steel quiz

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

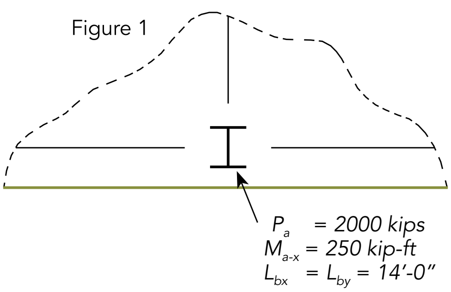
In particular, the use of the tables in Part 6 is demonstrated. Though Part 6 is titled "Design of Members Subject to Combined Forces," Table 6-1 is the Swiss Army knife of member design and can be used to design beams, columns and tension members—and beam-columns—essentially serving the same purpose as the tables contained in Parts 3 through 5 of the *Manual*.

1 Using the design tables located in Parts 1 through 15 of the 14th Edition AISC *Manual*, determine the compression strength of a W14×22 column with an unbraced length of 10 ft. Use LRFD.

2 Determine the strong-axis bending strength of a W12×53 with an unbraced length equal to 26 ft using Table 6-1. Use LRFD.

3 Select the lightest W14 column based on the criteria shown in Fig. 1. Use ASD and Table 6-1.

Figure 1



4 Select a W16 drag strut beam using Table 6-1 based on the following criteria: unbraced length of 10 ft with a strong axis bending moment of 200 kip-ft and an axial compressive load of 25 kips. Use LRFD.

5 Size a W14 hanger shown in Fig. 2 using Table 6-1. Use ASD.

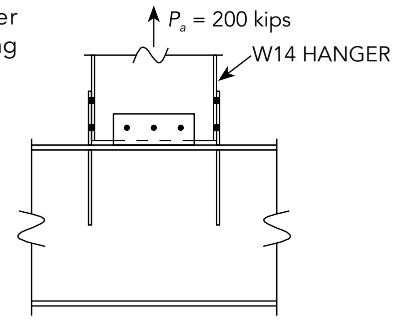


Figure 2

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1 A W14×22 shape size is not provided in Table 4-1. However, Table 6-1 can be used to determine the strength. The axial compressive strength is equal to 110 kips.

$$p = \frac{1}{\Phi_c P_n}$$

$$\Phi_c P_n = \frac{1}{p} = \frac{1}{9.08 \times 10^{-3}} = 110 \text{ kips}$$

To illustrate the relationship between the tables, use ASD to calculate the compressive strength calculated for a W14×90 column with an unbraced length equal to 14 ft using Table 4-1 and Table 6-1.

- Per Table 4-1, the axial capacity is equal to 682 kips.
- Per Table 6-1, the axial capacity is equal to 680 kips. (The difference is due to rounding.)

$$\frac{P_n}{\Omega_c} = \frac{1}{1.47 \times 10^{-3}} = 680 \text{ kips}$$

2 The strong-axis bending strength is equal to 198 kips. Note that you can also determine this value using Table 3-10.

$$b_x = \frac{8}{9\Phi_b M_{nx}}$$

$$\Phi_b M_{nx} = \frac{8}{9b_x} = \frac{8}{9 \times 4.5 \times 10^{-3}} = 198 \text{ kip-ft}$$

3 A W14×311 is the lightest adequate W14 shape. Assuming that the compression load will control the design, select trail size based on p.

$$p \times 10^3 = \frac{1}{2000} \times 10^3 = 0.5$$

Try a W14×283 ($p \times 10^3 =$ 0.451 < 0.5, $b_x \times 10^3 = 0.657$)

By inspection, $pP_r > 0.2$

$$\frac{0.451 \times 2000 \text{ kips}}{1000} + \frac{0.657 \times 250 \text{ k-ft}}{1000} = 1.07 > 1.0\ (NG)$$

Try a W14×311
($p \times 10^3 = 0.411$, $b_x \times 10^3 = 0.591$)

$$\frac{0.411 \times 2000 \text{ kips}}{1000} + \frac{0.591 \times 250 \text{ k-ft}}{1000} = 0.97 < 1.0\ (OK)$$

4 Assume that $pP_r < 0.2$, therefore adjust b_x value by (8/9). Calculate required adjusted b_x.

$$\left(\frac{8}{9}\right) b_x = \left(\frac{8}{9}\right)\left(\frac{1}{200 \text{ k-ft}} \times 10^3\right) = 4.44$$

Per Table 6-1, try a W16×40
($b_x = 3.88 < 4.44$, $pP_r = 2.91$)

$$\frac{1}{2} \times \left(\frac{2.91 \times 25\text{kips}}{1000}\right) + \frac{9}{8} \times \left(\frac{3.88 \times 200}{1000}\right) = 0.91 < 1.0$$

Use a W16×40 beam. Note that $pP_r = 0.07 < 0.2$, and the initial assumption is verified.

5 Calculate required t_y and t_r.

$$t_y = t_r = \frac{1}{200 \text{ kips}} \times 10^3 = 5$$

Per Table 6-1, try a W14×30 (t_y= 3.77 < 5 and t_r = 4.64 < 5), don't let the inverse trip you up. The value calculated above is a maximum, not a minimum—i.e., a t_y or t_r less than 5 refers to a column with a strength greater than 200 kips.

Tension Yield Strength

$$\frac{F_y \times A_g}{1.67} = \frac{1}{3.77} \times 1000 = 265 \text{ kips}$$

Tension Rupture Strength

$$\frac{(0.75 \times A_g) \times F_u}{2.0} = \frac{1}{4.64} \times 1000 = 215 \text{ kips}$$

Use a W14×30 hanger. Note that Table 6-1 assumes a 25% reduction in gross area when checking the tension rupture strength—assuming the connection detail is not known at the time of member selection and that most details can be configured to develop an effective area equal to $0.75A_g$. This assumption must be checked in practice.

Steel Solutions Center

Anyone is welcome to submit questions and answers for Steel Quiz. If you are interested in submitting one question or an entire quiz, contact AISC's Steel Solutions Center at 866.ASK.AISC or at **solutions@aisc.org**.