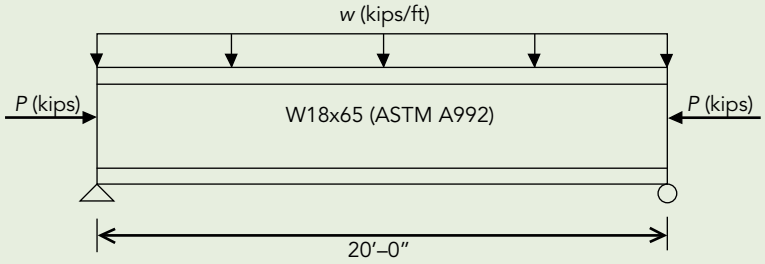
steel quiz

LOOKING FOR A CHALLENGE? This month, let's commune with a pencil, calculator, the AISC *Steel Construction Manual* and the back of an envelope. The following diagram will be used for all questions. You can solve using LRFD or ASD.



Note: The W18x65 is restrained laterally against rotation at the supports but unbraced between them.

1 Assuming flexural strength controls and C_b = 1, what is the maximum uniform load, *w*, that the member can resist when *P* = 0 kips?

2 What is the actual value of C_b for the case investigated in Question 1?

3 If a deflection limit of *l*/360 were specified, does this change the answer determined in Question 1? Assume all the load is considered for the deflection calculation, and use an effective load factor of 1.5 if you're using LRFD (a service load of 5.61/1.5 = 3.74 kips/ft).

4 Switch to the assumption now, that the uniformly distributed load is all dead load (w_d = 3.74 kips/ft). True or False? Specifying a mid-span camber ordinate of ½ in. is reasonable to eliminate the resulting dead load deflection.

5 The actual end reactions for the loading in Question 1 are 56.1 kips (LRFD) or 37.4 kips (ASD). If the shear connections were to be designed for the shear strength of the beam, how many times higher would the design reaction be?

6 True/False: Applying a 7.5 kip-ft (LRFD) or 5 kip-ft (ASD) torsional moment to the member at mid-span, and assuming torsional simple supports, the maximum warping normal stress at the supports is 5.23 ksi (LRFD) or 3.49 ksi (ASD).

7 Switch to the assumption now that *w* = 0. What is the maximum axial load *P* that the column can resist? Use *K* = 1.

8 Why was the resistance factor for compression members in Chapter E of the 2005 AISC *Specification* increased to 0.9 from the 0.85 value that was employed since the 1986 AISC *LRFD Specification*?

9 What is the maximum geometric variation in straightness that is permitted for a compression member?

10 If this member were a beam-column, what tables in the AISC *Manual* exist specifically for use in the design of this member?

EC If the loading in Question 10 were P_u = 60 kips and M_u = 180 kip-ft (LRFD) or P_a = 40 kips and M_a = 120 kips (ASD), is a W18x65 adequate?

steel quiz ANSWERS

1 From Section F2 in the 2005 AISC *Specification* (or a sharp eye in Table 3-10), the maximum moment that this unbraced W18x65 can resist is 281 kip-ft (LRFD) or 187 kip-ft (ASD). Because the maximum moment is $wl^2/8$, the maximum uniform load, w, that the beam can carry is 5.61 kips/ft (LRFD) or 3.74 kips/ft (ASD).

2 C_b = 1.14. This can be calculated using Equation F1-1 in Section F1 in the 2005 AISC *Specification*, and many common cases are provided in Table 3-1 in the *Manual*. With this value of C_b, the maximum moments change to 320 kip-ft (LRFD) or 213 kip-ft (ASD); the maximum uniform loads change to 6.40 kips/ft (LRFD) or 4.26 kips/ft (ASD).

3 No (but it would have been much more likely with a more typical beam span). A deflection limit of $l/360$ would require that the applied service load must be limited to 5.75 kips/ft, which is much higher than the results determined in Question 1.

4 False. While the maximum deflection due to dead load is 0.43 in., ½ in. is a very small camber ordinate; AISC recommends that cambers less than ¾ in. should not be specified. Also, note that this beam is a short span and may not fit in the typical cambering machine.

5 Using Chapter G in the 2005 AISC *Specification*, the shear yielding strength of the beam web is 248 kips (LRFD) or 165 kips (ASD); these values also can be determined using values in Part 3 of the *Manual* (Tables 3-2 and 3-6, for example). This means that the resulting design reactions will be overspecified by a factor of almost 4½.

6 False. A torsional simple support condition precludes the development of warping normal stresses at the ends of the member. Please see Chapter 3 of AISC *Design Guide 9*, available as a free download for AISC members at **www.aisc.org/epubs**, for more on this topic.

7 From Section E3 in the 2005 AISC *Specification*, the maximum axial force that this W18x65 can resist is 214 kips (LRFD) or 142 kips (ASD).

8 Elimination of universal mill plates from usage in modern welded columns reduced the scatter in data that factors into the determination of the resistance factor. This benefit is also realized in ASD, since $\Omega = 1.5/\phi$. Please see the commentary to Chapter E for more on this topic.

9 The permitted out-of-straightness is 0.24 in., per Section 6.4.2 of the AISC *Code of Standard Practice*, available as a free download at **www.aisc.org/code**, which limits the maximum variation in straightness of compression members to $l/1000$.

10 Part 6 contains Table 6-1, which provides axial and flexural constants that can be used as described in the front of that chapter. Interestingly, you also could have manipulated the individual constants in this table to determine the answers for the beam and column in the above questions. This table also provides constants for loading as a tension member. Check it out if you haven't already.

EC Yes. The interaction ratio for this loading is 0.780, which is less than unity as required.

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**.

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