BRNO UNIVERSITY OF TECHNOLOGY

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FACULTY OF CIVIL ENGINEERING

FAKULTA STAVEBNÍ

INSTITUTE OF BUILDING STRUCTURES

ÚSTAV POZEMNÍHO STAVITELSTVÍ

HOUSE WITH TATTOO STUDIO

RODINNÝ DOM S TETOVACÍM ŠTÚDIOM

CALCULATION

BACHELOR'S THESIS

BAKALÁRSKA PRÁCA

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VEDÚCI PRÁCE

BRNO 2025

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1. STAIRCASE CALCULATION

1.1. Staircase 1.PP- 1.NP

Clear height of the underground areas = 2390 m

Slab thickness = 0,25 m

Flooring 1PP = 0,23 m

Flooring 1NP = 0,15< m

Total rinse of the stairs: **H = 2770 mm**

Used equation: 2h + w = <600-650> mm, usually taken 630 mm

where: **h** = recommended rise of step

w = design width of step

supposed h' = 160 mm, value **<130-160>mm** – standard for public buildings

!! barrier-free buildings is the rise of the step h = max 160 mm

- ➔ number of steps
  n = H/h'
  n = 2770/160
  n = 17,31 -> chosen 19 steps

! max 16 steps in one flight (max 18 in family house) !

We have 2 flights, 1 flight have 9 steps and 1 have 10 steps

- ➔ real rise of step
  h = H/n
  h = 2770/19
  h = 145,789 mm < max 160 mm
- ➔ real width of step
  w = 630 – 2h
  w = 630 – 2*145,789
  w = 325,78 mm -> rounded to 10 mm down
  w = 275 mm

! min 310 mm in barrierless access building !

- ➔ slope of staircase
  tg(α) = h/w
  tg(α) = 145,80/320
  tg(α) = 25,43 **° < 28°**

! max 28° in barrierless access buildings !

- ➔ length of one flight
  L = (n-1)*w

L1 = (9-1)*275 L1= 2200 mm

L2 = (10-1)*275 L2=2475 mm

→ min width of half-space landing 900mm → chosen **900mm**

1.2. Staircase 1.NP- 2.NP

Clear height of the underground areas = 2875 m

Slab thickness = 0,25 m

Flooring 1PP = 0,15 m

Flooring 1NP = 0,15 m

Total rinse of the stairs: **H = 3225 mm**

Used equation: 2h + w = <600-650> mm, usually taken 630 mm

where: **h** = recommended rise of step

w = design width of step

supposed h' = 160 mm, value **<130-160>mm** – standard for public buildings

!! barrier-free buildings is the rise of the step h = max 160 mm

- ➔ number of steps
  n = H/h'
  n = 3225/160
  n = 20,156 -> chosen 22steps

! max 16 steps in one flight (max 18 in family house) !

We have 3 flights, 1 flight have 5 steps , 8 steps and 9 steps

- ➔ real rise of step
  h = H/n
  h = 3225/22
  h = 146,59mm < max 160 mm
- ➔ real width of step
  w = 630 – 2h
  w = 630 – 2*146,59
  w = 336,818 mm -> rounded to 10 mm down
  w = 310 mm

! min 310 mm in barrierless access building !

- ➔ slope of staircase
  tg(α) = h/w
  tg(α) = 153,409/320

$tg(\alpha) = 25{,}61$ **° < 28°**

! max 28° in barrierless access buildings !

- ➔ length of one flight — $L = (n-1)*w$

	$L1 = (5-1)*310$	$L1= 1240$ mm
	$L2 = (8-1)*310$	$L2=2170$ mm
	$L3 = (9-1)*310$	$L3= 2480$ mm

→ min width of half-space landing 900mm → chosen 900mm

2. ROOF OUTLET CALCULATION

2.1. Roof outlet

Used equation: $Q_r = A * i * C$ (l/s)

Where:

A (m^2)	Effective roof area	Acc. to ČSN EN 12 056-3
I (l/s*m^2)	Rainfall intensity	Acc. to tab.10 ČSN 75 6760:2003
C (-)	Water flow factor	Acc.to tab.11 ČSN 75 6760:2003

Effective roof area

- The effective area of the roof is determined by the footprint area of the building's roof, to which 50% of the parapet wall areas are added.

Roof footprint area A1 = 95,382 m^2

Parapet wall area A2 = 5,218/2 = 2,609 m^2

Effective roof area A3 = 95,382+2,60 = 97,991 m^2

Rainfall intensity

i = 0,03 l/s*m2

Water flow factor

C = 1

Calculation:

$Q_r = A * I * C$ (l/s)

$Q_r = 97{,}991 * 0{,}03 * 1$

Q_r = 2,94 l/s

table:

Střešní vpusti TW

Název výrobku TOPWET	Typ odvodnění	Rozměr (DN)	Doporučená návrhová kapacita průtoku naměřena dle ČSN 1253-1:2016)*	Přepočet doporučené návrhové kapacity na plochu střechy)**	Naměřený průtok TOPWET dle ČSN 1253-1:2016)***	Dovolený průtok dešťového odpadního potrubí dle ČSN 75 6760 již přepočtený na plochu střechy	
						vnitřní	vnější
TW(E) 75 S	svislé	DN 70	**5.1 l/s (35 mm)**	**170 m^2**	5.1 l/s (35 mm)	106 m^2	66 m^2
TW(E) 110 S	svislé	DN 100	**8.5 l/s (45 mm)**	**283 m^2**	5.6 l/s (35 mm)	270 m^2	100 m^2
TW(E) 125 S	svislé	DN 125	**11.2 l/s (55 mm)**	**373 m^2**	7.9 l/s (45 mm)	420 m^2	200 m^2
TW(E) 160 S XL	svislé	DN 150	**12.2 l/s (55 mm)**	**406 m^2**	8.9 l/s (45 mm)	833 m^2	300 m^2
TW(E) 75 V	vodorovné	DN 70	**4.0 l/s (35 mm)**	**133 m^2**	4.0 l/s (35 mm)	106 m^2	66 m^2
TW(E) 110 V	vodorovné	DN 100	**7.5 l/s (45 mm)**	**250 m^2**	5.4 l/s (35 mm)	270 m^2	100 m^2
TW(E) 125 V	vodorovné	DN 125	**9.1 l/s (55 mm)**	**303 m^2**	7.5 l/s (45 mm)	420 m^2	200 m^2

➔ **chosen: 2x vertical inlet TW 110 S, DN 100, flow rate 8,5 l/s**

2.2. Safety overflow

Used equation: $\mathbf{Q_{not} = (0{,}07-0{,}03 \cdot C) \cdot A}$

Where:

A (m^2) Effective roof Area Acc. to ČSN EN 12 056-3

C (-) Water flow factor Acc.to tab.11 ČSN 75 6760:2003

Calculation:

$Q_{not} = (0{,}07-0{,}03 \cdot C) \cdot A$

$Q_{not} = (0{,}07 - 0{,}03 \cdot 1) \cdot 97{,}991$

$Q_{not} =$ **3,92 l/s**

Pojistné přepady kulaté TWPP

Průtokové kapacity (l/s)			Hladina vody (mm)										
Název výrobku TOPWET	Typ odvodnění	Rozměr (DN)	5 mm	15 mm	25 mm	35 mm	45 mm	50 mm	55 mm	60 mm	75 mm	110 mm	125 mm
TWPP 50	vodorovné	DN 50	0.08	0.14	0.30	0.50	0.80	**0.90**	-	-	-	-	-
TWPP 75	vodorovné	DN 70	0.08	0.16	0.37	0.60	0.90	1.00	1.20	1.41	**1.90**	-	-
TWPP 110	vodorovné	DN 100	0.09	0.20	0.50	0.90	1.25	1.50	1.70	2.00	-	**5.50**	-
TWPP 125	vodorovné	DN 125	0.10	0.22	0.40	0.70	1.10	1.30	1.50	1.95	-	-	**7.60**

➔ **chosen: 2x safety overflow TWPP 125, DN125, flow rate 7,6 l/s**

3. FOUNDATIONS

3.1. CALCULATION OF SPANS

Important for calculation of foundation is span lin which we are calculating. In case of my house, there is one wall which goes from underground layer up to attics. Second one is wall which is peripheral wall in underground and goes up to first floor as internal load-bearing wall.

$Span_1$ is calculated as $\frac{0,3+4,22}{2} = 2,26$ m for all floors.

$Span_2$ is calculated as $\frac{4,64}{2} + 0,3 + 2,11 = 4,73$ m for floors up to first floor.

3.2. PERNAMENT LOAD

a) FLOOR IN CONTACT WITH SOIL Gd1 - UNDERGROUND

LAYER	THICKNESS [m]	DENSITY [kN/m^3]	Gk [kN/m^2]
RC slab	0,15	25	3,75
separation layer	0,0029	10	0,029
drainage layer	0,15	20	3
separation layer	0,0029	10	0,029
waterproofing layer	0,004	10	0,04
cement screed	0,05	22	1,1
thermal insulation	0,14	1,2	0,168
waterproofing layer	0,05	18	0,9
cement screed	0,05	18	0,9
waterproofing layer	0,001	10	0,01
leveling layer	0,006	18	0,108
ceramic tiles	0,01	22	0,22

		Σ=	10,254

$G_{d1} = \gamma_f$ x span x G_k = 1,35 x 1 x 10,254 = 13,843 kN/m

Permanent load for $span_1$: G_{d1} x $span_1$ = 13,8429 x 2,26 = 31,285 kN

b) FLOOR IN CONTACT WITH SOIL Gd2 -FIRST FLOOR

LAYER	THICKNESS [m]	DENSITY [kN/m³]	Gk [kN/m²]
RC slab	0,15	25	3,75
separation layer	0,0029	10	0,029
drainage layer	0,15	20	3
separation layer	0,0029	10	0,029
bitumenous waterproofing layer	0,004	10	0,04
cement screed	0,05	22	1,1
thermal insulation	0,14	1,2	0,168
asphalt layer	0,05	10	0,5
floor screed	0,05	18	0,9
board XPS	0,0055	2	0,011
laminate flooring	0,008	7	0,056
		Σ=	9,583

$G_{d2} = \gamma_f$ x span x G_k = 1,35 x 1 x 9,583 = 12,937 kN/m

Permanent load for $span_1$: G_{d2} x $span_2$ = 12,937 x 4,73 = 61,192 kN

c) BASEMENT CEILING Gd3

LAYER	THICKNESS [m]	DENSITY [kN/m³]	Gk [kN/m²]

concrete slab ceiling	0,25		3,57
lightweight ceramic concrete	0,1	6	0,6
fiberboard	0,03	5	0,15
screed	0,075	22	1,65
waterproofing layer	0,001	8	0,008
tile adhesive	0,006	16	0,096
ceramic tiles	0,01	24	0,24
		Σ=	6,314

$G_{d3} = \gamma_f$ x span x G_k = 1,35 x 1 x 6,314 = 8,524 kN/m

Permanent load for $span_1$: G_{d3} x $span_1$ = 8,524 x 2,26 = 19,264 kN

d) FIRST FLOOR CEILING Gd4

LAYER	THICKNESS [m]	DENSITY [kN/m³]	Gk [kN/m²]
concrete slab ceiling	0,25		3,57
light-weight ceramic concrete	0,1	6	0,6
fiberboard	0,03	5	0,15
screed	0,075	22	1,65
waterproofing layer	0,001	8	0,008
tile adhesive	0,006	16	0,096
ceramic tiles	0,01	24	0,24
		Σ=	6,314

$G_{d4} = \gamma_f$ x span x G_k = 1,35 x 1 x 6,314 = 8,524 kN/m

Permanent load for $span_1$: G_{d4} x $span_1$ = 8,524 x 2,26 = 19,264 kN

e) SECOND FLOOR CEILING + ROOF Gd5

LAYER	THICKNESS [m]	DENSITY [kN/m^3]	Gk [kN/m^2]
concrete slab ceiling	0,25		3,57
waterproofing layer	0,004	10	0,04
thermal insulation	0,7	2	1,4
protective layer	0,0093	10	0,093
drainage layer	0,041	5	0,205
roof substrate	0,08	12	0,96
sedum mat	0,0325	5	0,1625
		Σ=	6,4305

$G_{d5} = \gamma_f$ x span x G_k = 1,35 x 1 x 6,431 = 8,681 kN/m

Permanent load for $span_1$: G_{d5} x $span_1$ = 8,681 x 2,26 = 19,621 kN

Permanent load for $span_2$: G_{d5} x $span_2$ = 8,681 x 4,73 = 41,061 kN

f) EXTERNAL WALL IN GROUND FLOOR LB V_{d6}

LAYER	THICKNESS [m]	DENSITY [kN/m^3]	Gk [kN/m^2]
protective layer	0,005	2	0,01
thermal insulation	0,14	2,5	0,35
waterproofing layer	0,004	12	0,048
lost formwork+ concrete	0,3	22	6,6
plaster	0,01	18	0,18
stucco layer	0,002	18	0,036

Σ=	7,224

$V_{d6} = \gamma_f \times G_k = 1,35 \times 7,224 = 9,752$ kN/m

Shear force in -1st: V_{d6} x total height =

= 9,752 x 3,31 = 32,280 kN

g) INTERNAL LOAD-BEARING WALL V_{d7}

LAYER	THICKNESS [m]	DENSITY [kN/m³]	Gk [kN/m²]
ceramic tiles	0,008	23	0,184
adhesive for tiles	0,0015	18	0,027
plaster	0,01	18	0,18
supporting layer	0,005	18	0,09
load-bearing wall	0,24	10	2,4
supporting layer	0,005	18	0,09
plaster	0,01	18	0,18
waterproofing layer	0,002	12	0,024
ceramic tiles	0,008	23	0,184
		Σ=	3,359

$V_{d7} = \gamma_f \times G_k = 1,35 \times 3,359 = 4,535$ kN/m

Shear force in 1st floor : V_{d6} x total height =

= 4,535 x 2,28 = 10,339 kN

h) EXTERNAL LOAD-BEARING WALL V_{d8}

LAYER	THICKNESS [m]	DENSITY [kN/m^3]	Gk [kN/m^2]
finish layer	0,002	18	0,036
insulation layer	0,0045	2,5	0,01125
thermal insulation	0,14	1,5	0,21
mineral insulation	0,02	2,5	0,05
plaster	0,01	18	0,18
load-bearing structure	0,3	7	2,1
plaster	0,01	18	0,18
stucco layer	0,002	18	0,036
		Σ=	2,80325

$V_{d8} = \gamma_f \times G_k$ = 1,35 x 2,803= 3,784 kN/m

Shear force in 1st and 2nd floor : V_{d6} x total height =

= 3,784 x 6,35 = 24,029 kN

i) ROOF ATTIC V_{d9}

LAYER	THICKNESS [m]	DENSITY [kN/m^3]	Gk [kN/m^2]
plaster	0,002	18	0,036
adhesive mortar	0,003	18	0,054
thermal insulation	0,14	2,5	0,35
lost formwork + concrete	0,3	22	6,6
thermal insulation	0,14	2,5	0,35
adhesive mortar	0,003	18	0,054

stucco layer	0,002	18	0,036
		Σ=	7,48

$V_{d9} = \gamma_f \times G_k$ = 1,35 x 2,803 = 10,098 kN/m

Shear force in: V_{d9} x total height =

= 10,098 x 1,0 = 10,098 kN

3.3. VARIABLE LOAD

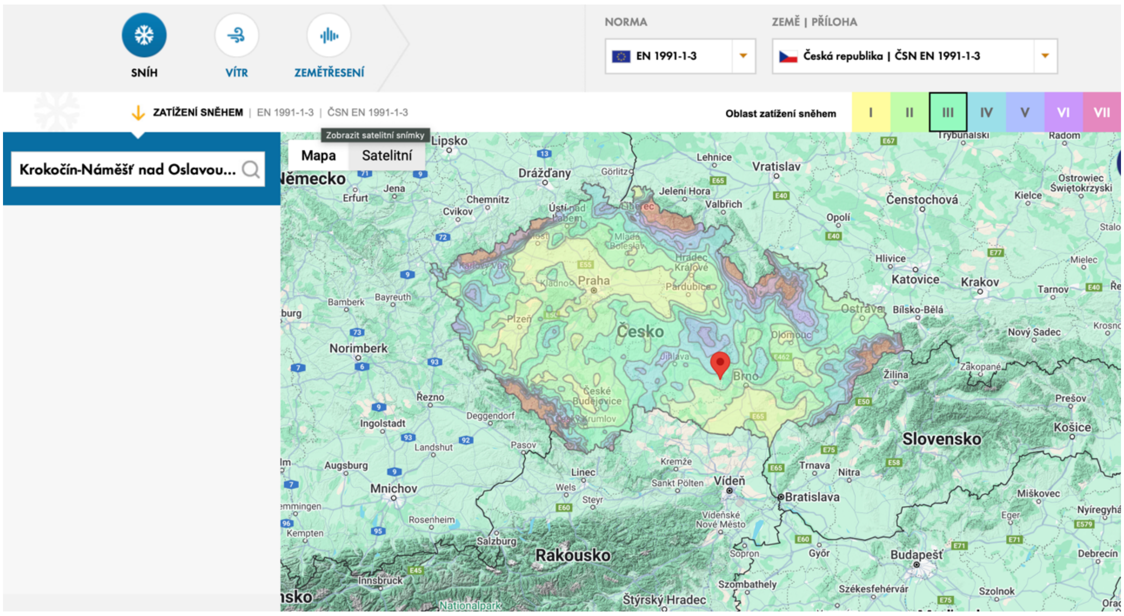
Varieble load for whole calculation is 2,5 kN/m- office buildings and garages. Even though for living area is used 1,5 kN/m, we want to be on the safe side.

$Q_d = \gamma_q \times Q_d = 1{,}5 \times 2{,}5 = 3{,}75$ kN/m

Variable load for $span_1 = Q_d \times span_1 \times$ number of floors $= 3{,}75 \times 2{,}26 \times 3 = 25{,}425$ kN

Variable load for $span_2 = Q_d \times span_2 \times$ number of floors $= 3{,}75 \times 4{,}73 \times 2 = 35{,}475$ kN

3.4. SNOW LOAD



For calculation of snow load by using Dlubal map for s_k. Snow zone is III. = 1,5 kN/m^2, for location Krokočín.

$s_d = \gamma_q \times s_k = 1{,}5 \times 1{,}5 = 2{,}25$ kN/m

Snow load for $span_1 = 2{,}25 \times 2{,}26 = 5{,}085$ kN

Snow load for $span_2 = 2{,}25 \times 4{,}73 = 10{,}643$ kN

3.5. RESULTING LOADS

Resulting load for $span_1$ for foundation 1:

$G_{d1} + G_{d3} + G_{d4} + G_{d5} + V_{d6} + V_{d7} + V_{d8} + V_{d9} + Q_{d1} + S_{d1}$ =

31,285 + 19,264 + 19,264 + 19,621 + 9,752 + 2,525 + 3,784 + 10,098 + 25,425 + 5,085 = 146,103 kN

Resulting load for $span_2$ for foundation 2:

$G_{d2} + G_{d5} + V_{d6} + V_{d7} + V_{d9} + Q_{d2} + S_{d2}$ =

61,192 + 41,061 + 9,752 + 2,525 + 10,098 + 35,475 + 10,642 = 170,745 kN

3. CALCULATION OF DIMENSION OF FOUNDATIONS

a) Foundation strip n. 1

$\mathbf{A_{eff}} = \frac{G_d}{R_{dt}} = \frac{146,103}{250} = 0,5844 \text{ m}^2$

$A_{eff} = l \times b$ (for foundation strip l = 1m)

$0,5844 = 1 \times b \Rightarrow b = 0,5844 \approx 0,8$ m

$a = \frac{b-d}{2} = \frac{0,8-0,3}{2} = 0,25$ m

height of the foundation h (m)

h = a x tg (α) = 0,25 x tg (45) = 0,25 => 0,8 m

- minimal height for sandy soil is 0,8 m for height

check:

$\boldsymbol{\sigma} \leq Rdt$

$A_{eff} = 0,8 \times 0,8 = 0,64 \text{ m}^2$

$\boldsymbol{\sigma} = \frac{G_d}{A_{eff}} = \frac{146,103}{0,64} = 228,286$ kPa

228,286 kPa ≤ 250 kPa

b) Foundation strip n. 2

A_{eff} = $\frac{G_d}{R_{dt}} = \frac{170,745}{250}$ = 0,683 m^2

A_{eff} = l x b (for foundation strip l = 1m)

0,683 = 1 x b => b = 0,683 ≈ 0,8 m

a = $\frac{b-d}{2} = \frac{0,9-0,3}{2}$ = 0,3 m

height of the foundation h (m)

h = a x tg (α) = 0,3 x tg (45) = 0,3 => 0,8 m

- minimal height for sandy soil is 0,8m for height

check:

$\boldsymbol{\sigma}$ ≤ Rdt

A_{eff} = 0,8 x 0,8 = 0,64 m^2

$\boldsymbol{\sigma} = \frac{G_d}{A_{eff}} = \frac{170,745}{0,64}$ = 237,145 kPa

237,145 kPa ≤ 250 kPa