Faculty of Applied Sciences
ArGEnCo Department (Architecture, Geology, Environment & Constructions) – Sector Arkhê (Architecture)
Laboratory of Architecture: Performances & Techniques (LAP&T)
Director: Dr. Eng. Jean-Marie HAUGLUSTAINE, Associate Professor

Cold bridges on the building site of the European Bank of Investment at Luxemburg – Report 07

I the undersigned,

Jean-Marie HAUGLUSTAINE, civil engineer in architecture, doctor in applied sciences, Associate Professor at the ArGEnCo Department (Architecture, Geology, Environment and Construction) of the University of Liège,

Director of the Laboratory of Architecture: Performances & Techniques,

have been put in charge by the Joint venture CFE-VINCI, of assessing the cold bridges identified on the building site and of studying the ways to reduce their importance.

The present report is devoted to the following cold bridge study:

- The wall connection between the bank and the alley to the cafeteria.
- The report also contains a short analysis of two different kinds of windows.

This report includes this flyleaf and 59 pages of calculations and conclusions.

So written in LIEGE, the 27th of February, 2008,

J.-M. HAUGLUSTAINE.

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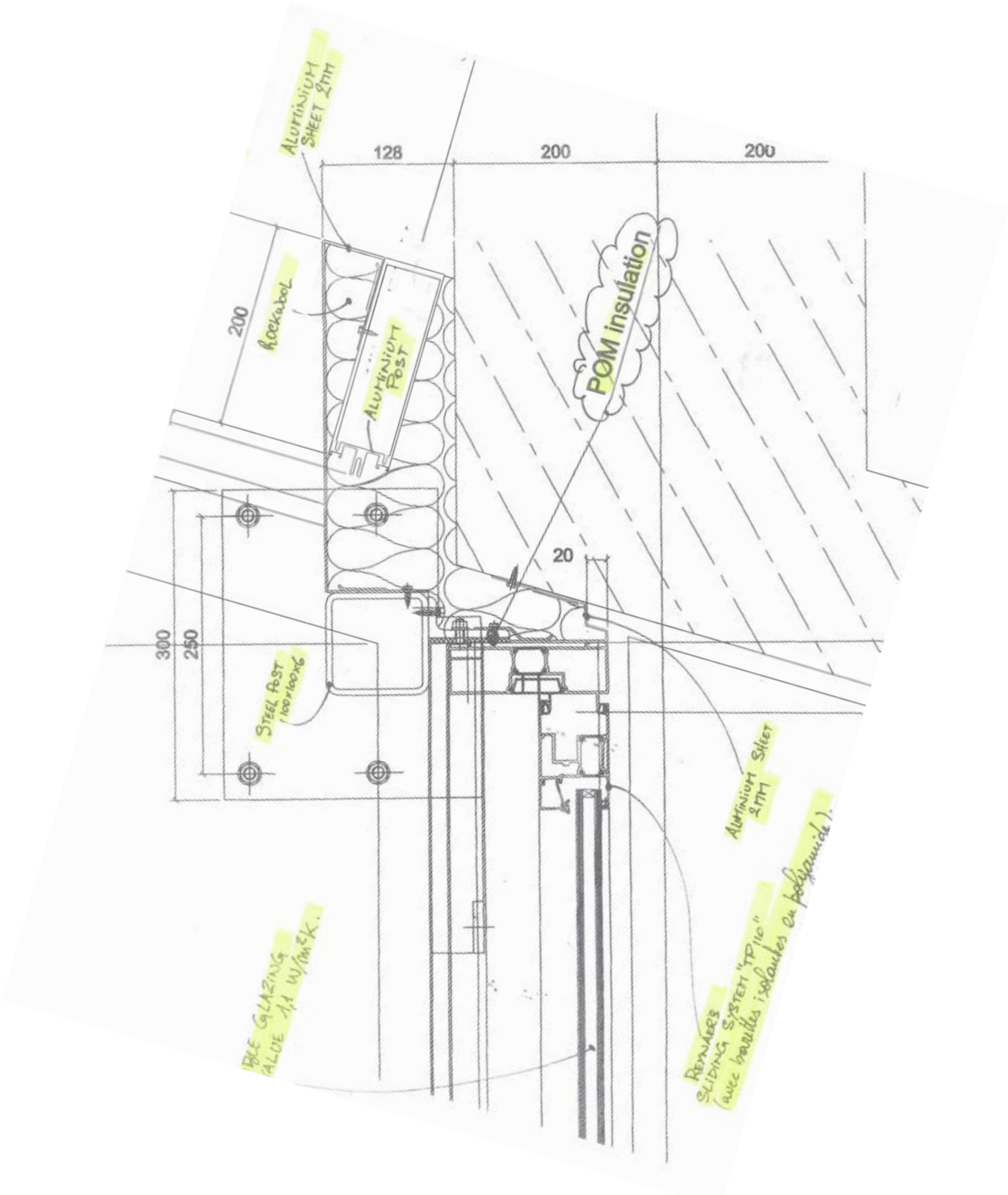
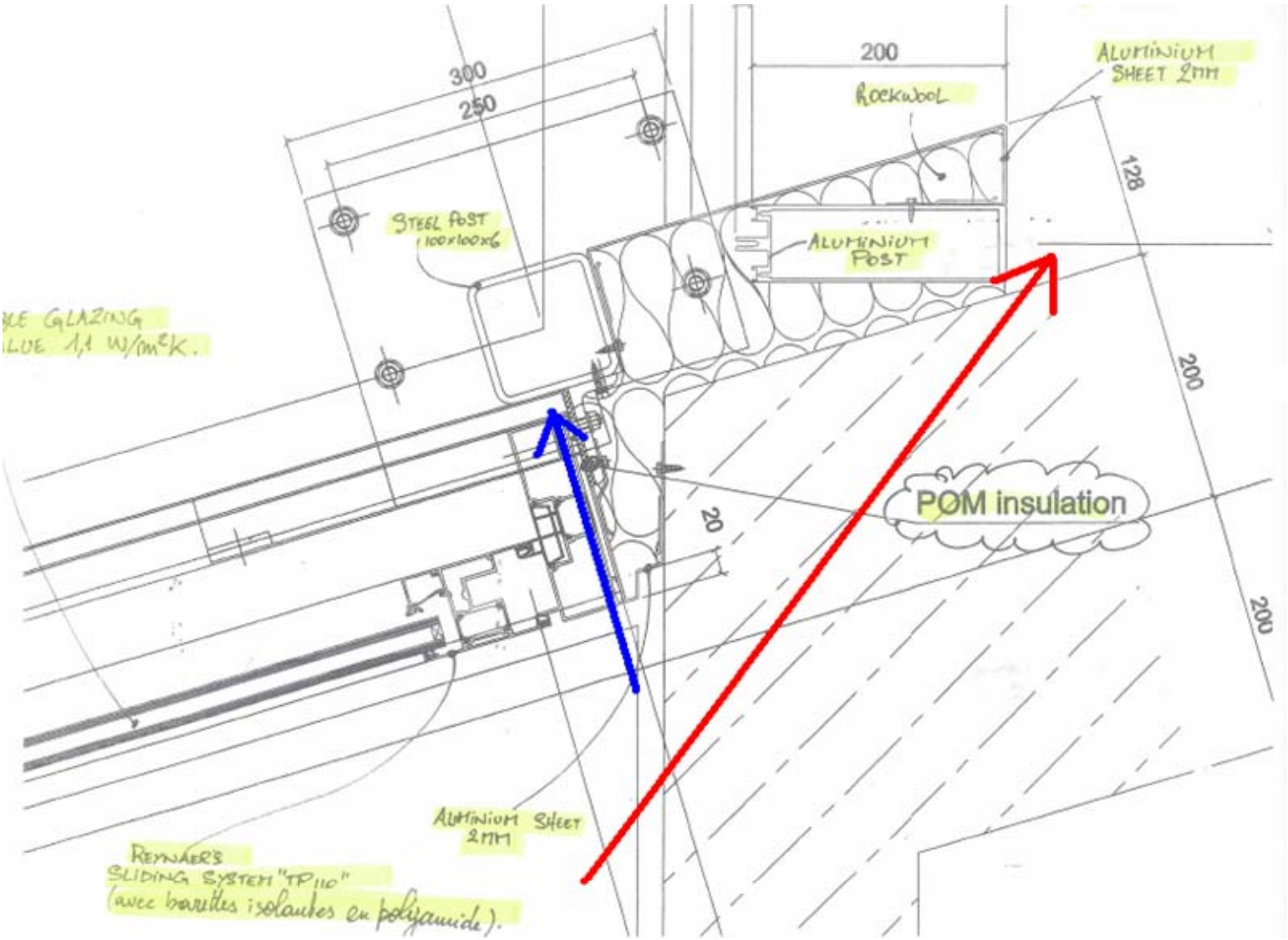
STUDY OF THERMAL BRIDGES – REPORT 04

1. Wall connection between the cafeteria and the alley to exist

1.1. First analysis, fictive material

1.1.1 Input data:

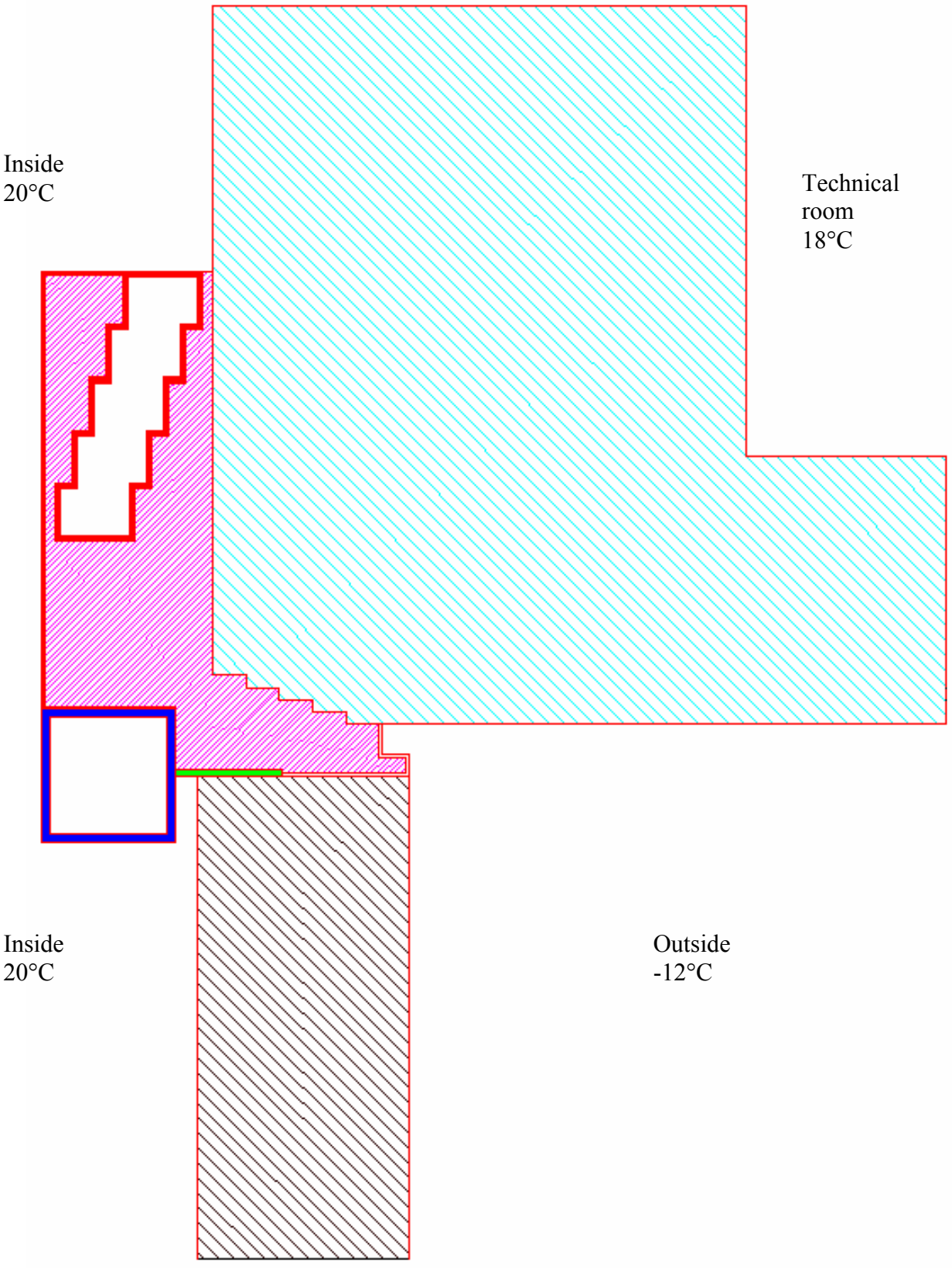




The main concern about this situation seemed to be the red arrow: it translates the possibility of a thermal bridge through the non insulated reinforced concrete wall, which was to be modeled and studied. But a quick look at the sketch made us realize that it may not be the main concern: the blue arrow shows the location of a weakness in the thermal insulation which should also be taken care of.

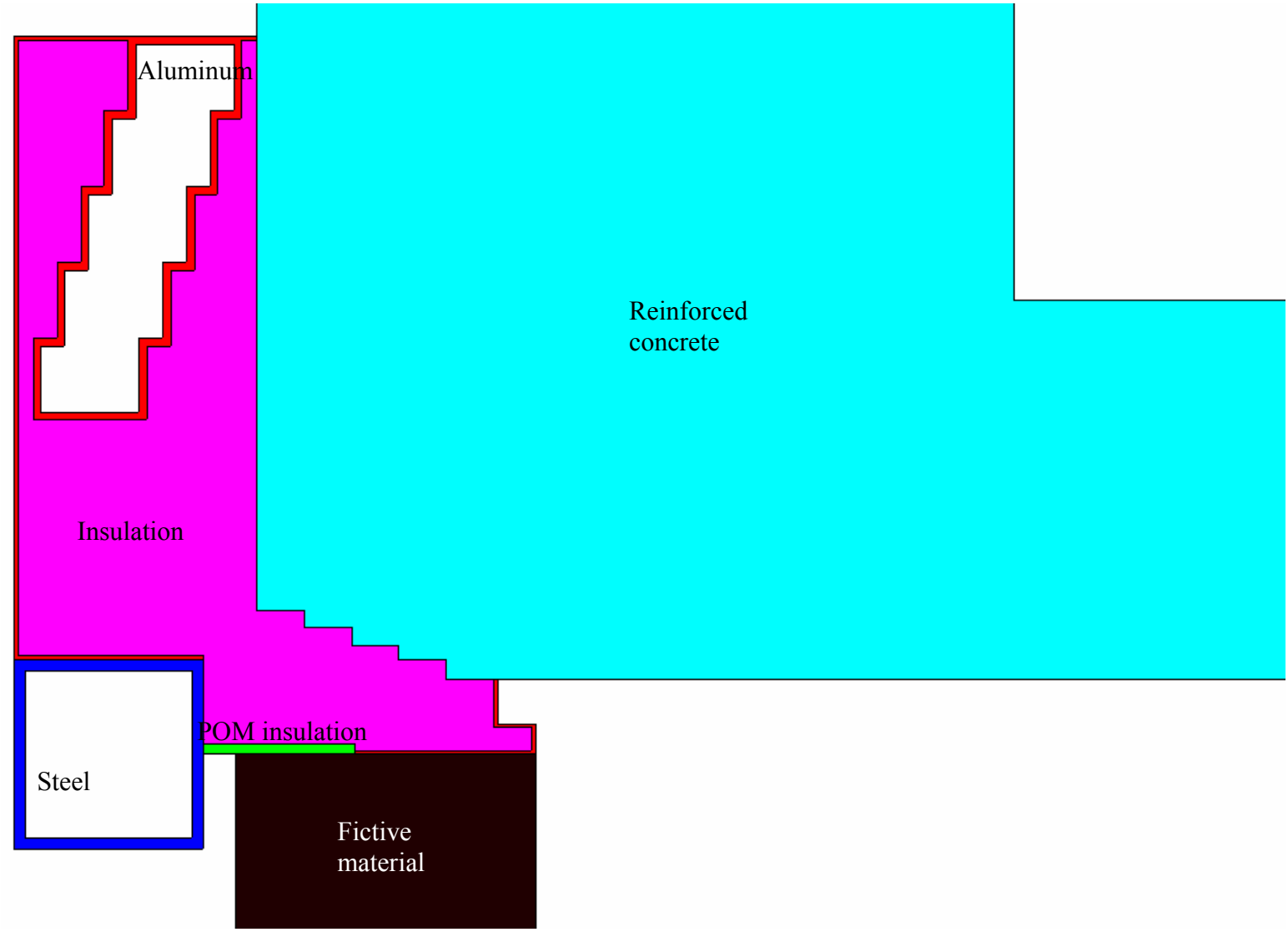
Indeed, the “red” thermal bridge has to go through at least 30 centimeters of reinforced concrete (which thermal conductivity is 1.7 W/mK), whereas the “blue” one has just to go through 15 centimeters of aluminum (which thermal conductivity is about 200 W/mK), and a little bit of a thermal insulation (POM insulation, λ = 0,31 W/mK).

Horizontal section (simulation)



Hypotheses:

- Trisco does not allow modeling a non orthogonal structure. This, in consequence, obliged to model a stair-shaped steel frame, to respect the inside volumes and to get as close as possible to the real external exchange surfaces.
- The lambda values used in this model are all coming from the Trisco data base (from the Belgian standard NBN B62-002 or from the Physibel data base).
- The temperatures used are 20°C inside (h = 8), -12°C outside (h = 20), and 18°C in the technical room.

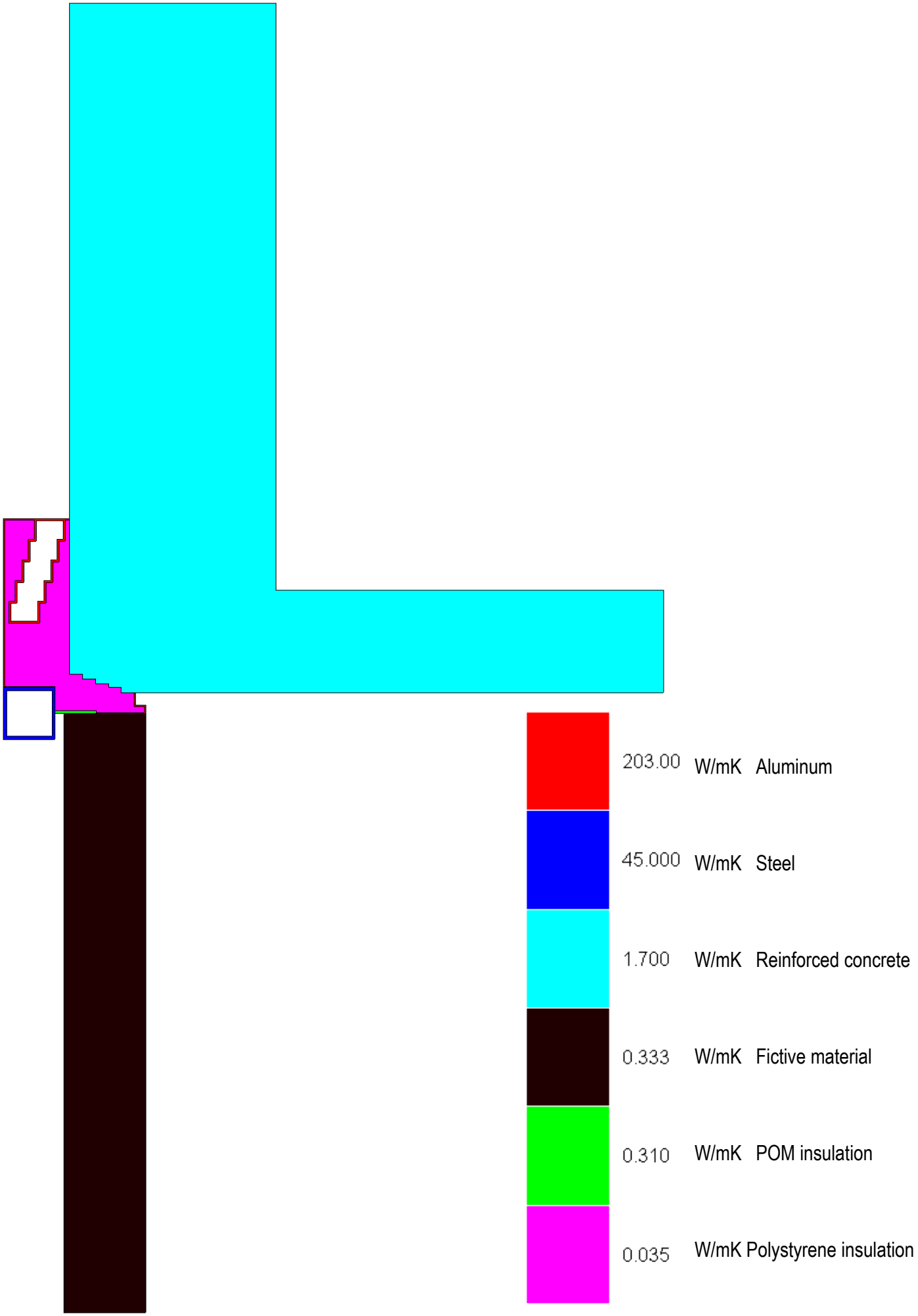


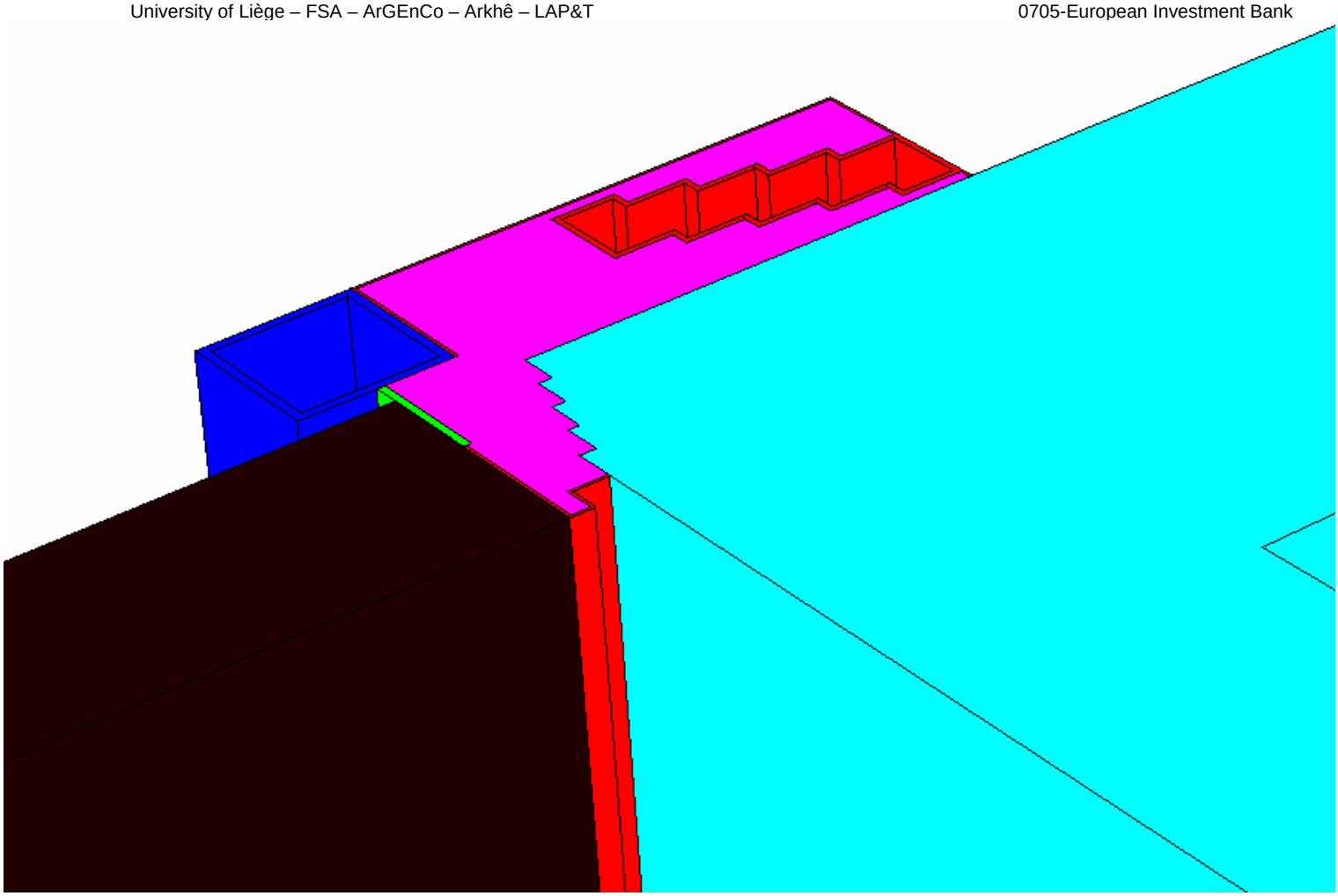
Note: For a first sketch and a first model, we have decided not to model the window. This decision has two goals: first, modeling the window would be difficult; and, for a first model, the goal is to see where the main problems occur. That is why we have created a "fictive material" according to this principle:

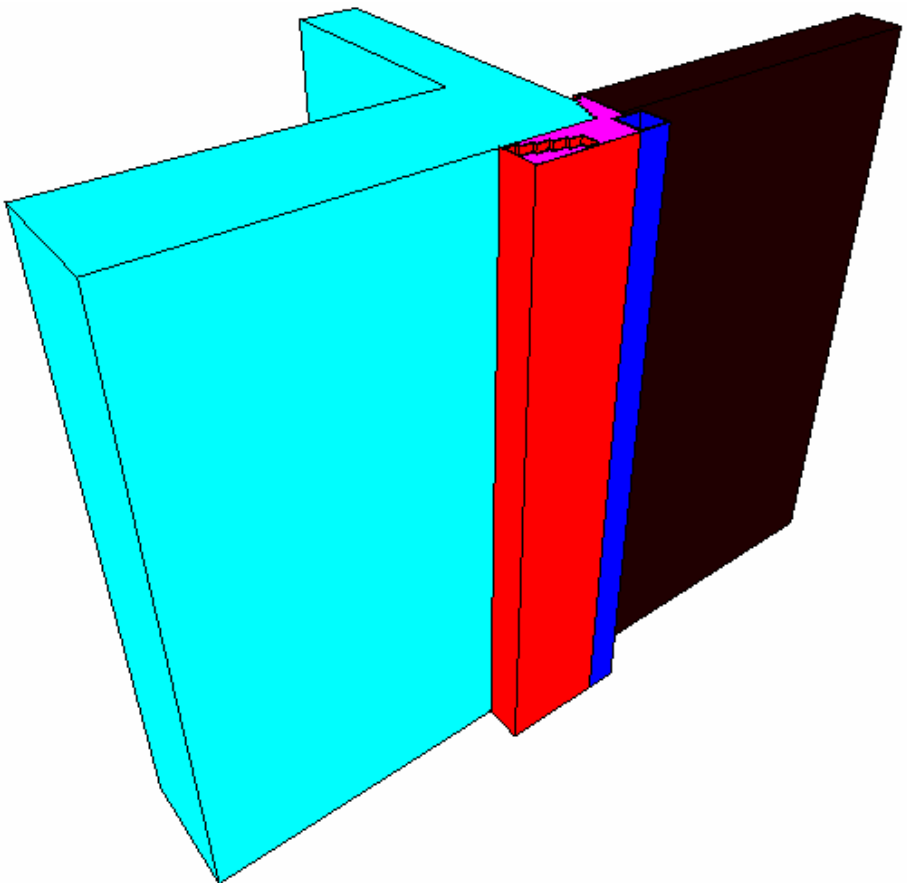
- The window is this one: an aluminum frame and a double glass sheet with argon gas inside. This gives us a total thermal transmission coefficient U for the window of: U_w = 2.108W/m²K.
- The thermal resistance associated is then R = 1/U = 0,4744 m²K/W

Knowing that the Trisco program only allows us to give a λ value for each material, the lambda value (thermal conductivity of the fictive material) depends on the given thickness: for a 15.8 centimeters thickness, as it is given in the sketch, we have a λ value of: λ = e/R = 0.333 W/mK,.

This case could be studied in a two dimension analysis. Trisco is a 3D program, which is why the sketch has simply been extruded to reach 2 meters high.


203.00 W/mK Aluminum
45.000 W/mK Steel
1.700 W/mK Reinforced concrete
0.333 W/mK Fictive material
0.310 W/mK POM insulation
0.035 W/mK Polystyrene insulation





Data

TRISCO data file: first model.trc

GRID
Grid unit = 0.01 m

No.	X	Y	Z
0-1	10.000	5.000	5.000
1-2	0.200	5.000	5.000
2-3	0.400	5.000	5.000
3-4	0.400	5.000	5.000
4-5	0.400	5.000	5.000
5-6	0.850	5.000	5.000
6-7	0.400	5.000	5.000
7-8	0.850	5.000	5.000
8-9	0.400	5.000	5.000
9-10	0.850	5.000	5.000
10-11	0.400	5.000	5.000
11-12	0.850	5.000	5.000
12-13	0.400	5.000	5.000
13-14	0.200	5.000	5.000
14-15	0.400	5.000	5.000
15-16	0.850	5.000	5.000
16-17	0.400	5.000	5.000
17-18	0.850	5.000	5.000
18-19	0.300	5.000	5.000
19-20	0.100	5.000	5.000
20-21	0.500	0.200	5.000
21-22	0.350	0.600	5.000
22-23	0.400	1.000	5.000
23-24	0.850	1.200	5.000
24-25	0.100	0.200	5.000
25-26	0.300	3.800	5.000
26-27	0.100	0.200	5.000
27-28	0.700	2.000	5.000
28-29	2.300	1.000	5.000
29-30	0.200	1.000	5.000
30-31	2.500	0.200	5.000
31-32	0.200	0.400	5.000
32-33	0.200	1.300	5.000
33-34	2.100	0.200	5.000
34-35	0.300	1.300	5.000
35-36	0.200	0.200	5.000
36-37	0.500	0.800	5.000
37-38	0.200	0.200	5.000
38-39	1.300	0.400	5.000
39-40	0.200	0.200	5.000
40-41	0.200	0.300	
41-42	1.100	0.900	
42-43	0.200	0.200	
43-44	0.200	2.350	
44-45	0.600	0.460	
45-46	0.200	0.440	
46-47	0.800	0.160	
47-48	0.200	0.200	
48-49	0.100	0.540	
49-50	0.700	0.900	
50-51	0.200	0.900	
51-52	5.300	5.040	
52-53	5.000	5.030	
53-54	5.000	0.400	

54-55	5.000	3.500	
55-56	5.000	0.400	
56-57	5.000	2.030	
57-58	5.000	1.570	
58-59	5.000	0.400	
59-60	5.000	3.600	
60-61	5.000	0.400	
61-62	5.000	3.600	
62-63	5.000	0.400	
63-64	5.000	3.500	
64-65	5.000	0.200	
65-66	5.000	0.200	
66-67	5.000	5.000	
67-68	5.000	5.000	
68-69	5.000	5.000	
69-70	5.000	5.000	
70-71	5.000	5.000	
71-72		5.000	
72-73		5.000	
73-74		5.000	
74-75		5.000	
75-76		5.000	
76-77		5.000	
77-78		5.000	
78-79		5.000	
79-80		5.000	
80-81		5.000	
81-82		5.000	
82-83		5.000	
83-84		5.000	
84-85		5.000	
85-86		5.000	
Sum	137.800	254.020	200.000

BLOCKS

No.	Col.	Xmin	Xmax	Ymin	Ymax	Zmin	Zmax
1	5	28	71	51	57	0	40
2	5	28	56	57	86	0	40
3	5	30	71	50	51	0	40
4	5	31	71	49	50	0	40
5	5	34	71	46	49	0	40
6	5	39	71	44	46	0	40
7	4	1	28	65	66	0	40
8	4	12	26	64	65	0	40
9	4	1	2	47	66	0	40
10	4	1	21	47	48	0	40
11	4	12	13	62	66	0	40
12	4	24	26	62	66	0	40
13	4	10	13	62	63	0	40
14	4	22	26	62	63	0	40
15	4	10	11	60	63	0	40
16	4	22	23	60	63	0	40
17	4	8	11	60	61	0	40
18	4	18	23	60	61	0	40
19	4	8	9	58	61	0	40
20	4	18	20	58	61	0	40
21	4	6	9	58	59	0	40
22	4	16	20	58	59	0	40
23	4	6	7	55	59	0	40
24	4	16	17	55	59	0	40
25	4	4	7	55	56	0	40

26	4	14	17	55	56	0	40
27	4	4	5	53	56	0	40
28	4	14	15	53	56	0	40
29	4	4	15	53	54	0	40
30	4	45	46	42	44	0	40
31	4	45	51	42	43	0	40
32	4	50	51	39	43	0	40
33	4	32	51	39	40	0	40
34	3	21	32	39	41	0	40
35	2	1	21	45	47	0	40
36	2	1	21	30	32	0	40
37	2	1	3	30	45	0	40
38	2	19	21	30	45	0	40
39	6	2	4	48	65	0	40
40	6	4	6	56	65	0	40
41	6	4	15	48	53	0	40
42	6	6	8	59	65	0	40
43	6	8	10	61	65	0	40
44	6	10	12	63	65	0	40
45	6	15	17	48	55	0	40
46	6	17	20	48	58	0	40
47	6	20	21	48	60	0	40
48	6	21	23	41	60	0	40
49	6	23	26	41	62	0	40
50	6	26	28	41	65	0	40
51	6	28	30	41	51	0	40
52	6	30	31	41	50	0	40
53	6	31	32	41	49	0	40
54	6	32	34	40	49	0	40
55	6	34	39	40	47	0	40
56	6	39	45	40	44	0	40
57	6	45	50	40	42	0	40
58	10	3	19	32	45	0	40
59	11	13	24	63	64	0	40
60	11	13	22	62	63	0	40
61	11	11	22	61	62	0	40
62	11	11	18	60	61	0	40
63	11	9	18	59	60	0	40
64	11	9	16	58	59	0	40
65	11	7	16	56	58	0	40
66	11	7	14	55	56	0	40
67	11	5	14	54	55	0	40
68	29	21	25	0	39	0	40
69	29	1	21	0	30	0	40
70	29	1	28	66	86	0	40
71	29	0	1	0	86	0	40
72	30	56	71	57	86	0	40
73	31	49	51	0	20	0	40
74	31	46	51	43	44	0	40
75	31	48	51	29	30	0	40
76	31	51	71	0	44	0	40
77	32	25	51	0	39	0	40

COLOURS

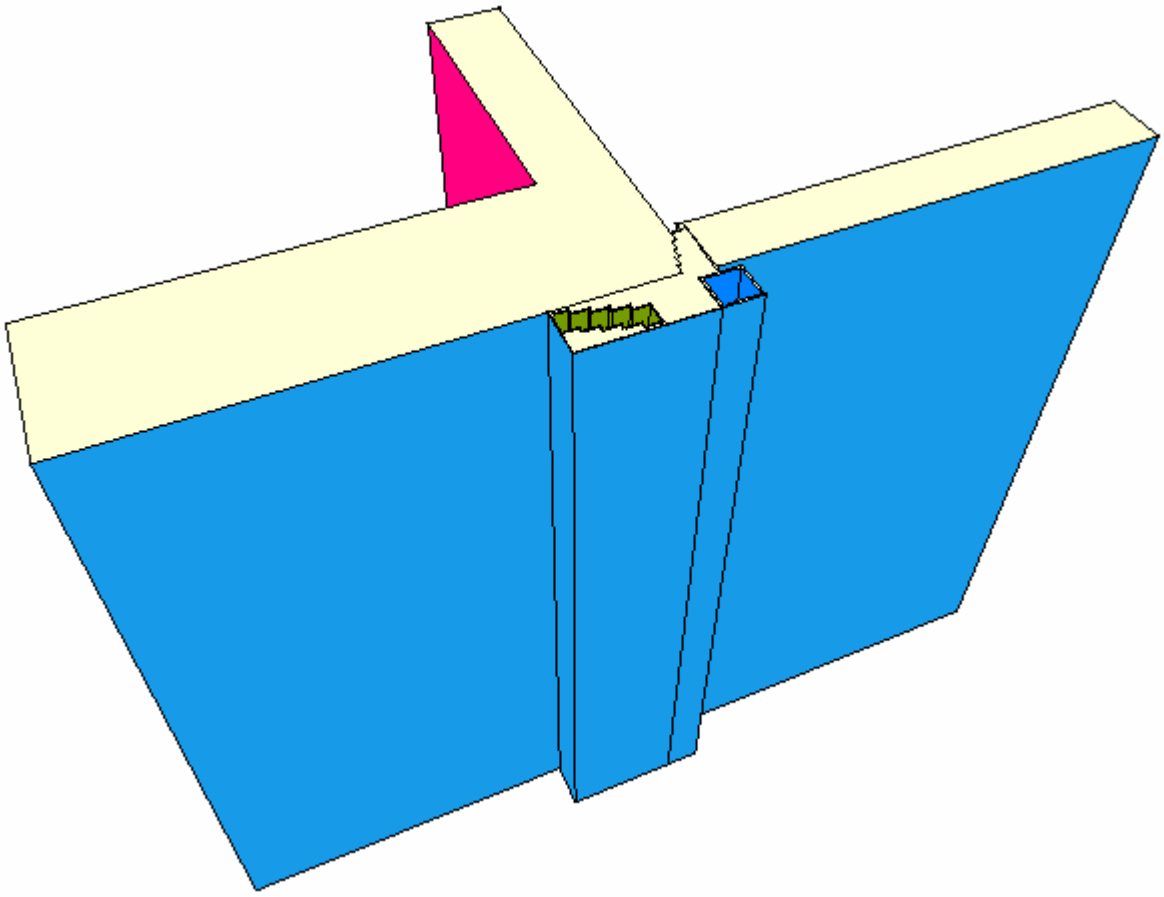
Col.	Type	CEN-rule	Name	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]
2	MATERIAL		steel	45.000	0.90			
3	MATERIAL		POM insulation	0.310	0.90			
4	MATERIAL		aluminum 99%	203.000	0.90			
5	MATERIAL		reinforced concrete	1.700	0.90			
6	MATERIAL		polystyrene insul.	0.035	0.90			

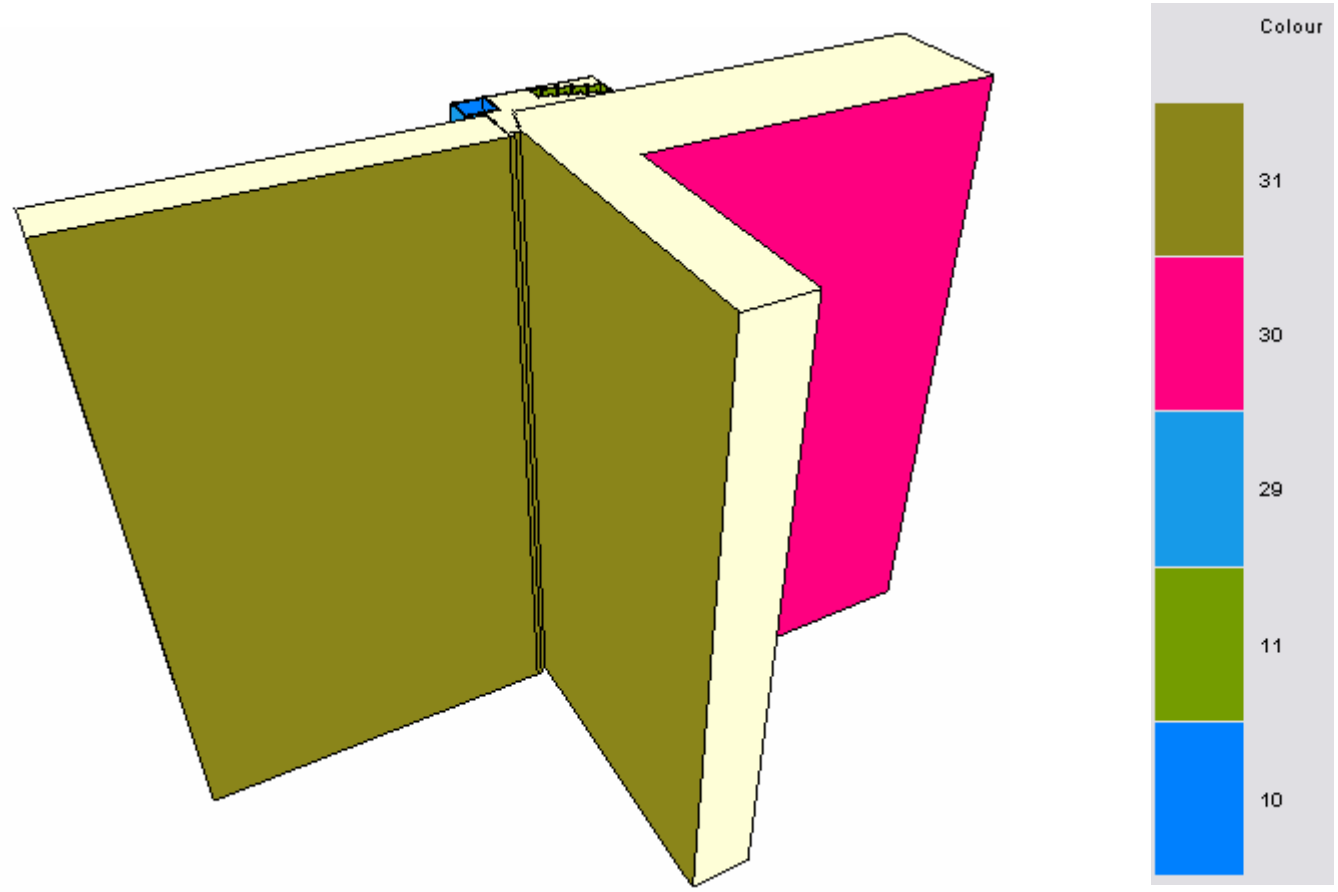
10	BC_FREE	NIHIL	CAVITY 1					0
11	BC_FREE	NIHIL	CAVITY 2					0
29	BC_SIMPL	NIHIL	INSIDE HALL			20.0	8.00	0
30	BC_SIMPL	NIHIL	INSIDE TECHNICAL			18.0	8.00	0
31	BC_SIMPL	NIHIL	OUTSIDE			-12.0	20.00	0
32	MATERIAL		frame and glass	0.333	0.90			

Col.	ta [°C]	hc [W/m²K]	Pc [W]	tr [°C]	C1	C2	C3
10		3.00	0				
11		3.00	0				
29							
30							
31							

Calculation parameters
Maximum number of iterations = 10000
Maximum temperature difference = 0.0001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Linear radiation
Smallest accepted view factor = 0.0001
Number of visibility rays between radiative surfaces = 100
Black radiation heat transfer coeff. = 5.25 W/(m².K)

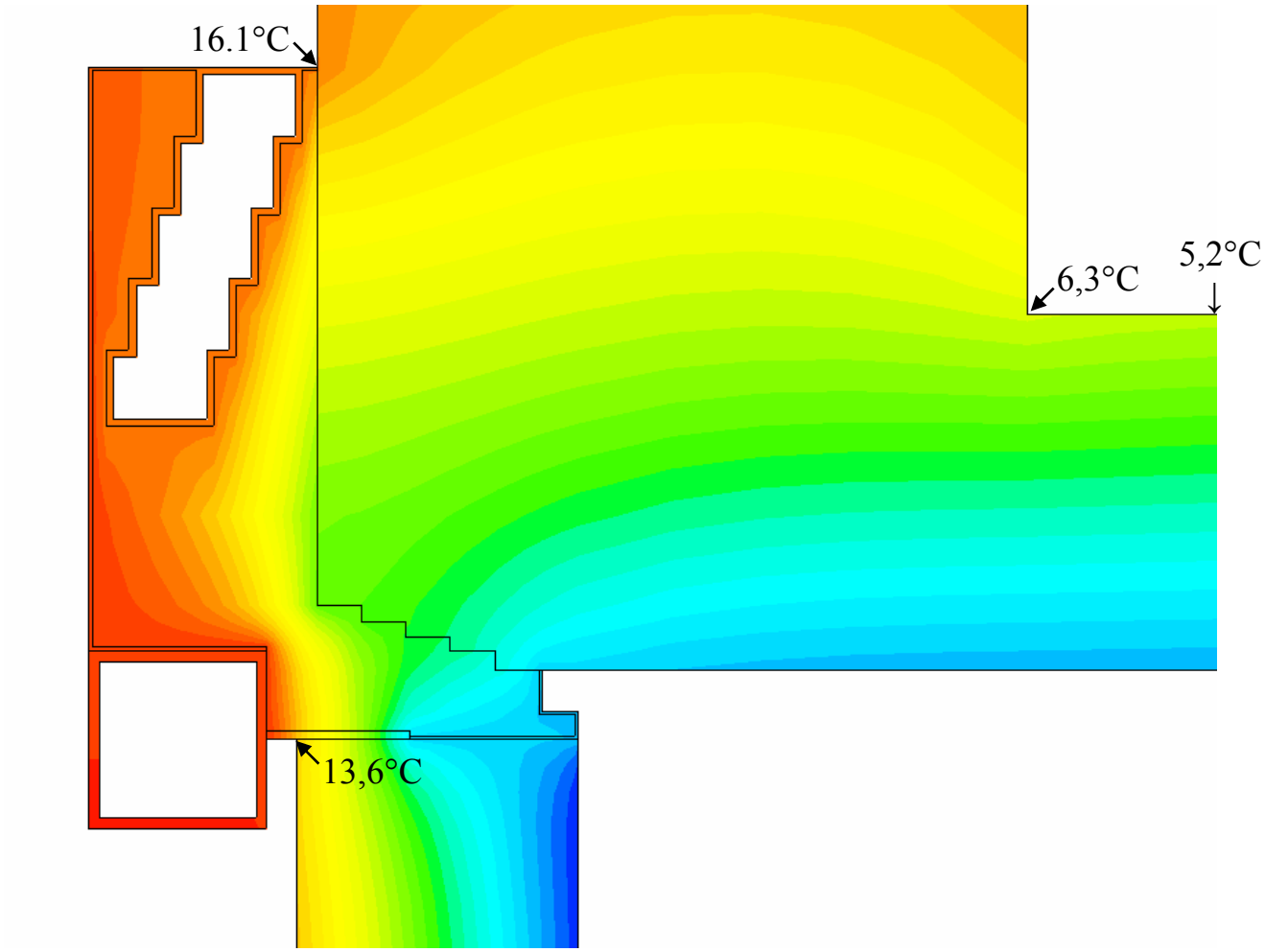
Boundary conditions

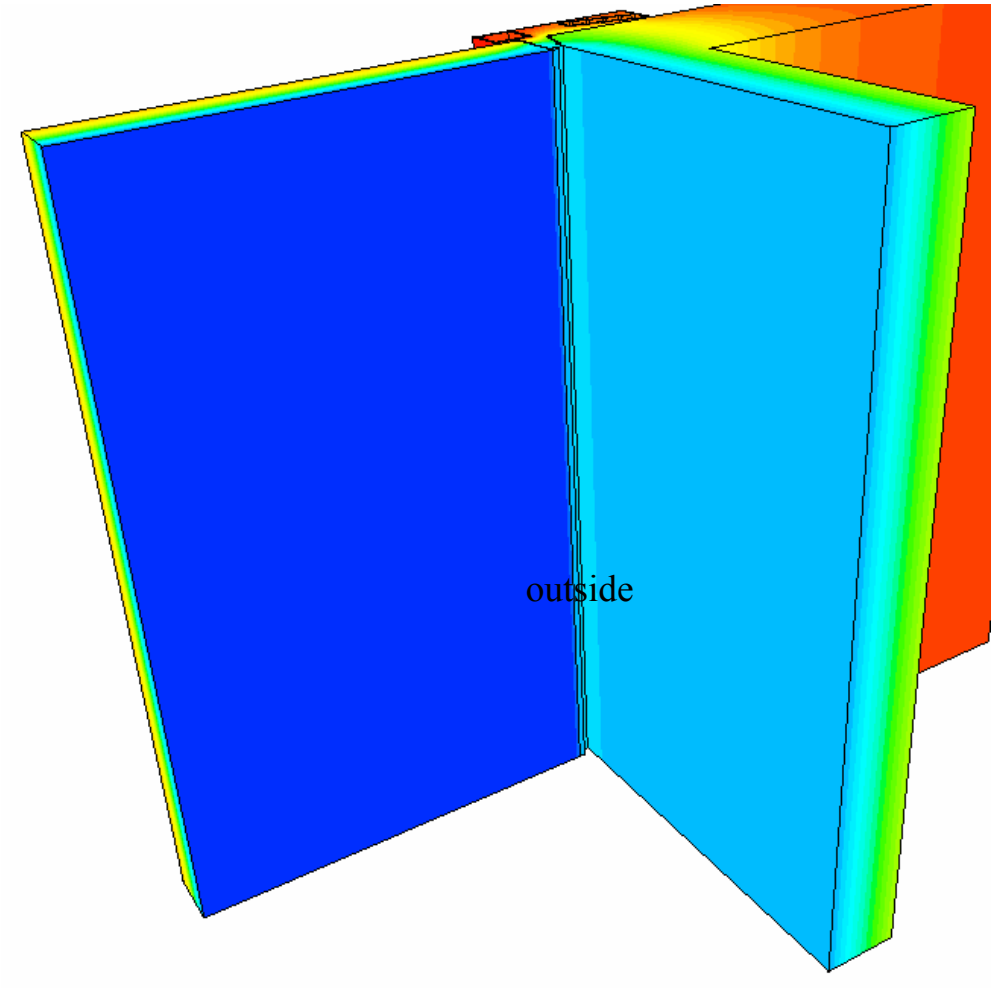


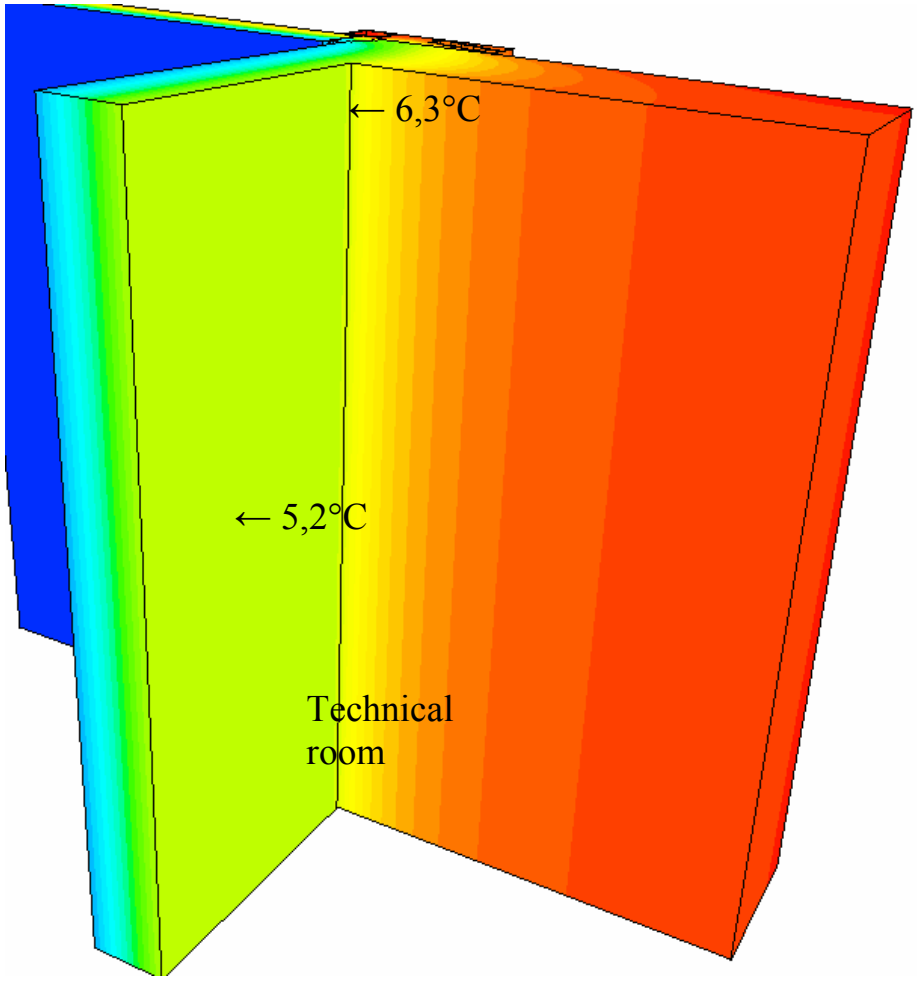


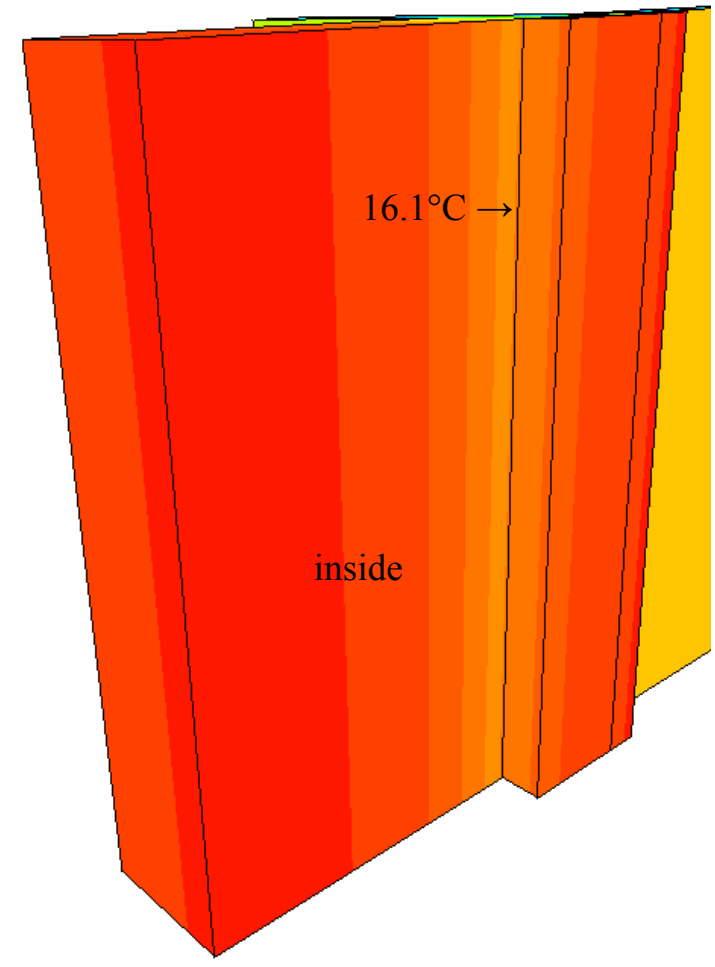
1.1.2. Graphical results:

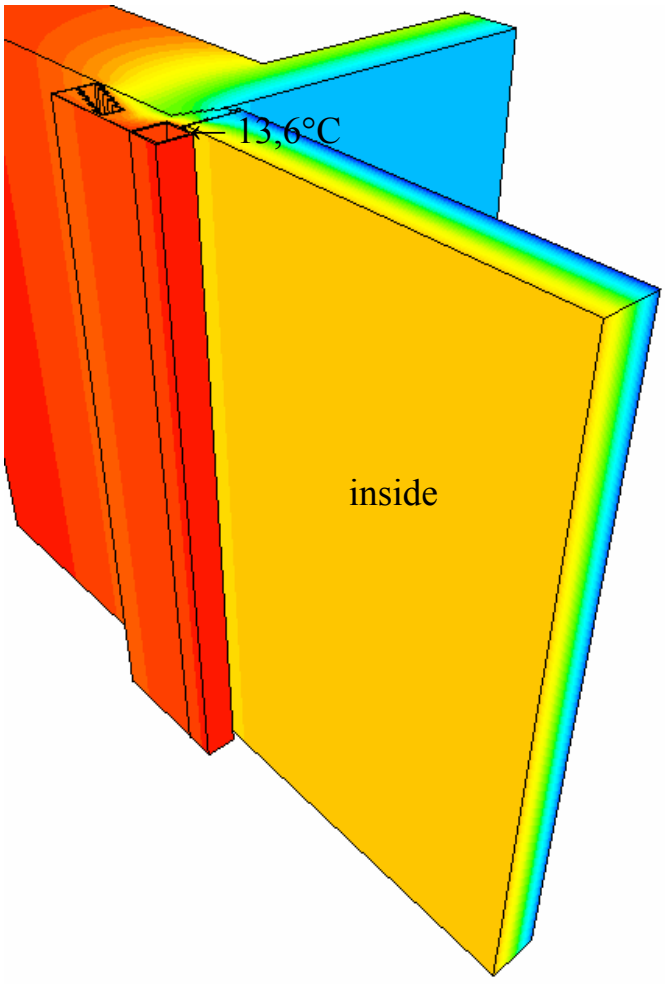
General temperature views in the model




outside


← 6,3°C
← 5,2°C
Technical
room


16.1°C →
inside


13.6°C
inside

1.1.3. Numerical results:

TRISCO - Calculation Results

TRISCO data file: first model.trc

Number of nodes = 141379
Heat flow divergence for total object = 0.000266426
Heat flow divergence for worst node = 0.696016

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
2	MATERIAL	steel	18.80	21	47	0	19.05	7	30	40
3	MATERIAL	POM insulation	-5.19	32	40	0	18.88	21	39	38
4	MATERIAL	aluminum 99%	-6.11	49	43	0	18.85	3	47	19
5	MATERIAL	reinforced concrete	-6.87	71	44	0	19.33	28	86	40
6	MATERIAL	polystyrene insul.	-6.11	49	42	0	18.86	21	41	37
10	BC_FREE	CAVITY 1	18.80	18	45	0	19.05	7	32	40
11	BC_FREE	CAVITY 2	16.22	24	63	0	16.60	13	64	0
29	BC_SIMPL	INSIDE HALL	12.42	25	34	32	19.33	28	86	40
30	BC_SIMPL	INSIDE TECHNICAL	5.19	71	57	5	18.36	56	86	40
31	BC_SIMPL	OUTSIDE	-9.89	51	29	0	-5.34	49	44	18
32	MATERIAL	frame and glass	-9.89	51	29	0	13.84	25	2	40

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
10	BC_FREE	CAVITY 1	18.93	0.30	0.30
11	BC_FREE	CAVITY 2	16.39	0.71	0.71
29	BC_SIMPL	INSIDE HALL		164.46	0.00
30	BC_SIMPL	INSIDE TECHNICAL		183.31	1.80
31	BC_SIMPL	OUTSIDE		0.00	345.97

TRISCO - Temperatures in corner nodes

TRISCO data file: first model.trc

X	Y	Z	t [°C]
1	30	0	19.05
1	30	40	19.05
1	66	0	17.30
1	66	40	17.30
3	32	0	19.04
3	32	40	19.04
3	45	0	18.86
3	45	40	18.86
5	54	0	16.43
5	54	40	16.43
5	55	0	16.47
5	55	40	16.47
7	55	0	16.47
7	55	40	16.47
7	58	0	16.50
7	58	40	16.50
9	58	0	16.51
9	58	40	16.51
9	60	0	16.54
9	60	40	16.54
11	60	0	16.54
11	60	40	16.54
11	62	0	16.57

11	62	40	16.57
13	62	0	16.58
13	62	40	16.58
13	64	0	16.60
13	64	40	16.60
14	54	0	16.34
14	54	40	16.34
14	56	0	16.30
14	56	40	16.30
16	56	0	16.29
16	56	40	16.29
16	59	0	16.25
16	59	40	16.25
18	59	0	16.25
18	59	40	16.25
18	61	0	16.23
18	61	40	16.23
19	32	0	19.00
19	32	40	19.00
19	45	0	18.80
19	45	40	18.80
21	30	0	19.00
21	30	40	19.00
21	39	0	18.88
21	39	40	18.88
22	61	0	16.22
22	61	40	16.22
22	63	0	16.22
22	63	40	16.22
24	63	0	16.22
24	63	40	16.22
24	64	0	16.24
24	64	40	16.24
25	0	0	13.84
25	0	40	13.84
25	39	0	13.64
25	39	40	13.64
28	66	0	16.10
28	66	40	16.10
28	86	0	19.33
28	86	40	19.33
46	43	0	-6.09
46	43	40	-6.09
46	44	0	-5.92
46	44	40	-5.92
51	0	0	-9.54
51	0	40	-9.54
51	43	0	-6.11
51	43	40	-6.11
56	57	0	6.29
56	57	40	6.29
56	86	0	18.36
56	86	40	18.36
71	44	0	-6.87
71	44	40	-6.87
71	57	0	5.19
71	57	40	5.19

These are the temperatures that we have mentioned here above in the pictures.

13.64°C could be satisfying. Nevertheless, it seems important, as that temperature is on the edge (an inside air at 20°C and 50% RH will probably condensate on a surface at 12°C, see Mollier's graph), to model the real (or a little bit simplified) frame of the window.

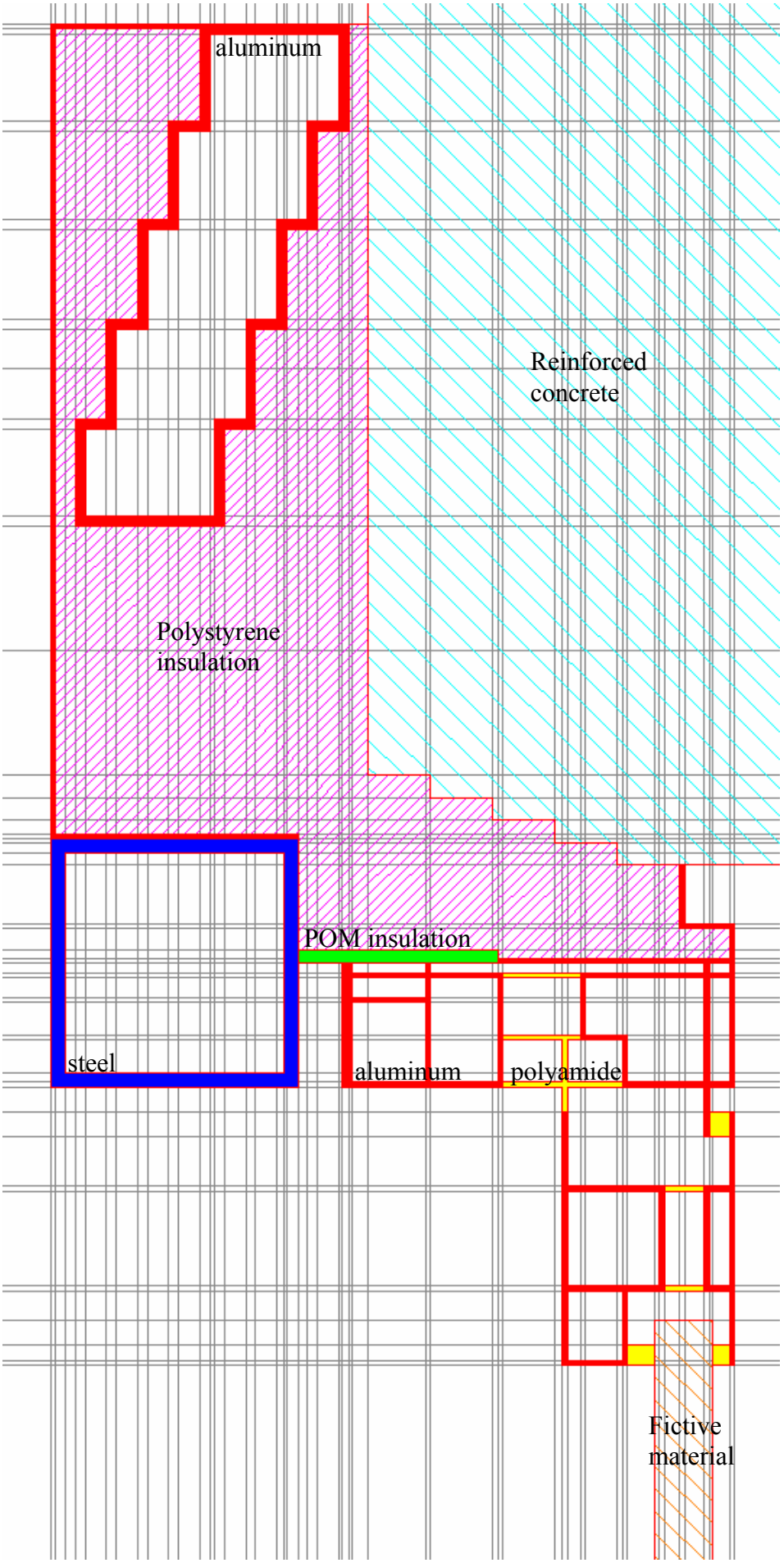
1.2. Real frame

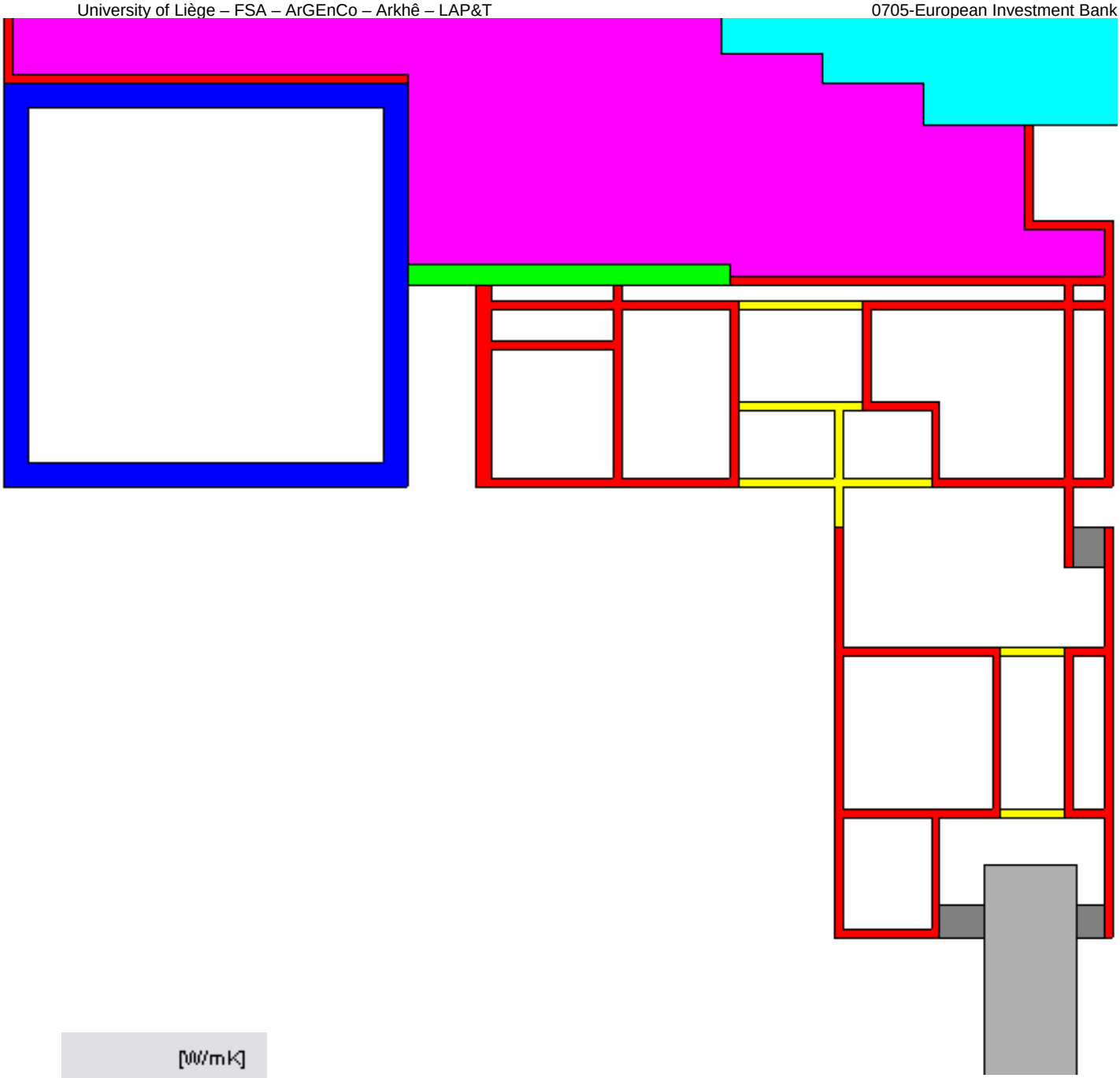
1.2.1. Input data

Horizontal section

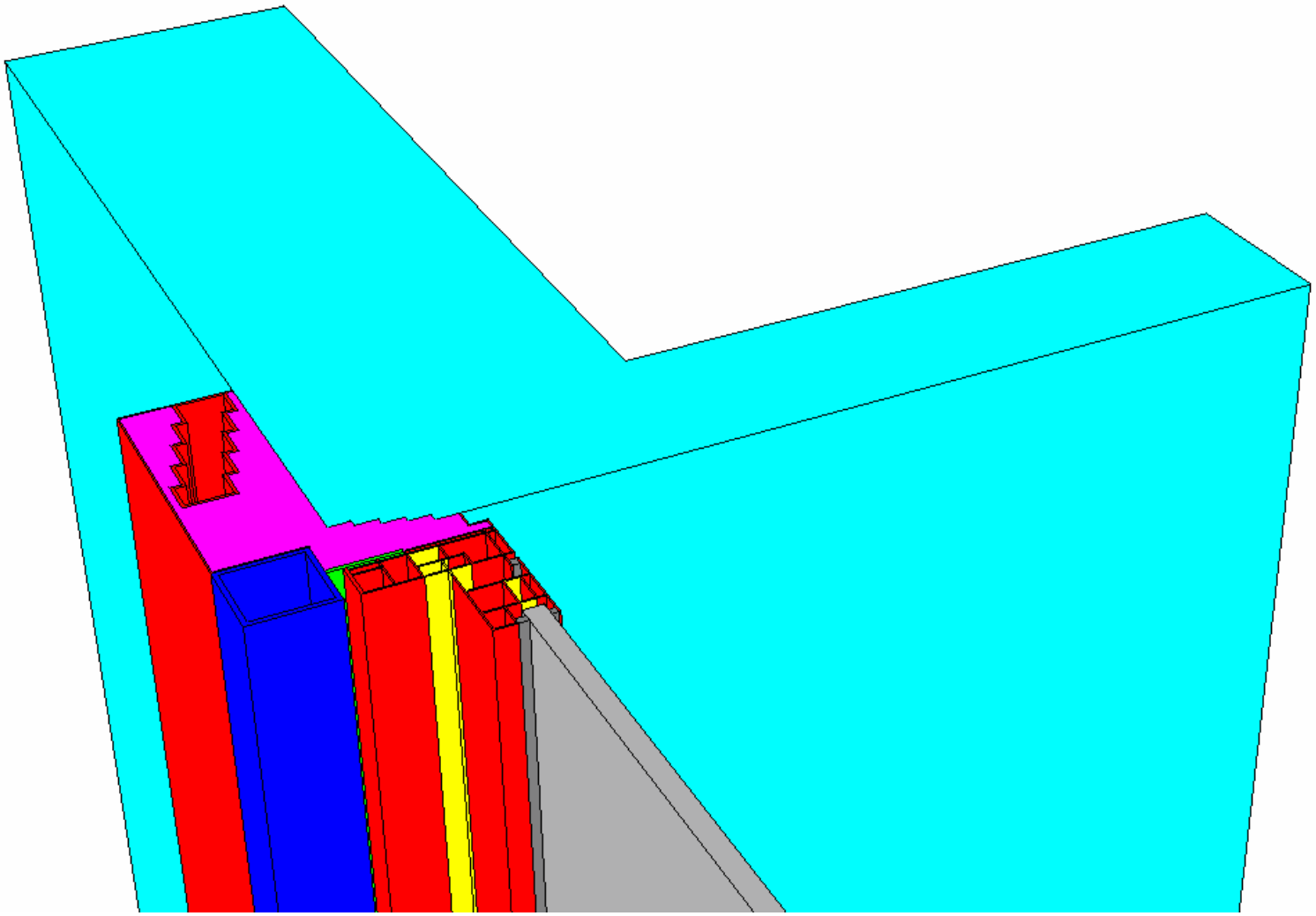
We can see here that the frame is composed of different materials:

- A major part of the frame is made of aluminium (99% in the physibel data base, λ = 203 W/mK).
- The thermal breaks inside the frame are made of polyamide 6.6, containing 25% of glass fibre (λ = 0,3 W/mK).
- We have modelled also three joints, made of polyethylene (λ = 0,2 W/mK)
- A thermal break has also been placed between the aluminium frame and the steel structure : polyoxymethylene copolymer extruded (POM-C E), which has a thermal conductance of 0.31 W/mK, according to the standard DIN 52 612.
- The glass itself is replaced by another fictive material: the real glass has a “U” value of 1.1 W/m²K, which gives us a “R” value of 0.91 m²K/W. Given that it is composed of two sheets (4 mm) of glass, with a 15 mm thick slide of argon (gas), which makes a total thickness of 23 mm, the fictive λ value of the fictive material is 0.0253 W/mK.





[W/mK]	
203.000	aluminum
45.000	steel
1.700	Reinforced concrete
0.310	POM insulation
0.300	Polyamide 6.6, 25% glass fibre
0.200	polyethylene
0.035	Polystyrene insulation
0.025	Fictive “glass” material



TRISCO - Input Data

TRISCO data file: real frame.trc

GRID
Grid unit = 0.01 m

No.	X	Y	Z
0-1	10.000	5.000	5.000
1-2	0.200	5.000	5.000
2-3	0.400	5.000	5.000
3-4	0.400	5.000	5.000
4-5	0.400	5.000	5.000
5-6	0.850	5.000	5.000
6-7	0.400	5.000	5.000
7-8	0.850	5.000	5.000
8-9	0.400	5.000	5.000
9-10	0.850	5.000	5.000
10-11	0.400	5.000	5.000
11-12	0.850	5.000	5.000
12-13	0.400	5.000	5.000
13-14	0.200	5.000	5.000
14-15	0.400	5.000	5.000
15-16	0.850	5.000	5.000
16-17	0.400	5.000	5.000
17-18	0.850	5.000	5.000
18-19	0.300	5.000	5.000
19-20	0.100	5.000	5.000

20-21	0.500	0.200	5.000
21-22	0.350	0.600	5.000
22-23	0.400	1.000	5.000
23-24	0.850	1.200	5.000
24-25	0.100	0.200	5.000
25-26	0.300	3.800	5.000
26-27	0.100	0.200	5.000
27-28	0.700	2.000	5.000
28-29	2.300	1.000	5.000
29-30	0.200	1.000	5.000
30-31	2.500	0.200	5.000
31-32	0.200	0.400	5.000
32-33	0.200	1.300	5.000
33-34	2.100	0.200	5.000
34-35	0.300	1.300	5.000
35-36	0.200	0.200	5.000
36-37	0.500	0.800	5.000
37-38	0.200	0.200	5.000
38-39	1.300	0.400	5.000
39-40	0.200	0.200	5.000
40-41	0.200	0.300	
41-42	1.100	0.900	
42-43	0.200	0.200	
43-44	0.200	2.350	
44-45	0.600	0.460	
45-46	0.200	0.440	
46-47	0.800	0.160	
47-48	0.200	0.200	
48-49	0.100	0.540	
49-50	0.700	0.900	
50-51	0.200	0.900	
51-52	5.300	5.040	
52-53	5.000	5.030	
53-54	5.000	0.400	
54-55	5.000	3.500	
55-56	5.000	0.400	
56-57	5.000	2.030	
57-58	5.000	1.570	
58-59	5.000	0.400	
59-60	5.000	3.600	
60-61	5.000	0.400	
61-62	5.000	3.600	
62-63	5.000	0.400	
63-64	5.000	3.500	
64-65	5.000	0.200	
65-66	5.000	0.200	
66-67	5.000	5.000	
67-68	5.000	5.000	
68-69	5.000	5.000	
69-70	5.000	5.000	
70-71	5.000	5.000	
71-72		5.000	
72-73		5.000	
73-74		5.000	
74-75		5.000	
75-76		5.000	
76-77		5.000	
77-78		5.000	
78-79		5.000	
79-80		5.000	
80-81		5.000	

81-82		5.000	
82-83		5.000	
83-84		5.000	
84-85		5.000	
85-86		5.000	
Sum	137.800	254.020	200.000

BLOCKS

No.	Col.	Xmin	Xmax	Ymin	Ymax	Zmin	Zmax
1	5	28	71	51	57	0	40
2	5	28	56	57	86	0	40
3	5	30	71	50	51	0	40
4	5	31	71	49	50	0	40
5	5	34	71	46	49	0	40
6	5	39	71	44	46	0	40
7	4	1	28	65	66	0	40
8	4	12	26	64	65	0	40
9	4	1	2	47	66	0	40
10	4	1	21	47	48	0	40
11	4	12	13	62	66	0	40
12	4	24	26	62	66	0	40
13	4	10	13	62	63	0	40
14	4	22	26	62	63	0	40
15	4	10	11	60	63	0	40
16	4	22	23	60	63	0	40
17	4	8	11	60	61	0	40
18	4	18	23	60	61	0	40
19	4	8	9	58	61	0	40
20	4	18	20	58	61	0	40
21	4	6	9	58	59	0	40
22	4	16	20	58	59	0	40
23	4	6	7	55	59	0	40
24	4	16	17	55	59	0	40
25	4	4	7	55	56	0	40
26	4	14	17	55	56	0	40
27	4	4	5	53	56	0	40
28	4	14	15	53	56	0	40
29	4	4	15	53	54	0	40
30	4	45	46	42	44	0	40
31	4	45	51	42	43	0	40
32	4	50	51	30	43	0	40
33	4	50	51	20	29	0	40
34	4	32	51	39	40	0	40
35	4	37	51	37	38	0	40
36	4	47	48	28	40	0	40
37	4	40	51	30	31	0	40
38	4	40	41	30	34	0	40
39	4	37	41	33	34	0	40
40	4	37	38	33	38	0	40
41	4	47	51	26	27	0	40
42	4	47	51	24	25	0	40
43	4	47	48	24	27	0	40
44	4	43	44	24	27	0	40
45	4	40	41	20	25	0	40
46	4	35	36	20	29	0	40
47	4	35	41	20	21	0	40
48	4	35	44	24	25	0	40
49	4	35	44	26	27	0	40
50	4	32	33	30	38	0	40
51	4	29	30	30	39	0	40
52	4	25	27	30	39	0	40

53	4	25	33	30	31	0	40
54	4	25	30	35	36	0	40
55	4	25	33	37	38	0	40
56	3	21	32	39	41	0	40
57	2	1	21	45	47	0	40
58	2	1	21	30	32	0	40
59	2	1	3	30	45	0	40
60	2	19	21	30	45	0	40
61	6	2	4	48	65	0	40
62	6	4	6	56	65	0	40
63	6	4	15	48	53	0	40
64	6	6	8	59	65	0	40
65	6	8	10	61	65	0	40
66	6	10	12	63	65	0	40
67	6	15	17	48	55	0	40
68	6	17	20	48	58	0	40
69	6	20	21	48	60	0	40
70	6	21	23	41	60	0	40
71	6	23	26	41	62	0	40
72	6	26	28	41	65	0	40
73	6	28	30	41	51	0	40
74	6	30	31	41	50	0	40
75	6	31	32	41	49	0	40
76	6	32	34	40	49	0	40
77	6	34	39	40	47	0	40
78	6	39	45	40	44	0	40
79	6	45	50	40	42	0	40
80	7	33	37	37	38	0	40
81	7	33	37	33	34	0	40
82	7	33	40	30	31	0	40
83	7	35	36	29	34	0	40
84	7	44	47	26	27	0	40
85	7	44	47	24	25	0	40
86	8	41	42	20	22	0	40
87	8	49	50	20	22	0	40
88	8	48	50	28	29	0	40
89	9	42	49	0	23	0	40
90	10	3	19	32	45	0	40
91	11	13	24	63	64	0	40
92	11	13	22	62	63	0	40
93	11	11	22	61	62	0	40
94	11	11	18	60	61	0	40
95	11	9	18	59	60	0	40
96	11	9	16	58	59	0	40
97	11	7	16	56	58	0	40
98	11	7	14	55	56	0	40
99	11	5	14	54	55	0	40
100	12	27	29	38	39	0	40
101	13	30	47	38	39	0	40
102	14	48	50	38	39	0	40
103	15	27	29	36	37	0	40
104	16	27	29	31	35	0	40
105	17	30	32	31	37	0	40
106	18	33	37	34	37	0	40
107	19	33	35	31	33	0	40
108	20	36	40	31	33	0	40
109	21	38	47	34	37	0	40
110	21	41	47	31	34	0	40
111	22	48	50	31	37	0	40
112	23	36	47	28	30	0	40
113	23	36	50	27	28	0	40

114	24	36	43	25	26	0	40
115	25	44	47	25	26	0	40
116	26	48	50	25	26	0	40
117	27	36	40	21	24	0	40
118	28	41	42	22	24	0	40
119	28	42	49	23	24	0	40
120	28	49	50	22	24	0	40
121	29	35	42	0	20	0	40
122	29	25	35	0	30	0	40
123	29	21	25	0	39	0	40
124	29	1	21	0	30	0	40
125	29	1	28	66	86	0	40
126	29	0	1	0	86	0	40
127	30	56	71	57	86	0	40
128	31	49	51	0	20	0	40
129	31	46	51	43	44	0	40
130	31	48	51	29	30	0	40
131	31	51	71	0	44	0	40

COLOURS

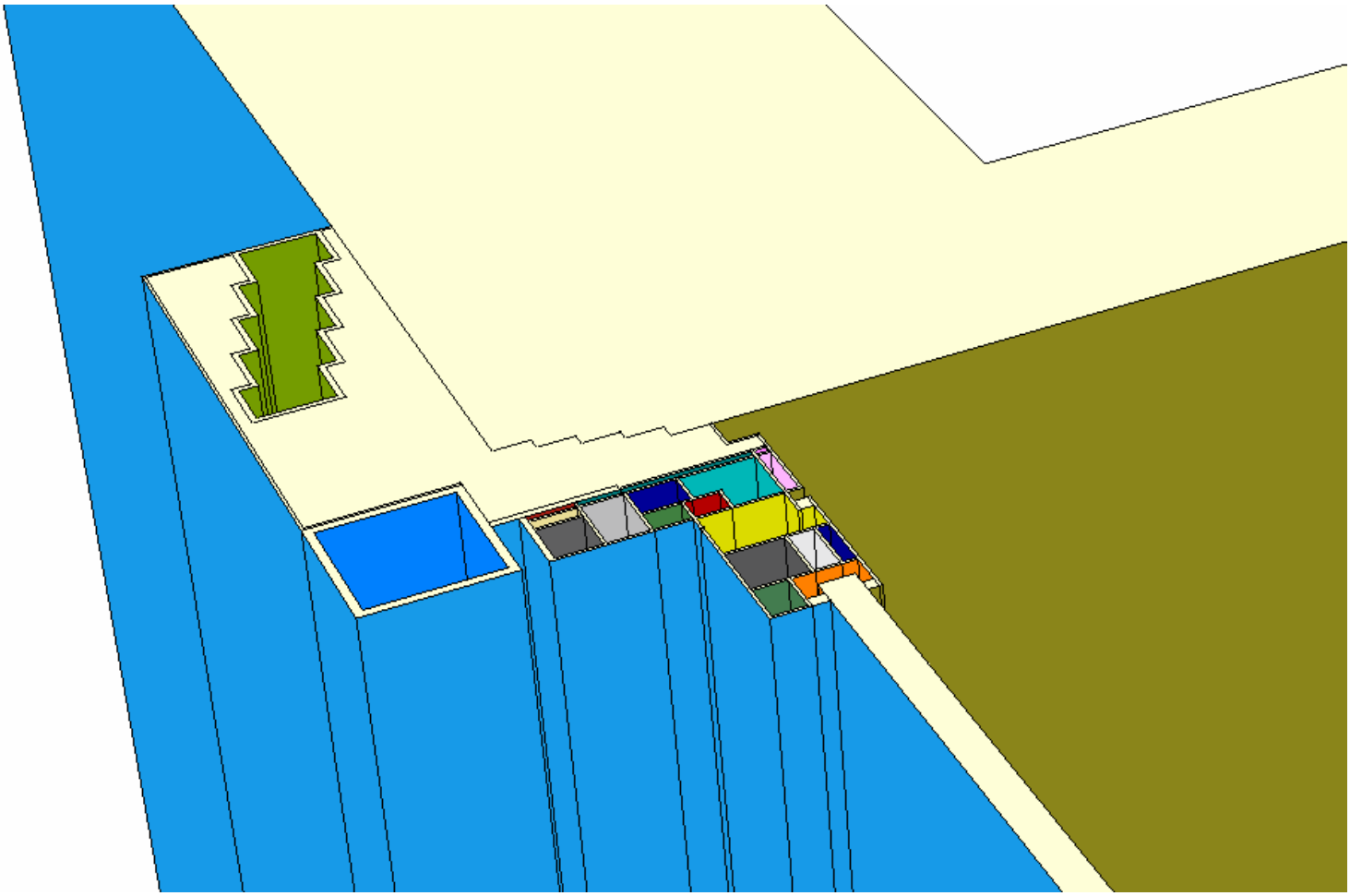
Col.	Type	CEN-rule	Name	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]
2	MATERIAL		steel	45.000	0.90			
3	MATERIAL		POM insulation	0.310	0.90			
4	MATERIAL		aluminum 99%	203.000	0.90			
5	MATERIAL		reinforced concrete	1.700	0.90			
6	MATERIAL		polystyrene insul.	0.035	0.90			
7	MATERIAL		polyamide 6.6 (25%)	0.300	0.90			
8	MATERIAL		polyethylene	0.200	0.90			
9	MATERIAL		fictive glass	0.025	0.90			
10	BC_FREE	NIHIL	CAVITY 1					0
11	BC_FREE	NIHIL	CAVITY 2					0
12	BC_FREE	NIHIL	CAVITY 3					0
13	BC_FREE	NIHIL	CAVITY 4					0
14	BC_FREE	NIHIL	CAVITY 5					0
15	BC_FREE	NIHIL	CAVITY 6					0
16	BC_FREE	NIHIL	CAVITY 7					0
17	BC_FREE	NIHIL	CAVITY 8					0
18	BC_FREE	NIHIL	CAVITY 9					0
19	BC_FREE	NIHIL	CAVITY 10					0
20	BC_FREE	NIHIL	CAVITY 11					0
21	BC_FREE	NIHIL	CAVITY 12					0
22	BC_FREE	NIHIL	CAVITY 13					0
23	BC_FREE	NIHIL	CAVITY 14					0
24	BC_FREE	NIHIL	CAVITY 15					0
25	BC_FREE	NIHIL	CAVITY 16					0
26	BC_FREE	NIHIL	CAVITY 17					0
27	BC_FREE	NIHIL	CAVITY 18					0
28	BC_FREE	NIHIL	CAVITY 19					0
29	BC_SIMPL	NIHIL	INSIDE HALL			20.0	8.00	0
30	BC_SIMPL	NIHIL	INSIDE TECHNICAL ROOM			18.0	8.00	0
31	BC_SIMPL	NIHIL	OUTSIDE			-12.0	20.00	0

Col.	ta [°C]	hc [W/m²K]	Pc [W]	tr [°C]	C1	C2	C3
10		3.00	0				
11		3.00	0				
12		3.00	0				
13		3.00	0				
14		3.00	0				
15		3.00	0				

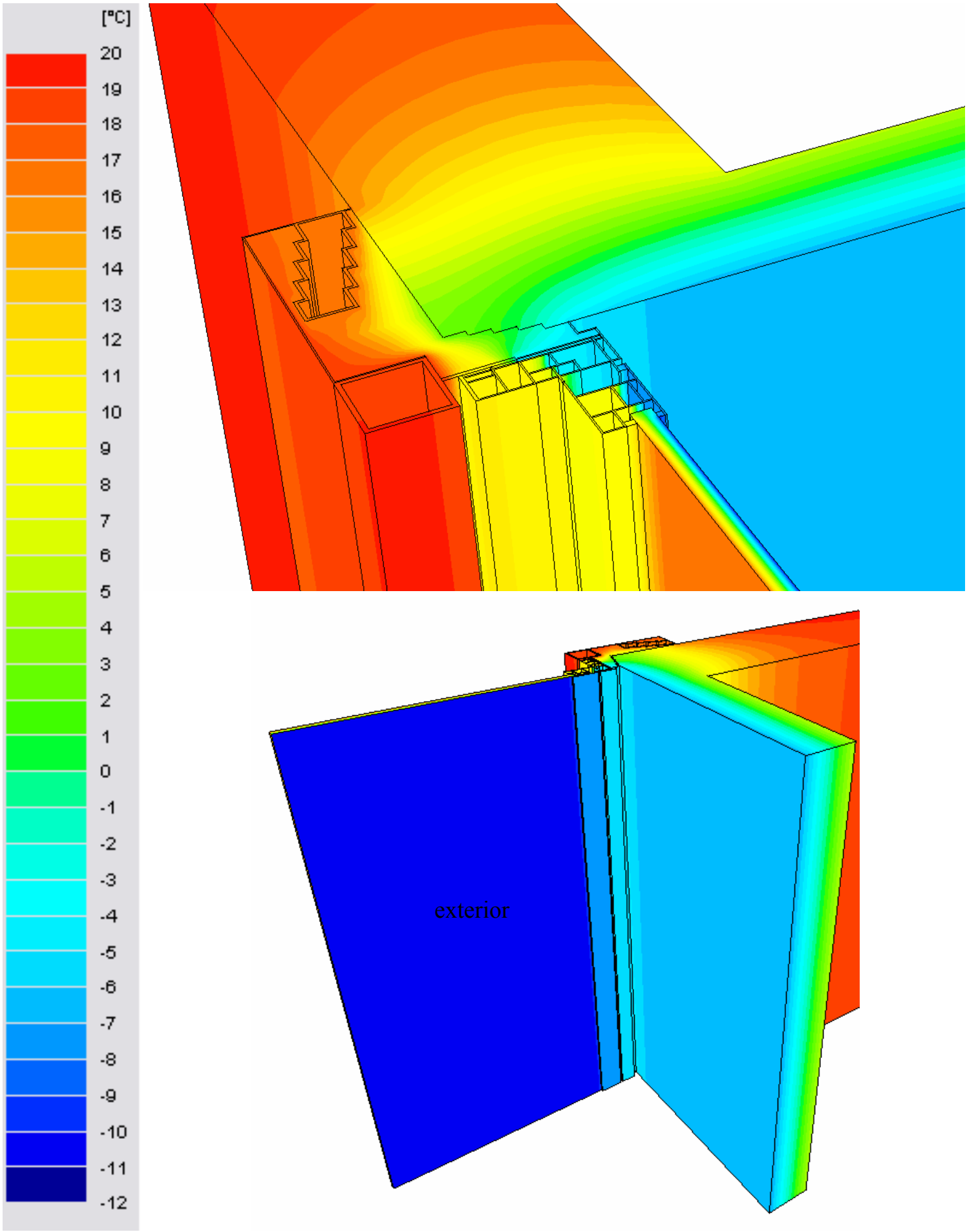
16	3.00	0
17	3.00	0
18	3.00	0
19	3.00	0
20	3.00	0
21	3.00	0
22	3.00	0
23	3.00	0
24	3.00	0
25	3.00	0
26	3.00	0
27	3.00	0
28	3.00	0
29		
30		
31		

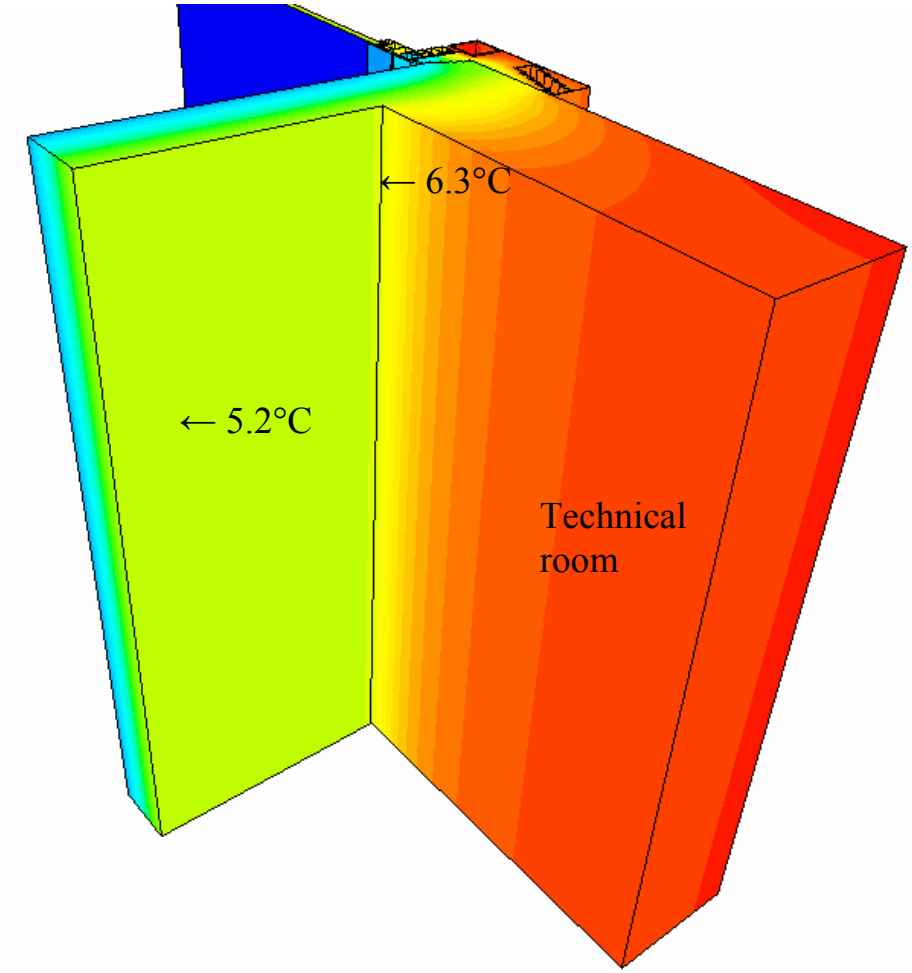
Calculation parameters
Maximum number of iterations = 10000
Maximum temperature difference = 0.0001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Linear radiation
Smallest accepted view factor = 0.0001
Number of visibility rays between radiative surfaces = 100
Black radiation heat transfer coeff. = 5.25 W/(m².K)

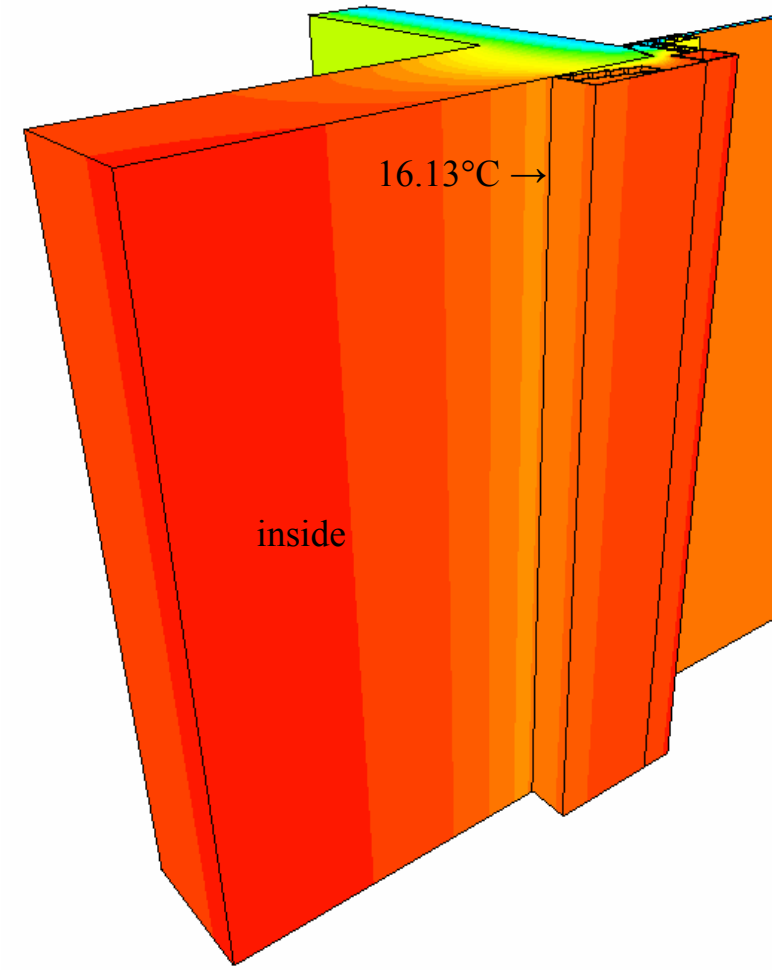
Boundary conditions

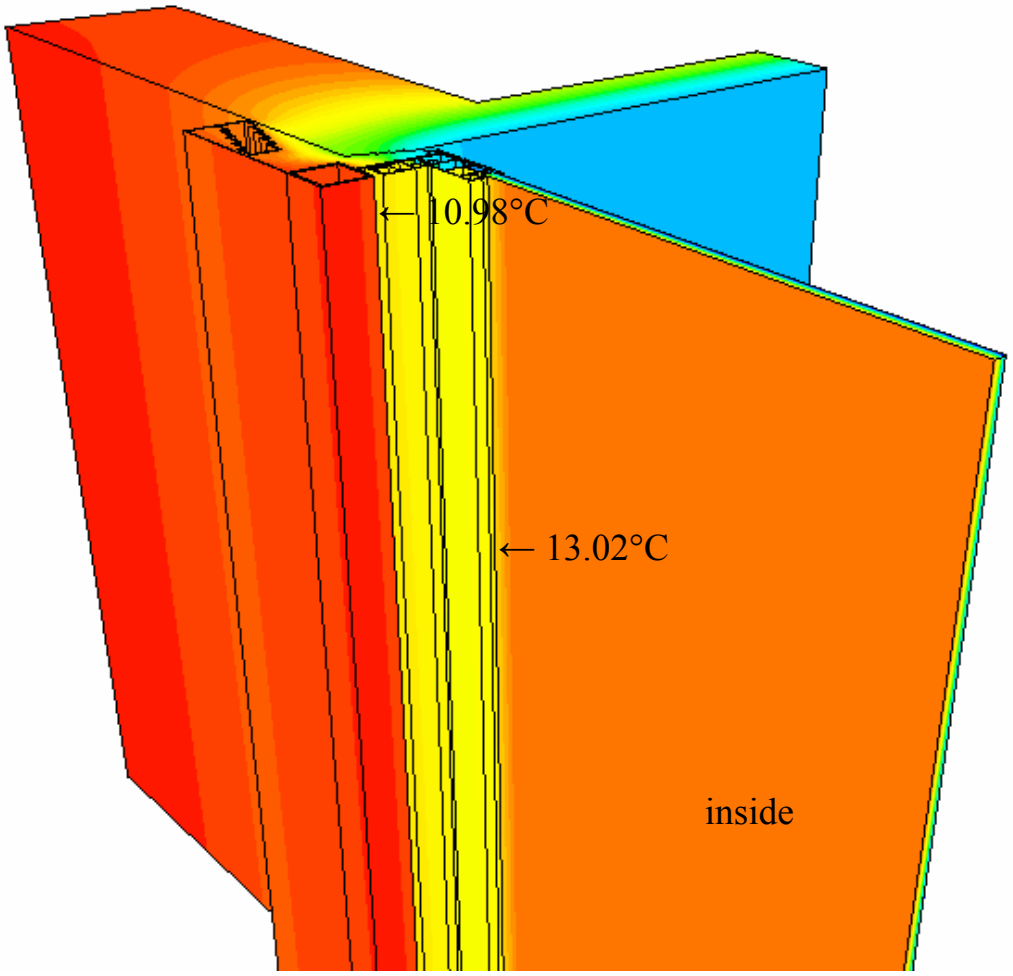


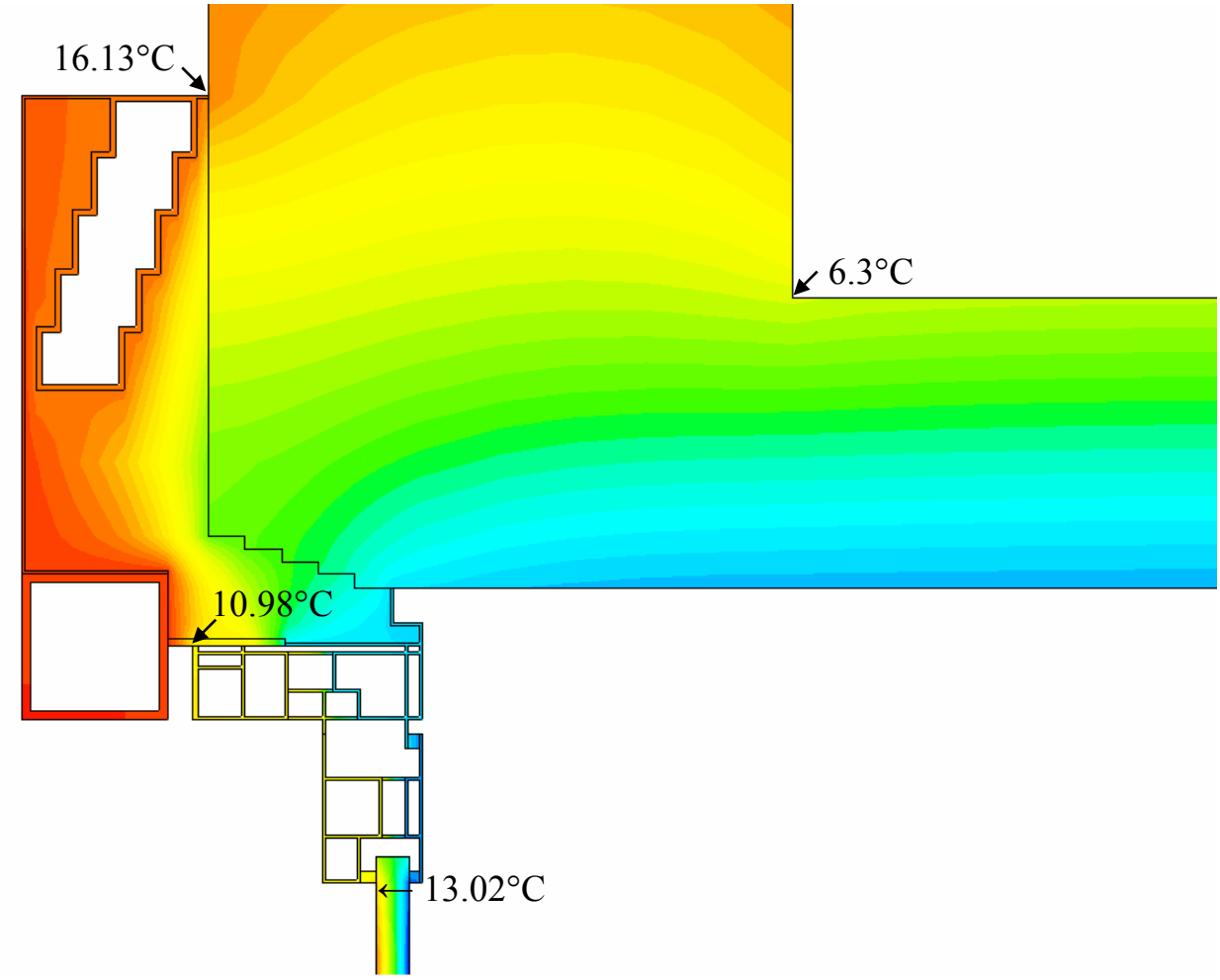
1.2.2. Graphical results




← 6.3°C
← 5.2°C
Technical
room


16.13°C →
inside


10.98°C
13.02°C
inside


16.13°C
6.3°C
10.98°C
13.02°C

1.2.3. Numerical results

TRISCO - Calculation Results

TRISCO data file: real frame.trc

Number of nodes = 129013
Heat flow divergence for total object = 7.6068e-005
Heat flow divergence for worst node = 0.0301901

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
2	MATERIAL	steel	18.77	21	47	0	19.03	7	30	40
3	MATERIAL	POM insulation	-4.15	32	39	40	18.84	21	39	21
4	MATERIAL	aluminum 99%	-7.70	50	20	39	18.83	3	47	25
5	MATERIAL	reinforced concrete	-6.87	71	44	0	19.33	28	86	18
6	MATERIAL	polystyrene insul.	-5.31	46	42	40	18.83	3	48	22
7	MATERIAL	polyamide 6.6 (25%)	-7.53	47	25	40	10.89	34	30	40
8	MATERIAL	polyethylene	-9.79	49	20	17	13.05	42	20	5
9	MATERIAL	glass	-10.62	49	19	40	16.72	42	19	0
10	BC_FREE	CAVITY 1	18.77	19	45	40	19.03	7	32	40
11	BC_FREE	CAVITY 2	16.25	24	63	0	16.63	13	64	40
12	BC_FREE	CAVITY 3	10.74	29	39	40	11.01	28	39	21
13	BC_FREE	CAVITY 4	-5.08	47	38	40	10.77	30	38	21
14	BC_FREE	CAVITY 5	-5.16	50	39	40	-5.07	48	39	22
15	BC_FREE	CAVITY 6	10.77	29	37	40	10.98	27	36	21
16	BC_FREE	CAVITY 7	10.84	29	35	40	11.04	27	31	21
17	BC_FREE	CAVITY 8	10.58	32	37	37	10.95	30	31	21
18	BC_FREE	CAVITY 9	-4.71	37	37	40	10.66	33	34	0
19	BC_FREE	CAVITY 10	3.38	35	33	0	10.81	33	31	0
20	BC_FREE	CAVITY 11	-4.81	40	31	40	6.27	36	31	23
21	BC_FREE	CAVITY 12	-5.13	47	31	40	-4.65	38	34	22
22	BC_FREE	CAVITY 13	-5.26	50	34	40	-5.08	48	37	22
23	BC_FREE	CAVITY 14	-7.63	50	28	40	8.87	36	29	0
24	BC_FREE	CAVITY 15	8.55	43	26	27	8.99	36	25	0
25	BC_FREE	CAVITY 16	-7.53	47	25	40	8.68	44	25	0
26	BC_FREE	CAVITY 17	-7.60	50	25	40	-7.51	48	26	27
27	BC_FREE	CAVITY 18	8.83	40	24	27	9.08	36	21	0
28	BC_FREE	CAVITY 19	-7.68	50	22	39	8.97	41	22	1
29	BC_SIMPL	INSIDE HALL	7.68	35	30	9	19.33	28	86	18
30	BC_SIMPL	INSIDE TECHNICAL	5.19	71	57	37	18.36	56	86	24
31	BC_SIMPL	OUTSIDE	-10.62	49	19	40	-4.96	47	44	22

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
10	BC_FREE	CAVITY 1	18.90	0.31	0.31
11	BC_FREE	CAVITY 2	16.42	0.70	0.70
12	BC_FREE	CAVITY 3	10.88	0.25	0.25
13	BC_FREE	CAVITY 4	-0.01	15.51	15.51
14	BC_FREE	CAVITY 5	-5.12	0.03	0.03
15	BC_FREE	CAVITY 6	10.89	0.17	0.17
16	BC_FREE	CAVITY 7	10.96	0.16	0.16
17	BC_FREE	CAVITY 8	10.77	0.29	0.29
18	BC_FREE	CAVITY 9	4.58	9.22	9.22
19	BC_FREE	CAVITY 10	8.68	3.56	3.56
20	BC_FREE	CAVITY 11	-1.12	4.12	4.12
21	BC_FREE	CAVITY 12	-4.89	0.29	0.29
22	BC_FREE	CAVITY 13	-5.16	0.08	0.08
23	BC_FREE	CAVITY 14	0.66	13.50	13.50
24	BC_FREE	CAVITY 15	8.76	0.38	0.38
25	BC_FREE	CAVITY 16	0.37	10.67	10.67

26	BC_FREE	CAVITY 17	-7.56	0.05	0.05
27	BC_FREE	CAVITY 18	8.98	0.11	0.11
28	BC_FREE	CAVITY 19	1.23	7.50	7.50
29	BC_SIMPL	INSIDE HALL		153.98	0.00
30	BC_SIMPL	INSIDE TECHNICAL		183.04	1.81
31	BC_SIMPL	OUTSIDE		0.00	335.21

TRISCO - Temperatures in corner nodes

TRISCO data file: real frame.trc

X	Y	Z	t [°C]
1	30	0	19.02
1	30	40	19.02
1	66	0	17.32
1	66	40	17.32
3	32	0	19.02
3	32	40	19.02
3	45	0	18.84
3	45	40	18.84
5	54	0	16.46
5	54	40	16.46
5	55	0	16.49
5	55	40	16.49
7	55	0	16.50
7	55	40	16.50
7	58	0	16.53
7	58	40	16.53
9	58	0	16.54
9	58	40	16.54
9	60	0	16.56
9	60	40	16.56
11	60	0	16.57
11	60	40	16.57
11	62	0	16.60
11	62	40	16.60
13	62	0	16.60
13	62	40	16.60
13	64	0	16.63
13	64	40	16.63
14	54	0	16.37
14	54	40	16.37
14	56	0	16.33
14	56	40	16.33
16	56	0	16.32
16	56	40	16.32
16	59	0	16.28
16	59	40	16.28
18	59	0	16.28
18	59	40	16.28
18	61	0	16.26
18	61	40	16.26
19	32	0	18.96
19	32	40	18.96
19	45	0	18.77
19	45	40	18.77
21	30	0	18.97
21	30	40	18.97
21	39	0	18.84
21	39	40	18.84

22	61	0	16.25
22	61	40	16.25
22	63	0	16.25
22	63	40	16.25
24	63	0	16.25
24	63	40	16.25
24	64	0	16.27
24	64	40	16.27
25	30	0	11.04
25	30	40	11.04
25	39	0	10.98
25	39	40	10.98
27	31	0	11.04
27	31	40	11.04
27	35	0	10.98
27	35	40	10.98
27	36	0	10.98
27	36	40	10.98
27	37	0	10.97
27	37	40	10.97
27	38	0	10.97
27	38	40	10.97
27	39	0	10.98
27	39	40	10.98
28	66	0	16.13
28	66	40	16.13
28	86	0	19.33
28	86	40	19.33
29	31	0	10.95
29	31	40	10.95
29	35	0	10.84
29	35	40	10.84
29	36	0	10.84
29	36	40	10.84
29	37	0	10.77
29	37	40	10.77
29	38	0	10.77
29	38	40	10.77
29	39	0	10.74
29	39	40	10.74
30	31	0	10.95
30	31	40	10.95
30	37	0	10.77
30	37	40	10.77
30	38	0	10.76
30	38	40	10.76
30	39	0	10.74
30	39	40	10.74
32	31	0	10.82
32	31	40	10.82
32	37	0	10.58
32	37	40	10.58
33	31	0	10.81
33	31	40	10.81
33	33	0	10.67
33	33	40	10.67
33	34	0	10.66
33	34	40	10.66
33	37	0	10.58
33	37	40	10.58
35	20	0	9.08

35	20	40	9.08
35	30	0	7.68
35	30	40	7.69
35	31	0	7.16
35	31	40	7.17
35	33	0	3.38
35	33	40	3.38
36	21	0	9.08
36	21	40	9.08
36	24	0	8.99
36	24	40	8.99
36	25	0	8.99
36	25	40	8.99
36	26	0	8.85
36	26	40	8.84
36	27	0	8.84
36	27	40	8.84
36	30	0	6.82
36	30	40	6.83
36	31	0	6.26
36	31	40	6.27
36	33	0	2.53
36	33	40	2.53
37	34	0	-4.66
37	34	40	-4.66
37	37	0	-4.71
37	37	40	-4.71
38	34	0	-4.66
38	34	40	-4.66
38	37	0	-4.71
38	37	40	-4.72
40	21	0	9.01
40	21	40	9.01
40	24	0	8.84
40	24	40	8.84
40	31	0	-4.81
40	31	40	-4.81
40	33	0	-4.72
40	33	40	-4.72
41	22	0	8.97
41	22	40	8.97
41	24	0	8.83
41	24	40	8.83
41	31	0	-4.81
41	31	40	-4.81
41	34	0	-4.72
41	34	40	-4.72
42	0	0	16.31
42	0	40	16.31
42	20	0	13.02
42	20	40	13.02
42	22	0	8.80
42	22	40	8.80
42	23	0	5.95
42	23	40	5.96
43	25	0	8.69
43	25	40	8.69
43	26	0	8.57
43	26	40	8.57
44	25	0	8.68
44	25	40	8.68

44	26	0	8.57
44	26	40	8.57
46	43	0	-5.31
46	43	40	-5.31
46	44	0	-5.20
46	44	40	-5.20
47	25	0	-7.53
47	25	40	-7.53
47	26	0	-7.52
47	26	40	-7.52
47	28	0	-5.15
47	28	40	-5.15
47	30	0	-5.13
47	30	40	-5.13
47	31	0	-5.13
47	31	40	-5.13
47	37	0	-5.08
47	37	40	-5.08
47	38	0	-5.08
47	38	40	-5.08
47	39	0	-5.07
47	39	40	-5.07
48	25	0	-7.53
48	25	40	-7.53
48	26	0	-7.52
48	26	40	-7.52
48	29	0	-5.15
48	29	40	-5.16
48	30	0	-5.13
48	30	40	-5.14
48	31	0	-5.13
48	31	40	-5.13
48	37	0	-5.08
48	37	40	-5.08
48	38	0	-5.08
48	38	40	-5.08
48	39	0	-5.08
48	39	40	-5.08
49	0	0	-10.52
49	0	40	-10.52
49	20	0	-9.78
49	20	40	-9.78
49	22	0	-6.30
49	22	40	-6.30
49	23	0	-3.77
49	23	40	-3.77
50	22	0	-7.68
50	22	40	-7.68
50	24	0	-7.60
50	24	40	-7.60
50	25	0	-7.60
50	25	40	-7.60
50	26	0	-7.58
50	26	40	-7.59
50	27	0	-7.58
50	27	40	-7.58
50	28	0	-7.63
50	28	40	-7.63
50	31	0	-5.20
50	31	40	-5.20
50	37	0	-5.16

50	37	40	-5.16
50	38	0	-5.16
50	38	40	-5.16
50	39	0	-5.16
50	39	40	-5.16
51	20	0	-7.69
51	20	40	-7.70
51	29	0	-7.64
51	29	40	-7.65
51	30	0	-5.21
51	30	40	-5.21
51	43	0	-5.27
51	43	40	-5.27
56	57	0	6.33
56	57	40	6.33
56	86	0	18.36
56	86	40	18.36
71	44	0	-6.87
71	44	40	-6.87
71	57	0	5.19
71	57	40	5.19

We can see that the temperatures that we reach are not satisfying:

- 11°C on the face of the window frame is too low: condensation might appear.
- 6.3°C on the edge of the wall of the technical space is far too low: condensation will appear.

A first remark that could be studied is, here again, that -12°C is not a usual condition. For the same reasons that we did it in the previous report (-12°C is too extreme, condensation is not a problem if it is in small quantities and if it can be dried, …), we are going to try the same model, with 0.9°C outside, the average temperature in Luxembourg during an average January month.

1.3. Real frame, 0.9°C outside

1.3.1. Input data

The only difference with the previous model is the outside temperature. Therefore, the input data will be the exact same that in the 1.2 chapter.

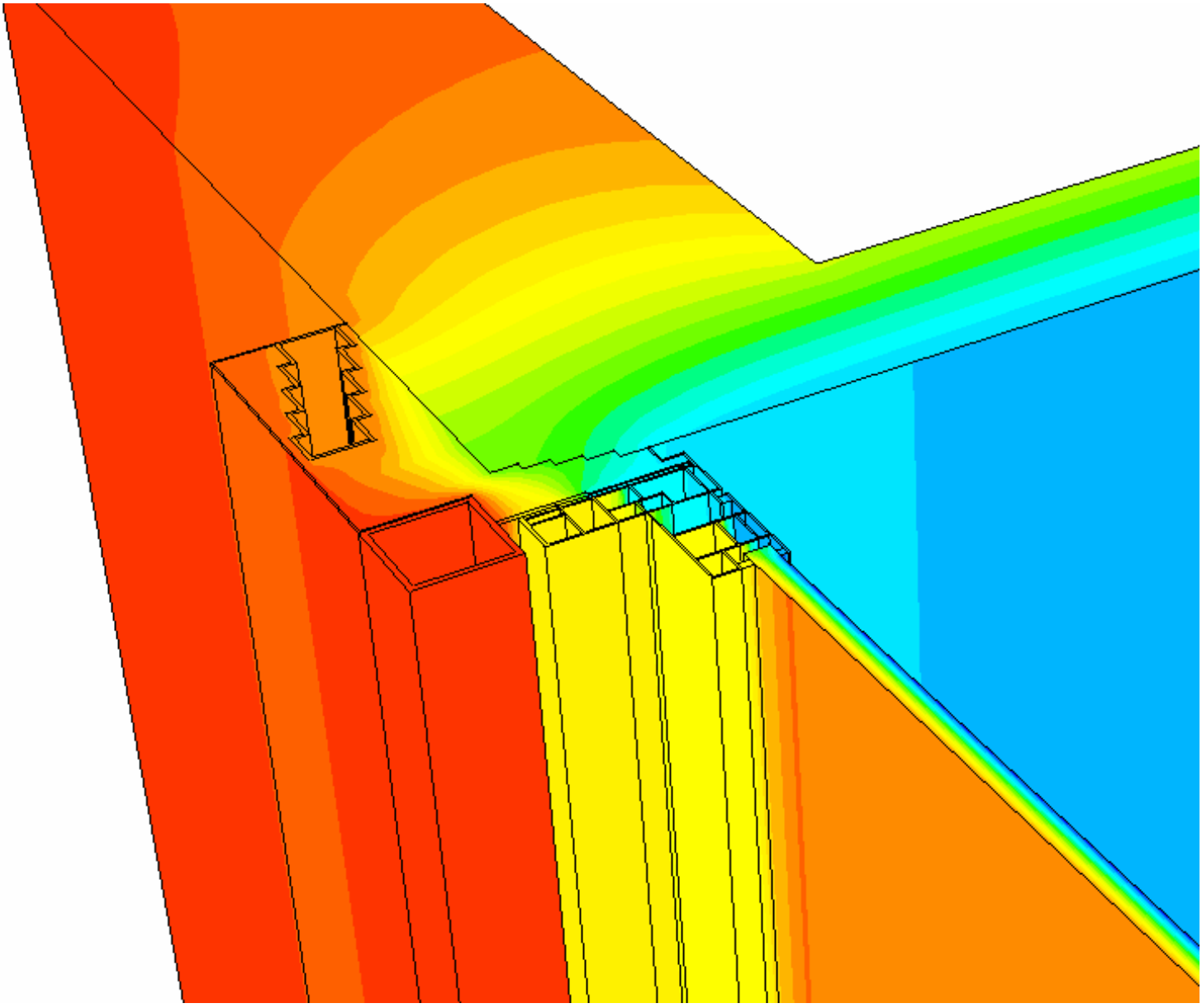
TRISCO - Input Data

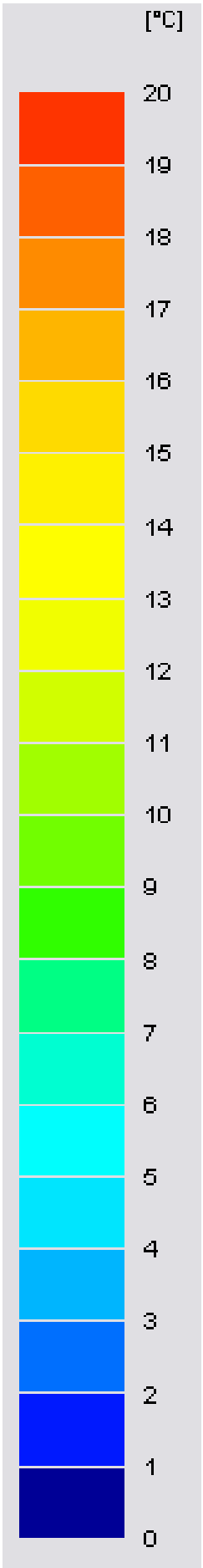
COLOURS

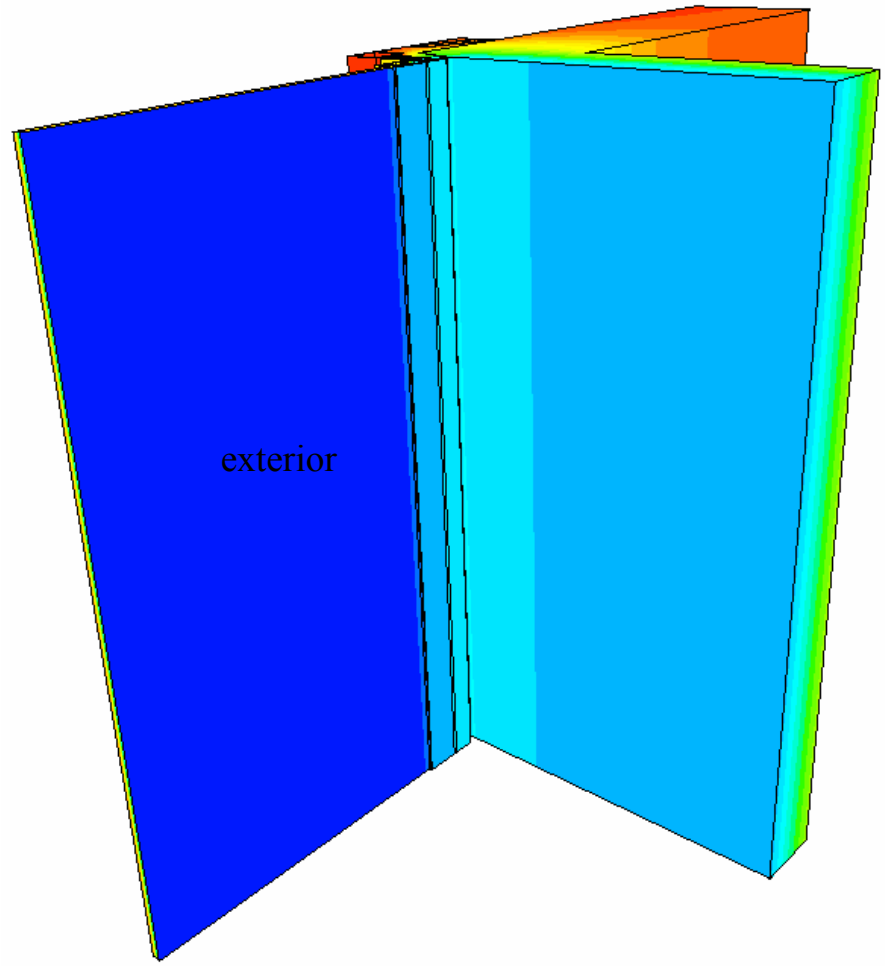
Col.	Type	CEN-rule	Name	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]
2	MATERIAL		steel	45.000	0.90			
3	MATERIAL		POM insulation	0.310	0.90			
4	MATERIAL		aluminum 99%	203.000	0.90			
5	MATERIAL		reinforced concrete	1.700	0.90			
6	MATERIAL		polystyrene insul.	0.035	0.90			
7	MATERIAL		polyamide 6.6 (25%)	0.300	0.90			
8	MATERIAL		polyethylene	0.200	0.90			
9	MATERIAL		fictive glass	0.025	0.90			
10	BC_FREE	NIHIL	CAVITY 1					0
11	BC_FREE	NIHIL	CAVITY 2					0
12	BC_FREE	NIHIL	CAVITY 3					0
13	BC_FREE	NIHIL	CAVITY 4					0
14	BC_FREE	NIHIL	CAVITY 5					0
15	BC_FREE	NIHIL	CAVITY 6					0
16	BC_FREE	NIHIL	CAVITY 7					0

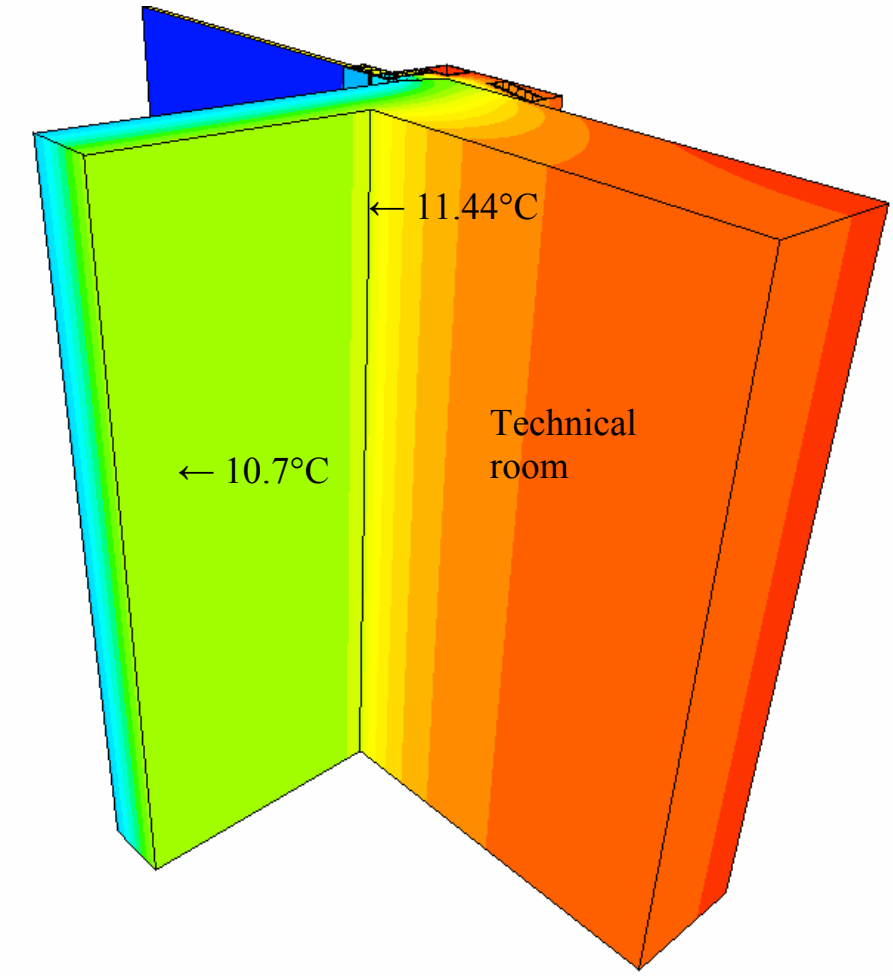
17	BC_FREE	NIHIL	CAVITY 8			0
18	BC_FREE	NIHIL	CAVITY 9			0
19	BC_FREE	NIHIL	CAVITY 10			0
20	BC_FREE	NIHIL	CAVITY 11			0
21	BC_FREE	NIHIL	CAVITY 12			0
22	BC_FREE	NIHIL	CAVITY 13			0
23	BC_FREE	NIHIL	CAVITY 14			0
24	BC_FREE	NIHIL	CAVITY 15			0
25	BC_FREE	NIHIL	CAVITY 16			0
26	BC_FREE	NIHIL	CAVITY 17			0
27	BC_FREE	NIHIL	CAVITY 18			0
28	BC_FREE	NIHIL	CAVITY 19			0
29	BC_SIMPL	NIHIL	INSIDE HALL	20.0	8.00	0
30	BC_SIMPL	NIHIL	INSIDE TECHNICAL	18.0	8.00	0
31	BC_SIMPL	NIHIL	OUTSIDE	0.9	20.00	0

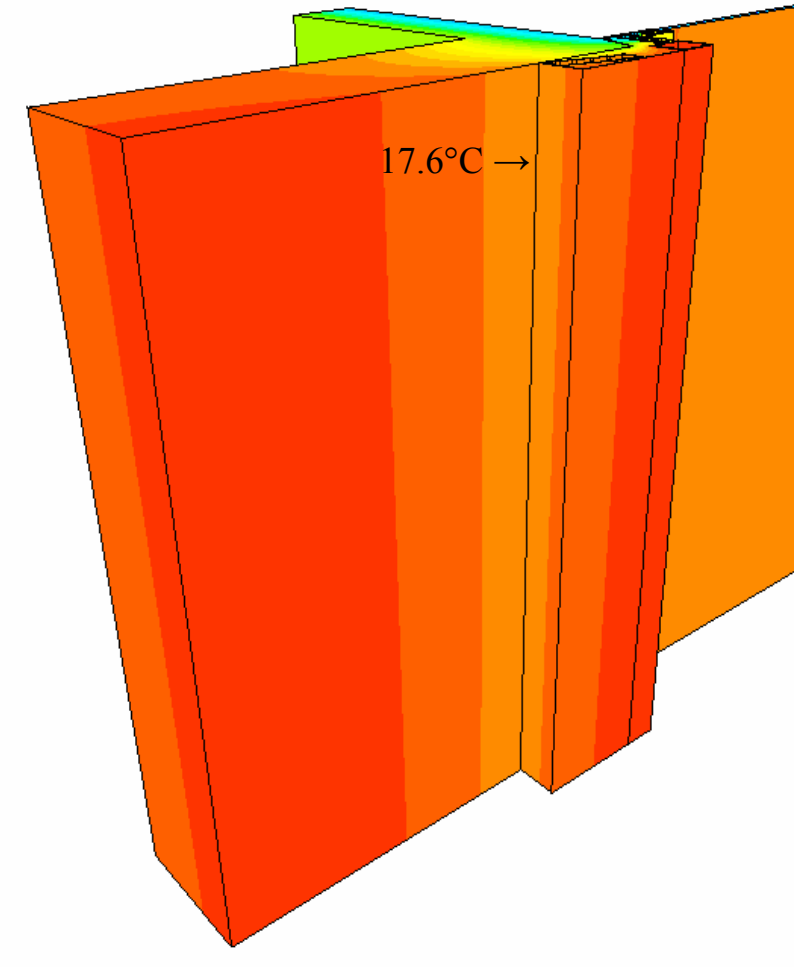
1.3.2. Graphical results

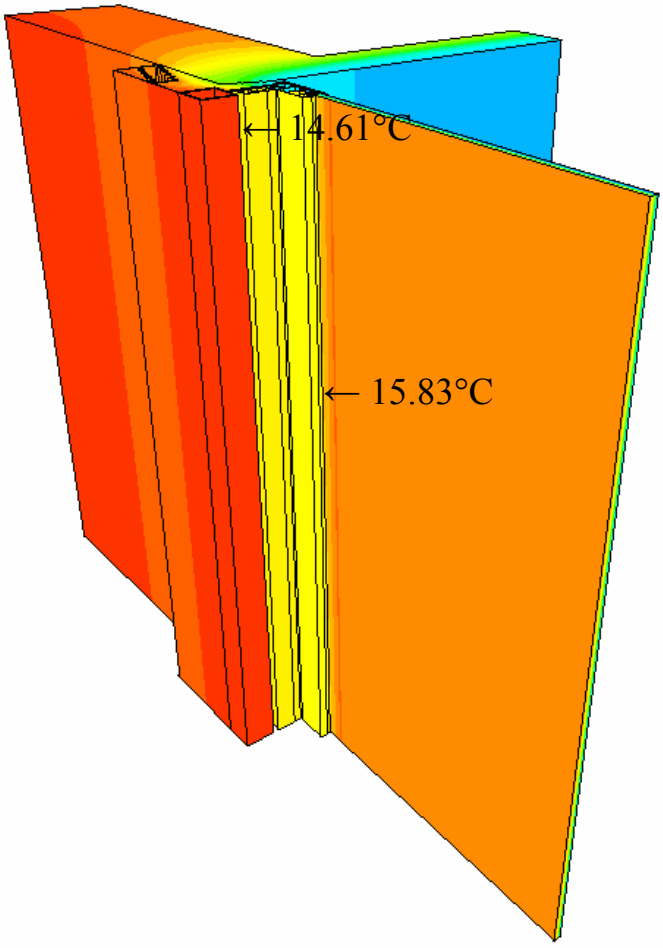


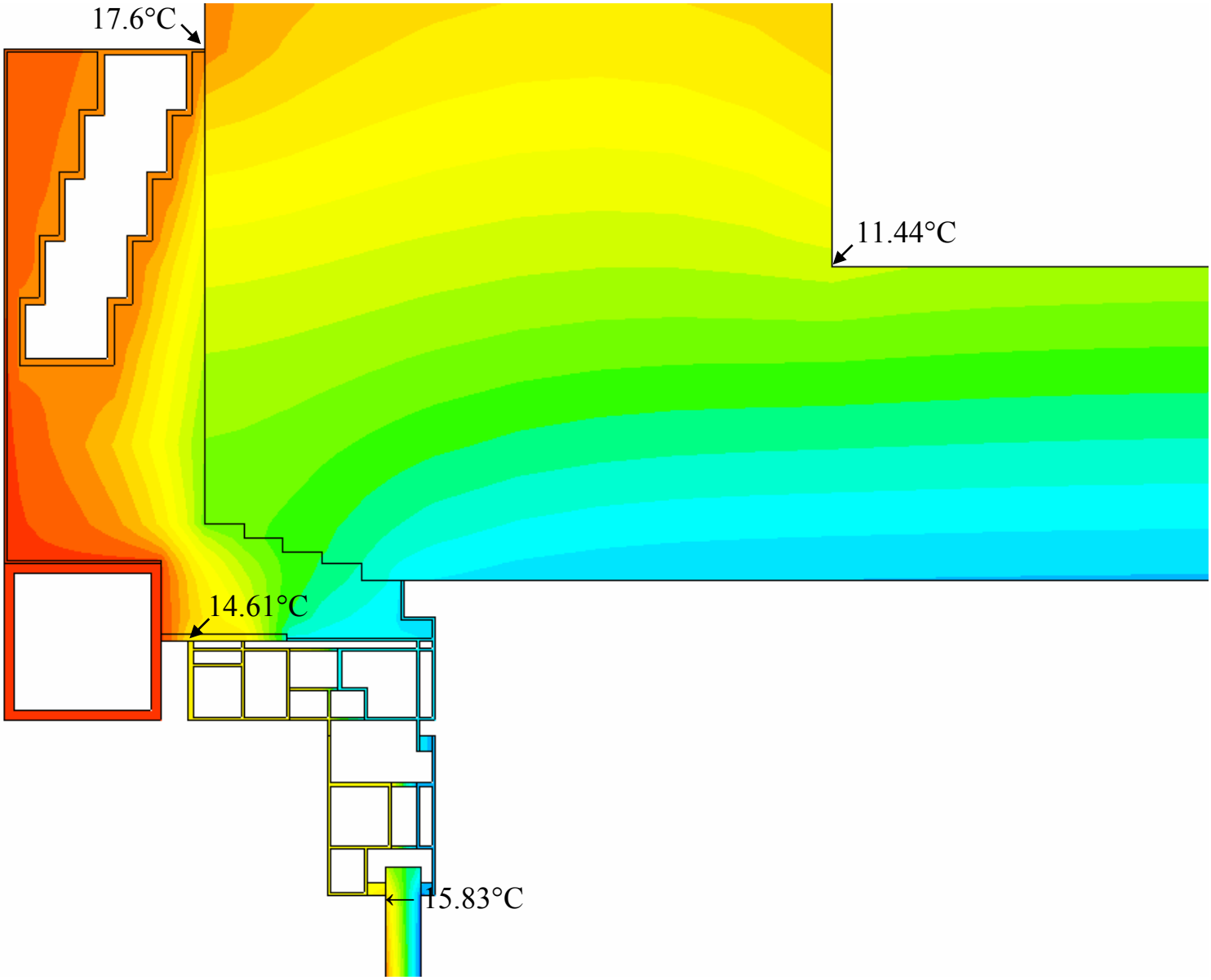

[°C]
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0


exterior


← 11.44°C
← 10.7°C
Technical
room


17.6°C →

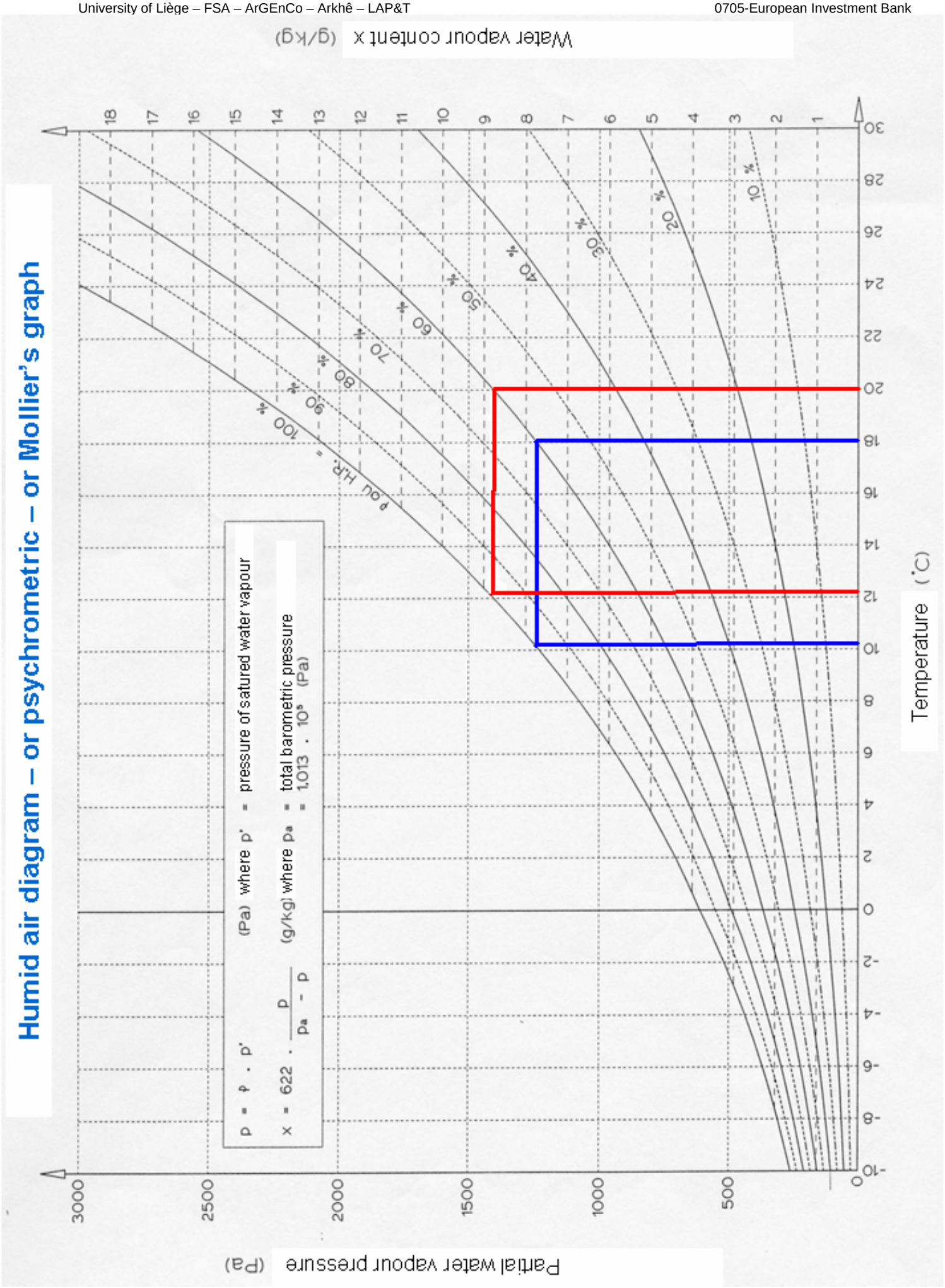

← 14.61°C
← 15.83°C



Those results are already much better. Mollier's graph (see them hereunder) teaches us that:

- With an inside temperature of 20°C, condensation might appear if the face temperature downs to 12°C (with 60% of relative humidity).
- With an inside temperature of 18°C, condensation might appear if the face temperature downs to 10°C, with 60% of relative humidity.

Now, seeing that, we could argue that those results are satisfying enough to ensure there will be no major problems, perhaps a little bit of condensation during only a few cold days.
The main problem could appear in the technical room, where the temperature is lower, where the risks are bigger in case of very cold days (the non-insulated wall is only composed of 20 centimetres of reinforced concrete).
We are going to try to insulate this one on a fourth model.


Humid air diagram – or psychrometric – or Mollier's graph
Water vapour content x (g/kg)
Partial water vapour pressure (Pa)
Temperature (°C)
p = ρ . p'
(Pa) where p' = pressure of satured water vapour
x = 622 . p / (pa - p)
(g/kg) where pa = total barometric pressure = 1,013 . 10⁵ (Pa)
ρ ou HR = 100 %
90 %
80 %
70 %
60 %
50 %
40 %
30 %
20 %
10 %

TRISCO - Calculation Results

TRISCO data file: real frame 0.9°C.trc

Number of nodes = 129013
Heat flow divergence for total object = 0.000493873
Heat flow divergence for worst node = 0.15763

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
2	MATERIAL	steel	19.25	21	47	40	19.40	7	30	0
3	MATERIAL	POM insulation	5.56	32	39	40	19.29	21	39	16
4	MATERIAL	aluminum 99%	3.46	50	20	39	19.28	3	47	13
5	MATERIAL	reinforced concrete	3.82	71	44	16	19.40	28	86	28
6	MATERIAL	polystyrene insul.	4.86	46	42	40	19.28	21	41	18
7	MATERIAL	polyamide 6.6 (25%)	3.56	47	25	40	14.56	34	30	40
8	MATERIAL	polyethylene	2.22	49	20	17	15.85	42	20	5
9	MATERIAL	glass	1.73	49	19	40	18.05	42	19	0
10	BC_FREE	CAVITY 1	19.25	19	45	40	19.40	7	32	0
11	BC_FREE	CAVITY 2	17.67	24	63	0	17.91	13	64	0
12	BC_FREE	CAVITY 3	14.46	29	39	0	14.62	28	39	21
13	BC_FREE	CAVITY 4	5.00	47	38	40	14.48	30	38	20
14	BC_FREE	CAVITY 5	4.95	50	39	40	5.01	48	39	23
15	BC_FREE	CAVITY 6	14.48	29	37	0	14.61	27	36	20
16	BC_FREE	CAVITY 7	14.52	29	35	0	14.64	27	31	20
17	BC_FREE	CAVITY 8	14.37	32	37	37	14.59	30	31	21
18	BC_FREE	CAVITY 9	5.22	37	37	40	14.41	33	34	40
19	BC_FREE	CAVITY 10	10.06	35	33	0	14.51	33	31	40
20	BC_FREE	CAVITY 11	5.17	40	31	40	11.79	36	31	23
21	BC_FREE	CAVITY 12	4.98	47	31	40	5.26	38	34	22
22	BC_FREE	CAVITY 13	4.90	50	34	40	5.01	48	37	23
23	BC_FREE	CAVITY 14	3.51	50	28	40	13.35	36	29	0
24	BC_FREE	CAVITY 15	13.16	43	26	27	13.42	36	25	0
25	BC_FREE	CAVITY 16	3.56	47	25	40	13.24	44	25	0
26	BC_FREE	CAVITY 17	3.52	50	25	40	3.57	48	26	27
27	BC_FREE	CAVITY 18	13.33	40	24	27	13.48	36	21	0
28	BC_FREE	CAVITY 19	3.48	50	22	39	13.41	41	22	1
29	BC_SIMPL	INSIDE HALL	12.64	35	30	9	19.40	7	30	0
30	BC_SIMPL	INSIDE TECHNICAL	10.70	71	57	17	18.43	56	86	27
31	BC_SIMPL	OUTSIDE	1.73	49	19	40	5.04	47	44	22

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
10	BC_FREE	CAVITY 1	19.33	0.19	0.19
11	BC_FREE	CAVITY 2	17.78	0.43	0.43
12	BC_FREE	CAVITY 3	14.55	0.15	0.15
13	BC_FREE	CAVITY 4	8.04	9.27	9.27
14	BC_FREE	CAVITY 5	4.98	0.02	0.02
15	BC_FREE	CAVITY 6	14.55	0.10	0.10
16	BC_FREE	CAVITY 7	14.59	0.10	0.10
17	BC_FREE	CAVITY 8	14.48	0.18	0.18
18	BC_FREE	CAVITY 9	10.78	5.51	5.51
19	BC_FREE	CAVITY 10	13.23	2.13	2.13
20	BC_FREE	CAVITY 11	7.37	2.46	2.46
21	BC_FREE	CAVITY 12	5.12	0.17	0.17
22	BC_FREE	CAVITY 13	4.96	0.05	0.05
23	BC_FREE	CAVITY 14	8.45	8.06	8.06
24	BC_FREE	CAVITY 15	13.29	0.23	0.23
25	BC_FREE	CAVITY 16	8.28	6.36	6.36
26	BC_FREE	CAVITY 17	3.55	0.03	0.03
27	BC_FREE	CAVITY 18	13.42	0.06	0.06

28	BC_FREE	CAVITY 19	8.79	4.47	4.47
29	BC_SIMPL	INSIDE HALL		95.39	0.00
30	BC_SIMPL	INSIDE TECHNICAL		102.43	2.85
31	BC_SIMPL	OUTSIDE		0.00	194.98

TRISCO - Temperatures in corner nodes

TRISCO data file: last model 080129 0.9°C.trc

X	Y	Z	t [°C]
1	30	0	19.40
1	30	40	19.40
1	66	0	18.34
1	66	40	18.34
3	32	0	19.40
3	32	40	19.40
3	45	0	19.29
3	45	40	19.29
5	54	0	17.80
5	54	40	17.80
5	55	0	17.83
5	55	40	17.83
7	55	0	17.83
7	55	40	17.83
7	58	0	17.85
7	58	40	17.85
9	58	0	17.85
9	58	40	17.85
9	60	0	17.87
9	60	40	17.87
11	60	0	17.87
11	60	40	17.87
11	62	0	17.89
11	62	40	17.89
13	62	0	17.89
13	62	40	17.89
13	64	0	17.91
13	64	40	17.91
14	54	0	17.75
14	54	40	17.75
14	56	0	17.72
14	56	40	17.72
16	56	0	17.72
16	56	40	17.72
16	59	0	17.70
16	59	40	17.70
18	59	0	17.69
18	59	40	17.69
18	61	0	17.68
18	61	40	17.68
19	32	0	19.37
19	32	40	19.37
19	45	0	19.25
19	45	40	19.25
21	30	0	19.37
21	30	40	19.37
21	39	0	19.29
21	39	40	19.29
22	61	0	17.68
22	61	40	17.68

22	63	0	17.67
22	63	40	17.67
24	63	0	17.67
24	63	40	17.67
24	64	0	17.69
24	64	40	17.69
25	30	0	14.64
25	30	40	14.64
25	39	0	14.61
25	39	40	14.61
27	31	0	14.64
27	31	40	14.64
27	35	0	14.61
27	35	40	14.61
27	36	0	14.61
27	36	40	14.61
27	37	0	14.60
27	37	40	14.60
27	38	0	14.60
27	38	40	14.60
27	39	0	14.60
27	39	40	14.60
28	66	0	17.60
28	66	40	17.60
28	86	0	19.40
28	86	40	19.40
29	31	0	14.59
29	31	40	14.59
29	35	0	14.52
29	35	40	14.52
29	36	0	14.52
29	36	40	14.52
29	37	0	14.48
29	37	40	14.48
29	38	0	14.48
29	38	40	14.48
29	39	0	14.46
29	39	40	14.46
30	31	0	14.59
30	31	40	14.59
30	37	0	14.48
30	37	40	14.48
30	38	0	14.48
30	38	40	14.48
30	39	0	14.46
30	39	40	14.46
32	31	0	14.51
32	31	40	14.51
32	37	0	14.37
32	37	40	14.37
33	31	0	14.51
33	31	40	14.51
33	33	0	14.42
33	33	40	14.42
33	34	0	14.41
33	34	40	14.41
33	37	0	14.36
33	37	40	14.36
35	20	0	13.48
35	20	40	13.48
35	30	0	12.64

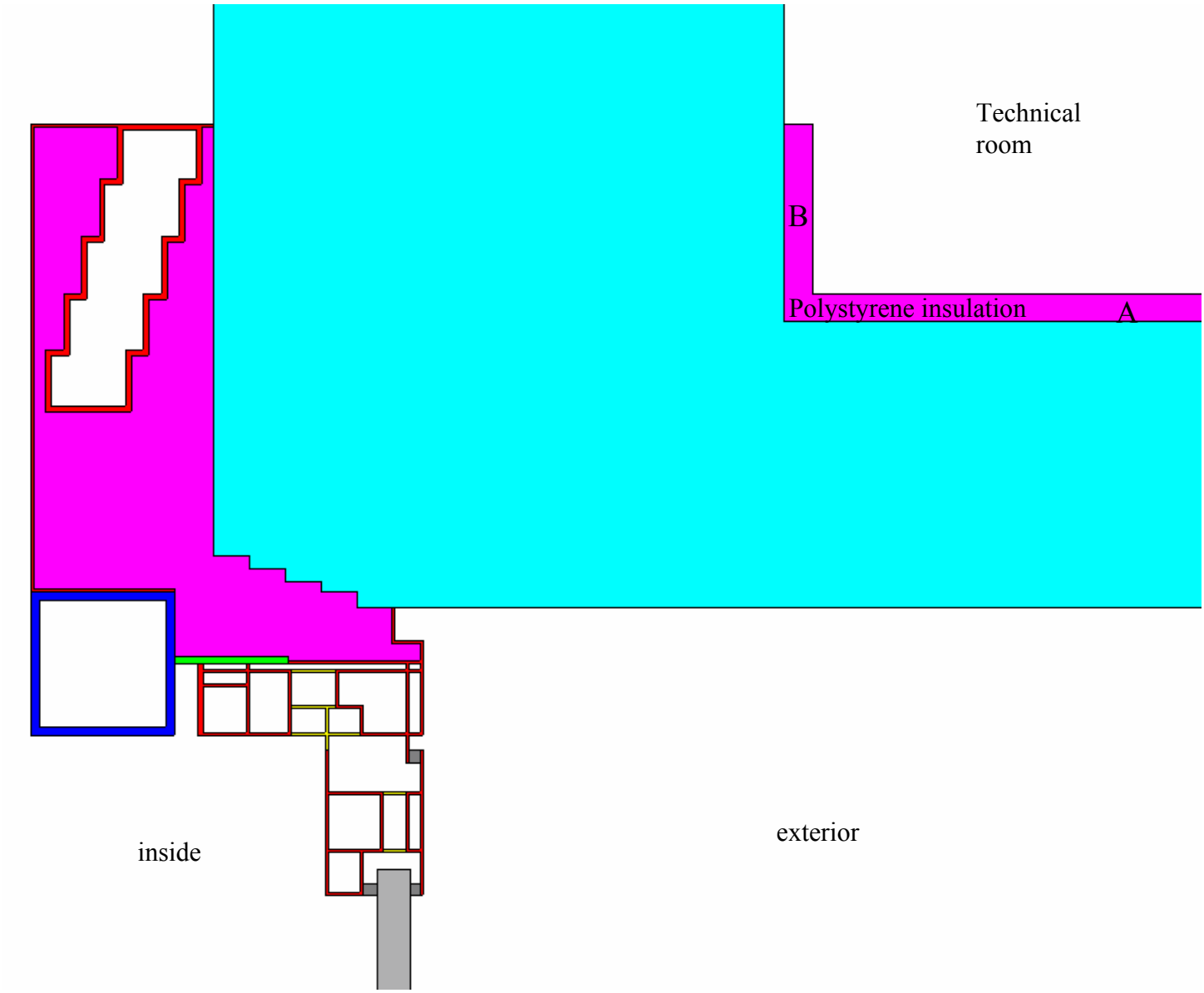
35	30	40	12.64
35	31	0	12.32
35	31	40	12.33
35	33	0	10.06
35	33	40	10.06
36	21	0	13.48
36	21	40	13.48
36	24	0	13.42
36	24	40	13.42
36	25	0	13.42
36	25	40	13.42
36	26	0	13.34
36	26	40	13.34
36	27	0	13.34
36	27	40	13.34
36	30	0	12.12
36	30	40	12.13
36	31	0	11.79
36	31	40	11.79
36	33	0	9.55
36	33	40	9.55
37	34	0	5.26
37	34	40	5.26
37	37	0	5.22
37	37	40	5.22
38	34	0	5.25
38	34	40	5.25
38	37	0	5.22
38	37	40	5.22
40	21	0	13.44
40	21	40	13.44
40	24	0	13.33
40	24	40	13.33
40	31	0	5.17
40	31	40	5.17
40	33	0	5.22
40	33	40	5.22
41	22	0	13.41
41	22	40	13.41
41	24	0	13.33
41	24	40	13.33
41	31	0	5.16
41	31	40	5.16
41	34	0	5.22
41	34	40	5.22
42	0	0	17.80
42	0	40	17.80
42	20	0	15.83
42	20	40	15.83
42	22	0	13.31
42	22	40	13.31
42	23	0	11.61
42	23	40	11.61
43	25	0	13.24
43	25	40	13.24
43	26	0	13.17
43	26	40	13.17
44	25	0	13.24
44	25	40	13.24
44	26	0	13.17
44	26	40	13.17

46	43	0	4.86
46	43	40	4.86
46	44	0	4.92
46	44	40	4.92
47	25	0	3.57
47	25	40	3.56
47	26	0	3.57
47	26	40	3.57
47	28	0	4.96
47	28	40	4.96
47	30	0	4.98
47	30	40	4.98
47	31	0	4.98
47	31	40	4.98
47	37	0	5.00
47	37	40	5.00
47	38	0	5.01
47	38	40	5.00
47	39	0	5.01
47	39	40	5.01
48	25	0	3.56
48	25	40	3.56
48	26	0	3.57
48	26	40	3.57
48	29	0	4.96
48	29	40	4.96
48	30	0	4.97
48	30	40	4.97
48	31	0	4.97
48	31	40	4.97
48	37	0	5.00
48	37	40	5.00
48	38	0	5.00
48	38	40	5.00
48	39	0	5.01
48	39	40	5.01
49	0	0	1.78
49	0	40	1.78
49	20	0	2.22
49	20	40	2.22
49	22	0	4.30
49	22	40	4.30
49	23	0	5.81
49	23	40	5.81
50	22	0	3.48
50	22	40	3.48
50	24	0	3.52
50	24	40	3.52
50	25	0	3.52
50	25	40	3.52
50	26	0	3.53
50	26	40	3.53
50	27	0	3.53
50	27	40	3.53
50	28	0	3.51
50	28	40	3.51
50	31	0	4.93
50	31	40	4.93
50	37	0	4.95
50	37	40	4.95
50	38	0	4.96

50	38	40	4.95
50	39	0	4.95
50	39	40	4.95
51	20	0	3.47
51	20	40	3.47
51	29	0	3.50
51	29	40	3.50
51	30	0	4.93
51	30	40	4.93
51	43	0	4.89
51	43	40	4.89
56	57	0	11.44
56	57	40	11.44
56	86	0	18.43
56	86	40	18.43
71	44	0	3.82
71	44	40	3.82
71	57	0	10.70
71	57	40	10.70

1.4. Real frame, 2 cm insulation in technical room, 0.9°C outside

1.4.1. Input data



The insulation in the technical room is a 2 centimetre thick polystyrene insulation. The whole wall, directly submitted to the external conditions has to be insulated (A part of the insulation on the sketch above). Therefore, there must be some insulation (B part) on the other wall. This will be explained hereafter.

TRISCO - Input Data

TRISCO data file: insulated technical.trc

GRID
Grid unit = 0.01 m

No.	X	Y	Z
0-1	10.000	5.000	5.000
1-2	0.200	5.000	5.000
2-3	0.400	5.000	5.000
3-4	0.400	5.000	5.000
4-5	0.400	5.000	5.000
5-6	0.850	5.000	5.000
6-7	0.400	5.000	5.000
7-8	0.850	5.000	5.000
8-9	0.400	5.000	5.000
9-10	0.850	5.000	5.000
10-11	0.400	5.000	5.000
11-12	0.850	5.000	5.000
12-13	0.400	5.000	5.000
13-14	0.200	5.000	5.000
14-15	0.400	5.000	5.000
15-16	0.850	5.000	5.000
16-17	0.400	5.000	5.000
17-18	0.850	5.000	5.000
18-19	0.300	5.000	5.000
19-20	0.100	5.000	5.000
20-21	0.500	0.200	5.000
21-22	0.350	0.600	5.000
22-23	0.400	1.000	5.000
23-24	0.850	1.200	5.000
24-25	0.100	0.200	5.000
25-26	0.300	3.800	5.000
26-27	0.100	0.200	5.000
27-28	0.700	2.000	5.000
28-29	2.300	1.000	5.000
29-30	0.200	1.000	5.000
30-31	2.500	0.200	5.000
31-32	0.200	0.400	5.000
32-33	0.200	1.300	5.000
33-34	2.100	0.200	5.000
34-35	0.300	1.300	5.000
35-36	0.200	0.200	5.000
36-37	0.500	0.800	5.000
37-38	0.200	0.200	5.000
38-39	1.300	0.400	5.000
39-40	0.200	0.200	5.000
40-41	0.200	0.300	
41-42	1.100	0.900	
42-43	0.200	0.200	
43-44	0.200	2.350	
44-45	0.600	0.460	
45-46	0.200	0.440	
46-47	0.800	0.160	
47-48	0.200	0.200	
48-49	0.100	0.540	
49-50	0.700	0.900	

50-51	0.200	0.900	
51-52	5.300	5.040	
52-53	5.000	5.030	
53-54	5.000	0.400	
54-55	5.000	3.500	
55-56	5.000	0.400	
56-57	2.000	2.030	
57-58	3.000	1.570	
58-59	5.000	0.400	
59-60	2.000	3.600	
60-61	3.000	0.400	
61-62	5.000	3.600	
62-63	5.000	0.400	
63-64	5.000	3.500	
64-65	5.000	0.200	
65-66	5.000	0.200	
66-67	5.000	5.000	
67-68	5.000	5.000	
68-69	5.000	5.000	
69-70	5.000	5.000	
70-71	5.000	5.000	
71-72	5.000	5.000	
72-73	5.000	5.000	
73-74		5.000	
74-75		5.000	
75-76		5.000	
76-77		5.000	
77-78		5.000	
78-79		5.000	
79-80		5.000	
80-81		5.000	
81-82		5.000	
82-83		5.000	
83-84		5.000	
84-85		5.000	
85-86		5.000	
Sum	137.800	254.020	200.000

BLOCKS

No.	Col.	Xmin	Xmax	Ymin	Ymax	Zmin	Zmax
1	5	28	73	51	57	0	40
2	5	28	56	57	86	0	40
3	5	30	73	50	51	0	40
4	5	31	73	49	50	0	40
5	5	34	73	46	49	0	40
6	5	39	73	44	46	0	40
7	4	1	28	65	66	0	40
8	4	12	26	64	65	0	40
9	4	1	2	47	66	0	40
10	4	1	21	47	48	0	40
11	4	12	13	62	66	0	40
12	4	24	26	62	66	0	40
13	4	10	13	62	63	0	40
14	4	22	26	62	63	0	40
15	4	10	11	60	63	0	40
16	4	22	23	60	63	0	40
17	4	8	11	60	61	0	40
18	4	18	23	60	61	0	40
19	4	8	9	58	61	0	40
20	4	18	20	58	61	0	40
21	4	6	9	58	59	0	40

22	4	16	20	58	59	0	40
23	4	6	7	55	59	0	40
24	4	16	17	55	59	0	40
25	4	4	7	55	56	0	40
26	4	14	17	55	56	0	40
27	4	4	5	53	56	0	40
28	4	14	15	53	56	0	40
29	4	4	15	53	54	0	40
30	4	45	46	42	44	0	40
31	4	45	51	42	43	0	40
32	4	50	51	30	43	0	40
33	4	50	51	20	29	0	40
34	4	32	51	39	40	0	40
35	4	37	51	37	38	0	40
36	4	47	48	28	40	0	40
37	4	40	51	30	31	0	40
38	4	40	41	30	34	0	40
39	4	37	41	33	34	0	40
40	4	37	38	33	38	0	40
41	4	47	51	26	27	0	40
42	4	47	51	24	25	0	40
43	4	47	48	24	27	0	40
44	4	43	44	24	27	0	40
45	4	40	41	20	25	0	40
46	4	35	36	20	29	0	40
47	4	35	41	20	21	0	40
48	4	35	44	24	25	0	40
49	4	35	44	26	27	0	40
50	4	32	33	30	38	0	40
51	4	29	30	30	39	0	40
52	4	25	27	30	39	0	40
53	4	25	33	30	31	0	40
54	4	25	30	35	36	0	40
55	4	25	33	37	38	0	40
56	3	21	32	39	41	0	40
57	2	1	21	45	47	0	40
58	2	1	21	30	32	0	40
59	2	1	3	30	45	0	40
60	2	19	21	30	45	0	40
61	6	2	4	48	65	0	40
62	6	4	6	56	65	0	40
63	6	4	15	48	53	0	40
64	6	6	8	59	65	0	40
65	6	8	10	61	65	0	40
66	6	10	12	63	65	0	40
67	6	15	17	48	55	0	40
68	6	17	20	48	58	0	40
69	6	20	21	48	60	0	40
70	6	21	23	41	60	0	40
71	6	23	26	41	62	0	40
72	6	26	28	41	65	0	40
73	6	28	30	41	51	0	40
74	6	30	31	41	50	0	40
75	6	31	32	41	49	0	40
76	6	32	34	40	49	0	40
77	6	34	39	40	47	0	40
78	6	39	45	40	44	0	40
79	6	45	50	40	42	0	40
80	7	33	37	37	38	0	40
81	7	33	37	33	34	0	40
82	7	33	40	30	31	0	40

83	7	35	36	29	34	0	40
84	7	44	47	26	27	0	40
85	7	44	47	24	25	0	40
86	8	41	42	20	22	0	40
87	8	49	50	20	22	0	40
88	8	48	50	28	29	0	40
89	9	42	49	0	23	0	40
90	10	3	19	32	45	0	40
91	11	13	24	63	64	0	40
92	11	13	22	62	63	0	40
93	11	11	22	61	62	0	40
94	11	11	18	60	61	0	40
95	11	9	18	59	60	0	40
96	11	9	16	58	59	0	40
97	11	7	16	56	58	0	40
98	11	7	14	55	56	0	40
99	11	5	14	54	55	0	40
100	12	27	29	38	39	0	40
101	13	30	47	38	39	0	40
102	14	48	50	38	39	0	40
103	15	27	29	36	37	0	40
104	16	27	29	31	35	0	40
105	17	30	32	31	37	0	40
106	18	33	37	34	37	0	40
107	19	33	35	31	33	0	40
108	20	36	40	31	33	0	40
109	21	38	47	34	37	0	40
110	21	41	47	31	34	0	40
111	22	48	50	31	37	0	40
112	23	36	47	28	30	0	40
113	23	36	50	27	28	0	40
114	24	36	43	25	26	0	40
115	25	44	47	25	26	0	40
116	26	48	50	25	26	0	40
117	27	36	40	21	24	0	40
118	28	41	42	22	24	0	40
119	28	42	49	23	24	0	40
120	28	49	50	22	24	0	40
121	29	35	42	0	20	0	40
122	29	25	35	0	30	0	40
123	29	21	25	0	39	0	40
124	29	1	21	0	30	0	40
125	29	1	28	66	86	0	40
126	29	0	1	0	86	0	40
127	30	57	73	59	86	0	40
128	30	56	57	66	86	0	40
129	31	49	51	0	20	0	40
130	31	46	51	43	44	0	40
131	31	48	51	29	30	0	40
132	31	51	73	0	44	0	40
133	6	56	73	57	59	0	40
134	6	56	57	57	66	0	40

COLOURS

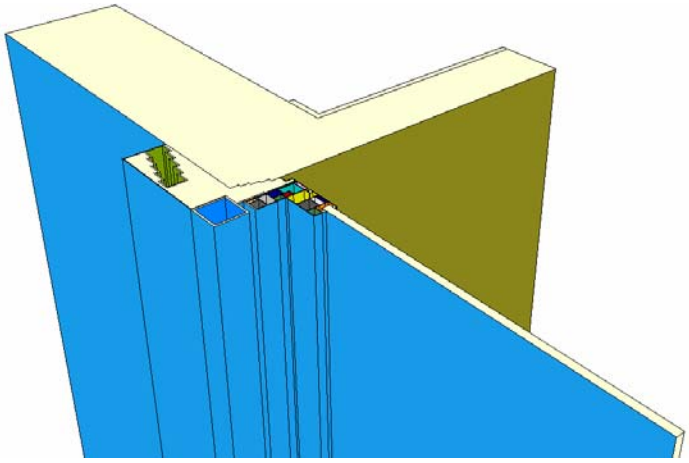
Col.	Type	CEN-rule	Name	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]
2	MATERIAL		steel	45.000	0.90			
3	MATERIAL		POM insulation	0.310	0.90			
4	MATERIAL		aluminum 99%	203.000	0.90			
5	MATERIAL		reinforced concrete	1.700	0.90			
6	MATERIAL		polystyrene insul.	0.035	0.90			

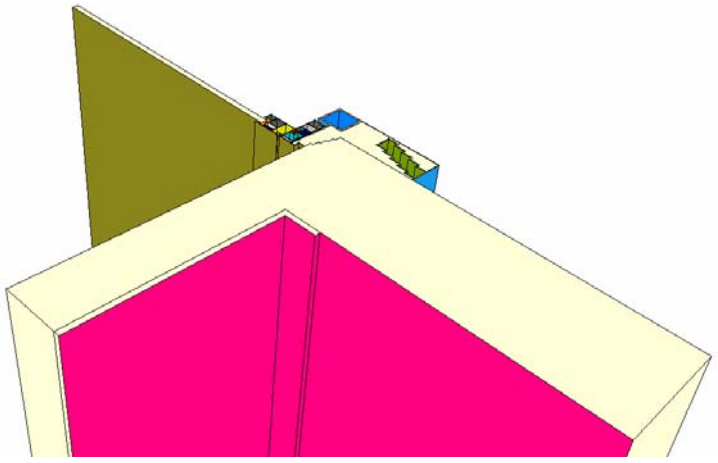
7	MATERIAL		polyamide 6.6 (25%)	0.300	0.90			
8	MATERIAL		polyethylene	0.200	0.90			
9	MATERIAL		glass	0.025	0.90			
10	BC_FREE	NIHIL	CAVITY 1					0
11	BC_FREE	NIHIL	CAVITY 2					0
12	BC_FREE	NIHIL	CAVITY 3					0
13	BC_FREE	NIHIL	CAVITY 4					0
14	BC_FREE	NIHIL	CAVITY 5					0
15	BC_FREE	NIHIL	CAVITY 6					0
16	BC_FREE	NIHIL	CAVITY 7					0
17	BC_FREE	NIHIL	CAVITY 8					0
18	BC_FREE	NIHIL	CAVITY 9					0
19	BC_FREE	NIHIL	CAVITY 10					0
20	BC_FREE	NIHIL	CAVITY 11					0
21	BC_FREE	NIHIL	CAVITY 12					0
22	BC_FREE	NIHIL	CAVITY 13					0
23	BC_FREE	NIHIL	CAVITY 14					0
24	BC_FREE	NIHIL	CAVITY 15					0
25	BC_FREE	NIHIL	CAVITY 16					0
26	BC_FREE	NIHIL	CAVITY 17					0
27	BC_FREE	NIHIL	CAVITY 18					0
28	BC_FREE	NIHIL	CAVITY 19					0
29	BC_SIMPL	NIHIL	INSIDE HALL			20.0	8.00	0
30	BC_SIMPL	NIHIL	INSIDE TECHNICAL			18.0	8.00	0
31	BC_SIMPL	NIHIL	OUTSIDE			0.9	20.00	0

Calculation parameters
Maximum number of iterations = 10000
Maximum temperature difference = 0.0001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Linear radiation
Smallest accepted view factor = 0.0001
Number of visibility rays between radiative surfaces = 100
Black radiation heat transfer coeff. = 5.25 W/(m².K)

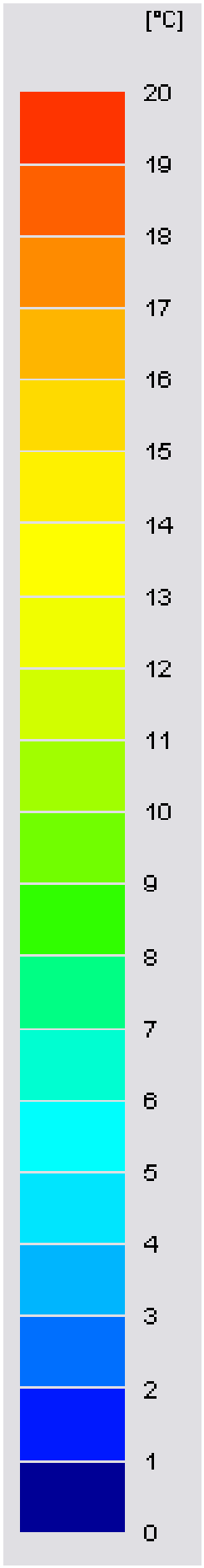
Boundary conditions

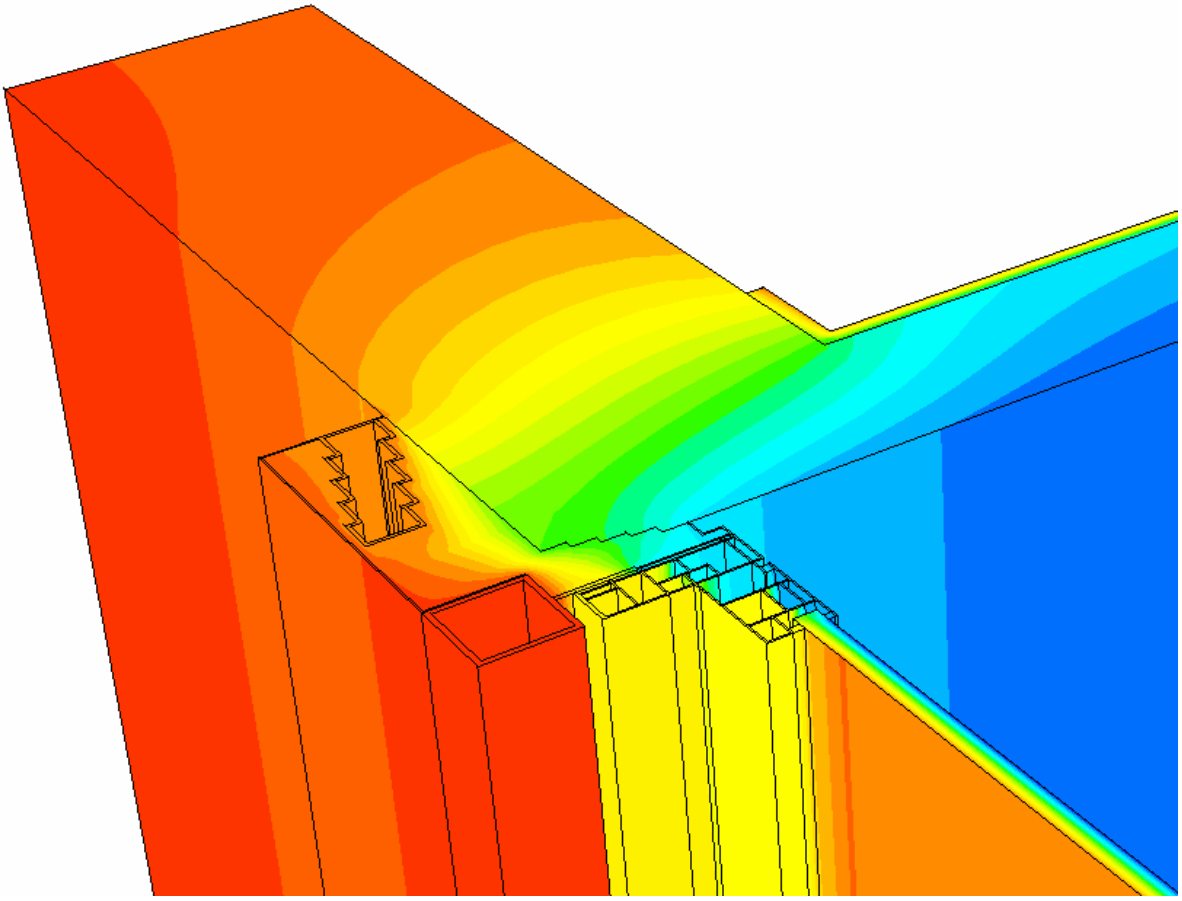
The boundary conditions are the same than in the previous model.

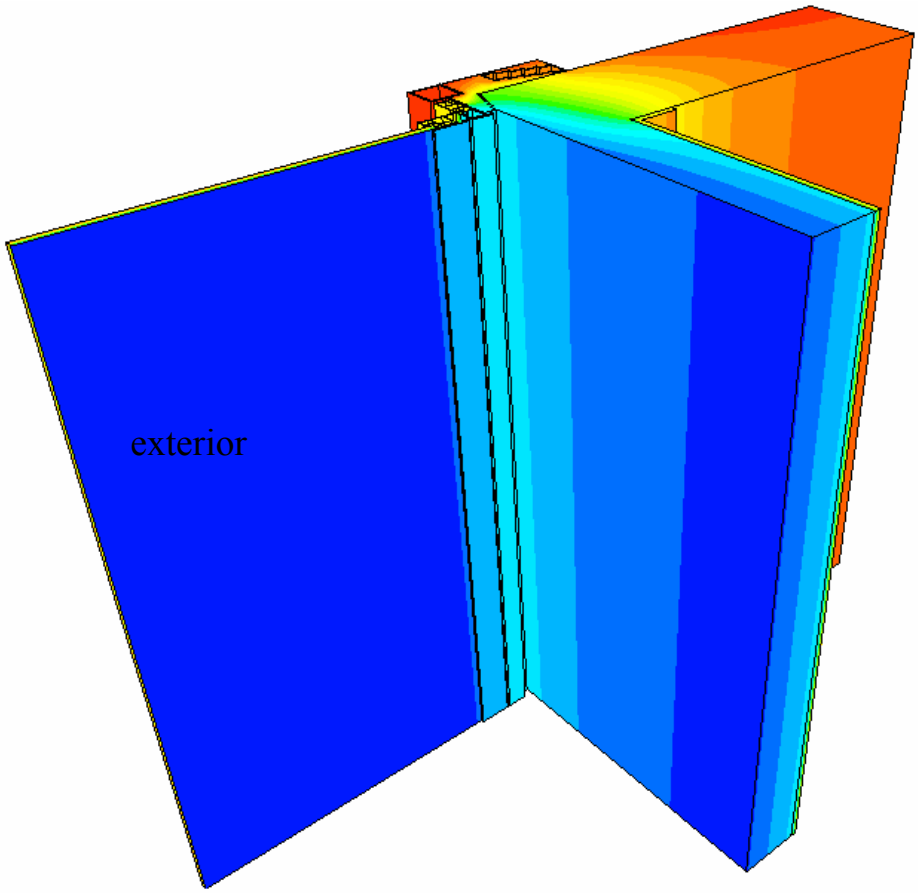


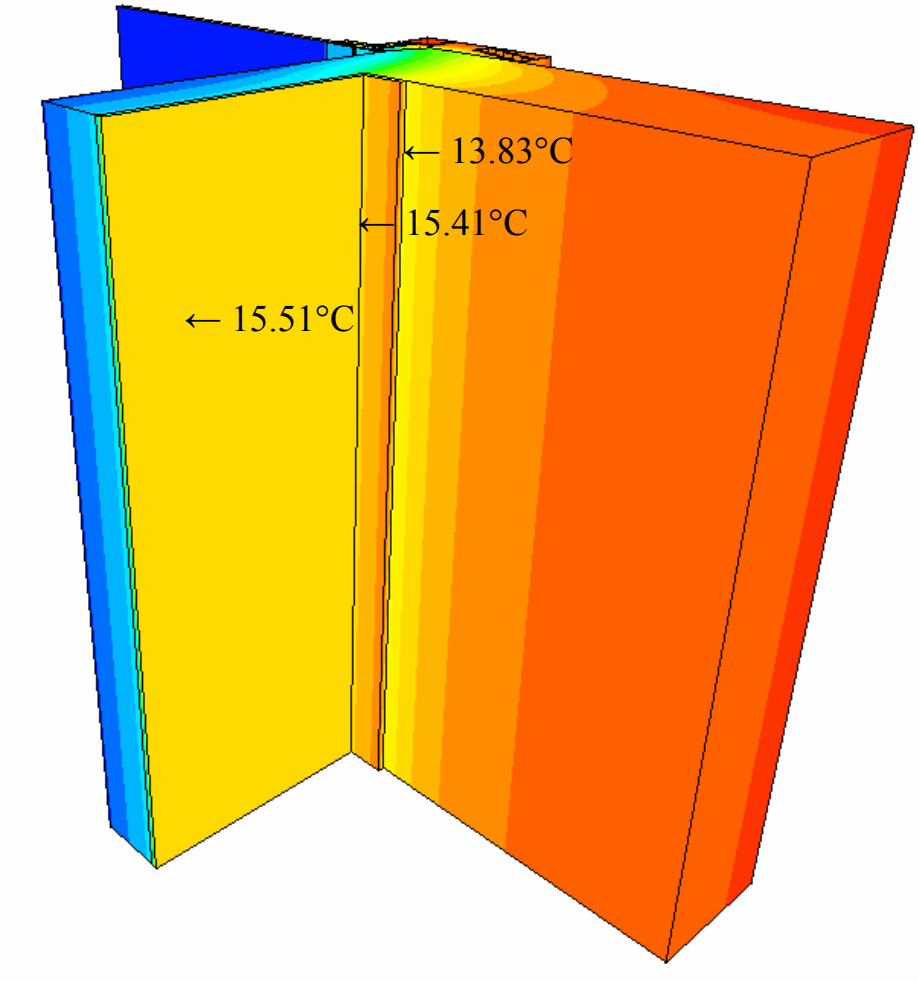


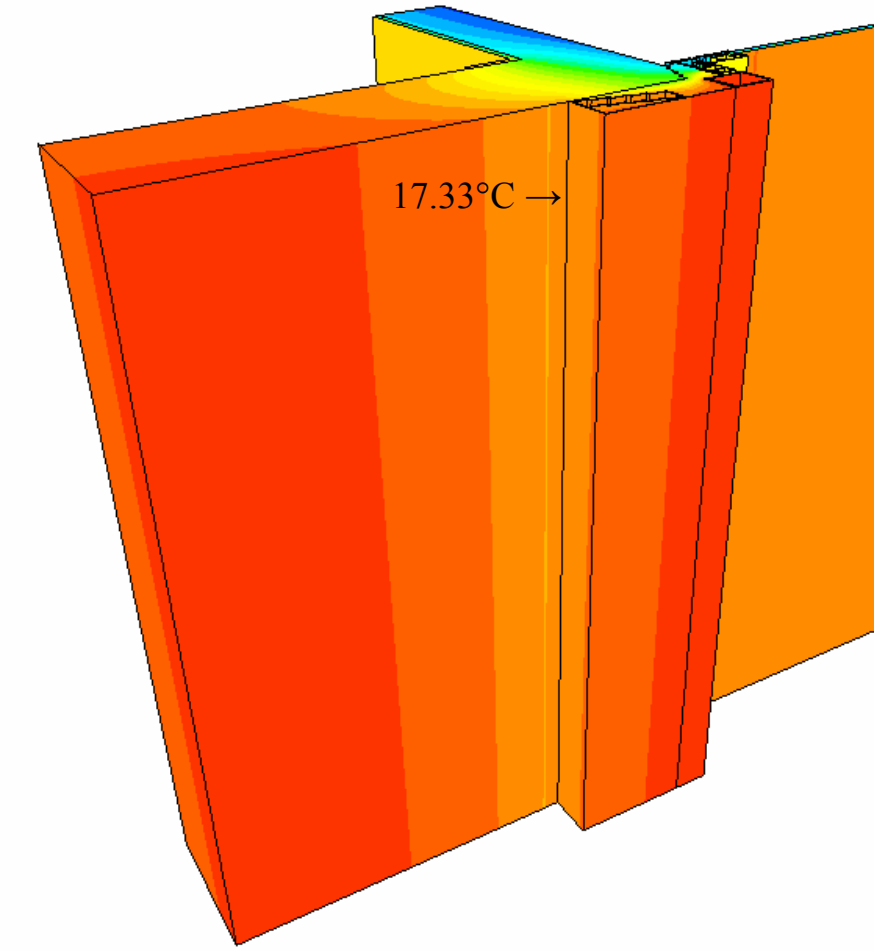
1.4.2. Graphical results

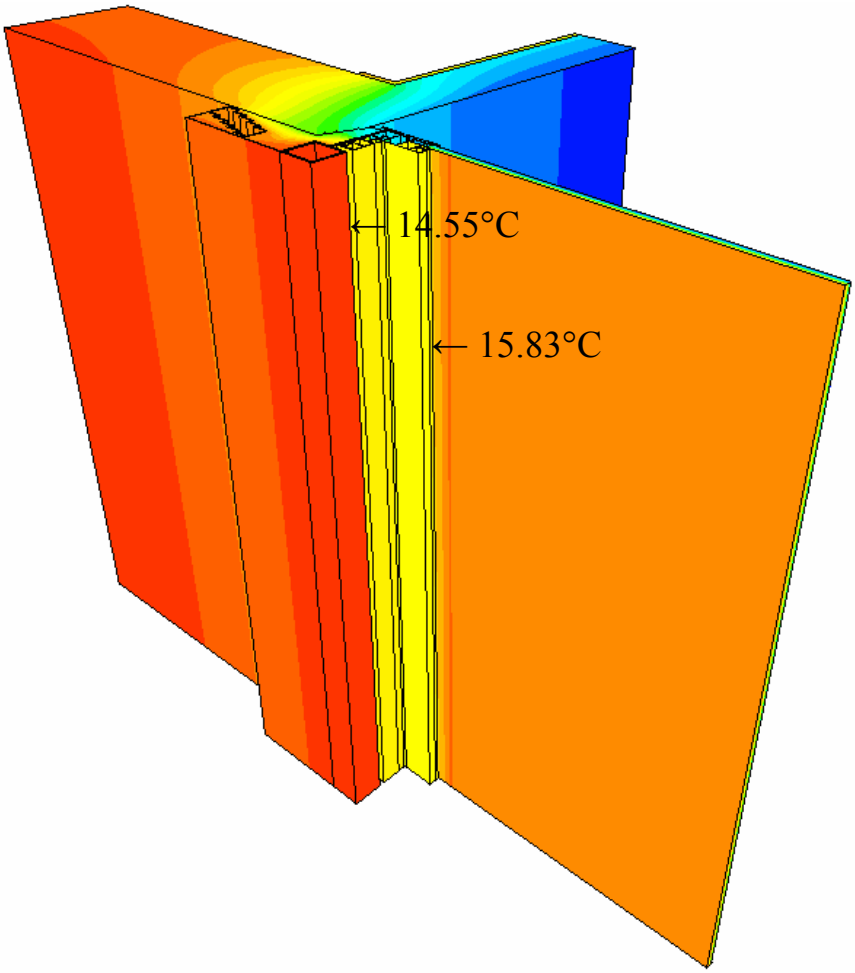


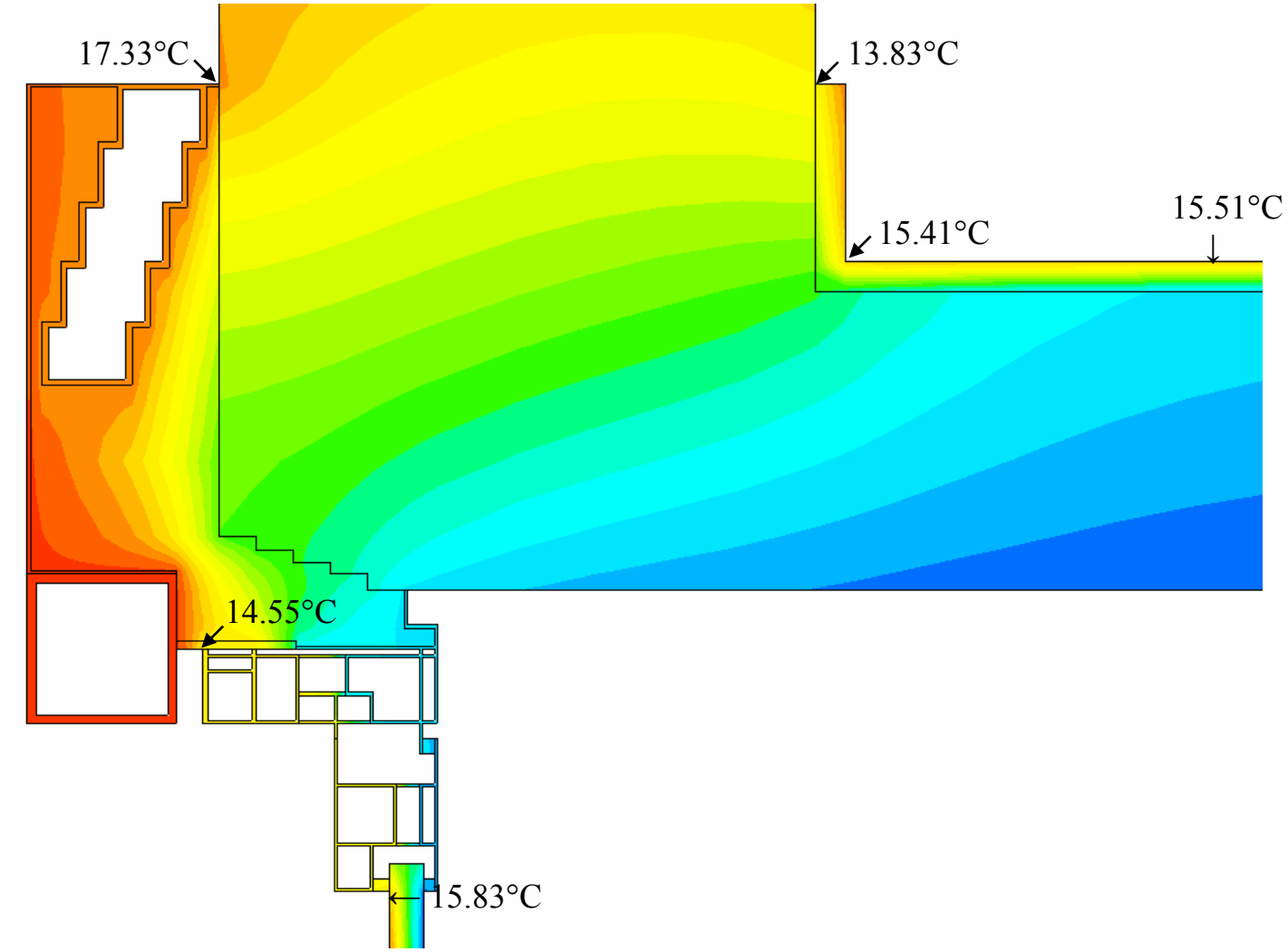





← 13.83°C
← 15.41°C
← 15.51°C


17.33°C →


14.55°C
15.83°C


17.33°C
13.83°C
15.51°C
15.41°C
14.55°C
15.83°C

We can see here on this last picture that the temperature targets are satisfied everywhere, even with -12°C outside. Not one of the corner nodes temperature is below 12°C, which should ensure there will be no condensation at all.

1.4.3. Numerical results

TRISCO - Calculation Results

TRISCO data file: insulated technical.trc

Number of nodes = 131842
Heat flow divergence for total object = 9.00564e-005
Heat flow divergence for worst node = 0.223608

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
2	MATERIAL	steel	19.19	21	47	0	19.36	7	30	40
3	MATERIAL	POM insulation	5.43	32	39	40	19.24	21	39	20
4	MATERIAL	aluminium 99%	3.45	50	20	0	19.22	3	47	20
5	MATERIAL	reinforced concrete	1.93	73	44	18	19.38	28	86	0
6	MATERIAL	polystyrene insul.	4.31	73	57	12	19.23	21	41	20
7	MATERIAL	polyamide 6.6 (25%)	3.55	47	25	0	14.51	34	30	0
8	MATERIAL	polyethylene	2.21	49	20	25	15.84	42	20	2
9	MATERIAL	glass	1.73	49	19	0	18.05	42	19	40
10	BC_FREE	CAVITY 1	19.19	18	45	40	19.36	7	32	0
11	BC_FREE	CAVITY 2	17.41	24	63	0	17.68	13	64	40
12	BC_FREE	CAVITY 3	14.41	29	39	40	14.56	28	39	21
13	BC_FREE	CAVITY 4	4.87	47	38	40	14.42	30	38	21
14	BC_FREE	CAVITY 5	4.82	50	39	40	4.88	48	39	26
15	BC_FREE	CAVITY 6	14.42	29	37	40	14.55	27	36	21
16	BC_FREE	CAVITY 7	14.46	29	35	40	14.59	27	31	21
17	BC_FREE	CAVITY 8	14.31	32	37	37	14.53	30	31	21
18	BC_FREE	CAVITY 9	5.10	37	37	40	14.36	33	34	0
19	BC_FREE	CAVITY 10	9.98	35	33	40	14.45	33	31	0
20	BC_FREE	CAVITY 11	5.04	40	31	40	11.73	36	31	30
21	BC_FREE	CAVITY 12	4.85	47	31	40	5.14	38	34	26
22	BC_FREE	CAVITY 13	4.77	50	34	40	4.88	48	37	26
23	BC_FREE	CAVITY 14	3.49	50	28	0	13.33	36	29	0
24	BC_FREE	CAVITY 15	13.14	43	26	19	13.40	36	25	0
25	BC_FREE	CAVITY 16	3.55	47	25	0	13.22	44	25	0
26	BC_FREE	CAVITY 17	3.51	50	25	0	3.56	48	26	27
27	BC_FREE	CAVITY 18	13.30	40	24	19	13.46	36	21	0
28	BC_FREE	CAVITY 19	3.46	50	22	0	13.39	41	22	0
29	BC_SIMPL	INSIDE HALL	12.58	35	30	12	19.38	28	86	0
30	BC_SIMPL	INSIDE TECHNICAL	13.83	56	66	39	18.41	56	86	40
31	BC_SIMPL	OUTSIDE	1.73	49	19	0	4.86	48	30	26

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
10	BC_FREE	CAVITY 1	19.27	0.20	0.20
11	BC_FREE	CAVITY 2	17.53	0.48	0.48
12	BC_FREE	CAVITY 3	14.49	0.15	0.15
13	BC_FREE	CAVITY 4	7.93	9.35	9.35
14	BC_FREE	CAVITY 5	4.85	0.02	0.02
15	BC_FREE	CAVITY 6	14.50	0.10	0.10
16	BC_FREE	CAVITY 7	14.54	0.10	0.10
17	BC_FREE	CAVITY 8	14.43	0.18	0.18
18	BC_FREE	CAVITY 9	10.70	5.55	5.55
19	BC_FREE	CAVITY 10	13.17	2.14	2.14
20	BC_FREE	CAVITY 11	7.27	2.48	2.48

21	BC_FREE	CAVITY 12	5.00	0.17	0.17
22	BC_FREE	CAVITY 13	4.83	0.05	0.05
23	BC_FREE	CAVITY 14	8.39	8.11	8.11
24	BC_FREE	CAVITY 15	13.27	0.23	0.23
25	BC_FREE	CAVITY 16	8.26	6.36	6.36
26	BC_FREE	CAVITY 17	3.53	0.03	0.03
27	BC_FREE	CAVITY 18	13.39	0.06	0.06
28	BC_FREE	CAVITY 19	8.77	4.47	4.47
29	BC_SIMPL	INSIDE HALL		98.84	0.00
30	BC_SIMPL	INSIDE TECHNICAL		40.54	2.49
31	BC_SIMPL	OUTSIDE		0.00	136.90

TRISCO - Temperatures in corner nodes

TRISCO data file: insulated technical.trc

X	Y	Z	t [°C]
1	30	0	19.35
1	30	40	19.35
1	66	0	18.16
1	66	40	18.16
3	32	0	19.35
3	32	40	19.35
3	45	0	19.23
3	45	40	19.23
5	54	0	17.56
5	54	40	17.56
5	55	0	17.59
5	55	40	17.59
7	55	0	17.59
7	55	40	17.59
7	58	0	17.61
7	58	40	17.61
9	58	0	17.61
9	58	40	17.61
9	60	0	17.63
9	60	40	17.63
11	60	0	17.64
11	60	40	17.64
11	62	0	17.65
11	62	40	17.65
13	62	0	17.66
13	62	40	17.66
13	64	0	17.68
13	64	40	17.68
14	54	0	17.50
14	54	40	17.50
14	56	0	17.47
14	56	40	17.47
16	56	0	17.46
16	56	40	17.46
16	59	0	17.44
16	59	40	17.44
18	59	0	17.44
18	59	40	17.44
18	61	0	17.42
18	61	40	17.42
19	32	0	19.32
19	32	40	19.32
19	45	0	19.19

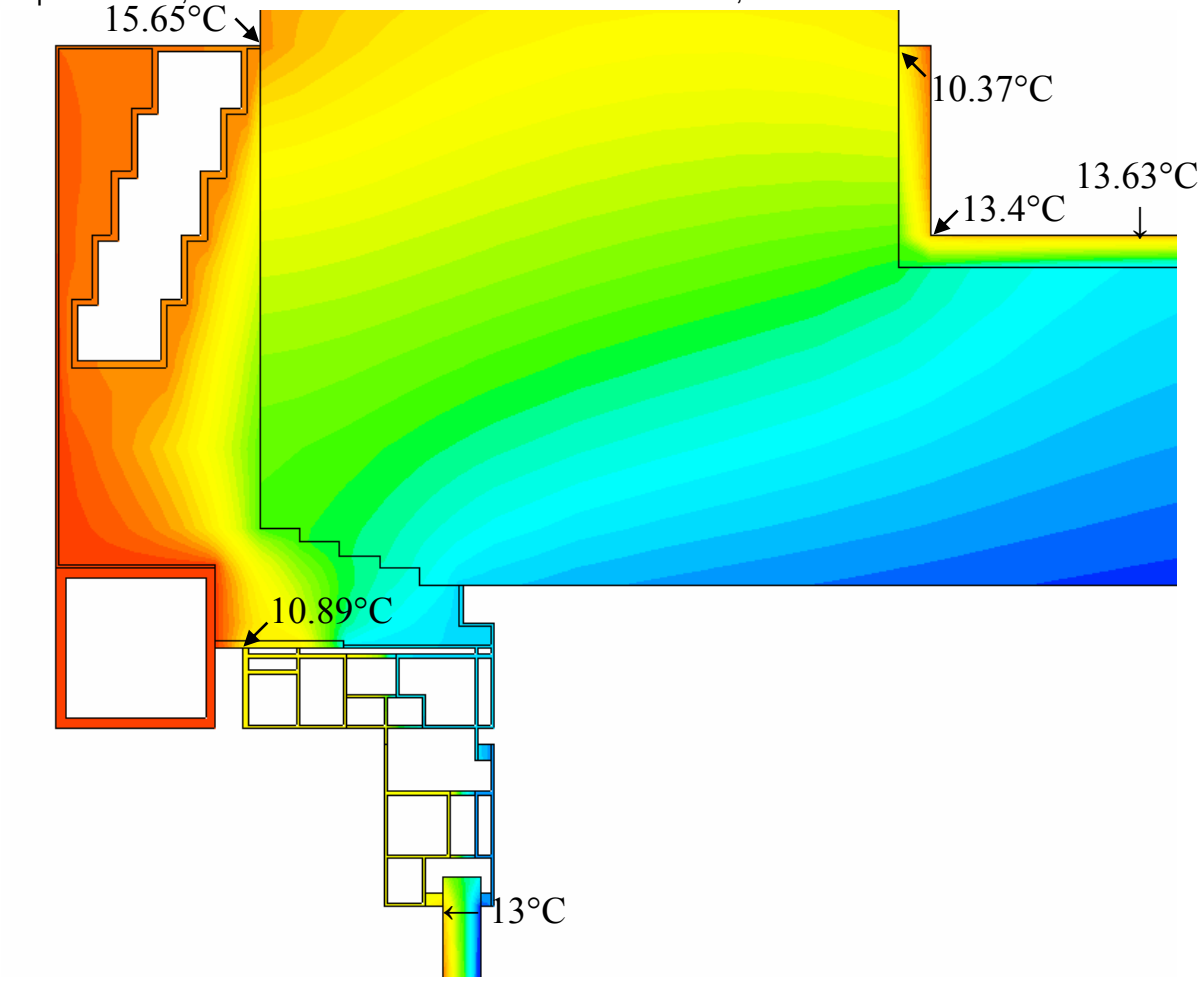
19	45	40	19.19
21	30	0	19.32
21	30	40	19.32
21	39	0	19.24
21	39	40	19.24
22	61	0	17.42
22	61	40	17.42
22	63	0	17.41
22	63	40	17.41
24	63	0	17.41
24	63	40	17.41
24	64	0	17.42
24	64	40	17.42
25	30	0	14.59
25	30	40	14.59
25	39	0	14.55
25	39	40	14.55
27	31	0	14.59
27	31	40	14.59
27	35	0	14.55
27	35	40	14.55
27	36	0	14.55
27	36	40	14.55
27	37	0	14.55
27	37	40	14.55
27	38	0	14.55
27	38	40	14.55
27	39	0	14.55
27	39	40	14.55
28	66	0	17.33
28	66	40	17.33
28	86	0	19.38
28	86	40	19.38
29	31	0	14.53
29	31	40	14.53
29	35	0	14.46
29	35	40	14.46
29	36	0	14.46
29	36	40	14.46
29	37	0	14.42
29	37	40	14.42
29	38	0	14.42
29	38	40	14.42
29	39	0	14.41
29	39	40	14.41
30	31	0	14.53
30	31	40	14.53
30	37	0	14.42
30	37	40	14.42
30	38	0	14.42
30	38	40	14.42
30	39	0	14.40
30	39	40	14.40
32	31	0	14.45
32	31	40	14.45
32	37	0	14.31
32	37	40	14.31
33	31	0	14.45
33	31	40	14.45
33	33	0	14.36
33	33	40	14.36

33	34	0	14.36
33	34	40	14.36
33	37	0	14.31
33	37	40	14.31
35	20	0	13.46
35	20	40	13.46
35	30	0	12.59
35	30	40	12.59
35	31	0	12.27
35	31	40	12.27
35	33	0	9.98
35	33	40	9.98
36	21	0	13.46
36	21	40	13.46
36	24	0	13.40
36	24	40	13.40
36	25	0	13.40
36	25	40	13.40
36	26	0	13.32
36	26	40	13.31
36	27	0	13.31
36	27	40	13.31
36	30	0	12.07
36	30	40	12.07
36	31	0	11.73
36	31	40	11.73
36	33	0	9.46
36	33	40	9.46
37	34	0	5.13
37	34	40	5.13
37	37	0	5.10
37	37	40	5.10
38	34	0	5.13
38	34	40	5.13
38	37	0	5.10
38	37	40	5.10
40	21	0	13.42
40	21	40	13.42
40	24	0	13.31
40	24	40	13.31
40	31	0	5.05
40	31	40	5.04
40	33	0	5.10
40	33	40	5.09
41	22	0	13.39
41	22	40	13.39
41	24	0	13.31
41	24	40	13.31
41	31	0	5.04
41	31	40	5.04
41	34	0	5.10
41	34	40	5.10
42	0	0	17.80
42	0	40	17.80
42	20	0	15.83
42	20	40	15.82
42	22	0	13.30
42	22	40	13.30
42	23	0	11.60
42	23	40	11.60
43	25	0	13.22

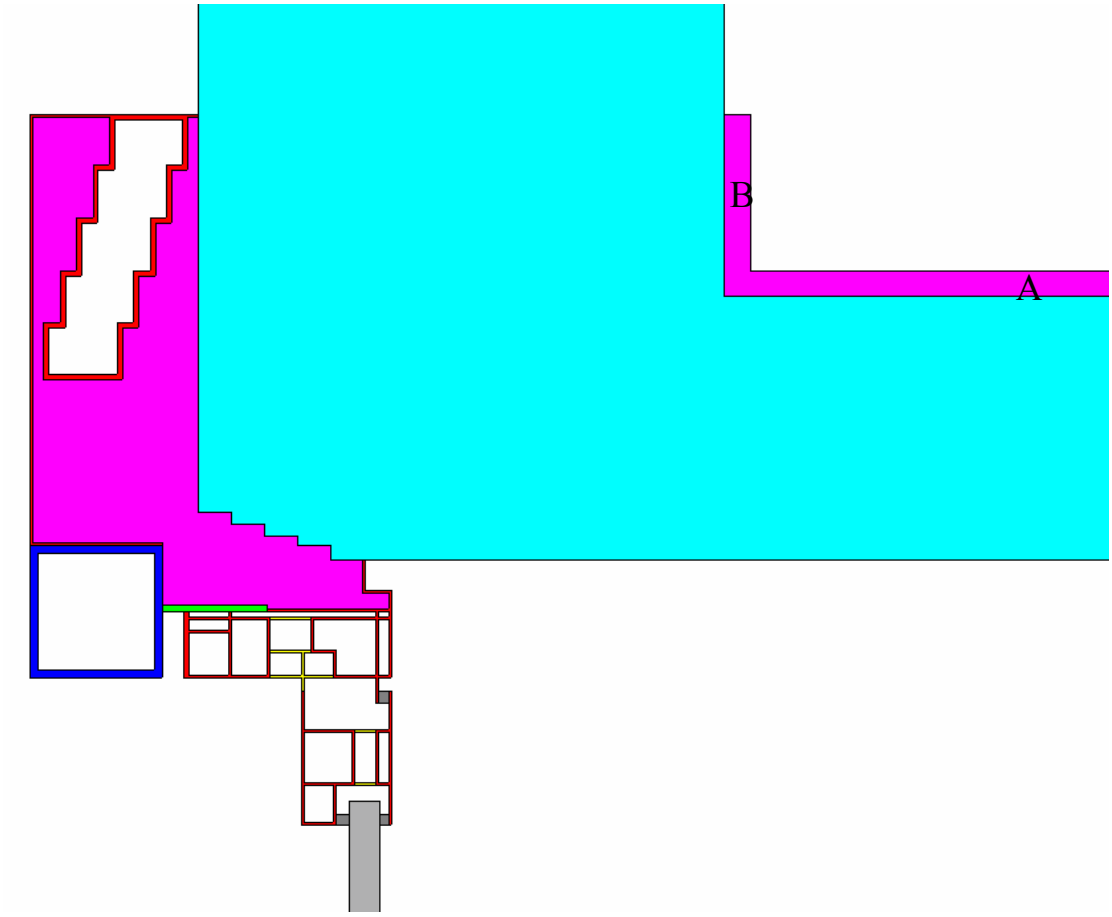
43	25	40	13.22
43	26	0	13.15
43	26	40	13.15
44	25	0	13.22
44	25	40	13.22
44	26	0	13.15
44	26	40	13.15
46	43	0	4.70
46	43	40	4.70
46	44	0	4.74
46	44	40	4.74
47	25	0	3.55
47	25	40	3.55
47	26	0	3.55
47	26	40	3.55
47	28	0	4.84
47	28	40	4.84
47	30	0	4.85
47	30	40	4.85
47	31	0	4.85
47	31	40	4.85
47	37	0	4.87
47	37	40	4.87
47	38	0	4.88
47	38	40	4.87
47	39	0	4.88
47	39	40	4.88
48	25	0	3.55
48	25	40	3.55
48	26	0	3.55
48	26	40	3.55
48	29	0	4.84
48	29	40	4.84
48	30	0	4.85
48	30	40	4.85
48	31	0	4.85
48	31	40	4.85
48	37	0	4.87
48	37	40	4.87
48	38	0	4.87
48	38	40	4.87
48	39	0	4.87
48	39	40	4.87
49	0	0	1.78
49	0	40	1.78
49	20	0	2.22
49	20	40	2.22
49	22	0	4.29
49	22	40	4.28
49	23	0	5.79
49	23	40	5.79
50	22	0	3.46
50	22	40	3.46
50	24	0	3.51
50	24	40	3.51
50	25	0	3.51
50	25	40	3.51
50	26	0	3.51
50	26	40	3.51
50	27	0	3.51
50	27	40	3.52

50	28	0	3.49
50	28	40	3.49
50	31	0	4.81
50	31	40	4.81
50	37	0	4.82
50	37	40	4.82
50	38	0	4.82
50	38	40	4.82
50	39	0	4.82
50	39	40	4.82
51	20	0	3.45
51	20	40	3.45
51	29	0	3.48
51	29	40	3.48
51	30	0	4.81
51	30	40	4.81
51	43	0	4.74
51	43	40	4.74
56	66	0	13.83
56	66	40	13.83
56	86	0	18.41
56	86	40	18.41
57	59	0	15.41
57	59	40	15.41
57	66	0	18.22
57	66	40	18.22
73	44	0	1.93
73	44	40	1.93
73	59	0	15.51
73	59	40	15.51

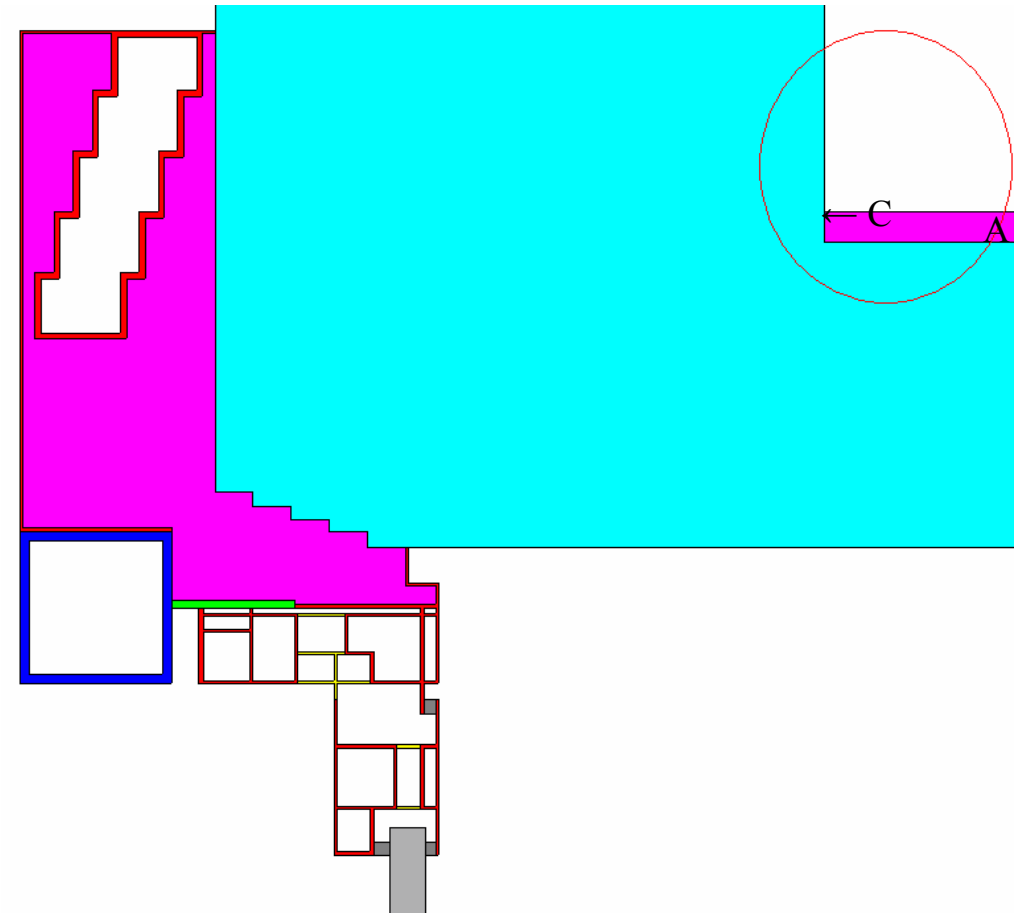
As a comparison note, these are the results for the exact same model, with -12°C outside:



This is the way we insulated the technical room : with insulation on both sides of the edge (A and B).



This is not an interesting solution to only insulate one side of the edge (A): this will of course help to raise the temperature on the wall (from 5.19°C to 13.64°C). Nevertheless, the temperature on the edge (C point) will slip from 6.29°C to 5.15°C (The comparison is made with the first non insulated model, with -12°C outside).



2. Short analysis of the thermal properties of two different kinds of windows

Here is some information that we took directly from the technical data:

Ipasol neutre 68/34
Thermal transmission coefficient: U_g = 1.1 W/m²K
Sun factor: g = 37%
Light transmission: 68%

Silverstar combi Neutral 70/40
Thermal transmission coefficient: U_g = 1.1 W/m²K
Sun factor: g = 40%
Light transmission: 70%

The inside temperature of the glazed hall mainly depends on the thermal transmission coefficient (1.1 W/m²K) of the glazing system, which is the same for both systems.
Sun factors, wished as small as possible in order to avoid overheating in some particular moments of the year, are characterized by the part of incident solar radiation on the glass that enters in the building. We can see that for both proposed systems, those characteristics are quite similar: only 10% differentiates 0.37 and 0.4. This difference is not significant enough to encourage the choice of one glass instead of the other one.
This means that using Ipasol or Silverstar won't make any big difference, as far as the inside temperature and the overheating risks are concerned.

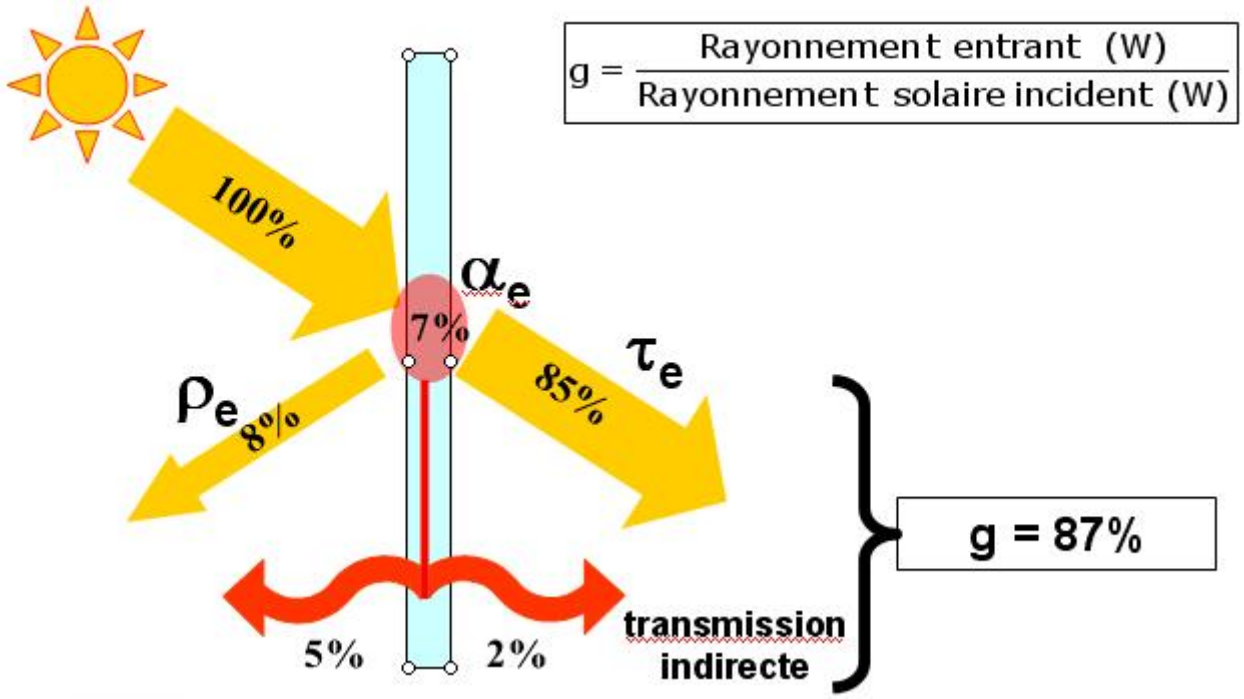


FIG: example of the calculation of the g factor, for a simple glazing system.