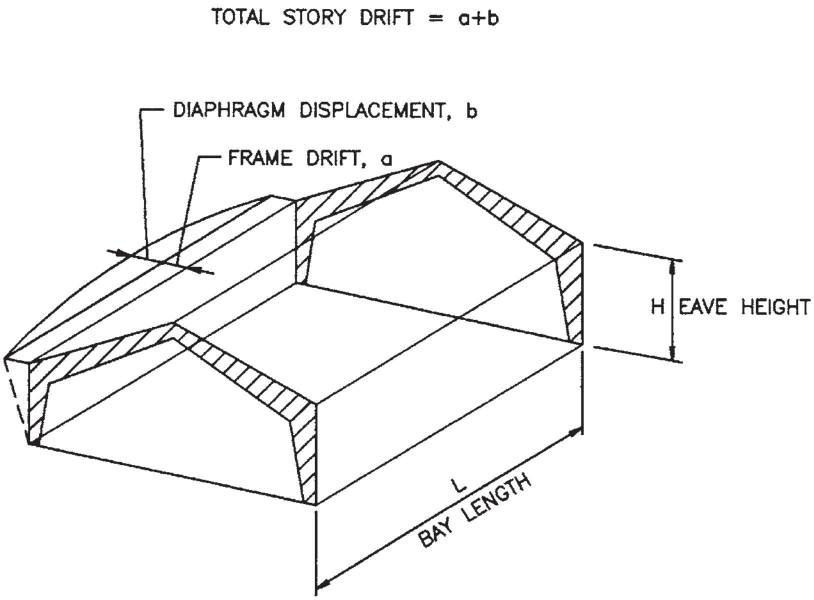
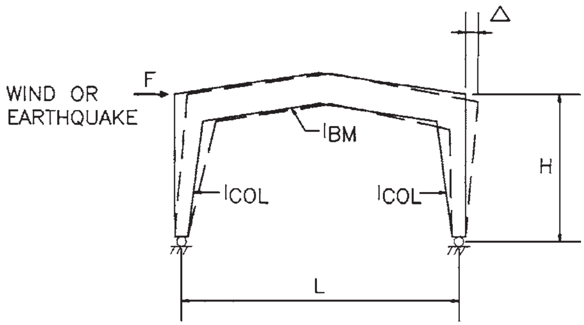


FIGURE 11.3 Components of story drift.



$$\Delta = \frac{FH^2}{6E}\left(\frac{H}{I_{COL}} + \frac{L}{2I_{BM}}\right)$$

FIGURE 11.4 An approximate formula for computing frame drift in a two-hinged frame with constant member section.

We recommend that a drift limit established for the building apply to all service load combinations that include live, snow, and wind loading. An argument can be made that the dead and moderate collateral loads applied prior to the installation of cladding, equipment, and finishes attached to the frame need not be included in the drift calculations. The drift from seismic loading can be evaluated separately, using the relatively lenient code-supplied criteria mentioned in Sec. 11.2.2.

Excessive structural distortion due to snow is real and should not be ignored. Ruddy[13] tells of two pre-engineered buildings, used as a school and an office, that had suspended ceilings. After some

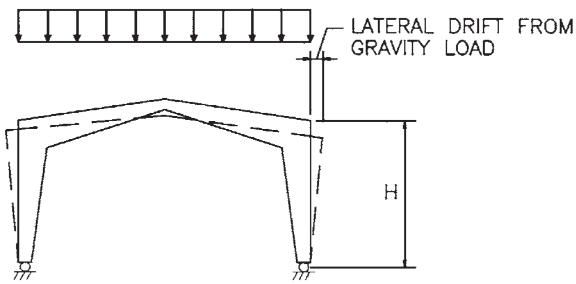


FIGURE 11.5 Lateral displacement of rigid frame under gravity load.

snow had accumulated on the roofs, the ceilings in both buildings became noticeably displaced. The local building officials called on the scene insisted that both buildings be vacated, snow removed, and structural capacity of the roofs rechecked. After an occurrence like this, building designers tend to use rather strict displacement limits for future projects.

Lateral movement caused by gravity loads is less pronounced in multiple-span rigid frames than in their single-span siblings and is virtually absent in tapered-beam and truss systems.

11.2.7 Lateral Drift and Deflections: The Discussion

Are large story drifts always harmful? What concerns the designers is not only an absolute value of the story drift but also an angle of curvature assumed by the wall.

In elastic theory, the larger the slope of a deflected shape of a flexural member, the larger the stresses are. Brittle materials, such as unreinforced masonry and glass, can be simply broken up by large stresses; ductile materials, such as reinforced masonry and concrete, can tolerate some cracking without failure. However, large cracks, especially in single-wythe masonry and concrete walls, are likely to become gateways for water intrusion, which can damage interior finishes and hasten wall deterioration caused by freeze-thaw cycles. The overall degree of wall curvature depends on a magnitude of three deflection components (Fig. 11.6):

1. Story drift, a sum of the frame drift (D_f) and diaphragm deflection D_{diaph}
2. Horizontal deflection of supporting girts and wind columns, if any, D_{girt}
3. Horizontal deflection of the wall itself D_w

Of these, the first two depend on a stiffness of the metal building and the third one is a function of the wall's stiffness. The second component, D_{girt}, occurs only when intermediate girts provide lateral support for the wall, as is often needed for tall walls made of steel studs and brick veneer. In this case, the points where the wall curvature changes—points of inflection—occur near the girt locations (Fig. 11.6*a*). Obviously, horizontal deflections of the walls spanning from foundation to roof without any intermediate girts, such as full-height CMU or precast, do not include D_{girt} (Fig. 11.6*b*).

The critical issue in this discussion is whether the wall functions as a simply supported or continuous member. Stresses and deflections in simply supported beams are not affected by movement of supports. In contrast, continuous members are statically indeterminate and are influenced structurally by yielding supports.

The ends of any simply supported member rotate freely. Therefore, a wall may be considered simply supported only if its ends at the base and at the roof are free to rotate. The maximum horizontal deflection of a simply supported wall may be taken as D_w, not D_{max}, since the movement of supports is irrelevant. If, however, the wall is fixed at the bottom—a CMU wall doweled into the foundation is one example—the end rotation at the base is prevented, the simple-span model does