CV3011 2022/23 Sem 1

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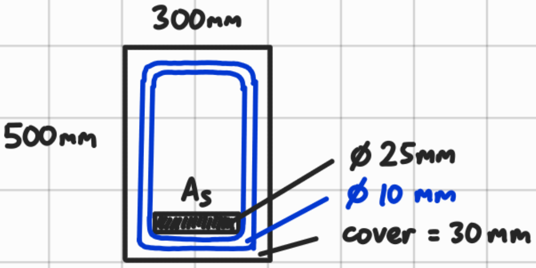
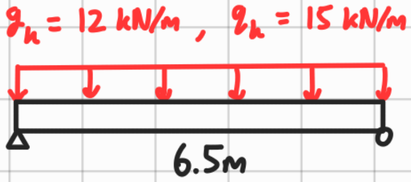
1.





$\gamma_{con} = 24 \text{ kN/m}^3$

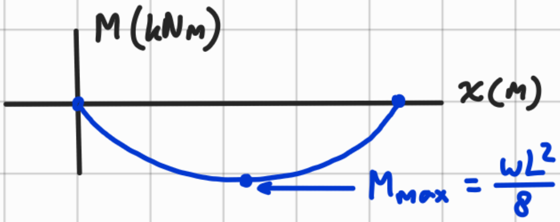
$f_{ck} = 30 \text{ N/mm}^2$

$f_{yk} = 460 \text{ N/mm}^2$

$f_{yv} = 250 \text{ N/mm}^2$

(a) $w = 1.35\left[12 + (24 \times 500 \times 300 \times 10^{-6})\right] + 1.5(15) = 43.56 \text{ kN/m}$

For a simply supported beam with UDL,



$$M_{Ed} = \frac{43.56\,(6.5)^2}{8} = 230.05 \text{ kNm}$$

$$d = h - \text{cover} - \text{link} - \frac{\text{Main bar}}{2}$$
$$= 500 - 30 - 10 - \frac{25}{2} = 447.5 \text{ mm}$$

- $k = \dfrac{230.05 \times 10^6}{(300)(447.5)^2(30)} = 0.1276 \leq k_{bal} = 0.167$ (No moment redistribution for simply supported)

  $\Rightarrow$ Compression steel not needed

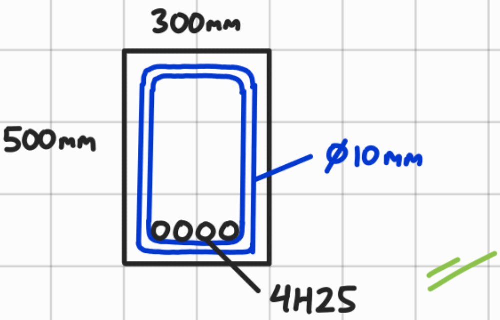
- $z = 447.5\left(0.5 + \sqrt{0.25 - \dfrac{0.1276}{1.134}}\right) = 389.7 \text{ mm} < 0.95d = 425 \text{ mm}$

- $A_{s,req} = \dfrac{230.05 \times 10^6}{0.87(460)(389.7)} \text{ mm}^2 = 1475 \text{ mm}^2 \Rightarrow$ Provide 4H25,

  $A_{s,prov} = 4 \times 490 = 1960 \text{ mm}^2$

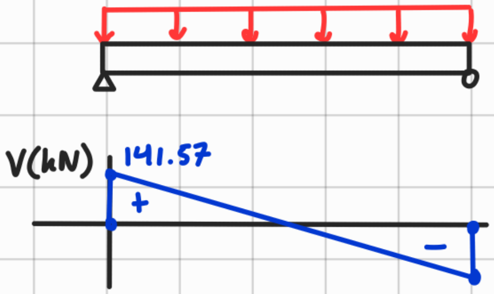
Crack control : $\rho = \dfrac{1960}{(300)(447.5)} \times 100\% = 1.46\%$ $> 0.15\%$, $< 4.0\%$ OK!

Cross-section :



(b) $w = 43.56 \text{ kN/m}$

$$R_A = R_B = \frac{43.56 \times 6.5}{2} = 141.57 \text{ kN}$$



As the support details are not given, assume $V_{Ef} = 141.57$ kN

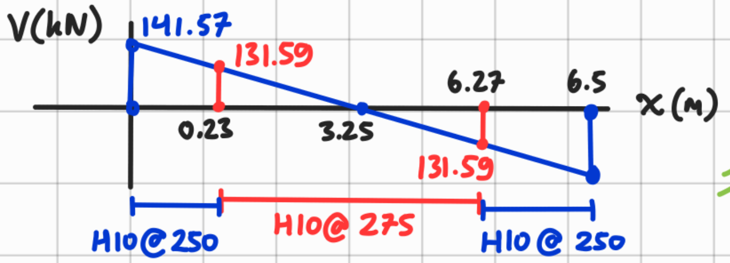
- $V_{Rd,max(22)} = 0.124(300)(447.5)(30)\left(1 - \frac{30}{250}\right) \times 10^{-3} \text{ kN} = 439.5 \text{ kN}$
  $V_{Rd,max(45)} = 0.180(300)(447.5)(30)\left(1 - \frac{30}{250}\right) \times 10^{-3} \text{ kN} = 638.0 \text{ kN}$

- $V_{Ef} \leq V_{Rd,max(45)}$, continue.
- $V_{Ef} \leq V_{Rd,max(22)}$, use $\theta = 22°$.

- $V_{Ed,1d} = 141.57 - (447.5 \times 10^{-3})(43.56) = 122.08 \text{ kN}$
- $$\frac{A_{sw}}{s} = \frac{122.08 \times 10^3}{0.78(447.5)(250)\cot 22°} = 0.565 \text{ mm}^2/\text{mm} \Rightarrow \text{use H10@250}$$
  $\frac{A_{sw}}{s} = 0.628 \text{ mm}^2/\text{mm}$ (Zone 1 + 2)

- $$\frac{A_{sw,min}}{s} = \frac{0.08(30)^{0.5}(300)}{250} = 0.525 \text{ mm}^2/\text{mm} \Rightarrow \text{use H10@275}$$
  $\frac{A_{sw}}{s} = 0.571 \text{ mm}^2/\text{mm}$ (Zone 3)

- $V_{min} = 0.571 \times 0.78 \times 477.5 \times 250 \cot(22°) \times 10^{-3} \text{ kN}$
  $= 131.59 \text{ kN}$



(c) • $\rho_o = 10^{-3} \times \sqrt{30} \times 100\% = 0.548\%$

• $\rho = \dfrac{1475}{(300)(447.5)} \times 100\% = 1.10\% > 0.35\% \Rightarrow$ use eqn.

• $\rho > \rho_o$: Basic $\dfrac{l}{d} = 1.0\left[11 + \dfrac{1.5\sqrt{30} \times 0.548\%}{1.10\%}\right] = 15.09$

Simplified approach:

$$\frac{l}{d} = \frac{6.5 \times 10^3}{447.5} = 14.5 < 15.09 \times \frac{1960}{1475} = 20.1 \,// \quad \text{OK!}$$

Less conservative approach:

Office Area

$F_1 = 1.0$

$F_2 = 1.0$

• $\sigma_{su} = 0.87(460)\left(\dfrac{[12 + (24 \times 500 \times 300 \times 10^{-6})] + 0.3(15)}{43.56}\right)$

$= 185 \text{ N/mm}^2$

• $\sigma_s = 185 \times \dfrac{1475}{1960} \times \dfrac{1}{1.0} = 139.22 \text{ N/mm}^2$

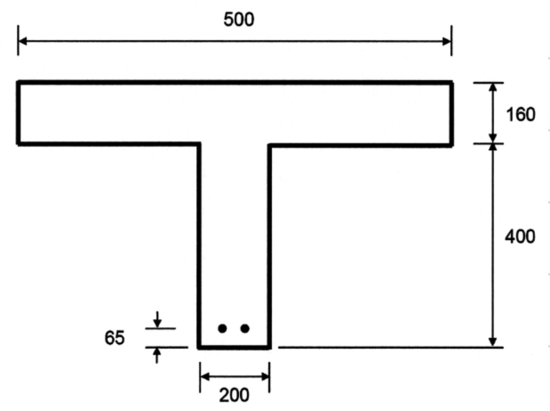
• $F_3 = \dfrac{310}{139.22} = 2.23$

$$\frac{l}{d} = \frac{6.5 \times 10^3}{447.5} = 14.5 < 15.09 \times 1.0 \times 1.0 \times 2.23 = 33.6 \,// \quad \text{OK!}$$

② (a) $l = 7\ m$

$f_{ck} = 40\ N/mm^2$

$f_{yk} = 460\ N/mm^2$



$d = 160 + 400 - 65$

$= 495\ mm$

- $w = 1.35(49.6) + 1.5(40) = 126.96\ kN/m$
- $M_{Ed} = \frac{wL^2}{8} = \frac{126.96(7)^2}{8} = 777.63\ kNm$
- $k = \frac{777.63 \times 10^6}{(500)(495)^2(40)} = 0.159$
- $z = 495\left(0.5 + \sqrt{0.25 - \frac{0.159}{1.134}}\right) = 411.5\ mm < 0.95d = 470\ mm$
- $s = 2(495 - 411.5) = 167\ mm > 160m \Rightarrow$ Stress block outside of flange
- $M_f = 0.567(40)(500-200)(160)(495 - 0.5 \times 160) \times 10^{-6}\ kNm = 451.8\ kNm$
- $k_w = \frac{(777.63 - 451.8) \times 10^6}{(200)(495)^2(40)} = 0.1662 \leq k_{bal} = 0.167$

  (no moment redistribution)
- $z_w = 495\left(0.5 + \sqrt{0.25 - \frac{0.1662}{1.134}}\right) = 406.7\ mm < 0.95d = 470\ mm$
- $A_{s,req} = \frac{451.8 \times 10^6}{0.87(460)(495 - 0.5 \times 160)} + \frac{(777.63 - 451.8) \times 10^6}{0.87(460)(406.7)} = 4722.2\ mm^2$

$\Longrightarrow$ Provide 4H40 ; $A_{s,prov} = 5024\ mm^2$

(b) • $\rho_o = 10^{-3} \times \sqrt{40} \times 100\% = 0.632\ \%$

• $\rho = \dfrac{4722.2}{(200)(495)} \times 100\% = 4.77\ \% > 0.35\% \implies$ use eqn.

• $\rho > \rho_o$: Basic $\dfrac{l}{d} = 1.0\left[11 + \dfrac{1.5\sqrt{40} \times 0.632\%}{4.77\%}\right] = 12.26$

Shopping Area

$F_1 = 1 - 0.1\left(\dfrac{500}{200} - 1\right) = 0.85 \geq 0.8$

$F_2 = 1.0$

• $\sigma_{su} = 0.87\,(460)\left(\dfrac{49.6 + 0.6\,(40)}{1.35\,(49.6) + 1.5\,(40)}\right) = 232\ N/mm^2$

• $\sigma_s = 232 \times \dfrac{4722.2}{5024} \times \dfrac{1}{1.0} = 218.06\ N/mm^2$

• $F_3 = \dfrac{310}{218.06} = 1.42$

$\dfrac{l}{d} = \dfrac{7 \times 10^3}{495} = 14.14 < 12.26 \times 0.85 \times 1.0 \times 1.42 = \underline{\underline{14.80}}$ Ok!

③ $h = 200$ mm $\qquad f_{ck} = 50\ N/mm^2$

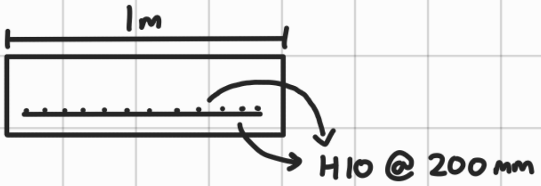
cover $= 25$ mm $\qquad f_{ctm} = 4.1$ MPa

ϕ 10mm bars $\qquad f_{yk} = 500\ N/mm^2$

$g_k = 5\ kN/m^2$

(a) Corner Slab A

Check using d_y as $d_y < d_x$



$$d_y = 200 - 25 - 10 - \frac{10}{2}$$
$$= 160\text{mm}$$

For H10 @ 200, $A_s = 393\ mm^2/m$

- $\frac{z}{d}$ assumed to be $0.95 \rightarrow z = 0.95(160) = 152$ mm
- $M = A_s \times 0.87 f_{yk} \times z = 393 \times (0.87 \times 500) \times 152 \times 10^{-6}$ kNm
  $= 26.0$ kNm/m

2 adjacent discontinous:

Square slab, no long edge

$$M_{sx} = \beta_{sx} \times n \times l_x^2 \Rightarrow n = \frac{M_{sx}}{\beta_{sx} l_x^2} = \frac{26}{\beta_{sx}(8)^2}$$

$\beta_{sx} = 0.047$ (-ve M) $\longrightarrow$ Use higher value of β

$\beta_{sx} = 0.036$ (+ve M)

$$\Rightarrow n = \frac{26}{0.047 \times 8^2} = 8.644\ kN/m^2$$

$$1.35(5) + 1.5 q_k = 8.644$$

$$q_k = \frac{8.644 - 1.35(5)}{1.5} = 1.26\ kN/m^2$$

(b) • $\rho_o = 10^{-3} \times \sqrt{50} \times 100\% = 0.707\ \%$

• $\rho = \frac{393}{(1000)(160)} \times 100\% = 0.25\% < 0.35\% \Longrightarrow$ Table 5.8

Table 5.8 Span/effective depth ratios for slabs

Location	$\frac{A_{s,req}}{bd} \geqslant 1.5\%$	$\frac{A_{s,req}}{bd} = 0.5\%$	$\frac{A_{s,req}}{bd} \leqslant 0.35\%$
One-or two-way spanning slab:			
Simply supported	14	20	30
End span	18	26	$\boxed{39}$
Interior span	20	30	45
Flat slab	17	24	36
Cantilever	6	8	12

Office Area

$F_1 = 1.0$

$F_2 = \frac{7}{8} = 0.875 \leq 1.0$

- $\sigma_{su} = 0.87(500)\left(\frac{5 + 0.3(1.26)}{1.35(5) + 1.5(1.26)}\right) = 270.8\ N/mm^2$

- $\sigma_s = 270.8 \times \frac{393}{393} \times \frac{1}{1.0} = 270.8\ N/mm^2$

- $F_3 = \frac{310}{270.8} = 1.145$

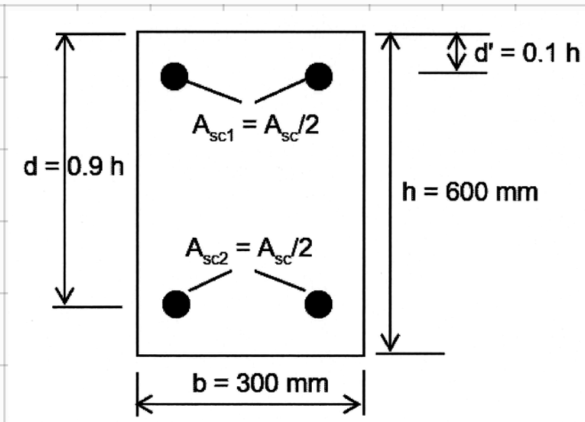
$$\frac{l}{d} = \frac{8000}{160} = 50 > 39 \times 1.0 \times 0.875 \times 1.145 = 39$$ ✗ NOT OK!

Two solutions:

1.) Increase $A_{s,prov}$ (reduce spacing, increase bar size)

2.) Reduce concrete cover (to increase d)

4. (a)



$d = 540$ mm

$d' = 60$ mm

$f_{ck} = 40$ N/mm²

$f_{yk} = 500$ N/mm²

$A_{sc} = 2\% \times (600 \times 300) = 3600 \text{ mm}^2$

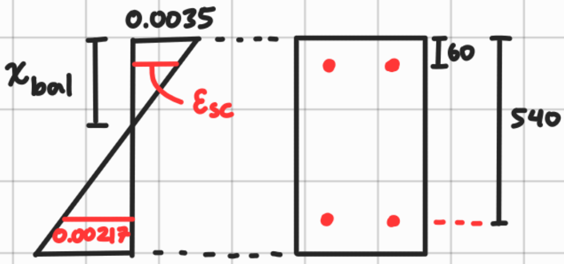
Pure Compression

$M = 0$

$N = [0.567(40)(600 \times 300) + 0.87(500)(3600)] \times 10^{-3}$ kN

$= 5648.4$ kN

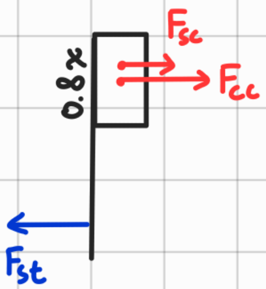
(b) **Balanced Case**



$$x_{bal} = \frac{540}{1 + \frac{0.00217}{0.0035}} = 333 \text{ mm}$$

$$\varepsilon_{sc} = 0.0035\left(\frac{333 - 60}{333}\right) = 0.00287 > 0.00217$$

(Compression steel has yielded.)



$N = F_{cc} + F_{sc} - F_{st}$

$= \left[0.567(40)(300)(0.8 \times 333) + 0.87(500)\left(\frac{3600}{2}\right) - 0.87(500)\left(\frac{3600}{2}\right)\right] \times 10^{-3}$ kN

$= 1813 + 783 - 783$

$= 1813$ kN

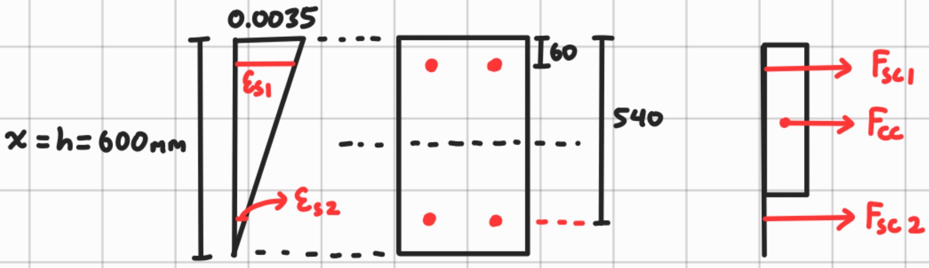
$M = F_{cc}\left(\frac{h}{2} - \frac{0.8x}{2}\right) + F_{sc}\left(\frac{h}{2} - d'\right) + F_{st}\left(d - \frac{h}{2}\right)$

$= \left[1813\left(\frac{600}{2} - \frac{0.8 \times 333}{2}\right) + 783\left(\frac{600}{2} - 60\right) + 783\left(540 - \frac{600}{2}\right)\right] \times 10^{-3}$ kNm

$= 302.4 + 187.9 + 187.9$

$= 678.2$ kNm

(c) Zero tension



$$\varepsilon_{s1} = \frac{0.0035}{600} \times 540 = 0.00315 > 0.00217$$ (Yielded !)

use $F_s = 0.87 f_y A_s$

$$\varepsilon_{s2} = \frac{0.0035}{600} \times 60 = 0.00035 < 0.00217$$ (Have NOT yielded)

use $F_s = f_s A_s = E_s \varepsilon_s A_s$

$$N = F_{cc} + F_{sc1} + F_{sc2}$$
$$= \left[0.567(40)(300)(0.8 \times 600) + 0.87(500)\left(\frac{3600}{2}\right) + (200000)(0.00035)\left(\frac{3600}{2}\right)\right] \times 10^{-3} \text{ kN}$$
$$= 3266 + 783 + 126$$
$$= 4175 \text{ kN}$$

$$M = F_{cc}\left(\frac{h}{2} - \frac{0.8x}{2}\right) + F_{sc}\left(\frac{h}{2} - d'\right) - F_{st}\left(d - \frac{h}{2}\right)$$
$$= \left[3266\left(\frac{600}{2} - \frac{0.8 \times 600}{2}\right) + 783\left(\frac{600}{2} - 60\right) - 126\left(540 - \frac{600}{2}\right)\right] \times 10^{-3} \text{ kNm}$$
$$= 196.0 + 187.9 - 30.2$$
$$= 353.7 \text{ kNm}$$

atb glhf ! <3 ☺