Metal Construction Association

Guidelines for Commercial Roofing

Metal Roof Design for Cold Climates

Product XXX
Revised 3/04

Metal Construction Association

Association Background

The Metal Construction Association (MCA) was formed in 1983 as a non-profit organization dedicated to promoting the use of metal in construction. Committed professionals in the metals industry have guided and supported the Association's initiatives in market development, educational programs, issue and product awareness, and publication of technical guidelines and specifications manuals. The Metal Construction Association also monitors and confronts challenges affecting the industry, such as code restrictions, fire testing, and wind load regulations.

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Metal Roof Design for Cold Climates

Northern climates have always posed some unique challenges to all types of roofing material. Snow and ice pull and tug on roof membranes, and over time can threaten to tear them apart. Freezing phenomena can pry flashings away from roofs, inhibit proper drainage, rip gutters from eaves, and even threaten personal safety at building perimeters. Another demand placed upon any roofing system by a cold climate is the wide range of temperatures to which it is exposed, producing exaggerated thermal movement and stress. Because materials change dimension in direct proportion to their temperatures, "thermal cycling" of the roof means that it constantly undergoes movement and stress.

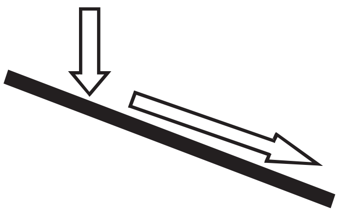


Figure 1: Vertical loads translate to vector forces (drag loads) that accummulate to the panels' fixed point.

In these climates, roof temperatures can also change suddenly causing dimensional changes in roof materials (thermal shock). In some higher elevations, ultraviolet exposure can be more severe than south Florida. 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 for the roof.

Metal roofs have long been considered a product of choice for snow areas because of their superior response and tolerance to many of the above-mentioned characteristics of these environments. The text in this section is provided for informational purposes regarding the use of metal roofing in these climates. It is the responsibility of the architect or project designer to determine acceptable products and roof design appropriate for any specific project or end-use. It is not the purpose of this section to address load requirements for structural design purposes, or to address the effects of drifting snow on roof design.[1] This material is meant to assist the designer in making prudent and informed decisions by an 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 panels. This adds a vertical load to the roof's surface that is translated to a vector load parallel to the panels' surface. This is sometime called a "drag load" or "gravity load" (Figure 1). It represents forces that attempt to pull a panel down the slope of the roof. In cases of small, unitized metal roof products, or products which have multiple points of positive fixity, vector loads are distributed over each attachment and do not have a cumulative effect.

SINE OF ROOF ANGLES

Slope:12	Degrees	Sine
1	4° 45′	0.08305
2	9° 28′	0.16441
3	14° 2′	0.24272
4	18° 26′	0.31623
5	22° 37′	0.38462
6	26° 34′	0.44721
7	30° 15′	0.50387
8	33° 41′	0.55470
9	36° 52′	0.60000
10	39° 48′	0.64018
11	42° 30′	0.67572
12	45° 0′	0.70710

Figure 2

Most popular "standing seam" and similar type products are designed with "floating" attachments that enable the panel to respond freely to thermally induced stresses. Most of these panel designs involve a singular point of attachment, or "fixity." This is the point at which the panel is rigidly attached to the structure or substrate, and thermal movement accumulates from that point, with the other attachments being of a "floating" or sliding nature. With such a design, the vector loads of 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.[2]

Calculation of 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 its fixed point and the fastening thereof. The total vector force is normally expressed in pounds per linear foot (in a perpendicular direction to the roof slope) hence it is found by multiplying vector force (in pounds per sq ft) by the roof length (in ft from eave to ridge dimensioned in plan view [or roof run]).

Example: (See Figure 3)

A roof is 35 ft (in plan) from eave to ridge. The design (roof) snow load is 58 psf, and the slope of the roof is 7:12. (A 7:12 slope translates to 30º15', and the sine of 30º15' = .50387).

The resulting vector force is: 58 psf x .50387 = 29.224 psf

Tributary vector force then is: 29.22 psf x 35 ft (roof length) = 1022.7 pounds per (linear) foot along fixity point

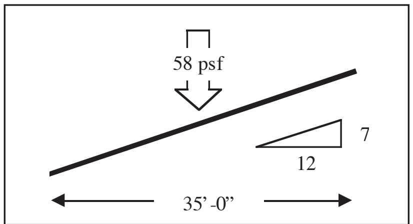


Figure 3: Resulting vector (or drag) load in this example is 1022.7 lbs./linear foot of eave.

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

1. The roof design snow load, not ground snow, should be used in 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 model codes provide reduction multipliers for this purpose. In other cases, roof snow may be increased from ground snow (see #6) on the following page.
2. The vector loads are actually reduced by the coefficient of friction between metal coverings and whatever they bear 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, its very purpose is to minimize friction between metal panel and substrate. Often, because this coefficient is unknown, it is not utilized (assumed to be 1.0) in calculation.
3. Shear values for common threaded fasteners into various substrates are usually 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 1,023 pounds per linear foot. If a published (allowable) shear load were, say 340 pounds, then fastening would be required every four in., or .33 ft (340/1,023 = .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 designer/engineer discretion. Most screw manufacturers recommend a safety factor of 3 to 4 to obtain allowable shears from ultimate shear values.
5. 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 a parapet or other wall condition that extends above lower rooflines. Such conditions can increase roof loads significantly (see Figure 4). When a lower roof has an eave above that is not protected with snow guards, the discharge of sliding snow can also cause added

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

loads to the lower roof. Determination must also be made with respect to using uniform or non-uniform loads in design. Governing building codes should be consulted and appropriate engineering standards and calculations are vital to determine the actual in-service roof loads in all such cases.[1]

6. When determining slope for a barrel vault, use an imaginary straight line from eave to apex to represent 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, and snow often thaws from multiple causes simultaneously. The following explanations of snowmelt phenomena are not unique to metal roofing, but are similar on all types of roofing. In some cases, the effects of these snowmelt patterns may be a bit different for metal roofing, but in most cases, they are similar regardless of the roof material type.

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 then 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 that have retained liquid water re-freeze, causing a denser and more solid "crust" on the surface. 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 that may evaporate during this process, the moisture and its weight are still present, but dimensionally the depth of the blanket is reduced. A side effect of this crust is significant tensile strength—cohesion, binding the snow blanket to itself as a unit.

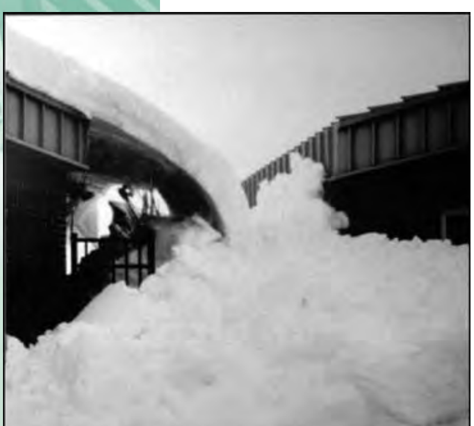


Figure 5: Sudden release of roof snow

Solar Thaw. Other snowmelt phenomena occur in the opposite direction, from the bottom up, and happen from two different causes. Snow is somewhat translucent. The non-reflected energy of sunlight that strikes the roof surface through the blanket of snow converts to heat and raises the temperature of the roof surface. As the temperature rises, the snow blanket melts from the bottom up. This melt phenomenon is actually more common and frequent on most roofs than ambient thaw and occurs even when ambient air temperatures are well below freezing. It can also occur on a cloudy day, although to a lesser degree. Under normal circumstances, melt-water that results from solar thaw will drain freely from beneath the blanket of snow. The lower portion of the blanket, however, will absorb some of this melt-water, thus increasing the density of the blanket from the bottom-up.

The aforementioned phenomenon is the most common, particularly when the roof is a dark color with a high solar absorption value. It can have some side effects of which the building owner or designer should be aware. The first 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 roof and snow. When sunlight warms the surface of the roof, not only is the bond broken, but the roof surface is also lubricated by melt-water, greatly diminishing any frictional resistance that may have existed between snow and roof. This often results with the entire vector force of the snow blanket experienced at the ridge area. The force usually exceeds the cohesive (or tensile) strength within the blanket, and the blanket splits at the ridge area. This can cause a sudden release of the entire accumulation of snow from the roof. (Figure 5. Also see "Design Considerations With Respect To Snow Shed.")

When snow is retained on a roof, either by design, or due to the physical geometry of the roof, solar thaw can pose some special drainage considerations. Because this type of thaw occurs even 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 that has different solar absorption characteristics than the roof, or if the 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, and snow melts. When the melt-water leaves the warm surface of the roof it falls to the ground. If the ground is below freezing, 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 and 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 the same as or darker than 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 will not necessarily 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.

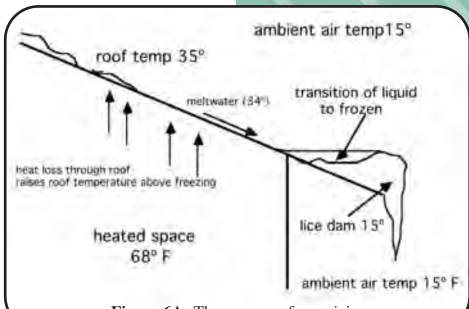


Figure 6A: The process of eave icing

Heat Loss Thaw. Another cause of snowmelt is heat from within the building escaping through the roof construction, warming the surface of the roof to temperatures above outside ambient air. This mode of snowmelt is not uncommon, but perhaps the least desired because this phenomenon 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 (Figure 6A). Ice 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 is by no means unique to metal roofing but happens on all roof types.) 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). Often 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, however, is temperature sensitive. When conditions change this bond can be broken causing sudden release of the ice and snow blanket, which creates 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 (see Figure 6A). This liquid melt-water can submerse upslope roof construction. Depending on the infiltration characteristics of that construction, leakage and other sub-roof water or freeze damage may occur. The third problem of icing is the point-loaded weight of the ice bank. Ice weighs about 5 pounds per foot per inch of thickness. Many structures and roof materials will simply not tolerate 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 any 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 building 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. A red, brown, or dark gray roof will achieve much higher surface temperatures than blue, green, or white.

2) Orient the direction of the roof planes to face an east-west rather than north-south direction. This ensures that they will have exposure to the sunlight, at least for part of the day.

3) Utilize designs having a "cold roof," like a vented attic. By keeping the attic space cool with outside air, the escaped building heat is vented to the outside, rather than warming the roof from beneath.

4) Insulate the ceiling adequately. The more insulation, the less building heat loss to the roof's underside.

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 rather unpredictable shaded areas on a roof that may be prone to icing. Also, the roof should be free of large overhang areas that protrude outside the insulated building envelope. This avoids the "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 the above cannot be met, then compliance with as many items as possible will certainly improve the ice-free roof. One area of compliance can go a long way toward forgiving the breach of 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 things can also be done 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 aforementioned criteria are exhausted or not possible, then the only remaining

Figure 7: De-icification cabling integrated with snow guards (Note that it runs into and through the gutter as well)

solution outside of changing the design is to provide mechanical/electrical means to induce thaw that can prevent icing, or at least reduce its negative effects on the roof system. A self-regulating heating cable is often a favored solution in such instances (Figure 7). When cables are surface mounted, care must be taken in their installation so as not to cause unwanted holes through the roof membrane with the attachment. 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 the icing phenomenon, but to mitigate the negative effect of it—static water pressure behind the ice dam and mechanical damage to the seams and joints. With that in mind, the arrangement of cabling is normally 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. The cabling may not keep the eave entirely ice-free, but it provides a channel through which liquid melt-water can drain.

When guttering is utilized in such situations, it may be advisable to extend heating cables through the guttering, down the drain piping, and below the frost line. Alternatively, guttering can also utilize the solar thaw tact if gutters and down piping will have long periods of exposure to direct sunlight. Using a very dark color for these elements will help to keep them thawed without heating cables. Since this method is not 100% reliable, it is also advisable to use open-faced downspout design, so that if a downspout freezes at some point, it does not burst. Another drainage design sometimes employed in severe alpine environments is the use of a suspended chain, rather than a downspout.

Underlayment Upgrades. A practice favored by many designers in ice and snow country is to utilize a "peel-and-stick" modified bituminous sheet at troublesome areas such as eaves, valleys, and transition areas. Such diligence in underlayment anticipates occasional hydrostatic pressure behind dense snow and ice. When utilizing such products, 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 200ºF. Metals with low-gloss finishes, like copper, lead and zinc can result in temperatures over 200ºF. Popular SBS (styrene-butadiene-styrene) rubber-modified asphalts may have softening temperatures in the same range. This means that asphalt can 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 in. inside the heated building envelope. For example, if a cold eave overhang extends 24 in. outside the building wall, the membrane should be at least 54 in. in coverage.
3. If metallic-coated steel panels are used over a modified asphalt granular surface, a slip-sheet of some sort should be incorporated between the two to prevent abrasion to the underside of the roof panel as it moves thermally. According to the Copper Development Association, if copper is used, then 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 underside. It can also freeze, heaving panels and causing other kinds of damage.

Design Considerations with Respect to Snow Shed

When possible, it is considered appropriate to let snow shed at will from a low-rise roof. However, if not anticipated during design, it can also be very inconvenient, destructive, or both. Locations of ingress and egress, as well as parking should anticipate this snow slide. Building entrances should be beneath gables, and not eaves. Pedestrian and vehicular traffic patterns must be routed away from potentially dangerous snow-shed zones. Anything within the trajectory of sliding snow must be designed to withstand its impact. This includes lower roof planes, other construction, incidental mechanicals, landscaping and vegetation. When possible, eave areas should be made inaccessible to pedestrian and vehicular traffic. Often this can be accomplished by landscaping. When it is not practical within building design to provide for natural snow-shed, snow retention devices may be employed.

In heavy snow areas, and designs that provide for snow-shed at will, another consideration is whether the "drop zone" is accessible for periodic snow removal. Heavy accumulations on the ground can cause damage to building walls. It can also inhibit proper site drainage, directing roof run-off and snowmelt-water into, rather than away from, building walls and foundations.

High roofs become more unpredictable and more hazardous to utilize the "shed-at-will" philosophy, and snow retention devices should be utilized on such roofs with only carefully selected and limited exceptions.

Figure 8A: "Fence" type snowguard system

Design Considerations with Respect to Snow Retention

Serious accidents, even fatalities, have resulted from rooftop avalanche. Shedding snow may also do serious damage to shrubs and other landscape. It can cause damage to lower adjacent roofs, and can also abrade paint finishes and damage standing seams as it slides down the surface of factory finishes on roof surfaces and valleys. In many cases it is also a maintenance nuisance, necessitating frequent snow removal from the ground below. In cases where these risks or nuisances are present, the designer may wish to incorporate snow retention into the building design.

The first step in snow retention applications is to determine the loads that are to be resisted by the snow retention system. These are the same "drag" loads discussed earlier, (the effects of gravity loads induced by snow) and they are calculated in the same fashion—by converting vertical roof snow to vector loads, then calculating tributary areas (Figure 3). Safety factors should be utilized in accordance with usual practices, but also with an awareness of the appropriateness and accuracy of the snow guard product testing, and the durability of the attachment method.

Figure 8B: "Cleat" type snowguard system

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). Such assemblies are usually installed at or near the eaves. Depending upon specific job conditions and load-to-failure characteristics of the devices, they may also be repeated in parallel rows up the slope of the roof, but with greater concentration near the eave area.

The second snow guard style 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 progressing up the slope of the roof, once again with greater concentration near the eaves. This style relies upon the shear strength within a snow bank to "bridge" between the individual units (Figure 8B).

Both styles of snow guards (fence and cleat) have demonstrated satisfactory performance when designed and installed properly and adequately. The theory of all snow retention devices is to restrain or retard movement of 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. 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 its success has to do with the densification and monolithic properties of snow banks. Snow banks densify in wedge patterns. As the snow bank compacts from thaw and its own weight, the densest layers (and therefore those with the greatest shear, tensile, and compressive strengths) lie at its base, and toward its downslope end; hence interface of snow retention devices at this location is strongly preferred and most effective (Figures 9 & 10).

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

Methods of attaching these devices are also varied. Some devices are custom made to attach to the structure below the roofing, usually before roofing is placed, and on a job-specific basis. The weatherproofing of such a device while preserving thermal movement characteristics of panels is a formidable challenge. Extreme caution should be used when such designs are incorporated due to the necessary penetration of the device through the metal roof membrane, and the near-impossible waterproofing problems presented.

Other pre-manufactured, surface-mounted devices simply screw through the roof and into the deck or structure below. This practice is prudent for some roofs, but not for others. A face-fastened panel system has multitudes of screw penetrations, so the addition of a few more is consistent with roof design and prudent. Obviously, care in weatherproofing such devices is of paramount importance, and the holding strength of the device to resist vector forces explained earlier will be highly dependent upon the nature and frequency of attachment. Generally speaking, such devices should not be used on panels that are designed to move thermally, such as standing seam, as the method of attachment would violate freedom of thermal movement.

Many pre-manufactured devices are adhesively mounted or soldered. Obviously, soldered devices can only be used on solderable metals that include copper and terne, but exclude coated steel and aluminum. Adhesively mounted units of metal or plastic have been used on all metals, but precautions are strongly advised. Most recommended adhesives are temperature-sensitive curing compounds that can only be applied when weather is warm and stays warm throughout the duration of the cure time. Cure times can be 30 days or longer, which limits the installation seasonally. Additionally, many of the premium paint (PVDF) systems used on metal panels have chemical compositions that render the surface a rather "non-stick" characteristic. Hence the strength of the cured adhesive bond is minimal.

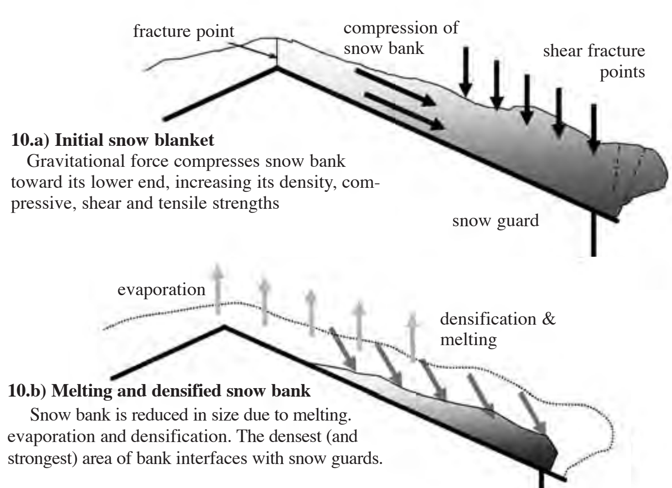


Figure 10:
THE PROCESS OF THAW AND DENSIFICATION

Adhesives are chemical compounds that change with age and exposure. It should be

known and anticipated that the service life of such a device may have serious limitations and decreasing holding strength with time. Finally, the load testing done by most manufacturers of this type of product is a dynamic load-to-failure, rather than the sustained load that will be experienced in service. Because of the elastic nature of most adhesives, the in-service static load may show much earlier failure pressures than the lab-tested dynamic load-to-failure. From this standpoint, when such lab results are relied upon in design, a safety factor of 3 to 5 may be advisable.

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. Again, appropriateness of lab testing should be scrutinized as well as the specific details of attachment. Some products utilize "cup point" set screws that may tear the seam material under load or sever and abrade panel coatings leading to premature corrosion. Others use round tipped setscrews and are preferred. Some use only one setscrew, others use several. Load-to-failure lab testing varies from very low figures to extremely high ones, depending upon the gage of metal, specific type of product, and its anchorage details. These tested loads are also highly contingent upon proper installation and tensioning of any fasteners required for attachment in strict accordance with test methods. While dynamic load testing is acceptable for mechanical attachments, testing should be panel-specific. When relying upon ultimate tested loads, screw tensions should be periodically verified. If so, safety factors of 2 may be adequate.

Other issues to be considered when using snow retention devices include verifying metals compatibility, matching corrosion resistance of the device being used with that of the panel material. In many cases, color matching is desired. Devices that utilize air-dried paints to match the color of roof panels may provide a perfect match initially, but a very poor one after weathering a few years. This is due to inferior characteristics of air-dried paints when compared to the factory-applied finishes of metal panels. Powder coating will generally provide greater longevity in terms of color stability, but is still not equal to that of factory-applied PVDF panel finishes.

During product selection, it is also 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 then spacing parts, or assemblies in accordance with those figures. Using the previous example as illustrated by Figure 3, the vector load determined from the example was 1,023 pounds per linear foot along the point of fixity. If panels are 16-in. (1.33-ft) wide, then each panel will experience 1,364 pounds of force from design snow loads (1023 x 1.33). This is the same force that would be experienced by the snow guard devices. If a cleat type device is selected, and that device has allowable loads of 180 pounds for example, then 8 devices per panel would be required (1364÷180 = 7.6, rounded = 8). If a mechanically attached device is selected for use and that attachment has allowable loads of 850 pounds for example, then two rows would be required (1364÷850 = 1.6, rounded = 2).

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 close to (within 12-in. of) the eave end of the panels. This is because at some point, the snow bank that envelops the snowguard will shear at the approximate location of the guard, and whatever portion of the bank is below the guard may fall from the roof. The size of this falling portion should be minimized for obvious reasons. This 12-in. placement of the first row of snow guards can be obviated if the system utilizes heating cables at the eave area, in which case the snow guards should be located immediately upslope of that cabling (see Figure 7). Successive rows should be spaced approximately as shown by Figure 11. 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.

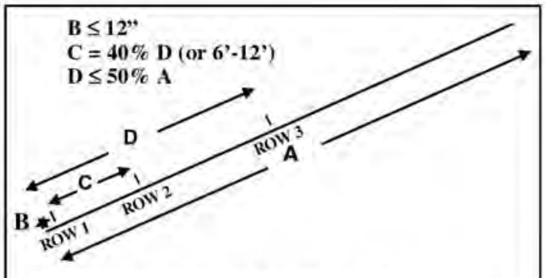
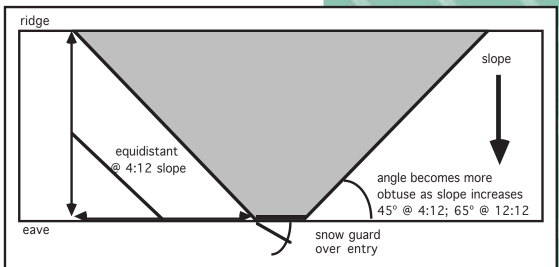


Figure 11: Guideline for spacing of multiple rows

Because of the site-specific and product-specific nature of system design and integration, any plan callouts and project specifications should be product specific (proprietary spec) and as calculated. Any substitution should be indicated to demonstrate equivalence in terms of holding strength, or mathematically proven to be adequate by site-specific and product-specific factors.

In highly critical applications it may be advisable to use a minimum of two rows of parts or assemblies, even though the math may show one row to be adequate. This is because under some circumstances, the compressive strength of a blanket of snow may be lacking causing the blanket to "buckle." The loop of the buckled blanket may fold over the snow guard and potentially fall to the ground. Such conditions are rare, but have been observed, particularly with steep slopes and minimal accumulation of new fallen snow that is water-laden.

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 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 (Figure 12).



NOTE: All figures are approximate and vary with tensile strength of snow

Figure 12: Approximate tributary area to a localized snowguard

When using devices that clamp onto panel seams, they may be used on alternating seams (manufacturer consenting), but should not be used any less frequently. 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 to ensure thermal cycling characteristics of the roof are preserved, clamp-on devices should avoid panel attachment at clip locations, unless those clips are dual component clips, in which case such prohibition is not necessary.

Summary

Metal roofing is a preferred material in cold climates because of its durability, sustainability, clean lines, and attractive appearance. It can have a service life many times longer than other roof types. Adherence to these guidelines have 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.

Notes

Notes

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