RESEARCH HIGHLIGHTS

Technical Series 01-104

MONITORING THE PERFORMANCE OF AN EIFS RETROFIT ON A 15-STOREY APARTMENT BUILDING

Introduction

In March 1995, a 15-storey, 112-unit cooperative housing complex in Toronto, Ontario commissioned an extensive rehabilitation plan to address issues of air and water leakage and general deterioration. Among its many recommendations for the renewal of the building, the rehabilitation plan included the replacement of the existing windows and doors and installation of an exterior insulation finish system. The objectives of the wall retrofit included bringing the building into compliance with Ministry of Housing requirements, improving the durability and appearance of the wall systems, reducing air and water leakage and realizing energy cost savings.

The successful bid for the exterior cladding retrofit was an Exterior Insulation Finish System (EIFS) manufactured by Dryvit Systems Canada Inc., specifically their "Infinity MD" system which includes a means of draining moisture from within the applied EIFS overcladding. While not promoted as a pressure-equalized rainscreen system, venting of the vertical drainage channels cut into the interior face of the insulation panels was expected to provide some localized pressure equalization of the EIFS system. As moisture draining or rainscreen EIFS systems were a relatively new concept at the time this work was undertaken (1997), this rehabilitation project provided an excellent research opportunity; Canada Mortgage and Housing Corporation initiated a project to evaluate the retrofitted walls. The research project had the following objectives:

- document the development of a building envelope retrofit strategy for a high-rise apartment building;
- monitor, assess and document the performance of a high-rise apartment building envelope retrofit with respect to heat, air and moisture control;
- assess the degree to which the monitoring protocol can be implemented as part of regular operation and maintenance activities for new and existing buildings; and
- assess the potential for the development of a commercially viable, building envelope performance monitoring protocol.

Research Program

The existing exterior walls of the building were solid masonry infill within the reinforced concrete structural frame. The assembly consisted of clay brick with a raked face; filled 25 mm collar joint; concrete block backup; 25 mm thick expanded polystyrene foam insulation and an adhered, approximately 12 mm thick, plaster finish on the inside.

The new EIFS over-cladding system consists of an acrylic stucco lamina (base coat, reinforcing mesh and finish coat) installed over 75 mm expanded polystyrene insulation. As a fully adhered system, the insulation is applied directly to the brick masonry (substrate) using

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a two-coat trowel-applied proprietary Dryvit material; the first coat prepares the surface while the second coat adheres the insulation to the prepared surface. The coating is intended to operate as the air barrier and drainage plane and may also function as the vapour barrier. The lamina and insulation act as the first line of defense against precipitation. The second line of defense is the flashed drainage plane located at the substrate. Vertical channels located in the interior face of the insulation are intended to drain rainwater that penetrates to the coating (see Figure 1). The channels are flashed to the exterior every five stories and also laterally within the cavity above window heads. Intersections of the trowelled-on air barrier and other elements are sealed with self-adhering, rubber-modified bitumen sheet membrane, tape and/or sealant. Further, spray urethane foam is installed between the window frame and the rough opening.

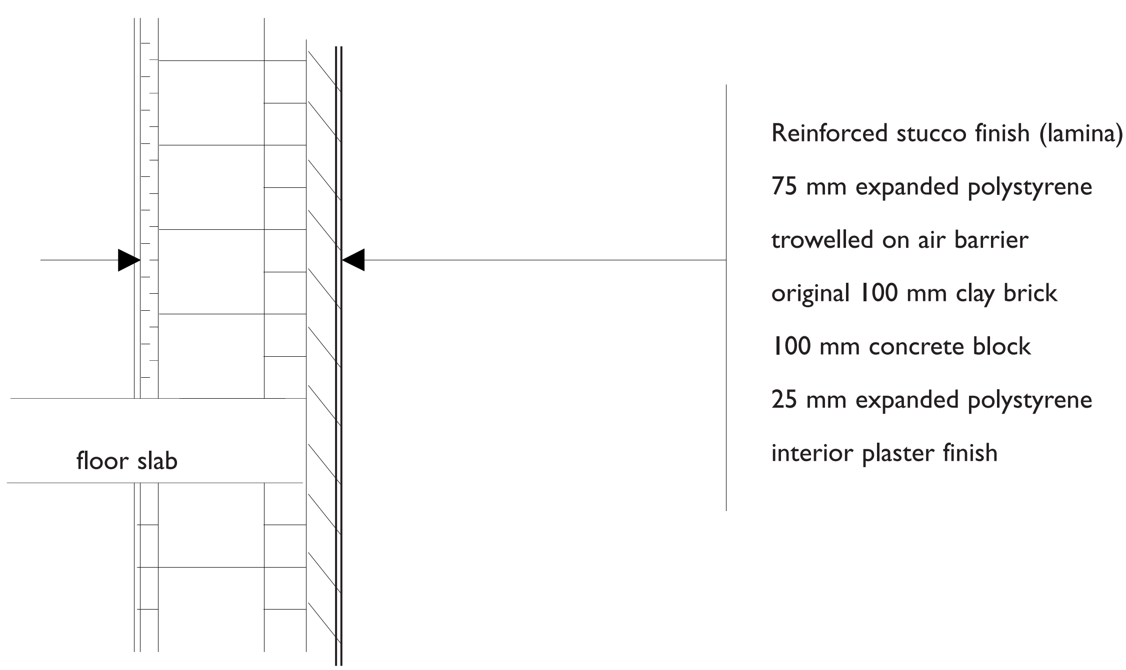
Two data acquisition systems were installed for the full monitoring period (from the fall of 1997—the time of the retrofit—to early 1999). One was installed at the 12th floor and the other at the second floor, both with west exposures; the building has a fairly open exposure on the west side. A third data acquisition system was moved over the course of the research project between three other monitoring stations: the 12th floor east exposure, 12th floor north exposure, and 2nd floor east exposure. Each monitoring station consisted of up to seven thermocouples, at the following possible locations: air barrier, lamina, slab edge, slab edge below drain block, drain block, above drain block, shear wall, window jamb.

Pressure taps referenced to the interior were installed to allow measurement/calculation of the air pressure difference across the masonry, across the air barrier, across the lamina and across the entire wall.

Duff gauges were installed in shallow depressions in the exterior face of the polystyrene insulation and embedded in the lamina to detect moisture in the lamina. Duff gauges were also installed to detect moisture to the interior of the drainage plane. Each of the permanent wall stations also included rainfall sensors mounted on the exterior wall.

Exterior conditions were measured on the roof of the building using a weather station that recorded air temperature, relative humidity, wind speed and direction, rainfall on a horizontal surface, and rain impacting on vertical surfaces.

Figure 1: Section of Retrofitted Wall Assembly



Results

While the installation of the draining EIFS was initially slower than that of a conventional EIFS system, it proceeded essentially at normal speed once the drain blocks were put in place.

The temperature on the inside of the air barrier (the coating applied to the masonry) was compared to the coincident dew point temperature of the inside air to determine if condensation was likely to occur in the masonry. In all cases, the dew point temperature of the air was considerably below the air barrier temperature indicating that condensation does not occur on the inside of the air barrier. A similar comparison was done to determine that condensation also does not occur on the inside of the exterior finish (lamina). It was also found that the temperature of the masonry remained relatively stable, even while the exterior temperature varied by more than 20°C. Using a calculated temperature index for the wall, it was determined that the full value of the installed insulation is being obtained.

The output of the duff gauges was expected to be less than 15 per cent. However, the measured moisture content of the duff gauges under the lamina was generally higher than 15 per cent indicating that some moisture penetrated the exterior finish. Because the rain gauge events did not correlate to a change in the moisture content from the duff gauges, it was postulated that the moisture content in the lamina could be due to vapour movement. The duff gauges at the interior of the drainage plane always read less than 15 per cent indicating that external water was not penetrating the drainage plane.

The pressure difference measured across the wall was typically less than ±20 Pa. As the pressure difference across the masonry and across the air barrier tracked very closely, it was concluded that either the masonry or the trowel-on coating is effectively performing the air barrier function. The lamina experiences roughly half the pressure difference across the wall during high winds. During gust conditions, the magnitude of the lamina pressure difference is greater than that at the interior layers.

The monitoring of the heat, air and moisture transport characteristics of the retrofitted wall assembly demonstrated that the wall retrofit strategy met its intended objectives. The retrofitted walls effectively prevented water penetration, reduced air leakage and improved the overall appearance of the building. The monitoring project also served to provide feedback concerning envelope monitoring protocols, equipment and data analysis for the benefit of building envelope researchers and practitioners.

Implications for the Housing Industry

The project found that an EIFS over-cladding can be designed and constructed to bring older buildings in accordance with the National Building Code with respect to environmental separation. The EIFS system installed on this building maintains the original masonry in a warm and stable environment and provides effective control of heat transfer, air leakage, vapour diffusion and rain penetration. However, some moisture penetration of the exterior finish was observed, though due to the limited amount of data, it was not possible with any degree of certainty to determine the source of the moisture, although vapour penetration is suspected. It was also impossible to say whether the durability of the system would be compromised by this moisture penetration since the performance of the system under these conditions is unknown. It should be noted that this research project only monitored the wall assembly for a relatively short time. Longer term monitoring will be required to determine how well the retrofitted wall performs over time.

While the installation of the EIFS has improved the overall durability (and the appearance) of the wall assembly of the building, additional research must be undertaken to determine the extent of the energy cost savings that can be attributed to this work. CMHC will evaluate this aspect of the work in another research project that will focus on the energy impact of each retrofit activity undertaken in the building.

The development of a monitoring protocol for measuring building envelope performance with respect to heat, air and moisture control requires expert knowledge, not only of building envelope performance and construction, but also of sensors, instrumentation and data acquisition. A well-defined objective is necessary before any monitoring is undertaken. Each sensor must have a specific purpose as it is pointless to install sensors in the hope that some understanding can be gleaned from the data. The volume of data becomes impossible to manage without a predetermined purpose for each sensor. In existing buildings, where the as-built details are frequently not well known and the locations to be monitored are normally not easily accessible, monitoring can be difficult at best.

Therefore, due to the expertise required and the unique nature of individual buildings, it was concluded that the potential is limited for developing a commercially viable building envelope monitoring protocol for buildings similar in size and type to the building monitored in this project.

Project Manager: Duncan Hill, Research Division

Research Report: *Monitoring the Performance of an EIFS Retrofit on a 15-Storey Apartment Building*

Research Consultant: Morrison Hershfield Limited.

Housing Research at CMHC

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