

ASDIP Retain 5.5.6.3 CANTILEVER RETAINING WALL DESIGN www.asdipsoft.com

GEOMETRY			APPLIED LOADS		
Conc. Stem Height	4.50	ft	Surcharge	D = 0.0	L = 100.0 psf
Stem Thickness Top	8.0	in	Strip Pressure	D = 0.0	L = 0.0 psf
Stem Thickness Bot	12.0	in	<i>Strip 0.0 ft deep, 0.0 ft wide @ 0.0 ft from Stem</i>		
Footing Thickness	12.0	in	Stem Vertical	D = 0.0	L = 0.0 k/ft
Toe Length	0.00	ft	Stem Horizontal	D = 0.0	L = 0.0 k/ft
Heel Length	2.50	ft	Eccentricity	ev = 6.0	eh = 6.0 in
Soil Cover @ Toe	0.50	ft	Wind Load =	0.0 psf	Height = 5.00 ft
Backfill Height	4.50	ft	Uniform Seismic Pressure		50.0 psf
Backfill Slope Angle	0.0	deg			

BACKFILL PROPERTIES

Wall taper $\alpha = a \tan(\text{taper} / H) = a \tan((12.0 - 8.0) / 12 / 4.50) = 0.074 \text{ rad}$
 Backfill slope $\beta = \text{slope} * \pi / 180 = 0.0 * 3.14 / 180 = 0.000 \text{ rad}$
 Internal friction $\phi = \text{Int. friction} * \pi / 180 = 28.0 * 3.14 / 180 = 0.489 \text{ rad}$
 Wall-soil friction $\delta = \phi / 2 = 0.489 / 2 = 0.244 \text{ rad}$
 Footing length $ftg = \text{toe} + \text{stem} + \text{heel} = 0.00 + 12.0 / 12 + 2.50 = 3.50 \text{ ft}$
 Height for Stability $H_s = \text{wedge} + \text{backfill} + \text{footing} = 0.00 + 4.50 + 12.0 / 12 = 5.50 \text{ ft}$
 Earth pressure theory = **Coulomb Active** Moist density = **120 pcf** Saturated density = **130 pcf**

$$\text{Active coefficient } k_a = \frac{\cos^2(\phi - \alpha)}{\cos^2 \alpha * \cos(\delta + \alpha) * [1 + (\frac{\sin(\phi + \delta) * \sin(\phi - \beta)}{\cos(\delta + \alpha) * \cos(\beta - \alpha)})^{1/2}]^2} = 0.36$$

Active pressure $p_a = k_a * \gamma = 0.36 * 120.0 = 42.8 \text{ psf/ft of height}$

- For stability analysis (non-seismic)

Active force $P_a = k_a * \gamma * H_s^2 / 2 = 0.36 * 120.0 * 5.50^2 / 2 = 0.6 \text{ k/ft}$

$P_{ah} = P_a * \cos(\delta + \alpha) = 0.6 * \cos(0.244 + 0.074) = 0.6 \text{ k/ft}$

$P_{av} = P_a * \sin(\delta + \alpha) = 0.6 * \sin(0.244 + 0.074) = 0.2 \text{ k/ft}$

Water force $P_w = (k_a * (\gamma_s - \gamma_w - \gamma) + \gamma_w) * (\text{water table})^2 / 2$

$$P_w = (0.36 * (130.0 - 62.4 - 120.0) + 62.4) * 1.00^2 / 2 = 0.0 \text{ k/ft}$$

$$\text{Passive coefficient } k_p = \frac{\cos^2(\phi + \alpha)}{\cos^2 \alpha * \cos(\delta - \alpha) * [1 - (\frac{\sin(\phi + \delta) * \sin(\phi + \beta)}{\cos(\delta - \alpha) * \cos(\beta - \alpha)})^{1/2}]^2} = 3.34$$

- For stem design (non-seismic)

$$\text{Active force } Pa = ka * \gamma * H^2 / 2 = 0.36 * 120.0 * 4.50^2 / 2 = 0.4 \text{ k/ft}$$

$$Pah = Pa * \text{Cos}(\delta + \alpha) = 0.4 * \text{Cos}(0.244 + 0.074) = 0.4 \text{ k/ft}$$

$$Pav = Pa * \text{Sin} \beta = 0.4 * \text{Sin}(0.000) = 0.0 \text{ k/ft}$$

$$\text{Water force } Pw = (ka * (\gamma_s - \gamma_w - \gamma) + \gamma_w) * (\text{Water table} - Ftg)^2 / 2$$

$$Pw = (0.36 * (130.0 - 62.4 - 120.0) + 62.4) * (1.00 - 12.0 / 12)^2 / 2 = 0.0 \text{ k/ft}$$

- For stability analysis (seismic)

$$\text{Seismic force} = \text{Pressure} * Hs = 50.0 * 5.50 / 1000 = 0.3 \text{ k/ft}$$

- For stem design (seismic)

$$\text{Seismic force} = \text{Pressure} * H = 50.0 * 4.50 / 1000 = 0.2 \text{ k/ft}$$

OVERTURNING CALCULATIONS (Comb. D+H+0.6W)**- Overturning Forces**

$$\text{Backfill} = \text{Lat factor} * Pah = 1.00 * 0.6 = 0.6 \text{ k/ft}$$

$$\text{Arm} = Hs / 3 = 5.50 / 3 = 1.83 \text{ ft}$$

$$\text{Moment} = 0.6 * 1.83 = 1.1 \text{ k-ft/ft}$$

$$\text{Water table} = \text{Lat factor} * Pw = 1.00 * 0.0 = 0.0 \text{ k/ft}$$

$$\text{Arm} = \text{Water table} / 3 = 1.00 / 3 = 0.33 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.33 = 0.0 \text{ k-ft/ft}$$

$$\text{Surcharge} = \text{Factor} * ka * \text{Surcharge} * Hs * \text{Cos}(\delta + \alpha) = 1.00 * 0.36 * 100.0 * 5.50 * 0.95 = 0.2 \text{ k/ft}$$

$$\text{Arm} = Hs / 2 = 5.50 / 2 = 2.75 \text{ ft}$$

$$\text{Moment} = 0.2 * 2.75 = 0.5 \text{ k-ft/ft}$$

$$\text{Strip load} = \sum \text{Lat factor} * 2 * Q / n * [\beta - \text{Sin} \beta * \text{Cos}(2\alpha)] = 0.0 \text{ k/ft}$$

$$\text{Arm} = 0.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Concentrated Hor.} = \text{Factor} * Ph = 1.00 * 0.00 + 0.00 * 0.00 = 0.0 \text{ k/ft}$$

$$\text{Arm} = \text{Stem} + (Ftg - Ecc) / 12 = 4.50 + (12.0 - 6.0) / 12 = 5.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 5.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Wind load} = \text{WL factor} * \text{Pressure} * \text{Wind height} = 0.60 * 0.0 * 5.00 = 0.0 \text{ k/ft}$$

$$\text{Arm} = Ftg + \text{Stem} - \text{Wind height} / 2 = 12.0 / 12 + 4.50 - 5.00 / 2 = 3.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 3.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Backfill seismic} = \text{EQ factor} * \text{Seismic Force} = 0.00 * 0.3 = 0.0 \text{ k/ft}$$

$$\text{Arm} = 0.5 * Hs = 0.5 * 5.50 = 2.75 \text{ ft}$$

$$\text{Moment} = 0.0 * 2.75 = 0.0 \text{ k-ft/ft}$$

$$\text{Water seismic} = \text{EQ factor} * Pwe = 0.00 * 0.0 = 0.0 \text{ k/ft}$$

$$\text{Arm} = \text{Water table} / 3 = 1.00 / 3 = 0.33 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.33 = 0.0 \text{ k-ft/ft}$$

Wall selfweight seismic effect not considered in calculations

Wall seismic = 0.0 kip

Moment = 0.0 k-ft/ft

Overturning force $R_h = 0.6 + 0.0 + 0.2 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 = 0.8$ k/ft

Overturning moment $OTM = 1.1 + 0.0 + 0.5 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 = 1.6$ k-ft/ft

Arm of hor. resultant = $OTM / R_h = 1.6 / 0.8 = 2.00$ ft

- Resisting Forces

Stem weight $W_{Stem} = DL \text{ factor} * Thickness * Height * \gamma_c = 1.00 * 8.0 / 12 * 4.50 * 0.15 = 0.5$ k/ft

Arm = $Toe + Thickness / 2 = 0.00 + 8.0 / 12 / 2 = 0.33$ ft

Moment = $0.5 * 0.33 = 0.2$ k-ft/ft

Stem taper $W_{Taper} = DL \text{ factor} * \Delta Thick * Height / 2 * \gamma_c = 1.00 * (12.0 - 8.0) / 12 * 4.50 / 2 * 0.15 = 0.1$ k/ft

Arm = $Toe + Thick + \Delta Thick / 3 = 0.00 + 8.0 / 12 + (12.0 - 8.0) / 12 / 3 = 0.78$ ft

Moment = $0.1 * 0.78 = 0.1$ k-ft/ft

CMU stem at top = $1.00 * 0.00 = 0.0$ k/ft

Arm = 0.00

Moment = $0.0 * 0.00 = 0.0$ k-ft/ft

Ftg. weight $W_{Ftg} = DL \text{ factor} * Length * Thickness * \gamma_c = 1.00 * 3.50 * 12.0 / 12 * 0.15 = 0.5$ k/ft

Arm = $Length / 2 = 3.50 / 2 = 1.75$ ft

Moment = $0.5 * 1.75 = 0.9$ k-ft/ft

Key weight $W_{Key} = DL \text{ factor} * Depth * Thickness * \gamma_c = 1.00 * 0.00 / 12 * 0.0 / 12 * 0.15 = 0.0$ k/ft

Arm = $Toe + Stem - Thickness / 2 = 0.00 + (12.0 - 0.0 / 2) / 12 = 1.00$ ft

Moment = $0.0 * 1.00 = 0.0$ k-ft/ft

Soil cover = $DL \text{ factor} * Toe * Soil \text{ cover} * \gamma = 1.00 * 0.00 * 0.50 * 120.0 = 0.0$ k/ft

Arm = $Toe / 2 = 0.00 / 2 = 0.00$ ft

Moment = $0.0 * 0.00 = 0.0$ k-ft/ft

Stem wedge = $DL \text{ factor} * \Delta Thick * Height / 2 * \gamma = 1.00 * 0.33 * 4.50 / 2 * 120.0 = 0.1$ k/ft

Arm = $Toe + Thick - \Delta Thick * 2 / 3 = 0.00 + 12.0 / 12 - (12.0 - 8.0) / 12 * 2 / 3 = 0.78$ ft

Moment = $0.1 * 0.78 = 0.1$ k-ft/ft

Backfill weight = $DL \text{ factor} * Heel * Height * \gamma = 1.00 * 2.50 * 4.50 * 120.0 = 1.4$ k/ft

Arm = $Ftg - Heel / 2 = 3.50 - 2.50 / 2 = 2.25$ ft

Moment = $1.4 * 2.25 = 3.0$ k-ft/ft

Backfill slope = $DL \text{ factor} * (Heel + \Delta Thick) * Wedge / 2 * \gamma =$

$= 1.00 * (2.5 + (12.0 - 8.0) / 12) * 0.00 / 2 * 120.0 = 0.0$ k/ft

Arm = $ftg - (Heel + \Delta Thick) / 3 = 3.50 - (2.50 + (12.0 - 8.0) / 12) / 3 = 2.56$ ft

Moment = $0.0 * 2.56 = 0.0$ k-ft/ft

Water = $Factor * Heel * (Water - Ftg) * (\gamma_s - \gamma) = 1.00 * 2.50 * (1.00 - 12.0 / 12) * (130.0 - 120.0) = 0.0$ k/ft

Arm = $Ftg - Heel / 2 = 3.50 - 2.50 / 2 = 2.25$ ft

Moment = $0.0 * 2.25 = 0.0$ k-ft/ft

Seismic backfill = $EQ \text{ factor} * (P_{aev} - P_{av}) = 0.00 * (0.2 - 0.2) = 0.0$ k/ft

Arm = $Footing \text{ length} = 3.50$ ft

Moment = $0.0 * 3.50 = 0.0$ k-ft/ft

Backfill $P_{av} = Lat \text{ factor} * P_{av} = 1.00 * 0.2 = 0.2$ k/ft

Arm = $Footing \text{ length} = 3.50$ ft

Moment = $0.2 * 3.50 = 0.7$ k-ft/ft

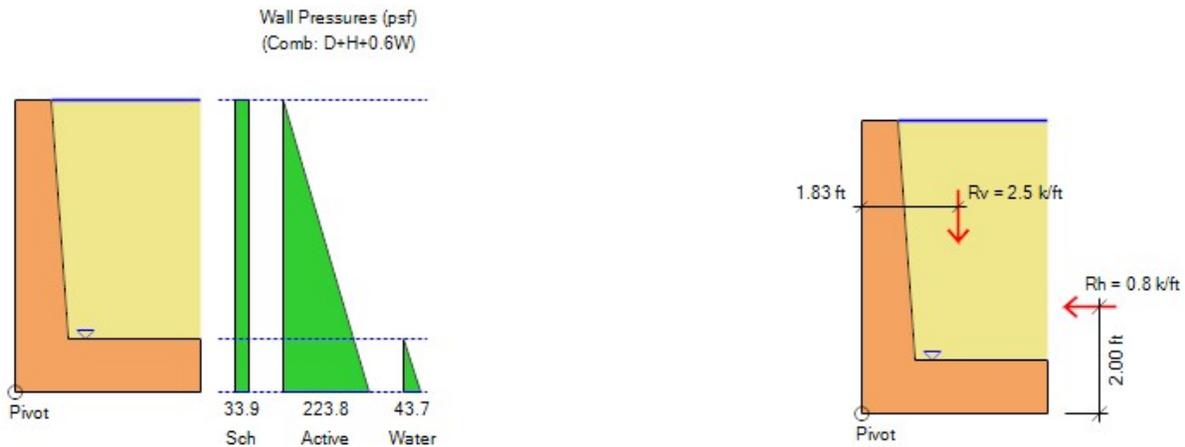
Concentrated = $DL \text{ factor} * Ver \text{ load} = 1.00 * 0.0 = 0.0$ k/ft

Arm = $Toe + (Stem - Ecc) / 12 = 0.00 + (8.0 - 6.0) / 12 = 0.17$ ft

Moment = $0.0 * 0.17 = 0.0$ k-ft/ft

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Surcharge = $Srch\ factor * (Heel + \Delta Thick) * Surcharge = 1.00 * 0.0 * (2.5 + (12.0 - 8.0) / 12) = 0.0\ k/ft$
 Arm = $ftg - (Heel + \Delta Thick) / 2 = 3.50 - (2.50 + (12.0 - 8.0) / 12) / 2 = 2.08\ ft$
 Moment = $0.0 * 2.08 = 0.0\ k-ft/ft$
 Strip = $Strip\ factor * Surcharge * Heel = 1.00 * 0.0 / 1000 * 2.50 = 0.0\ k/ft$
 Arm = $Footing - Heel / 2 = 3.50 - 2.50 / 2 = 2.25\ ft$
 Moment = $0.0 * 2.25 = 0.0\ k-ft/ft$
 Buoyancy = $DL\ factor * \gamma_w * Water\ table * Ftg = 1.00 * 62.4 * 1.00 * 3.50 = -0.2\ k/ft$
 Arm = $Footing / 2 = 3.50 / 2 = 1.75\ ft$ Moment = $-0.2 * 1.75 = -0.4\ k-ft/ft$
 Passive force = $0.0\ k/ft$ (Ignore passive pressure in overturning)
 Arm = $0.50\ ft$ Moment = $0.0 * 0.50 = 0.0\ k-ft/ft$
 Ver. resultant $R_v = \Sigma\ Vertical\ forces = 2.5\ k/ft$
 Resisting moment $RM = \Sigma\ Moments = 4.6\ k-ft/ft$
 Arm of ver. resultant = $RM / R_v = 4.6 / 2.5 = 1.83\ ft$
 Overturning SF = $RM / OTM = 4.6 / 1.6 = 2.78 > 1.50\ OK$



SOIL BEARING PRESSURES (Comb. D+H+0.7E)

Eccentricity = $\frac{Ftg}{2} - \frac{RM - OTM}{R_v} = \frac{3.50}{2} - \frac{4.6 - 2.2}{2.5} = 0.79\ ft$
 Bearing length = $Min(Ftg, 3 * (Ftg / 2 - Ecc)) = Min(3.50, 3 * (3.50 / 2 - 0.79)) = 2.88\ ft$
 Toe bearing = $\frac{R_v}{0.75 * Ftg - 1.5 * Ecc} = \frac{2.5}{0.75 * 3.50 - 1.5 * 0.79} = 1.7\ ksf < 2.0\ ksf\ OK$
 Heel bearing = $0.0\ ksf$

SLIDING CALCULATIONS (Comb. D+H+0.6W)

$$\text{Sliding force } R_h = 0.6 + 0.0 + 0.2 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 = 0.8 \text{ k/ft}$$

$$\text{Passive coefficient } k_p \text{ (Coulomb)} = 3.34$$

$$\text{Passive depth } D_p = \text{Soil cover} + \text{Fig} + \text{Key} - \text{Neglect depth} = 0.50 + (12.0 + 0.0) / 12 - 0.00 = 1.50 \text{ ft}$$

$$\text{Passive pressure top} = k_p * \gamma * \text{Neglect depth} + \text{Water} = 3.34 * 120.0 * 0.00 + 0.00 = 0.00 \text{ ksf}$$

$$\text{Passive pressure bot} = k_p * \gamma * (D_p + \text{Neglect depth}) + \text{Water} = 3.34 * 120.0 * (1.50 + 0.00) + -0.11 = 0.49 \text{ ksf}$$

$$\text{Passive force} = (\text{Pressure top} + \text{Pressure bot}) / 2 * D_p = (0.00 + 0.49) / 2 * 1.50 = 0.4 \text{ k/ft}$$

$$\text{Friction force} = \text{Max}(0, R_v * \text{Friction coeff.}) = \text{Max}(0, 2.5 * 0.35) = 0.9 \text{ k/ft}$$

$$\text{Sliding S.F.} = (\text{Passive} + \text{Friction}) / R_h = (0.4 + 0.9) / 0.8 = 1.51 > 1.50 \quad \text{OK}$$

STEM DESIGN (Comb. 0.9D+1.6H+E)

$$\text{Backfill} = \text{Lat factor} * P_{ah} = 1.6 * 0.4 = 0.7 \text{ k/ft}$$

$$\text{Arm} = H_b / 3 = 4.50 / 3 = 1.50 \text{ ft}$$

$$\text{Moment} = 0.7 * 1.50 = 1.0 \text{ k-ft/ft}$$

$$\text{Water table} = \text{Lat factor} * P_w = 1.6 * 0.0 = 0.0 \text{ k/ft}$$

$$\text{Arm} = (\text{Water table} - \text{Fig}) / 3 = (1.00 - 12.0 / 12) / 3 = 0.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Surcharge} = \text{Factor} * k_a * \text{Surcharge} * H_s * \text{Cos}(\delta + \alpha) = 1.6 * 0.36 * 100.0 * 4.50 * 0.95 = 0.2 \text{ k/ft}$$

$$\text{Arm} = H_b / 2 = 4.50 / 2 = 2.25 \text{ ft}$$

$$\text{Moment} = 0.2 * 2.25 = 0.5 \text{ k-ft/ft}$$

$$\text{Vert. Concentrated} = \text{Factor} * \text{Shear} = 0.9 * 0.00 + 0.0 * 0.00 = 0.0 \text{ k/ft}$$

$$\text{Factor} * \text{Moment} = 0.9 * 0.0 + 0.0 * 0.0 = 0.0 \text{ k-ft/ft}$$

$$\text{Hor. Concentrated} = \text{Factor} * \text{Load} = 0.9 * 0.0 + 0.00 * 0.0 = 0.0 \text{ k/ft}$$

$$\text{Arm} = \text{Stem} - \text{Ecc} = 4.50 - 6.0 / 12 = 4.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 4.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Strip load} = \sum \text{Lat factor} * 2 * Q / n * [\beta - \text{Sin} \beta * \text{Cos}(2\alpha)] = 1.60 * 0.0 = 0.0 \text{ k/ft}$$

$$\text{Arm} = 0.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Wind load} = \text{WL factor} * \text{Pressure} * \text{Wind height} = 0.0 * 0.00 * 5.00 = 0.0 \text{ k/ft}$$

$$\text{Arm} = \text{Stem} - \text{Wind height} / 2 = 4.50 - 5.00 / 2 = 2.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 2.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Backfill seismic} = \text{EQ factor} * (P_{aeh} - P_{ah}) = 1.0 * (0.4 - 0.4) = 0.2 \text{ k/ft}$$

$$\text{Arm} = 0.6 * H_b = 0.6 * 4.50 = 2.70 \text{ ft}$$

$$\text{Moment} = 0.2 * 2.70 = 0.5 \text{ k-ft/ft}$$

$$\text{Water seismic} = \text{EQ factor} * P_{we} = 1.0 * 0.0 = 0.0 \text{ k/ft}$$

$$\text{Arm} = (\text{Water table} - \text{Fig}) / 3 = (1.00 - 12.0 / 12) / 3 = 0.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Wall seismic} = 0.0 \text{ kip}$$

$$\text{Moment} = 0.0 \text{ k-ft/ft}$$

$$\text{Max. shear} = 0.7 + 0.0 + 0.2 + 0.0 + 0.0 + 0.0 + 0.0 + 0.2 + 0.0 + 0.0 = 1.1 \text{ k/ft}$$

$$\text{Shear at critical section} = \text{Max shear} - \text{Max shear} / H_b * d = 1.1 - 1.1 / 4.50 * 9.0 / 12 = 0.9 \text{ k/ft}$$

$$\text{Max. Moment} = 1.0 + 0.0 + 0.5 + 0.0 + 0.0 + 0.0 + 0.0 + 0.5 + 0.0 + 0.0 = 2.0 \text{ k-ft/ft}$$

$$\text{Size factor } \lambda_s = \sqrt{2 / (1 + d / 10)} = \sqrt{2 / (1 + 9.0 / 10)} = 1.00$$

ACI Eq. (22.5.5.1.3)

$$\text{Shear strength } \phi V_c = \phi * 8 * \lambda_s * \rho^{1/3} * (f'_c * 1000)^{1/2} * b * d / 1000$$

ACI Table 22.5.5.1

$$\phi V_c = 0.75 * 8 * 1.00 * (0.0029)^{1/3} * (2500)^{1/2} * 12 * 9.0 / 1000 = 4.7 \text{ k/ft} > 0.9 \text{ k/ft} \quad \text{OK}$$

$$\text{Shear friction } \phi V_n = \phi * \mu * A_v f_y$$

ACI 22.9.4.2

$$\phi V_n = 0.75 * 0.6 * 0.31 * 60.0 = 8.4 \text{ k/ft} > 1.1 \text{ k/ft} \quad \text{OK}$$

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Use #5 @ 12.0 in $A_s = 0.31 \text{ in}^2/\text{ft}$ $\rho = A_s / b d = 0.31 / (12 * 9.7) = 0.0027$

Bending strength $\phi M_n = \phi * d^2 * f_c * q * (1 - 0.59 * q)$ $q = \rho * f_y / f_c = 0.064$ **ACI 22.2**
 $\phi M_n = 0.90 * 9.7^2 * 2.5 * 0.064 * (1 - 0.59 * 0.064) = 13.0 \text{ k-ft/ft} > 2.0 \text{ k-ft/ft}$ **OK**

Hooked $L_{dh} = \text{Max}(8 * db, 6 \text{ in}, f_y / 55 / (f_c)^{1/2} * (db)^{1.5} * \psi_r * \psi_c) =$
 $\text{Max}(8 * 0.63, 6 \text{ in}, 60.0 * 1000 / 55 / (2500)^{1/2} * (0.63)^{1.5} * 1.0 * 0.77) = 8.3 \text{ in}$ **ACI 25.4.3**

Dev. length at footing = $F_{tg} - \text{Cover} = 12.0 - 3.0 = 9.0 \text{ in} > 8.3 \text{ in}$ **OK**

$A_{s \text{ min}} = 0.0018 * b * t = 0.0018 * 12.0 * 12.0 = 0.26 \text{ in}^2/\text{ft}$ **ACI 7.6.1.1**

Min. steel area ratio = $A_{s \text{ min}} / A_s = 0.26 / 0.31 = 0.84 < 1.0$ **OK**

$A_{s \text{ S\&T vert}} = 0.0018 * b * t = 0.0018 * 12.0 * 12.0 = 0.26 \text{ in}^2/\text{ft}$ **ACI 24.4.3.2**

$A_{s \text{ S\&T hor}} = 0.0018 * b * t = 0.0018 * 12.0 * 12.0 = 0.26 \text{ in}^2/\text{ft}$ **ACI 24.4.3.2**

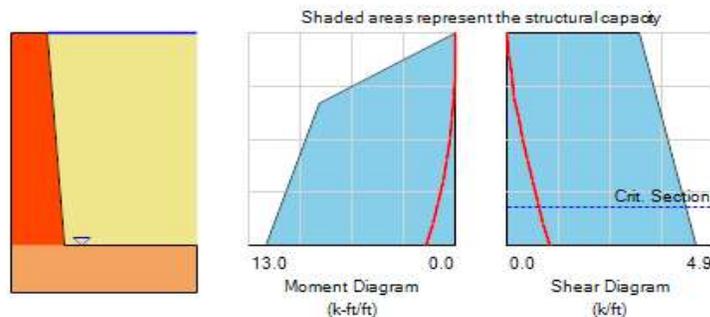
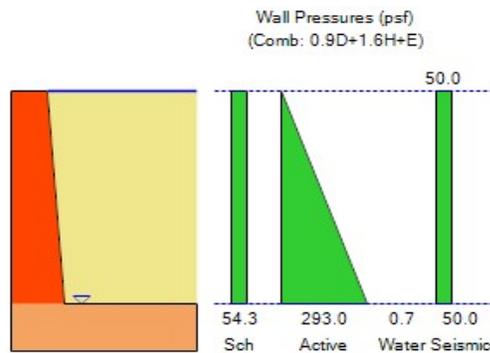
Min. steel S&T ratio = $A_{s \text{ S\&T}} / A_s = \text{Max}(0.26 / 0.31, 0.26 / 0.27) = 0.97 < 1.0$ **OK**

Max. steel area for $f_y/E_s + 0.003$ tension strain = $1.30 \text{ in}^2/\text{ft} > 0.31 \text{ in}^2/\text{ft}$ **OK** **ACI 21.2.2**

$f_s = \text{Min}(M_{svc} / (A_s * j * d), 0.66 F_y) = \text{Min}(1.3 * 12 / (0.31 * 0.9 * 9.7), 0.66 * 60.0) = 5.6 \text{ ksi}$

$S_{\text{max cracking}} = \text{Min}(15 * 40 / f_s - 2.5 C_c, 12 * 40 / f_s) =$
 $\text{Min}(15 * 40 / 5.6 - 2.5 * 2.0, 12 * 40 / 5.6) = 85.0 \text{ in}$ **ACI Table 24.3.2**

$S_{\text{max}} = \text{Min}(S_{\text{max cr}}, 3 * t, 18.0) = \text{Min}(85.0, 3 * 12.0, 18.0) = 18.0 \text{ in} > 12.0 \text{ in}$ **OK** **ACI 7.7.2.3**



HEEL DESIGN (Comb. 1.2D+1.6L+1.6H)

Bearing force = 0.0 k/ft (Neglect bearing pressure for heel design)

Arm = N.A.

Moment = 0.0 k-ft/ft

Concrete weight = $DL\ factor * Thick * Heel * \gamma_c = 1.20 * 12.0 / 12 * 2.50 * 0.15 = 0.5\ k/ft$ Arm = $Heel / 2 = 2.50 / 2 = 1.25\ ft$ Moment = $0.5 * 1.25 = 0.6\ k-ft/ft$ Backfill weight = $DL\ factor * Heel * Height * \gamma = 1.20 * 2.50 * 4.50 * 120.0 = 1.6\ k/ft$ Arm = $Heel / 2 = 2.50 / 2 = 1.25\ ft$ Moment = $1.6 * 1.25 = 2.0\ k-ft/ft$ Backfill slope = $DL\ factor * (Heel + \Delta Thick) * Wedge / 2 * \gamma =$

$$= 1.20 * (2.5 + (12.0 - 8.0) / 12) * 0.00 / 2 * 120.0 = 0.0\ k/ft$$

Arm = $Heel * 2 / 3 = 2.50 * 2 / 3 = 1.67\ ft$ Moment = $0.0 * 1.67 = 0.0\ k-ft/ft$ Water = $Factor * Heel * (Water\ table - Ftg) * (\gamma_s - \gamma) = 1.20 * 2.50 * (1.00 - 12.0 / 12) * (130.0 - 120.0) = 0.0\ k/ft$ Arm = $Heel / 2 = 2.50 / 2 = 1.25\ ft$ Moment = $0.0 * 1.25 = 0.0\ k-ft/ft$ Surcharge = $Srch\ factor * (Heel + \Delta Thick) * Surcharge = (1.20 * 0.0 + 1.60 * 100.0) * (2.5 + (12.0 - 8.0) / 12) = 0.5\ k/ft$ Arm = $Heel / 2 = 2.50 / 2 = 1.25\ ft$ Moment = $0.5 * 1.25 = 0.6\ k-ft/ft$ Strip = $Strip\ factor * Surcharge * Heel = (1.20 * 0.0 + 1.6 * 0.0) / 1000 * 2.50 = 0.0\ k/ft$ Arm = $Heel / 2 = 12$ $2.50 / 2 = 1.25\ ft$ Moment = $0.0 * 1.25 = 0.0\ k-ft/ft$ Max. Shear $V_u = -0.0 + 0.5 + 1.6 + 0.0 + 0.0 + 0.5 + 0.0 = 2.5\ k/ft$ Max. Moment $M_u = -0.0 + 0.6 + 2.0 + 0.0 + 0.0 + 0.6 + 0.0 = 3.2\ k-ft/ft$ Size factor $\lambda_s = 1.0$ for footings

ACI 13.2.6.2

Shear strength $\phi V_c = \phi * 8 * \lambda_s * \rho^{1/3} * (f_c * 1000)^{1/2} * b * d / 1000$

ACI Table 22.5.5.1

$$\phi V_c = 0.75 * 8 * 1.0 * (0.0027)^{1/3} * (2500)^{1/2} * 12 * 9.7 / 1000 = 4.9\ k/ft > 2.5\ k/ft \quad OK$$

Use #5 @ 12.0 in $A_s = 0.31\ in^2/ft$ $\rho = A_s / b d = 0.31 / (12 * 9.7) = 0.0027$ Bending strength $\phi M_n = \phi * d^2 * f_c * q * (1 - 0.59 * q)$ $q = \rho * f_y / f_c = 0.064$

ACI 22.2

$$\phi M_n = 0.90 * 9.7^2 * 2.5 * 0.064 * (1 - 0.59 * 0.064) = 13.0\ k-ft/ft > M_u = 3.2\ k-ft/ft \quad OK$$

Cover factor = $Min(2.5, (Cover + db / 2, Spacing / 2) / db) = Min(2.5, (2.0 + 0.63 / 2, 12.0 / 2) / 0.63) = 2.5$ Straight $L_d = Max(12.0, 3 / 40 * f_y / (f_c)^{1/2} * Size * Casting / Cover * Grade * db * ratio)$

ACI 25.4.2.3

$$= Max(12.0, 3 / 40 * 60.0 * 1000 / (2500)^{1/2} * 0.8 * 1.0 / 2.5 * 1.0 * 0.63 * 0.24) = 12.0\ in$$

Hooked $L_{dh} = Max(8 * db, 6\ in, f_y / 55 / (f_c)^{1/2} * (db)^{1.5} * \psi_r * \psi_c) =$

ACI 25.4.3

$$Max(8 * 0.63, 6\ in, 60.0 * 1000 / 55 / (2500)^{1/2} * (0.63)^{1.5} * 1.0 * 0.77) = 8.3\ in$$

Dev. length at toe side = $Stem - Cover = (12.0 - 2.0) = 10.0\ in > 8.3\ in \quad OK$ Dev. length at heel side = $Heel - Cover = 2.50 * 12 - 2.0 = 28.0\ in > 12.0\ in \quad OK$ $A_s\ min = 0.0018 * b * t = 0.0018 * 12.0 * 12.0 = 0.26\ in^2/ft$

ACI 7.6.1.1

Min. steel area ratio = $A_s\ min / A_s = 0.26 / 0.31 = 0.84 < 1.0 \quad OK$ $A_s\ S\&T\ min = 0.0018 * b * t = 0.0018 * 12.0 * 12.0 = 0.26\ in^2/ft$

ACI 24.4.3.2

Min. steel S&T ratio = $A_s\ S\&T\ min / A_s = Max(0.26 / 0.51, 0.26 / 0.40) = 0.65 < 1.0 \quad OK$ Max. steel area for $f_y/E_s + 0.003$ tension strain = $1.32\ in^2/ft > 0.31\ in^2/ft \quad OK$

ACI 21.2.2

 $f_s = Min(Msvc / (A_s * j * d), 0.66 F_y) = Min(2.5 * 12 / (0.31 * 0.9 * 9.7), 0.66 * 60.0) = 10.8\ ksi$ Smax cracking = $Min(15 * 40 / f_s - 2.5 C_c, 12 * 40 / f_s) =$

ACI Table 24.3.2

$$Min(15 * 40 / 10.8 - 2.5 * 2.0, 12 * 40 / 10.8) = 44.5\ in$$

Smax = $Min(Smax\ cr, 3 * t, 18.0) = Min(44.5, 3 * 12.0, 18.0) = 18.0\ in \geq 12.0\ in \quad OK$

ACI 7.7.2.3

TOE DESIGN (Comb. 1.4D+0.9H)

$$\text{Bearing force} = (\text{Bearing1} + \text{Bearing2}) / 2 * \text{Toe} = (1.7 + 1.7) / 2 * 0.00 = 0.0 \text{ k/ft}$$

$$\text{Arm} = (\text{Bearing1} * \text{Toe}^2 / 2 + (\text{Bearing2} - \text{Bearing1}) * \text{Toe}^2 / 3) / \text{Force}$$

$$= (1.7 * 0.00^2 / 2 + (1.7 - 1.7) * 0.00^2 / 3) / 0.0 = 0.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Water Buoyancy} = \text{Factor} * \gamma_w * \text{Water table} * \text{Toe} = 1.4 * 62.4 * 1.00 * 0.00 = 0.0 \text{ k/ft}$$

$$\text{Arm} = \text{Toe} / 2 = 0.00 / 2 = 0.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Concrete weight} = \text{DL factor} * \text{Thick} * \text{Toe} * \gamma_c = 1.4 * 12.0 / 12 * 0.00 * 0.15 = 0.0 \text{ k/ft}$$

$$\text{Arm} = \text{Toe} / 2 = 0.00 / 2 = 0.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Soil cover} = \text{DL factor} * \text{Toe} * \text{Height} * \gamma = 1.4 * 0.00 * 0.00 * 120.0 = 0.0 \text{ k/ft}$$

$$\text{Arm} = \text{Toe} / 2 = 0.00 / 2 = 0.00 \text{ ft}$$

$$\text{Moment} = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$$

$$\text{Max. Shear } V_u = 0.0 + 0.0 - 0.0 - 0.0 = 0.0 \text{ k/ft}$$

$$\text{Shear at crit. section } V_u = \text{Max shear} * (\text{Toe} - d) / \text{Toe} = 0.0 * (0.00 - 8.8 / 12) / 0.00 = 0.0 \text{ k/ft}$$

$$\text{Max. Moment } M_u = 0.0 + 0.0 - 0.0 - 0.0 = 0.0 \text{ k-ft/ft}$$

Size factor $\lambda_s = 1.0$ for footings

ACI 13.2.6.2

$$\text{Shear strength } \phi V_c = \phi * 8 * \lambda_s * \rho^{1/3} * (f_c * 1000)^{1/2} * b * d / 1000$$

ACI Table 22.5.5.1

$$\phi V_c = 0.75 * 8 * 1.0 * (0.0019)^{1/3} * (2500)^{1/2} * 12 * 8.8 / 1000 = 4.0 \text{ k/ft} > 0.0 \text{ k/ft} \quad \text{OK}$$

$$\text{Use \#4 @ 12.0 in} \quad A_s = 0.20 \text{ in}^2/\text{ft} \quad \rho = A_s / b d = 0.20 / (12 * 8.8) = 0.0019$$

$$\text{Bending strength } \phi Mn = \phi * d^2 * f_c * q * (1 - 0.59 * q) \quad q = \rho * f_y / f_c = 0.046$$

ACI 22.2

$$\phi Mn = 0.90 * 8.8^2 * 2.5 * 0.046 * (1 - 0.59 * 0.046) = 7.7 \text{ k-ft/ft} > M_u = 0.0 \text{ k-ft/ft} \quad \text{OK}$$

$$\text{Cover factor} = \text{Min} (2.5, (\text{Cover} + db / 2, \text{Spacing} / 2) / db) = \text{Min} (2.5, (3.0 + 0.50 / 2, 12.0 / 2) / 0.50) = 2.5$$

$$\text{Straight } L_d = \text{Max} (12.0, 3 / 40 * f_y / (f_c)^{1/2} * \text{Size} * \text{Casting} / \text{Cover} * \text{Grade} * db * \text{ratio})$$

ACI 25.4.2.3

$$= \text{Max} (12.0, 3 / 40 * 60.0 * 1000 / (2500)^{1/2} * 0.8 * 1.0 / 2.5 * 1.0 * 0.50 * 0.00) = 12.0 \text{ in}$$

$$\text{Hooked } L_{dh} = \text{Max} (8 * db, 6 \text{ in}, f_y / 55 / (f_c)^{1/2} * (db)^{1.5} * \psi_r * \psi_c) =$$

ACI 25.4.3

$$\text{Max} (8 * 0.50, 6 \text{ in}, 60.0 * 1000 / 55 / (2500)^{1/2} * (0.50)^{1.5} * 1.0 * 0.77) = 6.0 \text{ in}$$

Dev. length at heel side = N.A.

Dev. length at toe side N.A. =

$$A_s \text{ min} = 0.0018 * b * t = 0.0018 * 12.0 * 12.0 = 0.00 \text{ in}^2/\text{ft}$$

ACI 7.6.1.1

$$\text{Min. steel area ratio} = A_s \text{ min} / A_s = 0.00 / 0.20 = 0.00 < 1.0 \quad \text{OK}$$

$$A_s \text{ S\&T min} = 0.0018 * b * t = 0.0018 * 12.0 * 12.0 = 0.00 \text{ in}^2/\text{ft}$$

ACI 24.4.3.2

$$\text{Min. steel S\&T ratio} = A_s \text{ S\&T min} / A_s = \text{Max}(0.00 / 0.20, 0.00 / 0.20) = 0.00 < 1.0 \quad \text{OK}$$

$$\text{Max. steel area for } f_y/E_s + 0.003 \text{ tension strain} = 1.18 \text{ in}^2/\text{ft} > 0.20 \text{ in}^2/\text{ft} \quad \text{OK}$$

ACI 21.2.2

$$f_s = \text{Min} (M_{svc} / (A_s * j * d), 0.66 F_y) = \text{Min} (0.0 * 12 / (0.20 * 0.9 * 8.8), 0.66 * 60.0) = 0.0 \text{ ksi}$$

$$S_{\text{max cracking}} = \text{Min} (15 * 40 / f_s - 2.5 C_c, 12 * 40 / f_s) =$$

ACI Table 24.3.2

$$\text{Min} (15 * 40 / 0.0 - 2.5 * 3.0, 12 * 40 / 0.0) = \infty \text{ in}$$

$$S_{\text{max}} = \text{Min} (S_{\text{max cr}}, 3 * t, 18.0) = \text{Min} (\infty, 3 * 12.0, 18.0) = 18.0 \text{ in} \quad \geq 12.0 \text{ in} \quad \text{OK}$$

ACI 7.7.2.3

ASDIP Retain 5.5.6.3 CANTILEVER RETAINING WALL DESIGN www.asdipsoft.com

SHEAR KEY DESIGN (Comb. 1.4D+0.9H)

Shear key depth = 0.0 in Shear key thickness = 0.0 in
 Passive force = Lat factor * (Passive1 + Passive2) / 2 * Key = 0.9 * (0.5 + 0.6) / 2 * 0.0 / 12 = 0.0 k/ft
 Shear at crit. section $V_u = \text{Max shear} * (\text{Key} - d) / \text{Key} = 0.0 * (0.0 - 0.1) / 0.0 = 0.0 \text{ k/ft}$
 $\text{Arm} = (\text{Passive1} * \text{Key}^2 / 2 + (\text{Passive2} - \text{Passive1}) * \text{Key}^2 / 3) / \text{Force}$
 $= (0.6 * 0.00^2 / 2 + (0.5 - 0.6) * 0.00^2 / 3) / 0.0 = 0.00 \text{ ft}$

Max. moment $M_u = 0.0 * 0.00 = 0.0 \text{ k-ft/ft}$

Size factor $\lambda_s = 1.0$ for footings

ACI 13.2.6.2

Shear strength $\phi V_c = \phi * 8 * \lambda_s * \rho^{1/3} * (f_c * 1000)^{1/2} * b * d / 1000$

ACI Table 22.5.5.1

$\phi V_c = 0.75 * 8 * 1.0 * (0.1667)^{1/3} * (2500)^{1/2} * 12 * 0.1 / 1000 = 0.2 \text{ k/ft} > 0.0 \text{ k/ft}$ **OK**

Use #4 @ 12.0 in $A_s = 0.20 \text{ in}^2/\text{ft}$ $\rho = A_s / b d = 0.20 / (12 * 0.1) = 0.1667$

Bending strength $\phi M_n = \phi * d^2 * f_c * q * (1 - 0.59 * q)$ $q = \rho * f_y / f_c = 4.000$

ACI 22.2

$\phi M_n = 0.90 * 0.1^2 * 2.5 * 4.000 * (1 - 0.59 * 4.000) = 0.1 \text{ k-ft/ft} > M_u = 0.0 \text{ k-ft/ft}$ **OK**

$A_{s \text{ min}} = 0.0018 * b * t = 0.0018 * 12.0 * 0.0 = 0.00 \text{ in}^2/\text{ft}$

ACI 7.6.1.1

Min. steel area ratio = $A_{s \text{ min}} / A_s = 0.00 / 0.20 = 0.00 < 1.0$ **OK**

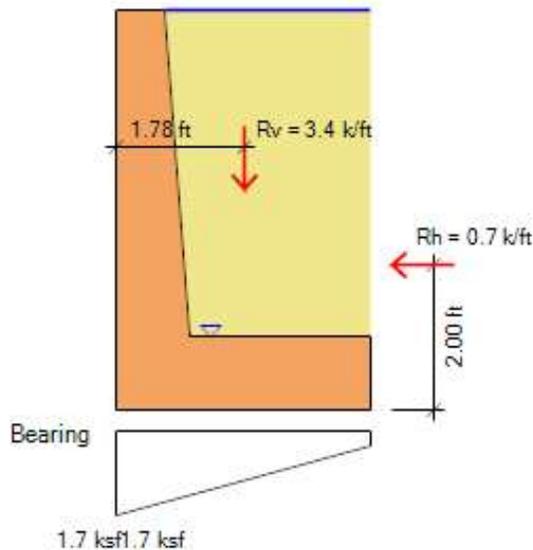
$A_{s \text{ S\&T}} = 0.0018 * b * t = 0.0018 * 12.0 * 0.0 = 0.00 \text{ in}^2/\text{ft}$

ACI 24.4.3.2

Min. steel S&T ratio = $A_{s \text{ S\&T}} / A_s = \text{Max}(0.00 / 0.20, 0.32 / 0.40) = 0.81 < 1.0$ **OK**

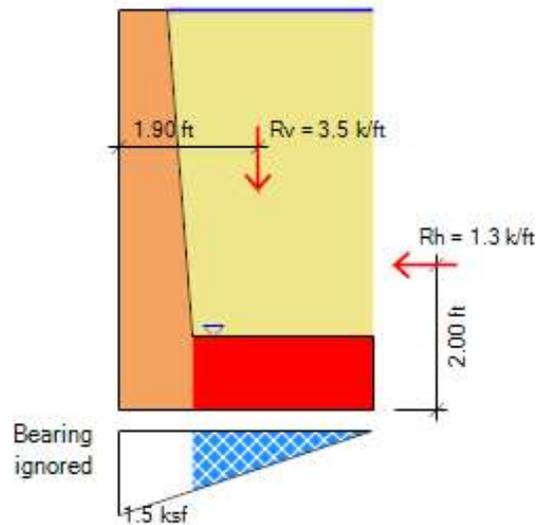
Max. steel area for $f_y/E_s + 0.003$ tension strain = $0.21 \text{ in}^2/\text{ft} > 0.20 \text{ in}^2/\text{ft}$ **OK**

ACI 21.2.2



Toe Design Ratios

Bending	0.00 < 1.00	✓	(1.4D+0.9H)
Shear	0.00 < 1.00	✓	(1.4D+0.9H)



Heel Design Ratios

Bending	0.24 < 1.00	✓	(1.2D+1.6L+1.6H)
Shear	0.51 < 1.00	✓	(1.2D+1.6L+1.6H)

ASDIP Retain 5.5.6.3 CANTILEVER RETAINING WALL DESIGN www.asdipsoft.com

DESIGN CODES	
General Analysis	IBC 2018
Concrete Design	ACI 318-19
Masonry Design	TMS 402-16
Load Combinations	ASCE 7-10/16

	MATERIALS		
	Stem	Footing	
Concrete f _c	2.5	2.5	ksi
Rebars f _y	60.0	60.0	ksi
Masonry f _m	1.5		ksi

