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Specification Section J10 Limit States

Section J10 of the 2005 AISC *Specification* specifies several parameters to resist local failures. However, after reading descriptions before each limit state, I still find it difficult to determine which limit states apply to a given load. For instance, it is hard to picture what "a pair of compressive single-concentrated forces or the compressive components in a pair of double-concentrated forces, applied at both flanges of a member at the same location" looks like. I would be grateful if you could please provide clarification of the descriptions for the limit states in Section J10.

First you should keep in mind that some of the limit states apply only to tension loads, some to only compressive loads, and some to both. This is discussed in the *Specification* Commentary on page 16.1-355 as follows:

Single concentrated forces may be tensile (such as those delivered by tension hangers) or compressive (such as those delivered by bearing plates at beam interior positions, reactions at beam ends, and other bearing connections). Flange local bending applies only for tensile forces, web local yielding applies to both tensile and compressive forces, and the remainder of these limit states apply only to compressive forces. Double concentrated forces, one tensile and one compressive, form a couple on the same side of the loaded member, such as that delivered to column flanges through welded and bolted moment connections.

Flange local bending applies only to tension forces, so it need not be checked where only compression will occur such as in seated connections. It applies to both single forces, such as hangers, and double forces, such as moment connections.

Web local yielding applies to both tension and compression forces, and also applies to both single and double forces. It would be checked, for example, at seats, hangers, and moment connections. It is also usually checked at the gusset-to-beam interface of vertical bracing connections.

Web crippling applies only to compression forces, but applies to both single and double forces. It would be checked, for example, at seats and moment connections, but not hangers. It is also usually checked at the gusset-to-beam interface with vertical bracing connections, if compression can exist.

Web sidesway buckling applies only to compression forces, and applies only to single forces such as a column bearing on an unrestrained beam.

Web compression buckling, like web crippling, applies only to compression forces, and applies to both single and double forces. However the compression force must be applied to both sides of the member, so that the web acts similar to a column. This limit state is not checked, for instance, with seats or where a moment connection is present on only one side of the column.

Web panel zone shear only needs to be checked where double forces lead to a shear in the web.

Larry S. Muir, P.E.

Increasing Composite Beam Strength

Is it possible to add strength to an existing composite beam by adding mechanical anchors (expansion bolts) from below? The idea is to drill through the flange and install the anchor through the flange and into the concrete slab above.

I have never seen shear connectors being added from the underside of a slab to provide additional composite strength. I do not know that a bolt shaft without a head being inserted into the slab could provide clamping capacity between the concrete and steel beam. In the traditional stud installation, the head of the stud clamps the deck/fill to the steel beam to develop the horizontal shear capacity.

A common approach to add capacity is to core from the topside of the slab, and after placing the additional studs, cast the core hole full of grout. See FAQ 4.5.5 on the website at www.aisc.org/faq for discussion of this approach.

Kurt Gustafson, S.E., P.E.

External Load on a Pretensioned Bolt

What is the behavior of a pretensioned bolt subjected to an external tension load? Will the pretension force reduce the tension strength of bolt?

A pretensioned high-strength bolt subjected to an externally applied tension force does not see appreciable additional tension until the external load exceeds that pretension force. The *Guide to Design Criteria for Bolted and Riveted Joints* (a free download at www.boltcouncil.org) includes the following explanation:

"As a result of the preload, the externally applied loads mainly change the contact pressure between the plates; very little fastener elongation is introduced and therefore there is only a minor change in bolt tension."

Since the available tensile strength of the bolt is less than the required pretension force, the externally applied load is always accommodated in a properly sized pretensioned connection.

Kurt Gustafson, S.E., P.E.

Connection Filler Plates

What criteria are used to design filler plates in connections?

Typically, fillers in bolted connections do not resist load, other than through-thickness compression, which is not a limit state that needs to be checked. However, the filler can affect the bolt strength if it is above a certain thickness. This is discussed in Section J5 of the AISC *Specification* (a free download from www.aisc.org/epubs).

In welded construction, which also is covered in Section J5, fillers over ¼ in. thick are required to "be welded to the part on which it is fitted with sufficient weld to transmit the splice plate load, applied at the surface of the filler." In such cases the filler must be able to transmit that portion of the load delivered by the weld. This may involve extending the filler well beyond the bounds of the other connection elements.

Larry S. Muir, P.E.

steel interchange

Shear on Box Shapes

I am working on the design of box sections in shear. According to Chapter G of the AISC *Specification*, the coefficient K_v should be taken equal to 5 for box sections. The commentary indicates that this is because the elements are restrained. Is K_v = 5 appropriate for each axis of a box shape?

Yes. The provisions of AISC 360-05 Section G5 apply to the calculation of both strong and weak axis shear strength. The "h" and "t" values may change depending on the shape and axis under consideration, however K_v = 5 for either case.

Brad Davis, Ph.D., S.E.

Maximum Fillet Weld Size

Section J2.2b of the AISC *Specification* states that the maximum size of a fillet weld permitted along edges for material ¼ in. or more in thickness, shall not be greater than the thickness of the material minus 1⁄16 in., unless the weld is specifically designated on the drawings to be built out to obtain full throat thickness. Does this mean that the weld size can be larger than the thickness of the thicker part?

No, the maximum fillet weld size limitation in Section J2.2b refers to fillet welds in lap joints. A weld cannot be made to air, as would be required to make the leg bigger than the thicker material. The statement simply reflects that there is a difficulty in making welds on edges equal to the full thickness of the material. The corner tends to melt into the weld, making it seem like the weld size is larger than it actually is. To prevent this, the requirement is to size the weld no larger than 1⁄16 in. less than the material thickness, or provide special notation to build out the weld to obtain the proper size.

Kurt Gustafson, S.E., P.E.

Bolted Connections for High-Seismic Applications

Is it required to use slip-critical connections for high-seismic applications?

Bolted connections for the lateral force resisting system in high-seismic applications are required to have the faying surfaces prepared as slip critical Class A, but are not specifically required to be designed as slip-critical connections. The subject is addressed in Section 7.2 of the AISC *Seismic Provisions* as follows:

"All bolts shall be pretensioned high-strength bolts and shall meet the requirements for *slip-critical* faying surfaces in accordance with *Specification* Section J3.8 with a Class A surface."

So, this means the connections are designed for shear bearing values, and the joints are prepared as Class A and the bolts installed as pretensioned. The resulting joints have some slip resistance for moderate earthquakes but will be expected to slip in larger earthquakes (when slip can't realistically be prevented anyway).

Kurt Gustafson, S.E., P.E.

Winter Construction

What is the lowest air temperature in which we can weld? Can we avoid preheating?

Section 5.12.1 of AWS D1.1 addresses minimum ambient temperature requirements. One of the parameters stated is that welding shall not be done when the ambient temperature is less than 0 °F. If the ambient temperature is lower than this limit, you would likely need to provide a heated enclosure around the area being welded and a means to raise the ambient temperature. Preheat requirements still apply, when preheat is required.

Kurt Gustafson, S.E., P.E.

Torsional Constant of T-shape

I am trying to calculate the flexural-torsional buckling strength of a non-standard T-shape per *Specification* Section E4. How are the torsional constant and warping constant calculated?

To compute the flexural-torsional buckling strength of a tee, you'll need J, C_w, and distances from the shear center to the centroid. AISC *Design Guide 9* provides the information you need. On page 9, the first paragraph under Equation 3.32 discusses these calculations for structural tees. Note that the shear center is at the intersection of the flange centerline and web centerline for a T-shape.

Brad Davis, Ph.D., S.E.

Preheat for Welding

Table 3.1 of AWS D1.1 lists the required preheat for welding based on the category of the base metal. When welding steels of different categories together, which category requirement do we follow?

This is covered in Section 3.5.1 of AWS D1.1 as follows: "The minimum preheat or interpass temperature applied to a joint composed of base metals with different minimum preheats from Table 3.2 (based on category and thickness) shall be the higher of these minimum preheats."

Kurt Gustafson, S.E., P.E.

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