

DESIGNING A SNOW RETENTION SYSTEM

By Brian C. Stearns

For as long as man has been designing sloped roofs in regions with snow and ice, there has been a need for a system or mechanism to manage the sudden sliding or dumping of an accumulated snow mass. When snow falls on a cold roof surface, it begins to accumulate. As heat—either from within the building structure or from exterior temperature change—begins to melt the snow, the running water is pulled by gravity down to the roof surface. A thin film of water will then accumulate between the snow and the roof surface and act as a lubricant that causes a shear plane between the roof and the snow mass. When this happens on a steep or slick enough roof surface, the entire mass will often and unpredictably slide off like an avalanche (*Figure 1*). Building owners search for a solution to this problem because of both safety and maintenance concerns.

I once attended a seminar during which the speaker showed some pictures of a beautiful ancient stone roof that appeared to be two or three large slabs of slate or shale stacked to create a shingled effect. This picturesque setting had a European ambience and was spectacular in terms of roofing simplicity. One of the pictures showed baseball-sized rocks randomly scattered around the roof surface. The orator explained that this was quite possibly the

original snow retention mechanism. The theory, he noted, was that building owners of the era would strategically place these rocks on the roof as winter set in. Then they would pour boiling water over the rocks during subfreezing temperatures to freeze them in place. Their goal was to create a physically attached system that “added friction to an otherwise frictionless surface.”

As a knowledgeable roofing contractor, I thought this was about the craziest notion I had heard in a long time. Why would someone freeze a rock in place that would eventually pop loose and come off with the same mass it was supposed to be retaining? And who would possibly have had the time to do such a thing when survival alone during this long-ago era was far more consuming



Figure 1 – Snow dumping from upper roof to lower roof, thus pushing snow off the lower roof above the door.

than managing snow and ice on a crude shelter? I didn't have the heart to tell this guy that these rocks were probably no more than the result of bored kids who were throwing stones up on the roof to be mischievous and kill time.

My background is in slate roofing. Most of my work was accomplished in the Northeastern U.S. Nearly all of the roofs that I have installed or repaired have had some sort of outdated snow retention system. Some of these systems worked well, while others caused more damage to the roofs than they prevented. Finding a solution to this problem became my personal mission. Eventually, this mission led me out of the slate roofing business and into the snow retention manufacturing business. What drives me from day to day is a constant search to improve upon what we now offer and to invent even newer and better ways to prevent avalanching snow and ice from any and all roof surfaces.

To understand snow retention systems, one must first have a grasp of what they are intended to do. These systems are designed to hold snow and ice in place on the roof until they melt and come off the roof as water, or in the case of pad-style snow guards, as very small pieces that come off slowly. Pad-style snow guards can be thought of as increasing friction, while pipe-style retention systems act as a barrier as needed on the roof surface. In pipe-style applications, the barrier allows the melted running water to drain off under the snow mass while retaining the more solid mass above. When functioning properly, the snow should essentially melt into the roof.

It is a common misconception that snow guards are designed to break up the snow and ice mass as it begins to slide off the roof. This simply is not the case. Imagine a 1,000-pound mass of snow and ice: whether it slides off as a single block or as many smaller blocks, the impact of the 1,000-pound mass on the ground is exactly the same. With pad-style snow guards, the snow slumps against numerous ice-cream-cone-looking objects, with the net effect being enhanced friction between roof and snow, which does, in fact, come off in very small and random pieces—not all at once like an avalanche.

Some of the most common areas that snow guards are used to protect are walkways, garage entrances, gutters, shrubs, points of egress, and parking areas. Some of the less common areas of need are behind plumbing vent penetrations, above mechan-



Figure 2 – Typical “pig tail” or wire loop-style guard.

ical units, behind metal chimneys, and behind some parapet façades. The first step in finding the right snow retention system is to estimate the mass or volume of snow and ice that one is attempting to manage. The most reliable way to do this is to use the local building design ground snow load. The ground snow load is used by building design professionals and is established by the American Society of Civil Engineers (ASCE).

The next step in the design process is to determine whether or not the published ground snow load needs to be modified by various site-specific factors, including roof pitch, drifting conditions, building orientation, etc. These design considerations can be found in the ASCE-7 publication. Ground snow load is typically provided in pounds per sq ft (psf). The adjusted ground snow load (psf) multiplied by the roof area to be managed will give the mass or volume of snow and ice to be retained.

Calculating that number for any given roof should not be difficult. However, ground snow load values *do* change and are revised as better information becomes available. Published ground snow loads are guidelines, but no one has the ability to forecast exactly how much snow will fall in a given year. This was apparent in the eastern U.S. in the winter of 2010-11. That does not mean that the snow retention system should be overengineered; this is a crucial piece of design expertise. If a snow retention system is designed to retain more snow and ice than the building itself is designed to withstand, structural damage to the building may occur. In this situation, it is possible that the snow retention system won't yield when overloaded (which it should do) but, rather, will hold too great a weight on the roof and lead the building to collapse. This happened over and over again in February.

The next step is choosing the best snow guard design for a specific project. This

decision should first be based upon the function of the device itself. Pad-style guards, when used properly, are typically installed over the entire roof surface in quantities recommended by the manufacturer (see sidebar on page 32). Pad-style guards add friction but, as explained above, will allow the snow to slide off the roof in very small pieces as the mass melts and slumps. Pipe-style guards are used as a barricade or fence intended to keep all snow and ice on the roof, including that which has slumped. In many cases, more than one tier of pipe-style guards will be needed to manage the potential snow accumulation. In certain applications, both pad-style and pipe-style are used on the same building in combination to protect differing roof areas.

Pad-style snow guards are generally not as strong as pipe-style systems but, when properly used, will accomplish the same thing. The difference is that pad-style snow guards need to be installed over the entire roof surface to be effective. There is a very old pad-style device that is called a wire loop or pig tail (see Figure 2). When properly installed over an entire roof surface, this device creates a wire mesh effect. Also, when correctly installed in the proper geo-



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Figure 3 – Pipe-style snow guards create more of a barricade than pad-style snow guards.

graphic region, this is probably among the best snow retention systems available. The problem is that these wire loop guards have an allowable load of 50 pounds each. This means that on a project where the snow load will be greater than 50 pounds, more than one snow guard per sq ft is required. Otherwise, the system is destined to fail. Likewise, if the project has a snow load of 25 pounds, one wire loop per two sq ft is required.

Pipe-style devices are a little more involved (Figure 3). Tests should be performed on each component part of each pipe-style device. The pipe-style system's performance in a given roof substrate can then be evaluated and tweaked to determine the optimum bracket spacing to best manage the given load. To envision their use, think of waves washing over a coral reef. As the wave approaches the reef, the hydraulic pressure will sometimes make the water crest and wash over the top. The more water to hit the reef, the larger the resulting wave. This same sort of phenomenon happens with pipe-style snow guards. They will retain a large snow mass. However, if the mass begins to slide, the pressure will often force the snow and ice behind the fence to crest and come over the top of the rails. This is most common when the roof does not have enough tiers of pipe-style snow guards installed. As with pad-style snow guards, the pipe-style systems have a given capacity. If the project's snow loads exceed the capacity, either additional tiers of guards should be installed or the system should be supplemented with pad guards to add friction and prevent sliding over the barricade.

Unfortunately, for either financial or aesthetic reasons, the wrong snow retention device is often used, and the system fails. In fact, every snow retention device of which this author is aware will work if it is used properly. The key is having the correct roof-specific and product-specific data. Every snow guard manufacturer should be able to provide written documentation and verified test results that state the point at which each and every snow guard it manufactures will yield on the roof surface—in other words, the *actual* tested failure point, not the *perceived* failure point. I say perceived failure since guessing seems to have been a common method of design in years past.

The failure point is a critical piece of information because it is important that the system yields if the roof is overloaded and is not capable of supporting the weight of the snow mass being held back. How does one design a snow retention system without knowing the strength of the device being considered? Manufacturers of snow retention devices should test to ultimate failure. A safety factor of at least two should then be

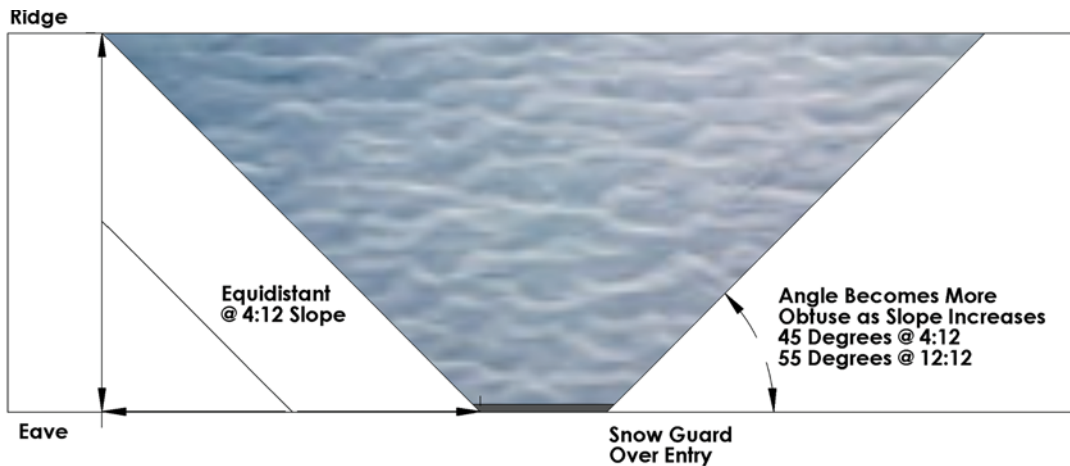


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applied to the ultimate load value to establish an allowable load. Depending upon the roof conditions and importance factor (ASCE-7), the safety factor may need to be increased.

In theory, snow retention system design should stop here. Knowing the weight of the mass and the capability of the device should be sufficient. The mathematical formulas are rather straightforward. However, there is far more to design than a simple calculation.

Sometimes snow is a liquid and sometimes snow is a solid. The mass to be managed will change as the temperature changes. Combine this issue with the fact that this ever-changing mass is poised on a sloped roof surface. For these reasons, the chosen style or type of device requires careful consideration. Talk to a technical salesperson at the company from which the device is being purchased. He or she should



Note: All figures are approximate and vary with tensile strengths of snow.

Figure 4 – If a second row of snow guards were required halfway up the roof slope in this drawing, then the second row would be nearly twice the length of the section along the eave.

be able to explain all of the variables. But understand that even though the physical calculations applied may be mechanical, the science of snow and ice management is ever-evolving.

Every year, more is learned about the effects of snow and ice on roofs and how to

better manage them. In the late 1990s, the Army Corps of Engineers' Cold Regions Research and Engineering Laboratory (CRREL) conducted a study that included a discussion about the effects of snow and ice on plumbing vents. The issue had become apparent on metal roofs, as plumbing vents



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seemed to be sheared off by the snow mass. The researchers determined that snow and ice tend to build up and away from any roof obstruction at a 45° angle (Figure 4). This means that a simple 3-in plumbing vent installed near the eaves and at the center of a building could, at certain times, be carrying nearly half of the roof snow load (Figures

5, 6, and 7). As conditions changed and the snow mass shifted, the plumbing vents were sheared off. This becomes very important when snow guards are installed only over doorways. An 8-ft-wide snow fence installed above a doorway in the middle of a building will sometimes carry half of the snow load for the entire roof (Figure 4). Just

like the plumbing vent, this small row of snow guards can be sheared off. For this reason, we recommend using a safety factor of three rather than two to determine the right quantities in such areas.

Over the past two winters, we have had an opportunity to watch a different phenomenon unfold. I call this the “glacial effect.” In the Northeast, snow has tended to accumulate and stay for longer periods. It used to be that a January or February thaw would melt and clear the winter’s accumulation off the roof. These past two years have stayed cold, and the typical thaw periods did not occur. Instead, we saw a good deal of slowmelt often brought on by thermal loss from within the structures. The result was a slow quarter- to half-inch “creep” of the entire snow and ice mass each day.

On our own commercial steel building, which has a pipe-style snow guard system with multiple tiers, the snow and ice mass crept out over the eaves sometimes as much as 18 inches before we were forced to knock it down (Figures 8 and 9). On some buildings, this “creep” effect was left alone and it began to curl back toward the side of build-



Figure 5 – Standard 3-in plumbing vent prevents snow from sliding off a metal roof.



Figure 6 – Small skylight holds back an inordinate amount of snow relative to its size.



Figure 7 – Inadequate amount of snow guards above a door cause buildup of snow and get torn off each year.



Figure 8 – Snow crept over the eaves as much as 18 inches on Alpine SnowGuard’s own building in Morrisville, VT.

ings (Figure 10). This was happening all over Vermont on buildings that had snow retention systems. The point is that we can calculate to the best of our abilities the snow loads that will be on a roof based upon published reliable data. However, we cannot manage Mother Nature. A snow retention system can do exactly what it is designed to do, but designers and building owners should recognize that the systems themselves may need to be managed in extreme and unusual conditions. This includes removing snow and ice behind snow retention systems if snow loads in the area appear to have exceeded the building design loads.

Another interesting development in the



Figure 9 – Creep effect is witnessed on Alpine SnowGuard’s metal structure.

world of snow retention systems is the need for snow guards arising due to the installation of solar arrays. These arrays are being



Figure 10 – This building, obviously with no snow retention devices, shows the typical “creep-and-curl” phenomenon.

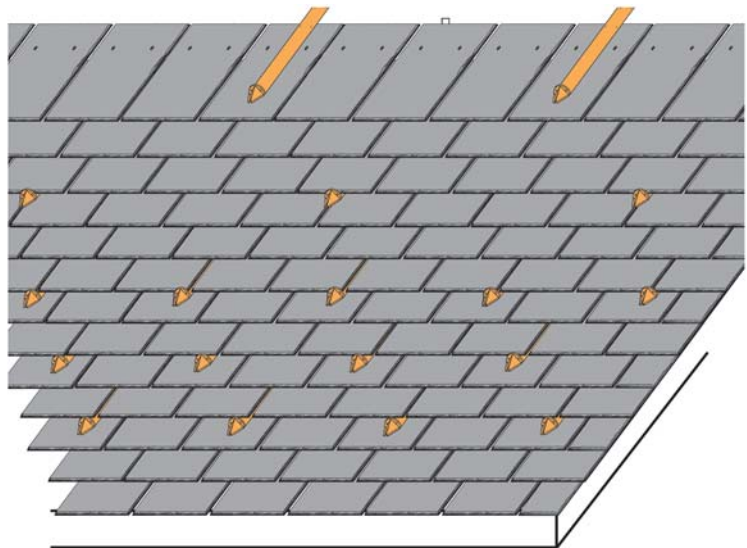
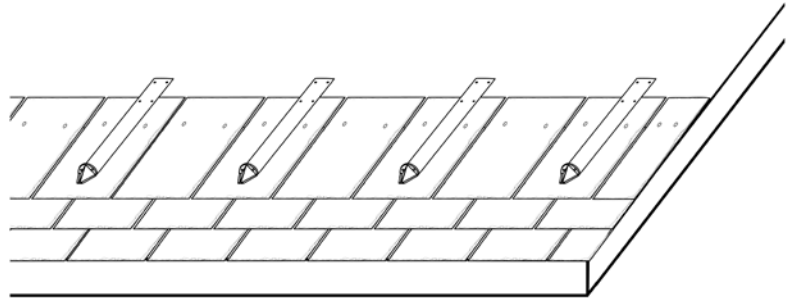


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INSTALLATION INSTRUCTIONS FOR #10 SNOW GUARD

Most installations use a 2 x 4 layout. These images show a sample installation of a roof with a rafter length of more than 15 ft, a roof pitch of 24/12 or less, and a ground snow load (snow load in psf) of less than 75 psf.

All snow guard installations of this type start with a standard three-row pattern along the eave. Remaining snow guards should be spaced evenly between the three-row pattern and the peak of the roof. If the rafter length is 15 ft or less, one generally needs the three-row pattern, which requires 17 snow guards per 10 ft of eave.



INSTALLATION

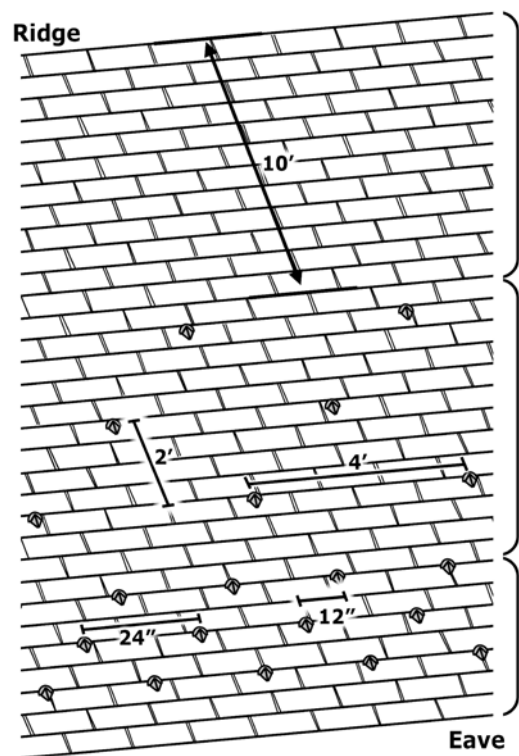
1. The third row of shingles should be installed in the usual manner. The snow guard should then be placed on the shingle with the up-slope, top end of the strap resting on the roof deck above the shingle.
2. Place the snow guard low enough on the shingle so that the next course of shingles (course 4) lies properly over the top of the snow guard. The top of the pad should be three times the thickness of the shingle below the shingle or a minimum of 5/8 in.
3. Two fasteners of a material compatible with the snow guard and the roof should be used to attach the snow guard to the roof. Horizontal spacing should be 24 inches on center.
4. Install two more courses of shingles and another row of snow guards. Repeat these steps for the three-row pattern, and install the remaining snow guards using the spacing required for the roof conditions.

2 X 4 PATTERN

The top 10 ft of rafter do not generally require snow guards except in extreme snow-load areas. For areas with a ground snow load less than 75 psf and a roof pitch of 24/12 or less, space rows 2 ft vertically and 4 ft horizontally as shown in the graphic at right. Use three rows 24 inches on center, horizontally, with the middle row staggered 12 in.

MORE EXTREME SNOW AREAS

For more extreme snow areas with a ground snow load greater than 75 psf, installation recommendations require closer placement of guards. For roofs needing 75 to 110 psf where the roof pitch is less than 24/12 but more than 6/12, use 17 to 21 snow guards per square (2 x 3 pattern), with guards spaced 2 ft vertically and 3 ft horizontally to 10 ft from the ridge. For roofs needing 111 psf to 150 psf and a roof pitch of less than 24/12 but more than 6/12, use 22 to 27 guards per square (2 x 2 pattern), spacing them 2 ft x 2 ft to within 10 ft of the ridge.



installed on top of many composition shingle roofs that have rarely needed snow retention systems to date. The granules on the surface of composition shingles have always functioned as friction. But now we are now installing glass arrays above these composition shingle roofs that act as an almost frictionless surface no different than a metal or slate roof. This, combined with the thermal differential between the existing roof and the panels, will certainly create a need for some creative engineering. This is an example of how ever-changing needs and technology continually impact and change how we deal with snow on a roof.

When designing snow retention systems, gather all of the building-specific information available. Then gather all of the snow retention information available. Talk with local roofing contractors about their

experience with given snow retention products, discuss the situation with a variety of snow retention product manufacturers, and

design from an educated perspective that minimizes guesswork. 

Brian Stearns

Brian Stearns is the president of Vermont Slate and Copper Services, Inc. (Vermont Slate) of Morrisville, VT. He began his career in the slate roofing industry in 1979 as a slate roofing installer and salvage technician. In 1984, Brian started Vermont Slate and traveled the country installing slate roofs. In 1998, he coauthored *The Slate Book*. The success of *The Slate Book* led Brian to a brief career as a slate roofing consultant. As the slate consulting business evolved, Vermont Slate became recognized as a leader in the snow guard manufacturing industry. Vermont Slate began to do business as Alpine SnowGuards in 1999 and, in 2007, expanded into the solar market under the trade name EcoFasten Solar. EcoFasten Solar utilizes the same but improved-upon patented attachment technology that launched Alpine SnowGuards. Brian divides his time between his home in Wisconsin and his business in Vermont.

