

Tutorial



Calculating the equivalent thermal transmittance (U_{2D}) and linear thermal transmittance (Ψ) of a repeating thermal bridge



TR2D Tutorial a

1. Introduction

[wall_internal_insulation.tr2](#)

This tutorial shows how to calculate the U_{2D} -value and ψ -value for a repeating thermal bridge.

Key elements:

- Creating a geometrical model from scratch
- Derived thermal properties: U_{2D} -value and ψ -value

Note: this tutorial is partly assembled from:

- How to create the design grid for a geometrical model from scratch or with a .dxf underlayer?
- How to add materials and boundary conditions to a geometrical model?
- How to generate a linear and an equivalent thermal transmittance?

2. Case study data

The example is a massive brickwork wall which is internally insulated. The thermal insulation is interrupted by a wooden stud at regular distances, causing a thermal bridge effect. This thermal bridge effect is quantified using the program Trisco2D.

The geometry and corresponding material properties are (from outside to inside):






- Exterior plaster (10 mm) ($\lambda=1$ W/mK)
- Masonry wall (190 mm) ($\lambda=0.9$ W/mK)
- Insulation layer (120 mm) with wooden stud (40 mm) every 600 mm ($\lambda=0.035$ W/mK, $\lambda=0.13$ W/mK)
- Interior plaster (10 mm) ($\lambda=0.43$ W/mK)



The boundary conditions imposed by EN ISO 10211 are:

- Indoors: temperature $\theta_i = 20$ °C, wall surface heat transfer coefficient = 7.7 W/m²K
- Outdoors: temperature $\theta_e = 0$ °C, wall surface heat transfer coefficient = 25 W/m²K



3. Creating the design grid (= minimum grid)

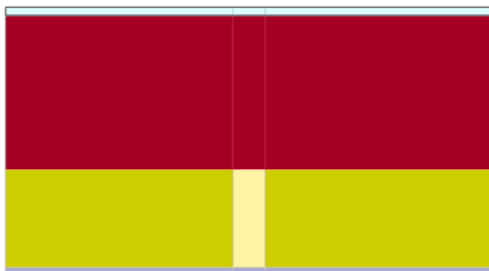
- Open Trisco2D and adjust optionally the model unit: *Grid* → *Grid Unit...*
- Activate a grid mesh in the **Grid window** by clicking with the left mouse button within.
- Insert a new line in the **Grid window**   ("insert before" or "insert after").
Alternatively, new grid lines can be added by clicking with the left mouse button in the **Image window** after activating   ("set vertical grid line" or "set horizontal grid line").
- In the **Grid window** the dimensions can be adjusted.
Alternatively, the grid lines can be moved by clicking (left mouse button) on a grid line with the cursor after activating  ("move grid line") and holding the left mouse button. Meanwhile the status bar (bottom left) indicates the new position of the grid line.





No.	ΔX [mm]	ΔY [mm]
0-1	280.000	10.000
1-2	40.000	190.000
2-3	280.000	120.000
3-4		10.000
Sum	600.000	330.000

4. Adding material properties

- The **Colours window** can be in 3 modes (submenu *Colours*):
 - o *List All*: all colours from the colour database are shown (also the free colours);
 - o *List Defined*: all colours defined in the colour database are shown;
 - o *List Present*: all colours defined within the project are shown.
 - Select *Colours* → *List Defined*
 - Materials can be added to the model in the **Blocks window**. Here the user defines:
 - 1) the colour number;
 - 2) the x and y range of the block to be coloured.
- A new block can be added by activating a block (left mouse button) and add a new block   ("insert before" or "insert after"). When blocks overlap, the program applies the superposition principle and gives priority to the block with the highest block number. When the desired material is not available in the colour database, it can be created by:
- o Switching first the **Colours window** to "List all" mode (*Colours* → *List All*) and
 - Writing the data in a (free) colour (e.g. colour 57 is used to input cement sand render here), or
 - Load a material property from a material database (*Colour* → *Load Material*) into a (free) colour.



No.	Col.	Xmin	Xmax	Ymin	Ymax
1	145	0	3	3	4
2	151	0	3	2	3
3	15	1	2	2	3
4	180	0	3	1	2
5	57	0	3	0	1

- o Alternatively, materials can be added to the model by first selecting the desired colour in the **Colours window** and then paint the desired cells with  ("Draw")  or paint a desired zone ("Fill").

Note: when selecting materials with the “Draw” option the number of blocks can increase rapidly. To reduce the number of blocks it is advisable to intermediately optimise the number of blocks by *Blocks* → *Optimise Blocks*.

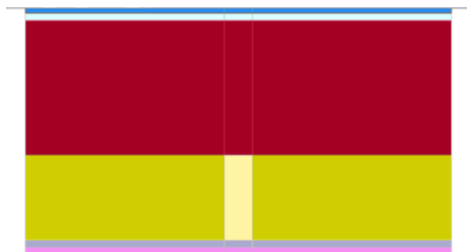
5. Adding boundary conditions

- Boundary conditions are also added using blocks, so, first add two new grid lines in the **Grid window**:

- o Click on the mesh 0-1 ΔY in the **Grid window** and insert a new grid line before 
- o Click on the mesh 4-5 ΔY in the **Grid window** and insert a new grid line after 

Note: the mesh size of these added elements is not of importance (take e.g. 1 cm).


- Boundary conditions are defined as colours of the type “BC_SIMPL” within the **Colours window**.
- A boundary condition can be created by the user or adopted from the colour database.
- In the same way as for materials, new blocks can be added to the model: take colour 170 (exterior boundary condition) and colour 174 (interior boundary condition).



No.	Col.	Xmin	Xmax	Ymin	Ymax
1	145	0	3	4	5
2	151	0	3	3	4
3	15	1	2	3	4
4	180	0	3	2	3
5	57	0	3	1	2
6	170	0	3	0	1
7	174	0	3	5	6

No.	ΔX [mm]	ΔY [mm]
0-1	280.000	10.000
1-2	40.000	10.000
2-3	280.000	190.000
3-4		120.000
4-5		10.000
5-6		10.000
Sum	600.000	350.000






6. Linear thermal transmittance (Ψ)

- *Edit* → *Derived Thermal Properties...* and check “Linear thermal transmittance” 
- The **Lengths of flanking elements window** and **U-values of flanking elements window** open automatically.
- Within the **Lengths of flanking elements window**, the length can be defined by filling in the corresponding coordinates.


Alternatively, these flanking lengths can be defined with the mouse cursor:

- o Activate the desired row in the **Lengths of flanking elements window** by clicking with the left mouse button.
 - o Select with the left mouse button the starting point in the grid.
 - o Hold the left mouse button down and select the end point in the grid.
 - Within the **U-value of flanking elements window** the line along which the 1D U-value should be calculated can be defined by filling in the corresponding coordinates.
- Alternatively, this can be selected with the mouse in the same way as for the lengths of the flanking elements (see above).


Note: for non-homogeneous flanking elements, the U-value can be defined within the cell “Enforced U-value [W/m²K]”.

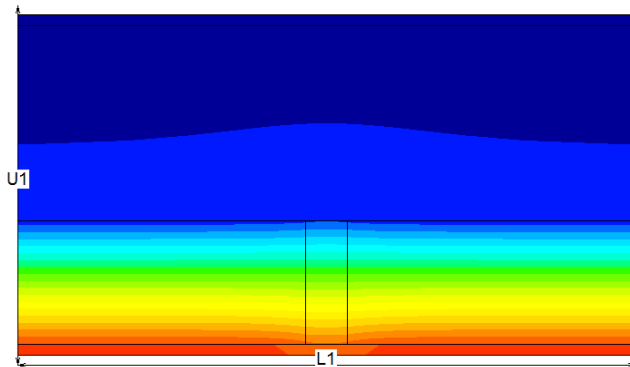
- Run the simulation by clicking the magic wand 
- Before the simulation starts an automatic grid discretisation is proposed: click “yes”.
- The simulation automatically starts and the model then shows the temperature field.
- Within the **Image window** the user can switch to:
 - o Show Materials 
 - o Show Temperatures 
 - o (Adjust)Temperature Range 
 - o Show (discretisation) Grid 
- To see the result:

Go first to the **Graphic Output window** by clicking  ("Graphic Output").

Within the **Graphic Output window**: select "Derived thermal properties" 





The image will now show the derived thermal property data (including the equation).
The size of the figure and the font of the text can be adjusted (*Settings* → *Image Size*).
This image can be saved in .png format for direct use in a report.

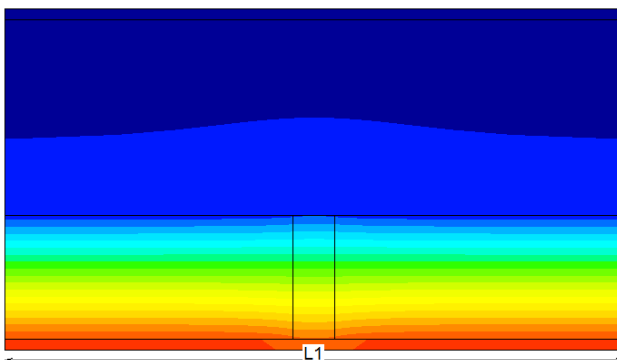
- Alternatively, the result can also be consulted within the **Text output window** 



$$\begin{aligned}\psi &= Q/(\theta_i - \theta_e) - U_1 \cdot L_1 \\ Q &= 3.584 \text{ W/m} \\ \theta_i &= 20^\circ\text{C} \\ \theta_e &= 0^\circ\text{C} \\ U_1 &= 0.260 \text{ W}/(\text{m}^2 \cdot \text{K}) \\ L_1 &= 0.6 \text{ m} \\ \psi &= 0.023 \text{ W}/(\text{m} \cdot \text{K})\end{aligned}$$

7. Equivalent thermal transmittance (U_{2D})

- *Edit* → *Derived Thermal Properties...* → select "Equivalent thermal transmittance" 
- The **Lengths of flanking elements window** opens automatically.
- Define the length of the flanking element (full width):
Apply the same method as for the example of a linear thermal transmittance (see above).
- Run the simulation by pressing the magic wand 
- Go to the **Graphic output window** by clicking  ("Graphic Output") to see the result.
- Alternatively, the result can also be consulted in the **Text Output window** 



$$\begin{aligned}U_{eq} &= Q/((\theta_i - \theta_e) \cdot L_1) \\ Q &= 3.584 \text{ W/m} \\ \theta_i &= 20^\circ\text{C} \\ \theta_e &= 0^\circ\text{C} \\ L_1 &= 0.6 \text{ m} \\ U_{eq} &= 0.299 \text{ W}/(\text{m}^2 \cdot \text{K})\end{aligned}$$