3.1.2 Live Load

Live load refers to the weight of building occupants, furniture, storage items, portable equipment, and partitions (the International Building Code[2] lists partition loads in the "Live Loads" section). Owing to the fact that live load is relatively short-term, not easily predictable or quantifiable, it carries large factors of safety (uncertainty, really) in the ultimate design methods. Other sources of live load arise during construction, repair, or maintenance of the building, and these are even more difficult to predict and quantify.

To deal with this uncertainty, building codes have enacted conservative values for live loads—the framing must be designed to resist the loads which might occur only once or twice in the lifetime of the structure, if at all. For example, office buildings are normally designed for the live load of 50 psf while the actual weight of all the people and furniture in a typical office probably does not exceed 15 psf.

It is quite probable that the design live load will occur in a relatively small area of the building at some time or another; it is much less probable that the whole floor will ever see that load. To reflect this reality, building codes set forth the rules governing the *live load reduction* for members supporting relatively large floor or roof areas. For single-story metal building systems, *roof live load,* essentially an allowance for the roof loading during its construction and maintenance, is the load being reduced. With live load reduction, larger uniform loads are assigned to secondary members supporting limited roof areas than to primary structural framing. The reduction formulas are included in the building codes.

The magnitude of roof live load is often compared to snow load and the larger value used in the design.

3.1.3 Snow Load

The design snow load represents the maximum probable weight of snow that can collect on the roof. Unlike live load, snow load is independent of the building occupancy but is highly dependent on location. Building codes and the *MBMA Manual* have traditionally provided maps of ground snow load. Now, both the *MBMA Manual* and the International Building Code defer to ASCE 7[3] for ground snow load determination. Once determined, the magnitude of ground snow load is typically reduced to arrive at the design roof snow load, by multiplying ground snow load by certain coefficients. For example, ASCE 7-98 provides the following formula for determination of flat-roof snow load:

$$p_f = 0.7\, C_e C_t I p_g,$$

where p_f is flat-roof snow load, p_g is ground snow load, C_e and C_t are the exposure and thermal factors, and I is the importance factor. These factors can be found in various tables included in ASCE 7. To arrive at the design snow load on a sloped roof, the p_f is multiplied by the slope factor C_s.

The main reason roof snow load is usually less than the corresponding ground snow load is that some snow is often removed from roofs by melting and wind. However, there are circumstances when the opposite is true: More snow might collect on a superinsulated and sheltered roof than on warm ground. In one case, the measured weight of snow on the roof of a collapsed freezer building was found to be more than twice the value allowed by code—and also exceeded the weight of snow that accumulated on the ground.[4]

When applicable, two other snow-related factors often prove critical: snow sliding and snow drift. Most people living in northern climates have watched snow sliding down a smooth pitched roof; this snow can slide onto an adjacent roof below and add to the snow load on it.

Roof snow drifts against walls and parapets are another familiar sight. The amount of this *additional* snow load depends on the roof size, wall or parapet height, and other factors (Fig. 3.1). (Note that the snow on the gable roof is shown following its slope, as any snow must necessarily do, but the snow load is actually specified as horizontal load acting on the projected area of the roof.) The extra weight from sliding and drifting snow is highly concentrated and cannot be averaged out over

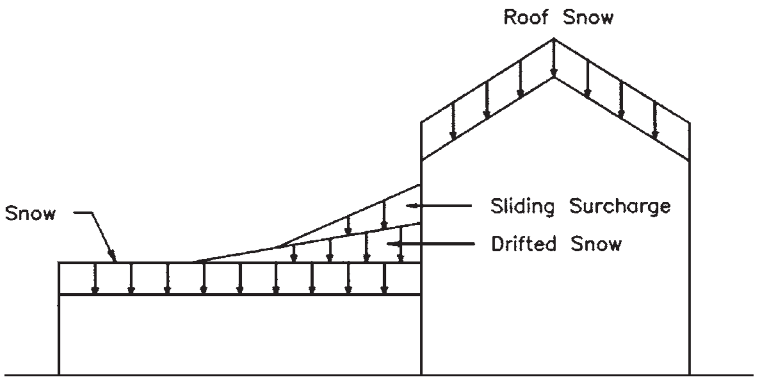

FIGURE 3.1 Snow load on buildings.

the whole roof. It follows that some elements of the roof structure must resist higher snow loads than others. Indeed, the roof areas adjacent to walls and high parapets are often designed for up to three times (and sometimes more) the snow loading elsewhere.

Another design condition that should be considered is unbalanced snow on gable roofs. The design requirements of various codes vary in this regard. The unbalanced-snow provisions of ASCE 7-98 Section 7.6, referenced in the 2002 edition of the *MBMA Manual,* specify the level of loading as a function of the building size, roof slope, flat and sloped-roof snow loading, and other factors. These provisions are rather complex, but presumably they represent a more accurate assessment of unbalanced snow depths accumulating on gable and hip roofs.

The unbalanced roof snow loading should not be confused with *partial loading.* Partial loading is normally considered in the design of continuous structural members such as purlins or multiple-span rigid frames. A partial load occurs when some spans carry a reduced level of live or snow load, while the other spans are fully loaded. It has been long recognized that some structural effects, such as the positive bending moments, of partial loading are more severe than those produced by a full uniform load.

Some spans of continuous members may even experience stress reversals under partial loading: The flanges that would be in compression under a full load may become loaded in tension, and the members in the less loaded spans may flex upward rather than downward. Again, the 2002 edition of the *MBMA Manual* defers to ASCE 7-98 for load determination. Section 7.5 of ASCE 7 indicates three loading conditions to be considered, with full balanced snow load being placed on some spans and half the load on the remaining spans.

The actual snow load accumulation is not likely to follow the neat partial-loading formulas, but neither will it occur in a 100 percent uniform fashion. The depth of snow may vary not only along the length of the building, but also across it, from eave to eave, and the formulas are a handy approximation of the complex reality. Besides, the roof may experience partial loading during snow removal. Despite the typical recommendations that snow be removed throughout the roof in a uniform fashion a little bit at a time, it is much too convenient to totally clear some areas at once—and unintentionally produce a classic partial load.

3.1.4 Rain and Rain-on-Snow Load

These two loads have been rarely used in the past, although some codes contained them for a long time. Now, the International Building Code and ASCE 7 include them on the same footing as the other, more familiar loads.