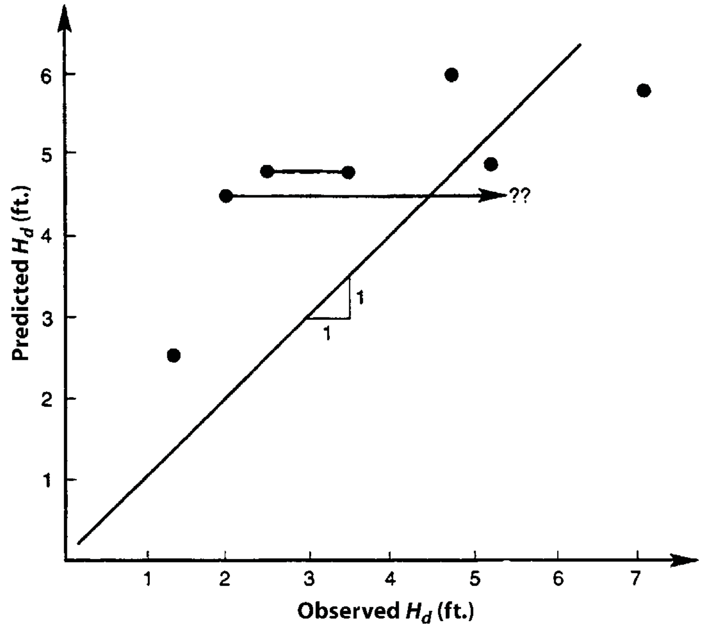


Figure VIII-1 Comparison of observed windward surcharge drift height with values predicted by ASCE 7-05.

history, the observed surcharge height was generally characterized as ranging from 2.5 to 3.5 ft.

For three of the case histories, the provisions overpredict the observed values, and for two others, the provisions underpredict the observed values. The ratios of observed to predicted range from 0.53 to 1.23, with a mean of 0.84. For the windward drifts considered, the overload for the surcharge was no more than 23%. As noted by O'Rourke and DeAngelis, the overload for the total snow load (balanced plus surcharge) is less, and it is unlikely that a snow overload of 23% would result in significant structural performance problems given the safety factors commonly used in building design.

As with drifts on lower roofs discussed in Chapter 7 of this guide, the sloped roof snow load in Equation 7-2 is the balanced load below the roof projection drift load. The sloped roof snow load, p_s, is $0.7C_eC_tIC_sp_g$, where p_g is the 50-year MRI ground snow load. Minimum roof snow loading and rain-on-snow surcharge loads do not influence this balanced load. In addition, if the cross-wind length of the roof projection is small (that is, the plan dimension perpendicular to the direction of wind under consideration less than 15 ft) then the drift load does not need to be considered for that wind direction. Drifts will form at such roof projections, but the cross-wind plan dimension of the drift and the total drift load (in lbs) is relatively small and can be neglected without affecting the overall integrity of the structural system. The author is not aware of any structural-performance problems related to this 15 ft cutoff for roof projection drifts.

8.1 Example 8.1: Parapet Wall Drift

Determine the design snow drift loads for the roof structure shown in **Figure VIII-2**. The site is in a suburban area (Terrain Category B) where p_g is 30 lb/ft^2. A line of conifers about 50 ft to the west of the structure serves as an obstruction. That is, the top of the trees is more than 5 ft (50 ft/10) above roof elevation. The structure is a large, heated warehouse deemed to be of ordinary importance. It has parapet walls on the east and west elevations only. The parapet wall is nominally flush with the roof edge at the north elevation.

Solution

Balanced Load: The building is located in Terrain Category B, and the roof is partially exposed (due to the presence of the conifers as well as the parapet wall); therefore, C_e is 1.0 from Table 7-2. From Tables 7-3 and 7-4, $C_t = I = 1.0$. For a roof slope of ¼ on 12, C_s is 1.0 irrespective of the roof's surface or thermal characteristics. Hence, the balanced load is

$$\begin{aligned} p_s &= 0.7 C_e C_t C_s I p_g \\ &= 0.7(1.0)(1.0)(1.0)(1.0)(30 \text{ lb/ft}^2) \\ &= 21 \text{ lb/ft}^2 \end{aligned}$$

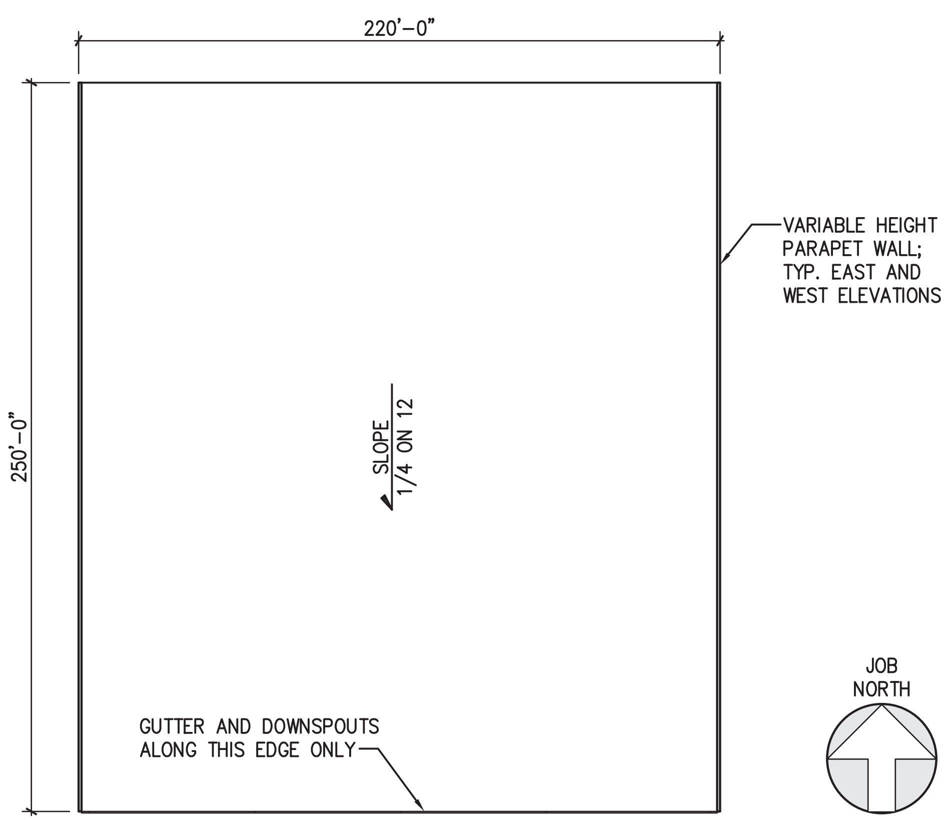


Figure VIII-2 Plan of monoslope roof for Example 8.1.

Drift Load: The height of the parapet wall at the southeast and southwest corners is

$$h = 250 \text{ ft } (1/4 \text{ in./ft}) = 62.5 \text{ in.} = 5.2 \text{ ft}$$

The snow density (γ) is $\gamma = 0.13p_g + 14 = 0.13(30 \text{ lb/ft}^2) + 14 = 18 \text{ lb/ft}^3$ (Equation 7-3), and the depth of the balanced snow is

$$h_b = \frac{p_s}{\gamma} = \frac{21 \text{lb/ft}^2}{18 \text{lb/ft}^2} = 1.17 \text{ ft}$$

The space available for drift formation (the clear height above the balanced snow, h_c, is 5.2 ft – 1.17 ft = 4 ft) is large compared to the balanced snow depth ($h_c/h_b > 0.2$). Therefore, the parapet wall drift must be considered. For an upwind fetch of 220 ft and a ground snow load of 30 lb/ft^2,

$$h_d = \frac{3}{4}[(0.43)(\sqrt[3]{220})(\sqrt[4]{30+10}) - 1.5] = 3.8 \text{ ft}$$

The drift height is not limited by the space available for drift formation because the drift height is less than h_c. The maximum drift surcharge load at the parapet wall is

$$p_d = \gamma\ h_d = 18 \text{ lb/ft}^3 \text{ (3.8 ft)} = 68 \text{ lb/ft}^2$$

The total maximum roof snow load (balanced plus drift) is

$$21 \text{ lb/ft}^2 + 68 \text{ lb/ft}^2 = 89 \text{ lb/ft}^2$$

and the lateral extent is

$$w = 4\ h_d = 4(3.8 \text{ ft}) = 15.2 \text{ ft}$$

The resulting parapet wall drift load at the southwest corner is shown in **Figure VIII-3**. The design drift at the southeast corner is similar. Since both drifts have the same snow source area, it is unlikely that both design drifts would occur simultaneously. The issue of the possible simultaneous occurrence of drifts adjacent to an RTU is discussed in Chapter 13 of this guide (Question 2).

The ground snow load in this case is large enough that the minimum roof snow load ($p_f = I$ (20 lb/ft^2) = 20 lb/ft) is less than the balanced load and thus does not govern. Similarly, the ground snow load is large enough that the rain-on-snow surcharge does not apply (see Section 7.10).

If the roof is a continuous-beam system (for example, a metal building system roof with lapped purlins), then the roof also needs to be checked for the partial load provisions in Section 7.5. The resultant partial load would be considered a separate load case from the balanced-plus-drift load case determined above.

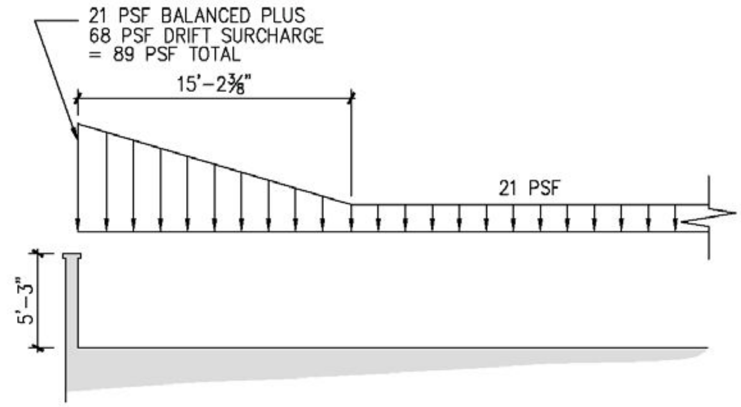


Figure VIII-3 Parapet wall drift at southwest corner for Example 8.1.

8.2 Example 8.2: Rooftop Unit (RTU) Drift

Solve the same problem as Example 8.1, except a 4 ft × 12 ft × 20 ft RTU is located as shown in **Figure VIII-4** and the roof has no parapets.

Solution

Balanced Load: Although the parapets have been removed, the stand of conifers is still in close proximity, so C_e, C_t, I, and p_f are the same as in Example 8.1 ($p_s = 21$ lb/ft^2 and $h_b = 1.17$ ft).

Drift: The clear height to the top of the RTU is $h_c = 4.0$ ft – 1.17 ft = 2.8 ft and $h_c/h_b > 0.2$. Therefore, a roof projection drift needs to be considered. Since the cross-wind dimension of the RTU is only 12 ft, which is less than the 15 ft (4.58 m) minimum for an east–west wind, drifting along the east and west sides of the RTU need not be considered. For a north–south wind, the larger of the upwind fetch distances is 160 ft (48.8 m). Hence,

$$h_d = 0.75[(0.43)(\sqrt[3]{160})(\sqrt[4]{30+10}) - 1.5] = 3.3 \text{ ft}$$

Since this drift height is greater than the clear height, h_c, the drift width, w, is larger than $4h_d$. Using the "equating the areas" relation from Section 7.7.1, the drift width is

$$w = 4h_d^2/h_c = 4(3.3 \text{ ft})^2/2.8 \text{ ft} = 15.6 \text{ ft}$$

Yet from the "aerodynamically streamlined drift" relation, the drift width cannot exceed

$$w \leq 8h_c = 8(2.8 \text{ ft}) = 22.4 \text{ ft}$$

In this case, the "equating the area" relation controls, and the total maximum load (balanced plus drift) is

$$p_{\max} = h_{\text{RTU}} \times \gamma = 4.0 \text{ ft}(18 \text{ lb/ft}^3) = 72 \text{ lb/ft}^2$$

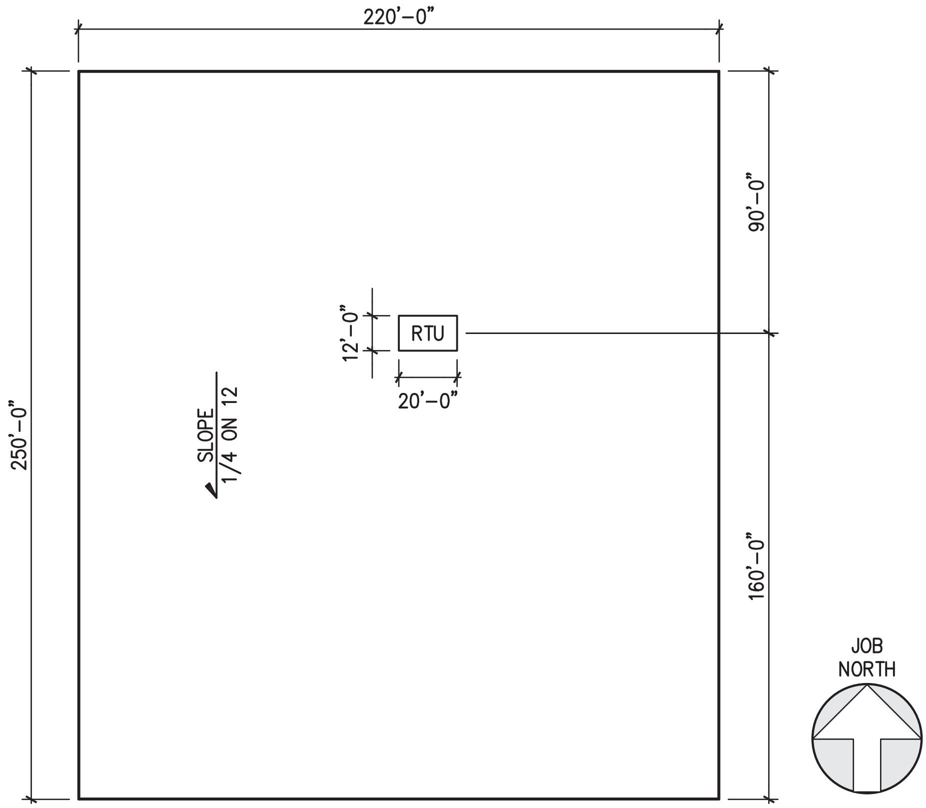


Figure VIII-4 Plan view of monoslope roof for Example 8.2.

The resulting load at the RTU is sketched in **Figure VIII-5**.

8.3 Example 8.3: Parapet Wall Drift, Low Ground Snow Load

Solve the same problem as Example 8.1, except that p_g is 15 lb/ft^2.

Solution

Balanced Load: In Example 8.1, p_g is 30 lb/ft^2 and the balanced load is 21 lb/ft^2 for the structure. The balanced load is proportional to the ground snow load; therefore, the new balanced load is

$$p_s = \frac{15\ \text{lb/ft}^2}{30\ \text{lb/ft}^2}(21\ \text{lb/ft}^2) = 10.5\ \text{lb/ft}^2\ \text{(round to 11 lb/ft}^2\text{)}$$

Of course, the new balanced load could also have been calculated directly from Equation 7-2. Recalling from Example 8.1 that $C_e = C_t = C_s = I = 1.0$,

$$p_s = 0.7\ C_e C_t C_s I p_g$$

$$= 0.7(1.0)\ (1.0)\ (1.0)\ (1.0)(15\ \text{lb/ft}^2)$$

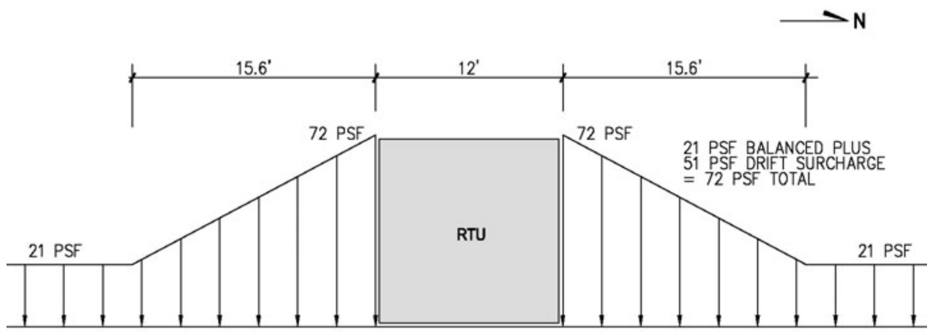


Figure VIII-5 Parapet wall drift at southwest corner for Example 8.2.

$= 10.5\ \text{lb/ft}^2$ (round to 11 lb/ft^2)

The roof geometry has not changed, and the parapet wall height, h, at the southeast and southwest corners is still 5.2 ft.

The new snow density, γ, is

$\gamma = 0.13p_g + 14 = 0.13(15\ \text{lb/ft}^2) + 14 = 15.9\ \text{lb/ft}^3$ (round to 16 lb/ft^3), and the depth of the balanced load below the parapet wall drift becomes

$$h_b = \frac{p_s}{\gamma} = \frac{11\ \text{lb/ft}^2}{16\ \text{lb/ft}^3} = 0.69\ \text{ft (round to 0.7 ft)}$$

Therefore, enough space is available ($h_c = 5.2\ \text{ft} - 0.7\ \text{ft} = 4.5\ \text{ft}$) for formation of a significant drift ($h_c/h_b > 0.2$).

For our upwind fetch of 220 ft and our ground snow load of 15 lb/ft^2,

$$h_d = 0.75[(0.43)(\sqrt[3]{220})(\sqrt[4]{15+10}) - 1.5] = 3.2\ \text{ft}$$

Note that the new surcharge drift height is less than that for Example 8.1 but not significantly less, only 84% of the previous value of 3.8 ft. Although h_d is an increasing function of p_g, the increase is less than a one-to-one ratio.

As in Example 8.1, the drift height, h_d, is less than h_c (3.2 ft < 4.5 ft). The surcharge height is not limited by the space available for drift formation, and the width or lateral extent from the parapet is four times the surcharge height.

$$w = 4h_d = 4(3.2\ \text{ft}) = 12.8\ \text{ft}$$

The maximum drift surcharge load is

$$p_d = h_d \gamma = 3.2\ \text{ft}\ (16\ \text{lb/ft}^3) = 51.2\ \text{lb/ft}^2\ \text{(round to 51 lb/ft}^2)$$

Thus, the total maximum load (balanced plus drift surcharge) at the parapet wall is $11\ \text{lb/ft}^2 + 51\ \text{lb/ft}^2 = 62\ \text{lb/ft}^2$. The resulting load at the southwest corner is sketched in **Figure VIII-6**.

For this example, the ground snow load is small enough that the minimum roof snow load or the rain-on-snow enhanced uniform load may govern. Finally, if the roof is a continuous-beam system, various partial load cases must be checked also.

Note: Drifting is frequently a problem with a new or enlarged RTU on an existing roof. Since reinforcing an existing roof is often complicated and expensive, it might be desirable to raise the base of the replacement RTU high enough above the roof level so that windward drifts do not form. An example is described in Chapter 13 (Question 3).

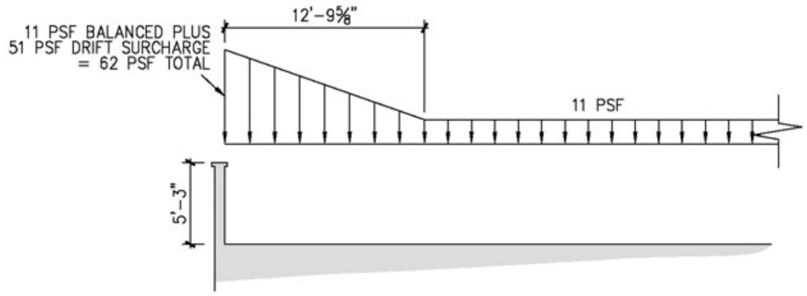
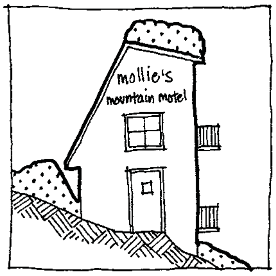


Figure VIII-6 Parapet wall drift at southwest corner for Example 8.3.



9

Sliding Snow Loads

As explained in Chapter 4, there are theoretical differences between the design snow load on a nominally flat roof and on a sloped roof. On sloped roofs, snow simply slides off or, for very steep slopes, does not stick in the first place. From a structural standpoint, snow sliding off a roof is beneficial as long as the sliding snow does not collect in an undesirable location. The roof geometry and the immediate adjacent site plan should be such that the snow sliding off a roof does not pose a hazard to people, parked cars, or other adjacent objects. Clever designers in snowy climates often locate the main entrance at an end wall of a gable roof structure (e.g., a north or south wall for a north–south ridgeline) to avoid snow sliding onto people. If a main entrance is located along a side wall (east or west wall for a north–south ridgeline), then the designer often places a small gable roof above the entrance to deflect sliding snow to either side. This small cross-gable roof, however, can lead to large ice dams.

Snow that slides off a roof and collects against a wall is another concern. In this instance, the snow pile exerts a lateral load on the wall. Some metal-building manufacturers offer snow girts as an option for such situations. ASCE 7-05 does not address this issue; Chapter 13 of this guide offers suggestions for estimating the load. ASCE 7-05 does, however, have design load provisions for snow that slides onto an adjacent roof. These are discussed below.

At first glance, one might think that the load that slides onto a lower roof should be the complement of the sloped roof load, p_s, and that the sliding load plus the sloped roof snow load should equal the flat roof load, p_f. If this were the case, the sliding load on the lower roof would be proportional to $1 - C_s$, where C_s is the slope factor for the upper roof. This approach appears to be compatible with physics and makes sense intuitively. Following the $1 - C_s$ approach, low-sloped upper roofs would produce small sliding loads and steeply sloped upper roofs would produce large sliding loads. The following example explains why this theory is flawed.

Consider a case when the only significant snowfall for a winter season occurs on February 1, resulting in 15 lb/ft^2 of snow on a sloped roof. The weather remains cold and cloudy for the next few days, and then it becomes warm and sunny. Upon the arrival of the mild conditions, the upper-roof snow begins to melt, and it all slides en masse onto the lower level roof on February 6. In this case, the sliding snow load is proportional to the sloped roof snow load. The annual maximum load on the upper roof of 15 lb/ft^2 occurred between February 1 and February 6. The sliding load on the lower roof, which arrives on February 6, was due to the same 15 lb/ft^2 originally on the upper roof. The $1 - C_s$ principle is flawed because it neglects the aspect of time; an extant upper roof snow might be sliding load snow in the future.

The example above could lead to an "equality" concept, whereby the sliding snow load on the lower roof is proportional to C_s for the upper roof. However, this reasoning also is flawed. Consider a steep roof subject to a number of snowfalls over the course of a winter. Each snowfall initially sticks to the steeply sloped roof, but its stability is precarious and eventually a gust of wind or a slamming door causes the upper roof snow to slide onto a lower roof. In this case, the load on the upper roof is never very large, but the accumulated sliding load could be substantial. The "equality" concept is flawed because more than one sliding event may occur over the course of a winter season, and the design snow load for the steep upper roof is small compared to the accumulated sliding load on the lower roof.

Because there is not sufficient case-history information to establish a more detailed approach that includes C_s, ASCE 7-05 prescribes a simple approach in Section 7.9. The total sliding load per unit length of eave should be $0.4p_fW$, where W is the horizontal distance from the eave to ridge for the sloped upper roof. This sliding snow load is distributed uniformly on the lower roof over a distance of 15 ft starting from, and perpendicular to, the upper roof eave. If the horizontal measurement of the lower roof from the eave of the upper roof to the edge of the lower roof is less than 15 ft, the sliding load is reduced proportionately.

Recognizing that the potential for sliding snow is an increasing function of roof slope, ASCE 7-05 provides lower bounds where sliding loads do not need to be considered. For instance, as shown in **Figure IX-1,** sliding only occurs when the component of the gravity load parallel to the roof surface (proportional to sin θ) is larger than the frictional resistance (proportional to cos θ). These lower limits for sliding snow are ¼ on 12 for slippery roof surfaces and 2 on 12 for nonslippery surfaces. These lower limits are approximately half the slope for some case histories where sliding snow was known to have occurred; sliding has been recorded on a slippery ½-on-12 roof and on a nonslippery 4-on-12 roof.

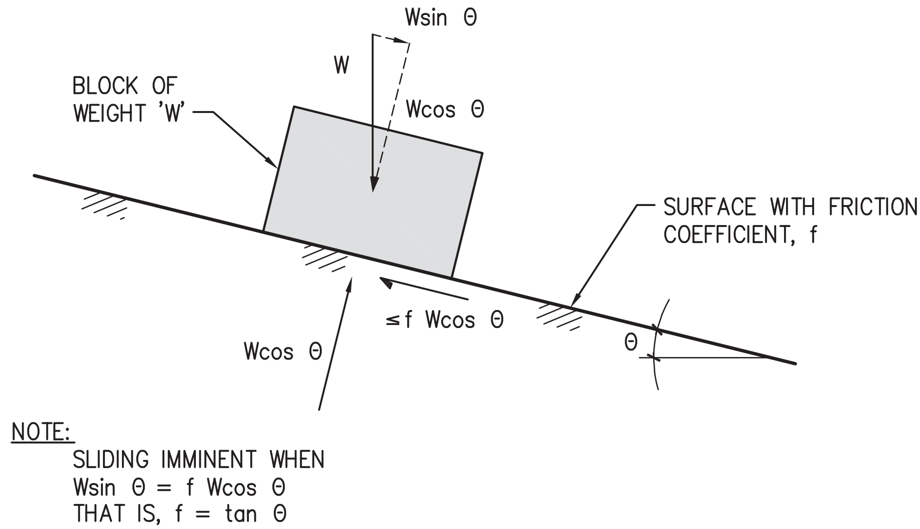


Figure IX-1 Onset of sliding on a sloped roof.

It is reasonable to assume that these limits and the sliding load are related to the thermal factor, C_t, for the upper roof. With all other things being equal, the potential for snow sliding off a warm roof is greater than for snow sliding off a cold roof. Such refinement of sliding snow loads requires additional case-history information.

Finally, the sliding snow load is superimposed on the lower roof's balanced load. The sliding snow load may be reduced if a portion of the snow from the upper roof is blocked by any combination of balanced and/or sliding snow on the lower roof. As with partial loading and balanced loading below a drift, the balanced load on the lower roof for the sliding load case is p_s, as given in Equation 7-2. Therefore, the sliding load from the upper roof is superimposed on $0.7C_e C_t C_s I p_g$ for the lower roof.

9.1 Example 9.1: Sliding Snow Load, Residential Gable Roof (4 on 12)

Determine the design roof snow load due to sliding for an unheated garage attached to a "cold roof" (heated but also vented), shingled residence as sketched in **Figure IX-2.** The structures are located in a suburban site (Terrain Category B) with scattered, nearby tall trees and p_g is 30 lb/ft^2.

Solution

Flat Roof and Balanced Loads: Both the residence and the garage are partially exposed (trees provide some shelter for residence, and trees and residence provide some shelter for garage), and the building is in Terrain Category B; thus, C_e is 1.0 from Table 7-2. From Table 7-3, C_t is 1.1 for the cold-roof residence and C_t is 1.2 for the unheated garage. The residence is considered to be of ordinary importance (I is 1.0). The garage is considered