ISSUE 690

BULLETIN

THERMAL BRIDGES IN EXTERNAL WALL FRAMING

March 2024

- Thermal bridges can significantly reduce the thermal performance, warmth and comfort of a new home. They can also affect durability.
- To build homes with lower operating costs and fewer operational greenhouse gas emissions, building practitioners need to reduce thermal bridging.
- This bulletin looks at thermal bridges in external framed walls and framing fractions and how to reduce the impact in new homes.

1 INTRODUCTION

1.0.1 Thermal bridges are building materials or elements that have lower thermal resistance than other materials around them. Heat flows more easily through them from the warmer interior of a building to the colder exterior. Houses with lots of thermal bridges require more purchased energy to keep warm. Wall framing and concrete slabs are both classic examples of thermal bridging – heat flows more easily through them than it does through insulation materials (Figure 1).

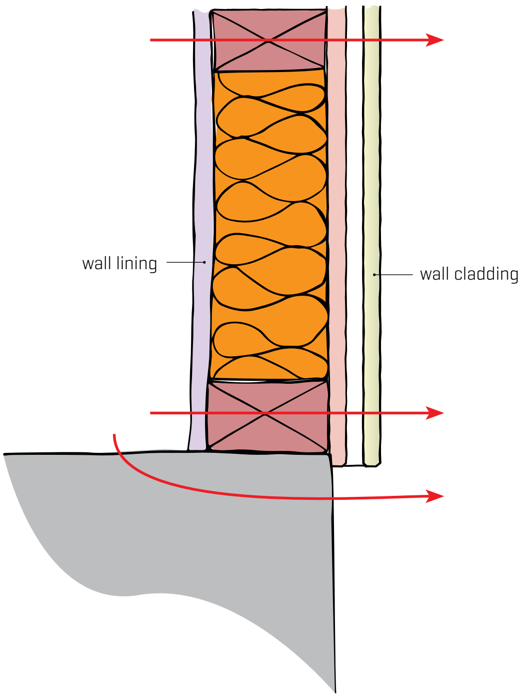


Figure 1. Typical thermal bridges through the wall and the concrete slab.

1.0.2 In wall framing, thermal bridging occurs with both timber and steel.

1.0.3 While 90 mm timber framing has an R-value (a measure of thermal resistance or insulation value) of approximately R0.7, the most commonly available wall insulation that fits in a 90 mm cavity has an R-value of up to R2.8. Walls with 140 mm framing can accommodate insulation materials with an R-value of R4.0.

1.0.4 The calculation of the construction R-value of the whole wall includes both of these factors – the R-value of the framing and the R-value of the insulation product – as well as other factors such as the cavity behind the cladding. As the percentage of framing in the wall reduces compared to the insulation, the total wall construction R-value increases. The less framing in a wall the better it is from a thermal performance perspective.

1.0.5 Thermal bridging occurs in all the elements that are part of a building's thermal envelope – walls, roof, floor, glazing and doors – and at the junctions of these elements. This bulletin focuses on the thermal bridging that comes from external wall framing.

1.0.6 As the industry moves to building homes with improved thermal performance, it is becoming more important for designers and builders to understand what thermal bridges are and how their impact can be reduced. MBIE has made it clear that the minimum allowable construction R-values for walls are likely to be increased in a future Building Code update.

1.0.7 Knowing the wall framing fraction – the percentage of wall area minus door openings and glazed areas made up by framing – is also becoming more important. For example, the BRANZ *House insulation guide* 6th edition requires designers to know this to work out the construction R-value of a wall assembly.

1.0.8 Architects and designers improving the thermal performance of a wall must also carefully consider moisture management in the wall assembly.

1.0.9 While improvements to thermal performance will typically reduce operational greenhouse gas emissions as a result of lower heating requirements, architects and designers should also consider the embodied carbon in any construction materials used. The BRANZ CO_2RE tool looks at this issue. Some manufacturers produce environmental product declarations that can be consulted. The BRANZ carbon tool CO_2NSTRUCT provides an Excel spreadsheet with values for embodied greenhouse gas and energy for some construction materials.

2 THE EXTENT OF THERMAL BRIDGING IN WALLS

2.0.1 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/framing fraction of exterior walls (Figure 2), which indicates the extent of thermal bridging. It found that the average percentage of framing in the walls was 34% of total wall area (with a range of 24–57%).

2.0.2 The Beacon research also found that an average 3% of wall area is left uninsulated (with a range of 0.5–10%). This is largely the result of timing. Areas such as corners and internal/external wall junctions can become inaccessible after wall underlay is installed, yet insulation is generally installed after the underlay is in place. These uninsulated areas appear to be commonly found and are an important weakness of the thermal envelope that designers and building consent authorities often do not consider when determining compliance with Building Code clause H1 *Energy efficiency*.

3 THERMAL BRIDGES AND CLAUSE H1

3.0.1 Architects and designers calculating the thermal performance of a new wall for compliance with clause H1 need to consider the effects of both the insulation material installed in the wall and the amount of framing.

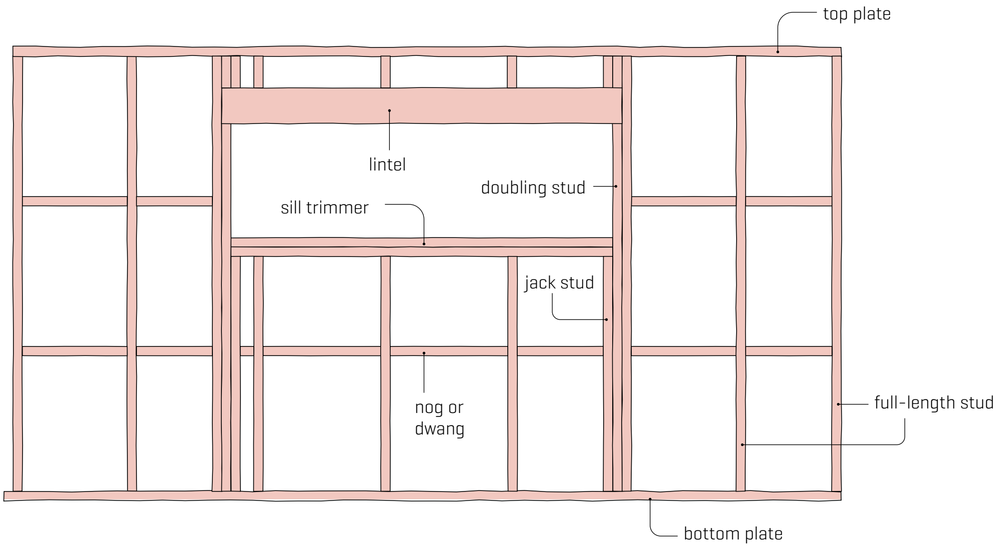


Figure 2. The common elements of timber wall framing.

3.0.2 If you are using H1/AS1 to demonstrate compliance, you can exclude some timber members from the calculation. These are (in H1/AS1 2.1.4.3 b) "lintels, sills, additional studs that support lintels and sills, and additional studs at corners and junctions" (see Figure 3). These exclusions make it possible to achieve a nominal construction R-value of R2.0 (the minimum required under H1/AS1) with 90 mm framing, at least on paper.

3.0.3 MBIE has made it clear that the thermal performance required of walls is likely to be increased in a future update to the H1 Acceptable Solutions and Verification Methods. It is also possible that the exclusions may be removed at some point in the future.

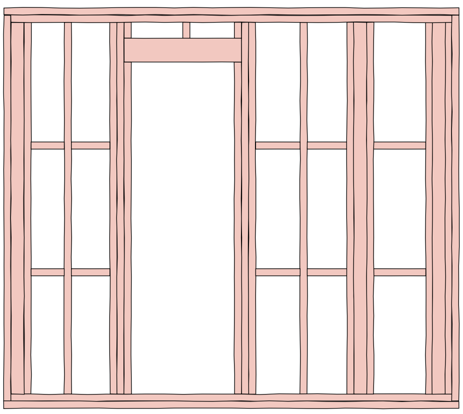
4 DETERMINING FRAMING FRACTIONS IN THE BUILD PROCESS

4.0.1 BRANZ *House insulation guide* 6th edition requires a value to be entered for the frame fraction (the percentage of wall area minus door openings and glazed areas made up by framing). A difficulty with entering a representative value for the frame fraction is that designers often do not know the precise frame layout at the design stage and there are no easy ways to determine it, so they simply work from a nominal stud spacing.

4.0.2 Some frame and truss manufacturers are developing calculators that are able to provide detailed information of the amount of framing that goes into each individual wall section. (One calculator is already operational at the time this bulletin is being published.) The current version of the *House insulation guide* includes the option to record the source of the frame fraction value that is entered and also what it represents. For example, is it all of the framing? Is it all of the studs, dwangs and plates? The latter solves the problem of how to demonstrate the validity of the framing area that has been excluded from the calculation such as lintels and sills.

4.0.3 The *House insulation guide* also includes an estimator for the frame fraction based on the

43%



23%

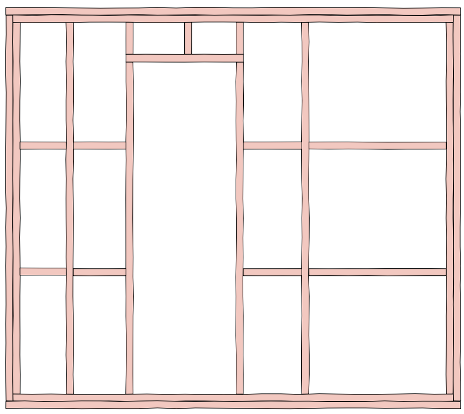


Figure 3. Actual timber framing in a new house wall (left, making up 43% of the wall area) and the framing that is counted for compliance with H1/AS1 (right, making up 23% of the wall area).

dimensions of a wall and the area of windows and doors. With time, the accuracy of the estimator will improve because of the ability to compare the results with the actual results from frame manufacturers.

5 REDUCING MOISTURE RISK

5.0.1 Increasing the thermal performance of a wall can often increase the risks presented by movement of moisture into wall assemblies. Reduced heat flow means there is less drying capacity in a wall. Moisture will typically enter walls via bulk air movement (convection) or vapour diffusion.

5.0.2 Bulk air movement (convection) into walls can bring significant quantities of moisture into an assembly. A reasonable level of airtightness helps to minimise the risk of this happening.

5.0.3 Vapour diffusion also contributes to the moisture load inside assemblies but is not as strong a driver as convection.

5.0.4 Excess moisture inside the building and entering the wall cavity brings a higher risk of condensation and a greater chance of mould growth, corrosion of fixings and other adverse effects. This can reduce durability.

5.0.5 Moisture management typically involves a package of actions:

- Reducing the levels of moisture produced in living spaces in the first place – for example, by house occupants not using unflued gas heaters, not drying washing inside and so on.
- Ensuring that any excess moisture that is created inside a house is carried to the outside through effective ventilation. This requires exhaust fans in bathrooms and a rangehood over a cooktop. Where homes have a high level of airtightness, mechanical ventilation of the whole home may be required. BRANZ research indicates that relying on occupants to open windows on a regular basis does not guarantee sufficient ventilation.
- Preventing moisture from living areas from getting into wall spaces – for example, through a flush-stopped plasterboard wall lining without any gaps.
- Specifying an air barrier/control layer in the wall itself where it may be required – for example, with secondary insulation layers (see Figure 4). This may be a flexible proprietary sheet material or a rigid material such as plywood, which provides bracing as well as air and vapour control.
- Avoiding construction assemblies where highly conductive materials (such as steel or concrete) interrupt the insulation layer without mitigating measures (such as thermal breaks or a continuous exterior insulation layer) that avoid localised cold spots within or on the interior surface of the wall.
- Avoiding construction assemblies with material layers that have a low vapour permeability near the exterior of the wall.

6 REDUCING THERMAL BRIDGES IN NEW HOMES

6.0.1 The Beacon research found no indications that frame and truss manufacturers are adding unnecessary timber in the panels they construct. The study pointed to estimates that frame and truss manufacturers supply over 90% of the framing to new residential builds in New Zealand and that this is a competitive and cost-sensitive industry where adding unnecessary timber would obviously come at a cost. It also found little additional framing added on site.

6.0.2 There are still a few opportunities available for minimising unnecessary framing in a wall:

- Work out the optimal placement of windows, doors and openings early in the design stage based on standard material sizes. This can be done with a 1,200 mm grid design. Place windows, doors and so on where studs exist anyway. In some instances, shifting a window anywhere from a few millimetres to 300 mm to one side could negate the need for additional framing.
- Avoid dwangs wherever possible. NZS 3604:2011 *Timber-framed buildings* does not specifically require dwangs in wall framing and in particular not the dwangs commonly seen in wall construction today that are installed flush with both inside and outside faces of the stud and therefore create a classic thermal bridge. While dwangs may be required for fixing sheet linings or claddings or to provide support for fixing shelves, sanitary fixtures and so on, try to minimise their use as much as possible.
- Bear in mind that cladding selection can have an impact on the amount of framing required in a wall. Some cladding types will reduce the need for extra timber.

6.1 SECONDARY INSULATION LAYERS

6.1.1 A secondary insulation layer on either the inside (Figure 4) or the outside of the main exterior wall framing can significantly reduce thermal bridging in the wall. For example, with 45 mm horizontal battens over a plywood air/vapour control layer (which also provides the required bracing), there will only be a complete bridge where the battens cross the studs. (Note that Figure 4 shows an air/vapour control layer, not a vapour barrier. BRANZ research has shown that, under typical New Zealand conditions, levels of water vapour transmission through building materials is seldom sufficient to require the installation of a vapour barrier.)

6.1.2 Secondary insulation layers require additional labour and time but can give substantial improvements in thermal performance, which can be identified with BRANZ *House insulation guide* 6th edition.

6.2 OTHER CONSTRUCTION METHODS AND MATERIALS – SIPS

6.2.1 Reductions in thermal bridging can also be achieved with different construction methods such as use of structural insulated panels (SIPS). SIPs are lightweight sandwich panels with two high-density face layers bonded to a low-density cellular core. The face layers are usually engineered wood panels, cement board or metal. The core provides insulation and structural support by distributing load between the face layers. Common core materials include polystyrene (EPS or XPS), polyurethane (PUR) or polyisocyanurate (PIR). SIPs are commonly available as panels 1.2 m wide and 2.4 m, 2.7 m, 3 m or 3.3 m long (longer by special order).

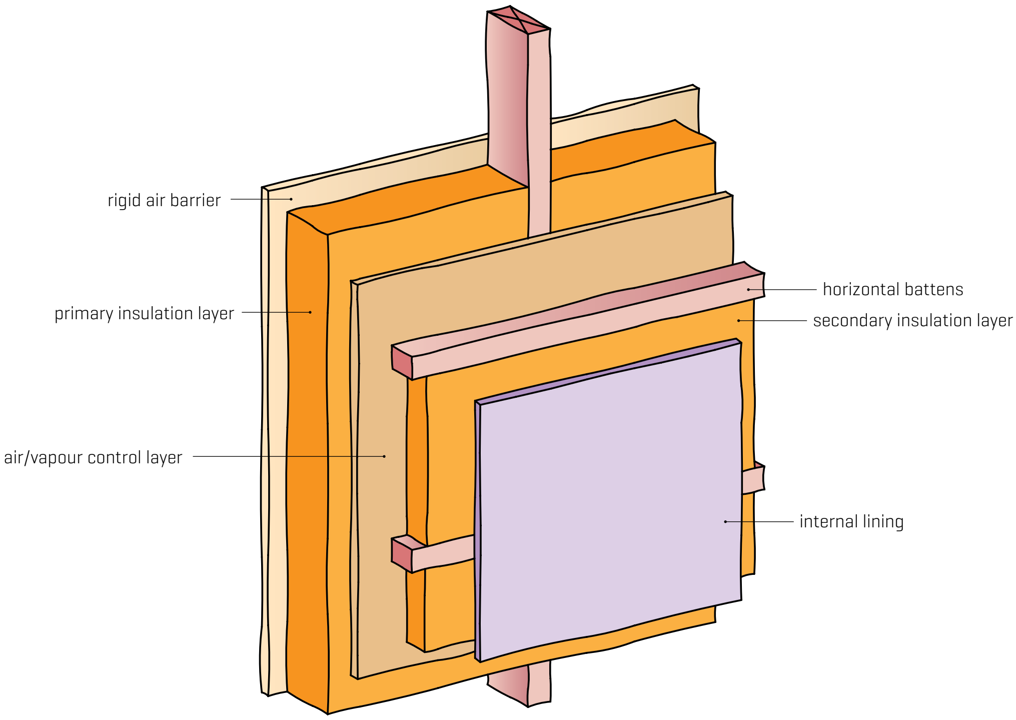


Figure 4. A 45 mm thick interior batten fixed over a plywood air/vapour control layer creates space for a secondary layer of insulation.

6.2.2 The thermal performance of SIPs depends on the material components and their thickness. Manufacturers claim R-values of around R2.3–R2.8 for 100–115 mm thick panels with a standard EPS core to as much as R9.0 for panels over 300 mm thick with EPS that includes graphite.

6.2.3 While SIPs are increasingly being used in residential construction in New Zealand, they are not currently included in Acceptable Solutions or Verification Methods – Building Code compliance must use an Alternative Solution. For clauses such as B1 *Structure*, this requires an engineering assessment.

6.3 INSULATING ALL CAVITY SPACES

6.3.1 The Beacon research found that an average 3% of wall area is left uninsulated. Finding ways to ensure that no area of wall is left uninsulated will lift the thermal performance of the whole wall.

7 LIGHT STEEL FRAMING AND THERMAL BRIDGES

7.0.1 Light steel framing has a higher degree of thermal conductivity than timber framing, and thermal

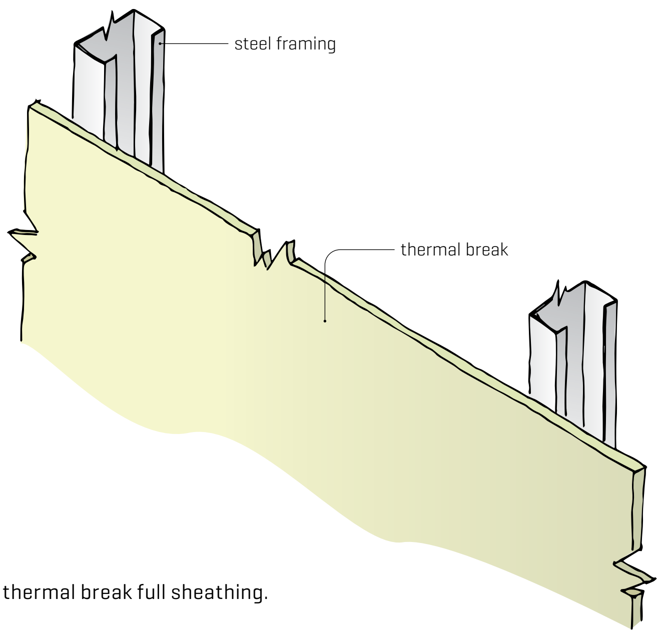


Figure 5. NASH recommends thermal break full sheathing.

breaks are a crucial part of steel frame construction. Thermal break full sheathing as shown in Figure 5 is recommended.

7.0.2 Thermal breaks for light steel framing are required:

- on the outside face of all external wall framing (studs, plates, braces and dwangs/nogs) forming part of the thermal envelope of the building
- between top plates and the heel of truss bottom chords or rafters/ceiling joists at external walls
- between soffit bearers and the wall framing it is attached to
- for skillion roofs, to be fixed to the outside edge of the rafter or truss top chord.

7.0.3 Acceptable Solution E3/AS1 1.1.4d requires that steel framing in housing and residential buildings uses a thermal break with a minimum R0.25 at the outside face of each steel framing member.

7.0.4 Publications from the National Association of Steel Framed Housing provide extensive guidance on the requirements and application of thermal breaks in different climate zones – see www.nashnz.org.nz/publications/downloads.

7.0.5 BRANZ is aware that a number of BCAs are asking architects and designers for more information around their management of thermal bridging of steel beams and portals and how they will comply with clause E3. Although details are beyond the scope of this bulletin, this is an issue that should be addressed in building consent applications.

8 MORE INFORMATION

CO_2RE

CO_2NSTRUCT

ER64 *Thermal bridging in external walls: Stage two*

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

BRANZ Research Now: Warmer drier healthier #2 *Measuring the extent of thermal bridging in external timber-framed walls in New Zealand*

You can find details around how to reduce thermal bridging in other parts of a building's thermal envelope in these BRANZ bulletins:

BU685 *Insulation of concrete slab-on-ground floors less than 300 m^2*

BU680 *Insulating glass units (IGUs)*

BU672 *Specifying floors under H1*

BU670 *Specifying windows and doors under H1*

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