Czech Technical University in Prague
Faculty of Civil Engineering Thákurova 7, 166 29 Praha 6

TECHNICAL REPORT
PART CONCRETE

Diploma Project
RESIDENTIAL APARTMENT BUILDING

Name: Bc. Yosufi Mohammad Fayez
Consultant: Ing. Josef Novák, Ph.D.
Academic year: 2019/2020
Signature:
Apartment Building Multifunctional

Identification data:

- **Project name:** Residential apartment building (Multifunctional)
- **Location:** Prague Pod Harfou
- **Function of the building:** Apartment building, Administrative, Shopping, Garage.
- **Stage:** Building permits.
- **Investor:** Private.
- **Supplier:** Will be selected by tender.

2. General description of architectural and engineering design of the building:

a) Purpose of this object:

- This Apartment building is located in an urban area Pod Harfou Prague 09 Czech Republic the total area of the building is 667 m² this building is consists of 7 floors including of the basement, the basement is provided for car parking, ventilation and boiler rooms for the whole residence of the building and on the ground floor there is stores and storage’s, staircase, elevators, roof is not accessible to public except repair and maintain reason there s also 4 Apartments

Apartments type:

- Basement: boiler room, ventilation room 1x staircase, 1x corridors, 1x elevator the rest of the area is provided for motor and car parking.
- Ground floor: 1x staircase, 1x elevator 8x corridors, 1x toilets, 1x shopping, 1x technical room and also there is 24x storage's.
- 2nd floor: 10x offices 1x men toilet, 1x women toilet, 1x disable toilet, 1x cleaning room 1x corridor, 1x staircase, 1x elevator and 1x balcony in one sides of the building.
- On the 3th to the last floors which is 4x apartment, each apartment consists of 1x bed room, 1x bath with toilet, 1x corridor, 1x kitchen with dinning room except apartment A-J as they have one single bed room.
- there is opening in order to have accessibility to the roof for service or emergency case.
- Generally Surrounding the building with dimension of 1,5m there is stone pavements and the other area of the building will be after the rough landscaping grassed and planted with low and medium greenery.
- Generally in order to prevent the transformation of noise to the structure, Sound which transmission caused by footsteps on staircases can be an unpleasant experience and design, insufficient impact sound insulation can cause discomfort to my design, the acoustic solution is done by HTT Halfen system (impact sound insulation) The solutions can be done by 3 steps.

- A: flight to the landing connection is done by HALFEN HTT impact sound insulation unit with the length of l = 1200 mm with its fire grading F90/F120 – impact sound pressure level L = 12 dB.
- B: the connection between landing and main bearing structure which support the landing is implemented by HBB-T Halfen bi-trapez box bearing at the bottom.
- C: HTPL joint sheets insulation to be attached on the side wall, following the stairway, using the integrated self-adhesive tape. The joints must be cleaned and carried out without lack the width shall be 50 mm it is adhesive tape.
4. Evaluation of structural solutions:

Due to structural solution for main bearing elements and their satisfactory together with architects plan there are several solution for basement which is a wall system and it more suits to our projects to determine a wall system ans slab without beam and several other solution for further floors but from all alternatives the structural solutions of variant A,C is determined for our design.

4.1 Evaluation of structural solution in basement:

In the basement one of the best key function to solve the structural solution is that the two-way monolithic concrete solid slab with depth $h = 200$ mm supported by columns $300x300$mm and reinforced concrete walls in all external parts of the building in the both directions by the way slab without beam is used here in order to prevent reduction of the basement height. Also slab of the staircase is assumed as a one-way slab which is supported in concrete walls. the judgments of the geometry of structural elements is given later.

This solution can reduce both depth and reinforcement of the slab, but has the inconvenience of beams, which may hinder matching the internal walls sequence, especially for dwellings. For a safe preliminary evaluation of the quantity of materials the slab “voids” due to stairs and lifts assumed as not present. The resulting extra volume of concrete takes into accounts deformations of form works and any loss of concrete during casting (pump filling, etc.).

4.2. Evaluation of structural solution in ground:

In the ground floor one of the key function to solve the structural solution is that the tow-way concrete solid slab with depth $h = 200$ mm supported by $(300 \times 300)$ mm columns and reinforced concrete walls wit the thickness of $300$mm in all external parts of the building in the both directions, so main bearing elements are horizontally concrete slab, shell and vertically reinforced walls,colums. The system is a combine solution.

Also slab of the staircase is assumed as a one-way slab which is supported in concrete walls. the judgments of the geometry of structural elements is given later,as e can see that in the ground floor( floor above)of it is provided for the offices with very light weight of the partitions walls, therefore two way monolithic concrete slab or slab without beam is one the convenient way to solve the bearing structures.

Shell is supported vertically by two columns and horizontally with tow beams.

Obviously this solution can make ease the reduction height on one sides which is provided for stores.

Also in order to prevent lateral loads the building is provided by several shear walls in both sides and concrete core.

4.3 Evaluation of structural solution 2nd floors(Office):

In the 2th floors which is provided to be a offices with the balcony, the key function to have a solution for the structure is that the two-way monolithic concrete solid slab with depth $h = 200$ mm supported by $(300 \times 300)$ mm columns and reinforced concrete walls on both sides with the thickness of $t = 300$mm the system is mainly a combined system, the two external parts of the building in the one directions is provided concrete walls and in the other sides is masonry porotherm bricks $300$mm which is a dry fix system,Also slab of the staircase is assumed as a one-way slab which is supported in concrete walls. the judgments of the geometry of structural elements is given later. This solution can make ease the detailing connection of the thermal insulation's and has high economic benefits in compare to other solutions.
This is mention-able that the building is supported by two reinforced concrete walls with the thickness of 300mm from basement to the final finished structures in order to prevent lateral loads, the concrete core of sufficient to prevent lateral load as well as the two other walls.

4.4 Evaluation of structural solution from 3th to the seven floors (Apartments):

Obviously from 3th floors to the seven floors which is provided to be apartments with the balcony and one of the key function to have a solution for the structure is that the two-way monolithic concrete solid slab with depth \( h = 200 \text{ mm} \) supported by reinforced concrete walls with the thickness of 300mm on two sides and and 300 mm masonry bricks on one sides and concrete columns 300x300mm, the system is mainly a combined system, the two external parts of the building in the both directions is provided concrete walls and in the other sides is masonry Porotherm bricks 300mm which is a dry fix system, Also slab of the staircase is assumed as a one-way slab which is supported in concrete walls. the judgments of the geometry of structural elements is given later. This solution can make ease the detailing connection of the thermal insulation's and has high economic benefits in compare to other solutions.

The highest benefits in this solution is that supporting of each flat with two reinforced concrete walls can make a perfect fixed joint and basically it can prevent sound transmissions, deformation and etc. …

This is mention-able that the building is supported by two reinforced concrete walls with the thickness of 300mm from basement to the final finished structures in order to prevent lateral loads, the concrete core of sufficient to prevent lateral load as well as the two other walls.

5. Evaluation of loads:

Structure is designed according to eurocodes therefore permanent, variable, and snow loads are take in to consideration during the design evaluations within respect to safety factors.

6. Loads bearing elements:

As the structure is a combine system of bearing elements there are walls columns beams are as a main bearing element.

7. Horizontal elements:

Horizontal bearing elements are monolithic one way / two way reinforced concrete slab and beams firstly the concrete slab is transferring the load to to the columns then vertically transferred to the foundations.

8. Vertical elements:

In this structure the main bearing elements are walls and columns so both of this element transferring the load from roof to the foundation of the structures.

9. Stiffening elements:

So, in order to prevent the displacement of the building due to lateral loads, therefore there are walls on both sides of the building with concrete core which is located in elevator shaft so this elements with their corporations can present as a main stiffening element.

10. Vertical communications:

One-way staircase and elevator are as a main communication in the buildings both of them initiate from the basement till the 5th floors, there is one opening in last floor in order to have accessibly to the roof.

---

Student: Bc. Yosufi Mohammad Fayez 2th year, Building Structures, Civil Engineering Czech Technical University In Prague
Subject: Diploma project 01.10.2019
Object: Residential Apartment Building (Multifunctional)
11. Foundation:

Basically the general vertical load of the building is distributed vertically by two courses of the shallow foundations into subsoil.

1) By reinforced concrete wall from whole round of the building including of concrete core, in subsoil bearing capacity shall be provided with strip footing.

2) By reinforce concrete columns which positioned mainly inside of the building, in subsoil bearing capacity shall be provided with pad footing.

Generally this strip foundation is a continues reinforced concrete strip on which the load bearing walls with the thickness of 300 mm are built centrally.

This represents a level base for the walls and its dimensions must be sufficient to allocate the load imparted to the foundation to subsoil area capable of supporting the building weight without excessive compaction, so due to the fact that the use of concrete as it is easy to place, spread and level in the foundation trench. Due to its ability to harden concrete creates a basis for walls and develops proper compressive strength to support the foundations’ load therefore The basic purpose of this foundation is to spread the load over a larger area so that the soil is able to withstand the stress, and safe bearing pressure is not exceeded. This represents a level base for the walls and its dimensions must be sufficient to allocate the load imparted to the foundation to subsoil area capable of supporting the building weight without excessive compaction, so due to the fact that the use of concrete as it is easy to place, spread and level in the foundation trench. Due to its ability to harden concrete creates a basis for walls and develops proper compressive strength to support the foundations load, therefore the basic purpose of this foundation is to spread the load over a larger area so that the soil has capability to withstand the stress, and safe bearing pressure is not exceeded.
Preliminary Design (Design dimensions of all elements)

Apartment Building Multifunction

Name: Bc. Yosufi Mohammad Fayez
Consultant: Ing. Josef Novák, Ph.D.
Academic year: 2019/2020
Signature:
Contents:

- General description of the building.
- Evaluation of structural solution in basement.
- Evaluation of structural solution in ground floor.
- Evaluation of structural solution in second floor.
- Evaluation of structural solution from second to fifth floors.
- Preliminary design dimension of all bearing elements.
- Fundamental Requirements.
- Design cover for main reinforcement.
- General determination of Slab, beam, column, walls depth design.
- Evaluation of the loads in the structure.
- Strength of masonry.
- Design of ceramic lentils.
- Design the geometry of the staircase.
- Dimensions of the staircase.
- Preliminary check of the depth of the slab.
- Perpendicular and head clearance of the staircase.
- Evaluation of the loads in staircase.
General description of the building:

This is mention-able that this apartment building (multifunctional) is located in an urban area Pod Harfou of the Prague Czech Republic the total area of the building is 667 m² this building is consist of 7 floors including of the basement. Basically, the basement is provided for car parking, ventilation and boiler rooms for the whole residence of the building and on the ground floor there is stores and storage’s, staircase , elevators.
Subject: Diploma Project

Object: Residential Apartment Building (Multifunctional)
**Evaluation of structural solution in basement:**

In the basement one of the best key function to solve the structural solution is that the two-way monolithic concrete solid slab with depth \( h = 200 \text{ mm} \) supported by columns 300x300mm and reinforced concrete walls in all external parts of the building in the both directions by the way slab without beam is used here in order to prevent reduction of the basement height. Also slab of the staircase is assumed as a one-way slab which is supported in concrete walls. The judgments of the geometry of structural elements is given later.

This solution can reduce both depth and reinforcement of the slab, but has the inconvenience of beams, which may hinder matching the internal walls sequence, especially for dwellings. For a safe preliminary evaluation of the quantity of materials the slab “voids” due to stairs and lifts assumed as not present. The resulting extra volume of concrete takes into accounts deformations of form works and any loss of concrete during casting (pump filling, etc.).

**BASEMENT : - 6,420 M, - 3,320M**

![Diagram of basement structural solution]

**Evaluation of structural solution in ground floor:**

In the ground floor one of the key function to solve the structural solution is that the tow-way concrete solid slab with depth \( h = 200 \text{ mm} \) supported by (300 x 300) mm columns and reinforced concrete walls wit the thickness of 300mm in all external parts of the building in the both directions, so main bearing elements are horizontally concrete slab, shell and vertically reinforced walls, columns. The system is a combine solution.
Also slab of the staircase is assumed as a one-way slab which is supported in concrete walls. The judgments of the geometry of structural elements is given later. As we can see that in the ground floor (floor above) of it is provided for the offices with very lightweight of the partitions walls, therefore two way way monolithic concrete slab or slab without beam is one the convenient way to solve the bearing structures.

Shell is supported vertically by two columns and horizontally with two beams.

Obviously this solution can make ease the reduction height on one side which is provided for stores.

Also in order to prevent lateral loads the building is provided by several shear walls in both sides and concrete core.

**Evaluation of structural solution 2nd floors (Office):**

In the 2nd floors which is provided to be offices with the balcony, the key function to have a solution for the structure is that the two-way monolithic concrete solid slab with depth $h = 200$ mm supported by $(300 \times 300)$ mm columns and reinforced concrete walls on both sides with the thickness of $t = 300$ mm the system is mainly a combined system, the two external parts of the building in the one direction is provided concrete walls and in the other side is masonry porotherm bricks $300$ mm which is a dry fix system. Also slab of the staircase is assumed as a one-way slab which is supported in concrete walls. The judgments of the geometry of structural
elements is given later. This solution can make ease the detailing connection of the thermal insulation's and has high economic benefits in compare to other solutions.

This is mention-able that the building is supported by two reinforced concrete walls with the thickness of 300mm from basement to the final finished structures in order to prevent lateral loads, the concrete core of sufficient to prevent lateral load as well as the two other walls.

**Evaluation of structural solution from 3th to the seven floors(Apartments):**

Obviously from 3th floors to the seven floors which is provided to be apartments with the balcony and one of the key function to have a solution for the structure is that the two-way monolithic concrete solid slab with depth \( h = 200 \) mm supported by reinforced concrete walls with the thickness of 300mm on two sides and and 300 mm masonry bricks on one sides and concrete columns 300x300mm, the system is mainly a combined system, the two external parts of the building in the both directions is provided concrete walls and in the other sides is masonry Porotherm bricks 300mm which is a dry fix system. Also slab of the staircase is assumed as a one-way slab which is supported in concrete walls. The judgments of the geometry of structural elements is given later. This solution can make ease the detailing connection of the thermal insulation's and has high economic benefits in compare to other solutions.
The highest benefits in this solution is that supporting of each flat with two reinforced concrete walls can make a perfect fixed joint and basically it can prevent sound transmissions, deformation and etc.…

This is mention-able that the building is supported by two reinforced concrete walls with the thickness of 300mm from basement to the final finished structures in order to prevent lateral loads, the concrete core of sufficient to prevent lateral load as well as the two other walls.

Preliminary Design (Design dimensions of all elements)

Apartment House Multifunction

Fundamental Requirements:

Used documents, standards

ČSN EN 1990 Eurocode: Basis of structural design
ČSN EN 1991-1-1 Eurocode 1: Actions on structures: General actions - Densities, self-weight and imposed loads.
ČSN EN 1991-1-3 Eurocode 1: Actions on structures: General actions - Snow loads
ČSN EN 1991-1-4 Eurocode 1: Actions on structures: General actions - Wind


1: basic materials of concrete and steel.

Concrete:

Strength class of the concrete  C40/50[Mpa]
Characteristic cylinder strength.  $f_{ck} = 40 \text{ [MPa]}$
Cube Characteristic cube strength.  $f_{ck} = 50 \text{ [MPa]}$
Target mean cylinder strength.  $f_{cm} = 48 \text{ [MPa]}$
Mean axial tensile strength.  $f_{cm} = 3.5 \text{ [MPa]}$
Mean secant modulus of elasticity.  $E_{cm} = 35 \text{ [GPa]}$
Concrete density.  $\rho = 2500 \text{ [kg/m}^3\text{]}$
Partial safety factor for concrete.  1.5 [-]

Steel:

Steel grade B500 S B

The Class is  B
Characteristic yield strength  $f_{yk} = 500 \text{ [Mpa]}$
Characteristic strain at maximum force  $\epsilon_{uk} = 5 \text{ [%]}$
Density  $\rho = 7850 \text{ [kg/m}^3\text{]}$
Modulus of elasticity  $E = 210 000 \text{ MPa [N/mm}^2\text{]}$
Partial safety factor for steel  1.15 [-]

Things to remember is that all of this data which is marked above is achieved from sample test of the materials (concrete & steel) to be judged for the durability of the structure.
**Design cover for main reinforcement:**

we need to take into account in the design of the cover reinforcement secure transmission of forces in cohesion protection of steel against influence of the environment (thermal insulation, corrosion). According to Eurocode EN 206-1 for my building I need to take into considerations the influence of the environment as follows.

XC1- for internal slabs and foundations C25/30  

XC2 - for reinforced walls.

Xc1 – dry or permanently wet concrete inside the building with low air humidity.

XC2- wet rarely dry concrete suffer subject the long-term water like many foundations.

\[
C_{nom} = c_{min} + \Delta c_{dev}  \\
C_{min} = \max \left( C_{min,b} ; C_{min,dur} ; 10 \text{ mm} \right)
\]

\[\Delta c_{dev} = 10 \text{ mm} \] (technology allowance)

\[C_{min,b} = 10 \text{ mm} \] (cover depth necessary for good mechanical bond between steel and concrete, equal to diameter of steel bars)

The value \(C_{min,dur}\) depends on the “structural class”, which has to be determined first. So in my case the structure service life is designed for 50 years therefore the initiation of the structure class is nominated as s4.

The minimum cover with regard to the durability for reinforcement steel according EN 10080.

Table: 1.4.2 determination of \(C_{min,dur}\) which is function of structure class and exposure class.

<table>
<thead>
<tr>
<th>Structural Class</th>
<th>Exposure Class according to Table 4.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>X0 10                   X1 10           X2 10           X3 15           X4 20           XD1 25         XD2 30         XD3 30         XD4 40         XD5 45         XD6 50         XD7 55</td>
</tr>
<tr>
<td>S2</td>
<td>X0 10                   X1 10           X2 15           X3 20           X4 25           XD1 30         XD2 35         XD3 35         XD4 40         XD5 45         XD6 50         XD7 55</td>
</tr>
<tr>
<td>S3</td>
<td>X0 10                   X1 15           X2 20           X3 25           X4 30           XD1 35         XD2 40         XD3 40         XD4 45         XD5 50         XD6 55         XD7 60</td>
</tr>
<tr>
<td>S4</td>
<td>X0 10                   X1 15           X2 25           X3 30           X4 35           XD1 40         XD2 45         XD3 45         XD4 50         XD5 55         XD6 60         XD7 65</td>
</tr>
<tr>
<td>S5</td>
<td>X0 15                   X1 20           X2 30           X3 35           X4 40           XD1 45         XD2 50         XD3 55         XD4 60         XD5 65         XD6 70         XD7 75</td>
</tr>
<tr>
<td>S6</td>
<td>X0 20                   X1 25           X2 35           X3 40           X4 45           XD1 50         XD2 55         XD3 60         XD4 65         XD5 70         XD6 75         XD7 80</td>
</tr>
</tbody>
</table>

\[
C_{nom} = c_{min} + \Delta c_{dev}  \\
C_{min} = \max \left( C_{min,b} ; C_{min,dur} ; 10 \text{ mm} \right)
\]

\[C_{min} = 15 \text{ [mm]} \]  
\[C = c_{min} + \Delta c_{dev} \]
\[ C_{slab} = 10 + 15 = 25 \text{ [mm]} \]
\[ C_{wall} = 10 + 25 = 35 \text{ [mm]} \]

**Slab depth design:**

The slab depth is evaluated from the extreme area of the most loaded parts of the building which is nominated as a tributary area. The load is collecting by 2 - way monolithic reinforced slab then transferred to the beams then to the walls and finally by the wall transferred to the foundation part of the building.

**Empirical estimation:**

Basement slab: \[ h_s = \left( \frac{L_x + L_y}{75} \right) = \left( \frac{7300 + 6000}{75} \right) = [177.33 \text{ Approx.} \text{ = } 200 \text{ mm}] \]

Effective depth: \[ d = h_s - c - \phi = 200 - 25 - 16/2 = [167 \text{ mm}] \]

**Deflection control:** \[ \lambda = \frac{L}{d} \leq \lambda_{\text{lim}} = Kc_1 \ast Kc_2 \ast Kc_3 \ast \lambda_d \text{, tab} \]

**Outer span in basement:**

L – Length of the shorter span 4300 [mm] in x - direction.

d – Effective width of cross section

Kc1 – effect of shape 1.0

Kc2 - effect of span 1.0

Kc3 - effect of reinforcement 1.2

\( \lambda_{d,\text{tab}} \) depend of the table we will consider 0.5% reinforcement ratio for the inner span.

<table>
<thead>
<tr>
<th>( \rho )</th>
<th>12/15</th>
<th>16/20</th>
<th>20/25</th>
<th>25/30</th>
<th>30/37</th>
<th>40/50</th>
<th>50/60</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 %</td>
<td>19.0</td>
<td>20.5</td>
<td>22.1</td>
<td>24.1</td>
<td>26</td>
<td>33.5</td>
<td>41.5</td>
</tr>
<tr>
<td>1.5 %</td>
<td>15.9</td>
<td>16.4</td>
<td>16.9</td>
<td>17.6</td>
<td>18</td>
<td>19.5</td>
<td>20.8</td>
</tr>
</tbody>
</table>

\[ \lambda = \frac{L}{d} \leq \lambda_{\text{lim}} = Kc_1 \ast Kc_2 \ast Kc_3 \ast \lambda_d \text{, tab} \]

\[ \lambda = \frac{l}{d} = \frac{4300}{167} = 25.75 \]

\[ \lambda_{\text{lim}} = Kc_1 \ast Kc_2 \ast Kc_3 \ast \lambda_d \text{, tab} = 1 \ast 1 \ast 1.2 \ast 33.5 = 40.2 \]
\[ \lambda \leq \lambda \text{ lim} \rightarrow 25.75 \leq 40.2 \]

**General conditions and relationships:**

\[ \lambda \leq \lambda \text{ lim} \]

We can see that after the evaluation the final depth of the concrete slab in basement and all typical floors is 200[mm] so in this case I will use the design further calculation within take into consideration the slab thickness to be 200 [mm] one of the reason which I have same slab heights is that this element have large span dimensions in each typical floors.

**Inner span in basement:**

\[ L = \text{Length of the longer span 6000 [mm] in x - y - directions.} \]
\[ d = \text{Effective width of cross section} \]
\[ K_{c1} = \text{effect of shape 1.0} \]
\[ K_{c2} = \text{effect of span 1.0} \]
\[ K_{c3} = \text{effect of reinforcement 1.2} \]
\[ \lambda_{d,\text{tab}} \text{ depend of the table we will consider 0.5\% reinforcement ratio for the inner span.} \]

\[
\lambda_{d,\text{tab}} \text{ for inner span of the continuous beam/slab}
\]

<table>
<thead>
<tr>
<th>( \rho )</th>
<th>Concrete class</th>
<th>12/15</th>
<th>16/20</th>
<th>20/25</th>
<th>25/30</th>
<th>30/37</th>
<th>40/50</th>
<th>50/60</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 %</td>
<td></td>
<td>21.9</td>
<td>23.7</td>
<td>25.5</td>
<td>27.8</td>
<td>30.8</td>
<td><strong>38.6</strong></td>
<td>48</td>
</tr>
<tr>
<td>1.5 %</td>
<td></td>
<td>18.3</td>
<td>18.9</td>
<td>19.5</td>
<td>20.3</td>
<td>21</td>
<td>22.5</td>
<td>24</td>
</tr>
</tbody>
</table>

\[
\lambda = \frac{L}{d} \leq \lambda \text{ lim} = Kc1 \times Kc2 \times Kc3 \times \lambda d, \text{tab}
\]
\[
\lambda \text{ lim} = Kc1 \times Kc2 \times Kc3 \times \lambda d, \text{tab} = 1 \times 1 \times 1.2 \times 33.5 = 40.2
\]
\[
\lambda = \frac{l}{d} = \frac{6000}{167} = 35.93
\]
\[
\lambda \leq \lambda \text{ lim} \rightarrow 35.93 \leq 40.2
\]

**Empirical estimation:**

Ground floor typical floor offices: \[ h_s = \left( \frac{L_x + L_y}{75} \right) = \left( \frac{7300 + 6000}{75} \right) = \left[ 177.33 \right. \text{ Approx.} = 200 \text{ mm} \]
Effective depth: \( d = hs - c - \phi = 200 - 25 - \frac{16}{2} = [167 \text{ mm}] \)

**Deflection control:** \( \lambda = \frac{L}{d} \leq \lambda_{\text{lim}} = Kc_1 * Kc_2 * Kc_3 * \lambda d, \text{tab} \)

**Outer span in basement:**

L – Length of the shorter span 4300 [mm] in x - direction.

d – Effective width of cross section

Kc₁ – effect of shape 1.0

Kc₂ – effect of span 1.0

Kc₃ - effect of reinforcement 1.2

\( \lambda_{d,\text{tab}} \) depend of the table we will consider 0.5% reinforcement ratio for the inner span.

<table>
<thead>
<tr>
<th>( \rho )</th>
<th>12/15</th>
<th>16/20</th>
<th>20/25</th>
<th>25/30</th>
<th>30/37</th>
<th>40/50</th>
<th>50/60</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5%</td>
<td>19.0</td>
<td>20.5</td>
<td>22.1</td>
<td>24.1</td>
<td>26.0</td>
<td>33.5</td>
<td>41.5</td>
</tr>
<tr>
<td>1.5%</td>
<td>15.9</td>
<td>16.4</td>
<td>16.9</td>
<td>17.6</td>
<td>18.0</td>
<td>19.5</td>
<td>20.8</td>
</tr>
</tbody>
</table>

\[
\lambda = \frac{L}{d} \leq \lambda_{\text{lim}} = Kc_1 * Kc_2 * Kc_3 * \lambda d, \text{tab} \]

\[
\lambda = \frac{l}{d} = \frac{4300}{167} = 25.75
\]

\[
\lambda_{\text{lim}} = Kc_1 * Kc_2 * Kc_3 * \lambda d, \text{tab} = 1 * 1 * 1.2 * 33.5 = 40.2
\]

\[
\lambda \leq \lambda_{\text{lim}} \rightarrow 25.75 \leq 40.2
\]

**General conditions and relationships:**

\( \lambda \leq \lambda_{\text{lim}} \)

We can see that after the evaluation the final depth of the concrete slab in basement and all typical floors is 200[mm] so in this case I will use the design further calculation within take into consideration the slab thickness to be 200 [mm] one of the reason which I have same slab heights is that this element have large span dimensions in each typical floors.

**Inner span in basement:**

L – Length of the longer span 6000 [mm] in x - y - directions.
d – Effective width of cross section

Kc1 – effect of shape 1.0

Kc2 - effect of span 1.0

Kc3- effect of reinforcement 1.2

λd,tab depend of the table we will consider 0.5% reinforcement ratio for the inner span.

<table>
<thead>
<tr>
<th>Concrete class</th>
<th>( \rho )</th>
<th>( 12/15 )</th>
<th>( 16/20 )</th>
<th>( 20/25 )</th>
<th>( 25/30 )</th>
<th>( 30/37 )</th>
<th>( 40/50 )</th>
<th>( 50/60 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5%</td>
<td></td>
<td>21.9</td>
<td>23.7</td>
<td>25.5</td>
<td>27.8</td>
<td>30.8</td>
<td><strong>38.6</strong></td>
<td>48</td>
</tr>
<tr>
<td>1.5%</td>
<td></td>
<td>18.3</td>
<td>18.9</td>
<td>19.5</td>
<td>20.3</td>
<td>21</td>
<td>22.5</td>
<td>24</td>
</tr>
</tbody>
</table>

\[
\lambda = \frac{L}{d} \leq \lambda_{\text{lim}} = Kc1 \times Kc2 \times Kc3 \times \lambda_d, \text{tab}
\]

\[
\lambda_{\text{lim}} = Kc1 \times Kc2 \times Kc3 \times \lambda_d, \text{tab} = 1 \times 1 \times 1.2 \times 33.5 = 40.2
\]

\[
\lambda = \frac{L}{d} = \frac{6000}{167} = 35.93
\]

\[
\lambda \leq \lambda_{\text{lim}} \rightarrow 35.93 \leq 40.2
\]

NOTE:

the principal is the same as basement because there is same bearing element in each directions and the structures has same construction solution in case load bearing elements.

**Empirical estimation:**

Typical floor slab: \( hs = \left( \frac{L_x + L_y}{75} \right) = \left( \frac{7300 + 6000}{75} \right) = [177.33 \text{ Approx.} = 200 \text{ mm} ] \)

Effective depth: \( d = hs - c - \phi = 200 - 25 - 16/2 = [167 \text{ mm} ] \)

**Deflection control:** \( \lambda = \frac{L}{d} \leq \lambda_{\text{lim}} = Kc1 \times Kc2 \times Kc3 \times \lambda_d, \text{tab} \)

**Outer span in basement:**
L – Length of the shorter span 4300 [mm] in x,y - direction.

d – Effective width of cross section

Kc₁ – effect of shape 1.0

Kc₂ - effect of span 1.0

Kc₃- effect of reinforcement 1.2

λd,tab depend of the table we will consider 0.5% reinforcement ratio for the inner span.

![Table](image)

\[
\lambda = \frac{L}{d} \leq \lambda_{\text{lim}} = Kc_1 \times Kc_2 \times Kc_3 \times \lambda d, \text{tab}
\]

\[
\lambda = \frac{L}{d} = \frac{4300}{167} = 25.75
\]

\[
\lambda_{\text{lim}} = Kc_1 \times Kc_2 \times Kc_3 \times \lambda d, \text{tab} = 1 \times 1.2 \times 33.5 = 40.2
\]

\[
\lambda \leq \lambda_{\text{lim}} \rightarrow 25.75 \leq 40.2
\]

**General conditions and relationships:**

\[
\lambda \leq \lambda_{\text{lim}}
\]

We can see that after the evaluation the final depth of the concrete slab in basement and all typical floors is 200[mm] so in this case I will use the design further calculation within take into consideration the slab thickness to be 200 [mm] one of the reason which I have same slab heights is that this element have large span dimensions in each typical floors.

**Inner span in basement:**

L – Length of the longer span 6000 [mm] in x - y - directions.

d – Effective width of cross section

Kc₁ – effect of shape 1.0

Kc₂ - effect of span 1.0

Kc₃- effect of reinforcement 1.2

λd,tab depend of the table we will consider 0.5% reinforcement ratio for the inner span.
\[ \lambda_{d,tab} \text{ for inner span of the continuous beam/slab} \]

<table>
<thead>
<tr>
<th>Concrete class</th>
<th>12/15</th>
<th>16/20</th>
<th>20/25</th>
<th>25/30</th>
<th>30/37</th>
<th>40/50</th>
<th>50/60</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho ) 0.5%</td>
<td>21.9</td>
<td>23.7</td>
<td>25.5</td>
<td>27.8</td>
<td>30.8</td>
<td>38.6</td>
<td>48</td>
</tr>
<tr>
<td>( \rho ) 1.5%</td>
<td>18.3</td>
<td>18.9</td>
<td>19.5</td>
<td>20.3</td>
<td>21</td>
<td>22.5</td>
<td>24</td>
</tr>
</tbody>
</table>

\[
\lambda = \frac{L}{d} \leq \lambda_{\text{lim}} = Kc_1 \cdot Kc_2 \cdot Kc_3 \cdot \lambda d, \text{tab}
\]
\[
\lambda_{\text{lim}} = Kc_1 \cdot Kc_2 \cdot Kc_3 \cdot \lambda d, \text{tab} = 1 \cdot 1.2 \cdot 33.5 = 40.2
\]
\[
\lambda = \frac{l}{d} = \frac{1600}{167} = 9.58
\]
\[
\lambda \leq \lambda_{\text{lim}} \rightarrow 9.58 \leq 40.2
\]

**Beam depth design:**

\[
h_B = \left( \frac{L}{12} - \frac{L}{15} \right) = \left( \frac{6000}{12} - \frac{6000}{15} \right) = 500 - 400 \,[\text{mm}]
\]
\[
h_B = 500 \text{mm}
\]
\[
b_B = \left( \frac{1}{2} - \frac{1}{3} \right)h_B = \left( \frac{500}{2} - \frac{500}{3} \right) = 250 - 166.67 \text{mm}
\]
\[
b_B = 300 \text{mm}
\]

so, in this case I will use the design further calculation within take into consideration the beam height to be \( h_{B,\text{final}} = 500 \text{ mm} \), \( b_B = 300 \text{ mm} \)

**Evaluation of the loads in the structure:**

Generally, actions for use in design shall be obtained from parts of EN 1991 as following:

- **EN1991-1.1** Densities, self-weight and imposed loads.
- **EN1991-1.3** Snow loads
- **EN1991-1.4** Wind loads

This is mention-able that with respect limited dimensions of the building, thermal actions were not considered, nor were impact and explosion action.
the partial safety factors have to be taken into consideration as the suggested values in EC2.

In this case for all loads consider are design values for the self-weight of the structures (dead loads) we consider partial safety factor of $\gamma = 1.35$ [-] and for variable loads $\gamma = 1.50$

**Evaluations of the load slab on the grade:**

**Load on the basement slab:**

<table>
<thead>
<tr>
<th>Permanent load</th>
<th>No #</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m$^3$]</th>
<th>Characteristic value [KN/m$^2$]</th>
<th>Safety factor</th>
<th>Design value [KN/m$^2$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Anti- sliding paint</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.35</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Another permanent load</td>
<td>10</td>
<td>0.01</td>
<td>1.35</td>
<td>0.0135</td>
<td>3.375</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>RC slab</td>
<td>100</td>
<td>25</td>
<td>2.5</td>
<td>1.35</td>
<td>3.375</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>plain concrete levelling</td>
<td>50</td>
<td>24</td>
<td>1.2</td>
<td>1.35</td>
<td>1.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Permanent load from typical slab gd</td>
<td>3.71</td>
<td>1.35</td>
<td>5.0085</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6.8 – Imposed loads on garages and vehicle traffic areas is determined by 2 categories category F traffic and parking areas for light vehicles ≤ 30kN gross vehicle weight and ≤ 8 seats but also not including of driver)

<table>
<thead>
<tr>
<th>Variable loads</th>
<th>No#</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m$^3$]</th>
<th>Characteristic value [KN/m$^2$]</th>
<th>Safety factor</th>
<th>Design value [KN/m$^2$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>category F</td>
<td>2</td>
<td>1.50</td>
<td>1.5</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>movable partition &lt;3kn/m</td>
<td>1.2</td>
<td>1.50</td>
<td>1.5</td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total variable load on typical floor slab gd</td>
<td>3.2</td>
<td>1.5</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The total value of characteristic load:

$$Fk = (Gk + Qk) = (3.71 + 3.2) = 6.91 KN / m^2$$

will be applied in software for further calculations.

The total value of design load:

$$Fd = (Gd + Qd) = (5.0085 + 7.8) = 9.80 KN / m^2$$

**Permanent load in one tributary area of the ground Floor.**

Category A: Areas for domestic and residential activities.

<table>
<thead>
<tr>
<th>Permanent load</th>
<th>No#</th>
<th>kind of layer s</th>
<th>thickness [mm]</th>
<th>Density [KN/m$^3$]</th>
<th>Characteristic value [KN/m$^2$]</th>
<th>Safety factor</th>
<th>Design value [KN/m$^2$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Epoxy layer</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Leveling concrete</td>
<td>60</td>
<td>24</td>
<td>1.44</td>
<td>1.35</td>
<td>1.944</td>
</tr>
</tbody>
</table>
Usually in case of the areas in residential, commercial, administration and social building shall be divided into some specific categories according to their specific uses in table 6.1 categories of use.

Variable loads in one tributary area of the typical floor.

### Permanent load from typical slab gd

<table>
<thead>
<tr>
<th>No#</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m³]</th>
<th>Characteristic value [KN/m²]</th>
<th>Safety factor</th>
<th>Design value [KN/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PVC plank</td>
<td>10</td>
<td>0.022</td>
<td>1.35</td>
<td>0.0297</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Leveling concrete</td>
<td>60</td>
<td>24</td>
<td>1.44</td>
<td>1.35</td>
<td>1.944</td>
</tr>
<tr>
<td>3</td>
<td>PE layer</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>acoustic insulation</td>
<td>50</td>
<td>0.3</td>
<td>0.015</td>
<td>1.35</td>
<td>0.0203</td>
</tr>
<tr>
<td>5</td>
<td>reinforce concrete slab</td>
<td>200</td>
<td>25</td>
<td>5</td>
<td>1.35</td>
<td>6.75</td>
</tr>
<tr>
<td></td>
<td>Permanent load from typical slab gd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.477</td>
</tr>
</tbody>
</table>

The total value of characteristic load:

\[ Fk = (Gk + Qk) = (6.47 + 5.2) = 11.67 \text{KN/m}^2 \]

will be applied in software for further calculations.

The total value of design load:

\[ Fd = (Gd + Qd) = (8.74 + 7.8) = 16.54 \text{KN/m}^2 \]

### Permanent load in one tributary area of the typical Floor(Offices)

Category B: Office areas. C2: Areas with fixed seats,

<table>
<thead>
<tr>
<th>No#</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m³]</th>
<th>Characteristic value [KN/m²]</th>
<th>Safety factor</th>
<th>Design value [KN/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PVC plank</td>
<td>10</td>
<td>0.022</td>
<td>1.35</td>
<td>0.0297</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Leveling concrete</td>
<td>60</td>
<td>24</td>
<td>1.44</td>
<td>1.35</td>
<td>1.944</td>
</tr>
<tr>
<td>3</td>
<td>PE layer</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>acoustic insulation</td>
<td>50</td>
<td>0.3</td>
<td>0.015</td>
<td>1.35</td>
<td>0.0203</td>
</tr>
<tr>
<td>5</td>
<td>reinforce concrete slab</td>
<td>200</td>
<td>25</td>
<td>5</td>
<td>1.35</td>
<td>6.75</td>
</tr>
<tr>
<td></td>
<td>Permanent load from typical slab gd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.477</td>
</tr>
</tbody>
</table>

The total value of permanent load:

\[Fd = (Gd + Qd) = (8.74 + 7.8) = 16.54 \text{KN/m}^2 \]

### Variable loads

<table>
<thead>
<tr>
<th>No#</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m³]</th>
<th>Characteristic value [KN/m²]</th>
<th>Safety factor</th>
<th>Design value [KN/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Category B Office areas</td>
<td></td>
<td>3</td>
<td>1.50</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>movable partition &lt;3kn/m</td>
<td></td>
<td>1.2</td>
<td>1.50</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

Student: Bc. Yousfi Mohammad Fayez 2th year, Building Structures, Civil Engineering Czech Technical University In Prague
Subject: Diploma Project 01.10.2019
Object: Residential Apartment Building (Multifunctional)
The total value of characteristic load:

\[ F_k = (G_k + Q_k) = (6.477 + 4.2) = 10.677\, KN/m^2 \]

will be applied in software for further calculations.

The total value of design load:

\[ F_d = (G_d + Q_d) = (8.75 + 6.3) = 15.05\, KN/m^2 \]

### Permanent load in one tributary area of the typical Floors apartments:

**Category A:** Areas for domestic and residential activities.

<table>
<thead>
<tr>
<th>No#</th>
<th>kind of layer s</th>
<th>thickness [mm]</th>
<th>Density [KN/m^3]</th>
<th>Characteristic value [KN/m^2]</th>
<th>Safety factor</th>
<th>Design value [KN/m^2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PVC plank</td>
<td>10</td>
<td>0.022</td>
<td>1.35</td>
<td>0.0297</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Leveling concrete</td>
<td>60</td>
<td>24</td>
<td>1.44</td>
<td>1.944</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>PE layer</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>acoustic insulation</td>
<td>50</td>
<td>0.3</td>
<td>0.015</td>
<td>0.0203</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>reinforce concrete slab</td>
<td>200</td>
<td>25</td>
<td>5</td>
<td>6.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Permanent load from typical slab qd</strong></td>
<td></td>
<td></td>
<td><strong>6.477</strong></td>
<td><strong>3.2</strong></td>
<td><strong>8.75</strong></td>
</tr>
</tbody>
</table>

The total value of characteristic load:

\[ F_k = (G_k + Q_k) = (6.477 + 3.2) = 9.677\, KN/m^2 \]

will be applied in software for further calculations.

The total value of design load:

\[ F_d = (G_d + Q_d) = (8.75 + 4.8) = 13.55\, KN/m^2 \times 4 = 52.88\, KN/m^2 \]
Permanen load in one tributary area of the roof structures:

<table>
<thead>
<tr>
<th>No#</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m³]</th>
<th>Characteristic value [KN/m²]</th>
<th>γ</th>
<th>Design value [KN/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>washed river gravel</td>
<td>50</td>
<td>15</td>
<td>0.0225</td>
<td>1.35</td>
<td>0.030</td>
</tr>
<tr>
<td>2</td>
<td>Bitumen water proofing</td>
<td>8</td>
<td></td>
<td>0.0305</td>
<td>1.35</td>
<td>0.04</td>
</tr>
<tr>
<td>3</td>
<td>XPS insulation</td>
<td>150</td>
<td>0.3</td>
<td>0.045</td>
<td>1.35</td>
<td>0.06</td>
</tr>
<tr>
<td>4</td>
<td>vapor barrier asphalt pn.</td>
<td>3.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>reinforced concrete slab</td>
<td>200</td>
<td>25</td>
<td>5</td>
<td>1.35</td>
<td>6.75</td>
</tr>
<tr>
<td>6</td>
<td>plaster</td>
<td>5</td>
<td>0</td>
<td>0.005</td>
<td>1.35</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td><strong>Total load from the roof</strong></td>
<td>5.10</td>
<td>1.35</td>
<td>6.88</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Categories of loaded area (of a roof) generally there are 3 categories according to table 6.9:
Category H – Accessible for normal maintenance and repair only.

Imposed load on the roof:

<table>
<thead>
<tr>
<th>No#</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m³]</th>
<th>Characteristic value [KN/m²]</th>
<th>Safety factor</th>
<th>Design value [KN/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>category F</td>
<td></td>
<td>1</td>
<td>1.50</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Snow load</td>
<td></td>
<td>0.75</td>
<td>1.50</td>
<td>1.125</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total variable load on typical floor slab qd</strong></td>
<td></td>
<td>2.75</td>
<td>1.50</td>
<td><strong>2.625</strong></td>
<td></td>
</tr>
</tbody>
</table>

The total value of characteristic load:

\[ F_k = (G_k + Q_k) = (5.10 + 2.75) = 7.85 \text{KN/m}^2 \]

will be applied in software for further calculations.

The total value of design load:

\[ F_d = (G_d + Q_d) = (6.88 + 2.625) = 9.505 \text{KN/m}^2 \]
**Internal forces:**

![Graph of internal forces](image)

**Load bearing walls (vertical Resistance):**

Preliminary design dimension and judgment of the resistance check of internal load bearing walls (tributary width) in structures, basically This load bearing wall shall transfer the total loads from slabs and beams of a tributary width vertically to the foundation of the structures. Basically the Load which carried by this wall to the foundation of the structure is \( N_{Ed} = 2400.76 \text{KN/m} \)

Calculate design load in the Bottom parts of the wall \( (N_{Ed}) \).

\[
N_{Ed} \leq N_{Rd}
\]

\[
N_{Ed} \leq N_{Rd} = 0.8A_c F_{cd} + A_s F_{yd}
\]
\[ Ac = \frac{N_{Ed}}{(0.8 \times F_{cd} + 0.02 \times F_{yd})} = \frac{2400.76 \times 1000}{(0.8 \times 20 + 0.02 \times 400)} = 100032 \text{mm}^2 \rightarrow \text{but we know that } Ac = B \times L \text{ therefore,} \]

\[ B \times L = 48675 \text{mm}^2 \rightarrow B = \frac{100032 \text{mm}^2}{1000 \text{mm}} = 100.032 \text{mm} \rightarrow \text{but we know that the minimum thickness of the load bearing wall is 200mm therefore we can confirms that} \]

\[ A_c = 200 \times 1000 = 200000 \text{ mm}^2 \]

\[ N_{Ed} \leq N_{Rd} = 0.8 \times 200000 \times 20 + 0.02 \times 200000 \times 400 = 4800000 \text{ N} = 4800 \text{ KN} \]

\[ N_{Ed} = 2400.76 \text{ KN} \leq N_{Rd} = 4800 \text{ KN} \text{ so the justification is confirmed by safe side.} \]

The judgment says that this estimation has implemented safely and rightly while the resistance is much higher than the applied load so means that we are in safe sides, but this judgment was only to those walls which subjected to the vertical load only.

\[ N_{Ed} \leq N_{Rd} \]

\[ N_{Ed} \leq NRd = 0.8Ac \times F_{cd} + As \times F_{yd} \]

\[ Ac = \frac{N_{Ed}}{(0.8 \times F_{cd} + 0.02 \times F_{yd})} = \frac{2400.76 \times 1000}{(0.8 \times 20 + 0.02 \times 400)} = 100.32 \text{mm}^2 \rightarrow \]

\[ \text{Min. area, } Ac = 0.063 \text{m}^2 \]

\[ \rightarrow \text{Column} = 300 \times 300 \text{mm} \]

\[ \text{Justification of the condition have been done by further calculation via RFEM software.} \]
General determinations of all basic internal forces:

Basic internal forces in roof structures:

Basic internal force on roof structures is confirmed by Combination of C06 surface dead load and variable load excluded of snow load according to category 1 $\text{sk} = 0.75 \text{ KN/m}^2$ for Prague Czech Republic.

**Moment $m_x$:**

Coordinates $x-y$ is assumed, max support moment is in support axis of B - 6, and C - 6, & max span moment is in each midspan moment which is supported by two parallel reinforced concrete walls; therefore, design justifications will focus on this part as an extreme one.

![Moment $m_x$](image1)

**Moment $m_y$:**

max support moment is in two edges of concrete core & max span moment is in two spans to the $y$- direction's midspan moment, therefore design justifications will focus on this part as an extreme one.

![Moment $m_y$](image2)

**Moment $m_{xy}$:**

Coordinates $x-y$ is assumed, Now as we see that the max moments are in each edges of concrete core, max support moment is in support axis of B - 6, while max span moment is in support C - 6, therefore design justifications will focus on this part as an extreme one.

![Moment $m_{xy}$](image3)
Global deformations:

Basically, we see that the maximum global deformation is in our max span in range of 14mm.

Loading moment:

\[ m_\phi = m_x \cos^2 \phi + m_y \sin^2 \phi + 2m_{xy} \sin \phi \cos \phi \]

Condition for Loading Moment:

\((-)m_{\phi_{\text{rd}}} < m_\phi < m_{\phi_{\text{rd}}})
\]

\[ m_x = -113.6 \]
\[ m_y = -83.21 \]
\[ m_{xy} = 38.73 \]

Design moments:

<table>
<thead>
<tr>
<th>Surface</th>
<th>Moment at x</th>
<th>Moment at y</th>
<th>Moment at xy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower surface</td>
<td>[ m_{Rx} = m_x +</td>
<td>m_{xy}</td>
<td>] kNm/m</td>
</tr>
<tr>
<td></td>
<td>(-74.87) kNm/m</td>
<td>(-44.48) kNm/m</td>
<td></td>
</tr>
<tr>
<td>Upper surface</td>
<td>[ m'_{Rx} = -m_x +</td>
<td>m_{xy}</td>
<td>] kNm/m</td>
</tr>
<tr>
<td></td>
<td>(152.33) kNm/m</td>
<td>(121.94) kNm/m</td>
<td></td>
</tr>
</tbody>
</table>
### Upper surface:

<table>
<thead>
<tr>
<th>Term</th>
<th>Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_s'x,\text{req.} = m'edx/(0.9<em>d'x</em>f_yd)$</td>
<td>Steel: $B500B$</td>
</tr>
<tr>
<td>$A_s'x,\text{req.} = 2403.011$</td>
<td>Concrete: $C30/37$</td>
</tr>
<tr>
<td>$A_s'x,\text{prov.} = \frac{A_s'x,\text{req.}}{\pi*(\phi/2)^2}$</td>
<td>$f_yd = 500/1.15$</td>
</tr>
<tr>
<td>$A_s'x,\text{prov.} = 2789.734$</td>
<td>$f_{cd} = 30/1.5$</td>
</tr>
<tr>
<td>$n = \text{A'sx,req.}/(\pi*(\phi/2)^2)$</td>
<td>$z'x = d'x - 0.4*x$</td>
</tr>
<tr>
<td>$n = 33$ Bars</td>
<td>$z'x = 131.676801$ mm</td>
</tr>
<tr>
<td>$n = 33$ Bars</td>
<td>$x'x = 75.8079960$ mm</td>
</tr>
<tr>
<td>$A_s'y,\text{req.} = m'edy/(0.9<em>d'y</em>f_yd)$</td>
<td>$b = 1000$ mm</td>
</tr>
<tr>
<td>$A_s'y,\text{req.} = 3480$</td>
<td>$n = 30$ Bars</td>
</tr>
<tr>
<td>$A_s'y,\text{prov.} = n'*(\phi/2)^2$</td>
<td>$d'y = h - c - \phi/2 - \phi_{str}$</td>
</tr>
<tr>
<td>$A_s'y,\text{prov.} = 3770$ mm$^2$</td>
<td>$\phi = 12$ mm</td>
</tr>
<tr>
<td>$n = A'sy,\text{req.}/(\pi*(\phi/2)^2)$</td>
<td>$\phi_{str} = 8$ mm</td>
</tr>
<tr>
<td>$n = 30$ Bars</td>
<td>$d'y = 162$ mm</td>
</tr>
<tr>
<td>$n = 30$ Bars</td>
<td>$x'y = 102.445652$ mm</td>
</tr>
<tr>
<td>$n = 30$ Bars</td>
<td>$b = 1000$ mm</td>
</tr>
<tr>
<td>$n = 30$ Bars</td>
<td>$x'y = 102.445652$ mm</td>
</tr>
</tbody>
</table>

### Resistance moment:

<table>
<thead>
<tr>
<th>Term</th>
<th>Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_{Rex} = A_{ex} * f_yd * z_e$</td>
<td>$m_{Rdy} = A_{dy} * f_yd * z_y$</td>
</tr>
<tr>
<td>$m_{Rex} = 77.14$ kNm</td>
<td>$m_{Rdy} = 132.4428034$ kNm</td>
</tr>
<tr>
<td>$m_{Rex} = m_{Rex} * \cos\phi^2 + m_{Rdy} * \sin\phi^2$</td>
<td>$m_{Rdx} = m_{Rex} * \cos\phi^2 + m_{Rdy} * \sin\phi^2$</td>
</tr>
<tr>
<td>$m_{Rex} = 159.7144722$ kNm</td>
<td>$m_{Rdy} = 198.3704159$ kNm</td>
</tr>
</tbody>
</table>
**Lower surface:**

<table>
<thead>
<tr>
<th>Expression</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{As}_{\text{req.}}$</td>
<td>$-902.5209644$</td>
<td>$\text{mm}^2$</td>
</tr>
<tr>
<td>$\text{As}_{\text{prov.}}$</td>
<td>$497.4333592$</td>
<td>$\text{mm}^2$</td>
</tr>
<tr>
<td>$\text{As}<em>{\text{req.}} - \text{As}</em>{\text{prov.}}$</td>
<td>$405.0873622$</td>
<td>$\text{mm}^2$</td>
</tr>
<tr>
<td>$\text{As}_{\text{req.}}$</td>
<td>$500$</td>
<td>$\text{N/mm}^2$</td>
</tr>
<tr>
<td>$\text{As}_{\text{prov.}}$</td>
<td>$434.7826087$</td>
<td>$\text{N/mm}^2$</td>
</tr>
<tr>
<td>$\phi$</td>
<td>$10$</td>
<td>$\text{mm}$</td>
</tr>
<tr>
<td>$\phi_{\text{str}}$</td>
<td>$8$</td>
<td>$\text{mm}$</td>
</tr>
<tr>
<td>$h_x$</td>
<td>$250$</td>
<td>$\text{mm}$</td>
</tr>
<tr>
<td>$h_y$</td>
<td>$212$</td>
<td>$\text{mm}$</td>
</tr>
<tr>
<td>$c$</td>
<td>$25$</td>
<td>$\text{mm}$</td>
</tr>
<tr>
<td>$d_x$</td>
<td>$b = 1000$</td>
<td>$\text{mm}$</td>
</tr>
<tr>
<td>$d_y$</td>
<td>$b = 1000$</td>
<td>$\text{mm}$</td>
</tr>
</tbody>
</table>

**Reliability Conditions:**

\[
(-)(m_{\text{R,ex}} - m_{\text{e}}) \times (m_{\text{R,ey}} - m_{\text{ey}}) + m_{\text{xy}}^2 \leq 0
\]

\[
-39633.603 < 0 \quad \text{TRUE}
\]

\[
(-)(m_{\text{R,ex}} + m_{\text{e}}) \times (m_{\text{R,ey}} + m_{\text{ey}}) + m_{\text{xy}}^2 \leq 0
\]

\[-3810.5489 < 0 \quad \text{TRUE}\]

- $m_{\text{ex}} \leq m_{\text{R,ex}} \quad \text{True}$
- $m_{\text{ey}} \leq m_{\text{R,ey}} \quad \text{True}$
- $m_{\text{e}} \geq -m_{\text{R,dx}} \quad \text{True}$
- $m_{\text{ey}} \geq -m_{\text{R,dy}} \quad \text{True}$
Basic internal forces in typical floors (apartments) 3-6:

**Moment mx:**

Basic internal force on typical floor (apartment's) structures is confirmed by Combination of C03 surface dead load and variable load.

Coordinates x-y is assumed, Now as we see that the max support moment is in two edges of concrete core max support moment is in support axis of B - 6, and C - 6, & max span moment is in each midspan moment which is supported by two parallel reinforced concrete walls; therefore, design justifications will focus on this part as an extreme one.

**Moment my:**

Coordinates x-y is assumed, max support moment is in two edges of concrete core max support moment is in support axis of B - 6, and C - 6, & max span moment is in two spans to the y- direction's midspan moment, therefore design justifications will focus on this part as an extreme one.

**Moment mxy:**

Coordinates x-y is assumed, Now as we see that the max moments are in each edges of concrete core, max support moment is in support axis of B - 6, while max span moment is in support C - 6, therefore design justifications will focus on this part as an extreme one.

These four apartments have same functionality therefore load distributions of one typical floor is equivalent to each one of them therefore design evaluation will take int account of one typical floor.
**Global deformations:**

Basically, we see that the maximum global deformation is in our max span in range of 14.8mm.

![Global deformations graph]

**Loading moment:**

\[ m\phi = mx\cos2\phi + my\sin2\phi + 2mxy\sin\phi\cos\phi \]

**Condition for Loading Moment:**

\((-)m'_{rd\phi} < m\phi < m_{rd\phi}\)

- \(mx = -47.08\)
- \(my = -38.09\)
- \(mxy = 56.97\)

**Design moments:**

| \(m_{R,dx}\) = \(m_x + |m_{xy}|\) | kNm/m | \(m_{R,dy}\) = \(m_y + |m_{xy}|\) | kNm/m |
|---------------------------------|--------|---------------------------------|--------|
| \(m_{R,dx}\) = 9.89             |        | \(m_{R,dy}\) = 18.88            |        |

**Upper surface**

| \(m'_{R,dx}\) = \(-m_x + |m_{xy}|\) | kNm/m | \(m'_{R,dy}\) = \(-m_y + |m_{xy}|\) | kNm/m |
|-------------------------------------|--------|----------------------------------|--------|
| \(m'_{R,dx}\) = 104.05             |        | \(m'_{R,dy}\) = 95.06            |        |

---

Student:  Bc. Yosufi Mohammad Fayez  2th year  Building Structures  Civil Engineering Czech Technical University In Prague
Subject:  Diploma Project
Object:  Residential Apartment Building (Multifunctional)
### Upper surface:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Steel: B500B</th>
<th>Concrete: C30/37</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{sxxreq.} = m'ed/(0.9<em>dx</em>fyd)$</td>
<td>fx = 500 N/mm²</td>
<td>fcd = 30 N/mm²</td>
</tr>
</tbody>
</table>

$A_{sxxreq.} = 1641.392318$  
$A_{sxxreq.} = 434.782609$  
$A_{sxxreq.} = 2789.734276$  

$A_{sxxprov} \geq A_{sxxreq.} \Rightarrow x'_x = \frac{A_{sxxprov}}{A_{sxxreq.}} \cdot f_yd/(0.8*b*fcd)$  
$A_{sxxprov} = 75.8079956$  

$n = 20.8985568$  
$n = 33$ Bars  
$12$ Bars $\phi 10$  
$12$ Bars $\phi 14$  

$x'_x = 131.67801$  
$b = 1000$ mm  
$c = 25$ mm  
$d'_x = h - c - \frac{\phi}{2} - \phi_{str}$  
$\phi = 10$ mm  
$d_x = 162$ mm  
$\phi_{str} = 8$ mm  

### Lower surface:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Steel: B500B</th>
<th>Concrete: C30/37</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{syyreq.} = m'ed/(0.9<em>dy</em>fyd)$</td>
<td>fx = 500 N/mm²</td>
<td>fcd = 30 N/mm²</td>
</tr>
</tbody>
</table>

$A_{syyreq.} = 3840$  
$A_{syyreq.} = 121.02173$  
$A_{syyreq.} = 204.419203$  

$n = 30.76995566$  
$n = 33$ Bars  
$12$ Bars $\phi 12$  
$12$ Bars $\phi 16$  

$x'_y = 121.02173$  
$b = 1000$ mm  
$c = 25$ mm  
$d'_y = h - c - \frac{\phi}{2} - \phi_{str}$  
$\phi = 10$ mm  
$d_y = 162$ mm  
$\phi_{str} = 8$ mm  

---

Student:  
Bc. Yosufi Mohammad Fayez  
2th year, Building Structures, Civil Engineering  
Czech Technical University In Prague  

Subject:  
Diploma Project  
01.10.2019  

Object:  
Residential Apartment Building (Multifunctional)
**Resistance moment:**

<table>
<thead>
<tr>
<th>Lower surface</th>
<th></th>
<th>Upper surface</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_{Rx}$ = $A_s * f_y * z_x$</td>
<td>$m_{Ry} = A_y * f_y * z_y$</td>
<td>$m_{Rd} = m_{Rx} * \cos \phi^2 + m_{Ry} * \sin \phi^2$</td>
<td></td>
</tr>
<tr>
<td>77.14 kNm</td>
<td>132.4428 kNm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m_{Rx}$ = 281.0073 kNm</td>
<td>$m_{Rd}$ = 278.6878 kNm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Reliability Conditions:**

1. $-39633.603 < 0$ TRUE
2. $-31224.393 < 0$ TRUE

<table>
<thead>
<tr>
<th>Condition</th>
<th>True</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_x \leq m_{Rx}$</td>
<td>True</td>
</tr>
<tr>
<td>$m_y \leq m_{Ry}$</td>
<td>True</td>
</tr>
<tr>
<td>$m_x \geq -m'_{Rx}$</td>
<td>True</td>
</tr>
<tr>
<td>$m_y \geq -m'_{Ry}$</td>
<td>True</td>
</tr>
</tbody>
</table>

General principle of surface designing of the reinforcement and calculation for administrative part and shopping area will be same procedures as mentioned above calculations therefore I will take into account for further design only roof structures and typical apartments.
Basic internal forces in typical floors (administrative):

**Moment mx:**

Basic internal force on typical floor (administrative) structures is confirmed by Combination of C02 surface dead load and variable load according to category B: office area.

**Moment my:**

Basic internal force on typical floor (administrative) structures is confirmed by Combination of C02 surface dead load and variable load according to category B: office area.

**Moment mxy:**

Basic internal force on typical floor (administrative) structures is confirmed by Combination of C02 surface dead load and variable load according to category B: office area.

**Global deformations: u→16.4mm**
Basic internal forces in typical floors (shopping area)

Moment \( mx \):

Basic internal force on typical floor (shopping area) structures is confirmed by Combination of C01 surface dead load and variable load.

\[ \text{Basic Internal Forces} \]

Moment \( my \):

Basic internal force on typical floor (shopping area) structures is confirmed by Combination of C01 surface dead load and variable load.

\[ \text{Basic Internal Forces} \]

Moment \( mxy \):

Basic internal force on typical floor (shopping area) structures is confirmed by Combination of C01 surface dead load and variable load.

\[ \text{Basic Internal Forces} \]

Global deformations: \( u \rightarrow 12.7 \text{mm} \)
**Basic internal stresses:**

**Roof structures:**

Stress $\sigma_x$:

Stress $\sigma_y$:

Stress $\sigma_{xy}$:
**Loading moment:**

\[ \sigma = \sigma_x \cos 2\phi + \sigma_y \sin 2\phi + 2\cdot \tau \cdot x \cdot \sin \phi \cdot \cos \phi \]

**Condition for Loading Moment:**

\[-f_{cd}\phi \leq \sigma \leq f_{td}\phi\]

\[\sigma_x = 0.60\]
\[\sigma_y = 1.20\]
\[\tau \cdot x = -0.38\]

### Design stresses

- \(f_{cd,x} = \sigma_x + |\tau|\)
- \(f_{cd,y} = \sigma_y + |\tau|\)
- \(f_{cd} = 0.98\)
- \(f_{td,x} = \rho_x \cdot f_{yd}\)
- \(f_{td,y} = \rho_y \cdot f_{yd}\)
- \(f_{cd} = 20.00\)
- \(f_{td} = f_{td,x} + f_{td,y}\)

\[f_{cd} = f_{cd,x} + f_{cd,y}\]
\[f_{td} = f_{td,x} + f_{td,y}\]

### Resisting stresses

- \(f_{td,x} = 13.66\)
- \(f_{td,y} = 17.30\)
- \(f_{cd} = 20.00\)
- \(f_{cd} = 20.00\)

### Steel:

- \(f_{yd} = 500/1.15\)
- \(f_{yd} = 434.78\)
- \(f_{yd} = 600.00\)

### Concrete:

- \(f_{cd} = 30/1.5\)
- \(f_{cd} = 20.00\)

### Loading conditions:

- \(v = 0.6 \times (1 - \frac{d}{h} \times 150/250)\)
- \(v = 0.53\)

### Calculations:

- \(\sigma_{cd} = 2 \times \tau \cdot x \cdot \sin \phi \cdot \cos \phi\)
- \(\sigma_{cd} = 0.76\)
- \(\nu \cdot f_{cd} = 15.84\)

- \(t = 600.00\)
- \(f_{cd} = 20.00\)
- \(f_{td} = 20.00\)

- \(\rho_x = 0.60\)
- \(\rho_y = 1.20\)
- \(\tau_{xy} = -0.38\)

- \(n = A_s \times \frac{4}{\pi \cdot \phi^2}\)
- \(n = A_s \times \frac{4}{\pi \cdot \phi^2}\)
- \(n = A_s \times \frac{4}{\pi \cdot \phi^2}\)

- \(A_s \cdot \sigma_x = 1352.40\)
- \(A_s \cdot \sigma_y = 2180.40\)
- \(n \cdot A_s \cdot \tau_{xy} = 6.94\)
- \(n \cdot A_s \cdot \tau_{xy} = 76.00\)

- \(A_s \cdot \sigma_x = 18845.56\)
- \(A_s \cdot \sigma_y = 23876.10\)

- \(A_s \cdot \sigma_x > A_s \cdot \sigma_y \times \text{True}\)

---

Student: Bc. Yosufi Mohammad Fayez 2th year, Building Structures, Civil Engineering Czech Technical University In Prague
Subject: Diploma Project 01.10.2019
Object: Residential Apartment Building (Multifunctional)
General principle of stress designing of the reinforcement and calculation for administrative part and shopping area will be same procedures as mentioned above calculations therefore I will take into account for further design only roof structures and typical apartments.
Basic internal stresses:

**Typical apartments:**

Stress $\sigma_x$:

Stress $\sigma_y$:

Stress $\sigma_{xy}$:
**Basic internal stresses:**

**Basement walls:**

Stress $\sigma_x$:

![Stress $\sigma_x$](image)

Stress $\sigma_y$:

![Stress $\sigma_y$](image)

Stress $\sigma_{xy}$:

![Stress $\sigma_{xy}$](image)
**Design of members:**—for column:

with respect to assumption of coordinates x-y designing for vertical member column 8 in axis of B-5 and horizontal member 72 shall be considered.

Longitudinal reinforcement.

Shear reinforcement for column:

Total amount of re-bars for vertical resistance of member 8.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>40</td>
<td>3.500</td>
<td>Straight</td>
<td>Straight</td>
<td>346.25</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>4</td>
<td>3.836</td>
<td>Straight</td>
<td>Straight</td>
<td>37.84</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>8</td>
<td>3.678</td>
<td>Straight</td>
<td>Straight</td>
<td>72.52</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>4</td>
<td>4.111</td>
<td>Straight</td>
<td>Straight</td>
<td>41.54</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>8</td>
<td>3.809</td>
<td>Straight</td>
<td>Straight</td>
<td>76.16</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>8</td>
<td>3.707</td>
<td>Straight</td>
<td>Straight</td>
<td>74.13</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>8</td>
<td>4.026</td>
<td>Straight</td>
<td>Straight</td>
<td>79.43</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>8</td>
<td>4.066</td>
<td>Straight</td>
<td>Straight</td>
<td>80.21</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>Shear</td>
<td>8.0</td>
<td>Ribbed</td>
<td>157</td>
<td>1.223</td>
<td>Hook</td>
<td>Hook</td>
<td>95.46</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>285</td>
<td></td>
<td></td>
<td>981.54</td>
</tr>
</tbody>
</table>

Vertical member resistance for Column 8 with four longitudinal re bars is confirmed.
**Design of members:**—for beam:

Longitudinal reinforcement.

<table>
<thead>
<tr>
<th>Member</th>
<th>Section</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member No. 72 - Rectangle 300/500</td>
<td>1 All round</td>
<td>10</td>
<td>20.0</td>
<td>31.42</td>
<td>6.274</td>
<td>0.516</td>
<td>7.757</td>
<td>204.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Shear reinforcement for beam:

<table>
<thead>
<tr>
<th>Section</th>
<th>Item No.</th>
<th>Item No.</th>
<th>d_u [mm]</th>
<th>Length [m]</th>
<th>x Location from to</th>
<th>Spacing s [m]</th>
<th>Number of Sections</th>
<th>Weight [kg]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member No. 67 - Rectangle 300/500</td>
<td>57</td>
<td>1</td>
<td>10.0</td>
<td>6.000</td>
<td>0.000</td>
<td>6.000</td>
<td>0.200</td>
<td>2</td>
<td>31.59 (115)</td>
</tr>
<tr>
<td>Member No. 68 - Rectangle 300/500</td>
<td>68</td>
<td>1</td>
<td>12.0</td>
<td>2.150</td>
<td>0.000</td>
<td>2.150</td>
<td>0.155</td>
<td>2</td>
<td>12.27 (115)</td>
</tr>
<tr>
<td>Member No. 69 - Rectangle 300/500</td>
<td>69</td>
<td>1</td>
<td>12.0</td>
<td>2.150</td>
<td>0.000</td>
<td>2.150</td>
<td>0.155</td>
<td>2</td>
<td>12.27 (115)</td>
</tr>
<tr>
<td>Member No. 70 - Rectangle 300/500</td>
<td>70</td>
<td>1</td>
<td>10.0</td>
<td>7.300</td>
<td>0.000</td>
<td>7.300</td>
<td>0.157</td>
<td>2</td>
<td>38.84 (115)</td>
</tr>
<tr>
<td>Member No. 71 - Rectangle 300/500</td>
<td>71</td>
<td>1</td>
<td>12.0</td>
<td>6.000</td>
<td>0.000</td>
<td>6.000</td>
<td>0.200</td>
<td>2</td>
<td>31.59 (115)</td>
</tr>
<tr>
<td>Member No. 72 - Rectangle 300/500</td>
<td>72</td>
<td>1</td>
<td>10.0</td>
<td>7.300</td>
<td>0.000</td>
<td>7.300</td>
<td>0.170</td>
<td>2</td>
<td>44.97</td>
</tr>
</tbody>
</table>

Total amount of re-bars for horizontal resistance of member 72.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Reinforcement Type</th>
<th>d_u [mm]</th>
<th>d_b [mm]</th>
<th>No. of Bars</th>
<th>Length [m]</th>
<th>Start</th>
<th>Anchorage Type</th>
<th>End</th>
<th>Bending Diameter [m]</th>
<th>Weight [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>4</td>
<td>6.496</td>
<td>Straight</td>
<td>Straight</td>
<td>64.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>4</td>
<td>6.571</td>
<td>Straight</td>
<td>Straight</td>
<td>64.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>4</td>
<td>8.220</td>
<td>Straight</td>
<td>Straight</td>
<td>81.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>4</td>
<td>4.842</td>
<td>Straight</td>
<td>Straight</td>
<td>47.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>Longitudinal</td>
<td>20.0</td>
<td>Ribbed</td>
<td>4</td>
<td>6.762</td>
<td>Straight</td>
<td>Straight</td>
<td>56.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Horizontal member resistance for beam number 72 with four longitudinal re bars is confirmed.

Student: Bc. Yousufi Mohammad Fayez  2th year, Building Structures, Civil Engineering Czech Technical University In Prague
Subject: Diploma Project 01.10.2019
Object: Residential Apartment Building (Multifunctional)
**Punching:**

for column:

with respect to assumption of coordinates x-y designing for vertical member column 8 in axis of B-5 shall be considered.
Earth pressure acting on basement walls (Horizontal Resistance):

Extreme parts of the Lateral earth pressure on basement wall is generally from back fill soil with maximum height of 2.65 m. the resultant force due to the earth pressure in our basement wall shall be calculated as follow.

\[ F_{EP} = \frac{1}{2} \times K \times \gamma \times h_{BS}^2 \]

where

- \( F_{EP} \) – Resultant force acting on the basement wall
- \( h_{BS} \) – height of backfill soil
- \( \gamma \) – specific weight of backfill soil
- \( K \) – coefficient of earth pressure at rest

Coefficient of earth pressure at rest can be calculated as follows:

\[ K = \frac{\mu}{(1 - \mu)} \]

where

- \( \mu \) is the poisons ratios for different kinds of back fill soil in my case I have a sandy clay which is wet \( \mu = 0.37 \)

\[ K = \frac{0.37}{(1 - 0.37)} = 0.587 \]

Specific weight of back fill soil can be calculated as follows:

\[ \gamma = \rho \times A_G \]

where:

- \( \rho \) – density of soil = 20 KN/m3
- \( A_G \) – Acceleration of gravity \( A_G = 9.81 \text{ m/s}^2 \)

in my case I have a sandy clay which is wet and the density can be considered 20 KN/m3

\[ \gamma = \rho \times A_G = \frac{9.81 \text{m/s}^2 \times 2000 \text{kg/m}^3}{\text{m}^3} = 19620 \frac{\text{N}}{\text{m}^2} = 19.62 \frac{\text{KN}}{\text{m}^2} \]

position of the acting force in earth pressure area can be calculated as follow:
\[ d_{bp} = \frac{h_{B}}{3} = \frac{2,87}{3} = 0,97 \text{m} \]

de where

\[ d_{bp} \quad \text{distance from the bottom parts of the basement wall.} \]

\[ F_{EP} = \frac{1}{2} \times 0,587 \times 19,62 \frac{KN}{m^3} \times 2,87m^2 = 47,44 \text{KN/m} \]

this is the final resultant force which acts in extreme part of the basement wall and of course that this force is much smaller than applied vertical force therefore the vertical designed reinforcement bar can be able (after judgment of further calculation) to resists this force and does not have any influence of changing the geometry of the reinforced wall.

**Design the geometry of the staircase:**

- Height of the floor \( h_{floor} = 3320 \text{ mm} \)
- Depth of the main slab \( h_s = 200 \text{ mm} \)
- Depth of floor structure \( h_f = 120 \text{ mm} \)

**Dimensions of the staircase:**

- Ideal height of one step is 170 mm
- \( 3320 / 170 = 19.529 \Rightarrow 20 \text{ steps (2 flights each of them with 10 steps)} \)
- Height of one step \( h = 3320/20 = 166 \Rightarrow 170 \text{ mm} \)
- Width of one step \( b = 630 – 2h \Rightarrow 630 - 2 \times 170 = 290 \text{ mm} \)
- **DESIGN: Staircase with 170 / 290 mm steps, 2 flights, 10 steps in each flight**
- Width of the flight – 1200 mm
- Width of the gap between the flights – 100 mm
- Width of the landing – 1500 mm, 1700mm
- Total Width of the flight and gap between is 1200*2+100 = 2500 mm
- Length of flight is \( 9 \times 290 = 2610 \text{ mm} \)
- Slope of the staircase is \( \alpha = \text{arc tan} (h/b) \Rightarrow \text{arc tan} (160 / 310) = 30.38^\circ \)

**Preliminary check of the depth of the slab.**

- The staircase is considered as one-way slab with the span of 2320 mm. The slab will be simply supported \( \Rightarrow \) the depth should be at least 2320/25 = 92.8 mm.
- The depth and flooring of landings is the same as the depth of the main slab – 200 mm.
- The depth of flights can be obtained from the details of flight-landing connections in my case, the depth is 140 mm.
- 200 mm > 92.8 mm and 140 mm > 92.8 mm => **OK**

**Perpendicular and head clearance of the staircase**

- Head clearance of the staircase should be more than \( 1500+750/cos\alpha = 1500+750/cos(27.30^\circ) = 2532 \text{ mm} \) > and more than 2100 mm.
- Head clearance of our staircase is \( h_1 = h_k - h_s - h_f - h = 3100 - 200 - 130 - 160 = 2600 \text{ mm} \) => **OK.**
Perpendicular clearance of the staircase should be more than \( 750 + 1500 \times \cos(27.30^\circ) = 2085 \text{ mm} \) and more than 1900 mm. Perpendicular clearance of our staircase is \( h_2 = h_1 \times \cos(30.38^\circ) = 2310 \text{ mm} > 2085 \text{ mm} \) => OK.

- Evaluations of the load which based on the landing of the staircase:

<table>
<thead>
<tr>
<th>No#</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m³]</th>
<th>Characteristic value [KN/m²]</th>
<th>( \nu )</th>
<th>Design value [KN/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PVC plank + others</td>
<td>40</td>
<td>0.022</td>
<td>1.35</td>
<td>0.0297</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>plain concrete leveling</td>
<td>60</td>
<td>24</td>
<td>1.44</td>
<td>1.35</td>
<td>1.944</td>
</tr>
<tr>
<td>3</td>
<td>PE layer</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Reinforced slab</td>
<td>200</td>
<td>25</td>
<td>5</td>
<td>1.35</td>
<td>5.75</td>
</tr>
<tr>
<td>1</td>
<td>live load</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Permanent and variable load from typical slab gd+ = 8.462 KN

Load in landing: \( F_d = 10.73 \text{ KN/m}^2 \)

<table>
<thead>
<tr>
<th>No#</th>
<th>kind of layer</th>
<th>thickness [mm]</th>
<th>Density [KN/m³]</th>
<th>Characteristic value [KN/m²]</th>
<th>( \nu )</th>
<th>Design value [KN/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reinforced slab</td>
<td>200/cos (27.30°)</td>
<td>25</td>
<td>5.625</td>
<td>1.35</td>
<td>7.60</td>
</tr>
<tr>
<td>2</td>
<td>PVC plank</td>
<td>0.5*160+310/310</td>
<td>25</td>
<td>0.813</td>
<td>1.35</td>
<td>1.10</td>
</tr>
<tr>
<td>3</td>
<td>steps</td>
<td>160/2</td>
<td>25</td>
<td>2.025</td>
<td>1.35</td>
<td>2.74</td>
</tr>
<tr>
<td>4</td>
<td>live load</td>
<td></td>
<td>2</td>
<td>1.5</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Total variable load on typical floor slab qd = 10.463 KN

Load in flights: \( F_d = 14.44 \text{ KN/m}^2 \)