Assessing the effect of attic moisture in wood framed multi-unit row housing blocks.

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ABSTRACT

This paper represents the results of poor moisture management and control of an extensive stock of row housing dwellings in Ontario specifically the National Capital Region. Damage caused by excessive build up of moisture in attic spaces, during the winter months affects all the roof components of the assembly in this region. A cumulative number and a variety of causes can be associated with this condition related and not limited to building orientation, roof construction, pitch, air leakage and design. Roof vents, usually required by the local building code, may require modifications to the formula to meet or exceed the requirements based on building design and other environmental effects.

Condensation in the attic space is generally more severe than condensation in the wall cavity even thought the wall area is normally greater. The best strategy for preventing attic moisture problems is to prevent or reduce the amount of warm, moisture-laden air to migrate into the attic space. Residential wood framed multi unit row house type dwellings constructed in the early to mid seventies experience significant deterioration around the fire separation walls between units. Moist interior air travels vertically up the wall and condenses on the underside of the roof sheathing at this area.

This paper will discuss the various solutions experienced in the prevention of moisture accumulation inherent to multi unit low-rise wood frame construction.

INTRODUCTION

Although rain penetration can cause attic moisture problems, condensation of warm air, which has leaked into the attic space, is the more common cause. Moisture in the attic is more prevalent, if appropriate precautions are not taken, in northern Canada and some parts of the Prairies, where outside temperatures are cold and winters are long. Moderately cold areas can also experience attic moisture if the outdoor air is very humid for long periods. These areas include some parts of British Columbia, some parts of the Maritimes, and Eastern Quebec. Condensation in attics is generally more severe than condensation in walls. Wet attics are a continent wide problem

For both pitched and low-slope roofs, it is important to provide adequate ventilation of the roof space above the insulation. Even where air and vapour barriers are used, indoor air always wants to seep up and into the attic on its way out of the house through the soffit and vents. There are many paths for air to seep into the attic space, including fixtures, partition walls, stack pipe openings, chimney, and other openings and through the vapour barrier itself. Inherent in row housing units, the perimeter and party wall or firewall separation between units extends to the underside of the roof sheathing. Moisture rises in the cavity of this wall and accumulates at the juncture of this wall at the roof sheathing on both sides of the fire separation.
The offsetting of individual units within the block(s) results in the increase in the accumulation of moisture by rain penetration and condensation of warm air in this area. Moisture in the attic can

be a serious problem. It arrives from two directions: from the inside of the house as warm air rises and condenses on the on the underside of the roof deck and from the outside as water leakage through failed shingles, or from underneath the shingles as melted snow backs up as a result of ice damming at the eaves, and building offsets due to elevation and grade changes. In addition to water damage, any moisture in the attic can be the start of a serious mould and roof deterioration problem – dangers both to your health and to your investment.

METHODOLOGY

Contemporary roofing designers recognize that their systems are vulnerable to moisture from three sources: rain penetration, the entry of water vapour, and ice damming. Certain building

science principles behind the problems of moisture and roofing should be understood. A detailed review of the three sources of moisture penetration into the attic space and the adaptation of effective detailing to prevent migration of moisture will relieve the situation.

Unknowingly, the roofing industry was making the wet-attic situation worse. How? They were following the correct procedure for ventilation, but solving only part of the problem instead of the whole problem. Ventilating a previously unventilated attic has the effect of making the attic colder. If nothing is done to stop warm, moist air from entering the attic space from the living space, condensation on the now-cooler surfaces is a certainty. Mold, mildew, and eventually leakage into the living space will probably follow. Insulation contractors, armed with the same lack of information about attics as the roofers, have caused similar problems. Insulating the attic floor makes the attic colder in the same way as adding ventilation. But, if contractors don't seal as well as insulate, they don't stop warm, moist air from entering the attic and causing big problems.

Rain Penetration

Roofs leak when water finds an opening and sufficient force is applied to drive the water inwards. Particularly vulnerable joints in multi unit row housing are at the perimeter walls, party walls and split level junctions. Flashing is used, where necessary, to prevent the entry of water through joints between materials. Proper installation of flashing is important, as is the selection of the most suitable materials for each specific location.

To eliminate rain penetration the builder must either close the openings or neutralize the driving force. Sloped shingle and tile roofs seldom leak because gravity offsets the forces acting to move the water inward. The NRC Building Digest Publication, *Moisture Considerations in Roof Design*, states "overlapping the shingles limits the direct entry of rain drops by impingement. Gravity acts to move water outward down the slope, counteracting the air pressure differential that tends to drive moisture inward." The greater the vertical height of the shingle lap, the greater the gravitational force. Leakage occurs when the roof is not sloped enough to let the force of gravity resist the wind force driving the rain through the openings.

The only way to control water penetration on low slope roofs is by applying a continuous waterproof membrane. Minimum and maximum slopes for particular roof coverings are given in Table 1. Avoid situations where water may pond. Roof leaks will occur and the damage will be considerable.

Table 1. Minimum Slopes for Various Roof Covering Types

Roof Covering Type	Minimum Slope
Asphalt Shingles	
▪ Normal application	1 in 3
▪ Low-slope application	1 in 5
Wood Shingles	1 in 4
Hand Split Shakes	1 in 3
Sheet Metal	1 in 4
Clay Tile	1 in 2

Source: *National Building Code,* Table 9.27.3.A

Water Vapour Penetration

Attic condensation on the inside surfaces of roofing material is caused by water vapour moving through the ceiling system. It condenses on roof members if their temperature is lower than the dew point. This happens in winter when the inside air has a higher moisture content and vapour pressure than the outside air. Humidifying the house can make the condensation worse.

Attic condensation and ice damming are related. Both can be caused by warm, moist air leaving the house and entering the attic. Attics will be in good shape if there are no holes, air leaks, or bypasses from the house to the attic and there is sufficient insulation to keep house heat from escaping. If you can ensure good air sealing and insulation, the attic will remain cool and dry, as if it were outside. For example, it is rare to see moisture problems or ice damming on the roof of a detached garage or unheated barn.

What To Do About A Wet Attic

There are many signs that an attic is wet. Prolonged wetness will rot out the roof sheathing. Often this is first noticed when re-shingling. If you have ceiling leaks only in the spring, it may be that ice has been forming on the sheathing all winter and it suddenly melts when a warm spell arrives. You may see water stains or evidence of mold on the sheathing, rafters, or trusses when you are inspecting the attic. You may find the insulation has been packed down or stained by water or ice. The smell of a moldy attic will enter the house under certain weather conditions usually in summer.

The usual response is to increase attic ventilation. This is the wrong approach. In some cases, adding ventilation will actually pull moist air up into the attic and make the problem worse. The best way to fix a wet attic is to stop air movement from the house. Once this is done, the existing ventilation is usually more than enough to keep the attic dry.

It is important to stop air leaks because a heated house is much like a chimney. Both a house and chimney are containers of warm air surrounded by cold air. Both tend to draw air in at the bottom and expel it at the top. All winter, a heated house is trying to push air through the top floor ceiling into the attic. Block up the air leaks and keeps the warmth in the house to save both energy costs and damage to your attic.

Air leaks are usually found at penetrations or discontinuities. Safety regulations prevent sealing of many types of pot lights in top floor ceilings. House air is dumped into the attic through them. Choose sealed pot lights or avoid them on the top floor.

Bathroom fans need to be ducted outside. Make sure that they are properly vented. If the ducts are located in the attic, ensure that there are solid metal rather than flex duct, insulated, and sloped to the outside. Do not wrap the insulation in plastic, as this will trap moisture. Taping the duct joints, or sealing them with mastic, is helpful for controlling leakage.

Plumbing stacks and chimneys are often sources of air leakage. Seal these where they pass through the attic floor. For metal chimneys inside a chase or for old masonry chimneys, you may need help from an expert to ensure proper sealing and avoidance of fire hazards. Seal holes made for electrical wiring and cable insulations.

There will be little air leakage in the middle of sheet of drywall or in the middle of an unbroken plaster ceiling. There may be many air leaks where partition or bearing walls meet the ceiling or around the perimeter of the house where the attic floor (or top floor ceiling) meets the outside walls.

All discontinuities should be inspected and sealed if necessary. Look for bypasses. They are major air passages from any floor into the attic. Dropped ceiling in the room below will often conceal a direct connection to the attic. Concrete block party walls between row houses often move house air into the attic.

There are several ways to check for these large and unexpected leaks. The blower door tester can pressurize the house with a big fan and amplify the leakage. Searching the attic at night for lights below can be helpful. Scanning batt insulation for dirty areas, which have been filtering the air from below, is also useful, although such straining seems to occur less frequently with blown insulation. Sometimes the holes are so big that you can see into the house below.

Some houses have heating or air conditioning ducts or equipment in the attic. These can be the major source of air leakage and heat loss in the attic. Good information on how to seal and insulate these devices has been published in *Home Energy Magazine*, available in some libraries.

Leaks can be sealed with caulking, expanding foam, plastic, or other methods. There are a number of publications giving details on sealing methods, including *Keeping the Heat In* from Natural Resources Canada, 1-800-387-2000 in Canada or (819) 995-2943 outside Canada.

Moisture severely damages building materials, causing them to deform and deteriorate. It causes curling, cupping and shrinkage in asphalt shingles, corrosion of metal roofing and rotting of

shingles and shakes. It may also saturate and weaken organic felts, resulting in severe damage to the fabric and the loss of its waterproof qualities.

Builders should use a roof system designed to prevent the entry of water vapour by both diffusion and air leakage, or one that is capable of removing the vapour by ventilation (NRC: *Moisture Considerations in Roof Design).*

Recommended techniques in designing and constructing vapour and air barriers to prevent water vapour from moving to the roof system.

- Installing a vapour barrier in 0.15 mm (6 mil) polyethylene on the warm side of the insulation in the ceiling
- Cutting air leakage to the attic space by sealing holes leading to and from the house below.

Where and How to Seal Attic Leaks

Leakage Path	**Single Component Foam**	**Two Component Foam**	**Other**
Attic hatch	Yes	Yes	Weatherstrip, caulk, latch and insulate.
Ducting for fans or heating systems	Yes	Yes	Insulate to R-25 minimum in Canada, seal boot to ceiling, and seal plenum shaft.
Plumbing stacks or plumbing walls	Yes	Yes	
Chimney Stacks			
Electrical penetrations and wiring	Yes	Yes	
Top plates at perimeter walls	Yes		
Recessed ceilings	Yes		First stuff with batt insulation.
Any light fixtures on the top floor			Caulk from below.
Knee walls		Below wall, between joists	Mineral fiber batts on vertical walls.

Plumbing penetrations	Yes	Yes	
Recessed lights		Yes	Plus drywall box (or replace with sealed units).
Perimeter and party walls	Yes		Drill or punch block cores in lowest course above ceiling, and then fill. Won't work if blocks are already filled with concrete, as in earthquake country.
Split level junctions and discontinuities		Yes	Stuff first with batt insulation.

It is impossible to completely prevent the passage of water vapour through the ceiling and into the roof structure; therefore, it is important to try to remove the vapour and deal with the condensation. Controlling the flow of moisture by air leakage and vapour diffusion into roof and attic spaces is necessary to limit moisture-induced deterioration. Given that imperfections normally exist in the vapour barrier systems, recent research indicates that adequate venting of roof and attic spaces is of significant concern.

In accordance with the National Building Code, and Provincial Codes, the unobstructed vent area of a typical average pitched roof shall be not less than 1/300 of the insulated ceiling area.. Ventilation is also a criteria required by shingle manufacturers in order to respect their warranty. Other design considerations when calculating net free ventilation are:

- Maximize air flow; locate vents at eaves and soffit, and near peak or along ridge
- Reduce free vent area on roofs with greater pitch 6/12 and stepper.
- Increases free vent area in the absence of polyethylene vapour barrier.
- Balance air flow of intake and exhaust vent area.

Although not usually recognized as a major design consideration, the proper ventilation of attic areas is an essential factor in gaining the maximum service life out of the building materials used in roof assembly, in addition to improving heating and cooling costs. Overlooking this consideration may result in:

- Premature failure of roofing including blistering.
- Buckling of the roofing due to deck movement.
- Rotting of wood members.
- Moisture accumulation in insulation.

The two fundamental benefits of an effective attic ventilation system are:

1) A cooler attic in summer months
2) A dryer attic in winter.

Both benefits result in energy savings, greater occupant comfort, and higher integrity of the dwelling. During the summer months, radiant heat from the sun can cause high roof deck temperature. Gradually, the entire attic space is heated, and, in turn, the entire dwelling feels the

effect of a hot roof. This heat build-up can be short-circuited by ventilating the underside of the roof deck. Research has reinforced the idea that prolonged exposure to high heat levels will accelerate aging and shorten the service life of asphalt roofing products. Having a properly ventilated flow through air space between the roof deck and a radiant barrier or layers of insulation present will offer protection against heat build- up.

Condensation results when water vapour comes in contact with a cold surface such as the underside of a roof deck. Condensed water vapor can soak insulation and affects its performance. It can also cause wood to rot, plaster to crack, and paint to peel. Proper attic ventilation can guide water vapor from the attic space before condensation can cause trouble. Adequate ventilation during cold weather will prevent vapor condensation and potential freeze-thaw cycles and the associated problems.

With proper ventilation, air will circulate freely under the roof deck and carry away water vapor before it can condense. Few people recognize the difference between a passive ventilator and a static ventilator. A static ventilator allows air exchange, whereas a passive ventilator allows for evaporation. Passive ventilators are normally recognized as low profile vents like ridge vents, mushroom vents, or even a gooseneck ventilator for flat roofs. These types of ventilators do not allow for air exchange but merely allow air to evaporate out through them. The air enters through the soffit into the attic space, and then gradually evaporates out through the ventilators. This type of vent releases the attic air by evaporation and is unable to exchange or replace it frequently. With inherently low clearance from the roof level, it is easily buried by snow following the initial snowstorm, rendering the ventilation system inactive. In windy conditions this type provides little to no protection to water or snow infiltration.

A static ventilator in retrospect is a higher profile and normally recognized as a turbine type or fixed ventilator. Attic air is frequently replaced through a combination of wind and pressure differential, creating a stack effect, replacing the attic air often.
A balanced system combines equally sized soffit vents and vents high on the ridge will provide a uniform natural draft effect from the bottom to the top of the attic space. Louver and vent openings should not be covered during the winter. Eaves or soffit vents should not be blocked by insulation. Structures with bath and kitchen mechanical vents are vented directly to the attic space require additional ventilation to remove excess water vapor.

Screens and louvers obstruct the openings, making it necessary to adjust the ratio upwards.

Locate the vents at the soffit, making sure that the ventilation area is evenly distributed and as high as possible at the ridge and gables. This method takes advantage of the stack effect in promoting good air movement. Power ventilators, while useful in the summer should not be used in the winter. By creating negative pressure in the attic space, they increase the flow of moist, warm air from the interior.

Moisture during Construction

Moisture can enter roofing materials while they are stored on the construction site. Builders should protect water-absorbing materials such as felts and wood, from rain or long periods of humidity.

Ice Damming

Ice damming is the build-up of ice at the edge of the roof, caused by heat escaping from the house and melting snow. This melt water flows down under the snow covering the roof. As it reaches the outer edge of the eave over the unheated soffit, it freezes, creating an ice dam. This ice dam stops the flow of melt water from reaching the eave. Ice then builds up in the form of icicles and slabs and the melt water can back up through the shingles and leak into the attic.

Ice build-up also causes structural damage to the eave, the roof and is a potential hazard to passerby's.

Ice damming usually occurs with a significant depth of snow on the roof. If the attic temperature is above freezing, it warms the roof sheathing and melts the snow lying on the shingles. This water runs down the roof until it melts the snow lying on the shingles. This water runs down the roof until it meets the roof overhang, which is not warmed by the attic and will be at the temperature of the surrounding air. If the air and the overhang are below freezing, then the water will freeze on the roof surface and start the ice dam.

An attic with no insulation will generally not have a problem with ice dams. The heat coming through the attic will tend to melt snow off as it lands and prevent much accumulation. A well-sealed and insulated attic will generally not have ice dams. Like the example of a detached garage, this generally results in a cool roof and no great amount of melting. Ice dams are more frequent if the roof is complicated by many valleys and dormers or a large roof overhang.

Ice dams will first show up where there is inadequate insulation or major air leaks. One way to find these locations is to look at the roof after the first heavy frost in fall or light snow. Watch where the snow melts off first and find out what is under that spot on the roof. One common sight in such conditions is a horizontal melt line across the roof of a storey-and-a-half house, where the short knee wall meets the ceiling. Other places are beneath a roof-ducted exhaust fan or over a leaky attic access hatch.

The basic relief for ice damming is to seal all attic air leaks and insulate thoroughly – the same as the attic condensation solution.

Take the following measures to help prevent ice dam problems:

- Provide eave protection, an impervious roofing strip, at eaves and in valley intersections, to stop water from penetrating through the shingles because of ice damming (fig. 4)
- Use high heel trusses, insulate to the outside of the top plates, and install cardboard baffles to ensure ventilation at the eaves
- Keep the attic space cold by insulating it from the warm house interior, thus reducing or eliminating snow melt
- Ensure that the outer edge of the gutters or eaves trough are lower than the slope line to allow snow and ice to slide clear.

CONCLUSIONS/RECOMMENDATIONS

Though a number of factors enter into the formation of condensation and ice dams, the fundamental problem is undesirable attic heat, which results in a warm roof surface. The solution is to maintain a cold roof. It is essential that the temperature of the air in the attic be same or as close to the outside air temperature.

CMHC's new report is the strongest official document to date that puts attic ventilation in proper perspective. Ventilation is needed to keep attics dry in spring, but in a growing number of cases it cannot cope with the moisture load coming from inside the house. This load can be reduced by preventive measures. According to CMHC and William B. Rose of the Building Research Council, University of Illinois, and the number one priority in coping with attic moisture problems – including ice damming and condensation – is to stop the air in the attic from becoming warm and moist from internal sources.

Spores of mold and mildew are showing up far too often in too many homes, sometimes in houses not yet two year old. Small children, elderly people, and people with allergies or respiratory problems are especially at risk. Asthma levels in Canada have increased three fold in the last 20 years; this is blamed largely on the increase in bacteria, mold, and chemicals in the attic atmosphere. Health, comfort, structural durability, asset value, and energy costs are all affected by wet-attic problems. The new understanding of why these problems happen, and of the real role of attic ventilation, is good new for roofers. By bringing in experts help to prevent recurrence, the roofer can provide better service, reduce callbacks, and better protect the product warranty.

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Keeping the Heat In from Natural Resources Canada

Table 1: Source: *National Building Code,* Table 9.27.3.A

(NRC: *Moisture Considerations in Roof Design).*