The impact of ventilation in New Zealand houses

Ventilation plays a major role in indoor air quality and moisture management in houses, lowering humidity levels and diluting and removing contaminants that impact on health and productivity. Research suggests, however, that houses are not being effectively ventilated. There are steps that both designers and home occupiers need to take to ensure healthier air in our homes.

The air in New Zealand houses is often host to excess moisture and a number of different contaminants, including volatile organic compounds (VOCs) and carbon dioxide (CO_2). (For more details about contaminants, see Research Now: Indoor air quality # 1 *An overview of indoor air contaminants in New Zealand houses*.)

To reduce the damage that excess moisture and contaminants can cause, Building Code clause G4 *Ventilation* requires that buildings have adequate ventilation with outdoor air. It specifically requires managing moisture, odours, gases, airborne particles and living contaminants such as bacteria.

Under Acceptable Solution G4/AS1, most buildings will comply with general ventilation requirements if the net openable area of windows and other openings is at least 5% of the floor area.

There are three main ways that air exchange occurs in a building:

- Unintended leakage (infiltration) through gaps in the building envelope.
- Occupants opening windows.
- Mechanical ventilation systems that may be switched on/off by occupants or triggered by other means.

In most homes, ventilation is provided by opening windows, with mechanical ventilation in the form of rangehoods over the kitchen cooktop and extract ventilation in bathrooms and laundries. (In June 2019, G4/AS1 was updated with a requirement for mechanical extract fans to remove moisture from rooms that contain cooktops, showers and baths in household units and accommodation units.) BRANZ testing has shown that fully opening windows for 10-15 minutes each day on a regular basis can be an effective tool to reduce the indoor moisture levels over time, provided the building is heated.

However, BRANZ research has also found that while opening windows can be effective, householders are not doing this sufficiently. The BRANZ 2015 House Condition Survey found that 11% of owner-occupied and 31% of rental houses felt damp. Assessors found signs of mould in almost half the houses visited.

AIRTIGHTNESS AND VENTILATION

International guidelines recommend that the ventilation rate should be 0.35-0.5 air changes per hour (ach) - in other words, one-third to one-half of the volume of air in a house is replaced each hour. This is enough to remove contaminants but not so high as to require excessive additional space heating.

In the past, some ventilation has been assumed to come from leakages due to unintentional openings in the building (infiltration). In an ideal world, this uncontrolled infiltration would be limited and ventilation would be provided by controlled, intentional means when necessary.

A means to limit infiltration is to measure the airtightness of a building as a quality control step, aiming to keep under a target value. BRANZ has a historical database of airtightness data, monitoring the state of our building stock over the years, and has recently added airtightness data from over 100 homes built since 2005. This clearly shows that houses are getting more airtight, with nearly 75% of the post-2010 homes having an airtightness of 5 ach @ 50 Pa or lower (see Figure 1 and the note below it). The infiltration rate in many of our new builds is significantly below 0.25 ach because of the increase in airtightness. This means that we are doing better from the energy efficiency point of view, as there is less uncontrolled leakage. However, there needs to be serious thought put into ventilating our newer housing.

In a side note, BRANZ study reports and *Build* articles often refer to airtightness measurements in the form 3 ach @ 50 Pa - Figure 1 here is a good example. This is a measurement carried out with special equipment to apply a specific level of air pressure in a house. A measure of 3 ach @ 50 Pa doesn't mean that, in ordinary circumstances, the whole volume of air in a house is changed three times in 1 hour - the actual infiltration rate would be considerably lower.

It is clear that infiltration alone will not provide anywhere near the level of ventilation required in a home - occupants must open windows or use mechanical ventilation.

Research suggests that the Building Code-minimum requirements based on passive/natural ventilation (opening windows) are not as effective in real life as they should be. Newer houses are often underventilated. BRANZ data from a survey of houses built since 1994 shows that roughly a third had average ventilation levels below international guidelines. Measured ventilation was often close to the estimated infiltration rates (based on blower door measurements), which indicates that house occupants weren't opening windows.

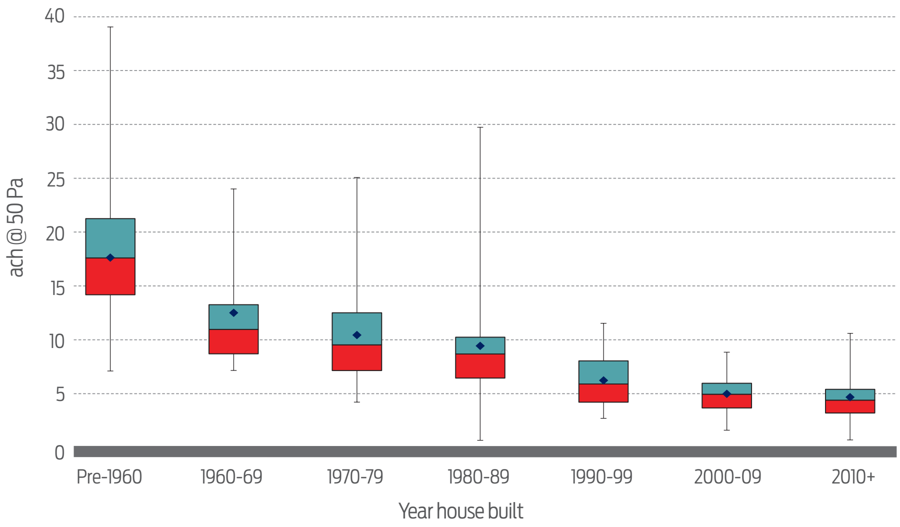

Figure 1. New houses are becoming considerably more airtight. Infiltration alone will not provide the ventilation required to ensure healthy indoor air. (Source: McNeil & Rupp, 2018)

The days of pegging out washing and regularly opening windows are long gone for many people. Excess moisture and poor ventilation are a widespread problem in our homes.

More-airtight houses are a good thing provided they are properly ventilated. Greater airtightness results in less uncontrolled infiltration. This has two benefits:

- Designers have more control - by minimising infiltration, energy losses are reduced and the right amount of ventilation is easier to provide.
- Thermal comfort is typically better with fewer draughts.

Draughts can have a real impact on indoor temperatures and occupant comfort, even in new homes, as not all are performing as well as Figure 1 above suggests. In a Wellington apartment complex finished in 2015, occupants of the double-glazed and insulated units said they were cold. Investigation found poor sealing and draughts were to blame. Fixing sealing strips to doors helped reduce draughts and made the apartments an average 1.4°C warmer.

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There are several opportunities with older buildings to improve airtightness. BRANZ undertook some experiments to make one of its older test buildings more airtight. Very significant improvements in airtightness were achieved with simple techniques that typically just needed an appropriate sealant for a junction and in some cases a skirting or scotia in combination with sealant where the gap was large. The work included:

- sealing the junction between ceiling and walls (top plate/walls) – this gave the single largest improvement
- for strip flooring, inserting expanding foam between the bottom plate and the last floor board before fitting the skirting board
- addressing window reveal to plasterboard connections and the connection between the window frame and the reveal itself – internal doorway jamb to plasterboard connections were filled with a bead of sealant
- sealing attic hatches with a closed-cell EPDM strip.

OPENING WINDOWS CAN PROVIDE EFFECTIVE VENTILATION

With more-airtight homes, ventilation is crucial. As the saying goes, "build tight and ventilate right". BRANZ projects have found that opening windows can be effective in tackling excess indoor moisture provided the room is heated and occupants are diligent in their actions. In one project, a north-facing room in a BRANZ test house was conditioned with a relative humidity of 70% (while heated to a constant temperature) with the internal door closed. The window was opened on consecutive mornings at 8 am to different widths over a range of external temperature and humidity conditions. The most effective case was when the window was opened to 300 mm. Within 10-15 minutes, the absolute airborne moisture content had reduced by 14%.

Even after an hour with no heating, the air temperature in the room did not drop to outside levels. As air has a low heat capacity, the cost to reheat the air in the room back to the recommended minimum of 18°C was low.

If a room has had excess moisture and low amounts of heating, it may take some time for the airing-out process to be effective. A BRANZ intervention identified that a homeowner of a modern home suffering condensation on double-glazed windows needed to consistently aerate the home twice a day for 2-3 weeks to reduce the internal humidity to acceptable levels. This was mainly due to moisture storage in linings or furnishings. Moisture levels could then be maintained by simply opening windows in the mornings.

Modern lifestyles are not as compatible with the level of diligence required, so mechanical ventilation may be a better option for many people.

MECHANICAL VENTILATION

Because passive ventilation alone cannot quickly remove large amounts of moisture from bathrooms, kitchens and laundries, localised air extraction systems such as kitchen rangehoods and bathroom extractor fans should be specified to remove the moisture at source. Extract systems must vent to the outside.

In NZS 4303:1990 *Ventilation for acceptable indoor air quality*, Table 2 sets out the mechanical extract airflow rate requirements. In houses, the minimum extract airflow rate is:

- for kitchens – 50 litres per second (l/s) intermittent, 12 l/s continuous
- for bathrooms and toilets – 25 l/s intermittent, 10 l/s continuous.

Mechanical ventilation will be a requirement in rental properties under the government's healthy homes standards. Rented homes must have an appropriately sized extractor fan in rooms with a bath or shower or indoor cooktop. The healthy homes standards will apply to new tenancies from 1 July 2021 and to all rental homes from 1 July 2024.

To provide more fresh air ventilation in a house, there are supply options (which bring fresh air in, forcing stale air out through gaps and cracks) and exhaust options (which expel stale air, leaving fresh outside air to be drawn in through gaps and cracks). The Building Code specifies that ventilation must be with outdoor air, so a supply system that draws air from a roofspace does not comply.

Balanced systems control the airflow both ways. A BRANZ project looked at the performance of a heat recovery ventilation system installed in a test house. Warm outgoing air from inside the house passes through a heat recovery core at the same time as the cold outside air brought in to replace it. While the two air streams never mix, they are close enough for heat to pass from the outgoing air to the incoming air. This reduces the need for additional heating and the energy loss associated with ventilation.

Cooking generates large amounts of moisture and particles that cannot be removed by passive ventilation alone. Kitchens, bathrooms and laundries should have localised extractors to remove moisture at source.

In the BRANZ test house, the heat recovery core recovered around 73% of heat from outgoing air (which is in line with the typical 70% efficiency for cross-flow cores). Care must be taken as the actual delivered efficiency can drop below 30% due to ducting air and heat losses. A proper design and installation are critical for the system to reach near the core efficiency. During installation, setting a balanced extract and intake airflow is critical for achieving optimal efficiency of the heat recovery system.

Heat recovery systems are best suited for use in colder climates and in homes with greater airtightness. Overseas research suggests that the infiltration rate should not exceed 10-20% of the flow rate through the heat recovery unit.

Anecdotally, more whole-house mechanical ventilation systems that provide continuous fresh outside air are being installed, although no quantifiable numbers exist.

While effective ventilation is crucial to achieving good indoor air quality, care needs to be taken not to overventilate. This means that excess amounts of heating energy will leave the house, resulting in higher than necessary power bills.

SUMMARY

It is not difficult to design and build a house or apartment that is reasonably airtight. Much more difficult is designing a home in a way that ensures effective ventilation and indoor air quality.

To provide effective ventilation in houses, researchers recommend:

- having an airtight structure that is also adequately ventilated – "build tight and ventilate right"
- ensuring effective insulation and heating systems to make rooms warmer
- eliminating airborne moisture at source – install mechanical extract ventilation in kitchens (rangehoods) and bathrooms and vent clothes dryers directly to the outdoors or specify a condensing dryer
- opening windows fully for at least 10-15 minutes each day if possible
- not occupying a house for several days after extensive repainting or use of chemicals inside to allow VOCs to disperse – using low-VOC materials is another option.

BRANZ is working in partnership with universities and other bodies in New Zealand and internationally to gather data and develop guidance for ventilation design. This includes research into apartments as well as houses. BRANZ has joined international groups of researchers under the umbrella of the International Energy Agency, working on larger projects covering occupant behaviour, ventilation and indoor air quality.

More information

Research Now: Indoor air quality #1 *An overview of indoor air contaminants in New Zealand houses*

Research Now: Indoor air quality #2 *An overview of indoor air contaminants in New Zealand schools*

Research Now: Indoor air quality #4 *Project: Indoor air quality in New Zealand homes and garages*

Research Now: Indoor air quality #5 *Project: Using a low-cost sensor platform to explore the indoor environment in New Zealand schools*

Research Now: Indoor air quality #6 *Project: Indoor air pollution at a New Zealand urban primary school*

BRANZ Bulletin 581 *Residential mechanical ventilation systems*

BRANZ Bulletin 607 *Passive ventilation*

McNeil, S. & Rupp, S. (2018). Airtightness trends. *Build*, 166, 90-91.

Pollard, A. (2018). *Could damp homes be too cold/underheated?* BRANZ Study Report SR389. Judgeford, New Zealand: BRANZ Ltd.