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!

Seismic Response Modification Coefficient (R-Factor)

The AISC *Seismic Provisions* state that these provisions are applicable for structures in Seismic Design Category (SDC) D or higher. Does this mean that even if one uses $R > 3$ in SDC A, B, or C he or she does not need to apply these provisions? At the same time, the same paragraph ("Scope") says that the provisions are intended for structures for which the seismic design forces have been determined in assumption of inelastic response. This tells me that if one uses $R = 5$, thus relying on inelastic response, he or she should use the provisions regardless of the SDC.

Question sent to AISC's Steel Solutions Center

Yes, as stated in the scope to the 2005 *Seismic Provisions*, "These provisions shall apply when the seismic response modification coefficient, *R*, (as specified in the applicable building code) is taken greater than 3." Use of *R* greater than 3 assumes a certain level of ductility is present and that the system has specific modes of failure that are ductile and controlled. Accordingly, the designer must meet the provisions that correspond to the ductility assumed.

A copy of the 2005 *Seismic Provisions* is available as a free download at **www.aisc.org/2005seismic**.

There is also a user note in the scope section that further explains that some systems with a code-defined *R*-factor less than 3 are permitted in SDC D and above, and that the *Seismic Provisions* do apply to these cases, as well.

Kurt Gustafson, S.E., P.E.
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Cruciform Column in SMRF Design

Is there any concern relative to using a cruciform column (symmetric column in both directions with one column web cut and welded to other column web) in an SMRF? If so, are there any design criteria or is there any research regarding the use of this type of column? The column and beam combination in either direction are pre-qualified per FEMA 350.

Question sent to AISC's Steel Solutions Center

I am assuming you want to use this type of cross-section for moment frames that intersect at one column location. Unless suitable test results are already available to you, the built-up cruciform columns will need to be qualified, as a column cross-section is a prequalification variable per Section P4 of the 2005 AISC *Seismic Provisions*. Also, if these columns are for bi-axial applications, the testing must account for that.

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Principal Axes Properties

I am looking for design section properties for steel angles with respect to the principal major and minor axes (as opposed to the *x* and *y* axis listed in the *Manual*). Is there a reference for this?

Question sent to AISC's Steel Solutions Center

Calculation of properties about any axis is a subject covered in many steel design texts. The equations for the moments of inertia about the principal axes are:

$$I_1 = I_x \cos^2\alpha + I_y \sin^2\alpha - 2I_{xy} \sin\alpha \cos\alpha$$

$$I_2 = I_x \sin^2\alpha + I_y \cos^2\alpha + 2I_{xy} \sin\alpha \cos\alpha$$

There was a paper published in *Engineering Journal* entitled "Tables for Equal Single-Angles in Compression" by Walker (second quarter, 1991) that contained some nice, simple geometric identities for most single-angle geometric properties. It can be downloaded from **www.aisc.org/epubs**.

The paper shows that $I_w = I_x + I_y - I_z$. Since one can look up the value of r_z from any recent edition of the AISC manual, one can easily determine $I_z = r_z^2 A$. Hence, with the above identity one can determine I_w without doing any trigonometry.

Kurt Gustafson, S.E., P.E.
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Strong Axis Bending of a Flat Plate

What is the formula for allowable stress for strong axis bending of a flat plate? I can find the weak axis of $0.75F_y$, but no strong axis.

Question sent to AISC's Steel Solutions Center

You must be looking at the 1989 (or older) ASD specification. Strong axis flexure of plate sections was not defined in that document, though it is now covered in the 2005 AISC specification. The nominal flexural strength of rectangular bars bent about either geometric axis can be found in Section F11 of the 2005 AISC *Specification for Structural Steel Buildings* (a free download at **www.aisc.org/2005spec**).

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Allowable Stress for Anchor Rods

Where can I find the allowable shear stress values for ASTM F1554 grade 105 anchor rods?

Question sent to AISC's Steel Solutions Center

AISC recommends avoiding resisting shear by anchor rods if possible. If such a transfer mechanism is considered, other considerations that should be evaluated include the method of shear

transfer mechanism of the plate on the normally large base plate hole size, number of anchor rods that will be engaged, and possibility of eccentric shear causing bending in the anchor rods. If the frictional resistance between the base plate and foundation is insufficient to resist the base shear, it is recommended to use base shear lugs, embedment, or other means to resist the shear rather than transferring the shear through the rods.

Refer to Section J3.6 and Table J3.2 of the 2005 AISC specification (a free download from **www.aisc.org/2005spec**). Note that this specification covers both ASD and LRFD. The table lists nominal stress values of F_{nt} and F_{nv} for tension and shear, respectively. Since you want to determine the shear strength, F_{nv} is of interest to you.

For ASD, one must divide the nominal stress values by the listed factor of safety (2.00, in this case) to convert to allowable stress. Thus, the allowable shear stress is equal to $0.40F_u/2.00 = 0.2F_u$ when threads are in the shear plane and $0.5F_u/2.00 = 0.25F_u$ when threads are excluded from the shear plane.

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Bracing of Double Angle Diagonal

What effective length should be used for diagonal double angle cross bracing? At the intersection, one set of double angles is continuous and the other is bolted or welded to a gusset plate. I reviewed literature that indicated the tension diagonal can be used to brace the compression diagonal. However, this was for single-angle cross bracing where each member is continuous at the intersection. It would be conservative to just use the diagonal length for out of plane buckling, but that may be more conservative than necessary.

Question sent to AISC's Steel Solutions Center

We recommend a paper entitled "Practical Application of Energy Methods to Structural Stability Problems" by R. Shankar Nair in the fourth quarter, 1997 issue of AISC's *Engineering Journal*, as it covers three cases of restraint at the center of the X-bracing. The conclusion varies based upon the details and restraint provided.

Also, the *Engineering Journal* paper "Effective Length Factor for the Design of X-bracing Systems" by El-Tayem, fourth quarter, 1986 also addresses the issue, with one test involving double-angles and, again, various levels of restraint. You can download these papers from **www.aisc.org/epubs**.

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Column-Beam Moment Ratio

What are the requirements for column-beam moment ratio for ordinary moment frames, if any, for Seismic Design Category A, B, or C? Do the strong column/weak beam requirements for special moment frames apply to OMF as well? Also, if there are requirements, do they change whether one is using the *Seismic Provisions* or the *Specification for Structural Steel Buildings*?

Question sent to AISC's Steel Solutions Center

The IBC Model Building Code and ASCE 7 standard do not necessarily require that the *Seismic Provisions* be employed for Seismic Design Categories A, B, and C, unless an *R*-factor greater than 3 is selected by the engineer of record. Typically, most design professionals will choose the classification of "Structural Steel Systems not Specifically Detailed for Seismic Resistance" with an $R = 3$, rather than follow the *Seismic Provisions* requirements.

If you are not required to follow the *Seismic Provisions*, there is no requirement of a strong column-weak beam relationship. However, even in SDC A, B, or C, if you choose to use the *Seismic Provisions* there is a difference between the SMF, IMF, and OMF detailing requirements. The answer to your specific question pertaining to the OMF system can be found in:

- Section 11.3, which indicates "No additional requirements beyond the Specification" are applicable;
- Section 11.4, "No requirements beyond Section 8.1";
- Section 11.6 for Column-Beam Moment Ratio, "No Requirements."

Thus, the strong column/weak beam requirement for SMF does not apply to OMF.

A copy of the 2005 *Seismic Provisions* is available as a free download at **www.aisc.org/2005seismic**.

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Steel Interchange is a forum for *Modern Steel Construction* readers 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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If you have a question or problem that your fellow readers might help you solve, please forward it to us. At the same time, feel free to respond to any of the questions that you have read here. Contact Steel Interchange via AISC's Steel Solutions Center:

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