Metal roof systems: Design considerations for snow and ice

by **Thomas L. Smith, AIA, CRC**

Unless taken into consideration during design, sliding snow, falling ice and ice dams can cause roof leakage and present hazards to people entering or leaving the building.

Many of these design considerations are applicable to other types of roof coverings, but because of the low coefficient of friction of the surface, metal systems should be carefully designed in snow country.

Design considerations should begin with the roof's geometry and its relationship to building elements and people passing below. When designing a new building or a conversion from an existing low-slope to a steep-slope system, primary building exits below the eave should be avoided. These exits should be below a rake or a low-slope area, such as a canopy.

Minor egress points below the eaves may be acceptable, but may require extra maintenance to keep them clear of snow or freezing water dripping from the eaves. Also, if people are likely to walk below an eave, landscape features such as retaining walls or shrubs should be used.

Sliding snow

If the exits are not below the eaves and if roof penetrations are not in danger of being harmed, it is usually best to allow the snow to slide off the roof. However, if snow retention is desired, this may be accomplished with snow guards.

When designing guards, calculate their requirements. Calculations should include snow weight (based on the design roof snow load, including drifts), strength and size of the guard, and attachment of the guard to the roof. The calculations, which should assume there will be no friction between the roof and the snow, will allow determination of the spacing between the rows of guards between the eave and the ridge.

For further information, refer to *Canadian Building Digest* 228, "Sliding Snow on Sloping Roofs."

At slopes greater than 3-in-12, retaining snow on metal roofs becomes increasingly difficult. But regardless of the slope, the design should place the weak point in the plane of the snow. Therefore, if the snow *does* slide, it simply shears within itself and will not tear off the guards and cause leakage.

The first row of guards should be placed at least two feet from the eave, so that the guard is not surrounded by the ice dams that develop at the eave. Otherwise, the ice may lift up the guard and cause leakage.

The guards should be screwed or clamped to the top of the panel ribs. If screws are used, sealant tape should be placed between the rib and the guard, and the screws should have a gasketed washer. The guards should be placed so that the screws or clamps do not interfere with concealed clips; otherwise, damage from thermal movement could occur.

If the guard is mounted to the pan of the panel, it should be attached with adhesive rather than a screw. Otherwise, if the guard is sheared off, the screw holes could allow a lot of water to enter the roof.

An extra row of guards should also be placed about two feet above roof penetrations, with the row extending a foot or two beyond the penetration.

If the roof is not equipped with snow guards, special attention should be paid to roof penetrations; otherwise, the penetrations could be sheared off or otherwise damaged. One approach is to place the penetrations near the ridge, where there will be little load pressing against them.

Another approach is to provide a cricket (splitter) above the penetration. Appendix Chapter 23 of the *Uniform Building Code* includes design criteria for splitters. Yet another approach is to provide a shroud over the penetration, which will allow snow to slide over the penetration without causing damage.

Falling ice

If snow falls on the roof, development of icicles should be expected. This occurs during warmer days when the snow melts, but the water freezes at the colder eave or freezes at night and causes an ice dam and formation of icicles. These dams form even when the roof is a "cold roof" (ventilated attic space). While it is possible to prevent snow slides, it is not possible to prevent falling ice.

Electrical de-icing systems are sometimes employed, but these seldom do more than melt a small area adjacent to the heated cable.

Eave ice dams cause a concentrated load that should be considered by the designer. Appendix Chapter 23 of the *Uniform Building Code* gives design criteria for this condition.

When ice is able to fall from an upper roof to a lower roof, damage can occur. Unfortunately, data is lacking on the magnitude of loads due to falling ice. If the lower roof is a protected membrane system, the likelihood for damage is probably minimal (particularly if heavy weight concrete pavers are used). However, if the lower roof is metal, some additional protection measures may be needed if the fall is greater than a few feet. Ice guards and other considerations for valleys and eaves for metal systems will be addressed in a future article. PR

Thomas L. Smith is NRCA director of technology and research.

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Part two: Snow and ice on metal roof systems

by **Thomas L. Smith, AIA, CRC**

Last month's "Tech Transfer" discussed various design considerations related to metal roof systems subjected to snow and ice. This article will continue the discussion by addressing ice guards, eaves and valleys.

The need for ice guards was previously reviewed; therefore, this article will focus on ice guard details. There are no "off-the-shelf" devices for protecting metal roofs from falling ice from an upper roof. Therefore, the designer needs to employ good judgment in designing the guard. Unfortunately, there is little information in the open literature or from manufacturers to assist the designer.

One approach that has been successfully used is placing a strip of plywood over the metal roof in the area where ice is expected to fall. For aesthetics, the plywood is covered with metal roofing. The key to this solution rests in several details.

First, the plywood should be preservative-treated for longevity, and the thickness should be ⅝ inches ($^{19}/_{32}$ inches) or greater. A strip of neoprene should be placed between the plywood and top of the standing seam ribs or battens to serve as a shock absorber. The neoprene pads should be about ⅜ inches thick and fairly spongy (have a low durometer).

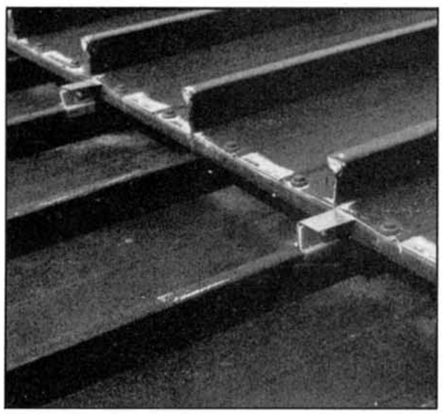
Because the plywood guard is intended to deflect (depress) under impact load, it should not be screwed to the metal roof. Rather, it should be retained by clips attached to the roof ribs. The clips should prevent the guard assembly from sliding down the roof and blowing off, but they should also allow guard deflection.

If the impact load is expected to be high, the ribs supporting the guard should be reinforced with special stiffener clips within the rib (typically stainless-steel of 20 gauge or greater should be used). If stiffeners are to be used, coordinate their design with the panel manufacturer.

The width of the plywood panel will depend on the distance between the upper and lower roofs. A width of 4 feet should be adequate if the distance is less than about 20 feet. The guard should be placed to provide protection on either side of the drip line.

Valleys and eaves

Where snow can accumulate on the roof, development of ice dams at valleys and eaves should be anticipated. On warmer days, also expect water behind the ice dam. Accordingly, the panel ribs or battens should be designed with sealant or sealant tape between the mating surfaces, so the panels are watertight even when subjected to water.



A metal roofing/plywood panel ice guard placed above a metal roof system.

If the clip goes over the rib of the bottom panel, and the sealant or sealant tape is then applied, a metal-to-metal joint occurs and can allow water infiltration. To avoid this, the sealant should be applied to the rib in the area of the clip prior to placement of the clip.

Because of the difficulties of eave and valley design and construction, it is prudent to design a modified bitumen underlayment (ASTM D 1970) extending a few feet beyond either side of the valley. At the eave, the underlayment should be detailed to allow for drainage of water from within the roof that leaks through the metal system and is intercepted by the underlayment.

At valleys, converging ice or snow may bend over ribs. Where bending is likely, the design should include rib stiffeners as previously described.

If gutters are used, extra care should be taken in their design. They should be capable of carrying the eave ice load and of accommodating the expansion of water turning to ice. As with any gutter design, the outer lip should be lower than the gutter-roof intersection. Gutters are problematic in climates with substantial snow and ice. In these climates, gutters should be avoided.

If the roof is a "warm roof" (no ventilation between the top of the insulation and metal roof), and there is an overhang, the overhang should also be warm to minimize edge icing.

In summary, metal systems can be successfully used in areas that receive snow, provided attention is paid to design and installation. The magnitude of the snow and icing conditions will dictate the degree of needed attention. In climates with severe conditions, metal roof systems should be avoided if the roof geometry is highly complex, because of the great difficulties these complexities present.

In addition to carefully detailing metal systems to accommodate snow and ice, consideration should also be given to selection of the system itself. With some panel systems, it is easier to design details to withstand the extreme conditions that are often encountered. PR

Thomas L. Smith is NRCA director of technology and research.

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