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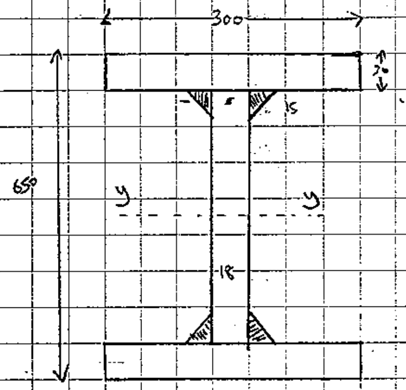
SUBJECT CV 3202 Steel Design A

A'111-12 S1



$h = 650$ mm
$b = 300$ mm
$t_f = 20$ mm
$h_w = 650 - 20 - 20 = 610$ mm $h_w = h - 2t_f$
$t_w = 18$ mm
$s = 15$ mm

[ai] beam under bending

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

outstand flanges: $c = (b - t_w - 2s)/2$
$= 126$ mm

$\frac{c}{t_f} = \frac{126}{20} = 6.3$

Limit for class 1 flange $= 9\varepsilon = 8.32 > 6.3$

∴ flange is class 1

web: $c = h - 2t_f - 2s$
$= 580$

$\frac{c}{t_w} = 32.22$

Limit for class 1 web $= 72\varepsilon = 66.6 > 32.2$

∴ web is class 1

∴ overall classification is class 1

[aii] column under compression

$\varepsilon = 0.9244$

$c = (b - t_w - 2s)/2$
$= 126$ mm.

$\frac{c}{t_f} = \frac{126}{20} = 6.3$

Limit for class 1 flange $= 9\varepsilon = 8.32 > 6.3$

∴ flange is class 1

web: $c = h - 2t_f - 2s$
$= 580$.

$\frac{c}{t_w} = 32.22$

Limit for class 2 web $= 38\varepsilon = 35 > 32.22$

∴ web is class 2

∴ overall classification is class 2.

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1b) Plastic Shear of Welded I Section.

$$A_v = \eta \Sigma (h_w t_w) \quad (\eta = 1)$$

$$= 610 \times 18$$

$$= 10980 \ mm^2$$

$$V_{pl,rd} = \frac{A_v \left(\frac{f_y}{\sqrt{3}}\right)}{\gamma_{mo}}$$

$$= 1743 \ KN$$

Bending Resistance:

$$M_{c,y,rd} = \frac{W_{pl,y} \cdot f_y}{\gamma_{mo}} = \frac{3187.1 \times 10^3 \times 275}{1} = 8764 \ KNm.$$

$$W_{pl,y} = (b \times t_f) \times (h - t_f) + b \times \left(\frac{h}{2} - t_f\right)^2$$

$$= (300 \times 20) \times (650 - 20) + 300\left(\frac{650}{2} - 20\right)^2$$

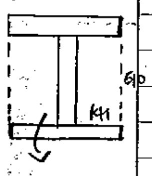
$$= 3187 \times 10^3 \ mm^3$$

1c) Cross section compression resistance => $N_{c,rd} = \frac{A f_y}{\gamma_{mo}}$

$$= \frac{(300 \times 20 \times 2 + 610 \times 18) \times 275}{1}$$

$$= 6320 \ KN.$$

member buckling resistance in compression



$I = I_{Big} - I_{small}$

$$I = \frac{1}{12} b h^3 - \left(\frac{1}{12} b h^3\right)_{small} = 6.86 \times 10^9 - 5.334 \times 10^9 = 1526 \times 10^6 \ mm^4$$

$$N_{cr} = \frac{\pi^2 \times E \times I}{L_{cr}^2} = \frac{\pi^2 \times 210\,000 \times 1526 \times 10^6}{5000^2}$$

$$= 126512 \ KN$$

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \sqrt{\frac{22980 \times 275}{126512 \times 10^3}} = 0.2234$$

$$\phi = 0.5\left(1 + 0.34(0.2234 - 0.2) + 0.2234^2\right)$$

$$= 0.529$$

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \lambda^2}} = 0.9916$$

$$N_{b,rd} = \chi \frac{A f_y}{\gamma_{m1}}$$

$$= 0.9916 \times \frac{22980 \times 275}{1}$$

$$= 6267 \ KN.$$

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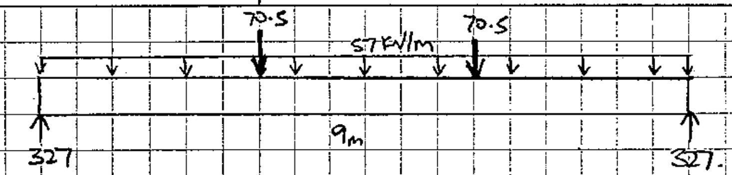
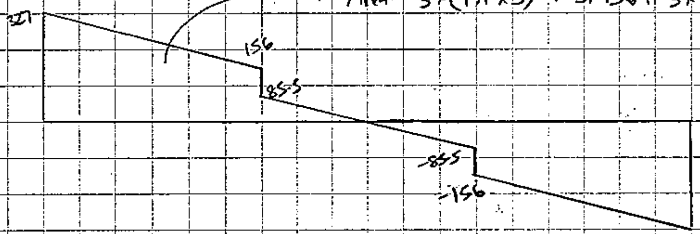
610x305 UB179



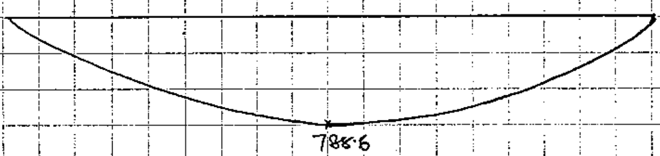
$P = 30 \times 1.35 + 20 \times 1.5 = 70.5\,KN$

$W = 20 \times 1.35 + 20 \times 1.5 = 57\,KN/m$

$Area = \frac{1}{2} \times (171 \times 3) + 3 \times 156 + \frac{1}{2} \times 85.5 \times 1.5 = 788.6\,KNm.$



$V_{max} = 327\,KN$



$M_{max} = 789\,KNm$

A = 228 cm²
r = 60.2 mm
b = 307.1
tf = 23.6
tw = 14.1
r = 16.5

Shear check:

$A_v = A - 2bt_f + (t_w + 2r)t_f \geq \eta h_w t_w$

$= 22800 - 2(307.1)(23.6) + (14.1 + 2 \times 16.5) \times 23.6 \geq 1 \times 573 \times 14.1$

$= 9416\,mm^2 \geq 8079\,mm^2.$

$V_{pl,rd} = \frac{A_v(f_y/\sqrt{3})}{\gamma_{M0}} = \frac{9416 \times (\frac{275}{\sqrt{3}})}{1.0} = 1495\,KN > V_{max} \rightarrow OK!$

High or low shear check: $0.5 V_{pl,rd} > V_{max}$

$748\,KN > V_{max} \rightarrow$ no reduction of moment resistance is required.

Bending Resistance: $M_{c,y,rd} = \frac{W_{pl,y} f_y}{\gamma_{M0}} = \frac{7486 \times 10^3 \times 275}{1} = 2059\,KNm > M_{max} \Rightarrow ok!$

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LTB check:

$$M_{cr} = C_1 \frac{\pi^2 E I_z}{L^2}\sqrt{\frac{I_w}{I_z} + \frac{L^2 G I_T}{\pi^2 E I_z}}$$

$$= 1.77 \frac{\pi^2 \times 210000 \times 11409 \times 10^4}{9000^2}\sqrt{\frac{10.15 \times 10^6}{11409 \times 10^4} + \frac{9000^2 \times 81000 \times 340.1 \times 10^4}{\pi^2 \times 210000 \times 11409 \times 10^4}}$$

$$= 5167195 \times \sqrt{88965 + 94365}$$

$$= 2212 \text{ KNm}$$

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

$$= \sqrt{\frac{5547 \times 10^3 \times 275}{2212 \times 10^6}} = 0.83$$

$$\phi_{LT} = 0.5\left[1 + 0.21(0.83 - 0.2) + 0.83^2\right]$$

$$= 0.9106$$

$$\chi_{LT} = \frac{1}{0.9106 + \sqrt{0.9106^2 - 0.83^2}} = 0.778$$

$$M_{b,rd} = \chi_{LT} \frac{W_y f_y}{\gamma_{M1}}$$

$$= 0.778 \times \frac{5547 \times 10^3 \times 275}{1}$$

$$= 1187 \text{ KNm} > M_{max}$$

Deflection:

Limiting Deflection: $\frac{L}{360} = \frac{9000}{360} = 25\text{mm}$.

Total Deflection $= \frac{23 P L^3}{648 EI}$ (double point load) $+ \frac{5}{384}\frac{wL^4}{EI}$ (UDL)

$$= \frac{23 \times 70.5 \times 10^3 \times 9000^3}{648 \times 210000 \times 153025 \times 10^4} + \frac{5}{384} \times \frac{57 \times 9000^4}{210000 \times 153025 \times 10^4}$$

$$= 5.7 \text{ mm} + 15.15$$

$$= 20.9 \text{ mm} < 25\text{mm} \rightarrow \text{OK!}$$

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3] 254 × 254 UC89   S275

Nominal moments about Z-Z Axis = $(150-100)\times\frac{b}{2} = 50\times\frac{256.3}{2} = 6.4$ KNm.

Nominal moment about y-y Axis = $175\times\frac{h}{2} = 175\times\frac{260.3}{2} = 22.8$ KNm.

Stiffness ratio = $\frac{4.8}{3.5} = 1.37 < 1.5$ ⇝ Moment distribute equally

⇒ Design moment $M_{yEd} = \frac{22.8}{2} = 11.4$ KNm.

Flexural Buckling about minor axis (Z-Z):

$$N_{cr} = \frac{\pi^2 EI}{L_{cr}^2} = \frac{\pi^2\times 210\,000\times 4860\times 10^4}{4800^2} = 4372 \text{ KN}$$

$$\bar{\lambda}_z = \sqrt{\frac{11300\times 275}{4372\times 10^3}} = 0.843$$

$$\phi_z = 0.5[1+0.49(0.843-0.2)+0.843^2]$$

$$= 1.013$$

$$\chi_z = \frac{1}{1.013+\sqrt{1.013^2-0.843^2}}$$

$$= 0.635$$

$$N_{b,rd} = 0.635\times 11300\times 275 = 1974 \text{ KN} > N_{max} = 425 \text{ KN}.$$

LTB about major axis (y-y)

$$M_{cr} = 1.77\times\frac{\pi^2\times 210\,000\times 4860\times 10^4}{4800^2}\sqrt{\frac{0.717\times 10^6}{4860\times 10^4}+\frac{4800^2\times 81000\times 102\times 10^4}{\pi^2\times 210\,000\times 4860\times 10^4}}$$

$$= 7738310\sqrt{14753+18898} = 1420 \text{ KNm.}$$

$$\bar{\lambda}_{LT} = \sqrt{\frac{W_y f_y}{M_{cr}}} = \left[\frac{1220\times 10^3\times 275}{1420\times 10^6}\right]^{0.5} = 0.486$$

$$\phi_{LT} = 0.5[1+0.21(0.486-0.2)+0.486^2]$$

$$= 0.648$$

$$\chi_{LT} = \frac{1}{0.648+\sqrt{0.648^2-0.486^2}} = 0.9286$$

$$M_{b,rd} = \chi_{LT}\frac{W_y f_y}{\gamma_{M1}} = 0.9286\,\frac{1220\times 10^3\times 275}{1} = 311.6 \text{ KNm} > M_{ymax} = 11.4 \text{ KNm}$$

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3c] Max no of stories = $\frac{311.6}{11.4}$ = 27

4a] Shear: M20 class 8.8 x 3 Bolts parallel to force.

Shear resistance of bolts = 94.1 kN x 3 = 282.3 kN > V_{max} = 175 kN → OK!

Adequacy of 2x 6mm fillet welds (longitudinal resistance) = 0.94 x 180mm x 2
= 338.4 kN > V_{max} = 175 kN → OK!

4b] plain shear of fin plate: $V_{pl,Rd} = \frac{A_v\left(\frac{f_y}{\sqrt{3}}\right)}{\gamma_{M0}} \times 2$ → $A_v = A - A_n$
$= (180 \times 9) - (9 \times 20) = 1440 \text{ mm}^2$

$= \frac{1440\left(\frac{275}{\sqrt{3}}\right)}{1} \times 2$ plates

= 457.3 kN > V_{max} = 175 kN.

Block tear resistance of fin plate: For bolt group subject to eccentric loading: $V_{eff,2,Rd} = 0.5\frac{f_u A_{nt}}{\gamma_{M2}} + \frac{1}{\sqrt{3}}\left(\frac{f_y A_{nv}}{\gamma_{M0}}\right)$ x 2 plates

$f_u = 430 \text{ N/mm}^2$
$A_{nt} = [60 - (\frac{20}{2})] \times 9 = 450 \text{ mm}^2$
$A_{nv} = [40 + 50 + 50 - 50] \times 9 = 810 \text{ mm}^2$

$= 0.5\frac{430(450)}{1} + \frac{1}{\sqrt{3}}\left[\frac{275(810)}{1}\right] \times 2$

= 322.1 kN > V_{max} = 175 kN

4c] Weakest link of this typical connection are the 3 M20 class 8.8 Bolts with shear resistance of 282.3 kN

THE END

* All the BEST for the EXAMS *

Done By: Zhi Hui