TECHNICAL HANDBOOK – AUGUST 2022

Guide for analyzing thermal bridges

What is a thermal bridge? And why we must address them.

Thermal bridges are localized areas on the facade with higher thermal conductivity than their neighboring areas. Typical thermal bridges are geometric thermal bridges, like corners, or material based thermal bridges like anchors, balconies, parapets passing though the insulation layer. Significant heat energy loss occurs at thermal bridges. Additionally, resulting low internal surface temperatures lead to condensation and mold growth in the vicinity of the thermal bridge.

How to assess thermal bridges?

To assess the thermal impact of a thermal bridge, the additional energy loss through the thermal bridge must be determined. This value is called linear thermal transmittance, ψ, in the case of continuous linear bridges, like balconies etc. or point thermal transmittance, χ, in the case of point thermal bridges, like beams etc.

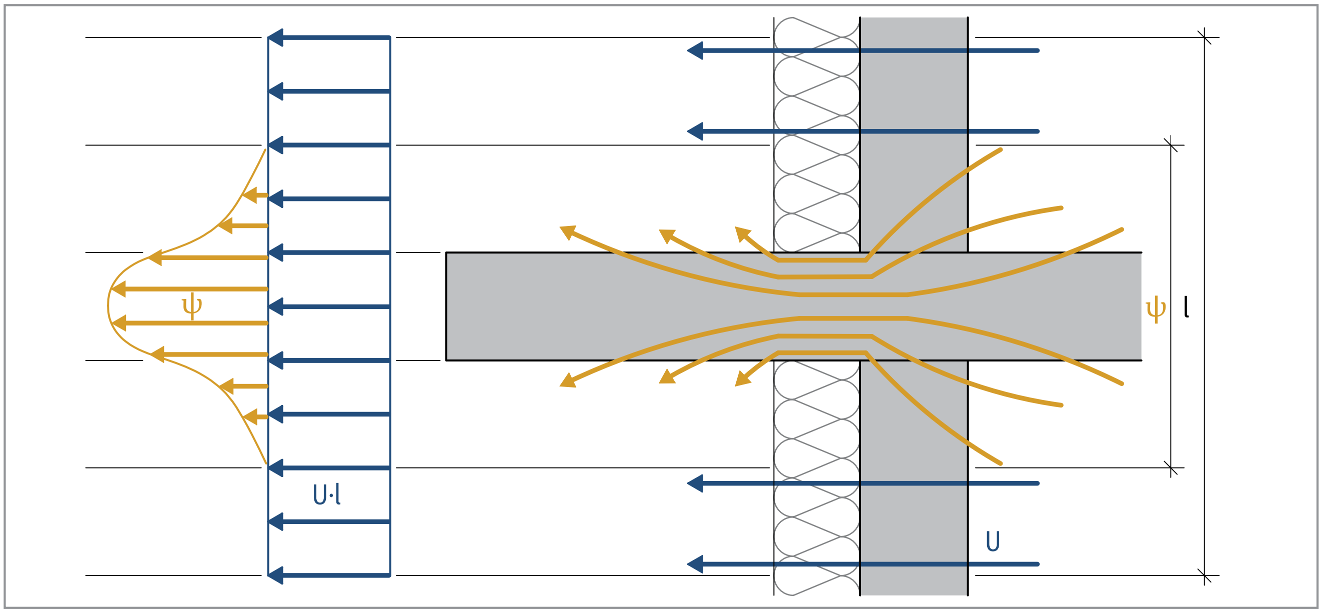

Figure 1: Pattern of heat flow through a building enclosure with materials that allow lateral heat flow to a thermal bridge

The rate of heat flow through a thermal bridge depends on a number of factors: the cross section area of the thermal bridge, the materials passing through the insulation layer, their geometry and the surrounding assemblies.

How to calculate the energy loss though a thermal bridge?

To identify the energy loss through a linear thermal bridge, the ψ value (thermal transmittance) must be determined. This can only be calculated by corresponding software (ex. heat).

i An R-value is a poor indicator of the thermal performance of a thermal bridge!

Calculating the thermal transmittance ψ

In this example we calculate the energy loss through a concrete balcony, which is a linear thermal bridge. This simplified detail should be modeled in a finite element (FE) software.

The additional heat loss due to the slab penetration (Q_{slab}) is equal to the total heat flow through a building assembly (Q) minus the heat flow though the clear field of the assembly (Q_0).

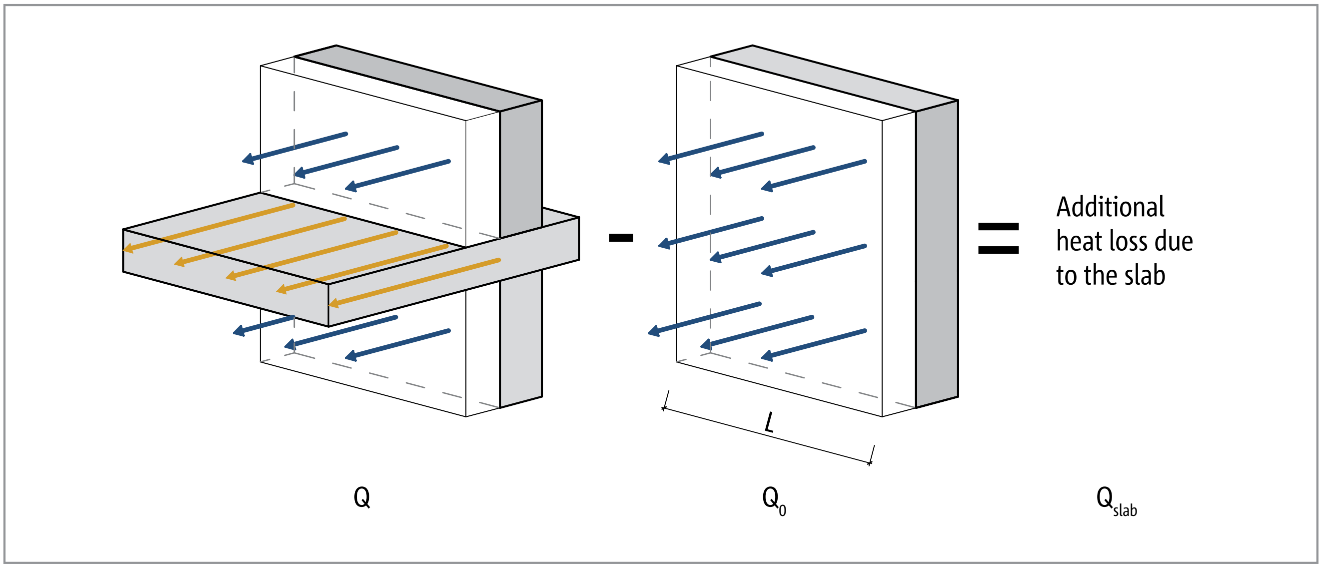

Figure 2: Example of process of determining the linear transmittance of a slab penetrating a wall

$$Q = Q_0 + Q_{slab}$$

$$Q = U_0 \cdot A + \psi_i \cdot L_i$$

- U_0 is the "clear wall" assembly heat transmittance (including the impact of frequent and distributed bridging elements)
- A is the area of the assembly, including all details in the analysis area
- ψ_i is the linear heat transmittance value of detail "i"
- L_i is the total length of the linear detail "i" in the analysis area

For this example, the total heat flow (Q) is calculated in an FE software. Q minus Q_0 (which is given as U•A) gives Q_{slab}. The heat loss due to the slab consists of the thermal transmittance (ψ) and the connection length of the linear thermal bridge (L).

Assembly 1: Balcony with thermal bridge

So for this Example:
concrete balcony thermal bridge

$\psi_1 = 1.08$ W/(m·K)	(= 0.63 Btu/(h·ft·°F))
$U_0 = 0.321$ W/(m²·K)	(= 0.057 Btu/(h·ft²·°F))
h = 200 mm	(= 8 in)
$k_{Insulation} = 0.035$ W/(m·K)	(= 0.243 Btu·in/(h·ft²·°F))
$k_{reinforced\ concrete} = 2.3$ W/(m·K)	(= 16 Btu·in/(h·ft²·°F))

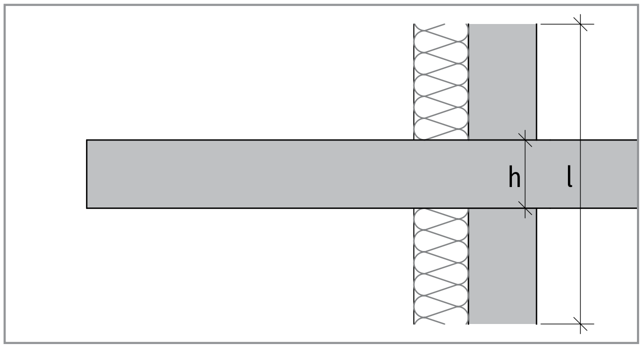

Figure 3: Assembly 1 – Balcony with thermal bridge

To include the effects of thermal bridging transmittances to whole building energy simulation, the overall wall or roof assembly U-value inputs into the energy model should be modified by using the appropriate ψ value. An equivalent total U-value ($U_{effective}$) can be entered into the models as:

$$U_{effective} = U_0 + \frac{\psi \cdot L}{A}$$

$$U_{effective\ 1} = 0.739\ \frac{W}{m^2 \cdot K} = 0.130\ \frac{Btu}{h \cdot ft^2 \cdot °F}$$

Assembly 2: Balcony with thermal break element

For the same wall construction, Assembly 2 shows the same situation with a thermal break element in the insulation line to reduce the heat loss. The ψ_2 value is 0.29 W/(m·K) or 0.17 Btu/(h·ft·°F) for this assembly with the thermal break element Schöck Isokorb® CM30 R0 H200. For the ψ value of a specific Schöck thermal break product, contact engineering-na@schoeck.com.

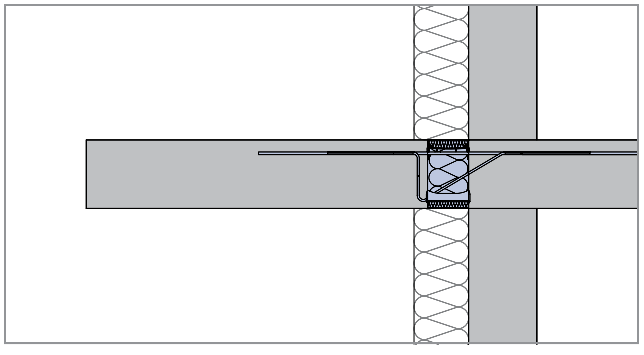

Figure 4: Assembly 2 – Balcony with thermal break element

The equivalent total U value ($U_{effective}$) is:

$$U_{effective\ 2} = 0.434\ \frac{W}{m^2 \cdot K} = 0.076\ \frac{Btu}{h \cdot ft^2 \cdot °F}$$

Result

The effect of using the thermal break element reduces the thermal heat loss through the thermal bridge by 73%. This number depends on many factors and can increase up to 90 %. For other construction details, the difference could be even higher. The reduction for steel construction is even more significant.

		Assembly 1 Balcony with thermal bridge	Assembly 2 Balcony with thermal break element
ψ value	[Btu/(h•ft•°F)]	0.630	0.170
	[W/(m•K)]	1.080	0.290
	difference (factor)	3.7	
	Percent improvement	73.0 %	
$U_{effective}$	[Btu/(h•ft²•°F)]	0.130	0.076
	[W/(m²•K)]	0.739	0.434
	difference (factor)	1.7	
	Percent improvement	41.5 %	

i A thermal break element reduces the thermal heat loss through the thermal bridge by 73%!

Why a simple R-value calculation is not accurate

The below example exemplifies why calculating an R-value for a thermal bridge does not adequately capture the true impact of a thermal bridge. The calculation of an R value is technically very simple. It´s the thickness, t, of a material divided by the thermal conductivity, k:

$$R = \frac{t}{k}$$

For Assembly 1, the R value for the thermal bridge is:

$$R_1 = \frac{0.3\ \text{m}}{2.3\ \text{W/(m•K)}} = 0.130\ \frac{\text{m}^2\text{•K}}{\text{W}} = 0.738\ \frac{\text{h•ft}^2\text{•°F}}{\text{Btu}}$$

For Assembly 2, the R value for the thermal bridge is:

$$R_2 = \frac{0.22\ \text{m}}{2.3\ \text{W/(m•K)}} + \frac{0.08\ \text{m}}{0.204\ \text{W/(m•K)}} = 0.488\ \frac{\text{m}^2\text{•K}}{\text{W}} = 2.771\ \frac{\text{h•ft}^2\text{•°F}}{\text{Btu}}$$

Next, calculate a theoretical R value out of the ψ value which has been calculated previously.

Rearrange the ψ value into a theoretic R value ($R_{theoretic}$) with h = height of the thermal bridge = 0.2 m (8"):

$$R_{theoretic} = \frac{h}{\psi}$$

For Assembly 1 (without thermal break):

$$R_{theoretic\ 1} = 0.185\ \frac{m^2 \cdot K}{W} = 1.050\ \frac{h \cdot ft^2 \cdot °F}{Btu}$$

For Assembly 2 (with Schöck Isokorb®):

$$R_{theoretic\ 2} = 0.683\ \frac{m^2 \cdot K}{W} = 3.876\ \frac{h \cdot ft^2 \cdot °F}{Btu}$$

	$R_{theoretic}$		traditional R value (wrong Method)	
	[(h•ft²•°F)/Btu]	[(m²•K)/W]	[(h•ft²•°F)/Btu]	[(m²•K)/W]
Assembly 1 Balcony with thermal bridge	1.050	0.185	0.738	0.130
Assembly 2 Balcony with thermal break element	3.876	0.683	2.771	0.488
Percent deviation between the calculation methods	~ 30 %			

Comparing the calculation methods, the R values differ up to 30 %. The traditional R value is much lower compared to the detailed method ($R_{theoretic}$) based on the modeled ψ value. This emphasizes the importance of considering the ψ value when calculating thermal performance.

i The thermal performance of a structural thermal break is not captured by using a simplified R-value.

Summary

- The thermal impact at thermal bridges is dependent on many parameters and should be modeled with Finite Elemente (FE) or Finite Difference (FD) software.
- The thermal performance of a structural thermal break is not captured by using a simplified R-value. The ψ value should instead be considered.
- The use of thermal break elements reduces heat loss significantly at structural penetrations through the building envelope.

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