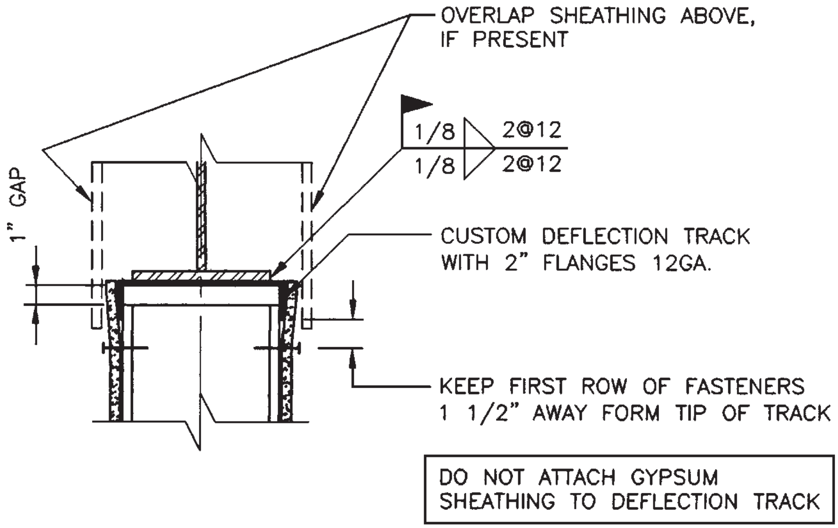

FIGURE 11.13 A custom detail for drywall partition running under primary frame allows for vertical deflection of the frame.

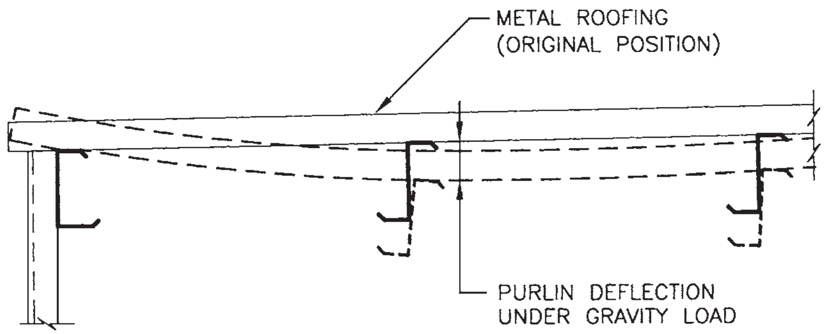

FIGURE 11.14 Shallow roof slope, such as $^1/_4$:12, may be insufficient for proper drainage when purlins deflect under load.

braced, they will tend to rotate under load. As explained in Chap. 10, their actual vertical deflections will be larger than those predicted by the calculations that neglect any reduction of the purlin stiffness due to rotation.

By contrast, the change in roof elevation is only

$$\Delta_{slope} = (5\text{ ft})(\tfrac{1}{4}\text{ in/ft}) = 1.25\text{ in} < 2\text{ in}$$

Therefore, the roof slope is insufficient for prevention of local ponding. As the reader can easily check, to make Δ_{slope} at least equal to Δ_{max}, either the roof slope needs to be increased to $^1/_2$:12 or the stricter purlin deflection limit of L/240 used. We prefer both, to account for any additional purlin deflection from suspended pipes and for the deflection of the roofing between the purlins.

Why is this issue so important? Accumulation and refreezing of melted water in this area can result not only in leaks, but also in significant ice loading that might overstress the purlins. As explained in Chap. 10, in some severe cases this could lead to collapse of the whole building. The author has investigated collapses of two metal buildings where this phenomenon has been identified as being among the main causes of their failure.

Over the centuries, builders and designers have concluded that a deflection limit of 1/360th of the member's length (L/360) is adequate to avoid cracking of plastered ceilings. The deflection limit is applicable to live load, snow, or any other superimposed load acting after the ceiling is constructed. This criterion has been widely adopted by the building codes. In the absence of plastered ceilings, limits that are less strict, such as *L*/180, have traditionally been applied.

The deflection provisions of the *International Building Code*[1] are representative. According to IBC Table 1604.3, the roof members supporting plaster ceilings should meet the *L*/360 limit; those supporting nonplaster ceilings, *L*/240; and those not supporting ceilings, *L*/180. These limits apply under either live, snow, or wind loading (equal to 70 percent of the loading specified for "components and cladding"). An exception is made for secondary members supporting formed metal roofing without any other roof covering—these purlins need only meet the *L*/150 criterion under *live* load. Presumably, their deflections under *snow* load are still limited to *L*/180.

What about the combined deflections from dead and live loading? IBC Table 1604.3 stipulates the limit of *L*/240 for the roof members supporting plaster ceilings; *L*/180 for those supporting nonplaster ceilings; and *L*/120 for those not supporting ceilings.

11.3.2 Other Recommended Criteria

AISC specification[14] limits maximum live-load allowable deflection of roof and floor members supporting plaster to *L*/360. The MBMA *Metal Building Systems Manual,*[12] in its section entitled "Serviceability," reprints some of the provisions of ASSC Design Guide No. 3. The Guide tabulates deflection limitations for various elements of roof construction including those required to satisfy ponding and drainage considerations. For example, it recommends the familiar deflection criteria of *L*/360 for roofs supporting plastered ceilings and *L*/240 for roofs supporting other ceilings. The Guide points out that some "maximum absolute value must also be employed which is consistent with the ceiling and partition details," and suggests a range of 3/8 in to 1 in. The Guide further recommends that the deflection of roof purlins be checked under a combination of dead and one-half design snow load (or a minimum of 5 lb/ft^2) to verify that positive drainage still exists when the members are deflected under load. These Guide criteria are based on the design live load or a 50-year snow.

The Guide states that the above-mentioned deflection criteria are most important along the building perimeter, and that the maximum purlin deflection in the field of the roof from snow load could be limited to *L*/150. Presumably, the last number applies only where no ceilings or partitions are present.

The Guide makes an important point about localized deflections from concentrated loads being probably of larger importance than those from uniform loads. Indeed, a common complaint of pre-engineered building users is that a light fixture or a pipe suspended from a purlin deflects the purlin too much in relation to its neighbors. In our opinion, the best safeguard against such high localized deflections, short of designing each purlin for every minute load—an impractical task—is to use more rigid purlins (and a generous collateral load allowance) everywhere. This means using the deflection limits stricter than *L*/150 throughout the roof.

ASCE 7[9] contains Commentary Appendix B, which deals with serviceability issues. Section CB.1.1 states:

> Deflections of about 1/300 of the span . . . are visible and may lead to general architectural damage or cladding leakage. Deflection greater than l/200 of the span may impair operation of movable components such as doors, windows, and sliding partitions.