Connection Design in the New AISC Manual

Part 2 — Changes to the 13th Edition Manual

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This is the second in a two-part series of articles exploring the many changes to the design of connections in the 2005 AISC Specification and its accompanying Manual of Steel Construction, 13th Edition. The first article (STRUCTURE®, November 2006) concentrated on changes to the Specification. This second part will discuss changes to the Manual.

Manual Changes

Prying Action (Part 9)

The prying action equations in the 13th Edition ASD/LRFD Manual remain the same in form as those in the 9th Edition ASD and 3rd Edition LRFD. A minor change from the formulation of the 9th Edition is that the moment arm "b" (see Manual for definition) for the double angle connection is now measured from the center of the bolt hole to the center of the other leg, rather than to its face. This change was incorporated into the 3rd Edition Manual.

A major change in the new manual is the use of F_u, the tensile strength, in place of F_y, the yield strength, in all equations. This is based on recent research, in which the manual formulas with F_u in place of F_y gave an excellent fit to current testing using currently available steels. This same idea has been around at least 15 years, but was not implemented in the Manual because of concerns about current steels from electric furnaces and older steels from integrated mills.

Plastic Section Modulus (Z) Rather than Elastic Section Modulus (S) (Part 15)

The 3rd Edition LRFD Manual and the 9th Edition ASD Manual both contain a table for S_{net}, the net elastic section modulus for bracket plates and other similar situations. This is table 15-2 of the 3rd Edition LRFD and a table (no number) on page 4-88 of the 9th Edition ASD Manual. Recent research has shown that the flexural strength of plates is much more closely approximated, though still conservative, when the elastic section modulus is replaced by the plastic section modulus. The new manual will use the plastic section modulus in most cases. The elastic section modulus will be used for cope buckling, because that was the model assumed to derive the empirical equations that predict behavior. Thus the 13th Edition Manual will have tables for both S and Z.

The use of the plastic section modulus for flexure of bracket plates ends an anomaly which has existed since the 9th Edition Manual: for a bracket plate welded to a column flange and containing one or more columns of bolts, the welds are analyzed by an inelastic method, the bolts are analyzed by an inelastic method, but the portion of the plate between them is analyzed by an elastic method. Now all three will be analyzed by inelastic methods.

Standard Shear Tabs (Part 10)

Standard shear tabs, i.e. those with a distance between the weld and a single column of bolts of 2½ to 3½ inches, can be designed without eccentricity for up to 9 rows of bolts. This result is based on recent research, and the recognition of the fact that bolt shear strengths have been reduced by 20% to account for end loaded connections. Since shear tabs are not end loaded, that 20% is used to increase the bolt strength. When these increased bolt strengths are matched to the test results, the effect of eccentricity is removed.

Also, based on theory and some testing, the weld size has been reduced from ¾t to ⅝t, where t is the tab thickness.

Extended Shear Tabs (Part 10)

This is a new connection based on a novel concept, that the plate should be the weak link and yield first, thereby protecting the more brittle components, the bolts and the weld, from fracture. This idea has been theoretically developed to provide a maximum plate thickness to protect the bolts and weld. Testing has demonstrated that the concept works, and so it has been incorporated into the Manual. As with the standard shear tab, the minimum weld size is ⅝t.

This type of shear tab will facilitate very economic beam to beam and beam to column web connections. For beam to beam, the tab can be extended so that the first line of bolts is clear of the carrying beam flange, eliminating the need to cope the carried beam. In a sense, the extended tab and carried beam (infill beam) can be considered in the same way as a double coped beam. The procedure does this and checks for flexure yielding and buckling, and shear yielding, in addition to the upper limit of plate thickness. The bolts are checked for an eccentricity from the bolt centroid to the face of the carrying member. The weld is the aforementioned ⅝t. For a column web connection, the tab is extended so that the first line of bolts clears the column flange tips. In this way erection is facilitated.

No stiffeners are required top and bottom because, as for the beam to beam connection, the beam with the extended tab can be thought of as a double coped beam and checked for shear, flexure and stability.

Note that in addition to being a very economical connection, this is also a perfect OSHA connection.

The procedure for extended shear tabs, and an example, are provided in the 13th Edition Manual.

Conclusions

Changes to both the Manual and the Specification have been discussed. Most of these changes will result in increased economy. However, in a few instances changes have been made to address potential problems that have not been properly addressed in previous editions of the Manual.

Changes that will make connections, and therefore steel fabrication, more economical include:

- The removal of arbitrary minimum loads
- Increased weld strengths based on direction of loading
- Use of the plastic section modulus (This represents a 50% increase in bending capacity)
- Minimum fillet welds based on the thinner part joined
- Column stiffener welds no longer required to develop the strength of the stiffener

- Shear yielding strength increased over previous LRFD Manuals
- Plate buckling strength increased over previous LRFD Manuals
- Greater net section strength for bolted moment beams
- Use of F_u instead of F_y in prying calculations
- Elimination of eccentricity in most standard shear tabs
- Improved design procedure for extended tabs, which eliminates the need for top and bottom stiffeners
- Reduction of weld for shear tabs from ¾ of the plate thickness to ⅝ of the plate thickness
- The U factor used with shear lag calculation will be increased for "long" connections

Changes that will make connections, and therefore steel fabrication, less economical include:

- Reduced strength of slip critical connections when oversized holes are used
- In some cases block shear capacity will be reduced
- The U factor used with shear lag calculation will be decreased for "short" connections■

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