Issues Related to Venting of Attics and Cathedral Ceilings

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ABSTRACT

Current model building codes require attic ventilation in all U.S. climates. Originally, these requirements were strictly based on concerns for condensation in attics during winter in cold climates, and they were based on limited technical information. Nevertheless, attic ventilation has become the uncontested strategy to minimize condensation and ice dams during winter and extreme attic temperatures during summer However, other strategies exist that address each of these problems as well as or better than attic ventilation. This paper examines issues such as summer attic temperatures, ice dams, and shingle durability and discusses the relative merits of attic ventilation compared to alternative design approaches in various climates. The authors support current recommendations for attic ventilation in cold and mixed climate but recommend that attic ventilation be treated as a design option in warm, humid climates. The authors review the new information on attic and roof ventilation in the 1997 ASHRAE Handbook—Fundamentals *and discuss the reasons for the changes.*

INTRODUCTION

Current building codes typically call for attic ventilation with the aim of minimizing condensation on the underside of roof sheathing. Summer cooling of the attic air, minimizing of ice dams, and extending the service life of the roof materials are often cited as additional benefits of attic ventilation. In fact, many asphalt roofing manufacturers warrant their products only for ventilated roofs. Attic ventilation is now firmly established as a critical element in residential roof construction, and lack of ventilation is routinely blamed for a variety of problems and failures.

However, there may be reasons why adding attic vents is either impractical or undesirable. Architectural details or geometry may be such that effective attic ventilation is improbable in all or part of the roof. Closing vents may be desirable for sound mitigation, especially near airports. Attic vents may also be undesirable for esthetic or historical reasons. Finally, venting rules for attics have been extended to apply to cathedral ceilings, but the validity of that extension has never been truly demonstrated. These issues have led us to reexamine the rationale for the current universal requirement in the United States for ventilation of all attics and cathedral ceilings in all climatic regions.

The earliest published research on attic ventilation in the Unites States was conducted by Rowley et al. (1939). Their conclusions included a promiment recommendation for indoor humidity control as an effective way to reduce condensation in roof and walls. They also recommended attic ventilation, but not specific attic ventilation rates or openings. The first requirements for 1:300 vent openings were promulgated in 1942 by the Federal Housing Administration (FHA 1942) with no supporting statement indicating a research basis. Subsequent research by Britton (1948) and Jordan et al. (1948) was inconclusive as to the need or adequacy of 1:300 attic vent openings, but this research pointed to other important factors that influence attic moisture levels. Britton (1948) found that a wet foundation could lead to high moisture levels in the attic. In a field study of three occupied houses in Madison, Wisconsin, Jordan et al. (1948) found that high absolute humidity in the living space correlated with attic condensation and moisture in the walls. However, by the time the Housing and Home Finance Agency (HHFA 1949) published *Condensation Control in Dwelling Construction,* this message had been lost,

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and the myopic fixation on attic and crawl space ventilation and the use of vapor retarders as moisture control strategies was firmly established.

The goal of this paper, as well as that of the 1997 ASHRAE *Handbook—Fundamentals* (ASHRAE 1997), is to restore balance to the approach to moisture control and to put attic ventilation in the appropriate context of a wider range of moisture control strategies.

MOISTURE CONTROL

Cold Inland Climates

Rowley et al. (1939) provided the first documented evidence that attic ventilation can reduce condensation on roof sheathing during cold weather. However, these researchers deemed ventilation necessary only if the ceiling did not have a vapor retarder. Natural attic ventilation and mechanical ventilation were tested in small test houses (57 by 57 in. [1.45 m by 1.45 m]) inside a conditioned room. The natural ventilation consisted of two gable vents, each with an opening of about 5.6 in.^{2} (36 cm^2) (total vent opening of 1:288), and the mechanical ventilation consisted of 0.05 cfm/ft^2 (0.25 L/s·m^2). Both types of ventilation were effective in eliminating condensation with an outdoor temperature of –10°F (–23°C) and indoor conditions of 70°F(21°C) and 40% relative humidity (RH). Reducing the vent openings or mechanical ventilation by 50% produced some condensation on the sheathing. This report probably provided the basis for the current 1:300 rule, even though Rowley et al. called this a preliminary study.

At first glance, the study by Rowley et al. (1939) appears to be of good quality, but the report raises some questions and concerns. First, the report does not specify the duration of each test. The paper indirectly indicates that the time for each case was short-on the order of two to three days. This short time would not have allowed the hydroscopic building materials to come to full equilibrium. Second, the means of measuring the moisture accumulation is sketchily described as the measurement of frost accumulation on metal plates; the results are given in terms of rate of accumulation. How the plates were installed and retrieved is not addressed. Most likely the plate was installed in the sample, and frost accumulation was based on a single measurement at the end of a short test sequence. The use of metal plates also ignores the difference between condensation on metal surfaces and moisture storage in hydroscopic and porous materials, and it tends to overestimate the potential for damage under transient conditions. Third, the reported total amounts of moisture accumulation are minor. The critical finding-that condensation occurred in the unvented attic but not in the naturally vented attic (1:288 total vent opening)—is based on a measured accumulation rate of 3.3 g/ft^2 (36 g/m^2) per 24 hours at the relatively severe conditions of –10°F (–23°C) outside and 40% relative humidity inside. At this rate and at these steady conditions, pine sheathing would require almost a month to change from 10% to 20% moisture content, which is still within the safe range. Given these considerations, Rowley's recommendation for attic ventilation is, in our view, not fully supported by the data.

Britton (1948) of the U.S. Housing and Home Finance Agency conducted tests of vented and unvented flat roof assemblies in a steady-state climatometer. The tests lasted several weeks and measurements were taken intermittently, an improvement over the tests by Rowley et al. (1939). However, Britton encountered procedural difficulties of sampling during the test, and he noted frost accumulation at anomalous places such as access ports and cable entries. The results of these tests provide some support for attic ventilation. However, this work was interrupted because of lack of funds, and the final results for roof systems were never presented. For actual buildings, Britton noted the importance of air pathways between the attic and the foundation area. This understanding is very fruitful in attic moisture forensics. Britton also recommended attic ventilation, and he appears to be the principal author of the tables on which climate-specific attic ventilation was first based (Britton 1949).

Jordan et al. (1948) took moisture readings in three attics in Madison, Wisconsin, during winter. Condensation in the attic occurred only in the house with high humidity in the living space. Signs of condensation also appeared in the walls. In this house, attic gable vent openings totaled about 1:520. The attic with 1:430 vent openings was the driest and also had the lowest indoor RH. In all three houses, higher moisture conditions in the attic corresponded with higher humidity conditions in the living space. The importance of indoor humidity was also evident in a recent survey of moisture levels in attics (BLP 1991), where "high attic moisture content was not found in the absence of high house humidities."

Early studies on attic moisture generally concluded that ceiling vapor retarders were effective in lowering attic moisture levels. This conclusion led to the provision that the attic vent area could be lowered to 1:600 if a ceiling vapor retarder were present. However, Hinrichs (1962) noted that air infiltration through the ceiling into the attic was the major source of condensation, and he therefore concluded that a vapor retarder was not a dependable means of attic moisture control. Dutt (1979) posed the question more directly and, on the basis of his calculations, argued in favor of an airflow retarder in the ceiling in addition to a vapor retarder. Samuelson (1995) demonstrated that if no air is moving from the living space to the attic, the higher temperatures in unvented attics make these attics drier. However, he stated that to guarantee no indoor air movement into the attic, the ceiling has to be airtight and the pressure of the attic air needs to be higher than that of the indoor air (i.e., pressurized attic or depressurized living space).

Thus, three important parameters emerge that regulate attic moisture conditions in cold climates: (1) indoor humidity, (2) ceiling airtightness and air pressure, and (3) attic ventilation. Burch et al. (1997) used a mathematical model to investigate the effect of various factors on roof sheathing moisture content in a cold climate (Madison, Wisconsin). Their analysis showed similar benefits from attic ventilation and turning off the humidifier (i.e., lowering indoor humidity). In their analysis, the benefits of increasing airtightness of the ceiling are modest, partly because they assumed that an airtight ceiling will reduce ventilation of the living space and therefore increase indoor humidity. This illustrates that increasing airtightness is unlikely to lead to significantly lower humidity in the attic unless it is accompanied by measures to control indoor humidity or increase attic air pressure to eliminate all airflow to the attic. In addition to requiring a fan pressurizing the attic, this approach demands an unvented, airtight attic. However, pressurization of the attic is usually not a practical solution since it may lead to air infiltration with potentially negative consequences for energy efficiency and indoor air quality.

The discussion of moisture conditions in attics and cathedral ceilings seems to be monopolized by the case of a framed cavity with a porous insulation material such as glass fiber. Other constructions deserve attention as well, notably roof systems with foam thermal insulation (which is relatively vapor impermeable) applied directly to the underside of the roof sheathing. When foam insulation is used in walls and low-slope roof systems, it generally demonstrates good moisture performance. In a sloped roof assembly, equally good moisture performance should be expected. When the foam is applied directly to the sheathing and carefully sealed, there is no moisture performance advantage to venting such roof systems (Rose 1995; Samuelson 1992).

This discussion clearly shows that in cold climates the two most effective measures to lower attic moisture conditions are first indoor humidity control and, as a secondary measure, attic ventilation. Indoor humidity control is beneficial to the entire building envelope, and it should, therefore, lead the list of recommendations. In cold climates, indoor humidity control is most easily accomplished by ventilating the living space, which also improves indoor air quality. It is also achieved by correcting wet foundations, disabling humidifiers, and correcting backdrafting of combustion appliances. In addition, attic ventilation in a cold climate clearly makes a cavity roof more moisture-tolerant and should therefore be encouraged as an additional safeguard in cold climates, unless foam insulation is applied directly to the roof sheathing.

As stated in the introduction, there may be reasons why adding attic vents is impractical or undesirable. The research clearly indicates that unvented attics in cold climates can perform well if indoor humidity is controlled, and, thus, there should be no objections to unvented attics as long as there is assurance that winter indoor humidity will remain low. In the case of rehabilitation of historical buildings or other buildings, this can often be judged from the previous performance of the building. In both new buildings and existing buildings, humidity control can be ensured by properly designed ventilation systems.

In cold climates, cathedral ceiling construction is inherently more prone to moisture damage than is attic construction because isolated conditions are created in each rafter cavity. While providing effective ventilation to attics with simple geometries is relatively easy and inexpensive, providing effective soffit and ridge ventilation to each individual cavity in a cathedral ceiling is far more difficult and the advantages of roof vents over normal soffit air leakage are slight (Rose 1995). Furthermore, Rose (1992) showed that during winter, a cathedral ceiling cavity with ridge vents but without sufficient soffit vents may act as a chimney and admit harmful amounts of humid indoor air into the cavity. Wind washing of the insulation, when cold air penetrates the ceiling insulation, is another common problem with ventilated cathedral ceilings, especially near the softlt vents. On balance, the case for vents in a cathedral ceiling is much weaker than that for attic vents. Indoor humidity control, combined with an airtight ceiling plane with a vapor retarder, can provide reliable moisture control in an unvented cathedral ceiling. However, while humidity control can usually be accomplished by providing adequate building ventilation, an airtight ceiling maybe much more difficult to achieve in practice. In addition to those measures, Rose (1995) demonstrated that the use of foam air chutes between the sheathing and the top of the insulation can be beneficial for moisture control in cathedral ceilings.

Wet, Cold Coastal Climates

All of the early studies were performed in cold climates or simulated cold climates. More recent data on attic ventilation in cold, wet coastal climates provide a different perspective. In such climates, the moisture in the outside air carried into the attic by ventilation is a major source of moisture in the attic. Using computer model simulation, Forest and Walker (1993) found that in wet coastal climates in Canada high attic ventilation rates resulted in higher sheathing moisture contents than did lower ventilation rates. The higher ventilation rates produced colder attics without sufficiently lowering attic water vapor pressures, resulting in high attic RH and moisture content in the sheathing. This suggests that unvented attics could have an advantage in wet, cold coastal climates, as long as indoor humidity is controlled by ventilation or dehumidification.

Warm, Humid Climates

No scientific claims have ever been made that attic ventilation is needed for moisture control in warm, humid climates. In these climates, the outside air is much more humid than the inside air, which is cooled and dehumidified by air conditioning. In such climates, attic venting tends to increase rather than reduce moisture levels in the attic. Air-conditioning ducts are commonly located in the attic space, and attic ventilation with humid outdoor air may therefore increase the danger of condensation on these ducts. When the ceiling is not airtight, attic ventilation may also increase the latent cooling load in the building. In short, if attic ventilation is required or recommended in warm, humid climates, it must be based on considerations other than moisture control.

ICE DAMS

Although attic ventilation is now generally credited for minimizing ice dams, early requirements for attic ventilation were entirely based on minimizing condensation in cold climates. The 1949 publication *Condensation Control in Dwelling Construction* (HHFA 1949) did not even mention minimizing ice dams as a potential benefit of attic ventilation but recommended installation of heavy roll roofing felt or sheet metal under the shingles over the eaves. By 1967, the "cold roof" concept had been introduced, but it was based on a combination of measures. Baker (1967) stated that for a permanent solution to ice dams, "consideration must be given to more adequate roof or ceiling insulation, ventilation of air spaces above the insulation, and moderation of inside temperatures." He observed that on insulated buildings, ice dams form at outdoor temperatures above 15°F (–9°C). Latta (1973) recognized the importance of air leaks and recommended attic ventilation but only after "blocking all passages by which warm air can leak into the space below the roof." Wolfert and Hinrichs (1974) only briefly mentioned ice dam minimization in their manual on attic ventilation.

Grange and Hendricks (1976) authored the first publication that fully focused on ice dams. They emphasized a combination of attic vents at the eaves and ridge and minimization of all attic heat sources. The importance of attic heat sources strongly emerged in a recent study of 33 houses in Ottawa, Ontario, Canada (SC 1996). All 16 houses with ice darns had interior chimneys, and their attics were about 7°F (4°C) warmer than attics of houses without ice dams. Houses with ice dams also tended to have less insulation in the ceiling and less cave ventilation, either due to fewer soffit vents or fewer insulation baffles at the eaves.

An important study of ice dams was conducted by Tobiassonet al. (1994), who observed that ice dams seldom occurred when outdoor temperatures were above 22°F (–5.5°C). Since ice dams also did not occur when the attic air temperature was below freezing, the researchers arrived at a "window" of temperature conditions that lead to ice darns. Conversely, ice dams can be avoided if attic air temperature can be kept below 30°F(–l°C) with an outdoor temperature of 22°F(–5.5°C). The authors proposed using this temperature combination for the design of attic ventilation, particularly the sizing and control of mechanical attic ventilation fans, and they showed the effectiveness of this approach in a building with severe ice dam problems.

The design temperature conditions delineated by Tobiasson et al. deserve some additional examination. We will determine how much snow is needed to create these design conditions in an unvented attic with a simple, steady-state temperature calculation. This simple calculation is intended to provide approximate numbers only. Table 1 shows the assumptions made in the calculation. We ignored the effect of solar radiation because much of the solar radiation is reflected by the thick snow cover and, therefore, does not significantly affect snow melting at the roof surface. First, we will assume no airflow into the attic or any heat source in the attic. Thus, in our calculation, all heat flow into the attic is through the attic insulation. Under those conditions, it would take at least 16 in. (405 mm) of snow on the roof to maintain the required 30°F (–l°C). To melt any snow, 143.5 Btu of heat would be needed per pound (334 kJ/kg) of snow on the roof, or about 84 Btu per square foot per inch of snow (3.5 kJ/mm·m^2). Ignoring the roof pitch, it would take 63 hours to melt 1 inch (25 mm) of snow with on a house with R-30 attic insulation and no other heat source. As snow melts, its insulating value decreases and more heat is therefore needed to maintain the attic above freezing. It seems obvious from these results that even an unvented attic is very unlikely to develop significant ice dams unless there are significant heat sources in the attic or significant warm air leakage from below. Chimneys, warm air ducts, attic hatches, plumbing vent stacks, or leaky bathroom exhaust fans are common sources of heat and warm air in the attic. These sources usually represent unnecessary heat loss, and it is, therefore, logical that any ice dam reduction strategy should focus on air leakage and heat sources first, before prescribing increased ventilation.

TABLE 1
Parameter Values Used in Calculation of Snow Depth

Variable	Assumed Value
Room temperature	70°F (–21°C)
Outdoor temperature	22°F (–5.5°C)
Attic temperature	30°F (–l°C)
R-value attic insulation	30 h·ft^2·F/Btu (5.3 m^2·K/W)
Thermal resistivity of snow[a]	0.25 hft^2·F/Btu·in. (1.7 m·K/W)
Density of snow[a]	7 lb/ft^3 (100 kg/m^3)
Heat of fusion of snow	143.5 Btu/lb (334 kJ/kg)
R-value of roof	2 h·ft^{2}F/Btu (0.35 m^2·K/W)

[a] Value is for freshly fallen snow (ASHRAE 1997).

The ability of vents to minimize ice dams is more questionable for cathedral ceiling roofs than for roofs over attics. The amount of venting needed to maintain the necessary cold conditions on the top of the roof is difficult to accomplish with vents. Mechanical ventilation of cathedral ceilings is not a practical option. Thus, ice dam minimization on cathedral ceiling roofs should focus on optimizing roof insulation and minimizing penetration of the insulation and roof. In roofs prone to ice dams, it is advisable to use waterproofing underpayment at the eaves, in valleys, and wherever snow drifts and ice dams are likely to occur.

DURABILITY OF SHINGLES

Many asphalt shingle manufacturers do not currently warrant their shingles on unvented roofs. The rationale is that shingles on unvented roofs are hotter and more prone to moisture damage than are shingles on vented roofs. Higher shingle temperatures accelerate aging, but does ventilation significantly reduce shingle temperature? There is no published research that reports the temperature of the top surface of shingles, but temperatures have been measured directly under shingles. During warm sunny days, temperatures directly under a shingle can be assumed to represent the minimum shingle temperature. The exterior surface temperature of a shingle is almost exclusively governed by a balance of absorbed solar radiation, convective surface heat loss (wind), and infrared radiation loss to the sky. Rose (1992) found that attic ventilation lowered the peak temperature of the sheathing surface directly below the shingles by about 10°F (6°C). The peak temperature below the shingles on unvented cathedral ceiling roofs was also higher than that on vented cathedral ceiling roofs, as long as a 1.25 in. (32 mm) ventilation slot was present between insulation and sheathing. Thus, attic or roof ventilation lowers peak shingle temperature by less than 10°F (6°C) because the effect of ventilation decreases closer to the shingle's exterior surface. This increase translates into a relative change in absolute temperature of less than 2%. As the rate of aging is likely related to absolute temperature, the effect of this modest rise in temperature is likely to be very small. The "color" of shingles has a greater effect on shingle temperature, and, hence, shingle durability, than does attic ventilation. Simpson and McPherson (1997) found that white roofs were as much as 36°F (20°C) cooler than gray roofs and as much as 54°F (30°C) cooler than brown roofs.

Of more concern may be the fact that the temperature of shingles over unvented attics and cathedral ceilings is more than 160°F (71°C) for a significantly longer time compared to that of shingles over vented roofs. However, currently no data are available on the effects of temperature duration on the durability of asphalt shingles. Here again, the color of the roof plays a more significant role than does ventilation. Ventilation can only be viewed as a supplementary strategy for lowering shingle temperatures.

The danger of moisture accumulation has also been mentioned as the reason for warranty restrictions. The merits of attic ventilation in controlling moisture in the attic sheathing have been discussed previously. If the concern is the moisture content of the shingles themselves, rain and sun are far more direct influences than is attic ventilation.

In short, on the basis of currently available information, we believe that it is unlikely that attic ventilation plays a major role in extending the service life of roof shingles. In our view, unless solid information to the contrary emerges, attic ventilation does not deserve the attention or credit it has received in relation to shingle durability.

HEATING AND COOLING LOADS

A 1978 workshop at the National Bureau of Standards (now the National Institute for Standards and Technology) brought together several researchers to discuss "Summer Attic and Whole-House Ventilation." The research results were published in a proceedings of that title, and the contributions to that workshop call into question the notion that attic ventilation saves cooling costs.

Dutt and Harrje (1978) compared six occupied townhouses in Twin Rivers, New Jersey, that were equipped with attic fans to similar townhouses without attic fans. The attics with fans were substantially cooler. However, these researchers noted that the heat flux across the ceiling was "a very small part of the house air-conditioning load" and "any difference between the air conditioner use between houses with and without attic fans is not discernible from other factors which lead to house-to-house variation in air conditioner use." Homes with and without powered attic fans used the same amount of energy for cooling, despite the wide difference in attic temperature. With the cost of operating the fan included, mechanical ventilation was a net energy loser. The authors conclude that some measures, such as increased attic or wall insulation, and the judicious location of windows and overhangs are probably effective in conserving energy in both summer and winter. They strongly conclude that means other than ventilation would be more effective in reducing summer cooling costs.

Grot and Siu (1978) reported that for ceiling insulation levels of R-11 land R-30, the ceiling heat gain for a two-story townhouse is only a small portion (less than 10%) of the sensible cooling load in central New Jersey. These researchers did not observe any difference in the operation of the air conditioner under average or maximum conditions.

Burch and Treado (1978) studied the effect of attic ventilation on heat gain. They compared closed ventilation, soffit vents, ridge vents, two 14 in. (0.36 m) diameter wind-driven turbines, and a 14 in. (0.36 m) diameter roof-mounted attic fan, rated at 1260 ft^3/min. (595 L/s) and controlled by a thermostat. These authors conclude that attic ventilation is not an effective energy conservation procedure for houses with 4 in. or 6.5 in. (102 mm or 165 mm) thick ceiling insulation. Performance of soffit vents without ridge vents was much like performance without ventilation, and enhanced ventilation (i.e., ridge vents, turbines, or a power fan) in addition to soffit vents produced less than 3% reduction in daily cooling loads for test houses.

However, Beal and Chandra (1995), in a more recent study, found that soffit vents were important in providing cooling to the attic. They found that a 1:230 attic vent ratio gave a 25% reduction in heat flow through the ceiling, but they did not indicate how much this decreased the total cooling load of the building.

In many houses in the southern Unites States, cooling equipment and/or air distribution or return ducts are located in the attic despite recommendations against such practice. Ducts usually leak air and, thus, attic air may be pulled directly into the house. Although venting can lower the dry-bulb temperature of this air, much of the time the wet-bulb temperature is likely to be higher in vented attics, especially in warm, humid climates. Thus, while the additional sensible load resulting from duct leakage may be lower in homes with vented attics, the additional latent load is likely to be higher.

Finally, attic ventilation allows outdoor air pressure variations to act directly across the ceiling plane. Homes with attic ventilation may have greater rates of air exchange across the ceiling compared to homes with closed attic air spaces, and this would carry a cooling season penalty.

In summary, attic ventilation may cool attic spaces, as insulation installers well know, and it has been tempting to imagine a direct translation of that temperature difference into cooling energy savings. However, heat gain through the ceiling represents a small amount of the total sensible gain, latent load increases due to attic ventilation may offset sensible load decreases, and attic ventilation may slightly increase winter heating loads. As with other desirable performance characteristics, attic ventilation takes a back seat to more direct methods. Savings in cooling energy can be achieved more directly with good insulation levels, efficient and well-maintained cooling equipment, latent load reduction, reduced solar and appliance heat gains, and use of natural strategies such as light-colored surfaces and good interior airflow.

CONCLUSIONS

We conclude that while attic ventilation can be beneficial under some circumstances and climates, it should not be viewed as the principal strategy to eliminate moisture and other problems in the attic and roof. Rather, attic ventilation should be part of a broader range of control strategies. Taking all factors into account, we make the following specific recommendations:

- Indoor humidity control should be the primary means to limit moisture accumulation in attics in cold and mixed climates; we recommend attic ventilation as an additional safeguard.
- To minimize the danger of ice dam formation, heat sources in the attic and warm air leakage into the attic from below should be minimized. Additional measures, including additional attic vents or temperature-controlled mechanical attic ventilation, should be considered. However, mechanical ventilation should not repressurize the attic.
- We recommend venting of attics in cold and mixed climates. However, if there are strong reasons why effective attic vents are undesirable, unvented attics can perform well in cold and mixed climates if measures are taken to control indoor humidity, to minimize heat sources in the attic, and to minimize air leakage into the attic from below, or vice versa.
- 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 humidity and minimize air leakage into the roof cavity, and a vapor retarder is installed in the ceiling.
- Ventilation should be treated as a design option in cold, wet coastal climates and hot and humid climates. Current technical information does not support a universal requirement for ventilation of attics or cathedral ceilings in these climates.
- Research should be directed toward better understanding of the factors that affect shingle durability and toward minimizing air leakage into the attic from below.

In summary, for each of the most commonly cited claims of benefits offered by attic ventilation-reducing moisture problems, minimizing ice dams, ensuring shingle service life, and reducing cooling load—other strategies have been shown to have a stronger and more direct influence. Consequently, attic ventilation should be shifted away from its position as the centerpiece and focus of regulation. The performance consequences of other design and construction decisions should be given increased consideration.

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