Tutorial

Calculating the linear thermal transmittance of a roof junction according to EN ISO 10211

BSC Tutorial c

BISCO

1. Introduction

roof_junction.bsc
roof_junction.dxf
roof_junction_prepared.dxf

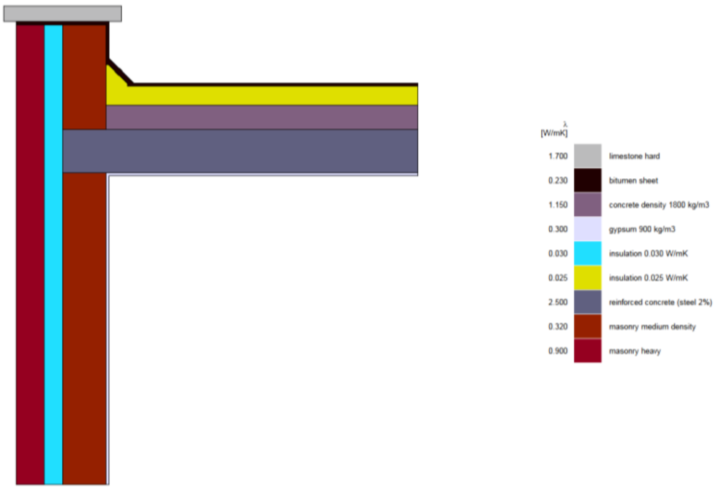
This tutorial explains how to model the linear thermal transmittance of a roof junction.

Key elements:

- Creating a geometrical model starting from a DXF file
- Derived thermal properties: linear thermal transmittance (Ψ)

2. Case study data

The configuration is a junction between a masonry wall and an insulated concrete roof structure:



The boundary conditions imposed by EN ISO 10211 (EN ISO 6946) are:

- Outdoors: temperature θ_e = 0 °C, surface heat transfer coefficient = 25 W/m^{2}K,
- Indoors: temperature θ_i = 20 °C, wall surface heat transfer coefficient = 7.7 W/m^{2}K, roof surface heat transfer coefficient = 10 W/m^{2}K.

3. Creating a geometry and adding material properties and boundary conditions

BISCO applies BMP files to define the building components geometry, material properties and boundary conditions. A BMP file can be generated from a DXF file within BISCO.
We distinguish between 3 possible ways of preparing the DXF file:

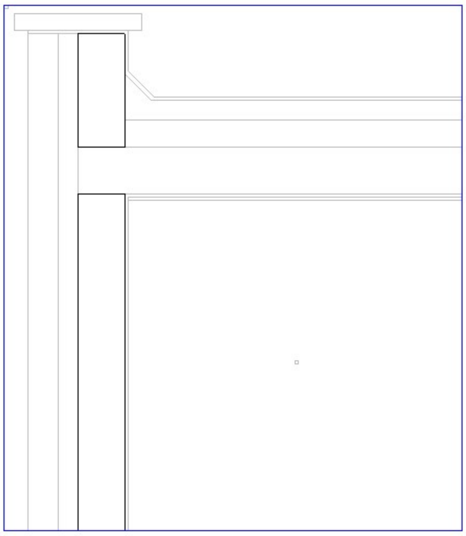
- Every material in a different layer.
- Every material in a different layer + layers containing colour information.
- All materials drawn in 1 layer.

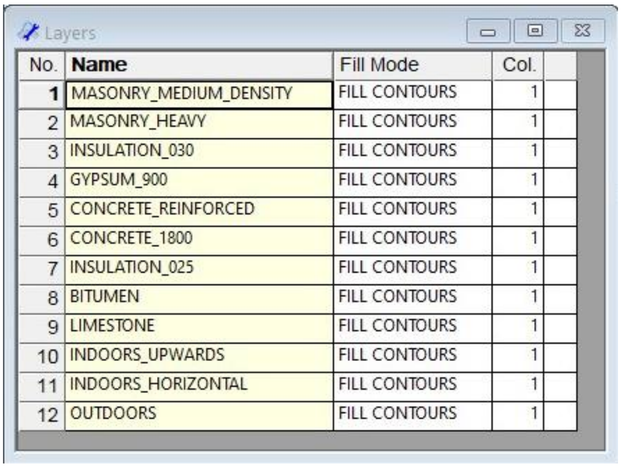
These 3 possibilities are discussed separately here.

a. DXF file with every material in a different layer

roof_junction.dxf

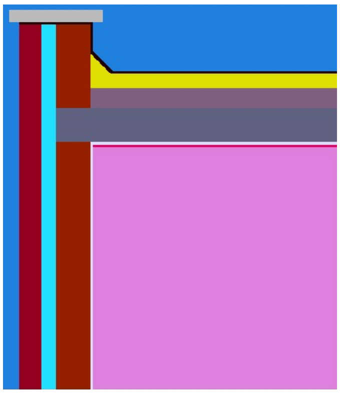
- Load the DXF file via BiscoDXF: *File → Open DXF...*: select roof_junction.dxf and click "YES" (Open and edit DXF first in BiscoDXF).
- A dialog box opens allowing to select layers which should not be recognised.
- Upon selecting <OK> the layers are recognised in BiscoDxf:

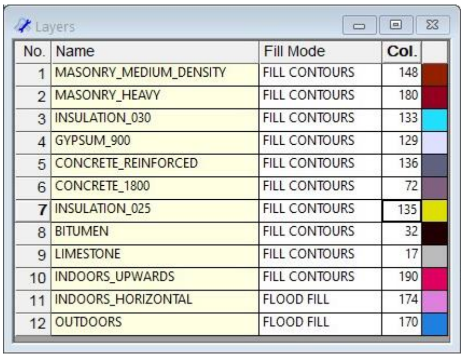




No.	Name	Fill Mode	Col.
1	MASONRY_MEDIUM_DENSITY	FILL CONTOURS	1
2	MASONRY_HEAVY	FILL CONTOURS	1
3	INSULATION_030	FILL CONTOURS	1
4	GYPSUM_900	FILL CONTOURS	1
5	CONCRETE_REINFORCED	FILL CONTOURS	1
6	CONCRETE_1800	FILL CONTOURS	1
7	INSULATION_025	FILL CONTOURS	1
8	BITUMEN	FILL CONTOURS	1
9	LIMESTONE	FILL CONTOURS	1
10	INDOORS_UPWARDS	FILL CONTOURS	1
11	INDOORS_HORIZONTAL	FILL CONTOURS	1
12	OUTDOORS	FILL CONTOURS	1

- The DXF Drawing window displays the corresponding lines in grey (all layers except the current layer) and black (for lines of the current layer).
  The rectangle in blue represents the border of the bitmap to be created. The left, right, top and bottom position of this border can be moved. Initially the bitmap border corresponds to the drawing extents from the DXF file header. The bitmap limits and bitmap resolution can be viewed and edited in the dialog box opened with *Bitmap → Set Bitmap & Pixel Size...* .
  The drawing unit is 1 cm (for this DXF drawing), so the proposed pixel size of 0.1 in the dialog box corresponds to 1 mm.
  The output bitmap will have a width of 1370 pixels and a height of 1574 pixels.
- The Layers window contains the script of the bitmap colouring.
- Enter the colour numbers (between 0 and 255) for each layer corresponding to the definition in the Colour database.
  Note: the Colour database can be accessed by opening a second BISCO project and going to *File → Open Colour Database...* .
  A list of the default Colour database can be found in the Physibel Knowlegde base: "MATERIAL AND BOUNDARY CONDITIONS: EN 10077-2, EN 6946 and EN 10456.pdf"
- Also edit the fill mode per layer (double click with the left mouse button on the corresponding cell, or press <Enter> on the selected cell).
  The fill mode defines how the lines in the corresponding layer must be filled using the chosen colour. The normal fill mode to colour a closed polyline is "fill contours", which colours the area inside the polyline.
- Finally the sequence of layers may be changed, which defines the priority of colouring. This can be done using the menu commands *Layers → Higher/Lower Priority* from the active Layers window.
  The first layer is first processed in bitmap colouring, then the second one, and so on.
- Generate the bitmap by clicking the magic wand. 
- Close BiscoDxf to load the generated bitmap directly in BISCO and save the BISCO file.





No.	Name	Fill Mode	Col.
1	MASONRY_MEDIUM_DENSITY	FILL CONTOURS	148
2	MASONRY_HEAVY	FILL CONTOURS	180
3	INSULATION_030	FILL CONTOURS	133
4	GYPSUM_900	FILL CONTOURS	129
5	CONCRETE_REINFORCED	FILL CONTOURS	136
6	CONCRETE_1800	FILL CONTOURS	72
7	INSULATION_025	FILL CONTOURS	135
8	BITUMEN	FILL CONTOURS	32
9	LIMESTONE	FILL CONTOURS	17
10	INDOORS_UPWARDS	FILL CONTOURS	190
11	INDOORS_HORIZONTAL	FLOOD FILL	174
12	OUTDOORS	FLOOD FILL	170

b. DXF file with every material in a different layer + layers containing colour information

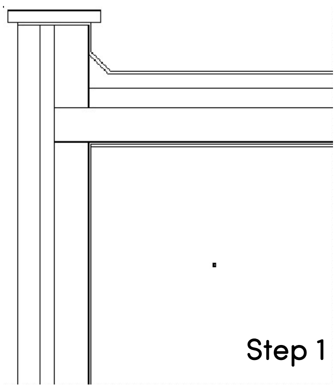
roof_junction_prepared.dxf

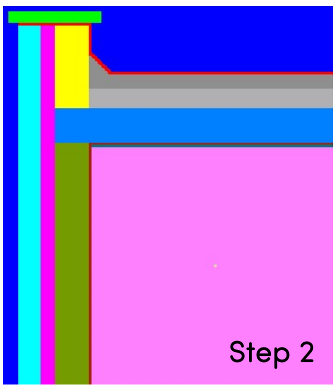
- The DXF file roof_junction_prepared.dxf is adjusted in that each layer contains now the information of the colours. The first 3 digits indicate the colour number, the 5th digit the filling mode (0="line",1="fill contours",2="flood fill", 3="skip").
- Generate the bitmap by clicking the magic wand 
- Close BiscoDxf to load the generated bitmap directly in BISCO and save the BISCO file.

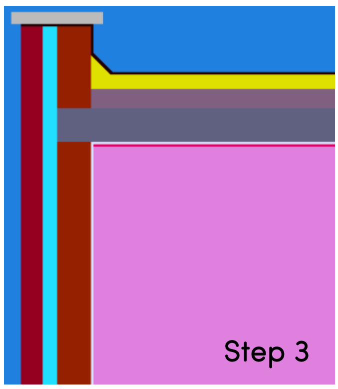
c. DXF file with all materials drawn in 1 layer

roof_junction_1layer.dxf

- An alternative procedure is possible when all materials are drawn in the same DXF layer (e.g. when exporting DXF files from SKETCHUP for which creating separate layers is not possible).
- Load the DXF file via BiscoDXF: *File → Open DXF…*: select roofJunction_1layer.dxf and click "YES" (Open and edit DXF first in BiscoDXF).
- A dialog box opens allowing to select layers which should not be recognised.
- Upon selecting <OK> the layers are recognised in BiscoDxf.
- Select fill mode "line" and generate the line drawing BMP file by clicking  .
- Close BiscoDxf to load the generated bitmap directly in BISCO and save the BISCO file.
- Select in the menu command of BISCO *Bitmap→ Fill Line Drawing* to fill the different elements in 1 step.
- Change the colours in the Colours window to the desired properties or use alternately F5 to change the colour index in accordance to the indexes in the Colour database.



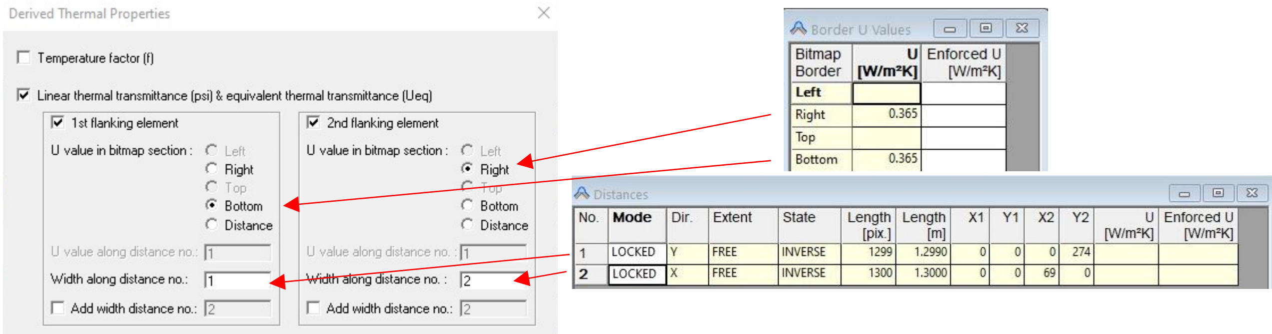




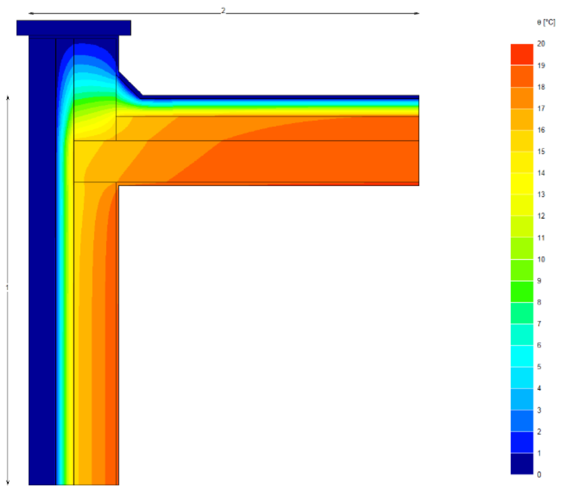
roof_junction_line_drawing.bsc roof_junction_line_drawing_fill.bsc roof_junction.bsc

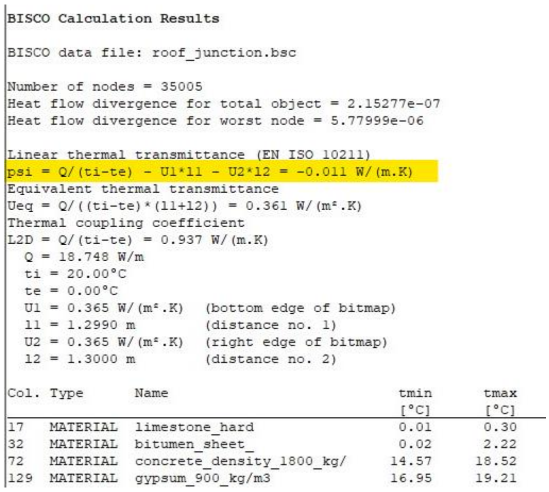
4. Calculation of the linear thermal transmittance

- Open the Distances window (*Edit →Distances*) to define the lengths of the flanking elements: *Edit →New row* or press <*Insert*> to add a new in row in the Distance window.
- Depending on the national regulation one should use interior or exterior flanking element dimensions. In what follows the exterior dimensions are used.
- For the vertical flanking element: select in the second column (Direction) "Y", in the third column (Extent) "Min" and in the fourth column (State) "Inverse". Activate now in the Bitmap window the cursor and click with the left mouse button on the blue zone above the roof. The vertical distance now appears in the Bitmap window. Optionally, to move the distance to the left side of the bitmap, the X-coordinate can be changed to "0". By double clicking with the left mouse button in the first column (Mode) the dimension can be locked.
- Apply the same procedure to define the horizontal flanking element.
- To define the desired output, the linear thermal transmittance in this case, go to *Edit →Derived Thermal Properties...* . Select "Linear thermal transmittance (psi)" and link the corresponding two flanking elements and their U-values to the numbers defined in the Border U-value window and the Distances window as in the figure below:



- Run the simulation by clicking the magic wand .
- See the results in the **Graphic Output window** or in the **Text Output window**





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BISCO Calculation Results

BISCO data file: roof_junction.bsc

Number of nodes = 35005
Heat flow divergence for total object = 2.15277e-07
Heat flow divergence for worst node = 5.77999e-06

Linear thermal transmittance (EN ISO 10211)
psi = Q/(ti-te) - U1*l1 - U2*l2 = -0.011 W/(m.K)
Equivalent thermal transmittance
Ueq = Q/((ti-te)*(l1+l2)) = 0.361 W/(m².K)
Thermal coupling coefficient
L2D = Q/(ti-te) = 0.937 W/(m.K)
  Q = 18.748 W/m
  ti = 20.00°C
  te = 0.00°C
  U1 = 0.365 W/(m².K)   (bottom edge of bitmap)
  l1 = 1.2990 m         (distance no. 1)
  U2 = 0.365 W/(m².K)   (right edge of bitmap)
  l2 = 1.3000 m         (distance no. 2)

Col. Type      Name                          tmin     tmax
                                             [°C]     [°C]
17   MATERIAL  limestone_hard                0.01     0.30
32   MATERIAL  bitumen_sheet_                0.02     2.22
72   MATERIAL  concrete_density_1800_kg/    14.57    18.52
129  MATERIAL  gypsum_900_kg/m3             16.95    19.21
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