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Trends in building and ductwork airtightness in New Zealand

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1 General introduction

New Zealand is located in the South Pacific. It has a temperate climate. The majority of the nation has a Köppen climate classification of Cfb, with small areas of the South Island having classifications of Bsk and Dfc.

Lightweight timber frame is the predominant residential structural system for single dwellings and row houses mainly due to seismic activity. Steel frame is also a growing market. However, apartments are generally constructed with steel or reinforced concrete.

A variety of cladding systems are in use, i.e. timber weatherboard/sheet, brick veneer, stucco, fibre-cement weatherboard/sheet.

Historically, single dwelling units make up the urban environment, with growth in recent times towards multi-unit developments, particularly in inner-city areas.

Table 1:Building consents by building type, 2017–2022 [1, 2]

Year ending	Non-residential ($million NZD in value)	Residential (number of dwellings)
2017	5,572	30,892
2018	5,606	32,548
2019	6,469	36,450
2020	5,978	37,734
2021	6,485	47,430
2022	7,816	50,732

Table 2: Estimated dwelling stock by decade of construction [3]

Decade	Estimated building stock
1900	18,002
1910	56,201
1920	64,145
1930	46,104
1940	66,007
1950	148,329
1960	192,894
1970	234,599
1980	172,907
1990	191,693
2000	222,851
2010	194,408
2020	68,080

Table 1 shows total building consents issued for both residential and non-residential building for the last 6 years. There is a clear increase in building activity of ~30% in the last 2 years.

Table 2 shows an estimate of the total number of buildings still standing from each decade of construction. Note that the 2020 numbers only include data till the end of 2022.

There are currently no energy efficiency certificate or airtightness targets as a requirement for compliance with the New Zealand building code.

2 Building airtightness

2.1 Introduction

At present there is no airtightness requirement/target in the New Zealand Building Code (NZBC). While there is no target in the NZBC, there is a recommendation by BRANZ [4] to aim for a target of 3ach@50Pa. BRANZ is an independent construction industry research organisation funded via a levy on construction activity.

Several decades of research have established that there has been a consistent trend to more-airtight construction, see 2.6.3. Currently new construction reaches an average of 4.6 in the latest sample [5]. 3ach@50Pa is relatively simple to accomplish given current trends in the industry and what is being achieved already.

Currently, there is increasing discussion in regard to improving energy efficiency in New Zealand, mainly driven by the obligation the nation has under the Paris Agreement and the state of the existing building stock. Given the makeup of heat loss paths, airtightness for new construction is likely to receive more attention in future iterations of the NZBC.

The latest iteration of clause H1 *Energy efficiency* [6] of the NZBC recommends that airtightness of the ceiling diaphragm be maintained for durability reasons (interstitial moisture in roof voids). However, there is no test or onus to prove this.

2.2 Airtightness indicator

For those buildings that have airtightness tested, results are commonly reported on either the by volume metric (ach@50Pa), with volume calculated by dimensions internal to the airtightness layer, or in some cases envelope permeability ($m^3/m^2/h$@50Pa). As there are no requirements the reporting metrics can differ based on project needs or preferences.

2.3 Requirements and drivers

There are no national requirements for airtightness apart from air permeability requirements for joinery/fenestration [7] and a requirement for the use of a rigid air barrier depending on the weathertightness risk assessment of the building [8] if using an Acceptable Solution compliance route.

There are voluntary schemes that encourage airtightness testing inside their frameworks.

2.3.1 Building airtightness requirements in the regulation

There are three pathways for compliance according to NZBC clause H1– the schedule, calculation and modelling methods. For residential construction, these are contained within compliance documents H1/AS1[9] and H1/VM1[10], which are the Acceptable Solution and Verification Method respectively. These are published by the Government and must be accepted as evidence of compliance by the local authorities. Neither the schedule nor calculation methods consider infiltration heat loss in the compliance pathway.

The modelling method protocol in [10] typically assumes 0.5ach of total air exchange – including both deliberate ventilation and infiltration as a lumped parameter. Architects/designers can actively target improved airtightness and mechanical ventilation. However, the compliance pathway offers neither incentive nor penalty, ie MVHR does not receive a credit for recovering heat from exhaust air.

Voluntary schemes (see 2.3.2) exist that encourage industry to measure airtightness and give a reduction in the infiltration rate assumed in modelling as a credit (scheme dependent). However, this does not feature in terms of compliance with the NZBC.

The BRANZ recommended airtightness target of 3ach@50Pa is easily achievable given current industry capability and cost constraints.

In the longer term, there are grounds to discuss the merits of using a permeability metric ($m^3/m^2/h$@50Pa) over a volume-based metric (ach@50Pa). This would make assessing durability via hygrothermal modelling a simpler task, similar to the methodology in [11].

While both energy and durability need to be factored in, the temperate climate does raise concerns for interstitial moisture, and the permeability metric leads to a natural pathway to assessing risk.

2.3.2 Incentive for building airtightness

Government

There is a current government retrofit scheme called the Warmer Kiwi Homes programme [12]. However, it does not address airtightness – the focus is on insulation.

The Healthy Homes Guarantee Act [13] and standards [14] have a requirement for draught control in rental buildings. This consists of a visual inspection of the buildings with no gaps bigger than ~3mm allowed.

Voluntary schemes

The New Zealand Green Building Council's Homestar v5 [15] scheme provides a mechanism to incentivise airtightness in its assessment framework (section EHC5). If a blower door test is undertaken, points are given under the framework. Otherwise, points are not applied and a rather high default value is assumed for the energy use estimate.

The Passive House Institute of New Zealand requires buildings that are tested to be less than 0.6ach@50Pa for the purpose of certification to the PHI standard.

2.3.3 Building airtightness justifications

Airtightness measurements of buildings are currently not a requirement of the NZBC.

BRANZ has an airtightness recommendation – see 2.3.1.

2.3.4 Sanctions

There are no sanctions apart from penalty in energy modelling in voluntary schemes, which assume higher infiltration than the mean identified in BRANZ research.

2.4 Building airtightness in the energy performance calculation

2.4.1 Calculation

The only pathway to account for airtightness in the NZBC is to use the modelling methods H1/VM1[10] or H1/VM2[16] energy efficiency compliance pathways.

H1/VM1 assumes a fixed value of $0.5h^{-1}$ for total air exchange, so there is no incentive to reduce air leakage from a compliance perspective. H1/VM2 (larger or commercial building) allows infiltration to be accounted for. The energy modelling protocol in H1/VM2 requires the modelling of two buildings, a reference using nominal tabulated R-Values, and the proposed building. However, the reference building and proposed building shall have the same leakage assumptions.

Historically, a lookup table has been used to convert airtightness results to infiltration for modelling purposes using the Annual Loss Factor [17] (ALF) online tool. This did give credit via the building performance index. However, it has been removed from the compliance path in the 5th edition of H1.

2.5 Building airtightness test protocol

2.5.1 Qualification of airtightness testers

Providers exist that assess competence of technicians [18, 19]. However, these assessments are not a requirement yet.

Due to a lack of demand, the scale of the market for qualified testers is currently small. As the NZBC is improved, it is anticipated to grow.

Due to the market size, testing does not form the main activity for those companies undertaking it.

2.5.2 National guidelines

Standards New Zealand has directly adopted the ISO method as AS/NZS ISO 9972:2015 [20]. Due to lack of national regulation or normative guidance, all test methods are valid.

2.5.3 Requirements on measuring devices

Equipment needs to meet the requirements of the AS/NZS/ISO standards and be calibrated on a regular basis.

2.6 Building airtightness tests performed

2.6.1 Tested buildings

A very low percentage of New Zealand buildings are tested for airtightness. It is mainly undertaken by individuals seeking compliance with voluntary schemes or researchers undertaking surveys.

2.6.2 Database

Data only exists in two forms at present – research databases and those maintained by voluntary scheme operators.

At the current time, the research databases are the most comprehensive due to the low amount of testing activity undertaken by industry. This is likely to change in the coming years.

2.6.3 Evolution of airtightness level

Figure 1 presents the range of airtightness test results from a research-based dataset held by BRANZ for buildings constructed over several decades.

Changes in construction practices have driven airtightness down over the decades from very loose (20ach@50Pa) to the current mean of around 4.6ach@50Pa.

Factors influencing these changes include the shift from tongue and groove flooring to sheet-based and slab-on-grade construction as well as improvements in joinery and interior lining practice. In recent years changes were required due to the weathertightness issues that occurred in NZ in the late 90's-early 2000's. Additional air seals in the joinery rough openings and other measures such as rigid air barriers have also had an impact.

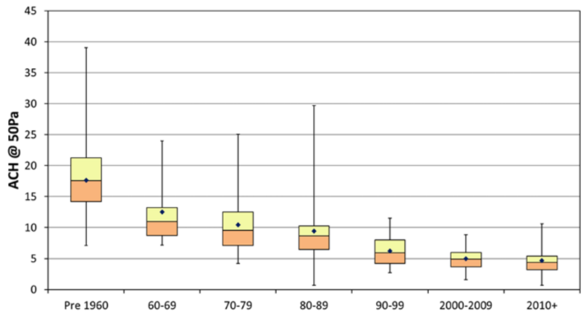

Figure 1: Airtightness test results over the decades for residential buildings

2.7 Guidelines to build airtight

Currently, there are only scattered recommendations and articles guiding industry on how to build more airtight. As energy efficiency targets are strengthened, this is likely to become more formalised.

2.8 Conclusion

Airtightness is currently not the most pressing issue for new-build New Zealand dwellings, with a mean airtightness of 4.6ach@50Pa in the most recent survey. However, this is some way away from the recommendation of 3ach@50Pa. With additional training of the industry, this could be readily achieved with minimal extra cost. Current energy efficiency and ventilation requirements present a greater problem at present. If we consider that there are diminishing returns of energy savings as infiltration is reduced, the real driver of improved airtightness must be durability of the building envelope combined with the cost/benefit relationship between construction detailing and energy savings.

As energy efficiency requirements are strengthened, change will likely be coming with respect to airtightness, as has happened in many other countries. A key part of this is the proposed Building for Climate Change [21] programme of work. Given New Zealand has a humid climate, there are risks in terms of building material durability to be managed alongside energy improvements.

Ventilation and IAQ are also critical for occupant experience as well as durability, and these need to be factored in to finding a balanced solution.

Given the spread of measurements and the nominal target at present of 3ach@50Pa, the pathway to improving airtightness could be considered evolutionary rather than revolutionary.

3 Ductwork airtightness

3.1 Introduction

Ductwork airtightness is not regulated in New Zealand.

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