InSights

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Design Snow Loads and Metal Buildings

By Vincent E. Sagan, P.E.

Throughout a significant portion of the United States, the design snow load on roofs typically exceeds the roof design live load, so many structural engineers need to be familiar with snow load determination. The level of complexity in calculating the design snow loads for a building or other structure can vary from simple to complex, depending on the building location, the roof geometry, and the roof finish. The design snow load calculations for a flat roof with no parapets on a big-box store located in Iowa is relatively simple. A roof with multiple levels and slopes on a ski lodge located in the Rocky Mountains of Colorado will likely involve a site-specific case study to determine the ground snow loads, and include consideration of windward, leeward, and intersecting snow drifts, and sliding snow.

Metal buildings are similar to other buildings when calculating the design snow loads. The design loads are determined according to the building code adopted by the local jurisdiction, typically an edition of the *International Building Code* (IBC), which references ASCE 7, *Minimum Design Loads for Buildings and Other Structures.* In addition, the geometry of metal building roofs can be simple, complex, or something in between, since metal buildings are typically custom-designed.

Metal Building Considerations

There are applications and features of metal buildings that are not as common with many other building types, which result in different provisions being applied when calculating the design snow loads according to ASCE 7-10. These applications and features include:

Unheated Buildings

Metal buildings are commonly used in agricultural applications for the storage of equipment and grain. These building can be unheated. Other examples of unheated structures are commercial warehouse/freight terminals; raw material storage; parking and vehicle storage; some recreational facilities such as ice rinks, exhibition buildings, and fair buildings; and refrigerated storage facilities. For unheated buildings, the thermal factor, C_t, from ASCE 7 Table 7-3 is 1.2. For heated buildings, C_t is 1.0.

Sloped, Slippery Roofs

Metal roofs are considered to be slippery surfaces. When the roof is sloped, the design snow load can be reduced by the roof slope factor, C_s, provided that the roof is unobstructed and there is sufficient space below the edge of the roof slope to

Metal building gable roof snow loading. Courtesy of the Metal Building Manufacturers Association.

accommodate the sliding snow. Obstructions to sliding snow can include snow retention devices or other roof projections. ASCE 7 Section 7.4 refers to Figure 7-2 to determine C_s for various conditions, accounting for the slope, the surface, and the thermal factor, C_t.

When snow slides off a sloped roof onto a lower roof, the design snow load on the lower roof due to sliding snow is determined using Section 7.9. According to this section, "Sliding loads shall be superimposed on the balanced snow load and need not be used in combination with drift, unbalanced, partial, or rain-on-snow loads."

Roof Overhangs

The sloped roof provisions also include Section 7.4.5, *Ice Dams and Icicles Along Eaves*. As stated in the commentary, "The intent is to consider heavy loads from ice that forms along eaves only for structures where such loads are likely to form." It also states, "This provision is intended for short roof overhangs and projections …"

Gable Roofs

Gable roofs, common in metal buildings, are susceptible to snow drifting on one side of the ridge, creating an unbalanced loading condition. ASCE 7 Section 7.6.1 defines the snow load cases, balanced and unbalanced, for gable and hip roofs. Loading diagrams for these load cases are shown in Figure 7-5.

Snow Load Design Resources

Several resources are available that are helpful in obtaining snow load design information, as well as determining appropriate snow design loads. These resources include the following:

- Applied Technology Council (ATC) Ground Snow Load Website, **http://snowload.atcouncil.org**, provides a way for engineers to easily obtain ASCE 7 site-specific ground snow loads. A location can be selected by directly entering the GPS coordinates or the mailing address. If needed, a map of the United States can

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be used to find the GPS coordinates of a particular location. This website overcomes the challenges in using the snow loads map (Figure 7-1) that is printed in ASCE 7. These challenges include insufficient spatial resolution of the map to determine some site-specific ground snow loads and the lack of reference cities or towns on the map. These ground snow loads can then be used with the equations provided in ASCE 7 to determine design snow loads for buildings and other structures. The Metal Building Manufacturers Association (MBMA) assisted in the development of the website.

- MBMA *Metal Building Systems Manual*, 2012 edition, includes step-by-step examples for calculating snow design loads, as well as wind and seismic design loads, according to the 2012 IBC and the referenced ASCE 7-10 standard. The manual also contains tabulated snow, wind, seismic, and rainfall design data for every county in the United States based on the 2012 IBC, ASCE 7-10, and USGS and NOAA data.
- *Snow Loads: Guide to the Snow Load Provisions of ASCE 7-10*, authored by Michael O'Rourke, Ph.D., P.E., of Rensselaer Polytechnic Institute, provides detailed explanations of the snow load provisions of ASCE7-10 and demonstrates their application through multiple examples. Similar guides exist for the 2002 and 2005 editions of ASCE 7.

Future Changes in Design Snow Loads

Engineers familiar with ASCE 7 know that the standard is continually changing, incorporating the latest research on building loads and performance. While significant changes to the wind and seismic provisions of the load standard have occurred frequently, the changes to the snow load provisions have been more modest. The changes in the snow provisions in the 2016 edition of ASCE 7 will be more substantive than in past years, including the following:

- Revision of Figure 7-1, the ground snow loads map for the continental United States: The contours and values will be removed for six western states (Colorado, Idaho, Montana, New Mexico, Oregon, and Washington). For each of these states, Figure 7-1 will include a reference to a table that contains approximately forty locations and their ground snow load and elevation, similar to what is done for ground snow loads in Alaska (Table 7-1). Note that the last time this figure was revised was in the 1995 edition!
- New provisions for snow loads on air-supported structures.
- New provisions for snow loads on open frame equipment structures.
- New provisions for intersecting drifts (Section 7.7.3).
- Addition of definitions to Section 7.1, including *drift*, *freezer building*, and *ventilated roof*.
- Addition of the importance factor, I_s, to drift heights (Figure 7-9).
- Changes and clarifications on thermal conditions for freezer buildings, partial loading on continuous beams (Section 7.5.1), drift criteria, including canopy drifts and the effect of parapets (Sections 7.7 and 7.8), and snow retention devices and sliding snow (Section 7.9).

For future editions of ASCE 7, the changes to the ground snow load map, Figure 7-1, should continue. The net effect will be more information that is more accurate, especially in areas that are identified as CS, which require site-specific Case Studies to establish ground snow loads.

In addition, design snow loads on photovoltaic systems will likely be addressed. Recent research on solar paneled roof snow loads was recently completed by Dr. O'Rourke and Nicholas Isyumov, Ph.D. P.Eng., of Western University. The project, sponsored by the American Iron and Steel Institute, FM Global, and the MBMA, will result in a guideline for snow loads on solar paneled roofs, which will be published by ASCE.

Summary

Although metal building applications and features may require different ASCE 7 provisions to be used in the determination of design snow loads, the design load process is similar to other buildings. Resources are available to assist engineers in determining the loads more easily and accurately. Design snow load provisions for all buildings, including metal buildings, are changing with the new edition of ASCE 7. The changes should add clarity to the requirements.▪