RESEARCH HIGHLIGHT

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EVALUATION OF AIR LEAKAGE CONTROL MEASURES TO COMPARTMENTALIZE NEWLY CONSTRUCTED SUITES IN A HIGH-RISE RESIDENTIAL BUILDING

INTRODUCTION

Both practical experience and research have shown that air movement from floor to floor and suite to suite is relatively common in multi-unit residential buildings (MURBs). While smoke and fire control measures are implemented where building services penetrate fire separations, little other attention is given during construction to ensuring the airtightness of internal partitions. Limiting the amount of uncontrolled air movement within MURBs will improve building performance by

- reducing odour transfer between suites
- enhancing smoke and fire integrity between zones
- limiting stack and wind effect pressures across the building envelope that could otherwise adversely affect durability
- reducing ventilation air flows needed to maintain pressurization in corridors
- minimizing paths for sound transfer between suites
- permitting better sizing of in-suite ventilation and space conditioning systems
- enhancing occupant comfort

While the intrinsic benefits of air leakage control *within* MURBs are relatively well-understood, there is little practical knowledge available regarding how easily internal partitions between suites, and between suites and common areas could be sealed. Accordingly, CMHC initiated a research project to assess the extent to which suites could be air sealed from one another, from other adjacent interior areas, and from the outdoors, using readily available technologies and construction practices.

NOTE: Air sealing the interior and exterior partitions of a suite is often referred to as "compartmenting." This involves the design and installation of a continuously sealed air barrier system to fully enclose a suite, thereby separating it from adjacent indoor and outdoor areas. The air barrier system may consist of any combination of materials, components or assemblies that can be either permanently (for example, drywall to concrete floor slab) or temporarily (weather-stripped corridor or balcony doors) sealed together to form an airtight system.

RESEARCH PROGRAM

A building developer agreed to undertake a project to "compartmentalize" two test suites in a high-rise residential building. The researchers assisted the developer in the compartmenting of the test suites by providing recommendations on the design and implementation of air-tightness details, conducting depressurization testing during construction to provide feedback on the success of the implementation of air leakage control measures, and assessing the degree of compartmentalization ultimately achieved in the test suites.

The two test suites (1707 and 2908) were in the same building but located on different floors and had different floor plans. Different approaches were used to air seal their exterior walls. The exterior walls of suite 1707 had spray-applied polyurethane foam inserted in the wall cavity, while suite 2908 used conventional fiberglass batt insulation, sheet polyethylene and drywall as the basis of the exterior air barrier system. In either case, the exterior wall air barrier system was connected to an interior air barrier system that was based on an adaptation of the "airtight drywall" approach. This approach involves sealing various airtight materials and assemblies of the interior wall, floor and ceiling together to form a continuous air barrier system around the perimeter of the suites.

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Depressurization tests were performed in the test suites before and after the application of drywall to help identify air leakage problems early enough in the construction stage to ensure that problems could be addressed. Additional tests were conducted in neighbouring suites to assess the degree of compartmentalization in conventionally constructed units. Air sealing detail drawings were developed to document the measures implemented.

FINDINGS

The test suites (shown in bold) and conventional suites airtightness tests results are provided in Table 1. They are expressed as equivalent leakage area (ELA), normalized leakage area (NLA), forced air change per hour at 50 Pascals indoor-outdoor pressure difference (ACH @50Pa), and normalized flow index which is the forced air leakage at 75 Pascals divided by the total surface area of the suite tested. For brevity, only the NLA results are discussed here.

Based on the results, the NLA of test suite 1707 does not compare favourably with conventional suite 1708, especially given the fact that spray-applied urethane foam was used in the exterior walls of test suite 1707. It was difficult to find what caused the difference between the results of the two suites. However, when test suite 1707 is compared to other 07 series suites (that is, suites with similar details and floor plans) on different floors, the results are more encouraging in that the test suite was found to be more airtight. It would appear from the limited test data that the 07 series suites are more leaky than the 08 series suites—that is, the average air leakage expressed in terms of NLA was 0.98 cm^2/m^2 (1.43 $in^2/100ft^2$) versus 0.38 cm^2/m^2 (0.55 $in^2/100ft^2$). This suggests that there are inherent features of the 07 suites that make them more leaky.

The NLA of test suite 2908 was much less than the neighbouring conventional suite 2907 indicating that the air sealing in test suite 2908 was relatively successful. However, there was notably more air leakage area in test suite 2908 compared to similar 08 series suites on other floors. This difference is likely due to test suite 2908 being on the uppermost floor—where there are building services penetrating the ceiling to the mechanical penthouse and dropped ceilings that tend to complicate air sealing efforts—in comparison to suites on other floors which are surrounded by concrete on four of six containing surfaces.

In summary, the air sealing work done to compartmentalize test suite 2908 was relatively successful compared to suite 2907. While the NLA of test suite 1707 was less than other 07 suites on different floors, it was anticipated that the use of spray-applied polyurethane foam on the exterior walls would have had a greater impact than it appeared to have. This observation tends to support previous research by CMHC and others that the leakage area of the exterior envelope of suites represents a relatively small proportion of the overall suite leakage area. This emphasizes the need for the design and implementation of air sealing measures as part of the construction of the interior partitions surrounding individual suites.

During the airtightness testing, air leakage locations detected by smoke pencils were documented. The locations included wiring and plumbing penetrations of interior wall, ceiling and floors, under or around interior wall sill plates, window-wall joints, poorly gasketed operable units in windows and balcony doors, and electrical outlets in exterior walls. While detailed design drawings were prepared to guide the implementation of the air sealing measures, construction sequencing and scheduling of the various trades could undermine efforts to seal together various components and assemblies. Additionally, air sealing work could be undone by other trades as they work in, around and through the designated air barrier system.

	Test Suite 1707*	Suite 1708	Suite 2207	Suite 2208	Suite 2907	**Test Suite 2908***
Envelope Area m^2 (ft^2)	**197 (2,121)**	217 (2,334)	197 (2,121)	217 (2,334)	221 (2,379)	**241 (2,594)**
Heated Volume (ft^3)	**4,672**	5,496	4,672	5,496	5,939	**6,987**
Flow Co-efficient C (cfm/Pa^n)	**24.1**	7.3	24.6	6.8	77.6	**17.6**
Flow Exponent ($0.5<n<1.00$)	**0.45**	0.72	0.51	0.74	0.45	**0.68**
Correlation Coefficient ($r^2 > 0.99$)	**0.995**	0.998	0.997	0.995	0.998	**0.997**
ELA @ 10 Pa cm^2 (in^2)	**130 (20.1)**	71.6 (11.1)	150 (23.3)	70.3 (10.9)	414 (64.2)	**160 (24.9)**
NLA @ 10 Pa cm^2/m^2 (in^2/ 100 ft^2)	**0.66 (0.95)**	0.33 (0.48)	0.76 (1.1)	0.32 (0.47)	1.87 (2.7)	**0.66 (0.96)**
ACH @ 50 Pa	**1.82**	1.31	2.31	1.33	4.56	**2.18**
Normalized Flow Index $L/s/m^2$@75 Pa	**0.42**	0.38	0.56	0.38	1.23	**0.68**

Table 1: Airtightness Test Results

CONCLUSIONS

Since the ultimate goal was to assess the extent to which suites could be compartmentalized, it is important to note that the two test suites were constructed with NLA's less than the 0.7 cm^2/m^2 maximum allowable for energy-efficient houses constructed under the R-2000 Program. Furthermore, data collected for new suites in other buildings constructed by the same developer indicate that NLA's in the range of 1.0 cm^2/m^2 are to be expected for conventional construction (the conventional suites tested during this project seemed to be exceptionally tight—perhaps due to the use of concrete party walls). In either comparison, it seems that the measures implemented in the test suites did reduce the overall leakage areas.

Smoke pencil testing indicated that the leakage found was primarily a result of leakage from the common corridor and floor-to-floor penetrations as well as minor imperfections in the air barrier on exterior walls. This observation suggests that the development and implementation of air sealing details on interior partitions still represent a challenge to overcome if consistent and effective compartmentalization of individual suites is to be achieved. Air leakage control design guidance for architects and training for contractors will be necessary if individual suites are to be compartmentalized in an efficient and cost-effective manner.

Implications for the Housing Industry

This research demonstrates that the air leakage between suites and common areas in MURBs can be significantly reduced which should, in turn, result in reduced odour transfer, energy consumption, noise transmission and enhanced building envelope durability and smoke/fire control. However, the design professionals and construction contractors will require guidance on proper design and construction details, construction sequencing and quality assurance procedures to ensure the desired results are achieved.

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Research Report: Evaluation of Air Leakage Control Measures to Compartmentalize Newly Constructed Suites in a High-Rise Residential Building

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