Hygrothermal Performance Testing of Wall Assemblies Employing a Three-Dimensional Weather-Resistive Barrier and Drainage Membrane

Marcus Jablonka

Achilles Karagiozis, PhD

ABSTRACT

This paper studies a weather resistive barrier and drainage membrane for residential and commercial construction, formed from a thin (0.55 mm) sheet of HDPE with a pattern of studs and channels that provide for a drainage and ventilation space on both sides of the sheet.

The 3-dimensional membrane provides a secondary plane of moisture resistance to withstand inward moisture transport. It acts as a separator between cladding and secondary plane of moisture resistance (the plastic sheet), creating a drained and vented air space that provides a capillary break and drainage path. The product provides for more rapid drying of material outside the moisture barrier by allowing air movement through the cavity. In addition, the membrane provides a second interior drained and vented air space between the plastic sheet and the sheathing board that accelerates drying of materials inside the plane of the product by allowing air movement through this space.

Airflow, drainage and drying characteristics of wall assemblies employing the proposed embossed weather resistive barrier were independently tested in full-scale wall systems. The laboratory data was then used to validate features of an advanced hygro-thermal computer model. Good agreement was found between lab data and model predictions. Following this, the advanced computer model was utilized to evaluate the hygro-thermal performance of these wall assemblies for 5 different climates: Toronto, Seattle, Atlanta, Baton Rouge, and Norfolk.

Dynamic time dependent interior and exterior conditions were included in the hygric analysis. A transient moisture analysis was deployed to understand the complex heat, air and moisture transport present in the envelope walls.

Within the simulated timeframe the hygro-thermal results conclusively demonstrate the beneficial performance of this 3-dimensional membrane. Ventilation on both sides of the membrane has shown enhanced drying performance when compared to asphalt impregnated building paper. An extensive improvement in moisture management has been proven when employing the proposed weather resistive barrier, which performs far better than conventional building paper in regards to drying performance of the wall cavity.

Further long-term field testing as part of a field investigation is currently ongoing at the ORNL Natural Exposure Test facility in Charleston, SC. Results from this study, as well as incorporation of those results in advanced hygro-thermal computer modeling, will be available at the time of presentation of this paper.

INTRODUCTION

Energy efficiency in buildings can be improved by reducing the amount of energy that leaves the interior surface and by collecting as much of the supplemental energy as possible. As building envelope systems are exposed to lower levels of transport energy (reduced transmission losses), moisture issues tend to rise. Indeed, in applications where energy transmission is virtually eliminated, moisture accumulation problems may become prevalent. Even with relatively moderate to high energy transport rates in existing buildings, moisture-induced

Marcus Jablonka *is vice president of research and development and production at Cosella-Dorken Products, Inc., Beamsville, ON, Canada.* ***Achilles Karagiozis*** *is a senior research engineer in the Building Envelopes Program at Oak Ridge National Laboratory, Oak Ridge, TN.*

problems are widespread. In fact, these problems seem to indiscriminately be caused by, or related to envelope claddings, weather resistive barriers, installation details, and climatic conditions.

Of particular importance in today's wall systems is the deployment of weather-resistive barriers (WRBs). These material systems are a part of exterior wall systems that protect building materials from exterior water penetration, controlling the diffusion of water vapor in both directions and possibly providing resistance to air leakage that occurs across the wall system. In many ways, WRBs perform like a shell for buildings, and they either totally impede or substantially reduce the water penetration. One of the key duties of weather resistive barriers is to keep building materials dry, consequently improving building durability and decreasing maintenance costs by reducing the risk of moisture-related problems from the presence of bugs, mold, mildew, rot, and corrosion. Some weather-resistive barriers also reduce air infiltration, cutting utility costs, and at the same time increasing the overall occupant comfort.

While many problems are being experienced today with a number of code approved weather resistive barriers, a three-dimensional WRB is an innovative product that satisfies moisture control requirements of existing codes; moreover, it includes additional mechanisms for drying. This novel weather resistive barrier includes a dual cavity ventilation system that promotes an effective method of drying, which is to draw moisture to a drying energy and always towards the outside. This paper details some of the extensive hygrothermal research analysis performed to validate the superior performance of this embossed polyethylene weather resistive barrier (embossed PE WRB).

Literature Review on Weather Resistive Barriers

The article by Fisette [1997] presents a clear description of the function of housewraps, felt paper, and weather penetration barriers. The weather barrier works as the second line of defense. Many exterior cladding systems function as a weather/rain screen and need weather barriers due to the large number of joints, overlaps, and connections. Water is driven by wind towards the interior of the assembly, creating rain intrusion. Forces due to the presence of dynamic wind pressures, gravity, surface tension, and finally the capillary suction provided by the construction materials may all exist when water is present. Frequently, the installation method can be the determining factor in whether or not a particular weather resistive barrier will allow the envelope system to perform satisfactorily. In many applications where air cavity ventilation is not present, envelope systems will fail with small water penetration loads.

In Figure 1, a building envelope failure is shown for a vinyl clad wall system, using an SBPO weather resistive barrier that is "breathable".

An excellent study on measurements of the performance of weather resistive barriers is provided by Pazera [2003].

Figure 1 *Failure building envelope system with a "breathable" type WRB.*

Burnett [2004a, 2004b], based on field forensics, concluded that the location of the membrane, its method of installation, and the type of cladding system employed influenced the overall performance of the envelope system. Indeed, failures occur in many membrane type weather resistive barrier systems as wind can tear their attachment to the sheathing boards.

Failures from the northwest Pacific, northern, mixed, and southern regions of the USA certainly show the need to investigate the interaction between the various components of the building envelope system. The weather resistive barrier can be expected to perform the following functions:

1. Must control the transport of water vapor into the building envelope assembly depending on climatic conditions and other components of the building envelope system
2. Must control the ingress of liquid water
3. Must provide control to reduce wind washing
4. Must provide control for ingress of atmospheric pollutants
5. Must provide structural integrity for mechanical loads (tensile forces by wind)
6. Must be durable (with acceptable limits for aging) for the set service life of the WRB, which should be equivalent to the service life of the enclosure cladding system
7. Must provide acceptable enclosure protection and drying performance during installed exposure and prior to the installation of the cladding
8. Must integrate with other sub-systems used (brick ties, penetrations, etc.)

Historically, building paper was the only class of weather resistive barrier. These WRB are made out of waste papers, old rags, and wood, which have been chemically treated and bound with asphalt to provide resistance against environmental elements. A classification in four different categories was initiated by the ASTM D6 committee: dry or unsaturated papers, saturated papers, saturated coated papers, and, finally, duplexed papers. The United States Federal Specification UU-B-790a (1968) on Building Fiber and Vegetable Fiber divided the building papers into 4 papers, 7 grades and 11 styles. Material composition based on treatment of the pulp and manufacturing process was used to differentiate the various building papers.

In 2003, five types of WRB were identified by the ASTM E06 Task Group E06.55.07 on Weather Resistive Barriers, as:

1. Type C : Asphalt-impregnated cellulose fiber based
2. Type M : Micro-porous film
3. Type P : Polymeric fibrous WRB
4. Type PP : Perforated polymeric film
5. Type LA : Liquid applied (trowel)

An excellent paper on code requirement has been presented by Thorsell [2004]. The model codes require the use of a weather-resistant barrier paper (usually specified as #15 felt, or Grade D Kraft Paper) behind capillary absorptive exterior claddings. The BOCA requires a layer of #15 felt over the sheathing, regardless of the siding type. Although 15-pound felt has been used as the standard for performance comparison, substitution of "equivalent" WRB materials or systems is permitted, upon the availability of acceptable performance requirements.

Today, there is a lot of speculation and confusion among building envelope practitioners regarding what material properties are required for weather resistive membranes. A recent DOE sponsored study by Karagiozis [2006] has developed performance criteria for a number of climatic zones in the USA.

Background Physics

In most current weather resistive barrier applications, an intentional or unintentional air space is left between the cladding and the weather resistive barrier. Many times, this air space is in discontinuous contact, or a continuous air space which is either vented or ventilated allows the exterior surface of the weather resistive barrier to interact hygro-thermally with the adjacent air. However, in all applications, the membrane weather resistive barriers are stapled or screwed securely to the sheathing board, intentionally eliminating an air space between the exterior surface of the sheathing board and the inner surface of the weather resistive barrier.

This type of weather resistive barrier system is present with a number of building papers, as well as perforated and non-perforated synthetic weather resistive barriers, and is the prevalent method in today's construction practice. However, there are some serious drawbacks with this type of weather resistive barrier as it does not allow any moisture that intentionally or unintentionally condenses at the interface of the sheathing board and the membrane to dry out efficiently.

In order to dry out the liquid moisture that is present within the gap, it needs to change phase from liquid to vapor (a process that requires energy) and then slowly diffuse through the membrane or exterior sheathing. This type of mass transfer process is very inefficient and has caused serious moisture induced problems when water is present. While there are differences in drying by vapor diffusion processes between the vapor open spun bonded poly-olefin (SBPO) weather resistive barriers and the vapor tight 15 # felt papers at low relative humidity, and the high liquid transport of 15 # paper and negligible liquid flow for SBPO weather resistive barriers, the combined effect makes them vulnerable to moisture induced problems. This becomes even more critical and important when highly capacitive exterior cladding materials are employed that allow for solar driven moisture to occur.

Description of Proposed Material

In this paper, a new class of weather resistive barriers will be introduced, with a function based on air exchange in the cavity between the membrane and the sheathing board.

The innovative weather resistive barrier introduced in this paper does not include the aforementioned shortcomings. Air ventilation is designed into the wall system, and ventilation is allowed to occur on both sides of the weather resistive barrier. This allows a more effective method of mass transfer than vapor diffusion: air transport dries out both the cladding and the sheathing board at the same time. Also, the new weather resistive barrier isolates the microclimatic chamber between membrane and sheathing board from the microclimatic chamber between membrane and exterior cladding.

The embossed Polyethylene made WRB achieves this performance due to its 3-dimensional design as shown in Figure 2.

Even at rather small air cavity ventilation strengths, the amount of moisture that can be extracted from wall systems is very large – at magnitudes of 10 to 300 times higher than by vapor diffusion.

This innovative weather resistive barrier operates like a system that has the following functionalities:

- drains bulk water on both sides of the membrane
- creates two micro-climatic zones in the wall (cladding zone and interior wall
- zone)
- dries wall through sufficient ventilation (two air cavity systems are created)
- prevents solar moisture drive towards interior of wall

Based on its moisture control principles, this membrane has some built-in structural stiffness, and due to the very low water vapor permeance (0.1 perm or less), the wall is essentially split into two separate microclimatic regions: an exterior cladding region and an interior region. The same is true for liquid transport, as no water penetration due to capillary suction is possible through this sheet of polyethylene. At the same time, effective drainage can occur quite efficiently with the low surface tension offered by the polyethylene surface on both interior and exterior surfaces of the WRB. The dual cavity

Figure 2 *New embossed polyethylene WRB with dual cavity ventilation.*

weather resistive barrier allows load separation to the designer when introducing thermal and moisture control strategies, optimizing either the interior or exterior hygric loads. The designs employing this WRB become more effective and more tolerant of water penetration or water condensation occurring on either side of the weather resistive barrier.

Conceptually, the embossed polyethylene WRB, when applied in a variety of absorptive cladding systems or other claddings, can offer enhanced drying performance. This is provided in two ways. First, it provides an effective drainage sub-system that has been extensively demonstrated with in-situ application in basement foundation systems. Secondly, it also offers two distinct ventilation cavities, one next to the absorptive or leaky cladding, and the other next to the sheathing board. These double and separate ventilation cavities now equip the wall system with additional drying capabilities by short-circuiting the inward solar driven moisture that is convected away by air in the first cavity.

With conventional weather resistive barriers, building papers, or perforated or un-perforated SBPO, the water vapor moves from the high vapor concentration potential to the lower concentration potential. In many instances, this promotes drying of the cladding towards the exterior and interior, which consequently results in moisture accumulation on the sheathing board. As the water vapor permeance of a conventional weather resistive membrane becomes higher, this effect is more significant, especially when solar driven moisture conditions are present.

Research Objectives

The research performed intends to provide a quantitative analysis of the hygrothermal performance of a new class of weather resistive barriers and to make clear the impact of its hygrothermal performance on a number of wall systems as a function of climate. The approach undertaken was one that integrated laboratory testing, advanced modeling, and field testing.

Overview/Methodology

This research project required a holistic approach to moisture engineering analysis. The envelope performance is dependent on the wall composition as well as the interior and exterior loads.

Straube [2005], characterized the airflow, drainage behavior, water retention, and drying behavior behind the three-dimensionally patterned (studs & channels) HDPE membrane to provide quantitative empirical results that allowed comparison of standard wall types and generated data for use in advanced hygrothermal models by Karagiozis [2005].

For the laboratory investigations, wall systems were constructed with a foil faced Polyisocyanurate board sealed to the studs, impeding moisture and air flow through the back of the wall, with Fiberglass batt insulation, a 2” x 6” stud frame with OSB sheathing, with 1) embossed PE WRB with vinyl siding, 2) #15 felt with vinyl siding, 3) embossed PE WRB with cement board, and 4) #15 felt paper with cement board.

A number of measurements were performed, such as temperature and relative humidity (RH) sensors installed in batt insulation, temperature and moisture content sensors installed in the back of the sheathing board, and temperature and RH sensors installed between vinyl siding and the embossed PE WRB. The walls were sealed on the sides with silicone to prevent water leakage and aluminum tape to prevent diffusion. Tests were performed to measure air flow and pressure drops through the cladding air cavity, the drainage capability of the two weather resistive barrier systems (building paper and embossed PE WRB), the drying out performance of the two weather resistive barrier systems, and finally to measure the drying out performance of both systems after injecting water on the outside surface of the sheathing board (between sheathing board and WRB). These drying tests were performed using a 1 Pa fan to simulate influence by wind and stack effects and heat lamps to provide a moderate solar effect. Figure 4 shows the wall drainage assembly.

Drainage and water retention results are shown in Figure 5 for both the conventional #15 felt paper and the embossed PE WRB system. Similar performance is observed except that the water absorption by #15 felt resulted in retaining 21% more water at the end of the 15 minute drain interval than by embossed PE WRB in the second test interval. Figure 6 shows the superior drying out performance of the embossed PE WRB system when compared to the conventional 15 # felt paper.

Hygrothermal Modeling Analysis

Results generated by the advanced hygrothermal analysis were post processed or/and extracted in various manners to produce performance indicators, such as instantaneous relative humidity, moisture content, and water absorption in sensitive layers. Results were then summarized from outputs for the above activities.

Two selected wall systems were used in the hygrothermal modeling analysis. The walls were assumed to be located in

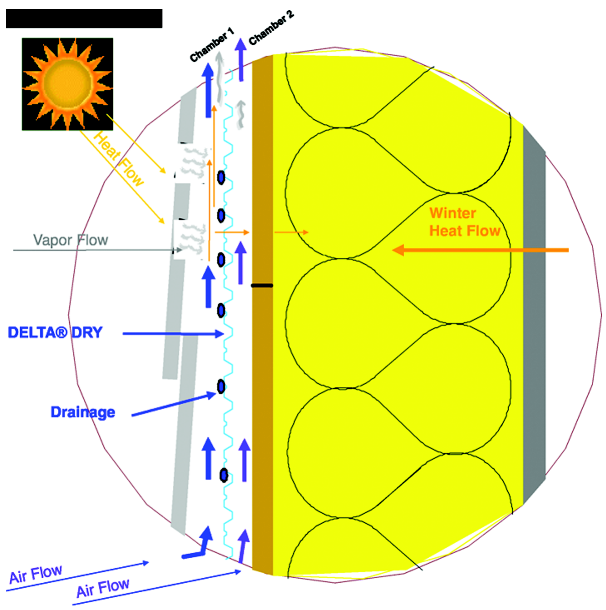


Figure 3 *Illustration of the dual ventilation cavity system: New class of WRB.*

Figure 5 *Drainage testing of embossed PE weather resistive barrier system (Straube et al. 2005).*

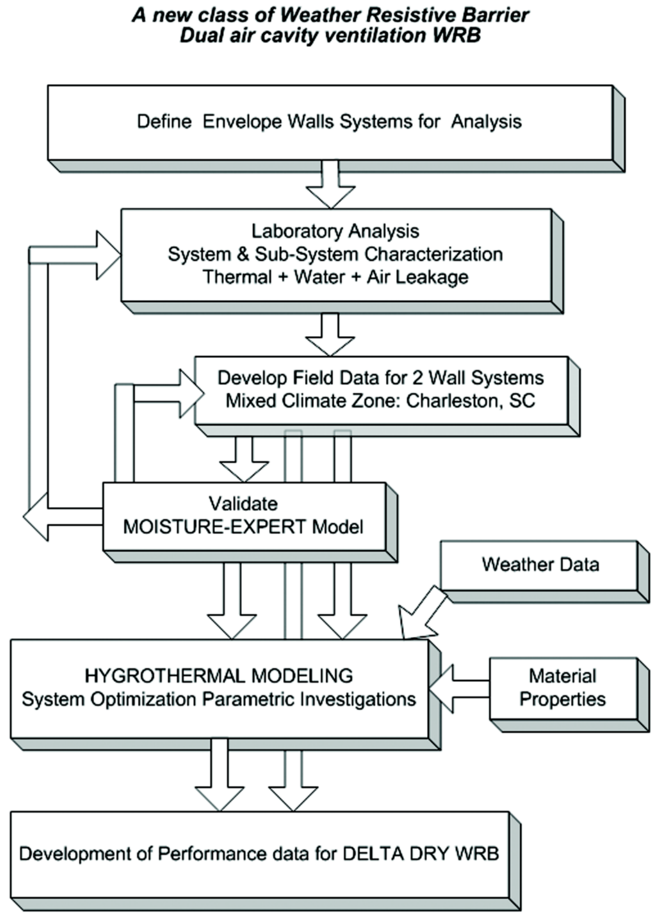


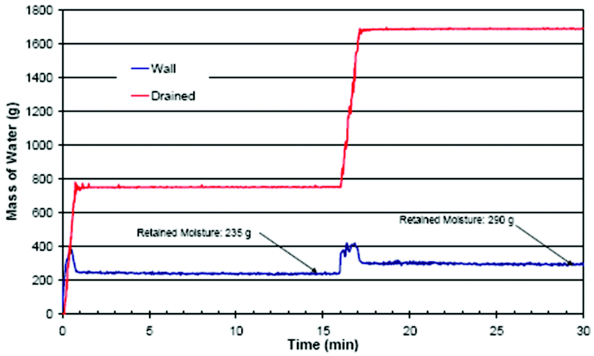
Figure 4 *Research approach to characterize the performance of the embossed PE WRB.*

residential buildings and had above average moisture production loads (5.6 kg/day for 140 m^2 of floor area.

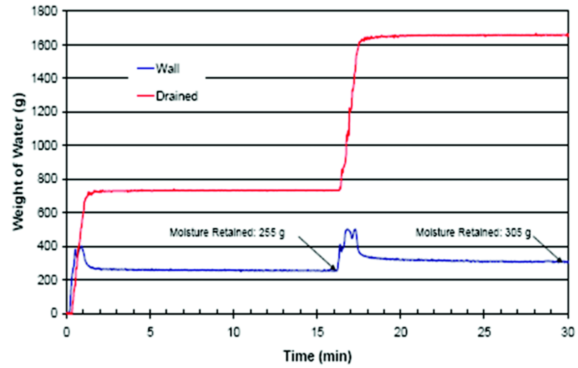
Research on the performance of these wall systems was conducted to characterize the hygrothermal performance of wall systems employing the proprietary embossed PE WRB system.

This overall research project included three main research activities:

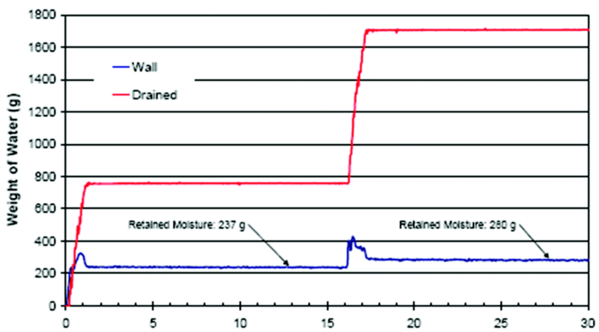
1. Determination of the hygrothermal material properties (water vapor permeance, absorption, and liquid diffusivity) of the embossed PE sheet,
2. the laboratory testing and quantification of the airflow, drainage and drying characteristics of the embossed PE WRB product in walls,
3. the quantification of the hygrothermal performance of a wall assembly including the weather resistive barrier sheet by integrating activities a) and b) with dynamic climatic conditions for a number of Canadian and US climates included in the recent field monitoring in Charleston, SC.



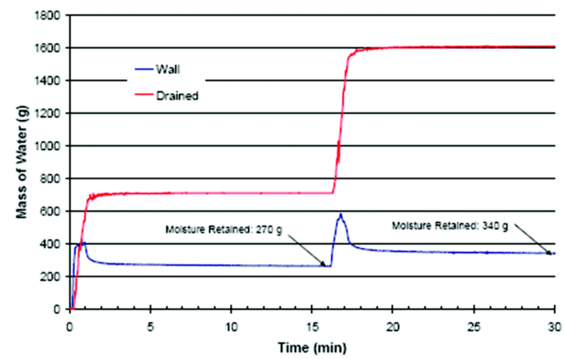
First drainage test results for wall with three-dimensional WRB.



First drainage test results for wall with #15 felt.



Second drainage test results for wall with three-dimensional WRB.



Second drainage test results for wall with #15 felt.

Figure 6 *Drainage and water retention comparison of embossed PE WRB and 15 # paper.*

This research is an application of moisture engineering which includes multiple component research. Integration of new products to the construction market requires extensive tests that quantify the hygrothermic advantageous performances.

Some of the issues that needed to be addressed are summarized below:

- How does the embossed PE drainage and ventilation sheet perform as a substitute for # 15 sheathing paper?
- How can one quantify the benefits or disadvantages of the embossed PE WRB system?
- How much moisture can the system withstand in the winter and release the difference between that amount and what it can naturally handle during the summer (short term and long term hygrothermal performance of the envelope system)?

Wall Configurations

As the research was focused to understand the possible hygrothermal characteristics of the operation of the dual ventilation cavity, more emphasis was given to the brick wall assembly and less to the vinyl wall system. The vinyl system already has adequate ventilation potential for enhanced drying capabilities. Below, the wall assemblies examined are shown.

Wall Assemblies

The tested wall assembly for brick (Wall 1) is shown in Figure 8. For Seattle and Toronto climates, a 2” x 6” stud arrangement was employed, while a 2” x 4” stud was used for Atlanta, Baton Rouge, and Norfolk.

- Wall Type (see Figure 8 below (Clay Brick (100 mm))
- Geographic locations (Toronto, Seattle, Atlanta, Baton Rouge, Norfolk)
- Indoor ventilation conditions (at least 0.3 ACH)
- Water penetration rates of 1% (Exterior Weather Resistive Barrier)
- # 15 Felt Paper or embossed PE WRB
- 2” x 4” (or 2” x 6”) wood studs
- Interior vapor control strategy (6-mil Polyethylene sheet)

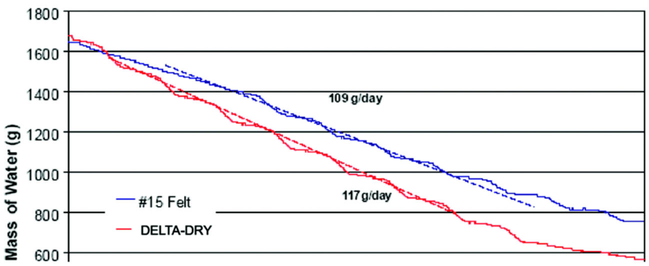


Figure 7 *Drying tests for embossed PE WRB and #15.*

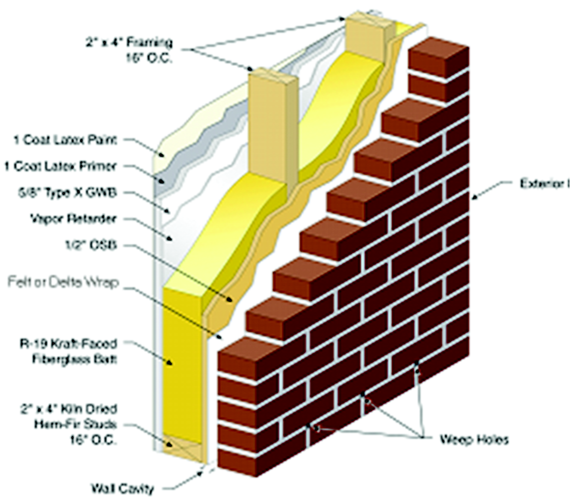


Figure 8 *Wall assemblies.*

The tested wall was a brick wall system (Reservoir Cladding with Oriented Strand Board (OSB) Sheathing).

Governing Transport Equations

The MOISTURE-EXPERT hygrothermal model developed by Karagiozis [2002], [2005] was applied in the analysis. The governing equations employed in the analysis for the combined mass and energy transfer are as follows:

Moisture transfer:

$$\frac{\partial(\rho_m T)u)}{\partial t} = \underbrace{-D_\phi(u, T, x, y)\nabla\phi}_{\text{Liquid flow}} - \underbrace{\delta_p(u, T)\nabla P_v}_{\text{Vapor flow}} + \underbrace{\rho_v \vec{V}_a}_{\text{Airflow}} \tag{1}$$

Energy transfer:

$$\rho_m(u, T)C_p(u, T)\frac{\partial T}{\partial t} \tag{2}$$

$$= \underbrace{-\nabla \cdot (\rho_a C_p(T)\vec{V}_a T)}_{\text{Convection}} + \underbrace{\nabla \cdot (k(u, T)\Delta T)}_{\text{Conduction}} + \underbrace{L_v \cdot (\delta_p(u, T)\Delta P_v)}_{\text{Evaporation}}$$

$$+ L_{ice} \cdot \rho_m(u, T)u\frac{\partial f_l(T)}{\partial t}$$

where

ϕ	=	relative humidity, –
t	=	time, s
T	=	temperature, K
c	=	specific heat, J/kg·K
w	=	moisture content, kg/m
$psat$	=	saturation vapor pressure, Pa
k	=	thermal conductivity, W/(m·K)
L_v, L_{ice}	=	latent heat of phase change, J/kg
D_ϕ	=	liquid conduction coefficient, kg/m·s
δ_p	=	vapor permeability, kg/(m·s·Pa)

On the left-hand side of Eq. (1) and (2) are the storage terms. The fluxes on the right-hand side in both equations are influenced by heat as well as moisture: The conductive heat flux and the enthalpy flux by vapor diffusion with phase changes in the energy equation strongly depend on the moisture fields and fluxes. The liquid flux in the moisture transport equation is only slightly influenced by the temperature effect on the liquid viscosity and consequently on D_ϕ. The vapor flux, however, is simultaneously governed by the temperature and the moisture field because of the exponential changes in the saturation vapor pressure with temperature. Due to this close coupling and the strong non-linearity of both transport equations, a stable and efficient numerical solver had to be designed for their solution. Additional terms were included in Equations 1 and 2 to incorporate the air transport contributions for both the energy balance and mass balance governing equations.

Parametric Modeling Analysis

A modeling analysis of the combined, heat, air, and moisture (hygrothermal) performance was required to quantify and characterize the performance of the wall systems. A series of simulations (combination of 1-D and 2-D simulations) were performed to analyze a number of important factors. Some of these are detailed below:

Simulation Period

A period of two years was selected; both the cold and hot conditions were employed. Initially, dry conditions were employed at an equilibrium moisture content (EMC) of 8%. The start of the simulation period was the 1st of July during the 10th percentile coldest year followed by the 10th percentile hottest year.

Modeling Results

A series of moisture simulations were performed to analyze the heat and moisture performance of Wall 1 and Wall 2 (see Figures 8–10).

Transient heat, air and moisture transfer computer simulations were performed for five location conditions. The

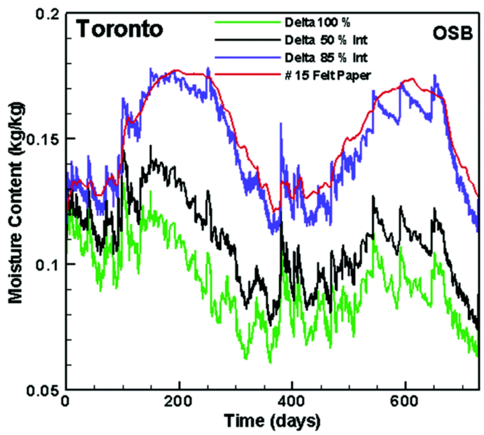


Figure 9 *The effect of embossed PE WRB performance (100% ventilated, 50% blocked interior, and 85% blocked interior) versus #15 felt paper scenario.*

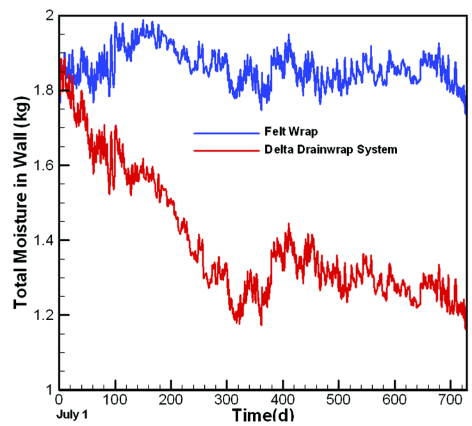


Figure 10 *Total moisture in wall (kg) as a function of time (cold year followed by warm year) for Toronto.*

hourly exterior temperature, relative humidity, cloud index, solar irradiation, wind speed and orientation, and rain precipitation were included in the model. In addition, the air changes that occur due to wind pressure differences or buoyancies were also included in the simulations. Moreover, a 1% water penetration (of what strikes the exterior wall) was included in the simulations which deposited water at the exterior surface of the OSB sheathing board. The proposed ASHRAE SPC 160P was followed as closely as possible.

Results are focused on capillary absorptive cladding systems and are projected for each of the five cities examined. The effect of ventilation gap flow blockage is shown for each city. Two blockage scenarios were examined, one at 50% flow blockage and another at 85% blockage.

Toronto Results

In Figure 9, the moisture content of the middle element of the OSB layer is plotted out against time for a two year interval, starting on July 1. The results are shown for Wall 1 (brick cladding). The initial moisture content was 12% and the impact of the presence of the ventilation gap is clearly shown. Even at 50% effectiveness, based on the air resistance values provided by the University of Waterloo, the embossed PE WRB performed significantly better than the # 15 Felt Paper. Even at 50% blockage, enough ventilation existed to allow effective drying of the sheathing board. The results also show that if the ventilation of the second cavity (between embossed PE WRB and sheathing board) is reduced to 85%, the embossed PE WRB system performs according to the #15 Felt Paper system.

Figure 10 shows the total moisture accumulation in the whole wall as a function of time. The benefits of employing the embossed PE sheet become even more evident in this plot. It is obvious that the wall with the #15 Felt Paper wall does not dry out but remains fairly constant.

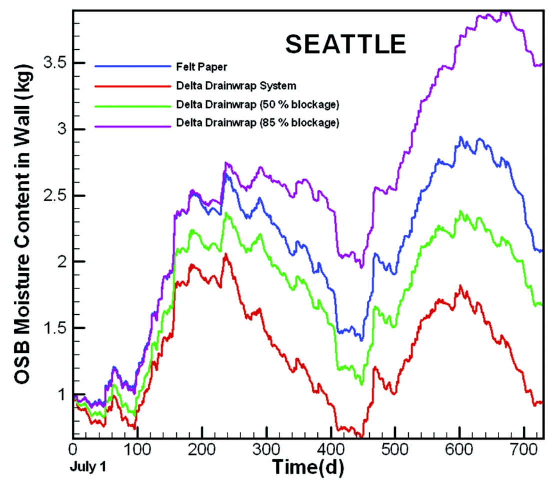


Figure 11 *Ventilation strength and air gap effectiveness 100%, 50%, and 15% efficiency.*

Seattle Results

In Figure 11, the moisture performance is shown for the brick wall system for a period of 2 years in Seattle. The embossed PE WRB system performs substantially better than the #15 Felt Paper.

CONCLUSIONS

The physics and moisture transport phenomena have been presented on the new class of weather resistive barriers. This new WRB shows potential for providing solutions to existing building moisture problems, as well as solutions to the future net-zero energy building envelope systems.

A series of laboratory, modeling and field testing have been proposed to characterize the performance of the embossed PE WRB. In this paper, the first two have been described and results presented. It is expected that data on the field testing will be available during the presentation.

Both laboratory and modeling have confirmed the potential of the dual ventilated cavity WRB to perform substantially better than conventional membrane WRBs. A series of simulations were performed to analyze the heat and moisture performance of two wall systems (brick veneer and vinyl) for application in residential construction. Additional tests were performed to determine the vapor permeance of two embossed PE WRB systems. The dynamic time dependent interior and exterior conditions were included in the hygric analysis. Five different climates were investigated: Toronto, Seattle, Atlanta, Baton Rouge, and Norfolk, and results have been presented for Toronto and Seattle.

The intention of this investigation was to provide insight for the use of the embossed PE WRB system which includes a dual exterior cavity ventilation system for a range of climate conditions. Additional simulations were performed to investigate the hygrothermal impact of blockage on one of these systems. This additional work was performed for a number of climatic loads.

Simulations were parametrically executed to investigate the use of two wall systems, as a function of interior environmental conditions (RH 35-55%) and interior vapor retarder (10 perms), for the climatic conditions described above. Additionally, the impact of water penetration was investigated for the walls, as perfect walls do not exist. Hourly simulations were performed for a period of 2 years, using a state-of-the-art hygrothermal model (MOISTURE-EXPERT, Karagiozis (2001, 2005) in both 1D and 2D). A transient moisture analysis was deployed to understand the complex heat, air, and moisture transport dynamics present in the building envelope.

The results demonstrated very good performance in the application of the embossed PE WRB product for the Seattle and Toronto climates. The product works very well in cold to mixed climates – better than in warm and hot humid climates. The overall moisture in the wall is reduced with the application of the product, for these colder climates.

Within the existing timeframe, the hygrothermal results have conclusively demonstrated the beneficial performance of the embossed PE WRB system. Ventilation on both sides of this weather resistive barrier has shown enhanced drying performance when compared to the #15 Felt Paper. The analysis also includes an additional water leakage source of 1% of that which strikes the exterior wall directed at the exterior surface of the sheathing membrane. No net accumulation was observed in the investigated wall systems.

The embossed PE WRB system is simple and easy to install. Attention is needed to provide the necessary engineering details for top and bottom ventilation.

An extensive improvement in moisture management has been proven when employing embossed PE as a weather resistive barrier in the wall for most climates. Embossed PE WRB is able to perform significantly better than conventional building paper in regards to drying performance of the wall cavity.

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