Measuring the extent of thermal bridging in external timber-framed walls in New Zealand

Measurements made of 47 newly constructed houses in Auckland, Hamilton, Wellington and Christchurch found the average percentage of timber framing compared to wall area was 34%. This is much higher than the 14–18% framing content generally assumed by regulators and the industry. Such high levels strongly indicate that thermal bridging is compromising the thermal performance of walls and may mean that designed R-values are not being achieved.

Having our houses well insulated with a minimum of thermal bridges has substantial health, energy efficiency and financial benefits.

This project looked at thermal bridging in external timber-framed walls. Thermal bridges are materials or elements that are better at conducting heat. Heat flows more easily through them than other materials from the warmer interior to the colder exterior. Houses with lots of thermal bridges are harder to keep warm.

Timber framing is a thermal bridge. As the percentage of framing in the wall increases compared to the insulation, total wall R-value (a measure of thermal resistance or insulation value) falls.

There has been anecdotal evidence that wall framing percentages are higher than generally assumed. A research project funded by the Building Research Levy and carried out by Beacon Pathway assessed 47 new houses under construction to determine the as-built framing content and the extent of thermal bridging in exterior walls. The aim was to gain information about:

- the scale of the issue of high framing percentages in New Zealand houses
- the effect that high framing percentages have on as-built R-values
- the reasons why high percentages of framing might be occurring.

External walls greater than a few metres in length usually consist of a number of individual prefabricated panels. Data was collected for individual panels. This was used to calculate framing percentages for each panel, then aggregated to determine the percentages for walls, levels and the whole house.

The research was carried out on a case study basis. Samples came from:

- Auckland – 28 houses consisting of 49 levels and 683 panels
- Hamilton – 4 houses consisting of 6 levels and 86 panels
- Wellington – 4 houses consisting of 4 levels and 86 panels
- Christchurch – 11 houses consisting of 12 levels and 248 panels.

In total, 47 separate dwellings were assessed consisting of 71 separate levels and made up of a total of 1,103 separate framing panels.

Figures used here are for the net panel area – door openings and glazed areas are not included in the calculation of the framing percentages. This is the same approach as New Zealand Building Code clause H1 *Energy efficiency*, which considers doors, glazed areas and other openings separately to the framed and insulated sections of the wall.

In calculating framing percentages, hard copy framing panel elevations, plan layouts and frame schedules (lists of framing with dimensions) for each dwelling were supplied by the frame and truss manufacturers. (Frame and truss manufacturers supply over 90% of the framing to new residential builds in New Zealand.) Changes made on site were recorded. Data for each wall panel was then entered into the database.

The researchers also calculated and reported the percentage of framing added on site and the percentage of the wall typically left uninsulated such as gaps at external corners, inter-wall junctions and mid-depth blocking for services.

A series of interviews with representatives from suppliers, cladding manufacturers and frame and truss companies were carried out to determine what was driving the framing content in external walls. There was good industry cooperation.

Results

The final results are based on 1,103 wall panels across 71 levels and 47 houses.

- The average number of panels in each level of a dwelling is 15.5 (range 6-41).
- The average percentage of framing in walls was 34% of wall area (range 24-57%).
- Most wall panels have framing percentages of 20-50%, but some have percentages of 50-100%. Smaller panels can have framing as high as 70-100%.
- There is little framing added on site - the average for panels with added framing was just under 2% of wall area (range 0.04-8%). The average site-added, full-depth framing timber by level is just 0.7% (range 0.1-4.0%)
- The average percentage by level of uninsulated areas was 3% (range 0.5-10%).

What do the findings mean?

The average framing percentages of the case study dwellings are significantly higher than those assumed in R-value calculations used to establish compliance with Building Code clauses H1 *Energy efficiency* and E3 *Internal moisture*.

NZS 4218:2009 *Thermal insulation - Housing and small buildings*, which provides methods for compliance with clause H1, has instructions for calculating construction R-values that do not sufficiently account for the full effects of thermal bridging. The definitions of what needs to be counted exclude a significant number of the framing elements that contribute to thermal bridging and heat loss. Specifically excluded are lintels, additional studs that support lintels and additional studs at corners and junctions.

The deemed-to-comply compliance methods set out in H1/AS1 and E3/AS1 may therefore not be achieving the minimum R-values assigned/claimed.

BRANZ carried out some modelling using actual examples from the case studies to determine the impact of the difference between actual framing compared to framing using the NZS 4218:2009 definitions.

Figure 1 shows the difference between the actual framing installed on a site from a case study wall panel (left-hand side) compared to how the wall would be assessed in the definition provided in NZS 4218:2009 (right-hand side).

In this example, the actual as-built framing (left-hand side) does not meet the construction R-value requirements of clause H1 even with R2.8 insulation in the walls (the maximum R-value of widely available glass fibre insulation that will fit 90 mm framing).

The framing on the right, calculated using NZS 4218:2009, only just achieves the minimum construction R-value for zone 1 (R1.9) with the maximum R2.8 insulation.

BRANZ looked at an additional three sets of measurements from three different case study dwellings, comparing actual as-built framing with the figures using NZS 4218:2009. In some cases, the minimum construction R-value of R1.9 set out in clause H1 was only achieved with R2.8 insulation. In other cases, even installing R2.8 insulation was not enough to achieve levels set out in clause H1.

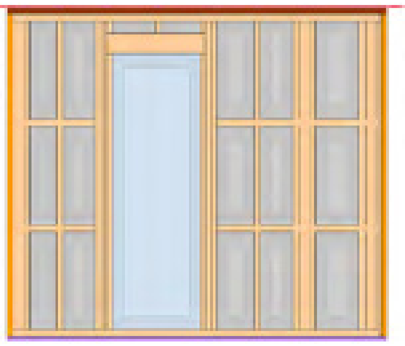
The fact that an average 3% of wall area is left uninsulated complicates matters further. This is largely the result of timing. Areas such as corners (see photograph page 3) and internal/external wall junctions can become inaccessible after building underlay is installed, yet insulation is generally installed after the underlay is in place. These areas appear to be commonly found and are an important weakness of the thermal envelope that is not currently considered in clause H1 calculations.

Possible explanations for higher framing ratios

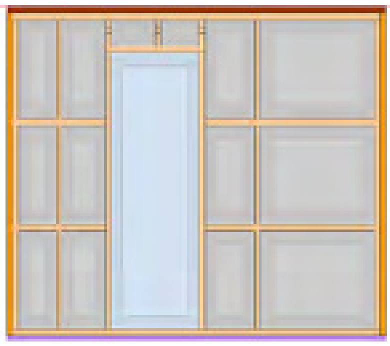
The research found that minimal additional framing was being added on site. There are also no indications that frame and truss manufacturers are adding unnecessary timber in the panels they construct - it is a competitive industry, and adding unnecessary timber would obviously come at a cost.

The increase in framing is likely to have a number of origins:

- Design requirements added to one area of regulations without consideration of other areas. For example, Acceptable Solution E2/AS1 requires cavities behind most claddings to improve weathertightness. Cavity battens require timber framing to be nogged at 800 mm centres compared with the NZS 3604:2011 *Timber-framed buildings* minimum 1200 mm centres. In effect, E2/AS1 added another line

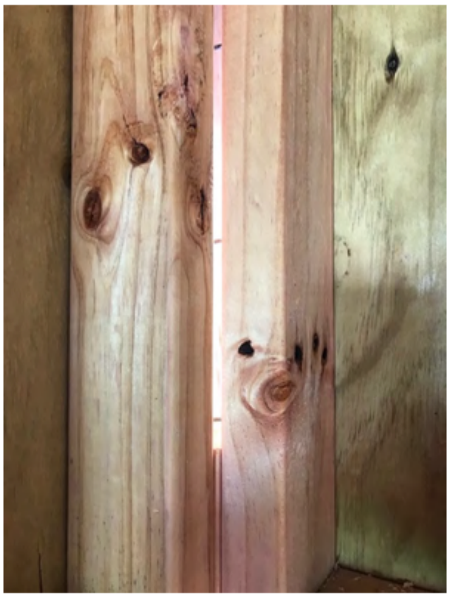


Construction R-value with R2.0 insulation, R1.44
Construction R-value with R2.8 insulation, R1.57
Framing Ratio 43%



Construction R-value with R2.0 insulation, R1.79
Construction R-value with R2.8 insulation, R2.00
Framing ratio 23%

Figure 1. Actual timber framing (left) compared to allowable definitions under NZS 4218:2009 (right).



An external corner junction showing the light coming through the wall underlay. Installing insulation in the gap between the studs is practically impossible at this stage with the underlay in place.

of nogging in standard-height wall framing. E2/AS1 also generally changed the internal corner junction from three-stud to five-stud.

- Building in higher wind zones and how wind zone requirements are calculated and applied by local authorities and design and building professionals.
- Cladding trends such as increasing popularity of vertical profiles, which require 400 mm or 480 mm nog/dwang spacing depending on wind zone.
- Changing styles and preferences. For example, designers may want double sills or double studs at smaller centres based on their personal preferences. Other design choices such as a double-height entrance vestibule or stairwell means the exterior wall may be 5-6 metres high, with a higher percentage of timber.
- More multi-storey dwellings. Structural requirements may lead to higher framing content on lower floors to carry the weight of upper storeys.
- Less than optimal placement of windows, doors and openings at the design stage. In some instances, shifting a window anywhere from a few millimetres to 300 mm to one side could negate the need for additional framing. There appears to be a lack of design thinking about minimising framing to achieve a better-performing thermal envelope.
- The majority of framing is made off site. Frame and truss design software does not assess thermal performance, and although it is efficient in not using unnecessary timber, it can result in double studs where panels meet. Walls are typically made up of multiple panels.

Conclusion

The percentage of wall framing in 47 newly constructed houses compared to net wall area (excluding doors and windows) was measured at 34%. This is much higher than the 14-18% framing content generally assumed by regulators and the industry. The content of timber framing in external walls in residential new builds is at such high levels that the increased thermal bridging will compromise the thermal performance of walls. This may mean that designed R-values are not being achieved.

The research findings suggest that unnecessary additional timber is not being added by frame manufacturers or builders on site. It appears to come from changing regulations, changing building styles and preferences, more multi-storey houses and less-than-optimal placement of doors and windows at the design stage. As wall framing is typically made up of multiple panels, there can also be a doubling up of studs where panels meet.

There is an opportunity for the results of this research to contribute to the Building Code review that the Ministry of Business, Innovation and Employment currently has under way. Follow-up work in this area is currently being developed.

More information

BRANZ External Research Report ER53 *Measuring the extent of thermal bridging in external timber-framed walls in New Zealand*

BRANZ Thermal Bridging Calculation Tool www.branz.co.nz/thermal-bridging-calculation-tool