Investigation of Ventilation Drying of Rainscreen Walls in the Coastal Climate of British Columbia

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ABSTRACT

Building envelope failures that occurred in recent years in the region of southern British Columbia (BC) promoted the adoption of rainscreen principle in both rehabilitation and new construction. An air cavity behind the cladding would provide a capillary break and allow water that may penetrate the cavity accidentally to drain out. Some drying would also occur through ventilation if vents are provided at both the top and the bottom of the cavity. Existing research has indicated that ventilation helps drying in certain climates, but how beneficial it is to the damp southern BC climate, characterized by long periods of rain and wetting, is unknown. Current practice varies in terms of specifying cavity depth and slot vent heights for panel systems. A research program is developed to study the influence of design details on the drying performance of building envelope systems through analysis and field measurements.

A simplified method is applied to estimate the drying provided by cavity ventilation for a stucco wall under steady-state conditions, assuming that the sheathing panel stays wet. The analysis shows that the cavity depth and vent size have a positive impact on the airflow rate in the cavity; however, the amount of moisture removed by the ventilation is governed by the properties of the sheathing membrane once the airflow rate reaches a threshold value. For panel systems, an air cavity depth of 19 mm (3/4") provides higher airflow and drying rates compared to a 10 mm (3/8") cavity. For cavity depths greater than 19 mm (3/4"), higher ventilation rates can be achieved through larger vent openings, but the drying rates are not significantly influenced. A similar trend is observed from simulation results using a commercially available computer program. Two wetting conditions are investigated, the first assuming an initially wet sheathing panel, and the second assuming 1% rain leakage into sheathing panels. The simulation results show that ventilation does help drying but that an optimum ventilation rate does exist. Once this optimum ventilation rate is exceeded, ventilation may induce wetting. Analysis of field monitored data also indicates occurrence of ventilation wetting due to clear sky radiation. These observations will be verified through field measurements of full-scale wall assemblies on a two-story building envelope test facility under controlled indoor and realistic outdoor conditions.

INTRODUCTION

The 2006 British Columbia Building Code (BCBC, 2006) calls for rainscreen wall construction in the region west of the coastal mountain in BC. The primary function of the air cavity behind the cladding is to provide a capillary break and drainage for accidentally entered rain water or condensation. The air cavity also provides drying for wet materials that enclose the cavity, i.e. wetted cladding or wetted sheathing panels, if an open vent is also provided at the top. In response to the building envelope failures, which occurred in the region of southern BC, the rainscreen principle has been widely adopted in both retrofit and new construction. The current common practice in this region is to design a rainscreen wall with a minimum air cavity depth of 10 mm (3/8 in.). The City of Vancouver Bylaw (1999) requires an air cavity of 19 mm (3/4 in.) instead. Although rainscreen design is already a common practice in this region, questions regarding the drying capacity provided by the cavity ventilation still

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remain. For example, how much drying can the cavity ventilation provide under damp winter conditions in this region? There is also the question regarding ventilation wetting potential. There is no consensus regarding the size of vent height. Some practitioners prescribe the same opening size for both the bottom and top vents while others prefer much smaller top vents (i.e., 6 mm) to minimize rain penetration and ventilation wetting. Field examination also showed a variation of construction, some with clear opening at the top but others with the top opening blocked.

Extensive research has been done on evaluating the airflow rate in the air cavity and the moisture removal by cavity ventilation through laboratory testing, field measurements, and simulations (Bassett and Mcneil 2005a, 2005b; Davidovic 2004; Hansen et al. 2002; Hazleden 2001; Straube and Burnett 1995; VanStraaten and Straube 2004; Onysko 2003). The parameters studied include types of cladding, ranging from brick to wood siding, vinyl, and metal; air cavity geometry including cavity depth and vent size; and moisture removal under various climatic conditions (winter vs. summer) and moisture loading (wet cladding vs. wet sheathing panels). The general conclusions are that ventilation drying is beneficial for wet panel cladding and for solar-driven inward vapor diffusion in summer. The drying provided in winter is minimal (Rousseau and Dalgliesh 2004; Shi and Burnett 2006). Hazleden (2001) conducted laboratory testing on the drying performance of stucco walls with wood stud initially immersed wet. In his tests, the depth of cavity and the size of vent height were investigated. The laboratory testing indicated that panels with both bottom and top vents dried faster than comparable panels with bottom vent only, and the walls with a 19 mm cavity dried faster than panels with a 10 mm cavity. Onysko (2003) conducted a parametric analysis of ventilation drying of stucco walls by simulations. He found that the cavity depth behind the stucco significantly affects the drying rate, while the vent gap height was not as critical to the rate at which moisture was removed.

In spite of existing research, there is no field data reported in the coastal climate of BC to clarify the above questions. A research program is designed to evaluate the influence of design details on the ventilation drying and wetting in rainscreen walls through both analyses using a simplified method, a commercially available computer program, and field measurements. As a first step, analyses are carried out to estimate ventilation drying and wetting for a stucco wall with different design details to provide insights on the ventilation drying/wetting mechanism and provide guidelines for the experimental design. This paper presents the analysis procedure and results.

ANALYSIS

The amount of moisture to be removed by cavity ventilation is determined by the airflow rate, the moisture ratio of outdoor air, and the moisture ratio of cavity air at the exit. The condition of air at the outlet is governed by the heat and mass transfer between air and cavity surfaces. Therefore, three steps are followed to estimate the moisture removal by cavity ventilation. Firstly, the airflow rate induced by pressure difference driven by thermal buoyancy and wind pressure; secondly, the temperature profile of the air flowing through the cavity since the air temperature at the outlet determines its capacity for moisture intake; and thirdly, the actual moisture removal under specific moisture loads.

Calculation of Airflow Rate

A set of equations were developed by Straube and Burnett (1995) and widely adopted by other researchers (Davidovic 2004; Bassett and McNeil 2005a, 2005b) to calculate cavity airflow rate. To accurately estimate the airflow rate, the assumption of friction loss factors for the exit, entrance and the cavity are critical.

$$\Delta P_{drive} = \Delta P_{entrance} + \Delta P_{cavity} + \Delta P_{exit} \tag{1}$$

$$\Delta P_{entrance} = (\xi_1 + \xi_{elbow}) \cdot \frac{\rho}{2} \cdot \left(\frac{Q}{A_{entrance}}\right)^2 \tag{2}$$

$$\Delta P_{exit} = (\xi_2 + \xi_{elbow}) \cdot \frac{\rho}{2} \cdot \left(\frac{Q}{A_{exit}}\right)^2 \tag{3}$$

where ρ is the air density, Q is airflow rate, and A is the area of the entrance and exit openings. ξ_1 and ξ_2 are friction loss factors for the entrance and the exit, respectively. Straube and Burnett (1995) recommended $\xi_1 = 0.5$ for the entrance and $\xi_2 = 0.88$ for the exit. These values are valid for turbulent flow. Straube et al (2004) adopted Idelchik's equation (Idelchik 1994) to calculate friction loss factors for laminar and transitional flow as follows:

$$\xi_{entrance} = 6.5\ \mathrm{Re}^{-0.4} + 0.5 \cdot (0.066 \ln(\mathrm{Re}) + 0.16) \tag{4}$$

$$\xi_{exit} = 6.5\ \mathrm{Re}^{-0.4} + 0.066 \ln(\mathrm{Re}) + 0.16 \tag{5}$$

ξ_{elbow} is the friction loss factor for a rectangular elbow or return, recommended by Hens (1992).

$$\xi_{elbow} = 0.885 \cdot \left(\frac{d_1}{d_2}\right)^{-0.86} \tag{6}$$

where d_1 is the cavity depth and d_2 is the entry slot depth.

For a laminar flow in the wall cavity, the pressure loss can be calculated as follows (Straube and Burnett 1995):

$$\Delta P_{cavity} = \frac{Q \cdot h}{4611 \cdot \gamma \cdot b \cdot d} \tag{7}$$

where, γ is a blockage factor for cavities in masonry wall, h is the height, b is the width, and d is the depth of the cavity, in m.

In this study, a local friction factor $\xi_{entrance} = 1.26$, and $\xi_{exit} = 1.49$, corresponding to a Reynolds number of 100, are used. The friction factors for the rectangular elbow of entrance and exit are calculated using equation 6.

The impact of cavity depth and vent gap height on the airflow rate for a 2.4 m (8 ft) high cavity wall is shown in Figure 1. In this calculation, it is assumed that the air flows from the bottom to the top under 1 Pa pressure differential. A range of –1 to 3 Pa was observed by Straube and Burnett (1995) through a long-term field test for a low-rise building.

The analysis shows that for a 10 mm (3/8") cavity, the airflow rate is mainly governed by the pressure loss through the cavity. The variation of bottom vent heights from 10 mm (3/8") to 19 mm (3/4") has no impact on the airflow rate. When the top vent height reaches 6 mm (3/8"), the airflow rate becomes constant. With the increase of cavity depth, the influence of the vent height becomes more significant. The variation of top vent height has slightly more influence than the bottom vent given that the exit friction loss factor is slightly higher than the entrance (1.49 vs. 1.26). When the cavity depth is increased to 38 mm (1/5"), the influence of the vent height becomes more significant, which means that when the cavity is opened up, the friction losses of entrance and exit govern the total pressure loss.

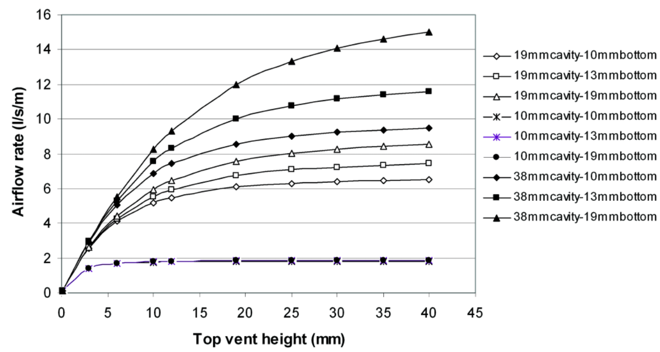

Figure 1 *Estimated airflow rate for a 2.4 m (8 ft.) high wall cavity with various cavity depth and slot vent height.*

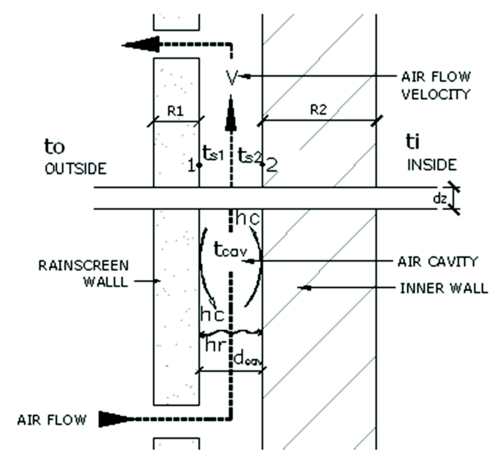

Figure 2 *Heat balance in a ventilated cavity (Hens 2003).*

Calculation of Temperature Profile in the Cavity

To predict the moisture removal by the cavity ventilation, it is important to know the influence of ventilation on the temperature profile within the cavity since the air temperature at the outlet will determine the maximum amount of moisture the ventilation air can carry.

A heat-balance procedure developed by Hens (2003) is adopted to estimate the temperature gradient of air temperature along the cavity height, as shown in Figure 2.

For a cavity with depth of d_{cav} and height of h, the heat balance for each cavity surface can be expressed as follows:

Cavity Surface 1:

$$\frac{t_o - t_{s1}}{R_1} + h_c(t_{cav} - t_{s1}) + h_r(t_{s2} - t_{s1}) = 0 \quad (8)$$

Cavity Surface 2:

$$\frac{t_i - t_{s2}}{R_2} + h_c(t_{cav} - t_{s2}) + h_r(t_{s1} - t_{s2}) = 0 \quad (9)$$

where, t_o, t_{s1}, t_{s2} and t_i, are temperatures in °C or °F for outdoor, the exterior surface of the air cavity, interior surface of the cavity, and indoor, respectively. R_1 is the thermal resistance in m^2·°C/W or ft^2·°F/Btu between the outdoor and the cavity surface 1, and R_2 is the thermal resistance in m^2·°C/W or ft^2·°F/Btu between cavity surface 2 and the indoor. h_c is the convective surface heat transfer coefficient along the cavity surface in W/m^2·°C or Btu/ft^2·°F. h_r is the radiative heat transfer coefficient between cavity surface 1 and surface 2.

The heat balance in the cavity can be expressed as follows:

$$[h_c(t_{s1} - t_{cav}) + h_c(t_{s2} - t_{cav})]\mathrm{dz} = \rho_a c_a d_{cav} v dt_{cav} \quad (10)$$

where, ρ_a is the air density, c_a is the specific heat of air, v is air speed in m/s, and z is the distance from the bottom vent.

The heat balance solution is (Hens 2003) as follows:

$$t_{cav} = t_{cav,\infty} - (t_{cav,\infty} - t_{cav,0})\exp\left(-\frac{z}{d_t}\right) \quad (11)$$

where $t_{cav,\infty}$ is the equilibrium temperature in an infinite cavity or the temperature in a non-ventilated cavity. The temperature in the air cavity changes exponentially, from the inflow value to the value without ventilation $t_{cav,\infty}$. dt is the ventilation influence length and can be calculated as follows:

$$dt = \frac{\rho_a c_a d_{cav}}{h_c(2 - C_1 - C_2)}$$

$$C_1 = \frac{h_c\left(h_c + h_r + \frac{1}{R_2}\right) + h_r h_c}{D}$$

$$C_2 = \frac{h_c\left(h_c + h_r + \frac{1}{R_1}\right) + h_r h_c}{D}$$

where

$$D = \left(h_c + h_r + \frac{1}{R_1}\right)\left(h_c + h_r + \frac{1}{R_2}\right) - h_r^2$$

The wall configuration shown in Figure 3 is used as an example to predict the temperature profile in the air cavity and ventilation drying capacity. The material properties used in the calculation are listed in Table 1. The outdoor conditions are assumed as 5°C (41°F) and 90% relative humidity (RH), typical winter conditions for the southern BC region. The interior conditions are assumed as 21°C (70°F) and 50% RH.

The temperature profile within the cavity as a function of the airflow rate is shown in Figure 4. With the increase of air speed, the air temperature slightly decreases. When the air speed increases from 0.1 m/s (0.3 ft/s) to 1.0 m/s (3.3 ft/s), the temperature at the cavity outlet drops only by about 0.4°C (0.7°F). The cavity ventilation has a minimal impact on the cavity temperature and heat loss for a well-insulated wall assembly. Therefore, the ventilation drying potential can be calculated as follows:

$$W_{max} = \rho_a d_{cav} v (W_{out-s} - W_{in}) \tag{12}$$

where W_{out-s} is the saturated moisture ratio at the outlet and W_{in} is the moisture ratio at the cavity inlet. The results are shown in Figure 5. The outlet air temperature drops with the increase of airflow rate; however, the maximum capacity for moisture removal increases due to the increased airflow rate.

Calculation of Actual Moisture Removal by Ventilation

The drying capacity provided by the cavity ventilation depends on the air conditions at inlet and outlet and the airflow rate. The actual amount of moisture removal is also governed by the moisture load and the material properties of wall components.

The mass balance procedure developed by Hens (2003) is followed to estimate the actual moisture removal.

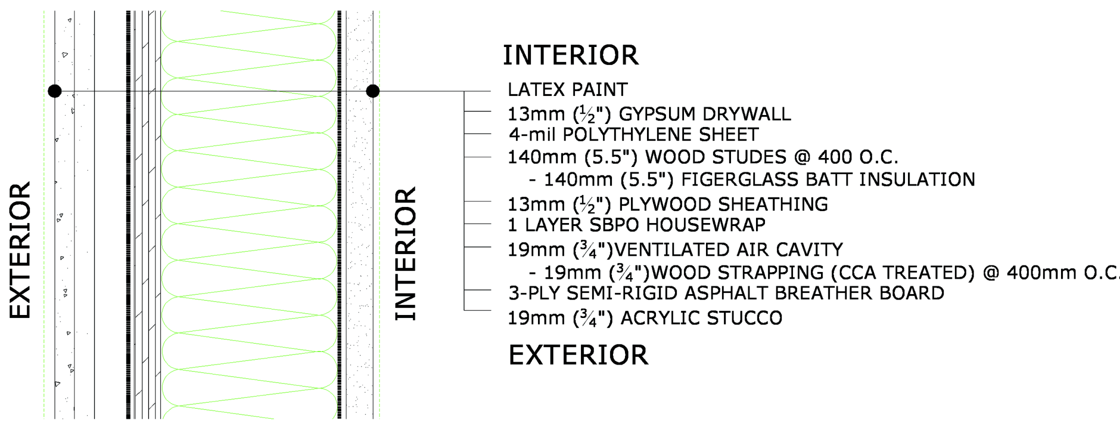

Figure 3 *Configuration of a stucco rainscreen wall used in the calculation.*

Table 1. Material Properties of Wall Components

Wall Assembly	Thermal Resistance, m·°C/W (ft·°F/Btu)	Vapor Resistance, m^2·Pa·s /ng (in.·Hg·h·ft/gr)
Exterior air film	0.030 (0.170)	0.000007 (0.00040)
19 mm acrylic stucco	0.054 (0.307)	0.008751 (0.500068)
3-ply (2mm) semirigid asphalt breather board	0.061 (0.346)	0.002857 (0.163460)
19 mm air cavity	1.180 (6.70)	0.000109 (0.006240)
0.2 mm one-layer SBPO housewrap	n/a	0.000349 (0.019970)
13 mm plywood sheathing	0.155 (0.880)	0.007446 (0.426010)
140 mm fiberglass batt insulation	4.000 (22.713)	0.000967 (0.055330)
0.1 mm(4 mil) polyethylene film	n/a	0.265600 (15.195900)
12.5 gypsum drywall, 1 coat primer, 2 coats latex @ 50% RH	0.078 (0.443)	0.004275 (0.244590)
Interior air film	0.120 (0.681)	0.00005 (0.002860)

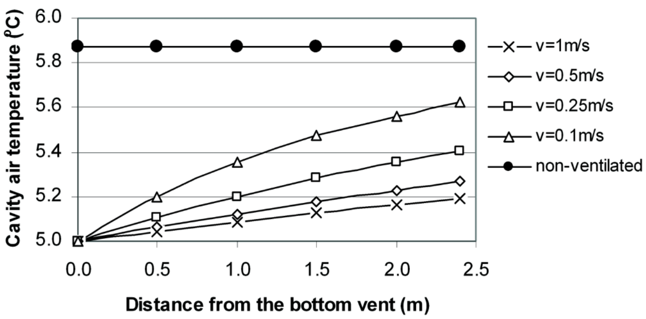

Figure 4 *Temperature profile within a 19 mm (0.75 in.) air cavity.*

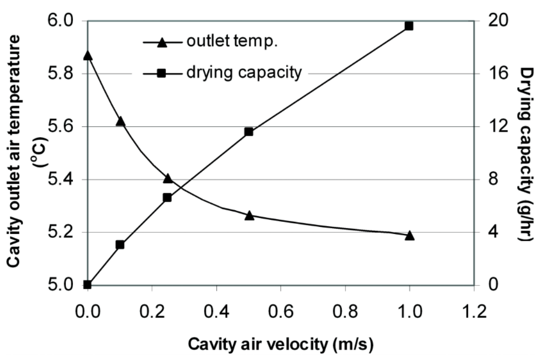

Figure 5 *Air temperature at the outlet and maximum drying capacity for a 19 mm (0.75 in.) cavity under various air speeds.*

The moisture balance for each cavity surface can be expressed as follows (Hens, 2003):

Cavity Surface 1:

$$\frac{P_o - P_{s1}}{Z_1} + \beta(P_{cav} - P_{s1}) = 0 \tag{13}$$

Cavity surface 2:

$$\frac{P_i - P_{s2}}{Z_2} + \beta(P_{cav} - P_{s2}) = 0 \tag{14}$$

where, P_o, P_i, P_{s1}, and P_{s2} are vapor pressure for outdoor, indoor, cavity surface 1, and cavity surface 2 in Pa, respectively. Z_1 is the vapor resistance in ng/Pa·s·m^2 between the outdoor and cavity surface 1, and Z_2 is the vapor resistance between cavity surface 2 and the indoor. β is the surface film coefficient for diffusion. A value of 2.87×10^{-8} s/m is used in the calculation.

The moisture balance in the cavity can be expressed as:

$$[\beta(P_{s1} - P_{cav}) + \beta(P_{s2} - P_{cav})]\mathrm{d}z = \frac{d_{cav}v}{RT_{cav}} dp_{cav} \tag{15}$$

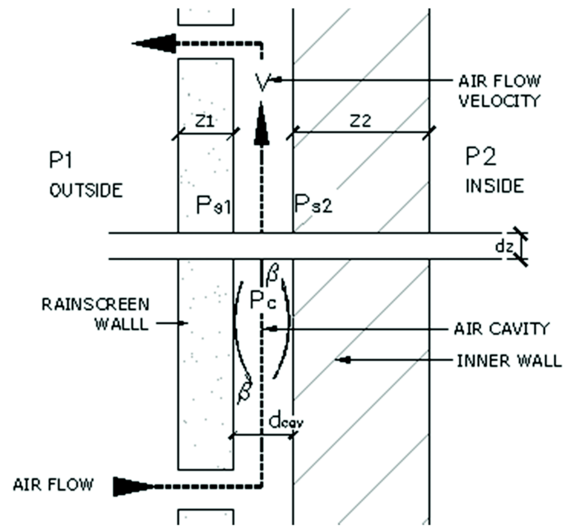

Figure 6 *Moisture balance in a ventilated wall cavity (adopted from Hens 2003).*

The solution for the amount of moisture removal by ventilation is as follows:

$$\begin{aligned} W_v &= \rho d_{cav} v (W_{out} - W_{in}) \\ &= \frac{d_{cav}v}{RT_{cav,\infty}}(P_{cav,\infty} - P_{cav,0})\left[1 - \exp\left(-\frac{h}{d_m}\right)\right] \end{aligned} \tag{16}$$

where P_{cav} is the vapor pressure in the case of an infinite cavity or a non-ventilated cavity. $P_{cav,0}$ is the vapor pressure at cavity inlet, h is the height of the cavity. d_m is the ventilation-influence length, and can be calculated as follows:

$$d_m = d_{cav}v/\left[RT_{cav,\infty}\left(\frac{1}{Z_1 + \beta^{-1}} + \frac{1}{Z_2 + \beta^{-1}}\right)\right] \tag{17}$$

The ventilation drying rate is calculated for the wall assembly shown in Figure 3 under the assumption that the plywood sheathing is wet and the vapor pressure at its exterior surface is at saturation pressure. Figure 7 shows the comparison between the maximum drying capacity and the actual drying for a 19 mm (3/4") cavity under various cavity airflow speeds. The curve denoted "actual-plywood only" refers to the case without sheathing membrane. When the sheathing membrane is not considered, the actual drying rates reach the maximum drying capacity at a lower airflow speed (<0.2m/s or 0.7ft/s). When the airflow rate increases, the drying capacity exceeds its actual drying, indicating that saturation is not reached when the air leaves the cavity at the outlet. When the sheathing membrane is taken into account, the actual drying rate is much lower than the drying capacity. In this situation, the drying is not governed by the airflow rate but rather the vapor permeance of the sheathing membrane. The drying rate is almost proportional to the vapor permeance of the sheathing membrane.

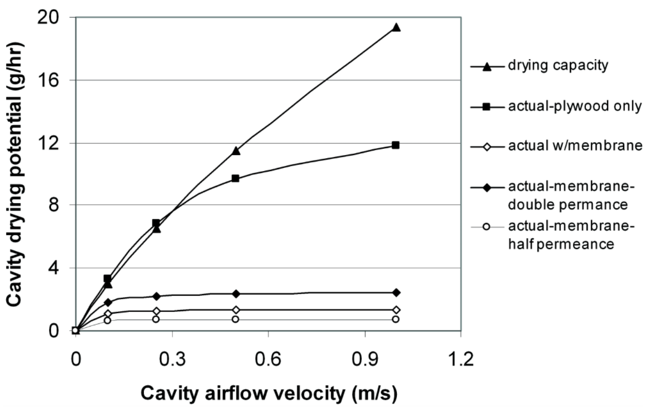

Figure 7 *Comparison between drying capacity and actual drying for a 19 mm (0.75 in.) cavity stucco wall under various air speeds.*

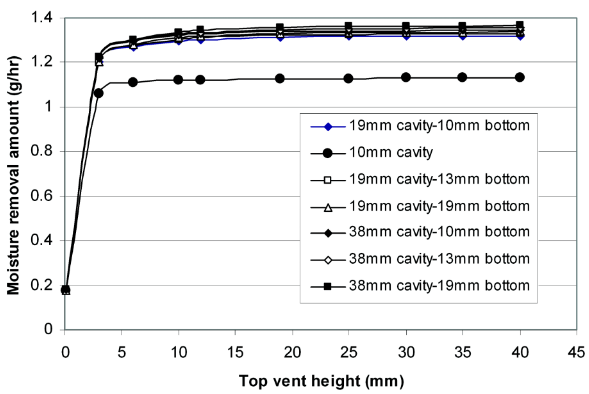

Figure 8 *Ventilation drying rates for a stucco wall when the plywood is assumed wet under steady-state conditions (outdoor: 5°C [41°F] and 90% RH; indoor: 21°C [70°F] and 50% RH).*

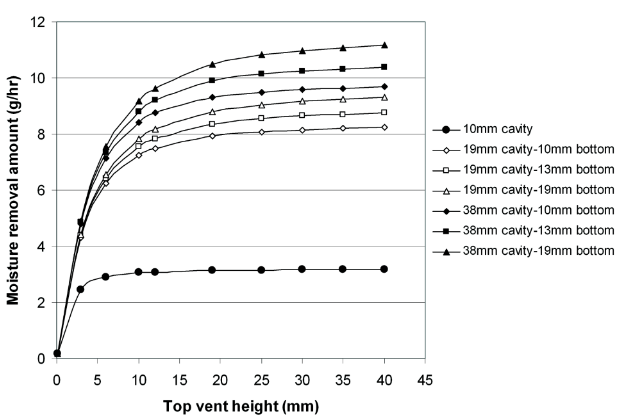

Figure 9 *Ventilation drying rates for a stucco wall when the plywood is assumed wet but without including a sheathing membrane under steady-state conditions (outdoor: 5°C [41°F] and 90% RH; indoor: 21°C [70°F] and 50% RH).*

The actual drying rates under 1 Pa pressure differential across the bottom and top vents are shown in Figure 8 for different combination of cavity depth and vent height.

The analysis shows that a 19 mm (3/4”) cavity has higher moisture removal than the 10 mm (3/8”) cavity; however, the difference between a 19 mm (3/4”) cavity and a 38 mm (1.5”) cavity is minimal. The variation in vent height does not have a significant impact on the amount of moisture removed, although these two variables do influence the airflow rate, as shown in Figure 1. This trend indicates that the amount of moisture removed by the ventilation is governed by the amount of moisture that can be released from the wet material once the airflow rate reaches a threshold value.

Figure 9 shows the drying rates provided by ventilation for the same wall but without the sheathing membrane. It can be seen that the drying rate pattern is similar to the airflow rate pattern. The moisture removal is doubled for a 10 mm (3/8”) cavity. The moisture removals are 6-8 times more for the 19 mm (3/4”) and 38 mm (1.5”) cavities; the actual drying rates are still below the maximum drying capacity.

A similar trend (with respect to the effect of ventilation on drying) is observed from simulation results using a commercially-available computer program. The same wall configuration shown in Figure 1 is simulated over two years using the cold-year weather data from the program. Simulations start on November 1.

Figure 10 shows the moisture content of plywood over a two-year period with initial moisture content of 30%. It takes 50-130 days for plywood to dry from the initial moisture level of 30% to 18%, depending on the ventilation rate. A higher ventilation rate results in faster drying of plywood until an air change rate of 130 ach is reached. Further increase of the ventilation rate has no impact on the moisture performance of plywood. Figure 10 also indicates that the permeability of sheathing membrane makes a noticeable impact only when the ventilation rate reaches a certain level. For example, at the optimum ventilation rate of 130 ach, the moisture content of plywood is reduced by about 2% when using the spun-bonded polyolefin as sheathing membrane (with a permeance of 2865 ng/m^2·Pa·s or 50.1 perm), in comparison to the 2-layer building paper as sheathing membrane (with a permeance of 300 ng/m^2·Pa·s or 5.2 perm).

The effect of ventilation is also investigated under a second wetting condition with 1% rain leakage introduced into the first 5 mm of the plywood sheathing from the exterior. Figure 11 shows the moisture content in plywood over a two-year simulation period. A higher ventilation rate results in lower moisture content in plywood until an air change rate of 130 ach is reached. Further increase of the ventilation rate (i.e., 200 ach) may increase the moisture content of the plywood, which indicates a potential for ventilation wetting. With 1% rain leakage introduced into the plywood, the sheathing panel remains at an unacceptable high moisture level above 20% for over 2 months, even at the optimum ventilation rate. Figure 12

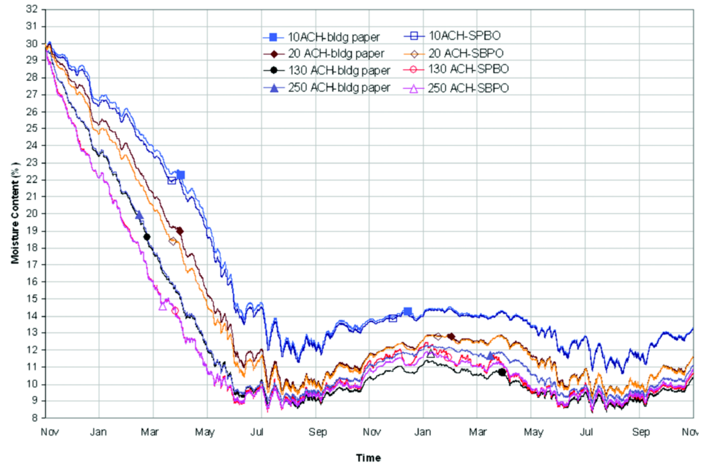

Figure 10 *Impact of ventilation rate and sheathing membrane on the moisture content of plywood over a two-year simulation period (plywood has an initial moisture content of 30%).*

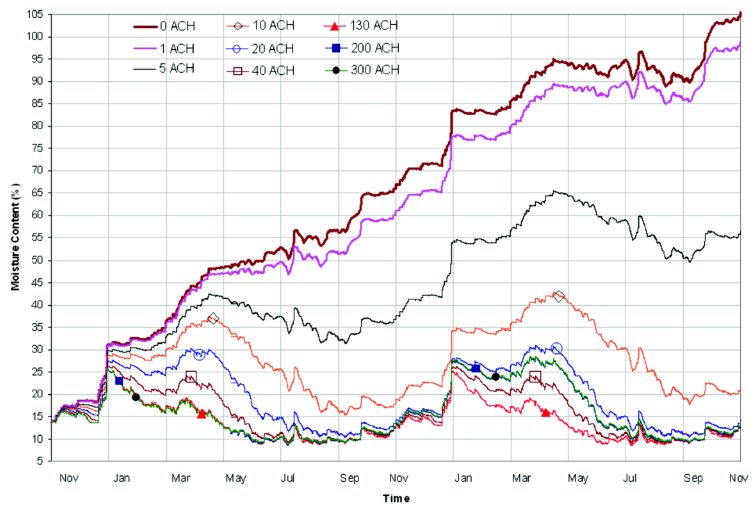

Figure 11 *Impact of ventilation rate on the moisture content of plywood over a two-year simulation period with a 1% rain leakage introduced into the plywood.*

shows the relationship between the moisture content of plywood over the period from January to May for the second year of simulation. With the provision of the ventilation rate as little as 10 ach, the plywood moisture content decreases from 28% without cavity ventilation to 13% when no rain leakage is introduced. When 1% rain leakage is introduced, a cavity ventilation rate of 40 ach reduces the moisture content of the plywood sheathing from 88% to 20%. Further increase in ventilation rate makes minimal impact. A significant 8% increase in moisture content is observed when the ventilation rate is increased from the optimum value of 130 ach to 150 ach. Then, the moisture content remains at the 8% higher level independent of any further increase. Further investigation is required to make an appropriate explanation for this trend.

Potential of Ventilation Wetting

The long-wave radiant heat exchange between the wall surface and the sky during clear nights may cool down the wall surface below the dew point temperature of outdoor air. Depending on the wall configuration and outdoor conditions, the so-called undercooling effect may reduce the temperatures of cavity surfaces to a point where condensation may occur within the air cavity, thus increasing the wetting potential through the cavity ventilation. There are some concerns that higher ventilation rates may increase this ventilation wetting potential, as indicated in Figure 12. To investigate this wetting potential for ventilated wall assemblies, a set of field data collected for the same wall construction shown in Figure 3 were analyzed. These field data were collected for a project to

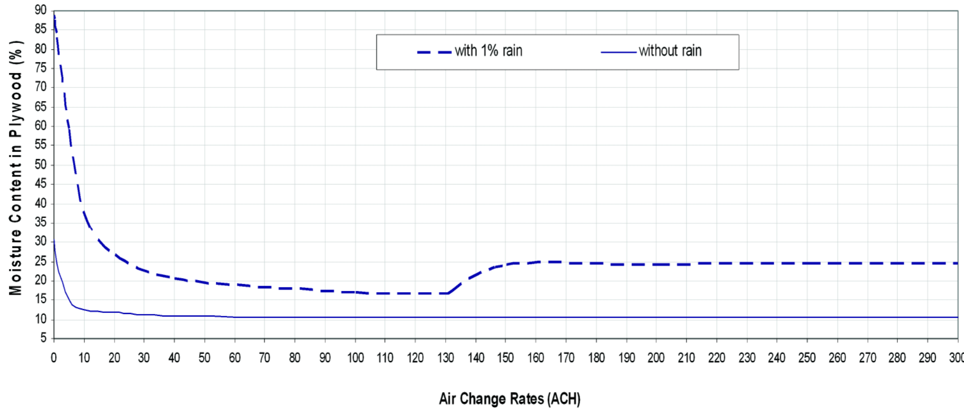

Figure 12 *Relation between ventilation rate and the average moisture content of plywood over a period of five months from January to May in the second year of simulation.*

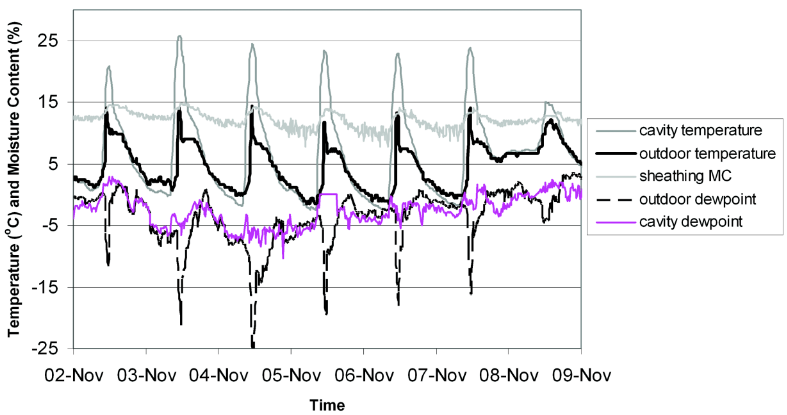

Figure 13 *Comparison of air temperature and dew-point temperature between the outdoor and ventilated air cavity for a stucco wall facing east during the period of November 2–9, 2003.*

monitor field performance of rainscreen walls constructed in the Vancouver region (RDH 2005). Drying and wetting due to cavity ventilation was not the primary focus; therefore, only the air cavity conditions were monitored, not the cladding surface temperatures. By studying the one-year data, some periods were noticed when the cavity temperature was lower than the outdoor air temperature. During these periods, it was also noticed that the vapor pressure in the cavity was lower than the outdoor vapor pressure. These conditions occurred typically during the fall and the spring, but sometimes in the rainy winter season as well. Figure 13 shows the conditions in the air cavity and the moisture content of the plywood sheathing in comparison with outdoor conditions for a few consecutive days with undercooling effect.

It can be seen that during the seven days from Nov. 2 to Nov. 9, the temperature in the air cavity fluctuates between day and night. During the daytime, the cavity temperature was raised by as much as 15°C (27°F) with an average of 5°C (9°F) above the outdoor air temperature due to solar radiation, and the cavity temperature was dropped by as much as 2.6°C (4.7°F) with an average of 1.2°C (2.2°F) below the outdoor air temperature due to undercooling over a 24-hour daily cycle. During the night, the dew point temperature (i.e., vapor pressure) of the cavity air is lower than that of the outdoor air; therefore, moisture is deposited in the cavity when outdoor air flows through the cavity. When the sun comes out in the morning, the cavity dew point temperature becomes higher than the outdoor dew point temperature, which indicates that condensation in the cavity may evaporate and increase the vapor pressure in the cavity. A similar diurnal variation as to the temperature was noted in the moisture content of the plywood sheathing. The increase in moisture content of the plywood sheathing may be attributed to solar-driven inward vapor diffusion because of the condensation formed on both the exterior and interior surface of the stucco cladding. The field monitoring data did indicate wetting potential in wall cavities due to undercooling. However, measurements on both ventilated and non-ventilated wall assemblies under the same field conditions are required in order to quantify the wetting potential due to cavity ventilation.

CONCLUSION

A simplified method is used to analyze the influence of cavity and vent design on the performance of ventilation drying for a panel wall assembly under the cold and humid coastal climate of British Columbia. The commonly-used design configurations are examined. The steady-state analysis shows that the cavity ventilation has minimal impact on the temperature profile within the air cavity for a standard 38 × 140 mm (2 × 6) wood-framed wall, exerting minimal influence over the heat loss. The cavity depth and slot vent height has influences on the airflow rate. For a 10 mm (3/8") cavity, the influence of slot vent height is minimal. With the increase of cavity depth, larger openings provide higher airflow rate.

The maximum drying capacity provided by cavity ventilation is determined by the ventilation airflow rate, however, the actual amount of moisture removal depends on the wall configuration and the moisture supply to the air cavity. For the cases with initially wet plywood, the amount of moisture removal by cavity ventilation is governed by the vapor permeability of the sheathing membrane once the ventilation rate reaches a threshold value. When the sheathing membrane as a governing layer is removed, the amount of moisture removal varies with the airflow rate while the actual moisture removal is still well below the maximum drying capacity. Therefore, the importance of cavity ventilation depends on the moisture loads and wall design. Similar conclusions are drawn from simulation results using a commercially available computer program, which takes into account cladding wetting and drying due to rain and solar radiation and moisture storage effect. Ventilation does help drying; however, an optimum ventilation rate exists. Further increase of ventilation has no positive impact on drying, in some cases it increases wetting, for example, when rain leakage is introduced periodically to the wall assembly.

The field-monitored data indicates the occurrence of ventilation wetting due to undercooling effect, especially when a clear night follows rain. The condensation formed on the cladding and cavity surfaces increases the moisture content on the sheathing panel due to solar driven inward diffusion. Further field testing will be necessary to quantify ventilation drying and wetting for the cold and humid climate in southern British Columbia.

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