This month’s Steel Quiz takes a look at the design for torsion in W-shapes as addressed in AISC Design Guide 9: *Torsional Analysis of Structural Steel Members* and Chapter H of the AISC Specification.

Figures 1 and 2 illustrate normal stresses due to bending ($\sigma_b$) and warping ($\sigma_w$) and shear stresses due to bending ($\tau_{b}$), torsion ($\tau_t$) and warping ($\tau_w$) in a wide-flange beam subject to shear, bending and torsional loading. The figures also indicate the location of the maximum stresses, which can be used to determine the locations on the cross section that need to be checked.

The calculated normal stresses due to bending and warping are:

- $\sigma_b = 18.7$ ksi
- $\sigma_w = 8.24$ ksi

The calculated shear stresses due to bending, torsion and warping are:

- $\tau_{b, \text{flange}} = 0.420$ ksi
- $\tau_{b, \text{web}} = 1.61$ ksi
- $\tau_{w, \text{flange}} = 0.375$ ksi
- $\tau_{w, \text{web}} = 0$ ksi
- $\tau_t, \text{flange} = 6.76$ ksi
- $\tau_t, \text{web} = 4.11$ ksi

Using ASD, verify that the peak normal stress, $f_n$, and peak shear stress, $f_s$, satisfy the requirements in Chapter H of the AISC Specification. Assume that the limit state of buckling does not control. Note that the stresses at the 10 highlighted locations can be calculated to determine the location of maximum stress.
Combining the shear stresses and normal stresses at the locations shown in Figure 3, the maximum normal stress and maximum shear stress are:

\[ F_n \text{ max} = 26.9 \text{ ksi} \]
\[ F_v \text{ max} = 7.56 \text{ ksi} \]

The allowable normal stress per equation (H3-7) is:

\[ \frac{F_n}{\Omega} = \frac{50 \text{ ksi}}{1.67} = 29.9 \text{ ksi} > 26.9 \text{ ksi} \text{ (OK)} \]

The allowable shear stress per equation (H3-8) is:

\[ \frac{F_v}{\Omega} = \frac{0.6F_v}{\Omega} = \frac{30 \text{ ksi}}{1.67} = 18 \text{ ksi} > 7.56 \text{ ksi} \text{ (OK)} \]

This information is taken from AISC Design Example H.6. The complete design example can be viewed at www.aisc.org/examples.

Everyone 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.