THE THERMAL TRANSMITTANCE OF MASONRY ACCORDING TO EN 1745

1. Introduction

Some examples are given showing how to calculate the thermal transmittance of masonry according to the standard EN 1745. The examples were prepared using the programs BISCO, TRISCO and SOLIDO.

2. Example 1

BISCO data brick_vertical_joint.bsc and brick_vertical_joint_clustered.bsc

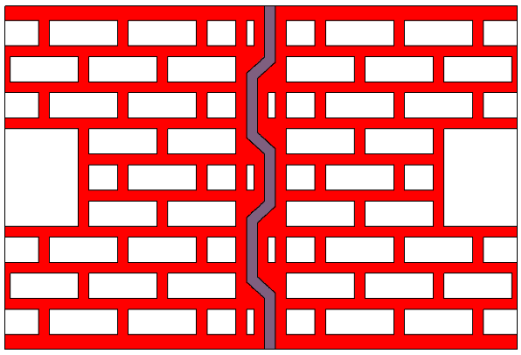

Figure 1. Example 1

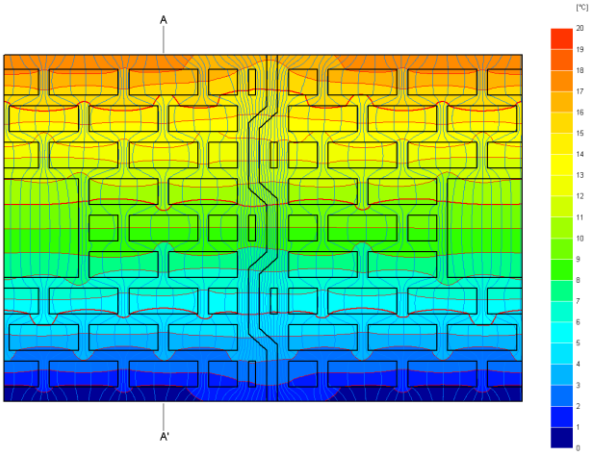

Figure 2. Results obtained by BISCO

A masonry unit with a vertical joint is shown in Figure 1.
The thermal conductivity of the fired clay is 0.8 W/mK; the one of the mortar is 1.0 W/mK.
At the external side the temperature is 0°C, with a surface heat transfer coefficient h_e = 25 W/m^{2}K.
At the internal side the temperature is 20°C, with a surface heat transfer coefficient h_e = 7.7 W/m^{2}K.
The equivalent thermal conductivity of the air cavities is calculated according to EN ISO 6946.
Figure 2 shows isotherms and heat flow lines (increment 0.1) obtained with the program BISCO.
Table 1 (upper part) contains the relevant thermal results: thermal transmittance U and equivalent thermal conductivity λ_{eq}.

BISCO data brick_vertical_joint.bsc

n	Q [W]	Δθ [K]	L [W/K]	l [m]	h [m]	S [m^2]	U [W/m^{2}K]	d [m]	h_e [W/m^{2}K]	h_i [W/m^{2}K]	λ_{eq} [W/mK]
59934	6,3170	20,0	0,316	0,286	1,000	0,286	**1,104**	0,190	25,0	7,7	**0,258**

BISCO data brick_vertical_joint_clustered.bsc

n	Q [W]	Δθ [K]	L [W/K]	l [m]	h [m]	S [m^2]	U [W/m^{2}K]	d [m]	h_e [W/m^{2}K]	h_i [W/m^{2}K]	λ_{eq} [W/mK]
59933	6,3170	20,0	0,316	0,286	1,000	0,286	**1,104**	0,190	25,0	7,7	**0,258**

Table 1 – Derived thermal properties obtained with BISCO without (top) and with (bottom) the TRISCO preparation

In order to prepare a 3D calculation in which a horizontal joint is included, the BISCO data are adapted twofold (data brick_vertical_joint_clustered_bis.bsc):

- Cavities with identical dimensions get the same colour; the equivalent thermal conductivity is defined via Colours-> cluster EQUIMAT.
- The vertical joint is shifted to the left. This is justified: Figure 2 shows that the axis AA' is almost adiabatic.

Figure 3 shows the adapted masonry unit. Figure 4 shows isotherms and heat flow lines (increment 0.1) obtained with the program BISCO.

Table 1 (lower part) contains the relevant thermal results: thermal transmittance U and equivalent thermal conductivity λ_{eq}. The results are practically identical, i.e. the adaptations made are justified.

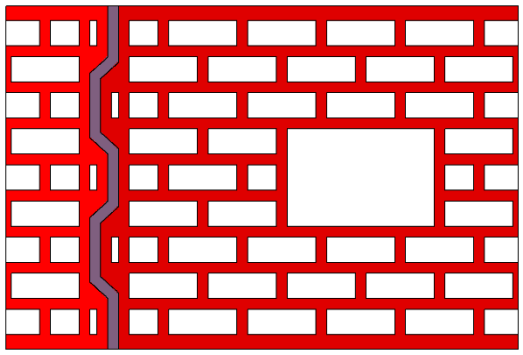

Figure 3. Example 1, adapted

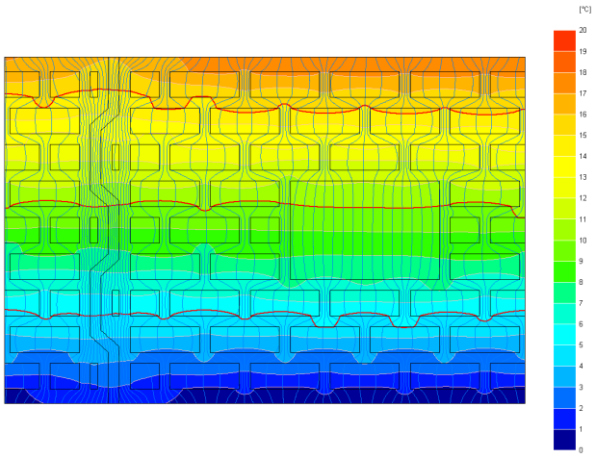

Figure 4. Results obtained by BISCO

3. Example 2

TRISCO data brick_vertical&horizontal_joint.trc

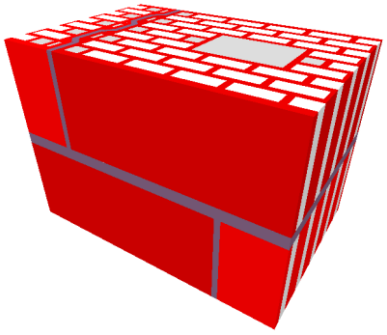

Figure 5. Example 2

Colours

Col.		Type	CEN-rule	Name	Pat.	λ [W/mK]	ε [-]	θ [°C]	h [W/m²K]	q [W/m²]
4		MATERIAL		fired clay 1900 kg/m3		0.800				
36		MATERIAL		fired clay 1900 kg/m3		0.800				
170		BC_SIMPL	HE	exterior				0.0	25.00	0
174		BC_SIMPL	HI_NORML	interior (normal)				20.0	7.70	0
176		MATERIAL		mortar		1.000				
192		EQUIMAT	NIHIL	CAVITY TYPE 1		0.250				
193		EQUIMAT	NIHIL	CAVITY TYPE 2		0.076				
194		EQUIMAT	NIHIL	CAVITY TYPE 3		0.070				
195		EQUIMAT	NIHIL	CAVITY TYPE 4		0.061				

Figure 6. TRISCO thermal data

For a masonry unit as in example 1 with a horizontal joint as well, the TRISCO data can be created as follows.

- Menu File > Import Data > BISCO data. brick_vertical_joint_clustered_bis.bsc.
- Menu File > Save As > brick_vertical&horizontal_joint.trc.
- Window Grid: Z 0-1 = 95 mm (assuming a brick height of 190 mm).
- Window Blocks: select all blocks (Ctrl A). Menu Blocks > Copy.
- Menu Blocks > Transform Coordinates: use Scaling with X=-1, Y=1, Z=1.
- Menu Blocks > Transform Coordinates: use Translation with X=286, Y=0, Z=107.
- Menu Edit > Deselect All.
- Window Blocks: select last block position.
- Menu Edit > Insert after. Colour =176, X_{min}=0, X_{max}=57, Y_{min}=1, Y_{max}=68, Z_{min}=1, Z_{max}=2.

- Block 159 (external boundary condition): Z_{max}=2.
- Block 160 (internal boundary condition): Z_{max}=2.
- Menu Edit > Areas: enter X_{min}=0, X_{max}=57, Y_{min}=0, Y_{max}=0, Z_{min}=0, Z_{max}=3.
- Menu Edit > Derived Thermal Properties: Thermal Transmittance of Element, Name = Uwall.
- Refine the grid.

Figure 7 and Figure 8 show the isotherms and the heat flow densities.
Table 2 (upper part) contains the relevant thermal results: thermal transmittance U and equivalent thermal conductivity λ_{eq}.

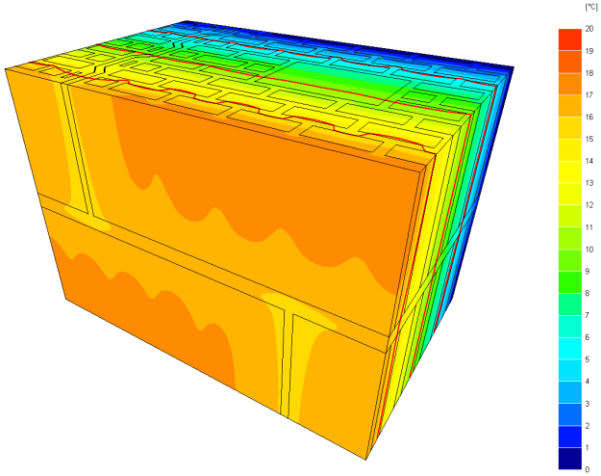

Figure 7. Example 2 isotherms

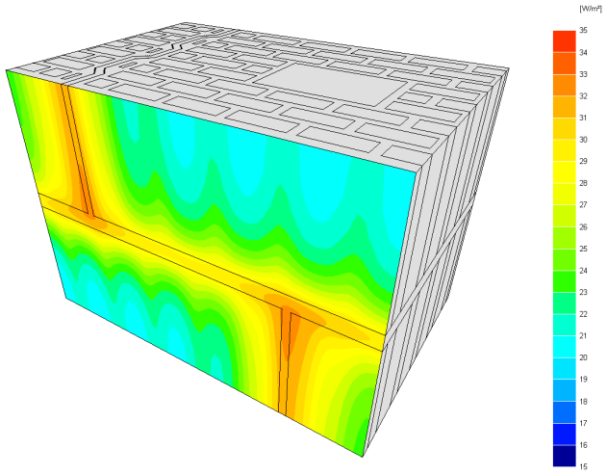

Figure 8. Example 2 heat flow densities

TRISCO data brick_vertical&horizontal_joint.trc

n	Q [W]	Δθ [K]	L [W/K]	l [m]	h [m]	S [m^2]	U [W/m^2K]	d [m]	h_e [W/m^2K]	h_i [W/m^2K]	λ_{eq} [W/mK]
258633	1,4660	20,0	0,073	0,286	0,202	0,058	**1,269**	0,190	25,0	7,7	**0,307**

BISCO data brick_vertical_joint.bsc

n	Q [W]	Δθ [K]	L [W/K]	l [m]	h [m]	S [m^2]	U [W/m^2K]	d [m]	h_e [W/m^2K]	h_i [W/m^2K]	λ_{eq} [W/mK]
22265	2,4980	20,0	0,125	1,000	0,101	0,101	**1,237**	0,190	25,0	7,7	**0,297**

Table 2 - Derived thermal properties obtained with TRISCO (top) and BISCO (bottom)

The effect of both the vertical and horizontal joint can be estimated in a simplified way by a 2D simulation. In the BISCO data brick_horizontal_joint.bsc a vertical section through a half brick and a half joint is considered (Figure 9). For the brick, the equivalent thermal conductivity of the masonry unit with the vertical joint (example 1) is used: λ_{eq} = 0.258 W/mK (see Table 1).
Isotherms and heat flow lines are shown in Figure 10. The thermal transmittance U obtained in this way (see Table 2) is somewhat lower than the value obtained by the 3D simulation.

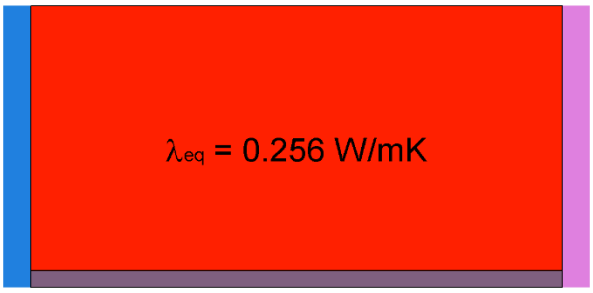

Figure 9. Example 2, 2D simplified

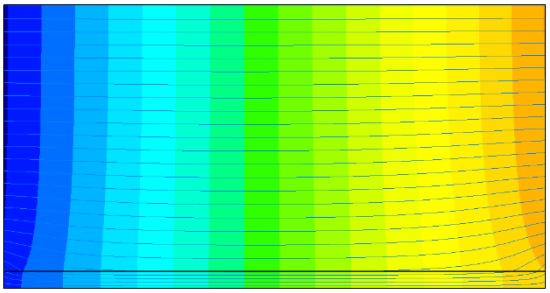

Figure 10. Example 2, 2D simplified results

4. Example 3

SOLIDO data brick2.sld

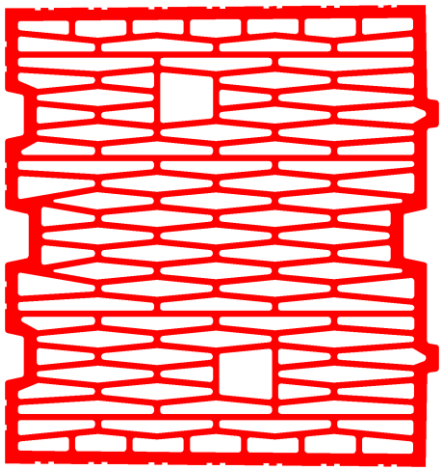

Figure 11. Section of brick used in example 3

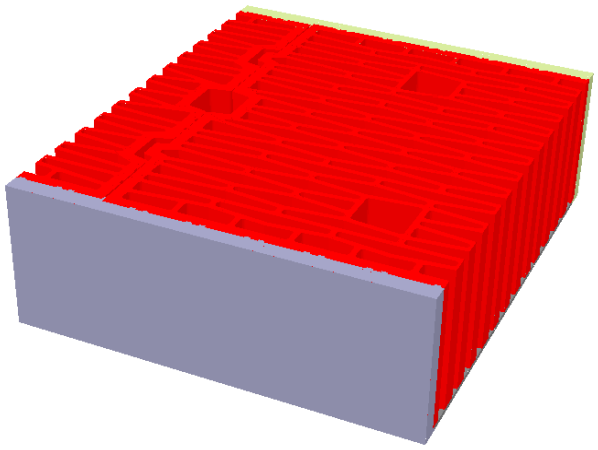

Figure 12. 3D view of masonry

The geometrical model of the brick shown in Figure 11 is available in STL format (file brick.stl). A thermally relevant part of the masonry is shown in Figure 12. Half a brick height (190 / 2 mm = 95 mm) is applied. At the bottom a half mortar joint (6 / 2 mm = 3 mm) is applied. The left and right borders can be considered as adiabatic (as in example 2).
Figure 13 and Figure 14 show the isotherms and the heat flow densities.
Table 3 contains the relevant thermal results: thermal transmittance U and equivalent thermal conductivity λ_{eq}.

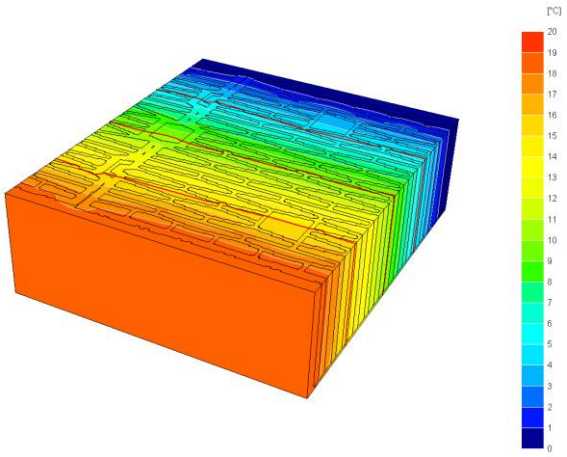

Figure 13. Example 3 isotherms

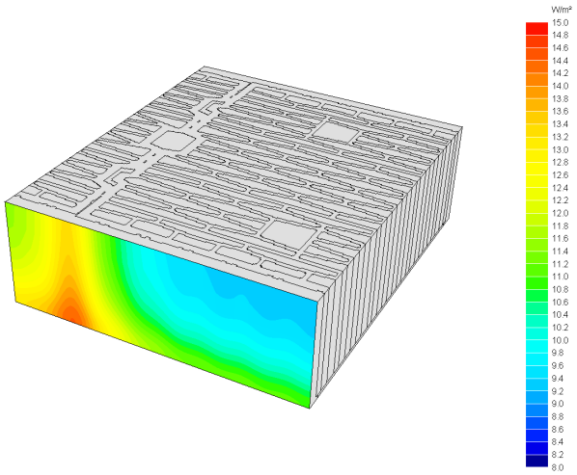

Figure 14. Example 3 heat flow densities

SOLIDO data brick2.sld

n	Q [W]	$\Delta\theta$ [K]	L [W/K]	l [m]	h [m]	S [m^2]	U [W/m^2K]	d [m]	h_e [W/m^2K]	h_i [W/m^2K]	λ_{eq} [W/mK]
1307625	0,2983	20,0	0,015	0,274	0,098	0,027	**0,555**	0,32	25,0	7,7	**0,196**

Table 3 - Derived thermal properties obtained with SOLIDO

5. References

EN 1745:2012 *Masonry and masonry products – Methods for determining design thermal values*

EN ISO 6946:2017 *Building components and building elements - Thermal resistance and thermal transmittance - Calculation methods*