


PRCTI20241387

Calculations required to be provided by the Permittee on site for all Inspections

**City of Puyallup
Building
REVIEWED
FOR
COMPLIANCE**

BSnowden
09/23/2024
8:14:56 AM




September 3, 2024

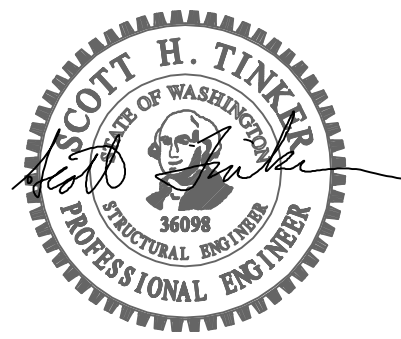
City of Puyallup Development & Permitting Services ISSUED PERMIT	
Building	Planning
Engineering	Public Works
Fire	Traffic

STRUCTURAL CALCULATIONS
(Permit Submittal)

**CENTERIS DATA CENTER VOLTAGE PARK
FOUNDATIONS SOUTH YARD**
1023 39th Avenue SE
Puyallup, WA 98374

Quantum Job Number: 23444.01

Prepared for:
CENTERIS DATA CENTERS
18300 Cascade Avenue S
Seattle, WA 981188



Prepared by:
QUANTUM CONSULTING ENGINEERS
1511 Third Avenue, Suite 323
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QUANTUM | CONSULTING ENGINEERS

CENTERIS SOUTH YARD

1023 39TH AVE SE
PUYALLUP, WA 38374

QUANTUM JOB NUMBER: 23444.01

INDEX

DESIGN CRITERIA 3

RETAINING WALL 6

PIPE FRAMES 256

EQUIPMENT ANCHORAGE 284

Structural Design Criteria

Building Code: 2021 International Building Code
Building Department: City of Puyallup

Seismic Criteria

S_s : 1.26
 S_1 : 0.43 Seismic Soil Site Class: D
 S_{ds} : 1.01 Seismic Design Category: D
 S_{d1} : 0.50 Cs: 0.15

Wind Criteria

Wind Speed: 97
Risk Category: II
Wind Exposure: B
Kzt: 1

Geotechnical Criteria

Allowable Bearing Pressure: 2500 PSF
Minimum Footing Width: Continuous: 18" min.
Frost Depth: 18" min.
Soils Consultant: GeoEngineers
Soils Report Number: #4565-064-09
Soils Report Date: June 14, 2024
Active Soil Pressure (Restrained/Unrestrained): 55 PCF / 35 PCF
Seismic Surcharge Pressure: 8H PSF
Passive Soil Pressure: 300
Coefficient of Friction: 0.4

Materials Criteria

Concrete (28 Day Strength):

Foundation/Slab on Grade: $F'_c = 3,000 \text{ PSI}$
Walls and Columns: $F'_c = 3,000 \text{ PSI}$

Reinforcing Steel:

Grade 60: $F_y = 60,000 \text{ PSI}$

Structural Steel:

Wide-Flange Sections: A-992: $F_y = 50,000 \text{ PSI}$
Miscellaneous Sections: A-36: $F_y = 36,000 \text{ PSI}$
Tube Sections: A-500: $F_y = 46,000 \text{ PSI}$
Pipe Sections: A-53: $F_y = 35,000 \text{ PSI}$
Welding: $F_y = 70,000 \text{ PSI}$

Building Loads

Snow Load Roof 25 psf

Assembly Loads

14" Water Pipe	
14" Pipe STD	54.6 plf
Water	60.8 plf
Fittings / Misc.	4.6 plf
Total:	120.0 plf

8" Water Pipe	
8" Pipe STD	28.6 plf
Water	21.7 plf
Fittings / Misc.	9.7 plf
Total:	60.0 plf

6" Water Pipe	
6" Pipe STD	19.0 plf
Water	12.5 plf
Fittings / Misc.	8.5 plf
Total:	40.0 plf

⚠ This is a beta release of the new ATC Hazards by Location website. Please [contact us](#) with feedback.

ℹ The ATC Hazards by Location website will not be updated to support ASCE 7-22. [Find out why.](#)

ATC Hazards by Location

Search Information

Address: 1015 39th Ave SE Puyallup, WA 98374
Coordinates: 47.1590004, -122.2794422
Elevation: 489 ft
Timestamp: 2023-12-01T15:13:57.333Z
Hazard Type: Wind



ASCE 7-16

MRI 10-Year 67 mph
 MRI 25-Year 73 mph
 MRI 50-Year 78 mph
 MRI 100-Year 82 mph
 Risk Category I 92 mph
 Risk Category II 97 mph
 Risk Category III 104 mph
 Risk Category IV 108 mph

ASCE 7-10

MRI 10-Year 72 mph
 MRI 25-Year 79 mph
 MRI 50-Year 85 mph
 MRI 100-Year 91 mph
 Risk Category I 100 mph
 Risk Category II 110 mph
 Risk Category III-IV 115 mph

ASCE 7-05

ASCE 7-05 Wind Speed 85 mph

The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Please note that the ATC Hazards by Location website will not be updated to support ASCE 7-22. [Find out why.](#)

Disclaimer

Hazard loads are interpolated from data provided in ASCE 7 and rounded up to the nearest whole integer. Per ASCE 7, islands and coastal areas outside the last contour should use the last wind speed contour of the coastal area – in some cases, this website will extrapolate past the last wind speed contour and therefore, provide a wind speed that is slightly higher. NOTE: For queries near wind-borne debris region boundaries, the resulting determination is sensitive to rounding which may affect whether or not it is considered to be within a wind-borne debris region.

Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

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ATC Hazards by Location

Search Information

Address: 1015 39th Ave SE Puyallup, WA 98374
Coordinates: 47.1590004, -122.2794422
Elevation: 489 ft
Timestamp: 2023-12-01T15:14:56.409Z
Hazard Type: Seismic
Reference Document: ASCE7-16
Risk Category: III
Site Class: D-default



Basic Parameters

Name	Value	Description
S _S	1.257	MCE _R ground motion (period=0.2s)
S ₁	0.433	MCE _R ground motion (period=1.0s)
S _{MS}	1.508	Site-modified spectral acceleration value
S _{M1}	* null	Site-modified spectral acceleration value
S _{DS}	1.005	Numeric seismic design value at 0.2s SA
S _{D1}	* null	Numeric seismic design value at 1.0s SA

* See Section 11.4.8

Additional Information

Name	Value	Description
SDC	* null	Seismic design category
F _a	1.2	Site amplification factor at 0.2s
F _v	* null	Site amplification factor at 1.0s
CR _S	0.914	Coefficient of risk (0.2s)
CR ₁	0.898	Coefficient of risk (1.0s)
PGA	0.5	MCE _G peak ground acceleration
F _{PGA}	1.2	Site amplification factor at PGA
PGA _M	0.6	Site modified peak ground acceleration
T _L	6	Long-period transition period (s)
SsRT	1.257	Probabilistic risk-targeted ground motion (0.2s)
SsUH	1.375	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
SsD	1.5	Factored deterministic acceleration value (0.2s)
S1RT	0.433	Probabilistic risk-targeted ground motion (1.0s)
S1UH	0.483	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
S1D	0.6	Factored deterministic acceleration value (1.0s)
PGA _d	0.5	Factored deterministic acceleration value (PGA)

* See Section 11.4.8

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QUANTUM | CONSULTING ENGINEERS

CENTERIS SOUTH YARD

1023 39TH AVE SE

PUYALLUP, WA 38374

QUANTUM JOB NUMBER: 23444.01

RETAINING WALL

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained - EQ

Code Reference.

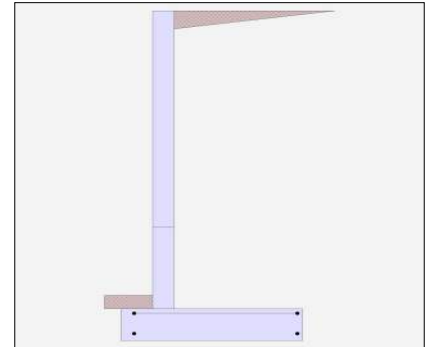
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	11.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	97.333
Total Seismic Force	=	1,184.222

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

Cantilevered Retaining Wall

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LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 11' Retained - EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.98	OK
Sliding	=	1.53	OK
Global Stability	=	1.86	
Total Bearing Load	=	8,684 lbs	
...resultant ecc.	=	12.99 in	
Eccentricity outside middle third			
Soil Pressure @ Toe	=	3,303 psf	OK
Soil Pressure @ Heel	=	0 psf	OK
Allowable	=	3,333 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	3,961 psf	
ACI Factored @ Heel	=	0 psf	
Footing Shear @ Toe	=	3.1 psi	OK
Footing Shear @ Heel	=	31.3 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	3,419.4 lbs	
less 100% Passive Force	=	625.0 lbs	
less 100% Friction Force	=	4,602.6 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 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

		2nd	Bottom		
Design Height Above Ftg	ft =	Stem OK	Stem OK		
Wall Material Above "Ht"	=	3.00	0.00		
Design Method	=	Concrete	Concrete	SD	SD
Thickness	=	SD	SD		
Rebar Size	=	8.00	8.00		
Rebar Spacing	=	# 4	# 6		
Rebar Placed at	=	6.00	6.00		
	=	Edge	Edge		

Design Data

fb/FB + fa/Fa	=	0.748	0.971
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Total Force @ Section

Service Level	lbs =		
Strength Level	lbs =	2,570.7	4,458.7

Moment....Actual

Service Level	ft-# =		
Strength Level	ft-# =	7,893.3	18,311.3
Moment.....Allowable	ft-# =	10,542.0	18,848.3

Shear.....Actual

Service Level	psi =		
Strength Level	psi =	34.3	66.1
Shear.....Allowable	psi =	57.4	77.3
Anet (Masonry)	in2 =		
Wall Weight	psf =	100.0	100.0
Rebar Depth 'd'	in =	6.25	5.63

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 =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

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DESCRIPTION: 11' Retained - EQ

Concrete Stem Rebar Area Details

2nd Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2957 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2957 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.7669 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.7669 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.88 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9144 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	1.00 ft
Heel Width	=	<u>4.67</u>
Total Footing Width	=	5.67
Footing Thickness	=	14.00 in

f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	3,961	0	psf
Mu' : Upward	=	1,855	5,813	ft-#
Mu' : Downward	=	141	22,366	ft-#
Mu: Design	=	1,714	16,553	ft-#
φ Mn	=	3,944	22,163	ft-#
Actual 1-Way Shear	=	3.13	31.31	psi
Allow 1-Way Shear	=	43.82	48.20	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 6 @ 12.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: #4@ 5.47 in, #5@ 8.48 in, #6@ 12.03 in, #7@ 16.41 in, #8@ 21.61 in, #9@ 27.35 in, #10@ 34.74 in

Key: No key defined

Min footing T&S reinf Area	1.71	in2
Min footing T&S reinf Area per foot	0.30	in2 /ft
<u>If one layer of horizontal bars:</u>	<u>If two layers of horizontal bars:</u>	
#4@ 7.94 in	#4@ 15.87 in	
#5@ 12.30 in	#5@ 24.60 in	
#6@ 17.46 in	#6@ 34.92 in	

Cantilevered Retaining Wall

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LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 11' Retained - EQ

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)	2,590.5	4.06	10,505.9	Soil Over HL (ab. water tbl)	5,284.4	3.67	19,384.9
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.67	19,384.9
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	60.0	0.50	30.0
Seismic Earth Load =	829.0	6.08	5,042.8	Surcharge Over Toe =			
=				Stem Weight(s) =	1,100.0	1.33	1,466.7
Total =	3,419.4	O.T.M. =	15,548.7	Earth @ Stem Transitions =			
				Footing Weight =	992.3	2.84	2,813.0
				Key Weight =			
				Vert. Component =	1,247.4	5.67	7,073.0
Resisting/Overturning Ratio =			1.98	Total =	8,684.1 lbs	R.M.=	30,767.6
Vertical Loads used for Soil Pressure =		8,684.1 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 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) 0.178 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.

Cantilevered Retaining Wall

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DESCRIPTION: 11' Retained - EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: 2nd

Stem Design Height: 3.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in
Development length for #4 bar specified in this stem design segment = 13.15 in

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #6 bar specified in this stem design segment (25.4.2.4a) = 25.63 in
Development length for #6 bar specified in this stem design segment = 19.72 in

Hooked embedment length into footing for #6 bar specified in this stem design segment = 10.35 in
As Provided = 0.8800 in²/ft
As Required = 0.7669 in²/ft

Cantilevered Retaining Wall

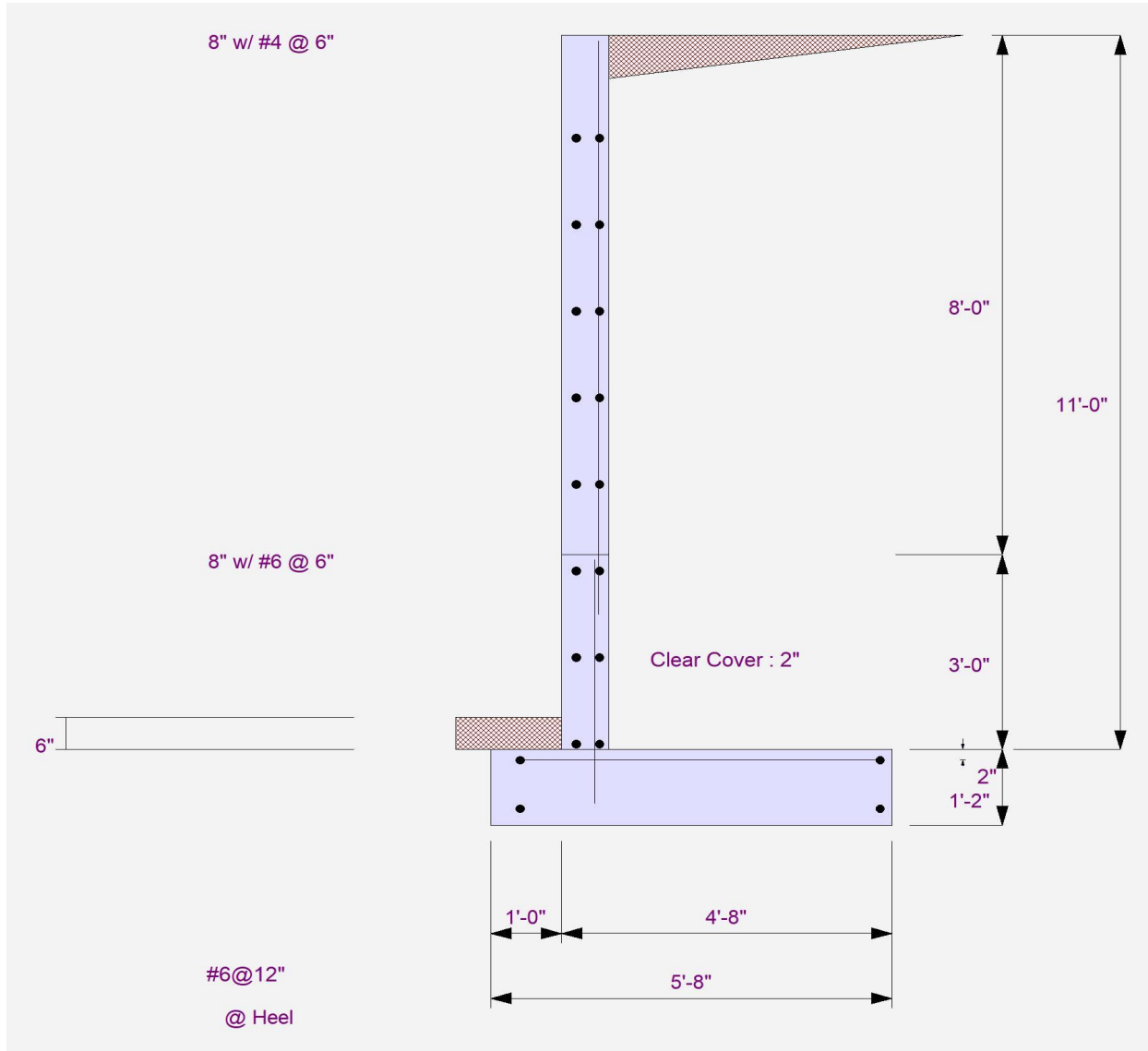
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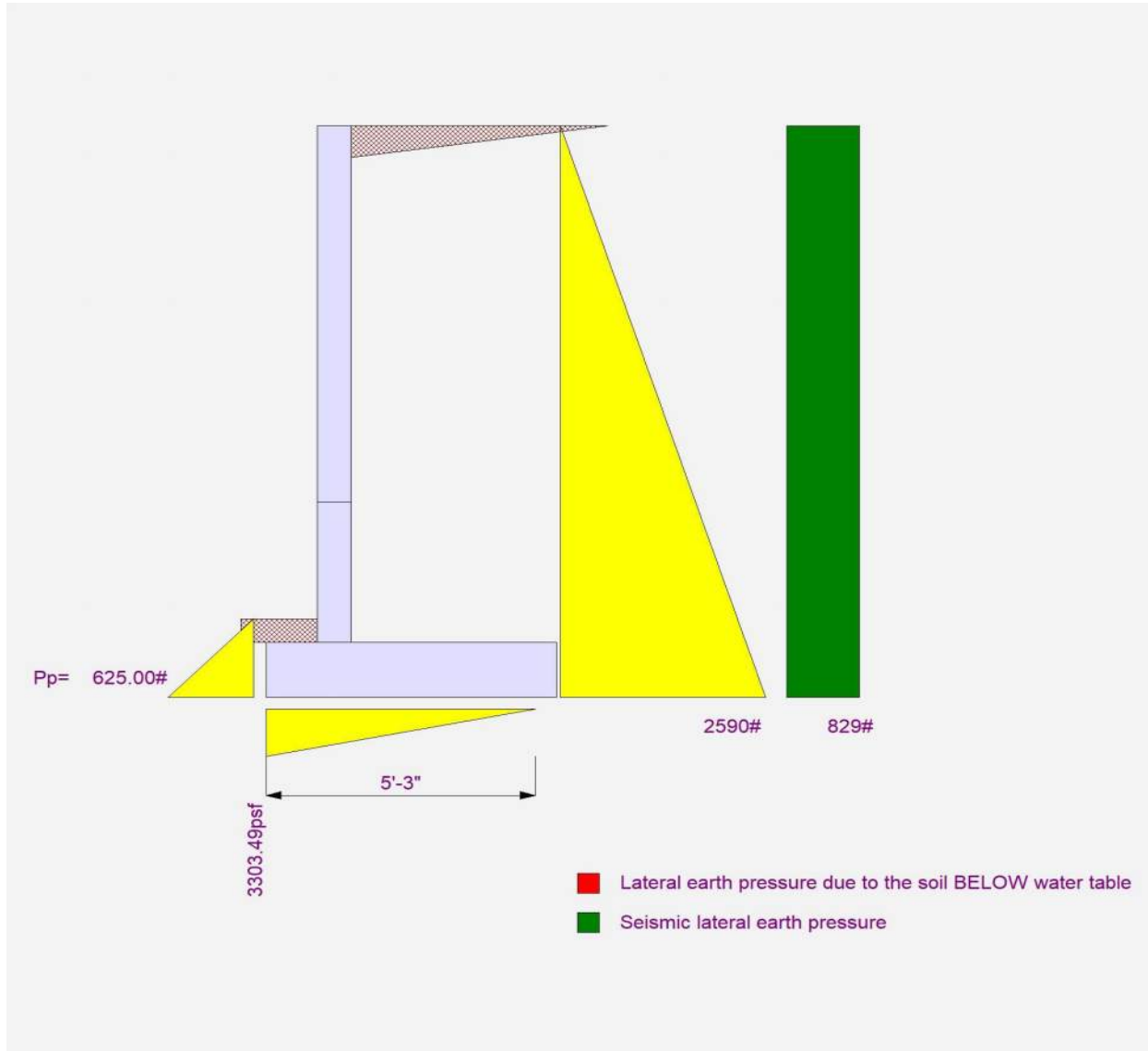
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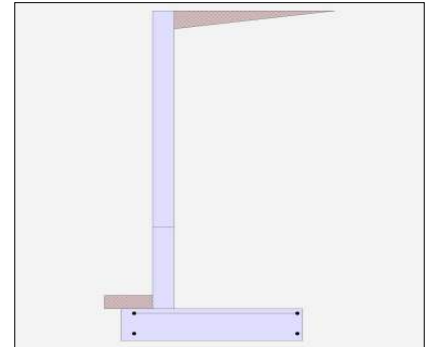
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	11.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

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DESCRIPTION: 11' Retained

Design Summary

Wall Stability Ratios

Overturning	=	2.93	OK
Sliding	=	2.02	OK
Global Stability	=	1.86	
Total Bearing Load	=	8,684 lbs	
...resultant ecc.	=	6.02 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	2,345 psf	OK
Soil Pressure @ Heel	=	718 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,811 psf	
ACI Factored @ Heel	=	861 psf	
Footing Shear @ Toe	=	2.2 psi	OK
Footing Shear @ Heel	=	21.6 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	2,590.5 lbs	
less 100% Passive Force	=	625.0 lbs	
less 100% Friction Force	=	4,602.6 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 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

		2nd	Bottom		
Design Height Above Ftg	ft =	Stem OK	Stem OK		
Wall Material Above "Ht"	=	3.00	0.00		
Design Method	=	Concrete	Concrete		
Thickness	=	SD	SD	SD	SD
Rebar Size	=	8.00	8.00		
Rebar Spacing	=	# 4	# 6		
Rebar Placed at	=	6.00	6.00		
	=	Edge	Edge		

Design Data

fb/FB + fa/Fa	=	0.453	0.659
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Total Force @ Section

Service Level	lbs =		
Strength Level	lbs =	1,792.0	3,388.0

Moment....Actual

Service Level	ft-# =		
Strength Level	ft-# =	4,778.7	12,422.7
Moment.....Allowable	ft-# =	10,542.0	18,848.3

Shear.....Actual

Service Level	psi =		
Strength Level	psi =	23.9	50.2
Shear.....Allowable	psi =	57.4	77.3
Anet (Masonry)	in2 =		
Wall Weight	psf =	100.0	100.0
Rebar Depth 'd'	in =	6.25	5.63

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 =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained

Concrete Stem Rebar Area Details

2nd Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.179 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.179 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.5203 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.5203 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.88 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9144 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	1.00 ft
Heel Width	=	4.67
Total Footing Width	=	5.67
Footing Thickness	=	14.00 in

f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,811	861	psf
Mu' : Upward	=	1,348	10,579	ft-#
Mu' : Downward	=	141	22,366	ft-#
Mu: Design	=	1,207	11,788	ft-#
φ Mn	=	3,944	22,163	ft-#
Actual 1-Way Shear	=	2.16	21.55	psi
Allow 1-Way Shear	=	43.82	48.20	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 6 @ 12.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: #4@ 7.68 in, #5@ 11.90 in, #6@ 16.90 in, #7@ 23.05 in, #8@ 30.34 in, #9@ 38.41 in, #10@ 48.78 in

Key: No key defined

Min footing T&S reinf Area	1.71	in2
Min footing T&S reinf Area per foot	0.30	in2 /ft
<u>If one layer of horizontal bars:</u>	<u>If two layers of horizontal bars:</u>	
#4@ 7.94 in	#4@ 15.87 in	
#5@ 12.30 in	#5@ 24.60 in	
#6@ 17.46 in	#6@ 34.92 in	

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 11' Retained

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)	2,590.5	4.06	10,505.9	Soil Over HL (ab. water tbl)	5,284.4	3.67	19,384.9
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.67	19,384.9
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	60.0	0.50	30.0
				Surcharge Over Toe =			
				Stem Weight(s) =	1,100.0	1.33	1,466.7
				Earth @ Stem Transitions =			
Total	= 2,590.5	O.T.M.	= 10,505.9	Footing Weight =	992.3	2.84	2,813.0
				Key Weight =			
Resisting/Overturning Ratio		=	2.93	Vert. Component =	1,247.4	5.67	7,073.0
Vertical Loads used for Soil Pressure =		8,684.1	lbs	Total =	8,684.1	lbs	R.M.= 30,767.6

* 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 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) 0.126 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained

Rebar Lap & Embedment Lengths Information

Stem Design Segment: 2nd

Stem Design Height: 3.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in
Development length for #4 bar specified in this stem design segment = 13.15 in

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #6 bar specified in this stem design segment (25.4.2.4a) = 25.63 in
Development length for #6 bar specified in this stem design segment = 19.72 in

Hooked embedment length into footing for #6 bar specified in this stem design segment = 10.35 in
As Provided = 0.8800 in²/ft
As Required = 0.5203 in²/ft

Cantilevered Retaining Wall

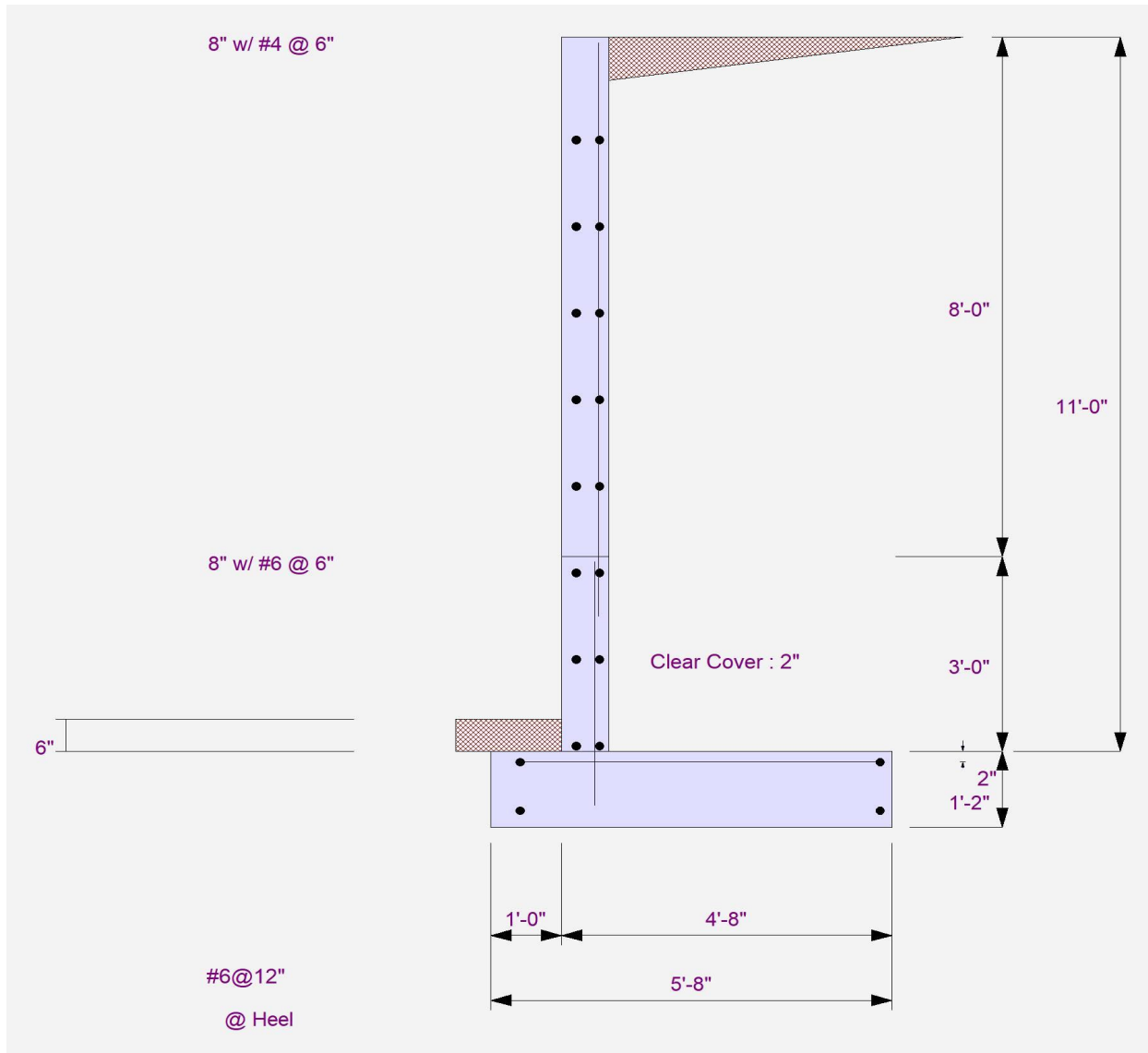
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 11' Retained



Cantilevered Retaining Wall

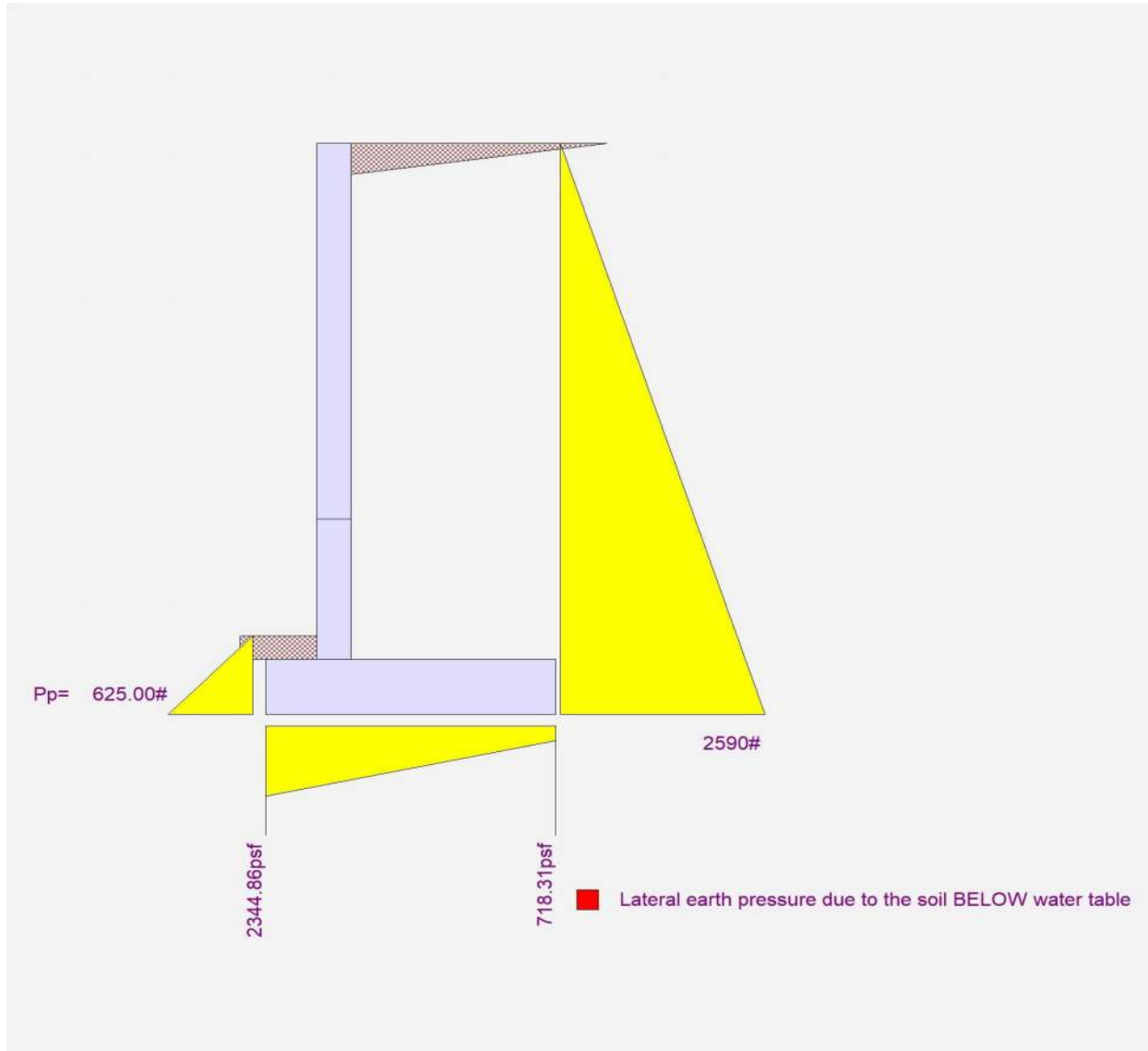
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 11' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 10' Retained - EQ

Code Reference.

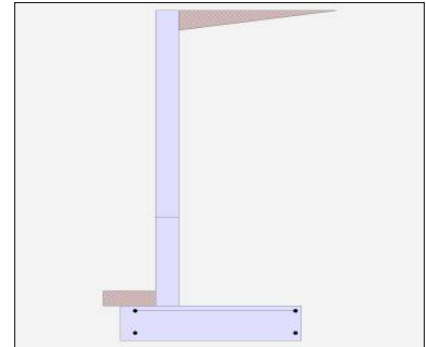
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	10.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	89.333
Total Seismic Force	=	997.556

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained - EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.96	OK
Sliding	=	1.55	OK
Global Stability	=	1.90	
Total Bearing Load	=	7,220	lbs
...resultant ecc.	=	11.93	in
Eccentricity outside middle third			
Soil Pressure @ Toe	=	3,026	psf OK
Soil Pressure @ Heel	=	0	psf OK
Allowable	=	3,333	psf
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	3,619	psf
ACI Factored @ Heel	=	0	psf
Footing Shear @ Toe	=	2.8	psi OK
Footing Shear @ Heel	=	27.6	psi OK
Allowable	=	82.2	psi

Sliding Calcs

Lateral Sliding Force	=	2,880.4	lbs
less 100% Passive Force	=	625.0	lbs
less 100% Friction Force	=	3,826.4	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 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

		2nd	Bottom		
Design Height Above Ftg	ft =	Stem OK	Stem OK		
Wall Material Above "Ht"	=	3.00	0.00		
Design Method	=	Concrete	Concrete	SD	SD
Thickness	=	SD	SD		
Rebar Size	=	8.00	8.00		
Rebar Spacing	=	# 4	# 6		
Rebar Placed at	=	6.00	6.00		
	=	Edge	Edge		

Design Data

fb/FB + fa/Fa	=	0.511	0.732
---------------	---	-------	-------

Total Force @ Section

Service Level	lbs =		
Strength Level	lbs =	1,997.3	3,693.3

Moment....Actual

Service Level	ft-# =		
Strength Level	ft-# =	5,390.0	13,800.0
Moment.....Allowable	ft-# =	10,542.0	18,848.3

Shear.....Actual

Service Level	psi =		
Strength Level	psi =	26.6	54.7
Shear.....Allowable	psi =	57.4	77.3

Anet (Masonry)

Wall Weight	psf =	100.0	100.0
Rebar Depth 'd'	in =	6.25	5.63

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 =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained - EQ

Concrete Stem Rebar Area Details

2nd Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2019 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2019 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.5779 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.5779 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.88 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9144 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	1.00 ft
Heel Width	=	4.17
Total Footing Width	=	5.17
Footing Thickness	=	14.00 in

f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	3,619	0	psf
Mu' : Upward	=	1,683	3,786	ft-#
Mu' : Downward	=	141	16,016	ft-#
Mu: Design	=	1,542	12,230	ft-#
φ Mn	=	3,944	22,163	ft-#
Actual 1-Way Shear	=	2.84	27.57	psi
Allow 1-Way Shear	=	43.82	48.20	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 6 @ 12.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: #4@ 7.40 in, #5@ 11.47 in, #6@ 16.29 in, #7@ 22.21 in, #8@ 29.25 in, #9@ 37.02 in, #10@ 47.02 in

Key: No key defined

Min footing T&S reinf Area	1.56	in2
Min footing T&S reinf Area per foot	0.30	in2 /ft
<u>If one layer of horizontal bars:</u>	<u>If two layers of horizontal bars:</u>	
#4@ 7.94 in	#4@	15.87 in
#5@ 12.30 in	#5@	24.60 in
#6@ 17.46 in	#6@	34.92 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained - EQ

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)	2,182.2	3.72	8,122.5	Soil Over HL (ab. water tbl)	4,204.0	3.42	14,370.7
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.42	14,370.7
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	60.0	0.50	30.0
Seismic Earth Load =	698.3	5.58	3,898.8	Surcharge Over Toe =			
=				Stem Weight(s) =	1,000.0	1.33	1,333.3
Total =	2,880.4	O.T.M. =	12,021.2	Earth @ Stem Transitions =			
				Footing Weight =	904.8	2.59	2,338.8
				Key Weight =			
				Vert. Component =	1,050.8	5.17	5,432.7
Resisting/Overturning Ratio =			1.96	Total =	7,219.6 lbs	R.M.=	23,505.5
Vertical Loads used for Soil Pressure =		7,219.6 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 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) 0.163 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained - EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: 2nd

Stem Design Height: 3.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in
Development length for #4 bar specified in this stem design segment = 13.15 in

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #6 bar specified in this stem design segment (25.4.2.4a) = 25.63 in
Development length for #6 bar specified in this stem design segment = 19.72 in

Hooked embedment length into footing for #6 bar specified in this stem design segment = 10.35 in
As Provided = 0.8800 in²/ft
As Required = 0.5779 in²/ft

Cantilevered Retaining Wall

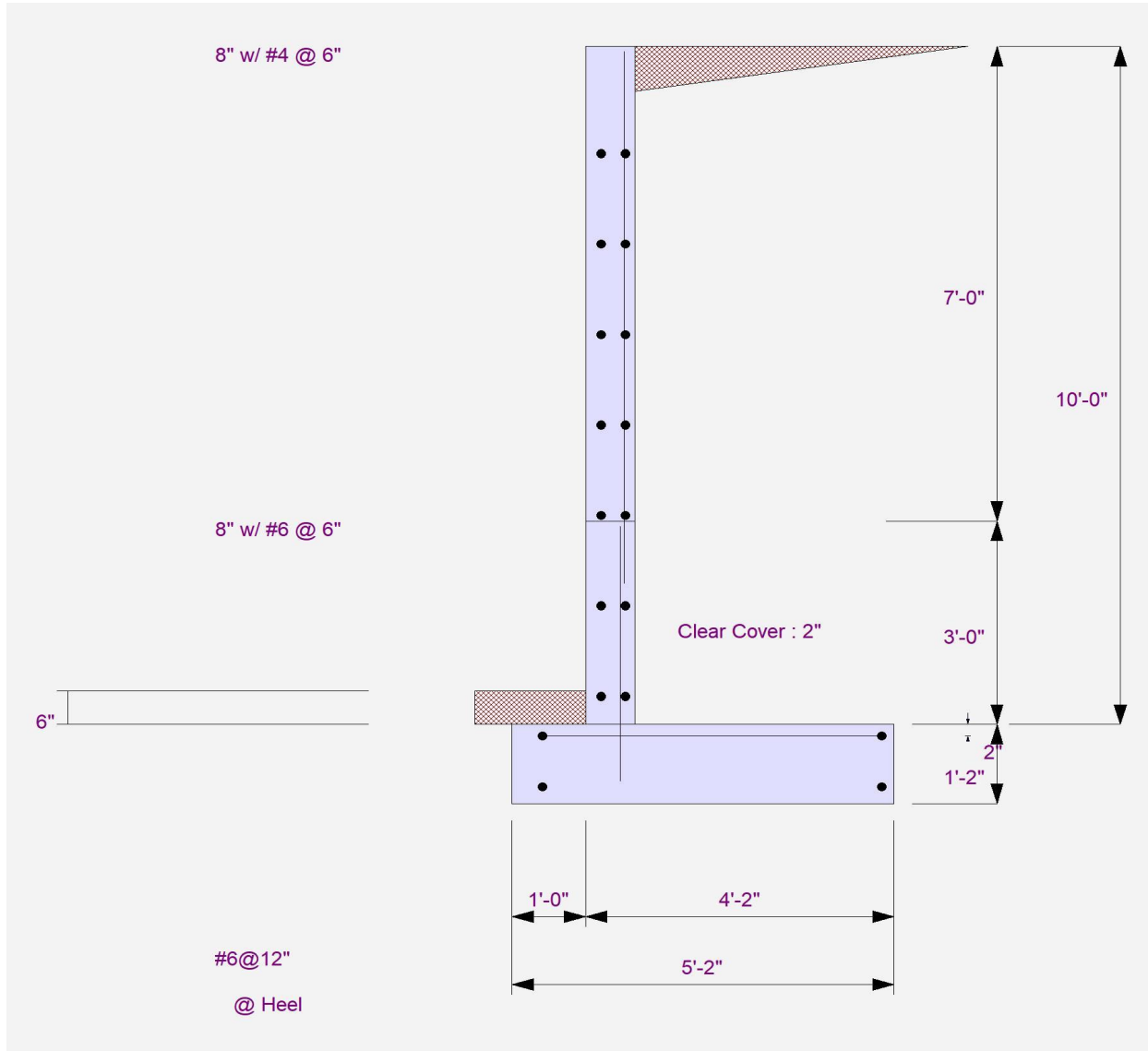
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 10' Retained - EQ



Cantilevered Retaining Wall

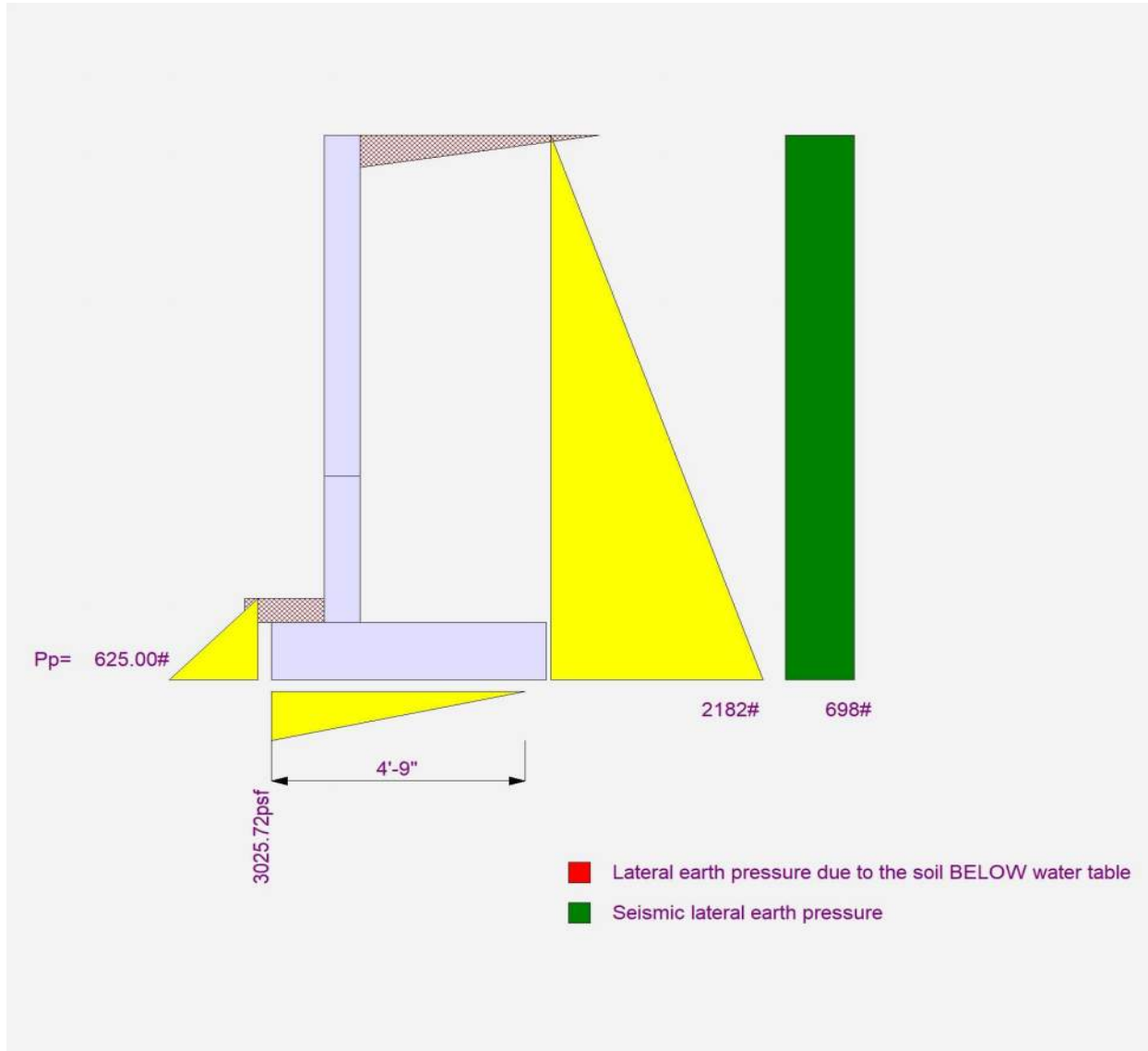
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 10' Retained - EQ



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 10' Retained

Code Reference.

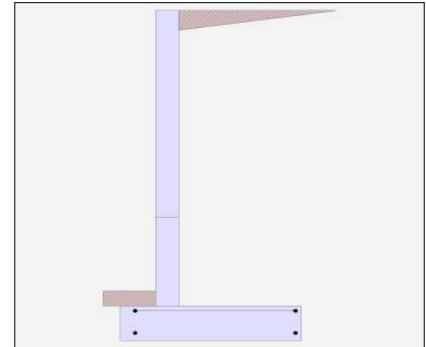
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	10.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 10' Retained

Design Summary

Wall Stability Ratios

Overturning	=	2.89	OK
Sliding	=	2.04	OK
Global Stability	=	1.90	
Total Bearing Load	=	7,220 lbs	
...resultant ecc.	=	5.45 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	2,133 psf	OK
Soil Pressure @ Heel	=	660 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,551 psf	
ACI Factored @ Heel	=	790 psf	
Footing Shear @ Toe	=	1.9 psi	OK
Footing Shear @ Heel	=	18.9 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	2,182.2 lbs	
less 100% Passive Force	=	625.0 lbs	
less 100% Friction Force	=	3,826.4 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 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

		2nd	Bottom		
Design Height Above Ftg	ft =	Stem OK	Stem OK		
Wall Material Above "Ht"	=	3.00	0.00		
Design Method	=	Concrete	Concrete		
Thickness	=	SD	SD	SD	SD
Rebar Size	=	8.00	8.00		
Rebar Spacing	=	# 4	# 6		
Rebar Placed at	=	6.00	6.00		
	=	Edge	Edge		

Design Data

fb/FB + fa/Fa	=	0.303	0.495
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Total Force @ Section

Service Level	lbs =		
Strength Level	lbs =	1,372.0	2,800.0

Moment....Actual

Service Level	ft-# =		
Strength Level	ft-# =	3,201.3	9,333.3
Moment.....Allowable	ft-# =	10,542.0	18,848.3

Shear.....Actual

Service Level	psi =		
Strength Level	psi =	18.3	41.5
Shear.....Allowable	psi =	57.4	77.3

Anet (Masonry)

Wall Weight	psf =	100.0	100.0
Rebar Depth 'd'	in =	6.25	5.63

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 =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained

Concrete Stem Rebar Area Details

2nd Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.1199 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.3909 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.3909 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.88 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9144 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	1.00 ft
Heel Width	=	4.17
Total Footing Width	=	5.17
Footing Thickness	=	14.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,551	790	psf
Mu' : Upward	=	1,219	7,288	ft-#
Mu' : Downward	=	141	16,016	ft-#
Mu: Design	=	1,078	8,727	ft-#
φ Mn	=	3,944	22,163	ft-#
Actual 1-Way Shear	=	1.93	18.87	psi
Allow 1-Way Shear	=	43.82	48.20	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 6 @ 12.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: #4@ 7.93 in, #5@ 12.30 in, #6@ 17.46 in, #7@ 23.80 in, #8@ 31.34 in, #9@ 39.68 in, #10@ 50.39 in

Key: No key defined

Min footing T&S reinf Area	1.56	in2
Min footing T&S reinf Area per foot	0.30	in2 /ft
<u>If one layer of horizontal bars:</u>	<u>If two layers of horizontal bars:</u>	
#4@ 7.94 in	#4@	15.87 in
#5@ 12.30 in	#5@	24.60 in
#6@ 17.46 in	#6@	34.92 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained

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)	2,182.2	3.72	8,122.5	Soil Over HL (ab. water tbl)	4,204.0	3.42	14,370.7
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.42	14,370.7
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	60.0	0.50	30.0
				Surcharge Over Toe =			
				Stem Weight(s) =	1,000.0	1.33	1,333.3
				Earth @ Stem Transitions =			
Total	= 2,182.2	O.T.M.	= 8,122.5	Footing Weight =	904.8	2.59	2,338.8
				Key Weight =			
				Vert. Component =	1,050.8	5.17	5,432.7
Resisting/Overturning Ratio		=	2.89	Total =	7,219.6 lbs	R.M.=	23,505.5
Vertical Loads used for Soil Pressure =		7,219.6 lbs		* 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 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) 0.115 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained

Rebar Lap & Embedment Lengths Information

Stem Design Segment: 2nd

Stem Design Height: 3.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in
Development length for #4 bar specified in this stem design segment = 13.15 in

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #6 bar specified in this stem design segment (25.4.2.4a) = 25.63 in
Development length for #6 bar specified in this stem design segment = 19.72 in

Hooked embedment length into footing for #6 bar specified in this stem design segment = 10.35 in
As Provided = 0.8800 in²/ft
As Required = 0.3909 in²/ft

Cantilevered Retaining Wall

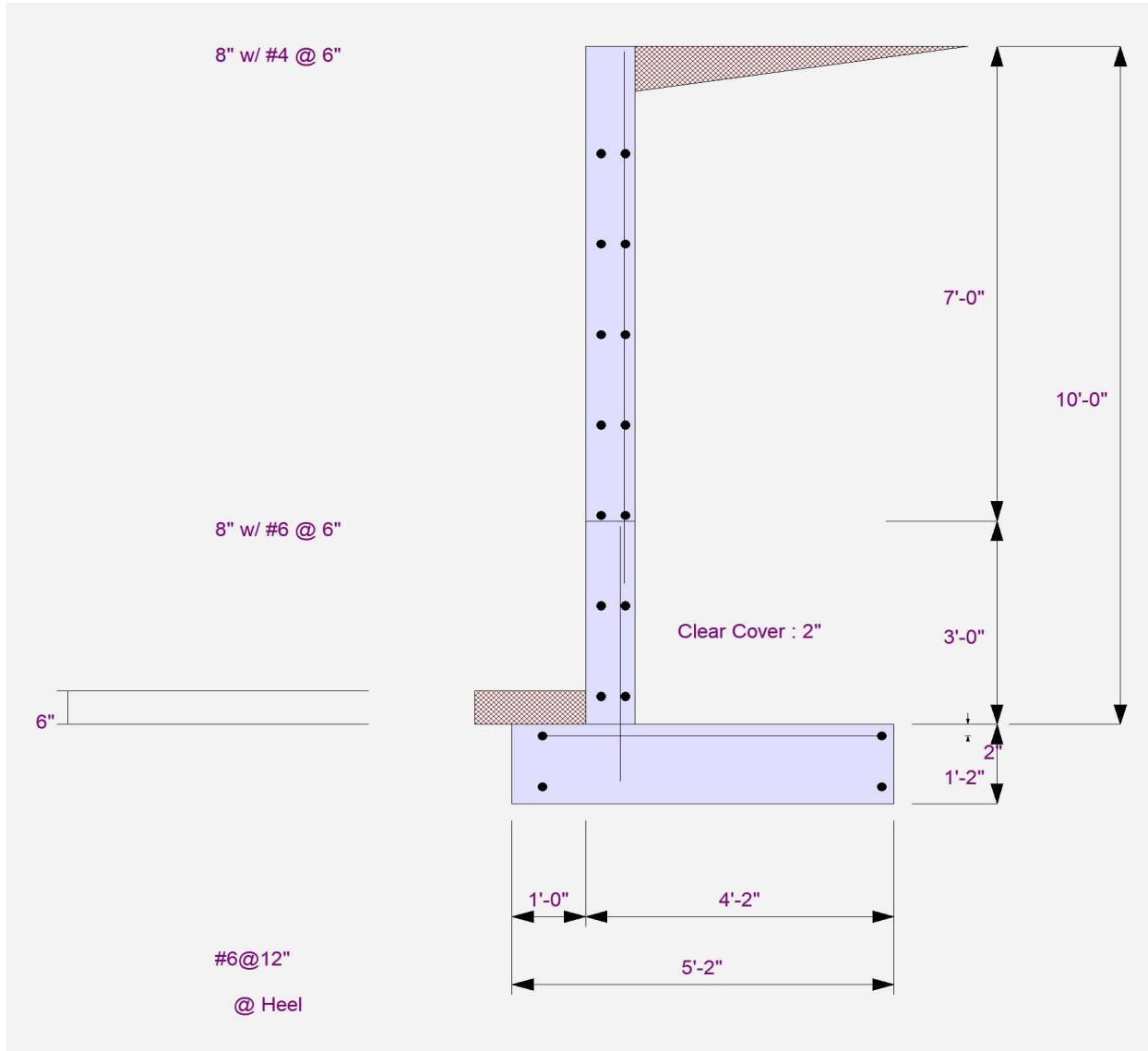
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 10' Retained



Cantilevered Retaining Wall

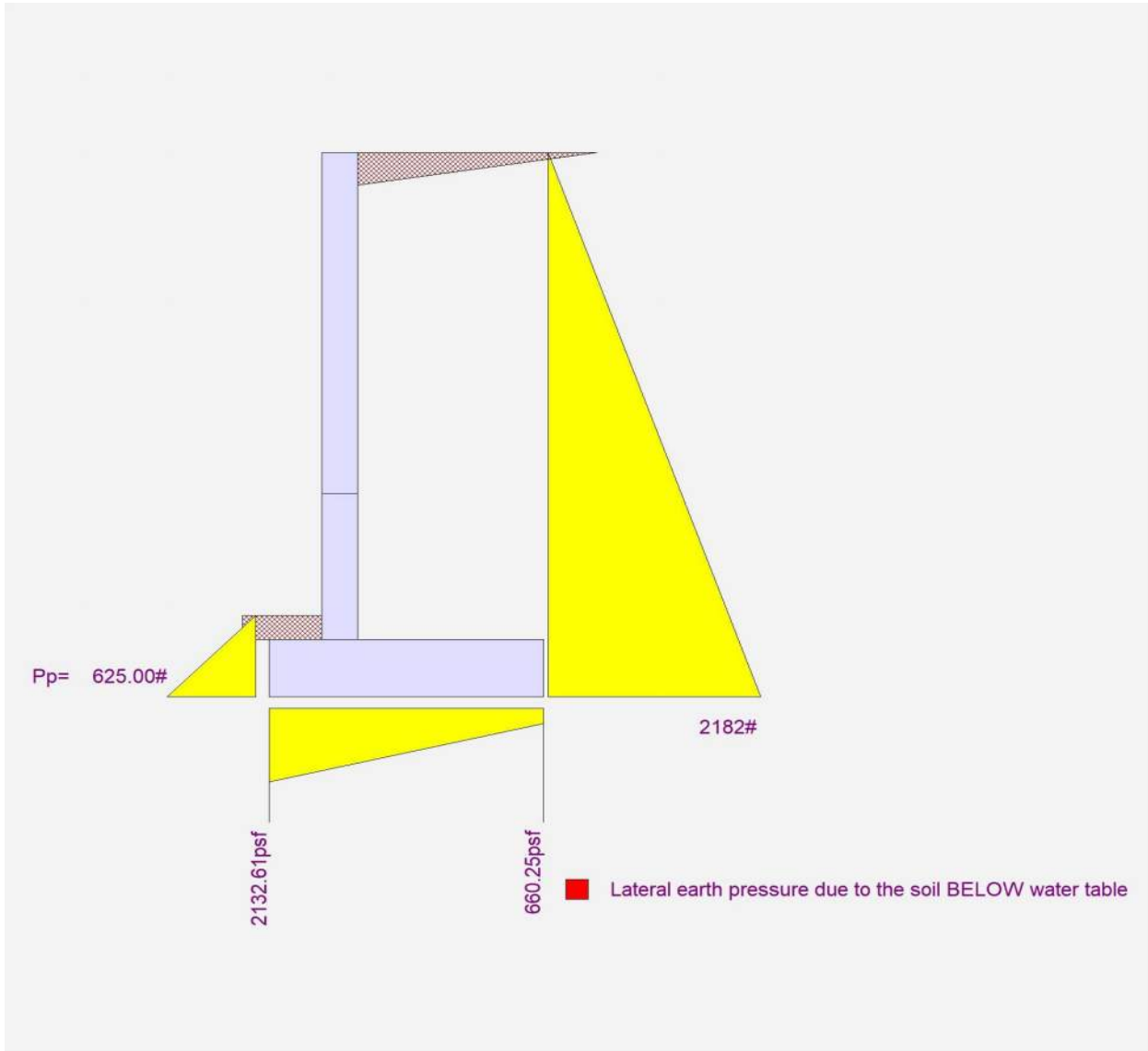
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 10' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained - EQ

Code Reference.

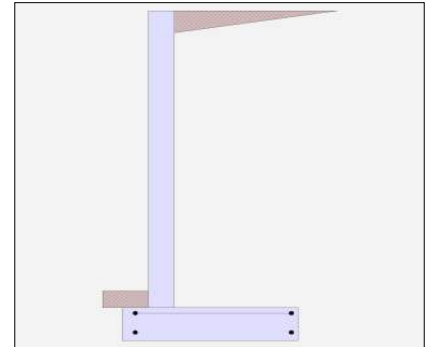
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	9.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	80.000
Total Seismic Force	=	800.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained - EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.88	OK
Sliding	=	1.57	OK
Global Stability	=	1.91	
Total Bearing Load	=	5,874	lbs
...resultant ecc.	=	11.55	in
Eccentricity outside middle third			
Soil Pressure @ Toe	=	3,041	psf OK
Soil Pressure @ Heel	=	0	psf OK
Allowable	=	3,333	psf
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	3,647	psf
ACI Factored @ Heel	=	0	psf
Footing Shear @ Toe	=	0.1	psi OK
Footing Shear @ Heel	=	26.4	psi OK
Allowable	=	82.2	psi

Sliding Calcs

Lateral Sliding Force	=	2,310.0	lbs
less 100% Passive Force	=	506.3	lbs
less 100% Friction Force	=	3,113.4	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 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

Design Height Above Ftg	ft =	Stem OK		
		0.00		
Wall Material Above "Ht"	=	Concrete		
Design Method	=	SD	SD	SD
Thickness	=	8.00		
Rebar Size	=	# 4		
Rebar Spacing	=	6.00		
Rebar Placed at	=	Edge		

Design Data

fb/FB + fa/Fa	=	0.952
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	2,988.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	10,044.0

Moment.....Allowable	=	10,542.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	39.8

Shear.....Allowable	psi =	57.4
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Anet (Masonry)

Wall Weight	psf =	100.0
Rebar Depth 'd'	in =	6.25

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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained - EQ

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.3763 in ² /ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in ² /ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.3763 in ² /ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in ² /ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in ² /ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	3.83
Total Footing Width	=	4.50
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	3,647	0	psf
Mu' : Upward	=	771	2,537	ft-#
Mu' : Downward	=	57	11,650	ft-#
Mu: Design	=	715	9,113	ft-#
φ Mn	=	2,739	16,844	ft-#
Actual 1-Way Shear	=	0.09	26.36	psi
Allow 1-Way Shear	=	43.82	49.51	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 4 @ 6.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: #4@ 8.16 in, #5@ 12.64 in, #6@ 17.95 in, #7@ 24.48 in, #8@ 32.23 in, #9@ 40.80 in, #10@ 51.82 in

Key: No key defined

Min footing T&S reinf Area	1.17	in ²
Min footing T&S reinf Area per foot	0.26	in ² /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained - EQ

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)	1,750.0	3.33	5,833.3	Soil Over HL (ab. water tbl)	3,416.4	2.92	9,970.2
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.92	9,970.2
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
Seismic Earth Load =	560.0	5.00	2,800.0	Surcharge Over Toe =			
=				Stem Weight(s) =	900.0	1.00	903.0
Total =	2,310.0	O.T.M. =	8,633.3	Earth @ Stem Transitions =			
				Footing Weight =	675.0	2.25	1,518.8
				Key Weight =			
				Vert. Component =	842.7	4.50	3,792.2
				Total =	5,874.3 lbs	R.M.=	16,197.6

Resisting/Overturning Ratio = 1.88
 Vertical Loads used for Soil Pressure = 5,874.3 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 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) 0.169 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained - EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.4000 in ² /ft
As Required =	0.3763 in ² /ft

Cantilevered Retaining Wall

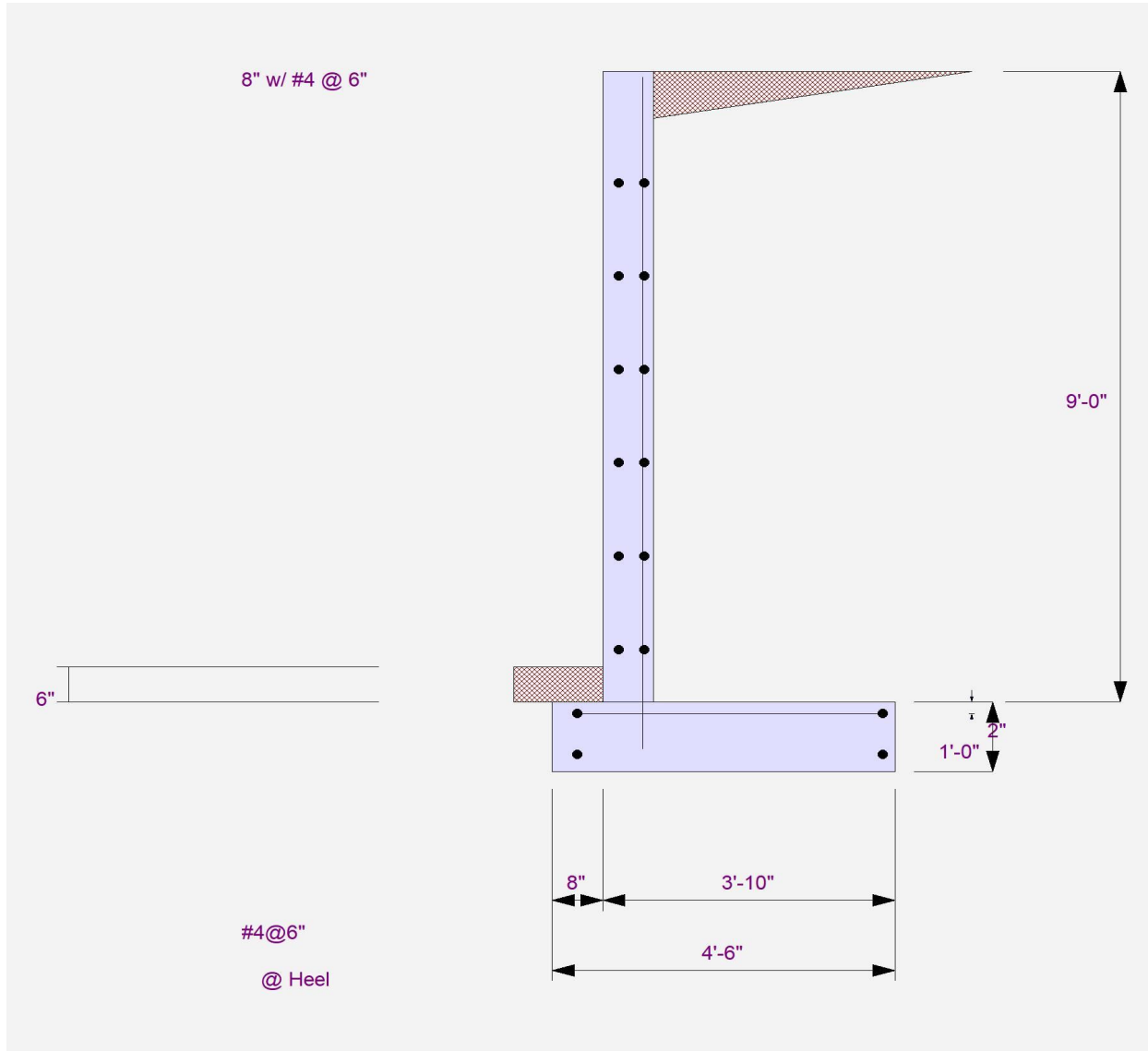
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained - EQ



Cantilevered Retaining Wall

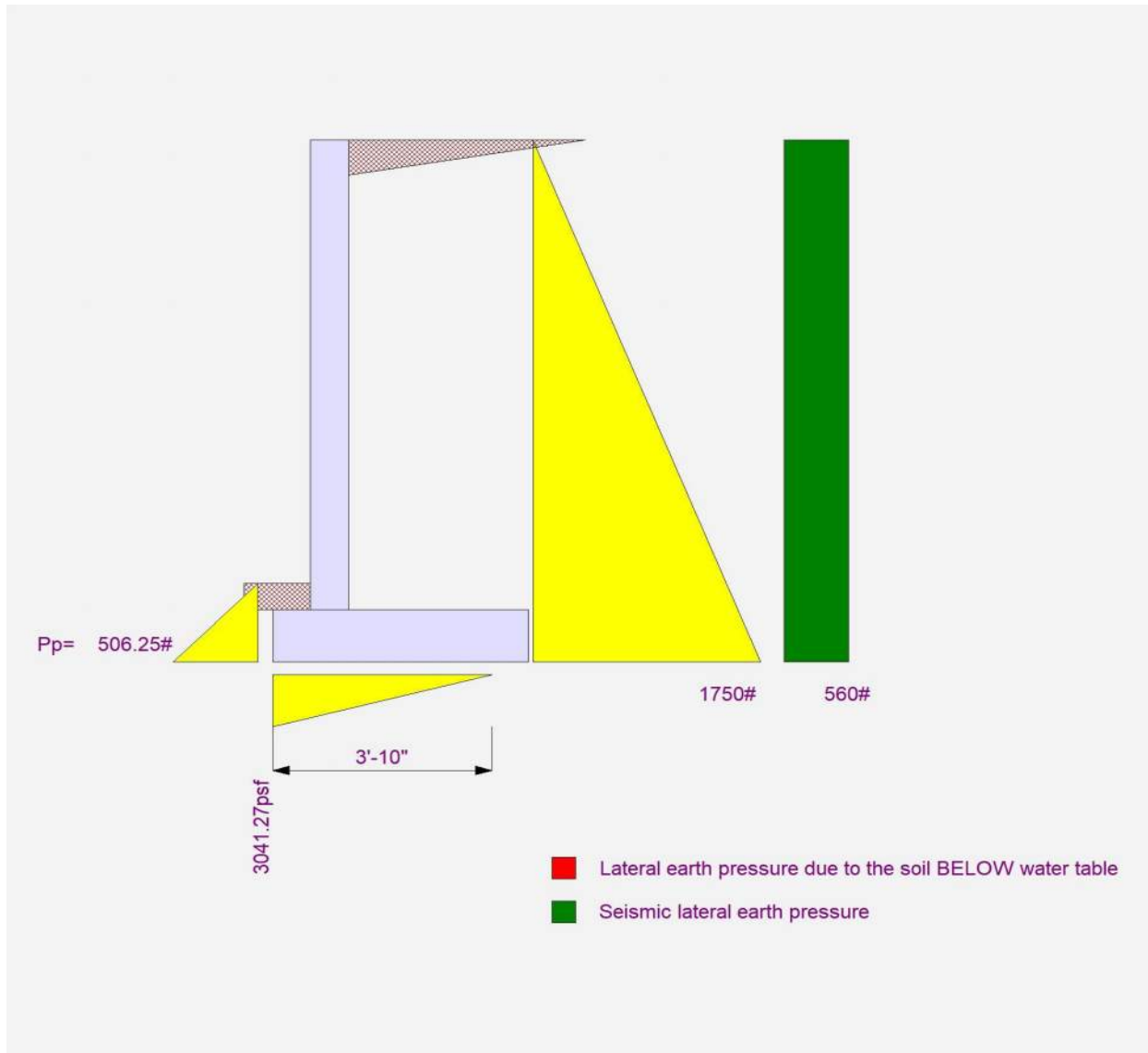
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained - EQ



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained

Code Reference.

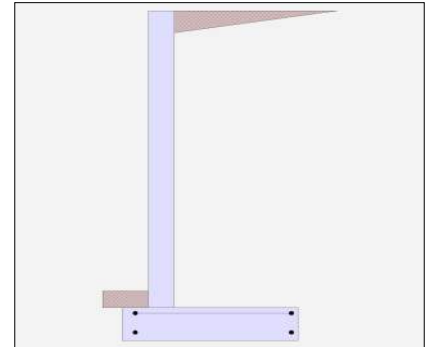
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	9.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained

Design Summary

Wall Stability Ratios

Overturning	=	2.78	OK
Sliding	=	2.07	OK
Global Stability	=	1.91	
Total Bearing Load	=	5,874	lbs
...resultant ecc.	=	5.83	in
Eccentricity within middle third			
Soil Pressure @ Toe	=	2,151	psf OK
Soil Pressure @ Heel	=	460	psf OK
Allowable	=	2,500	psf
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,579	psf
ACI Factored @ Heel	=	552	psf
Footing Shear @ Toe	=	0.1	psi OK
Footing Shear @ Heel	=	17.7	psi OK
Allowable	=	82.2	psi

Sliding Calcs

Lateral Sliding Force	=	1,750.0	lbs
less 100% Passive Force	=	506.3	lbs
less 100% Friction Force	=	3,113.4	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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	6.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.645
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	2,268.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	6,804.0

Moment.....Allowable	=	10,542.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	30.2

Shear.....Allowable	psi =	57.4
---------------------	-------	------

Anet (Masonry)	in2 =	
----------------	-------	--

Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2549 in ² /ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in ² /ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2549 in ² /ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in ² /ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in ² /ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	3.83
Total Footing Width	=	4.50
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,579	552	psf
Mu' : Upward	=	556	5,137	ft-#
Mu' : Downward	=	57	11,650	ft-#
Mu: Design	=	500	6,513	ft-#
φ Mn	=	2,739	16,844	ft-#
Actual 1-Way Shear	=	0.09	17.70	psi
Allow 1-Way Shear	=	43.82	49.51	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 4 @ 6.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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	1.17	in ²
Min footing T&S reinf Area per foot	0.26	in ² /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained

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)	1,750.0	3.33	5,833.3	Soil Over HL (ab. water tbl)	3,416.4	2.92	9,970.2
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.92	9,970.2
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
				Surcharge Over Toe =			
				Stem Weight(s) =	900.0	1.00	903.0
				Earth @ Stem Transitions =			
Total	= 1,750.0	O.T.M. =	5,833.3	Footing Weight =	675.0	2.25	1,518.8
				Key Weight =			
				Vert. Component =	842.7	4.50	3,792.2
Resisting/Overturning Ratio		= 2.78		Total =	5,874.3 lbs	R.M.=	16,197.6
Vertical Loads used for Soil Pressure =		5,874.3 lbs		* 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 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) 0.119 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.4000 in ² /ft
As Required =	0.2549 in ² /ft

Cantilevered Retaining Wall

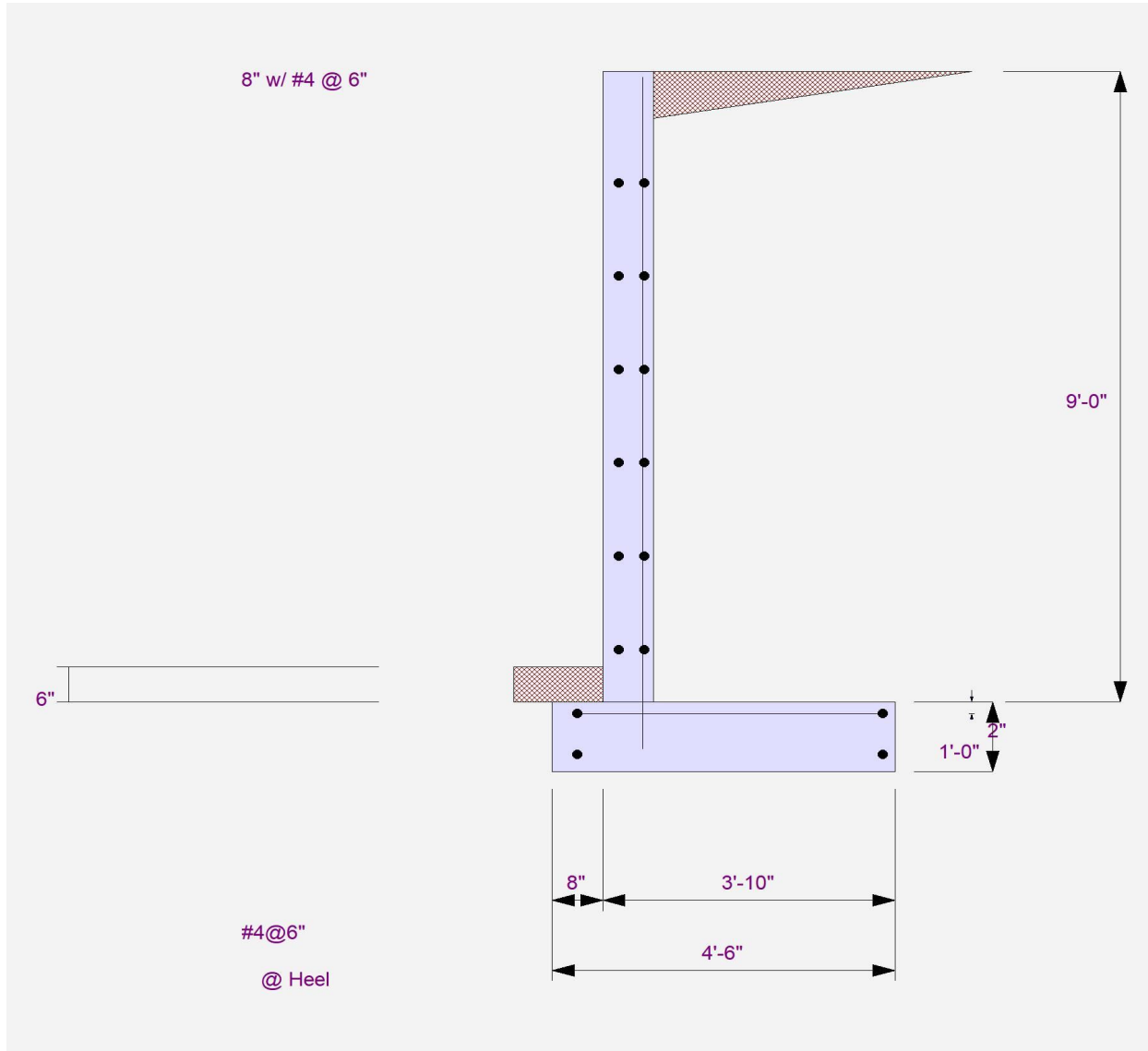
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained



Cantilevered Retaining Wall

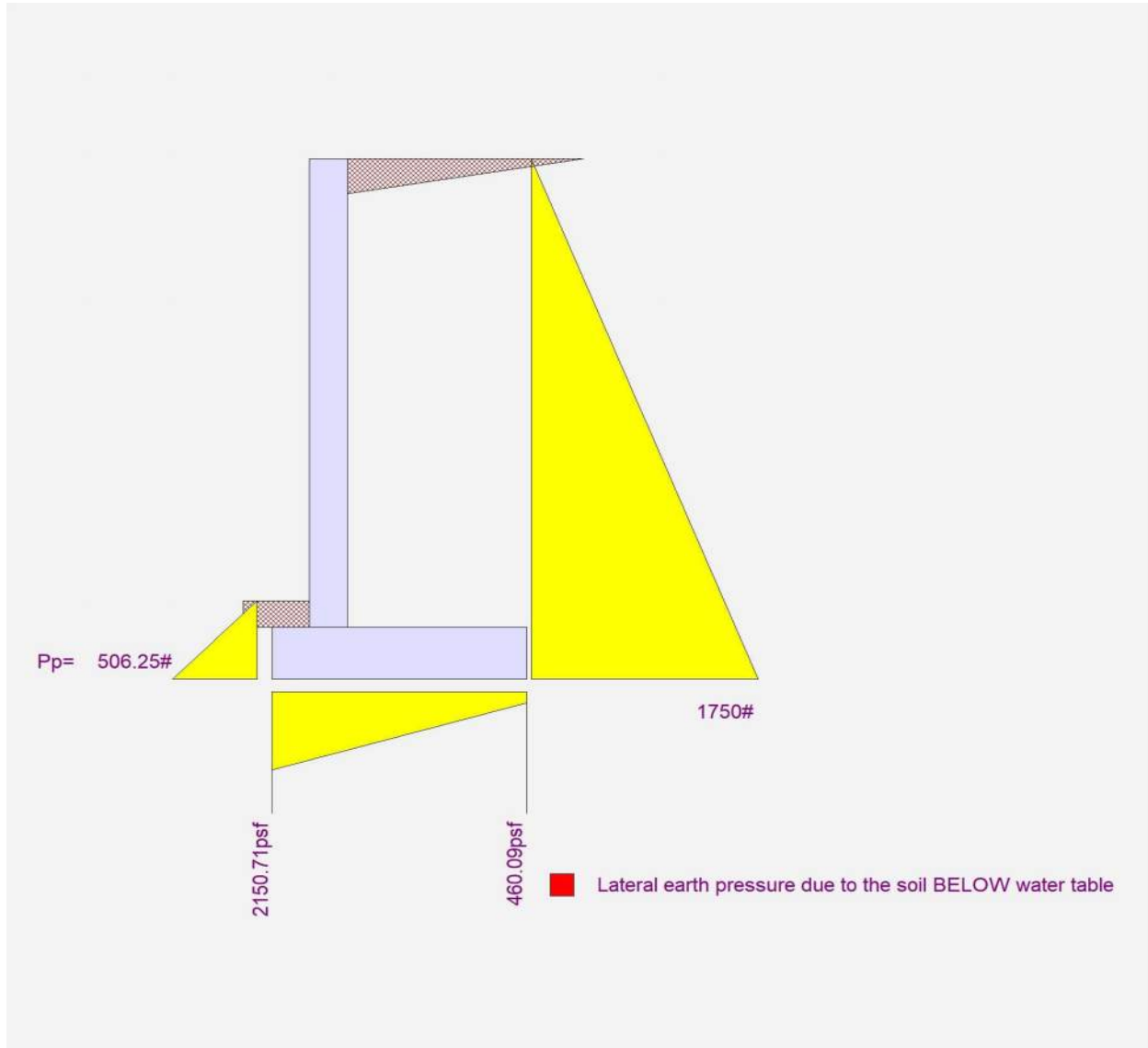
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ

Code Reference.

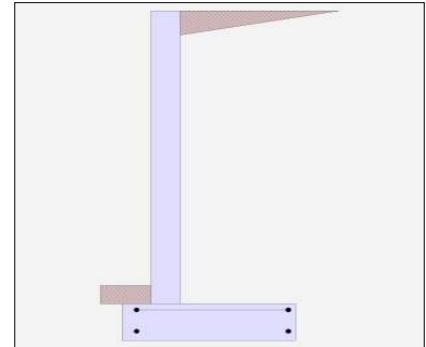
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	8.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	72.000
Total Seismic Force	=	648.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.84	OK
Sliding	=	1.60	OK
Global Stability	=	1.97	

Total Bearing Load	=	4,680	lbs
...resultant ecc.	=	10.47	in

Eccentricity outside middle third

Soil Pressure @ Toe	=	2,767	psf	OK
Soil Pressure @ Heel	=	0	psf	OK
Allowable	=	3,333	psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	3,309	psf	
ACI Factored @ Heel	=	0	psf	
Footing Shear @ Toe	=	0.1	psi	OK
Footing Shear @ Heel	=	22.7	psi	OK
Allowable	=	82.2	psi	

Sliding Calcs

Lateral Sliding Force	=	1,871.1	lbs	
less 100% Passive Force	=	506.3	lbs	
less 100% Friction Force	=	2,480.2	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 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

Design Height Above Ftg	ft =	Stem	OK
		0.00	
Wall Material Above "Ht"	=	Concrete	
Design Method	=	SD	SD SD
Thickness	=	8.00	
Rebar Size	=	# 4	
Rebar Spacing	=	9.00	
Rebar Placed at	=	Edge	

Design Data

fb/FB + fa/Fa	=	0.985
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	2,368.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	7,082.7

Moment.....Allowable	=	7,185.3
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	31.6

Shear.....Allowable	psi =	50.2
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2654 in ² /ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in ² /ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2654 in ² /ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2667 in ² /ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in ² /ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	3.33
Total Footing Width	=	4.00
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	3,309	0	psf
Mu' : Upward	=	694	1,395	ft-#
Mu' : Downward	=	57	7,633	ft-#
Mu: Design	=	637	6,238	ft-#
φ Mn	=	2,739	11,388	ft-#
Actual 1-Way Shear	=	0.09	22.75	psi
Allow 1-Way Shear	=	43.82	43.25	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 4 @ 9.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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	1.04	in ²
Min footing T&S reinf Area per foot	0.26	in ² /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ

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)	1,417.5	3.00	4,252.5	Soil Over HL (ab. water tbl)	2,556.8	2.67	6,822.4
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.67	6,822.4
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
Seismic Earth Load =	453.6	4.50	2,041.2	Surcharge Over Toe =			
=				Stem Weight(s) =	800.0	1.00	802.7
Total =	1,871.1	O.T.M.	6,293.7	Earth @ Stem Transitions =			
				Footing Weight =	600.0	2.00	1,200.0
				Key Weight =			
				Vert. Component =	682.6	4.00	2,730.4
				Total =	4,679.6 lbs	R.M.=	11,568.9

Resisting/Overturning Ratio = 1.84
 Vertical Loads used for Soil Pressure = 4,679.6 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 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) 0.154 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2667 in ² /ft
As Required =	0.2654 in ² /ft

Cantilevered Retaining Wall

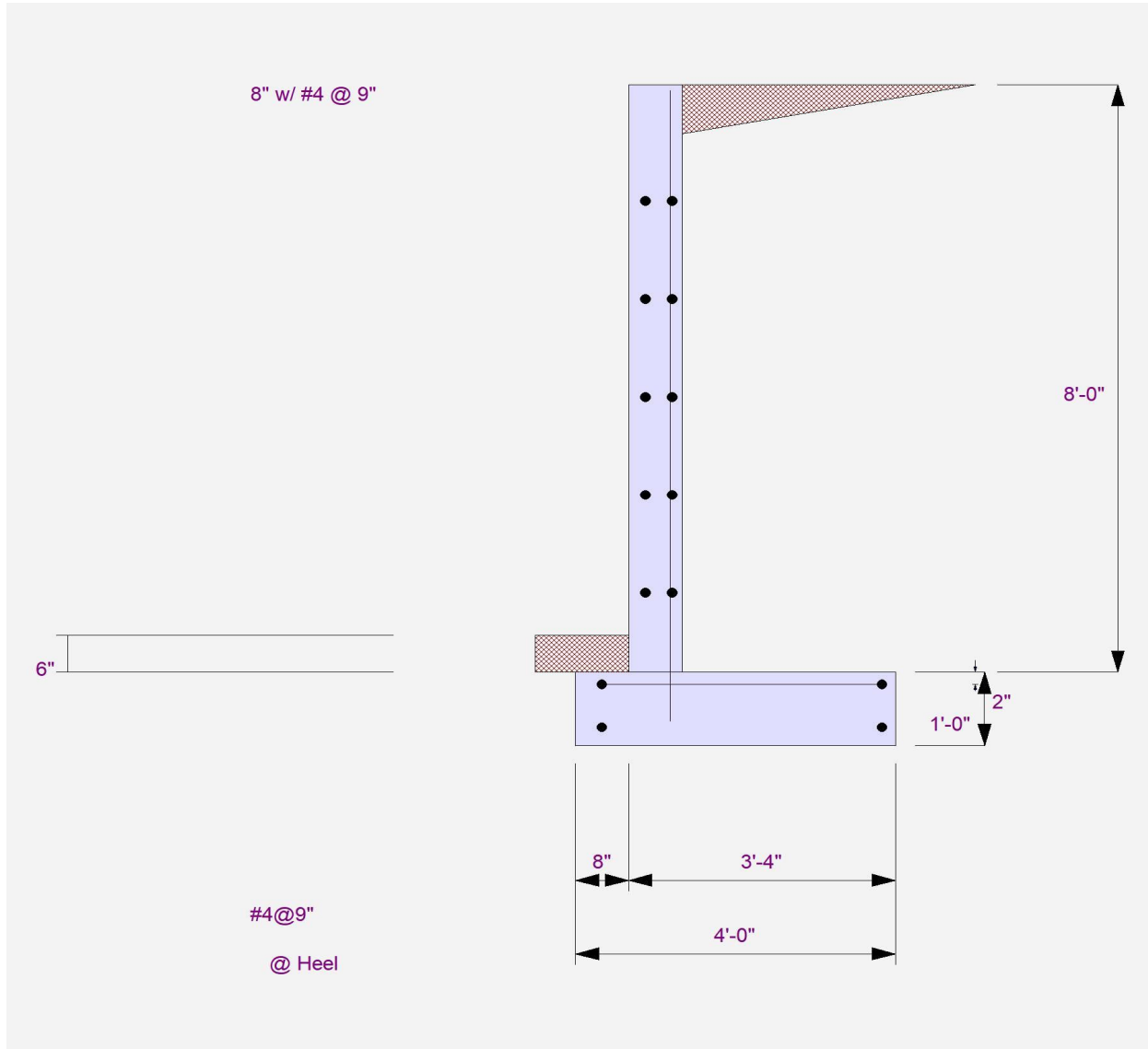
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ



Cantilevered Retaining Wall

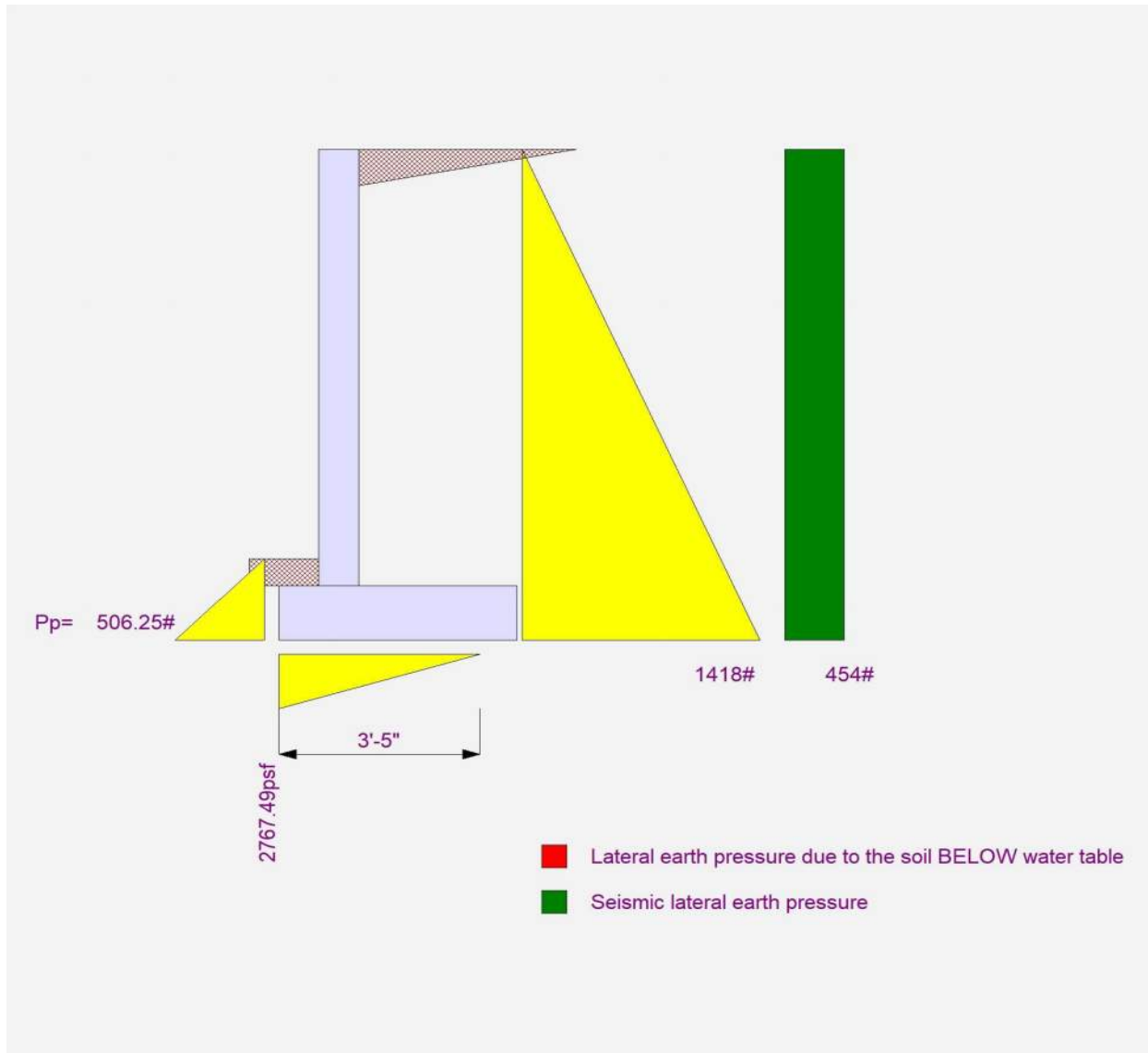
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 8' Retained - EQ



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - Rebar Centered

Code Reference.

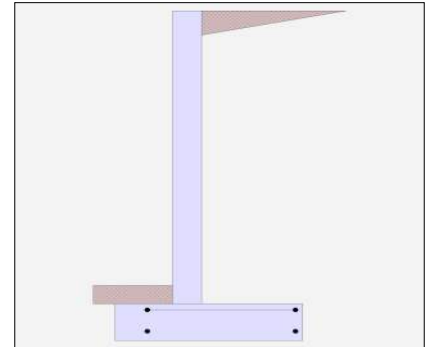
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	8.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - Rebar Centered

Design Summary

Wall Stability Ratios

Overturning	=	3.02	OK
Sliding	=	2.02	OK
Global Stability	=	1.89	
Total Bearing Load	=	4,452 lbs	
...resultant ecc.	=	2.86 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,367 psf	OK
Soil Pressure @ Heel	=	689 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,621 psf	
ACI Factored @ Heel	=	817 psf	
Footing Shear @ Toe	=	6.7 psi	OK
Footing Shear @ Heel	=	15.7 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	1,417.5 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	2,359.5 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 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

Design Height Above Ftg	ft =	Stem OK		
Wall Material Above "Ht"	=	Concrete		
Design Method	=	SD	SD	SD
Thickness	=	8.00		
Rebar Size	=	# 4		
Rebar Spacing	=	8.00		
Rebar Placed at	=	Center		

Design Data

fb/FB + fa/Fa	=	0.955
---------------	---	-------

Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,792.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	4,778.7

Moment.....Allowable	=	5,001.8
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	37.3

Shear.....Allowable	psi =	60.5
---------------------	-------	------

Anet (Masonry)	in2 =	
----------------	-------	--

Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	4.00
-----------------	------	------

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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - Rebar Centered

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2885 in ² /ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in ² /ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2885 in ² /ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.3 in ² /ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.6503 in ² /ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	1.33 ft
Heel Width	=	3.00
Total Footing Width	=	4.33
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,621	817	psf
Mu' : Upward	=	1,361	2,617	ft-#
Mu' : Downward	=	223	6,174	ft-#
Mu: Design	=	1,138	3,558	ft-#
φ Mn	=	2,739	11,388	ft-#
Actual 1-Way Shear	=	6.67	15.69	psi
Allow 1-Way Shear	=	43.82	43.25	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 4 @ 9.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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	1.12	in ²
Min footing T&S reinf Area per foot	0.26	in ² /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - Rebar Centered

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)	1,417.5	3.00	4,252.5	Soil Over HL (ab. water tbl)	2,240.0	3.16	7,085.9
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.16	7,085.9
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	79.8	0.67	53.1
				Surcharge Over Toe =			
				Stem Weight(s) =	800.0	1.66	1,330.7
				Earth @ Stem Transitions =			
Total	= 1,417.5	O.T.M. =	4,252.5	Footing Weight =	649.5	2.17	1,406.2
				Key Weight =			
				Vert. Component =	682.6	4.33	2,955.6
Resisting/Overturning Ratio		= 3.02		Total =	4,451.9 lbs	R.M.=	12,831.4
Vertical Loads used for Soil Pressure =		4,451.9 lbs		* 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 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) 0.070 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - Rebar Centered

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.3000 in ² /ft
As Required =	0.2885 in ² /ft

Cantilevered Retaining Wall

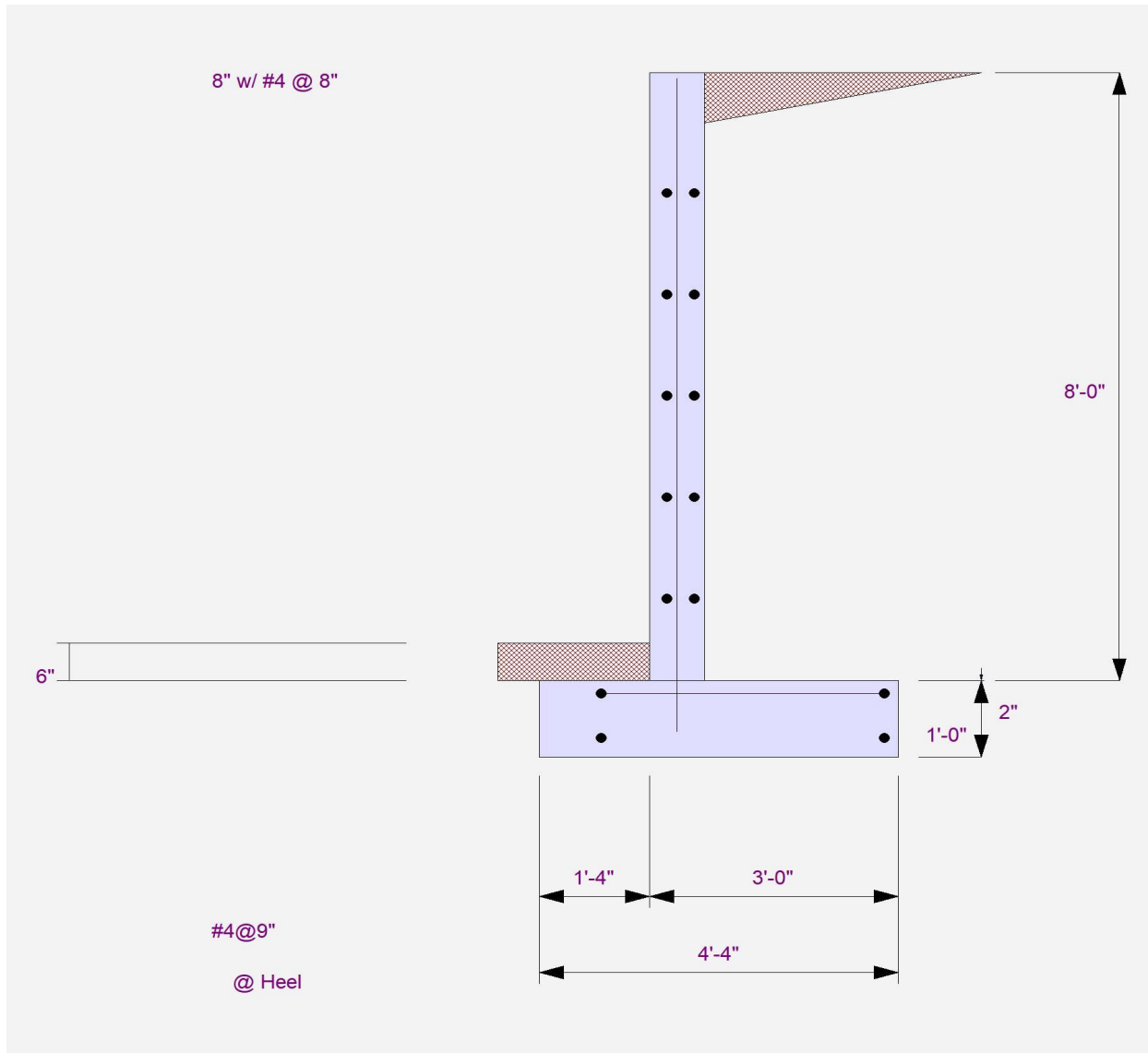
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - Rebar Centered



Cantilevered Retaining Wall

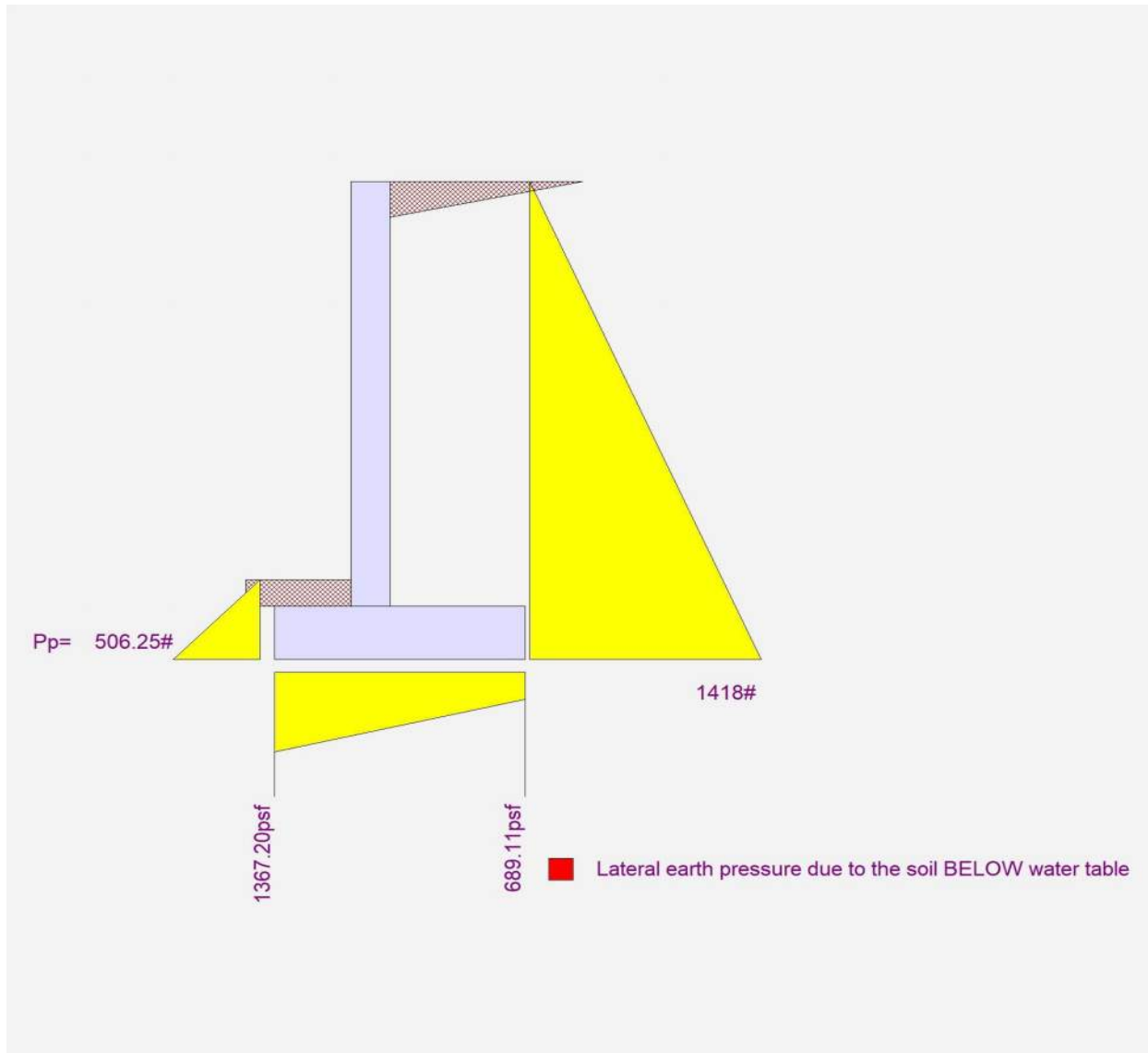
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - Rebar Centered



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained

Code Reference.

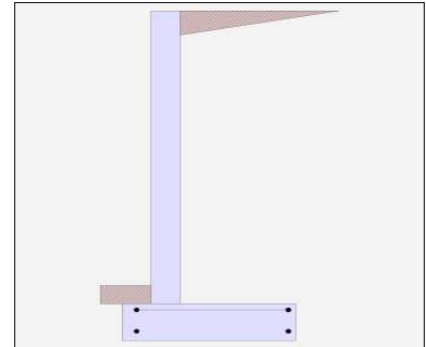
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	8.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained

Design Summary

Wall Stability Ratios

Overturning	=	2.72	OK
Sliding	=	2.11	OK
Global Stability	=	1.97	
Total Bearing Load	=	4,680 lbs	
...resultant ecc.	=	5.24 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,936 psf	OK
Soil Pressure @ Heel	=	404 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,315 psf	
ACI Factored @ Heel	=	483 psf	
Footing Shear @ Toe	=	0.1 psi	OK
Footing Shear @ Heel	=	15.2 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	1,417.5 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	2,480.2 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 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

Design Height Above Ftg	ft =	Stem OK		
		0.00		
Wall Material Above "Ht"	=	Concrete		
Design Method	=	SD	SD	SD
Thickness	=	8.00		
Rebar Size	=	# 4		
Rebar Spacing	=	10.00		
Rebar Placed at	=	Edge		

Design Data

fb/FB + fa/Fa	=	0.735
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,792.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	4,778.7

Moment.....Allowable	=	6,495.1
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	23.9

Shear.....Allowable	psi =	48.4
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.179 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.179 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.24 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	3.33
Total Footing Width	=	4.00
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,315	483	psf
Mu' : Upward	=	497	3,155	ft-#
Mu' : Downward	=	57	7,633	ft-#
Mu: Design	=	440	4,478	ft-#
φ Mn	=	2,739	11,388	ft-#
Actual 1-Way Shear	=	0.09	15.17	psi
Allow 1-Way Shear	=	43.82	43.25	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 4 @ 9.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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

If one layer of horizontal bars:

#4@ 9.26 in
 #5@ 14.35 in
 #6@ 20.37 in

If two layers of horizontal bars:

#4@ 18.52 in
 #5@ 28.70 in
 #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained

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)	1,417.5	3.00	4,252.5	Soil Over HL (ab. water tbl)	2,556.8	2.67	6,822.4
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.67	6,822.4
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
				Surcharge Over Toe =			
				Stem Weight(s) =	800.0	1.00	802.7
				Earth @ Stem Transitions =			
				Footing Weight =	600.0	2.00	1,200.0
				Key Weight =			
				Vert. Component =	682.6	4.00	2,730.4
Total	= 1,417.5	O.T.M. =	4,252.5	Total =	4,679.6 lbs	R.M.=	11,568.9
Resisting/Overturning Ratio		=	2.72				
Vertical Loads used for Soil Pressure =		4,679.6 lbs					

* 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 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) 0.108 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2400 in ² /ft
As Required =	0.2387 in ² /ft

Cantilevered Retaining Wall

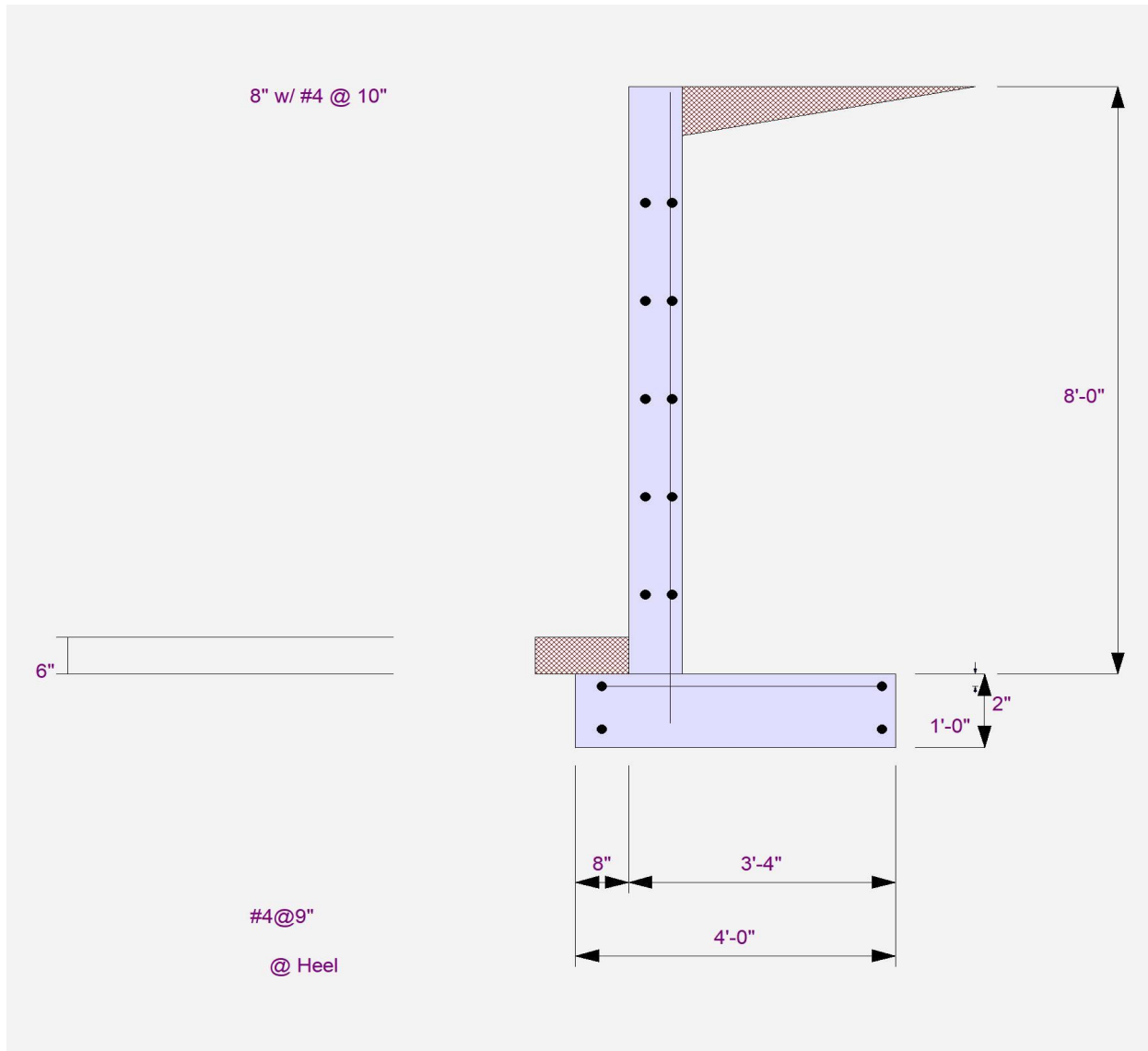
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ

Code Reference.

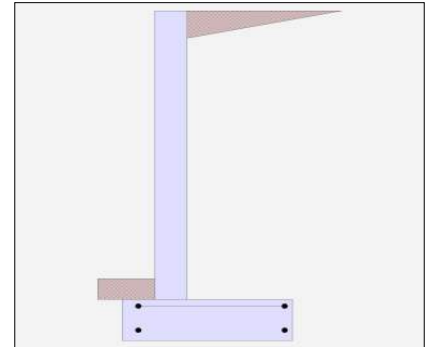
Calculations per IBC 2021 1807.3, ASCE 7-16

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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	64.000
Total Seismic Force	=	512.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.79	OK
Sliding	=	1.64	OK
Global Stability	=	2.04	
Total Bearing Load	=	3,622 lbs	
...resultant ecc.	=	9.41 in	
Eccentricity outside middle third			
Soil Pressure @ Toe	=	2,501 psf	OK
Soil Pressure @ Heel	=	0 psf	OK
Allowable	=	3,333 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,980 psf	
ACI Factored @ Heel	=	0 psf	
Footing Shear @ Toe	=	0.1 psi	OK
Footing Shear @ Heel	=	19.1 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	1,478.4 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	1,919.5 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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	9.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.663
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,820.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	4,769.3

Moment.....Allowable	=	7,185.3
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	24.3

Shear.....Allowable	psi =	50.2
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Bottom

SD SD SD

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.1787 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1787 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2667 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	2.83
Total Footing Width	=	3.50
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,980	0	psf
Mu' : Upward	=	617	651	ft-#
Mu' : Downward	=	57	4,647	ft-#
Mu: Design	=	561	3,996	ft-#
φ Mn	=	2,739	11,388	ft-#
Actual 1-Way Shear	=	0.09	19.14	psi
Allow 1-Way Shear	=	43.82	43.25	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 4 @ 9.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ

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)	1,120.0	2.67	2,986.7	Soil Over HL (ab. water tbl)	1,817.2	2.42	4,394.6
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.42	4,394.6
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
Seismic Earth Load =	358.4	4.00	1,433.6	Surcharge Over Toe =			
=				Stem Weight(s) =	700.0	1.00	702.3
Total =	1,478.4	O.T.M. =	4,420.3	Earth @ Stem Transitions =			
				Footing Weight =	525.0	1.75	918.8
				Key Weight =			
				Vert. Component =	539.3	3.50	1,887.7
				Total =	3,621.7 lbs	R.M.=	7,916.8

Resisting/Overturning Ratio = 1.79
 Vertical Loads used for Soil Pressure = 3,621.7 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 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) 0.139 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2667 in ² /ft
As Required =	0.2383 in ² /ft

Cantilevered Retaining Wall

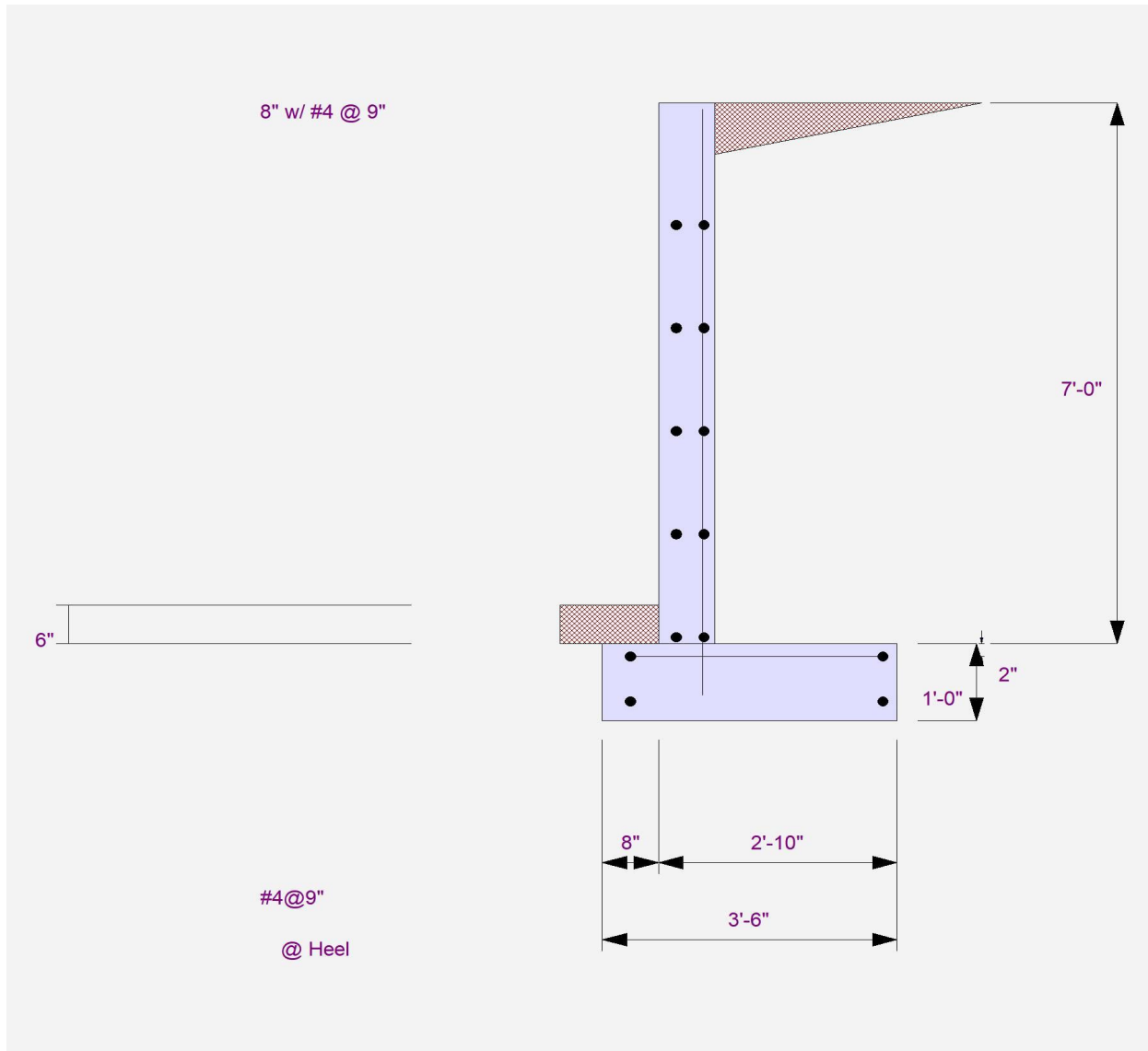
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ



Cantilevered Retaining Wall

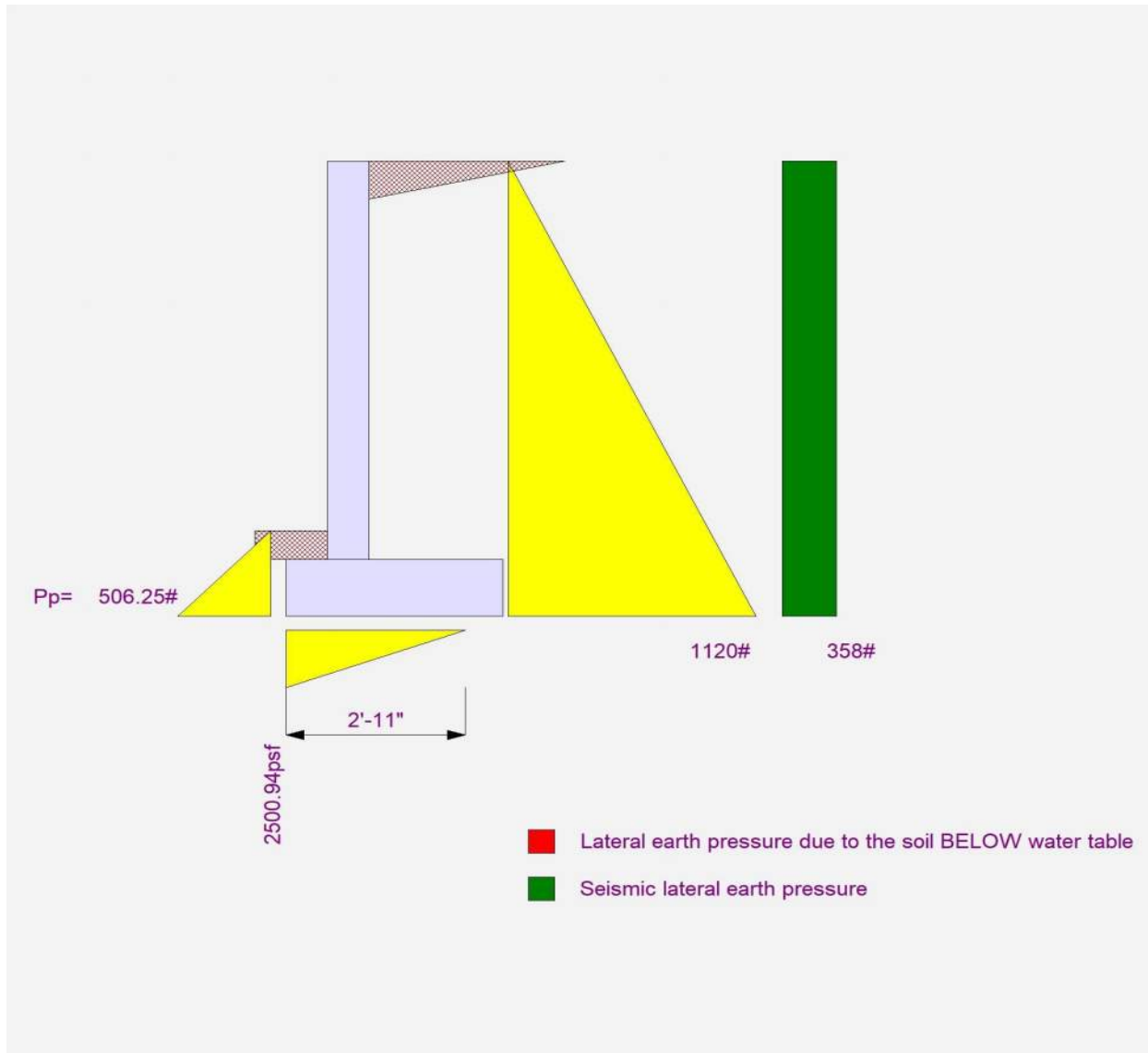
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 7' Retained

Code Reference.

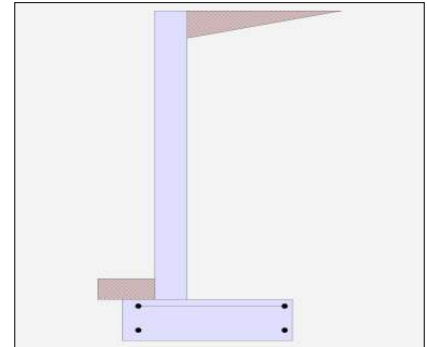
Calculations per IBC 2021 1807.3, ASCE 7-16

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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.600
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained

Design Summary

Wall Stability Ratios

Overtuning	=	2.65	OK
Sliding	=	2.39	OK
Global Stability	=	2.04	

Total Bearing Load	=	3,622	lbs
...resultant ecc.	=	4.66	in

Eccentricity within middle third

Soil Pressure @ Toe	=	1,724	psf	OK
Soil Pressure @ Heel	=	345	psf	OK
Allowable	=	2,500	psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	2,055	psf	
ACI Factored @ Heel	=	411	psf	
Footing Shear @ Toe	=	0.1	psi	OK
Footing Shear @ Heel	=	12.7	psi	OK
Allowable	=	82.2	psi	

Sliding Calcs

Lateral Sliding Force	=	1,120.0	lbs	
less 100% Passive Force	=	506.3	lbs	
less 100% Friction Force	=	2,173.0	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 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

Design Height Above Ftg	ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete	
Design Method	=	SD	SD SD
Thickness	=	8.00	
Rebar Size	=	# 4	
Rebar Spacing	=	9.00	
Rebar Placed at	=	5.75	i

Design Data

fb/FB + fa/Fa	=	0.486
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,372.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	3,201.3

Moment.....Allowable	=	6,585.3
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	19.9

Shear.....Allowable	psi =	51.6
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	5.75
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.131 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2667 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9347 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	2.83
Total Footing Width	=	3.50
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,055	411	psf
Mu' : Upward	=	438	1,755	ft-#
Mu' : Downward	=	57	4,647	ft-#
Mu: Design	=	381	2,892	ft-#
φ Mn	=	2,739	11,388	ft-#
Actual 1-Way Shear	=	0.09	12.67	psi
Allow 1-Way Shear	=	43.82	43.25	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	# 4 @ 9.00 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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

If one layer of horizontal bars:

#4@ 9.26 in
 #5@ 14.35 in
 #6@ 20.37 in

If two layers of horizontal bars:

#4@ 18.52 in
 #5@ 28.70 in
 #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained

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)	1,120.0	2.67	2,986.7	Soil Over HL (ab. water tbl)	1,817.2	2.42	4,394.6
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.42	4,394.6
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
				Surcharge Over Toe =			
				Stem Weight(s) =	700.0	1.00	702.3
				Earth @ Stem Transitions =			
Total	= 1,120.0	O.T.M. =	2,986.7	Footing Weight =	525.0	1.75	918.8
				Key Weight =			
Resisting/Overturning Ratio		= 2.65		Vert. Component =	539.3	3.50	1,887.7
Vertical Loads used for Soil Pressure =		3,621.7 lbs		Total =	3,621.7 lbs	R.M.=	7,916.8

* 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 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) 0.096 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2667 in/ft
As Required =	0.1746 in/ft

Cantilevered Retaining Wall

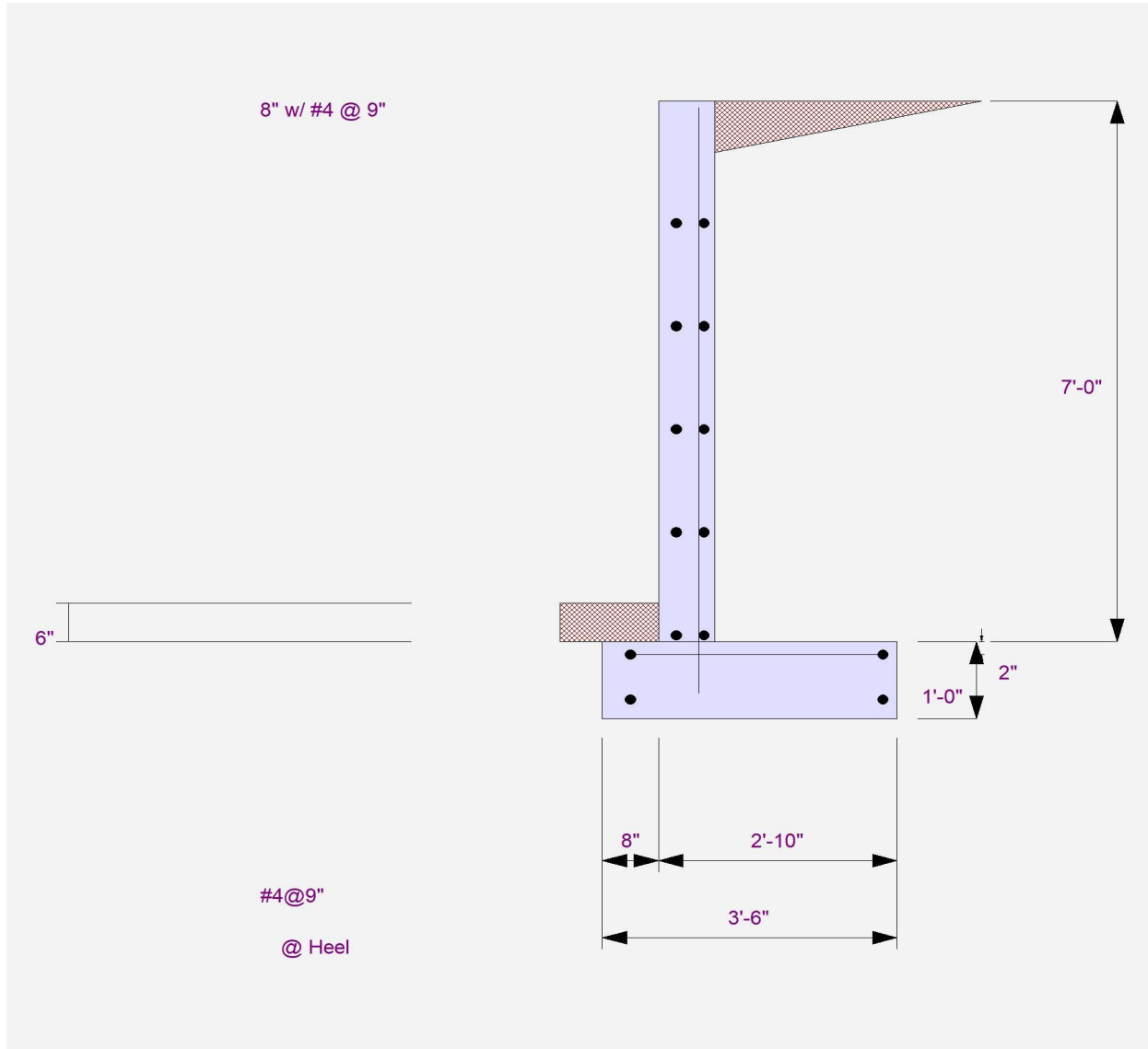
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained



Cantilevered Retaining Wall

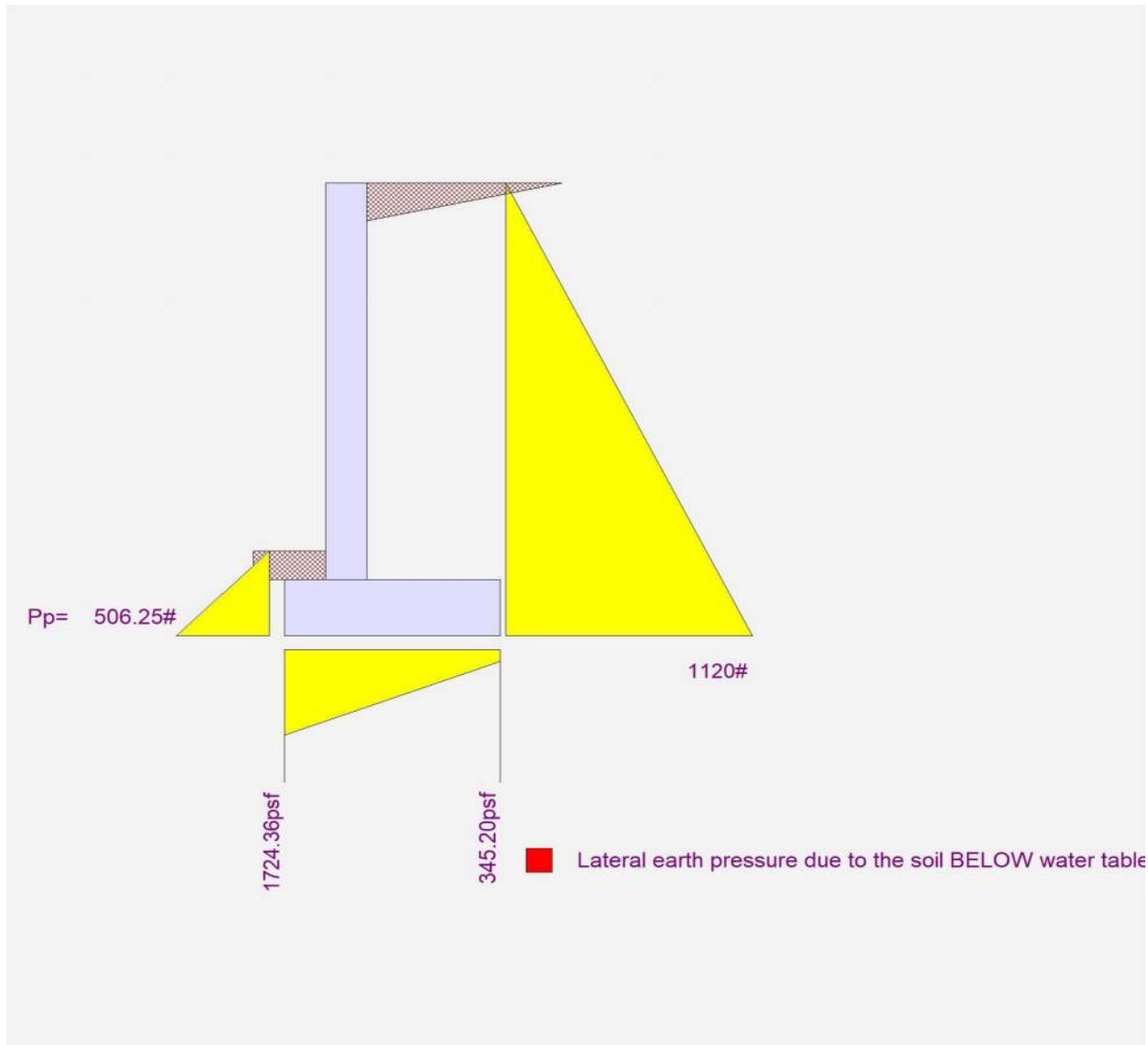
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ

Code Reference.

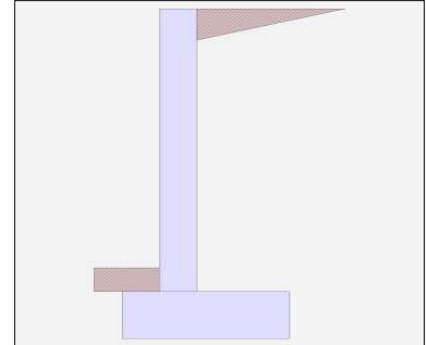
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	6.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	56.000
Total Seismic Force	=	392.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.73	OK
Sliding	=	1.71	OK
Global Stability	=	2.14	

Total Bearing Load	=	2,701 lbs
...resultant ecc.	=	8.38 in

Eccentricity outside middle third

Soil Pressure @ Toe	=	2,246 psf	OK
Soil Pressure @ Heel	=	0 psf	OK
Allowable	=	3,333 psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	2,664 psf	
ACI Factored @ Heel	=	0 psf	
Footing Shear @ Toe	=	0.1 psi	OK
Footing Shear @ Heel	=	14.7 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	1,131.9 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	1,431.4 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 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

Design Height Above Ftg	ft =	Stem OK		
Wall Material Above "Ht"	=	Concrete		
Design Method	=	SD	SD	SD
Thickness	=	8.00		
Rebar Size	=	# 4		
Rebar Spacing	=	12.00		
Rebar Placed at	=	5.75 i		

Design Data

fb/FB + fa/Fa	=	0.605
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,344.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	3,024.0

Moment.....Allowable	=	4,998.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	19.5

Shear.....Allowable	psi =	46.9
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	5.75
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.1237 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9347 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	2.33
Total Footing Width	=	3.00
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,664	0	psf
Mu' : Upward	=	542	225	ft-#
Mu' : Downward	=	57	2,543	ft-#
Mu: Design	=	486	2,318	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	0.09	14.71	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ

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)	857.5	2.33	2,000.8	Soil Over HL (ab. water tbl)	1,197.6	2.17	2,596.8
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.17	2,596.8
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
Seismic Earth Load =	274.4	3.50	960.4	Surcharge Over Toe =			
=				Stem Weight(s) =	600.0	1.00	602.0
Total =	1,131.9	O.T.M. =	2,961.2	Earth @ Stem Transitions =			
				Footing Weight =	450.0	1.50	675.0
				Key Weight =			
				Vert. Component =	412.9	3.00	1,238.8
				Total =	2,700.7 lbs	R.M.=	5,126.0

Resisting/Overturning Ratio = 1.73
 Vertical Loads used for Soil Pressure = 2,700.7 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 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) 0.125 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 6' Retained - EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2000 in ² /ft
As Required =	0.1728 in ² /ft

Cantilevered Retaining Wall

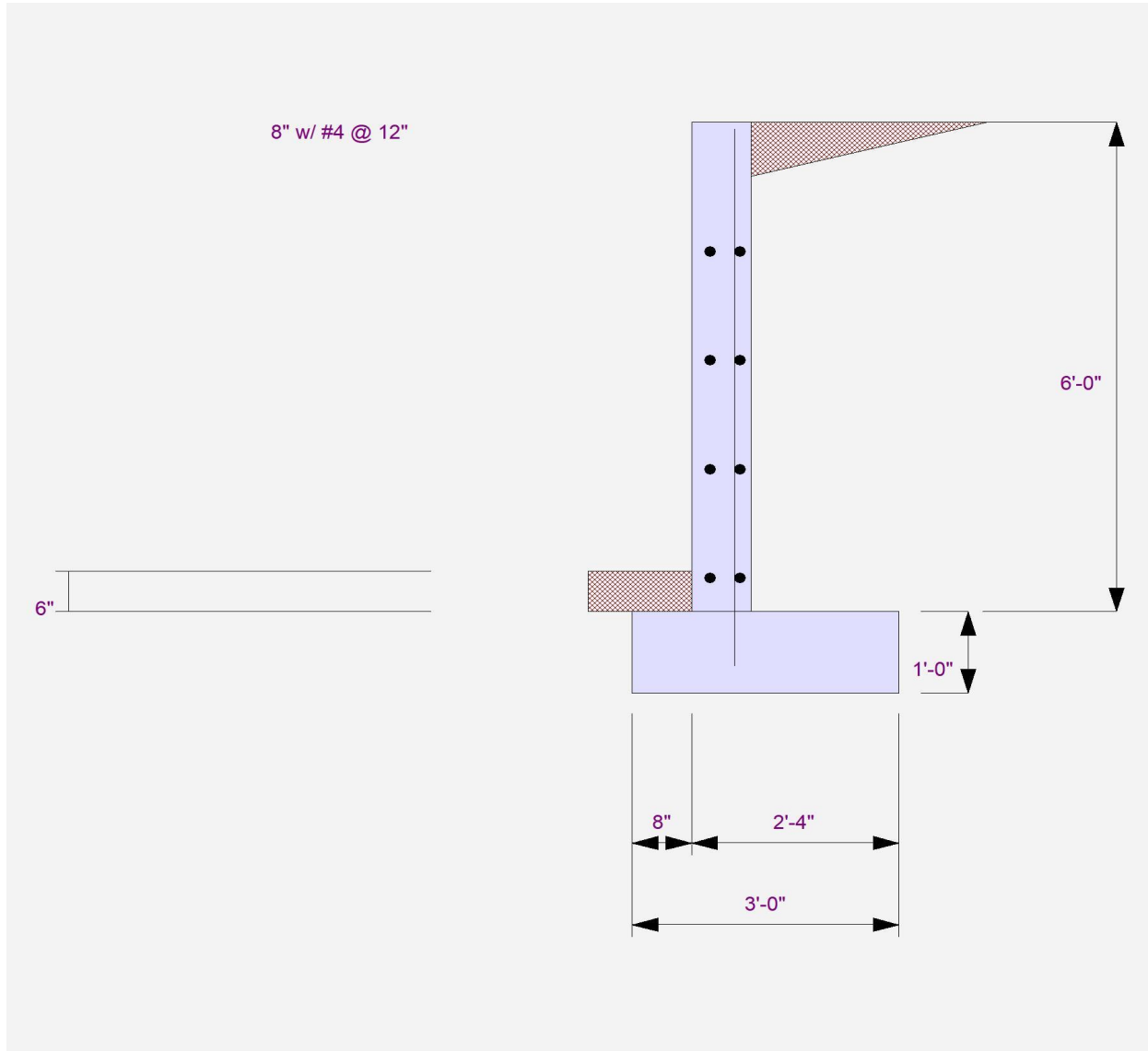
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 6' Retained - EQ



Cantilevered Retaining Wall

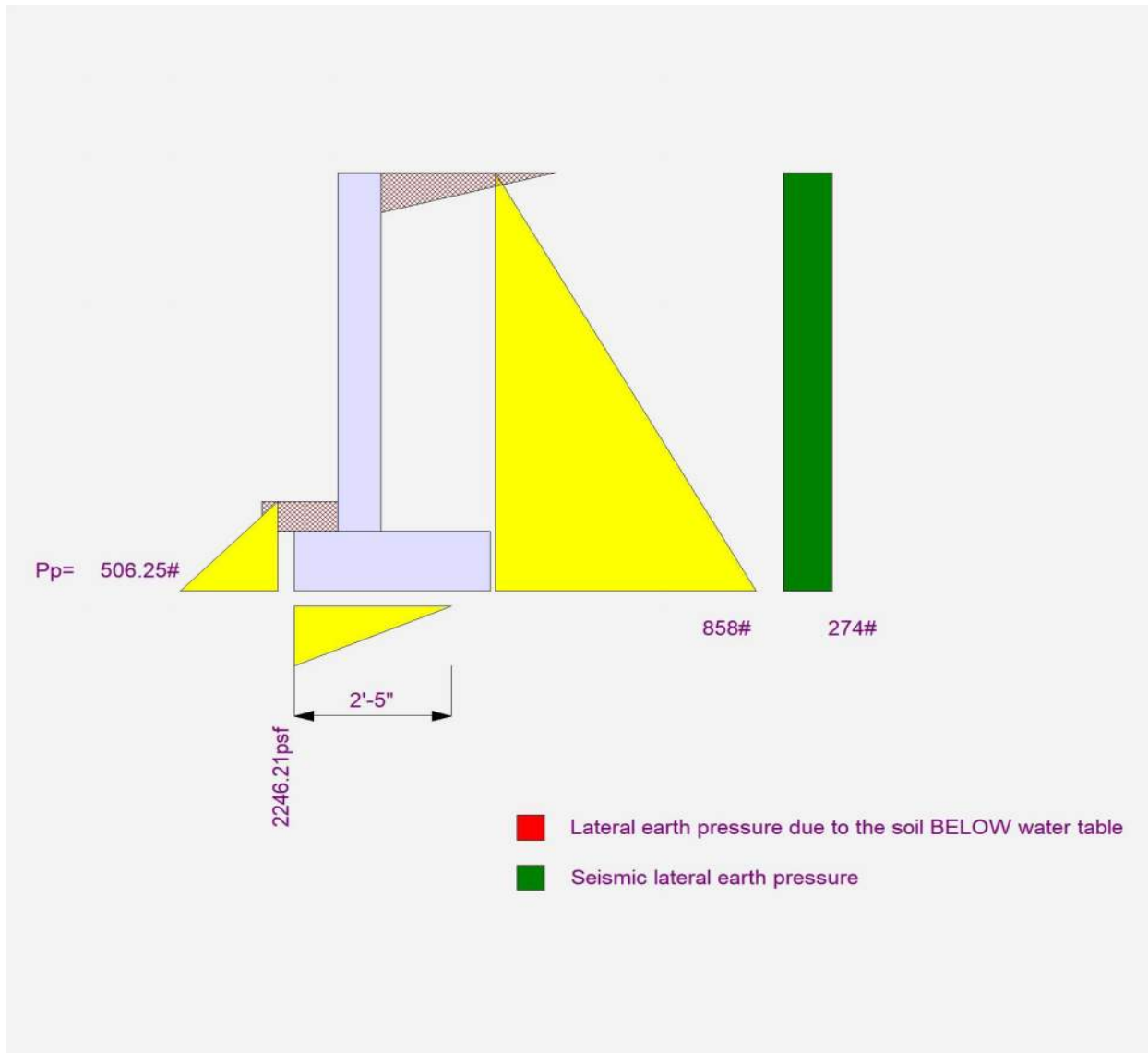
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 6' Retained - EQ



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 6' Retained

Code Reference.

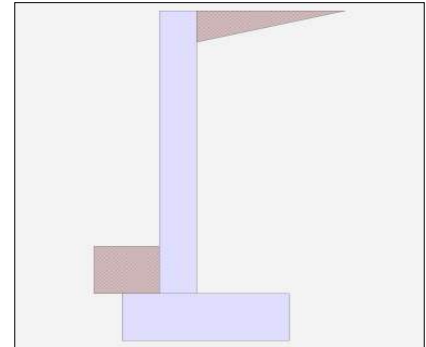
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	6.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00
Height of Soil over Toe	=	12.00 in
Water table above bottom of footing	=	0.0 ft

Soil Data

Allow Soil Bearing	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 6' Retained

Design Summary

Wall Stability Ratios

Overturning	=	2.57	OK
Sliding	=	2.74	OK
Global Stability	=	2.42	
Total Bearing Load	=	2,741 lbs	
...resultant ecc.	=	4.26 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,562 psf	OK
Soil Pressure @ Heel	=	265 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,857 psf	
ACI Factored @ Heel	=	315 psf	
Footing Shear @ Toe	=	0.1 psi	OK
Footing Shear @ Heel	=	9.7 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	857.5 lbs	
less 100% Passive Force	=	900.0 lbs	
less 100% Friction Force	=	1,452.7 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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	12.00
Rebar Placed at	=	5.75 i

Design Data

fb/FB + fa/Fa	=	0.403
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,008.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	2,016.0

Moment.....Allowable	=	4,998.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	14.6

Shear.....Allowable	psi =	46.9
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	5.75
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 6' Retained

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.0825 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9347 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	2.33
Total Footing Width	=	3.00
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,857	315	psf
Mu' : Upward	=	391	830	ft-#
Mu' : Downward	=	73	2,543	ft-#
Mu: Design	=	318	1,713	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	0.12	9.68	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained

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)	857.5	2.33	2,000.8	Soil Over HL (ab. water tbl)	1,197.6	2.17	2,596.8
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.17	2,596.8
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	80.4	0.34	26.9
				Surcharge Over Toe =			
				Stem Weight(s) =	600.0	1.00	602.0
				Earth @ Stem Transitions =			
				Footing Weight =	450.0	1.50	675.0
				Key Weight =			
				Vert. Component =	412.9	3.00	1,238.8
Total	= 857.5	O.T.M. =	2,000.8	Total =	2,740.9 lbs	R.M.=	5,139.5
Resisting/Overturning Ratio		=	2.57	* 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 =		2,740.9 lbs					

Vertical component of active lateral soil pressure IS 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) 0.087 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2000 in ² /ft
As Required =	0.1728 in ² /ft

Cantilevered Retaining Wall

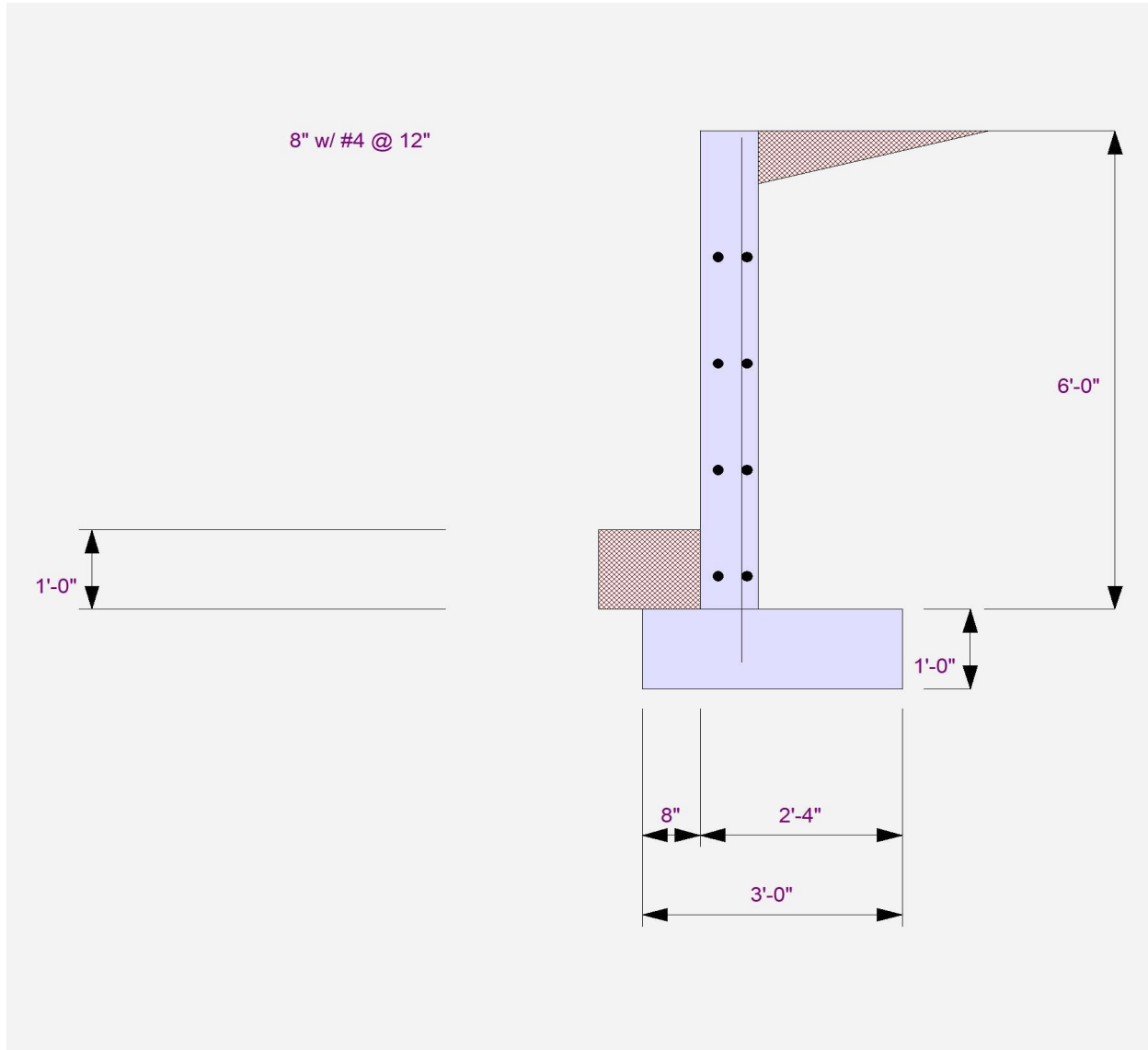
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 6' Retained



Cantilevered Retaining Wall

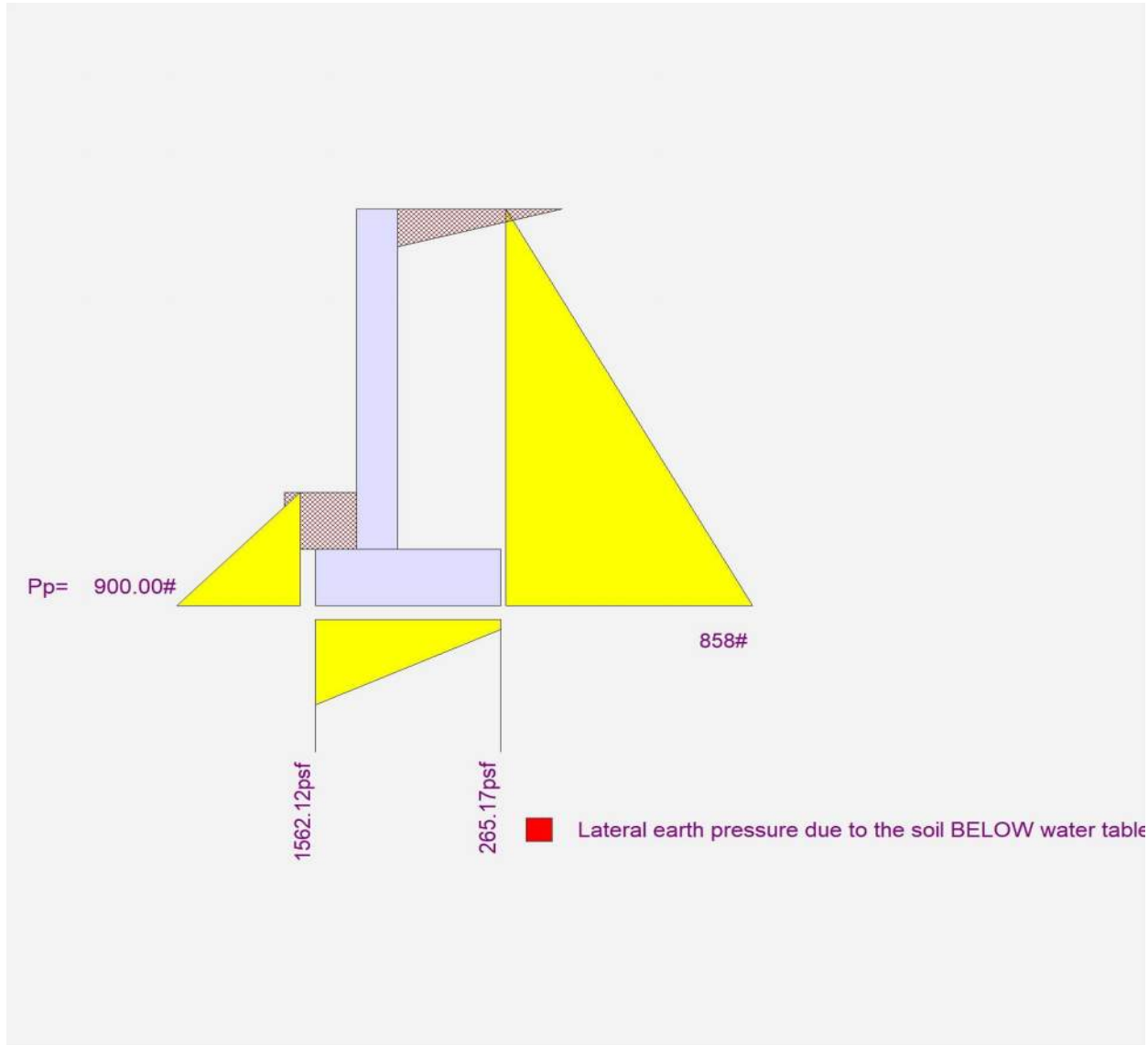
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 6' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ

Code Reference.

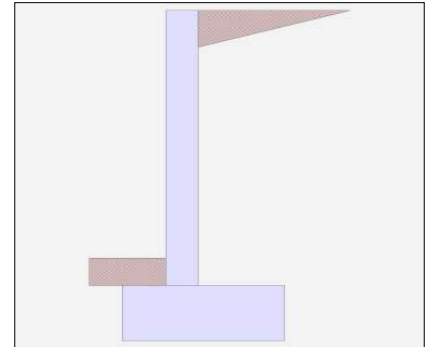
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	5.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	48.000
Total Seismic Force	=	288.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained - EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.64	OK
Sliding	=	1.81	OK
Global Stability	=	2.29	
Total Bearing Load	=	1,892 lbs	
...resultant ecc.	=	7.48 in	
Eccentricity outside middle third			
Soil Pressure @ Toe	=	2,013 psf	OK
Soil Pressure @ Heel	=	0 psf	OK
Allowable	=	3,333 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,366 psf	
ACI Factored @ Heel	=	0 psf	
Footing Shear @ Toe	=	0.1 psi	OK
Footing Shear @ Heel	=	11.4 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	831.6 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	1,002.5 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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	6.00
Rebar Size	=	# 4
Rebar Spacing	=	16.00
Rebar Placed at	=	3.75 i

Design Data

fb/FB + fa/Fa	=	0.726
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	940.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	1,766.7

Moment.....Allowable	=	2,431.7
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	20.9

Shear.....Allowable	psi =	49.1
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	75.0
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Rebar Depth 'd'	in =	3.75
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained - EQ

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.1144 in2/ft		
0.0018bh : 0.0018(12)(6) :	0.1296 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.1296 in2/ft	#4@ 18.52 in	#4@ 37.04 in
Provided Area :	0.15 in2/ft	#5@ 28.70 in	#5@ 57.41 in
Maximum Area :	0.6096 in2/ft	#6@ 40.74 in	#6@ 81.48 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	1.83
Total Footing Width	=	2.50
Footing Thickness	=	12.00 in
f'c = 3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,366	0	psf
Mu' : Upward	=	468	75	ft-#
Mu' : Downward	=	57	1,442	ft-#
Mu: Design	=	411	1,367	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	0.09	11.38	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.65	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ

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)	630.0	2.00	1,260.0	Soil Over HL (ab. water tbl)	798.0	1.84	1,464.3
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		1.84	1,464.3
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
Seismic Earth Load =	201.6	3.00	604.8	Surcharge Over Toe =			
=				Stem Weight(s) =	375.0	0.92	345.0
Total =	831.6	O.T.M. =	1,864.8	Earth @ Stem Transitions =			
				Footing Weight =	375.0	1.25	468.8
				Key Weight =			
				Vert. Component =	303.4	2.50	758.4
				Total =	1,891.6 lbs	R.M.=	3,050.0

Resisting/Overturning Ratio = 1.64
 Vertical Loads used for Soil Pressure = 1,891.6 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 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) 0.112 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.1500 in ² /ft
As Required =	0.1500 in ² /ft

Cantilevered Retaining Wall

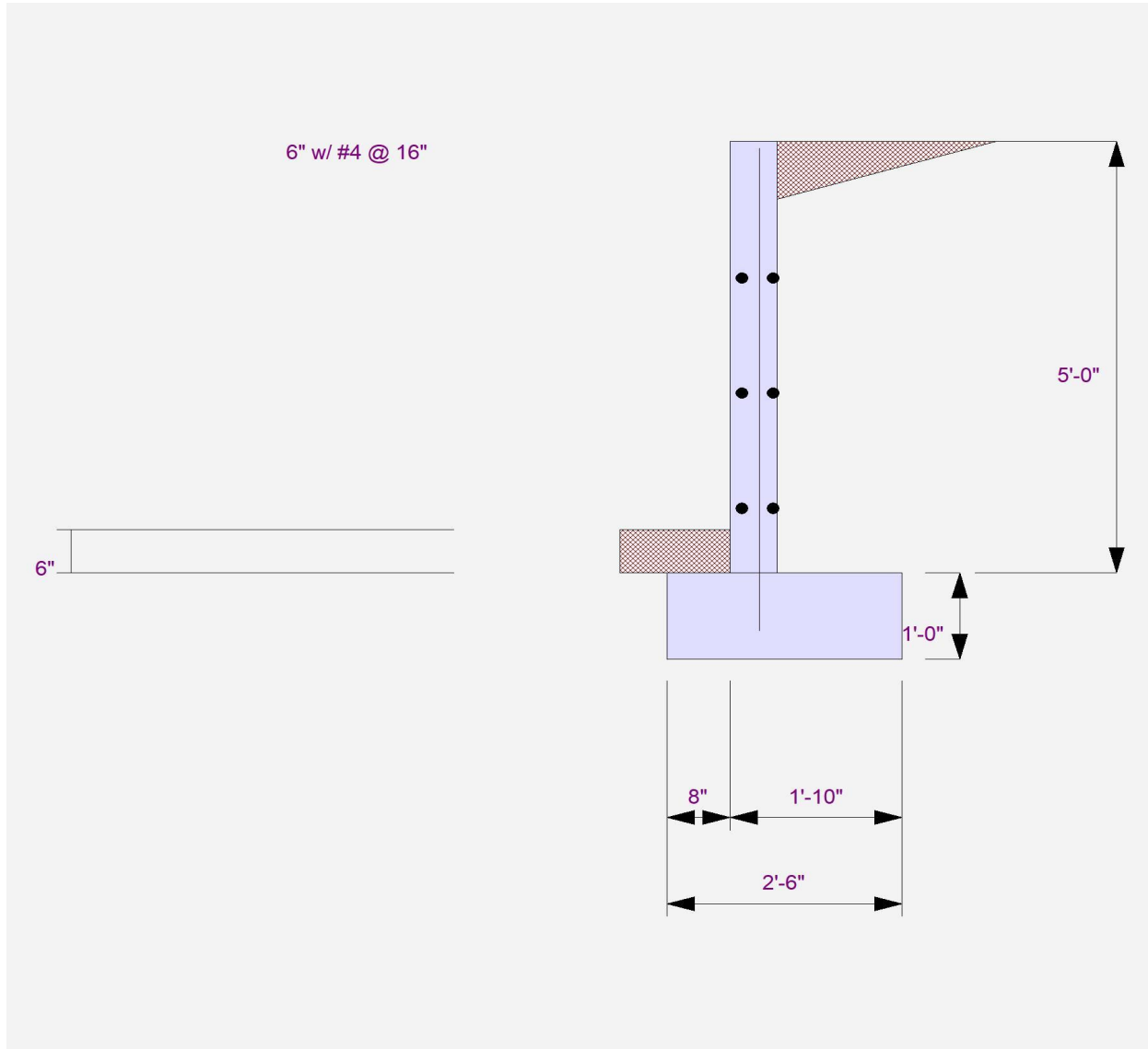
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained - EQ



Cantilevered Retaining Wall

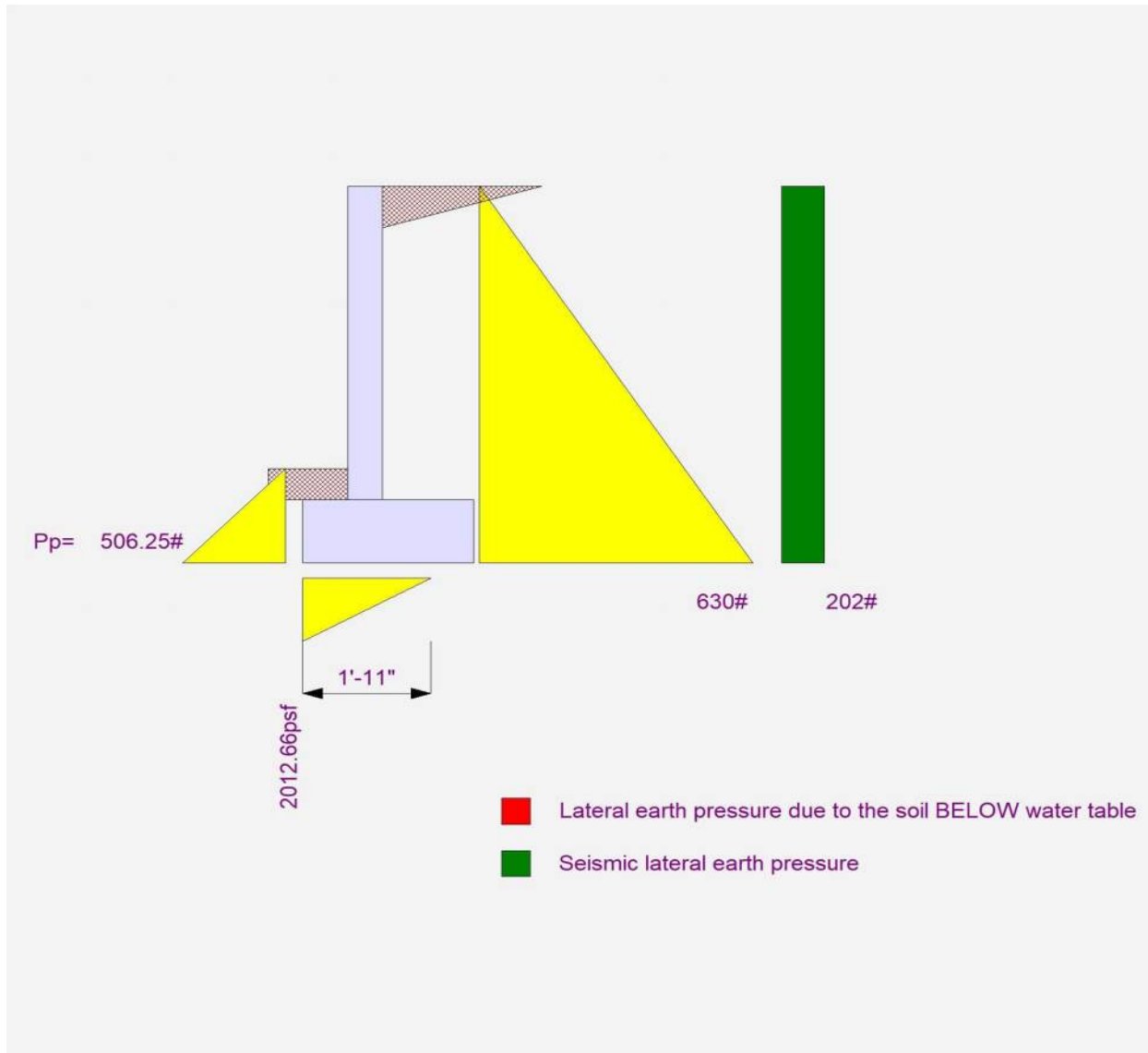
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained - EQ



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained

Code Reference.

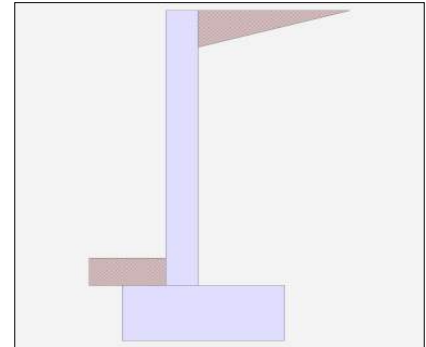
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	5.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained

Design Summary

Wall Stability Ratios

Overturning	=	2.42	OK
Sliding	=	2.39	OK
Global Stability	=	2.29	
Total Bearing Load	=	1,892 lbs	
...resultant ecc.	=	3.64 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,308 psf	OK
Soil Pressure @ Heel	=	205 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,538 psf	
ACI Factored @ Heel	=	241 psf	
Footing Shear @ Toe	=	0.1 psi	OK
Footing Shear @ Heel	=	7.5 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	630.0 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	1,002.5 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 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

Design Height Above Ftg

ft =	Stem OK		
	0.00		
Wall Material Above "Ht"	=	Concrete	
Design Method	=	SD	SD SD
Thickness	=	6.00	
Rebar Size	=	# 4	
Rebar Spacing	=	16.00	
Rebar Placed at	=	3.75 i	

Design Data

fb/FB + fa/Fa	=	0.479
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	700.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	1,166.7

Moment.....Allowable	=	2,431.7
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	15.6

Shear.....Allowable	psi =	49.1
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	75.0
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Rebar Depth 'd'	in =	3.75
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.0756 in2/ft		
0.0018bh : 0.0018(12)(6) :	0.1296 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1296 in2/ft	#4@ 18.52 in	#4@ 37.04 in
Provided Area :	0.15 in2/ft	#5@ 28.70 in	#5@ 57.41 in
Maximum Area :	0.6096 in2/ft	#6@ 40.74 in	#6@ 81.48 in

Footing Data

Toe Width	=	0.67 ft
Heel Width	=	1.83
Total Footing Width	=	2.50
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,538	241	psf
Mu' : Upward	=	319	417	ft-#
Mu' : Downward	=	57	1,442	ft-#
Mu: Design	=	263	1,025	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	0.09	7.53	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.65	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained

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)	630.0	2.00	1,260.0	Soil Over HL (ab. water tbl)	798.0	1.84	1,464.3
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		1.84	1,464.3
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	40.2	0.34	13.5
				Surcharge Over Toe =			
				Stem Weight(s) =	375.0	0.92	345.0
				Earth @ Stem Transitions =			
Total	= 630.0	O.T.M. =	1,260.0	Footing Weight =	375.0	1.25	468.8
				Key Weight =			
				Vert. Component =	303.4	2.50	758.4
Resisting/Overturning Ratio		= 2.42		Total =	1,891.6 lbs	R.M.=	3,050.0
Vertical Loads used for Soil Pressure =		1,891.6 lbs		* 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 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) 0.073 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in

Development length for #4 bar specified in this stem design segment = 13.15 in

Hooked embedment length into footing for #4 bar specified in this stem design segment = 5.63 in

As Provided = 0.1500 in²/ft

As Required = 0.1296 in²/ft

Cantilevered Retaining Wall

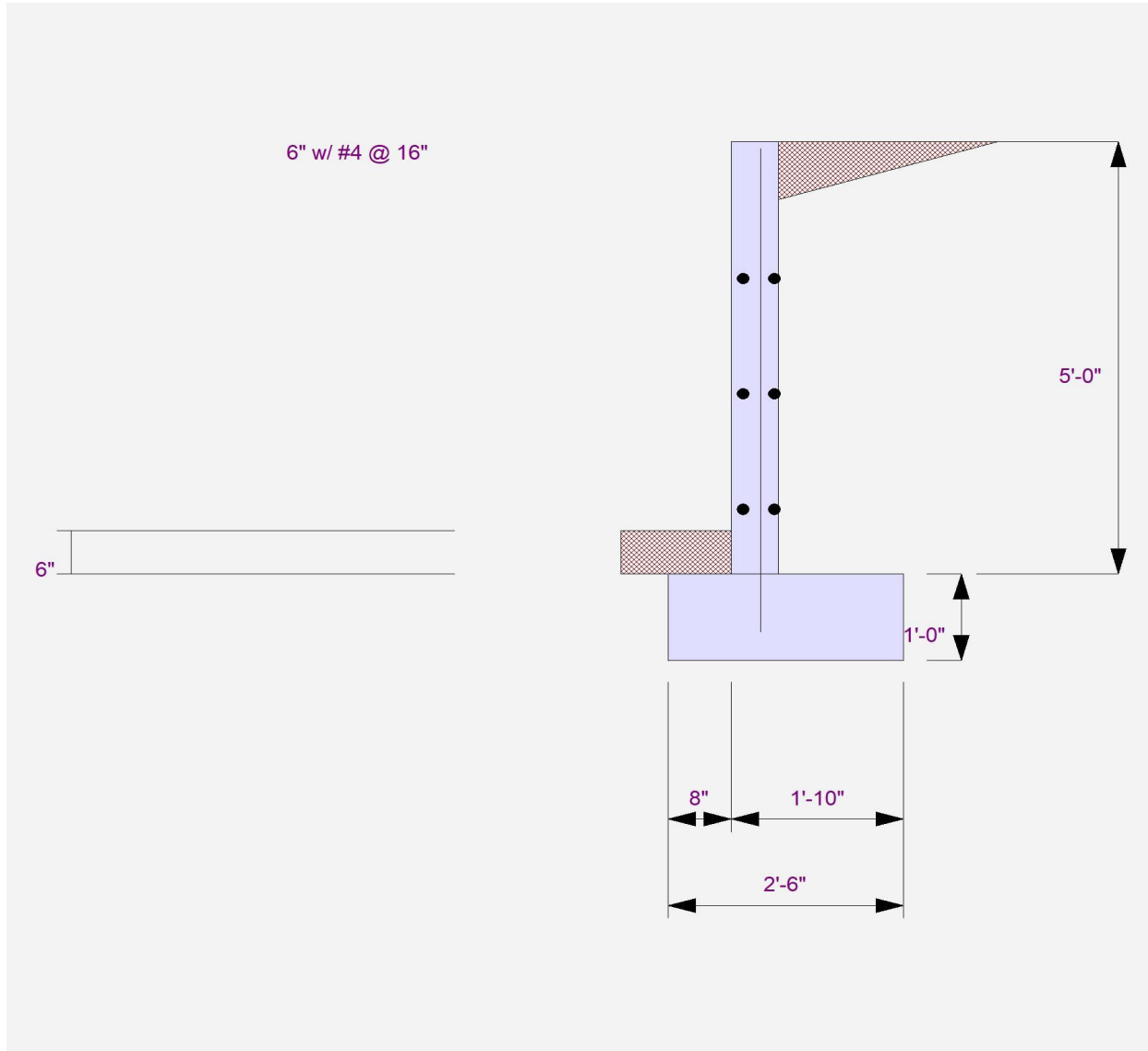
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 5' Retained



Cantilevered Retaining Wall

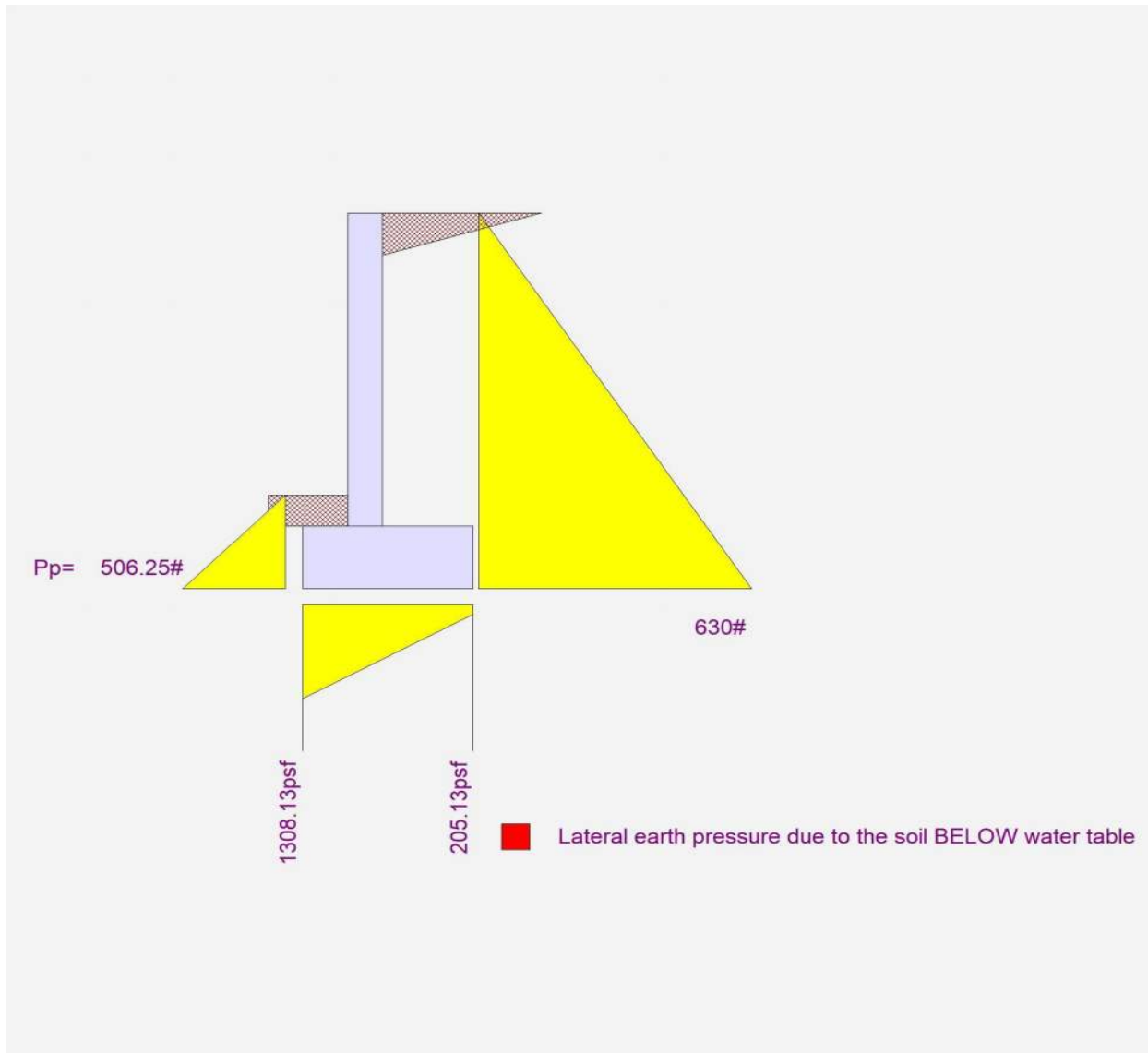
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 5' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ

Code Reference.

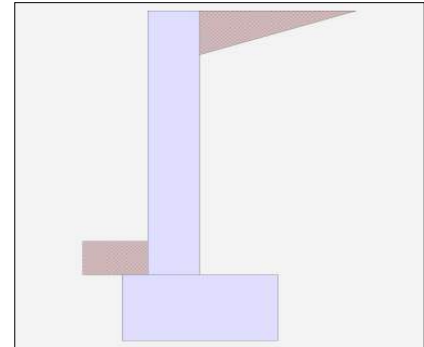
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	4.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	40.000
Total Seismic Force	=	200.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.59	OK
Sliding	=	2.17	OK
Global Stability	=	2.69	
Total Bearing Load	=	1,412 lbs	
...resultant ecc.	=	6.63 in	
Eccentricity outside middle third			
Soil Pressure @ Toe	=	2,102 psf	OK
Soil Pressure @ Heel	=	0 psf	OK
Allowable	=	3,333 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,504 psf	
ACI Factored @ Heel	=	0 psf	
Footing Shear @ Toe	=	0.9 psi	OK
Footing Shear @ Heel	=	8.2 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	577.5 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	748.4 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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	12.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.168
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	608.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	917.3

Moment.....Allowable	=	5,448.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	8.1

Shear.....Allowable	psi =	45.6
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.0344 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.33 ft
Heel Width	=	1.67
Total Footing Width	=	2.00
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,504	0	psf
Mu' : Upward	=	125	13	ft-#
Mu' : Downward	=	14	719	ft-#
Mu: Design	=	111	706	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	0.87	8.20	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.52	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ

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)	437.5	1.67	729.2	Soil Over HL (ab. water tbl)	481.6	1.50	721.6
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		1.50	721.6
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	19.8	0.17	3.3
Seismic Earth Load =	140.0	2.50	350.0	Surcharge Over Toe =			
=				Stem Weight(s) =	400.0	0.66	265.3
Total =	577.5	O.T.M. =	1,079.2	Earth @ Stem Transitions =			
				Footing Weight =	300.0	1.00	300.0
				Key Weight =			
				Vert. Component =	210.7	2.00	421.4
Resisting/Overturning Ratio =			1.59	Total =	1,412.1 lbs	R.M.=	1,711.6
Vertical Loads used for Soil Pressure =		1,412.1 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 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) 0.117 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2000 in ² /ft
As Required =	0.1728 in ² /ft

Cantilevered Retaining Wall

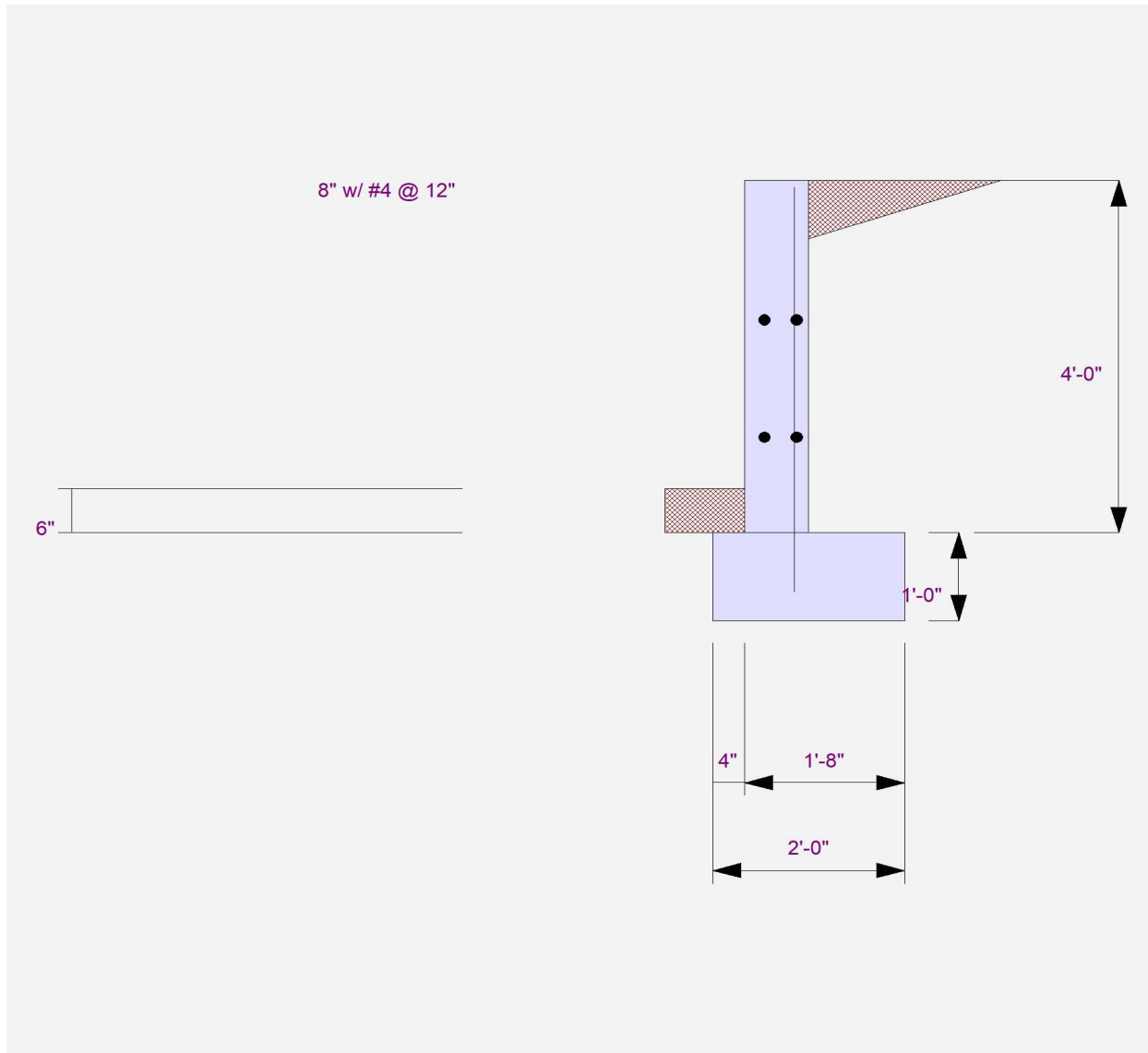
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 4' Retained - EQ



Cantilevered Retaining Wall

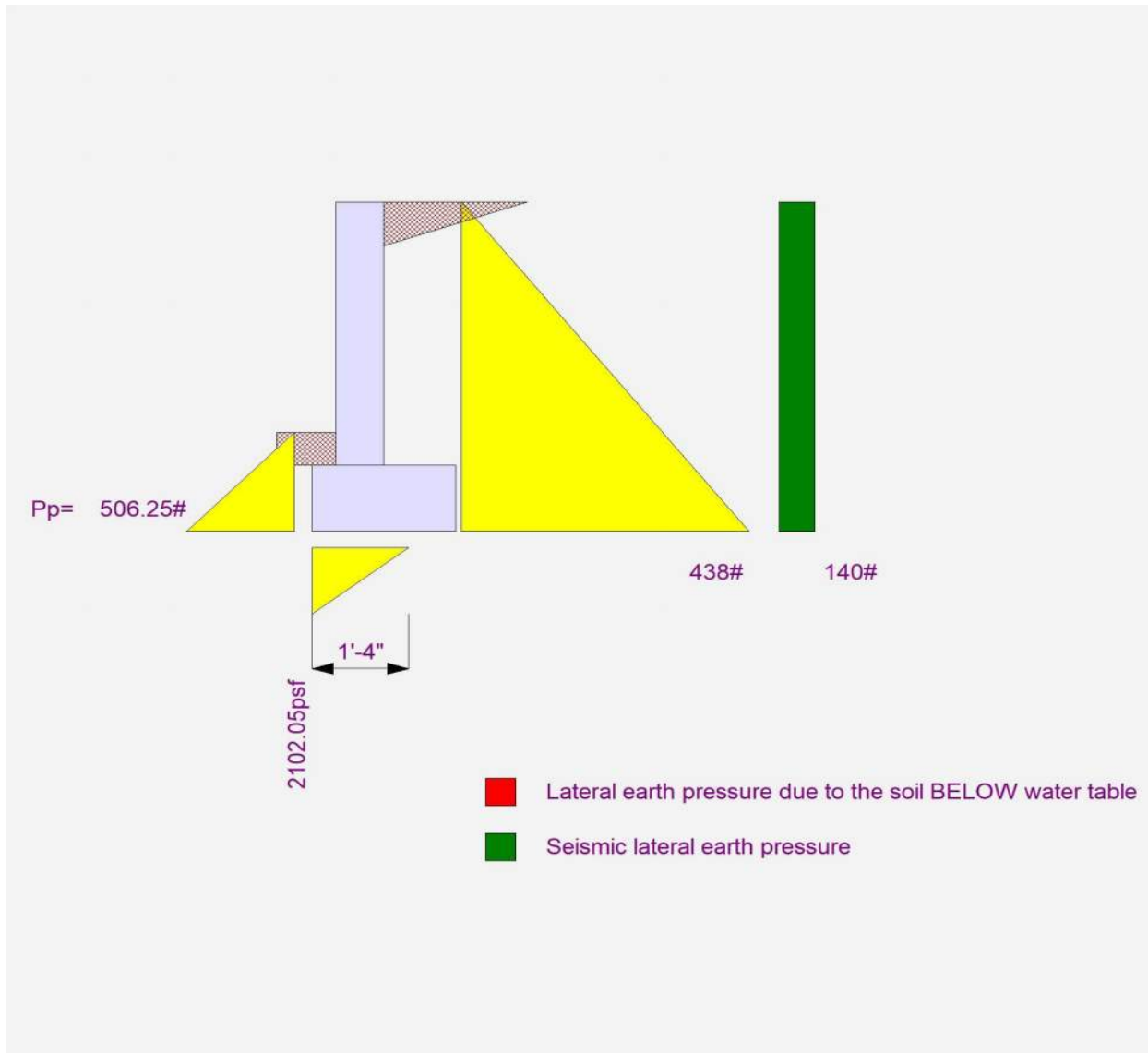
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained

Code Reference.

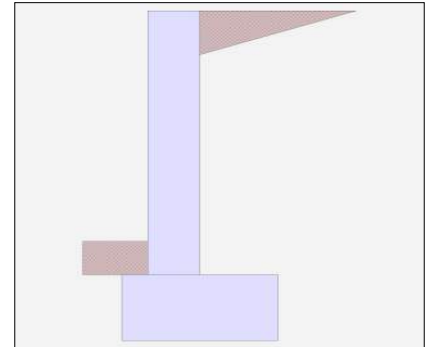
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	4.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained

Design Summary

Wall Stability Ratios

Overturing	=	2.35	OK
Sliding	=	2.87	OK
Global Stability	=	2.69	
Total Bearing Load	=	1,413 lbs	
...resultant ecc.	=	3.64 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,346 psf	OK
Soil Pressure @ Heel	=	65 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,603 psf	
ACI Factored @ Heel	=	77 psf	
Footing Shear @ Toe	=	0.9 psi	OK
Footing Shear @ Heel	=	5.3 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	437.5 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	748.7 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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	12.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.109
---------------	---	-------

Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	448.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	597.3

Moment.....Allowable	=	5,448.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	6.0

Shear.....Allowable	psi =	45.6
---------------------	-------	------

Anet (Masonry)	in2 =	
----------------	-------	--

Wall Weight	psf =	100.0
-------------	-------	-------

Rebar Depth 'd'	in =	6.25
-----------------	------	------

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 =	3,000.0
Fy	psi =	60,000.0

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LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.0224 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	0.33 ft
Heel Width	=	1.67
Total Footing Width	=	2.00
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,603	77	psf
Mu' : Upward	=	84	167	ft-#
Mu' : Downward	=	14	719	ft-#
Mu: Design	=	70	552	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	0.86	5.29	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.52	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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained

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)	437.5	1.67	729.2	Soil Over HL (ab. water tbl)	481.6	1.50	723.0
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		1.50	723.0
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	20.0	0.17	3.3
				Surcharge Over Toe =			
				Stem Weight(s) =	400.0	0.67	266.5
				Earth @ Stem Transitions =			
Total	= 437.5	O.T.M. =	729.2	Footing Weight =	300.5	1.00	300.9
				Key Weight =			
				Vert. Component =	210.7	2.00	422.0
Resisting/Overturning Ratio		= 2.35		Total =	1,412.7 lbs	R.M.=	1,715.8
Vertical Loads used for Soil Pressure =		1,412.7 lbs		* 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 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) 0.075 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2000 in ² /ft
As Required =	0.1728 in ² /ft

Cantilevered Retaining Wall

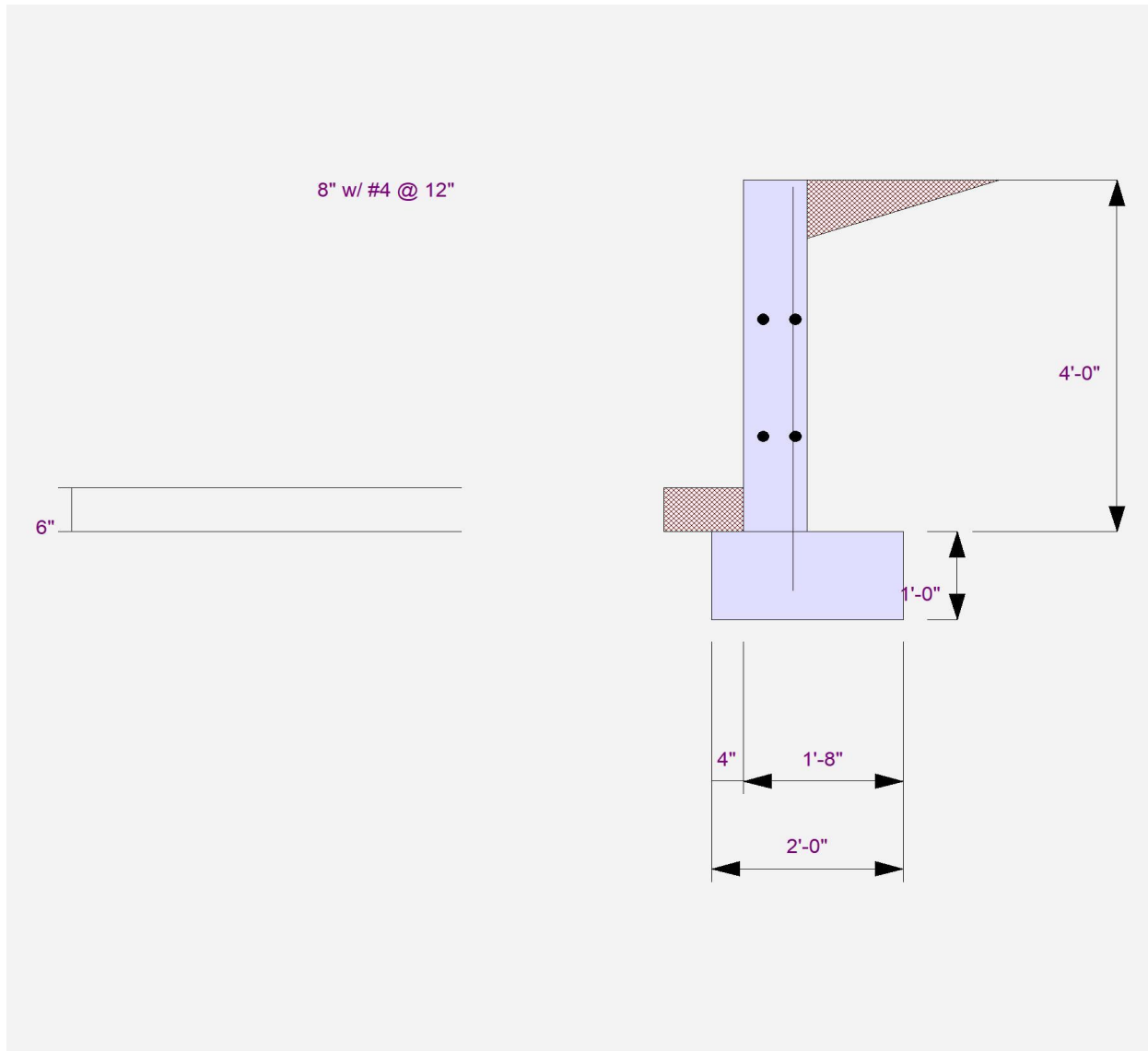
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained



Cantilevered Retaining Wall

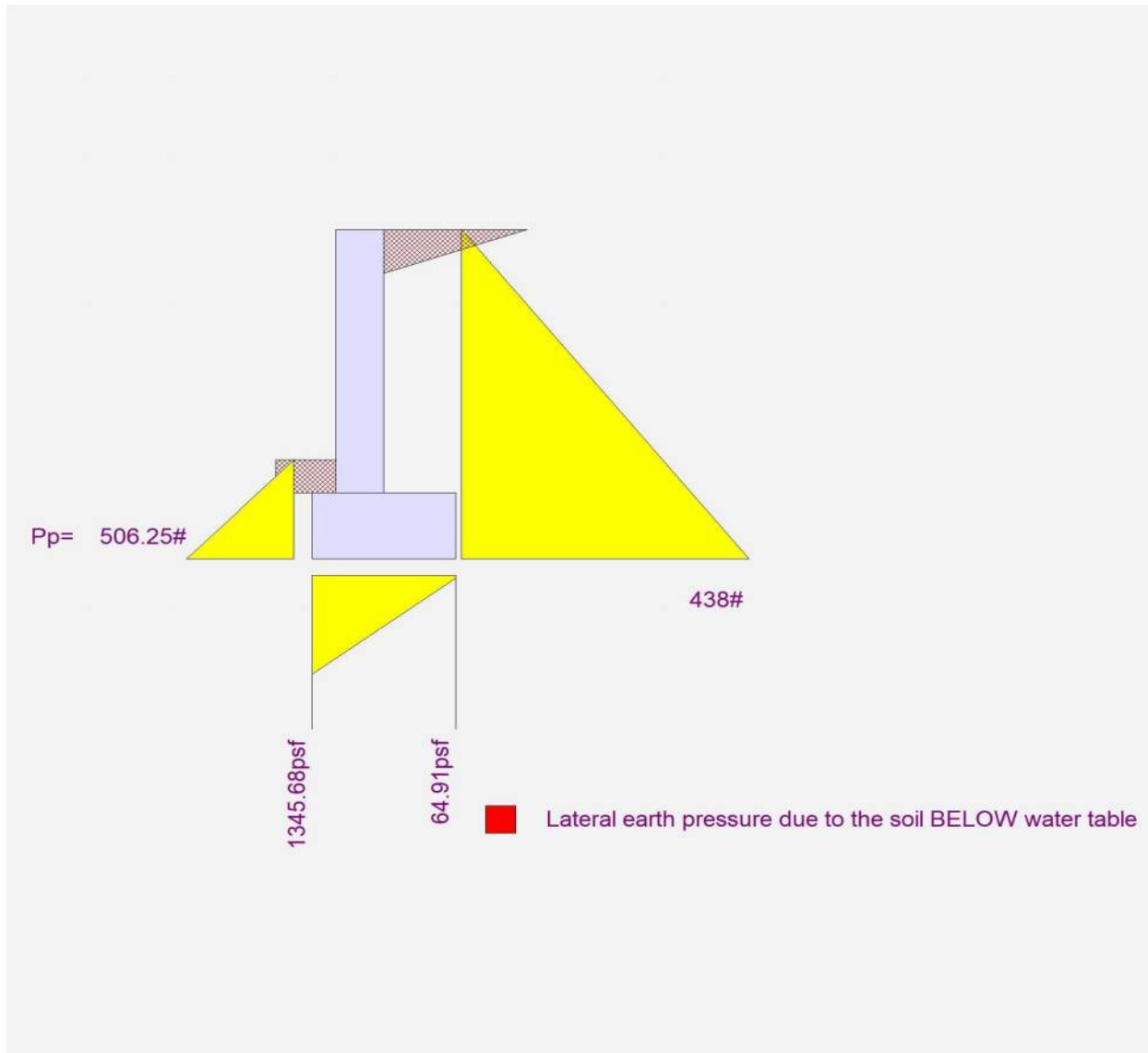
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ (P_Line)

Code Reference.

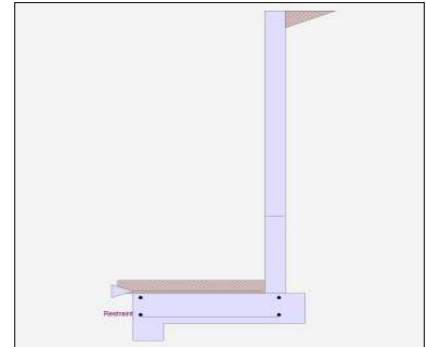
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	11.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	97.333
Total Seismic Force	=	1,184.222

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	1.30	Ratio < 1.5!
Slab Resists All Sliding !			
Global Stability	=	1.06	
Total Bearing Load	=	4,573 lbs	
...resultant ecc.	=	21.57 in	
Eccentricity outside middle third			
Soil Pressure @ Toe	=	2,953 psf	OK
Soil Pressure @ Heel	=	0 psf	OK
Allowable	=	3,333 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	3,006 psf	
ACI Factored @ Heel	=	0 psf	
Footing Shear @ Toe	=	28.6 psi	OK
Footing Shear @ Heel	=	22.1 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	3,419.4 lbs
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Vertical component of active lateral soil pressure IS 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

		2nd	Bottom		
Design Height Above Ftg	ft =	Stem OK	Stem OK		
Wall Material Above "Ht"	=	3.00	0.00		
Design Method	=	Concrete	Concrete		
Thickness	=	SD	SD	SD	SD
Rebar Size	=	8.00	8.00		
Rebar Spacing	=	# 4	# 6		
Rebar Placed at	=	6.00	6.00		
	=	Edge	Edge		
Design Data					
fb/FB + fa/Fa	=	0.748	0.971		
Total Force @ Section					
Service Level	lbs =				
Strength Level	lbs =	2,570.7	4,458.7		
Moment....Actual					
Service Level	ft-# =				
Strength Level	ft-# =	7,893.3	18,311.3		
Moment.....Allowable	ft-# =	10,542.0	18,848.3		
Shear.....Actual					
Service Level	psi =				
Strength Level	psi =	34.3	66.1		
Shear.....Allowable	psi =	57.4	77.3		
Anet (Masonry)	in2 =				
Wall Weight	psf =	100.0	100.0		
Rebar Depth 'd'	in =	6.25	5.63		

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 =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ (P_Line)

Concrete Stem Rebar Area Details

2nd Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2957 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2957 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.7669 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.7669 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.88 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9144 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	4.33 ft
Heel Width	=	1.33
Total Footing Width	=	5.66
Footing Thickness	=	14.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

	<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	3,006	0	psf
Mu' : Upward	=	15,353	0	ft-#
Mu' : Downward	=	2,644	1,719	ft-#
Mu: Design	=	12,710	1,719	777 ft-#
φ Mn	=	18,644	3,944	2,739 ft-#
Actual 1-Way Shear	=	28.56	22.12	13.71 psi
Allow 1-Way Shear	=	47.92	43.82	43.82 psi
Toe Reinforcing	=	# 4 @ 6.00 in		
Heel Reinforcing	=	None Spec'd		
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@ 6.48 in, #5@ 10.05 in, #6@ 14.27 in, #7@ 19.46 in, #8@ 25.62 in, #9@ 32.44 in, #10@ 41.20 in

Heel: $\phi Mn = \phi^5 * \lambda * \sqrt{fc} * Sm$

Key: Slab Resists Sliding - No Force on Key

Min footing T&S reinf Area	1.71	in2
Min footing T&S reinf Area per foot	0.30	in2 /ft
<u>If one layer of horizontal bars:</u>		<u>If two layers of horizontal bars:</u>
#4@ 7.94 in		#4@ 15.87 in
#5@ 12.30 in		#5@ 24.60 in
#6@ 17.46 in		#6@ 34.92 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ (P_Line)

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)	2,590.5	4.06	10,505.9	Soil Over HL (ab. water tbl)	875.6	5.33	4,665.5
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		5.33	4,665.5
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	259.8	2.17	562.5
Seismic Earth Load =	829.0	6.08	5,042.8	Surcharge Over Toe =			
=				Stem Weight(s) =	1,100.0	4.66	5,129.7
Total =	3,419.4	O.T.M. =	15,548.7	Earth @ Stem Transitions =			
				Footing Weight =	990.5	2.83	2,803.1
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	1,247.4	5.66	7,060.5
				Total =	4,573.3 lbs	R.M.=	20,271.3

Resisting/Overturning Ratio = **1.30**
 Vertical Loads used for Soil Pressure = 4,573.3 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 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) 0.159 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: 2nd

Stem Design Height: 3.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in
Development length for #4 bar specified in this stem design segment = 13.15 in

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #6 bar specified in this stem design segment (25.4.2.4a) = 25.63 in
Development length for #6 bar specified in this stem design segment = 19.72 in

Hooked embedment length into footing for #6 bar specified in this stem design segment = 10.35 in
As Provided = 0.8800 in²/ft
As Required = 0.7669 in²/ft

Cantilevered Retaining Wall

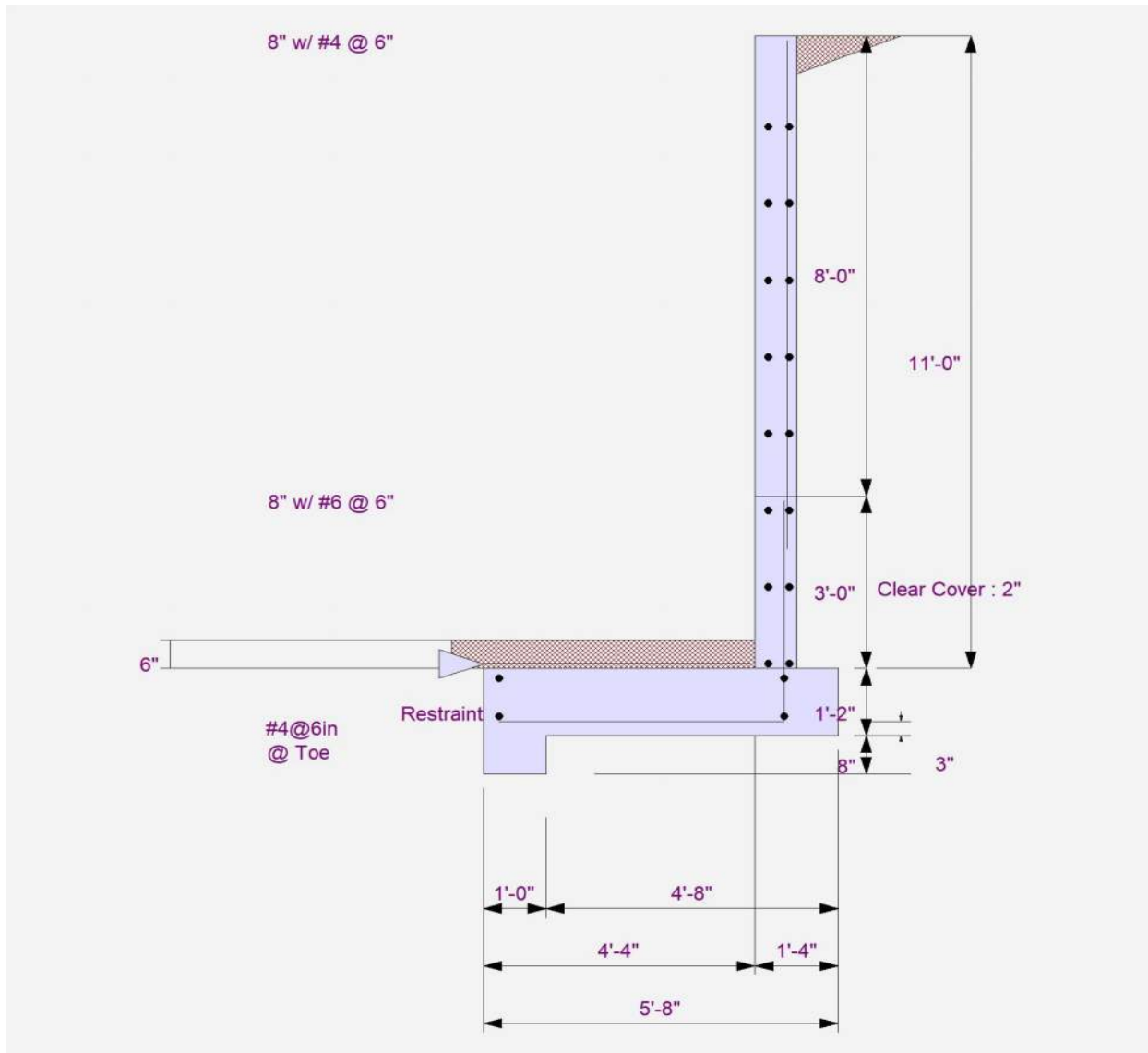
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Cantilevered Retaining Wall

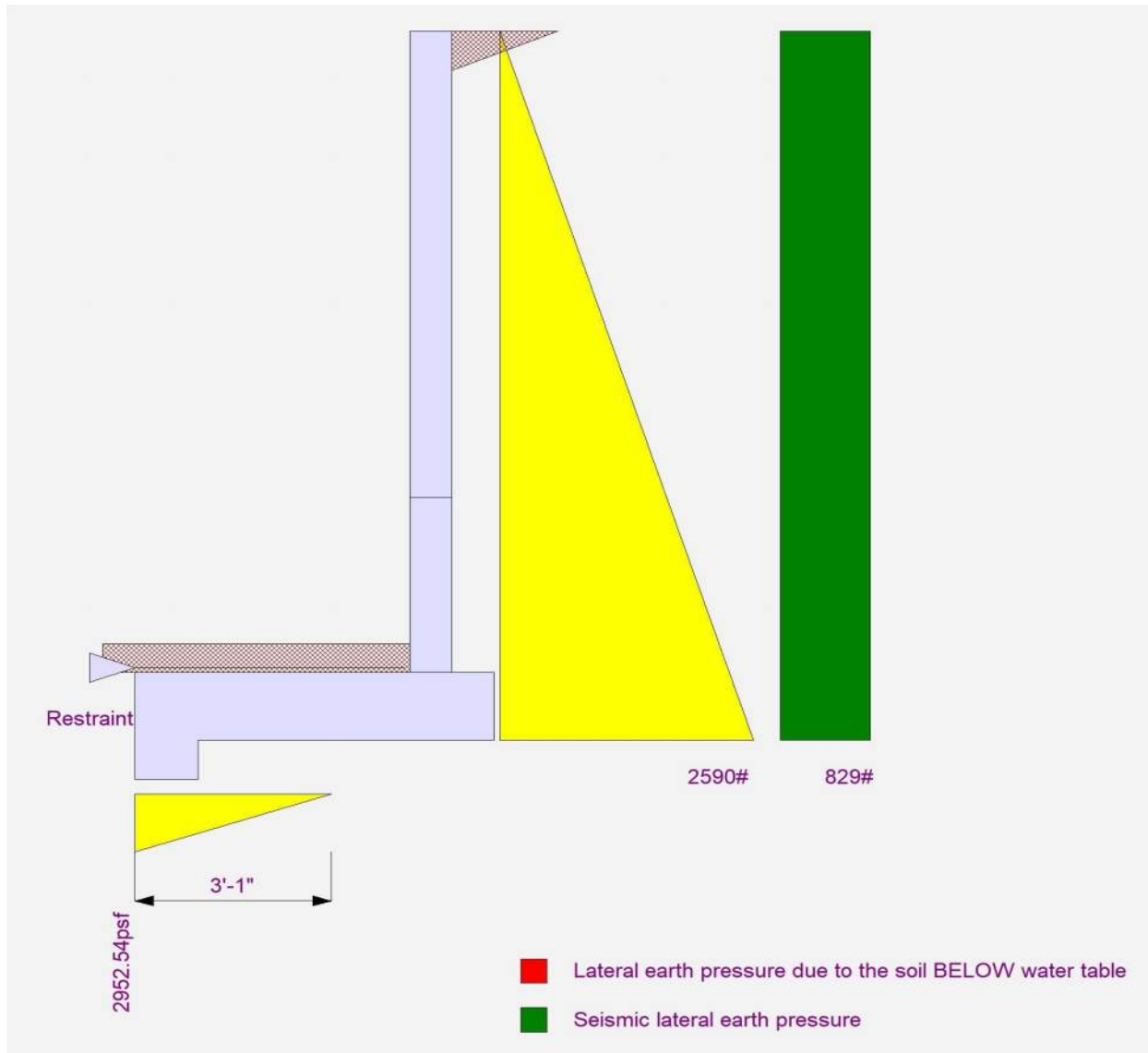
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DESCRIPTION: 11' Retained -EQ (P_Line)



Cantilevered Retaining Wall

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DESCRIPTION: 11' Retained -EQ

Code Reference.

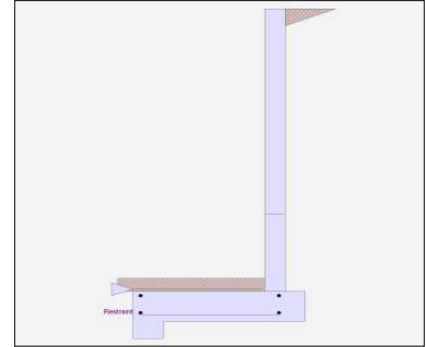
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	11.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ

Design Summary

Wall Stability Ratios

Overturning	=	1.93	OK
Slab Resists All Sliding !			
Global Stability	=	1.06	
Total Bearing Load	=	4,573 lbs	
...resultant ecc.	=	8.34 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,403 psf	OK
Soil Pressure @ Heel	=	213 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,429 psf	
ACI Factored @ Heel	=	217 psf	
Footing Shear @ Toe	=	20.6 psi	OK
Footing Shear @ Heel	=	20.8 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	2,590.5 lbs
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Vertical component of active lateral soil pressure IS 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

		2nd	Bottom		
Design Height Above Ftg	ft =	Stem OK	Stem OK		
Wall Material Above "Ht"	=	3.00	0.00		
Design Method	=	Concrete	Concrete		
Thickness	=	SD	SD	SD	SD
Rebar Size	=	8.00	8.00		
Rebar Spacing	=	# 4	# 6		
Rebar Placed at	=	6.00	6.00		
	=	Edge	Edge		
Design Data					
fb/FB + fa/Fa	=	0.453	0.659		
Total Force @ Section					
Service Level	lbs =				
Strength Level	lbs =	1,792.0	3,388.0		
Moment....Actual					
Service Level	ft-# =				
Strength Level	ft-# =	4,778.7	12,422.7		
Moment.....Allowable	ft-# =	10,542.0	18,848.3		
Shear.....Actual					
Service Level	psi =				
Strength Level	psi =	23.9	50.2		
Shear.....Allowable	psi =	57.4	77.3		
Anet (Masonry)	in2 =				
Wall Weight	psf =	100.0	100.0		
Rebar Depth 'd'	in =	6.25	5.63		

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 =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ

Concrete Stem Rebar Area Details

2nd Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.179 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.179 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.5203 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.5203 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.88 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9144 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	4.33 ft
Heel Width	=	1.33
Total Footing Width	=	5.66
Footing Thickness	=	14.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

	<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	= 1,429	217		psf
Mu' : Upward	= 10,495	58		ft-#
Mu' : Downward	= 2,644	1,719		ft-#
Mu: Design	= 7,851	1,661	777	ft-#
φ Mn	= 18,644	3,944	2,739	ft-#
Actual 1-Way Shear	= 20.64	20.80	13.71	psi
Allow 1-Way Shear	= 47.92	43.82	43.82	psi
Toe Reinforcing	= # 4 @ 6.00 in			
Heel Reinforcing	= None Spec'd			
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@ 7.93 in, #5@ 12.30 in, #6@ 17.46 in, #7@ 23.80 in, #8@ 31.34 in, #9@ 39.68 in, #10@ 50.39 in

Heel: $\phi Mn = \phi^5 * \lambda * \sqrt{fc} * Sm$

Key: Slab Resists Sliding - No Force on Key

Min footing T&S reinf Area	1.71	in2
Min footing T&S reinf Area per foot	0.30	in2 /ft
<u>If one layer of horizontal bars:</u>		<u>If two layers of horizontal bars:</u>
#4@ 7.94 in		#4@ 15.87 in
#5@ 12.30 in		#5@ 24.60 in
#6@ 17.46 in		#6@ 34.92 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ

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)	2,590.5	4.06	10,505.9	Soil Over HL (ab. water tbl)	875.6	5.33	4,665.5
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		5.33	4,665.5
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	259.8	2.17	562.5
				Surcharge Over Toe =			
				Stem Weight(s) =	1,100.0	4.66	5,129.7
				Earth @ Stem Transitions =			
Total	= 2,590.5	O.T.M. =	10,505.9	Footing Weight =	990.5	2.83	2,803.1
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	1,247.4	5.66	7,060.5
Resisting/Overturning Ratio		= 1.93		Total =	4,573.3 lbs	R.M.=	20,271.3
Vertical Loads used for Soil Pressure =		4,573.3 lbs		* 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 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) 0.076 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 11' Retained -EQ

Rebar Lap & Embedment Lengths Information

Stem Design Segment: 2nd

Stem Design Height: 3.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in
Development length for #4 bar specified in this stem design segment = 13.15 in

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #6 bar specified in this stem design segment (25.4.2.4a) = 25.63 in
Development length for #6 bar specified in this stem design segment = 19.72 in

Hooked embedment length into footing for #6 bar specified in this stem design segment = 10.35 in
As Provided = 0.8800 in²/ft
As Required = 0.5203 in²/ft

Cantilevered Retaining Wall

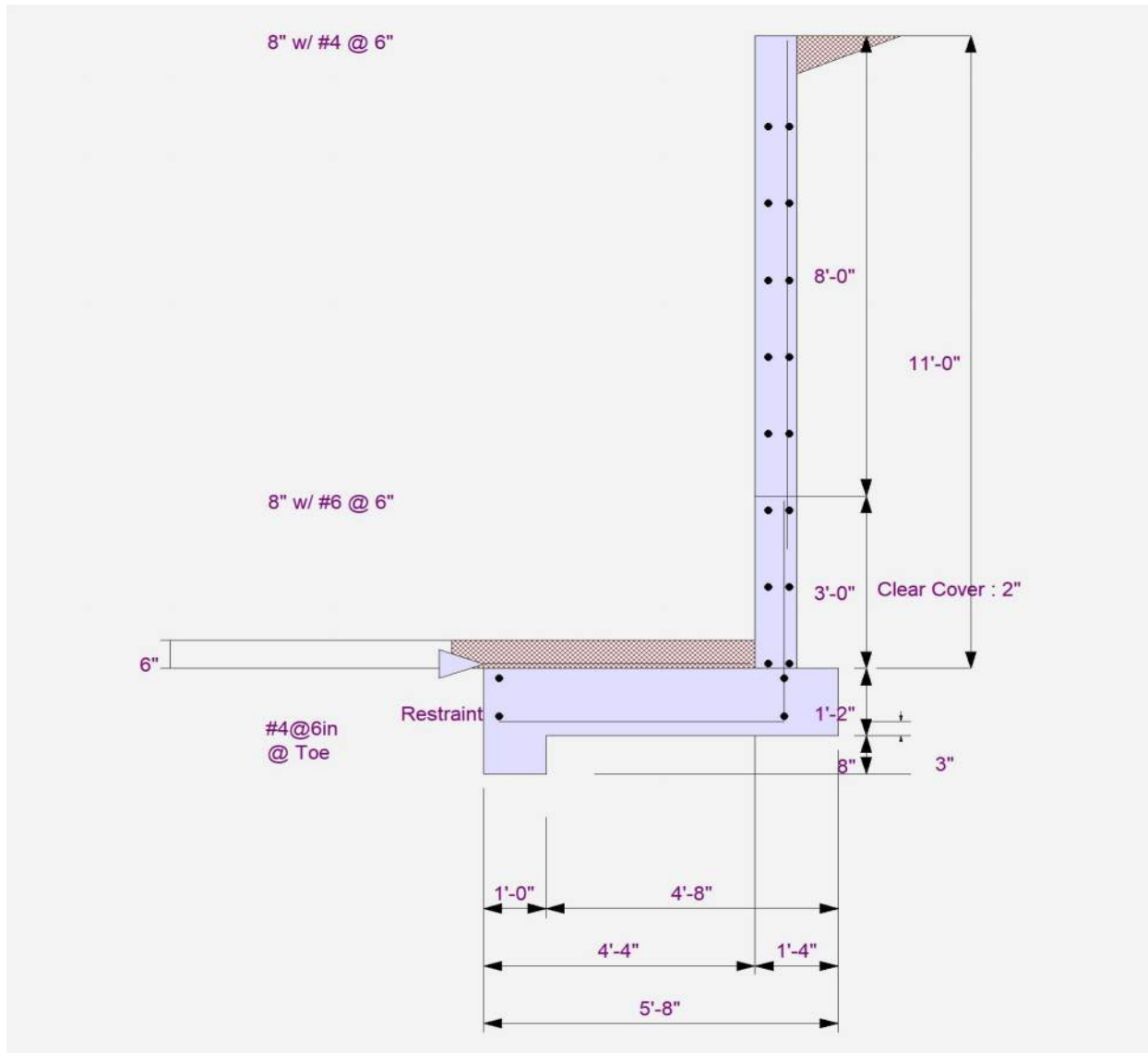
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 11' Retained -EQ



Cantilevered Retaining Wall

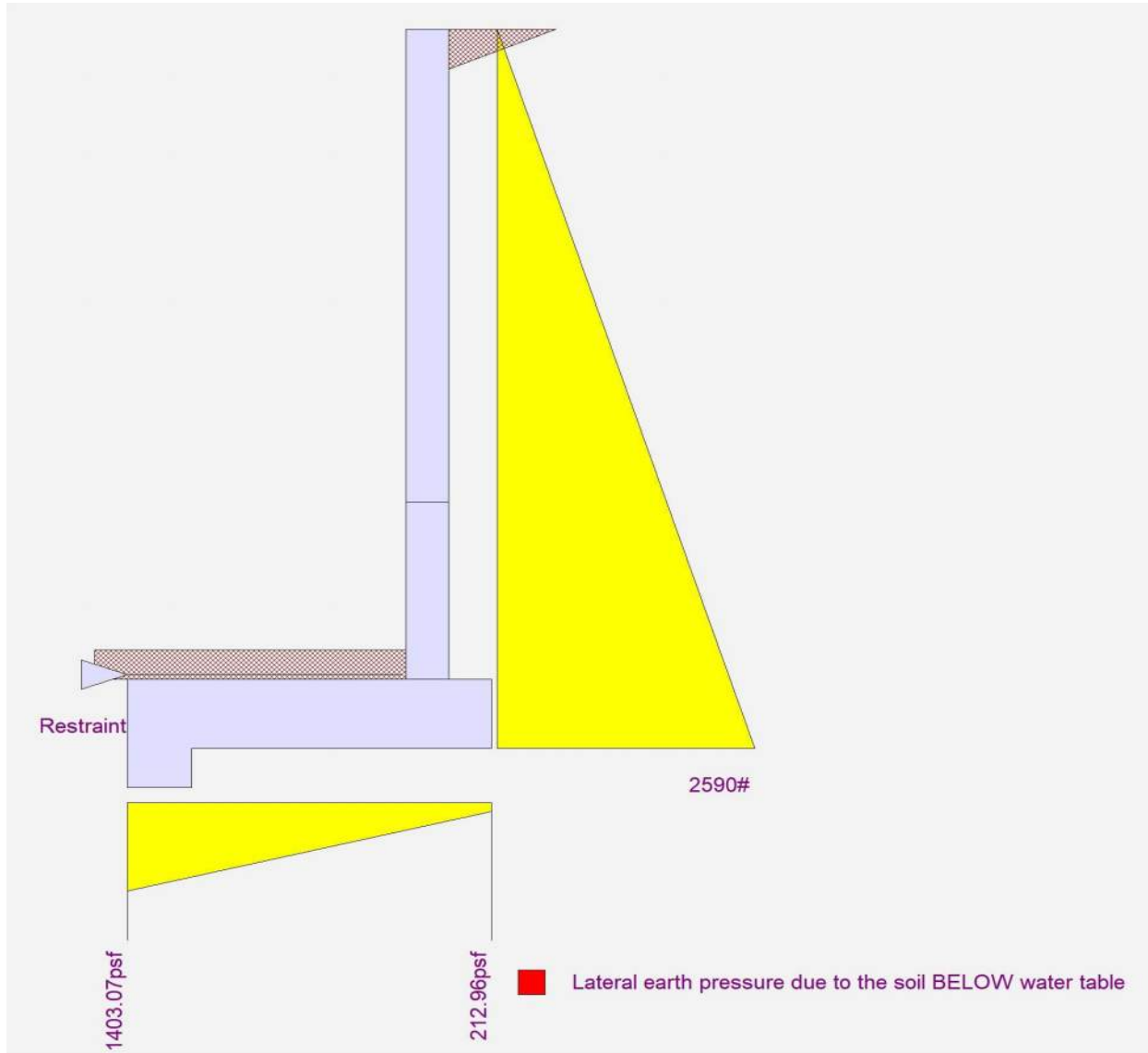
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 11' Retained -EQ



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained -EQ (P_Line)

Code Reference.

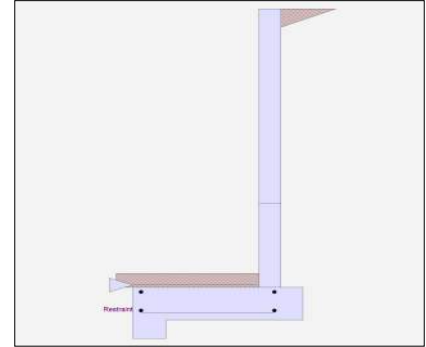
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	10.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	89.333
Total Seismic Force	=	997.556

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained -EQ (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	1.35	Ratio < 1.5!
Slab Resists All Sliding !			
Global Stability	=	1.16	
Total Bearing Load	=	4,080 lbs	
...resultant ecc.	=	18.53 in	
Eccentricity outside middle third			
Soil Pressure @ Toe	=	2,625 psf	OK
Soil Pressure @ Heel	=	0 psf	OK
Allowable	=	3,333 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,728 psf	
ACI Factored @ Heel	=	0 psf	
Footing Shear @ Toe	=	26.4 psi	OK
Footing Shear @ Heel	=	19.3 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	2,880.4 lbs
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Vertical component of active lateral soil pressure IS 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

Design Height Above Ftg

Wall Material Above "Ht"

Design Method

Thickness

Rebar Size

Rebar Spacing

Rebar Placed at

Design Data

fb/FB + fa/Fa

Total Force @ Section

Service Level

Strength Level

Moment....Actual

Service Level

Strength Level

Moment.....Allowable

Shear.....Actual

Service Level

Strength Level

Shear.....Allowable

Anet (Masonry)

Wall Weight

Rebar Depth 'd'

Masonry Data

f'm

Fs

Solid Grouting

Modular Ratio 'n'

Equiv. Solid Thick.

Masonry Block Type

Masonry Design Method

Concrete Data

f'c

Fy

	2nd	Bottom		
Stem OK	Stem OK	Stem OK		
ft =	3.00	0.00		
Concrete	Concrete	Concrete		
=	SD	SD	SD	SD
=	8.00	8.00		
=	# 4	# 6		
=	6.00	6.00		
=	Edge	Edge		
=	0.511	0.732		
lbs =				
lbs =	1,997.3	3,693.3		
ft-# =				
ft-# =	5,390.0	13,800.0		
ft-# =	10,542.0	18,848.3		
psi =				
psi =	26.6	54.7		
psi =	57.4	77.3		
in2 =				
psf =	100.0	100.0		
in =	6.25	5.63		

psi =		
psi =		
=		
=		
=		
=		
=		
=	ASD	
psi =	3,000.0	3,000.0
psi =	60,000.0	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained -EQ (P_Line)

Concrete Stem Rebar Area Details

2nd Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2019 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2019 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.5779 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.5779 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.88 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9144 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	3.83 ft
Heel Width	=	1.33
Total Footing Width	=	5.16
Footing Thickness	=	14.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	2,728	0		psf
Mu' : Upward	=	11,846	0		ft-#
Mu' : Downward	=	2,068	1,478		ft-#
Mu: Design	=	9,778	1,478	767	ft-#
φ Mn	=	18,644	3,944	2,739	ft-#
Actual 1-Way Shear	=	26.39	19.28	13.59	psi
Allow 1-Way Shear	=	47.92	43.82	43.82	psi
Toe Reinforcing	=	# 4 @ 6.00 in			
Heel Reinforcing	=	None Spec'd			
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@ 7.93 in, #5@ 12.30 in, #6@ 17.46 in, #7@ 23.80 in, #8@ 31.34 in, #9@ 39.68 in, #10@ 50.39 in

Heel: $\phi Mn = \phi^5 * \lambda * \sqrt{fc} * Sm$

Key: Slab Resists Sliding - No Force on Key

Min footing T&S reinf Area	1.56	in2
Min footing T&S reinf Area per foot	0.30	in2 /ft
<u>If one layer of horizontal bars:</u>		<u>If two layers of horizontal bars:</u>
#4@ 7.94 in		#4@ 15.87 in
#5@ 12.30 in		#5@ 24.60 in
#6@ 17.46 in		#6@ 34.92 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained -EQ (P_Line)

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)	2,182.2	3.72	8,122.5	Soil Over HL (ab. water tbl)	796.0	4.83	3,843.4
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		4.83	3,843.4
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	229.8	1.92	440.1
Seismic Earth Load =	698.3	5.58	3,898.8	Surcharge Over Toe =			
=				Stem Weight(s) =	1,000.0	4.16	4,163.3
Total =	2,880.4	O.T.M.	12,021.2	Earth @ Stem Transitions =			
				Footing Weight =	903.0	2.58	2,329.7
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	1,050.8	5.16	5,422.2
				Total =	4,079.6 lbs	R.M.=	16,248.7

Resisting/Overturning Ratio = **1.35**
 Vertical Loads used for Soil Pressure = 4,079.6 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 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) 0.141 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained -EQ (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: 2nd

Stem Design Height: 3.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in
Development length for #4 bar specified in this stem design segment = 13.15 in

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #6 bar specified in this stem design segment (25.4.2.4a) = 25.63 in
Development length for #6 bar specified in this stem design segment = 19.72 in

Hooked embedment length into footing for #6 bar specified in this stem design segment = 10.35 in
As Provided = 0.8800 in²/ft
As Required = 0.5779 in²/ft

Cantilevered Retaining Wall

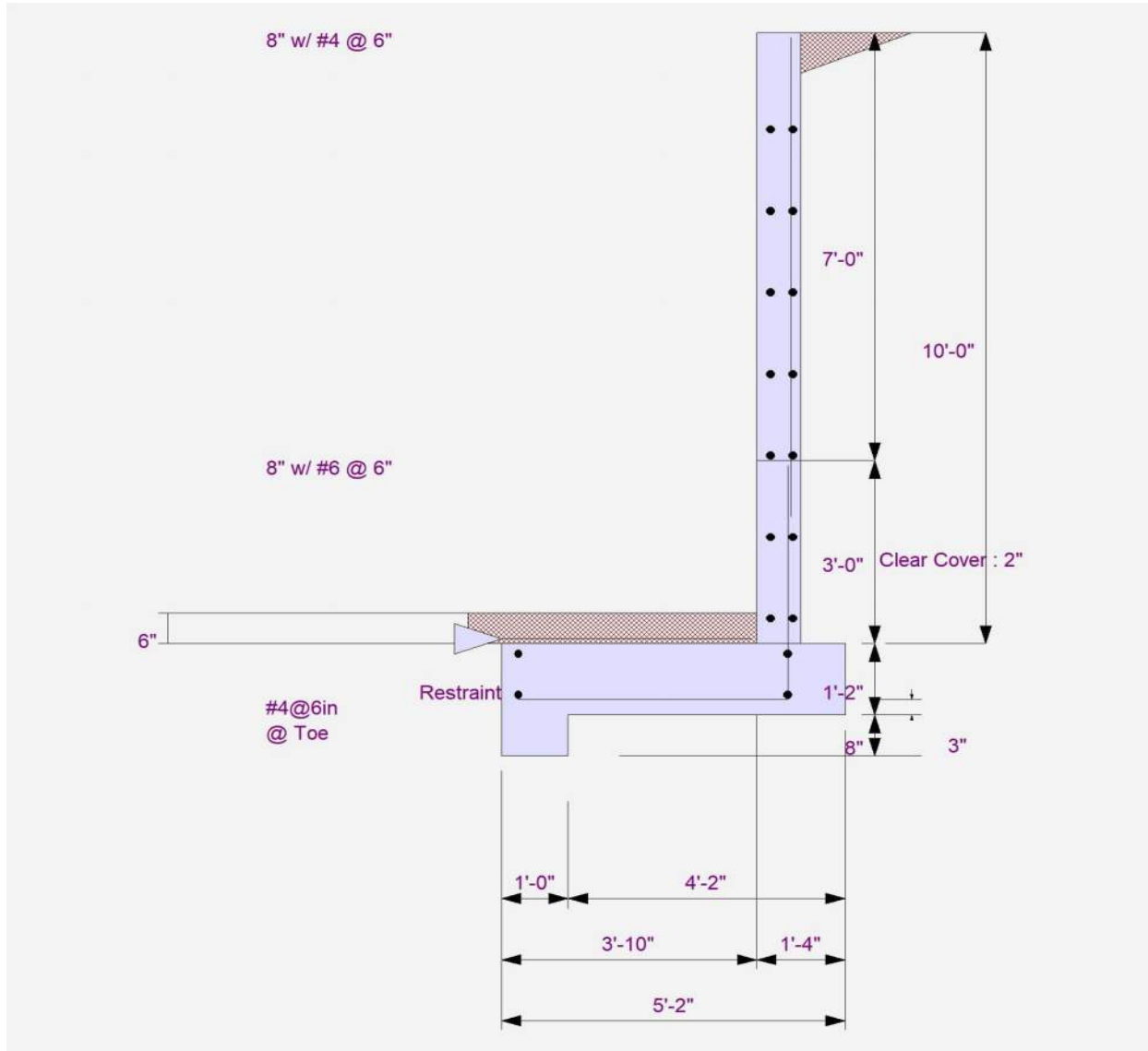
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 10' Retained -EQ (P_Line)



Cantilevered Retaining Wall

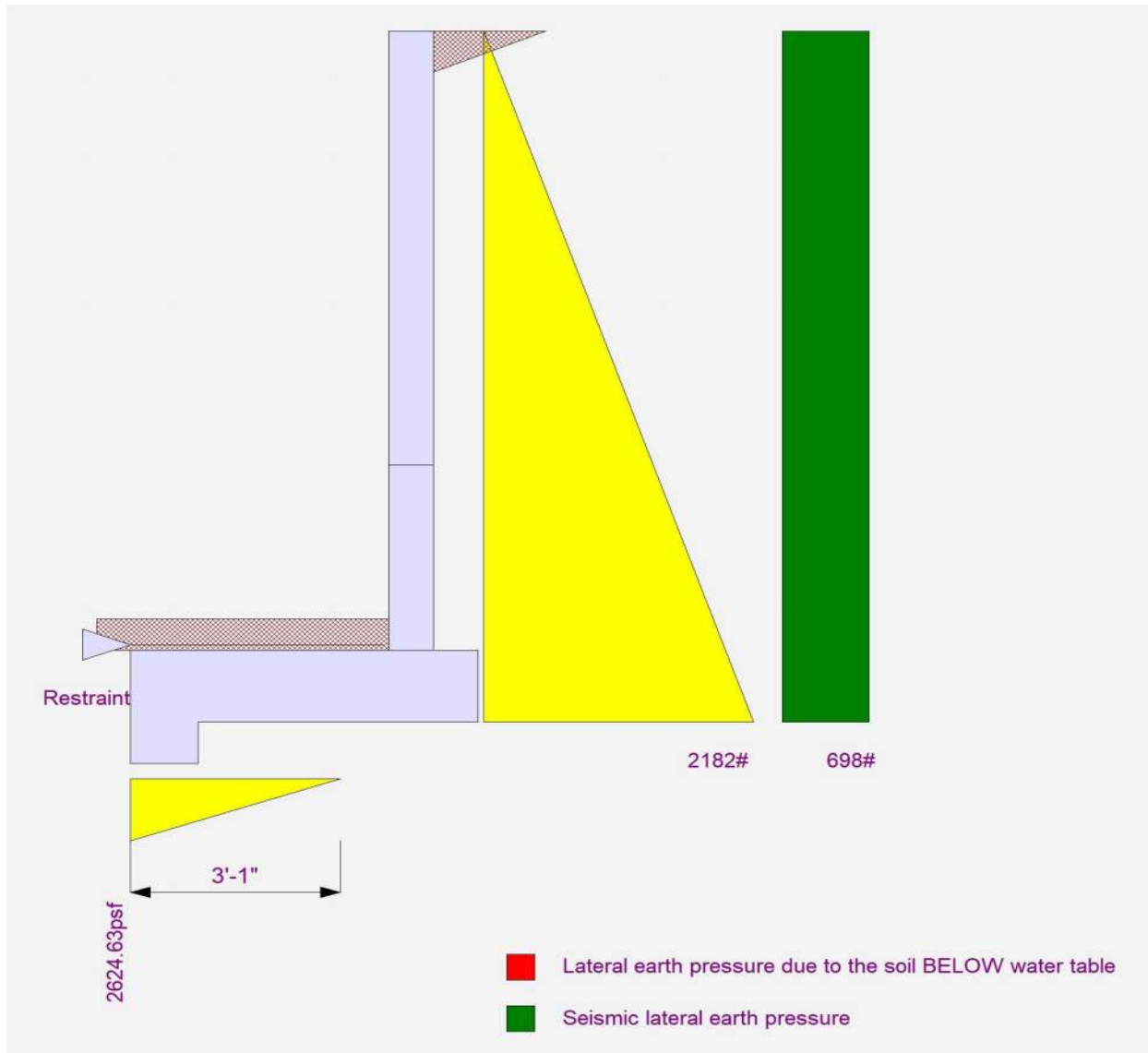
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 10' Retained -EQ (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 10' Retained (P_Line)

Code Reference.

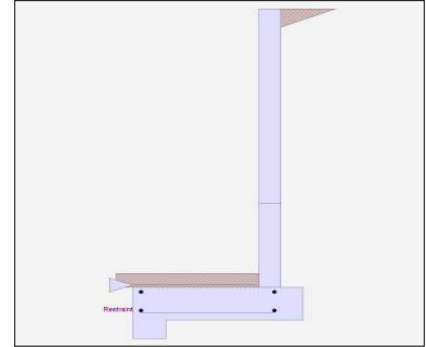
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	10.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	2.00	OK
Slab Resists All Sliding !			
Global Stability	=	1.16	
Total Bearing Load	=	4,080 lbs	
...resultant ecc.	=	7.06 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,331 psf	OK
Soil Pressure @ Heel	=	250 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,384 psf	
ACI Factored @ Heel	=	260 psf	
Footing Shear @ Toe	=	17.7 psi	OK
Footing Shear @ Heel	=	17.7 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	2,182.2 lbs
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Vertical component of active lateral soil pressure IS 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

		2nd	Bottom		
Design Height Above Ftg	ft =	Stem OK	Stem OK		
Wall Material Above "Ht"	=	3.00	0.00		
Design Method	=	Concrete	Concrete		
Thickness	=	SD	SD	SD	SD
Rebar Size	=	8.00	8.00		
Rebar Spacing	=	# 4	# 6		
Rebar Placed at	=	6.00	6.00		
	=	Edge	Edge		
Design Data					
fb/FB + fa/Fa	=	0.303	0.495		
Total Force @ Section					
Service Level	lbs =				
Strength Level	lbs =	1,372.0	2,800.0		
Moment....Actual					
Service Level	ft-# =				
Strength Level	ft-# =	3,201.3	9,333.3		
Moment.....Allowable	ft-# =	10,542.0	18,848.3		
Shear.....Actual					
Service Level	psi =				
Strength Level	psi =	18.3	41.5		
Shear.....Allowable	psi =	57.4	77.3		
Anet (Masonry)	in2 =				
Wall Weight	psf =	100.0	100.0		
Rebar Depth 'd'	in =	6.25	5.63		

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 =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained (P_Line)

Concrete Stem Rebar Area Details

2nd Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.1199 in2/ft	Horizontal Reinforcing Options :	
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	One layer of : Two layers of :	
	=====	#4@ 13.89 in	#4@ 27.78 in
Required Area :	0.1728 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Provided Area :	0.4 in2/ft	#6@ 30.56 in	#6@ 61.11 in
Maximum Area :	1.016 in2/ft		

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.3909 in2/ft	Horizontal Reinforcing Options :	
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	One layer of : Two layers of :	
	=====	#4@ 13.89 in	#4@ 27.78 in
Required Area :	0.3909 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Provided Area :	0.88 in2/ft	#6@ 30.56 in	#6@ 61.11 in
Maximum Area :	0.9144 in2/ft		

Footing Data

Toe Width	=	3.83 ft
Heel Width	=	1.33
Total Footing Width	=	5.16
Footing Thickness	=	14.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	1,384	260		psf
Mu' : Upward	=	8,109	68		ft-#
Mu' : Downward	=	2,068	1,478		ft-#
Mu: Design	=	6,041	1,411	767	ft-#
φ Mn	=	18,644	3,944	2,739	ft-#
Actual 1-Way Shear	=	17.73	17.75	13.59	psi
Allow 1-Way Shear	=	47.92	43.82	43.82	psi
Toe Reinforcing	=	# 4 @ 6.00 in			
Heel Reinforcing	=	None Spec'd			
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@ 7.93 in, #5@ 12.30 in, #6@ 17.46 in, #7@ 23.80 in, #8@ 31.34 in, #9@ 39.68 in, #10@ 50.39 in

Heel: $\phi Mn = \phi^5 * \lambda * \sqrt{fc} * Sm$

Key: Slab Resists Sliding - No Force on Key

Min footing T&S reinf Area	1.56	in2
Min footing T&S reinf Area per foot	0.30	in2 /ft
<u>If one layer of horizontal bars:</u>		<u>If two layers of horizontal bars:</u>
#4@ 7.94 in		#4@ 15.87 in
#5@ 12.30 in		#5@ 24.60 in
#6@ 17.46 in		#6@ 34.92 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained (P_Line)

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)	2,182.2	3.72	8,122.5	Soil Over HL (ab. water tbl)	796.0	4.83	3,843.4
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		4.83	3,843.4
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	229.8	1.92	440.1
				Surcharge Over Toe =			
				Stem Weight(s) =	1,000.0	4.16	4,163.3
				Earth @ Stem Transitions =			
Total	= 2,182.2	O.T.M. =	8,122.5	Footing Weight =	903.0	2.58	2,329.7
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	1,050.8	5.16	5,422.2
Resisting/Overturning Ratio		= 2.00		Total =	4,079.6 lbs	R.M.=	16,248.7
Vertical Loads used for Soil Pressure =		4,079.6 lbs		* 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 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) 0.072 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 10' Retained (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: 2nd

Stem Design Height: 3.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in
Development length for #4 bar specified in this stem design segment = 13.15 in

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #6 bar specified in this stem design segment (25.4.2.4a) = 25.63 in
Development length for #6 bar specified in this stem design segment = 19.72 in

Hooked embedment length into footing for #6 bar specified in this stem design segment = 10.35 in
As Provided = 0.8800 in²/ft
As Required = 0.3909 in²/ft

Cantilevered Retaining Wall

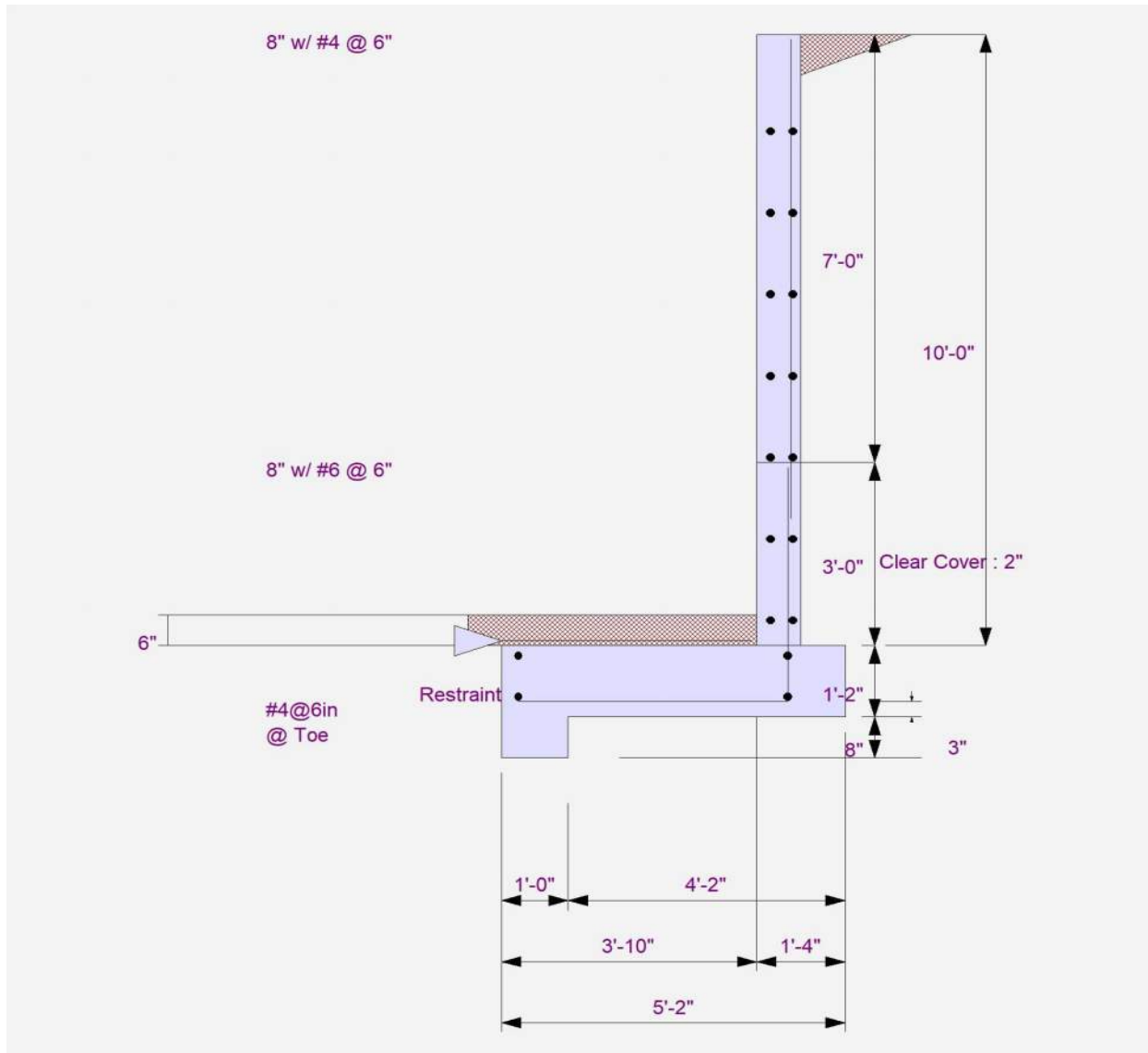
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 10' Retained (P_Line)



Cantilevered Retaining Wall

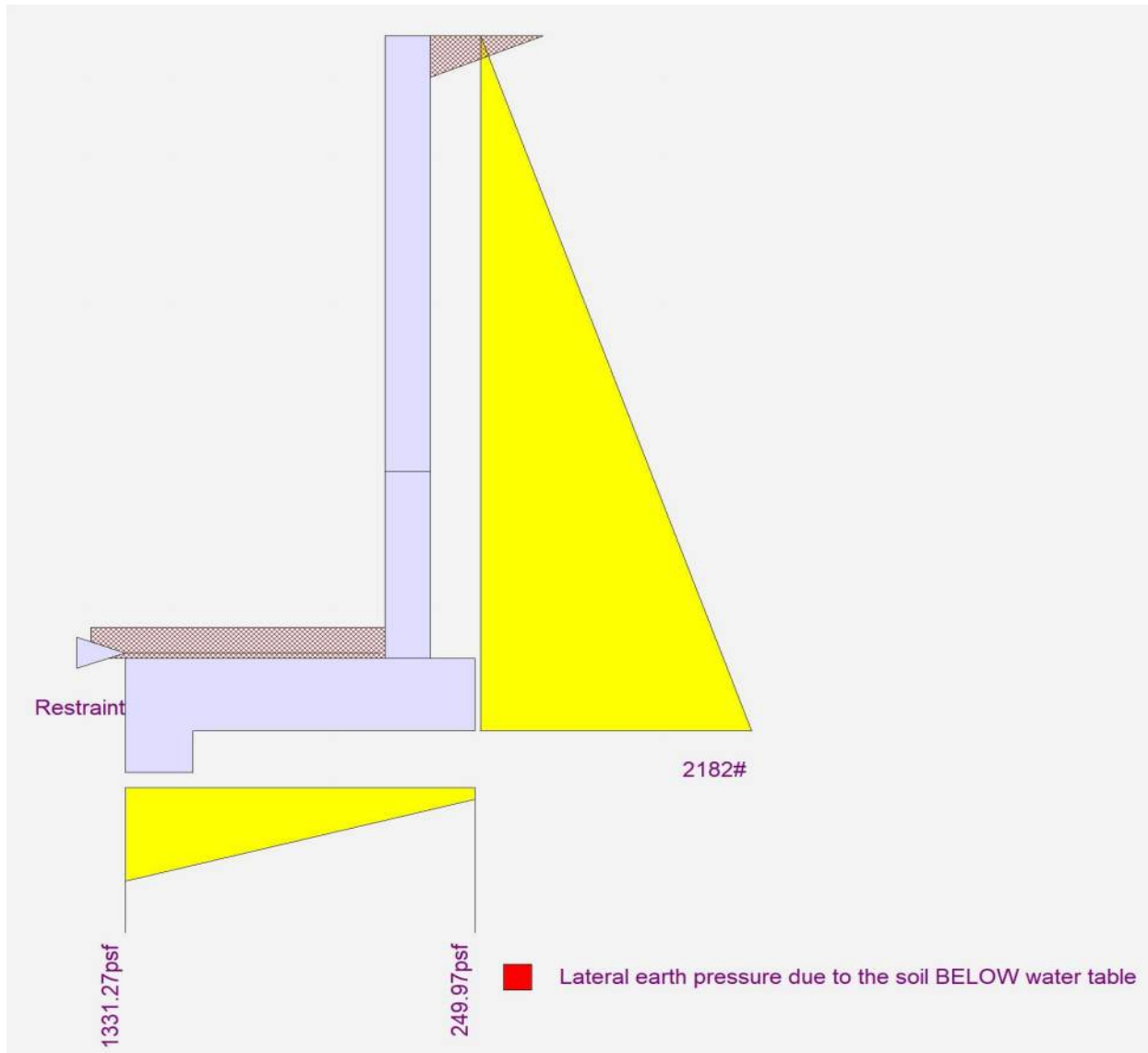
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

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DESCRIPTION: 10' Retained (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained -EQ (P_Line)

Code Reference.

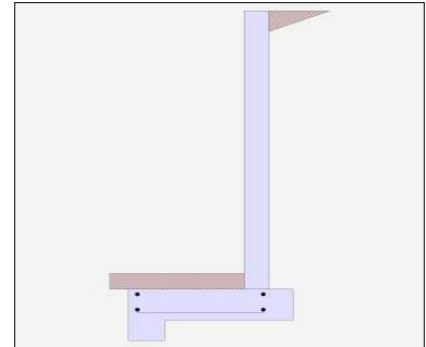
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	9.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	80.000
Total Seismic Force	=	800.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained -EQ (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	1.37 Ratio < 1.5!
Sliding	=	1.24 Ratio < 1.5!
Global Stability	=	1.23
Total Bearing Load	=	3,424 lbs
...resultant ecc.	=	15.90 in
Eccentricity outside middle third		
Soil Pressure @ Toe	=	2,467 psf OK
Soil Pressure @ Heel	=	0 psf OK
Allowable	=	3,333 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	2,604 psf
ACI Factored @ Heel	=	0 psf
Footing Shear @ Toe	=	28.3 psi OK
Footing Shear @ Heel	=	19.4 psi OK
Allowable	=	82.2 psi

Sliding Calcs

Lateral Sliding Force	=	2,310.0 lbs
less 100% Passive Force	=	1,056.3 lbs
less 100% Friction Force	=	1,814.9 lbs
Added Force Req'd	=	0.0 lbs OK
...for 1.5 Stability	=	593.9 lbs NG

Vertical component of active lateral soil pressure IS 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

Design Height Above Ftg

ft =	Stem OK		
	0.00		
Wall Material Above "Ht"	=	Concrete	
Design Method	=	SD	SD SD
Thickness	=	8.00	
Rebar Size	=	# 4	
Rebar Spacing	=	6.00	
Rebar Placed at	=	Edge	

Design Data

fb/FB + fa/Fa	=	0.952
---------------	---	-------

Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	2,988.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	10,044.0

Moment.....Allowable	=	10,542.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	39.8

Shear.....Allowable	psi =	57.4
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained -EQ (P_Line)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.3763 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.3763 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	3.17 ft
Heel Width	=	1.33
Total Footing Width	=	4.50
Footing Thickness	=	12.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	2,604	0		psf
Mu' : Upward	=	8,113	0		ft-#
Mu' : Downward	=	1,266	1,219		ft-#
Mu: Design	=	6,847	1,219	724	ft-#
φ Mn	=	15,044	2,739	2,739	ft-#
Actual 1-Way Shear	=	28.32	19.40	12.71	psi
Allow 1-Way Shear	=	51.33	43.82	43.82	psi
Toe Reinforcing	=	# 4 @ 6.00 in			
Heel Reinforcing	=	None Spec'd			
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@ 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Min footing T&S reinf Area	1.17	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained -EQ (P_Line)

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)	1,750.0	3.33	5,833.3	Soil Over HL (ab. water tbl)	716.4	4.17	2,986.2
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		4.17	2,986.2
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	190.2	1.59	301.5
Seismic Earth Load =	560.0	5.00	2,800.0	Surcharge Over Toe =			
=				Stem Weight(s) =	900.0	3.50	3,153.0
Total =	2,310.0	O.T.M. =	8,633.3	Earth @ Stem Transitions =			
				Footing Weight =	675.0	2.25	1,518.8
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	842.7	4.50	3,792.2
				Total =	3,424.3 lbs	R.M.=	11,801.6

Resisting/Overturning Ratio = 1.37
 Vertical Loads used for Soil Pressure = 3,424.3 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 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) 0.137 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained -EQ (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.4000 in ² /ft
As Required =	0.3763 in ² /ft

Cantilevered Retaining Wall

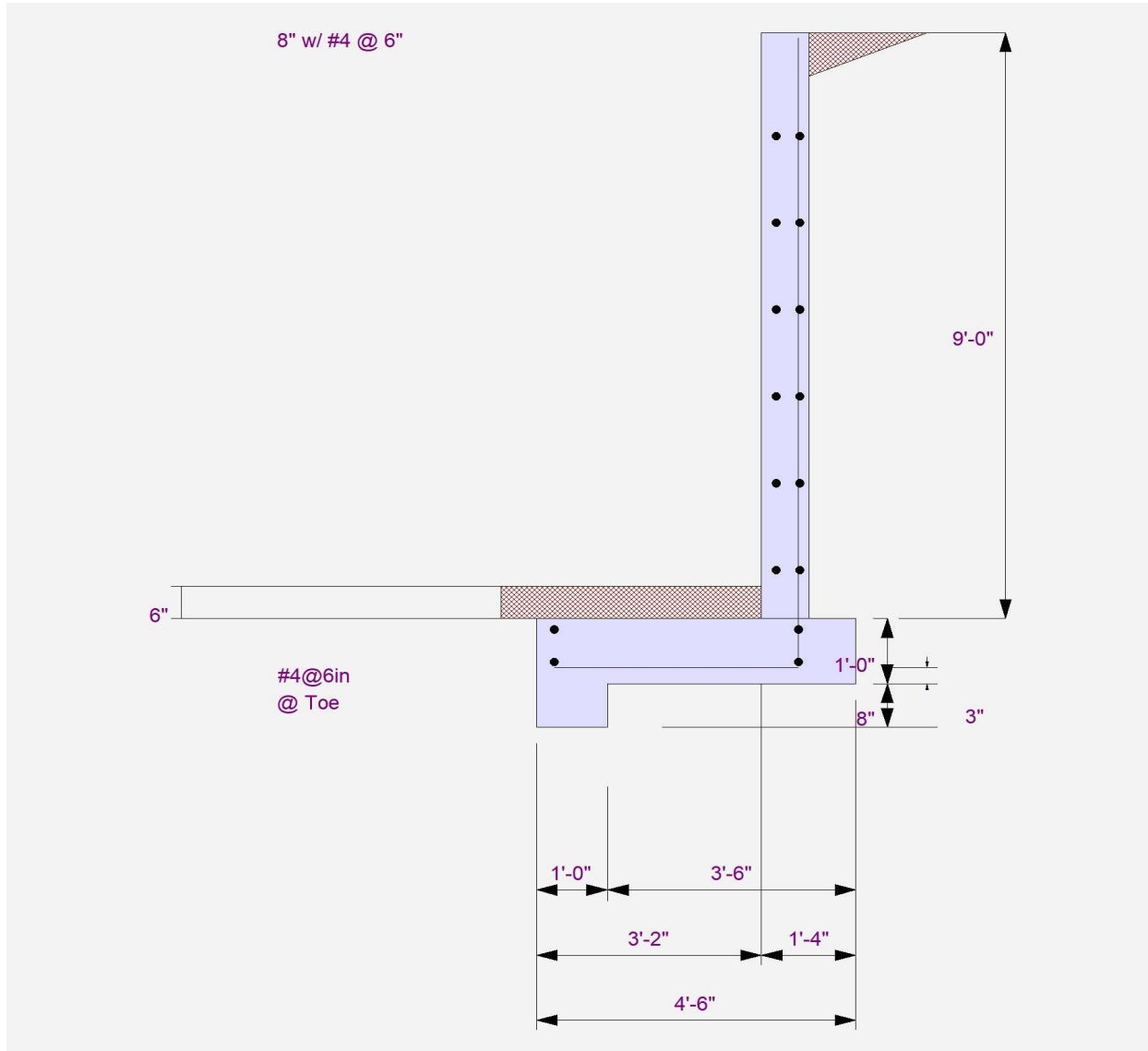
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained -EQ (P_Line)



Cantilevered Retaining Wall

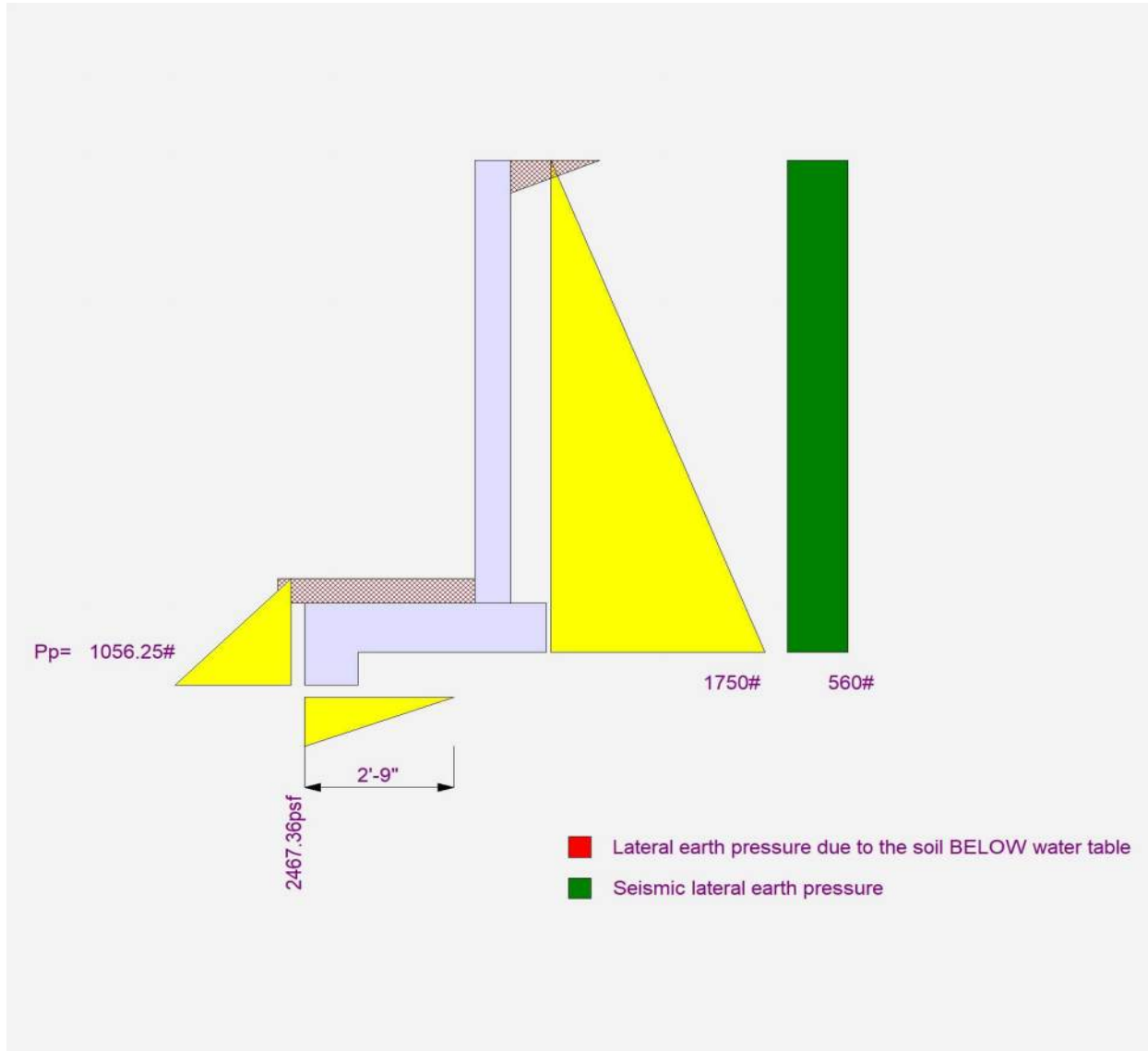
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained -EQ (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained (P_LINE)

Code Reference.

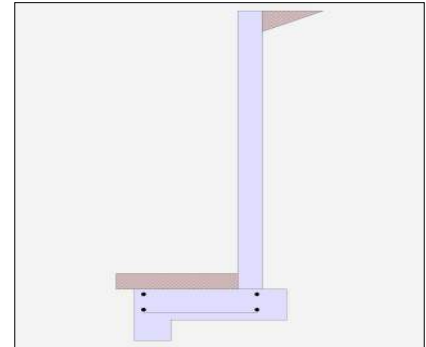
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	9.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
	=	
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained (P_LINE)

Design Summary

Wall Stability Ratios

Overturning	=	1.83	OK
Sliding	=	1.62	OK
Global Stability	=	1.23	
Total Bearing Load	=	3,353 lbs	
...resultant ecc.	=	7.60 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,542 psf	OK
Soil Pressure @ Heel	=	70 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,617 psf	
ACI Factored @ Heel	=	73 psf	
Footing Shear @ Toe	=	19.7 psi	OK
Footing Shear @ Heel	=	18.3 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	1,750.0 lbs	
less 100% Passive Force	=	1,056.3 lbs	
less 100% Friction Force	=	1,777.0 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 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

Design Height Above Ftg

ft =	Stem OK		
	0.00		
Wall Material Above "Ht"	=	Concrete	
Design Method	=	SD	SD SD
Thickness	=	8.00	
Rebar Size	=	# 4	
Rebar Spacing	=	6.00	
Rebar Placed at	=	Edge	

Design Data

fb/FB + fa/Fa	=	0.645
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	2,268.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	6,804.0

Moment.....Allowable	=	10,542.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	30.2

Shear.....Allowable	psi =	57.4
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained (P_LINE)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2549 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2549 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.4 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	2.83 ft
Heel Width	=	1.33
Total Footing Width	=	4.16
Footing Thickness	=	12.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	1,617	73		psf
Mu' : Upward	=	5,072	34		ft-#
Mu' : Downward	=	1,009	1,219		ft-#
Mu: Design	=	4,063	1,185	749	ft-#
φ Mn	=	15,044	2,739	2,739	ft-#
Actual 1-Way Shear	=	19.70	18.31	13.03	psi
Allow 1-Way Shear	=	51.33	43.82	43.82	psi
Toe Reinforcing	=	# 4 @ 6.00 in			
Heel Reinforcing	=	None Spec'd			
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@ 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Min footing T&S reinf Area 1.08 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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained (P_LINE)

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)	1,750.0	3.33	5,833.3	Soil Over HL (ab. water tbl)	716.4	3.83	2,742.6
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.83	2,742.6
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	169.8	1.42	240.3
				Surcharge Over Toe =			
				Stem Weight(s) =	900.0	3.16	2,847.0
				Earth @ Stem Transitions =			
Total	= 1,750.0	O.T.M. =	5,833.3	Footing Weight =	624.0	2.08	1,297.9
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	842.7	4.16	3,505.7
				Total =	3,352.9 lbs	R.M.=	10,683.5
Resisting/Overturning Ratio		= 1.83		* 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 =		3,352.9 lbs					

Vertical component of active lateral soil pressure IS 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) 0.093 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 9' Retained (P_LINE)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.4000 in ² /ft
As Required =	0.2549 in ² /ft

Cantilevered Retaining Wall

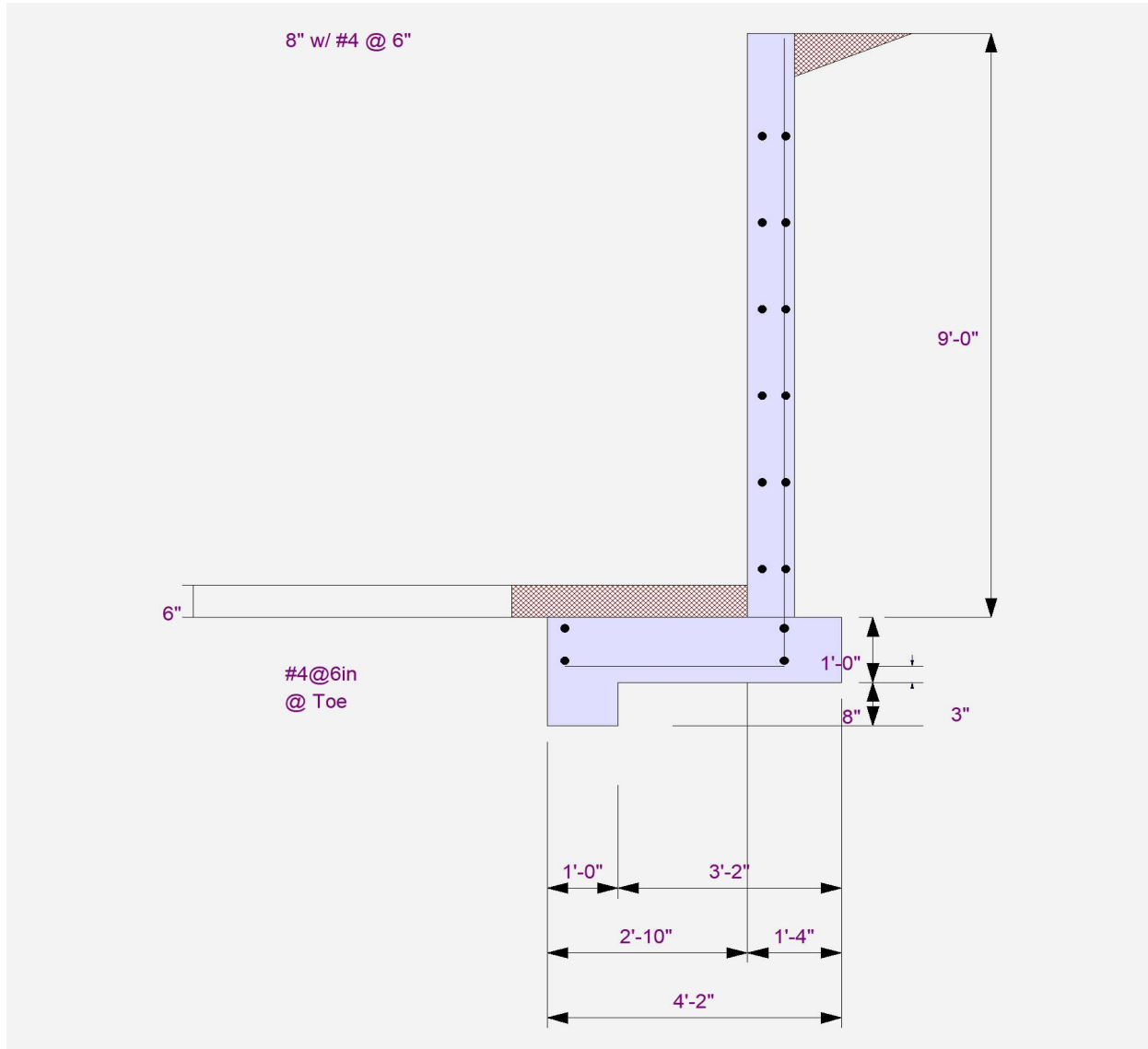
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained (P_LINE)



Cantilevered Retaining Wall

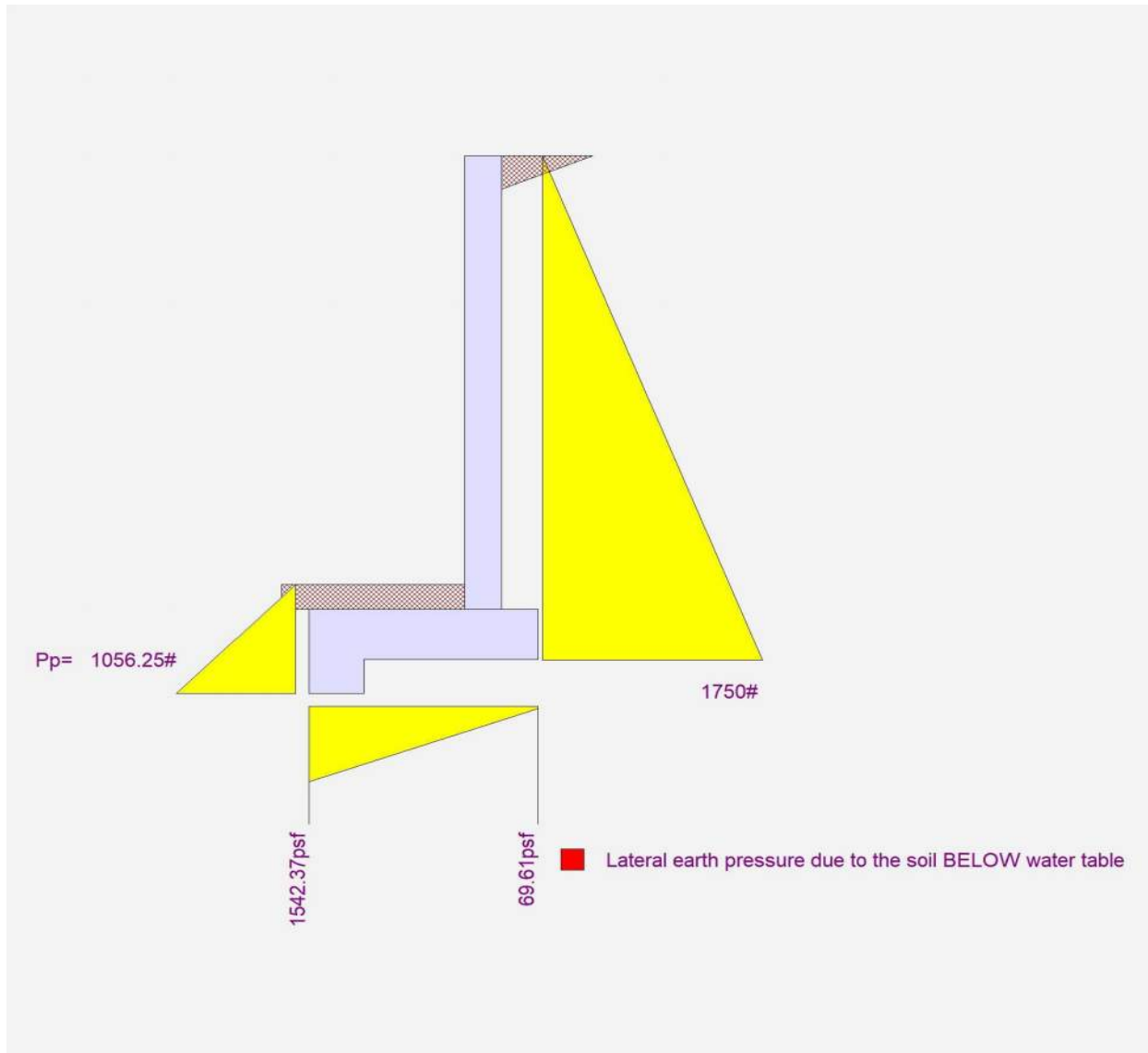
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 9' Retained (P_LINE)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ (P_LINE)

Code Reference.

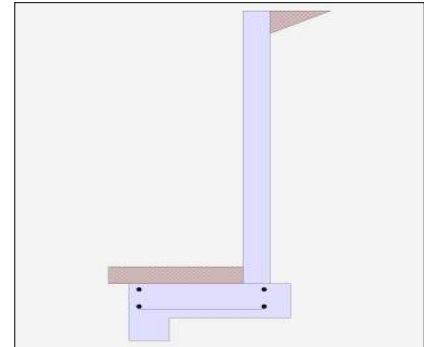
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	8.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	72.000
Total Seismic Force	=	648.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ (P_LINE)

Design Summary

Wall Stability Ratios

Overturing	=	1.36 Ratio < 1.5!
Sliding	=	1.37 Ratio < 1.5!
Global Stability	=	1.29
Total Bearing Load	=	2,836 lbs
...resultant ecc.	=	14.40 in
Eccentricity outside middle third		
Soil Pressure @ Toe	=	2,363 psf OK
Soil Pressure @ Heel	=	0 psf OK
Allowable	=	3,333 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	2,511 psf
ACI Factored @ Heel	=	0 psf
Footing Shear @ Toe	=	23.4 psi OK
Footing Shear @ Heel	=	14.7 psi OK
Allowable	=	82.2 psi

Sliding Calcs

Lateral Sliding Force	=	1,871.1 lbs
less 100% Passive Force	=	1,056.3 lbs
less 100% Friction Force	=	1,502.9 lbs
Added Force Req'd	=	0.0 lbs OK
...for 1.5 Stability	=	247.5 lbs NG

Vertical component of active lateral soil pressure IS 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	9.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.985
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	2,368.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	7,082.7

Moment.....Allowable	=	7,185.3
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	31.6

Shear.....Allowable	psi =	50.2
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ (P_LINE)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2654 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.2654 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2667 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	2.83 ft
Heel Width	=	1.17
Total Footing Width	=	4.00
Footing Thickness	=	12.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	2,511	0		psf
Mu' : Upward	=	6,118	0		ft-#
Mu' : Downward	=	1,009	718		ft-#
Mu: Design	=	5,109	718	694	ft-#
φ Mn	=	10,188	2,739	2,739	ft-#
Actual 1-Way Shear	=	23.41	14.69	12.34	psi
Allow 1-Way Shear	=	44.84	43.82	43.82	psi
Toe Reinforcing	=	# 4 @ 9.00 in			
Heel Reinforcing	=	None Spec'd			
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@ 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Min footing T&S reinf Area	1.04	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ (P_LINE)

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)	1,417.5	3.00	4,252.5	Soil Over HL (ab. water tbl)	483.2	3.75	1,811.2
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.75	1,811.2
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	169.8	1.42	240.3
Seismic Earth Load =	453.6	4.50	2,041.2	Surcharge Over Toe =			
=				Stem Weight(s) =	800.0	3.16	2,530.7
Total =	1,871.1	O.T.M. =	6,293.7	Earth @ Stem Transitions =			
				Footing Weight =	600.0	2.00	1,200.0
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	682.6	4.00	2,730.4
				Total =	2,835.6 lbs	R.M.=	8,562.5

Resisting/Overturning Ratio = 1.36
 Vertical Loads used for Soil Pressure = 2,835.6 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 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) 0.131 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ (P_LINE)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2667 in ² /ft
As Required =	0.2654 in ² /ft

Cantilevered Retaining Wall

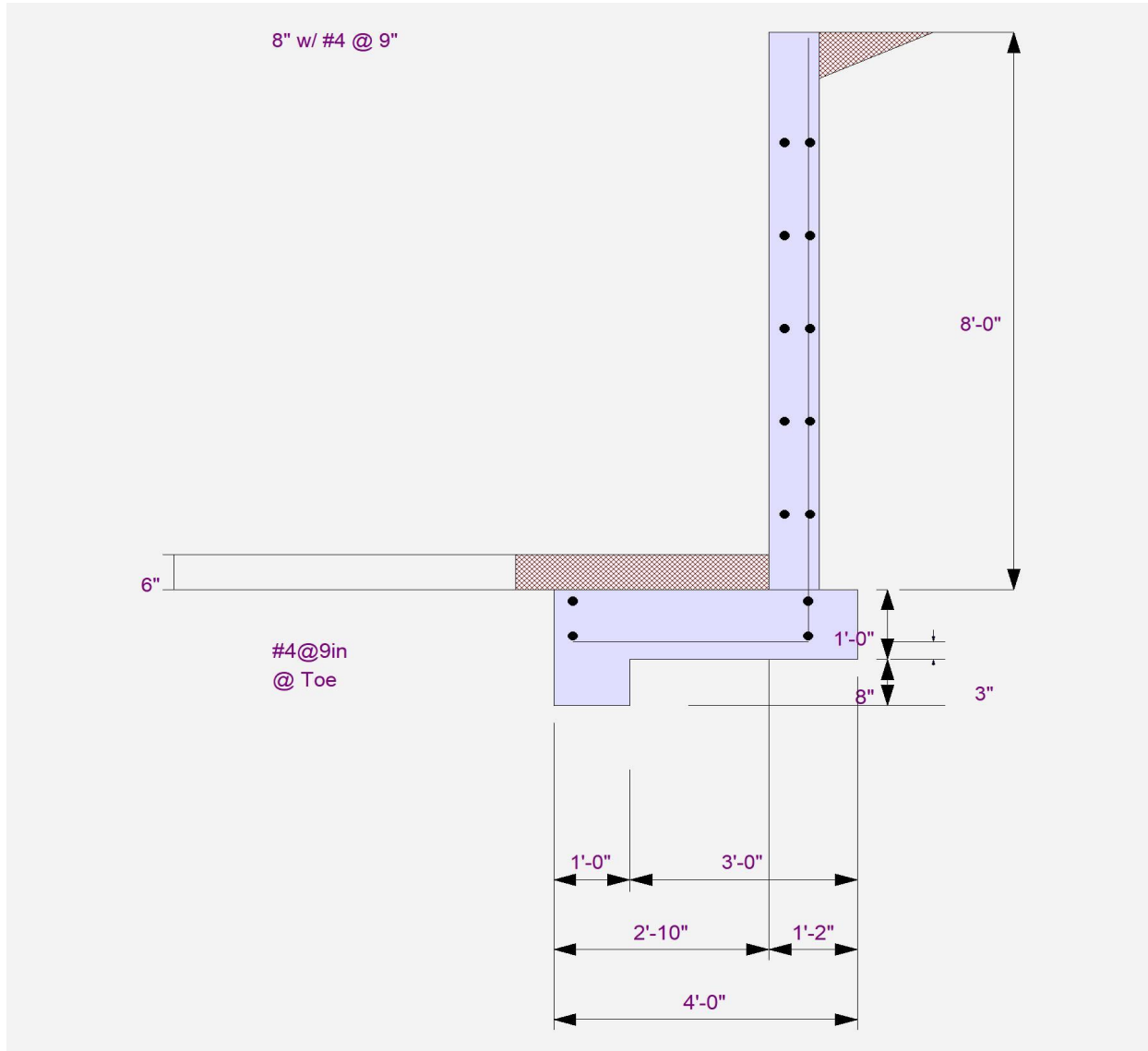
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 8' Retained - EQ (P_LINE)



Cantilevered Retaining Wall

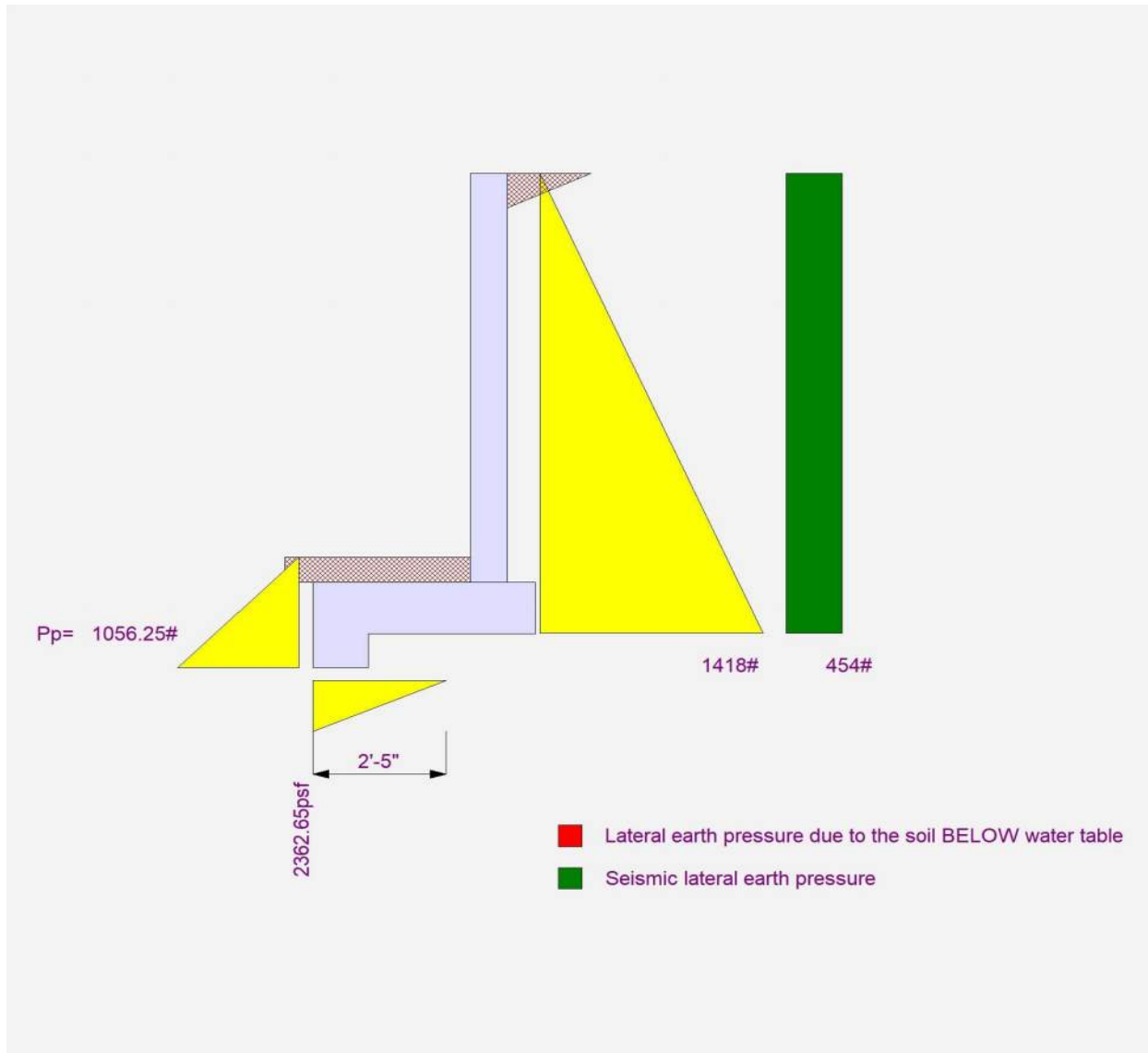
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained - EQ (P_LINE)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained (P_LINE)

Code Reference.

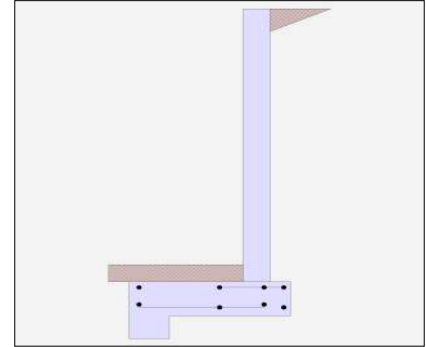
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	8.00 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained (P_LINE)

Design Summary

Wall Stability Ratios

Overturning	=	2.01	OK
Sliding	=	1.81	OK
Global Stability	=	1.29	
Total Bearing Load	=	2,836 lbs	
...resultant ecc.	=	5.76 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,219 psf	OK
Soil Pressure @ Heel	=	198 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,296 psf	
ACI Factored @ Heel	=	211 psf	
Footing Shear @ Toe	=	15.2 psi	OK
Footing Shear @ Heel	=	14.2 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	1,417.5 lbs	
less 100% Passive Force	=	- 1,056.3 lbs	
less 100% Friction Force	=	- 1,502.9 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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	10.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.735
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,792.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	4,778.7

Moment.....Allowable	=	6,495.1
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	23.9

Shear.....Allowable	psi =	48.4
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained (P_LINE)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.179 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.179 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.24 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	2.83 ft
Heel Width	=	1.17
Total Footing Width	=	4.00
Footing Thickness	=	12.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	1,296	211		psf
Mu' : Upward	=	4,166	32		ft-#
Mu' : Downward	=	1,009	718		ft-#
Mu: Design	=	3,156	686	694	ft-#
φ Mn	=	10,188	11,388	2,739	ft-#
Actual 1-Way Shear	=	15.23	14.23	12.34	psi
Allow 1-Way Shear	=	44.84	43.25	43.82	psi
Toe Reinforcing	=	# 4 @ 9.00 in			
Heel Reinforcing	=	# 4 @ 9.00 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@ 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Min footing T&S reinf Area	1.04	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

#4@ 9.26 in
 #5@ 14.35 in
 #6@ 20.37 in

If two layers of horizontal bars:

#4@ 18.52 in
 #5@ 28.70 in
 #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained (P_LINE)

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)	1,417.5	3.00	4,252.5	Soil Over HL (ab. water tbl)	483.2	3.75	1,811.2
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.75	1,811.2
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	169.8	1.42	240.3
				Surcharge Over Toe =			
				Stem Weight(s) =	800.0	3.16	2,530.7
				Earth @ Stem Transitions =			
Total	= 1,417.5	O.T.M. =	4,252.5	Footing Weight =	600.0	2.00	1,200.0
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	682.6	4.00	2,730.4
				Total =	2,835.6 lbs	R.M.=	8,562.5
Resisting/Overturning Ratio		= 2.01		* 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 =		2,835.6 lbs					

Vertical component of active lateral soil pressure IS 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) 0.068 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained (P_LINE)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2400 in ² /ft
As Required =	0.2387 in ² /ft

Cantilevered Retaining Wall

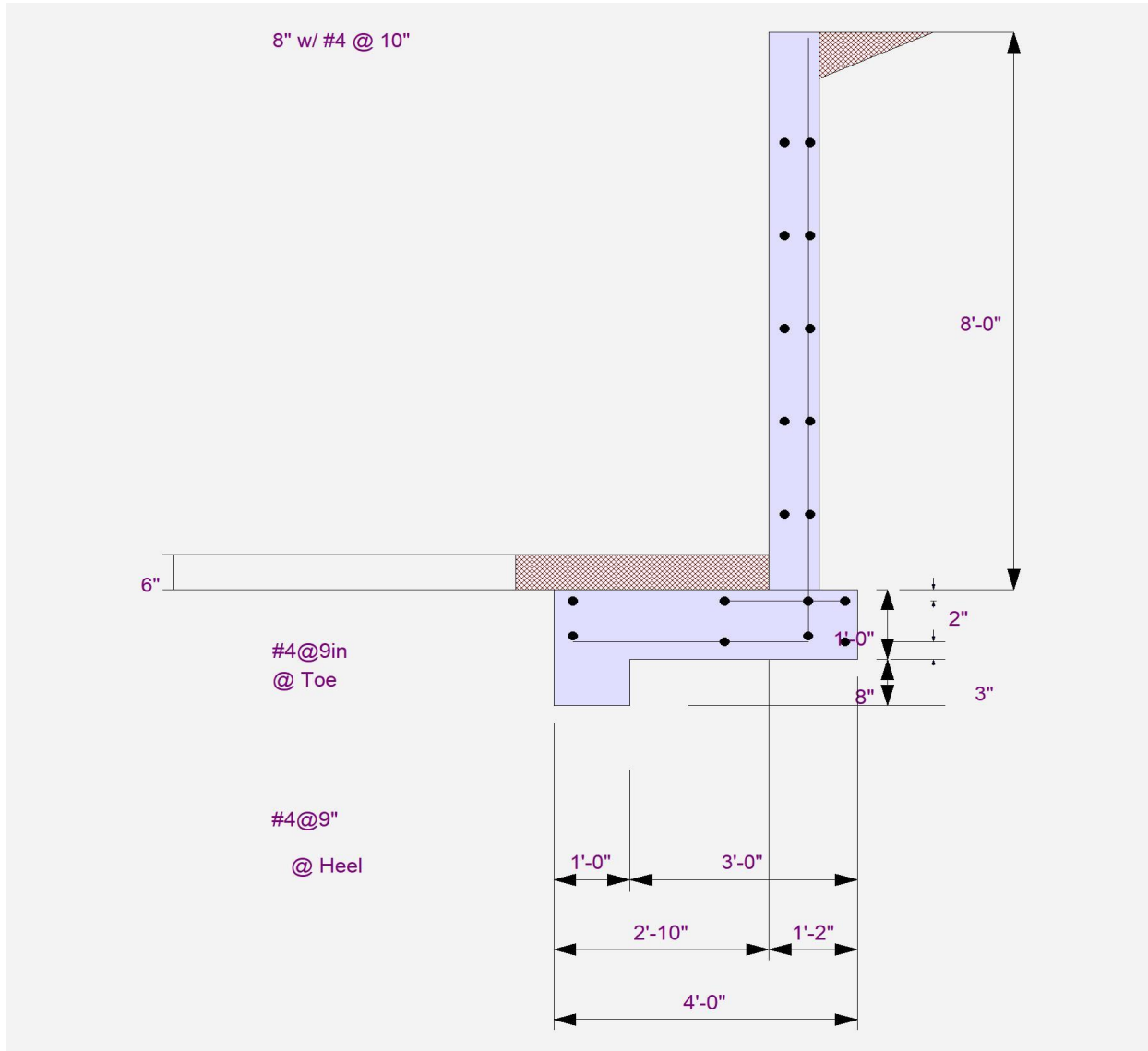
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 8' Retained (P_LINE)



Cantilevered Retaining Wall

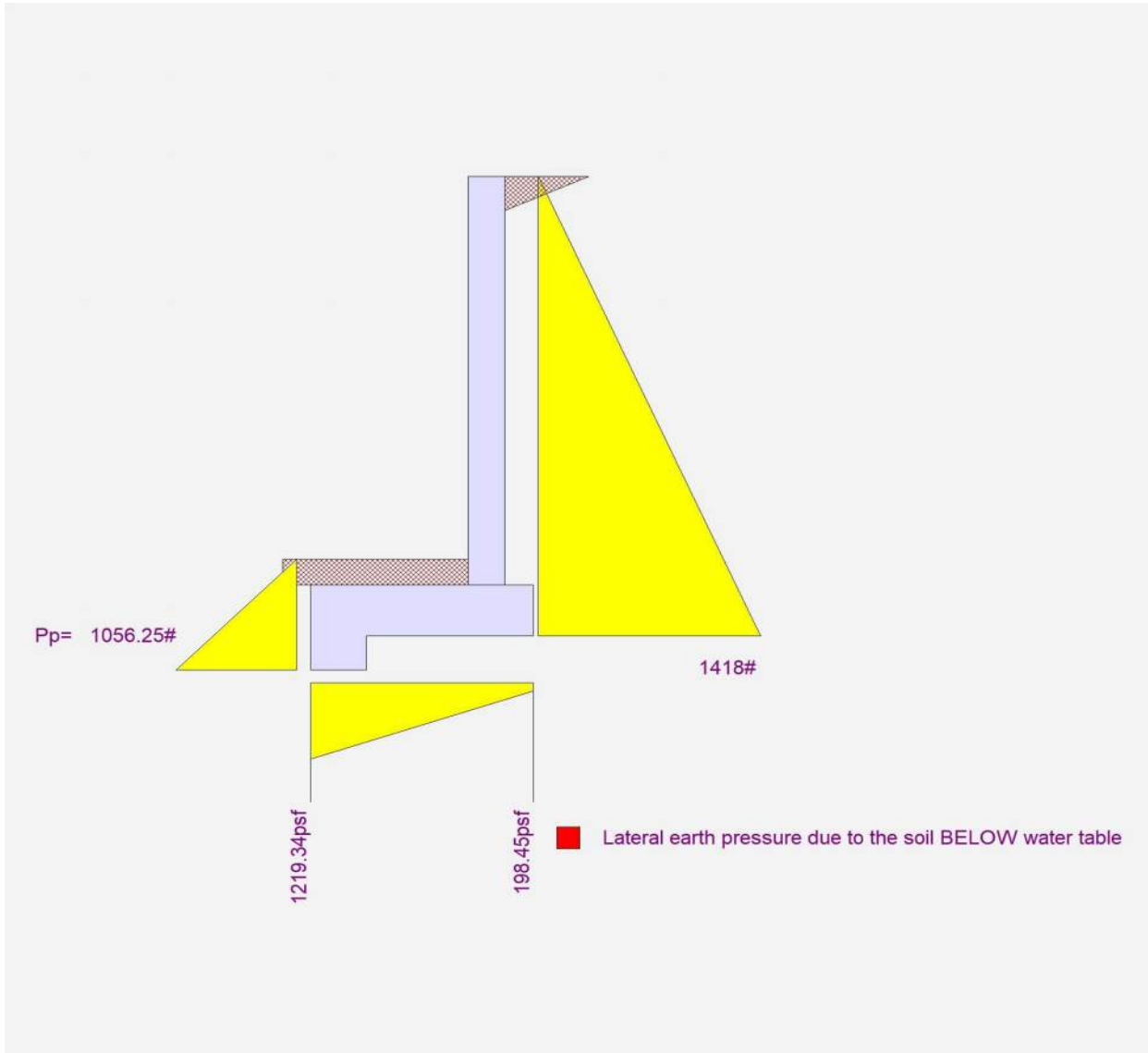
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 8' Retained (P_LINE)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (P_LINE)

Code Reference.

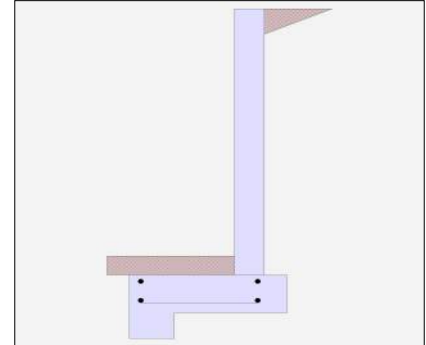
Calculations per IBC 2021 1807.3, ASCE 7-16

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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	64.000
Total Seismic Force	=	512.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (P_LINE)

Design Summary

Wall Stability Ratios

Overturning	=	1.42	Ratio < 1.5!
Sliding	=	1.58	OK
Global Stability	=	1.47	
Total Bearing Load	=	2,427	lbs
...resultant ecc.	=	11.92	in
Eccentricity outside middle third			
Soil Pressure @ Toe	=	2,138	psf OK
Soil Pressure @ Heel	=	0	psf OK
Allowable	=	3,333	psf
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,328	psf
ACI Factored @ Heel	=	0	psf
Footing Shear @ Toe	=	19.4	psi OK
Footing Shear @ Heel	=	12.2	psi OK
Allowable	=	82.2	psi

Sliding Calcs

Lateral Sliding Force	=	1,478.4	lbs
less 100% Passive Force	=	- 1,056.3	lbs
less 100% Friction Force	=	- 1,286.3	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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	9.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.663
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,820.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	4,769.3

Moment.....Allowable	=	7,185.3
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	24.3

Shear.....Allowable	psi =	50.2
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (P_LINE)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.1787 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1787 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2667 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	2.33 ft
Heel Width	=	1.17
Total Footing Width	=	3.50
Footing Thickness	=	12.00 in
Key Width	=	12.00 in
Key Depth	=	8.00 in
Key Distance from Toe	=	0.00 ft
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	2,328	0		psf
Mu' : Upward	=	4,157	0		ft-#
Mu' : Downward	=	684	585		ft-#
Mu: Design	=	3,473	585	685	ft-#
φ Mn	=	10,188	2,739	2,739	ft-#
Actual 1-Way Shear	=	19.40	12.17	12.23	psi
Allow 1-Way Shear	=	44.84	43.82	43.82	psi
Toe Reinforcing	=	# 4 @ 9.00 in			
Heel Reinforcing	=	None Spec'd			
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@ 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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Min footing T&S reinf Area	0.91	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (P_LINE)

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)	1,120.0	2.67	2,986.7	Soil Over HL (ab. water tbl)	422.8	3.25	1,373.4
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.25	1,373.4
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	139.8	1.17	162.9
Seismic Earth Load =	358.4	4.00	1,433.6	Surcharge Over Toe =			
=				Stem Weight(s) =	700.0	2.66	1,864.3
Total =	1,478.4	O.T.M.	4,420.3	Earth @ Stem Transitions =			
				Footing Weight =	525.0	1.75	918.8
				Key Weight =	100.0	0.50	50.0
				Vert. Component =	539.3	3.50	1,887.7
				Total =	2,426.9 lbs	R.M.=	6,257.0

Resisting/Overturning Ratio = **1.42**
 Vertical Loads used for Soil Pressure = 2,426.9 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 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) 0.119 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (P_LINE)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) = 17.09 in

Development length for #4 bar specified in this stem design segment = 13.15 in

Hooked embedment length into footing for #4 bar specified in this stem design segment = 5.63 in

As Provided = 0.2667 in²/ft

As Required = 0.2383 in²/ft

Cantilevered Retaining Wall

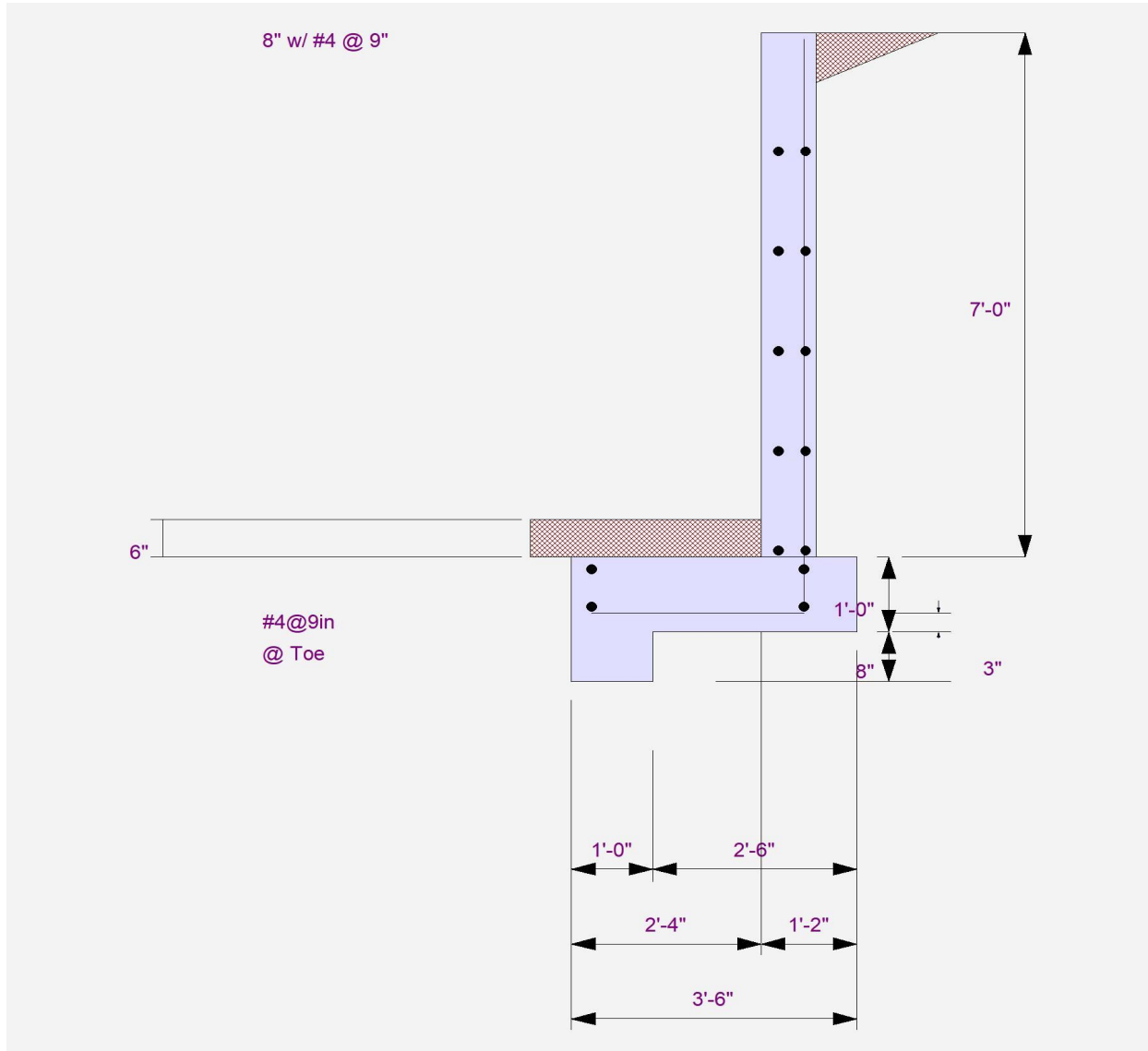
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (P_LINE)



Cantilevered Retaining Wall

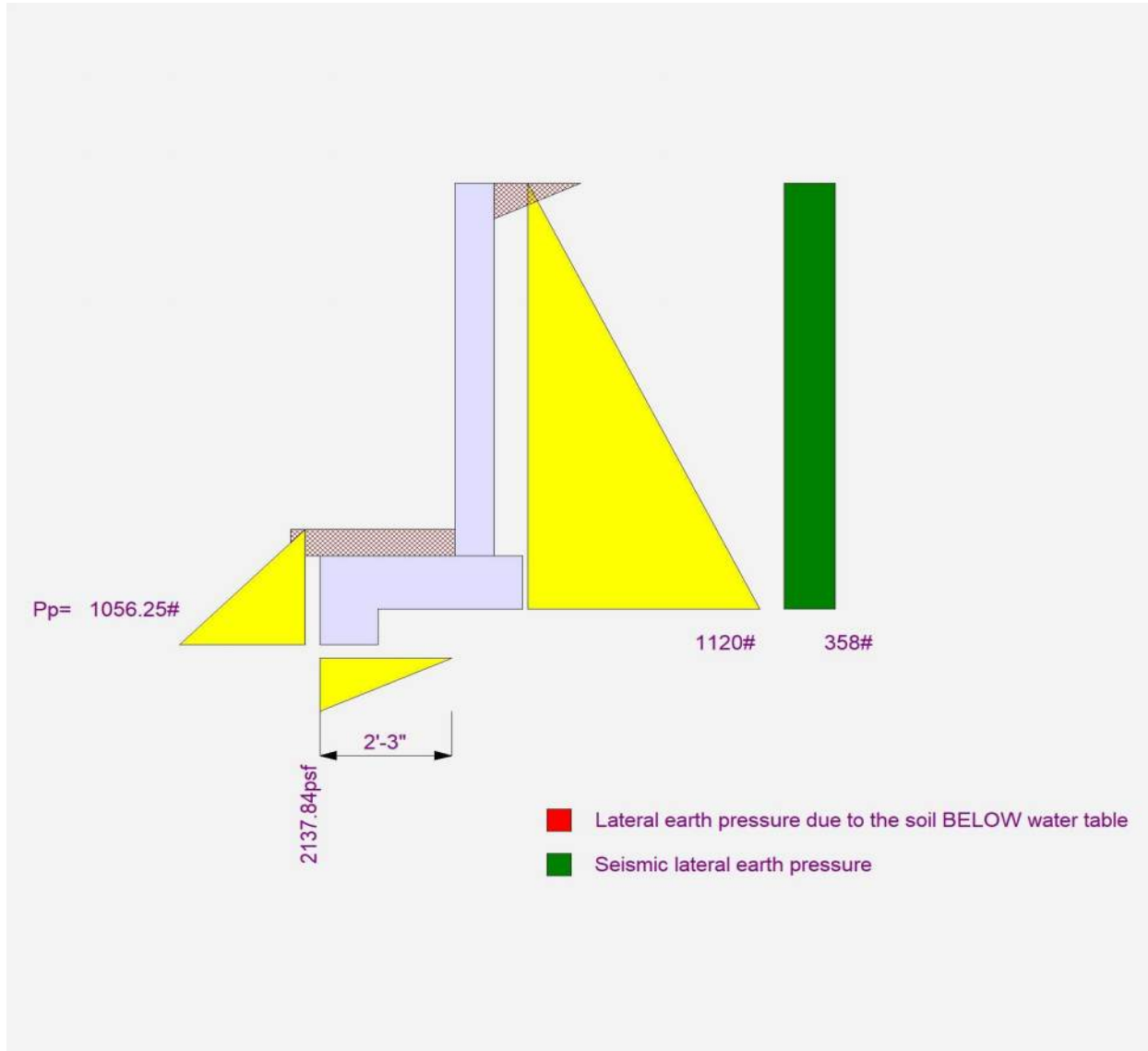
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (P_LINE)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained (P_LINE)

Code Reference.

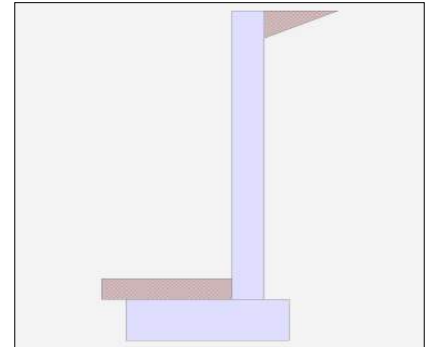
Calculations per IBC 2021 1807.3, ASCE 7-16

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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.600
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained (P_LINE)

Design Summary

Wall Stability Ratios

Overturning	=	1.95	OK
Sliding	=	1.68	OK
Global Stability	=	1.47	
Total Bearing Load	=	2,293 lbs	
...resultant ecc.	=	5.12 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,213 psf	OK
Soil Pressure @ Heel	=	160 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,299 psf	
ACI Factored @ Heel	=	171 psf	
Footing Shear @ Toe	=	9.5 psi	OK
Footing Shear @ Heel	=	11.1 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	1,120.0 lbs	
less 100% Passive Force	=	506.3 lbs	
less 100% Friction Force	=	1,376.0 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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	9.00
Rebar Placed at	=	5.75 i

Design Data

fb/FB + fa/Fa	=	0.486
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,372.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	3,201.3

Moment.....Allowable	=	6,585.3
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	19.9

Shear.....Allowable	psi =	51.6
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	5.75
-----------------	------	------

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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained (P_LINE)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.131 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2667 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9347 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	2.17 ft
Heel Width	=	1.17
Total Footing Width	=	3.34
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,299	171	psf
Mu' : Upward	=	2,484	29	ft-#
Mu' : Downward	=	593	585	ft-#
Mu: Design	=	1,890	556	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	9.46	11.10	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.87	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained (P_LINE)

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)	1,120.0	2.67	2,986.7	Soil Over HL (ab. water tbl)	422.8	3.09	1,305.7
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		3.09	1,305.7
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	130.2	1.09	141.3
				Surcharge Over Toe =			
				Stem Weight(s) =	700.0	2.50	1,752.3
				Earth @ Stem Transitions =			
				Footing Weight =	501.0	1.67	836.7
				Key Weight =			
				Vert. Component =	539.3	3.34	1,801.4
Total	= 1,120.0	O.T.M.	= 2,986.7	Total	= 2,293.3 lbs	R.M.	= 5,837.4
Resisting/Overturning Ratio		=	1.95	* 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 =		2,293.3	lbs				

Vertical component of active lateral soil pressure IS 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) 0.071 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained (P_LINE)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2667 in ² /ft
As Required =	0.1746 in ² /ft

Cantilevered Retaining Wall

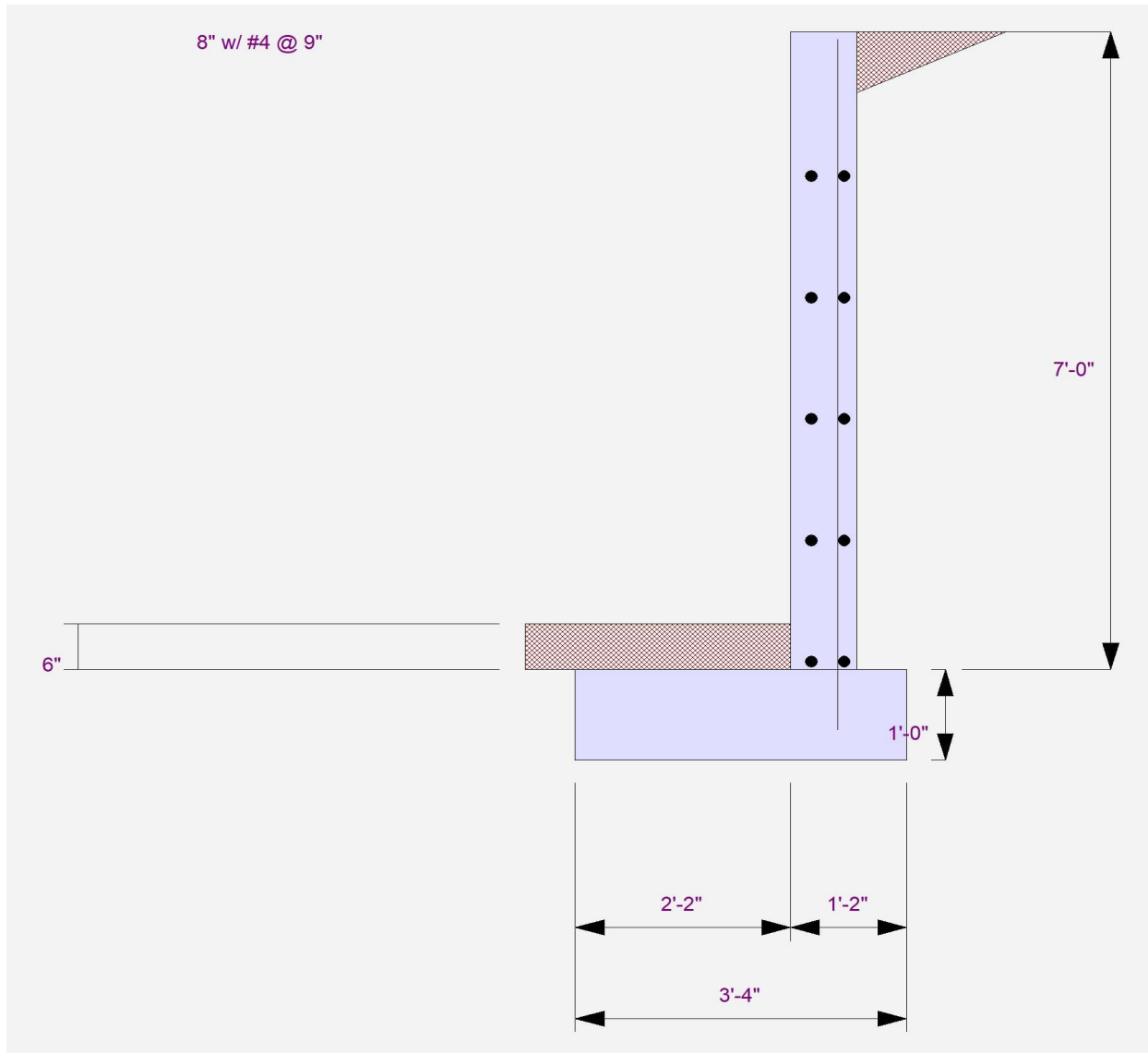
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained (P_LINE)



Cantilevered Retaining Wall

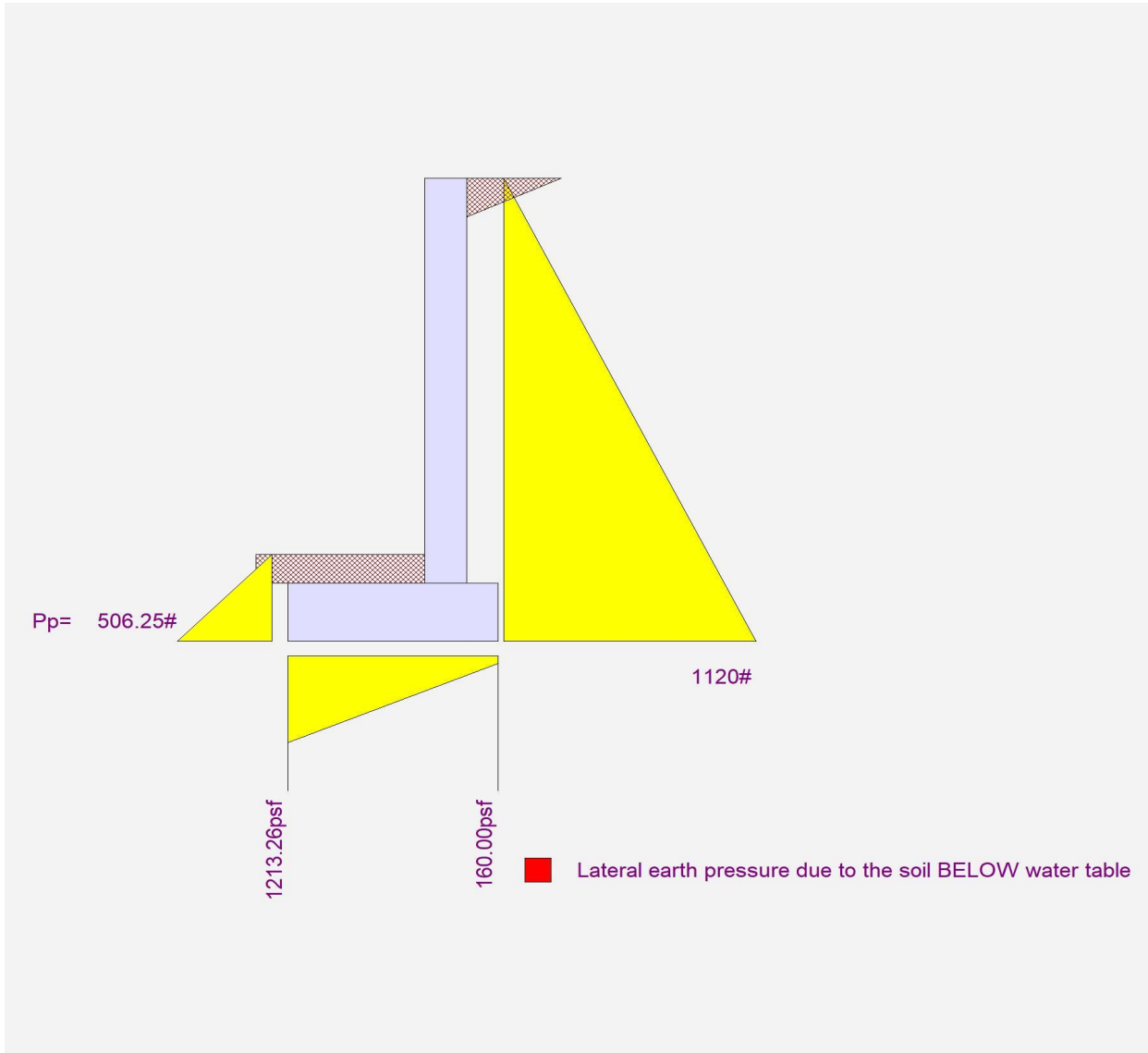
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained (P_LINE)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ (P_Line)

Code Reference.

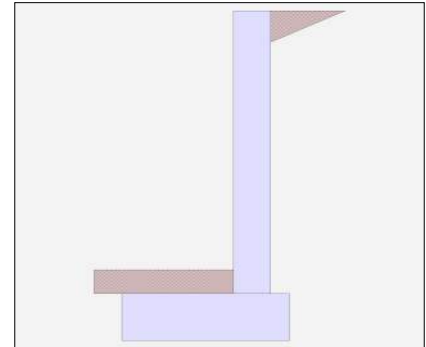
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	6.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	56.000
Total Seismic Force	=	392.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	1.39 Ratio < 1.5!
Sliding	=	1.30 Ratio < 1.5!
Global Stability	=	1.60
Total Bearing Load	=	1,823 lbs
...resultant ecc.	=	10.41 in
Eccentricity outside middle third		
Soil Pressure @ Toe	=	1,922 psf OK
Soil Pressure @ Heel	=	0 psf OK
Allowable	=	3,333 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	2,081 psf
ACI Factored @ Heel	=	0 psf
Footing Shear @ Toe	=	11.8 psi OK
Footing Shear @ Heel	=	8.4 psi OK
Allowable	=	82.2 psi

Sliding Calcs

Lateral Sliding Force	=	1,131.9 lbs
less 100% Passive Force	=	506.3 lbs
less 100% Friction Force	=	966.2 lbs
Added Force Req'd	=	0.0 lbs OK
...for 1.5 Stability	=	225.4 lbs NG

Vertical component of active lateral soil pressure IS 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	12.00
Rebar Placed at	=	5.75 i

Design Data

fb/FB + fa/Fa	=	0.605
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,344.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	3,024.0

Moment.....Allowable	=	4,998.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	19.5

Shear.....Allowable	psi =	46.9
---------------------	-------	------

Anet (Masonry)	in2 =	
----------------	-------	--

Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	5.75
-----------------	------	------

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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ (P_Line)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.1237 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9347 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	2.00 ft
Heel Width	=	1.00
Total Footing Width	=	3.00
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,081	0	psf
Mu' : Upward	=	2,700	0	ft-#
Mu' : Downward	=	504	278	ft-#
Mu: Design	=	2,196	278	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	11.81	8.41	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ (P_Line)

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)	857.5	2.33	2,000.8	Soil Over HL (ab. water tbl)	240.0	2.83	680.0
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.83	680.0
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	120.0	1.00	120.0
Seismic Earth Load =	274.4	3.50	960.4	Surcharge Over Toe =			
=				Stem Weight(s) =	600.0	2.33	1,400.0
Total =	1,131.9	O.T.M.	2,961.2	Earth @ Stem Transitions =			
				Footing Weight =	450.0	1.50	675.0
				Key Weight =			
				Vert. Component =	412.9	3.00	1,238.8
				Total =	1,822.9 lbs	R.M.=	4,113.8

Resisting/Overturning Ratio = 1.39
 Vertical Loads used for Soil Pressure = 1,822.9 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 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) 0.107 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2000 in ² /ft
As Required =	0.1728 in ² /ft

Cantilevered Retaining Wall

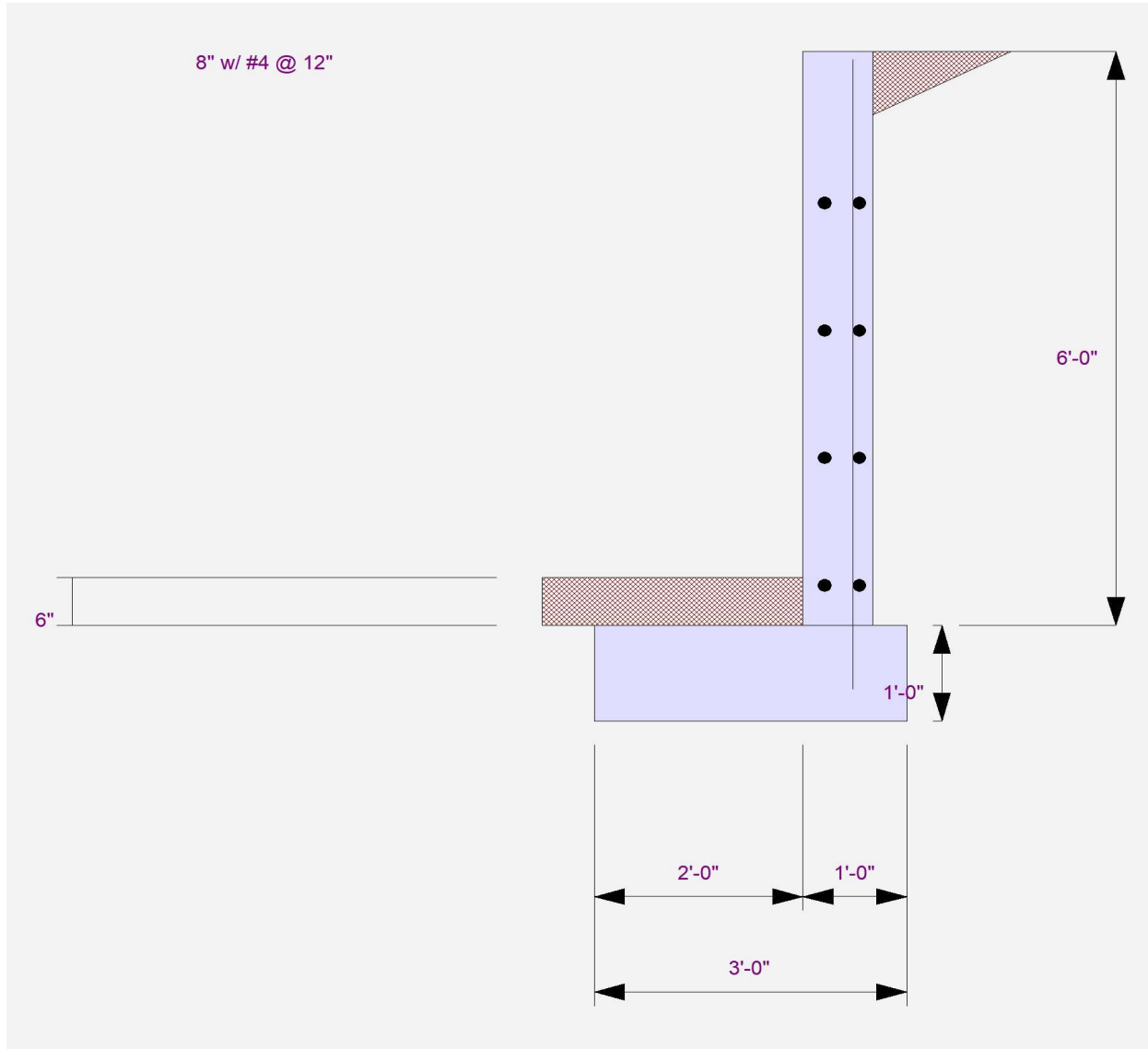
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ (P_Line)



Cantilevered Retaining Wall

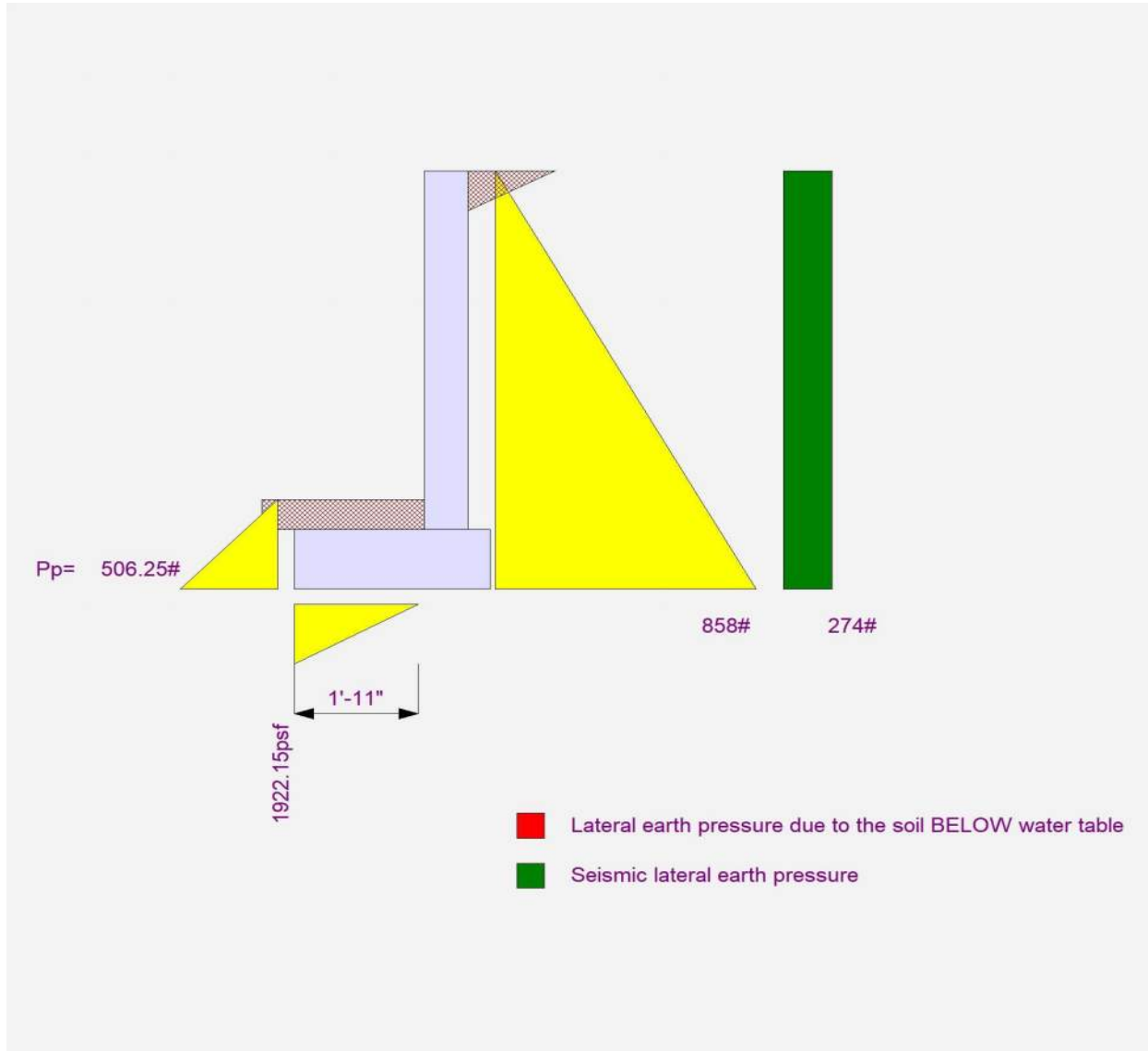
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained - EQ (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained (P_Line)

Code Reference.

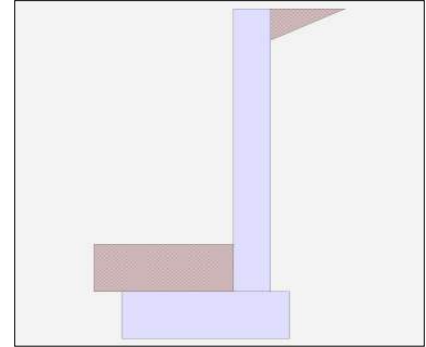
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	6.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00
Height of Soil over Toe	=	12.00 in
Water table above bottom of footing	=	0.0 ft

Soil Data

Allow Soil Bearing	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	2.12	OK
Sliding	=	2.25	OK
Global Stability	=	1.79	
Total Bearing Load	=	1,943 lbs	
...resultant ecc.	=	4.21 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,102 psf	OK
Soil Pressure @ Heel	=	193 psf	OK
Allowable	=	2,500 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,215 psf	
ACI Factored @ Heel	=	213 psf	
Footing Shear @ Toe	=	6.8 psi	OK
Footing Shear @ Heel	=	7.7 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	857.5 lbs	
less 100% Passive Force	=	900.0 lbs	
less 100% Friction Force	=	1,029.8 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 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

Design Height Above Ftg	ft =	Stem OK		
		0.00		
Wall Material Above "Ht"	=	Concrete		
Design Method	=	SD	SD	SD
Thickness	=	8.00		
Rebar Size	=	# 4		
Rebar Spacing	=	12.00		
Rebar Placed at	=	5.75 i		

Design Data

fb/FB + fa/Fa	=	0.403
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,008.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	2,016.0
Moment.....Allowable	=	4,998.0

Shear.....Actual

Service Level	psi =	
Strength Level	psi =	14.6
Shear.....Allowable	psi =	46.9
Anet (Masonry)	in2 =	
Wall Weight	psf =	100.0
Rebar Depth 'd'	in =	5.75

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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained (P_Line)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.0825 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.9347 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	2.00 ft
Heel Width	=	1.00
Total Footing Width	=	3.00
Footing Thickness	=	12.00 in
f'c = 3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,215	213	psf
Mu' : Upward	=	1,984	14	ft-#
Mu' : Downward	=	648	278	ft-#
Mu: Design	=	1,336	264	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	6.75	7.66	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained (P_Line)

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)	857.5	2.33	2,000.8	Soil Over HL (ab. water tbl)	240.0	2.83	680.0
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.83	680.0
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	240.0	1.00	240.0
				Surcharge Over Toe =			
				Stem Weight(s) =	600.0	2.33	1,400.0
				Earth @ Stem Transitions =			
				Footing Weight =	450.0	1.50	675.0
				Key Weight =			
				Vert. Component =	412.9	3.00	1,238.8
Total	= 857.5	O.T.M.	= 2,000.8	Total =	1,942.9 lbs	R.M.=	4,233.8
Resisting/Overturning Ratio		=	2.12	* 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 =		1,942.9 lbs					

Vertical component of active lateral soil pressure IS 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) 0.061 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2000 in ² /ft
As Required =	0.1728 in ² /ft

Cantilevered Retaining Wall

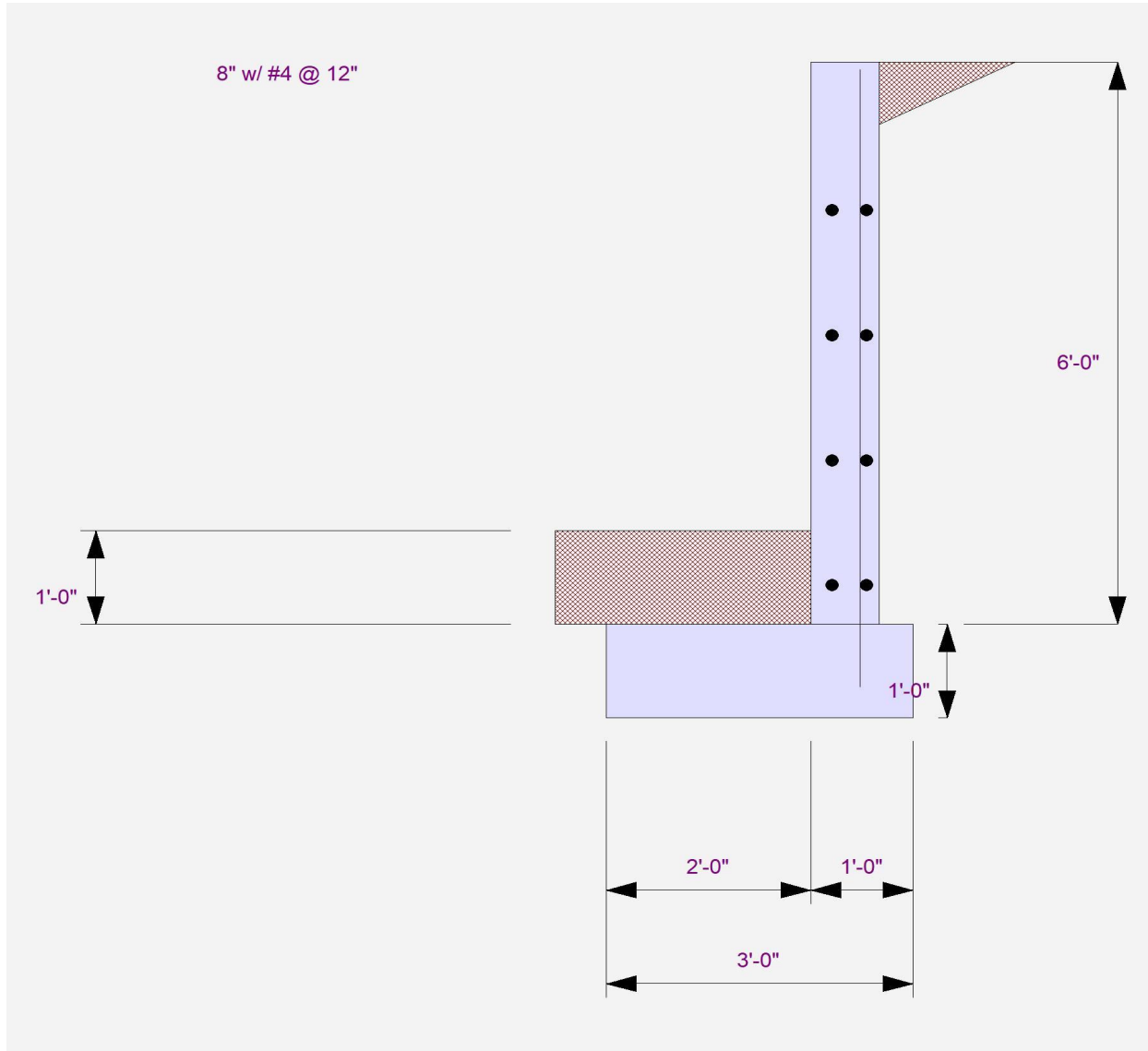
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained (P_Line)



Cantilevered Retaining Wall

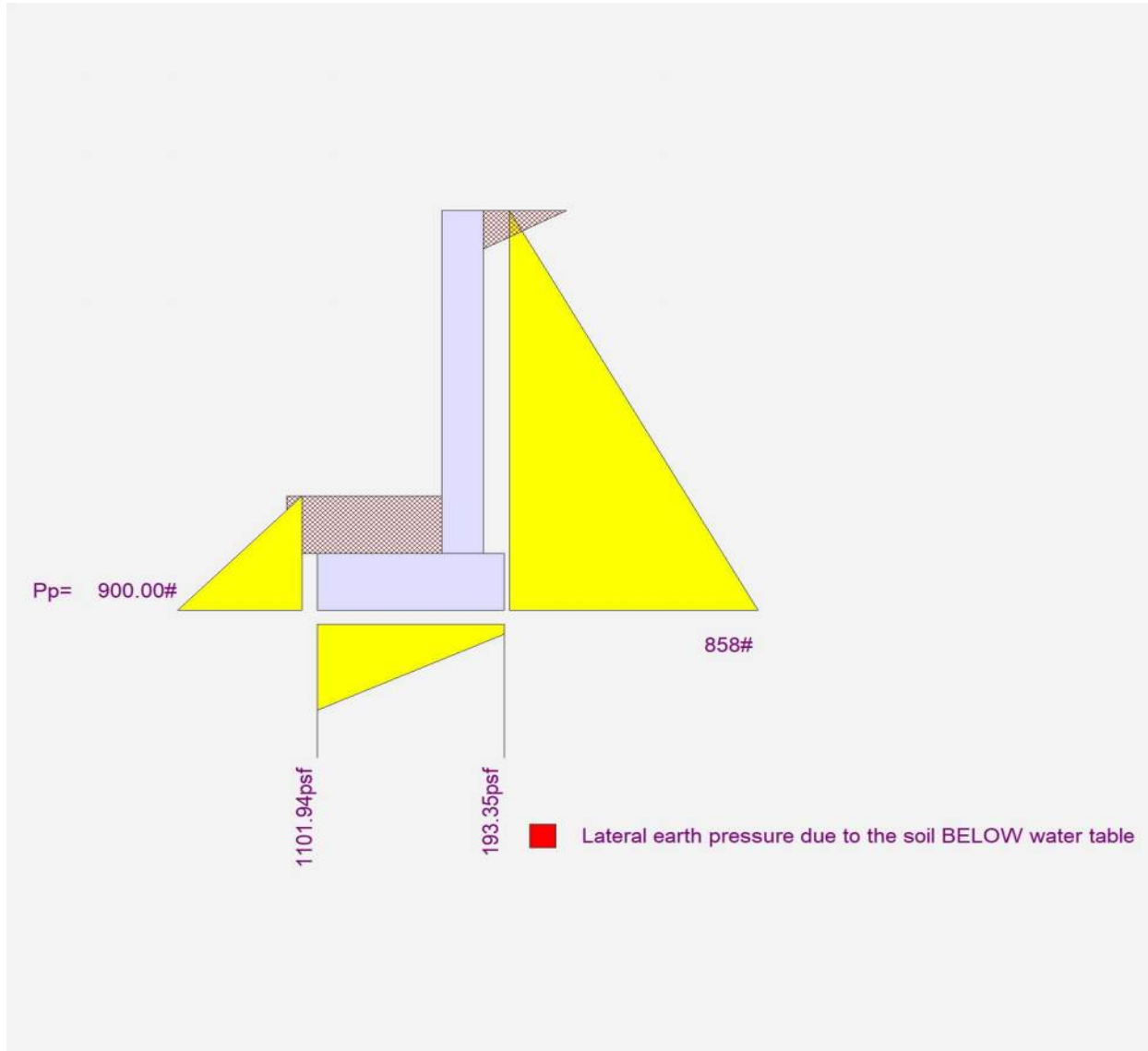
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 6' Retained (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ (P_Line)

Code Reference.

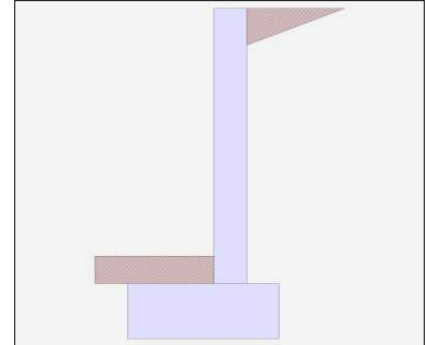
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	5.00 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	=	3,333.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	8.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	48.000
Total Seismic Force	=	288.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	1.28	Ratio < 1.5!
Sliding	=	1.51	OK
Global Stability	=	1.91	
Total Bearing Load	=	1,408	lbs
...resultant ecc.	=	9.56	in
Eccentricity outside middle third			
Soil Pressure @ Toe	=	2,546	psf OK
Soil Pressure @ Heel	=	0	psf OK
Allowable	=	3,333	psf
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	2,797	psf
ACI Factored @ Heel	=	0	psf
Footing Shear @ Toe	=	9.0	psi OK
Footing Shear @ Heel	=	7.8	psi OK
Allowable	=	82.2	psi

Sliding Calcs

Lateral Sliding Force	=	831.6	lbs
less 100% Passive Force	=	506.3	lbs
less 100% Friction Force	=	746.1	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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	6.00
Rebar Size	=	# 4
Rebar Spacing	=	16.00
Rebar Placed at	=	3.75 i

Design Data

fb/FB + fa/Fa	=	0.726
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	940.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	1,766.7

Moment.....Allowable	=	2,431.7
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	20.9

Shear.....Allowable	psi =	49.1
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	75.0
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Rebar Depth 'd'	in =	3.75
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ (P_Line)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.1144 in2/ft		
0.0018bh : 0.0018(12)(6) :	0.1296 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.1296 in2/ft	#4@ 18.52 in	#4@ 37.04 in
Provided Area :	0.15 in2/ft	#5@ 28.70 in	#5@ 57.41 in
Maximum Area :	0.6096 in2/ft	#6@ 40.74 in	#6@ 81.48 in

Footing Data

Toe Width	=	1.33 ft
Heel Width	=	1.00
Total Footing Width	=	2.33
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,797	0	psf
Mu' : Upward	=	1,486	0	ft-#
Mu' : Downward	=	223	355	ft-#
Mu: Design	=	1,264	355	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	8.99	7.79	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.60	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ (P_Line)

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)	630.0	2.00	1,260.0	Soil Over HL (ab. water tbl)	300.0	2.08	624.0
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.08	624.0
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	79.8	0.67	53.1
Seismic Earth Load =	201.6	3.00	604.8	Surcharge Over Toe =			
=				Stem Weight(s) =	375.0	1.58	592.5
Total =	831.6	O.T.M.	1,864.8	Earth @ Stem Transitions =			
				Footing Weight =	349.5	1.17	407.2
				Key Weight =			
				Vert. Component =	303.4	2.33	706.9
				Total =	1,407.7 lbs	R.M.=	2,383.6

Resisting/Overturning Ratio = 1.28
 Vertical Loads used for Soil Pressure = 1,407.7 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 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) 0.152 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.1500 in ² /ft
As Required =	0.1500 in ² /ft

Cantilevered Retaining Wall

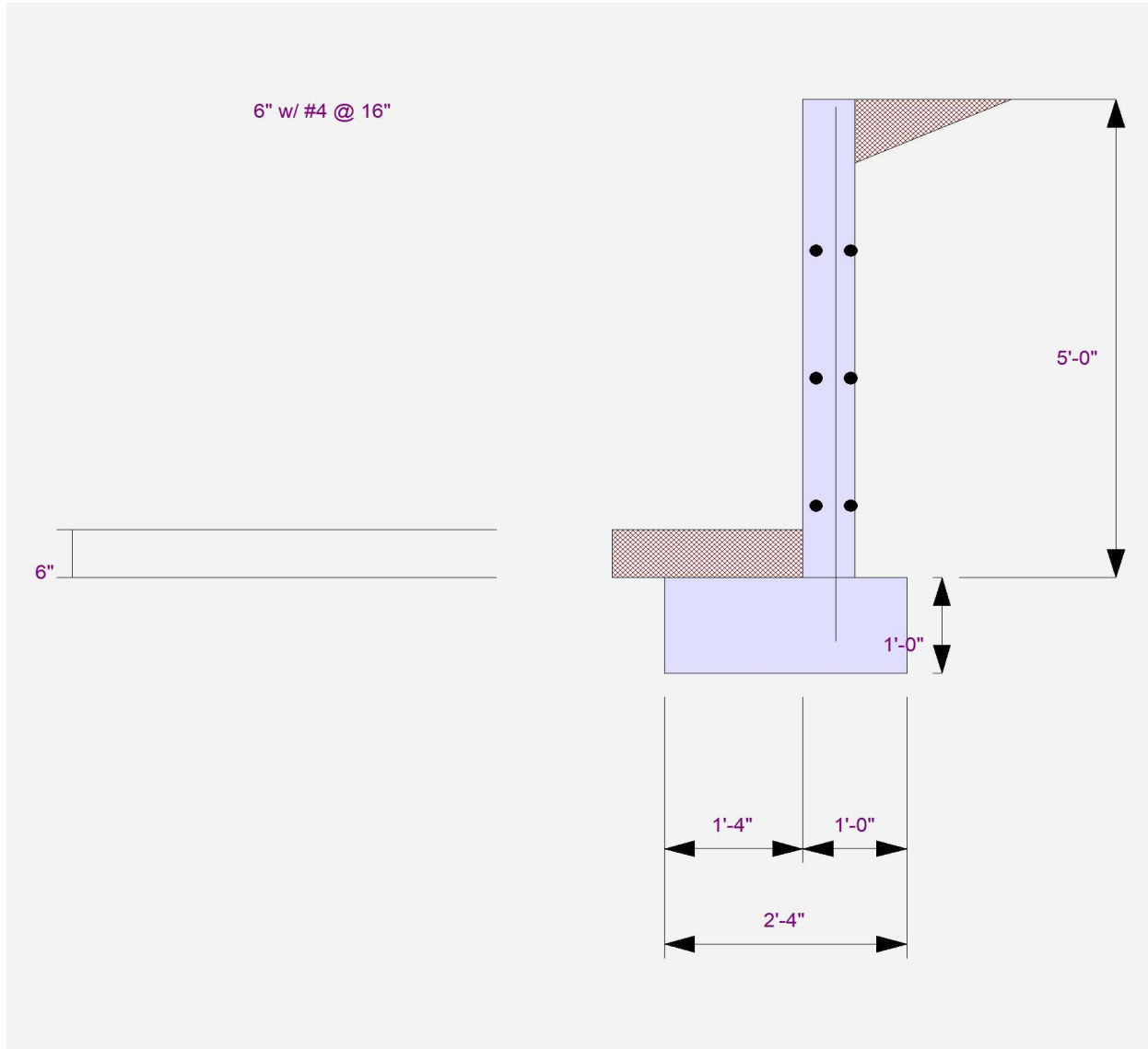
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ (P_Line)



Cantilevered Retaining Wall

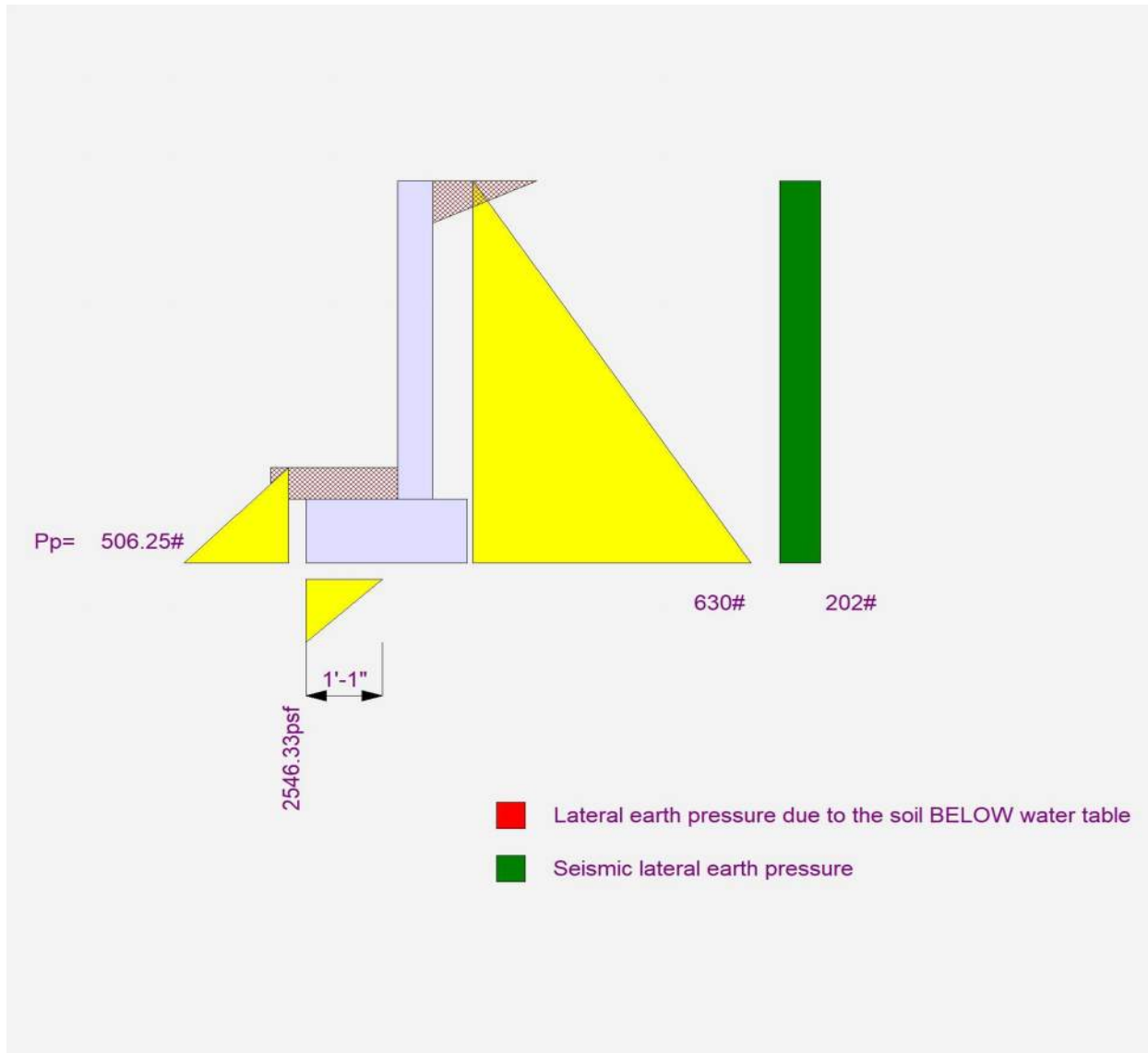
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained - EQ (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained (P_Line)

Code Reference.

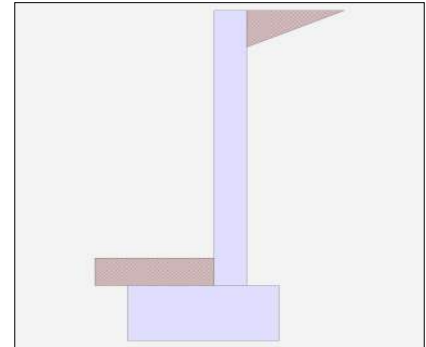
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	5.00 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	=	35.0 psf/ft
	=	
Passive Pressure	=	525.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	1.89	OK
Sliding	=	2.12	OK
Global Stability	=	1.91	
Total Bearing Load	=	1,408	lbs
...resultant ecc.	=	4.40	in
Eccentricity within middle third			
Soil Pressure @ Toe	=	1,175	psf OK
Soil Pressure @ Heel	=	33	psf OK
Allowable	=	2,000	psf
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,290	psf
ACI Factored @ Heel	=	37	psf
Footing Shear @ Toe	=	4.4	psi OK
Footing Shear @ Heel	=	7.1	psi OK
Allowable	=	82.2	psi

Sliding Calcs

Lateral Sliding Force	=	630.0	lbs
less 100% Passive Force	=	590.6	lbs
less 100% Friction Force	=	746.1	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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	6.00
Rebar Size	=	# 4
Rebar Spacing	=	16.00
Rebar Placed at	=	3.75 i

Design Data

fb/FB + fa/Fa	=	0.479
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	700.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	1,166.7

Moment.....Allowable	=	2,431.7
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	15.6

Shear.....Allowable	psi =	49.1
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Anet (Masonry)	in2 =	
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Wall Weight	psf =	75.0
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Rebar Depth 'd'	in =	3.75
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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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 5' Retained (P_Line)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.0756 in2/ft		
0.0018bh : 0.0018(12)(6) :	0.1296 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.1296 in2/ft	#4@ 18.52 in	#4@ 37.04 in
Provided Area :	0.15 in2/ft	#5@ 28.70 in	#5@ 57.41 in
Maximum Area :	0.6096 in2/ft	#6@ 40.74 in	#6@ 81.48 in

Footing Data

Toe Width	=	1.33 ft
Heel Width	=	1.00
Total Footing Width	=	2.33
Footing Thickness	=	12.00 in

f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,290	37	psf
Mu' : Upward	=	930	16	ft-#
Mu' : Downward	=	223	355	ft-#
Mu: Design	=	707	339	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	4.39	7.08	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.60	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained (P_Line)

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)	630.0	2.00	1,260.0	Soil Over HL (ab. water tbl)	300.0	2.08	624.0
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.08	624.0
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	79.8	0.67	53.1
				Surcharge Over Toe =			
				Stem Weight(s) =	375.0	1.58	592.5
				Earth @ Stem Transitions =			
Total	= 630.0	O.T.M.	= 1,260.0	Footing Weight =	349.5	1.17	407.2
				Key Weight =			
				Vert. Component =	303.4	2.33	706.9
Resisting/Overturning Ratio		=	1.89	Total =	1,407.7 lbs	R.M.=	2,383.6
Vertical Loads used for Soil Pressure =		1,407.7 lbs		* 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 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) 0.070 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.

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.1500 in ² /ft
As Required =	0.1296 in ² /ft

Cantilevered Retaining Wall

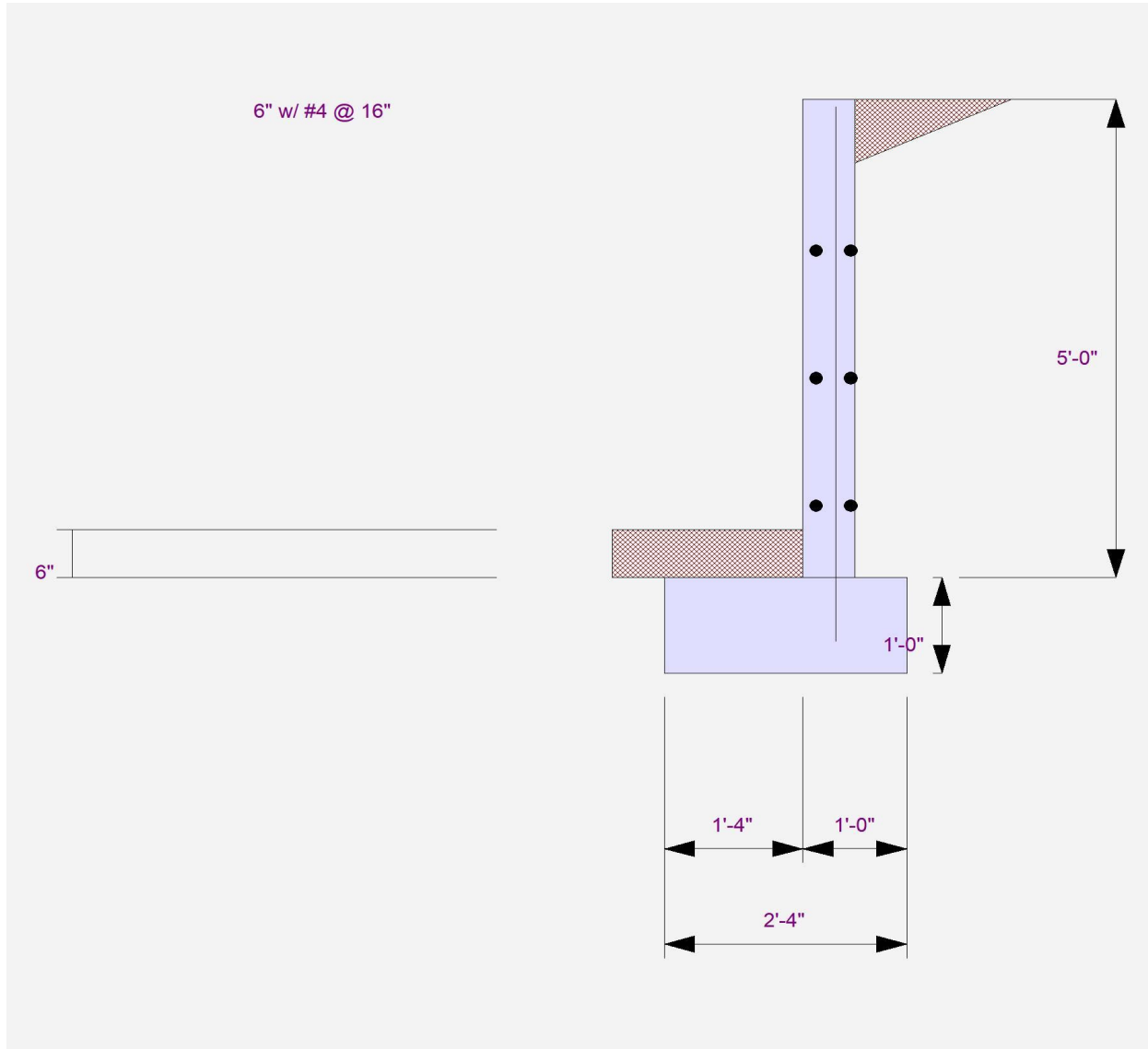
Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained (P_Line)



Cantilevered Retaining Wall

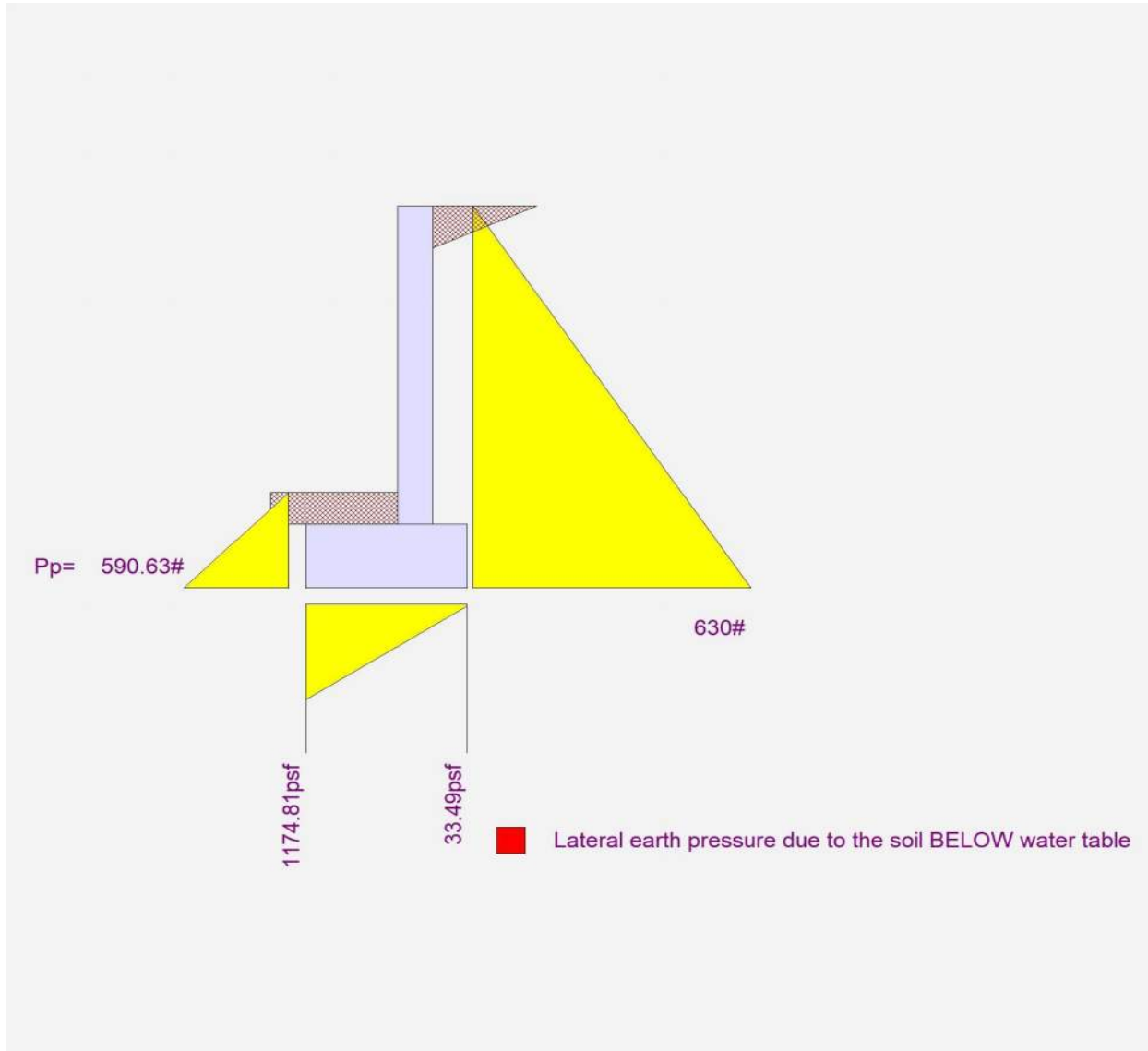
Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 5' Retained (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ (P_Line)

Code Reference.

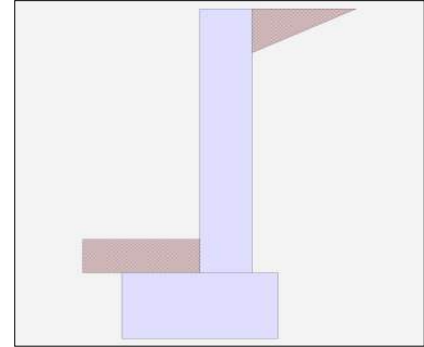
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	4.00 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	=	2,667.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	525.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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

Earth Pressure Seismic Load

Method	:	Uniform
Multiplier Used	=	5.000
(Multiplier used on soil density)		

Lateral Load Applied to Stem

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

Uniform Seismic Force	=	25.000
Total Seismic Force	=	125.000

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

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained - EQ (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	1.66	OK
Sliding	=	2.27	OK
Global Stability	=	2.36	
Total Bearing Load	=	1,131	lbs
...resultant ecc.	=	5.31	in
Eccentricity outside middle third			
Soil Pressure @ Toe	=	1,353	psf OK
Soil Pressure @ Heel	=	0	psf OK
Allowable	=	2,667	psf
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,541	psf
ACI Factored @ Heel	=	0	psf
Footing Shear @ Toe	=	2.7	psi OK
Footing Shear @ Heel	=	4.9	psi OK
Allowable	=	82.2	psi

Sliding Calcs

Lateral Sliding Force	=	525.0	lbs
less 100% Passive Force	=	590.6	lbs
less 100% Friction Force	=	599.3	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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	12.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.146
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	548.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	797.3
Moment.....Allowable	=	5,448.0

Shear.....Actual

Service Level	psi =	
Strength Level	psi =	7.3
Shear.....Allowable	psi =	45.6
Anet (Masonry)	in2 =	
Wall Weight	psf =	100.0
Rebar Depth 'd'	in =	6.25

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 =	3,000.0
Fy	psi =	60,000.0

Bottom

SD SD SD SD

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained - EQ (P_Line)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.0299 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	1.00 ft
Heel Width	=	1.00
Total Footing Width	=	2.00
Footing Thickness	=	12.00 in
f'c = 3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,541	0	psf
Mu' : Upward	=	617	0	ft-#
Mu' : Downward	=	126	154	ft-#
Mu: Design	=	491	154	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	2.75	4.91	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.52	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained - EQ (P_Line)

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)	437.5	1.67	729.2	Soil Over HL (ab. water tbl)	160.0	1.83	293.3
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		1.83	293.3
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	60.0	0.50	30.0
Seismic Earth Load =	87.5	2.50	218.8	Surcharge Over Toe =			
=				Stem Weight(s) =	400.0	1.33	533.3
Total =	525.0	O.T.M. =	947.9	Earth @ Stem Transitions =			
				Footing Weight =	300.0	1.00	300.0
				Key Weight =			
				Vert. Component =	210.7	2.00	421.4
Resisting/Overturning Ratio		=	1.66	Total =	1,130.7 lbs	R.M.=	1,578.0
Vertical Loads used for Soil Pressure =		1,130.7 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 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) 0.075 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.

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained - EQ (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2000 in ² /ft
As Required =	0.1728 in ² /ft

Cantilevered Retaining Wall

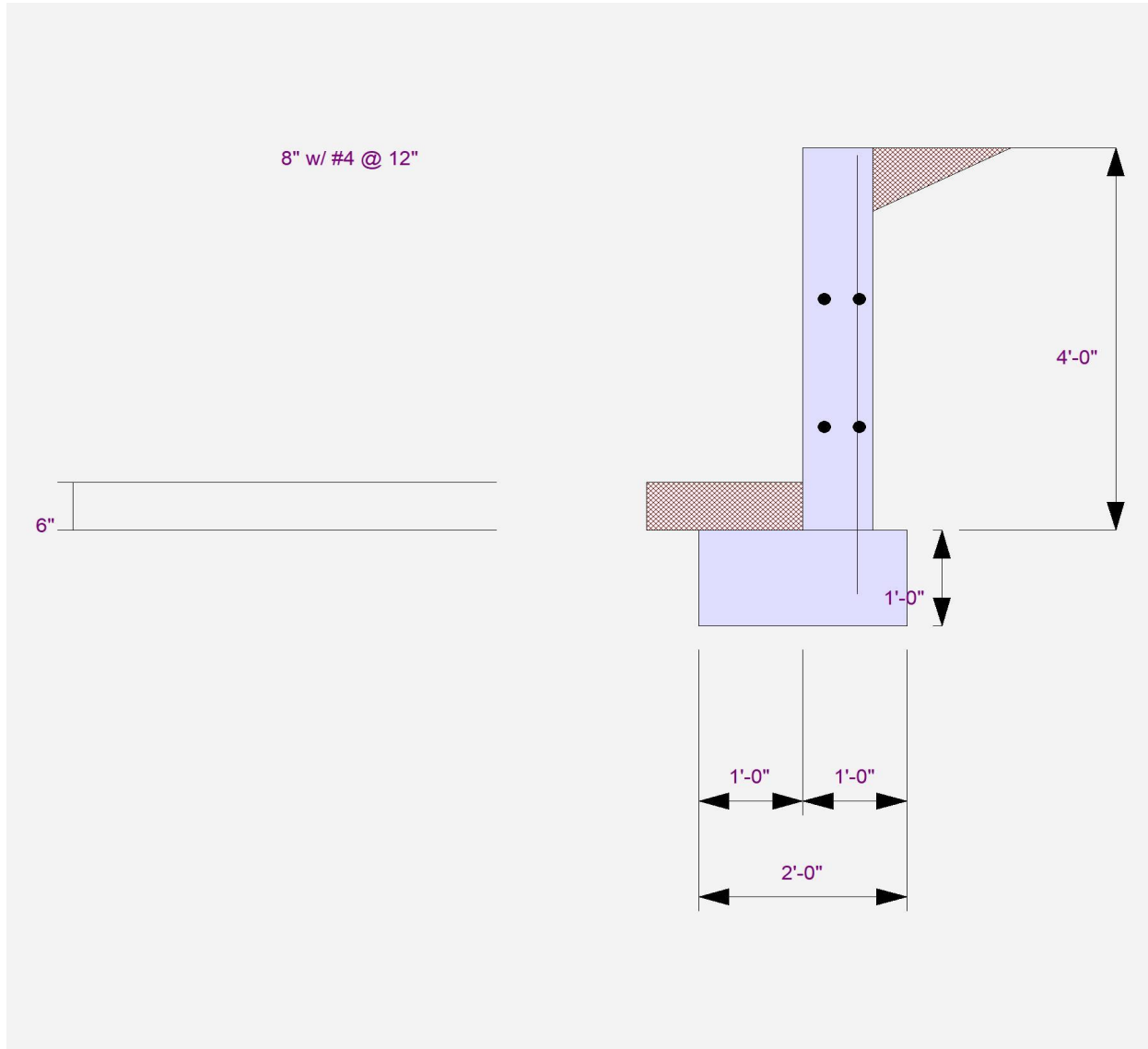
Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ (P_Line)



Cantilevered Retaining Wall

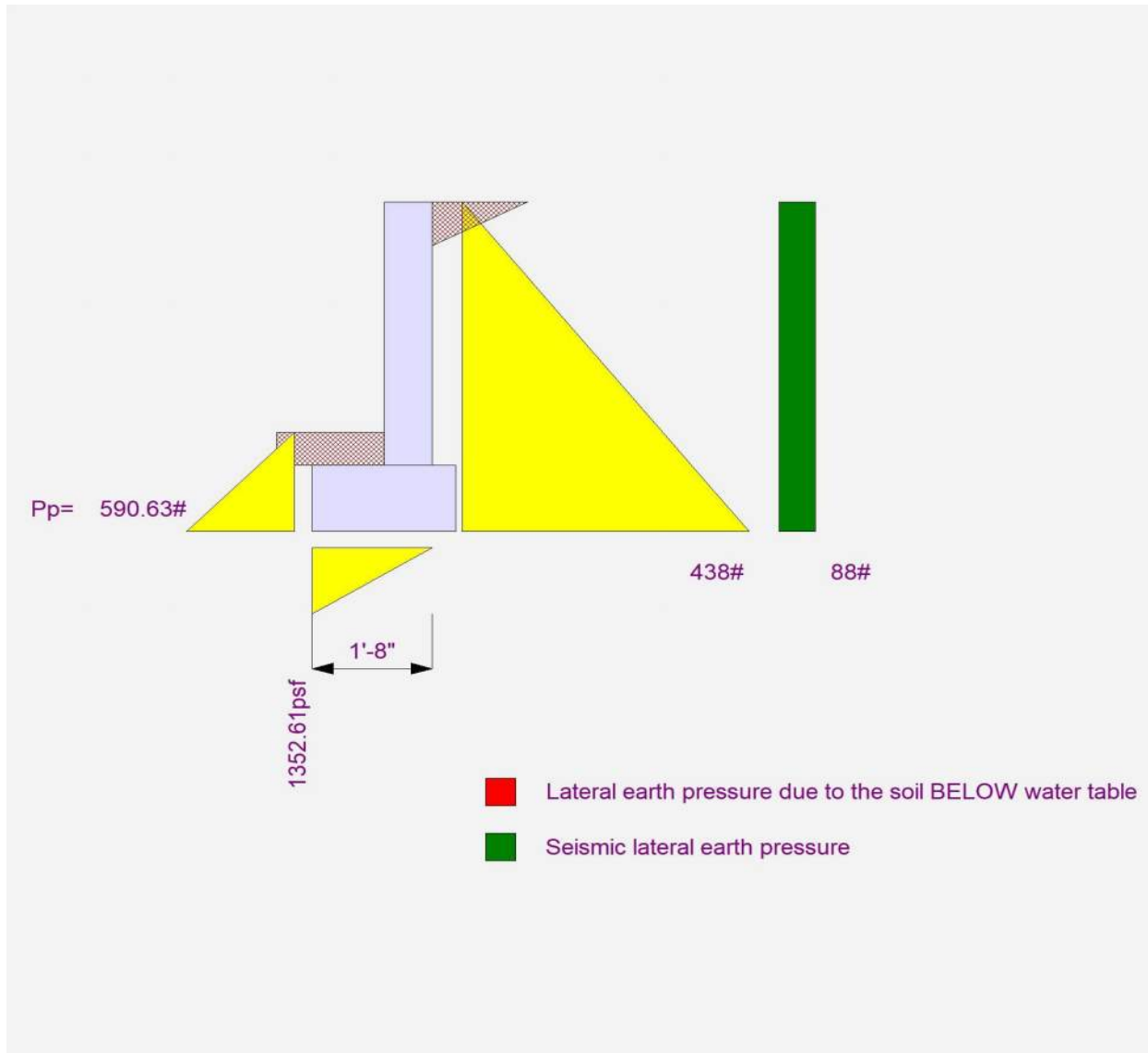
Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained - EQ (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained (P_Line)

Code Reference.

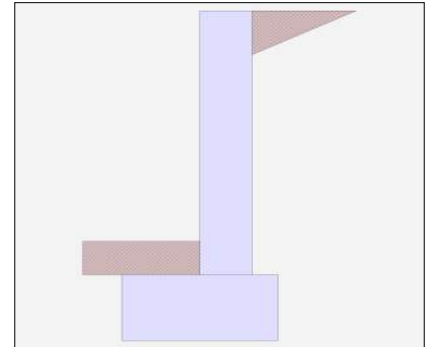
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	4.00 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	=	35.0 psf/ft
Passive Pressure	=	525.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 4' Retained (P_Line)

Design Summary

Wall Stability Ratios

Overturning	=	2.16	OK
Sliding	=	2.72	OK
Global Stability	=	2.36	
Total Bearing Load	=	1,131 lbs	
...resultant ecc.	=	2.99 in	
Eccentricity within middle third			
Soil Pressure @ Toe	=	988 psf	OK
Soil Pressure @ Heel	=	143 psf	OK
Allowable	=	2,000 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,126 psf	
ACI Factored @ Heel	=	162 psf	
Footing Shear @ Toe	=	1.9 psi	OK
Footing Shear @ Heel	=	4.2 psi	OK
Allowable	=	82.2 psi	

Sliding Calcs

Lateral Sliding Force	=	437.5 lbs	
less 100% Passive Force	=	590.6 lbs	
less 100% Friction Force	=	599.3 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 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

Design Height Above Ftg

ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	SD
Thickness	=	8.00
Rebar Size	=	# 4
Rebar Spacing	=	12.00
Rebar Placed at	=	Edge

Design Data

fb/FB + fa/Fa	=	0.109
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Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	448.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	597.3

Moment.....Allowable	=	5,448.0
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Shear.....Actual

Service Level	psi =	
Strength Level	psi =	6.0

Shear.....Allowable	psi =	45.6
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Anet (Masonry)	in2 =	
----------------	-------	--

Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	6.25
-----------------	------	------

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 =	3,000.0
Fy	psi =	60,000.0

Bottom

SD SD SD SD

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained (P_Line)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.0224 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u> <u>Two layers of :</u>	
Required Area :	0.1728 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.2 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	1.016 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	1.00 ft
Heel Width	=	1.00
Total Footing Width	=	2.00
Footing Thickness	=	12.00 in
f'c = 3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	1,126	162	psf
Mu' : Upward	=	483	12	ft-#
Mu' : Downward	=	126	154	ft-#
Mu: Design	=	357	142	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	1.89	4.23	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Key: No key defined

Min footing T&S reinf Area	0.52	in2
Min footing T&S reinf Area per foot	0.26	in2 /ft

If one layer of horizontal bars:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained (P_Line)

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)	437.5	1.67	729.2	Soil Over HL (ab. water tbl)	160.0	1.83	293.3
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		1.83	293.3
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	60.0	0.50	30.0
				Surcharge Over Toe =			
				Stem Weight(s) =	400.0	1.33	533.3
				Earth @ Stem Transitions =			
Total	= 437.5	O.T.M. =	729.2	Footing Weight =	300.0	1.00	300.0
				Key Weight =			
				Vert. Component =	210.7	2.00	421.4
Resisting/Overturning Ratio		= 2.16		Total =	1,130.7 lbs	R.M.=	1,578.0
Vertical Loads used for Soil Pressure =		1,130.7 lbs		* 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 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) 0.055 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.

Cantilevered Retaining Wall

Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained (P_Line)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2000 in ² /ft
As Required =	0.1728 in ² /ft

Cantilevered Retaining Wall

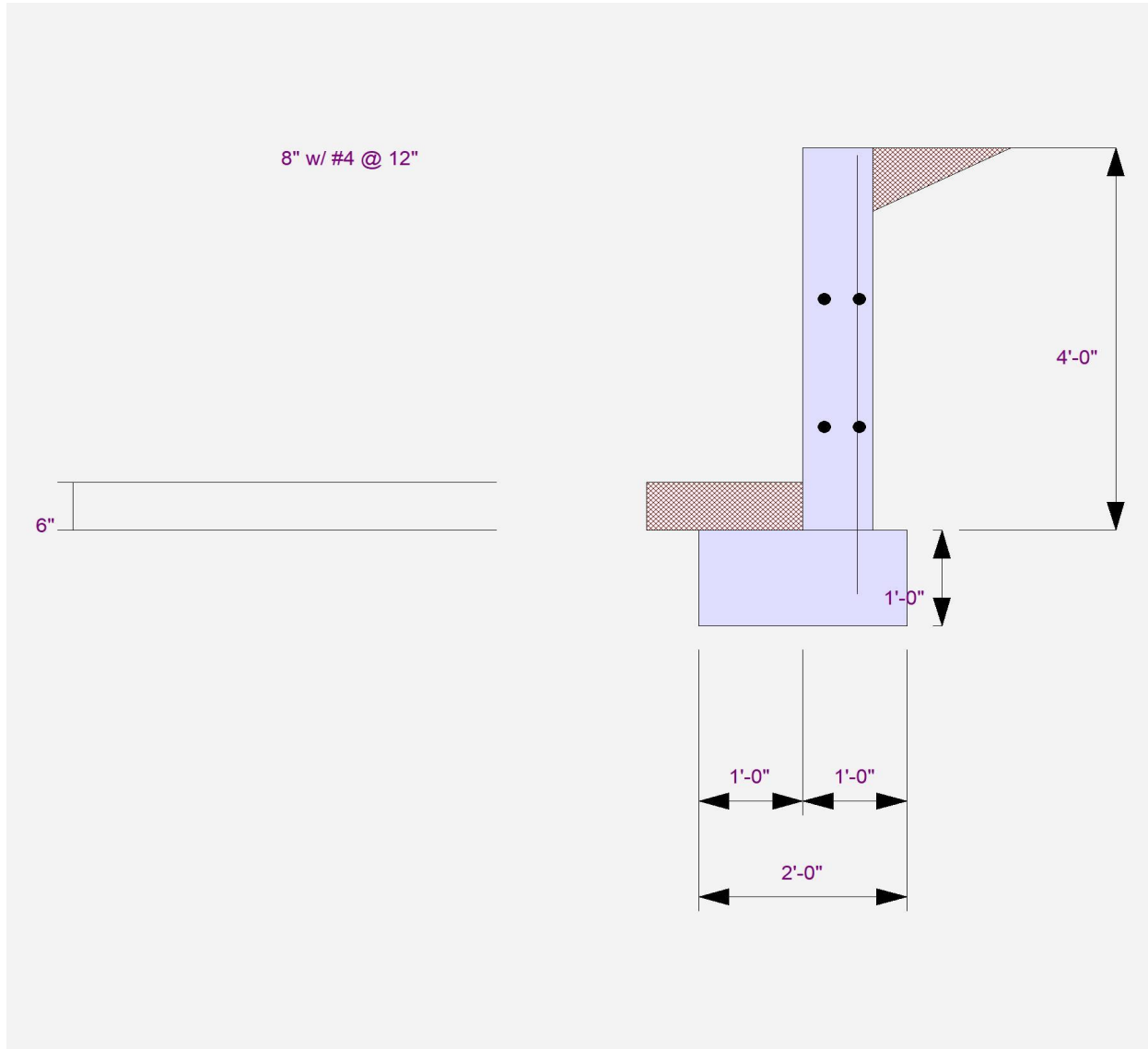
Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained (P_Line)



Cantilevered Retaining Wall

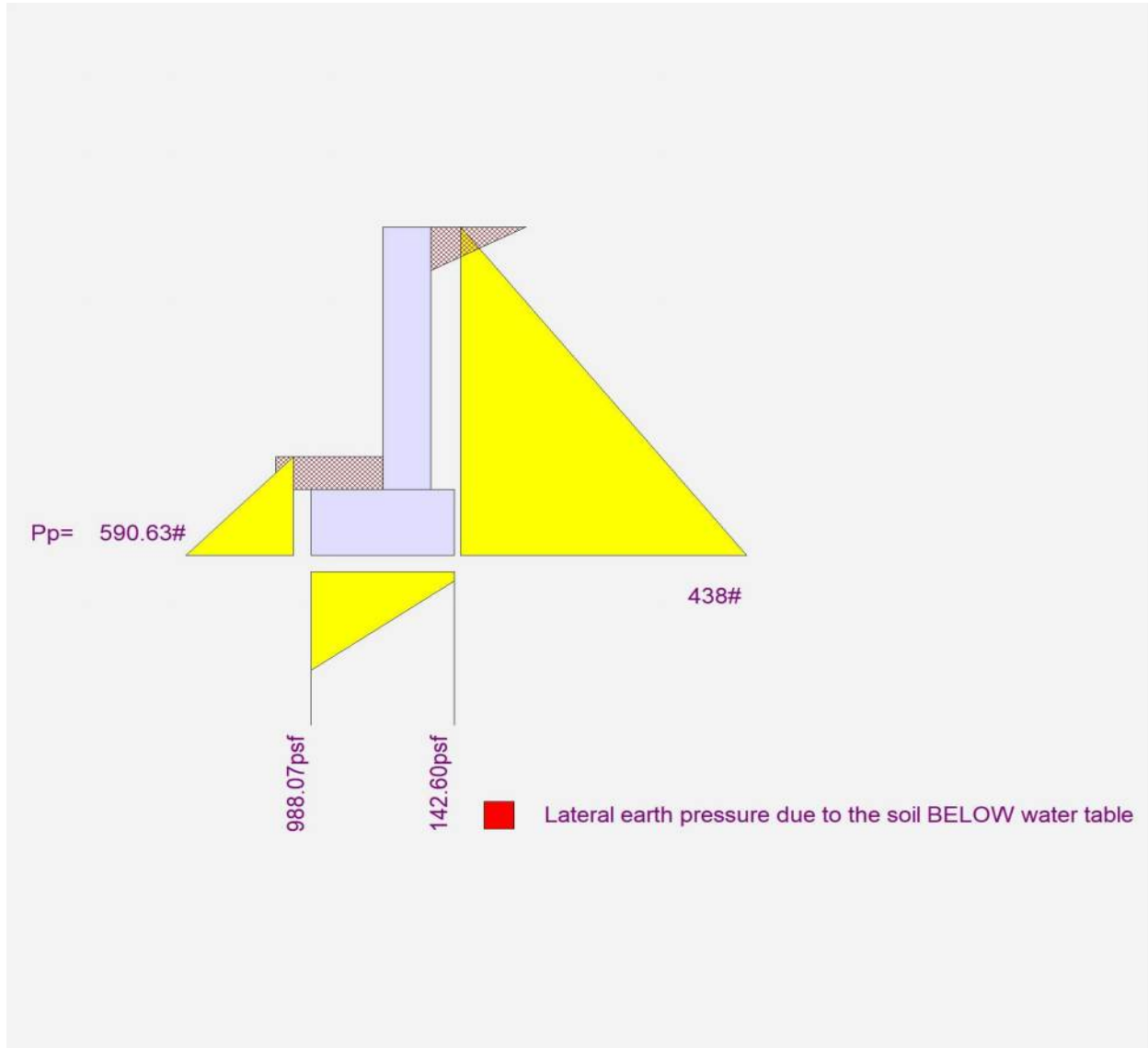
Project File: Retaining Walls.ec6

LIC# : KW-06016450, Build:20.24.04.09

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 4' Retained (P_Line)



Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (7' Terrace Wall)

Code Reference.

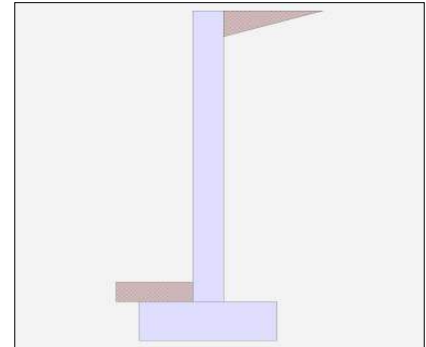
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	7.50 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	=	2,500.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.530
Soil height to ignore for passive pressure	=	0.00 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	=	Seismic (E) (Strength 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	=	Spread Footing
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (7' Terrace Wall)

Design Summary

Wall Stability Ratios

Overturning	=	1.73	OK
Sliding	=	1.63	OK
Global Stability	=	1.69	

Total Bearing Load	=	2,926	lbs
...resultant ecc.	=	7.26	in

Eccentricity outside middle third

Soil Pressure @ Toe	=	2,179	psf	OK
Soil Pressure @ Heel	=	0	psf	OK
Allowable	=	2,500	psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	2,416	psf	
ACI Factored @ Heel	=	0	psf	
Footing Shear @ Toe	=	7.4	psi	OK
Footing Shear @ Heel	=	17.6	psi	OK
Allowable	=	82.2	psi	

Sliding Calcs

Lateral Sliding Force	=	1,264.4	lbs	
less 100% Passive Force	=	506.3	lbs	
less 100% Friction Force	=	1,550.8	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 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

Design Height Above Ftg	ft =	Stem OK	0.00
Wall Material Above "Ht"	=	Concrete	
Design Method	=	SD	SD SD
Thickness	=	8.00	
Rebar Size	=	# 4	
Rebar Spacing	=	10.00	
Rebar Placed at	=	Center	

Design Data

fb/FB + fa/Fa	=	0.968
---------------	---	-------

Total Force @ Section

Service Level	lbs =	
Strength Level	lbs =	1,575.0

Moment....Actual

Service Level	ft-# =	
Strength Level	ft-# =	3,937.5

Moment.....Allowable	=	4,065.1
----------------------	---	---------

Shear.....Actual

Service Level	psi =	
Strength Level	psi =	32.8

Shear.....Allowable	psi =	56.2
---------------------	-------	------

Anet (Masonry)	in2 =	
----------------	-------	--

Wall Weight	psf =	100.0
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Rebar Depth 'd'	in =	4.00
-----------------	------	------

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 =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (7' Terrace Wall)

Concrete Stem Rebar Area Details

Bottom Stem	<u>Vertical Reinforcing</u>	<u>Horizontal Reinforcing</u>	
As (based on applied moment) :	0.2377 in2/ft		
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	=====	<u>One layer of :</u>	<u>Two layers of :</u>
Required Area :	0.2377 in2/ft	#4@ 13.89 in	#4@ 27.78 in
Provided Area :	0.24 in2/ft	#5@ 21.53 in	#5@ 43.06 in
Maximum Area :	0.6503 in2/ft	#6@ 30.56 in	#6@ 61.11 in

Footing Data

Toe Width	=	1.17 ft
Heel Width	=	1.83
Total Footing Width	=	3.00
Footing Thickness	=	12.00 in
f'c =	3,000 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

		<u>Toe</u>	<u>Heel</u>	
Factored Pressure	=	2,416	0	psf
Mu' : Upward	=	1,413	92	ft-#
Mu' : Downward	=	172	1,986	ft-#
Mu: Design	=	1,241	1,894	ft-#
φ Mn	=	2,739	2,739	ft-#
Actual 1-Way Shear	=	7.43	17.63	psi
Allow 1-Way Shear	=	43.82	43.82	psi
Toe Reinforcing	=	None Spec'd		
Heel Reinforcing	=	None Spec'd		
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: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

Heel: $\phi Mn = \phi * 5 * \lambda * \sqrt{fc} * Sm$

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:

- #4@ 9.26 in
- #5@ 14.35 in
- #6@ 20.37 in

If two layers of horizontal bars:

- #4@ 18.52 in
- #5@ 28.70 in
- #6@ 40.74 in

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (7' Terrace Wall)

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)	1,264.4	2.83	3,582.4	Soil Over HL (ab. water tbl)	1,047.0	2.42	2,532.0
HL Act Pres (be water tbl)				Soil Over HL (bel. water tbl)		2.42	2,532.0
Hydrostatic Force				Water Table			
Buoyant Force =				Sloped Soil Over Heel =			
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 =	70.2	0.59	41.1
				Surcharge Over Toe =			
				Stem Weight(s) =	750.0	1.50	1,127.5
				Earth @ Stem Transitions =			
				Footing Weight =	450.0	1.50	675.0
				Key Weight =			
				Vert. Component =	608.9	3.00	1,826.6
Total	= 1,264.4	O.T.M.	= 3,582.4	Total =	2,926.1 lbs	R.M.=	6,202.1
Resisting/Overturning Ratio		=	1.73	* 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 =		2,926.1 lbs					

Vertical component of active lateral soil pressure IS 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) 0.151 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.

Cantilevered Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (7' Terrace Wall)

Rebar Lap & Embedment Lengths Information

Stem Design Segment: Bottom

Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #4 bar specified in this stem design segment (25.4.2.4a) =	17.09 in
Development length for #4 bar specified in this stem design segment =	13.15 in
Hooked embedment length into footing for #4 bar specified in this stem design segment =	5.63 in
As Provided =	0.2400 in ² /ft
As Required =	0.2377 in ² /ft

Cantilevered Retaining Wall

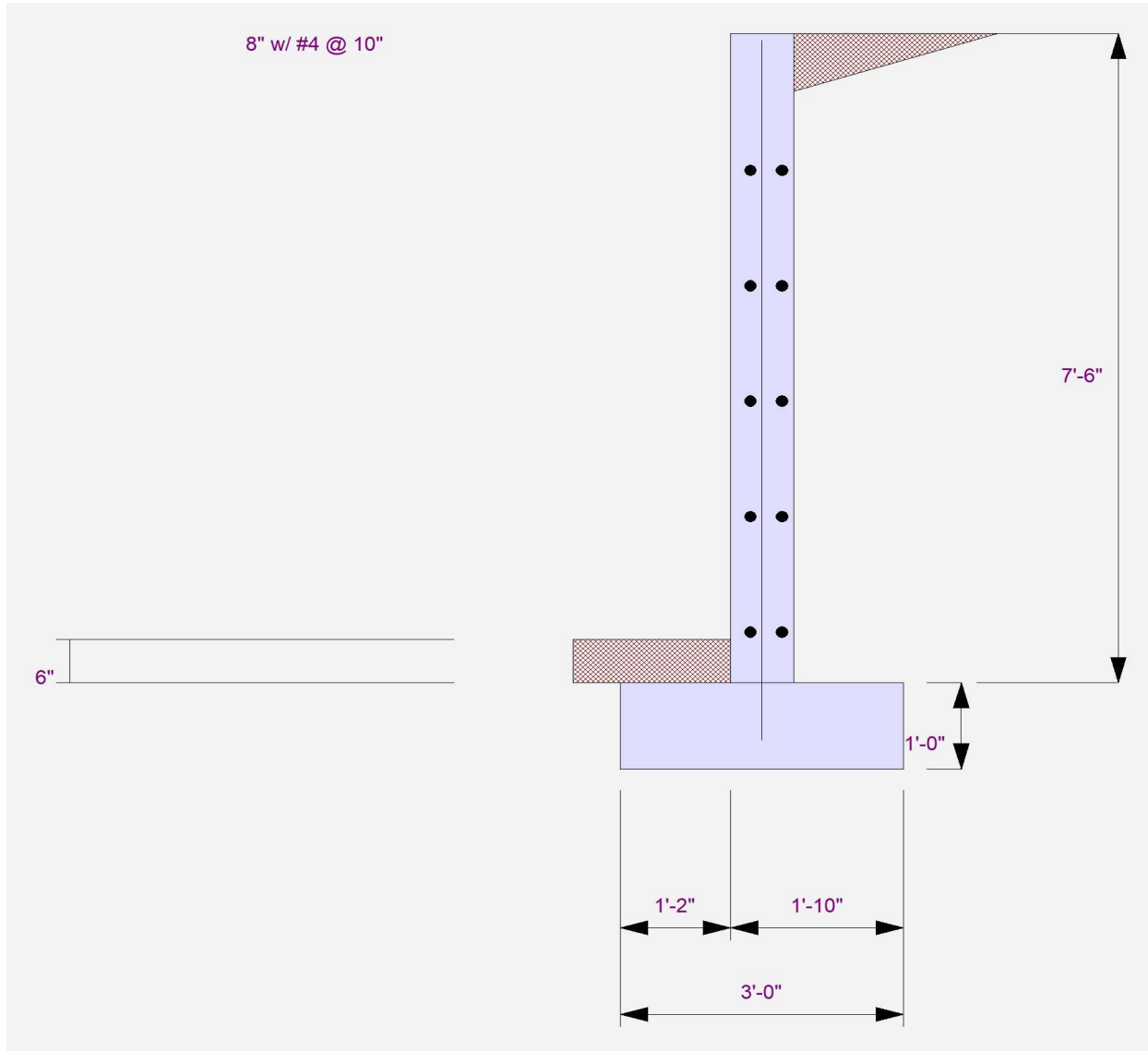
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (7' Terrace Wall)



Cantilevered Retaining Wall

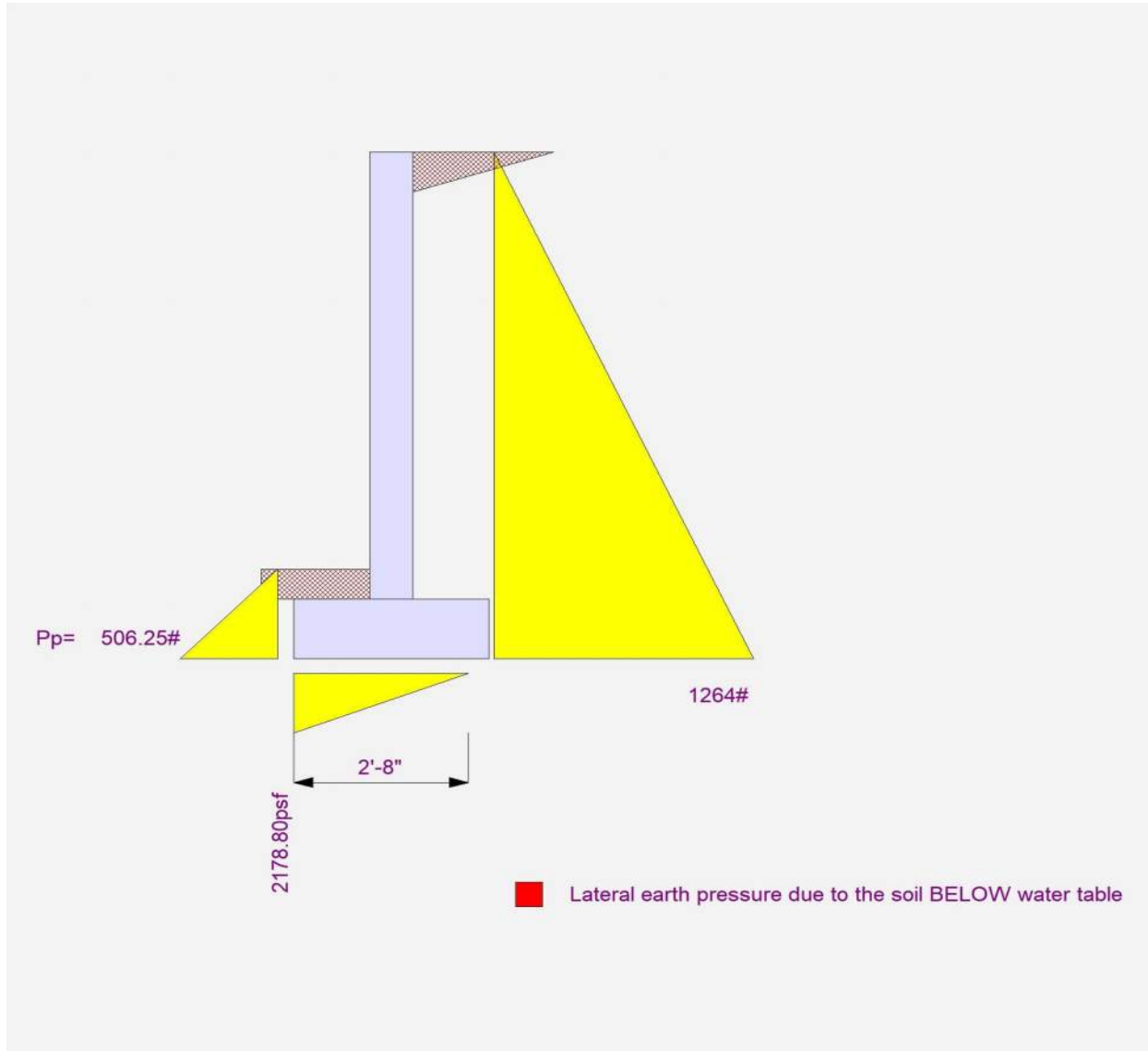
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Retained - EQ (7' Terrace Wall)



Restrained Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall

Code Reference

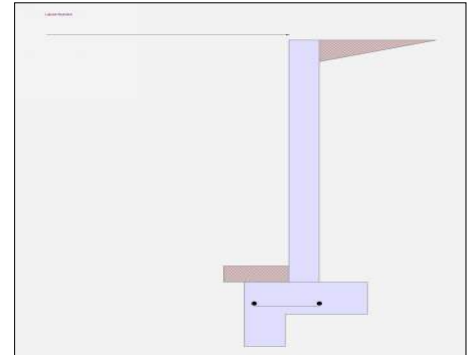
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	7.50 ft
Wall height above soil	=	ft
Total Wall Height	=	7.50 ft
Top Support Height	=	7.5 ft
Slope Behind Wall	=	0
Height of Soil over Toe	=	6 in

Soil Data

Allow Soil Bearing	=	2,500.0 psf
Equivalent Fluid Pressure Method		
At-Rest Heel Pressure	=	55.0 psf/ft
	=	0.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density	=	120.0 pcf
Footing||Soil Frictior	=	0.5250 psf
Soil height to ignore for passive pressure	=	0.0 in



Surcharge Loads

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

Axial Load Applied to Stem

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

Earth Pressure Seismic Load

Uniform Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	7.50 ft
...Height to Bottom	=	0.0 ft
Load Type	=	Seismic (E) (Strength Level)
Wind on Exposed Stem	=	0.00 psf (Strength Level)
Wind acts left-to-right toward retention side.		
K_h Soil Density Multiplier	=	0.2 g

Adjacent Footing Load

Adjacent Footing Load	=	lbs
Footing Width	=	ft
Eccentricity	=	in
Wall to Ftg CL Dist	=	ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	ft
Poisson's Ratio	=	0.3
Added seismic per unit area	=	0.0 psf

Design Summary

Total Bearing Load	=	2,470.0 lbs
...resultant ecc.	=	0.0 in
Soil Pressure @ Toe	=	823.33 psf OK
Soil Pressure @ Heel	=	823.33 psf OK
Allowable	=	psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	988.0 psf
ACI Factored @ Heel	=	988.0 psf
Footing Shear @ Toe	=	3.246 psi OK
Footing Shear @ Heel	=	-2.644 psi OK
Allowable	=	82.158 psi
Reaction at Top	=	308.346 lbs
Reaction at Bottom	=	1,677.50 lbs

Sliding Calcs

Lateral Sliding Force	=	1,677.50 lbs
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Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing

Concrete Stem Construction

Thickness	=	8.00 in	F_y	=	60000 psi
Wall Weight	=	100.0 psf	f'_c	=	3000 psi
Stem is FIXED to top of footing					

	@ Top Support	Mmax Between Top & Base	@ Base of Wall
Design Height Above Ftg	Stem OK = 7.5 ft	Stem OK = 4.187 ft	Stem OK = 0.00 ft
Rebar Size	# 4	# 4	# 4
Rebar Spacing	10.00 in	10.00 in	10.00 in
Rebar Placed at	Center	Center	Center
Rebar Depth 'd'	4.0 in	4.0 in	4.0 in
Design Data			
fb/FB + fa/Fa	=	0.272	0.609
Mu....Actual	=	0.0 ft-#	1,106.84 ft-#
Mn * Phi.....Allowable	=	4,065.12 ft-#	4,065.12 ft-#
Shear Force @ this height	=	494.993 lbs	1,980.01 lbs
Shear.....Actual	=	10.312 psi	41.250 psi
Shear.....Allowable	=	56.196 psi	56.196 psi

Load Factors

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

Restrained Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall

Footing Strengths & Dimensions

Toe Width	=	.16666666 ft
Heel Width	=	.83333333
Total Footing Width	=	3.0
Footing Thickness	=	12.0 in
Key Width	=	12.0 in
Key Depth	=	12.0 in
Key Distance from Toe	=	0.0 ft
f'c =	3,000 psi	Fy = 60000 psi
Footing Concrete Density	=	150 pcf
Min. As %	=	0.0018
Cover @ Top	=	2 in @ Btm.= 3 in

Footing Design Results

	<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	988.0	988.0	psf
Mu' : Upward	=	672.39		ft-#
Mu' : Downward	=	171.50		ft-#
Mu: Design	=	501	185	1,411.6 ft-#
Actual 1-Way Shear	=	3.246	-2.644	17.8 psi
Allow 1-Way Shear	=	43.818	43.818	0.0 psi

Other Acceptable Sizes & Spacings:

Toe: # 7 @ 18.00 in	-or-	phiMn = phi * 5 * lambda * sqrt(fc) * Sm
Heel: None Spec'd	-or-	phiMn = phi * 5 * lambda * sqrt(fc) * Sm
Key: # 0 @ 0.00 in	-or-	phiMn = phi * 5 * lambda * sqrt(fc)
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

Summary of Forces on Footing : Slab is NOT providing sliding, stem is FIXED at footing

Forces acting on footing for sliding & soil pressure....

Sliding Forces

Stem Shear @ Top of Footing	=	1,237.50 lbs
Heel Active Pressure	=	440.0
Sliding Force	=	1,677.50 lbs

Load & Moment Summary For Footing : For Soil Pressure Calcs

Moment @ Top of Footing Applied from Stem	=		-1,546.91 ft-#
Surcharge Over Heel	=	0.0	0.0
Adjacent Footing Load	=	0.0 lbs	0.0 ft
Axial Dead Load on Stem	=	0.0 lbs	0.0 ft
Soil Over Toe	=	70.0 lbs	0.5833 ft
Surcharge Over Toe	=	0.0 lbs	0.0 ft
Stem Weight	=	750.0 lbs	1.50 ft
Soil Over Heel	=	1,050.0 lbs	2.417 ft
Footing Weight	=	600.0 lbs	1.126 ft
Total Vertical Force	≡	2,470.0 lbs	Base Moment = 2,831.93ft-#

Stem is specified to be fixed to footing, and top restraint is assumed to react out any tendency for moment at the footing/soil interface, so uniform soil pressure is assumed.

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

Restrained Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall

Rebar Lap & Embedment Lengths Information

Restrained Retaining Wall

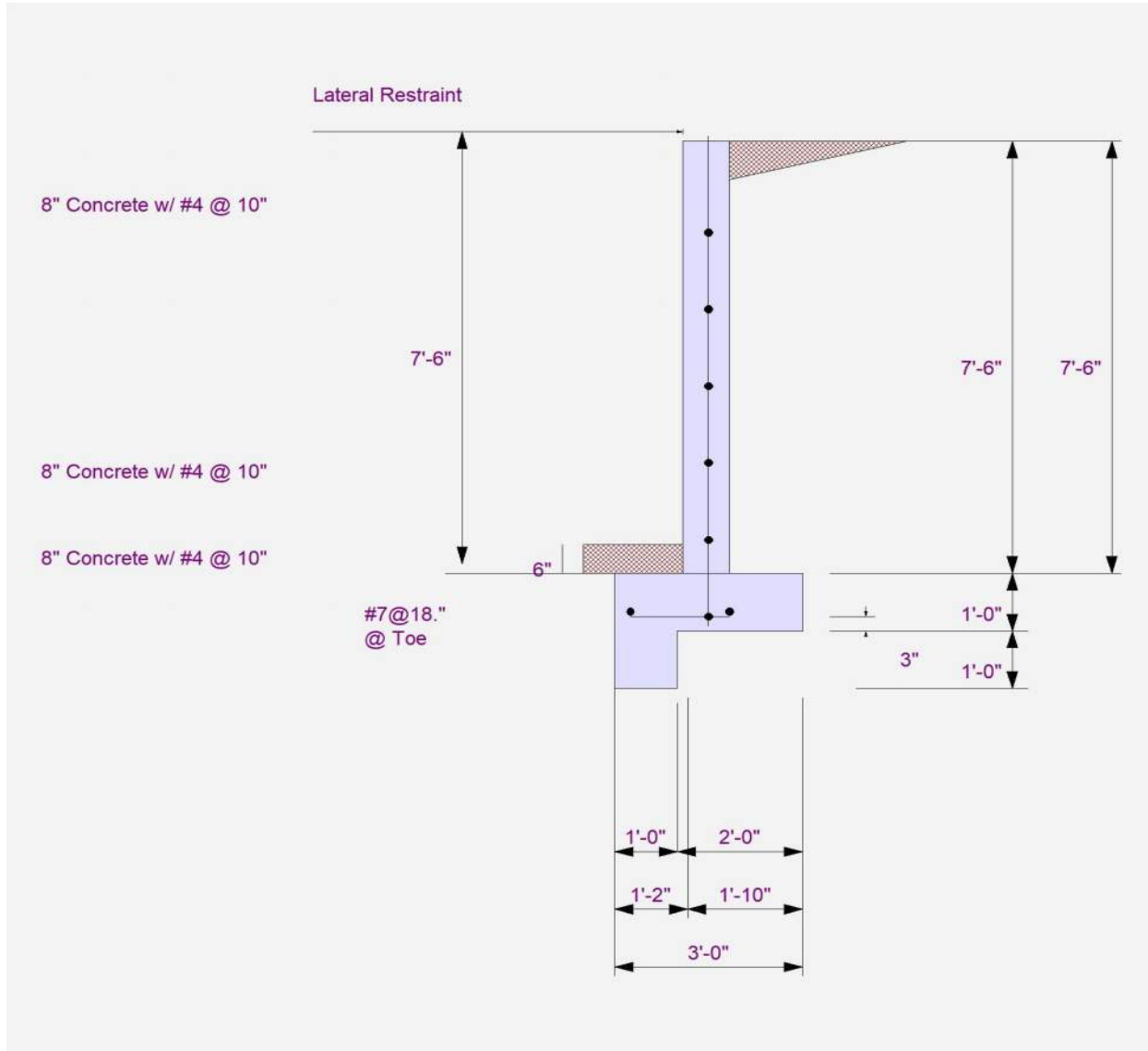
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall



Restrained Retaining Wall

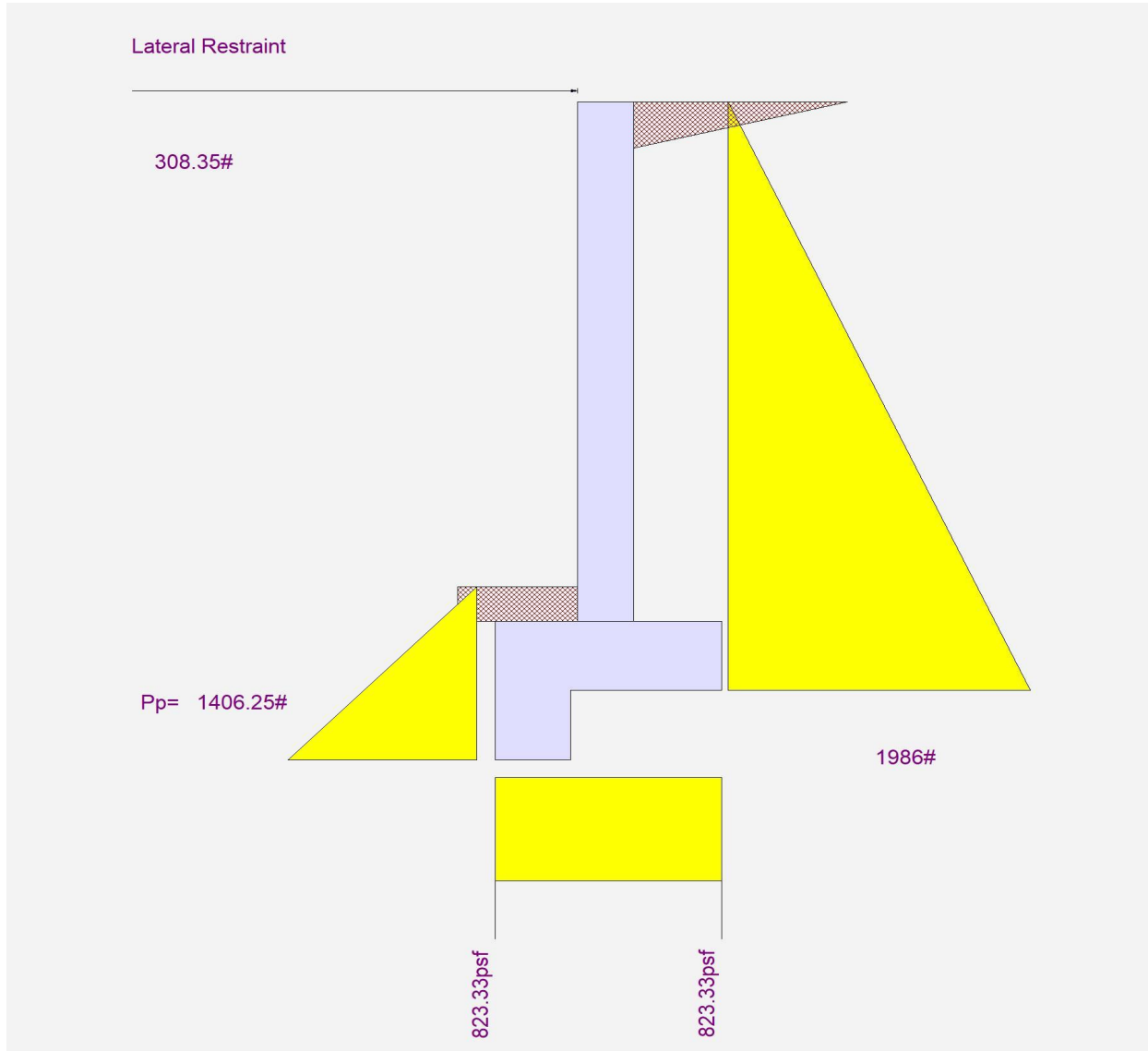
Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall



Restrained Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall - EQ

Code Reference

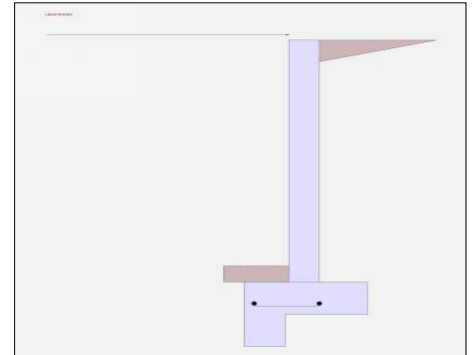
Calculations per IBC 2021 1807.3, ASCE 7-16

Criteria

Retained Height	=	7.50 ft
Wall height above soil	=	_____ ft
Total Wall Height	=	7.50 ft
Top Support Height	=	7.5 ft
Slope Behind Wall	=	0
Height of Soil over Toe	=	6 in

Soil Data

Allow Soil Bearing	=	2,500.0 psf
Equivalent Fluid Pressure Method		
At-Rest Heel Pressure	=	55.0 psf/ft
	=	0.0 psf/ft
Passive Pressure	=	450.0 psf/ft
Soil Density	=	120.0 pcf
Footing||Soil Frictior	=	0.5250 psf
Soil height to ignore for passive pressure	=	in



Surcharge Loads

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

Axial Load Applied to Stem

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

Earth Pressure Seismic Load

Uniform Lateral Load Applied to Stem

Lateral Load	=	60.0 #/ft
...Height to Top	=	7.50 ft
...Height to Bottom	=	ft
Load Type	=	Seismic (E) (Strength Level)
Wind on Exposed Stem	=	0.00 psf (Strength Level)
Wind acts left-to-right toward retention side.		
K_h Soil Density Multiplier	=	0.2 g

Adjacent Footing Load

Adjacent Footing Load	=	lbs
Footing Width	=	ft
Eccentricity	=	in
Wall to Ftg CL Dist	=	ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	ft
Poisson's Ratio	=	0.3
Added seismic per unit area	=	0.0 psf

Design Summary

Total Bearing Load	=	2,470.0 lbs
...resultant ecc.	=	0.0 in
Soil Pressure @ Toe	=	823.33 psf OK
Soil Pressure @ Heel	=	823.33 psf OK
Allowable	=	psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	988.0 psf
ACI Factored @ Heel	=	988.0 psf
Footing Shear @ Toe	=	3.246 psi OK
Footing Shear @ Heel	=	-2.644 psi OK
Allowable	=	82.158 psi
Reaction at Top	=	409.596 lbs
Reaction at Bottom	=	1,846.25 lbs

Sliding Calcs

Lateral Sliding Force	=	1,846.25 lbs
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Vertical component of active lateral soil pressure IS NOT considered in the calculation of soil bearing

Concrete Stem Construction

Thickness	=	8.00 in	F_y	=	60000 psi
Wall Weight	=	100.0 psf	f'_c	=	3000 psi
Stem is FIXED to top of footing					

	@ Top Support	Mmax Between Top & Base	@ Base of Wall
Design Height Above Ftg	Stem OK = 7.5 ft	Stem OK = 4.277 ft	Stem OK = 0.00 ft
Rebar Size	# 4	# 4	# 4
Rebar Spacing	10.00 in	10.00 in	10.00 in
Rebar Placed at	Center	Center	Center
Rebar Depth 'd'	4.0 in	4.0 in	4.0 in
Design Data			
fb/FB + fa/Fa	=	0.338	0.733
Mu....Actual	=	0.0 ft-#	1,373.97 ft-#
Mn * Phi.....Allowable	=	4,065.12 ft-#	4,065.12 ft-#
Shear Force @ this height	=	699.66 lbs	2,317.51 lbs
Shear.....Actual	=	14.576 psi	48.281 psi
Shear.....Allowable	=	56.196 psi	56.196 psi

Load Factors

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

Restrained Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall - EQ

Footing Strengths & Dimensions

Toe Width	=	.16666666 ft
Heel Width	=	.83333333
Total Footing Width	=	3.0
Footing Thickness	=	12.0 in
Key Width	=	12.0 in
Key Depth	=	12.0 in
Key Distance from Toe	=	ft
f'c =	3,000 psi	Fy = 60000 psi
Footing Concrete Density	=	150 pcf
Min. As %	=	0.0018
Cover @ Top	=	2 in @ Btm.= 3 in

Footing Design Results

	<u>Toe</u>	<u>Heel</u>	<u>Key</u>	
Factored Pressure	=	988.0	988.0	psf
Mu' : Upward	=	672.39		ft-#
Mu' : Downward	=	171.50		ft-#
Mu: Design	=	501	185	1,411.6 ft-#
Actual 1-Way Shear	=	3.246	-2.644	17.8 psi
Allow 1-Way Shear	=	43.818	43.818	43.8 psi

Other Acceptable Sizes & Spacings:

Toe: # 7 @ 18.00 in	-or-	$\phi M_n = \phi * 5 * \lambda * \sqrt{f_c} * S_m$
Heel: None Spec'd	-or-	$\phi M_n = \phi * 5 * \lambda * \sqrt{f_c} * S_m$
Key: # 0 @ 18.00 in	-or-	$\phi M_n = \phi * 5 * \lambda * \sqrt{f_c}$
Min footing T&S reinf Area		0.78 in ²
Min footing T&S reinf Area per foot		0.26 in ² /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

Summary of Forces on Footing : Slab is NOT providing sliding, stem is FIXED at footing

Forces acting on footing for sliding & soil pressure....

Sliding Forces

Stem Shear @ Top of Footing	=	1,406.25 lbs
Heel Active Pressure	=	440.0
Sliding Force	=	1,846.25 lbs

Load & Moment Summary For Footing : For Soil Pressure Calcs

Moment @ Top of Footing Applied from Stem	=		-1,800.03ft-#
Surcharge Over Heel	=	0.0	0.0
Adjacent Footing Load	=	0.0 lbs	0.0 ft
Axial Dead Load on Stem	=	0.0 lbs	0.0 ft
Soil Over Toe	=	70.0 lbs	0.5833 ft
Surcharge Over Toe	=	0.0 lbs	0.0 ft
Stem Weight	=	750.0 lbs	1.50 ft
Soil Over Heel	=	1,050.0 lbs	2.417 ft
Footing Weight	=	600.0 lbs	1.126 ft
Total Vertical Force	≡	2,470.0 lbs	Base Moment = 2,578.80ft-#

Stem is specified to be fixed to footing, and top restraint is assumed to react out any tendency for moment at the footing/soil interface, so uniform soil pressure is assumed.

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

Restrained Retaining Wall

Project File: Retaining Walls - Updated.ec6

LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall - EQ

Rebar Lap & Embedment Lengths Information

Restrained Retaining Wall

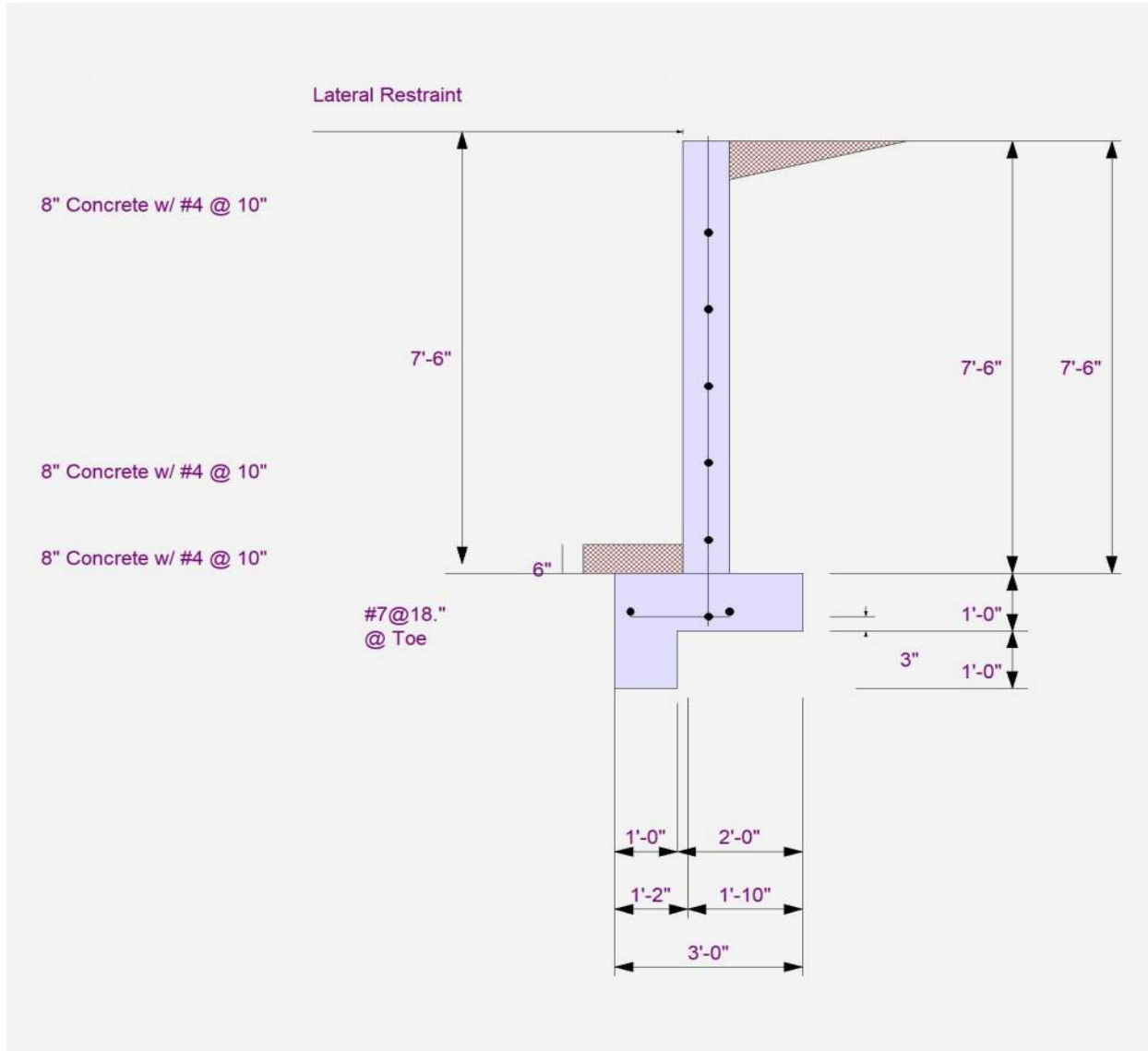
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LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

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DESCRIPTION: 7' Terrace Wall - EQ



Restrained Retaining Wall

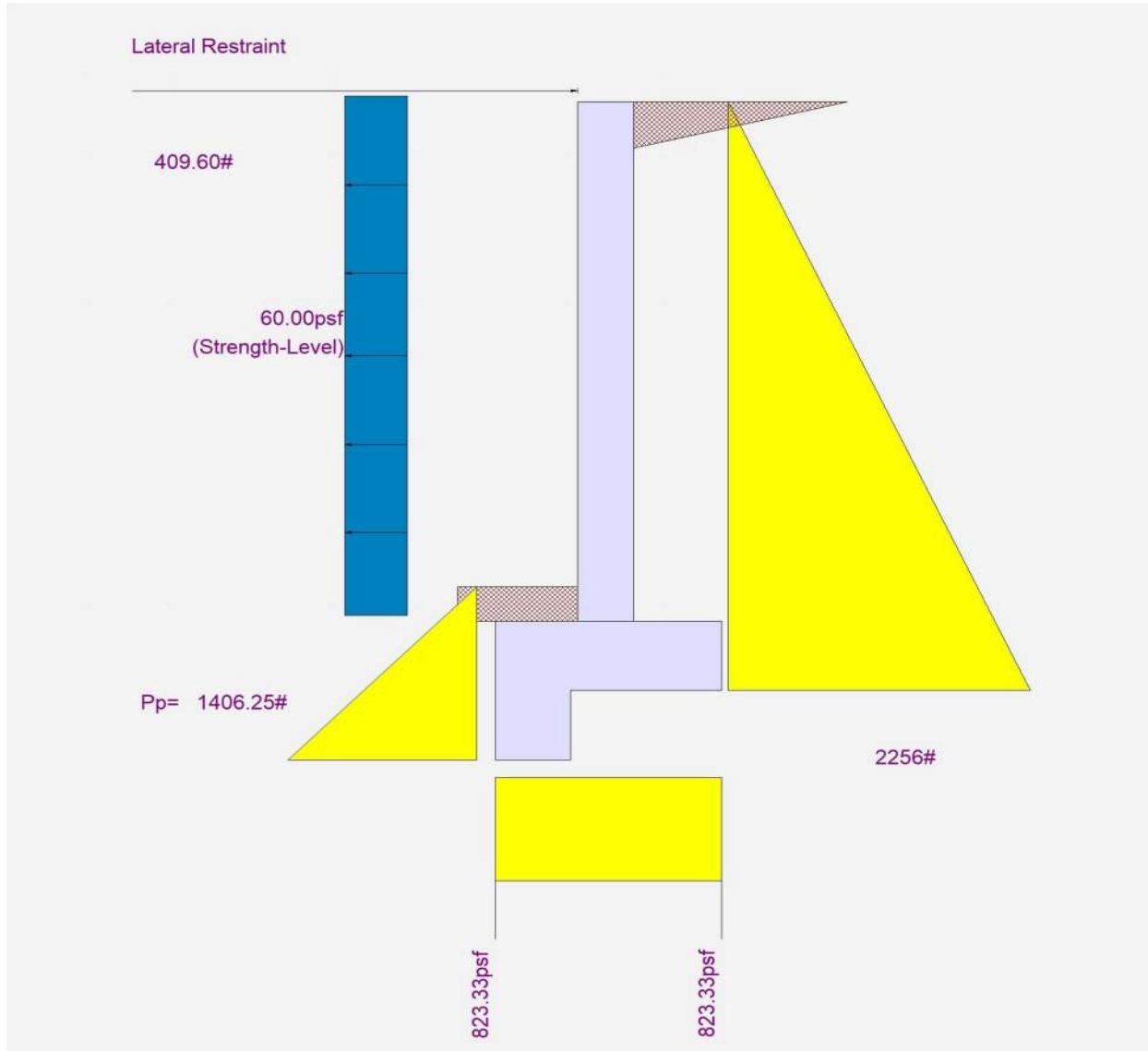
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LIC# : KW-06016450, Build:20.24.05.02

QUANTUM CONSULTING ENGINEERS

(c) ENERCALC INC 1983-2023

DESCRIPTION: 7' Terrace Wall - EQ





QUANTUM | CONSULTING ENGINEERS

CENTERIS SOUTH YARD

1023 39TH AVE SE
PUYALLUP, WA 38374

QUANTUM JOB NUMBER: 23444.01

PIPE FRAMES

Seismic Base Shear for the Equivalent Lateral Force Procedure

Per IBC 2021 & ASCE 7-16 Chapter 15.4

Structure: **Pipe Frames**
 Address: **1015 39th Ave SE Puyallup, WA 98374**
 Latitude: **47.1590** Longitude: **-122.2794**

Structure Classification

Risk Category: **II** per ASCE Table 1.5-1

Seismic Force-Resisting System: **Steel Ordinary Moment Frames** per ASCE 15.7.14

R: **3 1/2** per ASCE Table 15.4-2
 W_o : **3** per ASCE Table 15.4-2
 C_d : **3 1/4** per ASCE Table 15.4-2
 h_n (ft): **10.00** height above the base to the highest level of the structure

Site Ground Motion

S_1 (g-sec): **0.43** S_s (g-sec): **1.26**
 Site Class: **C Per Geotechnical Report** per ASCE 11.4.3

F_v **1.50**

F_a **1.20**

S_{M1} (g-sec): **0.65** S_{MS} (g-sec): **1.51** per ASCE 11.4.4
 S_{D1} (g-sec): **0.43** S_{DS} (g-sec): **1.01** per ASCE 11.4.5
 SDC : **D** per ASCE 11.6
 I_E : **1.00** per ASCE Table 1.5-2


Fundamental Period per ASCE 12.8.2

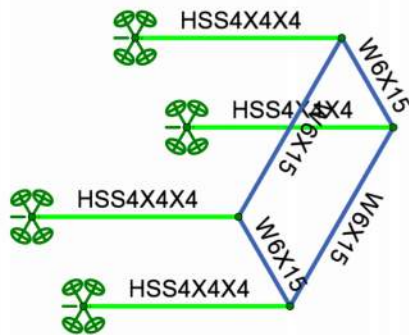
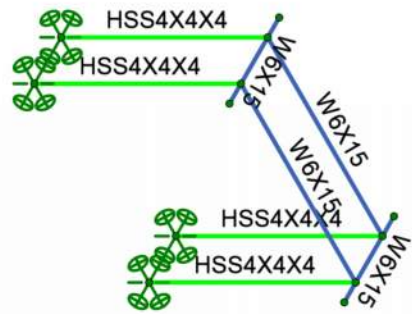
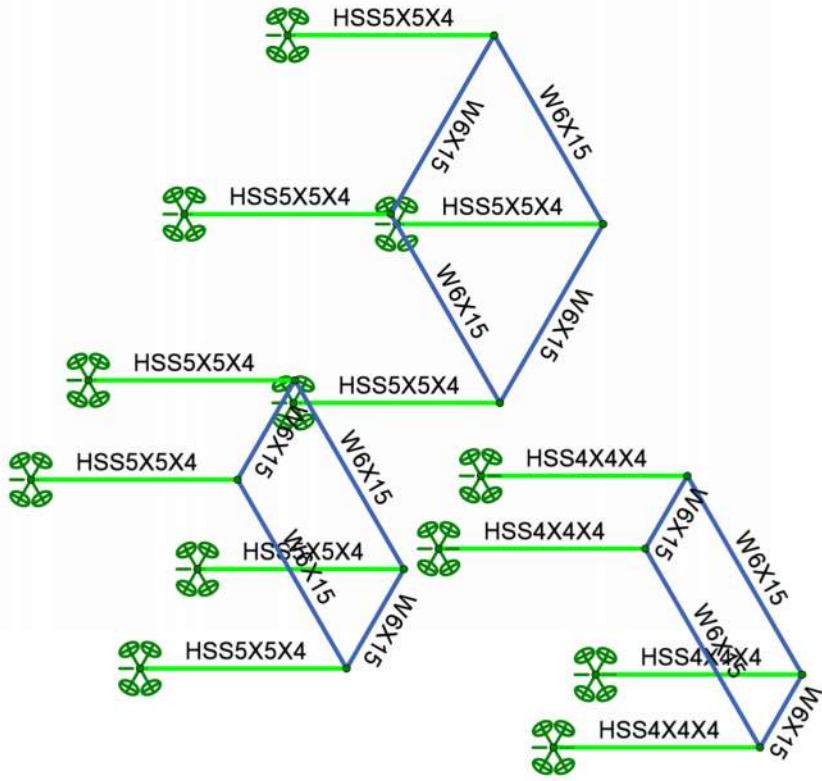
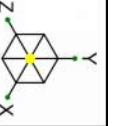
Period Method: **Approximate Fundamental Period**
 Structure Type: **All Other Structural Systems**
 T_L (sec): **6.00** ASCE Figures 22-14 through 22-17
 T_s : 0.43
 T_a (sec): 0.11 $C_t * h_{nx}$ per ASCE Eq. 12.8-7
 T_{use} (sec): **0.11** $\tau \leq T_L$

Equivalent Lateral Force Procedure Design Base Shear per ASCE 12.8

C_s : 0.287 = $S_{DS} / (R/I_E)$ per ASCE Eq. 12.8-2
 C_{s-max} : 1.100 = $S_{D1} / (T_a * R/I_E)$ for $T \leq T_L$ per ASCE Eq. 12.8-3
 C_{s-max} : -- = $S_{D1} * T_L / (T_a^2 * R/I_E)$ for $T > T_L$ per ASCE Eq. 12.8-4
 C_{s-min} : 0.044 per ASCE Eq. 15.4-1
 C_{s-min} : -- = $0.8S_1 / (R/I_E)$ for $S_1 \Rightarrow 0.6g$ per ASCE Eq. 15.4-2
 C_{s-use} : 0.287

V: **0.287 W** = $C_{s-use} * W$ per ASCE Eq. 12.8-1

	Quantum Consulting Engineers LLC	Project: Centeris	Date: 9/3/24	Job No: 23444.01
	1511 Third Avenue, Suite 323		Designer: TVM	Sheet: 1
	Seattle, WA 98101	Client: Centeris	Checked By:	



Member Material Sets

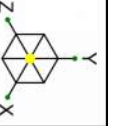
- A992
- A500 Gr. C RECT



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 23444.01

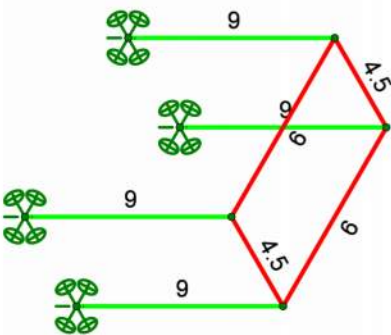
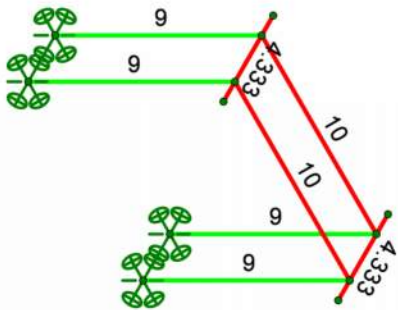
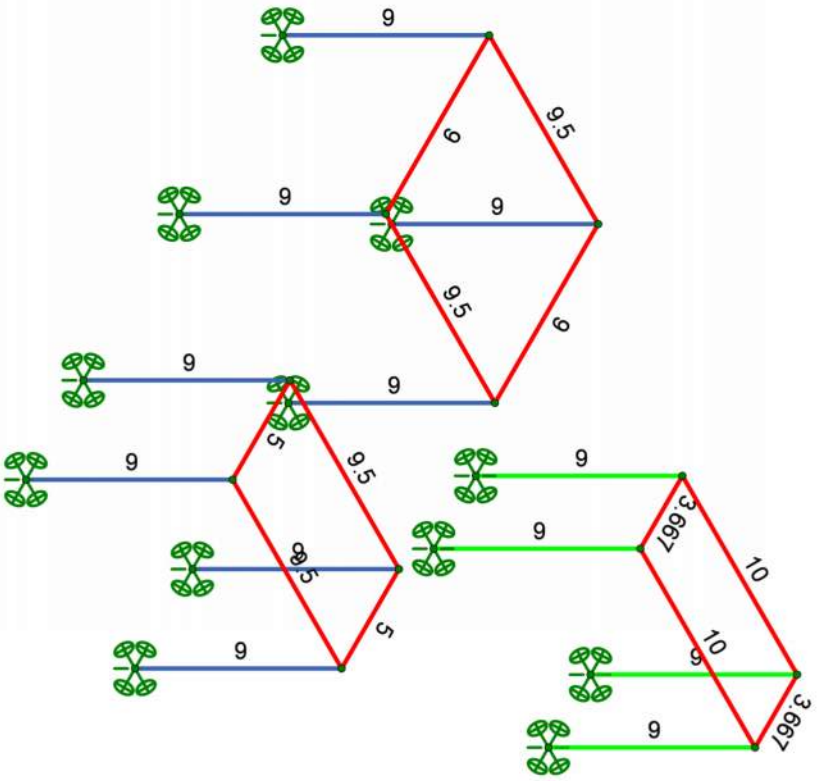
Chiller Pipe Frames

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Section Sets

- COLUMN_5X5
- COLUMN_4x4
- MF BEAM_1



Member Length (ft) Displayed

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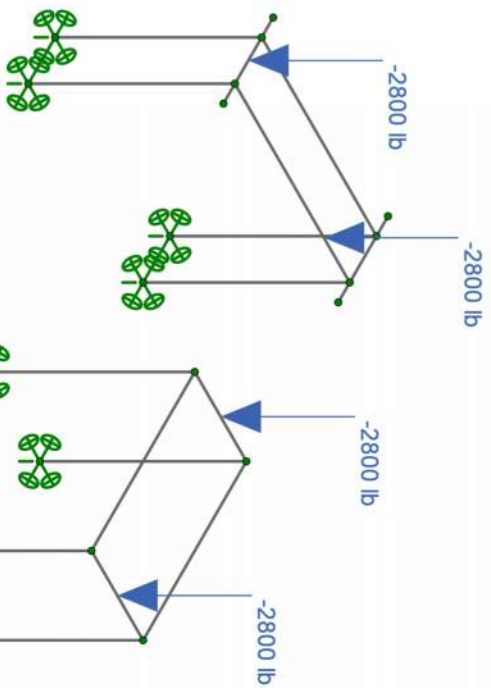
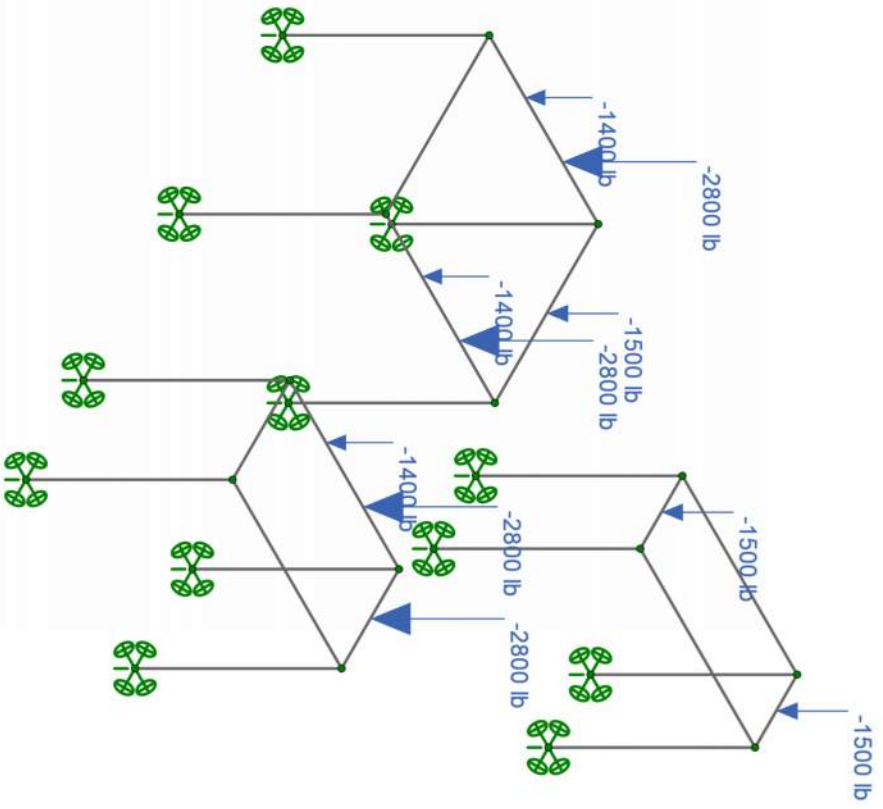
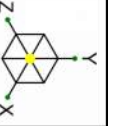
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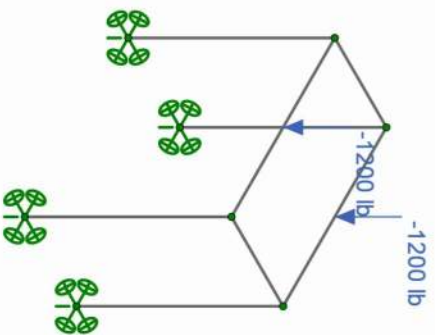
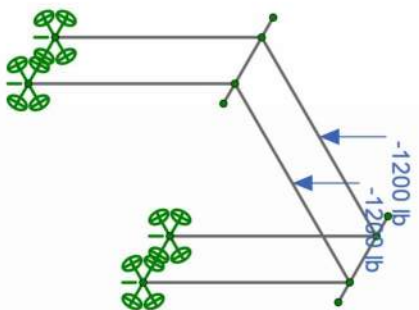
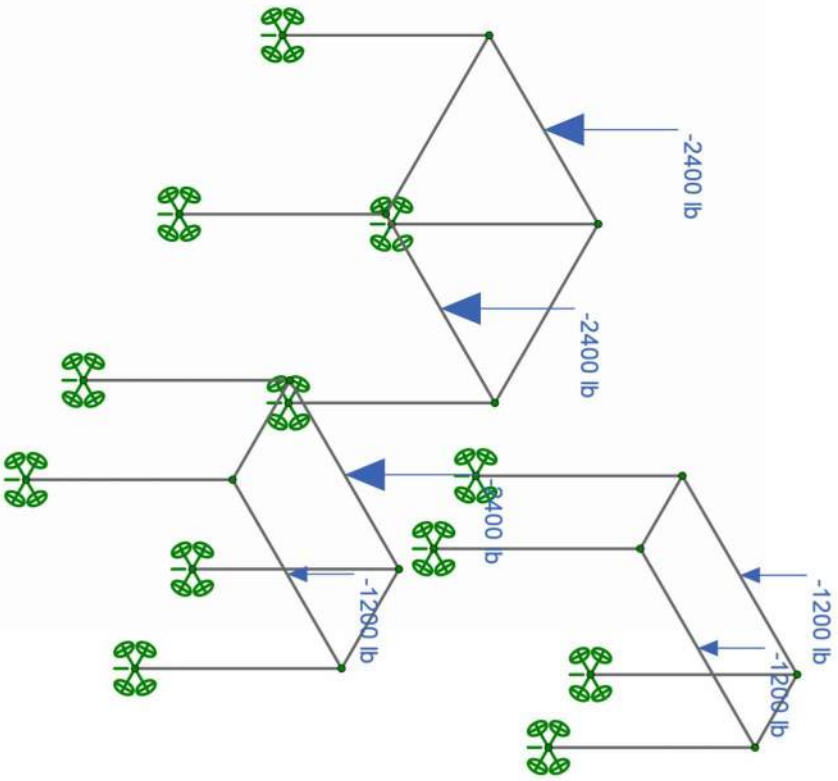
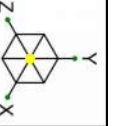
Loads: BLC 1, Dead



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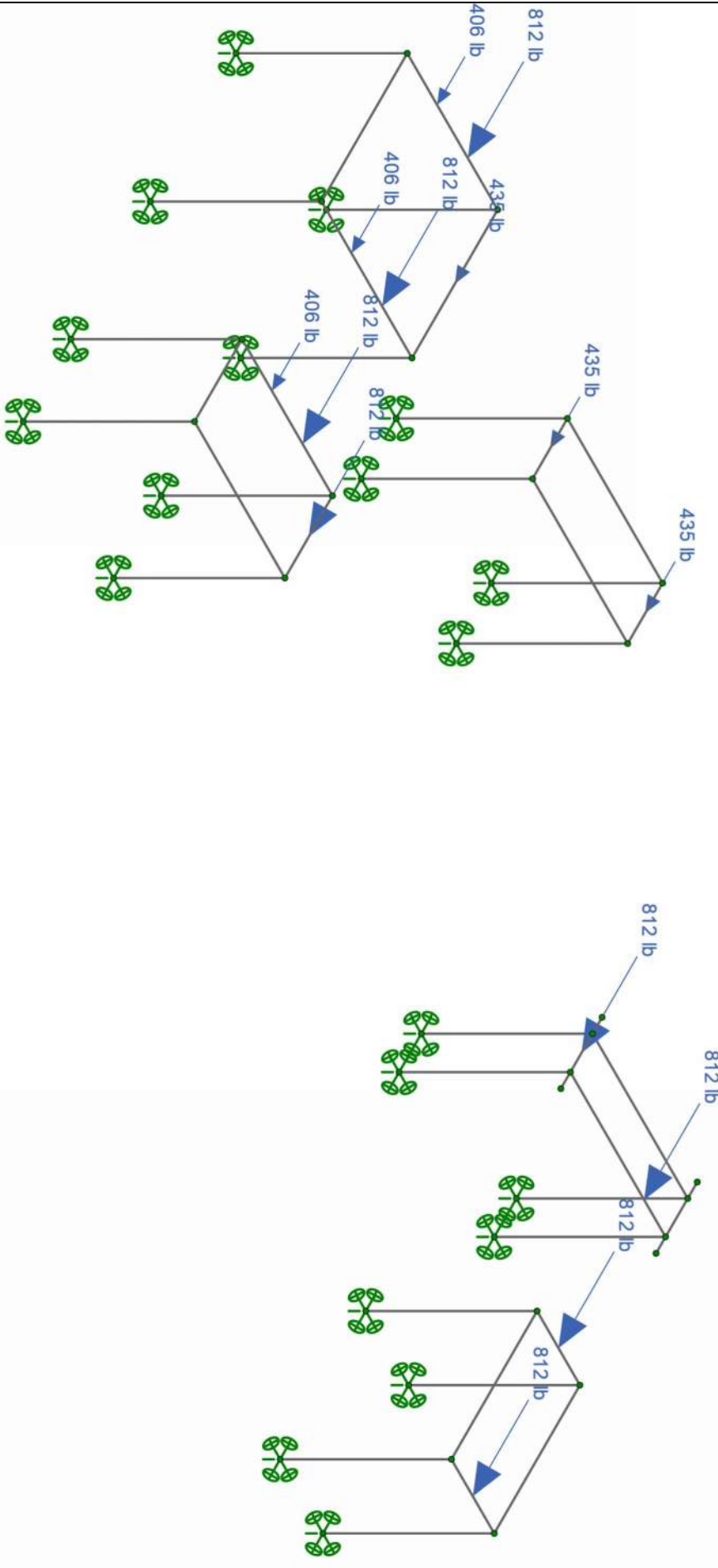
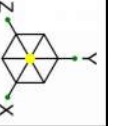
Loads: BLC 2, Snow



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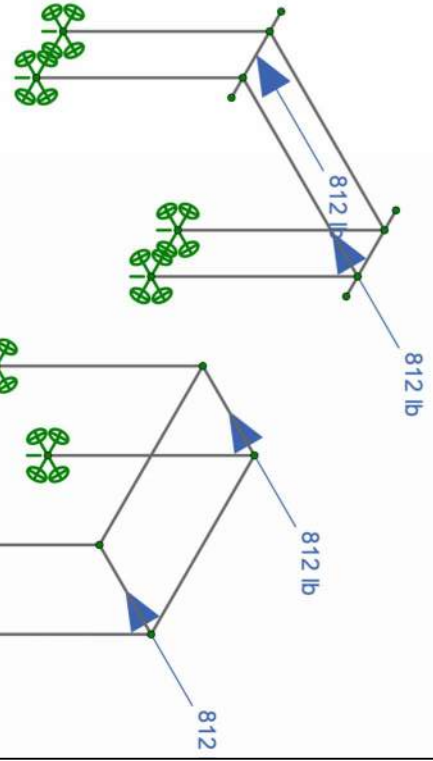
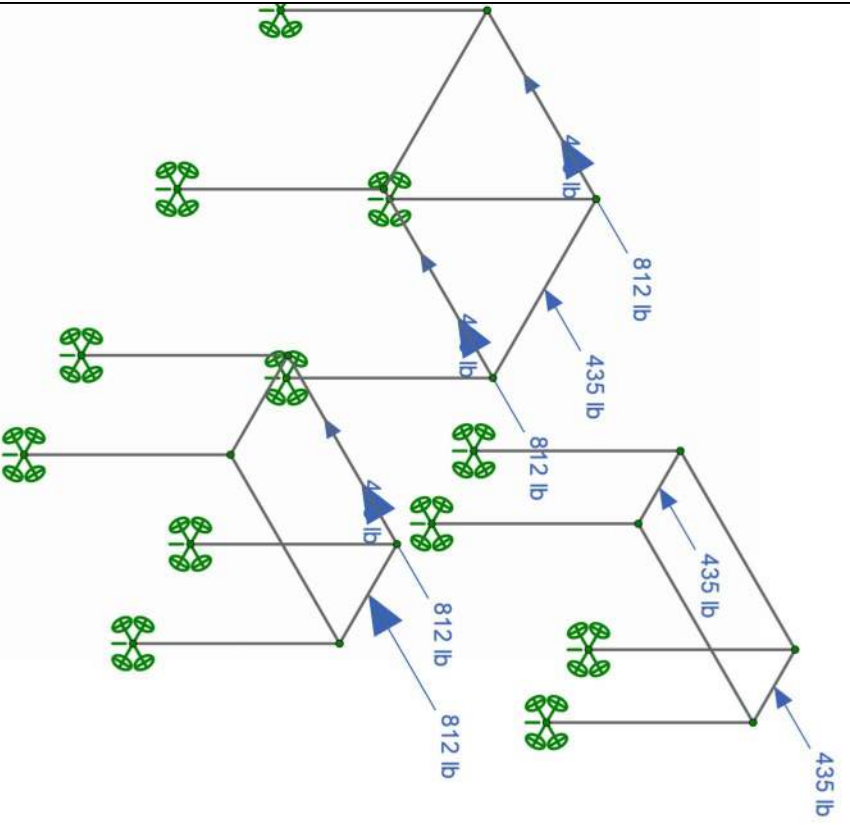
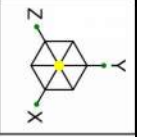
Loads: BLC 3, EQX



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Loads: BLC 4, EQZ



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Chiller Pipe Frames

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Company : Quantum Consulting Engineers
 Designer : Travis Michaud
 Job Number : 23444.01
 Model Name : Chiller Pipe Frames

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Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Point
1	Dead	DL - Dead Load		-1		16
2	Snow	None				12
3	EQX	ELX - Earthquake Load X	0.29			16
4	EQZ	ELZ - Earthquake Load Z			0.29	16

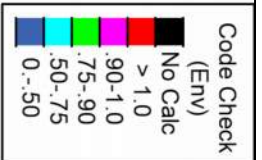
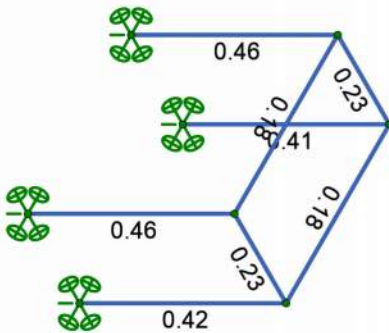
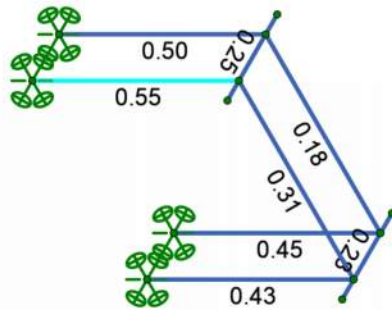
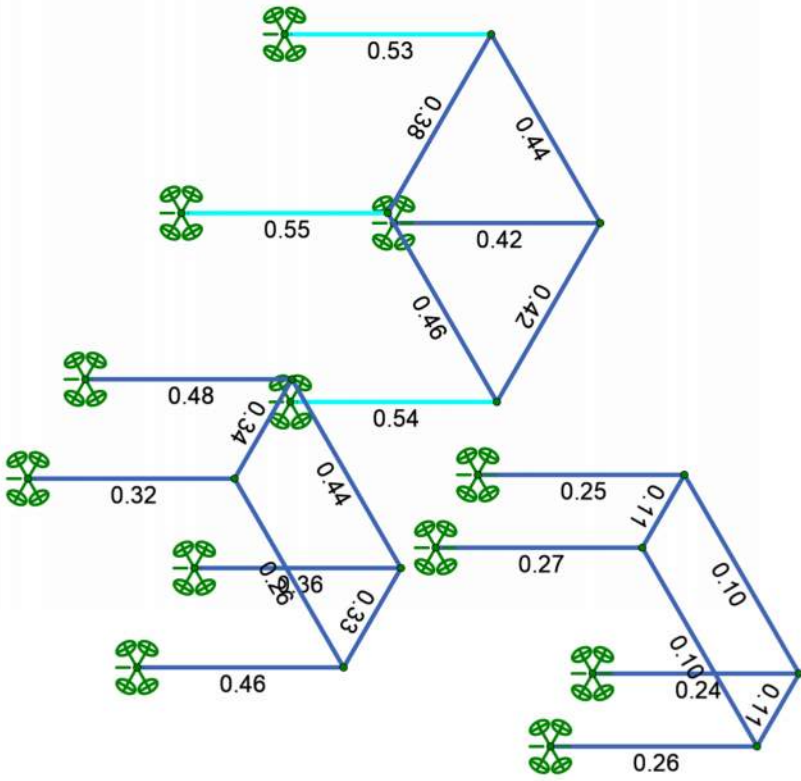
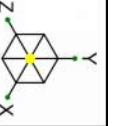


Company : Quantum Consulting Engineers
 Designer : Travis Michaud
 Job Number : 23444.01
 Model Name : Chiller Pipe Frames

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Load Combinations

	Description	Solve	P-Delta	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	ELX		Y	ELX	1								
2	ELX*Cd		Y	ELX	3								
3	ELZ*Cd		Y	ELZ	3								
4	ASD												
5	IBC 16-8	Yes	Y	DL	1								
6	IBC 16-10 (b)	Yes	Y	DL	1	SL	1						
7	IBC 16-12 (b) (a)	Yes	Y	DL	1	S _{Ds} *DL	0.14	ELX	0.7	ELZ	0.21		
8		Yes	Y	DL	1	S _{Ds} *DL	0.14	ELZ	0.7	ELX	0.21		
9	IBC 16-14 (a)	Yes	Y	DL	1	S _{Ds} *DL	0.105	ELX	0.525	ELZ	0.158	SL	0.75
10		Yes	Y	DL	1	S _{Ds} *DL	0.105	ELZ	0.525	ELX	0.158	SL	0.75
11	IBC 16-16 (a)	Yes	Y	DL	0.6	S _{Ds} *DL	-0.14	ELX	0.7	ELZ	0.21		
12		Yes	Y	DL	0.6	S _{Ds} *DL	-0.14	ELZ	0.7	ELX	0.21		
13	IBC 16-12 (b) (a) OS	Yes	Y	DL	1	S _{Ds} *DL	0.14	ELX	1.75	ELZ	0.525		
14		Yes	Y	DL	1	S _{Ds} *DL	0.14	ELZ	1.75	ELX	0.525		
15	IBC 16-14 (a) OS		Y	DL	1	S _{Ds} *DL	0.105	ELX	1.31	ELZ	0.39	SL	0.75
16			Y	DL	1	S _{Ds} *DL	0.105	ELZ	1.31	ELX	0.39	SL	0.75
17	IBC 16-16 (a) OS		Y	DL	0.6	S _{Ds} *DL	-0.14	ELX	1.75	ELZ	0.525		
18			Y	DL	0.6	S _{Ds} *DL	-0.14	ELZ	1.75	ELX	0.525		
19	Base Plate LRFD												
20	IBC 16-5		Y	DL	1.2	S _{Ds} *DL	0.2	ELX	1	ELZ	0.3	SL	0.2
21			Y	DL	1.2	S _{Ds} *DL	0.2	ELZ	1	ELX	0.3	SL	0.2
22	IBC 16-7		Y	DL	0.9	S _{Ds} *DL	-0.2	ELX	1	ELZ	0.3		
23			Y	DL	0.9	S _{Ds} *DL	-0.2	ELZ	1	ELX	0.3		
24	IBC 16-5 (os-a)		Y	DL	1.2	S _{Ds} *DL	0.2	ELX	2.5	ELZ	0.75	SL	0.2
25			Y	DL	1.2	S _{Ds} *DL	0.2	ELZ	2.5	ELX	0.75	SL	0.2
26	IBC 16-7 (os-a)		Y	DL	0.9	S _{Ds} *DL	-0.2	ELX	2.5	ELZ	0.75		
27			Y	DL	0.9	S _{Ds} *DL	-0.2	ELZ	2.5	ELX	0.75		



Member Code Checks Displayed (Enveloped)
Envelope Only Solution

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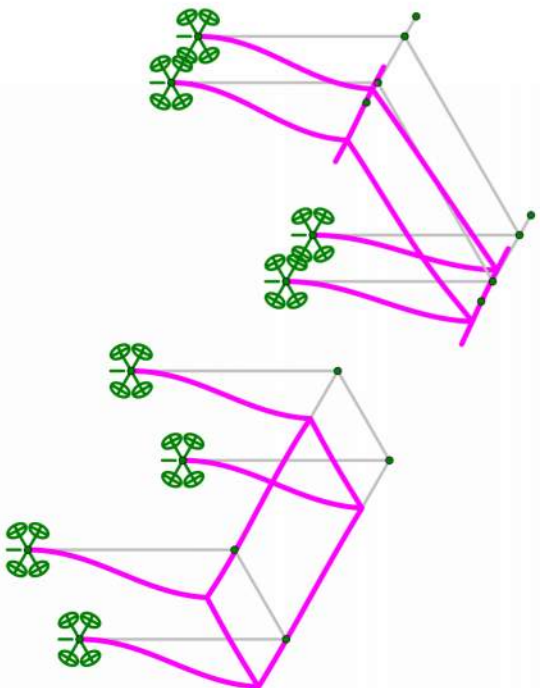
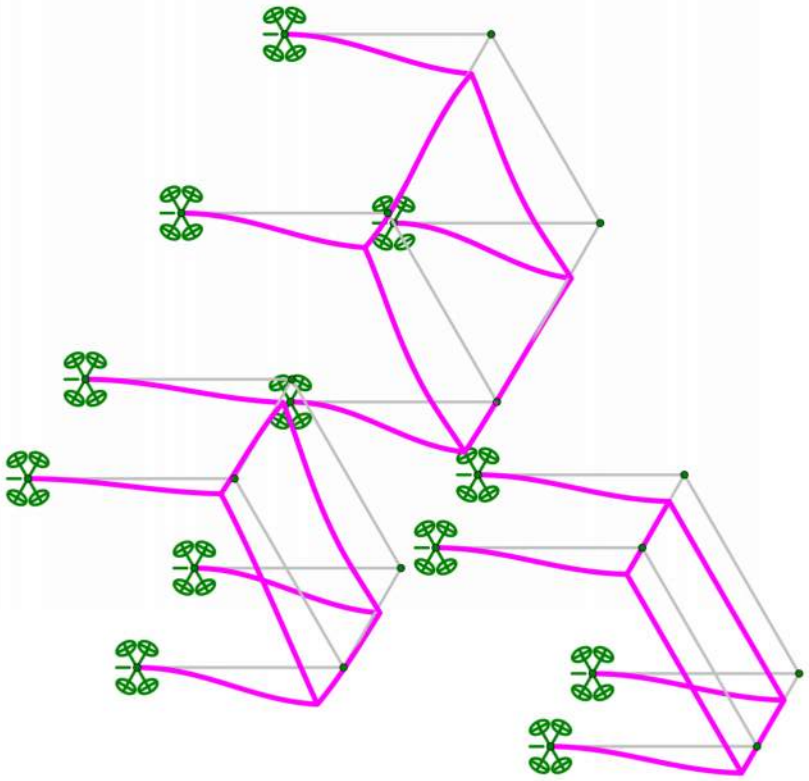
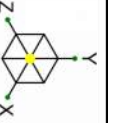
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Chiller Pipe Frames

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Max Drift = 1.04"
9' / 1.04" = H / 104 < H / 40 OK

Results for LC 2, ELX*Cd



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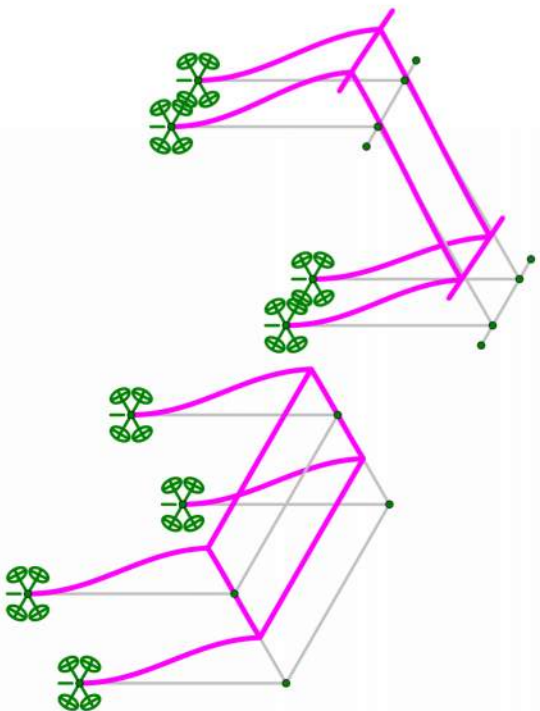
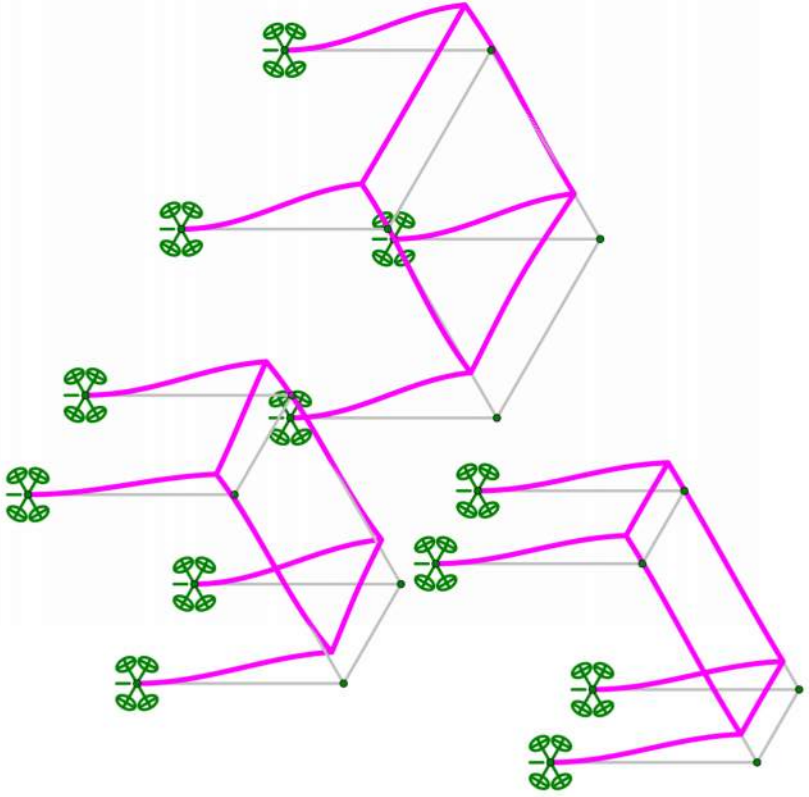
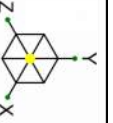
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Chiller Pipe Frames

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Max Drift = 0.95"
9' / 0.95" = H / 114 < H / 40 OK

Results for LC 3, ELZ*Cd



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Chiller Pipe Frames

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Company:	QCE	Date:	9/8/2022
Engineer:	TVM	Page:	1/7
Project:	Centeris		
Address:			
Phone:			
E-mail:			

1. Project information

Project description: Chiller Narrow Frames

Location:

Fastening description:

Comment:

2. Input Data & Anchor Parameters

General

Design method: ACI 318-19

Units: Imperial units

Anchor Information:

Anchor type: Bonded anchor

Material: F1554 Grade 36

Diameter (inch): 0.750

Effective Embedment depth, h_{ef} (inch): 8.000

Code report: ICC-ES ESR-4057

Anchor category: -

Anchor ductility: Yes

h_{min} (inch): 9.75

c_{ac} (inch): 18.55

C_{min} (inch): 1.75

S_{min} (inch): 3.00

Base Material

Concrete: Normal-weight

Concrete thickness, h (inch): 12.00

State: Cracked

Compressive strength, f'_c (psi): 3000

$\Psi_{c,v}$: 1.0

Reinforcement condition: Supplementary reinforcement not present

Supplemental edge reinforcement: Not applicable

Reinforcement provided at corners: No

Ignore concrete breakout in tension: No

Ignore concrete breakout in shear: No

Hole condition: Dry concrete

Inspection: Periodic

Temperature range, Short/Long: 150/110°F

Reduced installation torque (for AT-3G): Not applicable

Ignore 6do requirement: Not applicable

Build-up grout pad: No

Base Plate

Length x Width x Thickness (inch): 10.00 x 10.00 x 0.63

Yield stress: 50000 psi

Profile type/size: 4X4X1/4

Recommended Anchor

Anchor Name: SET-3G™ - SET-3G w/ 3/4"Ø F1554 Gr. 36

Code Report: ICC-ES ESR-4057



Company:	QCE	Date:	9/8/2022
Engineer:	TVM	Page:	2/7
Project:	Centeris		
Address:			
Phone:			
E-mail:			

Load and Geometry

Load factor source: ACI 318 Section 5.3

Load combination: not set

Seismic design: Yes

Anchors subjected to sustained tension: No

Ductility section for tension: 17.10.5.3 (d) is satisfied

Ductility section for shear: 17.10.6.3 (c) is satisfied

Ω_0 factor: not set

Apply entire shear load at front row: No

Anchors only resisting wind and/or seismic loads: No

Strength level loads:

N_{ua} [lb]: 3728

V_{uax} [lb]: 1300

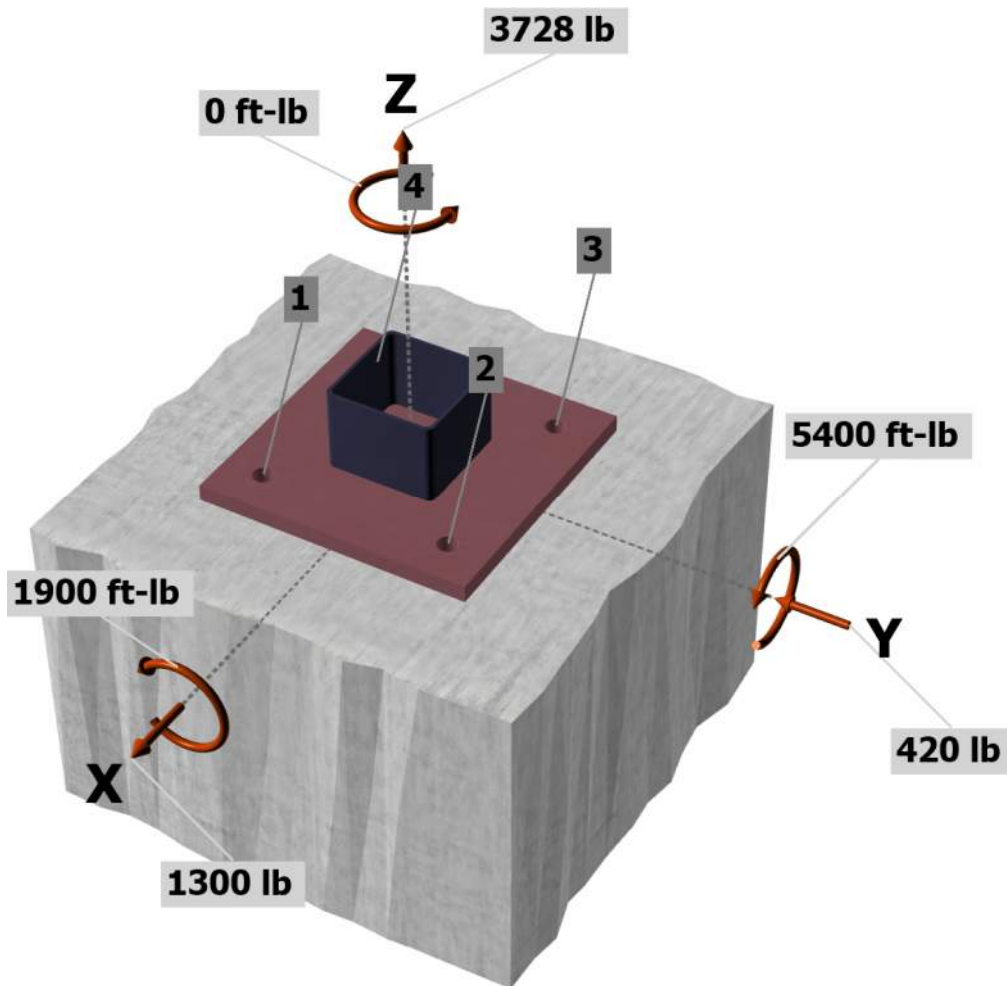
V_{uay} [lb]: -420

M_{ux} [ft-lb]: 1900

M_{uy} [ft-lb]: 5400

M_{uz} [ft-lb]: 0

<Figure 1>



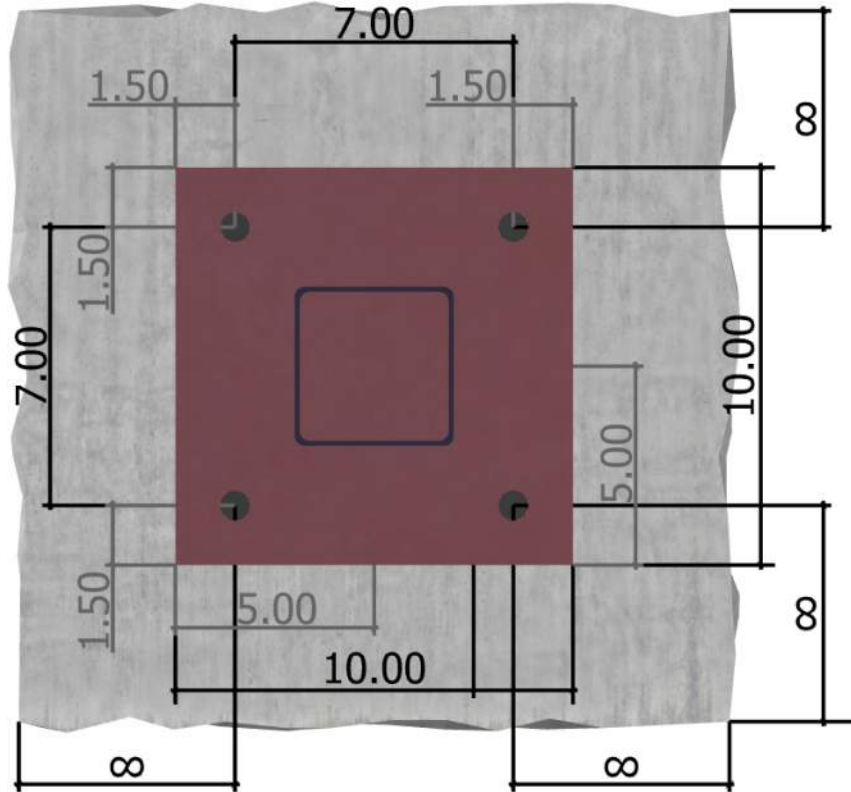
Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.



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<Figure 2>

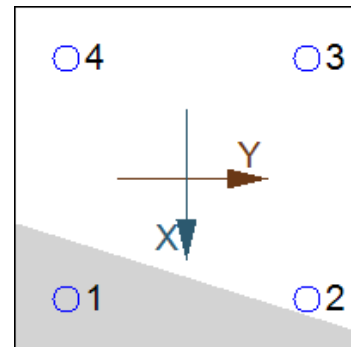


3. Resulting Anchor Forces

Anchor	Tension load, N _{ua} (lb)	Shear load x, V _{uax} (lb)	Shear load y, V _{uay} (lb)	Shear load combined, $\sqrt{(V_{uax})^2 + (V_{uay})^2}$ (lb)
1	0.0	325.0	-105.0	341.5
2	389.9	325.0	-105.0	341.5
3	6184.5	325.0	-105.0	341.5
4	4351.9	325.0	-105.0	341.5
Sum	10926.3	1300.0	-420.0	1366.2

Maximum concrete compression strain (‰): 0.23
 Maximum concrete compression stress (psi): 992
 Resultant tension force (lb): 10926
 Resultant compression force (lb): 7198
 Eccentricity of resultant tension forces in x-axis, e'_{Nx} (inch): 0.45
 Eccentricity of resultant tension forces in y-axis, e'_{Ny} (inch): 2.08
 Eccentricity of resultant shear forces in x-axis, e'_{Vx} (inch): 0.00
 Eccentricity of resultant shear forces in y-axis, e'_{Vy} (inch): 0.00

<Figure 3>





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4. Steel Strength of Anchor in Tension (Sec. 17.6.1)

N_{sa} (lb)	ϕ	ϕN_{sa} (lb)
19370	0.75	14528

5. Concrete Breakout Strength of Anchor in Tension (Sec. 17.6.2)

$$N_b = k_c \lambda_a \sqrt{f'_c} h_{ef}^{1.5} \quad (\text{Eq. 17.6.2.2.1})$$

k_c	λ_a	f'_c (psi)	h_{ef} (in)	N_b (lb)
17.0	1.00	3000	8.000	21069

$$0.75\phi N_{cbg} = 0.75\phi (A_{Nc} / A_{Nco}) \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b \quad (\text{Sec. 17.5.1.2 \& Eq. 17.6.2.1a})$$

A_{Nc} (in ²)	A_{Nco} (in ²)	$C_{a,min}$ (in)	$\Psi_{ec,N}$	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	$0.75\phi N_{cbg}$ (lb)
912.00	576.00	-	0.821	1.000	1.00	1.000	21069	0.65	13351

6. Adhesive Strength of Anchor in Tension (Sec. 17.6.5)

$$\tau_{k,cr} = \tau_{k,cr,short-term} K_{sat} (f'_c / 2,500)^n \alpha_{N,seis}$$

$\tau_{k,cr}$ (psi)	$f_{short-term}$	K_{sat}	$\alpha_{N,seis}$	f'_c (psi)	n	$\tau_{k,cr}$ (psi)
1310	1.00	1.00	1.00	3000	0.24	1369

$$N_{ba} = \lambda_a \tau_{cr} \pi d_a h_{ef} \quad (\text{Eq. 17.6.5.2.1})$$

λ_a	τ_{cr} (psi)	d_a (in)	h_{ef} (in)	N_{ba} (lb)
1.00	1369	0.75	8.000	25797

$$0.75\phi N_{ag} = 0.75\phi (A_{Na} / A_{Na0}) \Psi_{ec,Na} \Psi_{ed,Na} \Psi_{cp,Na} N_{ba} \quad (\text{Sec. 17.5.1.2 \& Eq. 17.6.5.1b})$$

A_{Na} (in ²)	A_{Na0} (in ²)	C_{Na} (in)	$C_{a,min}$ (in)	$\Psi_{ec,Na}$	$\Psi_{ed,Na}$	$\Psi_{cp,Na}$	N_{ba} (lb)	ϕ	$0.75\phi N_{ag}$ (lb)
709.84	422.18	10.27	-	0.796	1.000	1.000	25797	0.65	16835

8. Steel Strength of Anchor in Shear (Sec. 17.7.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\alpha_{V,seis}$	$\phi_{grout} \alpha_{V,seis} \phi V_{sa}$ (lb)
11625	1.0	0.65	0.75	5667

10. Concrete Pryout Strength of Anchor in Shear (Sec. 17.7.3)

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.



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$$\phi V_{cpq} = \phi \min |k_{cp} N_{ag} ; k_{cp} N_{cbg}| = \phi \min |k_{cp} (A_{Na} / A_{Na0}) \Psi_{ec,Na} \Psi_{ed,Na} \Psi_{cp,Na} N_{ba} ; k_{cp} (A_{Nc} / A_{Nc0}) \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b| \text{ (Sec. 17.5.1.2 \& Eq. 17.7.3.1b)}$$

k_{cp}	A_{Na} (in ²)	A_{Na0} (in ²)	$\Psi_{ed,Na}$	$\Psi_{ec,Na}$	$\Psi_{cp,Na}$	N_{ba} (lb)	N_a (lb)
2.0	758.84	422.18	1.000	1.000	1.000	25797	46369

A_{Nc} (in ²)	A_{Nc0} (in ²)	$\Psi_{ec,N}$	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	N_{cb} (lb)	ϕ
961.00	576.00	1.000	1.000	1.000	1.000	21069	35152	0.70

ϕV_{cpq} (lb)

49212

11. Results

Interaction of Tensile and Shear Forces (Sec. 17.8)

Tension	Factored Load, N_{ua} (lb)	Design Strength, ϕN_n (lb)	Ratio	Status	
Steel	6185	14528	0.43	Pass	
Concrete breakout	10926	13351	0.82	Pass (Governs)	
Adhesive	10926	16835	0.65	Pass	
Shear	Factored Load, V_{ua} (lb)	Design Strength, ϕV_n (lb)	Ratio	Status	
Steel	342	5667	0.06	Pass (Governs)	
Pryout	1366	49212	0.03	Pass	
Interaction check	$N_{ua} / \phi N_n$	$V_{ua} / \phi V_n$	Combined Ratio	Permissible	Status
Sec. 17.8.1	0.82	0.00	81.8%	1.0	Pass

SET-3G w/ 3/4"Ø F1554 Gr. 36 with hef = 8.000 inch meets the selected design criteria.

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.

Simpson Strong-Tie Company Inc. 5956 W. Las Positas Boulevard Pleasanton, CA 94588 Phone: 925.560.9000 Fax: 925.847.3871 www.strongtie.com



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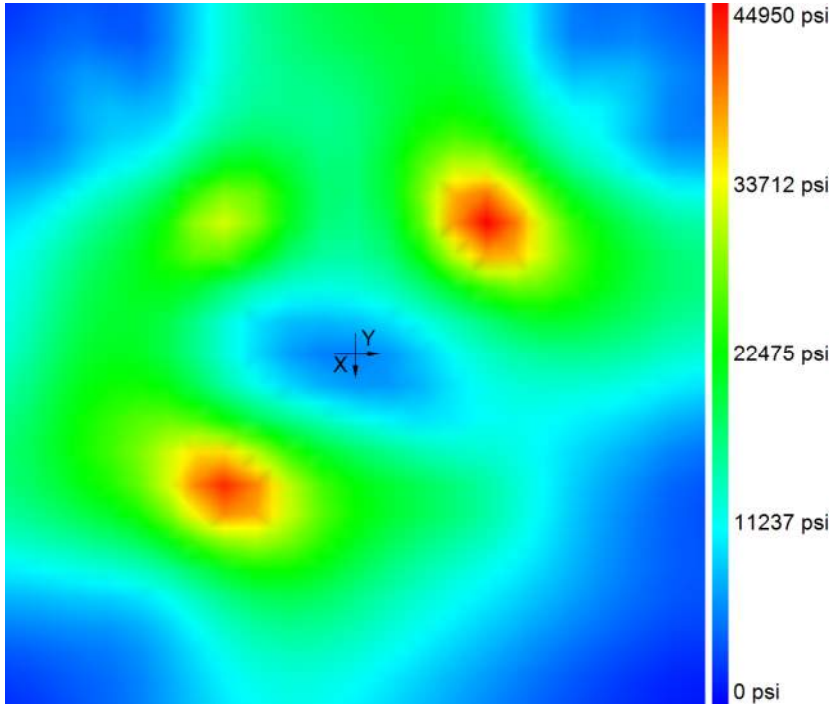
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Base Plate Thickness

Required base plate thickness: 0.625 inch

Steel **50000 psi**
 Maximum stress **44950 psi**
 Calculated plate thickness **0.625 inch**

Stress distribution



For ACI and CSA design methods, maximum base plate stress is limited to 0.9 times yield stress.
 For ETAG design method, maximum base plate stress is limited to yield stress divide by 1.5.
 Plate stress is derived using Von Mises theory.

$$\sigma_{xx} = \frac{F_{xx}}{t} + \frac{6M_{xx}}{t^2} \text{ (@ bottom) or } \sigma_{xx} = \frac{F_{xx}}{t} - \frac{6M_{xx}}{t^2} \text{ (@ top)}$$

$$\sigma_{yy} = \frac{F_{yy}}{t} + \frac{6M_{yy}}{t^2} \text{ (@bottom) or } \sigma_{yy} = \frac{F_{yy}}{t} - \frac{6M_{yy}}{t^2} \text{ (@ top)}$$

$$\sigma_{xy} = \frac{F_{xy}}{t} + \frac{6M_{xy}}{t^2} \text{ (@bottom) or } \sigma_{xy} = \frac{F_{xy}}{t} - \frac{6M_{xy}}{t^2} \text{ (@ top)}$$

$$\sigma_{xz} = \frac{V_x}{t}$$

$$\sigma_{yz} = \frac{V_y}{t}$$

$\sigma_{xx}, \sigma_{yy}, \sigma_{xy}$ as follows:

$$S_1 = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \sigma_{xy}^2}$$

$$S_2 = \frac{\sigma_{xx} + \sigma_{yy}}{2} - \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \sigma_{xy}^2}$$

$$S_3 = 0$$

$$\sigma_{Von\ Mises} = \sqrt{\frac{(S_1 - S_2)^2 + (S_1 - S_3)^2 + (S_2 - S_3)^2}{2}}$$

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.



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12. Warnings

- Per designer input, ductility requirements for tension have been determined to be satisfied – designer to verify.
- Per designer input, ductility requirements for shear have been determined to be satisfied – designer to verify.
- Designer must exercise own judgement to determine if this design is suitable.
- Refer to manufacturer's product literature for hole cleaning and installation instructions.

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1. Project information

Project description: Chiller Narrow Frames

Location:

Fastening description:

Comment:

2. Input Data & Anchor Parameters

General

Design method: ACI 318-19

Units: Imperial units

Anchor Information:

Anchor type: Bonded anchor

Material: F1554 Grade 36

Diameter (inch): 0.750

Effective Embedment depth, h_{ef} (inch): 10.000

Code report: ICC-ES ESR-4057

Anchor category: -

Anchor ductility: Yes

h_{min} (inch): 11.75

c_{ac} (inch): 26.73

C_{min} (inch): 1.75

S_{min} (inch): 3.00

Base Material

Concrete: Normal-weight

Concrete thickness, h (inch): 12.00

State: Cracked

Compressive strength, f'_c (psi): 3000

$\Psi_{c,v}$: 1.0

Reinforcement condition: Supplementary reinforcement not present

Supplemental edge reinforcement: Not applicable

Reinforcement provided at corners: No

Ignore concrete breakout in tension: No

Ignore concrete breakout in shear: No

Hole condition: Dry concrete

Inspection: Periodic

Temperature range, Short/Long: 150/110°F

Reduced installation torque (for AT-3G): Not applicable

Ignore 6do requirement: Not applicable

Build-up grout pad: No

Base Plate

Length x Width x Thickness (inch): 12.00 x 12.00 x 1.00

Yield stress: 50000 psi

Profile type/size: 5X5X1/4

Recommended Anchor

Anchor Name: SET-3G™ - SET-3G w/ 3/4"Ø F1554 Gr. 36

Code Report: ICC-ES ESR-4057



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Load and Geometry

Load factor source: ACI 318 Section 5.3

Load combination: not set

Seismic design: Yes

Anchors subjected to sustained tension: No

Ductility section for tension: 17.10.5.3 (d) is satisfied

Ductility section for shear: 17.10.6.3 (c) is satisfied

Ω_0 factor: not set

Apply entire shear load at front row: No

Anchors only resisting wind and/or seismic loads: No

Strength level loads:

N_{ua} [lb]: 500

V_{uax} [lb]: 2600

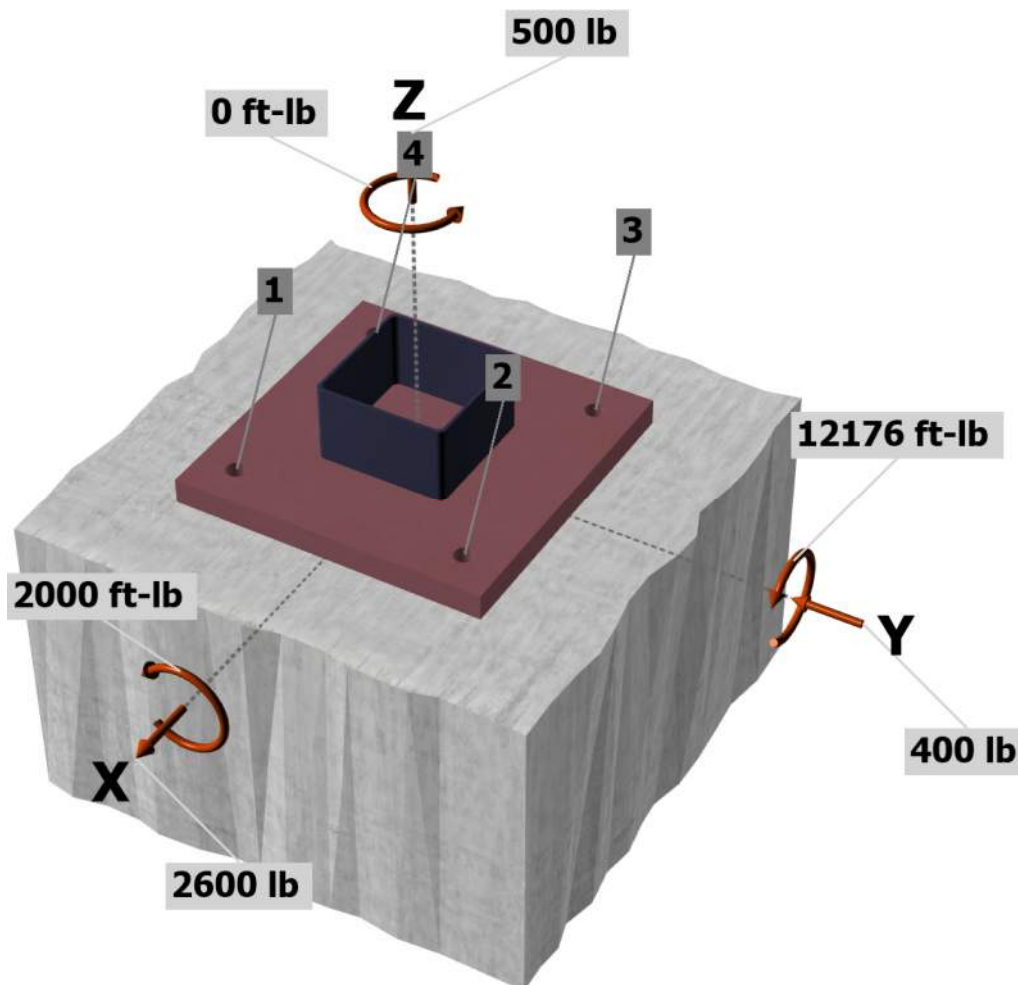
V_{uay} [lb]: -400

M_{ux} [ft-lb]: 2000

M_{uy} [ft-lb]: 12176

M_{uz} [ft-lb]: 0

<Figure 1>



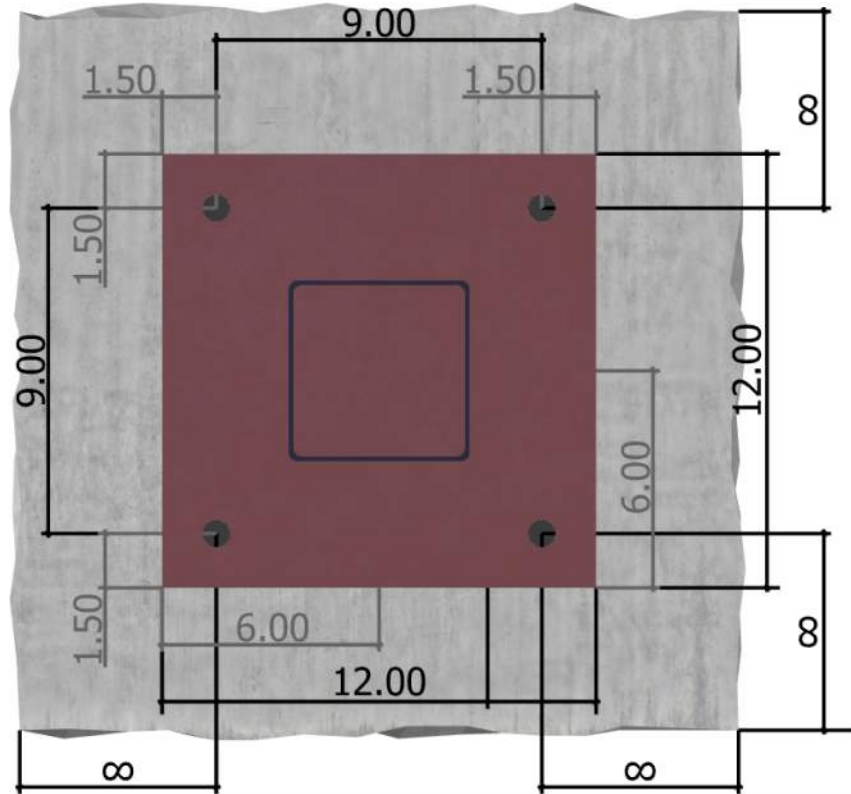
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<Figure 2>

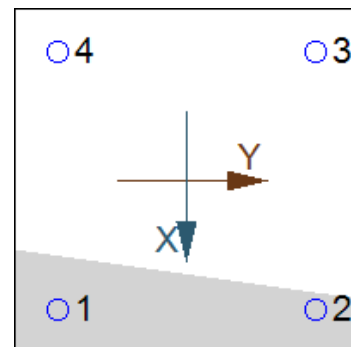


3. Resulting Anchor Forces

Anchor	Tension load, N _{ua} (lb)	Shear load x, V _{uax} (lb)	Shear load y, V _{uay} (lb)	Shear load combined, $\sqrt{(V_{uax})^2 + (V_{uay})^2}$ (lb)
1	0.0	650.0	-100.0	657.6
2	0.0	650.0	-100.0	657.6
3	8442.2	650.0	-100.0	657.6
4	7155.0	650.0	-100.0	657.6
Sum	15597.3	2600.0	-400.0	2630.6

Maximum concrete compression strain (‰): 0.27
 Maximum concrete compression stress (psi): 1165
 Resultant tension force (lb): 15597
 Resultant compression force (lb): 15097
 Eccentricity of resultant tension forces in x-axis, e'_{Nx} (inch): 0.37
 Eccentricity of resultant tension forces in y-axis, e'_{Ny} (inch): 0.00
 Eccentricity of resultant shear forces in x-axis, e'_{Vx} (inch): 0.00
 Eccentricity of resultant shear forces in y-axis, e'_{Vy} (inch): 0.00

<Figure 3>



Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.



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4. Steel Strength of Anchor in Tension (Sec. 17.6.1)

N_{sa} (lb)	ϕ	ϕN_{sa} (lb)
19370	0.75	14528

5. Concrete Breakout Strength of Anchor in Tension (Sec. 17.6.2)

$$N_b = k_c \lambda_a \sqrt{f'_c} h_{ef}^{1.5} \quad (\text{Eq. 17.6.2.2.1})$$

k_c	λ_a	f'_c (psi)	h_{ef} (in)	N_b (lb)
17.0	1.00	3000	10.000	29445

$$0.75\phi N_{cbg} = 0.75\phi (A_{Nc} / A_{Nco}) \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b \quad (\text{Sec. 17.5.1.2 \& Eq. 17.6.2.1a})$$

A_{Nc} (in ²)	A_{Nco} (in ²)	$C_{a,min}$ (in)	$\Psi_{ec,N}$	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	$0.75\phi N_{cbg}$ (lb)
1170.00	900.00	-	0.976	1.000	1.00	1.000	29445	0.65	18210

6. Adhesive Strength of Anchor in Tension (Sec. 17.6.5)

$$\tau_{k,cr} = \tau_{k,cr,short-term} K_{sat} (f'_c / 2,500)^n \alpha_{N,seis}$$

$\tau_{k,cr}$ (psi)	$f_{short-term}$	K_{sat}	$\alpha_{N,seis}$	f'_c (psi)	n	$\tau_{k,cr}$ (psi)
1310	1.00	1.00	1.00	3000	0.24	1369

$$N_{ba} = \lambda_a \tau_{cr} \pi d_a h_{ef} \quad (\text{Eq. 17.6.5.2.1})$$

λ_a	τ_{cr} (psi)	d_a (in)	h_{ef} (in)	N_{ba} (lb)
1.00	1369	0.75	10.000	32247

$$0.75\phi N_{ag} = 0.75\phi (A_{Na} / A_{Na0}) \Psi_{ec,Na} \Psi_{ed,Na} \Psi_{cp,Na} N_{ba} \quad (\text{Sec. 17.5.1.2 \& Eq. 17.6.5.1b})$$

A_{Na} (in ²)	A_{Na0} (in ²)	C_{Na} (in)	$C_{a,min}$ (in)	$\Psi_{ec,Na}$	$\Psi_{ed,Na}$	$\Psi_{cp,Na}$	N_{ba} (lb)	ϕ	$0.75\phi N_{ag}$ (lb)
607.11	422.18	10.27	-	0.965	1.000	1.000	32247	0.65	21817

8. Steel Strength of Anchor in Shear (Sec. 17.7.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\alpha_{V,seis}$	$\phi_{grout} \alpha_{V,seis} \phi V_{sa}$ (lb)
11625	1.0	0.65	0.75	5667

10. Concrete Pryout Strength of Anchor in Shear (Sec. 17.7.3)

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.



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$$\phi V_{cpq} = \phi \min |k_{cp} N_{ag}; k_{cp} N_{cbg}| = \phi \min |k_{cp} (A_{Na} / A_{Na0}) \Psi_{ec,Na} \Psi_{ed,Na} \Psi_{cp,Na} N_{ba}; k_{cp} (A_{Nc} / A_{Nc0}) \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b| \text{ (Sec. 17.5.1.2 \& Eq. 17.7.3.1b)}$$

k_{cp}	A_{Na} (in ²)	A_{Na0} (in ²)	$\Psi_{ed,Na}$	$\Psi_{ec,Na}$	$\Psi_{cp,Na}$	N_{ba} (lb)	N_a (lb)
2.0	873.03	422.18	1.000	1.000	1.000	32247	66683

A_{Nc} (in ²)	A_{Nc0} (in ²)	$\Psi_{ec,N}$	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	N_{cb} (lb)	ϕ
1521.00	900.00	1.000	1.000	1.000	1.000	29445	49762	0.70

ϕV_{cpq} (lb)

69667

11. Results

Interaction of Tensile and Shear Forces (Sec. 17.8)

Tension	Factored Load, N_{ua} (lb)	Design Strength, ϕN_n (lb)	Ratio	Status	
Steel	8442	14528	0.58	Pass	
Concrete breakout	15597	18210	0.86	Pass (Governs)	
Adhesive	15597	21817	0.71	Pass	
Shear	Factored Load, V_{ua} (lb)	Design Strength, ϕV_n (lb)	Ratio	Status	
Steel	658	5667	0.12	Pass (Governs)	
Pryout	2631	69667	0.04	Pass	
Interaction check	$N_{ua} / \phi N_n$	$V_{ua} / \phi V_n$	Combined Ratio	Permissible	Status
Sec. 17.8.1	0.86	0.00	85.7%	1.0	Pass

SET-3G w/ 3/4"Ø F1554 Gr. 36 with hef = 10.000 inch meets the selected design criteria.

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.

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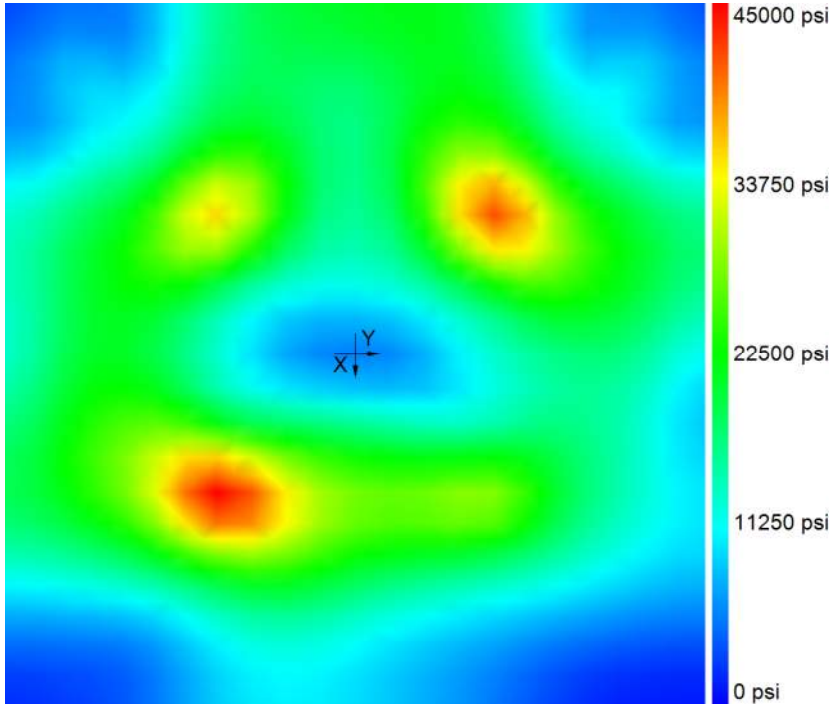
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Base Plate Thickness

Required base plate thickness: 0.784 inch

Steel **50000 psi**
 Maximum stress **45000 psi**
 Calculated plate thickness **0.784 inch**

Stress distribution



For ACI and CSA design methods, maximum base plate stress is limited to 0.9 times yield stress.
 For ETAG design method, maximum base plate stress is limited to yield stress divide by 1.5.
 Plate stress is derived using Von Mises theory.

$$\sigma_{xx} = \frac{F_{xx}}{t} + \frac{6M_{xx}}{t^2} \text{ (@ bottom) or } \sigma_{xx} = \frac{F_{xx}}{t} - \frac{6M_{xx}}{t^2} \text{ (@ top)}$$

$$\sigma_{yy} = \frac{F_{yy}}{t} + \frac{6M_{yy}}{t^2} \text{ (@bottom) or } \sigma_{yy} = \frac{F_{yy}}{t} - \frac{6M_{yy}}{t^2} \text{ (@ top)}$$

$$\sigma_{xy} = \frac{F_{xy}}{t} + \frac{6M_{xy}}{t^2} \text{ (@bottom) or } \sigma_{xy} = \frac{F_{xy}}{t} - \frac{6M_{xy}}{t^2} \text{ (@ top)}$$

$$\sigma_{xz} = \frac{V_x}{t}$$

$$\sigma_{yz} = \frac{V_y}{t}$$

$\sigma_{xx}, \sigma_{yy}, \sigma_{xy}$ as follows:

$$S_1 = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \sigma_{xy}^2}$$

$$S_2 = \frac{\sigma_{xx} + \sigma_{yy}}{2} - \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \sigma_{xy}^2}$$

$$S_3 = 0$$

$$\sigma_{Von\ Mises} = \sqrt{\frac{(S_1 - S_2)^2 + (S_1 - S_3)^2 + (S_2 - S_3)^2}{2}}$$



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12. Warnings

- Per designer input, ductility requirements for tension have been determined to be satisfied – designer to verify.
- Per designer input, ductility requirements for shear have been determined to be satisfied – designer to verify.
- Designer must exercise own judgement to determine if this design is suitable.
- Refer to manufacturer's product literature for hole cleaning and installation instructions.



QUANTUM | CONSULTING ENGINEERS

CENTERIS SOUTH YARD

1023 39TH AVE SE
PUYALLUP, WA 38374

QUANTUM JOB NUMBER: 23444.01

EQUIPMENT ANCHORAGE



Diesel Generator Set

mtu 20V4000 DS3250 43 °C

3,250 kWe/60 Hz/Standby/480 - 13,800V



System ratings

Voltage (L-L)	480V † ‡	600V ‡	4,160V	12,470V	13,200V	13,800V
Phase	3	3	3	3	3	3
PF	0.8	0.8	0.8	0.8	0.8	0.8
Hz	60	60	60	60	60	60
kW	3,250	3,250	3,250	3,250	3,250	3,250
kVA	4,062	4,062	4,062	4,062	4,062	4,062
Amps	4,886	3,909	563	188	177	170
skVA@30% voltage dip	7,061	1,028	8,171	5,297	5,936	6,488
Generator model*	941-VL60	941-VL70	941-M60	4P9.6-2400	4P9.6-2400	4P9.6-2400
Temp rise	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C
Connection	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE

* Consult the factory for alternate configuration. Generator model may end with -M or -R, depending on selection.

† UL 2200 offered

‡ CSA offered

Certifications and standards

- Emissions
 - EPA Tier 2 certified
 - South Coast Air Quality Management District (SCAQMD)
- Generator set is designed and manufactured in facilities certified to standards ISO 9001:2008 and ISO 14001:2004
- Seismic certification – optional
 - 2021 IBC certification
 - HCAI pre-approval
- UL 2200 - optional (refer to *System ratings* for availability)
- CSA - optional (refer to *System ratings* for availability)
 - CSA C22.2 No. 100
 - CSA C22.2 No. 14
- Performance Assurance Certification (PAC)
 - Generator set tested to ISO 8528-5 for transient response
 - Verified product design, quality, and performance integrity
 - All engine systems are prototype and factory tested
- Power rating
 - Accepts rated load in one step per NFPA 110
 - Permissible average power output during 24 hours of operation is approved up to 85%.

Standard features*

- Single source supplier
- Global product support
- Two (2) Year/3,000 Hour Basic Limited Warranty
- 20V4000 diesel engine
 - 95.4 liter displacement
 - Common rail fuel injection
 - 4-cycle
- HVO and GtL fuels meeting fuel specification EN15940
- Complete range of accessories
- Cooling system
 - Integral set-mounted
 - Engine-driven fan
- Generator
 - Brushless, rotating field generator
 - 2/3 pitch windings
 - Permanent Magnet Generator (PMG) supply to regulator
 - 300% short circuit capability
- Digital control panel(s)
 - UL recognized, CSA certified, NFPA 110
 - Complete system metering
 - LCD display

Standard equipment*

Engine

- Air cleaners
- Oil pump
- Oil drain extension and shut-off valve
- Full flow oil filter
- Closed crankcase ventilation
- Jacket water pump
- Inter cooler water pump
- Thermostats
- Blower fan and fan drive
- Radiator - unit mounted
- Electric starting motor - 24V
- Governor - electronic isochronous
- Base - structural steel
- SAE flywheel and bell housing
- Charging alternator - 24V
- Battery box and cables
- Bulkhead fuel connectors
- Flexible exhaust connection
- EPA certified engine

Generator

- NEMA MG1, IEEE, and ANSI standards compliance for temperature rise and motor starting
- Sustained short circuit current of up to 300% of the rated current for up to 10 seconds
- Self-ventilated and drip-proof
- Superior voltage waveform
- Digital, solid state, volts-per-hertz regulator
- Brushless alternator with brushless pilot exciter
- 4 pole, rotating field
- 130 °C maximum standby temperature rise
- 2-bearing, sealed
- Flexible coupling
- Full amortisseur windings
- 125% rotor balancing
- 3-phase voltage sensing
- $\pm 0.25\%$ voltage regulation no load to full load
- 5% maximum total harmonic distortion

Digital control panel(s)

- Digital metering
- Engine parameters
- Generator protection functions
- Engine protection
- CANBus ECU communications
- Windows®-based software
- Multilingual capability
- Communications to remote annunciator
- Programmable input and output contacts
- UL recognized, CSA certified, CE approved
- Event recording
- IP 54 front panel rating with integrated gasket
- NFPA 110 compatible

Application data

Engine

Manufacturer	mtu
Model	20V4000G94S
Type	4-cycle
Arrangement	20-V
Displacement: L (in ³)	95.4 (5,822)
Bore: cm (in)	17 (6.69)
Stroke: cm (in)	21 (8.27)
Compression ratio	16.4:1
Rated rpm	1,800
Engine governor	electronic isochronous (ADEC)
Maximum power: kWm (bhp)	3,490 (4,680)
Steady state frequency band	± 0.25%
Air cleaner	dry

Liquid capacity

Total oil system: L (gal)	390 (103)
Engine jacket water capacity: L (gal)	205 (54.2)
After cooler water capacity: L (gal)	50 (13.2)
System coolant capacity: L (gal)	860 (227)

Electrical

Electric volts DC	24
Cold cranking amps under -17.8 °C (0 °F)	4,200
Batteries: group size	8D
Batteries: quantity	6

Fuel system

Fuel supply connection size	-16 JIC 37° female 1" NPT adapter provided
Fuel return connection size	-16 JIC 37° female 1" NPT adapter provided
Maximum fuel lift - cranking: m (ft)	1 (3.3)*
Maximum fuel lift - running: m (ft)	3.1 (10)
Recommended fuel	diesel #2/HVO
Total fuel flow: L/hr (gal/hr)	1,620 (428)

* Fuel lift pump for cranking increases lift to: m (ft) 3.1 (10)

Fuel consumption

At 100% of power rating: L/hr (gal/hr)	844 (223)
At 75% of power rating: L/hr (gal/hr)	644 (170)
At 50% of power rating: L/hr (gal/hr)	447 (118)

Cooling - radiator system

Ambient capacity of radiator: °C (°F)	43 (108)
Maximum restriction of cooling air: intake and discharge side of radiator: kPa (in. H ₂ O)	0.12 (0.5)
Water pump capacity: L/min (gpm)	1,567 (414)
After cooler pump capacity: L/min (gpm)	567 (150)
Heat rejection to coolant: kW (BTUM)	1,300 (73,929)
Heat rejection to after cooler: kW (BTUM)	970 (55,163)
Heat radiated to ambient: kW (BTUM)	237 (13,472)
Fan power: kW (hp)	60.6 (81.3)

Air requirements

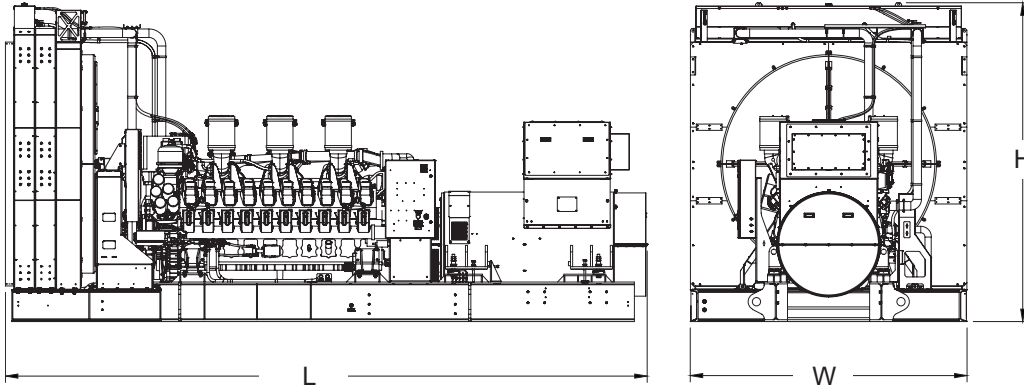
Aspirating: *m ³ /min (SCFM)	264 (9,323)
Air flow required for radiator cooled unit: *m ³ /min (SCFM)	3,082 (108,843)
Remote cooled applications; air flow required for dissipation of radiated generator set heat for a maximum of 25 °F rise: *m ³ /min (SCFM)	866 (30,384)

* Air density = 1.184 kg/m³ (0.0739 lbm/ft³)

Exhaust system

Gas temperature (stack): °C (°F)	525 (977)
Gas volume at stack temperature: m ³ /min (CFM)	702 (24,791)
Maximum allowable back pressure at outlet of engine, before piping: kPa (in. H ₂ O)	8.5 (34.1)

Weights and dimensions



Drawing above for illustration purposes only, based on standard open power 480 volt generator set. Lengths may vary with other voltages. Do not use for installation design. See website for unit specific template drawings.

System	Dimensions (L x W x H)	Weight
Open Power Unit (OPU)	7,756 x 3,072 x 3,590 mm (305.4 x 120.9 x 141.3 in)	27,340 kg (60,284 lb)

Weights and dimensions are based on open power units and are estimates only. Consult the factory for accurate weights and dimensions for your specific generator set.

Sound data

Unit type	Standby full load
Level 0 (OPU): dB(A)	95.1

Sound data is provided at 7 m (23 ft). Generator set tested in accordance with ISO 8528-10 and with infinite exhaust.

Emissions data

NO _x + NMHC	CO	PM
5.1	0.6	0.03

– All units are in g/hp-hr and shown at 100% load (not comparable to EPA weighted cycle values). Emission levels of the engine may vary with ambient temperature, barometric pressure, humidity, fuel type and quality, installation parameters, measuring instrumentation, etc. The data was obtained in compliance with US EPA regulations. The weighted cycle value (not shown) from each engine is guaranteed to be within the US EPA standards.

Rating definitions and conditions

- Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. No overload capability for this rating. Ratings are in accordance with ISO 8528-1, ISO 3046-1, BS 5514, and AS 2789. Average load factor: ≤ 85%.
- Nominal ratings at standard conditions: 25 °C and 300 meters (77 °F and 1,000 feet).
- Deration Factor:
 - Consult your local **mtu** Distributor for altitude derations.
 - Consult your local **mtu** Distributor for temperature derations.

3.25 mW Rolls Royce Generator Anchorage & Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

2.) Generator

Weight: 60.3 kips
 Total Height H: 141 in
 Total Width B: 121 in
 Total Width L: 305 in
 Center of Gravity: 88.125 in
 Snow Load: 25 psf

2) Seismic Design per ASCE 7-16 Chapter 13 Non-Structural Components

Electrical Components

ap = 1
 Rp = 2.5
 Sds = 1.01
 Ie = 1.25

Lateral Loads

Lateral resistance is provided by the Generator anchored to the concrete slab.

Fp = 12.18 kips ASCE 7-16 EQ 13.3-1
 X Fpmin = 22.83 kips ASCE 7-16 EQ 13.3-2 Controls
 Fpmax = 121.77 kips ASCE 7-16 EQ 13.3-3

EQ = 22.83 kips

Shear Connection

Number of Anchors = 2.0
 Anchor Shear = $V \cdot \Omega / \#$ = 11 kips/anchor < Capacity = 7.1 kips OK
 3/4" Titen HD Screw Anchors
 with 4 1/2" Embed

Overturning Resistance About Width

	C.O.G.	EQ	OT Moment
Generator	88.125 in	22.8 kips	168 k-ft

	Moment Arm	DL	Res. Moment
Resisting Dead Load	60.5 in	60.3 kips	304 k-ft

F.O.S. = M_R / M_{OT} = 1.8 Use Tension Capacity of Anchors

Anchor Tension = $M / d / \#$ = 16.6 kips/anchor < Capacity = 35.7 kips OK



Quantum Consulting Engineers LLC
 1511 Third Avenue, Suite 323
 Seattle, WA 98101

Project: Centeris Data Centers

Date: 9/3/24

Job No: 23444.01

Designer: TVM

Sheet: 1

Client: Centeris

Checked:

York Air Cooled Screw Generator Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

3) Wind Design per ASCE 7-16 Chapter 29 Non-Building Structure Procedure

Wind Speed V:	104.0 mph	ASCE 7-16 Risk Category III
Exposure Cat.	B	
Exposure Coe Kz:	0.62	Table 26.10-1 (H = 20')
Direction Coe. Kd:	0.85	Table 26.6-1
Topo Coe. Kzt:	1.00	Sec. 26.8
V_Pressure qz =	14.6 psf	EQ 26.10-1
Gust Factor G:	0.85	Sec 26.11
Af =	299 sqft	
h/d =	1.17	
Cf =	1.30	Figure 29.4-1
F =	4.82 kips	EQ 29.4-1

Shear Connection

WL < EQ Shear Connection OK By Inspection

Overturing Resistance About Width

$M_{OT} = F \cdot H / 2$	28 k-ft
$M_R = DL \cdot W / 2$	304 k-ft
F.O.S. = $M_R / M_{OT} =$	10.7 OK



Quantum Consulting Engineers LLC
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Seattle, WA 98101

Project: **Centeris Data Centers**

Date: **9/3/24**

Job No: **23444.01**

Designer: **TVM**

Sheet: **2**

Client: **Centeris**

Checked:

York Air Cooled Screw Generator Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

4) Foundation Design

Bearing Analysis

Allowable Bearing 2000 psf
 Footing Width: 6.5 ft
 Footing Length: 6.5 ft
 Thickened Edge Width: 1.0 ft

Dead Load: 60 kips
 Snow Load: 1.1 kips
 1.0DL+1.0SL Pressure: 2359 psf < 2000 psf OK

Earthquake OT 168 k-ft
 Applied Pressure: 3968 psf
 1.15DL+0.7EQ Pressure: 5444 psf < 2000 psf * (4/3) OK

Sliding Analysis

Slab-on-Grade Thickness 8 in

Allow. Coefficient of Friction: 0.3
 (0.7) Earthquake : 16.0 kips
 Dead Load: 65 kips Includes Slab-on-Grade Weight
 Sliding Resistance: 19.35 kips
 Unity Check $U_c =$ 1.21 > 1.0 OK



Quantum Consulting Engineers LLC
 1511 Third Avenue, Suite 323
 Seattle, WA 98101

Project: **Centeris Data Centers**

Date: **9/3/24**

Job No: **23444.01**

Designer: **TVM**

Sheet: **3**

Client: **Centeris**

Checked:



KWIK Bolt 3 Expansion Anchor 3.3.6

Table 8 - Stainless Steel KWIK Bolt 3 Allowable Loads in Normal-Weight Concrete¹

Anchor Diameter in. (mm)	Embedment Depth in. (mm)	$f'_c = 2000$ psi (13.8 MPa)		$f'_c = 3000$ psi (20.7 MPa)		$f'_c = 4000$ psi (27.6 MPa)		$f'_c = 6000$ psi (41.4 MPa)	
		Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)
1/4 (6.4)	1-1/8 (29)	260 (1.2)	595 (2.6)	320 (1.4)	675 (3.0)	380 (1.7)	725 (3.2)	470 (2.1)	805 (3.6)
	2 (51)	540 (2.4)	675 (3.0)	625 (2.8)		705 (3.1)	805 (3.6)	910 (4.0)	
	3 (76)	685 (3)		750 (3.3)		810 (3.6)			
3/8 (9.5)	1-5/8 (41)	605 (2.7)	880 (3.9)	670 (3.0)	1110 (4.9)	730 (3.2)	1345 (6.0)	950 (4.2)	1690 (7.5)
	2-1/2 (64)	1285 (5.7)	1570 (7.0)	1430 (6.4)	1570 (7.0)	1575 (7.0)	1590 (7.1)	1940 (8.6)	1590 (7.1)
	3-1/2 (89)	1620 (7.2)		1755 (7.8)		1885 (8.4)		2035 (9.1)	
1/2 (12.7)	2-1/4 (57)	1015 (4.5)	1875 (8.3)	1230 (5.5)	2130 (9.5)	1450 (6.4)	2380 (10.6)	1620 (7.2)	2740 (12.2)
	3-1/2 (89)	1445 (6.4)	3010 (13.4)	1975 (8.8)	3010 (13.4)	2510 (11.2)	3045 (13.5)	2655 (11.8)	3045 (13.5)
	4-3/4 (121)	1990 (8.9)		2250 (10.0)		2985 (13.3)			
5/8 (15.9)	2-3/4 (70)	1650 (7.3)	2875 (12.8)	1755 (7.8)	3485 (15.5)	1860 (8.3)	4095 (18.2)	2335 (10.4)	4625 (20.6)
	4 (102)	2455 (10.9)	4625 (20.6)	2900 (12.9)	4625 (20.6)	3340 (14.9)	4625 (20.6)	4395 (19.5)	
	5-1/2 (140)	3480 (15.5)		3885 (17.3)		4290 (19.1)		6260 (27.8)	
3/4 (19.1)	3-1/4 (83)	1550 (6.9)	3945 (17.5)	1950 (8.7)	4260 (18.9)	2350 (10.5)	5645 (25.1)	2610 (11.6)	5645 (25.1)
	4-3/4 (121)	2510 (11.2)	5535 (24.6)	3250 (14.5)	5535 (24.6)	3870 (17.2)		4670 (20.8)	
	8 (203)	2930 (13.0)		3735 (16.6)		4530 (20.2)				5120 (22.9)
1 (25.4)	4-1/2 (114)	3120 (13.9)	6080 (27.0)	3870 (17.2)	6770 (30.1)	4610 (20.5)	7470 (33.2)	4800 (21.4)	7470 (33.2)
	6 (152)	4400 (19.6)	7470 (33.2)	6400 (28.5)	7470 (33.2)	7200 (32.0)		7330 (32.6)	
	9 (229)	5600 (24.9)		8000 (35.6)		9390 (41.8)				9390 (41.8)

¹ Intermediate load values for other concrete strengths and embedments can be calculated by linear interpolation.

DWG NO. 0073180093.842

HOWARD INDUSTRIES INC.

LAUREL, MISS. USA 39440

THREE PHASE PAD DISTRIBUTION TRANSFORMERS

CUSTOMER : CORE

SPEC. CORE DATED

KVA 3000.0 BIL 95 TAPS SPECIAL

HIGH VOLTAGE 13200

LOW VOLTAGE 480Y/277

APPROX. CORE AND COIL WEIGHT 7261

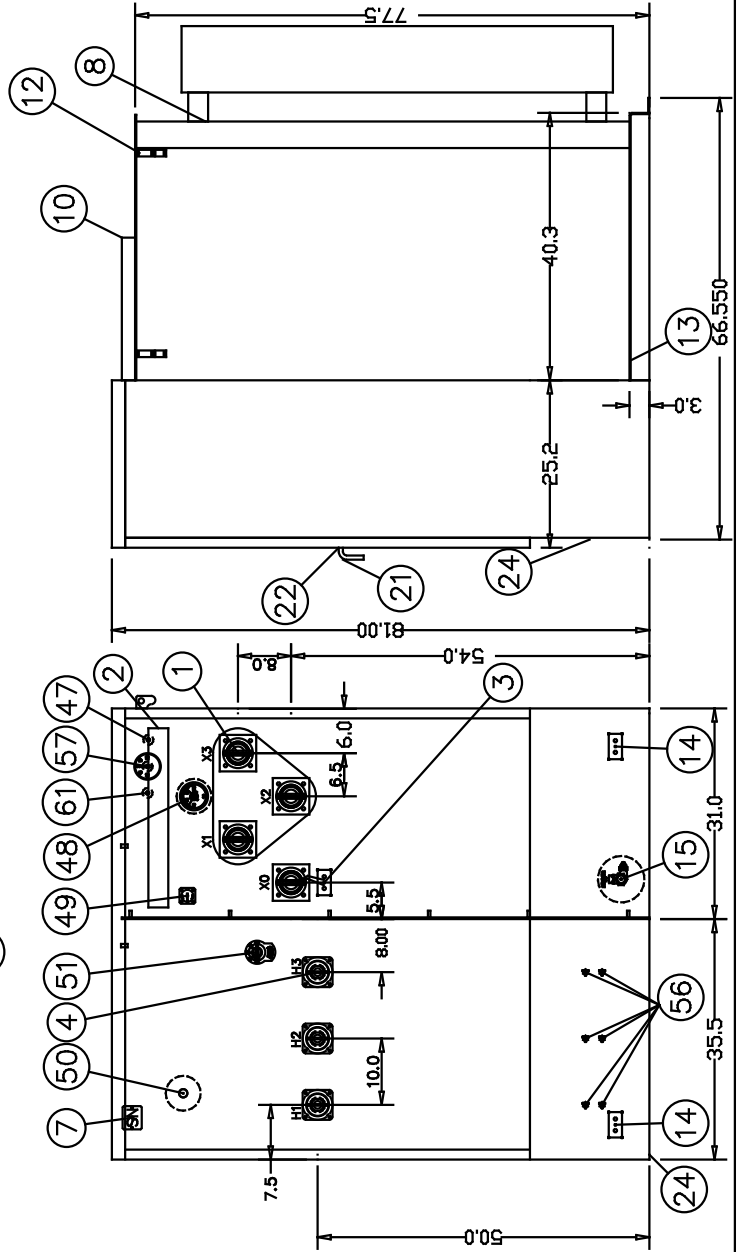
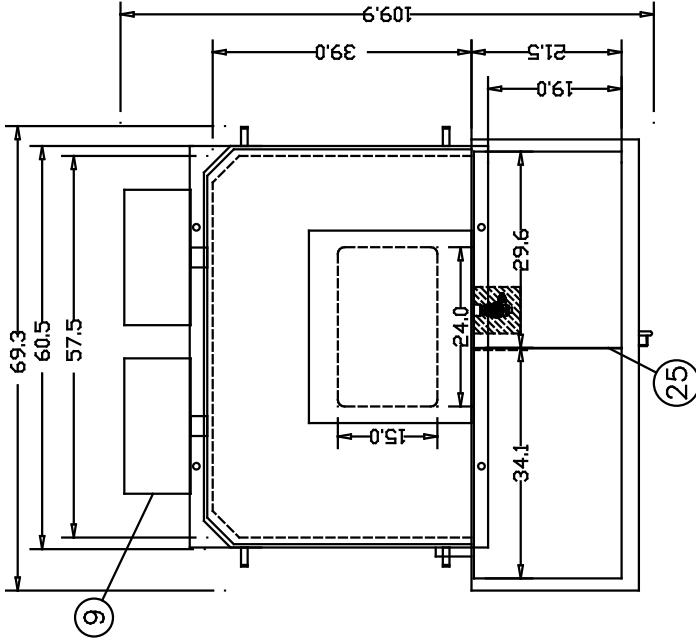
APPROX. TANK AND ACCESS. WEIGHT 3166

GAL. OF OIL 560 J APPROX. WEIGHT 4201

APPROX. TOTAL WEIGHT 14628

REV.	DATE	DESCRIPTION	BY	APP
A				

0073180093.842



DESCRIPTION	CAT NO
1 LV BUSHING W/INT. 10H SPADE	9397435696028
2 LV SPADE SUPPORT	JF
3 2 HOLE HORIZ NEMA GRD PAD	DATE: 08/24/22
4 HV PORC 95BIL W/2H G-SPADE	APP BY: CM
7 NP ON DOOR, SERIAL ON TANK	CC: 745
8 TANK	
9 COOLING RADIATORS	
10 HANDHOLE & SECURITY COVER	
12 LIFTING LUGS	
13 JACKING PROVISIONS	
14 2 HOLE HORIZ NEMA GRD PAD	
15 1 IN DRAIN VALVE AND SAMPLER	
21 PADLOCKABLE DOOR HANDLE	
22 3 PT LATCH PENTA SEC BOLT	
24 18 IN REMOVABLE SILL	
25 METAL LV-HV BARRIER	
47 PRV VIAT 301-010-01N	
48 DIAL THERM W/MAX POINTER	
49 2" MAGNETIC LL GAUGE	
50 OIL LEVEL PLUG	
51 TAP CHANGER HANDLE	
56 PROVISIONS FOR LTG ARR	
57 PRES VAC GAUGE	
61 SCHRADER BLEED VALVE	
SPECIAL NOTES	
A	
B	
C	
D	
E	

3000 KVA Transformer Anchorage & Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

2.) Transformer

Weight: 14.6 kips
 Total Height H: 81 in
 Total Width B: 69.3 in
 Total Width L: 109.9 in
 Center of Gravity: 54 in
 Snow Load: 25 psf

2) Seismic Design per ASCE 7-16 Chapter 13 Non-Structural Components

Electrical Components

ap = 1
 Rp = 2.5
 Sds = 1.01
 Ie = 1.25

Lateral Loads

Lateral resistance is provided by the transformer anchored to the concrete slab.

Fp = 2.96 kips ASCE 7-16 EQ 13.3-1
 X Fpmin = 5.54 kips ASCE 7-16 EQ 13.3-2 Controls
 Fpmax = 29.55 kips ASCE 7-16 EQ 13.3-3

EQ = 5.54 kips

Shear Connection

Number of Anchors = 2.0 3/4" Titen HD Screw Anchors
 with 4 1/2" Embed
 Anchor Shear = $V \cdot \Omega / \# = 2.77$ kips/anchor < Capacity = 7.1 kips OK

Overturning Resistance About Width

	C.O.G.	EQ	OT Moment
transformer	54 in	5.5 kips	24.9 k-ft

	Moment Arm	DL	Res. Moment
Resisting Dead Load	20 in	14.6 kips	24 k-ft

F.O.S. = $M_R / M_{OT} = 1.0$ Use Tension Capacity of Anchors

Anchor Tension = $M / d / \# = 7.5$ kips/anchor < Capacity = 35.7 kips OK

3000 KVA Transformer Anchorage & Foundation Desig

IBC 2021, ASCE 7-16, ACI 318-19

3) Wind Design per ASCE 7-16 Chapter 29 Non-Building Structure Procedure


Wind Speed V:	104.0	mph	ASCE 7-16 Risk Category III
Exposure Cat.	B		
Exposure Coe Kz:	0.62		Table 26.10-1 (H = 20')
Direction Coe. Kd:	0.85		Table 26.6-1
Topo Coe. Kzt:	1.00		Sec. 26.8
V_Pressure qz =	14.6	psf	EQ 26.10-1
Gust Factor G:	0.85		Sec 26.11
Af =	62	sqft	
h/d =	1.17		
Cf =	1.30		Figure 29.4-1
F =	1.00	kips	EQ 29.4-1

Shear Connection

WL < EQ Shear Connection OK By Inspection

Overturing Resistance About Width

$M_{OT} = F \cdot H / 2$	3	k-ft
$M_R = DL \cdot W / 2$	42	k-ft
F.O.S. = $M_R / M_{OT} =$	12.6	OK

	Quantum Consulting Engineers LLC	Project: Centeris Data Centers	Date: 2/2/24	Job No: 23444.01
	1511 Third Avenue, Suite 323		Designer: TVM	Sheet: 2
	Seattle, WA 98101	Client: Benaroya	Checked:	

3000 KVA Transformer Anchorage & Foundation Desig

IBC 2021, ASCE 7-16, ACI 318-19

4) Foundation Design

Bearing Analysis

Allowable Bearing 2000 psf
 Footing Width: 6.5 ft
 Footing Length: 6.5 ft
 Thickened Edge Width: 1.0 ft

Dead Load: 15 kips
 Snow Load: 1.1 kips
 1.0DL+1.0SL Pressure: 603 psf < 2000 psf OK

Earthquake OT 25 k-ft
 Applied Pressure: 590 psf
 1.15DL+0.7EQ Pressure: 1060 psf < 2000 psf * (4/3) OK

Sliding Analysis

Slab-on-Grade Thickness 8 in

Allow. Coefficient of Friction: 0.3
 (0.7) Earthquake : 3.9 kips
 Dead Load: 19 kips Includes Slab-on-Grade Weight
 Sliding Resistance: 5.66 kips
 Unity Check $U_c =$ 1.46 > 1.0 OK



Quantum Consulting Engineers LLC
 1511 Third Avenue, Suite 323
 Seattle, WA 98101

Project: Centeris Data Centers

Date: 2/2/24

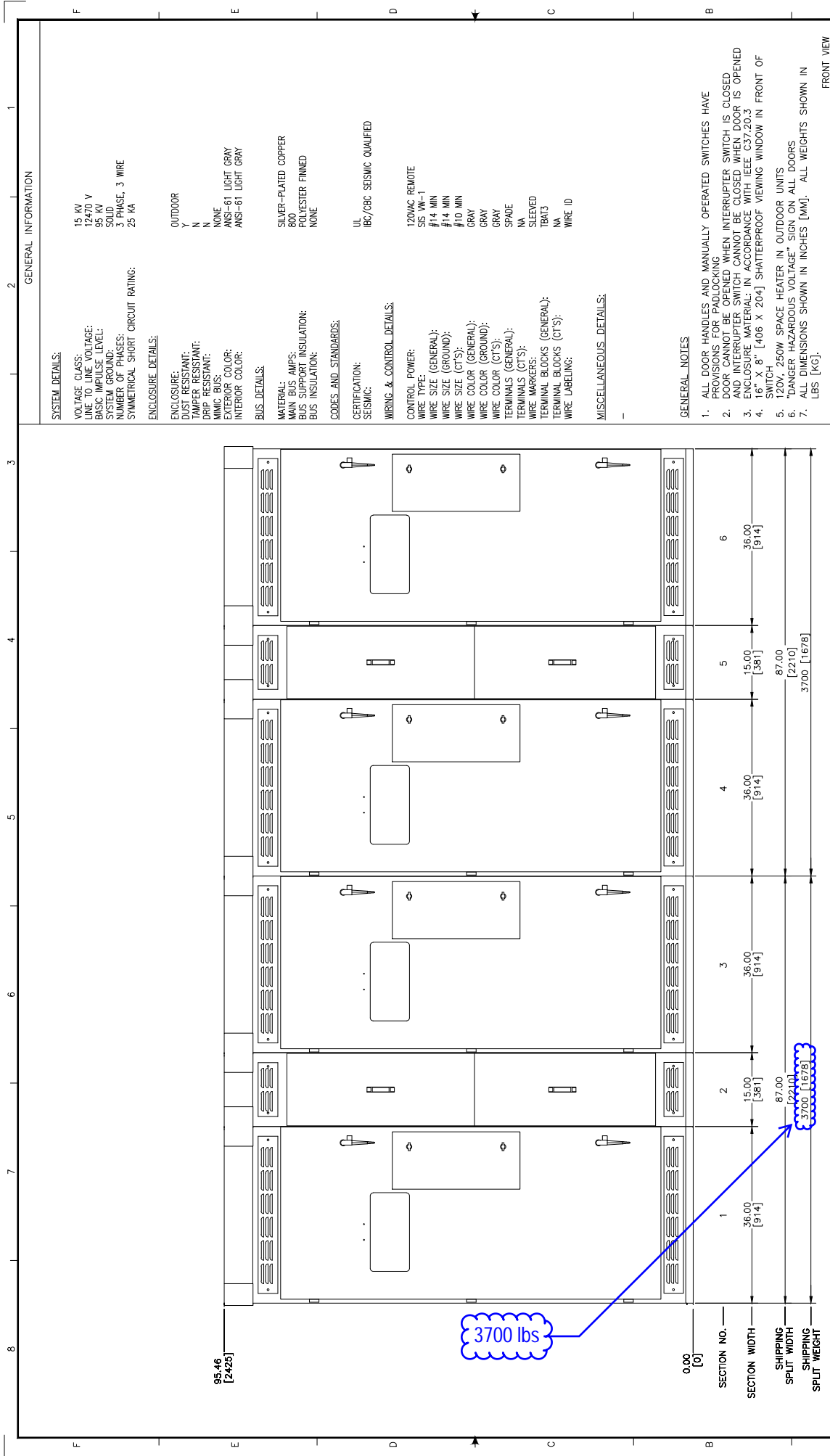
Job No: 23444.01

Designer: TVM

Sheet: 3

Client: Benaroya

Checked:



GENERAL INFORMATION

SYSTEM DETAILS:
 VOLTAGE CLASS: 15 KV
 LINE TO LINE VOLTAGE: 12470 V
 BASIC IMPULSE LEVEL: 95 KV
 SYSTEM GROUND: SOLID
 NUMBER OF PHASES: 3 PHASE, 3 WIRE
 SYMMETRICAL SHORT CIRCUIT RATING: 25 KA

ENCLOSURE DETAILS:
 ENCLOSURE: OUTDOOR
 DUST RESISTANT: Y
 FIRE RESISTANT: N
 DRIP RESISTANT: N
 MIMIC BUS: NONE
 EXTERIOR COLOR: ANSI-61 LIGHT GRAY
 INTERIOR COLOR: ANSI-61 LIGHT GRAY

BUS DETAILS:
 MATERIAL: SILVER-PLATED COPPER
 MAIN BUS AMPS: 800
 BUS SUPPORT INSULATION: POLYESTER FINNED
 BUS INSULATION: NONE

CODES AND STANDARDS:
 CERTIFICATION: UL
 SEISMIC: IBC/CBC SEISMIC QUALIFIED

WIRING & CONTROL DETAILS:
 CONTROL POWER: 120VAC REMOTE
 WIRE TYPE: SIS W-1
 WIRE SIZE (GENERAL): #14 MIN
 WIRE SIZE (GROUND): #14 MIN
 WIRE SIZE (CT'S): #10 MIN

TERMINALS & MARKERS:
 WIRE COLOR (GENERAL): GRAY
 WIRE COLOR (GROUND): GRAY
 WIRE COLOR (CT'S): GRAY
 TERMINALS (GENERAL): SPADE
 TERMINALS (CT'S): SLEEVED
 WIRE MARKERS: NONE
 TERMINAL BLOCKS (GENERAL): NONE
 TERMINAL BLOCKS (CT'S): NONE
 WIRE LABELING: WIRE ID

MISCELLANEOUS DETAILS:

GENERAL NOTES:
 1. ALL DOOR HANDLES AND MANUALLY OPERATED SWITCHES HAVE PROVISIONS FOR PADLOCKING
 2. DOOR CANNOT BE OPENED WHEN INTERRUPTER SWITCH IS CLOSED
 3. AND INTERRUPTER SWITCH CANNOT BE CLOSED WHEN DOOR IS OPENED
 4. ENCLOSURE MATERIAL: IN ACCORDANCE WITH IEEE C37.20.3
 5. 16" X 8" [406 X 204] SHATTERPROOF VIEWING WINDOW IN FRONT OF SWITCH
 6. 120V, 250W SPACE HEATER IN OUTDOOR UNITS
 7. "DANGER HAZARDOUS VOLTAGE" SIGN ON ALL DOORS
 8. ALL DIMENSIONS SHOWN IN INCHES [MM]. ALL WEIGHTS SHOWN IN LBS [KG].

FRONT VIEW

DATE: COLTRANE CONNER 01/03/2024
APP: COLTRANE CONNER 01/03/2024
PRODUCT CODE: G23P10H
REVISION: 1

TITLE: CENTERS DATA CENTER - MWS
TYPE: 1--MWSW
S.O.: G23P10H
REV.: 3321

OUTLINES: G23P10H-0
REV.: 001

REV.: 1
REV.: 1
REV.: 1

REV.: 1
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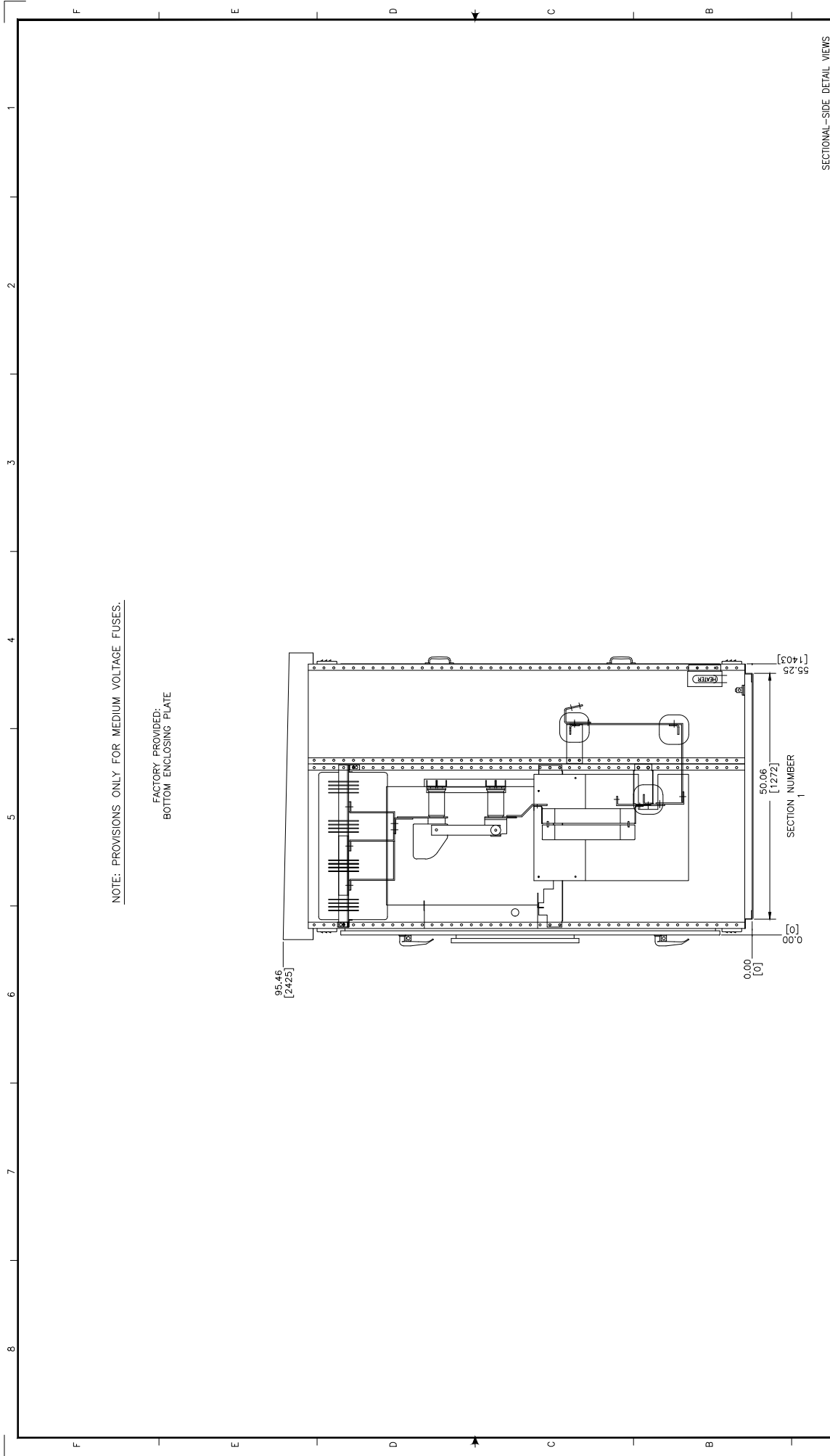
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Issued for Construction
 The information on this document is suitable for use in establishing final installation and construction details.
 CASE CODE: 341756454

CEC 01/08/2024 SHOP RELEASE 1



NOTE: PROVISIONS ONLY FOR MEDIUM VOLTAGE FUSES.

FACTORY PROVIDED:
BOTTOM ENCLOSING PLATE

SECTIONAL-SIDE DETAIL VIEWS

<p>Issued For Construction The information on this document is suitable for use in establishing final installation and construction details.</p> <p>CASE CODE: 341756454</p>		<p>DTR COLTRANE CONNER 01/03/2024</p> <p>APP COLTRANE CONNER 01/03/2024</p> <p>PRODUCT CODE 3321</p> <p>REVISION 1</p>	<p>DATE 01/03/2024</p> <p>DATE 01/03/2024</p> <p>S.O. G23P10H</p> <p>DWG SIZE</p>	<p>THE INFORMATION ON THIS DOCUMENT WAS CREATED BY EATON TO BE USED FOR THE PURPOSE IN WHICH IT WAS SUPPLIED.</p> <p>TITLE CENTERS DATA CENTER - MWS</p> <p>1--MWS</p>	<p>SECTION VIEW</p> <p>DWG G23P10H-V</p> <p>SHEET 001</p>
					<p>SECTION VIEW</p> <p>DWG LSE0035566-002</p> <p>SHEET 001</p>

CEC 01/08/2024 SHOP RELEASE 1

Eaton 15 KV MV Switch Anchorage Design

IBC 2021, ASCE 7-16, ACI 318-19

1.) MV Switch

Weight: 7.4 kips
 Total Height H: 95.46 in
 Total Width B: 50.06 in
 Total Width L: 174 in
 Center of Gravity: 57.28 in
 Snow Load: 25 psf

2) Seismic Design per ASCE 7-16 Chapter 13 Non-Structural Components

Electrical Components

ap = 1
 Rp = 2.5
 Sds = 1.01
 Ie = 1.25

Lateral Loads

Lateral resistance is provided by the chiller anchored to the concrete slab.

Fp = 1.49 kips ASCE 7-16 EQ 13.3-1
 X Fpmin = 2.80 kips ASCE 7-16 EQ 13.3-2 Controls
 Fpmax = 14.95 kips ASCE 7-16 EQ 13.3-3

EQ = 2.80 kips

Shear Connection

Number of Anchors = 8.0
 Anchor Shear = $V \cdot \Omega / \#$ = 0.35 kips/anchor < Capacity = 4.5 kips OK
 1/2" Titan HD Anchors
 with 4 1/2" Embed

Overturning Resistance About Width

	C.O.G.	EQ	OT Moment
MV Switch	57.276 in	2.8 kips	13.4 k-ft
	Moment Arm	DL	Res. Moment
Resisting Dead Load	25.03 in	7.4 kips	15 k-ft
F.O.S. = M_R / M_{OT} =	1.2 OK		

Eaton 15 KV MV Switch Anchorage Design

IBC 2021, ASCE 7-16, ACI 318-19

3) Wind Design per ASCE 7-16 Chapter 29 Non-Building Structure Procedure


Wind Speed V:	104.0	mph	ASCE 7-16 Risk Category III
Exposure Cat.	B		
Exposure Coe Kz:	0.62		Table 26.10-1 (H = 20')
Direction Coe. Kd:	0.85		Table 26.6-1
Topo Coe. Kzt:	1.00		Sec. 26.8
V_Pressure qz =	14.6	psf	EQ 26.10-1
Gust Factor G:	0.85		Sec 26.11
Af =	115	sqft	
h/d =	1.91		
Cf =	1.30		Figure 29.4-1
F =	1.86	kips	EQ 29.4-1

Shear Connection

WL < EQ Shear Connection OK By Inspection

Overturing Resistance About Width

$M_{OT} = F \cdot H / 2$	7	k-ft
$M_R = DL \cdot W / 2$	15	k-ft
F.O.S. = $M_R / M_{OT} =$	2.1	OK

	Quantum Consulting Engineers LLC	Project: Centeris Data Centers	Date: 2/2/24	Job No: 23444.01
	1511 Third Avenue, Suite 323		Designer: TVM	Sheet: 2
	Seattle, WA 98101	Client: Benaroya	Checked:	

4000A Switchgear Anchorage Design

IBC 2021, ASCE 7-16, ACI 318-19

1.) Switchgear

Weight: 2.2 kips
 Total Height H: 94 in
 Total Width B: 55.125 in
 Total Width L: 42 in
 Center of Gravity: 56.40 in
 Snow Load: 25 psf

2) Seismic Design per ASCE 7-16 Chapter 13 Non-Structural Components

Electrical Components

ap = 1
 Rp = 2.5
 Sds = 1.01
 Ie = 1.25

Lateral Loads

Lateral resistance is provided by the Switchgear anchored to the concrete slab.

Fp = 0.44 kips ASCE 7-16 EQ 13.3-1
 X Fpmin = 0.83 kips ASCE 7-16 EQ 13.3-2 Controls
 Fpmax = 4.44 kips ASCE 7-16 EQ 13.3-3

EQ = 0.83 kips

Shear Connection

Number of Anchors = 2.0
 Anchor Shear = $V \cdot \Omega / \#$ = 0.42 kips/anchor < Capacity = 4.5 kips OK
 1/2" Titan HD Anchors
 with 4 1/2" Embed

Overturning Resistance About Width

	C.O.G.	EQ	OT Moment
Switchgear	56.4 in	0.8 kips	3.92 k-ft
	Moment Arm	DL	Res. Moment
Resisting Dead Load	27.5625 in	2.2 kips	5 k-ft
F.O.S. = M_R / M_{OT} =	1.3 OK		

4000A Switchgear Anchorage Design

IBC 2021, ASCE 7-16, ACI 318-19

3) Wind Design per ASCE 7-16 Chapter 29 Non-Building Structure Procedure


Wind Speed V:	104.0	mph	ASCE 7-16 Risk Category III
Exposure Cat.	B		
Exposure Coe Kz:	0.62		Table 26.10-1 (H = 20')
Direction Coe. Kd:	0.85		Table 26.6-1
Topo Coe. Kzt:	1.00		Sec. 26.8
V_Pressure qz =	14.6	psf	EQ 26.10-1
Gust Factor G:	0.85		Sec 26.11
Af =	27	sqft	
h/d =	1.71		
Cf =	1.30		Figure 29.4-1
F =	0.44	kips	EQ 29.4-1

Shear Connection

WL < EQ Shear Connection OK By Inspection

Overturing Resistance About Width

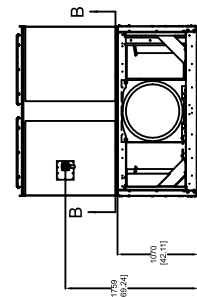
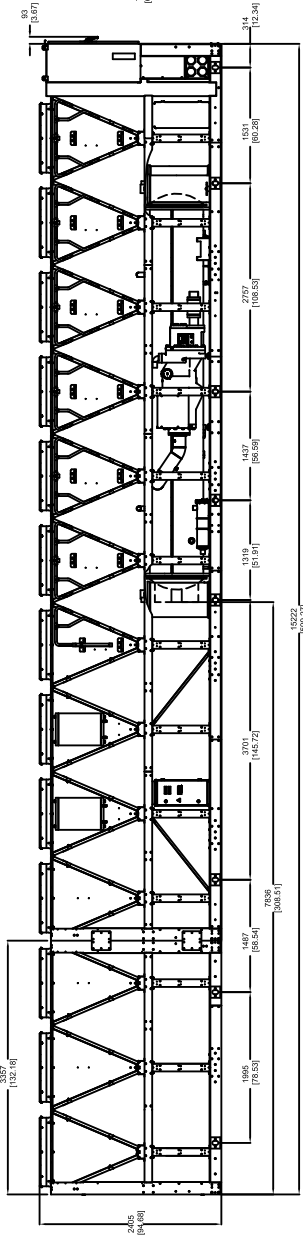
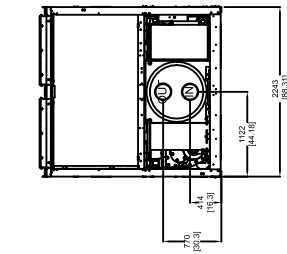
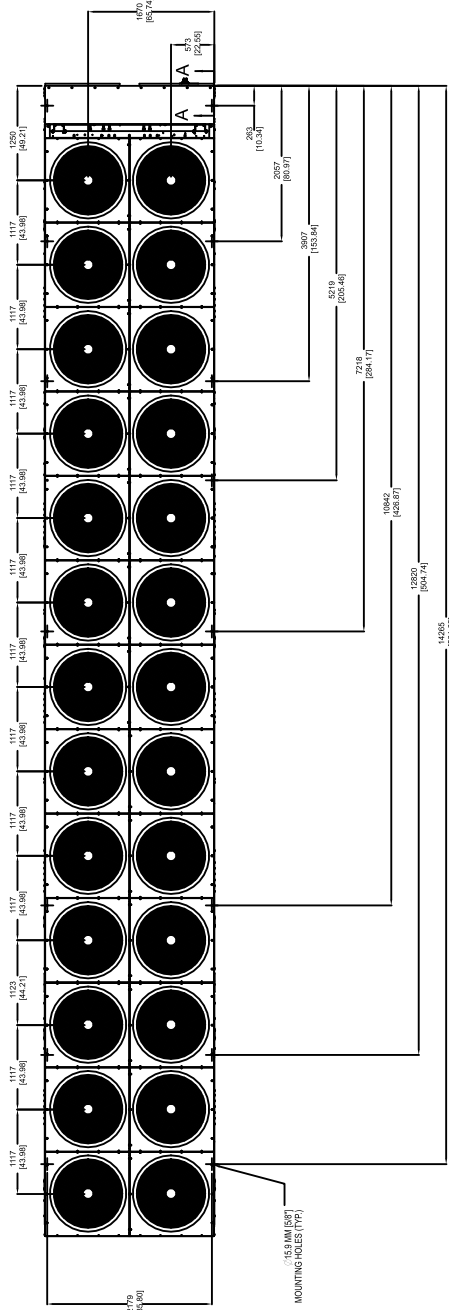
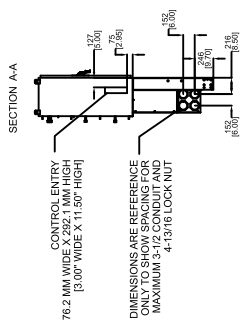
$M_{OT} = F \cdot H / 2$	2	k-ft
$M_R = DL \cdot W / 2$	5	k-ft
F.O.S. = $M_R / M_{OT} =$	2.9	OK

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- NOTES:
1. PLACEMENT ON LEVEL SURFACE
 2. FREE OF OBSTRUCTIONS (INCLUDING SHOW FOR WINDING PIPES) ON LEAD PERFORMANCE, RELIABLE OPERATION AND EASE OF MAINTENANCE, SITE MINIMUM CLEARANCES INDICATED BELOW, RESULTING IN UNPREDICTABLE AIR FLOW PATTERNS AND POSSIBLE UNIT CONTROLS WILL OPTIMIZE OPERATION WITHOUT INUISANCE HIGH PRESSURE PERFORMANCE DEGRADATION, ACCESS TO THE UNIT CONTROL CENTER ASSUMES SPRING ISOLATORS, RECOMMENDED MINIMUM CLEARANCES: SIDE TO WALL - 6" TO WALL - 4" TOP - NO OBSTRUCTIONS ALLOWED, DISTANCE BETWEEN ADJACENT UNITS - 10" WALL MAY BE HIGHER THAN THE UNIT.
 3. WEIGHT AND CENTER OF GRAVITY.
 4. WATER CONNECTIONS ARE GROOVED FOR VITALLIC CONNECTION.
 5. DIMENSIONS IN mm (INCHES).
 6. UNITS SHALL BE GROOVED TO AVOID INTERFERENCE WITH THE CONTROL AUTO TRANSFORMER ENCLOSURE LOCATED UNDERNEATH THE CONTROL PANEL.

NOZZLE LEGEND

- EVAPORATOR INLET LEFT END 2 PASS 8 DIA. (150Fpsig DWP)
- EVAPORATOR OUTLET LEFT END 2 PASS 8 DIA. (150Fpsig DWP)
- Vitalluc Grooved Nozzles (per ANSI / AWWA C-606)



PRODUCT DRAWING
 YORK YVAA Air Cooled Screw Chiller
 MODEL: YVAA 0523
NOT FOR CONSTRUCTION

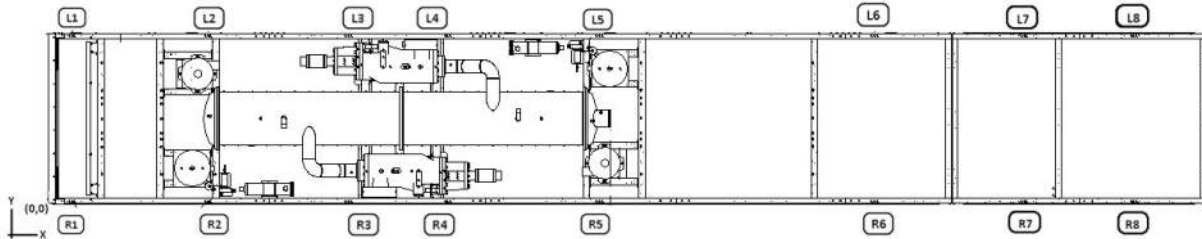
Project Name: CCI Data Center Seattle
 Location:
 Engineer:
 Contractor:
 For:

Sold To:
 Cust Purch Order#:
 Contract#:
 UNIT YVAA0523
 TAG:

Date: October 04, 2023
 Rev. Date: October 10, 2023
 Form No.: 201.28-EG1
 Dwg. Lev.: 0817
 Dwg. Scale: NTS



Project Name	Unit Tag	Date	Chiller Type
CCI Data Center Seattle	YVAA0523	2023-08-15	Air Cooled VSD Screw Chillers
PIN			Version
YVAA0523JPK46BHVTXXXSAKLAXX4556XDFXXV151W1SXGA2BMXKXRNXGXXXB1SXX			E.21.9.29933.0-D.98.0005



LOCATION	X Distance (in)	Y Distance (in)	JCI PART NUMBER	SAP NUMBER	COLOUR	Operating Weights (lb)
R1	10.4	1.3	029-25335-002	434004	Brick Red	1156
R2	81.0	1.3	029-25335-004	434005	Charcoal	2854
R3	153.8	1.3	029-25335-004	434005	Charcoal	2992
R4	205.5	1.3	029-25335-004	434005	Charcoal	2992
R5	284.2	1.3	029-25335-004	434005	Charcoal	3247
R6	426.9	1.3	029-25335-002	434004	Brick Red	1323
R7	504.7	1.3	029-25335-001	434002	Charcoal	444
R8	561.6	1.3	029-25335-002	434004	Brick Red	827
L1	10.4	87.1	029-25335-002	434004	Brick Red	1141
L2	81.0	87.1	029-25335-004	434005	Charcoal	2835
L3	153.8	87.1	029-25335-004	434005	Charcoal	2981
L4	205.5	87.1	029-25335-004	434005	Charcoal	2981
L5	284.2	87.1	029-25335-004	434005	Charcoal	3298
L6	426.9	87.1	029-25335-002	434004	Brick Red	1323
L7	504.7	87.1	029-25335-001	434002	Charcoal	444
L8	561.6	87.1	029-25335-002	434004	Brick Red	827

Total Weight (lb)		Centre of Gravity (in)	
Operating	31665	Xg	230.8
Shipping	30309	Yg	46.1

All values are de-rated by 15% apart from those which have part number. (029-25334-013 and 029-25336-014: 0% de-rated), (029-25335-004: 10% de-rated), (029-25335-001 and 029-25335-003: 25% de-rated)

York Air Cooled Screw Chiller Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

1.) Chiller

Weight: 31.7 kips
 Total Height H: 94.68 in
 Total Width B: 85.8 in
 Total Width L: 599.27 in
 Center of Gravity: 46.1 in
 Snow Load: 25 psf

2) Seismic Design per ASCE 7-16 Chapter 13 Non-Structural Components

Weight of Chiller is less than 25% total weight of chiller and slab-on-grade.

Wet-Side HVACR

ap = 1
 Rp = 2.5
 Sds = 1.01
 Ie = 1.25

Lateral Loads

Lateral resistance is provided by the chiller anchored to the concrete slab.

Fp = 6.40 kips ASCE 7-16 EQ 13.3-1
 X Fpmin = 12.00 kips ASCE 7-16 EQ 13.3-2 Controls
 Fpmax = 63.97 kips ASCE 7-16 EQ 13.3-3

EQ = 12.00 kips

Shear Connection

Number of Anchors = 16.0 1/2" Titan HD Anchors
 with 4 1/2" Embed
 Anchor Shear = $V \cdot \Omega / \#$ = 0.75 kips/anchor < Capacity = 4.5 kips OK

Overturning Resistance About Width

	C.O.G.	EQ	OT Moment
Chiller	46.1 in	12.0 kips	46.1 k-ft
	Moment Arm	DL	Res. Moment
Resisting Dead Load	42.9 in	31.7 kips	113 k-ft
F.O.S. = M_R / M_{OT} =	2.5 OK		



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Date: 1/25/24 Job No: 23444.01

Designer: TVM Sheet: 1

Client: Benaroya

Checked:

York Air Cooled Screw Chiller Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

3) Wind Design per ASCE 7-16 Chapter 29 Non-Building Structure Procedure

Wind Speed V:	104.0	mph	ASCE 7-16 Risk Category III
Exposure Cat.	B		
Exposure Coe Kz:	0.62		Table 26.10-1 (H = 20')
Direction Coe. Kd:	0.85		Table 26.6-1
Topo Coe. Kzt:	1.00		Sec. 26.8
V_Pressure qz =	14.6	psf	EQ 26.10-1
Gust Factor G:	0.85		Sec 26.11
Af =	394	sqft	
h/d =	1.10		
Cf =	1.30		Figure 29.4-1
F =	6.35	kips	EQ 29.4-1

Shear Connection

WL < EQ Shear Connection OK By Inspection

Overturing Resistance About Width

$M_{OT} = F \cdot H/2$	25	k-ft
$M_R = DL \cdot W/2$	113	k-ft
F.O.S. = $M_R / M_{OT} =$	4.5	OK



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Designer: TVM Sheet: 2

Client: Benaroya

Checked:

York Air Cooled Screw Chiller Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

4) Foundation Design

Bearing Analysis

Allowable Bearing	2000	psf
Footing Width:	47.8	ft
Footing Length:	8.2	ft
Thickened Edge Width:	1.0	ft

Dead Load:	32	kips
Snow Load:	9.7	kips
1.0DL+1.0SL Pressure:	370	psf < 2000 psf OK

Earthquake OT	46	k-ft
Applied Pressure:	118	psf
1.15DL+0.7EQ Pressure:	409	psf < 2000 psf * (4/3) OK

Sliding Analysis

Slab-on-Grade Thickness	8	in
-------------------------	---	----

Allow. Coefficient of Friction:	0.3	
(0.7) Earthquake :	8.4	kips
Dead Load:	71	kips Includes Slab-on-Grade Weight
Sliding Resistance:	21.18	kips
Unity Check $U_c =$	2.52	> 1.0 OK



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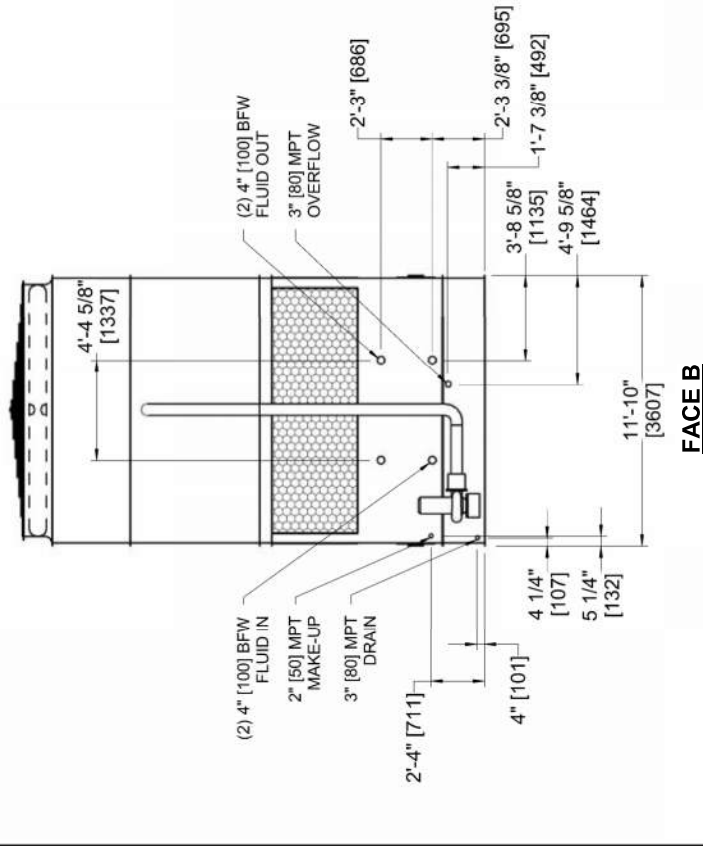
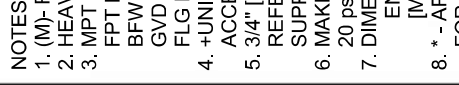
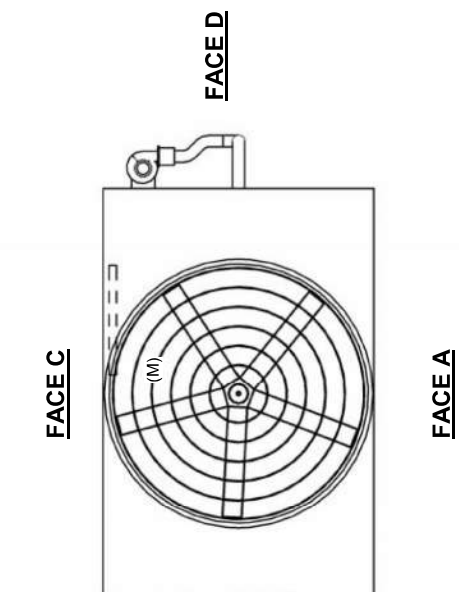
Project: Centeris Data Centers

Date: 1/25/24 Job No: 23444.01

Designer: TVM Sheet: 3

Client: Benaroya

Checked:



- NOTES:**
- (M)- FAN MOTOR LOCATION
 - HEAVIEST SECTION IS COIL SECTION
 - MPT DENOTES MALE PIPE THREAD
 - FPT DENOTES FEMALE PIPE THREAD
 - GVD DENOTES GROOVED
 - FLG DENOTES FLANGE
 - +UNIT WEIGHT DOES NOT INCLUDE ACCESSORIES (SEE ACCESSORY DRAWINGS)
 - 3/4" [19MM] DIA. MOUNTING HOLES. REFER TO RECOMMENDED STEEL SUPPORT DRAWING
 - MAKE-UP WATER PRESSURE 20 psi MIN [137 kPa], 50 psi MAX [344 kPa]
 - DIMENSIONS LISTED AS FOLLOWS:
ENGLISH FT-IN
[METRIC] [mm]
 - * - APPROXIMATE DIMENSIONS DO NOT USE FOR PRE-FABRICATION OF CONNECTING PIPING

SHIPPING WEIGHT	30160 lbs+ [13685] kg+	OPERATING WEIGHT	44310 lbs+ [20100] kg+	HEAVIEST SECTION WEIGHT	21530 lbs+ [9770] kg+	NO. OF SHIPPING SECTIONS	2	DRAWN BY:	AWT
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UNIT

ESW4 12-44018-SF

EVAPCO, INC.



DWG. #

SLWX41218-DA

TITLE

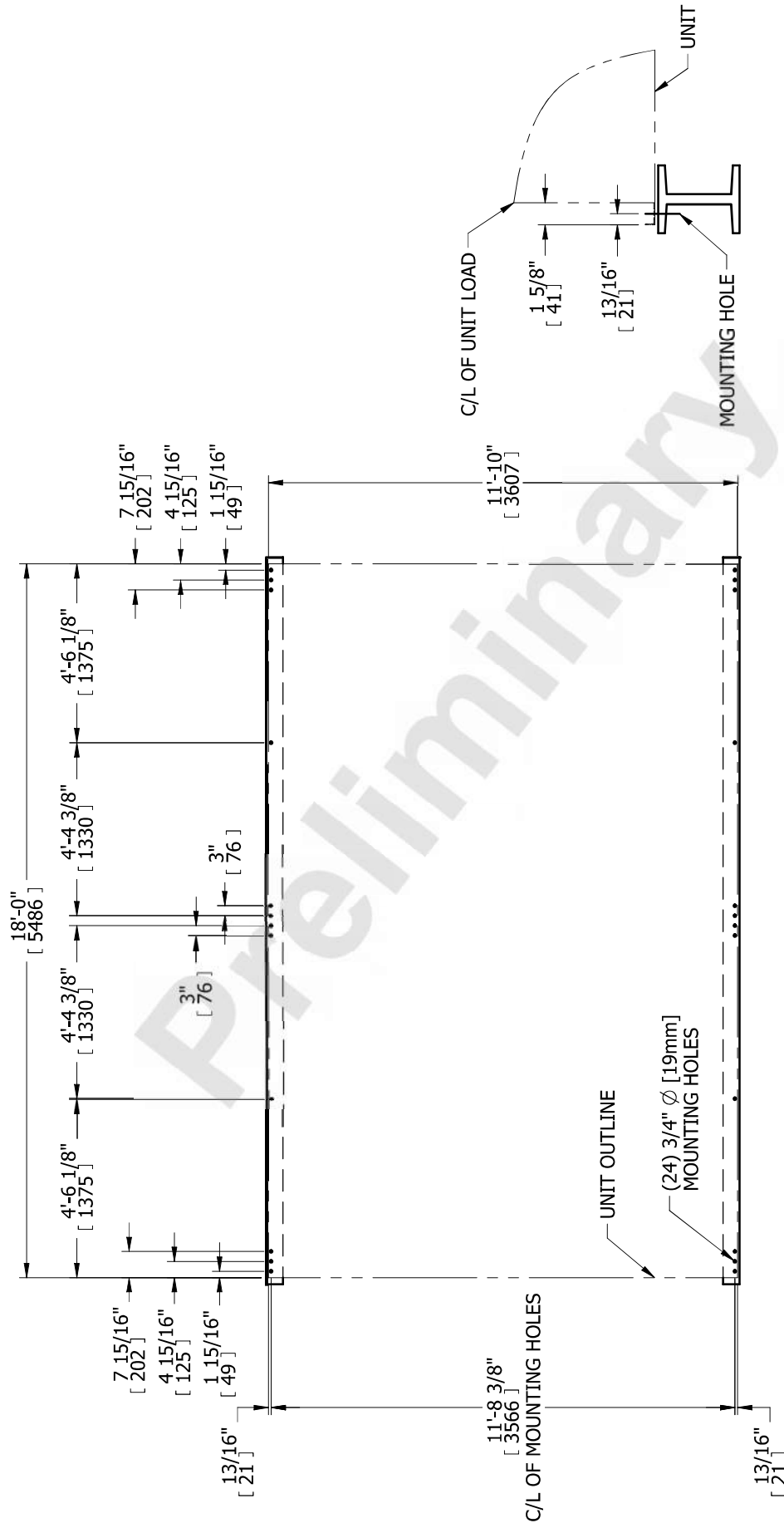
STEEL SUPPORT CONFIGURATION

SCALE

N.T.S.

DRAWN BY

MER



PLAN VIEW

TYPICAL END VIEW

NOTES:

1. BEAMS SHOULD BE SIZED IN ACCORDANCE WITH ACCEPTED STRUCTURAL PRACTICES. MAXIMUM DEFLECTION OF BEAM UNDER UNIT TO BE 1/360 OF UNIT LENGTH NOT TO EXCEED 1/2" [13mm].
2. DEFLECTION MAY BE CALCULATED BY USING 55% OF THE OPERATING WEIGHT AS A UNIFORM LOAD ON EACH BEAM. SEE CERTIFIED PRINT FOR OPERATING WEIGHT.
3. SUPPORT BEAMS AND ANCHOR HARDWARE ARE TO BE FURNISHED BY OTHERS. ANCHOR HARDWARE TO BE ASTM A325 5/8" [16mm] BOLT OR EQUIVALENT.
4. BEAMS MUST BE LOCATED UNDER THE FULL LENGTH OF THE PAN SECTION.
5. SUPPORTING BEAM SURFACE MUST BE LEVEL. DO NOT LEVEL THE UNIT BY PLACING SHIMS BETWEEN THE UNIT MOUNTING FLANGE AND THE SUPPORTING BEAM.

6. THE FACTORY RECOMMENDED STEEL SUPPORT CONFIGURATION IS SHOWN. CONSULT THE FACTORY FOR ALTERNATE SUPPORT CONFIGURATIONS.
7. UNIT SHOULD BE POSITIONED ON STEEL SUCH THAT THE ANCHORING HARDWARE FULLY PENETRATES THE BEAM'S FLANGE AND CLEARS THE BEAM'S WEB.
8. WHEN VIBRATION ISOLATION IS REQUIRED, THE VIBRATION ISOLATORS (BY OTHERS) MUST BE LOCATED UNDER THE SUPPORTING BEAMS AND NOT BETWEEN THE SUPPORTING STEEL BEAMS AND THE UNIT.
9. DIMENSIONS LISTED AS FOLLOWS: ENGLISH FT-IN [METRIC] [mm]

Evapco Cooling Tower Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

1.) Chiller

Weight: 44.3 kips
 Total Height H: 242 in
 Total Width B: 142 in
 Total Width L: 216 in
 Center of Gravity: 121 in
 Snow Load: 25 psf

2) Seismic Design per ASCE 7-16 Chapter 15 Non-Building Structures

Lateral System

Cooling Towers Concrete or Steel

R: 3.5 ASCE Table 15.4-2
 Ω_0 : 1.75 ASCE Table 15.4-2
 C_d : 3.0 ASCE Table 15.4-2
 I_E : 1.25

Lateral resistance is provided by the cooling tower anchored to the concrete slab.

Cs = 0.35914 From Quantum Seismic Spreadsheet
 EQ = 15.91 kips

Shear Connection

Number of Anchors = 24.0 5/8" Titan HD Anchors with 4 1/2" Embed
 Anchor Shear = $V \cdot \Omega / \#$ = 1.16 kips/anchor < Capacity = 6.4 kips OK

Overturing Resistance About Width

	C.O.G.	EQ	OT Moment
Chiller	121 in	15.9 kips	160 k-ft
	Moment Arm	DL	Res. Moment
Resisting Dead Load	71 in	44.3 kips	262 k-ft
F.O.S. = M_R / M_{OT} =	1.6 OK		

Evapco Cooling Tower Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

3) Wind Design per ASCE 7-16 Chapter 29 Non-Building Structure Procedure

Wind Speed V:	104.0 mph	ASCE 7-16 Risk Category III
Exposure Cat.	B	
Exposure Coe Kz:	0.62	Table 26.10-1 (H = 20')
Direction Coe. Kd:	0.85	Table 26.6-1
Topo Coe. Kzt:	1.00	Sec. 26.8
V_Pressure qz =	14.6 psf	EQ 26.10-1
Gust Factor G:	0.85	Sec 26.11
Af =	363 sqft	
h/d =	1.70	
Cf =	1.30	Figure 29.4-1
F =	5.85 kips	EQ 29.4-1

Shear Connection

WL < EQ Shear Connection OK By Inspection

Overturing Resistance About Width

$M_{OT} = F \cdot H / 2$	59 k-ft
$M_R = DL \cdot W / 2$	262 k-ft
F.O.S. = $M_R / M_{OT} =$	4.4 OK



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Evapco Cooling Tower Foundation Design

IBC 2021, ASCE 7-16, ACI 318-19

4) Foundation Design**Bearing Analysis**

Allowable Bearing 2000 psf
 Footing Width: 47.8 ft
 Footing Length: 8.2 ft
 Thickened Edge Width: 1.0 ft


Dead Load: 44 kips
 Snow Load: 9.7 kips
 1.0DL+1.0SL Pressure: 483 psf < 2000 psf OK

Earthquake OT 160 k-ft
 Applied Pressure: 412 psf
 1.15DL+0.7EQ Pressure: 744 psf < 2000 psf * (4/3) OK

Sliding Analysis

Slab-on-Grade Thickness 8 in

Allow. Coefficient of Friction: 0.3
 (0.7) Earthquake : 11.1 kips
 Dead Load: 83 kips Includes Slab-on-Grade Weight
 Sliding Resistance: 24.97 kips
 Unity Check $U_c =$ 2.24 > 1.0 OK

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	1511 Third Avenue, Suite 323 Seattle, WA 98101	Client: Benaroya	Designer: TVM	Sheet: 3
			Checked:	