RESEARCH HIGHLIGHT

Technical Series 01-126

Monitoring of Cavity Humidity Levels at Canada Life Building

INTRODUCTION

Water penetration can cause rapid deterioration of building materials, particularly if the materials stay wet for an extended period of time. If building materials have the opportunity to dry out, potential problems may be alleviated or avoided.

Field monitoring of humidity levels in the rainscreen wall cavity of Canada Life's new headquarters building at 181 University Avenue in Toronto was carried out to assess the wall's moisture intake and drying potential when subjected to rain. Specifically, the research sought answers to the following:

1. To how much rain is the surface of the panel exposed?
2. Does rain penetrate into the cavity?
3. If the cavity gets wet, how quickly does it dry?

RESEARCH PROGRAM

The exterior of the Canada Life building is stone veneer, precast concrete, curtain wall panels. A typical panel (see Figure 1) is composed of the following, from the interior to the exterior:

- 125-mm (4.92-in.) thick precast concrete panel, which includes a cast-in-place aluminium-frame window, glazed with vision and spandrel glass.
- 89-mm (3.50-in.) thick rigid insulation.
- 6-mm (0.23-in.) thick plastic Terra drain-mesh sheets.
- 75-mm (2.95-in.) thick stone.

Compartmentalization of the cavities is accomplished horizontally by a membrane at the head of the panel, which returns upward in front of the concrete floor slab and is sealed to its upper side. This membrane also serves as a drainage gutter for the cavity of the panel above.

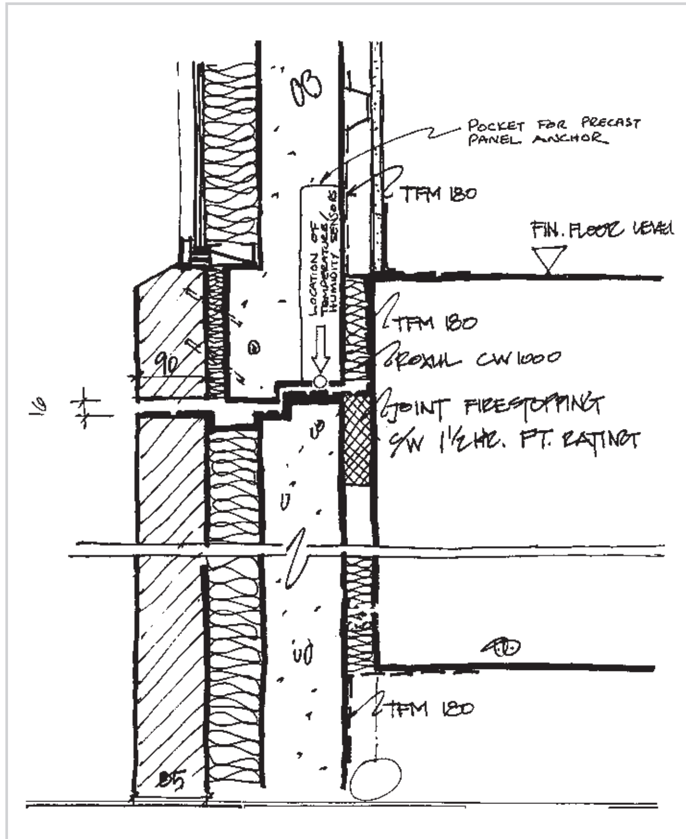

Figure 1 Detail of wall construction-section at horizontal panel-to-panel joint

Vertical compartmentalization is accomplished through the inclusion of a full-height EPDM foam gasket positioned between the stone veneer and the precast concrete panel along the window's left jamb and sill.

Two west-facing panels, located on the 12th floor (top floor) were instrumented to measure rainfall intensity, relative humidity, temperature and barometric pressure. The first panel (Panel 101) is near the centre of the building and the second (Panel 99) is approximately a quarter-building width from the north corner. The instrumentation consisted of:

- Two tipping-bucket rain gauges, installed at the window sill of the panels directly below those under investigation, to measure surface water runoff.
- Two relative humidity-temperature transducers, one placed in the bottom of each wall cavity through the anchor pockets in the precast concrete panel, to measure relative humidity and temperature in the cavities.
- One relative humidity transducer and one temperature transducer installed outside the building on the 11th floor (for accessibility) to measure the exterior ambient relative humidity and temperature.
- One relative humidity transducer and one temperature transducer installed inside the building at the 11th floor to measure the interior ambient relative humidity and temperature.
- One barometric pressure transducer installed outside the building on the 11th floor to measure the exterior barometric pressure.

The instruments were all connected to a computer-based data acquisition system. Data was sampled at the rate of one sample per second, continuously averaged and logged every 15 minutes.

RESULTS

During a monitoring period of four weeks in the spring of 1994, one significant rainstorm occurred. The amount of rainfall intercepted by the two monitored panels varied significantly. In a 15-minute period, the rain gauge for the centre panel (Panel 101) registered 124 mm (4.88 in.) of collected rainwater while the rain gauge on the other panel (Panel 99) received 205 mm (8.07 in.).

As relative humidity is temperature-dependent, the Humidity Ratio (HR) in the cavity was calculated from the relative humidity and temperatures measured over a period of 48 hours just prior to, during and following the rainstorm. The Humidity Ratio is defined as the mass ratio of water vapour to dry air in an air-vapour mixture and is typically measured as kilograms of water vapour per kilograms of dry air.

Prior to rainfall, water is present in the environment and in the cavity air in vapour form. The cavity's HR is established by a moisture balance based solely on the exchange of water vapour with the surrounding environments. Prior to rainfall, the exterior air is at or near saturation and, given sufficient time for an equilibrium condition to be established, the cavity HR will reach a plateau Maximum Vapour Contribution (MVC) limit. The MVC limits were established at 9.5 x 10-3 and 10.0 x 10-3 kg water vapour per kg dry air for Panels 101 and 99, respectively.

Any increase in the cavity's HR beyond the MVC limit can only occur during or following a rainfall as a result of evaporation of either free water that may be present in the wall cavity (due to leakage) or water that may be absorbed in the wetted wall materials. The timing of the HR incremental increase above MVC can be used to determine the wetting nature of the wall cavity. The evaporation of free water inside the cavity causes an immediate HR increase above the MVC limit. A delayed increase in HR above the MVC limit can be attributed to the evaporation of water absorbed in the wall materials. In order for the absorbed water to increase the cavity HR, absorption of rainwater must continue until the water sorption capacities of the various wall materials are reached, at which time water vapour molecules are released to the cavity air.

The HR curves for Panel 101 are shown in Figure 2. HR curves were also created for Panel 99. Within 15 minutes of the rainfall, the HR of both panels increased beyond the MVC limit. This "immediate" increase in HR was attributed to the evaporation of water present in the cavity. A comparison of the curves for Panel 99 and Panel 101 indicates that the rate of water intake was lower for the centre panel (Panel 101). Towards the end of the rainfall, the HR for both cavities dropped momentarily to the level delineated by the MVC limit line, suggesting that the free-running water had drained to the outside. This information could possibly be used to estimate the amount of water penetration.

Following the "drainage dip" in the cavity HR observed at the end of the rainfall, the HR of both cavities again rose above the MVC limit, indicating that additional moisture was being released due to evaporation of absorbed water. The level and duration of the HR rise above MVC provide some indication of the rate of evaporation of absorbed water and the rate of drainage of free water.

The HR curves can also be used to establish the cavity's drying time, which is defined as the time required for the cavity's HR to return to below the MVC limit. Using this approach, the drying time for Panel 101 was estimated at 2.25 hours and for Panel 99 at 10.0 hours.

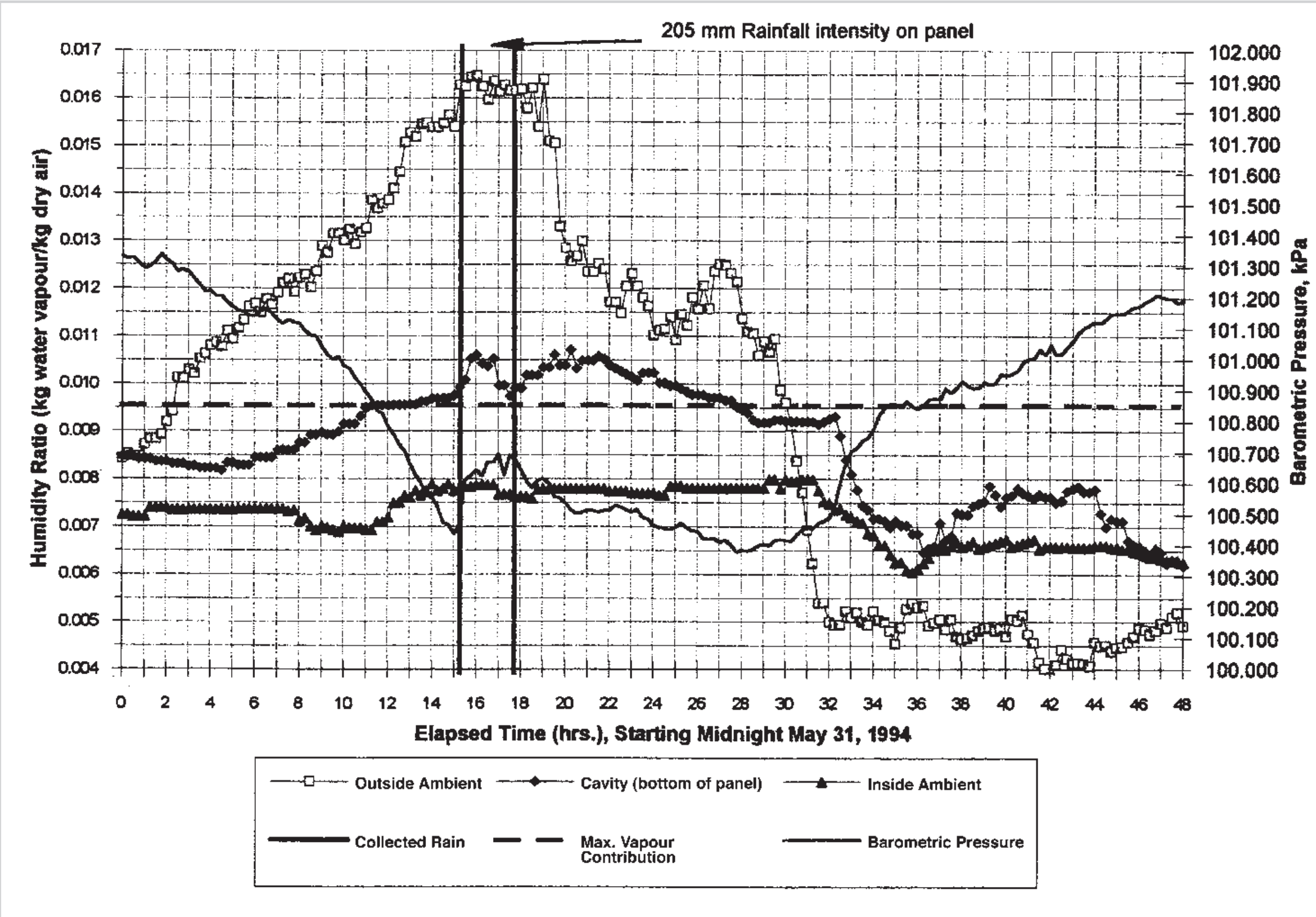

Figure 2 Humidity ratio for Panel 101

IMPLICATIONS FOR THE HOUSING INDUSTRY

The measured rainfall during the one storm that occurred was consistent with other laboratory research that shows that the centre of a building receives less rain on its surface than the building edges or top. Further, more water penetrated into the panel closer to the building's corner than that at the centre of the building.

The Humidity Ratio/Maximum Vapour Contribution (HR/MVC) concept used in this research holds a promising possibility for determining the amount of water penetration and drying potential of an existing rainscreen wall. Further monitoring of buildings is recommended to establish if the MVC limit can be determined for every rainfall with acceptable accuracy and repeatability for a given wall, and how it can be used to characterize and rate the rainscreen performance of a wall system.

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