

Typical Solutions

Q1 (50 %): Check the two way shear action (punching shear) only around an edge column (300×300) mm in a flat plate floor of a span (5.5 × 5.5) m. Find the area of vertical shear reinforcement if required. Assume $d = 190$ mm. Total $q_u = 25$ kPa (including slab weight), $f_c' = 28$ MPa, $f_y = 414$ MPa.

Solution:

$$(b_o) = (300 + 95) \times 2 + (300 + 190) = 1280 \text{ mm}$$

$$V_u = 25 \times (5.5 \times 2.9 - 0.395 \times 0.49) = 393.911 \text{ kN}$$

$$v_{ug} = \frac{V_u}{b_o \cdot d} = \frac{393.911 \times 10^3}{1280 \times 190} = 1.619 \text{ MPa}$$

$$v_c = \min. \begin{cases} 0.33 \sqrt{28} = 1.746 \text{ MPa} \\ 0.17 \left(1 + \frac{2}{1}\right) \times \sqrt{28} = 2.698 \text{ MPa} \\ 0.083 \left(2 + \frac{30 \times 190}{1280}\right) \times \sqrt{28} = 2.834 \text{ MPa} \end{cases}$$

$$\therefore v_c = 1.746 \text{ MPa}$$

$$\phi v_n = 0.75 \times 1.746 = 1.3095 \text{ MPa} < v_u = 1.619 \text{ MPa}$$

Not O.K.

\therefore Shear reinforcement is required

$$v_u = 1.716 \text{ MPa} < 0.75 \times 0.5 \times \sqrt{28} = 1.98 \text{ MPa} \text{ O.K.}$$

$$v_c = 0.17 \sqrt{f_c'} = 0.17 \times \sqrt{28} = 0.8995 \text{ MPa}$$

$$v_s = \frac{v_u}{\phi} - v_c = \frac{1.619}{0.75} - 0.8995 = 1.259 \text{ MPa}$$

$$v_s = \frac{A_v f_y}{b_o s} \text{ Where } s = \frac{d}{2} = \frac{190}{2} = 95 \text{ mm}$$

$$A_v = \frac{v_s b_o s}{f_y} = \frac{1.259 \times 1280 \times 95}{414} = 369.79 \text{ mm}^2$$

The required area of vertical shear reinforcement

$$= 369.79 \text{ mm}^2 \blacksquare$$

Q2 (50 %): for the longitudinal interior frame (A) of the flat plate floor shown in figure below by using direct design method find:

1. Longitudinal distribution of the static moment at factored loads.
2. Lateral distribution of the moment at exterior support.

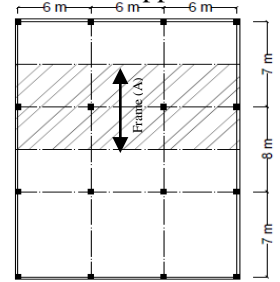
Slab thickness = 170 mm, $d = 144$ mm

$$q_u = 20.0 \text{ kN/m}^2$$

All edge beams = 350 × 700 mm

All columns = 500 × 500 mm

$$f_c' = 25 \text{ Mpa}, f_y = 420 \text{ Mpa}$$



Solution

a-Longitudinal distribution

$$q_u = 20 \text{ kN/m}^2, \ell_2 = \left(\frac{7}{2} + \frac{8}{2}\right) = 7.5 \text{ m}$$

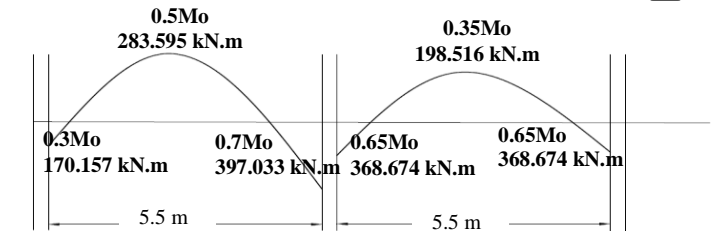
$$\ell_n = 6 - 0.5 = 5.5 \text{ m} > 0.65 * 6 = 3.9 \text{ m}$$

$$M_o = \frac{q_u * \ell_n^2 * \ell_2}{8} = \frac{20 * 5.5^2 * 7.5}{8}$$

$$M_o = 567.19 \text{ kN.m}$$

Table 8.10.4.2—Distribution coefficients for end spans

	Exterior edge unrestrained	Slab with beams between all supports	Slab without beams between interior supports	Without edge beam	Exterior edge fully restrained
Interior negative	0.75	0.70	0.70	0.70	0.65
Positive	0.63	0.57	0.52	0.50	0.35
Exterior negative	0	0.16	0.26	0.30	0.65



b-Lateral distribution

For exterior support

Negative moment = 170.157 kN.m

$$\alpha_f = 0$$

Find β_t :

$$\beta_t = \frac{c}{2I_s}$$

Calculate C:

$$C = \sum (1 - 0.63 \frac{x}{y}) \left(\frac{x^3 y}{3}\right)$$

$$C1 = \left(1 - 0.63 * \frac{350}{700}\right) \left(\frac{350^3 * 700}{3}\right) + \left(1 - 0.63 \frac{170}{530}\right) \left(\frac{170^3 * 530}{3}\right)$$

$$C1 = 7.545 \times 10^9 \text{ mm}^4$$

$$C2 = \left(1 - 0.63 * \frac{350}{530}\right) \left(\frac{350^3 * 530}{3}\right) + \left(1 - 0.63 \frac{170}{880}\right) \left(\frac{170^3 * 880}{3}\right)$$

$$C2 = 5.689 \times 10^9 \text{ mm}^4 \text{ Use larger } \therefore C = 7.545 \times 10^9 \text{ mm}^4$$

$$I_s = \frac{\ell_2 * h_{slab}^3}{12} = \frac{7500 * 170^3}{12} = 3.07 \times 10^9 \text{ mm}^4$$

$$\beta_t = \frac{c}{2I_s} = \frac{7.545 * 10^9}{2 * 3.07 * 10^9} = 1.229$$

-Exterior C.S coefficient % = $100 - 10\beta_t + 12\beta_t \left(\alpha_{f1} \frac{\ell_2}{\ell_1}\right) \times \left(1 - \frac{\ell_2}{\ell_1}\right)$

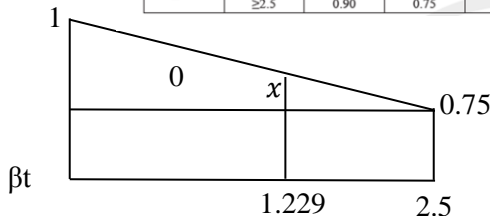
-Exterior C.S coefficient % = $100 - 10 * 1.229 = 87.71 \% = 0.8771$

-Exterior M.e.s = $0.8771 * 170.157 = 149.24 \text{ kN.m}$

-Exterior Mm.s = $170.157 - 149.24 = 20.917 \text{ kN.m} \blacksquare$

Table 8.10.5.2—Portion of exterior negative M_u in column strip

$a_n \ell_2 / \ell_1$	β_t	ℓ_2 / ℓ_1		
		0.5	1.0	2.0
0	≥ 2.5	0.75	0.75	0.75
≥ 1.0	0	1.0	1.0	1.0
	≥ 2.5	0.90	0.75	0.45



$$\frac{1 - 0.75}{2.5 - 0} = \frac{x}{2.5 - 1.229} \rightarrow x = 0.1271$$

-Exterior C.S factor = $0.75 + 0.1271 = 0.8771$

Of by using Interpolation