CIVE3205

Example F10

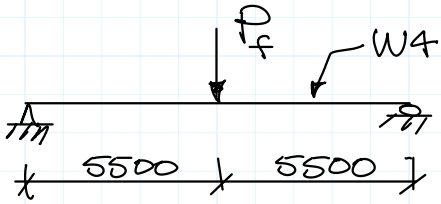
N.M. Holtz
Mar 11/2020

Revisions

- Mar 11, 2020 - original
- based on example B1, 2012-2019

Example F10

Given



ASTM A992 steel
Neglect self weight

Calculate max factored load, P_f for 3 cases
a) compression flange fully braced
b) " " braced only at ends
c) " " braced @ ends & centre.

W410x60:

$I_x = 216 \times 10^6$ mm^4
$Z_x = 1190 \times 10^3$ mm^3
$J = 328 \times 10^3$ mm^4
$C_w = 468 \times 10^9$ mm^6
$I_y = 12.0 \times 10^6$ mm^4

$d = 407$ mm
$b = 178$ mm
$t = 12.8$ mm
$w = 7.7$ mm
$h = d - 2t = 381$ mm

Local buckling (class 2?)

flange $\frac{b_{el}}{t} = \frac{178}{2 \times 12.8} = 6.95$

class 2 lim $= \frac{170}{\sqrt{345}} = 9.15$ OK

web $\frac{h}{w} = \frac{381}{7.7} = 49.5$

class 2 lim $= \frac{1700}{\sqrt{345}} = 91.5$ OK

$\therefore$ section is class 2 or better

a) fully braced

§13.5 $M_r = \phi M_p = \phi F_y Z$
$= 0.9 \times 345 \times 1190 \times 10^3 \times 10^{-6}$
$= 369.5$ kN-m

$M_f = \frac{P_f L}{4} = \frac{P_f \times 11}{4} = 369.5$

$P_f = 134.4$ kN ◀ a)

b) braced @ ends only (& not at load)

§13.6 $L = 11000$ mm

Last para of 13.6 (a) (ii) says to use $\omega_2 = 1.0$ & $L = 1.2 \times 11000 = 13200$ (assuming load is applied to top flange)

$$M_u = \frac{\omega_2 \pi}{L}\sqrt{EI_y GJ + \left(\frac{\pi E}{L}\right)^2 I_y C_w}$$

$$= \frac{1.0 \times \pi}{13200}\sqrt{200000 \times 12.0\times10^6 \times 77000 \times 328\times10^3 + \left(\frac{\pi \times 200000}{13200}\right)^2 \times 12\times10^6 \times 468\times10^9}$$

$$= 64.45\times10^6 \text{ N-mm}$$

$$= 64.45 \text{ kN-m}$$

$$M_p = F_y Z$$
$$= 345 \times 1190 \times 10^3 \times 10^{-6}$$
$$= 410.6 \text{ kN-m}$$

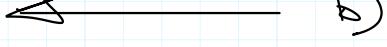
$$0.67 M_p = 275.1 \text{ kN-m}$$

$$M_u < 0.67 M_p$$

$\therefore$ $M_r = \phi M_u$
$= 0.9 \times 64.45$
$= 58.0$ kN-m

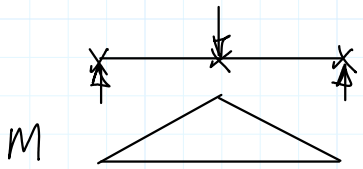
$$\frac{11}{4} P_f = 58.0$$

$$P_f = 21.1 \text{ kN}$$



b)

c) braced @ ends & mid point.



From Fig 2-17

$\omega_2 = 1.75$

$L = 5500$

$$M_u = \frac{1.75\pi}{5500}\sqrt{200000 \times 12.0\times10^6 \times 77000 \times 328\times10^3 + \left(\frac{\pi \times 200000}{5500}\right)^2 \times 12\times10^6 \times 468\times10^9}$$

$$= 365.8 \times 10^6 \text{ N-mm}$$

$$= 365.8 \text{ kN-m}$$

$$M_p = F_y Z$$

$$= 345 \times 1190 \times 10^3 \times 10^{-6}$$

$$= 410.6 \text{ kN-m}$$

$$0.67 M_p = 275.1 \text{ kN-m}$$

$$M_u > 0.67 M_p$$

$$\therefore M_r = 1.15\phi M_p\left[1 - \frac{0.28 M_p}{M_u}\right] \leq \phi M_p$$

$$= 1.15 \times 0.9 \times 410.6\left[1 - \frac{0.28 \times 410.6}{365.8}\right] \leq 0.9 \times 410.6$$

$$= 291.4 \leq 369.5$$

$$\therefore M_r = 291.4 \text{ kN-m}$$

$$\frac{11}{4} P_f = 291.4 \text{ kN-m}$$

$$P_f = 106 \text{ kN}$$ ← c)

Summary:

a) full support $P_f = 134$

b) support @ ends only $P_f = 21.1$

c) support @ ends & mid-pt. $P_f = 106$