The Pitfalls of Snow Retention on Metal Roofing

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ABSTRACT

Metal roofs have long been considered a product of choice for snow areas because of their superior response and tolerance to many of the characteristics of such environments. The author has had extensive experience in designing and investigating metal roofs used in cold climates domestically and in Western Europe and Scandinavia and has recently been a lead author for Metal Roof Design for Cold Climates.[1] *This document presents useful perspectives on snow and ice dynamics as it relates to both metal roof design and the art and science of snow retention systems. It is not the purpose of this paper to address load requirements or the effects of drifting snow on structure design;[2,3] it is to assist the designer in making informed decisions through awareness of snowmelt phenomena and snow guard styles and types. Concepts presented here are founded on conventional science harmonized with domestic and North European trade practice of more than 500 years.*

An aspect of metal roof design in cold climates that is commonly neglected has to do with snow retention. When snow blankets a roof, an adhesive bond occurs between the snow bank and the metal panels. The vertical load of snow is translated to a vector load parallel to the panels' surface. When the temperature-sensitive bond between roof surface and snow bank is broken, this force propels a blanket of snow from the roof in avalanche fashion. This can be a nuisance and a hazard. Snow guards have been used for a thousand years to mitigate these issues.

Popular "standing seam" products are designed with "floating" attachments that enable the panels to respond freely to thermal stress. These panel designs involve a singular point of positive attachment. The vector loads from a snow blanket on the roof's surface accumulate to that single point. Attachment at that single point must be adequate to resist the loads that are accumulated. Contrary to popular myth, the use of snow guards does not increase these loads except under rare circumstances. Any snow retention system must, however, be designed site-specifically to withstand these forces.[1,4]

Snow melts from a roof for many reasons. They are not mutually exclusive but can have differing effects. The first cause is the temperature of ambient air. This mode of thaw passes the melt-water from the top down. Other snowmelt phenomena occur from the bottom up and happen because of two different causes: solar gain of the roof surface and heat from within the building escaping through the roof construction. Both warm the surface of the roof. As the roof temperature rises, the snow bank melts from the bottom up. In each thaw mode, the snow bank, further solidifying and compacting its base at the roof interface, absorbs some liquid melt-water adjacent to the roof surface.

1. Guidelines for commercial roofing. *Metal Roof Design for Cold Climates*. Metal Construction Association.
2. *Metal Roofing Systems Design Manual, 1st ed*. Metal Building Manufacturers Association (MBMA 2000); Chapter 6 addresses roof snow load calculations.
3. ASCE 7-02, American Society of Civil Engineers; Section 7 addresses roof snow load calculations.
4. *Metal Roofing Systems Design Manual*, Section 7.9.6, 7.97.

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The latter mode (heat escape) is perhaps the most common, but it can cause inconsistent temperatures in various areas of the roof, precipitating the re-freezing of melt-water and formation of ice dams in a colder downslope area (commonly the eave.) It is noteworthy that despite publication to the contrary, snow guards do not cause ice dams, as they have no effect on roof temperatures. Ice dams do, however, constitute a crude but effective form of snowguard, as does any protrusion above the surface of the roof.[1,5]

Two different concepts of snow retention are common on metal roofing domestically. One utilizes continuous horizontal components, assembled laterally across the roof in the style of a "fence." Such assemblies are usually installed at the eaves. Depending upon the job and product specifics, they may also be repeated in parallel rows up the slope of the roof, but with greater concentration near the eaves. This method is also common on metal roofing in Northern Europe. The second concept practiced domestically consists of small individual units used as "cleats," which are spot located at or near the eave. They also may be repeated in some pattern up the slope of the roof. This style relies upon the shear strength within a snow bank to "bridge" between the individual units. This technique is also used on slate and tile roofs in Northern Europe but is obscure on metal roofing.

Both concepts of snow guard (fence and cleat) have demonstrated satisfactory performance when designed and installed properly and adequately. The theory of all snow retention devices is to restrain a bank of snow by restraining its base; hence, snow guard devices only a few inches in height have been used successfully even when snow banks are many feet in depth. The practice of concentrating placement near the eave has been used for centuries, and its success has to do with the densification and monolithic properties of snow banks.[1,5] *Snow banks accumulate and densify in wedge patterns. As the snow compacts from thaw and its own weight, the layers with the highest shear, tensile, and compressive strengths generally lie adjacent to the roof surface and toward the eaves. Interface of snow retention devices at this location is preferred, effective, and well proven.*

Methods of snow guard attachment are varied and deserving of scrutiny. Any device that penetrates the roof surface should not be used on panels that are designed to move thermally, as the weatherproofing of such a device is virtually impossible.

In the North American marketplace, many devices are also offered that are adhesively mounted or soldered. Adhesively mounted units popular in the U.S. are not used in Europe—and for good reason. The adhesives used are time- and temperature-sensitive curing compounds that can only be applied when weather is warm and stays warm throughout the duration of the cure time—as much as 28 days. Premium paint systems used on metal panels render the surface a "non-stick" characteristic so the adhesive bond is minimal and holding strength decreases as the adhesive ages.[6] *Most load testing of those parts is dynamic load-to-failure. Due to the elastic nature of the adhesive, in-service (sustained) loads may produce much earlier failure than the test. Given these factors, a safety factor of 3 or more may be advisable, and a replacement cycle of ten years or so is anticipated.*

The preferred practice is to use snow guards that utilize clamping methods that grip the standing seam in some fashion without actually puncturing the panel material. Because this method of attachment is mechanical rather than chemical, it is not subject to the aforementioned pitfalls and is much more predictable and consistent in behavior.[1] *This method is used almost exclusively for contemporary standing seam roofing in Northern Europe. Specifics of the attachments are varied. Any method that scores, abrades, or gouges the surface of seam material should be avoided on coated steel, as it will lead to corrosion. Tensile load testing is imperative to quantify holding strength, which ranges from very low figures to extremely high ones. Tested loads are highly contingent upon proper tensioning of any fasteners in strict accordance with test protocol. Testing should be panel-specific and appropriateness of test methods scrutinized. Provided that screw or bolt tensions are periodically verified, safety factors of 2 may be adequate.*

Other issues to be considered when using snow retention devices include verifying metals compatibility, service life, and durability. Metal roofing has a service life in most environments of 40 years. Snow retention systems should be as durable. When color matching is desired, components utilizing air-dried paint to match factory-painted roof panels may provide a perfect match initially but a poor one after weathering, reducing service life.[6]

It is also necessary to evaluate the frequency and placement of devices on a job-specific basis. The first step is to compare design roof loads with the allowable load for the device being considered and use frequency in accordance with those figures. Where multiple rows of devices are needed, they are generally arranged within the lower half of the roof slope. The first row of units or cross-members should be located very close to the eave end of the panels. Successive rows should be spaced some distance upslope.[1] *Exact placement can reflect some discretion with respect to aesthetic concerns. For example, it may be desirable to align a fence with other roof geometry such as the apex or downslope termination of a row of dormers or skylights. When snow guards are used at isolated locations, such as over an entry door or to protect a stack or flue, care should be taken in calculating the tributary loads to the isolated assembly. The shape of a retained snow bank above such an assembly will generally resemble a*

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5. Haddock, R.M. 1999. Use of snow retention devices—Science or science fiction? *Interface Magazine*, February 1999, Roof Consultants Institute.
6. Haddock, R.M. 2002. Metal roofing from A (Aluminum) to Z (Zinc)—Part III, Paint finishes for metal. *MetalMag* March 2002, Spiderweb Publications.

wedge, and not a rectangle; hence tributary areas may be much larger than first anticipated. Adequacy of panel pinning should also be verified on panels to which such localized assemblies are attached.[1,5]

Project specifications should be product specific (proprietary) because of the site and product-specific nature of system design and integration. Any substitution should be indicated to demonstrate equivalence in terms of holding strength and metals and finish compatibility. Substitution submittals should provide evidence of testing and load calculations in accordance with project specifics.