CV3011 PYP 15/16

1) a) sagging moment at end span

$= 300 + (360 \times 15\%) / 2$

$= 327$ kNm.

assume, using steel with diameter 32mm

$d = 500 - 40 - 13 - \frac{32}{2}$

$= 431$ mm

$K = \frac{M}{f_{cu} b d^2} = \frac{327 \times 10^6}{40 \times 300 \times 431^2}$

$= 0.147 \leq 0.167$ ~~0.129~~

$X_{bal} = \frac{\delta - K_1}{K_2} d$

$= \frac{0.85 - 0.44}{1.25}(431)$ (comp. steel ~~not~~ required)

$= 141.37$ mm

$d' = 40 + 13 + 16 = 69$

$Z = \left(0.5 + \sqrt{0.25 - \frac{K}{1.135}}\right) d = 365.1$ mm.

$A_s = \frac{M}{f_y Z \, 0.87} = 2059 \text{ mm}^2$

$\frac{d'}{d} = 0.16 > 0.125$ (not yielded)

provide 3H32 $= 2414 \text{ mm}^2$

$f_{sc} = E_{sc} \varepsilon_{sc}$

$= 700 \frac{x - d'}{x}$

$= 358.34$.

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

$= 254.81 \text{ mm}^2$ provide

$A_s = \frac{K_{bal} f_{cu} b d^2}{0.87 f_y Z} + A_s' \left(\frac{f_{sc}}{0.87 f_y}\right) = 1870.446 + 254.81 \left(\frac{358.34}{0.87 \times 500}\right)$

$= 2078 \text{ mm}^2$

b) Hogging moment $= 360 \times 0.85 = 306$ kNm.

$K = \frac{M}{f_{cu} b d^2} = \frac{306 \times 10^6}{40 \times 300 \times 431^2} = 0.137 > 0.129$

$\phi 10$ (comp. steel required)

$d' = 55$

$d = 442$

0.139

$\boxed{X_{bal} = \left(\frac{\delta - K_1}{K_2}\right) d} = 141.37$ mm

$d' = 40 + 13 + \frac{32}{2} = 69$ mm

56

$\frac{d'}{d} = 0.16 > 0.125$ (comp steel has not yielded !)

$f_{sc} = E_{sc} \varepsilon_{sc}$

$= 700 (x - d')/x$

$= 358.34 \text{ N/mm}^2$

$Z = 0.869 d$.

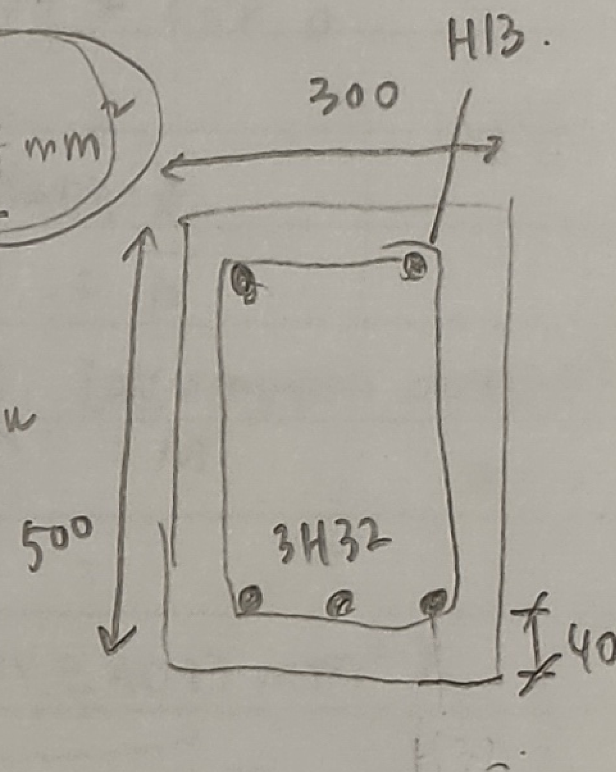
$A_s' = \frac{(K - K_{bal}) f_{cu} b d^2}{f_{sc} (d - d')} = 137.5 \text{ mm}^2$

$A_s = \frac{K_{bal} f_{cu} b d^2}{0.87 f_y Z} + \frac{A_s' f_{sc}}{0.87 f_y}$

$= 1764.98 + 113.27$

$= 1878.25 \text{ mm}^2$

3H32 → 2412 mm^2

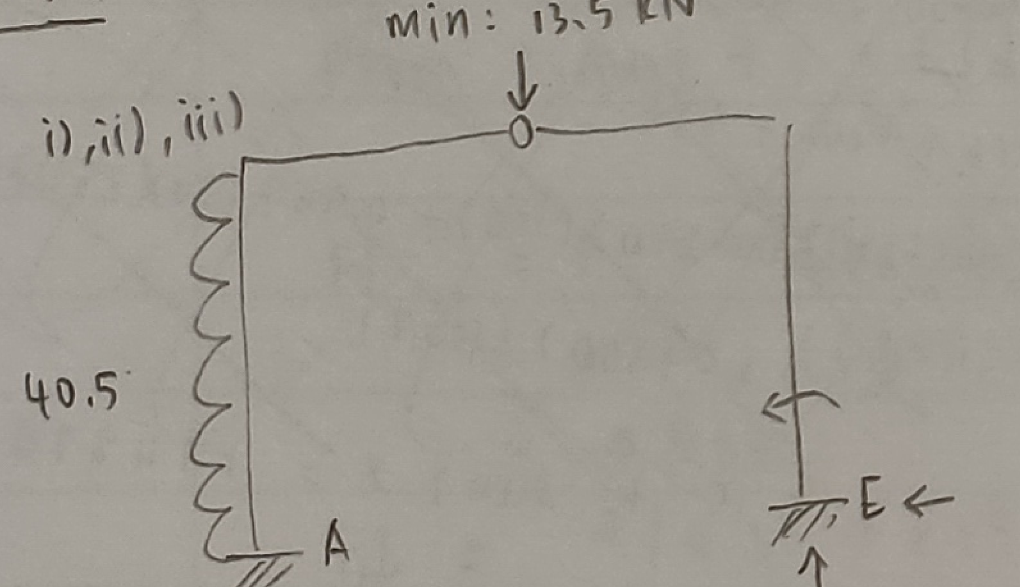


PYP 16/17

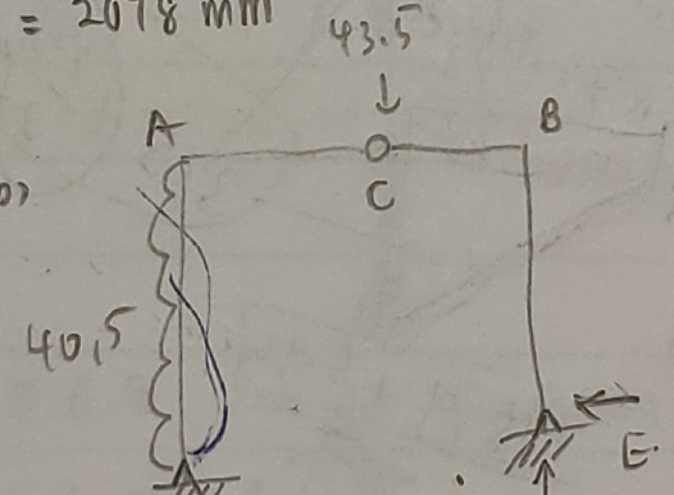
max: 43.5 kN

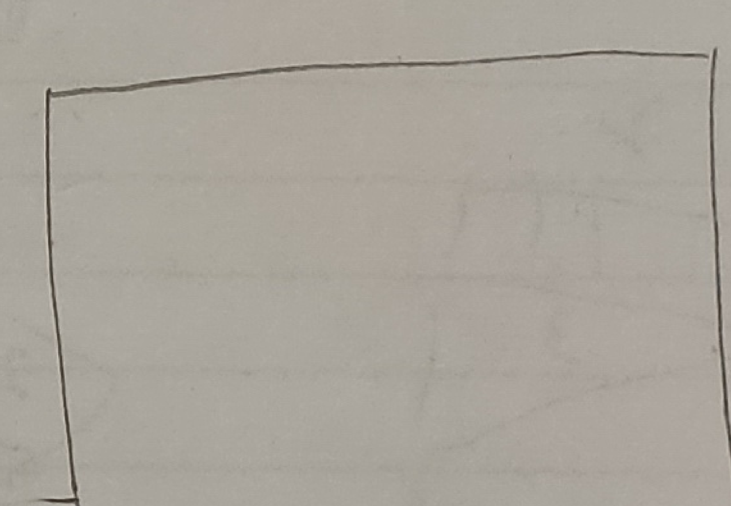
min: 13.5 kN

1) a) i), ii), iii)



b)





For max upward reaction at E (use max case).

$\Sigma M_A = 0$.

$40.5 \times 1.5 + 43.5 \times 3 = F_E \times 6$

$F_E = 31.875$ kN ✓

$F_A = 43.5 - 31.875 = 11.625$ kN ✓

max downward reaction of A (use min case)

$\Sigma M_A = 0$

$40.5 \times 1.5 + 13.5 \times 3 = F_E \times 6$

$F_E = 16.875$ kN

$F_A = 13.5 - 16.875 = -3.375$ kN

$E_y = 31.875$ kN

$A_y = 11.625$ kN.

$\Sigma M_C = 0$.

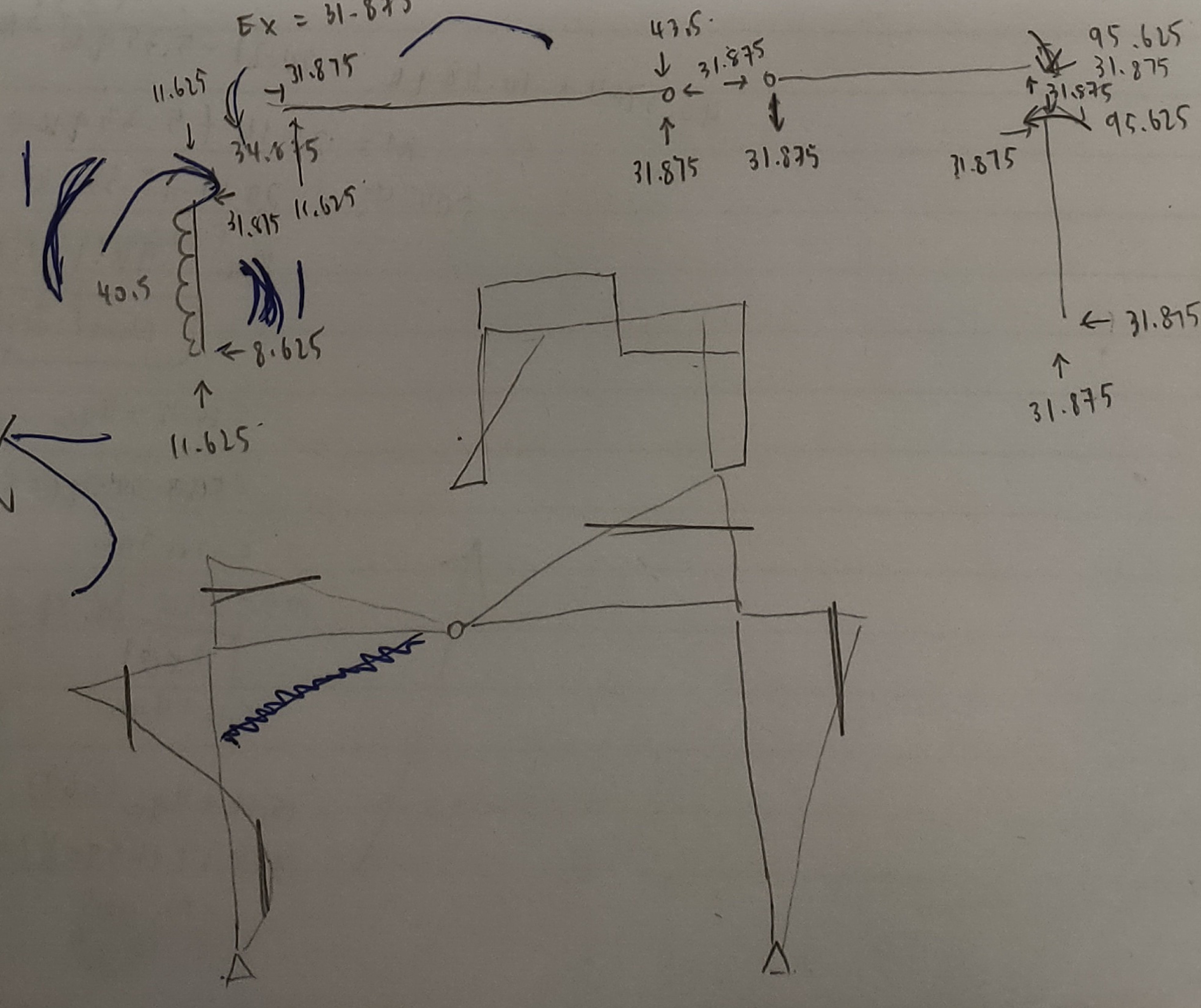
$31.875 \times 3 = 3 \times E_x$

$E_x = 31.875$

$\Sigma F_x = 0$.

$A_x + E_x = 40.5$

$A_x = 8.625$ kN.



CV3011 PYP 16/17

c) $f_{cu} = 30\ N/mm^2$ $d = 400$

$f_{yu} = 500\ N/mm^2$

$k = \frac{M}{f_{cu} b d^2} = \frac{95.625 \times 10^6}{30 \times 250 \times 400^2}$

$= 0.080 < 0.167$

(compression steel no need).

$z = \left(0.5 + \sqrt{0.25 - \frac{k}{1.135}}\right) d = 369.48\ mm.$

2H25

$F_{cc} = F_{ST}$

$0.567 \times 30 \times 0.8x \times 250 = 982 \times 0.87 \times 500$

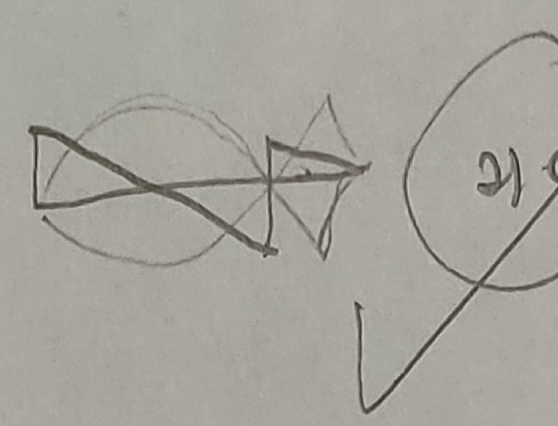
$x = 125.6\ mm.$

$\frac{x}{d} = 0.314 < 0.617$ (yielded).

$M = A_s(0.87 f_{yu}) z$

$= 982 \times 0.87 \times 500 \times (d - 0.4x)$

$= 149.4\ kNm > 95.625\ kNm.$



2) a) Check for ductile failure mode

Assume above flange ~~(Hogging)~~. 1-1 Saggiy

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

~~$0.567 f_{cu}(b_f - b_w) h_f + 0.567 f_{cu} b_w (0.8x) = 0.87 A_s f_{yu}$~~

~~637815 + 3402x = 1050090~~

$x = 121.168\ mm$

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

$0.87 \times 500 \times ~~2414~~ = 0.567 \times 30 \times 500 \times 0.8x + 0.87 \times 1010 \times 500$

$x = 89.76\ mm < 150 \cdot (h_f)$

$\frac{d'}{d} = 0.06 < 0.171$ yielded.

$M = F_{cc} z_c + F_{sc} z_s$ $d = 400 + 150 - 40 = 510$

$= 0.567 \times 30 \times 500 \times 0.80 \times 89.76 \times (d - 0.4x)$

$+ 0.87 \times 1010 \times 500 \times (d - d')$

$= 281.54 + 500.43$ critical

$= 500.43\ kNm$

Hogging. ~~Sagging~~ 2-2

~~below~~ ~~above flange~~ below flange

~~$F_{st} = F_{cc} + F_{sc}$~~

~~$0.87 \times 500 \times 402 = 0.567 \times 30 \times 500 \times 0.8x + 0.87 \times 1571 \times 500$~~

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

~~$0.567(30)(500-250)(150) + 0.567(30)(250)(0.8x)$~~

~~$= 0.87(500)(402)$~~

~~$637875 + 3402x = 174870$~~

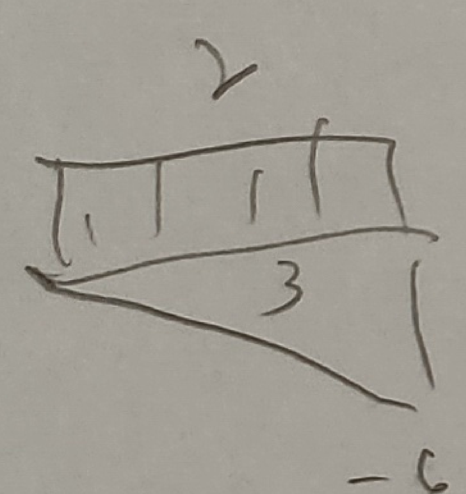
above flange $\frac{d'}{d} = 0.078 < 0.171$

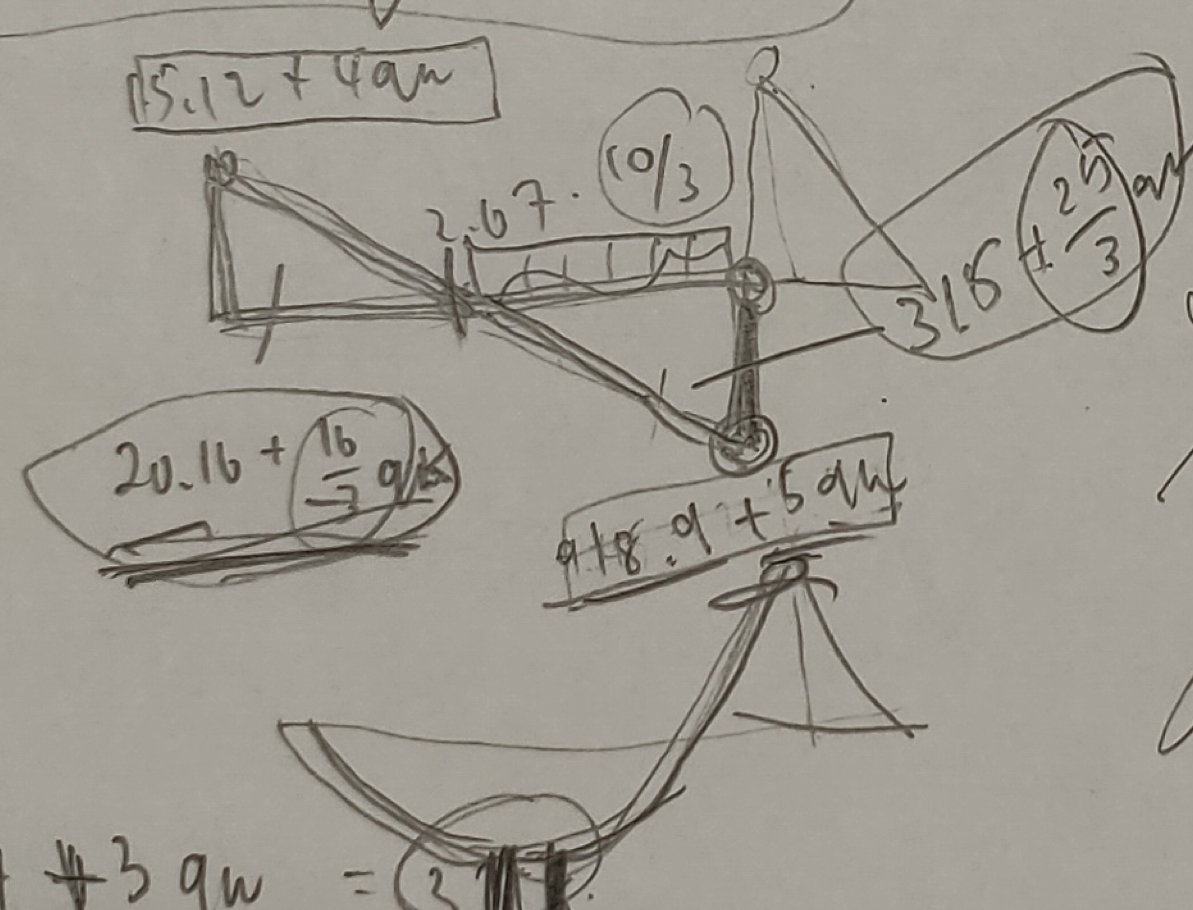
$F_{st} = F_{cc} + F_{sc}$

$0.87 \times 500 \times 1571 = 0.567 \times 30 \times 500 \times 0.8x + 0.87 \times 402 \times 500$

$x = 74.73\ mm < 150\ (h_f)$

$\therefore$ assumption correct.!





$11.34 + 3q_u = 311$

$q_u = 100$

$40.3704 + 10.68 q_u - 20.21 - 5.35 q_u - M = 0$

$M = 20.16 + 5.33 q_u.$

$500.43 = 20.16 + 5.33 q_u$

$q_u = 90.1\ kN/m$

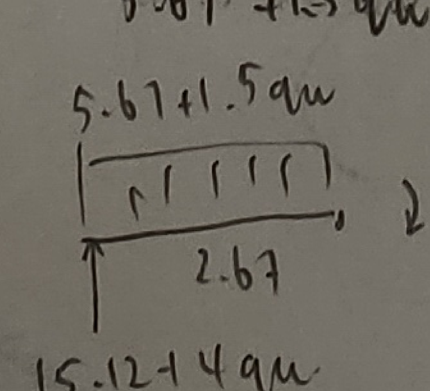
$\boxed{M_{max} \text{ occurs at } V = 0}$ $M = F_c z_c + F_{sc} z_s$

$= 0.567 \times 30 \times 500 \times 0.8 \times 74.73 \times (510 - 0.4x)$

$+ 0.87 \times 500 \times 402 \times (510 - 60)$

$= 328\ kNm$

$\frac{15.12 + 4q_u}{5.67 + 1.5 q_u} = \frac{8}{3} = 2.67$



self weight $= 0.175\ mm^2 \times 24 = 4.2\ kN/m$

load $= 4.2 \times 1.35 + 1.5 q_u$

$= 5.67 + 1.5 q_u\ kN/m.$

$S_1 = ~~32q_u + 120.96~~$

$S_1 = 15.12 + 4q_u$

$(5.67 + 1.5 q_u)8 = (45.36 + 12 q_u)\ kN.$

$15.12 + 4q_u (2.67)$

$-(5.67 + 1.5 q_u)(2.67)\frac{(2.67)}{2}$

$- M = 0$

$\Sigma M_2 = 0.$

$(45.36 + 12 q_u)(4)(3) - (45.36 + 12 q_u)(4)(1)$

$90.72 + 24 q_u - S_1(6)$

~~$725.76 + 192$~~$q_u - S_1 6 = 0$

NO:

CN3011 PYP 2015/16

DATE:

2) a) Design load $= 1.35 \times 70 + 1.5 \times 46$

$= 163.5$ kN/m

0.6 1.35

Simply supported

$V_{max} = wl/2 = (163.5)(6.2)/2 = 506.85$ kN

Gk/Qk

$M_{max} = wl^2/8 = (163.5)(6.2)^2/8 = 785.62$ kNm

Concrete cover 35mm, stirrup size 12mm, assume using ϕ32 bars,

$d = 575 - 35 - 12 - 32/2$

$= 512$ mm

assume NA in flange so $b = b_f$

$K = \frac{M}{bd^2 f_{ck}} = \frac{785.62 \times 10^6}{(650)(512)^2(40)} = 0.115 < 0.617$ (assume NA lies within flange)

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

$= 453.36$ m

$S = 2(d - z) = 117.28$ m < 150 (assumption correct)

$(10^3)\sqrt{f_{ck}}$

$A_s = \frac{M}{0.87 f_{yk} z} = \frac{785.62}{0.87(500)(453.36)} = 3984$ mm² → use 5H32 ($A_{s,prov} = 4023$ mm²)

$p = \frac{100 A_{s,req}}{bd} = \frac{100(3984)}{(275)(512)} = 2.83\ \%$

reinforcement in web, so $b = b_w$

From Figure 7, $l/d = 14$

F1: $= 1 - 0.1((b_f/b_w - 1) \geq 0.8$ ← T section

$= 1 - 0.1((650/275) - 1) \geq 0.8$

$= 0.864$

F2 $= 7/6.2 = 1.29 \leq 1$ ← span < 7

$= 1.0$

F3 $= 310/\sigma_s$

$\sigma_s = \sigma_{su}\left(\frac{A_{s,prov}}{A_{s,req}}\right)\left(\frac{1}{\delta}\right)$

$G_K/Q_K = 70/46 = 1.52$

For shopping area, $\psi_2 = 0.6$

$\sigma_{su} = 260$ N/mm²

$\delta = 1.0$ (simply supported)

$\sigma_s = 260 \times \frac{4023}{3984} \times \frac{1}{1}$

$= 262.55$ N/mm²

F3 $= 310/\sigma_s = 1.18$

Allowable L/d $= 1 \times 14 \times 0.864 \times 1.0 \times 1.18$

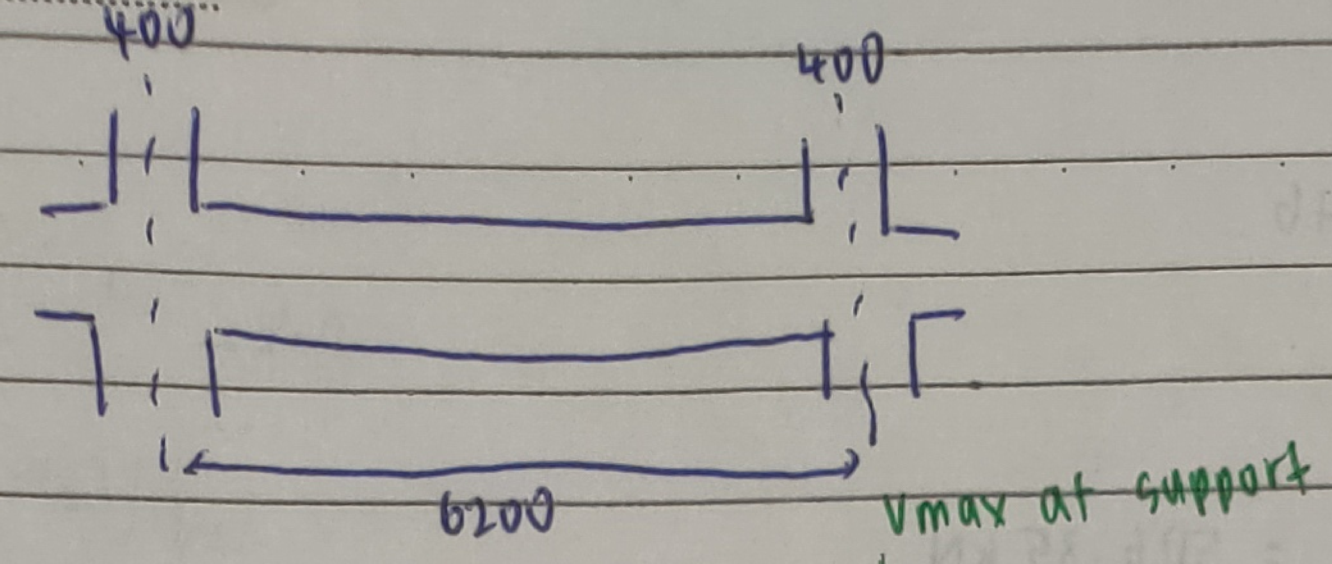
$= 14.27$ m

Actual L/d $= \frac{6.2 \times 10^3}{512} = 12.11$ m < 14.27m

∴ OK!

POP bazic™

27 b)



(Z1) V_{Ef} (at support face) $= 506.85 - 163.5(0.2)$

$= 474.15$ kN

$V_{Rd,max(22)} = 0.124\, b_w d\, (1 - f_{ck}/250)\, f_{ck}$

$= 0.124\,(275)(512)(1 - 40/250)(40)$

$= 586.63$ kN

since $V_{Ef} < V_{Rd,max(22)}$, then $\theta = 22°$, $\cot\theta = 2.5$

(Z2) at ld from support face, * d = 512 mm.

$V_{Eld} = 506.85 - 163.5(0.2 + 0.512)$

$= 390.438$ kN

$$\frac{A_{sw}}{s} = \frac{V_{Eld}}{0.78 d f_{yk} \cot\theta} = \frac{390.438}{0.78(512)(500)(2.5)} = 0.782$$

select $\phi 12$ with spacing of 275 mm, $A_{sw}/s = 0.822 > 0.782$

(Z3) $$\frac{A_{s,min}}{s} = \frac{0.08 f_{ck}^{0.5} b_w}{f_{yw}} = \frac{0.08(25)^{0.5}(275)}{500} = 0.22$$

select $\phi 12$ with spacing 400mm, $A_{sw}/s = 0.565 > 0.22$

$$V_{min} = \frac{A_{sw}}{s} 0.78 d f_{yk} \cot\theta = 0.565(0.78)(512)(500)(2.5) = 282 \text{ kN}$$

Z1 + Z2 ⇒ no. of stirrups

$$X_{L/R} = \frac{V_{Ef} - V_{min}}{W} = \frac{474.15 - 282.05}{163.5}$$

$= 1.175$ m

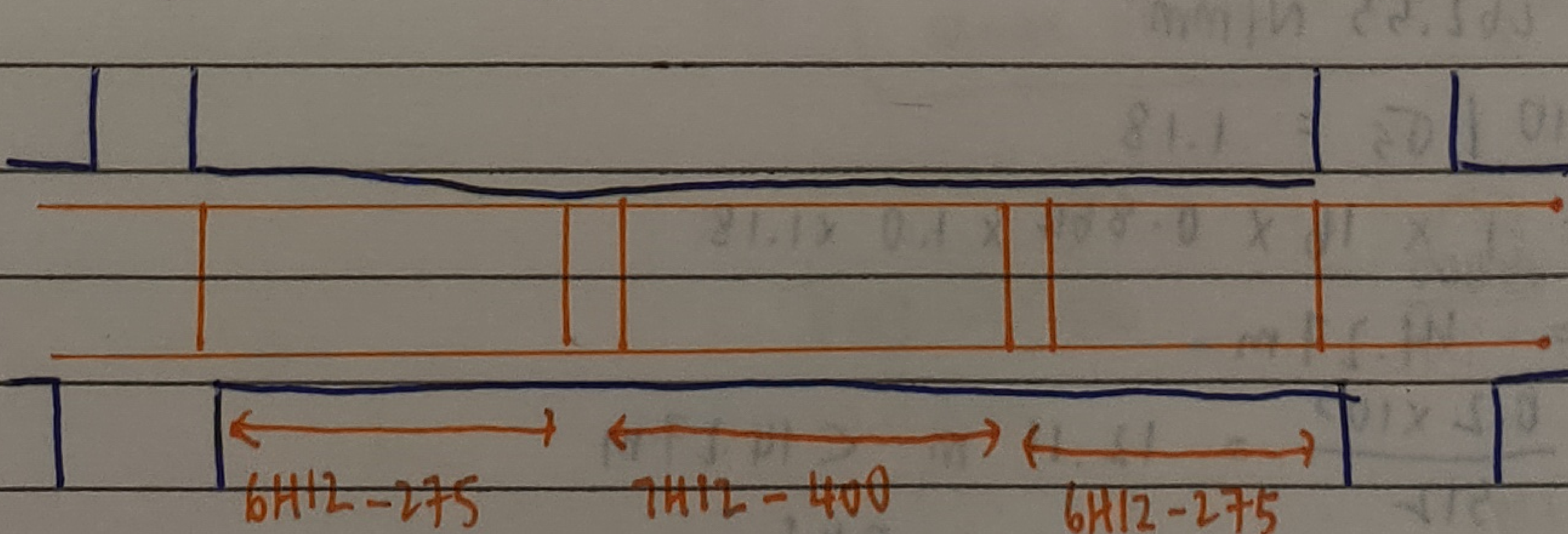
length $= (6-1)$ 5×275

$= 1375$ mm

$$\text{no. of links} = 1 + \frac{X_L}{S} = 1 + \frac{1.175 \times 10^3}{275} = 5.27 \approx 6$$

Z3 ⇒ $X_L = 6.2 - 2(1.375) - 2(0.2) = 3.05$ m

$$\text{no. of links} = \frac{X_L}{S} - 1 = \frac{3.05 \times 10^3}{400} - 1 = 6.625 \approx 7$$



① can concrete & unit weight be assumed ? 24/25
② what is $A_{s,min}$ & what significance it plays in the determination of $A_{s,req}$?

CV3011 PYP 2015/16

Monolithically → restrained

Date No.

Slab thickness
~~Design~~

3) a) Slab thickness = 150 mm

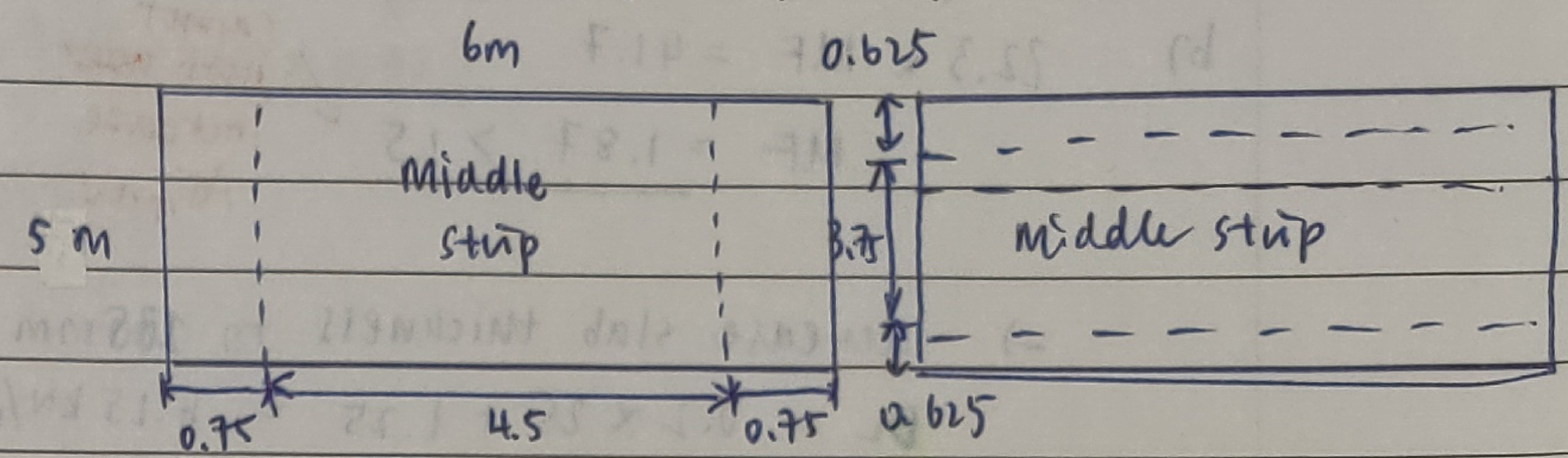
② Loadings

DL = $0.15 \times 25 + 1.25 = 5\ kN/m^2$

LL = $4\ kN/m^2$

Design load, $n = 1.35 \times 5 + 1.5 \times 4$

$\geq 12.75\ kN/m^2$



Based on table 3.14. Case 9, $l_y/l_x = 6/5 = 1.2$

③ β_{sx}, β_{sy} from Table

$\beta_{sx} = 0.074$

$\beta_{sy} = 0.056$

$\boxed{\frac{0.074}{0.056}}$

$A_{s,min} = \max(0.26\ (f_{ctm}/f_{yk})\ bd,\ 0.0013\ bd)$

$= 0.26\ (\frac{0.3(25)^{2/3}}{500}) \times 1000 \times 120$

$= 160\ mm^2$

④ M_{sx}, M_{sy}

$M_{sx} = \beta_{sx} \cdot n \cdot l_x^2 = 0.074\ (12.75)(5)^2 = 23.59\ kN\ m$

$M_{sy} = \beta_{sy} \cdot n \cdot l_x^2 = 0.056\ (12.75)(5)^2 = 17.85\ kNm$

⑤ d_x, d_y

$d_x = 150 - 25 - 5 = 120\ mm$

$d_y = 120 - 10 = 110\ mm$

Max spacing $= 2h < 250$

$= 2(150) = 300 < \underline{250}$

⑥ Flexural reinforcement

Midspan (x-dir)

K: $K = \frac{M}{f_{ck}bd^2} = \frac{23.59 \times 10^6}{25 \times 1000 \times 120^2} = 0.066 < 0.167$ (singly reinforced)

z: $z = d\left(0.5 + \sqrt{0.25 - \frac{K}{1.134}}\right) = 0.938\ d < 0.95\ d$

$A_{s,req}$: $A_{s,req} = \frac{M}{0.87 f_{yk} z} = \frac{23.59 \times 10^6}{0.87 \times 500 \times 0.938 \times 120} = 481.8\ mm^2$

⇒ Provide H10 - 150 ($A_{s,prov} = 524\ mm^2$) < 250

Midspan (y-dir)

$K = \frac{M}{f_{ck}bd^2} = \frac{17.85 \times 10^6}{25 \times 1000 \times 110^2} = 0.059 < 0.167$ (singly reinforced)

$z = d\left(0.5 + \sqrt{0.25 - \frac{K}{1.134}}\right) = 0.945\ d < 0.95\ d$.

$A_{s,req} = \frac{M}{0.87 f_{yk} z} = \frac{17.85 \times 10^6}{0.87 \times 500 \times 0.945 \times 110} = 394.75\ mm^2$

⇒ Provide H10 - 180 ($A_{s,prov} = 436\ mm^2$) < 250

Deflection check (shorter span) use formula

$p = \frac{A_{s,req}}{bd} \times 100 = 0.004015$ (> 0.35%)

$p_0 = 10^{-3}\sqrt{f_{cu}} = 0.005$

$p \leq p_0$, $l/d = K\left[11 + 1.5\sqrt{f_{cu}}\frac{p_0}{p} + 3.2\sqrt{f_{cu}}\left(\frac{p_0}{p} - 1\right)^{3/2}\right]$

$= 1.0\left[11 + 1.5\sqrt{25}\ \frac{0.005}{0.004015} + 3.2\sqrt{25}\left(\frac{0.005}{0.004015} - 1\right)^{3/2}\right]$

$= 22.3$

Allowable $l/d = 22.3 \times \frac{A_{s,prov}}{A_{s,req}} = 24.23$

Actual $l/d = \frac{5000}{120} = 41.7 > 24.23$ (Not ok!)

① Is it still ok to modify the section by ↑ $A_{s,prov}$ even if $A_{s,prov}/A_{s,req} > 1.5$? 7.5|1.5

Date No.

b) $22.3 \times MF = 41.7$

$MF = 1.87 > 1.5$ ← Cannot just ~~use~~ increase $A_{s,prov}$

Increase gradually by 20/25 mm

⇒ Increase slab thickness to 200 mm (175 mm)

$d_x = 200 - 25 - 5 = 170$ mm

$d_y = 170 - 10 = 160$ mm

$DL = 0.2 \times 25 + 1.25 = 6.25$ kN/m²

$LL = 4$ kN/m²

$n = 1.35 \times 6.25 + 1.5 \times 4 = 14.44$ kN/m²

$M_x = 0.0\cancel{47}^{74} \times 14.44 \times 5\cancel{4}^2 = \cancel{10.86}$ kNm; $\cancel{16.967}$ 26.714

$M_y = 0.056 \times 14.44 \times 5\cancel{4}^2 = \cancel{12.94}$ kNm 20.216

X-dir

$k = \frac{M}{f_{ck}bd^2} = \cancel{0.015}$ 0.037 < 0.167

$z = 0.\cancel{987}^{966} d < 0.95d$

$A_{s,req} = \cancel{154.6}$ mm² 380.26 mm²

⇒ Provide H10 - $\cancel{300}$ 200 ($A_{s,prov} = \cancel{262}$ $\cancel{314}$ 393 mm²)

Y-dir

$k = \frac{M}{f_{ck}bd^2} = \cancel{0.0203}$ 0.0316 < 0.167

$z = \cancel{0.982}^{0.971} d < 0.95d$

$A_{s,req} = \cancel{195.7}$ mm² 305.75

⇒ Provide H10 - $\cancel{300}$ 225 ($A_{s,prov} = \cancel{262}$ $\cancel{314}$ 349 mm²)

Deflection Check

$\rho = \frac{A_{s,req}}{bd} = \cancel{0.001825} = 0.00224 < 0.35\%$

Allowable $l/d = 30 \times \cancel{\frac{262}{154.6}} = \cancel{50.84}$ $\frac{393}{380.26} = 31$

Actual $l/d = \frac{5000}{170} = 29.41 < \cancel{50.84}$ 31.

∴ OK!

TP 2015/16 (column & footings)

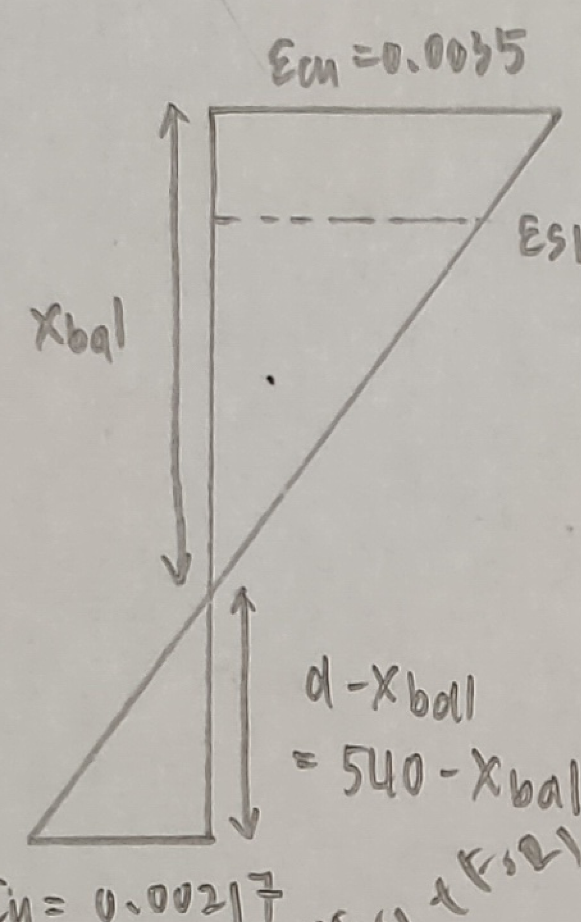
Q1 a) ① Pure axial compression, ($M=0$)

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

$= 0.567(25)(300\times600) + 0.87(500)(300\times600\times0.02)$

$= 4117.5$ kN   Point 1 → (0, 4117.5)

② Balanced condition of failure



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

$0.00217 X_{bal} = 1.89 - 0.0035 X_{bal}$

$0.00567 X_{bal} = 1.89$

$X_{bal} = 333$ mm //

① X_{bal}
② check for steel yielding.
③ $N_{bal} = F_{cc} + F_{sc} - F_{st}$
④ M_{bal} (abt centroidal line)

$\varepsilon_{sc} = 0.0035 \times \dfrac{333-60}{333} = 0.0029 > 0.00217$ → yielded !

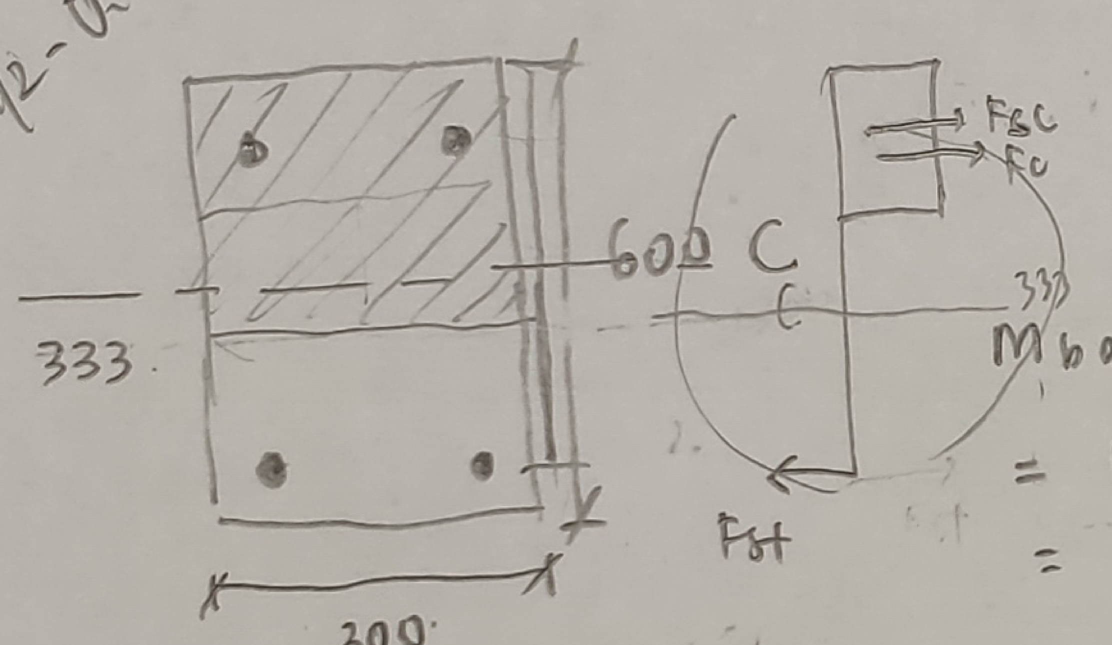
($F_{sc} = F_{ST} = 0.87 f_{yk} A_{sc}$) $A_{sc1} = A_{sc2}$

$F_c (h/2 - 0.4x) + (F_{s1}+F_{s2})(d - h/2)$

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

$= 0.567(25)(300)(0.8 X_{bal})$

$= 1132.9$ kN.



M_{bal} (about centroidal line)   same right?

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

$= 1132866[300 - 0.4(333)] + 2[0.87(500)(300)(600)(0.02)](540-360)$

$= 940.64$ kNm.

Point 2 (940.64, 1132.9)

③ Tension failure, Assume $x = 250$ mm (< 333mm)

$\varepsilon_{s1} = \dfrac{250-60}{250} \times 0.0035 = 0.00266 > 0.00217$ → yielded.

$F_{s1} = F_{s2} = 0.87 f_{yk} \times (600\times300)\times0.02 = 1566000$ N

$F_c = 0.567 f_{cu}(0.8x)(300) = 850500$ N.

① Assume an $x < X_{bal}$
② Check comp steel yield
③ $N = F_c + F_{s1} - F_{s2}$
④ M (abt centroidal line)

$N \; \cancel{N_{bal}} = F_c + F_{s1} - F_{s2}$

$= 850.5$ kN.

* F_c(Centroid $- 0.4X$) + $(F_{s1} + F_{s2})$($d -$ centroid)

$M \; \cancel{M_{bal}} = F_c(300 - 0.4\times250) + (F_{s1} + F_{s2})(540 - 300)$

$= 921.81$ kN

Point 3 (921.8, 850.5)

① Assume comp steel NOT yielded
$\varepsilon_{s1} = \dfrac{x - d'}{x} \times 0.0035$
$f_{s1} = F_{s1} \times \varepsilon_{s1} = 700 \dfrac{x - d'}{x}$
② $\Sigma F = 0$ $F_c + F_{s1} = F_{s2}$
③ M abt centroid of tension steel

④ Pure Bending ($N=0$)

Assume comp steel has NOT yielded.

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

$f_{s1} = \varepsilon_{s1} E_s = \dfrac{x-60}{x} 0.0035 \times 200\times10^3$

$= 700 \dfrac{(x-60)}{x}$

$\Sigma F = 0.$

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

$0.567 f_{cu} \times 300 \times 0.8x + f_{s1} \times 1800 = 0.87 f_{yk}(1800)$

$3402x + 1260000\left(\dfrac{x-60}{x}\right) = 783000$

$3402x^2 + 1260000x - 75600000 = 783000x$

$3402x^2 + 477000x - 75600000 = 0$

$x = 94.6$

$f_{s1} = 256.03 \Rightarrow F_{s1} = 460846$

Talling moment abt centreline of tension steel:

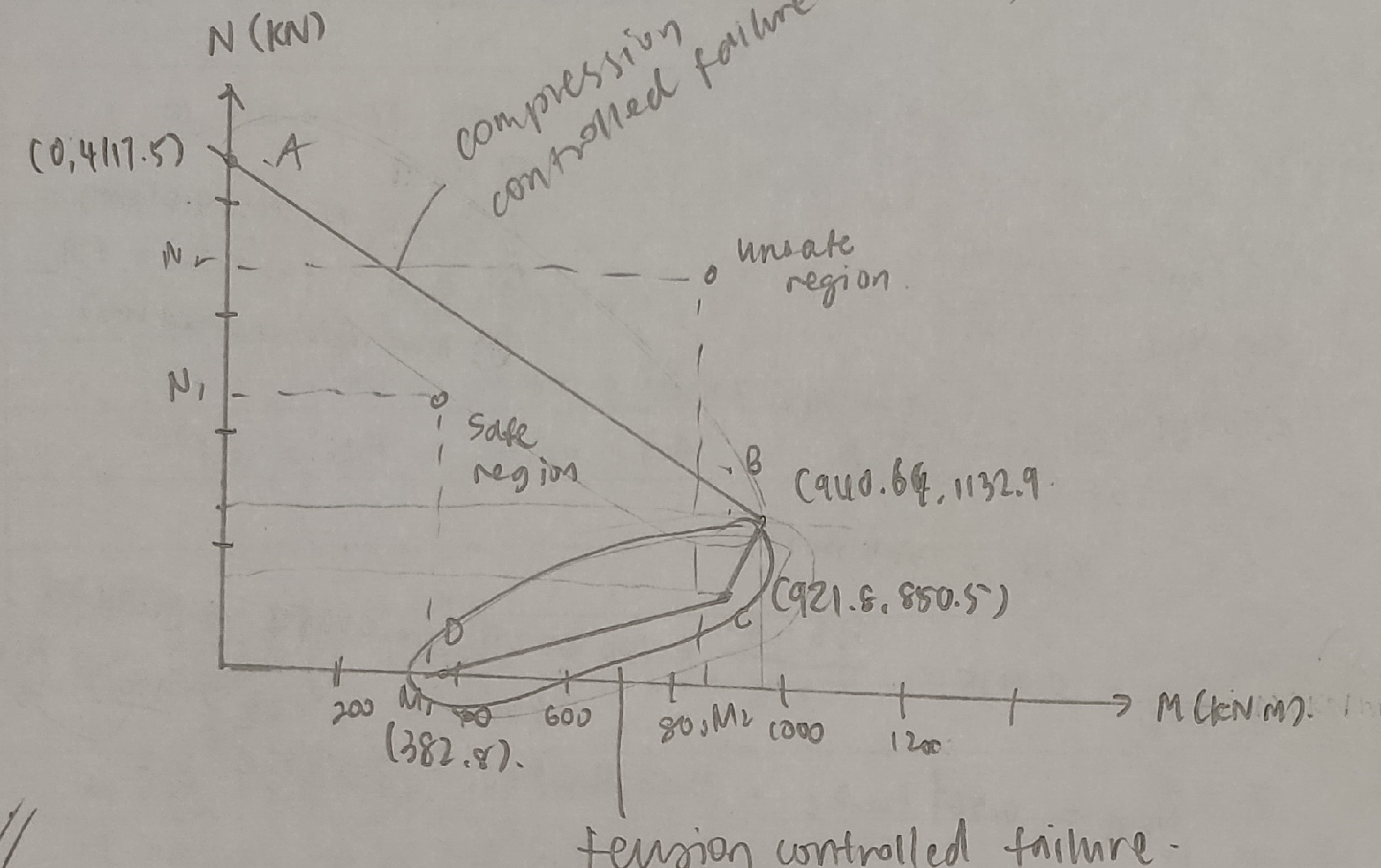
$$M = F_c(d - 0.4x) + F_s(d - d')$$

$$= 3402(94.6)(540 - 0.4 \times 94.6) + 460846(540 - 60)$$

$$= 382.8 \text{ kNm}$$

point 4 (382.8, 0)

b)



what more to say?

→ Point A is point of pure axial load, and point B is the balanced state, where yielding of steel & crushing of concrete occurs simultaneously. Point C is tension failure & Point D is pure bending.

From point A to B, compression controls the failures while from point B to D, tension controll the failures.
↳ tension steel not yielded.