RESEARCH REPORT
External Research Program

Compartmentalization of Existing High Rise Apartment Buildings

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COMPARTMENTALIZATION OF EXISTING HIGH RISE APARTMENT BUILDINGS

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FINAL REPORT

Compartmentalization of Existing High Rise Apartment Buildings

CR file 6585-L087

Presented to:

Duncan Hill

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ABSTRACT

Under an External Research Program grant, Morrison Hershfield evaluated the potential benefit of air sealing interior partition walls and floors as a method of air leakage control in an existing 15 story apartment building. Data on the leakage characteristics if separating elements was obtained by field testing and data used to model the building with CONTAM94. The model was calibrated against measured pressure differences across exterior walls, partition walls and floors. Modeling runs with modified leakage characteristics of partition elements were carried out to evaluate potential reduction in air change due to sealing suite partition walls and doors. It was found that such measures did reduce stack driven air change but that the economic benefit was relatively small when considering the building as whole.

SOMMAIRE

Grâce au Programme de subventions de recherche, Morrison Hershfield a évalué l'avantage possible d'assurer l'étanchéité à l'air des cloisons intérieures et des planchers comme moyen de rendre étanche à l'air un immeuble d'appartements de 15 étages. Les caractéristiques d'étanchéité à l'air par la dissociation des éléments a été obtenue par des essais sur place et les données ont servi à modéliser le bâtiment à l'aide de CONTAM94. Le modèle a été étalonné en fonction de différences de pression mesurées de part et d'autre des murs extérieurs, des cloisons et des planchers. Des modélisations ont été exécutées après avoir modifié les caractéristiques d'étanchéité à l'air des éléments des cloisons dans le but d'évaluer la réduction possible du renouvellement d'air attribuable à l'étanchéité des cloisons et des portes des appartements. On a découvert que de telles mesures réduisaient le renouvellement d'air dû à l'effet de tirage, mais que l'avantage économique était relativement faible pour l'ensemble du bâtiment.

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1. INTRODUCTION

Previous research has shown that it is theoretically possible to control air leakage in high rise apartments by air sealing the inner partitions (floors and demising wall to the common corridor) rather than the exterior envelope. If this approach is practical and effective, it would be particularly valuable for application to existing buildings. Morrison Hershfield received an External Research Program grant from CMHC to carry out a research program to determine the practicality of compartmentalizing existing apartment buildings and determining the effectiveness of compartmentalization on controlling unwanted air change, energy costs and comfort problems.

To accomplish these requirements, the following questions need to be answered

- How large and where are the air leakage points in typical apartment buildings floors, demising walls and exterior envelopes?

- Can air leakage through the floors and demising walls be controlled adequately to achieve the benefits of compartmentalization?

- How do the benefits of compartmentalization compare to sealing the envelope?

The initial stages of this project were to find a suitable candidate building, assess the air leakage and movement characteristics of the building using field test data and computer modeling. The computer modeling was used to determine the modifications to partition (interior wall and floor) air leakage characteristics required to achieve benefits beyond that achievable by retrofit envelope air sealing. This interim report summarizes and discusses the findings of these initial tasks.

The ability to achieve benefits, has to be tested by implementing compartmentalization in a sample of suites and envelope sealing in a sample of suites and comparing the air change and energy performance of the two alternatives against units which received no remedial action.

2. METHODOLOGY

2.1 Building Description

The project required a demonstration building. Morrison Hershfield originally attempted to make arrangements with a 22 storey, 195 unit, condominium project in Ottawa. While the project was encouraged by the Board, insufficient commitments to participation in the trial remedial program was evident from individual owners. It was decided that a single owner building was a far more suitable candidate for a research project.

Assistance was solicited from the Minto Corporation who offered the use of two virtually identical rental buildings in the west end of Ottawa. The Adventura I and II complexes are located on Deerfield Crescent in Ottawa. The two buildings are 15 storeys high and contain 12 units per typical floor (second and up) the first floor contains some amenity space, which differs between the two buildings.

The construction is of poured concrete slabs and shearwalls. As shown in Figure 1, the floor plan is almost square with dimensions 20.5 m by 33.3 m. All units have small balconies attached to a bay window section. The slabs are continuous through the bay window area. Examination and testing showed no significant air leakage past the slab in the bay window. Demising walls are of two types: poured concrete shear walls, or gypsum wall board on metal stud frames.

The suite to corridor demising walls are typically gypsum wall board on metal studs. In each of the four corner suites and the interior units on the short axis of each floor, the demising wall separating adjacent suites are primarily concrete shearwalls with a limited area of metal stud wall.

The interior units on the long axis of the floor plan are atypical for the building. There is a two bedroom unit and a bachelors suite on each side. The second bedroom of the former is on the same side of a shearwall as the bachelors suite with access through a door opening through the shearwall (see Figure 1). The suite separation is , therefore, primarily of metal stud construction.

The bachelor units are also unusual in that they are connected to a central exhaust system drawing from kitchens and bathrooms though duct risers to roof mounted fans. All other units have individual, occupant controlled exhaust fans which exit the side walls of each unit.

A roof mounted make-up air unit services a single outlet grill in the "U" shaped corridor of each floor. This system, and the central exhaust systems are controlled by a timer which we understand operates for four hours in the morning and four hours in the evening.

Plumbing services are arranged vertically so that there are a total of approximately 40 plumbing risers penetrating the slabs of each floor. Electrical risers go to meter rooms located on alternate floors which house the meters for each individual suite. We believe that the conduit from the meters to the suite panels is cast into the slab. Suites are heated with electrical base board heaters.

The corridors have dropped ceilings over most of their area. There are full height ceilings immediately in front of the elevators and at each corner in front of the entrance to the corner suites. The drop ceilings provide service space for the corridor mechanical/electrical services. The plans do not indicate services to suites routed though this space. The suites have dropped ceilings in the kitchen, bathroom, and chases leading to the perimeter (for exhaust ducts) to hide mechanical and electrical services. Plumbing risers are typically hidden in mechanical walls.

2.2 Building Testing

In order to gain data for modeling and assessment of the compartmentalization potential, it was necessary to gain some information on the comparative leakage of various building elements. Minto provided full access to two vacant corner suites (1608 and 1202) and limited access to an occupied suite beside and below each of these "test suites". Fan depressurization testing was carried out in four stages.

1. The main test suite was depressurized, by mounting a blower fan in the balcony door, to determine the leakage area of the entire suite.

2. A second door fan was set up at the entry door to the adjacent suite and a manometer arranged to measure the pressure difference between the main test suite and the adjacent suite. The flow at 50 Pa negative pressure in the test suite was determined with and without the adjacent suite depressurized to the same level (i.e. pressure difference between suites equal to 0).

3. Identical testing to stage 2 but with the suite below depressurized.

4. The second fan was set up in the door to a stairwell to depressurize the corridor. It was found that the fan operating at full capacity (about 2,500l/s) could depressurize the corridor to a maximum of -25 Pa. Pressure measurements in the test suites were taken at -25 Pa with and without the corridor depressurized to the same level.

In addition to these tests, smoke pencils were used while the test suites were pressurized with the door fan to determine the location of air leakage paths. It was noted that the entry doors were extremely leaky. In one test suite, another fan test was carried out with the gap between the door and its frame and floor taped in order to determine the leakage area of the suite.

2.3 Air Flow Modeling

To assess the impact of compartmentalization, we used a computer model called "CONTAM94" developed by George Walton of NIST in the USA. This program which is a refinement of a smoke control model, simulates multi-zone air flows and driving pressures under any input environmental conditions.

The critical inputs are air leakage characteristics of the zone separations and mechanical system characteristics. Once the basic model was developed, using field test data to estimate these parameters, simulation runs with and without supply and exhaust fans running was performed. Then leakage characteristics of partition elements were modified and the impact on flow patterns determined by additional runs. This provided some assessment to possible impact of air tightening specific surfaces. We, of course, concentrated on determining the effect of air sealing floors and suite demising walls.

2.4 Pressure Mapping

One way of evaluating the accuracy of the modeling work carried out was to see how well it predicted pressures in the building under environmental conditions which created significant stack forces. To do this, pressures across various building elements were measured on February 25, 1997, at which time the outdoor temperature was -20°C. (This was months after modeling had been completed). Pressure differences were measured across suite entrance doors, stairwell doors, elevator doors and garbage room doors on the 1st, 2nd, 7th and 16th floors, with make-up air fans on and off.

Access was gained to two example suites (1604 and 202) and pressure across the entry doors and to outdoors was measured with make-up air fans on and off, and with a window open to approximately 1,000 cm^2 and with the door taped-sealed.

3. RESULTS

3.1 Building Testing

The building testing was complicated by two factors.

1. While the day of testing was not a particular windy day, there was a significant variation in the pressure differentials measured across the exterior walls of the test suites. This can be attributed to the exposure at the height of the suites and an inability to average pressures around the building, since the suites were exposed on only two sides.

2. We suspect there may have been a malfunction of flow measurement equipment. During all early tests, the flow pressure (which is translated into the flow measurement) were very low. Measurements were made with two different Magnahelic gauges and an electronic manometer. All were consistent. During the later stages of testing in the second suite, higher flow pressures (meaning higher flows or greater leakage areas) were suddenly obtained. A new set of air flow measurements were taken for this suite but it was not possible to repeat the testing in the first suite.

   This anomaly could be explained by a sudden change in building condition (i.e. a leak formed or the internal building pressure changed dramatically) but we suspect that there may have been a blockage in the pressure tap on the fan. The earlier reading indicated air leakage characteristics that would be suspiciously tight so we have assumed that our second set of readings was correct. The initial flow reading for the two test suites were very similar.

The results show that corner suites have an overall Normalized Leakage Area (NLA) @ 10 Pa of approximately 0.8 cm/m^2. This is very close to the R-2000 standard of 0.7 cm/m^2 showing that the tested corner suites are remarkably tight (if one were to believe the initial test readings the NLA would be about .4 cm/m^2).

We found that taping the gap around the entry door reduced the flow rate by approximately 9% in the tested suite. The calculated door leakage area to achieve this result was 19 cm^2 leakage area. This is very close to ASHRAE's suggested value for non weather-stripped doors of 20 cm^2/door.

We found that depressurizing the adjacent suites beside and below had very little effect on the air flows measured during testing. The degree of difference was hard to judge with variations caused by wind effects, but it was about 5% of the total flow. Depressurizing the corridor made a substantial difference in the flow required to maintain the test suite at -25 Pa. Our calculations indicate that approximately 40% of the suite's leakage area was to the corridors (almost 10% of that could be accounted for by the gap around the door).

Smoke pencil testing showed leakage to the exterior at windows, floor to wall joints and through holes in the drywall where wires for the baseboard electric heaters run. Very little air leakage was found through the demising walls. Smoke testing was also done where drains ran through walls to mechanical risers. In general, the space around the drains were caulked. Where a gap had been left around a drain, smoke exited the suite (which was under pressure) but the velocity was relatively small.

Discussion

The field testing showed that the floor slabs and concrete shearwall walls which form most of the demising wall area have relatively little air leakage. In the corner suites, where the majority of the interior compartment separators are made of concrete, the overall air leakage rate of the suite is much lower than many would expect.

From the perspective of this investigative study, this has advantages and disadvantages. The disadvantage is that the units may not be "typical". However this characteristic improves the ability to get good research information from a trial building which treats a limited number of suites rather than a whole building. If the whole building was to be modified, it should only be necessary to compartmentalize the floors and suite to corridor demising walls since pressure conditions across suite to suite demising walls should be virtually identical. In a study addressing individual suites, it is necessary to isolate the test suite from adjacent unsealed suites. This could be a very difficult problem. The Adventura buildings limit this concern because the suites are isolated by the nature of the base construction.

Another advantage of having units relatively well compartmentalized is that if interior demising surfaces were very leaky compared to the exterior walls, a very large change in their leakage area would have be made to create a significant difference in the air flow moving through the suite. Where the interior demising surfaces are already relatively tight and they are the surfaces primarily governing air flow rates through suites, an incremental change to the air tightness of the interior demising walls translates almost directly to a change in overall air flow rates through the suites.

3.2 Modeling

CONTAM94 allows input of the air leakage characteristics of all the defined surfaces and mechanical systems and weather data. It outputs pressure across and flow rate through each of these defined surfaces as well as an air flow change rate for each zone. It will also model contaminant levels in each zone based on input source rates but this feature was not used for this project.

For the purposes of this study the inputs were modeled to provide the relative air leakage ratios as found during the field tests. The total leakage area of corner suites was assumed to be 200 cm^2. The leakage area of individual elements (interior concrete shearwalls, interior metal stud walls, weather stripped and non weather stripped doors, exterior walls and windows) was selected to provide the following proportions. These directly reflect test results.

- entry door - 10%,
- suite to suite demising walls - 5% each,
- floors - 5% each,
- suite to corridor demising wall - 30%,
- exterior walls and windows - 40%.

The actual CONTAM94 modeling assumptions used for a typical corner unit were:

Exterior walls	1.9 cm^2/m^2 x 37 m^2
Exterior door	4 l/s @ 75 Pa n = .65
Windows	1 cm^2/m perimeter x 26.8 m x
Unit floor	8 l/s @ 50 Pa n = .65
Unit demising wall	.35 cm^2/m^2 x 21.8 x 27.8
Demising wall to corridor	2 cm/m^2 x 20 m^2
Sealed	2 cm/m^2 x 10 m^2
Entry door, unsealed	15 l/s @ 75 n = .65
Sealed	4 l/s @ 75 n = .65

In order to gauge the effect of changing leakage characteristics numerous cases were run all based on indoor temperature of 20 °C and outdoor temperature of -20 °C and no wind pressure. The primary cases analyzed were:

- as found conditions with make-up air fans off,
- as found conditions with make-up air and central exhaust fans (for bachelor units) on,
- leakage area of entry doors on example suites on floors 2, 7 and 14 changed from 20 cm^2 to 5 cm^2 and fans off,
- as above with fans on,
- leakage area of suite to corridor walls reduced by 50% for example suites on floors 2, 7 and 14 and fans off, and
- same as above but with fans on.

The simulated pressures and flow rates across individual surfaces were examined, looking primarily at the suites on floors 2, 7 and 14 which were subject to modification of the assumed leakage areas. The following provides a summary of the findings.

1. Tightening interior elements made virtually no change in air flows in the two suites on each floor connected to central exhaust systems.

2. Air flows through floors and suite to suite demising walls showed negligible change indicating that there would be little need to spend significant dollars on further improving the air tightness of these already tight elements.
3. Weather stripping the suite entry doors reduced the simulated air flow through the suites by about 10%.
4. Sealing unit entry doors and reducing the leakage area of the suite to corridor demising walls by 50 % typically reduced the flow rates through both the suite to corridor elements and the exterior elements by about 40%.
5. The model indicated that with a make-up air supply of 350 L/s per floor, even the ground floor would be pressurized. This has not yet been confirmed since we have not been able to examine winter operations of the buildings. This would be unusual for an apartment building. In other buildings we have examined, stack forces have overwhelming effects of the corridor pressurization system so that the ground floors are typically under a negative pressure.

Table 1 and table 2 provide a summary of flows through the corridor to suite elements to give a sense of the relative magnitude of flow rates in the CONTAM94 output. The flows through exterior elements are virtually identical to these values since so little is going through the floors in this building. The direction of flow is provided by the convention of ***out*** of the suite to corridor or ***in*** to the suite from corridor.

Table 1: Leakage Through Corridor to Suite Elements With No Fans Operating (L/s)

	as found leakage areas	weather stripped entry door	weather stripped entry door and 50% reduction in corridor to suite leakage
2nd floor corner suite	28 out	22 out	15 out
2nd floor interior suite	22 out	20 out	13 out
7th floor corner suite	13 out	12 out	7 out
7th floor interior suite	10 out	9 out	6 out
14th floor corner suite	25 in	22 in	13 in
14th floor interior suite	20 in	18 in	12 in

Table 2: Leakage Through Corridor to Suite Elements With Fans Operating (L/s)

	as found leakage areas	weather stripped entry door	weather stripped entry door and 50% reduction in corridor to suite leakage
2nd floor corner suite	22 in	19 in	11 in
2nd floor interior suite	21 in	18 in	10 in
7th floor corner suite	32 in	30 in	18 in
7th floor interior suite	31 in	26 in	16 in
14th floor corner suite	49 in	42 in	25 in
14th floor interior suite	43 in	37 in	23 in

3.3 Cost/Benefit Analysis based on Modeling

The flow rates provided in Tables 1 and 2 are results of simulations at a 42°C temperature difference and no wind forces. At this temperature, difference, heating each L/s of incoming air would require about 50 watts of heat or 1.2 kWh per day.

To estimate annual energy impacts, CONTAM94 was used to determine the difference in infiltration flow rates through sample suites, with and without sealing measures, at several locations and exterior temperatures (-20, -10, 0, 10°C). [Exfiltration does not require heating in the suite but if the exfiltration resulted from the action of the corridor pressurization system the incoming air had to be heated at the expense of the building owner (who would have to recover costs in rent)].

The energy requirement to heat the difference in flow, due to a sealing measure, for 30 days was determined. The equation of the energy vs. temperature curve was determined. This equation was applied to the average monthly temperatures for Ottawa and the results were summed to provide a calculated annual energy saving, resulting from a reduction in stack force generated air change.

Assuming an electricity cost of $.08/kWh and assuming that the building operates without the make up air system on for 2/3 of the day one can show the possible savings to suite occupants resulting from the control of stack force generated air change. The savings are presented in Table 3.

Table 3: Annual Savings to Suite Occupants ($/yr) Due to Control of Stack Generated Air Change

	as found leakage areas	weather stripped entry door	weather stripped entry door and 50% reduction in corridor to suite leakage
2nd floor corner suite	base	$20	$90
2nd floor interior suite	base	$13	$55
7th floor corner suite	base	$7	$40
7th floor interior suite	base	$5	$27
14th floor corner suite	base	$0	0
14th floor interior suite	base	0	0

Wind forces will also generate unwanted air change but, on an annual basis, these will be less than stack generated air change but will affect all suites regardless of height. We do not believe that the impact on specific suites can be modeled reliably but it is reasonable to assume that the savings due to wind generated forces will be about 10 % of the value in Table 3 for the second floor units and will apply to all suites.

However, one should recognize that for the typical corner units, a flow at about 16 l/s is required to meet ASHRAE and code recommended ventilation levels. Theoretically, any reduction of stack driven air flow may result in the need for a higher level of mechanical ventilation which would reduce or eliminate the savings in suites that did not have a high air change rate to start with. The figures in Table 3 should be considered maximum estimated savings.

The above analysis indicates that weather-stripping entry doors may be cost effective to the occupants of suites living in the lower floors. Applying high quality weather-stripping on the doors, which would reduce the air leakage through it by 75%, would cost approximately $80. On units above the mid-point, there may be limited benefits in terms of direct energy savings to the occupant by this leakage reduction. Certainly there will be some benefits to weather stripping, due to the impact of wind effects on the windward side of the building, but in general upper suites receive air heated by other occupants or from the make-up air system from the corridor (which the suite occupant doesn't pay for directly).

The full benefits of compartmentalization is only achieved when the entire building is modified and the volume of make-up air can be reduced while still keeping the hallways pressurized relative to the suites, and the ground floor at neutral pressure relative to outdoors. This level of benefit would not be achieved in the proposed trial project where a limited number of suites will be addressed.

The economic justification for more extensive air sealing work is more difficult to assess. On the lower few floors, it may be justifiable to expend up to $500.00 in air sealing to a level that reduces leakage area by 50%. However, the benefit would reduce with height and a compensating benefit in reduction in make-up air requirement will not be achieved in a partial modification. We believe that the level of air sealing work required to achieve a 50% reduction in the suites is:

1. Seal corridor side of suite to corridor walls of test suites at
    - wall/floor joint.
    - wall/ceiling slab joint and any penetrations through the wall above the level of the dropped ceiling in the corridor. This modification will require cutting out a strip of the ceiling approximately 1 foot wide to gain access.
    - door moldings of entry doors.
2. Where the shear wall abuts against the corridor partition wall, ensure connections, of the exterior surface of the drywall to concrete shear walls, are sealed by injecting foam along the vertical junction.
3. Where there is metal stud wall between the suite and corridor at a shear wall, seal the wall/floor and wall/ceiling joint on one side and inject foam at the vertical junction of the shear wall and metal stud wall and at the suite to suite and suite to stud partition wall.

Our estimated cost for carrying out this work: $800 per unit.

An alternative to sealing the suite partition elements is, of course, air sealing the exterior wall elements. Our smoke testing showed that there was significant leakage at the wall floor intersection of exterior walls and some, but not excessive, leakage at the windows in the suites. Our estimates for carrying out exterior wall air sealing (this was done with programs such as the Ontario Hydro Non-Profit Program), is approximately $700 per corner units and $350 for the interior units. Because our testing indicated that the exterior walls were less air tight than the interior walls in the test suites, the benefits of a percentage improvement in air tightness of the exterior walls would be less than the same percentage in air tightness of interior components.

However, for a trial program, this relatively conventional upgrade should be tested on a side-by-side basis with compartmentalization.

Without such trial testing to validate modeling, we can only conclude that the cost of compartmentalizing an existing building - even one well-suited for the purpose, would not reduce energy costs by an amount to easily justify the costs.

3.4 Comparison of Modelled vs. Measured Pressures

A comparison of measured pressures with those preceded by the CONTAM94 model at the same temperature is provided in Tables 4 and 5. We would make the following observations:

- In examining the total pressure difference between the corridor and entrances of Suites 1604 and 202 (with fans off) it would appear that the neutral pressure plane of the building is higher than the model.

- The make-up air system of the building partially pressurizes the building by an amount that depends on air leakage area. The following table compares predicted and measured change.

	Predicted Change	Measured Change
Main corridor to outside	18 Pa	24 Pa
Corridor through 1604 to outside	4 Pa	19 Pa
Corridor through 202 to outside	12 Pa	25 Pa
Corridor through stairwells vent runs to outside	32 Pa	40 Pa

While this is significant variation in the individual reading with a greater change at upper floors, the average change is quite close, thus indicating that assumed leakage areas were, overall, quite close.

- The modelled pressure drop across entry door was a higher proportion of total indoor to outdoor pressure drop than we measured. This indicates that suite to corridor walls were leakier than we modelled.

Table 4 - Pressure Readings at Aventura - Make-up Air Off

Makeup Air Off		Measured Pressure February 25/97	Modeled Pressure (CONTAM94)
Upper Floor Corridor to	Stairwell	+ 5.0	+ 7.1
	Elevator	+ 4.5	+ 10.2
	Suite 1605 on east side	- 5.0	- 17.5
	Suite 1610 on south side	- 2.0	- 14.9
	Suite 1602 on west side	- 2.0	- 17.7
	Garbage Room	- 1.5	- 0.8
7th Floor Corridor to	Stairwell	- 1.2	- 5.0
	Elevator	- 1.5	- 2.0
	Suite 703 on north side	+ 3.6	+ 3.4
	Suite 706 on east side	+ 2.0	+ 3.6
	Suite 709 on south side	+ 7.0	+ 3.4
	Suite 702 on west side	- 2.2	+ 4.4
	Garbage Room	+ 12.4	- 1.1
2nd Floor Corridor to	Stairwell	- 3.1	- 11.7
	Elevator	- 2.4	- 8.7
	Suite 205 on east side	+ 14.7	+ 18.6
	Suite 202 on west side	+ 14.8	+ 18.7
	Garbage Room	- 3.2	- 1.3
1st Floor Corridor to	Stairwell	- 5.1	- 11.0
	Elevator	- 1.3	- 8.0
	Suite 105 on east side	+ 9.0	+ 10.6
	Suite 102 on west side	+ 28.1	+ 26.9
	Garbage Room	- 2.8	- 1.2
	Outside	+ 37.0	+ 28.9
Stairwell to	Mechanical penthouse	- 16.3	- 0.9
Mechanical Penthouse	Outside roof	- 10.0	- 33.0

In Suite Testing Suite 1604

	Measure February 25/97		Modeled (CONTAM 94)	
Condition	Suite to Outdoor Pressure (Pa)	Suite to Corridor Pressure (Pa)	Suite to Outdoor Pressure (Pa)	Suite to Corridor Pressure (Pa)
Normal - Make up on	- 21.6	+ 10.6	- 22.4	+ 46.3
Normal - Make up off	- 8.6	+ 4.0	- 6.9	+ 14.9
Window Open with Make up off	- 0.8	+ 11.1	- 0.2	+ 21.5
Door sealed - Make up off	- 7.0	+ 8.9	- 3.3	+ 18.8

In Suite Testing Suite 202

	Measure February 25/97		Modeled (CONTAM 94)	
Condition	Suite to Outdoor Pressure (Pa)	Suite to Corridor Pressure (Pa)	Suite to Outdoor Pressure (Pa)	Suite to Corridor Pressure (Pa)
Normal - Make up on	+ 4.8	- 2.5	- 2.0	+ 9.3
Normal - Make up off	+ 17.9	- 16.0	+ 4.5	- 18.7
Window Open with Make up off	+ 2.0	- 44.7	+ 0.3	- 22.8
Door sealed - Make up off	+ 11.1	- 26.5	+ 3.6	- 20.1

Table 5 - Pressure Readings at Aventura - Make-up Air On

Makeup Air On		Measured Pressure February 25/97	Modeled Pressure (CONTAM94)
Upper Floor Corridor to	Stairwell	+ 5.9	- 1.9
	Elevator	+ 5.0	+ 4.2
	Suite 1605 on east side	- 10.5	- 54.5
	Suite 1610 on south side	- 8.5	- 46.4
	Suite 1602 on west side	- 12.4	- 55.2
	Garbage Room	- 0.5	- 2.0
7th Floor Corridor to	Stairwell	- 2.0	- 6.1
	Elevator	- 1.1	- 0.04
	Suite 703 on north side	- 2.1	- 21.7
	Suite 706 on east side	- 4.7	- 23.9
	Suite 709 on south side	- 0.1	- 21.7
	Suite 702 on west side	- 2.6	- 26.9
	Garbage Room	- 3.5	- 2.1
2nd Floor Corridor to	Stairwell	- 8.7	- 8.5
	Elevator	- 7.5	- 2.5
	Suite 205 on east side	+ 2.0	- 26.6
	Suite 202 on west side	+ 2.3	- 9.3
	Garbage Room	- 9.8	- 2.2
1st Floor Corridor to	Stairwell	- 6.1	- 12.7
	Elevator	- 1.6	- 6.6
	Suite 105 on east side	+ 3.5	- 10.6
	Suite 102 on west side	+ 10.5	- 10.3
	Garbage Room	- 3.1	- 2.3
	Outside	+ 13.1	+ 10.6
Stairwell to	Mechanical penthouse	- 38.8	- 1.7
Mechanical Penthouse	Outside roof	- 18.0	- 70.1

- Taping the suite entry doors made a substantial difference in the ratio of pressure drop across suite to corridor walls suite to outdoor pressure drop. As suspected, a substantial portion of the suite to corridor leakage area was through the doors.

This comparison shows that the model developed from the limited testing data did reasonably predict overall behaviour of the building but that there were significant differences. Some of these differences could be resolved with additional modeling runs, changing assumptions to better predict actual behaviour.

This component of field work was an after the final comparison and further modeling was not carried out. Since the comparisons indicate that suite to corridor halls were leakier than we assumed in the modeling study, the impact of our sealing may be higher than we predicted.

3.5 Owner's Reactions

The intent of this project was to evaluate potential energy savings derived by compartmentalization and by testing and modeling and then by undertaking final remedials and monitoring.

Unfortunately, after reviewing the analysis detailed in the report, the owner of the subject building decided that the cost of trial remedials and perhaps, most importantly, the disruption caused by the construction was not justified by the limited savings potential.

The authors cannot fault this decision, especially in the case of a limited trial program. Our analysis shows that the savings accrual to tenants from reductions in energy consumption are limited, even in a building which is well-suited for suite compartmentalization. Savings accrued to the owner from reductions in make-up air heating would not be obtained until the entire building was addressed.

There would be non-monetary benefits of compartmentalization including reduced sound and odour transfer and increased control of conditions in individual suites. These seem to have little weight in cost/benefit analysis.

4. DISCUSSION AND RECOMMENDATIONS

1. The Adventura I and II apartment buildings are well-suited for the compartmentalization approach because the floors and suite demising walls are already fairly air-tight.

2. Modeling showed there is virtually no benefit to compartmentalization where suites are connected by central exhaust systems, such as was the case with the bachelor units.

3. Even with the suitability of the subject building for compartmentalization, the savings in suite heating costs were predicted to be modest and payback period fairly long, particularly if suites are treated individually.

4. Simple measures, such as weatherstripping entry doors are only effective if the suite to corridor demising walls have similar or lower leakage levels than the exterior halls.

5. Higher level of energy savings benefits could be achieved if all suites were treated because make-up air volume and heating requirements could be reduced.

6. Compartmentalization does not appear to be an attractive approach to owners of existing apartment buildings.

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