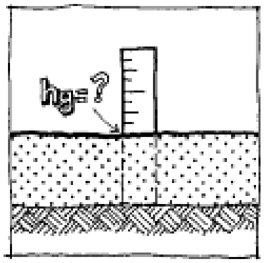


Chapter 2

Ground Snow Loads

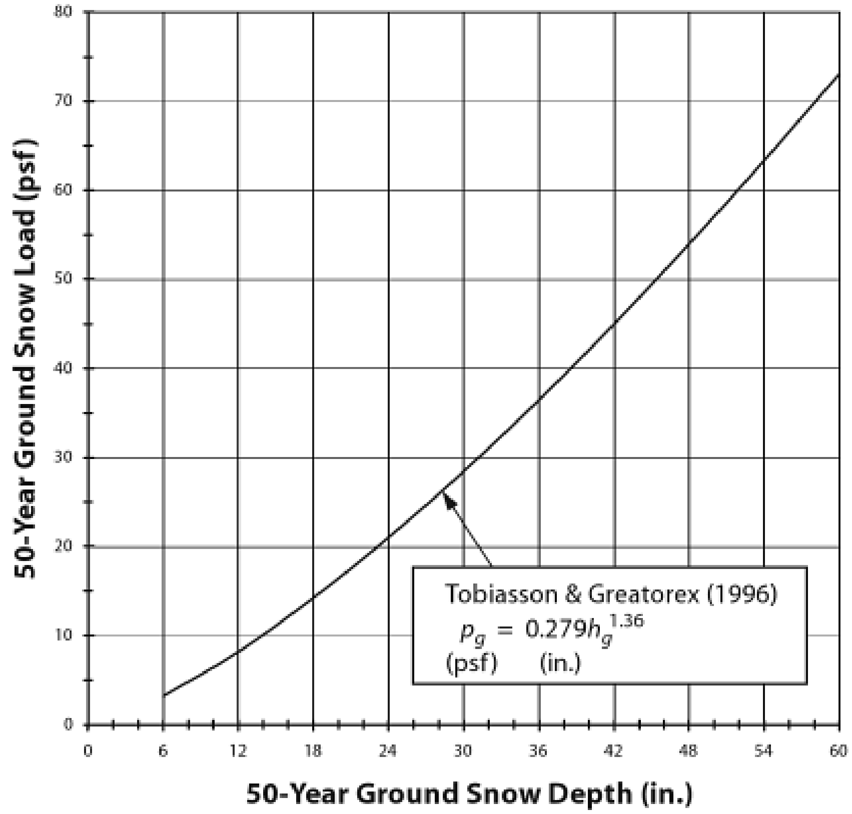
The roof snow loads specified in ASCE 7-10 are based on or related to the ground snow load, p_g. This approach, which mirrors Canadian practice, is used because of the relative abundance of ground snow measurement information in comparison to roof snow load measurements. As described in more detail in the ASCE 7-10 Commentary, the ground snow map (Figure 7-1) is based on daily recordings of ground snow load and depth at 204 National Weather Service (NWS) first-order stations in combination with daily readings of only ground snow depth at about 9,200 NWS "co-op" stations. Information at 3,300 additional stations, where depths and loads are usually measured monthly each winter primarily by the Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service or SCS), was also considered in the making of the map.

Since ground snow depth by itself is of little interest to structural engineers, a method was used to establish an equivalent snow density or unit weight for use with the depth data. Specifically, the NWS first-order station data (which included both the load and the depth) were used to generate a relationship between the 50-year ground snow depth and the 50-year ground snow load. This relation, in turn, was applied to the depth-only data (e.g., from an NWS co-op station). The relationship (Tobiasson and Greatorex 1996) between 50-year ground snow load, p_g, in lb/ft^2 and 50-year ground snow depth, h_g, in inches is

$$p_g = 0.279{h_g}^{1.36} \qquad \text{Equation G2-1}$$

This relationship is plotted in **Figure G2-1**. In essence, **Equation G2-1** establishes an equivalent density or unit weight. For example, the equivalent density is about 8 lb/ft^3 for a snow depth of 1 ft (i.e., a 50-year depth of 12 in. corresponds to a 50-year load of 8.2 lb/ft^2), and it is about 12 lb/ft^3 at 3 ft (i.e., a 50-yr depth of 36 in. corresponds to a 50-yr load of 36.5 lb/ft^2). This increase in equivalent density is due partially to the self-weight of the snowpack. Snow toward the bottom of the snowpack compacts (densifies) from

Figure G2-1
Relationship between 50-year ground snow load and 50-year ground snow depth used in determining ASCE 7-10 snow load map.



the weight of the snow above. Sack and Sheikh-Taheri (1986) developed a similar relationship, known as the Rocky Mountain Conversion Density (RMCD), between depth and load. The RMCD relation is bi-linear with a slope of 0.9 lb/ft^2 per in. for depths of 22 in. and less, and a slope of 2.36 lb/ft^2 per in. for deeper depths. As such, the RMCD load is about 20 lb/ft^2 for a depth of 22 in., similar to that for the Tobiasson and Greatorex relation in **Equation G2-1**. For snow depths above 22 in., the RMCD relation predicts larger loads than the Tobiasson and Greatorex relation, for example, 82 lb/ft^2 for a snow depth of 48 in. A comparison of **Equation G2-1** with other density relations is presented in Chapter 7.

The ground snow load map for the United States (Figure 7-1) presents the 50-year Mean Recurrence Interval (MRI) ground snow. That is, the ground snow load has a 2% annual probability of being exceeded. The ground snow load from Figure 7-1 for any user-supplied street address and zip code can be obtained conveniently, upon payment of a user fee, on the Internet (http://www.groundsnowbyzip.com).

2.1 Influence of Latitude, Elevation, and Coastlines

For most of the central Midwestern United States, bounded by Indiana on the east and Nebraska on the west, the ground snow loads are simply a function of

latitude. As one might expect, Louisiana has relatively small ground snow loads (0 or 5 lb/ft^2) whereas Wisconsin has relatively large values (25 to 70 lb/ft^2).

In the eastern United States, p_g generally increases with latitude, but two additional variables influence p_g: site elevation and the distance from the shoreline. Elevation is a factor in the East because of the string of mountains along the Appalachian Trail. In some locations, such as eastern Tennessee or Rochester, New York, the mapped ground snow load value in Figure 7-1 (10 and 40 lb/ft^2, respectively) applies to sites with elevations less than the given upper elevation limit (1,800 and 1,000 ft, respectively). Designers are provided with ground snow load information at lower elevations, where most of the buildings are located. At elevations greater than the upper limits, a site-specific case study (discussed shortly) is required.

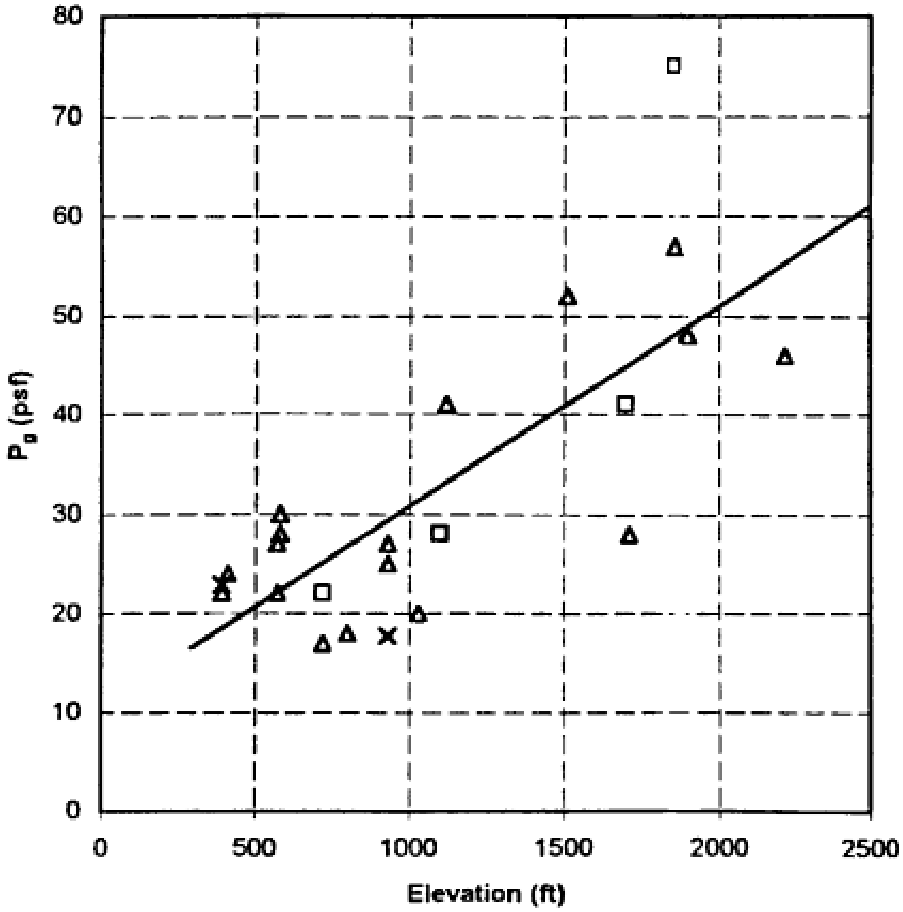
Locations downwind of the Great Lakes get what is known as "lake effect" snow. Low-pressure cells traveling over the Great Lakes pick up moisture from the lakes and return it as snow upon landfall. As a result, regions to the lee of the lake are particularly snowy. The Case Study (CS) areas of northwestern Indiana, western Michigan, northeastern Pennsylvania, and western New York are so designated because of these lake effect snows.

Latitude and elevation also influence ground snow load values in the West. For instance, the 50-year ground snow load at a given elevation in New Mexico is typically less than that for the same elevation in Montana. However, because of the more rugged and variable terrain, the overall pattern in the West is more complex. Unlike most regions in the Midwest and some in the East, where the 50-year ground snow load is strictly a function of latitude, all the design ground snow loads in the West are a function of site elevation. For some locations, such as southeast Arizona, ground snow loads are specified for a range of elevations: zero for elevations of 3,500 ft or less, 5 lb/ft^2 for elevations between 3,500 and 4,600 ft, etc. Other locales, such as the majority of western Colorado, require site-specific case studies.

2.2 Site-Specific Case Studies

All locations represented with a "CS" on Figure 7-1 require a site-specific case study in order to establish the design ground snow load. As noted on the map in relation to CS areas, "the extreme local variations in ground snow loads in these areas preclude mapping at this scale." Also, at all sites that have a higher elevation than that designated in parentheses on the map, the ground snow load must be established by a case study. For example, a case study is required for all areas in eastern Tennessee that have an elevation higher than 1,800 ft. As described in more detail by Tobiasson and Greatorex (1996), a case study involves regressing 50-year ground snow load values versus elevation for a number of sites in close proximity to the site of interest. The least squares straight line then establishes the local "reverse lapse" rate, which in turn can be used to establish the 50-year ground snow load for the site of interest. The lapse rate is the decrease in temperature for a unit increase in elevation. As used herein, a "reverse lapse" rate is the increase in ground snow load for a unit increase in elevation.

Figure G2-2
Case-study plot of 50-year ground snow load versus elevation for sites near Freedland, Pennsylvania.



A case study prepared by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) for Freedland, Pennsylvania, is shown in **Figure G2-2.** Note that there were 23 sites within a 25-mile radius of Freedland with known values of p_g. When plotted versus elevation, the least squares line has an approximate slope of 2 lb/ft^2 per 100 ft of elevation difference. From the plot, the 50-year ground snow load for Freedland with an elevation of 1,880 ft was 48 lb/ft^2. In the past, CRREL has provided on request and free of charge site-specific case studies that are similar to the Freedland case study shown in **Figure G2-2.**

Note that the reverse lapse rate is not uniform across the United States. Although the rate of 2.0 lb/ft^2 per 100 ft from **Figure G2-2** for Freedland is essentially identical to the 2.1 lb/ft^2 per 100 ft recommended by Tobiasson et al. (2002) for New Hampshire, it is substantially larger than the rate recommended for many locations in the West. For example, in north central Arizona, the ground snow load is 5 lb/ft^2 for sites between 3,000 and 4,500 ft, 10 lb/ft^2 for 4,500 to 5,400 ft, and 15 lb/ft^2 for 5,400 to 6,300 ft. This corresponds to a reverse lapse rate of about 0.5 lb/ft^2 per 100 ft of elevation difference, or about a quarter of the Pennsylvania–New Hampshire rate.

The ASCE 7-10 Commentary also refers to documents with valuable snow load information for Arizona, Colorado, Idaho, Montana, New Hampshire, Oregon, Washington, and parts of California. These references, typically prepared by a state structural engineers association or a state university,

present 50-year ground snow loads; some also present snow provisions. For New Hampshire, Tobiasson et al. (2002) present a town-by-town listing of ground snow loads for a specific elevation in each town.

Note that for some locations, the 50-year ground snow load value using a state reference is different from that using the ASCE 7-10 map. For example, the most recent state map for Washington (Structural Engineers Association of Washington (SEAW) 1995) contains zones that, when multiplied by the site elevation, give the 50-year ground snow load. For a site in Bellingham, Washington, with an elevation of 100 ft, the SEAW procedure gives a 50-year ground snow load of 15 lb/ft^2, while the ASCE 7-10 map gives 20 lb/ft^2. Unfortunately, the ASCE 7-10 text and Commentary are not clear about which 50-year value is to be used: the ASCE 7-10 value, the state value, the larger, the average, or other permutation. Structural engineers are advised to contact the local building official for guidance. It is anticipated that future versions of ASCE 7 will recommend using the state or local ground snow load map in such cases, as long as the state/local document meets certain criteria (e.g., 50-yr values are based on an extreme value statistical analysis). Nevertheless, the ASCE 7-10 text is clear that a 50-year MRI ground snow load is to be used in its provisions. Furthermore, irrespective of the exact source of the ground snow load value, it also is clear that a design according to the ASCE 7-10 provisions requires the use of the ASCE exposure and thermal factors, drifting relations, etc., as opposed to alternate provisions that may be part of the aforementioned state documents.

Example 2-1 Ground Snow Loads

Problem

Determine the 50-year ground snow load for (a) Chicago, Illinois, and (b) Williamsport, Pennsylvania.

Solution

a) Chicago, on the southwestern shore of Lake Michigan, is in a 25 lb/ft^2 ground snow load zone, as shown in **Figure G2-3.**

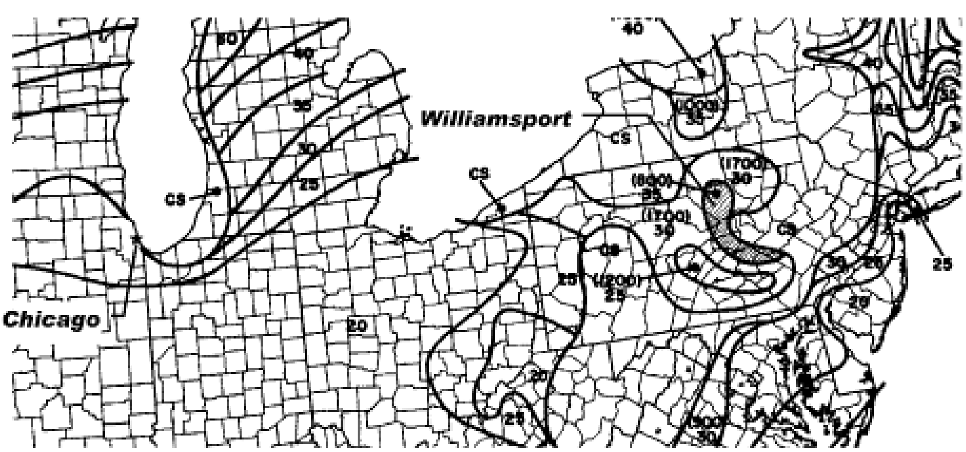


Figure G2-3
Portion of ASCE 7-10 ground snow load map showing Chicago, Illinois, and Williamsport, Pennsylvania (zone for Williamsport is cross-hatched) for use with Example 2-1.

b) Williamsport, located in north central Pennsylvania, has a ground elevation of 528 ft as per the TopoZone.com Web site. Furthermore, Williamsport is located in the cross-hatched region of **Figure G2-3,** where ground snow load of 35 lb/ft^2 is given for an elevation up to 800 ft. Since the case-specific site elevation of 528 ft is less than the 800-ft upper elevation, a case study is not required, and the 50-year ground snow load is 35 lb/ft^2.