Appendix D: Summary of Calculations and General Assumptions in Colum Design

Load eccentricity $= 0$

$f'_c = 25\ MPa$

$f_y = 400\ MPa$

$Diameter\ of\ the\ cross\ sectional\ area = 254\ mm = 10\ inches$

Therefore, concrete cross sectional area equals:

$$A_g = \frac{\pi d^2}{4} = \frac{\pi\, 254^2}{4} = 50670.75\ mm^2$$

Controlling Slenderness (CSA A23.3 Cl. 10.14.2):

$Radius\ of\ Gyration\ of\ circular\ columns\ (r) = 0.25D = 0.25\ (254) = 63.5\ mm$

Considering a pin-pin support, $k = 1\ and\ l_u = 1500\ mm,$

Therefore, the slenderness ratio equals:

$$\frac{kl_u}{r} = \frac{1 \times 1500}{63.5} = 23.62\ mm$$

In order to be able to ignore the slenderness effect, following condition should be satisfied (CSA A23.2 Eq. 10.15):

$$\frac{kl_u}{r} \leq \frac{25 - 10 \times (\frac{M_1}{M_2})}{\sqrt{\frac{P_f}{f'_c A_g}}}$$

Considering design load of $P_f = 600\ kN$;

If eccentricity equals zero; M_1 and M_2 (Moments at the ends of the columns) are both equal to zero:

$$23.62 \leq \frac{25 - 10 \times (\frac{0}{0})}{\sqrt{\frac{600 \times 1000}{25 \times 50670.75}}} = 36.33$$

Since the condition is satisfied, slenderness effect could be ignored.

Reinforcement Design

According to the CSA code (A23.3 Cl. 10.9.1 and 10.9.2), column reinforcement ratio (ρ_t) should be in the range from 1% to 8% of the cross sectional area. But since there is no lap splice region in the columns, the range will be limited between 1% to 4% (Brzev and Pao 2006) Also, according to A23.3 Cl. 10.9.3, minimum number of longitudinal bars for columns with circular ties shall be four. Assuming use of 4 Ø15 longitudinal bars:

$$Area\ of\ Reinforcement = A_{st} = 4 \times 200 = 800\ mm^2$$

Reinforcement ratio (A233 Cl.10.9) can be calculated as:

$$\rho_t = \frac{A_{st}}{A_g} = \frac{800\ mm^2}{50670.75\ mm^2} = 0.01579$$

Knowing that the reinforcement ratio is within the range:

$$0.01 \le 0.01579 \le 0.04$$

Therefore, 4 Ø15 steel bars could be selected as longitudinal bars.

Maximum Axial Load

Ratio of average stress in rectangular compression block to specified block (α_1) equals (A23.3 Eq. 10.1):

$$\alpha_1 = 0.85 - 0.0015\, f'_c \ge 0.67$$

Therefore:

$$\alpha_1 = 0.85 - 0.0015 \times 25 = 0.8125 \ge 0.67$$

Based on CSA A23 Eq. 10.10:

$$P_{ro} = \alpha_1 \varphi_C f'_c (A_g - A_{st}) + \varphi_s f_y A_{st}$$

Omitting the resistance factors of steel and concrete we can rewrite the equation as:

$$P_{ro} = \alpha_1 f'_c (A_g - A_{st}) + f_y A_{st}$$

Therefore, maximum factored axial load resistance of the reinforced column can be predicted as:

$$P_{ro} = \alpha_1 f'_c (A_g - A_{st}) + f_y A_{st} = 0.8125 \times 25\ (50670.75 - 800) + 400 \times 800$$

$$P_{ro} = 1332999.61 \text{ N} = 1333 \text{ KN}$$

Considering maximum capacity of the testing machine as 2670 kN, the calculated value of 1333 kN as the maximum predicted axial load capacity of the columns is within the safe margin (about 50% of the maximum load capacity of the testing machine).