PCA Example 11.2

A summary of the magnified moments for column C1 for all load combinations is provided in the following table.

No.	Load Combination	P_u (kips)	10.10.7.3		10.10.7.4	
			δ_s	M_2 (ft-kips)	δ_s	M_2 (ft-kips)
1	1.4D	871.4	---	48.7	---	48.7
2	1.2D + 1.6L + 0.5L$_r$	869.4	---	66.4	---	66.4
3	1.2D + 0.5L + 1.6L$_r$	797.6	---	49.5	---	49.5
4	1.2D + 1.6L$_r$ + 0.8W	722.0	1.14	147.0	1.38	173.5
5	1.2D + 1.6L$_r$ - 0.8W	799.3	1.14	-104.8	1.38	-131.3
6	1.2D + 0.5L + 0.5L$_r$ + 1.6W	710.9	1.14	276.7	1.39	331.9
7	1.2D + 0.5L + 0.5L$_r$ - 1.6W	865.4	1.14	-226.8	1.39	-281.9
8	0.9D + 1.6W	482.9	1.10	257.9	1.25	292.0
9	0.9D - 1.6W	637.4	1.10	-226.2	1.25	-260.3

d. Determine required reinforcement.

For the 22 × 22 in. column, try 8-No. 8 bars. Determine maximum allowable axial compressive force, $\phi P_{n,max}$.
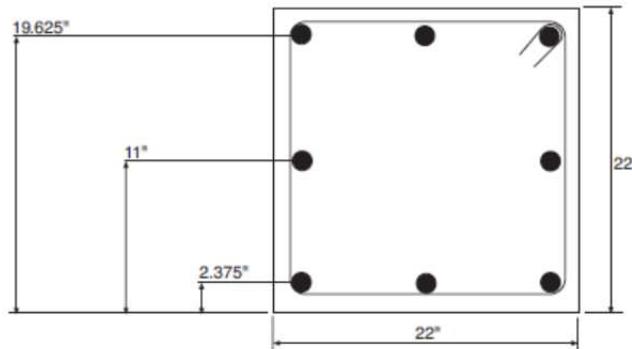
$$\phi P_{n,max} = 0.80\phi\left[0.85f_c'\left(A_g - A_{st}\right) + f_y A_{st}\right]$$

Eq. (10-2)

$$= (0.80 \times 0.65)[(0.85 \times 6)(22^2 - 6.32) + (60 \times 6.32)]$$

$$= 1,464.0 \text{ kips} > \text{maximum } P_u = 871.4 \text{ kips O.K.}$$

The following table contains results from a strain compatibility analysis, where compressive strains are taken as positive (see Parts 6 and 7). Use $M_u = M_2$ from the approximate method in 10.10.7.

Example 11.2 (cont'd)   **Calculations and Discussion**   Code
Reference

No.	P_u (kips)	M_u (ft-kips)	c (in.)	ε_t	ϕ	ϕP_n (kips)	ϕM_n (ft-kips)
1	871.4	48.7	14.85	-0.00096	0.65	871.4	459.4
2	869.4	66.4	14.82	-0.00097	0.65	869.4	459.7
3	797.6	49.5	13.75	-0.00128	0.65	797.6	468.2
4	722.0	147.0	12.75	-0.00162	0.65	722.0	474.1
5	799.3	-104.8	13.78	-0.00127	0.65	799.3	468.0
6	710.9	276.7	12.61	-0.00167	0.65	710.9	474.8
7	865.4	-226.8	14.76	-0.00099	0.65	865.4	460.2
8	482.9	257.9	7.36	-0.00500	0.90	482.9	557.2
9	637.4	-226.2	11.68	-0.00204	0.65	637.4	478.8

Therefore, since $\phi M_n > M_u$ for all $\phi P_n = P_u$, use a 22 × 22 in. column with 8-No. 8 bars (rg = 1.3%). The same reinforcement is also adequate for the load combinations from the magnified moment method of 10.10.7.

4. Design of column C2

a. Determine if slenderness effects must be considered.

   In part 3(c), k was determined to be 1.82 for the interior columns. Therefore,

   $$\frac{k\ell_u}{r} = \frac{1.82 \times 13.33 \times 12}{0.3 \times 24} = 40.4 > 22$$

   10.10.1

   Slenderness effects must be considered.

b. Determine total moment M_2 (including slenderness effects) and the design load combinations, using the approximate analysis of 10.10.7.

   The following table summarizes magnified moment computation for column C2 for all load combinations, followed by detailed calculations for combinations no. 4 and 5 to illustrate the procedure.

No.	Load Combination	ΣP_u (kips)	Δ_o (in.)	V_{us} (kips)	Q	δ	M_{2ns} (ft-kips)	M_{2s} (ft-kips)	M_2 (ft-kips)
1	1.4D	25,053	-	-	-	-	2.8	-	2.8
2	1.2D+1.6L+0.5L$_r$	24,795	-	-	-	-	27.4	-	27.4
3	1.2D+0.5L+1.6L$_r$	22,903	-	-	-	-	10.2	-	10.2
4	1.2D+1.6L$_r$+0.8W	21,908	0.28	302.6	0.12	1.14	-1.2	164.0	185.0
5	1.2D+1.6L$_r$-0.8W	21,908	0.28	302.6	0.12	1.14	-1.2	-164.0	-187.4
6	1.2D+0.5L+0.5L$_r$+1.6W	22,605	0.45	484.2	0.12	1.14	-5.1	328.0	368.9
7	1.2D+0.5L+0.5L$_r$-1.6W	22,605	0.45	484.2	0.12	1.14	-5.1	-328.0	-379.1
8	0.9D+1.6W	16,106	0.45	484.2	0.09	1.10	-0.9	328.0	358.6
9	0.9D-1.6W	16,106	0.45	484.2	0.09	1.10	-0.9	-328.0	-360.4

$$M_2 = M_{2ns} + M_{2s}$$

Eq. (10-19)

$$\delta_s M_{2s} = \frac{M_{2s}}{1-Q} \geq M_{2s}$$

Eq. (10-20)

This only provides a summary table without the intermediate results for stress, strain, or force on the concrete / bars.