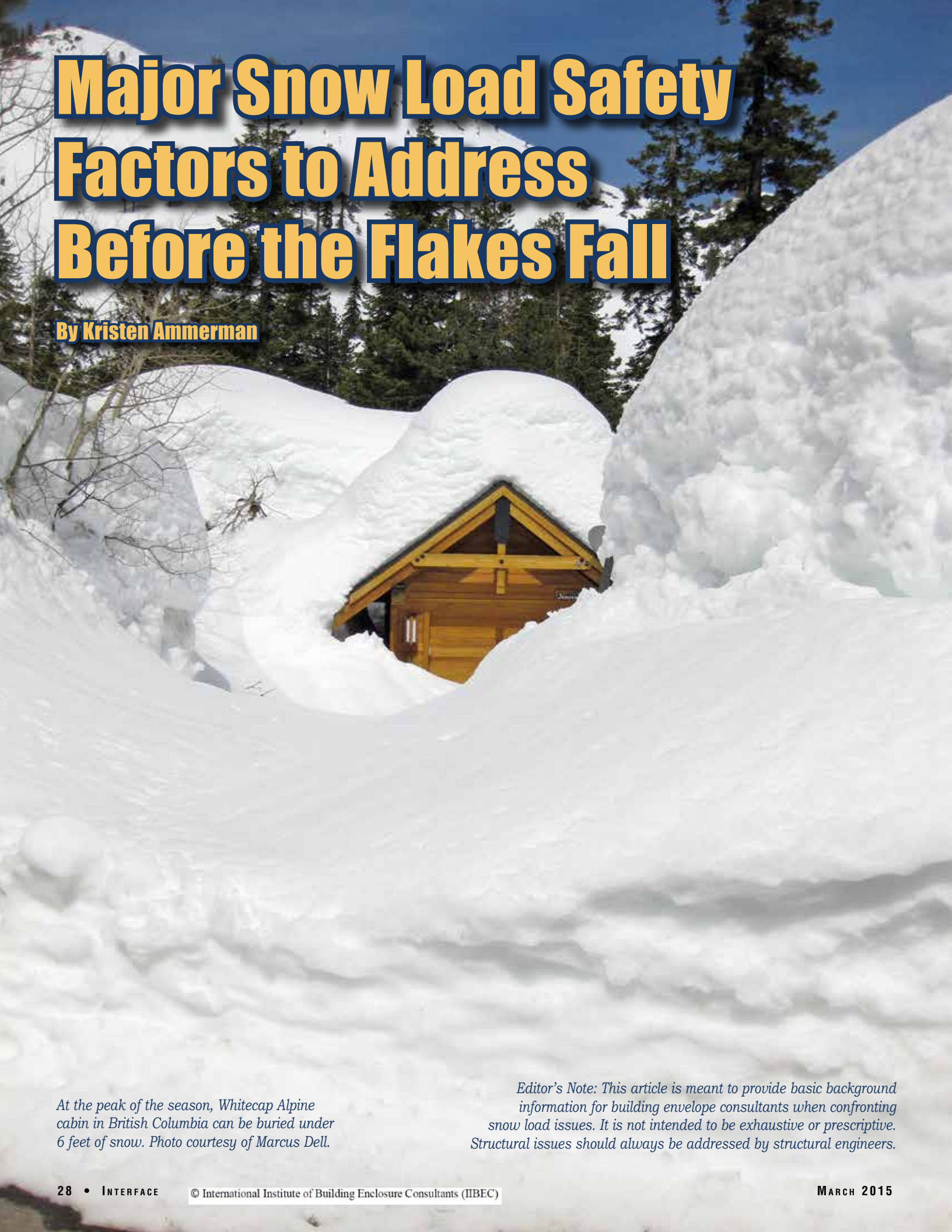


# Major Snow Load Safety Factors to Address Before the Flakes Fall

By Kristen Ammerman



At the peak of the season, Whitecap Alpine cabin in British Columbia can be buried under 6 feet of snow. Photo courtesy of Marcus Dell.

*Editor's Note: This article is meant to provide basic background information for building envelope consultants when confronting snow load issues. It is not intended to be exhaustive or prescriptive. Structural issues should always be addressed by structural engineers.*

**B**uilding owners concerned about the structural condition of their buildings under the weight of snow and ice may contact building envelope consultants following a considerable snow event. There are many factors to consider.

According to the Federal Emergency Management Agency (FEMA), “More often than not, attempting to remove snow from a roof is more hazardous than beneficial, posing risk to both personnel and the roofing structure.”<sup>1</sup> It would be much more proactive for those building owners to make that call before the snow began to fall. But if a client does call—be it before, during, or after a snow event—what concerns might a consultant be asked to address?

Excessive snow loading that can result in structural building damage and/or occupant or pedestrian safety issues or concerns is the result of many factors that can often be mitigated before the fact with the proper understanding and attention.

## DESIGN

Two important documents on snow load design are the American Society of Civil Engineers’ (ASCE’s) ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures*,<sup>2</sup> and Michael O’Rourke’s *Snow Loads: Guide to the Snow Load Provisions of ASCE 7-10*, published in 2010 by ASCE Press (Figure 1).

According to FEMA, structural failure from roof snow loads may occur from various causes, including the following:<sup>3</sup>

- Actual snow load significantly exceeds design snow load
- Drifting and sliding of snow
- Deficient workmanship
- Insufficient operation and maintenance
- Improper design
- Inadequate drainage design
- Insufficient design (older buildings built under inadequate codes)

## WHEN IS A FOOT NOT EQUAL TO A FOOT?

According to the 2012 International Building Code (IBC 2012), roof snow load is the weight of snow on the roof surface used in design of a building. Many factors affect this determination, including ground snow load value; impor-

tance, occupancy, and use of the building; wind exposure of the roof; roof slope; roof shape; roof obstructions; and the thermal condition of the building. Only recently have drifting and sliding snow loads been addressed in building codes. A foot of snow on the roof is not the same as a foot of snow on the ground and is not necessarily uniform across the roof’s surface; nevertheless, the basis for snow load computation begins with ground snow load.

The water content of snow may range from 3% for very dry snow to 33% for a wet, heavy snow, to nearly 100% for ice.<sup>4</sup> Snow can weigh anywhere from 3 to 21 pounds per cubic foot, according to moisture content.<sup>5</sup> Snow on the East Coast is typically heavier and more dense than snow in the western U.S., though exceptions exist. Uniform snow loads, which are based on flat roofs with no obstructions and protrusions, seldom apply. Variables are caused by all of the factors listed above, leading to unbalanced loads that can impact the vulnerability of different areas of a given roof and differ markedly among roofs on adjacent structures or even the same structure (Figure 2). An unbalanced load can be more structurally dangerous than a uniform load.

Snow guards or cleats are needed on a sloped roof to inhibit snow from sliding, particularly over entrances with pedestrian traffic. Unbalanced conditions may occur when snow slides from a higher to a lower roof area or accumulates behind obstructions. The dynamic force of the slide can also create an impact that overloads the structure.

## HOW HARD IS IT RAINING?

What if the snow turns into rain? What if the rain gets really heavy? What if it melts some, freezes up again, and then another snow falls?

All of these factors can have a serious

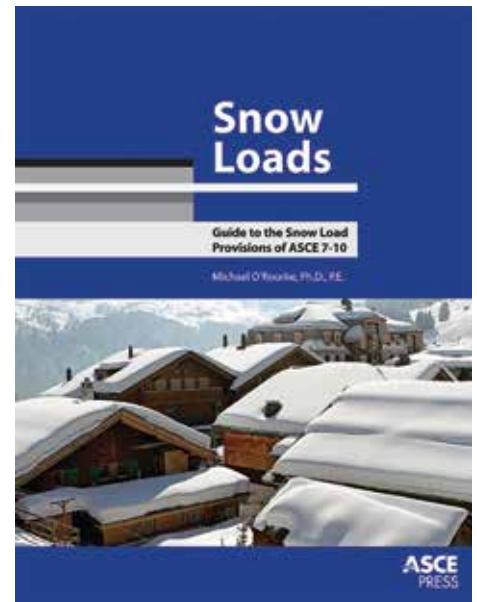


Figure 1 – Cover of *Snow Loads: Guide to the Snow Load Provisions of ASCE 7-10*, by Michael O’Rourke. Artwork by ASCE.

impact on the snow on the roof. Building code provisions for design snow loads account for light rain on snow, but do not consider heavy rainfall. The engineer must consider these additional loads according to the specific characteristics of the roof, its geographic and climatic location. Of course, rain can also wash snow away, reducing load; or it can cause snowmelt, which can then refreeze after being saturated, thus increasing load.

## DRAINAGE

Ice dams may also form, creating concentrated loads at eaves and reducing the ability of sloped roofs to shed snow and meltwater (Figure 3). If a roof’s drainage system is blocked or improperly designed or maintained, snowmelt may pose risks.<sup>6</sup> On low-sloped roofs, snowmelt accumulation may cause ponding.

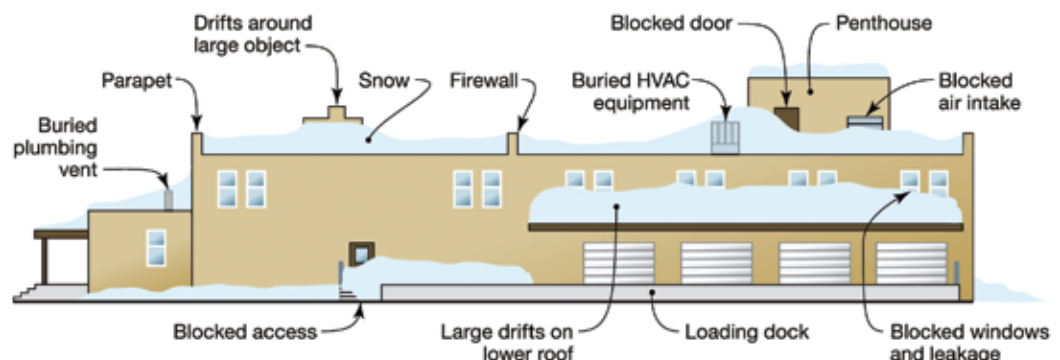


Figure 2 – Snow load from drifting and sliding snow on typical commercial or industrial building (Source: FEMA).



Figure 3 – This low-slope roof has plenty of insulation, but melting and refreezing can pose an issue. Photo courtesy of Richard Wagner.

#### WIND EXPOSURE

Wind exposure can have the greatest effect of all of the variables influencing snow load on a roof.<sup>7</sup> A building in an open area stands a better chance than one that is “sheltered,” where wind is not apt to blow snow off of a roof as it falls. Adjacent construction can, therefore, affect a building’s vulnerability to wind. It can also act as an “aerodynamic shade” to the nearby building, reducing its propensity to shed snow.<sup>8</sup>

#### INSULATION

A roof’s thermal properties can affect snow load. A well-insulated or well-ventilated roof typically retains more snow because interior heat cannot as easily melt it from beneath. Uninsulated areas below sloped roof systems can cause meltwater to flow down the roof slope and freeze at the eaves, resulting in ice dams, which also prevent snow from sliding off the roof and can create unbalanced loading conditions. They may also cause water infiltration into the building. According to one professional snow removal company:

Roofs of [many] older buildings were built with little or no insulation,

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so snow melted fairly quickly and roofs carried snow loads for very brief periods. If insulation has been added to a roof, less heat escapes, so snow and ice don't melt as rapidly, and snow loads accumulate to new and sometimes excessive weight levels.<sup>9</sup>

### AGE

The age of the structure should also be considered. Older steel and wood buildings may corrode, split, or rot, and experience "creep,"<sup>10</sup> reducing their load-carrying capacity. Prior to the 1970s, building codes did not address non-uniform snow loads.

### BEFORE THE SNOW FALLS

Review of a building's unique circumstances and condition prior to the first snowfall will provide valuable information to determine possible remedial action, put a snow event response plan into effect, and allay the fears of a building owner. Owners should contact a structural engineer to determine the building's baseline condition. If a building consultant is contacted, he or she should work in conjunction with a structural engineer.

According to FEMA, the following baseline information should be collected:

- Applicable building codes
- Design snow load
- Structural framing system
- Thermal properties
- Renovation history

### INSPECTION ITEMS

The entire roof structure and building should be examined, but the greatest attention should be paid to the roof, including areas that could accumulate snow and roof framing that could be vulnerable to excessive load. Other items FEMA notes for inspection are:

- Gutters and downspouts
- Seals around rooftop penetrations
- Openings around exhaust vents
- Flashing around rooftop equipment
- Roof soffit and ridge ventilation



Figure 4 – A sure sign of distress to wood-framed structures is separation of metal plate connectors (gang-nails) in a system of engineered trusses. This is prone to first occur at the king post, and it seems most frequently associated with scissors trusses (i.e., cathedral ceilings having rather long spans). Photo courtesy of Lyle Hogan.

- Cold eave electric heater operation
- Trusses out-of-plane and the condition of metal plates connecting truss members (Figure 4)
- Condition of lateral braces connected to roof structure
- Attic moisture content

Managing deficiencies ahead of a snow event is important in ensuring the integrity of the structure during the event. Small repairs can propagate into much larger issues.<sup>11</sup>

### WHEN TO SHOVEL?

One costly misconception about roof snow and ice dam removal, some experts say, is to wait as long as possible before having it removed so that the workers can get it all in one fell swoop. Experts, though, say this is not the way to go. "Roofs are rated for maximum weight loads, and they should never be 'tested.' Once roof snow load has reached 50% of capacity (maximum load), the snow should be removed."<sup>12</sup>

### WARNING SIGNS AFTER THE FACT

Once the sky has opened up in all its white glory and the snow is three feet deep on the roof, the building can provide warn-

ing signs that it is under too much stress. These signs in wood, metal, and steel-constructed buildings are like flashing orange traffic lights:<sup>13</sup>

- Sagging ceiling tiles, boards, or sprinkler lines and heads
- Popping, cracking, and creaking
- Sagging roof members, including metal decking or plywood sheathing
- Bowing truss bottom chords or web members
- Doors and/or windows that will no longer open or close
- Cracked or split wood members
- Cracks in walls or masonry
- Severe roof leaks
- Excessive accumulation of water at nondrainage locations on low-sloped roofs

What if one or more of these signs are present? If you are an owner, evacuate and call a structural engineer. If you are a building envelope consultant (and not a structural engineer), evacuate and call a structural engineer. If you are a structural engineer, determine the safest manner to remove the excess weight from the roof. Call a properly licensed, insured, professional snow removal company (Figures 5 and 6), and review


Figure 6 – This “team” is also questionable. Do not be the insurance carrier for that guy on the ladder or for his employer.



Figure 5 – Don’t call this fellow. He’s already on the phone anyway, texting his wife to bring him a beer.



building conditions have changed, prior to purchase of existing buildings, and as buildings age.

Make the falling of frozen precipitate an occasion to marvel at the beauty of nature, not a time to worry about safety and property damage. 

#### REFERENCES

1. Federal Emergency Management Agency, “Snow Load Safety Guide,” FEMA P-957, January 2013. p. 1-1.
2. This committee is currently studying snow loads. When the next edition of ASCE-7 comes out in 2016, there will likely be changes in the design loads for snow, according to RCI Senior Director of Technical Services Wanda Edwards.
3. Ibid.
4. Karl VanDevender and Doug Petty, “Ice and Snow Accumulations on Roofs,” Arkansas Cooperative Extension Service, 2006. [www.trumbull-ct.gov/filestorage/7112/7114/snow\\_load\\_information.pdf](http://www.trumbull-ct.gov/filestorage/7112/7114/snow_load_information.pdf).

5. C.A. Gooch, “Heavy Snow Loads,” *Dairy Facilities/Environmental Management Engineering*, Cornell University. Ithaca, NY, 1999.
6. FEMA, p. 2-6.
7. Ibid., p. 3-4.
8. Ibid., p. 3-9.
9. “Snow Loading,” [www.minn-snowta.com/snowloading.html](http://www.minn-snowta.com/snowloading.html).
10. The American Wood Council describes “creep” as the “time-dependent deformation of loaded member(s) undergoing elastic deformation.”
11. FEMA, p. 4-3.
12. Jeff Johnston, “Roof Snow Removal,” *HomeLink Magazine*, Winter 2014.
13. FEMA, p. 4-3.



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the removal plan prior to allowing the work to proceed.

After the excess weight has been removed and if and when the building is deemed safe from imminent collapse, work with the owner to resolve the issues that might have been better discovered and addressed in a pre-storm review and inspection. Encourage clients to have reviews performed whenever

## Stormwater Calculator Estimates Runoff

The U.S. Environmental Protection Agency (EPA) offers a free, downloadable desktop application called the National Stormwater Calculator (SWC) that estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States (including Puerto Rico). Estimates are based on local soil conditions, land cover, and historic rainfall records. It is designed to be used by anyone interested in reducing runoff from a property.

The SWC accesses several national databases that provide soil, topography, rainfall, and evaporation information for the chosen site. The user supplies information about the site’s land cover and selects the types of low-impact development controls he or she would like to use. Controls the user can choose include disconnection, rain harvesting, rain gardens, green roofs, street planters, infiltration basins, and porous pavement.

To download and implement the application, visit [www2.epa.gov/water-research/national-stormwater-calculator](http://www2.epa.gov/water-research/national-stormwater-calculator) and follow the link and the directions noted therein.

— EPA