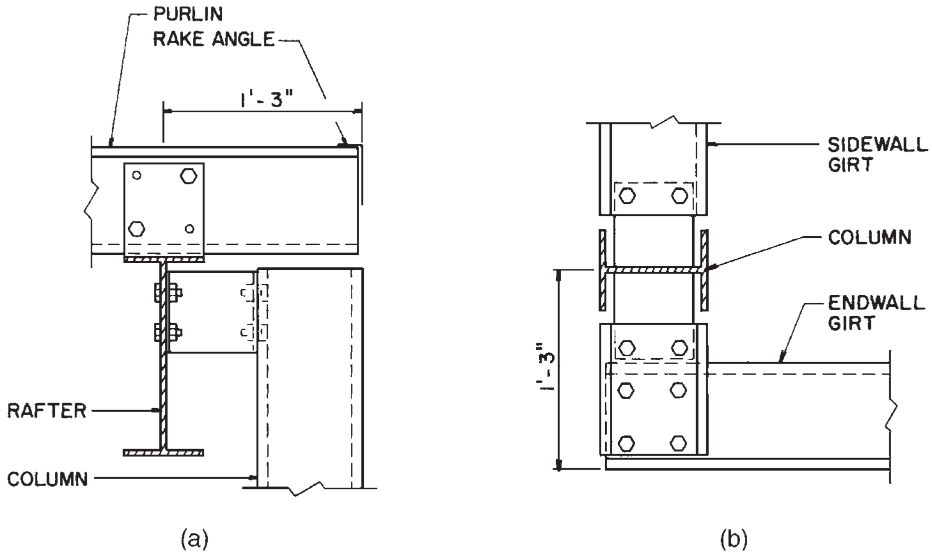

FIGURE 4.24 Endwall framing details for expandable endwalls. (a) Connection between endwall column and frame rafter; (b) plan at corner. (*Metallic Building Systems.*)

specifications.

According to a test program performed by Prof. Thomas M. Murray, single-sided welds do not reduce the ultimate structural capacity of the primary frames, except in the end-plate connections where seismic loading is involved. The simulation of cyclic seismic forces in the test program produced repeated local buckling, which resulted in fracture of the single-sided welds in the frame rafters near the end plates. Some feel that single-sided welding may be acceptable for static loads, but not for frames subjected to lateral forces, concentrated loading, or fatigue, where double-sided welds should be used.[7] Naturally, most rigid frames must resist both gravity and lateral loads.

4.12.2 Fabrication and Erection Tolerances

The normal fabrication and erection tolerances for metal building systems are included in the *MBMA Manual,* Sec. 9. It shows tolerances for cold-formed shapes, built-up structural members, and crane runway beams. The allowable tolerances in the *MBMA Manual* are generally more lenient than those used by AISC for fabrication and erection of structural steel. Why would these tolerances be of interest to the specifiers of metal building systems?

The main reason: Structural members in pre-engineered frames are designed with very little margin of error. Unlike stick-built structures that use a limited selection of framing sizes, the frame components of metal buildings can be designed with an efficiency level close to 100 percent. If the eccentricities that arise from tolerances are not considered in the design, the frames may become overstressed under the full design loading.

For example, the MBMA-allowed magnitude of sweep (a deviation from the theoretical location of the web, measured in the weak direction of the member) and of camber (a deviation from the theoretical location of the flange, measured in the strong direction) for built-up members other than runway beams is:

$$\frac{(\frac{1}{4}\text{ in})\,L}{10}$$

where L is the member length in feet. Thus a 20-ft-high column has an allowable sweep of ¼ × 20/10 = 0.5 in; an 80-ft-long frame rafter has an allowable sweep of 2.0 in. Presumably, the column has to be designed for this weak-axis eccentricity of 0.5 in, and torsion in the frame caused by the weak-axis eccentricity of 2.0 in should be similarly considered to avoid overstress under the design load. While torsion in the rafter can be relieved by kicker angles connecting the bottom flange of the rafter to purlins (see Fig. 4.19), an interior column with sweep cannot be readily braced; it must rely on its own strength to resist the resulting weak-axis eccentricity.

We should note that such "accidental" eccentricities are presumed to be included in AISC equations for structural steel framing and need not be checked for structural steel. However, as was just stated, the AISC tolerances are stricter than those of MBMA.

4.12.3 Torsion Resulting from Member Eccentricities

An examination of many commonly used details included in Chaps. 3 and 4 and other chapters suggests that these details sometimes seem to neglect torsional stresses. Torsion can be introduced by the methods of connecting structural members and by their asymmetric shapes. The issue of torsion caused by design misalignment of the intersecting elements was already discussed in Chap. 3. Torsion is present when the endwall columns are framed into the sides of the primary frames (Figs. 4.23 and 4.24), when exterior masonry walls or door jambs are attached to the bottom flanges of eave struts (see illustrations in Chaps. 7 and 10), and in many other similar cases.

Unfortunately, the so-called open cold-formed steel sections—those that do not form a welded tube or a pipe—have poor inherent resistance to torsion. Accordingly, it is often desirable to provide diagonal flange bracing ("kickers") in the situations just described. Two examples of using endwall frame flange braces appropriately are shown in Figs. 4.25 and 4.26. Where such flange bracing is impractical and the torsion-inducing detail cannot be changed, consideration should be given to using "closed" tubular sections in lieu of stock cold-formed members.

REFERENCES

1. *Manual of Steel Construction*, vol. II, *Connections*, American Institute of Steel Construction, Chicago, IL, 1992.
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3. Charles J. Carter, "Fixed vs. Pinned, the answer in *Technical Questions and Answers*," *Structure*, June 2001, p. 50.
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6. Jeffrey S. Nawrocki, "How Fabricators Can Combat Metal Buildings," *Modern Steel Construction*, May 1997, pp. 78–81.
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REVIEW QUESTIONS

1 Name at least three common profiles of exterior columns.

2 Select an eave height for the building with a single-span rigid frame 50 ft wide, carrying a roof live load of 40 psf, and having a roof pitch of 4:12. The minimum required clear height at the knee is 15 ft.