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COMPLEX THERMAL-TECHNICAL ANALYSIS OF THE DETACHED PANEL APARTMENT HOUSE OF TYPE B 70 IN ORIGINAL STATE (PART 1)

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CONTENTS

Used Symbols and Units		**7**
Introduction		**9**
1	**Evaluated Building**	**10**
Table 1.1	Floor plan of detached house of structural system B70	10
Table 1.2	Cross-section and front view of detached house of structural system B 70	11
2	**Thermal-Technical Properties and Evaluation of Envelope Constructions of a Building**	**12**
Table 2.1.1	Thermal-technical properties and evaluation of external wall 1	12
Table 2.1.2	Distribution of temperature and water vapour pressures in the external wall 1	13
Table 2.2.1	Thermal-technical properties and evaluation of external wall 2	14
Table 2.2.2	Distribution of temperature and water vapour pressures in external wall 2	15
Table 2.3.1	Thermal-technical properties and evaluation of flat roof	16
Table 2.3.2	Distribution of temperature and water vapour pressures in flat roof	17
Table 2.4.1	Thermal-technical properties and evaluation of floor on the ceiling.	18
Table 2.4.2	Distribution of temperature and water vapour pressures in floor on the ceiling	19
Table 2.5.1	Thermal-technical properties and evaluation of ceiling above the exterior	20
Table 2.5.2	Distribution of temperature and water vapour pressures in ceiling above the exterior	21
Table 2.6	Thermal-technical properties and evaluation of wooden windows	22
Table 2.7	Thermal-technical properties and evaluation of steel windows	23
3	**Evaluation on Dew Point Temperature and Calculation of Thermal Transmittance of Windows for the Modeled Details**	**24**
Table 3.1.1	Thermal-technical properties and a construction of wooden window	24
Table 3.1.2	Boundary conditions for a calculation of wooden window	25
Table 3.1.3	Thermal-technical evaluation of the wooden window	26
Table 3.2.1	Thermal-technical properties and a construction of steel window	27
Table 3.2.2	Boundary conditions for a calculation of steel window	28
Table 3.2.3	Thermal-technical evaluation of the steel window	29

4	**Evaluation of Hygienic Criterion and Calculation of the Linear Thermal Transmittance of Selected Details of the Building......**	**30**
Table 4.1.1	Marking of the position of detail in the building – detail 01.............	30
Table 4.1.2	Structural composition of detail 01..	31
Table 4.1.3	Boundary conditions for a calculation of detail 01..........................	32
Table 4.1.4	Thermal-technical evaluation of detail 01......................................	33
Table 4.2.1	Marking of the position of detail in the building – detail 02.............	34
Table 4.2.2	Structural composition of detail 02..	35
Table 4.2.3	Boundary conditions for a calculation of detail 02..........................	36
Table 4.2.4	Thermal-technical evaluation of detail 02......................................	37
Table 4.3.1	Marking of the position of detail in the building – detail 03.............	38
Table 4.3.2	Structural composition of detail 03..	39
Table 4.3.3	Boundary conditions for a calculation of detail 03..........................	40
Table 4.3.4	Thermal-technical evaluation of detail 03......................................	41
Table 4.4.1	Marking of the position of detail in the building – detail 04.............	42
Table 4.4.2	Structural composition of detail 04..	43
Table 4.4.3	Boundary conditions for a calculation of detail 04..........................	44
Table 4.4.4	Thermal-technical evaluation of detail 04......................................	45
Table 4.5.1	Marking of the position of detail in the building – detail 05.............	46
Table 4.5.2	Structural composition of detail 05..	47
Table 4.5.3	Boundary conditions for a calculation of detail 05..........................	48
Table 4.5.4	Thermal-technical evaluation of detail 05......................................	49
Table 4.6.1	Marking of the position of detail in the building – detail 06.............	50
Table 4.6.2	Structural composition of detail 06..	51
Table 4.6.3	Boundary conditions for a calculation detail 06.............................	52
Table 4.6.4	Thermal-technical evaluation of detail 06......................................	53
Table 4.7.1	Marking of the position of detail in the building – detail 07.............	54
Table 4.7.2	Structural composition of detail 07..	55
Table 4.7.3	Boundary conditions for a calculation of detail 07..........................	56
Table 4.7.4	Thermal-technical evaluation of detail 07......................................	57
Table 4.8.1	Marking of the position of detail in the building – detail 08.............	58
Table 4.8.2	Structural composition of detail 08..	59
Table 4.8.3	Boundary conditions for a calculation of detail 08..........................	60
Table 4.8.4	Thermal-technical evaluation of detail 08......................................	61
Table 4.9.1	Marking of the position of detail in the building – detail 09.............	62
Table 4.9.2	Structural composition of detail 09..	63

Table 4.9.3 Boundary conditions for a calculation of detail 09.......................... 64
Table 4.9.4 Thermal-technical evaluation of detail 09...................................... 65
Table 4.10.1 Marking of the position of detail in the building – detail 10............. 66
Table 4.10.2 Structural composition of detail 10.. 67
Table 4.10.3 Boundary conditions for a calculation of detail 10.......................... 68
Table 4.10.4 Thermal-technical evaluation of detail 10...................................... 69
Table 4.11.1 Marking of the position of detail in the building – detail 11............. 70
Table 4.11.2 Structural composition of detail 11.. 71
Table 4.11.3 Boundary conditions for a calculation of detail 11.......................... 72
Table 4.11.4 Thermal-technical evaluation of detail 11...................................... 73
Table 4.12.1 Marking of the position of detail in the building – detail 12............. 74
Table 4.12.2 Structural composition of detail 12.. 75
Table 4.12.3 Boundary conditions for a calculation of detail 12.......................... 76
Table 4.12.4 Thermal-technical evaluation of detail 12...................................... 77
Table 4.13.1 Marking of the position of detail in the building – detail 13............. 78
Table 4.13.2 Structural composition of detail 13.. 79
Table 4.13.3 Boundary conditions for a calculation of detail 13.......................... 80
Table 4.13.4 Thermal-technical evaluation of detail 13...................................... 81
Table 4.14.1 Marking of the position of detail in the building – detail 14............. 82
Table 4.14.2 Structural composition of detail 14.. 83
Table 4.14.3 Boundary conditions for a calculation of detail 14.......................... 84
Table 4.14.4 Thermal-technical evaluation of detail 14...................................... 85
Table 4.15.1 Marking of the position of detail in the building – detail 15............. 86
Table 4.15.2 Structural composition of detail 15.. 87
Table 4.15.3 Boundary conditions for a calculation of detail 15.......................... 88
Table 4.15.4 Thermal-technical evaluation of detail 15...................................... 89
Table 4.16.1 Marking of the position of detail in the building – detail 16............. 90
Table 4.16.2 Structural composition of detail 16.. 91
Table 4.16.3 Boundary conditions for a calculation of detail 16.......................... 92
Table 4.16.4 Thermal-technical evaluation of detail 16...................................... 93
Table 4.17.1 Marking of the position of detail in the building – detail 17............. 94
Table 4.17.2 Structural composition of detail 17.. 95
Table 4.17.3 Boundary conditions for a calculation of detail 17.......................... 96
Table 4.17.4 Thermal-technical evaluation of detail 17...................................... 97
Table 4.18.1 Marking of the position of detail in the building – detail 18............. 98

Table 4.18.2 Structural composition of detail 18 99
Table 4.18.3 Boundary conditions for a calculation of detail 18 100
Table 4.18.4 Thermal-technical evaluation of detail 18 101
Table 4.19.1 Marking of the position of detail in the building – detail 19 102
Table 4.19.2 Structural composition of detail 19 103
Table 4.19.3 Boundary conditions for a calculation of detail 19 104
Table 4.19.4 Thermal-technical evaluation of detail 19 105
Table 4.20.1 Marking of the position of detail in the building – detail 20 106
Table 4.20.2 Structural composition of detail 20 107
Table 4.20.3 Boundary conditions for a calculation of detail 20 108
Table 4.20.4 Thermal-technical evaluation of detail 20 109
Table 4.21.1 Marking of the position of detail in the building – detail 21 110
Table 4.21.2 Structural composition of detail 21 111
Table 4.21.3 Boundary conditions for a calculation of detail 21 112
Table 4.21.4 Thermal-technical evaluation of detail 21 113
Table 4.22.1 Marking of the position of detail in the building – detail 22 114
Table 4.22.2 Structural composition of detail 22 115
Table 4.22.3 Boundary conditions for a calculation of detail 22 116
Table 4.22.4 Thermal-technical evaluation of detail 22 117
Table 4.23.1 Marking of the position of detail in the building – detail 23 118
Table 4.23.2 Structural composition of detail 23 119
Table 4.23.3 Boundary conditions for a calculation of detail 23 120
Table 4.23.4 Thermal-technical evaluation of detail 23 121
Table 4.24.1 Marking of the position of detail in the building – detail 24 122
Table 4.24.2 Structural composition of detail 24 123
Table 4.24.3 Boundary conditions for a calculation of detail 24 124
Table 4.24.4 Thermal-technical evaluation of detail 24 125
Conclusion 126
References 127

Used Symbols and Units

A_f	Area of window frame	m^2
A_g	Area of window glazing	m^2
A_w	Area of window	m^2
b	Thermal effusivity of floor..	$W.s^{1/2}/(m^2.K)$
b_N	Standard value of thermal effusivity of floor	$W.s^{1/2}/(m^2.K)$
b_x	Reduction factor	-
c	Specific thermal capacity	J/(kg.K)
d	Thickness	m
f_{Rsi}	Temperature factor	-
i_{LV}	Gap permeability coefficient	$m^3/(m.s.Pa^{0.67})$
l	Length of joints of windows and entry doors	m
l_g	Length of perimeter of glazing	m
M_c	Annual amount of condensed water vapour in a construction	$kg/(m^2.a)$
$M_{c,max}$	Maximum permissible annual amount of condensed water vapour in a construction according to the standard	$kg/(m^2.a)$
M_d	Diffusion flow rate of water vapour	$kg/(m^2.s)$
M_{ev}	Annual amount of evaporated water vapour from a construction	$kg/(m^2.a)$
n	Air change rate	1/h
p_{de}	Partial pressure of water vapour of external air	Pa
p_{di}	Partial pressure of water vapour of internal air	Pa
$p_{sat,se}$	Partial pressure of saturated water vapour on external surface of a construction	Pa
$p_{sat,si}$	Partial pressure of saturated water vapour on internal surface of a construction	Pa
R	Thermal resistance	$m^2.K/W$
R_d	Diffusion resistance	m/s
R_N	Standard value of thermal resistance	$m^2.K/W$
R_{se}	Surface resistance of heat transfer on external side of a construction	$m^2.K/W$
R_{si}	Surface resistance of heat transfer on internal side of a construction	$m^2.K/W$
U	Thermal transmittance	$W/(m^2.K)$
U_f	Thermal transmittance of window frame	$W/(m^2.K)$

U_g	Thermal transmittance of window glazing	$W/(m^2.K)$
U_N	Standard value of thermal transmittance...........................	$W/(m^2.K)$
U_w	Thermal transmittance of window	$W/(m^2.K)$
$U_{w,N}$	Standard value of thermal transmittance of window	$W/(m^2.K)$
V_b	Volume of the heated space of building	m^3
ΔM_d	Condensed amount of water vapour	$kg/(m^2.s)$
$\Delta\theta_{si}$	Safety value of surface temperature..................................	K
$\Delta\theta_{10}$	Decrease of contact temperature	°C
θ_{dp}	Dew point temperature	°C
θ_e	Calculating external air temperature..................................	°C
θ_i	Calculating internal air temperature...................................	°C
θ_{si}	Internal surface temperature..	°C
$\theta_{si,80}$	Critical surface temperature for growth of moulds	°C
λ	Thermal conductivity coefficient	W/(m.K)
μ	Diffusion resistance factor	-
ρ	Apparent density	kg/m^3
Σ	Sum	-
φ_e	Relative humidity of external air	%
φ_i	Relative humidity of internal air	%
ψ	Linear thermal transmittance	W/(m.K)
ψ_g	Linear thermal transmittance in contact of glazing and frame	W/(m.K)

Introduction

Renovation of panel apartment buildings and related problems are becoming more and more current topic. The emphasis is put not only on a quality of housing but also on decreasing the energy need for heating and minimizing heat losses through envelope constructions of a building. This is possible to reach only by quality thermal protection in form of revovation of envelope constructions of a building, i.e. thermal insulation of external walls, roof and floor and replacement of original windows. An important factor for achieving lower energy need for heating but also the healthy indoor environment without the risk of growth of moulds is a correct solution of thermal bridges.

This publication presents issues of thermal-technical evaluation of envelope constructions and selected details of detached panel apartment house of structural system B 70 in its original state, which was built in the seventies and eighties of the twentieth century. The aim of team of authors was comprehensively calculate and analyse thermal-technical properties of this building. This publication can be used as a tool when renovating buildings built in this type of structural system.

The thermal-technical evaluation of the detached panel apartment house B 70 in its original state is divided into two publications (Part 1 and Part 2). This publication (Part 1) deals with a description of the building (Chapter 1), evaluation of envelope constructions (Chapter 2), windows (Chapter 3), evaluation of 24 selected details of the building from the point of view of hygienic criterion and calculation of linear themal transmittance (Chapter 4).

The second publication (Part 2) presents an evaluation of another details, calculation of ΔU-value and energy need for heating.

The publication is written in a clearly arranged tabular way, in form of professional handbook. It has no ambition to be a textbook, but only a handbook. It is intended not only for students of faculties of civil engineering and faculties of architecture, but also for the professional and general public.

The basic prerequisite for using this handbook is at least a minimum knowledge of building thermal technology and thermal protection of buildings.

Team of authors

1 Evaluated Building

Table 1.1 – Floor plan of detached house of structural system B 70

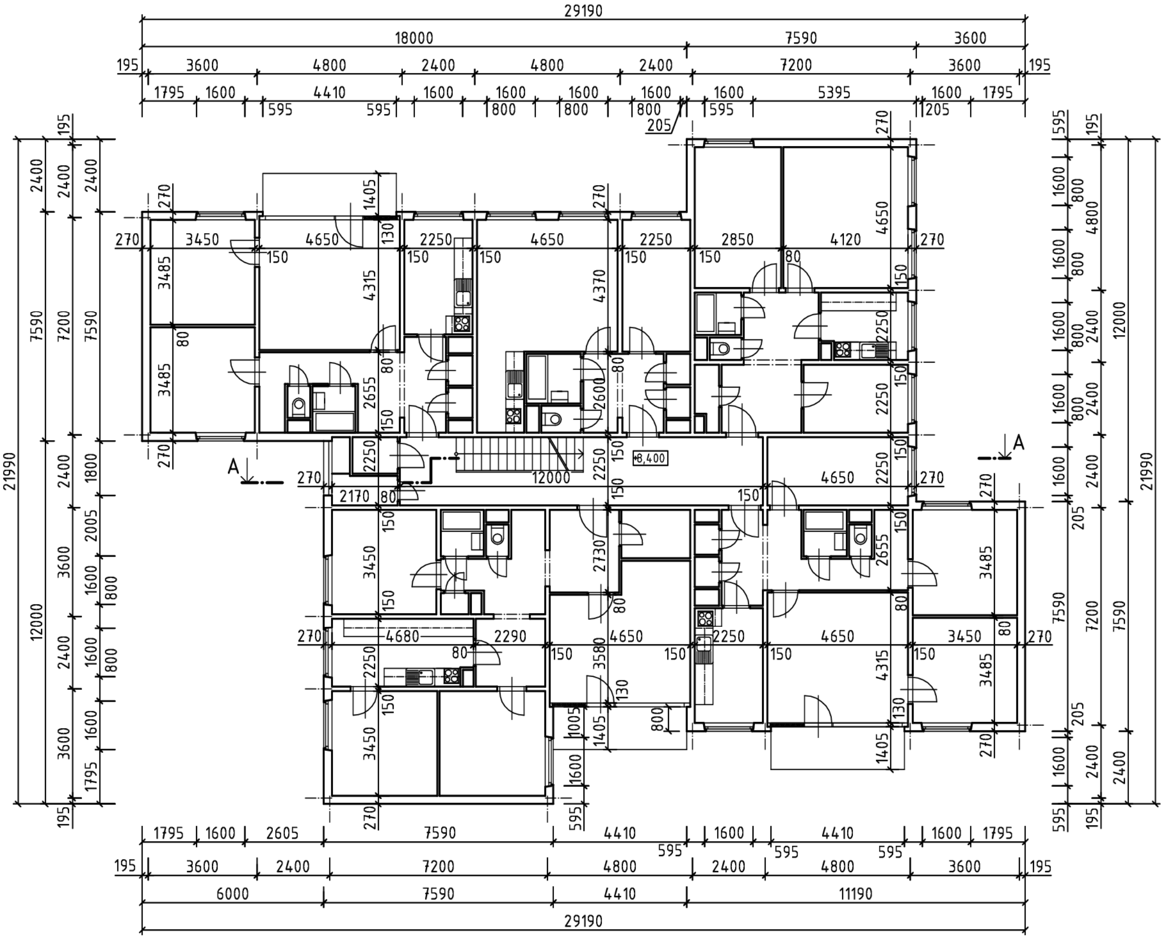
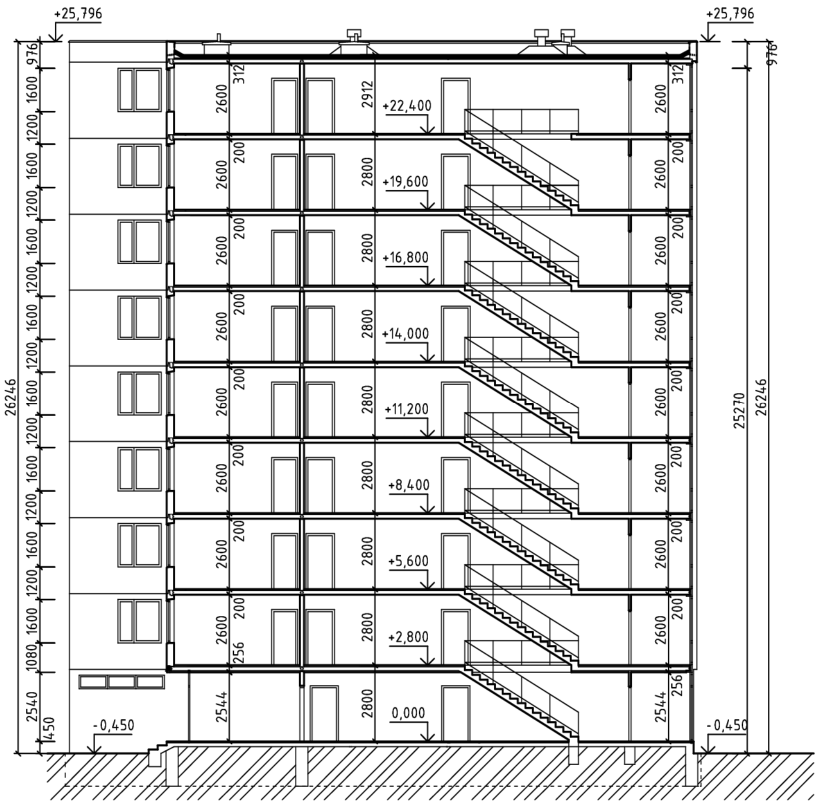
Structural system B 70 - detached house
Floor plan

Description of the evaluated building
The evaluated apartment house is built in the structural system B 70. It is a detached house. It has 8 living floors with flats and an entrance floor. The module of load-bearing walls is 2400, 3600 and 4800 mm. The construction height is 2800 mm. The building has a flat roof. External wall panels consist of reinforced concrete load-bearing wall with the thickness of 150 mm, polystyrene foam boards of 60 mm and reinforced concrete membrane of 60 mm. The thickness of internal load-bearing reinforced concrete walls and ceiling panels is 150 mm. The building has wooden windows with double glazing and steel windows.

Table 1.2 – Front view and cross-section of detached house of structural system B 70

Structural system B 70 - detached house

Cross-section



Front view

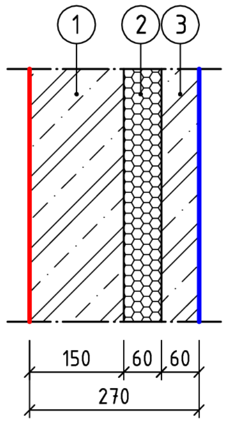
2 Thermal-Technical Properties and Evaluation of Envelope Constructions of a Building

Table 2.1.1 - Thermal-technical properties and evaluation of external wall 1

External wall 1

Boundary conditions for interior

$\theta_i = 20$ °C
$\varphi_i = 50$ %
$R_{si} = 0.13$ m^2.K/W



Boundary conditions for exterior

$\theta_e = -15$ °C
$\varphi_e = 84$ %
$R_{se} = 0.04$ m^2.K/W

No.	Material	Thickness	Apparent density	Thermal conductivity coefficient	Specific thermal capacity	Diffusion resistance factor	Thermal resistance	Diffusion resistance
	Symbol	d	ρ	λ	c	μ	R_j	$R_{d,j}\times10^{-9}$
	Unit	m	kg/m^3	W/(m.K)	J/(kg.K)	(-)	m^2.K/W	m/s
1	Reinforced concrete	0.150	2400	1.580	1020	29.0	0.095	23.11
2	Polystyrene foam	0.060	30	0.070*	1270	50.0	0.857	15.94
3	Reinforced concrete	0.060	2400	1.580	1020	29.0	0.038	9.24

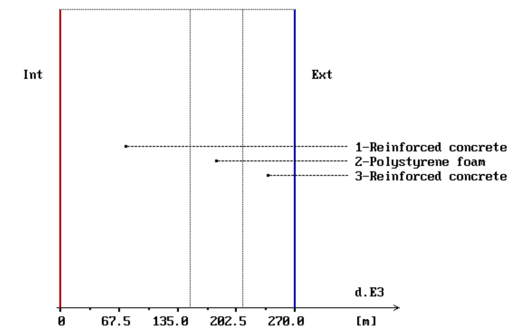
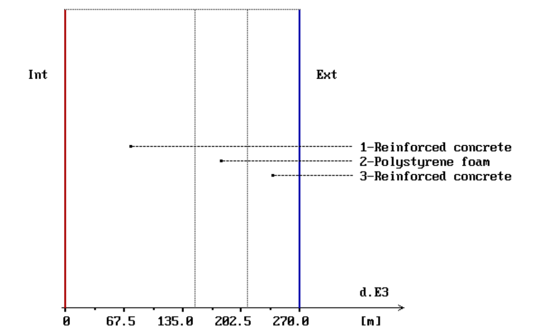
NOTE: The value λ W/(m.K) of the second layer is considered with a degradation influence (leaking of cement grout into insulation during a manufacturing of external panels in precast concrete plant)

Results of calculation of thermal-technical parameters

Thermal resistance of a construction	$R = 0.990$ m^2.K/W
Diffusion resistance of a construction	$R_d = 48.29\times10^9$ m/s
Thermal transmittance	$U = 0.862$ W/(m^2.K)
Internal surface temperature	$\theta_{si} = 16.08$ °C
Moisture regime	Water vapour condenses inside the construction

Evaluation of a construction of the fragment		Rating
Thermal resistance	$R = 0.99$ m^2.K/W $< R_N = 4.40$ m^2.K/W - standard value	not meet
Thermal transmittance	$U = 0.86$ W/(m^2.K) $> U_N = 0.22$ W/(m^2.K) - standard value	not meet
Risk of growth of moulds	$\theta_{si} = 16.08$ °C $> \theta_{si,80} + \Delta\theta_{si} = 12.82$ °C	meet
Moisture regime	$M_c = 0.032$ kg/(m^2.a) $< M_{ev} = 1.325$ kg/(m^2.a) - annual balance	meet
	$M_c = 0.032$ kg/(m^2.a) $< M_{c,max} = 0.5$ kg/(m^2.a) - permissible amount	meet

Table 2.1.2 - Distribution of temperature and water vapour pressures in the external wall 1

<table>
<tr><th colspan="3">External wall 1</th></tr>
<tr><th></th><th>Temperature distribution in a construction</th><th>Distribution of water vapour pressures in a const.</th></tr>
<tr><td rowspan="2">Representation in scale of thicknesses of layers of a construction</td><td>
</td><td>
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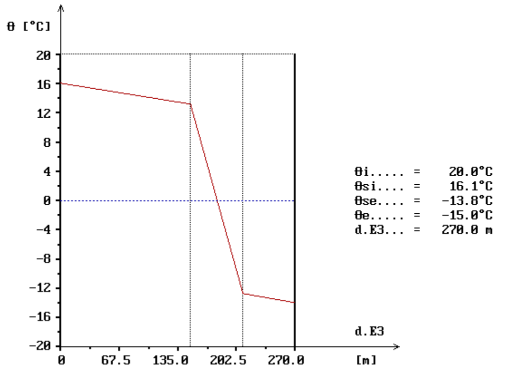
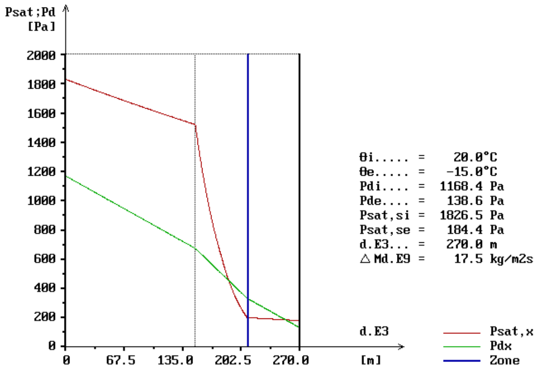
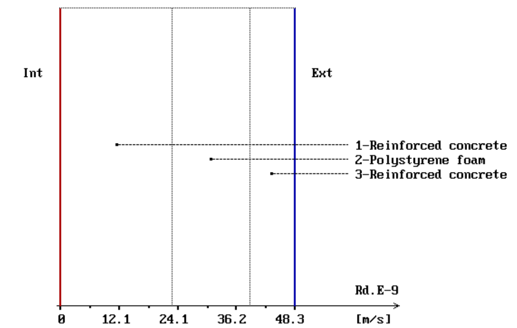
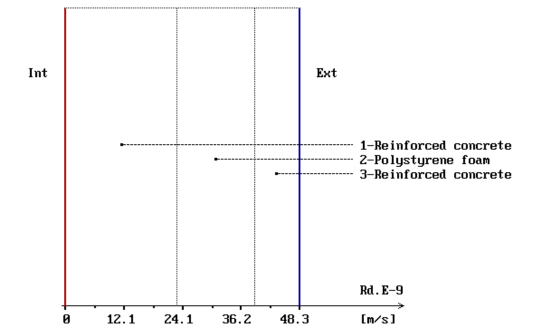
<tr><td>
</td><td>
</td></tr>
<tr><td rowspan="2">Representation in scale of diffusion resistances of layers of a constr.</td><td>
</td><td>
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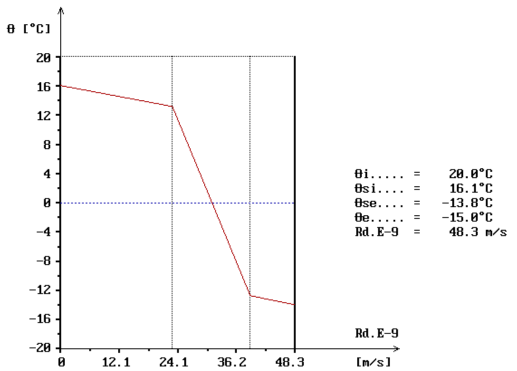
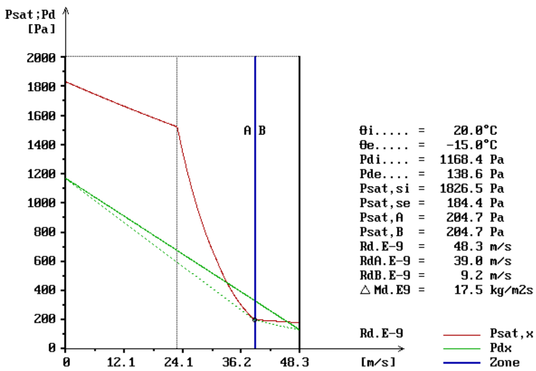
<tr><td>
</td><td>
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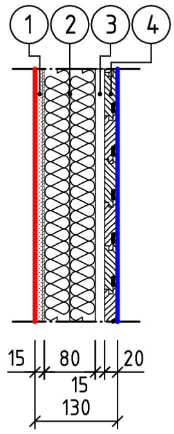
</table>

Table 2.2.1 - Thermal-technical properties and evaluation of external wall 2

External wall 2 (loggia wall)

Boundary conditions for interior

θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W



Boundary conditions for exterior

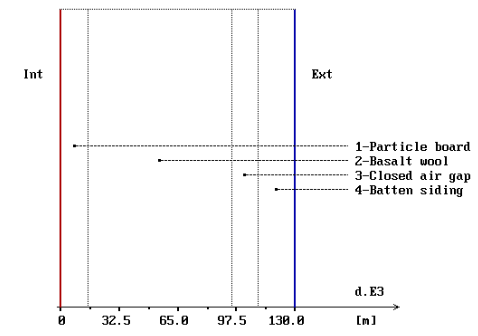
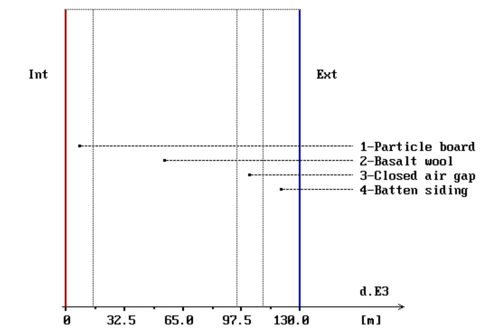
θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W

No.	Material	Thickness	Apparent density	Thermal conductivity coefficient	Specific thermal capacity	Diffusion resistance factor	Thermal resistance	Diffusion resistance
	Symbol	d	ρ	λ	c	μ	R_j	$R_{d,j}\times10^{-9}$
	Unit	m	kg/m^3	W/(m.K)	J/(kg.K)	(-)	m^2.K/W	m/s
1	Particle board	0.015	800	0.110	1500	12.5	0.136	1.00
2	Basalt wool	0.080	95	0.070	800	1.1	1.143	0.47
3	Closed air gap	0.015	1.2	0.090	1010	1.0	0.167	0.08
4	Batten siding	0.020	400	0.180	2510	157.0	0.111	16.68

Results of calculation of thermal-technical parameters	
Thermal resistance of a construction	R = 1.557 m^2.K/W
Diffusion resistance of a construction	R_d = 18.22×10^9 m/s
Thermal transmittance	U = 0.579 W/($m^{2\cdot}$.K)
Internal surface temperature	θ_{si} = 17.37 °C
Moisture regime	Water vapour condenses inside the construction

Evaluation of a construction of the fragment		**Rating**
Thermal resistance	R = 1.56 m^2.K/W < R_N = 4.40 m^2.K/W - standard value	not meet
Thermal transmittance	U = 0.58 W/(m^2.K) > U_N = 0.22 W/(m^2.K) - standard value	not meet
Risk of growth of moulds	θ_{si} = 17.37 °C > $\theta_{si,80}$ + $\Delta\theta_{si}$ = 12.82 °C	meet
Moisture regime	M_c = 4.386 kg/(m^2.a) < M_{ev} = 6.856 kg/(m^2.a) - annual balance	meet
	M_c = 4.386 kg/(m^2.a) > $M_{c,max}$ = 0.5 kg/(m^2.a) - permissible amount	not meet

Table 2.2.2 - Distribution of temperature and water vapour pressures in external wall 2

<table>
<tr><th colspan="3">External wall 2 (side loggia wall)</th></tr>
<tr><th></th><th>Temperature distribution in a construction</th><th>Distribution of water vapour pressures in a const.</th></tr>
<tr><td rowspan="2">Representation in scale of thicknesses of layers of a construction</td><td>
</td><td>
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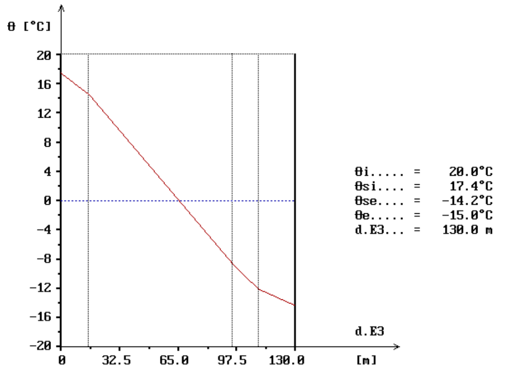
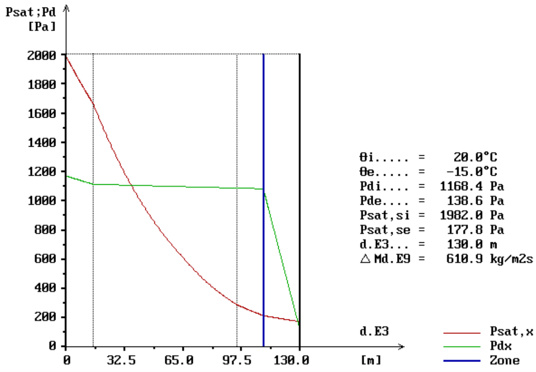
<tr><td>
</td><td>
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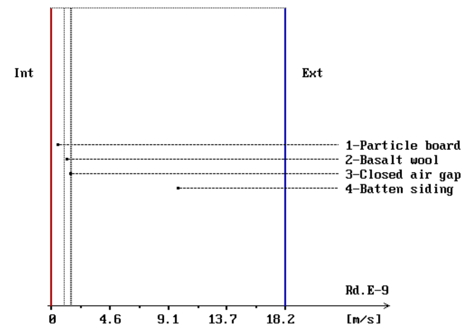
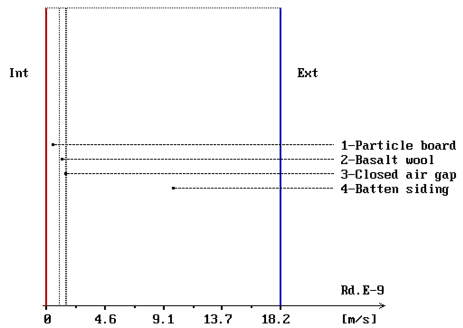
<tr><td rowspan="2">Representation in scale of diffusion resistances of layers of a constr.</td><td>
</td><td>
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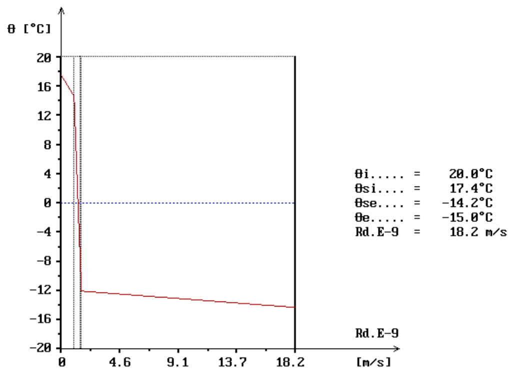
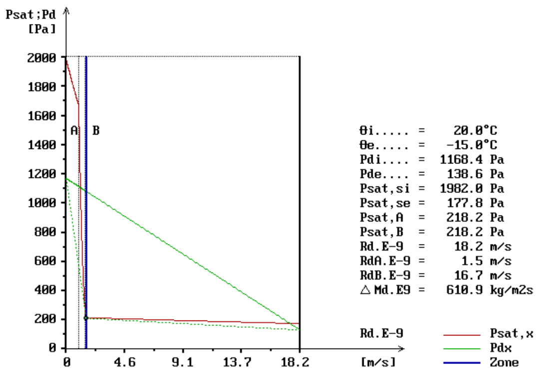
<tr><td>
</td><td>
</td></tr>
</table>

Table 2.3.1 - Thermal-technical properties and evaluation of flat roof

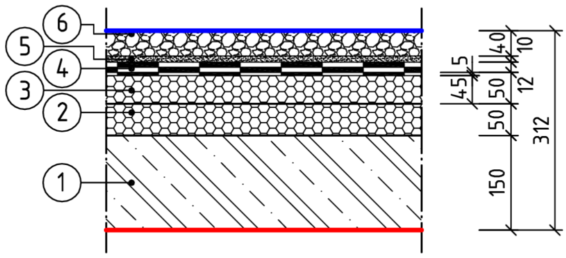
Flat roof

Boundary conditions for interior

θ_i = 20 °C

φ_i = 50 %

R_{si} = 0.10 m^2.K/W



Boundary conditions for exterior

θ_e = -15 °C

φ_e = 84 %

R_{se} = 0.04 m^2.K/W

No.	Material	Thickness	Apparent density	Thermal conductivity coefficient	Specific thermal capacity	Diffusion resistance factor	Thermal resistance	Diffusion resistance
	Symbol	d	ρ	λ	c	μ	R_j	$R_{d,j}\times10^{-9}$
	Unit	m	kg/m^3	W/(m.K)	J/(kg.K)	(-)	m^2.K/W	m/s
1	Reinforced concrete	0.150	2400	1.580	1020	29.0	0.095	23.11
2	Polystyrene foam	0.050	30	0.044	1270	50.0	1.136	13.28
3	Boards POLSID	0.045*	25	0.044	1270	45.0	1.023	10.76
4	Waterproof. membrane	0.017*	900	0.210	1470	19375.0	0.081	1749.8
5	Sand	0.010	1750	0.950	960	4.0	0.011	0.21
6	Gravel	0.040	1650	0.750	960	20.0	0.053	4.25

NOTE: Thermal insulation boards POLSID (total thickness 50 mm) is composed of polystyrene foam (45 mm) and bituminous strip (5 mm). The thickness of bituminous strip is included in the thickness of waterproofing membrane (layer No. 4).

Results of calculation of thermal-technical parameters	
Thermal resistance of a construction	R = 2.399 m^2.K/W
Diffusion resistance of a construction	R_d = 1801.37×10^9 m/s
Thermal transmittance	U = 0.394 W/(m^2.K)
Internal surface temperature	θ_{si} = 18.62 °C
Moisture regime	Water vapour condenses inside the construction

Evaluation of a construction of the fragment		**Rating**
Thermal resistance	R = 2.40 m^2.K/W < R_N = 6.50 m^2.K/W - standard value	not meet
Thermal transmittance	U = 0.39 W/(m^2.K) > U_N = 0.15 W/(m^2.K) - standard value	not meet
Risk of growth of moulds	θ_{si} = 18.62 °C > $\theta_{si,80}$ + $\Delta\theta_{si}$ = 12.82 °C	meet
Moisture regime	M_c = 0.153 kg/(m^2.a) < M_{ev} = 0.210 kg/(m^2.a) - annual balance	meet
	M_c = 0.153 kg/(m^2.a) > $M_{c,max}$ = 0.1 kg/(m^2.a) - permissible amount	not meet

Table 2.3.2 - Distribution of temperature and water vapour pressures in flat roof

Flat roof

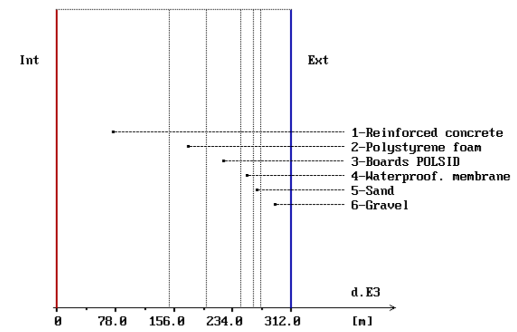
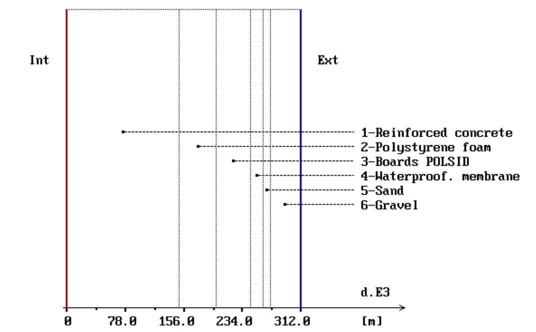
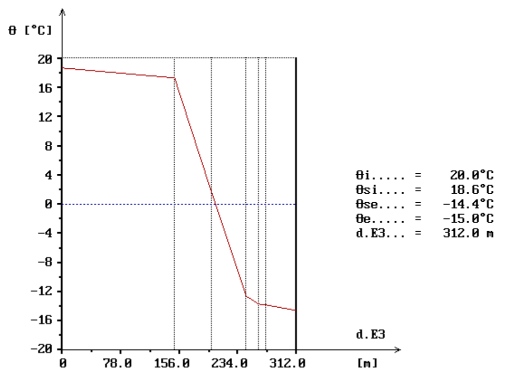
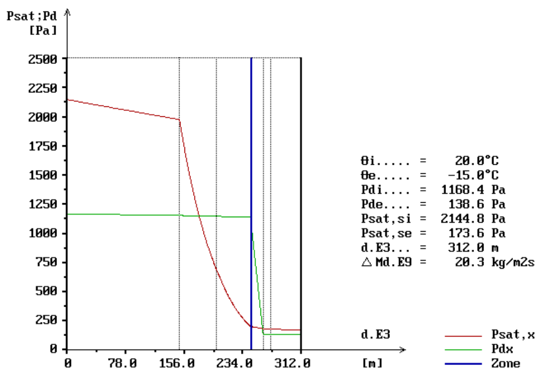
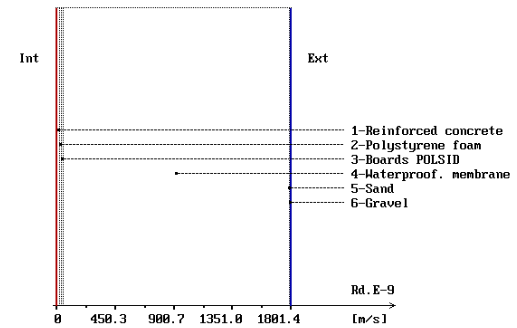
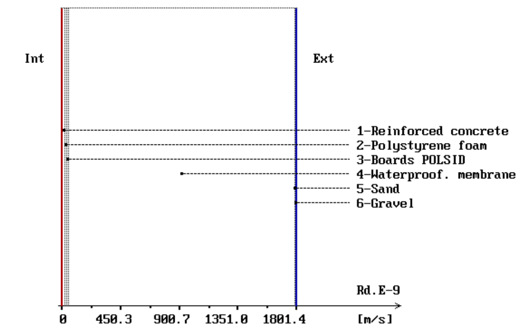
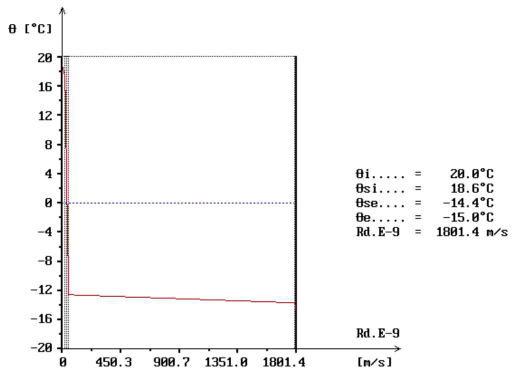
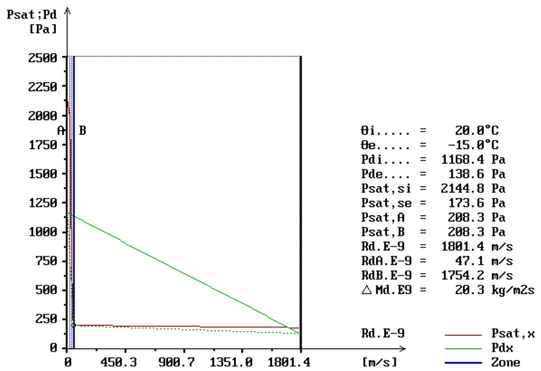
	Temperature distribution in a construction	Distribution of water vapour pressures in a const.
Representation in scale of thicknesses of layers of a construction		
		
Representation in scale of diffusion resistances of layers of a constr.		
		

Table 2.4.1 - Thermal-technical properties and evaluation of floor on the ceiling

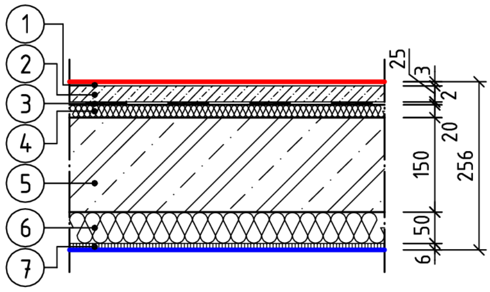
Floor on the ceiling (above the unheated space)

Boundary conditions for interior

θ_i = 20 °C

φ_i = 50 %

R_{si} = 0.17 m^2.K/W



Boundary conditions for exterior (unheated basement)

θ_e = 2.5 °C

φ_e = 60 %

R_{se} = 0.17 m^2.K/W

No.	Material	Thickness	Apparent density	Thermal conductivity coefficient	Specific thermal capacity	Diffusion resistance factor	Thermal resistance	Diffusion resistance
	Symbol	d	ρ	λ	c	μ	R_j	$R_{d,j}\times10^{-9}$
	Unit	m	kg/m^3	W/(m.K)	J/(kg.K)	(-)	m^2.K/W	m/s
1	PVC + adhesive	0.003	1400	0.160	1100	17110.0	0.019	272.68
2	Cement coating	0.025	2000	1.020	840	19.0	0.025	2.52
3	Tar paper	0.002	700	0.210	1470	9410.0	0.010	99.98
4	Boards FIBREX	0.020	115	0.050	840	2.0	0.400	0.21
5	Reinforced concrete	0.150	2400	1.340	1020	29.0	0.112	23.11
6	Basalt felt	0.050	95	0.060	800	1.1	0.833	0.29
7	Particle boards	0.006	1040	0.220	1580	6.5	0.027	0.21

Results of calculation of thermal-technical parameters	
Thermal resistance of a construction	R = 1.425 m^2.K/W
Diffusion resistance of a construction	R_d = 399.01×10^9 m/s
Thermal transmittance	U = 0.566 W/(m^2.K)
Internal surface temperature	θ_{si} = 18.31 °C
Moisture regime	Water vapour does not condense inside the construct.
Thermal effusivity of the floor	b = 806.02 W.s$^{1/2}$/(m^2.K)
Decrease of contact temperature of the floor	$\Delta\theta_{10}$ = 6.16 °C

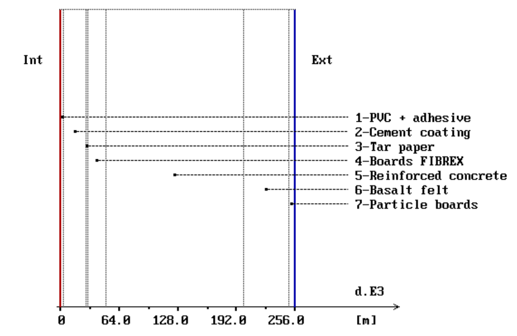
Evaluation of a construction of the fragment		**Rating**
Thermal resistance	R = 1.43 m^2.K/W < R_N = 1.70 m^2.K/W - standard value	not meet
Thermal transmittance	U = 0.57 W/(m^2.K) > U_N = 0.50 W/(m^2.K) - standard value	not meet
Risk of growth of moulds	θ_{si} = 18.31 °C > $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	meet
Thermal effusivity	b = 806 W.s$^{1/2}$/(m^2.K) $\in$ b_N(701 - 850) - less warm floor	not meet

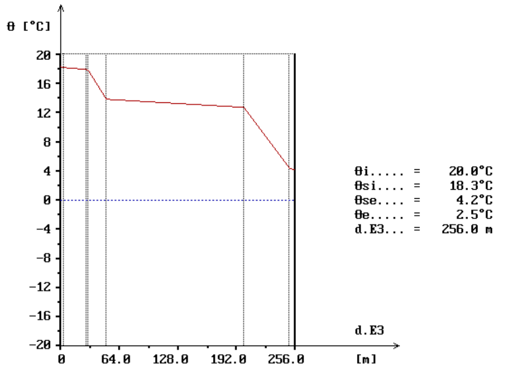
Table 2.4.2 - Distribution of temperature and water vapour pressures in floor on the ceiling

Floor on the ceiling (above the unheated space)

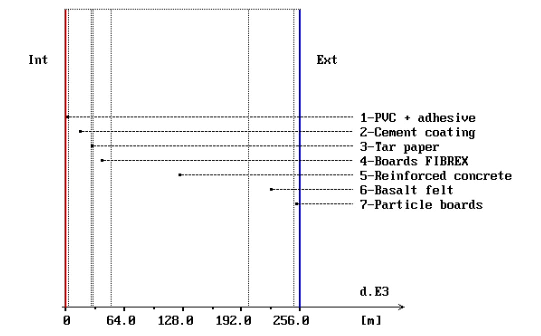
Representation in scale of thicknesses of layers of a construction

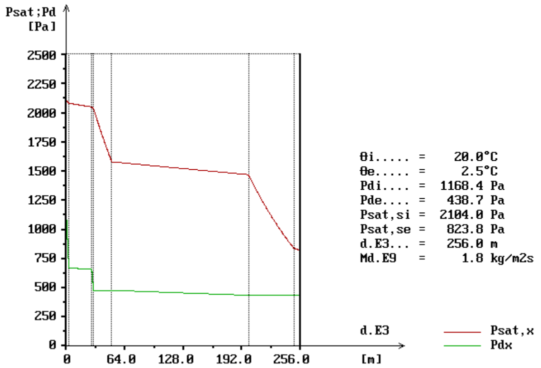
Temperature distribution in a construction





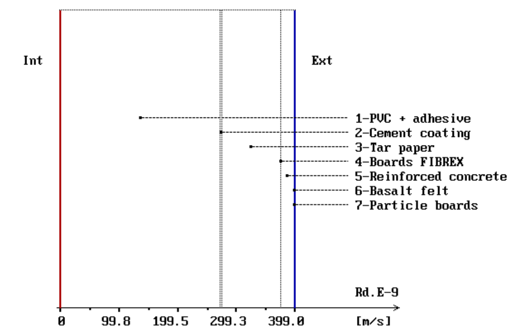
Distribution of water vapour pressures in a const.

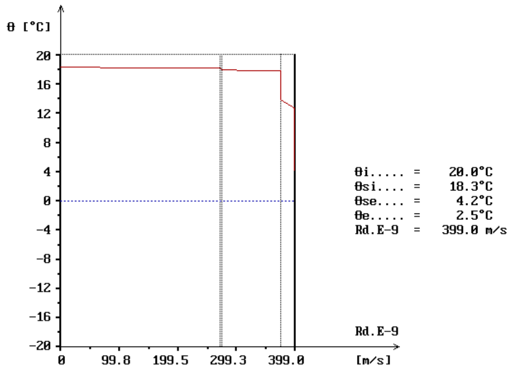




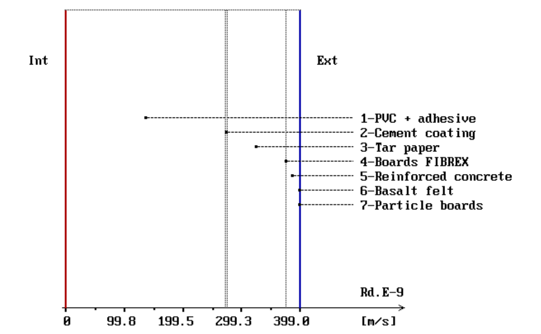
Representation in scale of diffusion resistances of layers of a constr.

Temperature distribution in a construction





Distribution of water vapour pressures in a const.



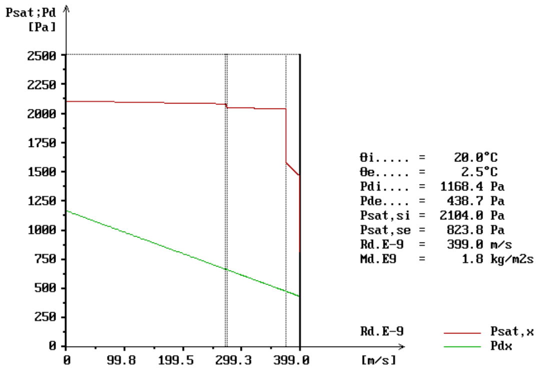


Table 2.5.1 - Thermal-technical properties and evaluation of ceiling above the exterior

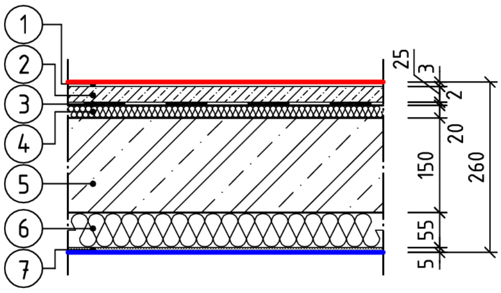
Ceiling above the exterior

Boundary conditions for interior

θ_i = 20 °C

φ_i = 50 %

R_{si} = 0.17 m^2.K/W



Boundary conditions for exterior

θ_e = -15 °C

φ_e = 84 %

R_{se} = 0.04 m^2.K/W

No.	Material	Thickness	Apparent density	Thermal conductivity coefficient	Specific thermal capacity	Diffusion resistance factor	Thermal resistance	Diffusion resistance
	Symbol	d	ρ	λ	c	μ	R_j	$R_{d,j}\times10^{-9}$
	Unit	m	kg/m^3	W/(m.K)	J/(kg.K)	(-)	m^2.K/W	m/s
1	PVC + adhesive	0.003	1400	0.160	1100	17110.0	0.019	272.68
2	Cement coating	0.025	2000	1.160	840	19.0	0.022	2.52
3	Tar paper	0.002	700	0.210	1470	9410.0	0.010	99.98
4	Boards FIBREX	0.020	115	0.052	840	2.0	0.385	0.21
5	Reinforced concrete	0.150	2400	1.580	1020	29.0	0.095	23.11
6	Boards LIGNOPOR	0.055	95	0.047	800	1.1	1.170	0.32
7	Plaster UNIFAS	0.005	2000	0.990	790	19.0	0.005	0.50

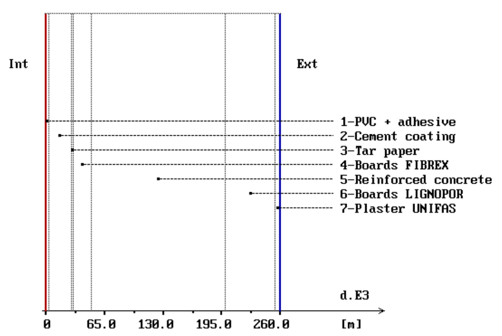
Results of calculation of thermal-technical parameters

Thermal resistance of a construction	R = 1.705 m^2.K/W
Diffusion resistance of a construction	R_d = 399.33×10^9 m/s
Thermal transmittance	U = 0.522 W/($m^{2\cdot}$.K)
Internal surface temperature	θ_{si} = 16.89 °C
Moisture regime	Water vapour does not condense inside the construct.
Thermal effusivity of the floor	b = 782.28 W.$s^{1/2}$/($m^{2\cdot}$.K)
Decrease of contact temperature of the floor	$\Delta\theta_{10}$ = 6.63 °C

Evaluation of a construction of the fragment		Rating
Thermal resistance	R = 1.71 m^2.K/W < R_N = 1.70 m^2.K/W - standard value	not meet
Thermal transmittance	U = 0.52 W/(m^2.K) > U_N = 0.15 W/(m^2.K) - standard value	not meet
Risk of growth of moulds	θ_{si} = 16.89 °C > $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	meet
Thermal effusivity	b = 782 W.$s^{1/2}$/($m^{2\cdot}$.K) $\in$ b_N(701 - 850) - less warm floor	not meet

Table 2.5.2 - Distribution of temperature and water vapour pressures in floor on the ceiling

<table>
<tr><th colspan="3">Ceiling above the exterior</th></tr>
<tr><th></th><th>Temperature distribution in a construction</th><th>Distribution of water vapour pressures in a const.</th></tr>
<tr><td rowspan="2">Representation in scale of thicknesses of layers of a construction</td><td>



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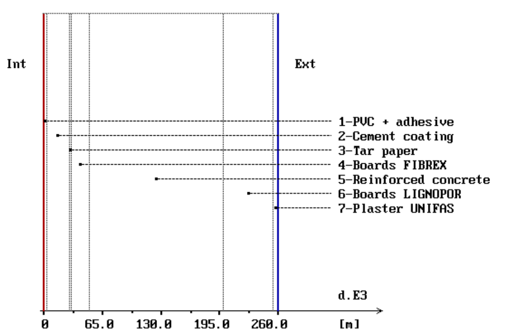

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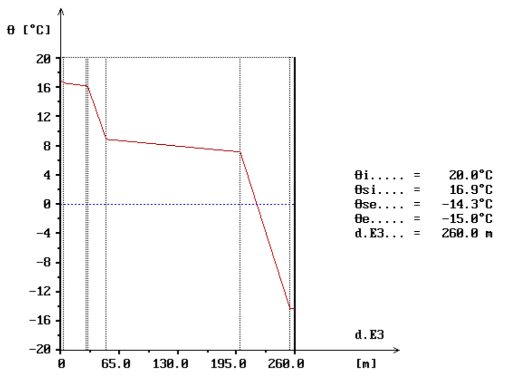

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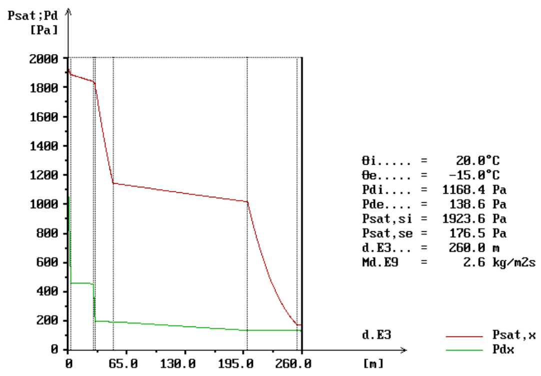
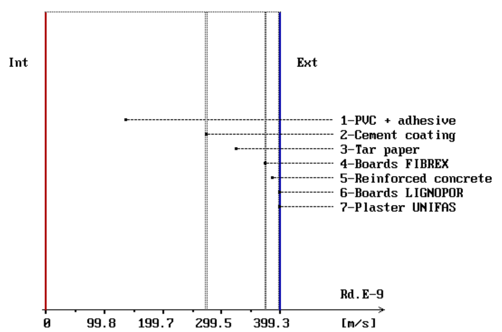


</td></tr>
<tr><td rowspan="2">Representation in scale of diffusion resistances of layers of a constr.</td><td>



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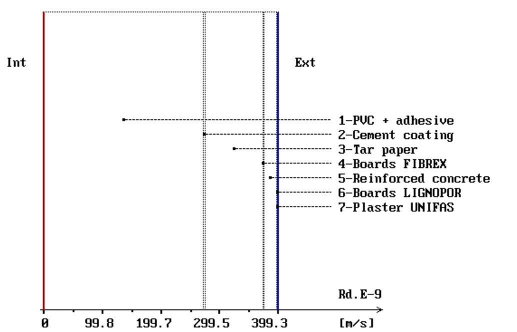

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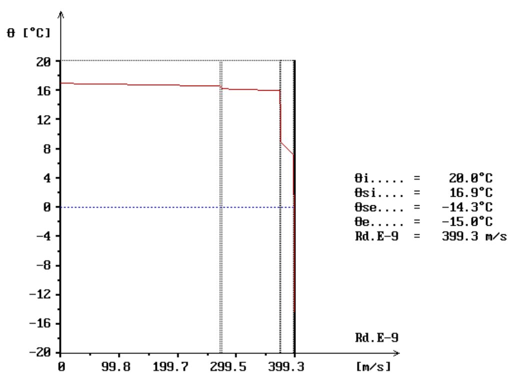

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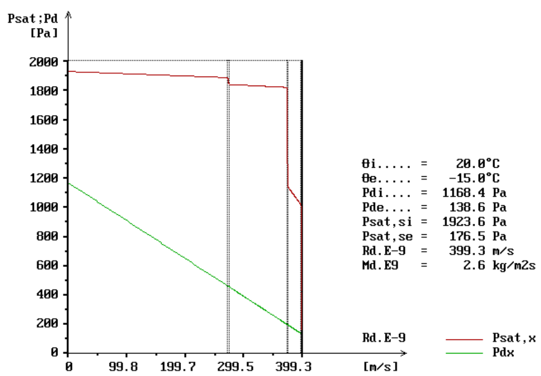


</td></tr>
</table>

Table 2.6 - Thermal-technical properties and evaluation of wooden windows

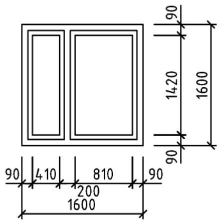
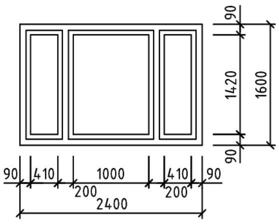
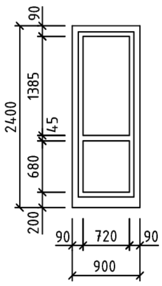
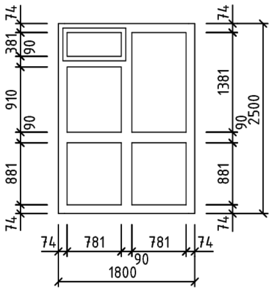
<table>
<tr><td rowspan="2">Order number</td><td rowspan="2">Number</td><td rowspan="2">Scheme of windows</td><td rowspan="2">Length of joints of windows l (m)</td><td rowspan="2">Gap permeability coefficient $i_{LV}\times10^4$ ($m^3/(m.s.Pa^{0.67})$)</td><td>U_f ($W/(m^2.K)$)</td><td>A_f (m^2)</td><td>U_g ($W/(m^2.K)$)</td><td>A_g (m^2)</td><td>ψ_g ($W/(m.K)$)</td><td>l_g (m)</td><td>A_w (m^2)</td></tr>
<tr><td colspan="7">Thermal transmittance of windows ($W/(m^2.K)$)
$$U_w = \frac{U_f.A_f + U_g.A_g + \psi_g.l_g}{A_w}$$</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">152</td><td rowspan="2"></td><td rowspan="2">8.836</td><td rowspan="2">1.4</td><td>1.627</td><td>0.828</td><td>2.798</td><td>1.732</td><td>0.050</td><td>8.120</td><td>2.560</td></tr>
<tr><td colspan="7">2.578</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">24</td><td rowspan="2"></td><td rowspan="2">13.232</td><td rowspan="2">1.4</td><td>1.627</td><td>1.256</td><td>2.798</td><td>2.584</td><td>0.050</td><td>12.160</td><td>3.840</td></tr>
<tr><td colspan="7">2.573</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">24</td><td rowspan="2"></td><td rowspan="2">6.240</td><td rowspan="2">1.4</td><td>1.627</td><td>0.673</td><td>2.798</td><td>1.487</td><td>0.050</td><td>7.010</td><td>2.160</td></tr>
<tr><td colspan="7">2.595</td></tr>
<tr><td colspan="5">Wooden: Σ l = 1810.400 m^2</td><td colspan="7" rowspan="2">Calculated air change rate is given in the next table
Weighted average thermal transmittance of windows ($W/(m^2.K)$)
$$U_w \frac{\sum (A_{wi}.U_{wi})}{\sum A_{wi}}$$</td></tr>
<tr><td colspan="3">$\sum (A_{wi}.U_{wi})$ (W/K)</td><td colspan="2">$\sum A_{wi}$ (m^2)</td></tr>
<tr><td colspan="3">1374.873</td><td colspan="2">533.120</td><td colspan="7">2.579</td></tr>
<tr><td colspan="3">Evaluation</td><td colspan="9">U_w = 2.58 $W/(m^2.K)$ > $U_{w.N}$ = 0.85 $W/(m^2.K)$ – not meet</td></tr>
</table>

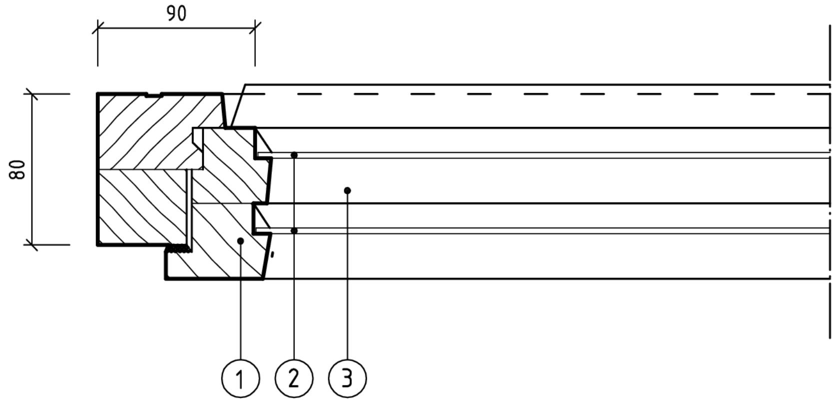
Table 2.7 - Thermal-technical properties and evaluation of steel windows

<table>
<tr><th rowspan="2">Order number</th><th rowspan="2">Number</th><th rowspan="2">Scheme of windows</th><th rowspan="2">Length of joints of windows l (m)</th><th rowspan="2">Gap permeability coefficient $i_{LV}\times10^4$ ($m^3/(m.s.Pa^{0.67})$)</th><th>U_f ($W/(m^2.K)$)</th><th>A_f (m^2)</th><th>U_g ($W/(m^2.K)$)</th><th>A_g (m^2)</th><th>ψ_g ($W/(m.K)$)</th><th>l_g (m)</th><th>A_w (m^2)</th></tr>
<tr><th colspan="7">Thermal transmittance of windows ($W/(m^2.K)$)
$$U_w = \frac{U_f.A_f + U_g.A_g + \psi_g.l_g}{A_w}$$</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">8</td><td rowspan="2">
</td><td rowspan="2">2.652</td><td rowspan="2">1.4</td><td>5.900</td><td>1.037</td><td>5.747</td><td>3.463</td><td>0.123</td><td>16.678</td><td>4.500</td></tr>
<tr><td colspan="7">6.238</td></tr>
<tr><td colspan="5">Steel: Σl = 21.216 m</td><td colspan="7">Calculated air change rate taking into account also values from the previous table</td></tr>
<tr><td colspan="5">Wooden and steel: Σl = 1831.62 m
Volume of building: V_b = 10075.30 m^3</td><td colspan="7">Calculated air change rate (1/h)
$$n = 25200\frac{\sum(i_{LV}.l)}{V_b} = 0.64$$</td></tr>
<tr><td colspan="3">$\sum(A_{wi}.U_{wi})$ (W/K)</td><td colspan="2">$\sum A_{wi}$ (m^2)</td><td colspan="7">Weighted average thermal transmittance of windows ($W/(m^2.K)$)
$$U_w = \frac{\sum(A_{wi}.U_{wi})}{\sum A_{wi}}$$</td></tr>
<tr><td colspan="3">224.568</td><td colspan="2">36.00</td><td colspan="7">6.238</td></tr>
<tr><td colspan="3">Evaluation</td><td colspan="9">U_w = 6.24 $W/(m^2.K)$ > $U_{w.N}$ = 0.85 $W/(m^2.K)$ – not meet</td></tr>
</table>

3 Evaluation on Dew Point Temperature and Calculation of Thermal Transmittance of Windows for the Modeled Details

Table 3.1.1 – Thermal-technical properties and a construction of wooden window

WOODEN WINDOW



Legend:

1. Wooden double window (λ = 0.18 W/(m.K))
2. Glass 3 mm (λ = 1.00 W/(m.K))
3. Closed air gap 37 mm (λ = 0.204 W/(m.K))

NOTE: Loggia doors are modeled like windows

$\boldsymbol{U_{\text{window, wooden}}}$ **= 2.579 W/(m^2.K) – see table 2.6**

Table 3.1.2 – Boundary conditions for a calculation of wooden window

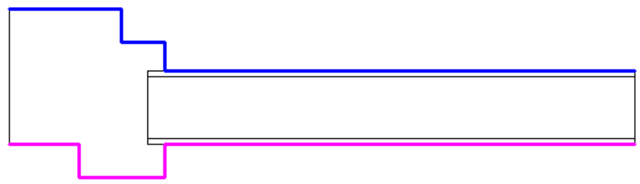
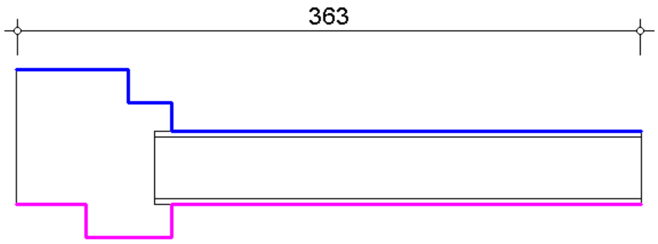
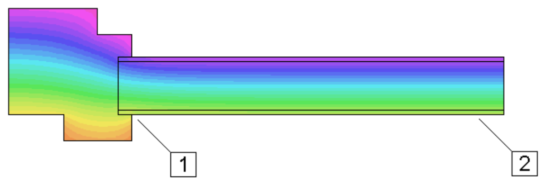
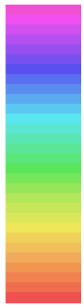
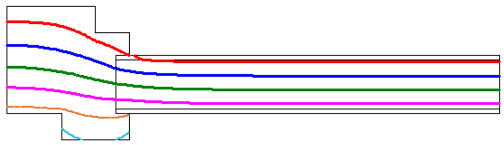
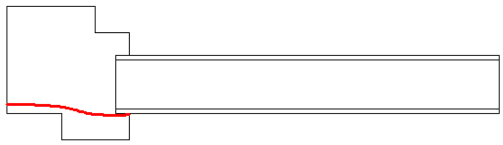
<table>
<tr><th colspan="2">WOODEN WINDOW</th></tr>
<tr><th colspan="2">Boundary conditions for a calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding length of window for a calculation of the thermal transmittance</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

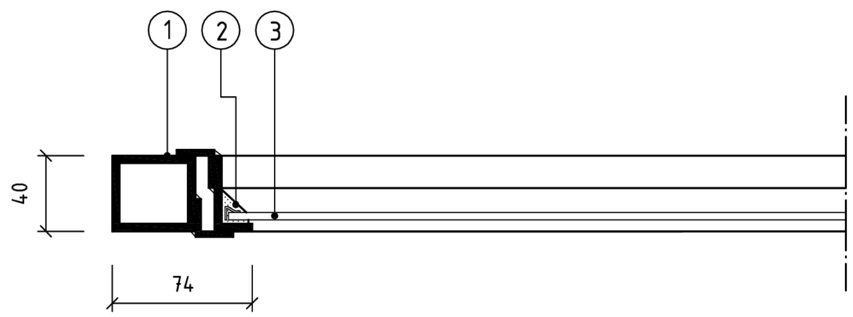
Table 3.1.3 – Thermal-technical evaluation of the wooden window

WOODEN WINDOW	
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.000 W/(m.K) λ = 0.204 W/(m.K) λ = 0.180 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C 5 °C -5 °C 10 °C 0 °C 15 °C	9.26 °C

Point	Temperature	Temperat. factor	Evaluation on dew point temperature	Rating
1	θ_{si} = 8.63 °C	f_{Rsi}= 0.675	θ_{si} = 7.27 °C < θ_{dp} = 9.26 °C	not meet
2	θ_{si} = 7.27 °C	f_{Rsi}= 0.636	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Thermal transmittance			U = 0.93630 / 0.363 = 2.579 W/(m^2.K)	

Table 3.2.1 – Thermal-technical properties and a construction of steel window

STEEL WINDOW



Legend:

1. Steel window (λ = 50 W/(m.K) and λ = 0.5 W/(m.K))
2. Glazier´s putty (λ = 0.22 W/(m.K))
3. Glass 4 mm (λ = 1.00 W/(m.K))

$\boldsymbol{U_{\text{window, steel}}}$ **= 6.238 W/(m^2.K) – see table 2.7**

Table 3.2.2 – Boundary conditions for a calculation of steel window

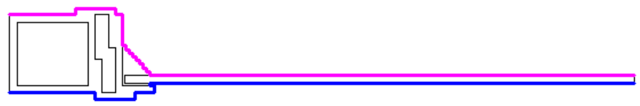
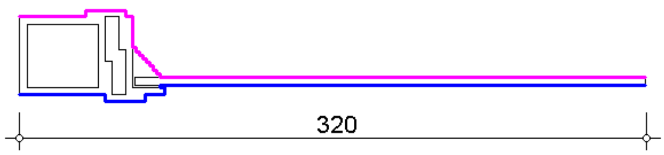
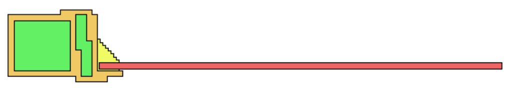
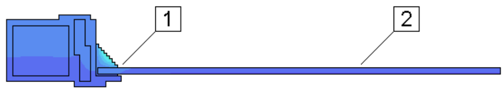
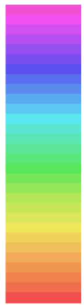
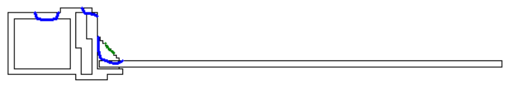
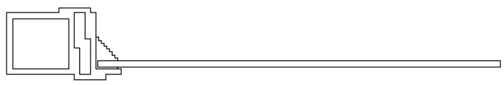
STEEL WINDOW	
Boundary conditions for a calculation of surface temperatures	
	
Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W
Boundary conditions and corresponding length of window for a calculation of the thermal transmittance	
	
Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W

Table 3.2.3 – Thermal-technical evaluation of the steel window

STEEL WINDOW	
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.000 W/(m.K) λ = 50.00 W/(m.K) λ = 0.220 W/(m.K) λ = 0.500 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	9.26 °C

Point	Temperature	Temperat. factor	Evaluation on dew point temperature	Rating
1	θ_{si} = -4.66 °C	f_{Rsi}= 0.295	θ_{si} = -6.15 °C < θ_{dp} = 9.26 °C	not meet
2	θ_{si} = -6.15 °C	f_{Rsi}= 0.253	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Thermal transmittance			U = 1.99612 / 0.320 = 6.238 W/(m^2.K)	

4 Evaluation of Hygienic Criterion and Calculation of the Linear Thermal Transmittance of Selected Details of the Building

Table 4.1.1 – Marking of the position of detail in the building – detail 01

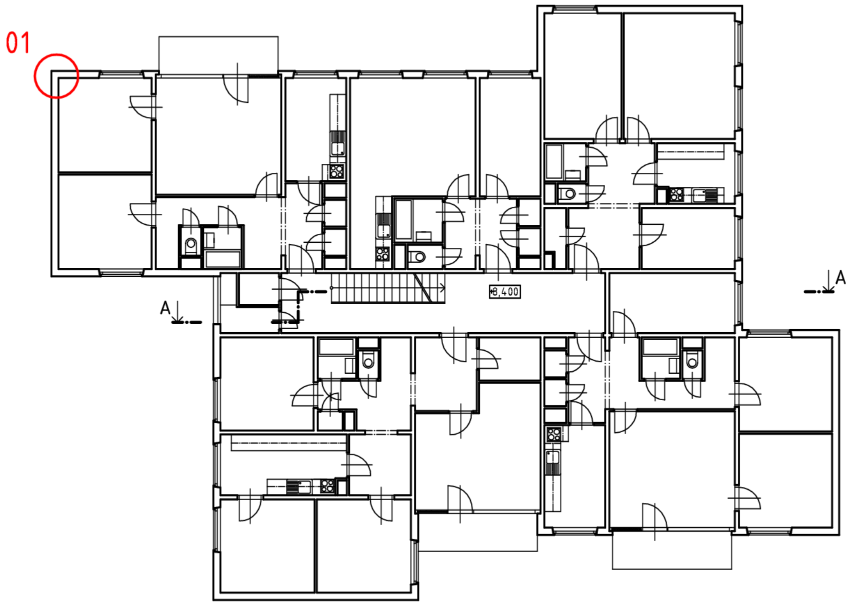
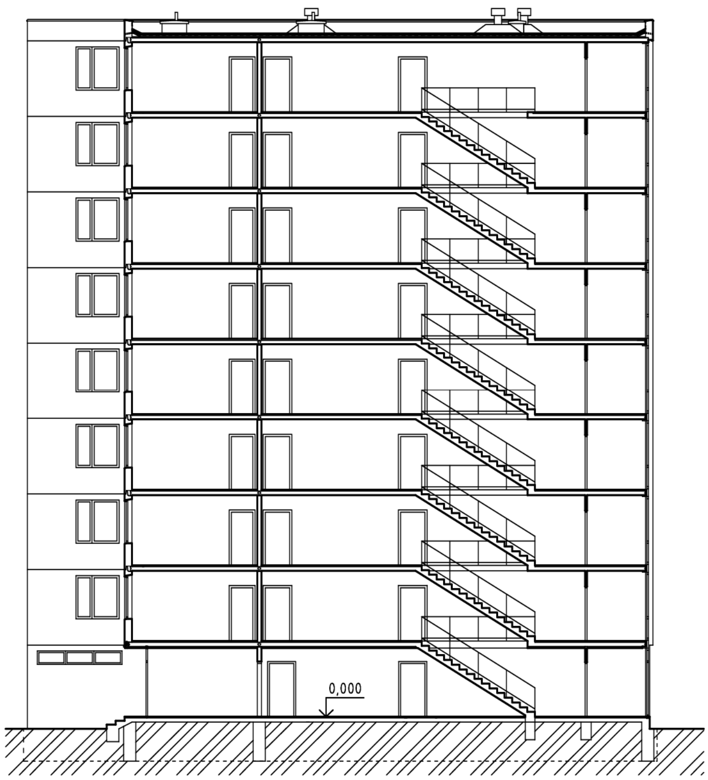
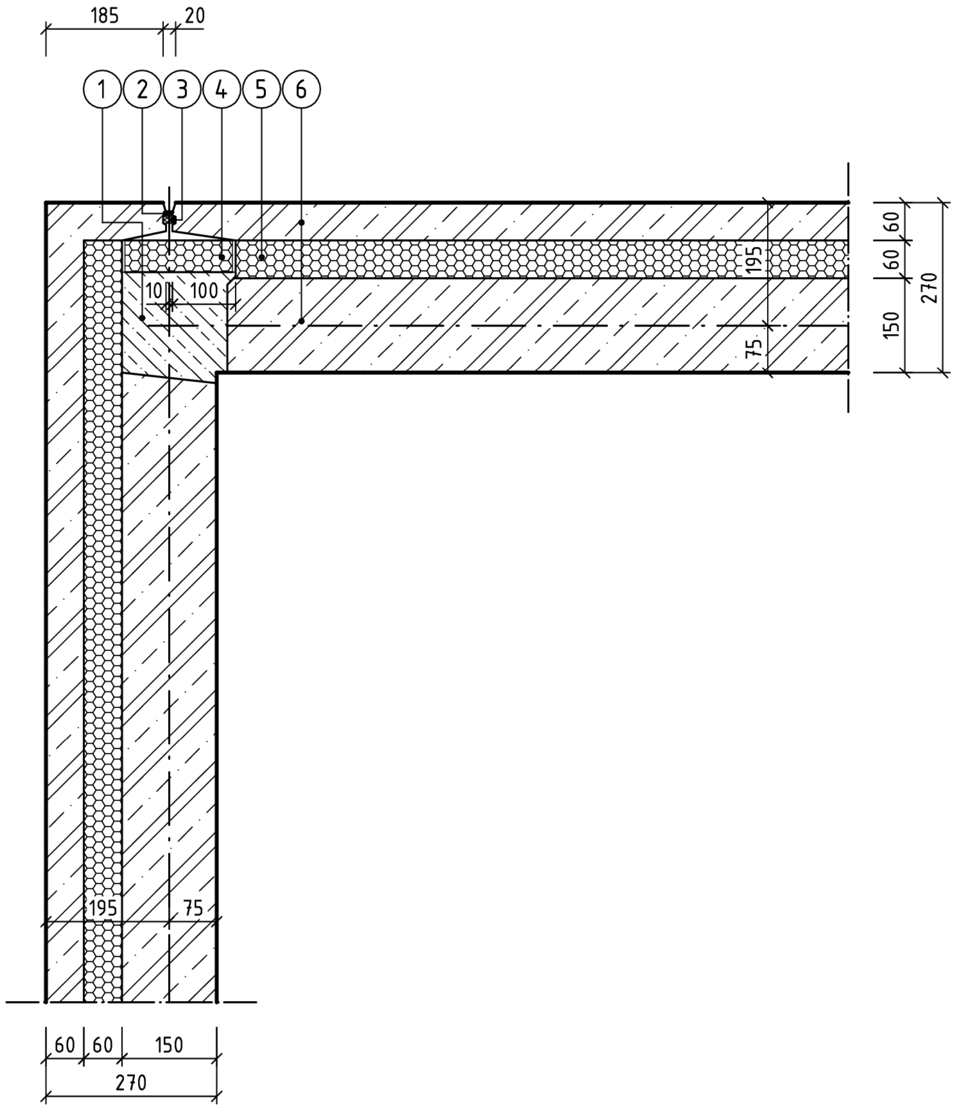
DETAIL 01
Floor plan

Section A-A


Table 4.1.2 – Structural composition of detail 01

DETAIL 01



Legend:

1. Concrete grout (λ = 1.36 W/(m.K))
2. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
3. Sealant profile (λ = 0.05 W/(m.K))
4. Polystyrene foam (λ = 0.044 W/(m.K))
5. Polystyrene foam (λ = 0.070* W/(m.K))
6. Reinforced concrete (λ = 1.58 W/(m.K))

NOTE: ***** The value λ W/(m.K) of the second layer is considered with a degradation influence (leaking of cement grout into insulation during a manufacturing of external panels in precast concrete plant)

$U_{wall,1}$ = 0.862 W/(m^2.K)

Table 4.1.3 – Boundary conditions for a calculation of detail 01

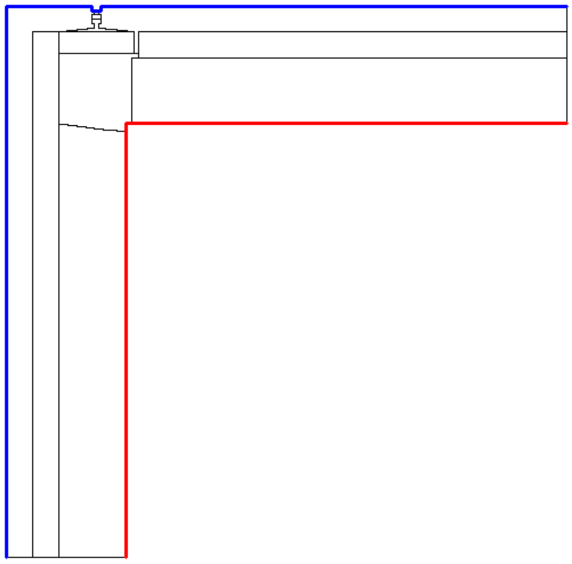
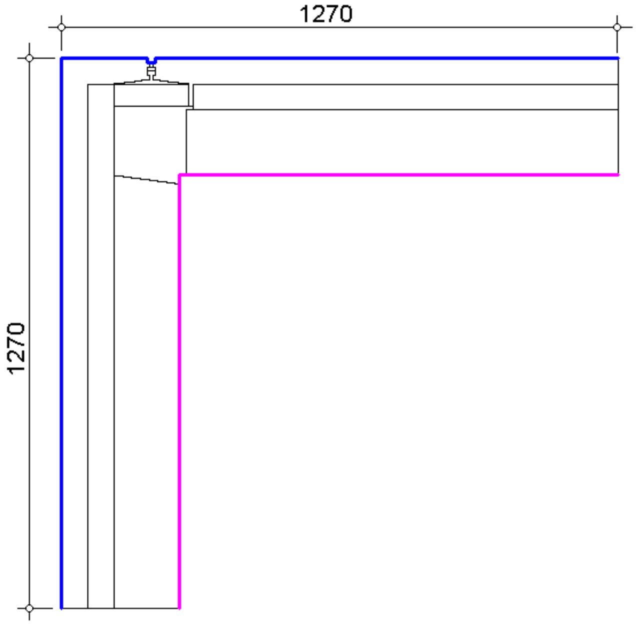
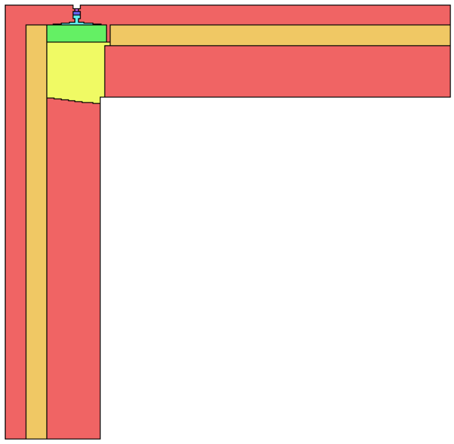
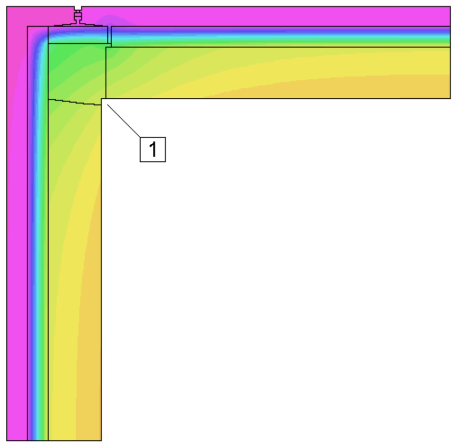
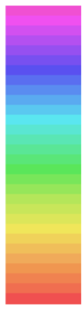
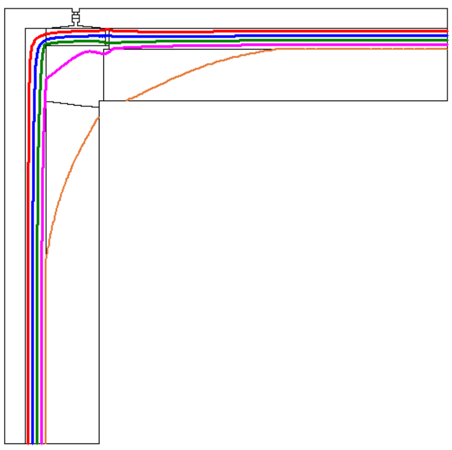
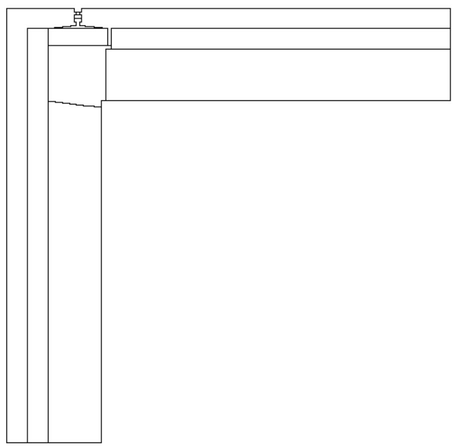
<table>
<tr><th colspan="2">DETAIL 01</th></tr>
<tr><th colspan="2">Boundary conditions for a calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.1.4 – Thermal-technical evaluation of detail 01

DETAIL 01

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.580 W/(m.K) λ = 0.070 W/(m.K) λ = 1.360 W/(m.K) λ = 0.044 W/(m.K) λ = 0.119 W/(m.K) λ = 0.050 W/(m.K) λ = 0.220 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 9.05 °C	f_{Rsi}= 0.687	θ_{si} = 9.05 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	not meet
			$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Linear thermal transmittance			ψ = 1.99724 - 0.862 × (1.270 + 1.270) = -0.192 W/(m.K)	

Table 4.2.1 – Marking of the position of detail in the building – detail 02

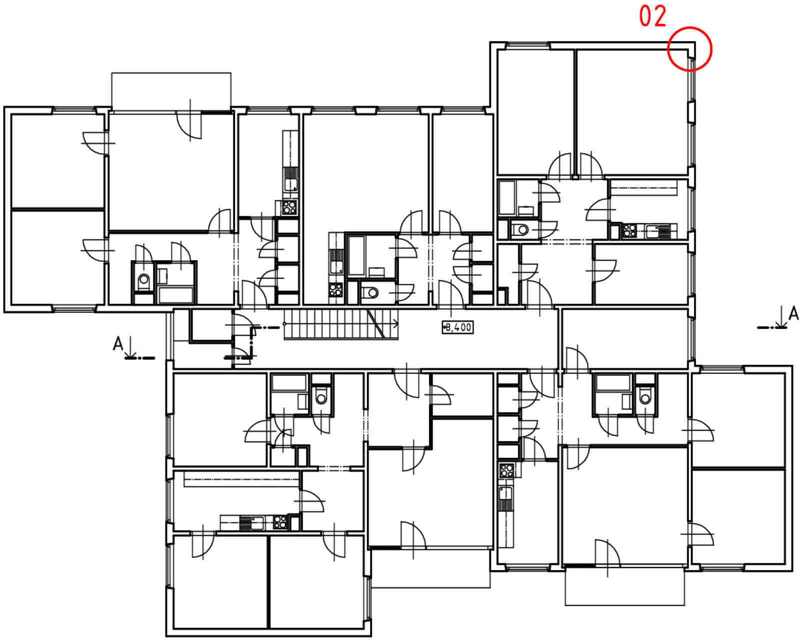
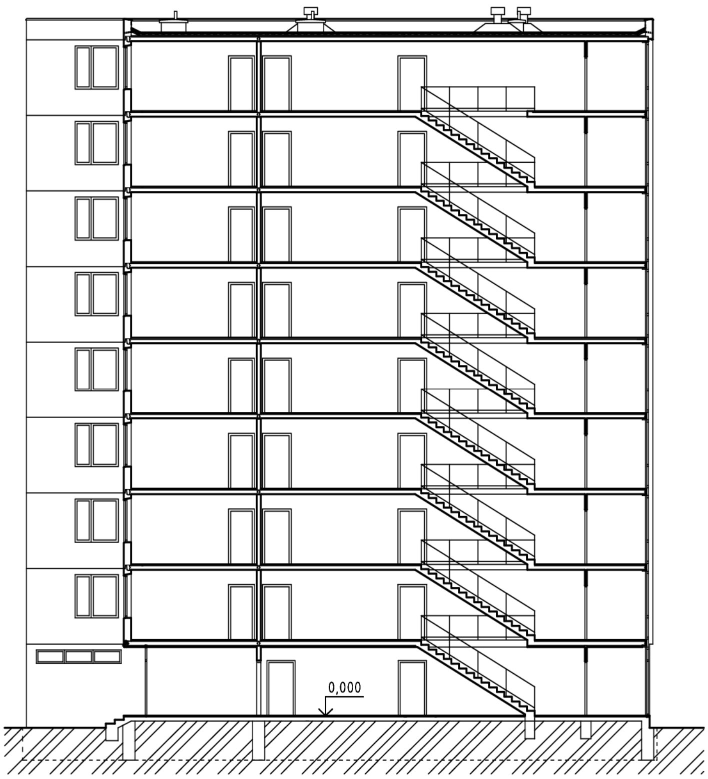
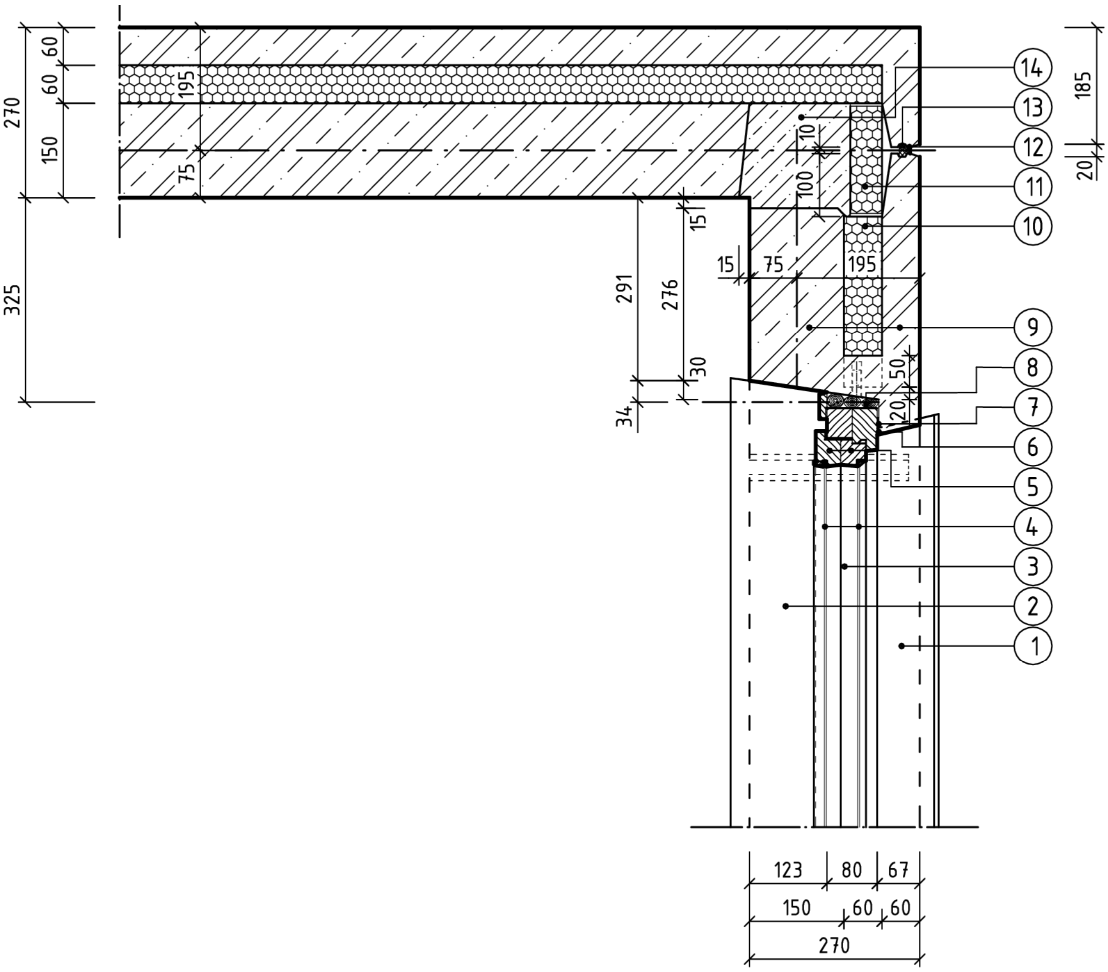
DETAIL 02
Floor plan

Section A-A


Table 4.2.2 – Structural composition of detail 02

DETAIL 02



Legend:

1. Sheet metal covering – in view
2. Internal window sill – in view
3. Closed air gap 37 mm (λ = 0.204 W/(m.K))
4. Glass 3 mm (λ = 1.00 W/(m.K))
5. Wooden window frame (λ = 0.18 W/(m.K))
6. Sealant (λ = 0.22 W/(m.K))
7. Microporous rubber (λ = 0.06 W/(m.K))
8. Seal - glass wool (λ = 0.07 W/(m.K))
9. Reinforced concrete (λ = 1.58 W/(m.K))
10. Polystyrene foam (λ = 0.07 W/(m.K))
11. Polystyrene foam (λ = 0.044 W/(m.K))
12. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
13. Sealant profile (λ = 0.05 W/(m.K))
14. Concrete grout (λ = 1.36 W/(m.K))

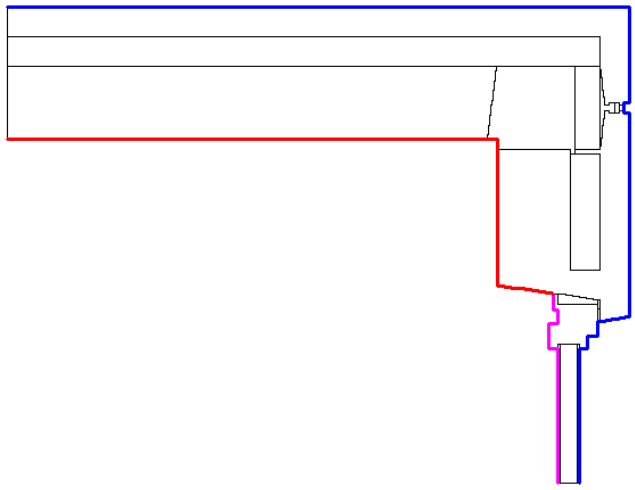
$U_{wall,1}$ = 0.862 W/(m^2.K)

$U_{window, wooden}$ = 2.579 W/(m^2.K)

Table 4.2.3 – Boundary conditions for a calculation of detail 02

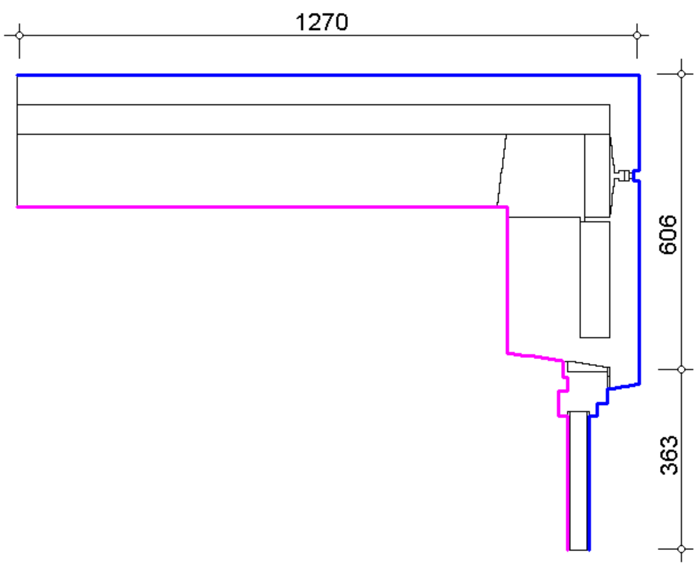
DETAIL 02

Boundary conditions for calculation of surface temperatures



Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % (red line) R_{si} = 0.25 m^2.K/W (magenta line) R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % (blue line) R_{se} = 0.04 m^2.K/W

Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance

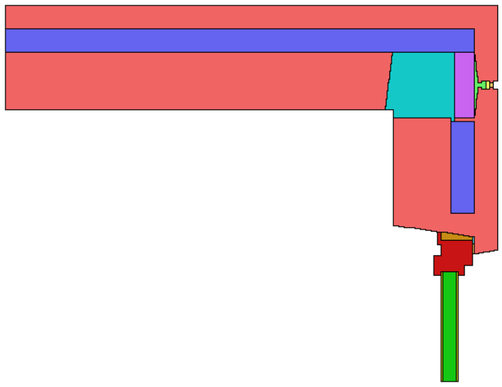


Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % (magenta line) R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % (blue line) R_{se} = 0.04 m^2.K/W

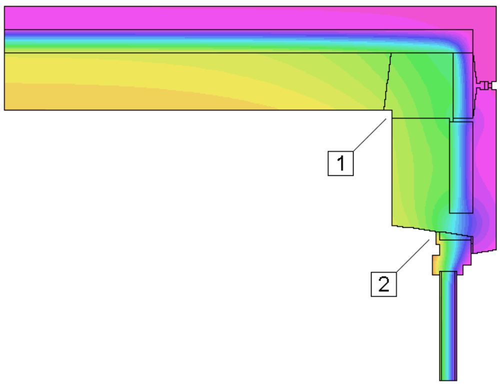
Table 4.2.4 Thermal-technical evaluation of detail 02

DETAIL 02

Modeled detail with marking the materials



Temperature field with marked critical temperatures

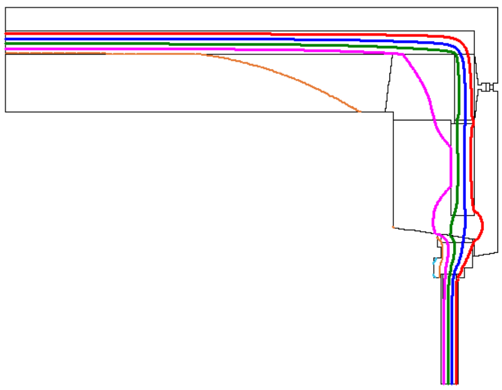


Legend:

λ = 1.580 W/(m.K)	λ = 0.044 W/(m.K)
λ = 0.220 W/(m.K)	λ = 0.180 W/(m.K)
λ = 0.050 W/(m.K)	λ = 0.070 W/(m.K)
λ = 0.119 W/(m.K)	λ = 1.000 W/(m.K)
λ = 0.060 W/(m.K)	λ = 0.204 W/(m.K)
λ = 0.070 W/(m.K)	λ = 1.360 W/(m.K)

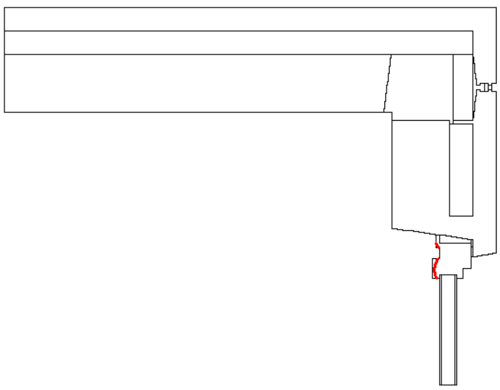
-15.0 °C ... -11.5 °C
-11.5 °C ... -8.0 °C
-8.0 °C ... -4.5 °C
-4.5 °C ... -1.0 °C
-1.0 °C ... 2.5 °C
2.5 °C ... 6.0 °C
6.0 °C ... 9.5 °C
9.5 °C ... 13.0 °C
13.0 °C ... 16.5 °C
16.5 °C ... 20.0 °C

Representation of characteristic isotherms



-10 °C   5 °C
-5 °C   10 °C
0 °C   15 °C

Representation of the critical isotherm



13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 8.15 °C	f_{Rsi}= 0.661	θ_{si} = 4.74 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 4.74 °C	f_{Rsi}= 0.564	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	

Linear thermal transmittance	ψ = 2.67538 - 0.862 × (1.270 + 0.606) - 2.579 × 0.363 = 0.122 W/(m.K)

Table 4.3.1 – Marking of the position of detail in the building – detail 03

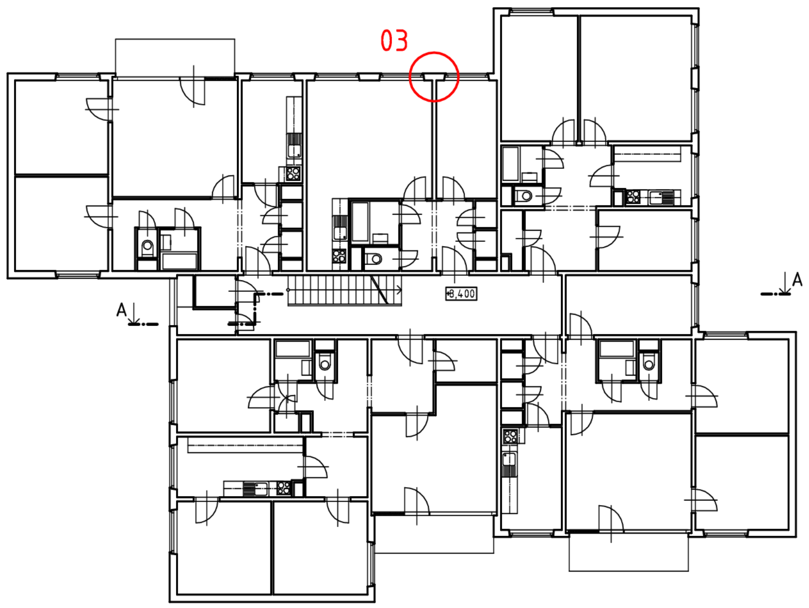
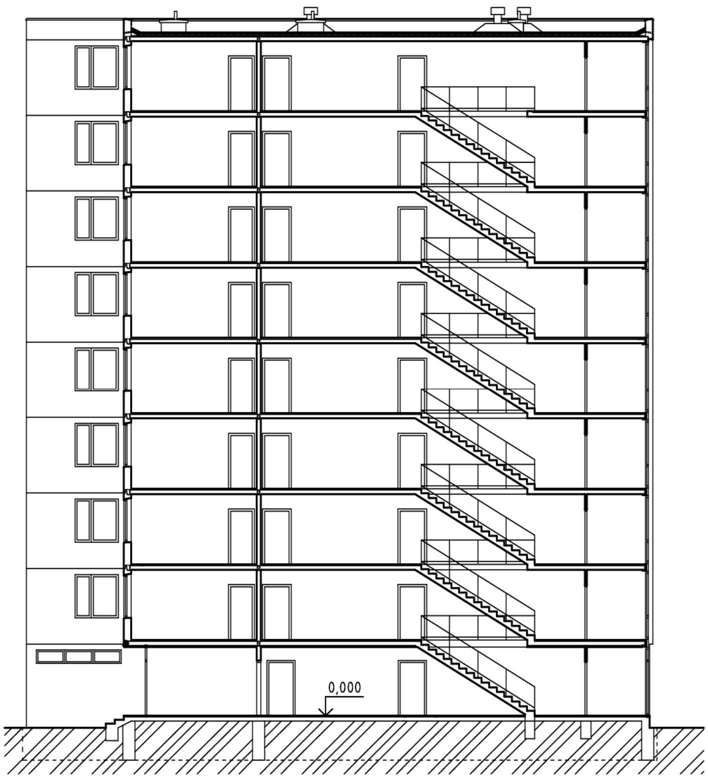
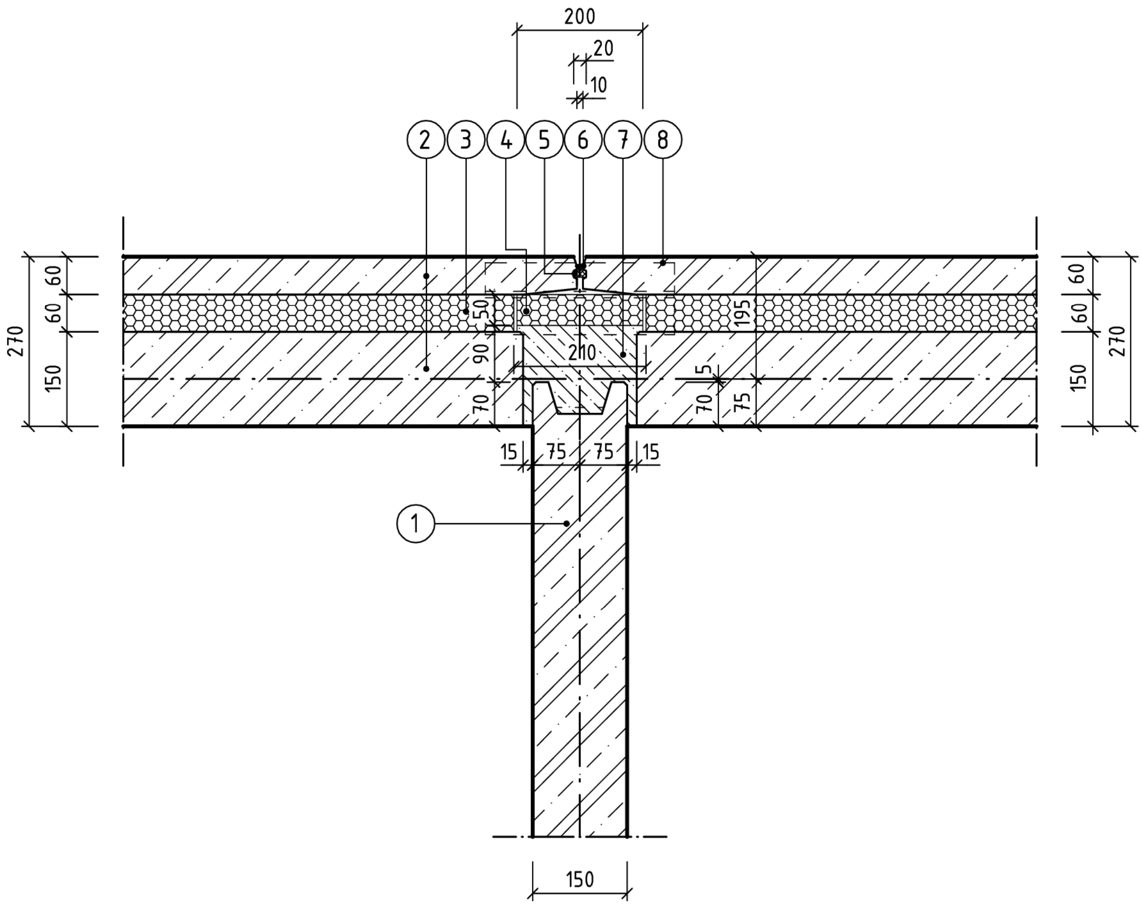
DETAIL 03
Floor plan

Section A-A


Table 4.3.2 – Structural composition of detail 03

DETAIL 03



Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Reinforced concrete (λ = 1.58 W/(m.K))
3. Polystyrene foam (λ = 0.070 W/(m.K))
4. Polystyrene foam (λ = 0.044 W/(m.K))
5. Sealant profile (λ = 0.05 W/(m.K))
6. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
7. Concrete grout (λ = 1.36 W/(m.K))
8. Galvanized sheet metal (not considered in model)

$U_{wall,1}$ = 0.862 W/(m^2.K)

Table 4.3.3 – Boundary conditions for a calculation of detail 03

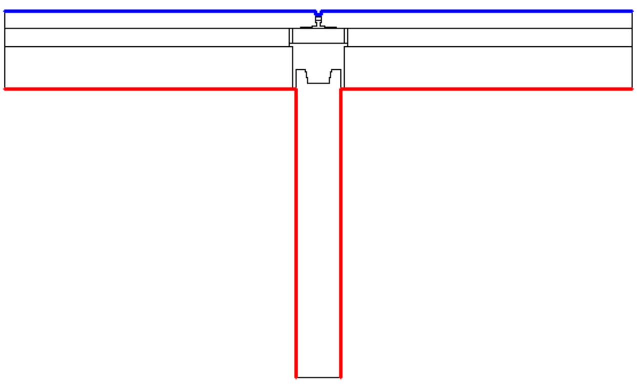
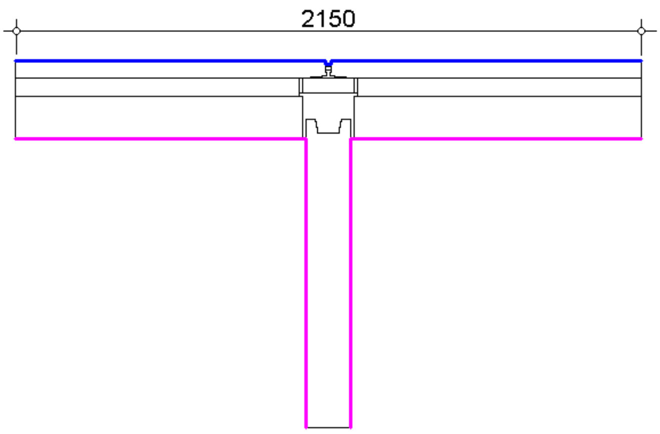
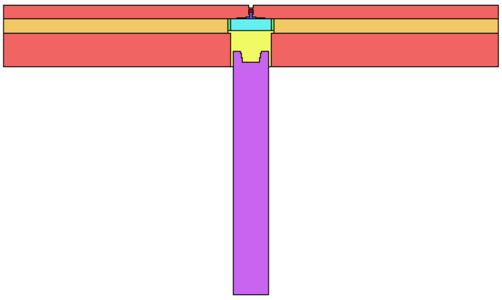
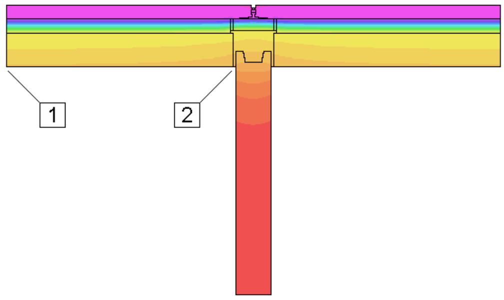
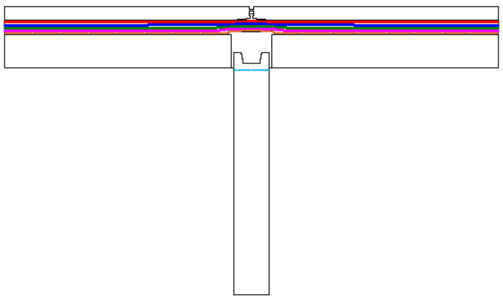
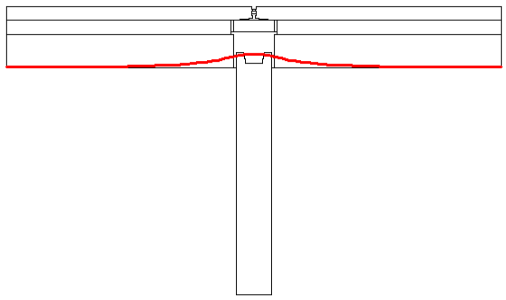
<table>
<tr><th colspan="2">DETAIL 03</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.3.4 – Thermal-technical evaluation of detail 03

DETAIL 03	
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.580 W/(m.K) λ = 0.070 W/(m.K) λ = 1.360 W/(m.K) λ = 0.278 W/(m.K) λ = 0.044 W/(m.K) λ = 0.119 W/(m.K) λ = 1.340 W/(m.K) λ = 0.050 W/(m.K) λ = 0.220 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 13.18 °C	f_{Rsi}= 0.805	θ_{si} = 13.18 °C > $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	meet
2	θ_{si} = 14.17 °C	f_{Rsi}= 0.833	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Linear thermal transmittance			ψ = 1.87294 - 0.862 × 2.150 = 0.020 W/(m.K)	

Table 4.4.1 – Marking of the position of detail in the building – detail 04

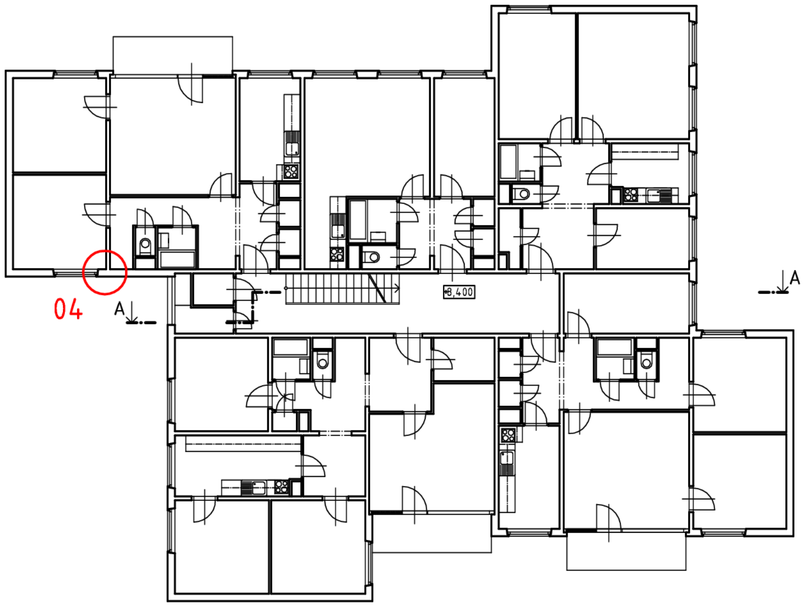
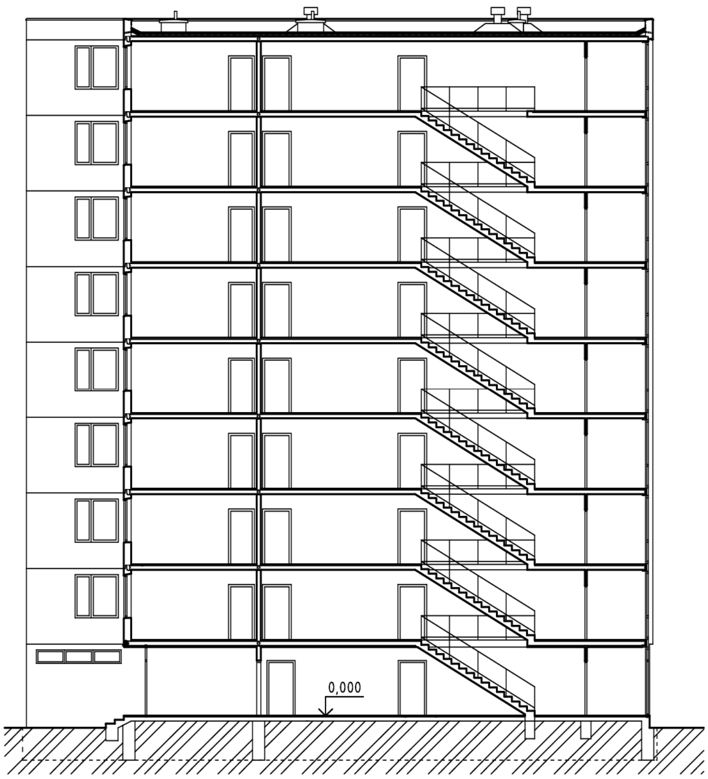
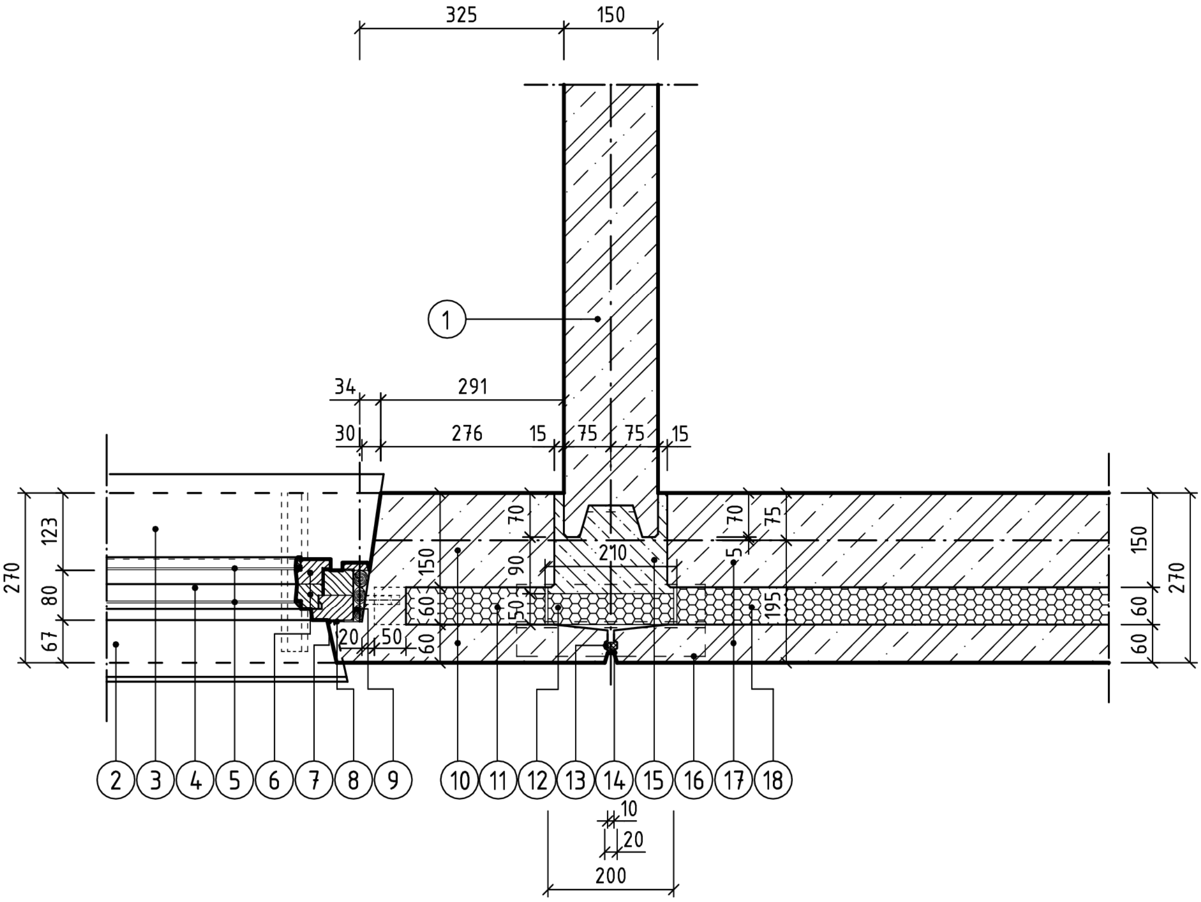
<table>
<tr><th>DETAIL 04</th></tr>
<tr><td>Floor plan</td></tr>
<tr><td>
</td></tr>
<tr><td>Section A-A</td></tr>
<tr><td>
</td></tr>
</table>

Table 4.4.2 – Structural composition of detail 04

DETAIL 04



Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Sheet metal covering – in view
3. Internal window sill – in view
4. Closed air gap 37 mm (λ = 0.204 W/(m.K))
5. Glass 3 mm (λ = 1.00 W/(m.K))
6. Wooden window frame (λ = 0.18 W/(m.K))
7. Sealant (λ = 0.22 W/(m.K))
8. Microporous rubber (λ = 0.06 W/(m.K))
9. Seal - glass wool (λ = 0.07 W/(m.K))
10. Reinforced concrete (λ = 1.58 W/(m.K))
11. Polystyrene foam (λ = 0.07 W/(m.K))
12. Polystyrene foam (λ = 0.044 W/(m.K))
13. Sealant profile (λ = 0.05 W/(m.K))
14. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
15. Concrete grout (λ = 1.36 W/(m.K))
16. Galvanized sheet metal (not considered in model)
17. Reinforced concrete (λ = 1.58 W/(m.K))
18. Polystyrene foam (λ = 0.07 W/(m.K))

$U_{\mathrm{wall,1}}$ **= 0.862 W/(m^2.K)**

$U_{\mathrm{window,\ wooden}}$ **= 2.579 W/(m^2.K)**

Table 4.4.3 – Boundary conditions for a calculation of detail 04

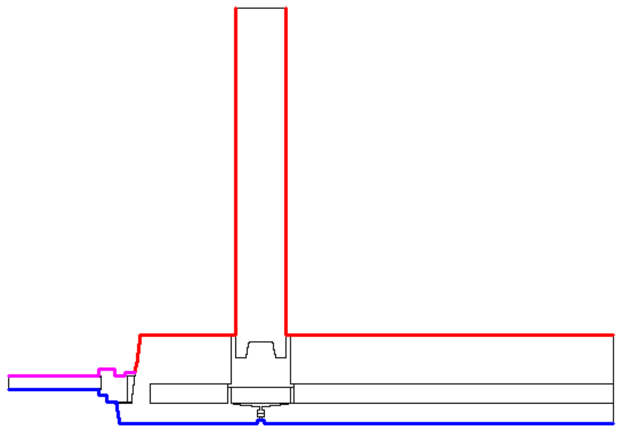
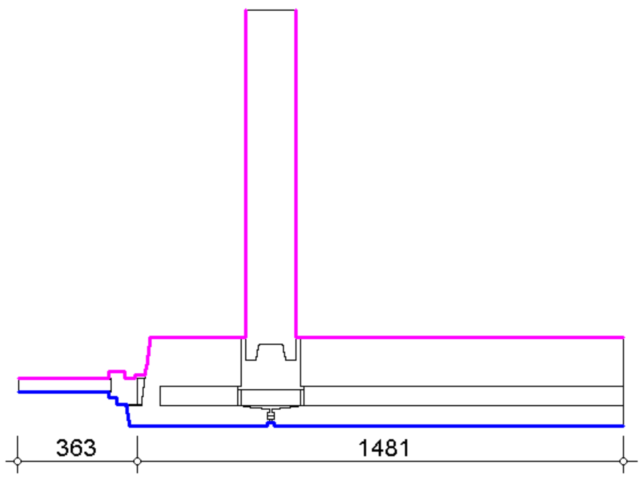
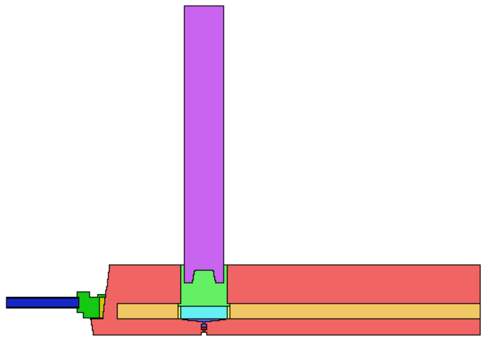
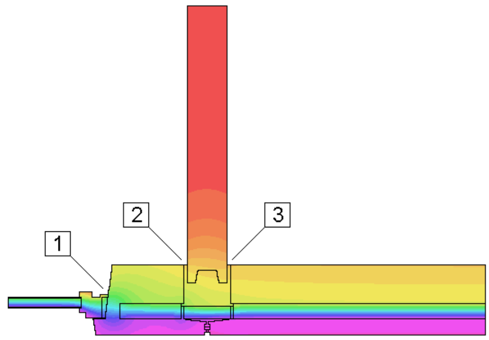
<table>
<tr><th colspan="2">DETAIL 04</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

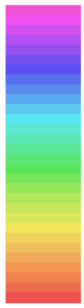
Table 4.4.4 Thermal-technical evaluation of detail 04

DETAIL 04

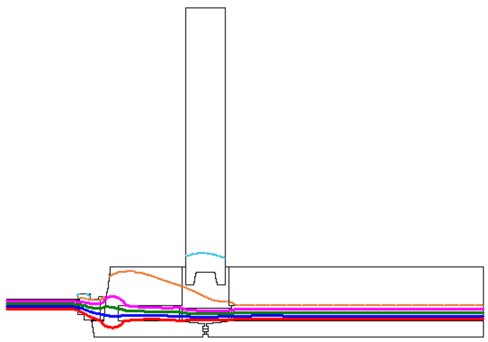
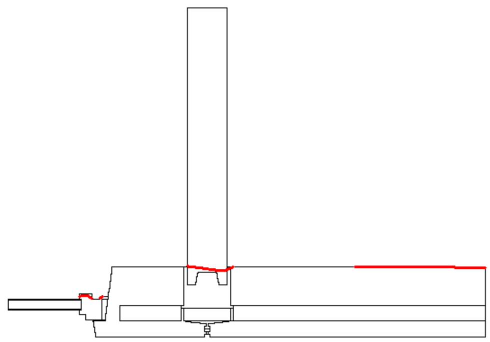
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

λ = 1.580 W/(m.K)	λ = 0.050 W/(m.K)
λ = 0.070 W/(m.K)	λ = 0.220 W/(m.K)
λ = 0.278 W/(m.K)	λ = 0.070 W/(m.K)
λ = 1.360 W/(m.K)	λ = 0.180 W/(m.K)
λ = 0.044 W/(m.K)	λ = 0.060 W/(m.K)
λ = 0.119 W/(m.K)	λ = 1.000 W/(m.K)
λ = 1.340 W/(m.K)	λ = 0.204 W/(m.K)



-15.0 °C	... -11.5 °C
-11.5 °C	... -8.0 °C
-8.0 °C	... -4.5 °C
-4.5 °C	... -1.0 °C
-1.0 °C	... 2.5 °C
2.5 °C	... 6.0 °C
6.0 °C	... 9.5 °C
9.5 °C	... 13.0 °C
13.0 °C	... 16.5 °C
16.5 °C	... 20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C, -5 °C, 0 °C, 5 °C, 10 °C, 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 5.62 °C	f_{Rsi}= 0.589	θ_{si} = 5.62 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 12.92 °C	f_{Rsi}= 0.780	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
3	θ_{si} = 13.58 °C	f_{Rsi}= 0.817		
Linear thermal transmittance			ψ = 2.57189 - 0.862 × 1.481 - 2.579 × 0.363 = 0.359 W/(m.K)	

Table 4.5.1 – Marking of the position of detail in the building – detail 05

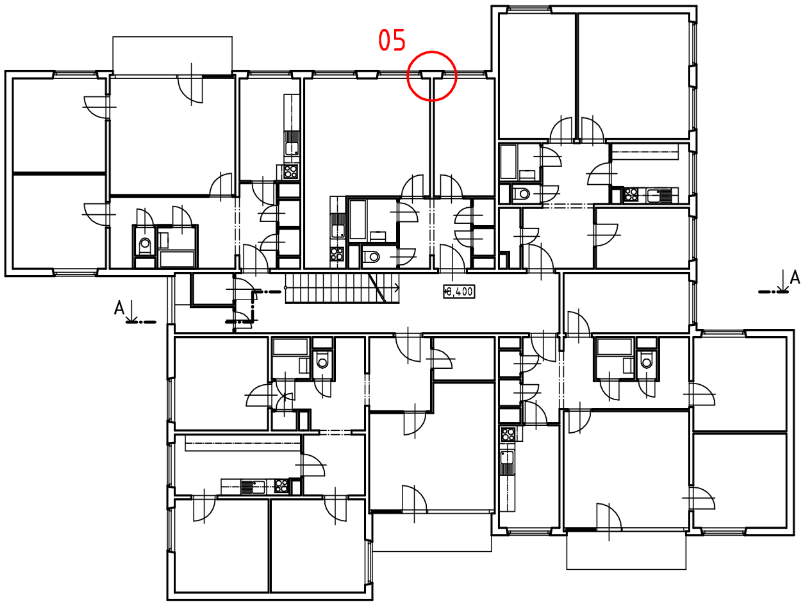
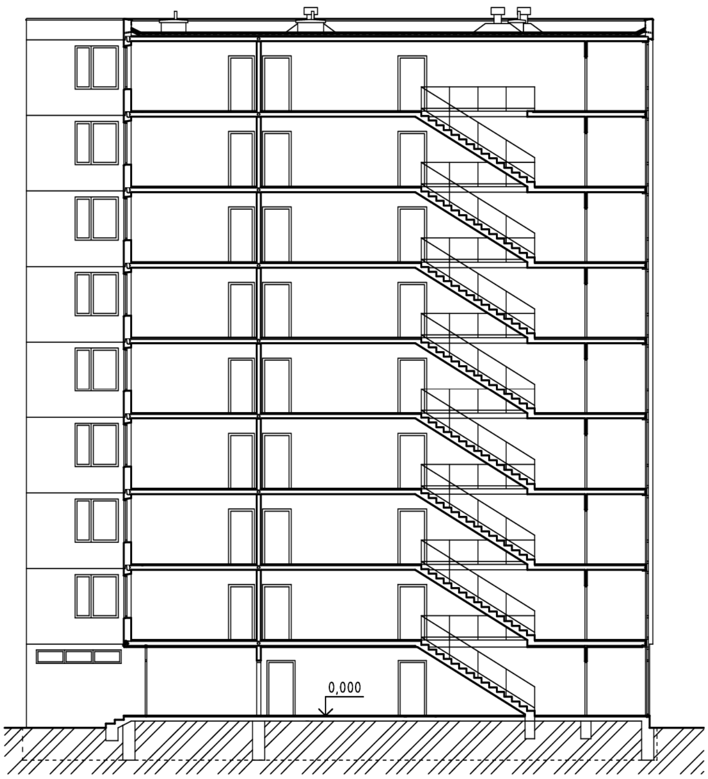
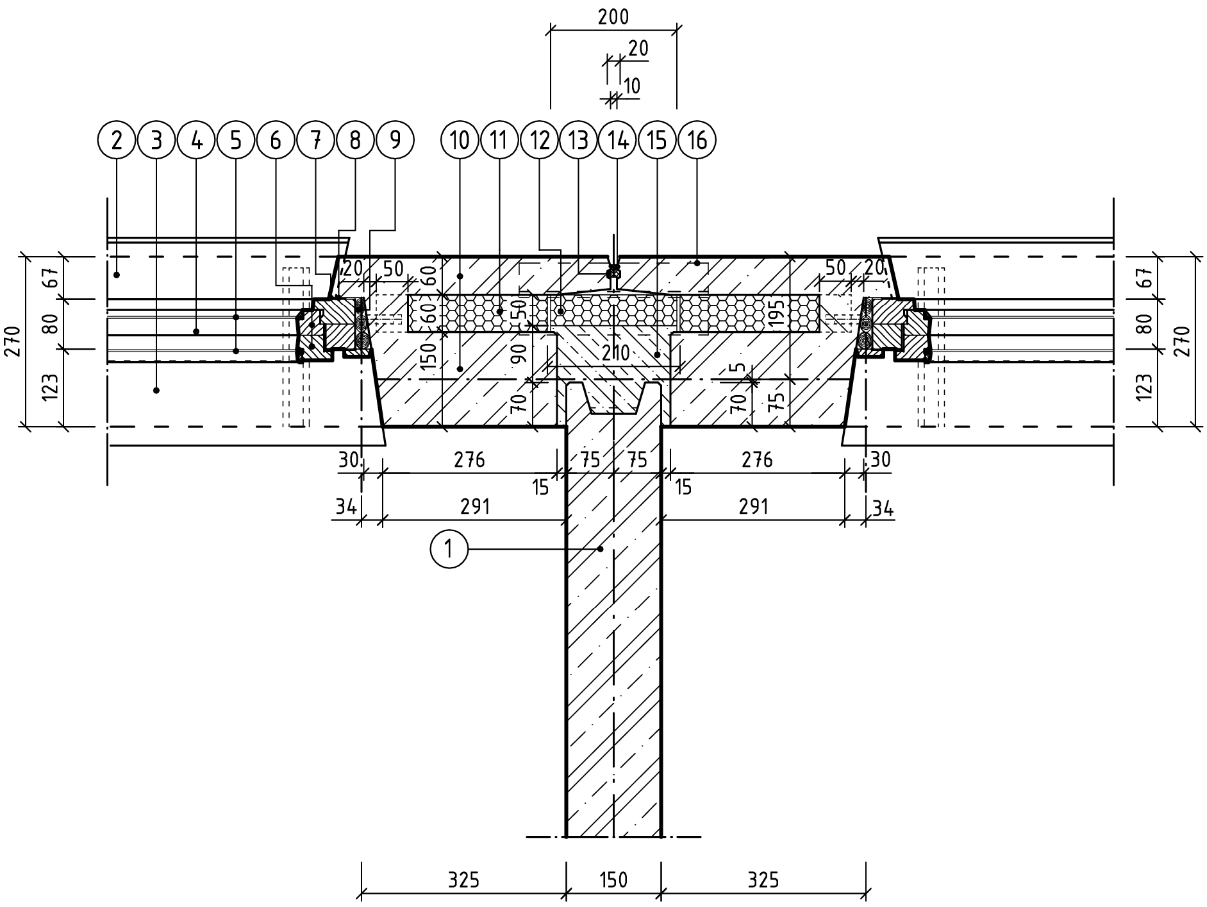
DETAIL 05
Floor plan

Section A-A


Table 4.5.2 – Structural composition of detail 05

DETAIL 05



Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Sheet metal covering – in view
3. Internal window sill – in view
4. Closed air gap 37 mm (λ = 0.204 W/(m.K))
5. Glass 3 mm (λ = 1.00 W/(m.K))
6. Wooden window frame (λ = 0.18 W/(m.K))
7. Sealant (λ = 0.22 W/(m.K))
8. Microporous rubber (λ = 0.06 W/(m.K))
9. Seal - glass wool (λ = 0.07 W/(m.K))
10. Reinforced concrete (λ = 1.58 W/(m.K))
11. Polystyrene foam (λ = 0.07 W/(m.K))
12. Polystyrene foam (λ = 0.044 W/(m.K))
13. Sealant profile (λ = 0.05 W/(m.K))
14. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
15. Concrete grout (λ = 1.36 W/(m.K))
16. Galvanized sheet metal (not considered in model)

$U_{wall,1}$ = 0.862 W/(m^2.K)

$U_{window,\ wooden}$ = 2.579 W/(m^2.K)

Table 4.5.3 – Boundary conditions for a calculation of detail 05

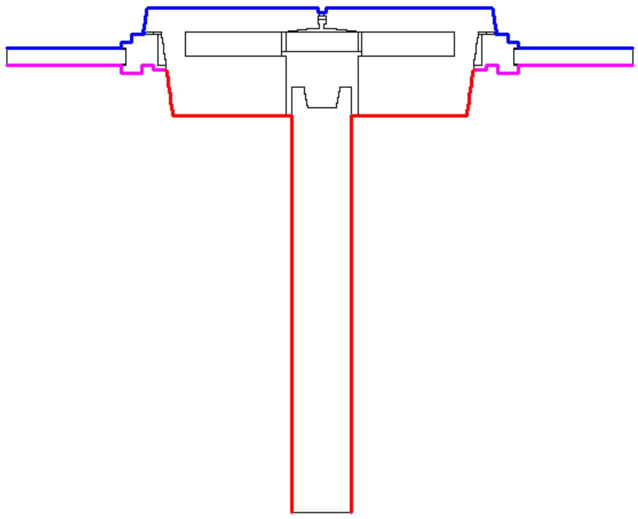
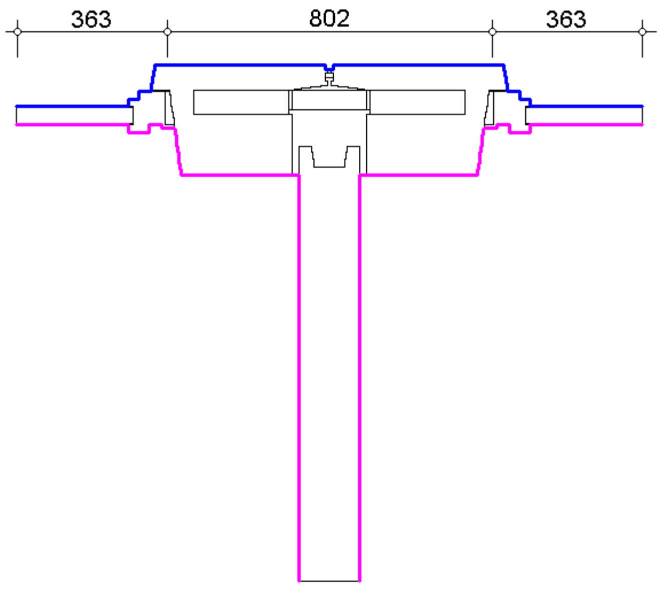
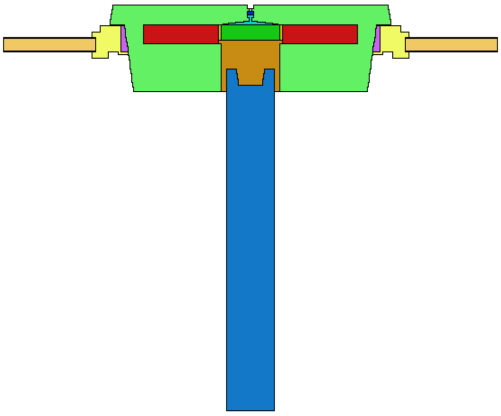
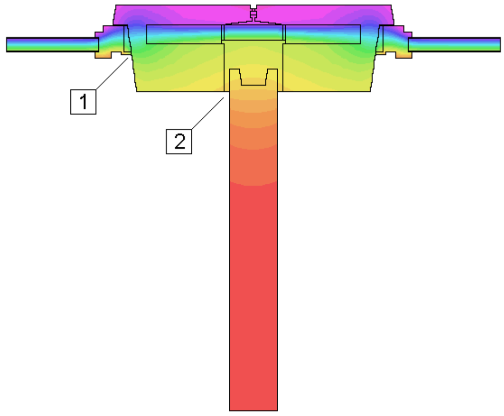
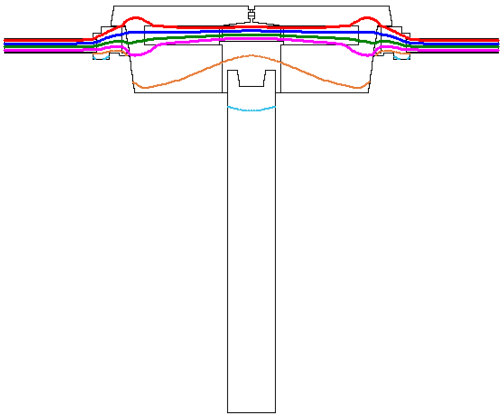
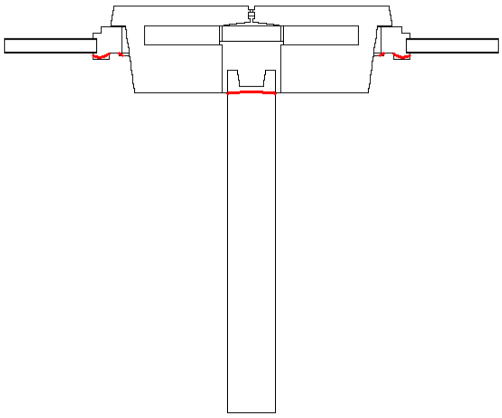
DETAIL 05	
Boundary conditions for calculation of surface temperatures	
	
Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.25 m^2.K/W R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W
Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance	
	
Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W

Table 4.5.4 – Thermal-technical evaluation of detail 05

DETAIL 05	
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.000 W/(m.K) λ = 0.204 W/(m.K) λ = 0.180 W/(m.K) λ = 1.580 W/(m.K) λ = 0.220 W/(m.K) λ = 0.060 W/(m.K) λ = 0.070 W/(m.K) λ = 0.070 W/(m.K) λ = 1.360 W/(m.K) λ = 0.278 W/(m.K) λ = 0.044 W/(m.K) λ = 0.119 W/(m.K) λ = 1.340 W/(m.K) λ = 0.050 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	**Temperature**	**Temperat. factor**	**Evaluation of hygienic criterion**	**Rating**
1	θ_{si} = 5.72 °C	f_{Rsi}= 0.592	θ_{si} = 5.72 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 12.34 °C	f_{Rsi}= 0.781	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	

Linear thermal transmittance	ψ = 3.30469 - 0.862 × 0.802 - 2.579 × (0.363 + 0.363) = 0.741 W/(m.K)

Table 4.6.1 – Marking of the position of detail in the building – detail 06

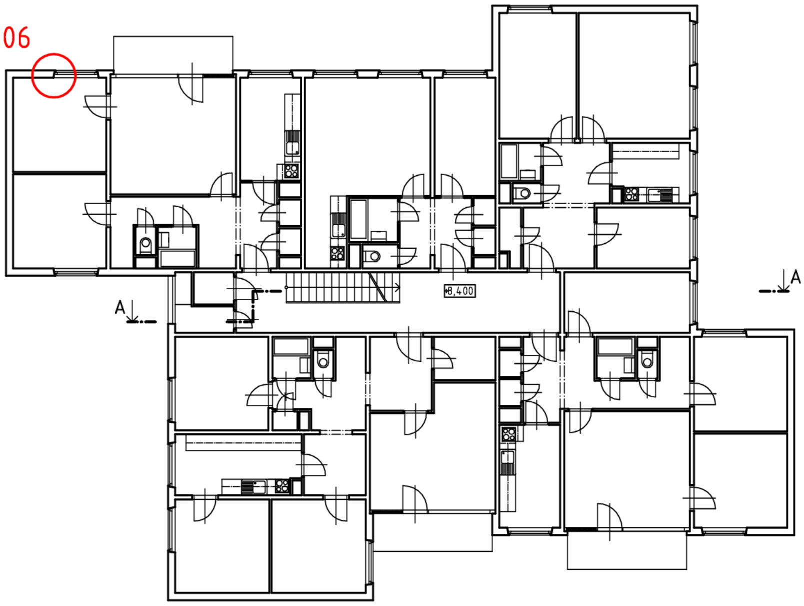
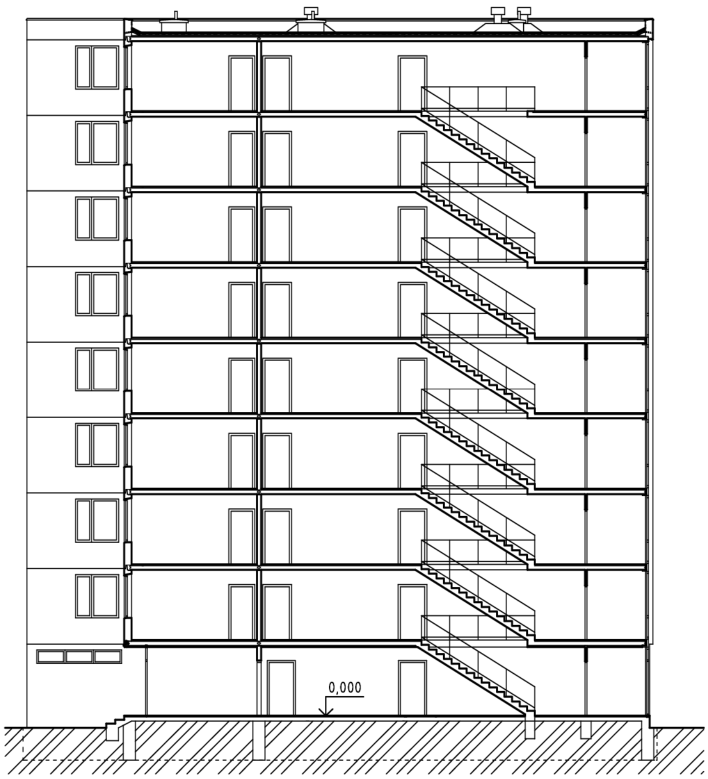
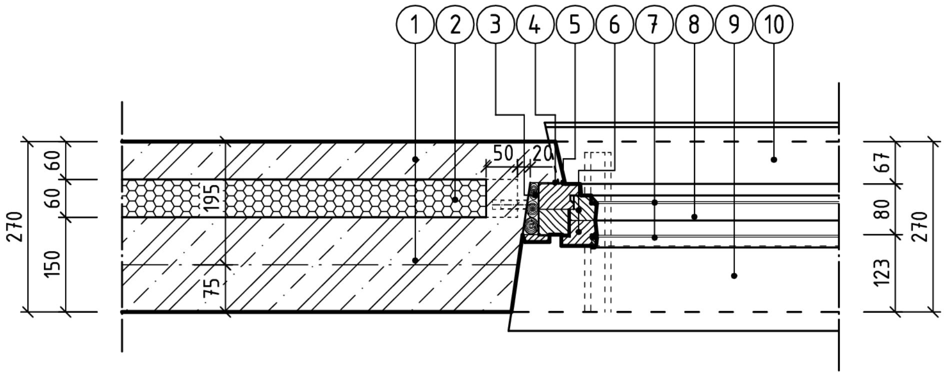
DETAIL 06
Floor plan

Section A-A


Table 4.6.2 – Structural composition of detail 06

DETAIL 06



Legend:

1. Reinforced concrete (λ = 1.58 W/(m.K))
2. Polystyrene foam (λ = 0.07 W/(m.K))
3. Seal - glass wool (λ = 0.07 W/(m.K))
4. Microporous rubber (λ = 0.06 W/(m.K))
5. Sealant (λ = 0.22 W/(m.K))
6. Wooden window frame (λ = 0.18 W/(m.K))
7. Glass 3 mm (λ = 1.00 W/(m.K))
8. Closed air gap 37 mm (λ = 0.204 W/(m.K))
9. Internal window sill – in view
10. Sheet metal covering – in view

$\boldsymbol{U_{\mathrm{wall,1}}}$ **= 0.862 W/(m^2.K)**

$\boldsymbol{U_{\mathrm{window,\ wooden}}}$ **= 2.579 W/(m^2.K)**

Table 4.6.3 – Boundary conditions for a calculation of detail 06

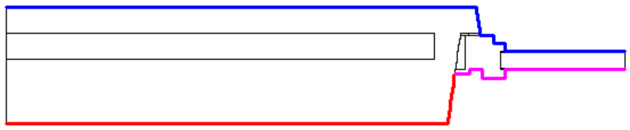
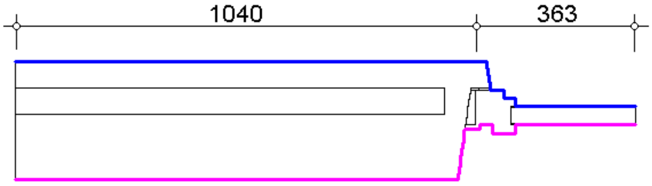
<table>
<tr><th colspan="2">DETAIL 06</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.6.4 – Thermal-technical evaluation of detail 06

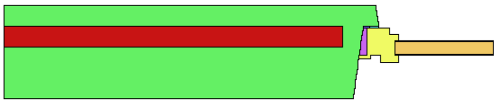
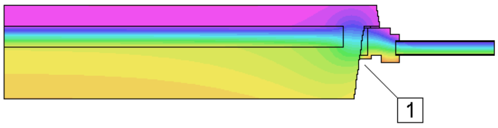
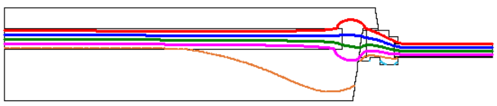
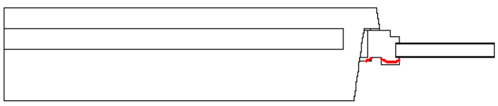
<table>
<tr><th colspan="5">DETAIL 06</th></tr>
<tr><td colspan="3">Modeled detail with marking the materials</td><td colspan="2">Temperature field with marked critical temperatures</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="3">Legend:
λ = 1.000 W/(m.K)
λ = 0.204 W/(m.K)
λ = 0.180 W/(m.K)
λ = 1.580 W/(m.K)
λ = 0.220 W/(m.K)
λ = 0.060 W/(m.K)
λ = 0.070 W/(m.K)
λ = 0.070 W/(m.K)</td><td colspan="2">
-15.0 °C ... -11.5 °C
-11.5 °C ... -8.0 °C
-8.0 °C ... -4.5 °C
-4.5 °C ... -1.0 °C
-1.0 °C ... 2.5 °C
2.5 °C ... 6.0 °C
6.0 °C ... 9.5 °C
9.5 °C ... 13.0 °C
13.0 °C ... 16.5 °C
16.5 °C ... 20.0 °C</td></tr>
<tr><td colspan="3">Representation of characteristic isotherms</td><td colspan="2">Representation of the critical isotherm</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="3">-10 °C
-5 °C
0 °C
5 °C
10 °C
15 °C</td><td colspan="2">13.12 °C</td></tr>
<tr><td>Point</td><td>Temperature</td><td>Temperat. factor</td><td>Evaluation of hygienic criterion</td><td>Rating</td></tr>
<tr><td>1</td><td>θ_{si} = 5.75 °C</td><td>f_{Rsi}= 0.593</td><td>θ_{si} = 5.75 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C</td><td>not meet</td></tr>
<tr><td></td><td></td><td></td><td colspan="2" rowspan="2">$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Linear thermal transmittance</td><td colspan="2">ψ = 2.16905 - 0.862 × 1.040 - 2.579 × 0.363 = 0.336 W/(m.K)</td></tr>
</table>

Table 4.7.1 – Marking of the position of detail in the building – detail 07

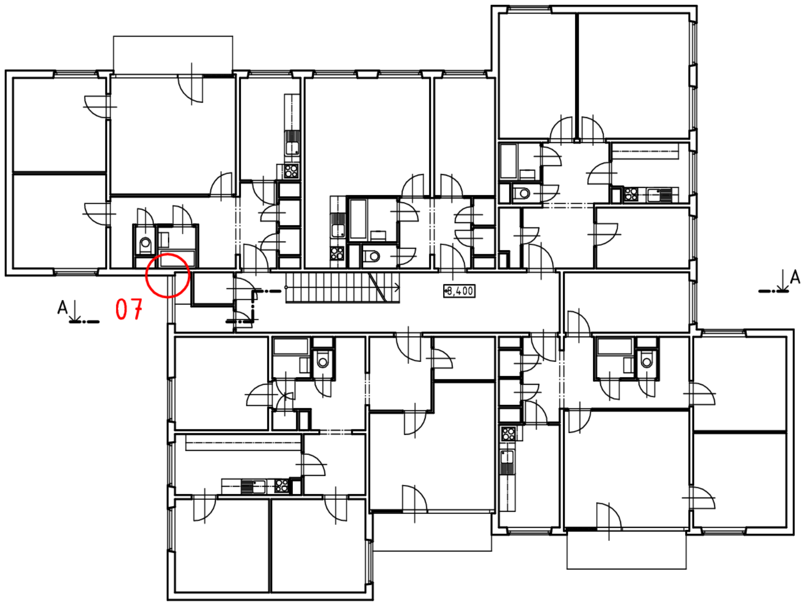
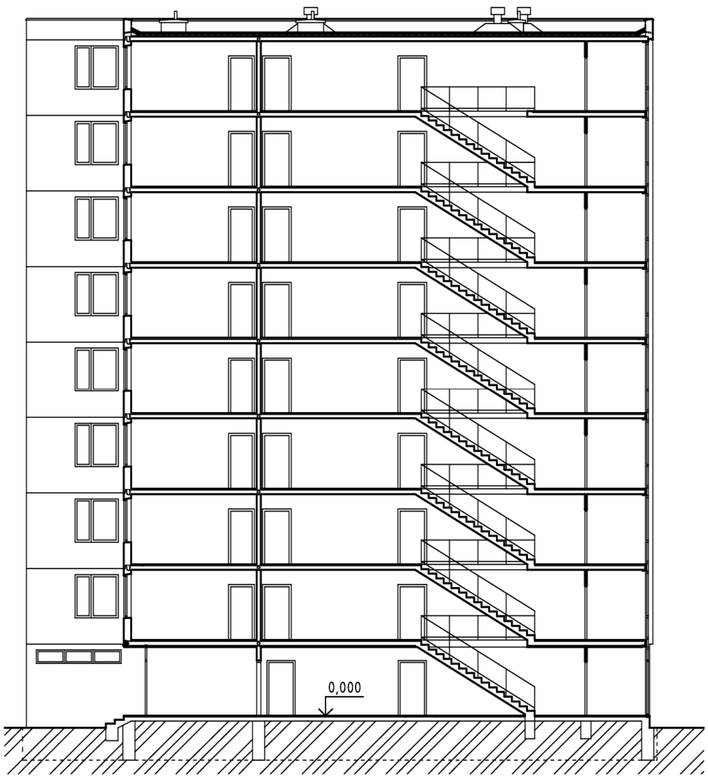
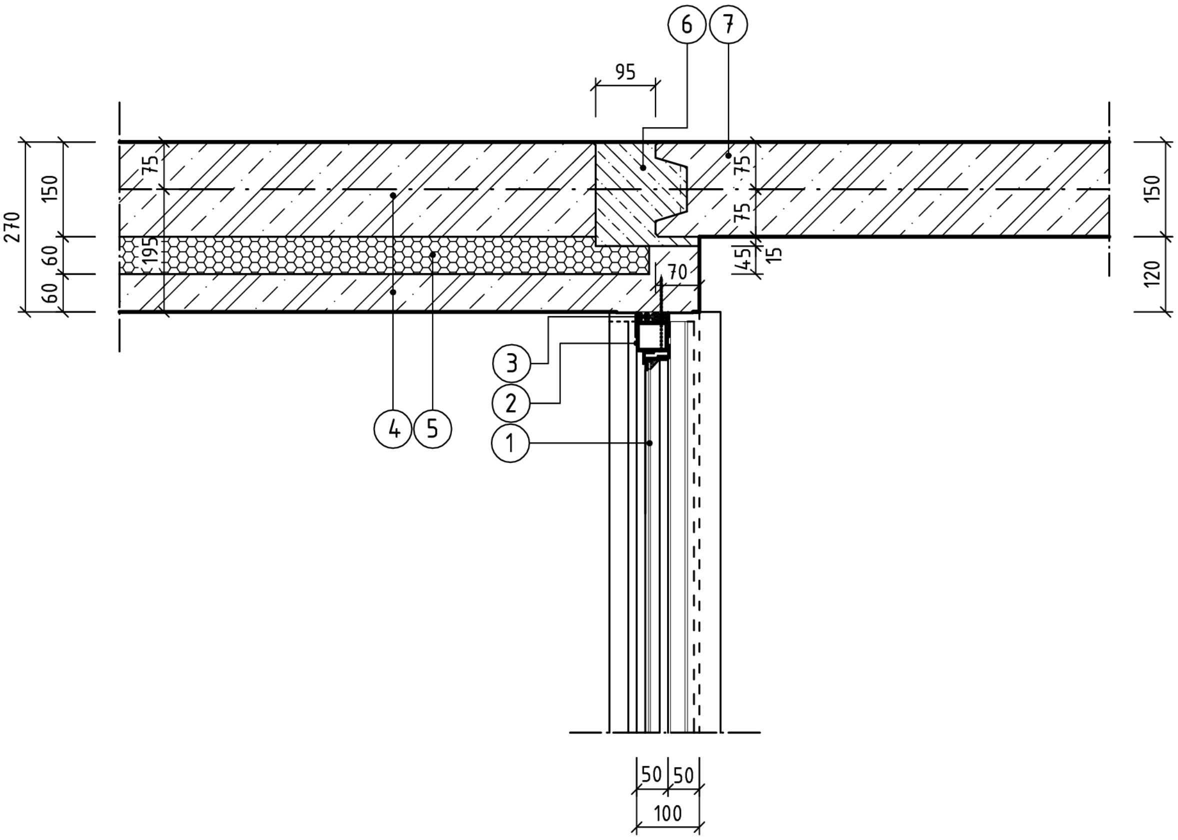
<table>
<tr><th>DETAIL 07</th></tr>
<tr><td>Floor plan</td></tr>
<tr><td></td></tr>
<tr><td>Section A-A</td></tr>
<tr><td></td></tr>
</table>

Table 4.7.2 – Structural composition detail 07

DETAIL 07



Legend:

1. Glass 4 mm (λ = 1.00 W/(m.K))
2. Steel window (λ = 50 W/(m.K) and λ = 0.5 W/(m.K))
3. Seal - glass wool (λ = 0.05 W/(m.K))
4. Reinforced concrete (λ = 1.58 W/(m.K))
5. Polystyrene foam (λ = 0.07 W/(m.K))
6. Concrete grout (λ = 1.36 W/(m.K))
7. Reinforced concrete (λ = 1.34 W/(m.K))

$\boldsymbol{U_{wall,1}}$ **= 0.862 W/(m^2.K)**

$\boldsymbol{U_{window,\ steel}}$ **= 6.238 W/(m^2.K)**

Table 4.7.3 – Boundary conditions for a calculation detail 07

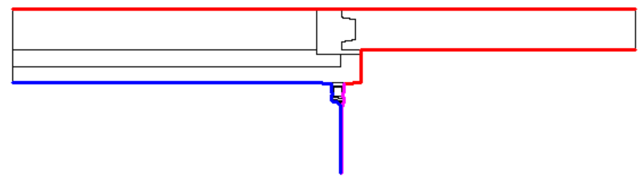
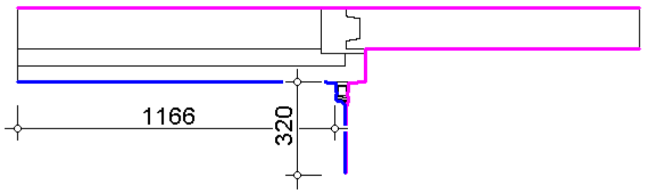
<table>
<tr><th colspan="2">DETAIL 07</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.7.4 – Thermal-technical evaluation of detail 07

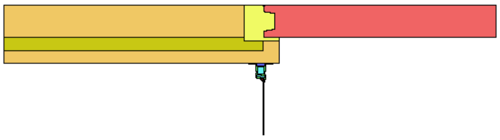
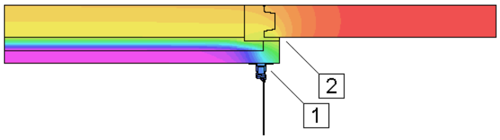
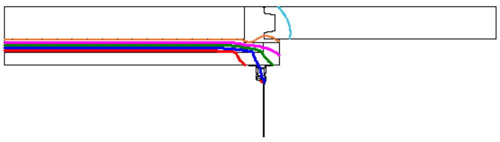
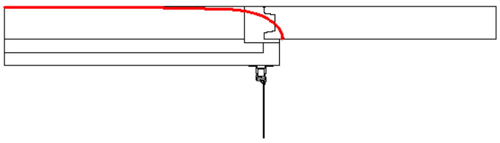
<table>
<tr><th colspan="5">DETAIL 07</th></tr>
<tr><td colspan="3">Modeled detail with marking the materials</td><td colspan="2">Temperature field with marked critical temperatures</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="3">Legend:
λ = 1.340 W/(m.K) λ = 0.050 W/(m.K)
λ = 1.580 W/(m.K) λ = 0.067 W/(m.K)
λ = 1.360 W/(m.K) λ = 0.220 W/(m.K)
λ = 50.00 W/(m.K) λ = 1.000 W/(m.K)
λ = 0.500 W/(m.K) λ = 0.070 W/(m.K)</td><td colspan="2">
-15.0 °C ... -11.5 °C
-11.5 °C ... -8.0 °C
-8.0 °C ... -4.5 °C
-4.5 °C ... -1.0 °C
-1.0 °C ... 2.5 °C
2.5 °C ... 6.0 °C
6.0 °C ... 9.5 °C
9.5 °C ... 13.0 °C
13.0 °C ... 16.5 °C
16.5 °C ... 20.0 °C</td></tr>
<tr><td colspan="3">Representation of characteristic isotherms</td><td colspan="2">Representation of the critical isotherm</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="3">-10 °C   5 °C
-5 °C   10 °C
0 °C   15 °C</td><td colspan="2">13.12 °C</td></tr>
<tr><th>Point</th><th>Temperature</th><th>Temperat. factor</th><th>Evaluation of hygienic criterion</th><th>Rating</th></tr>
<tr><td>1</td><td>θ_{si} = -2.53 °C</td><td>f_{Rsi}= 0.356</td><td>θ_{si} = -2.53 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C</td><td>not meet</td></tr>
<tr><td>2</td><td>θ_{si} = 11.42 °C</td><td>f_{Rsi}= 0.755</td><td colspan="2" rowspan="2">$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><th colspan="3">Linear thermal transmittance</th><td colspan="2">ψ = 3.69604 - 0.862 × 1.166 - 6.238 × 0.320 = 0.695 W/(m.K)</td></tr>
</table>

Table 4.8.1 – Marking of the position of detail in the building – detail 08

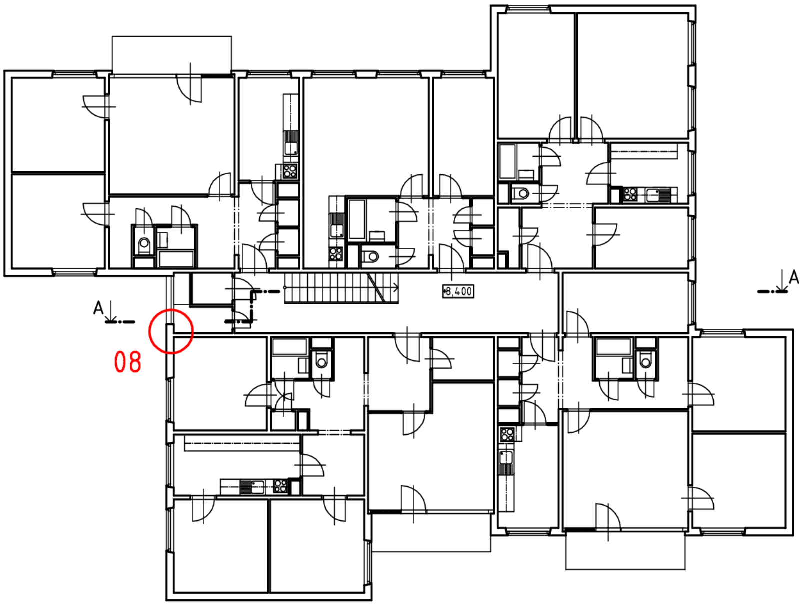
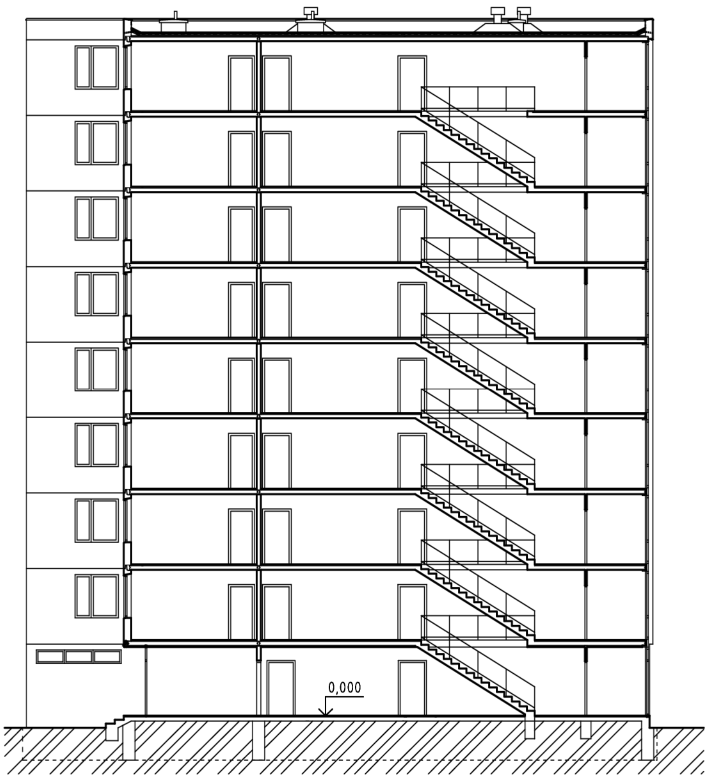
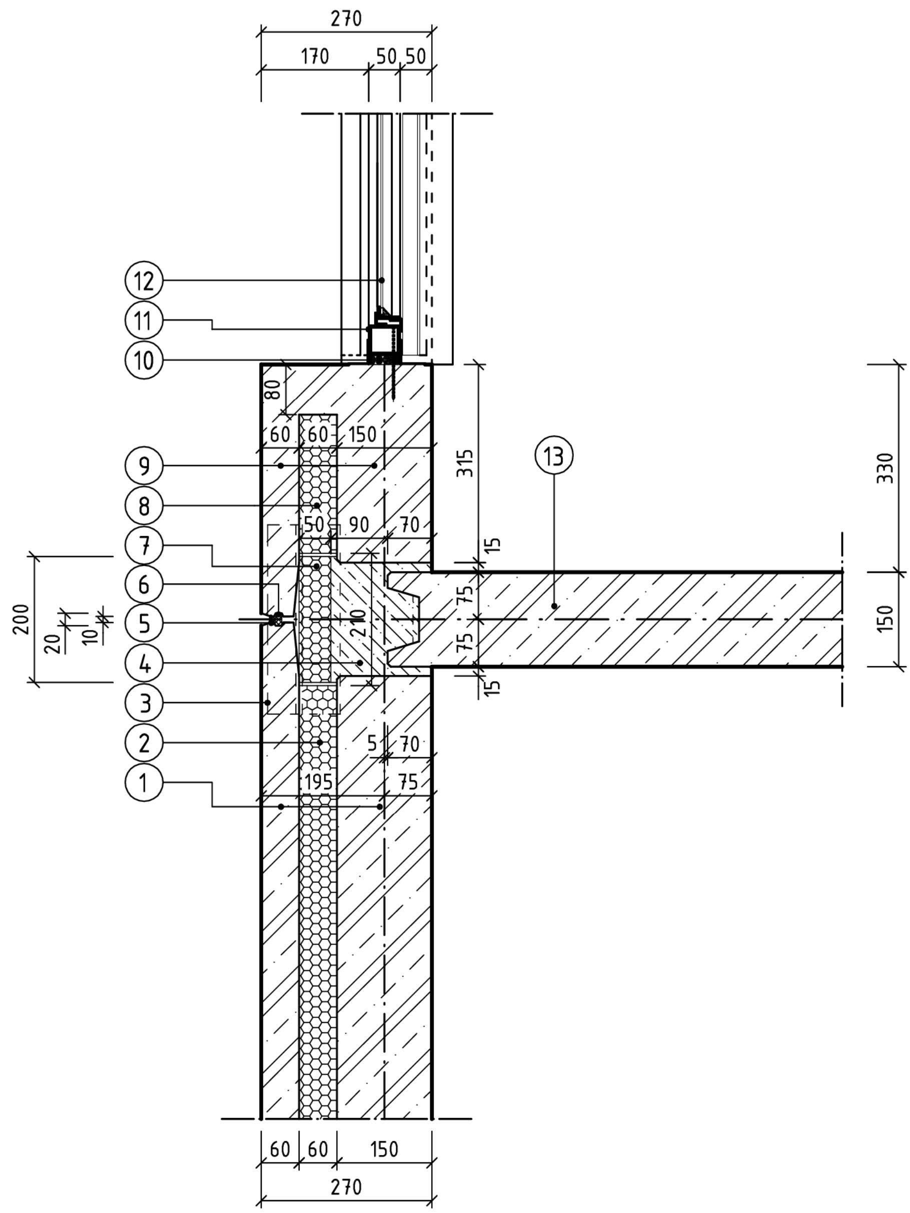
<table>
<tr><th>DETAIL 08</th></tr>
<tr><td>Floor plan</td></tr>
<tr><td>
</td></tr>
<tr><td>Section A-A</td></tr>
<tr><td>
</td></tr>
</table>

Table 4.8.2 – Structural composition of detail 08

DETAIL 08



Legend:

1. Reinforced concrete (λ = 1.58 W/(m.K))
2. Polystyrene foam (λ = 0.07 W/(m.K))
3. Galvanized sheet metal (not considered in model)
4. Concrete grout (λ = 1.36 W/(m.K))
5. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
6. Sealant profile (λ = 0.05 W/(m.K))
7. Polystyrene foam (λ = 0.044 W/(m.K))
8. Polystyrene foam (λ = 0.07 W/(m.K))
9. Reinforced concrete (λ = 1.58 W/(m.K))
10. Seal - glass wool (λ = 0.05 W/(m.K))
11. Steel window (λ = 50 W/(m.K) and λ = 0.5 W/(m.K))
12. Glass 4 mm (λ = 1.00 W/(m.K))
13. Reinforced concrete (λ = 1.34 W/(m.K))

$\boldsymbol{U_{\text{wall},1}}$ **= 0.862 W/(m^2.K)**

$\boldsymbol{U_{\text{window, steel}}}$ **= 6.238 W/(m^2.K)**

Table 4.8.3 – Boundary conditions for a calculation detail 08

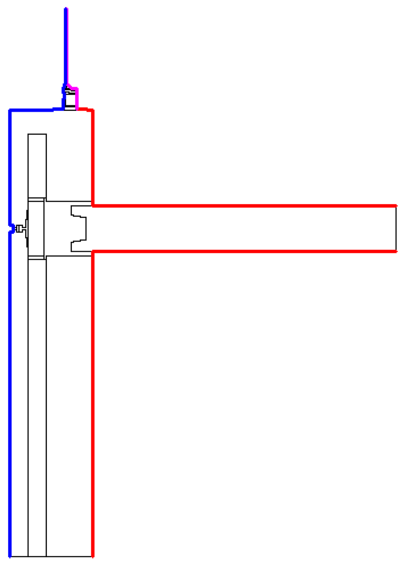
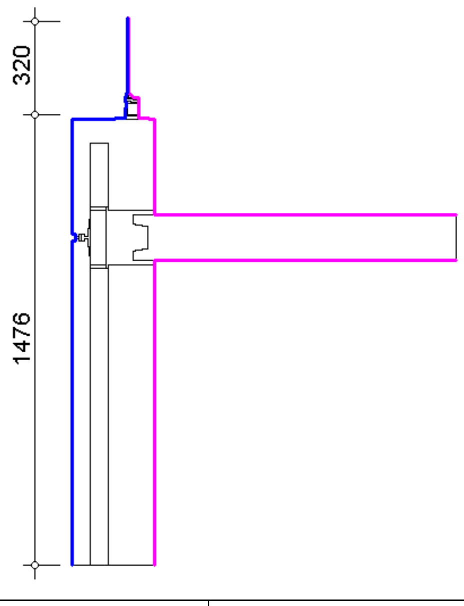
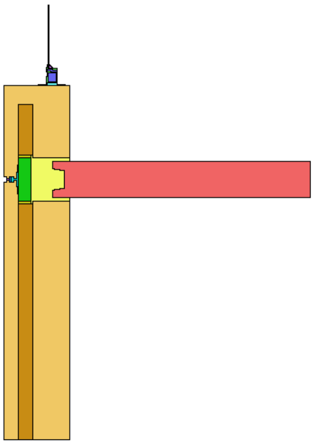
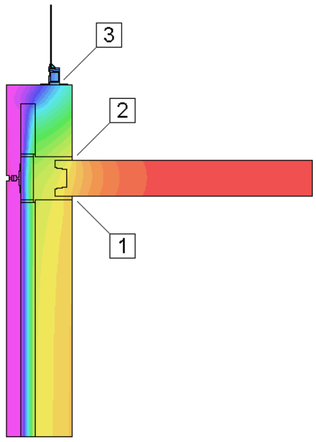
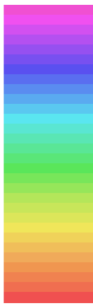
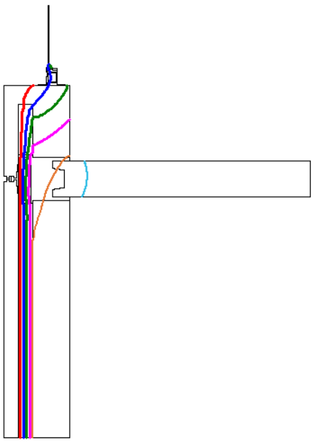
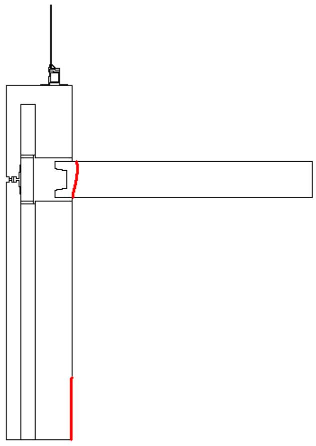
<table>
<tr><th colspan="2">DETAIL 08</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.8.4 – Thermal-technical evaluation of detail 08

DETAIL 08

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.340 W/(m.K) λ = 1.580 W/(m.K) λ = 1.360 W/(m.K) λ = 50.00 W/(m.K) λ = 0.050 W/(m.K) λ = 0.500 W/(m.K) λ = 0.220 W/(m.K) λ = 1.000 W/(m.K) λ = 0.070 W/(m.K) λ = 0.278 W/(m.K) λ = 0.044 W/(m.K) λ = 0.119 W/(m.K) λ = 0.050 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	**Representation of the critical isotherm**
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 12.88 °C	f_{Rsi}= 0.797	θ_{si} = -2.85 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 11.43 °C	f_{Rsi}= 0.755	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
3	θ_{si} = -2.85 °C	f_{Rsi}= 0.347		
Linear thermal transmittance			ψ = 4.07222 - 0.862 × 1.476 - 6.238 × 0.320 = 0.804 W/(m.K)	

Table 4.9.1 – Marking of the position of detail in the building – detail 09

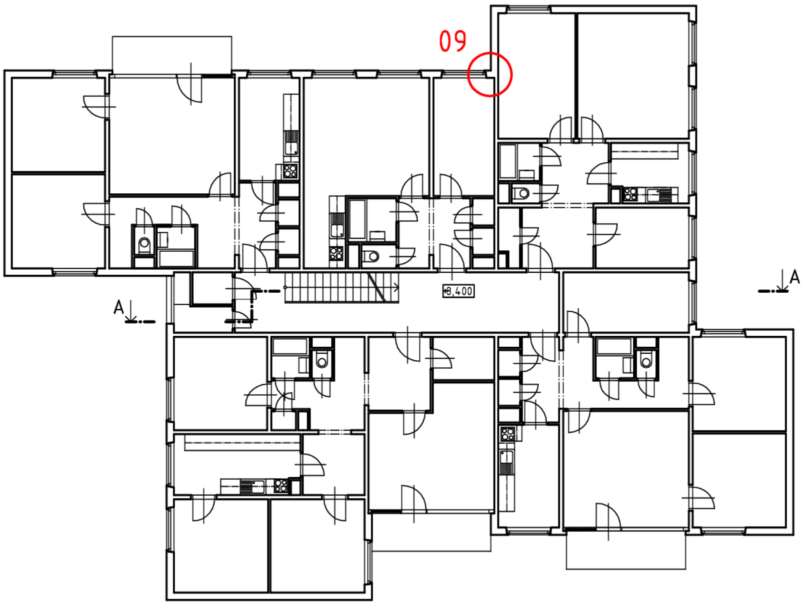
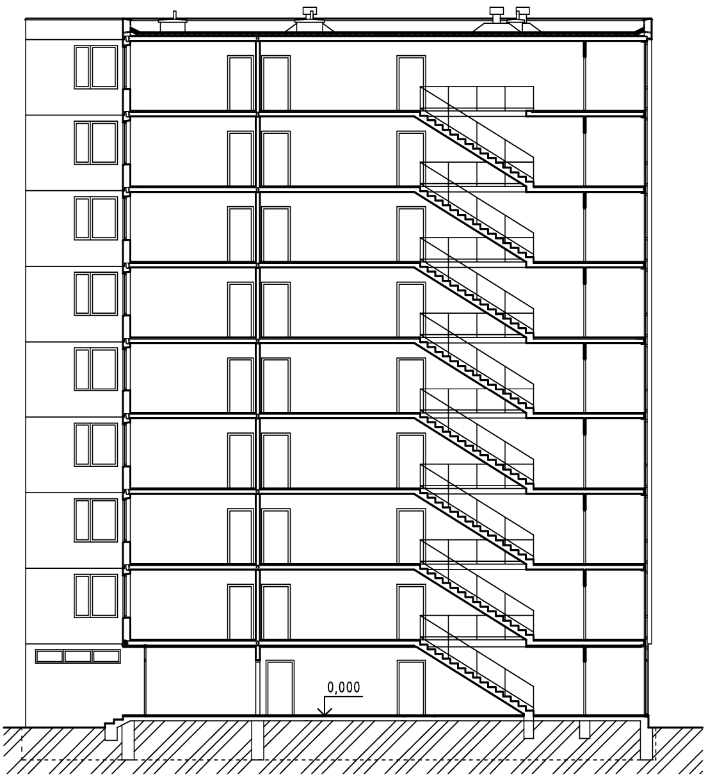
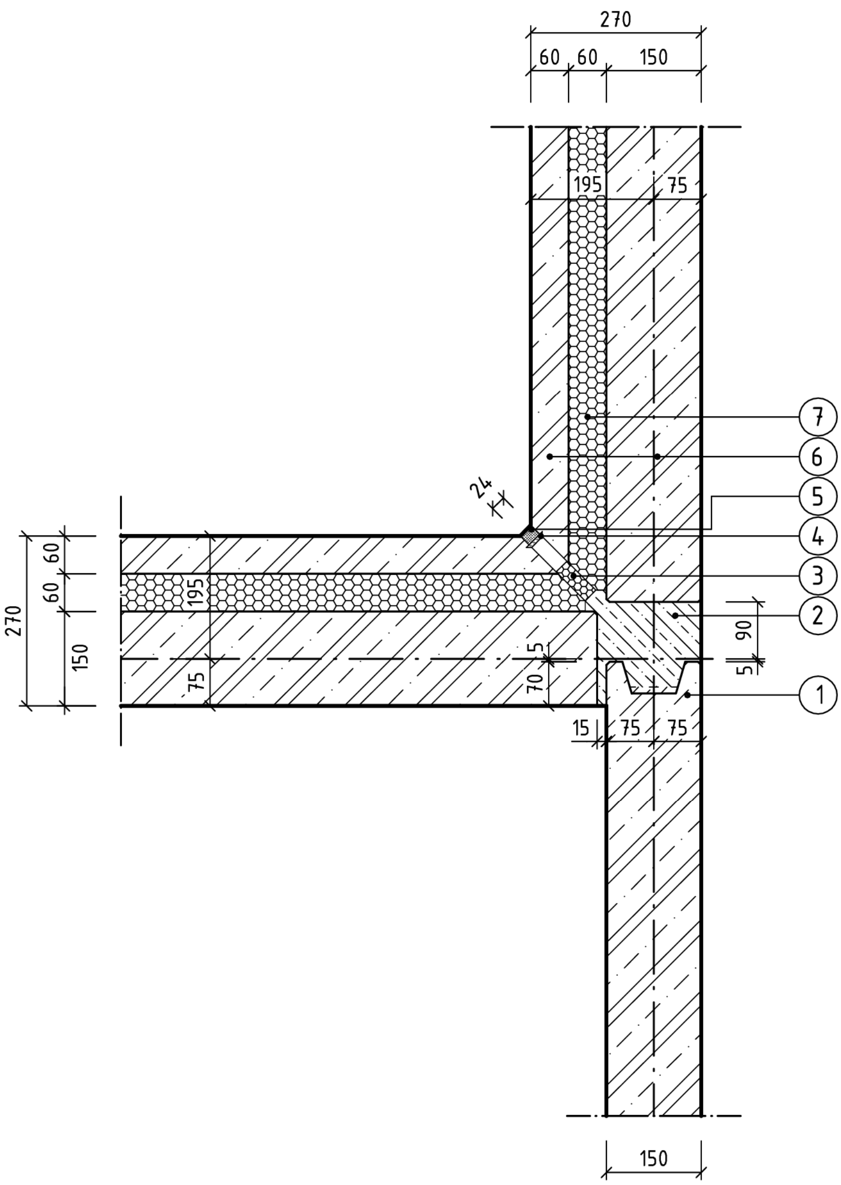
DETAIL 09
Floor plan

Section A-A


Table 4.9.2 – Structural composition of detail 09

DETAIL 09



Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Concrete grout (λ = 1.36 W/(m.K))
3. Filling - polystyrene foam (λ = 0.050 W/(m.K))
4. Sealant profile (λ = 0.05 W/(m.K))
5. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
6. Reinforced concrete (λ = 1.58 W/(m.K))
7. Polystyrene foam (λ = 0.07 W/(m.K))

$\boldsymbol{U_{\mathrm{wall},1}}$ **= 0.862 W/(m^2.K)**

Table 4.9.3 – Boundary conditions for a calculation of detail 09

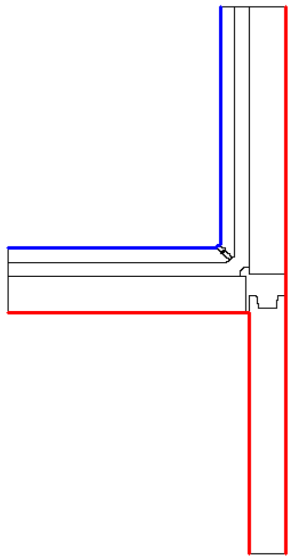
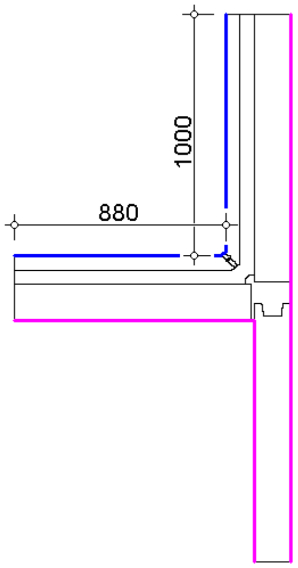
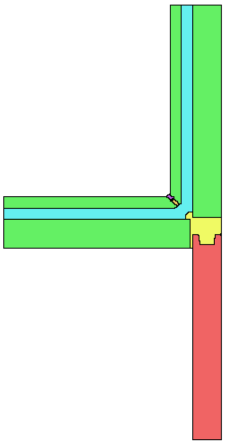
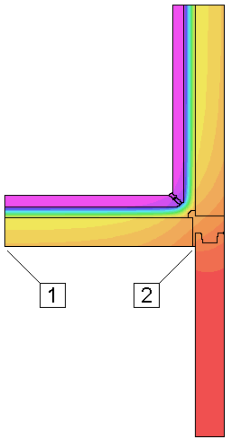
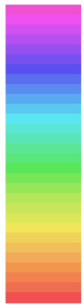
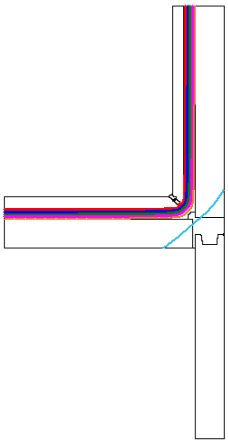
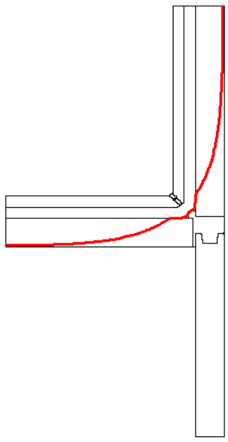
<table>
<tr><th colspan="2">DETAIL 09</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.9.4 – Thermal-technical evaluation of detail 09

DETAIL 09	
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.340 W/(m.K) λ = 0.067 W/(m.K) λ = 1.360 W/(m.K) λ = 1.580 W/(m.K) λ = 0.070 W/(m.K) λ = 0.050 W/(m.K) λ = 0.220 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 13.22 °C	f_{Rsi}= 0.806	θ_{si} = 13.22 °C > $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	meet
2	θ_{si} = 16.43 °C	f_{Rsi}= 0.898	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Linear thermal transmittance			ψ = 1.74967 - 0.862 × (1.000 + 0.880) = 0.129 W/(m.K)	

Table 4.10.1 – Marking of the position of detail in the building – detail 10

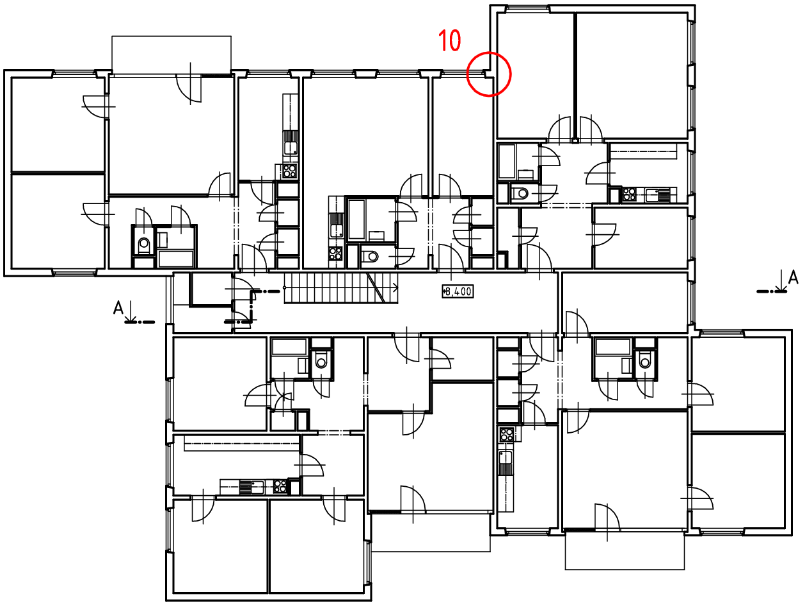
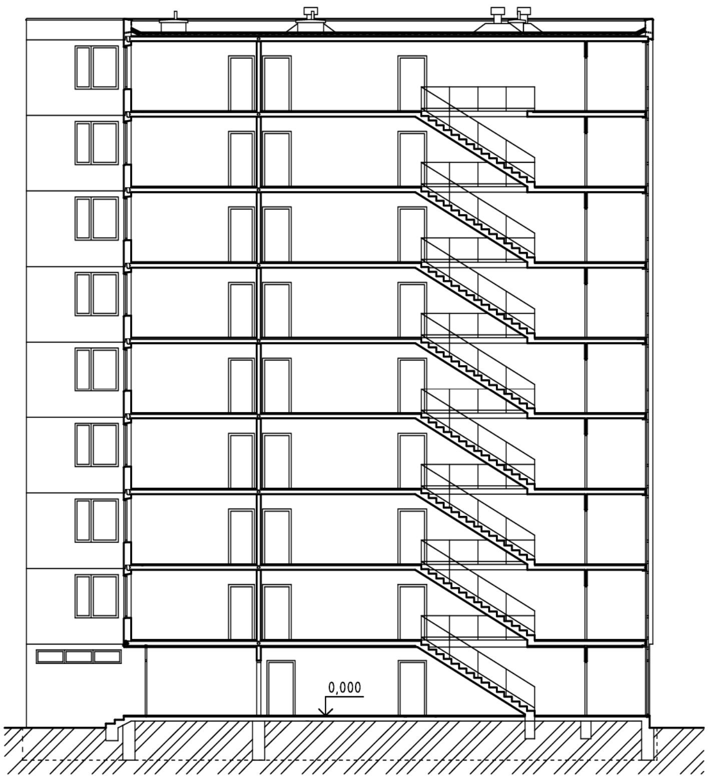
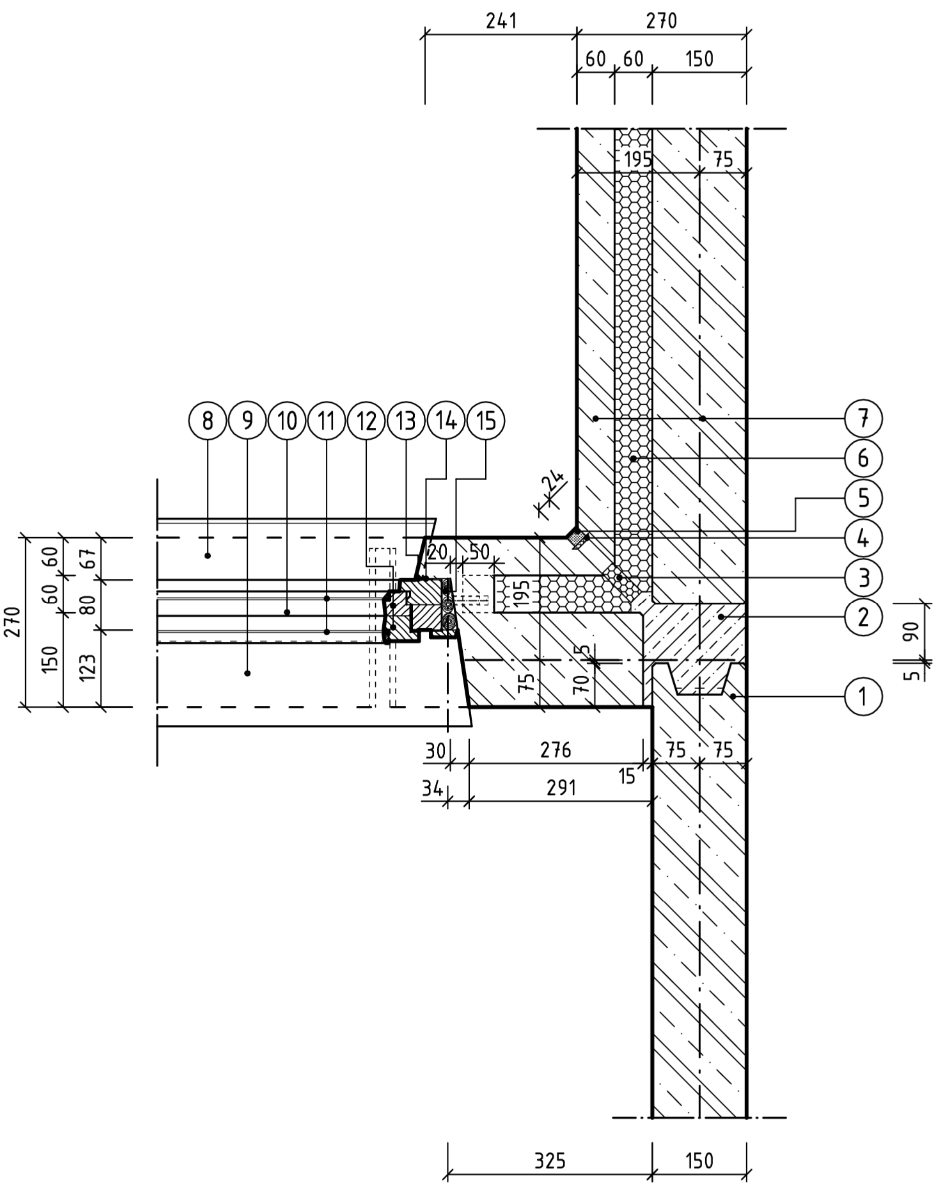
DETAIL 10
Floor plan

Section A-A


Table 4.10.2 – Structural composition of detail 10

DETAIL 10



Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Concrete grout (λ = 1.36 W/(m.K))
3. Filling - polystyrene foam (λ = 0.05 W/(m.K))
4. Sealant profile(λ =0.05 W/(m.K))
5. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
6. Polystyrene foam (λ = 0.07 W/(m.K))
7. Reinforced concrete (λ = 1.58 W/(m.K))
8. Sheet metal covering – in view
9. Internal window sill – in view
10. Closed air gap 37 mm (λ = 0.204 W/(m.K))
11. Glass 3 mm (λ = 1.00 W/(m.K))
12. Wooden window frame (λ = 0.18 W/(m.K))
13. Sealant (λ = 0.22 W/(m.K))
14. Microporous rubber (λ = 0.06 W/(m.K))
15. Seal - glass wool (λ = 0.07 W/(m.K))

$U_{wall,1}$ = 0.862 W/(m^2.K)

$U_{window, wooden}$ = 2.579 W/(m^2.K)

Table 4.10.3 – Boundary conditions for a calculation of detail 10

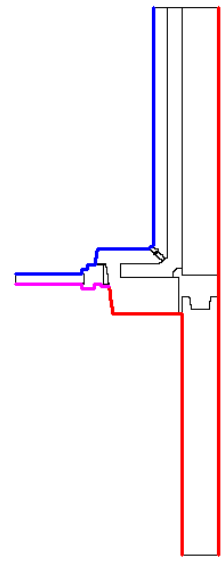
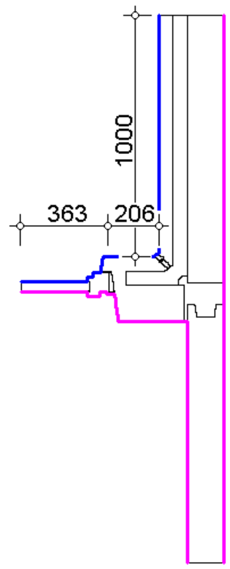
DETAIL 10	
Boundary conditions for calculation of surface temperatures	
	
Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.25 m^2.K/W R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W
Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance	
	
Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W

Table 4.10.4 – Thermal-technical evaluation of detail 10

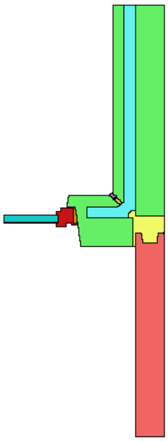
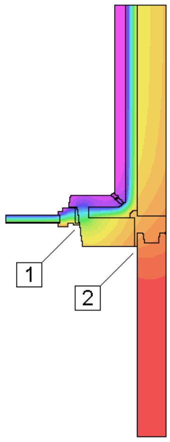
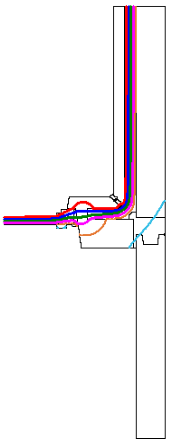
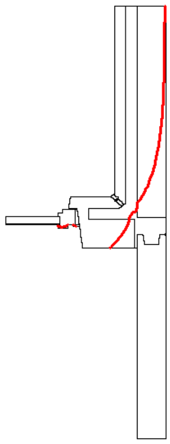
<table>
<tr><th colspan="6">DETAIL 10</th></tr>
<tr><td colspan="3">Modeled detail with marking the materials</td><td colspan="3">Temperature field with marked critical temperatures</td></tr>
<tr><td colspan="3"></td><td colspan="3">
</td></tr>
<tr><td colspan="3">Legend:
λ = 1.340 W/(m.K)
λ = 0.067 W/(m.K)
λ = 1.360 W/(m.K)
λ = 1.580 W/(m.K)
λ = 0.070 W/(m.K)
λ = 0.050 W/(m.K)
λ = 0.220 W/(m.K)
λ = 0.180 W/(m.K)
λ = 0.070 W/(m.K)
λ = 0.060 W/(m.K)
λ = 1.000 W/(m.K)
λ = 0.204 W/(m.K)</td><td colspan="3">
-15.0 °C ... -11.5 °C
-11.5 °C ... -8.0 °C
-8.0 °C ... -4.5 °C
-4.5 °C ... -1.0 °C
-1.0 °C ... 2.5 °C
2.5 °C ... 6.0 °C
6.0 °C ... 9.5 °C
9.5 °C ... 13.0 °C
13.0 °C ... 16.5 °C
16.5 °C ... 20.0 °C</td></tr>
<tr><td colspan="3">Representation of characteristic isotherms</td><td colspan="3">Representation of the critical isotherm</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td colspan="3">-10 °C
-5 °C
0 °C
5 °C
10 °C
15 °C</td><td colspan="3">13.12 °C</td></tr>
<tr><th>Point</th><th>Temperature</th><th>Temperat. factor</th><th colspan="2">Evaluation of hygienic criterion</th><th>Rating</th></tr>
<tr><td>1</td><td>θ_{si} = 6.84 °C</td><td>f_{Rsi}= 0.624</td><td colspan="2">θ_{si} = 6.84 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C</td><td>not meet</td></tr>
<tr><td>2</td><td>θ_{si} = 15.58 °C</td><td>f_{Rsi}= 0.874</td><td colspan="3" rowspan="2">$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="2">Linear thermal transmittance</td><td colspan="4">ψ = 2.45615 - 0.862 × (1.000 + 0.206) - 2.579 × 0.363 = 0.480 W/(m.K)</td></tr>
</table>

Table 4.11.1 – Marking of the position of detail in the building – detail 11

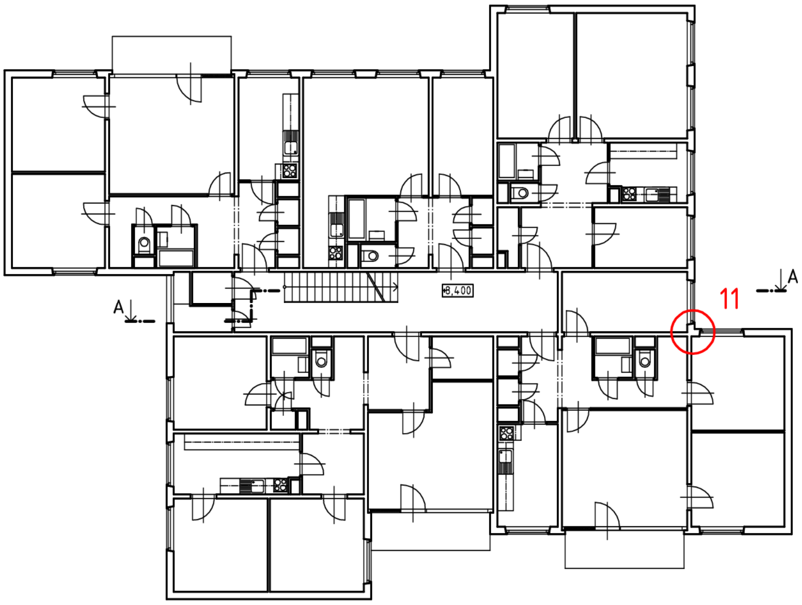
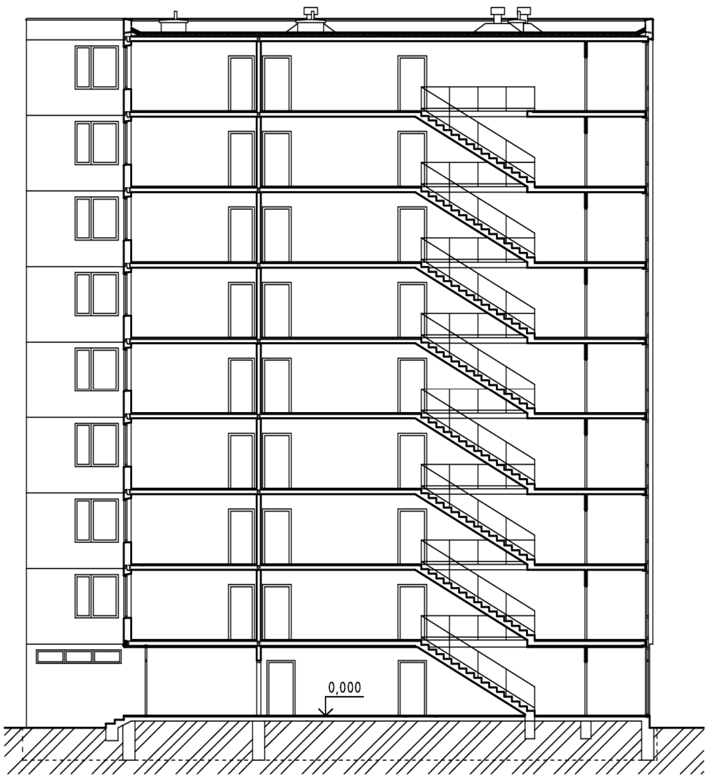
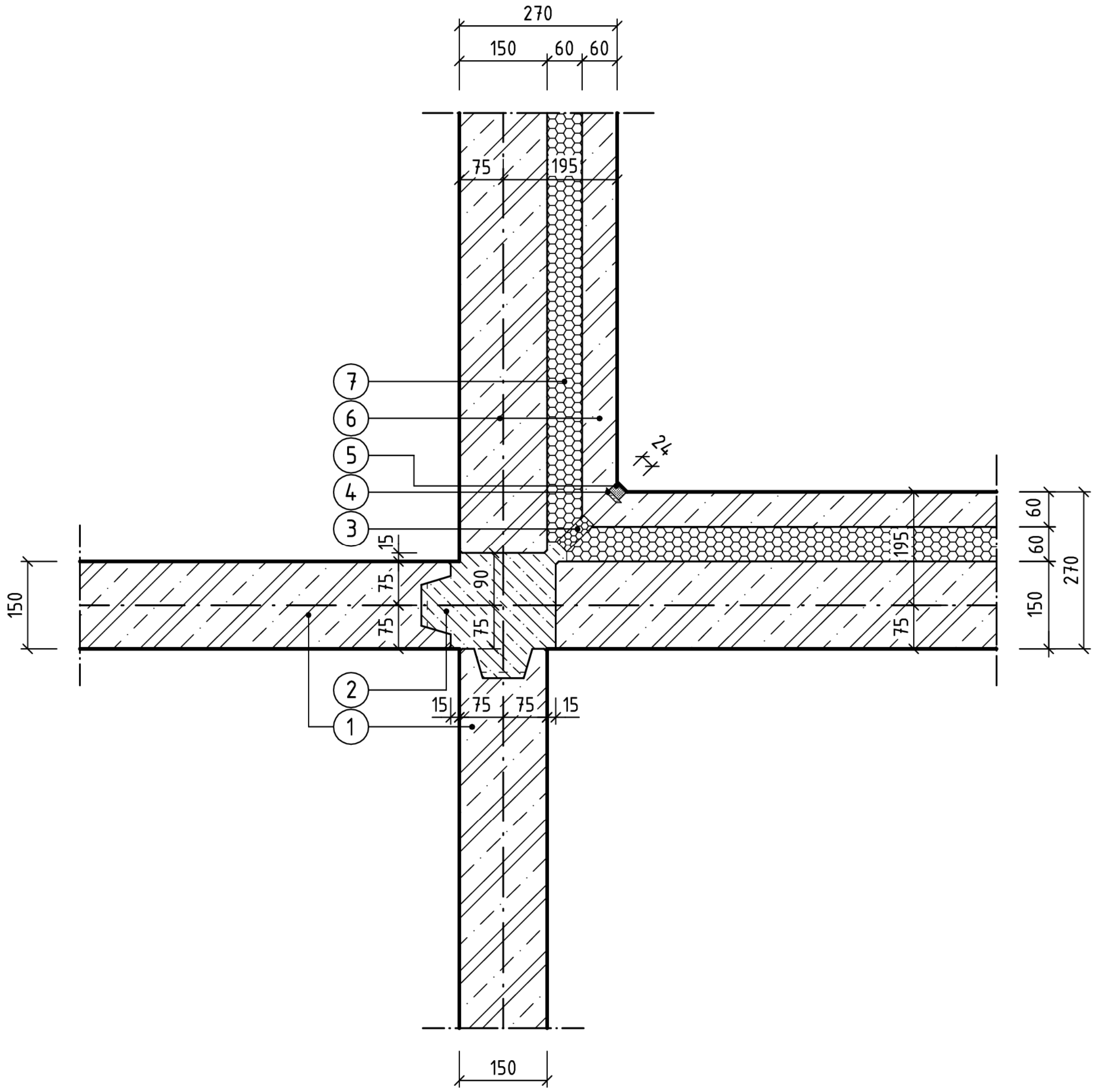
DETAIL 11
Floor plan

Section A-A


Table 4.11.2 – Structural composition of detail 11

DETAIL 11


Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Concrete grout (λ = 1.36 W/(m.K))
3. Filling - polystyrene foam (λ = 0.05 W/(m.K))
4. Sealant profile(λ =0.05 W/(m.K))
5. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
6. Reinforced concrete (λ = 1.58 W/(m.K))
7. Polystyrene foam (λ = 0.07 W/(m.K))

***U*$_{wall,1}$ = 0.862 W/(m^2.K)**

Table 4.11.3 – Boundary conditions for a calculation of detail 11

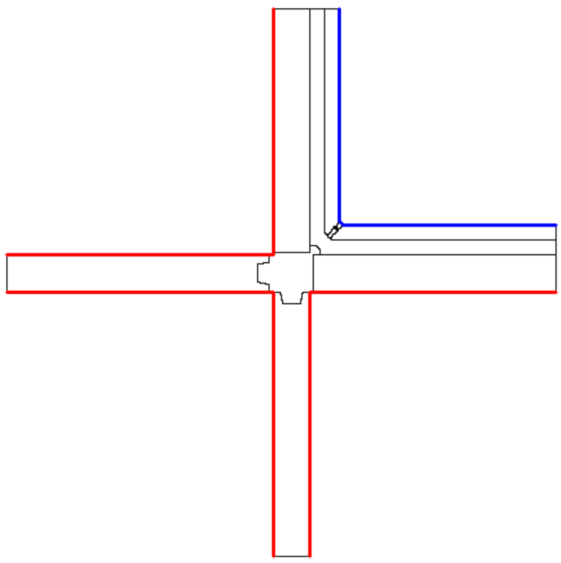
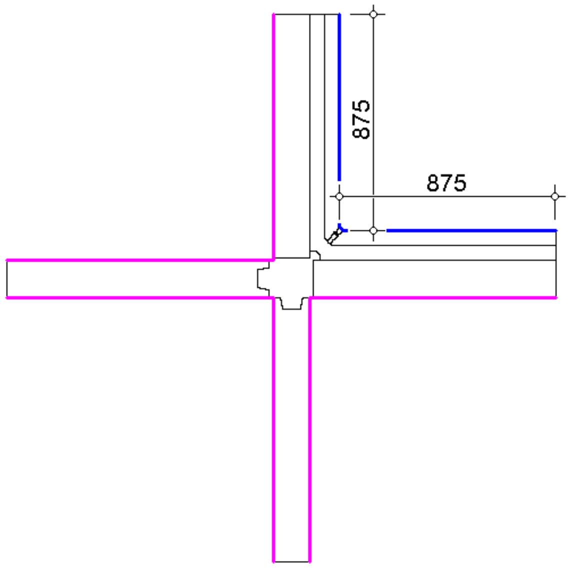
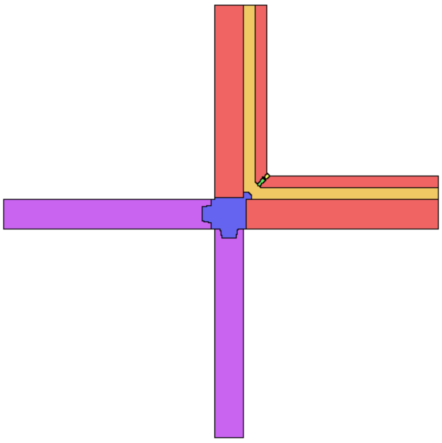
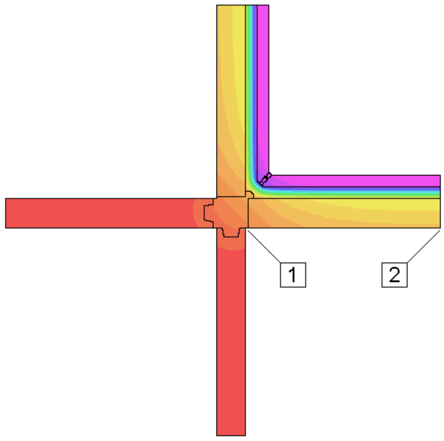
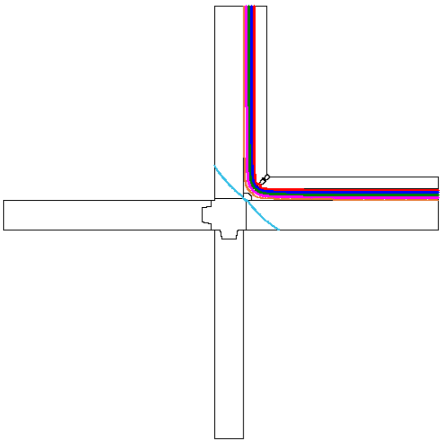
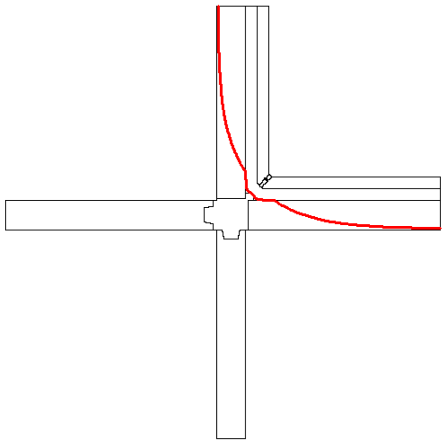
<table>
<tr><th colspan="2">DETAIL 11</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.11.4 – Thermal-technical evaluation of detail 11

DETAIL 11

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.580 W/(m.K) λ = 0.070 W/(m.K) λ = 0.220 W/(m.K) λ = 0.067 W/(m.K) λ = 0.050 W/(m.K) λ = 1.360 W/(m.K) λ = 1.340 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 17.15 °C	f_{Rsi}= 0.919	θ_{si} = 13.27 °C > $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	meet
2	θ_{si} = 13.27 °C	f_{Rsi}= 0.808	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Linear thermal transmittance			ψ = 1.64216 - 0.862 × 0.875 × 2 = 0.134 W/(m.K)	

Table 4.12.1 – Marking of the position of detail in the building – detail 12

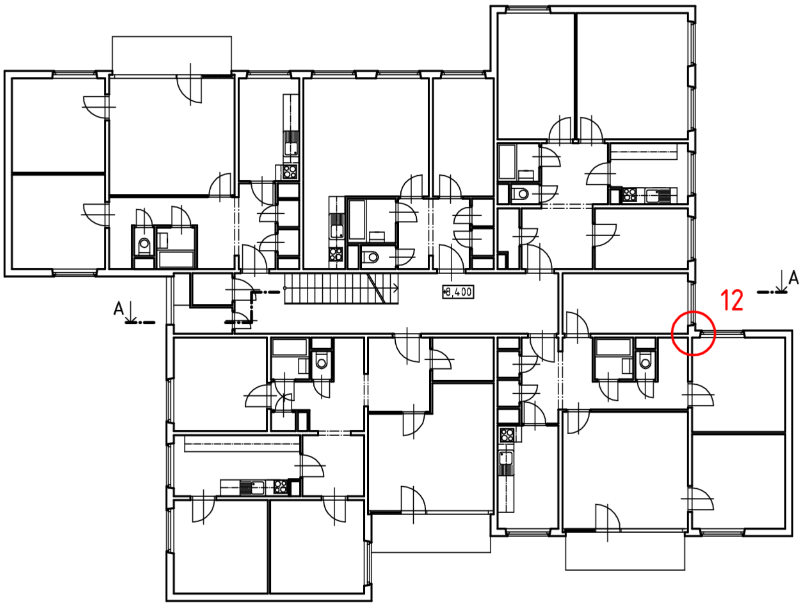
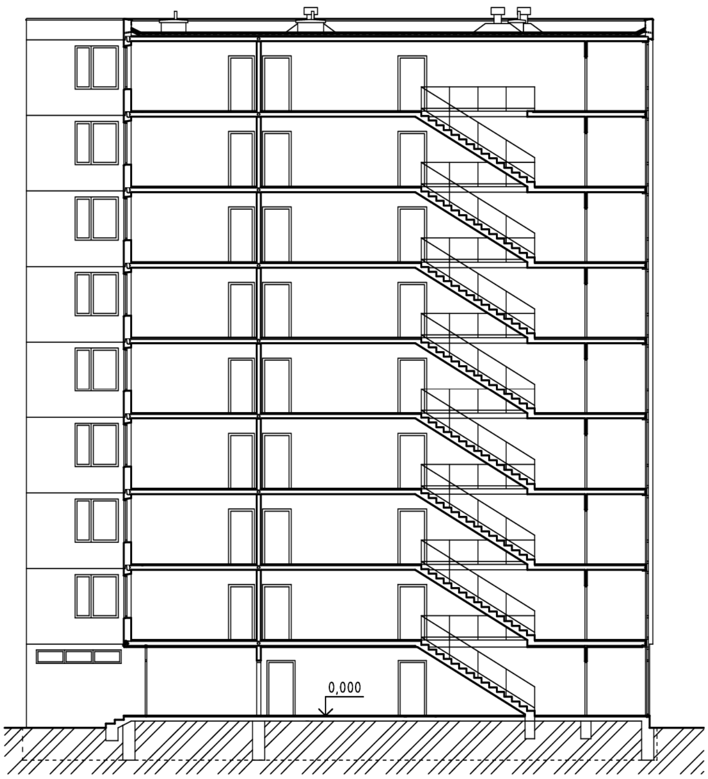
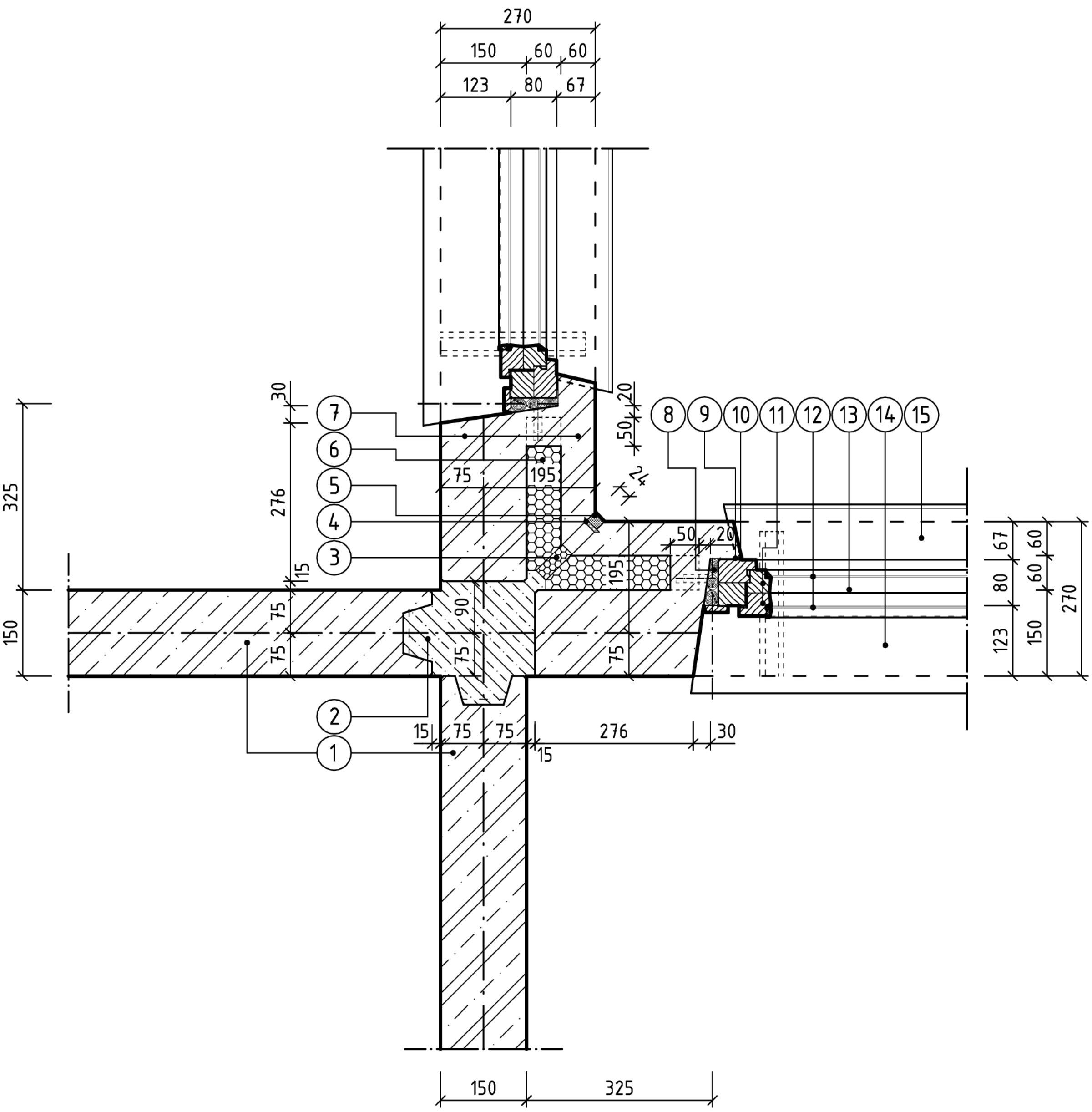
<table>
<tr><th>DETAIL 12</th></tr>
<tr><td>Floor plan</td></tr>
<tr><td></td></tr>
<tr><td>Section A-A</td></tr>
<tr><td></td></tr>
</table>

Table 4.12.2 – Structural composition of detail 12

DETAIL 12



Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Concrete grout (λ = 1.36 W/(m.K))
3. Filling - polystyrene foam (λ = 0.05 W/(m.K))
4. Sealant profile(λ =0.05 W/(m.K))
5. Sealant ELASTOPLAST (λ = 0.22 W/(m.K))
6. Polystyrene foam (λ = 0.07 W/(m.K))
7. Reinforced concrete (λ = 1.58 W/(m.K))
8. Seal - glass wool (λ = 0.07 W/(m.K))
9. Microporous rubber (λ = 0.06 W/(m.K))
10. Sealant (λ = 0.22 W/(m.K))
11. Wooden window frame (λ = 0.18 W/(m.K))
12. Glass 3 mm (λ = 1.00 W/(m.K))
13. Closed air gap 37 mm (λ = 0.204 W/(m.K))
14. Internal window sill – in view
15. Sheet metal covering – in view

$U_{wall,1}$ = 0.862 W/(m^2.K)

$U_{window, wooden}$ = 2.579 W/(m^2.K)

Table 4.12.3 – Boundary conditions for a calculation of detail 12

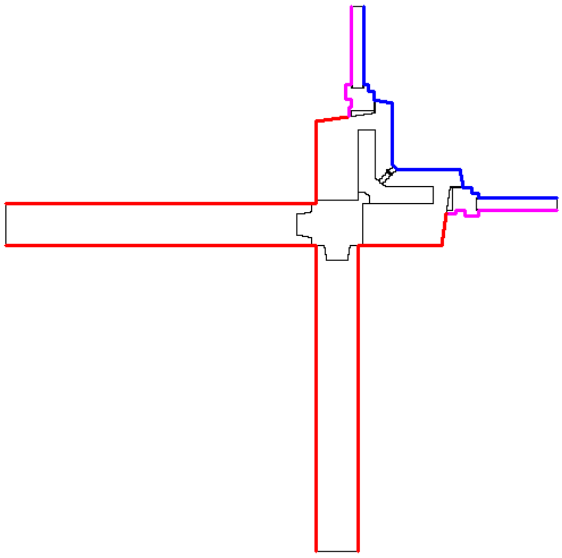
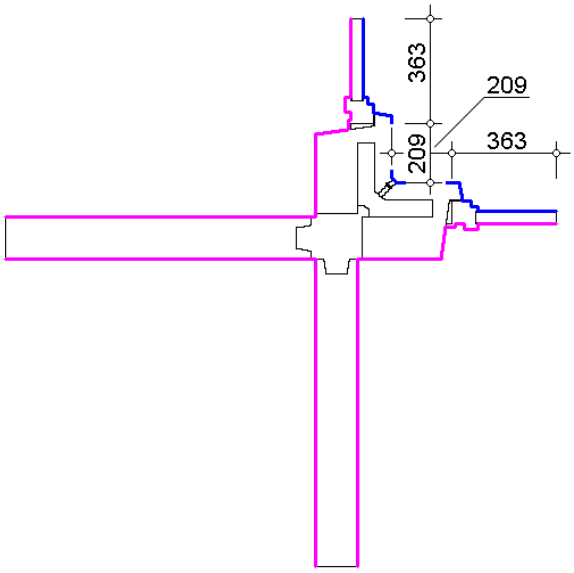
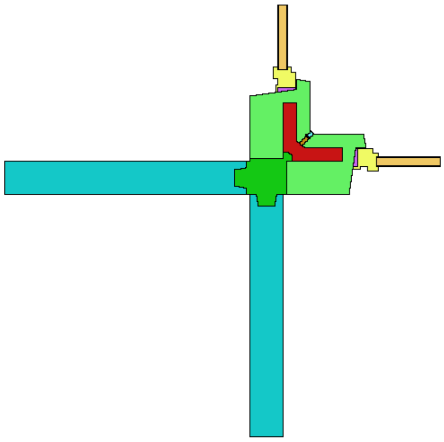
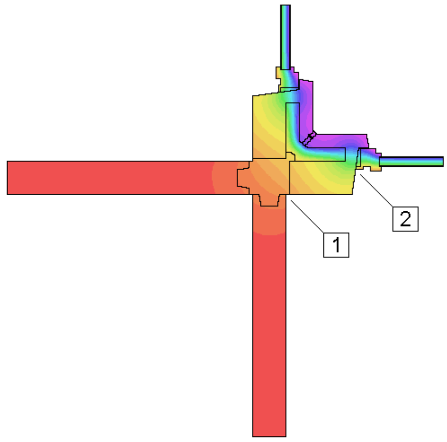
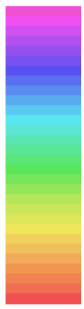
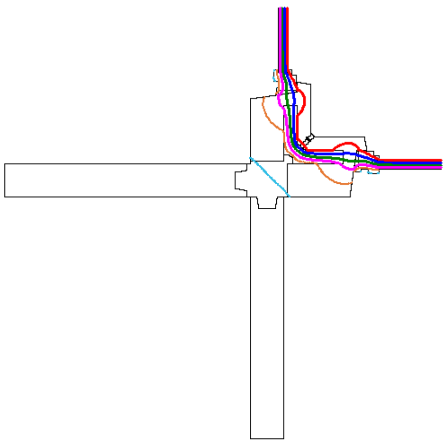
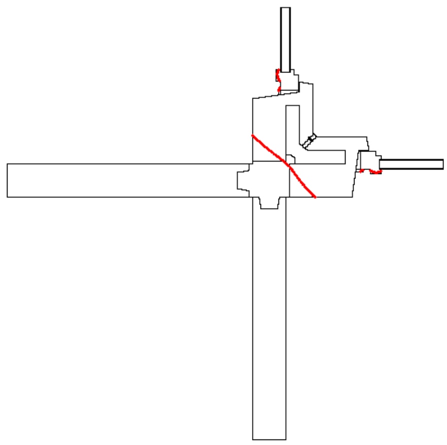
DETAIL 12	
Boundary conditions for calculation of surface temperatures	
	
Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.25 m^2.K/W R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W
Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance	
	
Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W

Table 4.12.4 – Thermal-technical evaluation of detail 12

DETAIL 12	
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 1.000 W/(m.K) λ = 0.204 W/(m.K) λ = 0.180 W/(m.K) λ = 1.580 W/(m.K) λ = 0.220 W/(m.K) λ = 0.060 W/(m.K) λ = 0.070 W/(m.K) λ = 0.070 W/(m.K) λ = 0.067 W/(m.K) λ = 0.050 W/(m.K) λ = 1.360 W/(m.K) λ = 1.340 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	**Temperature**	**Temperat. factor**	**Evaluation of hygienic criterion**	**Rating**
1	θ_{si} = 15.85 °C	f_{Rsi}= 0.881	θ_{si} = 6.65 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 6.65 °C	f_{Rsi}= 0.619	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	

Linear thermal transmittance	ψ = 3.07590 - (0.862 × 0.209 × 2) - (2.579 × 0.363 × 2) = 0.843 W/(m.K)

Table 4.13.1 – Marking of the position of detail in the building – detail 13

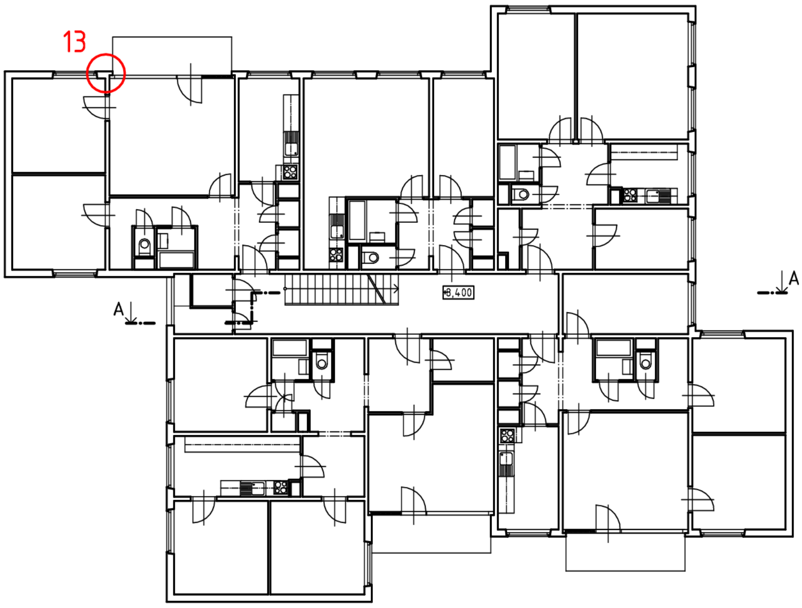
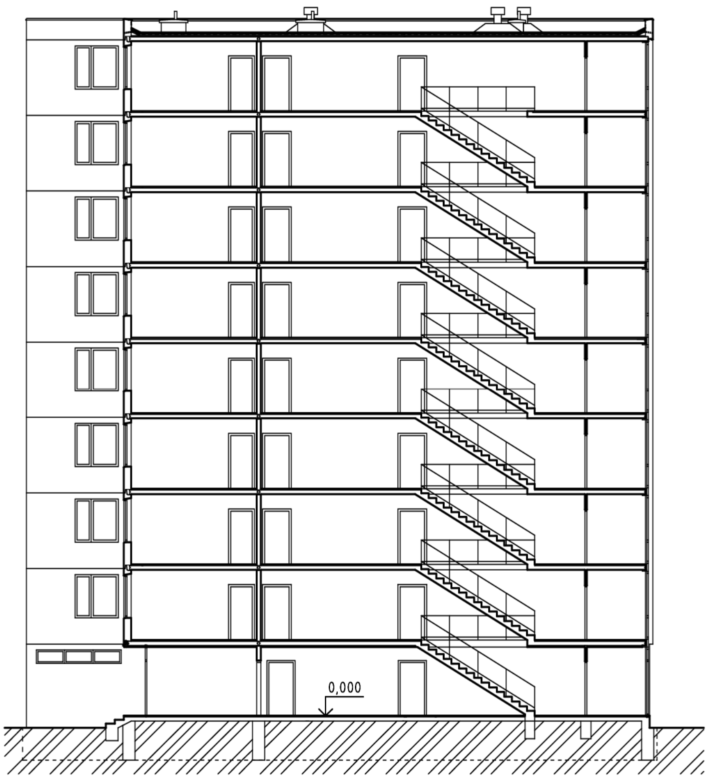
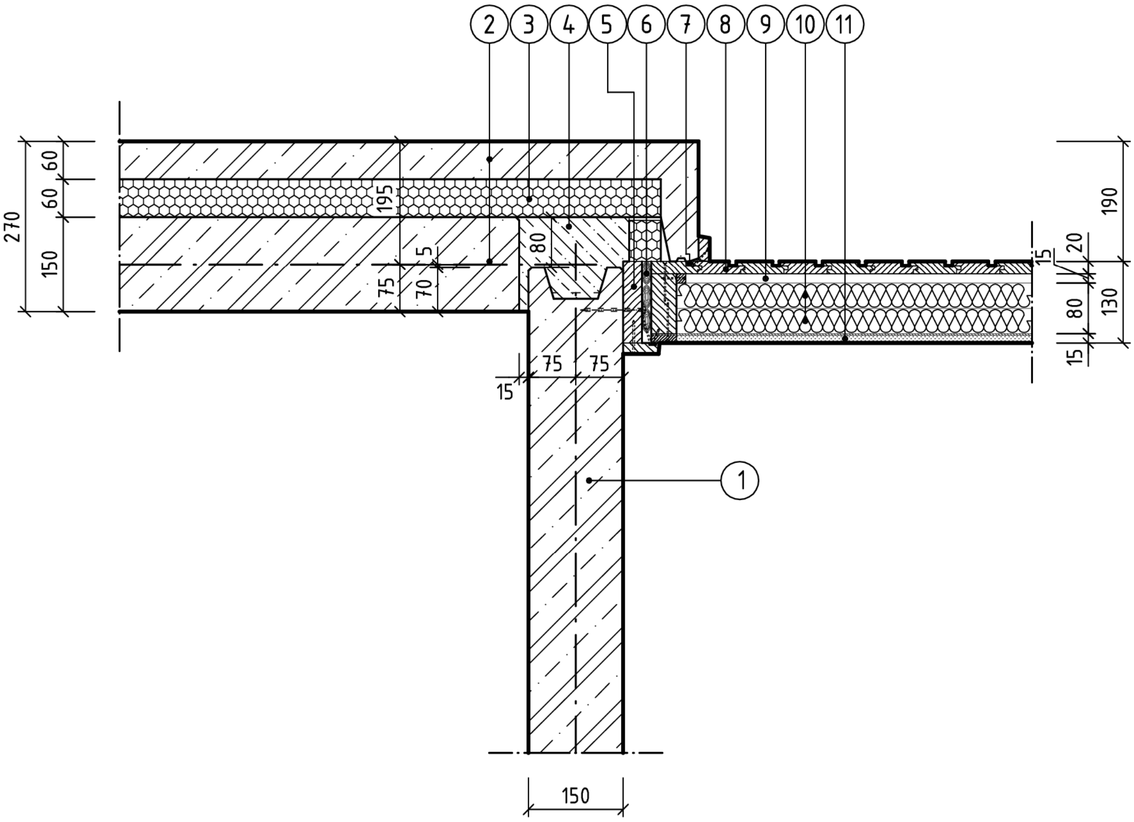
DETAIL 13
Floor plan

Section A-A


Table 4.13.2 – Structural composition of detail 13

DETAIL 13



Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Reinforced concrete (λ = 1.58 W/(m.K))
3. Polystyrene foam (λ = 0.07 W/(m.K))
4. Concrete grout (λ = 1.36 W/(m.K))
5. Wooden frame (λ = 0.18 W/(m.K))
6. Seal - glass wool (λ = 0.07 W/(m.K))
7. Sealant (λ = 0.22 W/(m.K))
8. Batten siding (λ = 0.18 W/(m.K))
9. Closed air gap (λ = 0.09 W/(m.K))
10. Basalt wool (λ = 0.07 W/(m.K))
11. Particle board (λ = 0.11 W/(m.K))

$U_{wall,1}$ = 0.862 W/(m^2.K)

$U_{wall,2}$ = 0.579 W/(m^2.K)

Table 4.13.3 – Boundary conditions for a calculation of detail 13

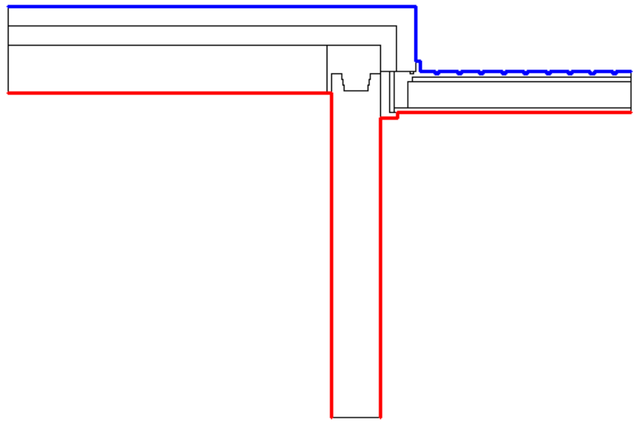
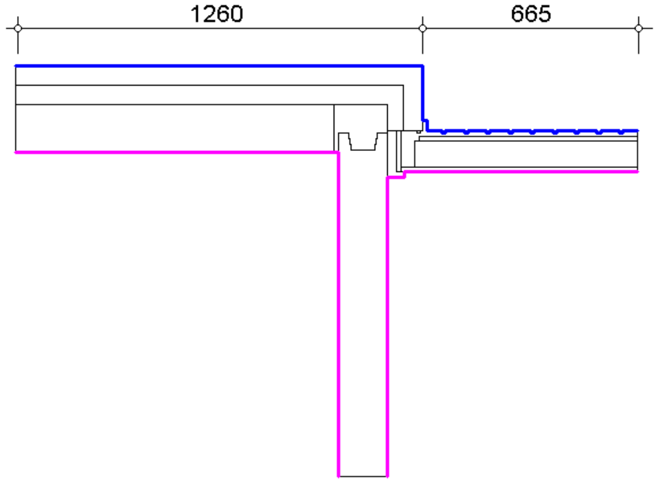
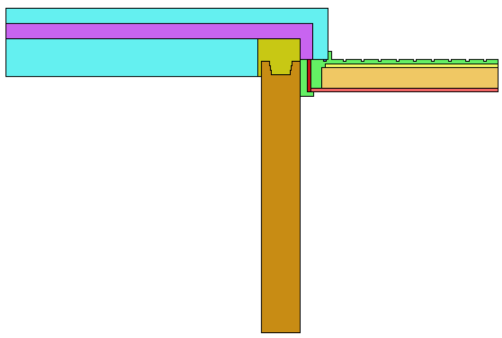
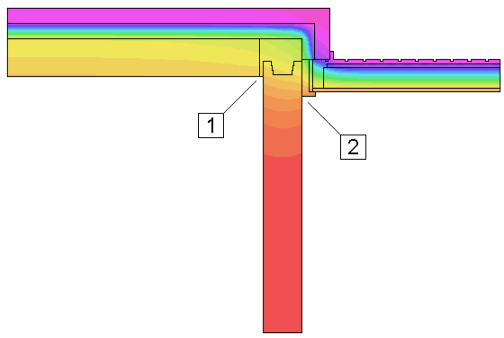
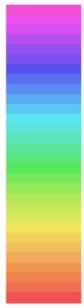
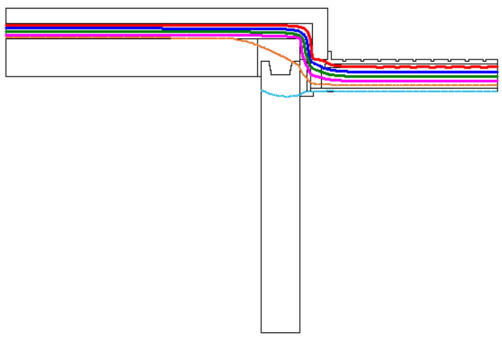
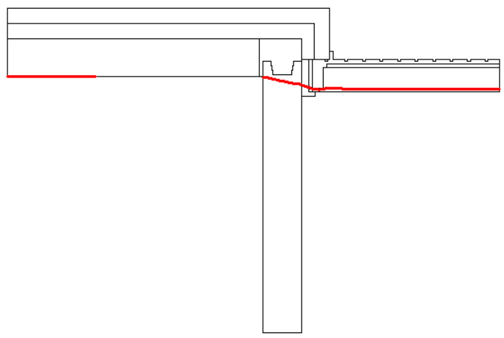
<table>
<tr><th colspan="2">DETAIL 13</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.13.4 – Thermal-technical evaluation of detail 13

DETAIL 13

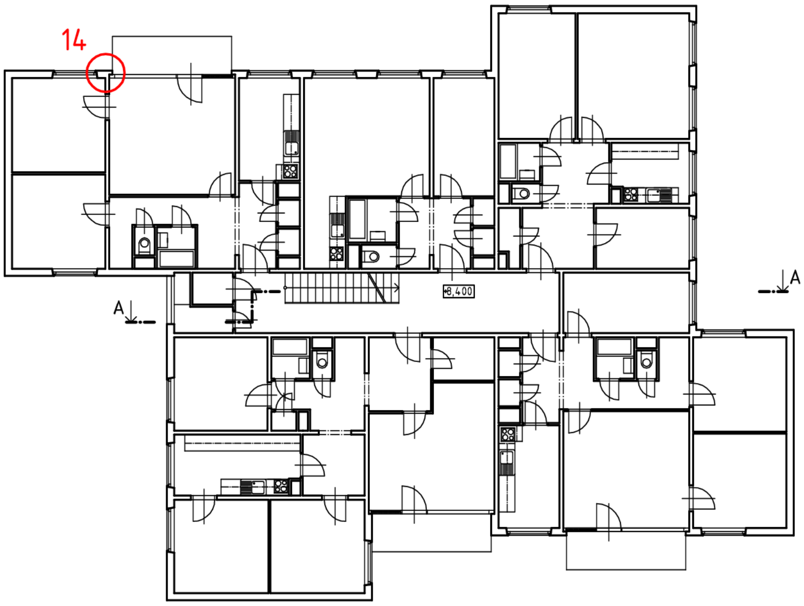
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 0.110 W/(m.K) λ = 0.070 W/(m.K) λ = 0.090 W/(m.K) λ = 0.180 W/(m.K) λ = 1.580 W/(m.K) λ = 0.220 W/(m.K) λ = 0.070 W/(m.K) λ = 0.070 W/(m.K) λ = 1.340 W/(m.K) λ = 1.360 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 12.67 °C	f_{Rsi}= 0.791	θ_{si} = 12.67 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 15.39 °C	f_{Rsi}= 0.868	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Linear thermal transmittance			ψ = 1.56271 - 0.862 × 1.260 - 0.579 × 0.665 = 0.092 W/(m.K)	

Table 4.14.1 – Marking of the position of detail in the building – detail 14

DETAIL 14

Floor plan



Section A-A

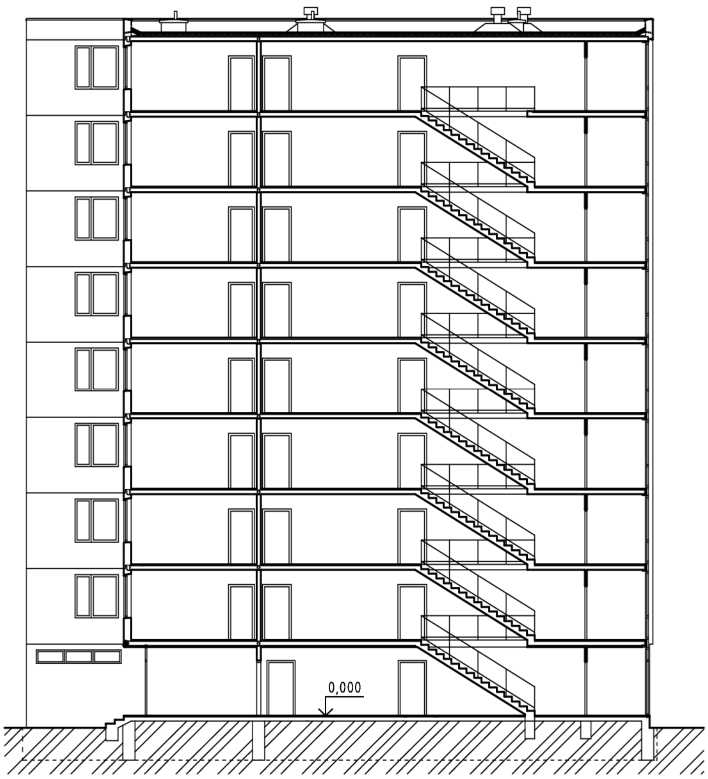
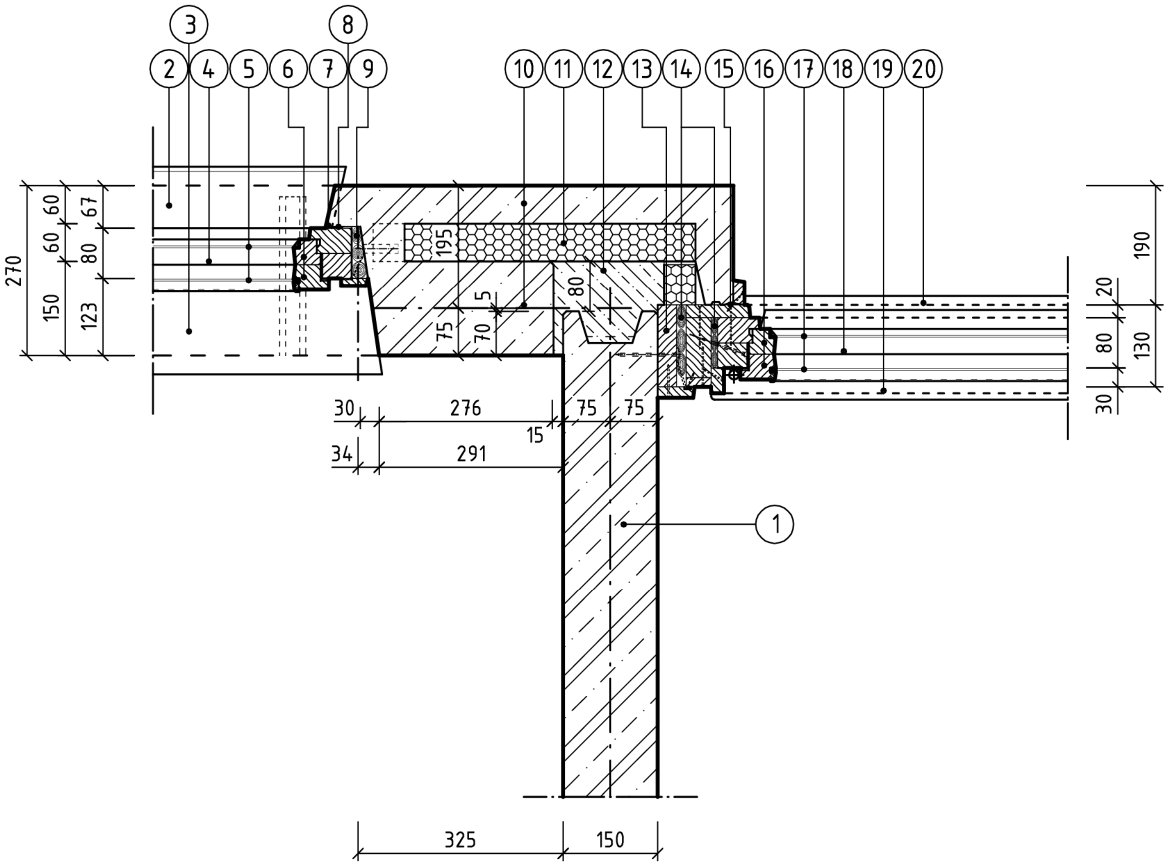


Table 4.14.2 – Structural composition of detail 14

DETAIL 14



Legend:

1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Sheet metal covering – in view
3. Internal window sill – in view
4. Closed air gap 37 mm (λ = 0.204 W/(m.K))
5. Glass 3 mm (λ = 1.00 W/(m.K))
6. Wooden window frame (λ = 0.18 W/(m.K))
7. Sealant (λ = 0.22 W/(m.K))
8. Microporous rubber (λ = 0.06 W/(m.K))
9. Seal - glass wool (λ = 0.07 W/(m.K))
10. Reinforced concrete (λ = 1.58 W/(m.K))
11. Polystyrene foam (λ = 0.07 W/(m.K))
12. Concrete grout (λ = 1.36 W/(m.K))
13. Wooden frame (λ = 0.18 W/(m.K))
14. Seal - glass wool (λ = 0.07 W/(m.K))
15. Sealant (λ = 0.22 W/(m.K))
16. Wooden window frame (λ = 0.18 W/(m.K))
17. Glass 3 mm (λ = 1.00 W/(m.K))
18. Closed air gap 37 mm (λ = 0.204 W/(m.K))
19. Internal window sill – in view
20. External window sill – in view

$U_{wall,1}$ = 0.862 W/(m^2.K)

$U_{window, wooden}$ = 2.579 W/(m^2.K)

Table 4.14.3 – Boundary conditions for a calculation of detail 14

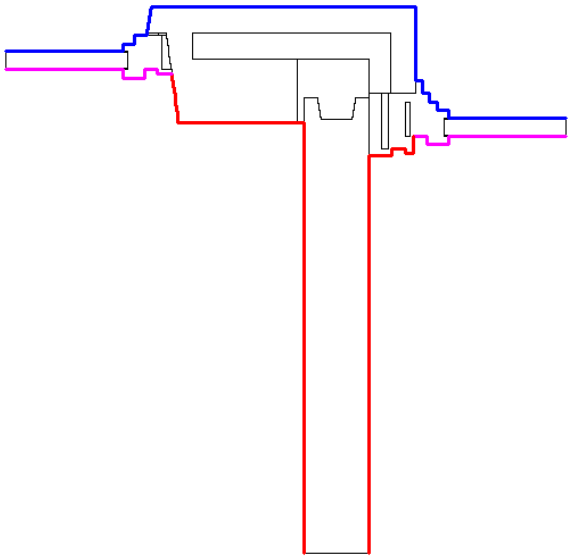
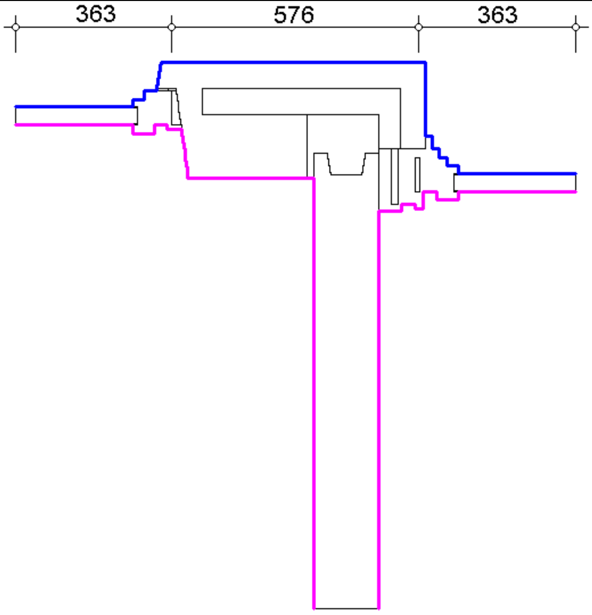
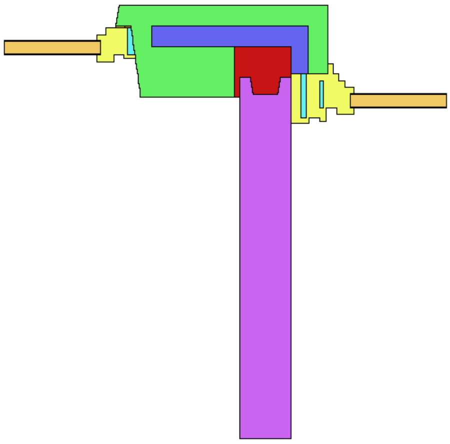
<table>
<tr><th colspan="2">DETAIL 14</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

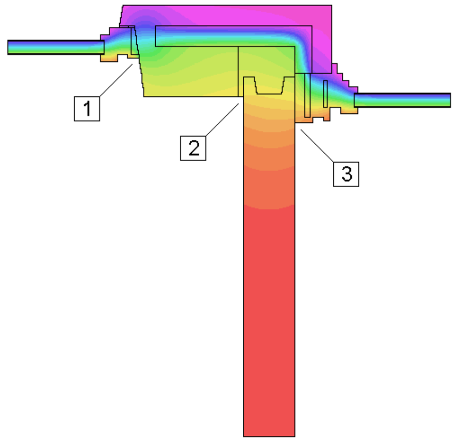
Table 4.14.4 – Thermal-technical evaluation of detail 14

DETAIL 14

Modeled detail with marking the materials

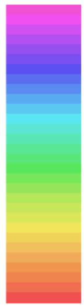


Temperature field with marked critical temperatures



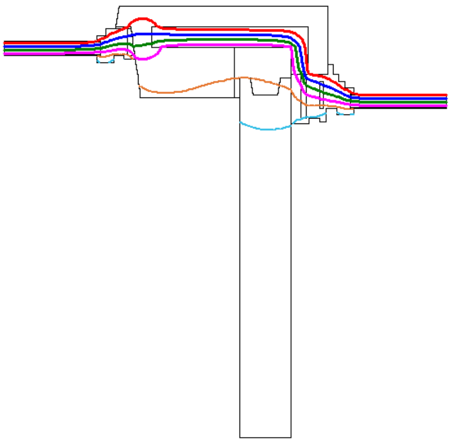
Legend:

λ = 1.000 W/(m.K)	λ = 0.070 W/(m.K)
λ = 0.204 W/(m.K)	λ = 1.340 W/(m.K)
λ = 0.180 W/(m.K)	λ = 1.360 W/(m.K)
λ = 1.580 W/(m.K)	λ = 0.060 W/(m.K)
λ = 0.070 W/(m.K)	λ = 0.220 W/(m.K)

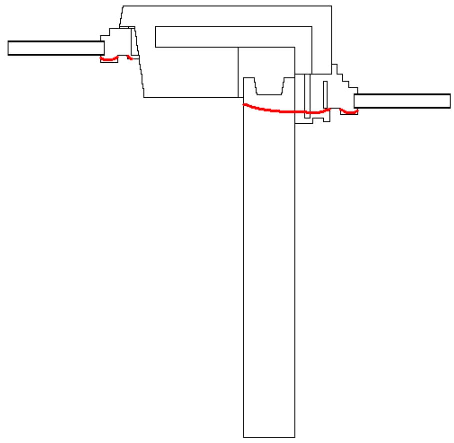


-15.0 °C	... -11.5 °C
-11.5 °C	... -8.0 °C
-8.0 °C	... -4.5 °C
-4.5 °C	... -1.0 °C
-1.0 °C	... 2.5 °C
2.5 °C	... 6.0 °C
6.0 °C	... 9.5 °C
9.5 °C	... 13.0 °C
13.0 °C	... 16.5 °C
16.5 °C	... 20.0 °C

Representation of characteristic isotherms



Representation of the critical isotherm



-10 °C	5 °C
-5 °C	10 °C
0 °C	15 °C

13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 5.55 °C	f_{Rsi}= 0.587	θ_{si} = 5.55 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 12.01 °C	f_{Rsi}= 0.772	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
3	θ_{si} = 14.76 °C	f_{Rsi}= 0.850		
Linear thermal transmittance			ψ = 2.79616 - 0.862 × 0.576 - (2.579 × 0.363 × 2) = 0.427 W/(m.K)	

Table 4.15.1 – Marking of the position of detail in the building – detail 15

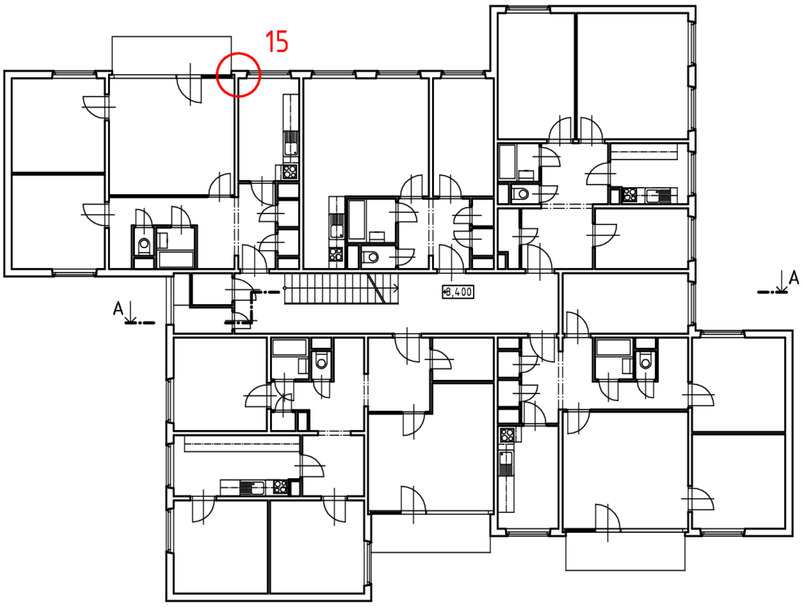
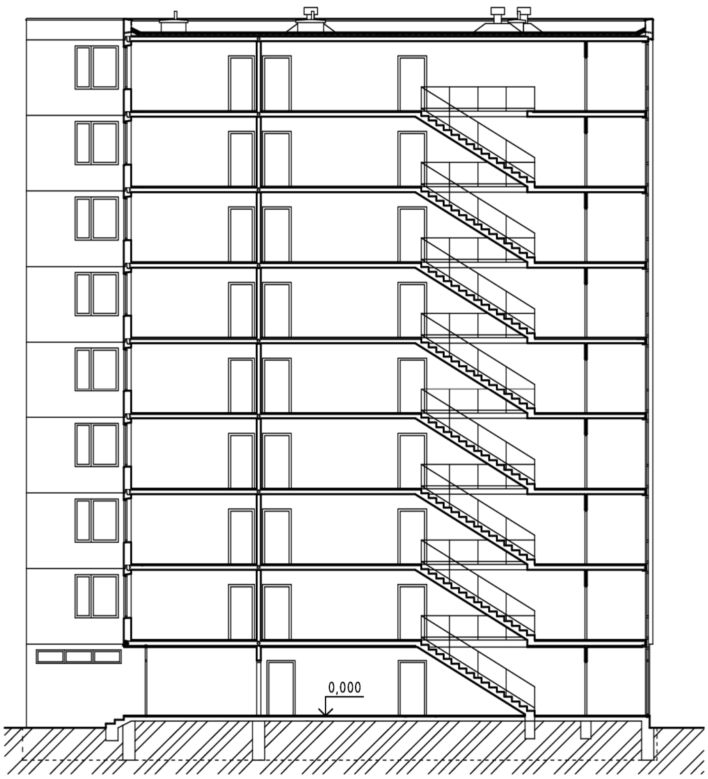
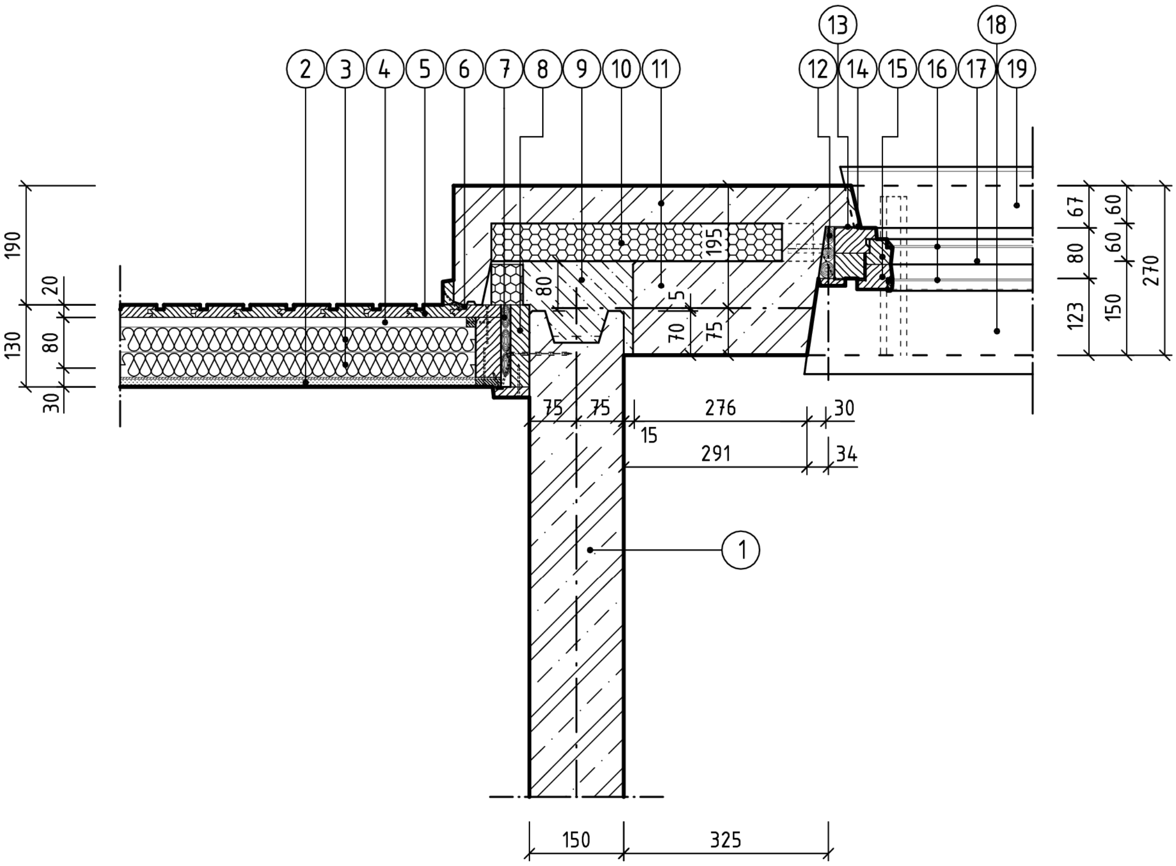
DETAIL 15
Floor plan

Section A-A


Table 4.15.2 – Structural composition of detail 15

DETAIL 15



Legend:

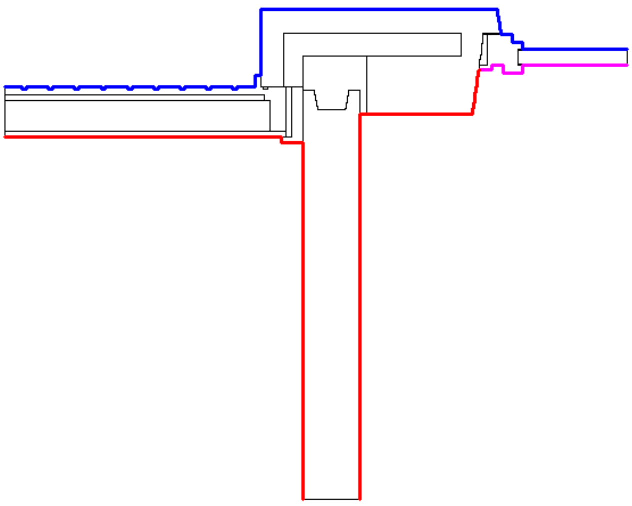
1. Reinforced concrete (λ = 1.34 W/(m.K))
2. Particle board (λ = 0.11 W/(m.K))
3. Basalt wool (λ = 0.07 W/(m.K))
4. Closed air gap (λ = 0.09 W/(m.K))
5. Batten siding (λ = 0.18 W/(m.K))
6. Sealant (λ = 0.22 W/(m.K))
7. Seal - glass wool (λ = 0.07 W/(m.K))
8. Wooden frame (λ = 0.18 W/(m.K))
9. Concrete grout (λ = 1.36 W/(m.K))
10. Polystyrene foam (λ = 0.07 W/(m.K))
11. Reinforced concrete (λ = 1.58 W/(m.K))
12. Seal - glass wool (λ = 0.07 W/(m.K))
13. Microporous rubber (λ = 0.06 W/(m.K))
14. Sealant (λ = 0.22 W/(m.K))
15. Wooden window frame (λ = 0.18 W/(m.K))
16. Glass 3 mm (λ = 1.00 W/(m.K))
17. Closed air gap 37 mm (λ = 0.204 W/(m.K))
18. Internal window sill – in view
19. Sheet metal covering – in view

$U_{wall,1}$ = 0.862 W/(m^2.K) **$U_{wall,2}$ = 0.579 W/(m^2.K)** **$U_{window, wooden}$ = 2.579 W/(m^2.K)**

Table 4.15.3 – Boundary conditions for a calculation of detail 15

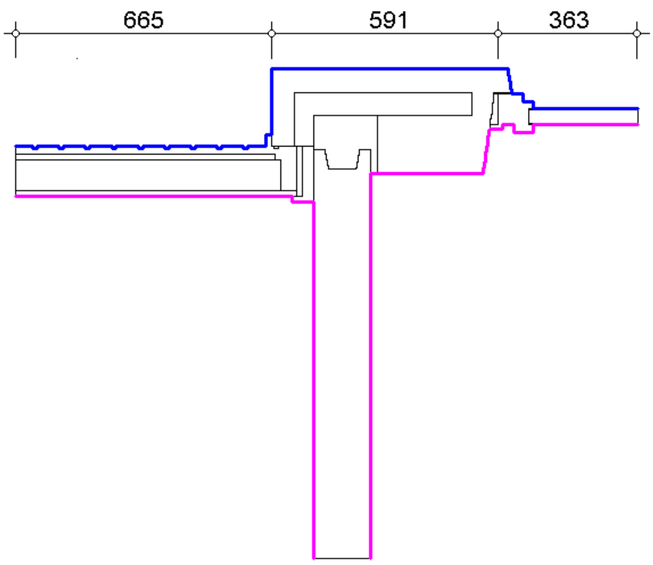
DETAIL 15

Boundary conditions for calculation of surface temperatures



Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.25 m^2.K/W R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W

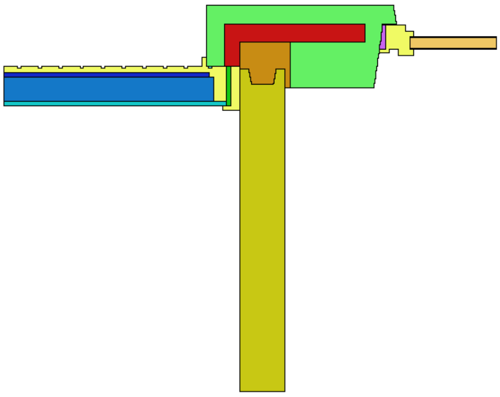
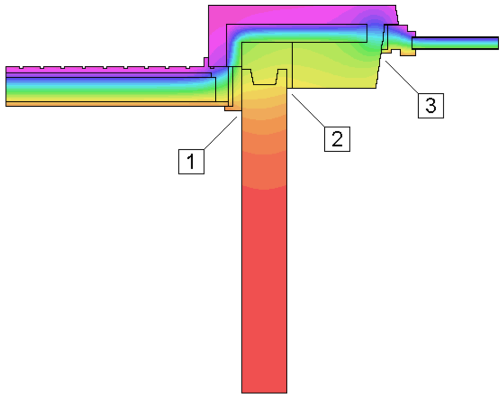
Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance



Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.13 m^2.K/W	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W

Table 4.15.4 – Thermal-technical evaluation of detail 15

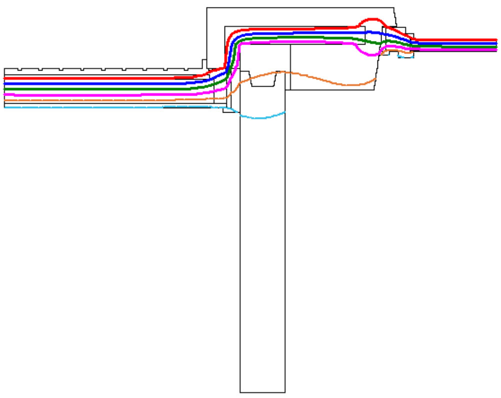
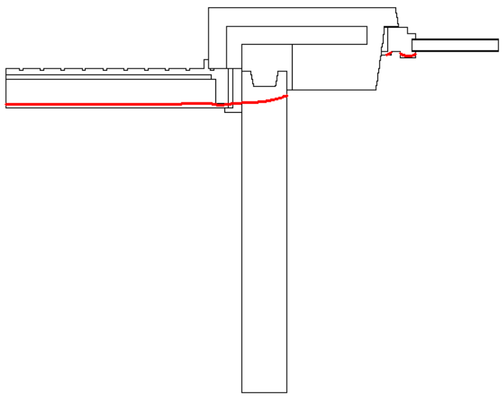
DETAIL 15

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

- λ = 1.000 W/(m.K)
- λ = 0.204 W/(m.K)
- λ = 0.180 W/(m.K)
- λ = 1.580 W/(m.K)
- λ = 0.220 W/(m.K)
- λ = 0.060 W/(m.K)
- λ = 0.070 W/(m.K)
- λ = 0.070 W/(m.K)
- λ = 1.360 W/(m.K)
- λ = 1.340 W/(m.K)
- λ = 0.070 W/(m.K)
- λ = 0.110 W/(m.K)
- λ = 0.070 W/(m.K)
- λ = 0.090 W/(m.K)

- -15.0 °C ... -11.5 °C
- -11.5 °C ... -8.0 °C
- -8.0 °C ... -4.5 °C
- -4.5 °C ... -1.0 °C
- -1.0 °C ... 2.5 °C
- 2.5 °C ... 6.0 °C
- 6.0 °C ... 9.5 °C
- 9.5 °C ... 13.0 °C
- 13.0 °C ... 16.5 °C
- 16.5 °C ... 20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C, -5 °C, 0 °C, 5 °C, 10 °C, 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 14.68 °C	f_{Rsi}= 0.848	θ_{si} = 5.53 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 11.96 °C	f_{Rsi}= 0.770	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
3	θ_{si} = 5.53 °C	f_{Rsi}= 0.587		
Linear thermal transmittance	ψ = 2.25982 - 0.862 × 0.591 - 0.579 × 0.665 - 2.579 × 0.363 = 0.429 W/(m.K)			

Table 4.16.1 – Marking of the position of detail in the building – detail 16

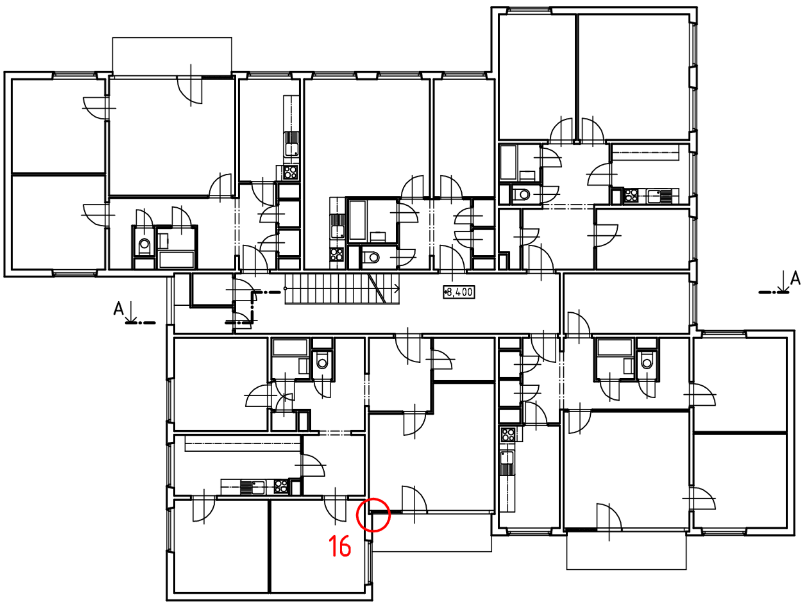
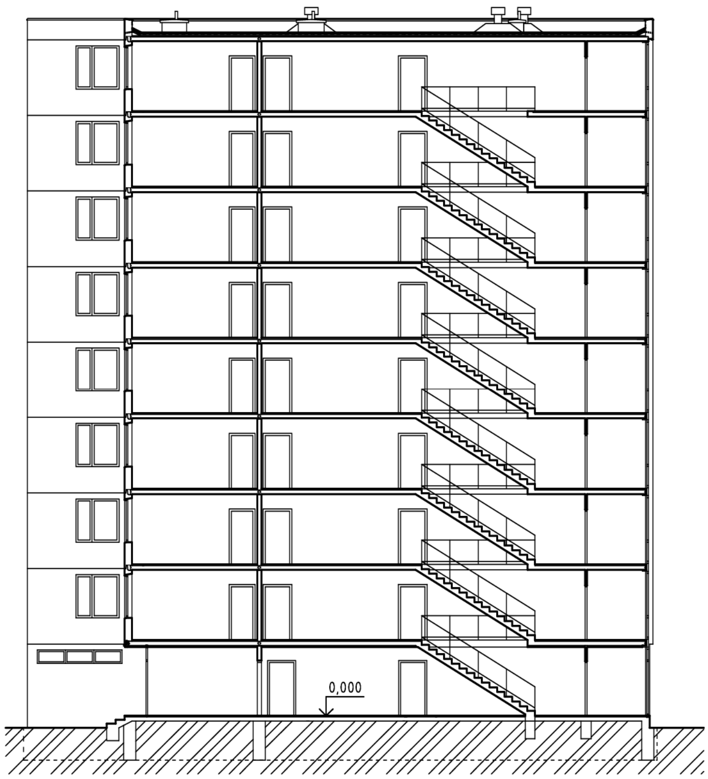
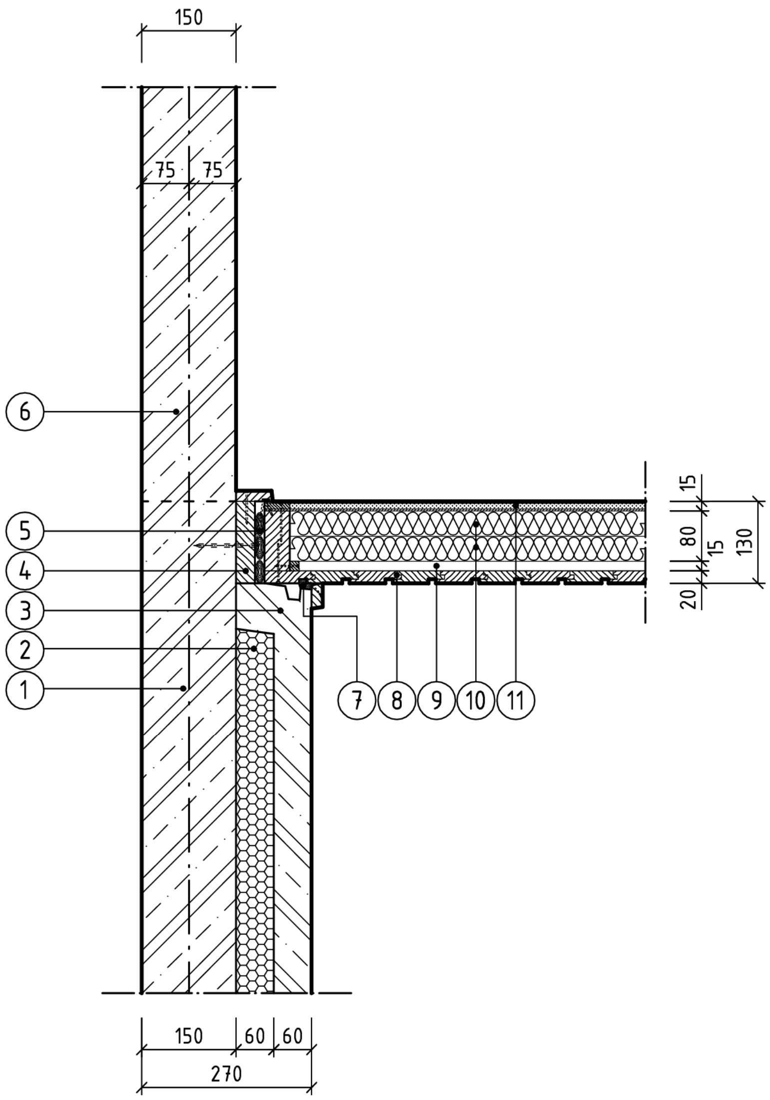
DETAIL 16
Floor plan

Section A-A


Table 4.16.2 – Structural composition of detail 16

DETAIL 16



Legend:

1. Reinforced concrete (λ = 1.58 W/(m.K))
2. Polystyrene foam (λ = 0.07 W/(m.K))
3. Reinforced concrete (λ = 1.58 W/(m.K))
4. Wooden frame (λ = 0.18 W/(m.K))
5. Seal - glass wool (λ = 0.07 W/(m.K))
6. Reinforced concrete (λ = 1.34 W/(m.K))
7. Sealant (λ = 0.22 W/(m.K))
8. Batten siding (λ = 0.18 W/(m.K))
9. Closed air gap (λ = 0.09 W/(m.K))
10. Basalt wool (λ = 0.07 W/(m.K))
11. Particle board (λ = 0.11 W/(m.K))

$\boldsymbol{U_{wall,1}}$ **= 0.862 W/(m^2.K)**

$\boldsymbol{U_{wall,2}}$ **= 0.579 W/(m^2.K)**

Table 4.16.3 – Boundary conditions for a calculation of detail 16

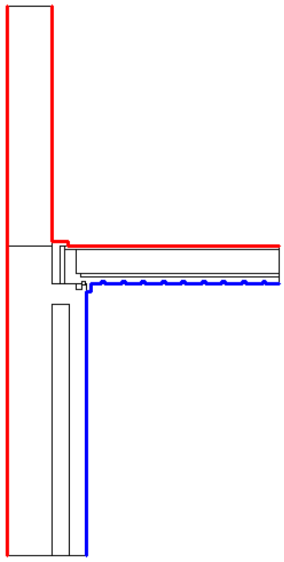
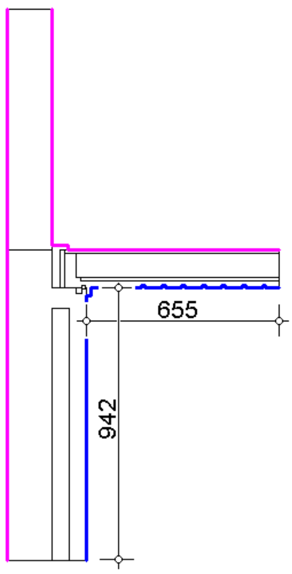
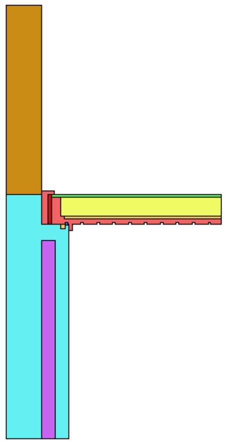
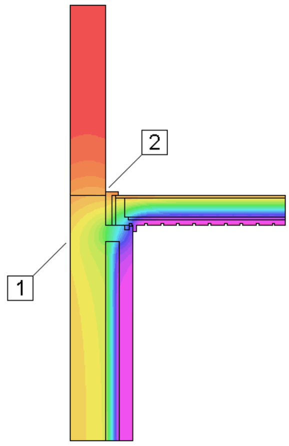
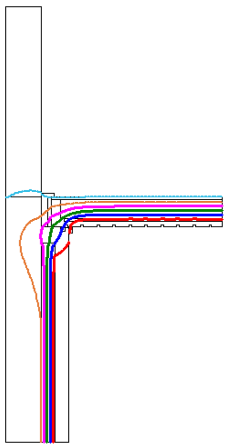
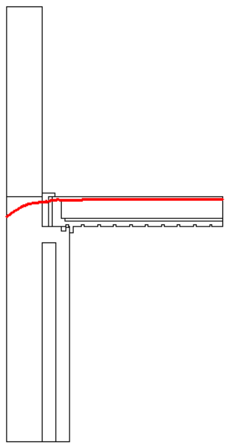
<table>
<tr><th colspan="2">DETAIL 16</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.16.4 – Thermal-technical evaluation of detail 16

DETAIL 16

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	
Legend: λ = 0.180 W/(m.K) λ = 0.090 W/(m.K) λ = 0.070 W/(m.K) λ = 0.110 W/(m.K) λ = 1.580 W/(m.K) λ = 0.220 W/(m.K) λ = 0.070 W/(m.K) λ = 0.070 W/(m.K) λ = 1.340 W/(m.K)	 -15.0 °C ... -11.5 °C -11.5 °C ... -8.0 °C -8.0 °C ... -4.5 °C -4.5 °C ... -1.0 °C -1.0 °C ... 2.5 °C 2.5 °C ... 6.0 °C 6.0 °C ... 9.5 °C 9.5 °C ... 13.0 °C 13.0 °C ... 16.5 °C 16.5 °C ... 20.0 °C
Representation of characteristic isotherms	**Representation of the critical isotherm**
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 11.62 °C	f_{Rsi}= 0.761	θ_{si} = 11.62 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 14.92 °C	f_{Rsi}= 0.855	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Linear thermal transmittance			ψ = 1.62728 - 0.862 × 0.942 - 0.579 × 0.655 = 0.436 W/(m.K)	

Table 4.17.1 – Marking of the position of detail in the building – detail 17

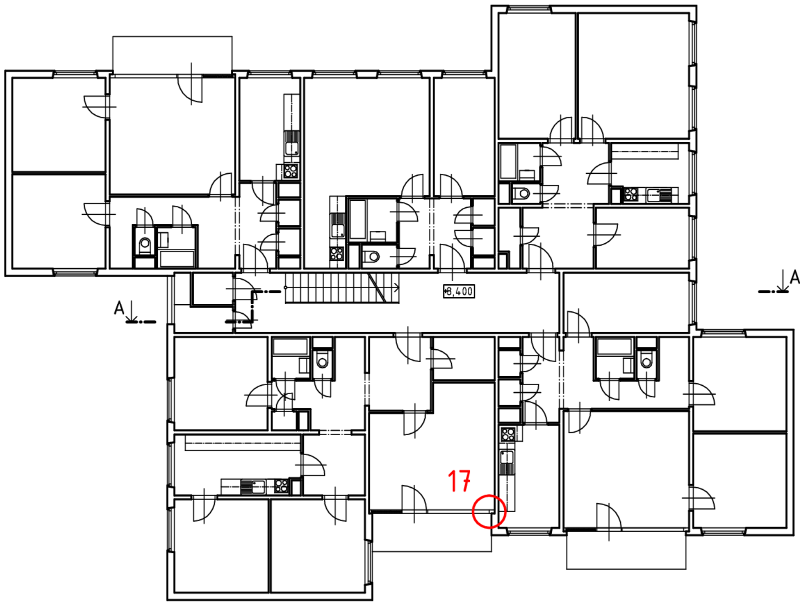
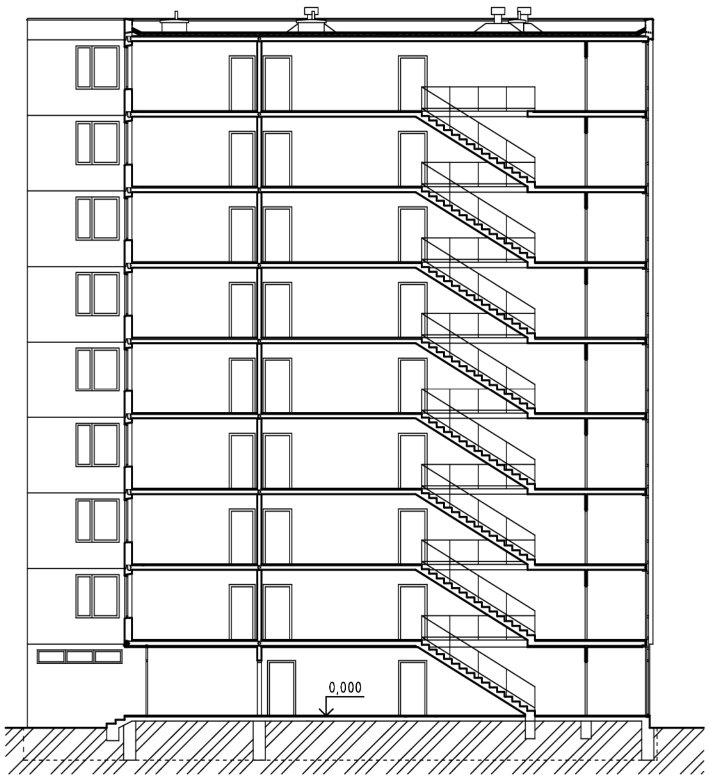
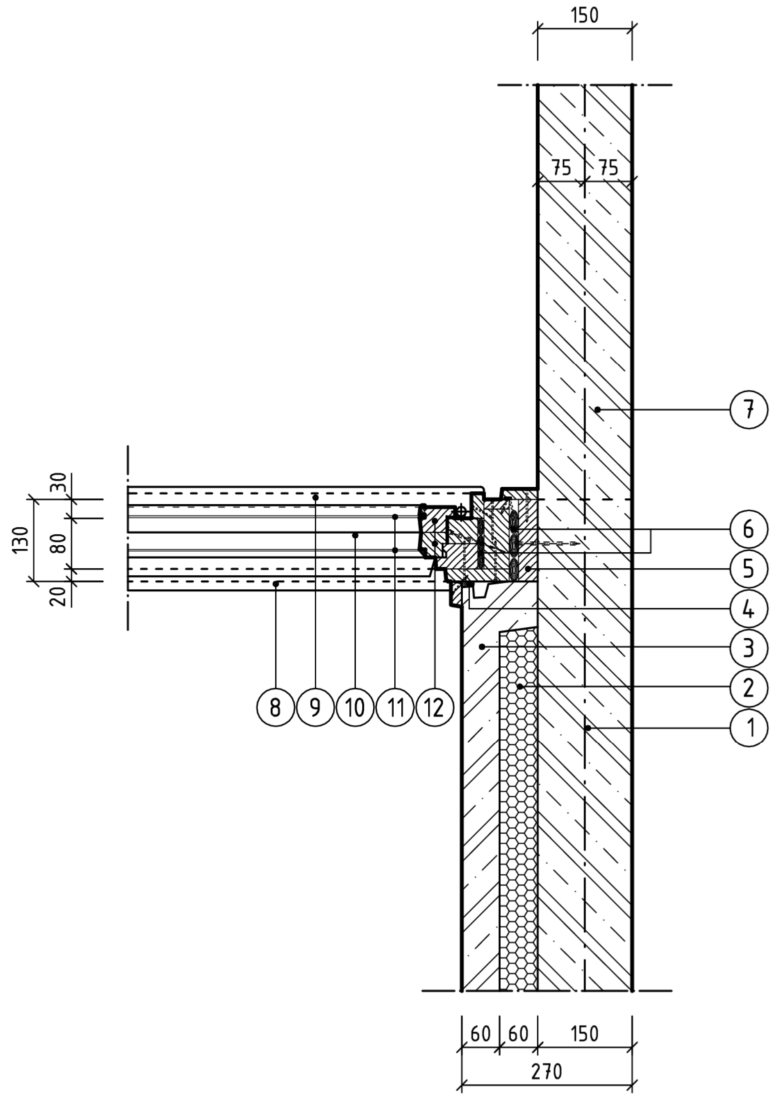
DETAIL 17
Floor plan

Section A-A


Table 4.17.2 – Structural composition of detail 17

DETAIL 17



Legend:

1. Reinforced concrete (λ = 1.58 W/(m.K))
2. Polystyrene foam (λ = 0.07 W/(m.K))
3. Reinforced concrete (λ = 1.58 W/(m.K))
4. Sealant (λ = 0.22 W/(m.K))
5. Wooden frame (λ = 0.18 W/(m.K))
6. Seal - glass wool (λ = 0.07 W/(m.K))
7. Reinforced concrete (λ = 1.34 W/(m.K))
8. External window sill – in view
9. Internal window sill – in view
10. Closed air gap 37 mm (λ = 0.204 W/(m.K))
11. Glass 3 mm (λ = 1.00 W/(m.K))
12. Wooden window frame (λ = 0.18 W/(m.K))

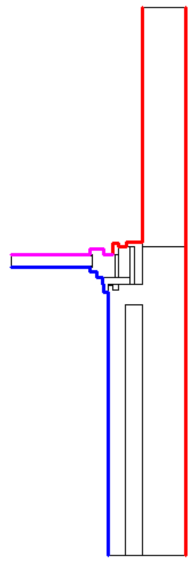
$\boldsymbol{U_{\mathrm{wall,1}}}$ **= 0.862 W/(m^2.K)**

$\boldsymbol{U_{\mathrm{window,\ wooden}}}$ **= 2.579 W/(m^2.K)**

Table 4.17.3 – Boundary conditions for a calculation of detail 17

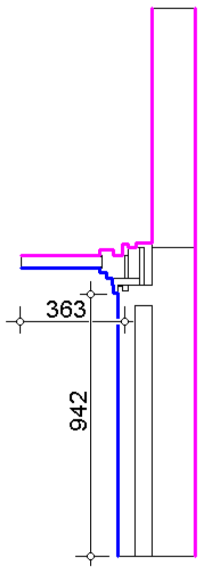
DETAIL 17

Boundary conditions for calculation of surface temperatures



Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.25 m^2.K/W (red line) R_{si} = 0.13 m^2.K/W (magenta line)	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W (blue line)

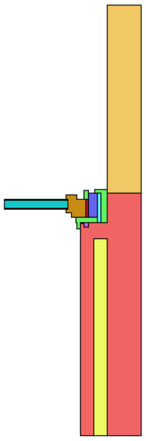
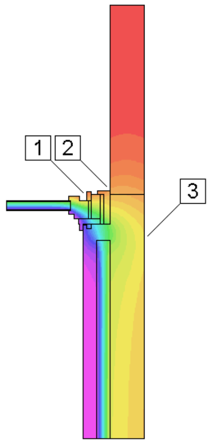
Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance



Boundary conditions for interior	Boundary conditions for exterior
θ_i = 20 °C φ_i = 50 % R_{si} = 0.13 m^2.K/W (magenta line)	θ_e = -15 °C φ_e = 84 % R_{se} = 0.04 m^2.K/W (blue line)

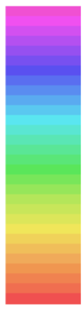
Table 4.17.4 – Thermal-technical evaluation of detail 17

DETAIL 17

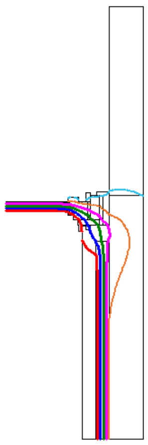
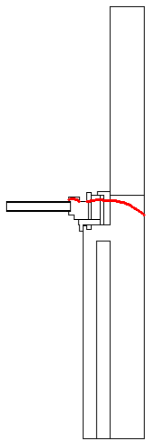
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

λ = 1.580 W/(m.K)	λ = 0.090 W/(m.K)
λ = 1.340 W/(m.K)	λ = 0.070 W/(m.K)
λ = 0.070 W/(m.K)	λ = 0.180 W/(m.K)
λ = 0.180 W/(m.K)	λ = 0.220 W/(m.K)
λ = 0.070 W/(m.K)	λ = 1.000 W/(m.K)
λ = 0.180 W/(m.K)	λ = 0.204 W/(m.K)



-15.0 °C	... -11.5 °C
-11.5 °C	... -8.0 °C
-8.0 °C	... -4.5 °C
-4.5 °C	... -1.0 °C
-1.0 °C	... 2.5 °C
2.5 °C	... 6.0 °C
6.0 °C	... 9.5 °C
9.5 °C	... 13.0 °C
13.0 °C	... 16.5 °C
16.5 °C	... 20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C, -5 °C, 0 °C, 5 °C, 10 °C, 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 11.59 °C	f_{Rsi}= 0.760	θ_{si} = 11.59 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 14.94 °C	f_{Rsi}= 0.855	$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
3	θ_{si} = 13.05 °C	f_{Rsi}= 0.801		
Linear thermal transmittance			ψ = 2.16787 - 0.862 × 0.942 - 2.579 × 0.363 = 0.420 W/(m.K)	

Table 4.18.1 – Marking of the position of detail in the building – detail 18

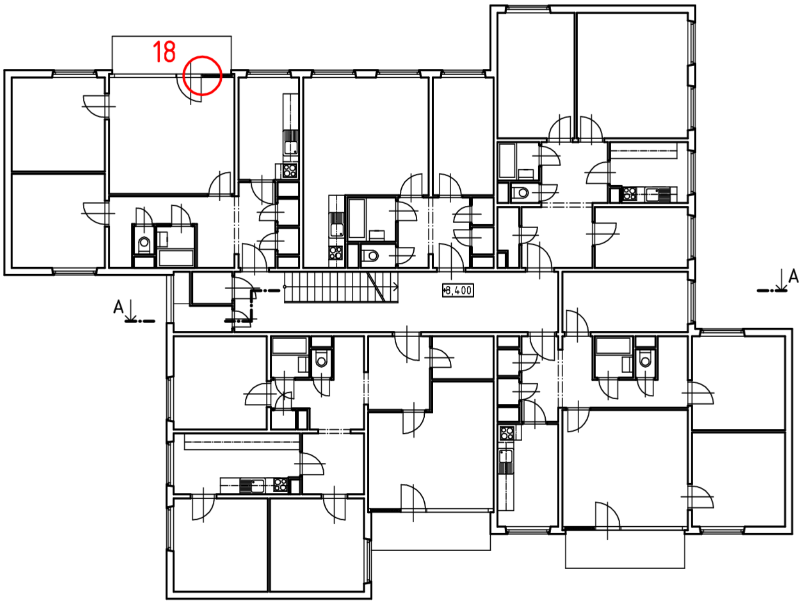
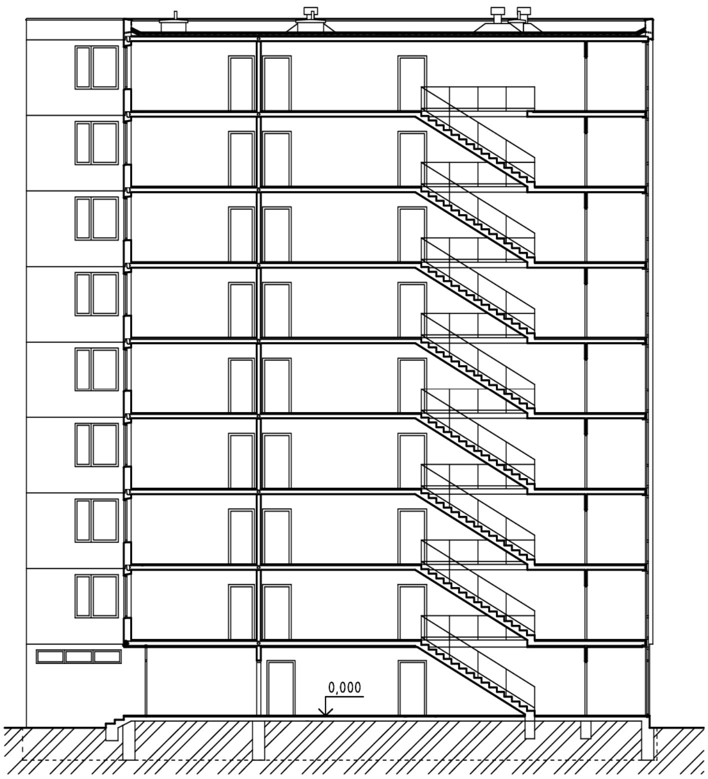
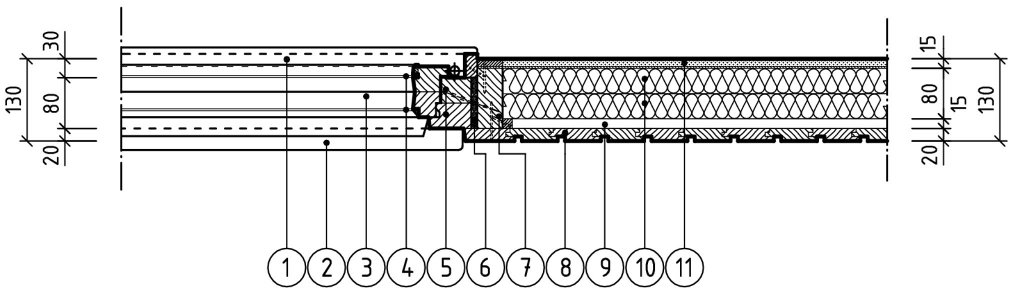
<table>
<tr><th>DETAIL 18</th></tr>
<tr><td>Floor plan</td></tr>
<tr><td></td></tr>
<tr><td>Section A-A</td></tr>
<tr><td></td></tr>
</table>

Table 4.18.2 – Structural composition of detail 18

DETAIL 18



Legend:

1. Internal window sill – in view
2. External window sill – in view
3. Closed air gap 37 mm (λ = 0.204 W/(m.K))
4. Glass 3 mm (λ = 1.00 W/(m.K))
5. Wooden window frame (λ = 0.18 W/(m.K))
6. Seal - glass wool (λ = 0.07 W/(m.K))
7. Wooden frame (λ = 0.18 W/(m.K))
8. Batten siding (λ = 0.18 W/(m.K))
9. Closed air gap (λ = 0.09 W/(m.K))
10. Basalt wool (λ = 0.07 W/(m.K))
11. Particle board (λ = 0.11 W/(m.K))

$U_{wall,2}$ = 0.579 W/(m^2.K)

$U_{window, wooden}$ = 2.579 W/(m^2.K)

Table 4.18.3 – Boundary conditions for a calculation of detail 18

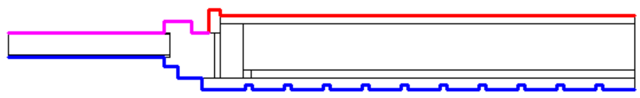
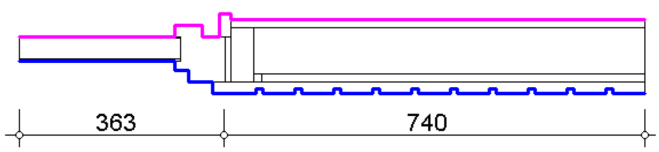
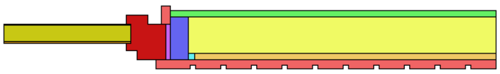
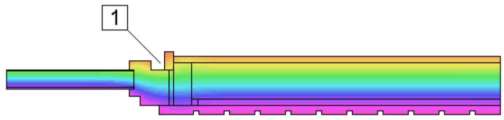
<table>
<tr><th colspan="2">DETAIL 18</th></tr>
<tr><th colspan="2">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W (red line)
R_{si} = 0.13 m^2.K/W (magenta line)</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
<tr><th colspan="2">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td></tr>
</table>

Table 4.18.4 – Thermal-technical evaluation of detail 18

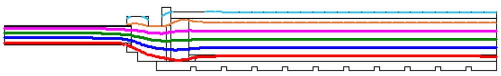
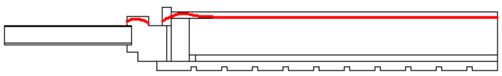
DETAIL 18

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

λ = 0.180 W/(m.K)	λ = 0.180 W/(m.K)
λ = 0.090 W/(m.K)	λ = 0.070 W/(m.K)
λ = 0.070 W/(m.K)	λ = 0.180 W/(m.K)
λ = 0.110 W/(m.K)	λ = 1.000 W/(m.K)
λ = 0.180 W/(m.K)	λ = 0.204 W/(m.K)

-15.0 °C	... -11.5 °C
-11.5 °C	... -8.0 °C
-8.0 °C	... -4.5 °C
-4.5 °C	... -1.0 °C
-1.0 °C	... 2.5 °C
2.5 °C	... 6.0 °C
6.0 °C	... 9.5 °C
9.5 °C	... 13.0 °C
13.0 °C	... 16.5 °C
16.5 °C	... 20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C; -5 °C; 0 °C; 5 °C; 10 °C; 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 10.91 °C	f_{Rsi}= 0.740	θ_{si} = 10.91 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
			$\theta_{si} = f_{Rsi}.(\theta_i - \theta_e) + \theta_e$ (Considered θ_i = 20 °C; θ_e = -15 °C)	
Linear thermal transmittance			ψ = 1.39660 - 0.579 × 0.740 - 2.579 × 0.363 = 0.032 W/(m.K)	

Table 4.19.1 – Marking of the position of detail in the building – detail 19

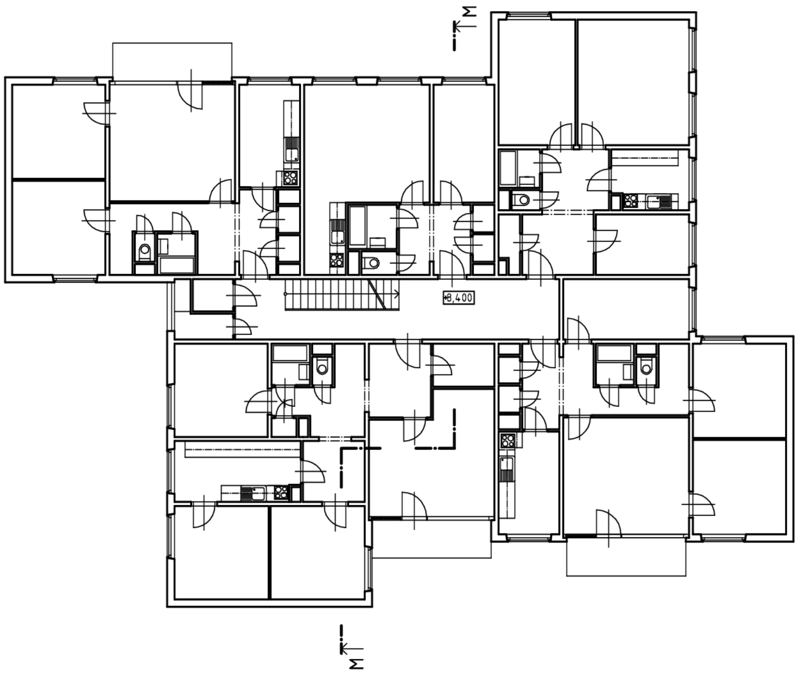
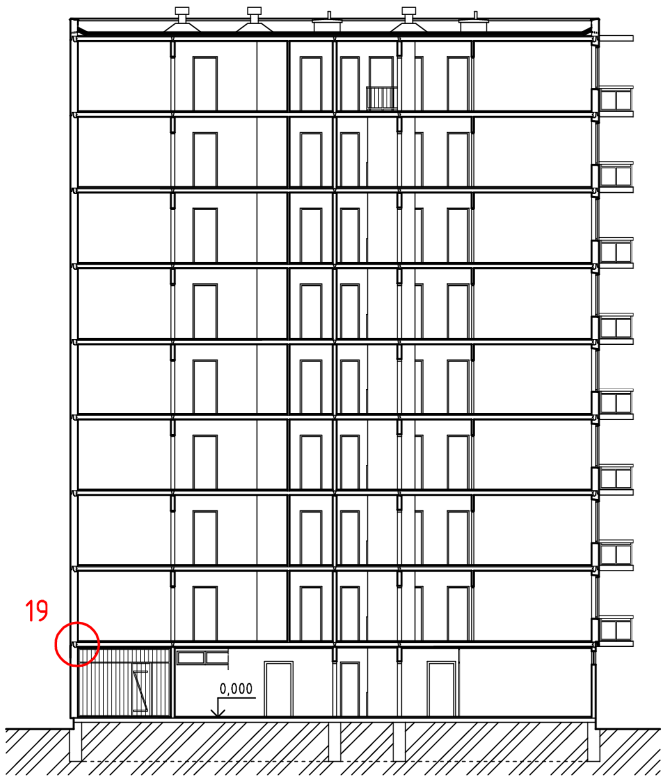
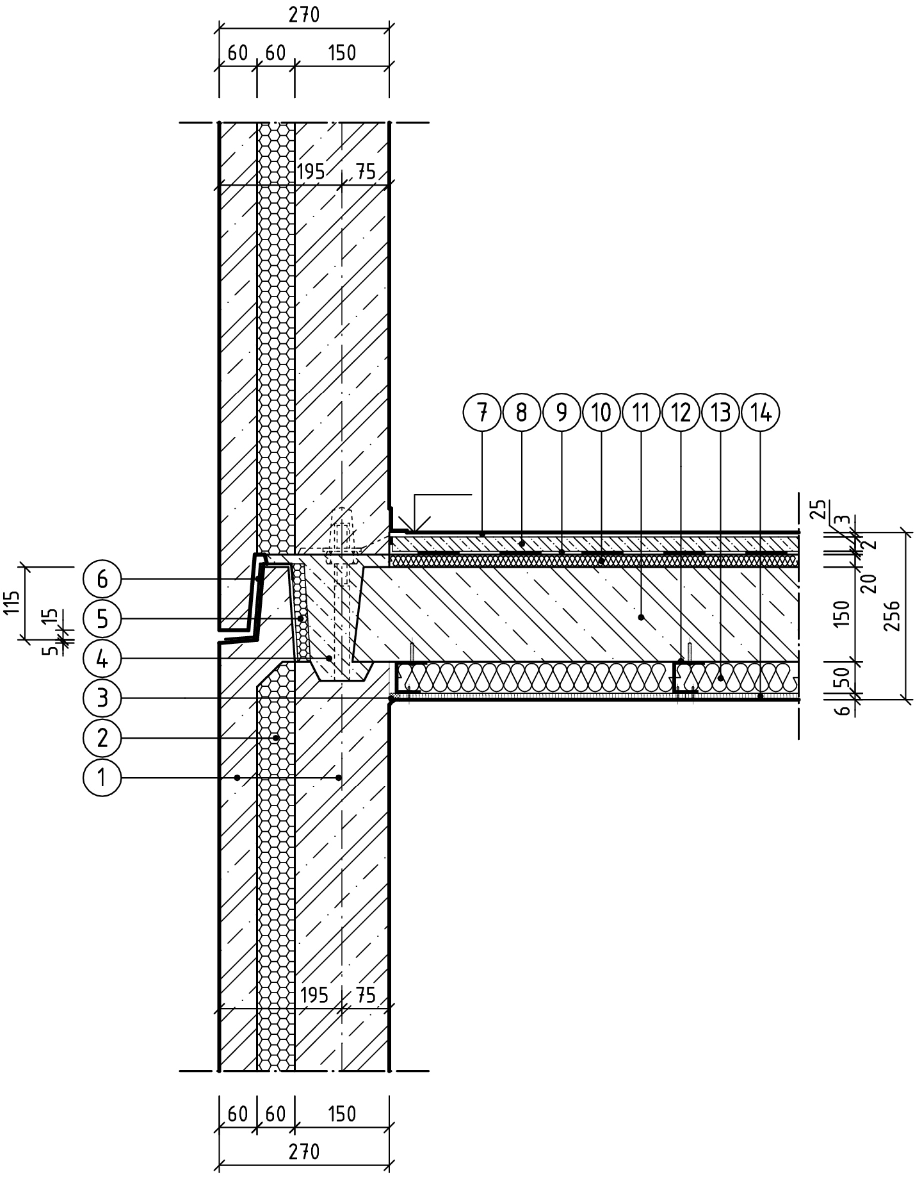
DETAIL 19
Floor plan

Section M-M


Table 4.19.2 – Structural composition of detail 19

DETAIL 19


Legend:

1. Reinforced concrete (λ = 1.58 W/(m.K))
2. Polystyrene foam (λ = 0.07 W/(m.K))
3. Sealant (λ = 0.22 W/(m.K))
4. Concrete grout (λ = 1.36 W/(m.K))
5. Polystyrene foam, th. 20 mm (λ = 0.044 W/(m.K))
6. Galvanized sheet metal (not considered in model)
7. PVC + adhesive (λ = 0.16 W/(m.K))
8. Cement coating (λ = 1.02 W/(m.K))
9. Tar paper (λ = 0.21 W/(m.K))
10. Boards FIBREX (λ = 0.05 W/(m.K))
11. Reinforced concrete ceiling panel (λ = 1.34 W/(m.K))
12. Steel profile (λ = 40.0 W/(m.K))
13. Basalt felt (λ = 0.06 W/(m.K))
14. Particle boards (λ = 0.22 W/(m.K))

$U_{wall,1}$ = 0.862 W/(m^2.K)

U_{floor} = 0.566 W/(m^2.K)

Table 4.19.3 – Boundary conditions for a calculation of detail 19

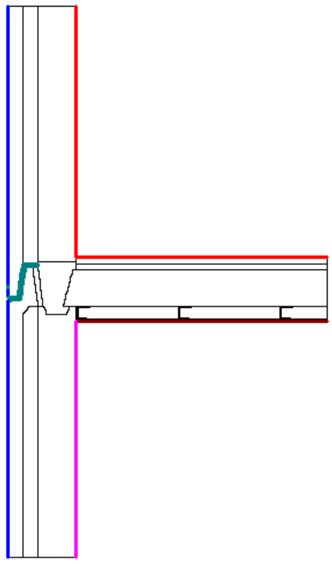
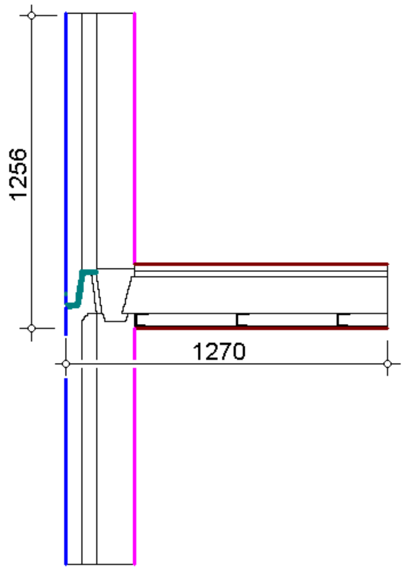
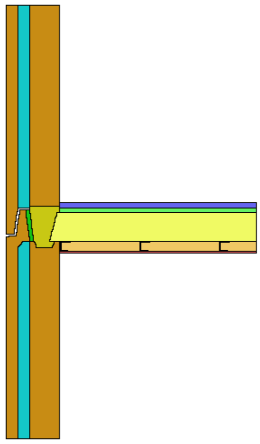
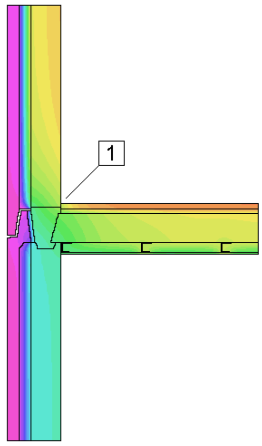
<table>
<tr><th colspan="3">DETAIL 19</th></tr>
<tr><th colspan="3">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td><td>Bound. condit. for unheated space</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W
R_{se} = 0.08 m^2.K/W</td><td>θ_e = 2.5 °C
φ_e = 60 %
R_{se} = 0.17 m^2.K/W
R_{se} = 0.13 m^2.K/W</td></tr>
<tr><th colspan="3">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="3">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td><td>Bound. condit. for unheated space</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W
R_{si} = 0.17 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W
R_{se} = 0.08 m^2.K/W</td><td>θ_e = 2.5 °C
φ_e = 60 %
R_{se} = 0.17 m^2.K/W
R_{se} = 0.13 m^2.K/W</td></tr>
</table>

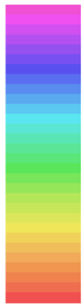
Table 4.19.4 – Thermal-technical evaluation of detail 19

DETAIL 19

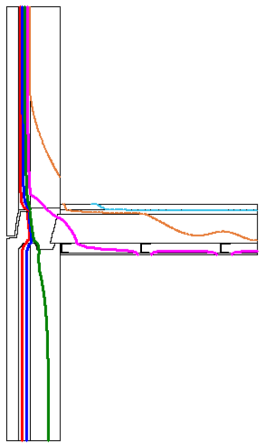
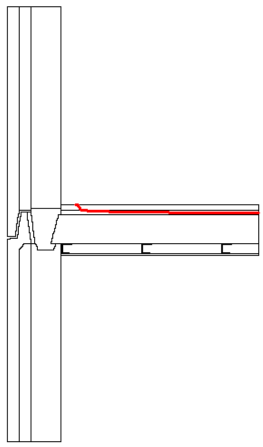
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

- λ = 0.220 W/(m.K)
- λ = 0.060 W/(m.K)
- λ = 1.340 W/(m.K)
- λ = 0.050 W/(m.K)
- λ = 0.210 W/(m.K)
- λ = 1.020 W/(m.K)
- λ = 0.160 W/(m.K)
- λ = 40.00 W/(m.K)
- λ = 1.580 W/(m.K)
- λ = 1.360 W/(m.K)
- λ = 0.044 W/(m.K)
- λ = 0.070 W/(m.K)



-15.0 °C	... -11.5 °C
-11.5 °C	... -8.0 °C
-8.0 °C	... -4.5 °C
-4.5 °C	... -1.0 °C
-1.0 °C	... 2.5 °C
2.5 °C	... 6.0 °C
6.0 °C	... 9.5 °C
9.5 °C	... 13.0 °C
13.0 °C	... 16.5 °C
16.5 °C	... 20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C, -5 °C, 0 °C, 5 °C, 10 °C, 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 7.88 °C	-	θ_{si} = 7.88 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
			NOTE: For more than two boundary conditions it is not possible to use the temperature factor. In calculation of ψ the value b_x is used.	
Linear thermal transmittance			ψ = 1.57588 - 0.862 × 1.256 - 0.566 × 1.270 × 0.5 = 0.134 W/(m.K)	

Table 4.20.1 – Marking of the position of detail in the building – detail 20

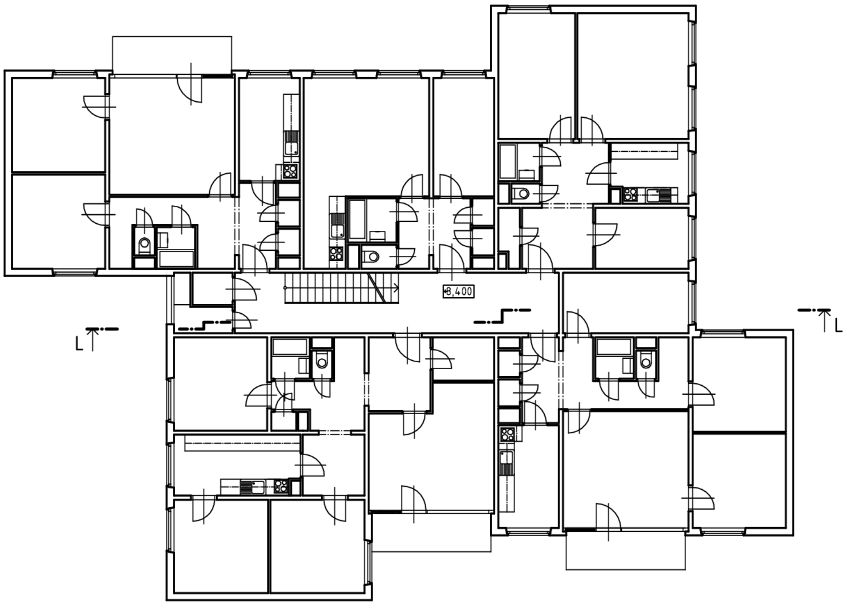
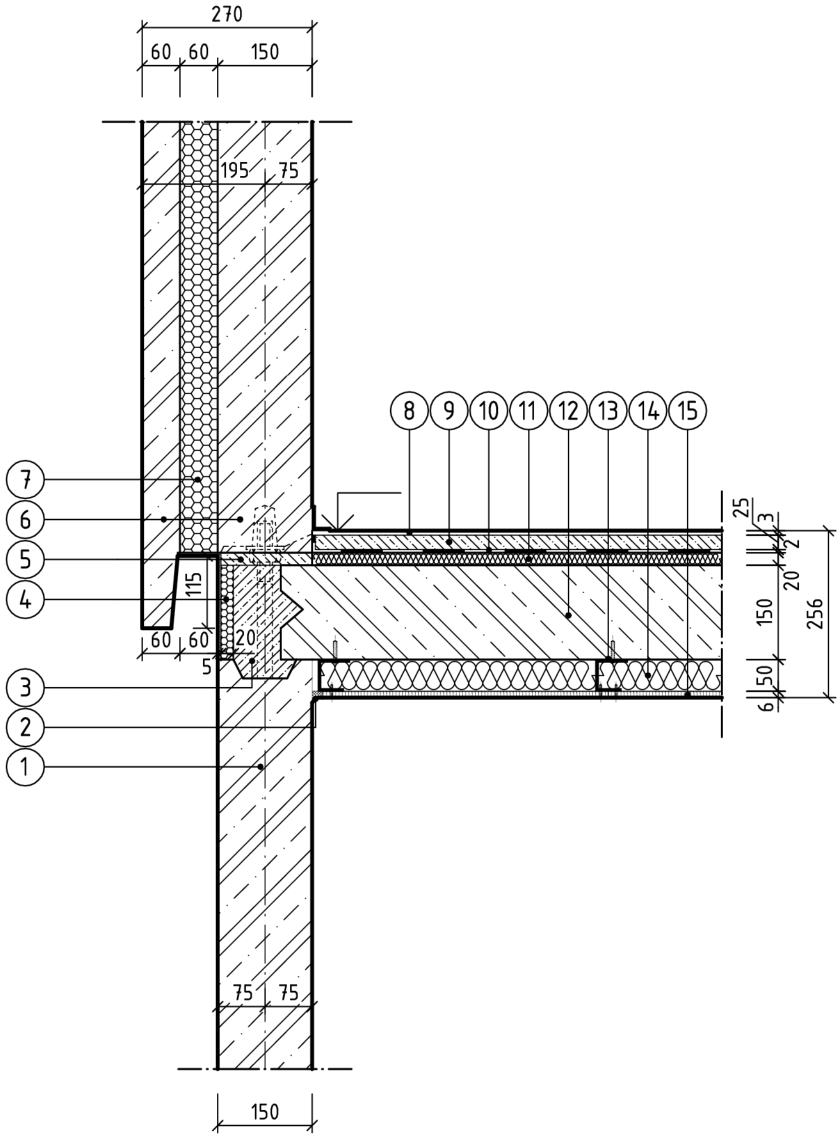
DETAIL 20
Floor plan

Section L-L


Table 4.20.2 – Structural composition of detail 20

DETAIL 20



Legend:

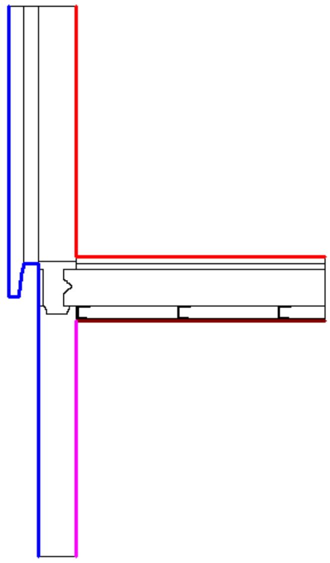
1. Reinforced concrete (λ = 1.58 W/(m.K))
2. Sealant (λ = 0.22 W/(m.K))
3. Concrete grout (λ = 1.36 W/(m.K))
4. Polystyrene foam th. 20 mm (λ = 0.044 W/(m.K))
5. Concrete grout (λ = 1.36 W/(m.K))
6. Reinforced concrete (λ = 1.58 W/(m.K))
7. Polystyrene foam (λ = 0.07 W/(m.K))
8. PVC + adhesive (λ = 0.16 W/(m.K))
9. Cement coating (λ = 1.02 W/(m.K))
10. Tar paper (λ = 0.21 W/(m.K))
11. Boards FIBREX (λ = 0.05 W/(m.K))
12. Reinforced concrete ceiling panel (λ = 1.34 W/(m.K))
13. Steel profile (λ = 40.0 W/(m.K))
14. Basalt felt (λ = 0.06 W/(m.K))
15. Particle boards (λ = 0.22 W/(m.K))

$U_{wall,1}$ = 0.862 W/(m^2.K) **U_{floor} = 0.566 W/(m^2.K)**

Table 4.20.3 – Boundary conditions for a calculation detail 20

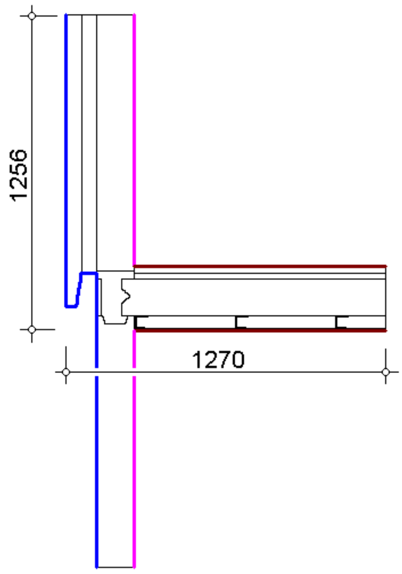
DETAIL 20

Boundary conditions for calculation of surface temperatures



Boundary conditions for interior	Boundary conditions for exterior	Bound. condit. for unheated space
θ_i = 20 °C φ_i = 50 % (red) R_{si} = 0.25 m^2.K/W	θ_e = -15 °C φ_e = 84 % (blue) R_{se} = 0.04 m^2.K/W	θ_e = 2.5 °C φ_e = 60 % (dark red) R_{se} = 0.17 m^2.K/W (magenta) R_{se} = 0.13 m^2.K/W

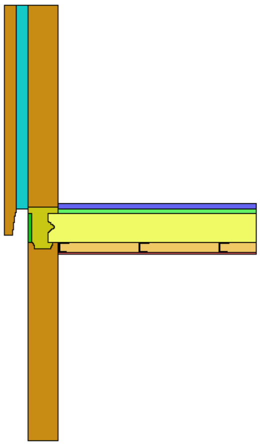
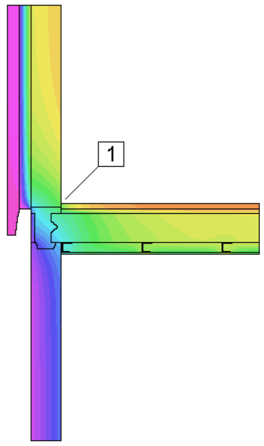
Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance



Boundary conditions for interior	Boundary conditions for exterior	Bound. condit. for unheated space
θ_i = 20 °C φ_i = 50 % (magenta) R_{si} = 0.13 m^2.K/W (dark red) R_{si} = 0.17 m^2.K/W	θ_e = -15 °C φ_e = 84 % (blue) R_{se} = 0.04 m^2.K/W	θ_e = 2.5 °C φ_e = 60 % (dark red) R_{se} = 0.17 m^2.K/W (magenta) R_{se} = 0.13 m^2.K/W

Table 4.20.4 – Thermal-technical evaluation of detail 20

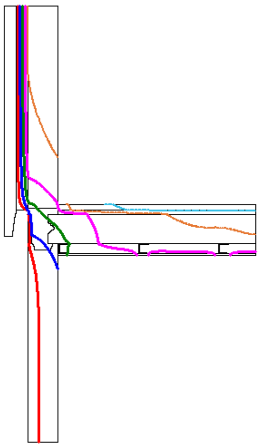
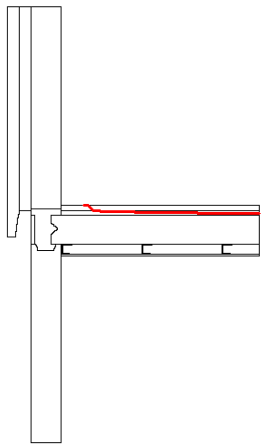
DETAIL 20

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

λ = 0.220 W/(m.K)	λ = 0.160 W/(m.K)
λ = 0.060 W/(m.K)	λ = 40.00 W/(m.K)
λ = 1.340 W/(m.K)	λ = 1.580 W/(m.K)
λ = 0.050 W/(m.K)	λ = 1.360 W/(m.K)
λ = 0.210 W/(m.K)	λ = 0.044 W/(m.K)
λ = 1.020 W/(m.K)	λ = 0.070 W/(m.K)

-15.0 °C	... -11.5 °C
-11.5 °C	... -8.0 °C
-8.0 °C	... -4.5 °C
-4.5 °C	... -1.0 °C
-1.0 °C	... 2.5 °C
2.5 °C	... 6.0 °C
6.0 °C	... 9.5 °C
9.5 °C	... 13.0 °C
13.0 °C	... 16.5 °C
16.5 °C	... 20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	

-10 °C	5 °C
-5 °C	10 °C
0 °C	15 °C

13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 5.05 °C	-	θ_{si} = 5.05 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
			NOTE: For more than two boundary conditions it is not possible to use the temperature factor. In calculation of ψ the value b_x is used.	
Linear thermal transmittance			ψ = 1.74443 - 0.862 × 1.256 - 0.566 × 1.270 × 0.5 = 0.302 W/(m.K)	

Table 4.21.1 – Marking of the position of detail in the building – detail 21

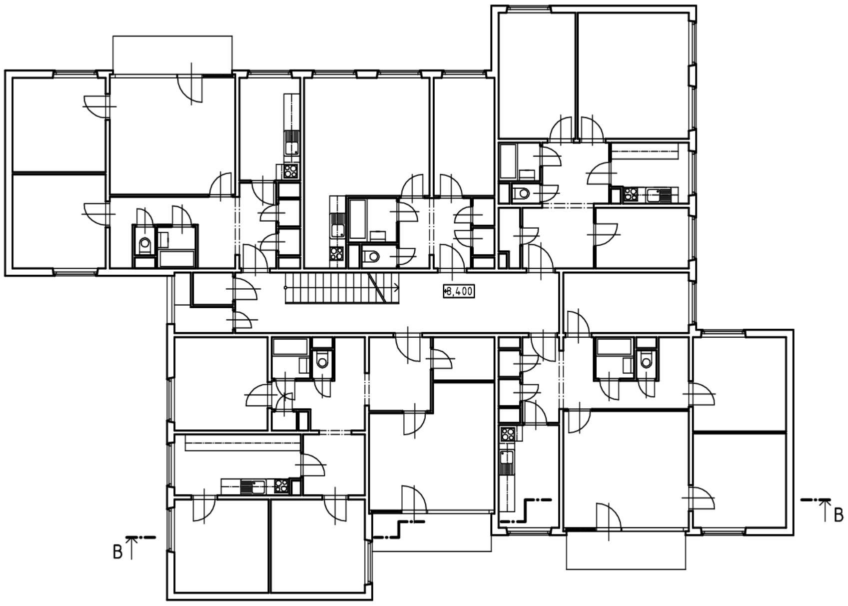
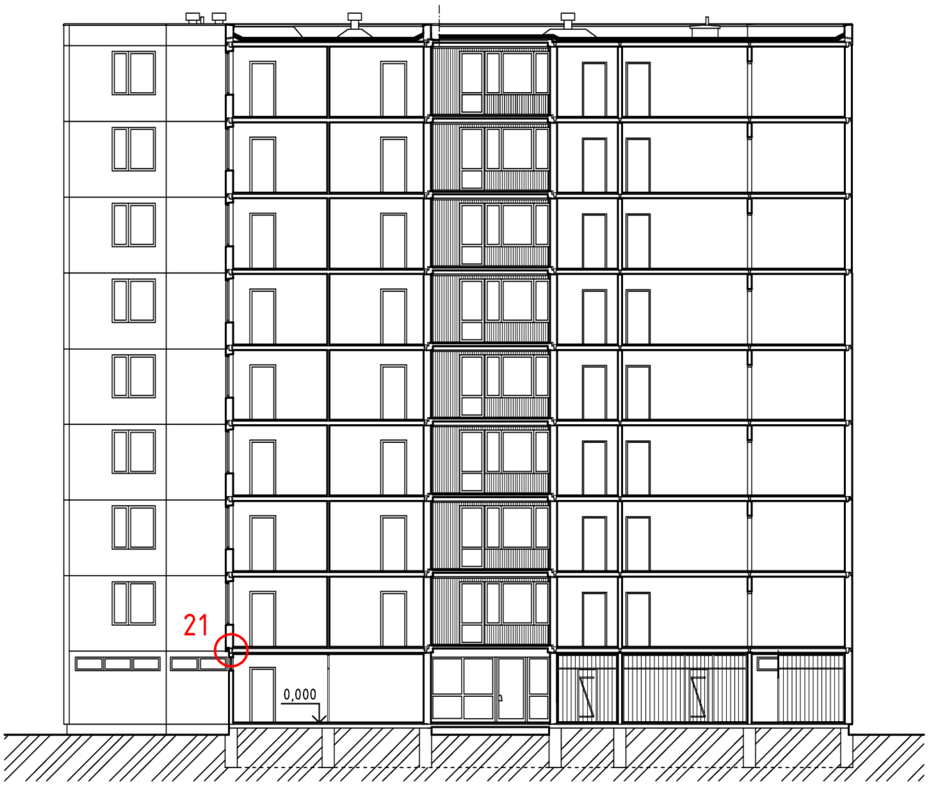
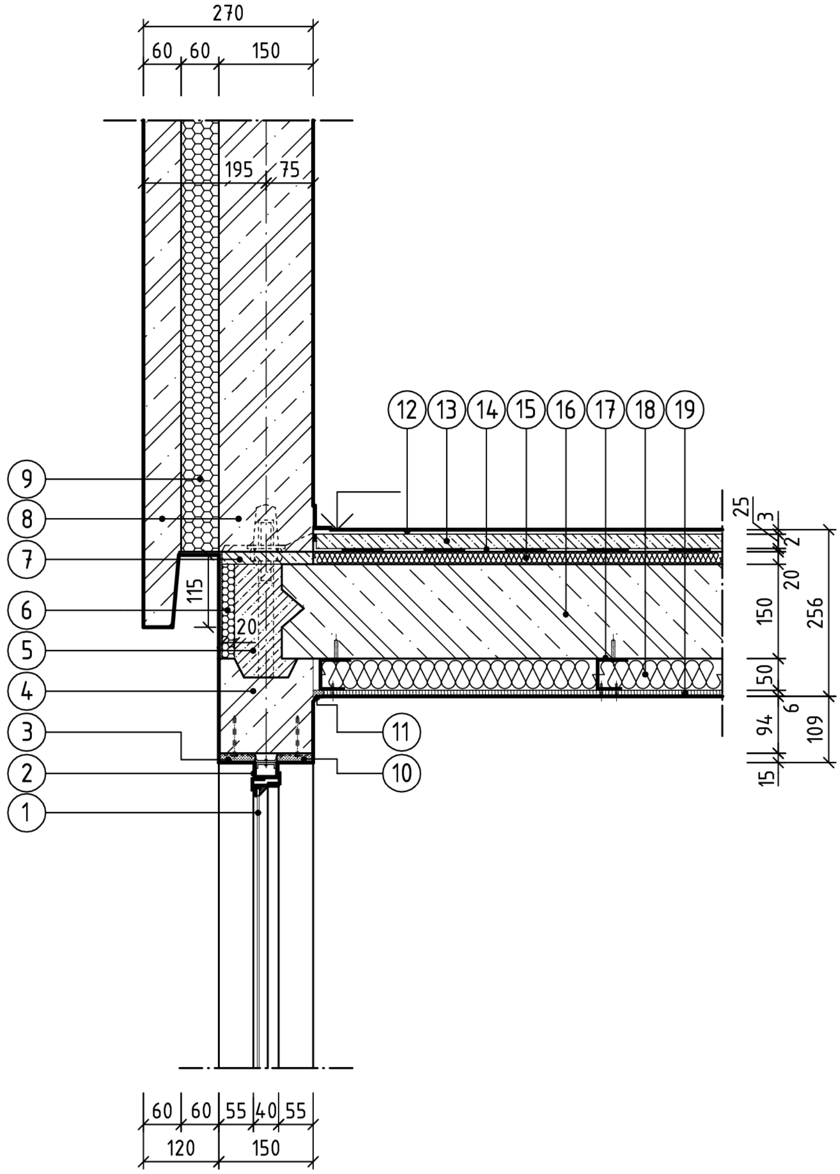
DETAIL 21
Floor plan

Section B-B


Table 4.21.2 – Structural composition of detail 21

DETAIL 21



Legend:

1. Glass 4 mm (λ = 1.00 W/(m.K))
2. Steel window (λ = 50 W/(m.K), λ = 0.5 W/(m.K))
3. Lime-cement plaster (λ = 0.99 W/(m.K))
4. Reinforced concrete (λ = 1.58 W/(m.K))
5. Concrete grout (λ = 1.36 W/(m.K))
6. Polystyrene foam th. 20 mm (λ = 0.044 W/(m.K))
7. Concrete grout (λ = 1.36 W/(m.K))
8. Reinforced concrete (λ = 1.58 W/(m.K))
9. Polystyrene foam (λ = 0.07 W/(m.K))
10. Lime plaster (λ = 0.88 W/(m.K))
11. Sealant (λ = 0.22 W/(m.K))
12. PVC + adhesive (λ = 0.16 W/(m.K))
13. Cement coating (λ = 1.02 W/(m.K))
14. Tar paper (λ = 0.21 W/(m.K))
15. Boards FIBREX (λ = 0.05 W/(m.K))
16. Reinforced concrete ceiling panel (λ = 1.34 W/(m.K))
17. Steel profile (λ = 40.0 W/(m.K))
18. Basalt felt (λ = 0.06 W/(m.K))
19. Particle boards (λ = 0.22 W/(m.K))

$U_{wall,1}$ = 0.862 W/(m^2.K)

U_{floor} = 0.566 W/(m^2.K)

Table 4.21.3 – Boundary conditions for a calculation detail 21

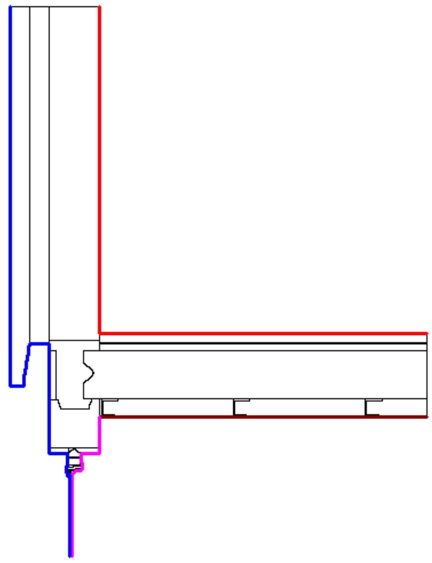
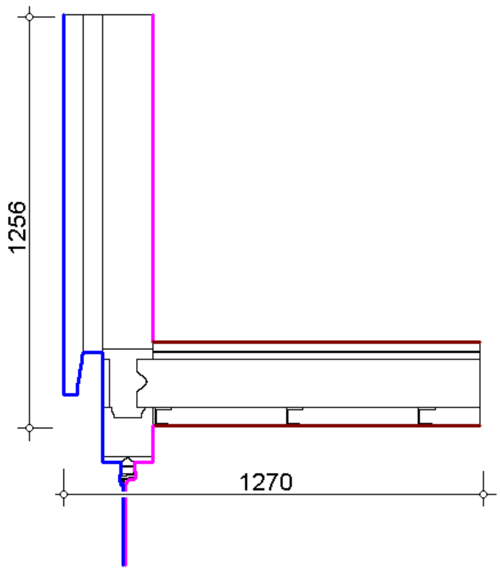
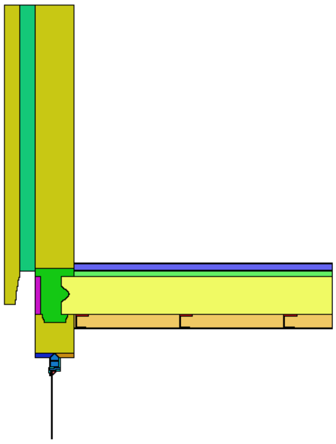
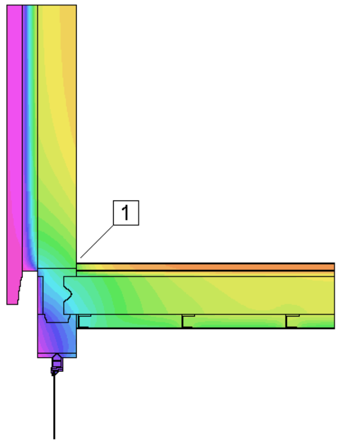
<table>
<tr><th colspan="3">DETAIL 21</th></tr>
<tr><th colspan="3">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td><td>Bound. condit. for unheated space</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td><td>θ_e = 2.5 °C
φ_e = 60 %
R_{se} = 0.17 m^2.K/W
R_{se} = 0.13 m^2.K/W</td></tr>
<tr><th colspan="3">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="3">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td><td>Bound. condit. for unheated space</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W
R_{si} = 0.17 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td><td>θ_e = 2.5 °C
φ_e = 60 %
R_{se} = 0.17 m^2.K/W
R_{se} = 0.13 m^2.K/W</td></tr>
</table>

Table 4.21.4 – Thermal-technical evaluation of detail 21

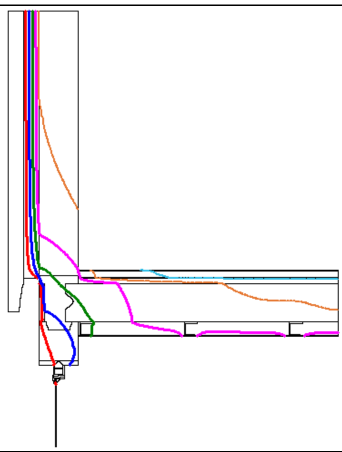
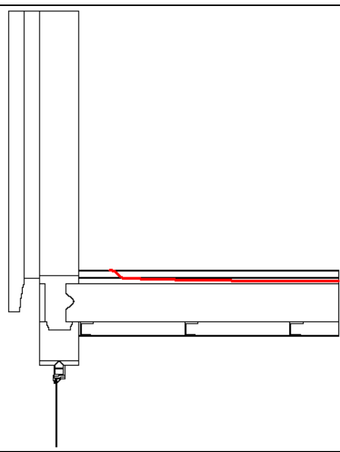
DETAIL 21

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

- λ = 0.220 W/(m.K)
- λ = 0.060 W/(m.K)
- λ = 1.340 W/(m.K)
- λ = 0.050 W/(m.K)
- λ = 0.210 W/(m.K)
- λ = 1.020 W/(m.K)
- λ = 0.160 W/(m.K)
- λ = 40.00 W/(m.K)
- λ = 0.880 W/(m.K)
- λ = 1.580 W/(m.K)
- λ = 1.360 W/(m.K)
- λ = 50.00 W/(m.K)
- λ = 0.500 W/(m.K)
- λ = 0.990 W/(m.K)
- λ = 1.000 W/(m.K)
- λ = 0.044 W/(m.K)
- λ = 0.070 W/(m.K)

-15.0 °C ... -11.5 °C
-11.5 °C ... -8.0 °C
-8.0 °C ... -4.5 °C
-4.5 °C ... -1.0 °C
-1.0 °C ... 2.5 °C
2.5 °C ... 6.0 °C
6.0 °C ... 9.5 °C
9.5 °C ... 13.0 °C
13.0 °C ... 16.5 °C
16.5 °C ... 20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C, -5 °C, 0 °C, 5 °C, 10 °C, 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 5.04 °C	-	θ_{si} = 5.04 °C < $\theta_{si,80}$ + $\Delta\theta_{si}$ = 13.12 °C	not meet
			NOTE: For more than two boundary conditions it is not possible to use the temperature factor. In calculation of ψ the value b_x is used.	
Linear thermal transmittance			ψ = 1.74528 - 0.862 × 1.256 - 0.566 × 1.270 × 0.5 = 0.303 W/(m.K)	

Table 4.22.1 – Marking of the position of detail in the building – detail 22

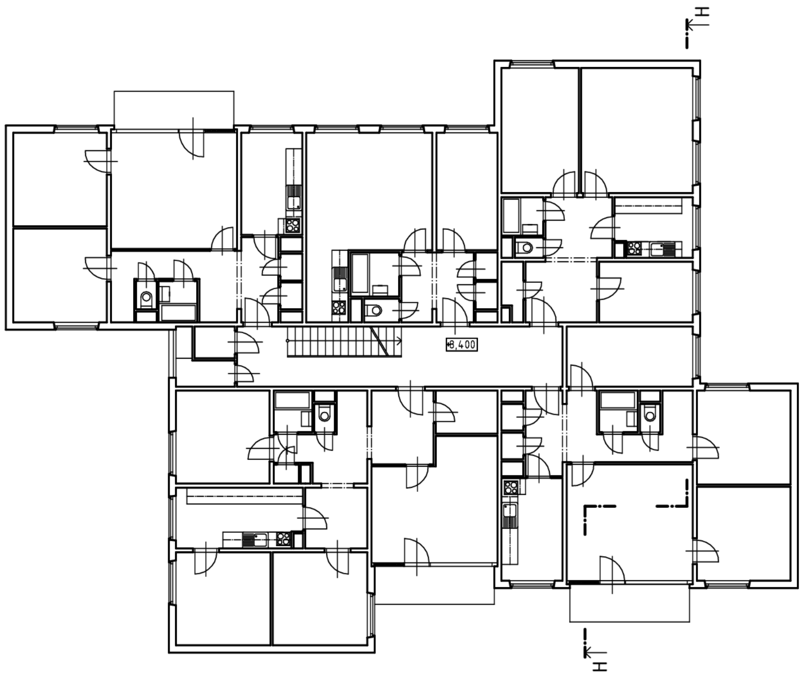
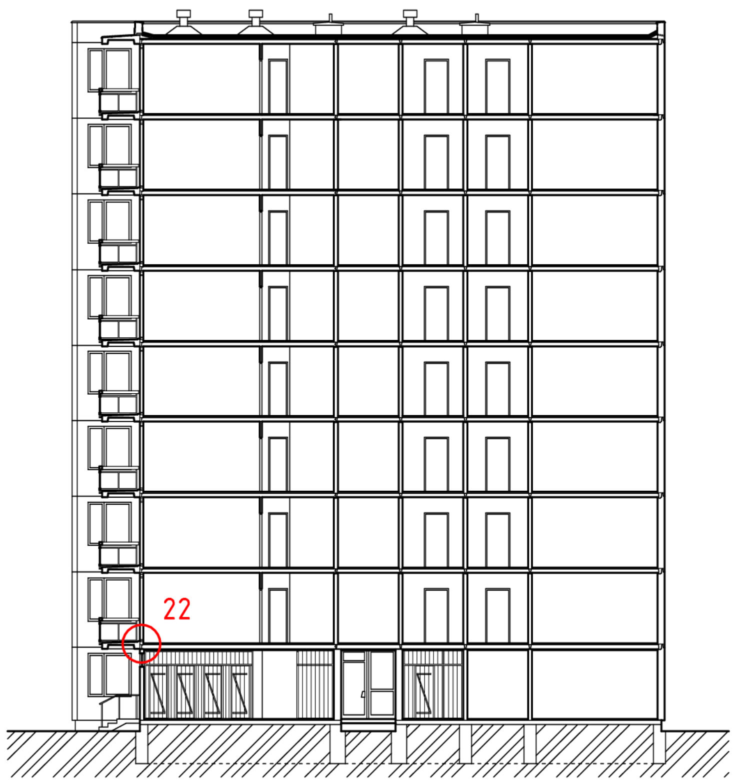
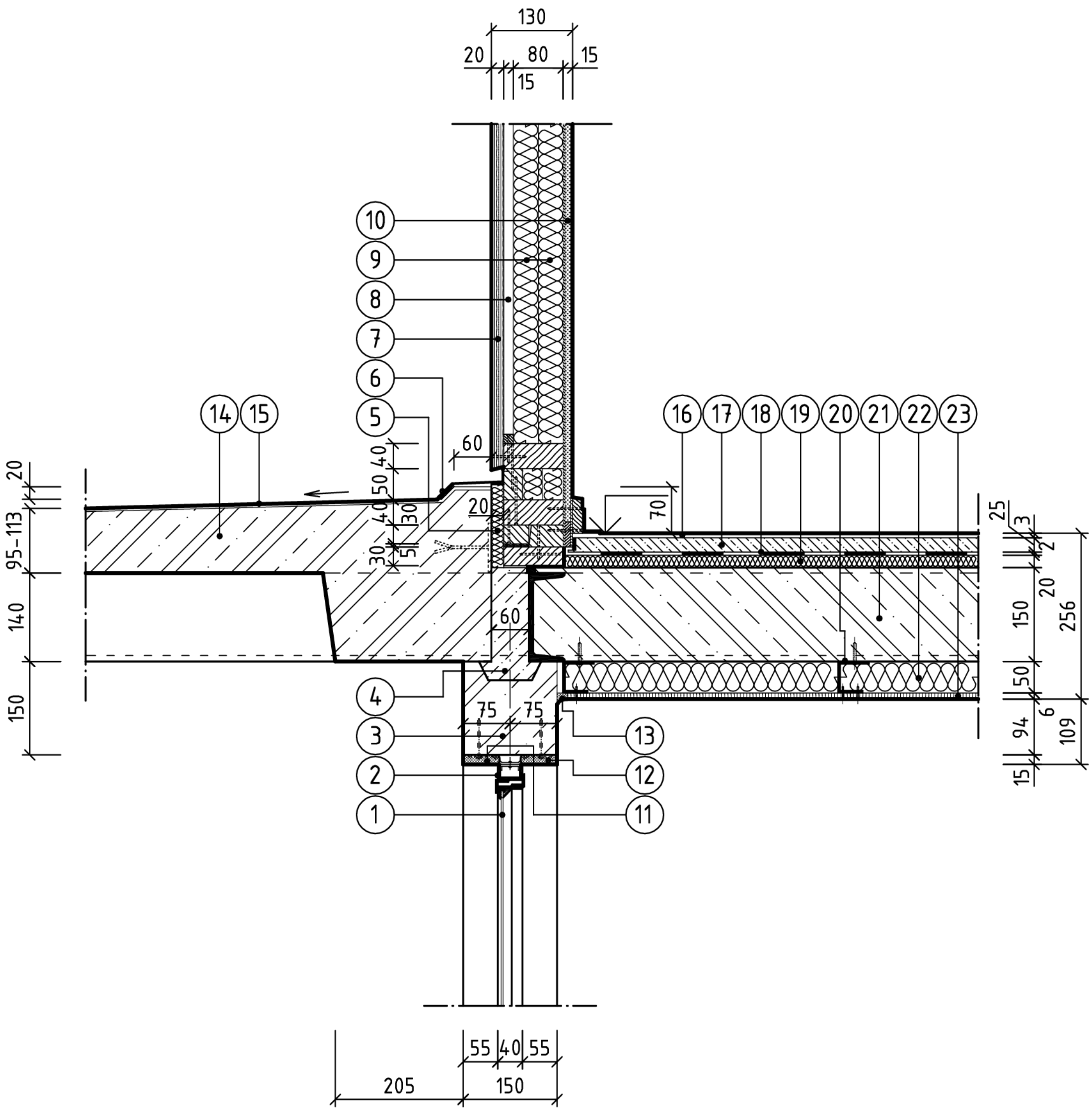
DETAIL 22
Floor plan

Section H-H


Table 4.22.2 – Structural composition of detail 22

DETAIL 22



Legend:

1. Glass 4 mm (λ = 1.00 W/(m.K))
2. Steel window (λ = 50 W/(m.K), λ = 0.5 W/(m.K))
3. Reinforced concrete (λ = 1.58 W/(m.K))
4. Concrete grout (λ = 1.36 W/(m.K))
5. Polystyrene foam th. 20 mm (λ = 0.044 W/(m.K))
6. Galvanized sheet metal (not considered in model)
7. Batten siding (λ = 0.18 W/(m.K))
8. Closed air gap (λ = 0.09 W/(m.K))
9. Basalt wool (λ = 0.07 W/(m.K))
10. Particle board (λ = 0.11 W/(m.K))
11. Lime-cement plaster (λ = 0.99 W/(m.K))
12. Lime plaster (λ = 0.88 W/(m.K))
13. Sealant (λ = 0.22 W/(m.K))
14. Loggia reinforced concrete panel (λ = 1.58 W/(m.K))
15. Coating (not considered in model)
16. PVC + adhesive (λ = 0.16 W/(m.K))
17. Cement coating (λ = 1.02 W/(m.K))
18. Tar paper (λ = 0.21 W/(m.K))
19. Boards FIBREX (λ = 0.05 W/(m.K))
20. Steel profile (λ = 40.0 W/(m.K))
21. Reinforced concrete ceiling panel (λ = 1.34 W/(m.K))
22. Basalt felt (λ = 0.06 W/(m.K))
23. Particle boards (λ = 0.22 W/(m.K))

$U_{wall,2}$ = 0.579 W/(m^2.K)

U_{floor} = 0.566 W/(m^2.K)

Table 4.22.3 – Boundary conditions for a calculation detail 22

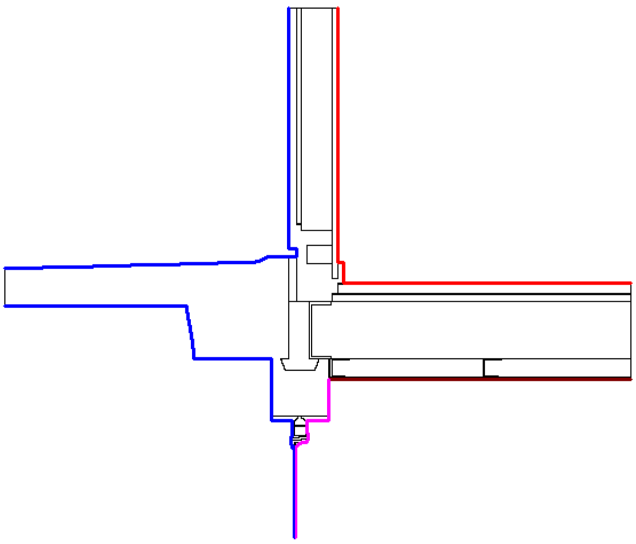
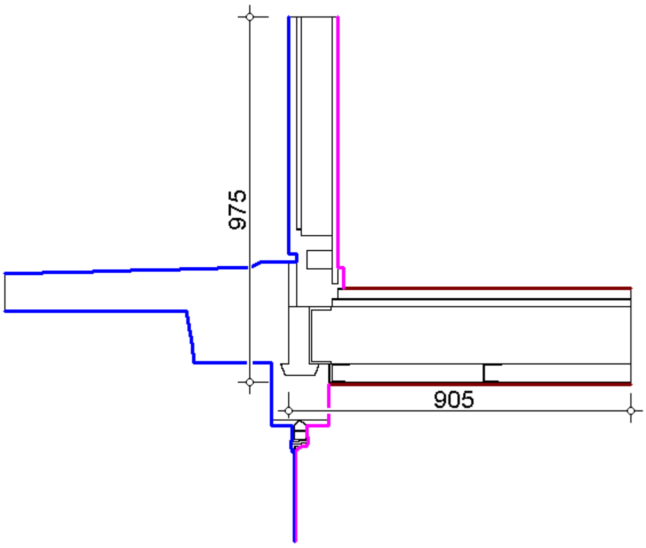
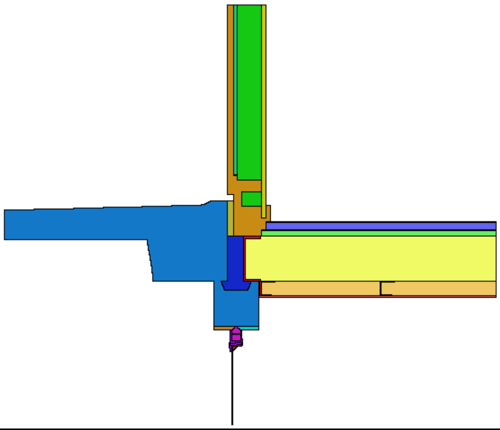
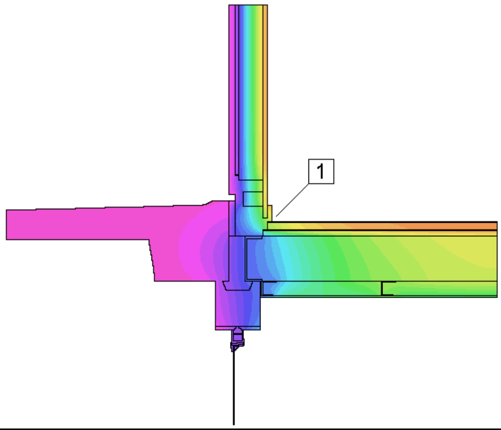
<table>
<tr><th colspan="3">DETAIL 22</th></tr>
<tr><th colspan="3">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td><td>Bound. condit. for unheated space</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td><td>θ_e = 2.5 °C
φ_e = 60 %
R_{se} = 0.17 m^2.K/W
R_{se} = 0.13 m^2.K/W</td></tr>
<tr><th colspan="3">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="3">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td><td>Bound. condit. for unheated space</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W
R_{si} = 0.17 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td><td>θ_e = 2.5 °C
φ_e = 60 %
R_{se} = 0.17 m^2.K/W
R_{se} = 0.13 m^2.K/W</td></tr>
</table>

Table 4.22.4 – Thermal-technical evaluation of detail 22

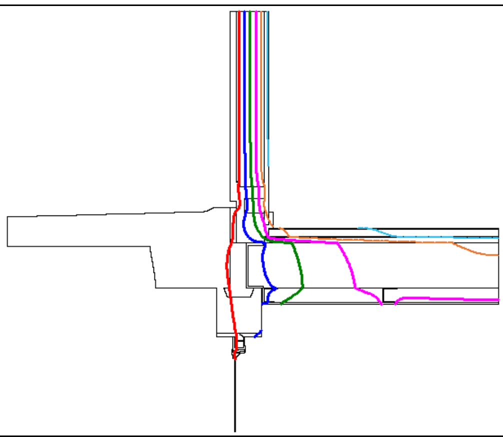
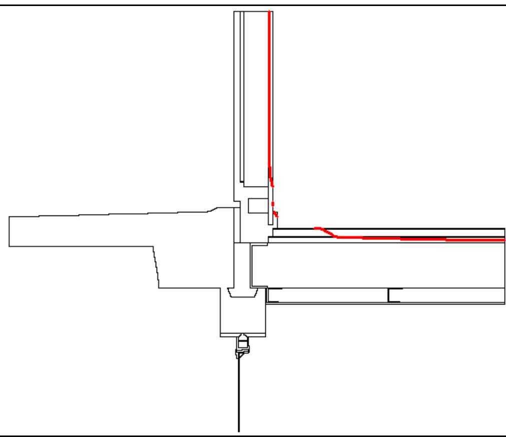
DETAIL 22

Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

λ = 0.220 W/(m.K)	λ = 0.880 W/(m.K)
λ = 0.060 W/(m.K)	λ = 1.580 W/(m.K)
λ = 1.340 W/(m.K)	λ = 1.360 W/(m.K)
λ = 0.050 W/(m.K)	λ = 50.00 W/(m.K)
λ = 0.210 W/(m.K)	λ = 0.500 W/(m.K)
λ = 1.020 W/(m.K)	λ = 0.090 W/(m.K)
λ = 0.160 W/(m.K)	λ = 0.220 W/(m.K)
λ = 40.00 W/(m.K)	λ = 0.990 W/(m.K)
λ = 0.180 W/(m.K)	λ = 0.044 W/(m.K)
λ = 0.110 W/(m.K)	λ = 1.000 W/(m.K)
λ = 0.070 W/(m.K)	

-15.0 °C	...	-11.5 °C
-11.5 °C	...	-8.0 °C
-8.0 °C	...	-4.5 °C
-4.5 °C	...	-1.0 °C
-1.0 °C	...	2.5 °C
2.5 °C	...	6.0 °C
6.0 °C	...	9.5 °C
9.5 °C	...	13.0 °C
13.0 °C	...	16.5 °C
16.5 °C	...	20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C, -5 °C, 0 °C, 5 °C, 10 °C, 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 9.14 °C	-	θ_{si} = 9.14 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
			NOTE: For more than two boundary conditions it is not possible to use the temperature factor. In calculation of ψ the value b_x is used.	
Linear thermal transmittance			ψ = 0.97074 - 0.579 × 0.975 - 0.566 × 0.905 × 0.5 = 0.150 W/(m.K)	

Table 4.23.1 – Marking of the position of detail in the building – detail 23

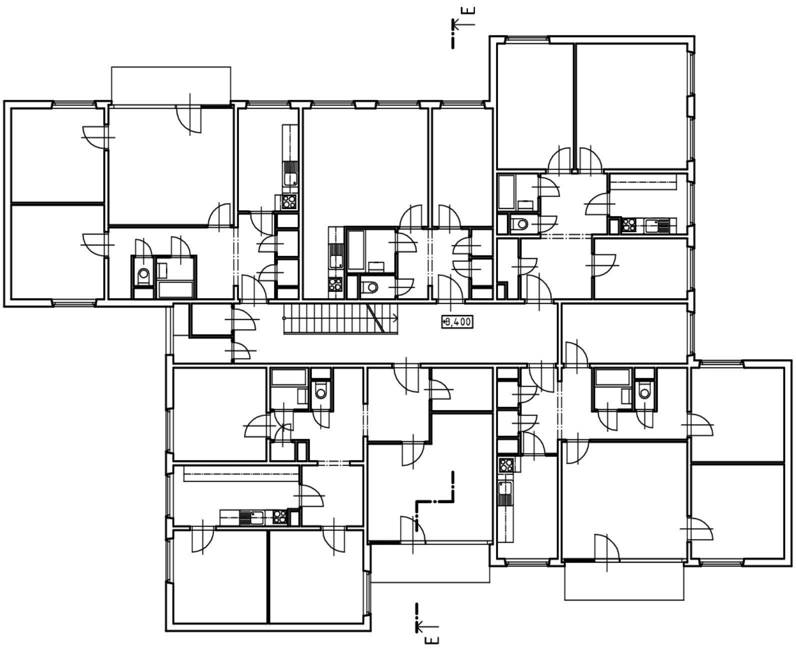
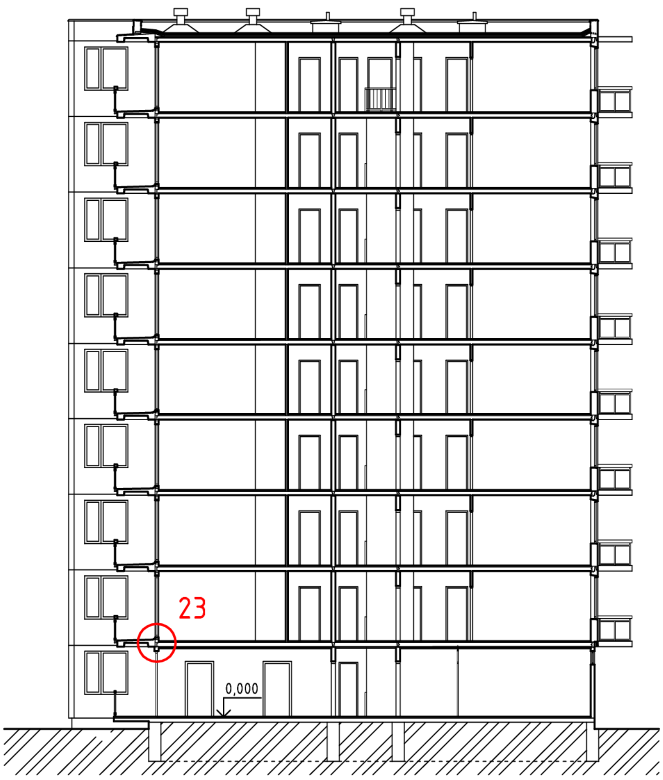
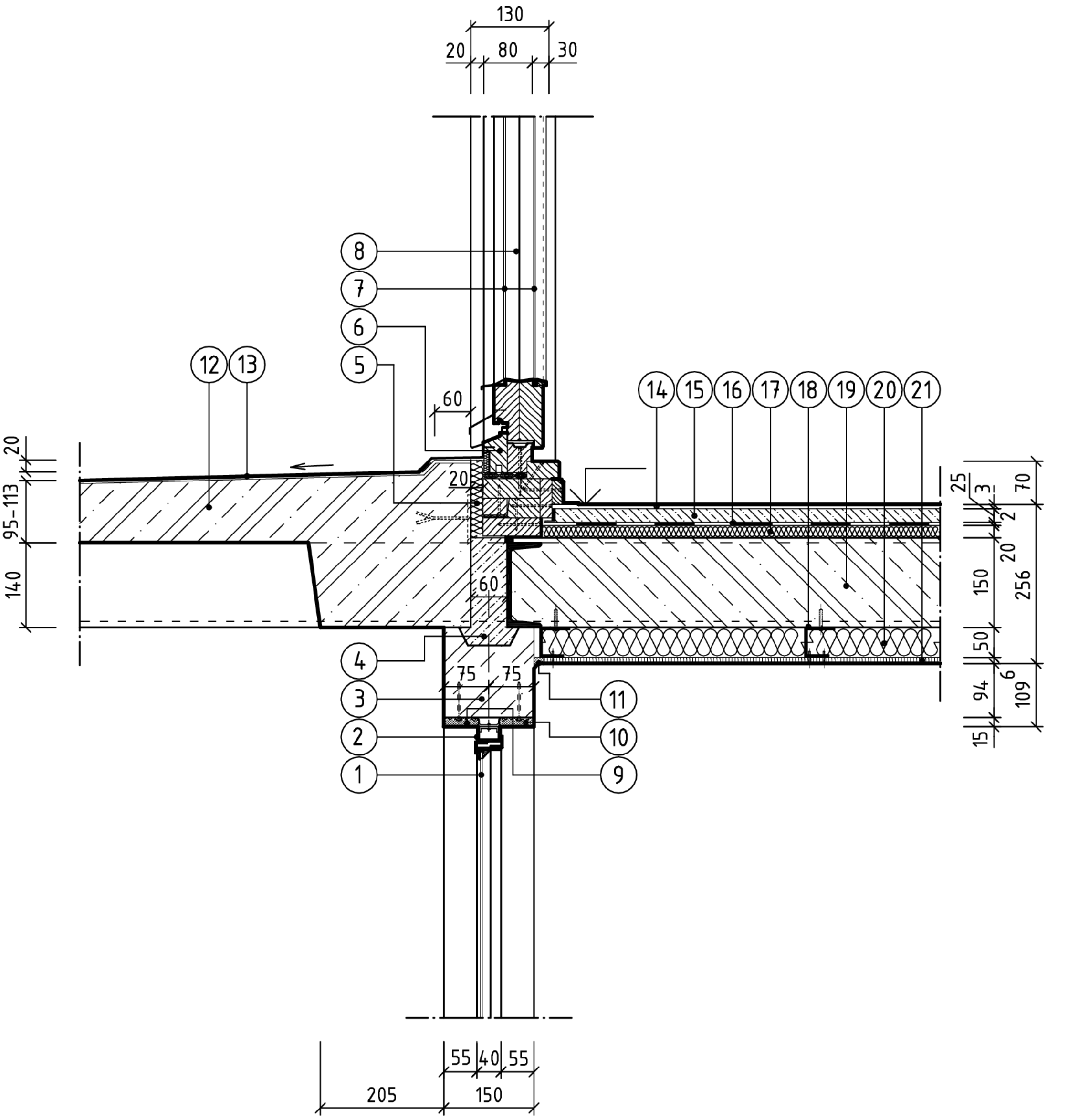
DETAIL 23
Floor plan

Section E-E


Table 4.23.2 – Structural composition of detail 23

DETAIL 23



Legend:

1. Glass 3 mm (λ = 1.00 W/(m.K))
2. Steel window (λ = 50 W/(m.K), λ = 0.5 W/(m.K))
3. Reinforced concrete (λ = 1.58 W/(m.K))
4. Concrete grout (λ = 0.88 W/(m.K))
5. Polystyrene foam th. 20 mm (λ = 0.044 W/(m.K))
6. Wooden loggia door frame (λ = 0.18 W/(m.K))
7. Glass 3 mm (λ = 1.00 W/(m.K))
8. Closed air gap 37 mm (λ = 0.88 W/(m.K))
9. Lime-cement plaster (λ = 0.99 W/(m.K))
10. Lime plaster (λ = 0.88 W/(m.K))
11. Sealant (λ = 0.22 W/(m.K))
12. Loggia reinforced concrete panel (λ = 1.58 W/(m.K))
13. Coating (not considered in model)
14. PVC + adhesive (λ = 0.16 W/(m.K))
15. Cement coating (λ = 1.02 W/(m.K))
16. Tar paper (λ = 0.21 W/(m.K))
17. Boards FIBREX (λ = 0.05 W/(m.K))
18. Steel profile (λ = 40.0 W/(m.K))
19. Reinforced concrete ceiling panel (λ = 1.34 W/(m.K))
20. Basalt felt (λ = 0.06 W/(m.K))
21. Particle boards (λ = 0.22 W/(m.K))

$U_{window, wooden}$ = 2.579 W/(m^2.K) **U_{floor} = 0.566 W/(m^2.K)** **$U_{wall,2}$ = 0.579 W/(m^2.K)**

Table 4.23.3 – Boundary conditions for a calculation detail 23

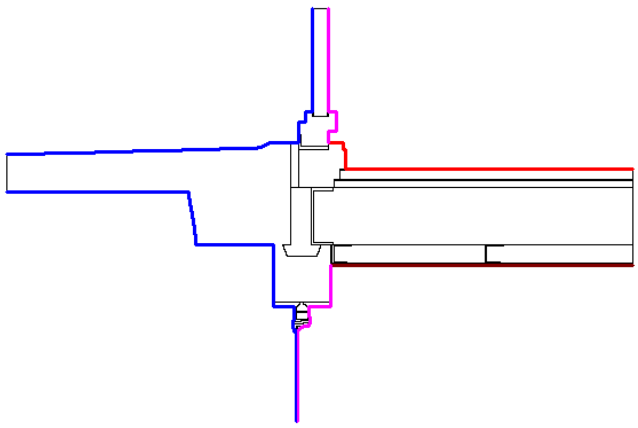
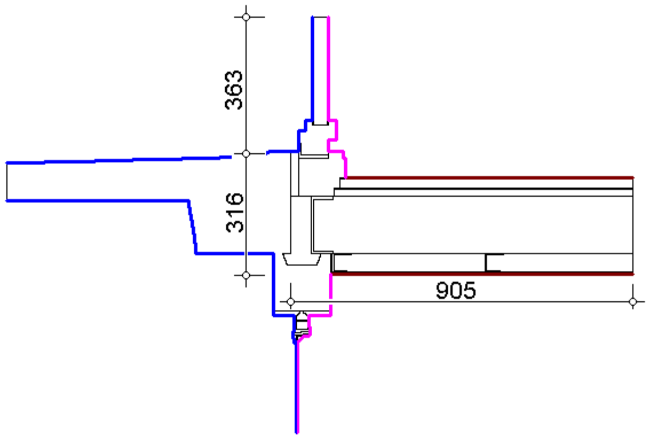
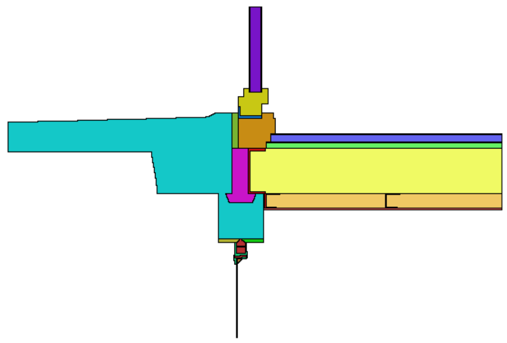
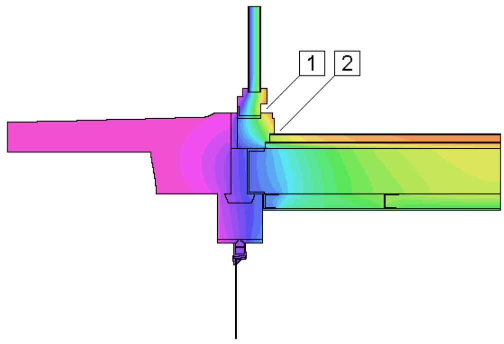
<table>
<tr><th colspan="3">DETAIL 23</th></tr>
<tr><th colspan="3">Boundary conditions for calculation of surface temperatures</th></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td><td>Bound. condit. for unheated space</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.25 m^2.K/W
R_{si} = 0.13 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td><td>θ_e = 2.5 °C
φ_e = 60 %
R_{se} = 0.17 m^2.K/W
R_{se} = 0.13 m^2.K/W</td></tr>
<tr><th colspan="3">Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance</th></tr>
<tr><td colspan="3">
</td></tr>
<tr><td>Boundary conditions for interior</td><td>Boundary conditions for exterior</td><td>Bound. condit. for unheated space</td></tr>
<tr><td>θ_i = 20 °C
φ_i = 50 %
R_{si} = 0.13 m^2.K/W
R_{si} = 0.17 m^2.K/W</td><td>θ_e = -15 °C
φ_e = 84 %
R_{se} = 0.04 m^2.K/W</td><td>θ_e = 2.5 °C
φ_e = 60 %
R_{se} = 0.17 m^2.K/W
R_{se} = 0.13 m^2.K/W</td></tr>
</table>

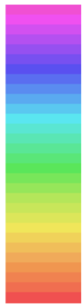
Table 4.23.4 – Thermal-technical evaluation of detail 23

DETAIL 23

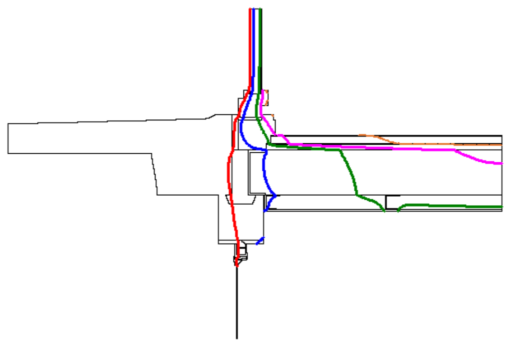
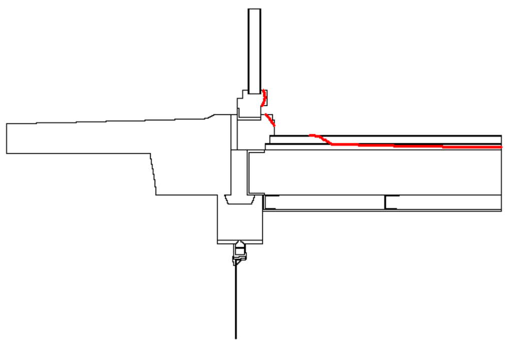
Modeled detail with marking the materials	Temperature field with marked critical temperatures
	

Legend:

λ = 0.220 W/(m.K)	λ = 1.580 W/(m.K)
λ = 0.060 W/(m.K)	λ = 0.070 W/(m.K)
λ = 1.340 W/(m.K)	λ = 1.000 W/(m.K)
λ = 0.050 W/(m.K)	λ = 0.204 W/(m.K)
λ = 0.210 W/(m.K)	λ = 1.360 W/(m.K)
λ = 1.020 W/(m.K)	λ = 50.00 W/(m.K)
λ = 0.160 W/(m.K)	λ = 0.500 W/(m.K)
λ = 40.00 W/(m.K)	λ = 0.220 W/(m.K)
λ = 0.180 W/(m.K)	λ = 0.990 W/(m.K)
λ = 0.180 W/(m.K)	λ = 0.044 W/(m.K)
λ = 0.880 W/(m.K)	



-15.0 °C	... -11.5 °C
-11.5 °C	... -8.0 °C
-8.0 °C	... -4.5 °C
-4.5 °C	... -1.0 °C
-1.0 °C	... 2.5 °C
2.5 °C	... 6.0 °C
6.0 °C	... 9.5 °C
9.5 °C	... 13.0 °C
13.0 °C	... 16.5 °C
16.5 °C	... 20.0 °C

Representation of characteristic isotherms	Representation of the critical isotherm
	
-10 °C -5 °C 0 °C 5 °C 10 °C 15 °C	13.12 °C

Point	Temperature	Temperat. factor	Evaluation of hygienic criterion	Rating
1	θ_{si} = 10.34 °C	-	θ_{si} = 9.56 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C	not meet
2	θ_{si} = 9.56 °C	-	**NOTE:** For more than two boundary conditions it is not possible to use the temperature factor. In calculation of ψ the value b_x is used.	
Linear thermal transmittance			ψ = 1.49608 - 2.579 × 0.363 - 0.579 × 0.316 - 0.566 × 0.905 × 0.5 ψ = 0.121 W/(m.K)	

Table 4.24.1 – Marking of the position of detail in the building – detail 24

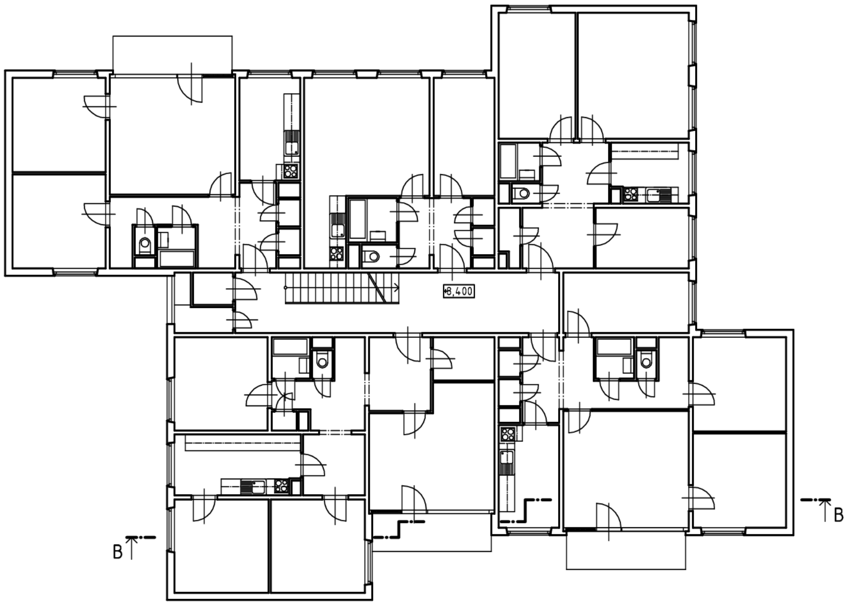
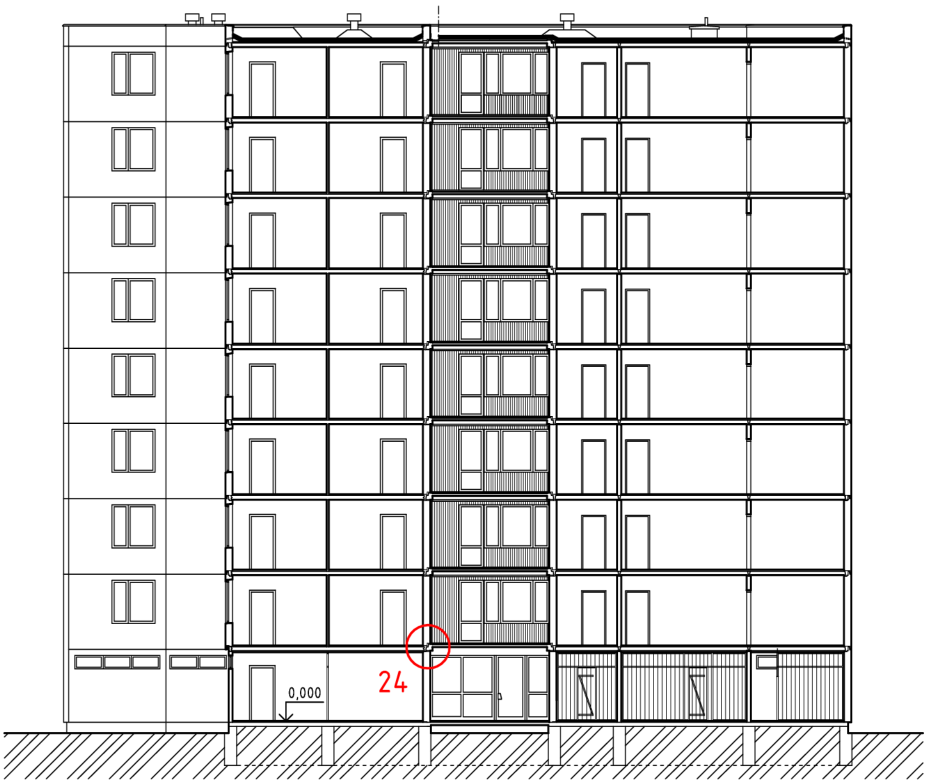
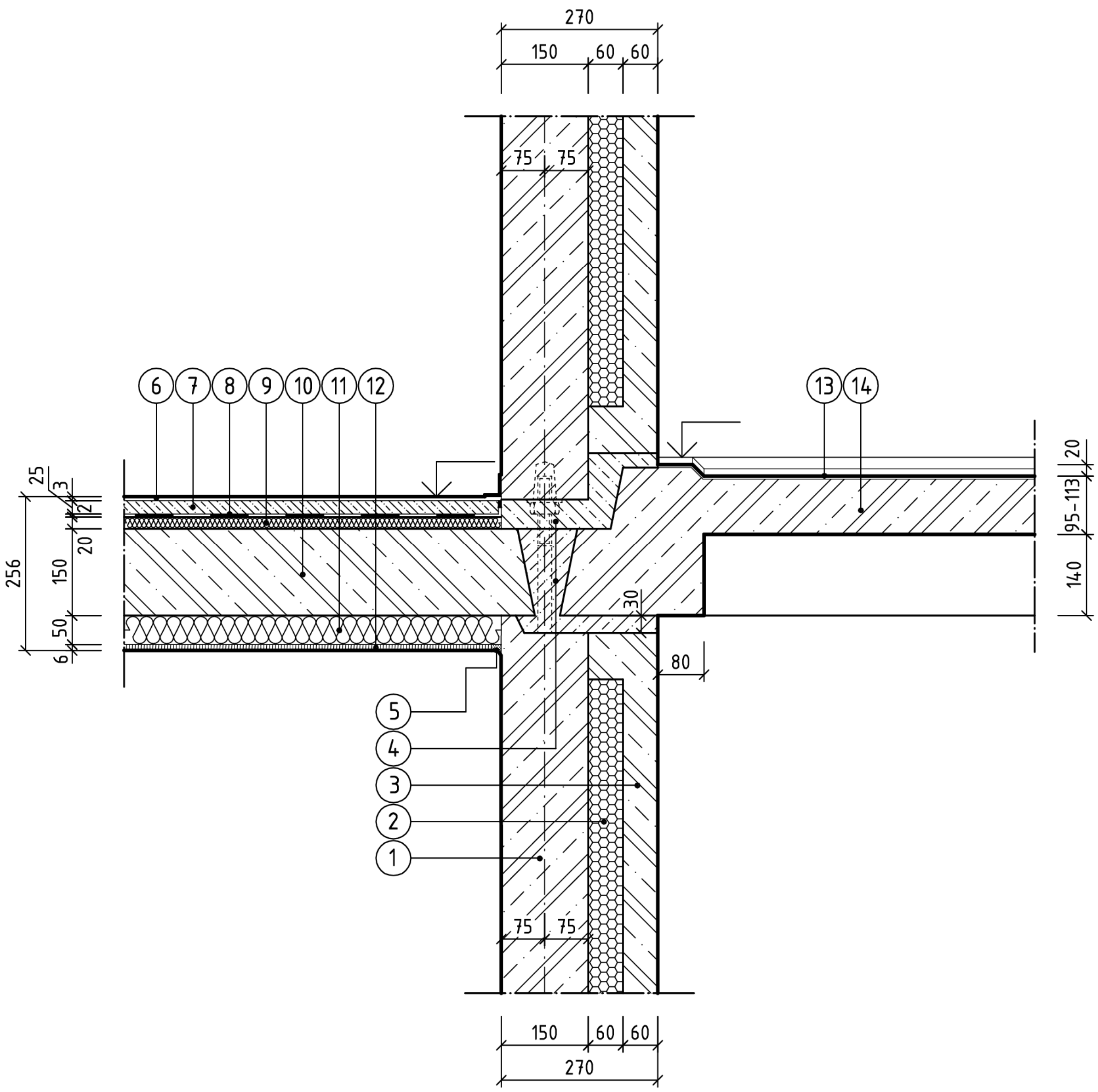
DETAIL 24
Floor plan

Section B-B


Table 4.24.2 – Structural composition of detail 24

DETAIL 24



Legend:

1. Reinforced concrete (λ = 1.58 W/(m.K))
2. Polystyrene foam (λ = 0.07 W/(m.K))
3. Reinforced concrete (λ = 1.58 W/(m.K))
4. Concrete grout (λ = 1.36 W/(m.K))
5. Sealant (λ = 0.22 W/(m.K))
6. PVC + adhesive (λ = 0.16 W/(m.K))
7. Cement coating (λ = 1.02 W/(m.K))
8. Tar paper (λ = 0.21 W/(m.K))
9. Boards FIBREX (λ = 0.05 W/(m.K))
10. Reinforced concrete ceiling panel (λ = 1.34 W/(m.K))
11. Basalt felt (λ = 0.06 W/(m.K))
12. Particle boards (λ = 0.22 W/(m.K))
13. Coating (not considered in model)
14. Loggia reinforced concrete panel (λ = 1.58 W/(m.K))

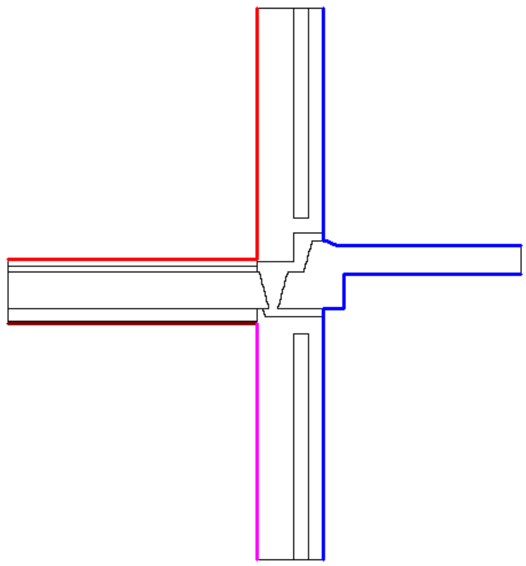
$U_{wall,1}$ = 0.862 W/(m^2.K)

U_{floor} = 0.566 W/(m^2.K)

Table 4.24.3 – Boundary conditions for a calculation detail 24

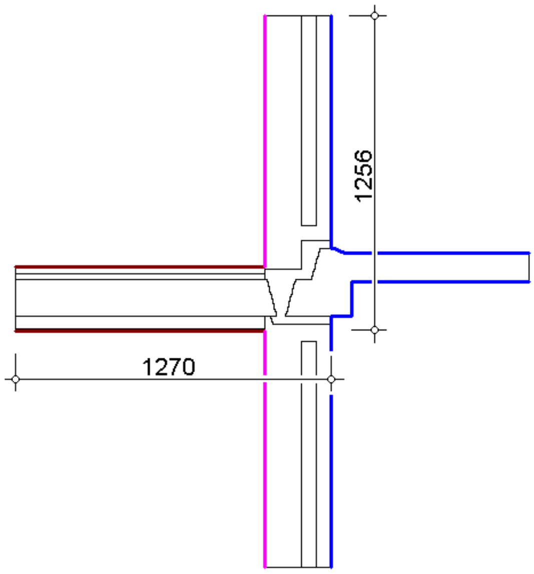
DETAIL 24

Boundary conditions for calculation of surface temperatures



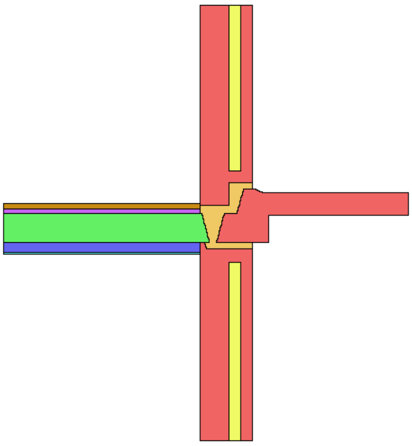
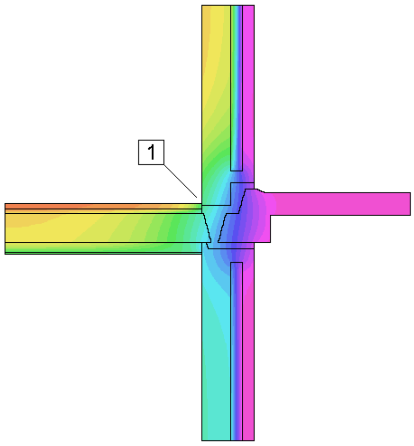
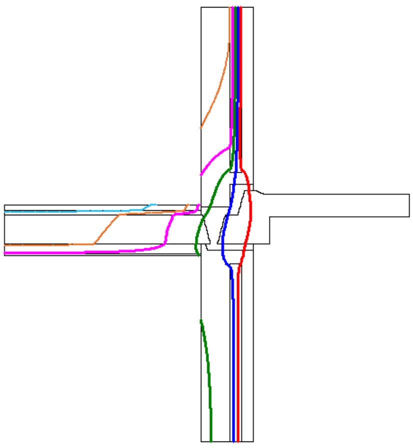
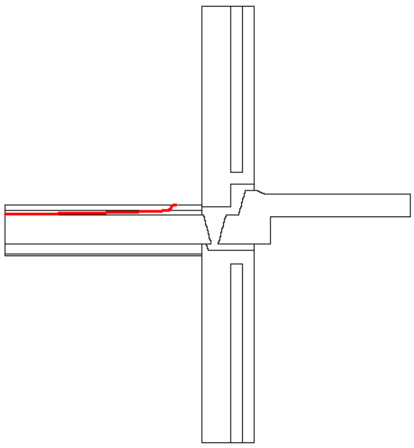
Boundary conditions for interior	Boundary conditions for exterior	Bound. condit. for unheated space
θ_i = 20 °C φ_i = 50 % (red line) R_{si} = 0.25 m^2.K/W	θ_e = -15 °C φ_e = 84 % (blue line) R_{se} = 0.04 m^2.K/W	θ_e = 2.5 °C φ_e = 60 % (dark red line) R_{se} = 0.17 m^2.K/W (magenta line) R_{se} = 0.13 m^2.K/W

Boundary conditions and corresponding lengths for a calculation of the linear thermal transmittance



Boundary conditions for interior	Boundary conditions for exterior	Bound. condit. for unheated space
θ_i = 20 °C φ_i = 50 % (magenta line) R_{si} = 0.13 m^2.K/W (dark red line) R_{si} = 0.17 m^2.K/W	θ_e = -15 °C φ_e = 84 % (blue line) R_{se} = 0.04 m^2.K/W	θ_e = 2.5 °C φ_e = 60 % (dark red line) R_{se} = 0.17 m^2.K/W (magenta line) R_{se} = 0.13 m^2.K/W

Table 4.24.4 – Thermal-technical evaluation of detail 24

<table>
<tr><th colspan="5">DETAIL 24</th></tr>
<tr><td colspan="3">Modeled detail with marking the materials</td><td colspan="2">Temperature field with marked critical temperatures</td></tr>
<tr><td colspan="3"></td><td colspan="2">
</td></tr>
<tr><td colspan="3">Legend:
λ = 1.580 W/(m.K)
λ = 1.360 W/(m.K)
λ = 0.070 W/(m.K)
λ = 1.340 W/(m.K)
λ = 0.220 W/(m.K)
λ = 0.060 W/(m.K)
λ = 0.050 W/(m.K)
λ = 0.210 W/(m.K)
λ = 1.020 W/(m.K)
λ = 0.160 W/(m.K)</td><td colspan="2">
-15.0 °C ... -11.5 °C
-11.5 °C ... -8.0 °C
-8.0 °C ... -4.5 °C
-4.5 °C ... -1.0 °C
-1.0 °C ... 2.5 °C
2.5 °C ... 6.0 °C
6.0 °C ... 9.5 °C
9.5 °C ... 13.0 °C
13.0 °C ... 16.5 °C
16.5 °C ... 20.0 °C</td></tr>
<tr><td colspan="3">Representation of characteristic isotherms</td><td colspan="2">Representation of the critical isotherm</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="3">-10 °C
-5 °C
0 °C
5 °C
10 °C
15 °C</td><td colspan="2">13.12 °C</td></tr>
<tr><th>Point</th><th>Temperature</th><th>Temperat. factor</th><th>Evaluation of hygienic criterion</th><th>Rating</th></tr>
<tr><td>1</td><td>θ_{si} = 2.79 °C</td><td>-</td><td>θ_{si} = 2.79 °C < $\theta_{si,80} + \Delta\theta_{si}$ = 13.12 °C</td><td>not meet</td></tr>
<tr><td></td><td></td><td></td><td colspan="2" rowspan="2">NOTE: For more than two boundary conditions it is not possible to use the temperature factor. In calculation of ψ the value b_x is used.</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Linear thermal transmittance</td><td colspan="2">ψ = 1.95855 - 0.862 × 1.256 - 0.566 × 1.270 × 0.5 = 0.516 W/(m.K)</td></tr>
</table>

5 Conclusion

This part of the publication solved problems of thermal-technical calculation, analysis and evaluation of envelope constructions, windows, and selected details of detached panel apartment house, built in structural system B 70, in its original state. The analysis of the results in chapter 2 showed that none of the envelope constructions meet the required standard values. It follows that, all envelope constructions must be renovated by additional themal insulation and windows must be replaced. In chapter 4, were evaluated 24 details of the building from the point of view of the hygienic criterion. The linear thermal transmittance was calculated, as well. The results showed that only three details meet the requirement of the standard on hygienic criterion.

The evaluation of another details and their thermal-technical parameters is in the second part of the publication titled Complex Thermal-Technical Analysis of the Detached Panel Apartment House of Type B 70 in Original State (Part 2).

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