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]

$\phi M_n = 108.7 \text{ kN·m/m} \geq (4/3) M_u = [4/3](41.77 \text{ kN·m/m}) = 55.69 \text{ kN·m/m}$

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-11 10.5.1) @ 0.03 m from base [Stem in negative flexure]

$\phi M_n = 105 \text{ kN·m/m} \geq (4/3) M_u = [4/3](40.16 \text{ kN·m/m}) = 53.54 \text{ kN·m/m}$

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-11 10.5.1) @ 1.09 m from base [Stem in negative flexure]

$\phi M_n = 45.82 \text{ kN·m/m} \geq (4/3) M_u = [4/3](11.13 \text{ kN·m/m}) = 14.85 \text{ kN·m/m}$

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-11 10.5.1) @ 3.96 m from base [Stem in negative flexure]

$\phi M_n = 0 \text{ kN·m/m} \geq (4/3) M_u = [4/3](0 \text{ kN·m/m}) = 0 \text{ kN·m/m}$

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]

$\beta_1 = 0.850 \quad (F'_c \leq 4000 \text{ psi})$

$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(23.28 \text{ cm²/m})(413.7 \text{ MPa})}{0.85 (20.69 \text{ MPa})} = 54.78 \text{ mm}$

$\varepsilon_t = 0.003 \left(\frac{d}{a / \beta_1} ?1 \right) = 0.003 \left[\frac{(191.8 \text{ mm})}{(54.78 \text{ mm}) / (0.850)} ?1 \right] = 0.0059$

$\varepsilon_t = 0.0059 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-11 10.3.5) @ 0.03 m from base [Stem in negative flexure]

$\beta_1 = 0.850 \quad (F'_c \leq 4000 \text{ psi})$

$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(16.48 \text{ cm²/m})(413.7 \text{ MPa})}{0.85 (20.69 \text{ MPa})} = 38.79 \text{ mm}$

$\varepsilon_t = 0.003 \left(\frac{d}{a / \beta_1} ?1 \right) = 0.003 \left[\frac{(190.5 \text{ mm})}{(38.79 \text{ mm}) / (0.850)} ?1 \right] = 0.0095$

$\varepsilon_t = 0.0095 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-11 10.3.5) @ 1.09 m from base [Stem in negative flexure]

$\beta_1 = 0.850 \quad (F'_c \leq 4000 \text{ psi})$

$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(6.56 \text{ cm²/m})(413.7 \text{ MPa})}{0.85 (20.69 \text{ MPa})} = 15.44 \text{ mm}$

$\varepsilon_t = 0.003 \left(\frac{d}{a / \beta_1} ?1 \right) = 0.003 \left[\frac{(195.3 \text{ mm})}{(15.44 \text{ mm}) / (0.850)} ?1 \right] = 0.0293$

$\varepsilon_t = 0.0293 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-11 10.3.5) @ 3.96 m from base [Stem in negative flexure]

$\beta_1 = 0.850 \quad (F'_c \leq 4000 \text{ psi})$

$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(6.56 \text{ cm²/m})(413.7 \text{ MPa})}{0.85 (20.69 \text{ MPa})} = 15.44 \text{ mm}$

$\varepsilon_t = 0.003 \left(\frac{d}{a / \beta_1} ?1 \right) = 0.003 \left[\frac{(195.3 \text{ mm})}{(15.44 \text{ mm}) / (0.850)} ?1 \right] = 0.0293$

$\varepsilon_t = 0.0293 \geq 0.004$ ✓

Stem Miscellaneous Checks [1.2D + 1.6L + 1.6H] (continued)

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

$\rho_h = \frac{A_{s\_horz} / s_{horz}}{t} = \frac{(200\ mm^2) / (304.8\ mm)}{(254\ mm)} = 0.0026$

$\rho_{h\_min} = 0.0020$ (bars No. 5 or less, not less than 60 ksi)

$\rho_h = 0.0026 \geq \rho_{h\_min} = 0.0020$ ✓

$3\ t_{wall} = 3\ (254\ mm) = 762\ mm$

18 inch limit governs

$s_{max} = 457.2\ mm$

$s_{horz} = 304.8\ mm \leq s_{horz\_max} = 457.2\ mm$ ✓

Development Check (ACI 318-11 12.12, 12.2.3)

$\frac{M_u}{\phi M_n} = \frac{(41.77\ kN \cdot m / m)}{(108.7\ kN \cdot m / m)} = 0.3844$ (ratio to represent excess reinforcement)

$\psi_e = 1.0$ (uncoated hooked bars)

$\lambda = 1.0$ (normal weight concrete)

$l_{dh} = 0.02\ \psi_e \frac{f_y}{\lambda \sqrt{F'_c}} d_b = 0.02\ (1.0) \frac{(413.7\ MPa)}{(1.0) \sqrt{20.69\ MPa}} (25.4\ mm) = 55.65\ cm$

Factoring l_{dh} by the 0.7 multiplier of 12.5.3(a): $l_{dh} = 38.95\ cm$

Factoring l_{dh} by the excess reinforcement ratio (0.3844) per 12.5.3(d): $l_{dh} = 14.97\ cm$

$8\ d_b = 8\ (25.4\ mm) = 8.0$

$8d_b$ minimum controls

$l_{dh\_prov} = 22.86\ cm \geq l_{dh} = 20.32\ cm$ ✓

Lap Splice Checks (ACI 318-05 12.14.2.3, 12.15.1, 12.15.2) - #5 lap with #8, from 0 m to 1.09 m (from stem base)

$\psi_t = 1.0$ (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)

$s / 2 = (304.8\ mm) / 2 = 152.4\ mm$

$cover + d_b / 2 = (50.8\ mm) + (25.4\ mm) / 2 = 63.5\ mm$

$c_b = 63.5\ mm$ (lesser of half spacing, ctr to surface)

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

$\frac{c_b + K_{tr}}{d_b} = \frac{(63.5\ mm) + (0.0)}{(25.4\ mm)} = 2.50$

$l_d = \left(\frac{3.}{40} \frac{f_y}{\sqrt{F'_c}} \frac{\psi_t\ \psi_e\ \psi_s\ \lambda}{2.5} \right) d_b = \left[\frac{3.}{40} \frac{(413.7\ MPa)}{\sqrt{20.69\ MPa}} \frac{(1.0)\ (1.0)\ (1.0)\ (1.0)}{2.5} \right] (25.4\ mm) = 83.47\ cm$

$l_{lap} = 1.3\ l_d = 1.3\ (83.47\ cm) = 108.5\ cm$

$l_{lap\_prov} = 108.5\ cm \geq l_{lap} = 108.5\ cm$ ✓

$1 / 5\ l_{lap} = 1 / 5\ (108.5\ cm) = 8.5445 > 6.0$

$s_{trans} = 0\ mm \leq 6.0$ ✓

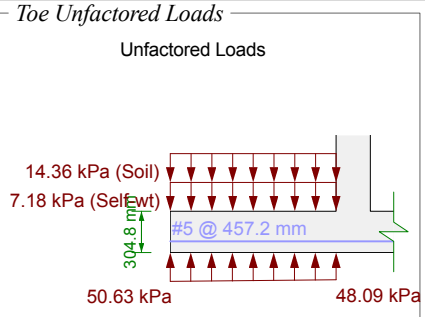
Cutoff Checks (ACI 318-11 12.10.3, 12.10.5) - #5 cut off at 0.03 m

No need to check cutoff bar extension. Cutoff bars are not required for flexure

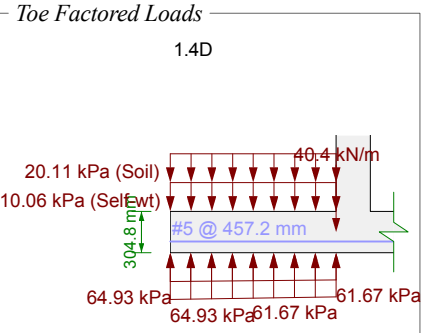
$\frac{2}{3} \phi V_n = \frac{2}{3} (108.7\ kN / m) = 413.7 \geq V_u = 39.77\ kN / m$ ✓

Toe Checks [1.4D]

Toe Unfactored Loads



Toe Factored Loads



Controlling Moment

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

M_{toe} = 25.03 kN·m / m ≥ M_{stem} = ?0 kN·m / m

M_u = ?0 kN·m / m (stem base moment controls)

Flexure Check (ACI 318-11 10.2)

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(4.37 \text{ cm}^2/\text{m})(413.7 \text{ MPa})}{0.85 (20.69 \text{ MPa})} = 10.29 \text{ mm}$$

$$\phi M_n = \phi A_s f_y (d - a/2) = (0.90)(4.37 \text{ cm}^2/\text{m})(413.7 \text{ MPa})[(220.7 \text{ mm}) - (10.29 \text{ mm})/2] = 35.1 \text{ kN·m/m}$$

ϕM_n = 35.1 kN·m / m ≥ M_u = ?0 kN·m / m ✓

Shear Check (ACI 318-11 11.1.1, 11.11.3.1)

λ = 1.0 (normal weight concrete)

$$V_c = 2 \lambda \sqrt{F'_c}\, d = 2 (1.0) \sqrt{20.69 \text{ MPa}}\, (220.7 \text{ mm}) = 166.7 \text{ kN/m}$$

$\phi V_n = \phi V_c$ = (0.750)(166.7 kN / m) = 125 kN / m

ϕV_n = 125 kN / m ≥ V_u = 33.35 kN / m ✓

Minimum Strain Check (ACI 318-11 10.3.5)

β_1 = 0.850 ($F'_c \le 4000$ psi)

$$a = \frac{A_s f_y}{0.85 F'_c} = \frac{(4.37 \text{ cm}^2/\text{m})(413.7 \text{ MPa})}{0.85 (20.69 \text{ MPa})} = 10.29 \text{ mm}$$

$$\varepsilon_t = 0.003 \left(\frac{d}{a/\beta_1} - 1 \right) = 0.003 \left[\frac{(220.7 \text{ mm})}{(10.29 \text{ mm})/(0.850)} - 1 \right] = 0.0517$$

ε_t = 0.0517 ≥ 0.004 ✓

Minimum Steel Check (ACI 318-11 10.5.1)

ϕM_n = 35.1 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 ✓

Shrinkage and Temperature Steel (ACI 318-11 7.12.2)

$$\rho_{ST\_prov} = \frac{A_{ST}}{t\, s_{ST}} = \frac{(157.5 \text{ cm}^2/\text{m})}{(304.8 \text{ mm})(304.8 \text{ mm})} = 0.0043$$

$$\rho_{ST\_min} = \frac{0.0018 (60000)}{f_y} = \frac{0.0018 (60000)}{(413.7 \text{ MPa})} = 0.0018$$

ρ_{ST_min} = 0.0018

ρ_{ST_prov} = 0.0043 ≥ ρ_{ST_min} = 0.0018 ✓

18 inch limit governs

s_{ST_max} = 457.2 mm

s_{ST} = 304.8 mm ≤ s_{ST_max} = 457.2 mm ✓

Development Check (ACI 318-11 12.12, 12.2.3)

$$\frac{M_u}{\phi M_n} = \frac{(?0 \text{ kN·m/m})}{(35.1 \text{ kN·m/m})} = ?0.0$$ (ratio to represent excess reinforcement)

ψ_t = 1.0 (12 inches or less cast below ? 3.00 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 = (457.2 mm) / 2 = 228.6 mm

cover + d_b / 2 = (76.2 mm) + (15.88 mm) / 2 = 84.14 mm

c_b = 84.14 mm (lesser of half spacing, ctr to surface)

K_{tr} = 0.0 (no transverse reinforcement)

$$\frac{c_b + K_{tr}}{d_b} = \frac{(84.14 \text{ mm}) + (0.0)}{(15.88 \text{ mm})} = 5.30$$

$$l_d = \left(\frac{3.}{40} \frac{f_y}{\lambda \sqrt{F'_c}} \frac{\psi_t \psi_e \psi_s}{2.5} \right) d_b = \left[\frac{3.}{40} \frac{(413.7 \text{ MPa})}{(1.0)\sqrt{20.69 \text{ MPa}}} \frac{(1.0)(1.0)(0.80)}{2.5} \right] (15.88 \text{ mm}) = 41.74 \text{ cm}$$

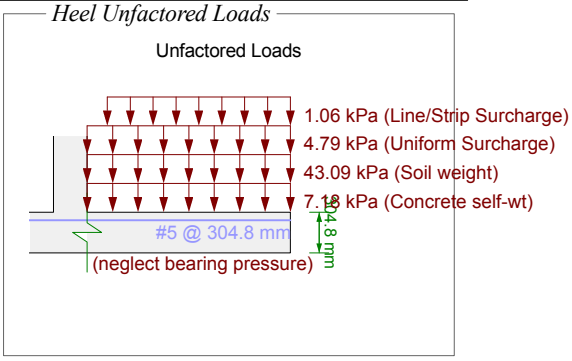
Factoring l_d by the excess reinforcement ratio (?0.0000) per 12.2.5: l_d = ?0 cm

12 inch minimum controls

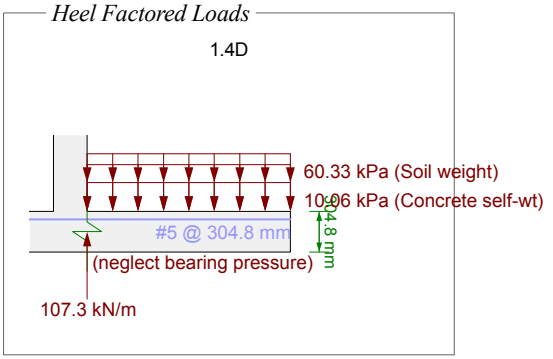
l_{d_prov} = 170.2 cm ≥ l_d = 30.48 cm ✓

Heel Checks [1.4D]

Heel Unfactored Loads



Heel Factored Loads



Controlling Moment

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

M_{heel} = 81.74 kN·m / m ≥ M_{stem} = ?0 kN·m / m

M_u = ?0 kN·m / m (stem base moment controls)

Flexure Check (ACI 318-11 10.2)

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(6.56\ cm^2/m)(413.7\ MPa)}{0.85(20.69\ MPa)} = 15.44\ mm$$

$$\phi M_n = \phi A_s f_y (d - a/2) = (0.90)(6.56\ cm^2/m)(413.7\ MPa)[(246.1\ mm) - (15.44\ mm)/2] = 58.23\ kN\cdot m/m$$

ϕM_n = 58.23 kN·m / m ≥ M_u = ?0 kN·m / m ✓

Shear Check (ACI 318-11 11.1.1, 11.11.3.1)

λ = 1.0 (normal weight concrete)

$$V_c = 2\lambda\sqrt{f'_c}\, d = 2(1.0)\sqrt{20.69\ MPa}(246.1\ mm) = 185.9\ kN/m$$

$$\phi V_n = \phi V_c = (0.750)(185.9\ kN/m) = 139.4\ kN/m$$

ϕV_n = 139.4 kN / m ≥ V_u = 107.3 kN / m ✓

Minimum Strain Check (ACI 318-11 10.3.5)

β_1 = 0.850 ($f'_c \le 4000$ psi)

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(6.56\ cm^2/m)(413.7\ MPa)}{0.85(20.69\ MPa)} = 15.44\ mm$$

$$\varepsilon_t = 0.003\left(\frac{d}{a/\beta_1} - 1\right) = 0.003\left[\frac{(246.1\ mm)}{(15.44\ mm)/(0.850)} - 1\right] = 0.0376$$

ε_t = 0.0376 ≥ 0.004 ✓

Minimum Steel Check (ACI 318-11 10.5.1)

ϕM_n = 58.23 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 ✓

Shrinkage and Temperature Steel (ACI 318-11 7.12.2)

$$\rho_{ST\_prov} = \frac{A_{ST}}{t\, s_{ST}} = \frac{(157.5\ cm^2/m)}{(304.8\ mm)(304.8\ mm)} = 0.0043$$

$$\rho_{ST\_min} = \frac{0.0018(60000)}{f_y} = \frac{0.0018(60000)}{(413.7\ MPa)} = 0.0018$$

ρ_{ST_min} = 0.0018

ρ_{ST_prov} = 0.0043 ≥ ρ_{ST_min} = 0.0018 ✓

18 inch limit governs

s_{ST_max} = 457.2 mm

s_{ST} = 304.8 mm ≤ s_{ST_max} = 457.2 mm ✓

Development Check (ACI 318-11 12.12, 12.2.3)

$\frac{M_u}{\phi M_n}$ = (?0 kN·m / m) / (58.23 kN·m / m) = ?0.0 (ratio to represent excess reinforcement)

ψ_t = 1.0 (12 inches or less cast below ? 9.38 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 = (304.8 mm) / 2 = 152.4 mm

cover + d_b / 2 = (50.8 mm) + (15.88 mm) / 2 = 58.74 mm

c_b = 58.74 mm (lesser of half spacing, ctr to surface)

K_{tr} = 0.0 (no transverse reinforcement)

$$\frac{c_b + K_{tr}}{d_b} = \frac{(58.74\ mm) + (0.0)}{(15.88\ mm)} = 3.70$$

$$l_d = \left(\frac{3.}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right) d_b = \left[\frac{3.}{40}\frac{(413.7\ MPa)}{(1.0)\sqrt{20.69\ MPa}}\frac{(1.0)(1.0)(0.80)}{2.5}\right](15.88\ mm) = 41.74\ cm$$

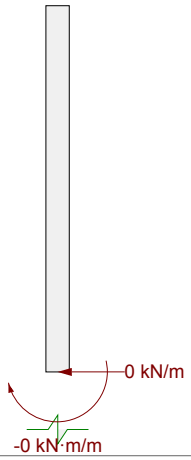
Factoring l_d by the excess reinforcement ratio (?0.0000) per 12.2.5: l_d = ?0 cm

12 inch minimum controls

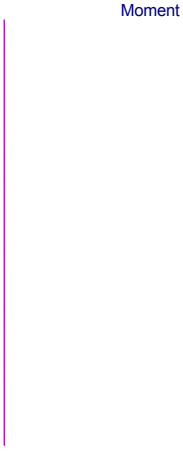
l_{d_prov} = 142.2 cm ≥ l_d = 30.48 cm ✓

Stem Forces [1.4D]

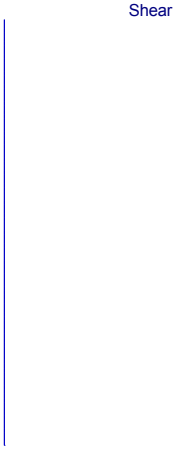
Stem Internal Forces



Stem Internal Forces



Stem Internal Forces

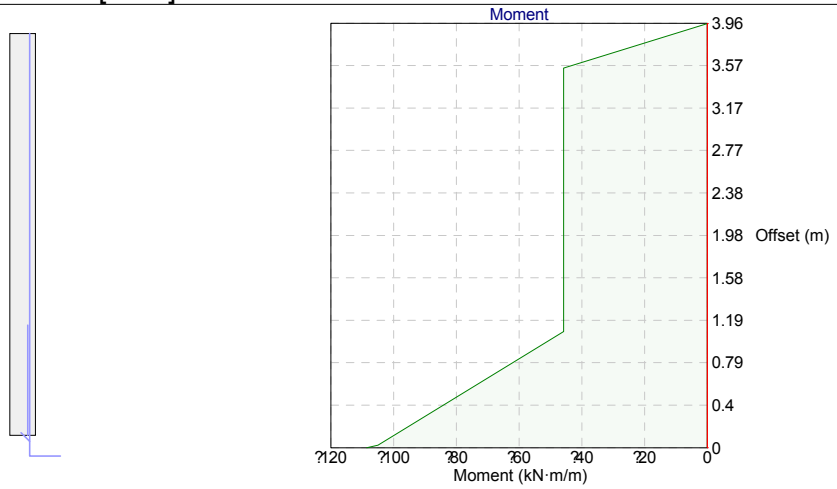


Stem Joint Force Transfer

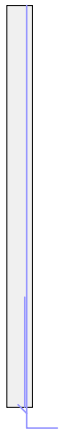
Location	Force
@ stem base	0 kN/m

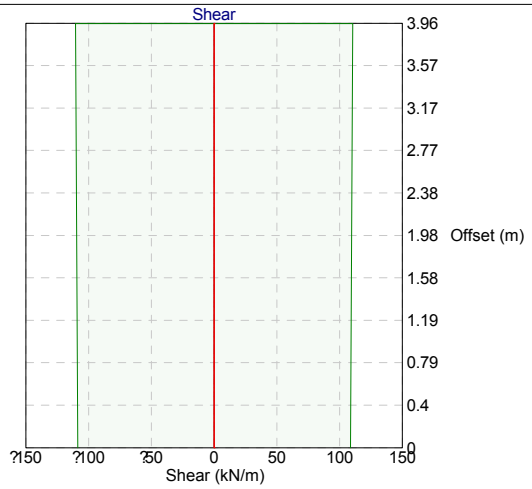
Stem Internal Forces

Stem Moment Checks [1.4D]



Stem Shear Checks [1.4D]





Stem Miscellaneous Checks [1.4D]

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

$\phi M_n = 108.7\ \text{kN·m/m} \geq (4/3)\,M_u = [4/3]\,(0\ \text{kN·m/m}) = 0\ \text{kN·m/m}$

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-11 10.5.1) @ 0.03 m from base [Stem in negative flexure]

$\phi M_n = 105\ \text{kN·m/m} \geq (4/3)\,M_u = [4/3]\,(0\ \text{kN·m/m}) = 0\ \text{kN·m/m}$

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-11 10.5.1) @ 1.09 m from base [Stem in negative flexure]

$\phi M_n = 45.82\ \text{kN·m/m} \geq (4/3)\,M_u = [4/3]\,(0\ \text{kN·m/m}) = 0\ \text{kN·m/m}$

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-11 10.5.1) @ 3.96 m from base [Stem in negative flexure]

$\phi M_n = 0\ \text{kN·m/m} \geq (4/3)\,M_u = [4/3]\,(0\ \text{kN·m/m}) = 0\ \text{kN·m/m}$

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]

$\beta_1 = 0.850 \quad (F'_c \leq 4000\ \text{psi})$

$a = \frac{A_s f_y}{0.85\,F'_c} = \frac{(23.28\ \text{cm}^2/\text{m})\,(413.7\ \text{MPa})}{0.85\,(20.69\ \text{MPa})} = 54.78\ \text{mm}$

$\varepsilon_t = 0.003\left(\frac{d}{a/\beta_1} ?1\right) = 0.003\left[\frac{(191.8\ \text{mm})}{(54.78\ \text{mm})/(0.850)} ?1\right] = 0.0059$

$\varepsilon_t = 0.0059 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-11 10.3.5) @ 0.03 m from base [Stem in negative flexure]

$\beta_1 = 0.850 \quad (F'_c \leq 4000\ \text{psi})$

$a = \frac{A_s f_y}{0.85\,F'_c} = \frac{(16.48\ \text{cm}^2/\text{m})\,(413.7\ \text{MPa})}{0.85\,(20.69\ \text{MPa})} = 38.79\ \text{mm}$

$\varepsilon_t = 0.003\left(\frac{d}{a/\beta_1} ?1\right) = 0.003\left[\frac{(190.5\ \text{mm})}{(38.79\ \text{mm})/(0.850)} ?1\right] = 0.0095$

$\varepsilon_t = 0.0095 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-11 10.3.5) @ 1.09 m from base [Stem in negative flexure]

$\beta_1 = 0.850 \quad (F'_c \leq 4000\ \text{psi})$

$a = \frac{A_s f_y}{0.85\,F'_c} = \frac{(6.56\ \text{cm}^2/\text{m})\,(413.7\ \text{MPa})}{0.85\,(20.69\ \text{MPa})} = 15.44\ \text{mm}$

$\varepsilon_t = 0.003\left(\frac{d}{a/\beta_1} ?1\right) = 0.003\left[\frac{(195.3\ \text{mm})}{(15.44\ \text{mm})/(0.850)} ?1\right] = 0.0293$

$\varepsilon_t = 0.0293 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-11 10.3.5) @ 3.96 m from base [Stem in negative flexure]

$\beta_1 = 0.850 \quad (F'_c \leq 4000\ \text{psi})$

$a = \frac{A_s f_y}{0.85\,F'_c} = \frac{(6.56\ \text{cm}^2/\text{m})\,(413.7\ \text{MPa})}{0.85\,(20.69\ \text{MPa})} = 15.44\ \text{mm}$

$\varepsilon_t = 0.003\left(\frac{d}{a/\beta_1} ?1\right) = 0.003\left[\frac{(195.3\ \text{mm})}{(15.44\ \text{mm})/(0.850)} ?1\right] = 0.0293$

$\varepsilon_t = 0.0293 \geq 0.004$ ✓

Stem Miscellaneous Checks [1.4D] (continued)

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

$\rho_h = \frac{A_{s\_horz} / s_{horz}}{t} = \frac{(200\ mm^2) / (304.8\ mm)}{(254\ mm)} = 0.0026$

$\rho_{h\_min} = 0.0020$ (bars No. 5 or less, not less than 60 ksi)

$\rho_h = 0.0026 \geq \rho_{h\_min} = 0.0020$ ✓

$3\ t_{wall} = 3\ (254\ mm) = 762\ mm$

18 inch limit governs

$s_{max} = 457.2\ mm$

$s_{horz} = 304.8\ mm \leq s_{horz\_max} = 457.2\ mm$ ✓

Development Check (ACI 318-11 12.12, 12.2.3)

$\frac{M_u}{\phi M_n} = \frac{(0\ kN{\cdot}m / m)}{(108.7\ kN{\cdot}m / m)} = 0.0$ (ratio to represent excess reinforcement)

$\psi_e = 1.0$ (uncoated hooked bars)

$\lambda = 1.0$ (normal weight concrete)

$l_{dh} = 0.02\ \psi_e \frac{f_y}{\lambda \sqrt{F'_c}} d_b = 0.02\ (1.0) \frac{(413.7\ MPa)}{(1.0) \sqrt{20.69\ MPa}} (25.4\ mm) = 55.65\ cm$

Factoring l_{dh} by the 0.7 multiplier of 12.5.3(a): $l_{dh} = 38.95\ cm$

Factoring l_{dh} by the excess reinforcement ratio (0.0000) per 12.5.3(d): $l_{dh} = 0\ cm$

$8\ d_b = 8\ (25.4\ mm) = 8.0$

$8d_b$ minimum controls

$l_{dh\_prov} = 22.86\ cm \geq l_{dh} = 20.32\ cm$ ✓

Lap Splice Checks (ACI 318-05 12.14.2.3, 12.15.1, 12.15.2) - #5 lap with #8, from 0 m to 1.09 m (from stem base)

$\psi_t = 1.0$ (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)

$s / 2 = (304.8\ mm) / 2 = 152.4\ mm$

$cover + d_b / 2 = (50.8\ mm) + (25.4\ mm) / 2 = 63.5\ mm$

$c_b = 63.5\ mm$ (lesser of half spacing, ctr to surface)

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

$\frac{c_b + K_{tr}}{d_b} = \frac{(63.5\ mm) + (0.0)}{(25.4\ mm)} = 2.50$

$l_d = \left(\frac{3.}{40} \frac{f_y}{\sqrt{F'_c}} \frac{\psi_t\ \psi_e\ \psi_s\ \lambda}{2.5} \right) d_b = \left[\frac{3.}{40} \frac{(413.7\ MPa)}{\sqrt{20.69\ MPa}} \frac{(1.0)\ (1.0)\ (1.0)\ (1.0)}{2.5} \right] (25.4\ mm) = 83.47\ cm$

$l_{lap} = 1.3\ l_d = 1.3\ (83.47\ cm) = 108.5\ cm$

$l_{lap\_prov} = 108.5\ cm \geq l_{lap} = 108.5\ cm$ ✓

$1 / 5\ l_{lap} = 1 / 5\ (108.5\ cm) = 8.5445 > 6.0$

$s_{trans} = 0\ mm \leq 6.0$ ✓

Cutoff Checks (ACI 318-11 12.10.3, 12.10.5) - #5 cut off at 0.03 m

No need to check cutoff bar extension. Cutoff bars are not required for flexure

$\frac{2}{3}\phi V_n = \frac{2}{3}(108.7\ kN / m) = 413.7 \geq V_u = 0\ kN / m$ ✓

Design Detail

Concrete f'c = 20.69 MPa
Rebar Fy = 413.7 MPa
Unit Weight = 23.56 kN/m³