Attic and Cathedral Ceiling Ventilation and

This article is about ice dams[1] and their prevention. Ice dams can occur in any northern or high-altitude climate,[2] but they are more prevalent and troublesome in areas where there are frequent or daily freeze/thaw cycles. In the far north, where it gets very cold and stays cold and snow covered for most of the winter, ice dams are not as severe unless there are gross inadequacies in the roof, attic, or cathedral ceiling assembly.

Ventilation requirements referenced in the building codes are usually not adequate for cathedral ceiling ventilation without adjustment.[3] Mathematical formulas have been developed to calculate the thermal loss of air passageways.[4] Test chambers have since verified the mathematical formulas and graphs that have been developed. These formulas and graphs can be used to size the air passageways needed under the roof deck in cathedral ceiling assemblies with various airway openings, insulation values, slope, and length of the roof/ceiling assembly to prevent ice dam formation.[5]

Attic and cathedral ceiling ventilation, roof sheathing condensation, and the study of ice dam formation on sloped roofs is not yet an exact science. The first documentation about ice dam conditions at the eaves appeared in an 1899 textbook.[6] The 1/300 net-free ventilating area requirement was first promulgated in 1942 by the Federal Housing Administration (FHA) with very little research to back it up.[7] By the 1960s, the 1/300 and later the 1/150 requirement had been adopted into all of the building codes, but the numbers were still arbitrary.

In the last decade, there have been numerous studies and research projects that indicate that vapor drive and condensation in the roof assembly can also be controlled by means other than venting from and to the outside.[8] The *NRCA Manual*[9] calls these compact or warm roof assemblies. However, in northern climates, nonventing methods must also include additional design features to prevent ice dam formation. Consequently, the most effective ice dam prevention method is usually under-deck ventilation, where this method is feasible.

Roofs with numerous skylights, dormers, chase protrusions, and other design complications that prohibit uniform soffit intake, uniform internal airflow, and upper roof exhaust make gravity ventilation systems difficult to achieve. Drilling small holes in wood joists to transfer airflow from one joist space to an adjacent joist space is not effective unless the airflow volume and pressure are balanced. The author has often encountered building owners or managers who proclaim they can't understand why some of their problem areas leak because they have ice dam protection membrane installed under the steep-roof covering.

The concept of polymer-modified ice dam protection membrane sealing around a nail shank (see Grace's Ice & Water Shield® *Product Information Sheet* or literature from manufacturers of similar products) is helpful in preventing leaks from ice dam conditions. It is a significant improvement from the previous method of two sheets of roofing felt cemented together with asphalt roof cement. However, it is not reasonable to conclude that this polymer-modified seal around a nail shank is going to be permanently 100% effective, especially in ice dam areas.

Some of the ice dam protection membrane failures the author has witnessed have been due to wrinkles and back laps

Ice dams can be more than 2 ft thick.

Ice Dam Protection

By Robert Humbarger, RRC, CDT

in the membrane application that are not difficult to explain. Other failures have been at shingle nails that were not driven straight, leaving a gap on one side of the nail shank, or roof sheathing panel that moves with expansion and contraction of the structure, causing the nail hole in the membrane on adjacent panels to elongate. Moisture content of the wood sheathing also causes dimensional changes in the roof deck, resulting in movement of the membrane on adjacent panels around the nails.

The *NRCA Manual* states, "Ice dam protection membranes cannot be relied upon to keep leaks from occurring. Careful consideration of roof ventilation, insulation, and project-specific detailing for particular climatic conditions is vital."[10] To help understand the demands placed on the ice- and water-type membranes around the fasteners, visualize a thick-walled balloon made of modified asphalt membrane sitting on a flat surface, filled with just enough water to fill out its shape without a lot of hydrostatic pressure. Now, visualize a few nails penetrating the sides of the membrane from the inside out. It may hold water for a while, but if the fastener shank is wobbled back and forth or if the membrane is slightly stretched to simulate differential deck movement, at some point it will probably start leaking around the nail shanks. ice dam protection membranes behind ice dams will also leak if some of the previously mentioned defects or dimensional changes occur in the membrane or substrate.

Ice dams can continue up-slope from horizontal.

Keep in mind that the best ventilation system can be ineffective if there is excessive heat loss into the attic or ventilating airways of cathedral ceilings. Since all of the reinsulation efforts after the first oil embargo of the 1970s, great improvements have been made in the depth of insulation in northern attics. These have improved the thermal insulation capabilities, but have also stopped up a lot of ventilation air passageways and overlooked a lot of warm air infiltration. Judging only from personal experiences (at a higher ratio of problem sites, which admittedly skews one's perception), I would hazard a guess that there now may be more BTUs lost to warm-air migration than to thermal-conductance loss.

Recommendations for Steep-Sloped Roofs in Northern Transition Climates:

1. Keep heat sources such as furnaces, heat ducts, exhaust air, and high-hat light fixtures out of the attic. If they have to be there, then great care must be made to keep the heat out of the attic permanently. R-40 attic insulation is a waste if you also have heat ducts or plenums with only R-5. The author has encountered numerous heat ducts in attics that were well insulated and may have been installed correctly but were spewing heat into the attic like crazy because a joint had come apart, tape had lost adhesion, or insulation fell away.
2. When insulation is added to the floor of the attic, make sure that the airflow from the eave or soffit is not restricted. If there are internal chases or wall cavities open to the floor of the attic, they must be covered and insulated to prevent warm-air infiltration and conduction into the attic. Also, where loose-fill (a.k.a. "blown-in") fibrous insulation is the only type used, some sort of

restraining material may be needed at wind-prone corners of the attic to keep it from being blown back and leaving the ceiling bare and uninsulated.

3. Vertical stud walls infilled with batt insulation used to separate warm areas from cold areas (such as around heating equipment areas) should have a rigid covering to stop air infiltration. The foil or paper vapor-retarder batt coverings, taped or stapled to the studs, are not adequate to prevent air infiltration, and in time they often fall down, leaving wide-open holes for warm-air migration. Also, where batt insulation is used to blanket a heat source area (such as heat ducts), some type of restraining material may be needed over the problem area because the next time someone has to get through that area to investigate a leak or trace a low-voltage wire, the batts are going to get all jumbled up and haphazardly replaced.
4. Simple, two-slope gable or four-way hip roofs with uniform soffit intakes, uniform internal air flow, balanced upper-roof exhaust, and without complications of valleys or numerous skylights, dormers, chase protrusions, or other design complications may perform adequately with the code-minimum 1/300 soffit-to-ridge ventilation design. The code alternative using a vapor retarder can be effective at preventing moisture migration, but a vapor retarder does nothing to prevent ice dams. Also, we find that the amount of intake and exhaust works best if it is balanced 50/50, not the 80/20 ratio minimum in the code. Another consideration is that when the roof slope is lower than 4/12 and/or there are restrictions in the intake airways near the eave or space over the top of the exterior wall, it is more difficult to prevent ice dams that do form from resulting in leaks to the interior. There are some fairly new-design eave vents available that are helpful if there is no other choice, but in my opinion, they are not as fail-safe as adequate overhang with 100% perforated soffits and a high-edge truss design.
5. Buildings with more complicated roofs and attics should be designed and constructed to have intake and exhaust to meet or exceed the 1/150 design, not the alternate-code minimum 1/300 design. If there are large dormers or chases that prevent the natural, uniform air flow from eave to ridge, additional ventilation may be needed at specific spots to move air around these obstructions. If there are long valleys in large roofs, additional ventilation should be directed to the underside of the valley. This airflow directional improvement can be achieved by the sizing and location distribution of intake and exhaust openings.
6. Power ventilation is another option, but great care must be used when mixing gravity ventilating systems with power vents. Power vents can cause exhaust vents to become intake vents and thereby decrease uniform intake from the soffit or eaves where it is most beneficial in preventing ice dams. If there is warm-air infiltration, defects in the attic floor or wall systems's power vent may also increase heat loss.
7. Vaulted or cathedral ceiling roof assemblies should be vented if possible. However, if there are numerous skylights, dormers, chase protrusions, or other design complications that prohibit uniform soffit intake and uniform internal airflow, and there is upper roof exhaust that makes a uniform gravity ventilation system difficult, then compact roofs may be the way to go.
8. A common problem with vaulted or cathedral ceiling roof assemblies that were intended to be ventilated systems is fibrous insulation pushed up into the ventilation airspace, blocking or restricting the air flow. This is addressed in Tobiasson's study, as is friction loss by the rough insulation surface in the airway. Remember that dimensional lumber sizes are nominal dimensions, not actual size, and that fibrous insulation thickness may be increased when pushed unto spaces that are not full-width joist spaces. The free and open airway is seldom as big as mathematically subtracting the specified insulation thickness from the nominal width of the framing member. It is easy to detail an airway on a roof section drawing, but if there is no allowance for on-site variations, the airway is often difficult to achieve during construction.
9. Do not expect ice- and water-protection membranes to turn a water-shedding roof system into a membrane system. A membrane system with nails through it is not a long-term solution. The valleys around crickets or saddles have lower slope in the valley centerline than the adjacent roofs. Roofs with slopes less than 4/12 with crickets or saddles often have valley slopes that are less than the minimum allowed for shingles. These areas should be roofed with a true membrane system or with a soldered-joint, sheet metal system.
10. The centerline of cricket or saddle valleys around roof protrusions, gable parapets, or curbs should be half the width of the valley away from the corner of the protrusion. When the centerline of the valley dead-ends on the corner, half of the valley is obstructed at the very point that is most difficult to flash.
11. Electric heat-tape systems can be a good solution to repeated ice dam formations when all else fails, but it is far better to solve the problem that is causing the ice dams.
12. Get and use copies of steep-slope research articles and design manuals, some of which are footnoted below. Then, design, construct, inspect, and retrofit for problem-free solutions, not just standard practices or code minimums.

No one likes inspecting attics. This author has inspected thousands of attics – mostly in Indiana and Michigan, but also in Ohio, Illinois, Minnesota, Missouri, Nevada, and Alaska. Many of the comments and recommendations in this article are from *in-situ* experience and trial and error, not testing or research. We have successfully mitigated or stopped ice dam problems on numerous facilities. However, it is not pleasant or inexpensive work, and hopefully the recommendations of this article will lessen the number of times it needs to be done retroactively.

Footnotes

1. *The NRCA Roofing & Waterproofing Manual, 5th Edition*, National Roofing Contractors Association, 10255 West Higgins Road, Rosemont, IL, 60018-5607, 2001, Vol. 2, p. 340, Figure 6.
2. Ibid., p. 339.
3. Wayne Tobiasson *et al.*, "Ventilating Cathedral Ceilings to Prevent Problematic Icings at Their Eaves," Cold Regions Research and Engineering Laboratory (CREEL), *Proceedings of the North American Conference on Roofing Technology*, Toronto, ON, Canada, 1999.
4. *ASHRAE Handbook of Fundamentals*, Chapter 2, Fluid Flow, Ventilation and Insulation, and 32 Duct Design, American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc., Atlanta, GA, 1997.
5. Tobiasson.
6. Anonymous, *International Library of Technology*, International Textbook Company, Scranton, PA, 1899. Reprint, *Chicago Review Press*, 1980.
7. W.B. Rose, *The History of Attic Ventilation Regulation and Research*, National Institute of Building Sciences, 1994. Reprinted with permission, RCI Building Envelope Symposium, November 2000.
8. Joe Lstiburek, *Vented and Unvented Roof Assemblies*, MRCA Convention, 2006.
9. *The NRCA Roofing & Waterproofing Manual*, p. 335.
10. Ibid., p. 340.

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Japanese Roof Iris

By Kristen Ammerman

The Japanese roof iris (*Iris tectorum*) is native to China but was first described in the west in the 1860s by a Russian scientist, Carl Maximowicz, who gave it its name. It grows about a foot tall with a spreading, rhizomatous habit common to most irises. Leaves are light green, about a foot long, broadly sword-shaped, and slightly corrugated down their length. Flowers are white or lavender.

In China, where it has been cultivated since at least the seventh century, the plant grows on the ground like any sensible iris. But in Japan, it was found growing on the ridges of thatched roofs. Apparently, this tradition started in Japan because of a decree by a Japanese emperor during a period of wartime when it became illegal to waste land in growing flowers. All available land had to be used for rice or vegetables.

The main reason for growing the plant was not for its flowers, but for a white powder that was made by grinding the roots. The powder was used to create the white faces of the Geisha girls (and women in general). The flower is also thought to ward off evil spirits and is said to help hold the thatch together. So, the plants were moved from the gardens to the roofs, where they remained until being "discovered" by science.

In northern Japan, the practice of growing plants on thatched roofs was called *shibamune*: 芝棟 - literally, "lawn ridge."

Terunobu Fijimori, of the University of Tokyo, writes on the dying art of shibamune, "It is not yet clear when the practice began, but on the Japanese islands, especially the Pacific Ocean side of eastern Japan and the middle part of the mountainous areas, people have somehow developed the custom of using plants...[that] can withstand dry conditions to form the ridge of the roof. Normally, when people covered their roofs with grass and built the ridge, they would finish by supporting the ridge with cypress bark or a cypress beam.

"In Ninohe, in Iwate Prefecture, there [are several] shibamune roofs... They are quite interesting because they do not look like buildings, but rather, as I look at the green grass rising thickly above the swelling brown of the thatched roofs, something different. From a little distance, it looks as though green lines have been drawn smoothly with a brush from the tops of the roofs to the sky, and dots of light above the green swing as the wind blows."

The Japanese roof iris is unique amongst irises because it grows about as well in the shade as in the sun. Like all irises, it should be planted with the rhizomes just at the surface of the soil. The colony will slowly increase in size, or the process may be accelerated by dividing the plants in the fall. If happy, it will reseed and is seemingly immune to pests.

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University of Toyko, "Background of my Work"