Airtightness in apartments in New Zealand

The airtightness of low-rise, stand-alone dwellings in New Zealand is fairly well understood. However, before this research little was known about apartments, which represent a significant and growing percentage of new building consents. BRANZ measured nine apartment buildings as an indication of the airtightness provided by the wider stock of apartments. In general, apartments had levels similar to typical new-build houses, approximately five air changes per hour at 50 pascals on average, with a strong dependence on construction style. Inter-apartment leakage was also investigated.

The airtightness of a building is a measure of how much air can leak through the structure through gaps (when all of the doors and windows are closed). Airtightness is important because it affects the building's energy efficiency and its ability to maintain a comfortable, draught-free indoor environment.

If the amount of air leakage is high, a building can be draughty and difficult or expensive to heat. Increasing the airtightness also needs to be balanced against the need to ventilate the space adequately to maintain good internal air quality and to avoid issues such as a build-up of moisture.

Although the basic forces that drive airflow through apartment buildings (wind pressure, stack pressure from thermal differences and ventilation-system pressure) are the same as stand-alone dwellings, the size of these forces is different. Airflow in apartment buildings is also slightly more complicated, as air may leak between neighbouring units (which can adversely affect air quality with smells and sound), and ventilation across units may be inconsistent.

Testing approach

The airtightness in individual apartments was measured by establishing a pressure difference between the inside and outside using a fan (a blower door), following the procedure described in ISO 9972:2015 *Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method*. Gaps were sealed and closed using tape, including sealing sinks and toilets (where water was not connected) and outlets and mechanical ventilation systems with no other means of being closed.

The blower door (Retrotec Blower Door, 5000 and 6000 series) was mounted in the entrance doorway of each apartment. Measurements were collected over a range of pressure differences and the overall result reported for a single pressure difference and the volume of the house – air changes per hour at 50 pascals (ach @ 50 Pa). (Note, this is not the same as the ventilation rate – the rate of air change in everyday circumstances. The actual rate of airflow in these apartments will be normally be much lower.)

BRANZ carried out 148 individual airtightness tests at nine apartment buildings.

The airtightness between apartments (walls shared with adjacent apartments and hallways) was tested at six of the nine buildings. The leakage between apartments was assessed using guarded testing, which involves measuring the pressure in neighbouring units at the same time.

Observations

In general, the apartments measured in this study had a similar level of airtightness to that expected from a typical new-build stand-alone dwelling – around 5 ach @ 50 Pa (Figure 1).

There was some variation in measurements (Table 1). The most and least airtight units measured 1.9 ach @ 50 Pa and 12.6 ach @ 50 Pa respectively.

The observations also revealed variability of airtightness and across individual buildings. Top-floor apartments were significantly less airtight than lower-floor apartments. This is probably because, above the ceiling of the top-floor units, the roof space is effectively vented to outside, whereas above the ceiling of the lower units is a well-sealed floor.

The observations also suggest a strong dependence on construction style. For apartment buildings where construction style was based on concrete cells, the average result was 3.5 ach @ 50 Pa (if top-floor and dual-key apartments were excluded). This represents reasonably airtight construction, although some other countries have stricter requirements. The leakage is most likely predominantly through the exterior faces.

Where guarded testing could be performed, inter-apartment leakage appeared to be insignificant in apartments where construction style was based on concrete cells but did occur in some instances, particularly when timber partition walls were used to separate dual-key apartments.

Apartments measured during this study

Opportunities to have several days' access to a building for testing are uncommon. The apartments were volunteered for measurement by parties involved in their construction (architects, developers and builders). Although these were not actively chosen to represent all apartment stock in New Zealand, they do represent an initial look at the level of airtightness being provided by the stock of apartments in New Zealand and how prevalent inter-unit air leakage may be.

A 5-storey apartment building in Auckland built in 2017 was tested before being occupied. Each apartment is separated by a concrete fire-separating wall. The units have mechanical ventilation systems and rangehoods installed. BRANZ tested units across the lower three floors at the western end of the building.

A new 4-storey student accommodation in Dunedin including studio and 4-bedroom apartments, both naturally ventilated, was tested while under construction, so no guarded testing was possible. In areas where faceplates and other fixtures were not yet installed, holes were plugged before testing. The units tested were in one block.

A 3-storey block in Miramar, Wellington, was occupied by tenants at the time of testing. The units are naturally ventilated with spot-exhaust ventilation for bathrooms, rangehoods and tumble dryers.

Three 2-storey penthouse apartments in central Wellington were tested while unoccupied and being renovated in 2019. These apartments are naturally ventilated with spot-exhaust ventilation for bathrooms, rangehoods and tumble dryers.

In a 12-storey building in central Auckland where construction was nearing completion, 23 units were tested. Most units are separated by concrete fire-separating walls, but some pairs of units are separated by timber-framed partition walls. Mechanical ventilation systems and rangehoods are installed.

A 4-storey hotel building in Queenstown was tested before being renovated. Some areas of the walls and ceilings had been opened up for inspection, and these were taped and sealed during testing. Some of the rooms were bedsit arrangements, so the adjoining door to larger neighbouring units was opened so that the space was more representative of a 'real' apartment.

A 6-storey apartment building in Te Atatū, Auckland, was tested before being renovated. These apartments are naturally ventilated with spot-exhaust ventilation for bathrooms, rangehoods and tumble dryers.

A low-rise, newly built social housing development in Wellington with a mixture of single and 2-storey units was tested once the build was completed and before it was occupied. These units are naturally ventilated with spot-exhaust ventilation for bathrooms and rangehoods.

A 3-storey retirement village in Upper Hutt was tested just as the construction was finished. In some units where faceplates and other fixtures were not yet installed, holes were plugged before testing. Testing was in one wing on all three floors. The apartments are mechanically ventilated by a central system with spot-exhaust ventilation for bathrooms and rangehoods.

Blower door fan mounted in entrance doorway.

Discussion

There is no set target for airtightness in the New Zealand building regulations - meaning none of the observations here represent passes or failures. The observed range of airtightness in these apartments is understandable, given that airtightness is often not a key consideration when constructing buildings in New Zealand.

In related research, BRANZ proposes an airtightness target of 3 ach @ 50 Pa for apartments and dwellings of all construction types. This should be an achievable target for industry with minimal additional cost.

Several leakage paths could be addressed easily with simple measures at current industry skill levels (McNeil, 2018). This recommendation mirrors New Zealand and international guidance (see information sources below). The major leakage pathways are:

- bottom plate/floor/plasterboard junctions
- window and door edge sealing details
- plumbing penetrations
- electrical penetrations
- lack of detailing behind bathtubs and fireplaces
- downlights/ceiling penetrations.

If these leakage pathways are addressed effectively, the proposed airtightness target of 3 ach @ 50 Pa should be achievable.

BRANZ thanks all involved in allowing access to test in their buildings. This research was funded by the Building Levy.

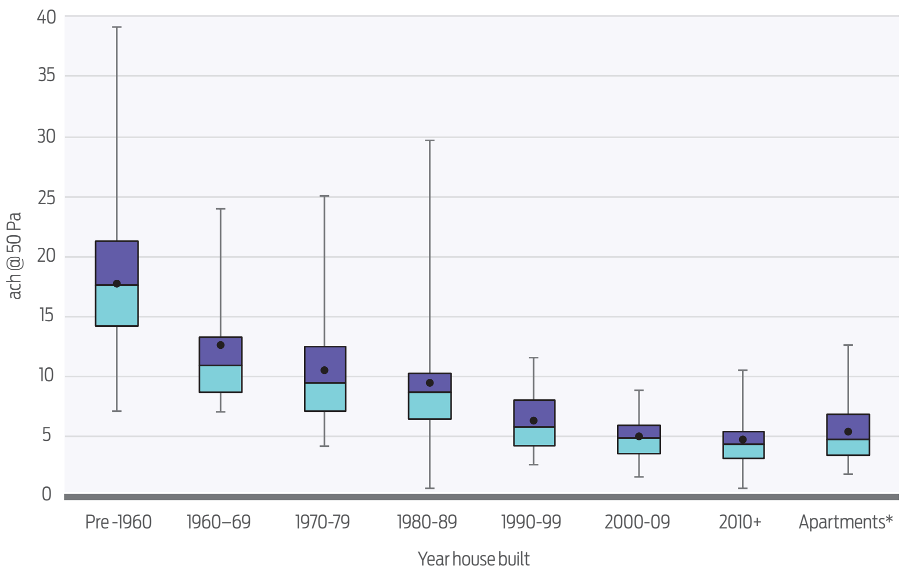

Figure 1. Comparison of observed airtightness in apartments with New Zealand houses over time. The black dots show average value, and the blue and purple bars show the 25th to 50th percentile and 50th to 75th percentile respectively.

More information

BRANZ Study Report SR455 *Airtightness of selected apartments in New Zealand*

BRANZ Research Now: Warmer drier healthier #4 A proposed airtightness target for New Zealand dwellings

BRANZ Research Now: Indoor air quality #3 *The impact of ventilation in New Zealand houses*

McNeil, S. (2018). Airtight fixes for older homes. *Build, 168,* 85-86.

Building Energy Codes. (2011). *Air leakage guide.* Washington, DC: US Department of Energy.

CMHC. (2017). *Air leakage control for multi-unit residential buildings.* Ottawa, Canada: Canada Mortgage and Housing Corporation.

EPA. (2008). *ENERGY STAR qualified homes thermal bypass checklist guide.* Washington, DC: US Environmental Protection Agency.

Higgins, J., Haaland, D. & Ricketts, L. (2017). *Illustrated guide - achieving airtight buildings.* Vancouver, Canada: BC Housing.

Table 1. Airtightness observed in New Zealand apartments.

SITE	BUILDING STATUS	APARTMENT FLOOR AREA (M^2)	AVERAGE AIRTIGHTNESS (ACH @ 50 PA)
Mid-rise apartment block, Stonefields, Auckland	Complete, unoccupied	60–105	2.7
Student accommodation, Dunedin	Incomplete, construction active	73	5.1
		21–26 (studio)	6.9
Medium-density apartments, Miramar, Wellington	Complete, occupied	40–52	5.3
Penthouse apartments, central Wellington	Construction active	-	7.1
High-rise apartments, central Auckland	Construction active	74 (stand-alone)	3.8
		30–50 (dual-key)	6.0
Mid-rise hotel, Queenstown	Some inspection openings, unlikely to affect measurements	25, 90–115	9.0
Mid-rise apartments, Te Atatū, Auckland	Complete, unoccupied	71–110	4.3 (all) 3.7 (all floors except top floor) 7.7 (top floor)
Medium-density social housing, Wellington	Complete, unoccupied	31–91	4.7
Retirement village, Upper Hutt	Construction active, near complete	63–75	4.2 (all) 6.3 (top floor) 3.4 (all floors except top floor)