CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

K124 DEPARTMENT OF ARCHITECTURAL ENGINEERING

DIPLOMA PROJECT

APARTMENT BUILDING

Student: Bc. Dayana Muratova 2022

CZECH TECHNICAL UNIVERSITY IN PRAGUE
Faculty of Civil Engineering
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DIPLOMA THESIS ASSIGNMENT FORM

I. PERSONAL AND STUDY DATA

Surname: Muratova Name: Dayana Personal number: 468550

Assigning Department: K124 Building Structures

Study programme: Civil Engineering

Branch of study: Building Structures

II. DIPLOMA THESIS DATA

Diploma Thesis (DT) title: Apartment building - Prague Letňany

Diploma Thesis title in English: Apartment building - Prague -Letňany

Instructions for writing the thesis:
The design of the new residential apartment building in Prague(Letňany zahrádky) Requirements for the apartment buildings to solve technical solution of the structures.
Envelop of the building - thermal evaluation of new buildings save energy performance and calculation.
Elaboration of documentation for building permit of a given building - technical report, drawing documentation, static design and calculation assessment of load-bearing elements and and fire safery solution in accordance with applicable Czech standard norms.

List of recommended literature:

1. Hollis M.: Surveying Buildings, RICS Books 2007
2. Assessment of Traditional Housing, BRE Watford, 2001
3. Whitlow R.: Materials and Structures, Longman 1992
4. Foster J.S.: Structures and Fabric, Parts I - III, Longman 1994
5. Schodek, D.: Structures- Pearson. New Yersay. 2004
6. Hanaor, A. : Principles of structures. Blackwell Science. 1998
7 Reguation No. 268/2009 Coll. (Regulation on technical requirements for constructions) of Act No. 183/2006 Coll.
8 Standards related to the Building Regulations
9 The Construction of Buildings, Barry R. BSP 1989
10 Prague Building Regulations
11 Study materials from the study at Faculty of Civil Engineering - CTU in Prague

Name of Diploma Thesis Supervisor: Ing. Malila Noori, Ph.D.

DT assignment date: 29.09.2021 DT submission date: 02.01.2022

DT Supervisor's signature Head of Department's signature

III. ASSIGNMENT RECEIPT

I declare that I am obliged to write the Diploma Thesis on my own, without anyone's assistance, except for provided consultations. The list of references, other sources and consultants' names must be stated in the Diploma Thesis and in referencing I must abide by the CTU methodological manual "How to Write University Final Theses" and the CTU methodological instruction "On the Observation of Ethical Principles in the Preparation of University Final Theses".

Assignment receipt date Student's name

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

K124 DEPARTMENT OF ARCHITECTURAL ENGINEERING

TECHNICAL REPORT

Designed by: Bc. Dayana Muratova

Consulted with: Ing. Malila Noori, Ph.D.

Annotation

The master project presents the architectural engineering design of the residential apartment building, which was solved and designed in five parts. The main civil engineering part deals with the technical solution, focusing on drawings such as plan views, sections, façade views and details. The structural part describes structural behavior of the load-bearing elements of the building, including preliminary design calculation. The foundation part describes subsoil interaction with the building. The building services part deals with the design of drainage, water and heat supply, including ventilation system. The last, fire safety part of the project is related to the proper design of building safety, preventing from fire incidents. This master project is solved according to the Czech standard norms.

Keywords: *residential building, structural solution, engineering, architectural design*.

CONTENT

1 Location of the apartment building

The area of the apartment building is located in the city district of Prague 9 – Letňany, parcels No. 760/64, 760/66. Designed building is a part of a residential complex “Letňany gardens” – building M. The building is not located in a seismically active area, inundation (flood) area or in the area affected by slope movement.

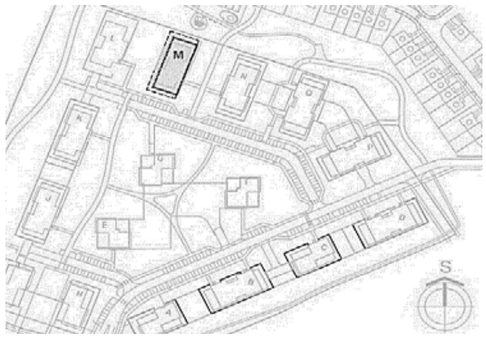


Fig. 1: Situation.

1.1 General information

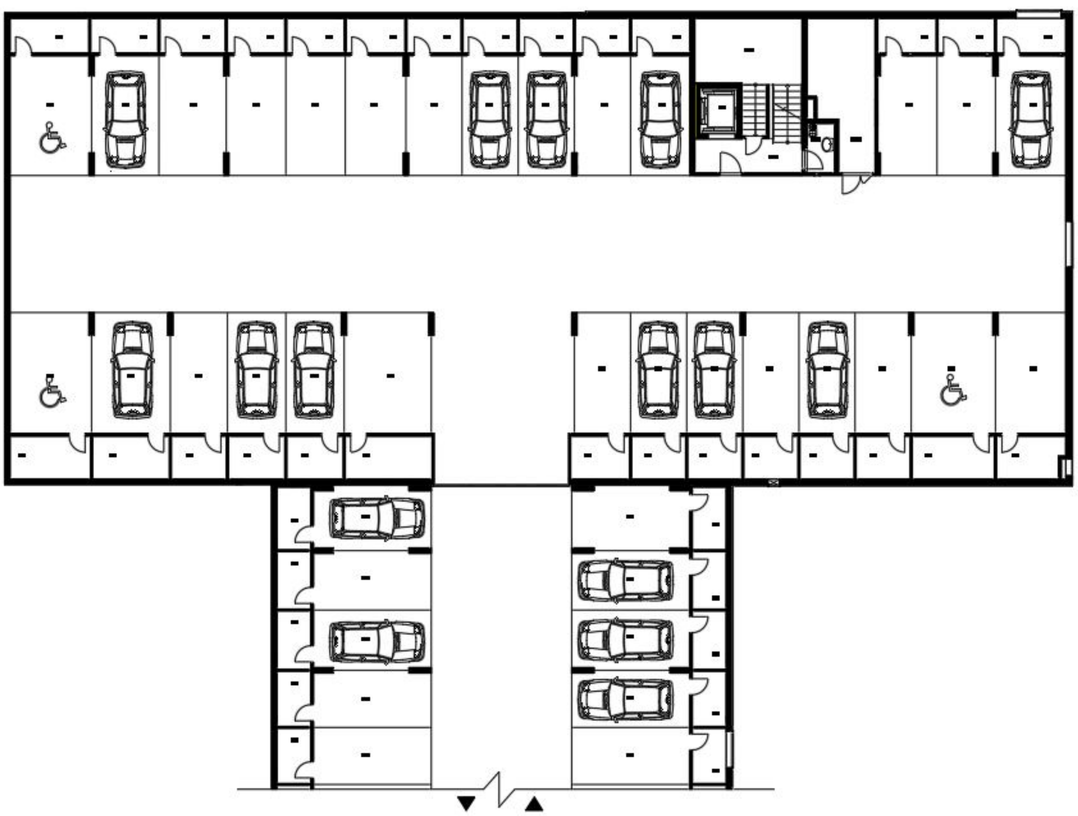


Fig. 2: Architectural plan of the underground floor.

Fig. 3: Architectural plan of the 1st floor.

The residential building contains 1 underground floor and 4 upper-ground floors. The area of underground floor is 47.6 x 20.6 m. The upper ground floors from 1 to 3 occupy an area of 47.5 x 20.7 m. The 4th floor recedes to the middle of the floor plan and has dimensions of 33.2 x 19.8 m. Total building height is 12.62 m. Underground floor's height is 2.97 m and upper typical floors have 2.80 m of height. There are 38 parking spaces, 38 storage rooms, 1 technical room and 1 cleaning room on the underground floor. Access to the garage side is provided by the entrance in object L through connecting neck between two buildings. On the 1st floor there are the main entrance to the building, stroller room and 10 apartments. There are 22 apartments in total on the 2nd – 3rd floors and 6 apartments on the 4th floor. The roof is green non – walkable. The spaces protruding in front of the façade plane are considered as terraces and balconies.

2 Foundation

2.1 Geological situation

The building is defined in height uniform level ± 0,00 = 261,800 m above sea level. The basement floor is also uniformly on the elevation of 258.450 m above sea level. The elevation height means that the basement is basically set on the existing ground level. The upper layer of the soil with thickness of 0.8 - 0.9 m, there are loess and loess clays (GT3) with a mean thickness of 1.5 m. The groundwater in the floor plan of the underground section is located at a depth of approximately 2.6 – 2.8 m below the surface of the terrain. Thus, the object will be supported on large piles which will be aligned to the level of the upper edge of the base concrete.

The foundation slab will be concreted to the concrete base of thickness 100 mm through separation foil, which ensures partial elimination of deformations. Designed separation is 2xPE geotextile foil with thickness of 0.20 mm.

2.2 Excavation

The excavation will be provided for the underground level. The excavation area is composed of backfill soil and gravel 16/32, compacted on bearing capacity of soil.

2.3 Piles

The apartment building will be based deeply on large-diameter piles with a diameter of 600 and 900 mm. The compacted embankment will be overfilled with layer of min. 300 mm, which will form a plain for drilling piles of deep foundation. Drilled piles will be stuck min. 0.5 m to the environment of kaolinitic sandstone (GT7). The pile heads will be aligned to the level of the upper edge of the base concrete. Calculation is provided in “Part 3” of the documentation.

2.4 Radon load

The site has a mean radon index based on assessment of radon volume activity in soil air and soil gas permeability. The proposed method of waterproofing the substructure and air – ventilated basement areas provide sufficient protection in terms of risk of intrusion radon from the subsoil into the building (according to ČSN 73 0601).

3 Structural design

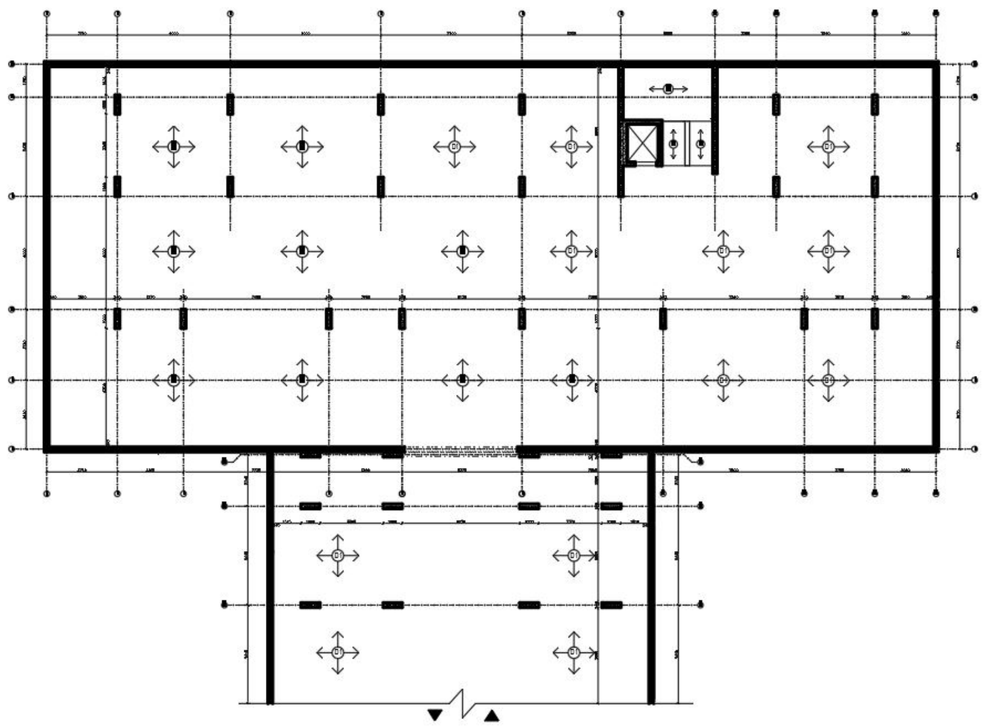


Fig. 4: Structural system of the underground floor.

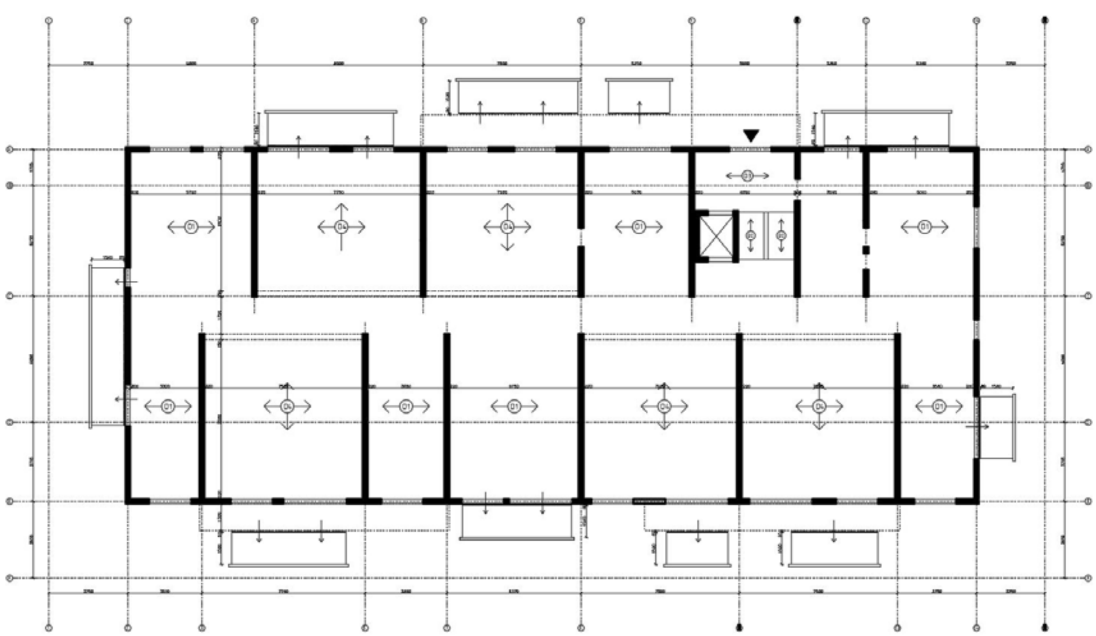


Fig. 5: Structural system of the 1st floor.

The load – bearing structure of the apartment building consists of monolithic reinforced concrete walls, pillars and reinforced concrete slabs. The underground floor is designed as a two – way flat slab with thickness of 250 mm supported on pillars. Pillars have dimensions of 240 x 1 000 mm made of reinforced concrete C30/37 XC2. The perimeter wall is made of watertight reinforced concrete C30/37 XC2 XD1 with thickness of 240 mm (integral waterproofing system with no external coating).

The structural system of upper ground floors is designed as a one – way and two – way transversal wall system. Two – way slabs will be supported by beam due to the long span with dimensions of 250 x 680 mm.

The structures protruding in front of the façade (balconies) are connected to other construction by using iso beams with elimination of thermal bridges (Bronze TiP MQ)**.** The connection between levels is provided by a staircase and an elevator. Used type of the staircase is precast staircase and landing is monolithic.

Preliminary design calculation is provided in “Part 2” of the documentation.

3.1 Staircase

The reinforced concrete staircase is designed as a two – flight precast, made of concrete C30/37, situated next to elevator shaft with monolithic reinforced concrete landing.

The basic geometry of the steps for upper ground floor staircases is 165/280 mm at inclination of 30.8˚, and 175/280 mm for the underground level due to different heights.

The flight of the staircase is placed on the landing by means of rubber blocks (BELAR) and dilated from reinforced concrete walls by 30 mm gap (limitation of impact sound transmission to neighboring ones protected areas). Reinforced concrete precast flight elements are bedded in landing by Schöck Tronsole® type F and to the reinforced concrete wall by Schöck Tronsole® type L.

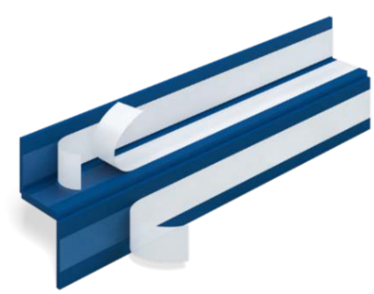


Fig. 6: Schöck Tronsole® type F – between precast flight and landing.

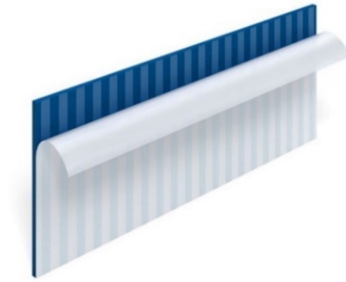


Fig. 7: Schöck Tronsole® type L – between concrete wall and landing.

Fig. 8: Schöck Tronsole® type B – between foundation slab and flight.

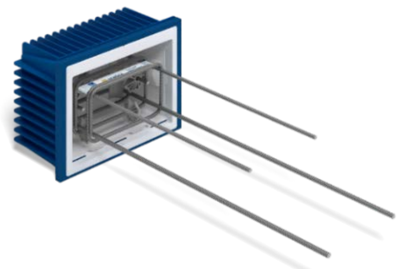


Fig. 9: Schöck Tronsole® type Z – wall case.

The staircase has steel railing with wooden handrail. Railing will be anchored to the walls of the elevator shaft and to the walls of the core. The handrails are 900 mm high from the side of the staircase walls.

The staircases on the 2^{nd} - 4^{th} floors are naturally illuminated by skylight (LIGHTWAY tube) - in combination with artificial lighting switched depending on the intensity of daylight. The skylights are situated in shafts of size 1 010/600 mm.

3.2 Elevator shaft

The elevator shafts are designed as a monolithic reinforced concrete with thickness of 200 mm. The acoustic solution of the noise from the elevator is carried out by dilatation from rest of the structures with 30 mm thickness filled with flexible EPS boards.

Installed type of elevator is KONE MonoSpace 500 with a nominal load capacity of 630 kg/8 persons, elevator shaft dimensions 1 650/2 010 mm, speed 0.63 m/s. The cabin and shaft doors are automatically sliding horizontally with a clear width of 900 mm. The generator of reserve energy source is installed in the room of UPC in the underground level.

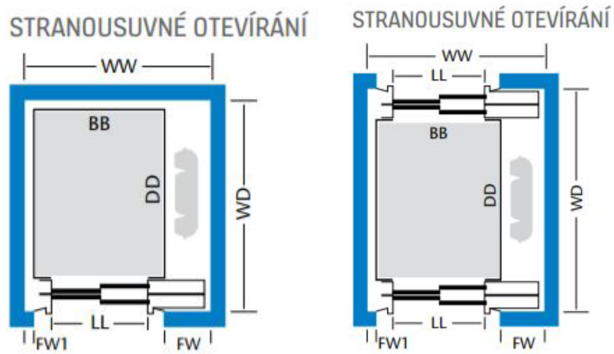


Fig. 10: Elevator KONE MonoSpace 500.

3.3 Balconies

The balconies are used as cantilever with 1 540 and 1 520 mm of span. Balconies are connected to other construction by using iso beams with elimination of thermal bridges**.** Non - insulated structure is made of concrete C30/37 XC-XF3.

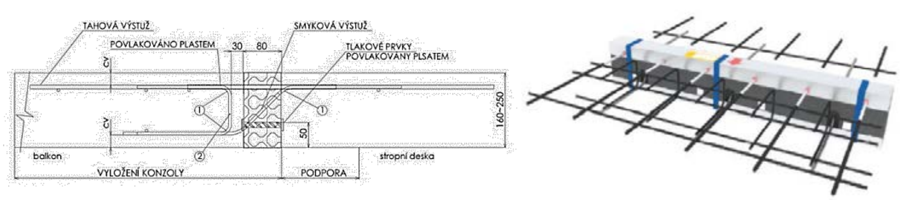


Fig. 11: Iso beam Bronze TiP MQ.

4 Materials

4.1 Reinforced concrete structures

Concrete in accordance with ČSN EN 206-1

Base slab – waterproof white bathtub concrete C30/37 XC2 XD1 XA1 D_{max} 22 Cl 0,20 S3

Piles C25/30 XC2 XA1 D_{max} 22 Cl 0,40 S4

Underground floor – perimeter wall	C30/37 XC2 XD1 XA1 D_{max} 22 Cl 0,20 S4
Underground floor – pillars	C30/37 XC2 XD1 D_{max} 22 Cl 0,40 S4
Underground floor – slab	C30/37 XC1 D_{max} 22 Cl 0,40 S4
1st – 4th floor – load-bearing walls	C30/37 XC1 D_{max} 22-Cl 0,40-S4
1st – 4th floor – slab	C30/37 XC1 D_{max} 22 Cl 0,40 S4
Balcony, terrace	C30/37 XC4 XF3 D_{max} 16 Cl 0,40 S4
Precast staircase flight	C30/37 XC1 D_{max} 22 Cl 0,40 S4
Monolithic landing	C25/30 XC1 D_{max} 22 Cl 0,40 S4

4.2 Masonry structures

1st – 4th floor – vertical structures	HELUZ UNI 25, M10
	HELUZ 24, M10
	HELUZ AKU Z 17.5, M10
	HELUZ 11.5, M10
	HELUZ 8, M10

4.3 Steel structures

Steel reinforcement grade: B500B

5 Insulation

The envelope of the building and the solution of the internal dividing structures comply with the current requirements of ČSN 73 0540 -2. For the classification of the building in terms of energy performance, see the Energy Performance Certificate of the building. The building complies with the requirements ČSN 73 0532 - Evaluation of sound insulation of building structures and in buildings.

a) Building envelope insulation

The perimeter walls are insulated with ETICS thermal insulation system based on facade polystyrene boards; resp. made of mineral wool with th. of 160 mm. Thermal

insulation XPS with th. of 40 mm is used in the plinth part. The flat roof compositions include slope slabs based on stabilized EPS with thickness of 80-160 mm.
Balcony consoles are thermally dilated using an iso beam that interrupts the heat flow. Reinforced concrete attics of terraces and roofs are thermally insulated using a contact thermal insulation system on all sides of the structure.

b) Internal insulation

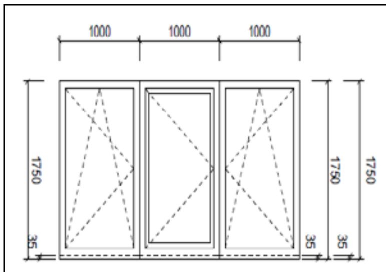
The ceiling above the underground floor is insulated with mineral wool with th. of 100 mm. Reinforced concrete walls between the apartments are insulated with mineral wool with th. 50 mm.
For thermal insulation of the walls of masonry ventilation shafts, adjacent to the heated spaces, it is used mineral wool with aluminum foil ORSTECH 65 H th. 60 mm.

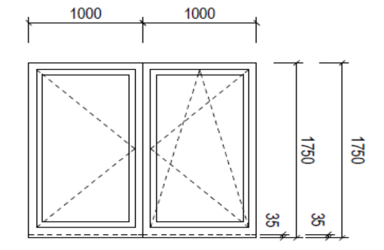
c) Acoustic insulation – traffic noise

Car traffic is the dominant source of noise in the area. The basis for determining the acoustic requirements for facades is a noise study. The acoustic study determines the requirements of laboratory soundproofing for the perimeter cladding and windows differentiated according to the ground plan situation in the range Rw = 31 dB to 34 dB. The fixed part of the perimeter cladding meets the maximum R´w requirement of the façade at 30 dB.
Elevator shafts are dilatated with acoustic insulation EPS-T 4000 with th. of 30 mm.

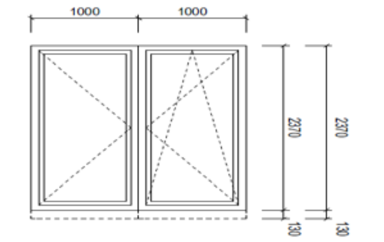
6 Windows

List of the windows:

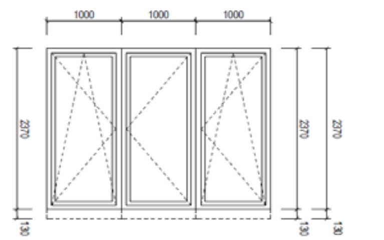
	**W01**	
	Dimensions:	1000/1750 + 1000/1750 + 1000/1750
	Description:	Triple-wing window
	Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
	Frame:	Plastic profile
	Color:	White



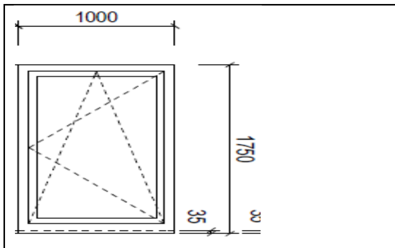
W02	
Dimensions:	1000/1750 + 1000/1750
Description:	Double-wing window
Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White



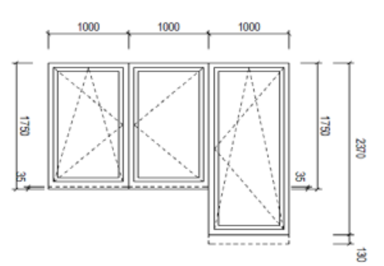
W03	
Dimensions:	1000/2370 + 1000/2370
Description:	French double-wing window
Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White



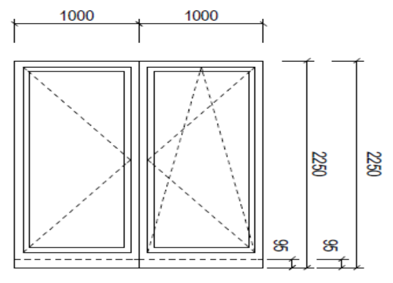
W04	
Dimensions:	1000/2370 + 1000/2370 + 1000/2370
Description:	French triple-wing window
Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White



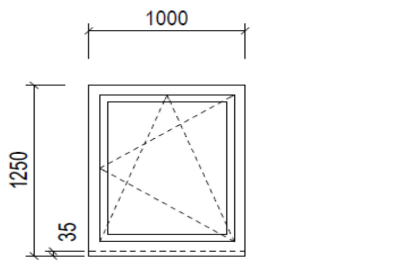
W05	
Dimensions:	1000/1750
Description:	Single-wing window
Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White



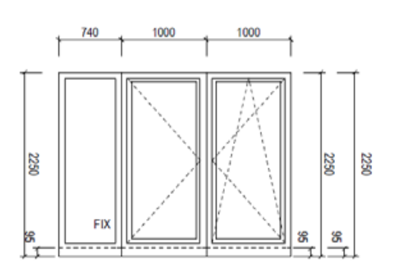
W06	
Dimensions:	1000/17502+ 1000/1750 + 1000/2370
Description:	Balcony double-wing window with door
Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White



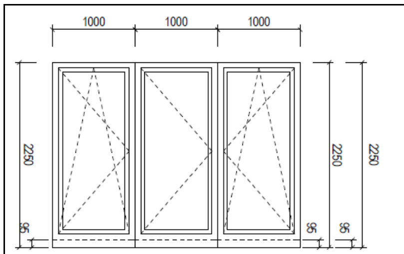
W07	
Dimensions:	1000/2250 + 1000/2250
Description:	French double-wing window
Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White



W08	
Dimensions:	1000/1250
Description:	Single-wing window
Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White



W09	
Dimensions:	740/2250 + 1000/2250 + 1000/2250
Description:	French triple-wing window
Glazing:	Double glazing, U_{max}=1.1 $Wm^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White

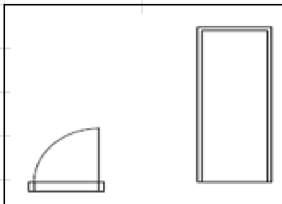


W10	
Dimensions:	1000/2250 + 1000/2250 + 1000/2250
Description:	Single-wing window
Glazing:	Double glazing, Umax=1.1 Wm-2K-1
Frame:	Plastic profile
Color:	White

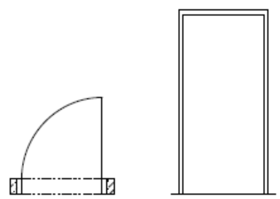
Table 1: Description of windows.

7 Doors

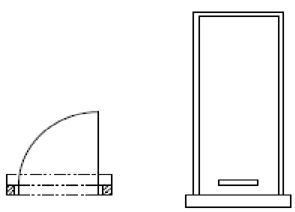
List of the doors:



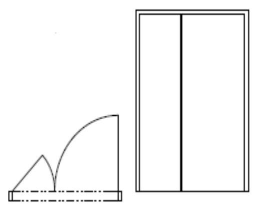
D01	
Dimensions:	700 x 1970
Description:	Steel door
Color:	Powder dye
Fire resistance:	EW 30 C2 DP1



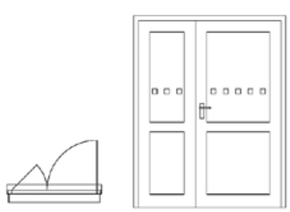
D02	
Dimensions:	900 x 1970
Description:	Steel door
Color:	Powder dye
Fire resistance:	EI 30 S-C S DP1



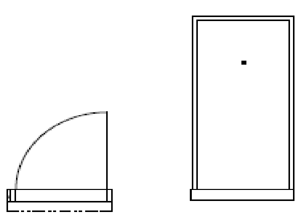
D03	
Dimensions:	800 x 1970
Description:	Wooden door with vent
Color:	Light grey
Fire resistance:	-



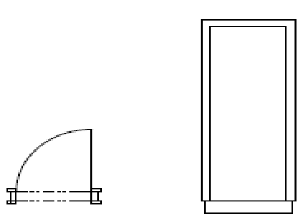
D04	
Dimensions:	1300 x 1970
Description:	Double swing steel door
Color:	Powder dye
Fire resistance:	EI 15 S-C DP3



D05	
Dimensions:	1800 x 2470
Description:	Aluminum double swing door
Color:	Grey
Fire resistance:	EI 30 S-C S DP1

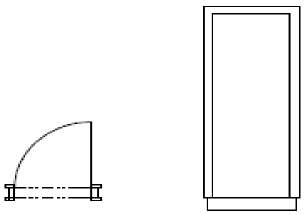


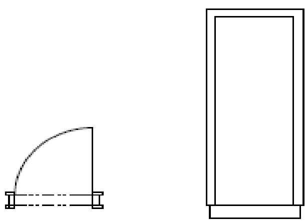
D06	
Dimensions:	900 x 1970
Description:	Steel door
Color:	Royal maple
Fire resistance:	EW 30 DP3

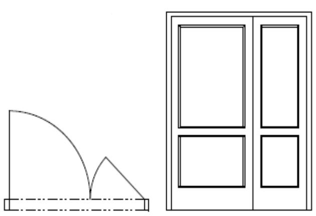


D07	
Dimensions:	700 x 1970
Description:	Wooden door
Color:	Light brown
Fire resistance:	-

	D08	
	Dimensions:	800 x 1970
	Description:	Single winged sliding door
	Color:	Light brown
	Fire resistance:	-

	D09	
	Dimensions:	800 x 1970
	Description:	Wooden door
	Color:	Light brown
	Fire resistance:	-

	D10	
	Dimensions:	700 x 1970
	Description:	Wooden door
	Color:	Light brown
	Fire resistance:	-

	D11	
	Dimensions:	1500 x 1970
	Description:	Laminate door
	Color:	Royal maple
	Fire resistance:	EI 15 C3 DP3

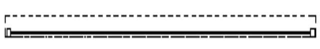
	G01	
	Dimensions:	6000 x 2250
	Description:	Aluminum rolling shutter door
	Color:	Grey
	Fire resistance:	EW 15 DP1

Table 2: Description of doors.

8 Lintels

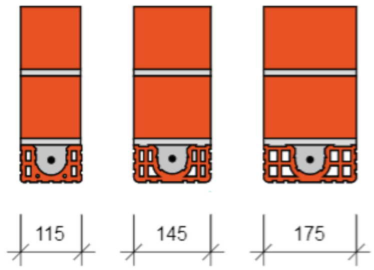


Fig. 12: Heluz lintel.

№	DEFINITION	DIMENSIONS	UL	1L	2L	3L	4L	TOTAL
P1	HELUZ 11.5	115/71/1250	1	35	37	37	27	137
P2	HELUZ 11.5	115/71/2000	-	1	1	1	1	4
P3	HELUZ 7	3x70/238/1250	-	10	11	11	6	38
								179

Table 3: Total amount of lintels.

9 Standard norms and literature

[1] ČSN 73 4301 Residential building

[2] EN 1990 Basis of structural design

[3] EN 1991-1 Actions on structures

[4] EN 1992-1 Design of concrete structures

[5] EN 1997-1 Geotechnical design

[6] ČSN 73 1001 Subsoil under shallow foundation

[7] ČSN EN 206-1 Concrete-part 1: Specification, performance, production, and conformity

[8] ČSN 730532 Acoustic requirements

[9] ČSN 732901 Implementation of external thermal insulation composite systems (ETICS)

[10] ČSN 730540-1 Thermal protection of buildings, part 1

[11] ČSN 730540-2 Thermal protection of buildings, part 2

[12] ČSN 730804 Fire safety construction: Production objects - ANNEX I, garages

[13] ČSN 730818 Fire safety of buildings: Object occupation by persons

[14] ČSN 730821 Fire safety of buildings: Fire resistance of building structures

[15] ČSN 730833 Fire safety of buildings: Housing and accommodation buildings

[16] ČSN 730872 Fire safety of buildings: Protection of fire extinguishing structures

Used literature:

[1] Hollis M.: Surveying Buildings, RICS Books 2007

[2] Assessment of Traditional Housing, BRE Watford, 2001

[3] Whitlow R.: Materials and Structures, Longman 1992

[4] Barry R.: The Construction of Buildings, BSP 1989

[5] Foster J.S.: Structures and Fabric, Parts I - III, Longman 1994

[6] Schodek, D.: Structures- Pearson. New Jersay, 2004

[7] Hanaor, A. : Principles of structures. Blackwell Science, 1998

Used web pages:

[1] www.wienerberger.cz

[2] www.schoeck-wittek.cz

[3] www.bronze.cz

[4] www.isover.cz

[5] www.kone.cz

[6] www.velux.cz

[7] www.lightway.cz

[8] www.heluz.com

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2) Thermal transmittance protocol
3) Energy performance certificate

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2) Plan view – underground floor, 1:60

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12 Used software

1) AutoCAD 2022
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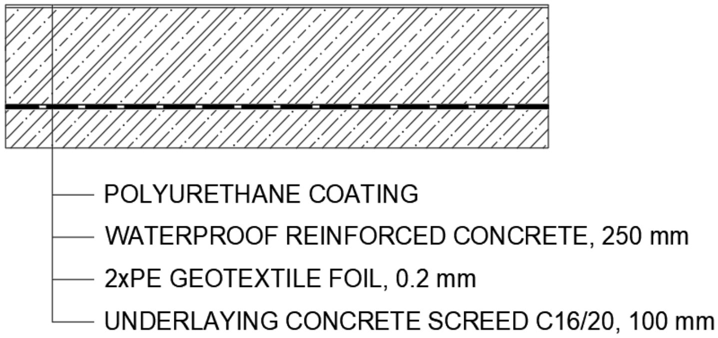
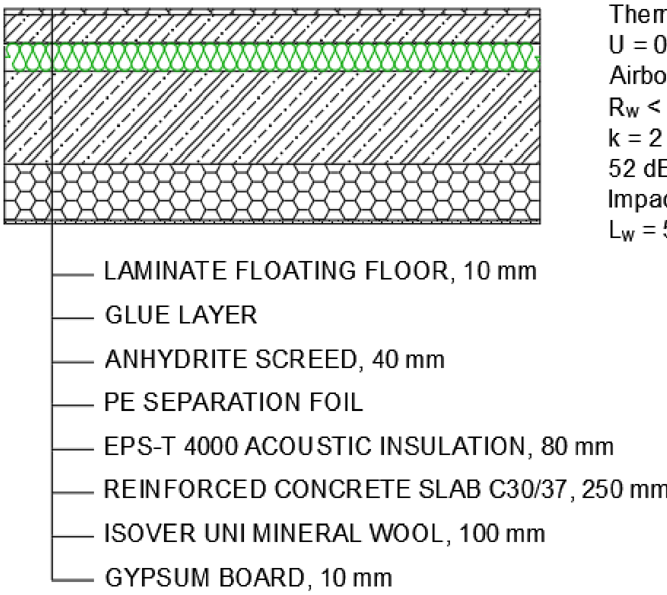
3) TEPLO 2020 EDU
4) ENERGIE 2020 EDU

List of compositions

1) F01 – Underground floor

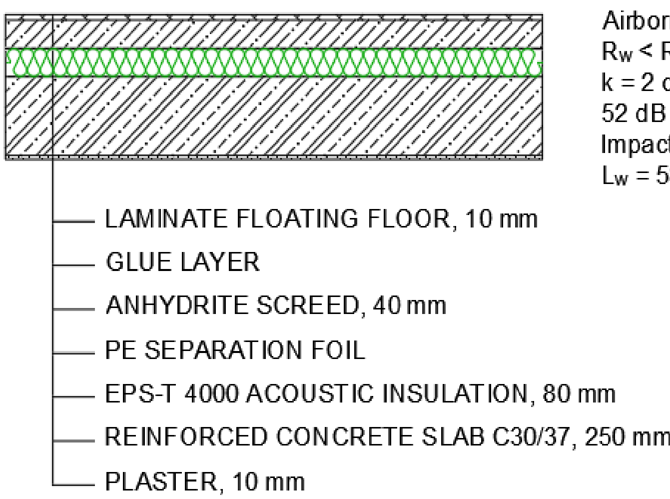


2) F02 – Ground floor



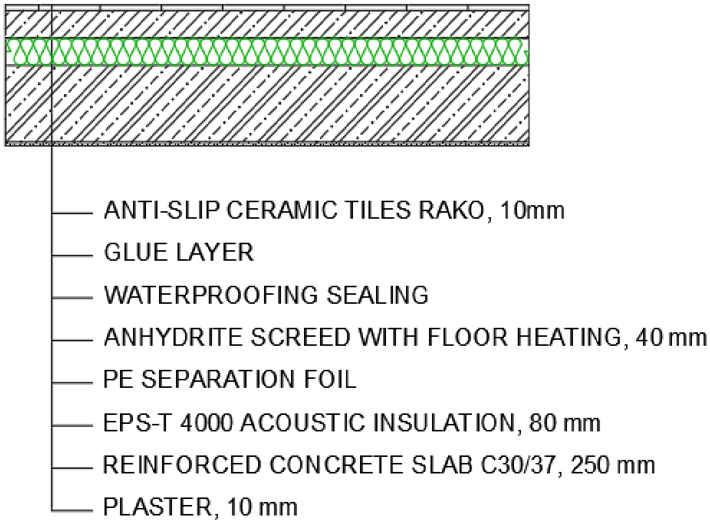
Thermal transmittance:
$U = 0.389\ W/m^2K$
Airborne resistance:
$R_w < R_w' - k$
$k = 2$ dB
52 dB < 56 - 2 = 54 dB
Impact resistance:
$L_w = 58$ dB

3) F03 – Typical floors

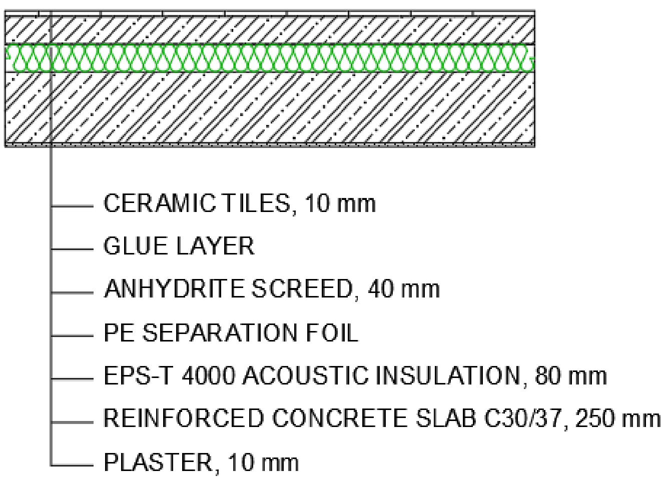


Airborne resistance:
$R_w < R_w' - k$
$k = 2$ dB
52 dB < 55 - 2 = 53 dB
Impact resistance:
$L_w = 58$ dB

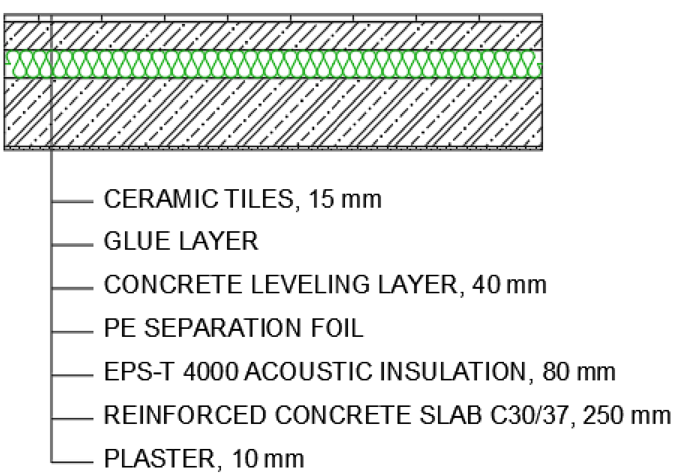
4) F04 – Floor of bathroom, WC



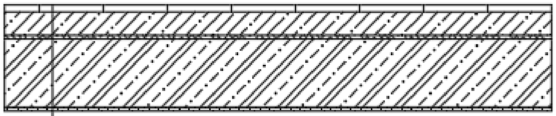
5) F05 – Floor of kitchen, storage room, corridor, cleaning room, stroller room



6) F06 – Staircase area, hallway in front of elevator

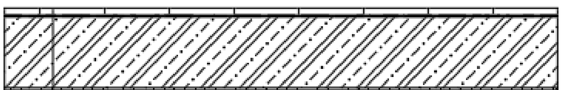


7) F07 – Landing



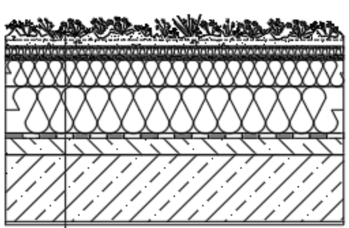
- CERAMIC TILES, 15 mm
- GLUE LAYER
- ANHYDRITE SCREED, 35 mm
- POLYETHYLENE FOAM (ETHAFOAM), 10 mm
- REINFORCED CONCRETE SLAB C25/30, 200 mm
- PLASTER, 10 mm

8) F08 – Balcony



- ANTIFREEZE TILES RAKO TAURUS GRANIT 30x30 cm, 15mm
- GLUE ANTIFREEZE
- WATERPROOFING LAYER FORTISOL, 5 mm
- REINFORCED CONCRETE IN SLOPE 2%, 200 mm
- PLASTER, 10 mm

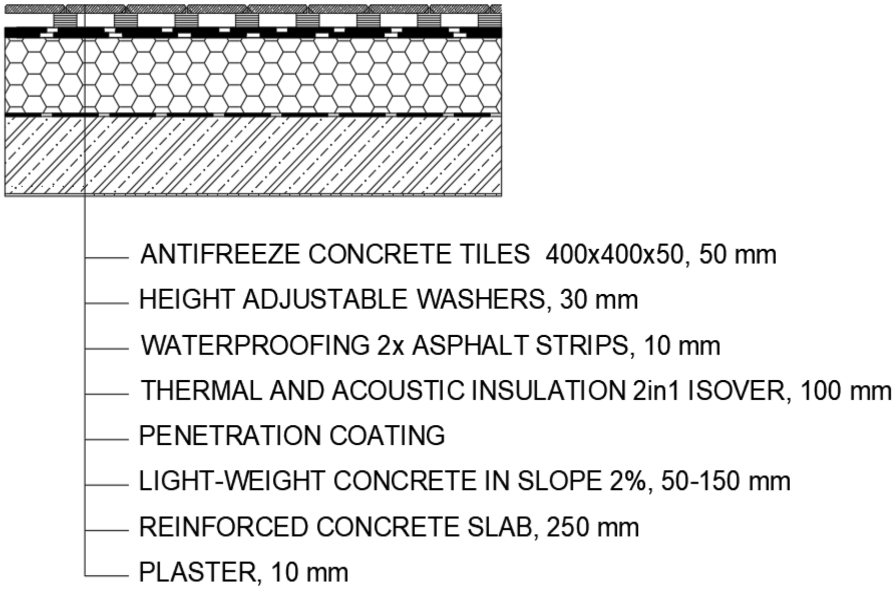
9) R01 – Green roof



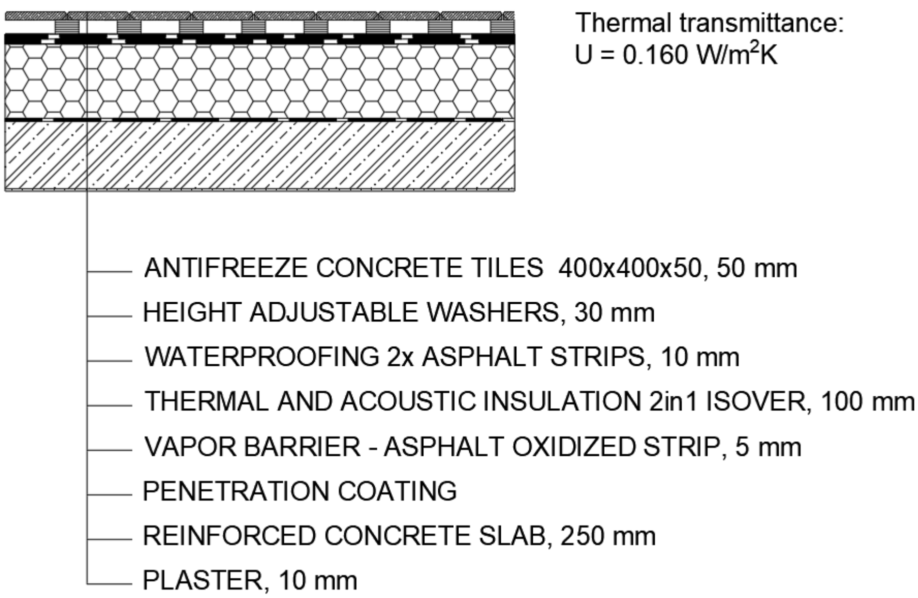
Thermal transmittance:
U = 0.148 W/m^2K

- DEK VEGETATION, 30 mm
- DEK EXTENSIVE ROOF SUBSTRATE (for drought-tolerant plants), 100 mm
- FILTER LAYER: NON-WOVEN POLYPROPYLENE FABRIC FILTEK 200, 2 mm
- DRAINAGE AND HYDROACCUMULATION LAYER: NOP FOIL DEKDREN T20 GARDEN, 20 mm
- SEPARATION FOIL: NON-WOVEN POLYPROPYLENE FABRIC FILTEK 300, 2.9 mm
- WATERPROOFING LAYER: PVC FOIL DEKPLAN 77, 2 mm
- SEPARATION FOIL: NON-WOVEN POLYPROPYLENE FABRIC FILTEK 300, 2.9 mm
- THERMAL INSULATION: EPS DEKPERIMETER SD 150, 80 mm
- THERMAL INSULATION: EPS 150, 140 mm
- VAPOR AND AIR-TIGHT LAYER: MODIFIED SBS ASPHALT STRIP, 4 mm
- ASPHALT EMULSION DEKPRIMER
- SILICATE LAYER IN SLOPE, 50-215 mm
- REINFORCED CONCRETE SLAB C30/37, 220 mm
- GYPSUM BOARD, 10 mm

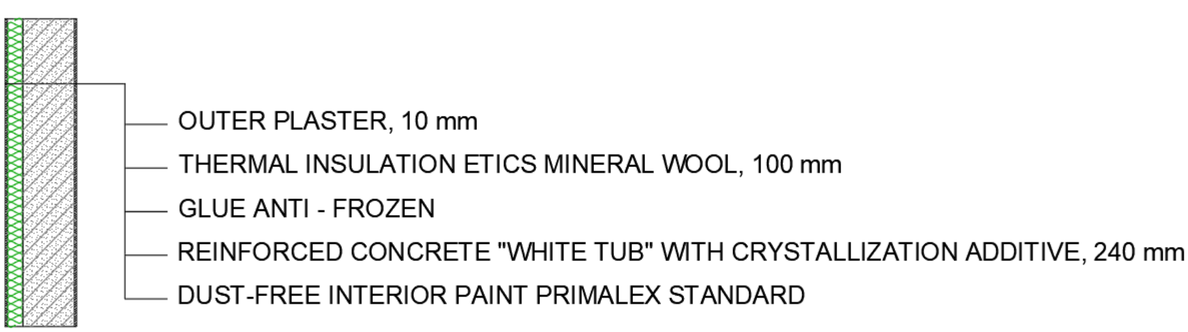
10) R02 – 1st floor terrace



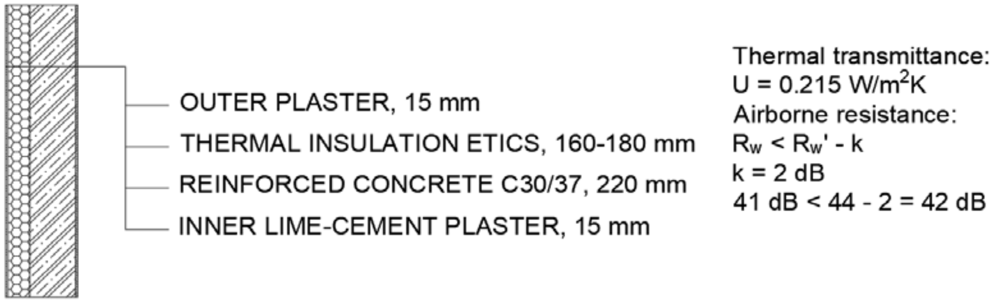
11) R03 – 4th floor terrace



12) PW01 – Perimeter wall of the underground floor

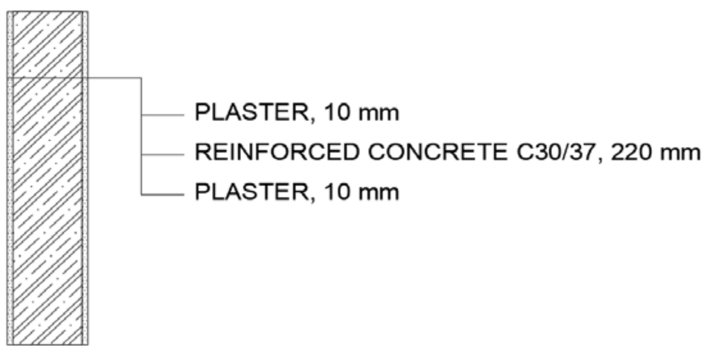


13) PW02 – Perimeter wall of the 1st – 3rd floors

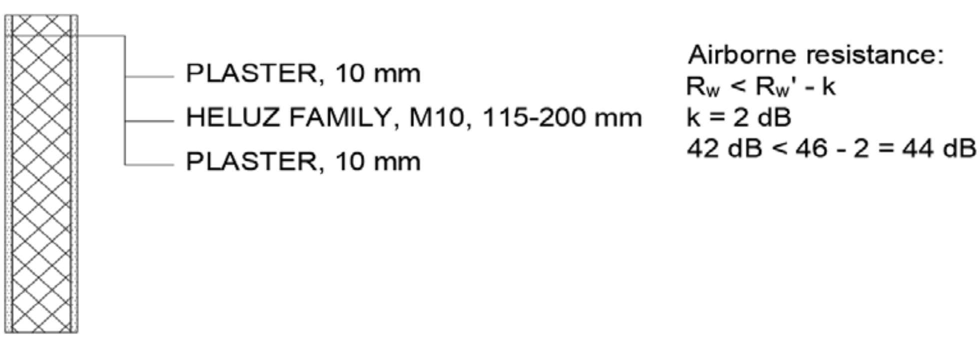


14) PW03 – Perimeter wall of the 4th floor

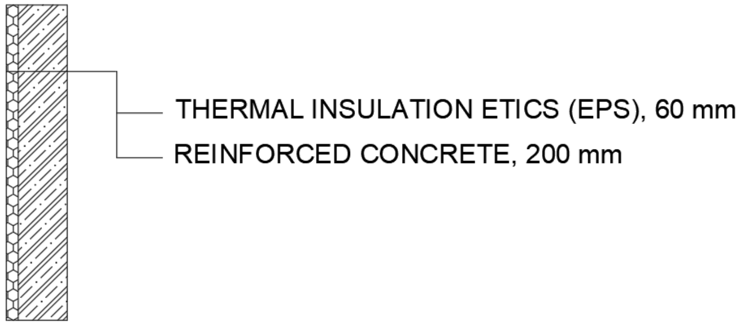
15) W01 – Load-bearing interior wall



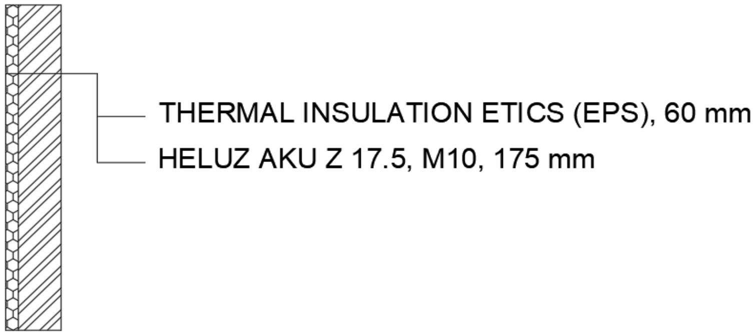
16) W02 – Partitions walls



17) W03 – Elevator wall on the roof



18) W04 – Ventilation shaft on the roof



SHRNUTÍ VLASTNOSTÍ HODNOCENÝCH KONSTRUKCÍ

Teplo 2017 EDU tepelná ochrana budov (ČSN 730540, EN ISO 6946, EN ISO 13788)

Název kce	Typ	R [m2K/W]	U [W/m2K]	Ma,max[kg/m2]	Odpaření	DeltaT10 [C]
F02 - Ground floor (be...	podlaha	2,245	0.389	nedochází ke kondenzaci v.p.		---
PW02 - Perimeter wall...	stěna	4.481	0.215	nedochází ke kondenzaci v.p.		---
R01 - Green roof...	střecha	6.640	0.148	nedochází ke kondenzaci v.p.		---
R03 - Terrace...	střecha	6,123	0.160	nedochází ke kondenzaci v.p.		---

Vysvětlivky:

R	tepelný odpor konstrukce
U	součinitel prostupu tepla konstrukce
Ma,max	maximální množství zkond. vodní páry v konstrukci za rok
DeltaT10	pokles dotykové teploty podlahové konstrukce.

KOMPLEXNÍ POSOUZENÍ SKLADBY STAVEBNÍ KONSTRUKCE Z HLEDISKA ŠÍŘENÍ TEPLA A VODNÍ PÁRY

podle EN ISO 13788, EN ISO 6946, ČSN 730540 a STN 730540

Teplo 2017 EDU

Název úlohy : **F02 - Ground floor (between 1.PP and 1.NP)**
Zpracovatel : Dayana Muratova
Zakázka : Diploma Project
Datum : 10/25/2021

ZADANÁ SKLADBA A OKRAJOVÉ PODMÍNKY :

Typ hodnocené konstrukce : Podlaha nad nevytápěným či méně vytáp. vnitřním prostorem
Korekce součinitele prostupu dU : 0.000 W/m2K

Skladba konstrukce (od interiéru) :

Číslo	Název	D [m]	Lambda [W/(m.K)]	c [J/(kg.K)]	Ro [kg/m3]	Mi [-]	Ma [kg/m2]
1	Laminát	0.0100	0.3700	1050.0	1600.0	94000.0	0.0000
2	Anhydritová sm	0.0400	1.2000	840.0	2100.0	20.0	0.0000
3	Pěnový polysty	0.0800	0.0510	1270.0	10.0	40.0	0.0000
4	Železobeton 3	0.2500	1.7400	1020.0	2500.0	32.0	0.0000
5	Isover Uni	0.1000	0.0380	800.0	40.0	1.0	0.0000
6	Sádrová omítka	0.0100	0.5700	1000.0	1300.0	10.0	0.0000

Poznámka: D je tloušťka vrstvy, Lambda je návrhová hodnota tepelné vodivosti vrstvy, C je měrná tepelná kapacita vrstvy, Ro je objemová hmotnost vrstvy, Mi je faktor difúzního odporu vrstvy a Ma je počáteční zabudovaná vlhkost ve vrstvě.

Číslo	Kompletní název vrstvy	Interní výpočet tep. vodivosti
1	Laminát	---
2	Anhydritová směs	---
3	Pěnový polystyren 1	---
4	Železobeton 3	---
5	Isover Uni	---
6	Sádrová omítka	---

Okrajové podmínky výpočtu :

Tepelný odpor při přestupu tepla v interiéru Rsi :	0.17 m2K/W
dtto pro výpočet vnitřní povrchové teploty Rsi :	0.25 m2K/W
Tepelný odpor při přestupu tepla v exteriéru Rse :	0.17 m2K/W
dtto pro výpočet vnitřní povrchové teploty Rse :	0.17 m2K/W
Návrhová venkovní teplota Te :	10.0 C
Návrhová teplota vnitřního vzduchu Tai :	21.0 C
Návrhová relativní vlhkost venkovního vzduchu RHe :	80.0 %
Návrhová relativní vlhkost vnitřního vzduchu RHi :	60.0 %

VÝSLEDKY VÝPOČTU HODNOCENÉ KONSTRUKCE :

Tepelný odpor a součinitel prostupu tepla podle EN ISO 6946:

Tepelný odpor konstrukce R : 2,245 m2K/W
Součinitel prostupu tepla konstrukce U : **0.389 W/m2K**

Součinitel prostupu zabudované kce U,kc : 0.41 / 0.44 / 0.49 / 0.59 W/m2K
Uvedené orientační hodnoty platí pro různou kvalitu řešení tep. mostů vyjádřenou přibližnou přirážkou podle poznámek k čl. B.9.2 v ČSN 730540-4.

Difúzní odpor a tepelně akumulační vlastnosti:

Difuzní odpor konstrukce ZpT : 4.1E+0012 m/s

Teplotní útlum konstrukce Ny* podle EN ISO 13786 : 2828.4
Fázový posun teplotního kmitu Psi* podle EN ISO 13786 : 14.6 h

Teplota vnitřního povrchu a teplotní faktor podle ČSN 730540 a EN ISO 13788:

Vnitřní povrchová teplota v návrhových podmínkách Tsi,p : 20.44 C
Teplotní faktor v návrhových podmínkách f,Rsi,p : **0.909**

Obě hodnoty platí pro odpor při přestupu tepla na vnitřní straně Rsi=0,25 m2K/W.

Difúze vodní páry v návrh. podmínkách a bilance vodní páry podle ČSN 730540:
(bez vlivu zabudované vlhkosti a sluneční radiace)

Průběh teplot a částečných tlaků vodní páry v návrhových okrajových podmínkách:

rozhraní:	i	1-2	2-3	3-4	4-5	5-6	e
theta [C]:	20.6	20.6	20.5	16.9	16.6	10.6	10.6
p [Pa]:	2113	754	753	748	737	737	736
p,sat [Pa]:	2427	2418	2407	1926	1886	1278	1275

Poznámka: theta je teplota na rozhraní vrstev, p je předpokládaný částečný tlak vodní páry na rozhraní vrstev a p,sat je částečný tlak nasycené vodní páry na rozhraní vrstev.

Při venkovní návrhové teplotě nedochází v konstrukci ke kondenzaci vodní páry.

Množství difundující vodní páry Gd : 1.791E-0010 kg/(m2.s)

Poznámka: Hodnocení difúze vodní páry bylo provedeno pro předpoklad 1D šíření vodní páry převažující skladbou konstrukce. Pro konstrukce s výraznými systematickými tepelnými mosty je výsledek výpočtu jen orientační. Přesnější výsledky lze získat s pomocí 2D analýzy.

KOMPLEXNÍ POSOUZENÍ SKLADBY STAVEBNÍ KONSTRUKCE Z HLEDISKA ŠÍŘENÍ TEPLA A VODNÍ PÁRY

podle EN ISO 13788, EN ISO 6946, ČSN 730540 a STN 730540

Teplo 2017 EDU

Název úlohy : **PW02 - Perimeter wall**
Zpracovatel : Dayana Muratova
Zakázka : Diploma Project
Datum : 10/25/2021

ZADANÁ SKLADBA A OKRAJOVÉ PODMÍNKY :

Typ hodnocené konstrukce : Stěna vnější jednoplášťová
Korekce součinitele prostupu dU : 0.000 W/m2K

Skladba konstrukce (od interiéru) :

Číslo	Název	D [m]	Lambda [W/(m.K)]	c [J/(kg.K)]	Ro [kg/m3]	Mi [-]	Ma [kg/m2]
1	Sádrová omítka	0.0100	0.5700	1000.0	1300.0	10.0	0.0000
2	Železobeton	0.2200	1.7400	1020.0	2500.0	32.0	0.0000
3	Isover EPS 100	0.1600	0.0370	1270.0	21.0	50.0	0.0000
4	weber.pas sili	0.0100	0.8000	920.0	1800.0	30.0	0.0000

Poznámka: D je tloušťka vrstvy, Lambda je návrhová hodnota tepelné vodivosti vrstvy, C je měrná tepelná kapacita vrstvy, Ro je objemová hmotnost vrstvy, Mi je faktor difúzního odporu vrstvy a Ma je počáteční zabudovaná vlhkost ve vrstvě.

Číslo	Kompletní název vrstvy	Interní výpočet tep. vodivosti
1	Sádrová omítka	---
2	Železobeton	---
3	Isover EPS 100	---
4	weber.pas silikát - silikátová omítka	---

Okrajové podmínky výpočtu :

Tepelný odpor při přestupu tepla v interiéru Rsi : 0.13 m2K/W
dtto pro výpočet vnitřní povrchové teploty Rsi : 0.25 m2K/W
Tepelný odpor při přestupu tepla v exteriéru Rse : 0.04 m2K/W
dtto pro výpočet vnitřní povrchové teploty Rse : 0.04 m2K/W

Návrhová venkovní teplota Te : -13.0 C
Návrhová teplota vnitřního vzduchu Tai : 21.0 C
Návrhová relativní vlhkost venkovního vzduchu RHe : 84.0 %
Návrhová relativní vlhkost vnitřního vzduchu RHi : 65.0 %

VÝSLEDKY VÝPOČTU HODNOCENÉ KONSTRUKCE :

Tepelný odpor a součinitel prostupu tepla podle EN ISO 6946:

Tepelný odpor konstrukce R : 4.481 m2K/W
Součinitel prostupu tepla konstrukce U : **0.215 W/m2K**

Součinitel prostupu zabudované kce U,kc : 0.24 / 0.27 / 0.32 / 0.42 W/m2K

Uvedené orientační hodnoty platí pro různou kvalitu řešení tep. mostů vyjádřenou přibližnou přirážkou podle poznámek k čl. B.9.2 v ČSN 730540-4.

Difúzní odpor a tepelně akumulační vlastnosti:

Difuzní odpor konstrukce ZpT : 8.2E+0010 m/s

Teplotní útlum konstrukce Ny* podle EN ISO 13786 : 307.4

Fázový posun teplotního kmitu Psi* podle EN ISO 13786 : 9.6 h

Teplota vnitřního povrchu a teplotní faktor podle ČSN 730540 a EN ISO 13788:

Vnitřní povrchová teplota v návrhových podmínkách Tsi,p : 19.22 C

Teplotní faktor v návrhových podmínkách f,Rsi,p : **0.948**

Obě hodnoty platí pro odpor při přestupu tepla na vnitřní straně Rsi=0,25 m2K/W.

Difúze vodní páry v návrh. podmínkách a bilance vodní páry podle ČSN 730540:

(bez vlivu zabudované vlhkosti a sluneční radiace)

Průběh teplot a částečných tlaků vodní páry v návrhových okrajových podmínkách:

rozhraní:	i	1-2	2-3	3-4	e
theta [C]:	20.0	19.9	19.0	-12.6	-12.7
p [Pa]:	1616	1606	945	194	166
p,sat [Pa]:	2344	2326	2196	205	203

Poznámka: theta je teplota na rozhraní vrstev, p je předpokládaný částečný tlak vodní páry na rozhraní vrstev a p,sat je částečný tlak nasycené vodní páry na rozhraní vrstev.

Při venkovní návrhové teplotě nedochází v konstrukci ke kondenzaci vodní páry.

Množství difundující vodní páry Gd : 1.877E-0008 kg/(m2.s)

Poznámka: Hodnocení difúze vodní páry bylo provedeno pro předpoklad 1D šíření vodní páry převažující skladbou konstrukce. Pro konstrukce s výraznými systematickými tepelnými mosty je výsledek výpočtu jen orientační. Přesnější výsledky lze získat s pomocí 2D analýzy.

KOMPLEXNÍ POSOUZENÍ SKLADBY STAVEBNÍ KONSTRUKCE Z HLEDISKA ŠÍŘENÍ TEPLA A VODNÍ PÁRY

podle EN ISO 13788, EN ISO 6946, ČSN 730540 a STN 730540

Teplo 2017 EDU

Název úlohy : **R01 - Green roof**
Zpracovatel : Dayana Muratova
Zakázka : Diploma Project
Datum : 10/25/2021

ZADANÁ SKLADBA A OKRAJOVÉ PODMÍNKY :

Typ hodnocené konstrukce : Střecha jednoplášťová
Korekce součinitele prostupu dU : 0.000 W/m2K

Skladba konstrukce (od interiéru) :

Číslo	Název	D [m]	Lambda [W/(m.K)]	c [J/(kg.K)]	Ro [kg/m3]	Mi [-]	Ma [kg/m2]
1	Železobeton 3	0.2200	1.7400	1020.0	2500.0	32.0	0.0000
2	Keramzitbeton	0.0500	0.2800	880.0	700.0	8.0	0.0000
3	Sindelit SBS	0.0040	0.2100	1470.0	1200.0	12507.0	0.0000
4	Isover EPS 150	0.1400	0.0350	1270.0	25.0	50.0	0.0000
5	DEK Perimeter	0.0800	0.0350	2060.0	28.0	50.0	0.0000
6	Alkorplan 35 1	0.0020	0.1600	960.0	1300.0	20000.0	0.0000

Poznámka: D je tloušťka vrstvy, Lambda je návrhová hodnota tepelné vodivosti vrstvy, C je měrná tepelná kapacita vrstvy, Ro je objemová hmotnost vrstvy, Mi je faktor difúzního odporu vrstvy a Ma je počáteční zabudovaná vlhkost ve vrstvě.

Číslo	Kompletní název vrstvy	Interní výpočet tep. vodivosti
1	Železobeton 3	---
2	Keramzitbeton	---
3	Sindelit SBS	---
4	Isover EPS 150	---
5	DEK Perimeter	---
6	Alkorplan 35 177	---

Okrajové podmínky výpočtu :

Tepelný odpor při přestupu tepla v interiéru Rsi : 0.10 m2K/W
dtto pro výpočet vnitřní povrchové teploty Rsi : 0.25 m2K/W
Tepelný odpor při přestupu tepla v exteriéru Rse : 0.04 m2K/W
dtto pro výpočet vnitřní povrchové teploty Rse : 0.04 m2K/W

Návrhová venkovní teplota Te : -15.0 C
Návrhová teplota vnitřního vzduchu Tai : 21.0 C
Návrhová relativní vlhkost venkovního vzduchu RHe : 84.0 %
Návrhová relativní vlhkost vnitřního vzduchu RHi : 60.0 %

VÝSLEDKY VÝPOČTU HODNOCENÉ KONSTRUKCE :

Tepelný odpor a součinitel prostupu tepla podle EN ISO 6946:

Tepelný odpor konstrukce R : 6.640 m2K/W

Součinitel prostupu tepla konstrukce U : **0.148 W/m2K**

Součinitel prostupu zabudované kce U,kc : 0.17 / 0.20 / 0.25 / 0.35 W/m2K
Uvedené orientační hodnoty platí pro různou kvalitu řešení tep. mostů vyjádřenou přibližnou přirážkou podle poznámek k čl. B.9.2 v ČSN 730540-4.

Difúzní odpor a tepelně akumulační vlastnosti:

Difuzní odpor konstrukce ZpT : 8.2E+0012 m/s

Teplotní útlum konstrukce Ny* podle EN ISO 13786 : 658.9
Fázový posun teplotního kmitu Psi* podle EN ISO 13786 : 12.9 h

Teplota vnitřního povrchu a teplotní faktor podle ČSN 730540 a EN ISO 13788:

Vnitřní povrchová teplota v návrhových podmínkách Tsi,p : 19.70 C
Teplotní faktor v návrhových podmínkách f,Rsi,p : **0.964**

Obě hodnoty platí pro odpor při přestupu tepla na vnitřní straně Rsi=0,25 m2K/W.

Difúze vodní páry v návrh. podmínkách a bilance vodní páry podle ČSN 730540:

(bez vlivu zabudované vlhkosti a sluneční radiace)

Průběh teplot a částečných tlaků vodní páry v návrhových okrajových podmínkách:

rozhraní:	i	1-2	2-3	3-4	4-5	5-6	e
theta [C]:	20.5	19.9	18.9	18.8	-2.5	-14.7	-14.8
p [Pa]:	1491	1411	1406	778	690	640	138
p,sat [Pa]:	2405	2316	2183	2169	495	169	168

Poznámka: theta je teplota na rozhraní vrstev, p je předpokládaný částečný tlak vodní páry na rozhraní vrstev a p,sat je částečný tlak nasycené vodní páry na rozhraní vrstev.

Při venkovní návrhové teplotě dochází v konstrukci ke kondenzaci vodní páry.

Kond.zóna číslo	Hranice kondenzační zóny levá [m]	pravá	Kondenzující množství vodní páry [kg/(m2s)]
1	0.5240	0.5240	6.496E-0012

Roční bilance zkondenzované a vypařené vodní páry:

Množství zkondenzované vodní páry za rok Mc,a: **0.0000 kg/(m2.rok)**
Množství vypařitelné vodní páry za rok Mev,a: **0.0474 kg/(m2.rok)**

Ke kondenzaci dochází při venkovní teplotě nižší než -10.0 C.

Bilance zkondenzované a vypařené vodní páry podle EN ISO 13788:

Roční cyklus č. 1

V konstrukci nedochází během modelového roku ke kondenzaci vodní páry.

Poznámka: Hodnocení difúze vodní páry bylo provedeno pro předpoklad 1D šíření vodní páry převažující skladbou konstrukce. Pro konstrukce s výraznými systematickými tepelnými mosty je výsledek výpočtu jen orientační. Přesnější výsledky lze získat s pomocí 2D analýzy.

KOMPLEXNÍ POSOUZENÍ SKLADBY STAVEBNÍ KONSTRUKCE Z HLEDISKA ŠÍŘENÍ TEPLA A VODNÍ PÁRY

podle EN ISO 13788, EN ISO 6946, ČSN 730540 a STN 730540

Teplo 2017 EDU

Název úlohy : **R03 - Terrace**
Zpracovatel : Dayana Muratova
Zakázka : Diploma Project
Datum : 10/25/2021

ZADANÁ SKLADBA A OKRAJOVÉ PODMÍNKY :

Typ hodnocené konstrukce : Střecha jednoplášťová
Korekce součinitele prostupu dU : 0.000 W/m2K

Skladba konstrukce (od interiéru) :

Číslo	Název	D [m]	Lambda [W/(m.K)]	c [J/(kg.K)]	Ro [kg/m3]	Mi [-]	Ma [kg/m2]
1	weber.pas sili	0.0100	0.8000	920.0	1800.0	30.0	0.0000
2	Železobeton 3	0.2500	1.7400	1020.0	2500.0	32.0	0.0000
3	Alfobit Al S 2	0.0050	0.2100	1470.0	800.0	144800.0	0.0000
4	Isover EPS 100	0.1000	0.0370	1270.0	21.0	50.0	0.0000
5	Asfaltový nátě	0.0100	0.2100	1470.0	1400.0	280.0	0.0000
6	Betonové dlažd	0.0500	0.0650	1500.0	400.0	40.0	0.0000

Poznámka: D je tloušťka vrstvy, Lambda je návrhová hodnota tepelné vodivosti vrstvy, C je měrná tepelná kapacita vrstvy, Ro je objemová hmotnost vrstvy, Mi je faktor difúzního odporu vrstvy a Ma je počáteční zabudovaná vlhkost ve vrstvě.

Číslo	Kompletní název vrstvy	Interní výpočet tep. vodivosti
1	weber.pas silikát - silikátová omítka	---
2	Železobeton 3	---
3	Alfobit Al S 25 J	---
4	Isover EPS 100	---
5	Asfaltový nátěr 2x	---
6	Betonové dlaždice	---

Okrajové podmínky výpočtu :

Tepelný odpor při přestupu tepla v interiéru Rsi : 0.10 m2K/W
dtto pro výpočet vnitřní povrchové teploty Rsi : 0.25 m2K/W
Tepelný odpor při přestupu tepla v exteriéru Rse : 0.04 m2K/W
dtto pro výpočet vnitřní povrchové teploty Rse : 0.04 m2K/W

Návrhová venkovní teplota Te : -13.0 C
Návrhová teplota vnitřního vzduchu Tai : 20.6 C
Návrhová relativní vlhkost venkovního vzduchu RHe : 84.0 %
Návrhová relativní vlhkost vnitřního vzduchu RHi : 55.0 %

VÝSLEDKY VÝPOČTU HODNOCENÉ KONSTRUKCE :

Tepelný odpor a součinitel prostupu tepla podle EN ISO 6946:

Tepelný odpor konstrukce R : 6.123 m2K/W
Součinitel prostupu tepla konstrukce U : **0.160 W/m2K**

Součinitel prostupu zabudované kce U,kc : 0.18 / 0.21 / 0.26 / 0.36 W/m2K
Uvedené orientační hodnoty platí pro různou kvalitu řešení tep. mostů vyjádřenou přibližnou přirážkou podle poznámek k čl. B.9.2 v ČSN 730540-4.

Difúzní odpor a tepelně akumulační vlastnosti:

Difuzní odpor konstrukce ZpT : 9,1E+0012 m/s

Teplotní útlum konstrukce Ny* podle EN ISO 13786 : 525,8
Fázový posun teplotního kmitu Psi* podle EN ISO 13786 : 10,1 h

Teplota vnitřního povrchu a teplotní faktor podle ČSN 730540 a EN ISO 13788:

Vnitřní povrchová teplota v návrhových podmínkách Tsi,p : 19,67 C
Teplotní faktor v návrhových podmínkách f,Rsi,p : **0.937**

Obě hodnoty platí pro odpor při přestupu tepla na vnitřní straně Rsi=0,25 m2K/W.

Difúze vodní páry v návrh. podmínkách a bilance vodní páry podle ČSN 730540:

(bez vlivu zabudované vlhkosti a sluneční radiace)

Průběh teplot a částečných tlaků vodní páry v návrhových okrajových podmínkách:

rozhraní:	i	1-2	2-3	3-4	4-5	5-6	e
theta [C]:	19.7	19.6	18.4	18.1	-5.5	-5.9	-12.6
p [Pa]:	1334	1333	1321	182	174	169	166
p,sat [Pa]:	2297	2282	2110	2082	384	371	204

Poznámka: theta je teplota na rozhraní vrstev, p je předpokládaný částečný tlak vodní páry na rozhraní vrstev a p,sat je částečný tlak nasycené vodní páry na rozhraní vrstev.

Při venkovní návrhové teplotě nedochází v konstrukci ke kondenzaci vodní páry.

Množství difundující vodní páry Gd : 1,396E-0010 kg/(m2.s)

Poznámka: Hodnocení difúze vodní páry bylo provedeno pro předpoklad 1D šíření vodní páry převažující skladbou konstrukce. Pro konstrukce s výraznými systematickými tepelnými mosty je výsledek výpočtu jen orientační. Přesnější výsledky lze získat s pomocí 2D analýzy.

VÝPOČET ENERGETICKÉ NÁROČNOSTI BUDOV A PRŮMĚRNÉHO SOUČINITELE PROSTUPU TEPLA podle vyhlášky č. 78/2013 Sb. a ČSN 730540-2

a podle EN ISO 13790, EN ISO 13789 a EN ISO 13370

Energie 2020

Název úlohy: **Residential building**
Zpracovatel: Dayana Muratova
Zakázka:
Datum: 4.11.2021

ZADANÉ OKRAJOVÉ PODMÍNKY:

Počet zón v budově: 1
Typ výpočtu potřeby energie: měsíční (pro jednotlivé měsíce v roce)

Okrajové podmínky výpočtu:

Název období	Počet dnů	Teplota exteriéru	Celková energie globálního slunečního záření [MJ/m2] Sever	Jih	Východ	Západ	Horizont
leden	31	-1,3 C	29,5	123,1	50,8	50,8	74,9
únor	28	-0,1 C	48,2	184,0	91,8	91,8	133,2
březen	31	3,7 C	91,1	267,8	168,8	168,8	259,9
duben	30	8,1 C	129,6	308,5	267,1	267,1	409,7
květen	31	13,3 C	176,8	313,2	313,2	313,2	535,7
červen	30	16,1 C	186,5	272,2	324,0	324,0	526,3
červenec	31	18,0 C	184,7	281,2	302,8	302,8	519,5
srpen	31	17,9 C	152,6	345,6	289,4	289,4	490,3
září	30	13,5 C	103,7	280,1	191,9	191,9	313,6
říjen	31	8,3 C	67,0	267,8	139,3	139,3	203,4
listopad	30	3,2 C	33,8	163,4	64,8	64,8	90,7
prosinec	31	0,5 C	21,6	104,4	40,3	40,3	53,6

Název období	Počet dnů	Teplota exteriéru	Celková energie globálního slunečního záření [MJ/m2] SV	SZ	JV	JZ
leden	31	-1,3 C	29,5	29,5	96,5	96,5
únor	28	-0,1 C	53,3	53,3	147,6	147,6
březen	31	3,7 C	107,3	107,3	232,9	232,9
duben	30	8,1 C	181,4	181,4	311,0	311,0
květen	31	13,3 C	235,8	235,8	332,3	332,3
červen	30	16,1 C	254,2	254,2	316,1	316,1
červenec	31	18,0 C	238,3	238,3	308,2	308,2
srpen	31	17,9 C	203,4	203,4	340,2	340,2
září	30	13,5 C	127,1	127,1	248,8	248,8
říjen	31	8,3 C	77,8	77,8	217,1	217,1
listopad	30	3,2 C	33,8	33,8	121,7	121,7
prosinec	31	0,5 C	21,6	21,6	83,2	83,2

PARAMETRY JEDNOTLIVÝCH ZÓN V BUDOVĚ :

PARAMETRY ZÓNY Č. 1 :

Základní popis zóny

Název zóny: Residential area
Typ zóny pro určení Uem,N: nová obytná budova
Typ zóny pro refer. budovu: bytový dům
Typ hodnocení: budova s téměř nulovou spotřebou energie

Obsazenost zóny: 31,0 m2/osobu
Uvažovaný počet osob v zóně: 106,5 (informativní údaj, ve výpočtu se nepoužije)

Objem z vnějších rozměrů: 19731,0 m3
Podlah. plocha (celková vnitřní): 3361.2,0
m2 Celk. energet. vztažná plocha: 3621,0 m2

Účinná vnitřní tepelná kapacita: 260,0 kJ/(m2.K)

Vnitřní teplota (zima/léto): 20,0 C / 20,0 C
Zóna je vytápěna/chlazena: ano / ne
Typ vytápění: nepřerušované

Regulace otopné soustavy: ano

Průměrné vnitřní zisky: 7926 W
.... odvozeny pro
· produkci tepla: 2,0+3,0 W/m2 (osoby+spotřebiče)
· časový podíl produkce: 70+20 % (osoby+spotřebiče)
· zohlednění spotřebičů: jen zisky
· požadovanou osvětlenost: 90,0 lx
· dodanou energii na osvětlení: 4,4 kWh/(m2.a)
(vztaženo na podlah. plochu z celk. vnitřních rozměrů)
· prům. účinnost osvětlení: 20 %
· trvalá přídavná tepelná ztráta: 0,0 W

Potřeba tepla na přípravu TV: 411939,0 MJ/rok
.... odvozeno pro
· roční potřebu teplé vody: 2190,0 m3
· teplotní rozdíl pro ohřev: (55,0 - 10,0) C

Zpětně získané teplo mimo VZT: 0,0 MJ/rok

Zdroje tepla na vytápění v zóně

Teplovzdušné vytápění: ne

Zdroj tepla č. 1 a na něj napojená otopná soustava:
Název zdroje tepla: Gas boiler (podíl 100,0 %)
Typ zdroje tepla: obecný zdroj tepla (např. kotel)
Účinnost výroby tepla: 90,0 %
Účinnost sdílení/distribuce: 88,0 % / 89,0 %
Příkon čerpadel vytápění: 150,0 W (prům. roční příkon)
Příkon regulace/emise tepla: 0,0 / 0,0 W

Zdroje tepla na přípravu TV v zóně

Název zdroje tepla: Gas boiler (podíl 100,0 %)
Typ zdroje přípravy TV: obecný zdroj tepla (např. kotel)
Účinnost zdroje přípravy TV: 90,0 %
Účinnost zpětného získávání tepla: 0,0 %
Objem zásobníku TV: 1000,0 l
Měrná tep. ztráta zásobníku TV: 3,9 Wh/(l.d)
Délka rozvodů TV: 170,0 m
Měrná tep. ztráta rozvodů TV: 128,7 Wh/(m.d)
Příkon čerpadel distribuce TV: 50,0 W
Příkon regulace: 0,0 W

Měrný tepelný tok větráním zóny č. 1 :

Objem vzduchu v zóně: 9011,2 m3
Podíl vzduchu z objemu zóny: 80,0 %
Typ větrání zóny: přirozené
Minimální násobnost výměny: 0,5 1/h
Návrhová násobnost výměny: 0,5 1/h
Měrný tepelný tok větráním Hv: 1486,848 W/K

Měrný tepelný tok prostupem mezi zónou č. 1 a exteriérem :

Název konstrukce	Plocha [m2]	U [W/m2K]	b [-]	H,T [W/K]	U,N,20 [W/m2K]
Wall	1400,0	0,215	1,00	322,000	0,300
Roof	704,0	0,148	1,00	112,640	0,160
Window	453,0 (1,0x453,0 x 1)	1,200	1,00	543,600	1,500
Door	3,2 (1,0x3,2 x 1)	1,500	1,00	4,800	1,700

Vysvětlivky: U je součinitel prostupu tepla konstrukce; b je činitel teplotní redukce; H,T je měrný tok prostupem tepla a U,N,20 je požadovaná hodnota součinitele prostupu tepla podle ČSN 730540-2 pro Tim=20 C.

Vliv tepelných vazeb je ve výpočtu zahrnut přibližně součinem (A * DeltaU,tbm).
Průměrný vliv tepelných vazeb DeltaU,tbm: 0,04 W/m2K

Měrný tok prostupem do exteriéru plošnými konstrukcemi Hd,c: 983,040 W/K
.... a příslušnými tepelnými vazbami Hd,tb: 51,204 W/K

Měrný tepelný tok nevytápěnými prostory u zóny č. 1 :

1. nevytápěný prostor

Název nevytápěného prostoru: Garage

Objem vzduchu v prostoru: 1900,0 m3
Násobnost výměny do interiéru: 0,0 1/h
Násobnost výměny do exteriéru: 1,0 1/h

Název konstrukce	Plocha [m2]	U [W/m2K]	Umístění	U,N,20 [W/m2K]
SDKP2	704,0	0,400	do interiéru	0,600
H4	704,0	0,376	do exteriéru	-----
V3	348,0	3,050	do exteriéru	-----
G1	10,0	4,500	do exteriéru	-----

Vysvětlivky: U je součinitel prostupu tepla konstrukce a U,N,20 je požadovaná hodnota součinitele prostupu tepla podle ČSN 730540-2 pro Tim=20 C.

Měrný tep. tok prostupem H,t,iu: 281,6 W/K
Měrný tep. tok prostupem H,t,ue: 1371,104 W/K
Měrný tok Hiu (z interiéru do nevytápěného prostoru): 281,6 W/K
Měrný tok Hue (z nevytápěného prostoru do exteriéru): 1998,104 W/K
Teplota v nevytápěném prostoru: -10,7 C (při návrhové venkovní teplotě -15,0 C).
Parametr b dle EN ISO 13789: 0,876

Měrný tepelný tok nevytápěnými prostory Hu: 246,815 W/K
.... a příslušnými tep. vazbami Hu,tb: 14,080 W/K

Solární zisky stavebními konstrukcemi zóny č. 1 :

Zeměpisná šířka lokality: 45,0 st. sev. šířky

		Markýza		Levá stěna		Pravá stěna		Celk.
Název výplně otvoru	**Orientace**	**Úhel**	**F,ov**	**Úhel**	**F,finL**	**Úhel**	**F,finR**	**F,fin**
Window	V	-----	1,000	-----	-------	-----	-------	1,000
Door	V	-----	1,000	-----	-------	-----	-------	1,000

		Okolí / Horiz.		Celkový	Způsob stanovení
Název výplně otvoru	**Orientace**	**Úhel**	**F,hor**	**činitel Fsh**	**celk. činitele stínění**
Window	V	-----	1,000	1,000	přímé zadání uživatelem
Door	V	-----	1,000	1,000	přímé zadání uživatelem

Vysvětlivky: F,ov je korekční činitel stínění markýzou, F,finL je korekční činitel stínění levou boční stěnou/žebrem (při pohledu zevnitř), F,finR je korekční činitel stínění pravou boční stěnou, F,fin je souhrnný korekční činitel stínění bočními stěnami, F,hor je korekční činitel stínění horizontem (okolím budovy) a úhel je příslušný stínící úhel.

Název konstrukce	Plocha [m2]	g/alfa [-]	Fgl/Ff [-]	Fc,h/Fc,c [-]	Fsh [-]	Orientace
Window	453,0	0,67	0,7/0,3	1,00/1,00	1,0	V (90°)
Door	3,2	0,67	0,7/0,3	1,00/1,00	1,0	V (90°)

Vysvětlivky: g je propustnost slunečního záření zasklení v průsvitných konstrukcích; alfa je pohltivost slunečního záření vnějšího povrchu neprůsvitných konstrukcí; Fgl je korekční činitel zasklení (podíl plochy zasklení k celkové ploše okna); Ff je korekční činitel rámu (podíl plochy rámu k celk. ploše okna); Fc,h je korekční činitel clonění pohyblivými clonami pro režim vytápění; Fc,c je korekční činitel clonění pro režim chlazení a Fsh je korekční činitel stínění nepohyblivými částmi budovy a okolní zástavbou.

Celkový solární zisk konstrukcemi Qs (MJ):

Měsíc:	**1**	**2**	**3**	**4**	**5**	**6**
Zisk (vytápění):	9782,2	17677,2	32504,5	51433,3	60310,4	62390,1
Měsíc:	**7**	**8**	**9**	**10**	**11**	**12**
Zisk (vytápění):	58307,8	55727,5	36952,7	26823,9	12478,0	7760,3

PŘEHLEDNÉ VÝSLEDKY VÝPOČTU PRO JEDNOTLIVÉ ZÓNY :

VÝSLEDKY VÝPOČTU PRO ZÓNU Č. 1 :

Název zóny: Residential area
Vnitřní teplota (zima/léto): 20,0 C / 20,0 C
Zóna je vytápěna/chlazena: ano / ne
Regulace otopné soustavy: ano

Měrný tepelný tok větráním Hv: 1486,848 W/K
Měrný tok prostupem do exteriéru Hd a celkový
měrný tok prostupem tep. vazbami H,tb: 1048,324 W/K
Ustálený měrný tok zeminou Hg: ---
Měrný tok prostupem nevytápěnými prostory Hu,t: 246,815 W/K
Měrný tok větráním nevytápěnými prostory Hu,v: ---
Měrný tok Trombeho stěnami H,tw: ---
Měrný tok větranými stěnami H,vw: ---
Měrný tok prvky s transparentní izolací H,ti: ---
Přídavný měrný tok podlahovým vytápěním dHt: ---

Výsledný měrný tok H: **2781,987 W/K**

Potřeba tepla na vytápění po měsících:

Měsíc	Q,H,ht[GJ]	Q,int[GJ]	Q,tec[GJ]	Q,sol[GJ]	Q,gn [GJ]	Eta,H [-]	fH [%]	Q,H,nd[GJ]
1	158,712	23,076	---	9,782	32,858	1,000	100,0	125,855
2	135,277	19,977	---	17,677	37,654	1,000	100,0	97,628
3	121,456	21,371	---	32,504	53,876	0,998	100,0	67,709
4	85,810	20,029	---	51,433	71,462	0,935	90,6	18,977
5	49,924	20,164	---	60,310	80,474	0,620	0,0	---
6	28,123	19,341	---	62,390	81,731	0,344	0,0	---
7	14,903	19,986	---	58,308	78,294	0,190	0,0	---
8	15,648	20,164	---	55,727	75,891	0,206	0,0	---
9	46,871	20,097	---	36,953	57,050	0,771	39,7	2,866
10	87,180	21,336	---	26,824	48,160	0,992	100,0	39,426
11	121,143	21,369	---	12,478	33,847	1,000	100,0	87,301
12	145,300	23,005	---	7,760	30,765	1,000	100,0	114,535

Vysvětlivky: Q,H,ht je potřeba tepla na pokrytí tepelné ztráty; Q,int jsou vnitřní tepelné zisky; Q,tec jsou tepelné zisky způsobené provozem ventilátorů a ztrátami z rozvodů teplé vody a akumulačních nádrží; Q,sol jsou solární tepelné zisky; Q,gn jsou celkové tepelné zisky; Eta,H je stupeň využitelnosti tepelných zisků; fH je část měsíce, v níž musí být zóna s regulovaným vytápěním vytápěna, a Q,H,nd je potřeba tepla na vytápění.

Potřeba tepla na vytápění za rok Q,H,nd: **554,296 GJ**

Roční energetická bilance výplní otvorů:

Název výplně otvoru	Orientace	Ql [GJ]	Qs,ini [GJ]	Qs [GJ]	Qs/Ql	U,eq,min	U,eq,max
Window	V	197,421	429,116	262,936	1,33	-3,5	0,9
Door	V	1,743	3,031	1,857	1,07	-3,2	1,2

Vysvětlivky: Ql je potřeba tepla na pokrytí tepelné ztráty prostupem za rok; Qs,ini jsou celkové solární zisky za rok; Qs jsou využitelné solární zisky za rok; Qs/Ql je poměr ukazující, kolikrát jsou využitelné solární zisky vyšší než ztráty prostupem, U,eq,min je nejnižší ekvivalentní součinitel prostupu tepla okna (rozdíl Ql-Qs vydělený plochou okna a počtem denostupňů) během roku a U,eq,max je nejvyšší ekvivalentní součinitel prostupu tepla okna během roku.

Energie dodaná do zóny po měsících:

Měsíc	Q,f,H[GJ]	Q,f,C[GJ]	Q,f,RH[GJ]	Q,f,F[GJ]	Q,f,W[GJ]	Q,f,L[GJ]	Q,f,A[GJ]	Q,fuel[GJ]
1	178,548	---	---	---	41,339	6,748	0,438	227,073
2	138,503	---	---	---	41,030	5,012	0,396	184,941
3	96,057	---	---	---	41,339	4,617	0,438	142,451
4	26,922	---	---	---	41,236	3,652	0,387	72,197
5	---	---	---	---	41,339	3,108	0,036	44,483
6	---	---	---	---	41,236	2,793	0,035	44,064
7	---	---	---	---	41,339	2,886	0,036	44,261
8	---	---	---	---	41,339	3,108	0,036	44,483
9	4,066	---	---	---	41,236	3,738	0,190	49,229
10	55,933	---	---	---	41,339	4,573	0,438	102,283
11	123,852	---	---	---	41,236	5,327	0,424	170,839
12	162,489	---	---	---	41,339	6,659	0,438	210,926

Vysvětlivky: Q,f,H je vypočtená spotřeba energie na vytápění; Q,f,C je vypočtená spotřeba energie na chlazení; Q,f,RH je vypočtená spotřeba energie na úpravu vlhkosti vzduchu; Q,f,F je vypočtená spotřeba energie na nucené větrání; Q,f,W je vypočtená spotřeba energie na přípravu teplé vody; Q,f,L je vypočtená spotřeba energie na osvětlení (popř. i na spotřebiče); Q,f,A je pomocná energie (čerpadla, regulace atd.) a Q,fuel je celková dodaná energie. Všechny hodnoty zohledňují vlivy účinností technických systémů.

Celková roční dodaná energie Q,fuel: **1337,228 GJ**

Průměrný součinitel prostupu tepla zóny

Měrný tepelný tok prostupem obálkou zóny Ht:	1295,1 W/K
Plocha obalových konstrukcí zóny:	3361,2 m2
Výchozí hodnota požadavku na průměrný součinitel prostupu tepla podle čl. 5.3.4 v ČSN 730540-2 (2011) Uem,N,20:	0,52 W/m2K
Průměrný součinitel prostupu tepla zóny U,em:	**0,40 W/m2K**

PŘEHLEDNÉ VÝSLEDKY VÝPOČTU PRO CELOU BUDOVU :

Faktor tvaru budovy A/V: 0,29 m2/m3

Rozložení měrných tepelných toků

Zóna	Položka	Plocha [m2]	Měrný tok [W/K]	Procento [%]
1	Celkový měrný tok H:	---	2781,987	100,00 %
z toho:	Měrný tok větráním Hv:	---	1486,848	53,45 %
	Měrný (ustálený) tok zeminou Hg:	---	---	0,00 %
	Měrný tok přes nevytápěné prostory Hu:	---	246,815	8,87 %
	.... z toho tok prostupem Hu,t:	---	246,815	8,87 %
	.... a tok větráním Hu,v:	---	---	0,00 %

Měrný tok tepelnými vazbami H,tb:	---	65,284	2,35 %
Měrný tok do ext. plošnými kcemi Hd,c:	---	983,040	35,34 %

rozložení měrných toků po konstrukcích:

Wall:	1400,0	322,000	11,57 %
Roof:	704,0	112,640	4,05 %
SDKP2:	704,0	246,815	8,87 %
Window:	453,0	543,600	19,54 %
Door:	3,2	4,800	0,17 %

Měrný tok budovou a parametry podle starších předpisů

Součet celkových měrných tepelných toků jednotlivými zónami Hc:	2781,988 W/K
Objem budovy stanovený z vnějších rozměrů:	19731,0 m3
Tepelná charakteristika budovy podle ČSN 730540 (1994):	0,25 W/m3K
Spotřeba tepla na vytápění podle STN 730540, Zmena 5 (1997):	18,2 kWh/(m3.a)

Poznámka: Orientační tepelnou ztrátu budovy lze získat vynásobením součtu měrných toků jednotlivých zón Hc působícím teplotním rozdílem mezi interiérem a exteriérem.

Průměrný součinitel prostupu tepla budovy

Měrný tepelný tok prostupem obálkou budovy Ht:	1295,1 W/K
Plocha obalových konstrukcí budovy:	3361,2 m2
Výchozí hodnota požadavku na průměrný součinitel prostupu tepla podle čl. 5.3.4 v ČSN 730540-2 (2011) Uem,N,20:	0,52 W/m2K
Průměrný součinitel prostupu tepla budovy U,em:	**0,40 W/m2K**

Celková a měrná potřeba tepla na vytápění

Celková roční potřeba tepla na vytápění budovy:	554,296 GJ	153,971 MWh
Objem budovy stanovený z vnějších rozměrů:	19731,0 m3	
Celková energeticky vztažná podlah. plocha budovy:	3621,0 m2	
Měrná potřeba tepla na vytápění budovy (na 1 m3):	13,7 kWh/(m3.a)	
Měrná potřeba tepla na vytápění budovy:	**44 kWh/(m2.a)**	
Hodnota byla stanovena pro počet denostupňů D =	3752.	

Poznámka: Měrná potřeba tepla je stanovena bez vlivu účinností systémů výroby, distribuce a emise tepla.

Celková energie dodaná do budovy

Měsíc	Q,f,H[GJ]	Q,f,C[GJ]	Q,f,RH[GJ]	Q,f,F[GJ]	Q,f,W[GJ]	Q,f,L[GJ]	Q,f,A[GJ]	Q,fuel[GJ]
1	178,548	---	---	---	41,339	6,748	0,438	227,073
2	138,503	---	---	---	41,030	5,012	0,396	184,941
3	96,057	---	---	---	41,339	4,617	0,438	142,451
4	26,922	---	---	---	41,236	3,652	0,387	72,197
5	---	---	---	---	41,339	3,108	0,036	44,483
6	---	---	---	---	41,236	2,793	0,035	44,064
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9	4,066	---	---	---	41,236	3,738	0,190	49,229
10	55,933	---	---	---	41,339	4,573	0,438	102,283
11	123,852	---	---	---	41,236	5,327	0,424	170,839
12	162,489	---	---	---	41,339	6,659	0,438	210,926

Vysvětlivky: Q,f,H je vypočtená spotřeba energie na vytápění; Q,f,C je vypočtená spotřeba energie na chlazení; Q,f,RH je vypočtená spotřeba energie na úpravu vlhkosti vzduchu; Q,f,F je vypočtená spotřeba energie na nucené větrání; Q,f,W je vypočtená spotřeba energie na přípravu teplé vody; Q,f,L je vypočtená spotřeba energie na osvětlení (popř. i na spotřebiče); Q,f,A je pomocná energie (čerpadla, regulace atd.) a Q,fuel je celková dodaná energie. Všechny hodnoty zohledňují vlivy účinností technických systémů.

Dodané energie:

Vyp.spotřeba energie na vytápění za rok Q,fuel,H:	786,370 GJ	218,436 MWh	62 kWh/m2
Pomocná energie na vytápění Q,aux,H:	2,865 GJ	0,796 MWh	0 kWh/m2
Dodaná energie na vytápění za rok EP,H:	**789,235 GJ**	**219,232 MWh**	**62 kWh/m2**
Vyp.spotřeba energie na chlazení za rok Q,fuel,C:	---	---	---
Pomocná energie na chlazení Q,aux,C:	---	---	---
Dodaná energie na chlazení za rok EP,C:	**---**	**---**	**---**
Vyp.spotřeba energie na úpravu vlhkosti Q,fuel,RH:	---	---	---
Pomocná energie na úpravu vlhkosti Q,aux,RH:	---	---	---
Dodaná energie na úpravu vlhkosti EP,RH:	**---**	**---**	**---**
Vyp.spotřeba energie na nucené větrání Q,fuel,F:	---	---	---
Pomocná energie na nucené větrání Q,aux,F:	---	---	---
Dodaná energie na nuc.větrání za rok EP,F:	**---**	**---**	**---**
Vyp.spotřeba energie na přípravu TV Q,fuel,W:	495,347 GJ	137,597 MWh	39 kWh/m2

Pomocná energie na přípravu teplé vody Q,aux,W:	0,426 GJ	0,118 MWh	0 kWh/m2
Dodaná energie na přípravu TV za rok EP,W:	**495,773 GJ**	**137,715 MWh**	**39 kWh/m2**
Vyp.spotřeba energie na osvětlení a spotř. Q,fuel,L:	52,220 GJ	14,506 MWh	4 kWh/m2
Dodaná energie na osvětlení za rok EP,L:	**52,220 GJ**	**14,506 MWh**	**4 kWh/m2**
Celková roční dodaná energie Q,fuel=EP:	**1337,228 GJ**	**371,452 MWh**	**103 kWh/m2**

Měrná dodaná energie budovy

Celková roční dodaná energie:	**371,452 MWh**
Objem budovy stanovený z vnějších rozměrů:	19731,0 m3
Celková energeticky vztažná podlah. plocha budovy:	3621,0 m2
Měrná dodaná energie EP,V:	33,0 kWh/(m3.a)
Měrná dodaná energie budovy EP,A:	**103 kWh/(m2.a)**

Poznámka: Měrná dodaná energie zahrnuje veškerou dodanou energii včetně vlivů účinností tech. systémů.

Rozdělení dodané energie podle energonositelů, primární energie a emise CO2

Energo-nositel	Faktory transformace			Vytápění ------ MWh/a ------			t/a	Teplá voda ------ MWh/a ------			t/a
	f,pN	f,pC	f,CO2	Q,f	Q,pN	Q,pC	CO2	Q,f	Q,pN	Q,pC	CO2
zemní plyn	1,1	1,1	0,1990	218,4	240,3	240,3	43,5	137,6	151,4	151,4	27,4
elektřina ze sítě	3,0	3,2	1,0120	---	---	---	---	---	---	---	---
SOUČET				**218,4**	**240,3**	**240,3**	**43,5**	**137,6**	**151,4**	**151,4**	**27,4**

Energo-nositel	Faktory transformace			Osvětlení ------ MWh/a ------			t/a	Pom.energie ------ MWh/a ------			t/a
	f,pN	f,pC	f,CO2	Q,f	Q,pN	Q,pC	CO2	Q,f	Q,pN	Q,pC	CO2
zemní plyn	1,1	1,1	0,1990	---	---	---	---	---	---	---	---
elektřina ze sítě	3,0	3,2	1,0120	14,5	43,5	46,4	14,7	0,9	2,7	2,9	0,9
SOUČET				**14,5**	**43,5**	**46,4**	**14,7**	**0,9**	**2,7**	**2,9**	**0,9**

Energo-nositel	Faktory transformace			Nuc.větrání ------ MWh/a ------			t/a	Chlazení ------ MWh/a ------			t/a
	f,pN	f,pC	f,CO2	Q,f	Q,pN	Q,pC	CO2	Q,f	Q,pN	Q,pC	CO2
zemní plyn	1,1	1,1	0,1990	---	---	---	---	---	---	---	---
elektřina ze sítě	3,0	3,2	1,0120	---	---	---	---	---	---	---	---
SOUČET				**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**

Energo-nositel	Faktory transformace			Úprava RH ------ MWh/a ------			t/a	Export elektřiny ------- MWh/a -------		
	f,pN	f,pC	f,CO2	Q,f	Q,pN	Q,pC	CO2	Q,el	Q,pN	Q,pC
zemní plyn	1,1	1,1	0,1990	---	---	---	---			
elektřina ze sítě	3,0	3,2	1,0120	---	---	---	---			
SOUČET				**---**	**---**	**---**	**---**			

Vysvětlivky: f,pN je faktor neobnovitelné primární energie v kWh/kWh; f,pC je faktor celkové primární energie v kWh/kWh; f,CO2 je součinitel emisí CO2 v kg/kWh; Q,f je vypočtená spotřeba energie dodávaná na daný účel příslušným energonositelem v MWh/rok; Q,el je produkce elektřiny v MWh/rok; Q,pN je neobnovitelná primární energie a Q,pC je celková primární energie použitá na daný účel příslušným energonositelem v MWh/rok a CO2 jsou s tím spojené emise CO2 v t/rok.

Součty pro jednotlivé energonositele:	**Q,f** [MWh/a]	**Q,pN** [MWh/a]	**Q,pC** [MWh/a]	**CO2** [t/a]
zemní plyn	356,032	391,636	391,636	70,850
elektřina ze sítě	15,420	46,260	49,344	15,605
SOUČET	**371,452**	**437,895**	**440,979**	**86,455**

Vysvětlivky: Q,f je energie dodaná do budovy příslušným energonositelem v MWh/rok; Q,pN je neobnovitelná primární energie a Q,pC je celková primární energie použitá příslušným energonositelem v MWh/rok a CO2 jsou s tím spojené emise CO2 v t/rok.

Měrná primární energie a emise CO2 budovy

Emise CO2 za rok:	86,455 t	
Celková primární energie za rok:	440,979 MWh	1 587,526 GJ
Neobnovitelná primární energie za rok:	**437,895 MWh**	**1 576,423 GJ**
Objem budovy stanovený z vnějších rozměrů:	19 731,0 m3	
Celková energeticky vztažná podlah. plocha budovy:	3 621,0 m2	
Měrné emise CO2 za rok (na 1 m3):	7,7 kg/(m3.a)	
Měrná celková primární energie E,pC,V:	39,1 kWh/(m3.a)	
Měrná neobnovitelná primární energie E,pN,V:	38,9 kWh/(m3.a)	
Měrné emise CO2 za rok (na 1 m2):	25 kg/(m2.a)	

Měrná celková primární energie E,pC,A:	**125 kWh/(m2.a)**
Měrná neobnovitelná primární energie E,pN,A:	**124 kWh/(m2.a)**

Protocol for the Energy Performance Certificate

Purpose of the certificate processing

☐ New building	☐ Building used by public authorities
☐ Sale of the building or its part	☐ Lease of the building or its part
☐ Larger change of the completed building	☒ Nearly Zero Energy Building
☐ Another purpose:	

Basic information about the evaluated building

Building identification data	
Building address (place, street, street number, ZIP code):	Letnany
Cadastral area:	Praha 18
Parcel number:	199 00
Date of building commissioning (or expected date of commissioning):	
Owner or builder:	
Address:	Hluckova
Company identification number:	
Tel./e-mail:	

Building type		
☐ Family house	☒ Residential house	☐ Building for accommod. and catering
☐ Administrative building	☐ Building for health service	☐ Building for education service
☐ Building for sport activities	☐ Building for business purposes	☐ Building for culture activities
☐ Another building type:		

Geometric characteristics of the building		
Parameter	units	value
Volume of the building V (volume of building zones with conditioned internal environment defined by the outer surfaces of building envelope constructions)	[m^3]	19731,0
Total area of the building envelope A (the sum of areas of external building constructions surrounding the volume of the building V)	[m^2]	3361,2
Shape factor A/V	[m^2/m^3]	0,29
Total energy reference area of the building A_c	[m^2]	3621,0

Types of energy (energy carriers) used in the building	
☐ Lignite	☐ Coal
☐ Oil	☐ Propan-butan/LPG
☐ Wood (logs), wood chips	☐ Wood pellets
☒ Natural gas	☒ Electricity
☐ System of thermal energy supply (district heating): *RES rate:* ☐ *to 50 % including,* ☐ *over 50 to 80 %,* ☐ *over 80 %*	
☐ Energy of surrounding environment (e.g. solar energy): *purpose:* ☐ *for heating,* ☐ *for hot water preparing,* ☐ *for the electricity production*	
☐ Other fuels or other types of energy supply:	

Types of energy delivered outside of the building		
☐ Electricity	☐ Heat	☒ None

Information about building components and technical systems

A) building components and constructions

a.1) requirements for thermal transmittance

Building envelope constructions	Area A_j	Thermal transmittance			Temper. reduction factor b_j	Heat transfer coeff. by transmittion $H_{T,j}$
		Calculated value U_j	Reference value $U_{N,rc,j}$	Fulfilled		
	[m^2]	[W/(m2.K)]	[W/(m2.K)]	[yes/no]	[-]	[W/K]
Wall	1 400,00	0,215	0,30		1,00	322,0
Roof	704,00	0,148	0,16		1,00	112,6
SDKP	704,00	0,400	0,60		0,88	246,8
Window	453,00	1,200	1,50		1,00	543,6
Door	3,20	1,500	1,70		1,00	4,8
Tepelné vazby						65,3
Total	**3 264,2**	**x**	**x**	**x**	**x**	**1 295,1**

Note: The evaluation of the fulfillment of requirements is required only for larger changes of the building and for other than larger changes of the completed building in the case of evaluation of energy performance in accordance with § 6, paragraph 2, point. c).

a.2) requirements for mean thermal transmittance

Zone	Prevailing design internal temperature $\Theta_{im,j}$	Zone volume V_j	Reference value of the mean thermal transmittance of the zone $U_{em,R,j}$	Product $V_j \cdot U_{em,R,j}$
	[°C]	[m^3]	[W/(m^2.K)]	[W.m/K]
Residential area	20,0	19 731,0	0,36	4 055,04
Total	**x**	**19 731,0**	**x**	**4 055,04**

Building	Mean thermal transmittance of the building		
	Calculated value U_{em} ($U_{em} = H_T/A$)	Reference value $U_{em,R}$ ($U_{em,R} = \Sigma(V_j \cdot U_{em,R,j})/V$)	Fulfilled
	[W/(m^{2}K)]	[W/(m^{2}K)]	[yes/no]
Total building	0,40	0,36	ne

Note: The evaluation of the fulfillment of requirements is required for a new building, a building with almost zero energy consumption and for larger changes of the completed building in the case of evaluation of energy performance in accordance with § 6, paragraph 2, point. a) and point b).

B) technical systems

b.1.a) heating

Assessed building/zone	Source type	Energy carriers	Coverage of partial energy needs for heating	Energy output	Efficiency of heat source[2)] $\eta_{H,gen}$	COP	Efficiency of energy distribution $\eta_{H,dis}$	Efficiency of energy emission $\eta_{H,em}$
	[-]	[-]	[%]	[kW]	[%]	[-]	[%]	[%]
Reference building	**x**[1)]	**x**	**x**	**x**	80	--	85	80
Assessed building/zone:								
Residential area	Gas boiler	zemní plyn	100,0	190,0	90		89	88

Note: [1)] **x** symbol means that there is no required reference value
[2)] it is not filled-in in the case of thermal energy supply system

b.1.b) requirements for the efficiency of the heating system

Assessed building/zone	Source type	Efficiency of heat source energy production $\eta_{H,gen}$ nebo $COP_{H,gen}$	Efficiency of reference heat source energy production $\eta_{H,gen,rq}$ or $COP_{H,gen}$	Fulfilled
	[-]	[%]	[%]	[yes/no]

Note: The evaluation of the fulfillment of requirements is required only for larger changes of the building and for other than larger changes of the completed building in the case of evaluation of energy performance in accordance with § 6, paragraph 2, point. c).

B) technical systems

b.2.a) cooling

Assessed building/zone	Type of cooling system	Energy carriers	Coverage of partial energy needs for cooling	Cooling output	Cooling factor of cold source $EER_{C,gen}$	Efficien-cy of energy distribu-tion $\eta_{C,dis}$	Efficien-cy of energy emission $\eta_{C,em}$
	[-]	[-]	[%]	[kW]	[-]	[%]	[%]
Reference building	x	x	x	x			
Assessed building/zone:							

b.2.b) requirements for the efficiency of the cooling system

Assessed building/zone	Type of cooling system	Cooling factor of cold source $EER_{C,gen}$	Cooling factor of reference cold source $EER_{C,gen}$	Fulfilled
	[-]	[-]	[-]	[yes/no]

Note: The evaluation of the fulfillment of requirements is required only for larger changes of the building and for other than larger changes of the completed building in the case of evaluation of energy performance in accordance with § 6, paragraph 2, point. c).

B) <u>technical systems</u>

b.3) ventilation

Assessed building/zone	Type of venti-lation system	Energy carriers	Heating energy output	Cooling energy output	Coverage of partial energy needs for venti-lation	Nominal electri-city input of venti-lation system	Nominal volume flow of venti-lation air	Specific input of fans for forced venti-lation SFP_{ahu}
	[-]	[-]	[kW]	[kW]	[%]	[kW]	[m^3/hour]	[W.s/m^3]
Reference building	**x**	**x**	**x**	**x**	**x**	**x**	**x**	
Assessed building/zone:								
Accomodation areas	Natural ventilation							

B) technical systems

b.4) air humidity adjustment

Assessed building/zone	Type of humidification system	Energy carriers	Nominal electricity input	Nominal energy output	Coverage of partial energy needs for air humidification	Efficiency of air humidification $\eta_{RH+,gen}$
	[-]	[-]	[kW]	[kW]	[%]	[%]
Reference building	x	x	x	x	x	
Assessed building/zone:						

Assessed building/zone	Type of dehumidification system	Energy carriers	Nominal electricity input	Nominal energy output	Coverage of partial energy needs for air dehumidification	Cooling output	Efficiency of air dehumidification $\eta_{RH-,gen}$
	[-]	[-]	[kW]	[kW]	[%]	[kW]	[%]
Reference building	x	x	x	x	x	x	
Assessed building/zone:							

B) technical systems

b.5.a) hot water preparation

Assessed building/zone	Type of hot water preparation in the building	Energy carriers	Coverage of partial energy needs for hot water preparation	Energy input for hot water preparation	Hot water tank volume	Efficiency of heat source for hot water preparation[1] $\eta_{W,gen}$	Efficiency of heat source for hot water preparation[1] COP	Specific heat loss of hot water tank $Q_{W,st}$	Specific heat loss of hot water distribution $Q_{W,dis}$
	[-]	[-]	[%]	[kW]	[liters]	[%]	[-]	[Wh/l.d]	[Wh/m.d]
Reference building	x	x	x	x	x	85	--	5,0	150,0
Assessed building/zone:									
Residential area	Gas boiler	zemní plyn	100,0	190,0	1000	90		3,9	128,7

Note: [1] not filled in case of thermal energy supply

b.5.b) requirements for the efficiency of the hot water preparation system

Assessed building/zone	Type of hot water preparation system	Efficiency of heat source for hot water preparation $\eta_{W,gen}$ nebo $COP_{W,gen}$	Efficiency of reference heat source for hot water preparation $\eta_{W,gen,rq}$ nebo $COP_{W,gen}$	Fulfilled
	[-]	[%]	[%]	[yes/no]

Note: The evaluation of the fulfillment of requirements is required only for larger changes of the building and for other than larger changes of the completed building in the case of evaluation of energy performance in accordance with § 6, paragraph 2, point. c).

B) technical systems

b.6) lighting

Assessed building/area	Type of lighting system	Coverage of partial lighting energy needs	Total electricity input for lighting of the building	Mean specific input for lighting related to the illumination zone $p_{L,lx}$
	[-]	[%]	[kW]	[W/(m^2.lx)]
Reference building	**x**	**x**	**x**	0,05
Assessed building/area:				
Residential area	Light	100	14,9	0,05

Energy performance of assessed building

a) list of considered zones and partial delivered energies in the building

Assessed building/zone	Heating EP_H	Cooling EP_C	Mechanical ventilation EP_F		Hot water prepa-ration EP_W	Lighting EP_L	Energy production from renewable energy source or cogeneration	
			Without humid. adjustment	With humidity adjustment			For the building	For the building and external delivery
Residential area	☒	☐	☐	☐	☒	☒	☐	☐

b) partial delivered energies

r.			Heating		Cooling		Ventilation		Air humidity adjustment		Hot water preparation		Lighting	
			Ref. building	Ass. building	Ref. building	Ass. building	Ref. building	Ass. building	Ref. building	Ass. building	Ref. building	Ass. building	Ref. building	Ass. building
(1)	Energy need	[MWh/year]	157,430	153,971			x	x			114,427	114,427	x	x
(2)	Calculated energy use	[MWh/year]	289,393	218,436							147,718	137,596	14,506	14,506
(3)	Auxiliary energy use	[MWh/year]	0,460	0,796							0,118	0,118		
(4)	Partial delivered energy (r.4)=(r.2)+(r.3)	[MWh/year]	289,853	219,232							147,836	137,715	14,506	14,506
(5)	Specific partial delivered energy related to total energy reference surface (r.4) / m^2	[kWh/(m2.year)]	82	62							42	39	4	4

c) energy production facility located in the building, on the building or on attached auxiliary objects

Production type	Utilization of produced energy	Produced energy	Total primary energy factor	Non-renew-able primary energy factor	Total primary energy	Non-renewable primary energy
units		[MWh/year]	[-]	[-]	[MWh/year]	[MWh/year]
Cogeneration unit EP_{CHP} - heat	Building					
	Delivery out of the building					
Cogeneration unit EP_{CHP} - electricity	Building					
	Delivery out of the building					
Photovoltaic panels EP_{PV} - electricity	Building					
	Delivery out of the building					
Solar thermal systems $Q_{H,sc,sys}$ - heat	Building					
	Delivery out of the building					
Others	Building					
	Delivery out of the building					

d) distribution of partial delivered energies, of the total primary energy and of the non-renewable primary energy according to energy carriers

Energy carriers	Partial calculated energy use/ Auxiliary energy use	Total primary energy factor	Non-renewable primary energy factor	Total primary energy	Non-renewable primary energy
	[MWh/year]	[-]	[-]	[MWh/year]	[MWh/year]
zemní plyn	356,033	1,1	1,1	391,636	391,636
elektřina ze sítě	15,420	3,2	3,0	49,344	46,260
Total	**371,452**	**x**	**x**	**440,979**	**437,895**

e) requirement for total delivered energy

(6)	Reference building	[MWh/year]	452,195	Fulfilled (yes/no)	ano
(7)	Assessed building		371,452		
(8)	Reference building	[kWh/m^2.year]	125		
(9)	Assessed building		103		

f) requirement for non-renewable primary energy

(10)	Reference building	[MWh/year]	420,859	Fulfilled (yes/no)	ne
(11)	Assessed building		437,895		
(12)	Reference building (r.10 / m^2)	[$kWh/m^2.year$]	120		
(13)	Assessed building (r.11 / m^2)		124		

g) primary energy of the assessed building

(14)	Total primary energy	[MWh/year]	440,979
(15)	Renewable primary energy (r.14 - r.11)	[MWh/year]	3,084
(16)	The use of renewable energy sources from the point of view of primary energy (r.15 / r.14 x 100)	[%]	0,7

h) values for the derivation of energy classes levels

Values corresponding to the upper limit of Class C:	Total delivered energy		[MWh/year]	480,144
	Non-renewable primary energy		[MWh/year]	556,837
	Mean thermal transmittance of the building		[$W/m^2.K$]	0,41
	Partial delivered energy:	heating	[MWh/year]	317,802
		cooling	[MWh/year]	
		ventilation	[MWh/year]	
		air humidity adjustment	[MWh/year]	
		hot water preparation	[MWh/year]	147,836
		lighting	[MWh/year]	14,506

Table h) contains values used for the derivation of energy classes levels according to Annex No. 2.

Analysis of the technical, economical and environmental suitability of alternative energy supply systems for new buildings and larger changes of completed buildings

Alternative systems	Feasibility assessment			
	Decentralized energy supply systems based on renewable energy sources	Cogeneration	System of the thermal energy supply	Heat pump
Technical suitability	yes	no	no	yes
Economical suitability	no	no	no	no
Ecological suitability	yes	no	yes	yes
Recommendations for implementation and justification				
Date of analysis completion	4.11.2021			
Author of analysis	Dayana Muratova			
Energy assessment	Obligation of the energy assessment preparation	no		
	Energy assessment is a part of the analysis	no		
	Date of the energy assessment preparation	--		
	Author of energy assessment	--		

Recommended technically and economically suitable measures to improve energy performance of the building

Measure description		Expected mean thermal transmittance of the buiilding	Expected delivered energy	Expected nonrenewable primary energy	Expected savings of total delivered energy	Expected savings of the nonrenewable primary energy
		[W/(m^2.K)]	[MWh/year]	[MWh/year]	[MWh/year]	[MWh/year]
Building components and building constructions:						
Windows triple glass Thermal insulation th. 200 mm			**x**	**x**		25,6
Building technical systems:						
heating:		**x**		x		
cooling:		**x**		x		
ventilation:		**x**		x		
air humidity adjustment:		**x**		x		
hot water preparation:		**x**		x		
lighting:		**x**		x		
Operation and maintenance of the building systems:						
		x	x	x		
Other - please specify:						
		x	x	x		
Total		**x**				25,6

Measure	Assessment of appropriateness			
	Building components and constructions	**Technical systems in the building**	**Maintenance and operation of building systems**	**Other - please specify:**
Technical suitability	yes	no	no	no
Functional suitability	yes	no	no	no
Economical suitability	yes	no	no	no
Recommendations for implementation and justification	Windows triple glass Thermal insulation th. 160 mm			
Date of recommended measures preparing	4.11.2021			
Author of analysis	Dayana Muratova			
Energy assessment	Energy assessment is a part of the analysis	no		
	Date of the energy assessment preparation	--		
	Author of energy assessment	--		

Energy specialist's final evaluation

New building or building with almost zero energy consumption	
• Building meets the requirement according to § 6 paragraph 1	No
• Building energy performance class for the total delivered energy	C
Larger change of completed building or other change of the building	
• Building meets the requirement according to § 6 paragraph 2 point a)	
• Building meets the requirement according to § 6 paragraph 2 point b)	
• Building meets the requirement according to § 6 paragraph 2 point c)	
• Fulfillment of requirements on the building energy performance is not required	
• Building energy performance class for the total delivered energy	
Building used by public authorities	
• Building energy performance class for the total delivered energy	
Sale or lease of the building or its part	
• Building energy performance class for the total delivered energy	
Another purpose of certificate processing	
• Building energy performance class for the total delivered energy	

Identification data of energy specialist who created the certificate

Name and surname	Dayana Muratova
Authorization No. of Ministry of Industry and Trade	
Energy specialist's signature	

Date of certificate creation

Date of certificate creation	4.11.2021

Source of information	http://www.mpo-efekt.cz/cz/ekis/i-ekis/

ENERGY PERFORMANCE CERTIFICATE

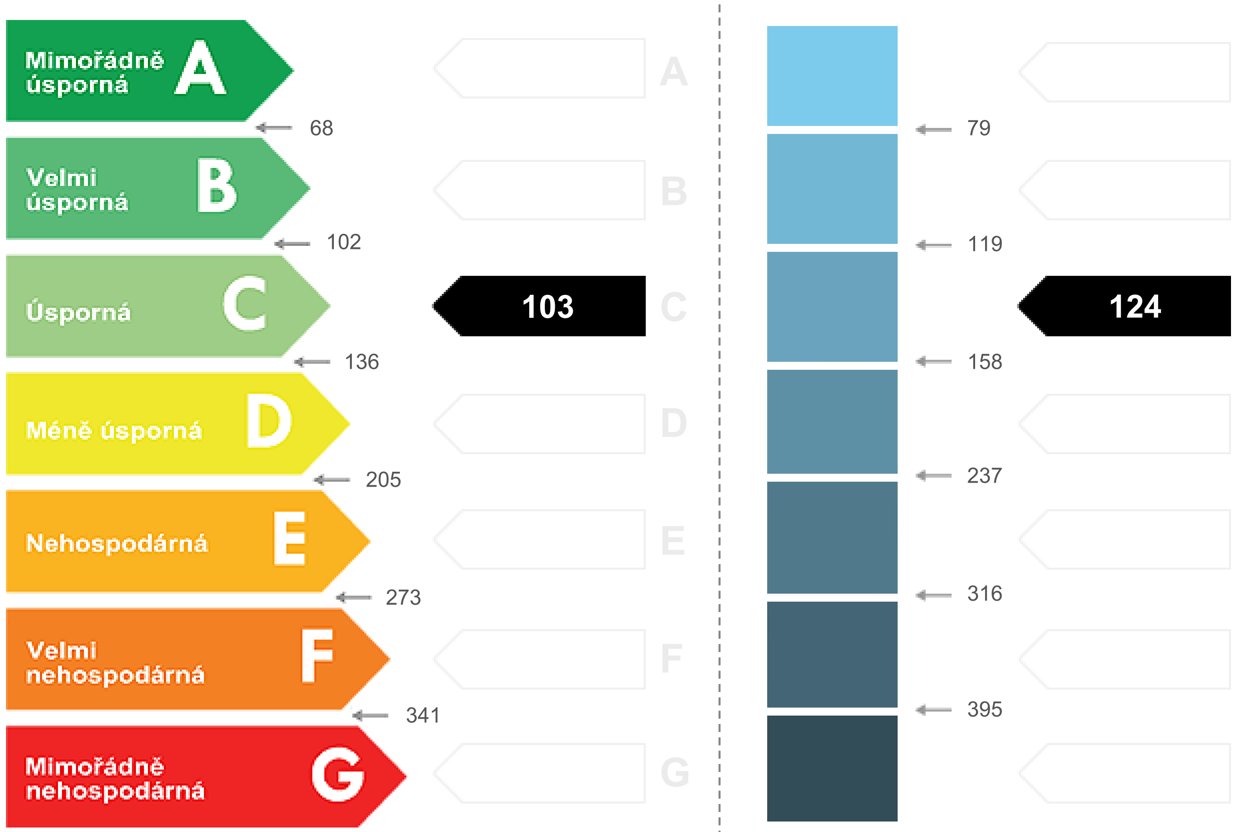
issued according to Act No. 406/2000 Coll., about energy management,
and Directive No. 78/2013 Coll., about building energy performance

Street, number:	
ZIP code, place:	
Building type:	
Building envelope area:	**3361,0 m^2**
Shape factor A/V:	**0,29 m^2/m^3**
Total energy reference area:	**3621,0 m^2**

ENERGY PERFORMANCE OF THE BUILDING

Total delivered energy (Energy input to the building)	**Non-renewable primary energy** (Impact of the building on the environment)

Specific values kWh/(m^2·year)



Values for the whole building MWh/year	**371,452**	**437,895**

RECOMMENDED MEASURES

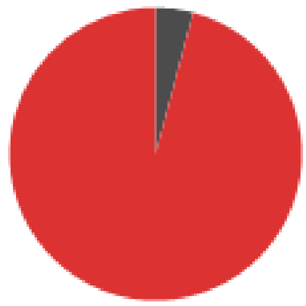
Measure for	Defined
Outdoor walls:	☐
Windows and doors:	☐
Roof:	☐
Floor:	☐
Heating:	☐
Cooling:	☐
Ventilation:	☐
Hot water prepar.:	☐
Lighting:	☐
Others:	☐

Description of measures can be found in protocol and their impact on energy performance is shown by an arrow.

Doporučení

DELIVERED ENERGY DISTRIBUTION TO ENERGY CARRIERS

Values for the whole building
MWh/year



Elektřina ze sítě: 15,4
Zemní plyn: 356

BUILDING ENERGY PERFORMANCE INDICATORS

	The building envelope	Heating	Cooling	Ventilation	Humidity adjustment	Hot water	Lighting
	U_{em} W/(m²·K)	Partial delivered energy			Specific values	kWh/(m²·year)	
Mimořádně úsporná							
A							
B		62					
C	0,40					39	4
D							
E							
F							
G							
Mimořádně nehospodárná							
Values for the whole building MWh/year		219,23				137,71	14,51

Author: Dayana Muratova
Contact:

Certificate No.:
Prepared on: 4.11.2021
Signature:

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

K133 DEPARTMENT OF CONCRETE AND MASONRY STRUCTURES

TECHNICAL REPORT

Designed by: Bc. Dayana Muratova

Consulted with: doc. Ing. Petr Bilý, Ph.D.

CONTENT

1 Location of the apartment building

The area of the apartment building is located in the city district of Prague 9 – Letňany, parcels No. 760/64, 760/66. Designed building is a part of a residential complex "Letňany gardens" – building M. The building is not located in a seismically active area, inundation (flood) area or in the area affected by slope movement.

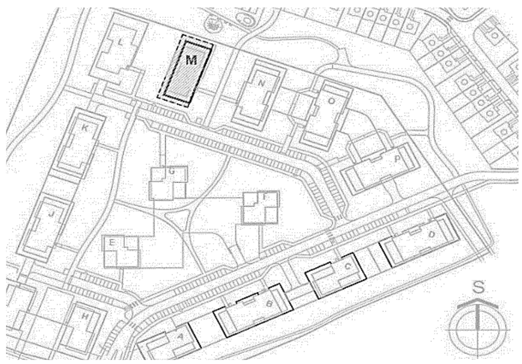


Fig. 1: Situation.

1.1 Geological situation

The building is defined in height uniform level ± 0,00 = 261,800 m above sea level. The basement floor is also uniformly on the elevation of 258.450 m above sea level. The elevation height practically means that the basement is basically set on the existing ground level. The upper layer of the soil with thickness of 0.8 - 0.9 m, there are loess and loess clays (GT3) with a mean thickness of 1.5 m. The groundwater in the floor plan of the underground section is located at a depth of approximately 2.6 – 2.8 m below the surface of the terrain. Thus, the object will be supported on large piles which will be aligned to the level of the upper edge of the base concrete.

1.2 Hydrogeological conditions

The groundwater shows a very mild basic reaction (pH = 7.4). In terms of the aggressiveness of the liquid environment on concrete structures, groundwater is classified in the sense of ČSN EN 206-1 with the degree of aggressiveness XA1 due to a slightly increased content of sulfate ions. According to the cited standards, the indicative minimum strength class of concrete C30/37 is stated.

2 General information

The residential building contains 1 underground floor and 4 upper ground floors. The area of underground floor is 47.6 x 20.6 m. The upper ground floors from 1 to 3 occupy an area of 47.5 x 20.7 m. The 4th floor recedes to the middle of the floor plan and has dimensions of 33.2 x 19.8 m. Total building height is 12.62 m. Underground floor's height is 2.97 m and upper typical floors have 2.80 m of height. There are 38 parking spaces, 38 storage rooms, 1 technical room and 1 cleaning room on the underground floor. Access to the garage side is provided by the entrance in object L through connecting neck between two buildings. On the 1st floor there are the main entrance to the building, stroller room and 10 apartments. There are 22 apartments in total on the 2nd – 3rd floors and 6 apartments on the 4th floor. The spaces protruding in front of the façade plane are considered as terraces and balconies.

3 Load – bearing structure

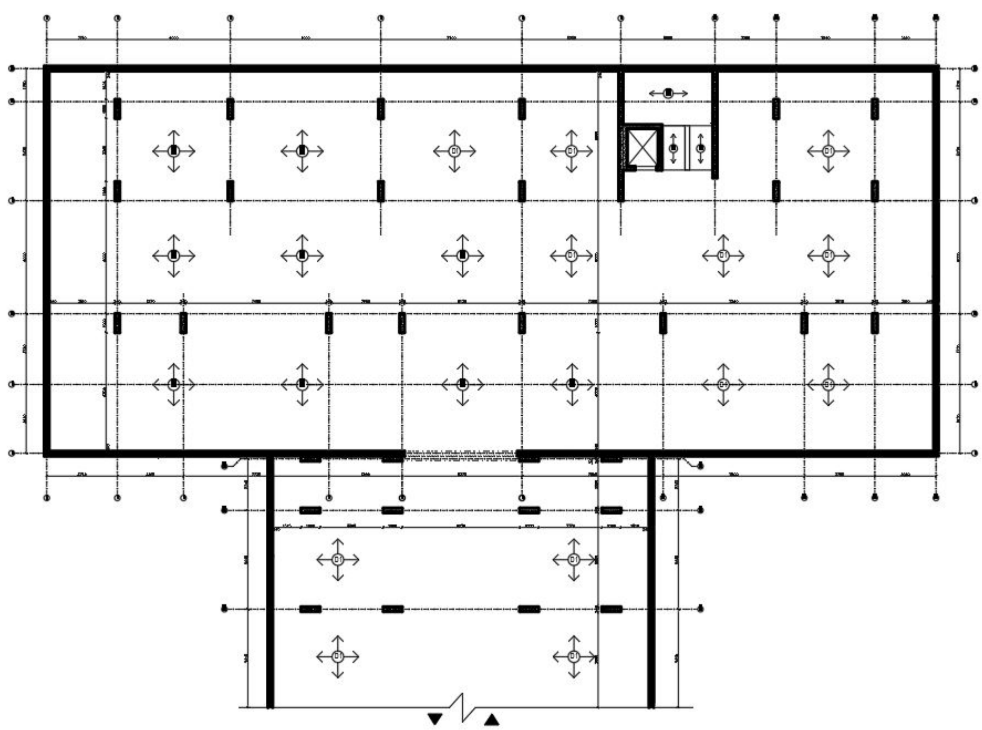


Fig. 2: Structural system of the underground floor.

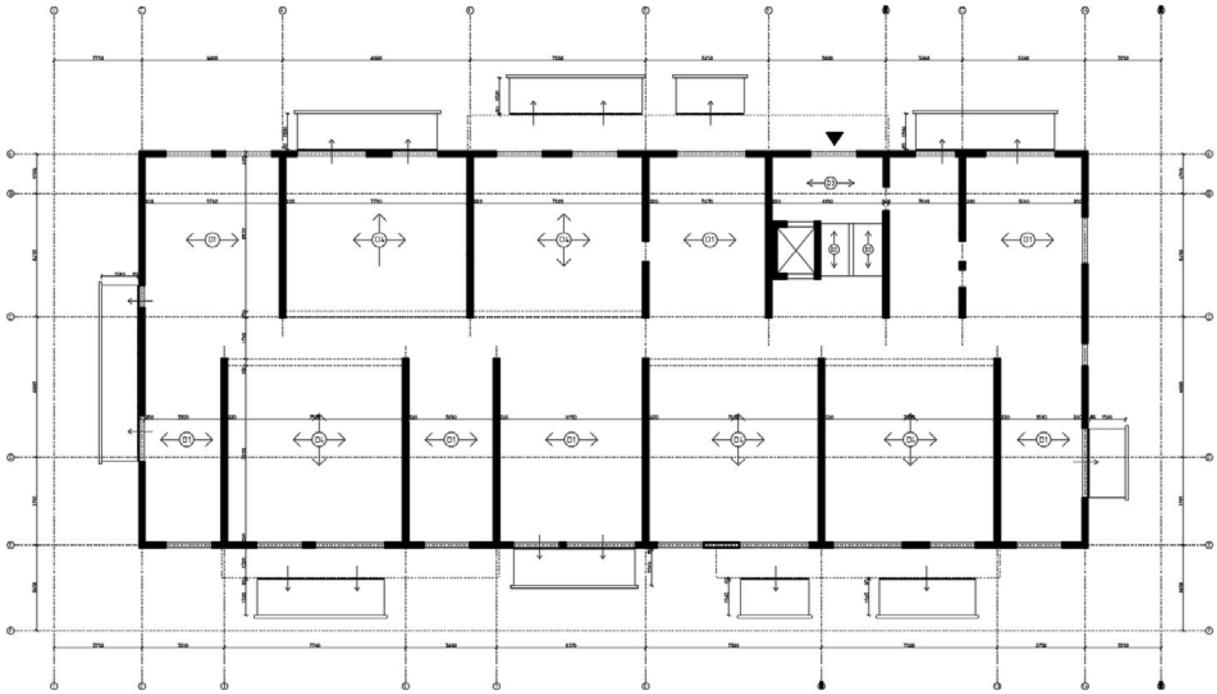


Fig. 3: Structural system of the 1st floor.

The load – bearing structure of the apartment building consists of monolithic reinforced concrete walls, pillars and reinforced concrete slabs. The underground floor is designed as a two – way flat slab with thickness of 250 mm supported on pillars. Pillars have dimensions of 240 x 1 000 mm made of reinforced concrete C30/37 XC2. The perimeter wall is made of watertight reinforced concrete C30/37 XC2 XD1 with thickness of 240 mm (integral waterproofing system with no external coating).

The structural system of upper ground floors is designed as a one – way and two – way transversal wall system. Two – way slabs will be supported by beam due to the long span with dimensions of 250 x 680 mm.

The structures protruding in front of the façade (balconies) are connected to other construction by using iso beams with elimination of thermal bridges (Bronze TiP MQ)**.** The connection between levels is provided by a staircase and an elevator. Used type of the staircase is precast staircase and landing is monolithic.

Structural design calculation is provided on page 9.

3.1 Staircase

The reinforced concrete staircase is designed as a two – flight precast, made of concrete C30/37, situated next to elevator shaft with monolithic reinforced concrete landing.

The basic geometry of the steps for upper ground floor staircases is 165/280 mm at inclination of 30.8˚, and 175/280 mm for the underground level due to different heights.

The flight of the staircase is placed on the landing by means of rubber blocks (BELAR) and dilated from reinforced concrete walls by 30 mm gap (limitation of impact sound transmission to neighboring ones protected areas). Reinforced concrete precast flight elements are bedded in landing by Schöck Tronsole® type F and to the reinforced concrete wall by Schöck Tronsole® type L.

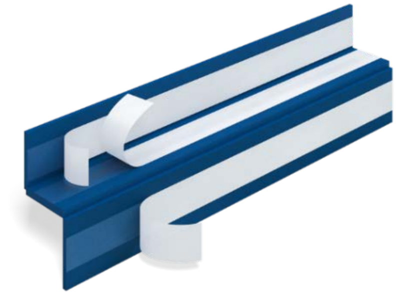


Fig. 4: Schöck Tronsole® type F – between precast flight and landing.

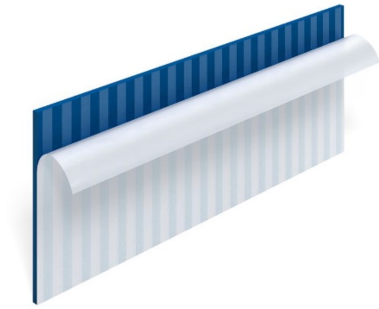


Fig. 5: Schöck Tronsole® type L – between concrete wall and landing.

Fig. 6: Schöck Tronsole® type B – between foundation slab and flight.

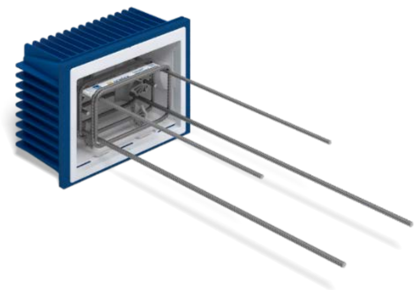


Fig. 7: Schöck Tronsole® type Z – wall case.

The staircase has steel railing with wooden handrail. Railing will be anchored to the walls of the elevator shaft and to the walls of the core. The handrails are 900 mm high from the side of the staircase walls.

Structural design of the staircase is provided on page 16.

3.2 Elevator shafts

Elevator shafts are designed as a monolithic reinforced concrete with thickness of 200 mm. The acoustic solution of the noise from the elevator is carried out by dilatation from rest of the structures with 30 mm thickness filled with flexible EPS boards. The shaft is connected with the construction only at the base level.

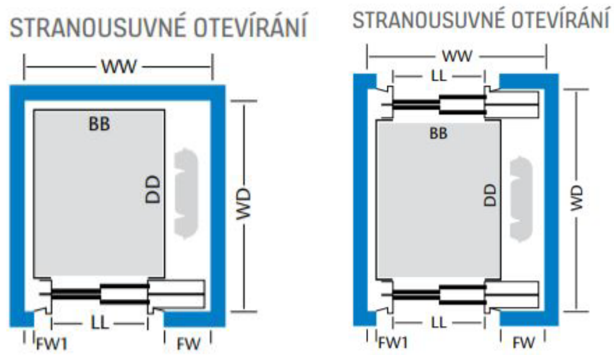


Fig. 8: KONE MonoSpace 500 - elevator.

3.3 Balconies

The balconies are used as cantilever with 1 540 and 1 520 mm of span. Balconies are connected to other construction by using iso beams with elimination of thermal bridges**.** Non - insulated structure is made of concrete C30/37 XC-XF3.

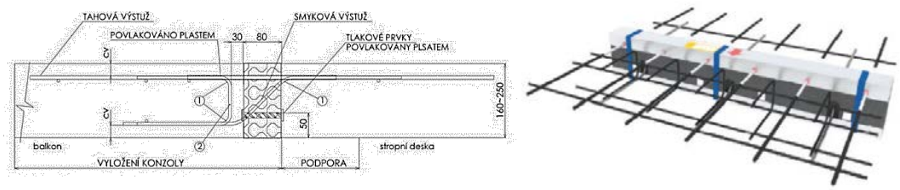


Fig. 9: Iso beam Bronze TiP MQ.

Structural design of the balcony is provided on page 15.

4 Loads

The loads are considered in accordance with valid standards and regulations of Eurocode.

4.1 Permanent load

The load factor is in accordance with EN 1991 considered as $\gamma_q = 1.35$.

4.2 Variable load

The variable load of slabs is considered by characteristic values as follows in accordance with EN 1991-1-1:2002:

Underground floor parking – Category F: $q_k = 2.5$ kN/m^2

Upper floors – residential area – Category A: slab $q_k = 1.5$ kN/m^2

staircase $q_k = 2.0$ kN/m^2

balcony $q_k = 2.5$ kN/m^2

Non-walkable roof – Category H: $q_k = 0.75$ kN/m^2

Terrace – Category C5: $q_k = 5.0$ kN/m^2

The load factor is in accordance with EN 1991 considered as $\gamma_q = 1.50$.

4.3 Snow load

The building is located in the I snow area according to the classification EN 1991-1-3 “Czech Republic: Snow Load on the ground” for which the characteristic value applies load $s_k = 0.75$ kN/m^2.

The load factor for snow load is $\gamma_q = 1.50$.

4.4 Wind load

The building is located in II wind region according to the classification EN 1991-1-4 “Wind actions” for which the characteristic value of initial wind speed is $\upsilon_{b,0} = 25$ m/s.
The load factor for wind loads is $\gamma_q = 1.50$.

5 Preliminary design

5.1 Reinforced concrete slab design

Underground floor (F2) – two – way reinforced concrete slab (D1) supported on pillars.

- Slab depth:

$$h_s = \frac{1}{33} * l_{n,max} = \frac{1}{33} * 6\,370 \approx 195\ mm$$

$$d = h_s - c - \frac{\emptyset}{2} = 195 - 25 - \frac{10}{2} = 165\ mm$$

- Span/depth ratio:

$$\lambda = \frac{l}{d} \leq \lambda_{lim} = k_{c1} * k_{c2} * k_{c3} * \lambda_{d,tab}$$

$$\lambda = \frac{6\,370}{165} = 37.4 \ \leq \ \lambda_{lim} = 1 * 1 * 1.3 * 24 = 31.2 \rightarrow 37.4\ mm \geq 31.2\ mm \rightarrow \textbf{NOT OK}$$

need to increase $h_s \rightarrow \boldsymbol{h_s = 250\ mm}, d = 220\ mm$

$$\lambda = \frac{6\,370}{220} = 28.9 \rightarrow 28.9\ mm \leq 31.2\ mm \ \rightarrow \ \textbf{OK}$$

FINAL DESIGN: $\boldsymbol{h_s = 250\ mm}$

Typical floors (**F3**) – one – way reinforced concrete slab (D1).

- Slab depth:

$$d_s \geq \frac{l}{k_{c1} * k_{c2} * k_{c3} * \lambda_{d,tab}} = \frac{6\,370}{1 * 1 * 1.3 * 30.8} \approx 160\ mm$$

$$h_s = d_s + c + \frac{\emptyset}{2} = 160 + 25 + \frac{10}{2} = \boldsymbol{200\ mm}$$

Typical floors (F3) – two – way reinforced concrete slab simply supported on beam (D4).

- Slab depth:

$$d_s \geq \frac{l}{k_{c1} * k_{c2} * k_{c3} * \lambda_{d,tab}} = \frac{8\ 000}{1 * 0.875 * 1.3 * 30.8} \approx 220\ mm$$

$$h_s = d_s + c + \frac{\emptyset}{2} = 220 + 25 + \frac{10}{2} = \mathbf{250\ mm}$$

where:

$\emptyset = 10\ mm$ (estimated)

$c = c_{min} + c_{dev} = 15 + 10 = 25\ mm$

$c_{min} = \max(c_{min,b};\ c_{min,dur}; 10\ mm) = \max\ (10; 15; 10) = 15\ mm$

d – effective depth of cross section

l – element span

k_{c1} – coefficient of cross – section (rectangular cross – section 1; T – shape cross – section 0.8)

k_{c2} – coefficient of span (for $l \leq 7m\ k_{c2} = 1.0$, other cases $k_{c2} = 7/l$)

k_{c3} – coefficient of stress in tensile reinforcement (assumed $k_{c3} = 1.1 - 1.3$)

$\lambda_{d,tab}$ – design span to depth ratio obtained from the table

FINAL DESIGN: $\boldsymbol{h_s = 250\ mm}$

5.2 Load calculation

SLAB (F02)				
PERMANENT LOAD	th. [m]	f_k [kN/m^2]	γ [-]	f_d [kN/m^2]
Laminate floating floor	0.01	0.061	1.35	0.082
Anhydrate screed	0.04	0.800	1.35	1.08
PE separation foil	-	0.009	1.35	0.012
EPS-T 4000 acoustic insulation	0.04	0.010	1.35	0.013
RC slab	0.25	6.250	1.35	8.438
ISOVER UNI mineral wool	0.1	0.070	1.35	0.095
Gypsum board	0.01	0.053	1.35	0.072
Partitions	0.175	1.200	1.35	1.620
TOTAL				**11.411**
VARIABLE LOAD	th. [m]	f_k [kN/m^2]	γ [-]	f_d [kN/m^2]
Category A	-	2	1.5	3
TOTAL				**14.411**

Table 1: Load of F2 slab.

SLAB (F03)				
PERMANENT LOAD	th. [m]	f_k [kN/m²]	γ [-]	f_d [kN/m²]
Laminate floating floor	0.01	0.061	1.35	0.082
Anhydrate screed	0.04	0.800	1.35	1.08
PE separation foil	-	0.009	1.35	0.012
EPS-T 4000 acoustic insulation	0.04	0.010	1.35	0.013
RC slab	0.25	6.250	1.35	8.438
Plaster	0.01	0.053	1.35	0.072
TOTAL				**9.946**
VARIABLE LOAD	th. [m]	f_k [kN/m²]	γ [-]	f_d [kN/m²]
Category A	-	2	1.5	3
TOTAL				**12.946**

Table 2: Load of F3 slab.

ROOF (R01)				
PERMANENT LOAD	th. [m]	f_k [kN/m²]	γ [-]	f_d [kN/m²]
DEK stonecrop mat	0.03	0.370	1.35	0.500
Substrate	0.1	1.480	1.35	2.000
EPS thermal insulation	0.08	0.028	1.35	0.038
Modified asphalt strips	0.004	0.002	1.35	0.003
RC slab	0.2	5.000	1.35	6.750
Plaster	0.01	0.053	1.35	0.072
TOTAL				9.364
VARIABLE LOAD	th. [m]	f_k [kN/m²]	γ [-]	f_d [kN/m²]
Category H	-	1	1.5	1.5
Snow load	-	0.6	1.5	0.9
TOTAL				**11.764**

Table 3: Load of the roof.

BALCONY (F08)				
PERMANENT LOAD	th. [m]	f_k [kN/m²]	γ [-]	f_d [kN/m²]
Ceramic tiles	0.015	0.00033	1.35	0.0004455
RC slab	0.2	5	1.35	6.75
Plaster	0.005	0.04	1.35	0.057
TOTAL				**6.808**
VARIABLE LOAD	th. [m]	f_k [kN/m²]	γ [-]	f_d [kN/m²]
Category A	-	2.5	1.5	3.75
Snow load	-	0.6	1.5	0.9
TOTAL				**11.458**

Table 4: Load of the balcony.

LANDING (F07)				
LOAD	th. [m]	f_k [kN/m²]	γ [-]	f_{dl} [kN/m²]
Ceramic tiles	0.015	0.00033	1.35	0.0004455
Anhydrate screed	0.035	0.700	1.35	0.945
Polyethylene foam	0.01	0.002	1.35	0.003
RC slab	0.13	4.750	1.35	6.413
Gypsum board	0.003	0.016	1.35	0.021
LIVE LOAD (Category A)	-	2	1.5	3
TOTAL				**10.382**
FLIGHT				
LOAD	th. [m]	f_k [kN/m²]	γ [-]	f_{df} [kN/m²]
Slab	0.14	3.5	1.35	4.725
Cladding	0.015	0.3	1.35	0.405
Step	-	1.75	1.35	2.363
LIVE LOAD (Category A)	-	2	1.5	3
TOTAL				**10.493**

Table 5: Load of the landing and flight.

5.3 Reinforced concrete pillar design

The most loaded pillar – C6.

$A = 7.75 * 5.625 = 43.594\ m^2$

$N_{Ed} \leq N_{Rd}$

$N_{Rd} = 0.8 * A_c * f_{cd} + A_s * \sigma_s \geq N_{Ed}$

$$A_c = \frac{N_{Ed}}{0.8 * f_{cd} + 0.02 * \sigma_s}$$

where:

$f_{cd} = 20\ MPa$

$\sigma_s = 400\ MPa$

- Calculation of load:

4 x typical floors → $43.594 * (14.411 + 3 * 12.946) = 2\,321.337\ kN$

1 x roof → $1 * 43.594 * 11.764 = 512.839\ kN$

Self weight of the column → $0.24 * 1 * 2.97 * 25 * 1.35 = 24.057\ kN$

$N_{Ed} = 24.057 + (2\,321.337 + 512.839) = 2\,858.233\ kN$

$$A_c = \frac{2\,858.233 * 10^3}{0.8 * 20 + 0.02 * 400} = 119\,093\ mm^2$$

Designed column → 240 x 1 000 mm; $A_c = 240\,000\ mm^2$ → **OK**

5.3.1 Punching check

- Control perimeters:

$u_0 = 2 * (a + 1.5d) = 2 * (240 + 1.5 * 250) = 1\ 230\ mm$

$u_1 = 2 * (a + 1.5d) + 2\pi * 2d = 2 * (240 + 1.5 * 250) + 2\pi * 2 * 250 = 4\ 371.593\ mm$

- Maximum punching shear resistance:

$\vartheta_{Ed,0} = \frac{\beta * V_{Ed}}{u_0 * d} \leq \vartheta_{Rd,max} = 0.4 * \upsilon * f_{cd}$

where:

$\beta = 1.15$

$V_{Ed} = A * f_d = 43.594 * 14.411 = 628.273\ kN$

$\upsilon = 0.6 * \left(1 - \frac{f_{ck}}{250}\right) = 0.6 * \left(1 - \frac{30}{250}\right) = 0.528$

$f_{ck} = 30\ MPa$

$f_{cd} = \frac{f_{ck}}{1.5} = \frac{30}{1.5} = 20\ MPa$

$\vartheta_{Ed,0} = \frac{1.15 * 628.273 * 10^3}{1\ 230 * 250} = 2.34\ MPa$

$\vartheta_{Rd,max} = 0.4 * 0.528 * 20 = 4.22\ MPa \rightarrow 2.34\ MPa \leq 4.22\ MPa \rightarrow$ **OK**

- Maximum resistance with reinforcement:

$\vartheta_{Ed,1} = \frac{\beta * V_{Ed}}{u_1 * d} \leq k_{max} * \vartheta_{Rd,c} = k_{max} * C_{Rd,c} * k * \sqrt[3]{(100\rho_l * f_{ck})}$

where:

$k_{max} = 1.8$

$C_{Rd,c} = 0.12$

$k = 1 + \sqrt{\frac{200}{d}} \leq 2 \rightarrow k = 1 + \sqrt{\frac{200}{220}} = 1.92 \leq 2$

$\rho_l = 0.005$

$\vartheta_{Ed,1} = \frac{1.15 * 628.273 * 10^3}{4\ 371.593 * 250} = 0.661\ MPa$

$\vartheta_{Rd,c} = 1.8 * 0.12 * 1.95 * \sqrt[3]{(100 * 0.005 * 30)} \rightarrow \vartheta_{Rd,c} = 1.038\ MPa$

$\vartheta_{Ed,1} = 0.661\ MPa\ \leq\ \vartheta_{Rd,c} = 1.038\ MPa \rightarrow$ **OK**

FINAL DESIGN: 240 x 1000 mm

5.4 Reinforced concrete beam design

- Dimensions of a cross – section B1:

$$h_b = \left(\frac{1}{12} \sim \frac{1}{10}\right) * l_b = \left(\frac{1}{12} \sim \frac{1}{10}\right) * 8\,000 = 665 \sim 800\ mm$$

$$h_b = 680\ mm$$

$$b_b = \left(\frac{1}{3} \sim \frac{2}{3}\right) * h_b = \left(\frac{1}{3} \sim \frac{2}{3}\right) * 680 = 225 \sim 455\ mm$$

$$b_b = 250\ mm$$

- Dimensions of a cross – section B2:

$$h_b = \left(\frac{1}{12} \sim \frac{1}{10}\right) * l_b = \left(\frac{1}{12} \sim \frac{1}{10}\right) * 7\,500 = 625 \sim 750\ mm$$

$$h_b = 680\ mm$$

$$b_b = \left(\frac{1}{3} \sim \frac{2}{3}\right) * h_b = \left(\frac{1}{3} \sim \frac{2}{3}\right) * 680 = 225 \sim 455\ mm$$

$$b_b = 250\ mm$$

- Dimensions of a cross – section B3:

$$h_b = \left(\frac{1}{12} \sim \frac{1}{10}\right) * l_b = \left(\frac{1}{12} \sim \frac{1}{10}\right) * 7\,740 = 645 \sim 774\ mm$$

$$h_b = 680\ mm$$

$$b_b = \left(\frac{1}{3} \sim \frac{2}{3}\right) * h_b = \left(\frac{1}{3} \sim \frac{2}{3}\right) * 680 = 225 \sim 455\ mm$$

$$b_b = 250\ mm$$

DESIGN: 250 x 680 mm

5.4.1 Preliminary check

- Bending check:

$$M_{Ed,max} = \frac{1}{8} * f_b * l_b^2$$

$f_b = (14.411 + 3 * 12.946 + 11.764) + (25 * 0.25 * 0.68 * 1 * 1.35) = 70.666\ kN/m$

$M_{Ed,max} = \frac{1}{8} * 70.666 * 8^2 = 565.328\ kNm$

$d_b = h_b - c - \frac{\emptyset}{2} - \emptyset_s = 680 - 25 - \frac{20}{2} - 10 = 635\ mm$

$\mu = \frac{M_{Ed,max}}{b_b * d_b^2 * f_{cd}} = \frac{565.328 * 10^6}{250 * 635^2 * 20} = 0.280 \rightarrow table: \xi = 0.421; \zeta = 0.832$

- Reinforcement ratio check:

$\rho_{s,req} = \frac{A_{s,req}}{A_c} = \frac{\frac{M_{Ed,max}}{\zeta * d_b * f_{yd}}}{b_b * d_b} < 0.04$

$\rho_{s,req} = \frac{\frac{565.328*10^6}{0.832*635*435}}{250*635} = 0.015 < 0.04 \rightarrow$ **OK**

- Shear check:

$V_{Rd,max} = \nu * f_{cd} * b_b * \zeta * d_b * \frac{cot\theta}{1 + cot^2\theta} \geq V_{Ed,max} = \frac{5}{8} * f_b * l_b$

where:

$\nu = 0.6 * \left(1 - \frac{f_{ck}}{250}\right) = 0.6 * \left(1 - \frac{30}{250}\right) = 0.5$

$cot\theta = 1.5$

$V_{Rd,max} = 0.5 * 20 * 250 * 0.832 * 635 * \frac{1.5}{1 + 1.5^2} = 609.600\ kN$

$V_{Ed,max} = \frac{5}{8} * 70.666 * 8 = 353.33\ kN$

$614.728\ kN > 353.33\ kN \rightarrow$ **OK**

FINAL DESIGN: 250 x 680 mm

5.5 Balcony design

- Empirical design of the slab:

$h_{balc} = \frac{1}{10} * l_k = \frac{1}{10} * 1\,540 = 154\ mm$

- Span/depth ratio:

$\lambda = \frac{l}{d} \leq \lambda_{lim} = k_{c1} * k_{c2} * k_{c3} * \lambda_{d,tab}$

$d \geq \frac{l}{d} = \frac{1\,540}{1 * 1 * 1.2 * 8} = 160\ mm$

$h \geq d + c + \frac{\emptyset}{2} = 160 + 25 + 5 = 185\ mm \rightarrow$ **NOT OK**

where:

$\emptyset = 10\ mm$ (estimated)

$c = c_{min} + c_{dev} = 15 + 10 = 25\ mm$

$c_{min} = \max(c_{min,b};\ c_{min,dur}; 10\ mm) = \max\ (10; 15; 10) = 15\ mm$

d – effective depth of cross section

l – element span

k_{c1} – coefficient of cross – section (rectangular cross – section 1; T – shape cross – section 0.8)

k_{c2} – coefficient of span (for $l \leq 7m$ $k_{c2} = 1.0$, other cases $k_{c2} = 7/l$)

k_{c3} – coefficient of stress in tensile reinforcement (assumed $k_{c3} = 1.1 - 1.3$)

$\lambda_{d,tab}$ – design span to depth ratio obtained from the table

FINAL DESIGN: $h_{balc} = 200\ mm$

- Static scheme:

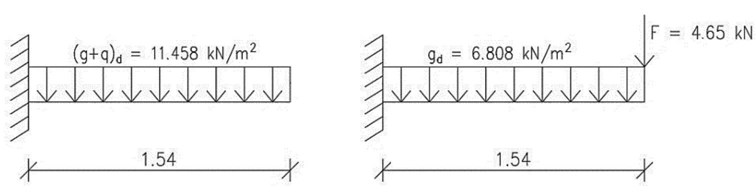


Fig.10: Static scheme of balcony.

$M_{Ed} = \frac{1}{2} * (g + q) * l^2 = \frac{1}{2} * 11.458 * 1.54^2 = 13.587\ kNm/m$

$M_{Ed} = \frac{1}{2} * g * l^2 + F * l = \frac{1}{2} * 6.808 * 1.54^2 + 4.65 * 1.54 = 15.234\ kNm/m$

	h [mm]	b [mm]	d [mm]	M_{ed} [kNm/m]	μ [-]	ξ [-]	As,req [mm^2]	ρ [%]
balcony	200	1000	170	15.234	0.0045	0.051	225	0.13

Table 6: Total check of balcony.

DESIGN OF THE BALCONY IS OK.

5.6 Staircase design

- Scheme of the staircase:

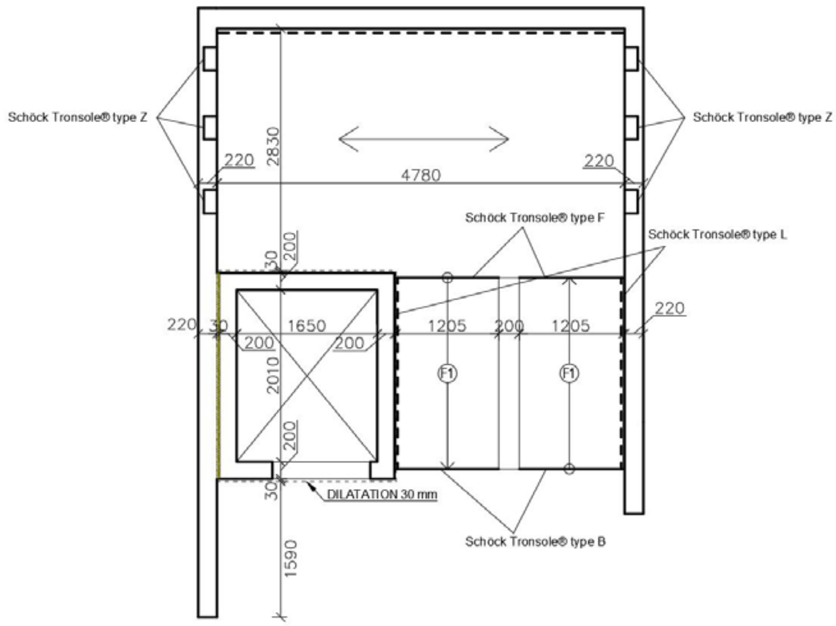


Fig.11: Scheme of the staircase.

- Design of two – flight staircase geometry:

Height of the floor $h = 2\,970\ mm$

Depth of the main slab $h_s = 250\ mm$

Depth of the floor structure $h_f = 100\ mm$

Thickness of staircase cladding $h_c = 15\ mm$

- Dimension of the staircase:

Ideal height of one step is 170 mm

2 970/170 = 17.4 → 18 steps (2 flights with 9 steps)

Height of one step $h = 2\,970/17 = 175\ mm$

Width of one step $b = 630 - 2 * h = 630 - 2 * 175 = 280\ mm$

DESIGN: Staircase with 175/280 mm steps, 2 flights, 9 steps in each flight

Width of one flight – 1205 mm

Width of the gap between the flights – 200 mm

Width of the staircase – 2 870 mm

Slope of the staircase $\alpha = \arctan\left(\frac{h}{b}\right) = \arctan\left(\frac{175}{280}\right) = 30.8°$

- Preliminary check of the depth of the slab:

The staircase is considered as one-way slab with the span of 2 240 mm

The depth should be at least 2 240/25 = 112 mm

The depth of landing 200 mm

The depth of flights 140 mm

200 mm > 112 mm and 140 mm > 112 mm → **OK**

- Perpendicular and head clearance of the staircase:

Head clearance of the staircase should be more than $1\ 500 + \frac{750}{cos\alpha} > 2\ 100\ mm$

$1\ 500 + \frac{750}{\cos(30.8°)} = 2\ 347\ mm > 2\ 100\ mm\ \rightarrow\ \mathbf{OK}$

Head clearance of staircase $h_1 = h_k - h_s - h_f - h = 2\ 970 - 250 - 100 - 175 = 2\ 445\ mm$

2 445 mm > 2 347 mm > 2 100 mm → **OK**

Perpendicular clearance of the staircase should be more than $750 + 1500 * cos\alpha > 1\ 900\ mm$

$750 + 1500 * \cos(30.8°) = 2\ 077\ mm > \ 1\ 900\ mm \rightarrow\ \mathbf{OK}$

Perpendicular clearance of staircase $h_2 = h_1 * cos\alpha = 2\ 445 * \cos(30.8°) = 2\ 164\ mm$

164 mm > 2 077 mm > 1 900 mm → **OK**

5.6.1 Design of the reinforcement

$$M_{Ed} = \frac{1}{12} * f_{df} * l^2 = \frac{1}{8} * 10.493 * 2.24^2 = 4.387\ kNm$$

$$d = h_s - c - \frac{\emptyset}{2} = 200 - 25 - \frac{10}{2} = 170\ mm$$

$$A_{s,req} = \frac{M_{Ed}}{0.9 * d * f_{yd}} = \frac{4.387 * 10^6}{0.9 * 170 * 435} = 65.915\ mm^2$$

$A_{s,prov} = 115\ mm^2$ (ANNEX 2) → $3\emptyset 7$

- Brittle failure precaution:

$$A_{s,prov} \geq A_{s,min1} = \max\left(0.26 * \frac{f_{ctm}}{f_{yk}} * b * d; 0.0013 * b * d\right)$$

where:

$f_{ctm} = f_{ct,eff} = 2.9\ MPa$ – mean value of the concrete tensile strength effective at the time when the first cracks may be expected to occur

$f_{yk} = \sigma_s = 500\ MPa$ – maximum stress permitted in the reinforcement immediately after formation of the crack

$$A_{s,min1} = \max\left(0.26 * \frac{2.9}{500} * 1\ 205 * 170; 0.0013 * 1\ 205 * 170\right) = (308.914; 266.305)$$

$115\ mm^2 \geq 308.94\ mm^2 \rightarrow$ **NOT OKAY**

- Excessive cracking precaution:

$$A_{s,prov} \geq A_{s,min2} = \frac{k_c * k * f_{ct,eff} * A_{ct}}{\sigma_s}$$

where:

$k_c = 0.4;\ k = 1$ – coefficients describing stress distribution in cross – section

$A_{ct} = 0.5 * b * d$ – area of concrete within tensile zone at the first crack

$$A_{s,min2} = \frac{0.4 * 1 * 2.9 * 0.5 * 1\ 205 * 170}{500} = 237.626\ mm^2$$

$115\ mm^2 \geq 237.626 mm^2 \rightarrow$ **NOT OK**

- Check of the design:

$$x = \frac{A_{s,prov} * f_{yd}}{0.8 * b * f_{cd}} = \frac{352 * 435}{0.8 * 1\ 205 * 20} = 7.9\ mm$$

$$z = d - 0.4 * x = 170 - 0.4 * 7.9 = 167\ mm$$

$$\xi = \frac{x}{d} \leq 0.45 \rightarrow 0.04 \leq 0.45$$

$$M_{Rd} \geq M_{Ed}$$

$$M_{Rd} = A_{s,prov} * f_{yd} * z = 352 * 435 * 167 * 10^{-6} = 25.571\ kNm$$

$M_{Rd} = 25.57\ kNm\ \geq M_{Ed} = 4.387\ kNm\ \rightarrow$ **OK**

FINAL DESIGN: $\boldsymbol{A_{s,prov} = 352\ mm^2 \rightarrow 7\emptyset 8}$

6 Materials

6.1 Reinforced concrete structures

Concrete in accordance with ČSN EN 206-1

Base slab – waterproof white bathtub concrete	C30/37 XC2 XD1 XA1 D_{max} 22 Cl 0,20 S3
Piles	C25/30 XC2 XA1 D_{max} 22 Cl 0,40 S4
Underground floor – perimeter wall	C30/37 XC2 XD1 XA1 D_{max} 22 Cl 0,20 S4
Underground floor – pillars	C30/37 XC2 XD1 D_{max} 22 Cl 0,40 S4
Underground floor – slab	C30/37 XC1 D_{max} 22 Cl 0,40 S4
1^{st} – 4^{th} floor – load-bearing walls	C30/37 XC1 D_{max} 22-Cl 0,40-S4
1^{st} – 4^{th} floor – slab	C30/37 XC1 D_{max} 22 Cl 0,40 S4
Balcony, terrace	C30/37 XC4 XF3 D_{max} 16 Cl 0,40 S4
Precast staircase flight	C30/37 XC1 D_{max} 22 Cl 0,40 S4
Monolithic landing	C25/30 XC1 D_{max} 22 Cl 0,40 S4

6.2 Masonry structures

1^{st} – 4^{th} floor – vertical structures	HELUZ UNI 25, M10
	HELUZ 24, M10
	HELUZ AKU Z 17.5, M10
	HELUZ 11.5, M10
	HELUZ 8, M10

6.3 Steel structures

Steel reinforcement grade: B500B

7 Standard norms and literatures

[1] ČSN EN 1990 Basis of structural design

[2] ČSN EN 1991-1 Action on structures

[3] ČSN EN 1992-1 Design of concrete structures

[4] ČSN EN 1996-1 Design of masonry structures

[5] ČSN 73 1001 Subsoil under shallow foundation

[6] ČSN EN 1997-1 Geotechnical design – Part 1: General rules

[7] ČSN EN 206-1 Concrete - Part 1: Specification, performance, production and conformity

[8] CM01_01 lecture – Concrete and Masonry structures 1, doc. Ing. Petr Bílý, Ph.D.

8 Used web pages

[1] www.schoeck.com/en/tronsole-type-f

[2] www.schoeck.com/cs/tronsole-typ-b

[3] www.schoeck.com/cs/tronsole-typ-l

[4] www.bronze.cz/termoizolacni-nosnik_tip-mq.html

9 List of drawings

1) Structural system of the underground floor, 1:50
2) Structural system of the 1st floor, 1:50
3) Formwork of the underground floor, 1:50
4) Formwork of the 1st floor, 1:50
5) Reinforcement of the staircase, 1:30

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

K135 DEPARTMENT OF GEOTECHNICS

TECHNICAL REPORT

Designed by: Bc. Dayana Muratova

Consulted with: Ing. Jan Salák, CSc.

CONTENT

1 Location of the residential building

The area of the apartment building is located in the city district of Prague 9 – Letňany, parcels No. 760/64, 760/66. Designed building is a part of a residential complex "Letňany gardens" – building M. The building is not located in a seismically active area, inundation (flood) area or in the area affected by slope movement.

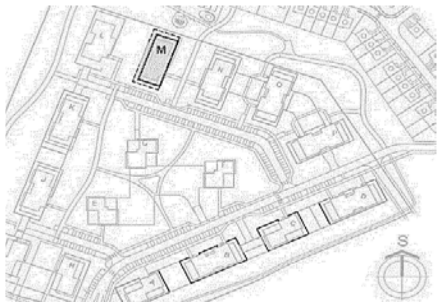


Fig. 1: Situation.

2 General information

The residential building contains 1 underground floor and 4 upper ground floors. The area of underground floor is 47.6 x 20.6 m. The upper ground floors from 1 to 3 occupy an area of 47.5 x 20.7 m. The 4^{th} floor recedes to the middle of the floor plan and has dimensions of 33.2 x 19.8 m. Total building height is 12.62 m. Underground floor's height is 2.97 m and upper typical floors have 2.80 m of height. There are 38 parking spaces, 38 storage rooms, 1 technical room and 1 cleaning room on the underground floor. Access to the garage side is provided by the entrance in object L through connecting neck between two buildings. On the 1^{st} floor there are the main entrance to the building, stroller room and 10 apartments. There are 22 apartments in total on the 2^{nd} – 3^{rd} floors and 6 apartments on the 4^{th} floor. The spaces protruding in front of the façade plane are considered as terraces and balconies.

3 Geological situation

3.1 Soil characteristic

The building is defined in height uniform level ± 0,00 = 261,800 m above sea level. The basement floor is also uniformly on the elevation of 258.450 m above sea level. The elevation height practically means that the basement is basically set on the existing ground level. The upper layer of the soil with thickness of 0.8 - 0.9 m, there are loess and loess clays (GT3) with a mean thickness of 1.5 m. The groundwater in the floor plan of the underground section is located at a depth of approximately 2.6 – 2.8 m below the surface of the terrain. Thus, the object will be supported on large piles which will be aligned to the level of the upper edge of the base concrete.

The groundwater shows a very mild basic reaction (pH = 7.4). In terms of the aggressiveness of the liquid environment on concrete structures, groundwater is classified in the sense of ČSN EN 206-1 with the degree of aggressiveness XA1 due to a slightly increased content of sulfate ions. According to the cited standards, the indicative minimum strength class of concrete C30/37 is stated.

By the recommendations of geological survey minimum deformation modulus E_{def} of fill must be bigger than 10 MPa. For calculation was used E_{def} = 12 MPa and total cohesion is equal to 60 kPa.

3.2 Excavation

The excavation will be provided for the underground level. The excavation area is composed of backfill soil and gravel 16/32, compacted on bearing capacity of soil. The excavated soil volume is 970 m^3.

3.3 Foundation slab

The foundation slab will be concreted to the concrete base of thickness 100 mm through separation foil, which ensures partial elimination of deformations. Designed separation is 2xPE geotextile foil with thickness of 0.20 mm.

3.4 Piles

The apartment building will be based deeply on large-diameter piles with a diameter of 600 and 900 mm. The compacted embankment will be overfilled with layer of min. 300 mm, which will form a plain for drilling piles of deep foundation. Drilled piles will be stuck min. 0.5 m to the environment of kaolinitic sandstone (GT7). The pile heads will be aligned to the level of the upper edge of the base concrete. Calculation is provided on page 5.

3.5 Radon load

The site has a mean radon index based on assessment of radon volume activity in soil air and soil gas permeability. The proposed method of waterproofing the substructure and air – ventilated basement areas provide sufficient protection in terms of risk of intrusion radon from the subsoil into the building (according to ČSN 73 0601).

4 Calculation

Soil section consists of 2,0 m loess clay and 20 m stiff clay. Borehole is supported by bentonite slurry and the pile will be concreted within 8 hours after boring. Piles carry 70% of the load and rest of it carries by foundation slab of thickness 250 mm.
Calculation in accordance with ČSN 73 1004.

- The most loaded pillar (C6):

N_{ed} = 2 858.233 kN

- Designed load on pile:

2 858.233 * 70% = 2 000.763 kN

- Characteristic load on pile (N_{ed}):

2 000.763 / 1,4 = **1 129.116 kN**

- Modulus of elasticity of concrete:

E_p = 23 000 MPa

- Modulus of soil deformability:

E_s = 12 MPa

- Fully mobilized side friction:

$$R_{sk} = m_2 * C_p * \sum Di * C_i$$

where:

$m_2 = 0.5$ (low density slurry + casting by concrete during 8 hours)

$C_p = \pi * d = \pi * 0.9 = 2.83\ m$

$D_i = D = 10\ m$ – height of the pile contributing to skin friction

$C_i = C_u = 60\ kPa$ – total cohesion

$$R_{sk} = 0.5 * 2{,}83 * 10 * 60 = \mathbf{849\ kN}$$

- Load at fully mobilized side friction:

$$R_{yk} = \frac{R_{sk}}{1 - \beta}$$

where:
$\beta = \beta_1 * C_k = 0.12 * 0.88 = 0.1056$
$\beta_1 \rightarrow \frac{D}{d} = \frac{8}{0.9} = 8.88 \rightarrow 0.12$ – factor of pile slenderness (table 1)
$C_k \rightarrow k = \frac{E_p}{E_{def}} = \frac{23\ 000}{12} = 1\ 916{,}67;\ \frac{D_p}{d} = \frac{10}{0.9} = 11.1 \rightarrow 0.88$ – pile compressibility factor

$$R_{yk} = \frac{849}{1 - 0.1056} = 949.239\ kN$$

- Ultimate load at pile base (toe):

$$R_{bk} = m_4 * A * C_u * N_c$$

where:
$m_4 = 0.7$
$A = \frac{\pi d^2}{4} = \frac{\pi * 0{,}9}{4} = 0.636\ m^2$ – area of tor in contact with subsoil
$C_u = 60\ kPa$ – cohesion
$N_c = 9$ – bearing capacity factor

$$R_{bk} = 0.7 * 0.636 * 60 * 9 = \mathbf{240.408\ kN}$$

- Total resistance of the pile:

$$R_{c,d} = \frac{R_{bk}}{\gamma_b} + \frac{R_{sk}}{\gamma_s}$$

where:
γ_b, γ_s – partial factors

$$R_{c,d} = \frac{240.408}{1.25} + \frac{849}{1} = \mathbf{1\ 241.326\ kN}$$

$R_{c,d} \geq N_{Ed} \rightarrow 1\ 241.326\ kN \geq 1\ 129.116\ kN \rightarrow$ **Design is okay**.

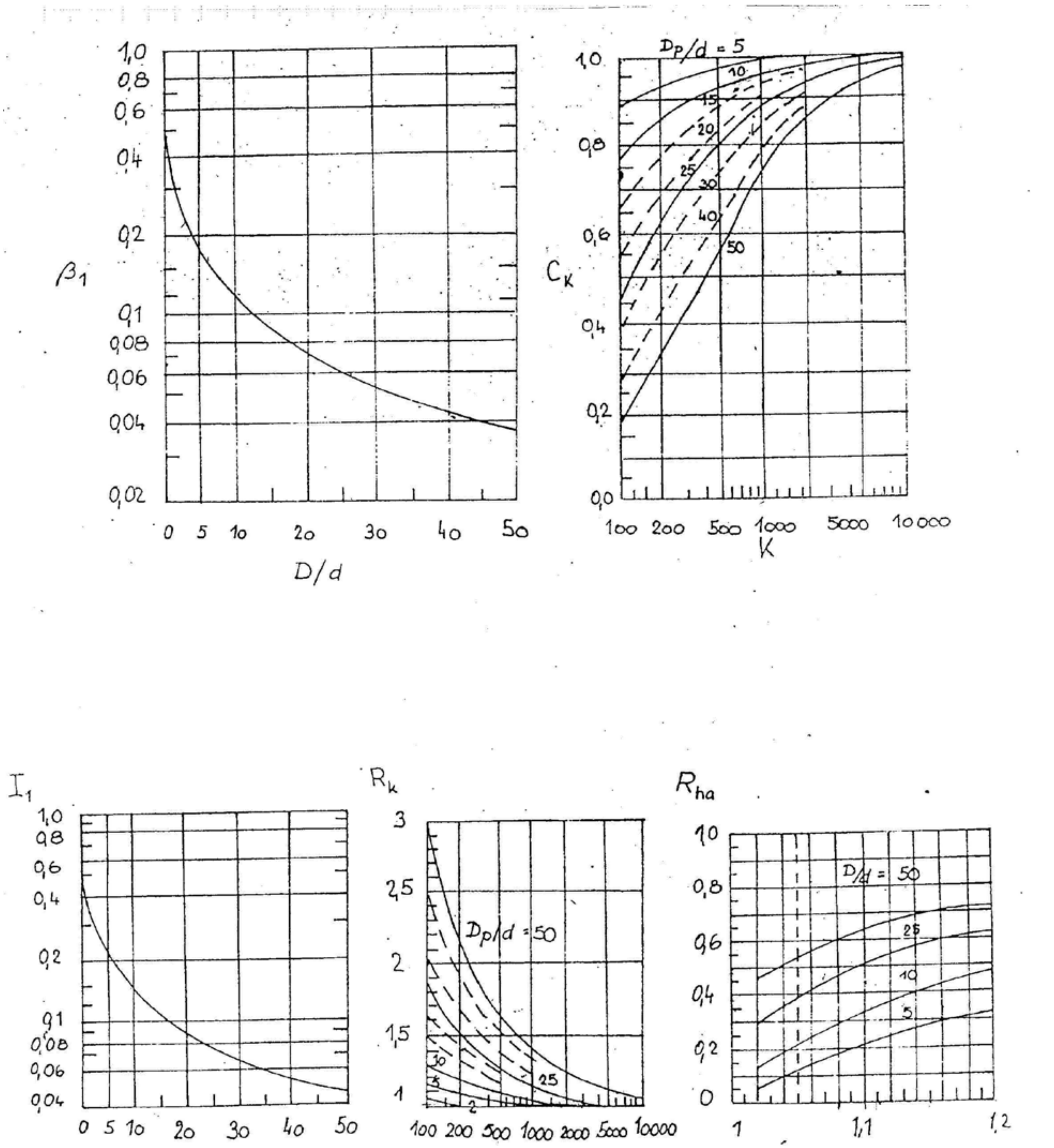


Table 1: Coefficients of pile foundation

5 Materials

Concrete in accordance with ČSN EN 206-1:

Basement slab – waterproof concrete	C30/37 XC2 XD1 XA1 D_{max} 22 Cl 0,20 S3
Piles	C25/30 XC2 XA1 D_{max} 22 Cl 0,40 S4
Underground floor – perimeter wall	C30/37 XC2 XD1 XA1 D_{max}22 Cl 0,20 S4
Underground floor – pillars	C30/37 XC2 XD1 D_{max} 22 Cl 0,40 S4
Underground floor – slab	C30/37 XC1 D_{max} 22 Cl 0,40 S4

6 Standard norms and literature

[1] EN 1990 Basis of structural design

[2] EN 1991-1 Actions on structures

[3] EN 1992-1 Design of concrete structures

[4] EN 1997-1 Geotechnical design

[5] ČSN 73 1001 Subsoil under shallow foundation

[6] ČSN 73 1004 Large diameter piles

[7] ČSN EN 206-1 Concrete-part 1: Specification, performance, production and conformity

Used lectures:

[Piles] – Foundation 1, doc. Ing. Jan Záleský, CSc.

7 List of drawings

1) Plan and 2x section of pile foundation, 1:70

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

K125 DEPARTMENT OF BUILDING SERVICES ENGINEERING

TECHNICAL REPORT

Designed by: Bc. Dayana Muratova

Consulted with: Ing. Pavla Dvořáková, Ph.D.

CONTENT

1 Location of the apartment building

The area of the apartment building is located in the city district of Prague 9 – Letňany, parcels No. 760/64, 760/66. Designed building is a part of a residential complex “Letňany gardens” – building M. The building is not located in a seismically active area, inundation (flood) area or in the area affected by slope movement.

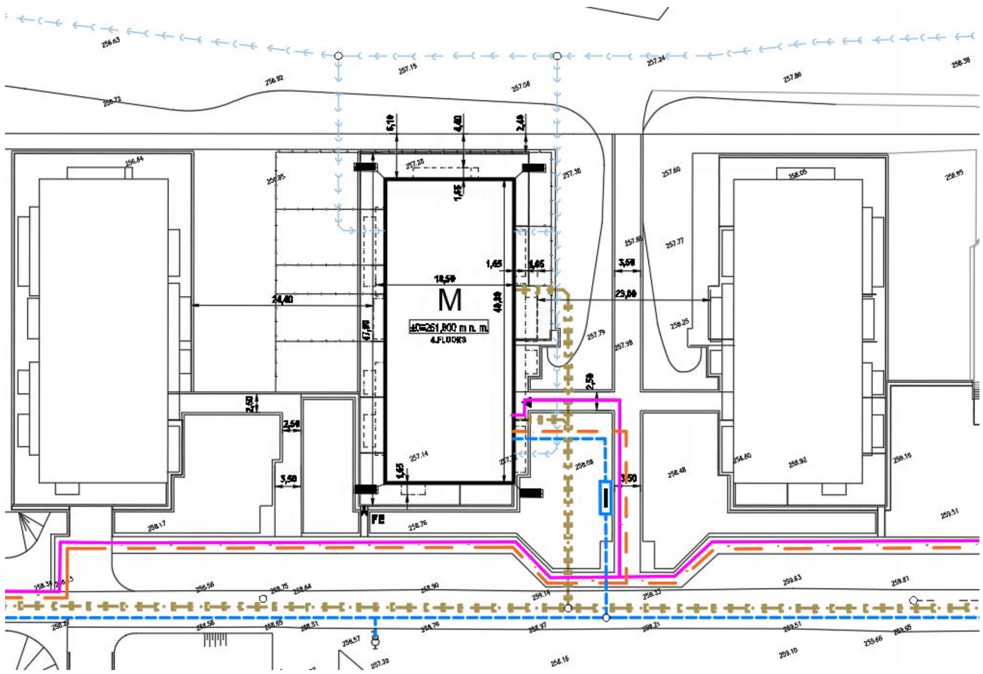


Fig. 1: Situation.

1.1 General information

The residential building contains 1 underground floor and 4 upper ground floors. The area of underground floor is 47.6 x 20.6 m. The upper ground floors from 1 to 3 occupy an area of 47.5 x 20.7 m. The 4th floor recedes to the middle of the floor plan and has dimensions of 33.2 x 19.8 m. Total building height is 12.62 m. Underground floor’s height is 2.97 m and upper typical floors have 2.80 m of height. There are 38 parking spaces, 38 storage rooms, 1 technical room and 1 cleaning room on the underground floor. Access to the garage side is provided by the entrance in object L through connecting neck between two buildings. On the 1st floor there are the main entrance to the building, stroller room and 10 apartments. There are 22 apartments in total on the 2nd – 3rd floors and 6 apartments on the 4th floor. The spaces protruding in front of the façade plane are considered as terraces and balconies.

1.2 Structural system

The load – bearing structure of the apartment building consists of monolithic reinforced concrete walls, pillars and reinforced concrete slabs. The underground floor is designed as a two – way flat slab with thickness of 250 mm supported on pillars. Pillars have dimensions of 240 x 1 000 mm made of reinforced concrete C30/37 XC2. The perimeter wall is made of watertight reinforced concrete C30/37 XC2 XD1 with thickness of 240 mm (integral waterproofing system with no external coating).

The structural system of upper ground floors is designed as a one – way and two – way transversal wall system. Two – way slabs will be supported by beam due to the long span with dimensions of 250 x 680 mm.

2 Drainage system

2.1 General information

The internal sewerage system includes complete distribution of waste pipes for the connection of fittings and drainage of the roof of the house. The building drainage is connected to the public drainage system. It has separated branches of waste water and rain water drainages as a 2-pipe system. The circular revision shaft is used for waste and rain water drainage outside the building. Drainage pipes will be placed under the ceiling in the underground level with inclination of 2%.

The following equipment is drained into the sewage system in the solved building: washbasin, bath, shower, toilet, sink, washing machine and dishwashing machine.

2.2 Drainage connection

Waste from individual installation objects will be led to the vertical waste pipe by a connecting pipe made of PP. The connecting pipes will be routed mainly in the grooves in walls, in partition walls or in the space behind the fixtures. The pipeline will be laid at the floor with a minimum slope of 2% towards the riser.

All connecting pipes will be provided with insulating layer of polyethylene with a thickness of 5 mm.

2.3 Waste water drainage

The vertical waste pipes are run mainly in the area of the installation shafts in parallel with water supply pipes. The waste pipes will be made of polypropylene pipes with high anti-noise properties. The drainage pipe of the underground will be fitted with cleaning fittings at a height of approx. 1.25 m above the clean floor. Sewer cleaning is enabled by ventilation pipes from a flat roof. The pipelines, passing through the building, will be covered with sound insulation made of mineral felt with th. 10 mm.

Ventilation of the waste pipe and the internal sewerage system will be ensured by leading the pipe to a free outdoor space above the roof level of the building. The outlet of the pipe will be made at least 0.5 m above the roof plane and terminated by ventilation in min. dimension of the waste pipe.

2.3.1 Sizing of waste water drainage

$$Q_{ww} = k * \sqrt{\sum(DU)} \leq \ Q_{max}$$

where:

DU – design drain [l/s]

k – drain coefficient, ($k = 0.5\ for\ residential\ building$)

$Q_{max} = 9.6\ [l/s]$ – from table for DN 125 with slope of 2%

Plumbing fixture	q [l/s]	DU_i [l/s]
Washbasin	0.5	25.00
Shower	0.8	3.50
Bath	0.3	16.50
Sink	0.8	19.50
Dish washer	0.8	19.00
Washing machine	0.8	19.00
WC	2	20.50
TOTAL		123.00

Table 1: Design of drain for waste water.

$$Q_{ww} = 0.5 * \sqrt{\sum(123.00)} = 5.55\ [l/s]$$

$Q_{ww} \leq Q_{max}$ → 5.55 [l/s] ≤ 9.6 [l/s] → OK

DESIGN: PVC DN 125

2.4 Rain water drainage

The roof and terraces will be drained by a system of internal and external rain sewers, which will be led by installation shafts together with other installations. Rain water drainage pipes will be provided under the ceiling with min. slope of 1% or along the walls. The internal waste pipe will be made of reinforced PP pipe with highly anti-noise properties. Along the entire length, the vertical rainwater drainage pipe will be provided with insulation with th. 5 mm made of polyethylene. Rainwater drainage pipes running along the facade in insulation will be made of PP.

2.4.1 Sizing of rain water drainage

$Q_{rw} = i * A * C \leq Q_{max}$

where:

i – rain intensity [l/sm^2], in Czech Republic $i = 0.03\ l/sm^2$

A – roof area in plan [m^2]

C – coefficient of rain water drain, ($C = 1$)

$Q_{rw} = 0.03 * 412.96 * 1 = 9.35\ [l/s]$

$Q_{rw} \leq Q_{max}$ → 9.35 [l/s] ≤ 9.6 [l/s] → OK

DESIGN: PVC DN 125

3 Water supply

3.1 General information

The documentation of the internal water supply includes complete distribution of cold and hot water and its circulation and further distribution of domestic fire water supply. The following will be connected to the internal water supply system in the solved building fixtures: washbasin, bath, shower, toilet, sink, washing machine and dishwashing machine.

An integral part of the project is fire water distribution system for connecting fire hydrant.

3.2 Water supply connection

The water source is public water supply system. The building will be supplied by a water connection pipe, which is connected to a main water meter shaft situated outside the building. Water supply pipes will be placed under the basement ceiling and always laid min. 0.3% of slope. Supply pipes are made of steel DN 50. After the water supply connection, the main branch will be divided into a separate branch of drinking water distribution and a branch of fire water distribution.

3.3 Internal water supply

The internal water supply includes cold and hot water distribution, circulation and fire water distribution. Horizontal pipes are placed under the basement ceiling with sound insulation elements. The CW (cold water), HW (hot water) and C (circulation) pipes will be run through installation shafts, which are located mainly in the bathrooms of individual apartments or in the kitchen areas. Drain shut-off valves and thermoregulation valves will be fitted at the base of each pipe. CW, HW and C pipes are connected to the hot water tank in the technical room of underground floor. Hot water will be heated by the gas boiler and supplied to all flats by the shafts.

3.3.1 Sizing of water supply

- Average daily water consumption:

$Q_P = q * n \ [l/day]$

where:

q – water consumption, in Czech Republic q = 120 [l/day]

n – number of people

$Q_P = 120 * 114$ = 13 680 [l/day]

- Maximum daily water consumption:

$Q_m = Q_P * k_d$

where:

k_d – development coefficient

$Q_m = 13\ 680 * 1.5 = 20\ 520\ [l/day]$

- Maximum hourly water consumption:

$$Q_h = Q_m * k_h$$

where:

k_h – development coefficient

$$Q_h = \frac{20\,520 * 1.8}{24} = 1\,539\ [l/hour]$$

- Flow calculation:

$$Q_v = \sqrt{\sum q_i^2 * n}\quad [l/s]$$

Plumbing fixture	q [l/s]	n	q^2*n [l/s]
Sink	0.2	39	1.56
Wash basin		50	2
Washing machine		38	1.52
Dish washer		38	1.52
Shower		7	0.28
Bath	0.3	33	2.97
WC	0.15	41	0.92
TOTAL			10.77

Table 2: Design of drain for water flow.

$$Q_v = \sqrt{10.77} = 3.28\ [l/s]$$

$$d = \sqrt{\frac{4 * Q_v}{\pi * v}}\ [m]$$

where:

d – inner diameter [m]

v – water flow velocity [m/s]

$$d = \sqrt{\frac{4 * 3.28 * 10^{-3}}{3.14 * 2.5}} = 0.04\ [m]$$

DESIGN: PP DN 20 – DN 50

4 Heating

4.1 Heat source

The building will be heated by central gas boiler, which is located in the technical room on the underground floor. It will ensure the supply of hot water preparation and hot water for heating emitters. The designed heating system is hot water with forced circulation of heating water with a nominal temperature drop of 75°/60°C at an outdoor temperature of -12°C. Each section of the building is heated by one heating branch, which has its own circulation pump and the heating water temperature is controlled by control valve. The heating system is two-pipe with a hot water distribution and will be placed under the ceiling of the underground floor.

According to the provided calculation, tubular radiators type of “KORALUX RONDO CLASSIC” will be used in the bathrooms, radiators type of “RADIK KLASIK TYP 11, 21” in living rooms and bedrooms and “ISAN” floor convectors will be placed under the french windows in the living rooms.

Only living rooms and bathrooms will be heated. Other spaces in the apartments (hall, storage room) will be heated indirectly. Common areas (stairs and corridors) and basement areas (garages and storages) will not be heated.

4.2 Piping

The piping of the floor distribution in the flats will be made of polyethylene aluminum pipes, designed for temperatures up to 95°C. The connection pipe from the underground floor to the upper floors will be protected by thermal insulation polyethylene. Thermal insulation is provided on all pipes except for deaeration and drainage.

All pipes and surfaces of equipment with a temperature higher than 60°C are provided with thermal insulation in places within reach of people. The heating pipelines are made of aluminum DN 15.

4.3 Heat source calculation

See the last pages of the documentation.

5 Ventilation

5.1 General information

The following types of ventilation system were used to ensure the right air conditioning equipment and to achieve the expected residential comfort in the building:

a) Fire ventilation system - natural, forced emergency ventilation of protected escape routes.

b) Central ventilation system - forced vacuum ventilation of (with natural supply, exhaust above the roof of the building) by using air handling unit.

c) Decentralized ventilation systems - air extraction from kitchens (exhaust above the roof of the building).

d) Ventilation equipment of other places - technical rooms, storage rooms (without heating and filtration).

e) Cooling systems - refrigerant split systems for heat dissipation in spare sources.

The air handling unit (AHU) “DUPLEX 250 Easy” is used for each floor. It is located in the corridor and connected through central ventilation shaft. Each flat will be equipped with air flow controller “SMART box”, which is connected to the AHU. Most rooms have direct ventilated windows as well.

5.2 Ventilation of the rooms

a) PEW ventilation

For A type of protected escape way, the fire protection norms prescribe a forced supply of fresh air in the value of min. 10 times the volume of the escape way. The fresh air intake will be provided by using of fan on the 1st floor.

b) Bathroom and WC

Sanitary facilities in the apartments are ventilated by exhaust fans, which are connected to the SMART box system. Each fan is equipped with an automatic non-return valve and a deceleration switch (2-20min). Doors with grilles will be used as a part of ventilation system as well.

c) Kitchen

A pipe connection for the kitchen hood is prepared in each apartment. The pipes are connected to a main pipe in the installation shafts, which opens above the roof of the building, terminated by ventilation heads. The extractor connection is designed for DN 160.

d) Living rooms and bedrooms

The fresh air will be supplied for living rooms and bedrooms by SMART box, which is connected to the AHU. Internet access allows detailed user control of the individual SMART boxes via smartphones and PCs.

e) Storage rooms

The storage rooms in which the washing machine is located will be ventilated by a fan, which is connected to the SMART box system. Other storage rooms will be ventilated by grilles on the doors.

5.3 Insulation

a) Noise insulation

The reason for the use of this insulation (mineral wool) is to prevent the penetration of noise from and into the pipelines.

b) Fire insulation

It is used wherever it is needed to insulate distributions from fire dampers at the interface of fire sections, or when the pipeline passes through a different fire section.

c) Thermal insulation

Mineral wool with thickness 25 mm will be used for thermal insulation. The pipeline running in the outdoor environment will be insulated in order to minimize the formation of condensate in the pipeline and especially on the surface of the pipeline.

6 Gas supply

The apartment building is equipped with gas boiler to heat water for heating emitters and for preparation of hot water. Every vertical branch is equipped with cleaning, drainage and gas shut-off valves.

7 Lighting

All the living areas are properly lighted according to relevant requirement in the building. The staircase area on the 2nd - 4th floors are naturally illuminated by skylight (LIGHTWAY tube) – in combination with artificial lighting switched depending on the intensity of daylight. The tubes are situated in shafts of size 1 010/600 mm. The skylight passes through the 2^{nd} - 4^{th} floors through the roof. Diffusers with semi-permeable glass are installed at the levels of the individual floors. The skylight is equipped with fixing rings anchored to the shaft.

8 Electricity

All the electricity is properly designed according to relevant requirements in the building. There is an electricity shaft located in the corridor area on each floor.

9 Standard norms and literature

[1] ČSN EN 806-1 (736660) Indoor plumbing for the supply of water intended for human consumption - Part 1: General
[2] ČSN 73 6005 Spatial arrangement of technical equipment management
[3] ČSN 75 5455 Calculation of internal water mains
[4] ČSN EN 1610 (756114) Implementation of sewers and sewer connections and their testing
[5] ČSN 75 6760 Internal sewerage
[6] ČSN EN 12831 Heating systems in buildings – Calculation method for heat loss

Used web pages:

[1] www.korado.com
[2] www.isan.cz
[3] www.lightway.cz
[4] www.vytapeni.tzb-info.cz

10 List of drawings

1) Situation, 1:250
2) Drainage and water supply – plan view of the underground floor, 1:70
3) Drainage and water supply – plan view of the 1^{st} floor, 1:70
4) Heating system – plan view of the underground floor, 1:70

5) Heating system – plan view of the 1st floor, 1:70
6) Ventilation system – plan view of the underground floor, 1:70
7) Ventilation system – plan view of the 1st floor, 1:70

Attached files:

- Technical catalogue of ventilation unit “DUPLEX Easy”
- Technical catalogue of air flow controller “SMART box”
- Heat source calculation

DESIGN OF HEAT SOURCES						
flat number	room number	room name	temp. [°C]	total heat loss Φ (W)	designed heat loss Φ (W)	type of heating source
1	1.02	BATHROOM	24	343	365	KORALUX RONDO CLASSIC
	1.03a	LIVING ROOM	20	1009	1025	ISAN TERMO
	1.04	BEDROOM	20	719	750	RADIK VK 21
	1.05	BEDROOM	20	592	601	RADIK VK 11
2	2.02	BATHROOM	24	340	365	KORALUX RONDO CLASSIC
	2.03a	LIVING ROOM	20	1185	1215	ISAN TERMO
	2.04	BEDROOM	20	702	708	RADIK VK 11
3	3.02	BATHROOM	24	480	507	KORALUX RONDO CLASSIC
	3.03	LIVING ROOM	20	786	894	RADIK VK 21
	3.04	BEDROOM	20	690	708	RADIK VK 11
	3.05	BEDROOM	20	729	750	RADIK VK 21
4	4.02	BATHROOM	24	722	726	KORALUX RONDO CLASSIC
	4.03a	LIVING ROOM	20	1183	1215	ISAN TERMO
	4.04	BEDROOM	20	599	601	RADIK VK 11
5	5.02	BATHROOM	24	404	429	KORALUX RONDO CLASSIC
	5.03a	LIVING ROOM	20	889	894	RADIK VK 21
6	6.02	BATHROOM	24	550	596	KORALUX RONDO CLASSIC
	6.03a	LIVING ROOM	20	1095	1215	ISAN TERMO
	6.04	BEDROOM	20	483	601	RADIK VK 11
7	7.02	BATHROOM	24	410	429	KORALUX RONDO CLASSIC
	7.03a	LIVING ROOM	20	1015	1025	ISAN TERMO
	7.04	BEDROOM	20	673	708	RADIK VK 11
8	8.02	BATHROOM	24	398	429	KORALUX RONDO CLASSIC
	8.03a	LIVING ROOM	20	1183	1215	ISAN TERMO
	8.04	BEDROOM	20	599	601	RADIK VK 11
9	9.02	BATHROOM	24	391	429	KORALUX RONDO CLASSIC
	9.03a	LIVING ROOM	20	1265	1268	ISAN TERMO
10	10.02	BATHROOM	24	444	507	KORALUX RONDO CLASSIC
	10.03a	LIVING ROOM	20	1370	1417	RADIK VK 21

Table for simplified heat output

Room name	Living room	Room number	1.03a	Floor	1	Flat number	1	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m	91.950	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	[m^3/h]	Supply air temperature Θ_{sup}	-12	[°C]			

Heat loss calculation

Description of the structure	Area										
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Area without holes $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	3	1.75	5.25	1	5.25	5.25	1.5	-12	1.00	7.88	
EW	5.03	2.8	14.08	1	5.25	8.83	0.3	-12	1.00	2.65	
IW1	5.85	2.8	16.38	1	1.58	14.80	2.7	20	0.00	0.00	
IW2	5.03	2.8	14.08	0	0	14.08	2.7	20	0.00	0.00	
IW3	6.63	2.8	18.56	0	0	18.56	2.7	20	0.00	0.00	
ID	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**11.387075**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **364.3864**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	60	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **1009.506**

Table for simplified heat output

Room name	Bedroom	Room number 1.04	Floor 1	Flat number 1		
Interior temperature Θ_i	20 [°C]	Exterior temperature Θ_e	-12 [°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5 [h^{-1}]	Volume of room V_m	35.410 [m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30 [m^3/h]	Supply air temperature Θ_{sup}	-12 [°C]			

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Area without holes $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	0	0.00	1.58	1.5	-12	1.00	2.36	
EW	3.67	2.8	10.28	2	3.946	6.33	0.3	-12	1.00	1.90	
IW1	3.4	2.8	9.52	0	0	9.52	2.7	20	0.00	0.00	
IW2	3.4	2.8	9.52	0	0	9.52	2.7	20	0.00	0.00	
IW3	3.71	2.8	10.39	1	1.576	8.81	2.7	15	0.16	3.72	
ID	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**12.3974375**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **396.718**

Heat loss by ventilation

Amount of ventilation air $V_i = max (V_m . n; V_{min,i})$	30	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**10.08**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **322.56**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **719.278**

Table for simplified heat output

Room name	Bedroom		Room number	1.05	Floor	1	Flat number	1	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	0.5	$[h^{-1}]$	Volume of room V_m			36.530	$[m^3]$	Air density ϱ	1.2 $[kg/m^3]$
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30	$[m^3/h]$	Supply air temperature Θ_{sup}			-12	[°C]		

Heat loss calculation

Description of the structure	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.45	2.8	9.66	2	3.946	5.71	0.3	-12	1.00	1.71	
IW1	4.05	2.8	11.34	0	0	11.34	2.7	20	0.00	0.00	
IW2	3.4	2.8	9.52	0	0	9.52	2.7	20	0.00	0.00	
IW3	2	2.8	5.60	0	0	5.60	2.7	24	-0.13	-1.89	
IW4	0.65	2.8	1.82	0	0	1.82	2.7	15	0.16	0.77	
IW5	1.45	2.8	4.06	1	1.576	2.48	2.7	15	0.16	1.05	
ID	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**8.420825**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **269.4664**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m . n; V_{min,i})$	30	$[m^3/h]$	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**10.08**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **322.56**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **592.0264**

Table for simplified heat output

Room name	Bathroom		Room number	1.02	Floor	1	Flat number	1
Interior temperature Θ_i	24	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p 0.28 Wh/kgK
Lowest air exchange rate n_{min}	1.5	$[h^{-1}]$	Volume of room V_m			12.345	$[m^3]$	Air density ϱ 1.2 $[kg/m^3]$
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15	$[m^3/h]$	Supply air temperature Θ_{sup}			15	[°C]	

Heat loss calculation

Description of the structure	Area						Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$					
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
IW1	2	2.8	5.60	0	0	5.60	2.7	20	0.11	1.68	
IW2	2.46	2.8	6.89	1	1.379	5.51	2.7	15	0.25	3.72	
IW3	1.99	2.8	5.57	0	0	5.57	2.7	20	0.11	1.67	
ID	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**8.2768**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **297.9648**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	15	$[m^3/h]$	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**1.26**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **45.36**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **343.3248**

Table for simplified heat output

Room name	Bathroom		Room number	2.02	Floor	1	Flat number	2		
Interior temperature Θ_i	24	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	1.5	$[h^{-1}]$	Volume of room V_m			12.404	$[m^3]$	Air density ϱ	1.2	$[kg/m^3]$
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15	$[m^3/h]$	Supply air temperature Θ_{sup}			15	[°C]			

Heat loss calculation

Description of the structure	Area						Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$					
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
IW1	2.01	2.8	5.63	0	0	5.63	2.7	20	0.11	1.69	
IW2	2.41	2.8	6.75	1	1.379	5.37	2.7	15	0.25	3.62	
IW3	2.01	2.8	5.63	0	0	5.63	2.7	20	0.11	1.69	
ID	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**8.2075**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **295.47**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m . n; V_{min,i})$	15	$[m^3/h]$	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**1.26**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **45.36**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **340.83**

Table for simplified heat output

Room name	Living room		Room number	2.03a	Floor	1	Flat number	2	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m			63.586	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	[m^3/h]	Supply air temperature Θ_{sup}			-12	[°C]			

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	4.41	2.8	12.35	2	6.32	6.03	0.3	-12	1.00	1.81	
ID	0.9	1.97	1.77	1	1.77	1.77	3.5	15	0.16	0.97	
IW1	6.28	2.8	17.58	0	0	17.58	2.7	20	0.00	0.00	
IW2	4.41	2.8	12.35	0	0	12.35	2.7	20	0.00	0.00	
IW3	2.69	2.8	7.53	1	1.77	5.76	2.7	15	0.16	2.43	
IW4	1.86	2.8	5.21	0	0	5.21	2.7	15	0.16	2.20	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**16.8799125**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **540.1572**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m \cdot n; V_{min,i})$	60	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **1185.277**

Table for simplified heat output

Room name	Bedroom		Room number	2.04	Floor	1	Flat number	2	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p 0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m			38.310	[m^3]	Air density ϱ 1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30	[m^3/h]	Supply air temperature Θ_{sup}			-12	[°C]		

Heat loss calculation

Description of the structure	Area										
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.25	2.8	9.10	2	3.95	5.15	0.3	-12	1.00	1.55	
IW1	4.1	2.8	11.48	0	0	11.48	2.7	20	0.00	0.00	
IW2	2.15	2.8	6.02	0	0	6.02	2.7	15	0.16	2.54	
IW3	0.31	2.8	0.87	0	0	0.87	2.7	15	0.16	0.37	
IW4	1.1	2.8	3.08	1	1.576	1.50	2.7	15	0.16	0.63	
IW5	4.41	2.8	12.35	0	0	12.35	2.7	20	0.00	0.00	
ID	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**11.86745**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **379.7584**
Heat loss by ventilation											
Amount of ventilation air $V_i = \max (V_m . n; V_{min,i})$			30	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$				**10.08**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **322.56**
Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]											**702.3184**

Table for simplified heat output

Room name	Bathroom	Room number	3.02	Floor	1	Flat number	3		
Interior temperature Θ_i	24	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK	
Lowest air exchange rate n_{min}	1.5	[h^{-1}]	Volume of room V_m	12.741	[m^3]	Air density ϱ	1.2	[kg/m^3]	
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15	[m^3/h]	Supply air temperature Θ_{sup}	15	[°C]				

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	1.75	1.75	1	1.75	1.75	1.5	-12	1.00	2.63	
EW	2.37	2.8	6.64	1	1.75	4.89	0.3	-12	1.00	1.47	
IW1	1.92	2.8	5.38	0	0	5.38	2.7	20	0.11	1.61	
IW2	2.37	2.8	6.64	1	1.379	5.26	2.7	15	0.25	3.55	
IW3	1.92	2.8	5.38	0	0	5.38	2.7	20	0.11	1.61	
ID	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**12.0715**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **434.574**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	15	[m^3/h]	Coefficient of heat loss by ventilation $H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**1.26**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$	**45.36**
Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]						**479.934**

Table for simplified heat output

Room name	Living room	Room number	3.03a	Floor	1	Flat number	3	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m	76.174	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	[m^3/h]	Supply air temperature Θ_{sup}	-12	[°C]			

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W1	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
W2	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED1	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
ED2	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	7.68	2.8	21.50	2	3.95	17.56	0.3	-12	1.00	5.27	
EW2	3.54	2.8	9.91	2	3.95	5.97	0.3	-12	1.00	1.79	
IW1	3.54	2.8	9.91	1	1.773	8.14	2.7	15	0.16	3.43	
IW2	7.68	2.8	21.50	0	0	21.50	2.7	20	0.00	0.00	
ID	0.9	1.97	1.77	1	1.77	1.77	3.5	15	0.16	0.97	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**4.40325**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **140.904**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	60	[m^3/h]	Coefficient of heat loss by ventilation $H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$	**645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **786.024**

Table for simplified heat output

Room name	Bedroom		Room number	3.04	Floor	1	Flat number	3
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m	36.177	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30	[m^3/h]	Supply air temperature Θ_{sup}	-12	[°C]			

Heat loss calculation

Description of the structure	Area										
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED1	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	2.5	2.8	7.00	2	3.95	3.05	0.3	-12	1.00	0.92	
IW1	4.13	2.8	11.56	0	0	11.56	2.7	20	0.00	0.00	
IW2	0.46	2.8	1.29	0	0	1.29	2.7	15	0.16	0.54	
IW3	5.4	2.8	15.12	0	0	15.12	2.7	20	0.00	0.00	
IW4	1.27	2.8	3.56	1	1.58	1.98	2.7	15	0.16	0.84	
IW5	2.03	2.8	5.68	0	0	5.68	2.7	15	0.16	2.40	
ID	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	

Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$	**11.4737**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$	**367.1584**

Heat loss by ventilation

Amount of ventilation air $V_i = max (V_m . n; V_{min,i})$	30	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**10.08**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$	**322.56**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]	**689.7184**

Table for simplified heat output

Room name	Bedroom		Room number	3.05	Floor	1	Flat number	3
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e		-12	[°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	0.5	$[h^{-1}]$	Volume of room V_m		40.255	$[m^3]$	Air density ϱ	1.2 $[kg/m^3]$
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30	$[m^3/h]$	Supply air temperature Θ_{sup}		-12	[°C]		

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	3.17	2.8	8.88	2	3.95	4.93	0.3	-12	1.00	1.48	
EW2	4.78	2.8	13.38	0	0	13.38	0.3	-12	1.00	4.02	
IW1	4.13	2.8	11.56	0	0	11.56	2.7	20	0.00	0.00	
IW2	1.25	2.8	3.50	1	1.58	3.50	2.7	15	0.16	1.48	
IW3	0.65	2.8	1.82	0	0	1.82	2.7	15	0.16	0.77	
IW4	1.92	2.8	5.38	0	0	5.38	2.7	24	-0.13	-1.81	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**12.70505**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **406.5616**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	30	$[m^3/h]$	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**10.08**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **322.56**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **729.1216**

Table for simplified heat output

Room name	Bathroom	Room number	4.02	Floor	1	Flat number	4
Interior temperature Θ_i	24	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	1.5	[h^{-1}]	Volume of room V_m	14.896	[m^3]	Air density ϱ	1.2 [kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15	[m^3/h]	Supply air temperature Θ_{sup}	15	[°C]		

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area A = x.y	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
IW1	1.91	2.8	5.35	0	0	5.35	2.7	15	0.25	3.61	
IW2	3.02	2.8	8.46	0	0	8.46	2.7	20	0.33	7.61	
IW3	1.91	2.8	5.35	0	0	5.35	2.7	20	0.11	1.60	
IW4	3.02	2.8	8.46	1	1.379	7.08	2.7	15	0.25	4.78	
ID	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**18.8083**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **677.0988**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m \cdot n; V_{min,i})$	15	[m^3/h]	Coefficient of heat loss by ventilation $H_v = V_i \cdot c_p \cdot ϱ \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**1.26**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$	**45.36**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **722.4588**

Table for simplified heat output

Room name	Living room	Room number	4.03a	Floor	1	Flat number	4		
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK	
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m	66.943	[m^3]	Air density ϱ	1.2	[kg/m^3]	
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	[m^3/h]	Supply air temperature Θ_{sup}	-12	[°C]				

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.76	2.8	10.53	2	6.32	4.21	0.3	-12	1.00	1.26	
IW1	7.58	2.8	21.22	0	0	21.22	2.7	20	0.00	0.00	
IW2	2.05	2.8	5.74	0	0	5.74	2.7	20	0.00	0.00	
IW3	2.7	2.8	7.56	0	0	7.56	2.7	15	0.16	3.19	
IW4	1.71	2.8	4.79	0	0	4.79	2.7	15	0.16	2.02	
IW5	4.88	2.8	13.66	1	1.58	12.09	2.7	20	0.00	0.00	
ID	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**16.8087875**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **537.8812**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m . n; V_{min,i})$	60	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . ϱ . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **1183.001**

Table for simplified heat output

Room name	Bedroom		Room number	4.04	Floor	1	Flat number	4	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m			39.073	[m^3]	Air density ϱ	1.2 [kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30	[m^3/h]	Supply air temperature Θ_{sup}			-12	[°C]		

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.4	2.8	9.52	2	3.95	5.57	0.3	-12	1.00	1.67	
IW1	4.44	2.8	12.43	0	0	12.43	2.7	20	0.00	0.00	
IW2	1.91	2.8	5.35	0	0	5.35	2.7	24	-0.13	-1.80	
IW3	0.78	2.8	2.18	0	0	2.18	2.7	15	0.16	0.92	
IW4	1.48	2.8	4.14	1	1.58	2.57	2.7	15	0.16	1.08	
IW5	3.66	2.8	10.25	0	0	10.25	2.7	20	0.00	0.00	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	

Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$ = **8.652875**; $\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ = **276.892**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	30 [m^3/h]	Coefficient of heat loss by ventilation $H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**10.08**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$	**322.56**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **599.452**

Table for simplified heat output

Room name	Bathroom	Room number	5.02	Floor	1	Flat number	5
Interior temperature Θ_i	24 [°C]	Exterior temperature Θ_e			-12 [°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	1.5 [h^{-1}]	Volume of room V_m			11.757 [m^3]	Air density ϱ	1.2 [kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15 [m^3/h]	Supply air temperature Θ_{sup}			20 [°C]		

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
IW1	1.74	2.8	4.87	0	0	4.87	2.7	20	0.11	1.46	
IW2	2.75	2.8	7.70	0	0	7.70	2.7	20	0.11	2.31	
IW3	1.75	2.8	4.90	0	0	4.90	2.7	20	0.11	1.47	
IW4	2.73	2.8	7.64	1	1.38	6.26	2.7	15	0.25	4.23	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**10.676425**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **384.3513**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m . n; V_{min,i})$	15	[m^3/h]	Coefficient of heat loss by ventilation $H_v = V_i . c_p . ϱ . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**0.56**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **20.16**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **404.5113**

Table for simplified heat output

Room name	Living room	Room number	5.03a	Floor	1	Flat number	5	
Interior temperature Θ_i	20 [°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	0.5 $[h^{-1}]$	Volume of room V_m			51.787	$[m^3]$	Air density ϱ	1.2 $[kg/m^3]$
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60 $[m^3/h]$	Supply air temperature Θ_{sup}			-12	[°C]		

Heat loss calculation

Description of the structure (EW - exterior wall, W - window, ED - exterior door, IW - interior wall, ID - interior door)	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.66	2.8	10.25	2	3.95	6.30	0.3	-12	1.00	1.89	
IW1	4.65	2.8	13.02	0	0	13.02	2.7	20	0.00	0.00	
IW2	1.86	2.8	5.21	0	0	5.21	2.7	24	-0.13	-1.76	
IW3	0.81	2.8	2.27	0	0	2.27	2.7	24	-0.13	-0.77	
IW4	5.46	2.8	15.29	0	0	15.29	2.7	20	0.00	0.00	
IW5	1.8	2.8	5.04	1	1.77	3.27	2.7	15	0.16	1.38	
ID	0.9	1.97	1.77	1	1.58	1.77	3.5	15	0.16	0.97	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**7.634325**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **244.2984**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m . n; V_{min,i})$	60 $[m^3/h]$	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **889.4184**

Table for simplified heat output

Room name	Bathroom	Room number	6.02	Floor	1	Flat number	6	
Interior temperature Θ_i	24	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	1.5	[h^{-1}]	Volume of room V_m	13.888	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15	[m^3/h]	Supply air temperature Θ_{sup}	20	[°C]			

Heat loss calculation

Description of the structure	Area										
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
IW1	1.84	2.8	5.15	0	0	5.15	2.7	20	0.11	1.55	
IW2	3	2.8	8.40	0	0	8.40	2.7	15	0.25	5.67	
IW3	1.84	2.8	5.15	0	0	5.15	2.7	20	0.11	1.55	
IW4	3	2.8	8.40	1	1.38	7.02	2.7	15	0.25	4.74	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**14.706325**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **529.4277**

Heat loss by ventilation

Amount of ventilation air $V_i = max(V_m . n; V_{min,i})$	15	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**0.56**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$	**20.16**
Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]							**549.5877**

Table for simplified heat output

Room name	Living room	Room number	6.03a	Floor	1	Flat number	6	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m	60.141	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	[m^3/h]	Supply air temperature Θ_{sup}	-12	[°C]			

Heat loss calculation

Description of the structure	Area						Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$					
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.31	2.8	9.27	2	6.32	2.95	0.3	-12	1.00	0.89	
IW1	4.46	2.8	12.49	0	0	12.49	2.7	20	0.00	0.00	
IW2	0.53	2.8	1.48	0	0	1.48	2.7	15	0.16	0.63	
IW3	2.41	2.8	6.75	1	1.77	4.98	2.7	15	0.16	2.10	
IW4	2.78	2.8	7.78	0	0	7.78	2.7	20	0.00	0.00	
IW5	6.87	2.8	19.24	0	0	19.24	2.7	20	0.00	0.00	
ID	0.9	1.97	1.77	1	1.58	1.77	3.5	15	0.16	0.97	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**14.0541**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **449.7312**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	60	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot ϱ \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$	**645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]	**1094.851**

Table for simplified heat output

Room name	Bedroom	Room number	6.04	Floor	1	Flat number	6
Interior temperature Θ_i	20 [°C]	Exterior temperature Θ_e			-12 [°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	0.5 [h^{-1}]	Volume of room V_m			34.068 [m^3]	Air density ϱ	1.2 [kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30 [m^3/h]	Supply air temperature Θ_{sup}			-12 [°C]		

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.4	2.8	9.52	2	3.95	5.57	0.3	-12	1.00	1.67	
IW1	4.46	2.8	12.49	0	0	12.49	2.7	20	0.00	0.00	
IW2	2.72	2.8	7.62	0	0	7.62	2.7	24	-0.13	-2.57	
IW3	4.46	2.8	12.49	1	1.58	10.91	2.7	20	0.00	0.00	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	20	0.00	0.00	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**5.0208**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **160.6656**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m \cdot n; V_{min,i})$	30 [m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**10.08**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **322.56**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **483.2256**

Table for simplified heat output

Room name	Bathroom		Room number	7.02	Floor	1	Flat number	7		
Interior temperature Θ_i	24	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	1.5	[h^{-1}]	Volume of room V_m			17.002	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15	[m^3/h]	Supply air temperature Θ_{sup}			20	[°C]			

Heat loss calculation

Description of the structure	Area						Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$					
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
IW1	3.13	2.8	8.76	0	0	8.76	2.7	20	0.11	2.63	
IW2	1.94	2.8	5.43	0	0	5.43	2.7	20	0.11	1.63	
IW3	3.13	2.8	8.76	0	0	8.76	2.7	20	0.11	2.63	
IW4	1.94	2.8	5.43	1	1.38	4.05	2.7	15	0.25	2.74	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**10.829725**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **389.8701**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m \cdot n; V_{min,i})$	15	[m^3/h]	Coefficient of heat loss by ventilation $H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**0.56**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **20.16**
Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]					**410.0301**

Table for simplified heat output

Room name	Living room		Room number	7.03a	Floor	1	Flat number	7		
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m			64.497	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	[m^3/h]	Supply air temperature Θ_{sup}			-12	[°C]			

Heat loss calculation

Description of the structure	Area						Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$					
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	4.46	2.8	12.49	2	6.32	6.17	0.3	-12	1.00	1.85	
IW1	5.46	2.8	15.29	0	0	15.29	2.7	20	0.00	0.00	
IW2	2.46	2.8	6.89	0	0	6.89	2.7	24	-0.13	-2.32	
IW3	0.65	2.8	1.82	0	0	1.82	2.7	15	0.16	0.77	
IW4	1.33	2.8	3.72	1	1.77	1.95	2.7	15	0.16	0.82	
IW5	4.81	2.8	13.47	1	1.58	11.89	2.7	20	0.00	0.00	
ID1	0.9	1.97	1.77	1	1.58	1.77	3.5	15	0.16	0.97	
ID2	0.8	1.97	1.58	1	1.58	1.58	3.5	20	0.00	0.00	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**11.5614**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **369.9648**

Heat loss by ventilation

Amount of ventilation air $V_i = \max (V_m \cdot n; V_{min,i})$	60	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **1015.085**

Table for simplified heat output

Room name	Bedroom	Room number	7.04	Floor	1	Flat number	7	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m	39.686	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30	[m^3/h]	Supply air temperature Θ_{sup}	-12	[°C]			

Heat loss calculation

Description of the structure	Area						Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$					
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	2.7	2.8	7.56	2	3.95	3.61	0.3	-12	1.00	1.08	
IW1	5.46	2.8	15.29	0	0	15.29	2.7	20	0.00	0.00	
IW2	1.8	2.8	5.04	0	0	5.04	2.7	15	0.16	2.13	
IW3	0.65	2.8	1.82	0	0	1.82	2.7	15	0.16	0.77	
IW4	0.89	2.8	2.49	0	0	2.49	2.7	15	0.16	1.05	
IW5	4.81	2.8	13.47	1	1.58	11.89	2.7	20	0.00	0.00	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	20	0.00	0.00	

Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$ | **10.948575** | $\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ | **350.3544**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	30	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot \varrho \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**10.08**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$	**322.56**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] | **672.9144**

Table for simplified heat output

Room name	Bathroom		Room number	8.02	Floor	1	Flat number	8	
Interior temperature Θ_i	24	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	1.5	$[h^{-1}]$	Volume of room V_m			14.383	$[m^3]$	Air density ϱ	1.2 $[kg/m^3]$
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15	$[m^3/h]$	Supply air temperature Θ_{sup}			20	[°C]		

Heat loss calculation

Description of the structure	Area						Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$					
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
IW1	1.84	2.8	5.15	0	0	5.15	2.7	20	0.11	1.55	
IW2	2.45	2.8	6.86	0	0	6.86	2.7	20	0.11	2.06	
IW3	1.07	2.8	3.00	0	0	3.00	2.7	20	0.11	0.90	
IW4	3.02	2.8	8.46	1	1.38	7.08	2.7	15	0.25	4.78	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**10.485325**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **377.4717**

Heat loss by ventilation

Amount of ventilation air $V_i = max\ (V_m \cdot n;\ V_{min,i})$	15	$[m^3/h]$	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot ϱ \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**0.56**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **20.16**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **397.6317**

Table for simplified heat output

Room name	Living room		Room number	8.03a	Floor	1	Flat number	8	
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p	0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	[h^{-1}]	Volume of room V_m			67.327	[m^3]	Air density ϱ	1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	[m^3/h]	Supply air temperature Θ_{sup}			-12	[°C]			

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.76	2.8	10.53	2	6.32	4.21	0.3	-12	1.00	1.26	
IW1	7.58	2.8	21.22	0	0	21.22	2.7	20	0.00	0.00	
IW2	2.05	2.8	5.74	0	0	5.74	2.7	20	0.00	0.00	
IW3	2.62	2.8	7.34	0	0	7.34	2.7	15	0.16	3.09	
IW4	1.71	2.8	4.79	0	0	4.79	2.7	15	0.16	2.02	
IW5	4.96	2.8	13.89	1	1.77	12.12	2.7	20	0.00	0.00	
ID1	0.9	1.97	1.77	1	1.58	1.77	3.5	15	0.16	0.97	

Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$	**16.82202188**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$	**538.3047**

Heat loss by ventilation

Amount of ventilation air $V_i = max (V_m \cdot n; V_{min,i})$	60	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot ϱ \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$	**645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **1183.425**

Table for simplified heat output

Room name	Bedroom	Room number	8.04	Floor	1	Flat number	8
Interior temperature Θ_i	20 [°C]	Exterior temperature Θ_e	-12 [°C]	Specific heat capacity of air c_p	0.28	Wh/kgK	
Lowest air exchange rate n_{min}	0.5 [h^{-1}]	Volume of room V_m	39.486 [m^3]	Air density ϱ	1.2	[kg/m^3]	
Smallest hygienic amount of air, permanent flow $V_{min,i}$	30 [m^3/h]	Supply air temperature Θ_{sup}	-12 [°C]				

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW	3.4	2.8	9.52	2	3.95	5.57	0.3	-12	1.00	1.67	
IW1	4.44	2.8	12.43	0	0	12.43	2.7	20	0.00	0.00	
IW2	1.84	2.8	5.15	0	0	5.15	2.7	24	-0.13	-1.74	
IW3	0.65	2.8	1.82	0	0	1.82	2.7	15	0.16	0.77	
IW4	3.79	2.8	10.61	0	0	10.61	2.7	20	0.00	0.00	
IW5	1.55	2.8	4.34	1	1.58	2.76	2.7	15	0.16	1.17	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	

Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$	**8.64815**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$	**276.7408**

Heat loss by ventilation

Amount of ventilation air $V_i = max (V_m . n; V_{min,i})$	30	[m^3/h]	Coefficient of heat loss by ventilation $H_v = V_i . c_p . ϱ . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**10.08**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$	**322.56**

Total heat loss = heat output $\Phi = \Phi_T+\Phi_V$ [W]	**599.3008**

Table for simplified heat output

Room name	Bathroom	Room number	9.02	Floor	1	Flat number	9
Interior temperature Θ_i	24 [°C]	Exterior temperature Θ_e			-12 [°C]	Specific heat capacity of air c_p	0.28 Wh/kgK
Lowest air exchange rate n_{min}	1.5 [h^{-1}]	Volume of room V_m			15.966 [m^3]	Air density ϱ	1.2 [kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15 [m^3/h]	Supply air temperature Θ_{sup}			20 [°C]		

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W	1	1.75	1.75	1	1.75	1.75	1.5	-12	1.00	2.63	
EW	2.46	2.8	6.89	1	1.75	5.14	0.3	-12	1.00	1.54	
IW1	2.31	2.8	6.47	0	0	6.47	2.7	20	0.11	1.94	
IW2	2.31	2.8	6.47	0	0	6.47	2.7	20	0.11	1.94	
IW3	2.44	2.8	6.83	1	1.38	5.45	2.7	15	0.25	3.68	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**10.3096**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **371.1456**

Heat loss by ventilation

Amount of ventilation air $V_i = max(V_m . n; V_{min,i})$	15	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**0.56**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **20.16**
Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]						**391.3056**

Table for simplified heat output

Room name	Living room	Room number	9.03a	Floor	1	Flat number	9		
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p		0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	$[h^{-1}]$	Volume of room V_m	69.235	$[m^3]$	Air density ϱ		1.2	$[kg/m^3]$
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	$[m^3/h]$	Supply air temperature Θ_{sup}	-12	[°C]				

Heat loss calculation

Description of the structure	Area: Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k . U_k . b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W1	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
W2	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED1	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
ED2	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	3.54	2.8	9.91	2	3.95	5.97	0.3	-12	1.00	1.79	
EW2	6.98	2.8	19.54	2	6.32	13.23	0.3	-12	1.00	3.97	
IW1	6.98	2.8	19.54	0	0	19.54	2.7	20	0.00	0.00	
IW2	3.54	2.8	9.91	1	1.77	8.14	2.7	24	-0.13	-2.75	
ID1	0.9	1.97	1.77	1	1.58	1.77	3.5	15	0.16	0.97	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**19.37389688**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **619.9647**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m . n; V_{min,i})$	60	$[m^3/h]$	Coefficient of heat loss by ventilation	$H_v = V_i . c_p . \varrho . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**20.16**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$ **645.12**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **1265.085**

Table for simplified heat output

Room name	Bathroom		Room number	10.02	Floor	1	Flat number	10	
Interior temperature Θ_i	24	[°C]	Exterior temperature Θ_e			-12	[°C]	Specific heat capacity of air c_p 0.28	Wh/kgK
Lowest air exchange rate n_{min}	1.5	[h^{-1}]	Volume of room V_m			12.434	[m^3]	Air density ϱ 1.2	[kg/m^3]
Smallest hygienic amount of air, permanent flow $V_{min,i}$	15	[m^3/h]	Supply air temperature Θ_{sup}			20	[°C]		

Heat loss calculation

Description of the structure	Area						Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Length	Height	Area $A = x.y$	Number of holes	Area of the holes	Plocha bez otvorů $A_k = A - A_o$					
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
IW1	2.32	2.8	6.50	0	0	6.50	2.7	15	0.25	4.38	
IW2	1.91	2.8	5.35	0	0	5.35	2.7	20	0.11	1.60	
IW3	2.32	2.8	6.50	0	0	6.50	2.7	20	0.11	1.95	
IW4	1.89	2.8	5.29	1	1.38	3.91	2.7	15	0.25	2.64	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.25	1.21	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**11.7859**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **424.2924**

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	15	[m^3/h]	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot ϱ \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**0.56**	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$ **20.16**
Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]						**444.4524**

Table for simplified heat output

Room name	Living room	Room number	10.03a	Floor	1	Flat number	10		
Interior temperature Θ_i	20	[°C]	Exterior temperature Θ_e	-12	[°C]	Specific heat capacity of air c_p		0.28	Wh/kgK
Lowest air exchange rate n_{min}	0.5	$[h^{-1}]$	Volume of room V_m	73.903	$[m^3]$	Air density ϱ		1.2	$[kg/m^3]$
Smallest hygienic amount of air, permanent flow $V_{min,i}$	60	$[m^3/h]$	Supply air temperature Θ_{sup}	-12	[°C]				

Heat loss calculation

Description of the structure EW - exterior wall W - window ED - exterior door IW - interior wall ID - interior door	Area: Length	Area: Height	Area: Area $A = x.y$	Area: Number of holes	Area: Area of the holes	Area: Plocha bez otvorů $A_k = A - A_o$	Heat transfer coefficient	Temperature behind the structure	Temp. reduction factor $b_u = (\Theta_i - \Theta_{u,k})/(\Theta_i - \Theta_e)$	Coefficient of heat loss of the structure by transmission $H_{T,k} = A_k \cdot U_k \cdot b_u$	Heat loss
	x	y	A	o	A_o	A_k	U_k	$\Theta_{u,k}$	$b_{u,k}$	$H_{T,k}$	
	m	m	m^2	-	m^2	m^2	$W.m^{-2}K^{-1}$	°C	-	$W.K^{-1}$	W
W1	3	1.75	5.25	1	5.25	5.25	1.5	-12	1.00	7.88	
W2	1	2.37	2.37	1	2.37	2.37	1.5	-12	1.00	3.56	
ED	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	6.63	2.8	18.56	2	3.95	14.62	0.3	-12	1.00	4.39	
EW2	4.79	2.8	13.41	1	5.25	8.16	0.3	-12	1.00	2.45	
IW1	4.6	2.8	12.88	1	1.58	11.30	2.7	15	0.16	4.77	
IW2	2.44	2.8	6.83	0	0	6.83	2.7	24	-0.13	-2.31	
IW3	1.37	2.8	3.84	0	0	3.84	2.7	24	-0.13	-1.29	
IW4	1.7	2.8	4.76	0	0	4.76	2.7	20	0.00	0.00	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										22.6583	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ 725.0656

Heat loss by ventilation

Amount of ventilation air $V_i = \max(V_m \cdot n; V_{min,i})$	60	$[m^3/h]$	Coefficient of heat loss by ventilation	$H_v = V_i \cdot c_p \cdot ϱ \cdot (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	20.16	$\Phi_V = H_V \cdot (\Theta_i - \Theta_e)$	645.12

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] | **1370.186**

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

K124 DEPARTMENT OF ARCHITECTURAL ENGINEERING

TECHNICAL REPORT

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CONTENT

1 Location of the apartment building

The area of the apartment building is located in the city district of Prague 9 – Letňany, parcels No. 760/64, 760/66. Designed building is a part of a residential complex "Letňany gardens" – building M. The building is not located in a seismically active area, inundation (flood) area or in the area affected by slope movement.

1.1 General information

The residential building contains 1 underground floor and 4 upper-ground floors. The area of underground floor is 47.6 x 20.6 m. The upper ground floors from 1 to 3 occupy an area of 47.5 x 20.7 m. The 4th floor recedes to the middle of the floor plan and has dimensions of 33.2 x 19.8 m. Total building height is 12.62 m. Underground floor's height is 2.97 m and upper typical floors have 2.80 m of height. There are 38 parking spaces, 38 storage rooms, 1 technical room and 1 cleaning room on the underground floor. Access to the garage side is provided by the entrance in object L through connecting neck between two buildings. On the 1st floor there are the main entrance to the building, stroller room and 10 apartments. There are 22 apartments in total on the 2nd – 3rd floors and 6 apartments on the 4th floor.

The fire height of the building is 9.15 m. Load-bearing structures ensuring the stability of buildings are non-flammable, they contain only structures of type DP1. The vertical load-bearing structures of basement form reinforced concrete walls of thickness 240 mm (perimeter and internal) and 220 mm (internal). External structures are complemented by thermal insulation (made of mineral wool in PEW area and at the underground floor). The ceiling structures are monolithic reinforced concrete slabs of thickness 250 mm.

2 Fire compartment

The apartment building is divided into individual fire compartments (FC) according to the principles of ČSN 73 0802, ČSN 73 0833 and according to Annex I of ČSN 73 0804 (Fire safety of garages). Separate fire compartments also include protected (PEW) and unprotected (NPEW) escape routes, elevator shafts, ventilation shafts for ventilation of the garage, storage rooms, stroller room, garage itself and technical room related to the operation of the building. Fuels, motor oils, paints, tires, etc. will not be stored in the fire compartments of the garage. The generator of reserve energy source is installed in the room of UPC in the underground level.

Fire compartments:

Underground floor

- FC P01.01 – garage area
- FC P01.02 – P01.07 – storage rooms
- FC P01.08 – technical room
- FC P01.09 – UPC room

1st floor

- FC N01.01 – N01.10 – apartments
- FC N01.11 – unprotected escape way (NPEW)
- FC N01.12 – stroller room

2nd floor

- FC N02.01 – N02.11 – apartments
- FC N02.12 – unprotected escape way (NPEW)

3rd floor

- FC N03.01 – N03.11 – apartments
- FC N03.12 – unprotected escape way (NPEW)

4th floor

- FC N04.01 – N04.06 – apartments
- FC N04.07 – unprotected escape way (NPEW)

The whole object:

- FC CHÚC A – protected escape way A type – UF – 4th F
- FC S-P01.02/N04 – elevator shaft
- FC S-N01.03/N04 – ventilation shaft

2.1 Fire risk and fire resistance grade

For fire compartment as an apartment unit is assumed that at a factor of c = 1.0 (influence of fire safety appliances), p_s = 10 kg/m^2, p_n = 40 kg/m^2 and a_n = 1.0, the calculated fire load p_v = 45 kg/m^2.

Apartment fire load p_v = 45 kg/m^2, **III. FRG**

Storage rooms fire load p_v = 45 kg/m^2, **III. FRG**

Stroller room fire load p_v = 15 kg/m^2, **III. FRG**

Room of UPC p_v = 3.0 kg/m^2 **I. FRG**

NPEW fire load p_v = 7.5 kg/m^2, **I. FRG**

PEW A **II. FRG**

Elevator shaft **II. FRG**

Ventilation shaft, electricity shaft **I. FRG**

Cleaning room is without fire risk.

3 Fire resistance

Perimeter wall HELUZ 24 – REW 180 DP1 > 45

Reinforced concrete perimeter wall th. of 220 mm – 90 DP1 > 60 DP1

Fire dividing walls between apartments HELUZ UNI 25 – REW 180 DP1 > 45

Partition walls HELUZ 11.5 – 120 DP1 > 60 DP1

Thermal insulation (ETICS) of perimeter wall in underground level – DP1

Reinforced concrete monolithic slabs th. of 250 mm – 60 DP1 = 60 DP1

Reinforced concrete beam with width of 250 mm – 45 DP1 > 30 DP1

Entrance doors of the apartments – EW 30 DP3

Fire doors from NPEW to PEW – EI 15 C3 DP3

Fire door from stroller room to PEW – EI 15 C2 D3

Fire doors of storage rooms of UF – EI 30 C2 DP3

Fire door of technical room – EW 15 C2 DP1

Fire door of garage to PEW – EI 30 S-C C3 DP1

Reinforced concrete roof slab thickness of 220 mm – 60 DP1 > 30

Gypsum board under ceilings with required fire resistance – EI 30 DP1

4 Protected escape ways

The apartment building has both main entrances at the level between underground floor and the 1st floor. There is a roof access on the 4th floor. Corridor connected to the staircase area form separate fire compartment as unprotected escape way (NPEW).

PEW A ventilation will be forced with a tenfold change of air per hour. Air supply will be provided for at least 10 minutes. The doors leading to the PEW will be equipped with self-closing device and the doors from the garage will also be smoke-tight. The air supply will be ensured by fire-insulated ventilation ducts with fans to the lowest level of the PEW floors. The control of the overpressure ventilation will be ensured by means of an electric fire alarm system; the pushbutton switch of this alarm system will be located in PEW A on each floor. The system will include a pressure sensor and a smoke-responsive sensor on the top floor.

From the fire compartment of garage, it is enough to have only one PEW because there are no more than 60 parking spaces.

Escape routes (PEW, NPEW) are designed that the widths of the corridors are at least 1.75 m, the widths of the staircase wings are at least 1.1 m. The doors on the escape routes have a minimum width of 0.9 m. that a 1.5 m escape lane can be expected.

The entrance door is designed suitable for disable people.

Number of evacuated people in the building is calculated as 20 m^2 for 1 evacuated person, because the exact number of residents in the building cannot be determined, there are flats with areas over 80 m^2. In the garage, the number of evacuated persons is calculated from number of parking places, which is multiplied with coefficient 0.5.

	Living area [m^2]	N. of evacuated people
1.PP	38(parking) x0.5	19
1.NP	482	24
2.NP	556.8	28
3.NP	556.8	28
4.NP	412.3	21
Σ E		**101 person**

Table 1: Number of evacuated people.

PEW and NPEW are equipped with emergency lighting which hold in case of fire for 15 min. Garage area is also equipped with emergency lighting. Emergency lights will be equipped with their own power source.

5 Fire – fighting equipment

No access areas are required for the residential building - the fire height does not exceed 12 m. It is not necessary to set up internal emergency routes. The fire protection line will not be greater than h = 22.5 m at a height, in the perimeter walls there are openings suitable for fire protection lines. Access to the roof will be enabled by protected escape routes and roof exits from the area of the highest stair landings (4^{th} floor). Fire extinguishers are located 1x powder 13A for 1st 10 meters and the same for other 20 meters. Each fire compartment equipped with own fire extinguisher.

5.1 Supply of fire water

There is a water pipeline DN 150 constructed under the build communications. There is outer hydrant located next to the main road. There is a fire hydrant at every floor in PEW and NPEW. The length of fire hose is designed is designed in a way that they will reach every place where the fire fight is supposed. The maximal distance is 40 m. Hydrant box in the underground level will be equipped with a 30 m hose. Pipeline will be from nonflammable material. Pipeline will be protected from freeze, due to the unheated underground level.

6 Fire design appliances

Electrical fire appliances (EFA) will be installed in each fire compartment. EFA system will be installed in all areas with a fire risk in the underground floor (storage rooms, technical room) and in stroller room on the 1st floor. EFA will not be installed in the apartments, there will be automatic smoke detectors. In the NPEW corridor will be fire alarm button based on signaling in every floor.

Fire compartments in apartments do not required installation of fire extinguishers. They will be installed in the common areas and corridors. In the underground level fire extinguishers will be installed in every 20 m of area.

7 Standard norms

[1] ČSN 730804 Fire safety construction: Production objects - ANNEX I, garages
[2] ČSN 730818 Fire safety of buildings: Object occupation by persons
[3] ČSN 730821 Fire safety of buildings: Fire resistance of building structures
[4] ČSN 730833 Fire safety of buildings: Housing and accommodation buildings
[5] ČSN 730872 Fire safety of buildings: Protection of fire extinguishing structures

8 List of drawings

1) Fire safety design of underground floor, 1:130
2) Fire safety design of 1^{st} floor, 1:110
3) Fire safety design of 2^{nd} – 3^{rd} floor, 1:110
4) Fire safety design of 4^{th} floor, 1:110