Cold Weather Considerations for Glass–reinforced Asphalt Shingles

By Raymond L. Corbin and L. D. Hogan

A B S T R A C T

Glass-reinforced, asphalt shingles are designed for application in a wide range of weather conditions; however, care should always be exercised whenever approaching climate extremes. While there are also hot weather precautions, this article focuses on matters of cold weather application.

Snow, ice, and water accumulation can exert considerable force, exceeding the allowable rooftop loads (as calculated for the design snow load). Additionally, ice dams can hold a significant amount of water. Through hydrostatic pressure, they can cause water to enter the structure that otherwise would not occur during ordinary rainfall conditions. Aspects of attic ventilation are explored at length. These and related issues are examined in this article.

Cold Temperature

ARMA (the Asphalt Roofing Manufacturing Association) and most glass fiber shingle manufacturers caution against the installation of glass-reinforced shingles in temperatures at or below 40 degrees F. At these temperatures, the shingles may be stressed, fractured, or broken as they are handled and installed. The damage inflicted may not be evident until after a year or two of weathering.

During cold-weather application, the fiber glass shingle's mat weight can make a difference. The heavier mat weights generally improve installation attributes in cold weather. Once the shingle is installed, however, properly-designed and manufactured shingles on a lighter glass mat can perform just as well.

Behavior and Influence of Ice on Shingle Roofs

In colder areas, ice can form on the shingle and lock to the granular surface. Through repeated cycles of melting and refreezing, the shingle can split and eventually be pulled apart. With cyclical expansion and contraction, the tensile strength of the asphalt shingle may be exceeded by the volume change of the ice bonded to it. This exceptional behavior of ice is its "phase transition" during which it shrinks (or contracts) by approximately 10% upon melting and expands in similar fashion during re-freezing.[1]

While a remote occurrence, glacier-type movement of ice on roofs (especially in alpine areas) can cause abrasive damage to the shingles. The loss of protective granular surfacing will expose the asphalt to harmful ultraviolet radiation, eventually leading to premature failure. Shingles that exhibit abrasion damage should be replaced.

Interior heat, escaping through an inadequately insulated and poorly ventilated roof system, can cause snow to melt. When the melted water refreezes at a colder, lower portion of he roof, an ice dam is created. It usually starts at the colder eaves, and without a proper waterproofing underlayment installed, capillary action will cause the melted water to invade beneath the shingles. Leakage and the potential for structural damage are the likely result.

Ice dams can form elsewhere on the roof, and waterproofing measures may be required on areas other than the eaves. Features giving off shadows (such as large roof projections, dormers, and higher roof levels) are prone to foster ice damming. These areas are blocked from the sun and can re-freeze, causing an ice dam and resultant leakage. *Figure 1* depicts ice damming on a roof where an ice and water membrane was not provided.

It should be noted that, while ice and water membranes are crucial, installing the product beyond the recommended boundaries can be unwise. For structures in cold climates having high interior humidity, water vapor can condense beneath the "barrier," resulting in unexplained leaks.[2]

Wind Influence on Steep Roof Shapes

Wind has an impact upon the performance of the roofing system, particularly in cold settings. Poorly-attached or inadequately-sealed shingles are vulnerable to blow-off. It has been shown that fastening as little as one inch above the intended line increases blow-off potential by 20 percent.[3]

In cold weather, it is critical that a bond be formed among the respective courses of shingles at the earliest opportunity. The heat-activated, sealing adhesive may be some months in developing a functional bond in cold climates. A late fall installation in a northern tier state may not be fully bonded until mid spring of the following year.[4] The installation is vulnerable to wind loss in the meantime. Hand tabbing of shingles (applying adhesive or flashing cement beneath tabs) may be appropriate in these settings.

Consideration must be given to the complex behavior of the wind as it impinges on roofs. Variables to consider are:

- Wind velocity (both instantaneous and average)
- Real wind speed and duration of gusts
- Pattern of wind acceleration
- Air density
- Roof shape and slope
- Height of ridge and eaves
- Shape of shingle unit and its adhesive type
- Shingle position relative to roof penetrations
- Air temperature
- Building orientation (leeward vs. windward)

Rooftop Snow Removal

Unless the framing system is designed for snow loads, the rate at which a roof can shed its snow load is important to the integrity of the structure. A "rain-on-snow" scenario can have calamitous influence on certain types of framing systems.

Not only is trafficking the snow pack an unsafe practice, substantial damage to the shingle product is more than probable. However, to maintain the structural integrity, it may become necessary to remove snow accumulation from the roof. The work should not be attempted by hand, as it is unsafe and can damage the roof covering. Snow rakes are available to assist in this effort, which is performed from the ground. It may also be prudent to engage a reputable contractor to carefully and safely remove the snow load.

This snow removal measure should not be confused with an attempt to remove an ice dam, which should not be removed from a roof. Chiseling away the ice accumulation is virtually certain to damage the shingle product. A preemptive strategy would be the use of heated cables along the eaves to melt the snow and prevent build-up.

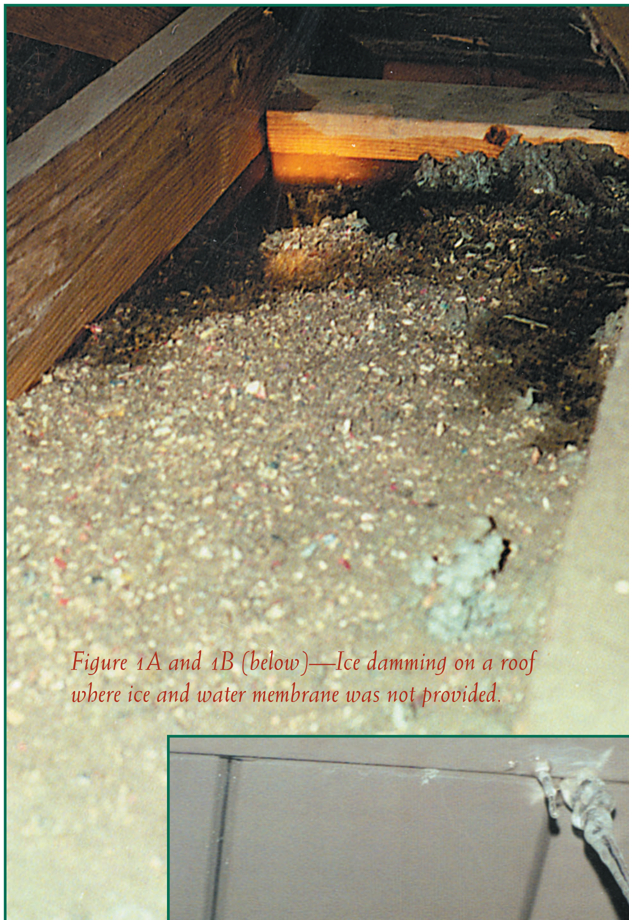
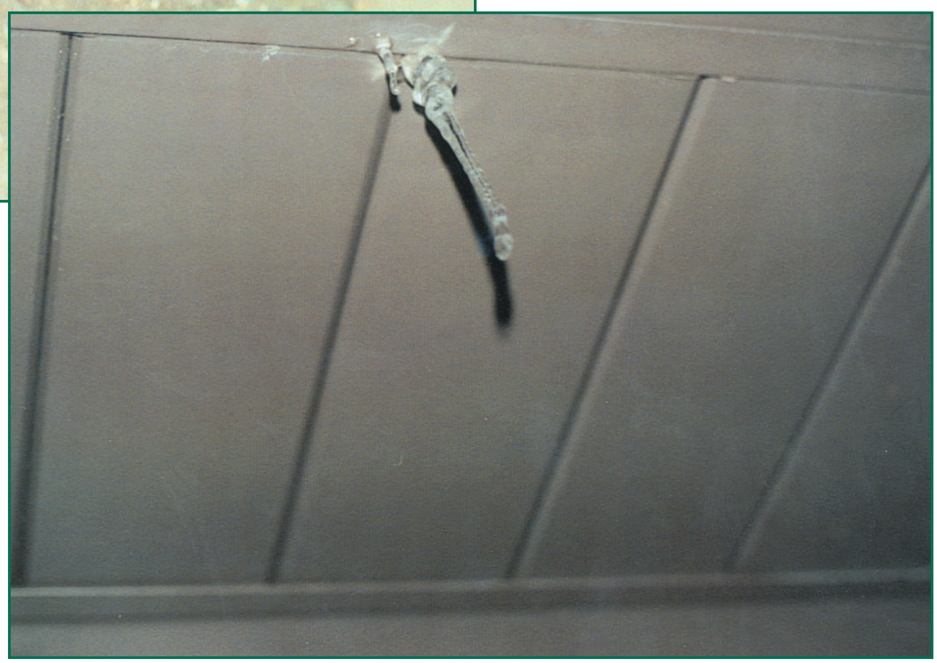


Figure 1A and 1B (below)—Ice damming on a roof where ice and water membrane was not provided.



Moisture Gain and the Ventilation Aspect

Ventilation of the attic region is extremely important to both the roof and the remainder of the building. Many investigations have identified substandard ventilation as the culprit in poor roof performance. Minimum ventilation area for steep roofing has been established at one sq. ft. of net free ventilation area for every 150 sq. ft. of attic space (1:150). Half of this total vent opening should be provided at the eaves and half at the ridge.

In cold conditions, lack of ventilation can lead to excessive moisture build up, which can adversely affect performance of the structure as well as the shingle product. As moisture reaches the cooler deck surface, it may condense and create the appearance of a roof leak. Moisture absorption into wood components can occur long before droplets of free water are formed on the underside of the deck. Moisture gain can lead to:

Figure 2—Moisture will accumulate in a wood deck long before water droplets are formed. Note the buckled plywood deck, mold formation, and soffit region blocked with glass fiber insulation

Figure 3—Air flow can virtually stall when batt insulation expands in a cathedral ceiling assembly. Photo courtesy of Wayne Tobiasson.

- decayed wood;
- expansion, warping, and buckling of the sheathing (*Figure 2*); and
- dripping into the building interior[5]

At the very least, movement of the deck from moisture gain will place additional stress upon the shingle product.

When ventilating a steep roof system, it is important to have a liberal air space between the insulation and the deck. With cathedral ceilings, the narrow airway produces greater resistance to air flow, and rather large airway heights are needed. Indeed, air flow virtually stalls when batt insulation expands in a cathedral assembly (*Figure 3*). Consequently, the ventilation aspect should be adjusted upward. Note also that 1" rigid board insulation can restrain the batt insulation while providing its own thermal benefit.

Attic insulation must be held back from the soffit region in order to serve as the intake port (*Figure 4*), and blown-in insulation is routinely over-sprayed into the eaves. A tightly-installed air barrier can reduce the tendency of the insulation to fill the cathedral passageway. It also increases the net insulating ability of the fiberglass insulation by keeping airflow away from it. A pre-manufactured baffle can also be used to keep blown-in insulation from becoming a ventilation impediment.

It should be noted that screens and louvers placed over vents reduce the effective airflow. Similarly, multiple coats of paint can render soffit openings virtually useless (*Figures 5a and 5b*). Other conditions have impact on venting effectiveness. *Figure 6* depicts a mold/mildew occurrence in a humid, southern climate (hot and dry at the time of the study). Attic insulation was properly held back at the edge, and the openings were present in the vinyl soffit cladding. However, carpentry was continuous along the eaves, so the soffit feature was completely useless. The mold/mildew colonies were fostered from a wintertime condensation scenario, drying to the powder shown during the hot season.

Wood responds to changes in temperature and moisture. However, it expands more from moisture increases than it does from thermal change. Even in cold conditions, when thermal expansion is usually not a concern, it is important to prevent excessive moisture migration into the system. Mold and mildew can be the signature of substandard ventilation. Development of mold and mildew is largely a cold-season phenomenon, but it is certainly not exclusive to "cold country." The colonies will dry to a powdery substance from the heat of the summer months. However, the interior of the structure may well experience pervasive indoor air problems during any season from the toxins released by the molds. Poor attic ventilation plays a role in all of this.

Moisture gain can cause the edges of deck sheathing to separate and rise. The respective sheets need to be spaced by 1/8", lest moisture cause swelling and buckling (*Figure 7*). Cyclical moisture change in wood decking can also cause nails to back

Figure 4—Attic insulation must be held back from the soffit region in order to serve as the intake port. A pre-manufactured baffle can be used to keep blown-in insulation from becoming a ventilation impediment.

out, compromising attachment of the sheathing to the framing supports. Deck movement can be slow and difficult to observe, usually becoming manifested over a long period.

Finally, excessive moisture weakens the shingles, reducing physical properties such as tear strength. Moisture drive will prematurely age shingles, weakening the bond of the shingle matrix to the fibrous glass mat. When excess moisture is combined with heat, the aging effect is accelerated.

Cold Decks and Super-insulated Attics

There is substantial misunderstanding about ice dams. A roof surface having a snow pack over the entire surface may experience no ice damming whatsoever. Conversely, a roof with very little snow accumulation may have pervasive leakage stemming from ice dams. As shown in *Figure 8*, the actual ice dam is a discrete portion of the total snow pack, mostly occurring at outlying walls of the structure.

A "cold roof deck" ordinarily has air space above the attic insulation and below the nailing deck. This arrangement fosters a cooler roof surface by allowing

Figures 5a and 5b—Multiple coats of paint can render soffit openings virtually useless. Airways and vent openings should be slightly larger than would be implied in the sizing calculation.

outside air to pass from the soffit, washing the underside of the nailing deck. This configuration enables the shingles to remain cooler in the winter by removing any heat escaping from the structure before it reaches the shingles. A cold roof helps prevent uneven melting of the covering snow and the subsequent re-freezing. Proper ventilation can reduce the formation of ice dams by maintaining a cold roof surface.

Figure 6—Mold/mildew in a humid southern climate. While attic insulation was properly held back at the edge and openings were present in the soffit cladding, the eaves carpentry was continuous along the entire perimeter. The mold/mildew colonies were fostered during a wintertime condensation scenario, drying to the powder during the hot season as shown.

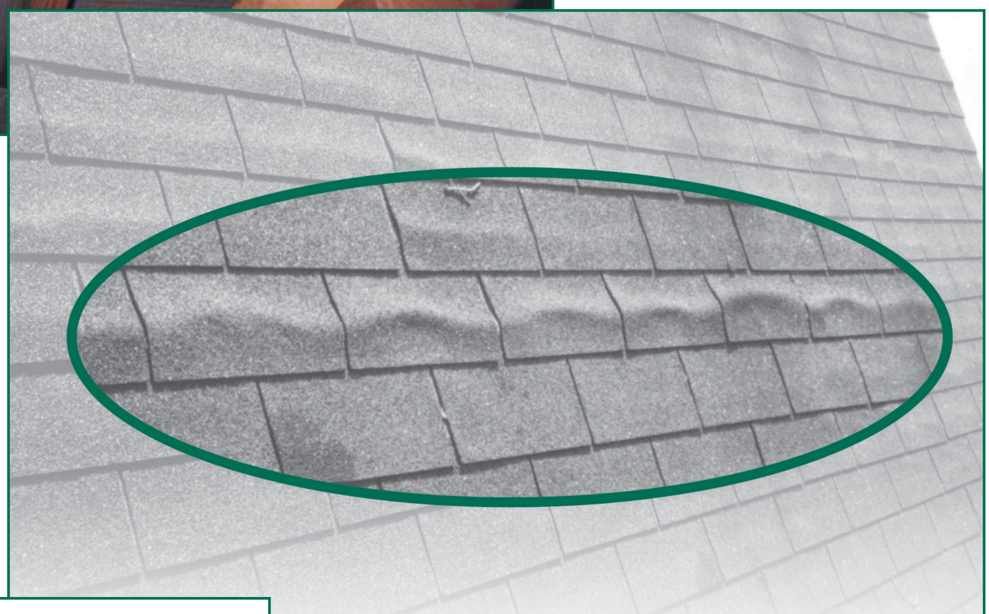


Figure 7—Moisture gain can cause the edges of deck sheathing to separate and rise. The respective sheets need to be spaced by 1/8", lest moisture cause swelling and buckling.

For a cold roof to function properly, its ventilation system should be sized to keep a snow-covered roof below freezing whenever the outside temperature is 22 degrees F (-5.6 degrees C) or colder. At warmer temperatures, the melted snow rarely re-freezes at the eaves.

Super-insulated attic floors will allow attic air to become colder as heat loss from the interior is reduced. The colder that air becomes, the less it is able to absorb and hold moisture, which is then free to condense on various surfaces in the attic.

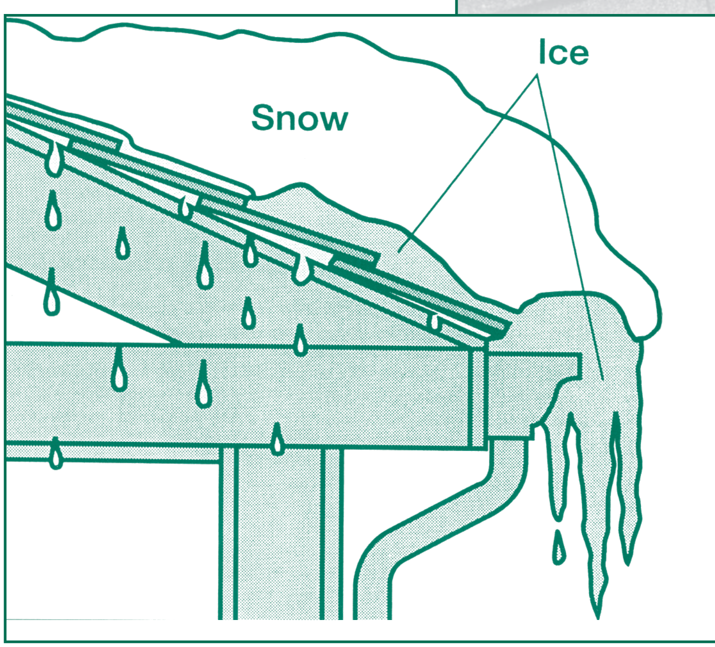


Figure 8—There is considerable misunderstanding about ice dams. The "ice dam" is a discrete portion of the total snow pack, occurring near the outlying walls.

Summary Comments

The intent of this article is to address some of the concerns regarding cold weather parameters for glass-reinforced shingles. When given the choice, the installer should wait for warmer weather. Otherwise, exercise as much care as possible during the application of glass-reinforced shingles. When designing for colder regions, take liberal precautions regarding ventilation aspect, moisture control, potential snow loads, and ice management.

Even the best products will not perform as intended if the roof system is not adequate for the cold conditions or if the application is improper. When proper application techniques are ambiguous or debatable, follow the guidelines as set forth by the shingle manufacturer, the National Roofing Contractor Association (NRCA), and the Asphalt Roofing Manufacturers Association (ARMA). ■

REFERENCES

1) Chapter "Ice," *McMillan's Encyclopedia of Physics*, 1996.
2) R.L. Corbin, "Water Dams: Up North, It's Ice—Down South, It's Pine Needles," *Interface*, January 1997, pg.7.
3) R.L. Corbin, "Proper Fastening of Self-Sealing Shingles," *Contractors Guide*, December 1992.
4) R.L. Corbin, "Mechanics for Properly Sealing Fiberglass Reinforced, Asphalt Roofing Shingles," *Interface*, April 2001, pg. 13.
5) MRCA, "The Theory and Practice of Steep Roof Ventilation," Oct. 1998, pg. 3.

About the Authors

Raymond L. Corbin is Director of the Better Understanding of Roofing Systems Institute (BURSI), sponsored by Johns Manville. He holds several United States roofing shingle design and application patents. Corbin is a faculty member of the Roofing Industry Educational Institute (RIEI), an Industry member of RCI, and has served as Chairman of the Code Committee for the Asphalt Roofing Manufacturers Association (ARMA).

Ray Corbin

Lyle Hogan is a senior engineer with Geoscience Group, Inc., working out of the firm's Greensboro, North Carolina office. He is a registered engineer, a Registered Roof Consultant, a licensed home inspector, and a Fellow of the Roof Consultants Institute. Mr. Hogan's technical articles have been published in numerous technical journals and conference proceedings. He is a recipient of RCI's Horowitz Award for outstanding contribution to *Interface* journal.

Lyle Hogan

Workplace Deaths in Britain

Britain has experienced a 34% increase in fatalities on the worksite. In 2000-01, there were 295 such deaths, with more than one-third occurring in the construction industry. Of those, 73 (68%) were caused by falls from heights.

—*Roofing Cladding & Insulation (RCI)*

Construction Degree Programs Coming of Age

According to a recent article in *ENR* magazine, schools nationwide are enrolling increasing numbers of students specifically studying for academic degrees in construction education. Construction education is no longer viewed as merely vocational. An estimated 170 universities currently offer bachelor-level construction education programs under various names, from construction management and building science to architectural design and construction and construction technology.

The Associated Schools of Construction lists 69 varying programs among its 96 members. Of 88 schools responding to ENR's survey, some 17,500 students were enrolled in the current school year, and approximately 3,400 graduated in the spring of 2001. Of these, only five percent are minorities and seven percent are women. There are 53 university programs accredited by the American Council for Construction Education (ACCE).

Institutions enrolling the largest number of students in their construction management programs: Colorado State University, 630; Texas A&M, 520; Purdue University, 485; Auburn University, 479; Brigham Young University, 465; Louisiana State University, 402; East Carolina University, 400; University of Cincinnati, 385; California State at Chico, 340; Iowa State University, 320. Kansas State University, 320; Arizona State University, 300; Indiana University/Purdue University, Indianapolis, 300.