Typical Solutions

Q1 (50 %): Check the two way shear action (punching shear) only around a corner column (450×450) mm in a flat plate floor of a span (7.5×7.5) m. Find the area of vertical shear reinforcement if required. Assume d =140 mm. Total q_u = 15 kPa (including slab weight), f_c\`= 28 MPa, f_y = 414 MPa.

Solution:

$(b_o) = (450 + 70) \times 2 = 1040$ mm

$Vu = 15 \times (3.975 \times 3.975 - 0.52 \times 0.52) = 232.953$ kN

$$v_{ug} = \frac{Vu}{b_o \cdot d} = \frac{232.953 \times 10^3}{1040 \times 140} = 1.599 \text{ MPa}$$

$$v_c = \min.\begin{cases} 0.33\sqrt{28} = \mathbf{1.746\ MPa} \\ 0.17\left(1+\frac{2}{1}\right)\times\sqrt{28} = 2.698 \text{ MPa} \\ 0.083\left(2+\frac{20\times140}{1280}\right)\times\sqrt{28} = 2.061 \text{ MPa}\end{cases}$$

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

$\phi v_n = 0.75 \times 1.746 = 1.3095$ MPa $<$ $v_u = 1.599$ MPa

Not O.K.

$\therefore$ Shear reinforcement is required

$v_u = 1.599 \text{ MPa} < 0.75 \times 0.5 \times \sqrt{28} = 1.98 \text{ MPa O.K.}$

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

$$v_s = \frac{v_u}{\phi} - v_c = \frac{1.599}{0.75} - 0.8995 = 1.2325 \text{ MPa}$$

$v_s = \frac{A_v f_y}{b_o s}$ Where $s = \frac{d}{2} = \frac{140}{2} = 70$ mm

$$A_v = \frac{v_s b_o s}{f_y} = \frac{1.2325 \times 1040 \times 70}{414} = 216.73 \text{ mm}^2$$

The required area of vertical shear reinforcement

= 216.73 mm^2 ■

Q2 (50 %): for the transverse 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.

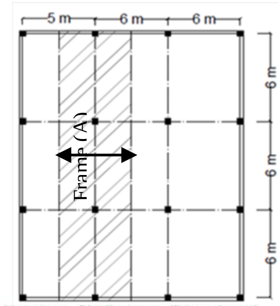
Slab thickness = 170 mm, d =144 mm

q_u = 35.0 kN/m^2

All edge beams = 350 × 700 mm

All columns = 400 × 400 mm

fc\`= 25 Mpa, fy = 420 Mpa,



Solution

a-Longitudinal distribution

q_u=35 kN/m^2 , $\ell_2 = \left(\frac{6}{2}+\frac{5}{2}\right) = 5.5$ m

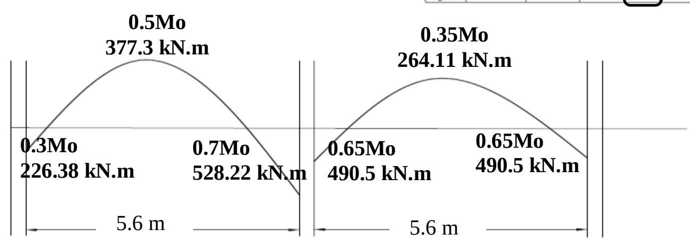
$\ell_n = 6 - 0.4 = \mathbf{5.6}$ m > 0.65*6 =3.9 m

$M_o = \frac{q_u * \ell_n^2 * \ell_2}{8} = \frac{35*5.6^2*5.5}{8}$

M_o= 754.6 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	Slab without beams between interior supports: With 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

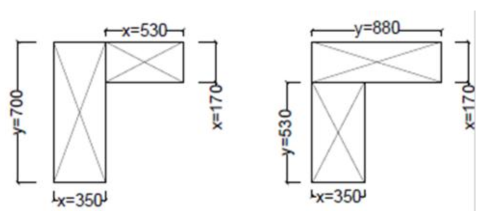
Negative moment = 226.38 kN.m

$\alpha_f = 0$

Find βt:

$\beta_t = \frac{C}{2I_S}$

Calculate C:



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

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

C1 = 7.545 × 10^9 mm^4

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

C2 = 5.689 × 10^9 mm^4 Use larger ∴ **C = 7.545 × 10^9** mm^4

$Is = \frac{\ell_2 \times h_{slab}^3}{12} = \frac{5500 \times 170^3}{12}$ =2.252× 10^9 mm^4

$\beta_t = \frac{C}{2I_S} = \frac{7.545 \times 10^9}{2 \times 2.252 \times 10^9} = 1.675$

-Exterior C.S $_{coefficient}$% = 100−10βt +12 βt $(\alpha_{f1}\frac{\ell_2}{\ell_1}) \times (1 - \frac{\ell_2}{\ell_1})$ → 0

-Exterior C.S $_{coefficient}$% = 100−10×1.675 = 83.25 % = **0.8325**

-Exterior Mc.s = 0.8325×226.38 = 188.46 kN.m

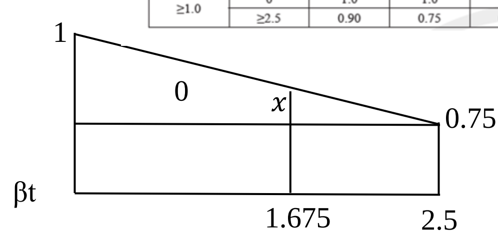
-Exterior Mm.s = 226.38 −188.46 =37.92 kN.m ■

Or by using Interpolation

Table 8.10.5.2—Portion of exterior negative M_u in column strip

βt = 1.675

$\alpha_{f1}\ell_2/\ell_1$	β_t	ℓ_2/ℓ_1 = 0.5	1.0	2.0
0	0	1.0	1.0	1.0
	≥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



$\frac{1-0.75}{2.5-0} = \frac{x}{2.5-1.675} \rightarrow x = 0.0825$

-Exterior C.S factor = 0.75 + 0.0825 = **0.8325**