

ROCHON REPORT

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Moisture Control Within Buildings

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Introduction:

Moisture migration into a building can occur anywhere between the basement level and roof level. The moisture migration can be in the form of bulkwater or water vapour. Both bulkwater and water vapour will travel through apertures in the building envelope. Water vapour can also diffuse through building materials that form the building envelope. A building envelope provides the separation between the living environment and the exterior environment. The building envelope consists of the roof, exterior walls, main floor over an unheated crawl space and foundation walls. Movement of water vapour through the building envelope can result in an accumulation of concealed condensation on the building components and within the building envelope.

Movement of bulkwater and water vapour through the building envelope develops when there is a pressure differential across the building envelope. Bulkwater migration can be controlled by providing adequate drainage on the exterior of the building.

The control of water vapour diffusion through the building envelope can be achieved by selecting proper building materials of low vapour permeance for the building envelope; and, ensuring that the

building envelope is airtight. The control of air leakage through the building envelope is the primary concern with respect to reducing the moisture flow into the living environment.

The Ontario Building Code provides basic standards to alleviate the migration of bulkwater and water vapour into the building envelope and living environment. The basic standards of the Ontario Building Code can be expanded to provide a more effective systematic design in the control of bulkwater and moisture flow through the building envelope. The systematic design controls but does not eliminate the potential for bulkwater and water vapour flow through the building envelope.

Bulkwater:

Bulkwater movement into a basement area will occur through the foundation walls and concrete slab on grade with an increase in hydrostatic pressure on the exterior face of the walls and at the underside of the concrete slab on grade. The hydrostatic pressure increase results from an increase in groundwater activity on the outside face of the foundation walls and at the underside of the concrete slab on grade. Pressure gradients across the walls above the exterior grade; and, through the roof system can lead to bulkwater migration into the building. Pressure gradients are created by air movement within tall buildings (stack effect), mechanical ventilation

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systems and wind pressure. Wind pressure on the exterior walls and roof can lead to wind driven precipitation migrating through the building envelope. Inadequate control of runoff precipitation can also lead to migration through the building envelope.

Water Vapour:

In addition to the pressure gradients creating movement of bulkwater through the building envelope, pressure gradients also develop with respect to water vapour. Since the building envelope is insulated, a vapour pressure gradient exists across the building envelope. Insulating the building envelope produces a potential for water vapour flow through the building envelope. The water vapour flow occurs in the form of water vapour diffusion through the building materials that form the building envelope; or, results from air leakage through apertures in the building envelope. Air leakage can develop through discontinuities in the air barrier due to the above-mentioned pressure gradients, related to stack effect, ventilation systems and wind.

Water vapour will diffuse from a high vapour pressure to a low vapour pressure. The vapour pressure is the actual amount of water vapour present in the air. Higher vapour pressures will exist in higher temperature areas, as well as, in areas exposed to large vapour loading such as in kitchens, laundry rooms and bathrooms. The ability of air to hold water vapour (the saturation vapour pressure) drops as the air temperature drops. Hence, during water vapour diffusion the saturation vapour pressure will be reached at some point in the colder area. The water vapour will deposit out in the form of condensation when the saturation vapour pressure is reached. The point of condensation development is called the "dew point". Air leakage through the

building envelope will carry more water vapour compared to vapour diffusion through building materials.

Bulkwater Control:

Foundation Walls:

The conventional construction of a foundation that encloses a basement area does not provide a watertight design. Since the exterior face of the foundation is in contact with a moist soil, a dampproofing membrane shall be applied overtop of the exterior foundation wall face to alleviate the migration of moisture through the wall. The exterior face of the foundation wall will also be exposed to groundwater activity (hydrostatic pressure); however, the alleviation of the hydrostatic pressure on the outside face of the wall can be achieved by introducing a proper drainage layer on the exterior face of the wall. The introduction of a drainage layer will alleviate the hydrostatic pressure and any resultant bulkwater flow through apertures in the wall construction. The drainage layer can consist of a free draining granular soil or a drainage pan that provides vertical drainage of groundwater down to a weeping tile system at the base of the foundation wall construction.

The base of the foundation wall construction must contain a weeping tile system on the exterior face of the wall to discharge the groundwater that is drained toward the bottom of the foundation wall construction. The weeping tile system must be connected to a drainage system that expels to daylight (storm sewer system).

Additional control of groundwater flow around the foundation can be provided at the exterior grade level. Positive drainage must be provided in the exterior grade along the exterior face of the

foundation walls to redirect runoff away from the foundation wall construction.

Furthermore, the installation of an eavestrough system at the roof level will discharge rainwater runoff away from the exterior grade alongside the foundation wall construction.

Exterior Walls and Roof:

Bulkwater migration through the roof and exterior walls can be alleviated by installing a watertight membrane; or, by installing a cladding that provides positive lap joints and a forgiving design. That is, the cladding must be able to shed water away from the building envelope. The shedding of water is accomplished by sealing penetrations through the building envelope; and, by providing a positive lap in the asphalt shingles in a conventional sloped roof, in the siding on the exterior walls and in the flashings in the cladding on the building envelope.

In some instances, a second line of defense is required behind the cladding material to offset inherent failures in the cladding. The second line of defense on the roof includes an eaves protection (ice and water shield) underneath conventional asphalt shingles; and, a moisture barrier behind siding, stucco and brick veneer on the exterior walls. The ice and water shield is utilized to prevent bulkwater migration through the roof system due to the accumulation of ice along the eaves (ice damming). The moisture barrier on the exterior wall and in behind the cladding must be of a material that does not restrict water vapour diffusion. The second line of defense must contain joints that have positive laps in the material. Furthermore, the second line of defense (moisture barrier) must contain a positive lap at flashing materials. Flashings are required at the base of the cladding where the runoff terminates.

The flashings must be installed to redirect runoff away from the building components.

One additional parameter can be introduced behind the cladding to provide a discontinuity between the cladding and the building envelope. An air space can be introduced behind the cladding to eliminate bulkwater bridging across the building envelope. Typically, air spaces are provided behind a stucco and brick veneer cladding. Weep holes are also introduced at the base of the cladding to allow trapped water within the cavity to escape. Cladding that consists of siding material is installed in such a manner that bulkwater can easily escape from behind the siding without penetrating a properly installed moisture barrier (positive lap joints).

Control of Water Vapour Diffusion and Air Leakage:

The introduction of insulation within the building envelope (exterior walls, floor frame over an unheated crawl space and roof) forces the dew point into the building envelope. In order to reduce the rate of water vapour diffusion into the building envelope, a vapour retarder and air barrier are introduced in the building envelope. The vapour retarder must be placed on the warm side of the dew point so that condensation does not become trapped within the building envelope. Typically, the vapour retarder is installed on the inside face of the building envelope since water vapour will diffuse from the inside to the outside in the cold winter season. The control of vapour diffusion during the cold winter season is most crucial in the conventional construction. The location of the air barrier can occur in any location across the section of the building envelope as long as the air barrier allows water vapour to diffuse through the building envelope. The more effective vapour retarder must

be installed on the warm side of the dew point. In some instances, the vapour retarder and air barrier can be installed as one component, as is the case with conventional construction (polyethylene sheet). The air barrier must be installed as a continuous barrier to prevent air leakage through the building envelope. Air movement through discontinuities in air barrier will transport larger quantities of water vapour than vapour diffusion. The discontinuities will lead to larger accumulations of concealed condensation within the building envelope.

Forgiving Design (Ventilation):

As mentioned above, the installation of the vapour retarder will only reduce the rate of vapour diffusion through the building envelope. Discontinuities in the air barrier will also allow some water vapour to pass through the building envelope. The building envelope must be designed and constructed as a forgiving building envelope. That is, there must be provisions made for the escape of the water vapour and moisture from within the building envelope. The exterior side of the building envelope must allow water vapour and moisture to dissipate quicker than the water vapour diffusion and moisture migration into the building envelope. The building envelope must be able to breathe.

Exterior Walls:

In conventional construction the cladding on the exterior walls provides the parameter for a forgiving building envelope design. Water vapour permeable moisture barriers, air spaces and a permeable cladding provides the forgiving design.

Roof

In the case of roof construction, the roofs are covered with a watertight membrane that acts as an effective vapour retarder and effective air barrier. The effective vapour retarder in this instance is located on the cold side of the dew point. The location of the vapour retarder (roof membrane) leaves the roof cavity exposed to an accumulation of concealed condensation since condensation will develop at the dew point behind the roof membrane. Ventilation through the roof cavity is required to provide the forgiving design within a building envelope. The ventilation removes water vapour that may condense within the roof cavity. The ventilation must be able to remove the water vapour at a higher rate than the water vapour diffusion through the building envelope. Once again, penetrations through the vapour retarder in the roof cavity must be properly sealed to prevent air leakage into the roof space. Air leakage into the roof space will create an abundance of water vapour movement and subsequent development of concealed condensation within the roof cavity due to the discontinuities.

Crawl Space:

An insulated floor frame over a crawl space must contain a vapour retarder above the insulation, as well as, an air barrier. Water vapour movement through the floor frame can only be removed from the crawl space by ventilation, which satisfies the forgiving design requirement. Since most crawl spaces contain earth floors, a vapour retarder must also be installed over the earth to reduce the moisture load within the space and floor frame above

Control of Indoor Relative Humidity:

In order to reduce the amount of water vapour diffusion through the building envelope, the interior relative humidity shall be controlled. Normal acceptable relative humidity ranges from 30% in the winter season to 40% in the summer season. The relative humidity can be controlled in the summer season by dehumidifying the interior living space; and, can be controlled in the winter season by humidifying the interior living space. Indoor relative humidity in the winter season will normally be less than the summer season due to the heating of the interior air. The relative humidity is a measure of the partial water vapour pressure compared to that of the saturation vapour pressure. As mentioned previously, the increase in temperature will increase the amount of water vapour that the air can hold (saturation vapour pressure). This increase in the saturation vapour pressure thus reduces the relative humidity within the household.

A dramatic reduction in the indoor relative humidity or a larger dependence on humidification during the winter season indicates that there is an abnormal loss of water vapour from the indoor air (drop in partial water vapour pressure). The abnormal loss of the water vapour indicates that a high rate of water vapour diffusion and/or air leakage is occurring through the building envelope. Abnormal reductions of indoor relative humidity indicates that water vapour is condensing within the building envelope. Close monitoring of the relative humidity can provide a measure on the performance of the building envelope.

Closing Remarks:

The building envelope in conventional construction will inevitably be prone to moisture migration. Proper construction practices can be utilized to **control** the moisture that comes in contact with the building envelope. The Ontario Building Code provides the standards required to control the moisture. The influence of moisture on the building envelope extends from the foundation to the roof. Moisture is controlled by providing proper drainage away from the building envelope; by installing proper building materials to reduce the rate of moisture flow through the building envelope; and, by constructing the building envelope with a forgiving design, which will allow the moisture to dissipate that eventually makes its way into the building envelope. Moisture is controlled within the building envelope when the dissipation rate exceeds the infiltration rate.

In addition, moisture levels (relative humidity) within the building must be controlled so that a moisture overload does not occur within the building envelope. Moisture control through the building envelope will assist in reducing the adverse effects that may develop within the building envelope (Mould growth). Mould development will occur with optimum temperature, moisture and food supply (organics). Moisture problems and associated mould growth within the building envelope can create adverse health effects on the occupants of the building.