

Project Example Gravity Calculation	Project # 08110.00	Date 6/28/09
--	-----------------------	-----------------

**Example section – 9 ft tall unreinforced wall, 4H:1V backslope, sand backfill**

Uniform soil (sand) -  $\gamma = 125 \text{ pcf}$   $\phi = 30^\circ$   $c = 0 \text{ psf}$

Wall is composed of three 24 SF blocks

$$\omega' = \arctan((3 \times 4)/(9 \times 12/\text{ft})) = 6.34^\circ \quad \delta = \frac{1}{2} \times 30^\circ = 15^\circ$$

Granular base aggregate –  $\phi = 40^\circ$

Unit fill aggregate –  $\phi = 35^\circ$

Weight of Wall

$$W_b = (3 \times 6,000 \text{ lb})/8 \text{ ft} = 2,250 \text{ lb/ft block}$$

$$W_a = (3 \times 43.32 \text{ ft}^3 \times 110 \text{ pcf})/8 \text{ ft} = 1,787 \text{ lb/ft aggregate fill}$$

$$\text{Total Wall Weight} = 2,250 + 1,787 = 4,037 \text{ lb/ft}$$

$$W' = 1,787 \text{ lb/ft} \times 0.80 + 2,250 \text{ lb/ft} = 3,680 \text{ lb/ft}$$

**Forces/Geometric Properties**

Center of Gravity

$x_{\text{block}}$  – 22.7" from face, with 2 additional inches removed due to rounding – 1.73' total

$$x_w = [(1.73 + 0.5 \times (9 \text{ ft} - 3 \text{ ft}) \times \tan(6.34^\circ)) \times (2,250 \text{ lb} + 1,787 \text{ lb})] / 4,037 \text{ lb} = 2.06 \text{ ft}$$

$$w_u = (44 \text{ in} - 2 \text{ in}) / 12 = 3.5 \text{ ft}$$

Soil force components

$$K_a = \frac{\cos^2(30^\circ + 6.34^\circ)}{\cos^2(6.34^\circ) \cos(6.34^\circ - 15^\circ) \left[ 1 + \sqrt{\frac{\sin(30^\circ + 15^\circ) \sin(30^\circ - 14.0^\circ)}{\cos(6.34^\circ - 15^\circ) \cos(6.34^\circ + 14.0^\circ)}} \right]^2} = 0.313$$

$$P_h = 0.5 \times (0.313) \times 125 \text{ pcf} \times (9 \text{ ft})^2 \times \cos(15^\circ - 6.34^\circ) = 1,564 \text{ lb/ft}$$

$$P_v = 0.5 \times (0.313) \times 125 \text{ pcf} \times (9 \text{ ft})^2 \times \sin(15^\circ - 6.34^\circ) = 238 \text{ lb/ft}$$

Project	Example Gravity Calculation	Project #	08110.00	Date	6/28/09
---------	-----------------------------	-----------	----------	------	---------

### Overturning

$$FS = [3,680 \text{ lb/ft} \cdot 2.06 \text{ ft} + 238 \text{ lb} \cdot (3.5 \text{ ft} + 9 \text{ ft} / 3 \cdot \tan(6.34^\circ))] / [1,564 \text{ lb} \cdot 9 \text{ ft} / 3]$$

$$= 1.81 > 1.5 \quad \text{OK!}$$

### Sliding

$$\mu_b = [(0.8 \cdot 3.5 \text{ ft} \cdot \tan(35^\circ)) + (0.2 \cdot 3.5 \text{ ft} \cdot 0.8 \cdot \tan(40^\circ))] / (3.5 \text{ ft}) = 0.69$$

Use the smaller of the following:

$$R_s = 0.69 \cdot (4,037 \text{ lb/ft} + 238 \text{ lb/ft}) = 2,950 \text{ lb/ft}$$

$$R_s = (4,037 \text{ lb/ft} + 238 \text{ lb/ft}) \cdot \tan(30^\circ) + 0 = 2,468 \text{ lb/ft}$$

$$FS = 2,468 \text{ lb/ft} / 1,564 \text{ lb/ft} = 1.58 > 1.5 \quad \text{OK!}$$

### Bearing

$$N_q = e^{\pi \cdot \tan(30^\circ)} \cdot (\tan(45^\circ + 30^\circ / 2))^2 = 18.40$$

$$N_c = (18.40 - 1) / \tan(30^\circ) = 30.14$$

$$N_\gamma = 2 \cdot (18.40 + 1) \cdot \tan(30^\circ) = 22.40$$

$$e = [1,564 \text{ lb/ft} \cdot 9 \text{ ft} / 3 - 4,037 \text{ lb/ft} \cdot (2.06 \text{ ft} - 3.5 \text{ ft}) - 238 \text{ lb/ft} \cdot (3.5 \text{ ft} / 2 + 9 \text{ ft} / 2 \cdot \tan(6.34^\circ))] / [4,037 \text{ lb/ft} + 238 \text{ lb/ft}] = 0.69 \text{ ft}$$

$$B_f' = 3.5 \text{ ft} + 0.75 \text{ ft} - 2 \cdot 0.69 \text{ ft} = 2.88 \text{ ft}$$

$$q_c = (4,037 \text{ lb} + 238 \text{ lb/ft}) / 2.88 \text{ ft} + 0.75 \text{ ft} \cdot 125 \text{ pcf} = 1,580 \text{ psf}$$

$$q_b = 0 \cdot 30.14 + (9'' + 9'') / 12 \cdot 125 \text{ pcf} \cdot 18.40 + 0.5 \cdot 125 \text{ pcf} \cdot 2.88 \text{ ft} \cdot 22.40 = 7,479 \text{ psf}$$

$$FS = 7,479 \text{ psf} / 1,580 \text{ psf} = 4.73 > 2.0 \quad \text{OK!}$$

Project Example Gravity Calculation	Project # 08110.00	Date 6/28/09
--	-----------------------	-----------------

### Internal Analysis, Upper 2 Courses

#### Weight of Wall

$$W_b = (2 \times 6,000 \text{ lb}) / 8 \text{ ft} = 1,500 \text{ lb/ft block}$$

$$W_a = (2 \times 43.32 \text{ ft}^3 \times 110 \text{ pcf}) / 8 \text{ ft} = 1,191 \text{ lb/ft aggregate fill}$$

$$\text{Total Wall Weight} = 1,500 \text{ lb/ft} + 1,191 \text{ lb/ft} = 2,691 \text{ lb/ft}$$

$$W' = 1,191 \text{ lb/ft} \times 0.80 + 1,500 \text{ lb/ft} = 2,453 \text{ lb/ft}$$

#### **Forces/Geometric Properties**

##### Center of Gravity

$x_{\text{block}}$  – 22.7" from face, with 2 additional inches removed due to rounding – 1.73' total

$$x_w = [(1.73 + 0.5 \times (6 \text{ ft} - 3 \text{ ft}) \times \tan(6.34^\circ)) \times (1,500 \text{ lb/ft} + 1,191 \text{ lb/ft})] / 2,691 \text{ lb/ft} = 1.90 \text{ ft}$$

$$w_u = (44 \text{ in} - 2 \text{ in}) / 12 = 3.5 \text{ ft}$$

##### Soil force components

$$K_a = 0.313$$

$$P_h = 0.5 \times (0.313) \times 125 \text{ pcf} \times (6 \text{ ft})^2 \times \cos(15^\circ - 6.34^\circ) = 695 \text{ lb/ft}$$

$$P_v = 0.5 \times (0.313) \times 125 \text{ pcf} \times (6 \text{ ft})^2 \times \sin(15^\circ - 6.34^\circ) = 106 \text{ lb/ft}$$

#### **Overturing**

$$\text{FS} = [2,453 \times 1.90 \text{ ft} + 106 \text{ lb} \times (3.5 \text{ ft} + 6 \text{ ft} / 3 \times \tan(6.34^\circ))] / [695 \text{ lb} \times 6 \text{ ft} / 3]$$

$$= 3.63 > 1.5 \quad \text{OK!}$$

#### **Interface Shear**

$$R_s = 362 \text{ lb/ft} + (1,500 \text{ lb/ft} + 1,191 \text{ lb/ft} + 106 \text{ lb/ft}) \times \tan(35.2^\circ) = 2,335 \text{ lb/ft}$$

$$\text{FS} = 2,335 \text{ lb/ft} / 695 \text{ lb/ft} = 3.36 > 1.5 \quad \text{OK!}$$

Project Example Gravity Calculation	Project # 08110.00	Date 6/28/09
--	-----------------------	-----------------

### Internal Analysis, Top Course

#### Weight of Wall

$$W_b = (6,000 \text{ lb})/8 \text{ ft} = 750 \text{ lb/ft block}$$

$$W_a = (43.32 \text{ ft}^3 * 110 \text{ pcf})/8 \text{ ft} = 596 \text{ lb/ft aggregate fill}$$

$$\text{Total Wall Weight} = 750 \text{ lb/ft} + 596 \text{ lb/ft} = 1,346 \text{ lb/ft}$$

$$W' = 596 \text{ lb/ft} * 0.80 + 750 \text{ lb/ft} = 1,227 \text{ lb/ft}$$

#### **Forces/Geometric Properties**

##### Center of Gravity

$x_{\text{block}}$  – 22.7" from face, with 2 additional inches removed due to rounding – 1.73 ft total

$$w_u = (44 \text{ in} - 2 \text{ in})/12 = 3.5 \text{ ft}$$

##### Soil force components

$$K_a = 0.313$$

$$P_h = 0.5 * (0.313) * 125 \text{ pcf} * (3 \text{ ft})^2 * \cos(15^\circ - 6.34^\circ) = 174 \text{ lb/ft}$$

$$P_v = 0.5 * (0.13) * 125 \text{ pcf} * (3 \text{ ft})^2 * \sin(15^\circ - 6.34^\circ) = 23 \text{ lb/ft}$$

#### **Overturning**

$$\begin{aligned} \text{FS} &= [1,227 \text{ lb/ft} * 1.73 \text{ ft} + 26 \text{ lb} * (3.5 \text{ ft} + 3 \text{ ft} / 3 * \tan(6.34^\circ))] / [174 \text{ lb} * 3 \text{ ft} / 3] \\ &= 12.75 > 1.5 \quad \text{OK!} \end{aligned}$$

#### **Interface Shear**

$$R_s = 362 \text{ lb/ft} + (750 \text{ lb/ft} + 596 \text{ lb/ft} + 26 \text{ lb/ft}) * \tan(35.2^\circ) = 1,330 \text{ lb/ft}$$

$$\text{FS} = 1,330 \text{ lb/ft} / 174 \text{ lb/ft} = 7.65 > 1.5 \quad \text{OK!}$$

Project	Example Gravity Calculation	Project #	08110.00	Date	6/28/09
---------	-----------------------------	-----------	----------	------	---------

**Example section – 10.5 ft tall wall, 150 psf surcharge, 18"x3' tail extension, clay backfill**

Uniform soil (sand) -  $\gamma = 120$  pcf  $\phi = 26^\circ$   $c = 150$  psf

Wall is composed of three 24 SF blocks and one 6 SF block

$\omega' = \arctangent(-8 \text{ in}/10.5 \text{ ft}) = -3.63^\circ$   $\delta = 3/4 * 26^\circ = 19.5^\circ$

Granular base aggregate –  $\phi = 40^\circ$

Unit fill aggregate –  $\phi = 35^\circ$

Weight of Wall

$W_b = (3 * 6,000 \text{ lb})/8 \text{ ft} + 1,800 \text{ lb}/4 \text{ ft} = 2,700 \text{ lb/ft block}$

$W_a = (3 * 43.32 \text{ ft}^3 * 110 \text{ pcf})/8 \text{ ft} + (10.75 \text{ ft}^3 * 110 \text{ pcf})/4 \text{ ft} = 2,083 \text{ lb/ft aggregate fill}$

$W_{te} = 18 \text{ in}/12 * 3 \text{ ft} * 145 \text{ pcf} = 653 \text{ lb/ft}$

$W_{sot} = (10.5 \text{ ft} - 3 \text{ ft}) * 18 \text{ in}/12/2 * 120 \text{ pcf} = 675 \text{ lb/ft}$

Total Wall Weight =  $2,700 + 2,083 + 653 + 675 = 6,111 \text{ lb/ft}$

$W' = (2,083 \text{ lb/ft} + 675 \text{ lb/ft}) * 0.80 + 2,700 \text{ lb/ft} + 653 \text{ lb/ft} = 5,559 \text{ lb/ft}$

**Forces/Geometric Properties**

Center of Gravity

$x_{block} = 22.7''$  from face, with 2 additional inches removed due to rounding – 1.73' total

$w_u = (44 \text{ in} - 2 \text{ in})/12 = 3.5 \text{ ft}$

$w_s = 2 * 4 \text{ in} + 2 \text{ in} - 18 \text{ in} = -8 \text{ in}$

$x_w = [(1.73 + 0.5 * (10.5 \text{ ft} - 3 \text{ ft}) * \tan(6.34^\circ)) * (2,700 \text{ lb} + 2,083 \text{ lb}) + (3.5 \text{ ft} + 18 \text{ in}/12) / 2 * 653 \text{ lb/ft} + (3.5 \text{ ft} + 2/3 * 18 \text{ in}/12 + 1/3 * (-8 \text{ in})/12) * 675 \text{ lb/ft}] / 6,111 \text{ lb} = 2.61 \text{ ft}$

Soil force components

$$K_a = \frac{\cos^2(26^\circ + -3.63^\circ)}{\cos^2(-3.63^\circ) \cos(-3.63^\circ - 19.5^\circ) \left[ 1 + \sqrt{\frac{\sin(26^\circ + 19.5^\circ) \sin(26^\circ - 0^\circ)}{\cos(-3.63^\circ - 19.5^\circ) \cos(-3.63^\circ + 0^\circ)}} \right]^2} = 0.372$$

$P_h = 0.5 * (0.372) * 120 \text{ pcf} * (10.5 \text{ ft})^2 * \cos(19.5^\circ - (-3.63^\circ)) = 2,265 \text{ lb/ft}$

$P_v = 0.5 * (0.372) * 120 \text{ pcf} * (10.5 \text{ ft})^2 * \sin(19.5^\circ - (-3.63^\circ)) = 967 \text{ lb/ft}$

$Q_h = 0.372 * 150 \text{ psf} * 10.5 \text{ ft} * \cos(19.5^\circ - (-3.63^\circ)) = 539 \text{ lb/ft}$

<b>Project</b> Example Gravity Calculation	<b>Project #</b> 08110.00	<b>Date</b> 6/28/09
---	------------------------------	------------------------

### Overturning

$$FS = [5,559 \times 2.61 \text{ ft} + 967 \text{ lb} \times (3.5 \text{ ft} + 18 \text{ in}/12 + 10.5 \text{ ft}/3 \times \tan(-3.63^\circ))] / [2,265 \text{ lb} \times 10.5 \text{ ft}/3 + 539 \text{ lb} \times 10.5 \text{ ft}/2] = 1.78 > 1.5 \quad \text{OK!}$$

### Sliding

$$\mu_b = [(0.8 \times 3.5 \text{ ft} \times \tan(35^\circ)) + (0.2 \times 3.5 \text{ ft} \times 0.8 \times \tan(40^\circ)) + 0.84 \times 18 \text{ in}/12] / (3.5 \text{ ft} + 18 \text{ in}/12) = 0.74$$

Use the smaller of the following:

$$R_s = 0.74 \times (6,111 \text{ lb/ft} + 967 \text{ lb/ft}) = 5,238 \text{ lb/ft}$$

$$R_s = (6,111 \text{ lb/ft} + 967 \text{ lb/ft}) \times \tan(26^\circ) + 150 \text{ psf} \times (3.5 \text{ ft} + 18 \text{ in}/12 + 9 \text{ in}/12) = 4,314 \text{ lb/ft}$$

$$FS = 4,314 \text{ lb/ft} / (2,265 \text{ lb/ft} + 539 \text{ lb/ft}) = 1.54 > 1.5 \quad \text{OK!}$$

### Bearing

$$N_q = e^{\pi \times \tan(26^\circ)} \times (\tan(45^\circ + 26^\circ/2))^2 = 11.85$$

$$N_c = (11.85 - 1) / \tan(26^\circ) = 22.25$$

$$N_\gamma = 2 \times (11.85 + 1) \times \tan(26^\circ) = 12.54$$

$$e = [2,265 \text{ lb/ft} \times 10.5 \text{ ft}/3 + 539 \text{ lb/ft} \times 10.5 \text{ ft}/2 - 6,111 \text{ lb/ft} \times (2.61 \text{ ft} - 3.5 \text{ ft}/2 - 18 \text{ in}/24) - 967 \text{ lb/ft} \times (3.5 \text{ ft}/2 + 10.5 \text{ ft}/2 \times \tan(-3.63^\circ))] / [6,111 \text{ lb/ft} + 967 \text{ lb/ft}] = 1.12 \text{ ft}$$

$$B_f' = 3.5 \text{ ft} + 18 \text{ in}/12 + 0.75 \text{ ft} - 2 \times 1.12 \text{ ft} = 3.52 \text{ ft}$$

$$q_c = (6,111 \text{ lb} + 967 \text{ lb/ft}) / 3.52 \text{ ft} + 0.75 \text{ ft} \times 120 \text{ pcf} = 2,101 \text{ psf}$$

$$q_b = 150 \text{ psf} \times 22.25 + (9'' + 9'') / 12 \times 120 \text{ pcf} \times 11.85 + 0.5 \times 120 \text{ pcf} \times 3.52 \text{ ft} \times 12.54 = 8,119 \text{ psf}$$

$$FS = 8,119 \text{ psf} / 2,101 \text{ psf} = 3.86 > 2.0 \quad \text{OK!}$$

<b>Project</b> Example Gravity Calculation	<b>Project #</b> 08110.00	<b>Date</b> 6/28/09
---	------------------------------	------------------------

### Internal Analysis, Upper 7.5 feet

#### Weight of Wall

$$W_b = (2 \times 6,000 \text{ lb})/8 \text{ ft} + 1,800 \text{ lb}/4 \text{ ft} = 1,950 \text{ lb/ft block}$$

$$W_a = (2 \times 43.32 \text{ ft}^3 \times 110 \text{ pcf})/8 \text{ ft} + (10.75 \text{ ft}^3 \times 110 \text{ pcf})/4 \text{ ft} = 1,487 \text{ lb/ft aggregate fill}$$

$$\text{Total Wall Weight} = 1,950 \text{ lb/ft} + 1,487 \text{ lb/ft} = 3,437 \text{ lb/ft}$$

### Forces/Geometric Properties

#### Center of Gravity

$x_{\text{block}} = 22.7''$  from face, with 2 additional inches removed due to rounding – 1.73' total

$$x_w = [(1.73 + 0.5 \times (7.5 \text{ ft} - 3 \text{ ft}) \times \tan(6.34^\circ)) \times (1,950 \text{ lb/ft} + 1,487 \text{ lb/ft})] / 3,437 \text{ lb/ft} = 1.98 \text{ ft}$$

$$w_u = (44 \text{ in} - 2 \text{ in}) / 12 = 3.5 \text{ ft}$$

$$\omega = \arctangent(2 \text{ in} / 18 \text{ in}) = 6.34^\circ \quad \delta = 1/2 \times 26^\circ = 13^\circ$$

#### Soil force components

$$K_a = \frac{\cos^2(26^\circ + 6.34^\circ)}{\cos^2(6.34^\circ) \cos(6.34^\circ - 13^\circ) \left[ 1 + \sqrt{\frac{\sin(26^\circ + 13^\circ) \sin(26^\circ - 0^\circ)}{\cos(6.34^\circ - 13^\circ) \cos(6.34^\circ + 0^\circ)}} \right]^2} = 0.311$$

$$P_h = 0.5 \times (0.311) \times 120 \text{ pcf} \times (7.5 \text{ ft})^2 \times \cos(13^\circ - 6.34^\circ) = 1,043 \text{ lb/ft}$$

$$P_v = 0.5 \times (0.311) \times 120 \text{ pcf} \times (7.5 \text{ ft})^2 \times \sin(13^\circ - 6.34^\circ) = 122 \text{ lb/ft}$$

$$Q_h = 0.311 \times 150 \text{ psf} \times 7.5 \text{ ft} \times \cos(13^\circ - 6.34^\circ) = 348 \text{ lb/ft}$$

### Overturning

$$\text{FS} = \frac{[(1,950 \text{ lb/ft} + 0.8 \times 1,487 \text{ lb/ft}) \times 1.98 \text{ ft} + 122 \text{ lb} \times (3.5 \text{ ft} + 7.5 \text{ ft} / 3 \times \tan(6.34^\circ))]}{[1,043 \text{ lb} \times 7.5 \text{ ft} / 3 + 348 \text{ lb/ft} \times 7.5 \text{ ft} / 2]} = 1.71 > 1.5 \quad \text{OK!}$$

### Interface Shear

$$R_s = 362 \text{ lb/ft} + (1,950 \text{ lb/ft} + 1,487 \text{ lb/ft} + 122 \text{ lb/ft}) \times \tan(35.2^\circ) = 2,872 \text{ lb/ft}$$

$$\text{FS} = 2,872 \text{ lb/ft} / (1,043 \text{ lb/ft} + 348 \text{ lb/ft}) = 2.06 > 1.5 \quad \text{OK!}$$

<b>Project</b> Example Gravity Calculation	<b>Project #</b> 08110.00	<b>Date</b> 6/28/09
---	------------------------------	------------------------

### Internal Analysis, Upper 4.5 feet

#### Weight of Wall

$$W_b = (6,000 \text{ lb})/8 \text{ ft} + 1,800 \text{ lb}/4 \text{ ft} = 1,200 \text{ lb/ft block}$$

$$W_a = (43.32 \text{ ft}^3 * 110 \text{ pcf})/8 \text{ ft} + (10.75 \text{ ft}^3 * 110 \text{ pcf})/4 \text{ ft} = 891 \text{ lb/ft aggregate fill}$$

$$\text{Total Wall Weight} = 1,200 \text{ lb/ft} + 891 \text{ lb/ft} = 2,091 \text{ lb/ft}$$

#### **Forces/Geometric Properties**

##### Center of Gravity

$x_{\text{block}}$  – 22.7" from face, with 2 additional inches removed due to rounding – 1.73 ft total

$$x_w = [(1.73 + 0.5 * (4.5 \text{ ft} - 3 \text{ ft}) * \tan(6.34^\circ)) * (1,200 \text{ lb/ft} + 891 \text{ lb/ft})] / 1,346 \text{ lb/ft} = 1.81 \text{ ft}$$

$$w_u = (44 \text{ in} - 2 \text{ in}) / 12 = 3.5 \text{ ft}$$

##### Soil force components

$$K_a = 0.311$$

$$P_h = 0.5 * (0.311) * 120 \text{ pcf} * (4.5 \text{ ft})^2 * \cos(13^\circ - 6.34^\circ) = 376 \text{ lb/ft}$$

$$P_v = 0.5 * (0.311) * 120 \text{ pcf} * (4.5 \text{ ft})^2 * \sin(13^\circ - 6.34^\circ) = 44 \text{ lb/ft}$$

$$Q_h = 0.311 * 150 \text{ psf} * 4.5 \text{ ft} * \cos(13^\circ - 6.34^\circ) = 209 \text{ lb/ft}$$

#### **Overturning**

$$\text{FS} = [(1,200 \text{ lb/ft} + 0.8 * 891 \text{ lb/ft}) * 1.81 \text{ ft} + 44 \text{ lb} * (3.5 \text{ ft} + 4.5 \text{ ft} / 3 * \tan(6.34^\circ))] / [376 \text{ lb} * 4.5 \text{ ft} / 3 + 209 \text{ lb/ft} * 4.5 \text{ ft} / 2] = 3.51 > 1.5 \quad \text{OK!}$$

#### **Interface Shear**

$$R_s = 362 \text{ lb/ft} + (2,091 \text{ lb/ft} + 44 \text{ lb/ft}) * \tan(35.2^\circ) = 1,868 \text{ lb/ft}$$

$$\text{FS} = 1,868 \text{ lb/ft} / (376 \text{ lb/ft} + 209 \text{ lb/ft}) = 3.20 > 1.5 \quad \text{OK!}$$

Project Example Gravity Calculation	Project # 08110.00	Date 6/28/09
--	-----------------------	-----------------

### Internal Analysis, Upper 1.5 feet

#### Weight of Wall

$$W_b = 1,800 \text{ lb/4 ft} = 450 \text{ lb/ft block}$$

$$W_a = (10.75 \text{ ft}^3 * 110 \text{ pcf}) / 4 \text{ ft} = 296 \text{ lb/ft aggregate fill}$$

$$\text{Total Wall Weight} = 450 \text{ lb/ft} + 296 \text{ lb/ft} = 746 \text{ lb/ft}$$

### Forces/Geometric Properties

#### Center of Gravity

$x_{\text{block}}$  – 22.7" from face, with 2 additional inches removed due to rounding – 1.73 ft total

$$w_u = (44 \text{ in} - 2 \text{ in}) / 12 = 3.5 \text{ ft}$$

#### Soil force components

$$K_a = 0.311$$

$$P_h = 0.5 * (0.311) * 120 \text{ pcf} * (1.5 \text{ ft})^2 * \cos(13^\circ - 6.34^\circ) = 42 \text{ lb/ft}$$

$$P_v = 0.5 * (0.311) * 120 \text{ pcf} * (1.5 \text{ ft})^2 * \sin(13^\circ - 6.34^\circ) = 5 \text{ lb/ft}$$

$$Q_h = 0.311 * 150 \text{ psf} * 1.5 \text{ ft} * \cos(13^\circ - 6.34^\circ) = 70 \text{ lb/ft}$$

### Overturning

$$\text{FS} = [(450 \text{ lb/ft} + 0.8 * 296 \text{ lb/ft}) * 1.73 \text{ ft} + 5 \text{ lb} * (3.5 \text{ ft} + 1.5 \text{ ft} / 3 * \tan(6.34^\circ))] / [42 \text{ lb} * 1.5 \text{ ft} / 3 + 70 \text{ lb/ft} * 1.5 \text{ ft} / 2] = 15.70 > 1.5 \quad \text{OK!}$$

### Interface Shear

$$R_s = 362 \text{ lb/ft} + (746 \text{ lb/ft} + 5 \text{ lb/ft}) * \tan(35.2^\circ) = 892 \text{ lb/ft}$$

$$\text{FS} = 892 \text{ lb/ft} / (42 \text{ lb/ft} + 70 \text{ lb/ft}) = 8.01 > 1.5 \quad \text{OK!}$$