EXAMPLE 5.4 *Built-Up Floor Girder Design*

Given

Loads

Floor live load	=	40 psf
Floor dead load	=	10 psf
Required girder span (support column spacing)	=	14 ft
Joist span (both sides of girder)	=	12 ft
Species	=	Southern Pine, No. 1
Maximum girder depth	=	12

Find Minimum number of 2x10s or 2x12s required for the built-up girder.

Solution

1. Calculate the design load

W = (Trib. floor joist span)(D + L) = (12 ft)(40 psf + 10 psf) = 600 plf

2. Determine tabulated design values (NDS-S Table 4B)

F_b = 1250 psi $F_{C\perp}$ = 565 psi
F_v = 90 psi E = $1.7\text{x}10^6$ psi

3. Lumber property adjustments (Section 5.2.4):

C_r = 1.2 (Table 5.4) C_D = 1.0
C_F = 1.0 C_b = 1.0
C_H = 2.0 C_L = 1.0

(compression flange laterally braced by connection of floor joists to top or side of girder)

F_b' = $F_bC_DC_rC_FC_L$ = 1,250 psi (1.0)(1.2)(1)(1) = 1,500 psi
F_V' = $F_lC_DC_H$ = 90 psi (1.25)(2.0) = 225 psi
$F_{c\perp}'$ = $F_{c\perp}C_b$ = 565 psi (1) = 565 psi
E' = E = $1.7\text{x}10^6$ psi

4. Determine number of members required due to bending

$$M_{max} = \frac{w\ell^2}{8} = \frac{(600\text{plf})(14\text{ ft})^2}{8} = 14{,}700 \text{ ft-lb}$$

$$f_b = \frac{M}{S} = \frac{(14{,}700 \text{ ft}-\text{lb})(12 \text{ in/ft})}{S} = \frac{176{,}400}{S}$$

$$f_b \leq F_b'$$

$$\frac{176{,}400}{S} \leq 1{,}500 \text{ psi}$$

$$S_x = 118 \text{ in}^3$$

Using Table 1B in NDS-S

5 2x10s S = 5(21.39) = 107 < 118 (marginal, but 5 too thick)
4 2x12s S = 4 (31.64) = 127 > 118 (OK)

5. Determine number of members required due to horizontal shear

$$V_{max} = \frac{w\ell}{2} = \frac{600\ \text{plf}\ (14\ \text{ft})}{2} = 4{,}200\ \text{lb}$$

$$f_v = \frac{3V}{2A} = \frac{3}{2}\left(\frac{4200}{A}\right) = 6{,}300\ \text{lb}/A$$

$$f_v \leq F_v'$$

$$\frac{6{,}300\ \text{lb}}{A} \leq 225\ \text{psi}$$

$$A = 28\ \text{in}^2$$

2 2x12s A = 33.8 > 28 OK

2 2x10s A = 27.8 ≈ 28 OK

6. Determine required bearing length using 4 2x12s

$$R_1 = R_2 = V_{max} = 4{,}200\ \text{lb}$$

$$f_{c\perp} = \frac{R}{A_b} = \frac{4{,}200\ \text{lb}}{(6\ \text{in})(\ell_b)} = \frac{700}{\ell_b}$$

$$f_{c1} \leq F_{c\perp}'$$

$$\frac{700}{\ell_b} \leq 565\ \text{psi}$$

$$\ell_b = 1.24\ \text{in}\quad \text{(OK)}$$

7. Determine member size due to deflection

$$\rho_{max} = \frac{5w\ell^4}{384EI} = \frac{5(480\ \text{plf})^*(14\ \text{ft})^4(1{,}728\ \text{in}^3/\text{ft}^3)}{384\,EI} = \frac{4.15 \times 10^8}{EI}$$

*includes 40 psf live load only

$$\rho_{all} \leq \ell/360 = 14\ \text{ft}(12\ \text{in/ft})/360 = 0.47\ \text{in}$$

$$\rho_{max} \leq \rho_{all}$$

$$\frac{4.15 \times 10^8}{EI} = 0.47\ \text{in}$$

$$EI = 8.8 \times 10^8$$

$$(1.7 \times 10^6)(I) = 8.8 \times 10^8$$

$$I = 519\ \text{in}^4$$

3 2x12s I = 534 > 519 okay