Modern Steel Construction's monthly *Steel Quiz* allows you to test your knowledge of steel design and construction. All references to LRFD specifications pertain to the 2005 *Specification for Structural Steel Buildings*, available as a free download from AISC's web site:

www.aisc.org/2005spec

ASD references pertain to the 1989 *ASD Specification for Structural Steel Buildings*. Where appropriate, other industry standards are also referenced.

Anyone is welcome to submit questions for *Steel Quiz*—one question or 10! If you or your firm are interested in submitting a *Steel Quiz* question or column, contact ▶

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This month's questions all relate to Chapter F - Design of members for Flexure, and Table B4.1 – Limiting Width-Thickness Ratios for Compression Elements of the 2005 AISC *Specification for Structural Steel Buildings* (a free download at www.aisc.org/2005spec).

1. What does the term L_b represent in relation to a beam?

2. What does the term L_p represent and how does it relate to the flexural strength of a beam?

3. What does the term L_r represent and how does it relate to the flexural strength of a beam?

4. What is the symbol that designates the width-thickness ratios of the various elements of the cross-section?

5. What is the significance of the width-thickness ratio in the design of beams?

6. What does the symbol λ_p represent?

7. What is the relationship of λ_p to the flexural strength of a beam?

8. What does the symbol λ_r represent?

9. What is the relationship of λ_r to the flexural strength of a beam?

10. What does the symbol M_n represent in relation to the flexural strength of a member?

The answers to these questions should give the necessary information to understand the basic design parameters involved in creating a Flexural Strength Chart for a particular rolled shape based on various spacing of bracing. Can you start to develop this chart? Next month we will touch on how the flexural design equations of the 2005 *Specification* relate to this developed chart.

Answers

All references refer to the 2005 AISC *Specification*.

1. L_b represents the actual unbraced length of a beam. This is the distance between points that are either braced against lateral displacement of the compression flange or braced against twist of the cross section as defined in Section F2.

2. L_p represents the unbraced length up to which yielding will control over lateral-torsional buckling. For a hinge to form in a compact section, a beam must be braced (see question 1) to prevent lateral-torsional buckling. The limiting bracing distance to assure hinge capability is defined as L_p. When $L_b < L_p$ for a compact section, the member is adequately braced to permit yielding of the section and the limit state of lateral-torsional buckling does not apply. L_p for doubly symmetric compact I-Shaped Members and channels bent about their major axis is defined by Equation (F2-5).

3. L_r represents the unbraced length at which lateral-torsional buckling transitions from the inelastic range to the elastic range. When the unbraced length L_b exceeds L_p but does not exceed L_r, inelastic lateral-torsional buckling can occur. When $L_b > L_r$, elastic lateral-torsional buckling can occur—that is, the lateral-torsional buckling limit state is reached before the yield stress is reached in any element of the cross section. L_r for doubly symmetric I-Shaped members and channels bent about their weak axis is defined by Equation (F2-6).

4. The Greek character lamda (λ) designates a slenderness parameter as defined in Section F3. This slenderness parameter is calculated as the ratio of the width to the thickness of the element in question (web, flange, etc). Some elements are stiffened by other elements, such as the web of an I-shaped section. Other elements which have a free edge are considered unstiffened, such as the projecting flange of an I-shape or the stem of a tee section.

5. Compression buckling strength is a function of the width-thickness ratio of the element or elements subject to compression. Flexural members will have portions of the cross-section subject to compression and thus a tendency to buckle if the components are too thin.

6. λ_p represents the limiting slenderness parameter for a **compact element** as defined in Section B4. An element is compact if $\lambda \le \lambda_p$. Subscripts are used in Chapter F to differentiate between flange and web elements. If $\lambda_f \le \lambda_{pf}$ the flange is compact. If $\lambda_w \le \lambda_{pw}$, the web is compact.

7. Certain beams are able to take advantage of an ability to develop a plastic hinge. To do so, the section must be compact, which means that none of the elements will buckle prior to yielding of the cross-section. This can be achieved when $\lambda \le \lambda_p$ for all of the elements of the cross section and the beam is braced (see questions 1 and 2). Compact sections make the most efficient use of their cross-section, since the entire cross-section is effective.

8. λ_r represents the limiting slenderness parameter for a non-compact element as defined in Section B4. An element is non-compact when $\lambda_p \le \lambda \le \lambda_r$. λ_r is the demising limit between that of a non-compact element and a slender-element—that is, the transition from inelastic local buckling to elastic local buckling. When $\lambda > \lambda_r$, the section is referred to as a slender-element section. Subscripts are used in Chapter F to differentiate between flange and web elements. If $\lambda_{pf} \le \lambda_f \le \lambda_{rf}$. the flange is non-compact. If $\lambda_{pw} \le \lambda_w \le \lambda_{rw}$. the web is non-compact.

9. In the design of a flexural member, λ_r is used to define parameters of element local buckling; specifically compression flange or web local buckling. When λ exceeds λ_p but not λ_r, the equation used models inelastic local buckling. When λ exceeds λ_r, the equation used models elastic local buckling.

10. M_n represents the Nominal Flexural Strength of a structural member as defined in Section F1 and determined in accordance with Sections F2 through F12. For LRFD designs, the available strength is determined as ϕM_n. For ASD designs, the available strength is determined as M_n/Ω. ★