Gravity Controls Over Seismic?

By Jerod G. Johnson, Ph.D., S.E.

Width/thickness ratios for members resisting both gravity and seismic loads are generally thought to be controlled by seismic criteria. This only makes sense, since the transient loads due to an earthquake typically impose demands far above and beyond those associated with simple gravity service conditions. Is it likely that gravity considerations would ever be more restrictive than seismic considerations?

If you answered 'no' to this question, you would be right – it is not *likely*. Nevertheless, there is a minority of conditions for which the converse is true and gravity criteria control over seismic criteria for a given shape. Section E7 of AISC 360-05 in the 13th Edition of the *Steel Construction Manual* requires adjustment to certain design parameters for slender compression elements. Here, the reduction factor Q is defined and has the effect of reducing the critical buckling stress (F_{cr}). Where does this adjustment become manifest?

Consider a W14x43 column in either a single-story braced frame or at the top level of a multi-story braced frame. This section supports both gravity and seismic loads. The ratio of the height to the web thickness (h/t_w) for this section is 37.4. Per Table B4.1, the limiting slenderness ratio (λ_r) for the web of this element is $1.49(E/F_y)^{0.5}$ or 35.9. Hence, this column is slender and subject to the provisions of Section B4. By contrast, depending on the magnitude of the axial force in the column, AISC 341-05 in the First Edition of the *Seismic Design Manual* would define this shape as seismically compact if the slenderness ratio of 37.4 is less than $3.14(E/F_y)^{0.5}(1\text{-}1.54C_a)$. AISC 341-10 in the Second Edition of the AISC *Seismic Design Manual* has a somewhat different equation, but the point still applies. Among other criteria, Section E7 of AISC 360-05 requires that design strengths be reduced by the Q factor, and that section properties be calculated based on 'effective' section dimensions. Though tedious, these calculations may validate the use of this column for its intended application in the braced frame. It is noteworthy that many of the commercially available and commonly used structural design software applications do not perform this particular slenderness check; it must always be verified by hand.

Again, the shapes for which the standard AISC 360-05 criteria for compactness may be more stringent than those in AISC 341-05 are among the minority. Eliminating these shapes from one's design database is not likely to cause dramatic changes in the cost or performance of the resulting structures. As an alternative to the column example, the next size up (W14x48) does not suffer from the same 'slenderness' classification and will certainly result in lower demand/capacity ratios for the given scenario. Such measures should be judged on a case-by-case basis.■

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