10.8 SPECIFYING EXPOSED FRAMING

Some architects of a "high-tech romantic" streak like to incorporate exposed steel framing into building exteriors. Exposed framing can look dramatic on sketch paper, but the real-life structure might not turn out so good, for several reasons.

First, as was mentioned in the preceding chapter, there could be a problem of obtaining a high-quality shop-applied paint or color-galvanized finish for primary framing. Exposed steel with a mediocre coating may not survive for long in a corrosive atmosphere.

Second, steel framing is used most efficiently when column and rafter flange bracing is available; such bracing, as well as bolted member splices, may not look particularly attractive when exposed to view.

Third, some architects forget that pre-engineered framing is built up from relatively thin plates. The web-to-flange welding usually occurs on one side of the web only. Apart from raising conceptual concerns in some structural engineer's minds, this kind of welding does not approximate a familiar smooth fillet line offered by hot-rolled steel and does not provide a good weather barrier.

Fourth, the framing-to-wall connections are difficult to weatherproof; the wall integrity depends solely on sealants. Owing to fabrication and erection tolerances, the gaps between framing and siding are rarely uniform in width and may require massive amounts of sealants. The results are rarely pretty. On one project where exposed steel was used, the only party totally satisfied with the building's appearance was the caulking salesman.

10.9 FAILURES OF PRE-ENGINEERED BUILDINGS

10.9.1 Main Causes of Metal Building Failures

Like any other type of construction, pre-engineered buildings can, and do, fail. Some of the failures have been rather dramatic, because they involved complete building collapses.

Consider the recent experiences of customers of commercial and industrial property insurer FM Global: "For a recent eight-year period, approximately 60% (loss dollars) of FM Global customer roof collapses involved metal roof systems (MRS) construction. This consisted of 74 collapses, causing nearly US$221 million in damages—an average loss of nearly US$3 million per incident. The damage typically represented about two-thirds of the entire structure vs. about one-fourth of the entire structure for other construction types."[16] Among the many possible causes of failures, the chief ones are

1. Overload (Fig. 10.16)
2. Improper design practices
3. Defective construction
4. Deterioration
5. Other, such as improper alterations or absence of any original design

These causes are examined separately in the remainder of this chapter. A combination of two or more of these causes is often responsible for the building failure.

10.9.2 Failures Caused by Overload

Many failures of metal building systems can be traced to overload—a condition when more loading is imposed on the structure than it was designed to resist. For example, a building designed for a 30-psf snow load might receive a documented record snowfall of 80 psf, or a building designed to resist

FIGURE 10.16 Building collapse under heavy snow accumulation.

80-mi/h winds gets hit with a 150-mi/h hurricane. A building collapse under either of those two scenarios could be blamed on simple overload. Indeed, even a perfectly designed and constructed building will collapse if the overload is severe enough.

But what if the building fails under a loading that is only slightly larger than the design load, e.g., a measured snowfall of 32 psf on a roof designed to carry 30 psf? An argument could be advanced that such a roof should be able to carry at least its design level of snow loading times a safety factor. So, for a design snow load of 30 psf and a safety factor of 1.67, the predicted failure load would be 51 (30×1.67) psf. Theoretically, the building should be able to carry an even higher load, because the actual strength of steel is likely to be higher than its nominal grade. In real life, design and construction irregularities could greatly reduce the theoretical failure load. (And there are those who argue that the buildings need not be able to support an ounce over the design load.)

As explained in Chap. 4, Sec. 4.12, pre-engineered buildings are designed for nearly full efficiency, so little "fat" remains to account for accidental local overload caused by some common factors. For example, overload could occur in frame columns that are not designed for the minimum eccentricities resulting from MBMA-permitted fabrication tolerances, particularly sweep.

Column sweep is an as-built out-of-straightness measured in the direction perpendicular to the web. According to Table 9.2 of the MBMA Manual's Common Industry Practices,[10] the allowable sweep in inches is equal to $^1/_{40}$ of the column length in feet. A 30-ft-high column could have as much as $^3/_4$ in of sweep. The unanticipated weak-axis bending moments resulting from the eccentricity of the design load could overstress a column designed for purely axial loading.

As for wind overload, the worst damage tends to occur at the building corners, eaves, and ridges—the areas where modern codes may prescribe much larger local pressures than some older codes. The wind-code provisions are continually being refined, reflecting the historical performance of the buildings designed under the prior code editions.