724755.	9.7450262	0.0022292	-0.0023458	3.9999999	0.000000	45.0000000	CY
0.0002388	11479.	48078724.	9.7056847	0.0023172	-0.0024578	3.9994226	0.000000	45.0000000	CY
0.0002488	11570.	46511416.	9.6690720	0.0024052	-0.0025698	3.9999865	0.000000	45.0000000	CY
0.0002588	11648.	45017678.	9.6347542	0.0024930	-0.0026820	3.9981874	0.000000	45.0000000	CY
0.0002688	11717.	43599781.	9.6033222	0.0025809	-0.0027941	3.9989194	0.000000	45.0000000	CY
0.0002788	11778.	42254419.	9.5744422	0.0026689	-0.0029061	3.9992534	0.000000	45.0000000	CY
0.0002888	11832.	40977856.	9.5477568	0.0027569	-0.0030181	3.9993262	0.000000	45.0000000	CY
0.0002988	11880.	39766483.	9.5229515	0.0028450	-0.0031300	3.9991704	0.000000	45.0000000	CY
0.0003088	11923.	38615829.	9.5001164	0.0029332	-0.0032418	3.9987206	0.000000	45.0000000	CY
0.0003188	11960.	37522074.	9.4786282	0.0030213	-0.0033537	3.9977904	0.000000	45.0000000	CY
0.0003288	11994.	36483511.	9.4584113	0.0031095	-0.0034655	3.9978659	0.000000	45.0000000	CY
0.0003388	12024.	35495633.	9.4399492	0.0031978	-0.0035772	3.9998961	0.000000	45.0000000	CY
0.0003488	12051.	34555677.	9.4231732	0.0032863	-0.0036887	3.9990007	0.000000	45.0000000	CY
0.0003588	12076.	33660580.	9.4070929	0.0033748	-0.0038002	3.9967095	0.000000	45.0000000	CY
0.0003688	12097.	32806052.	9.3925478	0.0034635	-0.0039115	3.9999208	0.000000	45.0000000	CY
0.0003788	12117.	31992577.	9.3790205	0.0035523	-0.0040227	3.9983473	0.000000	45.0000000	CY
0.0003888	12135.	31214209.	9.3665989	0.0036413	-0.0041337	3.9982382	0.000000	45.0000000	CY
0.0003988	12150.	30471308.	9.3549683	0.0037303	-0.0042447	3.9989813	0.000000	45.0000000	CY
0.0004088	12165.	29760656.	9.3444221	0.0038195	-0.0043555	3.9961949	0.000000	45.0000000	CY

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	305.000	11951.089	0.00300000

Note note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318-08, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are spirals or tied hoops.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318-08, Section 9.3.2.2 or the value required by the design standard being followed.

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

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

Shear force at pile head = 1000.000 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 305000.000 lbs

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

Depth X inches	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	1.5280	-709985.	1000.0000	0.000	0.000	7.569E+10	0.000	0.000	0.000
12.000	1.5273	-697779.	1000.0000	-0.000112	0.000	7.569E+10	0.000	0.000	0.000
24.000	1.5253	-685168.	1000.0000	-0.000221	0.000	7.569E+10	0.000	0.000	0.000
36.000	1.5220	-672160.	1000.0000	-0.000329	0.000	7.569E+10	0.000	0.000	0.000
48.000	1.5174	-658761.	1000.0000	-0.000434	0.000	7.569E+10	0.000	0.000	0.000
60.000	1.5116	-644980.	1000.0000	-0.000538	0.000	7.569E+10	0.000	0.000	0.000
72.000	1.5045	-630825.	1000.0000	-0.000639	0.000	7.569E+10	0.000	0.000	0.000
84.000	1.4963	-616304.	1000.0000	-0.000738	0.000	7.569E+10	0.000	0.000	0.000
96.000	1.4868	-601426.	1000.0000	-0.000834	0.000	7.569E+10	0.000	0.000	0.000
108.000	1.4762	-586198.	1000.0000	-0.000928	0.000	7.569E+10	0.000	0.000	0.000
120.000	1.4645	-570630.	1000.0000	-0.001020	0.000	7.569E+10	0.000	0.000	0.000
132.000	1.4518	-554731.	1000.0000	-0.001109	0.000	7.569E+10	0.000	0.000	0.000
144.000	1.4379	-538510.	1000.0000	-0.001196	0.000	7.569E+10	0.000	0.000	0.000
156.000	1.4231	-521977.	1000.0000	-0.001280	0.000	7.569E+10	0.000	0.000	0.000
168.000	1.4072	-505141.	1000.0000	-0.001361	0.000	7.569E+10	0.000	0.000	0.000
180.000	1.3904	-488012.	1000.0000	-0.001440	0.000	7.569E+10	0.000	0.000	0.000
192.000	1.3726	-470599.	1000.0000	-0.001516	0.000	7.569E+10	0.000	0.000	0.000
204.000	1.3540	-452914.	1000.0000	-0.001589	0.000	7.569E+10	0.000	0.000	0.000
216.000	1.3345	-434965.	1000.0000	-0.001660	0.000	7.569E+10	0.000	0.000	0.000
228.000	1.3142	-416765.	1000.0000	-0.001727	0.000	7.569E+10	0.000	0.000	0.000
240.000	1.2930	-398322.	1000.0000	-0.001792	0.000	7.569E+10	0.000	0.000	0.000
252.000	1.2712	-379649.	1000.0000	-0.001853	0.000	7.569E+10	0.000	0.000	0.000
264.000	1.2486	-360755.	1000.0000	-0.001912	0.000	7.569E+10	0.000	0.000	0.000
276.000	1.2253	-341651.	1000.0000	-0.001968	0.000	7.569E+10	0.000	0.000	0.000
288.000	1.2013	-322350.	1000.0000	-0.002021	0.000	7.569E+10	0.000	0.000	0.000
300.000	1.1768	-302861.	1000.0000	-0.002070	0.000	7.569E+10	0.000	0.000	0.000
312.000	1.1516	-283197.	1000.0000	-0.002117	0.000	7.569E+10	0.000	0.000	0.000
324.000	1.1260	-263368.	1000.0000	-0.002160	0.000	7.569E+10	0.000	0.000	0.000
336.000	1.0998	-243387.	1000.0000	-0.002200	0.000	7.569E+10	0.000	0.000	0.000
348.000	1.0732	-223264.	1000.0000	-0.002237	0.000	7.569E+10	0.000	0.000	0.000
360.000	1.0461	-203012.	1000.0000	-0.002271	0.000	7.569E+10	0.000	0.000	0.000
372.000	1.0187	-182642.	1000.0000	-0.002301	0.000	7.569E+10	0.000	0.000	0.000
384.000	0.9909	-162166.	1000.0000	-0.002329	0.000	7.569E+10	0.000	0.000	0.000
396.000	0.9628	-141596.	1000.0000	-0.002353	0.000	7.569E+10	0.000	0.000	0.000
408.000	0.9344	-120944.	1000.0000	-0.002374	0.000	7.569E+10	0.000	0.000	0.000
420.000	0.9058	-100221.	1000.0000	-0.002391	0.000	7.569E+10	0.000	0.000	0.000
432.000	0.8770	-79441.	1000.0000	-0.002405	0.000	7.569E+10	0.000	0.000	0.000
444.000	0.8481	-58614.	1000.0000	-0.002416	0.000	7.569E+10	0.000	0.000	0.000
456.000	0.8190	-37753.	1000.0000	-0.002424	0.000	7.569E+10	0.000	0.000	0.000
468.000	0.7899	-16871.	1000.0000	-0.002428	0.000	7.569E+10	0.000	0.000	0.000
480.000	0.7608	4021.6499	1000.0000	-0.002429	0.000	7.569E+10	0.000	0.000	0.000
492.000	0.7316	24912.	1000.0000	-0.002427	0.000	7.569E+10	0.000	0.000	0.000
504.000	0.7025	45787.	1000.0000	-0.002421	0.000	7.569E+10	0.000	0.000	0.000
516.000	0.6735	66636.	1000.0000	-0.002412	0.000	7.569E+10	0.000	0.000	0.000
528.000	0.6446	87447.	1000.0000	-0.002400	0.000	7.569E+10	0.000	0.000	0.000
540.000	0.6159	108206.	1000.0000	-0.002385	0.000	7.569E+10	0.000	0.000	0.000
552.000	0.5874	128903.	1000.0000	-0.002366	0.000	7.569E+10	0.000	0.000	0.000
564.000	0.5591	149525.	1000.0000	-0.002344	0.000	7.569E+10	0.000	0.000	0.000
576.000	0.5311	170060.	1000.0000	-0.002319	0.000	7.569E+10	0.000	0.000	0.000
588.000	0.5035	190497.	1000.0000	-0.002290	0.000	7.569E+10	0.000	0.000	0.000
600.000	0.4762	210823.	1000.0000	-0.002258	0.000	7.569E+10	0.000	0.000	0.000
612.000	0.4493	231027.	1000.0000	-0.002223	0.000	7.569E+10	0.000	0.000	0.000
624.000	0.4228	251096.	1000.0000	-0.002185	0.000	7.569E+10	0.000	0.000	0.000
636.000	0.3968	271020.	1000.0000	-0.002144	0.000	7.569E+10	0.000	0.000	0.000
648.000	0.3714	290787.	1000.0000	-0.002099	0.000	7.569E+10	0.000	0.000	0.000
660.000	0.3465	310385.	1000.0000	-0.002051	0.000	7.569E+10	0.000	0.000	0.000
672.000	0.3221	329803.	1000.0000	-0.002001	0.000	7.569E+10	0.000	0.000	0.000
684.000	0.2984	349030.	1000.0000	-0.001947	0.000	7.569E+10	0.000	0.000	0.000
696.000	0.2754	368054.	1000.0000	-0.001890	0.000	7.569E+10	0.000	0.000	0.000
708.000	0.2531	386864.	1000.0000	-0.001830	0.000	7.569E+10	0.000	0.000	0.000
720.000	0.2315	405450.	1000.0000	-0.001767	0.000	7.569E+10	0.000	0.000	0.000
732.000	0.2107	423801.	1000.0000	-0.001702	0.000	7.569E+10	0.000	0.000	0.000

744.000	0.1907	441905.	1000.0000	-0.001633	0.000	7.569E+10	0.000	0.000	0.000
756.000	0.1715	459754.	1000.0000	-0.001561	0.000	7.569E+10	0.000	0.000	0.000
768.000	0.1532	477335.	1000.0000	-0.001487	0.000	7.569E+10	0.000	0.000	0.000
780.000	0.1358	494640.	1000.0000	-0.001410	0.000	7.569E+10	0.000	0.000	0.000
792.000	0.1193	511658.	1000.0000	-0.001330	0.000	7.569E+10	0.000	0.000	0.000
804.000	0.1039	528378.	1000.0000	-0.001248	0.000	7.569E+10	0.000	0.000	0.000
816.000	0.0894	544792.	1000.0000	-0.001163	0.000	7.569E+10	0.000	0.000	0.000
828.000	0.0760	560890.	1000.0000	-0.001075	0.000	7.569E+10	0.000	0.000	0.000
840.000	0.0636	576663.	1000.0000	-0.000985	0.000	7.569E+10	0.000	0.000	0.000
852.000	0.0523	592101.	760.3246	-0.000892	0.000	7.569E+10	-39.9459	9163.1377	0.000
864.000	0.0422	601443.	134.2624	-0.000798	0.000	7.569E+10	-64.3978	18326.	0.000
876.000	0.0332	601163.	-707.9862	-0.000702	0.000	7.569E+10	-75.9770	27489.	0.000
888.000	0.0253	589593.	-1627.6657	-0.000608	0.000	7.569E+10	-77.3029	36653.	0.000
900.000	0.0186	566550.	-2516.9537	-0.000516	0.000	7.569E+10	-70.9117	45816.	0.000
912.000	0.0129	532966.	-3297.4555	-0.000429	0.000	7.569E+10	-59.1719	54979.	0.000
924.000	0.008271	490553.	-3917.7543	-0.000348	0.000	7.569E+10	-44.2112	64142.	0.000
936.000	0.004561	441489.	-4350.1781	-0.000274	0.000	7.569E+10	-27.8594	73305.	0.000
948.000	0.001690	388156.	-4587.0116	-0.000208	0.000	7.569E+10	-11.6129	82468.	0.000
960.000	-0.000443	332926.	-4636.4138	-0.000151	0.000	7.569E+10	3.3792	91631.	0.000
972.000	-0.001941	277990.	-4518.2935	-0.000103	0.000	7.569E+10	16.3076	100795.	0.000
984.000	-0.002912	225240.	-4260.3735	-6.299E-05	0.000	7.569E+10	26.6791	109958.	0.000
996.000	-0.003453	176202.	-3894.6274	-3.116E-05	0.000	7.569E+10	34.2785	119121.	0.000
1008.000	-0.003660	131997.	-3454.2269	-6.735E-06	0.000	7.569E+10	39.1215	128284.	0.000
1020.000	-0.003615	93350.	-2971.0769	1.113E-05	0.000	7.569E+10	41.4035	137447.	0.000
1032.000	-0.003392	60610.	-2473.9723	2.333E-05	0.000	7.569E+10	41.4473	146610.	0.000
1044.000	-0.003055	33804.	-1987.3596	3.082E-05	0.000	7.569E+10	39.6548	155773.	0.000
1056.000	-0.002653	12688.	-1530.6541	3.450E-05	0.000	7.569E+10	36.4628	164936.	0.000
1068.000	-0.002227	-3184.7347	-1118.0375	3.525E-05	0.000	7.569E+10	32.3067	174100.	0.000
1080.000	-0.001807	-14403.	-758.6430	3.386E-05	0.000	7.569E+10	27.5924	183263.	0.000
1092.000	-0.001414	-21640.	-457.0323	3.100E-05	0.000	7.569E+10	22.6760	192426.	0.000
1104.000	-0.001063	-25599.	-213.8659	2.726E-05	0.000	7.569E+10	17.8517	201589.	0.000
1116.000	-0.000760	-26972.	-26.6807	2.309E-05	0.000	7.569E+10	13.3459	210752.	0.000
1128.000	-0.000508	-26408.	109.3029	1.886E-05	0.000	7.569E+10	9.3181	219915.	0.000
1140.000	-0.000307	-24487.	200.4032	1.483E-05	0.000	7.569E+10	5.8653	229078.	0.000
1152.000	-0.000153	-21707.	253.7762	1.116E-05	0.000	7.569E+10	3.0302	238242.	0.000
1164.000	-3.930E-05	-18478.	276.8192	7.979E-06	0.000	7.569E+10	0.8103	247405.	0.000
1176.000	3.887E-05	-15122.	276.6950	5.316E-06	0.000	7.569E+10	-0.8310	256568.	0.000
1188.000	8.827E-05	-11876.	259.9809	3.175E-06	0.000	7.569E+10	-1.9547	265731.	0.000
1200.000	0.000115	-8905.6018	232.4356	1.528E-06	0.000	7.569E+10	-2.6362	274894.	0.000
1212.000	0.000125	-6309.1894	198.8728	3.221E-07	0.000	7.569E+10	-2.9576	284057.	0.000
1224.000	0.000123	-4135.0124	163.1223	-5.058E-07	0.000	7.569E+10	-3.0008	293220.	0.000
1236.000	0.000113	-2390.5524	128.0623	-1.023E-06	0.000	7.569E+10	-2.8425	302384.	0.000
1248.000	9.825E-05	-1054.0272	95.7020	-1.296E-06	0.000	7.569E+10	-2.5509	311547.	0.000
1260.000	8.170E-05	-84.2155	67.2964	-1.386E-06	0.000	7.569E+10	-2.1834	320710.	0.000
1272.000	6.498E-05	571.2338	43.4783	-1.348E-06	0.000	7.569E+10	-1.7863	329873.	0.000
1284.000	4.935E-05	969.1296	24.3950	-1.226E-06	0.000	7.569E+10	-1.3943	339036.	0.000
1296.000	3.556E-05	1165.6850	9.8375	-1.056E-06	0.000	7.569E+10	-1.0319	348199.	0.000
1308.000	2.400E-05	1212.9636	-0.6417	-8.679E-07	0.000	7.569E+10	-0.7146	357362.	0.000
1320.000	1.473E-05	1156.6374	-7.6295	-6.801E-07	0.000	7.569E+10	-0.4500	366526.	0.000
1332.000	7.674E-06	1034.8330	-11.7713	-5.063E-07	0.000	7.569E+10	-0.2403	375689.	0.000
1344.000	2.582E-06	877.8319	-13.7097	-3.547E-07	0.000	7.569E+10	-0.0828	384852.	0.000
1356.000	-8.397E-07	708.3966	-14.0412	-2.290E-07	0.000	7.569E+10	0.0276	394015.	0.000
1368.000	-2.914E-06	542.5205	-13.2883	-1.298E-07	0.000	7.569E+10	0.0979	403178.	0.000
1380.000	-3.956E-06	390.4273	-11.8515	-5.589E-08	0.000	7.569E+10	0.1416	429465.	0.000
1392.000	-4.255E-06	258.4947	-9.9023	-4.451E-09	0.000	7.569E+10	0.1833	516881.	0.000
1404.000	-4.063E-06	152.8055	-7.7268	2.815E-08	0.000	7.569E+10	0.1793	529569.	0.000
1416.000	-3.580E-06	72.8458	-5.6805	4.604E-08	0.000	7.569E+10	0.1618	542258.	0.000
1428.000	-2.958E-06	16.1364	-3.8893	5.309E-08	0.000	7.569E+10	0.1368	554946.	0.000
1440.000	-2.305E-06	-20.8851	-2.4142	5.272E-08	0.000	7.569E+10	0.1091	567634.	0.000
1452.000	-1.693E-06	-42.1913	-1.2688	4.772E-08	0.000	7.569E+10	0.0819	580322.	0.000
1464.000	-1.160E-06	-51.6857	-0.4337	4.027E-08	0.000	7.569E+10	0.0573	593011.	0.000
1476.000	-7.261E-07	-52.8940	0.1302	3.198E-08	0.000	7.569E+10	0.0366	605699.	0.000
1488.000	-3.926E-07	-48.7944	0.4715	2.392E-08	0.000	7.569E+10	0.0202	618387.	0.000
1500.000	-1.519E-07	-41.7534	0.6408	1.675E-08	0.000	7.569E+10	0.007987	631075.	0.000
1512.000	9.357E-09	-33.5380	0.6857	1.078E-08	0.000	7.569E+10	-0.000502	643763.	0.000
1524.000	1.068E-07	-25.3754	0.6476	6.108E-09	0.000	7.569E+10	-0.005842	656452.	0.000
1536.000	1.560E-07	-18.0394	0.5604	2.667E-09	0.000	7.569E+10	-0.008696	669140.	0.000
1548.000	1.708E-07	-11.9452	0.4500	2.901E-10	0.000	7.569E+10	-0.009705	681828.	0.000
1560.000	1.629E-07	-7.2415	0.3352	-1.231E-09	0.000	7.569E+10	-0.009429	694516.	0.000
1572.000	1.413E-07	-3.8914	0.2287	-2.113E-09	0.000	7.569E+10	-0.008325	707205.	0.000
1584.000	1.122E-07	-1.7378	0.1383	-2.559E-09	0.000	7.569E+10	-0.006731	719893.	0.000
1596.000	7.983E-08	-0.5525	0.0687	-2.741E-09	0.000	7.569E+10	-0.004874	732581.	0.000
1608.000	4.641E-08	-0.0687	0.0222	-2.790E-09	0.000	7.569E+10	-0.002883	745269.	0.000
1620.000	1.287E-08	0.000	0.000	-2.796E-09	0.000	7.569E+10	-0.000813	378979.	0.000

* This analysis makes computations of pile response using nonlinear moment-curvature relationships.
  The above values of total stress are computed for combined axial stress and do not equal the
  actual stresses in concrete and steel in the range of nonlinear bending.

Output Verification: Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

```
Pile-head deflection              =      1.5280045 inches
Computed slope at pile head       =       0.000000 radians
Maximum bending moment            =       -709985. inch-lbs
Maximum shear force               =  -4636.4137651 lbs
Depth of maximum bending moment   =       0.000000 inches below pile head
Depth of maximum shear force      =    960.0000000 inches below pile head
Number of iterations              =              6
Number of zero deflection points  =              5
```

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-lbs	Maximum Shear lbs	Pile-head Rotation radians
1	2	V = 1000.0000	S = 0.000	305000.	1.52800451	-709985.	-4636.4138	0.00000000

The analysis ended normally.

L-PILE OUTPUT

20-INCH PIPE PILE

1:4 BATTER

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

                    LPile Plus for Windows, Version 6 (6.0.28)

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

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

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James Marsland
GZA GeoEnvironmental, Inc.

Serial Number of Security Device:        361883089
Company Name Stored in Security Device:  GZA GeoEnvironmental, Inc.

------------------------------------------------------------------------------
                            Files Used for Analysis
------------------------------------------------------------------------------

Path to file locations:        J:\Geo\33940.ah\Work\Calcs\LPile\
Name of input data file:       33940.00_PROFILE_A-A_20-inch_batter.lp6d
Name of output report file:    33940.00_PROFILE_A-A_20-inch_batter.lp6o
Name of plot output file:      33940.00_PROFILE_A-A_20-inch_batter.lp6p
Name of runtime messeage file: 33940.00_PROFILE_A-A_20-inch_batter.lp6r

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

               Date:  October 31, 2013     Time:  16:58:48

------------------------------------------------------------------------------
                                Problem Title
------------------------------------------------------------------------------

Project Name: Eastport Breakwater

Job Number: 33940.00

Client: CEC

Engineer: JJM

Description: 24" vertical pile


------------------------------------------------------------------------------
                               Program Options
------------------------------------------------------------------------------

Engineering units are US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes pile response to lateral loading and will compute nonlinear
moment-curvature and nominal moment capacity for selected section types.

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output pile response for full length of pile
- Analysis assumes no soil movements acting on pile
- No p-y curves to be computed and output for user-specified depths

Solution Control Parameters:
- Number of pile increments                          =          139
- Maximum number of iterations allowed               =          100
- Deflection tolerance for convergence               =   1.0000E-05  in
- Maximum allowable deflection                       =     100.0000  in

Pile Response Output Options:
- 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 Sections                                =          1

Total Pile Length                                       =     139.00 ft

Depth of ground surface below top of pile               =      70.00 ft

Pile dimensions used for p-y curve computations defined using 2 points.
p-y curves are computed using values of pile diameter interpolated over
the length of the pile.

Point         Depth              Pile
                X              Diameter
                ft               in
-----       ---------        -----------
  1          0.00000         20.0000000
  2        139.000000         20.0000000
```

Input Structural Properties:

Pile Section No. 1:

```
   Section Type = Drilled Shaft with Permanent Casing
   Section Length                                        =         139.000 ft
   Pile Width                                            =          20.000 in
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                       =        0.000 degrees
                                                         =        0.000 radians

Pile Batter Angle                                        =      -14.000 degrees
                                                         =       -0.244 radians
```

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

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

```
Distance from top of pile to top of layer                =       70.000 ft
Distance from top of pile to bottom of layer             =      115.000 ft
NOTE:  Internal default values for p-y subgrade modulus will be computed for
the above soil layer.
```

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

```
Distance from top of pile to top of layer                =      115.000 ft
Distance from top of pile to bottom of layer             =      135.000 ft
NOTE:  Internal default values for p-y subgrade modulus will be computed for
the above soil layer.
```

Layer 3 is strong rock (vuggy limestone)

```
Distance from top of pile to top of layer                =      135.000 ft
Distance from top of pile to bottom of layer             =      155.000 ft
```

(Depth of lowest layer extends 16.00 ft below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 6 points

Point No.	Depth X ft	Eff. Unit Weight pcf
1	70.00	61.00000
2	115.00	61.00000
3	115.00	66.00000
4	135.00	66.00000
5	135.00	96.00000
6	155.00	96.00000

Summary of Soil Properties

Layer J Num.	Soil Type (p-y Curve Criteria)	kpy pci	Rock Emass psi	krm	Depth Test Type ft	Eff. Unit Wt., pcf	Cohesion Test Prop. psf	Friction Elas. Subgr. pci Ang., deg.	qu psi	RQD percent	Epsilon 50
1	Sand (Reese, et al.)	default	--	--	70.000	61.000	--	34.000	--	--	--
					115.000	61.000	--	34.000	--	--	--
2	Sand (Reese, et al.)	default	--	--	115.000	66.000	--	36.000	--	--	--
					135.000	66.000	--	36.000	--	--	--
3	Vuggy Limestone	--	--	--	135.000	96.000	--	--	20000.	--	--
					155.000	96.000	--	--	20000.	--	--

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 = 1

Load    Load         Condition               Condition            Axial Thrust
 No.    Type             1                       2                 Force, lbs
-----   ----   --------------------   -----------------------   ----------------
   1     2     V =   1000.00000 lbs   S =       0.0000 in/in            245000.

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 = 1

Pile Section No. 1:


Dimensions and Properties of Drilled Shaft with Permanent Casing:
-----------------------------------------------------------------

Length of Section                                    =    139.00000000 ft
Outer Diameter of Casing                             =     20.00000000 in
Concrete Cover Thickness Inside Casing               =      0.0000000 in
Casing Wall Thickness                                =      0.62500000 in
Yield Stress of Casing                               =     45.00000000 ksi
Elastic Modulus of Casing                            =          29000. ksi
Number of Reinforcing Bars                           =              0 bars
Area of Single Reinforcing Bar                       =      0.0000000 sq. in.
Edge-to-Edge Bar Spacing                             =      0.0000000 in
Rebar Offset                                         =      0.0000000 in
Yield Stress of Reinforcing Bars                     =      0.0000000 ksi
Elastic Modulus of Reinforcing Bars                  =          29000. ksi
Area of Concrete                                     =    276.11654182 sq. in.
Cross-sectional Area of Steel Casing                 =     38.04272354 sq. in.
Area of All Steel (Casing and Bars)                  =     38.04272354 sq. in.
Area Ratio of All Steel                              =           13.78 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =        2650.719 kips
Tensile Load for Cracking of Concrete                  =        -114.840 kips
Nominal Axial Tensile Capacity                         =       -1711.923 kips


Reinforcing Bar Dimensions and Positions Used in Computations:

     Bar          Bar Diam.      Bar Area          X              Y
    Number         inches         sq. in.        inches         inches
  ----------     ----------     ----------     ----------     ----------



Concrete Properties:
--------------------

Compressive Strength of Concrete                       =      4.0000000 ksi
Modulus of Elasticity of Concrete                      =   3604.9965326 ksi
Modulus of Rupture of Concrete                         =     -0.4743416 ksi
Compression Strain at Peak Stress                      =      0.0018863
Tensile Strain at Fracture of Concrete                 =     -0.0001154
Maximum Coarse Aggregate Size                          =       0.000000 in


Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                     kips
   ------     ------------------
      1             245.000


Definitions of Run Messages and Notes:
--------------------------------------

   C = concrete in section has cracked in tension.
   Y = stress in reinforcing steel has reached yield stress.
   T = ACI 318-08 criteria for tension-controlled section met, tensile strain in
       reinforcement exceeds 0.005 while simultaneously compressive strain in
       concrete more than than 0.003. See ACI 318-08, Section 10.3.4.
   Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.


Axial Thrust Force =    245.000 kips

    Bending       Bending       Bending       Depth to      Max Comp      Max Tens    Max Concrete   Max Steel     Max Casing   Run
   Curvature      Moment       Stiffness       N Axis        Strain        Strain        Stress        Stress        Stress     Msg
    rad/in.       in-kip        kip-in2          in          in/in         in/in          ksi           ksi           ksi
```

0.000001250	95.0814464	76065157.	97.4901813	0.0001219	0.0000969	0.4996496	0.000000	3.5303941	
0.000002500	190.1623984	76064959.	53.7508878	0.0001344	0.0000844	0.5486318	0.000000	3.8896894	
0.000003750	285.2423618	76064630.	39.1736998	0.0001469	0.0000719	0.5973066	0.000000	4.2492649	
0.000005000	380.3208422	76064168.	31.8870382	0.0001594	0.0000594	0.6456733	0.000000	4.6091206	
0.000006250	475.3973451	76063575.	27.5165873	0.0001720	0.0000470	0.6937310	0.000000	4.9692565	
0.000007500	570.4713763	76062850.	24.6042417	0.0001845	0.0000345	0.7414789	0.000000	5.3296726	
0.000008750	665.5424413	76061993.	22.5250992	0.0001971	0.0000221	0.7889163	0.000000	5.6903690	
0.0000100	760.6100456	76061005.	20.9667088	0.0002097	0.000009667	0.8360423	0.000000	6.0513456	
0.0000113	855.6736947	76059884.	19.7554863	0.0002222	-0.000002751	0.8828561	0.000000	6.4126024	
0.0000125	950.7322108	76058577.	18.7872789	0.0002348	-0.0000152	0.9293568	0.000000	6.7741386	
0.0000138	1045.7719418	76056141.	17.9957603	0.0002474	-0.0000276	0.9755410	0.000000	7.1359345	
0.0000150	1140.7674794	76051165.	17.3366673	0.0002601	-0.0000399	1.0214031	0.000000	7.4979503	
0.0000163	1235.6969316	76042888.	16.7793612	0.0002727	-0.0000523	1.0669376	0.000000	7.8601490	
0.0000175	1330.5437022	76031069.	16.3019700	0.0002853	-0.0000647	1.1121404	0.000000	8.2224998	
0.0000188	1425.2955185	76015761.	15.8884658	0.0002979	-0.0000771	1.1570078	0.000000	8.5849783	
0.0000200	1519.9432780	75997164.	15.5268361	0.0003105	-0.0000895	1.2015372	0.000000	8.9475650	
0.0000213	1614.4802482	75975541.	15.2079017	0.0003232	-0.0001018	1.2457264	0.000000	9.3102445	
0.0000225	1708.9012773	75951168.	14.9245273	0.0003358	-0.0001142	1.2895736	0.000000	9.6730041	
0.0000238	1719.9133505	72417404.	14.4488395	0.0003432	-0.0001318	1.3147669	0.000000	9.8827632	C
0.0000250	1799.8381351	71993525.	14.1917880	0.0003548	-0.0001452	1.3546137	0.000000	10.2165464	C
0.0000263	1879.2160863	71589184.	13.9573921	0.0003664	-0.0001586	1.3939985	0.000000	10.5489398	C
0.0000275	1958.1052959	71203829.	13.7426949	0.0003779	-0.0001721	1.4329376	0.000000	10.8800493	C
0.0000288	2036.5622194	70836947.	13.5452651	0.0003894	-0.0001856	1.4714476	0.000000	11.2099899	C
0.0000300	2114.6412371	70488041.	13.3630874	0.0004009	-0.0001991	1.5095461	0.000000	11.5388861	C
0.0000313	2192.3942352	70156616.	13.1944790	0.0004123	-0.0002127	1.5472511	0.000000	11.8668717	C
0.0000325	2269.8702076	69842160.	13.0380256	0.0004237	-0.0002263	1.5845812	0.000000	12.1940893	C
0.0000338	2347.1148748	69544144.	12.8925319	0.0004351	-0.0002399	1.6215555	0.000000	12.5206907	C
0.0000350	2424.0605978	69258874.	12.7565076	0.0004465	-0.0002535	1.6581398	0.000000	12.8463553	C
0.0000363	2500.8254427	68988288.	12.6294058	0.0004578	-0.0002672	1.6943871	0.000000	13.1715379	C
0.0000375	2577.4405761	68731749.	12.5104583	0.0004691	-0.0002809	1.7303135	0.000000	13.4963735	C
0.0000388	2653.8083035	68485376.	12.3984443	0.0004804	-0.0002946	1.7658667	0.000000	13.8203769	C
0.0000400	2730.1019738	68252549.	12.2934049	0.0004917	-0.0003083	1.8011360	0.000000	14.1443498	C
0.0000413	2806.1624618	68028181.	12.1940407	0.0005030	-0.0003220	1.8360358	0.000000	14.4674963	C
0.0000425	2882.1830479	67816072.	12.1006273	0.0005143	-0.0003357	1.8706704	0.000000	14.7907732	C
0.0000438	2957.9796230	67610963.	12.0118855	0.0005255	-0.0003495	1.9049360	0.000000	15.1132049	C
0.0000450	3033.7351060	67416336.	11.9281675	0.0005368	-0.0003632	1.9389366	0.000000	15.4357587	C
0.0000463	3109.3434203	67229047.	11.8486161	0.0005480	-0.0003770	1.9726089	0.000000	15.7578315	C
0.0000475	3184.8543019	67049564.	11.7731063	0.0005592	-0.0003908	2.0059832	0.000000	16.0797041	C
0.0000488	3260.3254119	66878470.	11.7015594	0.0005705	-0.0004045	2.0390936	0.000000	16.4017047	C
0.0000513	3410.8609227	66553384.	11.5680062	0.0005929	-0.0004321	2.1043438	0.000000	17.0443244	C
0.0000538	3561.1206391	66253407.	11.4467040	0.0006153	-0.0004597	2.1684633	0.000000	17.6866751	C
0.0000563	3711.0823736	65974798.	11.3359254	0.0006376	-0.0004874	2.2314386	0.000000	18.3286035	C
0.0000588	3860.7430456	65714775.	11.2342639	0.0006600	-0.0005150	2.2932615	0.000000	18.9700022	C
0.0000613	4010.1702894	65472168.	11.1408781	0.0006824	-0.0005426	2.3539808	0.000000	19.6113598	C
0.0000638	4159.3407900	65244561.	11.0546651	0.0007047	-0.0005703	2.4135745	0.000000	20.2524372	C
0.0000663	4308.2673231	65030450.	10.9748645	0.0007271	-0.0005979	2.4720531	0.000000	20.8933337	C
0.0000688	4457.0350544	64829601.	10.9011223	0.0007495	-0.0006255	2.5294786	0.000000	21.5347378	C
0.0000713	4605.4945279	64638520.	10.8321541	0.0007718	-0.0006532	2.5857321	0.000000	22.1753136	C
0.0000738	4753.7928118	64458208.	10.7680898	0.0007941	-0.0006809	2.6409302	0.000000	22.8163772	C
0.0000763	4901.9316984	64287629.	10.7084577	0.0008165	-0.0007085	2.6950723	0.000000	23.4579523	C
0.0000788	5049.8069689	64124533.	10.6523751	0.0008389	-0.0007361	2.7480696	0.000000	24.0989869	C
0.0000813	5197.5047684	63969289.	10.5998846	0.0008612	-0.0007638	2.7999950	0.000000	24.7403533	C
0.0000838	5345.0425228	63821403.	10.5507405	0.0008836	-0.0007914	2.8508610	0.000000	25.3822362	C
0.0000863	5492.4196137	63680227.	10.5046526	0.0009060	-0.0008190	2.9006653	0.000000	26.0246376	C
0.0000888	5639.5512737	63544240.	10.4609791	0.0009284	-0.0008466	2.9493311	0.000000	26.6665703	C
0.0000913	5786.5122698	63413833.	10.4198526	0.0009508	-0.0008742	2.9969251	0.000000	27.3089102	C
0.0000938	5933.3118596	63288660.	10.3811125	0.0009732	-0.0009018	3.0434535	0.000000	27.9517750	C
0.0000963	6079.9494141	63168306.	10.3445738	0.0009957	-0.0009293	3.0889138	0.000000	28.5951668	C
0.0000988	6226.4242993	63052398.	10.3100699	0.0010181	-0.0009569	3.1333033	0.000000	29.2390879	C
0.0001013	6372.6879218	62940128.	10.2772226	0.0010406	-0.0009844	3.1765752	0.000000	29.8828701	C
0.0001038	6518.7676463	62831495.	10.2460392	0.0010630	-0.0010120	3.2187547	0.000000	30.5268957	C
0.0001063	6664.6838147	62726436.	10.2164976	0.0010855	-0.0010395	3.2598591	0.000000	31.1714584	C
0.0001088	6810.4357791	62624697.	10.1884852	0.0011080	-0.0010670	3.2998857	0.000000	31.8165605	C
0.0001113	6956.0228867	62526048.	10.1618998	0.0011305	-0.0010945	3.3388320	0.000000	32.4622045	C
0.0001138	7101.4444802	62430281.	10.1366479	0.0011530	-0.0011220	3.3766952	0.000000	33.1083926	C
0.0001163	7246.6998971	62337203.	10.1126443	0.0011756	-0.0011494	3.4134726	0.000000	33.7551274	C
0.0001188	7391.7676973	62246465.	10.0897054	0.0011982	-0.0011768	3.4491419	0.000000	34.4020484	C
0.0001213	7536.6434977	62157885.	10.0677449	0.0012207	-0.0012043	3.4836983	0.000000	35.0490834	C
0.0001238	7681.3520187	62071531.	10.0468267	0.0012433	-0.0012317	3.5171637	0.000000	35.6966745	C
0.0001263	7825.8925795	61987268.	10.0268895	0.0012659	-0.0012591	3.5495352	0.000000	36.3448244	C
0.0001288	7970.2644944	61904967.	10.0078768	0.0012885	-0.0012865	3.5808102	0.000000	36.9935355	C
0.0001313	8114.4670720	61824511.	9.9897366	0.0013112	-0.0013138	3.6109859	0.000000	-37.7209396	C
0.0001338	8258.4996159	61745792.	9.9724206	0.0013338	-0.0013412	3.6400593	0.000000	-38.5065981	C
0.0001363	8402.3614242	61668708.	9.9558841	0.0013565	-0.0013685	3.6680277	0.000000	-39.2916875	C
0.0001388	8546.0517894	61593166.	9.9400856	0.0013792	-0.0013958	3.6948882	0.000000	-40.0762052	C
0.0001413	8689.5699988	61519080.	9.9249866	0.0014019	-0.0014231	3.7206379	0.000000	-40.8601484	C
0.0001438	8832.9153336	61446368.	9.9105512	0.0014246	-0.0014504	3.7452739	0.000000	-41.6435145	C
0.0001463	8976.0810033	61374913.	9.8967114	0.0014474	-0.0014776	3.7687882	0.000000	-42.4264473	C
0.0001488	9119.0535660	61304562.	9.8833647	0.0014702	-0.0015048	3.7911679	0.000000	-43.2092602	C
0.0001588	9676.9714800	60957301.	9.8306159	0.0015606	-0.0016144	3.8688634	0.000000	-45.0000000	CY
0.0001688	10110.	59910775.	9.7600639	0.0016470	-0.0017280	3.9262452	0.000000	45.0000000	CY
0.0001788	10421.	58300030.	9.6945965	0.0017329	-0.0018421	3.9670355	0.000000	45.0000000	CY
0.0001888	10665.	56503350.	9.6345230	0.0018185	-0.0019565	3.9915630	0.000000	45.0000000	CY
0.0001988	10864.	54661742.	9.5787380	0.0019038	-0.0020712	3.9999937	0.000000	45.0000000	CY
0.0002088	11031.	52842175.	9.5269184	0.0019887	-0.0021863	3.9999959	0.000000	45.0000000	CY
0.0002188	11171.	51069376.	9.4790667	0.0020735	-0.0023015	3.9998964	0.000000	45.0000000	CY
0.0002288	11292.	49364321.	9.4341388	0.0021581	-0.0024169	3.9992640	0.000000	45.0000000	CY
0.0002388	11397.	47734790.	9.3928441	0.0022425	-0.0025325	3.9999961	0.000000	45.0000000	CY
0.0002488	11487.	46177297.	9.3546470	0.0023270	-0.0026480	3.9988540	0.000000	45.0000000	CY
0.0002588	11566.	44698629.	9.3198774	0.0024115	-0.0027635	3.9996306	0.000000	45.0000000	CY
0.0002688	11635.	43292998.	9.2872145	0.0024959	-0.0028791	3.9999196	0.000000	45.0000000	CY
0.0002788	11696.	41958571.	9.2566921	0.0025803	-0.0029947	3.9999909	0.000000	45.0000000	CY
0.0002888	11750.	40692110.	9.2287910	0.0026648	-0.0031102	3.9999987	0.000000	45.0000000	CY
0.0002988	11798.	39490591.	9.2029794	0.0027494	-0.0032256	3.9999881	0.000000	45.0000000	CY
0.0003088	11841.	38350500.	9.1789528	0.0028340	-0.0033410	3.9999008	0.000000	45.0000000	CY
0.0003188	11879.	37268044.	9.1566177	0.0029187	-0.0034563	3.9995737	0.000000	45.0000000	CY
0.0003288	11913.	36238358.	9.1365090	0.0030036	-0.0035714	3.9987557	0.000000	45.0000000	CY
0.0003388	11945.	35260539.	9.1176176	0.0030886	-0.0036864	3.9970698	0.000000	45.0000000	CY
0.0003488	11972.	34328136.	9.0998381	0.0031736	-0.0038014	3.9999894	0.000000	45.0000000	CY
0.0003588	11997.	33440290.	9.0830425	0.0032585	-0.0039165	3.9991893	0.000000	45.0000000	CY
0.0003688	12019.	32594957.	9.0676314	0.0033437	-0.0040313	3.9966661	0.000000	45.0000000	CY
0.0003788	12039.	31787458.	9.0531286	0.0034289	-0.0041461	3.9998813	0.000000	45.0000000	CY
0.0003888	12058.	31016646.	9.0396944	0.0035142	-0.0042608	3.9978516	0.000000	45.0000000	CY
0.0003988	12075.	30280903.	9.0273798	0.0035997	-0.0043753	3.9999983	0.000000	45.0000000	CY
0.0004088	12089.	29575696.	9.0158218	0.0036852	-0.0044898	3.9981625	0.000000	45.0000000	CY

0.0004188	12103.	28902921.	9.0049871	0.0037708	-0.0046042	3.9999397	0.000000	45.0000000 CY
0.0004288	12115.	28255846.	8.9952652	0.0038567	-0.0047183	3.9977561	0.000000	45.0000000 CY

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	245.000	11911.901	0.00300000

Note note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318-08, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are spirals or tied hoops.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318-08, Section 9.3.2.2 or the value required by the design standard being followed.

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

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

Shear force at pile head = 1000.000 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 245000.000 lbs

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

Depth X inches	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	1.5448	-682144.	1000.0000	0.000	0.000	7.606E+10	0.000	0.000	0.000
12.000	1.5441	-669985.	1000.0000	-0.000107	0.000	7.606E+10	0.000	0.000	0.000
24.000	1.5422	-657516.	1000.0000	-0.000211	0.000	7.606E+10	0.000	0.000	0.000
36.000	1.5390	-644742.	1000.0000	-0.000314	0.000	7.606E+10	0.000	0.000	0.000
48.000	1.5347	-631669.	1000.0000	-0.000415	0.000	7.606E+10	0.000	0.000	0.000
60.000	1.5291	-618303.	1000.0000	-0.000513	0.000	7.606E+10	0.000	0.000	0.000
72.000	1.5223	-604651.	1000.0000	-0.000610	0.000	7.606E+10	0.000	0.000	0.000
84.000	1.5145	-590718.	1000.0000	-0.000704	0.000	7.606E+10	0.000	0.000	0.000
96.000	1.5054	-576510.	1000.0000	-0.000796	0.000	7.606E+10	0.000	0.000	0.000
108.000	1.4953	-562036.	1000.0000	-0.000886	0.000	7.606E+10	0.000	0.000	0.000
120.000	1.4842	-547300.	1000.0000	-0.000974	0.000	7.606E+10	0.000	0.000	0.000
132.000	1.4720	-532311.	1000.0000	-0.001059	0.000	7.606E+10	0.000	0.000	0.000
144.000	1.4588	-517075.	1000.0000	-0.001141	0.000	7.606E+10	0.000	0.000	0.000
156.000	1.4446	-501599.	1000.0000	-0.001222	0.000	7.606E+10	0.000	0.000	0.000
168.000	1.4294	-485891.	1000.0000	-0.001300	0.000	7.606E+10	0.000	0.000	0.000
180.000	1.4134	-469957.	1000.0000	-0.001375	0.000	7.606E+10	0.000	0.000	0.000
192.000	1.3964	-453805.	1000.0000	-0.001448	0.000	7.606E+10	0.000	0.000	0.000
204.000	1.3786	-437443.	1000.0000	-0.001518	0.000	7.606E+10	0.000	0.000	0.000
216.000	1.3600	-420877.	1000.0000	-0.001586	0.000	7.606E+10	0.000	0.000	0.000
228.000	1.3406	-404117.	1000.0000	-0.001651	0.000	7.606E+10	0.000	0.000	0.000
240.000	1.3204	-387169.	1000.0000	-0.001714	0.000	7.606E+10	0.000	0.000	0.000
252.000	1.2995	-370041.	1000.0000	-0.001773	0.000	7.606E+10	0.000	0.000	0.000
264.000	1.2778	-352742.	1000.0000	-0.001830	0.000	7.606E+10	0.000	0.000	0.000
276.000	1.2555	-335280.	1000.0000	-0.001885	0.000	7.606E+10	0.000	0.000	0.000
288.000	1.2326	-317661.	1000.0000	-0.001936	0.000	7.606E+10	0.000	0.000	0.000
300.000	1.2091	-299896.	1000.0000	-0.001985	0.000	7.606E+10	0.000	0.000	0.000
312.000	1.1850	-281991.	1000.0000	-0.002031	0.000	7.606E+10	0.000	0.000	0.000
324.000	1.1603	-263956.	1000.0000	-0.002074	0.000	7.606E+10	0.000	0.000	0.000
336.000	1.1352	-245798.	1000.0000	-0.002114	0.000	7.606E+10	0.000	0.000	0.000
348.000	1.1096	-227526.	1000.0000	-0.002151	0.000	7.606E+10	0.000	0.000	0.000
360.000	1.0836	-209148.	1000.0000	-0.002186	0.000	7.606E+10	0.000	0.000	0.000
372.000	1.0571	-190674.	1000.0000	-0.002217	0.000	7.606E+10	0.000	0.000	0.000
384.000	1.0303	-172111.	1000.0000	-0.002246	0.000	7.606E+10	0.000	0.000	0.000
396.000	1.0032	-153468.	1000.0000	-0.002272	0.000	7.607E+10	0.000	0.000	0.000
408.000	0.9758	-134755.	1000.0000	-0.002294	0.000	7.607E+10	0.000	0.000	0.000
420.000	0.9482	-115978.	1000.0000	-0.002314	0.000	7.607E+10	0.000	0.000	0.000
432.000	0.9203	-97148.	1000.0000	-0.002331	0.000	7.607E+10	0.000	0.000	0.000
444.000	0.8922	-78273.	1000.0000	-0.002345	0.000	7.607E+10	0.000	0.000	0.000
456.000	0.8640	-59361.	1000.0000	-0.002356	0.000	7.607E+10	0.000	0.000	0.000
468.000	0.8357	-40422.	1000.0000	-0.002363	0.000	7.607E+10	0.000	0.000	0.000
480.000	0.8073	-21464.	1000.0000	-0.002368	0.000	7.607E+10	0.000	0.000	0.000
492.000	0.7789	-2496.6832	1000.0000	-0.002370	0.000	7.607E+10	0.000	0.000	0.000
504.000	0.7504	16472.	1000.0000	-0.002369	0.000	7.607E+10	0.000	0.000	0.000
516.000	0.7220	35434.	1000.0000	-0.002365	0.000	7.607E+10	0.000	0.000	0.000
528.000	0.6937	54378.	1000.0000	-0.002358	0.000	7.607E+10	0.000	0.000	0.000
540.000	0.6654	73298.	1000.0000	-0.002348	0.000	7.607E+10	0.000	0.000	0.000
552.000	0.6373	92184.	1000.0000	-0.002335	0.000	7.607E+10	0.000	0.000	0.000
564.000	0.6094	111027.	1000.0000	-0.002319	0.000	7.607E+10	0.000	0.000	0.000
576.000	0.5817	129818.	1000.0000	-0.002300	0.000	7.607E+10	0.000	0.000	0.000
588.000	0.5542	148549.	1000.0000	-0.002278	0.000	7.607E+10	0.000	0.000	0.000
600.000	0.5270	167211.	1000.0000	-0.002253	0.000	7.606E+10	0.000	0.000	0.000
612.000	0.5001	185796.	1000.0000	-0.002225	0.000	7.606E+10	0.000	0.000	0.000
624.000	0.4736	204295.	1000.0000	-0.002194	0.000	7.606E+10	0.000	0.000	0.000
636.000	0.4475	222698.	1000.0000	-0.002161	0.000	7.606E+10	0.000	0.000	0.000
648.000	0.4217	240999.	1000.0000	-0.002124	0.000	7.606E+10	0.000	0.000	0.000
660.000	0.3965	259188.	1000.0000	-0.002085	0.000	7.606E+10	0.000	0.000	0.000
672.000	0.3717	277256.	1000.0000	-0.002042	0.000	7.606E+10	0.000	0.000	0.000
684.000	0.3475	295196.	1000.0000	-0.001997	0.000	7.606E+10	0.000	0.000	0.000
696.000	0.3238	312999.	1000.0000	-0.001949	0.000	7.606E+10	0.000	0.000	0.000
708.000	0.3007	330657.	1000.0000	-0.001898	0.000	7.606E+10	0.000	0.000	0.000

720.000	0.2782	348161.	1000.0000	-0.001845	0.000	7.606E+10	0.000	0.000	0.000
732.000	0.2564	365504.	1000.0000	-0.001789	0.000	7.606E+10	0.000	0.000	0.000
744.000	0.2353	382678.	1000.0000	-0.001729	0.000	7.606E+10	0.000	0.000	0.000
756.000	0.2149	399674.	1000.0000	-0.001668	0.000	7.606E+10	0.000	0.000	0.000
768.000	0.1953	416484.	1000.0000	-0.001603	0.000	7.606E+10	0.000	0.000	0.000
780.000	0.1764	433102.	1000.0000	-0.001536	0.000	7.606E+10	0.000	0.000	0.000
792.000	0.1584	449518.	1000.0000	-0.001467	0.000	7.606E+10	0.000	0.000	0.000
804.000	0.1412	465726.	1000.0000	-0.001395	0.000	7.606E+10	0.000	0.000	0.000
816.000	0.1249	481718.	1000.0000	-0.001320	0.000	7.606E+10	0.000	0.000	0.000
828.000	0.1095	497487.	1000.0000	-0.001243	0.000	7.606E+10	0.000	0.000	0.000
840.000	0.0951	513024.	1000.0000	-0.001163	0.000	7.606E+10	0.000	0.000	0.000
852.000	0.0816	528324.	1000.0000	-0.001081	0.000	7.606E+10	0.000	0.000	0.000
864.000	0.0692	543379.	1000.0000	-0.000996	0.000	7.606E+10	0.000	0.000	0.000
876.000	0.0577	558182.	865.7938	-0.000909	0.000	7.606E+10	-22.3677	4650.0469	0.000
888.000	0.0473	569505.	445.5812	-0.000820	0.000	7.606E+10	-47.6677	12083.	0.000
900.000	0.0380	573700.	-234.1040	-0.000730	0.000	7.606E+10	-65.6131	20701.	0.000
912.000	0.0298	568180.	-1072.8425	-0.000640	0.000	7.606E+10	-74.1766	29854.	0.000
924.000	0.0227	551715.	-1942.1052	-0.000552	0.000	7.606E+10	-70.7005	37421.	0.000
936.000	0.0166	524814.	-2710.9176	-0.000467	0.000	7.606E+10	-57.4349	41586.	0.000
948.000	0.0115	489398.	-3279.2286	-0.000387	0.000	7.606E+10	-37.2836	39013.	0.000
960.000	0.007289	448387.	-3693.1955	-0.000313	0.000	7.606E+10	-31.7109	52204.	0.000
972.000	0.003959	402601.	-4029.1892	-0.000246	0.000	7.606E+10	-24.2881	73611.	0.000
984.000	0.001392	353131.	-4235.9040	-0.000186	0.000	7.606E+10	-10.1644	87639.	0.000
996.000	-0.000507	302034.	-4272.4016	-0.000134	0.000	7.606E+10	4.0814	96529.	0.000
1008.000	-0.001835	251384.	-4151.2031	-9.078E-05	0.000	7.606E+10	16.1183	105420.	0.000
1020.000	-0.002686	202939.	-3900.9613	-5.495E-05	0.000	7.606E+10	25.5887	114311.	0.000
1032.000	-0.003153	158084.	-3553.1711	-2.647E-05	0.000	7.606E+10	32.3764	123202.	0.000
1044.000	-0.003321	117818.	-3139.5400	-4.707E-06	0.000	7.607E+10	36.5622	132093.	0.000
1056.000	-0.003266	82763.	-2689.9085	1.111E-05	0.000	7.607E+10	38.3764	140984.	0.000
1068.000	-0.003055	53195.	-2230.7362	2.184E-05	0.000	7.607E+10	38.1523	149875.	0.000
1080.000	-0.002742	29097.	-1784.1301	2.833E-05	0.000	7.607E+10	36.2821	158766.	0.000
1092.000	-0.002375	10209.	-1367.3620	3.143E-05	0.000	7.607E+10	33.1793	167657.	0.000
1104.000	-0.001988	-3904.9918	-992.8009	3.193E-05	0.000	7.607E+10	29.2476	176548.	0.000
1116.000	-0.001609	-13806.	-668.1743	3.053E-05	0.000	7.607E+10	24.8569	185439.	0.000
1128.000	-0.001255	-20121.	-397.0699	2.785E-05	0.000	7.607E+10	20.3272	194330.	0.000
1140.000	-0.000940	-23499.	-179.5929	2.441E-05	0.000	7.607E+10	15.9190	203221.	0.000
1152.000	-0.000669	-24574.	-13.0984	2.062E-05	0.000	7.607E+10	11.8301	212112.	0.000
1164.000	-0.000445	-23935.	107.0628	1.680E-05	0.000	7.607E+10	8.1968	221003.	0.000
1176.000	-0.000266	-22104.	186.8395	1.316E-05	0.000	7.607E+10	5.0993	229894.	0.000
1188.000	-0.000129	-19528.	232.8521	9.880E-06	0.000	7.607E+10	2.5694	238785.	0.000
1200.000	-2.905E-05	-16573.	251.8657	7.033E-06	0.000	7.607E+10	0.5995	247676.	0.000
1212.000	3.966E-05	-13525.	250.3750	4.659E-06	0.000	7.607E+10	-0.8479	256567.	0.000
1224.000	8.276E-05	-10592.	234.3027	2.756E-06	0.000	7.607E+10	-1.8308	265458.	0.000
1236.000	0.000106	-7917.6019	208.8035	1.296E-06	0.000	7.607E+10	-2.4191	274349.	0.000
1248.000	0.000114	-5588.1078	178.1627	2.309E-07	0.000	7.607E+10	-2.6877	283240.	0.000
1260.000	0.000111	-3643.0554	145.7715	-4.972E-07	0.000	7.607E+10	-2.7108	292130.	0.000
1272.000	0.000102	-2086.6686	114.1639	-9.492E-07	0.000	7.607E+10	-2.5571	301021.	0.000
1284.000	8.857E-05	-897.5409	85.0962	-1.185E-06	0.000	7.607E+10	-2.2875	309912.	0.000
1296.000	7.351E-05	-37.3956	59.6538	-1.258E-06	0.000	7.607E+10	-1.9529	318803.	0.000
1308.000	5.837E-05	541.5489	38.3720	-1.219E-06	0.000	7.607E+10	-1.5941	327694.	0.000
1320.000	4.426E-05	890.6972	21.3583	-1.106E-06	0.000	7.607E+10	-1.2415	336585.	0.000
1332.000	3.184E-05	1060.6495	8.4090	-9.516E-07	0.000	7.607E+10	-0.9167	345476.	0.000
1344.000	2.142E-05	1098.1092	-0.8871	-7.814E-07	0.000	7.607E+10	-0.6327	354367.	0.000
1356.000	1.309E-05	1043.9538	-7.0603	-6.124E-07	0.000	7.607E+10	-0.3962	363258.	0.000
1368.000	6.727E-06	932.2637	-10.6891	-4.565E-07	0.000	7.607E+10	-0.2086	372149.	0.000
1380.000	2.131E-06	790.0995	-12.3469	-3.206E-07	0.000	7.607E+10	-0.0677	381040.	0.000
1392.000	-9.685E-07	637.8228	-12.5642	-2.080E-07	0.000	7.607E+10	0.0315	389931.	0.000
1404.000	-2.861E-06	489.7819	-11.8049	-1.191E-07	0.000	7.607E+10	0.0951	398822.	0.000
1416.000	-3.826E-06	355.2059	-10.4544	-5.242E-08	0.000	7.607E+10	0.1300	407713.	0.000
1428.000	-4.119E-06	239.1850	-8.7521	-5.533E-09	0.000	7.607E+10	0.1537	447810.	0.000
1440.000	-3.959E-06	145.1872	-6.9191	2.479E-08	0.000	7.607E+10	0.1518	460121.	0.000
1452.000	-3.524E-06	72.9813	-5.1758	4.200E-08	0.000	7.607E+10	0.1387	472432.	0.000
1464.000	-2.951E-06	20.7202	-3.6281	4.939E-08	0.000	7.607E+10	0.1192	484744.	0.000
1476.000	-2.339E-06	-14.3844	-2.3316	4.989E-08	0.000	7.607E+10	0.0969	497055.	0.000
1488.000	-1.754E-06	-35.5321	-1.3037	4.595E-08	0.000	7.607E+10	0.0744	509366.	0.000
1500.000	-1.236E-06	-45.9436	-0.5347	3.952E-08	0.000	7.607E+10	0.0537	521678.	0.000
1512.000	-8.052E-07	-48.5961	0.002748	3.207E-08	0.000	7.607E+10	0.0358	533989.	0.000
1524.000	-4.665E-07	-46.0662	0.3452	2.460E-08	0.000	7.607E+10	0.0212	546300.	0.000
1536.000	-2.149E-07	-40.4570	0.5326	1.777E-08	0.000	7.607E+10	0.0100	558612.	0.000
1548.000	-3.990E-08	-33.3886	0.6040	1.195E-08	0.000	7.607E+10	0.001898	570923.	0.000
1560.000	7.187E-08	-26.0313	0.5944	7.261E-09	0.000	7.607E+10	-0.003493	583234.	0.000
1572.000	1.344E-07	-19.1650	0.5335	3.696E-09	0.000	7.607E+10	-0.006669	595546.	0.000
1584.000	1.606E-07	-13.2500	0.4446	1.139E-09	0.000	7.607E+10	-0.008134	607857.	0.000
1596.000	1.617E-07	-8.5003	0.3457	-5.763E-10	0.000	7.607E+10	-0.008357	620168.	0.000
1608.000	1.468E-07	-4.9501	0.2491	-1.637E-09	0.000	7.607E+10	-0.007735	632480.	0.000
1620.000	1.224E-07	-2.5114	0.1633	-2.226E-09	0.000	7.607E+10	-0.006578	644791.	0.000
1632.000	9.333E-08	-1.0187	0.0931	-2.504E-09	0.000	7.607E+10	-0.005111	657102.	0.000
1644.000	6.232E-08	-0.2615	0.0416	-2.605E-09	0.000	7.607E+10	-0.003476	669414.	0.000
1656.000	3.080E-08	-0.004744	0.0103	-2.626E-09	0.000	7.607E+10	-0.001750	681725.	0.000
1668.000	-7.151E-10	0.000	0.000	-2.627E-09	0.000	7.607E+10	4.136E-05	347018.	0.000

* This analysis makes computations of pile response using nonlinear moment-curvature relationships.
The above values of total stress are computed for combined axial stress and do not equal the actual stresses in concrete and steel in the range of nonlinear bending.

Output Verification: Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =      1.5447655 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       -682144. inch-lbs
Maximum shear force              =  -4272.4016220 lbs
Depth of maximum bending moment  =       0.000000 inches below pile head
Depth of maximum shear force     =     996.0000000 inches below pile head
Number of iterations             =              12
Number of zero deflection points =               5
```

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-lbs	Maximum Shear lbs	Pile-head Rotation radians
1	2	V = 1000.0000	S = 0.000	245000.	1.54476547	-682144.	-4272.4016	0.00000000

The analysis ended normally.

A-PILE OUTPUT

20-INCH PIPE PILE

VERTICAL

J:\Geo\33940.ah\Work\Calcs\APile\33940_20 inch.cpt

1

AXIALLY LOADING PILE ANALYSIS PROGRAM - APILEplus
VERSION 5.0 - (C) COPYRIGHT ENSOFT,INC.,1987-2008.

Eastport - 20" Pile

DESIGNER : JJM

DATE : NOV 2013

PILE PROPERTIES :

PERIMETER OF PILE WITH NONCIRCULAR SECTION= 0.00 IN.
TIP AREA OF PILE WITH NONCIRCULAR SECTION = 0.00 SQF
OUTSIDE DIAMETER OF CIRCULAR PILE = 20.00 IN.
INTERNAL DIAMETER OF CIRCULAR PILE = 18.75 IN.
PILE LENGTH = 70.00 FT.
MODULUS OF ELASTICITY = 0.290E+08 PSI

LENGTH OF SURFACE SECTION WITH ZERO SKIN FRICTION = 0.00 FT.
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	SAND	1.00	61.00	34.00	42.00
45.00	SAND	1.00	61.00	34.00	42.00
45.00	SAND	1.00	66.00	36.00	62.00
65.00	SAND	1.00	66.00	36.00	62.00
65.00	SAND	1.00	96.00	45.00	145.00
80.00	SAND	1.00	96.00	45.00	145.00

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
0.74E+00	0.85E+02	0.00	0.00	5.00	0.00	0.00
0.74E+00	0.85E+02	0.00	0.00	5.00	0.00	0.00
0.74E+00	0.13E+03	0.00	0.00	5.00	0.00	0.00
0.74E+00	0.13E+03	0.00	0.00	5.00	0.00	0.00
0.74E+00	0.29E+03	0.00	0.00	5.00	0.00	0.00
0.74E+00	0.29E+03	0.00	0.00	5.00	0.00	0.00

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

DEPTH FT.	PLASTIC INDEX PI %	YIELD STRESS RATIO	Qc FROM CPT KSF
0.00	0.00	5.00	0.100E-02
45.00	0.00	5.00	0.100E-02
45.00	0.00	5.00	0.200E-01
65.00	0.00	5.00	0.200E-01
65.00	0.00	5.00	0.200E-01
80.00	0.00	5.00	0.200E-01

1

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

PILE PENETRATION FT.	FED. HWY. METHOD TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPACITY KIP	ARMY CORPS METHOD TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPACITY KIP	LAMBDA 2 METHOD TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPACITY KIP
0.0	0.0	0.0*	0.0	0.0	0.0*	0.0	0.0	0.0*	0.0
1.0	0.1	0.7*	0.8	0.1	0.8*	0.9	0.2	0.8*	1.0
2.0	0.5	1.5*	2.0	0.3	1.7*	2.0	0.8	1.7*	2.5
3.0	1.0	2.5*	3.6	0.7	2.8*	3.5	1.7	2.8*	4.4
4.0	1.8	3.7*	5.5	1.2	4.1*	5.3	2.8	4.0*	6.8
5.0	2.8	5.0*	7.9	1.9	5.5*	7.4	4.1	5.5*	9.6
6.0	4.1	6.6*	10.6	2.7	7.1*	9.9	5.7	7.0*	12.8
7.0	5.6	8.2*	13.8	3.7	8.9*	12.6	7.5	8.8*	16.3

8.0	7.3	10.1*	17.3	4.9	10.9*	15.7	9.5	10.7*	20.2
9.0	9.2	12.1*	21.3	6.2	13.0*	19.1	11.7	12.8*	24.5
10.0	11.4	14.2*	25.6	7.6	15.2*	22.8	14.0	15.1*	29.1
11.0	13.8	16.6*	30.3	9.2	17.7*	26.9	16.6	17.5*	34.1
12.0	16.4	19.1*	35.5	11.0	20.3*	31.2	19.3	20.1*	39.3
13.0	19.2	21.7*	41.0	12.9	23.0*	35.9	22.1	22.8*	45.0
14.0	22.3	24.6*	46.9	14.9	26.0*	40.9	25.1	25.7*	50.9
15.0	25.6	27.6*	53.2	17.1	29.1*	46.2	28.3	28.8*	57.1
16.0	29.1	30.7*	59.9	19.5	32.3*	51.8	31.6	32.1*	63.7
17.0	32.9	34.1*	67.0	22.0	35.8*	57.8	35.1	35.5*	70.5
18.0	36.8	37.6*	74.3	24.7	39.4*	64.0	38.6	39.1*	77.7
19.0	40.6	41.2*	81.9	27.5	43.1*	70.6	42.3	42.8*	85.2
20.0	44.5	45.1*	89.6	30.5	47.1*	77.5	46.2	46.7*	92.9
21.0	48.4	49.1*	97.4	33.6	51.2*	84.7	50.0	50.8*	100.9
22.0	52.2	53.2*	105.4	36.9	55.4*	92.3	53.9	55.0*	109.0
23.0	56.1	57.4*	113.5	40.3	59.7*	100.0	57.8	59.3*	117.1
24.0	60.0	61.7*	121.6	43.9	64.0*	107.9	61.7	63.7*	125.3
25.0	63.8	65.9*	129.7	47.6	68.4*	116.0	65.5	68.0*	133.5
26.0	67.7	70.1*	137.8	51.5	72.7*	124.2	69.4	72.3*	141.7
27.0	71.6	74.3*	145.9	55.3	77.0*	132.3	73.3	76.6*	149.8
28.0	75.4	78.5*	154.0	59.2	78.6*	137.8	77.1	80.9*	158.0
29.0	79.3	82.8*	162.1	63.1	82.2*	145.3	81.0	85.2*	166.2
30.0	83.2	87.0*	170.2	67.0	85.8*	152.8	84.9	89.5*	174.4
31.0	87.1	91.2*	178.3	70.8	89.4*	160.3	88.7	93.8*	182.5
32.0	90.9	95.4*	186.4	74.7	93.1*	167.8	92.6	98.1*	190.7
33.0	94.8	99.5*	194.3	78.6	96.7*	175.3	96.5	102.4*	198.9
34.0	98.7	103.1*	201.8	82.4	100.3*	182.7	100.4	106.2*	206.6
35.0	102.5	106.7*	209.3	86.3	103.9*	190.2	104.2	109.9*	214.1
36.0	106.4	110.4*	216.8	90.2	107.6*	197.7	108.1	113.5*	221.6
37.0	110.3	114.0*	224.3	94.0	111.2*	205.2	112.0	117.1*	229.1
38.0	114.1	117.6*	231.8	97.9	114.8*	212.7	132.2	120.8*	253.0
39.0	118.0	121.2*	239.3	101.8	118.5*	220.2	136.1	124.4*	260.5
40.0	121.9	124.9*	246.8	105.6	122.1*	227.7	140.0	128.0*	268.0
41.0	125.7	128.5*	254.2	109.5	125.7*	235.2	143.8	131.6*	275.5
42.0	129.6	132.1*	261.7	113.4	129.3*	242.7	147.7	135.3*	283.0
43.0	133.5	135.8*	269.2	117.3	133.0*	250.2	151.6	138.9*	290.5
44.0	137.4	139.4*	276.7	121.1	136.6*	257.7	155.4	142.5*	298.0
45.0	141.2	143.0*	284.2	125.0	140.2*	265.2	159.3	146.1*	305.5
46.0	145.1	160.5*	305.6	128.9	148.9*	277.7	179.6	160.5*	340.1
47.0	149.0	164.1*	313.1	132.7	152.5*	285.2	183.4	164.1*	347.6
48.0	152.8	167.8*	320.6	136.6	156.1*	292.7	187.3	167.8*	355.1
49.0	156.7	171.4*	328.1	140.5	159.8*	300.2	191.2	171.4*	362.6
50.0	160.6	175.0*	335.6	144.3	163.4*	307.7	195.0	175.0*	370.1
51.0	164.4	178.7*	343.1	148.2	167.0*	315.2	198.9	178.7*	377.6
52.0	168.3	182.3*	350.6	152.1	170.6*	322.7	219.2	182.3*	401.5
53.0	172.2	185.9*	358.1	156.0	174.3*	330.2	223.0	185.9*	408.9
54.0	176.0	189.5*	365.6	159.8	177.9*	337.7	226.9	189.5*	416.4
55.0	179.9	193.2*	373.1	163.7	178.9*	342.6	230.8	193.2*	423.9
56.0	183.8	196.8*	380.6	167.6	178.9*	346.4	234.6	196.8*	431.4
57.0	187.7	200.4*	388.1	171.4	178.9*	350.3	254.9	200.4*	455.3
58.0	191.5	204.0*	395.6	175.3	178.9*	354.2	258.8	204.0*	462.8
59.0	195.4	207.7*	403.1	179.2	178.9*	358.0	262.6	207.7*	470.3
60.0	199.3	211.3*	410.6	183.0	178.9*	361.9	266.5	211.3*	477.8
61.0	203.1	214.9*	418.1	186.9	178.9*	365.8	270.4	214.9*	485.3
62.0	207.0	218.6*	425.6	190.8	206.9*	397.7	290.6	218.6*	509.2
63.0	210.9	222.2*	433.1	194.6	210.5*	405.2	294.5	222.2*	516.7
64.0	214.7	225.8*	440.6	198.5	214.2*	412.7	298.4	225.8*	524.2
65.0	218.6	229.4*	448.1	202.4	217.8*	420.2	302.3	229.4*	531.7
66.0	222.5	277.6*	500.1	206.3	277.6*	483.9	322.5	277.6*	600.2
67.0	226.4	281.3*	507.6	210.1	281.3*	491.4	326.4	281.3*	607.7
68.0	230.2	284.9*	515.1	214.0	284.9*	498.9	330.3	284.9*	615.2
69.0	234.1	288.5*	522.6	217.9	288.5*	506.4	350.5	288.5*	639.0
70.0	238.0	292.2*	530.1	221.7	292.2*	513.9	354.4	292.2*	646.5

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*  API RP-2A (1994)  *
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PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0*	0.0
1.00	0.1	0.8*	0.8
2.00	0.4	1.7*	2.0
3.00	0.8	2.8*	3.6
4.00	1.4	4.0*	5.5
5.00	2.2	5.5*	7.7
6.00	3.2	7.0*	10.2
7.00	4.3	8.8*	13.1
8.00	5.7	10.7*	16.4
9.00	7.2	12.8*	20.0
10.00	8.9	15.1*	23.9
11.00	10.7	17.5*	28.2
12.00	12.7	20.1*	32.8
13.00	15.0	22.8*	37.8
14.00	17.4	25.7*	43.1
15.00	19.9	28.8*	48.7
16.00	22.7	32.1*	54.7
17.00	25.6	35.5*	61.1
18.00	28.7	39.1*	67.8
19.00	32.0	42.8*	74.8
20.00	35.4	46.7*	82.1
21.00	39.0	50.8*	89.8
22.00	42.8	55.0*	97.9
23.00	46.7	59.3*	106.1
24.00	50.6	63.7*	114.2
25.00	54.5	68.0*	122.4
26.00	58.3	72.3*	130.6
27.00	62.2	76.6*	138.8
28.00	66.1	80.9*	146.9
29.00	69.9	85.2*	155.1
30.00	73.8	89.5*	163.3
31.00	77.7	93.8*	171.5
32.00	81.5	98.1*	179.6

33.00	85.4	102.4*	187.8
34.00	89.3	106.2*	195.5
35.00	93.1	109.9*	203.0
36.00	97.0	113.5*	210.5
37.00	100.9	117.1*	218.0
38.00	104.8	120.8*	225.5
39.00	108.6	124.4*	233.0
40.00	112.5	128.0*	240.5
41.00	116.4	131.6*	248.0
42.00	120.2	135.3*	255.5
43.00	124.1	138.9*	263.0
44.00	128.0	142.5*	270.5
45.00	131.8	146.1*	278.0
46.00	135.7	160.5*	296.2
47.00	139.6	164.1*	303.7
48.00	143.4	167.8*	311.2
49.00	147.3	171.4*	318.7
50.00	151.2	175.0*	326.2
51.00	155.1	178.7*	333.7
52.00	158.9	182.3*	341.2
53.00	162.8	185.9*	348.7
54.00	166.7	189.5*	356.2
55.00	170.5	193.2*	363.7
56.00	174.4	196.8*	371.2
57.00	178.3	200.4*	378.7
58.00	182.1	204.0*	386.2
59.00	186.0	207.7*	393.7
60.00	189.9	211.3*	401.2
61.00	193.8	214.9*	408.7
62.00	197.6	218.6*	416.2
63.00	201.5	222.2*	423.7
64.00	205.4	225.8*	431.2
65.00	209.2	229.4*	438.7
66.00	213.1	277.6*	490.7
67.00	217.0	281.3*	498.2
68.00	220.8	284.9*	505.7
69.00	224.7	288.5*	513.2
70.00	228.6	292.2*	520.7

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*****************************************************
*  NORWEIGIAN GEOTECHNICAL INSTITUTE (NGI) METHOD  *
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PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
1.00	0.0	0.0	0.0
2.00	0.0	0.0	0.0
3.00	0.0	0.0	0.0
4.00	0.0	0.0	0.0
5.00	0.0	0.0	0.0
6.00	0.1	0.0	0.1
7.00	0.1	0.0	0.1
8.00	0.1	0.0	0.1
9.00	0.2	0.0	0.2
10.00	0.2	0.0	0.2
11.00	0.3	0.0	0.3
12.00	0.4	0.0	0.4
13.00	0.4	0.0	0.4
14.00	0.5	0.0	0.5
15.00	0.6	0.0	0.6
16.00	0.7	0.0	0.7
17.00	0.8	0.0	0.8
18.00	0.9	0.0	0.9
19.00	1.1	0.0	1.1
20.00	1.2	0.0	1.2
21.00	1.4	0.0	1.4
22.00	1.5	0.0	1.5
23.00	1.7	0.0	1.7
24.00	1.8	0.0	1.8
25.00	2.0	0.0	2.0
26.00	2.2	0.0	2.2
27.00	2.4	0.0	2.4
28.00	2.6	0.0	2.6
29.00	2.9	0.0	2.9
30.00	3.1	0.0	3.1
31.00	3.3	0.0	3.3
32.00	3.6	0.0	3.6
33.00	3.9	0.0	3.9
34.00	4.1	0.0	4.1
35.00	4.4	0.0	4.4
36.00	4.7	0.0	4.7
37.00	5.0	0.0	5.0
38.00	5.3	0.0	5.3
39.00	5.7	0.0	5.7
40.00	6.0	0.0	6.0
41.00	6.4	0.0	6.4
42.00	6.7	0.0	6.7
43.00	7.1	0.0	7.1
44.00	7.5	0.0	7.5
45.00	7.9	0.0	7.9
46.00	8.3	0.0	8.3
47.00	8.7	0.0	8.7
48.00	9.1	0.0	9.1
49.00	9.6	0.0	9.6
50.00	10.0	0.0	10.0
51.00	10.5	0.0	10.5
52.00	11.0	0.0	11.0
53.00	11.5	0.0	11.5
54.00	12.0	0.0	12.0
55.00	12.5	0.0	12.5
56.00	13.0	0.0	13.0
57.00	13.5	0.0	13.5

58.00	14.1	0.0	14.1
59.00	14.6	0.0	14.6
60.00	15.2	0.0	15.2
61.00	15.8	0.0	15.8
62.00	16.4	0.0	16.4
63.00	17.0	0.0	17.0
64.00	17.6	0.0	17.6
65.00	18.3	0.0	18.3
66.00	18.9	0.0	18.9
67.00	19.6	0.0	19.6
68.00	20.3	0.0	20.3
69.00	21.0	0.0	21.0
70.00	21.7	0.0	21.7

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***********************************
*  IMPERIAL COLLEGE (MTD) METHOD  *
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PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
1.00	0.0	0.0	0.0
2.00	0.0	0.0	0.0
3.00	0.0	0.0	0.0
4.00	0.0	0.0	0.0
5.00	0.0	0.0	0.0
6.00	0.0	0.0	0.0
7.00	0.0	0.0	0.0
8.00	0.0	0.0	0.0
9.00	0.0	0.0	0.0
10.00	0.0	0.0	0.0
11.00	0.0	0.0	0.0
12.00	0.0	0.0	0.0
13.00	0.0	0.0	0.0
14.00	0.0	0.0	0.0
15.00	0.0	0.0	0.0
16.00	0.0	0.0	0.0
17.00	0.0	0.0	0.0
18.00	0.0	0.0	0.0
19.00	0.0	0.0	0.0
20.00	0.0	0.0	0.0
21.00	0.0	0.0	0.0
22.00	0.0	0.0	0.0
23.00	0.0	0.0	0.0
24.00	0.0	0.0	0.0
25.00	0.0	0.0	0.0
26.00	0.0	0.0	0.0
27.00	0.0	0.0	0.0
28.00	0.0	0.0	0.0
29.00	0.0	0.0	0.0
30.00	0.0	0.0	0.0
31.00	0.0	0.0	0.0
32.00	0.0	0.0	0.0
33.00	0.0	0.0	0.0
34.00	0.0	0.0	0.0
35.00	0.0	0.0	0.0
36.00	0.0	0.0	0.0
37.00	0.0	0.0	0.0
38.00	0.0	0.0	0.0
39.00	0.0	0.0	0.0
40.00	0.0	0.0	0.0
41.00	0.0	0.0	0.0
42.00	0.0	0.0	0.0
43.00	0.0	0.0	0.0
44.00	0.0	0.0	0.0
45.00	0.0	0.0	0.0
46.00	0.0	0.0	0.0
47.00	0.0	0.0	0.0
48.00	0.0	0.0	0.0
49.00	0.0	0.0	0.0
50.00	0.0	0.0	0.0
51.00	0.0	0.0	0.0
52.00	0.0	0.0	0.0
53.00	0.0	0.0	0.0
54.00	0.0	0.0	0.0
55.00	0.0	0.0	0.0
56.00	0.0	0.0	0.0
57.00	0.0	0.0	0.0
58.00	0.0	0.0	0.0
59.00	0.0	0.0	0.0
60.00	0.0	0.0	0.0
61.00	0.0	0.0	0.0
62.00	0.0	0.0	0.0
63.00	0.0	0.0	0.0
64.00	0.0	0.0	0.0
65.00	0.0	0.0	0.0
66.00	0.0	0.0	0.0
67.00	0.0	0.0	0.0
68.00	0.0	0.0	0.0
69.00	0.0	0.0	0.0
70.00	0.0	0.0	0.0

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.

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*************************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
*************************************************
```

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.1761E-01	0.1000E-01
			0.3522E-01	0.2000E-01
			0.7044E-01	0.4000E-01
			0.1057E+00	0.6000E-01
			0.1409E+00	0.8000E-01
			0.1585E+00	0.9000E-01
			0.1761E+00	0.1000E+00
			0.1761E+00	0.5000E+00
			0.1761E+00	0.2000E+01
2	10	0.2252E+02		
			0.0000E+00	0.0000E+00
			0.5132E+00	0.1000E-01
			0.1026E+01	0.2000E-01
			0.2053E+01	0.4000E-01
			0.3079E+01	0.6000E-01
			0.4106E+01	0.8000E-01
			0.4619E+01	0.9000E-01
			0.5132E+01	0.1000E+00
			0.5132E+01	0.5000E+00
			0.5132E+01	0.2000E+01
3	10	0.4496E+02		
			0.0000E+00	0.0000E+00
			0.5132E+00	0.1000E-01
			0.1026E+01	0.2000E-01
			0.2053E+01	0.4000E-01
			0.3079E+01	0.6000E-01
			0.4106E+01	0.8000E-01
			0.4619E+01	0.9000E-01
			0.5132E+01	0.1000E+00
			0.5132E+01	0.5000E+00
			0.5132E+01	0.2000E+01
4	10	0.4500E+02		
			0.0000E+00	0.0000E+00
			0.5132E+00	0.1000E-01
			0.1026E+01	0.2000E-01
			0.2053E+01	0.4000E-01
			0.3079E+01	0.6000E-01
			0.4106E+01	0.8000E-01
			0.4619E+01	0.9000E-01
			0.5132E+01	0.1000E+00
			0.5132E+01	0.5000E+00
			0.5132E+01	0.2000E+01
5	10	0.5502E+02		
			0.0000E+00	0.0000E+00
			0.5132E+00	0.1000E-01
			0.1026E+01	0.2000E-01
			0.2053E+01	0.4000E-01
			0.3079E+01	0.6000E-01
			0.4106E+01	0.8000E-01
			0.4619E+01	0.9000E-01
			0.5132E+01	0.1000E+00
			0.5132E+01	0.5000E+00
			0.5132E+01	0.2000E+01
6	10	0.6496E+02		
			0.0000E+00	0.0000E+00
			0.5132E+00	0.1000E-01
			0.1026E+01	0.2000E-01
			0.2053E+01	0.4000E-01
			0.3079E+01	0.6000E-01
			0.4106E+01	0.8000E-01
			0.4619E+01	0.9000E-01
			0.5132E+01	0.1000E+00
			0.5132E+01	0.5000E+00
			0.5132E+01	0.2000E+01
7	10	0.6500E+02		
			0.0000E+00	0.0000E+00
			0.5132E+00	0.1000E-01
			0.1026E+01	0.2000E-01
			0.2053E+01	0.4000E-01
			0.3079E+01	0.6000E-01
			0.4106E+01	0.8000E-01
			0.4619E+01	0.9000E-01
			0.5132E+01	0.1000E+00
			0.5132E+01	0.5000E+00
			0.5132E+01	0.2000E+01
8	10	0.7253E+02		
			0.0000E+00	0.0000E+00
			0.5132E+00	0.1000E-01
			0.1026E+01	0.2000E-01
			0.2053E+01	0.4000E-01
			0.3079E+01	0.6000E-01
			0.4106E+01	0.8000E-01
			0.4619E+01	0.9000E-01
			0.5132E+01	0.1000E+00
			0.5132E+01	0.5000E+00
			0.5132E+01	0.2000E+01
9	10	0.7996E+02		
			0.0000E+00	0.0000E+00
			0.5132E+00	0.1000E-01
			0.1026E+01	0.2000E-01
			0.2053E+01	0.4000E-01
			0.3079E+01	0.6000E-01
			0.4106E+01	0.8000E-01
			0.4619E+01	0.9000E-01
			0.5132E+01	0.1000E+00
			0.5132E+01	0.5000E+00
			0.5132E+01	0.2000E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1826E+02	0.1000E-01
0.3652E+02	0.2000E-01
0.7304E+02	0.4000E-01
0.1461E+03	0.2600E+00
0.2191E+03	0.8400E+00
0.2629E+03	0.1460E+01
0.2922E+03	0.2000E+01
0.2922E+03	0.3000E+01
0.2922E+03	0.4000E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.6238E+00	0.4013E-03	0.1826E+00	0.1000E-03
0.6238E+01	0.4013E-02	0.1826E+01	0.1000E-02
0.3132E+02	0.2009E-01	0.9130E+01	0.5000E-02
0.6290E+02	0.4031E-01	0.1826E+02	0.1000E-01
0.2637E+03	0.1824E+00	0.7636E+02	0.5000E-01
0.3217E+03	0.2706E+00	0.9296E+02	0.1000E+00
0.4051E+03	0.7342E+00	0.1763E+03	0.5000E+00
0.4592E+03	0.1275E+01	0.2304E+03	0.1000E+01
0.5209E+03	0.2322E+01	0.2922E+03	0.2000E+01

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**************************************************
* COMPUTE INTERNALLY-GENERATED LOAD-TRANSFER     *
* (t-z) CURVES FOR VERIFICATION                  *
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T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.1000E+01		
			0.0000E+00	0.0000E+00
			0.1761E-01	0.1000E-01
			0.3522E-01	0.2000E-01
			0.7044E-01	0.4000E-01
			0.1057E+00	0.6000E-01
			0.1409E+00	0.8000E-01
			0.1585E+00	0.9000E-01
			0.1761E+00	0.1000E+00
			0.1761E+00	0.5000E+00
			0.1761E+00	0.2000E+01
2	10	0.2000E+01		
			0.0000E+00	0.0000E+00
			0.4696E-01	0.1000E-01
			0.9392E-01	0.2000E-01
			0.1878E+00	0.4000E-01
			0.2818E+00	0.6000E-01
			0.3757E+00	0.8000E-01
			0.4227E+00	0.9000E-01
			0.4696E+00	0.1000E+00
			0.4696E+00	0.5000E+00
			0.4696E+00	0.2000E+01
3	10	0.3000E+01		
			0.0000E+00	0.0000E+00
			0.7044E-01	0.1000E-01
			0.1409E+00	0.2000E-01
			0.2818E+00	0.4000E-01
			0.4227E+00	0.6000E-01
			0.5635E+00	0.8000E-01
			0.6340E+00	0.9000E-01
			0.7044E+00	0.1000E+00
			0.7044E+00	0.5000E+00
			0.7044E+00	0.2000E+01
4	10	0.4000E+01		
			0.0000E+00	0.0000E+00
			0.9392E-01	0.1000E-01
			0.1878E+00	0.2000E-01
			0.3757E+00	0.4000E-01
			0.5635E+00	0.6000E-01
			0.7514E+00	0.8000E-01
			0.8453E+00	0.9000E-01
			0.9392E+00	0.1000E+00
			0.9392E+00	0.5000E+00
			0.9392E+00	0.2000E+01
5	10	0.5000E+01		
			0.0000E+00	0.0000E+00
			0.1174E+00	0.1000E-01
			0.2348E+00	0.2000E-01
			0.4696E+00	0.4000E-01
			0.7044E+00	0.6000E-01
			0.9392E+00	0.8000E-01
			0.1057E+01	0.9000E-01
			0.1174E+01	0.1000E+00
			0.1174E+01	0.5000E+00
			0.1174E+01	0.2000E+01
6	10	0.6000E+01		
			0.0000E+00	0.0000E+00
			0.1409E+00	0.1000E-01
			0.2818E+00	0.2000E-01
			0.5635E+00	0.4000E-01
			0.8453E+00	0.6000E-01
			0.1127E+01	0.8000E-01

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                                        0.1268E+01      0.9000E-01
                                        0.1409E+01      0.1000E+00
                                        0.1409E+01      0.5000E+00
                                        0.1409E+01      0.2000E+01
 7        10      0.7000E+01
                                        0.0000E+00      0.0000E+00
                                        0.1644E+00      0.1000E-01
                                        0.3287E+00      0.2000E-01
                                        0.6575E+00      0.4000E-01
                                        0.9862E+00      0.6000E-01
                                        0.1315E+01      0.8000E-01
                                        0.1479E+01      0.9000E-01
                                        0.1644E+01      0.1000E+00
                                        0.1644E+01      0.5000E+00
                                        0.1644E+01      0.2000E+01
 8        10      0.8000E+01
                                        0.0000E+00      0.0000E+00
                                        0.1878E+00      0.1000E-01
                                        0.3757E+00      0.2000E-01
                                        0.7514E+00      0.4000E-01
                                        0.1127E+01      0.6000E-01
                                        0.1503E+01      0.8000E-01
                                        0.1691E+01      0.9000E-01
                                        0.1878E+01      0.1000E+00
                                        0.1878E+01      0.5000E+00
                                        0.1878E+01      0.2000E+01
 9        10      0.9000E+01
                                        0.0000E+00      0.0000E+00
                                        0.2113E+00      0.1000E-01
                                        0.4227E+00      0.2000E-01
                                        0.8453E+00      0.4000E-01
                                        0.1268E+01      0.6000E-01
                                        0.1691E+01      0.8000E-01
                                        0.1902E+01      0.9000E-01
                                        0.2113E+01      0.1000E+00
                                        0.2113E+01      0.5000E+00
                                        0.2113E+01      0.2000E+01
10        10      0.1000E+02
                                        0.0000E+00      0.0000E+00
                                        0.2348E+00      0.1000E-01
                                        0.4696E+00      0.2000E-01
                                        0.9392E+00      0.4000E-01
                                        0.1409E+01      0.6000E-01
                                        0.1878E+01      0.8000E-01
                                        0.2113E+01      0.9000E-01
                                        0.2348E+01      0.1000E+00
                                        0.2348E+01      0.5000E+00
                                        0.2348E+01      0.2000E+01
11        10      0.1100E+02
                                        0.0000E+00      0.0000E+00
                                        0.2583E+00      0.1000E-01
                                        0.5166E+00      0.2000E-01
                                        0.1033E+01      0.4000E-01
                                        0.1550E+01      0.6000E-01
                                        0.2066E+01      0.8000E-01
                                        0.2325E+01      0.9000E-01
                                        0.2583E+01      0.1000E+00
                                        0.2583E+01      0.5000E+00
                                        0.2583E+01      0.2000E+01
12        10      0.1200E+02
                                        0.0000E+00      0.0000E+00
                                        0.2818E+00      0.1000E-01
                                        0.5635E+00      0.2000E-01
                                        0.1127E+01      0.4000E-01
                                        0.1691E+01      0.6000E-01
                                        0.2254E+01      0.8000E-01
                                        0.2536E+01      0.9000E-01
                                        0.2818E+01      0.1000E+00
                                        0.2818E+01      0.5000E+00
                                        0.2818E+01      0.2000E+01
13        10      0.1300E+02
                                        0.0000E+00      0.0000E+00
                                        0.3053E+00      0.1000E-01
                                        0.6105E+00      0.2000E-01
                                        0.1221E+01      0.4000E-01
                                        0.1832E+01      0.6000E-01
                                        0.2442E+01      0.8000E-01
                                        0.2747E+01      0.9000E-01
                                        0.3053E+01      0.1000E+00
                                        0.3053E+01      0.5000E+00
                                        0.3053E+01      0.2000E+01
14        10      0.1400E+02
                                        0.0000E+00      0.0000E+00
                                        0.3287E+00      0.1000E-01
                                        0.6575E+00      0.2000E-01
                                        0.1315E+01      0.4000E-01
                                        0.1972E+01      0.6000E-01
                                        0.2630E+01      0.8000E-01
                                        0.2959E+01      0.9000E-01
                                        0.3287E+01      0.1000E+00
                                        0.3287E+01      0.5000E+00
                                        0.3287E+01      0.2000E+01
15        10      0.1500E+02
                                        0.0000E+00      0.0000E+00
                                        0.3522E+00      0.1000E-01
                                        0.7044E+00      0.2000E-01
                                        0.1409E+01      0.4000E-01
                                        0.2113E+01      0.6000E-01
                                        0.2818E+01      0.8000E-01
                                        0.3170E+01      0.9000E-01
                                        0.3522E+01      0.1000E+00
                                        0.3522E+01      0.5000E+00
                                        0.3522E+01      0.2000E+01
16        10      0.1600E+02
                                        0.0000E+00      0.0000E+00
                                        0.3757E+00      0.1000E-01
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                                        0.7514E+00      0.2000E-01
                                        0.1503E+01      0.4000E-01
                                        0.2254E+01      0.6000E-01
                                        0.3006E+01      0.8000E-01
                                        0.3381E+01      0.9000E-01
                                        0.3757E+01      0.1000E+00
                                        0.3757E+01      0.5000E+00
                                        0.3757E+01      0.2000E+01
17          10      0.1700E+02
                                        0.0000E+00      0.0000E+00
                                        0.3992E+00      0.1000E-01
                                        0.7984E+00      0.2000E-01
                                        0.1597E+01      0.4000E-01
                                        0.2395E+01      0.6000E-01
                                        0.3193E+01      0.8000E-01
                                        0.3593E+01      0.9000E-01
                                        0.3992E+01      0.1000E+00
                                        0.3992E+01      0.5000E+00
                                        0.3992E+01      0.2000E+01
18          10      0.1800E+02
                                        0.0000E+00      0.0000E+00
                                        0.4227E+00      0.1000E-01
                                        0.8453E+00      0.2000E-01
                                        0.1691E+01      0.4000E-01
                                        0.2536E+01      0.6000E-01
                                        0.3381E+01      0.8000E-01
                                        0.3804E+01      0.9000E-01
                                        0.4227E+01      0.1000E+00
                                        0.4227E+01      0.5000E+00
                                        0.4227E+01      0.2000E+01
19          10      0.1900E+02
                                        0.0000E+00      0.0000E+00
                                        0.4461E+00      0.1000E-01
                                        0.8923E+00      0.2000E-01
                                        0.1785E+01      0.4000E-01
                                        0.2677E+01      0.6000E-01
                                        0.3569E+01      0.8000E-01
                                        0.4015E+01      0.9000E-01
                                        0.4461E+01      0.1000E+00
                                        0.4461E+01      0.5000E+00
                                        0.4461E+01      0.2000E+01
20          10      0.2000E+02
                                        0.0000E+00      0.0000E+00
                                        0.4696E+00      0.1000E-01
                                        0.9392E+00      0.2000E-01
                                        0.1878E+01      0.4000E-01
                                        0.2818E+01      0.6000E-01
                                        0.3757E+01      0.8000E-01
                                        0.4227E+01      0.9000E-01
                                        0.4696E+01      0.1000E+00
                                        0.4696E+01      0.5000E+00
                                        0.4696E+01      0.2000E+01
21          10      0.2100E+02
                                        0.0000E+00      0.0000E+00
                                        0.4931E+00      0.1000E-01
                                        0.9862E+00      0.2000E-01
                                        0.1972E+01      0.4000E-01
                                        0.2959E+01      0.6000E-01
                                        0.3945E+01      0.8000E-01
                                        0.4438E+01      0.9000E-01
                                        0.4931E+01      0.1000E+00
                                        0.4931E+01      0.5000E+00
                                        0.4931E+01      0.2000E+01
22          10      0.2200E+02
                                        0.0000E+00      0.0000E+00
                                        0.5090E+00      0.1000E-01
                                        0.1018E+01      0.2000E-01
                                        0.2036E+01      0.4000E-01
                                        0.3054E+01      0.6000E-01
                                        0.4072E+01      0.8000E-01
                                        0.4581E+01      0.9000E-01
                                        0.5090E+01      0.1000E+00
                                        0.5090E+01      0.5000E+00
                                        0.5090E+01      0.2000E+01
23          10      0.2300E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
24          10      0.2400E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
25          10      0.2500E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
```

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                                        0.5132E+01      0.2000E+01
26          10      0.2600E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
27          10      0.2700E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
28          10      0.2800E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
29          10      0.2900E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
30          10      0.3000E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
31          10      0.3100E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
32          10      0.3200E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
33          10      0.3300E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
34          10      0.3400E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
35          10      0.3500E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
```

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                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
36          10      0.3600E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
37          10      0.3700E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
38          10      0.3800E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
39          10      0.3900E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
40          10      0.4000E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
41          10      0.4100E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
42          10      0.4200E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
43          10      0.4300E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
44          10      0.4400E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
45          10      0.4500E+02
                                        0.0000E+00      0.0000E+00
```

```
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
46          10      0.4600E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
47          10      0.4700E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
48          10      0.4800E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
49          10      0.4900E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
50          10      0.5000E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
51          10      0.5100E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
52          10      0.5200E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
53          10      0.5300E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
54          10      0.5400E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
```

```
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
55          10      0.5500E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
56          10      0.5600E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
57          10      0.5700E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
58          10      0.5800E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
59          10      0.5900E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
60          10      0.6000E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
61          10      0.6100E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
62          10      0.6200E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
63          10      0.6300E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
64          10      0.6400E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
```

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                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
65          10      0.6500E+02
                                        0.0000E+00      0.0000E+00
                                        0.5132E+00      0.1000E-01
                                        0.1026E+01      0.2000E-01
                                        0.2053E+01      0.4000E-01
                                        0.3079E+01      0.6000E-01
                                        0.4106E+01      0.8000E-01
                                        0.4619E+01      0.9000E-01
                                        0.5132E+01      0.1000E+00
                                        0.5132E+01      0.5000E+00
                                        0.5132E+01      0.2000E+01
```

APPENDIX B

STATIC PILE CAPACITIES
COMPRESSION - TENSION

GZA
GeoEnvironmental, Inc.
477 Congress Street, Suite 700
Portland, Maine 04101
(207) 879-9190
Fax (207) 879-0099
http://www.gza.com

Engineers and Scientists

JOB 03.033940.00 EASTPORT PIER
SHEET NO 7 OF
Calculated By CLS Date 12-9-13
Checked By DDF Date 7/24/14
Scale

ESTIMATE STATIC PILE CAPACITY

UPLIFT

ASSUME SHORTEST PILE WILL BE 50 FT EMBEDDED

N = 25 BLOWS/FT (SEE SOIL PROFILE SHEET 2)

MYERHOF METHOD

$f_f = \frac{N}{25}$ (GRANULAR SOIL) ksf

$f_f = \frac{25}{25} = 1 \text{ ksf}$

$Q_s = \pi d L f_f = \pi \left(\frac{20}{12}\right) 50 (1) = \underline{262 \text{ kips}}$

NORDLUND METHOD

SEE SPILE CALCULATION SHEET 3

$Q_s = 389 \text{ kips}$

THIS IS JUDGED LESS CONSERVATIVE BECAUSE IT DOESNT USE A LIMITING f_s VALUE AT DEPTH GREATER THAN 15 TO 20 D. THERE FORE USE MYERHOF ESTIMATE

$T_{ALL} = \frac{Q_s}{3} = \frac{262}{3} = 87^k$

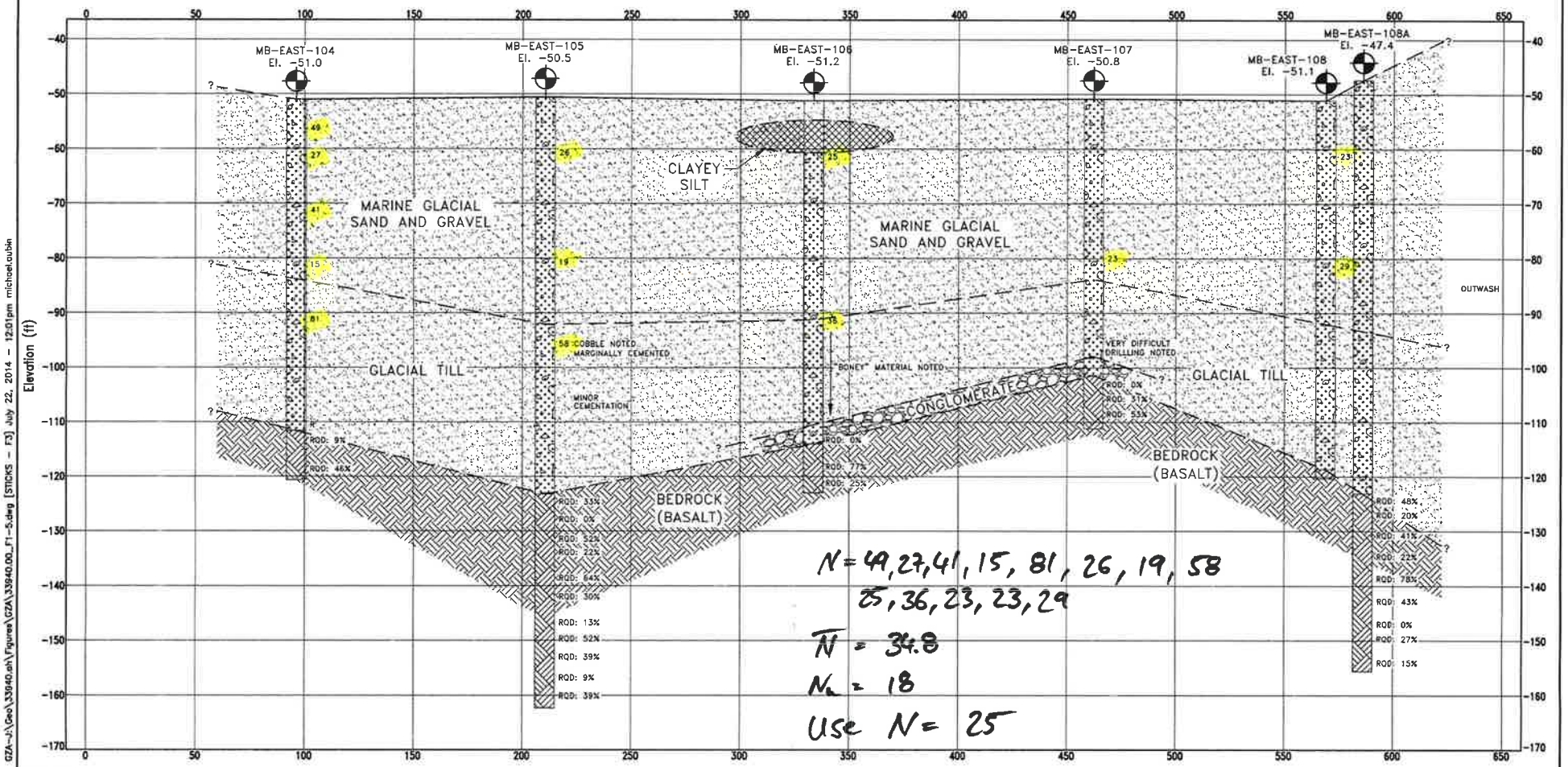
T_{MAX} (FROM SHEET ~~SK-10~~ 4) = 64 k (PLUMB) 176 k (BATTER)

SIDE FRICTION IS SUFFICIENT FOR PLUMB PILES, NOT FOR BATTER PILES.

AH/CLS

(2)

7/22/14



N = 49, 27, 41, 15, 81, 26, 19, 58
25, 36, 23, 23, 29

$\bar{N}$ = 34.8

N_L = 18

Use N = 25

NOTES:

1) THIS GENERALIZED INTERPRETIVE SOIL PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDRIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED, AND HAVE BEEN DEVELOPED BY INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS AND SAMPLES. ACTUAL SOIL TRANSACTIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO THE EXPLORATION LOGS.

2) THE LOCATION AND ELEVATION OF THE BORINGS WERE LOCATED USING OPTICAL SURVEY METHODS AND SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHODS USED.

3) BORINGS WERE PERFORMED BY MAINE TEST BORINGS, INC OF HERMON, MAINE BETWEEN MAY 28, 2013 AND JUNE 17, 2013 AND OBSERVED BY SCHONEWALD ENGINEERING ASSOCIATES.

4) UNLESS SPECIFICALLY STATED BY WRITTEN AGREEMENT, THIS DRAWING IS THE SOLE PROPERTY OF GZA GEOENVIRONMENTAL, INC. (GZA). THE INFORMATION SHOWN ON THE DRAWING IS SOLELY FOR USE BY GZA'S CLIENT OR THE CLIENT'S DESIGNATED REPRESENTATIVE FOR THE SPECIFIC PROJECT AND LOCATION IDENTIFIED ON THE DRAWING. THE DRAWING SHALL NOT BE TRANSFERRED, REUSED, COPIED, OR ALTERED IN ANY MANNER FOR USE AT ANY OTHER LOCATION OR FOR ANY OTHER PURPOSE WITHOUT THE PRIOR WRITTEN CONSENT OF GZA. ANY TRANSFER, REUSE, OR MODIFICATION TO THE DRAWING BY THE CLIENT OR OTHERS, WITHOUT THE PRIOR WRITTEN EXPRESS CONSENT OF GZA, WILL BE AT THE USER'S SOLE RISK AND WITHOUT ANY RISK OR LIABILITY TO GZA.

LEGEND:

MB-EAST-109 — INDICATES BOREHOLE DESIGNATION
El. -38.8 — INDICATES APPROXIMATE GROUND SURFACE ELEVATION (NAVDBB)

OUTWASH — 23 — INDICATES STANDARD PENETRATION TEST VALUE (SPT)

BEDROCK — RQD: 27% — INDICATES ROCK QUALITY DESIGNATION (RQD)

Prepared By: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com	Eastport Breakwater Replacement Eastport, Maine Maine Department of Transportation		Project No.: 33940.00 File Name: 33940.00_F1-5_R0.dwg
Project Mgr.: AH Designed By: SMF Revised By: CLS Drawn By: SBB Revision No.: 1 Date: 7/21/14	Title: INTERPRETIVE SUBSURFACE – PROFILE A-A'		Figure No.: 3

©2013– GZA GeoEnvironmental, Inc. GZA-J:\Geo\33940.sh\Figures\GZA\33940.00_F1-5.dwg [STICKS - F3] July 22, 2014 - 12:01pm michael.cubbin

3

12-9-13

ÚÄÄÄÄÄÄÄÄ ULTIMATE STATIC PILE CAPACITY/Federal Highway Administration ÄÄÄÄÄÄÄÄ¿
Nordlund (1963, 1979) and Tomlinson (1979, 1980) methods

Project Name : Eastport Pier Client :
File Name : 20-Inch Pipe Project Manager : A Haag
Date : 11/11/11 Computed by : CLS

Depth of Top of Pile = 0.00 ft. Pile length = 50.00 ft.
Depth to Water Table = 0.00 ft.
Diameter of pile = 20.00 in.
Type of Pile = Pipe Pile

SKIN FRICTION CONTRIBUTION

Layer	Soil Type	Thickness (ft)	Effective Stress (psf)	Internal Friction Angle	N-SPT	Pile Perimeter (ft)
1	Cohesionless	50.00	1565.00	35.77*	29.23*	5.24

Layer	Soil Type	Undrained Shear Strength (psf)	Adhesion	Pile Taper	Sliding Friction Angle	Skin Resistance (Kips)
1	Cohesionless	--	--------	----	28.54	388.59

Total Side Friction : 388.59

POINT RESISTANCE CONTRIBUTION

Effective Stress at pile Tip (psf)	Internal Friction Angle	SPT Value	Pile End Area (ft*ft)	Bearing Capacity Factor Nq	End Bearing Resistance (Kips)
3130.00	33.06*	20.21	2.18	47.74	202.00

Limiting End Bearing Resistance : 111.88

Ultimate Static Pile Capacity : 500.47

ÀÄÄÄÄÄ Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu ÄÄÄÄÄÙ

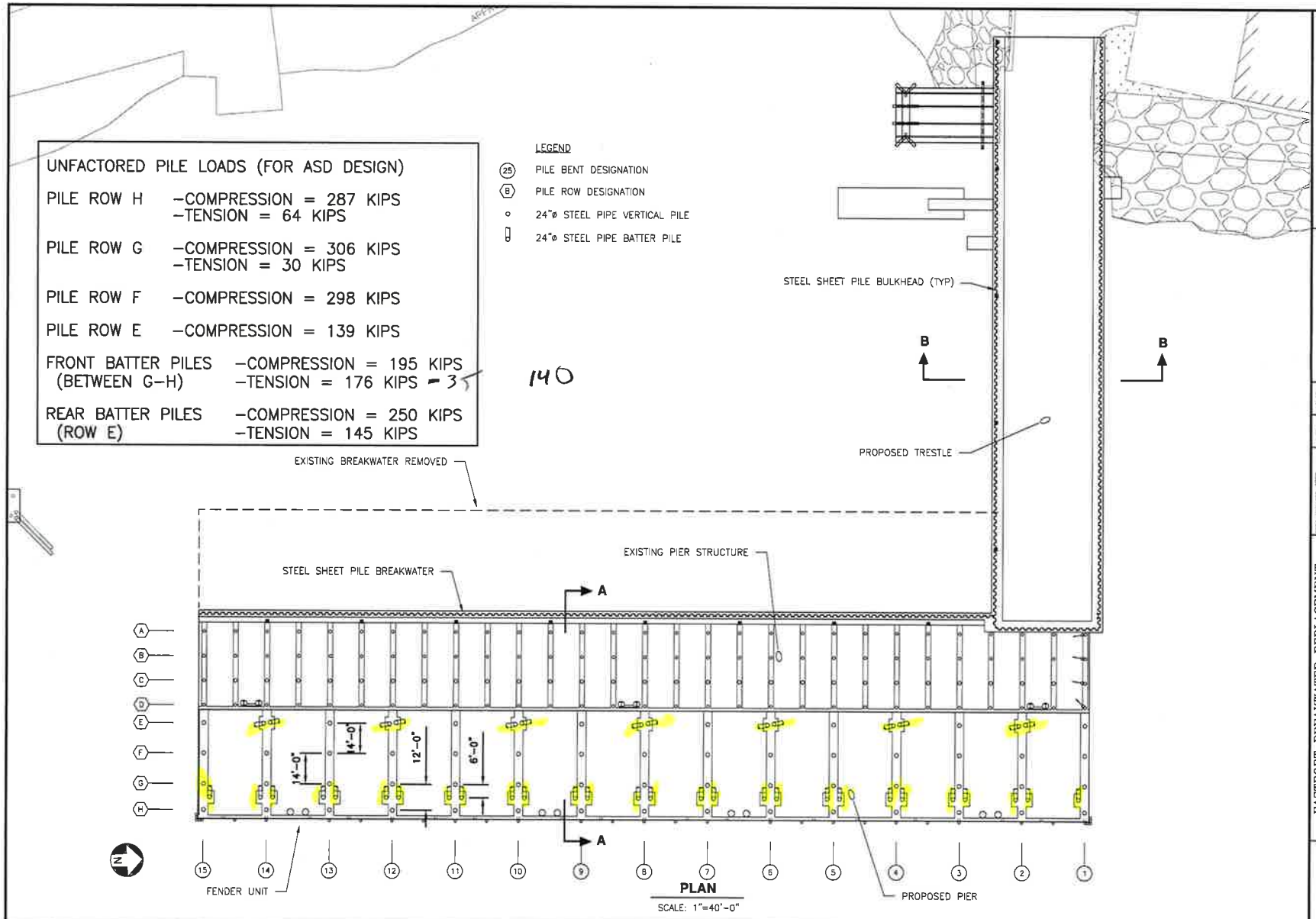
IGNORE FOR TENSION
(BASED ON CLOSED-END PILE)

UNFACTORED PILE LOADS (FOR ASD DESIGN)

PILE ROW H	–COMPRESSION = 287 KIPS –TENSION = 64 KIPS	
PILE ROW G	–COMPRESSION = 306 KIPS –TENSION = 30 KIPS	
PILE ROW F	–COMPRESSION = 298 KIPS	
PILE ROW E	–COMPRESSION = 139 KIPS	
FRONT BATTER PILES (BETWEEN G–H)	–COMPRESSION = 195 KIPS –TENSION = 176 KIPS	140 – 3
REAR BATTER PILES (ROW E)	–COMPRESSION = 250 KIPS –TENSION = 145 KIPS	

LEGEND

- (25) PILE BENT DESIGNATION
- (B) PILE ROW DESIGNATION
- ○ 24"ø STEEL PIPE VERTICAL PILE
- 24"ø STEEL PIPE BATTER PILE



PLAN
SCALE: 1"=40'-0"

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BR-1669(600)S
PIN 16686.00
BRIDGE NO 3257
BRIDGE PLANS

PROJ. MANAGER	KKK	BY	DATE
DESIGN DETAILED	ECL	KKK	5-09
DESIGN REVIEWED			5-09
DESIGN DETAILED			
REVISION 1			
REVISION 2			
REVISION 3			
REVISION 4			
PILE CHANGES			

SIGNATURE
P.E NUMBER
DATE

EASTPORT BREAKWATER REPLACEMENT
EASTPORT, ME
WASHINGTON COUNTY

CONCEPT DESIGN #4
PILE/PILE CAP PLAN

SHEET NUMBER
Sk-10
10 OF 10

12-9-13

4

APPENDIX C

PILE DRIVABILITY

GZA
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http://www.gza.com

Engineers and Scientists

JOB 03.033940.00
SHEET NO 5 OF
Calculated By CLS Date 12-9-13
Checked By DDF Date 7/24/14
Scale

CHECK DRIVABILITY USING GRLWEAP 2010

INPUT PARAMETERS

SOIL N ~ 25 TYPICAL

L = 140' ; 65 FT EMBEDDED

SIDE FRICTION ESTIMATED STATICALLY = 262k FOR A 50' PILE; EXTRAPOLATE FOR 65' PILE Q_s ~ 340k. TYPICAL EXPERIENCE SUGGESTS IT WILL RANGE FROM 10 - 30 % AT END OF DRIVE FOR THESE SOIL CONDITIONS

MAX LOAD = 250 + 145 = 395 SHEET 4, ROW "E"
195 + 176 = 371 " " , ROW "G-H"

COMPRESSIVE STRUCTURAL LOAD

TENSION LOAD FROM ANCHOR

RULT = MAX LOAD × FS

ASSUME
- FS = 2.0 FOR STATIC LOAD TEST
- LOCKOFF LOAD = MAX TENSION LOAD
- NO REDUCTION OF TENSION LOAD DUE TO RELAXATION OR COMPRESSION

RULT = 395 × 2.0 = 790k

HAMMER = DELMAG D46-23
RATED = 107 FT-KIPS
FUEL - ADJUSTABLE

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JOB 03.0 33940.00
SHEET NO 6 OF
Calculated By CLS Date 12-9-13
Checked By DDF Date 7/24/14
Scale

RESULTS OF WEAP ANALYSES ARE ATTACHED ON SHEETS 8-13, AND TABULATED BELOW.

SUMMARY OF GRLWEAP 2010 RESULTS

RUN	PILE SIZE	LENGTH (FT) TOTAL	EMBEDDED	QUAKE SIDE	QUAKE TOE	DAMPING SIDE	DAMPING TOE	% FRICTION	RESULTS @ 790k RUT σMAX (KSI)	RESIST (BL/IN)	STROKE (FT)
R*	PP20x0.625	140	65	0.1	0.04	0.05	0.15	5	39.6	6.4	6.8
R1	"	"	"	0.1	0.04	0.05	0.15	5	44.5	8.2	4.3
R2	"	"	"	0.1	0.30	0.15	0.15	35	30.65	10.1	7.6

* INDICATES HAMMER WAS RUN ON REDUCED FUEL SETTING TO LIMIT DRIVING STRESS, FUEL SETTING WAS THIRD FROM HIGHEST FOR ANALYSIS (3/5).

NOTES:

1. RUN R2 APPROXIMATES MAX. ENERGY LOSS THROUGH SOIL RESISTANCE → CONCLUDE HAMMER IS BIG ENOUGH.

2. RUNS R* AND R1 APPROX. MIN SOIL RESISTANCE (MAX STRESS)
   - FROM R1 NOTE STRESS APPROACHING MAX ALLOW 45ksi
   - FROM R* NOTE STRESS IS LOWER WITH REDUCED FUEL, SAME HAMMER

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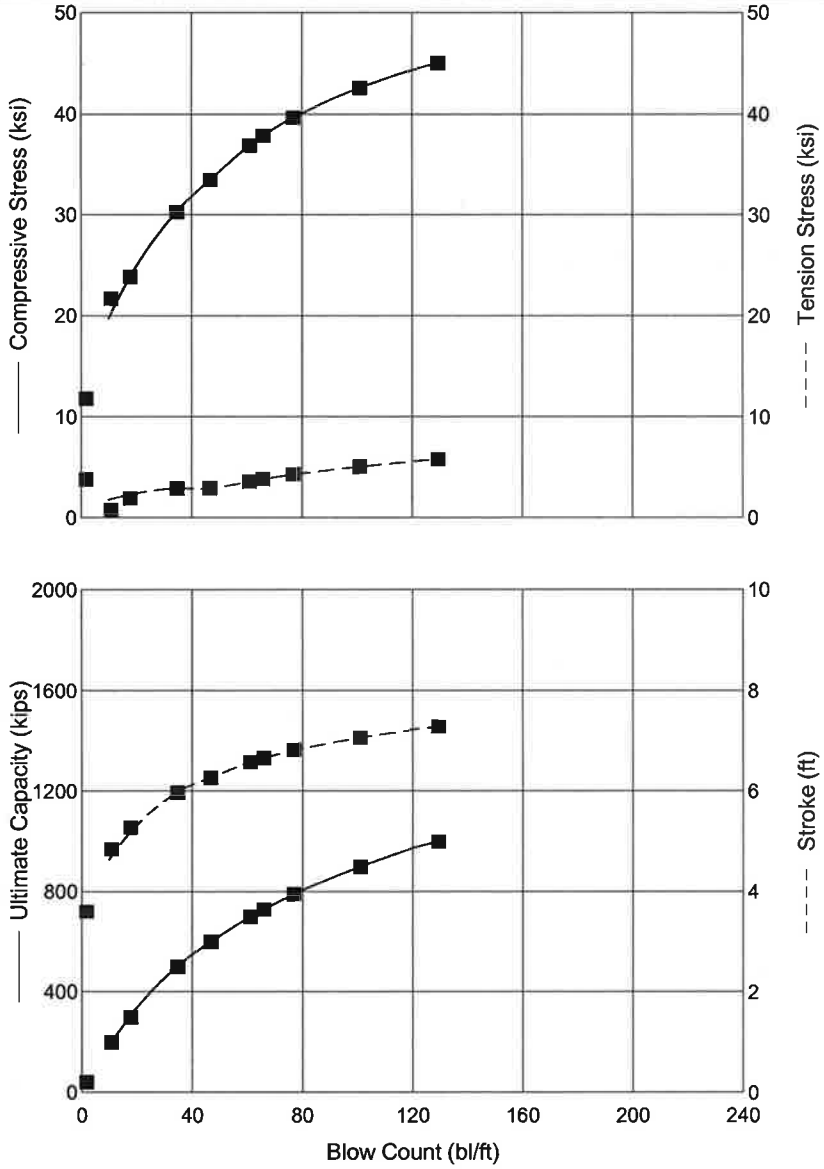
JOB 03.033940.00
SHEET NO 7 OF
Calculated By CLS Date 12-9-13
Checked By DDF Date 7/24/14
Scale

CONCLUSION

SINCE THE PROPOSED HAMMER IS CAPABLE OF INSTALLING THE PILES TO THE BEDROCK SURFACE WITHOUT EXCEEDING ALLOWABLE DRIVING STRESS (0.9)(50) = 45 KSI ; AND THE BLOW COUNT IS IN THE 5 TO 15 BLOWS/IN RANGE THE HAMMER IS CONSIDERED SUITABLE FOR INSTALLING THESE PILES

GZA Geo Environmental, Inc.
Eastport PP20 X 0.625

09-Dec-2013
GRLWEAP Version 2010

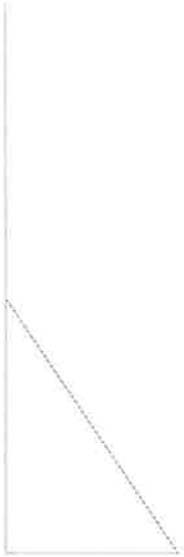


DELMAG D 46-23

Ram Weight	10.14	kips
Efficiency	0.800	
Pressure	1195 (81%)	psi
Helmet Weight	3.40	kips
Hammer Cushion	109975	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	65.00	ft
Pile Top Area	38.70	in2

Pile Model

Skin Friction Distribution



Res. Shaft = 5 %
(Proportional)

R
8
12-9-13

R
9
12-9-13

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Eastport PP20 X 0.625

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
200.0	21.70	0.77	10.8	4.85	33.79
300.0	23.82	1.92	17.8	5.28	33.88
40.0	11.77	3.78	1.7	3.60	41.50
500.0	30.23	2.89	34.7	5.97	38.09
600.0	33.43	2.95	46.9	6.27	40.16
700.0	36.86	3.60	61.1	6.58	42.37
730.0	37.83	3.85	66.0	6.66	42.95
790.0	39.63	4.30	76.9	6.82	44.06
900.0	42.56	5.07	101.1	7.07	45.78
1000.0	44.97	5.76	129.5	7.28	47.21

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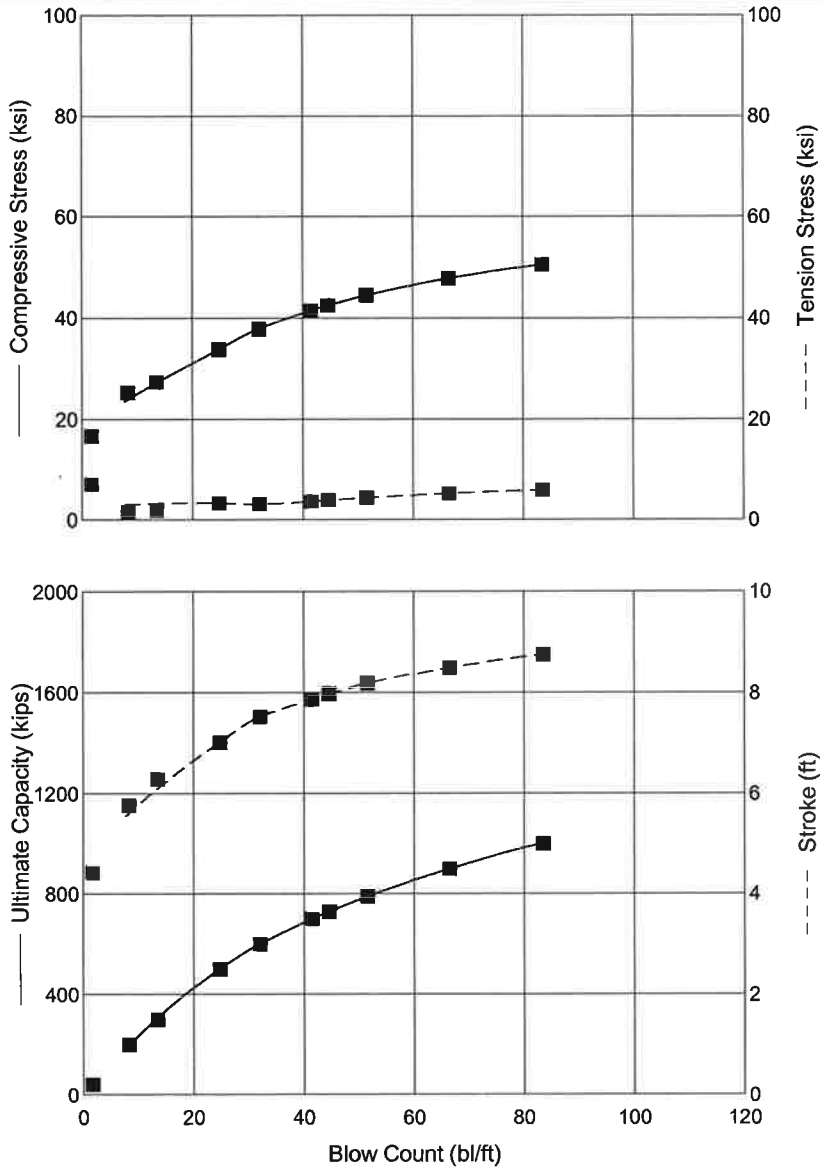
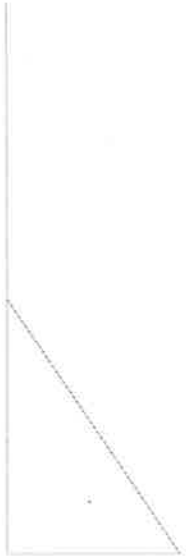


DELMAG D 46-23

Ram Weight	10.14	kips
Efficiency	0.800	
Pressure	1475 (100%)	psi
Helmet Weight	3.40	kips
Hammer Cushion	109975	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	65.00	ft
Pile Top Area	38.70	in2

Pile Model

Skin Friction Distribution



Res. Shaft = 5 %
(Proportional)

R1
12-9-13

R1

11
12-9-13

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09-Dec-2013
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
200.0	25.18	1.50	8.3	5.77	48.02
300.0	27.32	1.77	13.5	6.29	47.78
40.0	16.67	7.07	1.7	4.43	56.90
500.0	33.73	3.33	24.8	7.01	51.36
600.0	37.79	3.12	32.1	7.52	55.04
700.0	41.44	3.60	41.5	7.86	57.41
730.0	42.50	3.83	44.6	7.97	58.22
790.0	44.48	4.31	51.6	8.17	59.55
900.0	47.72	5.20	66.5	8.49	61.70
1000.0	50.35	5.86	83.5	8.75	63.52

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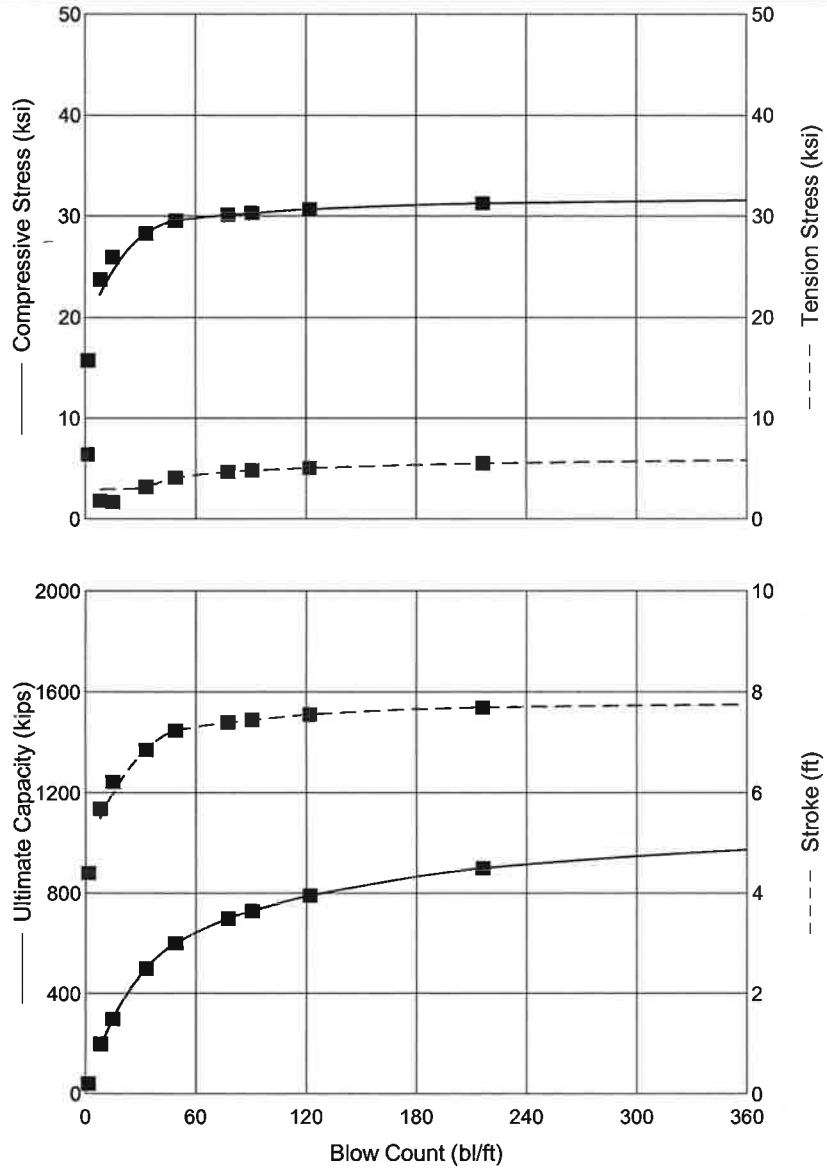
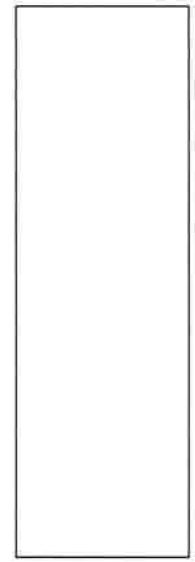
GRLWEAP Version 2010



DELMAG D 46-23

Ram Weight	10.14	kips
Efficiency	0.800	
Pressure	1475 (100%)	psi
Helmet Weight	3.40	kips
Hammer Cushion	109975	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.300	in
Skin Damping	0.150	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	65.00	ft
Pile Top Area	38.70	in2

Pile Model



Skin Friction Distribution

Res. Shaft = 35 %
(Proportional)

12-9-13 (N) R2

R2
13
12-9-13

GZA Geo Environmental, Inc.
Eastport PP20 X 0.625

09-Dec-2013
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
200.0	23.70	1.82	8.6	5.68	48.68
300.0	25.92	1.66	15.1	6.22	48.25
40.0	15.72	6.40	1.6	4.40	57.72
500.0	28.25	3.15	33.3	6.85	49.87
600.0	29.52	4.05	49.3	7.23	52.05
700.0	30.10	4.65	77.8	7.39	52.91
730.0	30.25	4.80	90.9	7.44	53.03
790.0	30.65	5.05	122.0	7.55	53.87
900.0	31.25	5.51	216.4	7.69	54.58
1000.0	31.67	5.94	439.1	7.77	55.11

APPENDIX D

ROCK ANCHOR DESIGN

Subject: Design of rock anchors to resist uplift forces on batter piles due to mooring/wave loads for the replacement of the breakwater and pier in Eastport, ME.

References:

(1) International Building Code, IBC 2006.
(2) Bowles, Foundation Analysis and Design, 4th Edition, 1988.
(3) ACI 318R-05, Building Code Requirements For Structural Concrete and Commentary
(4) G.S. LittleJohn and D.A. Bruce, Rock Anchors-state of the Art Part 1 Design.
(5) FHWA-NHI-05-039, Micropile Design and Construction Reference Manual, December 2005.
(6) Recommendations for Prestressed Rock & Soil Anchors, Post Tension Institute (PTI), 4th. Edition dated 2004.

Rock Anchor Design:

Corrosion: Rock anchors are double corrosion protected.

Load required to be resisted by the Anchor:

Design load based on structural analysis by Childs Engineering Corp. (CEC), the maximum anchor load to be resisted is 176 kips (ref. SK-10).

For 20-inch dia, 1/4 batter for pier structure: $P_{tension} := 176kips$ (working load)

Size Rock Anchor:

Guaranteed Ultimate Tensile Stress of continuously threaded bar: $F_{guts} := 150ksi$

Area of Steel Rebar Required:
(maximum working load not to exceed 60% of guaranteed ultimate tensile strength (GUTS))

$$A_{s3} := \frac{P_{tension}}{0.6 \cdot F_{guts}} = 1.96 \cdot in^2$$

Based on required area of steel, select the following bar diameters for the rock anchors.

Use a Grade 150 ksi, 1.75 inch diameter (Williams Form Engineering Corp., DYWIDAG, or equivalent) $A_{bar} := 2.60in^2$

Check test load on bar size:

Test Load: $P_{test} := P_{tension} \cdot 1.33 = 234.08 \cdot kips$

Max test load not to exceed 80% of GUTS. Area of steel required:

$$A_{steel_test} := \frac{(P_{test})}{0.8 \cdot F_{guts}} = 1.95 \cdot in^2 < A_{bar} = 2.6 \cdot in^2$$ OK

1) Calculate the required Bond Length of the Anchor into Bedrock:

Assume:

~ Capacity derived from grout bond stress within bedrock.
~ No Capacity derived from overburden soils, refer to subsurface conditions.

Required Ultimate Tension Capacity to Be Resisted:

Tensile load (working load): $P_{tension} = 176 \cdot kips$

Factor of Safety $FS := 2$

Ultimate design Load: $P_{Ultimate} := P_{tension} \cdot FS = 352 \cdot kips$

Diameter of Anchor Drill Hole: $D_{RockSocket} := 5.0in$

Ultimate Bond Stresses: $f_{Bedrock} := 200 \cdot psi$

(per PTI Ed. 4, 250psi to 450 psi in Granite or Basalt, select bond stress at low end of range due to fracture and RQD of encountered rock mass)

Determine the Frictional Surface Area within the bonded zone of Rock Socket per Linear Foot:

Frictional area per foot of anchor in Basalt Rock Socket

$$S_{RockSocket} := 2 \cdot \left(\frac{D_{RockSocket}}{2}\right) \cdot \frac{1 \cdot ft}{1 \cdot ft}$$

$$S_{RockSocket} = 1.31 \cdot \frac{ft^2}{ft}$$

Unit Capacities (allowable capacity per foot):

Allowable frictional capacity per foot in Bedrock:

$$P_{AllRockFoot} := \frac{f_{Bedrock}}{FS} \cdot S_{RockSocket}$$

$$P_{AllRockFoot} = 18.8 \cdot \frac{kips}{ft}$$

Determine Required Embedment into Bedrock:

$$L_{RockSocket} := \frac{P_{tension}}{\frac{f_{Bedrock}}{FS} \cdot S_{RockSocket}}$$

$$L_{RockSocket} = 9.34 \cdot ft$$

Select minimum length of Embedment into Bedrock:

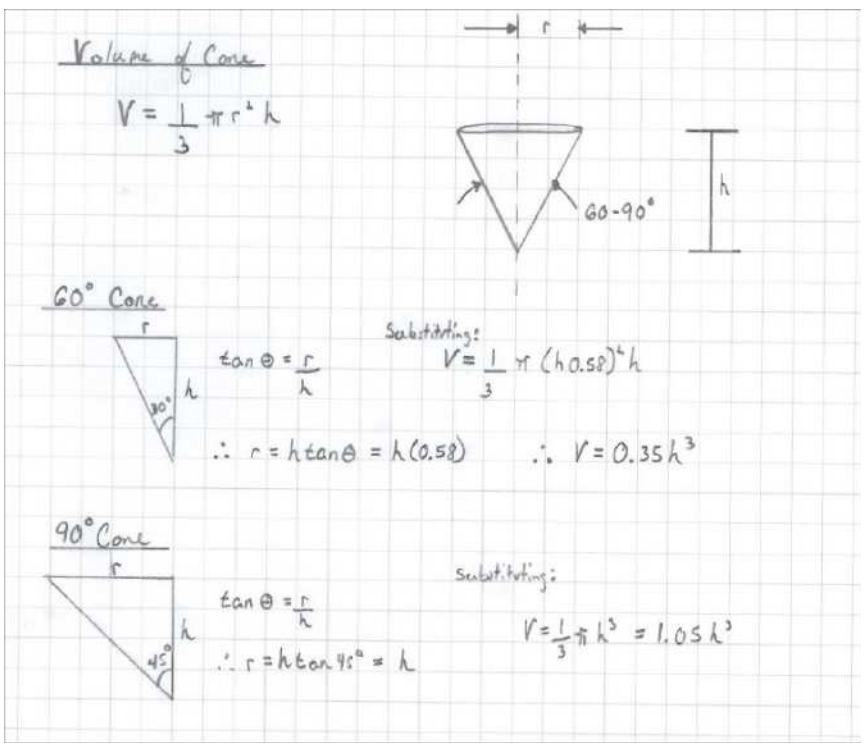
$L_{anchor_bond} := 10 \cdot ft$ minimum Rock Socket Length of 10 feet required

2) Check Uplift Capacity based on Rock Cone Failure:

The height of rock cone is based upon the rock type (i.e. weathered or competent). Littlejohn and Bruce (1975) recommend applying a 60/90 degree cone at the midpoint of the bond length. ASCE reccomends the following:

For the design of anchors in competent or fractured rock masses where the bond length is supported by pull-out tests, the potential for rock mass failure is assumed to initiate at the base of the anchor as shown in Figure 6-3a. For preliminary design where pull-out tests are not yet available or in highly fractured and very weak material, such as clay shale, the potential for failure is assumed to initiate at the midpoint of the socket as shown in Figure 6-3b. However, in the case of highly fractured and very weak material, pull-out tests must be performed to verify that the bond length is sufficient to develop the ultimate design load as specified in EM 1110-2-2000.

One also needs to select a 60 or 90 degree cone. Typically 90 degrees is selected for sound rock masses and 60 degrees is selected for fractored rock masses. Refer below for the derivation of the volume equations:



Select rock cone based on RQD reported on boring logs:

Boring	Depth	RQD(%)
MB-EAST-102	11.7'-16.7'	46%
MB-EAST-102	16.7'-21.7'	63%
MB-EAST-103	21.8'-23.9'	0%
MB-EAST-103	23.9'-28.5'	27%
MB-EAST-104	60.'-65.0'	9%
MB-EAST-104	65.1'-69.9'	46%

Check working tensile load against dead weight of 60-degree rock cone due to generally low RQD.

Bond between the Grout and Bedrock (cone method):

Height of Rock Cone: $h_{cone} := 18ft$

Volume of Rock Cone: $V_r := .35 \cdot h_{cone}^3$ $V_r = 2041.2 \cdot ft^3$

Boyuant Unit Weight of Rock: $_{brock} := 96pcf$

Rock Pullout Load: $P_p := V_r \cdot {}_{brock}$ $P_p = 195.96 \cdot kips$

Factor of Safety for Rock Pullout: $FS_{rock} := 1.0$ (Dead weight)

Allowable Uplift Capacity $P_{all.tens} := \frac{P_p}{FS_{rock}}$ $P_{all.tens} = 195.96 \cdot kips$

$P_{all.tens} = 195.96 \cdot kips$ > $P_{tension} = 176.00 \cdot kips$ OK

Required length of Anchor based on Rock Cone: $L_{anchor_cone} := 2 \cdot h_{cone} = 36.0\,ft$

NOTE: Bedrock is overlain by approximately 60 feet of glacial till sand & gravel overburden, adding to the dead weight of the rock cone. Dead weight is not considered to be the driving factor in rock anchor design.

3) Bond between the Grout and Anchor (Development Length-ACI 12.2.2):

Check bond between grout and anchor based on the required development length for the anchor in grout.

Nominal Anchor Diameter $d_{anchor} := 1.75in$

Reinforcement Yield Stress:
(guaranteed ultimate tensile strength) $F_{yBar1} := 150000$

Compressive Strength of Grout: $f_{c1} := 4000$

Reinforcement Location Factor: $:= 1.0$

Coating Factor: $:= 1.0$ (assume uncoated bar inside double corrosion protected rock anchor in bonded zone)

Normal Weight Aggregate Factor: $:= 1.0$

Required Development Length: $l_{develop} := \frac{(\cdot\ \cdot\ \cdot F_{yBar1}) \cdot d_{anchor}}{20 \cdot \sqrt{f_{c1}}}$

$l_{develop} = 17.3\,ft$

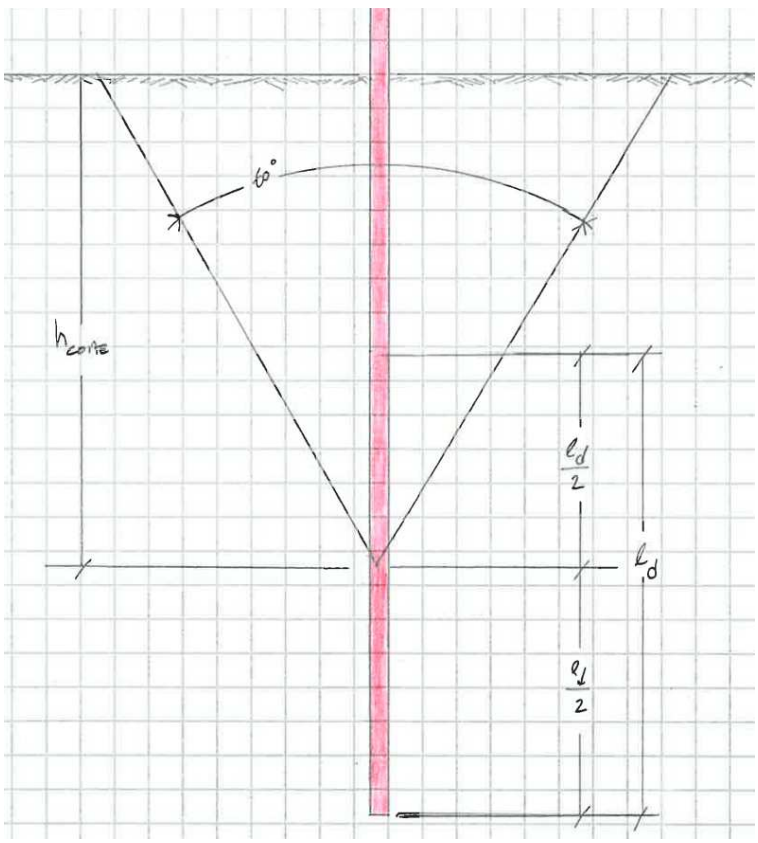
Summary of Failure Modes:

Failure Mode:	Required Length:
Bond length between grout and (sound) bedrock:	$L_{anchor_bond} = 10\,ft$
Anchor length required for rock cone pullout (2h): (not considering soil overburden)	$L_{anchor_cone} = 36\,ft$
Bond length between grout and anchor (development length):	$l_{develop} = 17.3\,ft$

Calculate Length of Bonded Anchor Zone:

$$L_{anchor.1} := \frac{1}{2} l_{develop} + h_{cone} = 26.65\,ft$$

Say 27 ft



Summary:

Provide rock anchor with minimum 27 ft bonded zone, with unbonded zone extending a minimum of 2 feet into sound bedrock. Minimum of 12-inches of overdrill recommended. Total drill depth into bedrock is 30 feet.

Provide double corrosion protection for rock anchor:

Bonded Zone:

- plain threadbar inside pre-grouted corrugated sheething, surrounded by grout in rock socket

Unbonded Zone:

- threadbar inside greased smooth sheething, surrounded by grout in the center of the pile

Subject: Check the structural capacity of the PP20x0.625 pipe piles subject to post tensioning loads of 234 kips with the pile head restained from lateral movement by the driving template, falsework or by other means (temporary construction loading). Piles will be partially filled with concrete, therefore, use a transfromed section to accound for the additional stiffness resulting from the concrete.

References:

(1) Steel Construction Manual. American Institute of Steel Construction (AISC). 13th Edition.

(2) International Building Code, IBC 2009.

Corrosion: Pipe piles are coated.

Loading Conditions:

- The compressive load is based on the maximum test load required for testing and locking off the post-tensioned rock anchors.

Stressing Load applied to pipe pile: (proof test to 133% of design load) $P_{test} := 133\% \cdot 176kips = 234.08 \cdot kips$

Moment applied to pipe pile: $M_{test} := 0kip \cdot ft$

Steel Pipe Pile Specifications:

PP20x0.625 $OD_s := 20in$ $ID_s := 18.75in$

Steel Area: $A_s := \frac{\cdot\left(OD_s^2 - ID_s^2\right)}{4} = 38.04 \cdot in^2$

Steel Yield Stress: $F_y := 50ksi$

Young's Modulus of Steel: $E_s := 29000ksi$

Concrete Fill Specifications:

Pipe piles filled with concrete: $ODc := 18.75in$ $IDc := 7in$

Concrete Area: $A_c := \frac{\cdot\left(ODc^2 - IDc^2\right)}{4} = 237.63 \cdot in^2$

Concrete Yield Strength: $F_c := 4ksi$

Young's Modulus of Concrete: $E_c := 3605ksi$

Transform Concrete into Equivalent Steel Area:

$$:= \frac{P \cdot L}{AE} \quad > \quad \frac{PL}{A_c \cdot E_c} = \cdot \frac{PL}{A_{ES} \cdot E_{ES}} \quad > \quad A_{cE.c} := A_{ES} \cdot E_{ES}$$

Equivalent Area of Steel from Concrete: $A_{ES} := \frac{A_c \cdot E_c}{E_s} = 29.54 \cdot in^2$

Outer Diameter of Transformed Section: $OD_{ES} := 18.75in$

Inner Diameter of Transfromed Section: $ID_{ES} := \sqrt{\left| \frac{A_{ES}}{\frac{}{4}} - OD_{ES}^2 \right|} = 17.72 \cdot in$

Equivalent Section:

Outer Diameter of Section: $OD_s = 20.00 \cdot in$

Inner Diameter of Section: $ID_{ES} = 17.72 \cdot in$

Yield Strength of Steel: $E_s = 29000.00 \cdot ksi$

Young's Modulus of Steel: $F_y = 50.00 \cdot ksi$

Equivalent Area of Steel: $A_E := \frac{}{4}\left(OD_s^2 - ID_{ES}^2\right) = 67.58 \cdot in^2$

Equivalent Moment of Inertia: $I_E := \frac{}{64} \cdot \left(OD_s^4 - ID_{ES}^4\right) = 3015.68 \cdot in^4$

Equivalent Radius of Gyration: $r_c := \sqrt{\frac{I_E}{A_E}} = 6.68 \cdot in$

Equivalent Section Modulus: $S_{xE} := 0.0982 \frac{\left(OD_s^4 - ID_{ES}^4\right)}{OD_s} = 301.65 \cdot in^3$

Check Structural Capacity of Pile (AISC, Chap E3 - Flexural Buckling):

Effective Length Factor, K (rotation free and translation fixed): $K_1 := 0.8$

NOTE: THIS ASSUMES THAT THE PILE HEAD MOVEMENT IS RESTRAINED LATERALY BY STEEL TEMPLATE, FALSEWORK OR BY OTHER MEANS.

Laterally unbraced length of pile:
(Top of pile to point of fixity below mudline) $L_{pile} := 75ft$

Slenderness Ratio: $\frac{K_1 \cdot L_{pile}}{r_c} = 107.79$ > 200, not recommended for compression (however, temporary condition during post-tensioning)

Check Flexural Buckling Stress:

$$\frac{K_1 \cdot L_{pile}}{r_c} = 107.79 \quad > \quad 4.71 \cdot \sqrt{\frac{E_s}{F_y}} = 113.43$$

Use AISC Eq E3-3

Elastic Critical Buckling Stress: $F_e := \frac{{}^{2} \cdot E_s}{\left(\frac{K_1 \cdot L_{pile}}{r_c}\right)^2} = 24.64 \cdot ksi$

Flexural Buckling Stress: $F_{cr} := 0.877 F_e = 21.61 \cdot ksi$

Applied Compressive Stress: $F_{cA} := \frac{1.67 \cdot P_{test}}{A_E} = 5.78 \cdot ksi$

Allowable Flexural Strenght: $M_a := F_{cr} \cdot S_{xE} = 6517.44 \cdot in \cdot kips$

Apply Interaction Equation (AISC Sec. H1):

Compression Ratio:

(If >0.2, use $f_c/F_{CR}+8/9(M_r/M_a)$ <= 1.0)

$$\frac{F_{cA}}{F_{cr}} = 0.27$$

Interaction Equation:

(1.0, therefore within limits.)

$$\frac{F_{cA}}{F_{cr}} + \frac{8 \cdot M_{test}}{9 \cdot M_a} = 0.27$$

OK

APPENDIX E

PILE DETAILS

Subject: Design stressing plate to support the test/lockoff loads for rock anchor within the new piles for the Eastport Breakwater.

References:
1. ACI Manual of Concrete Practice.
2. International Building Code, IBC 2009.

Corrosion: Stressing Plate to be epoxy coated.

Design Criteria:

Anchor Load: $P_{ReqUltimate} := 176kips$

Maximum Anchor Test Load: $P_{test} := P_{ReqUltimate} \cdot 1.33 = 234.1 \cdot kips$

Compressive Strength of Concrete: $f_{c_footing} := 4000psi$

Plate Size: (10"x10" plate on PP20x0.625 pile) $L_{plate} := 10in$

Design Stressing Plate for Lockoff Load:

Point load on plate: $P_{lock} := P_{ReqUltimate} \cdot 110\% = 193.6 \cdot kip$

Uniform pressure: $P_{unif} := \frac{P_{lock}}{L_{plate}^2} = 1.94 \cdot ksi$

For a 10-inch plate, load per linear inch: $L_{li} := \frac{L_{plate}}{2} \cdot P_{unif}$ $L_{li} = 9.68 \cdot \frac{kip}{in}$

Maximum moment: $M_{max} := \frac{L_{li} \cdot \left(\frac{L_{plate}}{2}\right)^2}{2} = 10.08 \cdot ft \cdot kips$

Allowable bending stress: Use GR50 Steel $F_b := 50ksi$

Required Section Mod. $s_{xreq} := \frac{M_{max}}{0.66 \cdot F_b} = 3.67 \cdot in^3$

Thickness of Stressing Plate: $t_{plate} := 2.75in$ $D_{hole} := 2.0in$ For 1.75" bar

$$L_{platehole} := \frac{L_{plate} - D_{hole}}{2} = 4 \cdot in$$

$$s_x := \frac{L_{platehole} \cdot t_{plate}^2}{6} = 5.04 \cdot in^3$$

$s_x = 5.04 \cdot in^3$ > $s_{xreq} = 3.67 \cdot in^3$ OK

Design Stressing Plate For Test Load:

Point load on plate: $P_{test} = 234.1 \cdot kip$

Uniform pressure: $P_{unif_test} := \frac{P_{test}}{L_{plate}^2} = 2.34 \cdot ksi$

For a 10-inch plate, load per linear inch: $L_{li_test} := \frac{L_{plate}}{2} \cdot P_{unif_test} = 0.98\, ft \cdot ksi$

Maximum moment: $M_{max_test} := \frac{L_{li_test} \cdot \left(\frac{L_{plate}}{2}\right)^2}{2} = 12.19 \cdot ft \cdot kips$

Allowable bending stress: Use GR50 Steel $F_b = 50 \cdot ksi$

Required Section Mod. $s_{xreq_test} := \frac{M_{max_test}}{0.66 \cdot F_b} = 4.43 \cdot in^3$

Thickness of Plate: $t_{plate_test} := 2.75in$ $D_{hole} = 2.00 \cdot in$ For 1.75" bar

$$L_{platehole_test} := \frac{L_{plate} - D_{hole}}{2} = 4 \cdot in$$

$$s_{x_test} := \frac{L_{platehole_test} \cdot t_{plate_test}^2}{6} = 5.04 \cdot in^3$$

$s_{x_test} = 5.04 \cdot in^3$ > $s_{xreq_test} = 4.43 \cdot in^3$ OK

Summary: Use a 3.0"x10"x10" GR50 plate for the stressing plate located at the top of the pile.

Subject: Design anchor plate for rock anchor embedment within pile new pile cap for Eastport Breakwater Replacement project at Eastport, ME.

References:
1. ACI Manual of Concrete Practice.
2. International Building Code, IBC 2009.

Corrosion: Anchor Plate to be epoxy coated.

Design Criteria:

Design Anchor Load: $P_{ReqUltimate} := 176kips$

Anchor Lockoff Load: $P_{lock} := P_{ReqUltimate} \cdot 110\% = 193.6 \cdot kips$

Compressive Strength of Concrete: $f_{c_footing} := 4000psi$

Plate Size: (Assume 10in x 10in Plate) $L_{plate} := 10in$

Assume distance from bottom of plate to breakout of pile cap is 36 -inches and that the reinforcing steel does not contribute to the shear resistance (conservative).

Concrete Embedment: $d_{emb} := 36in$

Shear Area: $A_{shear} := 4 \cdot \sqrt{2} \cdot d_{emb} \cdot \left[\frac{L_{plate} + (L_{plate} + 2 \cdot d_{emb})}{2}\right]$ (Assumes a 1V:1H break out)

$A_{shear} = 9368 \cdot in^2$

Allowable Shear per Plate: $F_{all} := 2 \cdot \sqrt{4000} \cdot 9000$ (Change last number to A_{shear})

$F_{all} = 1138420$ pounds > $P_{lock} = 193600 \cdot lbf$ OK

Design Bearing Plate Size:

Plate Size: (Assume Square Plate) $L_{plate} = 10.00 \cdot in$

Tension load on each plate $P_{lock} = 193.6 \cdot kip$

Uniform pressure: $P_{unif} := \frac{P_{lock}}{L_{plate}^2} = 1.9 \cdot ksi$

For a 10 inch plate, load per linear inch: $w_{li} := \frac{L_{plate}}{2} \cdot P_{unif}$ $\quad w_{li} = 9.7 \cdot \frac{kip}{in}$

Maximum moment: $M_{max} := \frac{w_{li} \cdot \left(\frac{L_{plate}}{2}\right)^2}{2}$ $\quad M_{max} = 121 \cdot kip \cdot in$

Allowable bending stress: Use GR50 Steel $\quad F_b := 50ksi$

Required Section Mod. $s_{xreq} := \frac{M_{max}}{0.66 \cdot F_b} = 3.67 \cdot in^3$

Thickness of Plate: $t_{plate} := 2.75in$ $\quad D_{hole} := 2.0in$ $\quad$ For 1.75" bar

$$L_{platehole} := \frac{L_{plate} - D_{hole}}{2} = 4.00 \cdot in$$

$$s_x := \frac{L_{platehole} \cdot t_{plate}^2}{6}$$

$s_x = 5.04 \cdot in^3$ > $s_{xreq} = 3.67 \cdot in^3$ OK

Summary: Use a 2.75"x10"x10" GR50 plate with minimum 36-inches of embedment into pile cap for the anchor plate.

Subject: Batter piles are to be driven closed ended with concrete plug. Determine size of concrete plug and shear plates for 20-inch diameter batter piles (PP20x0.625) to be anchored by post tensioned rock anchors for the support of berthing loads on the Eastport Breakwater Replacement project in Eastport, ME.

References:
(1) NAVFAC DM 7.02 - Foundations and Earth Structures, 1986
(2) AISC Steel Construction Manual, 13th ed., 2007

Corrosion: Pipe piles are coated.

Pile Information: Batter pile driven to bedrock for uplift resistance on berthing pier. Compressive loads at batter pile are per Structural Engineer.

PP20x0.625 I.D: $ID := 18.75in$

Design capacity for driven batter piles: $Q_d := 250kips$

Determine Plug Size:

Try 5 foot plug: $L_{plug} := 5ft$

Allowable bond stress between steel and concrete: $F_f := 30psi$

Total allowable load on plug: $P_{all} := L_{plug} \cdot \cdot ID \cdot F_f = 106.03 \cdot kips$

P_{all} < 250 kips N.G., shear reinforcement is required for concrete plug

Try 8" x 1.5" x 1.0" shear plates with 1/4-inch weld on both sides: $l_{weld} := 8in$

Weld size, in sixteenths of an inch: $D_{weld} := 4$

Weld electrode strength: $F_{EXX} := 70ksi$

Allowable capacity of weld (AISC, 8-8): $P_{weld} := \frac{.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot \frac{D_{weld}}{16} \cdot 1in \cdot l_{weld}}{2} = 29.7 \cdot kips$

Shear resistance of 1 plate: $P_{plate} := 2 \cdot P_{weld} = 59.4 \cdot kips$

Try 4 shear plates:

$P_{shear_total} := 4 \cdot P_{plate} = 237.59 \cdot kips$ > $P_{req} := Q_d - P_{all} = 143.97 \cdot kips$ OK

Ues 4 - 8" x 1.5" x 1.0" shear plates welded to inside of pile and evenly spaced around perimeter with 5/16" weld on long sides of plate.