0.6 Dead + wind

0.6 Dead + 0.7 earthquake

The IBC's second ("alternate") set of load combinations has been already described. One code provision quite relevant to metal building systems concerns the alternate load combination of "dead + wind." In that combination, the code allows using only two-thirds of the of the minimum dead load likely to be in place during a design wind event.

The dead load in load combinations should include collateral load if that increases the total effect. Collateral load should be ignored for uplift determination in the "dead + wind" combination but included when the wind acts downward. Thermal loading, not included in the above "basic" combinations, should be considered when appropriate, as discussed above. Both balanced and unbalanced (plus partial) snow loading should be considered in all the loading combinations involving snow.

Occasionally, projects may require that some nonstandard load combinations be considered, whether based on the local code provisions or on engineering judgment. In this case, the specifiers should bring the manufacturers' attention to this requirement early—at the bidding or negotiating stage—and be prepared to persevere in the face of some resistance to altering routine practice and the available computer programs.

3.3 HOW METAL BUILDINGS WORK STRUCTURALLY

3.3.1 Some Building Anatomy

A typical single-story metal building system is supported by *main frames* forming a number of bays (Fig. 1.2). *Bay size* is the space between frame centerlines measured along the sidewall. In the perpendicular direction, *frame clear span* is the clear distance between frame columns. At the roof level, *metal roof panels* form a weathertight enclosure and carry structural loads to *purlins,* the secondary structural members spanning between the main frames. Metal building systems can have a variety of wall materials, the original and still the most popular being metal siding, supported by sidewall or endwall *girts.*

Endwalls are commonly framed with *endwall columns,* which provide support for the girts and therefore are spaced at the intervals dictated by the girt's structural capacity. The endwall columns carry roof beams spanning from column to column, as in post-and-beam framing. If a future building expansion is planned, a regular main frame can be used instead of the endwall framing; the only function of the endwall columns then is lateral and vertical girt support. During the future expansion, the columns are removed and one or more bays added.

3.3.2 Lateral Stability of Metal Buildings: Typical Approach

A building lacking lateral stability against wind and earthquake loads will not be standing for long. The most popular pre-engineered structure, *rigid frame,* relies on its own moment-resisting ability to laterally support the building (Fig. 3.4). Other frame systems, such as the familiar post-and-beam construction, do not possess such rigidity of their own and, absent of any rigid walls, may collapse like a house of cards if pushed laterally (Fig. 3.5*a*). Thus the second way to achieve lateral stability of the building is to provide *braced frames,* as shown in Fig. 3.5*b.* Vertical bracing not only resists lateral loads but also stiffens the building in general, especially against the crane-induced loads, minimizes vibrations, and helps during building erection. Vertical rigidity can also be provided by *shear walls,* discussed separately.

A typical design solution for metal building systems is to provide moment-resisting frames spanning the short direction of the building and braced frames in the exterior walls. The vertical bracing located in the endwalls acts primarily in resisting lateral loads acting in the direction parallel to the frames, while the sidewall bracing resists the loads in the perpendicular direction.

The *roof diaphragm,* usually a system of horizontal braces, distributes the loads among the lateral load-resisting elements.

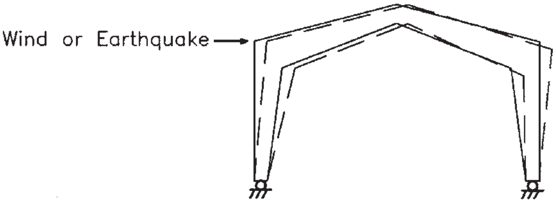

FIGURE 3.4 Rigid frame's moment-resisting ability.

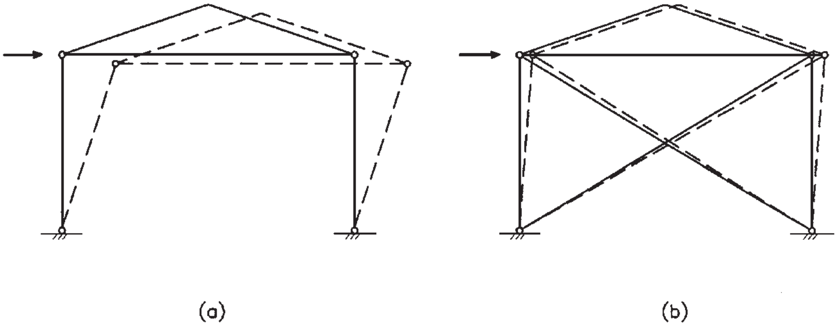

FIGURE 3.5 Post-and-beam frames. (*a*) Unbraced (unstable); (*b*) braced (stable).

3.3.3 The Roof Diaphragm

When rigid frames are used in combination with endwall bracing, the roof diaphragm plays a relatively minor role in resisting wind or earthquake loads acting parallel to the frames, since its span is only one bay—between the frames. However, the roof diaphragm plays a critical role in buildings with nonrigid frame types such as a simple-span beam and bar joist system, where the diaphragm spans the distance between the endwalls (Fig. 3.6).

While roof bracing represents the usual type of roof diaphragm found in metal building systems, the same result can be achieved by the rigidity of roof decking made of steel, wood, or concrete. Corrugated metal roof deck is probably the most common diaphragm used in conventional construction; it has its place in metal building systems as well. Through-fastened metal roofing operates on the same principle as metal deck, although it possesses a lesser degree of rigidity owing to the thinner metal gages.

Still, the typical roof diaphragm construction in metal building systems is made of diagonal steel rods resisting tension forces and struts designed for compression. The diaphragm is essentially a horizontal truss that includes the rafters of primary frames.

For simplicity of construction, the diaphragm rods are placed below the purlins (Fig. 3.7), even though theoretically both the rods and the struts should be located in the same plane. The vertical distance between the purlins and the rods should exceed the maximum expected vertical deflection of the purlins under the full gravity load.

Some manufacturers prefer steel cables instead of rods. The cables, however, tend to loosen; even rods are difficult to tighten and to maintain in a taut condition throughout the service life of the building. The loose rods or cables may allow the building to undergo significant movements before they become engaged, leading to damage of nonstructural elements. The rod connection details are discussed below.

The diaphragm struts may consist of added purlins designed for axial compression, which usually requires that they be laterally braced at close intervals, as shown in Fig. 3.8. Without lateral bracing, a