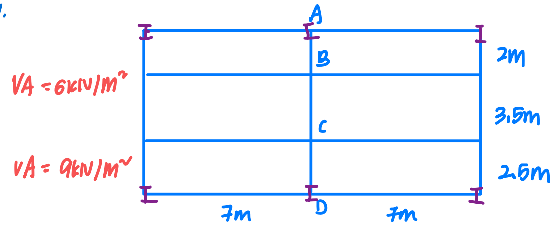
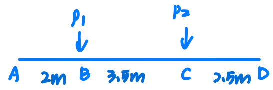
CV3012 2022-2023 Semester 2 By Tan Yi Xun

1.





PA = 8kN/m²

(a) $VA = 6kN/m^2$ $i_1 = 6(1.5) + 8(1.35) = 19.8kN/m^2$

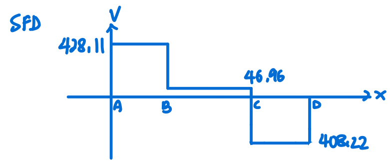
$VA = 9kN/m^2$ $i_2 = 9(1.5) + 8(1.35) = 24.3kN/m^2$

$P_1 = [\frac{1}{2}(7\times2) + \frac{1}{2}(7\times3.5)] \times 19.8 = 381.15kN$

$P_2 = [\frac{1}{2}(7\times3.5)] \times 19.8 + [\frac{1}{2}(7\times2.5)] \times 24.3 = 455.18kN$

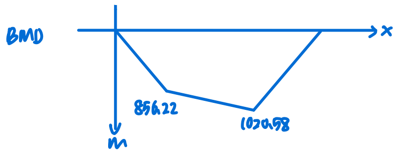
$A_y = 428.11kN$ $D_y = 408.22kN$

SFD



$N_{Ed} = 428.11kN$

BMD



$M_{Ed} = 1020.58kNm$

(b) ① Selection

$f_y = 355 N/mm^2$, assume $M = 1020.58kNm$

$M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}}$

$W_{pl} > \frac{M \cdot \gamma_{M0}}{f_y} = 2874.873 cm^3$

(listed section designation all satisfies $W_{pl} > 2874.873cm^3$)

∴ Choose any of 3
- 686×254×125
- 610×229×125
- 533×210×122

② Section Classification

$\varepsilon = \sqrt{235/f_y} = 0.8136$

→ outstand flange $c_f/t_f = 6.51 \le 9\varepsilon = 7.32$ ∴ class 1 flange

→ internal web $c_w/t_w = 52.6 \le 72\varepsilon = 58.58$ ∴ class 1 web

∴ Class 1 cross section

③ LTB resistance check (Segment BC → L = 3.5m)

$\psi = \frac{856.22}{1020.58} = 0.839 \Rightarrow C_1 = 1.75 - 1.05\psi + 0.3\psi^2 = 1.08 < 2.3$

$M_{cr} = C_1 \frac{\pi^2 E I_z}{L^2} \sqrt{\frac{I_w}{I_z} + \frac{L^2 G I_t}{\pi^2 E I_z}} = 1.08(2591.3) = 2798.604kNm$

1.08(2170.4) = 2344.032
1.08(1754.5) = 1894.782

$\bar{\lambda}_{LT} = \sqrt{W_y f_y / M_{cr}} = 0.7114$ 0.7465 0.7743

$h/b = 2.679 > 2$ → buckling curve b $\alpha_{LT} = 0.34$

$\phi_{LT} = 0.5(1 + 0.34(0.7114 - 0.2) + 0.7114^2) = 0.84$ 0.8715 0.8974

$\chi_{LT} = 0.7772$ 0.7569 0.7402

$M_{b,Rd} = \chi_{LT} \frac{W_y f_y}{\gamma_{M1}} = 1100.87kNm > M_{Ed} = 1020.58kNm$ ∴ LTB resistance is adequate

988kNm < M_{Ed} ∴ LTB resistance isn't adequate

840kNm < M_{Ed} ∴ LTB resistance isn't adequate

LTB resistance check (Segment CD → L = 2.5m)

$\psi = 0$ $C_1 = 1.77$

$M_{cr} = 1.77(4948.2) = 8758.314kNm$

$\bar{\lambda}_{LT} = \sqrt{W_y f_y / M_{cr}} = 0.4022$

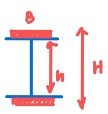
$\alpha_{LT} = 0.34$

$\phi_{LT} = 0.6153$

$\chi_{LT} = 0.9252$

$M_{b,Rd} = 1310.446kNm > M_{Ed}$

(c) 200x10mm S355 plates



h = 677.9mm
H = 697.9mm
B = 200mm

$W = \frac{bh^2}{4}$

additional moment capacity

① 686×254×125 $W = \frac{BH^2}{4} - \frac{Bh^2}{4} = \frac{B(H^2-h^2)}{4} = 1375.8cm^3$

$M_{add} = \chi_{LT} \frac{W f_y}{\gamma_{M1}} = 488.409kNm$

② 610×229×125 $W = 1244.4cm^3$

$M_{add} = 441.762cm^3$

③ 533×210×122 $W = 1109cm^3$

$M_{add} = 393.695cm^3$

610×229×125 (h = 612.2mm)

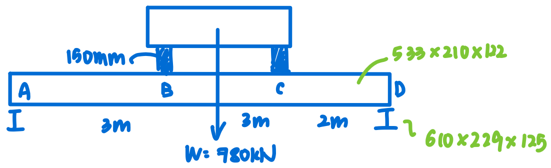
$\frac{B(H^2-h^2)}{4} = 1244.4cm^3$

$M_{add} =$

533×210×122 (h = 544.5) 1109cm³

291.41kNm

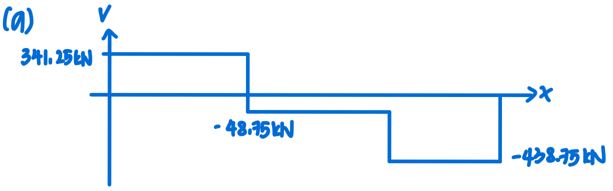
2.

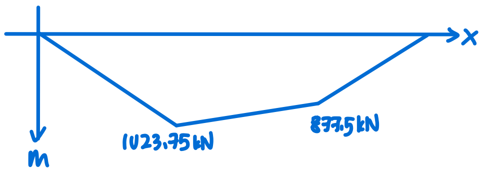


$F_B = F_C = 780kN/2 = 390kN$

$D_y = 438.75kN$ $\quad A_y = 341.25kN$

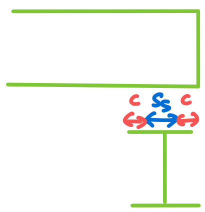
(a)





(b) Transverse force

Location	Magnitude	Load Type
A	341.25kN	(c)
B	390kN	(a)
C	390kN	(a)
D	438.75kN	(c)



(c) Location D ⇒ load type (c)

UB 533×210×122 $\quad h = 544.5cm,\ b = 211.9mm,\ t_w = 12.7mm,\ t_f = 21.3mm$

→ $h_w = h - 2t_f = 501.9mm$

refer to UB 610×229×125

→ $S_s = t_w + 1.6r + 2T_f = 11.9 + 1.6(12.7) + 2(19.6) = 71.42mm$

$c = (b - S_s)/2 = (229 - 71.42)/2 = 78.79mm$

→ $k_F = 2 + 6\left(\frac{S_s + c}{h_w}\right) = 3.7957 < 6$

→ $F_{cr} = 0.9 k_F E \frac{t_w^3}{h_w} = 0.9(3.7957)(210000)\left(\frac{12.7^3}{501.9}\right)$

$= 2927.842$

→ $m_1 = \frac{f_{yf} b_f}{f_{yw} t_w} = 16.6850$

assume $\bar{\lambda}_F > 0.5$ $\quad m_2 = 0.02\left(\frac{h_w}{t_f}\right)^2 = 11.1047$

→ $l_e = \frac{k_F E t_w^2}{2 f_{yw} h_w} = 350.1631mm > S_s + c = 150.21mm$

$\therefore l_e = 150.21mm$

→ $l_y = \min \begin{cases} l_e + t_f\sqrt{\frac{m_1}{2} + \left(\frac{l_e}{t_f}\right)^2 + m_2} = 327.3711mm \\ l_e + t_f\sqrt{m_1 + m_2} = 262.4949mm \end{cases}$

$= 262.4949mm$

→ $\bar{\lambda}_F = \sqrt{\frac{l_y t_w f_{yw}}{F_{cr}}} = 0.5596 > 0.5$ (assumption is correct)

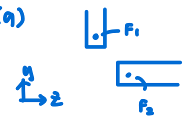
$\chi_F = 0.8935 < 1$

$L_{eff} = 234.55\ mm$

$F_{Rd} = 819.17\ kN > F_{Ed}$

$\therefore$ adequate

3. (a)



$F_1 = 60(3.3)/2 = 99\,kN$

$F_2 = 50(2.9)/2 = 72.5\,kN$

Total $F = F_1 + F_2 + 2200 = 2371.5\,kN$ //

$M_{z,Ed} = F_1(100 + 260/2) = 22.77\,kNm$ //

$M_{y,Ed} = F_2(100 + 260/2) = 16.675\,kNm$ //

(b) → $A = 132(10^2)\,mm^2$, $i = 95.8\,mm$, $W_{pl} = 1160(10^3)\,mm^3$

pin-fix

effective length factor 0.85

$0.85L = 0.85(5.9) = 5.015\,m$

① Cross sectional Resistance check

$$N_{c,Rd} = \frac{Af_y}{\gamma_{M0}} = 3630\,kN > N_{Ed} = 2371.5\,kN$$

∴ adequate

② Buckling Resistance about y, z axis

$\varepsilon = \sqrt{235/275} = 0.9244$

$\lambda_1 = 93.9\varepsilon = 86.8$

$\bar{\lambda} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = 0.6031 > 0.2$

buckling curve a → $\alpha = 0.21$

$\phi = 0.5[1 + 0.21(\bar{\lambda} - 0.2) + \bar{\lambda}^2] = 0.7242$

$\chi = 0.8888 < 1$ ($\chi_y = \chi_z = \chi$ since it's SHS)

$$N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}} = 3226.45\,kN > N_{Ed} = 2371.5\,kN$$

∴ adequate

③ Bending Resistance check

For Square Hollowed Section, $M_{b,Rd} = M_{c,z,Rd}$

$$M_{c,z,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} = 319\,kNm > M_{z,Ed} > M_{y,Ed}$$

∴ adequate

④ Combined Check

$$\frac{N_{Ed}}{N_{b,min,Rd}} + 1.0\frac{M_{y,Ed}}{M_{b,Rd}} + 1.5\frac{M_{z,Ed}}{M_{c,z,Rd}}$$

$$= \frac{2371.5}{3226.45} + \frac{22.77}{319} + 1.5\frac{16.675}{319}$$

$= 0.88 < 1$

∴ satisfied

(c) pin-pin

effective length $1.0L = 5.9\,m$

① Cross sectional Resistance check

$N_{c,Rd} = 3630\,kN > N_{Ed} = 2371.5\,kN$

∴ adequate

② Buckling Resistance about y, z axis

$\varepsilon = \sqrt{235/275} = 0.9244$

$\lambda_1 = 93.9\varepsilon = 86.8$

$\bar{\lambda} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = 0.7095 > 0.2$

buckling curve a → $\alpha = 0.21$

$\phi = 0.5[1 + 0.21(\bar{\lambda} - 0.2) + \bar{\lambda}^2] = 0.8052$

$\chi = 0.8432 < 1$ ($\chi_y = \chi_z = \chi$ since it's SHS)

$$N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}} = 3060.83\,kN > N_{Ed} = 2371.5\,kN$$

∴ adequate

③ Bending Resistance check

For Square Hollowed Section, $M_{b,Rd} = M_{c,z,Rd}$

$$M_{c,z,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} = 319\,kNm > M_{z,Ed} > M_{y,Ed}$$

∴ adequate

④ Combined Check

$$\frac{N_{Ed}}{N_{b,min,Rd}} + 1.0\frac{M_{y,Ed}}{M_{b,Rd}} + 1.5\frac{M_{z,Ed}}{M_{c,z,Rd}}$$

$$= \frac{2371.5}{3060.83} + \frac{22.77}{319} + 1.5\frac{16.675}{319}$$

$= 0.9246$

∴ satisfied

4. $F_{Ed} = 1280kN$,

base plate $t = 50mm$, S265

M24 class 8.8

(a) $f_{jd} = f_{cd} = (\alpha_{cc} f_{ck}) / \gamma_c$

$= 0.85(25)/1.5$

$= 14.167 N/mm^2$

$A_{req} = N_{Ed}/f_{jd} = N_{Ed}/f_{cd} = \frac{1280(10)^3}{14.167}$

$= 90.35(10)^3 mm^2$

(b) $t = 14.2mm$

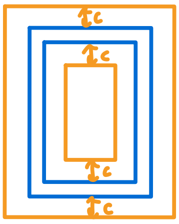
$A_{eff} = (100+2c)(300+2c) -$

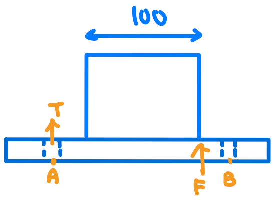
$(300-2c-28.4)(100-2c-28.4)$

$= 30000 + 800c + \cancel{4c^2}$

$- [19446.56 - 686.4c + \cancel{4c^2}]$

$= 1486.4c + 10553.44$





$A_{req} = A_{eff}$

$c = 53.68 mm$

$t = c\left[\frac{3 f_{jd} \gamma_{M0}}{f_y}\right]^{0.5}$

$= 53.68\left[\frac{3(14.167)(1)}{265}\right]^{0.5}$

$= 21.5mm$

baseplate thickness $50mm > 21.5mm$

∴ adequate

(c) → Moment about A

$1280(200) + 80(10)^3 = F(250 - 14.2/2)$

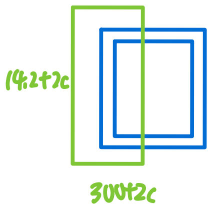
$F = 1383.285kN$

$T = 1280 - 1383.285$

$= -103.285kN$

$= 103.25kN$ (opposite direction as assumed)

→ New effective area



$A_{eff} = (300+2c)(14.2+2c)$

$= 4c^2 + 628.4c + 4260$

$A_{req} = N_{Ed}/f_{cd} = 1383.285(10^3)/14.167$

$= 97.64(10)^3 mm^2$

$A_{eff} = A_{req}$

$c = 93.25mm$

$c = -250.85mm$ (not possible)

∴ $c = 93.25$

→ $h + 2c < L_{base.plate} = 600mm$

$b + 2c < L_{base.plate} = 600mm$

→ $t = 93.25\left[\frac{3(14.167)(1)}{265}\right]^{0.5}$

$= 37.34mm < 50mm$

∴ adequate