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Moisture Management in Exterior Walls – Case Studies

By M.Z. Rousseau

IRC recently completed its cross-Canada Building Science Insight Seminar Series (BSI) 2003 on moisture management in small buildings. Several private-sector building envelope specialists presented case studies concerning failures they had encountered related to poor control of rain penetration and condensation. Out of the 15 case studies presented in the seminar series, a recurring problem appeared to be the balcony/exterior wall junction. Poorly designed or built junctions provided a path for rainwater infiltration into the wall, and contributed to the premature deterioration of wood-based elements of the wall. For several years, "leaky condos" on the West Coast made the news, and one could be led to believe that rain penetration failures are specific to wet climates. These case studies indicate, however, that such problems can also develop in drier regions, such as Ottawa.

Highlights of three of the case studies presented by Morrison Hershfield Limited at BSI 2003 are given below. These case studies emphasize the importance of adequate detailing at junctions between walls and penetrating elements such as balconies, windows and doors.

The building complexes were about 10 years old, multi-unit residential wood-frame construction, three to four storeys high. Some of the facades included balconies supported either by cantilevered joists or joists anchored to the wall at one end and supported by posts at the other end. The triggers of the investigation varied from case to case. In one case, small amounts of rainwater tended to find its way into the units, wetting carpets and staining ceilings on an intermittent basis. In another building, the balcony had collapsed by about 50 mm when someone stepped on it. In the third building, an advanced state of deterioration of the structure was observed during renovations to replace a patio door. Interestingly in all cases the exterior cladding was not showing any telltale signs of the deterioration going on within the wall. Building occupants had not complained of serious damage or problems. In other words, in ten years of service life, few minor symptoms on the interior and none on the exterior of the buildings had been apparent. There were no "red flags" to indicate a progressive state of deterioration of the structure.

When the envelope specialists removed the siding during their assessment of the repair work needed, they observed that the wood-based sheathing board, and in places the stud cavity materials, exhibited severe deterioration resulting in a major loss of structural capacity (Figure 1).

In certain cases, damage to wood materials adjacent to windows and doors (head and beneath sills) provided a clear trail of the water leakage and the location of its excessive accumulation (Figure 2).

Lack of continuity of the second line of defence (i.e. the sheathing membrane – also called the water-resistive membrane – and the flashings) at the balcony level and at openings had allowed water infiltration on the interior side of the membrane, resulting in repetitive and excessive wetting of the moisture-sensitive materials of the walls. A portion of the water running down the face of the wood-based sheathing board was absorbed and remained there long enough to initiate rot. The spatial distribution of the damage on this element demonstrated clearly the water leakage path from floor to floor (Figure 3).

Figure 1. Damage to the wall elements adjacent to a balcony joist/wall connection

Figure 2. Pattern of damage to the sheathing board underneath the windows (Project B)

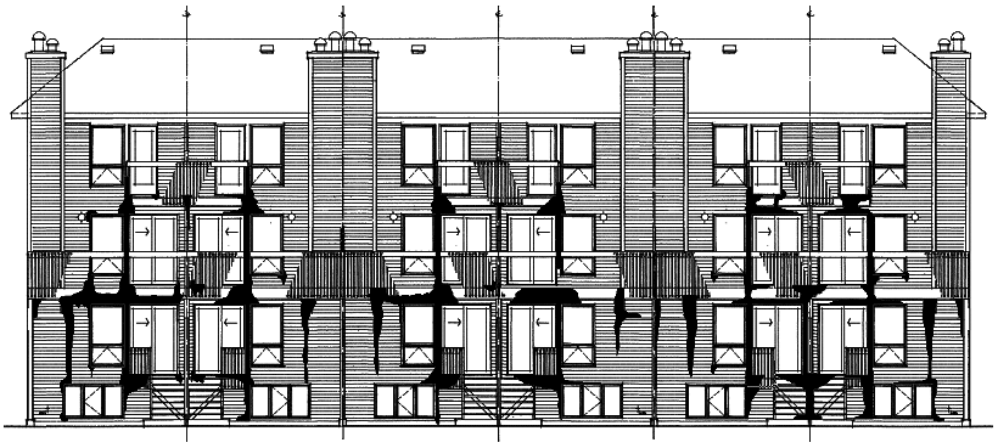

Figure 3. Pattern of distribution of the damage to the exterior sheathing board (Project A)

An examination of particular as-built construction details found a lack of continuity of the second line of defence as follows:

- The framing and flooring of the balcony were completed before the sheathing membrane was installed. With this construction sequence, continuity of the sheathing membrane vis-à-vis the balcony floor was hardly possible due to lack of accessibility.
- Again at the balcony level, no flashing or effective drainage plane was in place to direct the water that reached the outside face of the sheathing membrane back to the outside. In one case a metal flashing was in place but it was crushed against the wall by the ledger board (Figure 4), eliminating the possibility for a free path for water evacuation at this strategic location.
- The sheathing membrane and the flashing found at the wall/window junctions were installed in a reverse lap fashion, promoting the entrapment of water on the interior side of the sheathing membrane (Figure 5).

Figure 4. Flashing is in place, but is crushed between the wall and the ledger board, resulting in little potential for water drainage on its face (Project A)

Expensive repair work was necessary to replace damaged materials and to rebuild the wall assemblies so that the root of the problem would be eliminated. To start with, complete detailed drawings of the junctions and interfaces were designed and presented to the contractor to ensure that the sequencing of work done by the trades would be compatible with the design intent.

Here are some elements for the rehabilitation of the facades of these buildings:

- Ensure continuity of the second line of defence against water infiltration at the balcony level. This may be easier to accomplish when the balcony joists are fastened to the wall, as opposed to cantilevered joists penetrating all the way through the wall. This decision affects the sequence of construction, and needs to be acknowledged early on in the planning of the construction.
- Provide a clear path for water drainage at the face of the sheathing membrane, using a clear air space and properly lapped flashings (so that the situation in Figure 4 is avoided).

- Ensure that membranes and flashing are installed in a shingle-like fashion to avoid water entrapment inwards of the sheathing membrane.
- Install a drip cap flashing at the window head, projecting laterally to protect the opening from excessive moisture loading, and with end dams to avoid redistribution of the water loads to the side of the opening.
- Avoid extending a waterproof membrane to the underside of the head of a rough opening. This will reduce risks of creating a pocket for water entrapment as seen in Figure 5 (for example, during weather exposure during construction work).
- Install a pan flashing over the rough sill of doors and windows. It is intended to collect any accidental water leakage and evacuate it back to the outside (with proper lapping).
- Install eavestroughs and downspouts on sloped roofs to reduce the water loading on the balcony decks.

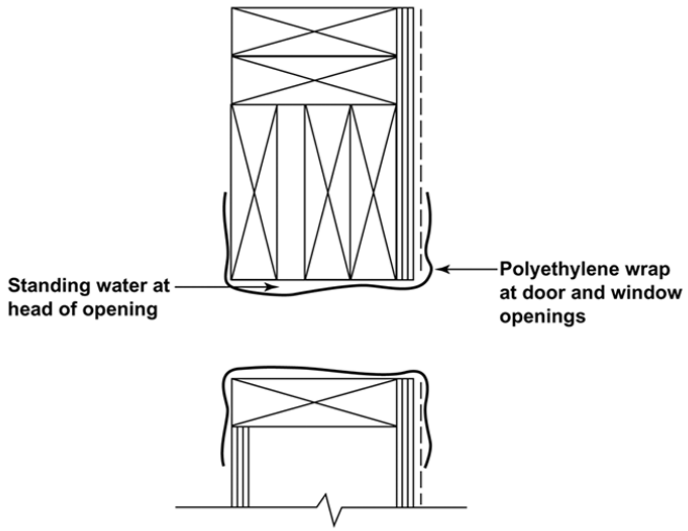

Figure 5.Example of reverse lap between membranes at the window head (Projects A et C)

Madeleine Rousseau is a researcher in the Building Envelope and Structure Program of the National Research Council's Institute for Research in Construction. She was the technical leader of BSI 2003. This article is based on one of the seminar papers entitled "Field Experience with Moisture Management – Putting Principles into Practice." These case studies were part of contributions by Mr. Kevin Chouinard and Mr.William Brown of Morrison Hershfield Limited, guest speakers at BSI 2003.