CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

DEPARTMENT OF BUILDING STRUCTURES

BACHELOR PROJECT OF RESIDENTIAL BUILDING

2020 **DAYANA MURATOVA**

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BACHELOR´S THESIS ASSIGNMENT FORM

I. PERSONAL AND STUDY DATA

Surname: Muratova Name: Dayana Personal number: 486560

Assigning Department: K124 - Building Structures

Study programme: Civil Engineering

Branch of study: Building Structures

II. BACHELOR THESIS DATA

Bachelor Thesis (BT) title: Residential building in Prague

Bachelor Thesis title in English: Residential building in Prague

Instructions for writing the thesis:

This thesis includes the design of the new residential building located in Prague with the structural solution, envelop of the building and fire safety solution in accordance with applicable Czech standard norms.

List of recommended literature:

1. Hollis M.: Surveying Buildings, RICS Boks 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 1969
5. Foster J.S.: Structures and Fabric, Parts I - III, Longman 1994
6. Schodek, D.: Structures- Pearson, New Yersay, 2004
7. Hanaor, A.: Principles of structures, Blackwell Science, 1998

Name of Bachelor Thesis Supervisor: Ing. Mallia Noori, Ph.D.

BT assignment date: 24.02.2020 BT submission date: 17.05.2020

[redacted]
BT Supervisor's signature

[redacted]
Head of Department's signature

III. ASSIGNMENT RECEIPT

I declare that I am obliged to write the Bachelor 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 Bachelor 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

[redacted]
Student's name

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

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TECHNICAL REPORT OF RESIDENTIAL BUILDING

PART 1

DAYANA MURATOVA

ABSTRACT

This bachelor thesis is worked and solved as a project of residential building, which most focused on building structures solution. The project consists of five parts. The 1^{st} part is civil engineering, focused on structural design and technical solution, which include plan views, roof, sections, facade views and 6 details of all parts of the building. The 2^{nd} part is focused on preliminary design and structural solution of concrete structures from the point of view of concrete. The 3^{rd} part is relating to design of foundation of the residential building, which consists of plan view, sections and calculation. Also, subsoil interaction with the building, design of combination of foundation slab and piles. Part 4 is focused on plan of the generally solution of building services systems, composed of proper design of drainage, water supply system and heating system of the building. The 5^{th} part is about basic solution from the point of view of fire safety, including proper design of securing safety. All structural solutions of residential building are provided in accordance with Czech standard norms.

THANK YOU

I would like to thank my supervisor, Ing. Malila Noori, Ph.D., for providing me good knowlages, for her effort and patience, for spending her time to consult my bachelor project. I would like to thank my parents, my friends who were supporting me during this time as well.

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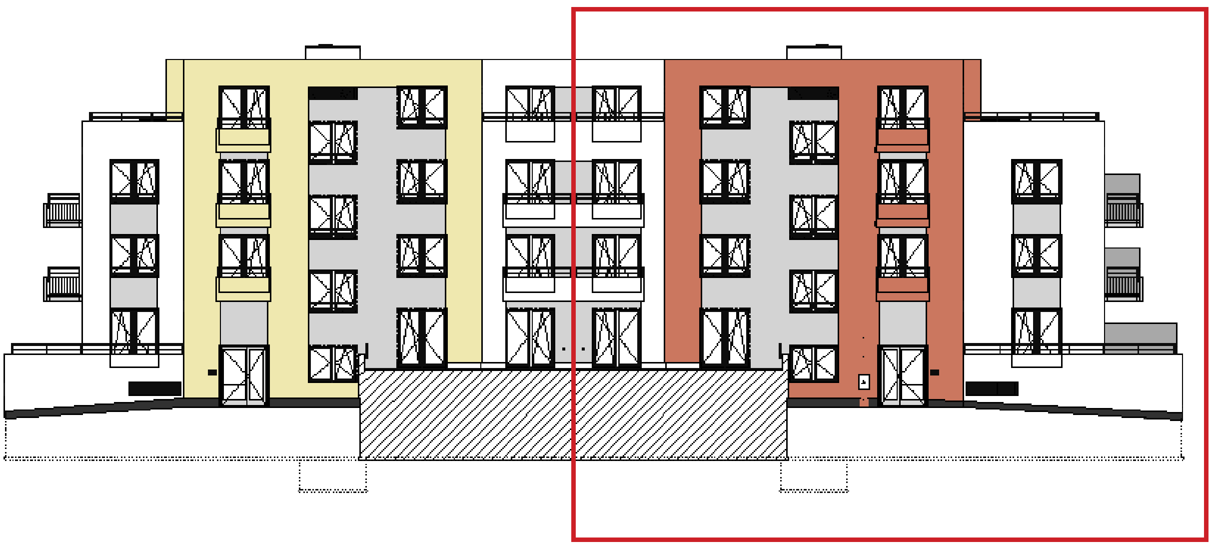
1 LOCATION OF THE RESIDENTIAL BUILDING

The residential building is located in Prague 9 – Letňany, specifically at parcels No. 760/64, 760/66. It is a part of residential complex "Letňanské zahrady" – building O. The location is limited by Veselská street from the south, by AUTO Štangl company from the west, north and east parts consist of parcel No. 760/1(field), the southern border runs along parcel No. 796/1.

1.1 GENERAL INFORMATION



It was chosen half part of the building, because both of the sides are mirror. The residential building has 1 underground floor and 4 above – ground floors. The underground floor of the building delimits the space on the area of the rectangle in the basement with dimensions of 47.73 x 18.82 m. The above – ground floor occupies an area of 24.79 x 19.44 m. Floors 1 to 3 are identical, 4^{th} floor recedes to the middle of the floor plan and has dimensions of 15.89 x 19.0 m. Total height of the building is 12.47 m. Underground floor's height is 2.97 m and upper typical floors have 2.80 m of height.

The entrance to the building is from the hallway and access to the garage side is provided by the entrance in object P. The entrance of the object O is closed by fire resisting rolling shutter with dimensions of 6 000 x 2 250 mm from both sides. There are 17 parking spaces, storage rooms and technical room on the underground floor. Other parking spaces are located outside the building. Also, basement is not fully under the surrounding ground, it is only half of the level. The above – ground floors (1 - 4) are considered for the living purpose. On the 1st floor there are the main entrance to the building, a pram and cleaning room, and 4 apartments. There are 6 apartments on the 2nd – 3rd floors and 3 apartments on the last 4th floor. In total, building has 19 apartments.

The roof is non – walkable. The spaces protruding in front of the façade plane are considered as terraces and balconies.

2 FOUNDATION

2.1 GEOLOGICAL SITUATION, SOIL CHARACTERISTIC

The proposed residential building is defined by the uniform level of the 1st floor on the elevation of ±0.00 = 262.45 m. n.m. The basement floor is also uniformly on the elevation of 259.10 m. n.m. The elevation height practically means that the basement is basically set on the existing ground level. The loess and loess clay (GT3) with a mean thickness of 2 meters + the local thin position of quaternary sand – gravel clays GT6 of the order of magnitude of the first decimeters will be fully exposed below the floor plate of the basement part. 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.

The pre-Quaternary foundation of the assessed sector is formed by kaolinitic sandstone (objects N and P) and by Ordovician quartzite (object O). Since the pre-Quaternary foundation appears at the level about 20 meters below the ground floor object should be supported on large diameter piles.

Waterproofing will be provided in the basement against pressure water by asphalt strips.

2.2 EXCAVATION

The excavation was 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 850 m^3.

2.3 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 foil with thickness of 0.40 mm.

2.4 PILES

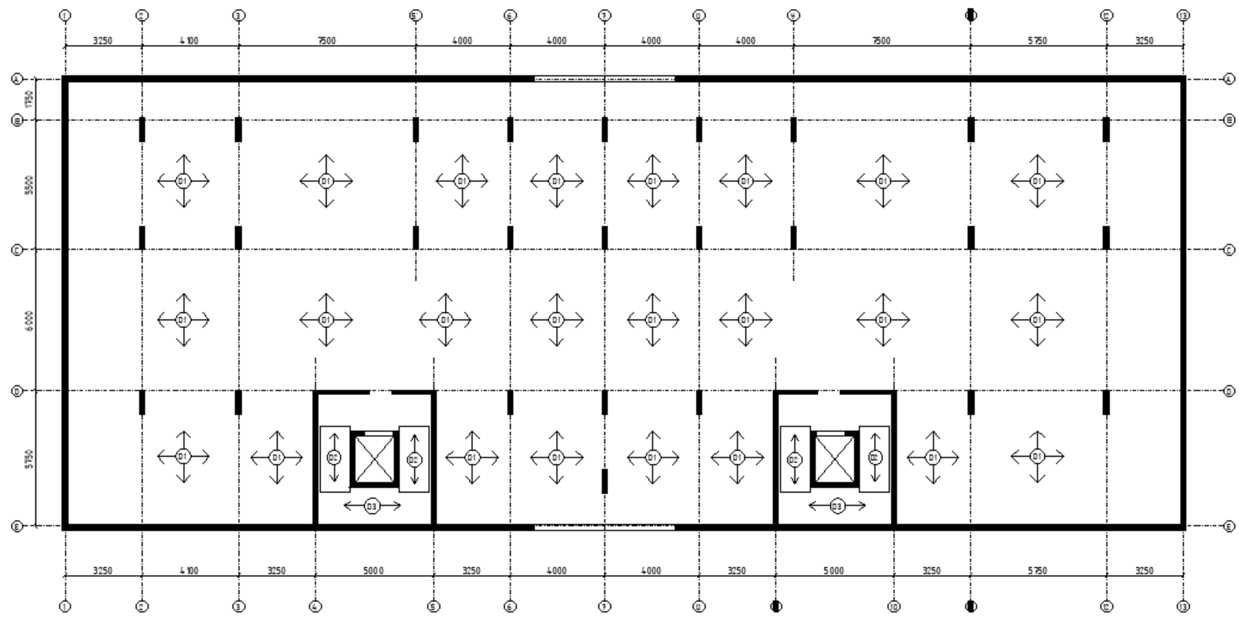
The residential building will be based deep on large diameter piles. Piles with diameter of 900 mm will be used for columns and 600 mm for perimeter wall and wall of the elevator shaft. Designed length of the piles is 14 m. Calculation of the piles are provided via file (Foundation part 3).

2.5 RADAN LOAD

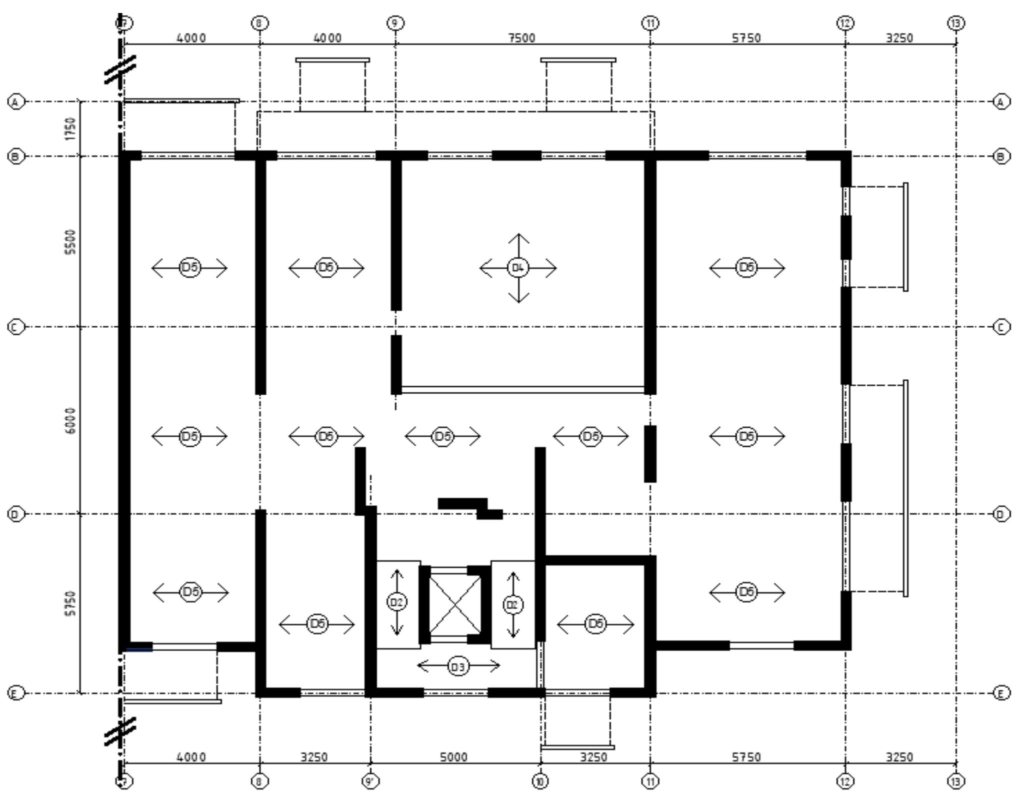
The site has a mean radon index based on assessment of radon volume activity in soil air and soil gas permeability. The proposed method of waterproofing the substructure and air – ventilated basement areas provide sufficient protection in terms of risk of intrusion radon from the subsoil into the building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

3 STRUCTURAL SYSTEM

Scheme of structural system of the underground level:



Scheme of structural system of the first level:



The underground level is designed as a two – way flat slab with thickness of 250 mm supported on columns for the purpose of garage with dimensions of 240 x 1 000 mm. The perimeter wall is made of waterproof reinforced concrete with thickness of 240 mm. The structural system of above – ground floors (1 + 4) is designed as a one – way and two – way bi – directional wall system, which was chosen for the reason of easy separation of apartments. Therefore, using of wall system was the best solution for residential building and it is much stiffer than skeleton (column) system. Two – way slab between 9 and 11 intersections is supported by beam due to the long span with dimensions of 300 x 650 mm.

The load – bearing structure of the building consists of monolithic reinforced concrete walls, columns (pillar) and reinforced concrete ceiling slabs.

The slabs of the building are defined as a residential areas and designed in basic thickness of 200 mm and 230 mm depending on the span of the structure. Calculation is provided via file (Concrete part 2).

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.

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. In each level there is one communication core with a staircase and an elevator, which is connecting all floors.

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

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 1 000 mm high from the side of the staircase walls. Rises and treads are made of ceramic tiles. Calculation is provided via file (Concrete part 2).

The staircase spaces are illuminated by a daylight tubes.

The flight of the staircase is placed on the landing by means of rubber blocks 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.

Used precast elements:

Schöck Tronsole® type F – between precast flight and landing

Schöck Tronsole® typ F

Schöck Tronsole® type L – between concrete wall and landing

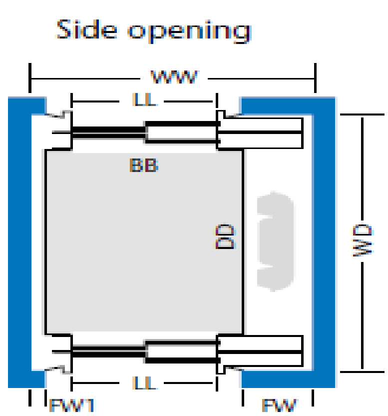
Schöck Tronsole® typ L

Schöck Tronsole® type B – between foundation slab and flight

3.2 ELEVATOR

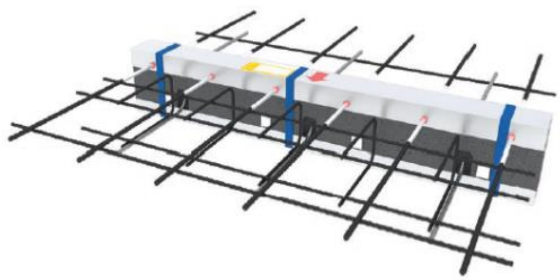
The elevator shafts are designed as monolithic reinforced concrete with thickness of 200 mm. The acoustic solution of the noise from the elevator is carried out by dilatation from rest of the structures with 30 mm thickness filled with flexible impact sound EPS-T 4000. The shaft is connected with the construction only at the base level.

Chosen 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. That elevator works as evacuation as well. The generator of reserve energy source is installed in the room of UPC in the underground level.



3.3 BALCONIES

The balconies are used as cantilever with 1 540 mm of span. Balconies are connected to other construction by using iso beams with elimination of thermal bridges (Bronze TiP MQ). Non - insulated structure is made of concrete C30/37.



Balcony isobeam Bronze TiP MQ

4 MATERIALS

4.1 REINFORCED CONCRETE STRUCTURES

Concrete in accordance with ČSN EN 206-1

Basement slab – waterproof concrete	C30/37-XC2, XD1-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-D_{max}=22-Cl 0,20-S4
Underground floor – columns	C30/37-XC2-D_{max}=22-Cl 0,40-S4
Underground floor – slab	C30/37-XC1-D_{max}=22-Cl 0,40-S4
1st to 4th floor – load-bearing walls	C30/37-XC1-D_{max}=22-Cl 0,40-S4
1st to 4th floor – slab	C30/37-XC1-D_{max}=22-Cl 0,40-S4
Balcony, loggia	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	C30/37-XC1-D_{max}=22-Cl 0,40-S4

4.2 MASONRY STRUCTURES

2nd floor – vertical structures	POROTHERM 25 AKU SYM P15+M10 POROTHERM 24 P+D P15+M10
3rd floor – vertical structures	POROTHERM 25 AKU SYM P15+M10 POROTHERM 24 P+D P10+M10
4th floor – vertical structures	POROTHERM 25 AKU SYM P15+M10

4.3 STEEL STRUCTURES

Reinforced bars B500B

5 INSULATION

Staircase is separated by acoustic elements of Schöck Tronsole® between landing and precast flight, reinforced concrete wall and precast flight, foundation slab and precast flight.

Façade of the building satisfies acoustic requirements with accordance ČSN 730532.

The wall composition also satisfies acoustic requirements.

For flooring inside the building is used sound impact insulation EPS-T 4000 with thickness of 40 mm.

For the elevators is used sound impact insulation EPS-T 4000 with thickness of 30 mm.

For perimeter walls is used fire resistance thermal insulation ETICS with thickness of 60 – 140 mm.

Fore terraces is used 2 in 1 thermal and acoustic insulation ISOVER with thickness of 100 mm.

For roof structure is used thermal insulation EPS ISOVER with thickness of 30 – 160 mm.

6 WINDOWS

More details in attachment of windows and doors description.

6.1 ROOF ENTRANCE WINDOW

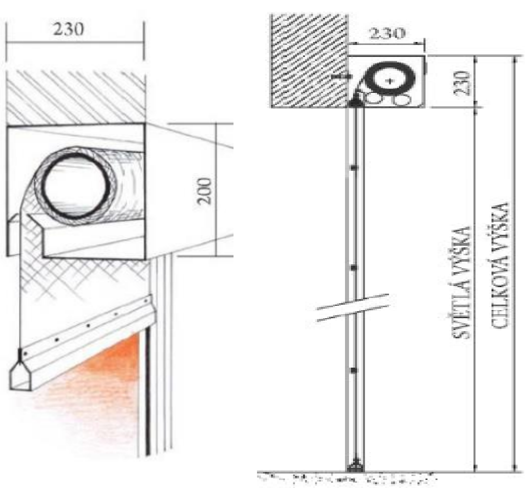
Roof entrance window type is VELUX CXP, 900 x 1 200 mm.

7 DOORS

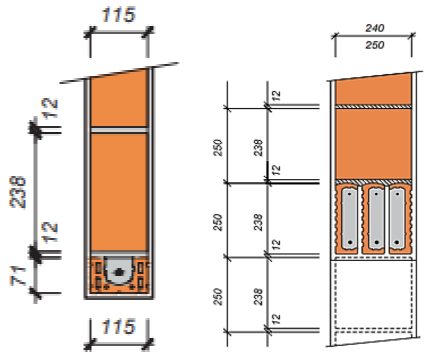
More details in attachment of windows and doors description.

7.1 GARAGE DOOR

The garage door is fire resisting rolling shutter with dimensions of 6 000 x 2 250 mm by company Hörmann.



8 LINTELS



LINTELS								
	DEFINITION	DIMENSIONS	UL	1L	2L	3L	4L	TOTAL
P1	POROTHERM 11.5	115/70/750	-	-	-	-	-	2
P2	POROTHERM 11.5	115/70/1000	-	-	-	-	-	1
P3	POROTHERM 11.5	115/70/1250	-	18	20	20	12	85
P4	POROTHERM 11.5	115/70/2000	-	1	1	1	1	5
P5	POROTHERM 7	3x70/238/1250	-	3	5	5	3	16
								90

9 STANDARD NORMS AND LITERATURE

ČSN 73 4301 Residential building

EN 1990 Basis of structural design

EN 1991-1 Actions on structures

EN 1992-1 Design of concrete structures

EN 1997-1 Geotechnical design

ČSN 73 1001 Subsoil under shallow foundation

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

ČSN 730532 Acoustic requirements

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

ČSN 730540-1 Thermal protection of buildings, part 1

ČSN 730540-2 Thermal protection of buildings, part 2

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

ČSN 730818 Fire safety of buildings: Object occupation by persons

ČSN 730821 Fire safety of buildings: Fire resistance of building structures

ČSN 730833 Fire safety of buildings: Housing and accommodation buildings

ČSN 730872 Fire safety of buildings: Protection of fire extinguishing structures

USED WEB PAGES:

[1] www.wienerberger.cz

[2] www.schoeck-wittek.cz

[3] www.bronze.cz

[4] www.isover.cz

[5] www.kone.cz

USED LITERATURE:

[1] Hollis M.: Surveying Buildings, RICS Boks 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 LECTURES:

[k124bs-2-okno-dvere] – Building structures 1, Ing. Malila Noori, Ph.D.

[k124-2staircase] – Building structures 1, doc.Ing. Eva Burgetová, CSc., doc.Ing. Hana Gattermayerová, CSc.

[CM01_01 – 07] – Concrete and Masonry structures 1, Ing. Petr Bílý, Ph.D.

[125bse_Drainage, Water Supply, heating] – Building services systems 1, prof. Ing. Karel Kabele, CSc., doc.Ing. Michal Kabrhel, Ph.D.

[Design of fire safety] – Fire safety, doc.Ing. Václav Kupilík, CSc., Ing. arch. Petr Hejtmánek, Ph.D.

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

10 LIST OF ATTACHMENTS

1) Description of the windows and doors
2) TEPLO calculation of the u - value

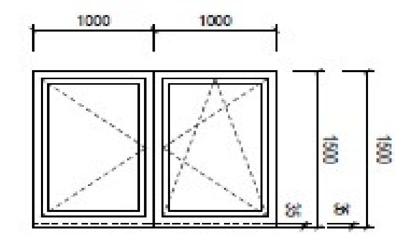
11 LIST OF DRAWINGS

1) Situation, scale 1:250
2) Plan view of 1.PP, scale 1:50
3) Plan view of 1.NP, scale 1:50
4) Plan view of 2-3.NP, scale 1:50
5) Plan view of 4.NP, scale 1:50
6) Plan view of roof, scale 1:50
7) Section A-A’, scale 1:50
8) Section B-B’, scale 1:50
9) South – west view, scale 1:50

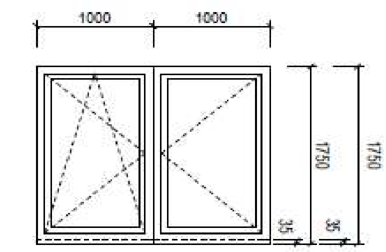
10) North – west view, scale 1:50
11) South – east view, scale 1:50
12) Detail 1, scale 1:8
13) Detail 2, scale 1:10
14) Detail 3, scale 1:10
15) Detail 4, scale 1:10
16) Detail 5, scale 1:10
17) Detail 6, scale 1:5

12 SOFTWARES

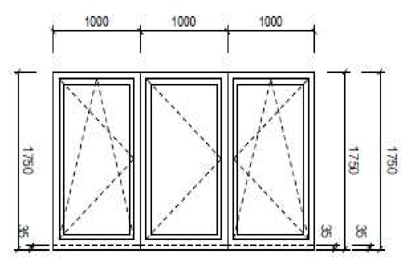
1) AutoCAD 2020
2) MS Office
3) TEPLO 2017



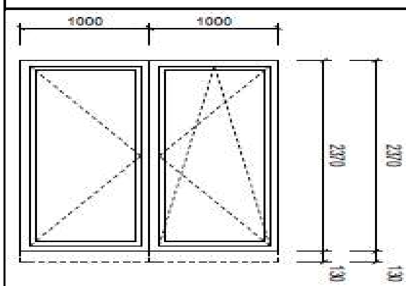
W01	
Dimensions:	1000/1500 + 1000/1500
Description:	Double-wing window with sill
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



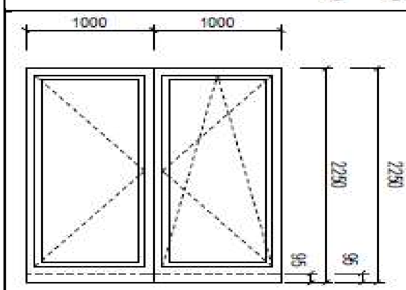
W02	
Dimensions:	1000/1750 + 1000/1750
Description:	Double-wing window with sill
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



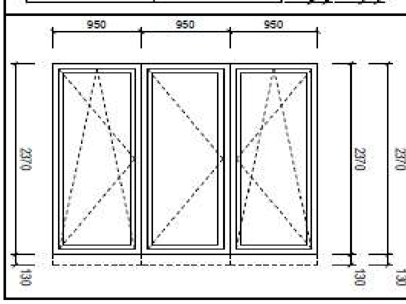
W03	
Dimensions:	1000/1750 + 1000/1750 + 1000/1750
Description:	Double-wing window with sill
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



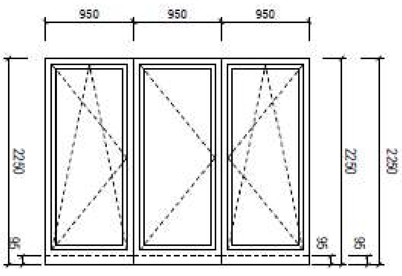
W04	
Dimensions:	1000/2370(130) + 1000/2370(130)
Description:	French double-wing window
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



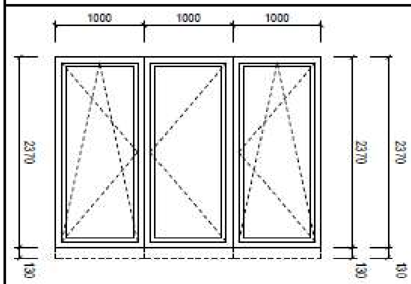
W05	
Dimensions:	1000/2250 + 1000/2250
Description:	French double-wing window
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



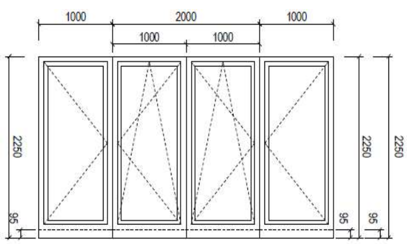
W06	
Dimensions:	950/2370(130) x3
Description:	French three-wing window
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



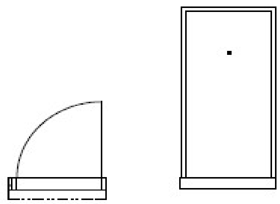
W07	
Dimensions:	950/2250 + 950/2250 + 950/2250
Description:	French three-wing window
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



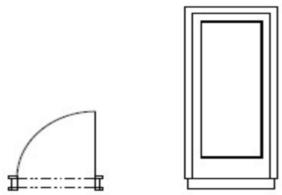
W08	
Dimensions:	1000/2370(130) x3
Description:	French three-wing window
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



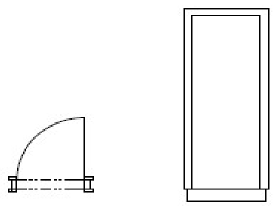
W09	
Dimensions:	1000/2250 + 2000/2250 + 1000/2250
Description:	French four-wing window
	Casement side and top hung
Glazing:	Double glazing, U_{max}=1.1 W $m^{-2}K^{-1}$
Frame:	Plastic profile
Color:	White RAL 9016



D01	
Dimensions:	900 x 1970
Description:	Security door NEXT SD 101F
Color:	Grey
Fire resistance:	EW 30 DP3

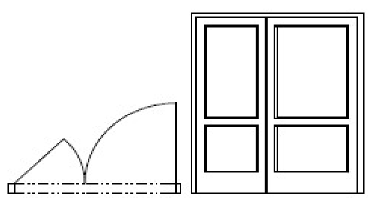


D02	
Dimensions:	800 x 1970
Description:	Glazed wooden door
Color:	Ivory
Fire resistance:	-

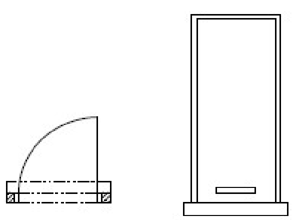


D03	
Dimensions:	700 x 1970
Description:	Wooden door
Color:	Ivory
Fire resistance:	-

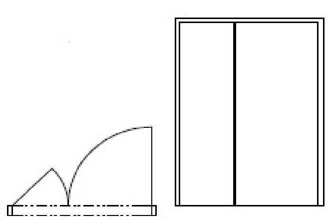
D04	
Dimensions:	800 x 1970
Description:	Single-winged sliding door
Color:	White
Fire resistance:	-



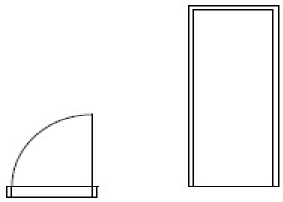
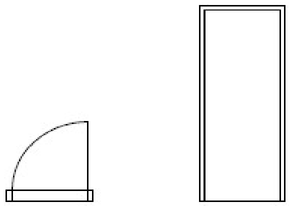
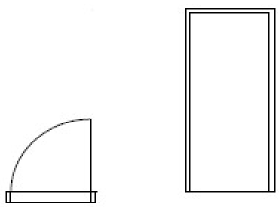
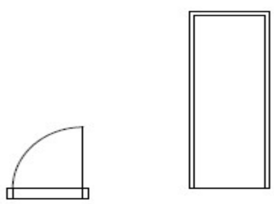
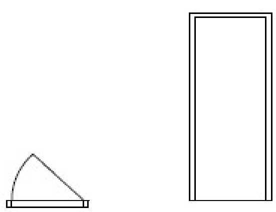
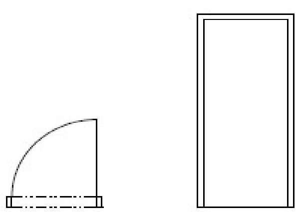
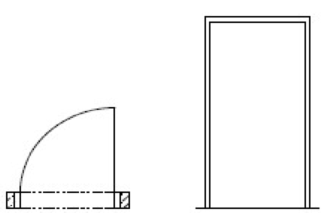
D05	
Dimensions:	1600 x 1970
Description:	Double glazed wooden door
Color:	Black
Fire resistance:	EI 15 S-C DP3
Additional:	Self-closing device

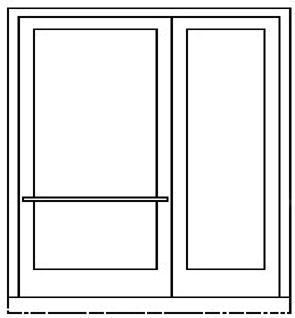


D06	
Dimensions:	800 x 1970
Description:	Wooden door
Color:	Grey
Fire resistance:	-
Additional:	Door vent (500x60)

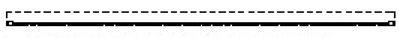


D07	
Dimensions:	1500 x 2100
Description:	Double swing steel door
Color:	RAL 7001
Fire resistance:	EW 15 C2 DP1

	**D08**	
	Dimensions:	800 x 1970
	Description:	Steel door
	Color:	RAL 7001
	Fire resistance:	EI 30 C2 DP1
	**D09**	
	Dimensions:	700 x 1970
	Description:	Wooden door
	Color:	White grey
	Fire resistance:	EI 30 C2 DP3
	**D10**	
	Dimensions:	800 x 1970
	Description:	Steel door
	Color:	RAL 7001
	Fire resistance:	EW 30 C2 DP1
	**D11**	
	Dimensions:	700 x 1970
	Description:	Steel door
	Color:	RAL 7001
	Fire resistance:	EW 30 C2 DP1
	**D12**	
	Dimensions:	700 x 1970
	Description:	Wooden door
	Color:	White grey
	Fire resistance:	-
	**D13**	
	Dimensions:	800 x 1970
	Description:	Wooden door
	Color:	White grey
	Fire resistance:	EI 30 C2 DP3
	**D14**	
	Dimensions:	900 x 1970
	Description:	Steel door
	Color:	RAL 1028
	Fire resistance:	EI 30 S-C S DP1



D15	
Dimensions:	1950 x 2470
Description:	Double swing aluminum door
Color:	RAL 9006
Fire resistance:	EI 30 S-C S DP1
Additional:	Self-closing device



G01	
Dimensions:	6000 x 2250
Description:	Fire resisting rolling shutter
Color:	White
Fire resistance:	EW 15 DP1

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

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

Teplo 2017 EDU

Název úlohy : **Flat roof - R1**
Zpracovatel : Dayana Muratova
Zakázka :
Datum : 3/5/2020

ZADANÁ SKLADBA A OKRAJOVÉ PODMÍNKY :

Typ hodnocené konstrukce : Strecha jednoplášťová
Korekce soucinitele prostupu dU : 0.000 W/m2K

Skladba konstrukce (od interiéru) :

Císlo	Název	D [m]	Lambda [W/(m.K)]	c [J/(kg.K)]	Ro [kg/m3]	Mi [-]	Ma [kg/m2]
1	Baumit jemná š	0.0010	0.8000	850.0	1600.0	12.0	0.0000
2	Železobeton 1	0.2000	1.4300	1020.0	2300.0	23.0	0.0000
3	Dörken Delta-L	0.0050	0.1700	1000.0	930.0	10000.0	0.0000
4	Isover EPS 200	0.2000	0.0340	1270.0	30.0	70.0	0.0000
5	Asfaltový nátě	0.0100	0.2100	1470.0	1400.0	280.0	0.0000

Poznámka: D je tlouštka vrstvy, Lambda je návrhová hodnota tepelné vodivosti vrstvy, C je merná tepelná kapacita vrstvy, Ro je objemová hmotnost vrstvy, Mi je faktor difúzního odporu vrstvy a Ma je pocátecní zabudovaná vlhkost ve vrstve.

Císlo	Kompletní název vrstvy	Interní výpocet tep. vodivosti
1	Baumit jemná štuková omítka (FeinPutz)	---
2	Železobeton 1	---
3	Dörken Delta-LUXX	---
4	Isover EPS 200S	---
5	Asfaltový nátěr 2x	---

Okrajové podmínky výpoctu :

Tepelný odpor pri prestupu tepla v interiéru Rsi : 0.10 m2K/W
dtto pro výpocet vnitrní povrchové teploty Rsi : 0.25 m2K/W
Tepelný odpor pri prestupu tepla v exteriéru Rse : 0.04 m2K/W
dtto pro výpocet vnitrní povrchové teploty Rse : 0.04 m2K/W

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

VÝSLEDKY VÝPOCTU HODNOCENÉ KONSTRUKCE :

Tepelný odpor a soucinitel prostupu tepla podle EN ISO 6946:

Tepelný odpor konstrukce R : 6.117 m2K/W

Soucinitel prostupu tepla konstrukce U : **0.160 W/m2K**

Soucinitel prostupu zabudované kce U,kc : 0.18 / 0.21 / 0.26 / 0.36 W/m2K
Uvedené orientacní hodnoty platí pro ruznou kvalitu rešení tep. mostu vyjádrenou približnou prirážkou podle poznámek k cl. B.9.2 v CSN 730540-4.

Difúzní odpor a tepelne akumulacní vlastnosti:

Difuzní odpor konstrukce ZpT : 2.1E+0012 m/s

Teplotní útlum konstrukce Ny* podle EN ISO 13786 : 262
Fázový posun teplotního kmitu Psi* podle EN ISO 13786 : 9.3 h

Teplota vnitrního povrchu a teplotní faktor podle CSN 730540 a EN ISO 13788:

Vnitrní povrchová teplota v návrhových podmínkách Tsi,p : 19.29 C
Teplotní faktor v návrhových podmínkách f,Rsi,p : **0.961**

Obe hodnoty platí pro odpor pri prestupu tepla na vnitrní strane Rsi=0,25 m2K/W.

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

Prubeh teplot a cástecných tlaku vodní páry v návrhových okrajových podmínkách:

rozhraní:	i	1-2	2-3	3-4	4-5	5-6	6-7	e
theta [C]:	20.1	20.1	20.0	20.0	5.5	-11.9	-12.0	-12.8
p [Pa]:	1334	1292	1205	786	777	767	185	166
p,sat [Pa]:	2346	2346	2339	2336	902	218	216	202

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

Pri venkovní návrhové teplote dochází v konstrukci ke kondenzaci vodní páry.

Kond.zóna císlo	Hranice kondenzacní zóny levá	[m]	pravá	Kondenzující množství vodní páry [kg/(m2s)]
1	0.2226		0.2226	1.094E-0009

Rocní bilance zkondenzované a vyparené vodní páry:

Množství zkondenzované vodní páry za rok Mc,a: **0.0078 kg/(m2.rok)**
Množství vyparitelné vodní páry za rok Mev,a: **0.0141 kg/(m2.rok)**

Ke kondenzaci dochází pri venkovní teplote nižší než -10.0 C.

Poznámka: Hodnocení difúze vodní páry bylo provedeno pro predpoklad 1D šírení vodní páry prevažující skladbou konstrukce. Pro konstrukce s výraznými systematickými tepelnými mosty je výsledek výpoctu jen orientacní. Presnejší výsledky lze získat s pomocí 2D analýzy.

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

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

Teplo 2017 EDU

Název úlohy : **Ground floor - F2 (ceiling between 1.PP and 1.NP)**
Zpracovatel : TT 2017
Zakázka :
Datum : 3/5/2020

ZADANÁ SKLADBA A OKRAJOVÉ PODMÍNKY :

Typ hodnocené konstrukce : Podlaha nad nevytápeným ci méne vytáp. vnitrním prostorem
Korekce soucinitele prostupu dU : 0.000 W/m2K

Skladba konstrukce (od interiéru) :

Císlo	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	Beton hutný 1	0.0500	1.2300	1020.0	2100.0	17.0	0.0000
3	PE folie	0.0001	0.3500	1470.0	900.0	144000.0	0.0000
4	Isover Akustic	0.0400	0.0440	840.0	30.0	1.0	0.0000
5	Železobeton 1	0.2500	1.4300	1020.0	2300.0	23.0	0.0000
6	Isover Orstech	0.1000	0.0370	800.0	100.0	1.0	0.0000
7	Baumit hlazená	0.0100	0.6000	1000.0	1110.0	10.0	0.0000

Poznámka: D je tlouštka vrstvy, Lambda je návrhová hodnota tepelné vodivosti vrstvy, C je merná tepelná kapacita vrstvy, Ro je objemová hmotnost vrstvy, Mi je faktor difúzního odporu vrstvy a Ma je pocátecní zabudovaná vlhkost ve vrstve.

Císlo	Kompletní název vrstvy	Interní výpocet tep. vodivosti
1	Laminát	---
2	Beton hutný 1	---
3	PE folie	---
4	Isover Akustic SSP 2	---
5	Železobeton 1	---
6	Isover Orstech 100	---
7	Baumit hlazená omítka	---

Okrajové podmínky výpoctu :

Tepelný odpor pri prestupu tepla v interiéru Rsi : 0.17 m2K/W
dtto pro výpocet vnitrní povrchové teploty Rsi : 0.25 m2K/W
Tepelný odpor pri prestupu tepla v exteriéru Rse : 0.17 m2K/W
dtto pro výpocet vnitrní povrchové teploty Rse : 0.17 m2K/W

Návrhová venkovní teplota Te : 10.0 C
Návrhová teplota vnitrního vzduchu Tai : 21.0 C
Návrhová relativní vlhkost venkovního vzduchu RHe : 60.0 %
Návrhová relativní vlhkost vnitrního vzduchu RHi : 89.0 %

VÝSLEDKY VÝPOCTU HODNOCENÉ KONSTRUKCE :

Tepelný odpor a soucinitel prostupu tepla podle EN ISO 6946:

Tepelný odpor konstrukce R : 3.871 m2K/W
Soucinitel prostupu tepla konstrukce U : **0.400 W/m2K**

Soucinitel prostupu zabudované kce U,kc : 0.26 / 0.29 / 0.34 / 0.44 W/m2K
Uvedené orientacní hodnoty platí pro ruznou kvalitu rešení tep. mostu vyjádrenou približnou prirážkou podle poznámek k cl. B.9.2 v CSN 730540-4.

Difúzní odpor a tepelne akumulacní vlastnosti:

Difuzní odpor konstrukce ZpT : 5.1E+0012 m/s

Teplotní útlum konstrukce Ny* podle EN ISO 13786 : 2131.2
Fázový posun teplotního kmitu Psi* podle EN ISO 13786 : 15.9 h

Teplota vnitrního povrchu a teplotní faktor podle CSN 730540 a EN ISO 13788:

Vnitrní povrchová teplota v návrhových podmínkách Tsi,p : 20.36 C
Teplotní faktor v návrhových podmínkách f,Rsi,p : **0.942**

Obe hodnoty platí pro odpor pri prestupu tepla na vnitrní strane Rsi=0,25 m2K/W.

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

Prubeh teplot a cástecných tlaku vodní páry v návrhových okrajových podmínkách:

rozhraní:	i	1-2	2-3	3-4	4-5	5-6	6-7	e
theta [C]:	20.6	20.5	20.4	20.4	18.0	17.5	10.5	10.4
p [Pa]:	2212	769	768	746	746	737	737	736
p,sat [Pa]:	2419	2408	2392	2392	2063	2005	1268	1264

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

Pri venkovní návrhové teplote nedochází v konstrukci ke kondenzaci vodní páry.

Množství difundující vodní páry Gd : 3.071E-0010 kg/(m2.s)

Poznámka: Hodnocení difúze vodní páry bylo provedeno pro predpoklad 1D šírení vodní páry prevažující skladbou konstrukce. Pro konstrukce s výraznými systematickými tepelnými mosty je výsledek výpoctu jen orientacní. Presnejší výsledky lze získat s pomocí 2D analýzy.

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

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

Teplo 2017 EDU

Název úlohy : **Perimeter wall - W2**
Zpracovatel : Dayana Muratova
Zakázka :
Datum : 3/5/2020

ZADANÁ SKLADBA A OKRAJOVÉ PODMÍNKY :

Typ hodnocené konstrukce : Stena vnejší jednoplášťová
Korekce soucinitele prostupu dU : 0.000 W/m2K

Skladba konstrukce (od interiéru) :

Císlo	Název	D [m]	Lambda [W/(m.K)]	c [J/(kg.K)]	Ro [kg/m3]	Mi [-]	Ma [kg/m2]
1	Baumit štuková	0.0100	0.4700	790.0	1800.0	25.0	0.0000
2	Železobeton 1	0.2000	1.4300	1020.0	2300.0	23.0	0.0000
3	Isover Super-V	0.1400	0.0350	840.0	29.0	1.0	0.0000
4	Baumit sádrová	0.0100	0.7000	1000.0	1200.0	10.0	0.0000

Poznámka: D je tlouštka vrstvy, Lambda je návrhová hodnota tepelné vodivosti vrstvy, C je merná tepelná kapacita vrstvy, Ro je objemová hmotnost vrstvy, Mi je faktor difúzního odporu vrstvy a Ma je pocátecní zabudovaná vlhkost ve vrstve.

Císlo	Kompletní název vrstvy	Interní výpocet tep. vodivosti
1	Baumit štuková omítka	---
2	Železobeton 1	---
3	Isover Super-Vent Plus	---
4	Baumit sádrová štuková omítka	---

Okrajové podmínky výpoctu :

Tepelný odpor pri prestupu tepla v interiéru Rsi : 0.13 m2K/W
dtto pro výpocet vnitrní povrchové teploty Rsi : 0.25 m2K/W
Tepelný odpor pri prestupu tepla v exteriéru Rse : 0.04 m2K/W
dtto pro výpocet vnitrní povrchové teploty Rse : 0.04 m2K/W

Návrhová venkovní teplota Te : -13.0 C
Návrhová teplota vnitrního vzduchu Tai : 20.6 C
Návrhová relativní vlhkost venkovního vzduchu RHe : 84.0 %
Návrhová relativní vlhkost vnitrního vzduchu RHi : 60.0 %

VÝSLEDKY VÝPOCTU HODNOCENÉ KONSTRUKCE :

Tepelný odpor a soucinitel prostupu tepla podle EN ISO 6946:

Tepelný odpor konstrukce R : 4.461 m2K/W
Soucinitel prostupu tepla konstrukce U : **0.200 W/m2K**

Soucinitel prostupu zabudované kce U,kc : 0.24 / 0.27 / 0.32 / 0.42 W/m2K
Uvedené orientační hodnoty platí pro ruznou kvalitu rešení tep. mostu vyjádrenou približnou prirážkou podle poznámek k cl. B.9.2 v CSN 730540-4.

Difúzní odpor a tepelne akumulací vlastnosti:

Difuzní odpor konstrukce ZpT : 2.7E+0010 m/s

Teplotní útlum konstrukce Ny* podle EN ISO 13786 : 263.2
Fázový posun teplotního kmitu Psi* podle EN ISO 13786 : 9.1 h

Teplota vnitrního povrchu a teplotní faktor podle CSN 730540 a EN ISO 13788:

Vnitrní povrchová teplota v návrhových podmínkách Tsi,p : 18.83 C
Teplotní faktor v návrhových podmínkách f,Rsi,p : **0.947**

Obe hodnoty platí pro odpor pri prestupu tepla na vnitrní strane Rsi=0,25 m2K/W.

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

(bez vlivu zabudované vlhkosti a slunecní radiace)

Prubeh teplot a cástecných tlaku vodní páry v návrhových okrajových podmínkách:

rozhraní:	i	1-2	2-3	3-4	e
theta [C]:	19.7	19.5	18.5	-12.6	-12.7
p [Pa]:	1455	1392	229	192	166
p,sat [Pa]:	2288	2266	2127	205	203

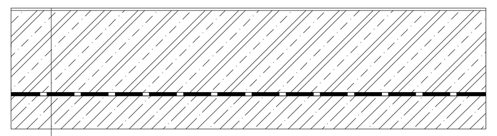
Poznámka: theta je teplota na rozhraní vrstev, p je predpokládaný cástecný tlak vodní páry na rozhraní vrstev a p,sat je cástecný tlak nasycené vodní páry na rozhraní vrstev.

Pri venkovní návrhové teplote nedochází v konstrukci ke kondenzaci vodní páry.

Množství difundující vodní páry Gd : 5.054E-0008 kg/(m2.s)

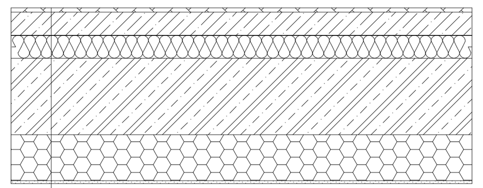
Poznámka: Hodnocení difúze vodní páry bylo provedeno pro predpoklad 1D šírení vodní páry prevažující skladbou konstrukce. Pro konstrukce s výraznými systematickými tepelnými mosty je výsledek výpoctu jen orientacní. Presnejší výsledky lze získat s pomocí 2D analýzy.

UNDERGROUND LEVEL - F1



- ANTIFIRE PAINTING
- POLYURETHANE COATING 3 mm
- WATERPROOF REINFORCED CONCRETE 250 mm
- PE FOIL SEPARATION LAYER
- 2xPE WOVEN GEOTEXTILE
- UNDERLAYING CONCRETE(piles head connects with upper surfece) 100 mm

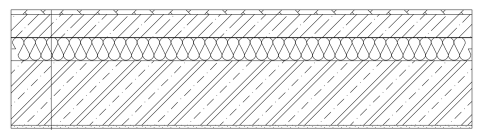
GROUND FLOOR - F2



Thermal transmittance:
$U = 0.40\ W/m^2K$
Airborne resistance:
$R_w < R_w' - k$
$k = 2$ dB
52 dB < 56 - 2 = 54 dB
Impact resistance:
$L_w = 58$ dB

- LAMINATE FLOATING FLOOR 10 mm
- GLUE LAYER
- CONCRETE LEVELING ANHYDRITE SCREED WITH FLOOR HEATING 50 mm
- PE FOIL SEPARATION LAYER
- EPS ACOUSTIC INSULATION 40 mm
- REINFORCED CONCRETE SLAB 250 mm
- MINERAL WOOL INSULATION 100 mm
- PLASTER 10 mm

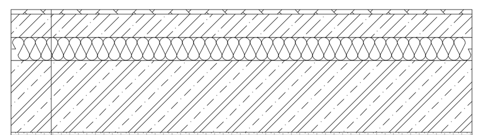
TYPICAL FLOORS - F3



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

- LAMINATE FLOATING FLOOR 10 mm
- CONCRETE LEVELING ANHYDRITE SCREED WITH FLOOR HEATING 50 mm
- PE FOIL SEPARATION LAYER
- EPS ACOUSTIC INSULATION 40 mm
- REINFORCED CONCRETE SLAB 200 mm
- PLASTER 5 mm

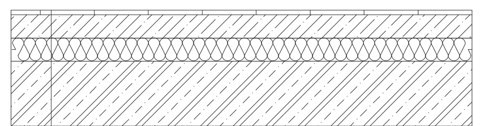
TYPICAL FLOORS - F4



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

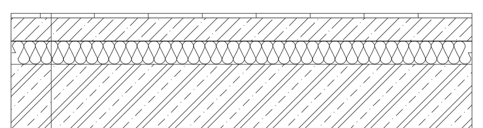
- LAMINATE FLOATING FLOOR 10 mm
- CONCRETE LEVELING ANHYDRITE SCREED WITH FLOOR HEATING 50 mm
- PE FOIL SEPARATION LAYER
- EPS ACOUSTIC INSULATION 40 mm
- REINFORCED CONCRETE SLAB 230 mm
- PLASTER 5 mm

FLOOR OF BATHROOM, WC - F5



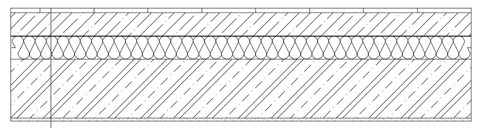
- ANTI-SLIP CERAMIC TILES RAKO 10 mm
- GLUE LAYER
- WATERPROOFING SEALING
- CONCRETE LEVELING ANHYDRITE SCREED WITH FLOOR HEATING 50 mm
- PE FOIL SEPARATION LAYER
- EPS ACOUSTIC INSULATION 40 mm
- REINFORCED CONCRETE SLAB 200 mm
- PLASTER 5 mm

FLOOR OF BATHROOM, WC - F6



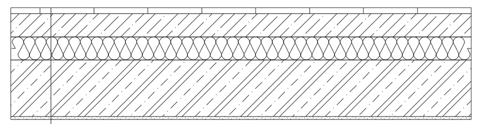
- ANTI-SLIP CERAMIC TILES RAKO 10 mm
- GLUE LAYER
- WATERPROOFING SEALING
- CONCRETE LEVELING ANHYDRITE SCREED WITH FLOOR HEATING 50 mm
- PE FOIL SEPARATION LAYER
- EPS ACOUSTIC INSULATION 40 mm
- REINFORCED CONCRETE SLAB 230 mm
- PLASTER 5 mm

CORRIDOR, CLEANING ROOM, PRAM ROOM - F7



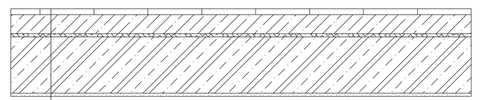
- CERAMIC TILES 10 mm
- GLUE LAYER
- CONCRETE LEVELING ANHYDRITE SCREED WITH FLOOR HEATING 50 mm
- PE FOIL SEPARATION LAYER
- EPS ACOUSTIC INSULATION 40 mm
- REINFORCED CONCRETE SLAB 200 mm
- PLASTER 5 mm

STAIRCASE AREA, HALLWAY IN FRONT OF ELEVATOR - F8



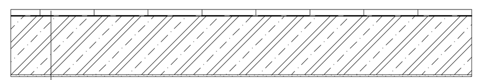
- CERAMIC TILES 15 mm
- GLUE LAYER
- CONCRETE LEVELING LAYER 50 mm
- PE FOIL SEPARATION LAYER
- EPS ACOUSTIC INSULATION 40 mm
- REINFORCED CONCRETE SLAB 250 mm
- PLASTER 10 mm

LANDING - F9



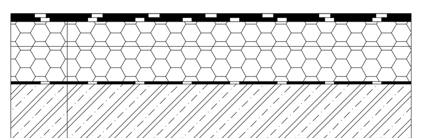
- CERAMIC TILES 15 mm
- GLUE LAYER
- CONCRETE LEVELING ANHYDRITE SCREED WITH FLOOR HEATING 35 mm
- POLYETHYLENE FOAM (ETHAFOAM) 10 mm
- REINFORCED CONCRETE SLAB 190 mm
- PLASTER 10 mm

BALCONY - F10



- ANTIFREEZE TILES RAKO TAURUS GRANIT 30x30 cm 15 mm
- GLUE ANTIFREEZE
- WATERPROOFING LAYER FORTISOL 5 mm
- REINFORCED CONCRETE IN SLOPE 2% 220 mm
- PLASTER 5 mm

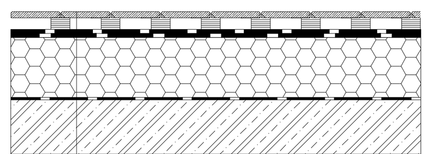
FLAT ROOF - R1



Thermal transmittance:
$U = 0.16\ W/m^2K$

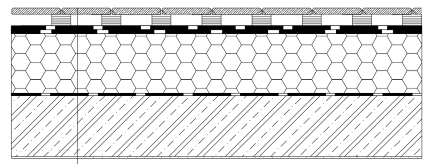
- WATERPROOFING 2x ASPHALT MODIFIED STRIPS 10 mm
- THERMAL INSULATION ISOVER EPS INCLINED 30-160 mm
- THERMAL INSULATION ISOVER EPS IN SLOPE 3% 200 mm
- VAPOR BARRIER - ASPHALT OXIDIZED STRIP 5 mm
- PENETRATION COATING
- REINFORCED CONCRETE SLAB 200 mm
- PLASTER 5 mm

ROOF TERRACE - R2



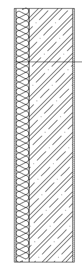
- ANTIFREEZE TILES RAKO TAURUS GRANIT 30x30 cm 10 mm
- HEIGHT ADJUSTABLE WASHERS 30 mm
- WATERPROOFING 2x ASPHALT STRIPS 10 mm
- THERMAL AND ACOUSTIC INSULATION 2in1 ISOVER 100 mm
- VAPOR BARRIER - ASPHALT OXIDIZED STRIP 5 mm
- PENETRATION COATING
- REINFORCED CONCRETE SLAB 200 mm
- PLASTER 5 mm

TERRACE ABOVE THE 1st FLOOR - R3



- ANTIFREEZE TILES RAKO TAURUS GRANIT 30x30 cm 10 mm
- HEIGHT ADJUSTABLE WASHERS 30 mm
- WATERPROOFING 2x ASPHALT STRIPS 10 mm
- THERMAL AND ACOUSTIC INSULATION 2in1 ISOVER 100 mm
- PENETRATION COATING
- LIGHT-WEIGHT CONCRETE IN SLOPE 2% 50-150 mm
- REINFORCED CONCRETE SLAB 250 mm
- PLASTER 5 mm

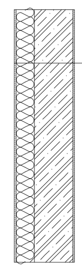
PERIMETER WALL OF UL - W1



- OUTER PLASTER 5 mm
- THERMAL INSULATION ETICS 60 mm
- GLUE ANTI - FROZEN
- REINFORCED CONCRETE C30/37 240 mm
- INNER PLASTER 5 mm

Thermal transmittance:
$U = 0.20\ W/m^2K$
Airborne resistance:
$R_w < R_w' - k$
$k = 2$ dB
41 dB < 44 - 2 = 42 dB

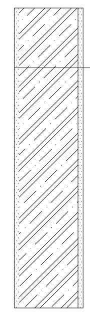
PERIMETER WALL - W2



- OUTER PLASTER 10 mm
- THERMAL INSULATION ETICS 140 mm
- REINFORCED CONCRETE C30/37 200 mm
- INNER PLASTER 10 mm

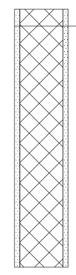
Thermal transmittance:
$U = 0.20\ W/m^2K$
Airborne resistance:
$R_w < R_w' - k$
$k = 2$ dB
41 dB < 44 - 2 = 42 dB

LOAD BEARING INTERIOR WALL - W3



- PLASTER 10 mm
- REINFORCED CONCRETE C30/37 220 mm
- PLASTER 10 mm

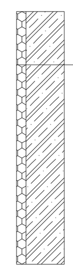
PARTITION WALLS- W4



- PLASTER 10 mm
- POROTHERM, 42 dB 115-250 mm
- PLASTER 10 mm

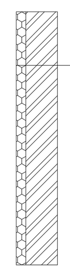
Airborne resistance:
$R_w < R_w' - k$
$k = 2$ dB
42 dB < 47 - 2 = 45 dB

ELEVATOR WALL ON THE ROOF - W5



- THERMAL INSULATION ETICS (EPS) 60 mm
- REINFORCED CONCRETE 200 mm

VENTILATION SHAFTS ON THE ROOF - W6



- THERMAL INSULATION ETICS (EPS) 60 mm
- POROTHERM 17.5 P+D 175 mm

±0,000 = +262,450 BpV

DESIGNED BY:	SUPERVISOR:	CZECH TECHNICAL UNIVERSITY IN PRAGUE	
DAYANA MURATOVA	Ing. MALILA NOORI, Ph.D.		
PART:	CONSULTED WITH:		
BUILDING STRUCTURES	Ing. MALILA NOORI, Ph.D.		
SUBJECT: 124BPRO - BACHELOR PROJECT			
OBJECT: RESIDENTIAL BUILDING		SCALE:	1:50
		DATE:	05/2020
DRAWING: COMPOSITIONS		DRAWING N:	2

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

DEPARTMENT OF CONCRETE AND MASONRY STRUCTURES

TECHNICAL REPORT OF RESIDENTIAL BUILDING

CONCRETE STRUCTURES

PART 2

DAYANA MURATOVA

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2 GEOLOGICAL SITUATION 4
3 STRUCTURAL SYSTEM 4
3.1 STAIRCASE, ELEVATOR SHAFTS 6
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1 LOCATION OF THE RESIDENTIAL BUILDING

The residential building is located in Prague 9 – Letňany, specifically at parcels No. 760/64, 760/66. It is a part of residential complex “Letňanské zahrady” – building O. The location is limited by Veselská street from the south, by AUTO Štangl company from the west, north and east parts consist of parcel No. 760/1(field), the southern border runs along parcel No. 796/1.

1.1 GENERAL INFORMATION

The residential building has 1 underground floor and 4 above – ground floors. The underground floor of the building delimits the space on the area of the rectangle in the basement with dimensions of 47.73 x 18.82 m. The above – ground floor occupies an area of 24.79 x 19.44 m. Floors 1 to 3 are identical, 4^{th} floor recedes to the middle of the floor plan and has dimensions of 15.89 x 19.0 m. Total height of the building is 12.47 m. Underground floor’s height is 2.97 m and upper typical floors have 2.80 m of height. There are parking spaces, storage rooms and utility rooms on the underground floor. The above – ground floors (1 - 4) are considered for the living purpose. On the 1^{st} floor there are the main entrance to the building, a pram and cleaning room, and 4 apartments. There are 6 apartments on the 2^{nd} – 3^{rd} floors and 3 apartments on the last 4^{th} floor. The roof is non – walkable. The spaces protruding in front of the façade plane are considered as terraces and balconies.

The entrance to the building is from the hallway and access to the garage side is provided by the entrance in object P. The entrance of the object O is closed by fire resisting rolling shutter with dimensions of 6 000 x 2 250 mm. 10 parking places are available for the guests of residents directly in front of building.

2 GEOLOGICAL SITUATION

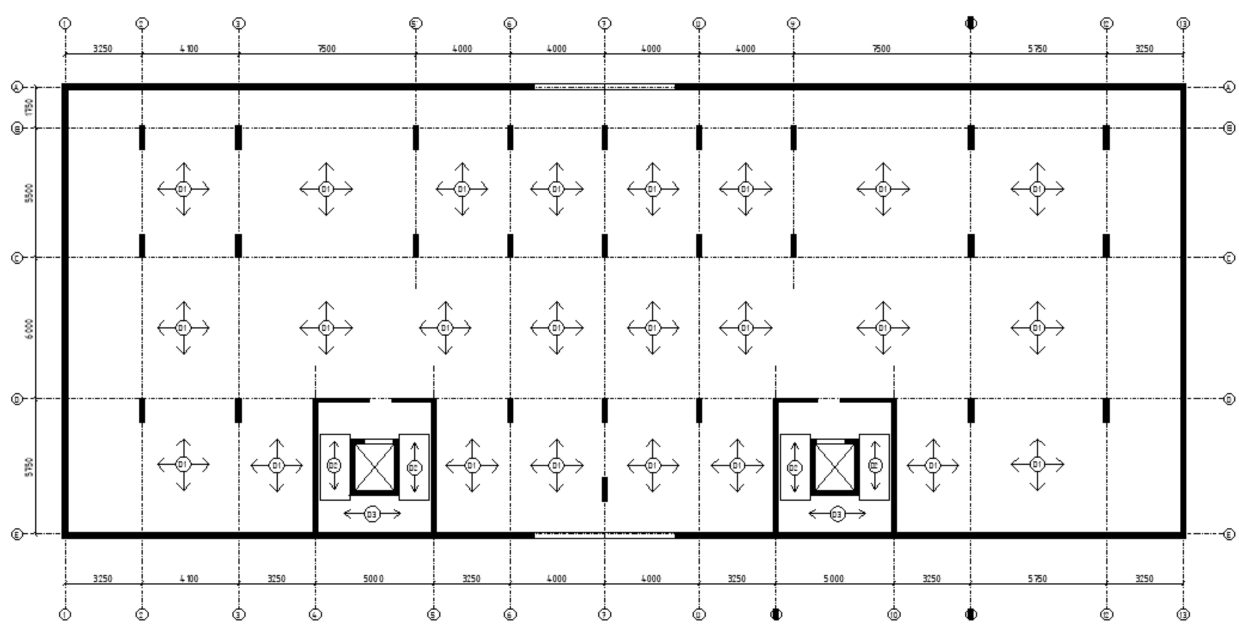
The proposed residential building is defined by the uniform level of the 1st floor on the elevation of ±0.00 = 262.45 m. n.m. The basement floor is also uniformly on the elevation of 259.10 m. n.m. The elevation height practically means that the basement is basically set on the existing ground level. The loess and loess clay (GT3) with a mean thickness of 2 meters + the local thin position of quaternary sand – gravel clays GT6 of the order of magnitude of the first decimeters will be fully exposed below the floor plate of the basement part.

The pre-Quaternary foundation of the assessed sector is formed by kaolinitic sandstone (objects N and P) and by Ordovician quartzite (object O). Since the pre-Quaternary foundation appears at the level about 20 meters below the ground floor object should be supported on large diameter piles.

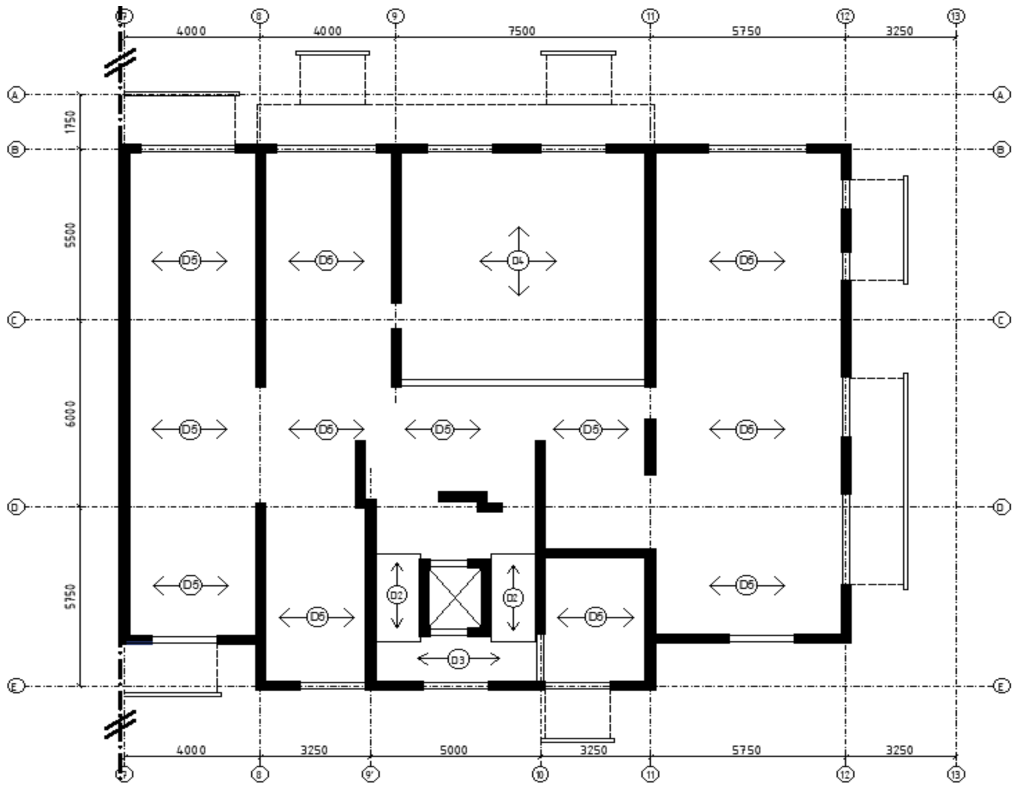
Waterproofing will be provided in the basement against pressure water by asphalt strips.

3 STRUCTURAL SYSTEM

Scheme of structural system of the underground level:



Scheme of structural system of the first level:



The underground level is designed as a two – way flat slab with thickness of 250 mm supported on columns for the purpose of garage with dimensions of 240 x 1 000 mm. The perimeter wall is made of waterproof reinforced concrete with thickness of 240 mm. The structural system of above – ground floors (1 - 4) is designed as a one – way and two – way bi – directional wall system, which was chosen for the reason of easy separation of apartments. Therefore, using of wall system was the best solution for residential building and it is much stiffer than skeleton (column) system. Two – way slab between 9 and 11 intersections is supported by beam due to the long span with dimensions of 300 x 650 mm.

The load – bearing structure of the building consists of monolithic reinforced concrete walls, columns (pillar) and reinforced concrete ceiling slabs.

The slabs of the building are defined as a residential areas and designed in basic thickness of 200 mm and 230 mm depending on the span of the structure.

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.

3.1 STAIRCASE, ELEVATOR SHAFTS

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. In each level there is one communication core with a staircase and an elevator, which is connecting all floors.

The basic geometry of the steps of these above – ground floor staircases is 165/280 mm at inclination of 30.8˚, and 175/280 of the underground level, due to different heights. Calculation is provided via (Concrete part 2).

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. Rises and treads are made of ceramic tiles.

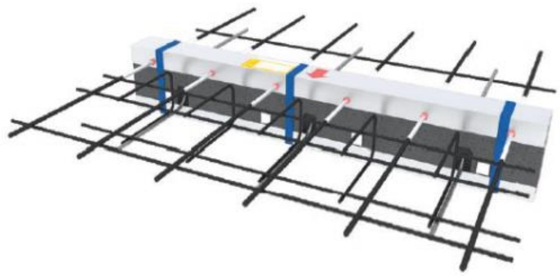
The staircase has steel railing with wooden handrail. Railing will be anchored to the walls of the elevator shaft and to the walls of the core. The handrails are 1 000 mm high from the side of the staircase walls.

The staircase spaces are illuminated by a daylight tubes.

Elevator shafts are designed as 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.

3.2 BALCONIES

The balconies are used as cantilever with 1 540 mm of span. Balconies are connected to other construction by using iso beams with elimination of thermal bridges (Bronze TiP MQ). Non - insulated structure is made of concrete C30/37.



Balcony isobeam Bronze TiP MQ

4 LOADS

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

4.1 PERMANENT LOAD

Calculation is provided via (Concrete part 2).

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:

Living rooms	2.00 kN/m^2
Balconies, loggia	2.50 kN/m^2

Staircase	2.00 kN/m^2
Non-walkable roof	0.75 kN/m^2
Garage parking	3.00 kN/m^2
Soil load	20.00 kN/m^2

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

4.3 CLIMATE LOAD

5.3.1 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 $\gamma_q = 1.50$.

5.3.2 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 MATERIALS

5.1 REINFORCED CONCRETE STRUCTURES

Concrete in accordance with ČSN EN 206-1

Basement slab – waterproof concrete	C30/37-XC2, XD1-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-D_{max}=22-Cl 0,20-S4
Underground floor – columns	C30/37-XC2-D_{max}=22-Cl 0,40-S4
Underground floor – slab	C30/37-XC1-D_{max}=22-Cl 0,40-S4
1st to 4th floor – load-bearing walls	C30/37-XC1-D_{max}=22-Cl 0,40-S4
1st to 4th floor – slab	C30/37-XC1-D_{max}=22-Cl 0,40-S4
Balcony, loggia	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	C30/37-XC1-D_{max}=22-Cl 0,40-S4

5.2 MASONRY STRUCTURES

2nd floor – vertical structures	POROTHERM 25 AKU SYM P15+M10 POROTHERM 24 P+D P15+M10
3rd floor – vertical structures	POROTHERM 25 AKU SYM P15+M10 POROTHERM 24 P+D P10+M10
4th floor – vertical structures	POROTHERM 25 AKU SYM P15+M10

5.3 STEEL STRUCTURES

Reinforced bars B500B

6 STANDARD NORMS AND LITERATURE

EN 1990	Basis of structural design
EN 1991-1	Actions on structures
EN 1992-1	Design of concrete structures
EN 1997-1	Geotechnical design

ČSN 73 1001 Subsoil under shallow foundation

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

USED WEB PAGES:

[1] www.schoeck-wittek.cz

[2] www.bronze.cz

USED LECTURES:

[CM01_01 – 07] – Concrete and Masonry structures 1, Ing. Petr Bílý, Ph.D.

7 LIST OF ATTACHMENTS

Preliminary design of concrete structures:

1) RC slab calculation
2) RC column calculation
3) RC beam calculation
4) Balcony calculation
5) Staircase calculation

8 LIST OF DRAWINGS

1) Structural system of the underground level
2) Structural system of the 1st level
3) Formwork of the underground level
4) Formwork of the 1st level
5) Reinforcement of the staircase

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

DEPARTMENT OF CONCRETE AND MASONRY STRUCTURES

PRELIMINARY DESIGN
CONCRETE STRUCTURES
PART 2

DAYANA MURATOVA

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1 REINFORCED CONCRETE SLAB DESIGN

Floor above underground level (F2) – two – way reinforced concrete slab supported on columns.

- Slab depth:

$$h_s = \frac{1}{33} * l_{n,max} = \frac{1}{33} * 7\,500 \approx 230\,mm$$

$$d = h_s - c - \frac{\emptyset}{2} = 230 - 25 - \frac{10}{2} = 200\,mm$$

where:

$\emptyset = 10\,mm$ (estimated)

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

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

- Span/depth ratio:

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

where:

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

$$\lambda = \frac{7\,500}{200} = 37.5 \ \leq \ \lambda_{lim} = 1 * 1 * 1.2 * 24.6 = 29.52\,mm \ \rightarrow 37.5 \geq 29.52 \rightarrow \textbf{NOT OK}$$

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

- <u>Calculation of load:</u>

SLAB (F2)				
PERMANENT LOAD	th. [m]	fk [kN/m^2]	γ [-]	fd [kN/m^2]
LAMINATE FLOATING FLOOR	0.01	0.061	1.35	0.082
CONCRETE LEVELING LAYER	0.05	1.100	1.35	1.485
SEPARATION FOIL	-	0.009	1.35	0.012
ACOUSTIC INSULATION EPS	0.04	0.010	1.35	0.013
RC SLAB	0.25	6.250	1.35	8.438
MINERAL WOOL INSULATION	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				**11.816**
VARIABLE LOAD	th. [m]	fk [kN/m^2]	γ [-]	fd [kN/m^2]
CATEGORY A	-	2	1.5	3
TOTAL				**3**

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

- <u>Slab depth:</u>

$$d_s \geq \frac{l}{k_{c1} * k_{c2} * k_{c3} * \lambda_{d,tab}} = \frac{5\ 750}{1 * 1 * 1.2 * 30.8} \approx 170\ mm$$

$$h_s = d_s + c + \frac{\emptyset}{2} = 170 + 25 + \frac{10}{2} = \mathbf{200\ mm}$$

where:

$\emptyset = 10\ mm$ (estimated)

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

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

- <u>Calculation of load:</u>

SLAB F3				
PERMANENT LOAD	th. [m]	fk [kN/m^2]	γ [-]	fd [kN/m^2]
LAMINATE FLOATING FLOOR	0.01	0.061	1.35	0.082
CONCRETE LEVELING LAYER	0.05	1.100	1.35	1.485
SEPARATION FOIL	-	0.009	1.35	0.012
ACOUSTIC INSULATION EPS	0.04	0.010	1.35	0.013
RC SLAB	0.2	5.000	1.35	6.750
PLASTER	0.005	0.042	1.35	0.057
TOTAL				**8.599**
VARIABLE LOAD	th. [m]	fk [kN/m^2]	γ [-]	fd [kN/m^2]
CATEGORY A	-	2	1.5	3
TOTAL				**3**

Typical floors (**F4)** – two – way reinforced concrete slab simply supported on beam.

- <u>Slab depth:</u>

$$d_s \geq \frac{l}{k_{c1} * k_{c2} * k_{c3} * \lambda_{d,tab}} = \frac{7\ 500}{1 * 0.93 * 1.3 * 30.8} \approx 200\ mm$$

$$h_s = d_s + c + \frac{\emptyset}{2} = 200 + 25 + \frac{10}{2} = \mathbf{230\ mm}$$

where:

$\emptyset = 10\ mm$ (estimated)

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

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

h_s – depth of the slab

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 $l \leq 7\ m\ k_{c2} = 1.0$, 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

Roof (R1) – non – walkable flat roof.

ROOF				
PERMANENT LOAD	th. [m]	fk [kN/m^2]	γ [-]	fd [kN/m^2]
WATERPROOF 2x ASPHALT STRIPS	0.01	0.002	1.35	0.003
THERMAL INSULATION EPS	0.2	0.060	1.35	0.081
VAPOR BARRIER	0.005	0.047	1.35	0.063
RC SLAB	0.2	5.000	1.35	6.750
PLASTER	0.005	0.042	1.35	0.057
TOTAL				**6.937**
VARIABLE LOAD	th. [m]	fk [kN/m^2]	γ [-]	fd [kN/m^2]
CATEGORY H	-	1	1.5	1.5
SNOW LOAD	-	0.6	1.5	0.9
TOTAL				**2.4**

2 REINFORCED CONCRETE COLUMN DESIGN

Most loaded column – C11.

$A = 6.6225 * 5.75 = 38.1\ m^2$

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

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

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

where:

$f_{cd} = 20\ MPa$

$\sigma_s = 400\ MPa$

- <u>Calculation of load:</u>

4 x typical floors → $38.1 * (14.816 + 3 * 11.599) = 1\ 890.255\ kN$

1 x roof → $1 * 38.1 * 9.337 = 355.739\ kN$

Self weight of the column → $0.24 * 1 * 2.8 * 25 = 16.8\ kN$

$$N_{Ed} = 16.8 + (1\,890.255 + 355.739) = 2\,262.794\,kN$$

$$A_c = \frac{2\,262.794 * 10^3}{0.8 * 20 + 0.02 * 400} = 94\,283\,mm^2$$

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

2.1 PRELIMINARY CHECK OF PUNCHING

- Control perimeters:

$$u_0 = 2 * (a + b) = 2 * (240 + 1\,000) = 2\,480\,mm$$

$$u_1 = 2 * (a + b) + 2\pi * 2d = 2 * (240 + 1\,000) + 2\pi * 2 * 220 = 5\,244.6\,mm$$

- Maximum punching shear resistance:

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

where:

$$\beta = 1.15$$

$$V_{Ed} = A * f_d = 38.1 * 11.816 = 450.189\,kN$$

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

$$f_{ck} = 30\,MPa$$

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

$$\vartheta_{Ed,0} = \frac{1.15 * 450.189 * 10^3}{2\,480 * 220} = 0.95\,MPa$$

$\vartheta_{Rd,max} = 0.4 * 0.528 * 20 = 4.22\,MPa \rightarrow 0.95\,MPa \leq 4.22\,MPa$ → **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:

$k_{max} = 1.8$

$C_{Rd,c} = 0.12$

$$k = 1 + \sqrt{\frac{200}{d}} \leq 2 \;\rightarrow k = 1 + \sqrt{\frac{200}{220}} = 1.95 \leq 2$$

$\rho_l = 0.005$

$$\vartheta_{Ed,1} = \frac{1.15 * 450.189 * 10^3}{5\,244.6 * 220} = 0.45\ MPa$$

$$1.8 * \vartheta_{Rd,c} = 1.8 * 0.12 * 1.95 * \sqrt[3]{(100 * 0.005 * 30)} \rightarrow \ \vartheta_{Rd,c} = 0.57\ MPa$$

$\vartheta_{Ed,1} = 0.45\ MPa\ \leq\ \vartheta_{Rd,c} = 0.57\ MPa \rightarrow$ **OK**

FINAL DESIGN: 240 x 1000 mm

3 REINFORCED CONCRETE BEAM DESIGN

- Dimensions of a cross – section:

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

$h_b = 650\ mm$

$$b_b = \left(\frac{1}{3} \sim \frac{2}{3}\right) * h_b = \left(\frac{1}{3} \sim \frac{2}{3}\right) * 650 = 216 \sim 144\ mm$$

$b_b = 200\ mm \rightarrow$ will be increased to 250 mm according to below calculation

3.1 PRELIMINARY CHECK

- Bending check:

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

$$f_b = (11.816 * 7.5) + (25 * 0.25 * 7.5 * 0.25) = 100.339\ kN/m$$

$$M_{Ed,max} = \frac{1}{8} * 100.339 * 7.5^2 = 313.559\ kNm$$

$$d_b = h_b - c - \frac{\emptyset}{2} - \emptyset_s = 650 - 25 - \frac{20}{2} - 10 = 605\ mm$$

$$\mu = \frac{M_{Ed,max}}{b_b * d_b^2 * f_{cd}} = \frac{313.559 * 10^6}{300 * 605^2 * 20} = 0.17 \rightarrow table: \xi = 0.234; \zeta = 0.906$$

- Reinforcement ratio check:

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

$$\rho_{s,req} = \frac{\frac{313.559*10^6}{0.906*605*435}}{250*605} = 0.00869 < 0.04 \rightarrow \textbf{OK}$$

- 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:

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

$$cot\theta = 1.5$$

$$V_{Rd,max} = 0.5 * 20 * 250 * 0.906 * 605 * \frac{1.5}{1 + 1.5^2} = 632.457\ kN$$

$$V_{Ed,max} = \frac{5}{8} * 100.339 * 7.5 = 470.339\ kN$$

$632.457\ kN > 470.339\ kN \rightarrow$ **OK**

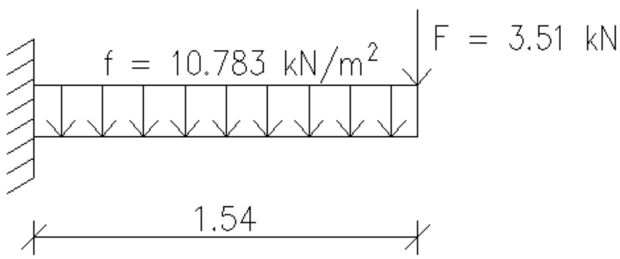
FINAL DESIGN: 250 x 650 mm

4 BALCONY DESIGN

- Calculation of load:

BALCONY				
PERMANENT LOAD	th. [m]	fk [kN/m^2]	γ [-]	fd [kN/m^2]
CERAMIC TILES	0.015	0.00033	1.35	0.0004455
RC SLAB	0.18	4.5	1.35	6.075
PLASTER	0.005	0.04245	1.35	0.057
TOTAL				**6.133**
VARIABLE LOAD	th. [m]	fk [kN/m^2]	γ [-]	fd [kN/m^2]
CATEGORY A (BALCONIES)	-	2.5	1.5	3.75
SNOW LOAD	-	0.6	1.5	0.9
TOTAL				**4.65**

- Static scheme:



$M_{Ed} \leq M_{Rd}$

$V_{Ed} \leq V_{Rd}$

$F = 1.17 * 0.12 * 25 = 3.51\ kN$

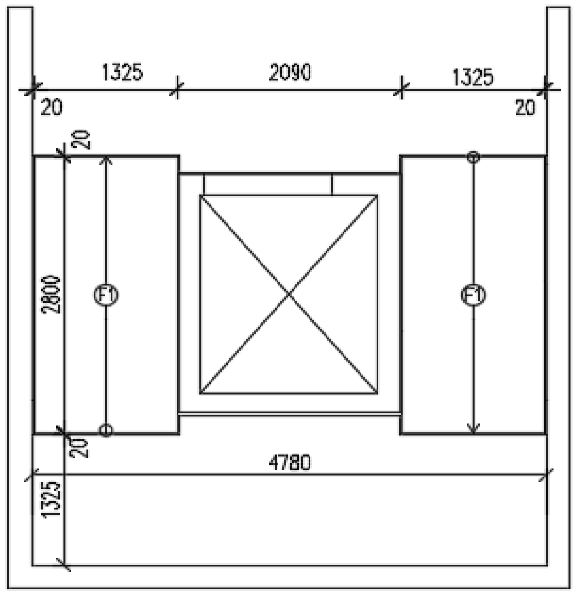
$M_{Ed} = \frac{1}{2} * f * l^2 + F * l = \frac{1}{2} * 10.783 * 1.54^2 + 3.51 * 1.54 = 17.876\ kNm$

$V_{Ed} = f * l + F = 10.783 * 1.54 + 2.13 = 18.736\ kN$

Designed iso beam – BRONZE TiP MQ → $M_{Rd} = 21.0\ kNm;\ V_{Rd} = 34.8\ kN$

5 STAIRCASE DESIGN

- 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 – 1 325 mm

Width of the staircase – 4 780 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 2 800 mm

The depth should be at least 2 800/25 = 112 mm

The depth of landing 190 mm

The depth of flights 140 mm

190 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 $1\,500 + \frac{750}{cos\alpha} > 2\,100\ mm$

$$1\,500 + \frac{750}{\cos(30.8°)} = 2\,347\ mm$$

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 $750 + 1500 * cos\alpha >$ $1\,900\ mm$

$750 + 1500 * \cos(30.8°) = 2\,077\ mm$

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

2 164 mm > 2 077 mm > 1 900 mm → **OK**

- Calculation of load:

LANDING				
LOAD	th. [m]	fk [kN/m^2]	γ [-]	fdl [kN/m^2]
CERAMIC TILES	0.015	0.00033	1.35	0.0004455
CONCRETE LEVELING LAYER	0.035	0.770	1.35	1.040
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				**10.477**
FLIGHT				
LOAD	th. [m]	fk [kN/m^2]	γ [-]	fdf [kN/m^2]
SLAB	-	3.99	1.35	5.387
CLADDING	-	0.775	1.35	1.046
STEP	-	1.75	1.35	2.363
LIVE LOAD (CATEGORY A)	-	2	1.5	3
TOTAL				**11.795**

5.1 DESIGN OF THE REINFORCEMENT

$$M_{Ed} = \frac{1}{8} * f_{df} * l^2 = \frac{1}{8} * 11.795 * 2.8^2 = 11.56\ kNm$$

$$d = h_s - c - \frac{\emptyset}{2} = 190 - 25 - \frac{10}{2} = 160\ mm$$

$$A_{s,req} = \frac{M_{Ed}}{0.9 * d * f_{yd}} = \frac{11.56 * 10^6}{0.9 * 160 * 435} = 184.7\ mm^2$$

$A_{s,prov} = 201\ mm^2$ (ANNEX 2) → $4\emptyset 8$

- 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

$$A_{s,min1} = \max\left(0.26 * \frac{2.9}{500} * 1\,275 * 160; 0.0013 * 1\,275 * 160\right) = (307.6; 265.2)$$

$201\ mm^2 \leq 307.6\ mm^2$ → **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

$$A_{s,min2} = \frac{0.4 * 1 * 2.9 * 0.5 * 1\,275 * 160}{500} = 236.64\ mm^2$$

$201\ mm^2 \leq 236.64\ mm^2$ → **NOT OK**

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

- <u>Check of the design:</u>

$$x = \frac{A_{s,prov} * f_{yd}}{0.8 * b * f_{cd}} = \frac{352 * 435}{0.8 * 1\ 275 * 20} = 7.5\ m$$

$$z = d - 0.4 * x = 160 - 0.4 * 7.5 = 157\ mm$$

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

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

$$M_{Rd} = A_{s,prov} * f_{yd} * z = 352 * 435 * 157 * 10^{-6} = 24.04\ kNm$$

$24.04\ kNm\ \geq 11.56\ kNm$ → **OK**

6 MATERIALS

Concrete in accordance with ČSN EN 206-1

Reinforced concrete slab	C30/37-XC1-D_{max}=22-Cl 0,40-S4
Reinforced concrete column	C30/37-XC1-D_{max}=22-Cl 0,40-S4
Reinforced concrete beam	C30/37-XC1-D_{max}=22-Cl 0,40-S4
Balcony	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	C30/37-XC1-D_{max}=22-Cl 0,40-S4

7 STANDARD NORMS

EN 1990	Basis of structural design
EN 1991-1	Actions on structures
EN 1992-1	Design of concrete structures
ČSN EN 206-1	Concrete-part 1: Specification, performance, production and conformity

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

DEPARTMENT OF GEOTECHNICS

TECHNICAL REPORT OF RESIDENTIAL BUILDING FOUNDATION

PART 3

DAYANA MURATOVA

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1 LOCATION OF THE RESIDENTIAL BUILDING

The residential building is located in Prague 9 – Letňany, specifically at parcels No. 760/64, 760/66. It is a part of residential complex "Letňanské zahrady" – building O. The location is limited by Veselská street from the south, by AUTO Štangl company from the west, north and east parts consist of parcel No. 760/1(field), the southern border runs along parcel No. 796/1.

1.1 GENERAL INFORMATION

The residential building has 1 underground floor and 4 above – ground floors. The underground floor of the building delimits the space on the area of the rectangle in the basement with dimensions of 47.73 x 18.82 m. The above – ground floor occupies an area of 24.79 x 19.44 m. Floors 1 to 3 are identical, 4th floor recedes to the middle of the floor plan and has dimensions of 15.89 x 19.0 m. Total height of the building is 12.47 m. Underground floor's height is 2.97 m and upper typical floors have 2.80 m of height. There are parking spaces, storage rooms and utility rooms on the underground floor. The above – ground floors (1 - 4) are considered for the living purpose. On the 1st floor there are the main entrance to the building, a pram and cleaning room, and 4 apartments. There are 6 apartments on the 2nd – 3rd floors and 3 apartments on the last 4th floor. The roof is non – walkable. The spaces protruding in front of the façade plane are considered as terraces and balconies.

The entrance to the building is from the hallway and access to the garage side is provided by the entrance in object P. The entrance of the object O is closed by fire existing rolling shutter with dimensions of 6 000 x 2 250 mm. 10 parking places are available for the guests of residents directly in front of building.

1.2 STRUCTURAL SYSTEM

The underground level is designed as a two – way flat slab with thickness of 250 mm supported on columns for the purpose of garage with dimensions of 240 x 1 000 mm. The perimeter wall is made of waterproof reinforced concrete with thickness of 240 mm. The structural system of above – ground floors (1 - 4) is designed as a one – way and two – way bi – directional wall system, which was chosen for the reason of easy separation of apartments. Therefore, using of wall system was the best solution for residential building and it is much stiffer than skeleton (column) system. Two – way slab between 9 and 11 intersections is supported by beam due to the long span with dimensions of 300 x 650 mm.

The load – bearing structure of the building consists of monolithic reinforced concrete walls, columns (pillar) and reinforced concrete ceiling slabs.

The slabs of the building are defined as a residential areas and designed in basic thickness of 200 mm and 230 mm depending on the span of the structure.

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.

2 GEOLOGICAL SITUATION

2.1 SOIL CHARACTERISTIC

The proposed residential building is defined by the uniform level of the 1st floor on the elevation of ±0.00 = 262.45 m. n.m. The basement floor is also uniformly on the elevation of 259.10 m. n.m. The elevation height practically means that the basement is basically set on the existing ground level. The loess and loess clay (GT3) with a mean thickness of 2 meters + the local thin position of quaternary sand – gravel clays GT6 of the order of magnitude of the first decimeters will be fully exposed below the floor plate of the basement part. 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.

The pre-Quaternary foundation of the assessed sector is formed by kaolinitic sandstone (objects N and P) and by Ordovician quartzite (object O). Since the pre-Quaternary foundation appears at the level about 20 meters below the ground floor object should be supported on large diameter piles.

2.2 EXCAVATION

The excavation was 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 850 m^3.

2.3 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 foil with thickness of 0.40 mm.

2.4 PILES

The residential building will be based deep on large diameter piles. Piles with diameter of 900 mm will be used for columns and 600 mm for perimeter wall and wall of the elevator shaft. Designed length of the piles is 14 m. Calculation is provided via file (Foundation part 3).

2.5 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).

3 MATERIALS

3.1 REINFORCED CONCRETE STRUCTURES

Concrete in accordance with ČSN EN 206-1

Basement slab – waterproof concrete	C30/37-XC2, XD1-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-D_{max}=22-Cl 0,20-S4
Underground floor – columns	C30/37-XC2-D_{max}=22-Cl 0,40-S4
Underground floor – slab	C30/37-XC1-D_{max}=22-Cl 0,40-S4

4 STANDARD NORMS AND LITERATURE

EN 1990	Basis of structural design
EN 1991-1	Actions on structures
EN 1992-1	Design of concrete structures
EN 1997-1	Geotechnical design
ČSN 73 1001	Subsoil under shallow foundation

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

USED LECTURES:

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

5 LIST OF ATTACHMENTS

1) Calculation of pile foundation

6 LIST OF DRAWINGS

1) Plan and 2x section of pile foundation

CZECH TECHNICAL UNIVERSITY IN PRAGUE
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CALCULATION
FOUNDATION PART 3

DAYANA MURATOVA

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2 COEFFICIENTS OF PILE FOUNDATION, TABLE 1 ………………………………. 6
3 MATERIALS ……………………………………………………………………… 7
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1 CALCULATION OF LARGE DIAMETER PILES

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 column (C11):

N_{ed} = 2 262.79 kN

Designed load on pile:

2 262.79 * 70% = 1 583.95 kN

Characteristic load on pile:

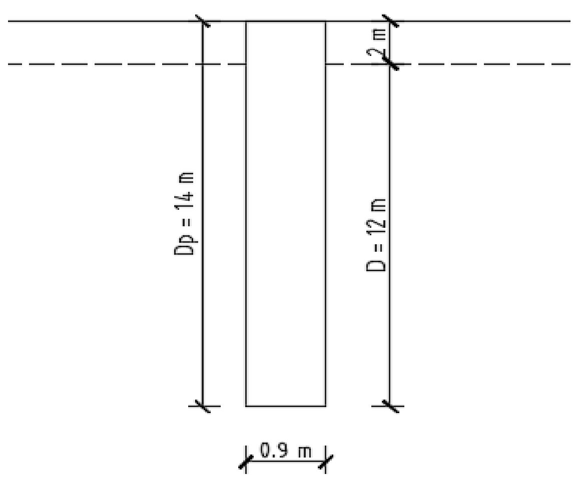
1 583.95 / 1,4 = **1 131.39 kN**

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)

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

$D_i = D = 12\ m$ – height of the pile contributing to skin friction

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

$R_{sk} = 0.5 * 2{,}83 * 12 * 60 = \mathbf{1\ 018.8\ kN}$

- Load at fully mobilized side friction:

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

where:

$\beta = \beta_1 * C_k = 0.09 * 0.9 = 0.081$

$\beta_1 \rightarrow \frac{D}{d} = \frac{12}{0.9} = 13.33 \rightarrow 0.09$ – factor of pile slenderness (table 1)

$C_k \rightarrow k = \frac{E_p}{E_{def}} = \frac{23\ 000}{12} = 1\ 916{,}67;\ \frac{D_p}{d} = \frac{14}{0.9} = 15.5 \rightarrow 0.9$ – pile compressibility factor

$R_{yk} = \frac{1\ 018.8}{1-0{,}081} = 1\ 108.59\ kN$

- 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

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

- <u>Total resistance of the pile:</u>

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

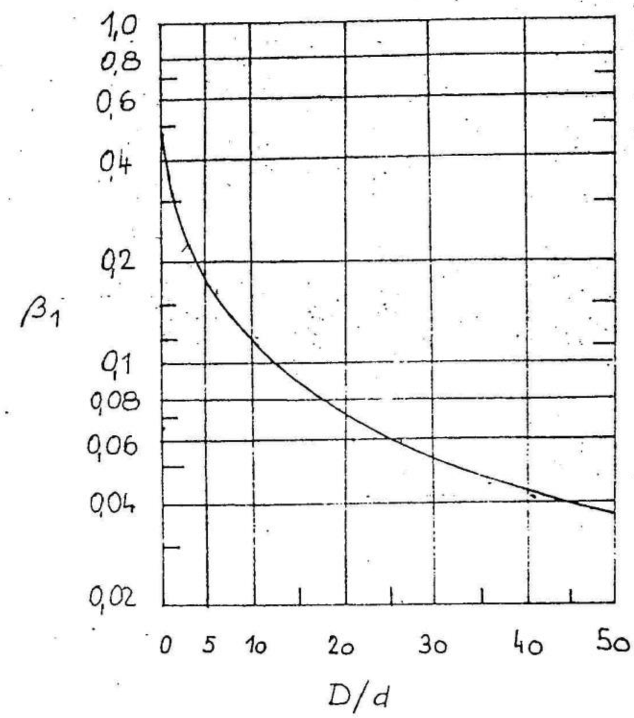
where:

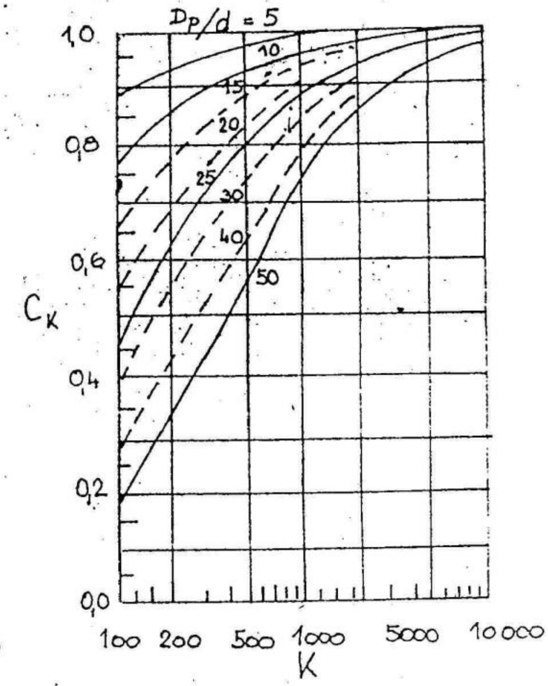
γ_b, γ_s – partial factors

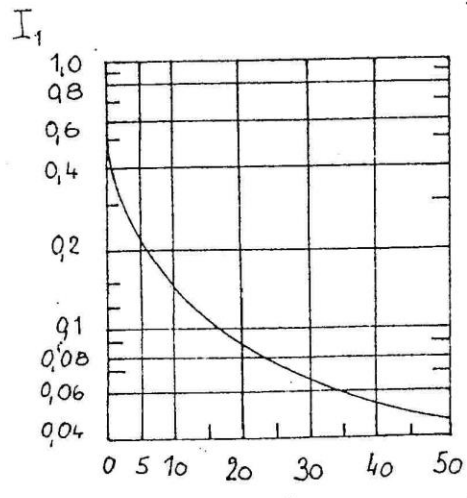
$R_{c,d} = \frac{240.408}{1.25} + \frac{1\ 018.8}{1} = \mathbf{1\ 211.13\ kN}$

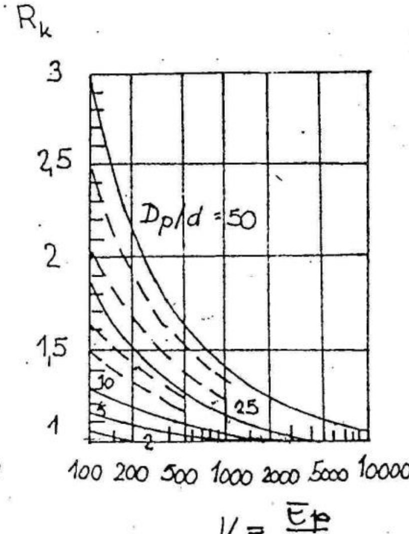
$R_{c,d} \geq N_{Ed} \rightarrow 1\ 211.13\ kN \geq 1\ 131.39\ kN$ <u>design is okay</u>

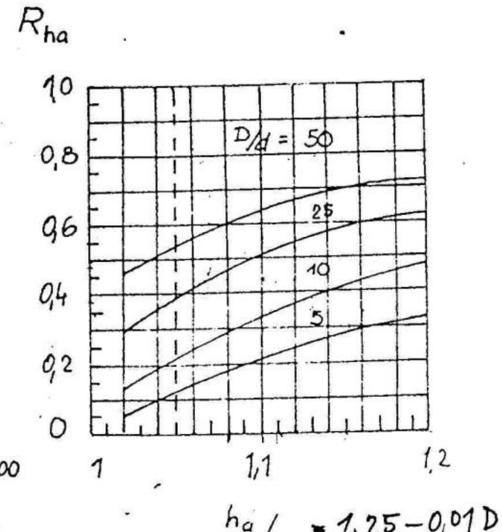
2 COEFFICIENTS OF PILE FOUNDATION, TABLE 1











3 MATERIALS

Piles	C25/30-XC2, XA1-D_{max}=22-Cl 0,40-S4
Underground floor – slab	C30/37-XC1-D_{max}=22-Cl 0,40-S4

4 STANDARD NORMS

ČSN 73 1001	Subsoil under shallow foundation
ČSN 73 1004	Large diameter piles
EN 1997-1	Geotechnical design

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

DEPARTMENT OF INDOOR ENVIRONMENTAL AND BUILDING SERVICES ENGINEERING

TECHNICAL REPORT OF RESIDENTIAL BUILDING

BUILDING SERVICES SYSTEMS

PART 4

DAYANA MURATOVA

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1 LOCATION OF THE RESIDENTIAL BUILDING

The residential building is located in Prague 9 – Letňany, specifically at parcels No. 760/64, 760/66. It is a part of residential complex “Letňanské zahrady” – building O. The location is limited by Veselská street from the south, by AUTO Štangl company from the west, north and east parts consist of parcel No. 760/1(field), the southern border runs along parcel No. 796/1.

1.1 GENERAL INFORMATION

The residential building has 1 underground floor and 4 above – ground floors. The underground floor of the building delimits the space on the area of the rectangle in the basement with dimensions of 47.73 x 18.82 m. The above – ground floor occupies an area of 24.79 x 19.44 m. Floors 1 to 3 are identical, 4^{th} floor recedes to the middle of the floor plan and has dimensions of 15.89 x 19.0 m. Total height of the building is 12.47 m. Underground floor’s height is 2.97 m and upper typical floors have 2.80 m of height. There are parking spaces, storage rooms and utility rooms on the underground floor. The above – ground floors (1 - 4) are considered for the living purpose. On the 1^{st} floor there are the main entrance to the building, a pram and cleaning room, and 4 apartments. There are 6 apartments on the 2^{nd} – 3^{rd} floors and 3 apartments on the last 4^{th} floor. The roof is non – walkable. The spaces protruding in front of the façade plane are considered as terraces and balconies.

The entrance to the building is from the hallway and access to the garage side is provided by the entrance in object P. The entrance of the object O is closed by fire existing rolling shutter with dimensions of 6 000 x 2 250 mm. 10 parking places are available for the guests of residents directly in front of building.

The roof is non – walkable. The spaces protruding in front of the façade plane are considered as terraces and balconies.

1.2 STRUCTURAL SYSTEM

The underground level is designed as a two – way flat slab with thickness of 250 mm supported on columns for the purpose of garage with dimensions of 240 x 1 000 mm. The perimeter wall is made of waterproof reinforced concrete with thickness of 240 mm. The structural system of above – ground floors (1 - 4) is designed as a one – way and two – way bi – directional wall system, which was chosen for the reason of easy separation of apartments. Therefore, using of wall system was the best solution for residential building and it is much stiffer than skeleton (column) system. Two – way slab between 9 and 11 intersections is supported by beam due to the long span with dimensions of 300 x 650 mm. The load – bearing structure of the building consists of monolithic reinforced concrete walls, columns (pillar) and reinforced concrete ceiling slabs.

2 WATER SUPPLY

2.1 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. Shaft is located 5 m from the building. 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.

2.2 INTERNAL WATER SUPPLY

The internal water supply includes cold and hot water distribution, circulation and water for the fire purpose. All pipes are designed from a plastic polypropylene PP DN 50. Horizontal pipes are placed under the basement ceiling with sound insulation elements. Connection to the each apartment will be through the shafts. The plumbing fixtures such as washbasin, WC, bath, shower, sink, washing machine, dishwasher and terrace valves will be connected to the internal water supply in the building. Before the connection to the each flat on the cold and hot water pipelines will be installed water meters and valves inside the installation shafts. Piping in the flats is done in the walls. Cold and hot water, circulation piping is connected to the boiler in the technical room of underground level. Hot water will be heated by the boiler and supplied to all flats by the shafts. Not used hot water will go back by circulation pipe. Calculation is provided via (Building services part 4).

2.3 HOT WATER PREPARATION

The hot water preparation is solved as central system for the whole building by hot water tank, which is located in the technical room of underground level.

3 DRAINAGE

3.1 DRAINAGE CONNECTION

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. Drainage depth is 2.5 m below ground level. Drainage connection DN 200 will be made of PVC. Connecting piping is placed in a groove with gravel sand. For waste and rain water drainage is used revision shaft outside the building. It is circular shaft with diameter of 1000 mm and a depth of 1.4 m below the ground. Inner drainage is located under the ceiling in the underground level with inclination of 4%. Cleaning fittings are placed at a maximum distance of 18 m on waste water drainage and at a 25 m on rain water drainage. Calculation is provided via (Building services part 4).

3.2 WASTE WATER DRAINAGE

The plumbing fixtures such as washbasin, WC, bath, shower, sink, washing machine, dishwasher will be connected to the internal waste water drainage in the building.

Designed sizing of waste pipe is DN 100. Each flat has its vertical drainage, which is located inside the installation shaft. Ventilation of the waste pipe and internal pipes will be ensured by exiting to the roof.

3.3 RAIN WATER DRAINAGE

The roof and terraces will be drained by internal and external rain water drainage pipes, which will go through the installation shafts. The internal rain water drainage is designed from PVC DN 100 and will be installed under the ceiling or along the walls with a minimum inclination of 1%. Balcony drainage pipe is DN 50.

4 HEATING

4.1 HEAT SOURCE

The building is equipped with central gas boiler to heat water for heating emitters and for the preparation of hot water. It’s located in technical room in the underground level. Estimated power of the boiler is 100 kW. The heating source in the living rooms and bedrooms consists of radiators KORADO RADIK VENTIL KOMPAKT and in the bathroom are designed tubular radiators KORADO KORALUX. Calculation is provided via (Building services part 4).

4.2 PIPING

All the heating pipelines are made from copper DN 15.

5 VENTILATION

The garage ventilation, PEW and apartment ventilation was provided.

6 GAS SUPPLY

Gas supply system is designed to provide all the gas appliances sufficient amount of gas for their proper working. The object is equipped with central 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. Before every gas appliences in the groud floor is located gas meter and shut-off valve.

7 LIGHTING

All the living areas are properly lighted according to relevant codes in the building. The staircase spaces are illuminated by a daylight tubes.

8 ELECTRICITY

All the electricity is properly designed according to relevant codes in the building. There are electricity shaft located in the communication area on each floor.

9 STANDARD NORMS AND LITERATURE

Water supply	ČSN EN 806-1 (736660)
	ČSN 73 6005
	ČSN 75 5455
Drainage	ČSN EN 1610 (756114)
	ČSN 75 6760
Heating	ČSN EN 12831

USED WEB PAGES:

[1] www.korado.com

[2] www.vytapeni.tzb-info.cz

USED LECTURES:

[125bse_Drainage, Water Supply, heating] – Building services systems 1, prof. Ing. Karel Kabele, CSc., doc.Ing. Michal Kabrhel, Ph.D.

10 LIST OF ATTACHMENTS

1) Sizing of drainage system

2) Sizing of water supply

3) Calculation of heat loss

11 LIST OF DRAWINGS

1) Drainage and water supply – plan view of the underground level

2) Drainage and water supply – plan view of the 1st floor

3) Heating system – plan view of the underground level

4) Heating system – plan view of the 1st floor

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CALCULATION

BUILDING SERVICES SYSTEMS

PART 4

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1 DRAINAGE SYSTEMS

1.1 SIZING OF WASTE WATER DRAINAGE

Plumbing fixture	q [l/s]	DUi [l/s]
Washbasin	0.5	13.50
Shower	0.8	4.00
Bath	0.3	6.00
Sink	0.8	10.00
Dish washer	0.8	6.00
Washing machine	0.8	9.50
WC	2	9.50
TOTAL		**58.50**

- Design of waste water drain Q_{SD} [l/s]:

$$Q_{SD} = k * \sqrt{\sum(DU)}$$

where:

DU – design drain [l/s]

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

$$Q_{SD} = 0.5 * \sqrt{\sum(58.50)} = 3.82\ [l/s]$$

1.2 SIZING OF RAIN WATER DRAINAGE

- Design of rain water drain Q_D [l/s]:

$$Q_D = i * A * C$$

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, ($C = 1$)

$Q_D = 0.003 * 266 * 1 = 7.98\ [l/s]$

$Q_{SD} \leq Q_{max}$ → 3.82 [l/s] ≤ 8.4 [l/s] → **OK**

$Q_D \leq Q_{max}$ → 7.98 [l/s] ≤ 8.4 [l/s] → **OK**

DESIGN: PVC DN 100

2 WATER SUPPLY SYSTEM

2.1 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

$Q_P = 120 * 120$ = 14 400 [l/day]

- Maximum daily water consumption:

$Q_m = Q_P * k_d$

where:

k_d – development coefficient

$Q_m = 14\,400 * 1.5 = 21\,600\ [l/day]$

- Maximum hourly water consumption:

$Q_h = Q_m * k_h$

where:

k_h – development coefficient

$$Q_h = \frac{21\ 600 * 1.8}{24} = 1\ 620\ [l/hod]$$

- 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		20	0.8
Wash basin		27	1.08
Washing machine	0.2	19	0.76
Dish washer		19	0.76
Shower		8	0.32
Bath	0.3	12	1.08
WC	0.15	19	0.43
TOTAL			**5.23**

$$Q_v = \sqrt{5.23} = 2.29\ [l/s]$$

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

where:

d – inner diameter [m]

v – water flow velocity [m/s]

$$d = \sqrt{\frac{4 * 2.29 * 10^{-3}}{3.14 * 2.5}} = 0.03\ [m]$$

DESIGN: EKOPLASTIK PPR PN 20 – DN 50

3 HEATING SYSTEM

3.1 HEAT LOSS CALCULATION

Detailed calculation in attachment of heating system.

4 STANDARD NORMS

Drainage	ČSN EN 1610 (756114)
	ČSN 75 6760
Water supply	ČSN EN 806-1 (736660)
	ČSN 73 6005
	ČSN 75 5455
Heating	ČSN EN 12831

Table for simplified heat output

Room name	Bathroom	Room number	2.02	Floor	1	Flat number	F02		
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	13.692	[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 $H_{T,k} = A_k . U_k . b_u$	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
EW1	1.9	2.8	5.32	0	0	5.32	0.3	-12	1.00	1.60	
IW1	2.6	2.8	7.28	0	0	7.28	2.7	20	0.00	0.00	
IW2	2.6	2.8	7.28	0	0	7.28	2.7	20	0.00	0.00	
IW3	1.9	2.8	5.32	1	1.38	3.94	2.7	15	0.16	1.66	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.16	0.75	

Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$	4.012328125	$\Phi_T = H_T . (\Theta_i - \Theta_e)$	144.4438

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	$H_v = V_i . c_p . ϱ . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	1.26	$\Phi_V = H_V . (\Theta_i - \Theta_e)$	45.36

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] 189.8038

Table for simplified heat output

Room name	Living room		Room number	2.03a	Floor	1	Flat number	F02		
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			68.040	[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
W1	2	2.37	4.74	1	4.50	4.50	1.5	-12	1.00	6.75	
ED1	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	8.25	2.8	23.10	0	0	23.10	0.3	-12	1.00	6.93	
EW2	4	2.8	11.20	2	6.32	4.88	0.3	-12	1.00	1.46	
IW1	0.76	2.8	2.13	0	0	2.13	2.7	15	0.16	0.90	
IW2	1.1	2.8	3.08	1	1.58	1.50	2.7	15	0.16	0.63	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
IW3	7.5	2.8	21.00	0	0	21.00	2.7	20	0.00	0.00	
IW4	2.5	2.8	7.00	0	0	7.00	2.7	20	0.00	0.00	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										19.9004375	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **636.814**

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] **1281.934**

Table for simplified heat output

Room name	Bedroom		Room number	2.04	Floor	1	Flat number	F02		
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			44.016	[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
W1	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	
EW1	3.78	2.8	10.58	2	3.95	6.63	0.3	-12	1.00	1.99	
EW2	4.35	2.8	12.18	0	0	12.18	0.3	-12	1.00	3.65	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
IW1	4.27	2.8	11.96	0	0	11.96	2.7	20	0.00	0.00	
IW2	3.8	2.8	10.64	1	1.58	9.06	2.7	20	0.00	0.00	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**12.425075**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **397.6024**

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] 720.1624

Table for simplified heat output

Room name	Bedroom		Room number	2.05	Floor	1	Flat number	F02
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	44.016	[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 $H_{T,k} = A_k \cdot U_k \cdot b_u$	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	
ED1	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	3	2.8	8.40	2	4.34	4.06	0.3	-12	1.00	1.22	
IW1	5.9	2.8	16.52	0	0	16.52	2.7	20	0.00	0.00	
IW2	5.6	2.8	15.68	0	0	15.68	2.7	15	0.16	6.62	
IW3	3	2.8	8.40	1	1.58	6.82	2.7	15	0.16	2.88	
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 $H_T = \sum H_{T,k}$										**17.4910625**	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ **559.714**

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]							**882.274**

Table for simplified heat output

Room name	Bathroom	Room number	3.02	Floor	1	Flat number	F02		
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		13.692	[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	2.5	2.8	7.00	0	0	7.00	2.7	15	0.16	2.95	
IW2	2.5	2.8	7.00	0	0	7.00	2.7	20	0.00	0.00	
IW3	2.5	2.8	7.00	0	0	7.00	2.7	15	0.16	2.95	
IW4	2.5	2.8	7.00	1	1.38	5.62	2.7	15	0.16	2.37	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.16	0.75	

Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$	**9.031328125**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$	**325.1278**

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	$H_v = V_i . c_p . ϱ . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**1.26**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$	**45.36**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W]	**370.4878**

Table for simplified heat output

Room name	Living room		Room number	3.03a	Floor	1	Flat number	F03	
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			68.040	[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	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
W1	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
ED1	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	3.8	2.8	10.64	2	6.32	4.32	0.3	-12	1.00	1.30	
ID1	0.8	1.97	1.58	1	1.58	1.58	3.5	15	0.16	0.86	
IW1	3.9	2.8	10.92	0	0	10.92	2.7	15	0.16	4.61	
IW2	7.3	2.8	20.44	1	1.58	18.86	2.7	15	0.16	7.96	
IW3	7.3	2.8	20.44	0	0	20.44	2.7	20	0.00	0.00	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										24.1953125	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **774.25**

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] **1419.37**

Table for simplified heat output

Room name	Bedroom		Room number	3.04	Floor	1	Flat number	F03		
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			44.016	[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
W1	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	
EW1	3.5	2.8	9.80	2	3.95	5.85	0.3	-12	1.00	1.76	
IW1	3.4	2.8	9.52	0	0	9.52	2.7	20	0.00	0.00	
IW2	2.2	2.8	6.16	0	0	6.16	2.7	15	0.16	2.60	
IW3	1.2	2.8	3.36	0	0	3.36	2.7	15	0.16	1.42	
IW4	1.3	2.8	3.64	1	1.58	2.06	2.7	15	0.16	0.87	
IW5	4.6	2.8	12.88	0	0	12.88	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 $H_T = \sum H_{T,k}$										13.4211875	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ 429.478

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]						752.038

Table for simplified heat output

Room name	Bedroom		Room number		3.05	Floor	1	Flat number		F03		
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				47.852	$[m^3]$	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 $A = x.y$	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
W1	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	
EW1	3.6	2.8	10.08	2	3.95	6.13	0.3	-12	1.00	1.84	
IW1	4.6	2.8	12.88	0	0	12.88	2.7	20	0.00	0.00	
IW2	3	2.8	8.40	1	1.58	6.82	2.7	15	0.16	2.88	
IW3	0.6	2.8	1.68	0	0	1.68	2.7	20	0.00	0.00	
IW4	0.6	2.8	1.68	0	0	1.68	2.7	20	0.00	0.00	
IW5	4	2.8	11.20	0	0	11.20	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 $H_T = \sum H_{T,k}$										11.4970625	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **367.906**

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]							**690.466**

Table for simplified heat output

Room name	Bathroom		Room number	4.02	Floor	1	Flat number	F04		
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			16.324	[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										
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
EW1	1.8	2.8	5.04	0	0	5.04	0.3	-12	1.00	1.51	
IW1	3.8	2.8	10.64	0	0	10.64	2.7	20	0.00	0.00	
IW2	3.2	2.8	8.96	0	0	8.96	2.7	20	0.00	0.00	
IW3	0.8	2.8	2.24	0	0	2.24	2.7	15	0.16	0.95	
IW4	0.5	2.8	1.40	0	0	1.40	2.7	15	0.16	0.59	
IW5	0.9	2.8	2.52	1	1.38	1.14	2.7	15	0.16	0.48	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.16	0.75	
Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$										**4.282703125**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ **154.1773**

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	$H_v = V_i . c_p . ϱ . (\Theta_i - \Theta_{sup})/(\Theta_i - \Theta_e)$	**1.26**	$\Phi_V = H_V . (\Theta_i - \Theta_e)$	**45.36**

Total heat loss = heat output $\Phi = \Phi_T + \Phi_V$ [W] **199.5373**

Table for simplified heat output

Room name	Living room		Room number	4.03a	Floor	1	Flat number	F04	
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			55.468	[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
W1	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
ED1	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	5.5	2.8	15.40	2	6.32	9.08	0.3	-12	1.00	2.72	
EW2	4.8	2.8	13.44	2	3.16	10.28	0.3	-12	1.00	3.08	
IW1	3.2	2.8	8.96	0	0	8.96	2.7	24	-0.13	-3.02	
IW2	0.6	2.8	1.68	0	0	1.68	2.7	15	0.16	0.71	
IW3	4.2	2.8	11.76	0	0	11.76	2.7	20	0.00	0.00	
IW4	2.3	2.8	6.44	1	1.58	4.86	2.7	15	0.16	2.05	
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 $H_T = \sum H_{T,k}$										15.8789375	$\Phi_T = H_T . (\Theta_i - \Theta_e)$ = 508.126

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] 1153.246

Table for simplified heat output

Room name	Bedroom		Room number	4.04	Floor	1	Flat number	F04
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		34.020	$[m^3]$	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
W1	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	
EW1	3.2	2.8	8.96	2	3.95	5.01	0.3	-12	1.00	1.50	
IW1	3.7	2.8	10.36	0	0	10.36	2.7	24	-0.13	-3.50	
IW2	3.2	2.8	8.96	1	1.58	8.96	2.7	15	0.16	3.78	
IW3	1.2	2.8	3.36	0	0	3.36	2.7	15	0.16	1.42	
IW4	3.7	2.8	10.36	0	0	10.36	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 $H_T = \sum H_{T,k}$		9.984875	$\Phi_T = H_T . (\Theta_i - \Theta_e)$	**319.516**

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]						**642.076**

Table for simplified heat output

Room name	Bathroom + WC		Room number		5.02	Floor		1	Flat number		F05	
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					13.916	$[m^3]$	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: 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
IW1	1.8	2.8	5.04	0	0	5.04	2.7	20	0.00	0.00	
IW2	3.2	2.8	8.96	0	0	8.96	2.7	15	0.16	3.78	
IW3	2	2.8	5.60	0	0	5.60	2.7	15	0.16	2.36	
IW4	3.1	2.8	8.68	1	1.38	7.30	2.7	15	0.16	3.08	
ID1	0.7	1.97	1.38	1	1.38	1.38	3.5	15	0.16	0.75	

Coefficient of heat loss through transmission $H_T = \sum H_{T,k}$	**9.976328125**	$\Phi_T = H_T . (\Theta_i - \Theta_e)$	**359.1478**

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] **379.3078**

Table for simplified heat output

Room name	Living room		Room number	5.03a	Floor	1	Flat number	F05	
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		62.860	[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	2	2.37	4.74	1	4.74	4.74	1.5	-12	1.00	7.11	
ED1	0.8	1.97	1.58	1	1.58	1.58	1.5	-12	1.00	2.36	
EW1	5.2	2.8	14.56	2	6.32	8.24	0.3	-12	1.00	2.47	
EW2	5.5	2.8	15.40	2	3.95	11.45	0.3	-12	1.00	3.44	
IW1	2	2.8	5.60	0	0	5.60	2.7	15	0.16	2.36	
IW2	0.7	2.8	1.96	0	0	1.96	2.7	15	0.16	0.83	
IW3	3.2	2.8	8.96	1	1.58	7.38	2.7	15	0.16	3.11	
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 $H_T = \sum H_{T,k}$										22.5456875	$\Phi_T = H_T \cdot (\Theta_i - \Theta_e)$ 721.462

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] 1366.582

DESIGN OF HEATING SOURCES						
flat number	room number	room name	temp. [°C]	total heat loss Φ (W)	designed heat loss Φ (W)	type of heating source
F02	2.02	BATHROOM	24	190	225	KORALUX RONDO CLASSIC
	2.03a	LIVING ROOM	20	1282	1288	RADIK VK 21
	2.04	BEDROOM	20	720	750	RADIK VK 21
	2.05	BEDROOM	20	882	984	RADIK VK 21
F03	3.02	BATHROOM	24	370	405	KORALUX RONDO COMFORT-M
	3.03a	LIVING ROOM	20	1419	1450	RADIK VK 21
	3.04	BEDROOM	20	752	782	RADIK VK 20
	3.05	BEDROOM	20	690	701	RADIK VK 21
F04	4.02	BATHROOM	24	200	225	KORALUX RONDO CLASSIC
	4.03a	LIVING ROOM	20	1153	1159	RADIK VK 21
	4.04	BEDROOM	20	642	670	RADIK VK 21
F05	5.02	BATHROOM + WC	24	379	405	KORALUX RONDO COMFORT-M
	5.03a	LIVING ROOM	20	1367	1417	RADIK VK 21

CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

DEPARTMENT OF FIRE SAFETY AND HEALTHY BUILDINGS

TECHNICAL REPORT OF RESIDENTIAL BUILDING

FIRE SAFETY

PART 5

DAYANA MURATOVA

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1 LOCATION OF THE RESIDENTIAL BUILDING

The residential building is located in Prague 9 – Letňany, specifically at parcels No. 760/64, 760/66. It is a part of residential complex "Letňanské zahrady" – building O. The location is limited by Veselská street from the south, by AUTO Štangl company from the west, north and east parts consist of parcel No. 760/1(field), the southern border runs along parcel No. 796/1.

1.1 GENERAL INFORMATION

The residential building has 1 underground floor and 4 above – ground floors. The underground floor of the building delimits the space on the area of the rectangle in the basement with dimensions of 47.73 x 18.82 m. The above – ground floor occupies an area of 24.79 x 19.44 m. Floors 1 to 3 are identical, 4^{th} floor recedes to the middle of the floor plan and has dimensions of 15.89 x 19.0 m. Total height of the building is 12.47 m. Underground floor's height is 2.97 m and upper typical floors have 2.80 m of height.

The entrance to the building is from the hallway and access to the garage side is provided by the entrance in object P. The entrance of the object O is closed by fire resisting rolling shutter with dimensions of 6 000 x 2 250 mm from both sides. There are 17 parking spaces, storage rooms and technical room on the underground floor. Other parking spaces are located outside the building. Also, basement is not fully under the surrounding ground, it is only half of the level. The above – ground floors (1 - 4) are considered for the living purpose. On the 1^{st} floor there are the main entrance to the building, a pram and cleaning room, and 4 apartments. There are 6 apartments on the 2^{nd} – 3^{rd} floors and 3 apartments on the last 4^{th} floor. In total, building has 19 apartments.

The fire height of the building is 9.0 m. Load bearing construction and fire separation walls are type of DP1. Doors between FC and NPEW are DP3 and doors between NPEW and PEW are as well DP3. The entrance door is made of aluminum, garage entry gate is fire resistance rolling shutter type of DP1.

2 FIRE COMPARTMENT, FIRE RISK AND FIRE RESISTANCE GRADE

All apartments in the building create each fire compartment. Other fire compartments are: PEW (protected escape way), NPEW (non - protected escape way) in corridor, elevator shaft, shaft for ventilation and electricity, storage areas in underground level, technical room and pram room. In the garage no flammable liquid materials are stored. The generator of reserve energy source is installed in the room of UPC in the underground level.

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, III. FRG**

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

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

Room of UPC **p_v = 5,3 kg/m^2 I. FRG**

Cleaning room is without fire risk

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**

3 FIRE RESISTANCE

3.1 FIRE, PERIMETER AND INNER LOAD BEARING WALLS

Perimeter wall POROTHERM 24 P+D REW 180 DP1 > 45

Perimeter wall POROTHERM 19 AKU REW 180 DP1 > 45

Reinforced concrete perimeter walls thickness of 200, 220 and 240 mm 90 DP1 > 60 DP

Fire dividing walls between apartments POROTHERM 25 AKU REW 180 DP1 > 45

Partition walls POROTHERM 11.5 120 DP1 > 60 DP1

Outer thermal insulation (ETICS) of perimeter wall in underground level has reaction to fire class A1, amount of heat released Q = M. H = 18. 2.0 = 36 $MJ.kg^{-1}$ <150 $MJ.kg^{-1}$, DP1 type.

3.2 FIRE CEILINGS AND UNDERCEILINGS

Reinforced concrete slab thickness of 200 and 230 mm 60 DP1 = 60 DP1

Reinforced concrete beam 45 DP1 > 30 DP1

Gypsum board underceilings with required fire resistance EI 30 DP1

3.3 ROOF

Reinforced concrete slab thickness of 200 mm 60 DP1 > 30

4 PROTECTED ESCAPE WAYS

The corridor between PEW and apartments is non – protected escape way.

Ventilation of PEW A is forced with 10 times air volume exchange. Fresh air delivery will be secured for minimum 10 min. PEW doors will be equipped with self - closing devices.

From the fire compartment of garage it is enough to have only one PEW because there is less 60 parking spaces.

PEW and NPEW are minimum 1.75 m wide. The staircase wings are minimum 1.1 m wide and doors on the way are minimum 0.9 m wide. Escape line is, therefore, 1.5 m wide.

The entrance door is designed suitable for disable people and the elevator has doors on both sides that people enter to the elevator directly from intermediate landing of the main entrance door.

4.1 NUMBER OF EVACUATED 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.

	Residential building	
	Living area [m^2]	N. of evacuated people E
1.PP	17(parking) x0.5	9 (5)
1.NP	242.1	12
2.NP	272.3	14
3.NP	272.3	14
4.NP	190.8	10
Σ E	**55 persons**	

4.2 LENGTH OF PEW

PEW A maximum length 50 m < maximum allowed length 120 m.

NPEW from apartments – worst cases 1.NP – 4.NP maximum length 22 m. Maximum allowed 20 m is not suitable. There will be installed fire signaling appliance in the NPEW and will be equipped with siren signaling. Therefore, 20. (1 / 0.7) = 28.5 m > 22 m.

Critical point: PEW A II. FRG, first floor stairway, width 1 200 mm, 55 evacuating persons, synchronized evacuation. Therefore, U = E. s / K = 55. 1 / 120 ≈ 2, required width = 2 * 0.55 = 1.1 m < real width = 1.2 m **OK.**

4.3 EQUIPMENT OF ESCAPE WAYS

Doors in the escape ways will be opened to the direction of the escape except apartment doors and main entrance doors. Self – closing devices will be installed on all doors from NPEW and other FC to the PEW.

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 roofs will be enabled by protected escape routes and roof exits from the area of the highest stair landings (4th 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 APPLIENCES

Electrical fire appliances will be installed at every fire compartment. EFA will be installed at every FC with fire load in underground area (storages, technical room) and pram room in first 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 AND LITERATURE

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

ČSN 730818 Fire safety of buildings: Object occupation by persons

ČSN 730821 Fire safety of buildings: Fire resistance of building structures

ČSN 730833 Fire safety of buildings: Housing and accommodation buildings

ČSN 730872 Fire safety of buildings: Protection of fire extinguishing structures

USED LECTURES:

[Design of fire safety] – Fire safety, doc.Ing. Václav Kupilík, CSc., Ing. arch. Petr Hejtmánek, Ph.D.

8 LIST OF DRAWINGS

1) Fire safety design of underground level
2) Fire safety design of 1st floor
3) Fire safety design of 2nd – 3rd floor
4) Fire safety design of 4th floor