IF YOU'VE EVER ASKED YOURSELF "WHY?" about something related to structural steel design or construction, *Modern Steel Construction*'s monthly Steel Interchange column is for you! Send your questions or comments to solutions@aisc.org.

LRFD Design

Recently, I have seen many references to the "LRFD method" in connection with structural engineering. Can you please advise me on how I might become familiar with this procedure?

LRFD stands for Load and Resistance Factor Design (similarly, ASD stands for Allowable Stress Design). The main difference between LRFD and ASD is the load combinations used in the design. Both approaches result in a similar level of safety. The 2005 AISC specification facilitates the use of either LRFD or ASD, permitting the user to select whichever approach they are more comfortable with.

There is a short course on the new specification and manual being presented around the country titled *Design Steel Your Way with the 2005 AISC Specification*. You may consider attending one of these courses to learn more about the new specification. Visit **www.aisc.org/seminars** to learn where this seminar is being given in the fall.

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

Seismic Braced Frame Seminar

I remember that AISC presented a series of seismic braced frame seminars last year. Are there any scheduled in the future?

The seismic braced frame seminars are not being offered at this time. The good news, however, is that the seminar is currently available as an online seminar. Visit **www.aisc.org/seminars** and click on *Online Seminars* on the left side of the screen.

Sergio Zoruba, Ph.D., P.E.

Non-Seismic Braced Frame

I am designing a 12-story concentrically braced steel frame building. The Seismic Design Category is C. I'm taking $R = 3$, so the AISC *Seismic Provisions* are not applicable. What's more economical: HSS field-welded braces or W-shape field-bolted braces?

The more economical choice will probably depend on the project conditions, and the best approach is to discuss it with a steel fabricator and steel erector. They can help you find the right balance of shape type and associated connections for local material and labor costs. They can also best discuss what details are preferable.

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

Low-temperature Service

Ambient air temperatures in the northern regions can reach below zero routinely—say -20 °F. Is the AISC specification still valid?

Yes, but there are additional considerations. Strength increases slightly when temperatures drop below room temperature, but there is a reduction in ductility due to colder temperatures. ASTM A709 (which is commonly used in bridges) provides guidance on the notch toughness that should be specified in cold-temperature service. For example, at least 15 to 20 ft-lb at 10 °F is listed for structural steel for service at -30 to -60 °F.

Sergio Zoruba, Ph.D., P.E.

ϕ Factor for Shear

In Chapter G of the 2005 AISC specification, the h/t_w limit is $2.24\sqrt{(E/F_y)}$ for webs of rolled I-shaped members. This is a slight change from the $2.45\sqrt{(E/Fy)}$ from the 1999 LRFD specification. Why?

The reason for the change of the limitation is a result of the change in the resistance factor ϕ, that has been increased from 0.90 to 1.00 for qualified rolled I-shapes. For further discussion, please see the Commentary to Section G2.1 of the specification, available as a free download at **www.aisc.org/2005spec**.

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

Tension-only Bracing

We are designing a material handling system in a high seismic and high wind region, Seismic Design Category D. The system classification is Special Concentrically Braced Frames due to the height of the structures. Referring to the 2005 *Seismic Provisions*, is it acceptable to design the bent bracing as tension-only X-bracing?

Tension-only bracing is not permitted in SCBFs per Sections 13.2c and 13.3c of the 2005 AISC *Seismic Provisions*. The reason behind these requirements is to balance the tensile and compressive resistances across the width and breadth of the building to prevent the accumulation of inelastic drifts. It is important to realize the SCBF bracing connections must be able to undergo compression buckling to help in shedding seismic energy.

Tension-only bracing is allowed in Ordinary Concentrically Braced Frames (except in K-, V- or inverted-V configurations), though OCBF have a reduced response modification coefficient, R, as compared to SCBF.

Sergio Zoruba, Ph.D., P.E.

Bolt Torque

What is the required installation torque for each diameter of bolt?

The RCSC *Specification for Structural Joints Using ASTM A325 or A490 Bolts* (a free download at **www.boltcouncil.org**) does not recognize uncalibrated torque as a reliable method of ascertaining that the proper tension is achieved. The minimum required bolt pretension is listed for the bolt type and diameter in Table 8.1 of the RCSC specification. See Section 7 of the RCSC specification for pre-installation verification requirements. Calibrated torque

can be used to provide the required pretensions if the provisions for the calibrated wrench installation method are followed.

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

Recycled Steel

Does the AISC specification distinguish between the uses of recycled steel versus that produced from raw ore?

No. The AISC specification does not distinguish between steel made from recycled product versus that made from raw ore. The specification defines that the material must meet certain ASTM standards, which in turn define the mechanical and chemical requirements for the product.

The current EAF (electric arc furnace) steel-making process, which is based on the use of recycled steel, typically results in over 95% recycled content. This is the process most commonly used in the production of structural steel hot-rolled shapes in the U.S. today.

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

Serviceability and Strength Considerations for SC Bolted Joints

When designing for wind moments with oversized holes in a flange plated moment connection, can the slip-critical bolts be designed for serviceability or must they be designed for strength based on the 2005 AISC specification?

The Commentary Section J3.8 in the 2005 AISC specification discusses this in detail.

If the bolts slip, and that slip does not cause an increase in load, the bolts can be designed as slip-critical for the limit state of serviceability. This is typically the case for shear and moment connections of beams with oversized holes, as there is minimal slippage and small deformations in connection geometry, and no change in the load.

If the slippage would result in an increase in load, the slip-critical bolt must be designed for the limit state of strength. Some examples of cases where the strength limit state is applicable include high-aspect-ratio braced frames where slippage can result in significant P-Δ effects, long-span flat roof trusses where slip-induced ponding may result in large increases in loads, and built-up compression members where slippage between bolts can lead to reduced buckling strength when elements act independently rather than as a built-up unit.

Sergio Zoruba, Ph.D., P.E.

Undefined Yield Strength in Manual Listing

There is no listing for yield strength of ASTM A307 bolts in Table 1-C of the 9th edition ASD manual. Why is this not listed, and what is the value for it? Also, what is the definition of proof load listed in the table?

Materials that have no minimum yield stress listed in Table 1-C have no defined yield point for the material. Yield strength is not generally of interest for bolts, as rupture limit states control the strength of bolts.

Certain bolting and rod products have a required proof load that is stipulated in the ASTM standard. This is a defined tensile load measurement for bolts meeting a certain standard. This value is not relevant to design and has been omitted in subsequent AISC manuals, including the 13th Edition AISC *Steel Construction Manual*.

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

External Load Applied to Pre-tensioned Bolt

If addtional external load is applied on a pretensioned bolt, is the load additive?

No. The external load is not additive, as explained in the *Guide to Design Criteria for Bolted and Riveted Joints* by Kulak, Fisher, and Struik. Section 17.2 of the book provides this explanation:

> *Cooling of hot-driven rivets or tightening of a nut on a bolt results in axial force or preload in the fastener. Inasmuch as this load exists prior to the application of external loading, the fastener is prestressed. As a result of this preload, the externally applied loads mainly change the contact pressure between the plates; very little additional fastener elongation is introduced and therefore there is only a minor change in bolt tension.*

In practice, the change is so small, it is ignored in design. Furthermore, testing of bolts to failure shows that the preload is relieved by the bolt deformations that occur prior to bolt failure.

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

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Steel Interchange is a forum to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine.

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