ARCH 4213 - Building Technology III

Problem 1

Design the most economical square column footings for the values given below.

Col. Size inches	D kips	L kips	f_c' Ksi	F_Y Ksi	q_a ksf	Depth of ftg.
16 x 16	150	115	3	60	5	-6’

Assume h=20'' ∴ d=15.5''

$$q_e = 5000 - \frac{20}{12}(150) - \frac{(72-20)}{12}(100) = 4{,}316.7 \text{ psf} \approx 4.32 \text{ ksf}$$

$$A_f = \frac{150+115}{4.32} = 61.3 \text{ sf} \quad \text{Use: } 8'\text{-}0'' \times 8'\text{-}0''$$

$$q_e = \frac{1.2(150)+1.6(115)}{64} = 5.69 \text{ ksf}$$

Check double shear:

$$V_U = q_U[L^2-(a+d)^2] = 5.69\left[64 - \frac{(15.5+16)^2}{144}\right] = 325 \text{ kips}$$

$$b_o = 4(a+d) = 4(16+15.5) = 126''$$

$$d = \frac{V_U}{\phi 4\sqrt{f_C'}\, b_o} = \frac{330(1000)}{.85(4)\sqrt{3000}(126)} = 13.9'' < 15.5'' \text{ try } 14.5'' \text{ (h=19'')}$$

$$V_U = q_U[L^2-(a+d)^2] = 5.69\left[64 - \frac{(14.5+16)^2}{144}\right] = 327 \text{ kips}$$

$$b_o = 4(a+d) = 4(16+14.5) = 122''$$

$$d = \frac{V_U}{\phi 4\sqrt{f_C'}\, b_o} = \frac{327(1000)}{.85(4)\sqrt{3000}(122)} = 14.4'' < 14.5'' \text{ OK}$$

Check one-way shear:

$$V_U = q_U L\left(\frac{L}{2} - d - \frac{a}{2}\right) = 5.69(8)\left(4 - \frac{14.5}{12} - \frac{8}{12}\right) = 96.7 \text{ kips}$$

$$d = \frac{V_U}{\phi 2\sqrt{3000}\, L} = \frac{96.7(1000)}{.85(2)\sqrt{3000}(96)} = 10.8'' < 15.5'' \text{ OK}$$

Check Moment:

$$M_U = \frac{q_U L}{2}\left(\frac{L}{2} - \frac{a}{2}\right)^2 = 4.69(8)\left(\frac{8}{2} - \frac{8}{12}\right)^2 = 208.4 \text{ kip-ft}$$

$$R_U = \frac{M_U}{\phi L d^2} = \frac{208.4(12)}{.85(96)(14.5)^2} = .138 \text{ ksi} < .190 \text{ ksi} \quad \text{Use: } \rho_{Min}$$

$$A_S = \rho_{Min} L d = .0033(96)(14.5) = 4.59 \text{ in}^2 \quad \text{Use 6\#8 E.W.} \ (A_S = 4.71 \text{ in}^2)$$

Problem 2

Design the most economical square column footings for the values given below.

Col. Size inches	D kips	L kips	f_c' Ksi	F_Y Ksi	q_a ksf	Depth of ftg.
12 x 12	120	150	3	60	4	-6'

Assume h=20" $\therefore$ d=15.5"

$$q_e = 4000 - \frac{20}{12}(150) - \frac{(72-20)}{12}(100) = 3{,}316.7 \text{ psf} \approx 3.32 \text{ ksf}$$

$$A_f = \frac{120+150}{4.32} = 81.3 \text{ sf} \quad \text{Use: } 9'\text{-}4'' \times 9'\text{-}4'' \text{ (87 sf)}$$

$$q_e = \frac{1.2(120)+1.6(150)}{87} = 4.41 \text{ ksf}$$

Check double shear:

$$V_U = q_U[L^2-(a+d)^2] = 4.41\left[87 - \frac{(15.5+16)^2}{144}\right] = 353.3 \text{ kips}$$

$$b_o = 4(a+d) = 4(12+15.5) = 110''$$

$$d = \frac{V_U}{\phi 4\sqrt{f_C'}b_o} = \frac{353.2(1000)}{.85(4)\sqrt{3000}(110)} = 17.2'' > 15.5'' \text{ NG}$$

try d =16.5"

$$V_U = q_U[L^2-(a+d)^2] = 4.41\left[87 - \frac{(16.5+16)^2}{144}\right] = 351.3 \text{ kips}$$

$$b_o = 4(a+d) = 4(12+16.5) = 114''$$

$$d = \frac{V_U}{\phi 4\sqrt{f_C'}\, b_o} = \frac{351.3\,(1000)}{.85(4)\sqrt{3000}(114)} = 16.55'' \approx 16.5'' \text{ N}$$

Check one-way shear:

$$V_U = q_U L\left(\frac{L}{2} - d - \frac{a}{2}\right) = 4.41(9.33)\left(\frac{9.33}{2} - \frac{16.5}{12} - \frac{6}{12}\right) = 114.8 \text{ kips}$$

$$d = \frac{V_U}{\phi 2\sqrt{3000}\,L} = \frac{114.8(1000)}{.85(2)\sqrt{3000}(112)} = 11.1'' < 16.5'' \text{ OK}$$

Check Moment:

$$M_U = \frac{q_U L}{2}\left(\frac{L}{2} - \frac{a}{2}\right)^2 = \frac{4.41(9.33)}{2}\left(\frac{9.33}{2} - \frac{6}{12}\right)^2 = 356.9 \text{ kip-ft}$$

$$R_U = \frac{M_U}{\phi L d^2} = \frac{356.9(12)}{.90(112)(16.5)^2} = .156 \text{ ksi} < .190 \text{ ksi} \quad \text{Use: } \rho_{Min}$$

$$A_S = \rho_{Min} L d = .0033\,(112)(16.5) = 6.10 \text{ in}^2 \quad \text{Use 5\#10 E.W. } (A_S = 6.33 \text{ in}^2)$$