Achieving the Stringiest Envelope Possible: How Specified Airtightness Guarantees Efficiency

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A great building starts with a great envelope. Key parameters such as the effective R-value of the walls and roof, the U-value of the windows, and the window-to-wall ratio, all drive the required sizing and energy usage of the mechanical systems needed to heat and cool the building. Together, the overall performance of the building can be estimated via modelling and then realized in the real-world. But, what about airtightness?

The airtightness of a building's envelope is, in most cases, not precisely specified. Our building codes in Canada generally require a certain minimal level of airtightness, but testing it during construction and commissioning is rare, unless the building is going for certification under a third-party standard—LEED, IECC, Energy Star, ZERH, or Passive House, which all set minimum recommended or compulsory requirements. This creates an environment where airtightness is often a buried footnote within the design and specifications of new and major retrofit projects, and the level ultimately achieved is left to chance. So, as shown in Figure 1, we end up with leaky buildings that have significant stack and wind effect and require high volumes of make-up air to maintain pressurization, rather than tight buildings, which are much more energy efficient.

Regional energy codes within Canada, like the Toronto Green Standard and the BC Step Code, are setting ever-increasing tiered standards for new buildings, to extremely high-performance levels by the early 2030s. Essentially, by the turn of the decade, these standards will force virtually all new developments to have an overall energy performance equivalent to the Passive House Standard, which is viewed as having the most aggressive targets in general worldwide use. And what are the three pillars of the Passive House Standard? Maximum values for space heating / cooling demand; maximum value for total primary energy demand; and maximum value for airtightness. This is not by coincidence; the originators of the Passive House Standard understood that without an airtight building envelope, the energy demand requirements could not be achieved, so they made it a core requirement.

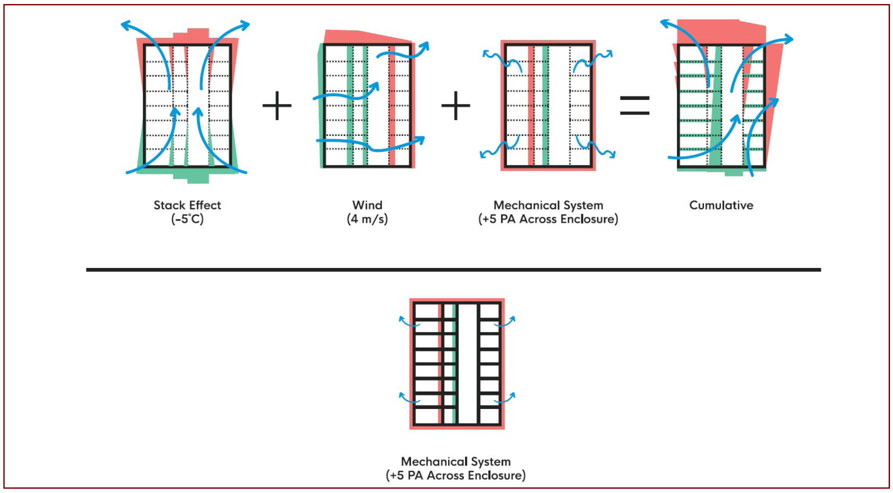

Figure 1. Seal effect. Adapted from Ricketts (2014), A Field Study of Airflow in a High-Rise Multi-Unit Residential Building, MA Thesis, University of Waterloo.

Unfortunately, an opportunity was missed this year, when a proposed change to the *National Energy Code* was withdrawn; the change would have made airtightness testing compulsory during the construction of large commercial, institutional, and multi-residential buildings designed to comply with the code's prescriptive path. The reasons are not clear, but may have had to do with

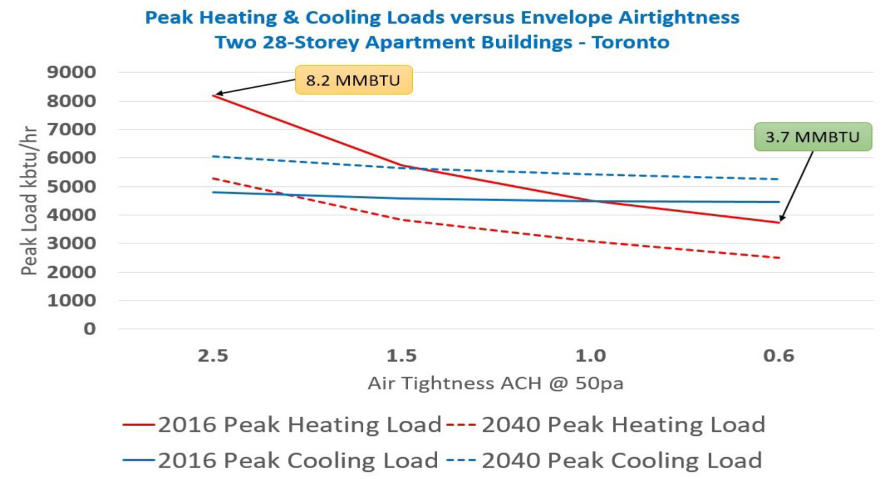

Figure 2. Model results.

the perceived lack of service providers who can perform whole building testing on large structures and the environmental constraints involved with testing such as wind intensity and outdoor temperature, which could delay construction schedules. But does that mean the status quo should continue? Absolutely not. If airtightness is not specified and tested as part of every project, we are collectively missing out on the benefits it provides.

To demonstrate the power of specifying airtightness, let's look at the results of energy modelling on a typical, new high-rise building. This building is a combined set of two adjacent 28-storey rental apartment towers being built to the Tier 1 requirements of the *Toronto Green Standard*. The developer is not targeting any specific certifications or energy performance standards, other than the TGS minimums, but there is a long-term incentive to reduce energy costs as they intend to own and operate the building for the foreseeable future. The major design elements are only as advanced as they need to be (e.g., double-pane windows, non-thermally broken balconies, and ERVs in-suite).

As shown by the solid red line in Figure 2 for the baseline model using 2016 weather data, the difference in the projected peak heating load between a typical airtightness of 2.5 ACH @ 50 pa and Passive House airtightness of 0.6 ACH @ 50 pa is over 50 per cent, 8.2 MMBTU down to 3.7 MMBTU. In correlation, the annual total heating energy usage is also reduced by nearly 50 per cent. The peak cooling load is also reduced by approximately seven per cent. In addition, the building becomes cooling-dominated as the airtightness exceeds 1.0 ACH @ 50 pa, where the lines cross. This result might be unexpected in Canada's climate, but it is what Passive House designers have understood for decades. Also on the graph in Figure 2 are dotted lines that are the result of the model using forecasted 2040 weather data, showing a trend toward low heating loads and higher cooling loads due to climate change.

By precisely specifying airtightness for this new building, two significant cost savings can be achieved. First, capital costs will decrease due to the reduced size of the heating system. Second, the energy performance will be better from the beginning, lowering operating costs through utility bill reductions. Combined, these savings will contribute to offsetting the minor increase in construction costs to achieve a high level of airtightness, which can be integrated into a project for typically less than one per cent of the total budget. The primary methods of achieving Passive House levels of airtightness are through detailed design of the envelope, specifying a mandatory target in tender documents, educating and supervising the tradespeople, using "pressurize and spray" technology to repeatably achieve and guarantee the required results for every project, and performing blower door testing during construction to verify compliance.

Codes, standards, and markets are quickly evolving as we realize that improving building performance is critical to reaching our 2030 & 2050 climate change targets. Specifying airtightness is one of the easiest and most cost-effective ways to immediately make a significant impact toward our shared goal. ■

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