RESEARCH HIGHLIGHTS

Technical Series 99-114

ON-SITE EXTERIOR WALL MONITORING METHODS FOR AIR LEAKAGE, CONDENSATION AND RAIN PENETRATION CONTROL PROBLEMS

Introduction

When wall moisture problems occur, to determine the appropriate scope of remedial repairs and to estimate repair costs, it is important to accurately diagnose the cause of the problem. Inaccurate diagnosis may result in incorrect or unneeded remedial repairs or repairs that may be more expensive than necessary. To improve the diagnosis of the problem, a field investigation may be expanded to include wall-performance monitoring. This report presents three specific monitoring protocols.

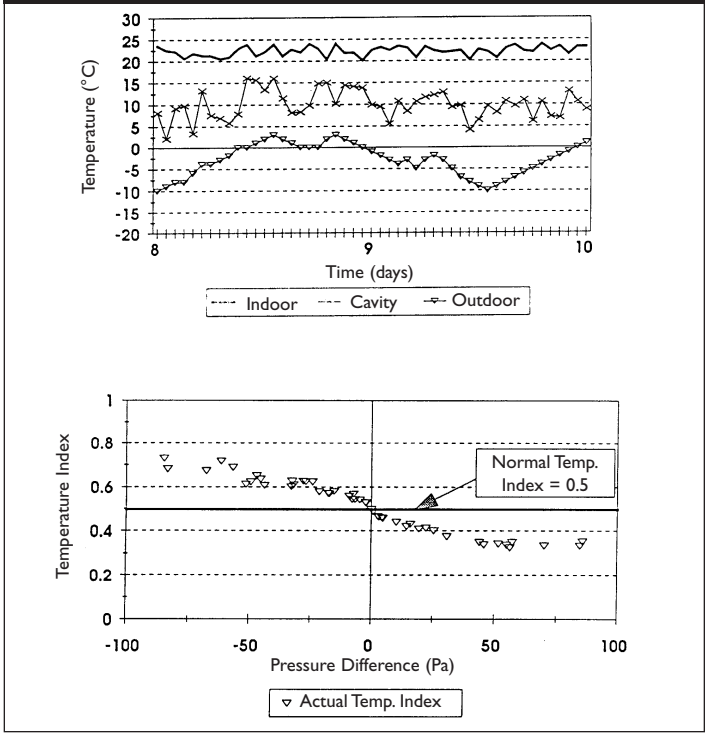
AIR LEAKAGE DETECTION AND ANALYSIS METHOD

This method can be used to determine if air leakage is occurring in an exterior wall. Temperature sensors are used to record the interior temperature, the temperature in the insulation cavity, and the exterior temperature. A pressure transducer is used to measure the pressure difference across the wall. All sensors are connected to a data logger, which should be set to a monitoring interval of 15 minutes. Data should be collected for one to two weeks. It is recommended that the analysis be completed with nighttime data only (12:00 a.m. to 6:00 a.m.) to eliminate temperature effects due to solar radiation.

The temperature index is calculated from the collected data. The temperature index is the fractional temperature drop in the wall due to conductive heat losses and the thermal resistance of the wall elements. The actual temperature index is then compared to the expected or theoretical temperature index. An actual temperature index higher than the expected index indicates that indoor air is exfiltrating through the wall. Conversely, a temperature index lower than expected indicates that outdoor air is infiltrating through the wall to the inside. Since air leakage is driven by an air pressure difference, comparing the measured temperature index with the monitored air pressure difference will confirm if air leakage is occurring.

To demonstrate the method, a residential building in Montreal was instrumented and monitored. The results were plotted on a graph, as shown in Figure 1. This graph indicates that the exterior wall is leaking air and the spread of the index change over the pressure difference range is indicative of the magnitude of the leakage problem. If the exterior wall were airtight, the pressure difference would not induce changes in cavity temperature and the temperature index would remain constant.

Figure 1
Air Leakage Detection Analysis-Montreal Building



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It is estimated that the fees and expenses for a consultant to undertake this monitoring in Canada in 1999 is $8,000, including the purchase of sensors, transducers, data logger, and necessary hardware.

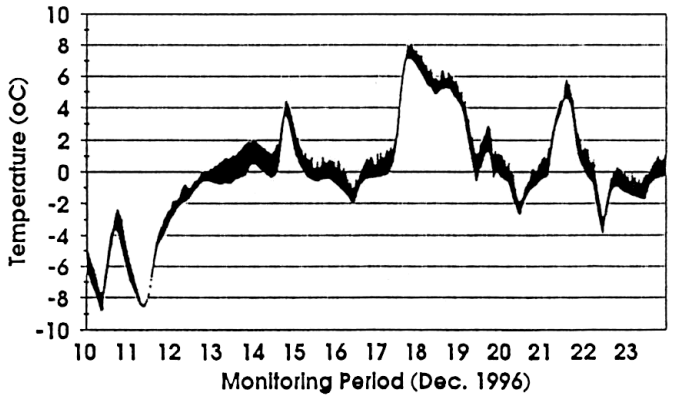
CONDENSATION DETECTION AND ANALYSIS

This method can be used to determine if condensation is the primary cause of a moisture problem. Temperature sensors record the interior and exterior temperatures and the temperatures in the cavity and the outside (cold) side of the cavity. The relative humidity in the cavity is also measured. A pressure transducer is used to measure the pressure difference across the wall. All sensors are connected to a data logger, which should be set to a monitoring interval of 30 minutes for a minimum of three weeks.

The air temperature and relative humidity conditions in the cavity are converted to dew point temperatures. The dew point temperatures are then compared to the cold-side cavity surface temperature. If the dew point is equal to or higher than the cavity surface temperature for prolonged periods of time, condensation is probably occurring.

To demonstrate the method, a building in Ottawa was instrumented and monitored. The cavity dew point temperature and the cavity surface temperature were plotted on a graph, as shown in Figure 2. The solid area in the graph illustrates that condensation is occurring and that moisture is supplied constantly to the cavity throughout the 14-day period represented by the graph. Examination of the pressure difference across the wall confirmed that air exfiltration is occurring.

Figure 2
Brick Cavity, Ottawa Bldg.
Cavity condensation potential



It is estimated that the fees and expenses to undertake this monitoring for a consultant in Canada in 1999 is $8,000, including the purchase of the necessary equipment.

RAIN AND MELT-WATER DETECTION AND ANALYSIS

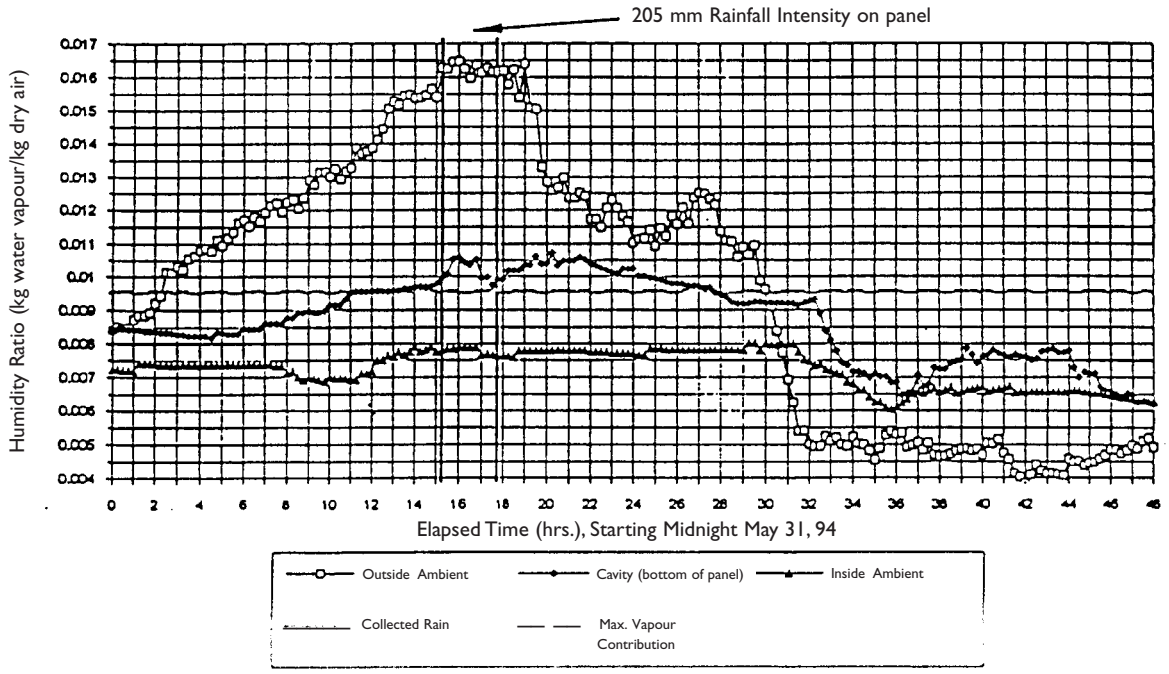
This method can be used to determine if rain or melt water is the source of moisture in a wall. The area of most severe damage should be monitored. Temperature sensors record the interior, exterior, and cavity temperatures. Relative humidity is measured at the same locations. It is also recommended that the cavity and exterior be instrumented with pressure taps to measure pressure difference during rain events to discriminate between rain penetration by gravity and rain penetration by wind-driven rain. All sensors should be connected to a data logger set with a continuous loop and a monitoring interval of 10 minutes. Data can be retrieved after a rain or melt-water event. Two or three events should be recorded.

Following a rain storm or melt-water event, if the relative humidity in the cavity rises and remains high for days or even weeks, it is likely that rain or melt water has penetrated the wall construction and that it is not draining or drying out adequately.

To demonstrate the method, a renovated 17-storey building in Toronto was instrumented and monitored. Figure 3 illustrates a wall panel experiencing light rain penetration. The humidity ratio of the cavity exceeds the outdoor condition on about June 30th and remains above the outdoor condition for several days.

It is estimated that the fees and expenses to undertake this monitoring for a consultant in Canada in 1999 is $9,000, including the purchase of the necessary equipment.

Figure 3
Rain Penetration Monitoring Data
Toronto Building



Implications for the Housing Industry

The diagnosis of the cause of an exterior wall moisture problem is considerably improved with wall monitoring. This report presents three relatively low-cost protocols for diagnosing air leakage, condensation, and rain or melt-water penetration. An initial outlay of $2,000 to $4,000 in 1999 dollars for equipment is required. Recommended equipment includes Setra Model 264 pressure transducers and ACR data loggers. The monitoring is expected to cost between $4,000 and $5,000 in 1999 dollars to install the sensors and report on the results. The test protocols will provide accurate information on actual wall performance. With such comprehensive analyses, consultants will be able to develop repair recommendations that are more effective and better suited to the moisture problem under investigation.

Project Manager: Jacques Rousseau

Research Report: *On-Site Exterior Wall Monitoring Methods for Air Leakage, Condensation and Rain Penetration Control Problems*

Research Consultants: Quirouette Building Specialists Ltd.

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

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