

Concentric Footing Analysis

Square spread footing under concentric axial load, ACI 318-19. Numbers come from `calc.py`; this sheet only presents them. Typst derives gravity loads below; checked Python demands are reconciled by the test suite.

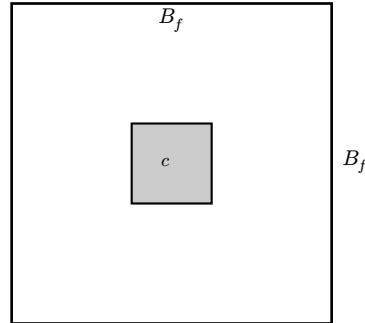


Figure 1: Footing plan and section: 3 ft × 3 ft × 12 in, d=9 in.

Loads Determination

$$A_r = B_r L_r = 519.75 \text{ ft}^2$$

Tributary area

$$W_c = b_c b_c L_c \gamma_c = 2.76 \text{ kip}$$

Column self weight

$$P_s = (D_{L_r} + L_{L_r}) A_r + W_c = 18.36 \text{ kip}$$

Typst-derived service load

$$P_{s, \text{checked}} = 18.4 \text{ kip}$$

Python-checked service load

$$P_u = 1.2(D_{L_r} A_r + W_c) + 1.6 L_{L_r} A_r = 26.18 \text{ kip}$$

Typst-derived factored load

$$P_{u, \text{checked}} = 26.2 \text{ kip}$$

Factored axial load

$$q_u = \frac{P_u}{A_f} = 2911.1 \text{ psf}$$

Factored gross pressure

Geometry and Materials

$$B_f = 3 \text{ ft}, A_f = 9 \text{ ft}^2$$

Footing plan dimensions

$$D_f = 12 \text{ in}, \text{cover} = 3 \text{ in}, d = D_f - \text{cover} = 9 \text{ in}$$

Effective depth

$$c = 14 \text{ in}, b_p = 6 \text{ in}$$

Column and base-plate widths

$$f'_c = 3000 \text{ psi}, f_y = 60 \text{ ksi}, \lambda = 1$$

Concrete and steel

$$N = 4, \#4 \text{ bars}, A_{s,1} = 0.1964 \text{ in}^2, A_s = 0.7854 \text{ in}^2$$

Reinforcement per direction

$$\rho = \frac{A_s}{B_f d} = 0.0024, \rho_{\min} = 0.0018$$

Reinforcement ratio

Soil Bearing

$$q = \frac{P_s}{A_f} = 2044.4 \text{ psf}$$

Acting service pressure

$$q_a = 2500 \text{ psf}$$

Allowable gross pressure

Soil bearing

OK

q : 2044.44 psf q_a : 2500 psf

D/C: 0.82

One-Way Shear

$$L_1 = \frac{B_f - c}{2} - d = 2 \text{ in}$$

Cantilever beyond d

$$V_u = q_u B_f L_1 = 1.46 \text{ kip}$$

Demand at d

$$V_c = 2\lambda\sqrt{f'_c} B_f d = 35.5 \text{ kip}$$

ACI 22.5

$$\phi V_c = 26.6 \text{ kip}$$

phi=0.75

One-way shear

OK

$$V_u: 1.46 \text{ kip} \quad \phi V_c: 26.62 \text{ kip}$$

D/C: 0.05

Two-Way Shear (Punching)

$$b_o = 4(c + d) = 92 \text{ in}$$

Critical perimeter at d/2

$$v_c = \min\left(4, 2 + \frac{4}{\beta}, 2 + \alpha_s \frac{d}{b_o}\right) \lambda \sqrt{f'_c} = 219.1 \text{ psi}$$

ACI 22.6

$$V_c = v_c b_o d = 181.4 \text{ kip}$$

Concrete shear strength

$$V_u = q_u (A_f - (c + d)^2) = 15.5 \text{ kip}$$

Punch demand

Two-way shear

OK

$$V_u: 15.51 \text{ kip} \quad \phi V_c: 136.05 \text{ kip}$$

D/C: 0.11

Flexure

$$L_c = \frac{B_f - c}{2} = 11 \text{ in}$$

Cantilever

$$M_u = q_u B_f \frac{L_c^2}{2} = 3.67 \text{ kip}\cdot\text{ft}$$

Demand

$$a = A_s \frac{f_y}{0.85 f'_c B_f} = 0.513 \text{ in}$$

Whitney stress block

$$M_n = A_s f_y \left(d - \frac{a}{2}\right) = 34.3 \text{ kip}\cdot\text{ft}$$

Nominal moment strength

$$\phi M_n = 30.9 \text{ kip}\cdot\text{ft}$$

phi=0.90

$$\rho = \frac{A_s}{B_f d} = 0.0024$$

vs rho_min 0.0018

Flexure

OK

$$M_u: 3.67 \text{ kip}\cdot\text{ft} \quad \phi M_n: 30.9 \text{ kip}\cdot\text{ft}$$

D/C: 0.12

Minimum steel

OK

$$\rho: 0 \quad \rho_{\min}: 0$$

D/C: 0.74

Concrete Bearing

$$A_1 = b_p^2 = 36 \text{ in}^2, A_2 = B_f^2 = 1296 \text{ in}^2$$

Plate and footing

$$\sqrt{\frac{A_2}{A_1}} = 6$$

$$B_n = 0.85f'_c A_1 \sqrt{\dots} = 183.6 \text{ kip}$$

$$\varphi B_n = 119.3 \text{ kip}$$

Uncapped ratio, capped at 2.0 for strength

ACI 22.8

phi=0.65

Concrete bearing

OK

P_u : 26.2 kip φB_n : 119.34 kip

D/C: 0.22