BRNO UNIVERSITY OF TECHNOLOGY

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

FACULTY OF CIVIL ENGINEERING

FAKULTA STAVEBNÍ

INSTITUTE OF BUILDING STRUCTURES

ÚSTAV POZEMNÍHO STAVITELSTVÍ

ENERGY SAVING AND HEAT PROTECTION ASSESSMENT

BLOCK OF FLATS IN BRNO

BYTOVÝ DŮM, BRNO

BACHELOR'S THESIS

BAKALÁŘSKÁ PRÁCE

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VEDOUCÍ PRÁCE

BRNO 2024

CONTENT

1.Identification of the building

Name of the building: Blocks of flats in Brno
Place of the building: Brno-Komin
Cadastral area: Komín [610585]
Parcel number: 2547/7
LV numbers: 5163
Aim of the object: Building for longterm living
Total area:876 m2
Built-up area:472.17 m2
Number of flats:8

The proposed design entails a residential building comprising four above-ground floors and one basement floor as garage, intended to accommodate 28 individuals. In plan, the residential house takes on a rectangular shape, with the entrance situated in the northwestern part. Each flat between in the second floor will feature a balcony, flats in 1st, 3rd and 4th floors will have terrace and the roof will be designed as a green roof structure.

For the construction of the peripheral walls, Porotherm 30 P10 blocks will be utilized in the above-ground storeys, while the basement will be constructed using site cast reinforced concrete. Similarly, the internal load-bearing walls will be constructed using Porotherm 25 AKU Z P15 blocks in the above-ground storeys, while the basement will incorporate site cast reinforced concrete. As for non-load-bearing walls which are separating the rooms, Porotherm 11.5 Profi blocks will be utilized, whereas the walls between the living place and technical room will be Porotherm 19 AKU Profi.

To ensure adequate insulation, above the first floor, the facade of the building will be equipped with an External Thermal Insulation Composite System (ETICS), incorporating Expanded Polystyrene (EPS) as the insulating material. Since there is contact with the soil, the facade of the garage will be equipped with XPS. The ceiling of the basement floor will be equipped with the Rockwool to ensure the needed thermal properties.

2.Aim of the assesment

The assessment's goal is to ensure that the building's structure meets the criteria outlined in Decree No. 268/2009, as amended by Decree No. 20/2012. It aims to verify compliance with §16 of the decree, covering aspects such as thermal performance, energy efficiency, sound insulation, protection against noise and vibrations, room acoustics, daylighting, and sunlight exposure. Fulfilling these requirements guarantees the building's safety, hygiene, and operational efficiency.

3.Used norms and standarts

Law no. 350/2012 Coll., about Territorial Planning and Building Regulations
Notice no. 20/2012 Coll., about Technical requirements of buildings
Notice no. 62/2012 Coll., about Documentation of buildings,
Notice no. 78/2013 Coll., about Energy Performance of buildings,
ČSN 730540 – 1,2,3,4: 2011 Thermal Protection of buildings,

4.Calculation of overall heat loss transfer coefficient

4.1 General Equations

$$U = \frac{1}{Rsi+R+Rse} = \frac{1}{Rt}$$

$$R = \frac{d}{\lambda}$$

Where:

R_{si} … internal surface resistance in [m^2.K/W]

R_{se} … external surface resistance in [m^2.K/W]

R … thermal resistance of a construction [m^2.K/W] determined by the addition of the individualcalculated thermal resistances of each layer of the structure.

d … the thickness of the layer [m]

λ … thermal conductivity coefficient [W/m.K]

4.2 Calculations for structures in contact with air and soil

A. Peripheral wall in the basement W1

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]
1	BAUMIT FL 68	0.01	1.4	0.0071
2	BAUMIT GRUND	0.001	1.4	0.0007
3	CONCRETE C30/37	0.3	1.43	0.2098
4	BITUMEN BASED PENETRATION	0.002	0.21	0.0095
5	BITUMEN FELT DAMP-PROOFING	0.004	0.21	0.0190
6	Austrotherm XPS TOP 30 SF	0.14	0.035	4.0000
7	BAUMIT STARCONTACT	0.01	0.8	0.0125
8	BAUMIT STARTEX	0.001	0.21	0.0048
9	BAUMIT GRUND	0.001	1.4	0.000714286
10	BAUMIT FL 68	0.01	1.4	0.007142857
			Σ R	4.2713
			Rsi	0.13
			Rse	0.04
			RT	4.4413
			U	0.205157382

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
W1	0,3*0,7=0,21	0,20	0,205	Satisfies

B. Peripheral wall above the basement W2

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]
1	PAINT	0.003	0.7	0.0043
2	BAUMIT FL 68	0.015	1,400	0.0000
3	BAUMIT GRUND	0.001	1,400	0.0000
4	POROTHERM 30 P10	0.3	0.18	1.6667
5	BAUMIT BAUMACOL FLEXUNI	0.01	0.75	0.0133
6	ISOVER EPS GREYWALL PLUS	0.14	0.031	4.5161
7	BAUMIT STARCONTACT	0.01	0.8	0.0125
8	BAUMIT STARTEX	0.001	0.21	0.0048
9	BAUMIT GRUND	0.001	1,400	0.0000
10	BAUMIT FL 68	0.015	1,400	0.0000
			Σ R	6.2177
			Rsi	0.13
			Rse	0.04
			RT	6.3877
			U	0.156550883

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
W2	0,3*0,7=0,21	0,20	0,15	Satisfies

C. Peripheral wall with ceramic tiles W4

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]
1	CERAMIC TILES	0.01	1,010	0.0000
2	BAUMIT BAUMACOL FLEXUNI	0.01	0.75	0.0133
3	BAUMIT RATIO GLATT	0.015	0.7	0.0214
4	BAUMIT GRUND	0.001	1,400	0.0000
5	POROTHERM 30 P10	0.3	0.18	1.6667
6	BAUMIT BAUMACOL FLEXUNI	0.01	0.75	0.0133
7	ISOVER EPS GREYWALL PLUS	0.14	0.031	4.5161
8	BAUMIT STARCONTACT	0.01	0.8	0.0125
9	BAUMIT GRUND	0.001	1,400	0.0000
10	BAUMIT FL 68	0.015	1,400	0.0000
			Σ R	6.2434
			Rsi	0.13
			Rse	0.04
			RT	6.4134
			U	0.15592322

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
W4	0,3*0,7=0,21	0,20	0,15	Satisfies

D. Basement floor F1

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]

1	FIBER-REINFORCED CONCRETE	0.1	1,580	0.0001
2	PE FOIL	0.0005	0.16	0.0031
3	AUSTROTHERM XPS TOP 50 SF	0.08	0.033	2.4242
4	DAMP-PROOFING AND PENETRATION	0.0045	0.21	0.0214
5	CONCRETE C30/37	0.3	1,430	0.0002
6	CONCRETE BASE LAYER	0.1	1,230	0.0001
			Σ R	2.4492
			R_{si}	0.13
			R_{se}	0.04
			R_T	2.6192
			U	0.381803202

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Floor F1	0,85*0,7=0,595	0,60	0,38	Satisfies

E. Floor with ceramic tiles in the first floor F2

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]
1	CERAMIC TILES	0.01	1,010	0.0000
2	BAUMIT FLEXTOP S1	0.005	0.75	0.0067
3	BAUMIT GRUND	0.001	1,400	0.0000
4	BAUMACOL PROTECT 2K	0.002	0.16	0.0125
5	CERESIT CN 87	0.055	0.99	0.0556
6	PE FOIL	0.0001	0.16	0.0006
7	ISOVER EPS RIGIFLOOR 4000	0.05	0.044	1.1364
8	CONCRETE C30/37	0.16	1,430	0.0001
9	WEBERPODKLAD A	0.001	0.26	0.0038
10	WEBERTHERM ELASTIK	0.005	0.8	0.0063
11	STROPROCK G	0.1	0.037	2.7027
12	PENETRATION LAYER	0.001	0.75	0.0013
13	INTERIOR PLASTER	0.01	0.8	0.0125
			Σ R	3.9318
			R_{si}	0.13
			R_{se}	0.04
			R_T	4.1018
			U	0.243796104

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Floor F2	0,45*0,7=0,315	0,30	0,24	Satisfies

F. Floor with laminate floor in the first floor F3

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]
1	LAMINATE FLOOR	0.008	1,010	0.0000
2	CERESIT CN 87	0.06	0.99	0.0606

3	PE FOIL	0.0005	0.16	0.0031
4	ISOVER EPS RIGIFLOOR 4000	0.05	0.044	1.1364
5	CONCRETE C30/37	0.16	1,430	0.0001
6	WEBERPODKLAD A	0.001	0.26	0.0038
7	WEBERTHERM ELASTIK	0.005	0.8	0.0063
8	STROPROCK G	0.1	0.037	2.7027
9	PENETRATION LAYER	0.001	0.75	0.0013
10	INTERIOR PLASTER	0.01	0.8	0.0125
			Σ R	3.9268
			R_{si}	0.13
			R_{se}	0.04
			R_T	4.0968
			U	0.244090168

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Floor F3	0,45*0,7=0,315	0,30	0,24	Satisfies

G. Terrace floor on the first floor F4

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]
1	CERAMIC TILES	0.01	1,010	0.00001
2	BAUMIT FLEXTOP S1	0.005	0.75	0.0067
3	BAUMIT GRUND	0.001	1,400	0.0000
4	BAUMACOL PROTECT 2K	0.002	0.16	0.0125
5	AUSTROTHERM XPS UNIVERSALPLATT	0.12	0.033	3.6364
6	PE FOIL	0.0005	0.16	0.0031
7	CERESIT CN 87	0.02	0.99	0.0202
8	DAMP-PROOFING	0.004	0.21	0.0190
9	CONCRETE C30/37	0.16	1,430	0.0001
10	WEBERPODKLAD A	0.001	0.26	0.0038
11	WEBERTHERM ELASTIK	0.005	0.8	0.0063
12	STROPROCK G	0.1	0.037	2.7027
13	PENETRATION LAYER	0.001	0.75	0.0013
14	INTERIOR PLASTER	0.01	0.8	0.0125
			Σ R	6.4247
			R_{si}	0.13
			R_{se}	0.04
			R_T	6.5947
			U	0.151637849

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Floor F4	0,24*0,7=0,17	0,15	0,15	Satisfies

H. Terrace floor on the 3rd and 4th floors F5

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]
1	CONCRETE BLOCKS FROM LINDNER	0.039	1,230	0.0000
2	FILTRATION ACCUMULATION AND SE	0.032	0.16	0.2000
3	WATERPROOFING	0.004	0.21	0.0190
4	STONE WOOL ISOVER INTENSE	0.2	0.035	5.7143
5	BITUMEN FELT	0.004	0.016	0.2500
6	CONCRETE C30/37	0.16	1,430	0.0001
7	PENETRATION LAYER	0.001	0.75	0.0013
8	INTERIOR PLASTER	0.01	0.8	0.0125
			Σ R	6.1973
			R_{si}	0.13
			R_{se}	0.04
			R_T	6.3673
			U	0.157052187

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Floor F5	0,24*0,7=0,17	0,15	0,15	Satisfies

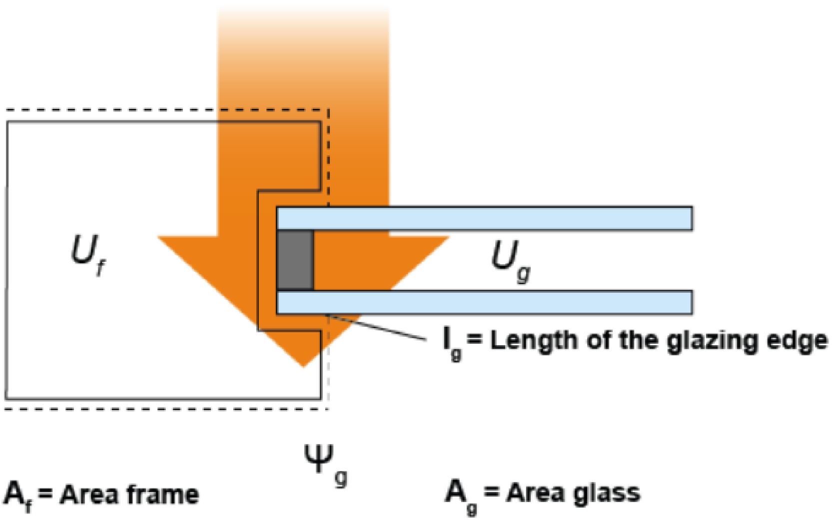
I. Green roof F6

Layer	Material	d [m]	λ [W/m.K]	R [m2.K/W]
1	VEGETATION	0.035	0.7	0.0500
2	VEGETATION SUBSTRATE	0.06	0.95	0.0632
3	FILTRATION ACCUMULATION AND SE	0.032	0.16	0.2000
4	WATERPROOFING	0.004	0.21	0.0190
5	WATERPROOFING	0.004	0.21	0.0190
6	ISOVER EPS RIGIFLOOR 4000	0.25	0.044	5.6818
7	BITUMEN FELT	0.004	0.016	0.2500
8	CONCRETE C30/37	0.16	1,430	0.0001
9	PENETRATION LAYER	0.001	0.75	0.0013
10	INTERIOR PLASTER	0.01	0.8	0.0125
			Σ R	6.2970
			Rsi	0.13
			Rse	0.04
			RT	6.4670
			U	0.154630809

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Floor F5	0,24*0,7=0,17	0,15	0,15	Satisfies

4.3 Heat transfer coefficients of windows and doors

The efficiency of heat transfer in windows and doors is influenced by the size of the glass and frame areas. This assessment involves considering the Ug value for glazing and the Uf value for frames. By combining these values, the overall heat transfer coefficient, Uw for windows, and Ud for doors can be determined. The goal is to minimize these values for optimal energy efficiency.



$$U_w = \frac{A_g \cdot U_g + A_f \cdot U_f + l_g \cdot \Psi_g}{A_w}$$

The Uw value, determined by a formula, is influenced by three main components: the window frame, the insulating glass unit, and the glazing edge.

Each component's contribution is calculated by multiplying its specific U value (Uf and Ug) by its corresponding area (Af and Ag), as heat loss occurs across the entire window surface separating indoors and outdoors. Additionally, the formula incorporates the glazing edge, representing heat loss at the edge of the insulating glass unit. This is calculated by multiplying the length of the glazing edge (lg) by the length-related linear heat transfer coefficient, Psi (Ψg), which accounts for the heat loss due to the interaction of the frame, glass, and spacer bar.

A. Window 2000x1500

Width of window	2
Height of window	1.5
Width of window frame with the wing	0.12
Heat transfer coefficient of glazing (Ug)	0.7 W/m2.K
Heat transfer coefficient of frame(Uf)	1 W/m2.K
Linear coefficient(ψg)	0.055
Heat transfer coefficient of the whole window(Uw)	0.85

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Window W1	1.05	1.2	0.85	Satisfies

B. Window 1250x1500

Width of window	1.25
Height of window	1.5
Width of window frame with the wing	0.12

Heat transfer coefficient of glazing (Ug)	0.7 W/m2.K
Heat transfer coefficient of frame(Uf)	1 W/m2.K
Linear coefficient(ψg)	0.055
Heat transfer coefficient of the whole window(Uw)	0.88

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Window W2	1.05	1.2	0.88	Satisfies

C. Entrance door to technical room

Width of door	1.35
Height of door	2.02
Width of door frame with the wing	0.12
Heat transfer coefficient of glazing (Ug)	1.1 W/m2.K
Heat transfer coefficient of frame(Uf)	1 W/m2.K
Linear coefficient(ψg)	0.055
Heat transfer coefficient of the whole window(Uw)	1.05

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Door D1	1.05	1.2	1.05	Satisfies

Width of window	0.4
Height of window	2.02
Width of window frame with the wing	0.12
Heat transfer coefficient of glazing (Ug)	1.1 W/m2.K
Heat transfer coefficient of frame(Uf)	1 W/m2.K
Linear coefficient(ψg)	0.055
Heat transfer coefficient of the whole window(Uw)	0.89

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Window W3	1.05	1.2	0.89	Satisfies

D. Entrance door to building

Width of door	1.35
Height of door	2.02
Width of door frame with the wing	0.12
Heat transfer coefficient of glazing (Ug)	1.1 W/m2.K
Heat transfer coefficient of frame(Uf)	1 W/m2.K
Linear coefficient(ψg)	0.055
Heat transfer coefficient of the whole window(Uw)	1.05

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Door D2	1.05	1.2	1.05	Satisfies

Width of window	0.4
Height of window	2.02
Width of window frame with the wing	0.12
Heat transfer coefficient of glazing (Ug)	1.1 W/m2.K
Heat transfer coefficient of frame(Uf)	1 W/m2.K

Linear coefficient(ψg)	0.055
Heat transfer coefficient of the whole window(Uw)	0.89

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Window W4	1.05	1.2	0.89	Satisfies

E. Balcony and terrace doors

Width of door	0.9
Height of door	2.02
Width of door frame with the wing	0.12
Heat transfer coefficient of glazing (Ug)	0.7 W/m2.K
Heat transfer coefficient of frame(Uf)	1 W/m2.K
Linear coefficient(ψg)	0.055
Heat transfer coefficient of the whole window(Uw)	0.9

Structure	Required U,N20 x 0,7	Recommended U,rec 20	Calculated U	Evaluation
Door D3	1.05	1.2	0.9	Satisfies

4.4 Conclusion

All structures and components in contact with air, such as walls, floors, doors, and windows, meet the standards' criteria. They comply with the requirement U = 1/ RT ≤ Ustandard [Wm-2K-1] specified in Standard ČSN 730540, where U,N20 is adjusted by a coefficient of 0.7. The values used for computations were obtained from the thermal conductivity design values table (návrhové hodnoty) in ČSN 73 0540-3 and also from software Teplo2017.

5. Energy performance certificate of the building

The energy performance of buildings is categorized from A to G, with A representing highly efficient buildings and G representing highly inefficient ones. Most buildings typically fall into category B, with A and C being less common. According to Decree 78/2013, it's required to compare a given building with a reference building. This reference building shares identical parameters such as area, shape, size, usage, and heating system with the actual building, but differs in aspects like window properties, door quality, thermal insulation, and energy efficiency. When comparing the reference building to the actual one, it's important to note that if their performances are similar, they are classified as category C, which is acceptable. However, the aim is for buildings to be more energy efficient, thus achieving higher categories is preferable.

5.1 Calculation

Internal temperature in the heating period 20 °C
External design temperature in winter -12 °C

Reduction factor b=(Ti-Tb)/(Ti-Te)
Ti internal temperature (20 °C)
Te external temperature (-12 °C)
Tb other temperature (soil -5 °C)

ΔU_1 = 0,02 for reference building
ΔU_1 = 0,05 for assessed building

$$Uem = \frac{HT}{A}$$

$$HT = \sum(AxBxU) + Ax\, \Delta U$$

Where :
HT... specific heat loss [W/K]
U ... coefficient of heat transfer through structures [W/m2.K]
A ... the sum of the areas of covered constructions [m2]
b ...temperature reduction factor [-]
ΔU.... average effect of all thermal bridges [W/m2.k].

Structure	Reference Building				Assessed Building			
	A [m2]	U [W/m2 .K]	Reduction Factor b [-]	Specific heat transmisson loss Hti [W/K]	A [m2]	U [W/m2 .K]	Reduction Factor b [-]	Specific heat transmisson loss Hti [W/K]
W1	275.22	0.3	1	82.566	275.22	0.2	1	55.044
W2	768.4325	0.3	1	230.52975	768.4325	0.15	1	115.264875
W4	25.8335	0.3	1	7.75005	25.8335	0.15	1	3.875025
F1	405.5	0.6	0.48	116.784	405.5	0.38	0.48	73.9632
F2	16.27	0.45	0.48	3.51432	16.27	0.24	0.48	1.874304
F3	256	0.45	0.48	55.296	256	0.24	0.48	29.4912
F4	44.41	0.24	0.79	8.420136	44.41	0.15	0.79	5.262585
F5	167.24	0.24	0.79	31.708704	167.24	0.15	0.79	19.81794
F6	53	0.24	0.48	6.1056	53	0.15	0.48	3.816
W1	90	1.5	1	135	90	0.85	1	76.5
W2	18.75	1.5	1	28.125	18.75	0.88	1	16.5
W3	0.8	1.5	1	1.2	0.8	0.89	1	0.712
W4	0.8	1.5	1	1.2	0.8	0.89	1	0.712
D1	2.72	1.7	1	4.624	2.72	1.05	1	2.856
D2	2.72	1.7	1	4.624	2.72	1.05	1	2.856
D3	14.5	1.7	1	24.65	14.5	0.9	1	13.05
Total area	2142.196		ΣHTi	742.09756		ΣHTi		421.595129
Thermal bridges ΔU			ΣAx ΔU1	42.84392		ΣAx ΔU1		107.1098
Nominal overall heat transfer loss HT			ΣHTi+ ΔU	784.94148		ΣHTi+ ΔU		528.704929
Average heat transfer coefficient			Uem,req= HT/ΣA+ΔU1	0.366419076		Uem= HT/ΣA+ΔU1		0.246805114
Class of the building			Uem /Uem,req	**0.673559676**		Class		**B Economical**

Klasifikační třídy	Kód barvy (CMYK)	Průměrný součinitel prostupu tepla budovy U_{em} [$W \cdot m^{-2} \cdot K^{-1}$]	Slovní vyjádření klasifikační třídy
A	X0X0	$U_{em} \leq 0,5 \cdot U_{em,rq}$	Velmi úsporná
B	70X0	$0,5 \cdot U_{em,rq} < U_{em} \leq 0,75 \cdot U_{em,rq}$	Úsporná
C	30X0	$0,75 \cdot U_{em,rq} < U_{em} \leq U_{em,rq}$	Vyhovující
D	00X0	$U_{em,rq} < U_{em} \leq 1,5 \cdot U_{em,rq}$	Nevyhovující
E	03X0	$1,5 \cdot U_{em,rq} < U_{em} \leq 2,0 \cdot U_{em,rq}$	Nehospodárná
F	07X0	$2,0 \cdot U_{em,rq} < U_{em} \leq 2,5 \cdot U_{em,rq}$	Velmi nehospodárná
G	0XX0	$U_{em} > 2,5 \cdot U_{em,rq}$	Mimořádně nehospodárná

Class B: 0,5* Uem,req < Uem ≤ 0,75* Uem,req

$0.1832 < 0.246 \leq 0.275$

The result is satisfactory, therefore it is **economical**