THERMAL BRIDGE HEAT LOSS ANALYSIS IN CASE OF 3 ENVIRONMENTS

1. Introduction

The heat loss through a thermal bridge between 2 environments (typically indoors and outdoors) can be described using a single linear thermal transmittance (ψ-value).

For a thermal bridge between 3 environments at different temperatures (e.g. indoors, outdoors and attic), 3 ψ-values are required. The procedure from Annex E of EN ISO 10211[1], is applied for a sample thermal bridge.

2. Sample thermal bridge

BISCO data node_3_env_calc1.bsc, node_3_env_calc2.bsc, node_3_env_calc3.bsc
TRISCO data node_3_env_calc1.trc, node_3_env_calc2.trc, node_3_env_calc3.trc

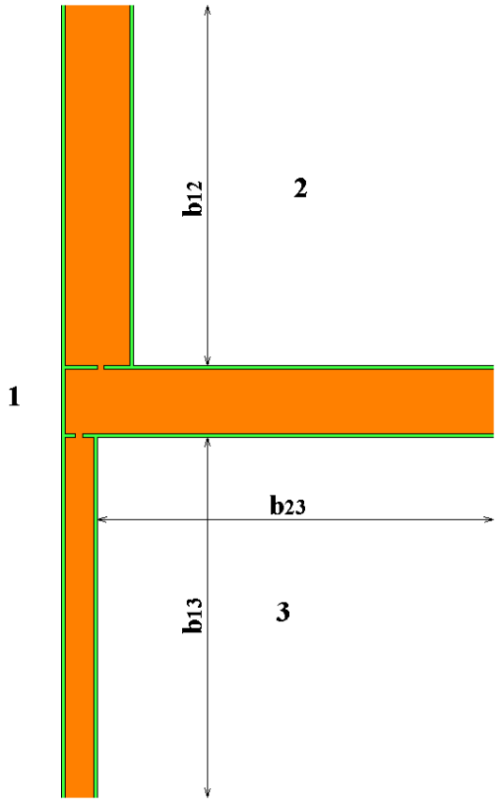

Figure 1. Section of a construction node between 3 environments.

Figure 1 shows a construction node between 3 environments. The thermal insulation (λ = 0.030 W/mK; d = 180 mm at the top and right, d = 80 mm at the bottom) is covered by a finishing material (λ = 1 W/mK, d = 10 mm). The flanking element lengths are $b_{12} = b_{13}$ = 1 m and b_{23} = 1.1 m.

At the surface of environment 1 a surface heat transfer h_1 = 25 W/m²K is assumed, while at the other surfaces $h_2 = h_3$ = 7.7 W/m²K is assumed.

The thermal transmittance values of the walls are U_{12} = 0.162 W/m²K, U_{23} = 0.159 W/m²K and U_{13} = 0.350 W/m²K.

3 thermal simulations are required to derive the thermal coupling coefficients L:

1) θ_1 = 1 °C θ_2 = 0 °C θ_3 = 0 °C
to derive $L_1 = L_{12} + L_{13}$

2) θ_1 = 0 °C θ_2 = 1 °C θ_3 = 0 °C
to derive $L_2 = L_{12} + L_{23}$

3) θ_1 = 0 °C θ_2 = 0 °C θ_3 = 1 °C
to derive $L_3 = L_{13} + L_{23}$

[1] EN ISO 10211:2017 Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations ; Annex E – Determination of values of thermal coupling coefficient and temperature weighting factor for more than two boundary temperatures

From each thermal coupling coefficient L_{ij} the linear thermal transmittance ψ_{ij} can now be derived:

$$\psi_{ij} = L_{ij} - U_{ij} b_{ij}$$

ψ_{ij} linear thermal transmittance between environments i and j [W/mK]
L_{ij} thermal coupling coefficient between environments i and j [W/mK]
U_{ij} thermal transmittance of the wall between environments i and j [W/m^{2}K]
b_{ij} flanking element length of the wall between environments i and j [m].

Table 1 shows the ψ-values derived.

	1-2	2-3	1-3
Thermal coupling coefficients L (results of 2D/3D simulation)	0,193	0,168	0,400
Thermal transmittances U	0,162	0,159	0,350
Widths b	1,000	1,100	1,000
Linear thermal transmittance ψ	0,0308	-0,0069	0,0498

Table 1. Linear thermal transmittance calculation
(Calculator_L_psi_3_environments.xlsx)

3. Discussion

Between an environment i with a temperature θ_i and an environment j with a temperature θ_j the heat transfer can now be calculated using the formula:

$$Q_{ij} = (U_{ij} S_{ij} + \psi_{ij} \ell_{ij}) \Delta\theta_{ij}$$

Q_{ij} heat loss between environments i and j [W]
U_{ij} thermal transmittance of the wall between environments i and j [W/m^{2}K]
S_{ij} surface of the wall between environments i and j [m^2]
ψ_{ij} linear thermal transmittance of the node between environments i and j [W/mK]
l_{ij} length of the node between environments i and j [m]
$\Delta\theta_{ij}$ temperature difference between environments i and j [K].

In this calculation it is important that the same dimension system is used as in the ψ-value calculations. In the case study above, internal dimensions were used (assuming environment 1 as outdoors); also special attention needs to be given to the definition of the length b_{23} in Figure 1.

The procedure for deriving 3 ψ-values is somewhat cumbersome and in practical cases it will be much easier to consider as much as possible 2 environmental temperatures only. 2 examples where such a simplified approach is justified:

- For a construction detail between an unheated attic, indoors and outdoors with a relatively good thermal insulation between attic and indoors, the attic temperature can be assumed to be equal to the outdoors temperature.
- For a construction detail between a ventilated underfloor space, indoors and outdoors, the underfloor space temperature can be assumed to be equal to the outdoors temperature.