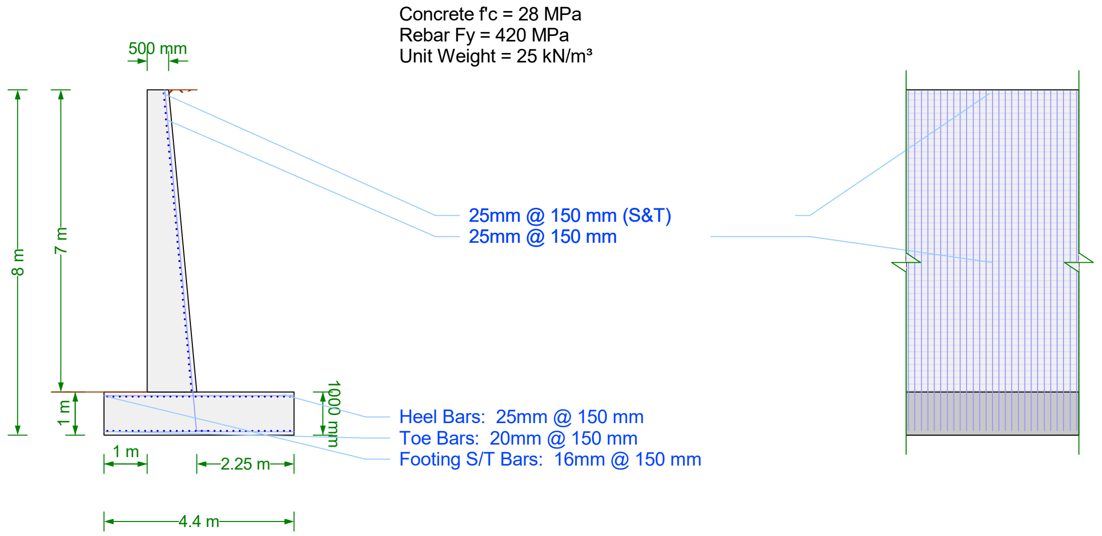
Design Detail



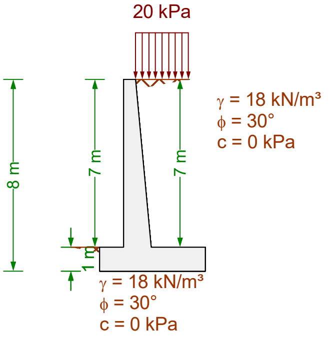
Check Summary

Ratio	Check	Provided	Required	Combination
----- Stability Checks -----				
✓ 0.996	Overturning	2.01	2.00	1.0D + 1.0L + 1.0H
✓ 0.844	Bearing Pressure	350 kPa	295.3 kPa	1.0D + 1.0L + 1.0H
✓ 0.720	Bearing Eccentricity	0.79 m	1.1 m	1.0D + 1.0L + 1.0H
----- Toe Checks -----				
✓ 0.052	Shear	603 kN/m	31.53 kN/m	1.2D + 1.6L + 1.6H
✓ 0.253	Moment	714.1 kN·m/m	180.4 kN·m/m	1.2D + 1.6L + 1.6H
✓ 0.067	Min Strain	0.0595	0.0040	1.2D + 1.6L + 1.6H
✓ 0.000	Min Steel	53.53 mm²	0 mm²	1.2D + 1.6L + 1.6H
✓ 0.092	Development	332.5 cm	30.48 cm	1.2D + 1.6L + 1.6H
✓ 0.328	S&T Max Spacing	150 mm	457.2 mm	1.2D + 1.6L + 1.6H
✓ 0.665	S&T Min Rho	0.0027	0.0018	1.2D + 1.6L + 1.6H
----- Heel Checks -----				
✓ 0.986	Shear	601.4 kN/m	593.1 kN/m	1.2D + 1.6L + 1.6H
✓ 0.611	Moment	1092 kN·m/m	667.2 kN·m/m	1.2D + 1.6L + 1.6H
✓ 0.108	Min Strain	0.0372	0.0040	1.2D + 1.6L + 1.6H
✓ 0.000	Min Steel	83.03 mm²	0 mm²	1.2D + 1.6L + 1.6H
✓ 0.273	Development	207.5 cm	56.7 cm	1.2D + 1.6L + 1.6H
✓ 0.328	S&T Max Spacing	150 mm	457.2 mm	1.2D + 1.6L + 1.6H
✓ 0.665	S&T Min Rho	0.0027	0.0018	1.2D + 1.6L + 1.6H
----- Stem Checks -----				
✓ 0.634	Moment	1277 kN·m/m	810.1 kN·m/m	1.2D + 1.6L + 1.6H
✓ 0.442	Shear	700.3 kN/m	309.9 kN/m	1.2D + 1.6L + 1.6H
✓ 0.091	Max Steel	0.0438	0.0040	1.2D + 1.6L + 1.6H
✓ 0.000	Min Steel	0 cm²/m	0 cm²/m	1.2D + 1.6L + 1.6H
✓ 0.228	Base Development	92.5 cm	21.13 cm	1.2D + 1.6L + 1.6H
✓ 0.880	Horz Bar Rho	0.0028	0.0025	1.2D + 1.6L + 1.6H
✓ 0.328	Horz Bar Spacing	150 mm	457.2 mm	1.2D + 1.6L + 1.6H

Criteria

Building Code	IBC 2012
Concrete Load Combs	IBC 2012 (Strength)
Masonry Load Combs	ASCE 7-10 (ASD)
Stability Load Combs	ASCE 7-10 (ASD)
Restrained Against Sliding	Yes
Neglect Bearing At Heel	Yes
Use Vert. Comp. for OT	Yes
Use Vert. Comp. for Sliding	No
Use Vert. Comp. for Bearing	Yes
Use Surcharge for Sliding & OT	No
Use Surcharge for Bearing	Yes
Neglect Soil Over Toe	No
Neglect Backfill Wt. for Coulomb	No
Factor Soil Weight As Dead	No
Use Passive Force for OT	No
Assume Pressure To Top	No
Extend Backfill Pressure To Key Bottom	No
Use Toe Passive Pressure for Bearing	No
Required F.S. for OT	2.00
Required F.S. for Sliding	1.50
Has Different Safety Factors for Seismic	No
Allowable Bearing Pressure	350 kPa
Req'd Bearing Location	Middle half
Wall Friction Angle	30°
Friction Coefficent	0.50
Soil Reaction Modulus	27146 kN/m³

Loads



Loading Options/Assumptions

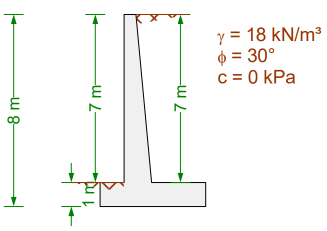
➔ Passive pressure neglects top 0 m of soil.

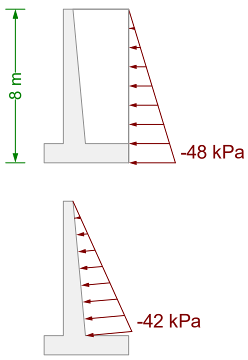
Load Combinations

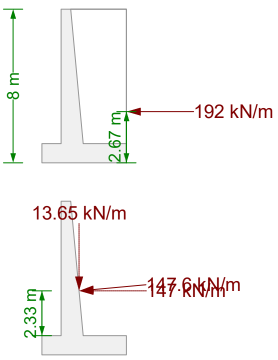
IBC 2012 (Strength)

1.2D + 1.6L + 1.6H
1.2D + 1.6L + 0.9H
1.2D + 0.5L + 1.6H
1.2D + 0.5L + 0.9H
1.2D + 1.6H
1.2D + 0.9H
0.9D + 1.6H
0.9D + 0.9H
1.4D

Backfill Pressure







Lateral Earth Pressure

Rankine Active Earth Pressure Theory

$K_a = \tan^2\left(45° - \frac{\phi}{2}\right) = \tan^2\left[45° - \frac{(30°)}{2}\right] = 0.3333$

$\sigma_a = \gamma H K_a - 2c\sqrt{K_a} = (18\ kN/m^3)(8\ m)(0.3333) - 2(0\ kPa)\sqrt{0.3333} = 48\ kPa$

$z_c = \frac{2c}{\gamma\sqrt{K_a}} = \frac{2(0\ kPa)}{(18\ kN/m^3)\sqrt{0.3333}} = 0\ m$

$\alpha_P = \alpha = (0°) = 0°$ (resultant force angle with horizontal)

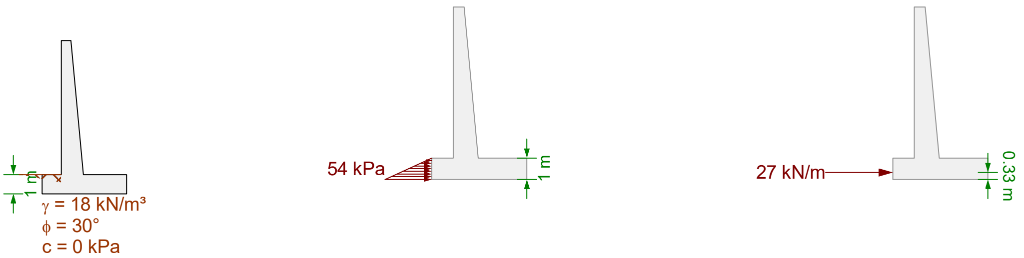
Lateral Earth Pressure (stem only)

$\sigma_a = \gamma H K_a - 2c\sqrt{K_a} = (18\ kN/m^3)(7\ m)(0.3333) - 2(0\ kPa)\sqrt{0.3333} = 42\ kPa$

$z_c = \frac{2c}{\gamma\sqrt{K_a}} = \frac{2(0\ kPa)}{(18\ kN/m^3)\sqrt{0.3333}} = 0\ m$

$\alpha_P = \alpha = (0°) = 0°$ (resultant force angle with horizontal)

Passive Pressure



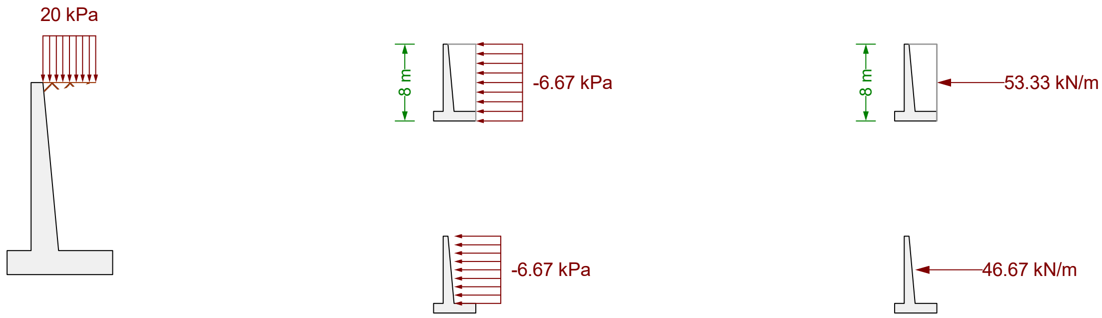
Lateral Earth Pressure

Rankine Passive Earth Pressure Theory

$$K_p = \tan^2\left(45° + \frac{\phi}{2}\right) = \tan^2\left[45° + \frac{(30°)}{2}\right] = 3.0$$

$$\sigma_p = \gamma\, H\, K_p + 2\, c\sqrt{K_p} = (18\ \text{kN / m}^3)(1\ \text{m})(3.0) + 2\,(0\ \text{kPa})\sqrt{3.0} = 54\ \text{kPa}$$

Uniform Surcharge Pressure



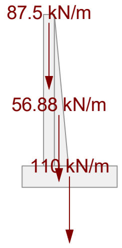
Lateral Surcharge Pressure

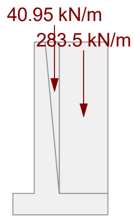
Rankine Active Earth Pressure Theory

$$K_a = \tan^2\left(45° - \frac{\phi}{2}\right) = \tan^2\left[45° - \frac{(30°)}{2}\right] = 0.3333$$

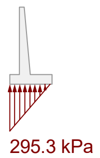
$$\sigma_{sur} = K_a\, q = (0.3333)(20\ \text{kPa}) = 6.67\ \text{kPa}$$

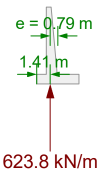
Wall/Soil Weights





Bearing Pressure





Friction

F = µ R = (0.50) (578.8 kN / m) = 289.4 kN / m

Bearing Pressure Calculation

Contributing Forces

	Vert Force	...offset	Horz Force	...offset	OT Moment
Backfill Pressure	-0 kN/m	-	-192 kN/m	2.67 m	512 kN·m/m
Uniform Surcharge Pressure	-45 kN/m	3.28 m	-53.33 kN/m	4 m	65.96 kN·m/m
Footing Weight	-110 kN/m	2.2 m	0 kN/m	-	-242 kN·m/m
Stem Weight	-87.5 kN/m	1.25 m	0 kN/m	-	-109.37 kN·m/m
Stem Weight	-56.88 kN/m	1.72 m	0 kN/m	-	-97.64 kN·m/m
Backfill Weight	-283.5 kN/m	3.28 m	0 kN/m	-	-928.46 kN·m/m
Backfill Weight	-40.95 kN/m	1.93 m	0 kN/m	-	-79.17 kN·m/m
	-623.83 kN/m				-878.68 kN·m/m

$$\frac{-\ 878.68\ \text{kN·m / m}}{-\ 623.83\ \text{kN / m}} = 1.41\ \text{m}$$

Note: Bearing resultant used for friction calcs is 578.8 kN/m - reduced per user options (for sliding check).

Stability Checks [1.0D + 1.0L + 1.0H]

Overturning Check

Overturning Moments

	Force	Distance	Moment
Backfill pressure (horz)	192 kN/m	2.67 m	512 kN·m/m
Surcharge (uniform) lateral pressure	53.33 kN/m	4 m	213.3 kN·m/m
		Total:	725.3 kN·m/m

Resisting Moments

	Force	Distance	Moment
Backfill pressure (vert)	0 kN/m	4.4 m	0 kN·m/m
Footing Weight	-110 kN/m	2.2 m	242 kN·m/m
Stem Weight	-87.5 kN/m	1.25 m	109.4 kN·m/m
Stem Weight	-56.88 kN/m	1.72 m	97.64 kN·m/m
Backfill Weight	-283.5 kN/m	3.28 m	928.5 kN·m/m
Backfill Weight	-40.95 kN/m	1.93 m	79.17 kN·m/m
		Total:	1457 kN·m/m

$$F.S. = \frac{RM}{OTM} = \frac{1457\ kN \cdot m / m}{725.3\ kN \cdot m / m} = 2.008 > 2.00\ (OK)$$

Sliding Check

Check not performed; restrained against sliding.

Bearing Capacity Check

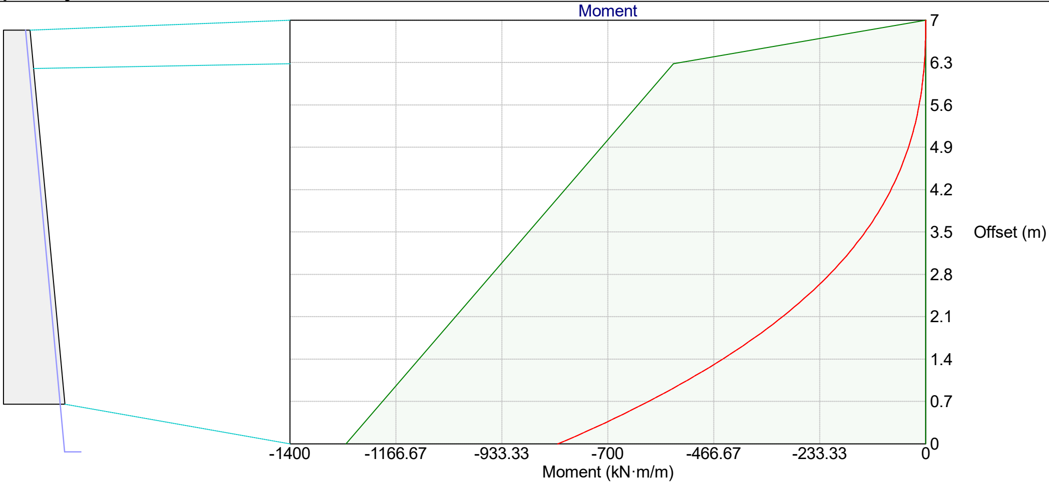
Bearing pressure < allowable (295.3 kPa < 350 kPa) - OK
Bearing resultant eccentricity < allowable (0.79 m < 1.1 m) - OK

Wall Top Displacement

(based on unfactored service loads)

Deflection due to stem flexural displacement	0.002 m
Deflection due to rotation from settlement	0.017 m
Total deflection at top of wall (positive towards toe)	0.02 m

Stem Flexural Capacity



Capacity (ACI 318-11 10.2) @ 0 m from base

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(32.69\ \text{cm}^2 / \text{m})(420\ \text{MPa})}{0.85\,(28\ \text{MPa})} = 57.69\ \text{mm}$$

$$\phi M_n = \phi A_s f_y (d - a / 2) = (0.90)(32.69\ \text{cm}^2 / \text{m})(420\ \text{MPa})[(1063\ \text{mm}) - (57.69\ \text{mm}) / 2] = 1277\ \text{kN·m / m}$$

Capacity (ACI 318-11 10.2) @ 6.29 m from base

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(32.69\ \text{cm}^2 / \text{m})(420\ \text{MPa})}{0.85\,(28\ \text{MPa})} = 57.69\ \text{mm}$$

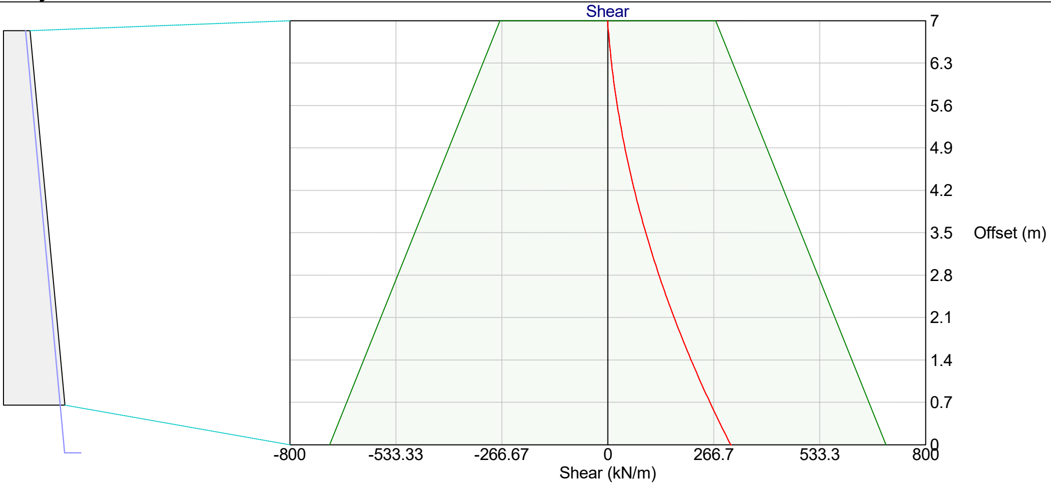
$$\phi M_n = \phi A_s f_y (d - a / 2) = (0.90)(32.69\ \text{cm}^2 / \text{m})(420\ \text{MPa})[(478.8\ \text{mm}) - (57.69\ \text{mm}) / 2] = 556\ \text{kN·m / m}$$

Capacity (ACI 318-11 10.2) @ 7 m from base

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(0\ \text{cm}^2 / \text{m})(420\ \text{MPa})}{0.85\,(28\ \text{MPa})} = 0\ \text{mm}$$

$$\phi M_n = \phi A_s f_y (d - a / 2) = (0.90)(0\ \text{cm}^2 / \text{m})(420\ \text{MPa})[(412.6\ \text{mm}) - (0\ \text{mm}) / 2] = 0\ \text{kN·m / m}$$

Stem Shear Capacity



Shear Capacity (ACI 318-11 11.1.1, 11.2.1) @ 0 m from base

λ = 1.0 (normal weight concrete)

$V_c = 2\,\lambda\,\sqrt{F'_c}\,d\; = \;2\,(1.0)\,\sqrt{28\text{ MPa}}\,(1063\text{ mm})\; = \;933.7\text{ kN / m}$

$\phi V_n = \phi\,V_c\; = \;(0.750)\,(933.7\text{ kN / m})\; = \;700.3\text{ kN / m}$

Shear Capacity (ACI 318-11 11.1.1, 11.2.1) @ 7 m from base

λ = 1.0 (normal weight concrete)

$V_c = 2\,\lambda\,\sqrt{F'_c}\,d\; = \;2\,(1.0)\,\sqrt{28\text{ MPa}}\,(412.6\text{ mm})\; = \;362.5\text{ kN / m}$

$\phi V_n = \phi\,V_c\; = \;(0.750)\,(362.5\text{ kN / m})\; = \;271.9\text{ kN / m}$

Stem Development/Lap Length Calculations

Main vertical stem bars (bottom end) - Development Length Calculation (ACI 318-11 12.2.3, 12.5)

$\psi_e = 1.0$ (uncoated hooked bars)

$\lambda = 1.0$ (normal weight concrete)

$$l_{dh} = 0.02\,\psi_e \frac{f_y}{\lambda\sqrt{F'_c}} d_b = 0.02\,(1.0)\frac{(420\text{ MPa})}{(1.0)\sqrt{28\text{ MPa}}}(24.89\text{ mm}) = 47.59\text{ cm}$$

Factoring l_{dh} by the 0.7 multiplier of 12.5.3 (a) : $l_{dh} = 33.31$ cm

$8\,d_b = 8\,(24.89\text{ mm}) = 7.840$ (minimum limit, does not control)

Main vertical stem bars (top end) - Development Length Calculation (ACI 318-11 12.2.3, 12.5)

$\psi_t = 1.0$ (bars are not horizontal)

$\psi_e = 1.0$ (bar not epoxy coated)

$\psi_s = 1.0$ (bars are #7 or larger)

$\lambda = 1.0$ (normal weight concrete)

$s / 2 = (150\text{ mm}) / 2 = 75\text{ mm}$

$\text{cover} + d_b / 2 = (75\text{ mm}) + (24.89\text{ mm}) / 2 = 87.45\text{ mm}$

$c_b = 75\text{ mm}$ (lesser of half spacing, ctr to surface)

$K_{tr} = 0.0$ (no transverse reinforcement)

$$\frac{c_b + K_{tr}}{d_b} = \frac{(75\text{ mm}) + (0.0)}{(24.89\text{ mm})} = 3.0130$$

$$l_d = \left(\frac{3.}{40}\frac{f_y}{\lambda\sqrt{F'_c}}\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right) d_b = \left[\frac{3.}{40}\frac{(420\text{ MPa})}{(1.0)\sqrt{28\text{ MPa}}}\frac{(1.0)(1.0)(1.0)}{2.5}\right](24.89\text{ mm}) = 71.38\text{ cm}$$

Toe Checks [1.2D + 1.6L + 1.6H]

Controlling Moment

Design moment M_u for toe need not exceed moment at stem base:

M_{toe} = 180.4 kN·m / m < M_{stem} = 810.1 kN·m / m

M_u = 180.4 kN·m / m (stem moment does not control)

Flexure Check (ACI 318-11 10.2)

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(21.08\ cm^2/m)(420\ MPa)}{0.85\,(28\ MPa)} = 37.19\ mm$$

$$\phi M_n = \phi A_s f_y (d - a/2) = (0.90)(21.08\ cm^2/m)(420\ MPa)[(915\ mm) - (37.19\ mm)/2] = 714.1\ kN{\cdot}m/m$$

ϕM_n = 714.1 kN·m / m ≥ M_u = 180.4 kN·m / m ✓

Shear Check (ACI 318-11 11.1.1, 11.11.3.1)

λ = 1.0 (normal weight concrete)

$$V_c = 2 \lambda \sqrt{F'_c}\, d = 2\,(1.0)\sqrt{28\ MPa}\,(915\ mm) = 804\ kN/m$$

$$\phi V_n = \phi V_c = (0.750)(804\ kN/m) = 603\ kN/m$$

ϕV_n = 603 kN / m ≥ V_u = 31.53 kN / m ✓

Minimum Strain Check (ACI 318-11 10.3.5)

$$\beta_1 = 0.85 - 0.05\left(\frac{F'_c - 4000}{1000}\right) = 0.85 - 0.05\left[\frac{(28\ MPa) - 4000}{1000}\right] = 0.8470$$

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(21.08\ cm^2/m)(420\ MPa)}{0.85\,(28\ MPa)} = 37.19\ mm$$

$$\varepsilon_t = 0.003\left(\frac{d}{a/\beta_1} - 1\right) = 0.003\left[\frac{(915\ mm)}{(37.19\ mm)/(0.8470)} - 1\right] = 0.0595$$

ε_t = 0.0595 ≥ 0.004 ✓

Minimum Steel Check (ACI 318-11 10.5.1)

ϕM_n = 714.1 kN·m / m ≥ (4 / 3) M_u = [4 / 3] (180.4 kN·m / m) = 240.5 kN·m / m

Check is waived per ACI 10.5.3 ✓

Shrinkage and Temperature Steel (ACI 318-11 7.12.2)

$$\rho_{ST\_prov} = \frac{A_{ST}}{t\, s_{ST}} = \frac{(157.5\ cm^2/m)}{(1000\ mm)(150\ mm)} = 0.0027$$

$$\rho_{ST\_min} = \frac{0.0018\,(60000)}{f_y} = \frac{0.0018\,(60000)}{(420\ MPa)} = 0.0018$$

ρ_{ST_min} = 0.0018

ρ_{ST_prov} = 0.0027 ≥ ρ_{ST_min} = 0.0018 ✓

18 inch limit governs

s_{ST_max} = 457.2 mm

s_{ST} = 150 mm ≤ s_{ST_max} = 457.2 mm ✓

Development Check (ACI 318-11 12.12, 12.2.3)

$$\frac{M_u}{\phi M_n} = \frac{(180.4\ kN{\cdot}m/m)}{(714.1\ kN{\cdot}m/m)} = 0.2526$$ (ratio to represent excess reinforcement)

ψ_t = 1.0 (12 inches or less cast below - 2.95 inches)

ψ_e = 1.0 (bar not epoxy coated)

ψ_s = 0.80 (bars are #6 or smaller)

λ = 1.0 (normal weight concrete)

s / 2 = (150 mm) / 2 = 75 mm

cover + d_b / 2 = (75 mm) + (20.07 mm) / 2 = 85.03 mm

c_b = 75 mm (lesser of half spacing, ctr to surface)

K_{tr} = 0.0 (no transverse reinforcement)

$$\frac{c_b + K_{tr}}{d_b} = \frac{(75\ mm) + (0.0)}{(20.07\ mm)} = 3.7377$$

$$l_d = \left(\frac{3.}{40}\,\frac{f_y}{\lambda\sqrt{F'_c}}\,\frac{\psi_t \psi_e \psi_s}{2.5}\right) d_b = \left[\frac{3.}{40}\,\frac{(420\ MPa)}{(1.0)\sqrt{28\ MPa}}\,\frac{(1.0)(1.0)(0.80)}{2.5}\right](20.07\ mm) = 46.03\ cm$$

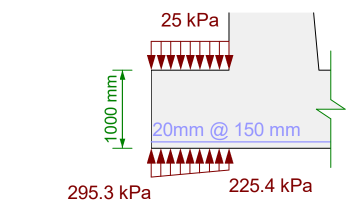
Factoring l_d by the excess reinforcement ratio (0.2526) per 12.2.5: l_d = 11.63 cm

12 inch minimum controls

l_{d_prov} = 332.5 cm ≥ l_d = 30.48 cm ✓

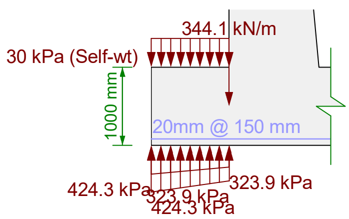
Toe Unfactored Loads

Unfactored Loads



Toe Factored Loads

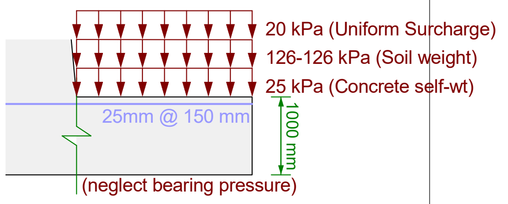
1.2D + 1.6L + 1.6H



Heel Checks [1.2D + 1.6L + 1.6H]

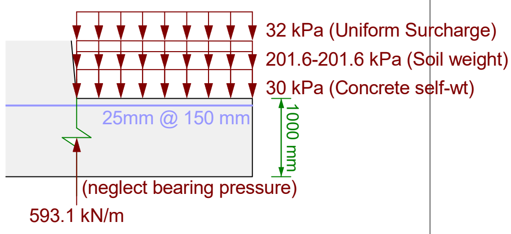
Heel Unfactored Loads

Unfactored Loads



Heel Factored Loads

1.2D + 1.6L + 1.6H



Controlling Moment

Design moment M_u for heel need not exceed moment at stem base:

M_{heel} = 667.2 kN·m / m < M_{stem} = 810.1 kN·m / m

M_u = 667.2 kN·m / m (stem moment does not control)

Flexure Check (ACI 318-11 10.2)

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(32.69\ \text{cm}^2/\text{m})(420\ \text{MPa})}{0.85\,(28\ \text{MPa})} = 57.69\ \text{mm}$$

$$\phi M_n = \phi A_s f_y (d - a/2) = (0.90)(32.69\ \text{cm}^2/\text{m})(420\ \text{MPa})[(912.6\ \text{mm}) - (57.69\ \text{mm})/2] = 1092\ \text{kN·m/m}$$

ϕM_n = 1092 kN·m / m ≥ M_u = 667.2 kN·m / m ✓

Shear Check (ACI 318-11 11.1.1, 11.11.3.1)

λ = 1.0 (normal weight concrete)

$$V_c = 2\lambda\sqrt{F'_c}\,d = 2(1.0)\sqrt{28\ \text{MPa}}\,(912.6\ \text{mm}) = 801.9\ \text{kN/m}$$

$$\phi V_n = \phi V_c = (0.750)(801.9\ \text{kN/m}) = 601.4\ \text{kN/m}$$

ϕV_n = 601.4 kN / m ≥ V_u = 593.1 kN / m ✓

Minimum Strain Check (ACI 318-11 10.3.5)

$$\beta_1 = 0.85 - 0.05\left(\frac{F'_c - 4000}{1000}\right) = 0.85 - 0.05\left[\frac{(28\ \text{MPa}) - 4000}{1000}\right] = 0.8470$$

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(32.69\ \text{cm}^2/\text{m})(420\ \text{MPa})}{0.85\,(28\ \text{MPa})} = 57.69\ \text{mm}$$

$$\varepsilon_t = 0.003\left(\frac{d}{a/\beta_1} - 1\right) = 0.003\left[\frac{(912.6\ \text{mm})}{(57.69\ \text{mm})/(0.8470)} - 1\right] = 0.0372$$

ε_t = 0.0372 ≥ 0.004 ✓

Minimum Steel Check (ACI 318-11 10.5.1)

ϕM_n = 1092 kN·m / m ≥ (4 / 3) M_u = [4 / 3] (667.2 kN·m / m) = 889.6 kN·m / m

Check is waived per ACI 10.5.3 ✓

Shrinkage and Temperature Steel (ACI 318-11 7.12.2)

$$\rho_{ST\_prov} = \frac{A_{ST}}{t\,s_{ST}} = \frac{(157.5\ \text{cm}^2/\text{m})}{(1000\ \text{mm})(150\ \text{mm})} = 0.0027$$

$$\rho_{ST\_min} = \frac{0.0018\,(60000)}{f_y} = \frac{0.0018\,(60000)}{(420\ \text{MPa})} = 0.0018$$

ρ_{ST_min} = 0.0018

ρ_{ST_prov} = 0.0027 ≥ ρ_{ST_min} = 0.0018 ✓

18 inch limit governs

s_{ST_max} = 457.2 mm

s_{ST} = 150 mm ≤ s_{ST_max} = 457.2 mm ✓

Development Check (ACI 318-11 12.12, 12.2.3)

$$\frac{M_u}{\phi M_n} = \frac{(667.2\ \text{kN·m/m})}{(1092\ \text{kN·m/m})} = 0.6111$$ (ratio to represent excess reinforcement)

ψ_t = 1.30 (more than 12 inches cast below - 35.44 inches)

ψ_e = 1.0 (bar not epoxy coated)

ψ_s = 1.0 (bars are #7 or larger)

λ = 1.0 (normal weight concrete)

s / 2 = (150 mm) / 2 = 75 mm

cover + d_b / 2 = (75 mm) + (24.89 mm) / 2 = 87.45 mm

c_b = 75 mm (lesser of half spacing, ctr to surface)

K_{tr} = 0.0 (no transverse reinforcement)

$$\frac{c_b + K_{tr}}{d_b} = \frac{(75\ \text{mm}) + (0.0)}{(24.89\ \text{mm})} = 3.0130$$

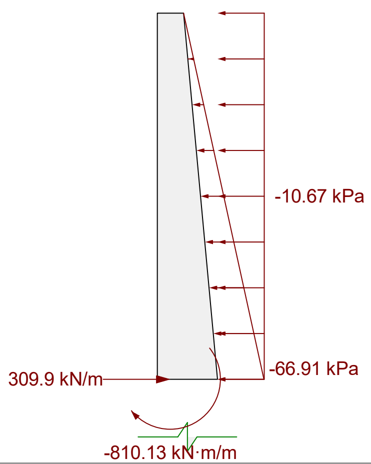
$$l_d = \left(\frac{3.}{40}\,\frac{f_y}{\lambda\sqrt{F'_c}}\,\frac{\psi_t\psi_e\psi_s}{2.5}\right) d_b = \left[\frac{3.}{40}\,\frac{(420\ \text{MPa})}{(1.0)\sqrt{28\ \text{MPa}}}\,\frac{(1.30)(1.0)(1.0)}{2.5}\right](24.89\ \text{mm}) = 92.8\ \text{cm}$$

Factoring l_d by the excess reinforcement ratio (0.6111) per 12.2.5: l_d = 56.7 cm

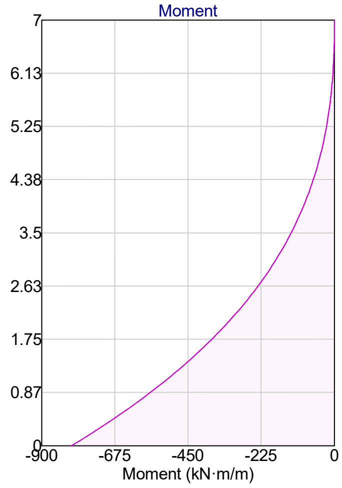
l_{d_prov} = 207.5 cm ≥ l_d = 56.7 cm ✓

Stem Forces [1.2D + 1.6L + 1.6H]

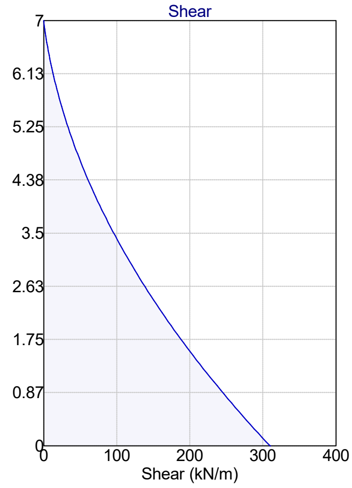
Stem Internal Forces



Stem Internal Forces



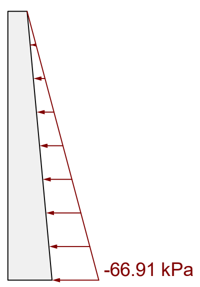
Stem Internal Forces

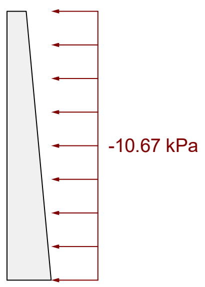


Stem Joint Force Transfer

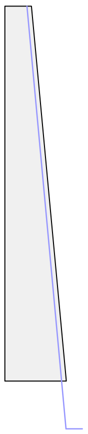
Location	**Force**
@ stem base	309.9 kN/m

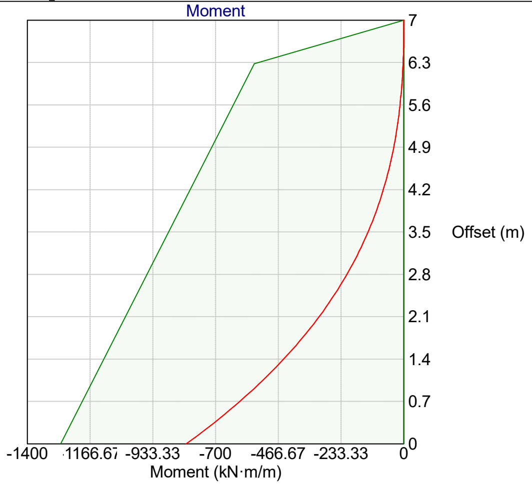
Stem Internal Forces





Stem Moment Checks [1.2D + 1.6L + 1.6H]





Check (ACI 318-11 Ch 10)   @ 0 m from base

ϕM_n = 1277 kN·m / m ≥ M_u = 810.1 kN·m / m ✓

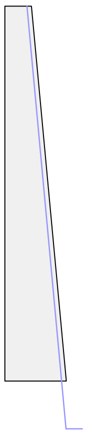
Check (ACI 318-11 Ch 10)   @ 6.29 m from base

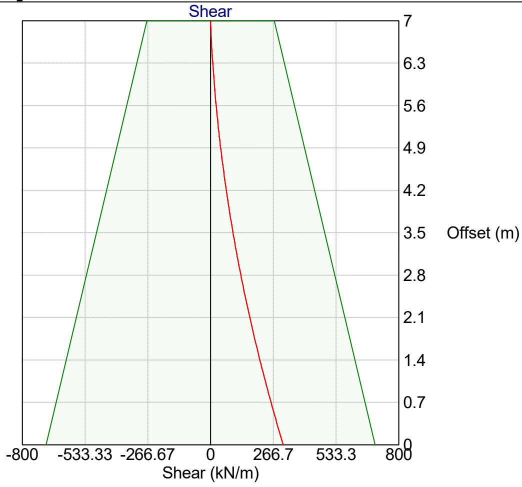
ϕM_n = 556 kN·m / m ≥ M_u = 3.23 kN·m / m ✓

Check (ACI 318-11 Ch 10)   @ 6.29 m from base

ϕM_n = 550.8 kN·m / m ≥ M_u = 3.23 kN·m / m ✓

Stem Shear Checks [1.2D + 1.6L + 1.6H]





Shear Check (ACI 318-11 Ch 11.1.1) @ 0 m from base

ϕV_n = 700.3 kN / m ≥ V_u = 309.9 kN / m ✓

Stem Miscellaneous Checks [1.2D + 1.6L + 1.6H]

Minimum Steel Check (ACI 318-11 10.5.1) @ 0 m from base [Stem in negative flexure]

ϕM_n = 1277 kN·m / m ≥ (4 / 3) M_u = [4 / 3] (810.1 kN·m / m) = 1080 kN·m / m

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-11 10.5.1) @ 7 m from base [Stem in negative flexure]

ϕM_n = 0 kN·m / m ≥ (4 / 3) M_u = [4 / 3] (0 kN·m / m) = 0 kN·m / m

Check is waived per ACI 10.5.3 ✓

Maximum Steel Check (ACI 318-11 10.3.5) @ 0 m from base [Stem in negative flexure]

$$\beta_1 = 0.85 - 0.05\left(\frac{F'_c - 4000}{1000}\right) = 0.85 - 0.05\left[\frac{(28\ \text{MPa}) - 4000}{1000}\right] = 0.8470$$

$$a = \frac{A_s\, f_y}{0.85\, F'_c} = \frac{(32.69\ \text{cm}^2 / \text{m})(420\ \text{MPa})}{0.85\,(28\ \text{MPa})} = 57.69\ \text{mm}$$

$$\varepsilon_t = 0.003\left(\frac{d}{a / \beta_1} - 1\right) = 0.003\left[\frac{(1063\ \text{mm})}{(57.69\ \text{mm}) / (0.8470)} - 1\right] = 0.0438$$

ε_t = 0.0438 ≥ 0.004 ✓

Maximum Steel Check (ACI 318-11 10.3.5) @ 7 m from base [Stem in negative flexure]

$$\beta_1 = 0.85 - 0.05\left(\frac{F'_c - 4000}{1000}\right) = 0.85 - 0.05\left[\frac{(28\ \text{MPa}) - 4000}{1000}\right] = 0.8470$$

$$a = \frac{A_s\, f_y}{0.85\, F'_c} = \frac{(32.69\ \text{cm}^2 / \text{m})(420\ \text{MPa})}{0.85\,(28\ \text{MPa})} = 57.69\ \text{mm}$$

$$\varepsilon_t = 0.003\left(\frac{d}{a / \beta_1} - 1\right) = 0.003\left[\frac{(412.6\ \text{mm})}{(57.69\ \text{mm}) / (0.8470)} - 1\right] = 0.0152$$

ε_t = 0.0152 ≥ 0.004 ✓

Wall Horizontal Steel (ACI 318-11 14.3.3, 14.3.5)

$$\rho_h = \frac{A_{s\_horz} / s_{horz}}{t} = \frac{(490.3\ \text{mm}^2) / (150\ \text{mm})}{(1150\ \text{mm})} = 0.0028$$

ρ_{h_min} = 0.0025 (bars larger than No. 5, or less than 60 ksi)

ρ_h = 0.0028 ≥ ρ_{h_min} = 0.0025 ✓

3 t_{wall} = 3 (500 mm) = 1500 mm

18 inch limit governs

s_{max} = 457.2 mm

s_{horz} = 150 mm ≤ s_{horz_max} = 457.2 mm ✓

Development Check (ACI 318-11 12.12, 12.2.3)

$$\frac{M_u}{\phi M_n} = \frac{(810.1\ \text{kN·m / m})}{(1277\ \text{kN·m / m})} = 0.6343$$ (ratio to represent excess reinforcement)

ψ_e = 1.0 (uncoated hooked bars)

λ = 1.0 (normal weight concrete)

$$l_{dh} = 0.02\,\psi_e \frac{f_y}{\lambda \sqrt{F'_c}}\, d_b = 0.02\,(1.0)\frac{(420\ \text{MPa})}{(1.0)\sqrt{28\ \text{MPa}}}(24.89\ \text{mm}) = 47.59\ \text{cm}$$

Factoring l_{dh} by the 0.7 multiplier of 12.5.3 (a) : l_{dh} = 33.31 cm

Factoring l_{dh} by the excess reinforcement ratio (0.6343) per 12.5.3 (d) : l_{dh} = 21.13 cm

8 d_b = 8 (24.89 mm) = 7.840 (minimum limit, does not control)

l_{dh_prov} = 92.5 cm ≥ l_{dh} = 21.13 cm ✓