THERMAL ANALYSIS A WALL TO WINDOW JUNCTION ACCORDING TO EN ISO 13789

1. Introduction

The thermal transmittance of a wall-window junction is calculated according to the applicable European standards. 2 approaches to analyse the problem are discussed:

1) 2D heat transmission calculation
2) heat transmission calculation 'by hand'.

2. Construction detail data

A wall-window junction is shown in Figure 1 and Figure 2.

Figure 1. Wall-window construction detail, internal (left) and external (right) view.

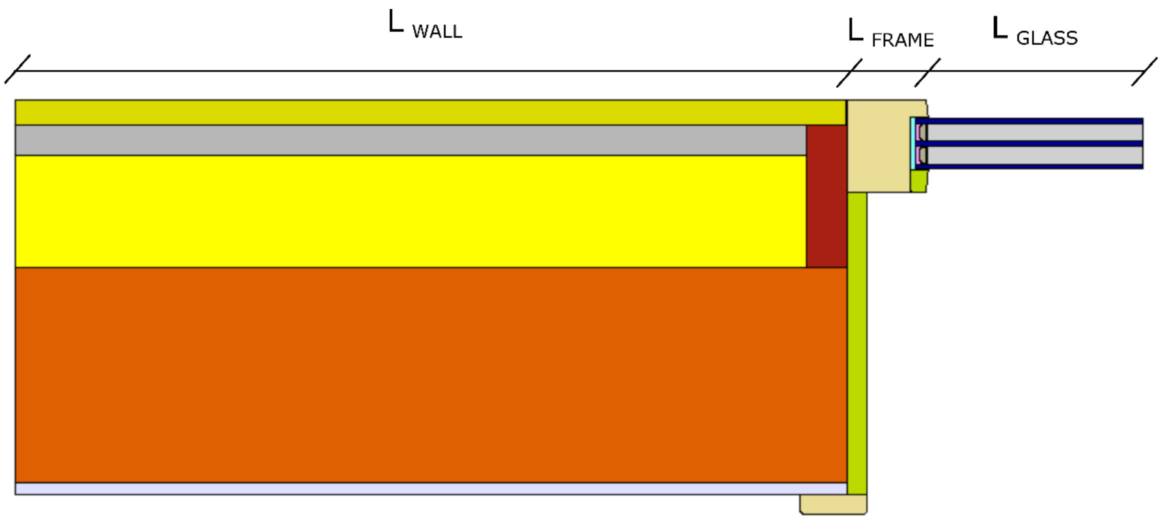

Figure 2. Horizontal section of the wall-window construction detail

3. To 2D thermal transmittance calculation

BISCO data wall_frame_wood_glazed.bsc
TRISCO data wall_frame_wood_glazed_trc.trc

The 2D transmission heat loss can be calculated in 1 step using the program BISCO. The calculated transmittance heat loss is Q_{2D} = 10.86 W/m.

The thermal coupling coefficient L^{2D} is obtained this value by the temperature difference assumed (20°C): L^{2D} = 0.543 W/mK.

From this value a linear thermal transmittance ψ can be derived:

$$\Psi_{tot} = L_{2D} - U_{wall} L_{wall+frame} - U_{glazing} L_{glazing} \quad (1)$$

ψ_{tot} = 0.543 – 0.275 x 0.81 – 0.7 x 0.19 W/mK = 0.187 W/mK.

This value takes into account the 2D thermal bridge effect of the wall edge, of the frame and of the glazing spacer. The ψ-value is useful in the heat transmission calculation of the whole building (using formula 2, see further). It is important to mention that the ψ-value depends on the definition of the flanking element lengths. When doing the whole building calculation the same definition needs to be applied.

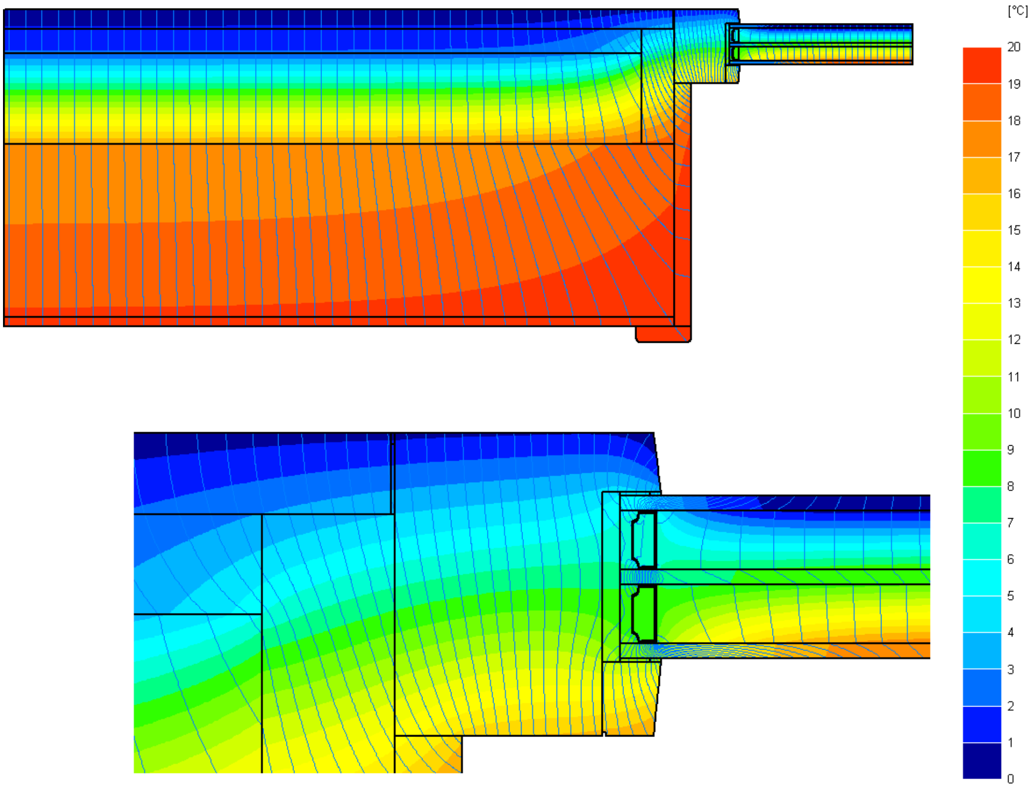

Figure 3. Isotherms and heat flow lines (increment 0.1 W/mK).

4. Thermal transmittance calculation 'by hand'

When doing whole building thermal transmittance calculations, the use of direct 2D thermal transmittance calculations as the one above is rare. Instead the building envelope is decomposed in:

- plane elements (walls, roofs, etc.) each with a surface S and a thermal transmittance U;
- linear joints (linear thermal bridges) each with a length L and a linear thermal transmittance Ψ,
- punctual elements (point thermal bridges) each with a point thermal transmittance χ.

The heat transmittance coefficient H_t of a building can be calculated in accordance to EN ISO 13789.

$$H_t = \sum_i U_i S_i + \sum_j \Psi_j L_j + \sum_k X_k \text{ [W/K]} \tag{2}$$

In case of the 2D wall-window junction, formula 2 can be used to derive the 2D heat transmission coefficient H_t^{2D}

$$H_t^{2D} = U_{wall} L_{wall} + U_{frame} L_{frame} + U_{glazing} L_{glazing} + \psi_{wall-edge} + \psi_{glazing-edge} \text{ [W/mK]} \tag{3}$$

Several European standards need to be applied to derive the requested values.

- EN ISO 6946 for the thermal transmittance of the wall U_{wall}
- EN ISO 10077-2 for the thermal transmittance of the frame U_{frame}
- EN 673 for the thermal transmittance of the glazing $U_{glazing}$
- EN ISO 10211 for the linear thermal transmittance of the wall edge junction $\psi_{wall-edge}$
- EN ISO 10077-2 for the linear thermal transmittance of the glazing edge $\psi_{glazing-edge}$

This looks a quite complex procedure, but in practice the values U_{frame} and $U_{glazing}$ are provided by frame and glazing manufacturers and default values are available for $\psi_{glazing-edge}$ and for $\psi_{wall-edge}$ (from thermal bridge catalogues) and therefore the calculation can be done "by hand".

For the wall-window junction considered, the values mentioned are calculated in detail, except for the triple glazing for which $U_{glazing}$ = 0.7 W/m^{2}K is assumed.

5. Wall thermal transmittance

The wall thermal transmittance can be derived according to EN ISO 6946. The value U_{wall} = 0.275 W/m^{2}K can be obtained by a hand calculation but is also listed in:

- BISCO data wall_with_adiabatic_frame.bsc (see in Window 'Border U Values')
- TRISCO data wall_with_adiabatic_frame_trc.trc) (see 'Edit'->'U Value)

6. Window frame thermal transmittance

BISCO data frame_wood_pane.bsc
TRISCO data frame_wood_pane_trc.trc

The thermal transmittance of a window frame according to EN ISO 10077-2 assumes an insulation panel instead of a glazing and an adiabatic wall junction. The value U_{frame} = 1.226 W/m^{2}K is obtained.

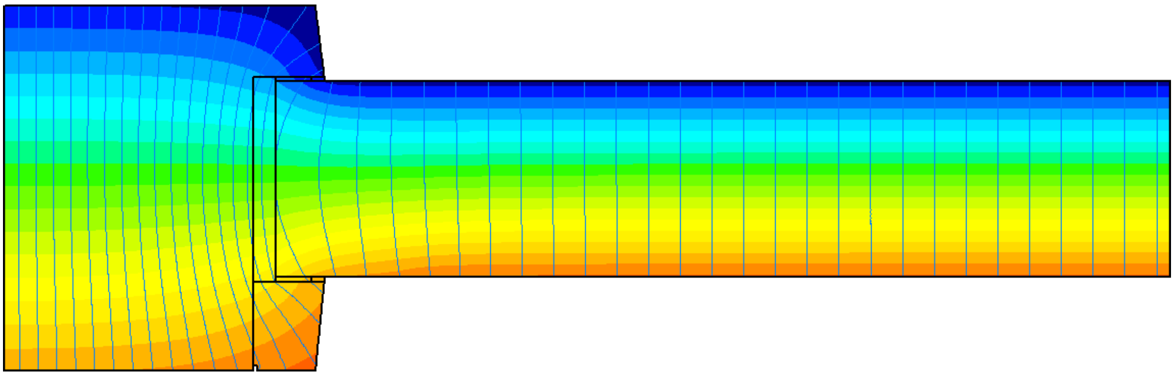

Figure 4. Window frame with panel: isotherms and heat flow lines (increment 0.1 W/mK).

7. Glazing edge linear thermal transmittance

BISCO data frame_wood_glazed.bsc
TRISCO data wall_frame_wood_glazed_trc.trc

The linear thermal transmittance of the glazing edge according to EN ISO 10077-2 can be derived from a 2D calculation with the glazing instead of the insulation panel. The value $\psi_{glazing\text{-}edge}$ = 0.085 W/mK is obtained.

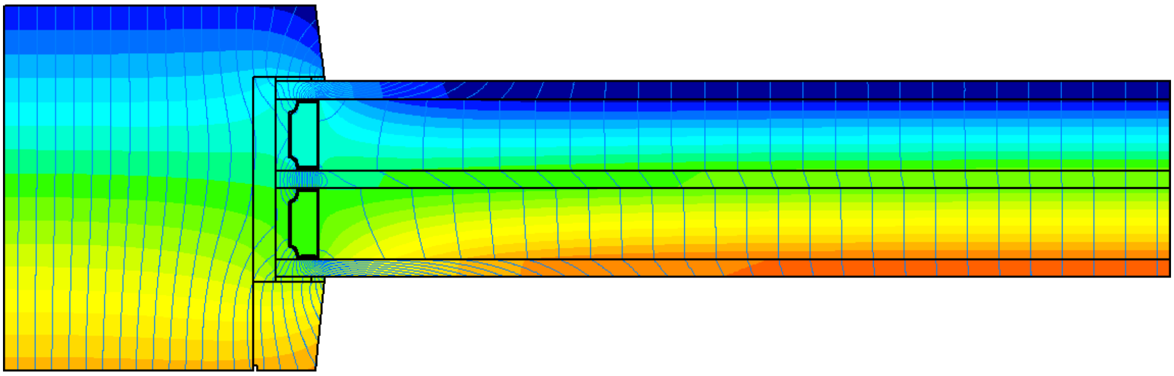

Figure 5. Window frame with glazing: isotherms and heat flow lines (increment 0.1 W/mK).

8. Wall edge linear thermal transmittance

BISCO data wall_with_adiabatic_frame.bsc
TRISCO data wall_with_adiabatic_frame_trc.trc

To calculate the linear thermal transmittance of the wall edge according to EN ISO 10211 the frame junction is considered as adiabatic. The value $\psi_{wall\text{-}edge}$ = 0.037 W/mK is obtained.

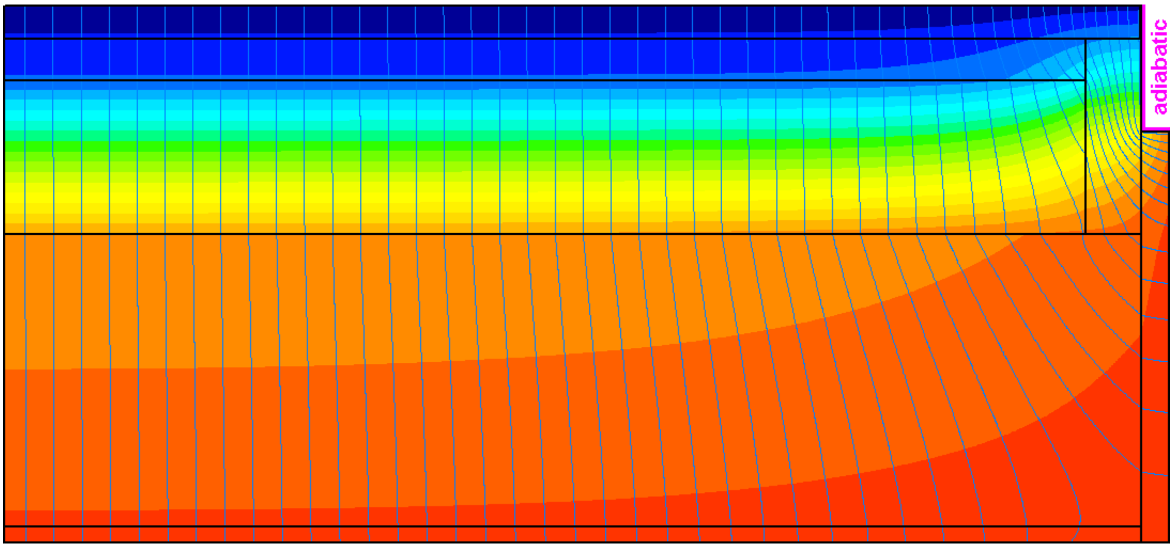

Figure 6. Window frame with glazing: isotherms and heat flow lines (increment 0.1 W/mK).

9. Thermal transmittance calculation 'by hand' (continued)

Now the value H_t^{2D} can be derived as all values in the formula 3 (EN ISO 13789) are known.

$$H_t^{2D} = U_{wall}\,L_{wall} + U_{frame}\,L_{frame} + U_{glazing}\,L_{glazing} + \psi_{wall-edge} + \psi_{glazing-edge} \quad (3)$$

The lengths L are specified in Figure 2.

H_t^{2D} = 0.275 x .738 + 1.226 x 0.072 + 0.7 x 0.19 + 0.085 + 0.037 W/mK = 0.546 W/mK.

This value is quite close to the value L^{2D} = 0.544 W/mK obtained by the 2D thermal transmittance calculation obtained above. Both values are not identical because of the assumptions in the hand calculation method (for example an adiabatic junction between wall and frame).

10. Discussion

Compared to the 2D thermal transmittance calculation requiring a numerical simulation, the calculation 'by hand' might look easier to apply. This is only the case if

- the U-value of the frame is known (for example from the manufacturer)
- the ψ-value of the glazing spacer is known (for example a default value from EN 10077-1)
- the ψ-value of the wall edge is known (for example from a thermal bridge catalogue).

A low precision of these 3 values will cause a low precision of the total transmission calculation.

There are also cases for which the hand-method becomes difficult. Consider the detail shown in Figure 7. The external insulation covers the window frame, and the application of formula 3 becomes impossible. Only a 2D thermal transmittance calculation allows a precise analysis of the thermal transmittance. The BISCO data wall_frame_wood_glazed_alt.bsc (TRISCO data wall_frame_wood_glazed_alt_trc.trc) allow the calculation of the linear thermal transmittance using formula 1.

ψ_{tot} = 0.4109 – 0.157 x 0.806 – 0.7 x 0.194 W/mK = 0.149 W/mK.

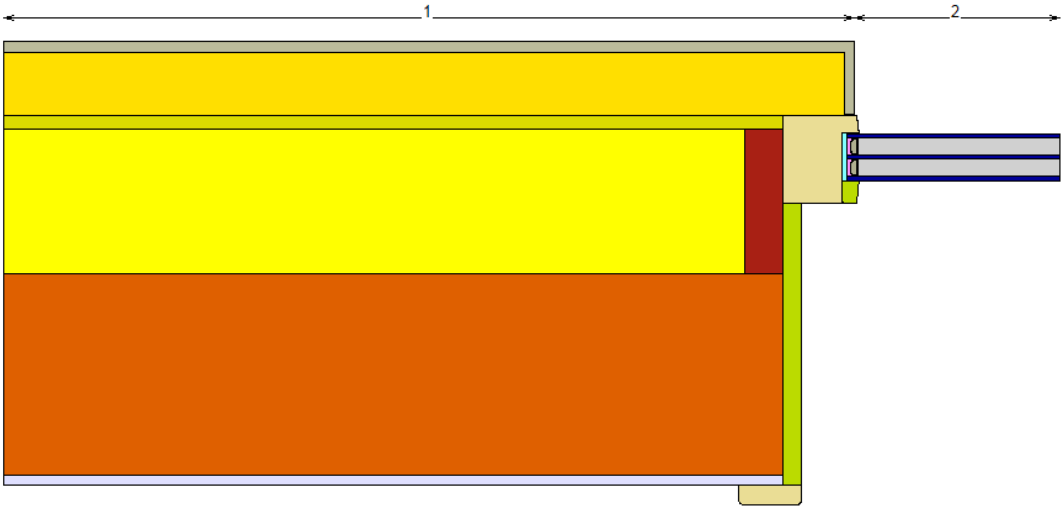

Figure 7. Horizontal section of an alternative wall-window construction detail

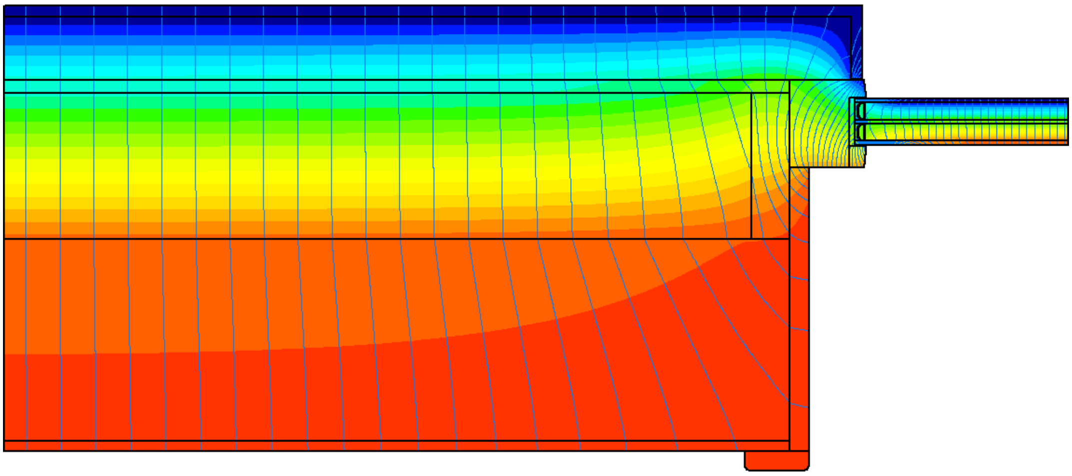

Figure 8. Isotherms and heat flow lines (increment 0.1 W/mK).

11. References

EN ISO 13789 – 2017 -Thermal performance of buildings - Transmission and ventilation heat transfer coefficients - calculation methods

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

EN ISO 10077-2 – 2017 - Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 2: Numerical method for frames

EN 673 – 2011- Glass in building - determination of thermal transmittance (U value) - Calculation method

EN ISO 10211 – 2017 - Thermal bridges in building construction - Heat flows and surface temperatures - Detailed calculations