Steel Design
Flexural Members
Example 1

Determine the flexural strength by hand of a W21x62 member where Fy = 50 ksi and the unbraced length is 20 ft. The beam is simply supported with a distributed loading and brace points only at the ends.

FLEXURAL MEMBERS ⟶ CHAPTER F

* USE TABLE USER NOTE F1.1 TO DETERMINE WHICH SECTION IS APPLICABLE TO YOUR MEMBER.

* TABLE IS BASED ON FLANGE AND WEB SLENDERNESS

SLENDERNESS

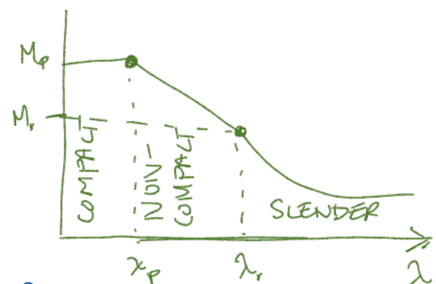
FLANGES: W21x62 ⟶ $\lambda = \frac{b_f}{2t_f} = \frac{8.24\,in}{2(0.615)} = 6.7$ ⟶ ALSO TABULATED IN TABLE 1-1

TABLE B4.1b:

$\lambda_{p,f} = 0.38\sqrt{\frac{E}{F_y}} = 0.38\sqrt{\frac{29000\,ksi}{50\,ksi}} = 9.2$

↳ CASE 10

$\lambda < \lambda_{p,f}$ ∴ FLANGE IS COMPACT



WEB: W21x62 ⟶ $\lambda = \frac{h}{t_w} = 46.9$

$\lambda_{p,w} = 3.76\sqrt{\frac{E}{F_y}} = 3.76\sqrt{\frac{29000\,ksi}{50\,ksi}} = 90.6$

↳ CASE 16

$\lambda < \lambda_{p,w}$ ∴ WEB IS COMPACT

TABLE USER NOTE F1.1 ⟶ GO TO SECTION F2.

F2.1 → YIELDING

$M_n = M_p = F_y Z_x$

$Z_x = 144\,in^3$ ⟶ TABLE 3-2

$M_n = 50\,ksi\,(144\,in^3) = 7200\,k\cdot in$

$\phi = 0.9$

∴ $\phi M_n = 0.9(7200\,k\cdot in) = 6480\,k\cdot in$

F2.2 → LATERAL TORSIONAL BUCKLING

↳ EQUATION IS BASED ON THE UNBRACED LENGTH OF THE SECTION

$L_b = 20\,ft$

$L_p = 1.76\,r_y\sqrt{\frac{E}{F_y}} = 1.76(1.77\,in)\sqrt{\frac{29000\,ksi}{50\,ksi}} = 75\,in = 6.3\,ft$

→ EQ. F2-5

$$L_r = 1.95 r_{ts} \frac{E}{0.7F_y}\sqrt{\frac{Jc}{S_x h_o} + \sqrt{\left(\frac{Jc}{S_x h_o}\right)^2 + 6.76\left(\frac{0.7F_y}{E}\right)^2}}$$

$$r_{ts} = \sqrt{\frac{I_y h_o}{2S_x}}$$

$I_y = 57.5\ in^4$

$h_o = 20.4\ in$

$S_x = 127\ in^3$

$F_y = 50\ ksi$

$J = 1.83\ in^4$

$c = 1.0$

$E = 29000\ ksi$

$$L_r = 1.95\sqrt{\frac{(57.5in^4)(20.4in)}{2(127in^3)}}\left(\frac{29000\ ksi}{0.7(50\ ksi)}\right) *$$

$$\sqrt{\frac{1.83in^4(1)}{(127in^3)(20.4in)} + \sqrt{\left(\frac{1.83in^4(1)}{127in^3(20.4in)}\right)^2 + 6.76\left(\frac{0.7(50ksi)}{29000\ ksi}\right)^2}}$$

$= 217.5\ in = 18.1\ ft$

$L_b > L_r \therefore$ USE EQ. F2-3 $\quad M_n = F_{cr} S_x \leq M_p$

$$F_{cr} = \frac{C_b \pi^2 E}{\left(\frac{L_b}{r_{ts}}\right)^2}\sqrt{1 + 0.078\frac{Jc}{S_x h_o}\left(\frac{L_b}{r_{ts}}\right)^2}$$

$C_b = 1.14$ → FROM TABLE 3-1

$$F_{cr} = \frac{1.14\pi^2(29000ksi)}{\left(\frac{20ft(12in/ft)}{2.15in}\right)^2}\sqrt{1 + 0.078\left(\frac{1.83in^4(1)}{127in^4(20.4in)}\right)\left(\frac{20ft(12in/ft)}{2.15in}\right)^2}$$

$= 34\ ksi$

$M_n = F_{cr} S_x = 34\ ksi(127in^3) = 4318.7\ k{\cdot}in$

$\phi = 0.9$

$\phi M_n = 0.9(4318.7\ k{\cdot}in) = 3886.9\ k{\cdot}in$

$\therefore \phi M_n = 3887\ k{\cdot}in$