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Cantilevered Retaining Wall

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DESCRIPTION: Design Example 1

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Code References

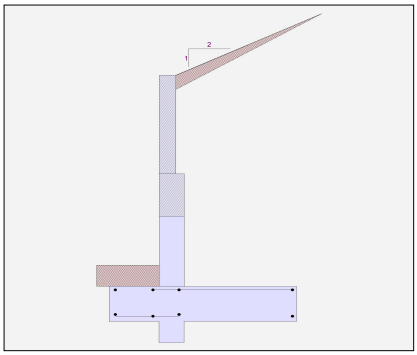
Calculations per IBC 2015, ACI 318-14, ACI 530-13

Criteria

Retained Height	=	10.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	2.00
Height of Soil over Toe	=	12.00 in
Water table above bottom of footing	=	0.0 ft

Soil Data

Allow Soil Bearing	=	3,000.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	45.0 psf/ft
	=	
Passive Pressure	=	389.0 psf/ft
Soil Density, Heel	=	110.00 pcf
Soil Density, Toe	=	110.00 pcf
Footing||Soil Friction	=	0.400
Soil height to ignore for passive pressure	=	12.00 in



Surcharge Loads

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

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 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) (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		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

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Mot / Mr = 40269.2 / 20949.7
=**1.92**

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Design Summary

Wall Stability Ratios

Overturning	=	1.92	OK
Sliding	=	1.36	Ratio < 1.5!
Global Stability	=	1.97	

calc'ed

Total Bearing Load	=	11,137	lbs
...resultant ecc.	=	19.47	in
Eccentricity outside middle third			
Soil Pressure @ Toe	=	2,846	psf OK
Soil Pressure @ Heel	=	0	psf OK
Allowable	=	3,000	psf
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	3,984	psf
ACI Factored @ Heel	=	0	psf
Footing Shear @ Toe	=	10.5	psi OK
Footing Shear @ Heel	=	20.9	psi OK
Allowable	=	75.0	psi

Sliding Calcs

Lateral Sliding Force	=	4,462.7	lbs

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

Load Factors

Building Code	
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.000
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"	=	Masonry	Masonry	Concrete		
Design Method	=	ASD	ASD	SD	SD	SD
Thickness	=	8.00	12.00	12.00		
Rebar Size	=	# 5	# 5	# 7		
Rebar Spacing	=	32.00	16.00	16.00		
Rebar Placed at	=	Edge	Edge	Edge		
Design Data						
fb/FB + fa/Fa	=	**0.511**	**0.436**	**0.656**		
Total Force @ Section						
Service Level	lbs =	490.7	1,001.0			
Strength Level	lbs =			3,600.0		
Moment....Actual						
Service Level	ft-# =	763.9	2,225.6			
Strength Level	ft-# =			12,000.0		
Moment.....Allowable	ft-# =	1,494.8	5,093.8	18,288.8		
Shear.....Actual						
Service Level	psi =	5.4	7.2			
Strength Level	psi =			31.4		
Shear.....Allowable	psi =	44.9	45.1	75.0		
Anet (Masonry)	in2 =	91.50	139.50			
Wall Weight	psf =	84.0	133.0	150.0		
Rebar Depth 'd'	in =	5.25	9.00	9.56		

(1/2)*(45pcf)*(10'-0")*(10'-
= **12000 lb-ft**

Masonry Data

f'm	psi =	1,500	1,500
Fs	psi =	32,000	32,000
Solid Grouting	=	Yes	Yes
Modular Ratio 'n'	=	21.48	21.48
Equiv. Solid Thick.	in =	7.63	11.63
Masonry Block Type	=	Normal Weight	
Masonry Design Method	=	ASD	

Concrete Data

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

Summary of Sliding Forces

	FS = 1.0	FS = 1.5
Lateral Force @ Base of Footing	4,357.66 lbs	6,536.48 lbs
less 100% Passive Force	- 2,420.44 lbs	- 2,420.44 lbs
less 100% Friction Force	- 3,632.36 lbs	- 3,632.36 lbs
Added Resisting Force Required	0.0 lbs	
Added Resisting Force Required for 1.5 Factor of Safety		483.68 lbs

Sliding Factor of Safety = 1.356: 1.00

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Concrete Stem Rebar Area Details

Bottom Stem	Vertical Reinforcing	Horizontal Reinforcing
As (based on applied moment) :	0.2885 in2/ft	
(4/3) * As :	0.3846 in2/ft	Min Stem T&S Reinf Area 0.863 in2
200bd/fy : 200(12)(9.5625)/60000 :	0.3825 in2/ft	Min Stem T&S Reinf Area per ft of stem Height : 0.259 in2/ft
0.0018bh : 0.0018(12)(12) :	0.2592 in2/ft	Horizontal Reinforcing Options :
	==========	One layer of : Two layers of :
Required Area :	0.3825 in2/ft	#4@ 9.26 in #4@ 18.52 in
Provided Area :	0.45 in2/ft	#5@ 14.35 in #5@ 28.70 in
Maximum Area :	1.2954 in2/ft	#6@ 20.37 in #6@ 40.74 in

Footing Data

Toe Width	=	2.00 ft
Heel Width	=	5.50
Total Footing Width	=	7.50
Footing Thickness	=	20.00 in
Key Width	=	12.00 in
Key Depth	=	12.00 in
Key Distance from Toe	=	2.00 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	Key	
Factored Pressure	=	3,984	0		psf
Mu' : Upward	=	7,135	4,026		ft-#
Mu' : Downward	=	864	18,407		ft-#
Mu: Design	=	6,271	14,381	1,760	ft-#
φ Mn	=	32,467	25,597	2,500	ft-#
Actual 1-Way Shear	=	10.46	20.89	22.88	psi
Allow 1-Way Shear	=	75.00	75.00	40.00	psi

Toe Reinforcing = # 7 @ 16.00 in
Heel Reinforcing = # 6 @ 16.00 in
Key Reinforcing = None Spec'd
Footing Torsion, Tu = 0.00 ft-lbs
Footing Allow. Torsion, φ Tn = 0.00 ft-lbs

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

Other Acceptable Sizes & Spacings

Toe: #4@ 5.55 in, #5@ 8.61 in, #6@ 12.22 in, #7@ 16.66 in, #8@ 18 in, #9@ 18 in, #10@ 18 in

Heel: #4@ 5.55 in, #5@ 8.61 in, #6@ 12.22 in, #7@ 16.66 in, #8@ 18 in, #9@ 18 in, #10@ 18 in

Key: phiMn = phi*5*lambda*sqrt(fc)*Sm

Min footing T&S reinf Area 3.24 in2
Min footing T&S reinf Area per foot 0.43 in2 /ft

If one layer of horizontal bars:	If two layers of horizontal bars:
#4@ 5.56 in	#4@ 11.11 in
#5@ 8.61 in	#5@ 17.22 in
#6@ 12.22 in	#6@ 24.44 in

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Summary of Overturning & Resisting Forces & Mome

how is this calc'ed and why does it not match total below? Total below appears to be correct, this number is off

Item	.....OVERTURNING..... Force lbs	Distance ft	Moment ft-#	.....RESISTING..... Force lbs	Distance ft	Moment ft-#
HL Act Pres (ab water tbl)	4,462.7	4.69	20,214.7			
HL Act Pres (be water tbl)						
Hydrostatic Force						
Buoyant Force =						
Surcharge over Heel =						
Surcharge Over Toe =						
Adjacent Footing Load =						
Added Lateral Load =						
Load @ Stem Above Soil =						
=						
Total =	4,462.7	**O.T.M.** =	20,949.7			
Soil Over HL (ab. water tbl)				4,950.0	5.25	25,987.5
Soil Over HL (bel. water tbl)					5.25	25,987.5
ble						
il Over Heel =				556.9	6.00	3,341.3
Surcharge Over Heel =						
Adjacent Footing Load =						
Axial Dead Load on Stem =						
* Axial Live Load on Stem =						
Soil Over Toe =				220.0	1.00	220.0
Surcharge Over Toe =						
Stem Weight(s) =				1,157.8	2.44	2,829.1
Earth @ Stem Transitions =				171.2	2.83	485.2
Footing Weight =				1,875.0	3.75	7,031.3
Key Weight =				150.0	2.50	375.0
Vert. Component =						
Total =				9,080.9 lbs	**R.M.=**	40,269.2

4462.7*4.69 = **20949.69**
** when sig digits are carried*

(14'-1") / 3
** Force applied 1/3 above base for triangular distribution*

(1/2)*(45pcf)*(14'-1")^2

Resisting/Overturning Ratio = **1.92**

Vertical Loads used for Soil Pressure = 11,136.7 lbs

how is this calc'ed

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

(110pcf)*(4'-6")*(10'-0")

(2'-0")+(1 measured

why sho

(110p

(110pcf (110pcf It looks due to t

F1.1 x1.1

F1.2 x1.1

F1.3 x1.1

total

x1 = = ((5 (500 = **2.4**

(110pc

(150pc

(150pc

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)	0.105	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
Calculated Rebar Stress, fs = 16352.84 psi

Lap Splice length for #5 bar specified in this stem design segment (25.4.2.3a) =	25.00 in
Development length for #5 bar specified in this stem design segment =	20.44 in

---

Stem Design Segment: 2nd
Stem Design Height: 3.33 ft above top of footing
Calculated Rebar Stress, fs = 13981.15 psi

Lap Splice length for #5 bar specified in this stem design segment (25.4.2.3a) =	25.00 in
Development length for #5 bar specified in this stem design segment =	17.48 in

---

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

Lap Splice length for #7 bar specified in this stem design segment (25.4.2.3a) =	40.95 in
Development length for #7 bar specified in this stem design segment =	31.50 in
Hooked embedment length into footing for #7 bar specified in this stem design segment =	14.70 in
As Provided =	0.4500 in2/ft
As Required =	0.3825 in2/ft

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F1: STEM WEIGHT
F2: SOIL OVER HEEL
F3: FOOTING WEIGHT
F4: SOIL OVER TOE
F5: SLOPED SOIL OVER HEEL
F6: SOIL AT STEM TRANSITION
F7: KEY WEIGHT

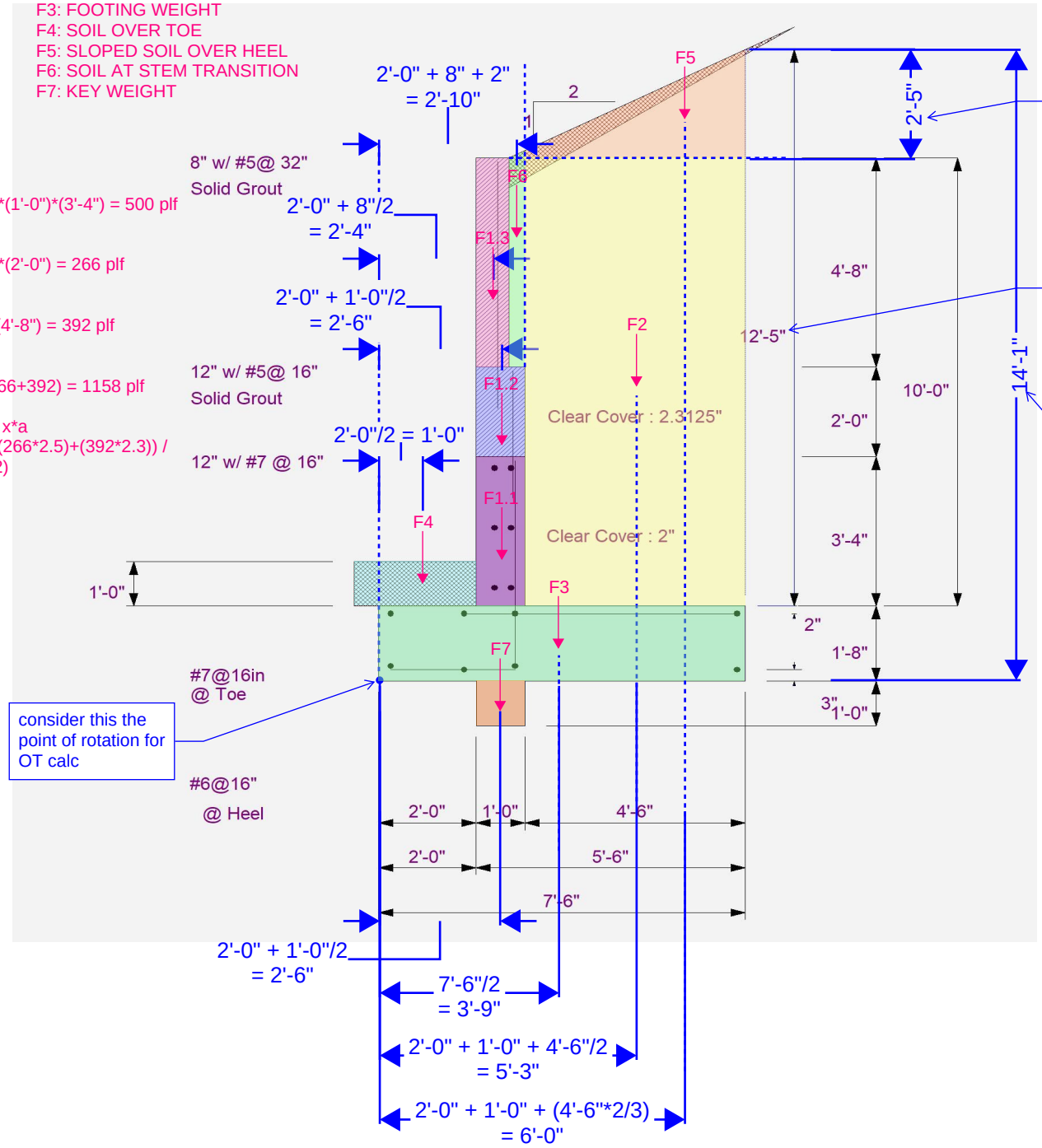
F1.1: (150pcf)*(1'-0")*(3'-4") = 500 plf
x1.1 = 2'-6"

F1.2: (133psf)*(2'-0") = 266 plf
x1.1 = 2'-6"

F1.3: (84psf)*(4'-8") = 392 plf
x1.1 = 2'-4"

total = (500+266+392) = 1158 plf

x1 = Σx*a / Σx*a
= ((500*2.5)+(266*2.5)+(392*2.3)) / (500+266+392)
= 2.44ft



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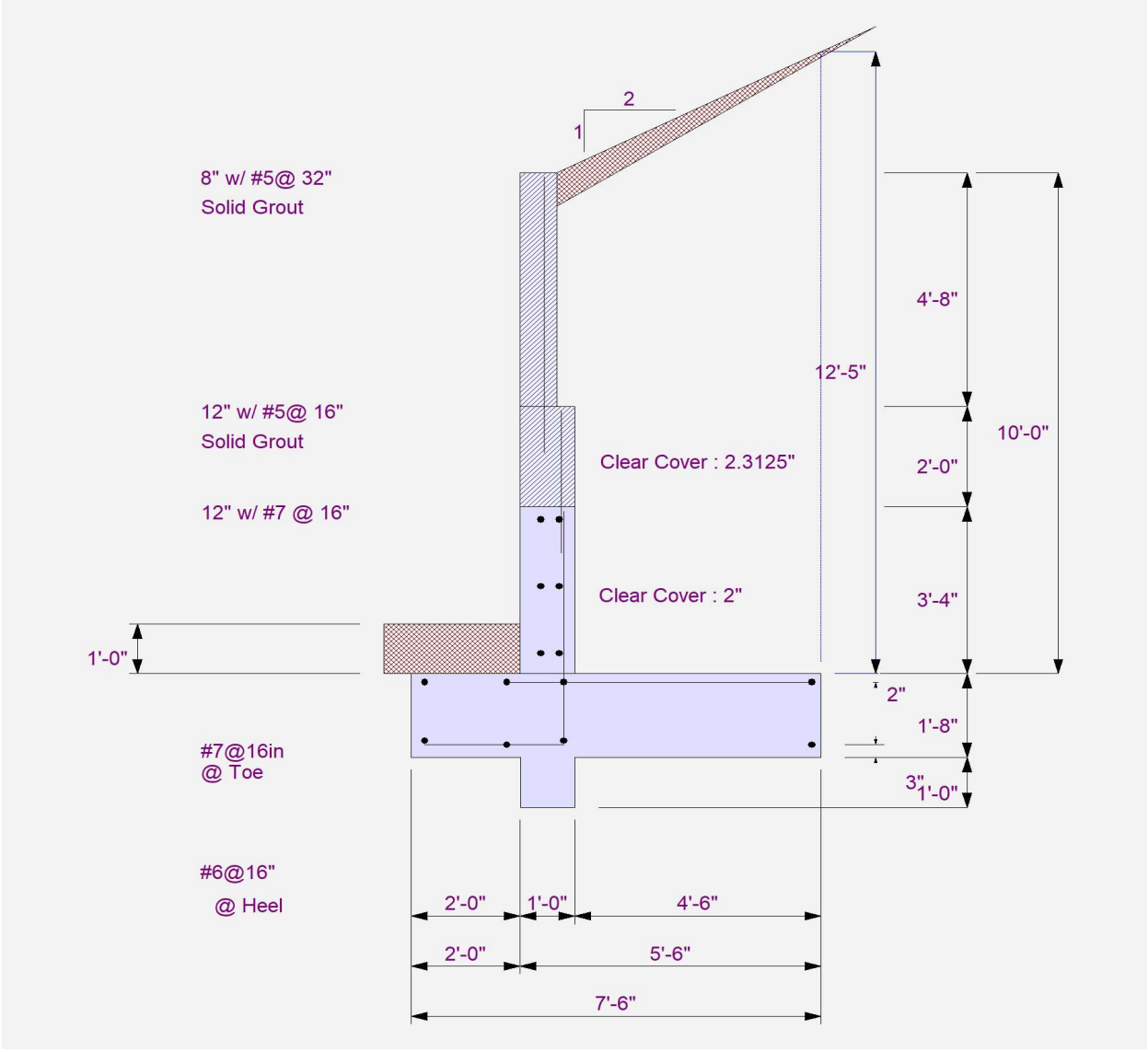

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