Adventures in Large Building Airtightness Testing

Lessons Learned from 7 Years of Testing in Seattle

BCBEC AGM & Conference 2018
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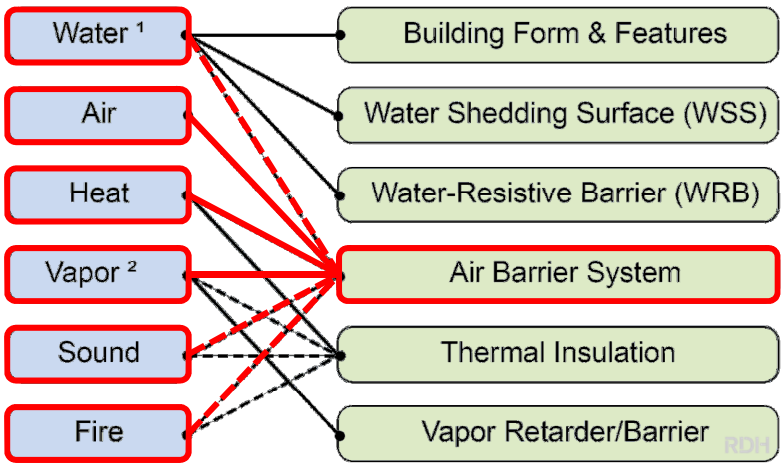
Why We Care

→ Infiltration and Exfiltration Affect:

- → Building Energy Consumption – Heat Loss and Gains ($)
- → Indoor Air Quality - Pollutants
- → Building Durability - Condensation
- → Occupant Comfort - Thermal & Acoustics

Why We Care



Primary Relationship *Secondary Relationship*

1 – Water is defined here as precipitation (rain, snow, hail, etc.) and ground water
2 – Vapor is separately defined here as the water vapor in air, as well as condensate moisture

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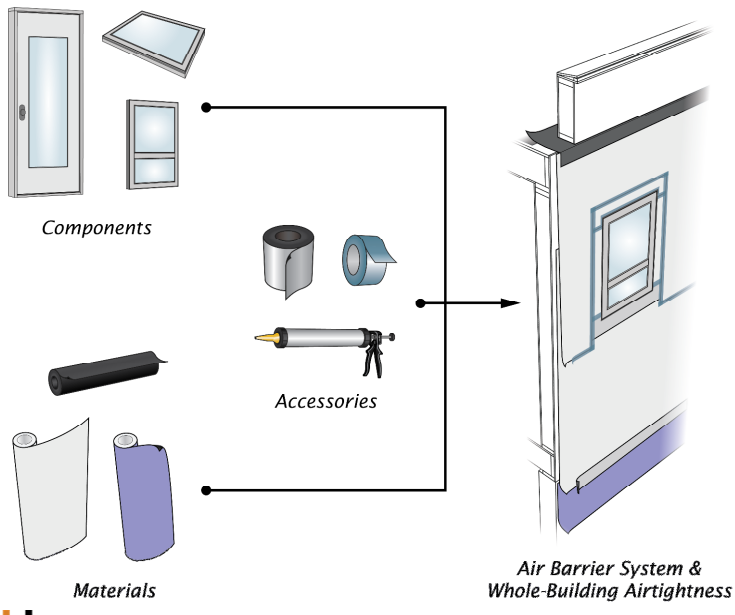

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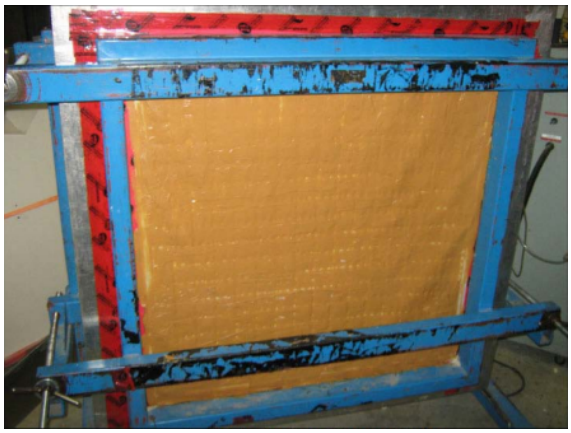
Material Requirements Don't Mean Much

→ Peanut Butter (brand unknown) – 20 mils

→ 0.0041 cfm/ft² @ 75 Pa – More than twice as tight as Tyvek!



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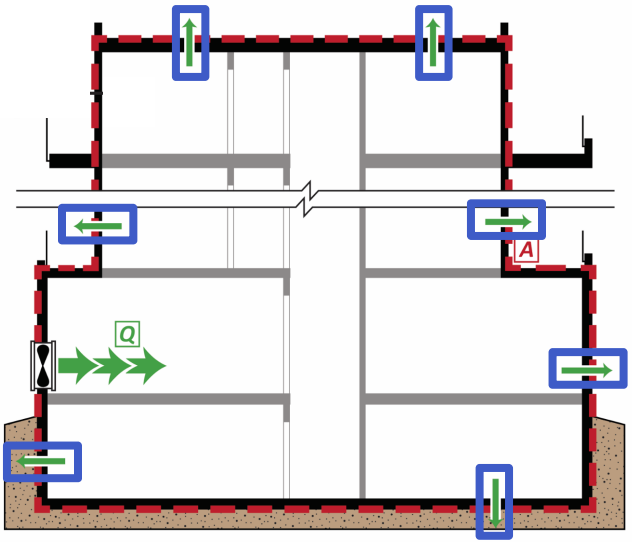
Airtightness Testing

Airflow In = Airflow Out ⟶ **Air Leakage Rate (L/s·m²)**



New Airtightness Requirements in BC Codes

→ **BC Building Code** (as of April 7, 2017)

- → Part 9: Required testing (no performance target for Step 1)
- → Part 3 Buildings (Part 10)
  - › NECB or ASHRAE 90.1 is still an option, Step Code is new option
  - › Whole building airtightness testing required for all Steps
  - › Except Step 1, measured airtightness result to be reflected in the energy model

→ **City of Vancouver**

- → Part 9: 1- & 2-family Dwellings
  - › Testing to achieve 3.5 ACH_{50}
- → Green Buildings Policy for Rezonings (as of May 1, 2017)
  - › Testing & reporting required
  - › Target is 2.0 L/s·m² at 75 Pa

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Key Considerations

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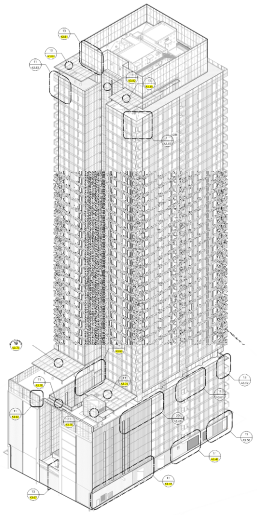
Where will the fans be installed?

→ Need to get uniform pressure throughout the building

→ Rule of thumb: never more than 6500 L/s through a typical single door opening

→ Everything is simpler when the building is tight



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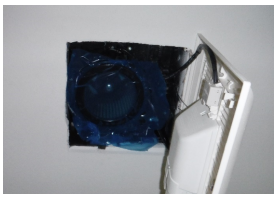
What building preparation is needed?

→ Typically test the air barrier system only
  → Shut down HVAC
  → Close dampers
  → Mask openings with gravity dampers or no dampers (i.e. continuous exhaust)
  → This can cost thousands of dollars in MURBs



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Test Methods and Procedures

→ More than just a bigger house test

How do you get here to seal these?

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All the small details

→ Tubing & connectors
→ Data cables & switches
→ Power supply
→ Gauge batteries
→ Need mechanical/electrical for operating the HVAC
→ Need somebody there with the keys!

→ Retrotec Support
Monday – Friday, 8am - 4pm

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Troubleshooting...

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Troubleshooting...

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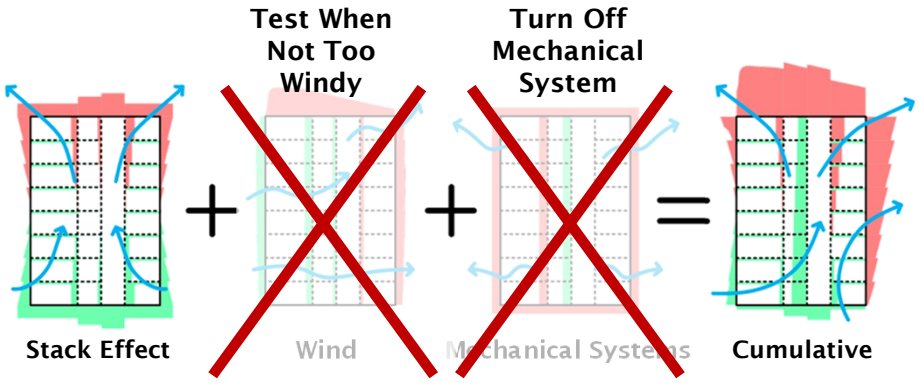
Weather Limitations



Vancouver usually not too difficult for wind.
At night better.

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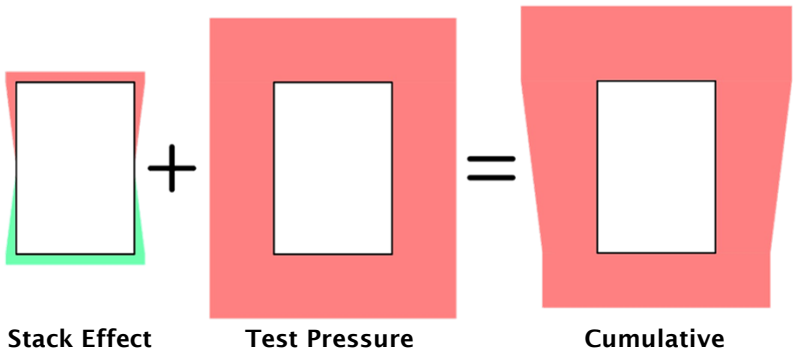
Weather Limitations



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Testing Challenges – Weather Limitations

→ ASTM E779

→ Height x ΔT < 200m°C

→ USACE Protocol

→ Baseline Pressure < 30% of lowest induced pressure
(i.e. lowest = 25Pa, baseline < 7.5 Pa)

→ ABAA Standard

$$P_{induced,min} \geq Max(|P_{base,pre}| + 10 \times STDev(P_{base,pre}), \frac{P_{Stack}}{2}, 10\ Pa)$$

→ CGSB 149.15-96

→ <20 km/h wind

1-10 Storeys	T ≥ 5°C
11-20 Storeys	T ≥ 8°C
21-30 Storeys	T ≥ 10°C
31+ Storeys	T ≥ 15°C

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Example

Height = 23 floors (86m)

Interior Temperature = 15°C

Outdoor Temperature = 11°C
(December!)

Theoretical Stack Effect = 16 Pa

8 Pa at Top
-8 Pa at Bottom

Based on ASTM E779
h x ΔT < 200m°C

Max ΔT = 2.3°C

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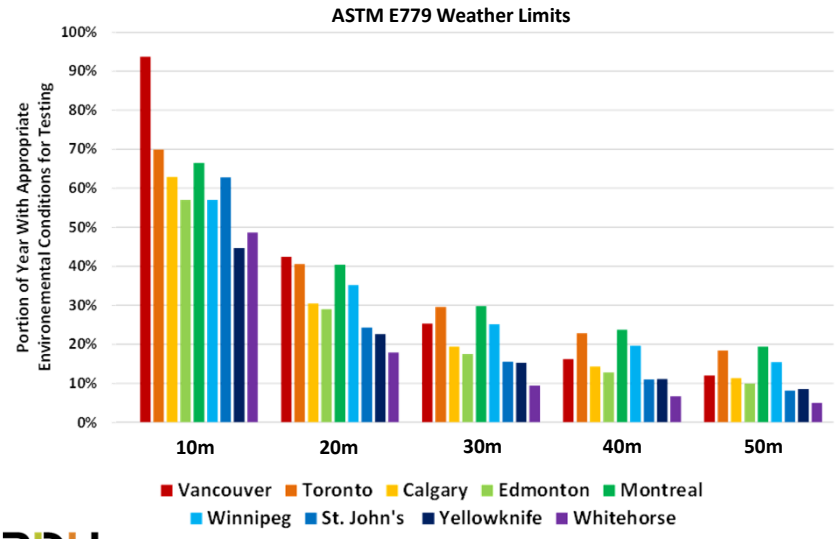
Testing Challenges – Weather Limitations



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Weather Limitations

The Problem

→ Tall buildings rely on really good weather to test

→ Need to test after the air barrier is complete

→ Need to test before occupancy

Typical project time constraints don't allow waiting for good weather to facilitate testing.

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Weather Limitations

The Solution

→ Most tall buildings have repeated floors plans

→ Most leakage is at transition floors
(window wall & curtain wall should be much tighter than limits)

Test smaller portions of the building using guarded testing.

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Case Study #1: Residential Tower

→ 125m tall 40-storey multi-unit residential building

→ Only 5°C ΔT ≈ 25 Pa Stack Effect

Strategy:

→ Test one 2-floor section per 10 typical floors

→ Testing top and bottom floor

→ Test unique floors
(restaurant on L8)

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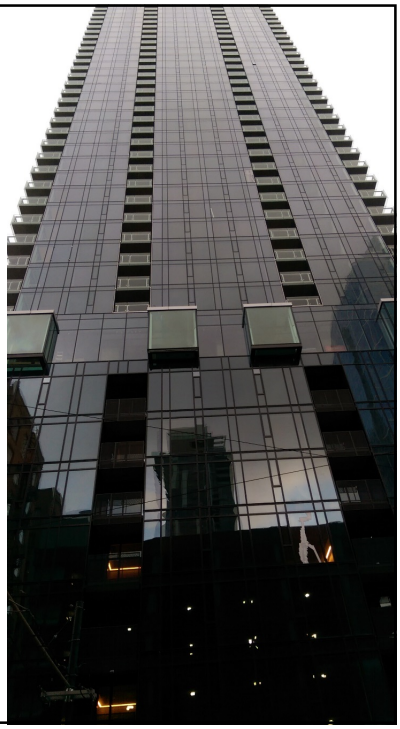
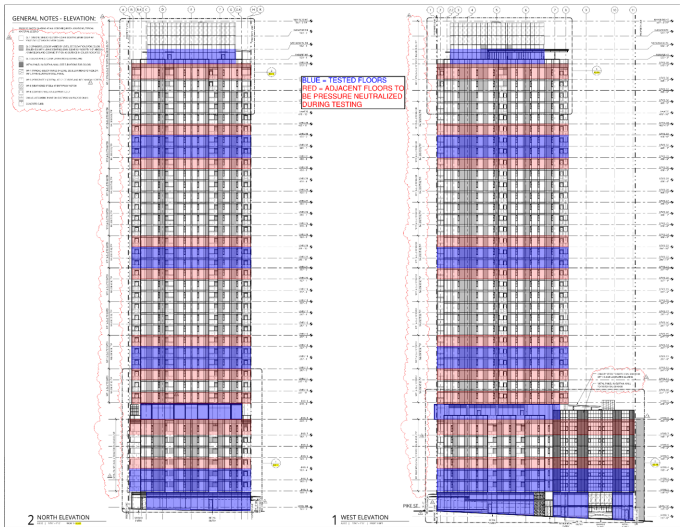


Case Study #1 – Compartmentalized Testing



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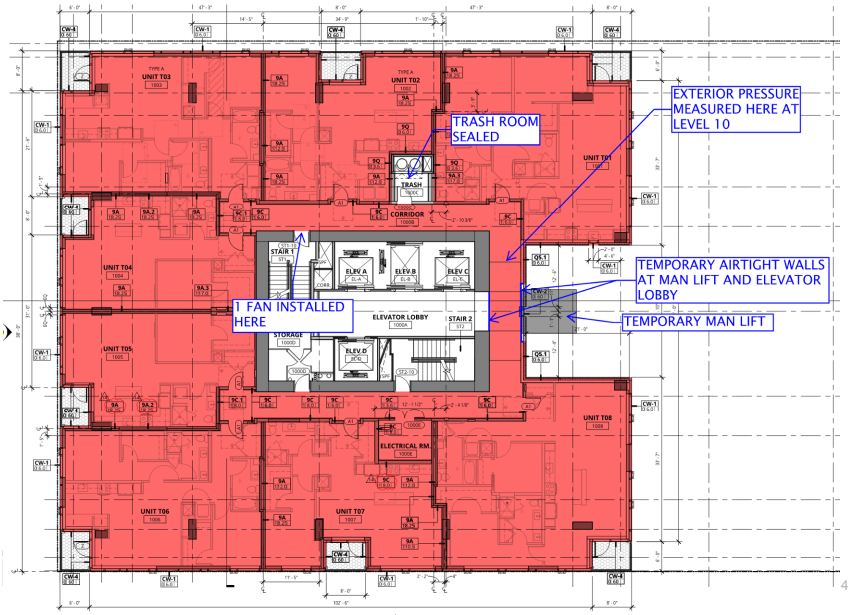
Case Study #1 – Compartmentalized Testing



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Case Study #1 – Temporary Air Sealing

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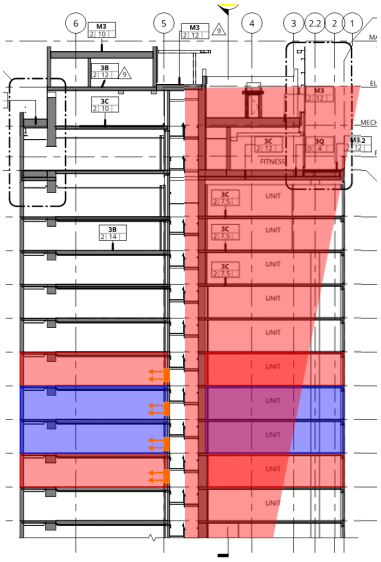
Case Study #1 – NPP Problems



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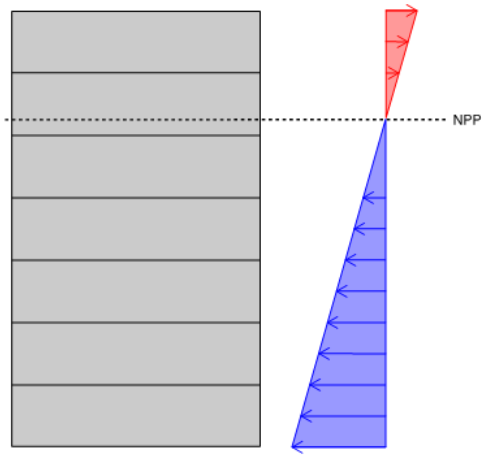
Case Study #1 – NPP Solutions

Shift NPP of stairwell and reduce stack height by opening stairwell doors on adjacent floors.

Reduced baseline from 25 Pa to 12 Pa.



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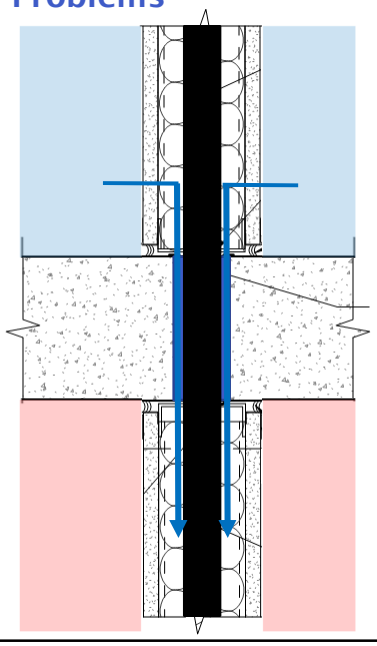
Caset Study #1 – Guarding Problems

- → Plumbing stacks penetrate each floor
- → Supposed to be air tight for smoke right?
- → Used intumescent sleeves which aren't airtight until heat is applied
- → Prevents equalizing and can get bypass within framed wall



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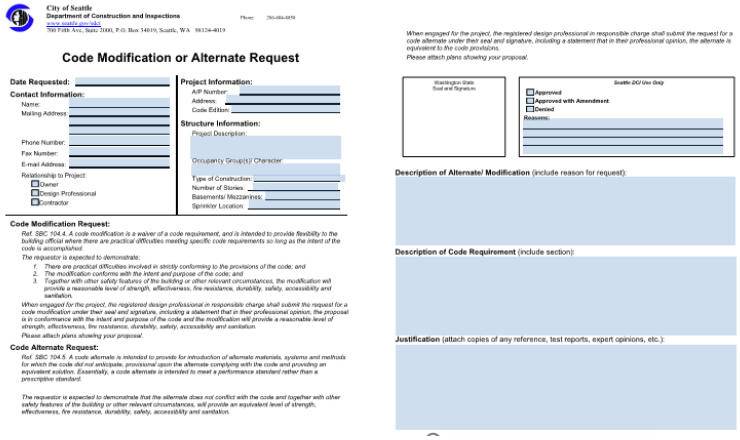
Case Study #1: Residential Tower

Code Alternate Request



City of Seattle
Department of Construction and Inspections
www.seattle.gov/dpd
700 Fifth Ave., Suite 2000, P.O. Box 34019, Seattle, WA 98124-4019

Code Modification or Alternate Request

Date Requested:

Contact Information:
Name:
Mailing Address:
Phone Number:
Fax Number:
E-mail Address:
Relationship to Project:
☐ Owner
☐ Design Professional
☐ Contractor

Project Information:
A/P Number:
Address:
Code Edition:

Structure Information:
Project Description:
Occupancy Group(s)/ Character
Type of Construction:
Number of Stories:
Basements/ Mezzanines:
Sprinkler Location:

Code Modification Request:

Ref. SBC 104.4. A code modification is a waiver of a code requirement, and is intended to provide flexibility to the building official where there are practical difficulties meeting specific code requirements so long as the intent of the code is accomplished.

The requestor is expected to demonstrate:

1. *There are practical difficulties involved in strictly conforming to the provisions of the code; and*
2. *The modification conforms with the intent and purpose of the code; and*
3. *Together with other safety features of the building or other relevant circumstances, the modification will provide a reasonable level of strength, effectiveness, fire resistance, durability, safety, accessibility and sanitation.*

When engaged for the project, the registered design professional in responsible charge shall submit the request for a code modification under their seal and signature, including a statement that in their professional opinion, the proposal is in conformance with the intent and purpose of the code and the modification will provide a reasonable level of strength, effectiveness, fire resistance, durability, safety, accessibility and sanitation.

Please attach plans showing your proposal.

Code Alternate Request:

Ref. SBC 104.5. A code alternate is intended to provide for introduction of alternate materials, systems and methods for which the code did not anticipate, provisional upon the alternate complying with the code and providing an equivalent solution. Essentially, a code alternate is intended to meet a performance standard rather than a prescriptive standard.

The requestor is expected to demonstrate that the alternate does not conflict with the code and together with other safety features of the building or other relevant circumstances, will provide an equivalent level of strength, effectiveness, fire resistance, durability, safety, accessibility and sanitation.

When engaged for the project, the registered design professional in responsible charge shall submit the request for a code alternate under their seal and signature, including a statement that in their professional opinion, the alternate is equivalent to the code provisions.

Please attach plans showing your proposal.

Washington State Seal and Signature

Seattle DCI Use Only
☐ Approved
☐ Approved with Amendment
☐ Denied
Reasons:

Description of Alternate/ Modification (include reason for request):

Description of Code Requirement (include section):

Justification (attach copies of any reference, test reports, expert opinions, etc.):

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Case Study #1: Residential Tower

The Results

Test Condition	Zone A (Level 1)	Zone B (Level 2-3)	Zone C (Level 8)	Zone D (L12-13)	Zone E (L21-22)	Zone F (L31-32)	Zone G (Level 39)
Depressurize	0.82	0.86	1.38	0.90	0.93	0.67	1.16
Pressurize	0.85	1.18	1.54	1.32	0.92	0.65	1.29
Average	**0.83**	**1.03**	**1.46**	**1.11**	**0.93**	**0.66**	**1.22**

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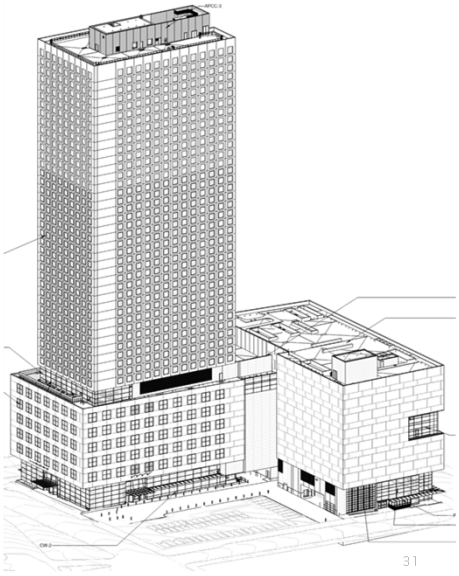
Case Study #2: Hotel Tower

→ 150 m tall 45-storey hotel

→ No balconies

→ No operable windows



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Case Study #2: Hotel Tower

The Problem

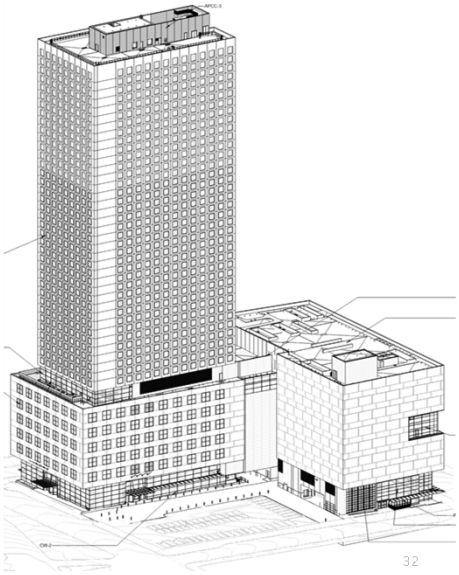
→ Can't open windows to shift the NPP

→ Can't get exterior pressure tap out on intermediate floors

The Solution

→ Complete tests before temporary lift is removed to allow for shifting of NPP

→ Follow same strategy as #1



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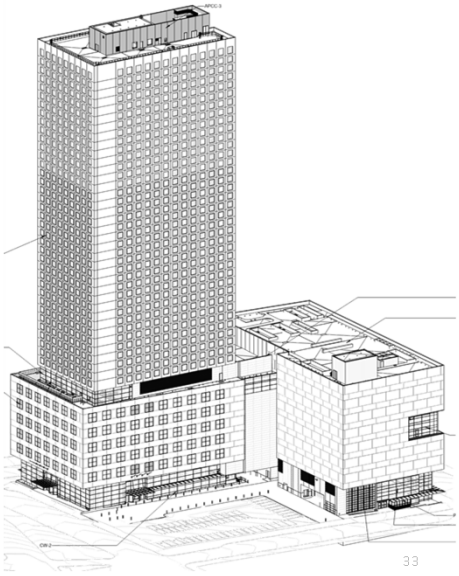
Case Study #2: Hotel Tower

Alternate Solution

→ Wait until fully enclosed (i.e. temporary lift removed)

→ Cool the building overnight with the HVAC system

→ Turn off the HVAC right before test and use thermal mass to maintain low ΔT



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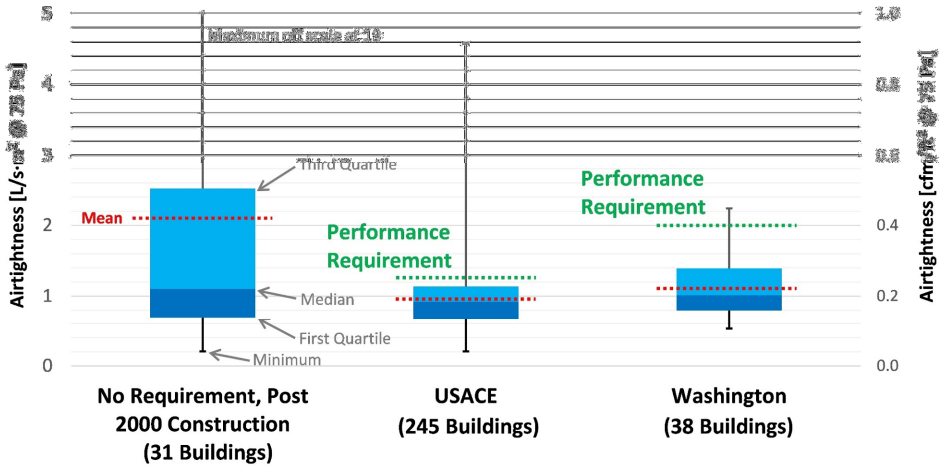
Impact of Requirements



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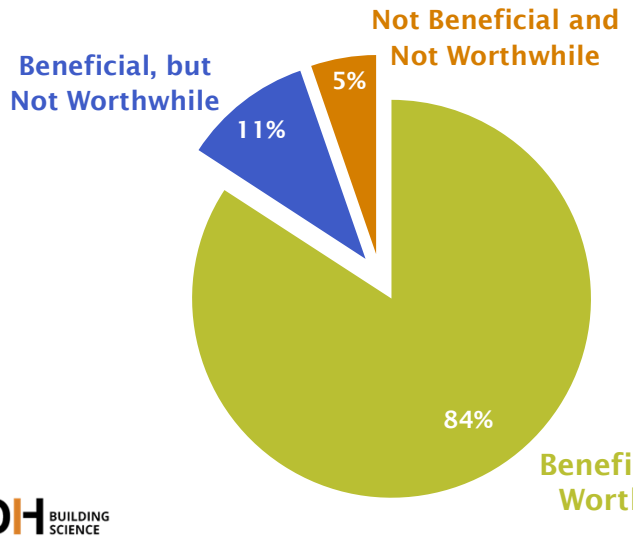
Impact of Requirements



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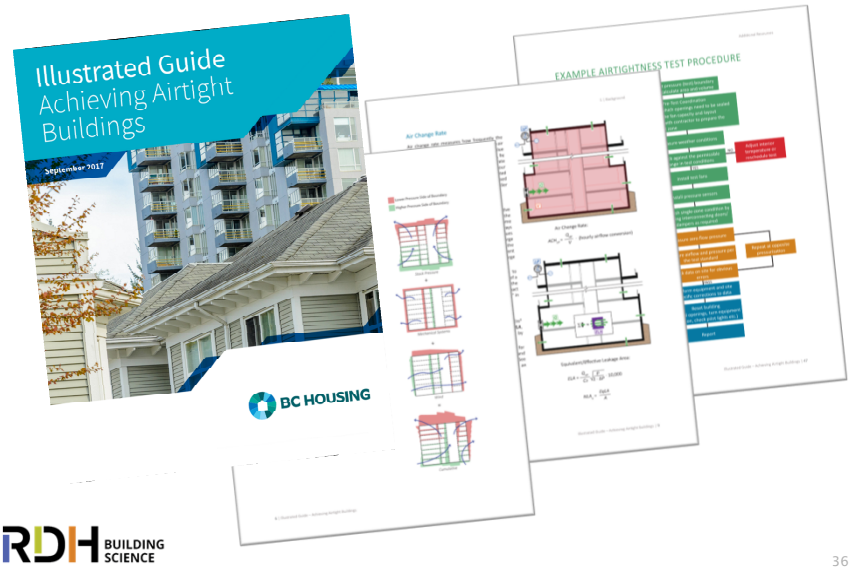
Guide to Achieving Airtight Buildings



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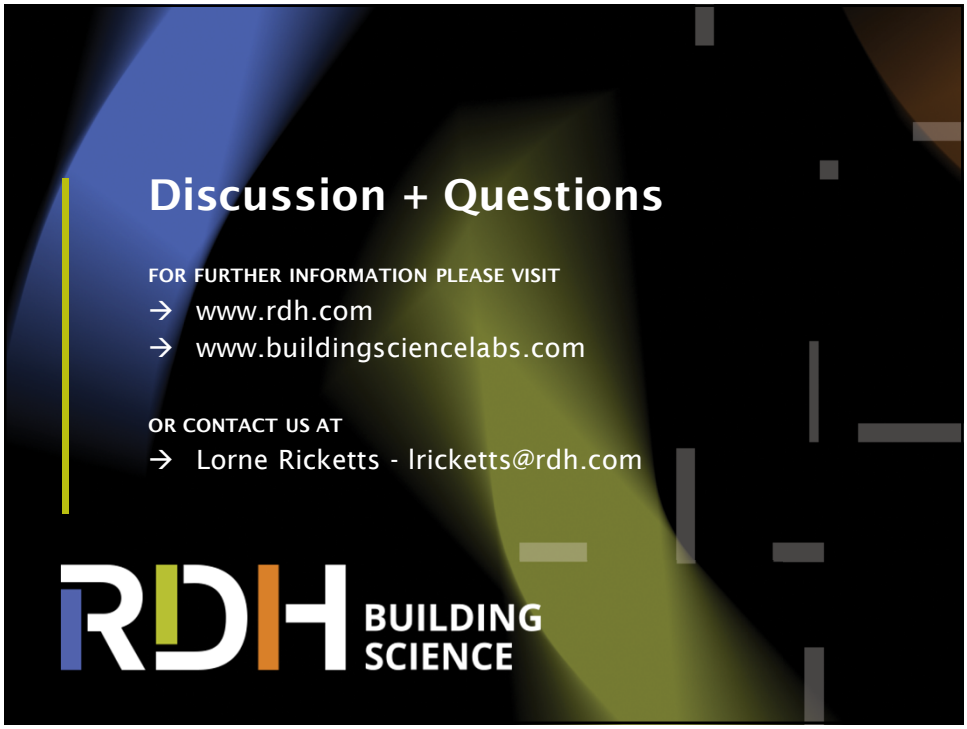
Discussion + Questions
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→ Lorne Ricketts - lricketts@rdh.com
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