AN IMPROVED AIRTIGHTNESS TEST PROCEDURE FOR MULTI-UNIT RESIDENTIAL BUILDINGS

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ABSTRACT

The goal of this project was to develop an improved, practical, yet accurate technique for measuring the airtightness of partition surfaces in Multi-Unit Residential Buildings – specifically low-rise MURBs. Two different approaches, identified as Methods 1 and 2, were developed and evaluated during field trials on a detached house and three low-rise MURB's. Method 1, a variation of the so-called "doors open/doors closed" technique, was based on measuring the change in blower door flow rates when a door (or window) in the adjacent suite on the other side of the partition surface of interest, was opened.

Method 2 used a different approach in which the partition's airtightness characteristics were determined by performing airtightness tests on both sides of the partition while simultaneously measuring the pressure differential across the partition. Unlike other techniques which require a number of simplifying assumptions (such as that all surfaces in the building have the same Flow Exponent, "n"), Method 2's only assumption is that the partition has the same "n" value as that measured during the airtightness test of the adjacent suite.

Some key findings include:

- Method 1 was unable to provide consistent or believable estimates of the partition's airtightness characteristics. Although it worked very well in the field trials on a detached house with a very leaky partition wall (relative to the building envelope), it failed when applied to actual MURB's with tight partitions.

- Method 2 was much more successful than Method 1. Applied 10 times on two of the three project MURB's, it was able - in all instances - to produce reasonable estimates of the partition leakage.

- Method 2 was also found to be easy to use and well-suited for field testing applications. Compared to a conventional airtightness test, Method 2 requires only one additional parameter to be measured (the pressure differential across the partition). Further, unlike other techniques, Method 2 can be performed by a single individual equipped with one blower door.

BACKGROUND

Airtightness testing has been a well-established practice for over 30 years and has been used to successfully

test hundreds of thousands of Canadian buildings. The vast majority of these have been performed on detached, or semi-detached, houses using CGSB 149.10 "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method" as the test method. First published in 1986, CGSB 149.10 has proven to be a robust methodology for field applications. In most cases, a detached house can be tested in an hour or two by a single individual equipped with approximately $3,000 to $5,000 worth of equipment (blower door, multi-channel micromanometer and associated hardware).

However, performing an airtightness test on a Multi-Unit Residential Building (MURB) is more problematic than testing a detached house. When a single unit in a MURB is tested, the air flow measured at the blower door is the sum of the air leakage across the exterior building envelope, plus the leakage which originates from Adjacent Units across common walls, floors or ceilings (commonly referred to as "partition leakage"). If the test objective is to determine the total leakage of the suite (i.e. both envelope and partition leakage), then existing test procedures can be used. However, if the focus of the test is to identify leakage through the building envelope, the partition leakage will result in the test results overstating the true envelope leakage.

To address this issue, various techniques have been developed to delineate the two leakage streams. Compared to CGSB 149.10, however, all of these involve additional resources in terms of equipment, manpower and time, and may also require some simplifying assumptions to be made about the leakage characteristics of the building. This issue is most pronounced when the airtightness test is performed for quality control (as opposed to research) purposes since the available resources are generally more limited.

OBJECTIVES

The objective of this project was to develop a practical, but relatively simple, airtightness test procedure which could be used to separate exterior envelope leakage from partition leakage in Multi-Unit Residential Buildings.

EXISTING MURB AIRTIGHTNESS TESTING PROCEDURES

Perhaps the best summary of current MURB airtightness testing techniques is "Evaluation Procedures for Low-Rise, Multi-Unit Residential and Mixed Use Buildings" published by Natural Resources Canada (2011). This document lists seven different protocols (shown in Table 1) applicable to MURBs ranging from the basic CGSB 149.10 blower door test conducted on the entire building, i.e. with all interior partition doors open and the entire building treated as a single zone, to more complex techniques which employ multiple blower doors and multiple tests

However, examination of Table 1 raises a couple of interesting observations. First, only two methods are explicitly capable of measuring (or estimating) partition leakage (Methods 4.4.3. and 4.4.5.). Both of these are based on the techniques developed by DePani at Concordia University which requires the simplifying assumption that all exterior surfaces of the Test Unit, as well as the partition surfaces which separate it from Adjacent Units, have flow exponents (n) equal to 0.65 (discussed in more detail in Section 3). While this is a reasonable value to use - if one has to assume a value - it nonetheless introduces a source of error since

actual values for "n" can range from 0.5 to 1.0.

In addition, several of the techniques require two or even three blower doors to perform the test. While it is theoretically possible for a single operator to conduct a multi-door test using remote speed controllers, it raises safety concerns since the operator may be "trapped" inside the Test Unit and cannot easily observe or access the Adjacent Unit(s). From a practical perspective, at least two operators would normally be required on-site. This effectively doubles the cost of the test.

Table 1: Summary of Current MURB Airtightness Tests Protocols (from "*Evaluation Procedures for Low-Rise, Multi-Unit Residential and Mixed Use Buildings*")

Ref.[1]	Test Description	Application	Number of		Estimates Partition Leakage?	Comment
			B/D	Tests/ Zones		
4.4.1.	CGSB 149.10 test. Treats all zones as one by opening all interior doors.	Whole building tests	1	1	No	Treats whole building as 1 zone.
4.4.2.	CGSB 149.10 test, but with 2 B/D for greater flow.	Whole building tests	2	1	No	Treats whole building as 1 zone. Requires multiple blower doors.
4.4.3.	Tests each of 2 or 3 zones individually, while also measuring partition ΔP.	Individual units within MURB	1	2 or 3	Yes	Assumes n=0.65. More complex test.
4.4.4.	CGSB 149.10 *BUT* with simultaneous depressurization of Adjacent Unit.	Individual units within MURB	2	1	Yes, if combined with 4.4.1. or 4.4.2.	More complex test. Requires multiple blower doors.
4.4.5.	Tests each of 2 or 3 zones individually, while also measuring partition ΔP.	Individual units within MURB	2	3	Yes	Assumes n=0.65. More complex test. Requires multiple blower doors.
4.4.6.	CGSB 149.10 test, but with 3 B/D for greater flow.	Whole building tests	3	1	No	More complex test. Treats whole building as 1 zone. Requires multiple blower doors.
4.4.7.	Multi-zone buildings	Individual units within MURB	1	4 or more	No	More complex test. Combination of 4.4.1. (or 4.4.2.) and 4.4.3.

DEVELOPMENT OF AN IMPROVED MURB TESTING TECHNIQUE - METHOD 1

Following review of the technical literature, an initial testing technique was conceived based on earlier research by one of the authors (Proskiw, 2003 & 2007), with some additional features and refinements. Identified as "Method 1", this technique uses the so-called "open-a-door/close-a-door" (or window) method.

With Method 1, the partition leakage is measured by conducting a standard CGSB 149.10 test on the first unit ("Test Unit"), while simultaneously measuring the pressure differential created between the Test Unit and the Adjacent Unit (see Fig. 1). The airtightness test is then repeated, but with an open door or window in the adjacent suite. The pressure differential across the partition wall is measured again. The airtightness test results and corresponding partition pressure differential data are then input into a purpose-designed spreadsheet which solves the corresponding flow equations. Using a trial-and-error process, solutions can then be found for the partition wall's flow coefficient (C_p) and flow exponent (n_p).

Field trials of Method 1 were initially conducted using a single, detached house reconfigured to simulate a two-unit MURB. Overall, these tests were completed with no problems; further, the results were easily analyzed using the spreadsheet (which solved 21 simultaneous equations). The field trials were then expanded to three, conventional MURB's (see Fig. 2 as an example).

Unfortunately, results from these three trials were very disappointing. Method 1 was only able to mathematically resolve the partition leakage characteristics once during the 14 times it was applied to the three MURB's. Solutions to individual flow equations often showed significant variation and produced values for the partition wall Flow Exponent (n_p) which were outside the physically possible range (i.e. $0.5 \leq n_p \leq 1.0$.

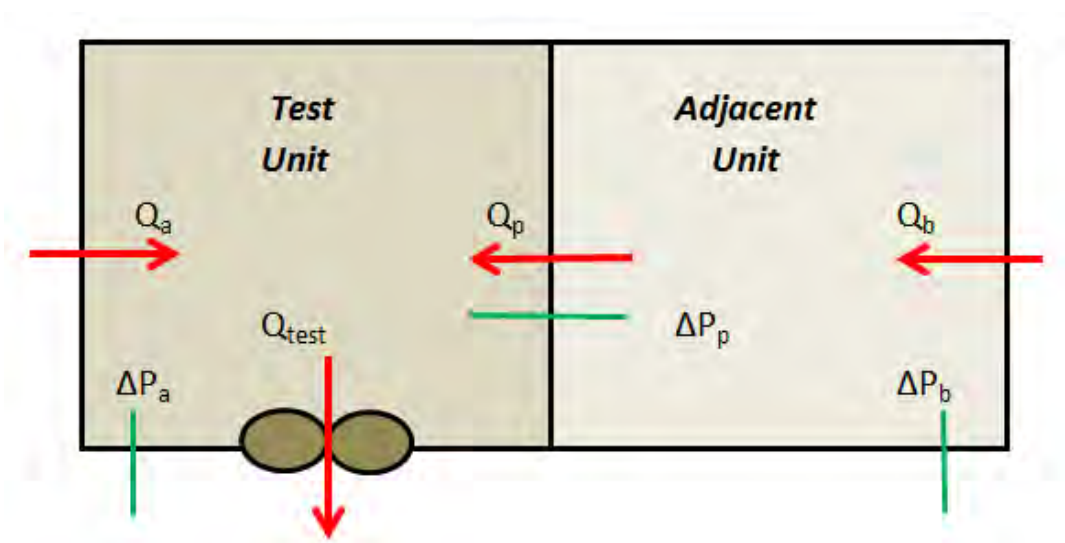

Figure 1: General MURB Airtightness Test Arrangement

Figure 2: Building #1

DEVELOPMENT OF AN IMPROVED UNDERSTANDING OF MURB AIR LEAKAGE

After considerable evaluation, it was concluded that Method 1 was not capable of separating exterior leakage from partition leakage in most MURB's. This lead to a re-evaluation of the basic flow mechanics of the test and, eventually, an improved understanding of the phenomenon and pointed the way towards development of Method 2. That process is described below.

The general power law equation used to describe air leakage in buildings is:

$$Q = C\Delta P^n \tag{1}$$

where:
Q = Air flow
C = Flow coefficient
n = Flow exponent
ΔP = Pressure differential

Now, if we apply this relationship to a two-unit MURB, such as shown in Fig. 1,

$$Q_b = C_b \Delta P_b^{nb} \text{ and}$$

$$Q_p = C_p \Delta P_p^{np}$$

But,

$Q_b = Q_p$

So,

$C_b \Delta P_b^{nb} = C_p \Delta P_p^{np}$ or

$$C_b/C_p = (\Delta P_p^{np} / \Delta P_b^{nb}) \quad (2)$$

Notice that Eq. (2) assumes no by-pass leakage, i.e. leakage which occurs through, but not across, the partitions - such as might occur across the building envelope directly into a partition wall and eventually into the test suite. If significant by-pass leakage is anticipated (based on physical examination of the structure), then the methodology described herein may not be appropriate.

Although the leakage across any building surface is a function of both the Flow Coefficient (C) and the Flow Exponent (n), both the literature (Love and Passmore, DePani) and personal experience have demonstrated that the Flow Exponent tends to cluster around a value of 0.65. However, since we do not normally measure ΔP_b during an airtightness test but rather ΔP_a and ΔP_p, it would be desirable to express Eq. (2) using these same two variables. This can be accomplished if we recall that...

$\Delta P_b = \Delta P_a - \Delta P_p$

Substituting into Eq. (5),

$$C_b/C_p = \Delta P_p^{np} / (\Delta P_a - \Delta P_p)^{nb} \quad (3)$$

So what? Well, the significance of Eq. (3) can be better understood if we set the indoor-to-outdoor pressure differential across the test suite (ΔP_a) to 50 Pa, the standard pressure differential used to express residential airtightness results. Then Eq. (3) becomes…

$$\mathbf{C_b/C_p = \Delta P_p^{np} / (50 - \Delta P_p)^{nb}} \quad \mathbf{(4)}$$

If we assume, for example, that both Flow Exponents (n_p and n_b) are equal to 0.65, the relationship between C_b/C_p and ΔP_a can be plotted as shown in Fig. (3).

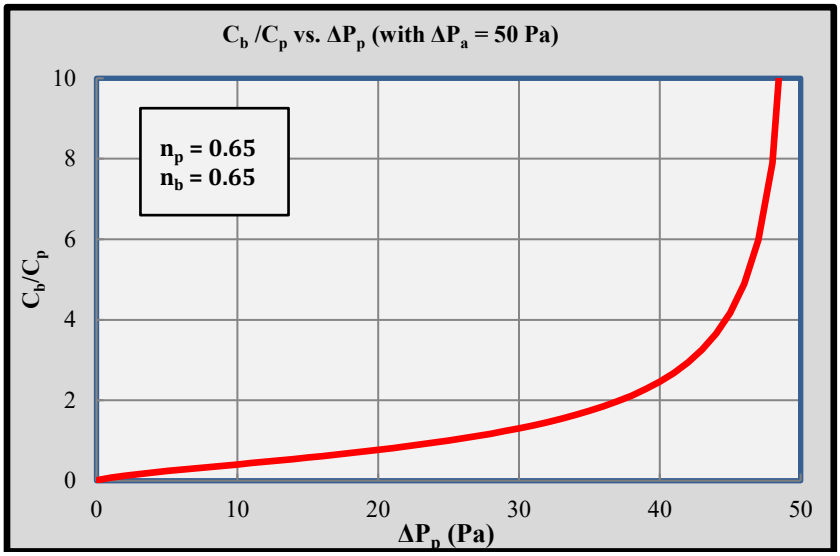

Figure 3: C_b /C_p vs. ΔP_p (with ΔP_a = 50 Pa)

However, Fig. 3 only applies when the indoor-to-outdoor pressure differential across the test suite (ΔP_a) is equal to 50 Pa. If we replace the X-axis (ΔP_a) with $\Delta P_p/\Delta P_a$ (defined as the Pressure Ratio), then by using Eq. (4), we can generate Fig. 4. This allows us to determine the C_b/C_p ratio by simply measuring ΔP_p and ΔP_a at any indoor-to-outdoor pressure differential experienced by the test suite (ΔP_a).

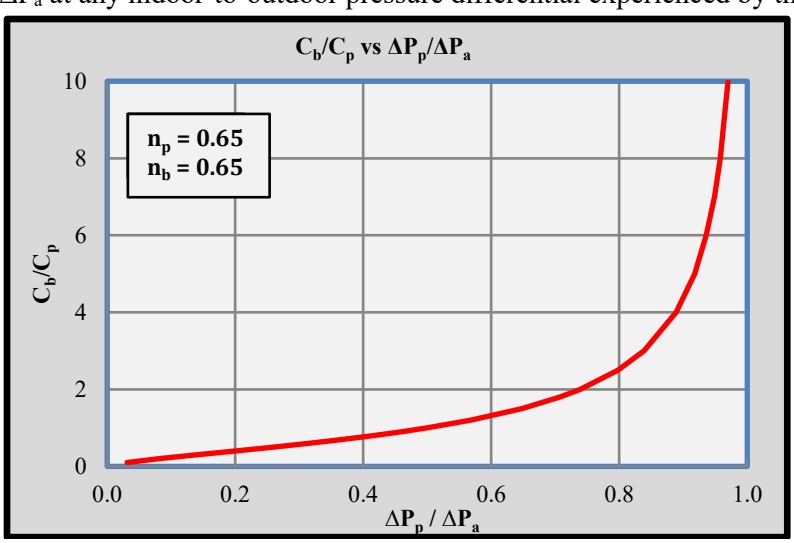

Figure 4: C_b/C_p vs $\Delta P_p/\Delta P_a$

Figure 4 also explains some of the difficulty associated with measuring MURB airtightness. Both ΔP_p and ΔP_a have an associated uncertainty due to measurement error. As the Pressure Ratio approaches 1, the uncertainty in the two pressure measurements will eventually become as large as the difference between the two measurements. This will produce an increasingly large error in the $\Delta P_p/\Delta P_a$ ratio and hence in the C_b/C_p ratio. *Fundamentally, this means that with a Pressure Ratio approaching 1, the error in the C_b/C_p ratio*

increases significantly and the accuracy of any test method, which relies on these two pressure measurements, will degrade.

So, what are typical C_b/C_p ratios in actual MURBs? To answer that question, and better understand what is physically occurring, we have to remember that the Flow Coefficient (C) is not an area-based metric (such as the normalized Leakage Area at 75 Pa, NLR_{75}) but the overall Flow Coefficient of a building or partition. Consider a very typical townhouse complex such as Building #1. These are essentially two-storey boxes butted side-by-side, back-to-back. Let's assume that each side of the box has 50 m^2 of surface area. And let's suppose we are trying to measure the partition leakage to the Adjacent Unit. That means that the partition surface area is 50 m^2, while the remaining surface area of the Adjacent Unit is 250 m^2 (even though some of that area consists of partitions separating it from other units). If both the partition and the rest of the exterior envelope are designed and constructed to the same standard of airtightness, then the C_b/C_p ratio would be 5. Except, in all likelihood they are not constructed to the same standard of airtightness. The partition contains no doors or windows, service penetrations, cantilevers, nor as many lineal metres of intersecting interior partitions, etc. In all likelihood, the partition's leakage rate per unit area is lower than that of the other five sides of the Adjacent Unit. As a result, it is easy to see how we could encounter C_b/C_p ratios of perhaps 10 or more for many MURBs.

If we now return to the buildings tested in this project, we can use Eq. (4) to estimate the range of C_b/C_p ratios for the various partitions measured in the field tests; these are shown in Table 2.

Table 2: C_b/C_p Ratios of The Project Buildings

Building	C_b/C_p ratio
Detached House - Trial Run	**0.3**
Building #1	**10 – 14**
Building #2	**7**
Building #3	**4 – 8**

If we assume C_b/C_p ratios of 4 to 14, and Flow Exponents of 0.65, Fig. 4 indicates that the corresponding $\Delta P_p/\Delta P_a$ ratios will range between about 0.90 to 0.99.

DEVELOPMENT OF AN IMPROVED MURB TESTING TECHNIQUE - METHOD 2

If we now return to Eq. (3)...

$$(C_b/C_p) = \Delta P_p^{np} / (\Delta P_a - \Delta P_p)^{nb} \quad \textbf{(5)}$$

If we assume that $n_p = n_b$, that is, the Flow Exponents of both the partition and the exterior envelope of the Adjacent Unit are equal, then we can re-arrange Eq. (5) to give

$$C_p = C_b / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb} \quad \textbf{(6)}$$

However, C_b in Eq. (6) is the Flow Coefficient of the Adjacent Unit *excluding* the partition whereas the airtightness results for the suite *include* the partition. Therefore, if we label the Flow Coefficient measured during the airtightness test of the adjacent suite as C_{test}, then...

$$C_{test} = C_b + C_p \quad \text{or } C_b = C_{test} - C_p$$

If we substitute this into Eq. (6)...

$$C_p = (C_{test} - C_p) / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}$$

$$= C_{test} / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb} - C_p / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}$$

Or

$$C_p + C_p / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb} = C_{test} / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}$$

$$C_p \{1 + 1/[\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}\} = C_{test} / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}$$

$$C_p = \{C_{test} / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}\} / \{1 + 1 / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}\}$$

$$\boxed{C_p = \frac{C_{test} / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}}{\{1 + 1 / [\Delta p_p / (\Delta p_a - \Delta p_p)]^{nb}\}} \quad (7)}$$

where:

ΔP_a = pressure differential between the Test Unit and the outdoors
ΔP_p = pressure differential across the partition wall
ΔP_b = pressure differential the Attached Unit and the outdoors
C_b = Flow Coefficient of the Attached Unit's exterior envelope
C_p = Flow Coefficient of the partition
C_{test} = Flow Coefficient measured during the airtightness test of the Adjacent Unit
n_b = Flow Exponent of the Attached Unit's exterior envelope
n_p = Flow Exponent of the partition

Equation (7) provides an explicit mathematical solution which can be used to calculate the partition's Flow Coefficient. Since Eq. (7) assumes that $n_p = n_b$, and n_b was measured during the airtightness test of the Adjacent Unit, this means we know n_p and can calculate C_p using Eq. (7). In other words, we have defined the partition's flow characteristics.

If we apply this process twice and conduct airtightness tests on both suites of the partition, with each functioning as the Test Unit and then as the Adjacent Unit, then the leakage characteristics across the partition can be calculated for both flow directions. Having each unit function first as the Test Unit and then as the Adjacent Unit also provides a check on the results since the leakage characteristics should be similar, although not identical, regardless of flow direction. It should be noted that the flow characteristics across a building surface's will vary (slightly) depending on the direction of flow.

FIELD TESTS OF METHOD 2

A field evaluation of Method 2 was performed using the results from Buildings #1 and #3. These are summarized in Table 3 and Figs. 5 to 8. (using a Pressure Ratio measured at 100 to 125 Pa). Note that Table 3 use a colour-coding scheme such that each row represents a single assessment of the partition leakage characteristics. Rows of the same colour describe tests conducted on the same partition (although usually in opposite directions) and can therefore be compared.

The "by-pass" referenced in Table 3 refers to a 12" diameter flexible by-pass duct which was installed between the two units using the windows as the entry/exit points to adjust the "leakage" between the two units. During the airtightness tests, air was free to flow both across the partition wall as well as through the by-pass duct. Further, the duct could be throttled by partially blocking one end.

OVERALL ASSESSMENT OF METHOD 2

Examining Table 3, the field tests clearly demonstrated that Method 2 performed significantly better than Method 1. It was able to mathematically resolve solutions for every set of tests and all of the results appeared plausible given the observed construction practices employed on the test buildings.

One question which emerged when examining these results is what (or which) parameters provide the most legitimate metric for comparing measurements of the same partition, particularly when the flow is in the same direction. Given that the ultimate objective is to provide an accurate measurement of the partition leakage and that this is typically calculated at an indoor-to-outdoor pressure differential of 50 Pa, the Q_{50} values likely provide the best comparison metric.

With respect to the issue of what pressure differential to use when measuring the Pressure Ratio (i.e. 50 Pa or 100 to 125 Pa), the results showed that the most consistent results were obtained when the higher Pressure Ratio (100 to 125 Pa) was used. For that reason, it is recommended for use with Method 2.

To better understand why Method 2 was successful, we must return to the earlier discussion and discuss equipment accuracy. Consider the impact of measuring a high $\Delta P_p/\Delta P_a$ ratio. For example, if the $\Delta P_p/\Delta P_a$ ratio equals 0.99 and is measured when $\Delta P_a = 100$ Pa, then ΔP_p would equal 1.0 Pa and the difference between the two measurements would also be 1.0 Pa. However, the accuracy of the micromanometer was ±1% of reading, which would translate into a potential error of 1.0 Pa (100 x 1%). In other words, the potential error

is equal to the difference between the two measurements. This suggests that with the types of equipment employed in this project (all of which were typical of what is used by most airtightness testing organizations), Method 2 should be able to measure the airtightness characteristics of MURB partitions with reasonable confidence provided the C_b/C_p ratio does not exceed approximately 14. This translates into a maximum $\Delta P_p/\Delta P_a$ ratio of about 0.99, assuming the two Flow Exponents have values close to 0.65 (which was generally the case for the types of buildings encountered in the project and is consistent with the literature).

However, even if $\Delta P_p/\Delta P_a$ ratios are encountered which exceed 0.99, Method 2 may still be acceptable as a test methodology for many applications. Assuming the exterior envelope of the MURB is not constructed to dramatically inferior levels of airtightness compared to the partition (which seems unlikely), Method 2 would still produce very low levels for the partition leakage. Even if the percentage error was high, the absolute error would be relatively low – i.e., the question would not be "Is the partition tight?" but "How tight (or very tight) is it?".

Fundamentally, Method 2 has an advantage over Method 1 in that Method 2 relies upon measuring changes in pressure differentials whereas Method 1 is based on measuring changes in the blower door flow rates. Since, with the equipment used in the project, the pressure measurements had an accuracy of ±1%, whereas the flow rate measurements had an accuracy of ±3% of reading, Method 2 had an inherent advantage over Method 1.

Table 3: Summary of Test Results – Method 2, Pressure Ratio ≈ 100 to 125 Pa

Date (2016)	Partition Tested	Partition Leakage Characteristics				C_b/C_p	Notes
		C_p (l/s•Pa^n)	n	Q_{10} (l/s)	Q_{50} (l/s)		
Building #1							
Jan. 26	15/16	4.4	0.607	18	47	7.9	
Jan. 26	16/15	3.8	0.632	16	45	9.6	
Building #3							
March 26	24/23	4.5	0.659	21	59	6.7	
March 28	24/23	4.1	0.647	18	52	8.1	
March 26	23/24	4.0	0.652	18	51	8.6	
March 28	23/24	7.1	0.644	31	88	4.2	
April 6	24/23	11.1	0.639	48	136	2.8	By-Pass 1/3 Open
April 6	23/24	14.0	0.644	48	133	3.2	By-Pass 1/3 Open
April 6	24/23	16.7	0.619	69	188	2.0	By-Pass Fully Open
April 6	23/24	14.0	0.644	62	174	2.4	By-Pass Fully Open

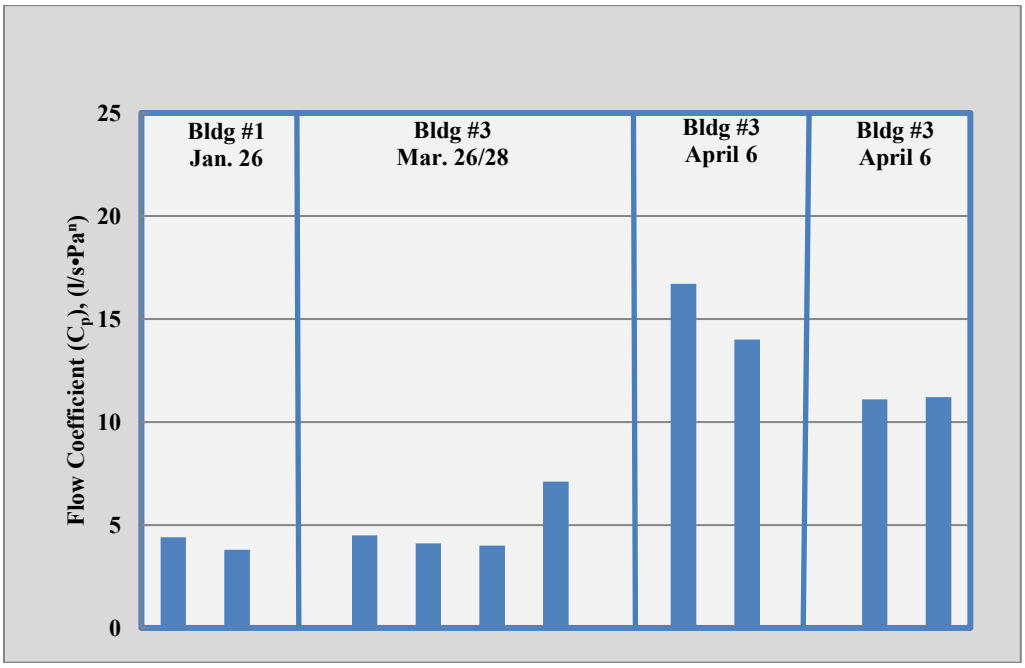

Figure 5: Method 2 – Flow Coefficients (With Pressure Ratio Measured at ≈ 100 to 125 Pa)

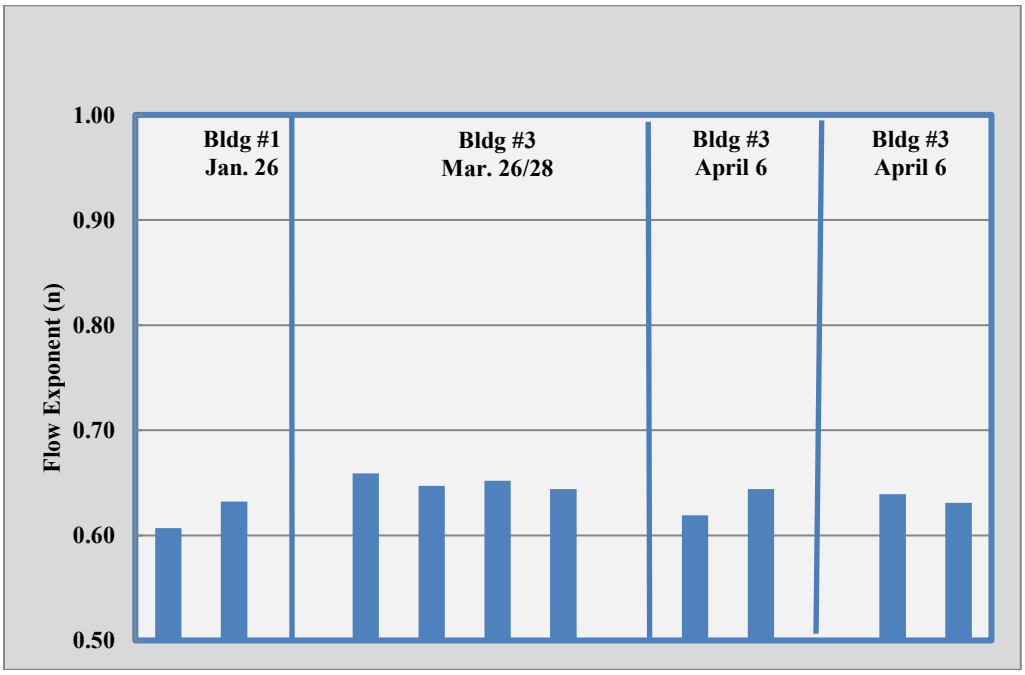

Figure 6: Method 2 – Flow Exponents (With Pressure Ratio Measured at ≈ 100 to 125 Pa)

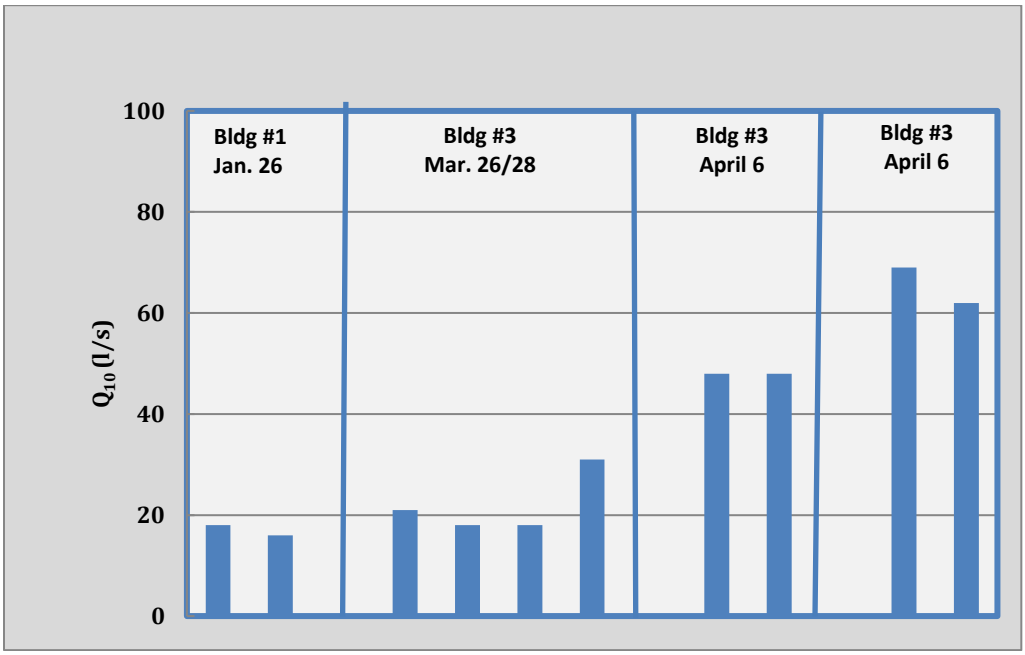

Figure 7: Method 2 – Q_{10} (With Pressure Ratio Measured at ≈ 100 to 125 Pa)

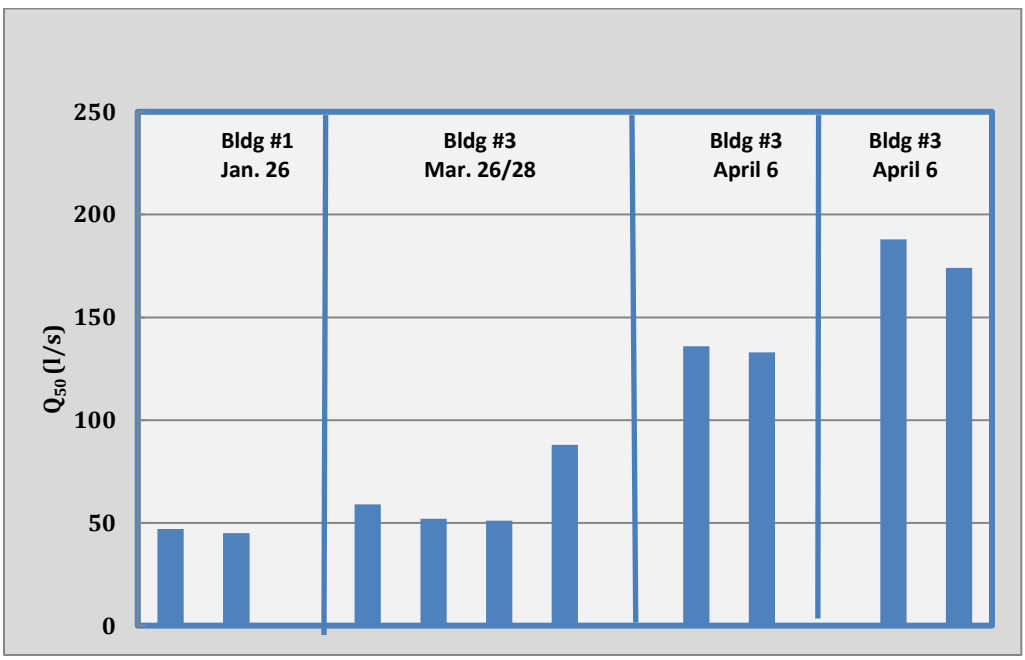

Figure 8: Method 2 – Q_{50} (With Pressure Ratio Measured at ≈ 100 to 125 Pa)

STEP-BY-STEP PROCEDURE FOR USING METHOD 2

Consider a MURB such as shown in Fig.1. To apply Method 2 and measure the partition leakage (in each direction), one unit is first defined as the "Test Unit" and the second as the "Adjacent Unit". A standard

CGSB 149.10 test is performed on the Test Unit and then the partition pressure differential is measured when the Test Unit indoor-to-outdoor pressure differential is about 100 to 125 Pa. The two units are reversed (the "Test Unit" becomes the "Adjacent Unit" and vice versa) and the process is repeated.

In more detail:

Step 1 - Set up the blower door in the Test Unit

Step 2 - Install a pressure tap between the Test Unit and the Adjacent Unit

Step 3 - Perform a CGSB 149.10 test on the Test Unit and

Step 4 - Measure ΔP_p & ΔP_a when $\Delta P_a \approx 100$ to 125 Pa

Step 5 - Move the blower door to the second suite (the new "Test Unit")

Step 6 - Perform a CGSB 14.10 test on the (new) Test Unit

Step 7 - Measure ΔP_p & ΔP_a when $\Delta P_a \approx 100$ to 125 Pa

Step 8 - Analyze the two airtightness results using manufacturer's software

Step 9 - Perform the final analysis using the developed spreadsheet, with inputs for C, n and ΔP_p from each test. The spreadsheet output's are C_p and n_p.

Step 10 - Subtract the partition leakage from the total unit leakage to arrive at the true envelope leakage.

When the two sets of airtightness results (C's & n's), along with the corresponding values for ΔP_p and ΔP_a are input into the spreadsheet, it calculates the partition's Flow Coefficient (C_p) using Eq. (7).

Method 2 Calculator				**Green - data input cell**	
Pressure Ratio Measured at ≈ 90Pa				**Yellow - output cell**	
Address:	**St. Annes Road**				
Date:	**26 Jan./16**				
Test Nos.	**1 & 8**			**8 & 1**	
Test Unit:	**#15**		**Test Unit:**	**#16**	
Adjacent Unit:	**#16**		**Adjacent Unit:**	**#15**	
A/T test results:			**A/T test results:**		
$C_a + C_p$ =	**40.5**	**l/s•Pa^n**	**$C_b + C_p$ =**	**38.7**	**l/s•Pa^n**
n_a =	**0.632**		**n_b =**	**0.607**	
ΔP_a =	**88.3**	**Pa**	**ΔP_a =**	**90.2**	**Pa**
ΔP_p =	**85.45**	**Pa**	**ΔP_p =**	**87.75**	**Pa**
Partition Leakage Characteristics:			***Partition Leakage Characteristics:***		
Test Unit:	**#15**		**Test Unit:**	**#16**	
C_p =	**4.4**	**l/s•Pa^n**	**C_p =**	**3.8**	**l/s•Pa^n**
n_p =	**0.607**		**n_p =**	**0.632**	
Q_{10} =	**18**	**l/s**	**Q_{10} =**	**16**	**l/s**
Q_{50} =	**47**	**l/s**	**Q_{50} =**	**45**	**l/s**
Average Values			**Percent Variation:**		
C_p =	**4.1**	**l/s•Pa^n**	**C_p =**	**14%**	
n_p =	**0.620**		**n_p =**	**-4%**	
Q_{10} =	**17**	**l/s**	**Q_{10} =**	**8%**	
Q_{50} =	**46**	**l/s**	**Q_{50} =**	**4%**	
C_b/C_p =	**7.9**		**C_b/C_p =**	**9.6**	

Figure 9: Example, Method 2 – Analysis Spreadsheet

CONCLUSIONS

1) Method 1 was unable to provide consistent or believable estimates of the partition's airtightness characteristics. Although it worked very well in the field trials on a detached house with a very leaky partition wall (relative to the building envelope), it failed when applied to actual MURBs with much tighter partitions.

2) Method 2 was much more successful than Method 1. Applied 10 times on two of the three project MURBs, it was able to produce reasonable estimates of the partition.

3) Method 2 was also found to be easy to use and well-suited for field testing applications. Compared

to a conventional airtightness test, Method 2 requires only one additional parameter to be measured (the pressure differential across the partition). Further, Method 2 can be performed by a single individual equipped with one blower door.

RECOMMENDATIONS

1) Method 2 is recommended as an acceptable technique for measuring partition leakage in Multi-Unit Residential Buildings and other buildings with significant internal partitioning.

2) Although Method 2 provided satisfactory results, opportunities exist to improve its accuracy including: exploring the best procedure for evaluating the Pressure Ratio, investigating improvements which would permit an explicit solution for the partition Flow Exponent and further investigation of by-pass flow.

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