manualwise

DESIGNING BEAM COPES

The latest edition of the AISC *Manual* includes updated design methods for beam copes.

BY BO DOWSWELL, PE, PhD

THE DESIGN METHODS for single- and double-coped beams have been revised for the 15th Edition *Steel Construction Manual*.

Here, we'll discuss the new design provisions and provide some background information on the local strength of coped beams, as well as new design recommendations for axially loaded beams based on the latest research.

B al B al

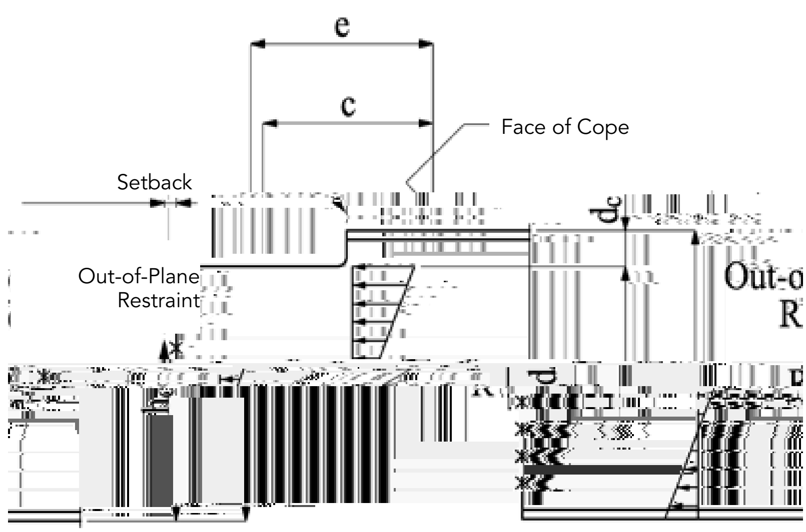
Let's start with beam-to-beam connections. In such connections, the top ange of the supported beam is usually coped to clear the supporting beam ange (see Figure 1). In some cases, the bottom ange must be coped to clear the supporting beam ange or to allow the beam to be dropped between two angles, as shown for the knife connection in Figure 2. For double-coped beams, where both the top and bottom ange are coped, a signi cant portion of the web is often removed. Figure 3 (opposite page) shows a skewed beam-to-beam connection with a long double cope at the supported beam.

For design purposes, the coped region can be modeled as a short beam with a length equal to the cope length. In addition to the constant shear force, *R*, the cope is subjected to a linearly-varying moment. The maximum moment is at the face of the cope, causing compressive flexural stresses at the reentrant corner, as shown in Figure 4. Due to the combined effect of the flexural and shear stresses, the cope

▲ Figure 1. Beam coped at the top flange.

▼ Figure 2. Beam coped at the bottom flange.

B D (@a a. l) is a principal with ARC International, LLC, in Birmingham, Ala., and also a consultant to AISC's Steel Solutions Center.


e
c
Face of Cope
Setback
Out-of-Plane
Restraint

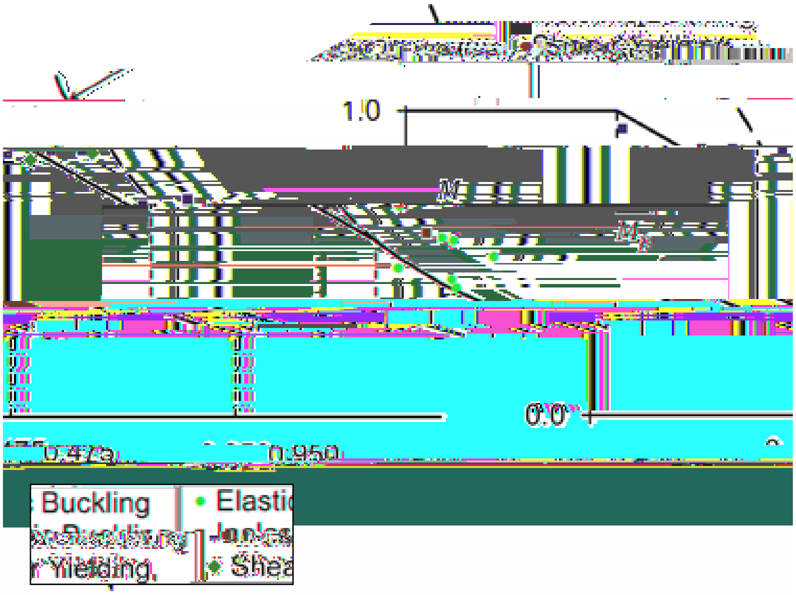


Figure 5. Buckling curve for single-coped beams.

Figure 6. Shear buckling of a single-coped beam.

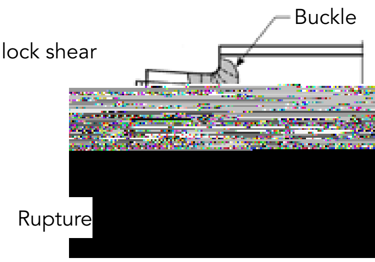


Figure 7. Block shear buckling.

nections, as shown in Figure 7. The failure is characterized by a combination of extensive yielding along the L-shape block shear failure pattern, with potential rupture at the tension plane, and localized buckling at the face of the cope. Based on the experimental results, it is believed that this failure mode can be eliminated by providing a minimum connection element depth of $h_0/2$, where h_0 is the depth of the coped section.

For further information on the background of the revised design guidelines for single-coped beams in the 15th Edition *Manual*, keep an eye out for the pending *Engineering Journal* article "Strength of Single-Coped Beams" (**www.aisc.org/ej**).

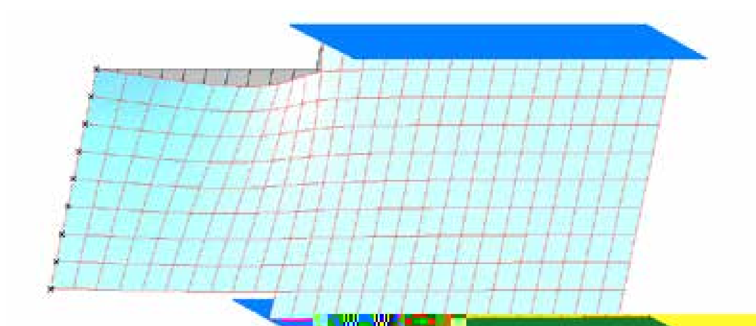
D -C B al

Figure 8 shows the buckled shape of a double-coped beam web, which is characterized by lateral translation and twisting. Because the behavior is similar to that of a rectangular beam, the design procedure was developed based on a lateral-torsional buckling model with an adjustment factor determined by curve tting data from the nite element models. The exural strength is determined in accordance with *Specification* Section F11, with C_b calculated using the equations in *Manual* Part 9. In most cases, the top and bottom cope lengths are equal and *Manual* Equation 9-15 is applicable.

An advantage of the new design procedures in the 15th Edition *Manual* is the ability to calculate the strength where different cope lengths are required at the top and bottom anges (Figure 9). When the bottom cope is equal to or longer than the top cope length, the bottom cope size has a negligible effect on the cope strength and *Manual* Equation 9-15 is valid. When the top cope is longer than the bottom cope, C_b is calculated with *Manual* Equation 9-16.

In most cases, the shear strength of double-coped beams can be calculated according to the shear yielding limit state in *Specification* Section J4.2. However, the experimental results showed that beams with slender webs and short copes can fail by shear buckling, where the buckle extends into the beam web at an angle of approximately 45° from vertical, well

Figure 8. Buckled shape of a double-coped beam.



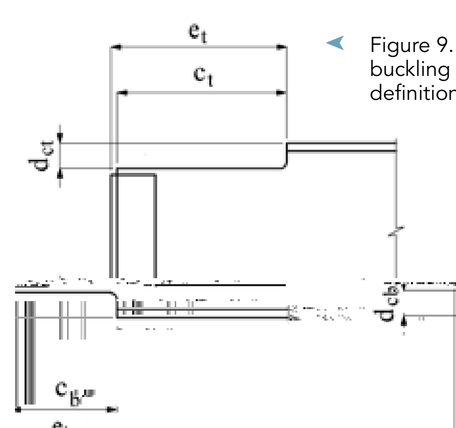


Figure 9. Shear buckling variable definitions.

beyond the face of the cope (Figure 10). In this case, the shear strength can be calculated according to *Specification* Section G3, with k