

#18098

Structural Calculations for:

Wen Residence Excavation Shoring

8529 West Mercer Way
Mercer Island, WA



- Design Criteria: IBC 2015
Roof Snow Load = 25 psf
Seismic: $S_s = 1.466$, $S_1 = 0.557$, SDC = D, R = 5
- Architect: PB Architects Inc., P.S.
5506 6th Avenue South
Seattle, WA 98108
Ph. (206) 443-9790
- Geotechnical Engineer: PanGEO Incorporated
3213 Eastlake Avenue East, Suite B
Seattle, WA 98102
Ph. (206) 262-0370

Wen Residence – Garage and Shoring
8529 West Mercer Way
Mercer Island, Washington**DESIGN SUMMARY:**

The proposed project is a single-family residence, with a detached garage, and accessory shoring elements to achieve foundation elevations. The CT Engineering scope of work includes design of a detached concrete garage structure and excavation shoring. Design of the wood structure is by others. Note that the garage structure and the excavation shoring have been provided with their own set of structural drawings so that they may have individual permitting tracts if needed by local jurisdiction.

The detached garage structure is a concrete structure. The concrete basement walls have been designed for permanent soil pressures. Although these walls receive benefit of the shoring piles – these benefits have been neglected. The roof of the garage structure is an elevated reinforced concrete two-way slab. Soil loading over the roof has been included as a live load. Foundations are conventional spread footings. Reference the geotechnical engineering report dated February 8, 2018 prepared by PanGEO incorporated (reference 17-405) for soil loading and foundation parameters.

The proposed foundation elements for both the house and the detached garage are founded at an elevation that require excavation shoring. Soldier piles with pipe braces have been designed to achieve the garage foundation elevation. Additional cantilever soldier piles have been designed both the temporary condition to achieve foundation elevation for the house footings and have for the final condition with finished grades and seismic surcharge.

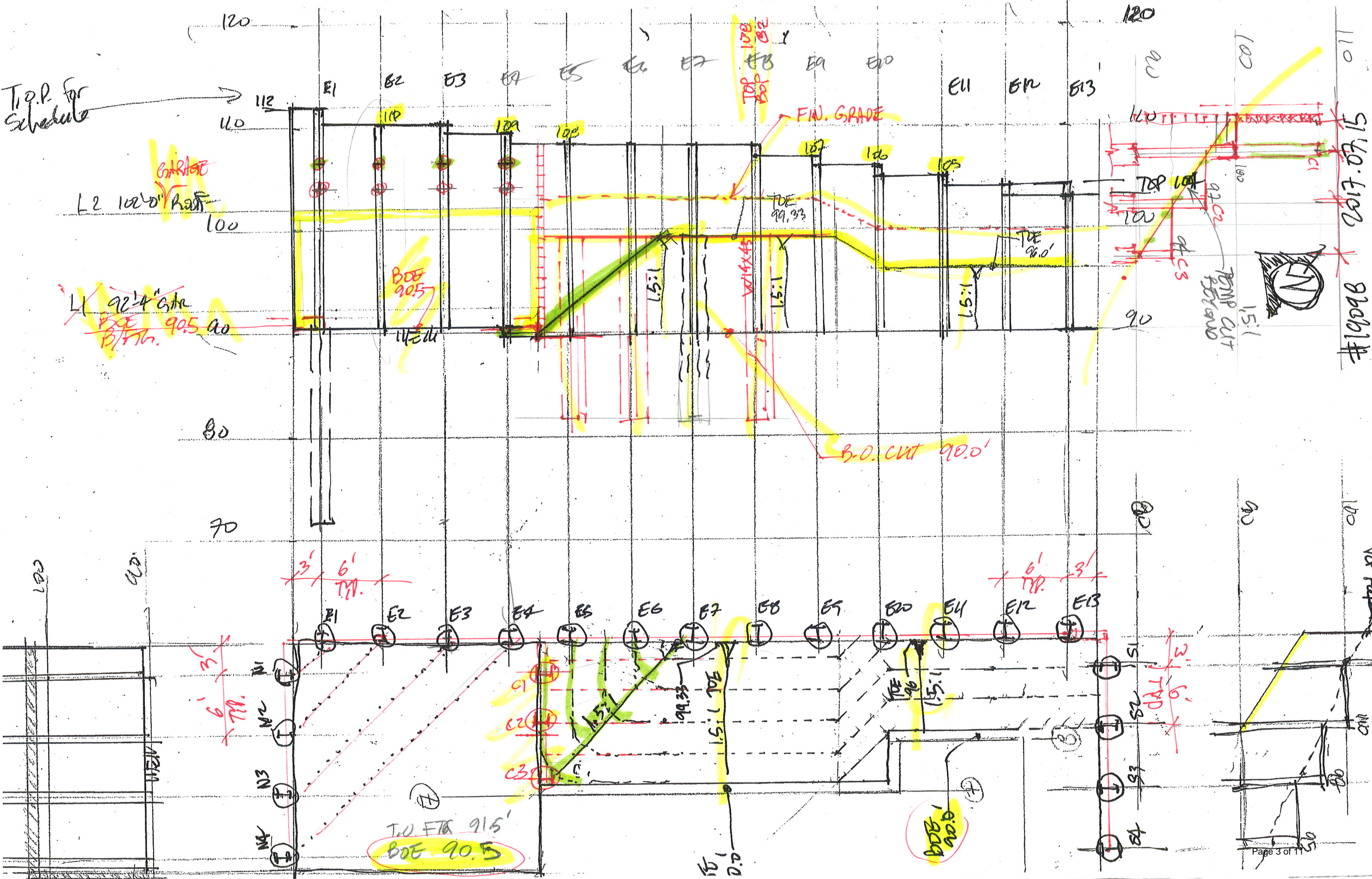
Feel free to phone with any questions during the review process pertaining to the construction documents and/or any accessory documents.

The following computer design software may have been used for various components:

Excel
Enercalc
Quickwall
Ram Concept

Note that various software releases may have been used. Where software references standards prior to current code cycle, various design parameters including load factors, load combinations, allowable design stresses, etc., have been verified to meet or exceed those as referenced by the current code.

T.O.P. for Schedule



#19098 017.07.15

Project: #1909B

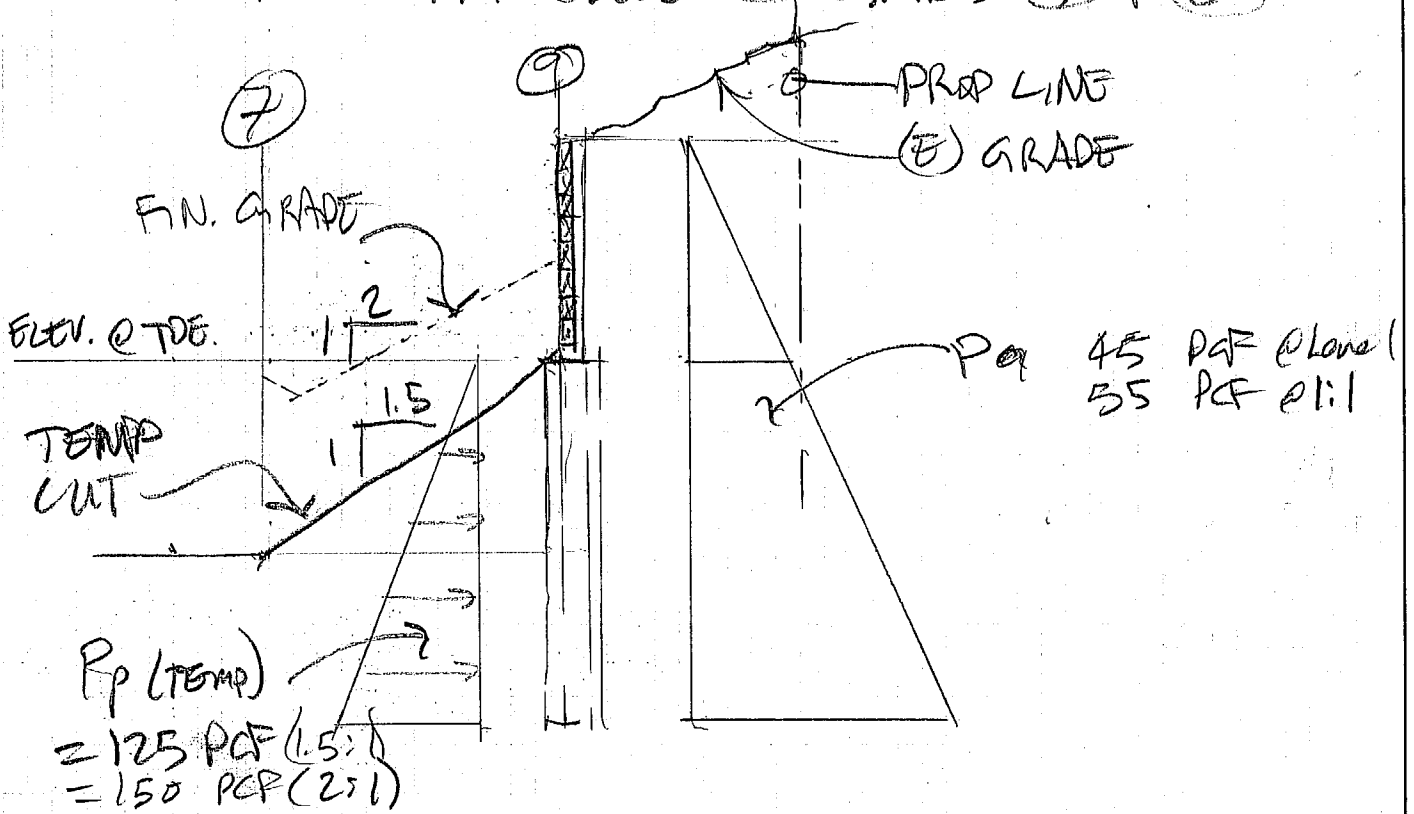
Date: Aug 2019

Client:

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SOLDIER PILES @ EAST WALL: (85 EB)

TEMP CASE w/ 1.5:1 SLOPE CUT @ TOE TO REACH FIBR ELEV @ GRIDS (7) + (8)



TEMP EA-EB

TOP @ 103'
 TOE @ 94.33'

H temp = 8.67 feet

PERM

TOE @ 103'
 H perm = 5'

→ Add seismic FH = 35 AS

$$Q_{equiv} = \frac{35}{55} = 0.64'$$

50 ksi strength = 50 k³ Say 1'

BoP @ 02

$$Q = 5 = 55 PCF$$

SEE SPREADSHEET:

W14x43 Spd = 62.7

Project: #12098

Date: Aug 2019

Client:

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BASE MATR CONT.

SEE DIAGRAM FOR PILES E7+E8 (31M)

SLABING BOTTOM PILES

Pa = 55

	TOP	TOE @ TEMP	H (m)	TDE @ PERM.	Ht perm.	7H SEISMIC	⊗
E5	108	92	16	103	5'	35	<1
E6	108	97	11	103	5'	35	<1
E7	108	99.33	8.67	103	5'	35	<1'
E8	"	"	"	"	"	"	"
E9	107	99.33	7.67	103	4	28	<1
E10	106	96	10	100	6	42	<1
E11	105	96	9	100	5	35	<1
E12	104	96	8	100	4	28	<1
E13	103	96	7	100	3	21	<1

Level Behind Pile

Pa = 45

S1	103	X	90	13	91	2
S2	100		90	10	70	1.6
S3	97		90	7	49	1.1
S4	95		90	5	35	0.8

N5	105	92.5	Perm. →	92.5	12.5	67.5	2
N6	102	92.5		92.5	9.5	66.5	1.5
N7	100	93		93	7	49	1.1
N8	100	94		94	6	42	1.0
N9	99	95		95	4	28	0.6
N10	98	96		96	2	21	0.3

Project: #1909B

Date:

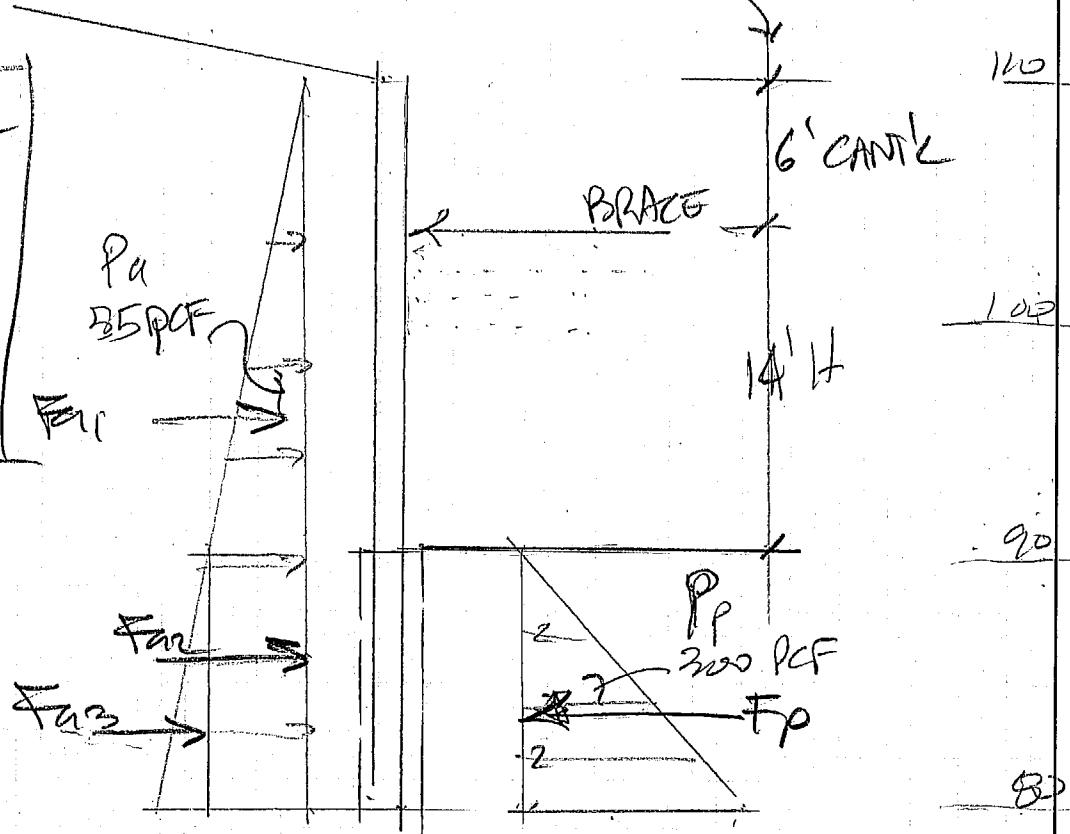
Client: WEN - STRG

Page Number:

BRACE PILES @ GARAGE AREA

DESIGN HTS

W14x32
 w/ SUTHP 30
 PIPE BRACE
 6' φ @ E1-E3
 8' φ @ E4



SEE EXCEL

$F_{a1} = 66.0 \text{ k}$
 $F_{a2} = 19.38 \text{ k}$
 $F_{a3} = 4.27 \text{ k}$

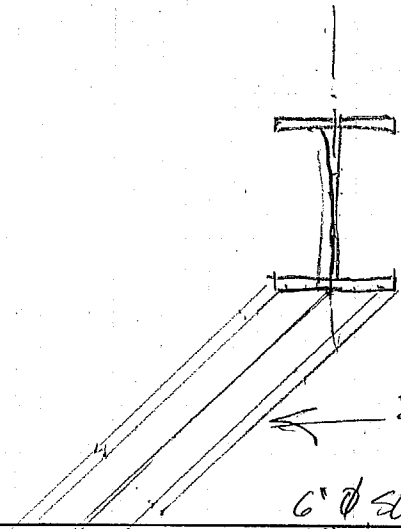
$R_{BRACE} = 43.08 \text{ k}$

$-M_{BRACE} = -11.38 \text{ kft}$
 $+M_{PILE} = 205.57 \text{ kft}$

$\sum P_{PIL} = 74.8 \text{ k}$

USE W14x32

$S_{APPR} = 123$
 $DF = 10''$



$F_{BRACE} = (\sqrt{2})(43.08)$
 $= 60.9 \text{ k}$
 $l_{max} = 26'$
 $l_{max} = 40'$

With Pa below Excav

JOB - # 19098 - Wen

CANTILEVER PILES - (Pa on pile Spa. and 1x Dia. below B.O.E.)

PILE #	Elevation		Elevation		H	Q	Pa	Pp1	xi	Pp2	xi2	x	FaQ	Fa1	Fa2	Fa3	Fp	Fp2	Fp3	ZFa -Z Fp	Mmax	fy=36ksi		fy=50ksi		1.2 * d	Elevation	GLOBAL
	SPA.	DIA.	T.O.P.	B.O.E.																		Sx Req'd	Sx Req'd	d	Z M(d)			
TEST	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(kcf)	(kcf)	(feet)	(kcf)	(feet)	(feet)	(kips)	(kips)	(kips)	(kips)	(kips)	(kips)	(kips)	(kips)	(ft-kips)	(in ³)	(in ³)	(feet)	(ft-kips)	(feet)	(feet)	at 1.2*d
C1 temp	6	2.0	100.0	90.5	9.5	0.00	0.045	0.300	1.0	0.300	16.0	5.63	0.00	12.18	4.81	1.43	18.43	0.00	0.00	0.00	94.98	47.97	34.54	10.26	0.00	12.31	78.2	1.5
C2 temp	6	2.0	97.0	90.5	6.5	0.00	0.045	0.300	1.0	0.300	16.0	3.94	0.00	5.70	2.30	0.70	8.71	0.00	0.00	0.00	31.75	16.03	11.54	7.22	0.00	8.66	81.8	1.5
C3 temp	6	2.0	94.0	90.5	3.5	0.00	0.045	0.300	1.0	0.300	16.0	2.32	0.00	1.65	0.73	0.24	2.63	0.00	0.00	0.00	5.64	2.85	2.05	4.21	0.00	5.06	85.4	1.6
E5-E8 temp	6	2.0	108.0	99.3	8.7	0.00	0.055	0.125	1.0	0.300	16.0	10.86	0.00	12.40	10.36	6.49	29.25	0.00	0.00	0.00	154.18	77.87	56.07	16.16	0.00	19.39	79.9	1.3
E5-E8 perm	6	2.0	108.0	103.0	5.0	1.00	0.055	0.150	1.0	0.300	16.0	6.51	1.65	4.13	4.29	2.33	12.40	0.00	0.00	0.00	44.83	22.64	16.30	10.43	0.00	12.52	90.5	1.5
temp E9	6	2.0	107.0	99.3	7.7	0.00	0.055	0.125	1.0	0.300	16.0	9.63	0.00	9.71	8.12	5.10	22.93	0.00	0.00	0.00	107.81	54.45	39.20	14.88	0.00	17.86	81.5	1.5
perm E9	6	2.0	107.0	103.0	4.0	1.00	0.055	0.150	1.0	0.300	16.0	5.44	1.32	2.64	2.99	1.63	8.58	0.00	0.00	0.00	26.10	13.18	9.49	8.76	0.00	10.51	92.5	1.5
temp E10	6	2.0	106.0	96.0	10.0	0.00	0.055	0.125	1.0	0.300	20.0	12.51	0.00	16.50	13.76	8.61	38.86	0.00	0.00	0.00	234.23	118.30	85.17	19.22	0.00	23.07	72.9	1.4
perm E10	6	2.0	106.0	100.0	6.0	1.00	0.055	0.150	1.0	0.300	20.0	7.57	1.98	5.94	5.83	3.15	16.91	0.00	0.00	0.00	70.80	35.76	25.75	12.11	0.00	14.53	85.5	1.5
temp E11	6	2.0	105.0	96.0	9.0	0.00	0.055	0.125	1.0	0.300	20.0	11.27	0.00	13.37	11.16	6.99	31.51	0.00	0.00	0.00	171.99	86.86	62.54	17.36	0.00	20.83	75.2	1.5
perm E11	6	2.0	105.0	100.0	5.0	1.00	0.055	0.150	1.0	0.300	20.0	6.51	1.65	4.13	4.29	2.33	12.40	0.00	0.00	0.00	44.83	22.64	16.30	10.43	0.00	12.52	87.5	1.5
temp E11	6	2.0	104.0	96.0	8.0	0.00	0.055	0.125	1.0	0.300	20.0	10.04	0.00	10.56	8.83	5.54	24.93	0.00	0.00	0.00	121.90	61.57	44.33	15.50	0.00	18.59	77.4	1.5
perm E11	6	2.0	104.0	100.0	4.0	1.00	0.055	0.150	1.0	0.300	20.0	5.44	1.32	2.64	2.99	1.63	8.58	0.00	0.00	0.00	26.10	13.18	9.49	8.76	0.00	10.51	89.5	1.5
S1 perm	5	2.0	103.0	90.0	13.0	2.00	0.045	0.300	1.0	0.300	20.0	8.10	5.85	19.01	10.93	2.95	38.75	0.00	0.00	0.00	282.30	142.58	102.66	14.61	0.00	17.53	72.5	1.5
S2 perm	6	2.0	100.0	90.0	10.0	1.60	0.045	0.300	1.0	0.300	20.0	6.78	4.32	13.50	7.08	2.07	26.96	0.00	0.00	0.00	164.10	82.88	59.67	12.27	0.00	14.72	75.3	1.5
S3 perm	6	2.0	97.0	90.0	7.0	1.10	0.045	0.300	1.0	0.300	20.0	4.80	2.08	6.62	3.50	1.04	13.23	0.00	0.00	0.00	57.75	29.17	21.00	8.75	0.00	10.50	79.5	1.5
S4 perm	6	2.0	95.0	90.0	5.0	0.80	0.045	0.300	1.0	0.300	20.0	3.52	1.08	3.38	1.84	0.56	6.85	0.00	0.00	0.00	22.16	11.19	8.06	6.45	0.00	7.74	82.3	1.5
N5 perm	6	2.0	105.0	92.5	12.5	2.00	0.045	0.300	1.0	0.300	20.0	8.43	6.75	21.09	11.00	3.20	42.04	0.00	0.00	0.00	316.04	159.62	114.92	15.20	0.00	18.24	74.3	1.5
N6 perm	6	2.0	102.0	92.5	9.5	1.50	0.045	0.300	1.0	0.300	20.0	6.44	3.85	12.18	6.37	1.87	24.27	0.00	0.00	0.00	140.60	71.01	51.13	11.67	0.00	14.00	78.5	1.5
N7 perm	6	2.0	100.0	93.0	7.0	1.10	0.045	0.300	1.0	0.300	20.0	4.80	2.08	6.62	3.50	1.04	13.23	0.00	0.00	0.00	57.75	29.17	21.00	8.75	0.00	10.50	82.5	1.5
N8 perm	6	2.0	100.0	94.0	6.0	1.00	0.045	0.300	1.0	0.300	20.0	4.18	1.62	4.86	2.64	0.79	9.90	0.00	0.00	0.00	37.79	19.09	13.74	7.64	0.00	9.17	84.8	1.5
N9 perm	6	2.0	99.0	95.0	4.0	0.60	0.045	0.300	1.0	0.300	20.0	2.88	0.65	2.16	1.19	0.37	4.37	0.00	0.00	0.00	11.59	5.86	4.22	5.26	0.00	6.31	88.7	1.6
N10 perm	6	2.0	98.0	96.0	2.0	0.30	0.045	0.300	1.0	0.300	20.0	1.73	0.16	0.54	0.36	0.13	1.19	0.00	0.00	0.00	1.83	0.93	0.67	3.03	0.00	3.64	92.4	1.7

W14X82 Sx Prov = 123
 W14X61 Sx Prov = 92.2
 W14X53 Sx Prov = 77.8
 W14X43 Sx Prov = 62.7
 W14X38 Sx Prov = 54.6
 W14X30 Sx Prov = 42.0
 W14X22 Sx Prov = 29.0

With Pa below Excav

JOB - # 19098 - Wen

PILE #	SPA. (feet)	DIA. (feet)	H (feet)	DF #2		Soil Arch Effect	Maximum Pressure (psf)	w (plf per ft)	a (ft)	b (ft)	l (ft)	Lagging V (lb per ft)	Lagging M (ft-lb per ft)	DF-L #2		HF #2	
				Lagging (in)	flange width (in)									fv = 95 psi Lagging d (v) (in per ft)	fb = 1250 psi Lagging d (m) (in per ft)	fv = 75 psi Lagging d (v) (in per ft)	fb = 1000 psi Lagging d (m) (in per ft)
TEST	6.0	2.0	14.5	2.40	12.0	0.5	797.5	398.75	0.5	4	5	797.5	1196.25	1.05	2.40	1.33	2.68
C1 temp	6.0	2.0	9.5	1.75	12.0	0.5	427.5	213.75	0.5	4	5	427.5	641.25	0.56	1.75	0.71	1.96
C2 temp	6.0	2.0	6.5	1.45	12.0	0.5	292.5	146.25	0.5	4	5	292.5	438.75	0.38	1.45	0.49	1.62
C3 temp	6.0	2.0	3.5	1.06	12.0	0.5	157.5	78.75	0.5	4	5	157.5	236.25	0.21	1.06	0.26	1.19
E5-E8 tem	6.0	2.0	8.7	1.85	12.0	0.5	476.85	238.425	0.5	4	5	476.85	715.275	0.63	1.85	0.79	2.07
E5-E8 per	6.0	2.0	5.0	1.54	12.0	0.5	330	165	0.5	4	5	330	495	0.43	1.54	0.55	1.72
temp E9	6.0	2.0	7.7	1.74	12.0	0.5	421.85	210.925	0.5	4	5	421.85	632.775	0.56	1.74	0.70	1.95
perm E9	6.0	2.0	4.0	1.41	12.0	0.5	275	137.5	0.5	4	5	275	412.5	0.36	1.41	0.46	1.57
temp E10	6.0	2.0	10.0	1.99	12.0	0.5	550	275	0.5	4	5	550	825	0.72	1.99	0.92	2.22
perm E10	6.0	2.0	6.0	1.66	12.0	0.5	385	192.5	0.5	4	5	385	577.5	0.51	1.66	0.64	1.86
temp E11	6.0	2.0	9.0	1.89	12.0	0.5	495	247.5	0.5	4	5	495	742.5	0.65	1.89	0.83	2.11
perm E11	6.0	2.0	5.0	1.54	12.0	0.5	330	165	0.5	4	5	330	495	0.43	1.54	0.55	1.72
temp E11	6.0	2.0	8.0	1.78	12.0	0.5	440	220	0.5	4	5	440	660	0.58	1.78	0.73	1.99
perm E11	6.0	2.0	4.0	1.41	12.0	0.5	275	137.5	0.5	4	5	275	412.5	0.36	1.41	0.46	1.57
S1 perm	6.0	2.0	13.0	2.20	12.0	0.5	675	337.5	0.5	4	5	675	1012.5	0.89	2.20	1.13	2.46
S2 perm	6.0	2.0	10.0	1.94	12.0	0.5	522	261	0.5	4	5	522	783	0.69	1.94	0.87	2.17
S3 perm	6.0	2.0	7.0	1.62	12.0	0.5	364.5	182.25	0.5	4	5	364.5	546.75	0.48	1.62	0.61	1.81
S4 perm	6.0	2.0	5.0	1.37	12.0	0.5	261	130.5	0.5	4	5	261	391.5	0.34	1.37	0.44	1.53
N5 perm	6.0	2.0	12.5	2.17	12.0	0.5	652.5	326.25	0.5	4	5	652.5	978.75	0.86	2.17	1.09	2.42
N6 perm	6.0	2.0	9.5	1.89	12.0	0.5	495	247.5	0.5	4	5	495	742.5	0.65	1.89	0.83	2.11
N7 perm	6.0	2.0	7.0	1.62	12.0	0.5	364.5	182.25	0.5	4	5	364.5	546.75	0.48	1.62	0.61	1.81
N8 perm	6.0	2.0	6.0	1.51	12.0	0.5	315	157.5	0.5	4	5	315	472.5	0.41	1.51	0.53	1.68
N9 perm	6.0	2.0	4.0	1.22	12.0	0.5	207	103.5	0.5	4	5	207	310.5	0.27	1.22	0.35	1.36
N10 perm	6.0	2.0	2.0	0.86	12.0	0.5	103.5	51.75	0.5	4	5	103.5	155.25	0.14	0.86	0.17	0.97

PILE WITH 1 TIEBACK

SINGLE ROW TIEBACK PILES - EQUIVALENT FLUID PRESSURE (TRIANGULAR) (Pa on pile Spa. Only and active below B.O.E.)

PILE #	SPA (feet)	DIA. (feet)	T.O.P. (feet)	B.O.E. (feet)	TB Elev. (feet)	H (feet)	L cant (feet)	Q (feet)	Pa (kcf)	Pp1 (kcf)	xi (feet)	x (feet)	FaQ (kips)	Fa1 (kips)	Fa2 (kips)	Fa3 (kips)	Fp (kips)	R TB		z' (feet)	Fa1+FaQ (z') (kips)	-M (ft-kips)	+M (ft-kips)	Mmax (ft-kips)	A36 Sx Req'd (in^3)	A572 Sx Req'd (in^3)	1.2 * d (feet)	B.O.P. (feet)	TB angle (degrees)	TB Force (kips)
																		ZFa -Z Fp (kips)	Z Mtb elev (ft-kips)											
E1 - E4	6	2	110.00	90.00	104.00	20.0	6.0	0.0	0.055	0.300	0.0	8.81	0.00	66.00	19.38	4.27	46.57	43.08	0.00	16.16	43.08	-11.88	205.57	205.57	103.82	74.75	10.57	79.4	0	43.08

TEMP. CANTL.

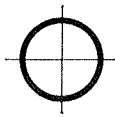
TEMPORARY CONDITION BEFORE TIEBACK INSTALLATION

PILE #	SPA. (feet)	DIA. (feet)	T.O.P. (feet)	TB Elev. (feet)	TEMP.	TEMP.	Q (feet)	Pa (kcf)	Pp1 (kcf)	xi (feet)	x (feet)	TEMP.	TEMP.	TEMP.	TEMP.	ZFa -Z Fp (kips)	TEMP.	
					B.O.E. (feet)	H (feet)						FaQ (kips)	Fa1 (kips)	Fa2 (kips)	Fa3 (kips)		Fp (kips)	-M (ft-kips)
E1 - E4	6	2	110	104	102	8.0	0	0.055	0.300	0	6.30	0.00	10.56	0.00	0.00	23.78	-13.22	-44.73

DESIGN	A36	A572
Mmax (ft-kips)	Sx Req'd (in^3)	Sx Req'd (in^3)

205.57 103.82 74.75

F_y = 36 ksi



COLUMNS

Standard steel pipe

Allowable concentric loads in kips

Nominal Dia.	12	10	8	6	5	4	3 1/2	3
Wall Thickness	0.375	0.365	0.322	0.280	0.258	0.237	0.226	0.216
Wt./ft	49.56	40.48	28.55	18.97	14.62	10.79	9.11	7.58
F _y 36 ksi								
0	315	257	181	121	93	68	58	48
6	303	246	171	110	83	59	48	38
7	301	243	168	108	81	57	46	36
8	299	241	166	106	78	54	44	34
9	296	238	163	103	76	52	41	31
10	293	235	161	101	73	49	38	28
11	291	232	158	98	71	46	35	25
12	288	229	155	95	68	43	32	22
13	285	226	152	92	65	40	29	19
14	282	223	149	89	61	36	25	16
15	278	220	145	86	58	33	22	14
16	275	216	142	82	55	29	19	12
17	272	213	138	79	51	26	17	11
18	268	209	135	75	47	23	15	10
19	265	205	131	71	43	21	14	9
20	261	201	127	67	39	19	12	
22	254	193	119	59	32	15	10	
24	246	185	111	51	27	13		
25	242	180	106	47	25	12		
26	238	176	102	43	23			
28	229	167	93	37	20			
30	220	158	83	32	17			
31	216	152	78	30	16			
32	211	148	73	29				
34	201	137	65	25				
36	192	127	58	23				
37	186	120	55	21				
38	181	115	52					
40	171	104	47					

Effective length in ft KL with respect to radius of gyration

Properties

Area A (in. ²)	14.6	11.9	8.40	5.58	4.30	3.17	2.68	2.23
I (in. ⁴)	279	161	72.6	28.1	15.2	7.23	4.79	3.02
r (in.)	4.38	3.67	2.94	2.25	1.88	1.51	1.34	1.16
Bending factor	0.333	0.398	0.500	0.657	0.789	0.987	1.12	1.29
a/10 ⁶	41.7	23.9	10.8	4.21	2.26	1.08	0.717	0.447

Note: Heavy line indicates KL/r of 200.

F_y = 36 ksi



COLUMNS

Extra strong steel pipe

Allowable concentric loads in kips

Nominal Dia.	12	10	8	6	5	4	3 1/2	3
Wall Thickness	0.500	0.500	0.500	0.432	0.375	0.337	0.318	0.300
Wt./ft	65.42	54.74	43.39	28.57	20.78	14.98	12.50	10.25
F _y 36 ksi								
0	415	348	276	181	132	95	79	65
6	400	332	259	166	118	81	66	52
7	397	328	255	162	114	78	63	48
8	394	325	251	159	111	75	59	45
9	390	321	247	155	107	71	55	41
10	387	318	243	151	103	67	51	37
11	383	314	239	146	99	63	47	33
12	379	309	234	142	95	59	43	28
13	375	305	229	137	91	54	38	24
14	371	301	224	132	86	49	33	21
15	367	296	219	127	81	44	29	18
16	363	291	214	122	76	39	25	16
18	353	281	203	111	65	31	20	12
19	349	276	197	105	59	28	18	11
20	344	271	191	99	54	25	16	
21	337	265	185	92	48	22	14	
22	334	260	179	86	44	21		
24	323	248	166	73	37	17		
26	312	236	152	62	32			
28	301	224	137	54	27			
30	289	211	122	47	24			
32	277	197	107	41				
34	264	183	95	36				
36	251	168	85	32				
38	237	152	76					
40	223	137	69					

Effective length in ft KL with respect to radius of gyration

Properties

Area A (in. ²)	19.2	16.1	12.8	8.40	6.11	4.41	3.68	3.02
I (in. ⁴)	362	212	106	40.5	20.7	9.61	6.28	3.89
r (in.)	4.33	3.63	2.88	2.19	1.84	1.48	1.31	1.14
Bending factor	0.339	0.408	0.521	0.688	0.822	1.03	1.17	1.36
a/10 ⁶	53.6	31.6	15.8	6.00	3.08	1.44	0.941	0.585

Note: Heavy line indicates KL/r of 200.