# Preventing Ice Dams on Roofs

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When a roof leaks, facility managers inevitably receive complaints from building occupants. If it is winter, ice dams are often the cause of this leakage.
Ice dams are ridges of ice that occur along eaves with overhangs (Photo 1). This water and ice build-up can cause leakage and damage to the underlying interior space and possibly result in safety concerns such as structural collapse, mold growth, and falling ice. Ice dams result in millions of dollars in damage and insurance claims each year.

## Ice Dam Formation

Accumulated snow on roofs acts as an insulation layer. If the underlying roof surface exceeds the freezing temperature of water (i.e. roofs over heated spaces), the underside of the snow layer will melt. Sources that melt the snow include heat from the underlying conditioned space, ambient heat, and solar radiation. The melt water will run down the roof toward the eaves. When it reaches cold, un-insulated overhangs, it freezes and forms a layer of ice. As this process continues, the ice height increases, creating a dam that retains melt water. This ponded water backs up and flows past the dry laps in the underlayment, resulting in interior leakage and subsequent damage (Figure 1). The damage is most severe in areas with frequent freeze-thaw cycles. Water that overflows the dam also creates icicles along the eave (Photo 2).

## Methods of Prevention

There are several methods of preventing ice dams and subsequent damage including:

- Insulating the ceiling line to keep attic space cold.
- Ventilating the attic space or roof framing cavity to keep the attic cold.
- Specifying appropriate materials at possible ice dam locations to prevent leakage through roof underlayment laps.
- Heating portions of the roof that could be susceptible to ice dam formation.
- Performing preventive maintenance prior to and during the winter.

Insulated ceilings and ventilated attics that create a cold roof surface are the best methods to prevent ice dams. All methods are discussed below.

### Insulation

Insulation should be placed in the attic to retard the conductive heat flow from the conditioned space to the exterior. Areas that leak heat, such as exhaust fans, ducts,

chimneys, attic hatches, and pipe penetrations through the ceiling need to be sealed. Since living space contains warm moist air and the attic space above insulation contains dry colder air during the winter, a vapor barrier is placed on the warm side of the insulation to stop moisture transfer to the attic. The vapor barrier, typically a 4 mil to 6 mil thick polyethylene sheet, is placed between the interior finish and insulation/framing.

## Ventilation

Ventilating the attic space or roof framing cavity will help keep the roof surface cold during the winter and remove moisture from the attic space. The two forces that provide ventilation for attics and framing cavities are convection and wind. Cold air enters at low vents (at eaves) and forces warmer air to exit at high vents (at ridges). As wind (air) flows over a building, it creates positive and negative pressures. Positive pressure forces air into the attic and negative pressure draws air out of the attic. Convection or natural flow is used for ventilation design. Nature or mechanical equipment can provide ventilation. A natural system relies on convection for ventilation. A mechanical system is designed to circulate a certain amount of air change per unit time. For both system types, intake vents are placed along the eaves and exhaust vents are placed along the ridge. A clear continuous path is needed between the intake and exhaust vents. The required amount of attic ventilation is stated in the building code and is a function of attic horizontal area. Most codes (Uniform Building Code, BOCA) require one square foot of ventilation for every 150 square feet of attic floor area. The reduction of vent area due to vent covers needs to be included when calculating the required vent area. The Code ventilation requirement does not directly address ice dams.

The Cold Regions Research Engineering Laboratory (CRREL) performed studies on several buildings with varying degrees of ice dams at Fort Drum, New York. This study consisted of placing instruments in the attics of buildings with histories of minor to severe ice damming. The CRREL study found that to avoid ice dams, the attic ventilation systems, natural or mechanical, should be sized to keep the roof surface below freezing when the outside temperature is 22° F. When the outside temperature is below 22° F, the outside air will circulate the attic air easily. When above 22° F, it is unlikely that the melt water will refreeze at the eave. Fifty-seven buildings at Fort Drum were modified according to these guidelines and the previous chronic ice dams were eliminated.

## Materials

Conventional roofing materials, such as shingles, wood shakes, and metal panels are used for steep-sloped roofs in cold regions. Specifying the appropriate underlayment at locations susceptible to ice dam formation is an important design consideration. For example, an impermeable underlayment is needed at areas susceptible to ice damming (e.g., overhangs). The underlayment should be installed over the length of the overhang and extend past the exterior wall into the conditioned space; about three feet is recommended at severe icing locations.

### Heated Roof Products

Products that control or eliminate ice dams by heating the roof surface in areas susceptible to ice dam formation range from an exposed wire on top of the roof to heating elements incorporated into the roofing material. The simplest, an exposed wire on top of the roof, creates tunnels in the snow and ice that direct water toward the eave. This system does not stop ice dam formation; it creates drainage outlets for the melt water. It is susceptible to weathering and can be a fire hazard. This type of product has a short warranty (typically one year) and a short service life ranging from three to five years. More extensive options include roof products that integrate the heat element into the roofing. Products are available for metal roofing, shingles, and shake and have five-year warranties. The heating roof product can be attached to a timer or temperature/snow sensor for activation in remote or partially habited locations. These heated shingles are placed at locations susceptible to ice dams. While functioning, the heated roof surface prevents ice and snow formation. Although these systems can be less expensive and extensive in scope of work than improving the attic insulation and ventilation characteristics, they rely on electrical power to function properly.

## Preventive Maintenance

Preventive maintenance can reduce the chances of ice dam development. Inspecting and removing leaves, sticks, and other debris from gutters and downspouts in the fall will allow water to flow through the gutter and downspout systems as intended. During the winter, keep the snow load to a minimum on the roof, especially along eaves and overhangs. A roof rake (a long-handled tool) allows a ground-based user to pull the snow off the roof. Care is required so that the roof is not damaged during snow removal. In addition, gutters and downspouts should be kept free of snow and ice formations, allowing a path for melted snow to exit the roof.

Ice accumulation can be removed by artificial heat (e.g., steam, electric heaters). Direct ice removal with hammers, chisels, and shovels is not recommended due to the high probability of roof damage. The best method is to let it melt naturally.

## Investigation Techniques

For buildings with ice dam problems, an evaluation should be performed to determine the cause of the ice dams and the appropriate scope of repairs prior to the start of work. Typical repairs usually consist of improving the attic ventilation and/or ceiling insulation/vapor barrier. Buildings with complicated roof framing or extensive mechanical systems in the attic make these types of repairs labor intensive, difficult to perform, and expensive. A less expensive option is heated roof surfaces at ice dam locations.

A typical investigation sequence includes the following elements:

- Review available drawings and other ice dam-related documents
- Observe site conditions (visual observations and destructive exploratory testing)
- Surveying and testing, as required
- Develop repair recommendations

## Observations

The following conditions should be observed: ice dam locations, existing intake and exhaust roof venting, roof/ceiling construction, and penetrations in the ceilings. Exploratory probing entails removing sections of finishes to expose the underlying conditions. This provides information regarding the as-built conditions but it is expensive and not performed on all projects.

## Survey

An infrared thermographic (IR) survey identifies heat leak locations in the ceiling assembly. As the temperature rises, infrared radiation gains in intensity. An IR camera will graphically show areas and locations of heat leaks, aiding in focusing the repair scope of work. IR surveys should be performed at night when the temperature contrast is the greatest.

## Testing

Air infiltration tests can determine large sources of air leakages; small air leaks are difficult to locate during this test. Typically, a fan creates a lower pressure in the room/living space to be tested. Wall openings are sealed with tape so as not to influence the testing. The ceiling is then inspected for air leaks that can be detected by touch or sound.

## Summary

- Ice dams, ridges of ice that occur along eaves with overhangs, can result in interior leakage and safety concerns.

- Keeping the roof surface cold with insulated ceilings and adequate attic ventilation is the best method to prevent ice dams. In addition, specifying the appropriate roofing materials in areas susceptible to ice damming to prevent leakage at underlayment laps is also important.

- Ice dam remediation ranges from heating the roof surface to increasing ceiling insulation and attic ventilation.

- Preventive maintenance, such as ensuring the roof drainage system functions properly and minimizing snow accumulation on the roof, reduces the effects of ice dams.

- Infrared thermographic surveys and air infiltration testing can assist in locating sources of heat leakage and focusing the repairs on these locations.