RESEARCH HIGHLIGHTS

Technical Series 00-100

MEASURED PRESSURE-EQUALIZED PERFORMANCE OF TWO PRECAST CONCRETE PANELS

Introduction

A literature review conducted by the National Research Council in 1992 to determine design guidelines for pressure-equalized rainscreen (PER) walls concluded that current guidelines were not comprehensive. As a consequence, a research and development project was initiated to generate design guidelines for PER walls. The project had three tasks, namely, computer modelling, experimental evaluation and development of design guidelines. CMHC jointly sponsored the experimental evaluation task of the project with the Institute for Research in Construction (IRC). In addition, several wall system manufacturers supplied test specimens and provided technical and practical information.

This Highlight summarizes the results of the experimental evaluation of two precast concrete sandwich panels that were supplied by the Canadian Precast Concrete Institute (CPCI).

Research program

The two specimens (Figures 1 and 2), each 2.40 m high by 1.19 m wide (8 ft. by 4 ft.) were installed side by side in a steel test frame, which was mounted and sealed to IRC's Dynamic Wall Test Facility. The specimens were similar with the exception that the cavity of one specimen was a 13-mm (0.5 in.) air space, while the cavity in the other specimen was formed using 13-mm deep Miradrain™. A "dimpled" plastic sheet with a geotextile bonded to the top of the dimples, the Miradrain™ was installed with the geotextile against the rainscreen. The systems were evaluated for air leakage characteristics, pressure-equalization response, deflection and water penetration.

Air Leakage Characteristics

Air leakage through the assemblies was measured at static pressure differences ranging up to 1,000 Pa (20.88 lb/ft.^{2}). Extraneous leakage and specimen perimeter leakage, were first determined. The effect of a defect in the air barrier was then examined by first intentionally opening one, then two and then three, 6-mm (0.23 in.) diameter leakage holes in the air barrier, 100 mm (3.93 in.) apart and 70 mm (2.75 in.) from the top.

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Figure 1. Details of construction of precast concrete test specimens

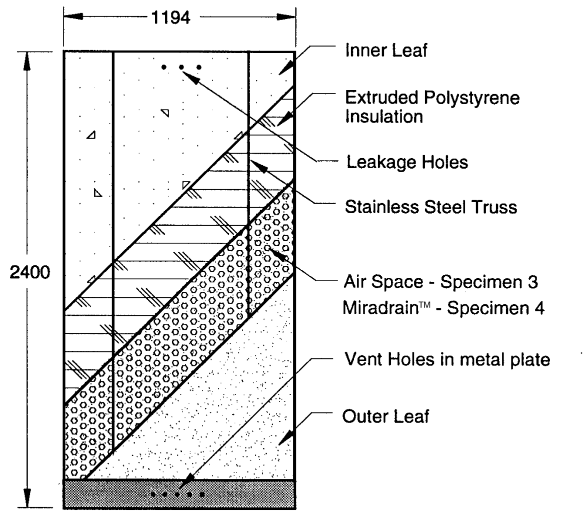
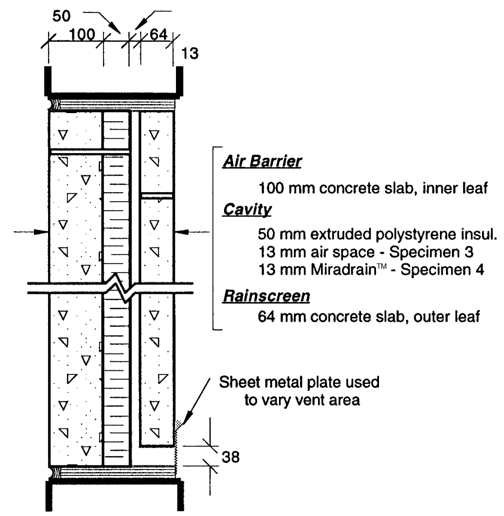


Figure 2. Section and venting details of Specimens 3 and 4



Pressure Equalization Response

The pressure-equalization response of the system was measured by subjecting the wall to sinusoidal pressure loadings, with varying frequencies (0.05 Hz to 5 Hz) and amplitudes (500 and 1,000 Pa-10.44 and 20.88 lb/ft.^{2}). The leakage in the air barrier was also varied and tested with no holes, one hole, two holes and three holes. Pressure taps were strategically located to record pressure differences across the air barrier. The pressure difference across the rainscreen was calculated by subtracting the pressure measured across the air barrier from the pressure across the wall.

Deflection

Deflections of the air barrier and rainscreen slabs were measured at the centre and outer edge of the air barrier slab at mid-height, at the centre and outer edge of the rainscreen slab at mid-height, and at the top centre of the rainscreen slab. Deflections were measured with no leakage holes and with three leakage holes, one vent hole and for a sinusoidal loading with an amplitude of 1,000 Pa and frequencies of 0.5 Hz and 1.0 Hz.

Water Penetration

Water penetration through an intentional defect in the rainscreen (a horizontal, 64 mm- (2.52 in.) wide and 5 mm- (0.19 in.) high saw cut, located 730 mm (28.74 in.) from the top of the slab) was measured under both static and dynamic pressure, with and without leakage openings in the air barrier and with and without the vents open. In essence, tests were conducted to simulate a face-sealed wall with a defect, a cavity wall (that is, one with an airtight air barrier to achieve static pressure-equalization but insufficient venting for dynamic pressure-equalization response) and a pressure-equalized system. Water was applied to the wall at a rate of 3.42 L/min/m^2 and any water that penetrated the wall was collected and recorded. This test was conducted only on the wall with the air cavity.

Results

Air Leakage

The specimen perimeter leakage was found to be less than 10 per cent of that measured through the leakage holes. The leakage created by one leakage hole was approximately equal to 0.1 L/s/m^2, which is the maximum flow rate recommended for air barriers by the *Technical Guide for Air Barrier Systems* published by the Canadian Construction Materials Centre.

Pressure-equalization Response

Pressure-equalization response refers to how well the cavity pressure matches the pressure applied to the wall, in terms of both magnitude and time lag. The pressure-equalization response was found to become worse as the air leakage through the air barrier increased, as the vent area in the rainscreen decreased and as the frequency of the applied pressure increased. However, the pressure difference across the rainscreen changed negligibly with the height of the specimen.

It was shown that the dynamic pressure equalization response of the specimens is directly related to the cavity volume-to-vent ratio and that for the precast concrete specimens, a minimum volume-to-vent ratio of about 50 m provided adequate response. This result can best be achieved by minimizing the volume before increasing the vent area.

The governing criteria for acceptable air barrier leakage for a precast wall, with respect to rain penetration control, appears to be that required for static pressure equalization rather than that required for dynamic pressure equalization. For example, an effective vent-resistance to air-barrier-leakage-resistance ratio of 20:1 (that is, a rainscreen that is 20 times leakier than the air barrier) will produce a rainscreen pressure difference of only 25 Pa (0.52 lb/ft.^{2}) if the design (static) pressure is 500 Pa (10.44 lb/ft.^{2}). This ratio is best achieved by decreasing the air barrier leakage before increasing the vent area.

The performances of the two specimens were nearly the same, with a slightly better performance for the open cavity. However, the difference in performance was not significant when considered in terms of the reduced labour and greater ease of manufacture of the specimen when the Miradrain™ is used to define and maintain the cavity.

Deflection

Deflections of the air barrier may adversely affect the pressure equalization response of the cavity, while deflections of the rainscreen may improve the pressure equalization response. The deflections were very small and difficult to measure accurately. Further, the composite action of the air barrier and the rainscreen, given that two stainless steel trusses join them, made distinguishing between the two deflections difficult. However, it appeared that the rainscreen was somewhat more flexible than the air barrier, which may contribute to pressure-equalization response of the cavity.

Water Penetration

For a "defective" face-sealed system, one third of the available water was forced through the defect when no pressure was applied, while a static pressure difference of 100 Pa (2.08 lb/ft.^{2}) forced most of the available water through the defect. For a drained cavity wall, about two-thirds of the available water was forced through the defect under dynamic conditions. For a pressure-equalized wall, only one-third of the water was forced through the defect under dynamic conditions. The amount of water entrained in the airflow through the vent holes was found to be negligible.

Of note was the observation that when water is present, the pressure difference across the rainscreen does not follow a sinusoidal waveform. On the positive half of the pressure cycle, water blocks the defect, venting decreases and the pressure difference across the rainscreen increases. On the negative half of the cycle, the blockage is removed, venting increases and the pressure difference across the rainscreen decreases. As a result, an asymmetrical waveform is present, which induces a higher average pressure difference across the rainscreen.

Implications for the Housing Industry

A wall designed to pressure-equalized rainscreen principles is better able to resist rain penetration, as demonstrated in this experimental work. For best results for precast concrete walls, the air barrier must be sufficiently airtight to achieve static pressure-equalization and there must be sufficient venting to achieve dynamic pressure-equalization. Similar results were obtained from research conducted on other wall systems. For precast concrete walls, these results are best obtained by minimizing the cavity volume and decreasing air-barrier leakage before increasing vent area. Water penetration through vent holes should not pose a problem, provided proper use is made of drips, baffles and upward-sloping flashing to control the movement of water.

CMHC Project Manager: Jacques Rousseau

Research Report: *Measured Pressure-Equalized Performance of Two Precast Concrete Panels—Performance of Pressure-Equalized Rainscreen Walls, A Collaborative Research and Development Project, Report date, May 31, 1995*

Research Consultants: National Research Council of Canada

A full report on this project is available from the Canadian Housing Information Centre at the address below.

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