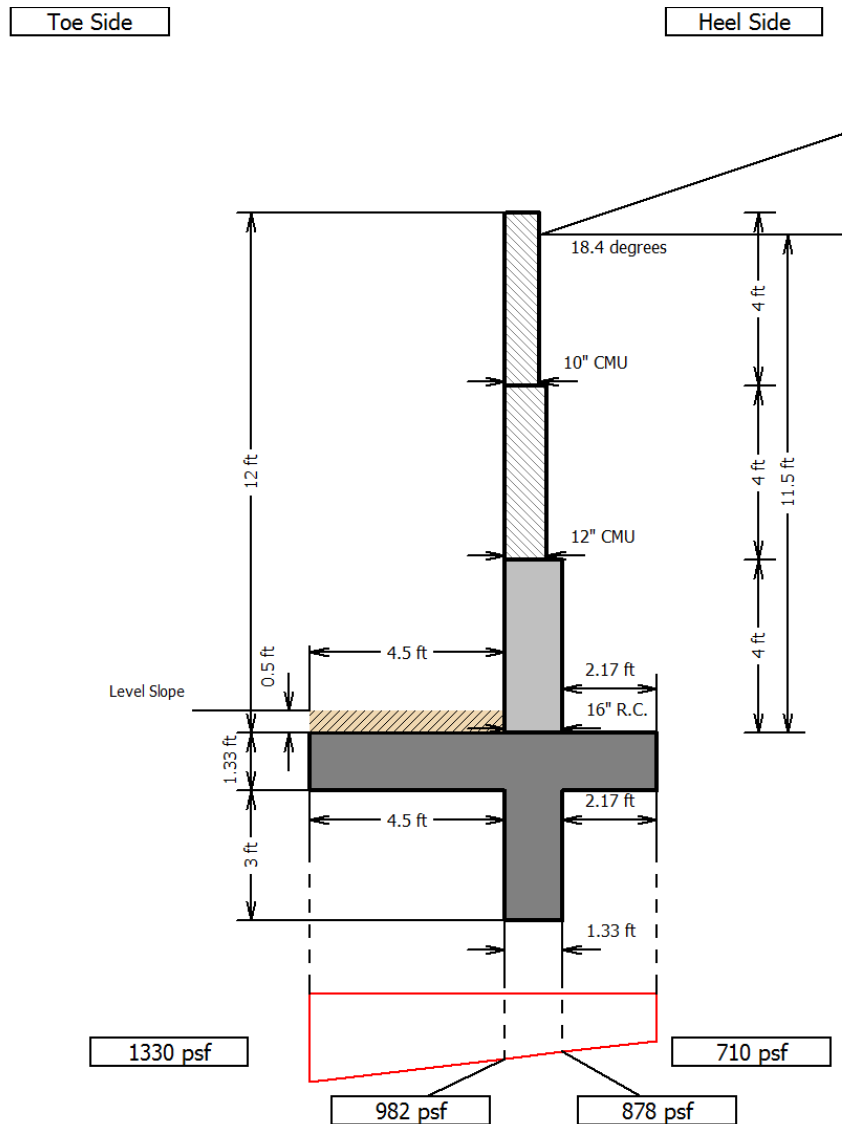


Cantilever or Restrained Retaining Wall Design Calculations

Organization: **F.E.C.**
 Project Name: **Ex1 Tall Wall**
 Design by: **LAA**
 Job #: **8106**
 Wall Type: **East Ret. Wall**
 Date: **7/5/2016**

Codes used: **2012 + 2015 IBC, ACI 318-14, ACI 530-11**



NOTES:

1. Refer to Table 19.2.1.1, ACI 318-14, for compressive strength requirements.
2. Refer to Table 19.3.1.1, ACI 318-14, for exposure categories and classes.
3. Refer to Table 19.3.2.1, ACI 318-14, for mixture requirements.

Input Parameters

General Data

Number of stem sections	3
Top Restrained	No
Concrete Unit Weight	150 pcf
Bar Strength (Fy)	60.00 ksi
Parapet Height	0.50 ft
Wind Pressure	0.00 psf
Groundwater (from top of stem)	13.33 ft
Full Ht. Distr. Loading	0.000 kips/ft
From Un. Vert. Surch.	0.000 kips/ft

Backfill Soils

Equivalent Fluid Pressure

Equiv. Active Pressure	40.0 psf/ft
Equiv. Passive Resistance	250.0 psf/ft
Slope Backfill Angle	18.40 degrees
Soil Cohesion	220.00 psf
Soil/Rock Unit Weight	110.0 pcf
Allow Bear. Capacity	2500 psf
Uniform Vert. Surcharge	0.0 psf
Wall Height (Stem+Foot.)	13.33 ft

2013 Mikola/Sitar

Seismic Kh	0.150 g
Overconsol. Ratio (OCR)	1.00

Passive Soils

Sliding Friction Coefficient	0.33
Passive Slope Angle	0.00 degrees
Soil Cohesion	220.00 psf
Soil/Rock Unit Weight	110.00 pcf
Ignore Passive Ht.	1.00 ft

Global Stability of a Vertical Cut

Stem Section Design - Top

Stem Type	Masonry
Masonry Strength (f'm)	2.00 ksi
Wall Height	4.00 ft
Section Size	10 in
Axial Live Load	0 lb/ft
Axial Dead Load	0 lb/ft

Reinforcement - Vertical

Vert. Bar Size Heel Side	#5
Vert. Spacing Heel Side	16 in
Bar Cover	3.00 in

Reinforcement - Horizontal

Horiz. Bar Size Heel Side	#5
Horiz. Spacing Heel Side	16 in

Stem Section Design - Middle

Stem Type	Masonry
Masonry Strength (f'm)	2.00 ksi
Wall Height	4.00 ft
Section Size	12 in

Reinforcement - Vertical

Vert. Bar Size Heel Side	#5
Vert. Spacing Heel Side	8 in
Bar Cover	3.00 in

Reinforcement - Horizontal

Horiz. Bar Size Heel Side	#5
Horiz. Spacing Heel Side	16 in

Stem Section Design - Bottom

Stem Type	Concrete
Concrete Strength (f'c)	3.00 ksi
Wall Height	4.00 ft
Stem Width	16.00 in

Reinforcement - Vertical

Vert. Bar Size Heel Side	#5
Vert. Spacing Heel Side	8.0 in
Bar Cover	3.00 in

Reinforcement - Horizontal

Horiz. Bar Size Heel Side	#5
Horiz. Spacing Heel Side	8.0 in

Footing Dimensions

Heel Width	2.17 ft
Stem Width Bottom	1.33 ft
Toe Width	4.50 ft
Footing Thickness	1.33 ft
Tot. Footing Width	8.00 ft
Footing Soil Cover	0.50 ft
Concrete Strength (f'c)	3.00 ksi
Sliding Restraint at the Toe	No

Foundation Setback

Base Shear Keyway

Apply pressure on both sides (IBC 1807.2.1)	No
Distance from Toe	4.50 ft
Keyway Embedment	3.00 ft
Keyway Width	1.33 ft
Keyway Vert. Bar	#5
Vert. Bar Spacing	16.0 in
Bar Cover	3.00 in

Heel Reinforcement

Bar Size	#5
Bar Spacing	8.0 in
Bar Cover	2.00 in

Toe Reinforcement

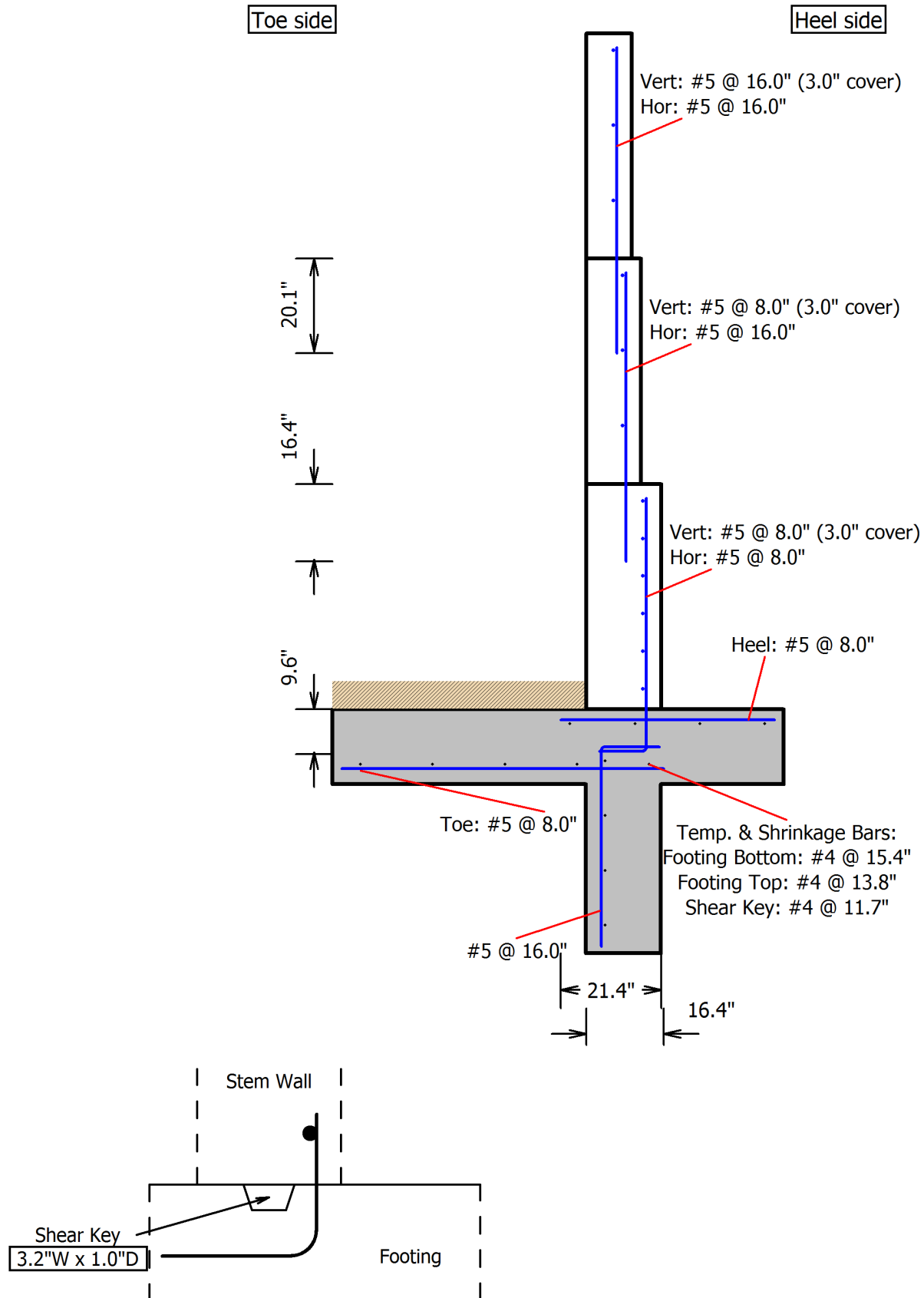
Bar Size	#5
Bar Spacing	8.0 in
Bar Cover	3.00 in

Shrinkage and Temperature Reinforcement

S & T Bar Size	#4
Nr of Bars Bottom	5
Nr of Bars Top	4
Nr of Bars Key	4

Footing Settlement

Poisson's ratio	0.35
Elastic Soil Modulus	700000 psf
Vert. Subgrade Modulus	100 ton/ft ³



Analysis and Design Results

Earth Pressures

Earth Press. - Horiz. Comp.	3571.43 lb
Earth Press. - Vert. Comp.	1265.79 lb
Uniform Surcharge Comp.	0.00 lb
Passive Resist. Comp.	1826.11 lb
Opposing Keyway Press. (1807.2.1)	0.00 lb
Equiv. Fluid Pressure Active	40.0 psf/ft
Equiv. Fluid Resistance Passive	250.0 psf/ft
Seismic Pressure Component	1018.52 lb
Sliding Friction Coefficient	0.33

Retaining Wall Stability

Overturning F.S. Results

Overturning Moment	21172.13 lb-ft
Resisting Moment	53083.51 lb-ft
F.S. against Overturning	2.51

Sliding F.S. Results

Sliding Force	4589.95 lb
Resisting Force	5976.24 lb
F.S. against Sliding	1.30

Footing Pressures

Resultant Loc. from Toe	3.69 ft
Resultant in middle third	
Toe Bearing Pressure	1330 psf
Heel Bearing Pressure	710 psf

Foundation Setback

Setback Does Not Apply when Passive Slope Angle ≥ 0

Surcharge Loads

Strip Load Does Not Apply	
Line Load Does Not Apply	
Point Load Does Not Apply	
Total Lateral Thrust	0.00 lb/ft
Total Resultant from Stem Top	0.00 ft

Footing Settlement

Average Bearing Pressure	975 psf
Distortion Settlement	0.25 in
Consolidation Settlement	0.37 in
Total Settlement	0.62 in

Settlement OK

Stronger soil over weaker layer or vice-versa are not considered

Stem Sections - Top

Flexure

Moment Demand (Mu)	474 lb-ft
Moment Capacity (PhiMn)	6224 lb-ft

Reinforcement - Vertical

Rho Min. Vertical	0.0015
Rho Max. Vertical	0.0100
Actual Rho Vertical	0.0020
Vert. Heel Side Steel Bar Used	#5 @ 16.0
Area of Steel - Vertical	0.23 in ²

Reinforcement - Horizontal

Rho Min. Horizontal	0.0015
Rho Max. Horizontal	0.0100
Actual Rho Horizontal	0.0020
Horiz. Heel Side Steel Bar Used	#5 @ 16.0
Area of Steel - Horizontal	0.23 in ²

Shear

Shear Demand (Vu)	426 lb
Shear Capacity (PhiVc)	9413 lb

Stem Sections - Middle

Flexure

Moment Demand (Mu)	5200 lb-ft
Moment Capacity (PhiMn)	15874 lb-ft

Reinforcement - Vertical

Rho Min. Vertical	0.0015
Rho Max. Vertical	0.0100
Actual Rho Vertical	0.0033
Vert. Heel Side Steel Bar Used	#5 @ 8.0
Area of Steel - Vertical	0.46 in ²

Reinforcement - Horizontal

Rho Min. Horizontal	0.0015
Rho Max. Horizontal	0.0100
Actual Rho Horizontal	0.0017
Horiz. Heel Side Steel Bar Used	#5 @ 16.0
Area of Steel - Horizontal	0.23 in ²

Shear

Shear Demand (Vu)	2102 lb
Shear Capacity (PhiVc)	11485 lb

Stem Sections - Bottom

Flexure

Moment Demand (Mu)	19359 lb-ft
Moment Capacity (PhiMn)	25595 lb-ft

Reinforcement - Vertical

Rho Min. Vertical	0.0018
Rho Max. Vertical	0.0155
Actual Rho Vertical	0.0024
Vert. Heel Side Steel Bar Used	#5 @ 8.0
Area of Steel - Vertical	0.46 in ²

Reinforcement - Horizontal

Rho Min. Horizontal	0.0018
Rho Max. Horizontal	0.0155
Actual Rho Horizontal	0.0024
Horiz. Heel Side Steel Bar Used	#5 @ 8.0
Area of Steel - Horizontal	0.46 in ²

Shear

Shear Demand (Vu)	5050 lb
Shear Capacity (PhiVc)	12509 lb

Heel Design

Flexure

Moment Demand (Mu)	2459 lb-ft
Moment Capacity (PhiMn)	27840 lb-ft
Rho Min. Heel	0.0018
Rho Max. Heel	0.0155
Actual Rho Used	0.0028
Heel Steel Used	#5 @ 8.0
Heel Area of Steel	0.46 in ²

Shear

Shear Demand (Vu)	4290 lb
Shear Capacity (PhiVn)	13455 lb

Toe Design

Flexure

Moment Demand (Mu)	11241 lb-ft
Moment Capacity (PhiMn)	25748 lb-ft
Rho Min. Toe	0.0018
Rho Max. Toe	0.0155
Actual Rho Used	0.0031
Toe Steel Used	#5 @ 8.0
Toe Area of Steel	0.46 in ²

Shear

Shear Demand (Vu)	3745 lb
Shear Capacity (PhiVn)	12469 lb

Base Shear Keyway

Moment Demand (Mu)	2922 lb-ft
Moment Capacity (PhiMn)	13053 lb-ft
Vertical reinforcement	#5 @ 16.0
Clear Cover	3.0 in

Bar Development

Heel into toe	21.4 in
Toe into heel	16.4 in
Bottom stem into footing	9.6 in
Middle stem into bottom stem	16.4 in
Top stem into middle stem	20.1 in

Stem - Top of Footing Shear Key

Bearing Stress (10% f'c)	300 psi
Pure Shear Stress	93 psi
Required Key Width	3.2 in
Required Key Depth	1.0 in

Shrinkage and Temperature

Max. spacing is 18.0 in

Bar Spacing Bottom	15.4 in
Bar Spacing Top	13.8 in
Bar Spacing Key	11.7 in

Global Stability

Req. Cohesion for Toe Circle	346.6 psf
Req. Cohesion for Base Circle	253.3 psf

Only valid for Cohesive Soils, not a comprehensive Slope Stability Analysis

Stem Wall Deflection

Deflection Req. for Active State	0.160 in
Approx. top of Stem Deflection	0.411 in

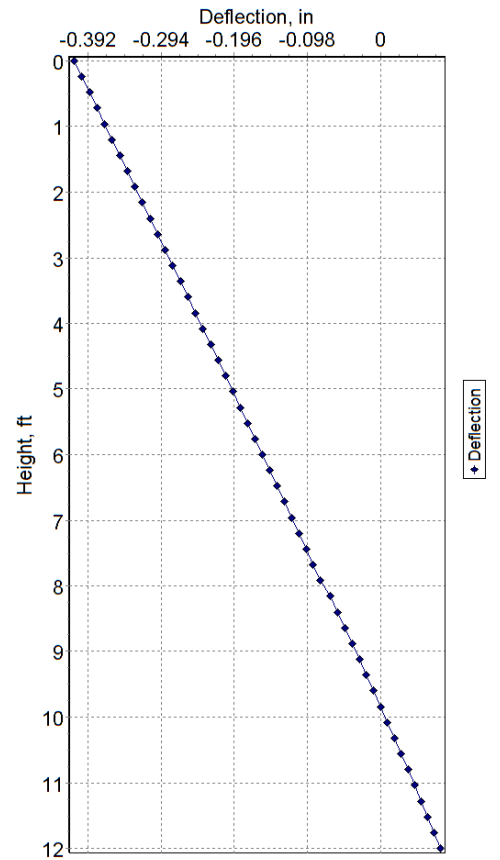
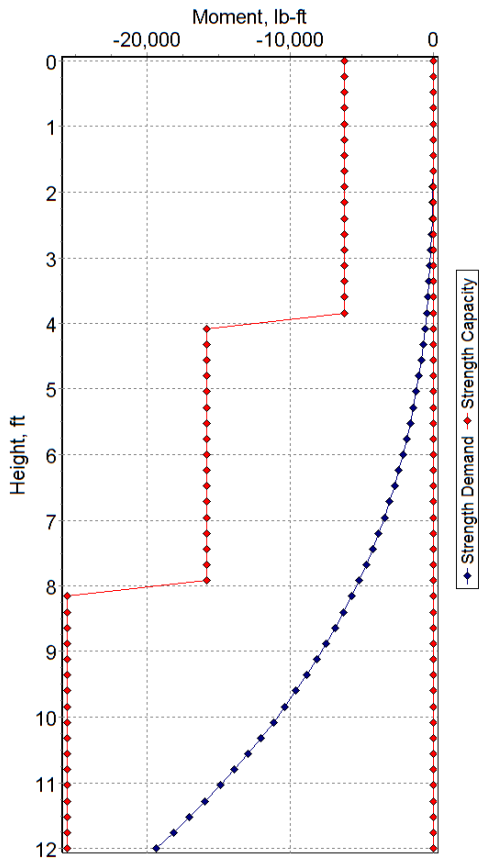
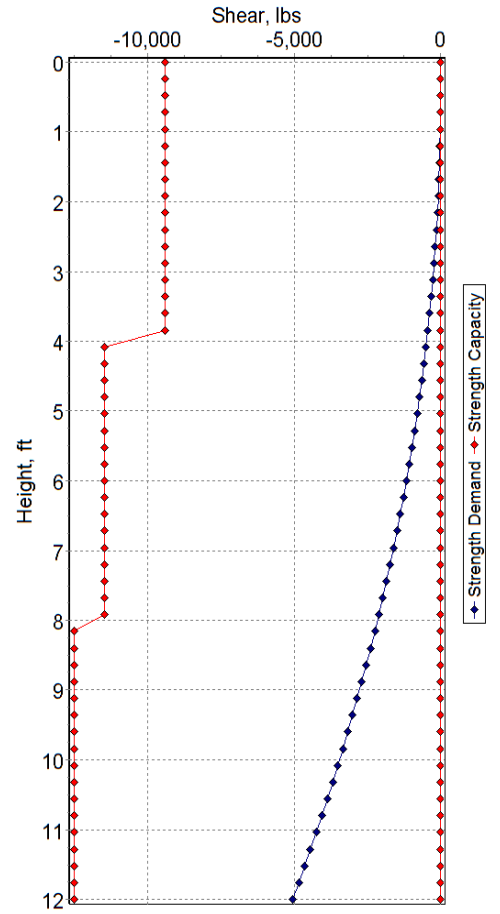
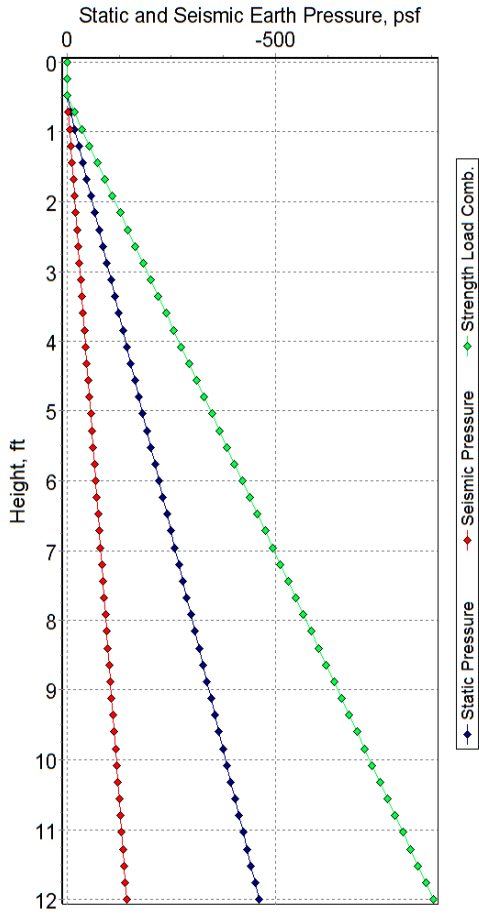
Deflection OK (< 0.60)

Design for Active Ka

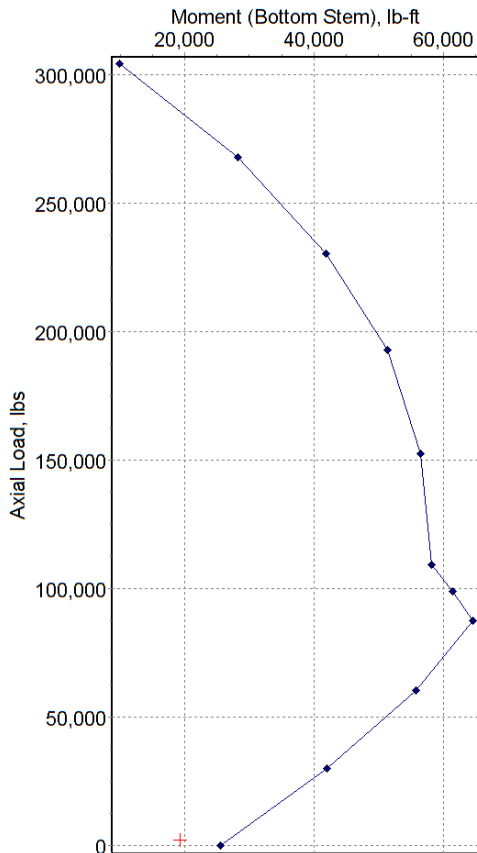
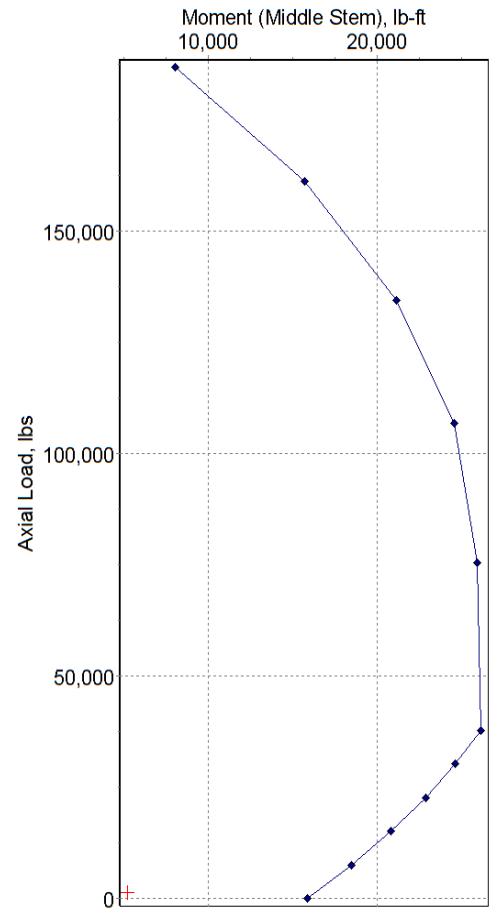
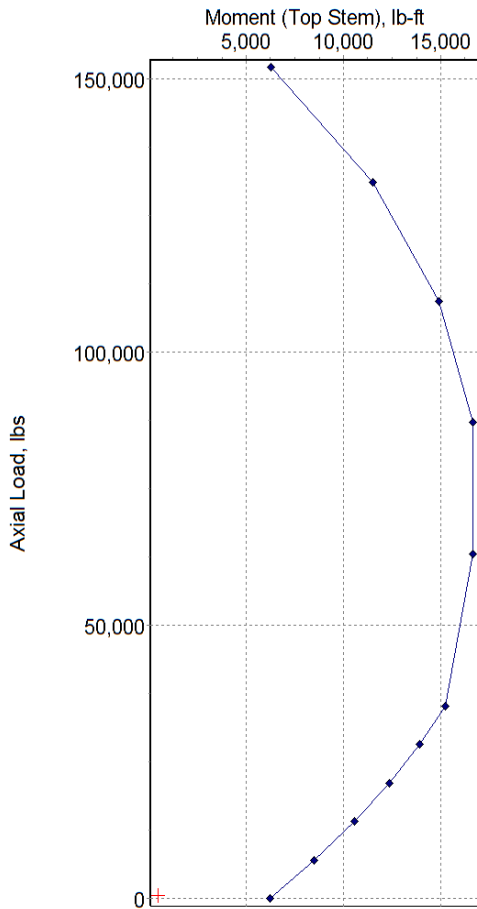
Table of Test Results - Stem Forces

Node #	Stem Ht, inch	Soil Press, psf	Vu, lb	phiVn, lb	Mu, lb-ft	phiMn, lb-ft	Slope/Rot, deg	Deflection, in
1	0.0	0.0	0.0	-9413.1	0.0	-6224.4	0.202	-0.411
2	2.9	0.0	0.0	-9413.1	0.0	-6224.4	0.202	-0.400
3	5.8	0.0	0.0	-9413.1	0.0	-6224.4	0.202	-0.390
4	8.6	-16.8	-1.8	-9413.1	-0.1	-6224.4	0.202	-0.380
5	11.5	-35.1	-8.1	-9413.1	-1.2	-6224.4	0.202	-0.370
6	14.4	-53.5	-18.7	-9413.1	-4.4	-6224.4	0.202	-0.360
7	17.3	-71.8	-33.7	-9413.1	-10.6	-6224.4	0.202	-0.350
8	20.2	-90.1	-53.2	-9413.1	-20.9	-6224.4	0.202	-0.339
9	23.0	-108.5	-77.0	-9413.1	-36.4	-6224.4	0.202	-0.329
10	25.9	-126.8	-105.2	-9413.1	-58.2	-6224.4	0.202	-0.319
11	28.8	-145.1	-137.9	-9413.1	-87.3	-6224.4	0.202	-0.309
12	31.7	-163.4	-174.9	-9413.1	-124.8	-6224.4	0.202	-0.299
13	34.6	-181.8	-216.3	-9413.1	-171.6	-6224.4	0.202	-0.289
14	37.4	-200.1	-262.1	-9413.1	-228.9	-6224.4	0.202	-0.279
15	40.3	-218.4	-312.4	-9413.1	-297.8	-6224.4	0.201	-0.268
16	43.2	-236.8	-367.0	-9413.1	-379.2	-6224.4	0.201	-0.258
17	46.1	-255.1	-426.0	-9413.1	-474.3	-6224.4	0.201	-0.248
18	49.0	-273.4	-489.4	-11484.5	-584.0	-15873.6	0.201	-0.238
19	51.8	-291.8	-557.2	-11484.5	-709.6	-15873.6	0.201	-0.228
20	54.7	-310.1	-629.5	-11484.5	-851.9	-15873.6	0.200	-0.218
21	57.6	-328.4	-706.1	-11484.5	-1012.1	-15873.6	0.200	-0.208
22	60.5	-346.7	-787.1	-11484.5	-1191.2	-15873.6	0.199	-0.198
23	63.4	-365.1	-872.5	-11484.5	-1390.2	-15873.6	0.199	-0.188
24	66.2	-383.4	-962.3	-11484.5	-1610.3	-15873.6	0.198	-0.178
25	69.1	-401.7	-1056.6	-11484.5	-1852.5	-15873.6	0.197	-0.168
26	72.0	-420.1	-1155.2	-11484.5	-2117.8	-15873.6	0.196	-0.158
27	74.9	-438.4	-1258.2	-11484.5	-2407.3	-15873.6	0.195	-0.148
28	77.8	-456.7	-1365.6	-11484.5	-2722.1	-15873.6	0.194	-0.138
29	80.6	-475.1	-1477.4	-11484.5	-3063.2	-15873.6	0.192	-0.129
30	83.5	-493.4	-1593.6	-11484.5	-3431.6	-15873.6	0.191	-0.119
31	86.4	-511.7	-1714.2	-11484.5	-3828.5	-15873.6	0.189	-0.110
32	89.3	-530.0	-1839.2	-11484.5	-4254.8	-15873.6	0.187	-0.100
33	92.2	-548.4	-1968.7	-11484.5	-4711.7	-15873.6	0.185	-0.091
34	95.0	-566.7	-2102.5	-11484.5	-5200.1	-15873.6	0.182	-0.082
35	97.9	-585.0	-2240.7	-12508.6	-5721.2	-25594.7	0.195	-0.067
36	100.8	-603.4	-2383.3	-12508.6	-6276.0	-25594.7	0.194	-0.058
37	103.7	-621.7	-2530.3	-12508.6	-6865.5	-25594.7	0.193	-0.048
38	106.6	-640.0	-2681.7	-12508.6	-7490.9	-25594.7	0.192	-0.038
39	109.4	-658.4	-2837.5	-12508.6	-8153.1	-25594.7	0.191	-0.029
40	112.3	-676.7	-2997.7	-12508.6	-8853.2	-25594.7	0.189	-0.019
41	115.2	-695.0	-3162.3	-12508.6	-9592.3	-25594.7	0.188	-0.010
42	118.1	-713.3	-3331.3	-12508.6	-10371.5	-25594.7	0.186	0.000
43	121.0	-731.7	-3504.7	-12508.6	-11191.7	-25594.7	0.185	0.009
44	123.8	-750.0	-3682.5	-12508.6	-12054.1	-25594.7	0.183	0.018
45	126.7	-768.3	-3864.7	-12508.6	-12959.7	-25594.7	0.181	0.028
46	129.6	-786.7	-4051.3	-12508.6	-13909.5	-25594.7	0.179	0.037
47	132.5	-805.0	-4242.3	-12508.6	-14904.7	-25594.7	0.177	0.046
48	135.4	-823.3	-4437.7	-12508.6	-15946.2	-25594.7	0.174	0.054
49	138.2	-841.7	-4637.5	-12508.6	-17035.1	-25594.7	0.172	0.063
50	141.1	-860.0	-4841.7	-12508.6	-18172.5	-25594.7	0.169	0.072
51	144.0	-878.3	-5050.3	-12508.6	-19359.5	-25594.7	0.166	0.080

Stem Forces



P-M Diagrams



References:

1. ACI 318-14: Building Code and Commentary
2. 2012 + 2015 IBC: International Building Code
3. Reinforced Concrete Fundamentals, 5th ed. Ferguson, Breen, & Jirsa, 1988, Wiley
4. Soil Mechanics : Principles and Applications Perloff and Baron, 1976, Ronald Press
5. The Design and Construction of Engineering Foundations, 2nd ed, F.D.C. Henry, 1986, Chapman and Hall
6. Geotechnical Engineering: Foundation Design John Cernica, 1995, Wiley
7. Foundation Analysis & Design, 1988, 4th Ed. J.E. Bowles, McGraw-Hill
8. Retaining Walls, EM 1110-2-2502, Corps. of Engineers, 1961
9. Active and Passive Earth Pressure Coefficient Tables, A.R. Jumikis, 1962, Rutgers State University
10. Engineering Design in Geotechnics, 2nd ed, F. Azizi, 2013
11. "BEAMANAL" Spreadsheet v2.5, Alex Tomanovich, P.E.
12. Modern Formulas for Statics and Dynamics: A Stress and Strain Approach, Pilkey & Chuang, 1978
13. Geotechnical Engineering & Soil Testing, Al-Khafaji & Andersland, 1992, Saunders
14. The Reinforced Concrete Design Handbook, SP-17(14), Vol. 2, ACI
15. SoilStructure Software : Retaining Wall v3.0.1