



## **BRIDGE ST BRIDGE REPLACEMENT ABUTMENT FOUNDATION CALCULATIONS**


ODOT DISTRICT 11

FEBRUARY 26, 2025



Engineers, Surveyors, Planners, Scientists  
5500 New Albany Rd., Columbus, OH 43054  
p. 614.775.4500 f. 614.775.4800  
emht.com

2023-0339



### Semi-Integral Abutment Data

#### Stem Dimensions (ft)

Diaphragm	3.00	ft
Stem Width 1	3.00	ft
Stem Width 2	3.00	ft
Stem Length	32.00	ft
Seat Width	3	ft
β =	90.00	ft

#### Footer Dimensions (ft)

Toe	1	ft
Stem Width (at Footer)	3.00	ft
Heel	3.00	ft
Total Footing Width, B	7.00	ft

#### Vertical Reactions

Number of Girders	8	
Exterior Girder (DC)	54.35	kips
Exterior Girder (DW)	9.9625	kips
Interior Girder (DC)	54.08406524	kips
Interior Girder (DW)	9.96	kips
Total DC =	433.20	kips
	13.54	kips/ft
Total DW =	79.70	kips
	2.49	kips/ft

#### Horizontal Reactions

Thermal (TU)	0.235	kips/ft
Height of Bearing	8.99	ft

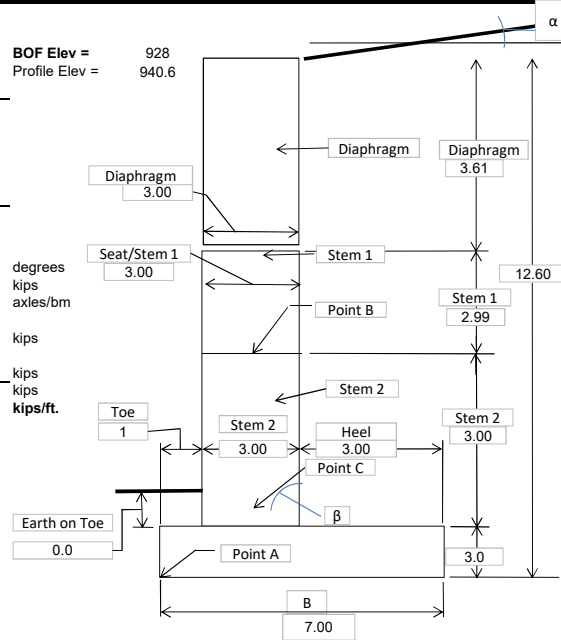
#### Live Load Surcharge

Live Ld. Surcharge Height, h <sub>eq</sub> (ft)	2.74	AASHTO Table 3.11.6.4-1
---	------	-------------------------

#### Material

Soil Unit Weight (k/ft <sup>3</sup> )	0.12	Concrete Unit Wt. (k/ft <sup>3</sup> )	0.15
Φ (°)	32	Earth on Toe (ft)	0.0
δ (degrees) =	21.33		
α (degrees) =	0		
K <sub>a</sub>	0.275		

Diaphragm	3.61	BOF Elev = 928
Stem Height 1	2.99	Profile Elev = 940.6
Stem Height 2	3.00	
Total Stem Height	9.60	
Skew =	0	degrees
Live Load per beam (LL)	90.50	kips
DF =	1.000	axles/bm
Impact =	1	
LL per Lane =	90.50	kips
Number of Lanes =	2	
Total LL =	181.00	kips
Pedestrian LL =	18.7	kips
Along Abutment	6.24	kips/ft.



Sum Moments ..... Clockwise is positive

Sum Moments .....Clockwise is positive					About "A"		About "B"			About "C"		
Item	Height (ft)	Width (ft)	Unit Weight (k/ft <sup>3</sup> )	P (kips)	Arm (ft.)	Moment (ft-k)	P (kips)	Arm (ft.)	Moment (ft-k)	P (kips)	Arm (ft.)	Moment (ft-k)
<b>Vertical Loads</b>												
<b>Concrete (DC)</b>												
Diaphragm	3.61	3.00	0.15	1.62	1.50	2.44	-	-	-	1.62	0.00	0.00
Stem 1	2.99	3.00	0.15	1.35	2.50	3.37	-	-	-	1.35	0.00	0.00
Stem 2	3.00	3.00	0.15	1.49	2.50	3.71	-	-	-	-	-	-
Footer	3.00	7.00	0.15	3.15	3.50	11.03	-	-	-	-	-	-
Approach Slab	1.42	10.00	0.15	2.13	3.75	7.99	2.13	1.25	2.66	2.13	1.25	2.66
Girders				13.53763723	2.00	27.07527447	-	-	-	13.5376372	-0.5	-6.77
<b>Dead Load (DW)</b>												
Future Wearing Surf.				2.490625	2	4.98125	-	-	-	2.490625	-0.5	-1.25
<b>Earth Load (EV)</b>												
Soil Above Toe	0.00	1.00	0.12	0.00	0.50	0.00	-	-	-	-	-	-
Soil Above Heel	9.60	3.00	0.12	3.46	5.50	19.01	-	-	-	-	-	-
<b>Vertical Component of Horizontal Earth Pressure from Soil Friction (EH<sub>v</sub>)</b>												
Vert. Load from EH <sub>v</sub>	12.60	-	0.12	0.95	7.00	6.67	-	-	-	-	-	-
<b>Live Load (LL)</b>												
Vehicle Reaction				6.24	2	12.48	-	-	-	6.24	-0.5	-3.12
<b>Live Load (LS<sub>v</sub>)</b>												
Live Load Surcharge	2.74	3.00	0.12	0.99	5.50	5.43	-	-	-	-	-	-
<b>Horizontal Loads</b>												
<b>Earth Load (EH<sub>h</sub>)</b>												
Active Earth Pressure	8.99		0.12	2.24	3.93	-8.81	-0.47	1.35	-0.63	-1.22	2.54	-3.09
<b>Live Load (LS<sub>h</sub>)</b>												
Live Load Surcharge	8.99	2.74	0.12	0.81	4.50	-3.66	-0.27	1.50	-0.40	-0.54	3.00	-1.62
<b>Thermal Uniform (TU)</b>												
Bearing Pads				0.24	8.99	-2.12	-0.24	2.99	-0.70	-0.24	5.99	-1.41

#### AASHTO LRFD Load Factors - AASHTO Table 3.4.1-1

	Vertical					Horizontal		
	DC	DW	EV	EH <sub>v</sub>	LL & LS <sub>v</sub>	EH	LS <sub>h</sub>	TU
Service I	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Strength I.a - Sliding & Eccentricity	0.90	0.65	1.00	1.50	0.00	1.50	1.75	0.50
Strength I.b - Bearing	1.25	1.50	1.35	1.50	1.75	1.50	1.75	0.50
Extreme Event II	1.00	1.00	1.00	1.00	0.50	1.00	0.50	0.00

Load Case	Footings/Piles (About A)			Stem 1 (About B)		Stem 2 (About C)	
	Per Foot of Abutment			Per Foot of Abutment		Per Foot of Abutment	
	P <sub>V</sub> (kips)	M <sub>A</sub> (ft-k)	P <sub>H</sub> (kips)	M <sub>B</sub> (ft-k)	P <sub>H</sub> (kips)	M <sub>C</sub> (ft-k)	P <sub>H</sub> (kips)
Service I	37.40	89.58	3.29	0.92	-0.98	-14.60	-1.99
Strength I.a	27.45	61.62	4.90	0.38	-1.30	-12.69	-2.89
Strength I.b	51.57	123.30	4.90	1.32	-1.30	-20.65	-2.89
Extreme Event II	33.79	84.57	2.65	1.83	-0.60	-10.82	-1.49

Pile Foundation

Pile Size      HP14x73                      Pile Capacity (kip)      530

Center to center spacing of piles along footer (ft)      6.5  
Length of segment to be analyzed, L (ft)      13

	Piles Per Segment	Dist. From Toe, A (ft)	Battered? (y,n)	Batter Rate (x:1)	Centroid of Pile Group from Toe, X <sub>y</sub> (ft)
Row 0					3.50
Row 1	2	1.5	n		
Row 2	2	5.50	n		
Row 3					
Sum of Piles	4				

Forces acting on the Segment

	P <sub>V</sub> (kips)	M <sub>A</sub> (ft-kip)	e (ft)	e-X <sub>y</sub>	M <sub>y</sub> (ft-kip)
Service I	486.19	1164.57	2.40	-1.10	-537.10
Strength I.a	356.85	801.02	2.24	-1.26	-447.95
Strength I.b	670.40	1602.91	2.39	-1.11	-743.49
Extreme Event II	439.22	1099.46	2.50	-1.00	-437.79

	Vertical Capacity (kip)	Dist. From Y, x <sub>i</sub> (ft)	(x <sub>i</sub> ) <sup>2</sup>	Pile Σ A(x <sub>i</sub> ) <sup>2</sup>
Row 0				
Row 1	530.0	-2.00	4.00	8.00
Row 2	530.0	2.00	4.00	8.00
Row 3				
			Σ (x) <sup>2</sup>	16.00

Vertical Loads

Vertical Load on a Single Pile in the Row

	Service I (kip)	Strength I.a (kip)	Strength I.b (kip)	Extreme Event II (kip)
Row 0				
Row 1	188.69	145.21	260.54	164.53
Row 2	54.41	33.22	74.66	55.08
Row 3				

Concurrent Lateral Resistance

Lateral Resistance Based on Batter of Piles (if present)

	Service I (k/ft)	Strength I.a (k/ft)	Strength I.b (k/ft)	Strength I.b (k/ft)
Row 0				
Row 1	0.00	0.00	0.00	0.00
Row 2	0.00	0.00	0.00	0.00
Row 3				
SUM =	0.00	0.00	0.00	0.00
Lat. Pile Resistance =	3.29	4.90	4.90	2.65

### Semi-Integral Abutment Data

#### Stem Dimensions (ft)

Diaphragm	3.00	ft
Stem Width 1	3.00	ft
Stem Width 2	3.00	ft
Stem Length	32.00	ft
Seat Width	3	ft
β =	90.00	ft

#### Footer Dimensions (ft)

Toe	1	ft
Stem Width (at Footer)	3.00	ft
Heel	3.00	ft
Total Footing Width, B	7.00	ft

#### Vertical Reactions

Number of Girders	8	
Exterior Girder (DC)	54.35	kips
Exterior Girder (DW)	9.9625	kips
Interior Girder (DC)	54.08406524	kips
Interior Girder (DW)	9.96	kips
Total DC =	433.20	kips
Total DW =	13.54	kips/ft
	79.70	kips
	2.49	kips/ft

#### Horizontal Reactions

Thermal (TU)	0.235	kips/ft
Height of Bearing	8.61	ft

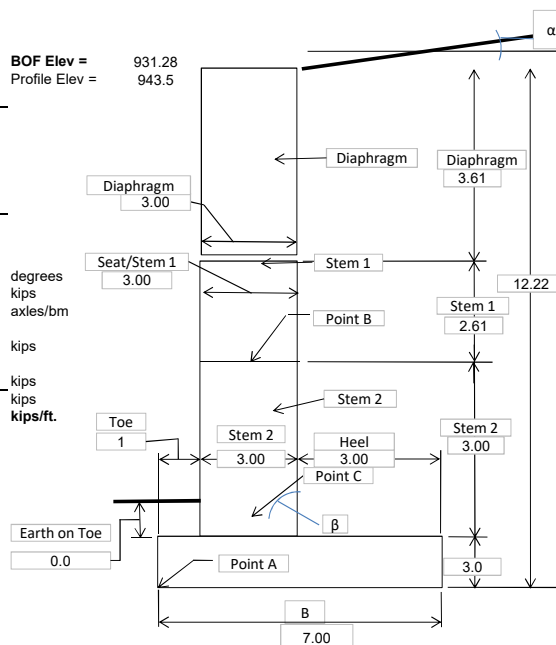
#### Live Load Surcharge

Live Ld. Surcharge Height, h <sub>sq</sub> (ft)	2.78	AASHTO Table 3.11.6.4-1
---	------	-------------------------

#### Material

Soil Unit Weight (k/ft <sup>3</sup> )	0.12	Concrete Unit Wt. (k/ft <sup>3</sup> )	0.15
Φ (°)	32	Earth on Toe (ft)	0.0
δ (degrees) =	21.33		
α (degrees) =	0		
K <sub>a</sub>	0.275		

Skew =	0	degrees
Live Load per beam (LL)	90.50	kips
DF =	1.000	axles/bm
Impact =	1	
LL per Lane =	90.50	kips
Number of Lanes =	2	
Total LL =	181.00	kips
Pedestrian LL =	18.7	kips
Along Abutment	6.24	kips/ft.



Sum Moments .....Clockwise is positive

Sum Moments .....Clockwise is positive					About "A"		About "B"			About "C"		
Item	Height (ft)	Width (ft)	Unit Weight (k/ft³)	P (kips)	Arm (ft.)	Moment (ft-k)	P (kips)	Arm (ft.)	Moment (ft-k)	P (kips)	Arm (ft.)	Moment (ft-k)
Vertical Loads												
Concrete (DC)												
Diaphragm	3.61	3.00	0.15	1.62	1.50	2.44	-	-	-	1.62	0.00	0.00
Stem 1	2.61	3.00	0.15	1.18	2.50	2.94	-	-	-	1.18	0.00	0.00
Stem 2	3.00	3.00	0.15	1.49	2.50	3.71	-	-	-	-	-	-
Footer	3.00	7.00	0.15	3.15	3.50	11.03	-	-	-	-	-	-
Approach Slab	1.42	10.00	0.15	2.13	3.75	7.99	2.13	1.25	2.66	2.13	1.25	2.66
Girders				13.53763723	2.00	27.07527447	-	-	-	13.5376372	-0.5	-6.77
Dead Load (DW)												
Future Wearing Surf.				2.490625	2	4.98125	-	-	-	2.490625	-0.5	-1.25
Earth Load (EV)												
Soil Above Toe	0.00	1.00	0.12	0.00	0.50	0.00	-	-	-	-	-	-
Soil Above Heel	9.22	3.00	0.12	3.32	5.50	18.26	-	-	-	-	-	-
Vertical Component of Horizontal Earth Pressure from Soil Friction (EH <sub>v</sub> )												
Vert. Load from EH <sub>v</sub>	12.22	-	0.12	0.90	7.00	6.28	-	-	-	-	-	-
Live Load (LL)												
Vehicle Reaction				6.24	2	12.48	-	-	-	6.24	-0.5	-3.12
Live Load (LS <sub>v</sub> )												
Live Load Surcharge	2.78	3.00	0.12	1.00	5.50	5.50	-	-	-	-	-	-
Horizontal Loads												
Earth Load (EH <sub>H</sub> )												
Active Earth Pressure	8.61		0.12	2.10	3.78	-7.93	-0.39	1.19	-0.47	-1.11	2.40	-2.65
Live Load (LS <sub>H</sub> )												
Live Load Surcharge	8.61	2.78	0.12	0.79	4.31	-3.40	-0.24	1.31	-0.31	-0.51	2.81	-1.44
Thermal Uniform (TU)												
Bearing Pads				0.24	8.61	-2.03	-0.24	2.61	-0.62	-0.24	5.61	-1.32

#### AASHTO LRFD Load Factors - AASHTO Table 3.4.1-1

	Vertical					Horizontal		
	DC	DW	EV	EH <sub>v</sub>	LL & LS <sub>v</sub>	EH	LS <sub>h</sub>	TU
Service I	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Strength I.a - Sliding & Eccentricity	0.90	0.65	1.00	1.50	0.00	1.50	1.75	0.50
Strength I.b - Bearing	1.25	1.50	1.35	1.50	1.75	1.50	1.75	0.50
Extreme Event II	1.00	1.00	1.00	1.00	0.50	1.00	0.50	0.00

Load Case	Footings/Piles (About A)			Stem 1 (About B)		Stem 2 (About C)	
	Per Foot of Abutment			Per Foot of Abutment		Per Foot of Abutment	
	P <sub>V</sub> (kips)	M <sub>A</sub> (ft-k)	P <sub>H</sub> (kips)	M <sub>B</sub> (ft-k)	P <sub>H</sub> (kips)	M <sub>C</sub> (ft-k)	P <sub>H</sub> (kips)
Service I	37.05	89.31	3.12	1.26	-0.87	-13.89	-1.86
Strength I.a	27.07	61.70	4.64	0.84	-1.13	-11.67	-2.68
Strength I.b	51.11	123.11	4.64	1.77	-1.13	-19.63	-2.68
Extreme Event II	33.43	84.05	2.49	2.04	-0.51	-10.29	-1.36

Pile Foundation

Pile Size      HP14x73                      Pile Capacity (kip)      530

Center to center spacing of piles along footer (ft)      6.5

Length of segment to be analyzed, L (ft)      13

	Piles Per Segment	Dist. From Toe, A (ft)	Battered? (y,n)	Batter Rate (x:1)	Centroid of Pile Group from Toe, X <sub>y</sub> (ft)
Row 0					3.50
Row 1	2	1.5	n		
Row 2	2	5.50	n		
Row 3					
Sum of Piles	4				

Forces acting on the the Segment

	P <sub>V</sub> (kips)	M <sub>A</sub> (ft-kip)	e (ft)	e-X <sub>y</sub>	M <sub>y</sub> (ft-kip)
Service I	481.63	1161.04	2.41	-1.09	-524.67
Strength I.a	351.96	802.16	2.28	-1.22	-429.72
Strength I.b	664.43	1600.39	2.41	-1.09	-725.10
Extreme Event II	434.57	1092.62	2.51	-0.99	-428.37

	Vertical Capacity (kip)	Dist. From Y, x <sub>i</sub> (ft)	(x <sub>i</sub> ) <sup>2</sup>	Pile Σ A(x <sub>i</sub> ) <sup>2</sup>
Row 0				
Row 1	530.0	-2.00	4.00	8.00
Row 2	530.0	2.00	4.00	8.00
Row 3				
			Σ (x) <sup>2</sup>	16.00

Vertical Loads

Vertical Load on a Single Pile in the Row

	Service I (kip)	Strength I.a (kip)	Strength I.b (kip)	Extreme Event II (kip)
Row 0				
Row 1	185.99	141.71	256.74	162.19
Row 2	54.82	34.28	75.47	55.10
Row 3				

Concurrent Lateral Resistance

Lateral Resistance Based on Batter of Piles (if present)

	Service I (k/ft)	Strength I.a (k/ft)	Strength I.b (k/ft)
Row 0			
Row 1	0.00	0.00	0.00
Row 2	0.00	0.00	0.00
Row 3			
SUM =	0.00	0.00	0.00
Lat. Pile Resistance =	3.12	4.64	4.64

### Pile Loads from Abutment Design Spreadsheet

Horizontal Strength I Load 4.64 k/Ft  
 Horizontal Service I Load 3.12 k/Ft  
 Number of Piles 12.00 Each

Pile Spa Dir of Load, S 4 ft  
 Pile Spa Normal to Load, S 6.5 ft  
 Pile Dia, B 1.167 ft  
 Space Ratio Direction of Loading, S/B 3.43 B  
 Max Strength Deflection 1.00 in  
 Max Service Deflection 1.00 in  
 Space Ratio Normal Loading, S/B 5.57 B

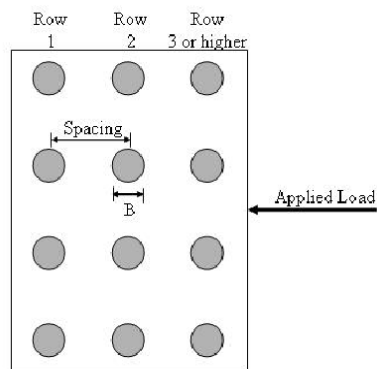
P-Multipliers, $P_m$			
	Direction of Loading (10.7.2.4-1)	Normal to Loading BDM 305.1.2	Composite $P_m$
Row 1	0.843	1.000	0.843
Row 2	0.496	1.000	0.496

BDM 305.1.2

$$P_m = 0.64 (S/B)^{0.34} \text{ for } 1.0 \leq S/B \leq 3.75$$

Table 10.7.2.4-1—Pile P-Multipliers,  $P_m$ , for Multiple Row Shading (averaged from Hannigan et al., 2006)

Pile CTC spacing (in the direction of loading)	P-Multipliers, $P_m$		
	Row 1	Row 2	Row 3 and higher
3B	0.8	0.4	0.3
5B	1.0	0.85	0.7





Subject: Bridge St: Rear Abutment Scour Design  
SFN 3431790  
Date: 1/8/2025 Job No. : 20230339  
Computed: AI Checked: TDA  
Sheet: 2 of 5

Check Pile capacity in Check Scour Case

**Strength Results -HP14x73**

Axial Load in Row 1 = 256.74 k Check Lpile with and without axial load.  
Axial Load in Row 2 = 75.47 k Check Lpile with and without axial load.

Results from Lpile

	Pile 1	Pile 2
Pm	0.843	0.496
Deflection (in)	1.00	1.00
Resistance from Lpile (k)	15.932	14.386
Mu from Lpile (lb-in)	2040210	1854592

Resistance by Row		
Row 1	Row 2	
15.932	14.386	

Total Resistance 30.32 k  
Total Combined Pile Resistance 30.32 k  
Total Strength Load at Abutment 30.16 k

OK

By inspection the abutment Footing is only deflecting 1 to achieve the lateral capacity to resist the strength load case. As such the service case does not need checked

#### Check Structural Resistance of Piles

Pull loadings from Lpile and substituting in the max Strength Axial Load from LEAP

	Vu (k)	Pu (k)	Mu (in-lb)	Mu (k-ft)
Row 1	15.932	256.74	2040210	170.02
Row 2	14.39	75.47	1854592	154.55
Row 3	0	0	0	0.00

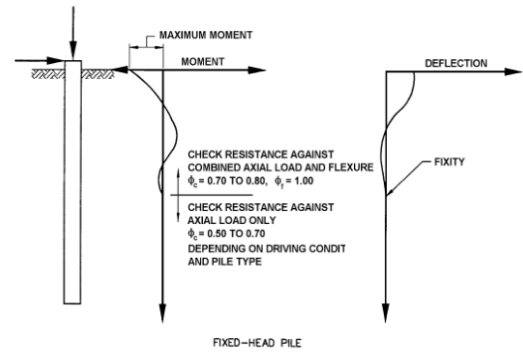
#### Pile Properties (HP14x73)

Fy	50 ksi	d =	13.6
d	13.6 in	bf =	14.6
tw	0.505	tf =	0.505
		tw =	0.505
Ix/y	729.00 in^4	Ag Steel	21.4 si
Sx/y	107.00 in^3		
Zx/y	118.00 in^3	rs =	5.84 in

#### Compression Check 6.9.4.1

Check compression only in pile below bending zone where the pile is subject to severe driving conditions  
 Use value in BDM Section C305.3.3 for pile capacity which has a phi\_C of 0.50 applied.

$$Pr = 530 \text{ kips} > 256.74 \text{ OK}$$



#### Combined Axial Compression and Flexure Check 6.9.2.2

#### Flexure Check 6.10.8.1.1 - Discretely Braced Flanges in Compression

$$f_{bu} + \frac{1}{3} f_t \leq \phi_f F_{nc} \quad (6.10.8.1.1-1)$$

$$f_t = 0 \text{ ksi}$$

$$f_{bu} = M/S_x = 19.07 \text{ ksi}$$

#### Flexure Check 6.10.8.2.2 - Local Buckling Resistance

$$\lambda_{da} = bfc/(2tfc) = 14.455446$$

$$\lambda_{da_{pf}} = 0.38 * (E/F_{yc})^{1/2} = 9.1516119$$

$$\lambda_{da_{rt}} = 0.56 * (E/F_{yr})^{1/2} = 16.119553$$

$$R_b = 1$$

$$R_h = 1$$

$$F_{yr} = 35 \text{ ksi}$$

$$F_{nc} = 38.582352 \text{ ksi}$$

#### 6.10.8.2.2—Local Buckling Resistance

The local buckling resistance of the compression flange shall be taken as:

- If  $\lambda_f \leq \lambda_{pf}$ , then:

$$F_{nc} = R_b R_e F_{yc} \quad (6.10.8.2.2-1)$$

- Otherwise:

$$F_{nc} = \left[ 1 - \left( 1 - \frac{F_{yc}}{R_e F_{yc}} \right) \left( \frac{\lambda_f - \lambda_{pf}}{\lambda_{rt} - \lambda_{pf}} \right) \right] R_b R_e F_{yc} \quad (6.10.8.2.2-2)$$

#### Flexure Check 6.10.8.2.3 - Lateral-Torsional Buckling Resistance

Lb = 336 in (Distance to point of fixity in Lpile from bottom of footing)  
 Lp = 94.442442 in  
 Lr = 354.62395 in  
 rt = 3.921509 in

- If  $L_b \leq L_p$ , then:

$$F_{nc} = R_b R_h F_{yc} \quad (6.10.8.2.3-1)$$

- If  $L_p < L_b \leq L_r$ , then:

$$F_{nc} = C_b \left[ 1 - \left( 1 - \frac{F_{yr}}{R_h F_{yc}} \right) \left( \frac{L_b - L_p}{L_r - L_p} \right) \right] R_b R_h F_{yc} \leq R_b R_h F_{yc} \quad (6.10.8.2.3-2)$$

- If  $L_b > L_r$ , then:

$$F_{nc} = F_{cr} \leq R_b R_h F_{yc} \quad (6.10.8.2.3-3)$$

$F_{cr}$  = elastic lateral-torsional buckling stress (ksi)

$$= \frac{C_b R_b \pi^2 E}{\left( \frac{L_b}{r_t} \right)^2} \quad (6.10.8.2.3-8)$$

Cb = 1 LRFD 6.10.8.2.3-6  
 Rb = 1  
 Rh = 1  
 Fyr = 35 ksi  
**Fnc = 36.073709 ksi**

$L_p$  = limiting unbraced length to achieve the nominal flexural resistance of  $R_b R_h F_{yc}$  under uniform bending (in.)

$$= 1.0 r_t \sqrt{\frac{E}{F_{yc}}} \quad (6.10.8.2.3-4)$$

$L_r$  = limiting unbraced length to achieve the onset of nominal yielding in either flange under uniform bending with consideration of compression flange residual stress effects (in.)

$$= \pi r_t \sqrt{\frac{E}{F_{yp}}} \quad (6.10.8.2.3-5)$$

$r_t$  = effective radius of gyration for lateral-torsional buckling (in.)

$$= \frac{b_{fc}}{\sqrt{12 \left( 1 + \frac{1}{3} \frac{D_c t_w}{b_{fc} t_{fc}} \right)}} \quad (6.10.8.2.3-9)$$

### Combined Axial Compression and Flexure Check 6.9.2.2

#### Nominal Compressive Resistance 6.9.4.1

$P_0 = F_y \cdot A_g = 1070$  Kips  $E = 29000$  ksi  
 $P_e = 982.8151$  Kips  $K = 1.2$   
 $P_0 / P_e = 1.0887094$   $l = 384$  in  
 $r_s = 5.84$  in  
 **$P_n = 678.39807$  kips**

#### Local Buckling 6.9.4.2.1

- Determine if section is slender  
 $b/t = 14.455$   
 $\lambda_{br} = 13.49$  Slender, Check Local Buckling

#### Local Buckling 6.9.4.2.2

$b = 7.300$  in  
 $P_{cr} = 678.398$  kips  
 $F_{cr} = 31.700845$  ksi  
 $b_e = 7.300$  in  
 $A_{eff} = 21.4$  in<sup>2</sup>  
 **$P_n = 678.39807$  kips**

$\Phi_c = 0.7$  6.15.2/BDM C305.3.3  $\Phi_f = 1.00$   
 $P_r = \Phi_c P_n = 474.88$  k  $\Phi_f M_n = 321.66$  k-ft

Eq 6.9.2.2.1-1 and 6.9.2.2.1-2

Pile	$P_u$ (k)	$M_u$ (k-ft)	$P_u/P_r$	Compression Ratio	Flexure Ratio	Combined	Status
Row 1	256.74	170.02	0.54	0.54	0.47	1.01	OK within 2%
Row 2	75.47	154.55	0.16	0.08	0.48	0.56	OK
Row 3	0	0.00	0.00	0.00	0.00	0.00	OK

Say this is acceptable considering very conservative scour depth and that stream invert has migrated to the face of abutment.

### Shear Check 6.12.1.2.3b

$A_w = 6.868$  in

$V_n = 199.17$  k

$\Phi_v = 1.00$

$\Phi_v V_n = 199.17$  k

> 18 k

in which:

$$V_p = 0.58 F_{yt} D t_w \quad (6.10.9.2-2)$$

OK

### Conclusion

This analysis proves the piles are capable of resisting the applied vertical and lateral loads under the Strength I load case in the check scour condition. By inspection the non-scour condition will also pass the same design.

# Pile Loads from Abutment Design Spreadsheet

Horizontal Extreme Event II 2.49 k/Ft

Horizontal Service Load 3.12 k/Ft

Number of Piles 12.00 Each

Max EE-II Deflection 0.70 in

Pile Space Dir of Load, S 4 ft

Pile Spa Normal to Load, S 6.5 ft

Pile Dia, B 1.167 ft

Max Service Deflection 1.00 in

Space Ratio Direction of

Loading, S/B 3.43 B

Space Ratio Normal

Loading, S/B 5.57 B

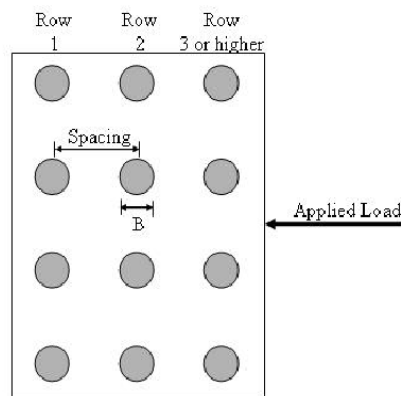
P-Multipliers, $P_m$			
	Direction of Loading (10.7.2.4-1)	Normal to Loading BDM 305.1.2	Composite $P_m$
Row 1	0.843	1.000	0.843
Row 2	0.496	1.000	0.496

BDM 305.1.2

$$P_m = 0.64 (S/B)^{0.34} \text{ for } 1.0 \leq S/B \leq 3.75$$

Table 10.7.2.4-1—Pile P-Multipliers,  $P_m$ , for Multiple Row Shading (averaged from Hannigan et al., 2006)

Pile CTC spacing (in the direction of loading)	P-Multipliers, $P_m$		
	Row 1	Row 2	Row 3 and higher
$3B$	0.8	0.4	0.3
$5B$	1.0	0.85	0.7





Subject: Bridge St: Rear Abutment Scour Check  
SFN 3431790  
Date: 1/8/2025 Job No. : 20230339  
Computed: AI Checked: TDA  
Sheet: 2 of 5

**Check Pile capacity in Check Scour Case**

**Strength Results -HP14x73**

Axial Load in Row 1 = 162.19 k Check Lpile with and without axial load.  
Axial Load in Row 2 = 55.10 k Check Lpile with and without axial load.

**Results from Lpile**

	Pile 1	Pile 2
Pm	0.843	0.496
Deflection (in)	0.70	0.70
Resistance from Lpile (k)	8.629	8.157
Mu from Lpile (lb-in)	1201591	1135883

Resistance by Row		
Row 1	Row 2	
8.629	8.157	k

Total Resistance

Total Combined Pile Resistance 16.79 k

Total Strength Load at Abutment 16.19 k

OK

**By inspection the abutment Footing is only deflecting 0.7 to achieve the lateral capacity to resist the Extreme Event load case. As such the service case does not need checked**

#### Check Structural Resistance of Piles

Pull loadings from Lpile and substituting in the max Strength Axial Load from LEAP

	Vu (k)	Pu (k)	Mu (in-lb)	Mu (k-ft)
Row 1	8.629	162.18774	1201591	100.13
Row 2	8.16	55.095849	1135883	94.66
Row 3	0	0	0	0.00

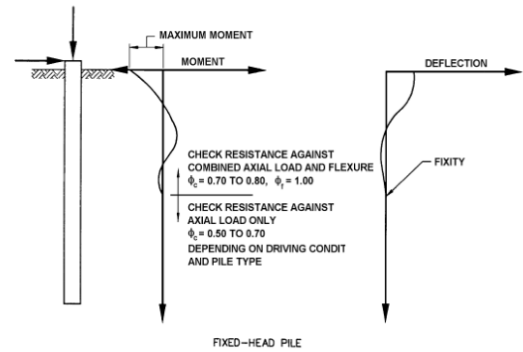
#### Pile Properties (HP14x73)

Fy	50 ksi	d =	13.6
d	13.6 in	bf =	14.6
tw	0.505	tf =	0.505
		tw =	0.505
Ix/y	729.00 in^4	Ag Steel	21.4 si
Sx/y	107.00 in^3		
Zx/y	118.00 in^3	rs =	5.84 in

#### Compression Check 6.9.4.1

Check compression only in pile below bending zone where the pile is subject to severe driving conditions  
 Use value in BDM Section C305.3.3 for pile capacity which has a phi\_C of 0.50 applied.

$$Pr = 530 \text{ kips} > 162.18774 \text{ OK}$$



#### Combined Axial Compression and Flexure Check 6.9.2.2

#### Flexure Check 6.10.8.1.1 - Discretely Braced Flanges in Compression

$$f_{bu} + \frac{1}{3} f_t \leq \phi_f F_{nc} \quad (6.10.8.1.1-1)$$

$$f_t = 0 \text{ ksi}$$

$$f_{bu} = M/S_x = 11.23 \text{ ksi}$$

#### Flexure Check 6.10.8.2.2 - Local Buckling Resistance

$$\lambda_{da} = b_{fc} / (2t_{fc}) = 14.455446$$

$$\lambda_{da_{pf}} = 0.38 * (E/F_{yc})^{1/2} = 9.1516119$$

$$\lambda_{da_{rt}} = 0.56 * (E/F_{yr})^{1/2} = 16.119553$$

$$R_b = 1$$

$$R_h = 1$$

$$F_{yr} = 35 \text{ ksi}$$

$$F_{nc} = 38.582352 \text{ ksi}$$

#### 6.10.8.2.2—Local Buckling Resistance

The local buckling resistance of the compression flange shall be taken as:

- If  $\lambda_f \leq \lambda_{pf}$ , then:

$$F_{nc} = R_b R_e F_{yc} \quad (6.10.8.2.2-1)$$

- Otherwise:

$$F_{nc} = \left[ 1 - \left( 1 - \frac{F_{yc}}{R_e F_{yc}} \right) \left( \frac{\lambda_f - \lambda_{pf}}{\lambda_{rt} - \lambda_{pf}} \right) \right] R_b R_e F_{yc} \quad (6.10.8.2.2-2)$$

#### Flexure Check 6.10.8.2.3 - Lateral-Torsional Buckling Resistance

Lb = 360 in (Distance to point of fixity in Lpile from bottom of footing)  
 Lp = 94.442442 in  
 Lr = 354.62395 in  
 rt = 3.921509 in

- If  $L_b \leq L_p$ , then:

$$F_{nc} = R_b R_h F_{yc} \quad (6.10.8.2.3-1)$$

- If  $L_p < L_b \leq L_r$ , then:

$$F_{nc} = C_b \left[ 1 - \left( 1 - \frac{F_{yr}}{R_h F_{yc}} \right) \left( \frac{L_b - L_p}{L_r - L_p} \right) \right] R_b R_h F_{yc} \leq R_b R_h F_{yc} \quad (6.10.8.2.3-2)$$

- If  $L_b > L_r$ , then:

$$F_{nc} = F_{cr} \leq R_b R_h F_{yc} \quad (6.10.8.2.3-3)$$

$F_{cr}$  = elastic lateral-torsional buckling stress (ksi)

$$= \frac{C_b R_b \pi^2 E}{\left( \frac{L_b}{r_t} \right)^2} \quad (6.10.8.2.3-8)$$

Cb = 1 LRFD 6.10.8.2.3-6  
 Rb = 1  
 Rh = 1  
 Fyr = 35 ksi  
**Fnc = 33.962462 ksi**

$L_p$  = limiting unbraced length to achieve the nominal flexural resistance of  $R_b R_h F_{yc}$  under uniform bending (in.)

$$= 1.0 r_t \sqrt{\frac{E}{F_{yc}}} \quad (6.10.8.2.3-4)$$

$L_r$  = limiting unbraced length to achieve the onset of nominal yielding in either flange under uniform bending with consideration of compression flange residual stress effects (in.)

$$= \pi r_t \sqrt{\frac{E}{F_{yr}}} \quad (6.10.8.2.3-5)$$

$r_t$  = effective radius of gyration for lateral-torsional buckling (in.)

$$= \frac{b_{fc}}{\sqrt{12 \left( 1 + \frac{1}{3} \frac{D_c t_w}{b_{fc} t_{fc}} \right)}} \quad (6.10.8.2.3-9)$$

### Combined Axial Compression and Flexure Check 6.9.2.2

#### Nominal Compressive Resistance 6.9.4.1

$P_0 = F_y \cdot A_g = 1070$  Kips  $E = 29000$  ksi  
 $P_e = 982.8151$  Kips  $K = 1.2$   
 $P_0 / P_e = 1.0887094$   $l = 384$  in  
 $r_s = 5.84$  in  
 **$P_n = 678.39807$  kips**

#### Local Buckling 6.9.4.2.1

- Determine if section is slender  
 $b/t = 14.455$   
 $\lambda_{br} = 13.49$  Slender, Check Local Buckling

#### Local Buckling 6.9.4.2.2

$b = 7.300$  in  
 $P_{cr} = 678.398$  kips  
 $F_{cr} = 31.700845$  ksi  
 $b_e = 7.300$  in  
 $A_{eff} = 21.4$  in<sup>2</sup>  
 **$P_n = 678.39807$  kips**

$\Phi_c = 0.7$  6.15.2/BDM C305.3.3  $\Phi_f = 1.00$   
 $P_r = \Phi_c P_n = 474.88$  k  $\Phi_c M_n = 302.83$  k-ft

Eq 6.9.2.2.1-1 and 6.9.2.2.1-2

Pile	$P_u$ (k)	$M_u$ (k-ft)	$P_u/P_r$	Compression Ratio	Flexure Ratio	Combined	Status
Row 1	162.18774	100.13	0.34	0.34	0.29	0.64	OK
Row 2	55.095849	94.66	0.12	0.06	0.31	0.37	OK
Row 3	0	0.00	0.00	0.00	0.00	0.00	OK

#### Shear Check 6.12.1.2.3b

$A_w = 6.868$  si

$V_n = 199.17$  k

$\Phi_v = 1.00$

$\Phi_v V_n = 199.17$  k

in which:

$$V_p = 0.58 F_{yt} D t_w \quad (6.10.9.2-2)$$

$\Phi_v V_n = 199.17$  k  $> 15.8$  k OK

#### Conclusion

This analysis proves the piles are capable of resisting the applied vertical and lateral loads under the Strength I load case in the check scour condition. By inspection the non-scour condition will also pass the same design.

- If  $\frac{P_0}{P_e} \leq 2.25$ , then:

$$P_n = \left[ 0.658^{\left( \frac{P_0}{P_e} \right)} \right] P_o \quad (6.9.4.1.1-1)$$

- Otherwise:

$$P_n = 0.877 P_o \quad (6.9.4.1.1-2)$$

$$P_e = \frac{\pi^2 E}{\left( \frac{K l}{r_s} \right)^2} A_g \quad (6.9.4.1.2-1)$$

$$P_n = F_{cr} A_{eff} \quad (6.9.4.2.2a-1)$$

$$F_{cr} = \frac{P_{cr}}{A_g} \quad (6.9.4.2.2a-2)$$

- For rolled-section and HSS members containing slender elements:

$$A_g = \sum (b \cdot t) \quad (6.9.4.2.2a-3)$$

# Pile Loads from Abutment Design Spreadsheet

Horizontal Strength Load 4.90 k/Ft  
 Horizontal Service Load 3.29 k/Ft  
 Number of Piles 12.00 Each

Pile Space Dir of Load, S 4 ft  
 Pile Spa Normal to Load, S 6.5 ft  
 Pile Dia, B 1.167 ft

Max Strength Deflection 0.65 in  
 Max Service Deflection 0.65 in

Space Ratio Direction of Loading, S/B 3.43 B  
 Space Ratio Normal Loading, S/B 5.57 B

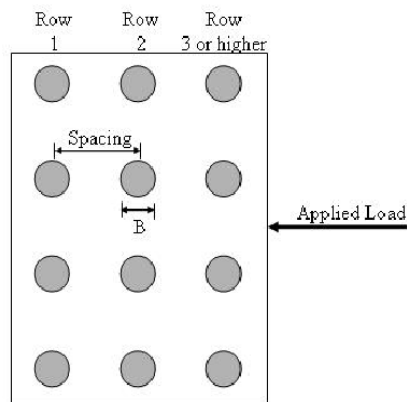
P-Multipliers, $P_m$			
	Direction of Loading (10.7.2.4-1)	Normal to Loading BDM 305.1.2	Composite $P_m$
Row 1	0.843	1.000	0.843
Row 2	0.496	1.000	0.496

BDM 305.1.2

$$P_m = 0.64 (S/B)^{0.34} \text{ for } 1.0 \leq S/B \leq 3.75$$

Table 10.7.2.4-1—Pile P-Multipliers,  $P_m$ , for Multiple Row Shading (averaged from Hannigan et al., 2006)

Pile CTC spacing (in the direction of loading)	P-Multipliers, $P_m$		
	Row 1	Row 2	Row 3 and higher
3B	0.8	0.4	0.3
5B	1.0	0.85	0.7





Subject: Bridge St: Forward Abutment Scour Design  
SFN 3431790  
Date: 1/8/2025 Job No. : 20230339  
Computed: AI Checked: TDA  
Sheet: 2 of 5

Check Pile capacity in Check Scour Case

**Strength Results -HP14x73**

Axial Load in Row 1 = 260.54 k Check Lpile with and without axial load.  
Axial Load in Row 2 = 74.66 k Check Lpile with and without axial load.

Results from Lpile

	Pile 1	Pile 2
Pm	0.843	0.496
Deflection (in)	0.65	0.65
Resistance from Lpile (k)	18.576	16.158
Mu from Lpile (lb-in)	1924436	1709594

Resistance by Row		
Row 1	Row 2	
18.576	16.158	k

Total Resistance

Total Combined Pile Resistance 34.73 k

Total Strength Load at Abutment 31.85 k

OK

By inspection the abutment Footing is only deflecting 0.65" to achieve the lateral capacity to resist the strength load case service case does not need checked

#### Check Structural Resistance of Piles

Pull loadings from Lpile and substituting in the max Strength Axial Load from LEAP

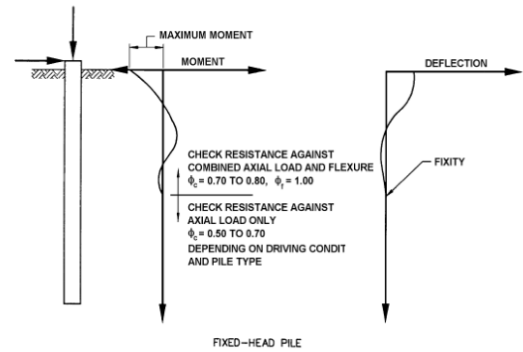
	Vu (k)	Pu (k)	Mu (in-lb)	Mu (k-ft)
Row 1	18.576	260.54	1924436	160.37
Row 2	16.16	74.66	1709594	142.47
Row 3	0	0	0	0.00

Pile Properties (HP14x73)				
Fy	50.00	ksi	d =	13.60
d	13.60	in	bf =	14.60
tw	0.51		tf =	0.51
			tw =	0.51
Ix/y	729.00	in^4	Ag Steel	21.40
Sx/y	107.00	in^3		
Zx/y	118.00	in^3	rs =	5.84
				in

#### Compression Check 6.9.4.1

Check compression only in pile below bending zone where the pile is subject to severe driving conditions  
 Use value in BDM Section C305.3.3 for pile capacity which has a phi\_C of 0.50 applied.

$$Pr = 530 \text{ kips} > 260.54 \text{ OK}$$



#### Combined Axial Compression and Flexure Check 6.9.2.2

#### Flexure Check 6.10.8.1.1 - Discretely Braced Flanges in Compression

$$f_{bu} + \frac{1}{3}f_c \leq \phi_f F_{nc} \quad (6.10.8.1.1-1)$$

$$f_l = 0.00 \text{ ksi}$$

$$f_{bu} = M/S_x = 17.99 \text{ ksi}$$

#### Flexure Check 6.10.8.2.2 - Local Buckling Resistance

$$\lambda_{da} = b_{fc}/(2t_{fc}) = 14.455446$$

$$\lambda_{da_{pf}} = 0.38*(E/F_{yc})^{1/2} = 9.1516119$$

$$\lambda_{da_{rt}} = 0.56*(E/F_{yr})^{1/2} = 16.119553$$

$$R_b = 1$$

$$R_h = 1$$

$$F_{yr} = 35 \text{ ksi}$$

$$F_{nc} = 38.582352 \text{ ksi}$$

#### 6.10.8.2.2—Local Buckling Resistance

The local buckling resistance of the compression flange shall be taken as:

- If  $\lambda_f \leq \lambda_{pf}$ , then:

$$F_{nc} = R_b R_e F_{yc} \quad (6.10.8.2.2-1)$$

- Otherwise:

$$F_{nc} = \left[ 1 - \left( 1 - \frac{F_{yc}}{R_e F_{yc}} \right) \left( \frac{\lambda_f - \lambda_{pf}}{\lambda_{rt} - \lambda_{pf}} \right) \right] R_b R_e F_{yc} \quad (6.10.8.2.2-2)$$

#### Flexure Check 6.10.8.2.3 - Lateral-Torsional Buckling Resistance

Lb = 312.00 in (Distance to point of fixity in Lpile from bottom of footing)  
 Lp = 94.442442 in  
 Lr = 354.62395 in  
 rt = 3.921509 in

- If  $L_b \leq L_p$ , then:

$$F_{nc} = R_b R_h F_{yc} \quad (6.10.8.2.3-1)$$

- If  $L_p < L_b \leq L_r$ , then:

$$F_{nc} = C_b \left[ 1 - \left( 1 - \frac{F_{yr}}{R_h F_{yc}} \right) \left( \frac{L_b - L_p}{L_r - L_p} \right) \right] R_b R_h F_{yc} \leq R_b R_h F_{yc} \quad (6.10.8.2.3-2)$$

- If  $L_b > L_r$ , then:

$$F_{nc} = F_{cr} \leq R_b R_h F_{yc} \quad (6.10.8.2.3-3)$$

$F_{cr}$  = elastic lateral-torsional buckling stress (ksi)

$$= \frac{C_b R_b \pi^2 E}{\left( \frac{L_b}{r_t} \right)^2} \quad (6.10.8.2.3-8)$$

Cb= 1 LRFD 6.10.8.2.3-6  
 Rb= 1  
 Rh= 1  
 Fyr= 35 ksi  
 Fnc= 37.457359 ksi

$L_p$  = limiting unbraced length to achieve the nominal flexural resistance of  $R_b R_h F_{yc}$  under uniform bending (in.)

$$= 1.0 r_t \sqrt{\frac{E}{F_{yc}}} \quad (6.10.8.2.3-4)$$

$L_r$  = limiting unbraced length to achieve the onset of nominal yielding in either flange under uniform bending with consideration of compression flange residual stress effects (in.)

$$= \pi r_t \sqrt{\frac{E}{F_{yr}}} \quad (6.10.8.2.3-5)$$

$r_t$  = effective radius of gyration for lateral-torsional buckling (in.)

$$= \frac{b_{fc}}{\sqrt{12 \left( 1 + \frac{1}{3} \frac{D_e t_w}{b_{fc} t_{fc}} \right)}} \quad (6.10.8.2.3-9)$$

### Combined Axial Compression and Flexure Check 6.9.2.2

#### Nominal Compressive Resistance 6.9.4.1

$$P_0 = F_y A_g = 1070 \text{ Kips} \quad E = 29000 \text{ ksi}$$

$$P_e = 982.8151 \text{ Kips} \quad K = 1.2$$

$$P_0 / P_e = 1.0887094 \quad l = 384 \text{ in}$$

$$r_s = 5.84 \text{ in}$$

$$P_n = 678.39807 \text{ kips}$$

#### Local Buckling 6.9.4.2.1

- Determine if section is slender  
 $b/t = 14.455$   
 $\lambda_{max} = 13.487$  Slender, Check Local Buckling

#### Local Buckling 6.9.4.2.2

$$b = 7.300 \text{ in}$$

$$P_{cr} = 678.398 \text{ kips}$$

$$F_{cr} = 31.700845 \text{ ksi}$$

$$b_e = 7.300 \text{ in}$$

$$A_{eff} = 21.4 \text{ in}^2$$

$$P_n = 678.39807 \text{ kips}$$

$$\phi_c = 0.7 \quad 6.15.2/BDM C305.3.3 \quad \phi_f = 1.00$$

$$P_r = \phi_c P_n = 474.88 \text{ k} \quad \phi_b M_n = 333.99 \text{ k-ft}$$

Eq 6.9.2.2.1-1 and 6.9.2.2.1-2

Pile	Pu (k)	Mu (k-ft)	Pu/Pr	Compression Ratio	Flexure Ratio	Combined	Status
Row 1	260.54	160.37	0.55	0.55	0.43	0.98	OK
Row 2	74.66	142.47	0.16	0.08	0.43	0.51	OK
Row 3	0	0.00	0.00	0.00	0.00	0.00	OK

### Shear Check 6.12.1.2.3b

$$A_w = 6.868 \text{ in}^2$$

in which:

$$V_n = 199.17 \text{ k}$$

$$V_p = 0.58 F_{yt} D t_w \quad (6.10.9.2-2)$$

$$\phi_v = 1.00$$

$$\phi_v V_n = 199.17 \text{ k} > 18.576 \text{ k} \quad \text{OK}$$

### Conclusion

This analysis proves the piles are capable of resisting the applied vertical and lateral loads under the Strength I load case in the check scour condition. By inspection the non-scour condition will also pass the same design.

$$\bullet \text{ If } \frac{P_0}{P_e} \leq 2.25, \text{ then:}$$

$$P_n = \left[ 0.658 \left( \frac{P_0}{P_e} \right) \right] P_o \quad (6.9.4.1.1-1)$$

$$\bullet \text{ Otherwise:}$$

$$P_n = 0.877 P_e \quad (6.9.4.1.1-2)$$

$$P_e = \frac{\pi^2 E}{\left( \frac{K l}{r_s} \right)^2} A_g \quad (6.9.4.1.2-1)$$

$$P_o = F_{cr} A_{eff} \quad (6.9.4.2.2a-1)$$

$$F_{cr} = \frac{P_{cr}}{A_g} \quad (6.9.4.2.2a-2)$$

For rolled-section and HSS members containing slender elements:

$$= A_g \sum (b/t)^2 \quad (6.9.4.2.2a-3)$$

# Pile Loads from Abutment Design Spreadsheet

Horizontal Extreme Event II 2.65 k/Ft

Horizontal Service Load 3.29 k/Ft  
 Number of Piles 12.00 Each

Max EE-II Deflection 0.50 in

Pile Space Dir of Load, S 4 ft  
 Pile Spa Normal to Load, S 6.5 ft  
 Pile Dia, B 1.167 ft

Max Service Deflection 0.50 in

Space Ratio Direction of Loading, S/B 3.43 B  
 Space Ratio Normal Loading, S/B 5.57 B

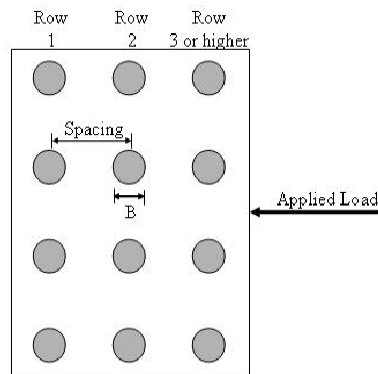
P-Multipliers, P <sub>m</sub>			
	Direction of Loading (10.7.2.4-1)	Normal to Loading BDM 305.1.2	Composite P <sub>m</sub>
Row 1	0.843	1.000	0.843
Row 2	0.496	1.000	0.496

BDM 305.1.2

$$P_m = 0.64 (S/B)^{0.34} \text{ for } 1.0 \leq S/B \leq 3.75$$

Table 10.7.2.4-1—Pile P-Multipliers, P<sub>m</sub>, for Multiple Row Shading (averaged from Hannigan et al., 2006)

Pile CTC spacing (in the direction of loading)	P-Multipliers, P <sub>m</sub>		
	Row 1	Row 2	Row 3 and higher
3B	0.8	0.4	0.3
5B	1.0	0.85	0.7





Subject: Bridge St: Forward Abutment Scour Check  
SFN 3431790  
Date: 1/8/2025 Job No. : 20230339  
Computed: AI Checked: TDA  
Sheet: 2 of 5

**Check Pile capacity in Check Scour Case**

**Strength Results -HP14x73**

Axial Load in Row 1 = 164.53 k Check Lpile with and without axial load.  
Axial Load in Row 2 = 55.08 k Check Lpile with and without axial load.

**Results from Lpile**

	Pile 1	Pile 2
Pm	0.843	0.496
Deflection (in)	0.50	0.50
Resistance from Lpile (k)	9.654	8.536
Mu from Lpile (lb-in)	1141343	1033399
Resistance by Row		
	Row 1	Row 2
Total Resistance	9.654	8.536
Total Combined Pile Resistance		18.19 k
Total Strength Load at Abutment		17.23 k

OK

**By inspection the abutment Footing is only deflecting 0.5" to achieve the lateral capacity to resist the strength load caseservice case does not need checked**

### Check Structural Resistance of Piles

Pull loadings from Lpile and substituting in the max Strength Axial Load from LEAP

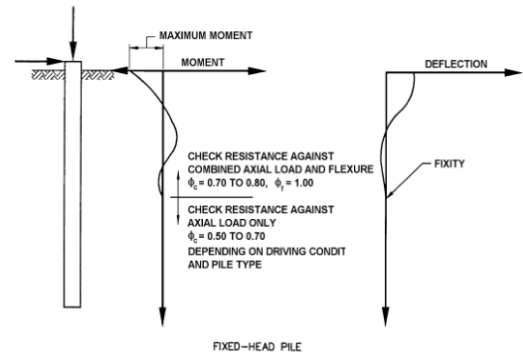
	Vu (k)	Pu (k)	Mu (in-lb)	Mu (k-ft)
Row 1	9.654	164.53	1141343	95.11
Row 2	8.54	55.08	1033399	86.12
Row 3	0	0	0	0.00

Pile Properties (HP14x73)				
Fy	50.00	ksi	d =	13.60
d	13.60	in	bf =	14.60
tw	0.51		tf =	0.51
			tw =	0.51
Ix/y	729.00	in^4	Ag Steel	21.40
Sx/y	107.00	in^3		
Zx/y	118.00	in^3	rs =	5.84
				in

### Compression Check 6.9.4.1

Check compression only in pile below bending zone where the pile is subject to severe driving conditions  
 Use value in BDM Section C305.3.3 for pile capacity which has a phi\_C of 0.50 applied.

$$Pr = 530 \text{ kips} > 164.53 \text{ OK}$$



### Combined Axial Compression and Flexure Check 6.9.2.2

#### Flexure Check 6.10.8.1.1 - Discretely Braced Flanges in Compression

$$f_{bu} + \frac{1}{3} f_c \leq \phi_f F_{nc} \quad (6.10.8.1.1-1)$$

$$f_l = 0.00 \text{ ksi}$$

$$fbu = M/S_x = 10.67 \text{ ksi}$$

#### Flexure Check 6.10.8.2.2 - Local Buckling Resistance

$$\lambda_{d1} = b_{fc} / (2t_{fc}) = 14.455446$$

$$\lambda_{d1p} = 0.38 * (E/F_{yc})^{1/2} = 9.1516119$$

$$\lambda_{d1f} = 0.56 * (E/F_{yr})^{1/2} = 16.119553$$

$$R_b = 1$$

$$R_h = 1$$

$$F_{yr} = 35 \text{ ksi}$$

$$F_{nc} = 38.582352 \text{ ksi}$$

#### 6.10.8.2.2—Local Buckling Resistance

The local buckling resistance of the compression flange shall be taken as:

- If  $\lambda_{d1} \leq \lambda_{d1p}$ , then:

$$F_{nc} = R_b R_h F_{yc} \quad (6.10.8.2.2-1)$$

- Otherwise:

$$F_{nc} = \left[ 1 - \left( 1 - \frac{F_{yc}}{R_b R_h F_{yc}} \right) \left( \frac{\lambda_{d1} - \lambda_{d1p}}{\lambda_{d1f} - \lambda_{d1p}} \right) \right] R_b R_h F_{yc} \quad (6.10.8.2.2-2)$$

using B-001-0-24 at FWD abutment

#### Flexure Check 6.10.8.2.3 - Lateral-Torsional Buckling Resistance

Lb = 318 in (Distance to point of fixity in Lpile from bottom of footing)  
 Lp = 94.442442 in  
 Lr = 354.62395 in  
 rt = 3.921509 in

- If  $L_b \leq L_p$ , then:

$$F_{nc} = R_b R_h F_{yc} \quad (6.10.8.2.3-1)$$

- If  $L_p < L_b \leq L_r$ , then:

$$F_{nc} = C_b \left[ 1 - \left( 1 - \frac{F_{yr}}{R_h F_{yc}} \right) \left( \frac{L_b - L_p}{L_r - L_p} \right) \right] R_b R_h F_{yc} \leq R_b R_h F_{yc} \quad (6.10.8.2.3-2)$$

- If  $L_b > L_r$ , then:

$$F_{nc} = F_{cr} \leq R_b R_h F_{yc} \quad (6.10.8.2.3-3)$$

$F_{cr}$  = elastic lateral-torsional buckling stress (ksi)

$$= \frac{C_b R_b \pi^2 E}{\left( \frac{L_b}{r_t} \right)^2} \quad (6.10.8.2.3-8)$$

Cb = 1 LRFD 6.10.8.2.3-6  
 Rb = 1  
 Rh = 1  
 Fyr = 35 ksi  
 Fnc = 37.111446 ksi

$L_p$  = limiting unbraced length to achieve the nominal flexural resistance of  $R_b R_h F_{yc}$  under uniform bending (in.)

$$= 1.0 r_t \sqrt{\frac{E}{F_{yc}}} \quad (6.10.8.2.3-4)$$

$L_r$  = limiting unbraced length to achieve the onset of nominal yielding in either flange under uniform bending with consideration of compression flange residual stress effects (in.)

$$= \pi r_t \sqrt{\frac{E}{F_{yp}}} \quad (6.10.8.2.3-5)$$

$r_t$  = effective radius of gyration for lateral-torsional buckling (in.)

$$= \frac{b_{fc}}{\sqrt{12 \left( 1 + \frac{1}{3} \frac{D_c t_w}{b_{fc} t_{fc}} \right)}} \quad (6.10.8.2.3-9)$$

### Combined Axial Compression and Flexure Check 6.9.2.2

#### Nominal Compressive Resistance 6.9.4.1

$P_o = F_y \cdot A_g = 1070$  Kips  $E = 29000$  ksi  
 $P_e = 982.8151$  Kips  $K = 1.2$   
 $P_o / P_e = 1.0887094$   $l = 384$  in  
 $r_s = 5.84$  in  
 **$P_n = 678.39807$  kips**

#### Local Buckling 6.9.4.2.1

- Determine if section is slender  
 $b/t = 14.455$   
 $\lambda_{br} = 13.487$  Slender, Check Local Buckling

#### Local Buckling 6.9.4.2.2

$b = 7.300$  in  
 $P_{cr} = 678.398$  kips  
 $F_{cr} = 31.700845$  ksi  
 $b_e = 7.300$  in  
 $A_{eff} = 21.4$  in<sup>2</sup>  
 **$P_n = 678.39807$  kips**

$\Phi_c = 0.7$  6.15.2/BDM C305.3.3  $\Phi_f = 1.00$   
 $P_r = \Phi_c P_n = 474.88$  k  $\Phi_f M_n = 330.91$  k-ft

Eq 6.9.2.2.1-1 and 6.9.2.2.1-2

Pile	$P_u$ (k)	$M_u$ (k-ft)	$P_u/P_r$	Compression Ratio	Flexure Ratio	Combined	Status
Row 1	164.53	95.11	0.35	0.35	0.26	0.60	OK
Row 2	55.08	86.12	0.12	0.06	0.26	0.32	OK
Row 3	0	0.00	0.00	0.00	0.00	0.00	OK

### Shear Check 6.12.1.2.3b

$A_w = 6.868$  si

in which:

$V_n = 199.17$  k

$$V_p = 0.58 F_{yt} D t_w \quad (6.10.9.2-2)$$

$\Phi_v = 1.00$

$\Phi_v V_n = 199.17$  k  $> 10.4$  k **OK**

### Conclusion

This analysis proves the piles are capable of resisting the applied vertical and lateral loads under the Strength I load case in the check scour condition. By inspection the non-scour condition will also pass the same design.

=====

LFile for Windows, Version 2022-12.011

Analysis of Individual Piles and Drilled Shafts  
Subjected to Lateral Loading Using the p-y Method  
© 1985-2022 by Ensoft, Inc.  
All Rights Reserved

=====

This copy of LFile is being used by:

EMH&T  
Ohio

Serial Number of Security Device: 139307911

This copy of LFile is licensed for exclusive use by:

EMHT Inc., New Albany, OH

Use of this software by employees of EMHT Inc.  
other than those of the office site in New Albany, OH  
is a violation of the software license agreement.

-----

Files Used for Analysis

-----

Path to file locations:

\20230339\ODOT\07\_D11 Bridge  
St\_Bowerston\120494\400-Engineering\Structures\SFN\_3431790\EngData\07\_Abutments\Stage 2\Piles\Scour\Updated Scour 02-10-2025\Strength - Verify 1\

Name of input data file:

RA\_Strength Case\_Scour.lp12d

Name of output report file:

RA\_Strength Case\_Scour.lp12o

Name of plot output file:

RA\_Strength Case\_Scour.lp12p

Name of runtime message file:

RA\_Strength Case\_Scour.lp12r

---

### Date and Time of Analysis

---

Date: February 26, 2025

Time: 13:44:28

---

### Problem Title

---

Project Name: SMP - CSX Rear Abutment

Job Number:

Client:

Engineer: BDE

Description:

---

### Program Options and Settings

---

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- 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
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

-----  
Pile Structural Properties and Geometry  
-----

Number of pile sections defined	=	1
Total length of pile	=	40.000 ft
Depth of ground surface below top of pile	=	13.4500 ft

Pile diameters used for p-y curve computations are defined using 2 points.

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.6000
2	40.000	14.6000

Input Structural Properties for Pile Sections:  
-----

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile  
Length of section = 40.000000 ft  
AISC Section Type = HP

AISC Section Name = HP14X73

Pile width = 14.600000 in

---

### Soil and Rock Layering Information

---

The soil profile is modelled using 2 layers

Layer 1 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	13.450000 ft
Distance from top of pile to bottom of layer	=	21.080000 ft
Effective unit weight at top of layer	=	126.000000 pcf
Effective unit weight at bottom of layer	=	126.000000 pcf
Undrained cohesion at top of layer	=	1500. psf
Undrained cohesion at bottom of layer	=	1500. psf
Epsilon-50 at top of layer	=	0.010000
Epsilon-50 at bottom of layer	=	0.010000
Subgrade k at top of layer	=	350.000000 pci
Subgrade k at bottom of layer	=	350.000000 pci

Layer 2 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	21.080000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	131.000000 pcf
Effective unit weight at bottom of layer	=	131.000000 pcf
Undrained cohesion at top of layer	=	4500. psf
Undrained cohesion at bottom of layer	=	4500. psf
Epsilon-50 at top of layer	=	0.004000
Epsilon-50 at bottom of layer	=	0.004000
Subgrade k at top of layer	=	1500. pci
Subgrade k at bottom of layer	=	1500. pci

(Depth of the lowest soil layer extends 10.000 ft below the pile tip)

-----  
Summary of Input Soil Properties  
-----

Layer	Soil Type	Layer	Effective	Cohesion	E50
Num. kpy	Name	Depth	Unit Wt.		or
pci	(p-y Curve Type)	ft	pcf	psf	krm
-----	-----	-----	-----	-----	-----
1	Stiff Clay	13.4500	126.0000	1500.	0.01000
350.0000	with Free Water	21.0800	126.0000	1500.	0.01000
350.0000					
2	Stiff Clay	21.0800	131.0000	4500.	0.00400
1500.	with Free Water	50.0000	131.0000	4500.	0.00400
1500.					

-----  
Modification Factors for p-y Curves  
-----

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
-----	-----	-----	-----
1	13.450	0.8430	1.0000
2	50.000	0.8430	1.0000

-----  
Static 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 Compute No.	Load Top y Type	Condition Run Analysis 1	Condition 2	Axial Thrust Force, lbs
1	5	y = 1.000000 in N.A. Yes	S = 0.0000 in/in	256740.

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force 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 Steel AISC Strong Axis:

Length of Section	=	40.000000 ft
Flange Width	=	14.600000 in
Section Depth	=	13.600000 in
Flange Thickness	=	0.505000 in
Web Thickness	=	0.505000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	21.400000 sq. in.
Moment of Inertia	=	729.000000 in^4
Elastic Bending Stiffness	=	21141000. kip-in^2
Plastic Modulus, Z	=	118.000000 in^3
Plastic Moment Capacity = Fy Z	=	5900.in-kip

# Axial Structural Capacities:

-----

Nom. Axial Structural Capacity =  $F_y A_s$  = 1070.000 kips  
 Nominal Axial Tensile Capacity = -1070.000 kips

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

Number	Axial Thrust Force kips
-----	-----
1	256.740

## Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 256.740 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in <sup>2</sup>	Depth to N Axis in	Max Total Stress ksi	Run Msg
-----	-----	-----	-----	-----	-----
0.00000430	89.2655598	20756666.	104.3451009	13.0050874	
0.00000860	178.5311196	20756666.	55.5725504	13.8446796	
0.00001290	267.7966794	20756666.	39.3150336	14.6842716	
0.00001720	357.0622392	20756666.	31.1862752	15.5238641	
0.00002150	446.3277990	20756666.	26.3090202	16.3634565	
0.00002580	535.5933588	20756666.	23.0575168	17.2030487	
0.00003010	624.8589186	20756666.	20.7350144	18.0426411	
0.00003440	714.1244784	20756666.	18.9931376	18.8822334	
0.00003871	803.3900382	20756666.	17.6383445	19.7218255	
0.00004301	892.6555980	20756666.	16.5545101	20.5614178	
0.00004731	981.9211578	20756666.	15.6677364	21.4010102	
0.00005161	1071.	20756666.	14.9287584	22.2406025	
0.00005591	1160.	20756666.	14.3034693	23.0801947	
0.00006021	1250.	20756666.	13.7675072	23.9197871	
0.00006451	1339.	20756666.	13.3030067	24.7593793	
0.00006881	1428.	20756666.	12.8965688	25.5989716	
0.00007311	1518.	20756666.	12.5379471	26.4385639	
0.00007741	1607.	20756666.	12.2191723	27.2781562	
0.00008171	1696.	20756666.	11.9339527	28.1177485	
0.00008601	1785.	20756666.	11.6772550	28.9573407	
0.00009031	1875.	20756666.	11.4450048	29.7969331	
0.00009461	1964.	20756666.	11.2338682	30.6365253	
0.00009891	2053.	20756666.	11.0410913	31.4761176	

0.0001032	2142.	20756666.	10.8643792	32.3157099	
0.0001075	2232.	20756666.	10.7018040	33.1553021	
0.0001118	2321.	20756666.	10.5517346	33.9948944	
0.0001161	2410.	20756666.	10.4127815	34.8344868	
0.0001204	2499.	20756666.	10.2837536	35.6740791	
0.0001247	2589.	20756666.	10.1636242	36.5136714	
0.0001290	2678.	20756666.	10.0515034	37.3532636	
0.0001333	2767.	20756666.	9.9466162	38.1928558	
0.0001376	2856.	20756666.	9.8482844	39.0324481	
0.0001419	2946.	20756666.	9.7559121	39.8720404	
0.0001462	3035.	20756666.	9.6689736	40.7116328	
0.0001505	3124.	20756666.	9.5870029	41.5512250	
0.0001548	3214.	20756666.	9.5095861	42.3908173	
0.0001591	3303.	20756666.	9.4363541	43.2304095	
0.0001634	3392.	20756666.	9.3669763	44.0700019	
0.0001677	3481.	20756666.	9.3011564	44.9095941	
0.0001763	3660.	20756666.	9.1791488	46.5887787	
0.0001849	3838.	20756666.	9.0684907	48.2679633	
0.0001935	4017.	20756666.	8.9676689	49.9471479	
0.0002021	4150.	20529976.	8.9310552	50.0000000	Y
0.0002107	4212.	19987264.	8.9817441	50.0000000	Y
0.0002193	4264.	19439494.	9.0407885	50.0000000	Y
0.0002279	4311.	18915047.	9.1003211	50.0000000	Y
0.0002365	4355.	18413348.	9.1599164	50.0000000	Y
0.0002451	4396.	17933516.	9.2192793	50.0000000	Y
0.0002537	4434.	17474788.	9.2781235	50.0000000	Y
0.0002623	4469.	17036030.	9.3363193	50.0000000	Y
0.0002709	4502.	16616219.	9.3937459	50.0000000	Y
0.0002795	4533.	16214429.	9.4502896	50.0000000	Y
0.0002881	4561.	15829816.	9.5058419	50.0000000	Y
0.0002967	4588.	15461602.	9.5602989	50.0000000	Y
0.0003053	4613.	15108397.	9.6138177	50.0000000	Y
0.0003139	4637.	14769943.	9.6661653	50.0000000	Y
0.0003225	4659.	14445094.	9.7174677	50.0000000	Y
0.0003311	4680.	14133512.	9.7675613	50.0000000	Y
0.0003397	4700.	13833866.	9.8167109	50.0000000	Y
0.0003483	4719.	13546068.	9.8646891	50.0000000	Y
0.0003569	4736.	13269413.	9.9115438	50.0000000	Y
0.0003655	4753.	13003194.	9.9573459	50.0000000	Y
0.0003741	4769.	12746729.	10.0021807	50.0000000	Y
0.0003828	4784.	12499722.	10.0459702	50.0000000	Y
0.0003914	4799.	12261673.	10.0887457	50.0000000	Y
0.0004000	4812.	12032123.	10.1305344	50.0000000	Y
0.0004086	4825.	11810646.	10.1713606	50.0000000	Y
0.0004172	4838.	11596851.	10.2112456	50.0000000	Y
0.0004258	4850.	11390372.	10.2502080	50.0000000	Y
0.0004344	4861.	11190814.	10.2882965	50.0000000	Y
0.0004430	4872.	10997732.	10.3255990	50.0000000	Y
0.0004516	4882.	10810987.	10.3620473	50.0000000	Y
0.0004602	4892.	10630310.	10.3976505	50.0000000	Y

## Summary of Results for Nominal Moment Capacity for Section 1

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

## Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.0	0.0	1	1	0.0	0.0
2	1.0	1.0	2	2	1.0	1.0
3	2.0	2.0	3	3	2.0	2.0
4	3.0	3.0	4	4	3.0	3.0
5	4.0	4.0	5	5	4.0	4.0
6	5.0	5.0	6	6	5.0	5.0
7	6.0	6.0	7	7	6.0	6.0
8	7.0	7.0	8	8	7.0	7.0
9	8.0	8.0	9	9	8.0	8.0
10	9.0	9.0	10	10	9.0	9.0
11	10.0	10.0	11	11	10.0	10.0
12	11.0	11.0	12	12	11.0	11.0
13	12.0	12.0	13	13	12.0	12.0
14	13.0	13.0	14	14	13.0	13.0
15	14.0	14.0	15	15	14.0	14.0
16	15.0	15.0	16	16	15.0	15.0
17	16.0	16.0	17	17	16.0	16.0
18	17.0	17.0	18	18	17.0	17.0
19	18.0	18.0	19	19	18.0	18.0
20	19.0	19.0	20	20	19.0	19.0
21	20.0	20.0	21	21	20.0	20.0
22	21.0	21.0	22	22	21.0	21.0
23	22.0	22.0	23	23	22.0	22.0
24	23.0	23.0	24	24	23.0	23.0
25	24.0	24.0	25	25	24.0	24.0
26	25.0	25.0	26	26	25.0	25.0
27	26.0	26.0	27	27	26.0	26.0
28	27.0	27.0	28	28	27.0	27.0
29	28.0	28.0	29	29	28.0	28.0
30	29.0	29.0	30	30	29.0	29.0
31	30.0	30.0	31	31	30.0	30.0
32	31.0	31.0	32	32	31.0	31.0
33	32.0	32.0	33	33	32.0	32.0
34	33.0	33.0	34	34	33.0	33.0
35	34.0	34.0	35	35	34.0	34.0
36	35.0	35.0	36	36	35.0	35.0
37	36.0	36.0	37	37	36.0	36.0
38	37.0	37.0	38	38	37.0	37.0
39	38.0	38.0	39	39	38.0	38.0
40	39.0	39.0	40	40	39.0	39.0
41	40.0	40.0	41	41	40.0	40.0
42	41.0	41.0	42	42	41.0	41.0
43	42.0	42.0	43	43	42.0	42.0
44	43.0	43.0	44	44	43.0	43.0
45	44.0	44.0	45	45	44.0	44.0
46	45.0	45.0	46	46	45.0	45.0
47	46.0	46.0	47	47	46.0	46.0
48	47.0	47.0	48	48	47.0	47.0
49	48.0	48.0	49	49	48.0	48.0
50	49.0	49.0	50	50	49.0	49.0
51	50.0	50.0	51	51	50.0	50.0
52	51.0	51.0	52	52	51.0	51.0
53	52.0	52.0	53	53	52.0	52.0
54	53.0	53.0	54	54	53.0	53.0
55	54.0	54.0	55	55	54.0	54.0
56	55.0	55.0	56	56	55.0	55.0
57	56.0	56.0	57	57	56.0	56.0

1	13.4500	0.00	N.A.	No	0.00	10445.
2	21.0800	6.6952	Yes	No	10445.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

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

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)  
 Displacement of pile head = 1.000000 inches  
 Rotation of pile head = 0.000E+00 radians  
 Axial load on pile head = 256740.0 lbs

Depth Res.	Soil	Deflect. Spr.	Bending Distrib.	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil p
X Es*H feet lb/inch		y Lat. inches lb/inch	Moment Load in-lbs lb/inch	lbs	radians	psi*	lb-in^2	
0.00		1.0000	-2040210.	15932.	0.00	32427.	2.08E+10	
0.00		0.00	0.00					
0.4000		0.9989	-1963455.	15930.	-4.63E-04	31659.	2.08E+10	
0.00		0.00	0.00					
0.8000		0.9956	-1886141.	15930.	-9.08E-04	30884.	2.08E+10	
0.00		0.00	0.00					
1.2000		0.9902	-1808289.	15930.	-0.00134	30105.	2.08E+10	
0.00		0.00	0.00					
1.6000		0.9827	-1729922.	15930.	-0.00174	29320.	2.08E+10	
0.00		0.00	0.00					
2.0000		0.9734	-1651062.	15930.	-0.00214	28530.	2.08E+10	
0.00		0.00	0.00					
2.4000		0.9622	-1571731.	15930.	-0.00251	27736.	2.08E+10	
0.00		0.00	0.00					
2.8000		0.9493	-1491952.	15930.	-0.00286	26937.	2.08E+10	
0.00		0.00	0.00					
3.2000		0.9348	-1411749.	15930.	-0.00320	26134.	2.08E+10	
0.00		0.00	0.00					
3.6000		0.9186	-1331142.	15930.	-0.00352	25327.	2.08E+10	
0.00		0.00	0.00					

4.0000	0.9010	-1250157.	15930.	-0.00381	24516.	2.08E+10
0.00	0.00	0.00				
4.4000	0.8820	-1168815.	15930.	-0.00409	23701.	2.08E+10
0.00	0.00	0.00				
4.8000	0.8617	-1087140.	15930.	-0.00435	22884.	2.08E+10
0.00	0.00	0.00				
5.2000	0.8402	-1005156.	15930.	-0.00460	22063.	2.08E+10
0.00	0.00	0.00				
5.6000	0.8176	-922885.	15930.	-0.00482	21239.	2.08E+10
0.00	0.00	0.00				
6.0000	0.7940	-840350.	15930.	-0.00502	20412.	2.08E+10
0.00	0.00	0.00				
6.4000	0.7694	-757577.	15930.	-0.00521	19583.	2.08E+10
0.00	0.00	0.00				
6.8000	0.7440	-674587.	15930.	-0.00537	18752.	2.08E+10
0.00	0.00	0.00				
7.2000	0.7178	-591406.	15930.	-0.00552	17919.	2.08E+10
0.00	0.00	0.00				
7.6000	0.6910	-508055.	15930.	-0.00565	17085.	2.08E+10
0.00	0.00	0.00				
8.0000	0.6636	-424560.	15930.	-0.00575	16249.	2.08E+10
0.00	0.00	0.00				
8.4000	0.6357	-340944.	15930.	-0.00584	15411.	2.08E+10
0.00	0.00	0.00				
8.8000	0.6075	-257231.	15930.	-0.00591	14573.	2.08E+10
0.00	0.00	0.00				
9.2000	0.5790	-173444.	15930.	-0.00596	13734.	2.08E+10
0.00	0.00	0.00				
9.6000	0.5503	-89609.	15930.	-0.00599	12895.	2.08E+10
0.00	0.00	0.00				
10.0000	0.5215	-5747.	15930.	-0.00600	12055.	2.08E+10
0.00	0.00	0.00				
10.4000	0.4926	78116.	15930.	-0.00599	12779.	2.08E+10
0.00	0.00	0.00				
10.8000	0.4639	161957.	15930.	-0.00597	13619.	2.08E+10
0.00	0.00	0.00				
11.2000	0.4354	245752.	15930.	-0.00592	14458.	2.08E+10
0.00	0.00	0.00				
11.6000	0.4071	329476.	15930.	-0.00585	15296.	2.08E+10
0.00	0.00	0.00				
12.0000	0.3792	413107.	15930.	-0.00577	16134.	2.08E+10
0.00	0.00	0.00				
12.4000	0.3517	496620.	15930.	-0.00566	16970.	2.08E+10
0.00	0.00	0.00				
12.8000	0.3248	579992.	15930.	-0.00554	17805.	2.08E+10
0.00	0.00	0.00				
13.2000	0.2985	663198.	15930.	-0.00539	18638.	2.08E+10
0.00	0.00	0.00				
13.6000	0.2730	746215.	15778.	-0.00523	19470.	2.08E+10
-63.417	1115.	0.00				

14.0000	0.2483	827559.	15259.	-0.00505	20284.	2.08E+10
-152.765	2953.	0.00				
14.4000	0.2245	905147.	14320.	-0.00485	21061.	2.08E+10
-238.543	5099.	0.00				
14.8000	0.2018	976981.	12996.	-0.00463	21780.	2.08E+10
-312.899	7444.	0.00				
15.2000	0.1801	1041327.	11341.	-0.00440	22425.	2.08E+10
-376.998	10049.	0.00				
15.6000	0.1595	1096690.	9400.	-0.00415	22979.	2.08E+10
-431.424	12980.	0.00				
16.0000	0.1402	1141801.	7221.	-0.00389	23431.	2.08E+10
-476.484	16310.	0.00				
16.4000	0.1222	1175609.	4848.	-0.00362	23769.	2.08E+10
-512.293	20126.	0.00				
16.8000	0.1054	1197278.	2326.	-0.00335	23986.	2.08E+10
-538.719	24525.	0.00				
17.2000	0.09002	1206194.	-293.784	-0.00307	24076.	2.08E+10
-552.834	29477.	0.00				
17.6000	0.07595	1202029.	-2841.	-0.00279	24034.	2.08E+10
-508.585	32143.	0.00				
18.0000	0.06321	1185803.	-5175.	-0.00252	23871.	2.08E+10
-463.970	35234.	0.00				
18.4000	0.05178	1158550.	-7297.	-0.00225	23599.	2.08E+10
-419.953	38927.	0.00				
18.8000	0.04165	1121291.	-9208.	-0.00198	23225.	2.08E+10
-376.606	43407.	0.00				
19.2000	0.03275	1075035.	-10914.	-0.00173	22762.	2.08E+10
-333.979	48948.	0.00				
19.6000	0.02505	1020778.	-12416.	-0.00149	22219.	2.08E+10
-292.090	55968.	0.00				
20.0000	0.01848	959500.	-13720.	-0.00126	21605.	2.08E+10
-250.897	65158.	0.00				
20.4000	0.01298	892168.	-14826.	-0.00104	20931.	2.08E+10
-210.260	77752.	0.00				
20.8000	0.00847	819738.	-15739.	-8.45E-04	20206.	2.08E+10
-169.829	96264.	0.00				
21.2000	0.00487	743161.	-17520.	-6.65E-04	19439.	2.08E+10
-572.221	564473.	0.00				
21.6000	0.00209	653189.	-19513.	-5.03E-04	18538.	2.08E+10
-258.280	593607.	0.00				
22.0000	3.62E-05	557079.	-20144.	-3.63E-04	17576.	2.08E+10
-4.690	622741.	0.00				
22.4000	-0.00140	460703.	-19699.	-2.45E-04	16611.	2.08E+10
189.8361	651875.	0.00				
22.8000	-0.00232	368569.	-18454.	-1.50E-04	15688.	2.08E+10
329.2164	681009.	0.00				
23.2000	-0.00283	283915.	-16657.	-7.41E-05	14840.	2.08E+10
419.2695	710143.	0.00				
23.6000	-0.00303	208841.	-14530.	-1.72E-05	14088.	2.08E+10
467.0182	739277.	0.00				

24.0000	-0.00300	144466.	-12259.	2.37E-05	13444.	2.08E+10
479.3591	767282.	0.00				
24.4000	-0.00280	91096.	-9996.	5.09E-05	12909.	2.08E+10
463.6108	793354.	0.00				
24.8000	-0.00251	48380.	-7846.	6.70E-05	12482.	2.08E+10
432.2878	826680.	0.00				
25.2000	-0.00216	15611.	-5883.	7.44E-05	12154.	2.08E+10
385.3603	855814.	0.00				
25.6000	-0.00180	-8283.	-4164.	7.53E-05	12080.	2.08E+10
331.0057	884948.	0.00				
26.0000	-0.00144	-24549.	-2712.	7.15E-05	12243.	2.08E+10
273.9594	914082.	0.00				
26.4000	-0.00111	-34496.	-1532.	6.47E-05	12343.	2.08E+10
217.9366	943216.	0.00				
26.8000	-8.18E-04	-39412.	-610.969	5.61E-05	12392.	2.08E+10
165.6704	972350.	0.00				
27.2000	-5.70E-04	-40500.	72.2309	4.69E-05	12403.	2.08E+10
118.9964	1001484.	0.00				
27.6000	-3.68E-04	-38835.	547.3513	3.77E-05	12386.	2.08E+10
78.9704	1030618.	0.00				
28.0000	-2.08E-04	-35338.	847.2874	2.91E-05	12351.	2.08E+10
46.0029	1059752.	0.00				
28.4000	-8.82E-05	-30772.	1006.	2.15E-05	12305.	2.08E+10
19.9985	1088886.	0.00				
28.8000	-2.11E-06	-25737.	1055.	1.50E-05	12255.	2.08E+10
0.4908	1118020.	0.00				
29.2000	5.54E-05	-20682.	1024.	9.58E-06	12204.	2.08E+10
-13.234	1147154.	0.00				
29.6000	8.99E-05	-15927.	939.6464	5.35E-06	12157.	2.08E+10
-22.031	1176288.	0.00				
30.0000	1.07E-04	-11675.	822.4376	2.16E-06	12114.	2.08E+10
-26.806	1205423.	0.00				
30.4000	1.11E-04	-8037.	689.8134	-1.20E-07	12078.	2.08E+10
-28.454	1234557.	0.00				
30.8000	1.06E-04	-5053.	554.8064	-1.63E-06	12048.	2.08E+10
-27.799	1263691.	0.00				
31.2000	9.49E-05	-2707.	426.7123	-2.53E-06	12024.	2.08E+10
-25.573	1292825.	0.00				
31.6000	8.13E-05	-949.902	311.5994	-2.95E-06	12007.	2.08E+10
-22.390	1321959.	0.00				
32.0000	6.66E-05	291.6126	212.8739	-3.03E-06	12000.	2.08E+10
-18.745	1351093.	0.00				
32.4000	5.22E-05	1101.	131.8507	-2.87E-06	12008.	2.08E+10
-15.014	1380227.	0.00				
32.8000	3.91E-05	1564.	68.2924	-2.56E-06	12013.	2.08E+10
-11.468	1409361.	0.00				
33.2000	2.76E-05	1763.	20.8910	-2.18E-06	12015.	2.08E+10
-8.282	1438495.	0.00				
33.6000	1.82E-05	1770.	-12.323	-1.77E-06	12015.	2.08E+10
-5.557	1467629.	0.00				

34.0000	1.07E-05	1649.	-33.646	-1.37E-06	12014.	2.08E+10
-3.328	1496763.	0.00				
34.4000	5.01E-06	1451.	-45.454	-1.01E-06	12012.	2.08E+10
-1.591	1525897.	0.00				
34.8000	9.48E-07	1215.	-50.010	-7.05E-07	12009.	2.08E+10
-0.307	1555032.	0.00				
35.2000	-1.76E-06	972.3815	-49.352	-4.52E-07	12007.	2.08E+10
0.5813	1584166.	0.00				
35.6000	-3.39E-06	742.6087	-45.221	-2.54E-07	12005.	2.08E+10
1.1398	1613300.	0.00				
36.0000	-4.20E-06	538.8846	-39.039	-1.05E-07	12003.	2.08E+10
1.4360	1642434.	0.00				
36.4000	-4.40E-06	368.0911	-31.912	-6.22E-10	12001.	2.08E+10
1.5336	1671568.	0.00				
36.8000	-4.20E-06	232.5271	-24.658	6.88E-08	12000.	2.08E+10
1.4890	1700702.	0.00				
37.2000	-3.74E-06	131.2036	-17.847	1.11E-07	11999.	2.08E+10
1.3490	1729836.	0.00				
37.6000	-3.14E-06	60.9226	-11.850	1.33E-07	11998.	2.08E+10
1.1500	1758970.	0.00				
38.0000	-2.47E-06	17.1191	-6.886	1.42E-07	11997.	2.08E+10
0.9184	1788104.	0.00				
38.4000	-1.77E-06	-5.529	-3.070	1.43E-07	11997.	2.08E+10
0.6715	1817238.	0.00				
38.8000	-1.09E-06	-12.704	-0.454	1.41E-07	11997.	2.08E+10
0.4186	1846372.	0.00				
39.2000	-4.17E-07	-10.231	0.9419	1.39E-07	11997.	2.08E+10
0.1628	1875506.	0.00				
39.6000	2.43E-07	-4.004	1.1009	1.37E-07	11997.	2.08E+10
-0.09656	1904640.	0.00				
40.0000	8.99E-07	0.00	0.00	1.37E-07	11997.	2.08E+10
-0.362	966887.	0.00				

\* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

#### Output Summary for Load Case No. 1:

Pile-head deflection	=	1.00000000 inches
Computed slope at pile head	=	0.000000 radians
Maximum bending moment	=	-2040210. inch-lbs
Maximum shear force	=	-20144. lbs
Depth of maximum bending moment	=	0.000000 feet below pile head
Depth of maximum shear force	=	22.00000000 feet below pile head
Number of iterations	=	10

Number of zero deflection points = 4  
Pile deflection at ground = 0.28258381 inches

-----  
Summary of Pile-head Responses for Conventional Analyses  
-----

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs  
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians  
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.  
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs  
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case	Load Type	Load 1	Load 2	Axial Loading	Pile-head Deflection	Pile-head Rotation	Max in lbs	
No.	1	Load 1	2	Load 2	lbs	inches	radians	lbs
1	y, in	1.0000	S, rad	0.00	256740.	1.0000	0.00	
	-20144.	-2040210.						

Maximum pile-head deflection = 1.0000000000 inches  
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

The analysis ended normally.

=====

LFile for Windows, Version 2022-12.011

Analysis of Individual Piles and Drilled Shafts  
Subjected to Lateral Loading Using the p-y Method  
© 1985-2022 by Ensoft, Inc.  
All Rights Reserved

=====

This copy of LFile is being used by:

EMH&T  
Ohio

Serial Number of Security Device: 139307911

This copy of LFile is licensed for exclusive use by:

EMHT Inc., New Albany, OH

Use of this software by employees of EMHT Inc.  
other than those of the office site in New Albany, OH  
is a violation of the software license agreement.

-----

Files Used for Analysis

-----

Path to file locations:

\20230339\ODOT\07\_D11 Bridge  
St\_Bowerston\120494\400-Engineering\Structures\SFN\_3431790\EngData\07\_Abutments\Stage 2\Piles\Scour\Updated Scour 02-10-2025\Strength - Verify 1\

Name of input data file:

FA\_Strength Case\_Scour.lp12d

Name of output report file:

FA\_Strength Case\_Scour.lp12o

Name of plot output file:

FA\_Strength Case\_Scour.lp12p

Name of runtime message file:

FA\_Strength Case\_Scour.lp12r

---

Date and Time of Analysis

---

Date: February 26, 2025

Time: 13:45:48

---

Problem Title

---

Project Name: SMP - CSX Rear Abutment

Job Number:

Client:

Engineer: BDE

Description:

---

Program Options and Settings

---

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- 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
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

-----  
Pile Structural Properties and Geometry  
-----

Number of pile sections defined	=	1
Total length of pile	=	30.000 ft
Depth of ground surface below top of pile	=	10.1700 ft

Pile diameters used for p-y curve computations are defined using 2 points.

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.6000
2	30.000	14.6000

Input Structural Properties for Pile Sections:  
-----

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile  
 Length of section = 30.000000 ft  
 AISC Section Type = HP

AISC Section Name = HP14X73

Pile width = 14.600000 in

---

### 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	=	10.170000 ft
Distance from top of pile to bottom of layer	=	11.700000 ft
Effective unit weight at top of layer	=	127.000000 pcf
Effective unit weight at bottom of layer	=	127.000000 pcf
Friction angle at top of layer	=	35.000000 deg.
Friction angle at bottom of layer	=	35.000000 deg.
Subgrade k at top of layer	=	90.000000 pci
Subgrade k at bottom of layer	=	90.000000 pci

Layer 2 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	11.700000 ft
Distance from top of pile to bottom of layer	=	21.700000 ft
Effective unit weight at top of layer	=	126.000000 pcf
Effective unit weight at bottom of layer	=	126.000000 pcf
Undrained cohesion at top of layer	=	1500. psf
Undrained cohesion at bottom of layer	=	1500. psf
Epsilon-50 at top of layer	=	0.010000
Epsilon-50 at bottom of layer	=	0.010000
Subgrade k at top of layer	=	350.000000 pci
Subgrade k at bottom of layer	=	350.000000 pci

Layer 3 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	21.700000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft

Effective unit weight at top of layer	=	131.000000	pcf
Effective unit weight at bottom of layer	=	131.000000	pcf
Undrained cohesion at top of layer	=	4500.	psf
Undrained cohesion at bottom of layer	=	4500.	psf
Epsilon-50 at top of layer	=	0.004000	
Epsilon-50 at bottom of layer	=	0.004000	
Subgrade k at top of layer	=	1500.	pci
Subgrade k at bottom of layer	=	1500.	pci

(Depth of the lowest soil layer extends 20.000 ft below the pile tip)

#### Summary of Input Soil Properties

Layer E50 Num. or krm	Soil Type Name kpy (p-y Curve Type) pci	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Angle of Friction deg.
1	Sand	10.1700	127.0000	--	35.0000
--	90.0000				
--	(Reese, et al.)	11.7000	127.0000	--	35.0000
--	90.0000				
2	Stiff Clay	11.7000	126.0000	1500.	--
0.01000	350.0000				
	with Free Water	21.7000	126.0000	1500.	--
0.01000	350.0000				
3	Stiff Clay	21.7000	131.0000	4500.	--
0.00400	1500.				
	with Free Water	50.0000	131.0000	4500.	--
0.00400	1500.				

#### Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 3 points

Point No.	Depth X ft	p-mult	y-mult
1	11.700	0.8430	1.0000

2	21.700	0.8430	1.0000
3	50.000	0.8430	1.0000

-----  
Static 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 Compute No.	Load Top y Type	Condition Run Analysis 1	Condition 2	Axial Thrust Force, lbs
vs. Pile Length				
1	5	y = 0.650000 in	S = 0.0000 in/in	260540.
N.A.		Yes		

V = shear force applied normal to pile axis  
M = bending moment applied to pile head  
y = lateral deflection normal to pile axis  
S = pile slope relative to original pile batter angle  
R = rotational stiffness applied to pile head  
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).  
Thrust force 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 Steel AISC Strong Axis:

-----

Length of Section	=	30.000000 ft
Flange Width	=	14.600000 in
Section Depth	=	13.600000 in
Flange Thickness	=	0.505000 in
Web Thickness	=	0.505000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	21.400000 sq. in.
Moment of Inertia	=	729.000000 in^4
Elastic Bending Stiffness	=	21141000. kip-in^2
Plastic Modulus, Z	=	118.000000in^3
Plastic Moment Capacity = Fy Z	=	5900.in-kip

## Axial Structural Capacities:

-----

Nom. Axial Structural Capacity = Fy As	=	1070.000 kips
Nominal Axial Tensile Capacity	=	-1070.000 kips

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

Number	Axial Thrust Force kips
-----	-----
1	260.540

## Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 260.540 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
-----	-----	-----	-----	-----	-----
0.00000429	89.0448780	20756666.	106.0341888	13.1830728	
0.00000858	178.0897559	20756666.	56.4170944	14.0205894	
0.00001287	267.1346339	20756666.	39.8780629	14.8581063	
0.00001716	356.1795118	20756666.	31.6085472	15.6956227	
0.00002145	445.2243898	20756666.	26.6468378	16.5331395	
0.00002574	534.2692677	20756666.	23.3390315	17.3706560	

0.00003003	623.3141457	20756666.	20.9763127	18.2081728	
0.00003432	712.3590237	20756666.	19.2042736	19.0456893	
0.00003861	801.4039016	20756666.	17.8260210	19.8832059	
0.00004290	890.4487796	20756666.	16.7234189	20.7207226	
0.00004719	979.4936575	20756666.	15.8212899	21.5582393	
0.00005148	1069.	20756666.	15.0695157	22.3957559	
0.00005577	1158.	20756666.	14.4333991	23.2332725	
0.00006006	1247.	20756666.	13.8881563	24.0707892	
0.00006435	1336.	20756666.	13.4156126	24.9083058	
0.00006864	1425.	20756666.	13.0021368	25.7458225	
0.00007293	1514.	20756666.	12.6373052	26.5833392	
0.00007722	1603.	20756666.	12.3130105	27.4208559	
0.00008151	1692.	20756666.	12.0228520	28.2583724	
0.00008580	1781.	20756666.	11.7617094	29.0958891	
0.00009009	1870.	20756666.	11.5254376	29.9334058	
0.00009438	1959.	20756666.	11.3106449	30.7709224	
0.00009867	2048.	20756666.	11.1145299	31.6084390	
0.0001030	2137.	20756666.	10.9347579	32.4459558	
0.0001072	2226.	20756666.	10.7693676	33.2834723	
0.0001115	2315.	20756666.	10.6166996	34.1209890	
0.0001158	2404.	20756666.	10.4753403	34.9585056	
0.0001201	2493.	20756666.	10.3440782	35.7960223	
0.0001244	2582.	20756666.	10.2218686	36.6335389	
0.0001287	2671.	20756666.	10.1078063	37.4710556	
0.0001330	2760.	20756666.	10.0011029	38.3085722	
0.0001373	2849.	20756666.	9.9010684	39.1460889	
0.0001416	2938.	20756666.	9.8070966	39.9836056	
0.0001459	3028.	20756666.	9.7186526	40.8211222	
0.0001501	3117.	20756666.	9.6352625	41.6586388	
0.0001544	3206.	20756666.	9.5565052	42.4961555	
0.0001587	3295.	20756666.	9.4820051	43.3336721	
0.0001630	3384.	20756666.	9.4114260	44.1711888	
0.0001673	3473.	20756666.	9.3444664	45.0087054	
0.0001759	3651.	20756666.	9.2203461	46.6837387	
0.0001845	3829.	20756666.	9.1077718	48.3587720	
0.0001930	4007.	20754083.	9.0058313	50.0000000	Y
0.0002016	4135.	20506484.	8.9728127	50.0000000	Y
0.0002102	4195.	19955770.	9.0240893	50.0000000	Y
0.0002188	4246.	19408024.	9.0817999	50.0000000	Y
0.0002274	4294.	18883997.	9.1400000	50.0000000	Y
0.0002359	4337.	18382329.	9.1984715	50.0000000	Y
0.0002445	4378.	17902888.	9.2566924	50.0000000	Y
0.0002531	4415.	17444531.	9.3144763	50.0000000	Y
0.0002617	4450.	17006125.	9.3716858	50.0000000	Y
0.0002703	4483.	16586652.	9.4281930	50.0000000	Y
0.0002788	4513.	16185185.	9.4838783	50.0000000	Y
0.0002874	4542.	15800882.	9.5386279	50.0000000	Y
0.0002960	4568.	15432966.	9.5923331	50.0000000	Y
0.0003046	4593.	15080309.	9.6450477	50.0000000	Y
0.0003132	4617.	14742124.	9.6967338	50.0000000	Y

0.0003217	4639.	14417776.	9.7473173	50.0000000	Y
0.0003303	4660.	14106440.	9.7968262	50.0000000	Y
0.0003389	4679.	13807255.	9.8453295	50.0000000	Y
0.0003475	4698.	13519897.	9.8926944	50.0000000	Y
0.0003561	4716.	13243663.	9.9389664	50.0000000	Y
0.0003646	4732.	12977646.	9.9843066	50.0000000	Y
0.0003732	4748.	12721572.	10.0286127	50.0000000	Y
0.0003818	4763.	12474941.	10.0718986	50.0000000	Y
0.0003904	4777.	12237254.	10.1141934	50.0000000	Y
0.0003990	4791.	12008051.	10.1555234	50.0000000	Y
0.0004075	4804.	11786909.	10.1959113	50.0000000	Y
0.0004161	4816.	11573435.	10.2353771	50.0000000	Y
0.0004247	4828.	11367268.	10.2739383	50.0000000	Y
0.0004333	4839.	11168069.	10.3116100	50.0000000	Y
0.0004419	4850.	10975370.	10.3484918	50.0000000	Y
0.0004504	4860.	10788902.	10.3845875	50.0000000	Y
0.0004590	4870.	10608492.	10.4198524	50.0000000	Y
0.0004676	4879.	10433888.	10.4542936	50.0000000	Y
0.0004762	4888.	10264843.	10.4879218	50.0000000	Y
0.0004848	4896.	10100737.	10.5209867	50.0000000	Y
0.0004933	4905.	9941749.	10.5532634	50.0000000	Y
0.0005019	4913.	9787685.	10.5847532	50.0000000	Y
0.0005105	4920.	9637969.	10.6157077	50.0000000	Y
0.0005448	4948.	9081504.	10.7328888	50.0000000	Y
0.0005791	4971.	8584231.	10.8408055	50.0000000	Y
0.0006135	4992.	8137522.	10.9403414	50.0000000	Y
0.0006478	5010.	7734201.	11.0323662	50.0000000	Y
0.0006821	5026.	7368092.	11.1178776	50.0000000	Y
0.0007164	5040.	7034654.	11.1972595	50.0000000	Y
0.0007507	5052.	6729511.	11.2713570	50.0000000	Y

-----  
Summary of Results for Nominal Moment Capacity for Section 1  
-----

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
-----	-----	-----
1	260.540000000	5052.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction

factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

-----  
 Layering Correction Equivalent Depths of Soil & Rock Layers  
 -----

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	10.1700	0.00	N.A.	No	0.00	2313.
2	11.7000	18.4995	No	No	2313.	17661.
3	21.7000	10.1855	Yes	No	19974.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

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

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)  
 Displacement of pile head = 0.650000 inches  
 Rotation of pile head = 0.000E+00 radians  
 Axial load on pile head = 260540.0 lbs

Depth Res.	Soil	Deflect. Spr.	Bending Distrib.	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil p
X		y	Moment					
Es*H		Lat. Load						
feet		inches	in-lbs	lbs	radians	psi*	lb-in^2	
lb/inch		lb/inch	lb/inch					
0.00		0.6500	-1924436.	18576.	0.00	31446.	2.08E+10	
0.00		0.00	0.00					

0.3000	0.6494	-1857412.	18574.	-3.28E-04	30774.	2.08E+10
0.00	0.00	0.00				
0.6000	0.6476	-1790086.	18574.	-6.44E-04	30100.	2.08E+10
0.00	0.00	0.00				
0.9000	0.6448	-1722469.	18574.	-9.49E-04	29423.	2.08E+10
0.00	0.00	0.00				
1.2000	0.6408	-1654572.	18574.	-0.00124	28743.	2.08E+10
0.00	0.00	0.00				
1.5000	0.6358	-1586406.	18574.	-0.00152	28061.	2.08E+10
0.00	0.00	0.00				
1.8000	0.6298	-1517981.	18574.	-0.00179	27375.	2.08E+10
0.00	0.00	0.00				
2.1000	0.6229	-1449310.	18574.	-0.00205	26688.	2.08E+10
0.00	0.00	0.00				
2.4000	0.6151	-1380402.	18574.	-0.00229	25998.	2.08E+10
0.00	0.00	0.00				
2.7000	0.6064	-1311271.	18574.	-0.00253	25305.	2.08E+10
0.00	0.00	0.00				
3.0000	0.5969	-1241925.	18574.	-0.00275	24611.	2.08E+10
0.00	0.00	0.00				
3.3000	0.5866	-1172378.	18574.	-0.00296	23915.	2.08E+10
0.00	0.00	0.00				
3.6000	0.5756	-1102640.	18574.	-0.00316	23216.	2.08E+10
0.00	0.00	0.00				
3.9000	0.5639	-1032723.	18574.	-0.00334	22516.	2.08E+10
0.00	0.00	0.00				
4.2000	0.5515	-962638.	18574.	-0.00351	21814.	2.08E+10
0.00	0.00	0.00				
4.5000	0.5386	-892396.	18574.	-0.00368	21111.	2.08E+10
0.00	0.00	0.00				
4.8000	0.5251	-822009.	18574.	-0.00382	20406.	2.08E+10
0.00	0.00	0.00				
5.1000	0.5110	-751489.	18574.	-0.00396	19700.	2.08E+10
0.00	0.00	0.00				
5.4000	0.4965	-680846.	18574.	-0.00408	18993.	2.08E+10
0.00	0.00	0.00				
5.7000	0.4816	-610092.	18574.	-0.00420	18284.	2.08E+10
0.00	0.00	0.00				
6.0000	0.4663	-539239.	18574.	-0.00430	17575.	2.08E+10
0.00	0.00	0.00				
6.3000	0.4507	-468298.	18574.	-0.00438	16864.	2.08E+10
0.00	0.00	0.00				
6.6000	0.4348	-397281.	18574.	-0.00446	16153.	2.08E+10
0.00	0.00	0.00				
6.9000	0.4186	-326200.	18574.	-0.00452	15441.	2.08E+10
0.00	0.00	0.00				
7.2000	0.4022	-255065.	18574.	-0.00457	14729.	2.08E+10
0.00	0.00	0.00				
7.5000	0.3857	-183889.	18574.	-0.00461	14016.	2.08E+10
0.00	0.00	0.00				

7.8000	0.3690	-112683.	18574.	-0.00464	13303.	2.08E+10
0.00	0.00	0.00				
8.1000	0.3523	-41459.	18574.	-0.00465	12590.	2.08E+10
0.00	0.00	0.00				
8.4000	0.3356	29772.	18574.	-0.00465	12473.	2.08E+10
0.00	0.00	0.00				
8.7000	0.3188	100998.	18574.	-0.00464	13186.	2.08E+10
0.00	0.00	0.00				
9.0000	0.3022	172208.	18574.	-0.00461	13899.	2.08E+10
0.00	0.00	0.00				
9.3000	0.2856	243390.	18574.	-0.00458	14612.	2.08E+10
0.00	0.00	0.00				
9.6000	0.2692	314532.	18574.	-0.00453	15324.	2.08E+10
0.00	0.00	0.00				
9.9000	0.2530	385623.	18574.	-0.00447	16036.	2.08E+10
0.00	0.00	0.00				
10.2000	0.2370	456651.	18569.	-0.00440	16748.	2.08E+10
-2.847	43.2444	0.00				
10.5000	0.2213	527568.	18502.	-0.00431	17458.	2.08E+10
-34.501	561.1985	0.00				
10.8000	0.2060	597952.	18314.	-0.00421	18162.	2.08E+10
-69.787	1220.	0.00				
11.1000	0.1910	667334.	17997.	-0.00410	18857.	2.08E+10
-106.491	2007.	0.00				
11.4000	0.1764	735228.	17550.	-0.00398	19537.	2.08E+10
-141.856	2895.	0.00				
11.7000	0.1623	801164.	16071.	-0.00385	20197.	2.08E+10
-679.913	15081.	0.00				
12.0000	0.1487	858158.	13655.	-0.00371	20768.	2.08E+10
-662.193	16032.	0.00				
12.3000	0.1356	906430.	11305.	-0.00355	21251.	2.08E+10
-643.044	17069.	0.00				
12.6000	0.1231	946220.	9028.	-0.00339	21650.	2.08E+10
-622.449	18200.	0.00				
12.9000	0.1112	977790.	6826.	-0.00322	21966.	2.08E+10
-600.359	19435.	0.00				
13.2000	0.09990	1001420.	4708.	-0.00305	22203.	2.08E+10
-576.636	20779.	0.00				
13.5000	0.08922	1017414.	2679.	-0.00288	22363.	2.08E+10
-550.718	22220.	0.00				
13.8000	0.07918	1026106.	752.6275	-0.00270	22450.	2.08E+10
-519.297	23610.	0.00				
14.1000	0.06978	1027900.	-1060.	-0.00252	22468.	2.08E+10
-487.491	25151.	0.00				
14.4000	0.06102	1023209.	-2758.	-0.00234	22421.	2.08E+10
-455.863	26896.	0.00				
14.7000	0.05289	1012444.	-4342.	-0.00217	22313.	2.08E+10
-424.442	28887.	0.00				
15.0000	0.04540	996013.	-5814.	-0.00199	22149.	2.08E+10
-393.246	31179.	0.00				

15.3000	0.03854	974323.	-7174.	-0.00182	21931.	2.08E+10
-362.288	33844.	0.00				
15.6000	0.03228	947780.	-8423.	-0.00166	21666.	2.08E+10
-331.563	36981.	0.00				
15.9000	0.02661	916786.	-9562.	-0.00149	21355.	2.08E+10
-301.050	40730.	0.00				
16.2000	0.02151	881741.	-10591.	-0.00134	21004.	2.08E+10
-270.698	45297.	0.00				
16.5000	0.01697	843044.	-11511.	-0.00119	20617.	2.08E+10
-240.413	51005.	0.00				
16.8000	0.01295	801095.	-12322.	-0.00105	20197.	2.08E+10
-210.030	58386.	0.00				
17.1000	0.00943	756293.	-13022.	-9.12E-04	19748.	2.08E+10
-179.247	68418.	0.00				
17.4000	0.00639	709045.	-13610.	-7.85E-04	19275.	2.08E+10
-147.496	83156.	0.00				
17.7000	0.00378	659770.	-14057.	-6.66E-04	18782.	2.08E+10
-100.828	95979.	0.00				
18.0000	0.00159	609081.	-14318.	-5.56E-04	18274.	2.08E+10
-44.089	99802.	0.00				
18.3000	-2.21E-04	557722.	-14386.	-4.55E-04	17760.	2.08E+10
6.3588	103626.	0.00				
18.6000	-0.00168	506354.	-14284.	-3.62E-04	17245.	2.08E+10
50.2609	107450.	0.00				
18.9000	-0.00283	455555.	-14036.	-2.79E-04	16737.	2.08E+10
87.4987	111274.	0.00				
19.2000	-0.00369	405816.	-13677.	-2.04E-04	16238.	2.08E+10
112.1227	109292.	0.00				
19.5000	-0.00430	357465.	-13257.	-1.38E-04	15754.	2.08E+10
121.0211	101266.	0.00				
19.8000	-0.00469	310623.	-12812.	-8.02E-05	15285.	2.08E+10
126.3353	97012.	0.00				
20.1000	-0.00488	265368.	-12353.	-3.03E-05	14832.	2.08E+10
128.8976	95087.	0.00				
20.4000	-0.00491	221741.	-11888.	1.19E-05	14395.	2.08E+10
129.2451	94834.	0.00				
20.7000	-0.00479	179753.	-11425.	4.68E-05	13975.	2.08E+10
127.7596	95939.	0.00				
21.0000	-0.00457	139391.	-10971.	7.44E-05	13571.	2.08E+10
124.7336	98267.	0.00				
21.3000	-0.00426	100623.	-10530.	9.53E-05	13182.	2.08E+10
120.4078	101799.	0.00				
21.6000	-0.00388	63399.	-10106.	1.09E-04	12810.	2.08E+10
114.9940	106592.	0.00				
21.9000	-0.00347	27655.	-8971.	1.17E-04	12452.	2.08E+10
515.5808	534917.	0.00				
22.2000	-0.00304	-1412.	-7174.	1.20E-04	12189.	2.08E+10
482.4857	571610.	0.00				
22.5000	-0.00261	-24225.	-5501.	1.17E-04	12417.	2.08E+10
447.0218	616959.	0.00				

22.8000	-0.00219	-41241.	-3959.	1.12E-04	12588.	2.08E+10
409.9063	672823.	0.00				
23.1000	-0.00180	-52937.	-2584.	1.04E-04	12705.	2.08E+10
353.9098	706319.	0.00				
23.4000	-0.00145	-60039.	-1424.	9.38E-05	12776.	2.08E+10
290.5804	722707.	0.00				
23.7000	-0.00113	-63365.	-483.694	8.31E-05	12809.	2.08E+10
231.7029	739095.	0.00				
24.0000	-8.49E-04	-63677.	254.1760	7.21E-05	12812.	2.08E+10
178.2248	755483.	0.00				
24.3000	-6.10E-04	-61670.	810.2917	6.12E-05	12792.	2.08E+10
130.7284	771871.	0.00				
24.6000	-4.09E-04	-57958.	1207.	5.08E-05	12755.	2.08E+10
89.4821	788259.	0.00				
24.9000	-2.44E-04	-53077.	1466.	4.12E-05	12706.	2.08E+10
54.4938	804647.	0.00				
25.2000	-1.12E-04	-47481.	1610.	3.25E-05	12650.	2.08E+10
25.5627	821035.	0.00				
25.5000	-1.00E-05	-41547.	1660.	2.48E-05	12591.	2.08E+10
2.3287	837423.	0.00				
25.8000	6.61E-05	-35575.	1636.	1.81E-05	12531.	2.08E+10
-15.682	853811.	0.00				
26.1000	1.20E-04	-29801.	1556.	1.24E-05	12473.	2.08E+10
-29.017	870199.	0.00				
26.4000	1.55E-04	-24398.	1435.	7.69E-06	12419.	2.08E+10
-38.261	886586.	0.00				
26.7000	1.75E-04	-19486.	1286.	3.89E-06	12370.	2.08E+10
-44.005	902974.	0.00				
27.0000	1.83E-04	-15142.	1123.	8.85E-07	12326.	2.08E+10
-46.825	919362.	0.00				
27.3000	1.82E-04	-11403.	953.6111	-1.42E-06	12289.	2.08E+10
-47.259	935750.	0.00				
27.6000	1.73E-04	-8274.	786.1101	-3.12E-06	12258.	2.08E+10
-45.797	952138.	0.00				
27.9000	1.59E-04	-5737.	626.5181	-4.34E-06	12232.	2.08E+10
-42.865	968526.	0.00				
28.2000	1.42E-04	-3755.	479.4693	-5.16E-06	12212.	2.08E+10
-38.828	984914.	0.00				
28.5000	1.22E-04	-2275.	348.4133	-5.68E-06	12198.	2.08E+10
-33.981	1001302.	0.00				
28.8000	1.01E-04	-1235.	235.8553	-5.99E-06	12187.	2.08E+10
-28.552	1017690.	0.00				
29.1000	7.91E-05	-565.607	143.5878	-6.14E-06	12180.	2.08E+10
-22.708	1034078.	0.00				
29.4000	5.68E-05	-190.031	72.9015	-6.21E-06	12177.	2.08E+10
-16.562	1050466.	0.00				
29.7000	3.43E-05	-29.067	24.7703	-6.23E-06	12175.	2.08E+10
-10.178	1066854.	0.00				
30.0000	1.19E-05	0.00	0.00	-6.23E-06	12175.	2.08E+10
-3.584	541621.	0.00				

\* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

#### Output Summary for Load Case No. 1:

Pile-head deflection = 0.65000000 inches  
 Computed slope at pile head = 0.000000 radians  
 Maximum bending moment = -1924436. inch-lbs  
 Maximum shear force = 18576. lbs  
 Depth of maximum bending moment = 0.000000 feet below pile head  
 Depth of maximum shear force = 0.000000 feet below pile head  
 Number of iterations = 10  
 Number of zero deflection points = 3  
 Pile deflection at ground = 0.23860057 inches

---

#### Summary of Pile-head Responses for Conventional Analyses

---

#### Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs  
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians  
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.  
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs  
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type	Load 1	Load 2	Axial Loading	Pile-head Deflection	Pile-head Rotation	Max in lbs
		Shear Max Moment					
		Pile-head in Pile	Pile-head				
		Load 1	Load 2	lbs	inches	radians	lbs
1	y, in	0.6500	S, rad	0.00	260540.	0.6500	0.00
		18576.	-1924436.				

Maximum pile-head deflection = 0.6500000000 inches  
 Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

The analysis ended normally.

=====

LFile for Windows, Version 2022-12.011

Analysis of Individual Piles and Drilled Shafts  
Subjected to Lateral Loading Using the p-y Method  
© 1985-2022 by Ensoft, Inc.  
All Rights Reserved

=====

This copy of LFile is being used by:

EMH&T  
Ohio

Serial Number of Security Device: 139307911

This copy of LFile is licensed for exclusive use by:

EMHT Inc., New Albany, OH

Use of this software by employees of EMHT Inc.  
other than those of the office site in New Albany, OH  
is a violation of the software license agreement.

-----

Files Used for Analysis

-----

Path to file locations:

\20230339\ODOT\07\_D11 Bridge  
St\_Bowerston\120494\400-Engineering\Structures\SFN\_3431790\EngData\07\_Abutments\Stage 2\Piles\Scour\Updated Scour 02-10-2025\Extreme Event II - Verify 1\

Name of input data file:

RA\_Extreme Event Case\_Scour.lp12d

Name of output report file:

RA\_Extreme Event Case\_Scour.lp12o

Name of plot output file:

RA\_Extreme Event Case\_Scour.lp12p

Name of runtime message file:

RA\_Extreme Event Case\_Scour.lp12r

---

### Date and Time of Analysis

---

Date: February 26, 2025

Time: 13:41:51

---

### Problem Title

---

Project Name: SMP - CSX Rear Abutment

Job Number:

Client:

Engineer: BDE

Description:

---

### Program Options and Settings

---

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- 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
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

-----  
Pile Structural Properties and Geometry  
-----

Number of pile sections defined	=	1
Total length of pile	=	40.000 ft
Depth of ground surface below top of pile	=	16.4000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.6000
2	40.000	14.6000

Input Structural Properties for Pile Sections:  
-----

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile  
Length of section = 40.000000 ft  
AISC Section Type = HP

AISC Section Name = HP14X73

Pile width = 14.600000 in

---

### Soil and Rock Layering Information

---

The soil profile is modelled using 2 layers

Layer 1 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	16.400000 ft
Distance from top of pile to bottom of layer	=	21.080000 ft
Effective unit weight at top of layer	=	126.000000 pcf
Effective unit weight at bottom of layer	=	126.000000 pcf
Undrained cohesion at top of layer	=	1500. psf
Undrained cohesion at bottom of layer	=	1500. psf
Epsilon-50 at top of layer	=	0.010000
Epsilon-50 at bottom of layer	=	0.010000
Subgrade k at top of layer	=	350.000000 pci
Subgrade k at bottom of layer	=	350.000000 pci

Layer 2 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	21.080000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	131.000000 pcf
Effective unit weight at bottom of layer	=	131.000000 pcf
Undrained cohesion at top of layer	=	4500. psf
Undrained cohesion at bottom of layer	=	4500. psf
Epsilon-50 at top of layer	=	0.004000
Epsilon-50 at bottom of layer	=	0.004000
Subgrade k at top of layer	=	1500. pci
Subgrade k at bottom of layer	=	1500. pci

(Depth of the lowest soil layer extends 10.000 ft below the pile tip)

-----  
Summary of Input Soil Properties  
-----

Layer	Soil Type	Layer	Effective	Cohesion	E50
Num. kpy	Name	Depth	Unit Wt.		or
pci	(p-y Curve Type)	ft	pcf	psf	krm
-----	-----	-----	-----	-----	-----
1	Stiff Clay	16.4000	126.0000	1500.	0.01000
350.0000	with Free Water	21.0800	126.0000	1500.	0.01000
350.0000					
2	Stiff Clay	21.0800	131.0000	4500.	0.00400
1500.	with Free Water	50.0000	131.0000	4500.	0.00400
1500.					

-----  
Modification Factors for p-y Curves  
-----

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
-----	-----	-----	-----
1	16.400	0.8430	1.0000
2	50.000	0.8430	1.0000

-----  
Static 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 Compute No.	Load Top y Type	Condition Run Analysis 1	Condition 2	Axial Thrust Force, lbs
1	5	y = 0.700000 in	S = 0.0000 in/in	162190.
N.A.		Yes		

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force 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 Steel AISC Strong Axis:

Length of Section	=	40.000000 ft
Flange Width	=	14.600000 in
Section Depth	=	13.600000 in
Flange Thickness	=	0.505000 in
Web Thickness	=	0.505000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	21.400000 sq. in.
Moment of Inertia	=	729.000000 in^4
Elastic Bending Stiffness	=	21141000. kip-in^2
Plastic Modulus, Z	=	118.000000 in^3
Plastic Moment Capacity = Fy Z	=	5900.in-kip

# Axial Structural Capacities:

-----

Nom. Axial Structural Capacity =  $F_y A_s$  = 1070.000 kips  
 Nominal Axial Tensile Capacity = -1070.000 kips

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

Number	Axial Thrust Force kips
-----	-----
1	162.190

## Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 162.190 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in <sup>2</sup>	Depth to N Axis in	Max Total Stress ksi	Run Msg
-----	-----	-----	-----	-----	-----
0.00000457	94.7564726	20756666.	64.8511793	8.5765285	
0.00000913	189.5129451	20756666.	35.8255897	9.4677659	
0.00001370	284.2694177	20756666.	26.1503931	10.3590033	
0.00001826	379.0258903	20756666.	21.3127948	11.2502406	
0.00002283	473.7823629	20756666.	18.4102359	12.1414780	
0.00002739	568.5388354	20756666.	16.4751966	13.0327154	
0.00003196	663.2953080	20756666.	15.0930256	13.9239527	
0.00003652	758.0517806	20756666.	14.0563974	14.8151901	
0.00004109	852.8082531	20756666.	13.2501310	15.7064275	
0.00004565	947.5647257	20756666.	12.6051179	16.5976649	
0.00005022	1042.	20756666.	12.0773799	17.4889022	
0.00005478	1137.	20756666.	11.6375983	18.3801396	
0.00005935	1232.	20756666.	11.2654753	19.2713770	
0.00006391	1327.	20756666.	10.9465128	20.1626144	
0.00006848	1421.	20756666.	10.6700786	21.0538517	
0.00007304	1516.	20756666.	10.4281987	21.9450891	
0.00007761	1611.	20756666.	10.2147753	22.8363265	
0.00008217	1706.	20756666.	10.0250655	23.7275639	
0.00008674	1800.	20756666.	9.8553252	24.6188013	
0.00009130	1895.	20756666.	9.7025590	25.5100387	
0.00009587	1990.	20756666.	9.5643419	26.4012760	
0.0001004	2085.	20756666.	9.4386900	27.2925134	
0.0001050	2179.	20756666.	9.3239643	28.1837508	

0.0001096	2274.	20756666.	9.2187991	29.0749882	
0.0001141	2369.	20756666.	9.1220472	29.9662255	
0.0001187	2464.	20756666.	9.0327377	30.8574629	
0.0001233	2558.	20756666.	8.9500437	31.7487003	
0.0001278	2653.	20756666.	8.8732564	32.6399376	
0.0001324	2748.	20756666.	8.8017648	33.5311750	
0.0001370	2843.	20756666.	8.7350393	34.4224124	
0.0001415	2937.	20756666.	8.6726187	35.3136498	
0.0001461	3032.	20756666.	8.6140994	36.2048872	
0.0001506	3127.	20756666.	8.5591266	37.0961245	
0.0001552	3222.	20756666.	8.5073876	37.9873619	
0.0001598	3316.	20756666.	8.4586051	38.8785993	
0.0001643	3411.	20756666.	8.4125328	39.7698367	
0.0001689	3506.	20756666.	8.3689508	40.6610740	
0.0001735	3601.	20756666.	8.3276626	41.5523114	
0.0001780	3696.	20756666.	8.2884918	42.4435488	
0.0001872	3885.	20756666.	8.2158824	44.2260235	
0.0001963	4075.	20756666.	8.1500274	46.0084983	
0.0002054	4264.	20756666.	8.0900262	47.7909731	
0.0002146	4454.	20756666.	8.0351315	49.5734478	
0.0002237	4613.	20622820.	8.0174051	50.0000000	Y
0.0002328	4692.	20154800.	8.0874160	50.0000000	Y
0.0002420	4749.	19627588.	8.1763196	50.0000000	Y
0.0002511	4801.	19121589.	8.2633939	50.0000000	Y
0.0002602	4849.	18636421.	8.3484821	50.0000000	Y
0.0002693	4894.	18171162.	8.4268220	50.0000000	Y
0.0002785	4936.	17725349.	8.5125710	50.0000000	Y
0.0002876	4975.	17298040.	8.5914716	50.0000000	Y
0.0002967	5011.	16888381.	8.6682998	50.0000000	Y
0.0003059	5045.	16495592.	8.7430613	50.0000000	Y
0.0003150	5077.	16118953.	8.8157532	50.0000000	Y
0.0003241	5107.	15757226.	8.8865732	50.0000000	Y
0.0003333	5135.	15410073.	8.9554179	50.0000000	Y
0.0003424	5162.	15076714.	9.0223509	50.0000000	Y
0.0003515	5187.	14756274.	9.0874934	50.0000000	Y
0.0003606	5211.	14448182.	9.1508631	50.0000000	Y
0.0003698	5233.	14152038.	9.2124210	50.0000000	Y
0.0003789	5254.	13866715.	9.2724403	50.0000000	Y
0.0003880	5274.	13592012.	9.3308276	50.0000000	Y
0.0003972	5293.	13327419.	9.3876252	50.0000000	Y
0.0004063	5311.	13072392.	9.4429043	50.0000000	Y
0.0004154	5328.	12826428.	9.4967290	50.0000000	Y
0.0004246	5345.	12589068.	9.5491569	50.0000000	Y
0.0004337	5360.	12359886.	9.6002402	50.0000000	Y
0.0004428	5375.	12138490.	9.6500256	50.0000000	Y
0.0004519	5388.	11922600.	9.6944897	50.0000000	Y
0.0004611	5401.	11712911.	9.7355269	50.0000000	Y
0.0004702	5412.	11510306.	9.7756737	50.0000000	Y
0.0004793	5423.	11314465.	9.8149365	50.0000000	Y
0.0004885	5434.	11123611.	9.8495624	50.0000000	Y

0.0004976	5442.	10937108.	9.8793984	50.0000000	Y
0.0005067	5451.	10756824.	9.9086667	50.0000000	Y
0.0005159	5459.	10582478.	9.9373480	50.0000000	Y
0.0005250	5466.	10411983.	9.9616754	50.0000000	Y
0.0005341	5472.	10244552.	9.9773710	50.0000000	Y
0.0005432	5477.	10082309.	9.9933258	50.0000000	Y
0.0005798	5490.	9470140.	10.0119505	50.0000000	Y
0.0006163	5499.	8922738.	10.0117372	50.0000000	Y
0.0006528	5506.	8434539.	10.0116187	50.0000000	Y
0.0006893	5512.	7996465.	10.0115907	50.0000000	Y
0.0007259	5517.	7601237.	10.0116524	50.0000000	Y
0.0007624	5522.	7242941.	10.0118058	50.0000000	Y
0.0007989	5526.	6916719.	10.0120563	50.0000000	Y
0.0008354	5529.	6618343.	10.0113544	50.0000000	Y

-----  
Summary of Results for Nominal Moment Capacity for Section 1  
-----

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	162.1900000000	5529.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

-----  
Layering Correction Equivalent Depths of Soil & Rock Layers  
-----

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
--------------	---	---	---	---	------------------------------------	------------------------------------

1	16.4000	0.00	N.A.	No	0.00	5235.
2	21.0800	4.6113	Yes	No	5235.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

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

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)  
 Displacement of pile head = 0.700000 inches  
 Rotation of pile head = 0.000E+00 radians  
 Axial load on pile head = 162190.0 lbs

Depth Res.	Soil	Deflect. Spr.	Bending Distrib.	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil p
X		y	Moment					
Es*H		Lat. Load						
feet		inches	in-lbs	lbs	radians	psi*	lb-in^2	
lb/inch		lb/inch	lb/inch					
0.00		0.7000	-1201591.	8629.	0.00	19611.	2.08E+10	
0.00		0.00	0.00					
0.4000		0.6993	-1160069.	8628.	-2.73E-04	19196.	2.08E+10	
0.00		0.00	0.00					
0.8000		0.6974	-1118337.	8628.	-5.37E-04	18778.	2.08E+10	
0.00		0.00	0.00					
1.2000		0.6942	-1076404.	8628.	-7.90E-04	18358.	2.08E+10	
0.00		0.00	0.00					
1.6000		0.6898	-1034277.	8628.	-0.00103	17936.	2.08E+10	
0.00		0.00	0.00					
2.0000		0.6843	-991964.	8628.	-0.00127	17512.	2.08E+10	
0.00		0.00	0.00					
2.4000		0.6776	-949472.	8628.	-0.00149	17087.	2.08E+10	
0.00		0.00	0.00					
2.8000		0.6699	-906810.	8628.	-0.00171	16660.	2.08E+10	
0.00		0.00	0.00					
3.2000		0.6612	-863984.	8628.	-0.00191	16231.	2.08E+10	
0.00		0.00	0.00					
3.6000		0.6516	-821003.	8628.	-0.00211	15800.	2.08E+10	

0.00	0.00	0.00				
4.0000	0.6410	-777874.	8628.	-0.00229	15368.	2.08E+10
0.00	0.00	0.00				
4.4000	0.6296	-734604.	8628.	-0.00247	14935.	2.08E+10
0.00	0.00	0.00				
4.8000	0.6173	-691203.	8628.	-0.00263	14500.	2.08E+10
0.00	0.00	0.00				
5.2000	0.6043	-647677.	8628.	-0.00279	14065.	2.08E+10
0.00	0.00	0.00				
5.6000	0.5906	-604035.	8628.	-0.00293	13628.	2.08E+10
0.00	0.00	0.00				
6.0000	0.5761	-560283.	8628.	-0.00307	13189.	2.08E+10
0.00	0.00	0.00				
6.4000	0.5611	-516431.	8628.	-0.00319	12750.	2.08E+10
0.00	0.00	0.00				
6.8000	0.5455	-472486.	8628.	-0.00330	12310.	2.08E+10
0.00	0.00	0.00				
7.2000	0.5294	-428456.	8628.	-0.00341	11869.	2.08E+10
0.00	0.00	0.00				
7.6000	0.5128	-384349.	8628.	-0.00350	11428.	2.08E+10
0.00	0.00	0.00				
8.0000	0.4958	-340172.	8628.	-0.00359	10985.	2.08E+10
0.00	0.00	0.00				
8.4000	0.4784	-295934.	8628.	-0.00366	10542.	2.08E+10
0.00	0.00	0.00				
8.8000	0.4606	-251643.	8628.	-0.00372	10099.	2.08E+10
0.00	0.00	0.00				
9.2000	0.4426	-207307.	8628.	-0.00378	9655.	2.08E+10
0.00	0.00	0.00				
9.6000	0.4244	-162934.	8628.	-0.00382	9211.	2.08E+10
0.00	0.00	0.00				
10.0000	0.4059	-118531.	8628.	-0.00385	8766.	2.08E+10
0.00	0.00	0.00				
10.4000	0.3874	-74106.	8628.	-0.00387	8321.	2.08E+10
0.00	0.00	0.00				
10.8000	0.3687	-29669.	8628.	-0.00389	7876.	2.08E+10
0.00	0.00	0.00				
11.2000	0.3501	14774.	8628.	-0.00389	7727.	2.08E+10
0.00	0.00	0.00				
11.6000	0.3314	59215.	8628.	-0.00388	8172.	2.08E+10
0.00	0.00	0.00				
12.0000	0.3128	103644.	8628.	-0.00386	8617.	2.08E+10
0.00	0.00	0.00				
12.4000	0.2944	148055.	8628.	-0.00383	9062.	2.08E+10
0.00	0.00	0.00				
12.8000	0.2760	192440.	8628.	-0.00379	9506.	2.08E+10
0.00	0.00	0.00				
13.2000	0.2580	236789.	8628.	-0.00374	9950.	2.08E+10
0.00	0.00	0.00				
13.6000	0.2401	281096.	8628.	-0.00368	10394.	2.08E+10

0.00	0.00	0.00				
14.0000	0.2226	325353.	8628.	-0.00361	10837.	2.08E+10
0.00	0.00	0.00				
14.4000	0.2054	369551.	8628.	-0.00353	11280.	2.08E+10
0.00	0.00	0.00				
14.8000	0.1887	413682.	8628.	-0.00344	11721.	2.08E+10
0.00	0.00	0.00				
15.2000	0.1724	457739.	8628.	-0.00334	12163.	2.08E+10
0.00	0.00	0.00				
15.6000	0.1566	501713.	8628.	-0.00323	12603.	2.08E+10
0.00	0.00	0.00				
16.0000	0.1414	545598.	8628.	-0.00311	13042.	2.08E+10
0.00	0.00	0.00				
16.4000	0.1268	589383.	8628.	-0.00298	13481.	2.08E+10
0.00	0.00	0.00				
16.8000	0.1128	633063.	8303.	-0.00284	13918.	2.08E+10
-135.528	5767.	0.00				
17.2000	0.09954	673507.	7522.	-0.00269	14323.	2.08E+10
-189.641	9145.	0.00				
17.6000	0.08702	709459.	6505.	-0.00253	14683.	2.08E+10
-234.281	12922.	0.00				
18.0000	0.07530	739886.	5297.	-0.00236	14988.	2.08E+10
-269.197	17161.	0.00				
18.4000	0.06439	763978.	3954.	-0.00218	15229.	2.08E+10
-290.350	21645.	0.00				
18.8000	0.05433	781243.	2526.	-0.00201	15402.	2.08E+10
-304.410	26894.	0.00				
19.2000	0.04514	791353.	1047.	-0.00182	15503.	2.08E+10
-311.832	33160.	0.00				
19.6000	0.03683	794136.	-451.559	-0.00164	15531.	2.08E+10
-312.698	40758.	0.00				
20.0000	0.02939	789571.	-1939.	-0.00146	15486.	2.08E+10
-307.102	50149.	0.00				
20.4000	0.02284	777789.	-3346.	-0.00128	15368.	2.08E+10
-278.917	58620.	0.00				
20.8000	0.01715	759441.	-4595.	-0.00110	15184.	2.08E+10
-241.678	67654.	0.00				
21.2000	0.01230	735387.	-7325.	-9.25E-04	14943.	2.08E+10
-895.724	349609.	0.00				
21.6000	0.00827	690564.	-11040.	-7.60E-04	14494.	2.08E+10
-652.175	378743.	0.00				
22.0000	0.00500	630590.	-13624.	-6.08E-04	13894.	2.08E+10
-424.810	407877.	0.00				
22.4000	0.00243	560715.	-15176.	-4.70E-04	13194.	2.08E+10
-221.523	437011.	0.00				
22.8000	4.89E-04	485635.	-15821.	-3.49E-04	12442.	2.08E+10
-47.530	466145.	0.00				
23.2000	-9.15E-04	409373.	-15709.	-2.45E-04	11678.	2.08E+10
94.4375	495279.	0.00				
23.6000	-0.00187	335213.	-14993.	-1.59E-04	10936.	2.08E+10

203.8112	524413.	0.00				
24.0000	-0.00244	265688.	-13828.	-8.97E-05	10239.	2.08E+10
281.8101	553548.	0.00				
24.4000	-0.00273	202609.	-12357.	-3.56E-05	9608.	2.08E+10
331.0272	582682.	0.00				
24.8000	-0.00279	147120.	-10710.	4.85E-06	9052.	2.08E+10
355.0171	611816.	0.00				
25.2000	-0.00268	99783.	-8999.	3.34E-05	8578.	2.08E+10
357.9093	640950.	0.00				
25.6000	-0.00246	60676.	-7314.	5.20E-05	8187.	2.08E+10
344.0655	670084.	0.00				
26.0000	-0.00218	29484.	-5726.	6.24E-05	7874.	2.08E+10
317.7922	699218.	0.00				
26.4000	-0.00187	5609.	-4284.	6.64E-05	7635.	2.08E+10
283.1168	728352.	0.00				
26.8000	-0.00154	-11744.	-3020.	6.57E-05	7697.	2.08E+10
243.6255	757486.	0.00				
27.2000	-0.00123	-23481.	-1949.	6.17E-05	7814.	2.08E+10
202.3615	786620.	0.00				
27.6000	-9.52E-04	-30552.	-1075.	5.54E-05	7885.	2.08E+10
161.7765	815754.	0.00				
28.0000	-7.03E-04	-33890.	-390.093	4.80E-05	7918.	2.08E+10
123.7266	844888.	0.00				
28.4000	-4.92E-04	-34372.	121.6598	4.01E-05	7923.	2.08E+10
89.5039	874022.	0.00				
28.8000	-3.18E-04	-32785.	480.2150	3.23E-05	7907.	2.08E+10
59.8941	903156.	0.00				
29.2000	-1.81E-04	-29812.	708.5599	2.51E-05	7878.	2.08E+10
35.2497	932291.	0.00				
29.6000	-7.77E-05	-26022.	830.5328	1.86E-05	7840.	2.08E+10
15.5724	961425.	0.00				
30.0000	-2.89E-06	-21868.	869.3380	1.31E-05	7798.	2.08E+10
0.5965	990559.	0.00				
30.4000	4.77E-05	-17696.	846.4539	8.49E-06	7756.	2.08E+10
-10.132	1019693.	0.00				
30.8000	7.86E-05	-13755.	780.9029	4.86E-06	7717.	2.08E+10
-17.181	1048827.	0.00				
31.2000	9.43E-05	-10207.	688.8404	2.08E-06	7681.	2.08E+10
-21.178	1077961.	0.00				
31.6000	9.86E-05	-7146.	583.4097	7.81E-08	7651.	2.08E+10
-22.752	1107095.	0.00				
32.0000	9.51E-05	-4607.	474.8055	-1.28E-06	7625.	2.08E+10
-22.500	1136229.	0.00				
32.4000	8.63E-05	-2585.	370.4917	-2.11E-06	7605.	2.08E+10
-20.964	1165363.	0.00				
32.8000	7.48E-05	-1047.	275.5202	-2.53E-06	7589.	2.08E+10
-18.608	1194497.	0.00				
33.2000	6.20E-05	63.4617	192.9065	-2.65E-06	7580.	2.08E+10
-15.815	1223631.	0.00				
33.6000	4.94E-05	809.2817	124.0258	-2.55E-06	7587.	2.08E+10

-12.886	1252765.	0.00					
34.0000	3.76E-05	1258.	68.9981	-2.31E-06	7592.	2.08E+10	
-10.043	1281900.	0.00					
34.4000	2.72E-05	1475.	27.0442	-1.99E-06	7594.	2.08E+10	
-7.438	1311034.	0.00					
34.8000	1.85E-05	1521.	-3.204	-1.64E-06	7594.	2.08E+10	
-5.165	1340168.	0.00					
35.2000	1.15E-05	1447.	-23.442	-1.30E-06	7593.	2.08E+10	
-3.268	1369302.	0.00					
35.6000	6.02E-06	1298.	-35.490	-9.83E-07	7592.	2.08E+10	
-1.752	1398436.	0.00					
36.0000	2.02E-06	1108.	-41.135	-7.05E-07	7590.	2.08E+10	
-0.600	1427570.	0.00					
36.4000	-7.52E-07	903.9777	-42.026	-4.72E-07	7588.	2.08E+10	
0.2283	1456704.	0.00					
36.8000	-2.52E-06	705.1682	-39.608	-2.86E-07	7586.	2.08E+10	
0.7794	1485838.	0.00					
37.2000	-3.50E-06	524.1888	-35.086	-1.44E-07	7584.	2.08E+10	
1.1048	1514972.	0.00					
37.6000	-3.90E-06	368.5700	-29.422	-4.09E-08	7583.	2.08E+10	
1.2550	1544106.	0.00					
38.0000	-3.89E-06	241.8002	-23.348	2.97E-08	7581.	2.08E+10	
1.2760	1573240.	0.00					
38.4000	-3.62E-06	144.3851	-17.388	7.43E-08	7580.	2.08E+10	
1.2072	1602374.	0.00					
38.8000	-3.18E-06	74.7584	-11.897	9.97E-08	7580.	2.08E+10	
1.0807	1631508.	0.00					
39.2000	-2.66E-06	30.0165	-7.096	1.12E-07	7579.	2.08E+10	
0.9201	1660643.	0.00					
39.6000	-2.11E-06	6.4675	-3.108	1.16E-07	7579.	2.08E+10	
0.7414	1689777.	0.00					
40.0000	-1.55E-06	0.00	0.00	1.17E-07	7579.	2.08E+10	
0.5535	859455.	0.00					

\* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

#### Output Summary for Load Case No. 1:

Pile-head deflection	=	0.70000000 inches
Computed slope at pile head	=	0.000000 radians
Maximum bending moment	=	-1201591. inch-lbs
Maximum shear force	=	-15821. lbs
Depth of maximum bending moment	=	0.000000 feet below pile head
Depth of maximum shear force	=	22.80000000 feet below pile head

Number of iterations = 6  
 Number of zero deflection points = 3  
 Pile deflection at ground = 0.12676830 inches

-----  
 Summary of Pile-head Responses for Conventional Analyses  
 -----

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs  
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians  
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.  
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs  
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case	Load Type	Load 1	Load 2	Axial Loading	Pile-head Deflection	Pile-head Rotation	Max in lbs
No. 1	1	Load 1 in-lbs	2	Load 2 lbs	inches	radians	lbs
1	y, in	0.7000	S, rad	0.00	162190.	0.7000	0.00
-15821.	-1201591.						

Maximum pile-head deflection = 0.7000000000 inches  
 Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

The analysis ended normally.

=====

LFile for Windows, Version 2022-12.011

Analysis of Individual Piles and Drilled Shafts  
Subjected to Lateral Loading Using the p-y Method  
© 1985-2022 by Ensoft, Inc.  
All Rights Reserved

=====

This copy of LFile is being used by:

EMH&T  
Ohio

Serial Number of Security Device: 139307911

This copy of LFile is licensed for exclusive use by:

EMHT Inc., New Albany, OH

Use of this software by employees of EMHT Inc.  
other than those of the office site in New Albany, OH  
is a violation of the software license agreement.

-----

Files Used for Analysis

-----

Path to file locations:

\20230339\ODOT\07\_D11 Bridge  
St\_Bowerston\120494\400-Engineering\Structures\SFN\_3431790\EngData\07\_Abutments\Stage 2\Piles\Scour\Updated Scour 02-10-2025\Extreme Event II - Verify 1\

Name of input data file:

FA\_Extreme Event Case\_Scour.lp12d

Name of output report file:

FA\_Extreme Event Case\_Scour.lp12o

Name of plot output file:

FA\_Extreme Event Case\_Scour.lp12p

Name of runtime message file:

FA\_Extreme Event Case\_Scour.lp12r

---

### Date and Time of Analysis

---

Date: February 26, 2025

Time: 13:18:26

---

### Problem Title

---

Project Name: SMP - CSX Rear Abutment

Job Number:

Client:

Engineer: BDE

Description:

---

### Program Options and Settings

---

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- 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
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

-----  
Pile Structural Properties and Geometry  
-----

Number of pile sections defined	=	1
Total length of pile	=	40.000 ft
Depth of ground surface below top of pile	=	13.1200 ft

Pile diameters used for p-y curve computations are defined using 2 points.

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.6000
2	40.000	14.6000

Input Structural Properties for Pile Sections:  
-----

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile	
Length of section	= 40.000000 ft
AISC Section Type	= HP

AISC Section Name	= HP14X73
-------------------	-----------

Pile width	= 14.600000 in
------------	----------------

---

### Soil and Rock Layering Information

---

The soil profile is modelled using 2 layers

Layer 1 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	= 13.120000 ft
Distance from top of pile to bottom of layer	= 21.700000 ft
Effective unit weight at top of layer	= 126.000000 pcf
Effective unit weight at bottom of layer	= 126.000000 pcf
Undrained cohesion at top of layer	= 1500. psf
Undrained cohesion at bottom of layer	= 1500. psf
Epsilon-50 at top of layer	= 0.010000
Epsilon-50 at bottom of layer	= 0.010000
Subgrade k at top of layer	= 350.000000 pci
Subgrade k at bottom of layer	= 350.000000 pci

Layer 2 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	= 21.700000 ft
Distance from top of pile to bottom of layer	= 50.000000 ft
Effective unit weight at top of layer	= 131.000000 pcf
Effective unit weight at bottom of layer	= 131.000000 pcf
Undrained cohesion at top of layer	= 4500. psf
Undrained cohesion at bottom of layer	= 4500. psf
Epsilon-50 at top of layer	= 0.004000
Epsilon-50 at bottom of layer	= 0.004000
Subgrade k at top of layer	= 1500. pci
Subgrade k at bottom of layer	= 1500. pci

(Depth of the lowest soil layer extends 10.000 ft below the pile tip)

-----  
Summary of Input Soil Properties  
-----

Layer	Soil Type	Layer	Effective	Cohesion	E50
Num.	Name	Depth	Unit Wt.		or
kpy	(p-y Curve Type)	ft	pcf	psf	krm
pci					
1	Stiff Clay	13.1200	126.0000	1500.	0.01000
350.0000	with Free Water	21.7000	126.0000	1500.	0.01000
350.0000					
2	Stiff Clay	21.7000	131.0000	4500.	0.00400
1500.	with Free Water	50.0000	131.0000	4500.	0.00400
1500.					

-----  
Modification Factors for p-y Curves  
-----

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	13.120	0.8430	1.0000
2	50.000	0.8430	1.0000

-----  
Static 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 Compute No.	Load Top y Type	Condition Run Analysis 1	Condition 2	Axial Thrust Force, lbs
1	5	y = 0.500000 in	S = 0.0000 in/in	164530.
N.A.		Yes		

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force 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 Steel AISC Strong Axis:

Length of Section	=	40.000000 ft
Flange Width	=	14.600000 in
Section Depth	=	13.600000 in
Flange Thickness	=	0.505000 in
Web Thickness	=	0.505000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	21.400000 sq. in.
Moment of Inertia	=	729.000000 in^4
Elastic Bending Stiffness	=	21141000. kip-in^2
Plastic Modulus, Z	=	118.000000 in^3
Plastic Moment Capacity = Fy Z	=	5900.in-kip

# Axial Structural Capacities:

-----

Nom. Axial Structural Capacity =  $F_y A_s$  = 1070.000 kips  
 Nominal Axial Tensile Capacity = -1070.000 kips

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

Number	Axial Thrust Force kips
-----	-----
1	164.530

## Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 164.530 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in <sup>2</sup>	Depth to N Axis in	Max Total Stress ksi	Run Msg
-----	-----	-----	-----	-----	-----
0.00000456	94.6205790	20756666.	65.7732897	8.6861301	
0.00000912	189.2411580	20756666.	36.2866448	9.5760893	
0.00001368	283.8617370	20756666.	26.4577632	10.4660485	
0.00001823	378.4823161	20756666.	21.5433224	11.3560077	
0.00002279	473.1028951	20756666.	18.5946579	12.2459669	
0.00002735	567.7234741	20756666.	16.6288816	13.1359262	
0.00003191	662.3440531	20756666.	15.2247557	14.0258854	
0.00003647	756.9646321	20756666.	14.1716612	14.9158447	
0.00004103	851.5852111	20756666.	13.3525877	15.8058039	
0.00004559	946.2057901	20756666.	12.6973290	16.6957631	
0.00005014	1041.	20756666.	12.1612082	17.5857223	
0.00005470	1135.	20756666.	11.7144408	18.4756815	
0.00005926	1230.	20756666.	11.3364069	19.3656407	
0.00006382	1325.	20756666.	11.0123778	20.2555999	
0.00006838	1419.	20756666.	10.7315526	21.1455592	
0.00007294	1514.	20756666.	10.4858306	22.0355184	
0.00007750	1609.	20756666.	10.2690170	22.9254776	
0.00008205	1703.	20756666.	10.0762939	23.8154369	
0.00008661	1798.	20756666.	9.9038574	24.7053960	
0.00009117	1892.	20756666.	9.7486645	25.5953553	
0.00009573	1987.	20756666.	9.6082519	26.4853145	
0.0001003	2082.	20756666.	9.4806041	27.3752737	
0.0001048	2176.	20756666.	9.3640561	28.2652329	

0.0001094	2271.	20756666.	9.2572204	29.1551922	
0.0001140	2366.	20756666.	9.1589316	30.0451514	
0.0001185	2460.	20756666.	9.0682034	30.9351106	
0.0001231	2555.	20756666.	8.9841959	31.8250698	
0.0001276	2649.	20756666.	8.9061889	32.7150290	
0.0001322	2744.	20756666.	8.8335617	33.6049883	
0.0001368	2839.	20756666.	8.7657763	34.4949475	
0.0001413	2933.	20756666.	8.7023642	35.3849067	
0.0001459	3028.	20756666.	8.6429153	36.2748659	
0.0001504	3122.	20756666.	8.5870694	37.1648251	
0.0001550	3217.	20756666.	8.5345085	38.0547844	
0.0001595	3312.	20756666.	8.4849511	38.9447436	
0.0001641	3406.	20756666.	8.4381469	39.8347028	
0.0001687	3501.	20756666.	8.3938727	40.7246620	
0.0001732	3596.	20756666.	8.3519287	41.6146213	
0.0001778	3690.	20756666.	8.3121356	42.5045805	
0.0001869	3879.	20756666.	8.2383729	44.2844989	
0.0001960	4069.	20756666.	8.1714719	46.0644174	
0.0002051	4258.	20756666.	8.1105175	47.8443358	
0.0002143	4447.	20756666.	8.0547508	49.6242542	
0.0002234	4605.	20615495.	8.0380198	50.0000000	Y
0.0002325	4682.	20138502.	8.1095683	50.0000000	Y
0.0002416	4738.	19611267.	8.1978060	50.0000000	Y
0.0002507	4790.	19105456.	8.2842109	50.0000000	Y
0.0002598	4838.	18620273.	8.3687351	50.0000000	Y
0.0002690	4883.	18155192.	8.4512594	50.0000000	Y
0.0002781	4925.	17709548.	8.5317109	50.0000000	Y
0.0002872	4963.	17282401.	8.6101114	50.0000000	Y
0.0002963	5000.	16872898.	8.6864725	50.0000000	Y
0.0003054	5033.	16480259.	8.7607971	50.0000000	Y
0.0003145	5065.	16103764.	8.8330797	50.0000000	Y
0.0003237	5095.	15742320.	8.9034634	50.0000000	Y
0.0003328	5123.	15395297.	8.9719479	50.0000000	Y
0.0003419	5150.	15062198.	9.0384908	50.0000000	Y
0.0003510	5175.	14741876.	9.1033145	50.0000000	Y
0.0003601	5198.	14434023.	9.1663336	50.0000000	Y
0.0003692	5220.	14138077.	9.2275715	50.0000000	Y
0.0003784	5241.	13852888.	9.2873108	50.0000000	Y
0.0003875	5261.	13578397.	9.3453968	50.0000000	Y
0.0003966	5280.	13314008.	9.4019075	50.0000000	Y
0.0004057	5298.	13059176.	9.4569131	50.0000000	Y
0.0004148	5315.	12813400.	9.5104769	50.0000000	Y
0.0004239	5332.	12576221.	9.5626558	50.0000000	Y
0.0004331	5347.	12347213.	9.6135011	50.0000000	Y
0.0004422	5362.	12125984.	9.6630587	50.0000000	Y
0.0004513	5376.	11912147.	9.7113200	50.0000000	Y
0.0004604	5388.	11702535.	9.7521091	50.0000000	Y
0.0004695	5400.	11500005.	9.7920186	50.0000000	Y
0.0004786	5411.	11304237.	9.8310545	50.0000000	Y
0.0004878	5421.	11114931.	9.8692210	50.0000000	Y

0.0004969	5431.	10929412.	9.9010302	50.0000000	Y
0.0005060	5439.	10749101.	9.9300759	50.0000000	Y
0.0005151	5447.	10574740.	9.9585363	50.0000000	Y
0.0005242	5455.	10405741.	9.9867376	50.0000000	Y
0.0005334	5462.	10240311.	10.0089308	50.0000000	Y
0.0005425	5467.	10078139.	10.0243552	50.0000000	Y
0.0005789	5483.	9470186.	10.0580476	50.0000000	Y
0.0006154	5491.	8923053.	10.0581337	50.0000000	Y
0.0006519	5499.	8434914.	10.0578789	50.0000000	Y
0.0006883	5505.	7996837.	10.0578811	50.0000000	Y
0.0007248	5510.	7601647.	10.0579870	50.0000000	Y
0.0007613	5514.	7243292.	10.0581419	50.0000000	Y
0.0007977	5518.	6916942.	10.0580603	50.0000000	Y
0.0008342	5521.	6618609.	10.0793602	50.0000000	Y

-----  
Summary of Results for Nominal Moment Capacity for Section 1  
-----

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	164.5300000000	5521.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

-----  
Layering Correction Equivalent Depths of Soil & Rock Layers  
-----

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
--------------	---	---	---	---	------------------------------------	------------------------------------

1	13.1200	0.00	N.A.	No	0.00	12123.
2	21.7000	7.2526	Yes	No	12123.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

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

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)  
Displacement of pile head = 0.500000 inches  
Rotation of pile head = 0.000E+00 radians  
Axial load on pile head = 164530.0 lbs

Depth Res.	Soil X	Deflect. Spr.	Bending Distrib. Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil p
	Es*H	y	Lat. Load					
feet		inches	in-lbs	lbs	radians	psi*	lb-in^2	
lb/inch	lb/inch	lb/inch	lb/inch					
0.00	0.00	0.5000	-1141343.	9654.	0.00	19117.	2.08E+10	
0.00	0.00	0.00	0.00					
0.4000	0.00	0.4994	-1094906.	9653.	-2.59E-04	18652.	2.08E+10	
0.00	0.00	0.00	0.00					
0.8000	0.00	0.4975	-1048269.	9653.	-5.06E-04	18185.	2.08E+10	
0.00	0.00	0.00	0.00					
1.2000	0.00	0.4945	-1001440.	9653.	-7.43E-04	17716.	2.08E+10	
0.00	0.00	0.00	0.00					
1.6000	0.00	0.4904	-954429.	9653.	-9.70E-04	17246.	2.08E+10	
0.00	0.00	0.00	0.00					
2.0000	0.00	0.4852	-907243.	9653.	-0.00118	16773.	2.08E+10	
0.00	0.00	0.00	0.00					
2.4000	0.00	0.4790	-859892.	9653.	-0.00139	16299.	2.08E+10	
0.00	0.00	0.00	0.00					
2.8000	0.00	0.4719	-812383.	9653.	-0.00158	15823.	2.08E+10	
0.00	0.00	0.00	0.00					
3.2000	0.00	0.4638	-764726.	9653.	-0.00176	15346.	2.08E+10	
0.00	0.00	0.00	0.00					
3.6000	0.00	0.4549	-716930.	9653.	-0.00194	14867.	2.08E+10	

0.00	0.00	0.00				
4.0000	0.4452	-669002.	9653.	-0.00210	14388.	2.08E+10
0.00	0.00	0.00				
4.4000	0.4348	-620953.	9653.	-0.00225	13906.	2.08E+10
0.00	0.00	0.00				
4.8000	0.4237	-572790.	9653.	-0.00238	13424.	2.08E+10
0.00	0.00	0.00				
5.2000	0.4119	-524522.	9653.	-0.00251	12941.	2.08E+10
0.00	0.00	0.00				
5.6000	0.3996	-476159.	9653.	-0.00263	12456.	2.08E+10
0.00	0.00	0.00				
6.0000	0.3867	-427708.	9653.	-0.00273	11971.	2.08E+10
0.00	0.00	0.00				
6.4000	0.3734	-379180.	9653.	-0.00282	11485.	2.08E+10
0.00	0.00	0.00				
6.8000	0.3596	-330582.	9653.	-0.00291	10999.	2.08E+10
0.00	0.00	0.00				
7.2000	0.3455	-281924.	9653.	-0.00298	10511.	2.08E+10
0.00	0.00	0.00				
7.6000	0.3310	-233214.	9653.	-0.00304	10024.	2.08E+10
0.00	0.00	0.00				
8.0000	0.3163	-184462.	9653.	-0.00308	9535.	2.08E+10
0.00	0.00	0.00				
8.4000	0.3014	-135676.	9653.	-0.00312	9047.	2.08E+10
0.00	0.00	0.00				
8.8000	0.2863	-86865.	9653.	-0.00315	8558.	2.08E+10
0.00	0.00	0.00				
9.2000	0.2712	-38039.	9653.	-0.00316	8069.	2.08E+10
0.00	0.00	0.00				
9.6000	0.2560	10795.	9653.	-0.00317	7796.	2.08E+10
0.00	0.00	0.00				
10.0000	0.2408	59626.	9653.	-0.00316	8285.	2.08E+10
0.00	0.00	0.00				
10.4000	0.2257	108447.	9653.	-0.00314	8774.	2.08E+10
0.00	0.00	0.00				
10.8000	0.2107	157247.	9653.	-0.00311	9263.	2.08E+10
0.00	0.00	0.00				
11.2000	0.1959	206020.	9653.	-0.00306	9751.	2.08E+10
0.00	0.00	0.00				
11.6000	0.1813	254754.	9653.	-0.00301	10239.	2.08E+10
0.00	0.00	0.00				
12.0000	0.1669	303442.	9653.	-0.00295	10727.	2.08E+10
0.00	0.00	0.00				
12.4000	0.1530	352075.	9653.	-0.00287	11214.	2.08E+10
0.00	0.00	0.00				
12.8000	0.1394	400643.	9653.	-0.00278	11700.	2.08E+10
0.00	0.00	0.00				
13.2000	0.1262	449138.	9567.	-0.00269	12186.	2.08E+10
-35.758	1360.	0.00				
13.6000	0.1136	496727.	9126.	-0.00258	12662.	2.08E+10

-147.834	6246.	0.00				
14.0000	0.1015	540819.	8287.	-0.00246	13104.	2.08E+10
-201.805	9543.	0.00				
14.4000	0.09002	580163.	7209.	-0.00233	13498.	2.08E+10
-247.298	13187.	0.00				
14.8000	0.07917	613704.	5934.	-0.00219	13834.	2.08E+10
-284.267	17235.	0.00				
15.2000	0.06901	640582.	4510.	-0.00204	14103.	2.08E+10
-309.070	21499.	0.00				
15.6000	0.05955	660223.	2984.	-0.00189	14300.	2.08E+10
-326.586	26324.	0.00				
16.0000	0.05083	672219.	1388.	-0.00174	14420.	2.08E+10
-338.189	31937.	0.00				
16.4000	0.04285	676300.	-248.802	-0.00158	14461.	2.08E+10
-344.007	38533.	0.00				
16.8000	0.03563	672331.	-1901.	-0.00143	14421.	2.08E+10
-344.201	46373.	0.00				
17.2000	0.02915	660309.	-3483.	-0.00127	14300.	2.08E+10
-315.094	51887.	0.00				
17.6000	0.02340	640907.	-4917.	-0.00112	14106.	2.08E+10
-282.339	57908.	0.00				
18.0000	0.01837	614883.	-6195.	-9.78E-04	13846.	2.08E+10
-250.138	65365.	0.00				
18.4000	0.01402	582984.	-7319.	-8.39E-04	13526.	2.08E+10
-218.511	74829.	0.00				
18.8000	0.01031	545943.	-8294.	-7.09E-04	13155.	2.08E+10
-187.427	87243.	0.00				
19.2000	0.00721	504485.	-9116.	-5.87E-04	12740.	2.08E+10
-155.276	103329.	0.00				
19.6000	0.00467	459356.	-9746.	-4.76E-04	12288.	2.08E+10
-107.244	110127.	0.00				
20.0000	0.00265	411673.	-10158.	-3.75E-04	11811.	2.08E+10
-64.441	116925.	0.00				
20.4000	0.00107	362430.	-10379.	-2.86E-04	11318.	2.08E+10
-27.669	123723.	0.00				
20.8000	-9.62E-05	312484.	-10439.	-2.08E-04	10817.	2.08E+10
2.6153	130521.	0.00				
21.2000	-9.19E-04	262540.	-10370.	-1.41E-04	10317.	2.08E+10
26.2902	137319.	0.00				
21.6000	-0.00145	213154.	-10202.	-8.61E-05	9823.	2.08E+10
43.5459	144117.	0.00				
22.0000	-0.00175	164733.	-9534.	-4.24E-05	9338.	2.08E+10
235.1476	646777.	0.00				
22.4000	-0.00186	121699.	-8342.	-9.24E-06	8907.	2.08E+10
261.4998	675911.	0.00				
22.8000	-0.00183	84669.	-7067.	1.46E-05	8536.	2.08E+10
269.3683	705045.	0.00				
23.2000	-0.00172	53828.	-5791.	3.06E-05	8227.	2.08E+10
262.5807	734179.	0.00				
23.6000	-0.00154	29028.	-4573.	4.02E-05	7979.	2.08E+10

244.8693	763313.	0.00				
24.0000	-0.00133	9865.	-3458.	4.47E-05	7787.	2.08E+10
219.6909	792447.	0.00				
24.4000	-0.00111	-4239.	-2474.	4.54E-05	7731.	2.08E+10
190.0998	821581.	0.00				
24.8000	-8.95E-04	-13962.	-1637.	4.33E-05	7828.	2.08E+10
158.6710	850715.	0.00				
25.2000	-6.95E-04	-20027.	-950.704	3.93E-05	7889.	2.08E+10
127.4686	879849.	0.00				
25.6000	-5.18E-04	-23151.	-409.460	3.43E-05	7920.	2.08E+10
98.0496	908983.	0.00				
26.0000	-3.66E-04	-24012.	-2.549	2.89E-05	7929.	2.08E+10
71.4966	938117.	0.00				
26.4000	-2.41E-04	-23221.	285.3705	2.34E-05	7921.	2.08E+10
48.4700	967251.	0.00				
26.8000	-1.41E-04	-21309.	471.9538	1.83E-05	7902.	2.08E+10
29.2730	996386.	0.00				
27.2000	-6.52E-05	-18719.	575.6204	1.36E-05	7876.	2.08E+10
13.9214	1025520.	0.00				
27.6000	-1.01E-05	-15805.	614.3463	9.65E-06	7847.	2.08E+10
2.2144	1054654.	0.00				
28.0000	2.75E-05	-12836.	604.7800	6.34E-06	7817.	2.08E+10
-6.200	1083788.	0.00				
28.4000	5.08E-05	-10009.	561.6585	3.69E-06	7789.	2.08E+10
-11.767	1112922.	0.00				
28.8000	6.29E-05	-7450.	497.4824	1.68E-06	7763.	2.08E+10
-14.973	1142056.	0.00				
29.2000	6.68E-05	-5236.	422.4052	2.09E-07	7741.	2.08E+10
-16.309	1171190.	0.00				
29.6000	6.49E-05	-3396.	344.2887	-7.89E-07	7722.	2.08E+10
-16.239	1200324.	0.00				
30.0000	5.93E-05	-1929.	268.8795	-1.40E-06	7708.	2.08E+10
-15.181	1229458.	0.00				
30.4000	5.15E-05	-812.173	200.0626	-1.72E-06	7696.	2.08E+10
-13.493	1258592.	0.00				
30.8000	4.27E-05	-5.874	140.1588	-1.82E-06	7688.	2.08E+10
-11.467	1287726.	0.00				
31.2000	3.40E-05	536.2196	90.2345	-1.75E-06	7694.	2.08E+10
-9.334	1316860.	0.00				
31.6000	2.59E-05	863.1483	50.4011	-1.59E-06	7697.	2.08E+10
-7.263	1345994.	0.00				
32.0000	1.87E-05	1023.	20.0902	-1.37E-06	7699.	2.08E+10
-5.367	1375129.	0.00				
32.4000	1.27E-05	1058.	-1.709	-1.13E-06	7699.	2.08E+10
-3.716	1404263.	0.00				
32.8000	7.84E-06	1008.	-16.249	-8.95E-07	7698.	2.08E+10
-2.343	1433397.	0.00				
33.2000	4.11E-06	903.6051	-24.875	-6.74E-07	7697.	2.08E+10
-1.251	1462531.	0.00				
33.6000	1.37E-06	770.2388	-28.902	-4.81E-07	7696.	2.08E+10

-0.426	1491665.	0.00				
34.0000	-5.08E-07	626.9090	-29.538	-3.19E-07	7695.	2.08E+10
0.1610	1520799.	0.00				
34.4000	-1.69E-06	487.1743	-27.840	-1.90E-07	7693.	2.08E+10
0.5465	1549933.	0.00				
34.8000	-2.34E-06	359.9411	-24.685	-9.24E-08	7692.	2.08E+10
0.7684	1579067.	0.00				
35.2000	-2.58E-06	250.3463	-20.766	-2.19E-08	7691.	2.08E+10
0.8643	1608201.	0.00				
35.6000	-2.55E-06	160.6191	-16.608	2.57E-08	7690.	2.08E+10
0.8684	1637335.	0.00				
36.0000	-2.33E-06	90.8695	-12.580	5.47E-08	7689.	2.08E+10
0.8101	1666469.	0.00				
36.4000	-2.02E-06	39.7682	-8.923	6.98E-08	7689.	2.08E+10
0.7136	1695603.	0.00				
36.8000	-1.66E-06	5.1019	-5.776	7.50E-08	7688.	2.08E+10
0.5975	1724738.	0.00				
37.2000	-1.30E-06	-15.798	-3.202	7.38E-08	7688.	2.08E+10
0.4750	1753872.	0.00				
37.6000	-9.55E-07	-25.752	-1.211	6.90E-08	7689.	2.08E+10
0.3546	1783006.	0.00				
38.0000	-6.38E-07	-27.531	0.2180	6.28E-08	7689.	2.08E+10
0.2408	1812140.	0.00				
38.4000	-3.51E-07	-23.758	1.1194	5.69E-08	7689.	2.08E+10
0.1348	1841274.	0.00				
38.8000	-9.15E-08	-16.875	1.5285	5.22E-08	7688.	2.08E+10
0.03567	1870408.	0.00				
39.2000	1.50E-07	-9.167	1.4720	4.92E-08	7688.	2.08E+10
-0.05922	1899542.	0.00				
39.6000	3.81E-07	-2.822	0.9628	4.78E-08	7688.	2.08E+10
-0.153	1928676.	0.00				
40.0000	6.09E-07	0.00	0.00	4.75E-08	7688.	2.08E+10
-0.248	978905.	0.00				

\* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

#### Output Summary for Load Case No. 1:

Pile-head deflection	=	0.50000000 inches
Computed slope at pile head	=	0.000000 radians
Maximum bending moment	=	-1141343. inch-lbs
Maximum shear force	=	-10439. lbs
Depth of maximum bending moment	=	0.000000 feet below pile head
Depth of maximum shear force	=	20.80000000 feet below pile head

Number of iterations = 8  
 Number of zero deflection points = 4  
 Pile deflection at ground = 0.12887137 inches

-----  
 Summary of Pile-head Responses for Conventional Analyses  
 -----

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs  
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians  
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.  
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs  
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case	Load Type	Load 1	Load 2	Axial Loading	Pile-head Deflection	Pile-head Rotation	Max in lbs
No. 1	1	Load 1 in-lbs	2 Load 2	lbs	inches	radians	lbs
1	y, in	0.5000	S, rad	0.00	164530.	0.5000	0.00
-10439.	-1141343.						

Maximum pile-head deflection = 0.5000000000 inches  
 Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

The analysis ended normally.