

# Ice Dams and Icicles

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# INTRODUCTION:



- Roofs that drain to cold eaves may experience **ice dams and icicles** at their roof eaves and gutters in winter<sup>1</sup>.
- Water that ponds upslope of ice dams may leak into the building envelope<sup>2</sup>.
- Ice dams and icicles can create problems and hazards for building structures and their occupants.

# ICE DAM:

- An ***ice dam*** is the accumulation of thick layers of ice at roof eaves and gutters that results from periodic melting of snow over warmer areas of roof flowing down and re-freezing at the colder eaves and overhangs.

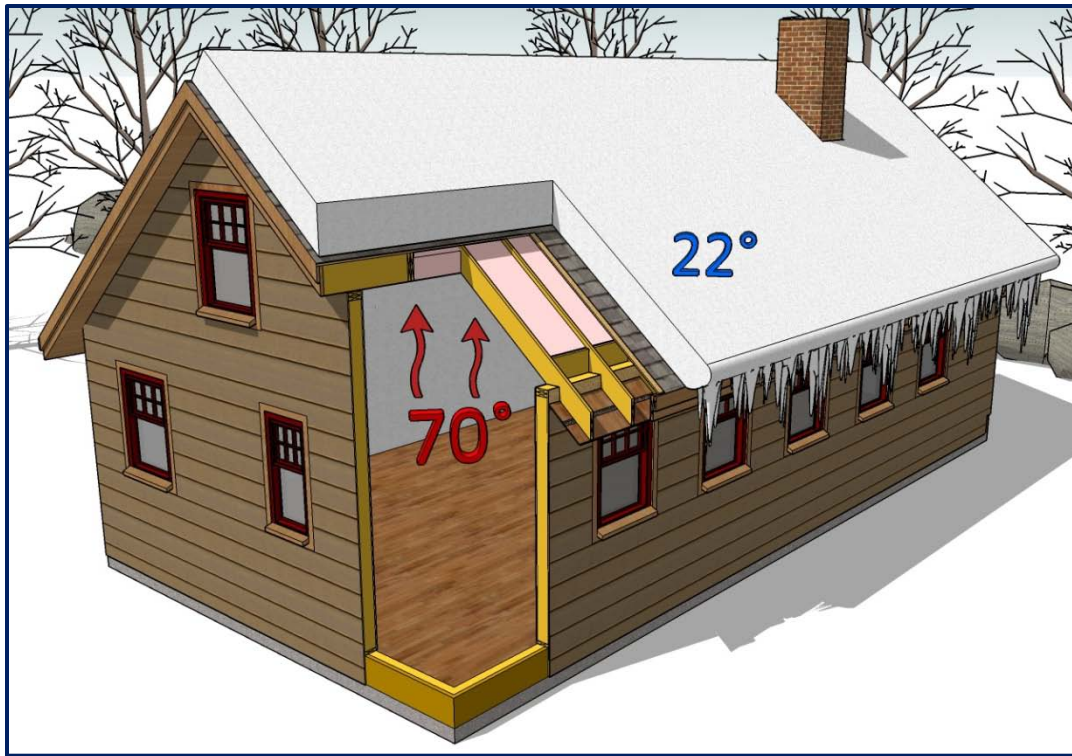


# ICICLE:

- **An icicle** is a spike of ice formed when water dripping or falling from an object freezes<sup>3</sup>.
- Icicles form when ice or snow melts and then re-freezes at the eave<sup>3</sup>.



# COLD REGIONS

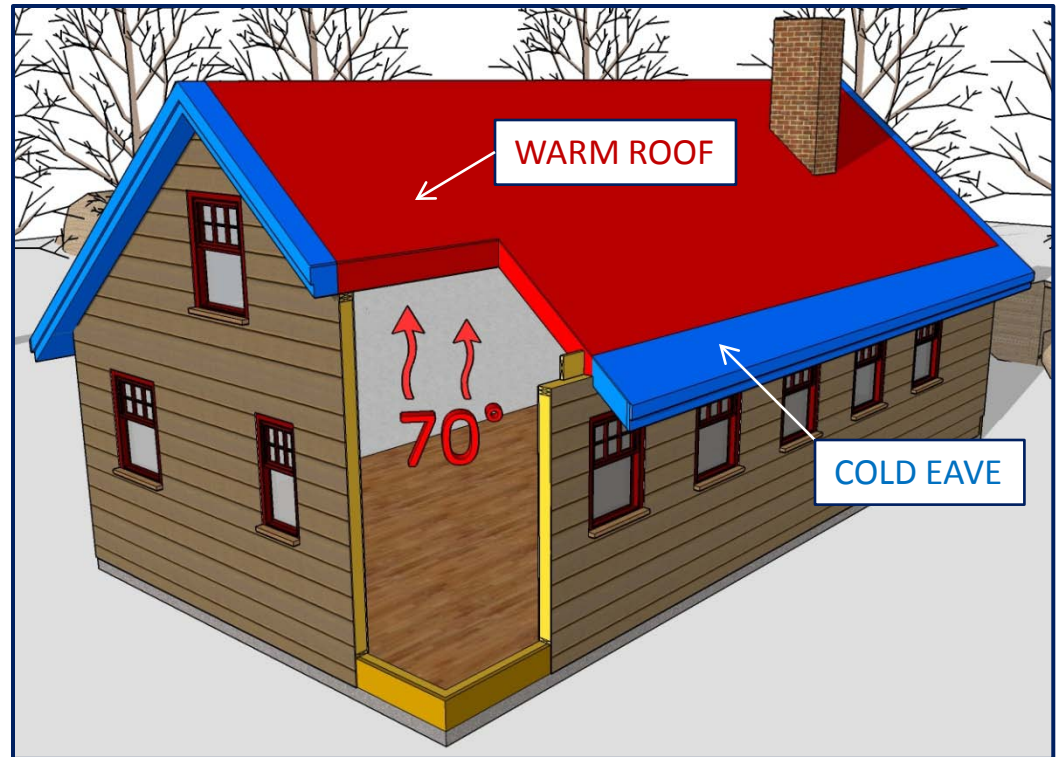


3D details are diagrammatic. Not for construction.

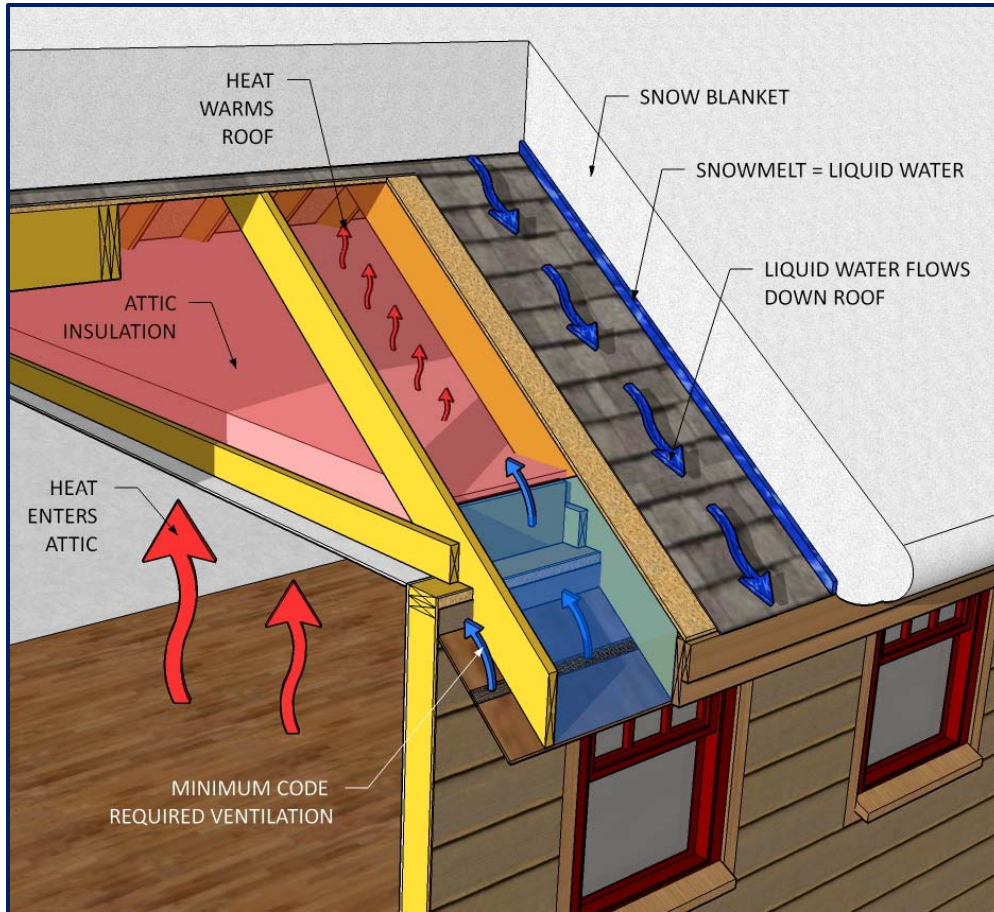
- Icings typically do not form when outside temperatures are above 22° F <sup>2</sup>. When it is warmer than 22° F outside, meltwater seldom re-freezes at roof eaves<sup>4</sup>.
- Snow is an insulator. As snow accumulates on a roof it creates a 'blanket' that insulates the exterior roof surface.
- The more snow on a roof, the greater the likelihood of creating icicles and ice dams<sup>4</sup>.

# HEAT LOSS = SNOWMELT

- Building heat – *not the sun* – is the primary cause of ice dams and icicles on roofs<sup>2</sup>.
- Warm air from interior heated space rises, and although roof insulation slows the escape of heat, some small percentage of heat is always lost through the roof assembly.



# HEAT LOSS = SNOWMELT

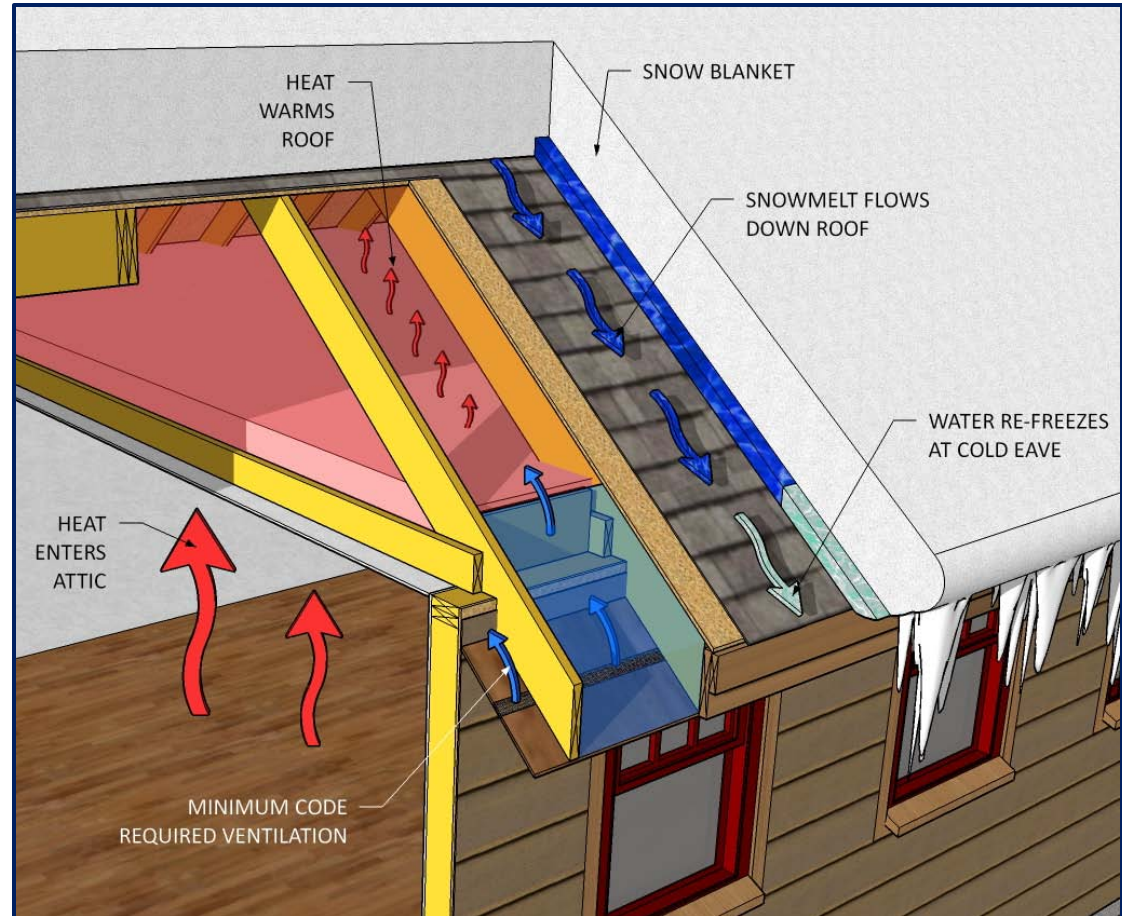


- Heat escapes the roof assembly and melts the bottom of the snow turning it to liquid water.
- Liquid water flows down the roof surface insulated by the snow blanket.
- Flowing water will freeze at a lower temperature than still water.
- The faster the water flows down roof, the less likely it is to re-freeze at the eave (roof pitch).
- The liquid water will run beyond the heated part of the roof some distance before re-freezing.

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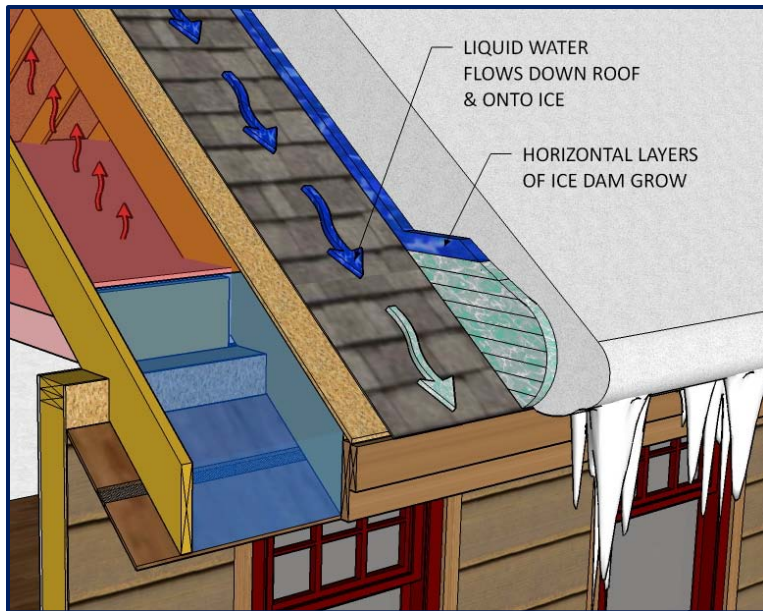
# HEAT LOSS = SNOWMELT

- When outside temperatures are below 22° F liquid water is more likely to re-freeze at the cold eave of the roof.
- Icicles grow as liquid water continues to run from the warm roof down to the cold eave.



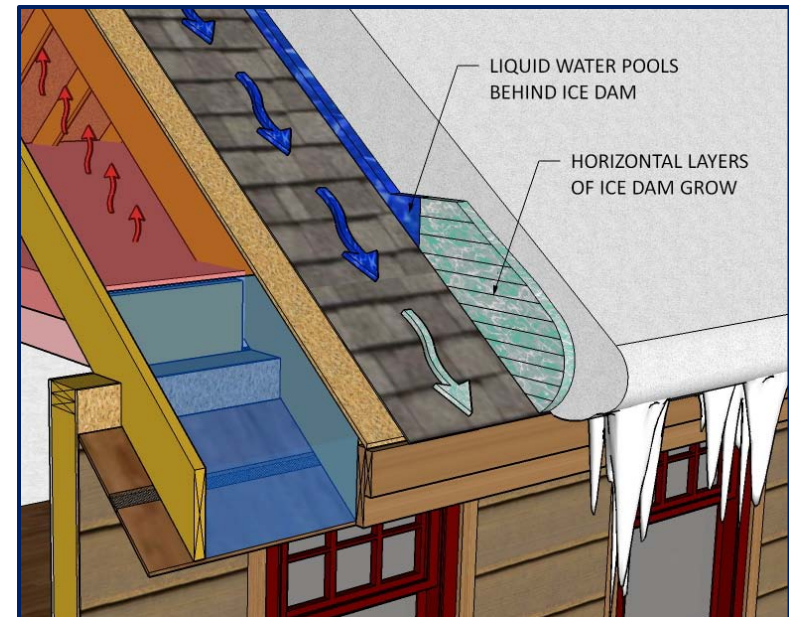
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# HEAT LOSS = SNOWMELT



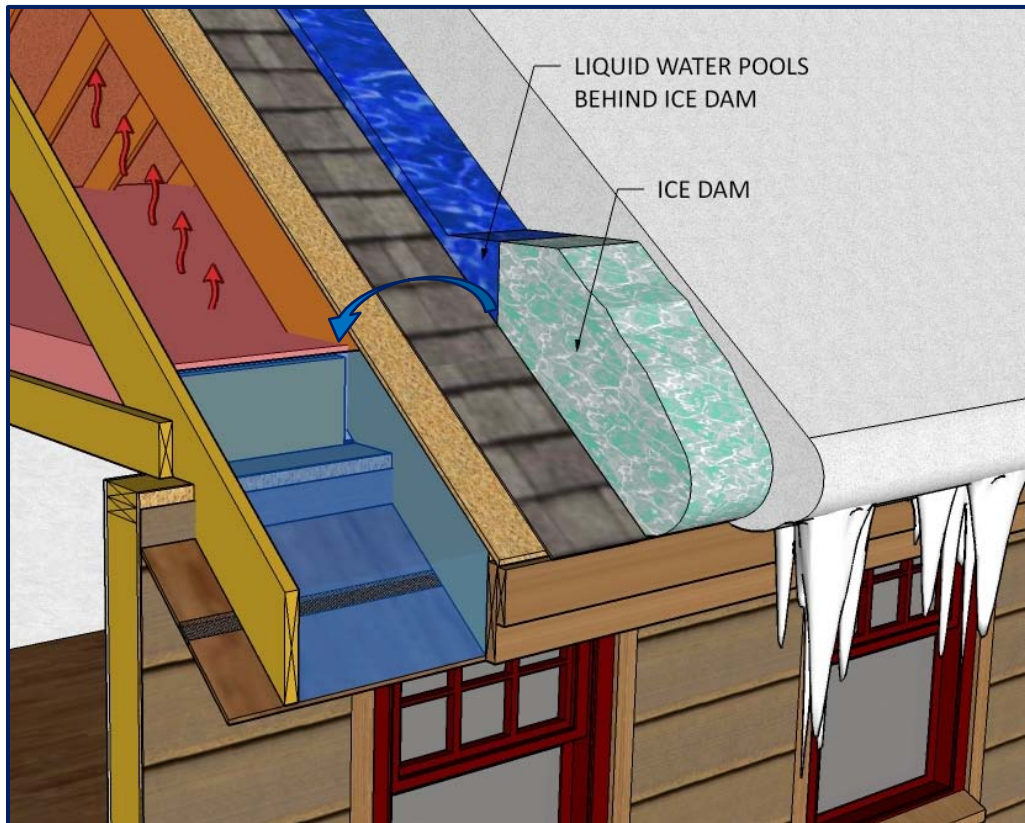
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- As liquid water continues to flow down the warm roof onto the cold eave and re-freeze, horizontal layers of ice build.



- As horizontal layers of ice build, the ice grows up the roof until it reaches the boundary between warm roof, and cold eave.

# HEAT LOSS = SNOWMELT



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- As the layers of ice continue to build, the ice can block the flow of liquid water trying to run down the roof.
- **Liquid water can collect behind the ice dam and may leak into the building.**

# VARIABLE CONDITIONS



*fig. D*

- Snow does not accumulate uniformly and many factors influence how it builds up on roofs.
- Interior and exterior air temperatures vary depending on location, time of day and weather conditions.
- Depth of snow blanket on roof varies with weather patterns, building orientation, wind and sun exposure.

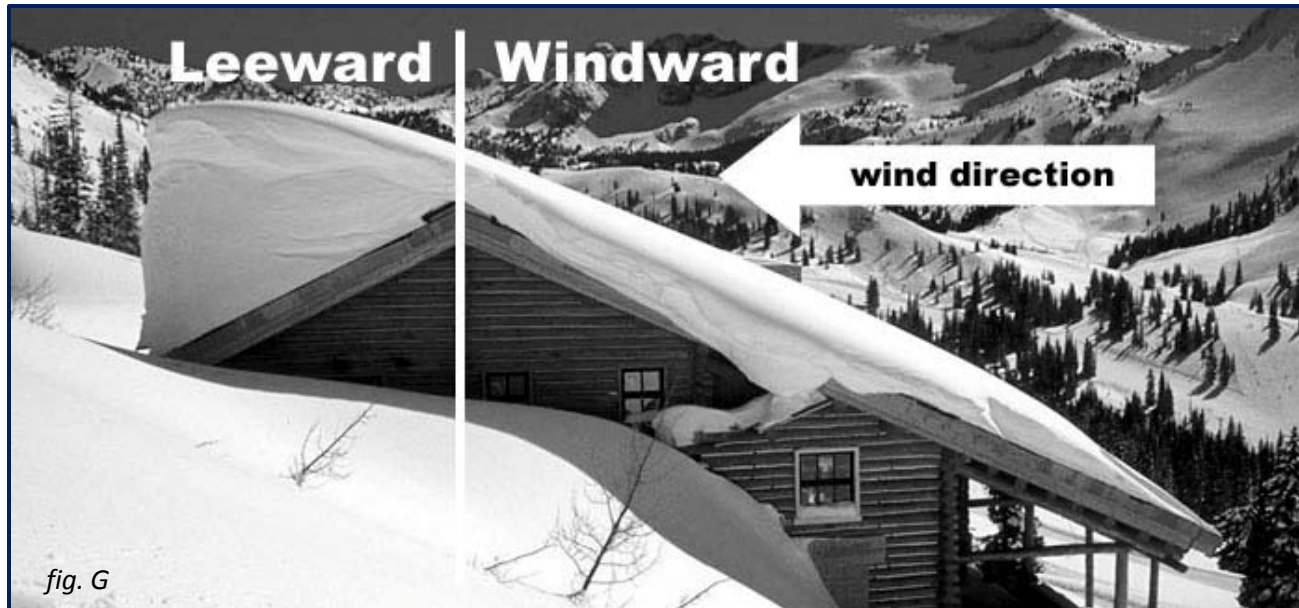
*fig. E*

## VARIABLE CONDITIONS: ROOF PITCH



- Steeply pitched roofs shed water faster than shallow pitched roofs.
- Long eaves with shallow roof pitches are much more likely to develop problematic icing.
- Complex roof geometries greatly affect where snow collects on a roof.

## VARIABLE CONDITIONS: SNOW DRIFTS



- Snow will drift into areas of “aerodynamic shade.”<sup>5</sup>
- Drifted snow can affect the operation of plumbing and HVAC equipment, and block air intakes and exhaust vents<sup>5</sup>.

*fig. E*

VARIABLE CONDITIONS:

# SNOW DRIFTS



*fig. H*

- Large snow drifts often form on lower roofs and around complex roof geometries such as gable dormers and valleys<sup>5</sup>.
- Peak snow loads on lower roofs can be considerably larger on lower roofs than upper roofs<sup>5</sup>.
- Lower roofs often have a shallower pitch than upper roofs and thus shed water more slowly than steep pitched roofs.

# DAMAGE & HAZARDS

- Ice dams and icicles can pose very serious threats to building structures and their occupants.
- Water intrusion into a building envelope can damage interior and exterior materials.
- Moisture within the building cavities can lead to potential biological growth. Damaged structural elements of a building can cause structural failures and collapses.
- Snow and ice can cause serious damage and injury to property and persons when falling from a roof.
- Non-uniform roof loading from snow drifts can lead to collapse.

# DAMAGE & HAZARDS

- Water that ponds upslope of ice dams may leak into the building since most pitched roofs are designed to shed water, not hold back standing water.<sup>2</sup>
- Ice dams can cause water to flow under roofing shingles onto the roofing underlayment and, potentially, into the building.
- Water and moisture within the building envelope can lead to potential biological growth.



# DAMAGE & HAZARDS

- The snowmelt cycle causes ice and snow to ‘creep’ down the roof surface. As ice moves, it can cause damage to roofing materials, gutters and fascia boards.
- Roof vents and pipe penetrations can be damaged or broken when heavy snow and ice creeps down roof.



*Fig. J*

# DAMAGE & HAZARDS

- When snow creeps and curls after large icicles have already formed, ice can curve back into building walls and windows.



*Fig. K*

# DAMAGE & HAZARDS



- The significant weight of snow and ice applies added stress to a building's structure, potentially causing failure.
- Property has been damaged and people have been killed by buildings collapsing under the weight of snow.
- This building in Easton, Massachusetts collapsed on February 2, 2011

# DAMAGE & HAZARDS



fig. N

- Heavy snow and ice falling from the roofs of taller buildings can pose a serious safety hazard to the building, property and pedestrians on the streets below.
- Falling snow and ice can bounce off the ground and back into the building causing damage to the lower windows and walls.

MITIGATION:

# MAINTENANCE

- In some conditions, manual removal of snow and icicles from the roof may be necessary.



MITIGATION:

# ICE & WATER SHIELD

- Installation of '*ice and water shield*' on the lower 1/3 of the roof surface, under the shingles and roofing felt, can reduce infiltration of water through the roof sheathing in the event an ice dam forms at the eave.
- Covering the entire roof with *ice and water shield* is **not** recommended, however, as it traps moisture and vapor inside the building.



fig. Q

MITIGATION:

# HEAT TRACE

- Application of electric heat trace on the zone between the eave edge and the heated part of the roof can reduce freezing of snowmelt water and can provide a heated path for the water to flow to the edge of the roof.
- This can lead to the formation of numerous icicles.

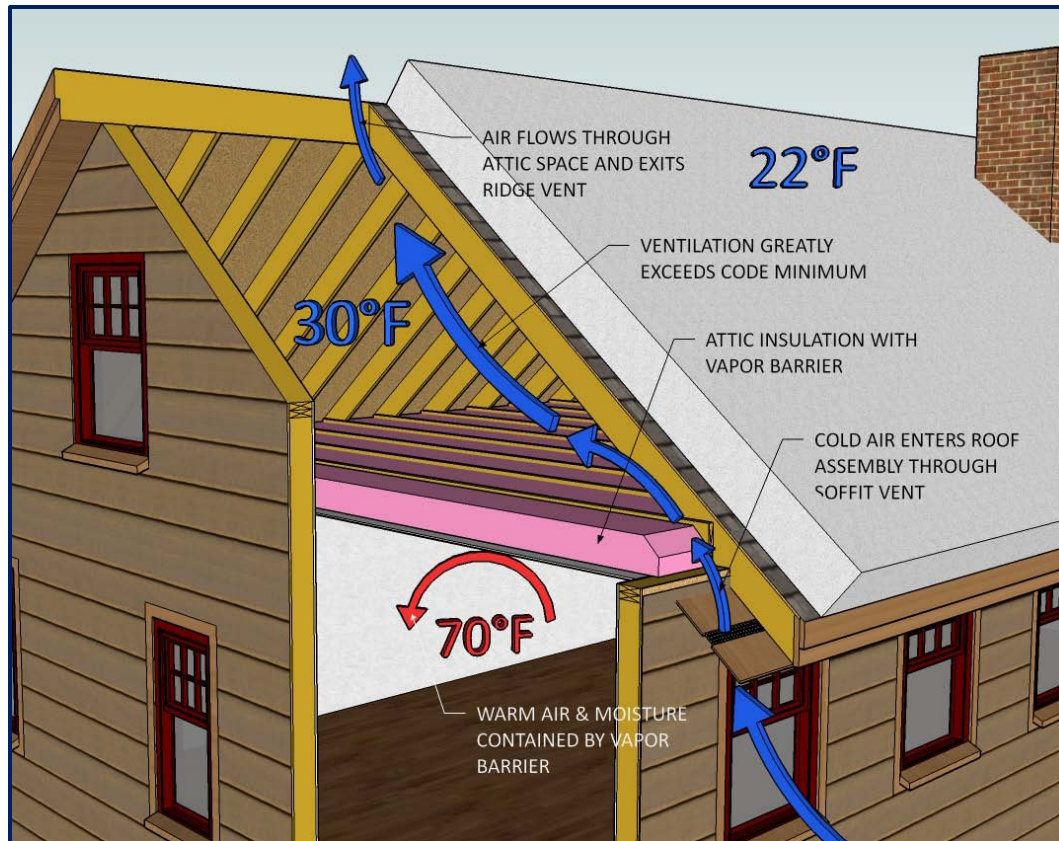


## DESIGN SOLUTIONS:

- Cold attic spaces
- Cold roof assembly
- Super insulated roofs with properly installed vapor barrier
- Steep roofs with fall zones
- Flat roofs with internal drain

DESIGN SOLUTION:

# COLD ATTIC SPACES



3D details are diagrammatic. Not for construction.

- A combination of insulation and roof ventilation is the most reliable approach to eliminate chronic problematic ice dam formation<sup>1</sup>.
- Attic and ridge vents allow air to flow through the attic space and escape.
- Studies show that icings can be avoided by sizing attic ventilation systems to maintain an attic temperature of 30° when the outside temperature is 22° F <sup>2</sup>.

DESIGN SOLUTION:

# COLD ATTIC SPACES

PROS:

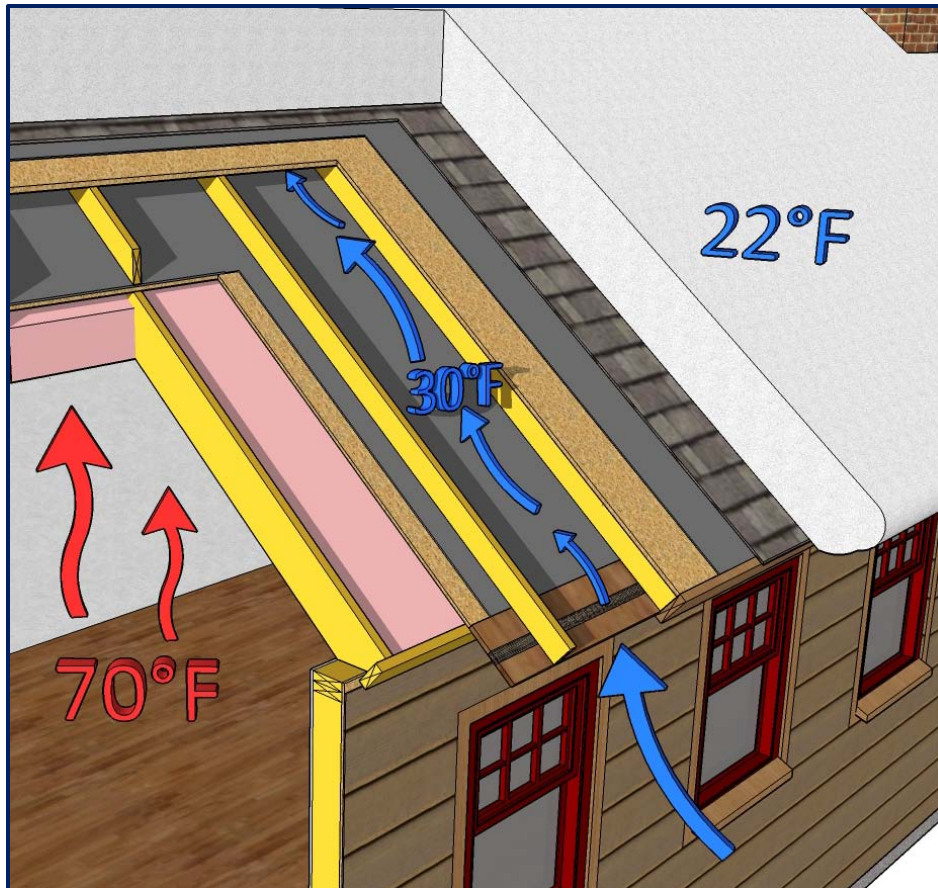
- Works with standard trusses.
- Can be used to modify existing structures.
- Simple design compared to other options.
- Energy efficient in Summer.

CONS:

- No mechanical equipment in attic.
- Pipes in attic will freeze. Protection required.
- Does not allow cathedral ceilings (can use scissor truss).

DESIGN SOLUTION:

# COLD ROOF ASSEMBLY



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- “Umbrella design”
- A cold roof is a double roof with the upper layer vented and the lower layer insulated<sup>6</sup>.
- The vented layer promotes continuous unrestricted air flow from the eave to ridge across the entire roof area<sup>6</sup>.
- Cold outside air ventilates a significant portion of the heat that would melt snow<sup>4</sup>.

DESIGN SOLUTION:

# COLD ROOF ASSEMBLY

PROS:

- Works with cathedral ceilings.
- Maximizes interior volume.

CONS:

- Expensive.
- Requires special venting such as ridge vents, or 'dog house' vents.
- Design must accommodate shear forces from snow (special blocking).

DESIGN SOLUTION:

# SUPER-INSULATED ROOF

- A super-insulated roof prevents escaping heat from melting snow by increasing insulation thickness<sup>6</sup>.
- When ceiling R-values are greater than R-50, the temperature on the surface of the roof can be maintained at the temperature of the snow<sup>6</sup>.

DESIGN SOLUTION:

# SUPER INSULATED ROOF

PROS:

- Simple to build.
- Maximizes interior space.
- No venting.
- Can use SIP panels.

CONS:

- Requires careful consideration of dew point.
- Requires carefully sealed vapor barrier (difficult to achieve).

DESIGN SOLUTION:

# STEEP ROOF PITCH



- A steep roof pitch allows melted snow to run off quickly, before it reaches freezing temperature.
- Narrow eaves provide less cold roof surface where melted snow can re-freeze.
- A deliberately planned fall zone allows snow and ice to fall from the roof safely away from sidewalks and entryways.

DESIGN SOLUTION:

# FLAT ROOFS

- Internally drained low-slope roofing systems can perform.
- Instead of snowmelt water flowing to the cold roof edge, it flows to internal drains that are kept ice free by the heat of the building or in some cases by electric heat trace.
- Flat roofs distribute snow loads uniformly over the roof surface.
- Wind scours roof surface.



NOTE: No icicles!

# THE END.

# PHOTO CREDITS:

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- Fig. B) Ice dam. [Online image] Available <http://www.hwconstruction.com/blog/2010/12/19/how-to-prevent-roof-damage-from-ice-dams-this-winter/>, March 4, 2011.
- Fig. C) Icicles. [Online image] Available <http://www.homeconstructionimprovement.com/ice-dam-problems/>, March 4, 2011.
- Fig. D) Extreme snow on roof. [Online image] Available [http://www.xtreemeexteriors.com/homeowners\\_snow\\_removal.html](http://www.xtreemeexteriors.com/homeowners_snow_removal.html), March 8, 2011
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- Fig. F) Snow on steep roof. [Online image] Available <http://whimfield.com/shingling-a-steep-roof-is-not-quite-as-scary-as-it-looks/>, March 3, 2011.
- Fig. G) Leeward side. [Online image] Available <http://www.fsavalanche.org/Encyclopedia/leeward.htm>, March 8, 2011
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- Fig. K) Snow curl on roof. [Online image] Available <http://www.flickr.com/photos/eyesee360/581153535/in/photostream/>, March 11, 2011
- Fig. L) Triton Technologies building collapse. [Online image] Available <http://www.dailymail.co.uk/news/article-1353169/Winter-storm-Bomb-scene-blizzard-ice-snow-killed-12-crushed-buildings.html>, March 8, 2011.

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Fig. N) Icicles on motel’s roof in Tahoe, CA. [Online image] Available [http://commons.wikimedia.org/wiki/File:Icicles on motel%27s roof in Tahoe, California.jpg](http://commons.wikimedia.org/wiki/File:Icicles_on_motel%27s_roof_in_Tahoe,_California.jpg), March 11, 2011.

Fig. O) “Massive Avalanche of Ice Off Roof.” February, 12, 2010. Available Youtube, March 8, 2011.

Fig. P) Snow removal on roof. [Online image] Available [http://weather.thefuntimesguide.com/2009/02/roof\\_snow\\_removal.php](http://weather.thefuntimesguide.com/2009/02/roof_snow_removal.php), March 11, 2011.

Fig. Q) Grace ice and water shield. [Online image] Available [http://www.na.graceconstruction.com/template.cfm?page=/underlayments/photo\\_watershield.html&did=8](http://www.na.graceconstruction.com/template.cfm?page=/underlayments/photo_watershield.html&did=8), March 11, 2011.

Fig. R) Heat trace. [Online image] Available <http://www.heatersplus.com/easyheat.htm>, March 11, 2011.

Fig. S) Heat trace melts snow. [Online image] Available <http://www.warmquest.com/products-guttermelt.php>, March 11, 2011.

Fig. T) Thallon, Rob. *Graphic Guide to Frame Construction* (p. 192). Newton, CT: Tauton, Press Inc. 1991.

Fig. U) Thallon, Rob. *Graphic Guide to Frame Construction* (p. 204). Newton, CT: Tauton, Press Inc. 2000.

Fig. V) Snow slides off steep roof. [Online image] Available <http://ty.cooldog.com/Snow2003.htm>, March 11, 2011.

Fig. W.) Snow on flat roof. [Online image] Available <http://www.dochemp.com/mtshastaski.html>, March 11, 2011.

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# NORWOOD

a r c h i t e c t u r e

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