

## 1. Introduction

[T-SLDe STL rainscreen cladding detail.sld](#)

This tutorial illustrates how to model the thermal transmittance of a rainscreen cladding wall by importing the bracket and insulator via STL format. The tutorial mainly focuses on importing and positioning STL geometries in the SOLIDO coordinate system.

Key elements:

- Creating a rainscreen cladding wall via STL files
- Transformation of STL files
- Derived thermal properties: equivalent and point thermal transmittance ( $U_{\text{equi}}$  and  $\chi$ )

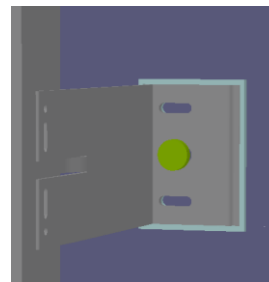
## 2. Case study data

The example concerns a rainscreen cladding wall:

- concrete wall:  $\lambda = 2 \text{ W/(m.K)}$ ,  $d = 20 \text{ cm}$
- insulation:  $\lambda = 0.035 \text{ W/(m.K)}$ ,  $d = 16 \text{ cm}$
- insulator (rigid plastic):  $\lambda = 0.17 \text{ W/(m.K)}$  ([insulator.stl](#))
- aluminium bracket:  $\lambda = 160 \text{ W/(m.K)}$  ([bracket.stl](#))
- aluminium L-profile:  $\lambda = 160 \text{ W/(m.K)}$ , 60 mm x 40 mm and thickness 2 mm
- stainless steel screw:  $\lambda = 17 \text{ W/(m.K)}$ ,  $\varnothing 10 \text{ mm}$ ,  $L = 10 \text{ cm}$
- highly ventilated cavity:  $d = 3 \text{ cm}$
- cladding:  $\lambda = 1 \text{ W/(m.K)}$ ,  $d = 1 \text{ cm}$

The boundary conditions imposed are in line with EN ISO 6946:

- Indoors:  $\theta_i = 20 \text{ }^\circ\text{C}$ , surface heat transfer coefficient =  $7.7 \text{ W/m}^2\text{K}$
- Outdoors:  $\theta_e = 0 \text{ }^\circ\text{C}$ , surface heat transfer coefficient =  $25 \text{ W/m}^2\text{K}$
- Highly ventilated outdoor cavity:  $\theta_e = 0 \text{ }^\circ\text{C}$ , surface heat transfer coefficient =  $7.7 \text{ W/m}^2\text{K}$



### 3. Loading and positioning STL files

#### Step 1: Loading the STL files

[insulator.stl](#)

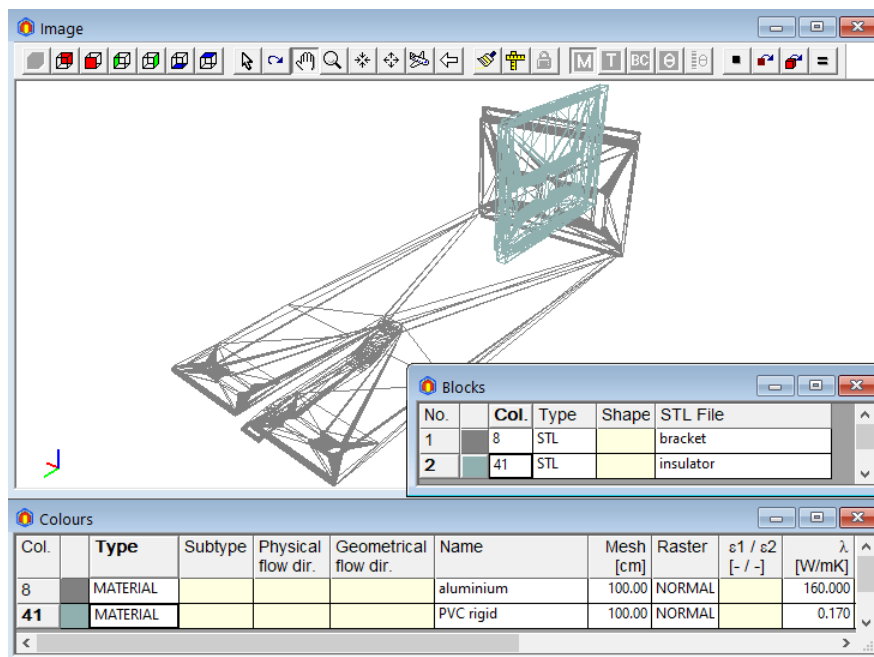
[bracket.stl](#)

Start the SOLIDO application and load the STL files for the insulator and the bracket in the **Block window**:

- Switch Type to STL and select an STL file by double clicking in the column 'STL File'
- Add a new row: *Edit* → *Insert After* or press  <Insert>.
- Assign the corresponding material properties by changing the colour reference number, and modify the thermal conductivity in the **Colours window** if needed.
- bracket = 8 (aluminium) and insulator = 41 (PVC)

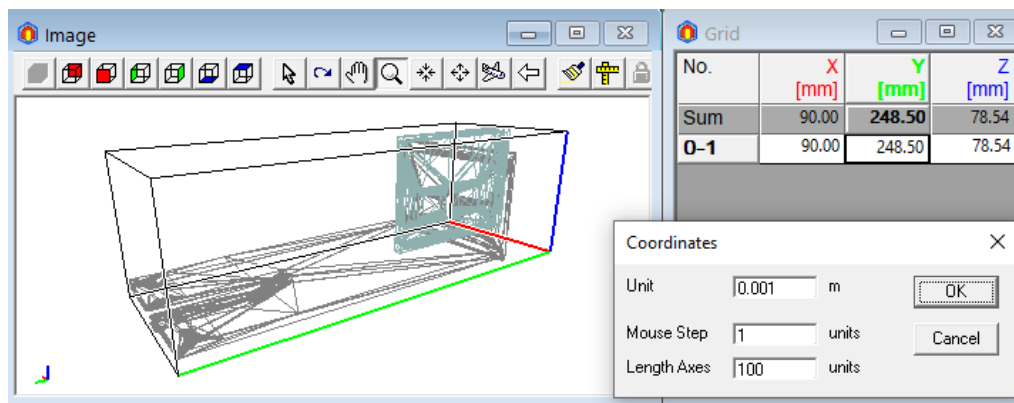
Note I: when the name of the STL file starts with the colour reference number, this colour will automatically be assigned in SOLIDO (e.g. 8\_bracket.stl results in colour index 8 which is aluminium)

Note II: multiple STL files can be imported in a single step.



Verify the model's scale:

- Activate the **Grid window** (*Edit* → *Grid Window*)
- Create minimum grid around the imported STL files: *Grid* → *Minimum Grid...*
- Adjust the grid unit to mm: *Settings* → *Coordinates...* :

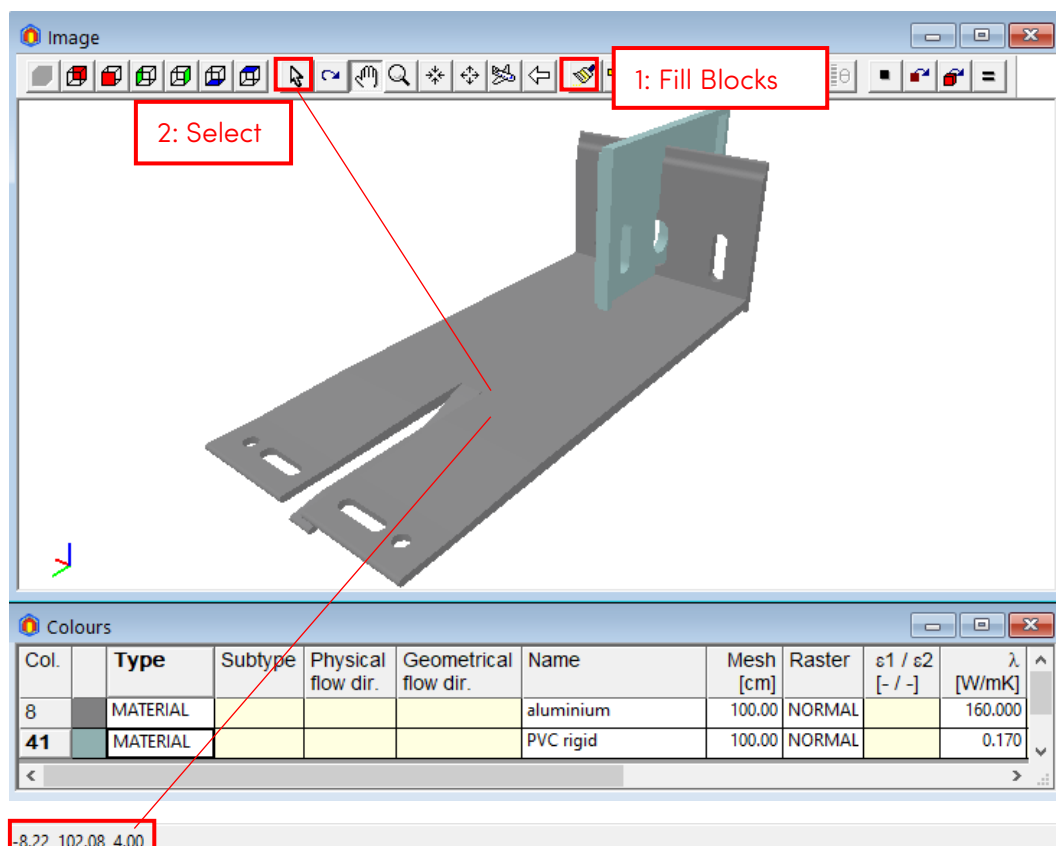


## Step 2: Positioning STL files

The STL files are positioned in SOLIDO according to the coordinates defined in the STL file itself. In most cases, the STL files will have been created within the same project using a SOLID modelling tool (e.g. SolidWorks, Rhino, Inventor, etc.), and no further manipulation will be required in SOLIDO. However, the purpose of this tutorial is specifically to discuss the block translation functions in SOLIDO. Therefore, two STL files have been selected that are not correctly positioned relative to each other and consequently require manipulation.

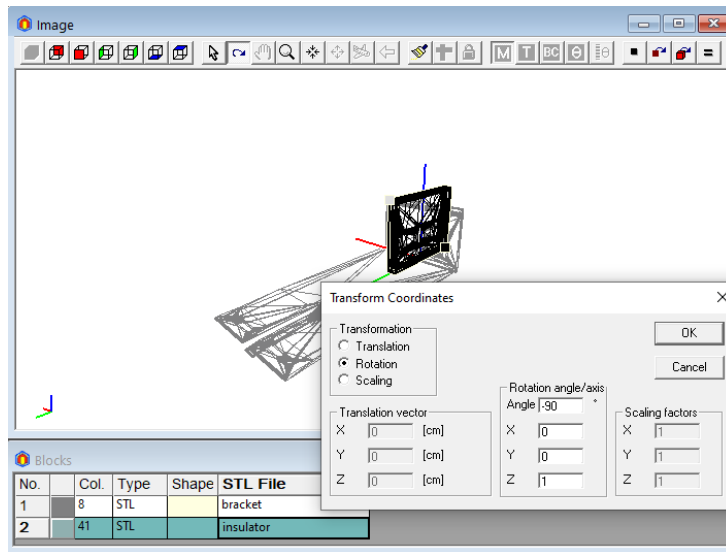
In this case, those coordinates are not suitable for direct use.

- o To visualise the surfaces: *Image* → *Fill blocks* or  click
- o Now switch to select mode. When you move the mouse over the object in the *Image* window, the coordinates (relative to the origin) are shown in the status bar:



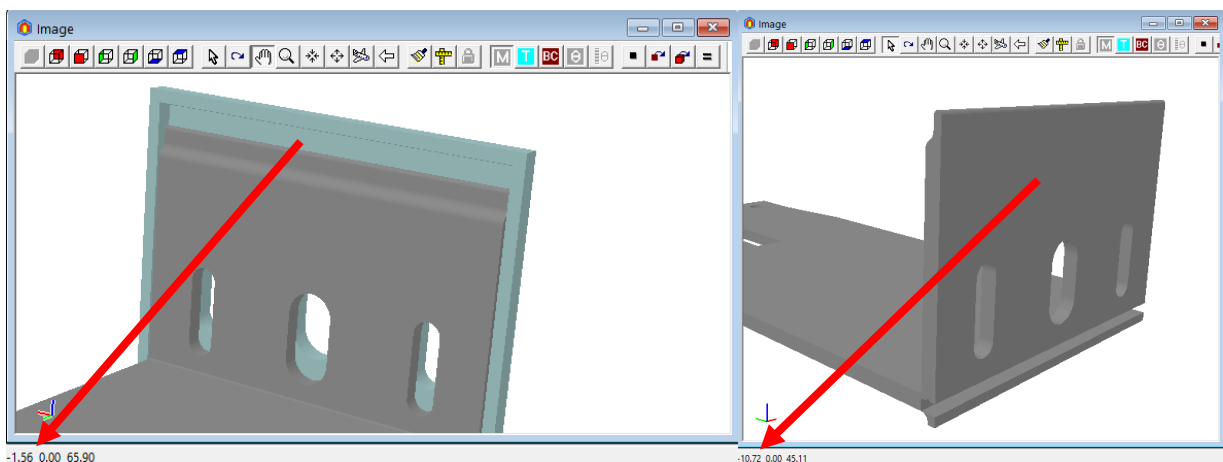
Based on this information, the STL files can be transformed to the correct position.

- Right click with the mouse on the insulator in the **Image window** (selection mode) or select the insulator in the **Block window**.
- To rotate the insulator 90°: *Block* → *Transform Coordinates...* ( or press 'Ctrl + F') and select Rotation, -90° around Z-axis:



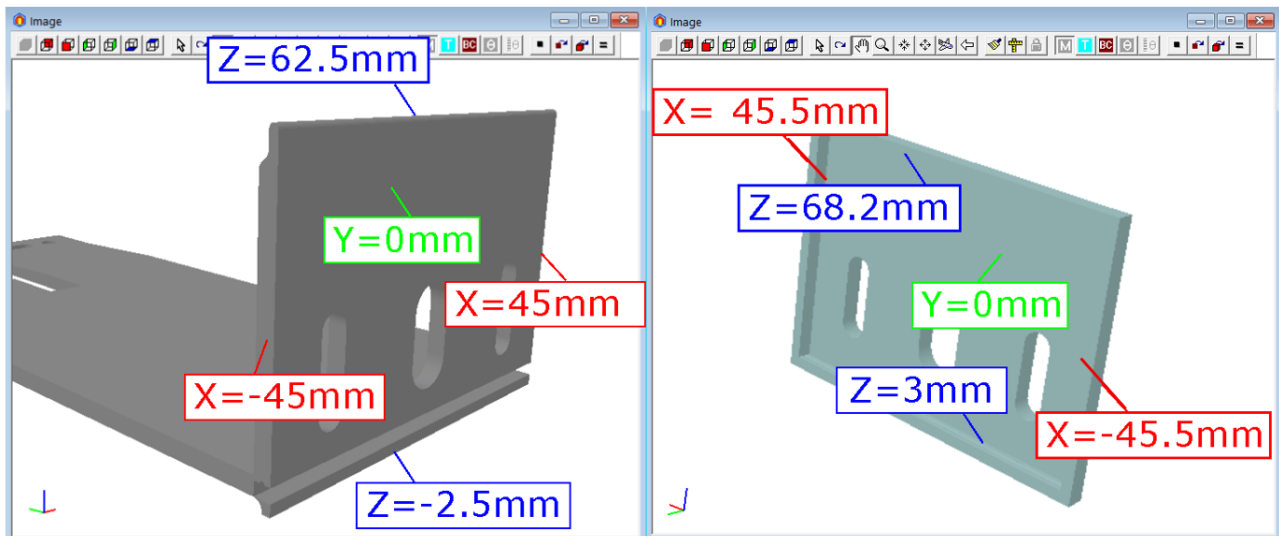
To verify the position of the insulator in reference to the bracket:

- Visualise the surfaces: *Image* → *Fill blocks* or click 
- Check the Y-position of the front side of the insulator by moving the mouse over the STL geometry: Y=0 mm
- Check the Y-position of the back side of the bracket: Y = 0 mm
- First hide the insulator in order to reach the back of the bracket:
  - *Edit* → *Clip Colour* and hide colour 8 (=bracket) or using 
  - Rotate the model and verify the Y-position
- This means that the front of the insulator (Y position) lies in the same plane as the back of the bracket. Only a translation in X and Z is required.



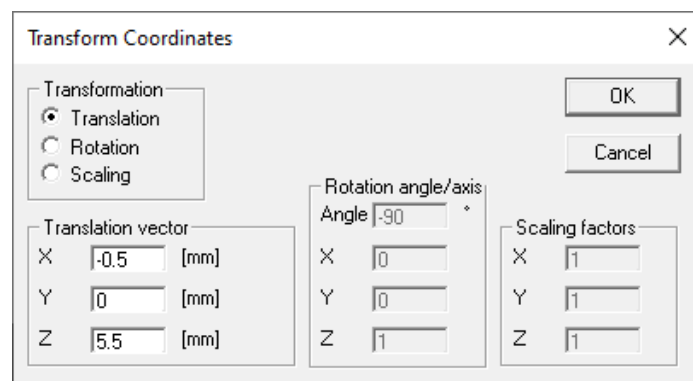
Note: In the **Image window** the wire model is shown for the selected block. To hide the geometry outlines of the selection: *Image* → *Hide Outline* (press <Ctrl + H>)

- Repeat the same steps to define the X and Z edges of the insulation and bracket:

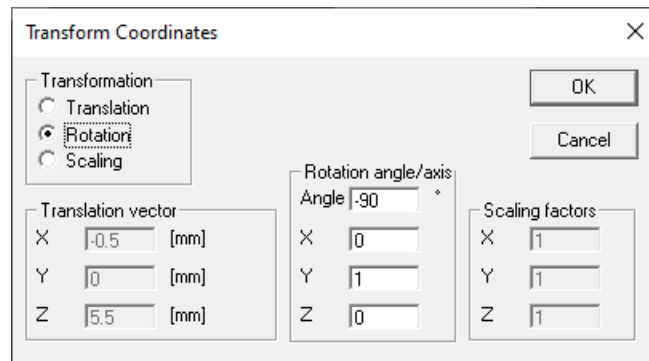


From this information it can be derived that the bracket needs to be transformed in X with -0.5 mm and Z with 5.5 mm.

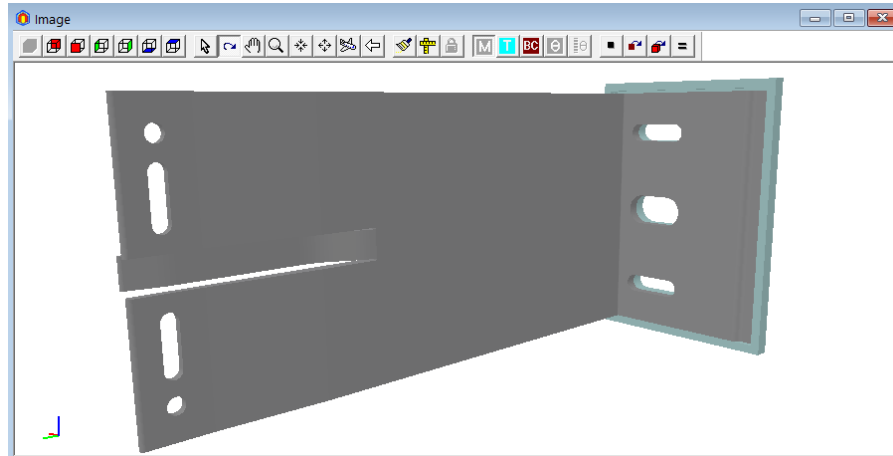
- Select the bracket
- *Block* → *Transform Coordinates...* ( or press 'Ctrl + F')
- Apply following transformation:



- Thereafter, select in the **Block window** both the bracket and insulator and rotate 90° around the Y-axis:
  - Select the corresponding row in the Block window, and
  - *Edit* → *Switch select*, or press <Ctrl + L>, or click 
  - Repeat for the second block
  - *Block* → *Transform Coordinates...* ( or press 'Ctrl + F')
  - Apply following transformation:

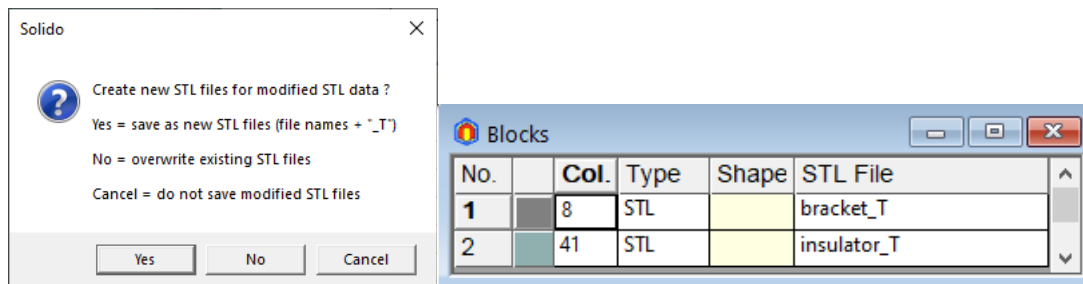


The final result (after filling the blocks) is then:



When saving the project a dialog box will appear giving the choice to either overwrite the original STL files or create new STL files (with the adjusted coordinates).

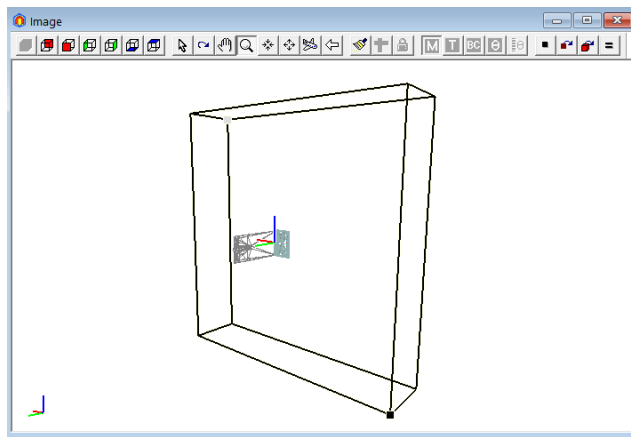
- o *File* → *Save*: select 'yes' to create new STL files



#### 4. Entering the other wall data via SOLIDS

Concrete layer: 20cm

- o Enter a new block by selecting *Edit* → *Insert After*. 
- o Switch the colour number to 120 (concrete) (and leave Type = SOLID, Shape = RECT)
- o Adjust the geometry in the **Block Points window** to the following result:



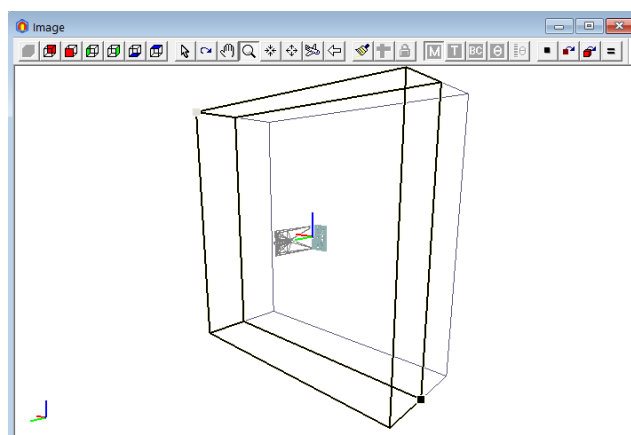
| Block Points |           |           |           |
|--------------|-----------|-----------|-----------|
| Point        | X<br>[mm] | Y<br>[mm] | Z<br>[mm] |
| Black        | -500.00   | -5.00     | -500.00   |
| Grey         | 500.00    | -205.00   | 500.00    |

| Blocks |      |       |       |             |
|--------|------|-------|-------|-------------|
| No.    | Col. | Type  | Shape | STL File    |
| 1      | 8    | STL   |       | bracket_T   |
| 2      | 41   | STL   |       | insulator_T |
| 3      | 120  | SOLID | RECT  |             |

### Insulation layer: 16cm

SOLIDO applies the superposition principle for its blocks: when overlap occurs, the row with the highest number has the highest priority. The insulation should have a lower priority than the bracket.

- o Select the first row in the **Block window** and insert a new block above it by selecting *Edit* → *Insert Before*.
- o Switch the colour number to 151 (and leave Type = SOLID, Shape = RECT)
- o Adjust the geometry in the **Block Points window** to the following result:



| Block Points |           |           |           |
|--------------|-----------|-----------|-----------|
| Point        | X<br>[mm] | Y<br>[mm] | Z<br>[mm] |
| Black        | -500.00   | -5.00     | -500.00   |
| Grey         | 500.00    | 190.00    | 500.00    |

| Blocks |      |       |       |             |
|--------|------|-------|-------|-------------|
| No.    | Col. | Type  | Shape | STL File    |
| 1      | 151  | SOLID | RECT  |             |
| 2      | 8    | STL   |       | bracket_T   |
| 3      | 41   | STL   |       | insulator_T |
| 4      | 120  | SOLID | RECT  |             |

### Cladding: 1cm

- o Enter a new block by selecting *Edit* → *Insert After*.
- o Switch the colour number to 26 (ceramic tiles) (and leave Type = SOLID, Shape = RECT)
- o Adjust the geometry in the **Block Points window** to the following result:

| Block Points |           |           |           |
|--------------|-----------|-----------|-----------|
| Point        | X<br>[mm] | Y<br>[mm] | Z<br>[mm] |
| Black        | -500.00   | 220.00    | -500.00   |
| Grey         | 500.00    | 230.00    | 500.00    |

| Blocks |      |       |       |             |
|--------|------|-------|-------|-------------|
| No.    | Col. | Type  | Shape | STL File    |
| 1      | 151  | SOLID | RECT  |             |
| 2      | 26   | SOLID | RECT  |             |
| 3      | 8    | STL   |       | bracket_T   |
| 4      | 41   | STL   |       | insulator_T |

## L-profile

- Repeat the same steps to enter the L-profile supporting the cladding (two parts). Select row 5 and insert two rows after:

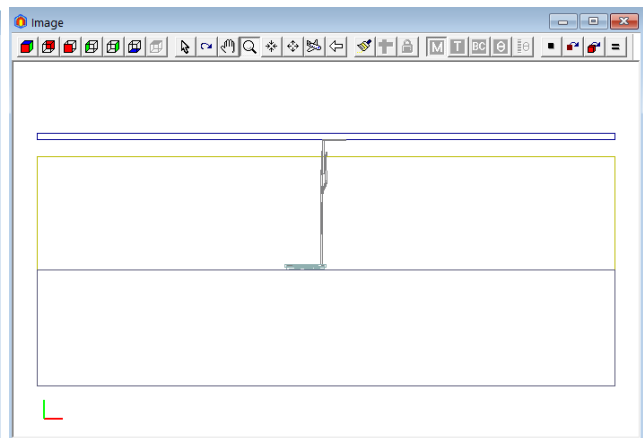
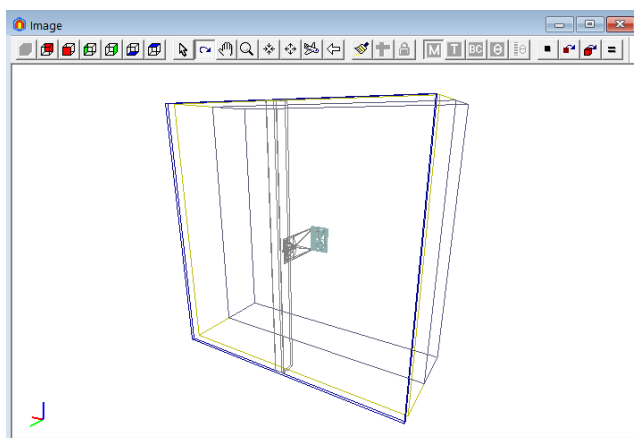
| Block Points |           |           |           |
|--------------|-----------|-----------|-----------|
| Point        | X<br>[mm] | Y<br>[mm] | Z<br>[mm] |
| Black        | -5.50     | 160.00    | -500.00   |
| Grey         | -3.50     | 220.00    | 500.00    |

| Blocks |      |       |       |             |
|--------|------|-------|-------|-------------|
| No.    | Col. | Type  | Shape | STL File    |
| 1      | 151  | SOLID | RECT  |             |
| 2      | 26   | SOLID | RECT  |             |
| 3      | 8    | STL   |       | bracket_T   |
| 4      | 41   | STL   |       | insulator_T |
| 5      | 120  | SOLID | RECT  |             |
| 6      | 8    | SOLID | RECT  |             |

| Block Points |           |           |           |
|--------------|-----------|-----------|-----------|
| Point        | X<br>[mm] | Y<br>[mm] | Z<br>[mm] |
| Black        | -5.50     | 218.00    | -500.00   |
| Grey         | 34.50     | 220.00    | 500.00    |

| Blocks |      |       |       |             |
|--------|------|-------|-------|-------------|
| No.    | Col. | Type  | Shape | STL File    |
| 1      | 151  | SOLID | RECT  |             |
| 2      | 26   | SOLID | RECT  |             |
| 3      | 8    | STL   |       | bracket_T   |
| 4      | 41   | STL   |       | insulator_T |
| 5      | 120  | SOLID | RECT  |             |
| 6      | 8    | SOLID | RECT  |             |
| 7      | 8    | SOLID | RECT  |             |

The resulting geometry: in perspective view (left) and top view (right):



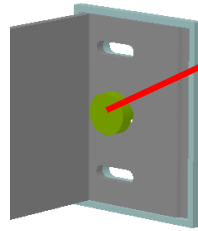
## Screw

- Enter a new block by selecting *Edit* → *Insert After*.
- Switch the colour number to 11 (stainless steel) (and leave Type = SOLID).
- Switch the Shape to CYL

By default the resulting cylinder will be vertical. To switch its base:

- Activate the **Block Points window** by clicking in a field.
- Blocks* → *Switch Base*
- Adjust the mesh fineness in the **Blocks window** to 1 mm
- Adjust the geometry in the **Block Points window** to the following result and repeat steps for the screw head:

| Blocks |      |       |       |             |        |           |
|--------|------|-------|-------|-------------|--------|-----------|
| No.    | Col. | Type  | Shape | STL File    | Enable | Mesh [mm] |
| 1      | 151  | SOLID | RECT  |             | YES    | 100.00    |
| 2      | 26   | SOLID | RECT  |             | YES    | 100.00    |
| 3      | 8    | STL   |       | bracket_T   | YES    | 100.00    |
| 4      | 41   | STL   |       | insulator_T | YES    | 100.00    |
| 5      | 120  | SOLID | RECT  |             | YES    | 100.00    |
| 6      | 8    | SOLID | RECT  |             | YES    | 100.00    |
| 7      | 8    | SOLID | RECT  |             | YES    | 100.00    |
| 8      | 11   | SOLID | CYL   |             | YES    | 1.00      |
| 9      | 11   | SOLID | CYL   |             | YES    | 1.00      |



| Block Points |        |        |        |
|--------------|--------|--------|--------|
| Point        | X [mm] | Y [mm] | Z [mm] |
| Black        | -35.00 | 4.00   | -10.00 |
| Red          | -35.00 | 4.00   | 10.00  |
| Green        | -15.00 | 4.00   | -10.00 |
| Blue         | -35.00 | 10.00  | -10.00 |

| Block Points |        |        |        |
|--------------|--------|--------|--------|
| Point        | X [mm] | Y [mm] | Z [mm] |
| Black        | -30.00 | -96.00 | -5.00  |
| Red          | -30.00 | -96.00 | 5.00   |
| Green        | -20.00 | -96.00 | -5.00  |
| Blue         | -30.00 | 4.00   | -5.00  |

Note:

The screw is modelled here as two cylinders, increasing the model's complexity (and thus the number of calculation nodes). It can be shown that modelling the screw as a rectangular block (with the area of the circle equal to the area of the square) is justified. For more information refer to the Physibel Knowledge base document: [S4 - Tips and tricks, Section 1: Meshing in SOLIDO](#)

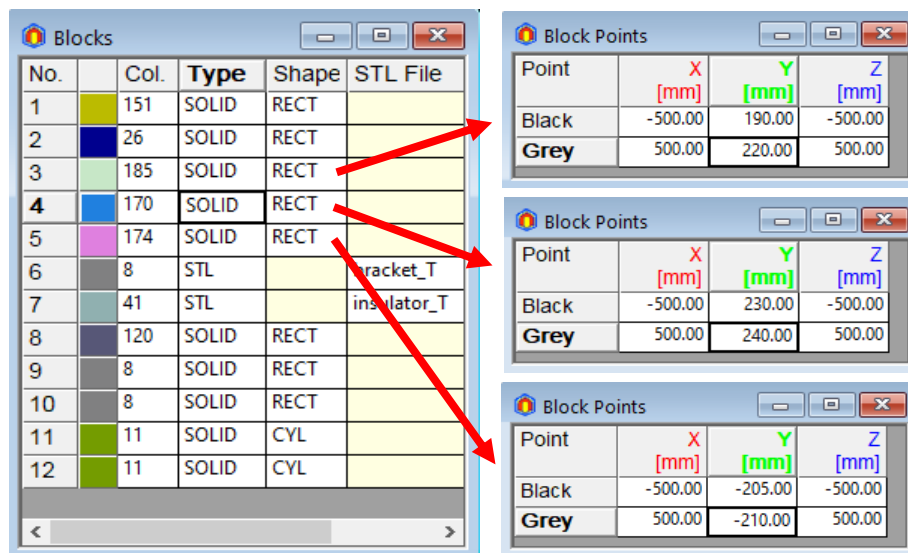
## 5. Adding boundary conditions to the model

This example has 3 boundary conditions for which the Colour type BC\_SIMPL will be used:

- Interior condition: 20°C, global surface coefficient  $h = 7.7 \text{ W/m}^2\text{K}$  (Colour 174)
- Exterior conditions: 0°C, global surface coefficient  $h = 25 \text{ W/m}^2\text{K}$  (Colour 170)
- Highly ventilated cavity: 0°C, global surface coefficient  $h = 7.7 \text{ W/m}^2\text{K}$  (Colour 185)

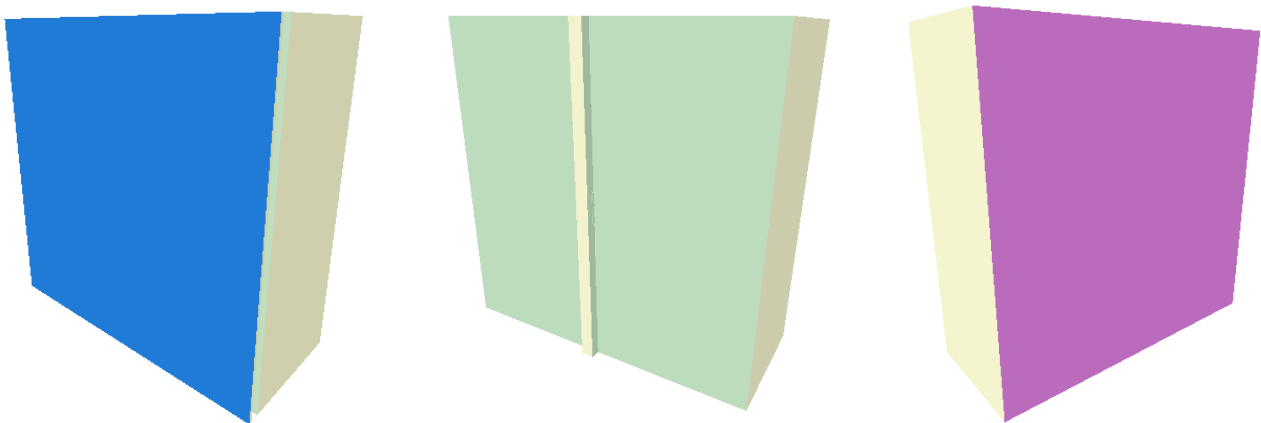
Boundary conditions are defined via blocks in the same way as materials. Because of the superposition principle, the highly ventilated cavity should be defined in the **Block window** before the bracket and insulator.

- o Activate the second row in the **Block window** (cladding) by clicking with the mouse, then enter a new block by selecting *Edit → Insert After*. 
- o Switch the colour number to 185 (highly ventilated cavity) (and leave Type = SOLID, Shape = RECT) and define its position in the **Block Points window** (see figure below).
- o Select the new block in the **Block window** by clicking with the mouse and copy the block via *Blocks → Copy After*. The coordinates from the previous block are copied; they only need adjustment in the Y-direction and a change of colour code:



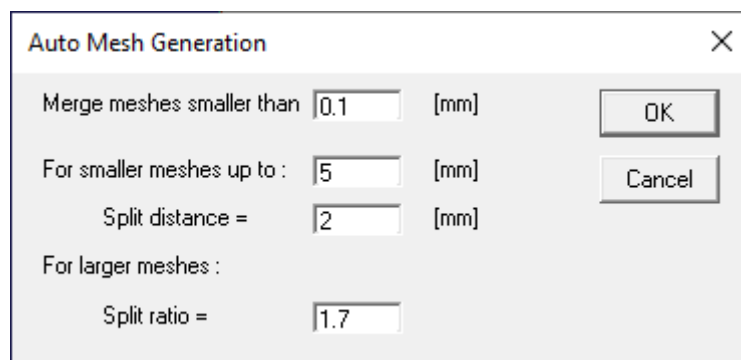
To see the boundary conditions:

- o Visualise the surfaces: *Image* → *Fill blocks* or click
- o *Image* → *Show BCs* or click



## 6. Discretisation of calculation grid

- o Use the automatic grid generation function with the following settings: *Grid* → *Auto Grid Generation*:



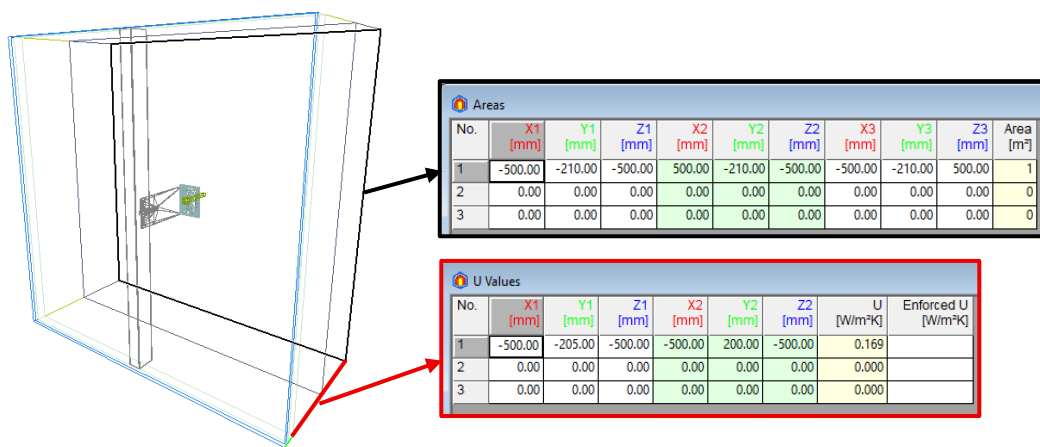
This results in a mesh with 885 630 calculation nodes.

Note: for a more detailed discussion of grid splitting, refer to [SOLIDO Manual](#).

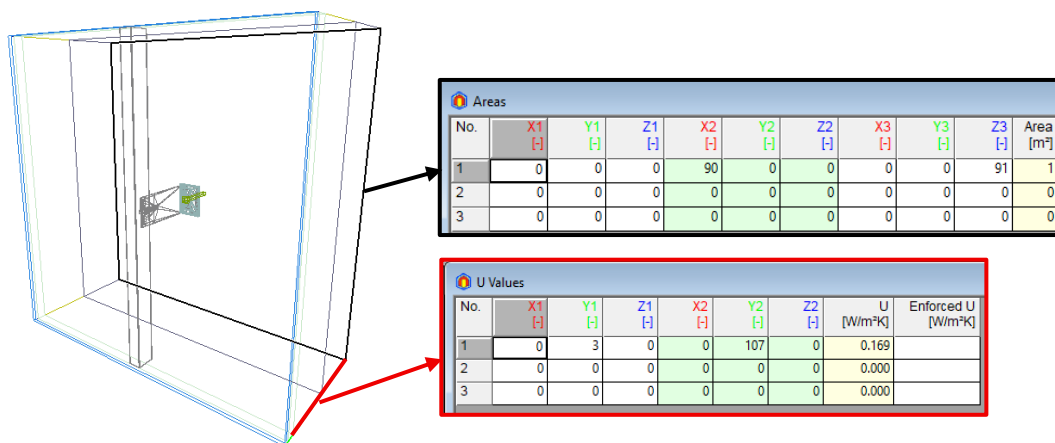
## 7. Set-up derived thermal properties

The desired thermal output is the point thermal transmittance ( $\chi$ -value, W/K) and the equivalent thermal transmittance ( $U_{eq}$ , W/m<sup>2</sup>K).

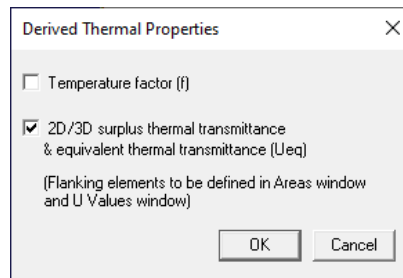
- To define the component's area: *Edit* → *Areas* and define the area via 3 points (see figure below)
- To define the  $U_{1D}$ -value of the wall (without bracket): *Edit* → *U values* and define the 1D  $U$ -value between 2 points (see figure below)



Alternatively, points can be located by grid number instead of by coordinate via *Block* → *Grid Number Coordinates*.



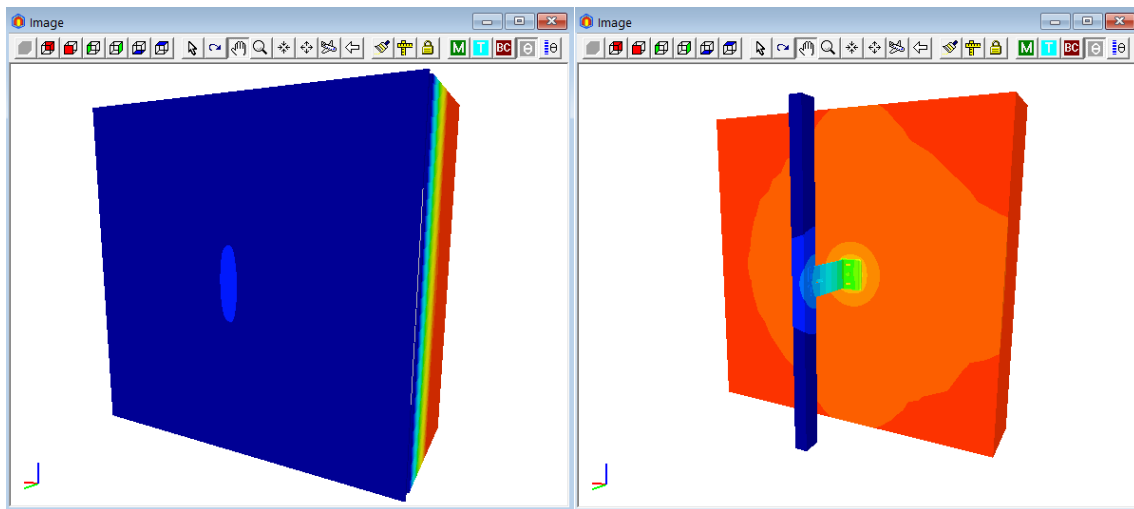
- Select the desired derived thermal output: *Edit* → *Derived Thermal Properties...* :



## 8. System calculation

- Start the calculation: *Calc* → *Calc*  *System*.

The calculated temperatures are shown in the **Image window**.



- Move the mouse cursor over the object in the **Image window** to see (in the status bar, at the bottom of the screen) the temperature at the mouse cursor position. (This requires the Image window to be active.)

Detailed output results can be explored in the **Graphic Output window** and **Text Output window**.

## 9. Results

In the **Text Output window** the following results can be found:

- $U_{eq} = 0.252 \text{ W/m}^2\text{K}$
- $\chi\text{-value} = 0.083 \text{ W/K}$  (indicated as dL in the text output)

```
2D/3D surplus thermal transmittance
dL = Q/(ti-te) - U1*A1 - U2*A2 - U3*A3 = 0.083 W/K
Equivalent thermal transmittance
Ueq = Q/((ti-te)*(A1+A2+A3)) = 0.252 W/(m².K)
Q = 5.033 W
ti = 20.00°C
te = 0.00°C
U1 = 0.169 W/(m².K)
X1=-500.00 Y1=-205.00 Z1=-500.00
X2=-500.00 Y2=200.00 Z2=-500.00
A1 = 1.00 m²
X1=-500.00 Y1=-210.00 Z1=-500.00
X2=500.00 Y2=-210.00 Z2=-500.00
X3=-500.00 Y3=-210.00 Z3=500.00
```