THERMAL BREAKS AND BRIDGES

Thermal bridges in buildings reduce the benefits of insulation, so we need to add thermal breaks. What does this all mean?

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Adding an insulation product with a given thermal resistance (R-value) to a wall doesn't usually mean the thermal resistance of the wall increases by the R-value of the insulation product. There is often a bit missing because thermal bridging has short-circuited the insulation, undermining the thermal resistance. Thermal bridges can also create cold spots where condensation or mould can form.

Framing acts as a thermal bridge. Where insulation is installed between framing, rather than on the outside like exterior insulation and finish systems (EIFS), the framing acts as a thermal bridge transferring additional heat through the insulation. This is because the thermal conductivity of the frame material is significantly higher than that of the insulation materials. For example, the thermal conductivity of timber is about twice that of most insulation materials and seven times that of some of the high performance rigid foam insulation materials, such as phenolic foam.

Thermal breaks, bridges and insulation

A thermal break is insulation material that is used in the region of a thermal bridge to increase the thermal resistance and so reduce or stop heat flow.

For building applications, a material is an insulation material if its thermal conductivity is less than 0.1 W/m°C and a thermal bridge if the conductivity is greater than 0.1 W/m°C. To insulate a building, there must be a sufficient thickness of the material to provide significant thermal resistance. A thin layer (10 mm) of insulation may not be sufficient for insulation but it can provide enough thermal resistance to act as a thermal break for high-conductivity materials that bridge the insulation. Remember that thermal conductivity is the inverse of thermal resistance (R-value), so the higher the R-value, the lower the thermal conductivity.

Timber with a typical thermal conductivity of 0.12 W/m°C falls just outside the category of an insulation material, but given a sufficient thickness, it can still provide some level of insulation. Cork however, makes the insulation category, with a thermal conductivity of 0.05 W/m°C.

Metals, such as steel with a thermal conductivity of approximately 40 W/m°C, obviously conduct a lot more heat than a typical insulation material with a thermal conductivity 1,000 times less, but because of its inherent strength, the cross-sectional thickness needed to form the web of a frame is usually less than a millimetre, and the total heat conducted is a lot less than the conductivity would suggest.

Increase insulation or frame depth

Although timber framing often thermally bridges insulation, it is usually easier and cheaper to use a higher R-value insulation product than to add thermal breaks to the frame. Other options include:

- using a cladding product with a higher thermal resistance
- using a design that minimises the amount of framing timber
- increasing framing depth from 90 to 140 mm.

Increasing the timber frame depth increases the thermal resistance through the frame and also the maximum possible insulation product R-value that will fit into the frame cavity. A maximum of R2.8 fits a 90 mm deep wall frame whereas an additional R1.5 can be added to a 140 mm deep frame. Fewer framing members will be needed to achieve the same overall structural properties, so the total area occupied by thermal bridges will reduce and the area occupied by insulation increase. Although the insulation will still be bridged by the framing, the insulation's overall effectiveness will be much higher.

Steel framing needs thermal breaks

Steel framing typically has a wall thickness of only 0.55, 0.75 or 0.95 mm BMT (base metal thickness) compared with the typical timber framing width of 45 mm, but because it has a thermal conductivity some 300 times that of timber, the thermal bridging is significantly higher unless thermal breaks are used.

A recommended thermal break material is 12 mm thick, high-density expanded polystyrene (see Building Code E3/AS1). It can be applied either as a compete sheathing on the outside of the frame or as a narrow strip applied to frame. It's important not to compress it as this reduces its thermal effectiveness. It should have a thermal resistance of at least R0.3 and be applied to all framing elements including dwangs, and top and bottom plates. The latter is particularly important for steel-framed brick veneer construction because perpends (weepholes) in the bottom rows of bricks will cause the air temperature in the cavity between the bricks and the framing to be close to the outside air temperature. It is difficult to achieve the minimum R-values set out in the schedule method of NZS 4218 unless a thermal break is used with steel framing behind brick veneer.

Importantly, thermal breaks must always be installed on the cold side of the frame, not the warm side, to lower the risk of condensation. This makes achieving both a thermal break and a drained and vented cavity difficult with steel.

Thermal options with steel framing

In general, there are more options for the specification of steel framing for thermal performance. The most important for thermal performance are depth (78, 90 or 140 mm), BMT (0.55, 0.75 or 0.95 mm) and the thickness, width and material used for the thermal break. It is important to consider all these variables.

Modelling highlights variables

Figures 1–3 show thermal modelling of temperature and heat flow for three steel framing options, and Figure 4 models timber framing. Facing what would be the interior lining, the perspective shows a cross section through to the exterior face (including direct fixed sheet cladding). The frame is located in the centre, running vertically, and is surrounded on both sides by insulation. The insulation has been set at the practical limit for a 78 mm frame space of R2.4.

STEEL FRAME WITHOUT A THERMAL BREAK

Without a thermal break, most of the steel frame is much closer to the colder exterior than the warmer interior temperature (see Figure 1). The interior surface temperature near the frame is noticeably less than the area either side, and the heat flow through the frame area is much higher (7 times) than the areas either side.

STEEL FRAME WITH THERMAL BREAK

Figure 2 includes a 12 mm thick expanded polystyrene thermal break between the steel frame and the direct fixed exterior cladding. The thermal break is the same width as the frame flange (40 mm). The frame is now at about the mean of the interior and exterior temperatures, the temperature drop at the surface near the frame is much less noticeable, and the heat flow at the frame is half what it was. The reason for the lower heat flow is partly that extra insulation has been added in the additional 12 mm space provided by the thermal break. The practical limit for a 90 mm frame space is R2.8.

Figure 3 shows what would happen if the base metal thickness of the frame was only 0.55 mm. Because there is already a thermal break, there is less impact, but the frame temperature is closer to the interior temperature, and the heat flow through the frame has reduced further.

TIMBER HAS MUCH LESS THERMAL BRIDGING

For comparison, Figure 4 shows a cross section through a timber frame with the same level of insulation. The presence of the frame is only just detectable in the temperature diagram, and there is only a small change in heat flow through the frame relative to the heat flow through the insulation. Nonetheless, it still represents a thermal bridging of the insulation by the frame.

Improving steel framing performance

Other options to make the thermal performance of a steel frame with a direct fixed cladding similar to that of a timber frame include:

- extending the width of the thermal break
- increasing the depth of the frame
- reducing the width of the flange
- using a cladding product with a higher thermal resistance.

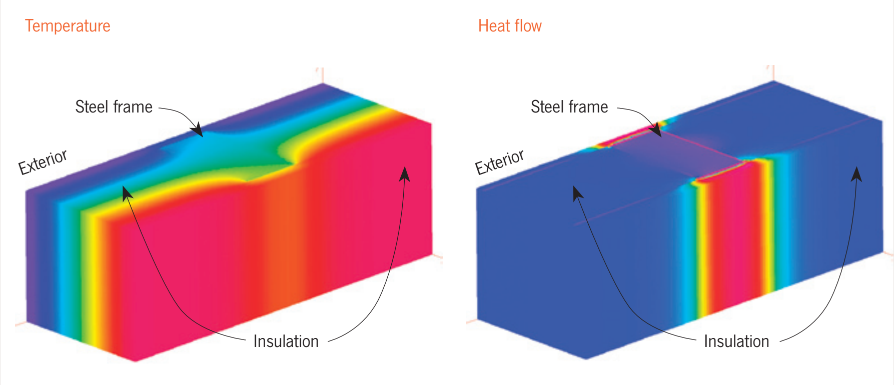

Figure 1: Modelling of 0.95 BMT, 78 mm steel frame without a thermal break. Colour in all figures signifies intensity – red is higher; blue is lower.

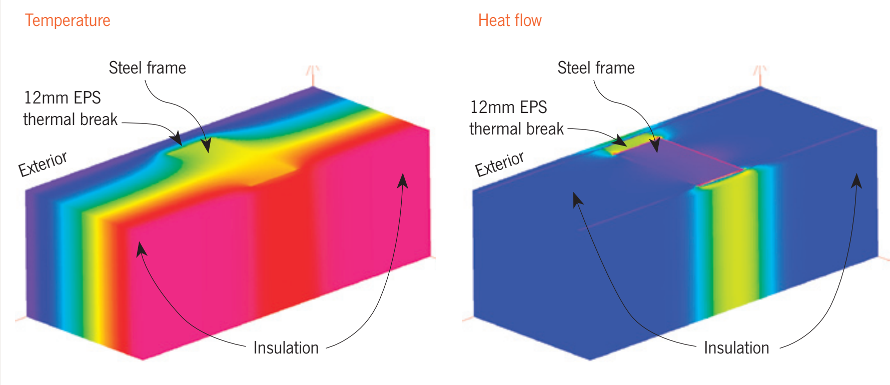

Figure 2: Modelling of same 0.95 BMT steel frame but with a thermal break.

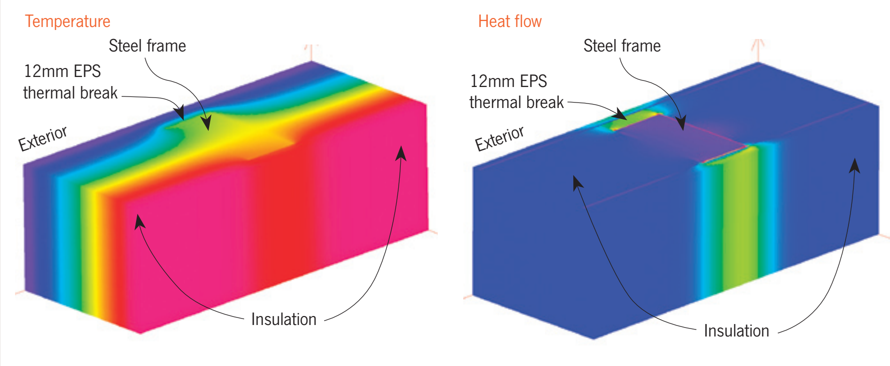

Figure 3: Modelling of 0.55 BMT steel frame with thermal break.

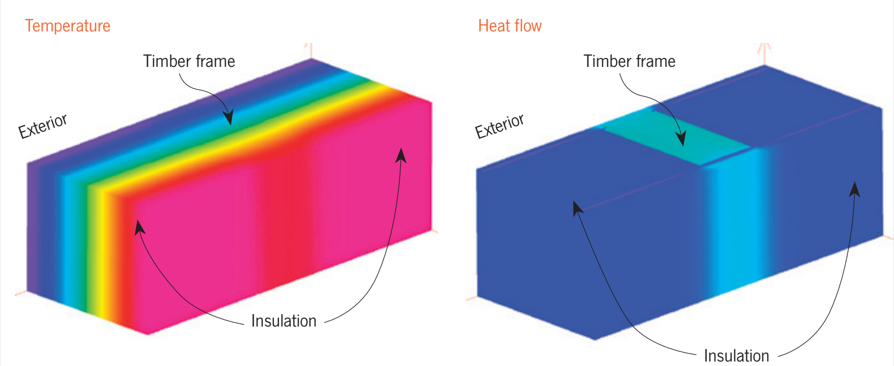

Figure 4: Modelling of 90 mm timber frame.