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1. Introduction

To calculate the thermal transmittance of a floor on ground U_g , EN ISO 13370 allows several methods:

1. a 3D numerical method as used for thermal bridges according to EN ISO 10211
2. a 2D numerical method, using a floor that is infinitely long and has a width equal to the characteristic dimension of the floor.
3. a simplified method as described in the standard.

To calculate the linear thermal transmittance of a wall/floor junction ψ_g only the 2D and the 3D numerical methods are applicable.

A case study shows the use of these methods.

2. Case study data

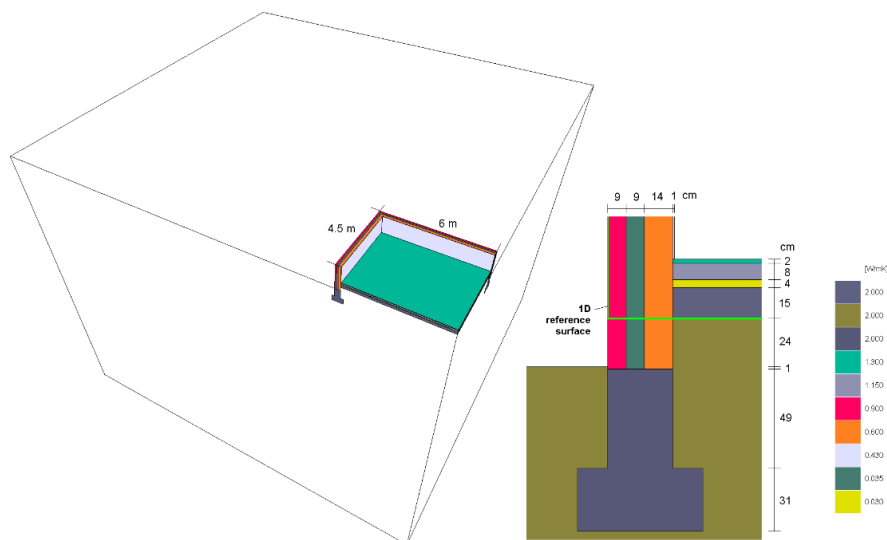


Figure 1: case study data

A building with external dimensions length 12 m ($c = 12$ m) and width 9 m ($b = 9$ m) is considered.

Because of symmetry it is sufficient to consider a quarter of the building.

Figure 1 shows the geometrical data and the thermal conductivities of the materials.

The boundary conditions are:

- Outdoors: temperature $\theta_e = 0$ °C, surface heat transfer coefficient = 25 W/m²K,

- Indoors: temperature $\theta_i = 20\text{ °C}$, wall surface heat transfer coefficient = $7.7\text{ W/m}^2\text{K}$,
floor surface heat transfer coefficient = $5.9\text{ W/m}^2\text{K}$.

The calculation of the foundation linear thermal transmittance will be based on the 1D reference surface specified in Figure 1 (**external dimensions**).

3. 3D numerical method

TRISCO data [foundation_psi_3D_TR0.trc](#) ; [foundation_psi_3D_TR1.trc](#)

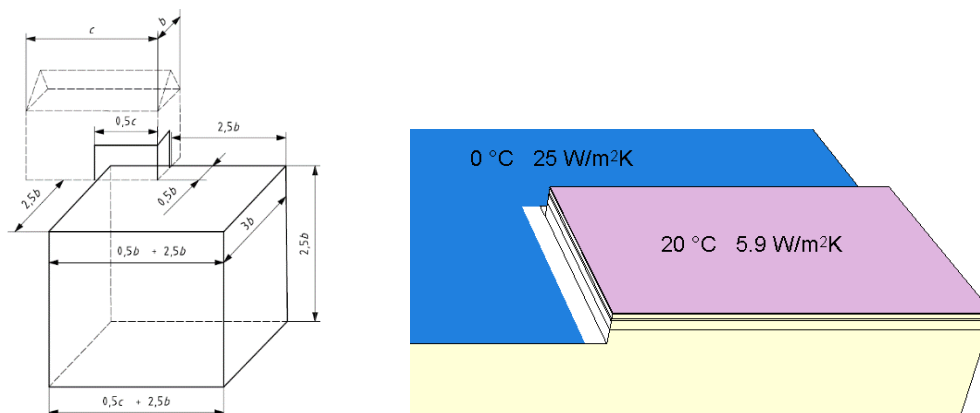


Figure 2 (left): 3D geometrical modelling rules according to EN ISO 10211
Figure 3 (right) : Boundary conditions used to derive the thermal transmittance U_g

Thermal transmittance of the floor U_g .

Figure 2 shows the 3D geometrical modelling rules according to EN ISO 10211. To derive the thermal transmittance of the floor U_g , the wall is replaced by an adiabatic condition and the foundation is replaced by ground as shown in Figure 3 and simulated in 3D (TRISCO data [foundation_psi_3D_TR0.trc](#)). The U_g -value is derived directly from the TRISCO results (Table 2) and also in the spreadsheet shown in Table 1 ([floor_U_psi_values.xlsx](#)) using the formulas listed in that table.

Linear thermal transmittance of the wall/floor junction ψ_g .

To derive the linear thermal transmittance of the wall/floor junction ψ_g , a second simulation of the complete model is required (TRISCO data [foundation_psi_3D_TR1.trc](#)).

The linear thermal transmittance ψ_g can be derived in TRISCO by dividing the 3D surplus thermal transmittance ($dL = L_{3D} - U_w S_w - U_g S_g = 0.581\text{ W/K}$) by the length of the thermal bridge ($c/2 + b/2 = 10.5\text{ m}$): $\psi_g = 0.055\text{ W/mK}$ (Table 3). The thermal transmittance U_g obtained above is defined in TRISCO as an enforced U-value. The ψ_g -value is derived also in the spreadsheet shown in Table 1 (spreadsheet [floor_U_psi_values.xlsx](#)).

Figure 4 and Figure 5 show the graphic results (isotherms) of both simulations.

Complete thermal transmittance of the floor U'_g .

It is possible to derive the complete thermal transmittance of the floor U'_g that includes the thermal bridge effects, using one single simulation (TRISCO data [foundation_psi_3D_TR1.trc](#), Table 3). The U'_g -value is derived directly in TRISCO and also in the spreadsheet shown in Table 1.

3D method	Q_{3D} [W]	$\Delta\theta_{ie}$ [K]	L_{3D} [W/K]	$c/2$ [m]	$b/2$ [m]	S_g [m ²]	U_g [W/m ² K]
foundation_psi_3D_TR0.trc	159.8	20.0	7.9900	6.000	4.500	27.000	0.296

	Q_{3D} [W]	$\Delta\theta_{ie}$ [K]	L_{3D} [W/K]	$c/2$ [m]	$b/2$ [m]	h [m]	S_g [m ²]	U_w [W/m ² K]	S_w [m ²]	U'_g [W/m ² K]	ψ_g [W/mK]
foundation_psi_3D_TR1.trc	258.9	20.0	12.9450	6.000	4.500	1.290	27.000	0.323	13.545	0.317	0.055

$$L_{3D} = \frac{Q_{3D}}{\Delta\theta_{ie}} \quad U_g = \frac{L_{3D}}{S_g} \quad U'_g = \frac{L_{3D} - U_w S_w}{S_g} \quad \psi_g = \frac{L_{3D} - U_w S_w - U_g S_g}{(c/2 + b/2)}$$

Table 1. Derivation of U_g , ψ_g and U'_g .

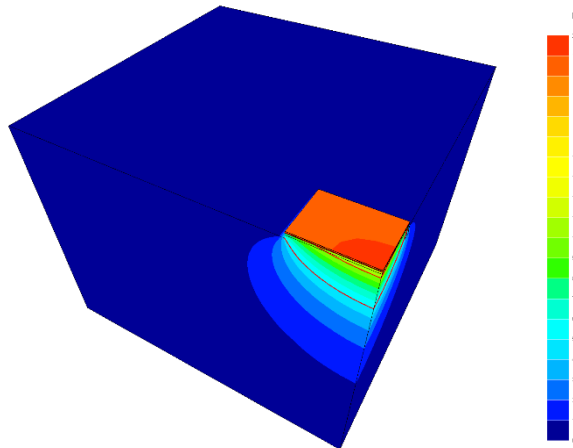


Figure 4
3D simulation without considering the junction:
isotherms

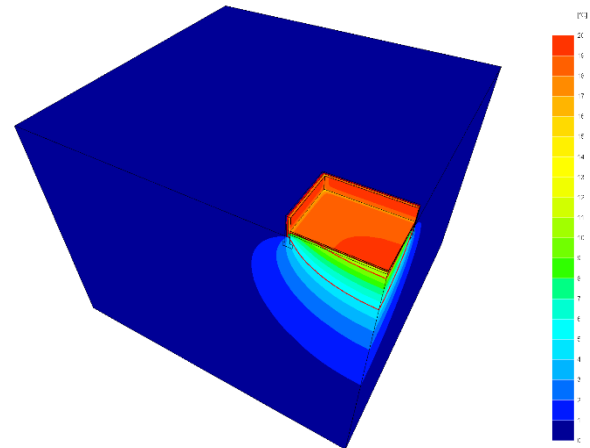


Figure 5
3D simulation for the complete 3D model:
isotherms

```

Ufloor = (Q/(ti-te))/A1 = 0.296 W/(m².K)
Q = 159.805 W
ti = 20.00°C
te = 0.00°C
A1 = 27 m²
Xmin=33 Xmax=78 Ymin=33 Ymax=78 Zmin=79 Zmax=79

```

```

2D/3D surplus thermal transmittance
dL = Q/(ti-te) - U1*A1 - U2*A2 - U3*A3 = 0.581 W/K
Q = 258.903 W
ti = 20.00°C
te = 0.00°C
U1 = 0.296 W/(m².K)
Xmin=78 Xmax=78 Ymin=78 Ymax=78 Zmin=0 Zmax=109
A1 = 27 m²
Xmin=33 Xmax=78 Ymin=33 Ymax=78 Zmin=79 Zmax=79
U2 = 0.323 W/(m².K)
Xmin=0 Xmax=78 Ymin=78 Ymax=78 Zmin=109 Zmax=109
A2 = 7.74001 m²
Xmin=33 Xmax=33 Ymin=33 Ymax=78 Zmin=79 Zmax=109
U3 = 0.323 W/(m².K)
Xmin=78 Xmax=78 Ymin=0 Ymax=78 Zmin=109 Zmax=109
A3 = 5.80501 m²
Xmin=33 Xmax=78 Ymin=33 Ymax=33 Zmin=79 Zmax=109

Ufloor = (Q/(ti-te) - U2*A2 - U3*A3)/A1 = 0.318 W/(m².K)
Q = 258.903 W
ti = 20.00°C
te = 0.00°C
A1 = 27 m²
Xmin=33 Xmax=78 Ymin=33 Ymax=78 Zmin=79 Zmax=79
U2 = 0.323 W/(m².K)
Xmin=0 Xmax=78 Ymin=78 Ymax=78 Zmin=109 Zmax=109
A2 = 7.74001 m²
Xmin=33 Xmax=33 Ymin=33 Ymax=78 Zmin=79 Zmax=109
U3 = 0.323 W/(m².K)
Xmin=78 Xmax=78 Ymin=0 Ymax=78 Zmin=109 Zmax=109
A3 = 5.80501 m²
Xmin=33 Xmax=78 Ymin=33 Ymax=33 Zmin=79 Zmax=109

```

Table 2. Derivation U_g in TRISCO
(text output [foundation_psi_3D_TR0.trc](#))

Table 3. Derivation of ψ_g and U'_g in TRISCO (text
output [foundation_psi_3D_TR1.trc](#))

4. 2D numerical method

TRISCO data [foundation_psi_2D_TR0.trc](#) ; [foundation_psi_2D_TR1.trc](#)

BISCO data [foundation_psi_BI0.bsc](#) ; [foundation_psi_BI1.bsc](#)

Trisco2D data [foundation_psi_no_wall.tr2](#) ; [foundation_psi_wall.tr2](#)

The 2D numerical method uses a floor that is infinitely long and has a width equal to the characteristic dimension of the floor B' , calculated as follows:

$$B' = \frac{S_g}{0.5P} = \frac{c \cdot b}{c + b} = 5.143 \text{ m}$$

Figure 6 shows the 2D geometrical modelling rules according to EN ISO 10211 (b in drawing is B' in formula above).

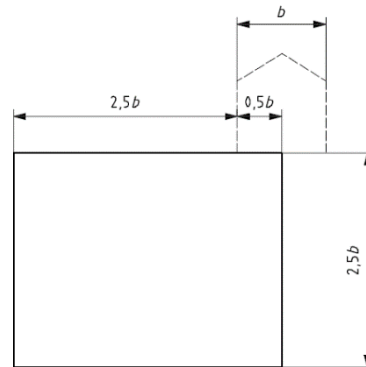


Figure 6: 2D geometrical modelling rules according to EN ISO 10211

Thermal transmittance of the floor U_g .

To derive the thermal transmittance of the floor U_g , the wall is replaced by an adiabatic condition and the foundation is replaced by ground and simulated in 2D (equivalent TRISCO or BISCO data mentioned above). The U_g -value is derived directly from the TRISCO (Table 5) or BISCO results and also in the spreadsheet shown in Table 4 ([floor U psi values.xlsx](#)) using the formulas listed in that table. The value $U_g = 0.307 \text{ W/m}^2\text{K}$ is close (slightly higher) than the method found using the 3D method, showing that the 2D method is a reliable.

Linear thermal transmittance of the wall/floor junction ψ_g .

To derive the linear thermal transmittance of a wall/floor junction ψ_g , a second simulation that considers the complete model is required (equivalent TRISCO or BISCO data mentioned above). The linear thermal transmittance ψ_g is derived in TRISCO (Table 6) or BISCO and in the spreadsheet shown in Table 4 (spreadsheet [floor U psi values.xlsx](#)). The thermal transmittance U_g obtained above is defined in TRISCO or BISCO as an enforced U-value. The ψ -value obtained is slightly higher than the one obtained by the 3D method. Figure 7 and Figure 8 show the graphic results (isotherms) of both simulations.

Complete thermal transmittance of the floor U'_g .

It is possible to derive the complete thermal transmittance of the floor U'_g that includes the thermal bridge effects, using one single simulation (Table 4 and Table 6).

2D method	Q_{2D} [W/m]	$\Delta\theta_{ie}$ [K]	L_{2D} [W/mK]	c [m]	b [m]	$B' (=2b_g)$ [m]	b_g [m]	U_g [W/m ² K]
foundation_psi_2D_TR0.trc	15.787	20.0	0.7894	12.000	9.000	5.143	2.57	0.307
foundation_psi_BI0.bsc								

	Q_{2D} [W/m]	$\Delta\theta_{ie}$ [K]	L_{2D} [W/mK]	b_g [m]	U_w [W/m ² K]	h_w [m]	U'_g [W/m ² K]	ψ_g [W/mK]
foundation_psi_2D_TR1.trc	25.555	20.0	1.2778	2.57	0.323	1.290	0.335	0.072
foundation_psi_BI1.bsc								

$$B' = \frac{S_g}{0.5P} = \frac{cb}{c+b} \quad L_{2D} = \frac{Q_{2D}}{\Delta\theta_{ie}} \quad U_g = \frac{L_{2D}}{b_g} \quad U'_g = \frac{L_{2D} - U_w h_w}{b_g} \quad \psi_g = L_{2D} - U_w h_w - U_g b_g$$

Table 4. Derivation of U_g , U'_g and ψ_g .

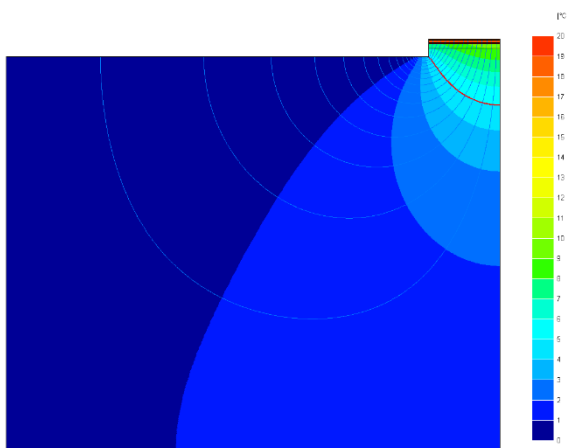


Figure 7

2D simulation without considering the junction:
isotherms and heat flow lines

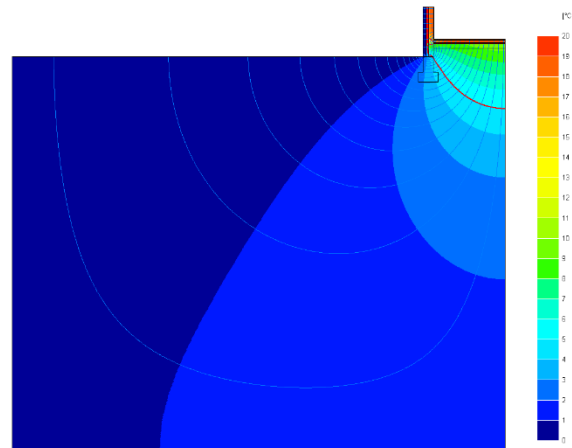


Figure 8

2D simulation for the complete 2D model:
isotherms and heat flow lines

```

Ufloor = (Q/(ti-te))/A1 = 0.307 W/(m2.K)
Q = 15.787 W
ti = 20.00°C
te = 0.00°C
A1 = 2.57 m2
Xmin=66 Xmax=146 Ymin=0 Ymax=1 Zmin=114 Zmax=114

```

```

Linear thermal transmittance (EN ISO 10211)
psi = (Q/(ti-te) - U1*A1 - U2*A2)/l = 0.072 W/(m.K)
Q = 25.555 W
ti = 20.00°C
te = 0.00°C
U1 = 0.307 W/(m2.K)
Xmin=0 Xmax=0 Ymin=0 Ymax=0 Zmin=0 Zmax=0
A1 = 2.57 m2
Xmin=66 Xmax=146 Ymin=0 Ymax=1 Zmin=132 Zmax=132
U2 = 0.323 W/(m2.K)
Xmin=0 Xmax=146 Ymin=1 Ymax=1 Zmin=188 Zmax=188
A2 = 1.29 m2
Xmin=66 Xmax=66 Ymin=0 Ymax=1 Zmin=132 Zmax=188
l = 1 m

Ufloor = (Q/(ti-te) - U2*A2)/A1 = 0.335 W/(m2.K)
Q = 25.555 W
ti = 20.00°C
te = 0.00°C
A1 = 2.57 m2
Xmin=66 Xmax=146 Ymin=0 Ymax=1 Zmin=132 Zmax=132
U2 = 0.323 W/(m2.K)
Xmin=0 Xmax=146 Ymin=1 Ymax=1 Zmin=188 Zmax=188
A2 = 1.29 m2
Xmin=66 Xmax=66 Ymin=0 Ymax=1 Zmin=132 Zmax=188

```

Table 5. Derivation U_g in TRISCO
(text output [foundation_psi_2D_TR0.trc](#))

Table 6. Derivation of ψ_g and U'_g in TRISCO
(text output [foundation_psi_2D_TR1.trc](#))

5. Simplified method

spreadsheet [floor_U_psi_values.xlsx](#)

The simplified method calculates U_g as follows:

1) Calculation of the characteristic dimension of the floor B' ,

$$B' = \frac{S_g}{0.5P} = \frac{c \cdot b}{c + b} = 5.143 \text{ m}$$

2) calculation of the total equivalent thickness

$$d_t = w + \lambda(R_{si} + R_f + R_{se})$$

w	[m]	total thickness of the wall
λ	[W/mK]	soil thermal conductivity
R_{si}	[m ² K/W]	internal surface resistance
R_f	[m ² K/W]	floor slab resistance
R_{se}	[m ² K/W]	external surface resistance

$d_t = 3.736 \text{ m}$

3) calculation of the floor thermal transmittance U_g

$$\text{if } d_t < B' \quad U_g = \frac{2\lambda}{\pi B' + d_t} \ln\left(\frac{\pi B'}{d_t} + 1\right)$$

$$\text{if } d_t \geq B' \quad U_g = \frac{\lambda}{0.457 B' + d_t}$$

$$U_g = 0.336 \text{ W/m}^2\text{K}.$$

No simplified method is available to calculate the linear thermal transmittance of the wall/floor junction.

6. Comparison of analytical, 2D and 3D method

The most detailed approach is the 3D numerical simulation.

The 2D numerical approach is a good estimation and results in a somewhat higher value of U_g and ψ_g .

The analytical approach allows only to calculate a conservative value of U_g .

	U_g [W/m ² K]	U'_g [W/m ² K]	ψ_g [W/mK]
3D method	0.296	0.317	0.055
2D method	0.307	0.335	0.072
analytical method	0.336	/	/

Table 7. Comparison of analytical method, 2D numerical method and 3D numerical method

7. References

EN ISO 13370:2017 *Thermal performance of buildings — Heat transfer via the ground — Calculation methods*

EN ISO 10211:2017 *Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations*