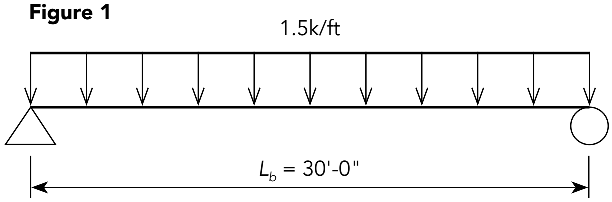
steel quiz

This month's Steel Quiz looks at the use of design tables in the AISC *Steel Construction Manual*.

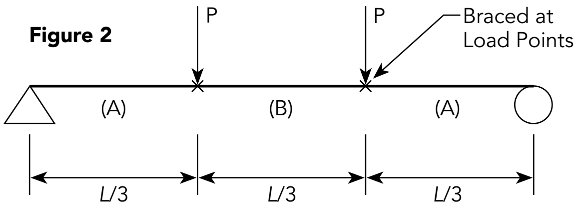
1 For the beam shown in Figure 1, calculate the C_b value. Lateral bracing is provided at the support points only.

Figure 1



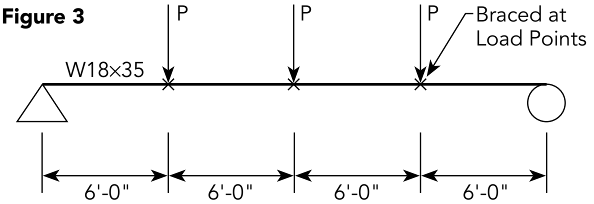
2 Assuming the length L in Figure 2 is long enough that lateral-torsional buckling controls, which of the following is true about the flexural strength of beam segments A? It is:
a) Equal to the flexural strength of segment B
b) Greater than the flexural strength of segment B
c) Less than the flexural strength of segment B

Figure 2



3 Given: From AISC *Manual* Table 3-6, the L_p value for a W18×35 beam is equal to 4.31 ft. The beam below has an unbraced length of 6 ft. True or False: The nominal flexural strength of the beam will be less than $M_p = F_yZ_x$.

Figure 3



4 True or False: C_b values are routinely useful in the design of HSS used as beams.

TURN PAGE FOR ANSWERS

1 Use *Specification* Equation (F1-1) to determine C_b.

$$M_{max} = M_B = \frac{w \times L^2}{8} = \frac{1.5\text{kip} - \text{ft} \times 30\text{ft}^2}{8} = 169 \text{ kip} - \text{ft}$$

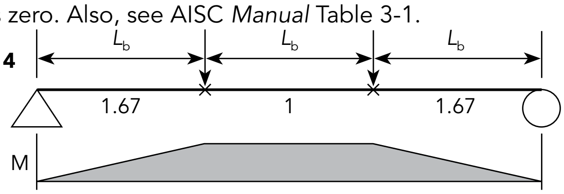
$$M_A = M_C = \frac{w \times x}{2}(L{-}x) = \frac{1.5\text{kip} - \text{ft} \times 7.5\text{ft}}{2}(30\text{ft} - 7.5\text{ft}) = 127\text{kip} - \text{ft}$$

$$C_b = \frac{12.5M_{max}}{2.5M_{max}{+}3M_A{+}4M_B{+}3M_C} = \frac{12.5 \times 169}{6.5 \times 169{+}6 \times 127} = 1.14$$

Note that this C_b value, and many others for common cases, are provided in AISC *Manual* Table 3-1.

2 b) Greater than the flexural strength of segment B. The C_b value for segments A is greater than that for segment B. Given that LTB controls the design, this is true because all other variables in AISC *Specification* Equation F2-2 are constant. The C_b value for each segment is shown in Figure 4 below and can be determined via the User Note in Section F1, where C_b = 1.0 for the case of equal end moments of opposite sign (uniform moment) and C_b = 1.67 when one end moment equals zero. Also, see AISC *Manual* Table 3-1.

Figure 4



3 False. Per AISC *Specification* Equation F2-2, the nominal flexural strength is equal to the plastic bending moment, $M_p = F_yZ_x$ (because of the effect of C_b). Per AISC *Manual* Table 3-6, L_p = 4.31ft and L_r = 12.3ft. Per AISC *Manual* Table 3-1, C_b = 1.11 for the two interior segments (the outer segments have a higher value of C_b). Per Table 1-1, S_x = 57.6 in.^{3}, Z_x = 66.5 in.^{3}

$$M_p = F_yZ_x = 50 \text{ ksi} \times 66.5\text{in.}^3 = 3{,}330 \text{ kip} - \text{in.}$$

$$M_n = C_b\left[M_p - (M_p - 0.7F_yS_x)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] \le M_p$$

$$= 1.11\left[3{,}330 - (3{,}330 - 0.7 \times 50 \times 57.6)\left(\frac{6 - 4.31}{12.3 - 4.31}\right)\right] \le 3{,}330\text{kip} - \text{in.}$$

$$= 3{,}380 \text{ kip} - \text{in.} \le 3{,}330 \text{ kip} - \text{in.}$$

$$= 3{,}330 \text{ kip} - \text{in.}$$

Therefore, the design is controlled by yielding and $M_n{=}M_p$. Note that AISC *Specification* Commentary Figure C-F1.2 clearly illustrates the effect C_b can have on the nominal flexural strength, M_n.

4 False. HSS beams are generally not sensitive to lateral-torsional buckling—because their torsional strength and stiffness are so high—and so their strength is governed by the yield or local buckling strength of the member. Therefore, C_b rarely impacts the design of an HSS beam.