CT ENGINEERING
INC

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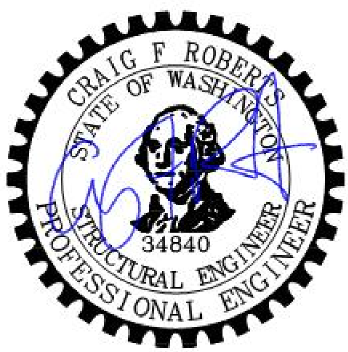
#18098

Structural Calculations for:

Wen Residence

Excavation Shoring

8529 West Mercer Way
Mercer Island, WA



03/06/2020

Design Criteria:	IBC 2015 Roof Snow Load = 25 psf Seismic: Ss = 1.466, S1 = 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

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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.

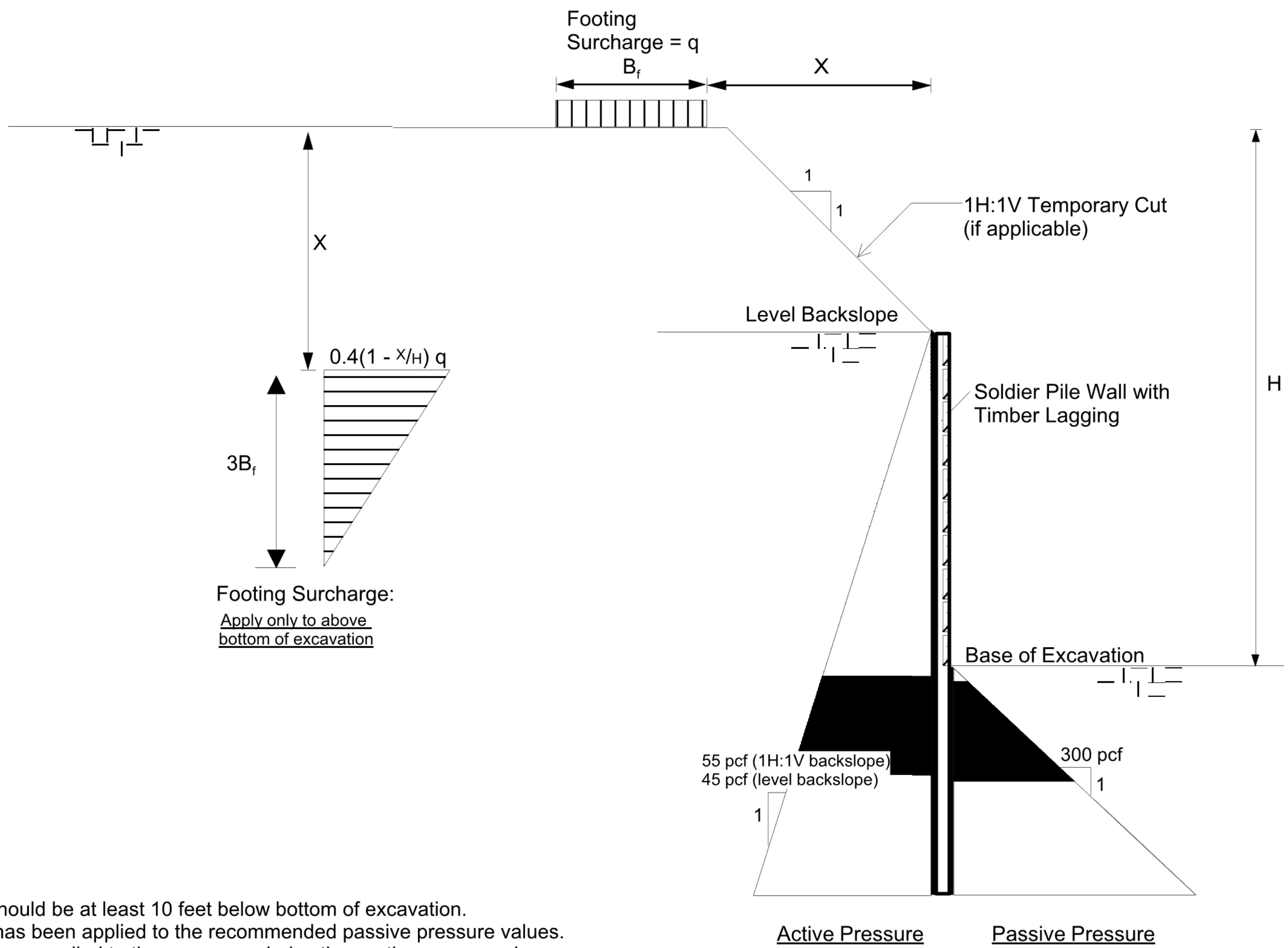
The detached garage structure is a concrete structure. The concrete basement walls have been designed for permanent soil pressures. Although these walls receive benefit of the shoring piles – these benefits have been neglected. The roof of the garage structure is an elevated reinforced concrete two-way slab. Soil loading over the roof has been included as a live load. Foundations are conventual 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.



Notes:
1. Minumum embedment should be at least 10 feet below bottom of excavation.
2. A factor of safety of 1.5 has been applied to the recommended passive pressure values. No factor of safety has been applied to the recommended active earth pressure values.
3. Active pressures should be applied over the full width of the pile spacing above the base of the excavation, and over one pile diameter below the base of the excavation.
4. Surcharge pressures should be applied over the entire length of the loaded area.
5. Passive pressure should be applied to two times the diameter of the soldier piles.
6. Use 50% of the active and surcharge pressures for lagging design with soldier piles spaced at 8' or less.
7. Refer to report text for additional discussions.

PanGEO INCORPORATED

Proposed Residence
825X W Mercer Way
Mercer Island, WA

DESIGN LATERAL PRESSURES CANTILEVERED SOLDIER PILE SHORING

Project No.	Figure No.
17-405	**3**

Todd Eaton

From: Scott Dinkelman <sdinkelman@pangeoinc.com>
Sent: Wednesday, August 21, 2019 10:43 AM
To: Todd Eaton
Subject: RE: Wen Shoring (17-405)

Hello Todd,
The earth pressures provided in our report can be used for the internal bracing condition, provided there is only one row of bracing.
Regarding the 1.5H:1V, the passive pressure for this condition should be reduced to 125 pcf.
For the 2H:1V slope, a passive pressure of 200 pcf can be used.
If you have any other questions, let me know.
Regards,
Scott

____

Scott D. Dinkelman, LG, LEG, LHG
Senior Engineering Geologist
Telephone: 206.262.0370
Mobile: 425.233.0097

From: Todd Eaton <TEaton@ctengineering.com>
Sent: Monday, August 19, 2019 3:01 PM
To: Scott Dinkelman <sdinkelman@pangeoinc.com>
Subject: FW: Wen Shoring

Hi Scott,
See attached for reference.
I believe that temporary pipe braces will be needed at piles E1 thru E4 (braced t by piles N1 thru N4). The balance of the piles at the east will have temporary slope cut at toe (verify 1.5H:1V) and permanent of of 2H:1V. Can you provide/verify soil pressures for these conditions. Call with any questions.
Thanks.

Todd Eaton PE
teaton@ctengineering.com

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- www.ctengineering.com

From: Todd Eaton
Sent: Tuesday, July 30, 2019 10:44 AM
To: Peter Bocek <pbocek@pbarch.com>
Subject: RE: Wen Shoring

Hi Peter,
Attached is shoring layout. I'll size the piles when updated soil parameters are received. At the garage, the pile heights (without slope cut behind piles) will dictate bracing needed as tiebacks do not seem to be an option without easements.

19098 Wen Shoring Progress Set 07-29-2019.pdf

Also, office manager wants to know if we can email billings to owner (would need email address) or do we send via mail.

Todd Eaton PE
teaton@ctengineering.com

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From: Peter Bocek <pbocek@pbarch.com>
Sent: Wednesday, July 24, 2019 4:45 PM
To: Todd Eaton <TEaton@ctengineering.com>
Subject: Re: Wen Shoring

Hi Todd,

Yes Pan Geo is expanding their scope of services. That said they should be able to assist with whatever you need. I'll contact them tomorrow and advise.

Thanks,

PB

Peter Bocek

PB Architects

206-443-9790

From: Todd Eaton <TEaton@ctengineering.com>
Sent: Tuesday, July 23, 2019 1:24 PM
To: Peter Bocek <pbocek@pbarch.com>
Subject: Wen Shoring

Hi Peter,
I've requested design parameters from PanGeo for the shoring piles with the 1.5:1 cut at the toe, and it is my understanding that PanGeo is in process to resolve separate item with client. Is there anything I can do to help?
Thanks.

Todd Eaton PE
teaton@ctengineering.com

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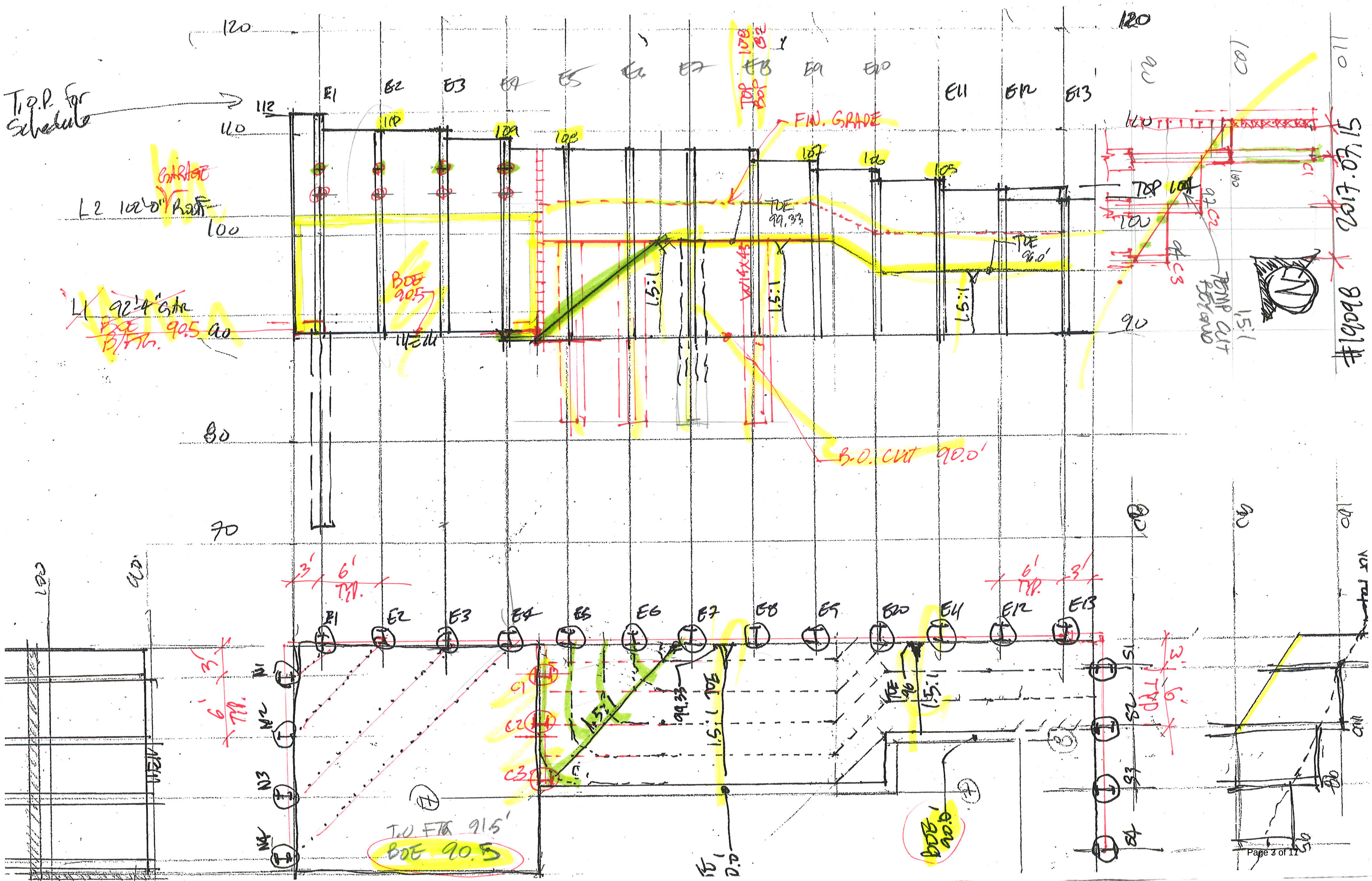
T.O.P. for Schedule
E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13
120
112
110
100
90
80
70
L2 102'-0" Roof
GARAGE
L1 92'-4" Gtr.
BOE 90.5
FIN. GRADE
TOE 99.33
TOE 96.0'
1.5:1
B.O. CUT 90.0'
TOP 108
TEMP CUT BELOW
C1
C2
C3
N1 N2 N3 N4
S1 S2 S3 S4
3' 6' TYP.
T.O. FTG 91.5'
BOE 90.5
BOE 90.0

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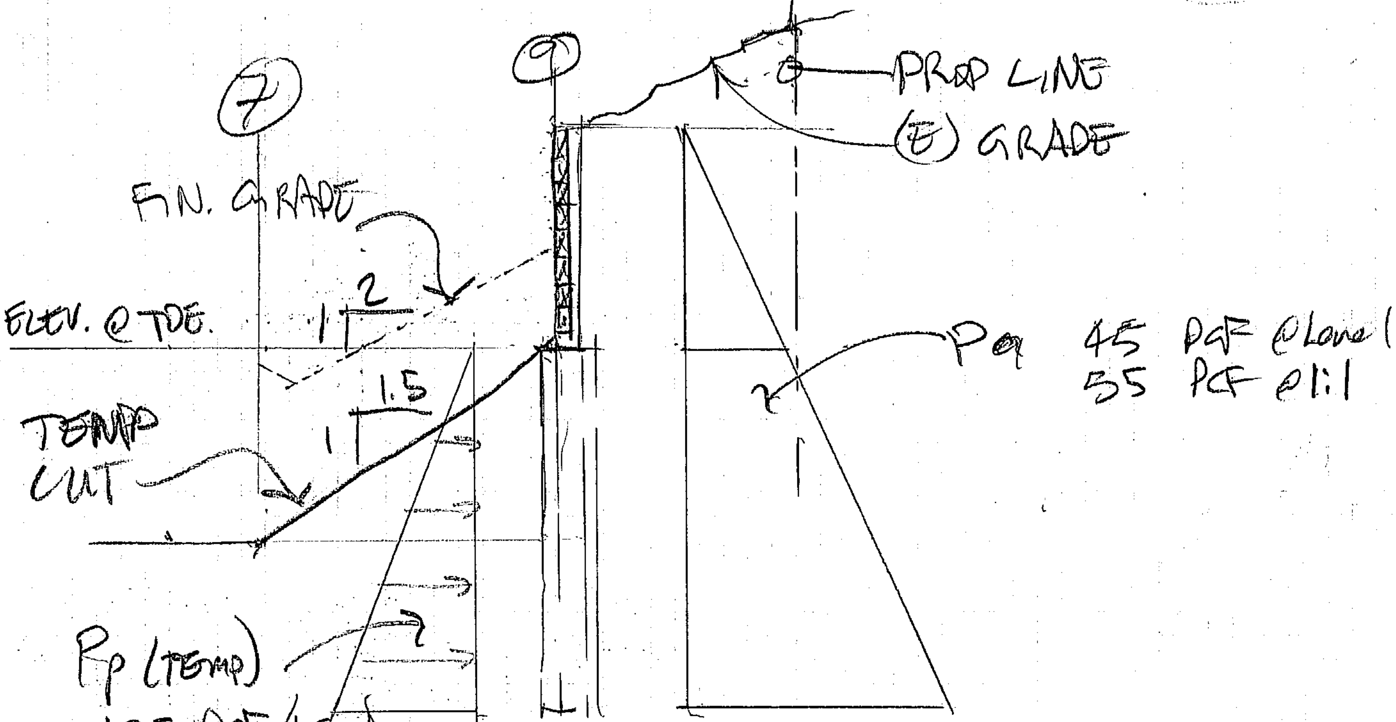
Project: #19098 Date: AUG 2019

Client: Page Number:

SOLDIER PILES @ EAST WALL. (E5 - E8)

TEMP CASE W/ 1.5:1 SLOPE CUT @ TOE
TO REACH FTG ELEVS @ GRIDS (7) + (8)



TEMP E7 - E8

TOP @ 108'
TOE @ 99.33'

H temp = 8.67 feet

PERM

TOE @ 103
H perm = 5'

→ Add SEISMIC 7H = 35 PSF

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

say 1'

Q = E = 55 PSF

50 ksi Sreq = 56 in³
Bop @ E2
W14X43 Sprov = 62.7

SEE SPREADSHEET:

200

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Project: #19098 Date: Aug 2019

Client: Page Number:

EAST WALL CONT.

SEE DIAGRAM FOR PILES E7 + E8 (3 m)

Sloping Behind Pile, Pa = 55

	TOP	TOE @ TEMP	H temp	TOE @ PERM.	H perm.	7H SEISMIC	[illegible]
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			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
Level Backfill							
N5	105	~~92.5~~		92.5	12.5	87.5	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		0.3

Perm. →

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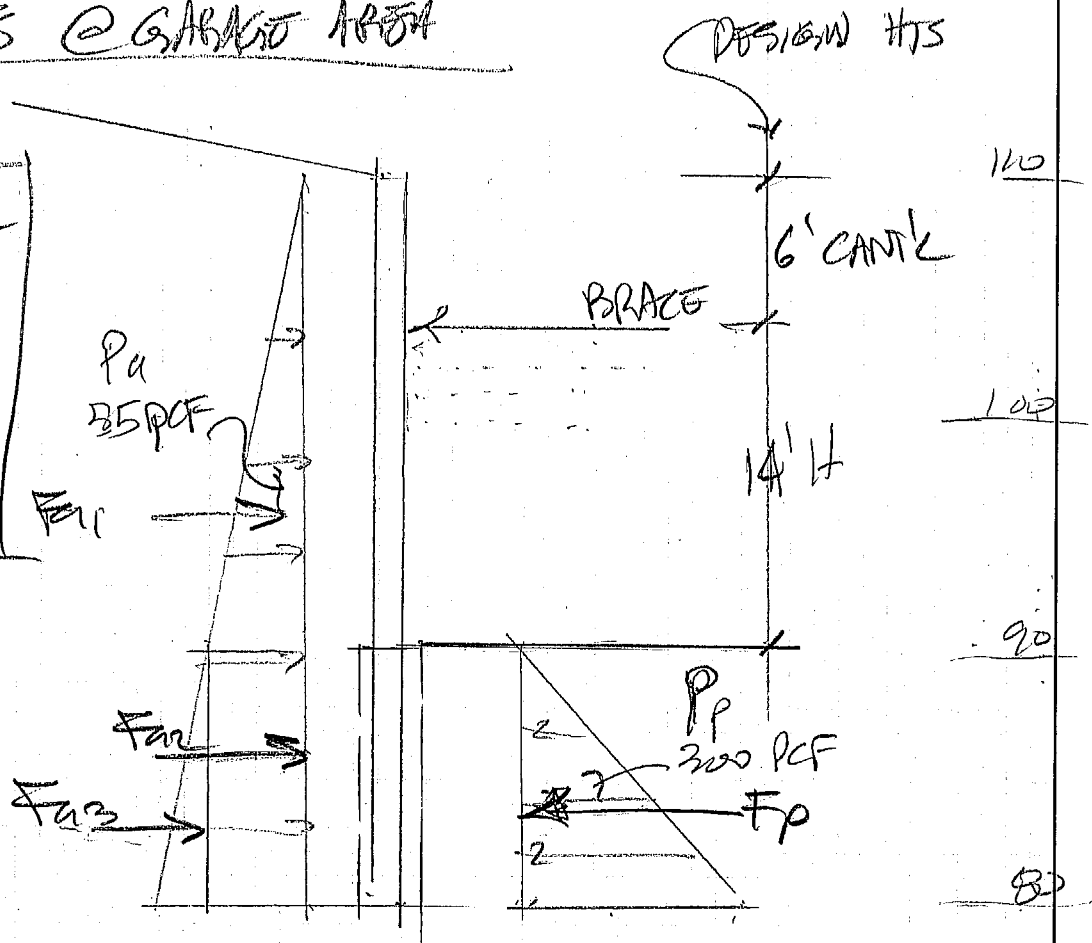
Project: #19098 Date:

Client: WSN – SHRG. Page Number:

BRACED PILES @ GARAGE AREA

USE W14x82
w/ SCHED 80
PIPE BRACE
6" ϕ @ E1-E3
8" ϕ @ E4



SEE EXCEL

$F_{a1} = 66.0\ k$

$F_{a2} = 19.38\ k$

$F_{a3} = 4.27\ k$

$R_{BRACE} = 43.08\ k$

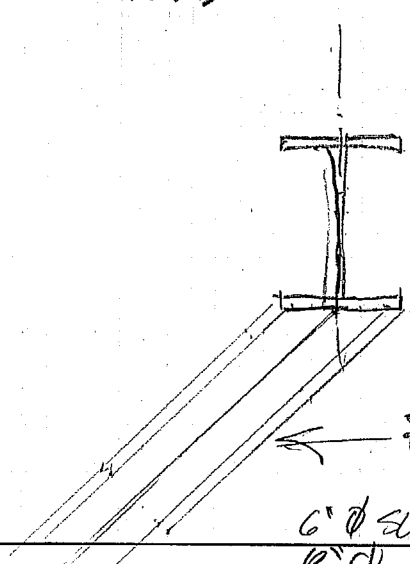
$-M_{BRACE\ EL} = -11.38\ k\text{-}ft$

$+M_{PILE} = 205.57\ k\text{-}ft$

S_x REQ'D = 74.8 in^3

USE W14x82

S_x prov = 123



← BRACE $F_{BRACE} = (\sqrt{2})(43.08)$ DF = 10"

$= 60.9\ k$

6" ϕ SCHED 80 PIPE $l_{max} = 26'$

8" ϕ $l_{max} = 40'$

Structural Engineers

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Project: Wen
Date:
Client: #19098
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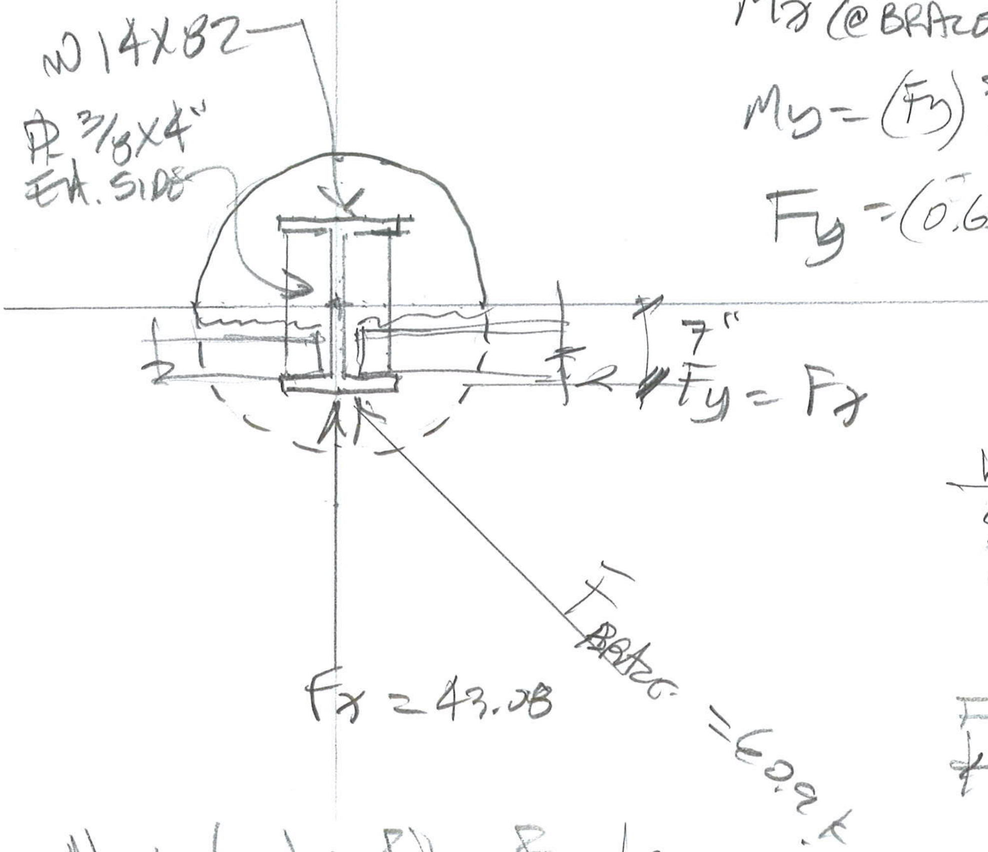
M_x (@ BRACE) = 11.88 K·ft

$M_y = (F_y)\ 7/12 = 25.13$ K·ft

$F_y = (0.66)(50) = 33$ ksi



W14x82
$S_x = 123\ in^3$
$S_y = 6.05\ in^3$

Neglect benefit of lean mix

Plate
$S_y > \frac{(3/8)(8)^2}{6} = 4.00\ in^3$

$f_x = \frac{M_x}{S_x} = \frac{(11.88)(12)}{123} = 1.16$ ksi

$f_y = \frac{M_y}{S_y + S_y\ plates} = \frac{(25.13)(12)}{(6.04 + 4.0)} = 30.04$ ksi

$\frac{f_x}{F_y} + \frac{f_y}{F_y} = \frac{1.16}{33.0} + \frac{30.04}{33.0} = 0.03 + 0.91$

$= 0.94 < 1.0$

Pile OK

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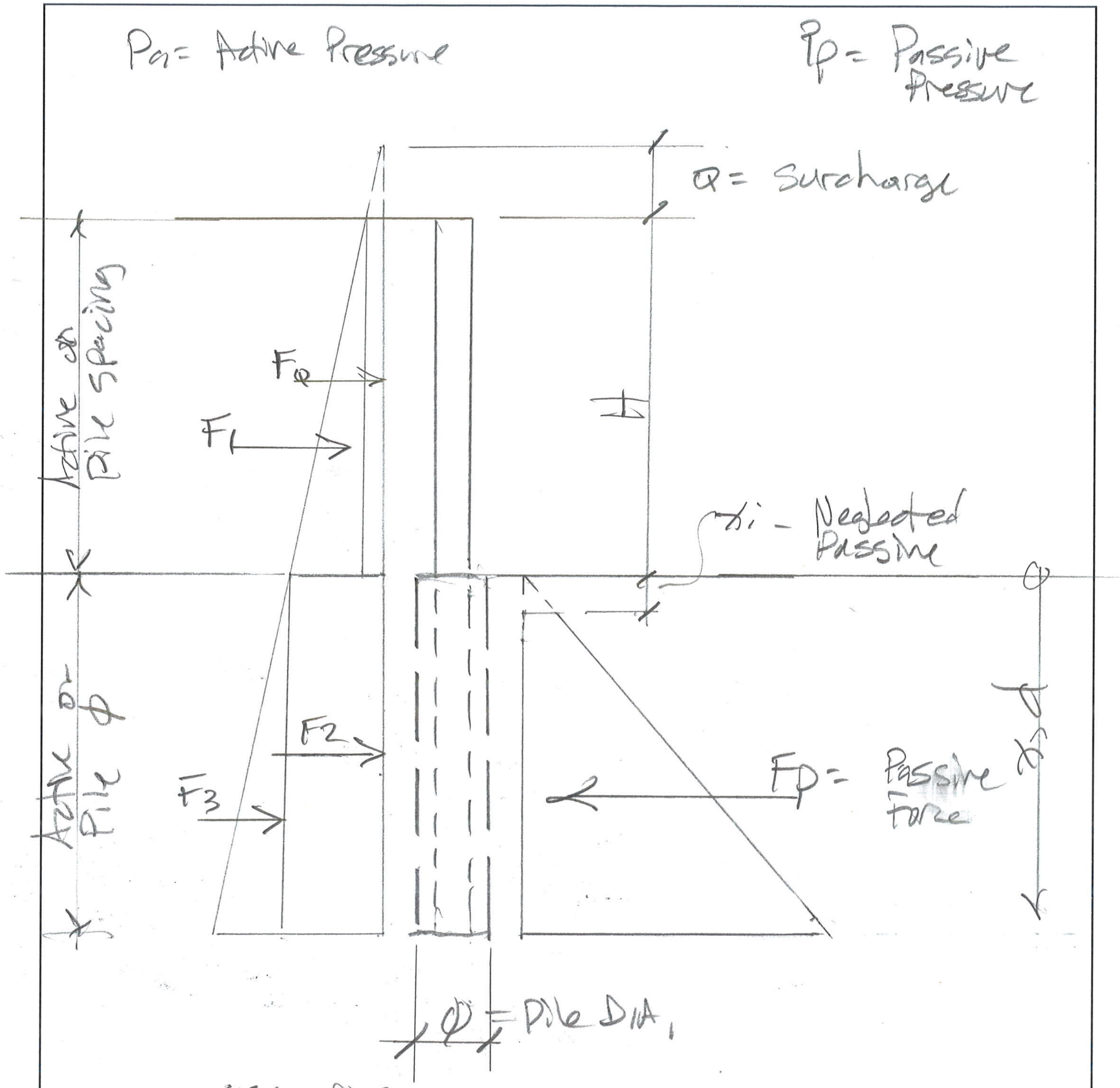
Project: Typical Pile spreadsheet
Date:

Client: Definitions
Page Number:



CANTILEVER PILE:

- Max Moment at point of zero shear at depth "y".
- Moment equilibrium at depth "d"
- Multiply d by 1.2, then check F.S. (overturning)

JOB - # 19098 - Wen

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

PILE #	SPA. (feet)	DIA. (feet)	Elevation T.O.P. (feet)	Elevation B.O.E. (feet)	H (feet)	Q (feet)	Pa (kcf)	Pp1 (kcf)	xi (feet)	Pp2 (kcf)	xi2 (feet)	x (feet)	FaQ (kips)	Fa1 (kips)	Fa2 (kips)	Fa3 (kips)	Fp (kips)	Fp2 (kips)	Fp3 (kips)	ZFa -Z Fp (kips)	Mmax (ft-kips)	fy=36ksi A36 Sx Req'd (in^3)	fy=50ksi A992 Sx Req'd (in^3)	d (feet)	Z M(d) (ft-kips)	1.2 * d (feet)	Elevation B.O.P. (feet)	GLOBAL F.O.S. at 1.2*d
TEST	6	2.0	106.0	91.5	14.5	0.00	0.055	0.300	1.0	0.300	20.0	9.64	0.00	34.69	15.38	5.11	55.18	0.00	0.00	0.00	433.79	219.08	157.74	16.96	0.00	20.36	71.1	1.5
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	0.055	0.300	1.0	0.300	20.0	9.57	8.25	25.78	15.26	5.03	54.33	0.00	0.00	0.00	418.50	211.36	152.18	16.79	0.00	20.14	72.4	1.5
N6 perm	6	2.0	102.0	92.5	9.5	1.50	0.055	0.300	1.0	0.300	20.0	7.30	4.70	14.89	8.83	2.93	31.35	0.00	0.00	0.00	186.01	93.94	67.64	12.87	0.00	15.45	77.1	1.5
N7 perm	6	2.0	100.0	93.0	7.0	1.10	0.055	0.300	1.0	0.300	20.0	5.43	2.54	8.09	4.84	1.62	17.08	0.00	0.00	0.00	76.29	38.53	27.74	9.64	0.00	11.56	81.4	1.5
N8 perm	6	2.0	100.0	94.0	6.0	1.00	0.055	0.300	1.0	0.300	20.0	4.72	1.98	5.94	3.64	1.23	12.78	0.00	0.00	0.00	49.88	25.19	18.14	8.40	0.00	10.08	83.9	1.5
N9 perm	6	2.0	99.0	95.0	4.0	0.60	0.055	0.300	1.0	0.300	20.0	3.22	0.79	2.64	1.63	0.57	5.63	0.00	0.00	0.00	15.23	7.69	5.54	5.76	0.00	6.92	88.1	1.5
N10 perm	6	2.0	98.0	96.0	2.0	0.30	0.055	0.300	1.0	0.300	20.0	1.88	0.20	0.66	0.48	0.20	1.53	0.00	0.00	0.00	2.38	1.20	0.86	3.28	0.00	3.94	92.1	1.6

W14X99 Sx Prov = 157
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

JOB - # 19098 - Wen

PILE #	SPA. (feet)	DIA. (feet)	H (feet)	DF #2 Lagging (in)	flange width (in)	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 fv = 95 psi Lagging d (v) (in per ft)	DF-L #2 fb = 1250 psi Lagging d (m) (in per ft)	HF #2 fv = 75 psi Lagging d (v) (in per ft)	HF #2 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 peri	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

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 ZFa -Z Fp (kips)	Z Mtb elev (ft-kips)	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)
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

TEMPORARY CONDITION BEFORE TIEBACK INSTALLATION

					TEMP.	TEMP.						TEMP.	TEMP.	TEMP.	TEMP.			TEMP.	DESIGN	A36	A572
PILE #	SPA.	DIA.	T.O.P.	TB Elev.	B.O.E.	H	Q	Pa	Pp1	xi	x	FaQ	Fa1	Fa2	Fa3	Fp	ZFa -Z Fp	-M	Mmax	Sx Req'd	Sx Req'd
	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(kcf)	(kcf)	(feet)	(feet)	(kips)	(kips)	(kips)	(kips)	(kips)	(kips)	(ft-kips)	(ft-kips)	(in^3)	(in^3)
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	205.57	103.82	74.75

COLUMNS
Standard steel pipe
Allowable concentric loads in kips

Nominal Dia.	12	10	8	6	5	4	3½	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							
Effective length in ft KL with respect to radius of gyration								
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					
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
B 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.

COLUMNS
Extra strong steel pipe
Allowable concentric loads in kips

Sched 80

Nominal Dia.	12	10	8	6	5	4	3½	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							
Effective length in ft KL with respect to radius of gyration								
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					
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
B 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.