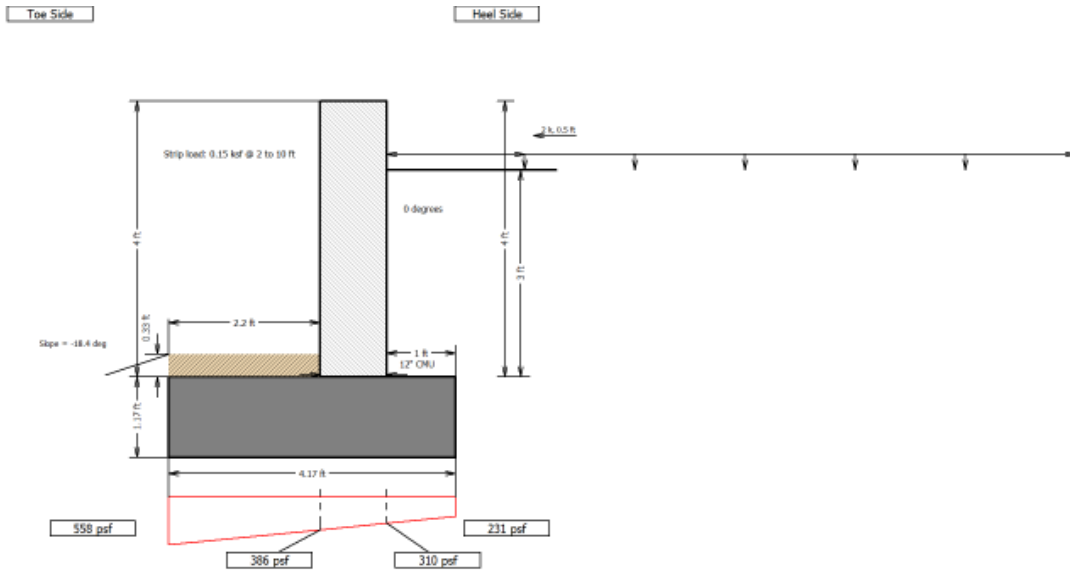


Cantilever or Restrained Retaining Wall Design Calculations

Organization: **F.E.C.**
 Project Name: **Ex 3 Driveway Short Wall**
 Design by: **LAA**
 Job #:
 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	1
Top Restrained	No
Concrete Unit Weight	150 pcf
Bar Strength (Fy)	60.00 ksi
Parapet Height	1.00 ft
Wind Pressure	0.00 psf
Groundwater (from top)	4.00 ft
Full Ht. Distr. Loading	0.000 kips/ft
From Un. Vert. Surch.	0.000 kips/ft

Backfill Soils

Rankine Method

Soil Friction Angle	25.0 degrees
Soil-Wall Friction Angle	0.0 degrees
Backfill Slope Angle	0.0 degrees
Backwall Inclination Ang.	90.0 degrees
Soil Cohesion	150.00 psf
Soil/Rock Unit Weight	112.0 pcf
Allow Bear. Capacity	1800 psf
Uniform Vert. Surcharge	0.0 psf
Wall Height (Stem+Foot.)	5.17 ft
	Inverted Triangle
Seismic Kh	0.22 g
Overconsol. Ratio (OCR)	1.00

Passive Soils

Sliding Friction Coefficient	0.33
Passive Slope Angle	-18.40 degrees
Soil Cohesion	200.00 psf
Soil/Rock Unit Weight	108.00 pcf
Ignore Passive Ht.	0.50 ft
Passive F.S.	1.33
F.S. on Sliding Fri. Coeff.	1.33

Global Stability of a Vertical Cut

Backfill Properties

Backwall Incl. Angle	90.00 degrees
Soil Cohesion	150.00 psf
Friction Angle	25.00 degrees
Soil/Rock Unit Weight	112.0 pcf
Stem + Footing Height	5.17 ft

Stem Section Design

Stem Type	Masonry
Masonry Strength (f'm)	2.20 ksi
Wall Height	4.00 ft
Section Size	12 in
Axial Live Load	0 lb/ft
Axial Dead Load	0 lb/ft

Reinforcement - Vertical

Vert. Bar Size Heel Side	#4
Vert. Spacing Heel Side	8 in
Bar Cover	3.00 in

Reinforcement - Horizontal

Horiz. Bar Size Heel Side	#4
Horiz. Spacing Heel Side	8 in

Footing Dimensions

Heel Width	1.00 ft
Stem Width Bottom	0.97 ft
Toe Width	2.20 ft
Footing Thickness	1.17 ft
Tot. Footing Width	4.17 ft
Footing Soil Cover	0.33 ft
Concrete Strength (f'c)	3.50 ksi
Sliding Restraint at the Toe	No

Surcharge Loads

Stem + Footing Height	5.17 ft
Strip Load (qS)	0.15 ksF
Dist. to Load Begin (x1)	2.00 ft
Dist. to Load End (x2)	10.00 ft
Footing Depth	1.00 ft
Surcharge Influence (Is)	6.25 ft

Additional Loads and Moments

Lateral Loads	Dist.from top, ft	Force, kips
Car impact load	0.50	2.00

Base Shear Keyway - Not Used

Heel Reinforcement

Bar Size	#4
Bar Spacing	8.0 in
Bar Cover	2.00 in

Toe Reinforcement

Bar Size	#4
Bar Spacing	8.0 in
Bar Cover	3.00 in

Shrinkage and Temperature Reinforcement

S & T Bar Size	#4
Nr of Bars Bottom	3
Nr of Bars Top	3

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

Active Earth Pressure Coeff.	0.406
Passive Resistance Coeff.	1.211
Earth Press. - Horiz. Comp.	395.22 lb
Earth Press. - Vert. Comp.	0.00 lb
Uniform Surcharge Comp.	0.00 lb
Passive Resist. Comp.	422.07 lb
Opposing Keyway Press. (1807.2.1)	0.00 lb
Equiv. Fluid Pressure Active	45.5 psf/ft
Equiv. Fluid Resistance Passive	102.0 psf/ft
Seismic Pressure Component	160.67 lb
Sliding Friction Coefficient	0.30

Retaining Wall Stability

Overturning F.S. Results

Overturning Moment	894.57 lb-ft
Resisting Moment	4168.42 lb-ft
F.S. against Overturning	4.66

Sliding F.S. Results

Sliding Force	845.85 lb
Resisting Force	1304.89 lb
F.S. against Sliding	1.54

Footing Pressures

Resultant Loc. from Toe	1.86 ft
Resultant in middle third	
Toe Bearing Pressure	558 psf
Heel Bearing Pressure	231 psf

Surcharge Loads

Strip Load Thrust	289.96 lb/ft
Strip Resultant	3.36 ft
Line Load Does Not Apply	
Point Load Does Not Apply	
Total Lateral Thrust	289.96 lb/ft
Total Resultant from Stem Top	3.36 ft

Footing Settlement

Average Bearing Pressure	371 psf
Distortion Settlement	0.05 in
Consolidation Settlement	0.12 in
Total Settlement	0.17 in

Settlement OK

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

Stem Section

Flexure

Moment Demand (Mu)	8190 lb-ft
Moment Capacity (PhiMn)	10731 lb-ft

Reinforcement - Vertical

Rho Min. Vertical	0.0015
Rho Max. Vertical	0.0100
Actual Rho Vertical	0.0022
Vert. Heel Side Steel Bar Used	#4 @ 8.0
Area of Steel - Vertical	0.30 in ²

Reinforcement - Horizontal

Rho Min. Horizontal	0.0015
Rho Max. Horizontal	0.0100
Actual Rho Horizontal	0.0022
Horiz. Heel Side Steel Bar Used	#4 @ 8.0
Area of Steel - Horizontal	0.30 in ²

Shear

Shear Demand (Vu)	2874 lb
Shear Capacity (PhiVc)	11917 lb

Heel Design

Flexure

Moment Demand (Mu)	225 lb-ft
Moment Capacity (PhiMn)	15626 lb-ft
Rho Min. Heel	0.0018
Rho Max. Heel	0.0181
Actual Rho Used	0.0021
Heel Steel Used	#4 @ 8.0
Heel Area of Steel	0.30 in ²

Shear

Shear Demand (Vu)	831 lb
Shear Capacity (PhiVn)	12555 lb

Toe Design

Flexure

Moment Demand (Mu)	1079 lb-ft
Moment Capacity (PhiMn)	14276 lb-ft
Rho Min. Toe	0.0018
Rho Max. Toe	0.0181
Actual Rho Used	0.0023
Toe Steel Used	#4 @ 8.0
Toe Area of Steel	0.30 in ²

Shear

Shear Demand (Vu)	748 lb
Shear Capacity (PhiVn)	11490 lb

Base Shear Keyway - Not Used

Bar Development

Heel into toe	15.8 in
Toe into heel	12.2 in
Stem into footing	8.9 in

Stem - Top of Footing Shear Key

Bearing Stress (10% f'c)	350 psi
Pure Shear Stress	101 psi

Shrinkage and Temperature

Max. spacing is 18.0 in

Bar Spacing Bottom	14.8 in
Bar Spacing Top	10.9 in

Global Stability

Req. Cohesion for Toe Circle	134.4 psf
Req. Cohesion for Base Circle	98.2 psf

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

Vertical Cut

Lambda	1.80
Ncf	5.32
F.S. against Toe Circle Failure	1.38
Actual Excavation Height	5.17 ft
F.S. Circular through Heel	1.38
Allowable Excavation Height	6.73 ft
F.S. Planar through Heel	1.25

Stem Wall Deflection

Deflection Req. for Active State	0.062 in
Approx. top of Stem Deflection	0.016 in

Deflection OK (< 0.20)

Design for K between Active and At Rest values

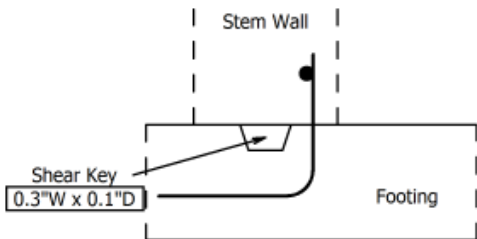
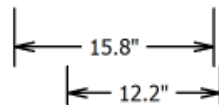
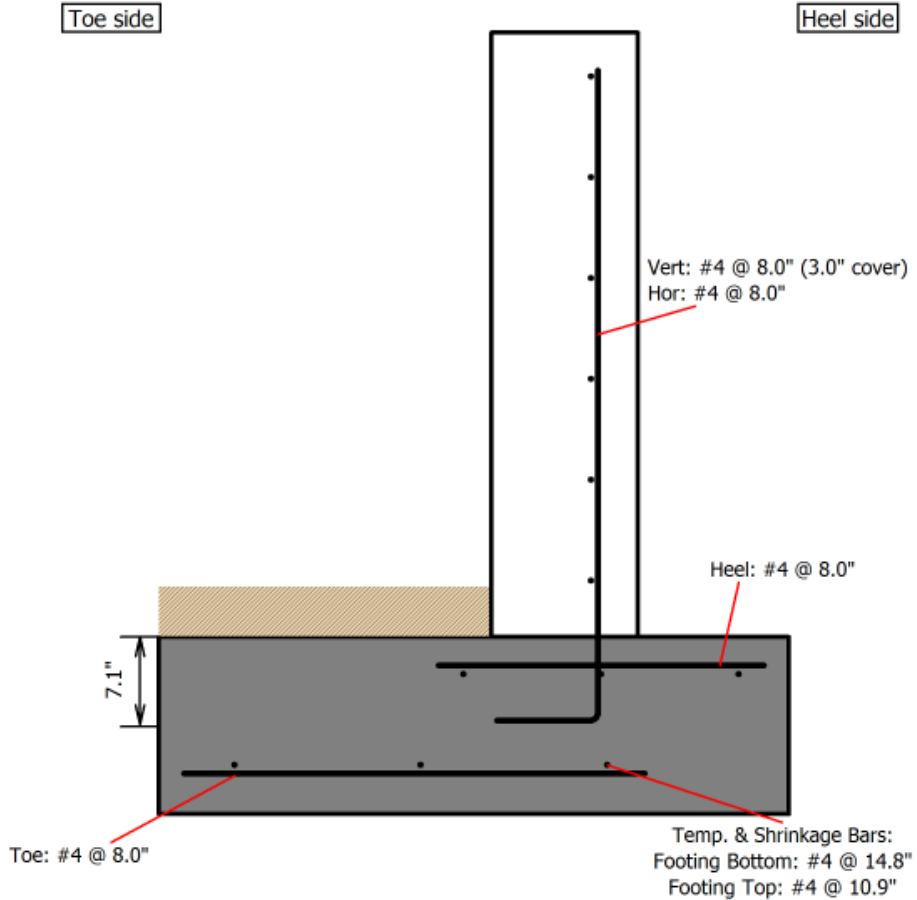


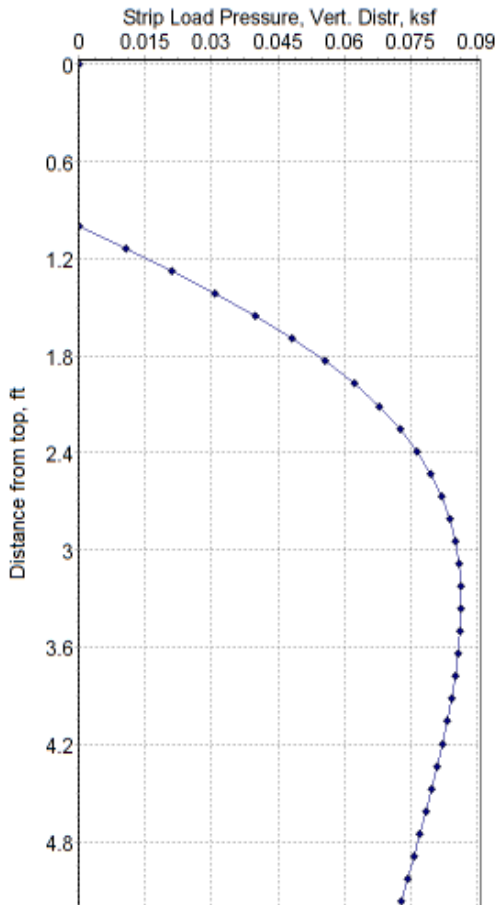
Table of Test Results - Stem Forces

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	-11917.1	0.0	-10731.0	0.026	-0.016
2	1.0	0.0	0.0	-11917.1	0.0	-10731.0	0.026	-0.015
3	1.9	0.0	0.0	-11917.1	0.0	-10731.0	0.026	-0.015
4	2.9	0.0	0.0	-11917.1	0.0	-10731.0	0.026	-0.014
5	3.8	0.0	0.0	-11917.1	0.0	-10731.0	0.026	-0.014
6	4.8	0.0	0.0	-11917.1	0.0	-10731.0	0.026	-0.014
7	5.8	0.0	0.0	-11917.1	0.0	-10731.0	0.026	-0.013
8	6.7	0.0	-2000.0	-11917.1	-120.0	-10731.0	0.026	-0.013
9	7.7	0.0	-2000.0	-11917.1	-280.0	-10731.0	0.026	-0.012
10	8.6	0.0	-2000.0	-11917.1	-440.0	-10731.0	0.026	-0.012
11	9.6	0.0	-2000.0	-11917.1	-600.0	-10731.0	0.026	-0.011
12	10.6	0.0	-2000.0	-11917.1	-760.0	-10731.0	0.026	-0.011
13	11.5	0.0	-2000.0	-11917.1	-920.0	-10731.0	0.026	-0.011
14	12.5	-76.1	-2008.4	-11917.1	-1080.2	-10731.0	0.026	-0.010
15	13.4	-80.4	-2025.6	-11917.1	-1241.5	-10731.0	0.026	-0.010
16	14.4	-84.8	-2043.1	-11917.1	-1404.3	-10731.0	0.025	-0.009
17	15.4	-89.1	-2061.0	-11917.1	-1568.4	-10731.0	0.025	-0.009
18	16.3	-93.4	-2079.1	-11917.1	-1734.0	-10731.0	0.025	-0.008
19	17.3	-97.8	-2097.7	-11917.1	-1901.1	-10731.0	0.025	-0.008
20	18.2	-102.1	-2116.6	-11917.1	-2069.7	-10731.0	0.024	-0.008
21	19.2	-106.5	-2135.8	-11917.1	-2239.8	-10731.0	0.024	-0.007
22	20.2	-110.8	-2155.4	-11917.1	-2411.4	-10731.0	0.024	-0.007
23	21.1	-115.1	-2175.3	-11917.1	-2584.6	-10731.0	0.023	-0.006
24	22.1	-119.5	-2195.6	-11917.1	-2759.5	-10731.0	0.023	-0.006
25	23.0	-123.8	-2216.2	-11917.1	-2935.9	-10731.0	0.022	-0.006
26	24.0	-128.2	-2237.2	-11917.1	-3114.1	-10731.0	0.022	-0.005
27	25.0	-132.5	-2258.5	-11917.1	-3293.9	-10731.0	0.021	-0.005
28	25.9	-136.8	-2280.2	-11917.1	-3475.5	-10731.0	0.021	-0.005
29	26.9	-141.2	-2302.2	-11917.1	-3658.8	-10731.0	0.020	-0.004
30	27.8	-145.5	-2324.6	-11917.1	-3843.8	-10731.0	0.020	-0.004
31	28.8	-149.9	-2347.3	-11917.1	-4030.7	-10731.0	0.019	-0.004
32	29.8	-154.2	-2370.3	-11917.1	-4219.4	-10731.0	0.018	-0.003
33	30.7	-158.5	-2393.7	-11917.1	-4410.0	-10731.0	0.018	-0.003
34	31.7	-162.9	-2417.5	-11917.1	-4602.4	-10731.0	0.017	-0.003
35	32.6	-167.2	-2441.6	-11917.1	-4796.8	-10731.0	0.016	-0.002
36	33.6	-171.6	-2466.0	-11917.1	-4993.1	-10731.0	0.015	-0.002
37	34.6	-175.9	-2490.8	-11917.1	-5191.3	-10731.0	0.015	-0.002
38	35.5	-180.2	-2516.0	-11917.1	-5391.6	-10731.0	0.014	-0.002
39	36.5	-184.6	-2541.5	-11917.1	-5593.9	-10731.0	0.013	-0.001
40	37.4	-188.9	-2567.3	-11917.1	-5798.3	-10731.0	0.012	-0.001
41	38.4	-193.3	-2593.5	-11917.1	-6004.7	-10731.0	0.011	-0.001
42	39.4	-661.5	-2620.0	-11917.1	-6213.2	-10731.0	0.010	-0.001
43	40.3	-201.9	-2646.9	-11917.1	-6423.9	-10731.0	0.009	-0.001
44	41.3	-206.3	-2674.1	-11917.1	-6636.7	-10731.0	0.008	0.000
45	42.2	-210.6	-2701.7	-11917.1	-6851.8	-10731.0	0.007	0.000
46	43.2	-215.0	-2729.6	-11917.1	-7069.0	-10731.0	0.006	0.000
47	44.2	-219.3	-2757.8	-11917.1	-7288.5	-10731.0	0.005	0.000
48	45.1	-223.6	-2786.5	-11917.1	-7510.3	-10731.0	0.004	0.000
49	46.1	-228.0	-2815.4	-11917.1	-7734.3	-10731.0	0.003	0.000
50	47.0	-232.3	-2844.7	-11917.1	-7960.7	-10731.0	0.001	0.000
51	48.0	-236.7	-2874.4	-11917.1	-8189.5	-10731.0	0.000	0.000

Table of Test Results - Backfill Surcharge Output

Node #	Vert. Height, ft	Strip Load Pr, ksf
0	1.000	0.000
1	1.139	0.011
2	1.278	0.021
3	1.417	0.031
4	1.556	0.040
5	1.695	0.048
6	1.834	0.056
7	1.973	0.062
8	2.112	0.068
9	2.251	0.073
10	2.390	0.077
11	2.529	0.080
12	2.668	0.082
13	2.807	0.084
14	2.946	0.085
15	3.085	0.086
16	3.224	0.086
17	3.363	0.086
18	3.502	0.086
19	3.641	0.086
20	3.780	0.085
21	3.919	0.084
22	4.058	0.083
23	4.197	0.082
24	4.336	0.081
25	4.475	0.080
26	4.614	0.079
27	4.753	0.077
28	4.892	0.076
29	5.031	0.074
30	5.170	0.073

Surcharges

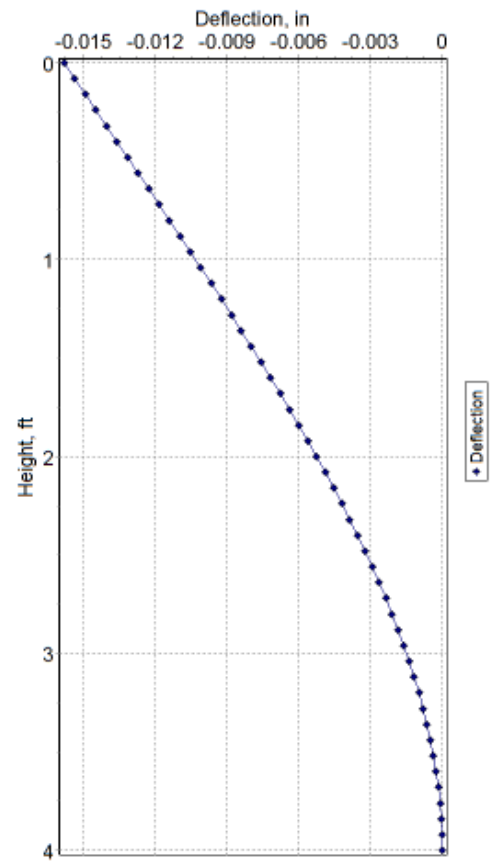
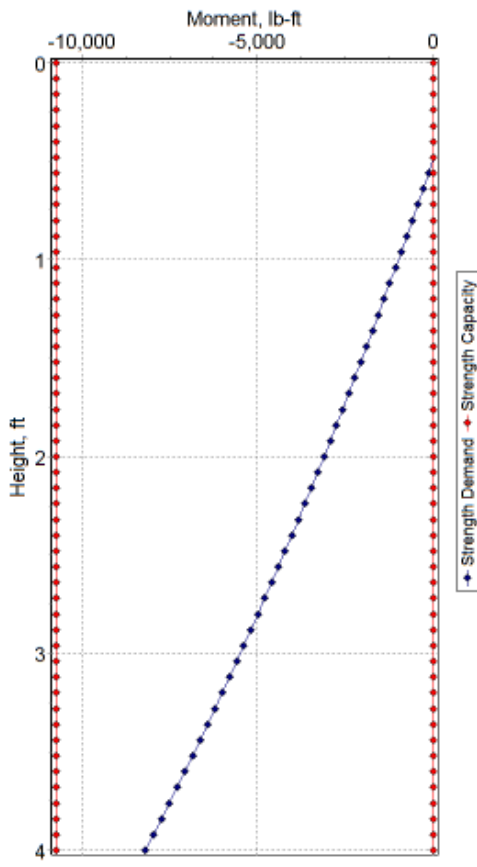
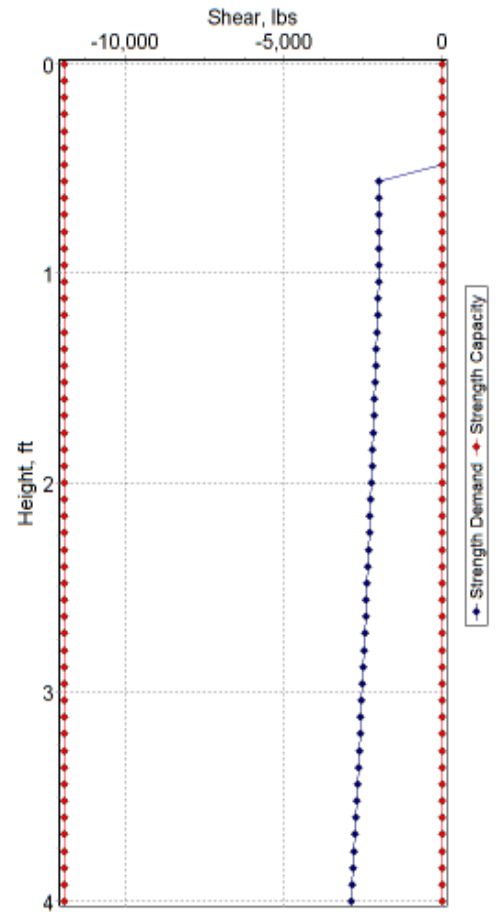
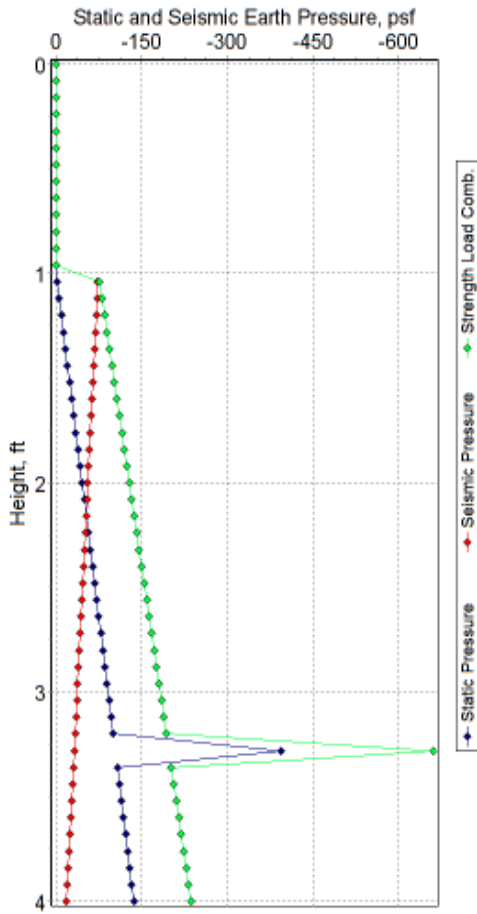


Line Load Does Not Apply

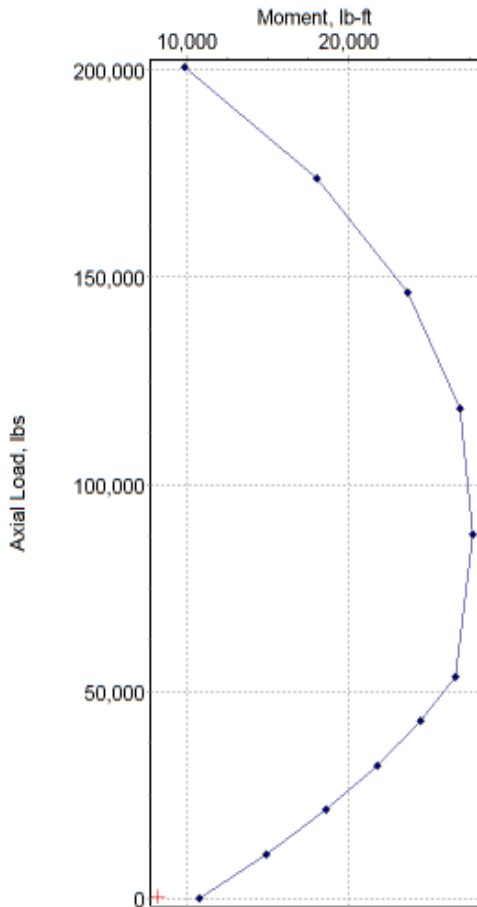
Point Load Does Not Apply
(Vertical Distribution)

Point Load Does Not Apply
(Horizontal Distribution)

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