MŰEGYETEM 1782

Budapest University of Technology and Economics
Faculty of Architecture

Diploma– Building Mechanics and Structures

Department of Urban Planning and Design

Budafok, Children’s Day Care Centre, Budapest

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Neptun Code:X84XG1

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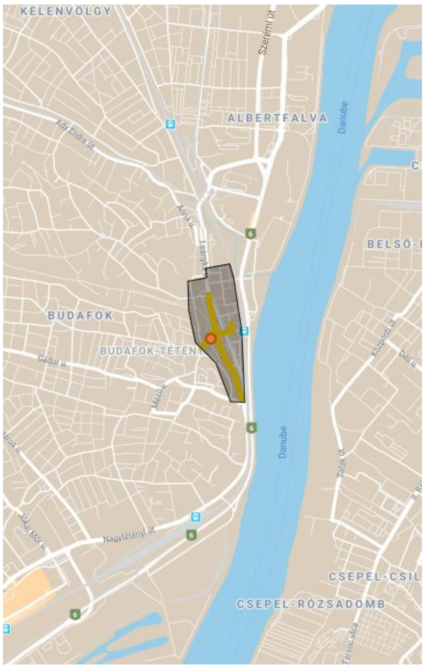
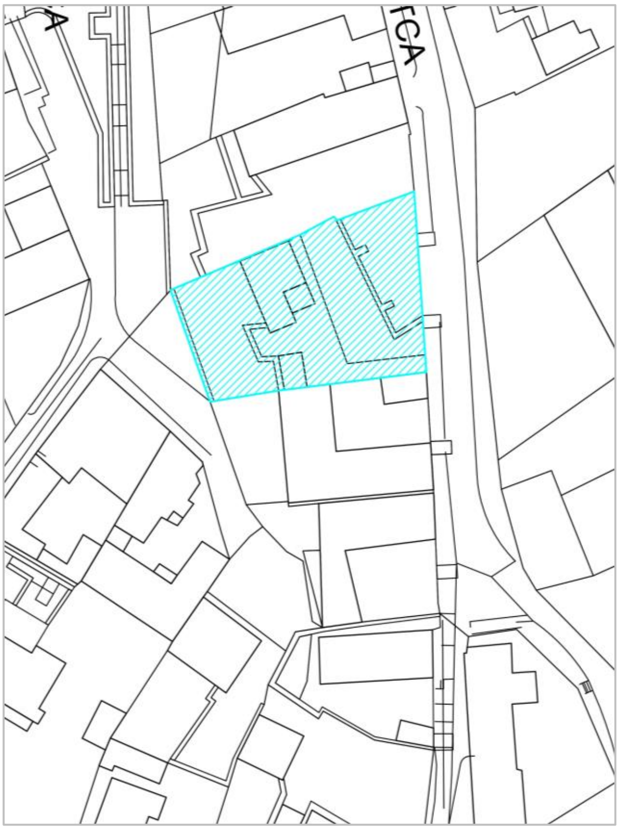
1. General Information about the Site:

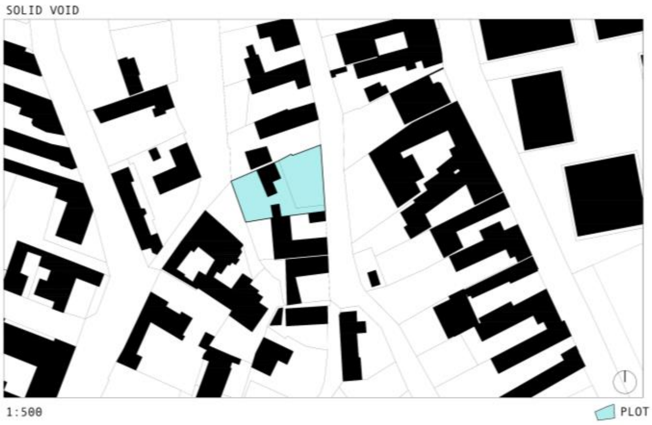
The plot chosen for this project is located in nearby of Budafok downtown area, Budapest. Since the chosen project is a children's day care center, the most suitable location would be somewhere that is located in a residential area for safety purpose, and away from the main street Mária Terézia u. where the termination of tram line 47 is located. The day care center is meant to serve children of adults living in the area. The chosen plot is a sloped terrain, with a 10.5 meter difference between the upper pedestrian street and the bottom vehicular street.





Budapest, Hosszúhegy u. 14, 1222

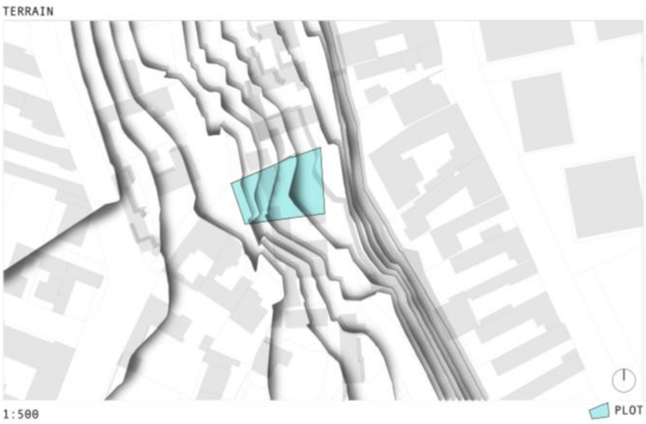
There is an existing building in the site that will be demolished.

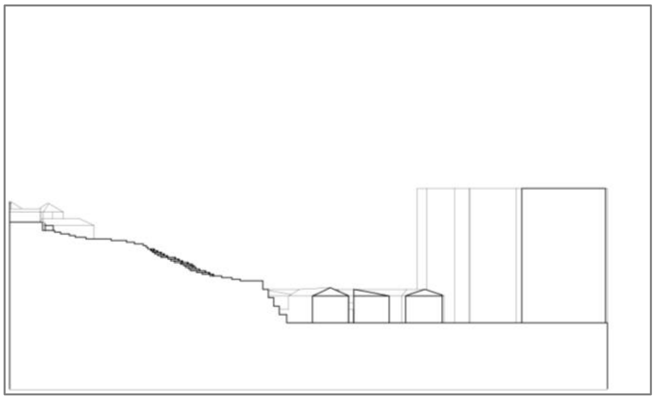


2. <u>Site Usage and Environment</u>

- **Terrain**

The terrain of the plot is sloped.





- **Climate**

The climate of Budapest, the capital of Hungary, is continental, with cold winters and warm summers.
The average temperature ranges from -4 in January to 26 in July.

The average precipitation is 592 per year. Source: Hungarian Meteorological Service

Since Hungary has cold winters, very special attention must be given to thermal insulation, especially in a residential building where flats are occupied 24 hours basis., to ensure comfortable temperatures inside the flats to make the spaces liveable. This means that the walls must be constructed in way that meet the requirement of the Hungarian building codes in which the heat conduction for the wall construction must be 0,24 (0,45) W/mK°.

Another thing to take into consideration are the thermal bridges that occur at the corners of the buildings or where there are changes in the materials. So, it must be ensured that thermal insulation and thermal breaks are installed were needed,

- **Surroundings**

There are no direct neighbouring buildings. The surrounding buildings are residential buildings.

- **Soil**

The soil is sufficiently loadbearing 1m below the surface, the use of special foundations is not required.

- **Sun path**

- **Orientation**

The building is oriented towards the east where the majority of the openings are. This means that in the early hours of the morning there will be very strong sunlight going into the group rooms from the east, therefore adequate shading is required, using vertical louvers. Th north and south façade do not require louvres since there is enough shade provided by neighbouring buildings

- **Sources of Noise**

There is are two streets bordering the site. The lower street is a vehicular street with medium vehicular movement . The upper street is pedestrian and which very minimal noise.

- **Thermal Insulation**

Thermal insulation is required to maintain comfortable temperatures inside the kindergarten. According to regulations, educational buildings require a temperature between 21 to 26 degree Celsius.

- **Acoustics**

Good room acoustics are essential in educational premises to ensure that children can hear their teachers well. If acoustics are poor, teachers may have to raise their voice, which can result in voice damage or loss.

WHO recommends maximum noise levels of 35 dB in schools.

3. Plot description:
Plot area:576 m2
Built up Area: 494 m2
Terrain: Sloped

Level	Area in square meter
Ground Level	186
First Level	188
Second Level	120
Total	494

Functional Description

Public Functions	None
Semi Public Functions	None
Private	Changing room, Changing room, Multipurpose hall, Group rooms, Administration and Gym

Building Program	
Ground Floor Functions	**Area in square meter**
Changing Room for Teachers	4
Multipurpose Hall	24.4
Children's Changing Room	14.2
Storage Room	7.5
Warm up Kitchen	12.6
Kitchen Storage	6.9
Heating Room	6
Electric Switch Room	2.6
Washing and Drying Room	13.7
Staff Washroom with Showers	7
Staff Changing Room	8.9
First Floor Functions	**Area**
Playground	40.9
Group Room	46
Group Room	47
Washrooms(2)	19.2
Staff WC	6.4
Storage Room	7.2
Second Floor Functions	**Area**
Gym	40
Offices	8.5
Shared Office	26.9
Staff WC	4.9

4. Description of Functions

Functions

The main function of the building is a day care center for children aged three to six.

Ground Floor Functions (Total Built up area 186sqm)

The ground floor has the main entrance hall where the main staircase connecting the levels is located. From the entrance hall connects to the changing room for children. There is also the multipurpose hall which different functions and activities may take place such as the teacher/parent meetings and could also serve as a dining area and a place to celebrate and have small events such as birthdays.

Further from the staircase is the elevator shaft that connects all three levels. Secondary functions such as the warm up kitchen, the maintenance storage and the laundry room and drying room are in the basement part of the building.

First Floor Functions (Total build up area 186 sqm)

The second floor is where the group rooms for children. Each group room has washroom/toilet. The second floor opens up to an outdoor playground and from the outdoor playground has a connection to an outdoor staircase, where the children can sit.

Third Floor Functions (Total Built up area 120 sqm)

The gym and administration are on the third floor. The administration includes a Director's office and a room for teachers and psychologist and they have a separate toilet. The gym has a small storage space. The third floor connects to outdoor terraces as well

5. <u>Structural Analysis of the Building</u>

The chosen structure for this project is monolithic reinforced concrete walls in the longitudinal direction. The layout of the walls is determined by the layout of the floor plans of the building. Basically, there is approximately a four meter span between the loadbearing walls. In addition, a ring beam at the perimeter of the building is required.

Monolithic R.C. Walls

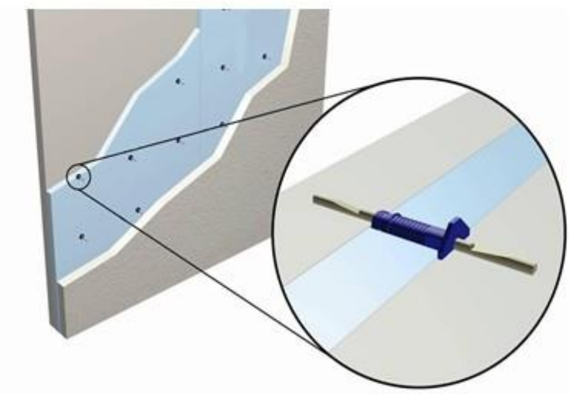
Precast Thermomass Walls with 20cm load bearing reinforced concrete, 20cm XPS thermal insulations and 10cm outer layer reinforced concrete. The plot will be excavated while the soil will be anchored for the construction process where the foundations will be poured and the reinforced thermomass walls will placed and then the soil will be refilled.

Thermomass System Cast in Place

Thermomass System CIP is a patented insulation system designed to create an integrally insulated cast-in-place concrete wall. The system is unique in that it allows a concrete contractor to incorporate a layer of insulation into a vertically cast concrete wall using traditional forming equipment and construction practices. When cast into a concrete wall, the insulation allows the layers of concrete to be left exposed or finished in a variety of methods.

Thermomass systems feature several different rigid insulation choices, depending on various project specifications and constraints. DOW/DUPONT Styrofoam Gridboard XPS Insulation is the choice for this project.

During the construction of the wall, the connectors locate the insulation within the wall, allowing both concrete layers to be placed to the specified thickness. During service, the connectors may transfer lateral and gravity loads from the exterior concrete layer to the structural layer.



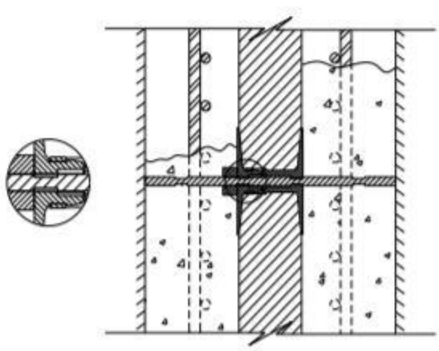


Figure 2

https://www.thermomass.com/website/wp-content/uploads/2017/04/thermomass_system_cip_twist_lock_procedure.pdf

- **Basement Walls**

There are parts of the building which are embedded into the terrain. The external walls of these parts require different solution than the thermomass, as these walls must be protected against the dampness and the water in the soil.

- **Foundations**

Reinforced concrete slab foundation are to be used for this project. The slab foundations will transfer the loads of the building to the soil. There is a basement and therefore a basement wall. Thickness of the R.C. slab is 30cm thick.

The building plot has an incline. The plot will be excavated, and horizontal anchors will be placed to hold the soil in place while the foundations and basement walls are poured. In addition the drainage system would be installed.

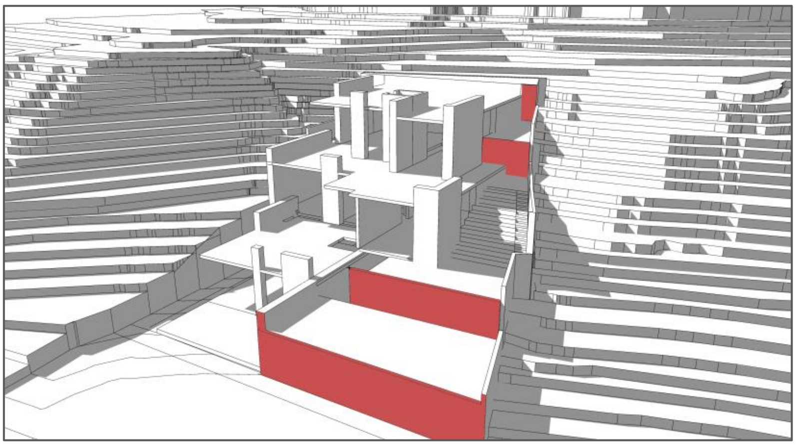
A longitudinal R.C. wall goes down to the lowest level of the slab foundation.

- **Slabs**

18 cm thick, four way supported reinforced concrete slabs. There is a difference in level between the indoor floor layers and outdoor floor layers, therefore there is a jump in the slab to lower down the level of the outdoor floor layers.

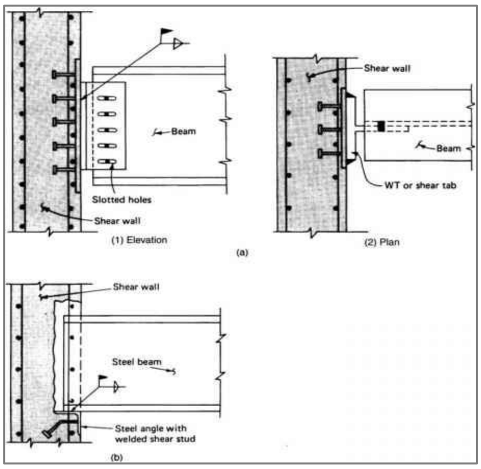
- **Retaining Walls**

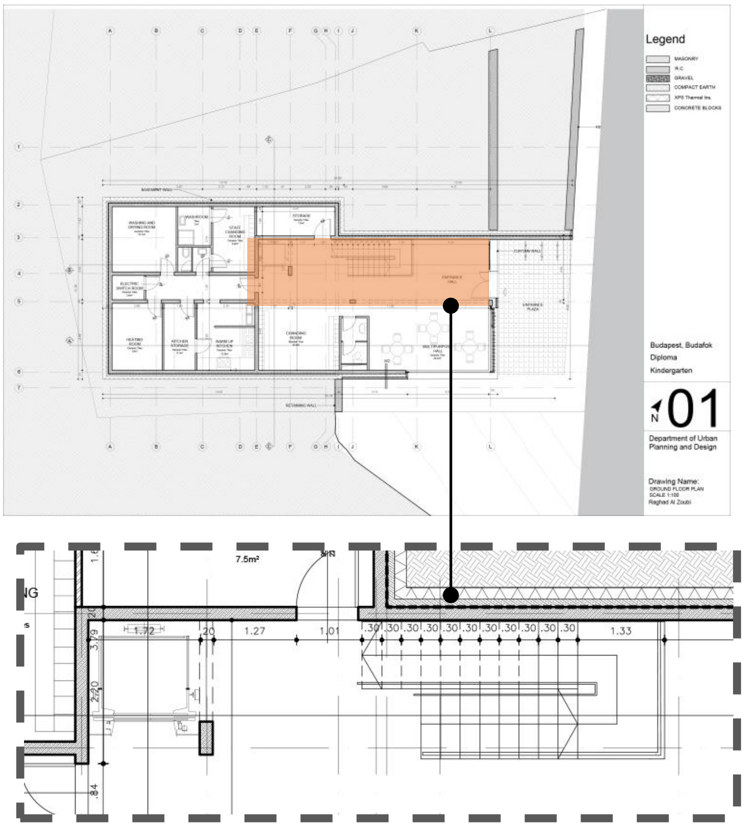
Due to the sloped nature of the site, retaining walls are required to hold the soil.

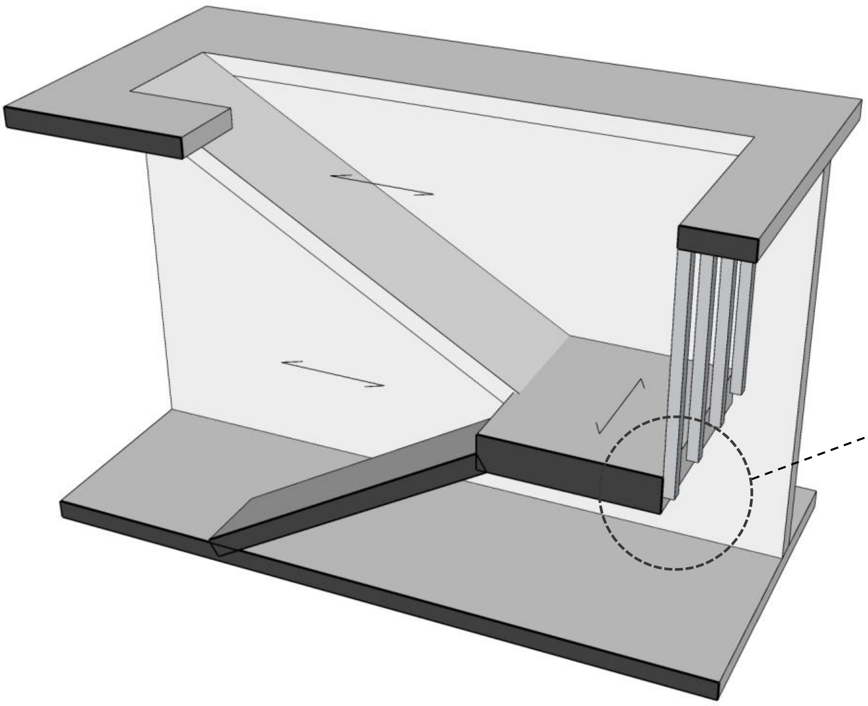


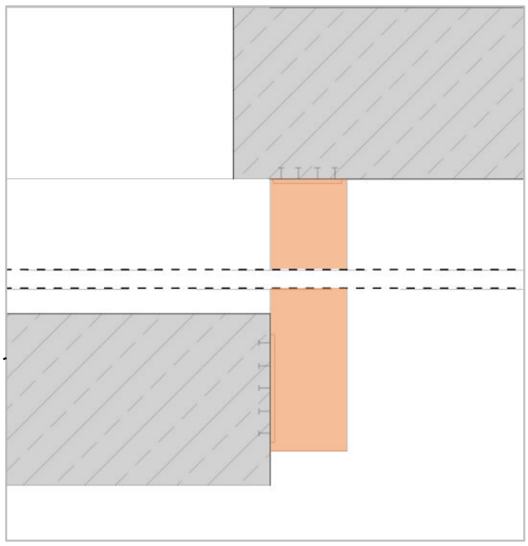
- **Staircase**

There is a staircase in the central space of the building. The staircase is partially loaded onto the loadbearing wall. Addition steel hangers act as additional support for the staircase. They can also serve as handrails.

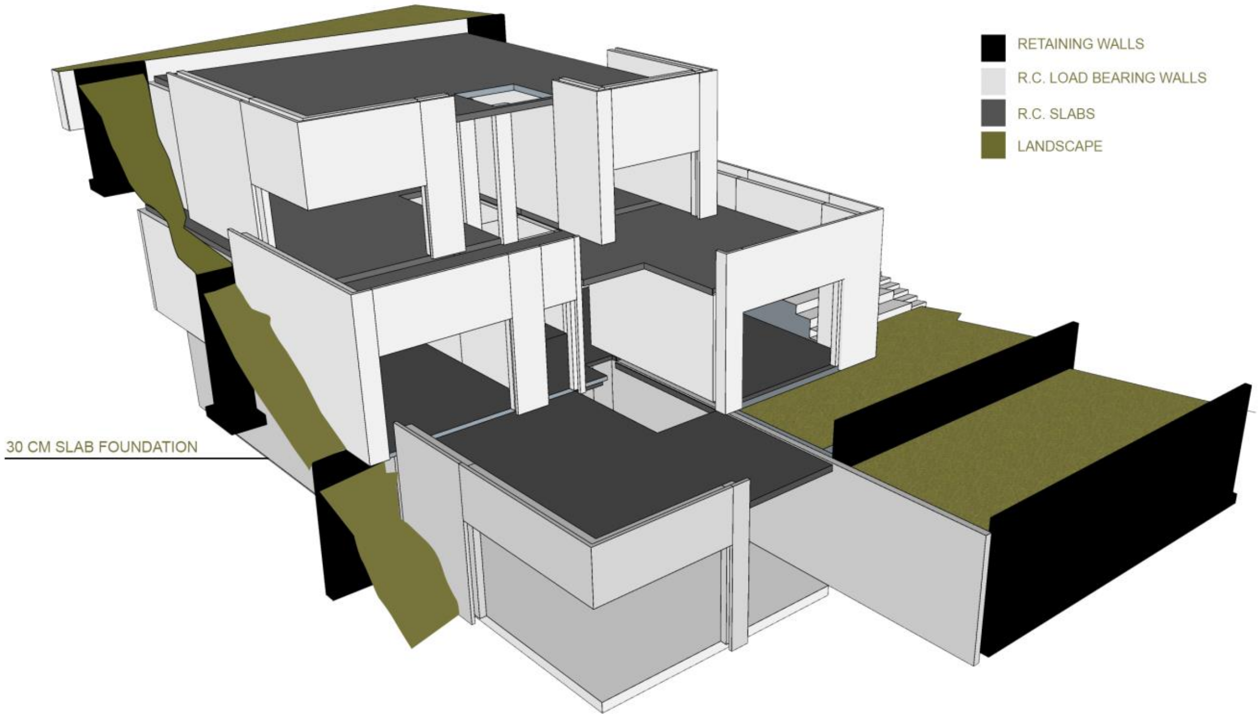


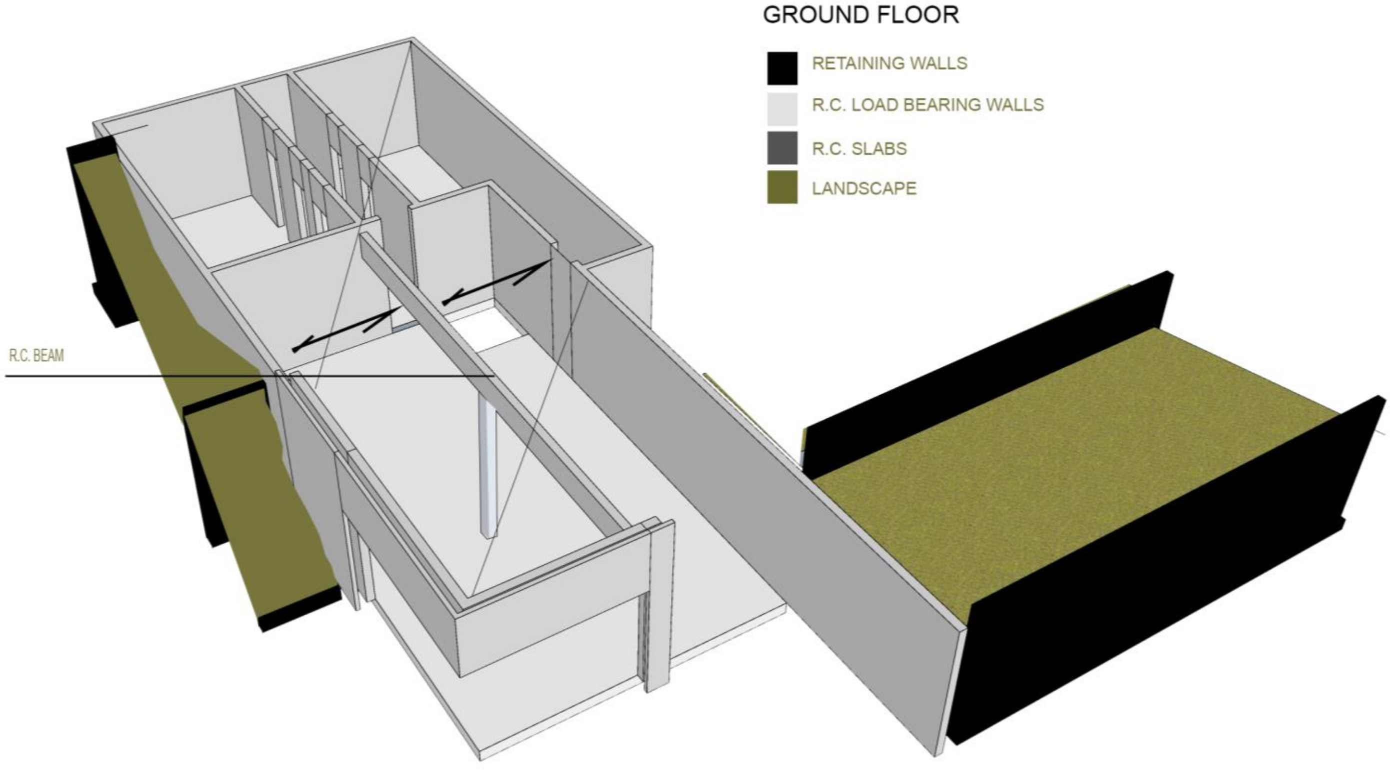


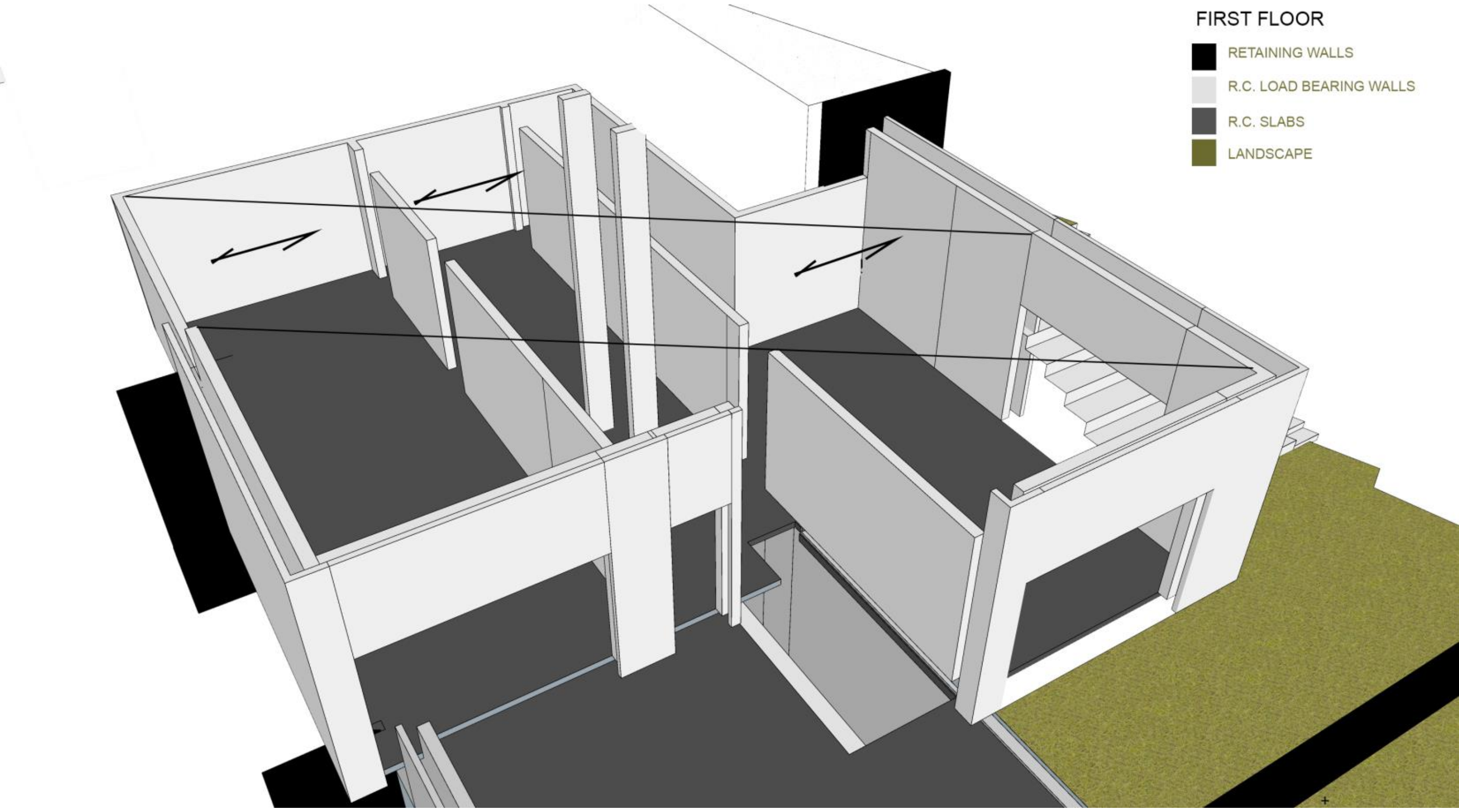


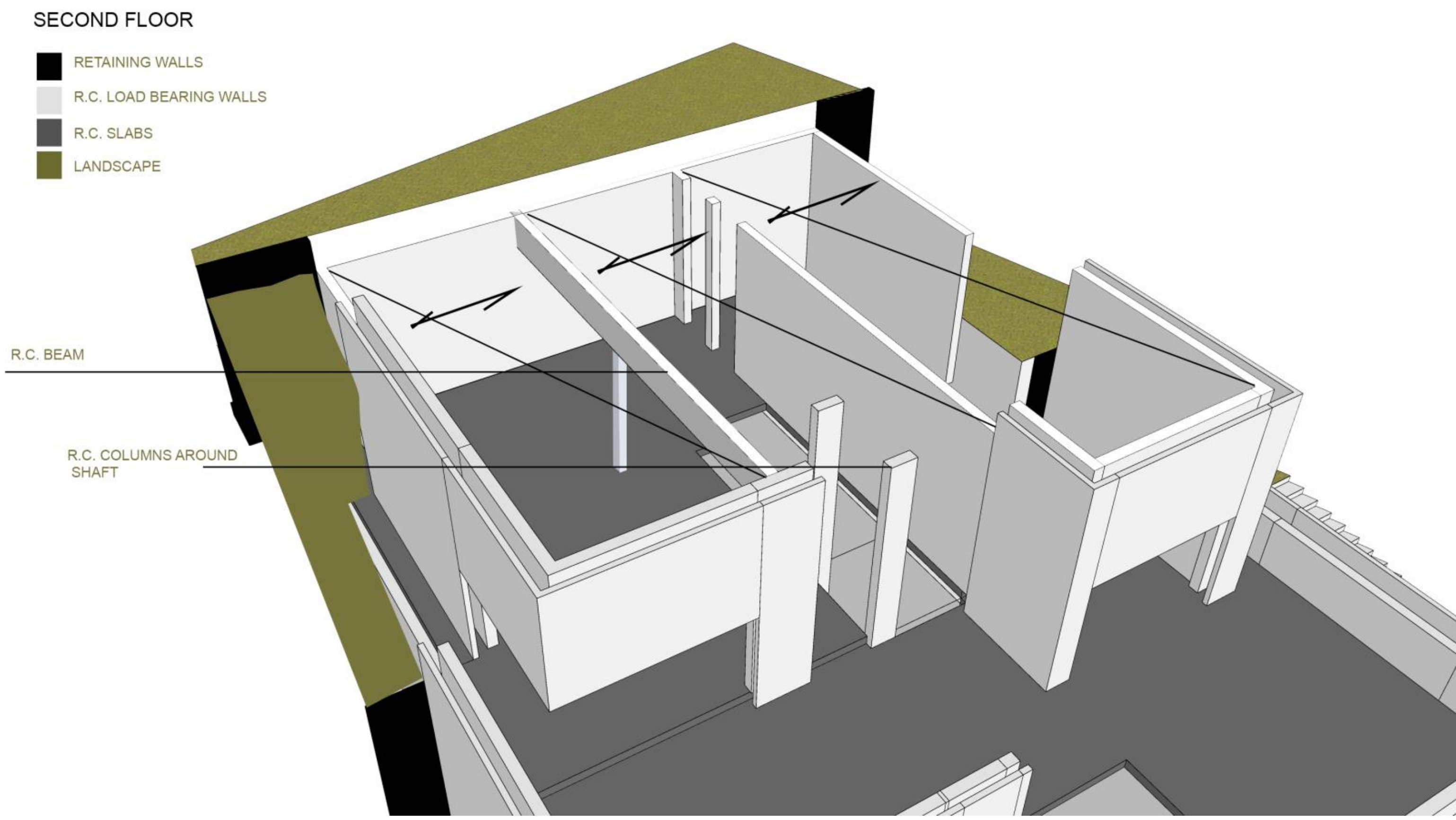


6. **Structural Model**

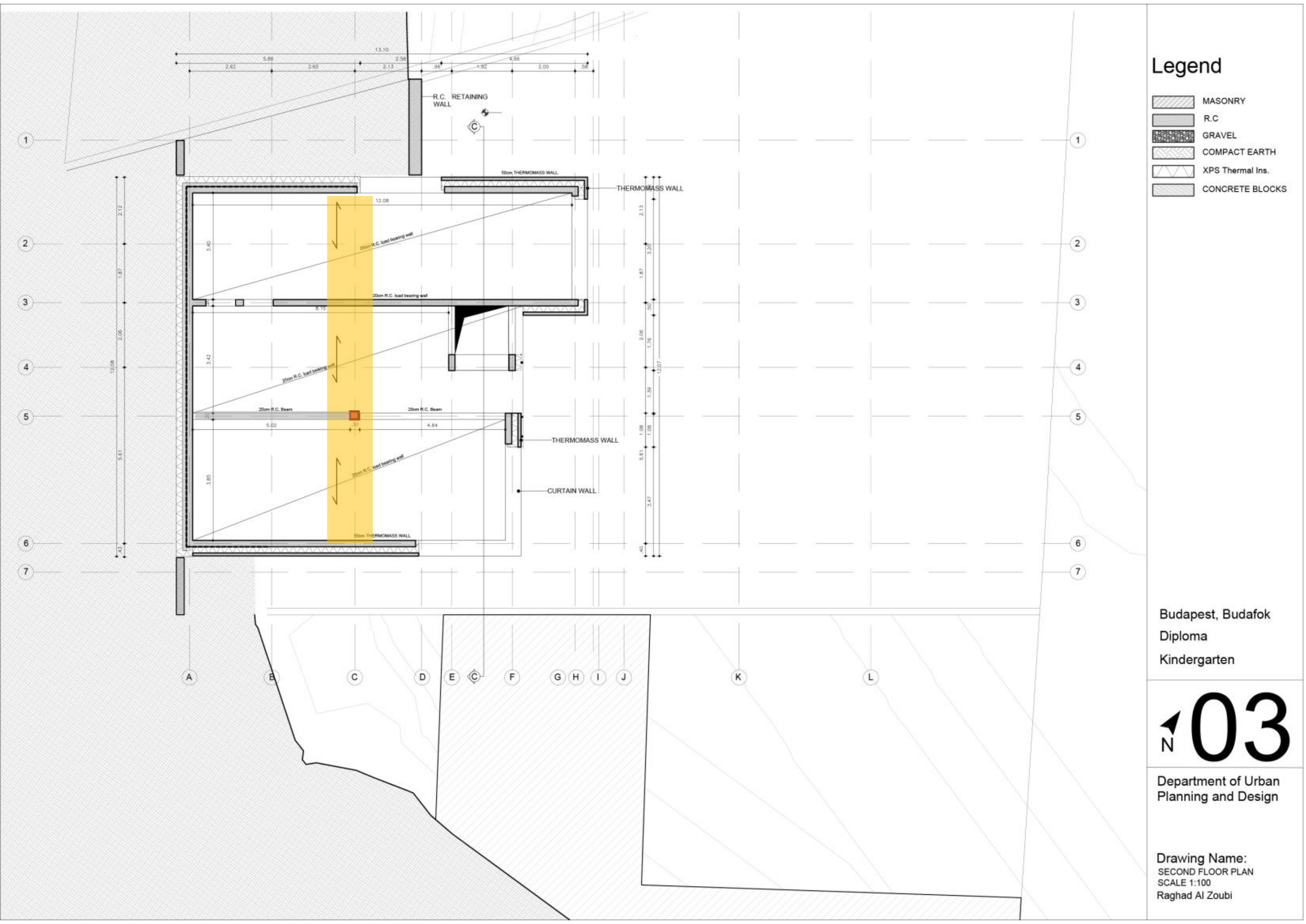


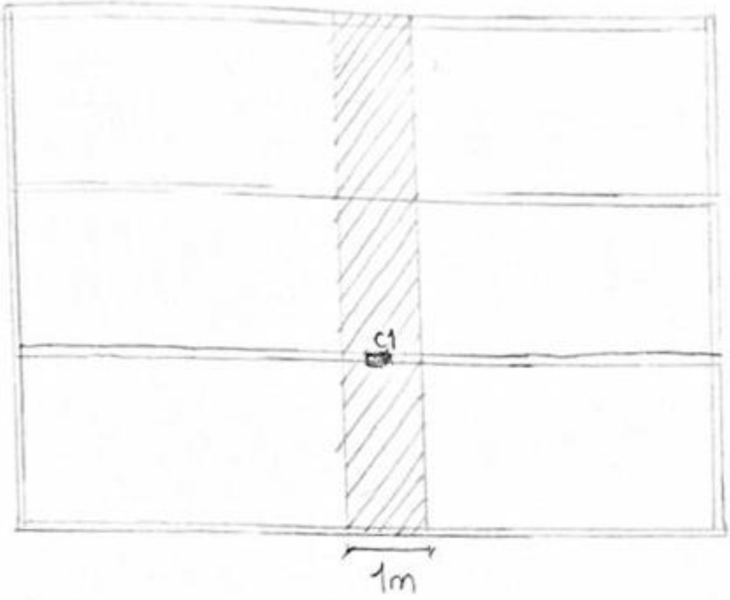


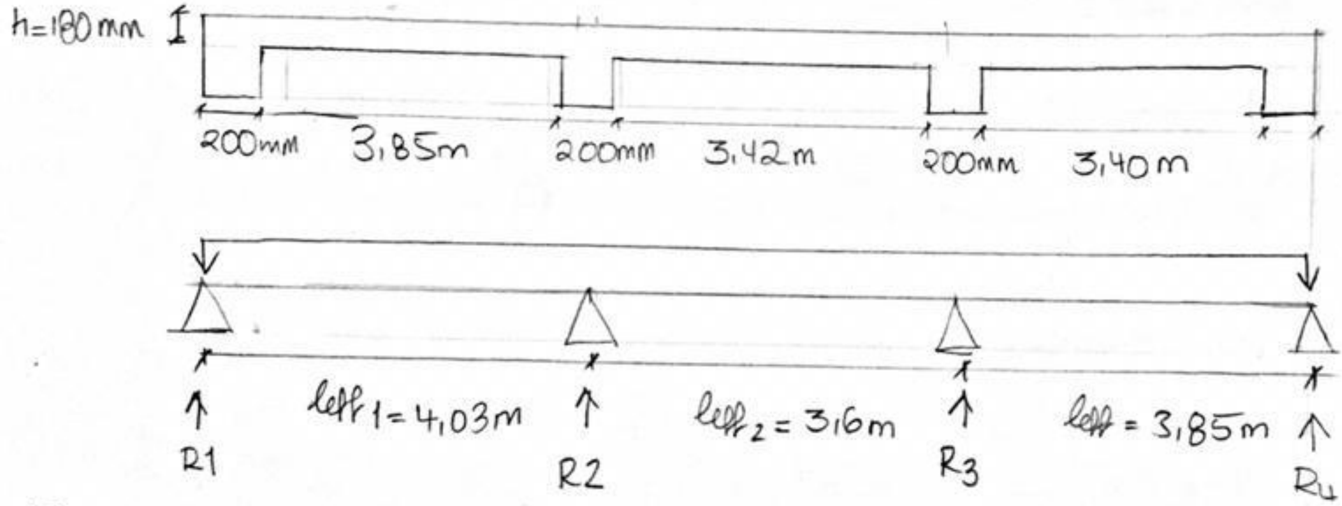

FIRST FLOOR
RETAINING WALLS
R.C. LOAD BEARING WALLS
R.C. SLABS
LANDSCAPE


SECOND FLOOR
RETAINING WALLS
R.C. LOAD BEARING WALLS
R.C. SLABS
LANDSCAPE
R.C. BEAM
R.C. COLUMNS AROUND
SHAFT

7. Calculations







LOADS

1) DEAD LOADS

FLOOR LAYERS

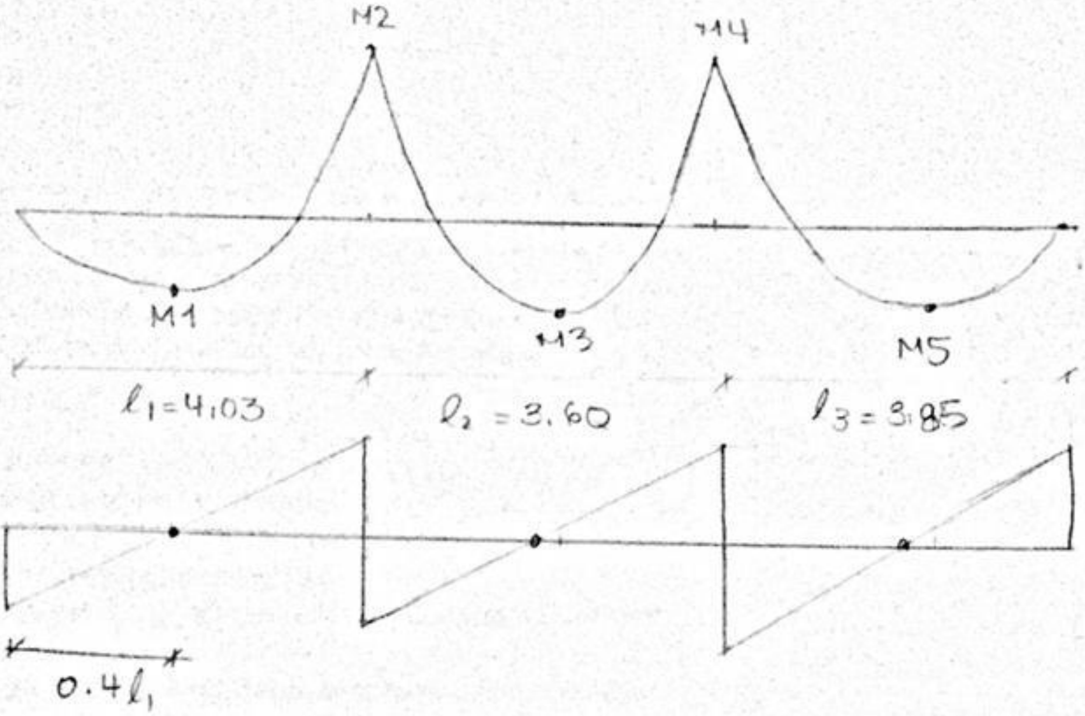
1cm	CERAMIC	→ 0,01 · 25	= 0,25 kN/m²
6cm	SCREED	→ 0,06 × 24	= 1,44 kN/m²
3cm	EPS + FOIL	→ 0,03 · 0,1	= 0,003 kN/m²
3cm	POLYSTERENE	→ 0,03 · 0,4	= 0,012 kN/m²
18cm	RC SLAB	→ 25 · 0,18	= 4,5 kN/m²
1cm	PLASTER + PAINT	→ 18 · 0,01	= 0,18 kN/m²

$\sum$ 6,385 kN/m²

2) LIVE LOADS

g_k FLOOR = 5 kN/m² SUBSTITUTING LOAD OF PARTITIONS = 0,8 kN/m²

P_{ED} FLOOR = 1,35 · 6,4 + (1,5)(5 + 0,8)



⇒ REACTION FORCES

- $R_1 = 0,4\ l_1\ P_{ED}$
  $= 0,4 \cdot 4,03 \cdot 17,34$
  $= 27,95\ kN$

- $R_2 = (0,6 \cdot 4,03 \cdot 17,34) + (0,5 \cdot 3,60 \cdot 17,34)$
  $= 41,93 + 31,21$
  $= 73,142\ kN$

- $R3 = (0,5 \cdot 3,6 \cdot 17,34) + (0,4 \cdot 3,85 \cdot 17,34)$
  $= 31.2 + 26,7$
  $= 57,9\ kN$

- $R4 = 0,4 \cdot 3,85 \cdot 17,34$
  $= 24,6\ kN$

⇒ MOMENT

$M1 = 0,4 \cdot l_1 \cdot R_1 - P_{ED} \cdot 0,4 l_1 \cdot 0,2 l_1$
$= (0,4 \cdot 4,03 \cdot 27.98) - (17,34 \cdot 0,4 \cdot 0,2 \cdot 4,03)$
$= 37.04 - 22,53$
$= 22,53\ kNm$

$M2 = 4,03 \cdot 27,95 - \left(17,34 \cdot 4,03 \cdot \frac{4,03}{2}\right)$
$= -28 \cdot 17\ kNm$

$M3 = R_1 \cdot (l_1 + l_2/2) + R_2 \cdot \frac{l_2}{2} - P_{ED} \cdot \frac{(l_1 + l/2)^2}{2}$
$= 27,95 \cdot \left(4,03 + \frac{3,6}{2}\right) + \left(73,14 \cdot \frac{3,6}{2}\right) - \frac{\left(17,34 \cdot \left(4,03 + \frac{3,6}{2}\right)^2\right.}{8} = 0.07$

$M4 = (l_3 \cdot R_4) - \left(17,34 \cdot l_3 \cdot \frac{l_3}{2}\right)$
$= (3,85 \cdot 24,6) - \left(17,34 \cdot 3,85 \cdot \frac{3.85}{2}\right)$
$= -35.7\ kNm$

$M5 = (0,4\ l_3 \cdot R_4) - (P_{ED} \cdot 0,4 l_3 \cdot 0.2 l_3)$
$= (0,4 \cdot 3,85 \cdot 24,8) - (17,34 \cdot 0,4 \cdot 3,85 \cdot 0,2 \cdot 3,85)$
$= 20,56\ kNm$

CROSS-SECTIONAL DATA

WIDTH = 1m

THICKNESS ⇒ $h = 180mm$

CONCRETE COVER $C_{nom} = 20mm$

MAIN REINFORCEMENT : $\phi 18 / 110$

$$As = \frac{12^2 \pi}{4} \cdot \frac{1000}{110} = 1028.3 \ mm^2$$

$$d = h - C_{nom} - \phi/2$$

$$= 180 - 20 - \frac{12}{2} = 154mm$$

$f_{cd} = 13{,}33 \ N/mm^2$ $\quad$ $F_{yd} = 435 \ N/mm^2$

$\Sigma N = 0 \quad N_c = N_s$

$N_c = f_{cd} X_c b$

$N_s = a_s f_{yd}$

$$13{,}33 \cdot X_c \cdot 1000 = 1028{,}3 \cdot 435 \Rightarrow X_c = 33.56 \ mm$$

$$M_{Rd} = N_s Z = a_s f_{yd} \left[d - \frac{X_c}{2}\right]$$

$$= 1028{,}3 \cdot 435 \cdot \left[154 - \frac{33{,}56}{2}\right] \cdot 10^{-6} = 61.30 \ kNm > M_{Ed}^{Max.} \ \therefore \text{SAFE!}$$

DESIGN OF BEAM B1

$b = 200mm$

$h = 400mm$

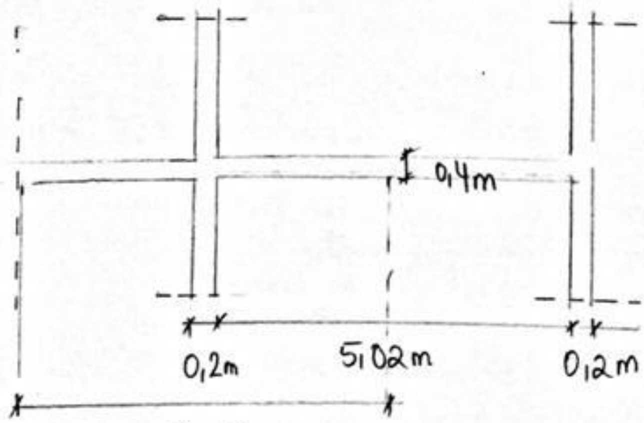
$\phi = 14 mm$

$\phi_{link} = 8mm$ stirrups

$C_{nom} = 20 mm$

$l_{eff} = 3{,}49 + 2(0{,}1)$

$= 3{,}69m$



$$d = h - c - \phi_{link} - \phi/2$$

$$= 363mm$$

LOADS

MASONRY INFILL: 10,24 KN/m

SELF WEIGHT OF THE BEAM(200/400) : G_{ED} Beam

$$G_{ED}\,beam = 1{,}35 \cdot 25 \cdot 0{,}2 \cdot 0{,}4 = 2{,}7 \text{ kN/m}$$

SUPPORT REACTION OF R.C. SLAB = P_{ED} SLAB · l_{eff} SLAB

$$P_{ED}\ BEAM = (17{,}34) \cdot (l_1) \leftarrow ?$$

INTERNAL FORCES

$$M_{ED} = \frac{P_{ED} \cdot l_{eff}^2}{8} = \frac{17{,}34 \cdot (3{,}69)^2}{8} = 61.89 \text{ KNm}$$

$$V_{ED} = \frac{P_{ED} \cdot l_{eff}}{2} = \frac{17{,}34 \cdot (3{,}69)^2}{2} = 67{,}06 \text{ KN}$$

ULTIMATE LIMIT STATE - STRENGTH ANALYSIS

f_{cd} = 13,33 N/mm²

f_{yd} = 435 N/mm²

BENDING

$N_c z = M_{RD} = M_{ED}$

$$X_c = d\left[1 - \sqrt{1 - \frac{2M_{ED}}{bd^2 f_{cd}}}\right] = 365 \cdot \left[1 - \sqrt{\frac{1 - 2(61.87)}{200 \cdot (365)^2 \cdot 13{,}33}}\right]$$

X_c = 70,36 mm

SELF WEIGHT OF C1 = $1{,}35 \cdot 25 \cdot (0{,}2) \cdot 0{,}3 \cdot 3$

$= 6{,}075$ kN

SELF WEIGHT OF BEAM B1 = $1{,}35 \cdot 25 \cdot 0{,}2 \cdot 0{,}4$

$= 2{,}7$ kN/m

$N_{ED} = 444{,}64$ kN

⇒ ULTIMATE LIMIT STATE - STRENGTH ANALYSIS

As 4Ø18 → $A_s = \frac{18^2 \pi}{4} \cdot 4$

$A_s = 1018{,}01 \text{ mm}^2$

$N_{RD} = bhf_{cd} + A_s \sigma_{sd} = (300 \cdot 200 \cdot 13{,}33) + (804{,}4 \cdot 435)$

$= 1149{,}693 \cdot 10^3 \text{ N} > N_{ED} = 444{,}64 \text{ kN}$

1149,693 kN

∴ SAFE ✓

DETERMINATION OF APPROXIMATE SIZES OF CROSS-SECTION

$N_{ED} = bhf_{cd} \Rightarrow b = h = \sqrt{\frac{N_{ED}}{f_{cd}}} = \sqrt{\frac{444{,}635 \cdot 10^3}{13{,}33}} = 182{,}63 \text{ mm}^2$

If $b_{min} = 200$ mm → $d = 200 - 20 - 8 - 16/2 = 163$ mm

DESIGN ⇒ $l_0 = l = 1 \cdot 3{,}000 \Rightarrow d = \frac{l_0}{d} = \frac{3000}{164} = 18{,}29$

$d = 164 \text{ mm}^2 \quad \varphi = 0{,}5$

$N_{R0} = \frac{N_{ED}}{\varphi} = \frac{444{,}64}{0{,}5} = 889{,}28$ kN

$A_{sreq} = \frac{N_{R0} - bhf_d}{f_{cd}} \Rightarrow A_{sreq} = 818.55 \text{ mm}^2$

If used 4Ø18 ⇒ $A_Ø = \frac{4 \cdot 18^2 \pi}{4} = 1018.01 \text{ mm}^2 > 818.55 \text{ mm}^2$

SAFE ✓

Calculations

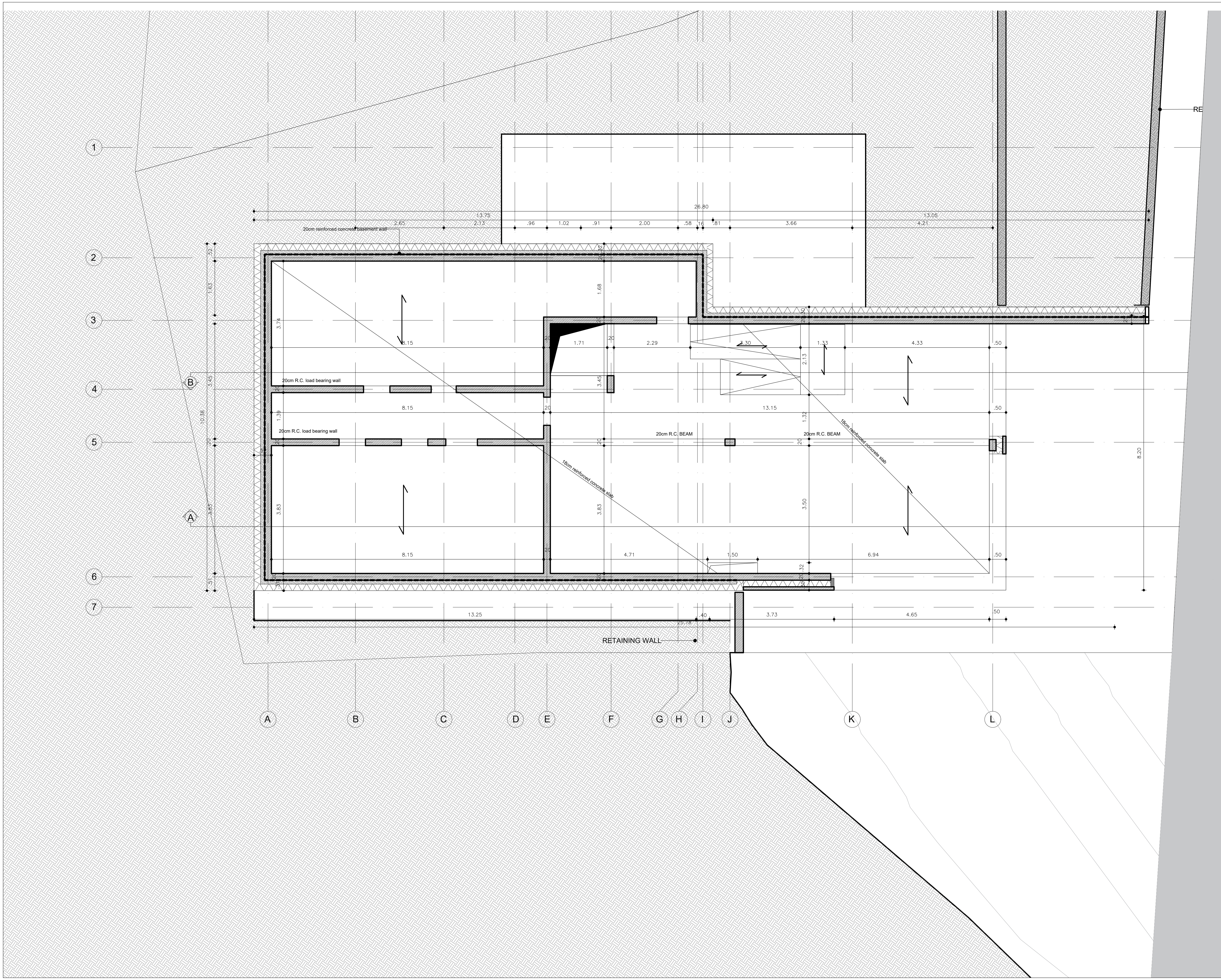
Slab Calculations		
leff1	4.03	m
leff2	3.6	m
leff3	3.85	m
Dead Loads	6.4	KN/m²
Live Loads	5	KN/m²
Ped Floor	17.34	KN/m²
Ped Slab	17.34	KN/m
R1	27.95208	KN
R2	73.14012	KN
R3	57.9156	KN
R4	26.7036	KN
Mmax1	22.52937648	KNm
Mmax2	-28.1617206	KNm
Mmax3	-0.0709206	KNm
Mmax4	-25.702215	KNm
Mmax5	20.561772	KNm
Cross Sectional Data		
Width	1	m
Thickness	180	mm
Cnom	20	mm
Φ	8	mm
Distance between center of rebars (mm)	110	mm
As	457.0181818	mm²
Effective Depth	156	mm
fcd	13.33	N/mm²
fyd	435	N/mm²
Xc	14.91394667	mm
Z	148.5430267	
Ns	198802.9091	
Moment Equilibrium		
2Med	-0.1418412	KNm
d²	24336	mm
bd²fcd	324398880	
2Med/bd^fcd	-4.3724E-10	
1-2Med/bd^fcd	1	
	1	
Strain C (Will the Steel Bars Yield?)	-2.1862E-10	
Xc required	-3.4105E-08	mm²
Xc provided	0.034284935	mm²
MRd	29.53078583	KNm

Calculations

Checking Beam G1		
b	200	mm
h	400	mm
Φ	14	mm
Φlink	8	mm
Cnom	20	mm
d	365	mm
Load of Masonry Infill	10.24	KN/m
Self Weight of Beam	2.7	KN/m
Support Reaction of R.C. Slab	23.409	KN
Ped Beam	36.349	KN/m
Leff	3.69	m
Leff Slab	4.03	m
Internal Forces		
VED	67.063905	KN
MED	61.86645236	KNm
Strength Analysis		
fcd	13.33	N/mm^2
fyd	435	N/mm^2
2Med	123732904.7	
d^2	133225	
bd^2fcd	355177850	
2Med/bd^fcd	0.348368866	
1-2Med/bd^fcd	0.651631134	
	0.807236728	
	0.192763272	
Xc	70.35859444	mm
Z	329.8207028	mm
As Required	431.2092248	mm^2
AΦ	153.958	mm^2
Minimum Number of Rebars Required	2.800823762	3
As Provided	461.874	mm^2

Calculations

Checking Column C1		
Beam Height	400	mm
Beam Width	200	mm
Cnom	20	mm
Height of Column	3	m
Ped Floor	17.34	KN/m²
leffc1	5.2	m
leffc2	4.92	m
n	0.486166	
Mb	55.62325	KNm
R1	34.38722	KN
R2	31.35086	KN
R3	48.39808	KN
fcd	13.33	N/mm²
fyd	435	N/mm²
Safety Factor (Dead Loads)	1.35	
Self Weight of C1 KN	6.075	KN
Self Weight of beam above C1 KN/m	2.7	KN/m
Reaction of C2 KN	48.39808	KN
Multi Span	4.98	m
Two Span	4.3625	m
Ned	444.6349	KN
Φ	18	mm
Cnom	20	mm
b=h	182.6361	mm²
bmin	200	mm
ϕ Reduction Factor	0.5	
d Effective Depth	163	
l	3000	mm
α	18.40491	mm
NR0	1242633	KN
As Required	818.5513	mm²
Asprovided	1018.008	mm²
Nrnull	889.2698	KN



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GRAVEL

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XPS Thermal Ins.

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01

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Drawing Name:

GROUND FLOOR PLAN

SCALE 1:100

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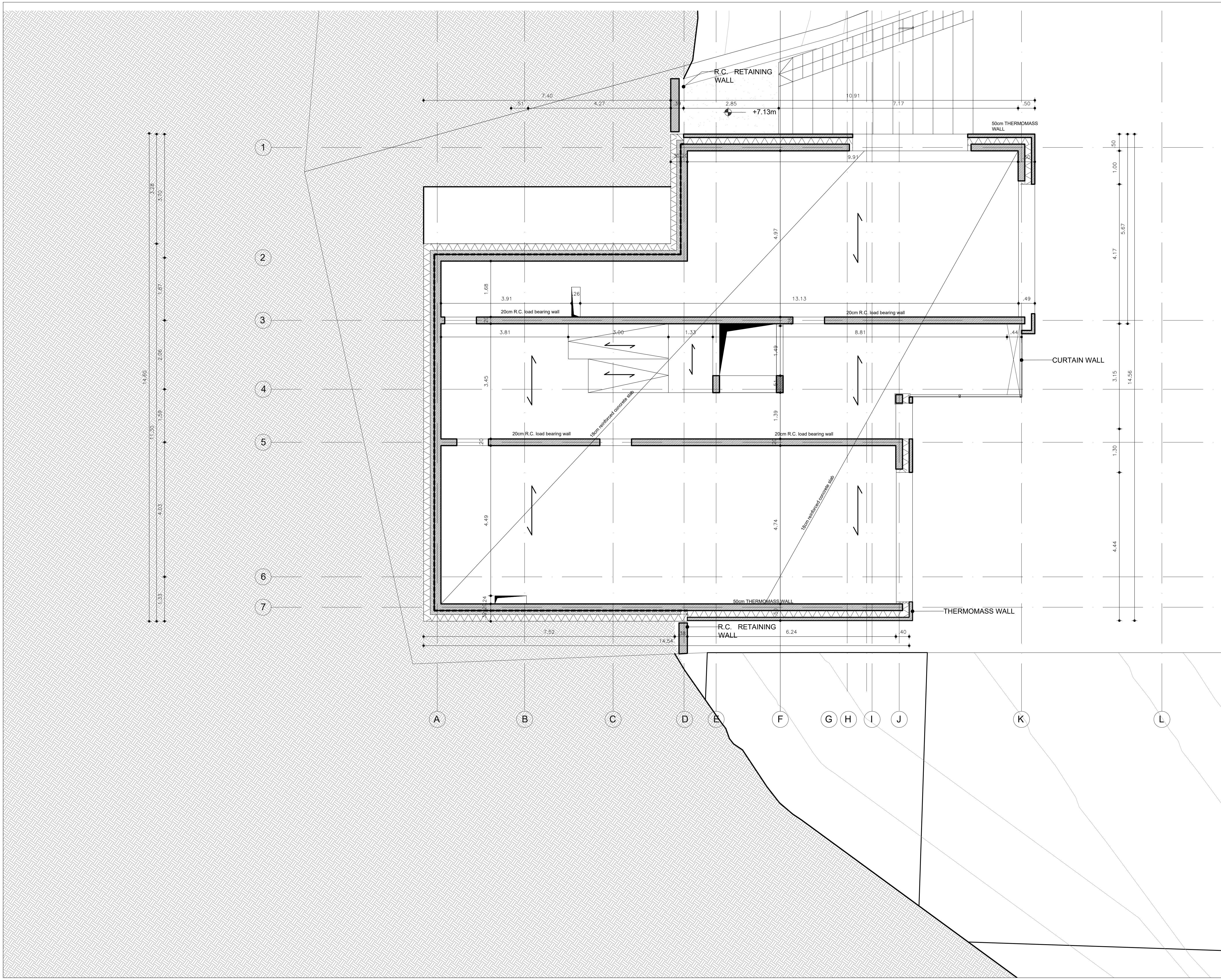

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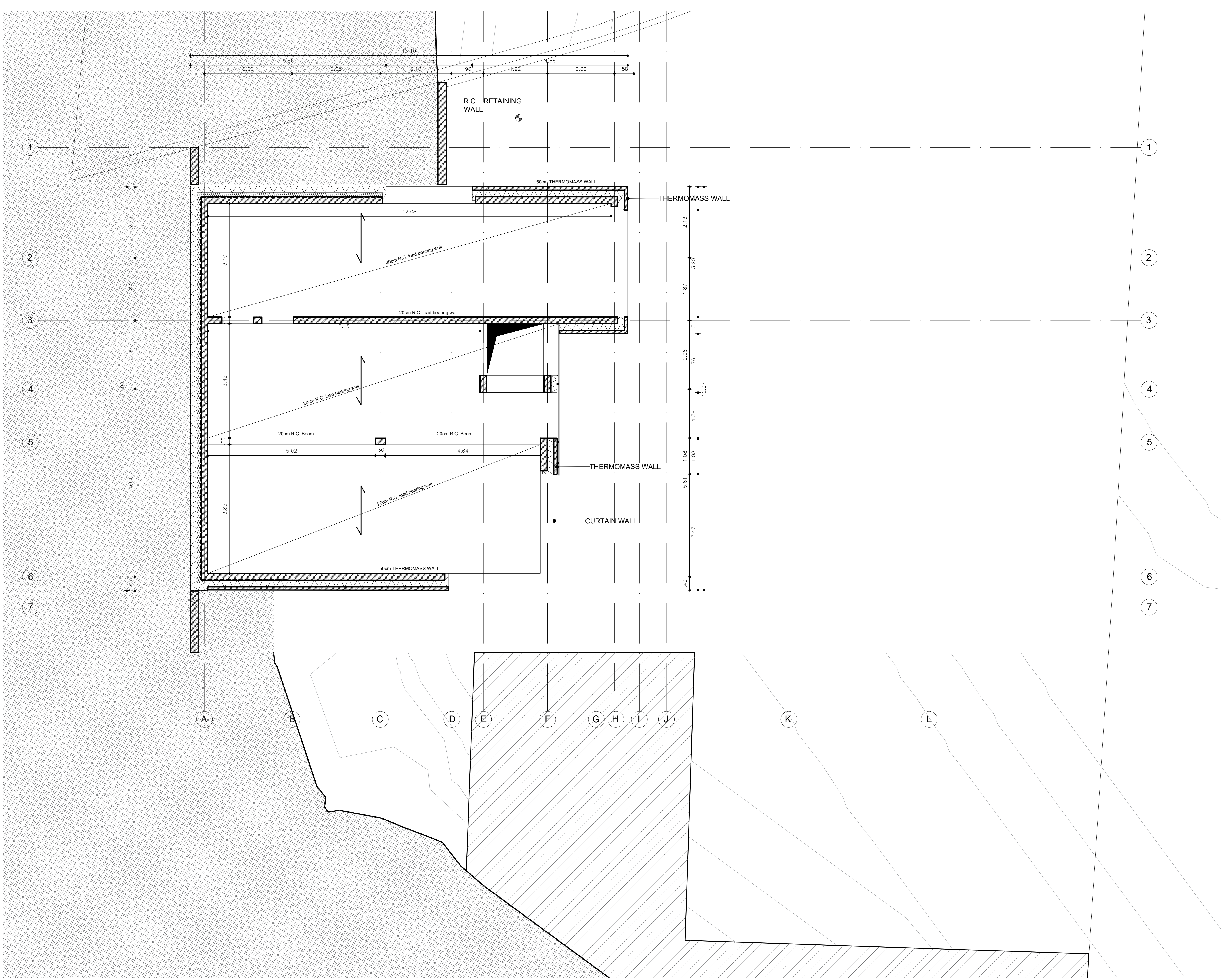
Drawing Name:
FIRST FLOOR STRUCTURAL PLAN SCALE 1:100

Raghad Al Zoubi



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Drawing Name:

SECOND FLOOR PLAN

SCALE 1:100

Raghad Al Zoubi