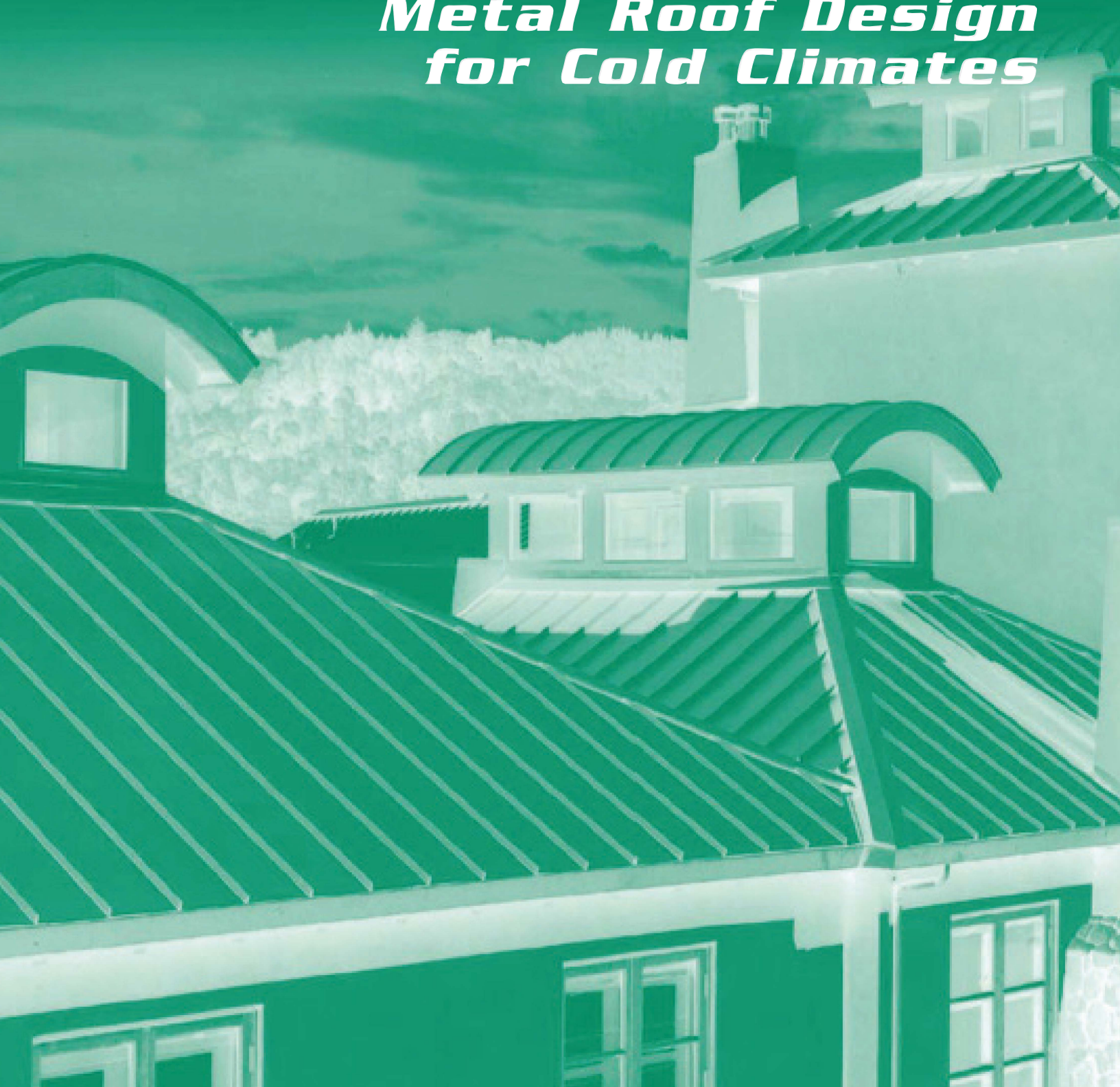




Guidelines for Commercial Roofing

Metal Roof Design for Cold Climates



Metal Roof Design for Cold Climates

Northern climates have always posed unique challenges to all types of roofing material. Snow and ice pull and tug on roof membranes and over time can tear the membrane apart. Freezing phenomena can pry flashings away from roofs, inhibit proper drainage, separate gutters from eaves, and threaten personal safety at building perimeters. Another demand placed upon any roofing system by a cold climate is the wide range of exposure temperatures. Because materials change dimension in direct proportion to an increase or decrease in temperature, “thermal cycling” of the roof means constant movement and stress.

In many climates, roof temperatures can also change very suddenly causing rapid dimensional changes in roof materials (thermal shock). In some higher elevations, ultraviolet exposure can be more severe than the typical testing values found in south Florida exposure. Condensation control can also be quite a challenge as moist room-side air migrates to the colder roof and condenses, sometimes freezing. Roof design for sites that experience snowfall and freezing temperatures is an important consideration due to the special challenges that this type of environment poses.

Metal roofs have long been considered a product of choice for snow areas because of superior response and tolerance to many of the characteristics of these environments. The following text is provided for informational purposes regarding the use of metal roofing in cold climates. It is the responsibility of the architect or project designer to determine acceptable products and a roof design appropriate for any specific project or end-use. It is not the purpose of this document to address load requirements for structural design purposes, or to address the effects of drifting snow on roof design.¹ This document provides the designer with the information required to make a

prudent and informed decision through awareness of some general design parameters and snowmelt phenomena.

Effects of Gravity Loads Induced by Snow

When snow blankets a roof, a strong, adhesive bond occurs between the snow blanket and the metal roof panels retaining the blanket in place. The blanket adds a vertical load to the roof surface that translates to a vector load parallel to the surface of the roof panel. This is sometimes referred to as a “drag load”, or “gravity load” (Figure 1). This load represents forces that attempt to pull the roof panel down the slope of the roof. In cases of small, unitized metal roof products, or products which have multiple points of positive fixity, these vector loads are distributed over each attachment and do not have a cumulative effect.

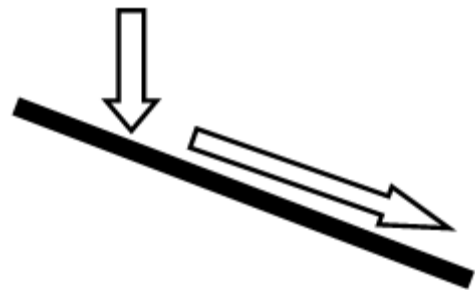


Figure 1: Vertical loads translate to vector forces (drag loads) that accumulate to the panels’ fixed point.

Most popular “standing seam” and similar type roof products are designed with “floating” attachments that enable the panel to respond freely to thermally induced stresses. These types of panel designs involve a singular point of attachment, or “fixity” point where the panel is rigidly attached to the structure or substrate. Thermal movement accumulates from that point. All other attachments would be “floating” or sliding in nature. With this type design, the vector loads of a snow blanket on

the roof's surface accumulate at that single "fixity" point which must be adequate to resist the accumulated loads.²

Calculation of the vector load is found by multiplying the vertical load by the sine of the roof angle. (Figure 2 can be used to find the degree of pitch and resulting sine of common roof slopes.) The resulting vector loads for the entire length of the panel, from eave to ridge, are tributary to the fixed point and the fastening thereof. The total vector force is normally expressed in lbs/lin ft. (in a perpendicular direction to the roof slope) hence it is found by multiplying vector force (in lbs/ft²) by the roof length (in feet from eave to ridge dimensioned in plan view [also known as the "roof run"]).

SINE OF ROOF ANGLES		
SLOPE:12	DEGREES	SINE
1	4° 45'	0.08305
2	9° 28'	0.16441
3	15° 0'	0.24272
4	18° 30'	0.31623
5	22° 30'	0.38462
6	26° 30'	0.44721
7	30° 15'	0.50387
8	33° 45'	0.55470
9	36° 45'	0.60000
10	39° 45'	0.64018
11	42° 30'	0.67572
12	45° 0'	0.70710

Figure 2

Example:

A roof is 35' (in plan) from eave to ridge. The design (roof) snow load is 58 lbs.ft² (psf). The slope of the roof is 7:12. (From Fig 2, a 7:12 slope translates to 30° 15'. The sine of 30° 15' = 0.50387)

Vector Load = 58 psf (0.50387) = 29.224 psf

Total Vector Force = 29.22 psf x 35 ft. (roof length)

= 1022.7 lbs/lin ft along fixity point

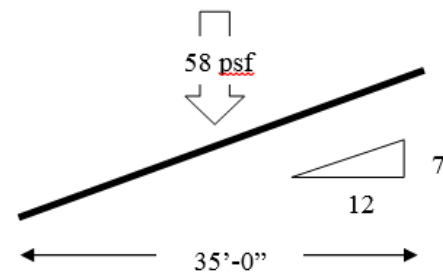


Figure 3: Total Vector Force (or drag) in this example is 1022.7 lbs/lin. ft of eave.

In calculating the vector forces that act upon the fixing of the panel, several factors should be considered:

1. The roof design snow load, not ground snow, should be used in these calculations. The roof snow (vertical load) is often reduced from ground snow by some factor. The basis of this reduction is that wind scouring normally reduces the depth of snow on a roof as compared to ground accumulation. Most design codes provide reduction multipliers for this purpose.
2. The vector loads experienced by the fixity point are actually reduced by the coefficient of friction between metal coverings and the material the covering bears upon, like asphalt felts or roof insulation. Although this coefficient can be substantial for some materials, it is almost nonexistent for others. For instance, if a slip-sheet is used beneath metal panels, the very purpose is to minimize friction between metal panel and substrate. Often, because this coefficient is unknown, it is not utilized in calculation.
3. Shear values for common threaded fasteners into various substrates are available from the fastener manufacturers. When a panel is fixed via threaded fasteners, the published or tested shear value of the fastener is normally compared against the total calculated vector force expected to determine the fastener frequency, or spacing. Using the foregoing example, the vector load

was found to be 1023 lbs/lin ft. If a published (allowable) shear value for each fastener is 340 pounds, fastening would be required every 4", or 0.33' ($340/1023 = 0.33$)

4. Safety factors are used when designing a connection based upon calculating the design failure load of any attachment. Appropriate safety factors are utilized at code prescribed levels or at the designer/engineer's discretion. Most screw manufacturers recommend a safety factor of 3 to 4 times to obtain allowable shear loading based on ultimate shear values.
5. Design roof snow loads should be considered when calculating vector forces and related point of fixity details. Caution should be exercised when roof and wall geometries create aerodynamic shade resulting in drift loads on roof areas. This may occur on roofs adjacent to parapet or other wall conditions that extend above lower roofs. Such conditions can increase design roof snow loads significantly over those of simple exposed gable roofs. (Figure 4).
6. When a lower roof has an eave above that is not protected with snow guards, the discharge of sliding snow can also cause increased loading to the lower roof. Design roof snow loads will be increased in such areas.
7. When determining slope for a barrel vault roof, use an imaginary straight line from eave to apex to represent the theoretical slope unless a more detailed evaluation is available.

Snow-Melt Phenomena

Snow melts on a roof due to several factors. Each factor can have different effects on resulting activity. It is also typical that snow thaws from multiple causes simultaneously. The following explanations of snowmelt phenomena are not unique to metal roofing, but are common on all types of roofing. In some cases, the effects of these snowmelt patterns may be different for metal roofing, however in most cases, snow melt is similar regardless of the roof material type.



Figure 4: Some building and roof geometries can create “drift loads”

Ambient Thaw

The first (and most obvious) cause of snowmelt is simply the temperature of ambient air. When snow accumulates on a roof, ambient air is typically at or below freezing. As ambient air rises above freezing, the snow blanket melts from the top down. Often, an incidental phenomenon is that the snow will develop a “crust” from this type of thaw.

The crust occurs because the outer surface of snow blanket melts and the melt-water begins to migrate downward into the blanket that acts somewhat as a sponge. When ambient temperature again drops, the outer layers of snow bank, which have retained liquid water, re-freeze causing a denser and more solid surface “crust”. This mode of thaw passes the melt-water from the top down and can increase the density of the blanket in the same direction. Except for a small amount of water that may evaporate during this process, the moisture and all of the weight are still present, however much the depth of the blanket is reduced dimensionally. A side effect of this crust is significant tensile strength and cohesion binding the snow blanket to itself.

Solar Thaw

A second snowmelt phenomena, Solar Thaw, occurs in the opposite direction, from the bottom up, and happens due to two different causes. Snow is somewhat translucent and can experience solar thaw due to non-reflected solar energy that strikes the roof surface through the blanket of snow converting to heat and raising the temperature of the roof surface. As the temperature rises, the snow blanket melts from the bottom up. This melt phenomenon is actually more frequent on most roofs than ambient thaw. Due to insulating characteristics of snow, solar thaw can occur even on cloudy days and when ambient air temperatures are well below freezing. Under normal circumstances, melt-water resulting from solar thaw will drain freely from beneath the snow blanket, however the lower portion of the snow blanket will absorb some of this melt-water and increase the density of the snow blanket from the bottom-up. This phenomenon is the most common, particularly when the roof is a dark color and has a high solar absorption value. This type of solar thaw can also have some side effects of which the building owner or designer should be aware. The first side effect is sudden release of snow from the rooftop.

When snow accumulations blanket a roof at low temperatures, a strong but temperature-sensitive adhesive bond is formed between the roof and snow. That adhesive bond is broken when solar thaw occurs. In addition, the roof surface is also lubricated by melt-water, greatly diminishing any remaining frictional resistance between the snow and roof. This often results with the entire vector force of the snow blanket experienced at the ridge area. The force typically exceeds the cohesive (or tensile) strength within the snow blanket which then fractures at the ridge area. This split can cause a sudden release of the entire accumulation of snow from one or both planes of the roof. (Figure 5) Also see “Design Considerations with Respect to a Snow Shed”.



Figure 5: Sudden release of roof snow

When snow is retained on a roof, either by design or due to the physical geometry of the roof, solar thaw can also pose special drainage considerations. Because solar thaw occurs when ambient air is well below freezing, the melt-water that drains from the roof can quickly re-freeze. This is especially true if it drains to a surface with lower solar absorption characteristics than the roof. This refreezing can also occur if the new surface is shaded from sunlight. An example might be a walkway or landscape that is shaded from sunlight by the building wall or nearby trees. The roof is warmed, snow melts, melt-water leaves the warm surface of the roof and falls to the ground. If the ground is below freezing temperatures, the melt-water will quickly re-freeze.

Similarly, if the eave is drained via guttering, and the gutter or down piping is a lighter color or shaded from sunlight, the gutter or down piping can freeze, burst, or otherwise fail. This problem can be alleviated to some degree in a number of ways: Gutters and down piping, if exposed, can be a color as dark or darker the roof itself. With a higher solar absorption characteristic gutters and down piping will be warmer than the roof surface from which the melt-water is shed. If possible, avoid locations or designs that will result with shading of these components. Additionally, open-faced downspouts can be utilized. This may not prevent freezing, but

may provide relief from freeze-bursting. Heat tracing the down piping, or routing it inside the building wall in a heated interior, is another alternative.

Heat Loss Thaw

The third major cause of snowmelt is heat from within the building escaping through the roof construction and warming the surface of the roof from below to temperatures above freezing. This mode of snowmelt is not uncommon, but perhaps the least desired because it can cause inconsistent temperatures in various areas of the roof. Differing roof temperatures can cause thawing and re-freezing of melt-water in a downslope area, the most common of which is the eave condition. (Figure 6A)

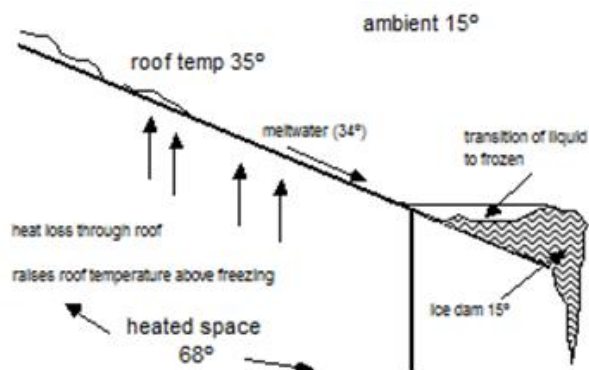


Figure 6A: The process of eave icing

Ice formation on a roof can have extremely damaging effects. The incredible force of freezing water is known to break solid steel engine blocks—and can certainly wreak havoc on a roof.

Constant re-freezing of melt-water, whether at the eave or some other roof area can accumulate to significant depths, forming ice dams. (This phenomenon happens on all types of roofs and is by no means unique to metal roofing.) Aside from potential mechanical damage to the roof itself, an ice dam can have several other effects on a roof. First, an ice dam will create rather unpredictable snow retention (Figure 6B). In this case, the bond of the ice to the roof is sufficient to withstand vector forces of snow blanketing the roof.



Figure 6B: Ice dams create unintentional snow retention

This bond is temperature sensitive however, when conditions change it can be broken causing a sudden release of both the ice and snow blanket creating a potential hazard to anything below the eave. Second, the ice dam is quite effective at retaining liquid melt-water on the roof upslope and adjacent to the ice formation (Figure 6A). This liquid melt-water can submerge upslope roof construction. Depending upon the infiltration characteristics of that construction, leakage and other sub-roof water or freeze damage may occur. The third effect of icing is the point-loaded weight of the ice bank. Ice weighs about 5 lbs/ft/in of thickness. Many structures and roof materials are not designed to support an ice build-up of several feet, which has been observed on some roofs.

Design Considerations with Respect to Icing

Icing conditions are never desired on any roof. While it is impossible to ensure that icing will never occur under any circumstance on a given roof, it is possible to reduce the likelihood. In a general sense, the icing tendencies of a roof will be greatly reduced if solar thaw modes rather than heat loss thaw modes can be induced. This can be accomplished best by a combination of basic design factors:

1. Use a roof color that has a high solar absorption value. Black and red have high absorption ratios. A prepainted metal roof with conventionally formulated dark colors such as red, brown dark bronze or dark gray will achieve much higher surface temperatures than colors such as green, blue or white. However, special cool pigmented dark colors are also available that can lower the surface temperatures.
2. When possible, orient the direction of gabled roof planes to face east-west rather than north-south. This ensures optimal exposure of both planes to sunlight, at least for part of the day.
3. Utilize “cold roof” designs such as a vented attic. By keeping the attic space cooled with outside air, the escaped building heat is vented to the outside, rather than warming the roof from beneath.
4. Insulate the ceiling adequately to reduce the building heat loss that migrates to the underside of the roof.
5. Be sure that attics are well ventilated

Ideally, the perfect roof geometry for cold and snowy climates is a steep-slope, southerly facing, simple shed roof design that is free of dormers, valleys, parapets, transition walls, and roof penetrations. Such simple and uniform geometry can help eliminate significant drifting as well as unpredictable shaded areas on a roof that may be prone to icing. Another design concern is to avoid large overhang areas that protrude outside the insulated building envelope. This avoids a “cold eave” situation that promotes icing.

When these criteria are met, the tendency for icing at best will be eliminated - at worst, greatly reduced. If complete compliance with these design suggestions cannot be met, then compliance with as many items as possible will certainly improve chances for an ice-free roof. One area of compliance can go a long way toward forgiving lack of compliance in another. For instance, if the

building design incorporates a vaulted ceiling so that a cold attic design is not practical, then extreme levels of insulation in the ceiling construction and the use of a solar absorptive color for the roof will go a long way toward forgiving the absence of attic ventilation and “cold roof” design. Other techniques can also be used to mitigate non-compliance with some of these criteria. If overhangs are used, but some building heat can be directed to escape into the soffit area beneath that overhang, the building heat loss may alleviate the “cold eave” situation and help to keep it thawed.

De-icification Cabling

When icing is imminent and the ice reduction criteria are exhausted or not possible, another solution, outside of changing the physical design, is to provide mechanical/electrical means to induce thaw and prevent or reduce icing on the roof system. A self-regulating heating cable is often a favored solution in such instances (Figure 7).



Fig. 7: De-icification cabling integrated with snow

When cables are surface mounted, care must be taken not to cause unwanted holes through the roof membrane during installation. Snow retention systems must also be incorporated to prevent migrating snow from tearing the heating cables from the roof surface. Heat cabling is often used, not to totally alleviate icing, but to mitigate the negative effects due to static water pressure behind the ice dam and mechanical damage to seams and joints. Cabling is normally arranged adjacent to seams and extends from the warm area of the roof

(just above intersection of the wall line to the roof) to the eave edge. Cabling may not keep the eave entirely ice-free, however it provides a liquid melt-water channel for drainage to eliminate the up-slope water pressure.

When guttering is utilized in addition to heat cabling, it may be beneficial to extend heating cables through the guttering, down the drain piping, and below the frost line to eliminate icing in any of these downstream components.

Underlayment Upgrades

Many building designers in ice and snow country utilize a “peel and stick” modified bituminous sheet at troublesome eaves, valleys, and transition areas. Such diligence in underlayment anticipates occasional hydrostatic pressure behind dense snow and ice. When using this type of product, additional attention should be given to several details:

1. Be sure that the softening (or flow) point of the material used is appropriate. Solar absorptive colors can result in roof temperatures near 200 °F. Metals with low gloss finishes, such as copper, lead, and zinc can result in temperatures over 200 °F. Popular rubber-modified asphalts may have softening temperatures in that same range. This means that asphalt could flow from beneath the panels under the hot summer sun.
2. When using such membranes at cold (icing) eaves, the membranes should be extended from the outer extremity of the eave to a distance of at least 30” inside the heated building envelope. For example, if a cold eave overhang extends 24” outside the building wall, the membrane should be at least 54” in coverage.
3. When coated steel panels are used over a modified asphalt granular surface, a slip-sheet should be incorporated between the surfaces to prevent abrasion to the underside of the roof panel as it moves thermally. According to the Copper Development Association, if copper is used, a slip sheet should be incorporated regardless of the surface of the membrane.

4. It is a mistake to rely too heavily upon this membrane for weather protection. If water is infiltrating to the panel underside on a frequent or prolonged basis, it can accelerate corrosion of coated steel products from the under side. It can also freeze, heaving panels and causing other panel and panel joint damage.

Design Considerations with Respect to Snow Shed

Under limited circumstances, it is considered acceptable to let snow shed at will from a low-rise roof. However, if not anticipated during design, it can also be very inconvenient and destructive. Locations of ingress and egress, as well as parking area design should anticipate this snow slide. Building entrances should be beneath gables, not eaves. Pedestrian and vehicular traffic patterns must be routed away from potentially dangerous snow-shed zones. Any permanent structure or fixture within the trajectory of sliding snow must be designed to withstand the anticipated impact. This concern includes lower roof planes, other construction elements, incidental mechanicals, landscaping and vegetation. Drop zones should be made inaccessible to pedestrian and vehicular traffic. When not practical within the building design to provide for natural snow-shed, snow retention devices should be employed.

In heavy snow areas, snow-shed can also inhibit proper site drainage, directing roof run-off and snowmelt-water towards, rather than away from, building walls and foundations.

Due to higher unpredictability and the increased hazards associated with the “shed-at-will” philosophy, only in carefully selected situations should snow retention devices be omitted in the design of the building.

Design Considerations for Snow Retention

Serious accidents and even fatalities have resulted from rooftop avalanches. Shedding snow is also known to do serious damage to landscaping, other building elements and roofs, themselves as massive

amounts of snow slide down the surface on the high quality factory finishes.

Note: MCA has published a Technical Bulletin; Qualifying Snow Retention Systems for Metal Roofing. Thorough review of this document is strongly advised as it is vital to guide users in the snow guard selection process. IAPMO has also developed an Evaluation Criteria for Snow retention systems. <http://www.iapmo.org/media/4702/ec-029-2018.pdf>

The first step in snow retention design is to determine the loads to be resisted by the snow retention system. These are the same “drag” loads discussed earlier, (Effects of Gravity Loads Induced by Snow) and may be calculated by converting vertical roof snow loads to vector loads, then calculating tributary areas. (Reference Figure 3) Safety factors should be utilized in accordance with normal design practices and building code requirements. Designers and engineers must be aware of the appropriateness, applicability, and efficacy of the snow guard product testing while also making sure that the type of load, frequency, and expected length of performance of the devices are all considered. (See the MCA Technical Bulletin, Qualifying Snow Retention Systems for Metal Roofing)

Two different methods of snow retention are quite common. One method utilizes continuous horizontal components, assembled laterally across the roof in the style of a “fence”. (Figure 8A)



Figure 8A: “Fence” type snowguard system

Such assemblies are usually installed at or near the eaves to be most effective. Depending upon specific job conditions and the allowable load characteristics of the system utilized, additional parallel rows of “fence” may be used up the roof slope.

A second method of snow retention involves dis-continuous, small individual units used as “cleats” which are generally concentrated at or near the eave. These “cleats” also may be repeated in some pattern progressing up the slope of the roof. This snow retention style relies upon the shear strength within a snow bank to “bridge” between the individual units. (Figure 8B)



Figure 8B: “Cleave” type snowguard system

Both styles of snowguards (fence and cleat) have demonstrated satisfactory performance when appropriately tested load capacities are matched to in-service vector forces and the snowguards are installed properly. The theory of all snow retention devices is to restrain or retard movement of a bank of snow by restraining the base; hence snow guard devices only a few inches in height have been used successfully even when snow banks are many feet in depth. It is common practice to concentrate multiple rows or units at the eave end of the roof. This practice has been used for centuries and the success of the design is based on the densification and monolithic properties of snow banks. Snow banks densify in wedge patterns. As the snow bank compacts from thaw and the weight of the snow in the bank, the densest layers (and therefore those with the greatest shear, tensile and compressive strengths) lie adjacent to the roof surface and especially toward the downslope (eave) end.

Installation of snow retention devices at this location has proven to be strongly preferred and most effective worldwide (Figures 9 & 10).



Figure 9: This project in Norway demonstrates appropriate placement of multiple rows, concentrated in the lower half of the roof

Attachment methods also vary. In rare cases, devices are custom made to attach to the structure below the roofing, usually before roofing is placed. This type of device is usually designed on a job-specific basis. At a minimum, the weatherproofing of such a device while preserving thermal movement characteristics of panels can be a formidable challenge. Extreme caution should be used when such designs are incorporated due to the penetration of the device through the metal roof membrane, and associated waterproofing problems.

The more common pre-manufactured, surface mounted devices screw through the roof and into the deck or the structure below. This practice is prudent for some roofs, but not others. A face-fastened panel system by design uses a multitude of penetrations (screw fastenings), so the addition of a few more penetrations is consistent with roof design. Weatherproofing of such devices is still of paramount importance and the holding strength of the device to resist the vector forces will be highly dependent the quantity of devices used and upon the nature and frequency of attachment.

Generally speaking, surface mounted devices should not be used on panels that are designed to move thermally, such as standing seam roofs. The connections to the roof deck and structure below the deck would violate the freedom of thermal movement that is required for standing seam roofing to be effective.

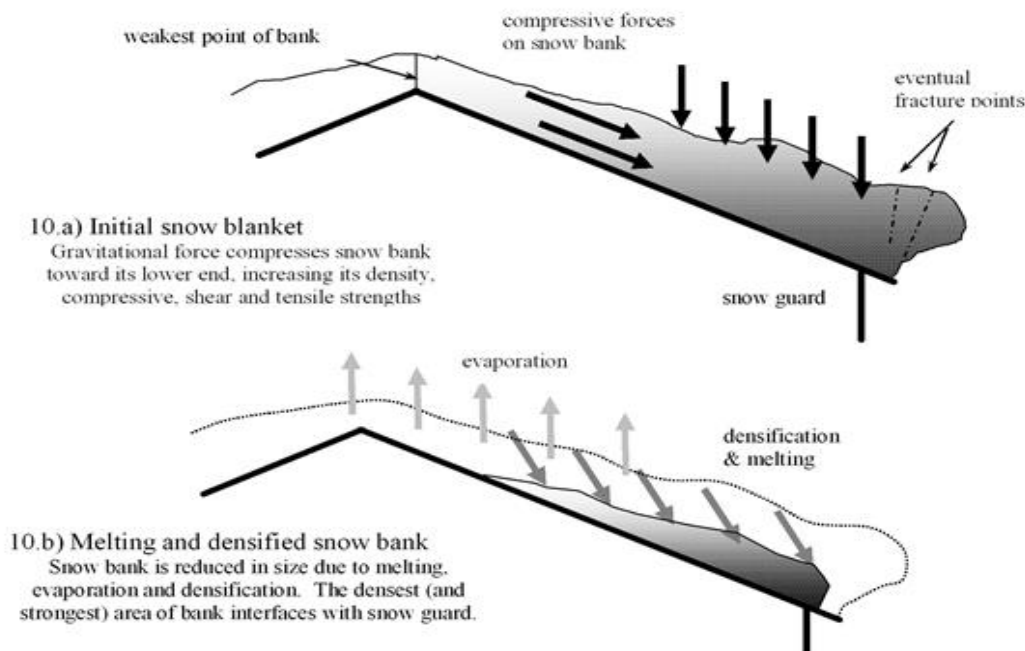


Figure 10: The Process of Thaw and Densification

As an alternate to fastening into the roof deck and support structure, some pre-manufactured devices are soldered or adhesively mounted directly to the roofing material. Obviously, soldered devices can only be used on solderable metals that include copper, zinc and terne, but exclude coated steel and aluminum.

Adhesively mounted devices of metal or plastic have also been widely used in the past. Although adhesive chemistries have improved over time, the fact remains that adhesive holding strength diminishes with age and environmental exposure making any test result on “out of box” samples irrelevant to actual aged performance.

Based on the significant reports of failure for adhered devices and a lack of scientific foundation for their use, adhered snow guards should not be considered for use as primary system components (see also the MCA Technical Bulletin: Qualifying Snow Retention Systems for Metal Roofing).

A more desirable alternative, when appropriately tested, involves the use of

mechanically attached snow guards that utilize a clamping attachment that grips the standing seam of the roof panel without puncturing the panel material. Because this attachment method is mechanical rather than chemical, the concerns regarding adhesive aging and the use of adhesives do not apply.

Some mechanical attachment products utilize “cup point” set screws or sharp nodes that are prone to tearing the seam material under load or, at the very least, damage panel coatings leading to premature base metal corrosion. Other clamping products use round tipped setscrews to avoid this panel damage and are preferred. Some use only one set screw, others use several. Again, appropriateness and completeness of lab testing as well as the specific details of attachment should be carefully evaluated before a final system choice is made. (See also the MCA Technical Bulletin Qualifying Snow Retention Systems for Metal Roofing).

Load-to-failure testing results in the lab vary greatly depending upon variables such as gauge thickness of metal, specific type of metal being used (e.g. copper coated steel, aluminum), and other details of the specific assembly – even including brand of roof manufacture. Performance in the field is highly contingent upon proper installation and the tensioning of attachment fasteners in strict accordance with the torque defined in the test reports or installation instructions. Thorough inspection by a qualified person should be performed to verify compliance with all snow guard manufacturer’s installation instructions..

Other issues to be considered when using snow retention devices include verifying metal compatibility which includes matching the corrosion resistance of the device being used with that of the roof panel material. In many cases, color matching between these elements should also be verified. Devices that utilize air-dried paints to match the color of roof panels may provide a perfect match initially, but color change after a few years of weathering may result in a poor color match. This is typically due to inferior characteristics of air-dried paints when compared to the factory applied finishes of metal panels. Powder coating the devices is an option that will provide greater longevity in terms of color stability, but generally even this level of finish is not equal to factory applied PVDF panel finishes.

During product selection, it will be necessary to evaluate the frequency of rows or spacing of devices on a job-specific basis. This is done by comparing the tributary service loads with the allowable load for the device being considered and spacing parts or assemblies in accordance with those calculations.

Using the previous example illustrated by Figure 3, the vector load determined from the example was 1,023 lbs/lin ft along the point of fixity. If panels are 16” (1.33’) wide, then each panel will experience 1,364 pounds of force delivered to the snow guard from design snow loads

(1023 x 1.33). If a cleat type device is selected, with an allowable load of 180 pounds per cleat, then 8 devices per panel would be required ($1364 \div 180 = 7.6$, rounded up = 8). If a continuous system is selected, with an allowable load of 850 pounds, then two rows would be required ($1364 \div 850 = 1.6$, rounded up = 2).

When multiple rows of devices are needed, the rows are generally arranged within the lower half of the roof slope. In most cases, the first row of units or cross-members should be located within 12” of the panel eave end. At some point, the snow bank that envelops the snowguard will shear at the approximate location of the guard. Whatever portion of the bank is below the guard may fall from the roof and this distance minimizes hazards of that falling snow. This 12” placement of the first row of snow guards can be altered when necessary if the system utilizes heating cables at the eave area. In this instance, the snow guards should be located immediately upslope of that cabling (Figure 7). Successive rows should be spaced approximately as shown in Figure 11.

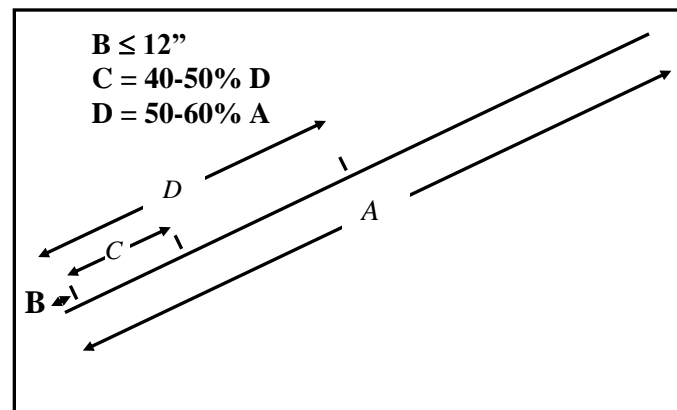


Figure 11: Guideline for spacing of multiple rows

Such placement can also reflect some discretion with respect to aesthetic and other concerns. For example, it may be desirable to align a fence with other roof geometry like the apex or downslope termination of a row of dormers or skylights.

Because of the site-specific and product-specific nature of system design and integration, any basis

of design callouts and project specifications should be product specific (proprietary spec) and as calculated for the specific snowguard product identified. Any substitute material must demonstrate equivalence in terms of holding strength, either by testing or mathematically proven to be adequate considering site-specific and product-specific factors.

In highly critical applications a minimum of two rows of parts or assemblies should be used, even though calculations may show one row to be adequate. This cautious approach should be considered because under some circumstances, the compressive strength of a snow blanket may be lacking causing the blanket to “buckle”. The loop of the buckled blanket may fold over the single row and potentially fall to the ground. Such conditions are rare, but have been observed, particularly with steep slopes and minimal accumulation of water-laden snow.

When snow guards are used at isolated locations such as over an entry door or to protect a stack or flue, care must 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 wedge, 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. (Figure 12)

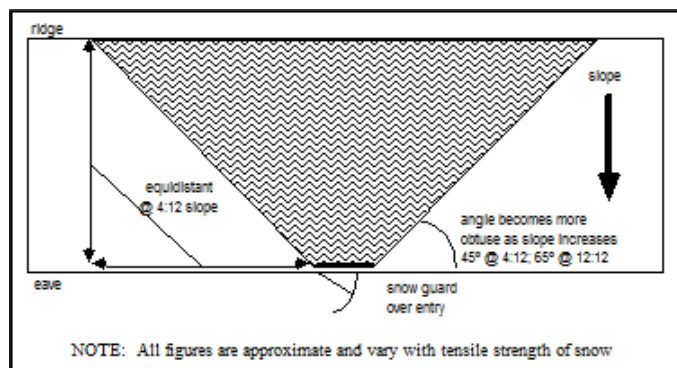


Figure 12: Approximate tributary area to a localized snowguard

Devices that clamp onto panel seams may be used at a minimum of alternating seams, but should not be used any less frequently. (Consult manufacturer installation instructions for specific direction.) A clamp that grips the seam will distribute loads to the pans at either side of the seam; hence uniform loading of panels still occurs when every other seam is skipped. This is not the case if a clamp is installed, for instance, at every third seam.

In order that thermal cycling characteristics of the roof are preserved, clamp-on devices should avoid panel attachment at clip locations, unless dual component clips were used in the original roofing installation.

Summary

Metal roofing is a preferred material in cold climates due to the material’s durability, sustainability, clean lines and attractive appearance. It can have a service life many times longer than that of other roof types. Adherence to these guidelines has proven beneficial toward trouble free serviceability over many years. Severe alpine climates may pose additional challenges not discussed herein. Consult with those experienced in alpine metal roof design when necessary for those special applications.

References

- (1) MBMA Metal Roofing Systems Design Manual, 2nd Edition Chapter 6.1.3, 2013
- (2) MBMA Metal Roofing Systems Design Manual, 2nd Edition Chapter 7.6, 2013

Founded in 1983, the Metal Construction Association brings together the diverse metal construction industry for the purpose of expanding the use of all metals used in construction. MCA promotes the benefits of metal in construction through:

- Technical guidance
- Product certification
- Educational and awareness programs
- Advocating for the interests of our industry
- Recognition of industry-achievement awards
- Monitoring of industry issues, such as codes and standards
- Research to develop improved metal construction products
- Promotional and marketing support for the metal construction industry
- Publications to promote use of metal wall and roof products in construction

For more information, please visit the MCA Web site at www.metalconstruction.org

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