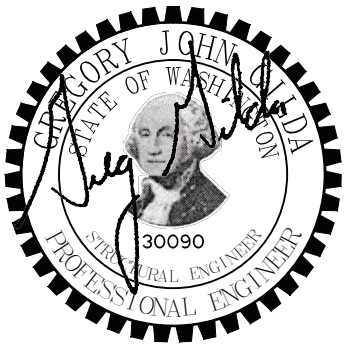
Structural Calculations

Mercer Lake House

6236 SE 22nd St

Mercer Island Washington, 98040

Retaining Wall



DCI Job Number23012-0025

February 2, 2024

DCI ENGINEERS

Project Title: MLH Beach House
Engineer: PL
Project ID: 23012-0025
Project Descr:

Cantilevered Retaining Wall

Project File: Retaining Wall.ec6

DESCRIPTION: Retaining Wall

Code Reference

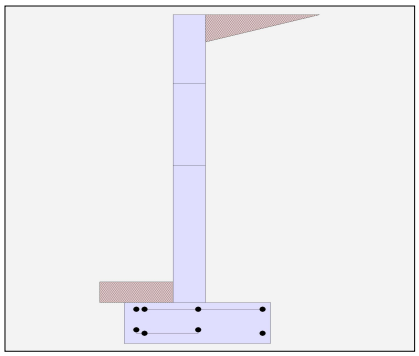
Calculations per IBC 2018 1807.3, CBC 2019, ASCE 7-16

Criteria

Retained Height	=	7.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00
Height of Soil over Toe	=	6.00 in
Water table above bottom of footing	=	0.0 ft

Soil Data

Allow Soil Bearing	=	2,000.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	5.0 psf/ft
	=	
Passive Pressure	=	300.0 psf/ft
Soil Density, Heel	=	130.00 pcf
Soil Density, Toe	=	130.00 pcf
Footing||Soil Friction	=	0.400
Soil height to ignore for passive pressure	=	12.00 in



Surcharge Loads

Surcharge Over Heel	=	50.0 psf
NOT Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	100.0 #/ft
...Height to Top	=	1.00 ft
...Height to Bottom	=	0.00 ft
Load Type	=	Live Load (L) (Service Level)
Wind on Exposed Stem (Strength Level)	=	0.0 psf

Adjacent Footing Load

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

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

Multiplier Used	=	1.000
(Multiplier used on soil density)		
Uniform Seismic Force	=	8.000
Total Seismic Force	=	64.000

Stem Weight Seismic Load

F_p / W_p Weight Multiplier = 0.452 g

Added seismic base force 221.5 lbs

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Design Summary

Wall Stability Ratios

Overturning	=	2.47	OK
Sliding	=	2.14	OK
Global Stability	=	8.32	

Total Bearing Load	=	2,428	lbs
...resultant ecc.	=	4.87	in

Eccentricity within middle third

Soil Pressure @ Toe	=	1,466 psf	OK
Soil Pressure @ Heel	=	153 psf	OK
Allowable	=	2,000 psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	2,109 psf	
ACI Factored @ Heel	=	220 psf	
Footing Shear @ Toe	=	5.0 psi	OK
Footing Shear @ Heel	=	8.3 psi	OK
Allowable	=	75.0 psi	

Sliding Calcs

Lateral Sliding Force	=	541.7 lbs	
less 100% Passive Force	-	187.5 lbs	
less 100% Friction Force	-	971.3 lbs	
Added Force Req'd	=	0.0 lbs	OK
....for 1.5 Stability	=	0.0 lbs	OK

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

Load Factors

Building Code	
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		3rd	2nd	Bottom		
		Stem OK	Stem OK	Stem OK		
Design Height Above Ftg	ft =	5.33	3.33	0.00		
Wall Material Above "Ht"	=	Concrete	Concrete	Concrete		
Design Method	=	SD	SD	SD	SD	SD
Thickness	=	8.00	8.00	8.00		
Rebar Size	=	# 5	# 5	# 5		
Rebar Spacing	=	16.00	18.00	18.00		
Rebar Placed at	=	Center	Edge	Edge		
Design Data						
fb/FB + fa/Fa	=	**0.021**	**0.080**	**0.346**		
Total Force @ Section						
Service Level	lbs =					
Strength Level	lbs =	105.1	260.4	749.9		
Moment....Actual						
Service Level	ft-# =					
Strength Level	ft-# =	84.7	444.9	1,916.1		
Moment.....Allowable	ft-# =	3,898.0	5,527.6	5,527.6		
Shear.....Actual						
Service Level	psi =					
Strength Level	psi =	2.2	3.5	10.1		
Shear.....Allowable	psi =	75.0	75.0	75.0		
Anet (Masonry)	in2 =					
Wall Weight	psf =	100.0	100.0	100.0		
Rebar Depth 'd'	in =	4.00	6.19	6.19		

Masonry Data

f'm	psi =	
Fs	psi =	
Solid Grouting	=	
Modular Ratio 'n'	=	
Equiv. Solid Thick.	=	
Masonry Block Type	=	
Masonry Design Method	=	ASD

Concrete Data

f'c	psi =	2,500.0	2,500.0	2,500.0
Fy	psi =	60,000.0	60,000.0	60,000.0

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Concrete Stem Rebar Area Details

3rd Stem	Vertical Reinforcing	Horizontal Reinforcing	
As (based on applied moment) :	0.0051 in2/ft		
(4/3) * As :	0.0068 in2/ft	Min Stem T&S Reinf Area 0.321 in2	
200bd/fy : 200(12)(4)/60000 :	0.16 in2/ft	Min Stem T&S Reinf Area per ft of stem Height : 0.192 in2/ft	
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	==========	One layer of :	Two layers of :
Required Area :	0.1728 in2/ft	#4@ 12.50 in	#4@ 25.00 in
Provided Area :	0.2325 in2/ft	#5@ 19.38 in	#5@ 38.75 in
Maximum Area :	0.5419 in2/ft	#6@ 27.50 in	#6@ 55.00 in

2nd Stem	Vertical Reinforcing	Horizontal Reinforcing	
As (based on applied moment) :	0.0168 in2/ft		
(4/3) * As :	0.0225 in2/ft	Min Stem T&S Reinf Area 0.384 in2	
200bd/fy : 200(12)(6.1875)/60000 :	0.2475 in2/ft	Min Stem T&S Reinf Area per ft of stem Height : 0.192 in2/ft	
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	==========	One layer of :	Two layers of :
Required Area :	0.1728 in2/ft	#4@ 12.50 in	#4@ 25.00 in
Provided Area :	0.2067 in2/ft	#5@ 19.38 in	#5@ 38.75 in
Maximum Area :	0.8382 in2/ft	#6@ 27.50 in	#6@ 55.00 in

Bottom Stem	Vertical Reinforcing	Horizontal Reinforcing	
As (based on applied moment) :	0.0726 in2/ft		
(4/3) * As :	0.0967 in2/ft	Min Stem T&S Reinf Area 0.639 in2	
200bd/fy : 200(12)(6.1875)/60000 :	0.2475 in2/ft	Min Stem T&S Reinf Area per ft of stem Height : 0.192 in2/ft	
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	==========	One layer of :	Two layers of :
Required Area :	0.1728 in2/ft	#4@ 12.50 in	#4@ 25.00 in
Provided Area :	0.2067 in2/ft	#5@ 19.38 in	#5@ 38.75 in
Maximum Area :	0.8382 in2/ft	#6@ 27.50 in	#6@ 55.00 in

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Footing Data

Toe Width	=	1.00 ft
Heel Width	=	2.00
Total Footing Width	=	3.00
Footing Thickness	=	12.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	0.42 ft

f'c = 2,500 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top 2.00 @ Btm.= 3.00 in

Footing Design Results

		Toe	Heel	
Factored Pressure	=	2,109	220	psf
Mu' : Upward	=	949	444	ft-#
Mu' : Downward	=	129	1,202	ft-#
Mu: Design	=	820 OK	757	ft-# OK
phiMn	=	11,610	13,005	ft-#
Actual 1-Way Shear	=	4.95	8.33	psi
Allow 1-Way Shear	=	75.00	75.00	psi
Toe Reinforcing	=	# 5 @ 12.00 in		
Heel Reinforcing	=	# 5 @ 12.00 in		
Key Reinforcing	=	None Spec'd		
Footing Torsion, Tu	=		0.00	ft-lbs
Footing Allow. Torsion, phi Tu	=		0.00	ft-lbs

If torsion exceeds allowable, provide supplemental design for footing torsion.

Other Acceptable Sizes & Spacings

Toe: #4@ 9.25 in, #5@ 14.35 in, #6@ 20.37 in, #7@ 27.77 in, #8@ 36.57 in, #9@ 46.29 in, #10@ 58.79 in

Heel: #4@ 9.25 in, #5@ 14.35 in, #6@ 20.37 in, #7@ 27.77 in, #8@ 36.57 in, #9@ 46.29 in, #10@ 58.79 in

Key: No key defined

Min footing T&S reinf Area	0.78	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:	If two layers of horizontal bars:
#4@ 9.26 in	#4@ 18.52 in
#5@ 14.35 in	#5@ 28.70 in
#6@ 20.37 in	#6@ 40.74 in

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Summary of Overturning & Resisting Forces & Moments

Item		.....OVERTURNING..... Force lbs	Distance ft	Moment ft-#		.....RESISTING..... Force lbs	Distance ft	Moment ft-#
HL Act Pres (ab water tbl)		160.0	2.67	426.7	Soil Over HL (ab. water tbl)	1,213.3	2.33	2,831.1
HL Act Pres (be water tbl)					Soil Over HL (bel. water tbl)		2.33	2,831.1
Hydrostatic Force					Water Table			
Buoyant Force	=				Sloped Soil Over Heel	=		
Surcharge over Heel	=	15.4	4.00	61.5	Surcharge Over Heel	=		
Surcharge Over Toe	=				Adjacent Footing Load	=		
Adjacent Footing Load	=				Axial Dead Load on Stem	=		
Added Lateral Load	=	100.0	1.50	150.0	* Axial Live Load on Stem	=		
Load @ Stem Above Soil	=				Soil Over Toe	=	65.0	0.50	32.5
Seismic Earth Load	=	44.8	4.00	179.2	Surcharge Over Toe	=		
Seismic Stem Self Wt	=	221.5	4.50	996.7	Stem Weight(s)	=	700.0	1.33	933.3
					Earth @ Stem Transitions	=			
					Footing Weight	=	450.0	1.50	675.0
					Key Weight	=		0.42	
					Vert. Component	=			
Total	=	541.7	**O.T.M.** =	1,814.1	**Total =**		2,428.3 lbs	**R.M.=**	4,471.9

Resisting/Overturning Ratio = **2.47**
Vertical Loads used for Soil Pressure = 2,428.3 lbs

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

If seismic is included, the OTM and sliding ratios may be 1.1 per section 1807.2.3 of IBC.

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.

Tilt

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)	0.095	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.

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Rebar Lap & Embedment Lengths Information

Stem Design Segment: 3rd
Stem Design Height: 5.33 ft above top of footing

Lap Splice length for #5 bar specified in this stem design segment (25.4.2.3a) =	23.40 in
Development length for #5 bar specified in this stem design segment =	18.00 in

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Stem Design Segment: 2nd
Stem Design Height: 3.33 ft above top of footing

Lap Splice length for #5 bar specified in this stem design segment (25.4.2.3a) =	23.40 in
Development length for #5 bar specified in this stem design segment =	18.00 in

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Stem Design Segment: Bottom
Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #5 bar specified in this stem design segment (25.4.2.3a) =	23.40 in
Development length for #5 bar specified in this stem design segment =	18.00 in
Hooked embedment length into footing for #5 bar specified in this stem design segment =	10.50 in
As Provided =	0.2067 in2/ft
As Required =	0.1728 in2/ft

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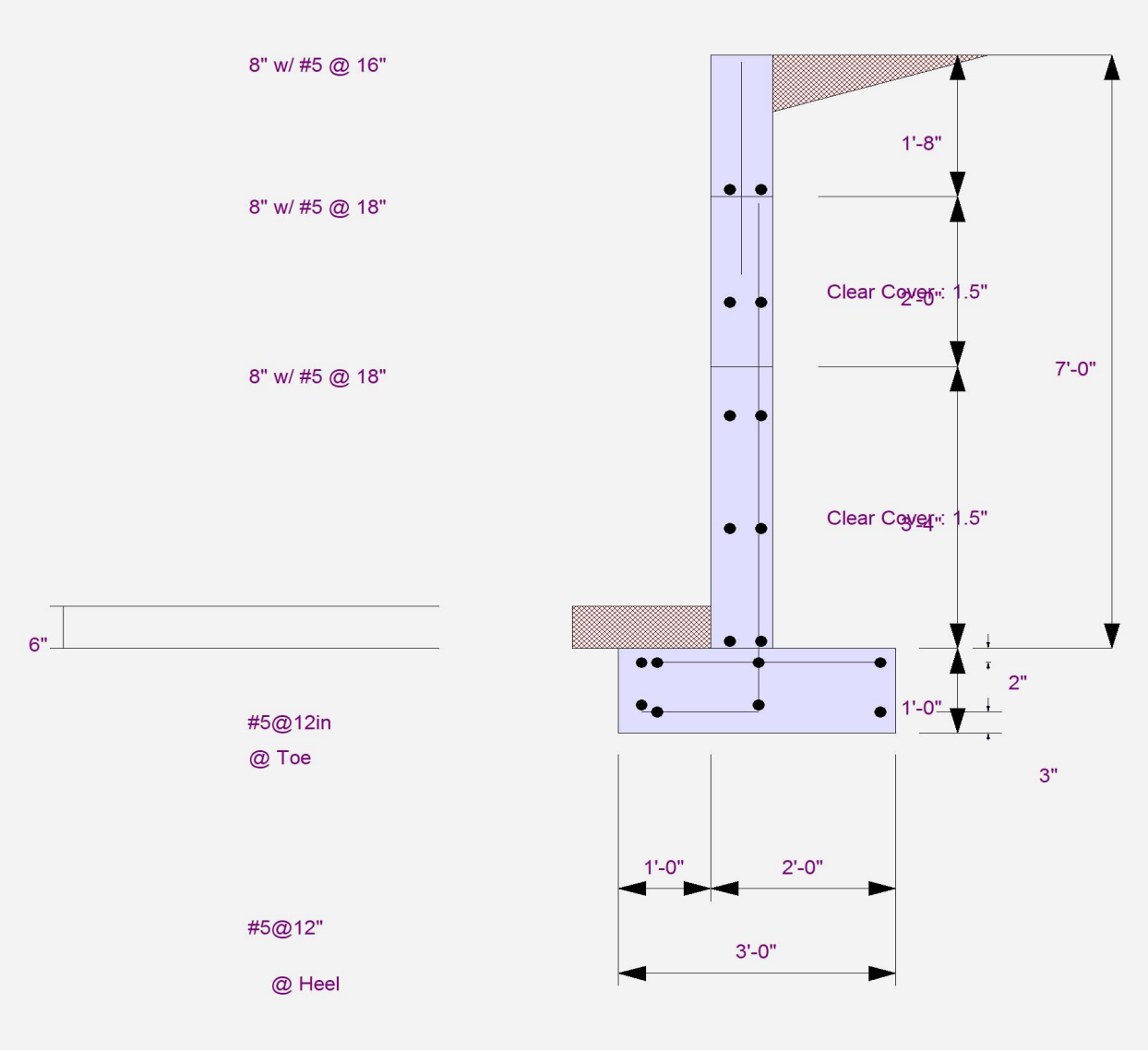

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