BRNO UNIVERSITY OF TECHNOLOGY

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

FACULTY OF CIVIL ENGINEERING

FAKULTA STAVEBNÍ

INSTITUTE OF BUILDING STRUCTURES

ÚSTAV POZEMNÍHO STAVITELSTVÍ

MUNICIPAL CENTRE IN NIVNICE

MUNICIPAL CENTRE IN NIVNICE

ENERGY LABEL

MASTER'S THESIS

DIPLOMOVÁ PRÁCE

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VEDOUCÍ PRÁCE

BRNO 2025

1. Technical parameters

1.1. Identification data

Name of the building:	Municipal centre
Type of building:	Civic amenities facility
Purpose of building:	Multifunctional building
Municipality:	Nivnice
Cadastral area:	704679 NIVNICE
Parcel numbers:	65, 64, 63, 61 ,57

1.2. Architectural and urban solution of the building

The subject of the documentation is fire safety solution of newly built municipal centre in town Nivnice, in cadastral area Nivnice [704679], on parcels 65, 64, 63, 61, 57, in the built-up area of town.

Designed building is permanent, detached construction with 2 above ground floors and a partial basement. It is located on flat land, without underground water. The shape of the building is rectangular with total area of 330,72 m2. The building is divided into two separate functional units, post office and administrative area with ceremony hall. Entrances to both parts are from the northeast side, through the first floor.

The roof construction is flat and green with simple intensive type of vegetation. On the roof are placed photovoltaic panels. Façade surface has silicon thin-layered plaster, and it is insulated by mineral wool. Fillings of windows and doors are wooden-aluminium with triple glazing. External shadings from aluminium will be connected to the load-bearing peripheral walls by Propasiv system blocks.

1.3. Layout solution of the building

The building is divided into 2 functionally separate units, post office and administrative area with ceremony hall.

The main entrance to the post office is from the northeast side, through the first floor. The entrance leads through automatic doors to the customer area with delivery window and post office counter. The service office is designed for 2 employees. There is also small kitchen with electrical stove, toilet, washroom and cleaning/changing room. The storage area for delivering and storing of packages has car entrance from northeast side and it has area of 29,73 m2. The total area of post office is 70,41 m2.

The main entrance to the administrative part with ceremony hall is from the northeast side, through the first floor. The entrance leads through automatic doors to the hallway with waiting room. On the first floor there is submission office for the first contact with public, hygienic area, small storage and ceremony hall. Hygienic area contains 2 separate toilets for disabled people, women toilet with 4 WC cabins and separate washroom and men toilet with 2 cabins and1 pisoar and separate washroom. In front of ceremony hall in small foyer with places to sit. 3

Ceremony hall has capacity of total cca 50 people, from which 40 can be seated. Total area is 72,96 m2. Ceiling is 6,35m high, going through 2 floors. Ceremony hall is connected with small storage area for chairs that serves also as a passage for a person leading the ceremony, or if needed as a cloak room.

In the underground floor is located cleaning room below the arm of staircase, technical room with geothermal heat pump and water heater, HVAC room, storage for office furniture, depository and archive. All rooms are considered without a permanent work position.

In the second floor are 3 offices for administrative work and public relations, hygienic area, printing/storage room for office supplies, kitchen, meeting room, mayor’s office with secretary office and vice mayor´s office. The meeting room is designed for 15 people. In hygienic area is washroom for women and toilet with 2 WC cabins and separated washroom for men with toilet with 1 WC cabin and pisoar.

All floors are connected by vertical communication in a form of staircase with electrical elevator.

1.4. Structural solution of the building

The building is standing on strip foundation and foundation slab from plain concrete. Load-bearing system is designed as mixed from masonry locks.

Peripheral walls in 1.P are made of hollow core concrete blocks, BTB 50/30/25 (P+D), LxWxH 500x300x250mm, filled with reinforced concrete. They are insulated by XPS 300 L, thick 80 and160 mm. Peripheral walls in 1.NP and 2.NP are bricked, made of ceramic blocks POROTHERM 30 PROFI, th. 300mm. Thermal insulation is made of mineral wool thick 200 mm, covered by silicon thin-layered plaster - ETICS system. Interior loadbearing wall are also made of ceramic blocks POROTHERM 30 PROFI, th. 300mm. Non-loadbearing partitions are made of ceramic block POROTHERM 11,5 PROFI thick 115 mm and POROTHERM 8 PROFI thick 80mm.

Ceiling structures are made of prefabricated prestressed ceiling panels (SPIROLL) placed on loadbearing walls and connected by concrete. Below spiroll panels on load-bearing walls are made reinforced concrete rings. The U-shaped staircase is designed as a left-hand turn from prefabricated reinforced concrete parts. There is a personal elevator in the mirror area, that is placed into prefabricated elevator shaft from reinforced concrete.

The roof structure is designed as a flat, green, simple intensive roof made of prestressed SPIROLL ceiling panels. The insulation is EPS with lowest thickness of 250 mm. Waterproofing is made of SBS asphalt felts.

Fillings of exterior windows and doors are wooden aluminium with triple glazing. Interior doors are mostly wooden placed in wooden frames, except for automatic doors that are made of safety glass and aluminium. Almost in all rooms is constructed dropped ceiling from plasterboard cassettes on load-bearing grid.

1.5. Climatic conditions of the location

Total area: 330, 72m2

Altitude: 240,24 m.n.m

Air conditions in exterior:

Winter θe = -14°C

Summer θe = +30°C

Soil θe = 5°C

Humidity ϕ 84 %

Air conditions in interior:

Winter θi = 20°C

Winter θi = 15°C basement

Winter θi = 5°C unheated spaces

Summer θi = max 26°C

Additional Δθai 0,6°C

Humidity ϕ 50 %

Volume of the object: 3126 m3

Paved areas: 112,84 m2

Built-up area: 443,57m2

2. <u>Aim of the assessment</u>

The goal of the thermal-technical evaluation is to determine the building's classification based on the standards for its envelope. The calculated heat transfer coefficient (U) [W/m²K] will be compared to the standard reference values, UN,20 and UREC,20 [W/m²K]. The assessment will be conducted following the guidelines outlined in ČSN 73 0540.

3. Background documents

- Situation drawings of surrounding areas
- Plan drawings
- Data from manufacturers
- Standards, norms, regulations

4. Used norms and regulations

- Act No. 183/2006 Coll. on Spatial Planning and Building Code (Building Act), as amended.
- Act No. 406/2000 Coll. on Energy Management, as amended.
- Decree No. 268/2009 Coll. on Technical Requirements for Buildings, as amended.
- Decree No. 499/2006 Coll. on Building Documentation, as amended.
- Decree No. 264/2020 Coll. on the Energy Performance of Buildings.
- ČSN 73 0540-1:2005 Thermal Protection of Buildings – Part 1: Terminology.
- ČSN 73 0540-2:2011 + Z1:2012 Thermal Protection of Buildings – Part 2: Requirements.
- ČSN 73 0540-3:2005 Thermal Protection of Buildings – Part 3: Design Values of Quantities.
- ČSN 73 0540-4:2005 Thermal Protection of Buildings – Part 4: Calculation Methods.

5. Average Heat Transfer Coefficient

The average heat transfer coefficient of a building, Uem [W/m²K], is determined to evaluate the building's structural and energy performance and serves as a basis for assessing the building's energy performance. It includes the total heat transfer at the building's system boundary or its heated zone. The average heat transfer coefficient depends on the specific heat loss through conduction, HT [W/K], and the total area of all cooled structures enclosing the building's volume or its heated zone, A [m²].

According to ČSN 73 0540-2:2011 + Z1:2012 Thermal Protection of Buildings – Part 2: Requirements, Article 5.3.1, the average heat transfer coefficient Uem [W/m²K] must meet the following condition:

$$U_{em} \leq U_{em,N}$$

where:

Uem [W/m²K] is the average heat transfer coefficient of the evaluated building.

Uem,N [W/m²K] is the required average heat transfer coefficient.

As per Article 5.3.3 of the standard ČSN 73 0540-2:2011 + Z1:2012, the required value of the average heat transfer coefficient is calculated using the reference building method. A reference building is defined as a building with the same dimensions and spatial arrangement as the evaluated building, with heat transfer coefficients corresponding to the required standard values.

The Uem,N value of the reference building is determined using the formula provided in Article 5.3.4 of the standard, but it must not exceed the corresponding value specified in Table 5 of the same standard.

$$Uem = HT$$

$$HT = \Sigma(A \cdot b \cdot U) + A \cdot \Delta U$$

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]

ΔU1 = 0,02 for reference building

ΔU2 = 0,05 for assessed building

6. Air circulation

The overall airtightness of the building envelope or its integral part is verified using the total intensity of air exchange n50 at a pressure difference of 50 Pa, in h-1, determined experimentally according to ČSN EN 13829. It is recommended that the condition be met:

$$n50 \leq n50,N$$

n50,N … is the recommended value of the total intensity of air exchange at a pressure difference of 50Pa, in h-1, which is determined according to the table of recommended values of the total intensity of air exchange n50,N.

It is recommended that the air tightness of rooms be very small if forced ventilation or air conditioning is used. It is recommended that the intensity of natural air exchange determined by calculation meets the requirement:

$$n \le 0{,}05\ h^{-1}$$

When the room is not in use, the lowest room ventilation intensity n_{min} [h^{-1}] is recommended to meet the condition:

$$n_{min} \ge n_{min,N}$$

Where

$n_{min,N}$ … is the recommended lowest intensity of room ventilation [h^{-1}] for the time when the room is not used

When the room is in use, the room ventilation intensity n [h^{-1}] must meet the requirement:

$$n \ge n_N$$

n_N ... is the required ventilation intensity of the used room [h^{-1}]

At the same time, the intensity of ventilation of the room in the heating season must meet the requirement:

$$n \le 1.5\ n_N$$

7. Energy Performance of a Building

According to Decree No. 264/2020 Coll. on Energy Performance of Buildings, new buildings must meet the requirements for nearly zero-energy buildings (NZEB). A nearly zero-energy building is defined as a building with very low energy performance, stricter requirements for the building envelope (heat transfer coefficient and airtightness), well-regulated heating, ventilation, and lighting systems, and, most importantly, partial energy supply from renewable sources.

The indicators of a building's energy performance are:
a) Primary energy from non-renewable sources
b) Total annual delivered energy
c) Delivered energy for technical systems, including heating, cooling, mechanical ventilation, humidity control, hot water preparation, and lighting
d) Average heat transfer coefficient of individual structures at the system boundary
e) Efficiency of technical systems

Buildings with nearly zero energy consumption must meet the average heat transfer coefficient condition:

$$U_{em} \le U_{em,R}$$

where:

U_{em} [W/m^2K] is the average heat transfer coefficient of the evaluated building.

$U_{em,R}$ [W/m²K] is the required average heat transfer coefficient of the reference building, as per Decree No. 264/2020 Coll.

The required average heat transfer coefficient for the reference building (definition of a reference building provided above) is calculated similarly to that of the evaluated building. However, the calculation incorporates a reduction factor fRf_RfR, which equals **0.7** for nearly zero-energy buildings. This reduction factor adjusts the required heat transfer coefficient values of individual structures as follows:

$$U_{R,j} = f_R \cdot U_N$$

where:

$U_{R,j}$ [W/m²K] is the heat transfer coefficient of the structures of the reference building.

f_R [-] is the reduction factor (for NZEB = 0.7).

U_N [W/m²K] is the required heat transfer coefficient value of structures as per ČSN 73 0540-2:2011 + Z1:2012 Thermal Protection of Buildings.

Evidence of compliance with the requirements of Decree No. 264/2020 Coll. on Energy Performance of Buildings is the Energy Performance Certificate of the Building. However, due to insufficient information about the technical and technological systems of the building and their energy performance, this certificate will not be prepared as part of the diploma thesis.

8. Energy Label of the Building Envelope

The Energy Label of the Building Envelope serves as an appendix to the Energy Performance Certificate of Buildings. It reflects the quality and thermal insulation properties of the building's envelope structures.

The protocol for the energy label of the building envelope and the energy label itself are technical documents used to demonstrate compliance with the heat transfer requirements of the building envelope.

The protocol for the energy label includes data describing the thermal behaviour of the building and its structures. The energy label provides a classification of the heat transfer of the building envelope and its graphical representation.

The classification levels for the energy label of the building envelope are based on the required standard value of the average heat transfer coefficient $U_{em,N}$.

Classification Levels for the Energy Label of the Building Envelope According to ČSN 73 0540-2:2011 + Z1:2012

Classification Level	Average Heat Transfer Coefficient Uem [W/m²K]	Description
A	Uem≤0.5·Uem,N ≤ 0,5·Uem,N	Very efficient
B	0,5·Uem,N < Uem ≤0,75·Uem,N	Efficient
C	0,75·Uem,N < Uem ≤ Uem,N	Compliant
D	Uem,N < Uem ≤ 1,5·Uem,N	Non-compliant
E	1,5·Uem,N < Uem ≤ 2.0·Uem,N	Inefficient
F	2,0·Uem,N < Uem ≤ 2,5·Uem,N	Very inefficient
G	Uem > 2,5·Uem,N	Extremely inefficient

Classification Levels for Building Energy Performance According to Decree No. 264/2020 Coll. on Energy Performance of Buildings

Classification Level	Average Heat Transfer Coefficient Uem [W/m²K]	Description
A	Uem ≤ 0,7·Uem,R	Exceptionally efficient
B	0,7·Uem,R < Uem ≤ 0,9·Uem,R	Very efficient
C	0,9·Uem,R < Uem ≤ 1,2·Uem,R	Efficient
D	1,2·Uem,R < Uem ≤ 1,7·Uem,R	Less efficient
E	1,7·Uem,R < Uem ≤ 2,3·Uem,R	Inefficient
F	2,3·Uem,R < Uem ≤ 2,9·Uem,R	Very inefficient
G	Uem > 2,9·Uem,R	Extremely inefficient

Table 3 - Required and Recommended Values of the Heat Transfer Coefficient UN for Buildings with a Predominant Design Indoor Temperature θim = 20°C

Popis konstrukce	Typ konstrukce	Požadované hodnoty U_N	Doporučené hodnoty U_N	Součinitel typu konstrukce	Činitel teplotní redukce
		[W/(m^2.K)]	[W/(m^2.K)]	**e_2** [-]	**b_1** [-]
Střecha plochá a šikmá se sklonem do 45° včetně Podlaha nad venkovním prostorem Strop pod nevytápěnou půdou se střechou bez tepelné izolace Podlaha a stěna s vytápěním	lehká	**0,24**	**0,16**	0,8	1,25
	těžká	**0,30**	**0,20**	0,8	1,00
Stěna venkovní Střecha strmá se sklonem nad 45°	lehká	**0,30**	**0,20**	1,0	1,25
	těžká	**0,38**	**0,25**	1,0	1,00
Podlaha a stěna přilehlá k zemině (s výjimkou podle poznámky 2) Strop a stěna vnitřní z vytápěného k nevytápěnému prostoru		**0,60**	**0,40**	0,8	0,49
Strop a stěna vnitřní z vytápěného k částečně vytápěnému prostoru		**0,75**	**0,50**	0,8	0,40
Stěna mezi sousedními budovami Strop mezi prostory s rozdílem teplot do 10 °C včetně		**1,05**	**0,70**	0,8	0,29
Stěna mezi prostory s rozdílem teplot do 10 °C včetně		**1,30**	**0,90**	1,0	0,29
Strop vnitřní mezi prostory s rozdílem teplot do 5 °C včetně		**2,2**	**1,45**	0,8	0,14
Stěna vnitřní mezi prostory s rozdílem teplot do 5 °C včetně		**2,7**	**1,80**	1,0	0,14
Okno a jiná výplň otvoru podle 4.6, z vytápěného prostoru (včetně rámu, který má nejvýše 2,0 W/(m^2.K))	nová	**1,80**	**1,20**	5,5	1,15
	upravená	**2,0**	**1,35**	6,0	1,15
Dveře, vrata a jiná výplň otvoru podle 4.6, z částečně vytápěného nebo nevytápěného prostoru vytápěné budovy (včetně rámu)		**3,5**	**2,3**	6,0	0,66

9. <u>Calculation</u>

Structure	Reference building				Assessed building			
	A (m2)	UN (W/M2*K)	b (-)	HTi (W/K)	A (m2)	U (W/M2*K)	b (-)	HTti (W/K)
W01	81,284	0,6	0,49	23,90	81,284	0,24	0,49	9,56
W02	59,36	0,6	0,49	17,45	59,36	0,236	0,49	6,86
W06	520,154	0,38	1	197,66	520,154	0,148	1	76,98
W09	28,424	0,38	1	10,80	28,424	0,186	1	5,29
F01	138,24	0,6	0,49	40,64	138,24	0,289	0,49	19,58
F06	72,96	0,6	0,49	21,45	72,96	0,269	0,49	9,62
F09	29,73	0,6	0,49	8,74	29,73	0,498	0,49	7,25
F10	10,44	0,6	0,49	3,07	10,44	0,289	0,49	1,48
F11	31,4	0,6	0,49	9,23	31,4	0,288	0,49	4,43
R01	285,95	0,3	1	85,79	285,95	0,116	1	33,17
O01	31,5	1,8	1,15	65,21	31,5	0,782	1,15	28,33
O02	1,6	1,8	1,15	3,31	1,6	0,906	1,15	1,67
O03	11,8	1,8	1,15	24,43	11,8	0,699	1,15	9,49
O04	13,475	1,8	1,15	27,89	13,475	0,607	1,15	9,41
O05	13	1,8	1,15	26,91	13	0,713	1,15	10,66
O06	16,6	1,8	1,15	34,36	16,6	0,646	1,15	12,33
O07	4,5	1,8	1,15	9,32	4,5	0,634	1,15	3,28
DE01	5,18	1,8	1,15	10,72	5,18	0,706	1,15	4,21
DE02	7,511	1,8	1,15	15,55	7,511	0,692	1,15	5,98
DG01	5,18	3,5	0,66	11,97	5,18	0,54	0,66	1,85
Total	**1368,28**		**ΣHTi**	**648,39**			**ΣHTi**	**261,41**
ΔU Ther. bridge	ΣA* ΔU	1368,288*0,02		**27,36**	ΣA*ΔU2	1368,288*0,05		**68,41**
HT,n Total specific heat transfer loss	ΣHT+ ΣA. ΔU			**675,75**	ΣHT+ ΣA. ΔU			**329,82**
Aver. heat tran. coeff.	Uem,req=HTn/ΣA+ΔU			**0,51**	Uem = 0,7. (ΣHTn / ΣA) + ΔU			**0,22**
Building envelope classification class according ČSN 73 0540-2					Uem /Uem,req =		0,22/0,51=	**0,43**

10. Assessment

$U_{em} \le 0,5 * U_{em,req}$

$0,22 \le 0,5*0,51$

$0,22 \le 0,255$

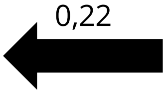
Complies

Clasification A - Very efficient

11. <u>Energy label</u>

<table>
<tr><th colspan="7">Energy label of the building envelope</th></tr>
<tr><td colspan="3">Detached house

Kanianka, PARCEL 129/2, 128/10, 1674/732</td><td colspan="4">Evaluation of building envelope</td></tr>
<tr><td colspan="3">Total area: 247m2</td><td colspan="2">Calculated</td><td colspan="2">Recomended</td></tr>
<tr><td colspan="3">Extremely wasteful Very efficient

0,5
0,75
1,0
1,5
2,0
2,5
</td><td colspan="4">0,22
</td></tr>
<tr><td colspan="3">CLASIFICATION</td><td colspan="4">A</td></tr>
<tr><td colspan="3">Average loss by heat transfer

Uem W/(m2 .K) Uem = HT/A</td><td colspan="4">0,22</td></tr>
<tr><td colspan="3">Required average loss by heat transfer of building envelope according the standard ČSN 73 0540-2 Uem,req W/(m2 .K)</td><td colspan="4">0,51</td></tr>
<tr><td colspan="7">Classification indicators CI and corresponding Uem</td></tr>
<tr><td>CI</td><td>0,5</td><td>0,75</td><td>1</td><td>1,5</td><td>2</td><td>2,5</td></tr>
<tr><td>Uem</td><td>0,26</td><td>0,39</td><td>0,51</td><td>0,77</td><td>1,03</td><td>1,28</td></tr>
<tr><td colspan="2">Valid until: 20.5. 2033</td><td colspan="5">Name: Barbora Husárová</td></tr>
</table>

12. Preliminary heat loss of the house

(Envelope method)

12.1. Total nominal overall heat transfer loss

HT= ΣHTi+ ΔU2

HT= 261,46W/K

ΔU1…..Thermal bridges, 0,02 for reference building

ΔU2…..Thermal bidges0,05 for assessed building

ΣHTi… Specific heat transm. Loss W/K

The values is taken from energy label of the house

12.2. Total overall heat transfer loss

Qti = HT . (ti,m – te)

Qti = 261,46* (20-(-14))

Qti = 8889,64 W

12.3. Heat loss by natural ventilation

Air volume of the house - simplified

Va = 0,8 * Vb

Va = 0.8 * 3126

Va = 2500 m3

Vb… outer volume of heated zones of the building

Vb = total volume- basement volume = 3126-363 = 2763m3

Number of air exchange

N = 0,5/h-1

Volume flow of ventilation air for health

Vih = n*Va

Vih = 0,5*2500

Vih = 1250 m3/h

Vih = 0,347 m3/s

12.4. Heat loss by ventilation

Qvi = 0,347* Vih * (ti,m – te)

Qvi = 0,347 * 1250* (20-(-14))

Qvi = 14747,5 W

12.5. The overall preliminary heat loss of building

Qi = Qti + Qvi

Qi = 8889,64 + 14747,5

Qi = 23,637 kW

13. Conclusion

Assessed building belongs to the class A - very efficient, according to the Czech standards. It is more energy efficient than the reference building, but nowadays we are trying to reach nearly zero energy building. The assessment of the overall heat loss of a building calculated by envelope method was established to be 23,637 kW.