



Reinforced Concrete Structures (II)

May. 31, 2014

Time: Three Hours

Fourth Year

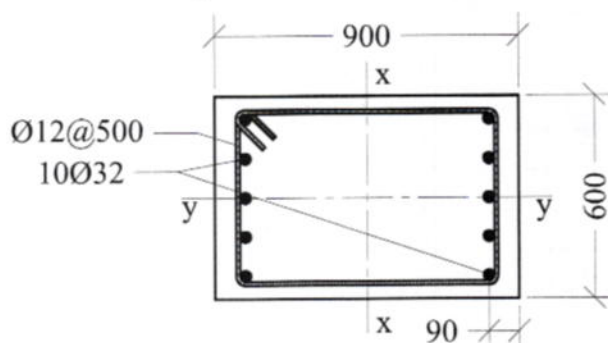
Final Exam - First Attempt

Closed Book & Notes

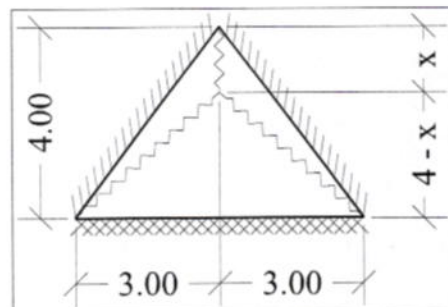
Note: Attempt Four Questions.

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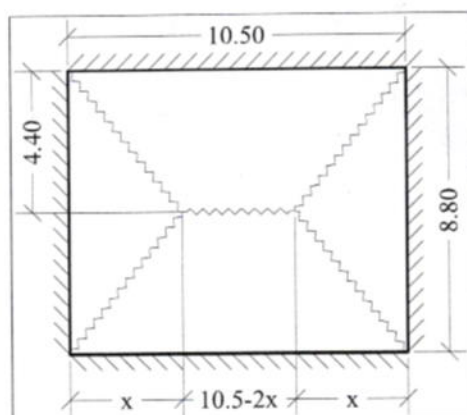
- Q1:** The tied column has $\ell_{ux} = 5.2$ m; $A_{st} = 8043$ mm²; $f_y = 400$ MPa; $f'_c = 27$ MPa; $\psi_{topx} = \psi_{botx} = 2$; storey stability index $Q_x = 0.2$, $P_u = 6300$ kN; top & bottom moments are equal causing single curvature: $M_{sx} = 590$ kN.m; $M_{nsx} = 342$ kN.m. Find if the column is SAFE per latest ACI 318M code?



- Q2:** A uniformly loaded isotropically reinforced concrete slab is supported as shown in the figure. Using the yield line analysis, find the nominal and factored collapse loads w_n & w_u . The plastic moments of resistance per meter width of the top and bottom bars are 40 and 30 kN.m/m respectively.



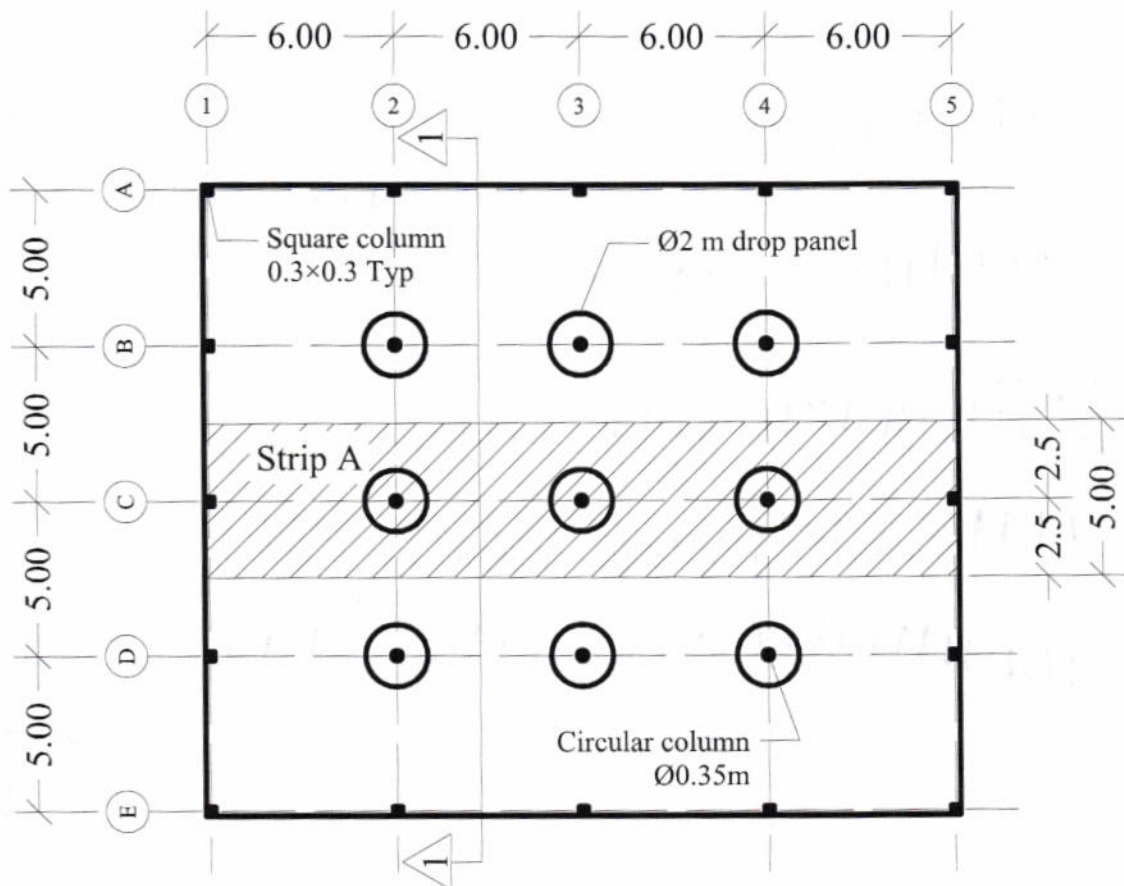
- Q3:** The uniformly loaded isotropically reinforced concrete slab is simply supported at its four edges, as shown in the figure. The nominal resistance moment $m_n = 26$ kN.m/m. Using yield line analysis (virtual work ITERATION); calculate the uniform load values w_n & w_u (in kN/m²).



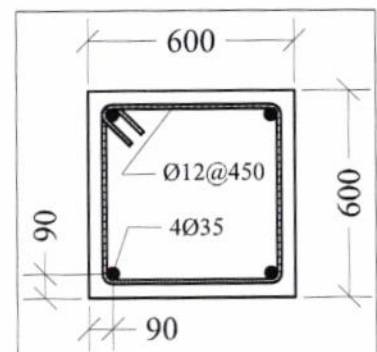


Q4: The flat plate carries service loading: total $D = 7.5 \text{ kN/m}^2$ (including the slab self-weight) & $L = 2.1 \text{ kN/m}^2$. Interior columns are circular of 350 mm in diameter; edge columns are square of $300 \times 300 \text{ mm}$. $f'_c = 27 \text{ N/mm}^2$, $f_y = 350 \text{ N/mm}^2$; Slab thickness is 210 mm; drop panel thickness = 60 mm (ie total slab thickness under drop panel = 270 mm). Using the latest ACI 318M Direct Design Method, find:

- For the shaded area of E-W strip A, the required spacing of $\varnothing 12 \text{ mm}$ bottom bars in the column strip across line 1-1 (for positive moment only); and
- Check two-way shear (punching shear) for interior columns.



Q5: The short tied $600 \times 600 \text{ mm}$ column has four 35 mm longitudinal bars. $f_y = 400 \text{ MPa}$; $f'_c = 25 \text{ MPa}$; $P_u = 2850 \text{ kN}$; $M_{uy} = 310 \text{ kN.m}$. Using the Bresler Reciprocal Method, calculate the allowable value of the factored bending moment M_{ux} .



Good Luck and Wish You Success

Reinforced Concrete Structures

Final Exam - First Attempt - 2024

Solutions



Q. $Q_x > 0.05 \rightarrow$ sway frame ; $K = 1.6$

$$\left(\frac{K P_u}{r}\right)_x = \frac{1.6 \times 5.2}{0.3 \times 0.9} = 30.8 > 22 \quad (\text{check } \delta_s)$$

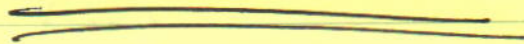
$$\delta_s = \frac{1}{1 - Q_x} = \frac{1}{1 - 0.2} = 1.25 ; M_2 = 1.25 \times 590 + 342 = 1079.5 \text{ kN.m}$$

$$\left(\frac{e}{h}\right)_x = \frac{1079.5 \times 1000 / 6300}{900} = 0.19$$

$$\rho_m = \frac{10^3 \times 32^2 \pi / 4}{900 \times 600} \times \frac{400}{0.85 \times 27} = 0.26$$

$$\gamma_x = \frac{900 - 2 \times 90}{900} = 0.8 \Rightarrow \alpha = 0.5 = \frac{0.7 P_u \times 1000}{27 \times 600 \times 900}$$

$$\therefore P_{u, \text{prov.}} = 10414.28 \Rightarrow P_u = 0.65 P_u = 6769.28 \text{ kN} > 6300 \Rightarrow 0.15$$



Q2: External work = $\frac{1}{3} \frac{6 \times 4}{2} \times \delta W_n = 4 W_n$

$\frac{2}{4}$

Internal work = $(3 \times 2 \times 40) \frac{\delta}{4-x} + (30 \times 3 \times 2) \frac{\delta}{4-x}$
 $+ 30 \times 5 \frac{\delta}{0.6x} \times 2 = \frac{2000 - 80x}{4x - x^2}$

or $W_n = \frac{1}{4} \frac{2000 - 80x}{4x - x^2}$

$\frac{\partial W}{\partial x} = 0 \Rightarrow (2000 - 80x)(4 - 2x) + (4x - x^2)(80) = 0$

$\therefore x = 2.087 \Rightarrow W_n = 114.78 \text{ kN/m}^2$ & $W_u = 103.302 \text{ kN/m}^2$

Q3: External work = $W_n \delta \left[\frac{8.8x}{2 \times 3} \times 2 + \frac{4.4 \times x}{2 \times 3} \times 4 + (10.5 - 2x) \times 4.4 \times \frac{1}{2} \times 2 \right]$

External work = $\frac{138.6 - 8.8x}{3} W_n \delta$

Internal work = $(26 \times 10.5 \frac{\delta}{4.4} + 26 \times 8.8 \frac{\delta}{x}) \times 2 = 52 \delta \frac{10.5x + 38.72}{4.4x}$

$\therefore W_n = \frac{390}{11} \frac{10.5x + 38.72}{138.6x - 8.8x^2}$

$\therefore x = 4.7 \text{ m}$ & $W_u = 6.15 \text{ kN/m}^2$

X	W _n
3	7.3
3.5	7.1
4	6.91
4.5	6.84
5	6.83
4.6	6.83

Q4: CS width $b = \frac{5}{4} \times 2 = 2.5 \text{ m}$

(3/4)

$\phi_{cs}^+ = 0.6$, column size equivalent $= (0.35^2 \pi / 4)^{0.5} = 0.31 \text{ m}$

$l_n = 6 - 0.31 = 5.7 \text{ m}$ $\rightarrow W_u = 1.2 \times 7.5 + 1.6 \times 2.1 = 12.36 \text{ kN/m}^2$

$M_u = \frac{12.36 \times 5 \times 5.7^2}{8} \times 0.35 \times \frac{0.6}{2.5} = 21.1 \text{ kN.m/m}$

$M_{u \text{ req}} = 21.1 / 0.9 = 23.43 \text{ kN.m/m}$

$d = 210 - 20 - 12/2 = 184 \text{ mm}$ $\therefore f'_c = 22.95 \text{ MPa}$

$\therefore a/d = 1 - \sqrt{1 - \frac{2 \times 23.43 \times 10^6}{22.95 \times 1000 \times 184^2}} = 0.03 \Rightarrow a = 5.63 \text{ mm}$

$A_s = 369.4 \text{ mm}^2/\text{m}$; $A_{s \text{ min}} = 420 \text{ mm}^2$ (controls)

$\therefore S = \frac{12^2 \pi / 4 \times 1000}{420} = 269 \text{ mm}$; $S_{\text{max}} = 2h = 820 \text{ mm}$

Use $\phi 12 @ 270 \text{ mm c/c}$

Q5: $\gamma = \frac{600 - 2 \times 90}{600} = 0.7$; $A_s = 3848 \text{ mm}^2$



$$P_{no} = [0.85 \times 25 (600^2 - 3848) + 400 \times 3848] \times 10^{-3} = 9107.6 \text{ kN}$$

$$P_{nrcy} = \frac{2850}{0.65} = 4384.6 \text{ kN}$$

$$\left(\frac{e}{h}\right)_y = \frac{310 \times 10^3 / 2850}{600} = 0.18$$
; $e_{cm} = 0.2$

$$\therefore \alpha_y = 0.45 \Rightarrow P_{noy} = 5785.71 \text{ kN}$$

$$\frac{1}{4384.6} = \frac{1}{P_{nox}} + \frac{1}{5785.7} - \frac{1}{9107.6} \Rightarrow P_{nox} = 6059.5 \text{ kN}$$

$$\therefore \alpha_x = \frac{0.7 P_n}{\gamma'_c A_g} = 0.47 \Rightarrow \left(\frac{e}{h}\right)_x = 0.19 \Rightarrow e_x = 114 \text{ mm}$$

$$\therefore M_{nx} = 114 \times 4384.6 = 499.844 \text{ kN.m}$$

$$M_{ux} = 0.65 \times 499.844 = 324.89$$
