ENGINEERING ANALYSIS FOR: EAST TOWN CROSSING 4' RETAINING WALL

DESIGN CRITERIA

SOIL PROPERTIE AND DESIGN LOADS:
BEARING CAPACITY: 2,000 PSF
LATERAL CAPACITY: 150 PSF/FT
SEISMIC SURCHARGE: 9H
LIVE LOAD SURCHARGE: 100 PSF

PRRWF20251393

Calculations required to be provided by the Permittee on site for all Inspections

City of Puyallup
Building
REVIEWED FOR COMPLIANCE
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EAST TOWN CROSSING
RETAINING WALLS

REVISIONS

01	----

REVISIONS

ENGINEER:	CP
CHECKED BY:	CP
DATE:	2025.05.13
TITLE:	STRUCTURAL ANALYSIS
PROJECT # :	----

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

GEOMETRY

Conc. Stem Height	4.50	ft	
Stem Thickness Top	8.0	in	
Stem Thickness Bot	12.0	in	
Footing Thickness	12.0	in	
Toe Length	0.00	ft	
Heel Length	2.50	ft	
Soil Cover @ Toe	0.50	ft	
Backfill Height	4.50	ft	OK
Backfill Slope Angle	0.0	deg	

APPLIED LOADS

Surcharge	D =	0.0	L =	100.0	psf
Strip Pressure	D =	0.0	L =	0.0	psf
Strip 0.0 ft deep, 0.0 ft wide @ 0.0 ft from Stem					
Stem Vertical	D =	0.0	L =	0.0	k/ft
Stem Horizontal	D =	0.0	L =	0.0	k/ft
Eccentricity	ev =	6.0	eh =	6.0	in
Wind Load =	0.0	psf	Height =	5.00	ft
Uniform Seismic Pressure				50.0	psf

BACKFILL PROPERTIES

Wall taper $\alpha = aTan\,(taper / H) =$ aTan ((12.0 - 8.0) / 12 / 4.50) = 0.074 rad

Backfill slope $\beta = slope * \pi / 180 =$ 0.0 * 3.14 / 180 = 0.000 rad

Internal friction $\phi = Int.\ friction * \pi / 180 =$ 28.0 * 3.14 / 180 = 0.489 rad

Wall-soil friction $\delta = \phi / 2 =$ 0.489 / 2 = 0.244 rad

Footing length $ftg = toe + stem + heel =$ 0.00 + 12.0 / 12 + 2.50 = 3.50 ft

Height for Stability $Hs = wedge + backfill + footing =$ 0.00 + 4.50 + 12.0 / 12 = 5.50 ft

Earth pressure theory = Coulomb Active   Moist density = 120 pcf   Saturated density = 130 pcf

$$\text{Active coefficient } ka = \frac{Cos^2(\phi - \alpha)}{Cos^2\alpha * Cos(\delta + \alpha) * [1 + (\frac{Sin(\phi + \delta) * Sin(\phi - \beta)}{Cos(\delta + \alpha) * Cos(\beta - \alpha)})^{½}]^2} = 0.36$$

Active pressure $pa = ka * \gamma =$ 0.36 * 120.0 = 42.8 psf/ft of height

- For stability analysis (non-seismic)

Active force $Pa = ka * \gamma * Hs^2 / 2 =$ 0.36 * 120.0 * 5.50² / 2 = 0.6 k/ft

$Pah = Pa * Cos\,(\delta + \alpha) =$ 0.6 * Cos(0.244 + 0.074) = 0.6 k/ft

$Pav = Pa * Sin\,(\delta + \alpha) =$ 0.6 * Sin(0.244 + 0.074) = 0.2 k/ft

Water force $Pw = (ka * (\gamma s - \gamma w - \gamma) + \gamma w) * (water\ table)^2 / 2$

Pw = (0.36 * (130.0 - 62.4 - 120.0) + 62.4) * 1.00² / 2 = 0.0 k/ft

$$\text{Passive coefficient } kp = \frac{Cos^2(\phi + \alpha)}{Cos^2\alpha * Cos(\delta - \alpha) * [1 - (\frac{Sin(\phi + \delta) * Sin(\phi + \beta)}{Cos(\delta - \alpha) * Cos(\beta - \alpha)})^{½}]^2} = 3.34$$

- For stem design (non-seismic)

Active force *Pa = ka * γ * H² / 2 =* 0.36 * 120.0 * 4.50² / 2 = 0.4 k/ft

*Pah = Pa * Cos (δ + α) =* 0.4 * Cos (0.244 + 0.074) = 0.4 k/ft

*Pav = Pa * Sin β =* 0.4 * Sin (0.000) = 0.0 k/ft

Water force *Pw = (ka * (γs - γw - γ) + γw) * (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 k/ft

- For stability analysis (seismic)

Seismic force = *Pressure * Hs =* 50.0 * 5.50 / 1000 = 0.3 k/ft

- For stem design (seismic)

Seismic force = *Pressure * H =* 50.0 * 4.50 / 1000 = 0.2 k/ft

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

- Overturning Forces

Backfill = *Lat factor * Pah =* 1.00 * 0.6 = 0.6 k/ft

Arm = *Hs / 3 =* 5.50 / 3 = 1.83 ft Moment = 0.6 * 1.83 = 1.1 k-ft/ft

Water table = *Lat factor * Pw =* 1.00 * 0.0 = 0.0 k/ft

Arm = *Water table / 3 =* 1.00 / 3 = 0.33 ft Moment = 0.0 * 0.33 = 0.0 k-ft/ft

Surcharge = *Factor * ka * Surcharge * Hs * Cos (δ + α) =* 1.00 * 0.36 * 100.0 * 5.50 * 0.95 = 0.2 k/ft

Arm = *Hs / 2 =* 5.50 / 2 = 2.75 ft Moment = 0.2 * 2.75 = 0.5 k-ft/ft

Strip load = *Σ Lat factor * 2 * Q / π * [β - Sin β * Cos (2α)] =* 0.0 k/ft

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

Concentrated Hor. = *Factor * Ph =* 1.00 * 0.00 + 0.00 * 0.00 = 0.0 k/ft

Arm = *Stem + (Ftg - Ecc) / 12 =* 4.50 + (12.0 - 6.0) / 12 = 5.00 ft Moment = 0.0 * 5.00 = 0.0 k-ft/ft

Wind load = *WL factor * Pressure * Wind height =* 0.60 * 0.0 * 5.00 = 0.0 k/ft

Arm = *Ftg + Stem - Wind height / 2 =* 12.0 / 12 + 4.50 - 5.00 / 2 = 3.00 ft

Moment = 0.0 * 3.00 = 0.0 k-ft/ft

Backfill seismic = *EQ factor * Seismic Force =* 0.00 * 0.3 = 0.0 k/ft

Arm = *0.5 * Hs =* 0.5 * 5.50 = 2.75 ft Moment = 0.0 * 2.75 = 0.0 k-ft/ft

Water seismic = *EQ factor * Pwe =* 0.00 * 0.0 = 0.0 k/ft

Arm = *Water table / 3 =* 1.00 / 3 = 0.33 ft Moment = 0.0 * 0.33 = 0.0 k-ft/ft

Wall selfweight seismic effect not considered in calculations

Wall seismic = 0.0 kip

Moment = 0.0 k-ft/ft

Overturning force Rh = 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 / Rh* = 1.6 / 0.8 = 2.00 ft

- Resisting Forces

Stem weight *WStem = DL factor * Thickness * Height * γc =* 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 *WTaper = DL factor * ΔThick * Height / 2 * γc =* 1.00 * (12.0 - 8.0) / 12 * 4.50 / 2 * 0.15 = 0.1 k/ft

Arm = *Toe + Thick + ΔThick / 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 *WFtg = DL factor * Length * Thickness * γc =* 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 *WKey = DL factor * Depth * Thickness * γc =* 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 factor * Toe * Soil cover * γ =* 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 factor * ΔThick * Height / 2 * γ =* 1.00 * 0.33 * 4.50 / 2 * 120.0 = 0.1 k/ft

Arm = *Toe + Thick - ΔThick * 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 factor * Heel * Height * γ =* 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 factor * (Heel + ΔThick) * Wedge / 2 * γ =*

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

Arm = *ftg - (Heel + ΔThick) / 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) * (γs - γ) =* 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 factor * (Paev - Pav) =* 0.00 * (0.2 - 0.2) = 0.0 k/ft

Arm = *Footing length =* 3.50 ft Moment = 0.0 * 3.50 = 0.0 k-ft/ft

Backfill Pav = *Lat factor * Pav =* 1.00 * 0.2 = 0.2 k/ft

Arm = *Footing length =* 3.50 ft Moment = 0.2 * 3.50 = 0.7 k-ft/ft

Concentrated = *DL factor * Ver 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

Surcharge = *Srch factor * (Heel + ΔThick) * Surcharge* =1.00 * 0.0 * (2.5 + (12.0 - 8.0) / 12) = 0.0 k/ft

Arm = *ftg - (Heel + ΔThick) / 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 * γw * 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)*

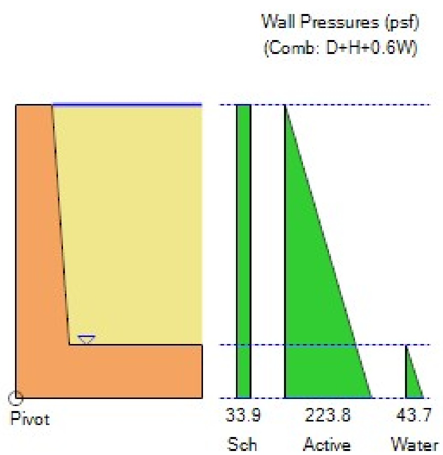
Arm = 0.50 ft Moment = 0.0 * 0.50 = 0.0 k-ft/ft

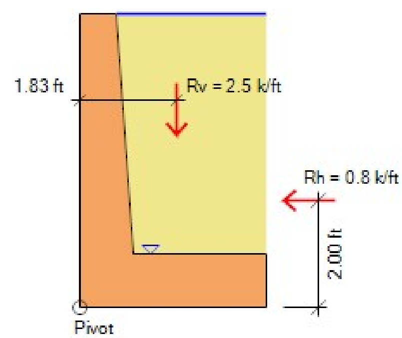
Ver. resultant Rv = *Σ Vertical forces* = 2.5 k/ft

Resisting moment RM = *Σ Moments* = 4.6 k-ft/ft

Arm of ver. resultant = *RM / Rv* = 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 = $\frac{Ftg}{2} - \frac{RM - OTM}{Rv} = \frac{3.50}{2} - \frac{4.6 - 2.2}{2.5}$ = 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 = $\frac{Rv}{0.75 * Ftg - 1.5 * Ecc} = \frac{2.5}{0.75 * 3.50 - 1.5 * 0.79}$ = 1.7 ksf < 2.0 ksf OK

Heel bearing = 0.0 ksf

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

Sliding force Rh = 0.6 + 0.0 + 0.2 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 = 0.8 k/ft

Passive coefficient *kp (Coulomb) =* 3.34

Passive depth *Dp = Soil cover + Ftg + Key - Neglect depth =* 0.50 + (12.0 + 0.0) / 12 - 0.00 = 1.50 ft

Passive pressure top = *kp * γ * Neglect depth + Water =* 3.34 * 120.0 * 0.00 + 0.00 = 0.00 ksf

Passive pressure bot = *kp * γ * (Dp + Neglect depth) + Water =* 3.34 * 120.0 * (1.50 + 0.00) + -0.11 = 0.49 ksf

Passive force = *(Pressure top + Pressure bot) / 2 * Dp =* (0.00 + 0.49) / 2 * 1.50 = 0.4 k/ft

Friction force = *Max (0, Rv * Friction coeff.) =* Max (0, 2.5 * 0.35) = 0.9 k/ft

Sliding S.F. = *(Passive + Friction) / Rh =* (0.4 + 0.9) / 0.8 = 1.51 > 1.50 OK

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

Backfill = *Lat factor * Pah =* 1.6 * 0.4 = 0.7 k/ft

Arm = *Hb / 3 =* 4.50 / 3 = 1.50 ft Moment = 0.7 * 1.50 = 1.0 k-ft/ft

Water table = *Lat factor * Pw =* 1.6 * 0.0 = 0.0 k/ft

Arm = *(Water table - Ftg) / 3 =* (1.00 - 12.0 / 12) / 3 = 0.00 ft Moment = 0.0 * 0.00 = 0.0 k-ft/ft

Surcharge = *Factor * ka * Surcharge * Hs * Cos (δ + α) =* 1.6 * 0.36 * 100.0 * 4.50 * 0.95 = 0.2 k/ft

Arm = *Hb / 2 =* 4.50 / 2 = 2.25 ft Moment = 0.2 * 2.25 = 0.5 k-ft/ft

Vert. Concentrated = Factor * Shear = 0.9 * 0.00 + 0.0 * 0.00 = 0.0 k/ft

Factor * Moment = 0.9 * 0.0 + 0.0 * 0.0 = 0.0 k-ft/ft

Hor. Concentrated = Factor * Load = 0.9 * 0.0 + 0.00 * 0.0 = 0.0 k/ft

Arm = Stem - Ecc = 4.50 - 6.0 / 12 = 4.00 ft Moment = 0.0 * 4.00 = 0.0 k-ft/ft

Strip load = *Σ Lat factor * 2 * Q / π * [β - Sin β * Cos (2α)] =* 1.60 * 0.0 = 0.0 k/ft

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

Wind load = *WL factor * Pressure * Wind height =* 0.0 * 0.00 * 5.00 = 0.0 k/ft

Arm = *Stem - Wind height / 2 =* 4.50 - 5.00 / 2 = 2.00 ft Moment = 0.0 * 2.00 = 0.0 k-ft/ft

Backfill seismic = *EQ factor * (Paeh - Pah) =* 1.0 * (0.4 - 0.4) = 0.2 k/ft

Arm = *0.6 * Hb =* 0.6 * 4.50 = 2.70 ft Moment = 0.2 * 2.70 = 0.5 k-ft/ft

Water seismic = *EQ factor * Pwe =* 1.0 * 0.0 = 0.0 k/ft

Arm = *(Water table - Ftg) / 3 =* (1.00 - 12.0 / 12) / 3 = 0.00 ft Moment = 0.0 * 0.00 = 0.0 k-ft/ft

Wall seismic = 0.0 kip

Moment = 0.0 k-ft/ft

Max. shear = 0.7 + 0.0 + 0.2 + 0.0 + 0.0 + 0.0 + 0.0 + 0.2 + 0.0 + 0.0 = 1.1 k/ft

Shear at critical section = *Max shear - Max shear / Hb * d =* 1.1 - 1.1 / 4.50 * 9.0 / 12 = 0.9 k/ft

Max. Moment = 1.0 + 0.0 + 0.5 + 0.0 + 0.0 + 0.0 + 0.0 + 0.5 + 0.0 + 0.0 = 2.0 k-ft/ft

Size factor λs = √(2 / (1 + d / 10)) = √(2 / (1 + 9.0 / 10)) = 1.00 ACI Eq. (22.5.5.1.3)

Shear strength *φ Vc = φ * 8 * λs * ρ⅓ * (f'c * 1000)½ * b * d / 1000* ACI Table 22.5.5.1

φ Vc = 0.75 * 8 * 1.00 * (0.0029)⅓ * (2500)½ * 12 * 9.0 / 1000 = 4.7 k/ft > 0.9 k/ft OK

Shear friction *φ Vn = φ * μ * Avf * fy* ACI 22.9.4.2

φ Vn = 0.75 * 0.6 * 0.31 * 60.0 = 8.4 k/ft > 1.1 k/ft OK

Use #5 @ 12.0 in As = 0.31 in²/ft *ρ = As / b d =* 0.31 / (12 * 9.7) = 0.0027

Bending strength *φ Mn = φ * d² * f'c * q * (1 - 0.59 * q)* q = ρ * fy / f'c = 0.064 ACI 22.2

φ Mn = 0.90 * 9.7² * 2.5 * 0.064 * (1 - 0.59 * 0.064) = 13.0 k-ft/ft > 2.0 k-ft/ft OK

Hooked *Ldh = Max (8 * db, 6 in, fy / 55 / (f'c)½ * (db)^1.5 * ψr * ψc) =*

Max (8 * 0.63, 6 in, 60.0 * 1000 / 55 / (2500)½ * (0.63)^1.5 * 1.0 * 0.77) = 8.3 in ACI 25.4.3

Dev. length at footing = *Ftg - Cover* = 12.0 - 3.0 = 9.0 in > 8.3 in OK

*As min = 0.0018 * b * t =* 0.0018 * 12.0 * 12.0 = 0.26 in²/ft ACI 7.6.1.1

Min. steel area ratio = *As min / As =* 0.26 / 0.31 = 0.84 < 1.0 OK

*As S&T vert = 0.0018 * b * t =* 0.0018 * 12.0 * 12.0 = 0.26 in²/ft ACI 24.4.3.2

*As S&T hor = 0.0018 * b * t =* 0.0018 * 12.0 * 12.0 = 0.26 in²/ft ACI 24.4.3.2

Min. steel S&T ratio = *As S&T / As =* Max(0.26 / 0.31, 0.26 / 0.27) = 0.97 < 1.0 OK

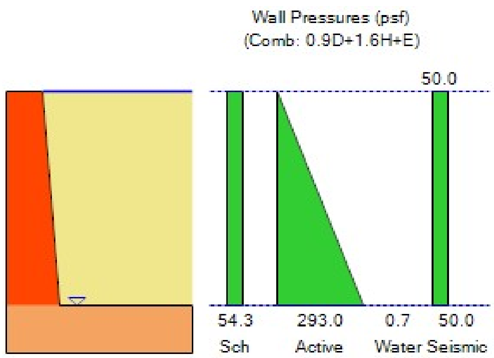
Max. steel area for fy/Es + 0.003 tension strain = 1.30 in²/ft > 0.31 in²/ft OK ACI 21.2.2

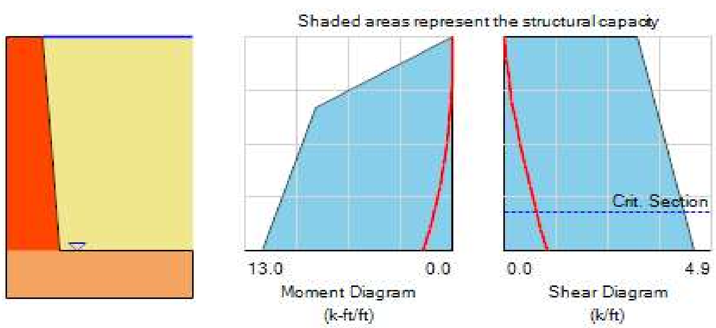
*fs = Min (Msvc / (As * j * d), 0.66 Fy) =* Min (1.3 * 12 / (0.31 * 0.9 * 9.7), 0.66 * 60.0) = 5.6 ksi

*Smax cracking = Min (15 * 40 / fs - 2.5 Cc, 12 * 40 / fs) =* ACI Table 24.3.2

Min (15 * 40 / 5.6 - 2.5 * 2.0, 12 * 40 / 5.6) = 85.0 in

*Smax = Min (Smax cr, 3 * t, 18.0)* = Min (85.0, 3 * 12.0, 18.0) = 18.0 in > 12.0 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 * γc* = 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 * γ* = 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 + ΔThick) * Wedge / 2 * γ* =

= 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) * (γs - γ)* = 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 + ΔThick) * 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 Vu = -0.0 + 0.5 + 1.6 + 0.0 + 0.0 + 0.5 + 0.0 = 2.5 k/ft

Max. Moment Mu = -0.0 + 0.6 + 2.0 + 0.0 + 0.0 + 0.6 + 0.0 = 3.2 k-ft/ft

Size factor λs = 1.0 for footings — ACI 13.2.6.2

Shear strength *φ Vc = φ * 8 * λs * ρ⅓ * (f'c * 1000)½ * b * d / 1000* — ACI Table 22.5.5.1

φ Vc = 0.75 * 8 * 1.0 * (0.0027)⅓ * (2500)½ * 12 * 9.7 / 1000 = 4.9 k/ft > 2.5 k/ft OK

Use #5 @ 12.0 in As = 0.31 in²/ft *ρ = As / b d* = 0.31 / (12 * 9.7) = 0.0027

Bending strength *φ Mn = φ * d² * f'c * q * (1 - 0.59 * q)* q = ρ * fy / f'c = 0.064 — ACI 22.2

φ Mn = 0.90 * 9.7² * 2.5 * 0.064 * (1 - 0.59 * 0.064) = 13.0 k-ft/ft > Mu = 3.2 k-ft/ft 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 *Ld = Max (12.0, 3 / 40 * fy / (f'c)½ * Size * Casting / Cover * Grade * db * ratio)* — ACI 25.4.2.3

= Max (12.0, 3 / 40 * 60.0 * 1000 / (2500)½ * 0.8 * 1.0 / 2.5 * 1.0 * 0.63 * 0.24) = 12.0 in

Hooked *Ldh = Max (8 * db, 6 in, fy / 55 / (f'c)½ * (db)^1.5 * ψr * ψc)* = — ACI 25.4.3

Max (8 * 0.63, 6 in, 60.0 * 1000 / 55 / (2500)½ * (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 OK

Dev. length at heel side = *Heel - Cover* = 2.50 * 12 - 2.0 = 28.0 in > 12.0 in OK

*As min = 0.0018 * b * t* = 0.0018 * 12.0 * 12.0 = 0.26 in²/ft — ACI 7.6.1.1

Min. steel area ratio = *As min / As* = 0.26 / 0.31 = 0.84 < 1.0 OK

*As S&T min = 0.0018 * b * t* = 0.0018 * 12.0 * 12.0 = 0.26 in²/ft — ACI 24.4.3.2

Min. steel S&T ratio = *As S&T min / As* = Max(0.26 / 0.51, 0.26 / 0.40) = 0.65 < 1.0 OK

Max. steel area for fy/Es + 0.003 tension strain = 1.32 in²/ft > 0.31 in²/ft OK — ACI 21.2.2

*fs = Min (Msvc / (As * j * d), 0.66 Fy)* = Min (2.5 * 12 / (0.31 * 0.9 * 9.7), 0.66 * 60.0) = 10.8 ksi

*Smax cracking = Min (15 * 40 / fs - 2.5 Cc, 12 * 40 / fs)* = — 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 >= 12.0 in OK — ACI 7.7.2.3

TOE DESIGN (Comb. 1.4D+0.9H)

Bearing force = *(Bearing1 + Bearing2) / 2 * Toe =* (1.7 + 1.7) / 2 * 0.00 = 0.0 k/ft

Arm = *(Bearing1 * Toe² / 2 + (Bearing2 - Bearing1) * Toe² / 3) / Force*

= (1.7 * 0.00² / 2 + (1.7 - 1.7) * 0.00² / 3) / 0.0 = 0.00 ft

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

Water Buoyancy = *Factor * γw * Water table * Toe =* 1.4 * 62.4 * 1.00 * 0.00 = 0.0 k/ft

Arm = *Toe / 2* = 0.00 / 2 = 0.00 ft   Moment = 0.0 * 0.00 = 0.0 k-ft/ft

Concrete weight = *DL factor * Thick * Toe * γc =* 1.4 * 12.0 / 12 * 0.00 * 0.15 = 0.0 k/ft

Arm = *Toe / 2* = 0.00 / 2 = 0.00 ft   Moment = 0.0 * 0.00 = 0.0 k-ft/ft

Soil cover = *DL factor * Toe * Height * γ =* 1.4 * 0.00 * 0.00 * 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

Max. Shear Vu = 0.0 + 0.0 - 0.0 - 0.0 = 0.0 k/ft

Shear at crit. section Vu = *Max shear * (Toe - d) / Toe* = 0.0 * (0.00 - 8.8 / 12) / 0.00 = 0.0 k/ft

Max. Moment Mu = 0.0 + 0.0 - 0.0 - 0.0 = 0.0 k-ft/ft

Size factor λs = 1.0 for footings   ACI 13.2.6.2

Shear strength *φ Vc = φ * 8 * λs * ρ⅓ * (f'c * 1000)½ * b * d / 1000*   ACI Table 22.5.5.1

φ Vc = 0.75 * 8 * 1.0 * (0.0019)⅓ * (2500)½ * 12 * 8.8 / 1000 = 4.0 k/ft   > 0.0 k/ft   OK

Use #4 @ 12.0 in   As = 0.20 in²/ft   *ρ = As / b d =* 0.20 / (12 * 8.8) = 0.0019

Bending strength *φ Mn = φ * d² * f'c * q * (1 - 0.59 * q)*   q = ρ * fy / f'c = 0.046   ACI 22.2

φ Mn = 0.90 * 8.8² * 2.5 * 0.046 * (1 - 0.59 * 0.046) = 7.7 k-ft/ft   > Mu = 0.0 k-ft/ft   OK

Cover factor = *Min (2.5, (Cover + db /2, Spacing / 2) / db) =* Min (2.5, (3.0 + 0.50 / 2, 12.0 / 2) / 0.50) = 2.5

Straight *Ld = Max (12.0, 3 / 40 * fy / (f'c)½ * Size * Casting / Cover * Grade * db * ratio)*   ACI 25.4.2.3

= Max (12.0, 3 / 40 * 60.0 * 1000 / (2500)½ * 0.8 * 1.0 / 2.5 * 1.0 * 0.50 * 0.00) = 12.0 in

Hooked *Ldh = Max (8 * db, 6 in, fy / 55 / (f'c)½ * (db)^1.5 * ψr * ψc) =*   ACI 25.4.3

Max (8 * 0.50, 6 in, 60.0 * 1000 / 55 / (2500)½ * (0.50)^1.5 * 1.0 * 0.77) = 6.0 in

Dev. length at heel side = N.A.

Dev. length at toe side N.A. =

*As min = 0.0018 * b * t =* 0.0018 * 12.0 * 12.0 = 0.00 in²/ft   ACI 7.6.1.1

Min. steel area ratio = *As min / As =* 0.00 / 0.20 = 0.00   < 1.0   OK

*As S&T min = 0.0018 * b * t =* 0.0018 * 12.0 * 12.0 = 0.00 in²/ft   ACI 24.4.3.2

Min. steel S&T ratio = *As S&T min / As =* Max(0.00 / 0.20, 0.00 / 0.20) = 0.00 < 1.0   OK

Max. steel area for fy/Es + 0.003 tension strain = 1.18 in²/ft   > 0.20 in²/ft   OK   ACI 21.2.2

*fs = Min (Msvc / (As * j * d), 0.66 Fy) =* Min (0.0 * 12 / (0.20 * 0.9 * 8.8), 0.66 * 60.0) = 0.0 ksi

*Smax cracking = Min (15 * 40 / fs - 2.5 Cc, 12 * 40 / fs) =*   ACI Table 24.3.2

Min (15 * 40 / 0.0 - 2.5 * 3.0, 12 * 40 / 0.0) = ∞ in

*Smax = Min (Smax cr, 3 * t, 18.0)* = Min (∞, 3 * 12.0, 18.0) = 18.0 in   >= 12.0 in OK   ACI 7.7.2.3

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 Vu = *Max shear * (Key - d) / Key* = 0.0 * (0.0 - 0.1) / 0.0 = 0.0 k/ft

Arm = *(Passive1 * Key² / 2 + (Passive2 - Passive1) * Key² / 3) / Force*

= (0.6 * 0.00² / 2 + (0.5 - 0.6) * 0.00² / 3) / 0.0 = 0.00 ft

Max. moment Mu = 0.0 * 0.00 = 0.0 k-ft/ft

Size factor λs = 1.0 for footings — ACI 13.2.6.2

Shear strength *φ Vc = φ * 8 * λs * ρ⅓ * (f'c * 1000)½ * b * d / 1000* — ACI Table 22.5.5.1

φ Vc = 0.75 * 8 * 1.0 * (0.1667)⅓ * (2500)½ * 12 * 0.1 / 1000 = 0.2 k/ft > 0.0 k/ft OK

Use #4 @ 12.0 in As = 0.20 in²/ft *ρ = As / b d* = 0.20 / (12 * 0.1) = 0.1667

Bending strength *φ Mn = φ * d² * f'c * q * (1 - 0.59 * q)* q = ρ * fy / f'c = 4.000 — ACI 22.2

φ Mn = 0.90 * 0.1² * 2.5 * 4.000 * (1 - 0.59 * 4.000) = 0.1 k-ft/ft > Mu = 0.0 k-ft/ft OK

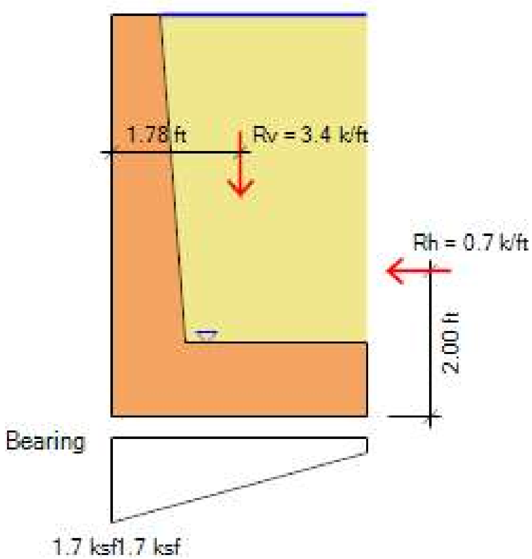
*As min = 0.0018 * b * t* = 0.0018 * 12.0 * 0.0 = 0.00 in²/ft — ACI 7.6.1.1

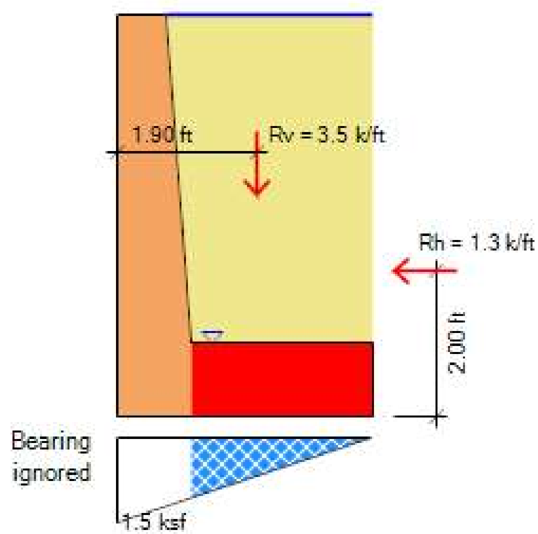
Min. steel area ratio = *As min / As* = 0.00 / 0.20 = 0.00 < 1.0 OK

*As S&T = 0.0018 * b * t* = 0.0018 * 12.0 * 0.0 = 0.00 in²/ft — ACI 24.4.3.2

Min. steel S&T ratio = *As S&T / As* = Max(0.00 / 0.20, 0.32 / 0.40) = 0.81 < 1.0 OK

Max. steel area for fy/Es + 0.003 tension strain = 0.21 in²/ft > 0.20 in²/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

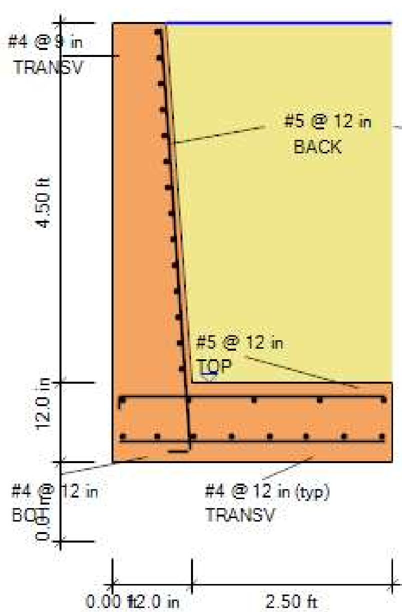
Bending	0.24	<	1.00	✓	(1.2D+1.6L+1.6H)
Shear	0.51	<	1.00	✓	(1.2D+1.6L+1.6H)

DESIGN CODES

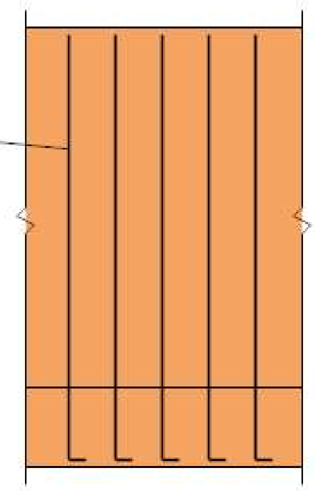
General Analysis	IBC 2018
Concrete Design	ACI 318-19
Masonry Design	TMS 402-16
Load Combinations	ASCE 7-10/16

MATERIALS

	Stem	Footing	
Concrete f'c	2.5	2.5	ksi
Rebars fy	60.0	60.0	ksi
Masonry f'm	1.5		ksi



SECTION



ELEVATION