Static Preliminary Design Report

Diploma Theses

Luxurious Villa

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Basic Information:

The project is to build a luxurious villa in Prague by the Eurocode and the Czech standard norms but in Arabic style.

1. General information

The building is located Prague – Průhonice, Růžová street. The investor is an Arabic man who wants to live in Prague but in Arabic style as much as possible. The building is design economically and utilizing modern ways of design and construction. The project emphasizes in good quality. The project utilized orthogonal architecture to blend in with the surrounding of nice and efficient buildings. Czech standard norms and the Eurocodes were used during the design.

2. Basic information

The building has 2 floors one ground floor and another upper ground floor, and the roof is walkable. The Length is 22.3 m & Width is 30.4 m, Height above the ground is 9.3 m. Parking spaces are located outside of the building. There are two floors, in the first floor there are two visitors hall, one for men and another for women, one dining room, four bedrooms for visitors (we also can divide them as two for men and another two for women, also it depends on the amount of visitors and the owner how to divide them), three bathrooms and one bathrooms where there are only washing basin, one balcony where the visitor hall and the dining room and in the middle of the house there is a big hall which is it for the family and consist the staircase to the other floor with opening to the next floor, total used area is 396 m^2. In the upper floor is going to be only for the family, nine bedrooms, two balconies, three bathrooms, two cloths room (or storage, it depends on the family), on corridor where connect the upper floor and the staircase ground floor and the roof through the upper floor and one technical room, totally area is ??? m^2. In the roof, is going to be walkable where the family could use it as much as possible and mainly in the summer, there is air handling unit for the ventilation.

3. Structural system

The building is obtained by two floors above the ground. The structural system of the building is consisting masonry wall and reinforced concrete slab, flat walkable roof. One-way slab with height 250 mm and the wall is made of Ytong Statik P5, 300 mm inner wall and Ytong Lambda

YQ P2.2, 500 mm the outer wall, with mortar class M5. The staircase is made with a reinforced concrete. The foundation is made of strip footing plain concrete.

Cod used: ČSN EN 1992-1-1 Eurocod 2

4. Materials

Concrete:

Reinforced concrete walls (communication areas)

C30/37 exposure class XC2, structural class S4

Reinforced concrete slabs

C30/37 exposure class XC2, structural class S4

Plain concrete strip footing foundations

C30/37 exposure class X0, structural class S4

Reinforcement bars: B500B

Ytong:
outer bearing and nonbearing wall is made of Ytong Lambda YQ P?, 500mm
Inner bearing walls made of Ytong Klasik P5, 300mm

5. Loads

The load generated from one-way slab first floor composition is 10.87 kN/m^2

The load generated from one-way slab roof composition is 11.14 kN/m^2

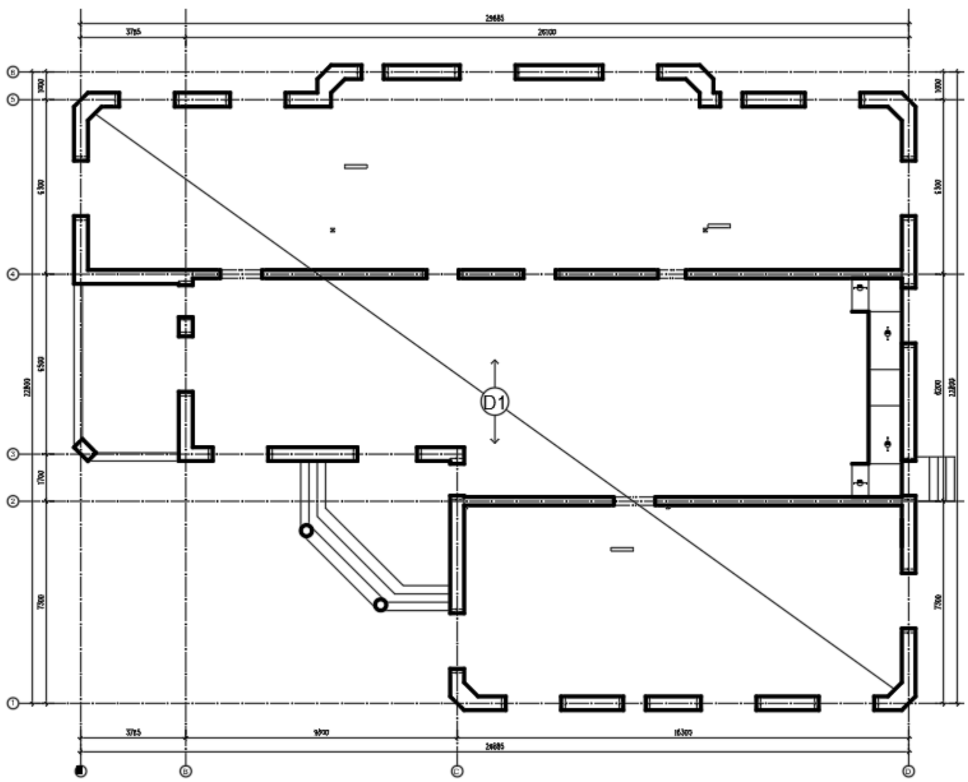
Live load for floor for domestic building is 2.0 kN/m^2

Live load for roof for domestic buildings (walkable roof) is 2 kN/m^2

Snow load =0.56 kN/m^2

6. Preliminary design:

Structural Scheme



I. <u>Design of the structural dimensions:</u>

1. Depth of the slab: h_s

One-way slab

1.1- Empirical estimation: $h_s = \left(\frac{1}{30} \sim \frac{1}{25}\right) l$

Concrete class: C30/37

$h_s = \left(\frac{1}{30} \sim \frac{1}{25}\right) * 6500 \text{ mm} = (217 \sim 260)\text{mm}$

Steel: B500B

h_s = 250 mm.

1.2- Effective depth: $d = h_s - c - \frac{\emptyset}{2}$

1.2.1- Cover depth: c → $c = c_{min} + \Delta c_{dev}$ → 100 years work life, Structural class XC2

c_{min}=max($c_{min,b}$:$c_{min,dur}$:10)mm → c_{min}=max(10:10:10)mm → c_{min}= 10 mm

$c = c_{min} + \Delta c_{dev}$ → c = 20 → c = 25 mm.

$d = h_s - c - \frac{\emptyset}{2}$ →

Steel bar: Ø 10 mm

$d = 250 – 25 - \frac{10}{2}$ → d = 220 mm.

d = 220 mm.

1.3- Span/depth ratio (deflection control):

$\lambda = \frac{l}{d} \leq \lambda_{lim} = k_{c_1} k_{c_2} k_{C_3} \lambda_{d,tab}$

k_{c_1} - effect of shape =1.0

$\lambda = \frac{6500 \text{ mm}}{220 \text{ mm}} \leq \lambda_{lim}$ = 1*1*1.2*30.8 ?

k_{c_2} - effect of span = 1.0

k_{c_3} - effect of reinforcement = 1.2

$\lambda_{d,tab}$ for slab consider the value for 0.5% reinforcement ratio, C30/37 = 30.8

→ $\lambda = 29.5 < \lambda_{lim} = 36.96$ Okay

2. Design of the Wall:

2.1- Calculation of the load:

Slab Load					
			Characteristic	γ_F	Design
			[kN/m^2]		[kN/m^2]
Permanent					
	Self-weight	$0.25m \times 25 \frac{kN}{m^3}$	6.25		
	Other	Floor structure	1		
		Partition wall	0.8		
	∑		8.05	1.35	10.87

Variable					
	Category A		2	1.5	3
∑			10.05		≈14
Roof Load					
			Characteristic	γ_F	Design
			[kN/m²]		[kN/m²]
Permanent					
	Self-weight	$0.25m \times 25\frac{kN}{m^3}$	6.25		
	Other		2		
	∑		8.25	1.35	11.14
Variable					
	Snow		0.56	1.5	0.84
	Live load		2	1.5	3
∑			10.81		≈15

2.2- Calculation of variable load:

Snow load s_k: $s_k = \mu_i C_e C_t s$ s_k = 0.8*1*1*0.7 s_k = 0.56

2.3- Calculation of N_{Ed} for the inner load bearing wall:

2.3.1- Tributing area

A = 1*6.5 = 6.5 m²

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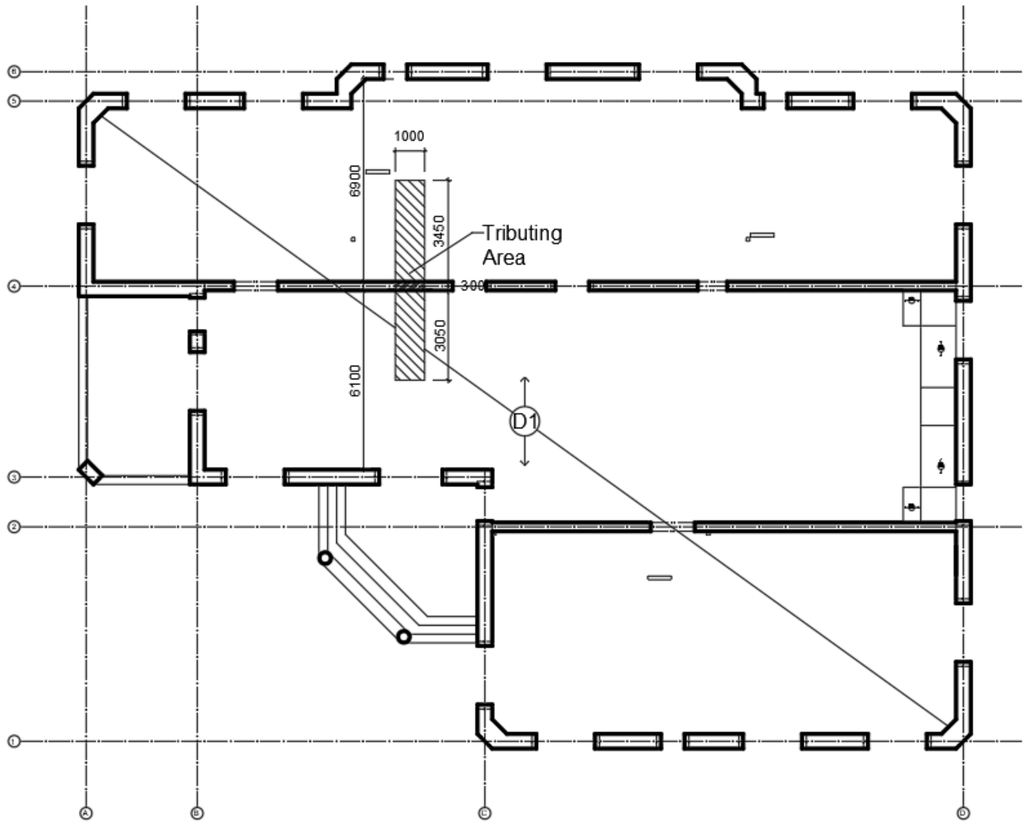


2.3.2- Estimation 1 m self-weight of the inner wall

Self-weight of the masonry, Ytong Statik 300 = 6.6 kN/m^3

Characteristic value of the masonry wall = 6.6 kN/m^3 * 0.3 m = 1.98 kN/m^2

Self-weight = 1.98 kN/m^2

Hight of the floor = 3.6 m, 2 floors

2.3.3- Load from the structures above:

Dead load	kN/m2	B (m)	kN/m	γ_F	kN/m
floor	8.05	6.5	52.33	1.35	70.65
roof	8.25	6.5	53.63	1.35	72.4
Wall self weight	1.98	2*3.6	14.26	1.35	19.25
Live load					
floor	2	6.5	13	1.5	19.5
roof	2.56	6.5	16.64	1.5	24.96
∑	22.84		**149.86**		**206.76** ≈207

N_{Ed} = 207 kN/m * 1 m → **N_{Ed} = 207 kN**

2.3.4- Strength of masonry/Ytong Statik P5, 300 mm with mortar class M5

Characteristic Strength of the masonry $f_k = 3.14\ N/mm^2$

Design Strength of the masonry $f_d = fk/\ \gamma_M = 3.14/2.2$ → $f_d = 1.43\ N/mm^2$

2.3.5- Dimension of the wall

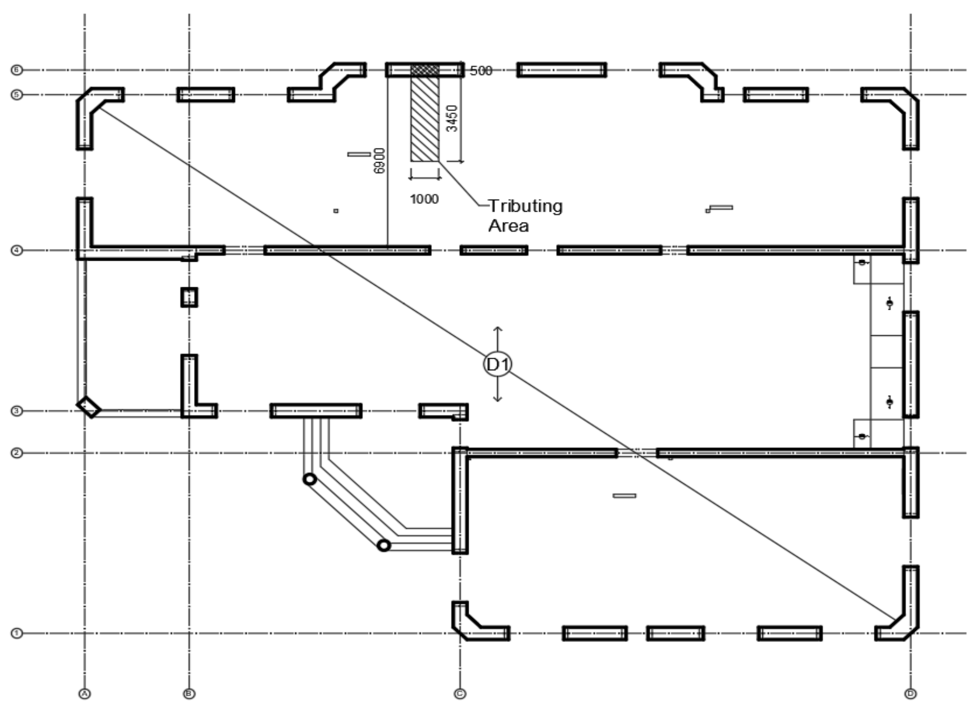
$A_{req} = N_{Ed}/(0.7*f_d)$→ $A_{req} = 207\ 000N/(0.7*1.43N/mm^2)$ → $A_{req} = 206\ 793\ mm^2$

$A_{prov} \geq Areq$ → $A_{prov} = b*t = 300mm*1000mm \geq Areq = 206\ 793\ mm^2$

$A_{prov} = 300\ 000\ mm^2 > A_{req} = 206\ 793\ mm^2$ → Design is satisfied

2.4- Calculation of N_{Ed} for the outer load bearing wall:

2.4.1- Tributing area
A = 1*3.45 ≈ 3.5 m²



2.4.2- Estimation 1 m self-weight of the outer wall

Self-weight of the masonry, Ytong Lambda YQ 500 = 4 kN/m^3

Characteristic value of the masonry wall = 4 kN/m^3 * 0.5 m = 2 kN/m^2

Self-weight = 2 kN/m^2

Hight of the floor = 3.6 m, 2 floors

2.4.3- Load from the structures above:

Dead load	kN/m2	B (m)	*kN/m*	γ_F	kN/m
floor	8.05	3.5	28.18	1.35	38.04
roof	8.25	3.5	28.88	1.35	38.98
Wall self weight	2	2*3.6	14.4	1.35	19.44
Live load					
floor	2	3.5	*7*	1.5	10.5
roof	2.56	3.5	8.96	1.5	13.44
∑	22.84		**87.42**		**120.4** ≈121

N_{Ed} = 121 kN/m * 1 m → **N_{Ed} = 121 kN**

2.4.4- Strength of masonry Ytong Statik P2.2, 500 mm with mortar class M5

Characteristic Strength of the masonry f_k = 1.25 N/mm^2

Design Strength of the masonry f_d = fk/ γ_M = 1.25/2.2 → f_d = 0.57 N/mm2

2.4.5- Dimension of the wall

A_{req} = N_{Ed}/(0.7*f_d)→ A_{req} = 121 000N/(0.7*0.57N/mm^2) → A_{req} = 303 258 mm^2

A_{prov} ≥ Areq → A_{prov} = b*t = 500mm*1000mm ≥ Areq = 303 258 mm^2

A_{prov} = 500 000 mm^2 > A_{req} = 303 258 mm^2 → Design is satisfied

According to the calculations above all the load-bearing structures is designable and it will carry the load successful.

II. Design of plain concrete Foundation

1. Inner foundation Pad Strip:

N_{Ed} = 207 kN

Type of the Soil: Very Clayey Gravel

R_d = 200 kPa for B = 1 m

$G_o = 0.1\ N_{Ed} \rightarrow G_o = 21$ kN

$\sigma = \frac{N_{Ed}+G_0}{A_{eff}} \leq R_d$

A_{eff} = (207 + 21)/200 = 1.14 m^2

A_{eff} = b*(b-2e) e=5%b

b^2–2b*0.05b=1.14 → **b=1.2 m**

h = a tan α

h =((1.2-0.3)/2)*tan(60^o)→ **h=0.8m**

A_{eff} = b*(b-2e)

A_{eff} = 1.2*(1.2-2*0.05*1.2) A_{eff} = 1.3 m^2

Design Stress:

$\sigma d = N_{Ed} / A_{eff}$

σd = 159.7 kN/m^2

Bending Moment:

$m_c = 0.5 * \sigma d * a^2$

m_c = 16.2 kNm/m

Tensile strength of concrete:

f_{ctd} = (0.8*2)/1.5

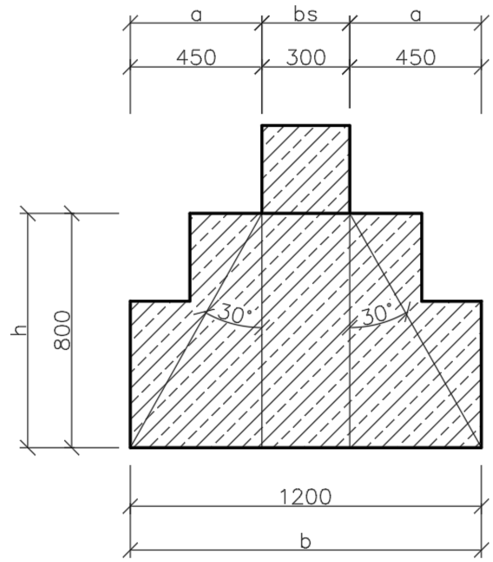
f_{ctd} =1.07 MPa (N/mm^2)

G = b*b*h*25 → G = 28.8 kN

Check of the footing:

1. Tensile stress < Tensile strength of concrete:
   $\sigma = m_c/W = m_c/(bh^2/6) < f_{ctd}$ $\sigma = 0.2$ MPa $< f_{ctd} = 1.07$ MPa Satisfied

2. Stress under the footing < Strength of subsoil
   $\sigma = (N_{Ed} + G)/A_{eff} < R_d$ $\sigma = 181$ kPa $< R_d = 200$ kPa   Satisfied



Design of inside Strip Footing is 1.2 m width and 0.8 m depth.

2. Outer foundation Pad Strip:

N_{Ed} = 121 kN

Type of the Soil: Sandy Gravel

R_d = 200 kPa

$G_o = 0.1\ N_{Ed} \rightarrow G_o = 12.5$ kN

$\sigma = \frac{N_{Ed}+G_0}{A_{eff}} \leq R_d$

A_{eff} = (121 + 12.1)/200 = 0.67 m^2

A_{eff} = b*(b-2e),e=5%b

b^2–2b*0.05b-0.57=0 → **b=0.9 m**

h = a tan α

h =((0.9-0.5)/2)*tan(60°) → **h= 0.4 m**

A_{eff} = b*(b-2e) A_{eff} = 0.9*(0.9-2*0.05*0.9) A_{eff} = 0.73 m^2

Design Stress:

σd = N_{Ed} / A_{eff}

σd = 166 kN/m^2

Bending Moment:

m_c = 0.5 * σd *a^2

m_c = 3.3 kNm/m

Tensile strength of concrete:

f_{ctd} = (0.8*2)/1.5

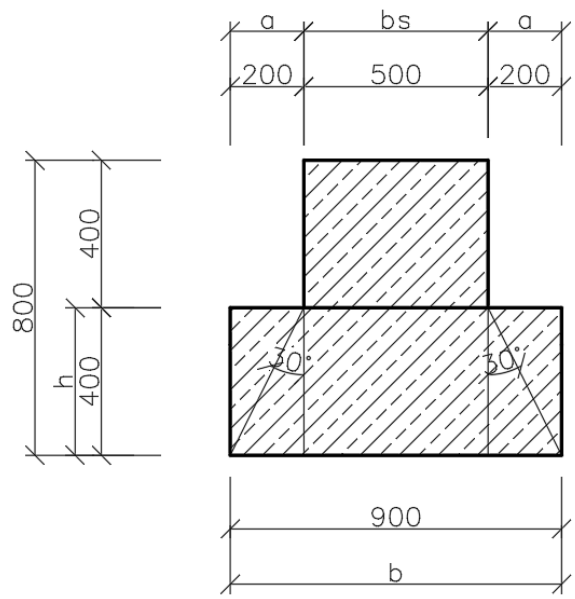
f_{ctd} =1.07 MPa (N/mm^2)

G = b*b*h*25 G = 3.2 kN → G = 8.1

Check of the footing:

1. Tensile stress < Tensile strength of concrete:
   $\sigma = m_c/W = m_c/(bh^2/6) < f_{ctd}$ $\sigma = 0.44$ MPa $< f_{ctd} = 1.07$ MPa Satisfied

2. Stress under the footing < Strength of subsoil
   $\sigma = (N_{Ed} + G)/A_{eff} < R_d$ $\sigma = 170$ kPa $< R_d = 200$ kPa Satisfied



Design of Strip Footing is 0.9 m width and 0.4 m depth.

III. Design of the staircase:

Design of the geometry of the staircase:

1.1- Dimension of the structure:

Height of the floor h_k =3600 mm

Depth of the main slab h_s = 250 mm

Depth of floor structure h_f = 100 mm

Thickness of cladding of the stairs h_c = 30 mm

1. 2- Dimensions of the staircase

Ideal height of one step in the administration building is 160 mm

$\frac{3600}{165}$ = 22 → 2 steps (4 flights with 3, 8, 8 and 3 steps)

Height of one step $h = \frac{3600}{22}$ = 164 mm

Width of one step $b = 630 - 2h$ = 300 mm

Staircase with 164/300 mm steps, 4 flights with 3, 8, 8 and 3 steps.

1.3- Other dimensions:

Width of the flight = 1200 mm

Width of the landing = 1200 mm

Slope of the staircase is: $\alpha = \arctan \frac{164}{300} = 28.7°$.