



civil & structural  
engineering & planning

# STRUCTURAL CALCULATIONS

Rudolf Residence  
Site Walls

5222 W Mercer Way  
Mercer Island, WA 98040



03/02/2018

250 4<sup>th</sup> Ave S Ste 200  
Edmonds, WA 98020  
Phone: (425) 778-8500  
Fax: (425) 778-5536

CG Project No.: 15227.15

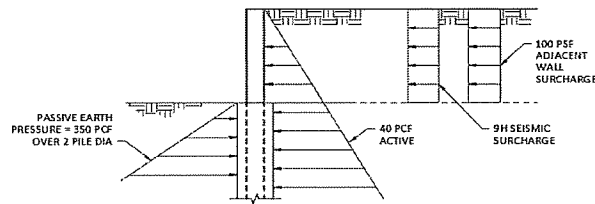
**Project Description and Scope**

A new single family residence is to be constructed on a sloping site. The project is located at 5222 W Mercer Way in Mercer Island, WA. Due to the steep slope, new retaining structures are required on the site. The retaining structures include soldier pile shoring walls as well as concrete walls. As part of this scope of work, CG Engineering will provide stamped structural calculations and stamped structural drawings for the soldier pile wall and the concrete retaining walls in conformance with the 2015 International Building Code and referenced documents.

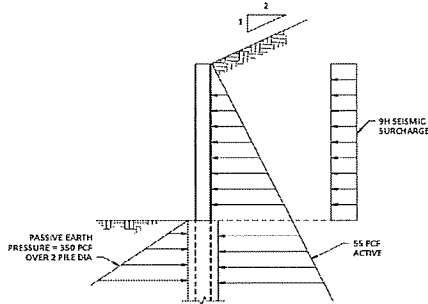
**Soil Design Parameters**

Geotechnical Report for shoring provided by Geotech Consultants, Inc.  
 Report No. 14348  
 Dated November 12, 2015

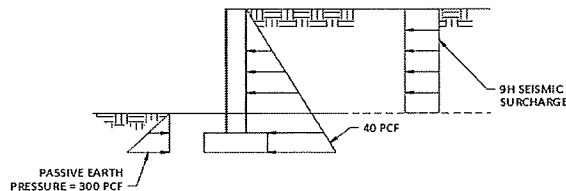
Wall A Pressure Diagram:



Wall B Pressure Diagram:



Concrete Wall Pressure Diagram:



250 4th Ave. South  
 Suite 200  
 Edmonds, WA 98020

Description	Project Summary	By	BTJ	Date	02/26/18
		Checked		Date	
		Scale		Sheet No.	
	Project	Rudolf Residence Site Walls	Job No.	15227.10	

## Dennis Titus

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**From:** Greg Guillen  
**Sent:** Monday, February 06, 2017 6:10 PM  
**To:** Rob Ward  
**Cc:** Dennis Titus; Joe Galusha; Ben James  
**Subject:** RE: Discuss Retaining walls with this plan

Thanks Rob.

Thank you,



Greg Guillen, PE, SE | Principal  
250 4th Ave S Ste 200, Edmonds, WA 98020  
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**From:** Rob Ward [mailto:robw@geotechnw.com]  
**Sent:** Monday, February 06, 2017 3:51 PM  
**To:** Greg Guillen <GregO@cgengineering.com>; James Rudolf <james@glacierpeakcapital.com>; Jessica Rudolf <jessierudolf@mac.com>  
**Cc:** Vicky Do <VickyD@cgengineering.com>; Jared Underbrink <JaredU@cgengineering.com>  
**Subject:** RE: Discuss Retaining walls with this plan

Greg,

In our study for this project, we recommended using an active pressure of 40 pcf for areas where the backslope is flat or near flat. For areas where there is a slope above, like for the wall on the eastern side of the site that parallels the street, the active pressure should be increased to 55 pcf. A surcharge is needed in the wall design for where the existing concrete wall exists at the property line – use 100 pcf for that surcharge.

For shoring design, a passive pressure on the portions of the soldier piles below the ground should be 350 pcf; this is an ultimate passive pressure and acts on 2X the diameter of the piles. A safety factor of 1.5 should be used to design the shoring wall.

As for any regular, concrete walls, use a bearing capacity of 1500 pcf and a coefficient of friction of 0.4 (ultimate).

Let me know if you need more info.

D. Robert Ward  
**Geotech Consultants, Inc.**  
*30 Years of Service 1986-2016*  
O (425) 747-5618 Cell (425) 260-1114  
2401 - 10th Avenue East  
Seattle, WA 98102

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We recommend reinforcing each pier its entire length. This typically consists of a cage of rebar extending a portion of the pier's length, with a full-length center bar. For design of the reinforcing, we recommend that the piers be assumed to have a point of fixity (point of maximum bending moment) at a depth of 10 feet below the top of the pile. The lateral capacity of a pier is a function of both the soil that surrounds the pier and the composition of the pier itself. Passive earth pressures on the grade beams will also provide some lateral resistance. If structural fill is placed against the outside of the grade beams, the design passive earth pressure from the fill can be assumed to be equal to that pressure exerted by an equivalent fluid with a density of 300 pcf. This passive resistance is an ultimate value that does not include safety factors.

### **FOUNDATION AND RETAINING WALLS**

Retaining walls backfilled on only one side should be designed to resist the lateral earth pressures imposed by the soil they retain. The following recommended parameters are for walls that restrain level backfill:

<b>PARAMETER</b>	<b>VALUE</b>
Active Earth Pressure *	40 pcf
Passive Earth Pressure	300 pcf
Soil Unit Weight	130 pcf

Where: pcf is Pounds per Cubic Foot, and active and Passive Earth Pressures are computed using the equivalent fluid pressures.

\* For a restrained wall that cannot deflect at least 0.002 times its height, a uniform lateral pressure equal to 10 psf times the height of the wall should be added to the above active equivalent fluid pressure.

The design values given above do not include the effects of any hydrostatic pressures behind the walls and assume that no surcharges, such as those caused by slopes, vehicles, or adjacent foundations will be exerted on the walls. If these conditions exist, those pressures should be added to the above lateral soil pressures. Where sloping backfill is desired behind the walls, we will need to be given the wall dimensions and the slope of the backfill in order to provide the appropriate design earth pressures. The surcharge due to traffic loads behind a wall can typically be accounted for by adding a uniform pressure equal to 2 feet multiplied by the above active fluid density. Heavy construction equipment should not be operated behind retaining and foundation walls within a distance equal to the height of a wall, unless the walls are designed for the additional lateral pressures resulting from the equipment.

The values given above are to be used to design only permanent foundation and retaining walls that are to be backfilled, such as conventional walls constructed of reinforced concrete or masonry. It is not appropriate to use the above earth pressures and soil unit weight to back-calculate soil strength parameters for design of other types of retaining walls, such as soldier pile, reinforced earth, modular or soil nail walls. We can assist with design of these types of walls, if desired. The passive pressure given is appropriate only for the depth of level, compacted fill placed in front of a retaining or foundation wall. The values for friction and passive resistance are ultimate values and do not include a safety factor. We recommend a safety factor of at least 1.5 for overturning and sliding, when using the above values to design the walls. Restrained wall soil parameters should

# RUDOLF RESIDENCE SITE WALLS

## DESIGN CRITERIA

MIN. EMBEDMENT = 10'

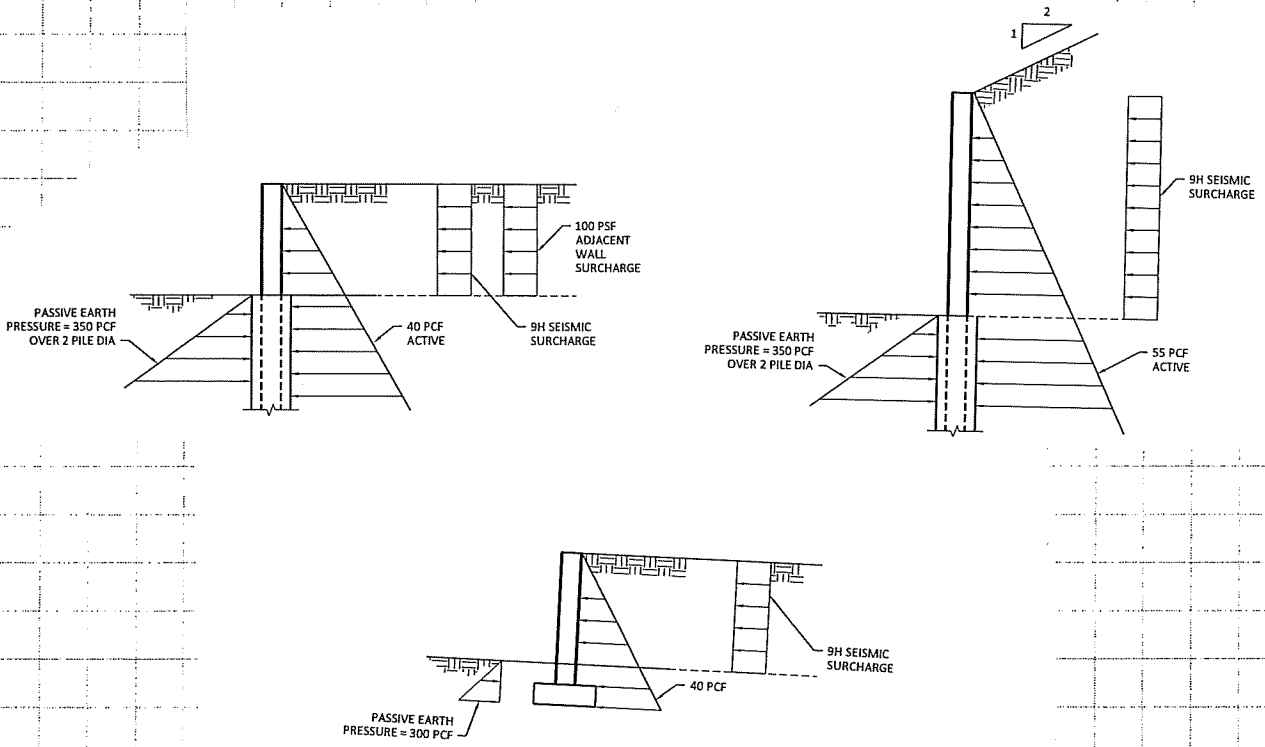
DEFLECTION LIMIT = 0.75"

SEISMIC SURCHARGE = 9H

F.S. STATIC = 1.5

F.S. W/ SEISMIC = 1.2

## PRESSURE DIAGRAMS



LOAD COMBINATIONS: LC1 = D+L+H

LC2 = D+0.7E+H



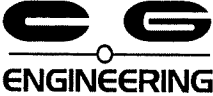
250 4th Ave. South  
 Suite 200  
 Edmonds, WA 98020  
 425.778.8500  
 www.cgeengineering.com

Description	By	BTJ	Date	3/20/17
	Checked		Date	
	Scale		Sheet No.	
	Project	RUDOLF RESIDENCE SITE WALLS		
	Job No.	15227.10		4

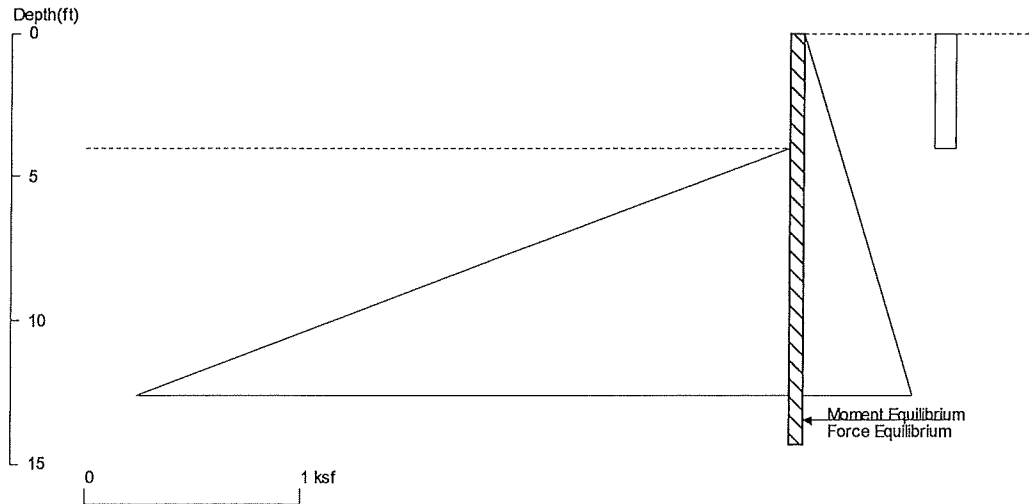
**Wall Design**

	Retaining Height	LC	Spacing (ft)	Pile Size	Deflection (in)	Min. Embed (ft)	Hole Diameter
<b>Site Wall A</b>	4'	LC1	8	W8x31	0.26	10.35	18"
		LC2	8	W8x31	0.26	9.76	18"
	6'	LC1	8	W10x39	0.62	14.17	18"
		LC2	8	W10x39	0.68	13.5	18"
<b>Site Wall B</b>	4'	LC1	10	W8x31	0.18	9.5	18"
		LC2	10	W8x31	0.21	9.48	18"
	6'	LC1	8	W8x31	0.48	11.6	18"
		LC2	8	W8x31	0.85	12.6	18"

LC1      D+L+H  
 LC2      D+0.7E+H

 <p>250 4th Ave. South                  Suite 200                  Edmonds, WA 98020</p>	Description	Wall Design	By	BTJ	Date	02/26/18
			Checked		Date	
			Scale		Sheet No.	
	Project	Rudolf Residence Site Walls	Job No.	15227.10		5

## 4' Retained - LC1 Wall A



<ShoringSuite> CIVILTECH SOFTWARE USA [www.civiltechsoftware.com](http://www.civiltechsoftware.com)

Licensed to 4324324234 3424343 Date: 3/23/2017  
 File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\\_Site Walls\Engineering\Site Wall A\4ft No EQ.sh8  
 UNITS: Dimension - ft; Force and Shear - kip; Pressure and Stress - ksf; Moment - kip-ft; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in.

Wall Height=4.0 Pile Diameter=1.5 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=10.35 Min. Pile Length=14.35  
 MOMENT IN PILE: Max. Moment=28.47 per Pile Spacing=8.0 at Depth=8.64

PILE SELECTION:  
 Request Min. Section Modulus = 10.4 in<sup>3</sup>/pile, F<sub>y</sub> = 50 ksi = 345 MPa, F<sub>b</sub>/F<sub>y</sub>=0.66  
 Selected Pile, W8X31, S = 27.5 in<sup>3</sup>/pile It is greater than Request Min. Section Modulus  
 Top Deflection = 0.26(in) based on E (ksi)= 29000.00, I (in<sup>4</sup>)/pile= 110.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
0	0	800	32.00	.04
0	.1	4	0.100	0

PASSIVE PRESSURES: Pressures will be divided by a Factor of Safety (F.S.) = 1.5

Z1	P1	Z2	P2	Slope
4.0	0.00	800.0	278.60	0.350

ACTIVE SPACING:

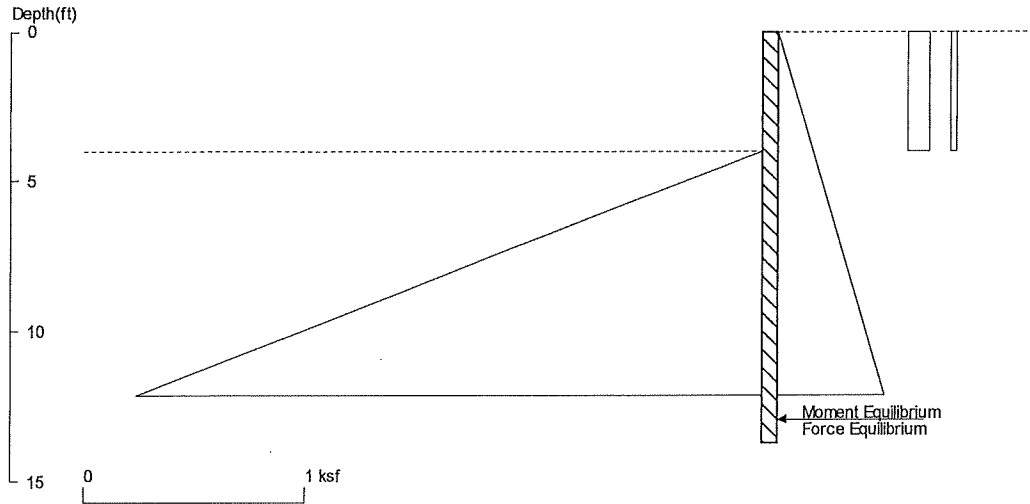
No.	Z depth	Spacing
1	0.00	8.00
2	4.00	1.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	4.00	3.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft  
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in

## 4' Retained LC2 Wall A



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Licensed to 4324324234 3424343 Date: 3/23/2017  
 File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\Site Walls\Engineering\Site Wall A\4ft with EQ.sh8  
 UNITS: Dimension - ft; Force and Shear - kip; Pressure and Stress - ksf; Moment - kip-ft; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in.

Wall Height=4.0 Pile Diameter=1.5 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=9.76 Min. Pile Length=13.76  
 MOMENT IN PILE: Max. Moment=31.24 per Pile Spacing=8.0 at Depth=8.33

PILE SELECTION:  
 Request Min. Section Modulus = 11.4 in<sup>3</sup>/pile, F<sub>y</sub> = 50 ksi = 345 MPa, F<sub>b</sub>/F<sub>y</sub>=0.66  
 Selected Pile, W8X31, S = 27.5 in<sup>3</sup>/pile It is greater than Request Min. Section Modulus  
 Top Deflection = 0.26(in) based on E (ksi)= 29000.00, I (in<sup>4</sup>)/pile= 110.0

**DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):**

Z1	P1	Z2	P2	Slope
0	0	800	32.00	.04
0	.1	4	0.100	0
0	.026	4	0.026	0

**PASSIVE PRESSURES: Pressures will be divided by a Factor of Safety (F.S.) =1.2**

Z1	P1	Z2	P2	Slope
4.0	0.00	800.0	278.60	0.350

**ACTIVE SPACING:**

No.	Z depth	Spacing
1	0.00	8.00
2	4.00	1.50

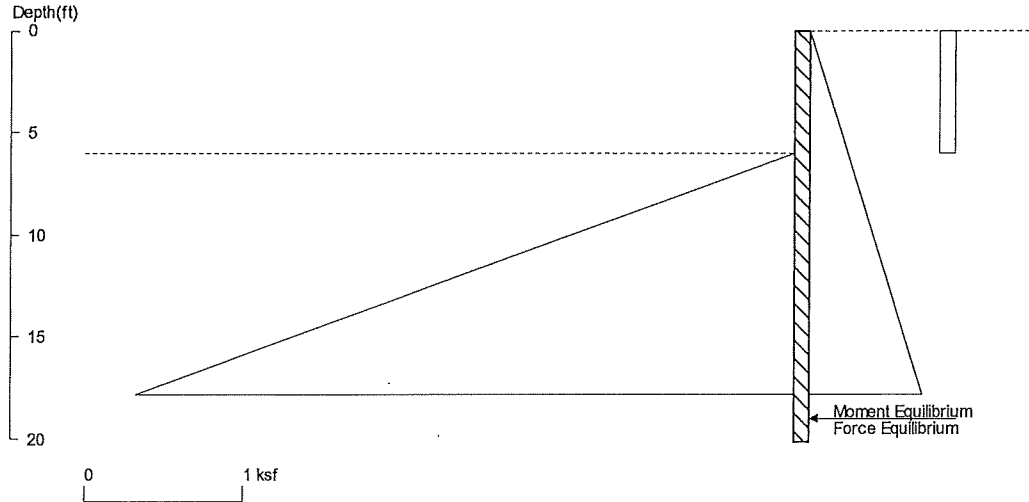
**PASSIVE SPACING:**

No.	Z depth	Spacing
1	4.00	3.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft  
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in



## 6' Retained - LC1 Wall A



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Licensed to 4324324234 3424343 Date: 3/23/2017  
 File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\Site Walls\Engineering\Site Wall A\6ft No EQ.sh8  
 UNITS: Dimension - ft; Force and Shear - kip; Pressure and Stress - ksf; Moment - kip-ft; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in.

Wall Height=6.0 Pile Diameter=1.5 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=14.17 Min. Pile Length=20.17  
 MOMENT IN PILE: Max. Moment=72.92 per Pile Spacing=8.0 at Depth=12.33

PILE SELECTION:  
 Request Min. Section Modulus = 26.5 in<sup>3</sup>/pile, F<sub>y</sub> = 50 ksi = 345 MPa, F<sub>b</sub>/F<sub>y</sub>=0.66  
 Selected Pile, W10X39, S = 42.1 in<sup>3</sup>/pile It is greater than Request Min. Section Modulus  
 Top Deflection = 0.62(in) based on E (ksi)= 29000.00, I (in<sup>4</sup>)/pile= 209.0

**DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):**

Z1	P1	Z2	P2	Slope
0	0	800	32.00	.04
0	.1	6	0.100	0

**PASSIVE PRESSURES: Pressures will be divided by a Factor of Safety (F.S.)=1.5**

Z1	P1	Z2	P2	Slope
6.0	0.00	800.0	277.90	0.350

**ACTIVE SPACING:**

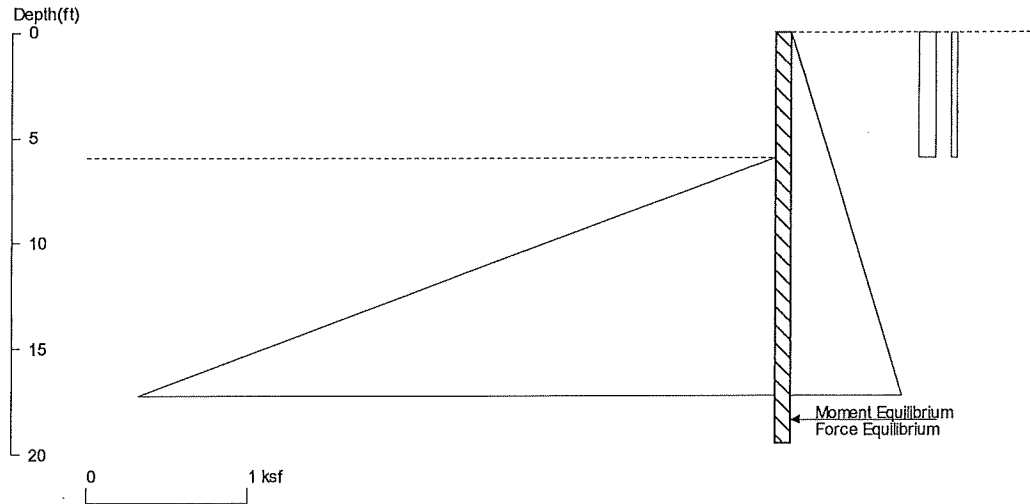
No.	Z depth	Spacing
1	0.00	8.00
2	6.00	1.50

**PASSIVE SPACING:**

No.	Z depth	Spacing
1	6.00	3.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft  
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in

## 6' Retained - LC2 Wall A



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Licensed to 4324324234 3424343 Date: 3/23/2017  
 File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\Site Walls\Engineering\Site Wall A\6ft with EQ.sh8  
 UNITS: Dimension - ft; Force and Shear - kip; Pressure and Stress - ksf; Moment - kip-ft; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in.

Wall Height=6.0 Pile Diameter=1.5 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=13.50 Min. Pile Length=19.50  
 MOMENT IN PILE: Max. Moment=82.84 per Pile Spacing=8.0 at Depth=11.96

PILE SELECTION:  
 Request Min. Section Modulus = 30.1 in<sup>3</sup>/pile, F<sub>y</sub> = 50 ksi = 345 MPa, F<sub>b</sub>/F<sub>y</sub>=0.66  
 Selected Pile, W10X39, S = 42.1 in<sup>3</sup>/pile It is greater than Request Min. Section Modulus  
 Top Deflection = 0.68(in) based on E (ksi)= 29000.00, I (in<sup>4</sup>)/pile= 209.0

**DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):**

Z1	P1	Z2	P2	Slope
0	0	800	32.00	.04
0	.1	6	0.100	0
0	.038	6	0.038	0

**PASSIVE PRESSURES: Pressures will be divided by a Factor of Safety (F.S.) =1.2**

Z1	P1	Z2	P2	Slope
6.0	0.00	800.0	277.90	0.350

**ACTIVE SPACING:**

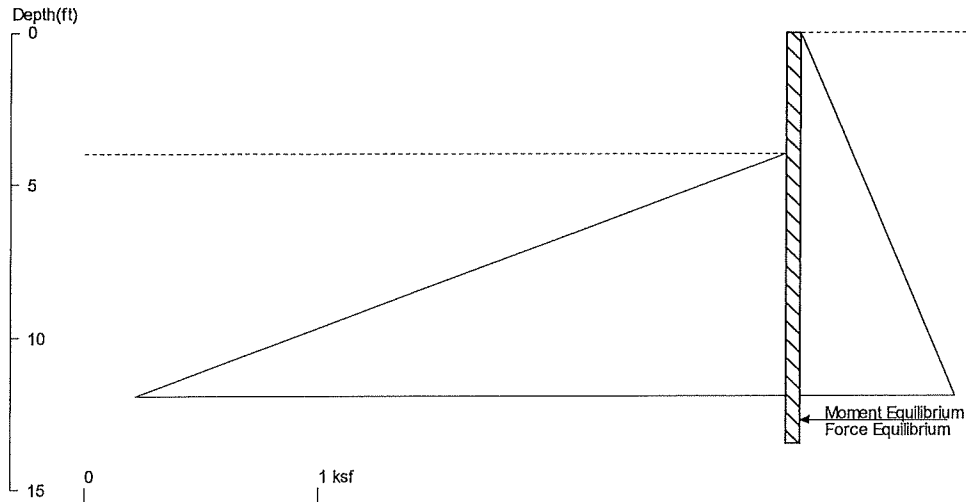
No.	Z depth	Spacing
1	0.00	8.00
2	6.00	1.50

**PASSIVE SPACING:**

No.	Z depth	Spacing
1	6.00	3.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft  
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in

## 4' Retained - LC1 Wall B



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 File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\Site Walls\Engineering\Site Wall B\4ft No EQ.sh8  
 UNITS: Dimension - ft; Force and Shear - kip; Pressure and Stress - ksf; Moment - kip-ft; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in.

Wall Height=4.0 Pile Diameter=1.5 Pile Spacing=10.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=9.50 Min. Pile Length=13.50  
 MOMENT IN PILE: Max. Moment=19.66 per Pile Spacing=10.0 at Depth=8.35

PILE SELECTION:  
 Request Min. Section Modulus = 7.1 in<sup>3</sup>/pile, F<sub>y</sub> = 50 ksi = 345 MPa, F<sub>b</sub>/F<sub>y</sub>=0.66  
 Selected Pile, W8X31, S = 27.5 in<sup>3</sup>/pile It is greater than Request Min. Section Modulus  
 Top Deflection = 0.18(in) based on E (ksi)= 29000.00, I (in<sup>4</sup>)/pile= 110.0

**DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):**

Z1	P1	Z2	P2	Slope
0	0	800	44.00	.055

**PASSIVE PRESSURES: Pressures will be divided by a Factor of Safety (F.S.) =1.5**

Z1	P1	Z2	P2	Slope
4.0	0.00	800.0	278.60	0.350

**ACTIVE SPACING:**

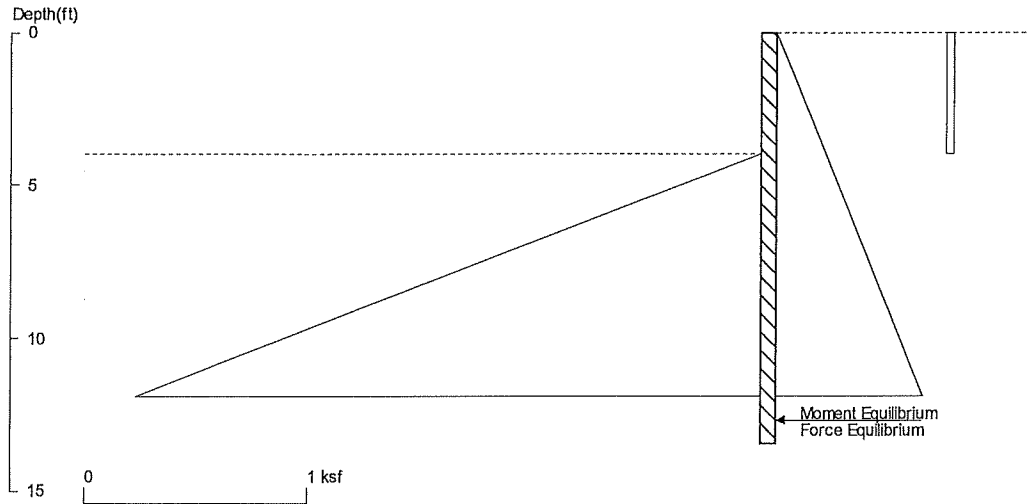
No.	Z depth	Spacing
1	0.00	10.00
2	4.00	1.50

**PASSIVE SPACING:**

No.	Z depth	Spacing
1	4.00	3.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft  
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in

## 4' Retained - LC2 Wall B



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Licensed to 4324324234 3424343 Date: 3/23/2017  
 File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\Site Walls\Engineering\Site Wall B\4ft with EQ.sh8  
 UNITS: Dimension - ft; Force and Shear - kip; Pressure and Stress - ksf; Moment - kip-ft; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in.

Wall Height=4.0 Pile Diameter=1.5 Pile Spacing=10.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=9.48 Min. Pile Length=13.48  
 MOMENT IN PILE: Max. Moment=26.41 per Pile Spacing=10.0 at Depth=8.28

PILE SELECTION:  
 Request Min. Section Modulus = 9.6 in<sup>3</sup>/pile, F<sub>y</sub> = 50 ksi = 345 MPa, F<sub>b</sub>/F<sub>y</sub>=0.66  
 Selected Pile, W8X31, S = 27.5 in<sup>3</sup>/pile It is greater than Request Min. Section Modulus  
 Top Deflection = 0.21(in) based on E (ksi)= 29000.00, I (in<sup>4</sup>)/pile= 110.0

**DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):**

Z1	P1	Z2	P2	Slope
0	0	800	44.00	.055
0	.036	4	0.036	0

**PASSIVE PRESSURES: Pressures will be divided by a Factor of Safety (F.S.) =1.2**

Z1	P1	Z2	P2	Slope
4.0	0.00	800.0	278.60	0.350

**ACTIVE SPACING:**

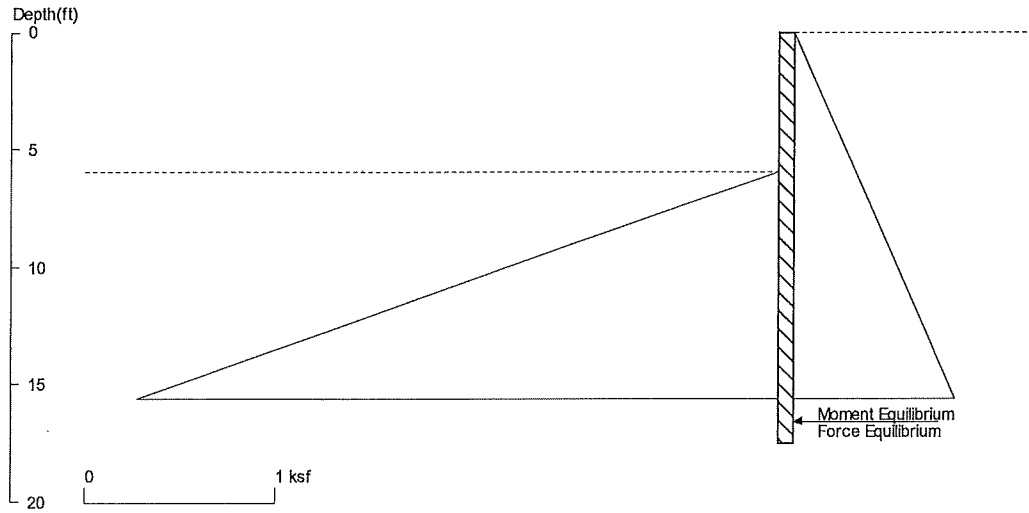
No.	Z depth	Spacing
1	0.00	10.00
2	4.00	1.50

**PASSIVE SPACING:**

No.	Z depth	Spacing
1	4.00	3.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft  
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in

## 6' Retained - LC1 Wall B



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Licensed to 4324324234 3424343 Date: 3/29/2017  
 File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\Site Walls\Engineering\Site Wall B\6ft LC1.sh8  
 UNITS: Dimension - ft; Force and Shear - kip; Pressure and Stress - ksf; Moment - kip-ft; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in.

Wall Height=6.0 Pile Diameter=1.5 Pile Spacing=10.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=11.56 Min. Pile Length=17.56  
 MOMENT IN PILE: Max. Moment=34.99 per Pile Spacing=10.0 at Depth=11.26

PILE SELECTION:  
 Request Min. Section Modulus = 12.7 in<sup>3</sup>/pile, F<sub>y</sub> = 50 ksi = 345 MPa, F<sub>b</sub>/F<sub>y</sub>=0.66  
 Selected Pile, W8X31, S = 27.5 in<sup>3</sup>/pile It is greater than Request Min. Section Modulus  
 Top Deflection = 0.48(in) based on E (ksi)= 29000.00, I (in<sup>4</sup>)/pile= 110.0

**DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):**

Z1	P1	Z2	P2	Slope
0	0	800	44.00	.055

**PASSIVE PRESSURES: Pressures will be divided by a Factor of Safety (F.S.) = 1.5**

Z1	P1	Z2	P2	Slope
6.0	0.00	800.0	277.90	0.350

**ACTIVE SPACING:**

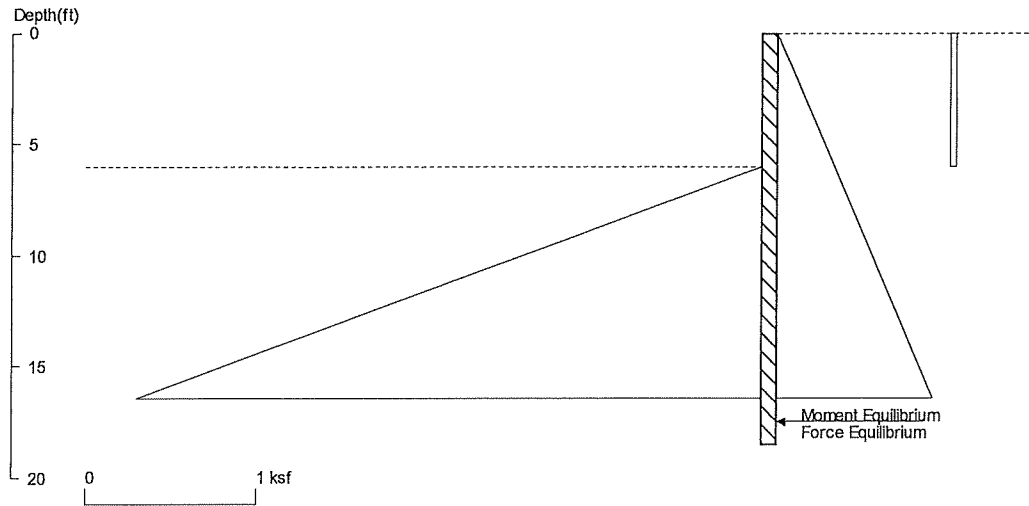
No.	Z depth	Spacing
1	0.00	6.00
2	6.00	1.50

**PASSIVE SPACING:**

No.	Z depth	Spacing
1	6.00	3.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft  
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in

## 6' Retained - LC2 Wall B



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 File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\\_Site Walls\Engineering\Site Wall B\6ft LC2.sh8  
 UNITS: Dimension - ft; Force and Shear - kip; Pressure and Stress - ksf; Moment - kip-ft; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in.

Wall Height=6.0 Pile Diameter=1.5 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=12.52 Min. Pile Length=18.52  
 MOMENT IN PILE: Max. Moment=60.44 per Pile Spacing=8.0 at Depth=11.61

PILE SELECTION:  
 Request Min. Section Modulus = 22.0 in<sup>3</sup>/pile, F<sub>y</sub> = 50 ksi = 345 MPa, F<sub>b</sub>/F<sub>y</sub>=0.66  
 Selected Pile, W8X31, S = 27.5 in<sup>3</sup>/pile It is greater than Request Min. Section Modulus  
 Top Deflection = 0.85(in) based on E (ksi)= 29000.00, I (in<sup>4</sup>)/pile= 110.0

**DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):**

Z1	P1	Z2	P2	Slope
0	0	800	44.00	.055
0	.038	6	0.038	0

**PASSIVE PRESSURES: Pressures will be divided by a Factor of Safety (F.S.) =1.2**

Z1	P1	Z2	P2	Slope
6.0	0.00	800.0	277.90	0.350

**ACTIVE SPACING:**

No.	Z depth	Spacing
1	0.00	8.00
2	6.00	1.50

**PASSIVE SPACING:**

No.	Z depth	Spacing
1	6.00	3.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft  
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft<sup>3</sup>; Deflection - in

## WALL A - LAGGING DESIGN updated 7/21/2016

### WALL GEOMETRY

Wall Ht =	6 ft	Earth Pressure =	20 pcf
Pile Spacing =	7.5 ft	Seismic Load =	9 H psf
		Adjacent Wall Surcharge =	50 psf

### DESIGN LOADS

Soil Load =	162.92 plf	Worst case loading applied over "D" of bottom lagging
Seismic Load =	51.75 plf	

### GOVERNING LOADS

0.6D+W+H =	462.92 plf	ASCE 2.4.1 load case 7
0.6D+0.7E+H =	499.14 plf	ASCE 2.4.1 load case 8

### LAGGING PROPERTIES

per 2015 NDS

Lagging Size = 6x12 DF#2  
 Pressure Treated = Yes  
 Load Duration = Permanent

W =	5.5 in	C <sub>D</sub> = 0.90	C <sub>F</sub> = 1.00	C <sub>i Fb</sub> = 0.80
D =	11.5 in	C <sub>D seismic</sub> = 1.6	C <sub>Fu</sub> = 1.00	C <sub>i Fv</sub> = 1.00
A =	63.25 in <sup>2</sup>	C <sub>M Fb</sub> = 1.00	C <sub>r</sub> = 1.15	
S =	57.98 in <sup>3</sup>	C <sub>M Fv</sub> = 1.00		
F <sub>b</sub> =	875	F' <sub>b</sub> = F <sub>b</sub> * C <sub>D</sub> * C <sub>M</sub> * C <sub>F</sub> * C <sub>Fu</sub> * C <sub>i</sub> * C <sub>r</sub> =	724.5 psi	F' <sub>b seismic</sub> = 1288.00 psi
F <sub>v</sub> =	170	F' <sub>v</sub> = F <sub>v</sub> * C <sub>D</sub> * C <sub>M</sub> * C <sub>i</sub> =	153 psi	F' <sub>v seismic</sub> = 217.60 psi

### BENDING DESIGN

<u>Load Case 7</u>	<u>Load Case 8</u>
M <sub>MAX</sub> = WL <sup>2</sup> /8 = 3254.9 Ft#	M <sub>MAX</sub> = WL <sup>2</sup> /8 = 3509.6 Ft#
fb = M/S = 673.7 psi	fb = M/S = 726.383 psi
fb/F'b = 93.0%	fb/F'b = 56.4%

### SHEAR DESIGN

<u>Load Case 7</u>	<u>Load Case 8</u>
V <sub>MAX</sub> = WL/2 = 1735.9 #	V <sub>MAX</sub> = WL/2 = 1871.8 #
f <sub>v</sub> = 3/2 * V/A = 41.17 psi	f <sub>v</sub> = 3/2 * V/A = 44.39 psi
f <sub>v</sub> /F' <sub>v</sub> = 26.9%	f <sub>v</sub> /F' <sub>v</sub> = 20.4%

### SUMMARY

Lagging Size = 6x12 DF#2	Governing Load Case = 0.6D+W+H
Max Pile Spacing = 7.5 ft	Bending Stress = <b>93.0%</b> <b>OK</b>
Max Retained Ht = 6 ft	Shear Stress = <b>26.9%</b> <b>OK</b>



250 4th Ave South  
 Suite 200  
 Edmonds, WA 98020

Description

Lagging Design

Project

Rudolf Site Walls

B BTJ

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Scale

Job No.

15227.1

Date

Date

Sheet No.

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## WALL B - LAGGING DESIGN updated 7/21/2016

### WALL GEOMETRY

Wall Ht =	4 ft	Earth Pressure =	28 pcf
Pile Spacing =	10 ft	Seismic Load =	8 H psf

### DESIGN LOADS

Soil Load =	107.33 plf	Worst case loading applied over "D" of bottom lagging
Seismic Load =	30.67 plf	

### GOVERNING LOADS

0.6D+W+H =	107.33 plf	ASCE 2.4.1 load case 7
0.6D+0.7E+H =	128.80 plf	ASCE 2.4.1 load case 8

### LAGGING PROPERTIES

per 2015 NDS

Lagging Size = 6x12 HF#2  
 Pressure Treated = Yes  
 Load Duration = Permanent

W =	5.5 in	C <sub>D</sub> =	0.90	C <sub>F</sub> =	1.00	C <sub>i Fb</sub> =	0.80
D =	11.5 in	C <sub>D seismic</sub> =	1.6	C <sub>fu</sub> =	1.00	C <sub>i Fv</sub> =	1.00
A =	63.25 in <sup>2</sup>	C <sub>M Fb</sub> =	1.00	C <sub>r</sub> =	1.15		
S =	57.98 in <sup>3</sup>	C <sub>M Fv</sub> =	1.00				
F <sub>b</sub> =	675	F <sub>b</sub> ' = F <sub>b</sub> * C <sub>D</sub> * C <sub>M</sub> * C <sub>F</sub> * C <sub>fu</sub> * C <sub>i</sub> * C <sub>r</sub> =	558.9 psi	F <sub>b seismic</sub> ' =	993.60 psi		
F <sub>v</sub> =	140	F <sub>v</sub> ' = F <sub>v</sub> * C <sub>D</sub> * C <sub>M</sub> * C <sub>i</sub> =	126 psi	F <sub>v seismic</sub> ' =	179.20 psi		

### BENDING DESIGN

<u>Load Case 7</u>	<u>Load Case 8</u>		
M <sub>MAX</sub> = WL <sup>2</sup> /8	1341.7 Ft#	M <sub>MAX</sub> = WL <sup>2</sup> /8	1610.0 Ft#
fb = M/S =	277.7 psi	fb = M/S =	333.223 psi
fb/F'b =	49.7%	fb/F'b =	33.5%

### SHEAR DESIGN

<u>Load Case 7</u>	<u>Load Case 8</u>		
V <sub>MAX</sub> = WL/2 =	536.7 #	V <sub>MAX</sub> = WL/2 =	644.0 #
f <sub>v</sub> = 3/2 * V/A =	12.73 psi	f <sub>v</sub> = 3/2 * V/A =	15.27 psi
f <sub>v</sub> /F' <sub>v</sub> =	10.1%	f <sub>v</sub> /F' <sub>v</sub> =	8.5%

### SUMMARY

Lagging Size = 6x12 HF#2	Governing Load Case = 0.6D+W+H
Max Pile Spacing = 10 ft	Bending Stress = <b>49.7% OK</b>
Max Retained Ht = 4 ft	Shear Stress = <b>10.1% OK</b>



250 4th Ave South  
 Suite 200  
 Edmonds, WA 98020

Description

Lagging Design

Project

Rudolf Site Walls

B/TJ

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Sheet No.

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**CONCRETE Wall E&G**

**CONCRETE RETAINING WALL SCHEDULE**

CONCRETE RETAINING WALL SCHEDULE									
WALL GEOMETRY						WALL REINFORCING			
Wall Type	MAX "H"	"T"	"B"	"t"	"D"	"S" BARS	"F" BARS	OT FS	SL FS
LC1	6'-0"	1'-3"	2'-10"	8"	12"	#4 @ 12" EDGE	#4 @ 9" (T&S)	3.77	1.5
LC2	6'-0"	1'-3"	2'-7"	8"	12"	#4 @ 12" EDGE	#4 @ 9" (T&S)	2.4	1.1
LC1	4'-0"	1'-0"	1'-7"	8"	12"	#4 @ 12" EDGE	#4 @ 9" (T&S)	3.29	1.58
LC2	4'-0"	1'-0"	1'-4"	8"	12"	#4 @ 13" EDGE	#4 @ 9" (T&S)	2.4	1.1

LC1        D+L+H  
 LC2        D+0.7E+H

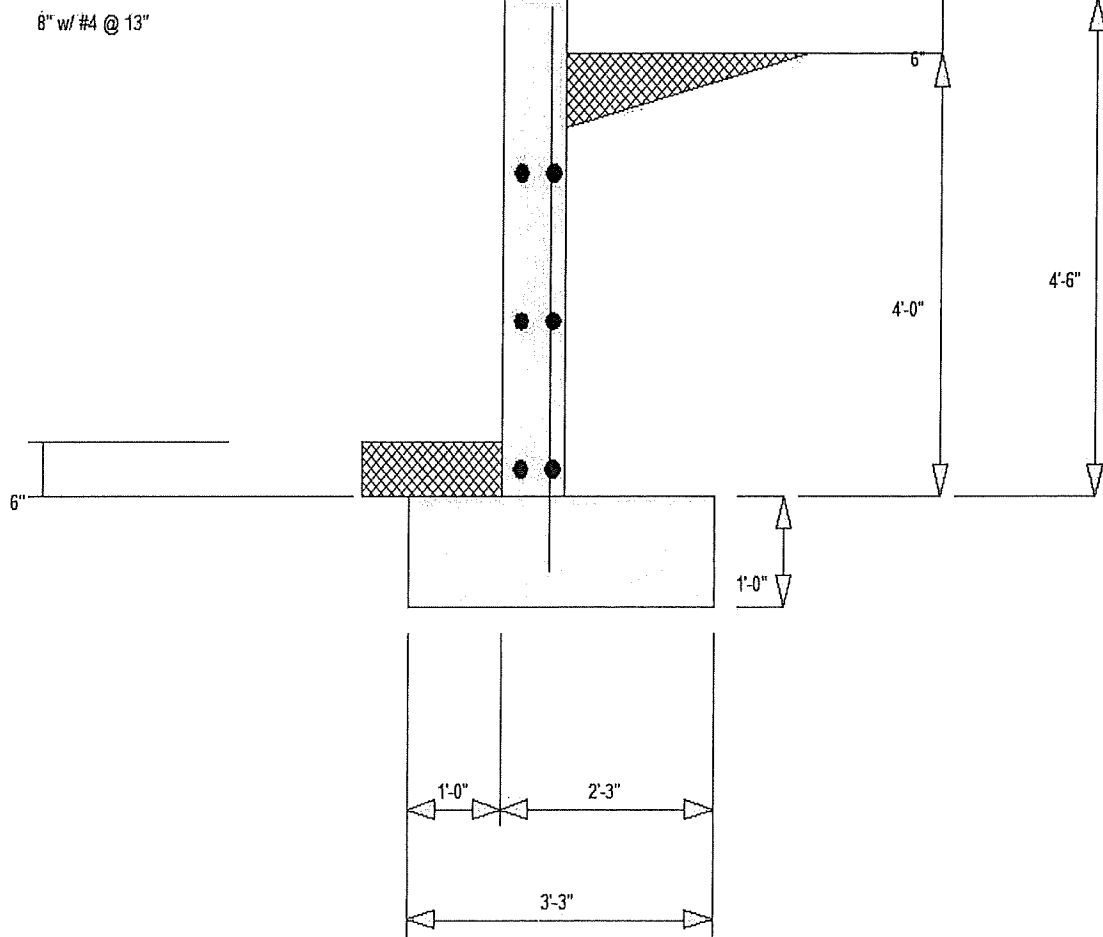


250 4th Ave. South  
 Suite 200  
 Edmonds, WA 98020

Description Concrete Wall Design	By	BTJ	Date	03/31/17
	Checked		Date	
	Scale		Sheet No.	
	Project	Rudolf Residence Site Walls	Job No.	15227.10

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4' LCI - NO EQ



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License To: CG ENGINEERING

**Criteria**

Retained Height = 4.00 ft  
Wall height above soil = 0.50 ft  
Slope Behind Wall = 0.00  
Height of Soil over Toe = 6.00 in  
Water height over heel = 0.0 ft

**Soil Data**

Allow Soil Bearing = 1,500.0 psf  
Equivalent Fluid Pressure Method = 40.0 psf/ft  
Active Heel Pressure = 300.0 psf/ft  
Passive Pressure = 130.00 pcf  
Soil Density, Heel = 0.00 pcf  
Soil Density, Toe = 0.00 pcf  
Footing/Soil Friction = 0.400  
Soil height to ignore for passive pressure = 12.00 in

**Concrete Stem Rebar Area Details**

Bottom Stem  
As (based on applied moment):  
0.0332 in<sup>2</sup>/ft  
0.0442 in<sup>2</sup>/ft  
200bf/ft; 200(12)(6.25)/60000 = 0.25 in<sup>2</sup>/ft  
0.0018bh; 0.0018(42)(9) = 0.1728 in<sup>2</sup>/ft  
One layer of: Two layers of:  
#4@ 12.50 in #4@ 25.00 in  
#5@ 19.39 in #5@ 38.75 in  
#6@ 27.50 in #6@ 55.00 in

Horizontal Reinforcing  
Min Stem T&S Reinf Area 0.864 in<sup>2</sup>  
Min Stem T&S Reinf Area per ft of stem Height = 0.192 in<sup>2</sup>/ft  
Horizontal Reinforcing Options:  
One layer of: Two layers of:  
#4@ 12.50 in #4@ 25.00 in  
#5@ 19.39 in #5@ 38.75 in  
#6@ 27.50 in #6@ 55.00 in

**Surcharge Loads**

Surcharge Over Heel = 0.0 psf  
Used To Resist Sliding & Overturning = 0.0  
Surcharge @ Toe = 0.0  
Used for Sliding & Overturning = 0.0

**Axial Load Applied to Stem**

Actual Dead Load = 0.0 lbs  
Actual Live Load = 0.0 lbs  
Actual Load Eccentricity = 0.0 in

**Stem Weight Seismic Load**

F<sub>p</sub> / W<sub>p</sub> Weight Multiplier = 0.200 g  
Added seismic base force = 63.0 lbs

**Footing Design Results**

Toe Width = 1.00 ft  
Heel Width = 2.25 ft  
Total Footing Width = 3.25 ft  
Footing Thickness = 12.00 in  
Key Depth = 0.00 in  
Key Distance from Toe = 0.00 ft  
Footing Concrete Density = 150.00 pcf  
Min. As % = 0.0018  
Cover @ Top = 3.00 in @ Elm = 3.00 in

Factored Pressure = 1,143 psf  
Mu' : Upward = 532 ft-lb  
Mu' : Downward = 129 ft-lb  
Mu : Design = 403 ft-lb  
Actual 1-Way Shear = 2.36 kips  
Allow 1-Way Shear = 75.00 psi  
Toe Reinforcing = None Spec'd  
Heel Reinforcing = None Spec'd  
Key Reinforcing = None Spec'd

Other Acceptable Sizes & Spacings  
Toes: #4@ 9.28 in, #6@ 14.35 in, #8@ 20.37 in, #10@ 27.78 in, #12@ 36.57 in, #16@ 46.50 in  
Heel: No req'd, #4@ 9.28 in, #6@ 14.35 in, #8@ 20.37 in, #10@ 27.78 in, #12@ 36.57 in, #16@ 46.50 in  
Key: No key defined

**Design Summary**

Overturning = 3.29 OK  
Sliding = 1.59 OK

Total Bearing Load = 1,761 lbs  
...resultant ecc. = 3.29 in

Soil Pressure @ Toe = 819 psf OK  
Soil Pressure @ Heel = 287 psf OK  
Allowable = 1,500 psf  
Soil Pressure Less Than Allowable

ACI Factored @ Toe = 1,143 psf  
ACI Factored @ Heel = 374 psf  
Footing Shear @ Toe = 2.4 psf OK  
Footing Shear @ Heel = 3.8 psf OK  
Allowable = 75.0 psf

Sliding Gates  
Lateral Sliding Force = 563.0 lbs  
less 100% Passive Force = 187.5 lbs  
less 100% Friction Force = 704.3 lbs  
Added Force Req'd = 0.0 lbs OK  
...for 1.5 Stability = 0.0 lbs OK

**Summary of Overturning & Resisting Forces & Moments**

Item	Force lbs	Overturning... Moment ft-lb	Resisting... Moment ft-lb
Heel Active Pressure	500.0	1.67	833.3
Surcharge over Heel			
Adjacent Footing Load			
Added Lateral Load			
Load @ Stem Above Soil			
Seismic Stem Soil Wt	63.0	3.25	204.8
Total	563.0	4.92	1,038.1
Resisting/Overturning Ratio			3.29
Vertical Loads used for Soil Pressure			1,760.8 lbs

**Stem Construction**

Design Height Above Fig = 0.00 ft  
Wall Material Above "Ht" = Concrete  
Design Method = LRFD  
Thickness = 8.00 in  
Rebar Size = # 4  
Rebar Spacing = 13.00 in  
Rebar Placed at = Edge  
Design Data  
f<sub>y</sub>/f<sub>u</sub> = 0.776

**Total Force @ Section**

Service Level lbs = 602.0  
Strength Level lbs = 885.2  
Moment... Actual ft-lb = 5,041.5  
Moment... Allowable ft-lb = 5,041.5  
Shear... Actual psi = 8.0  
Service Level psi = 82.2  
Strength Level psi = 100.0  
Shear... Allowable psi = 6.25  
Wall Weight in = 6.25  
Rebar Depth 'd' in = 6.25  
Masonry Data

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing**

**Load Factors**

Building Code = IBC 2015, ACI  
Dead Load = 1.200  
Live Load = 1.600  
Earth, H = 1.500  
Wind, W = 1.000  
Seismic, E = 1.000

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing**

**Load Factors**

Building Code = IBC 2015, ACI  
Dead Load = 1.200  
Live Load = 1.600  
Earth, H = 1.500  
Wind, W = 1.000  
Seismic, E = 1.000

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.**

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of Sliding Resistance.**

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.**

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of Sliding Resistance.**

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.**

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of Sliding Resistance.**

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing**

**Load Factors**

Building Code = IBC 2015, ACI  
Dead Load = 1.200  
Live Load = 1.600  
Earth, H = 1.500  
Wind, W = 1.000  
Seismic, E = 1.000

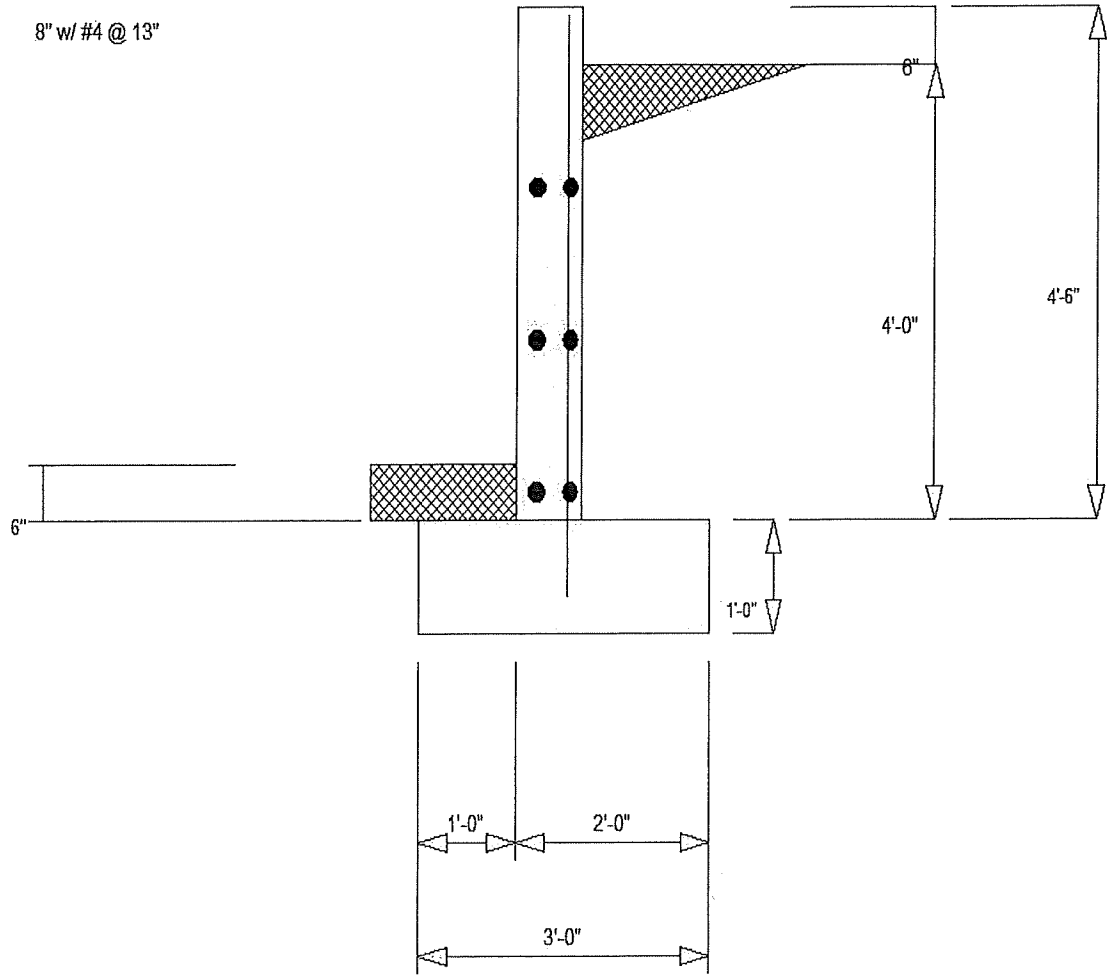
**Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing**

**Load Factors**

Building Code = IBC 2015, ACI  
Dead Load = 1.200  
Live Load = 1.600  
Earth, H = 1.500  
Wind, W = 1.000  
Seismic, E = 1.000

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4' LC2 - w/ EQ



**Criteria**

Retained Height	=	4.00 ft
Wall height above soil	=	0.50 ft
Slope behind Wall	=	0.00
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft

**Soil Data**

Allow Soil Bearing	=	1,500.0 psf
Equivalent Fluid Pressure Method	=	40.0 ps/ft
Active Heel Pressure	=	300.0 ps/ft
Passive Pressure	=	130,000 pcf
Soil Density, Heel	=	0.00 pcf
Soil Density, Toe	=	0.400
Footings Soil Friction	=	12.00 in
Soil height to ignore for passive pressure	=	12.00 in

**Lateral Load Applied to Stem**

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft
Load Type	=	Wind (W)
Wind on Exposed Stem (Service Level)	=	0.0 psf

**Axial Load Applied to Stem**

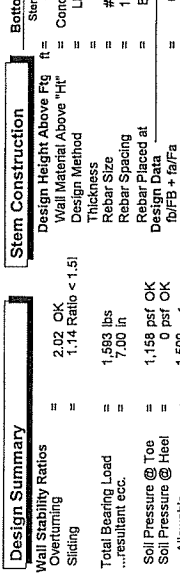
Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

**Earth Pressure Seismic Load**

Method - Uniform	=	9.000
Multiplier Used (Multiplier based on soil density)	=	225.000

**Stem Weight Seismic Load**

$F_p / W_p$ Weight Multiplier	=	0.200 g
Added seismic base force	=	63.0 lbs



**Surcharge Loads**

Surcharge Over Heel	=	0.0 psf
Used to Resist Sliding & Overturning	=	0.0
Surcharge Over Toe	=	0.0
Used for Sliding & Overturning	=	0.0

**Adjacent Footing Load**

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Fig CL Dist	=	0.00 ft
Footing Type	=	Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

**Soil Data**

Allow Soil Bearing	=	1,500.0 psf
Equivalent Fluid Pressure Method	=	40.0 ps/ft
Active Heel Pressure	=	300.0 ps/ft
Passive Pressure	=	130,000 pcf
Soil Density, Heel	=	0.00 pcf
Soil Density, Toe	=	0.400
Footings Soil Friction	=	12.00 in
Soil height to ignore for passive pressure	=	12.00 in

**Lateral Load Applied to Stem**

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft
Load Type	=	Wind (W)
Wind on Exposed Stem (Service Level)	=	0.0 psf

**Design Summary**

Wall Stability Ratios	=	2.02 OK
Overturning	=	1.14 Ratio < 1.51
Sliding	=	1.583 lbs
Total Bearing Load	=	7.00 in
...resultant ecc.	=	1,158 psf OK
Soil Pressure @ Toe	=	0 psf OK
Soil Pressure @ Heel	=	1,500 psf
Allowable	=	Soil Pressure Less Than Allowable
ACI Factored @ Toe	=	1,622 psf
ACI Factored @ Heel	=	0 psf
Footing Shear @ Toe	=	3.6 psi OK
Footing Shear @ Heel	=	7.1 psi OK
Allowable	=	75.0 psi
Sliding Cates	=	720.5 lbs
Lateral Sliding Force	=	less 100% Passive Force = 187.5 lbs
less 100% Friction Force	=	637.3 lbs
Added Force Req'd	=	0.0 lbs OK
...for 1.5 Stability	=	255.9 lbs NG

**Stem Construction**

Design Height Above Fig	=	Stem OK
Wall Material Above "H"	=	Concrete
Design Method	=	LRFD
Thickness	=	# 4
Rebar Spacing	=	13.00
Rebar Placed at	=	Edge
Design Data	=	0.247
lbFB + lbFA	=	0.247
Total Force @ Section	=	lbs = 782.0
Service Level	=	Strength Level
Moment.....Actual	=	ft-# = 1,245.2
Service Level	=	Moment.....Allowable
Strength Level	=	ft-# = 5,041.5
Shear.....Actual	=	psi = 10.4
Service Level	=	Strength Level
Strength Level	=	psi = 82.2
Shear.....Allowable	=	psi = 100.0
Wall Weight	=	psf = 6.25
Rebar Depth 'd'	=	in = 6.25
rm	=	psi = 3,000.0
F's	=	psi = 60,000.0

**Load Factors**

Building Code	=	IBC 2015, ACI
Dead Load	=	1.200
Live Load	=	1.600
Earth, H	=	1.600
Wind, W	=	1.000
Seismic, E	=	1.000

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing**

Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing	=	0.0 lbs
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**Concrete Data**

Masonry Design Method	=	ASD
Medium Weight	=	Medium Weight
Concrete Data	=	psi = 3,000.0
Fy	=	psi = 60,000.0

This Wall in File: R:\2015 Projects\15227.20 Rudolf Residence Civil Design\Site Walls\Engineering\S  
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 License: KW-06056761 Cantilevered Retaining Wall

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 License: KW-06056761 Cantilevered Retaining Wall

**Titl**

**Horizontal Deflection at Top of Wall due to settlement of soil**  
 (Deflection due to wall bending not considered)

Soil Spring Reaction Modulus = 250.0 pci  
 Horizontal Def @ Top of Wall (approximate only) = 0.048 in  
 The above calculation is not valid if the heel soil bearing pressure exceeds that of the toe, because the wall would then tend to rotate into the retained soil.

**Concrete Stem Rebar Area Details**

Bottom Stem Vertical Reinforcing Horizontal Reinforcing  
 As (based on applied moment): 0.0467 in<sup>2</sup>/ft  
 (4/3) - As = 0.0622 in<sup>2</sup>/ft  
 200bfy: 200(1/2)(6.25)/60000 = 0.25 in<sup>2</sup>/ft  
 0.0018bh: 0.0018(12)(9) = 0.1728 in<sup>2</sup>/ft

Required Area: 0.1728 in<sup>2</sup>/ft  
 Provided Area: 0.1846 in<sup>2</sup>/ft  
 Maximum Area: 1.015 in<sup>2</sup>/ft

Min Stem T&S Reinf Area 0.864 in<sup>2</sup>  
 Min Stem T&S Reinf Area per ft of stem Height : 0.192 in<sup>2</sup>/ft  
 Horizontal Reinforcing Options :  
 One layer of : Two layers of :  
 #4@ 12.50 in #4@ 25.00 in  
 #5@ 19.36 in #5@ 38.75 in  
 #6@ 27.50 in #6@ 55.00 in

**Footing Design Results**

Toe Heel  
 Factored Pressure = 1,622 0 psf  
 Mu : Upward = 713 125 ft-#  
 Mu : Downward = 129 715 ft-#  
 Mu: Design = 584 589 ft-#  
 Actual 1-Way Shear = 3.58 7.11 psi  
 Allow 1-Way Shear = 75.00 75.00 psi  
 Toe Reinforcing = None Specd  
 Heel Reinforcing = None Specd  
 Key Reinforcing = None Specd

Other Acceptable Sizes & Spacings  
 Toe: #4@ 9.26 in, #5@ 14.35 in, #6@ 20.37 in, #7@ 27.78 in, #8@ 36.57 in, #9@ 46  
 Heel: Not req'd; Mu < phi\*(5\*lambda)\*sqrt(fc)\*Sm  
 Key: No key defined

Min footing T&S reinf Area 0.78 in<sup>2</sup>  
 Min footing T&S reinf Area per foot 0.26 in<sup>2</sup>/ft  
 If one layer of horizontal bars:  
 #4@ 9.26 in  
 #5@ 14.35 in  
 #6@ 20.37 in

**Footing Dimensions & Strengths**

Toe Width = 1.00 ft  
 Heel Width = 2.00 ft  
 Total Footing Width = 3.00 ft  
 Footing Thickness = 12.00 in  
 Key Width = 0.00 in  
 Key Depth = 0.00 in  
 Key Distance from Toe = 0.00 ft

fc = 2,500 psi  
 Fy = 60,000 psi  
 Footing Concrete Density = 150.00 pcf  
 Min. As % = 0.0018  
 Cover @ Top = 3.00 @ Btm = 3.00 in

**Summary of Overturning & Resisting Forces & Moments**

Item	Force lbs	Overturning Distance ft	Moment ft-#	Resisting Force lbs	Resisting Distance ft	Moment ft-#
Heel Active Pressure	500.0	1.67	833.3	Soil Over Heel	683.3	2.33
Surcharge over Heel				Sloped Soil Over Heel		1,617.8
Surcharge Over Toe				Surcharge Over Heel		
Adjacent Footing Load				Adjacent Footing Load		
Added Lateral Load				Axial Dead Load on Stem		
Load @ Stem Above Soil	157.5	2.50	393.8	Axial Live Load on Stem		0.50
Seismic Earth Load	63.0	3.25	204.8	Soil Over Toe		
Seismic Stem Self Wt	720.5	0.1 M.	1,431.8	Surcharge Over Toe		
<b>Total</b>				Stem Weight(s)		800.0
				Earth @ Stem Transitions		
Resisting/Overturning Ratio				Footing Weight		675.0
Vertical Loads used for Soil Pressure =				Vert. Component		
				<b>Total</b>		<b>1,583.3 lbs R.M. = 2,892.8</b>

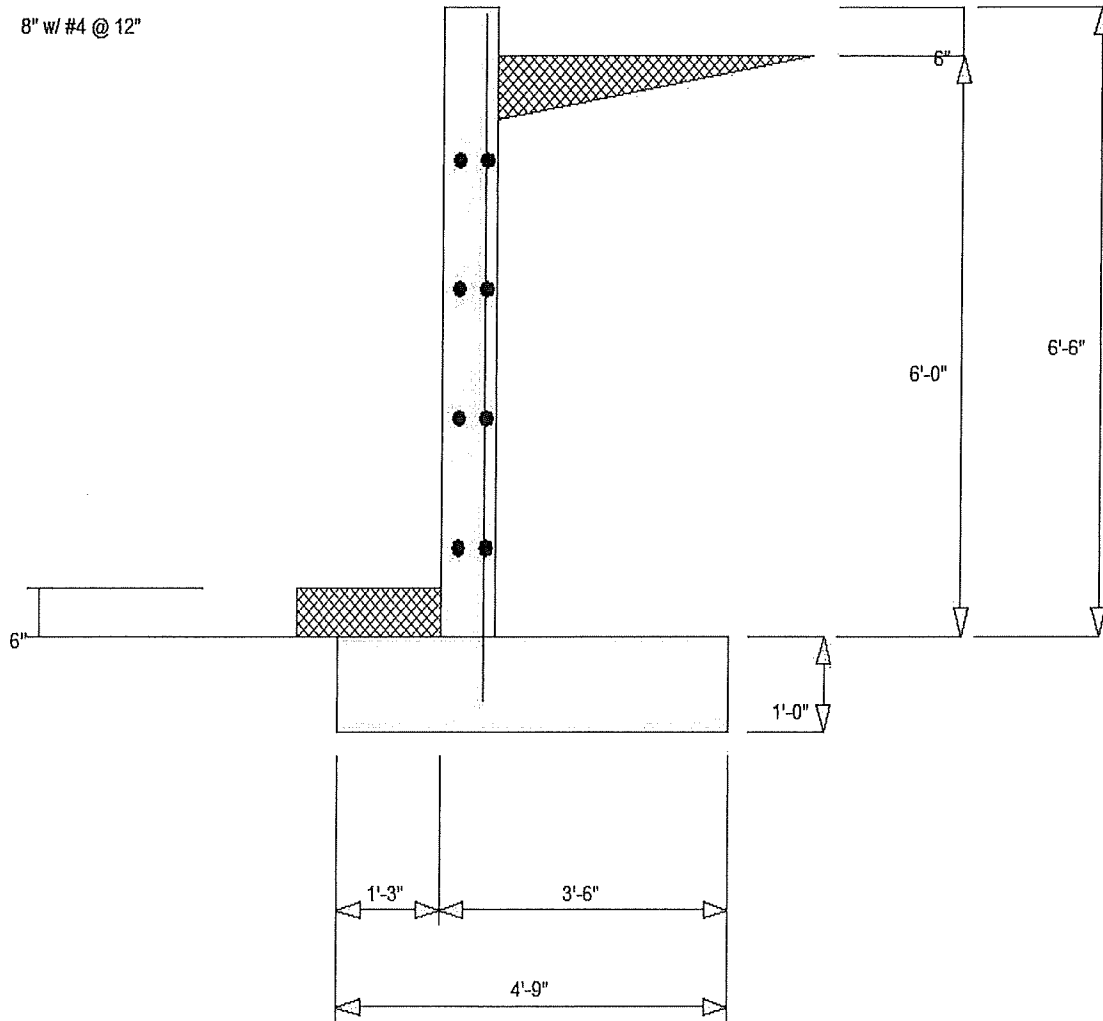
If seismic is included, the OTM and sliding ratios be 1.1 per section 1807.2.3 of IBC 2009 or IBC 201 calculation of Sliding Resistance.

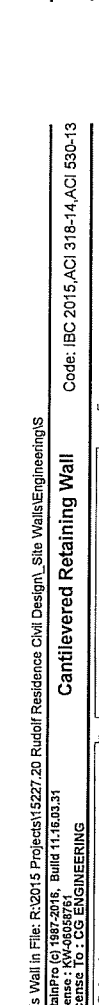
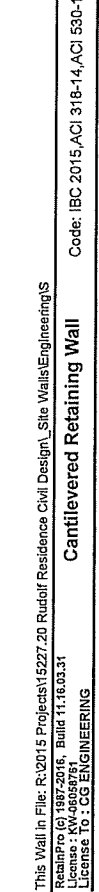
Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.

\* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.

6' LCI - NO EQ

8" w/ #4 @ 12"





**Criteria**

Retained Height = 6.00 ft  
Wall height above soil = 0.50 ft  
Slope Behind Wall = 0.00  
Height of Soil over Toe = 6.00 in  
Water height over heel = 0.0 ft

Allow Soil Bearing = 1,500.0 psf  
Equivalent Fluid Pressure Method = 40.0 psf/ft  
Active Heel Pressure = 300.0 psf/ft  
Passive Pressure = 130.00 pcf  
Soil Density, Heel = 0.00 pcf  
Soil Density, Toe = 0.400  
Footing/Soil Friction = 12.00 in  
Soil height to ignore for passive pressure = 0.400

**Surcharge Loads**

Surcharge Over Heel = 0.0 psf  
Used for Sliding & Overturning = 0.0  
Surcharge Over Toe = 0.0  
Used for Sliding & Overturning = 0.0

**Axial Load Applied to Stem**

Axial Dead Load = 0.0 lbs  
Axial Live Load = 0.0 lbs  
Axial Load Eccentricity = 0.0 in

**Stem Weight Seismic Load**

$F_p / W_p$  Weight Multiplier = 0.200 g  
Added seismic base force = 91.0 lbs

**Soil Data**

Allow Soil Bearing = 1,500.0 psf  
Equivalent Fluid Pressure Method = 40.0 psf/ft  
Active Heel Pressure = 300.0 psf/ft  
Passive Pressure = 130.00 pcf  
Soil Density, Heel = 0.00 pcf  
Soil Density, Toe = 0.400  
Footing/Soil Friction = 12.00 in  
Soil height to ignore for passive pressure = 0.400

**Lateral Load Applied to Stem**

Lateral Load = 0.0 #/ft  
...Height to Top = 0.00 ft  
...Height to Bottom = 0.00 ft  
Eccentricity = 0.00 ft  
Load Type = Wind (W)  
(Service Level)  
Footing Type = Line Load  
Base Above/Below Soil = 0.0 ft  
at Back of Wall = 0.300  
Poisson's Ratio = 0.200 g  
Added seismic base force = 91.0 lbs

**Design Summary**

Wall Stability Ratios = 3.77 OK  
Overturning = 1.51 OK  
Sliding = 3.57 OK  
Total Bearing Load = 3.59 in  
...resultant ecc. = 1,057 psf OK  
Soil Pressure @ Toe = 1,500 psf OK  
Soil Pressure @ Heel = 1,451 psf OK  
Allowable Soil Pressure Less Than Allowable = 655 psf  
ACI Factored @ Toe = 6.0 psi OK  
ACI Factored @ Heel = 6.2 psi OK  
Footing Shear @ Toe = 75.0 psi Allowable  
Footing Shear @ Heel = 1,071.0 lbs  
Lateral Sliding Force = 187.5 lbs  
less 100% Passive Force = - 1,429.0 lbs  
less 100% Friction Force = 0.0 lbs OK  
Added Force Req'd = 0.0 lbs OK  
...for 1.5 Stability = 0.0 lbs OK

**Stem Construction**

Design Height Above Fg = 0.00 ft  
Wall Material Above "Ht" = Concrete  
Design Method = LRFD  
Thickness = 8.00  
Rebar Size = # 4  
Rebar Spacing = 12.00  
Rebar Placed at = Edge  
Design Data = f<sub>y</sub>/F<sub>y</sub> + f<sub>a</sub>/F<sub>a</sub> = 0.500  
Total Force @ Section = 1,282.0 lbs  
Service Level = 2,726.5 lbs  
Strength Level = 5,448.0 lbs  
Moment...Actual = 17.1  
Strength Level = 82.2  
Shear...Allowable = 100.0  
Strength Level = 6.25  
Rebar Depth 'd' = 6.25 in  
F<sub>s</sub> =  
F<sub>s</sub> =  
Solid Grouting =  
Modular Ratio 'n' =  
Short Term Factor =  
Equiv. Soil Thick. =  
Masonry Block Type = Medium Weight  
Masonry Design Method = ASD  
Concrete Data =  
F<sub>c</sub> = 3,000.0  
F<sub>y</sub> = 60,000.0

**Design Summary**

Wall Stability Ratios = 3.77 OK  
Overturning = 1.51 OK  
Sliding = 3.57 OK  
Total Bearing Load = 3.59 in  
...resultant ecc. = 1,057 psf OK  
Soil Pressure @ Toe = 1,500 psf OK  
Soil Pressure @ Heel = 1,451 psf OK  
Allowable Soil Pressure Less Than Allowable = 655 psf  
ACI Factored @ Toe = 6.0 psi OK  
ACI Factored @ Heel = 6.2 psi OK  
Footing Shear @ Toe = 75.0 psi Allowable  
Footing Shear @ Heel = 1,071.0 lbs  
Lateral Sliding Force = 187.5 lbs  
less 100% Passive Force = - 1,429.0 lbs  
less 100% Friction Force = 0.0 lbs OK  
Added Force Req'd = 0.0 lbs OK  
...for 1.5 Stability = 0.0 lbs OK

**Concrete Stem Rebar Area Details**

Bottom Stem Vertical Reinforcing = 0.1022 in<sup>2</sup>/ft  
As (based on applied moment) = 0.1362 in<sup>2</sup>/ft  
(4/3) - As = 0.25 in<sup>2</sup>/ft  
200b/ft<sup>2</sup>: 200(12)/(6.25)/60000 = 0.1728 in<sup>2</sup>/ft  
Horizontal Reinforcing Options :  
One layer of : Two layers of :  
#4@ 12.50 in #4@ 25.00 in  
#5@ 19.38 in #5@ 38.75 in  
#6@ 27.50 in #6@ 55.00 in  
Maximum Area : 1.016 in<sup>2</sup>/ft

**Design Summary**

Wall Stability Ratios = 3.77 OK  
Overturning = 1.51 OK  
Sliding = 3.57 OK  
Total Bearing Load = 3.59 in  
...resultant ecc. = 1,057 psf OK  
Soil Pressure @ Toe = 1,500 psf OK  
Soil Pressure @ Heel = 1,451 psf OK  
Allowable Soil Pressure Less Than Allowable = 655 psf  
ACI Factored @ Toe = 6.0 psi OK  
ACI Factored @ Heel = 6.2 psi OK  
Footing Shear @ Toe = 75.0 psi Allowable  
Footing Shear @ Heel = 1,071.0 lbs  
Lateral Sliding Force = 187.5 lbs  
less 100% Passive Force = - 1,429.0 lbs  
less 100% Friction Force = 0.0 lbs OK  
Added Force Req'd = 0.0 lbs OK  
...for 1.5 Stability = 0.0 lbs OK

**Footing Design Results**

Toe Width	=	1.25 ft
Heel Width	=	3.50 ft
Total Footing Width	=	4.75 ft
Footing Thickness	=	12.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	0.00 in
Key Distance from Heel	=	0.00 in
Factored Pressure	=	1,451 psf
Mu' : Upward	=	1,079 psf
Mu' : Downward	=	202 psf
Mu : Design	=	878 psf
Actual 1-Way Shear	=	5.96 psi
Allow 1-Way Shear	=	75.00 psi
Toe Reinforcing	=	None Spec'd
Heel Reinforcing	=	None Spec'd
Key Reinforcing	=	None Spec'd

**Summary of Overturning & Resisting Forces & Moments**

Item	Overturning... Force lbs	Overturning... Distance ft	Moment ft-lb	Resisting... Force lbs	Resisting... Distance ft	Moment ft-lb
Heel Active Pressure	=	980.0	2.33	=	2,210.0	3.33
Surcharge over Heel	=			=		
Adjacent Footing Load	=			=		
Added Lateral Load	=			=		
Load @ Stem Above Soil	=			=		
Seismic Stem Self Wt	=	91.0	4.25	=	650.0	0.83
Total	=	1,071.0	0 T.M.	=	712.5	2.38
Resisting/Overturning Ratio	=			=		3.77
Vertical Loads used for Soil Pressure	=			=		3,572.5 lbs

**Other Acceptable Sizes & Spacings**

Toe: #4@ 9.26 in, #5@ 14.35 in, #6@ 20.37 in, #7@ 27.78 in, #8@ 35.57 in, #9@ 46 in  
Heel: Not req'd; Mu < phi\*S\*lambda\*sqrt(f'c)/S\*  
Key: No key defined

Min footing T&S rebar Area = 1.23 in<sup>2</sup>  
Min footing T&S rebar Area per foot = 0.28 in<sup>2</sup>/ft  
If one layer of horizontal bars:  
#4@ 9.26 in  
#5@ 14.35 in  
#6@ 20.37 in  
#8@ 40.74 in

**Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.**

Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.

Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.

Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.

**Design Factors**

Building Code = IBC 2015, ACI  
Dead Load = 1.200  
Live Load = 1.600  
Earth, H = 1.600  
Earth, V = 1.000  
Wind, W = 1.000  
Seismic, E = 1.000

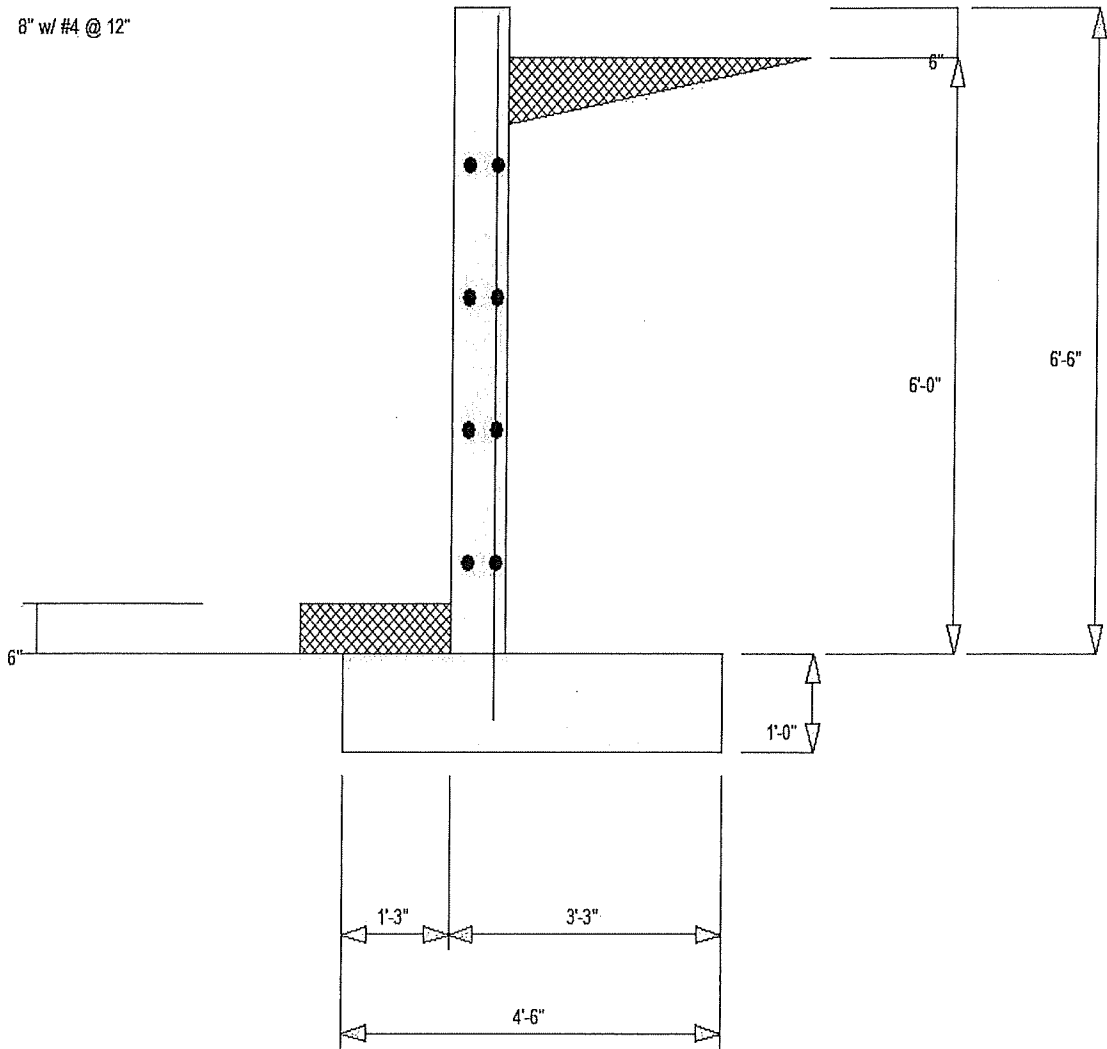
**Design Factors**

Building Code = IBC 2015, ACI  
Dead Load = 1.200  
Live Load = 1.600  
Earth, H = 1.600  
Earth, V = 1.000  
Wind, W = 1.000  
Seismic, E = 1.000



6' LC2 - W/ EQ

8" w/ #4 @ 12"



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Code: IBC 2015, ACI 318-14, ACI 530-13  
License To: CG ENGINEERING

### Cantilevered Retaining Wall

Design Summary		Stem Construction	
Wall Stability Ratios	= 2.40 OK	Design Height Above Flg	ft = 0.00
Overturning	= 1.10 Ratio < 1.51	Wall Material Above "H"	= Concrete
Sliding	= 3.90 lbs	Thickness	= LRFD
Total Bearing Load	= 8.11 in	Rebar Size	= # 4
...resultant ecc.	= 8.11 in	Rebar Spacing	= 12.00
Soil Pressure @ Toe	= 1,411 psf OK	Rebar Placed at	= Edge
Soil Pressure @ Heel	= 74 psf OK	Design Data	
Allowable	= 1,500 psf	Total Force @ Section	
Soil Pressure Less Than Allowable		Service Level	lbs = 0.799
ACI Factored @ Toe	= 1,975 psf	Strength Level	lbs = 1,680.0
ACI Factored @ Heel	= 105 psf	Moment.....Actual	
Footng Shear @ Toe	= 8.4 psi OK	Service Level	ft-# = 3,860.5
Footng Shear @ Heel	= 12.0 psi OK	Strength Level	ft-# = 5,448.0
Allowable	= 75.0 psi	Moment.....Allowable	
Sliding Cales		Shear.....Actual	
Lateral Sliding Force	= 1,379.7 lbs	Service Level	psi =
less 100% Passive Force	= - 187.5 lbs	Strength Level	psi = 22.1
less 100% Friction Force	= - 1,356.0 lbs	Shear.....Allowable	psi = 82.2
Added Force Req'd	= 0.0 lbs OK	Wall Weight	psf = 100.0
...for 1.5 Stability	= 546.1 lbs NG	Rebar Depth 'd'	in = 6.25

Load Factors		Masonry Data	
Building Code	IBC 2015, ACI	fm	psi =
Dead Load	1,200	Fs	psi =
Live Load	1,600	Solid Grouting	=
Earth, H	1,600	Modular Ratio 'n'	=
Wind, W	1,000	Short Term Factor	=
Seismic, E	1,000	Equiv. Solid Thick.	=
		Masonry Block Type	= Medium Weight
		Masonry Design Method	= ASD
		Concrete Data	
		f'c	psi = 3,000.0
		Fy	psi = 60,000.0

Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing

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### Cantilevered Retaining Wall

Criteria		Soil Data	
Retained Height	= 6.00 ft	Allow Soil Bearing	= 1,500.0 psf
Wall height above soil	= 0.50 ft	Equivalent Fluid Pressure Method	
Slope Behind Wall	= 0.00	Active Heel Pressure	= 40.0 psi/ft
Water height over heel	= 0.0 ft	Passive Pressure	= 300.0 psf/ft
		Soil Density, Heel	= 130.00 pcf
		Soil Density, Toe	= 0.00 pcf
		Footng Soil Friction	= 0.400
		Soil height to ignore for passive pressure	= 12.00 in

Surcharge Loads		Lateral Load Applied to Stem	
Surcharge Over Heel	= 0.0 psf	Lateral Load	= 0.0 #/ft
Used To Resist Sliding & Overturning		...Height to Top	= 0.00 ft
Surcharge Over Toe	= 0.0	...Height to Bottom	= 0.00 ft
Used for Sliding & Overturning		Load Type	= Wind (W)
		Wind on Exposed Stem =	0.0 psf
		(Service Level)	
		Uniform Seismic Force	= 63,000
		Total Seismic Force	= 441,000

Axial Load Applied to Stem		Earth Pressure Seismic Load	
Axial Dead Load	= 0.0 lbs	Method : Uniform	
Axial Live Load	= 0.0 lbs	Multiplier Used	= 9,000
Axial Load Eccentricity	= 0.0 in	(Multiplier used on soil density)	
		Stem Weight Seismic Load	
		Fp / Wp Weight Multiplier	= 0.200 g
		Added seismic base force	= 91.0 lbs

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Code: IBC 2015, ACI 318-14, ACI 530-13  
Title: Cantilevered Retaining Wall  
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Code: IBC 2015, ACI 318-14, ACI 530-13  
Title: Cantilevered Retaining Wall  
License To: CG ENGINEERING

**Concrete Stem Rebar Area Details**

Bottom Stem  
As (based on applied moment): 0.1448 in<sup>2</sup>/ft  
(4/3) \* As: 0.1928 in<sup>2</sup>/ft  
200bdly: 200(12)(6.25)/60000 = 0.25 in<sup>2</sup>/ft  
0.0016bh: 0.0016(12)(6) = 0.1178 in<sup>2</sup>/ft

Required Area: 0.1928 in<sup>2</sup>/ft  
Provided Area: 0.2 in<sup>2</sup>/ft  
Maximum Area: 1.016 in<sup>2</sup>/ft

Vertical Reinforcing  
Horizontal Reinforcing  
Min Stem T&S Rebar Area 1.248 in<sup>2</sup>  
Min Stem T&S Rebar Area per ft of stem Height: 0.192 in<sup>2</sup>/ft

Horizontal Reinforcing Options:  
One layer of: Two layers of:  
#4@ 12.50 in #4@ 25.00 in  
#5@ 19.38 in #5@ 38.75 in  
#6@ 27.50 in #6@ 55.00 in

**Footing Design Results**

Toe Width	= 1.25 ft	Heel	
Heel Width	= 3.25	Factored Pressure	= 1,975
Total Footing Width	= 4.50	Min.: Upward	= 103 psf
Footing Thickness	= 12.00 in	Min.: Downward	= 1,408
Key Width	= 0.00 in	Min. Design	= 3,724 ft#
Key Depth	= 0.00 in	Allow 1-Way Shear	= 1,206
Key Distance from Toe	= 0.00 ft	Allow 1-Way Shear	= 75.38
fc =	2,500 psi	Toe Reinforcing	= None Speed
Footing Concrete Density =	150.00 pcf	Heel Reinforcing	= None Speed
Min. As %	= 0.0018	Key Reinforcing	= None Speed
Cover @ Top	3.00	Other Acceptable Sizes & Spacings	

Toe: #4@ 9.26 in, #5@ 14.35 in, #6@ 20.37 in, #7@ 27.78 in, #8@ 36.57 in, #9@ 46  
Heel: Not req'd; Mu < phi\*5\*lambda\*sq(ft)\*S-m  
Key: No key defined

Min footing T&S rebar Area 1.17 in<sup>2</sup>  
Min footing T&S rebar Area per foot 0.26 in<sup>2</sup>/ft  
If one layer of horizontal bars: #4@ 9.26 in #4@ 16.52 in #5@ 28.70 in #6@ 40.74 in

**Horizontal Deflection at Top of Wall due to settlement of soil**  
(Deflection due to wall bending not considered)

Soil Spring Reaction Modulus 250.0 pci  
Horizontal Defl @ Top of Wall (approximate only) 0.057 in

The above calculation is not valid if the heel soil bearing pressure exceeds that of the toe, because the wall would then tend to rotate into the retained soil.

**Summary of Overturning & Resisting Forces & Moments**

Item	Force lbs	Overturning Moment ft#	Resisting Force lbs	Resisting Moment ft#
Heel Active Pressure	= 960.0	2.33		
Surcharge over Heel	=			
Surcharge over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Seismic Earth Load	= 308.7	3.50		
Seismic Stem Self Wt	= 91.0	4.25		
<b>Total</b>	<b>1,379.7</b>	<b>O.T.M. = 3,753.9</b>		
Resisting/Overturning Ratio		= 2.40		
Vertical Loads used for Soil Pressure		= 3,340.0 lbs		

Total = 3,340.0 lbs R.M. = 9,012.7  
\* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.

Vertical component of active lateral soil pressure IS considered in the calculation of Sliding Resistance.

Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.