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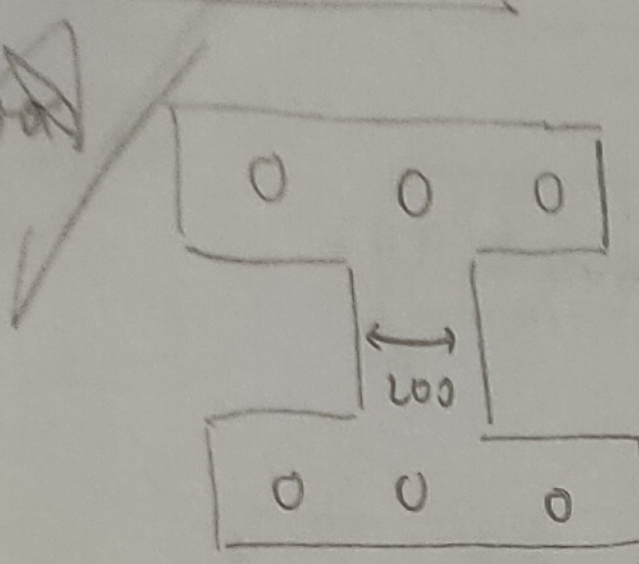


3T16 = 603 mm^2

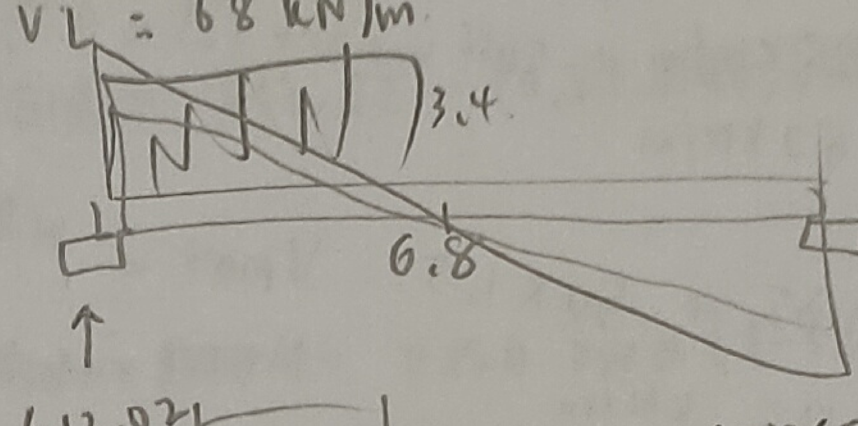
3T32 = 2414 mm^2

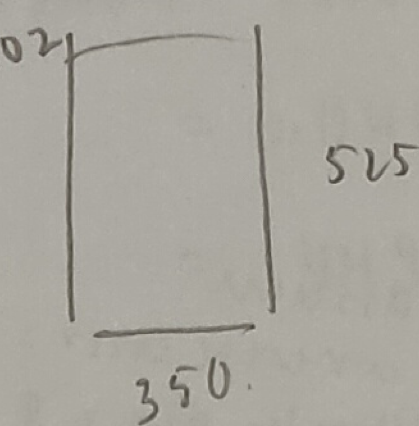
$F_{cc} + F_{SC} = F_{ST}$

$F_{cw} + F_{CF} + F_{SC} = F_{ST}$

2) a) PL : 58 kN/m

VL = 68 kN/m





180.3 kN/m × 6.8 = 1226.04

simply support

$M_{max} = 1042.134$ $(\frac{wl^2}{8})$

concrete cover = 25 mm

$\phi 32$

link = 12 mm

Assume NA ~~below~~ above flange

$F_{cf} + F_{cw} = F_{st}$

~~0.567 × 40 × (400 − 200) × 100 + 0.567 × 40 × 200 × 0.8x~~

~~= 0.87 × 500 × ( )~~

~~453600 + 3628.8 x =~~

$F_c + F_{sc} = F_{st}$

~~0.567 × 40 × 400 × 0.8x + 0.87 (500) (603)~~

~~= 0.87 (500) (2414)~~

~~0.567 × 40 × 400 × 0.8x = 787785~~

Assume below flange x = 108.55 > 100

$F_{cf} + F_{cw} + F_{sc} = F_{st}$

$0.567 f_{ck} (b - b_w) h_f + 0.567 f_{cu} b_w (0.8x) + 0. f_{sc} (603) = 0.87 (500)(2414)$

~~453600 + 0.567(40)(200)(0.8x) = 787785~~

~~0.567(40)(200)(0.8x) = 334185~~

~~x = 92.09 mm~~

Do not assume comp steel yield!

$f_{sc} = 700 (\frac{x - d'}{x})$

$\frac{d'}{d} = \frac{60}{340} = 0.176 > 0.171$ (not yielded)

~~x = 164.38 mm > 100 mm~~

$453600 + 3628.8 x + 700 \frac{(x - 60)}{x} (603) = 1050090$

$3628.8 x + 422100 (\frac{x - 60}{x}) = 596490$

$3628.8 x^2 + 422100 x - 25326000 = 596490 x = 0$

$\frac{x}{d} = 0.326 < 0.617$

$x = 110.96$ mm or −62.89 mm

$> h_f$ ∴ correct!

$M_f = 0.567 (40)(400 - 200)(100)(340 - 0.5 \times 100)$

= 131.54 kNm

~~$k_w = \frac{M - M_f}{f_{cu} b_w d^2} = 0.074 < 0.167$~~

$M_w = F_{cw} (d - 0.4x) = 0.567 (40)(200)(0.8 \times 110.96)(340 - 0.4 \times 110.96)$

= ~~401651.648~~ 119.03 kNm

$M_R = M_f + M_w + F_{sc} Z_c$

= ~~131.94~~ kNm 250 kNm ~~> 200 kNm~~ ok!

$F_{sc} Z_c = 422100 (\frac{x - 60}{x}) (d - 0.4x)$

= 57.3 kNm

250 + 57.3 = 307.3 kNm > 250 kN

$d = 525 - 25 - 12 - \frac{32}{2}$ = 460 mm (460)

$K = \frac{M}{f_{cu} b d^2} = \frac{1042.134 \times 10^3}{25 \times 350 \times 460^2}$

= 0.56 > 0.167

(comp. steel needed)

$d' = 25 + 12 + 16 = 53$ mm

$\frac{d'}{d} = 0.115 < 0.171$ yielded

$A_s' = \frac{(K - K_{bal}) f_{cu} b d^2}{0.87 f_{yk} (d - d')}$

= 4141.286 mm^2

$A_s = \frac{K_{bal} f_{cu} b d^2}{0.87 f_{yk} z} + A_s'$

= 1884.43 + 4141.286

= 6025.71

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$(1.2 \times 0.1) + (0.3 \times 0.7)$
↓

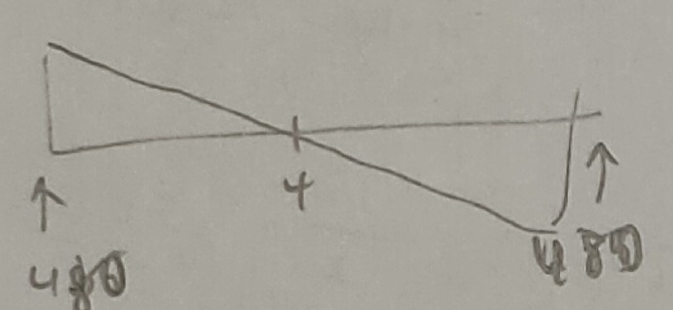
1)(a) dead load = 25 kN/m + self weight $(25 \times 0.33) = 33.25$
live load = 50 kN/m.

load = ~~25~~ 33.25 × 1.35 + 50 × 1.5
= 1120 kN/m.

1120 × 8 = 960 kN

$V_{max} = wl/2 = \frac{120(8)}{2}$
= 480 //

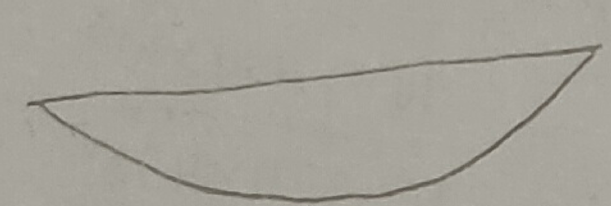
$M_{max} = wl^2/8$
$= 120(8)^2/8$
= 960 //



assume
concrete cover = 30
link dia = 8

$d = 800 - 30 - 8 - \frac{32}{2}$
= 746

$f_{cu} = 40 N/mm^2$



$K = \frac{M}{f_{cu} b d^2} = \frac{960 \times 10^6}{45 \times 1200 \times 746^2}$
= 0.058 < 0.167

$z = \left(0.5 + \sqrt{0.25 - \frac{K}{1.135}}\right) d$
= ~~[illegible]~~ 705 mm

s = 2(d − z) = ~~[illegible]~~ 82m × 100

$s > h_f$:

~~$M_f = 0.567 f_{cu} (b - b_w) h_f (d - 0.5 h_f)$~~
~~= 1420.68 kNm.~~

~~$K_w = \frac{(M - M_f)}{f_{cu} b_w d^2}$ =~~

$A_s = \frac{M}{0.87 f_{yk} z} = \frac{960 \times 10^6}{0.87 \times 500 \times 705}$
$= 3130 mm^2$

4H32 = $3218 mm^2$ ↑

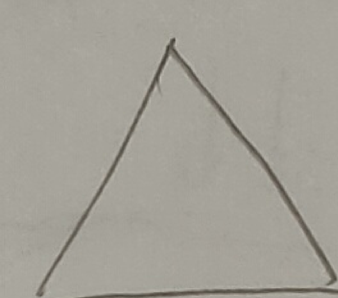
2)(a) $F_c = F_{ST}$

$0.567 f_{ck} b s = 0.87 \times 500 \times 943$

$0.567 f_{cu} (600)(0.8x) = 410205$

10886.4x = 410205

x =



max opening

x = 0.45d
= 550(0.45)
= 247.5 mm.

s = 0.8x
= 198 mm.

Area = $\frac{1}{2} \times 600 \times 600 - 150L$
= 180000 − 150L

0.567 × 40 × (180000 − 150L)
= 410205

4082400 − 3402L = 410205

−3402L = −3672195

L = 1079

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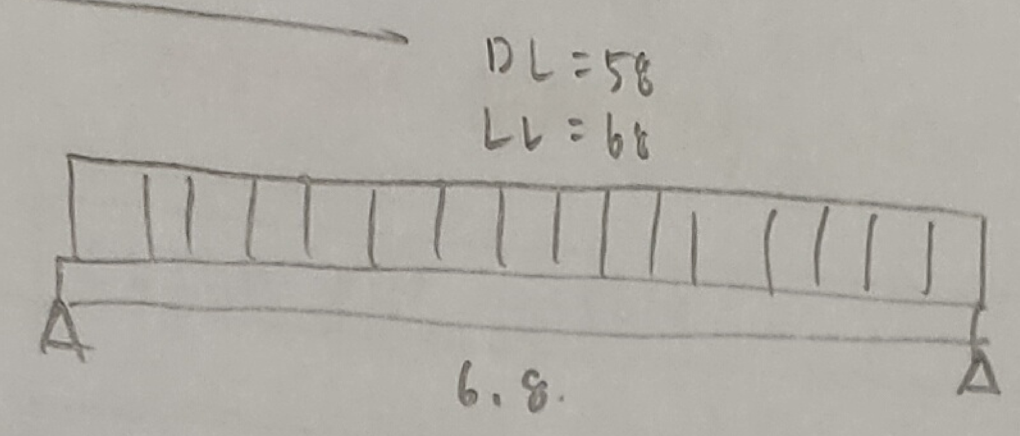
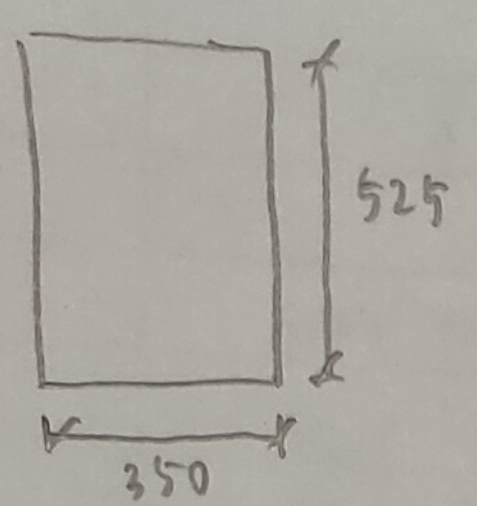
a)





Assume
concrete cover = 25 mm
link diameter = 12 mm
bar diameter = 32 mm

$d = 525 - 25 - 12 - \frac{32}{2}$
$= 472$ mm
d = 460 mm

Load = 1.35 × 58 + 1.5 × 68 = 180.3

$V_{max} = wl/2 = 613.02$ kN
$M_{max} = wl^2/8 = 1042.134$ kNm.

$k = \frac{M}{f_{cu}bd^2} = \frac{1042.134 \times 10^6}{25 \times 350 \times 460^2} = 0.563 > 0.167$
comp. steel needed.

$d' = 25 + 12 + \frac{32}{2} = 53$

$\frac{d'}{d} = \frac{53}{460} = 0.115 < 0.171$ comp steel yield!

$A_s' = \frac{(K - K_{bal}) f_{cu} b d^2}{0.87 f_{yk} (d - d')} = \frac{(0.563 - 0.167)(25)(350)(460)^2}{0.87(500)(460 - 53)}$

$= 4141.3 \text{ mm}^2$

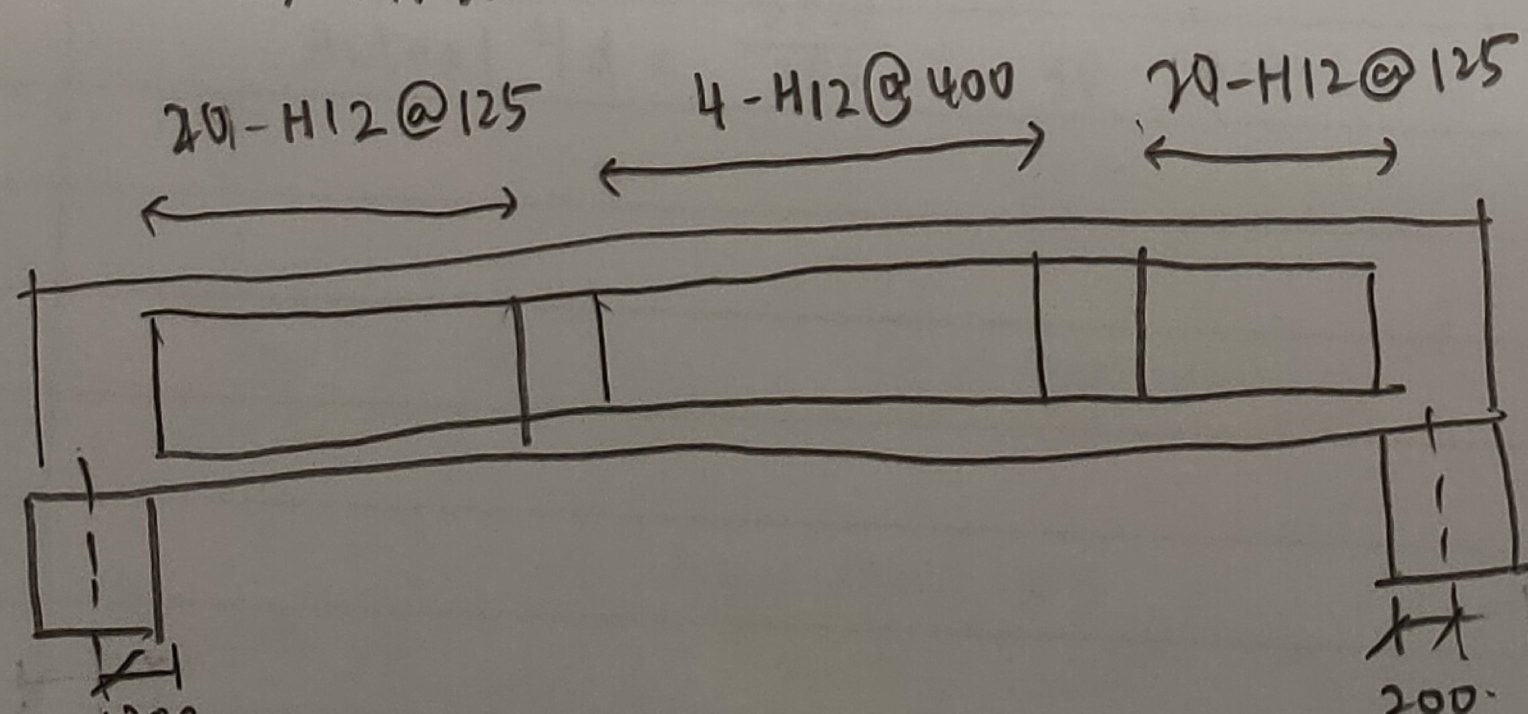
⇒ provide 6H32 (= 4827 mm²)

$A_s = \frac{K_{bal} f_{cu} b d^2}{0.87 f_{yk} z} + A_s'$ ~~z = d(0.5 + √(0.25 − K/1.135))~~ z = 0.82d

$= \frac{0.167(25)(350)(460)^2}{0.87(500)(0.82 \times 460)} + A_s'$

$= 1884.43 + 4141.3 = 6025.73 \text{ mm}^2$

⇒ 8H32 (= 6437 mm²)



$Z_3 \Rightarrow X_L = 6.8 - 2(2.35) - 2(0.2)$
$= 1.65$ m.

no. of links $= \frac{X_L}{S} - 1 = \frac{1650}{400} - 1 = 3.125$
≈ 4.

b) $V_{Ef} = 613.02 - 0.2(180.3) = 576.96$ kN
$V_{Eld} = 613.02 - (0.2 + 0.46)(180.3) = 494.02$ kN

$V_{Rd,max}(22) = 0.124\, b_w d (1 - f_{cu}/250) f_{cu}$
$= 0.124(350)(460)(1 - 25/250)(25)$
$= 449.2 \text{ kN} < 576.96$ kN.

$V_{Rd,max}(45) = 0.18\, b_w d (1 - f_{cu}/250) f_{cu}$
$= 652.1 \text{ kN} > 576.96$.

$\theta = 0.5 \sin^{-1} \left\{ \frac{V_{Ef}}{V_{Rd,max,45}} \right\}$
$= 0.5 \sin^{-1} \left(\frac{576.96}{652.1} \right)$
$= 31.11°$
cot θ = 1.66

$\frac{A_{sw}}{s} = \frac{V_{Eld}}{0.78 f_{yk} \cot\theta} = \frac{494.02}{0.78(460)(500)(1.66)}$
$= 1.66$

⇒ use ϕ12 @ 125 spacing
$\frac{A_{sw}}{s} = 1.808$

Minimum stirrup

$V_2 = 0.0624 (f_{cu}^{0.5} b_w d) \cot\theta$
$= 0.0624 (25^{0.5} (350)(460))(1.66)$
$= 83.385$ kN.

$\frac{A_{sw}}{s} = \frac{V_2}{0.78 d f_{yk} \cot\theta} = \frac{83.385}{0.78(460)(500)(1.66)}$
$\frac{0.08 f_{cu}^{0.5} b_w}{f_{yk}} = 0.28$

⇒ use ϕ12 @ 400 spacing < 0.75d
(A_{sw}/s = 0.565)

$V_2 = \frac{A_{sw}}{s} \times 0.78 d f_{yk} \cot\theta$
$= 168.26$ kN.

$X_2 = \frac{V_{Ef} - V_{min}}{w} = \frac{576.96 - 168.26}{180.3}$
$= 2.27$ m.

measure from face of support, ~~X = 2.27 − 0.2/2 = 2.17~~ 2.27

no. of stirrup $= 1 + \frac{X}{S} = 1 + \frac{2270}{125} = 19.16 \approx 20$

$(20 - 1) \times 125 = 2375$

One-way spanning slab.

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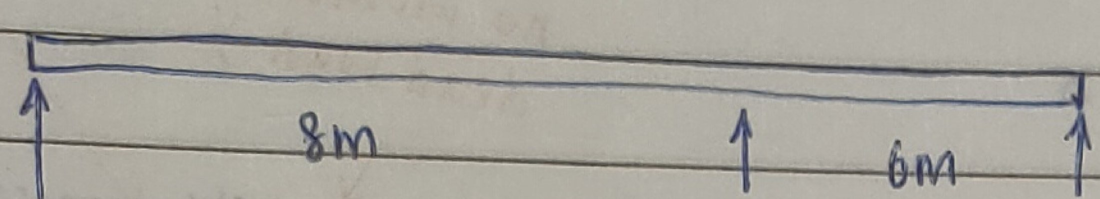
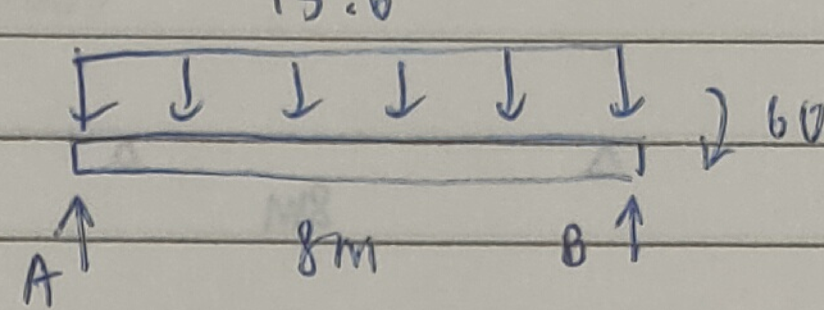
3)





slab thickness = 240mm

DL = 0.24 × 25 = 6 kN/m²

LL = 5 kN/m²

assume each bay > 30 m²

Q_k / G_k = 5/6 = 0.83 < 1.25

Q_k = 5 ≤ 5 kN/m²

∴ use single load case analysis

n = 1.35 × 6 + 1.5 × 5 = 15.6

$\Sigma M_B = 0$

RA (8) = 15.6 (8)(4) − 60 (0.8) ← redistribution

RA = 56.4 kN

$\Sigma F_y = 0$

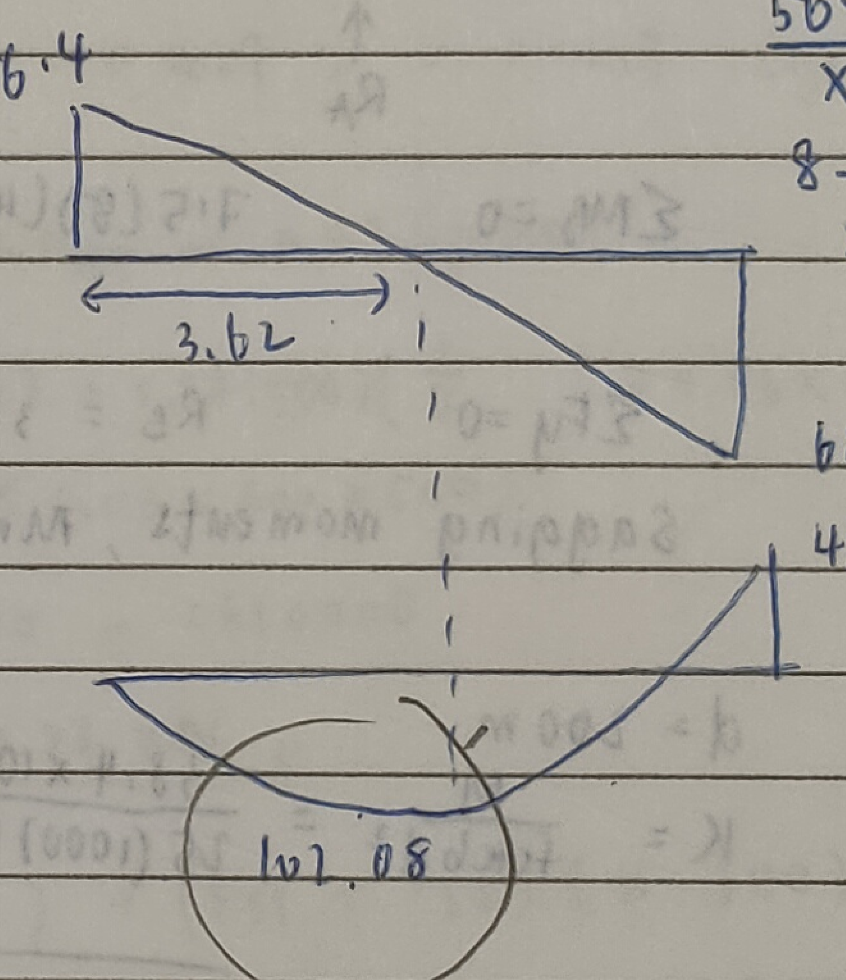
RA + RB = 15.6 (8)

RB = 68.4 kN

$\frac{56.4}{x} = \frac{68.4}{8-x}$

8 − x = 1.213x

x = 3.62



Mmax = 102.08 kNm

d = 200 m

$K = \frac{M}{f_{cu}bd^2}$ = 0.102 < ~~0.167~~ 0.116 (after redistribution) (singly reinforced)

$z = d(0.5 + \sqrt{0.25 - \frac{K}{1.134}})$ = 0.9 d

$A_{s,req} = \frac{M}{0.87 f_{yk} z}$ = 1303.7 mm²

Provide H13 − 90 ($A_{s,prov}$ = 1475 mm²)

b) deflection check

$\rho = \frac{A_s}{bd}$ = 0.0065

$\rho_o = 10^{-3}\sqrt{f_{ck}}$ = 0.005

ρ > ρo (Figure 7) ⇒ l/d = 17

Allowable l/d = 17 × $\frac{1475}{1303.7}$ = 19.23

Actual l/d = $\frac{8000}{200}$ = 40 > 19.23

$l/d = 1.3 [11 + 1.5\sqrt{25}\frac{0.005}{0.0065} + \frac{1}{12}\sqrt{25}\sqrt{0}]$

= 21.8

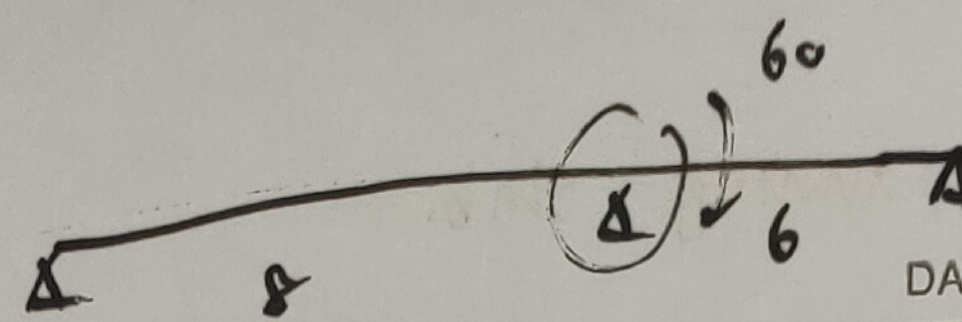
Allowable = 21.8 × $\frac{1475}{1303.7}$ = 24.7

Actual = 40 > 24.7

$\frac{21.8}{40}$ ~~$\frac{40}{21.8}$ = 1.83~~ 71.5

⇒ increase slab thickness

Question don't understand?



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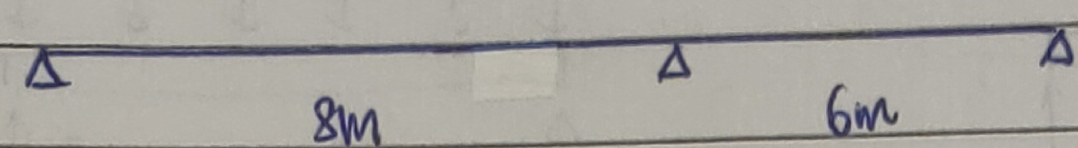
3) a)



no include dead load?

only imposed load.

$IL = 5\ kN/m^2$

$W = 1.5 \times 5 = 7.5\ kN/m$

$F = W \cdot l = 60\ kN$

Elastic moment at support B

$= 60 \times 0.125 \times 8 = 60\ kNm$

New support moment

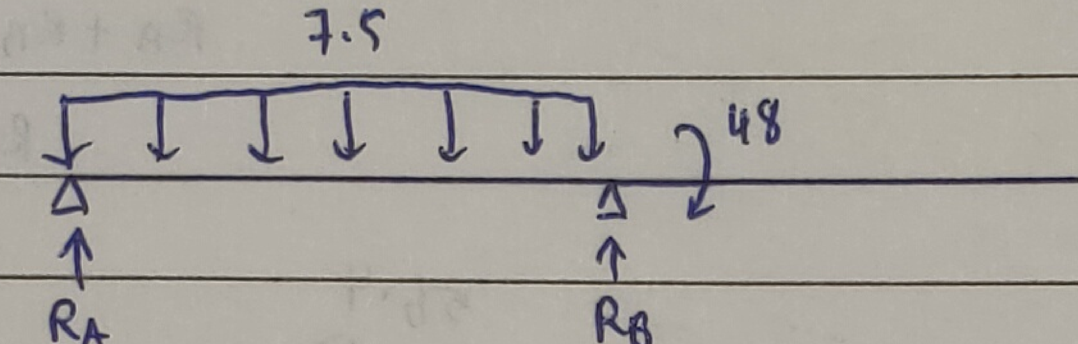
$= 60 \times 0.8 = 48\ kNm$

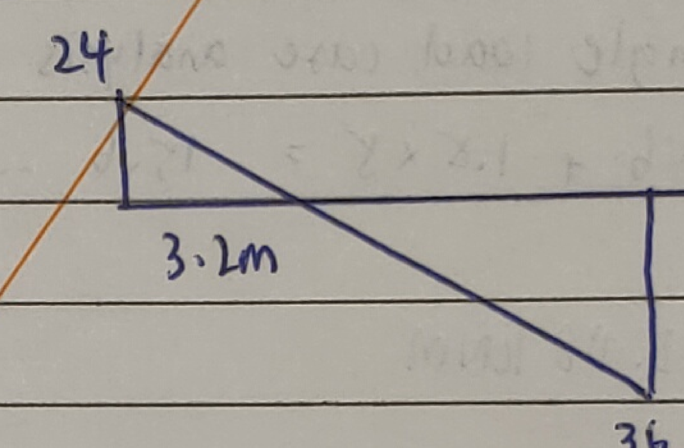
$DL = 0.24 \times 25 = 6\ kN/m^2$

$IL = 5\ kN/m^2$

$W = 1.35 \times 6 + 1.5 \times 5 = 15.6\ kN/m$ (for 1m strip)

$F = W \cdot l = 124.8\ kN$





$\frac{24}{x} = \frac{36}{8-x}$

$x = 3.2\ m$

$\Sigma M_B = 0 \quad 7.5(8)(4) - 48 = R_A(8)$

$R_A = 24\ kN$

$\Sigma F_y = 0 \quad R_B = 36\ kN$

Sagging moments, $M_{max} = 24 \times 3.2 \times \frac{1}{2} = 38.4\ kNm$

$d = 200\ m$

$K = \frac{M}{f_{ck} b d^2} = \frac{38.4 \times 10^6}{25(1000)(200)^2} = 0.0384 < 0.167$ (singly reinforcement)

$z = d\left(0.5 + \sqrt{0.25 - \frac{K}{1.134}}\right) = 0.965d < 0.95d$

$A_s = \frac{M}{0.87 f_{yk} z} = \frac{38.4 \times 10^6}{0.87 \times 500 \times 0.95 \times 200} = 464.61\ mm^2$ ($A_{s,req}$)

Provide $\phi 13$ at spacing of 275 mm, $A_{s,prov} = 483\ mm^2$

b) $\rho = A_{s,req} / bd = 0.232\% \leq 0.35\%$

Basic ratio $= 30$

Allowable $L/d = 30 \times \frac{A_{s,prov}}{A_{s,req}} = 31.187$

Actual $L/d = \frac{8000}{200} = 40 > 31.187$ $\therefore$ not satisfied.

$\Rightarrow$ Increase the $A_{s,prov}$

$30 \times MF = 40$

$MF = 1.33 < 1.5$

$\frac{A_{s,prov}}{A_{s,req}} = 1.33$

$A_{s,prov} = 619.47\ mm^2$

$\Rightarrow$ H13 - 200 ($A_{s,prov} = 664\ mm^2$)

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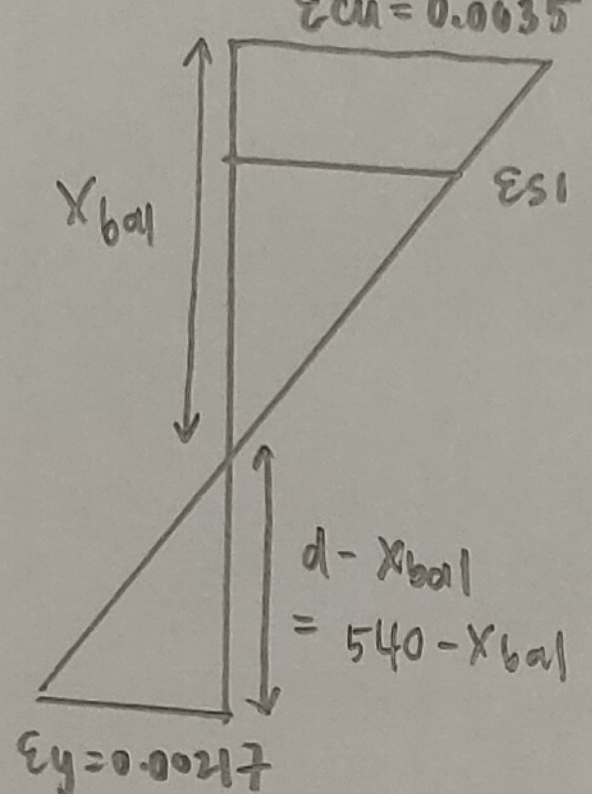
a) For pure compression failure (M=0)

$N_o = 0.567 f_{ck} A_c + 0.87 f_{yk} A_{sc}$

$= 0.567 (50)(600 \times 500) + 0.87(500)(0.03 \times 600 \times 500)$

$= \underline{12420 \text{ kN}}$

b) Balanced condition of failure



$\frac{X_{bal}}{540 - X_{bal}} = \frac{0.0035}{0.00217}$

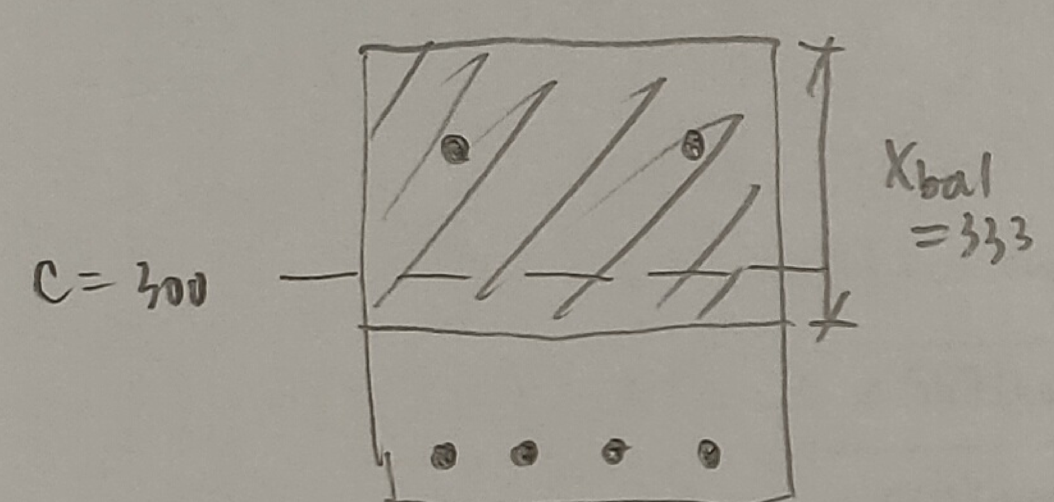
$0.62 X_{bal} = 540 - X_{bal}$

$1.62 X_{bal} = 540$

$X_{bal} = 333$ //

Check if compress steel yield

$\Rightarrow \varepsilon_{sc} = 0.0035 \times \frac{333 - 60}{333} = 0.0029 > 0.00217$ (yielded)



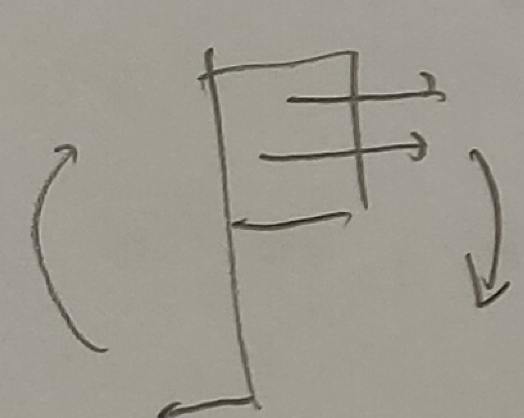
$N_{bal} = 0.567 f_{ck} A_c + 0.87 f_{yk} A_{sc1} - 0.87 f_{yk} A_{sc2}$

$= 0.567(50)(500)(0.8 \times 333) + 0.87(500)(\frac{1}{3} \times 0.03 \times 600 \times 500)$

$- 0.87 (500)(\frac{2}{3} \times 0.03 \times 600 \times 500)$

$= 3776220 + 1305000 - 2610000$

$= 2471220 = \underline{2471.22 \text{ kN}}$ //



$M_{bal} = F_c(300 - 0.4(333)) + (F_{s1} + F_{s2})(d - 300)$

$= 3776220(166.8) + (1305000 + 2610000)(540 - 300)$

$= \underline{1569.5 \text{ kNm}}$ //

c) Pure bending failure (N=0)

Assume comp. steel has NOT yielded.

$\varepsilon_{s1} = \frac{x - 60}{x} \times 0.0035$

$f_{s1} = E_{s1} \varepsilon_{s1} = 200 \times 10^3 \times 0.0035 \times \frac{x-60}{x}$

$= \underline{\frac{700(x-60)}{x}}$

$\Sigma F = 0$

$F_{s1} + F_c = F_{s2}$

$0.87 \left(\frac{700(x-60)}{x}\right)(\frac{1}{3} \times 0.03 \times 600 \times 500) + 0.567(50)(500)(0.8x) = 0.87(500)(\frac{2}{3} \times 0.03 \times 600 \times 500)$

$2100000 \left(\frac{x-60}{x}\right) + 11340x = 2610000$

$2100000x - 126000000 + 11340x^2 - 2610000x = 0$

$11340x^2 - 510000x - 126000000 = 0$

$x = 130.3$ m

$f_{s1} \Rightarrow 377.67 \leadsto F_{s1} = 1133000$ N

Taking moment at centreline of tension steel.

$M = F_c(d - 0.4x) + F_s(d - d')$

$= 0.567(50)(500)(0.8 \times 130.3)(540 - 0.4 \times 130.3) + 1133000.77(540 - 60)$

$= 720892463.8 + 543840369.6$

$= 1264.73 \text{ kNm}$