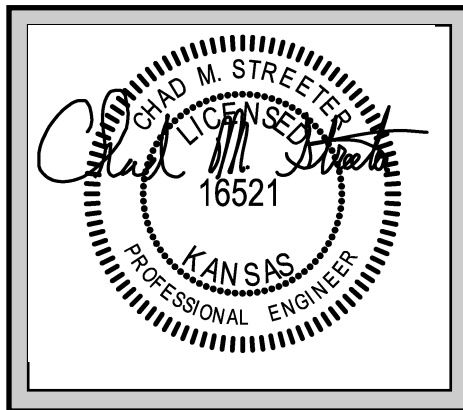


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Reinforced Soil Retaining Wall Design



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Segmental Retaining Wall Design Calculations per NCMA

Wall Geometry

Height	Backslope	Dead Load	Live Load	Distance to Slope	Wal below grade at toe
$H_w := 7.00 \cdot \text{ft}$	$\beta := 0.0 \cdot \text{deg}$	$q_d := 0 \cdot \text{psf}$	$q_l := 0 \cdot \text{psf}$	$Z := 1.0 \cdot \text{ft}$	$H_{\text{emb}} := .67 \cdot \text{ft}$

Soil Properties

Reinforced Soil (Internal)	Retained Soil (External)	Drainage Fill	Foundation Soil	Pullout
$\gamma_i := 110 \cdot \text{pcf}$	$\gamma_e := 120 \cdot \text{pcf}$	$\gamma_d := 110 \cdot \text{pcf}$	$\gamma_f := 120 \cdot \text{pcf}$	$C_i := 0.7$
$\phi_i := 32 \cdot \text{deg}$	$\phi_e := 26 \cdot \text{deg}$	$\phi_d := 32 \cdot \text{deg}$	$\phi_f := 26 \cdot \text{deg}$	
$C_{\text{dsi}} := 0.8$	$C_{\text{dse}} := 1.0$		$c_f := 0.0 \cdot \text{psf}$	

Segmental Unit Properties

Height	Length	Width	Setback	Center of Gravity	Batter
$H_u := 8 \cdot \text{in}$	$L_u := 18 \cdot \text{in}$	$W_u := 12 \cdot \text{in}$	$\Delta_u := 0.75 \cdot \text{in}$	$G_u := 6 \cdot \text{in}$	$\omega := \text{atan}\left(\frac{\Delta_u}{H_u}\right)$
Infilled Unit Weight					$\omega = 5.356 \cdot \text{deg}$
$\gamma_u := 120 \cdot \text{pcf}$					

Hinge Height

$$H_h := \text{if} \left[\tan(\omega) = 0, H, \left[2 \cdot \frac{(W_u - G_u)}{\tan(\omega)} \right] \right] \Rightarrow H_h = 10.667 \text{ ft} \text{ [Eq. 4-1]}$$

Internal Interface Friction Angle

$$\delta_i := \frac{2}{3} \cdot \phi_i \quad \delta_i = 21.33 \cdot \text{deg} \quad \text{[Eq. 3-17]}$$

Internal Active Earth Pressure

$$K_{a_i} := \frac{\cos(\phi_i + \omega)^2}{\cos(\omega)^2 \cdot \cos(\omega - \delta_i) \cdot \left[1 + \sqrt{\frac{\sin(\phi_i + \delta_i) \cdot \sin(\phi_i - \beta)}{\cos(\omega - \delta_i) \cdot \cos(\omega + \beta)}} \right]^2}$$

[Eq. 3-11] $K_{a_i} = 0.239$

External Interface Friction Angle

$$\delta_e := \text{if}(\phi_i > \phi_e, \phi_i, \phi_e) \quad \delta_e = 26 \cdot \text{deg} \quad \text{[Eq. 3-16]}$$

External Active Earth Pressure

$$K_{a_e} := \frac{\cos(\phi_e + \omega)^2}{\cos(\omega)^2 \cdot \cos(\omega - \delta_e) \cdot \left[1 + \sqrt{\frac{\sin(\phi_e + \delta_e) \cdot \sin(\phi_e - \beta)}{\cos(\omega - \delta_e) \cdot \cos(\omega + \beta)}} \right]^2}$$

[Eq. 3-11] $K_{a_e} = 0.304$

Orientation of Critical Internal Failure Surface

$$\alpha_i := \text{atan} \left[\frac{-\tan(\phi_i - \beta) + \sqrt{(\tan(\phi_i - \beta) \cdot (\tan(\phi_i - \beta) + \cot(\phi_i + \omega)) \cdot (1 + \tan(\delta_i - \omega) \cdot \cot(\phi_i + \omega)))}}{1 + \tan(\delta_i - \omega) \cdot (\tan(\phi_i - \beta) + \cot(\phi_i + \omega))} \right] + \phi_i \quad \text{[Eq. 3-14]}$$

$\alpha_i = 55.153 \cdot \text{deg}$

Orientation of Critical External Failure Surface

$$\alpha_e := \text{atan} \left[\frac{-\tan(\phi_e - \beta) + \sqrt{(\tan(\phi_e - \beta) \cdot (\tan(\phi_e - \beta) + \cot(\phi_e + \omega)) \cdot (1 + \tan(\delta_e - \omega) \cdot \cot(\phi_e + \omega)))}}{1 + \tan(\delta_e - \omega) \cdot (\tan(\phi_e - \beta) + \cot(\phi_e + \omega))} \right] + \phi_e \quad \text{[Eq. 3-14]}$$

$\alpha_e = 50.164 \cdot \text{deg}$

Eccentricity

$$L' := L - W_u - Z$$

$$L' = 3 \text{ ft}$$

[Fig. 2-10] [Eq. 5-1]

$$L'' := \frac{(L - W_u - Z) \cdot \tan(\beta) \cdot \tan(\omega)}{1 - \tan(\beta) \cdot \tan(\omega)}$$

$$L'' = 0 \text{ ft}$$

[Fig. 2-10] [Eq. 5-2]

$$L_\beta := L' + L''$$

$$L_\beta = 3 \text{ ft}$$

[Fig. 2-10] [Eq. 5-3]

$$h := L_\beta \cdot \tan(\beta)$$

$$h = 0 \text{ ft}$$

[Fig. 2-10] [Eq. 5-4]

$$W_{ri} := L \cdot \gamma_i \cdot H$$

$$W_{ri} = 3850 \cdot \text{plf}$$

[Eq. 5-15]

$$X_{ri} := \frac{1}{2} \cdot (L + H \cdot \tan(\omega))$$

$$X_{ri} = 2.828 \text{ ft}$$

[Eq. 5-19]

$$W_{r\beta} := \frac{1}{2} \cdot \gamma_i \cdot (L' - Z) \cdot h$$

$$W_{r\beta} = 0 \cdot \text{plf}$$

[Eq. 5-16]

$$X_{r\beta} := H \cdot \tan(\omega) + W_u + \frac{2}{3} \cdot L_\beta + Z$$

$$X_{r\beta} = 4.656 \text{ ft}$$

[Eq. 5-20]

$$X_{q\beta} := \frac{Z + L_\beta}{2} + [(H + h) \cdot \tan(\omega)] + W_u$$

$$X_{q\beta} = 3.656 \text{ ft}$$

[Eq. 5-21]

Actual Height of wall:

$$H_s := (H + h)$$

$$H_s = 7 \text{ ft}$$

Earth Pressures:

$$P_{sH} := \left[\frac{1}{2} \cdot K a_e \cdot \gamma_e \cdot (H + h)^2 \cdot \cos(\delta_e - \omega) \right]$$

$$P_{sH} = 835.516 \cdot \text{plf}$$

[Eq. 5-6]

$$Y_s := \frac{1}{3} \cdot (H + h)$$

$$Y_s = 2.333 \text{ ft}$$

[Eq. 5-9]

$$P_{qH} := (q_d + q_l) \cdot K a_e \cdot (H + h) \cdot \cos(\delta_e - \omega)$$

$$P_{qH} = 0 \cdot \text{plf}$$

[Eq. 5-8]

$$Y_q := \frac{1}{2} \cdot (H + h)$$

$$Y_q = 3.5 \text{ ft}$$

[Eq. 5-10]

$$e := \frac{\left[P_{sH} \cdot Y_s + P_{qH} \cdot Y_q - W_{ri} \cdot \left(X_{ri} - \frac{L}{2} \right) - W_{r\beta} \cdot \left(X_{r\beta} - \frac{L}{2} \right) - q_d \cdot (L_\beta) \cdot \left(X_{q\beta} - \frac{L}{2} \right) \right]}{W_{ri} + W_{r\beta} + q_d \cdot (L_\beta)}$$

$$e = 0.1782 \text{ ft}$$

[Eq. 5-25]

Check

$$e := \text{if}(e \leq 0, 0.075L, e)$$

$$e = 0.178 \text{ ft}$$

Surcharge is applied over: $(L' + L'') = 3 \text{ ft}$

$$B := L - 2 \cdot e$$

$$B = 4.644 \text{ ft}$$

[Eq. 5-24]

Bearing Capacity

$$Q_a := \frac{[W_{ri} + W_{r\beta} + (q_d + q_l) \cdot (L' + L'')]}{B}$$

$$Q_a = 829.115 \cdot \text{psf}$$

$$N_q := \tan\left(45 \cdot \text{deg} + \frac{\phi_f}{2}\right)^2 \cdot \exp(\pi \cdot \tan(\phi_f))$$

$$N_q = 11.854$$

[Fig. 4-5]

$$N_c := \text{if}[\phi_f = 0, 5.14, (N_q - 1) \cdot \cot(\phi_f)]$$

$$N_c = 22.254$$

[Fig. 4-5]

$$N_\gamma := 2 \cdot (N_q + 1) \cdot \tan(\phi_f)$$

$$N_\gamma = 12.539$$

[Fig. 4-5]

$$Q_{ult} := c_f \cdot N_c + \frac{1}{2} \cdot \gamma_f \cdot B \cdot N_\gamma + \gamma_f \cdot H_{emb} \cdot N_q$$

$$Q_{ult} = 4446.523 \cdot \text{psf}$$

[Eq. 4-20]

$$FS_{\text{bearing}} := \frac{Q_{ult}}{Q_a}$$

$$FS_{\text{bearing}} = 5.363$$

[Eq. 4-19]

Internal Stability

Reinforcement Properties

Geogrid Design Data

Backfill Soil

Type := (gravel)

1 2 3 4 5 6 7 8 9

Geogrid Number

$$\text{Type}^T = (411 \ 834 \ 1199 \ 1336 \ 2004 \ 2508 \ 3011 \ 3873 \ 7914)$$

$$\text{GN1} := 4$$

$$\text{GN2} := 2$$

$$\text{inter}^T = (1145 \ 1145 \ 1145 \ 1145 \ 1145 \ 1145 \ 0)$$

$$\text{slope}^T = (38 \ 38 \ 38 \ 38 \ 38 \ 38 \ 0)$$

$$\text{maxc}^T = (4540 \ 4540 \ 4540 \ 4540 \ 4540 \ 4540 \ 0) \quad x := 4..1 \quad x \text{ is the number of grids at the top of the wall of a different type}$$

$$T_a := \text{Type}_{\text{GN1}} \cdot \text{plf}$$

$$T_a = 1336 \cdot \text{plf}$$

$$T_{a2} := \text{Type}_{\text{GN2}} \cdot \text{plf}$$

$$T_{a2} = 834 \cdot \text{plf}$$

$$a_{cs} := \text{inter}_{\text{GN1}} \cdot \text{plf}$$

$$a_{cs} = 1145 \cdot \text{plf}$$

$$\lambda_{cs} := \text{slope}_{\text{GN1}} \cdot \text{deg}$$

$$\lambda_{cs} = 38 \cdot \text{deg}$$

$$V_{cs\text{max}} := \text{maxc}_{\text{GN1}} \cdot \text{plf}$$

$$V_{cs\text{max}} = 4540 \cdot \text{plf}$$

$$a_{cs2} := \text{inter}_{\text{GN2}} \cdot \text{plf}$$

$$a_{cs2} = 1145 \cdot \text{plf}$$

$$\lambda_{cs2} := \text{slope}_{\text{GN2}} \cdot \text{deg}$$

$$\lambda_{cs2} = 38 \cdot \text{deg}$$

$$V_{cs\text{max}2} := \text{maxc}_{\text{GN2}} \cdot \text{plf}$$

$$V_{cs\text{max}2} = 4540 \cdot \text{plf}$$

Tension in Geogrid

Number of Grids:	Grid Spacing (ft):	# of grids for that spacing:	Depth of first grid (ft):	Length of grids:		$L_r := \frac{L}{ft}$
$n_g := 3$	Spacing1 := 2	$n_1 := 3$	$h_1 := 2.33$	$L_1 := 5.0$	$L_2 := 5.0$	
	Spacing2 := 1.67	$n_2 := 0$				

Make all zero when using one geogrid

Note: make sure that the elevations don't excide the height of the wall (H) H = 7 ft

$$\begin{aligned} \text{top} &:= \text{length}(E) & p &:= 2.. \text{top} & \text{top} &= 3 \\ \text{grids} &:= \text{length}(E) & n &:= 1.. \text{top} & l &:= 1.. \text{grids} - 1 \end{aligned}$$

$$E = \begin{pmatrix} 2.33 \\ 4.33 \\ 6.33 \end{pmatrix} \text{ ft}$$

$$T_{a_x} := T_{a2} \quad T_{a_x} = \begin{pmatrix} 834 \\ 834 \\ 834 \\ 834 \end{pmatrix} \cdot \text{plf} \quad T_{a_x} := \frac{L \cdot T_a}{L} \quad T_a = \begin{pmatrix} 1336 \\ 1336 \\ 1336 \end{pmatrix} \cdot \text{plf} \quad L = \begin{pmatrix} 5 \\ 5 \\ 5 \end{pmatrix} \text{ ft}$$

$$T_a^T = (834 \ 834 \ 834 \ 834) \cdot \text{plf}$$

$$D_p := \frac{E_{p-1} + E_p}{2} \quad D_1 := 0 \cdot \text{ft} \quad D_{\text{grids}+1} := H$$

$$D^T = (0 \ 3.33 \ 5.33 \ 7) \text{ ft}$$

Total Applied Tensile Strength in the Geosynthetic reinf.:

$$F_{g_n} := \int_{D_n}^{D_{(n+1)}} (\gamma_i \cdot D + q_l + q_d) \cdot K a_i \cdot \cos(\delta_i - \omega) dD \quad [\text{Eq. 5-36}]$$

$$F_g^T = (139.992 \ 218.656 \ 259.952) \cdot \text{plf}$$

Safety factor:

$$FS_{\text{ten}_n} := \frac{T_{a_n}}{F_{g_n}} \quad FS_{\text{ten}}^T = (5.957 \ 3.814 \ 3.208)$$

Pullout Capacity

Anchorage Length of Geosynthetic

$$L_{a_n} := L_n - W_u - \left[(H + h) - E_n \right] \cdot \tan(90 \cdot \text{deg} - \alpha_i) + \left[(H + h) - E_n \right] \cdot \tan(\omega) \quad [\text{Eq. 5-46}]$$

$$L_a^T = (1.186 \quad 2.391 \quad 3.596) \text{ ft}$$

Note: If the anchorage length is less than 1ft then there is not enough embedment length and it has to be increased. Note that in some cases it might just be the top two grids.

Average Depth of overburden on Anchorage length

$$d_n := E_n + \left[(H - E_n) \cdot \tan(90 \cdot \text{deg} - \alpha_i) + \frac{L_{a_n}}{2} - (Z + H \cdot \tan(\omega) - \Delta_u) \right] \cdot \tan(\beta) \quad [\text{Eq. 5-47}]$$

$$d^T = (2.33 \quad 4.33 \quad 6.33) \text{ ft}$$

Anchorage Capacity

$$AC_n := 2 \cdot L_{a_n} \cdot C_i \cdot (d_n \cdot \gamma_i + q_d) \cdot \tan(\phi_i) \quad [\text{Eq. 5-45}]$$

$$AC^T = (266.008 \quad 996.423 \quad 2190.654) \cdot \text{plf}$$

$$F_g^T = (139.992 \quad 218.656 \quad 259.952) \cdot \text{plf}$$

Safety Factor

$$FS_{po} := \frac{\overrightarrow{AC}}{F_g} \quad [\text{Eq. 5-44}]$$

$$FS_{po}^T = (1.9 \quad 4.557 \quad 8.427)$$

Internal Sliding

Reduced reinforcement length

$$\Delta L_{l+1} := \begin{cases} \left[(E_{l+1} - E_l) \cdot \left(\frac{1}{\tan(\alpha_e)} - \tan(\omega) \right) \right] & \text{if } n_g > 2 \\ \text{Spacing}1 \cdot \text{ft} \cdot \left(\frac{1}{\tan(\alpha_e)} - \tan(\omega) \right) & \text{if } n_g = 2 \\ 0 & \text{if } n_g = 1 \end{cases} \quad [\text{Eq. 5-51}]$$

$$\Delta L^T = (0 \quad 1.481 \quad 1.481) \text{ ft}$$

$$L'_s := L_n - W_u - \Delta L_n \quad [\text{Eq. 5-50}]$$

$$L'_s{}^T = (4 \quad 2.519 \quad 2.519) \text{ ft}$$

Length of sloping ground

$$L_{s\beta_n} := L'_s + \frac{(L'_s - W_u) \cdot \tan(\beta) \cdot \tan(\omega)}{1 - \tan(\beta) \cdot \tan(\omega)} - Z \quad [\text{Eq. 5-53 \& 5-52}]$$

$$L_{s\beta}^T = (3 \quad 1.519 \quad 1.519) \text{ ft}$$

Height of slope above crest of wall

$$h'_n := L_{s\beta} \cdot \tan(\beta) \quad [\text{Eq. 5-54}]$$

$$h'^T = (0 \quad 0 \quad 0) \text{ ft}$$

Weight of reduced reinforced area

$$W'_{ri_n} := L'_{s_n} \cdot E_n \cdot \gamma_i \quad [\text{Eq. 5-55}]$$

$$W'_{ri}^T = (1025 \quad 1200 \quad 1754) \cdot \text{plf}$$

Weight of wedge beyond reinforced soil zone

$$W'_{r\beta_n} := \frac{1}{2} \cdot \left(L_{s\beta_n} \cdot h'_n \right) \cdot \gamma_i \quad [\text{Eq. 5-56}]$$

$$W'_{r\beta}^T = (0 \quad 0 \quad 0) \cdot \text{plf}$$

Friction developed by weight

$$R'_{s_n} := C_{dsi} \cdot \left[q_d \cdot \left(L_{s\beta_n} + Z \right) + W'_{ri_n} + W'_{r\beta_n} \right] \cdot \tan(\phi_i) \quad [\text{Eq. 5-49}]$$

$$R'_s{}^T = (512 \quad 600 \quad 877) \cdot \text{plf}$$

Shear capacity of facing elements

$$V_u := \min \left[V_{cs\max}, a_{cs} + \left(\text{if}(E_n > H_h, H_h, E_n) \cdot \gamma_u \cdot W_u \right) \cdot \tan(\lambda_{cs}) \right] \quad [\text{Eq. 4-25}]$$

$$V_u^T = (1363 \quad 1551 \quad 1738) \cdot \text{plf}$$

Driving Forces

From retained soil

$$P_{s_n} := \left[\frac{1}{2} \cdot K_{a_e} \cdot \gamma_e \cdot (E_n + h'_n)^2 \cdot \cos(\delta_e - \omega) \right] \quad [\text{Eq. 5-6}]$$

$$P_s^T = (93 \quad 320 \quad 683) \cdot \text{plf}$$

From surcharge

$$P_{q_n} := (q_d + q_l) \cdot K_{a_e} \cdot (E_n + h'_n) \cdot \cos(\delta_e - \omega) \quad [\text{Eq. 5-8}]$$

$$P_q^T = (0 \quad 0 \quad 0) \cdot \text{plf}$$

Factor of safety against internal sliding

$$P_a := P_{s_n} + P_{q_n} \quad [\text{Eq. 5-11}]$$

$$P_a^T = (93 \quad 320 \quad 683) \cdot \text{plf}$$

$$FS_{sl_n} := \frac{R'_{s_n} + V_{u_n}}{(P_a_n)} \quad [\text{Eq. 5-48}]$$

$$FS_{sl}^T = (20.265 \quad 6.728 \quad 3.828)$$

Local Stability of Facing Units

Facing Connection Strength

$$T_{\text{conn}_n} := \min \left[V_{\text{csmax}_n}, a_{\text{cs}_n} + \left(\text{if}(E_n > H_h, H_h, E_n) \cdot \gamma_u \cdot W_u \right) \cdot \tan(\lambda_{\text{cs}_n}) \right] \quad [\text{Eq. 5-59}]$$

$$T_{\text{conn}}^T = (1363 \quad 1551 \quad 1738) \cdot \text{plf}$$

$$FS_{\text{conn}_n} := \frac{T_{\text{conn}_n}}{F_{g_n}} \quad FS_{\text{conn}}^T = (9.739 \quad 7.093 \quad 6.688)$$

Resistance to Bulging

Shear capacity at each geogrid layer

$$V_{u_n} := \min \left[V_{\text{csmax}}, a_{\text{cs}} + \left(\text{if}(E_n > H_h, H_h, E_n) \cdot \gamma_u \cdot W_u \right) \cdot \tan(\lambda_{\text{cs}}) \right] \quad [\text{Eq. 4-25}]$$

$$V_u^T = (1363 \quad 1551 \quad 1738) \cdot \text{plf}$$

Driving Force at each geogrid layer

$$P_{a_n} := \left[\frac{1}{2} \cdot K a_i \cdot \gamma_i \cdot (E_n)^2 \cdot \cos(\delta_i - \omega) \right] + (q_d + q_l) \cdot K a_i \cdot (E_n) \cdot \cos(\delta_i - \omega) \quad [\text{Eq. 5-11}]$$

$$P_a^T = (69 \quad 237 \quad 506) \cdot \text{plf}$$

Sum of tension in reinforcement layers above layer being considered

$$F_{n+1} := \sum_{i=1}^n F_{g_i}$$

$$F^T = (0 \quad 140 \quad 359 \quad 619) \cdot \text{plf}$$

$$FS_{\text{sc}_n} := \frac{V_{u_n}}{P_{a_n} - F_n} \quad [\text{Eq. 5-61}]$$

$$FS_{\text{sc}}^T = (19.894 \quad 16.038 \quad 11.81)$$

Maximum unreinforced height of SRW units

$$y := E_1 = 2.33 \text{ ft}$$

$$q_w := 0 \cdot \text{psf}$$

Moment equilibrium

Driving Moments

$$P'_s := \left[\frac{1}{2} \cdot K a_i \cdot \gamma_i \cdot (y)^2 \cdot \cos(\delta_i - \omega) \right] \quad [\text{Eq. 4-5}]$$

$$P'_s = 68.537 \cdot \text{plf}$$

$$P'_q := (q_d + q_l) \cdot K a_i \cdot (y) \cdot \cos(\delta_i - \omega) \quad [\text{Eq. 4-6}]$$

$$P'_q = 0 \cdot \text{plf}$$

$$P'_a := P'_s + P'_q \quad [\text{Eq. 4-4}]$$

$$P'_a = 68.537 \cdot \text{plf}$$

$$Y'_s := \frac{1}{3} \cdot y \quad [\text{Eq. 4-7}]$$

$$Y'_s = 0.777 \text{ ft}$$

$$Y'_q := \frac{1}{2} \cdot y \quad [\text{Eq. 4-8}]$$

$$Y'_q = 1.17 \text{ ft}$$

$$M'_o := P'_s \cdot Y'_s + P'_q \cdot Y'_q \quad [\text{Eq. 4-17}]$$

$$M'_o = 53.23 \cdot \text{lbft}$$

Resisting Moments

$$W'_w := y \cdot \gamma_u \cdot W_u \quad [\text{Eq. 4-9}]$$

$$W'_w = 279.6 \cdot \text{plf}$$

$$X'_w := G_u + \frac{1}{2} \cdot (y) \cdot \tan(\omega) \quad [\text{Eq. 4-16}]$$

$$X'_w = 0.609 \text{ ft}$$

$$M'_r := W'_w \cdot X'_w \quad [\text{Eq. 4-15}]$$

$$M'_r = 170.338 \text{ ft} \cdot \text{plf}$$

$$FS_{ot} := \frac{M'_r}{M'_o} \quad [\text{Eq. 4-14}]$$

$$FS_{ot} = 3.2$$

Factor of Safety against Shear failure

$$V'_u := a_{cs} + W'_w \cdot \tan(\lambda_{cs}) \quad [\text{Eq. 4-25}]$$

$$FS_{sh} := \frac{V'_u}{P'_a} \quad [\text{Eq. 4-27}]$$

$$V'_u = \begin{matrix} 1363.447 \\ 1363.447 \end{matrix}$$

$$FS_{sh} = \begin{matrix} 19.894 \\ 19.894 \\ 19.894 \\ 19.894 \end{matrix}$$

Summary

Wal Height $H = 7 \text{ ft}$

Unreinforced Stability $FS_{ot} = 3.2$

$FS_{bearing} = 5.363$

Applied Bearing Stress $Q_a = 829 \cdot \text{psf}$

Grid Elevation	Geogrid Length	Tensile Force	Geogrid Strength	Anch. Length	Anch. Capacity	FS Grid Tension (1.0)	FS Pullout (1.5)	FS Int Sliding (1.5)	FS Conn (1.5)	FS Bulging (1.5)
$E_n =$	$L_n =$	$\frac{F_{g_n}}{\text{plf}} =$	$\frac{T_{a_n}}{\text{plf}} =$	$L_{a_n} =$	$\frac{AC_n}{\text{plf}} =$	$FS_{ten_n} =$	$FS_{po_n} =$	$FS_{sl_n} =$	$FS_{conn_n} =$	$FS_{sc_n} =$
2.33 ft	5 ft	140	834	1.19 ft	266	5.96	1.9	20.27	9.74	19.89
4.33	5	219	834	2.39	996	3.81	4.56	6.73	7.09	16.04
6.33	5	260	834	3.6	2191	3.21	8.43	3.83	6.69	11.81