

1. Introduction

For a roof junction construction detail the linear thermal transmittance and the point thermal transmittance are derived, for both the internal and the external dimension system, using the programs BISCO and TRISCO. Also the 3D temperature course is derived allowing a surface condensation risk evaluation.

2. Linear thermal transmittance

TRISCO data [roof junction T ext dim.trc](#) ; [roof junction T int dim.trc](#)
BISCO data [roof junction B ext dim.bsc](#) ; [roof junction B int dim.bsc](#)

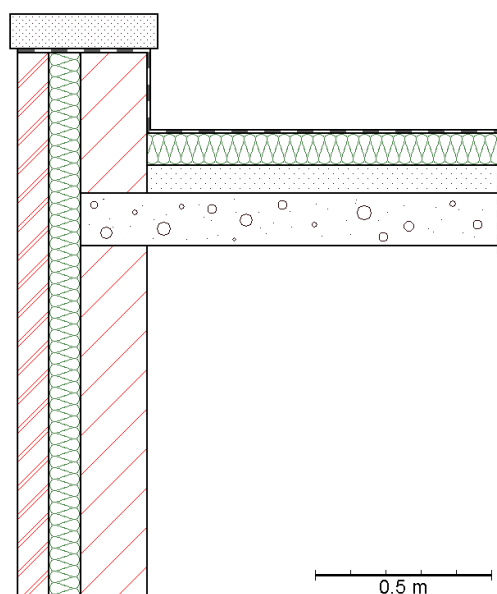


Figure 1: roof junction vertical section

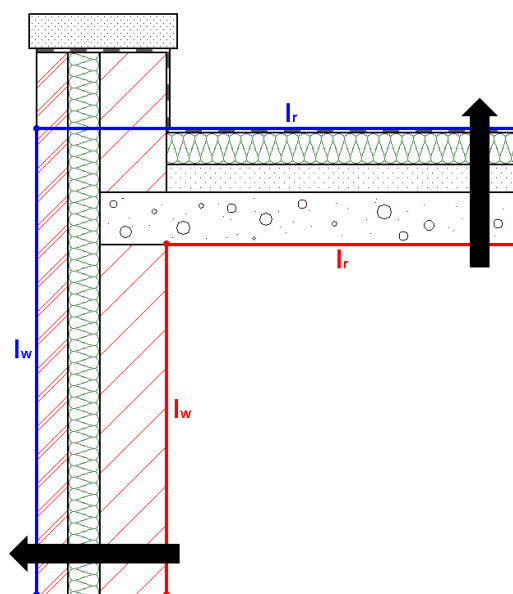


Figure 2: 1D reference dimensions

Figure 1 shows the roof junction vertical section. The linear thermal transmittance ψ of the junction is a quantity describing the influence of a linear thermal bridge on the total heat flow. It is defined as the supplementary heat flow rate compared to the heat flow rate through an almost fictive situation without thermal bridge, in which only 1D heat flows occur.

Therefore the ψ -value can be calculated from:

$$\psi = L^{2D} - U_w l_w - U_r l_r \quad L^{2D} = \frac{Q^{2D}}{\Delta\theta_{ie}}$$

ψ	linear thermal transmittance [W/mK]
L^{2D}	thermal coupling coefficient [W/mK]
Q^{2D}	total simulated heat loss [W/m]
$\Delta\theta_{ie}$	indoor-outdoor temperature difference [K]
U_w	thermal transmittance of the wall [W/m ² K]
l_w	height of the wall [m]
U_r	thermal transmittance of the roof [W/m ² K]
l_r	width of the roof [m]

This formula doesn't allow the ψ -value calculation without a clear definition of the height of the wall and the width of the roof. These flanking element dimensions can be defined in different ways. Figure 2 shows 2 practical possibilities: the external dimension system (blue coloured dimensions) and the internal dimension system (red coloured dimensions). Most national or regional thermal building regulations impose a system¹.

Strictly spoken the choice of a dimension system isn't of importance when calculating the total transmission heat transfer coefficient of a building. In spite of the dimension system used, an identical total transmission heat transfer coefficient H_t should be obtained.

Indeed H_t is calculated using the formula:

$$H_t = \sum_i U_i S_i + \sum_j \psi_j L_j + \sum_k \chi_k$$

H_t	total transmission heat transfer coefficient [W/K]
U_i	thermal transmittance of element i of the building envelope [W/m ² K]
S_i	area of element i of the building envelope [m ²]
ψ_j	linear thermal transmittance of thermal bridge j [W/mK]
L_j	length of thermal bridge j [m]
χ_k	point thermal transmittance of point thermal bridge [W/K]

In case of the external dimension system larger areas S and lower ψ -values occur compared to the case of the internal dimension system with smaller areas S and higher ψ -values. When the dimension system is consistently applied an identical H_t -value is obtained.

A point of interest is the length of the flanking elements to be considered in the numerical simulation. The right and bottom border are considered as adiabatic in the simulations. It can be shown that the ψ -value is independent on the length of the flanking elements if the 2D heat transfer effect is extinct at the flanking element borders. According to EN ISO 10211, a flanking element length of 1 m shall be considered here. For most construction details the length of 1 m is sufficient, but larger lengths are recommended in case of high conductivity materials (metals) and in case of low U -values.

¹ For example: internal dimensions in France, The Netherlands and in the United Kingdom, external dimensions in Belgium and in Germany.

The TRISCO data [roof_junction T ext dim.trc](#) and the BISCO data [roof_junction B ext dim.bsc](#) show the simulation procedure for the ψ -value calculations using external dimensions.

The TRISCO data [roof_junction T int dim.trc](#) and the BISCO data [roof_junction B int dim.bsc](#) show the simulation procedure for the ψ -value calculations using internal dimensions.

Material properties according to EN ISO 10456 were defined. The surface heat transfer coefficients were defined according to EN 6946.

Figure 3 shows the graphic results (isotherms and heat flow lines). These results of course are identical for four data sets mentioned.

The following ψ -values are obtained.

$$\psi_e = 16.036 / 20 - 0.291 \times 1.33 - 0.256 \times 1.37 = \mathbf{0.064 \text{ W/mK}}$$

$$\psi_i = 16.036 / 20 - 0.291 \times 1.00 - 0.256 \times 1.00 = \mathbf{0.255 \text{ W/mK}}$$

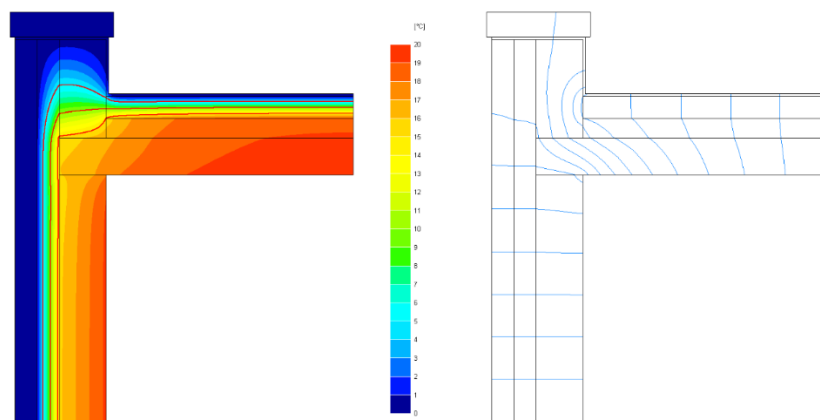


Figure 3: isotherms (line increment 5 °C, colour increment 1 °C) and heat flow lines (increment 1 W/m)

3. Point thermal transmittance

TRISCO data [roof_junction T ext dim 3D.trc](#) ; [roof_junction T int dim 3D.trc](#)

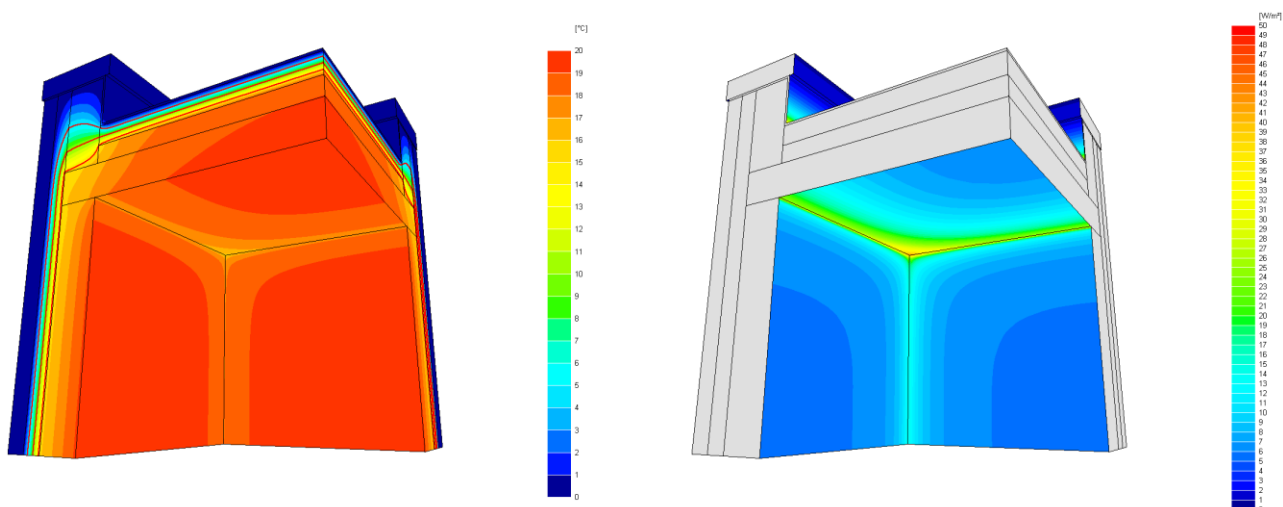


Figure 4: isotherms (line increment 5 °C, colour increment 1 °C) and heat flow densities

At the intersection of 2 roof junctions, a supplementary 3D thermal bridge effect occurs. The graphic results of a 3D simulation (Figure 4) show some lower surface temperatures and higher heat flow density in the 3D corner. The supplementary 3D effect can be characterised by a point thermal transmittance or χ -value. The χ -value can be derived using both the external and the internal dimension system.

It should be notified that the 3D data easily can be created from the 2D data by using the “revolve” function (Blocks → Revolve 90°...).

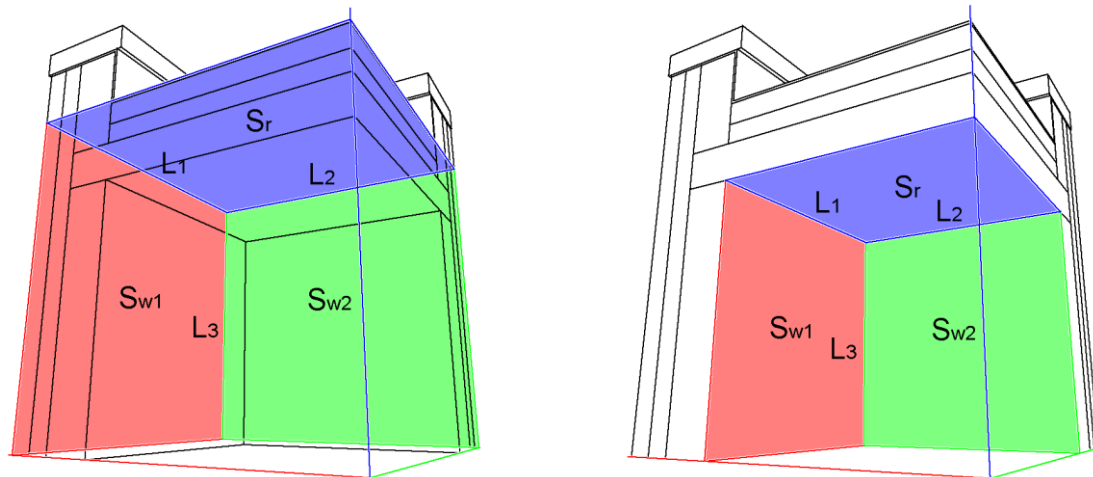


Figure 5: external (left) and internal (right) dimension system

$$\chi = L^{3D} - U_w S_{w1} - U_w S_{w2} - U_r S_r - \psi_1 L_1 - \psi_2 L_2 - \psi_3 L_3 \quad L^{3D} = \frac{Q^{3D}}{\Delta\theta_{ie}}$$

χ	point thermal transmittance [W/K]
L^{3D}	thermal coupling coefficient [W/mK]
U_w	thermal transmittance of the wall [W/m ² K]
S_{w1}	area of the left wall [m ²]
S_{w2}	area of the right wall [m ²]
ψ_1	linear thermal transmittance of the left roof junction [W/mK]
L_1	length of the left roof junction [m]
ψ_2	linear thermal transmittance of the right roof junction [W/mK]
L_2	length of the right roof junction [m]
ψ_3	linear thermal transmittance of the wall corner [W/mK]
L_3	length of the wall corner [m]

The calculation of the χ -value requires the calculation of the linear thermal transmittance of the wall junction first. Using the data [wall corner T ext dim.trc](#) and [wall corner T int dim.trc](#) this ψ -value is derived using respectively external and internal dimensions. One found:

$$\psi_{3e} = -0.129 \text{ W/mK}$$

$$\psi_{3i} = 0.087 \text{ W/mK}$$

Now the χ -value can be derived.

$$\chi_e = 29.198 / 20 - 0.291 \times 1.8221 - 0.291 \times 1.8221 - 0.256 \times 1.8769 - 0.064 \times 1.37 - 0.064 \times 1.37 - (-0.129) \times 1.33$$

$$\chi_e = -0.085 \text{ W/K}$$

$$\chi_i = 29.198 / 20 - 0.291 \times 1.00 - 0.291 \times 1.00 - 0.256 \times 1.00 - 0.255 \times 1.00 - 0.255 \times 1.37 - 0.087 \times$$

1.00

$\chi_i = 0.025 \text{ W/K}$

4. Surface condensation risk evaluation

TRISCO data [roof_junction_T_3D_condensation_risk.trc](#)

The 3D temperature course as calculated above (Figure 4) is obtained using internal heat transfer coefficients $h_i = 7.7 \text{ W/m}^2\text{K}$ (wall) and $h_i = 10 \text{ W/m}^2\text{K}$ (roof) in accordance to EN 6946.

According to EN ISO 13788, an internal surface heat transfer coefficient $h_i = 4 \text{ W/m}^2\text{K}$ shall be used for the assessment of surface condensation and mould growth.

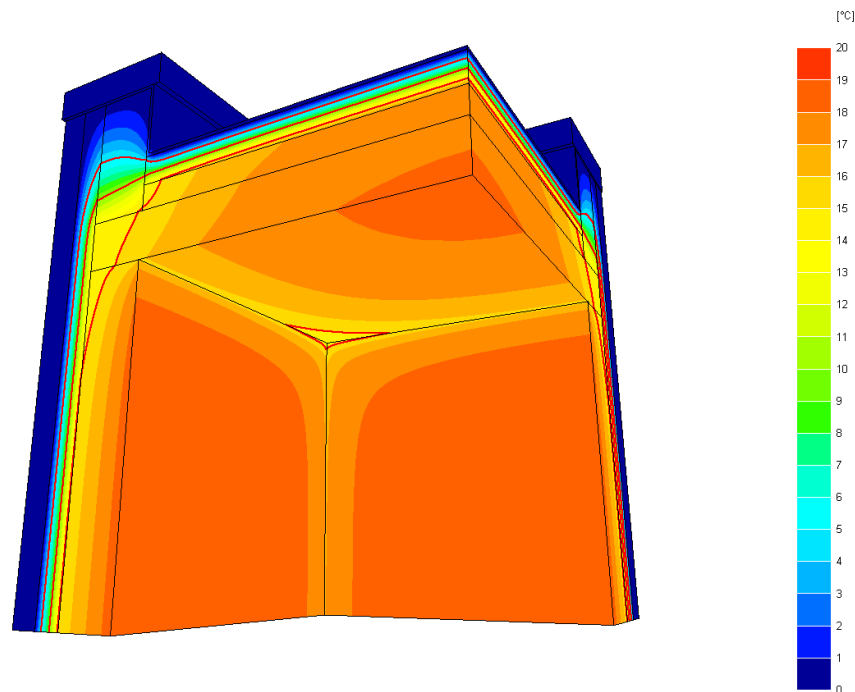


Figure 6: isotherms (line increment 5 °C, colour increment 1 °C)

Figure 6 shows the temperature distribution obtained using $h_i = 4 \text{ W/m}^2\text{K}$. The lowest surface temperature is 13.68 °C. Therefore the temperature factor is $f_{hi=4} = 0.684$.

The assessment of surface condensation or mould growth needs a further analysis of the indoor air humidity. Typical building regulations however require a minimum value for the temperature factor, which avoids this further analysis. A typical minimum requirement for dwellings is $f_{hi=4} > 0.7$. For the example given this requirement isn't fulfilled.

References

- **EN ISO 10211:** 2017 Thermal bridges in building construction - Heat flows and surface temperatures - Detailed calculations
- **EN ISO 10456:** 2007 Building materials and products -Hygrothermal properties
- **EN ISO 6946:** 2017 Building components and building elements – Thermal resistance and thermal transmittance - Calculation method
- **EN ISO 13788:** 2012 Hygrothermal performance of building components and building elements - Internal surface temperature to avoid critical surface humidity and interstitial condensation – Calculation methods