THERMAL BRIDGES
TO AMBIENT AIR
Calculation documentation
for Passive House
Building Certification

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Building certification → Examples of documents that need to be submitted for certification

A thermal bridge is a localised area of the building envelope where the heat flow is different (usually increased) in comparison with adjacent areas (if there is a difference in temperature between the inside and the outside).

Thermal bridges are especially relevant in cool temperate and colder climates. Here the effects are altered, usually decreased, interior surface temperatures (in the worst case this can lead to moisture accumulation in building components and mould growth) and altered, usually increased, heat losses. Therefore, it is extremely important to take thermal bridges into account during the energy balance study.
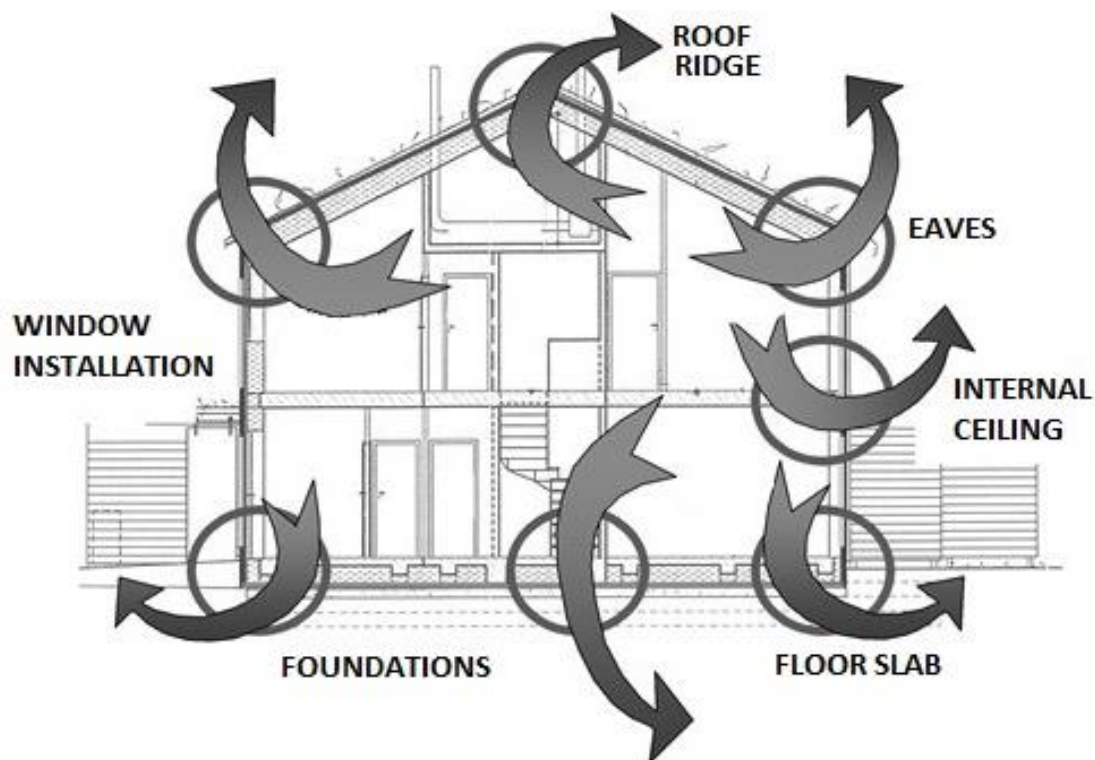
Two strategies can be used towards thermal bridges:

- considering just the ones with a linear transmittance Ψ greater than 0.01 W/(mK);
- considering all of them

There are several heat flow calculation software programs on the market. Any of those can be used for calculating thermal bridges for Building Certification. The drawing of the architectural detail and the assumption for internal/external temperatures and the interior/exterior thermal resistance used in the simulation has to be conform to the norm ISO 10211: 2007, though.

NOTE! **PHPP conventions must be respected; therefore, calculations should refer to external dimensions of the building.**

For Building Certification a report of every calculation must be submitted. It must contain:

1. a section drawing of the building in which the connection studied is marked;
2. a detail drawing with indication of the different materials and their conductivities and dimensions;
3. PHPP U-value calculation of the components involved;
4. boundary conditions used as input in the software (interior and exterior temperature, T_i and T_e ; interior and exterior thermal resistance, R_{si} and R_{se});
5. a drawing with isothermal lines as output from the software used;
6. results as output from the software (Ψ-value, if it is given, or other values e.g. heat flow though the connection, which will be used to calculate the Ψ-value);
7. calculation of Ψ (or χ) value:

$$\Psi = \frac{\phi_{2D} - \phi_{1D}}{\Delta T}$$

ϕ_{2D} is the real heat transfer rate per unit length [W/m] in the disturbed connection, calculated through the heat-flow software.
ϕ_{1D} is the theoretical heat transfer rate per unit length [W/m] in the undisturbed connection, calculated just through the evaluation of the lengths and the U-value of the components.
ΔT is the temperature difference between the two spaces to which the components are exposed.

8. minimal interior surface temperature and f_{Rsi} factor.
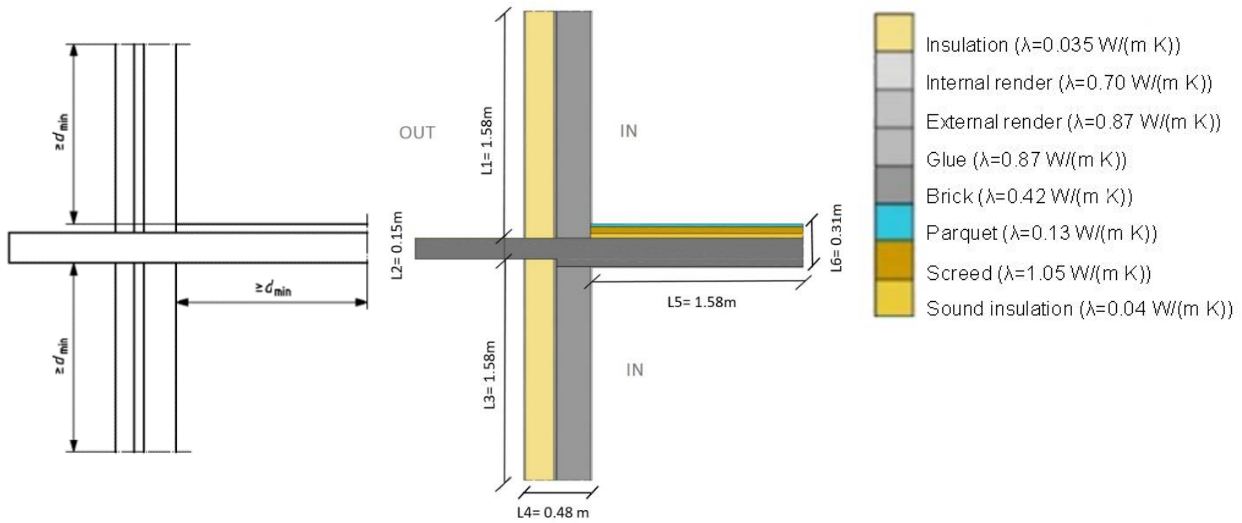
EXAMPLE: Balcony connection

1. A section drawing of the building in which the connection studied is marked
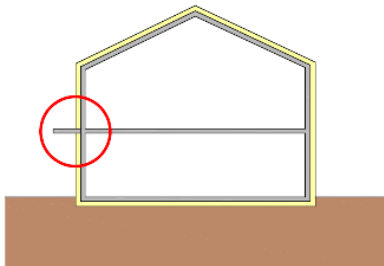
2. A detail drawing with indication of the different materials and their conductivities and dimensions

The norm ISO 10211:2007 states that the length of the flanking components should be the maximum between 1 m and three times the thickness of the component itself (d_{min}).

In this example, d_{min} should be the maximum between 1 m and three times **L4** (0.48 m*3 = 1.44 m). The length used for the flanking component is L1=L3=L5= 1.58 m. The total length of the wall is 3.31 m (L1 + L2 + L3).

3. PHPP U-value calculation of the adjacent constructions

In many heat-flow software the U-value is calculated automatically once the layers of the components are entered.

***NOTE!* Coherency needed between the U-value of the component entered in PHPP and the one used in the software.**

4. Boundary conditions used as input in the software

For the Ψ -value calculation, it does not matter which temperatures are set for the inside and outside as long as there is a temperature decline due to the building component, because the conductances are independent of the assumed boundary conditions for the temperatures.

For the f_{Rsi} factor calculation, conventionally, the following temperatures are used in the context of Component Certification in Passive House Institute:

$T_i = 20°C$, $T_e = -10°C$

$\Delta T = 20 - (-10) = 30$ K

In this example, the same temperature conditions are set for the psi-value and fRsi-factor calculation.

The internal and external thermal resistances should be defined according to the norm ISO 10211: 2007. In this example, interior and exterior thermal resistance are:

$R_{si} = 0.13$ (m²K)/W
$R_{se} = 0.04$ (m²K)/W

NOTE! **Be careful to enter the surface heat transmission resistances correctly in the simulation software. In some programs, the reverse of the thermal resistance must be entered. Always check the units displayed next to the value to enter.**

5. A drawing with isothermal lines as output from the software used
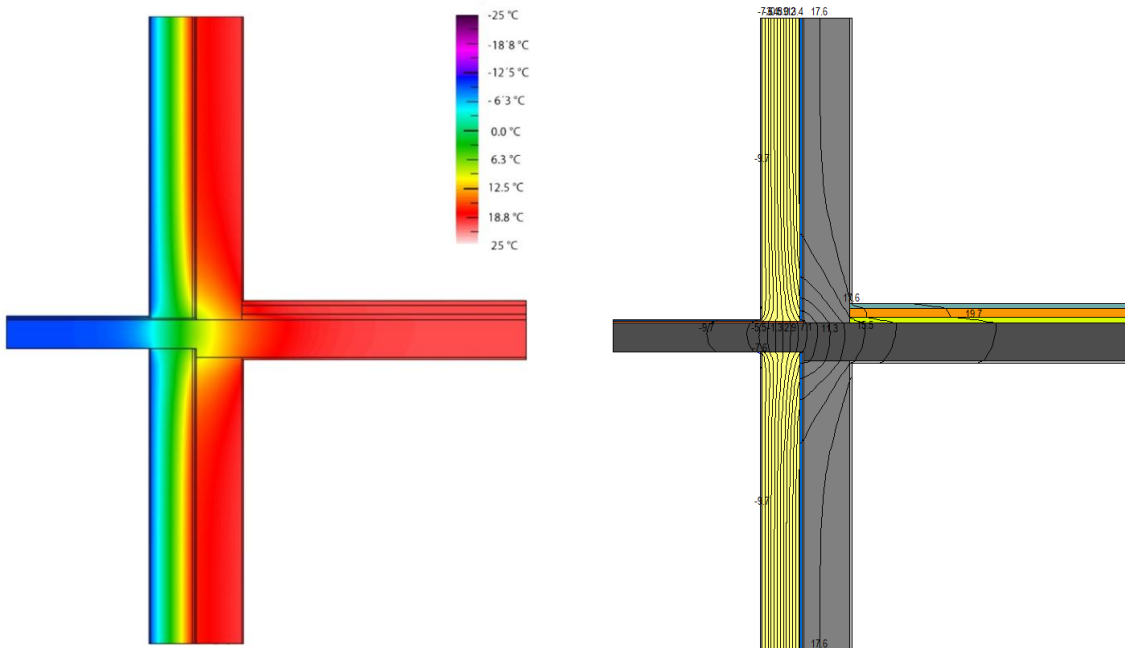
6. Results as output from the software

	U-factor W/m2-K	delta T C	Length mm	Rotation			Heat Flow W	Heat Flux W/m2
Exterior	0.3143	30.0	3310	N/A	Projected Y	▼	31.2070	9.4281
Interior	0.3467	30.0	3000.01	N/A	Projected Y	▼	31.2066	10.4022

Display
○ U-factor
○ R-value

% Error Energy Norm 6.45%

Export

OK

7. Calculation of Ψ-value

The thermal bridge is evaluated subtracting the length multiplied for the U-value of the component from the heat flow passing through the connection as given from the software simulation.

If THERM software is used, remember to refer to the exterior dimensions.

In this example:

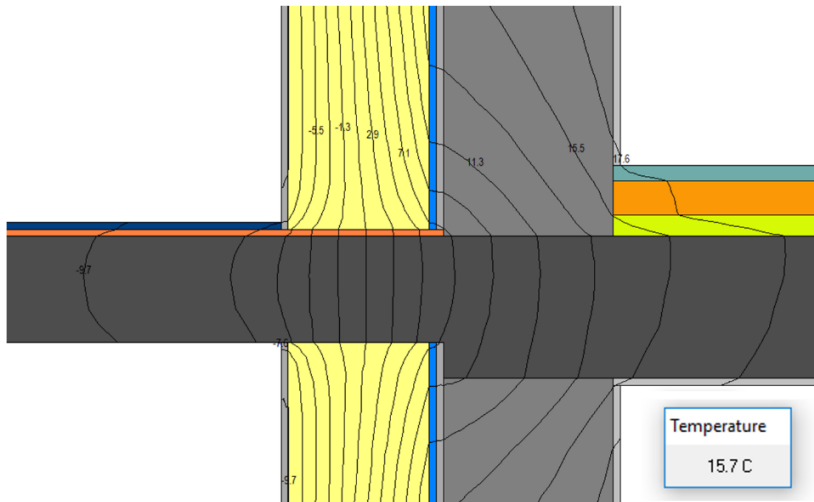$$\Psi = \frac{\phi_{2D} - \phi_{1D}}{\Delta T} = Ufactor * length - Uvalue * length$$

$$\Psi = 0.31 \frac{W}{m^2 K} * 3.31 \, m - 0.15 \frac{W}{m^2 K} * 3.31 \, \mathrm{m} = 0.53 \frac{W}{m\,K}$$

> **NOTE:** A punctual thermal bridge is a disturbance of the heat flow that is defined by a χ -value [W/K]:
>
> $$\chi = \frac{\phi'_{2D} - \phi'_{1D}}{\Delta T}$$
>
> The two quantities ϕ'_{2D} [W] and ϕ'_{1D} [W] (heat transfer rate) will be defined by the software used for the calculation.

8. Minimal interior surface temperature and f_{Rsi} factor

Temperature
15.7 C

The minimal interior surface temperature is determined through another simulation. This one will be identical to the first one, except from the fact that the surface internal resistance is 0.25 (m²K)/W for all the internal surfaces.

$$f_{Rsi} = \frac{T_{si} - T_e}{T_i - T_e} = \frac{15.7 - (-10)}{20 - (-10)} = 0.86 = 86\%$$