

Project Title:  
 Engineer:  
 Project ID:  
 Project Descr:

## Cantilevered Retaining Wall

Project File: Ticket 136481\_CRW - OH Prep.ec6

LIC# : KW-06000215, Build:20.25.11.24

Licensed ENERCALC User

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**DESCRIPTION:** Design Example 1 - Simplified for Hand Calc

### Code References

Governing Code : IBC 2024

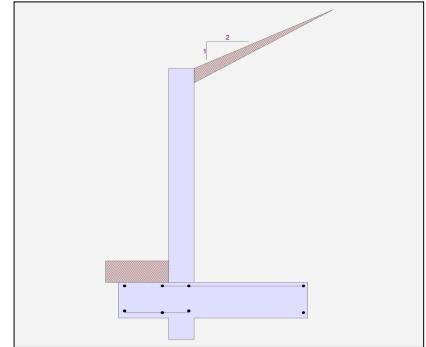
Referenced Design Standard(s) : ACI 318-19

#### 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
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	=	0.0 psf (Strength Level)

#### 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

Mr / Mot  
= 56123.8 ft-# / 20214.7 ft-#  
= 2.77

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Resisting / Sliding  
= (2420.44 # + 3700.75#) / 4357.66 #  
= 1.40

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### Design Summary

#### Wall Stability Ratios

Overturing	=	2.78	OK
Sliding	=	1.40	Ratio < 1.5!
Global Stability	=	2.00	

Total Bearing Load	=	11,308 lbs
...resultant ecc.	=	18.42 in
Eccentricity outside middle third		
Soil Pressure @ Toe	=	2,785 psf OK
Soil Pressure @ Heel	=	0 psf OK
Allowable	=	3,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	3,899 psf
ACI Factored @ Heel	=	0 psf
Footing Shear @ Toe	=	10.2 psi OK
Footing Shear @ Heel	=	19.3 psi OK
Allowable	=	75.0 psi

#### Sliding Calcs

Lateral Sliding Force	=	4,357.7 lbs
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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

### Summary of Sliding Forces

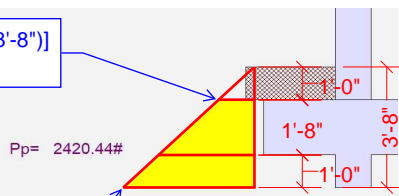
- Lateral Force @ Base of Footing
- less 100% Passive Force
- less 100% Friction Force
- Added Resisting Force Required
- Added Resisting Force Required for 1.5 Factor of Safety

4357.66 plf - 2420.44 plf - 3700.76 plf  
= - 1763.53 plf  
If negative, report 0

**Sliding Factor of Safety = 1.405: 1.00**

#### Passive Pressure Calc

$(1426.3 \text{ psf}) * [(1'-0") / (3'-8")]$   
= 389 psf



$(389 \text{ psf/ft}) * (3'-8")$   
= 1426.3 psf

Total Passive Pressure  
=  $(1/2) * (1426.3 \text{ psf}) * (3'-8")$   
= 2614.94 plf

Neglect 12" of Passive Pressure  
=  $(1/2) * (389 \text{ psf}) * (1'-0")$   
= 194.5 plf

Passive Pressure (Total - Neglect)  
= 2614.94 plf - 194.5 plf  
= 2420.44 plf

Pp= 2420.44#

$(389 \text{ psf/ft}) * (3'-8")$   
= 1426.3 psf

### Stem Construction

Design Height Above Ft	ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete	
Design Method	=	SD	SD SD
Thickness	=	12.00	
Rebar Size	=	# 7	
Rebar Spacing	=	16.00	
Rebar Placed at	=	Edge	

#### Design Data

fb/FB + fa/Fa = 0.656

fb / Fb  
= 12000 ft-# / 18288.79 ft-#  
= 0.656

Is axial load considered?

#### Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	3,600.0

#### Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	12,000.0

#### Moment....Allowable

	=	18,288.8
--	---	----------

#### Shear....Actual

Service Level	psi =	
Strength Level	psi =	31.4

#### Shear....Allowable

	psi =	47.3
--	-------	------

#### Anet (Masonry)

	in2 =	
--	-------	--

#### Wall Weight

	psf =	150.0
--	-------	-------

#### Rebar Depth 'd'

	in =	9.56
--	------	------

#### Masonry Data

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

#### Concrete Data

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

Active Pressure  
=  $(1/2) * (45 \text{ pcf}) * (10'-0")^2$   
= 2250 plf

1.6\*(Active)  
= 1.6\*(2250 plf)  
= 3600 plf

3600 plf \* (10ft/3)  
= 12000.0 ft-#

Vu / (bd)  
= 3600 lbs / (12in\*9.5625in)  
= 31.37 psi

d = wall thickness - cover  
- 1/2 bar diameter  
12" - 2" - (0.875" / 2)  
= 9.5625"

4357.66 plf \* 1.5  
= 6536.48 plf

FS = 1.0

4,357.66 lbs

FS = 1.5

6,536.48 lbs

- 2,420.44 lbs

- 2,420.44 lbs

- 3,700.75 lbs

- 3,700.75 lbs

0.0 lbs

9251.88 plf \* 0.4  
= 3700.752 plf

415.29 lbs

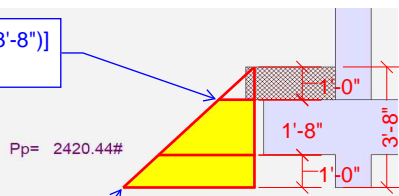
6536.48  
= 415.29

4357.66 plf - 2420.44 plf - 3700.76 plf  
= - 1763.53 plf  
If negative, report 0

**Sliding Factor of Safety = 1.405: 1.00**

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Passive Pressure (Total - Neglect)  
= 2614.94 plf - 194.5 plf  
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Pp= 2420.44#

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0.0018 MIN

Example, Area of #4 bar = 0.2in<sup>2</sup>

$0.0018bh = 0.0018 \cdot 12 \cdot 12$   
 $= 0.2592 \text{ in}^2/\text{ft}$

One Layer:  
 $0.2 \text{ in}^2 / 0.2592 \text{ in}^2/\text{ft}$   
 $= 0.771 \text{ ft} = \mathbf{9.259 \text{ in}}$

Two Layers:  
 $(2 \cdot 0.2 \text{ in}^2) / 0.2592 \text{ in}^2/\text{ft}$   
 $= 1.543 \text{ ft} = \mathbf{18.518 \text{ in}}$

### Concrete Stem Rebar Area Details

Bottom Stem	Vertical Reinforcing
As (based on applied moment) :	0.2885 in <sup>2</sup> /ft
0.0018bh : 0.0018(12)(12) :	0.2592 in <sup>2</sup> /ft
	=====
Required Area :	0.2885 in <sup>2</sup> /ft
Provided Area :	0.45 in <sup>2</sup> /ft
Maximum Area :	1.2954 in <sup>2</sup> /ft

### Horizontal Reinforcing

Horizontal Reinforcing Options :

One layer of : Two layers of :

#4@ 9.26 in	#4@ 18.52 in
#5@ 14.35 in	#5@ 28.70 in
#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	= 3,899	0		psf
Mu' : Upward	= 7,015	4,733		ft-#
Mu' : Downward	= 864	18,407		ft-#
Mu: Design	= 6,151	13,674	1,775	ft-#
φ Mn	= 32,467	25,597		2,500 ft-#
Actual 1-Way Shear	= 10.23	19.34		23.00 psi
Allow 1-Way Shear	= 39.39	34.80		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:  $\phi Mn = \phi \cdot 5 \cdot \lambda \cdot \text{sqrt}(f_c) \cdot S_m$

Min footing T&S reinf Area 3.24 in<sup>2</sup>  
 Min footing T&S reinf Area per foot 0.43 in<sup>2</sup>/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 & Moments

Item	.....OVERTURNING.....			.....RESISTING.....			
	Force lbs	Distance ft	Moment ft-#	Force lbs	Distance ft	Moment ft-#	
HL Act Pres (ab water tbl)	4,357.7	4.64	20,214.7	Soil Over HL (ab. water tbl)	4,950.0	5.25	25,987.5
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		5.25	
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =	556.9	6.00	3,341.3
Surcharge over Heel =				Surcharge Over Heel =			
Surcharge Over Toe =				Adjacent Footing Load =			
Adjacent Footing Load =				Axial Dead Load on Stem =			
Added Lateral Load =				* Axial Live Load on Stem =			
Load @ Stem Above Soil =				Soil Over Toe =	220.0	1.00	220.0
				Surcharge Over Toe =			
				Stem Weight(s) =	1,500.0	2.50	3,750.0
				Earth @ Stem Transitions =			
<b>Total</b>	<b>= 4,357.7</b>	<b>O.T.M. =</b>	<b>20,214.7</b>	Footing Weight =	1,875.0	3.75	7,031.3
				Key Weight =	150.0	2.50	375.0
				Vert. Component =	2,055.8	7.50	15,418.8
				<b>Total =</b>	<b>11,307.7 lbs</b>	<b>R.M.=</b>	<b>56,123.8</b>
<b>Resisting/Overturning Ratio</b>		<b>=</b>	<b>2.78</b>	* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.			
Vertical Loads used for Soil Pressure =		11,307.7 lbs					

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

Vertical component of active lateral soil pressure IS 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) 0.103 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.

The screenshot shows the ENERCALC software interface for a retaining wall design. The 'Soil Values' section is highlighted, showing the following parameters:

- Retained Height: 10 ft
- Soil Slope: 2:1
- Wall height above retained soil: (empty)
- Water table above bottom of footing: (empty)
- Height of Soil over top of Toe: 12.0 in
- Allow Soil Bearing: 3,000.0 psf
- Lateral Pressure Method: E.F.P., Coulomb
- Active Soil Pressure - Heel Side: 45 ps/ft
- Equivalent Soil Friction Angle: 38.160 deg (by back-solving Coulomb method)
- Passive Pressure: 389 ps/ft
- Soil Density (heel side): 110 pcf
- Soil Density @ Toe side: 110 pcf
- Soil Spring Reaction Modulus: 250 pci

At the bottom, there are checkboxes for the 'Use of vertical component of active lateral soil pressure':

- Use for Soil Pressure & Footing Design
- Use for Overturning Resistance
- Use for Sliding Resistance
- Use for Global Stability check

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### Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Stem Design Segment: Bottom

Lap Splice length for #7 bar specified in this stem design segment (25.4.2.4a) = 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 = 13.69 in

As Provided = 0.4500 in<sup>2</sup>/ft

As Required = 0.3825 in<sup>2</sup>/ft

$\Psi_r$ : Confining Reinforcement Factor = 1.00

$\Psi_o$ : Location Factor = 1.00

$\Psi_c$ : Concrete Strength Factor = 0.77



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