# What are thermal bridges? Why are they so Bad?

A thermal bridge is a penetration in the insulation layer with a highly conductive material, allowing increased amounts of heat flow through that material. This is a problem ï a BIG problem. Energy bills are increased, interior comfort is reduced, and the buildingôs integrity is compromised.
Sadly, thermal bridges are all around us. Chances are your home or office is full of them! For example, exposed concrete balconies are a very common thermal bridge in typical construction. The concrete slab extends out to the exterior air from the interior space. We spend money to keep that interior air warm in the winter, and cool in the summer, but then unnecessarily design our buildings to lose or gain heat.
Another class example is a structural stud, or even worse, a metal stud! Many designs expose one side of the stud to the interior, and one to the exterior. That is very bad. The standard 2×6 wood framed wall with R19 batten insulation is more realistically a R13, and if metal studs are used, you can count on an R9.

# Thermal bridging matters!

It matters a lot, and not just for energy loss.
Have you ever stood beside a cold interior surface in your home or office? We all have, especially in January. Thermal bridges cause these cold interior surfaces. Cold interior surfaces cause mold, mildew, and eventually decay. Yes, mold. If surface temperatures are below the interior airôs dew point temperature, then we get condensation. Continuous condensation is a serious problem for the interior occupantsôhealth, comfort, and the buildingôs integrity. Common locations for this are:

- Around low quality windows & doors
- Interior corners
- Behind furniture
- Where the building is in contact with the ground
- Rim joists
- Roof connections to the wall
- Concrete balcony penetrations through the wall
- Voids in the insulation layer

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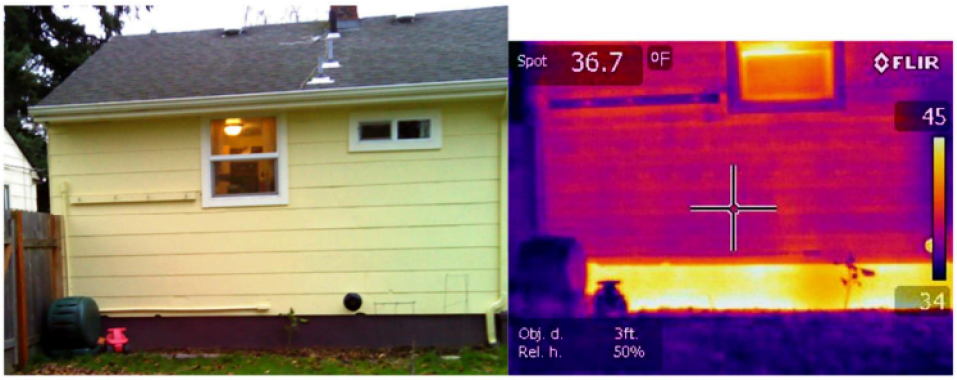
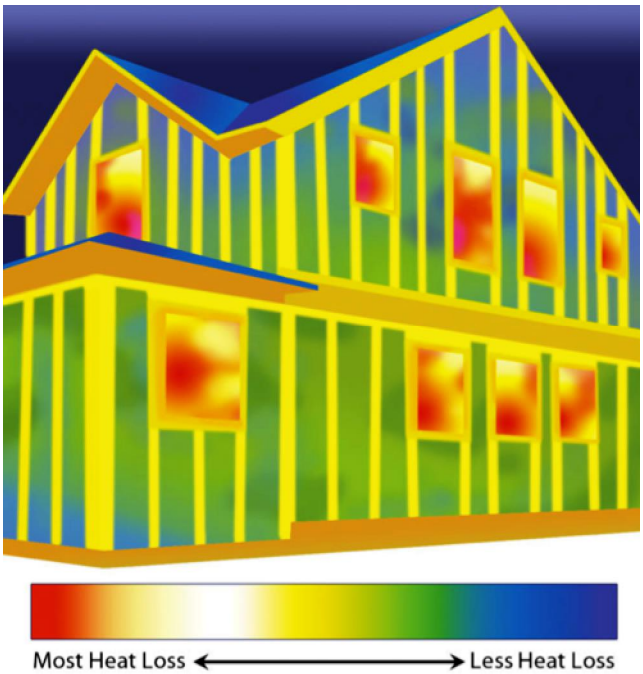



Thermal bridging is seen with the glowing from the foundation basement wall. That is a lot of energy being lost! Thereôs no use in heating up your backyard. This is a common reason why basements smell ómusky.ô Thatôs because so much heat is lost through un-insulated foundation walls and slabs, reducing interior surface temperatures, and allowing condensation to accumulate over time. Bad news.




A schematic representation of what thermal bridging looks like in a typical residential house. The yellow at the studs, and the rim joist locations is not a pretty color for a building scientist, or a homeowner. Even worse, the low quality windows outlined in red represent even more heat loss, low interior surface temperatures and an increased potential for forming interior condensation. We should strive for all exterior surfaces to be cold, and interior surfaces to be warm.

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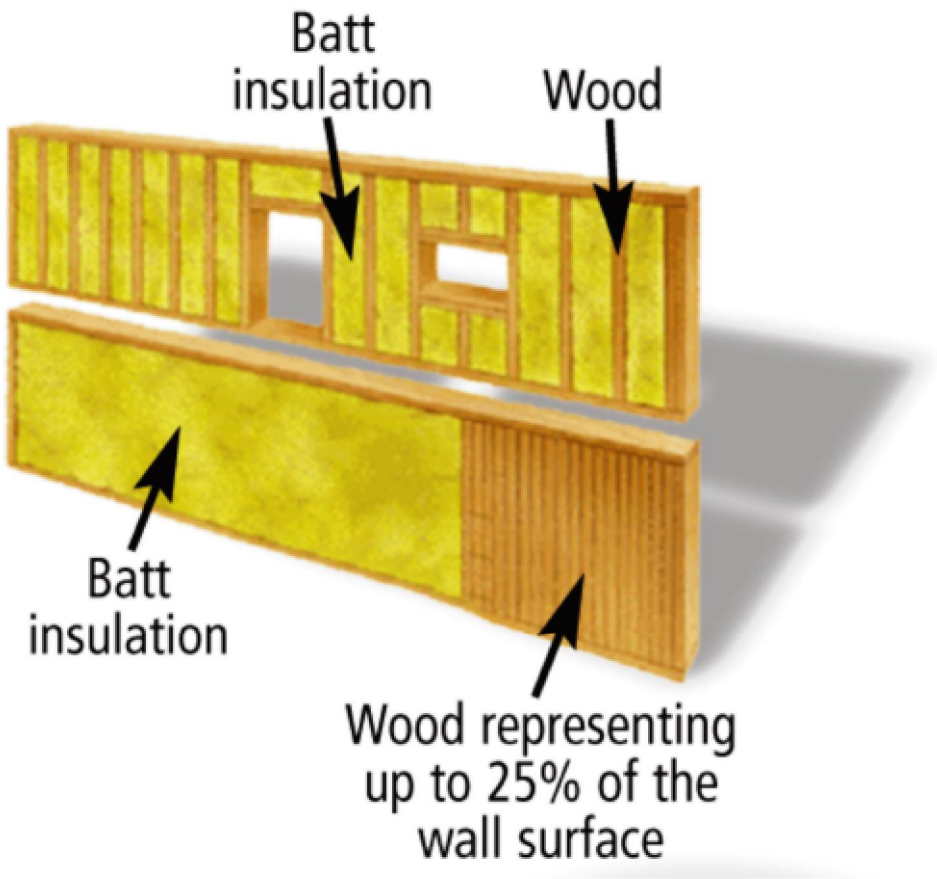
A great representation of how much framing studs are in typical construction. Each one of those studs will allow more heat loss than the insulation.
This needs to be accounted for! Next time you hear, óOh, my wall is an R-19!ô Ask them if that includes all of the framing? Chances are it does not, and it makes a very big difference.
Most óR-19Nwalls are more like an R-10 to R13 range, depending on how much framing was used. That is a 30% to 50% change in thermal resistance, thatôs no joke.



A void in the insulation layer. Although not a ócthermal bridge,ô it does produce the same negative effects: Reduced overall R-value, reduced interior surface temperatures, increased heat loss, reduced interior comfort, and structural durability ï none of which are good things. Please do not have voids in your insulation layers. Voids allow for air to move in the framing cavity. This is very bad. It reduces R-value due to increased convection heat transfer. Voids also increase the potential of moisture entering the cavity due to increased air movement. This is a problem most commonly found in batten insulation systems. Use great care when installing insulation batts and blown in insulation to ensure all voids are filled. Blown-in insulation eventually settles and creates voids. That is probably enough thermal bridge images for one day. We imagine that you now get the picture of what exactly a thermal bridge is, and why it is important to completely avoid them in your building design.

Best practices for thermal bridge free construction:
Use continuous insulation on the exterior side of framing, without voids
Reduce framing in the wall
Use thermally broken joints in balconies
Use high performance windows and doors
Use thermally broken foundation assemblies
No penetrations through the insulation layer with highly conductive materials

THERMAL BRIDGING

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INTRODUCTION

Material contained in this section will include:

ÅThe definition of a thermal bridge
ÅTypes of thermal bridges (repeating, non-repeating and geometrical)
ÅPhi (ɣ) values
ÅMethods of calculation (1-D, 2-D and 3-D)
ÅSequencing of construction processes and examples of common occurrences of thermal bridging

Thermal bridging can have a significant impact on the thermal and energy performance of the building envelope. In the past, when dwellings were relatively poorly insulated, thermal bridging had little influence on the overall thermal performance of the building. However, as dwellings have become better insulated, the relative importance of thermal bridging has increased. In very well insulated dwellings, the proportional effect that thermal bridging can have on the thermal performance of a dwelling can be significant. For example, in a notional semi-detached dwelling (89m$^2$ floor area) with a total fabric heat loss of just over 90W/K and a y value of 0.08 (roughly equivalent to a 2006 Part L1A compliant dwelling), then thermal bridging is likely to account for 16% of the dwellings total fabric conduction heat loss (see figure below). If no additional measures are taken to improve thermal bridging beyond this level (i.e. *y* value remains at 0.08) but the total fabric heat loss reduces by 25% by 2010 and 44% by 2013, then thermal bridging could account for almost 30% of the dwellings total fabric conduction heat loss by 2013.

Percentage of heat loss attributable to thermal bridging

Even when measures are taken to reduce thermal bridging, in very well insulated dwellings, thermal bridging can still account for a significant proportion of the overall fabric conduction heat loss.

Percentage of heat loss attributable to thermal bridging

In addition to an increase in fabric conduction heat loss, thermal bridging can also result in:

ÅAn increase in solar heat gains during the summer
ÅReduction in internal surface temperatures
ÅCold spots occurring within the building
ÅAn increased risk of both surface and interstitial condensation, which may result in mould growth and pattern staining

ÅReduction in indoor air quality (due to condensation and mould growth)
ÅDamage to building components
Although the aim, particularly in low and zero carbon dwellings, should be to try and design and construct dwellings that are thermal bridge free, it is important to realize that it is not generally possible to eliminate thermal bridging altogether. Instead, efforts should be made to minimize thermal bridging as much as is possible.

CONSTRUCTION OBSERVATIONS
Observations from construction practice have identified a number of areas where thermal bridges commonly occur as a result of issues associated with design, build-ability and construction practice. These areas include:
ÅAround windows, doors and roof lights
ÅTimber studwork in timber frame construction and in pre-fabricated panels
ÅStainless steel cavity wall ties
ÅBridged cavity masonry construction
ÅDiscontinuities in thermal insulation
ÅComplex detailing
ÅAround steel I-beams
All of these thermal bridges can be attributed to issues associated with the design of the building and the thermal envelope and /or issues associated with the way in which the dwellings have been constructed.
Around windows, doors & roof lights
Experience suggests that thermal bridges are common around windows, doors and roof lights. The areas where the thermal bridging occurs relate to:
ÅLintels
ÅJambs
ÅSills
ÅDoor thresholds.
ÅPosition of the window or doorframe.
Lintels
Thermal bridges commonly occur though box and top hat lintels. In these types of lintels heat flows through the path of least resistance, the perforated steel base plate, circumventing the insulation contained within the box or top hat (see figure and animation below).

THERMAL BRIDGE
A thermal bridge (or cold bridge) is an area of the building fabric, which has a higher thermal transmission than the surrounding parts of the fabric, resulting in a reduction in the overall thermal insulation of the structure.
It occurs when materials that have a much higher thermal conductivity than the surrounding material (i.e. they are poorer thermal insulators) penetrate the thermal envelope or where there are discontinuities in the thermal envelope. Heat then flows through the path created ï the path of least resistance ï from the warm space (inside) to the cold space (outside).

The higher thermal transmission of this part of the fabric results in a reduction in the thermal performance (an increase in U-value) as heat flows through the fabric, and the surfaces of the interior side of the bridge become cooler.
The use of the termôthermal bridgeôis somewhat misleading as it implies that the thermal envelope must be ôbridgedôin some way for a thermal bridge to occur. This is in fact not the case. Thermal bridges can occur in un-bridged construction where discontinuities exist in the thermal envelope.
Thermal bridges occur due to:
ÅGeometrical effects, such as corners.
ÅPenetrations through the thermal envelope, for instance windows and doors.
ÅJunctions between different elements (wall and floor) and different components (around windows and doors).
ÅPoor construction practice (gaps or discontinuities in thermal insulation).
The occurrence of thermal bridges can be attributable to:
ÅIssues associated with the design of the thermal envelope.
ÅBuild-ability and construction issues; or as is often the case
ÅA combination of both of the above points.

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