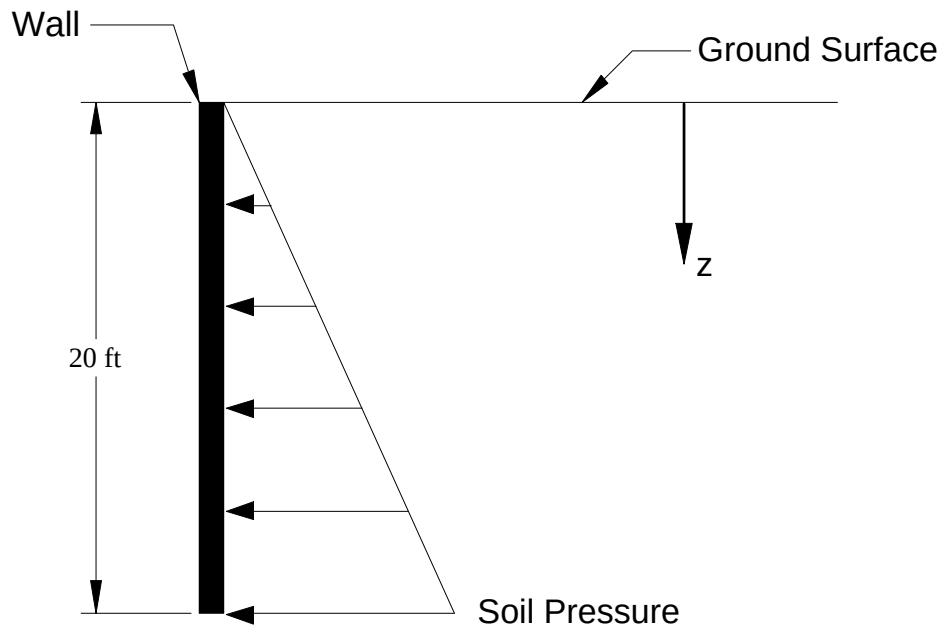
CE 115 Intro to Civil Eng: Geotechnical Engineering
Soil Pressure Acting on Wall



$$\sigma_h = k_a \gamma z \qquad \text{(Eq. 1)}$$

Where:

σ_h = soil pressure acting on wall

$k_a = \tan^2\left(45 - \frac{\phi}{2}\right)$, active earth pressure coefficient

γ = unit weight of soil (approximately 100 lb/ft^3)

z = depth below ground surface

Given: ϕ = 30 degrees

Find: Soil pressure acting on wall at depths of 10 feet and 20 feet below the ground surface.

Given

Soil friction angle $\phi := 30\text{deg}$

Soil unit weight $\gamma := 100\frac{\text{lbf}}{\text{ft}^3}$

Find: Soil pressure at depths of 10 and 20 feet below the ground surface

Active earth pressure coefficient $K_a := \left(\tan\left(45\text{deg} - \frac{\phi}{2}\right)\right)^2$ $K_a = 0.333$

Soil pressure at 10 ft $\sigma_{h\_10} := K_a \cdot \gamma \cdot 10\text{ft}$ $\sigma_{h\_10} = 333\frac{\text{lbf}}{\text{ft}^2}$

Soil pressure at 20 ft $\sigma_{h\_20} := K_a \cdot \gamma \cdot 20\text{ft}$ $\sigma_{h\_20} = 667\text{psf}$

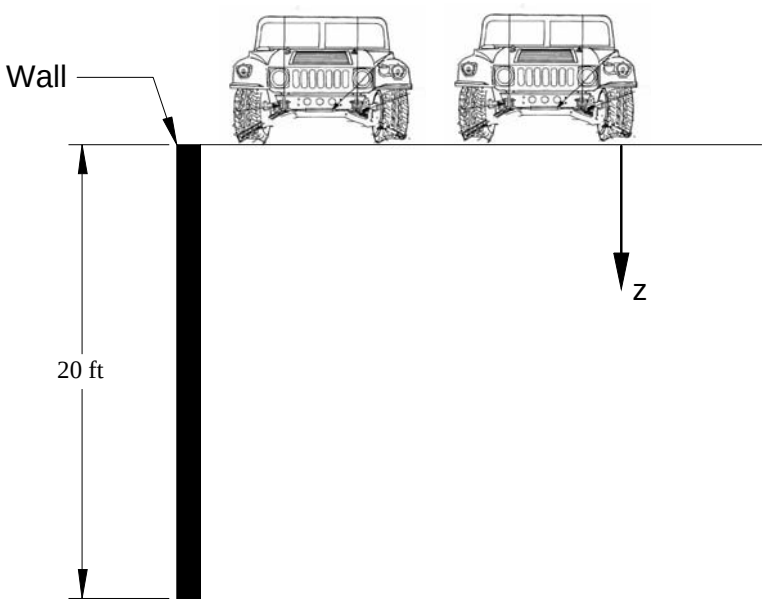
Alternatively

Depth where soil pressure is calculated $z := \begin{pmatrix} 10 \\ 20 \end{pmatrix}\text{ft}$

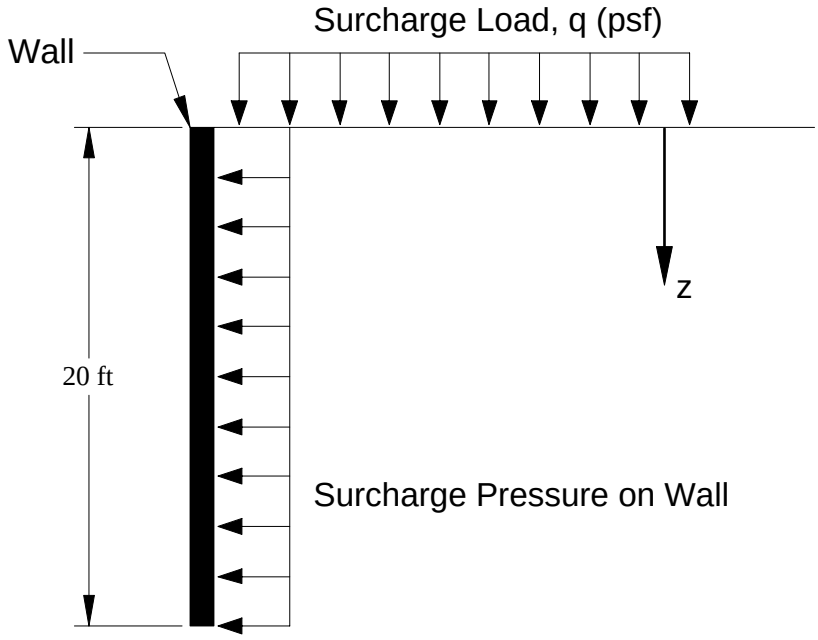
Soil pressure $\sigma_h := K_a \cdot \gamma \cdot z$ $\sigma_h = \begin{pmatrix} 333 \\ 667 \end{pmatrix}\text{psf}$

Surcharge Pressure Acting on Wall

A retaining wall with vehicles located behind the top of the wall is shown below. The vehicle weight imposes additional pressure on wall. The vehicle weight is called a surcharge load.



A simplification of the surcharge load used to determine the induced pressures on the wall is shown below.



$$\Delta\sigma_h = k_a q \qquad \text{(Eq. 2)}$$

Where:

$\Delta\sigma_h$ = surcharge pressure on wall
k_a = active earth pressure coefficient
q = surcharge load in pounds per square foot

Given: surcharge load, q = 100 lb/ft^2
ϕ = 30 degrees

Find: The surcharge pressure acting on the wall at depths of 10 feet and 20 feet.

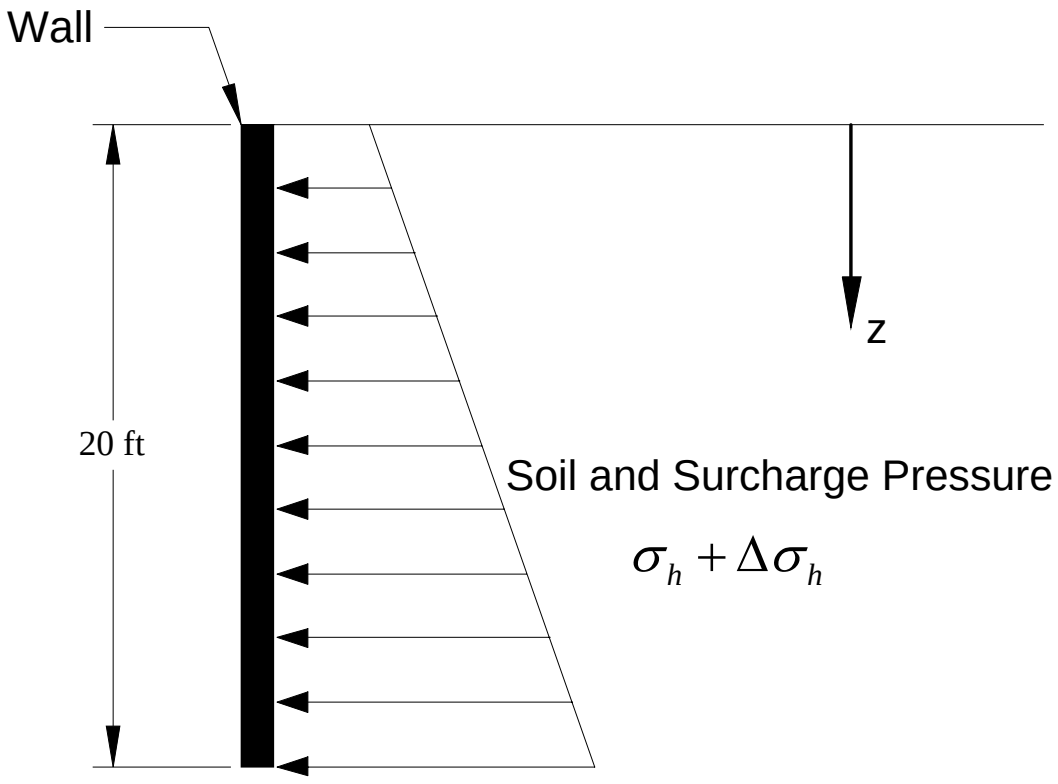
Given

Surcharge load $q := 100psf$

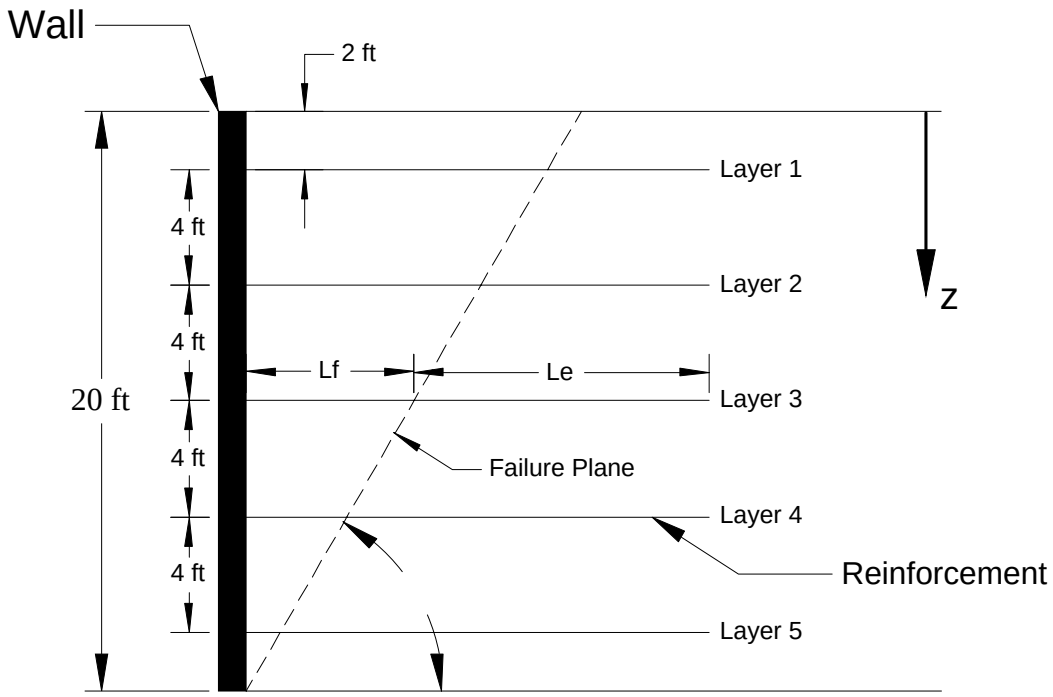
Find: Surcharge pressure at depths of 10 and 20 feet below the ground surface

Surcharge pressure, Same at all depths $\Delta\sigma_h := K_a \cdot q$ $\Delta\sigma_h = 33.333psf$

Total Pressure Acting on Wall



Calculate Pullout Force on Reinforcement



$$F_{pi} = (\sigma_h + \Delta\sigma_h)A_t \qquad \text{(Eq. 3)}$$

Where:

F_{pi} = pullout force for reinforcement layer i

$(\sigma_h + \Delta\sigma_h)$ = horizontal pressure at depth of reinforcement layer i

A_t = tributary area for reinforcement layer

$$A_t = S_v S_h \qquad \text{(Eq. 4)}$$

Where

S_v = vertical spacing between reinforcement layers

S_h = horizontal distance between reinforcement strips

Given: Pressure distribution calculated for the retaining wall above, and a horizontal reinforcement spacing, S_h, of 3 ft,

Find: The pullout force for layer 3 (F_{p3})

Given:

Horizontal spacing of reinforcement $S_h := 3ft$

Vertical spacing of reinforcement $S_v := 4ft$

Find: The pullout force applied to the reinforcement

Total soil pressure at depths of 10 and 20 feet below the ground surface

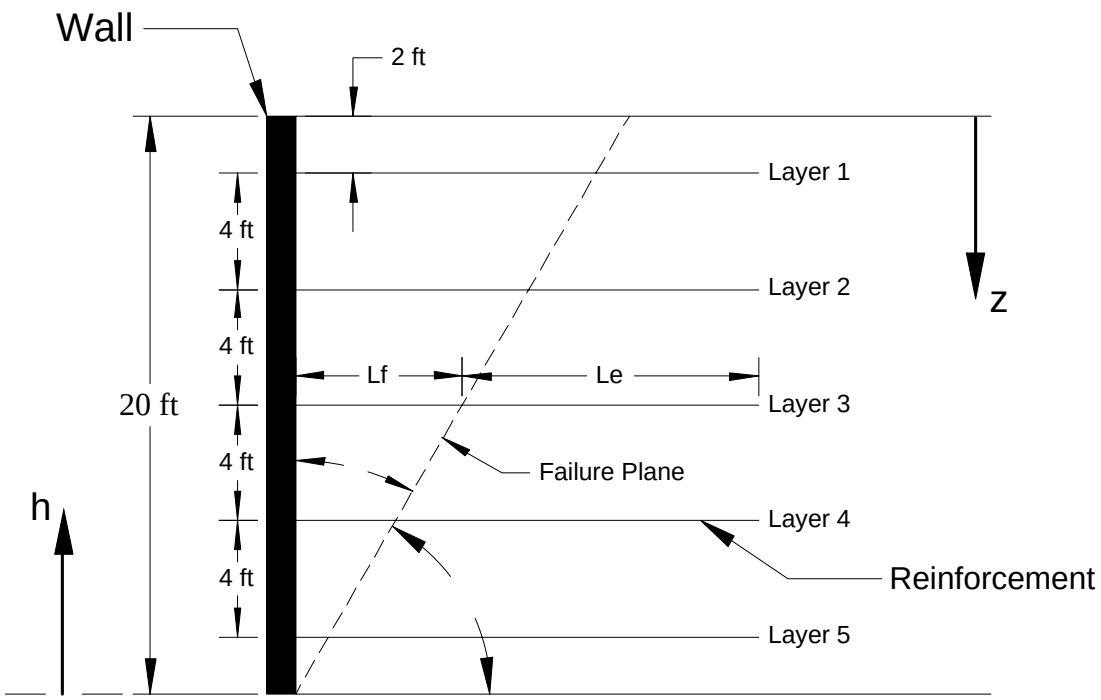
$\sigma_{hT} := \Delta\sigma_h + \sigma_h$ $\quad \sigma_{hT} = \begin{pmatrix} 367 \\ 700 \end{pmatrix} psf$

Pulllout force at depths of 10 and 20 feet below the ground surface

$F_p := (\Delta\sigma_h + \sigma_h) \cdot S_v \cdot S_h$ $\quad F_p = \begin{pmatrix} 4400 \\ 8400 \end{pmatrix} lbf$

Determine Reinforcement Length to Resist Pullout

Reinforcement resists pullout through the development of friction forces between the reinforcement and soil behind the failure plane.



Lf = distance from wall to failure plane
Le = distace from failure plane to end of reinforcement

$$Lf = h\tan\alpha \qquad \text{(Eq. 5)}$$

Where:

h = distance from base of wall to reinforcement layer i
α = angle between wall and failure plane

$$Le = \frac{(F_{pi})FS}{2b\gamma z\tan\left(\frac{2}{3}\phi\right)} \qquad \text{(Eq. 6)}$$

Where:

F_{pi} = pullout force for layer i
FS = factor of safety
b = width of reinforcement
γ = soil unit weight
z = depth below ground surface
ϕ = soil friction angle

Then the total reinforcement length, L, is Lf + Le.

Given: The retaining wall shown above, data from previous calculations (i.e. pullout force), reinforcement width of 0.5 ft, and a factor of safety of 1.5

Find: The reinforcement length for layer 3

Given

Horizontal spacing of reinforcement $S_h := 3ft$

Vertical spacing of reinforcement $S_v := 4ft$

Reinforcement width $b := 0.5ft$

Factor of safety $FS := 1.5$

Find: Reinforcement length of Layer 3

Distance from bottom of wall to layer 3 $h_{10} := 10ft$

Angle between wall and failure plane $\alpha := 90deg - \left(45deg + \frac{\phi}{2}\right)$

$\alpha = 30deg$

Distance from wall to failure plane $L_{f\_10} := h_{10} \cdot \tan(\alpha)$ $L_{f\_10} = 5.8ft$

Effective length of reinforcement at depths of 10 and 20 feet below the ground surface

$$L_{e\_10} := \frac{4400lbf \cdot FS}{2 \cdot b \cdot \gamma \cdot 10ft \cdot \tan\left(\frac{2}{3} \cdot \phi\right)}$$

$L_{e\_10} = 18.1ft$

Total reinforcement lenght

$L_{t\_10} := L_{f\_10} + L_{e\_10}$ $L_{t\_10} = 23.9ft$

CE 115 Intro to Civil Eng: Geotechnical Engineering Lab

Location: BEL 123

Objective: Design and build the most economical mechanically stabilized earth (MSE) wall.

Tasks:

1. In your assigned group, create a Mathcad worksheet to determine the required reinforcement length for the MSE wall. **This must be completed before the lab class begins.** Email yourself a copy of the Mathcad worksheet prior to class.
2. Determine the soil friction angle by building a wall without reinforcement and measuring the angle of the failure plane behind the wall. **Bring a protractor to measure the angle of the failure plane.**

   Failure Plane Angle, θ = _____

   Soil Friction Angle, ϕ = _____
3. Use your Mathcad worksheet from Task 1 and the friction angle from Task 2 to determine how much reinforcement you will need to build your wall. Submit a request for the number of 0.25 in by 11 in strips of paper you need.

Layer No.	Distance from Top of Wall (inches)	Reinforcement Length, L (inches)
1		
2		
3		
4		
5		
6		

4. Construct the MSE wall.

MSE Wall Design Data

Wall Height: 11 inches

Soil Unit Weight, γ: 100 lb/ft^3

Surcharge Load, q: 5 lb/ft^2

Factor of Safety: You choose

Reinforcement

Width, b: 0.25 inches

Horizontal Spacing, S_h: You choose. The box is 4 inches wide. Previously, only one strip was placed at each depth. As a result, S_b was 4 inches.

Vertical Spacing, S_v: You choose

Soil Friction Angle, ϕ: Obtained from Task 2 (While creating the Mathcad worksheet, assume ϕ = 36 degrees)

Wall Failure

Wall failure for this project is defined as 0.25 inches of outward movement/rotation of the wall face.