CIVE 3205
Example F20

N.M. Holtz
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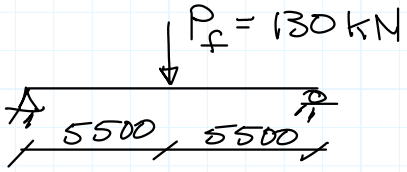
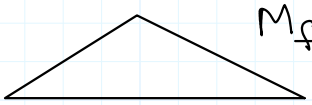
Revisions

- March 11, 2020 - original posting
- based on example B2, 2012-2019

Example F20



M



$M_f = \frac{130}{2} \times 5.5 = 358$ kN-m

Lateral support @ ends & midpoint
Grade 350 W steel
Select suitable section

$L = 5500$ mm
$w_2 = 1.75$ (from $\omega_2 = 0$ or Fig 2-15)

To use Beam Selection Tables (where $w_2 = 1.0$)

Use $L_{eq} \approx \frac{L}{(w_2+1)/2}$

$= \frac{5500}{(1.75+1)/2} = 4000$

Entering B.S. tables with $M = 358$, $L = 4000$

Try W460x67 ($M_r \approx 361$ kN-m)

$b = 190$ mm
$t = 12.7$ mm
$h = d - 2t = 429$ mm
$w = 8.5$ mm
$d = 454$ mm

$S_x = 1300 \times 10^3$ mm^3
$Z_x = 1470 \times 10^3$ mm^3
$I_y = 14.5 \times 10^6$ mm^4
$J = 372 \times 10^3$ mm^4
$C_w = 708 \times 10^9$ mm^6
$I_x = 295 \times 10^6$ mm^4

Section class:

$\frac{b_o}{t} = \frac{190}{2 \times 12.7} = 7.48$

< 9.09

class 2 limit $= \frac{170}{\sqrt{F_y}}$

$= \frac{170}{\sqrt{350}} = 9.09$

$\therefore$ flange is class 2 (or better)

$\frac{h}{w} = \frac{429}{8.5} = 50.5$ $\quad$ class 2 limit $= \frac{1700}{\sqrt{F_y}}$

< 90.9 $\quad = \frac{1700}{\sqrt{350}}$

$\therefore$ web is class 2 (or better) $= 90.9$

$\therefore$ Section is class 2 (or better) ⟵

Bending Strength:

$M_p = F_y Z = 350 \times 1470 \times 10^3 \times 10^{-6}$

$= 514$ kN-m

$0.67 M_p = 345$ kN-m

$\omega_2 = 1.75$

$L = 5500$ mm

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

$$= \left(\frac{1.75 \times \pi}{5500}\right) \sqrt{200\,000 \times 14.5 \times 10^6 \times 77000 \times 372 \times 10^3 + \left(\frac{\pi \times 200000}{5500}\right)^2 \times 14.5 \times 10^6 \times 708 \times 10^9} \times 10^{-6}$$

$= 465.7$ kN-m

$M_u > 0.67 M_p$

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

$= 1.15 \times 0.9 \times 514 \left(1 - \frac{0.28 \times 514}{466}\right) \leq 0.9 \times 514$

$= 368 \leq 462$ kN-m

$\therefore M_r = 368$ kN-m

$M_f = 358$ kN-m $< M_r$ $\quad \therefore$ OK in flexure

Check Shear: §13.4.1.1

$\frac{h}{w} = 50.5$

(a)(i) $\frac{1014}{\sqrt{F_y}} = \frac{1014}{\sqrt{350}} = 54.2$

$\frac{h}{w} < 54.2$

$\therefore F_s = 0.66 F_y$
$= 0.66 \times 350$
$= 231 \text{ MPa}$

$A_w = dw = 454 \times 8.5$

$V_r = \phi A_w F_s$
$= 0.9 \times 454 \times 8.5 \times 231 \times 10^{-3}$
$= 802 \text{ kN}$

$V_f = \frac{130 \text{ kN}}{2} = 65 \text{ kN} << V_r \quad \therefore V \text{ O.K.}$

Check Deflection:

Assume $P_d = P_L$ (dead = live)

$1.25 P_L + 1.5 P_L = 130 \text{ kN}$

$P_L = 47.3 \text{ kN}$ (service load)

$\Delta = \frac{Pl^3}{48EI_x}$ (H.B., p 5-148)

$= \frac{47300 \times 11000^3}{48 \times 200\,000 \times 295 \times 10^6}$

$= 22.2 \text{ mm}$

$\frac{\Delta}{L} = \frac{22.2}{11000} = \frac{1}{495}$

from App. D, worst cases for beams (except crane beams) is $\frac{1}{360}$

$\frac{1}{495} < \frac{1}{360} \quad \therefore \text{OK}$

$\therefore$ Use W460 x 67 ← but check availability