H. B. FLEMING, INC.
Contracting & Engineering
89 Pleasant Avenue
South Portland, ME 04106

Phone (207) 799-8514

LETTER OF TRANSMITTAL

DATE: 2/15/2016
JOB NO.:
ATTENTION: Eric Boyden
RE: Lunenburg Culvert Cofferdam

TO: J.A. McDonald, Inc
ATTN: Eric Boydon

WE ARE SENDING YOU ☒ Attached ☐ Under separate cover via _____ the following items:

☐ Shop drawings ☐ Prints ☒ Plans ☐ Samples ☐ Specifications
☐ Copy of letter ☐ Change order ☐ _____

COPIES	DATE	NO.	DESCRIPTION
1	2/15/16		Cofferdam Calculations
1	2/15/16		Cofferdam Plan View

THESE ARE TRANSMITTED as checked below:

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☐ For review and comment ☐ _____
☐ FOR BIDS DUE _____ ☐ PRINTS RETURNED AFTER LOAN TO US

REMARKS

Eric,

Attached are our calculations as well as plan view for the new arch culvert in Lunenberg. Please call w/ any questions.

Cofferdam

Thank You

COPY TO _____

SIGNED: _____

If enclosures are not as noted, kindly notify us at once.

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89 Pleasant Ave. South Portland, ME 04106

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www.hbfleming.com

PILE DRIVING BRIDGES SUBMARINE PIPELINES

Cofferdam Design Calculations

For

J.A. McDonald, Inc.

Project Name: LUNENBURG

Project Number: NH CULV(27)

STATE OF VERMONT
DAVID GIFFORD
NO. 9124
Civil
LICENSED
PROFESSIONAL ENGINEER

2/15/16

Lunenburg, VT

2/15/16

11.5' CUT, MAX EXCAVATION BEFORE STRUTS & CORNER BRACES ARE IN PLACE

Page: 1
Date: 2.15.16

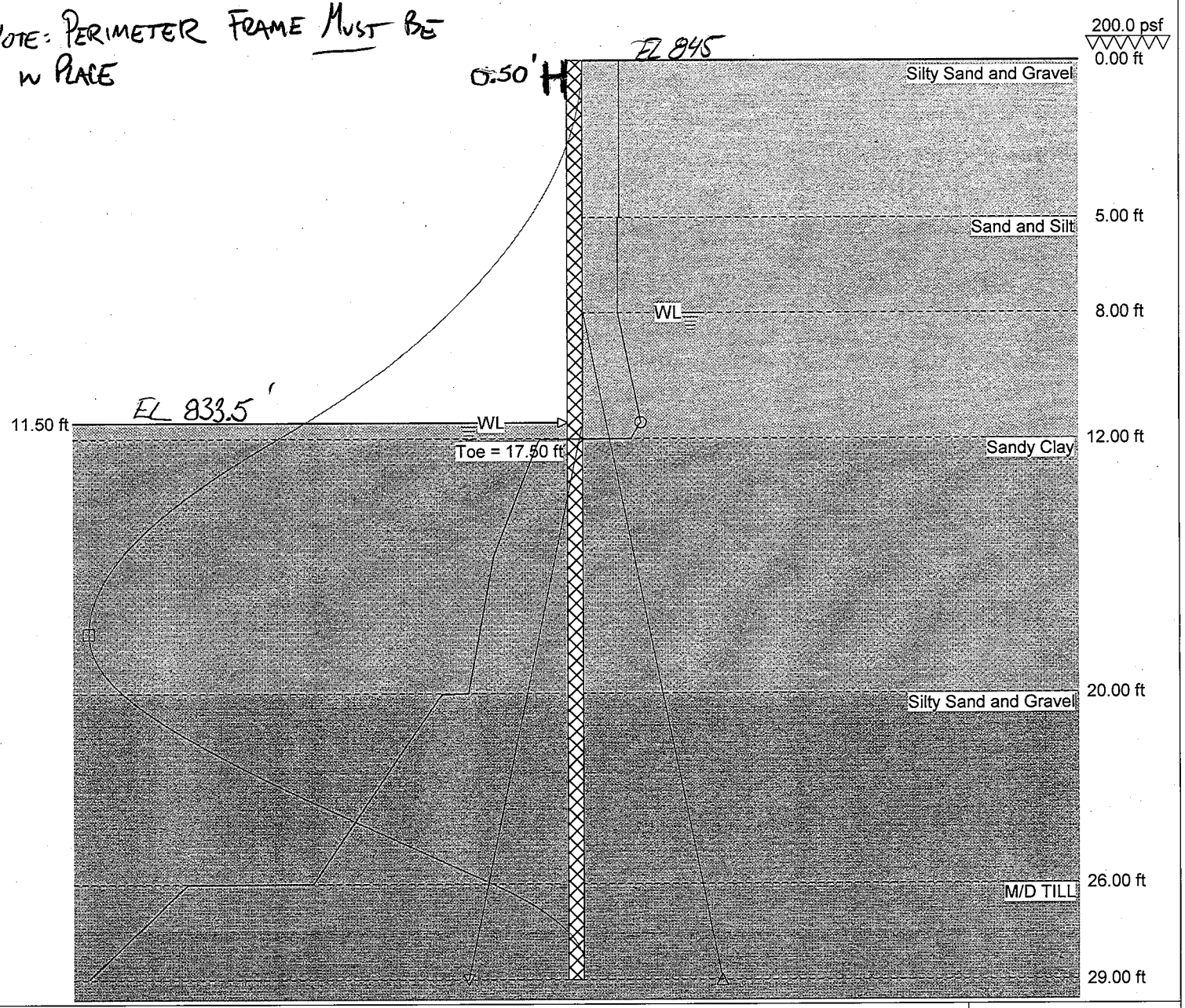
Sheet: PZ22
Works: Temporary
Pressure: Terzaghi (m = 1.0; a = 0.4)
Analysis: Net Pressure
FOS: 1.07
Toe: Cantilever

Maximum		d (ft)
○	550.0 psf	11.50
□	41032.1 ftlb/ft	18.12
△	1311.0 psf	29.00
△	1092.5 psf	29.00

$$\frac{41.032 \times 12''}{0.65\,(50\text{ ksi})} = 15.2\text{ in}^3$$

PZ22 $S_{xx} = 18.4\text{ in}^3$ OK

NOTE: PERIMETER FRAME MUST BE IN PLACE



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Page: 2
Date: 2.15.16

Sheet: PZ22
Works: Temporary
Pressure: Terzaghi (m = 1.0; a = 0.4)
Analysis: Net Pressure
FOS: 1.07
Toe: Cantilever

Input Data

Depth Of Excavation = 11.50ft
Surcharge = 200.0psf

Depth Of Active Water = 8.00ft
Depth Of Passive Water = 11.50ft

Water Density = 62.43pcf
Minimum Fluid Density = 31.82pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
5.00	Sand and Silt	114.00	51.60	0.0	0.0	30.0	0.0	0.25	0.00	3.50	0.00
12.00	Sandy Clay	118.37	56.00	417.6	0.0	0.0	0.0	1.00	2.00	1.00	2.00
20.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
26.00	M/D TILL	140.00	57.60	0.0	0.0	36.0	0.0	0.25	0.25	5.50	5.50

Solution

Sheet

Sheet Name	E (psi)	I (in^4/ft)	f (psi)	Z (in^3/ft)	Allowed M_{max} (ftlb/ft)	b (in)	A (in^2/ft)	W (lb/ft)	Upstand (ft)	Toe (ft)	Length (ft)
PZ22	3.04E+07	84.70	24966.8	18.40	38282.3	22.01	6.46	40.3	0.00	17.50	29.00

Pressure Model: Terzaghi (m = 1.0; a = 0.4); Ignore hydrostatic pressure in cohesive soils

Maxima

	Maximum	Depth (ft)
Pressure	550.0 psf	11.50
Bending Moment	41032.1 ftlb/ft	18.12
Deflection	6.1 in	0.00
Shear Force	4731.6 lb/ft	24.77

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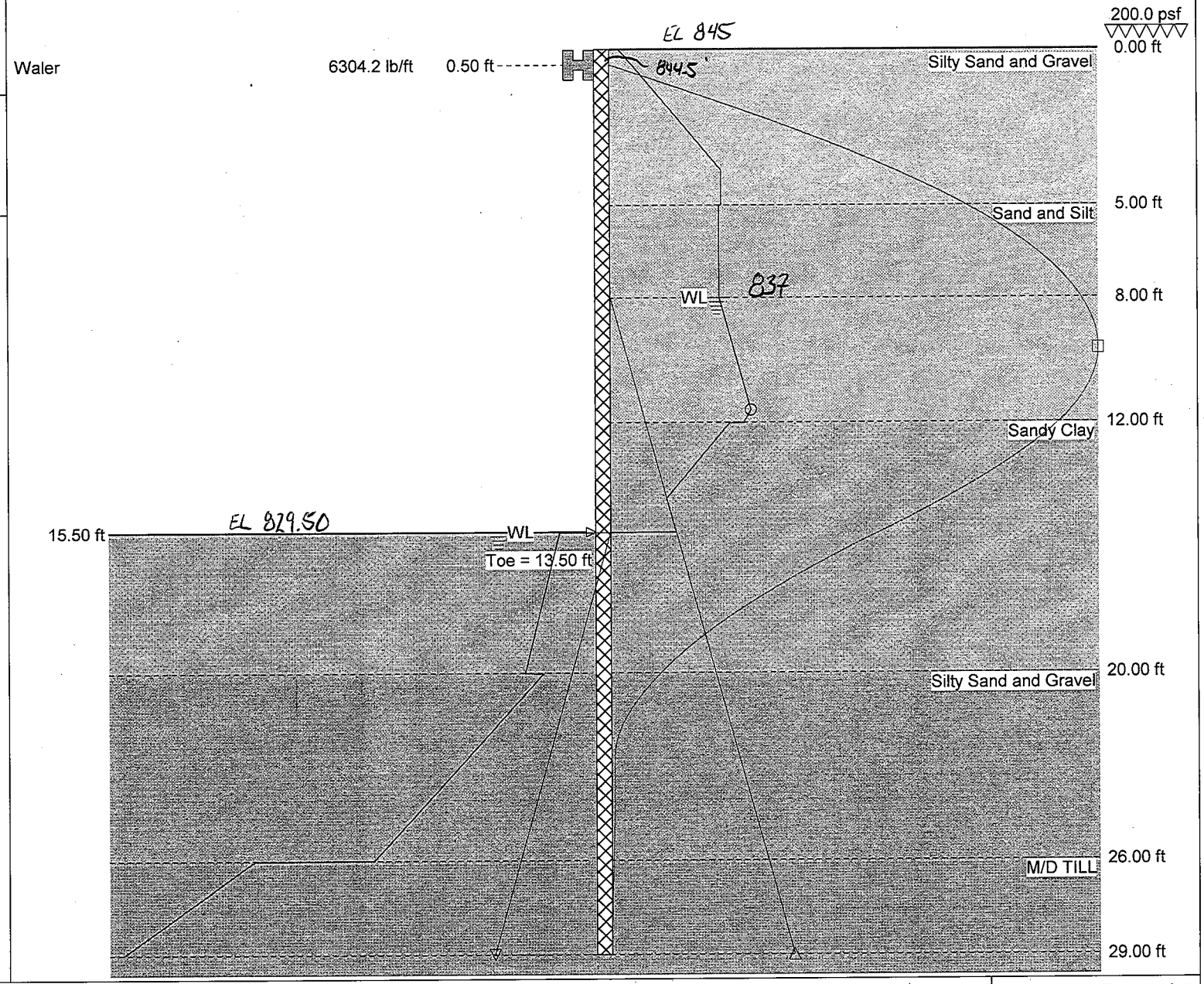
Sheet: PZ22
Works: Temporary
Pressure: Terzaghi (m = 1.0; a = 0.4)
Analysis: Net Pressure
FOS: 5.33
Toe: Free Earth Support

	Maximum	d (ft)
○	1010.2 psf	11.62
□	32449.0 ftlb/ft	9.64
△	1311.0 psf	29.00
△	842.8 psf	29.00

$$\frac{32.449^{\text{kft}} \times 12''}{.65\,(50\text{ ksi})} = 11.98\text{ in}^3$$

PZ22 $S_{x-x} = 18.4\text{ in}^3$ = OK



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Page: 2
Date: 2.11.16

Sheet: PZ22
Works: Temporary
Pressure: Terzaghi (m = 1.0; a = 0.4)
Analysis: Net Pressure
FOS: 5.33
Toe: Free Earth Support

Input Data

Depth Of Excavation = 15.50ft
Surcharge = 200.0psf

Depth Of Active Water = 8.00ft
Depth Of Passive Water = 15.50ft

Water Density = 62.43pcf
Minimum Fluid Density = 31.82pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
5.00	Sand and Silt	114.00	51.60	0.0	0.0	30.0	0.0	0.25	0.00	3.50	0.00
12.00	Sandy Clay	118.37	56.00	417.6	0.0	0.0	0.0	1.00	2.00	1.00	2.00
20.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
26.00	M/D TILL	140.00	57.60	0.0	0.0	36.0	0.0	0.25	0.25	5.50	5.50

Solution

Sheet

Sheet Name	E (psi)	I (in^4/ft)	f (psi)	Z (in^3/ft)	Allowed M_{max} (ftlb/ft)	b (in)	A (in^2/ft)	W (lb/ft)	Upstand (ft)	Toe (ft)	Length (ft)
PZ22	3.04E+07	84.70	24966.8	18.40	38282.3	22.01	6.46	40.3	0.00	13.50	29.00

Pressure Model: Terzaghi (m = 1.0; a = 0.4); Ignore hydrostatic pressure in cohesive soils

Load Model: Area Distribution

Supports

d (ft)	Type	L (ft)	B (ft)	Load (lb/ft)
0.50	Waler	108.00	30.00	6304.2

Maxima

	Maximum	Depth (ft)
Pressure	1010.2 psf	11.62
Bending Moment	32449.0 ftlb/ft	9.64
Deflection	1.3 in	11.99
Shear Force	6243.5 lb/ft	0.50

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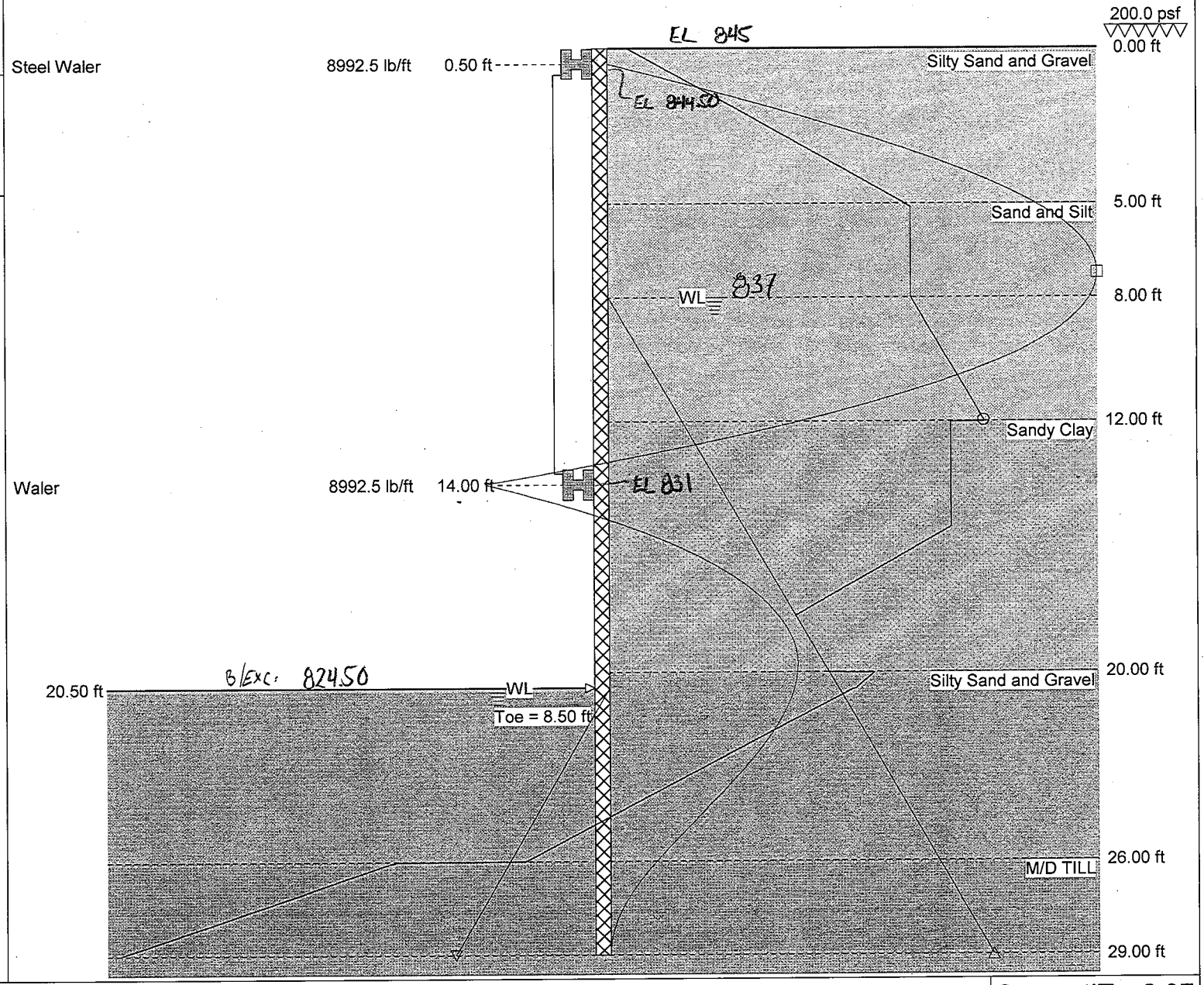
Date: 2.11.16

Sheet: PZ22
Works: Temporary
Pressure: Terzaghi (m = 1.0; a = 0.4)
Analysis: Net Pressure
FOS: 1.69

	Maximum	d (ft)
○	1283.6 psf	11.99
□	20377.0 ftlb/ft	7.23
△	1311.0 psf	29.00
△	530.7 psf	29.00



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Page: 2
Date: 2.11.16

Sheet: PZ22
Works: Temporary
Pressure: Terzaghi (m = 1.0; a = 0.4)
Analysis: Net Pressure
FOS: 1.69

Input Data

Depth Of Excavation = 20.50ft
Surcharge = 200.0psf

Depth Of Active Water = 8.00ft
Depth Of Passive Water = 20.50ft

Water Density = 62.43pcf
Minimum Fluid Density = 31.82pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
5.00	Sand and Silt	114.00	51.60	0.0	0.0	30.0	0.0	0.32	0.00	3.50	0.00
12.00	Sandy Clay	118.37	56.00	600.0	0.0	0.0	0.0	1.00	2.00	1.00	2.00
20.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
26.00	M/D TILL	140.00	57.60	0.0	0.0	36.0	0.0	0.25	0.25	5.50	5.50

Solution

Sheet

Sheet Name	E (psi)	I (in^4/ft)	f (psi)	Z (in^3/ft)	Allowed M_{max} (ftlb/ft)	b (in)	A (in^2/ft)	W (lb/ft)	Upstand (ft)	Toe (ft)	Length (ft)
PZ22	3.04E+07	84.70	24966.8	18.40	38282.3	22.01	6.46	40.3	0.00	8.50	29.00

Pressure Model: Terzaghi (m = 1.0; a = 0.4); Ignore hydrostatic pressure in cohesive soils

Load Model: Area Distribution

Supports

d (ft)	Type	Load (lb/ft)
0.50	Steel Waler	▸ 8992.5
14.00	Waler	◂ 8992.5

▸◂ - Load sharing

Maxima

	Maximum	Depth (ft)
Pressure	1283.6 psf	11.99
Bending Moment	20377.0 ftlb/ft	7.23
Deflection	0.3 in	7.10
Shear Force	7747.7 lb/ft	13.97

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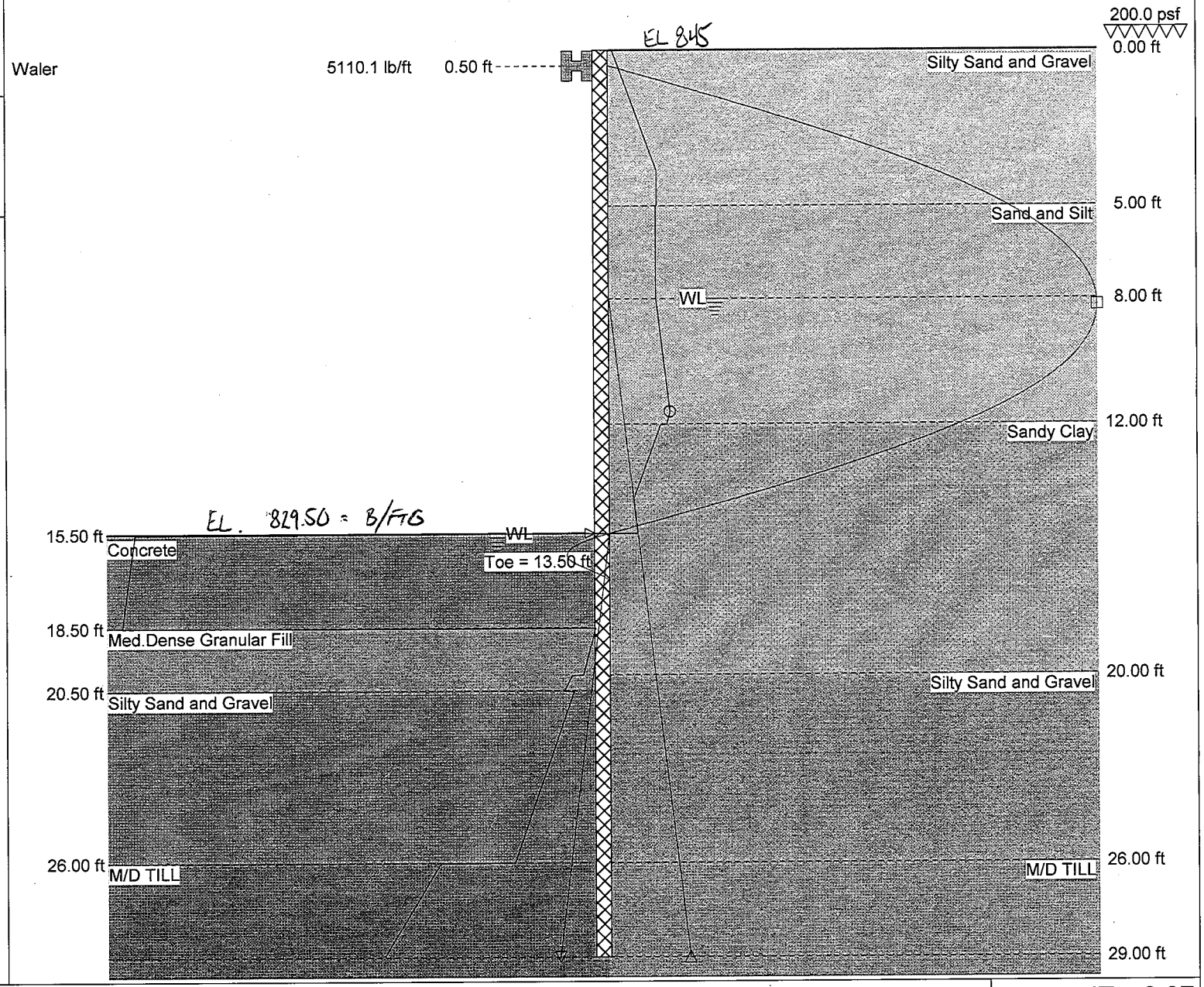
Sheet: PZ22
Works: Temporary
Pressure: Terzaghi (m = 1.0; a = 0.4)
Analysis: Net Pressure
FOS: 10.14
Toe: Fixed Earth Support

	Maximum	d (ft)
○	1010.2 psf	11.62
□	22359.8 ftlb/ft	8.22
△	1311.0 psf	29.00
△	842.8 psf	29.00



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Sheet: PZ22
Works: Temporary
Pressure: Terzaghi (m = 1.0; a = 0.4)
Analysis: Net Pressure
FOS: 10.14
Toe: Fixed Earth Support

Input Data

Depth Of Excavation = 15.50ft
Surcharge = 200.0psf

Depth Of Active Water = 8.00ft
Depth Of Passive Water = 15.50ft

Water Density = 62.43pcf
Minimum Fluid Density = 31.82pcf

Soil Profile — Active Side

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
5.00	Sand and Silt	114.00	51.60	0.0	0.0	30.0	0.0	0.25	0.00	3.50	0.00
12.00	Sandy Clay	118.37	56.00	417.6	0.0	0.0	0.0	1.00	2.00	1.00	2.00
20.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
26.00	M/D TILL	140.00	57.60	0.0	0.0	36.0	0.0	0.25	0.25	5.50	5.50

Soil Profile — Passive Side

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
5.00	Sand and Silt	114.00	51.60	0.0	0.0	30.0	0.0	0.32	0.00	3.50	0.00
12.00	Sandy Clay	118.37	56.00	600.0	0.0	0.0	0.0	1.00	2.00	1.00	2.00
15.50	Concrete	135.55	135.55	4175.7	0.0	0.0	0.0	1.00	2.00	1.00	2.00
18.50	Med.Dense Granular Fill	115.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	4.00	0.00
20.50	Silty Sand and Gravel	114.00	51.60	0.0	0.0	31.0	0.0	0.33	0.00	3.50	0.00
26.00	M/D TILL	120.00	57.60	0.0	0.0	36.0	0.0	0.25	0.00	5.50	0.00

Solution

Sheet

Sheet Name	E (psi)	I (in^4/ft)	f (psi)	Z (in^3/ft)	Allowed M_{max} (ftlb/ft)	b (in)	A (in^2/ft)	W (lb/ft)	Upstand (ft)	Toe (ft)	Length (ft)
PZ22	3.04E+07	84.70	24966.8	18.40	38282.3	22.01	6.46	40.3	0.00	13.50	29.00

Pressure Model: Terzaghi (m = 1.0; a = 0.4); Ignore hydrostatic pressure in cohesive soils

Load Model: Area Distribution

Supports

d (ft)	Type	L (ft)	B (ft)	Load (lb/ft)
0.50	Waler	108.00	30.00	5110.1

Maxima

	Maximum	Depth (ft)
Pressure	1010.2 psf	11.62
Bending Moment	22359.8 ftlb/ft	8.22
Deflection	0.4 in	8.53
Shear Force	5460.1 lb/ft	15.52

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2/15/16

LUNENBURG, VT VAOT NH CULV(27) - ARCH CULVERT CULVERT COFFERDAM

DESIGN CALCS

SIZE WALES

MAX LOAD = 8.99 k·ft MAX SPAN = 17.6'

$$\frac{wl^2}{8} = \frac{8.99 \times 17.6^2}{8} = 348.09 \text{ k·ft}$$

M_{MAX} HP 14×89 = 365.71 k·ft

HP14×89 OK

SIZE STRUTS & CORNER BRACES

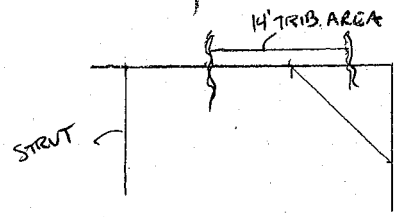
MAX LOAD = 8.99 k·ft
MAX TRIBUTARY AREA = 17.6'
} MAX LOAD = 158.22 kips

FOR KL = 30' USING GR. 50 MATERIAL, ϕP_N FOR HP 12×53 = 209 kips -

USE HP 12×53 (min) STRUTS @ ALL LOCATIONS

12.5' CORNER BRACE

= 8.99 k·ft (14')(1.414)
= 178 KIPS



FOR KL = 13' USING GR 50 MATERIAL, ϕP_N FOR HP 10×42 = 388 KIPS → USE HP10×42 (min)

CHECK MOMENT IN SHEETS

M_{MAX} = 41.032 k·ft $\frac{41.032 \times 12''}{0.65\,(50\text{ ksi})} = 15.15 \text{ in}^3$

PZ22 S_{x-x} = 18.4 in³ OK

USE PZ22 SHEETS

WELDED CONNECTION FOR CORNER BRACES

R_n = 8.99 × 14' = 125.86 KIPS

$$l_{min} = \frac{1.33\,(R_n)}{0.60\,(70\text{ ksi})(0.707)(5/16'')}$$

$$\frac{1.33(125.86)}{0.6(70)(.707)(5/16)} = 18'' \text{ WELD}$$

TOPS

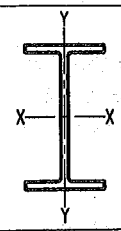
F_y = 36 ksi
F_y = 50 ksi

COLUMNS
HP shapes
strength in kips (ϕ = 0.85)

			HP12			
	60		84		74	
0	36	50	36	50	36	50
18	536	744	753	1050	667	927
32	520	714	729	1000	646	886
70	515	704	721	985	639	872
56	509	692	712	967	630	856
40	502	679	701	947	621	838
23	494	665	690	926	610	819
04	486	650	677	902	599	798
34	477	633	663	877	587	776
63	467	616	649	851	574	752
41	457	597	634	823	560	727
17	447	578	618	795	546	702
93	436	559	601	765	531	675
69	424	539	584	735	516	648
44	413	518	567	705	500	621
18	401	497	548	674	484	593
92	388	476	530	642	467	566
40	363	433	492	580	434	510
38	337	391	454	518	400	455
38	311	350	416	459	366	402
39	285	310	378	402	332	351
42	260	272	342	350	300	304
00	235	239	307	308	268	269
66	211	211	273	273	238	238
37	189	189	243	243	213	213
13	169	169	218	218	191	191
92	153	153	197	197	172	172
Properties						
77	93	129	170	235	143	197
8	17	23	25	34	22	30
53	206	243	732	862	506	597
0	43	60	95	132	75	105
.0	12.8	10.9	12.3	10.4	12.2	10.3
.4	41.2	30.2	54.0	36.9	48.9	34.9
	17.5		24.6		21.8	
	503		650		569	
	165		213		186	
	3.07		2.94		2.92	
	1.75		1.75		1.75	
	14400		18600		16300	
	4720		6090		5320	

F_y = 36 ksi
F_y = 50 ksi

COLUMNS
HP shapes
Design axial strength in kips (ϕ = 0.85)



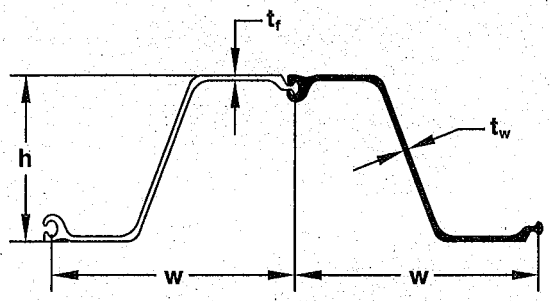
Designation		HP12				HP10				HP8	
Wt./ft		63		53		57		42		36	
F_y		36	50	36	50	36	50	36	50	36	50
Effective length KL (ft) with respect to least radius of gyration r_y	0	563	782	474	659	514	714	379	527	324	451
	6	545	747	459	629	491	670	362	494	302	408
	7	538	735	453	618	483	655	356	482	294	393
	8	531	721	447	607	474	638	349	469	286	377
	9	523	706	440	594	464	619	341	455	276	360
	10	514	689	432	579	453	599	333	440	266	342
	11	504	671	424	564	441	577	324	423	255	322
	12	494	651	415	547	429	555	314	406	243	302
	13	482	631	406	530	415	531	304	388	232	282
	14	471	610	396	512	401	506	294	369	219	262
	15	458	588	385	493	387	481	283	350	207	242
	16	446	565	374	474	372	456	272	331	195	222
	17	432	542	363	454	357	430	260	312	182	202
	18	419	518	351	434	341	404	249	293	170	184
	19	405	495	339	414	326	379	237	274	158	165
	20	391	471	327	394	310	354	225	255	146	149
	22	362	423	303	353	279	305	202	219	123	123
	24	333	376	278	314	248	259	179	185	104	104
	26	304	332	253	276	219	221	157	158	88	88
	28	275	288	229	240	191	191	136	136	76	76
	30	247	251	206	209	166	166	119	119	66	66
	32	221	221	183	183	146	146	104	104	58	58
	34	196	196	163	163	129	129	92	92	52	52
	36	174	174	145	145	115	115	82	82	46	46
	38	157	157	130	130	103	103	74	74	41	41
	40	141	141	117	117	93	93	67	67	37	37
Properties											
P_{wb} (kips)		116	161	88	122	121	168	79	110	75	104
P_{wi} (kips/in.)		19	26	16	22	20	28	15	21	16	22
P_{wb} (kips)		311	366	188	221	508	599	202	238	309	364
P_{wb} (kips)		54	75	38	53	65	90	36	50	40	56
L_c (ft)		12.0	10.2	11.9	10.1	10.2	8.7	10.0	8.5	8.1	6.9
L_p (ft)		43.0	30.7	38.7	28.3	45.6	31.1	35.9	25.6	35.7	24.4
A (in.²)		18.4		15.5		16.8		12.4		10.6	
I_x (in.⁴)		472		393		294		210		119	
I_y (in.⁴)		153		127		101		71.7		40.3	
r_x (in.)		2.88		2.86		2.45		2.41		1.95	
Ratio r_x/r_y		1.76		1.76		1.71		1.71		1.72	
$P_{wx}(KL)^2/10^4$		13500		11200		8400		6050		3420	
$P_{wy}(KL)^2/10^4$		4370		3630		2890		2060		1150	

Note: Heavy line indicates Kl/r of 200.

32.5

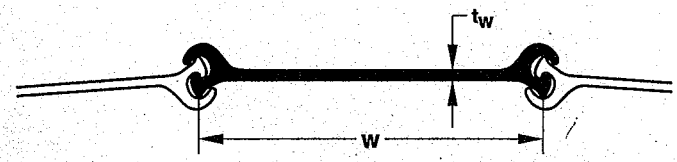
PZ/PS

PZ/PS Hot Rolled Steel Sheet Piling



PZ

SECTION	Width (w) in (mm)	Height (h) in (mm)	THICKNESS Flange (t_f) in (mm)	THICKNESS Wall (t_w) in (mm)	Cross Sectional Area in²/ft (cm²/m)	WEIGHT Pile lb/ft (kg/m)	WEIGHT Wall lb/ft² (kg/m²)	Section Modulus in³/ft (cm³/m)	Moment of Inertia in⁴/ft (cm⁴/m)	COATING AREA Both Sides ft²/ft of single (m²/m)	COATING AREA Wall Surface ft²/ft² of wall (m²/m²)
PZ 22	22.0 559	9.0 229	0.375 9.50	0.375 9.50	6.47 136.9	40.3 60.0	22.0 107.4	18.1 973	84.38 11500	4.48 1.37	1.22 1.22
PZ 27	18.0 457	12.0 305	0.375 9.50	0.375 9.50	7.94 168.1	40.5 60.3	27.0 131.8	30.2 1620	184.20 25200	4.48 1.37	1.49 1.49
PZ 35	22.6 575	14.9 378	0.600 15.21	0.500 12.67	10.29 217.8	66.0 98.2	35.0 170.9	48.5 2608	361.22 49300	5.37 1.64	1.42 1.42
PZ 40	19.7 500	16.1 409	0.600 15.21	0.500 12.67	11.77 249.1	65.6 97.6	40.0 195.3	60.7 3263	490.85 67000	5.37 1.64	1.64 1.64



PS

SECTION	Width (w) in (mm)	Web (t_w) in (mm)	Maximum Interlock Strength k/in (kN/m)	Minimum Cell Diameter* ft (m)	Cross Sectional Area in²/ft (cm²/m)	WEIGHT Pile lb/ft (kg/m)	WEIGHT Wall lb/ft² (kg/m²)	Section Modulus in³/sheet (cm³/sheet)	Moment of Inertia in⁴/sheet (cm⁴/sheet)	COATING AREA Both Sides ft²/ft of single (m²/m)	COATING AREA Wall Surface ft²/ft² of wall (m²/m²)
PS 27.5	19.69 500	0.4 10.2	24 4800	30 9.14	8.09 171.2	45.1 67.1	27.5 134.3	3.3 54	5.3 221	3.65 1.11	1.11 1.11
PS 31	19.69 500	0.5 12.7	24 4800	30 9.14	9.12 193.0	50.9 75.7	31.0 151.4	3.3 54	5.3 221	3.65 1.11	1.11 1.11

* Minimum cell diameter cannot be guaranteed for piles over 65 feet (19.81 m) in length
* Minimum cell diameter cannot be guaranteed if piles are spliced
* 58 Piles are needed to make a 30 foot diameter cell