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Ventilation for Roof Spaces

Current building codes across the country call for attic ventilation with the intent of minimizing condensation on the underside of the roof sheathing. Many building officials further suggest that summer cooling of the attic air, minimizing ice dams and extending the service life of roof materials as additional benefits of attic ventilation. Many asphalt shingle manufacturers will not warrant their products over unvented roof spaces. Over the years attic ventilation has established itself as the critical element in residential roof construction, and a lack of ventilation is routinely blamed for a variety of problems and failures.

The requirements for attic ventilation and more specifically ventilation of flat or cathedral roof spaces has come under considerable scrutiny over the past ten years with many landmark studies casting significant doubts as to the effectiveness of venting alone to control moisture related problems in roof assemblies. Without going into a historical recounting of these studies, I reference their conclusions, and acknowledge the sources at the end of this report.

Both studies: "Issues Related to Venting of Attics and Cathedral Ceilings", TenWolde & Rose (1999) and "Steep-Sloped Roofing Temperatures, a Numerical Analysis", Cash & Lyon (2002) have common results:

1.) The exclusion of warranty of roofing materials installed over non-vented roof decks has no justification; variations in geography, aspect, and colour of the shingles have greater influence on the average temperature of the shingles than the degree of venting.
2.) The necessity and effectiveness of vents in cathedral ceilings in cold and mixed climates is still a contested issue. Unvented cathedral ceilings can perform satisfactorily in cold and mixed climates if the cavity is properly insulated, measures are taken to control indoor relative humidity and minimize air leakage into the roof cavity, and a vapour retarder is installed in the ceiling.

Therefore from a research standpoint the necessity for ventilation of cathedrals has come under question. From a codes standpoint the issue of roof ventilation and vented air spaces has been debated and under review for years. The last issue of the model building code for the country, the National Building Code, included provision for those assemblies which can demonstrate that venting is not necessary can exclude this requirement from a proposed roof assembly.

The pertinent code reference 9.19.1.1. "Required Venting" and the Appendix note A-9.19.1.1.(1) "Venting of Attic and Roof Spaces" discusses why certain assemblies do not require the vented space. In fact the original exclusion from this clause was granted to pre-fabricated housing manufacturers using fibreglass insulation in cathedrals who successfully argued that they had greater control of workmanship with respect to the vapour barrier and could therefore stop moisture from migrating to the roof sheathing. The Ontario Building Code (OBC) has further issued an opinion on the internet at http://obc.mmah.gov.on.ca regarding exclusion to ventilation requirements for roof spaces, stating that “where a roof assembly is filled with rigid insulation (no gaps or empty space in between), Subsection 9.19 of the OBC need not apply and may be considered to be acceptable under sufficiency of compliance in Section 2.7 of the OBC. This opinion is based on the fact that, if a roof assembly does not contain any air space or air pockets in between, air will not turn into vapour and condense within such an assembly even under extreme weather condition.”

The requirements are easing up and the above branch opinion of the Ministry of Housing clearly recognizes this. However their opinion is based upon “filling the roof cavity” and they go on to state why they want it filled. So really the issue is not whether sprayed polyurethane foam (SPF) can be used at this location in the roof/ceiling assembly, but how.

Certainly the proposed assembly (SPF installed to the underside of the roof sheathing) with an air-tight low vapour permeance layer of sprayed polyurethane foam insulation eliminating any air leakage to the roof underside meets the criteria of preventing condensation at the roof sheathing. If it can be shown that leaving an air space between the SPF and the interior finish will not result in any condensation within this air space, then the requirement for filling the space can be relaxed as well. This determination can be achieved with a dewpoint/condensation potential analysis using the data from the specific roof assembly as inputs. The following analysis represents a generic cathedral ceiling and is equally applicable to flat roof assemblies.

Analysis

Water vapour flowing through an assembly in the winter from inside the structure toward the outside will condense when this vapour comes into contact with a temperature plane below the dewpoint for this vapour. For this design review, we will examine condensation potential on the underside of the foam insulation, i.e. in the air space between the foam and the inside finish.

At a given temperature the percentage of moisture present in comparison to the maximum that air can hold at that temperature is called relative humidity (RH). For example, a relative humidity of 50% means the air contains only half the moisture it is capable of holding, and a relative RH of 25% indicates that the air could hold four times as much. At a relative humidity of 100% it cannot hold any more water and is said to be saturated. The temperature at this saturation state is called the dewpoint temperature. When saturated air is cooled to a lower temperature, it cannot hold as much moisture so the excess water vapour returns to the liquid state. In other words, condensation occurs. The dewpoint temperature will vary depending upon on the air temperature and humidity. The following calculation(s) represents condensation potential, using steady state temperatures across the assembly. They are also calculated at 35% RH which is typical. In these calculations the individual RSI-values can be assigned slightly different numbers however, their relative values will not significantly alter the results.

A simple calculation determines the likelihood of condensation forming within the roof/ceiling air space.

$$T_x = T_i - (\Sigma R_x / \Sigma R(T_i - T_o))$$

Where: T_x = temperature at the underside of the sprayed polyurethane foam insulation

T_i = design temperature of the inside air

T_o = winter design temperature of the outside air

ΣR = sum of the thermal resistance of the assembly, including inside and outside air films

ΣR_x = sum of the thermal resistances from the inside to the underside of the sprayed polyurethane foam insulation

The following data was used in these calculations:

T_x = temperature at the underside of the sprayed polyurethane foam

$T_i = 21^\circ$ C

$T_o = -43^\circ$ C

At 85mm sprayed polyurethane foam thickness:

Material		**RSI-values**	
Outside Air Film		0.03	
Roof shingles		0.00	
Up to 19mm Roof Sheathing		0.11	
Min. 85mm Spray Foam		3.50	T_x
Air Space (up to 150mm)		0.25	
Poly Vapour Barrier		0.00	
13mm Gypsum Board		0.08	
Interior Air Film		0.11	
	ΣR	4.08	

ΣR_x = sum of the thermal resistances from the inside to the underside of the sprayed polyurethane foam insulation = 0.44

$T_x = 14.1^\circ$C

The dewpoint for 21° C, 35% RH air is 2.7° C, therefore for the generic assembly with a minimum thickness of sprayed polyurethane foam, the probability of condensation is negligible. This should allay any concerns over a void between the interior finish/vapour barrier and the spray foam resulting from different framing/truss sizes. The temperature chosen for this calculation was based upon the winter design temperature for Yellowknife.

Therefore in my opinion we can eliminate the need for ventilation completely for properly designed cathedrals and flat roof spaces constructed of either dimensional lumber or prefabricated wooden trusses or joists.

Regards,

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References:

1.) TenWolde, A, Rose, W. 1999. “Issues Related to Venting of Attics and Cathedral Ceilings”, ASHRAE Transactions V 105.
2.) Cash, C.G., Lyon, E.G. 2002. “What’s The Value of Ventilation” Professional Roofing March Issue, National Roofing Contractors Association.

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