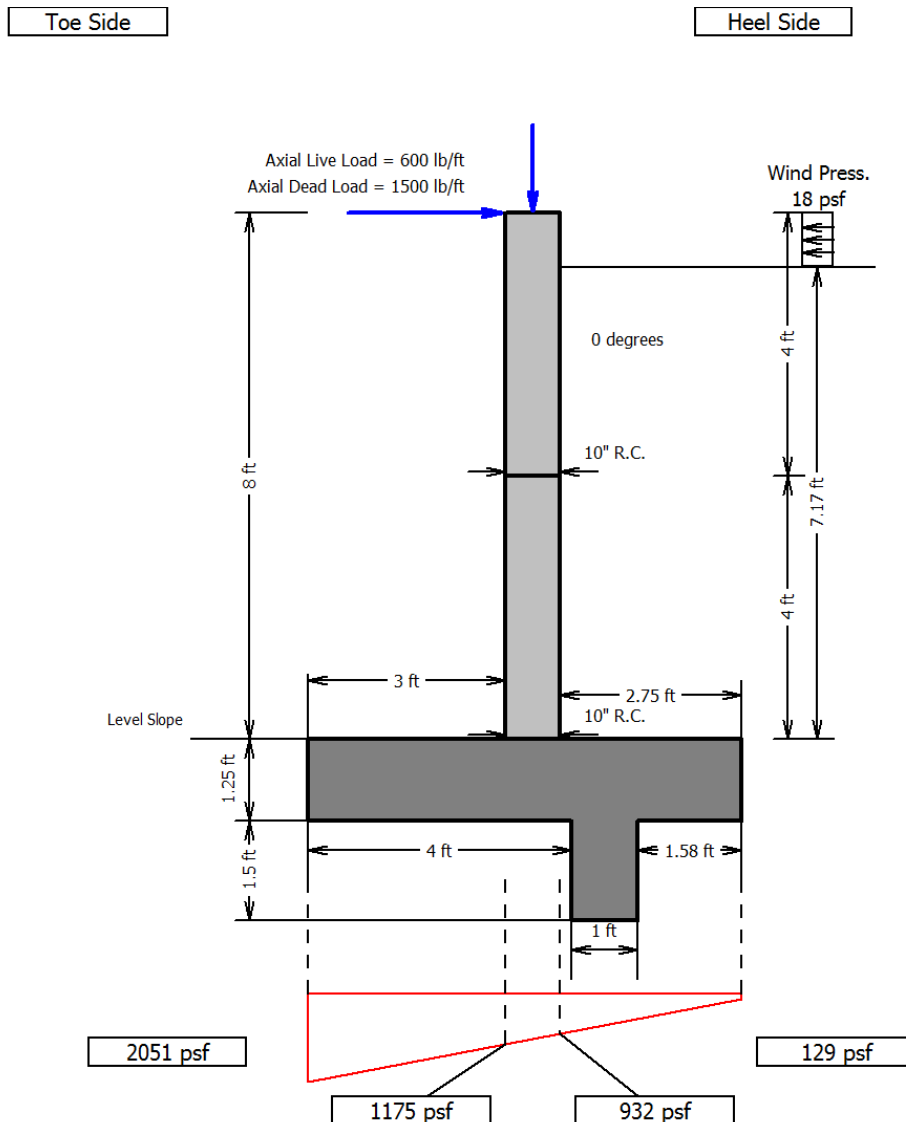


Cantilever or Restrained Retaining Wall Design Calculations

Organization: **F.E.C.**
 Project Name: **Ex2 Basement Wall**
 Design by: **LAA**
 Job #: **8437**
 Wall Type: **Guest House Basement**
 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	2
Top Restrained	Yes
Concrete Unit Weight	150 pcf
Bar Strength (Fy)	60.00 ksi
Parapet Height	0.83 ft
Wind Pressure	18.00 psf
Groundwater (from top of stem)	9.25 ft
Full Ht. Distr. Loading	0.000 kips/ft
From Un. Vert. Surch.	0.000 kips/ft

Backfill Soils

Coulomb Method

Soil Friction Angle	25.0 degrees
Soil-Wall Friction Angle	16.8 degrees
Backfill Slope Angle	0.0 degrees
Backwall Inclination Ang.	90.0 degrees
Soil Cohesion	150.00 psf
Soil/Rock Unit Weight	110.0 pcf
Allow Bear. Capacity	2600 psf
Uniform Vert. Surcharge	0.0 psf
Wall Height (Stem+Foot.)	9.25 ft

Uniform Seismic

Uniform Seismic	20.000 psf/ft
Overconsol. Ratio (OCR)	1.50

Passive Soils

Soil Friction Angle	25.0 degrees
Soil-Wall Friction Angle	-12.5 degrees
Passive Slope Angle	0.0 degrees
Ftng/Keyway Incln. Ang.	90.0 degrees
Soil Cohesion	150.00 psf
Soil/Rock Unit Weight	110.00 pcf
Ignore Passive Ht.	1.00 ft
Passive F.S.	1.25
F.S. on Sliding Fri. Coeff.	1.33

Global Stability of a Vertical Cut

Stem Section Design - Top

Stem Type	Concrete
Concrete Strength (f'c)	2.50 ksi
Wall Height	4.00 ft
Stem Width	10.00 in
Axial Live Load	600 lb/ft
Axial Dead Load	1500 lb/ft

Reinforcement - Vertical

Vert. Bar Size Toe Side	#5
Vert. Spacing Toe Side	16.0 in
Bar Cover	4.50 in

Reinforcement - Horizontal

Horiz. Bar Size Toe Side	#4
Horiz. Spacing Toe Side	9.0 in

Stem Section Design - Bottom

Stem Type	Concrete
Concrete Strength (f'c)	2.50 ksi
Wall Height	4.00 ft
Stem Width	10.00 in

Reinforcement - Vertical

Vert. Bar Size Toe Side	#5
Vert. Spacing Toe Side	16.0 in
Bar Cover	3.00 in

Reinforcement - Horizontal

Horiz. Bar Size Toe Side	#4
Horiz. Spacing Toe Side	9.0 in

Footing Dimensions

Heel Width	2.75 ft
Stem Width Bottom	0.83 ft
Toe Width	3.00 ft
Footing Thickness	1.25 ft
Tot. Footing Width	6.58 ft
Footing Soil Cover	0.00 ft
Concrete Strength (f'c)	2.50 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	4.00 ft
Keyway Embedment	1.50 ft
Keyway Width	1.00 ft
Keyway Vert. Bar	#4
Vert. Bar Spacing	16.0 in
Bar Cover	3.00 in

Heel Reinforcement

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

Toe Reinforcement

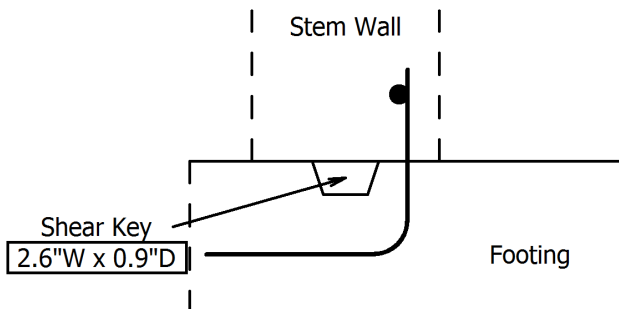
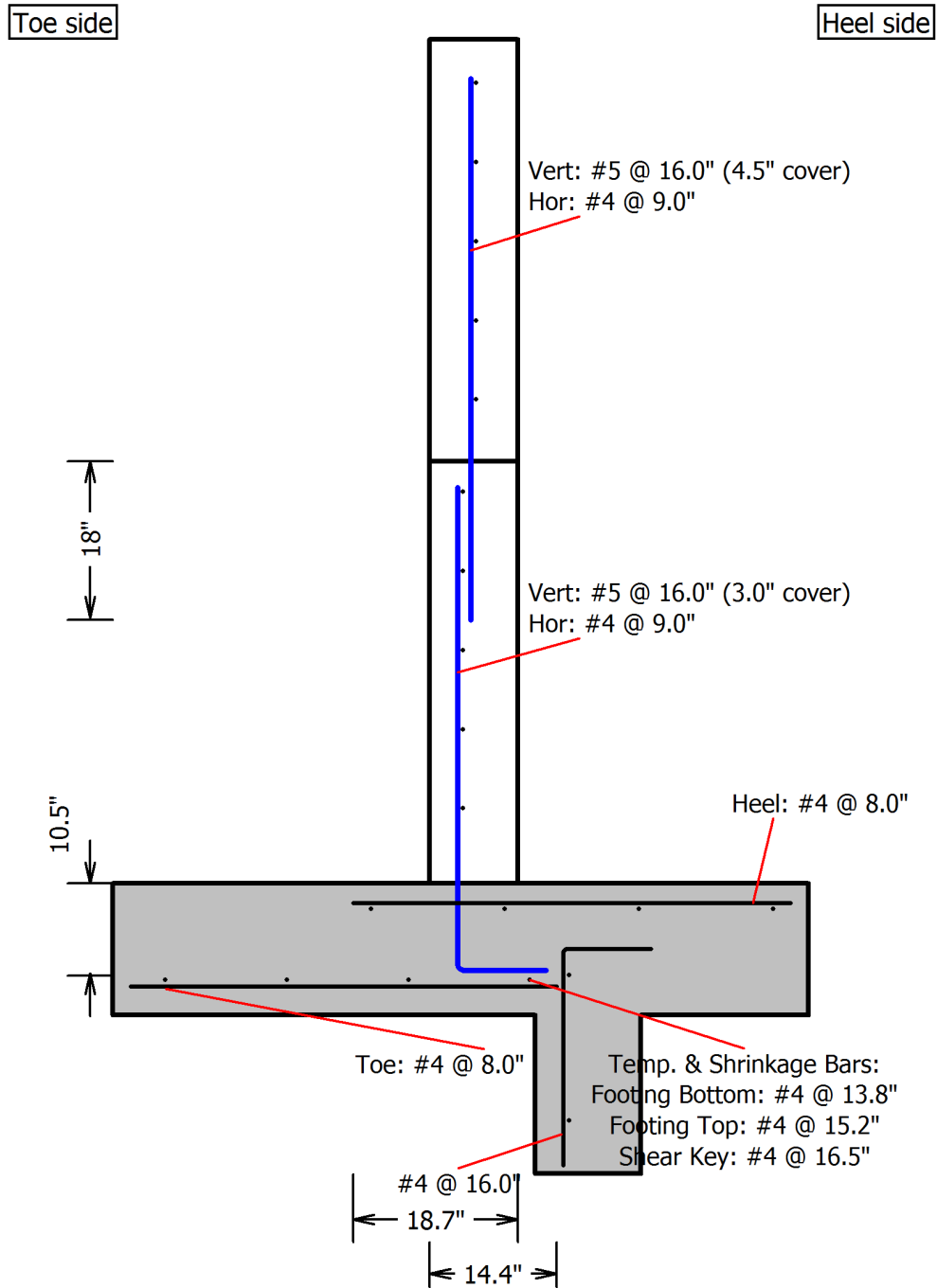
Bar Size	#4
Bar Spacing	8.0 in
Bar Cover	3.00 in

Shrinkage and Temperature Reinforcement

S & T Bar Size	#4
Nr of Bars Bottom	4
Nr of Bars Top	4
Nr of Bars Key	2

Footing Settlement

Poisson's ratio	0.35
Elastic Soil Modulus	900000 psf
Vert. Subgrade Modulus	110 ton/ft ³



Analysis and Design Results

Earth Pressures

At Rest Earth Pressure Coeff.	0.685
Passive Resistance Coeff.	3.552
Earth Press. - Horiz. Comp.	2687.14 lb
Earth Press. - Vert. Comp.	0.00 lb
Uniform Surcharge Comp.	0.00 lb
Passive Resist. Comp.	778.69 lb
Opposing Keyway Press. (1807.2.1)	0.00 lb
Equiv. At Rest Fluid Pressure	75.4 psf/ft
Equiv. Fluid Resistance Passive	312.6 psf/ft
Seismic Pressure Component	438.67 lb
Sliding Friction Coefficient	0.35

Retaining Wall Stability

Overturing F.S. Results

Not applicable.
The wall has a top restraint force of 385 lb/ft (service level).

Sliding F.S. Results

Sliding Force	3125.81 lb
Resisting Force	3813.79 lb
F.S. against Sliding	1.22

Footing Pressures

Resultant Loc. from Toe	2.54 ft
Resultant in middle third	
Toe Bearing Pressure	2051 psf
Heel Bearing Pressure	129 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	1072 psf
Distortion Settlement	0.18 in
Consolidation Settlement	0.35 in
Total Settlement	0.53 in

Settlement OK

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

Stem Sections - Top

Flexure

Moment Demand (Mu)	1503 lb-ft
Moment Capacity (PhiMn)	5141 lb-ft

Reinforcement - Vertical

Rho Min. Vertical	0.0018
Rho Max. Vertical	0.0129
Actual Rho Vertical	0.0019
Vert. Toe Side Steel Bar Used	#5 @ 16.0
Area of Steel - Vertical	0.23 in ²

Reinforcement - Horizontal

Rho Min. Horizontal	0.0018
Rho Max. Horizontal	0.0129
Actual Rho Horizontal	0.0022
Horiz. Toe Side Steel Bar Used	#4 @ 9.0
Area of Steel - Horizontal	0.27 in ²

Shear

Shear Demand (Vu)	578 lb
Shear Capacity (PhiVc)	4669 lb

Stem Sections - Bottom

Flexure

Moment Demand (Mu)	3480 lb-ft
Moment Capacity (PhiMn)	6711 lb-ft

Reinforcement - Vertical

Rho Min. Vertical	0.0018
Rho Max. Vertical	0.0129
Actual Rho Vertical	0.0019
Vert. Toe Side Steel Bar Used	#5 @ 16.0
Area of Steel - Vertical	0.23 in ²

Reinforcement - Horizontal

Rho Min. Horizontal	0.0018
Rho Max. Horizontal	0.0129
Actual Rho Horizontal	0.0022
Horiz. Toe Side Steel Bar Used	#4 @ 9.0
Area of Steel - Horizontal	0.27 in ²

Shear

Shear Demand (Vu)	2690 lb
Shear Capacity (PhiVc)	6019 lb

Heel Design

Flexure

Moment Demand (Mu)	2581 lb-ft
Moment Capacity (PhiMn)	16831 lb-ft

Rho Min. Heel	0.0018
Rho Max. Heel	0.0129
Actual Rho Used	0.0020
Heel Steel Used	#4 @ 8.0
Heel Area of Steel	0.30 in ²

Shear

Shear Demand (Vu)	3563 lb
Shear Capacity (PhiVn)	11475 lb

Toe Design

Flexure

Moment Demand (Mu)	5675 lb-ft
Moment Capacity (PhiMn)	15481 lb-ft
Rho Min. Toe	0.0018
Rho Max. Toe	0.0129
Actual Rho Used	0.0021
Toe Steel Used	#4 @ 8.0
Toe Area of Steel	0.30 in ²

Shear

Shear Demand (Vu)	3485 lb
Shear Capacity (PhiVn)	10575 lb

Base Shear Keyway

Moment Demand (Mu)	1246 lb-ft
Moment Capacity (PhiMn)	5787 lb-ft
Vertical reinforcement	#4 @ 16.0
Clear Cover	3.0 in

Bar Development

Heel into toe	18.7 in
Toe into heel	14.4 in
Bottom stem into footing	10.5 in
Top stem into bottom stem	18.0 in

Stem - Top of Footing Shear Key

Bearing Stress (10% f'c)	250 psi
Pure Shear Stress	85 psi
Required Key Width	2.6 in
Required Key Depth	0.9 in

Shrinkage and Temperature

	Max. spacing is 18.0 in
Bar Spacing Bottom	13.8 in
Bar Spacing Top	15.2 in
Bar Spacing Key	16.5 in

Global Stability

Req. Cohesion for Toe Circle	240.5 psf
Req. Cohesion for Base Circle	175.8 psf

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

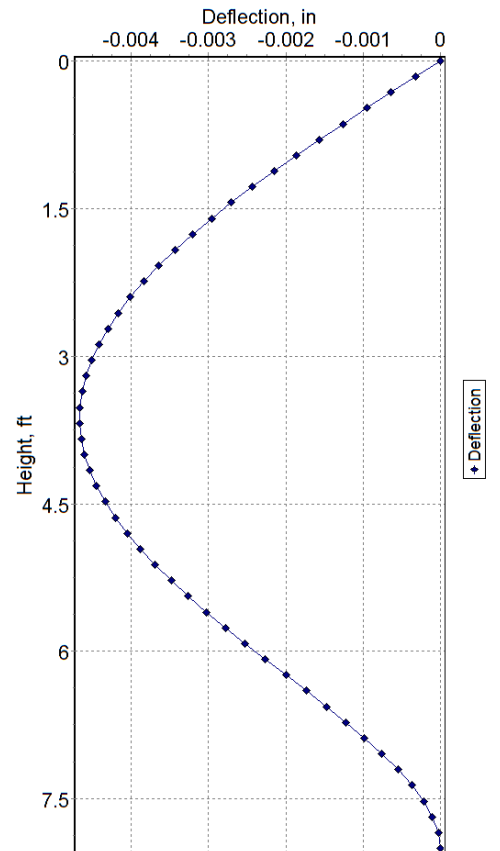
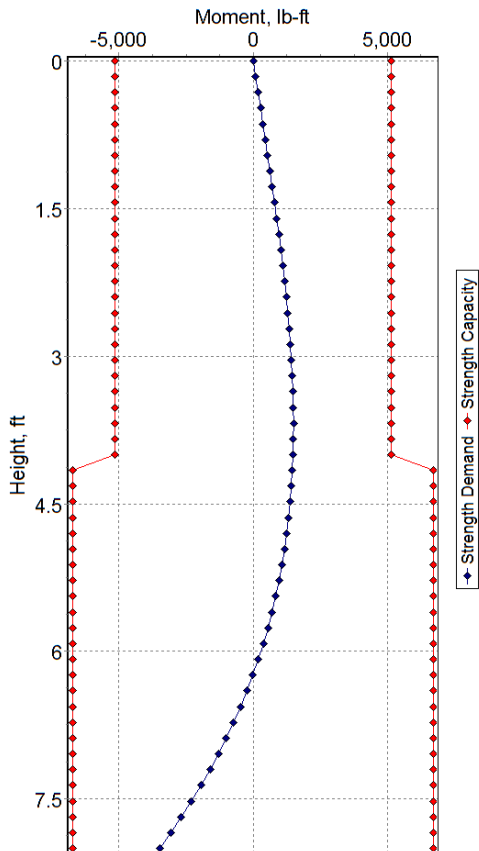
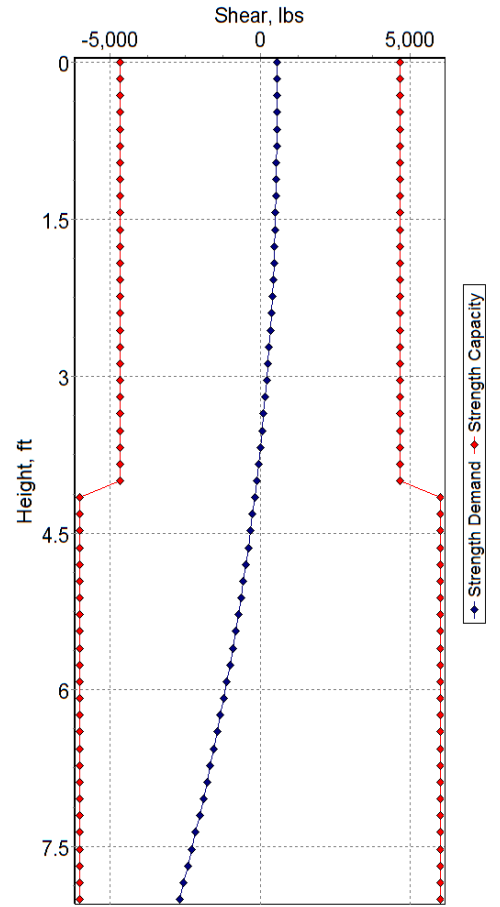
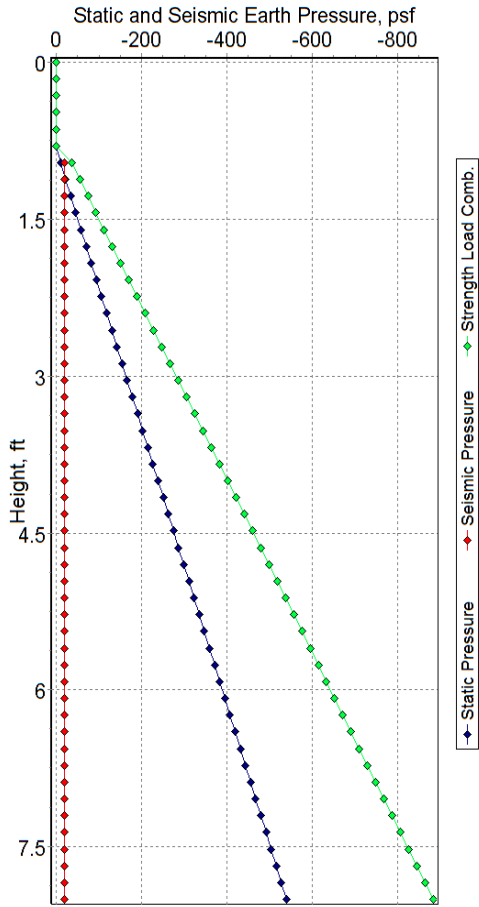
Stem Wall Deflection

The wall is restrained at the top against translation only and not rotation

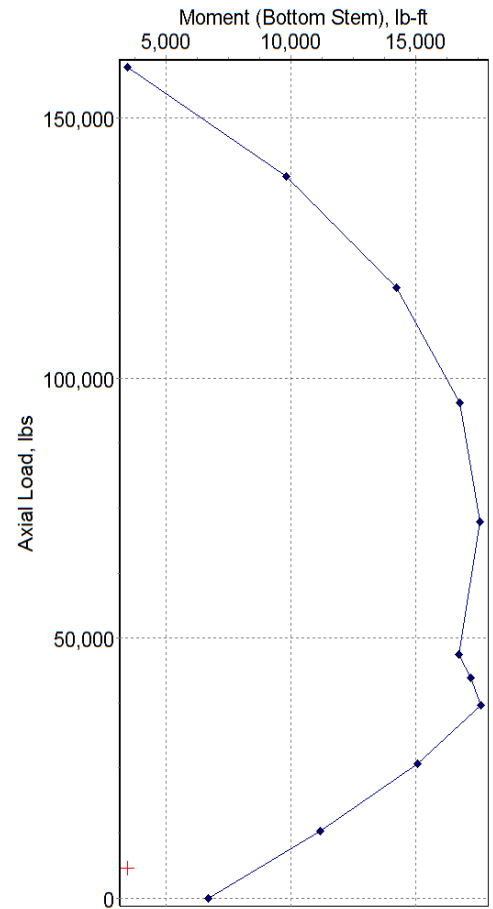
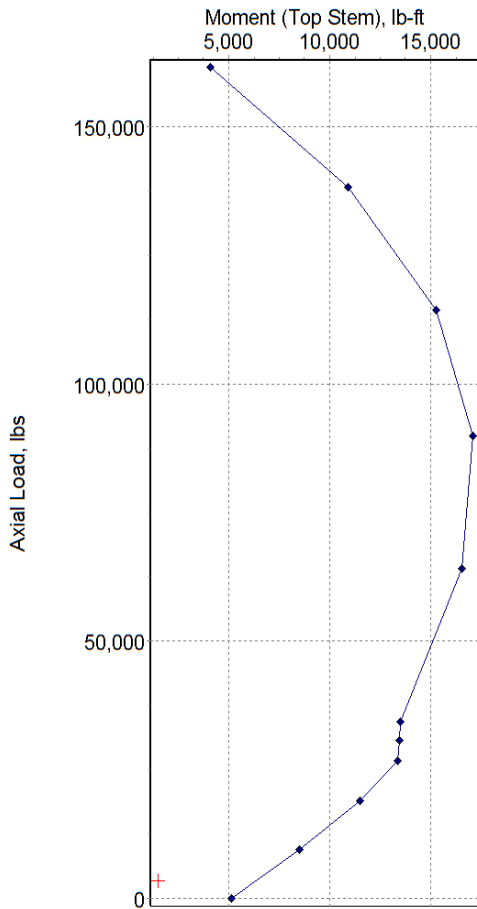
Table of Test Results - Stem Forces

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	578.1	-4668.8	0.0	-5141.2	-0.010	0.000
2	1.9	0.0	573.5	-4668.8	92.1	-5141.2	-0.010	0.000
3	3.8	0.0	568.9	-4668.8	183.5	-5141.2	-0.009	-0.001
4	5.8	0.0	564.3	-4668.8	274.2	-5141.2	-0.009	-0.001
5	7.7	0.0	559.7	-4668.8	364.1	-5141.2	-0.009	-0.001
6	9.6	0.0	555.1	-4668.8	453.3	-5141.2	-0.009	-0.002
7	11.5	-35.7	550.6	-4668.8	541.7	-5141.2	-0.009	-0.002
8	13.4	-55.0	543.3	-4668.8	629.3	-5141.2	-0.009	-0.002
9	15.4	-74.3	533.0	-4668.8	715.4	-5141.2	-0.008	-0.002
10	17.3	-93.6	519.6	-4668.8	799.7	-5141.2	-0.008	-0.003
11	19.2	-112.9	503.0	-4668.8	881.5	-5141.2	-0.007	-0.003
12	21.1	-132.2	483.4	-4668.8	960.5	-5141.2	-0.007	-0.003
13	23.0	-151.5	460.7	-4668.8	1036.1	-5141.2	-0.007	-0.003
14	25.0	-170.8	435.0	-4668.8	1107.8	-5141.2	-0.006	-0.004
15	26.9	-190.1	406.1	-4668.8	1175.1	-5141.2	-0.006	-0.004
16	28.8	-209.4	374.1	-4668.8	1237.5	-5141.2	-0.005	-0.004
17	30.7	-228.7	339.1	-4668.8	1294.6	-5141.2	-0.004	-0.004
18	32.6	-248.0	301.0	-4668.8	1345.9	-5141.2	-0.004	-0.004
19	34.6	-267.3	259.8	-4668.8	1390.8	-5141.2	-0.003	-0.004
20	36.5	-286.6	215.4	-4668.8	1428.8	-5141.2	-0.002	-0.005
21	38.4	-305.9	168.1	-4668.8	1459.6	-5141.2	-0.002	-0.005
22	40.3	-325.2	117.6	-4668.8	1482.5	-5141.2	-0.001	-0.005
23	42.2	-344.4	64.0	-4668.8	1497.0	-5141.2	0.000	-0.005
24	44.2	-363.7	7.4	-4668.8	1502.8	-5141.2	0.000	-0.005
25	46.1	-383.0	-52.4	-4668.8	1499.2	-5141.2	0.001	-0.005
26	48.0	-402.3	-115.2	-4668.8	1485.8	-5141.2	0.002	-0.005
27	49.9	-421.6	-181.1	-6018.8	1462.2	-6710.6	0.002	-0.005
28	51.8	-440.9	-250.1	-6018.8	1427.7	-6710.6	0.003	-0.004
29	53.8	-460.2	-322.2	-6018.8	1382.0	-6710.6	0.004	-0.004
30	55.7	-479.5	-397.4	-6018.8	1324.4	-6710.6	0.004	-0.004
31	57.6	-498.8	-475.7	-6018.8	1254.6	-6710.6	0.005	-0.004
32	59.5	-518.1	-557.1	-6018.8	1172.0	-6710.6	0.005	-0.004
33	61.4	-537.4	-641.5	-6018.8	1076.2	-6710.6	0.006	-0.004
34	63.4	-556.7	-729.0	-6018.8	966.6	-6710.6	0.006	-0.003
35	65.3	-576.0	-819.7	-6018.8	842.7	-6710.6	0.007	-0.003
36	67.2	-595.3	-913.4	-6018.8	704.1	-6710.6	0.007	-0.003
37	69.1	-614.6	-1010.2	-6018.8	550.3	-6710.6	0.007	-0.003
38	71.0	-633.9	-1110.0	-6018.8	380.7	-6710.6	0.008	-0.003
39	73.0	-653.2	-1213.0	-6018.8	194.9	-6710.6	0.008	-0.002
40	74.9	-672.5	-1319.1	-6018.8	-7.6	-6710.6	0.008	-0.002
41	76.8	-691.8	-1428.2	-6018.8	-227.3	-6710.6	0.008	-0.002
42	78.7	-711.1	-1540.5	-6018.8	-464.8	-6710.6	0.008	-0.001
43	80.6	-730.4	-1655.8	-6018.8	-720.5	-6710.6	0.007	-0.001
44	82.6	-749.7	-1774.2	-6018.8	-994.8	-6710.6	0.007	-0.001
45	84.5	-769.0	-1895.7	-6018.8	-1288.4	-6710.6	0.006	-0.001
46	86.4	-788.3	-2020.3	-6018.8	-1601.6	-6710.6	0.006	-0.001
47	88.3	-807.6	-2147.9	-6018.8	-1935.0	-6710.6	0.005	0.000
48	90.2	-826.9	-2278.7	-6018.8	-2289.1	-6710.6	0.004	0.000
49	92.2	-846.2	-2412.5	-6018.8	-2664.4	-6710.6	0.003	0.000
50	94.1	-865.5	-2549.5	-6018.8	-3061.3	-6710.6	0.002	0.000
51	96.0	-884.8	-2689.5	-6018.8	-3480.4	-6710.6	0.000	0.000

Stem Forces



P-M Diagrams



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