ARCH 332 Structural Design in Architecture

House Project in Ümitköy

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Group 2

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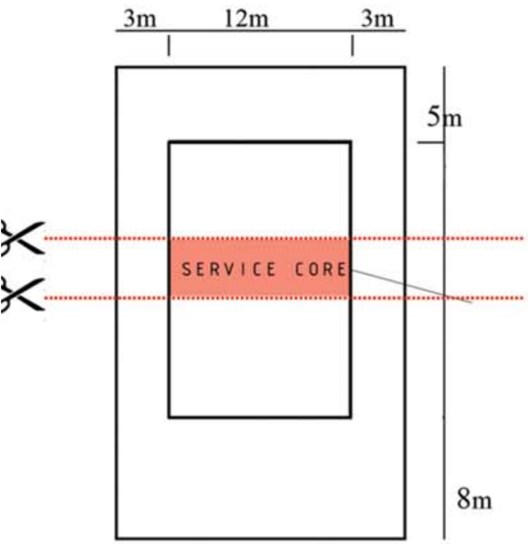
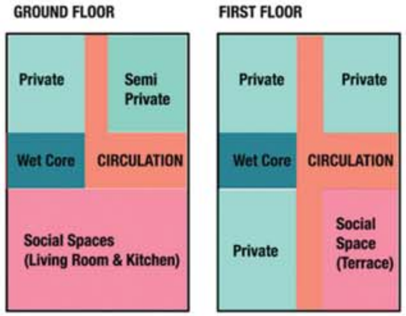
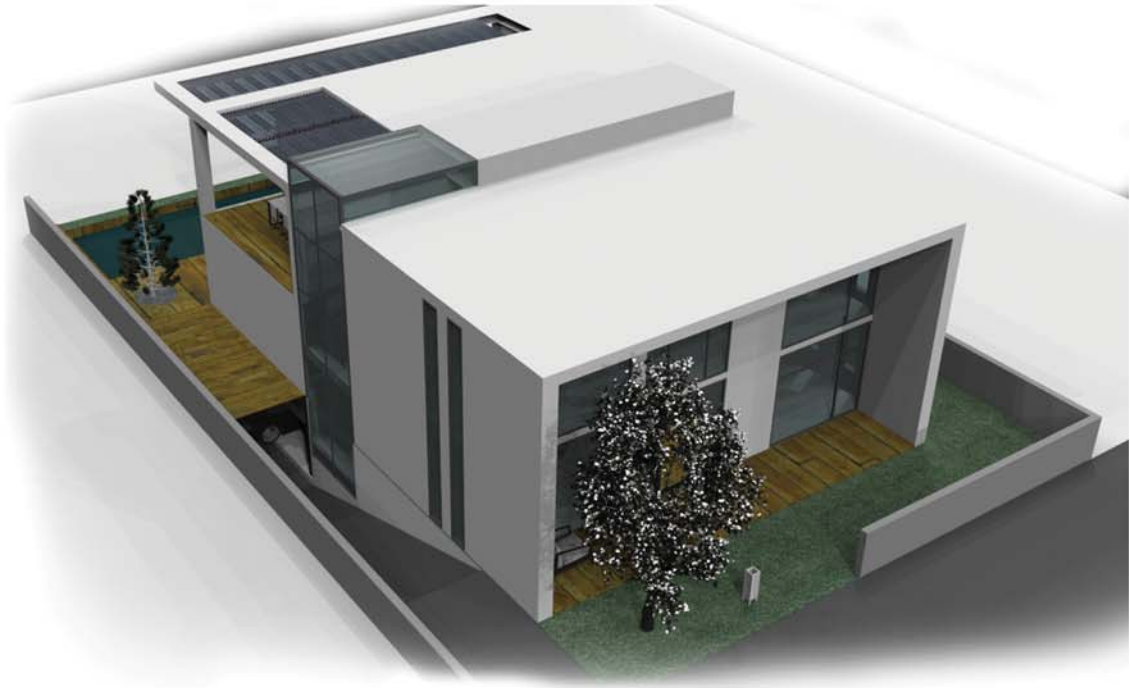
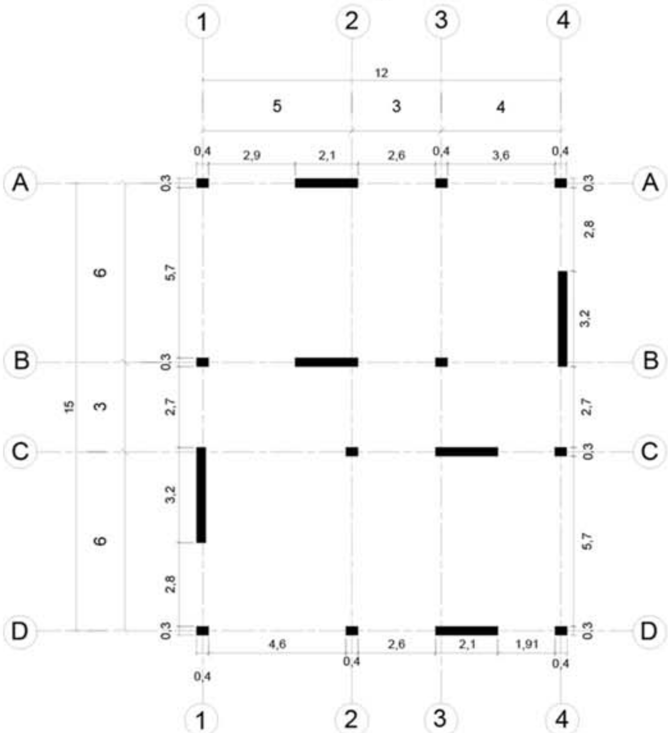
Design Idea & 3D Images







Structural System



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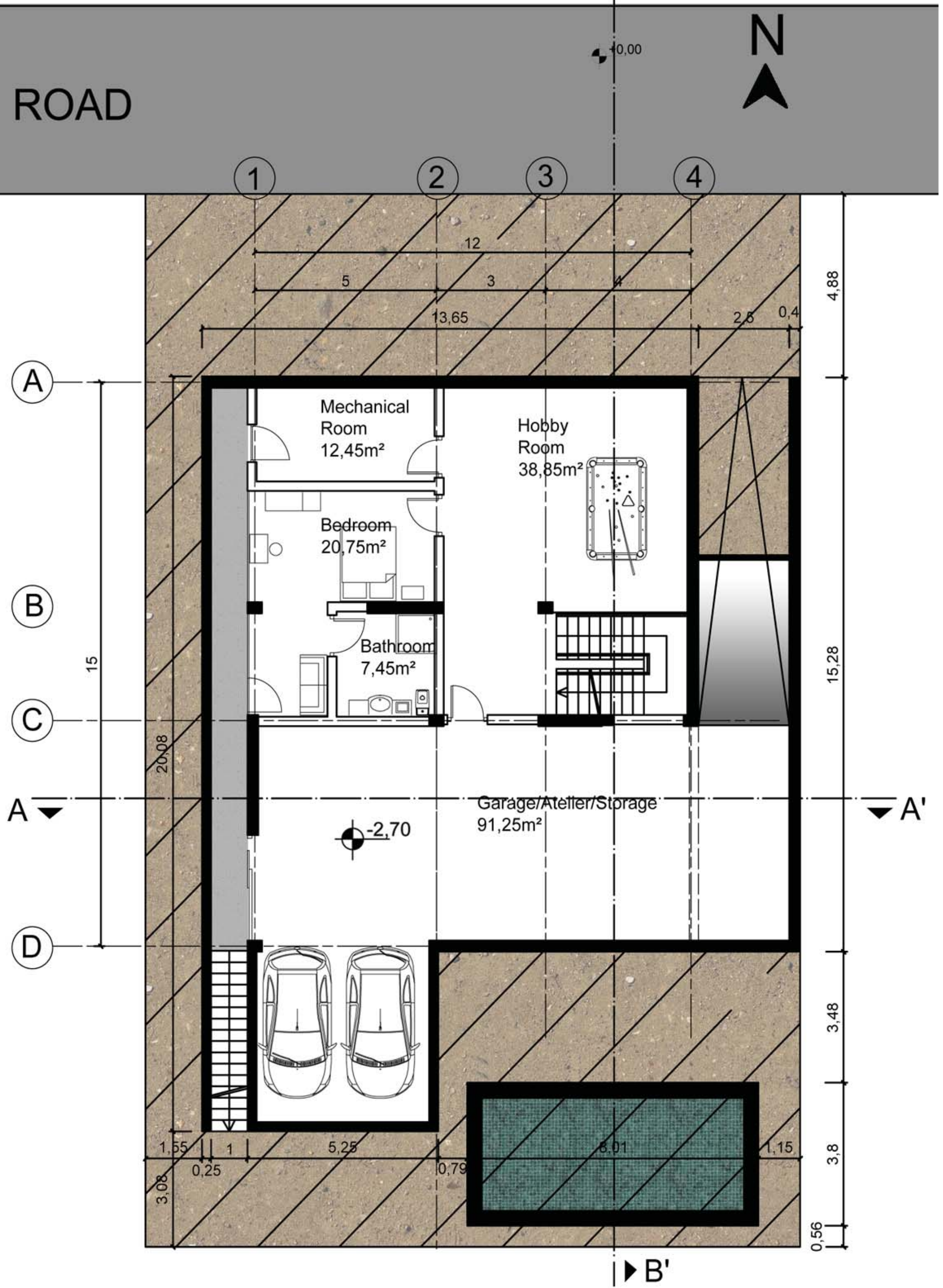
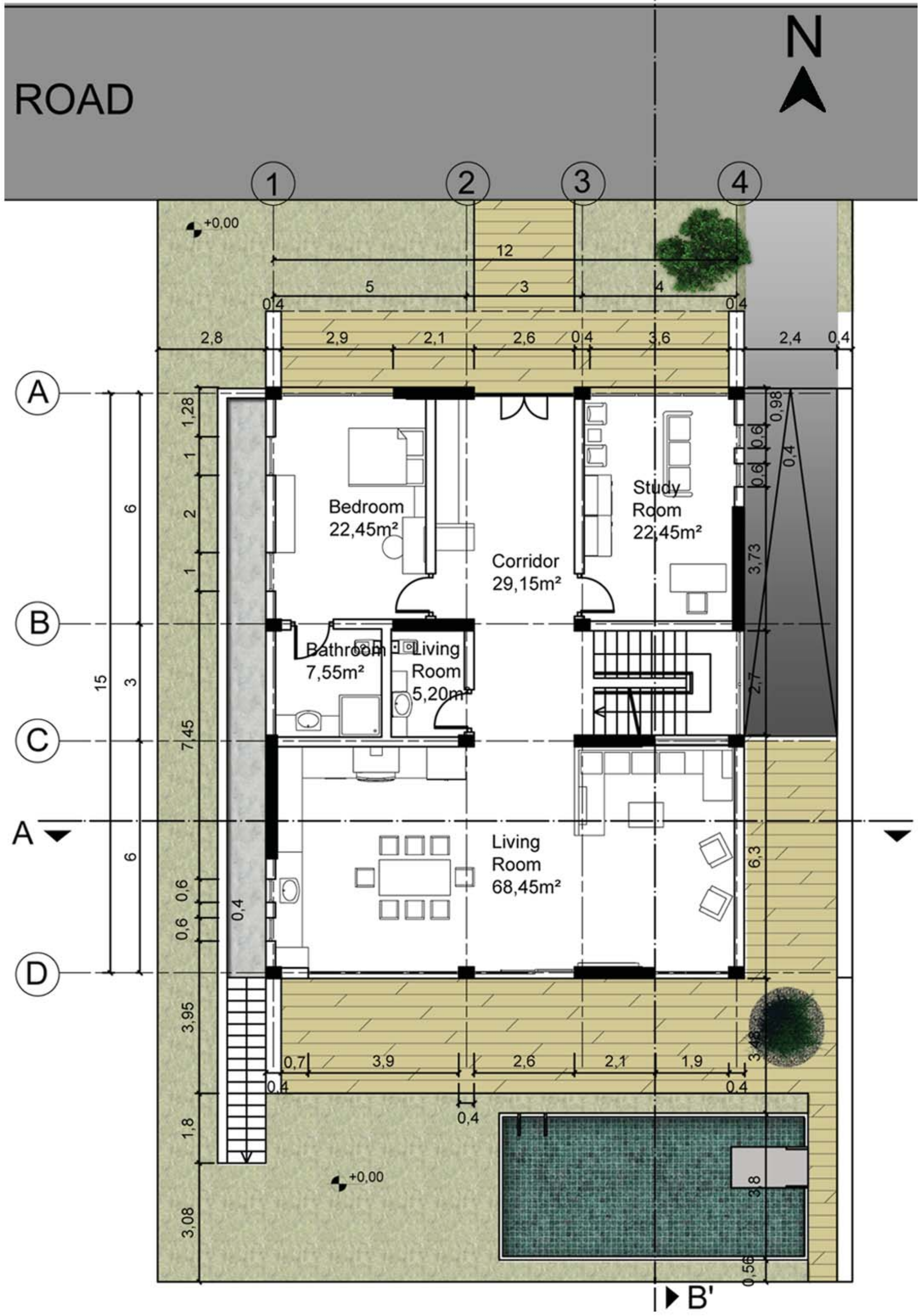
Floor Plans

-2.70 Floor Plan



+0.00 Floor Plan



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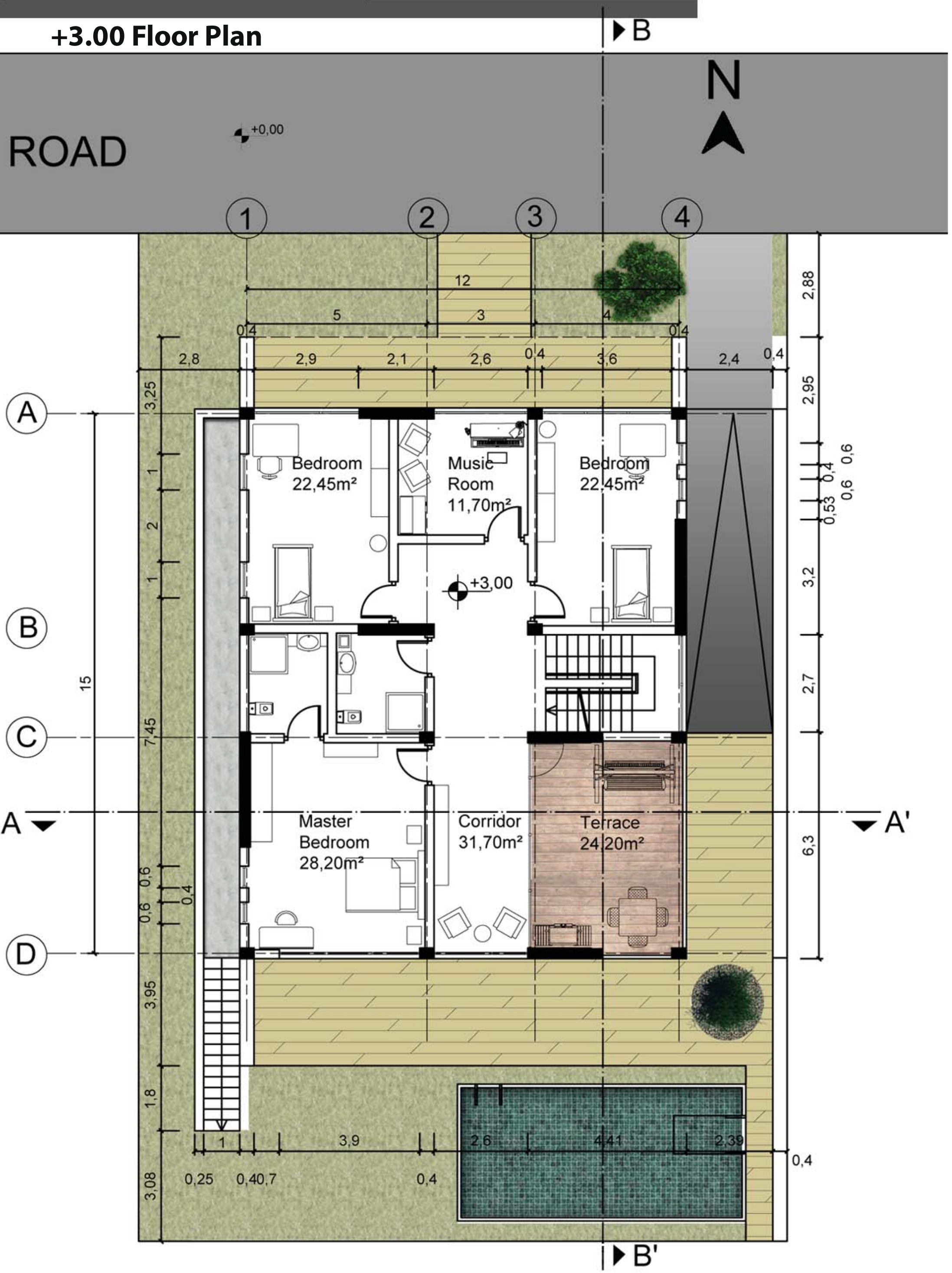
Floor Plans

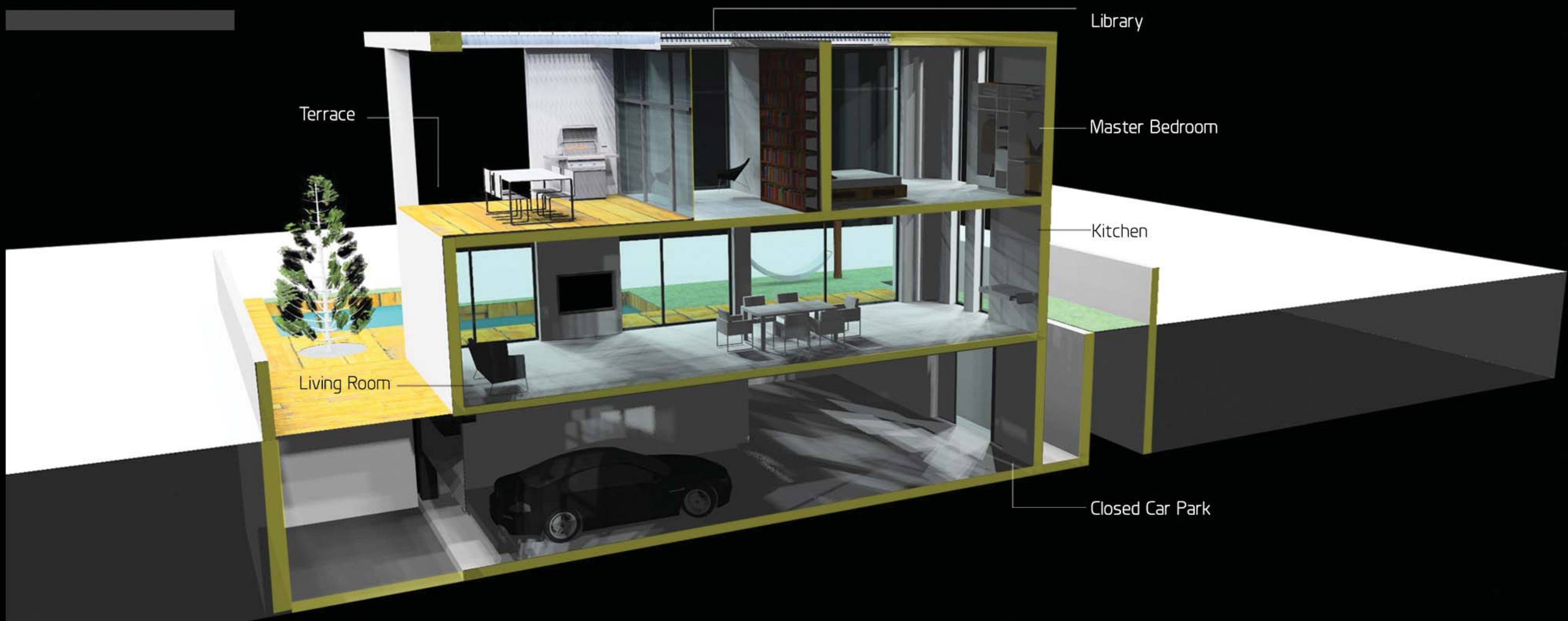
+3.00 Floor Plan



Site Plan

Sections


Children Bedroom
Terrace
Living Room
Study Room
Closed Car Park
Hobby Room


Library
Terrace
Master Bedroom
Kitchen
Living Room
Closed Car Park

Elevations

South Elevation

North Elevation

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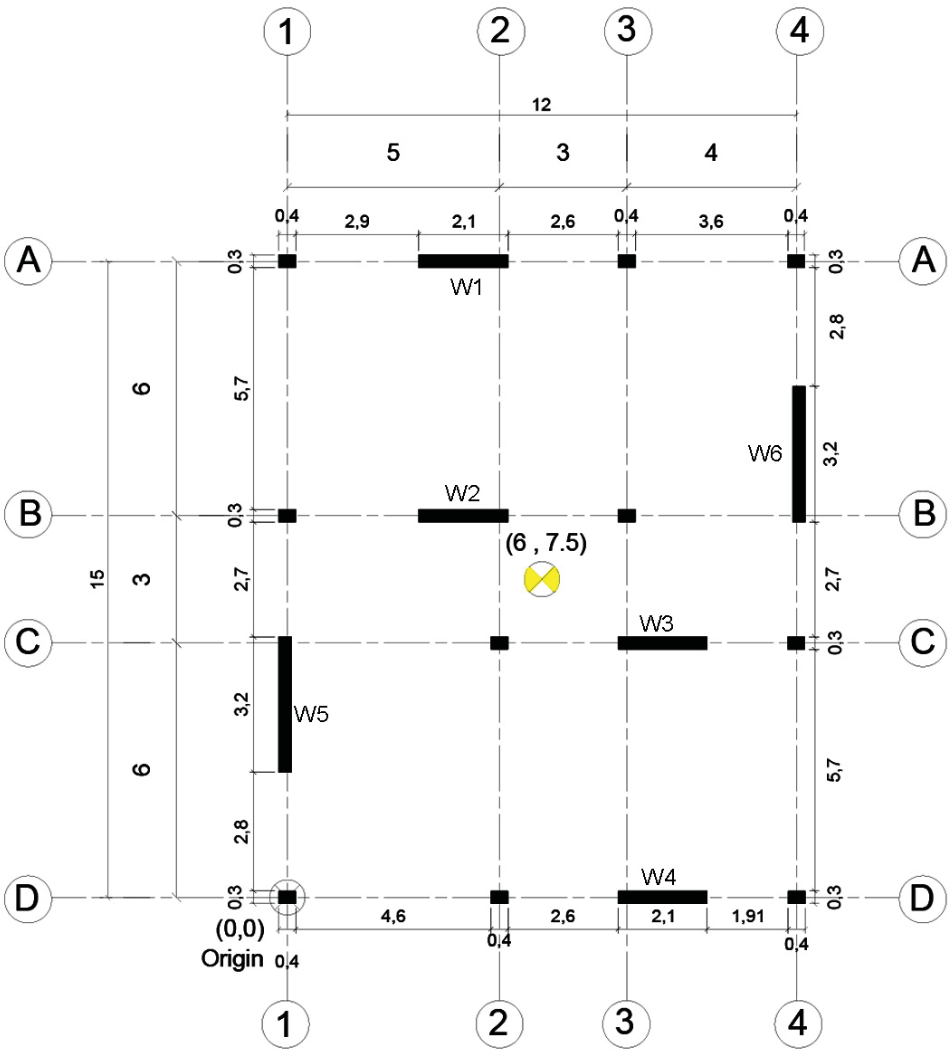
Elevations

East Elevation

West Elevation



Geometric Center

Since the slab is simply rectangular,the geometric center is located on midpoints of the lenghts on X and Y axis. The origin is depicted on the figure.

$$Gx = \frac{12}{2} = \boxed{6} \qquad Gy = \frac{15}{2} = \boxed{7.5}$$

Stiffness Center

Dİmensions of shear walls on X axis (namely W5,W4) = 0.3m X 3.2 m

$$X_R = \frac{\underbrace{\left[\frac{1}{12} \times 0.3 \times (3.2)^3 \times 0\right]}_{W5} + \underbrace{\left[\frac{1}{12} \times 0.3 \times (3.2)^3 \times 12\right]}_{W4}}{2 \times \left[\frac{1}{12} \times 0.3 \times (3.2)^3\right]} = \boxed{6}$$

Dİmensions of shear walls on Y axis (namely W1,W2,W3,W4) = 0.3m X 2.1 m

$$X_R = \frac{\underbrace{\left[\frac{1}{12} \times 0.3 \times (2.1)^3 \times 15\right]}_{W1} + \underbrace{\left[\frac{1}{12} \times 0.3 \times (2.1)^3 \times 9\right]}_{W2} + \underbrace{\left[\frac{1}{12} \times 0.3 \times (2.1)^3 \times 6\right]}_{W3} + \underbrace{\left[\frac{1}{12} \times 0.3 \times (2.1)^3 \times 0\right]}_{W4}}{4 \times \left[\frac{1}{12} \times 0.3 \times (2.1)^3\right]} = \boxed{7.5}$$

Shear Wall Percentage

$$\frac{\text{Area of the Footprint of Shear Walls on x Axis}}{\text{Floor Area}}$$

Total Floor Area : 180 m^2

Area of shear walls on Y direction : 0.3 x 2.1 x 4 = 2.52 m^2

The ratio of shear wall area on Y direction to floor area : 2.52 / 180 =0.014 ——> % 1,4 ☑

Area of shear walls on X direction : 0.3 x 3.2 x 2 = 1.92 m^2

The ratio of shear wall area on X direction to floor area : 1.92 / 180 =0.0106 ——> % 1 ☑

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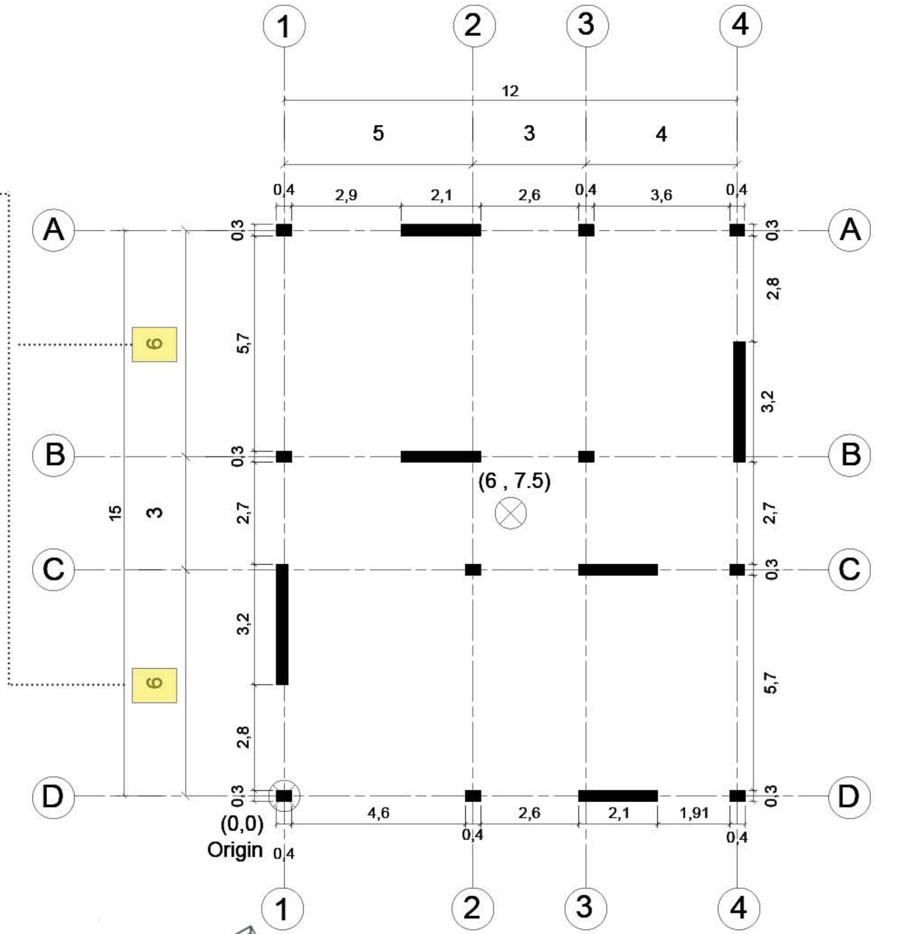
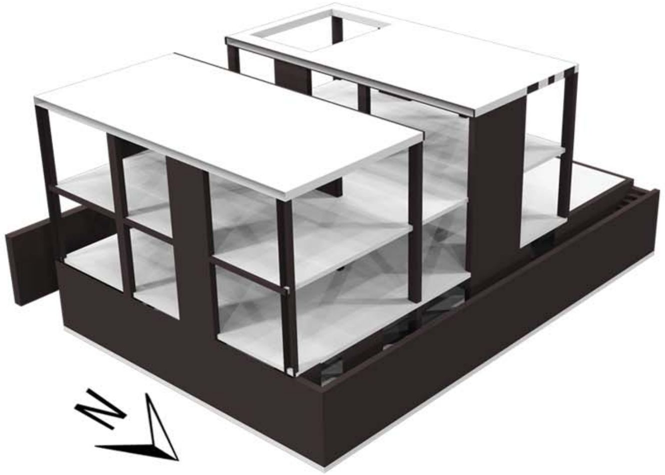
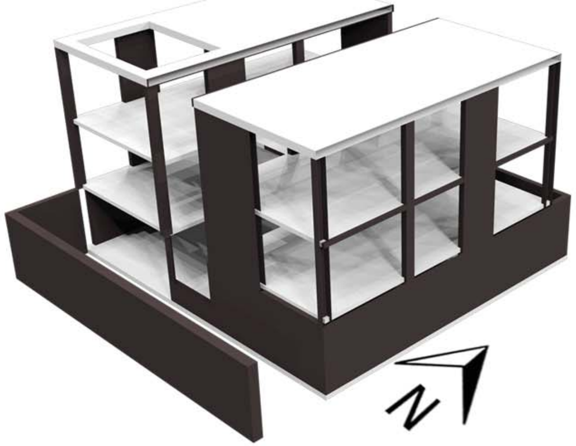
Slab System

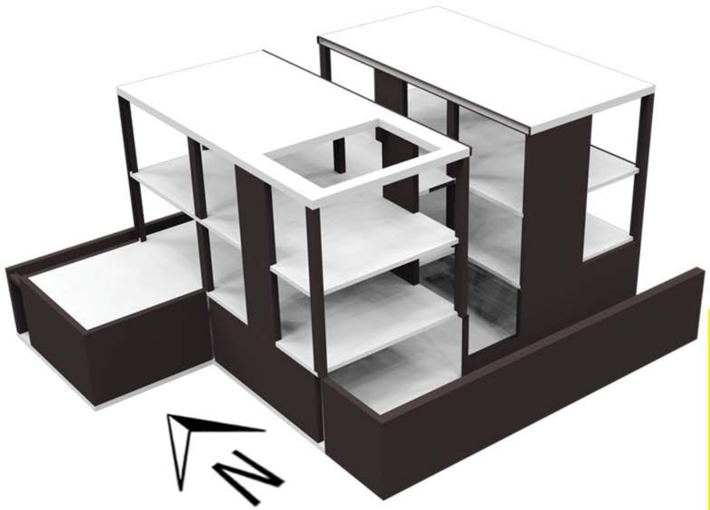
Flat Plate is selected as the structural system. According to the standars
The mimimum thickness should be greater than
h>200mm
h≥Long length / 30
The dimensions of columns in the span direction should not be less than 1/20 of the span length in that direction nor less than 300mm.

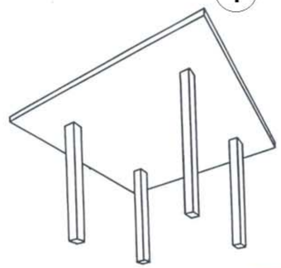
According to the rules
we choose **20 cm** as slab thickness.











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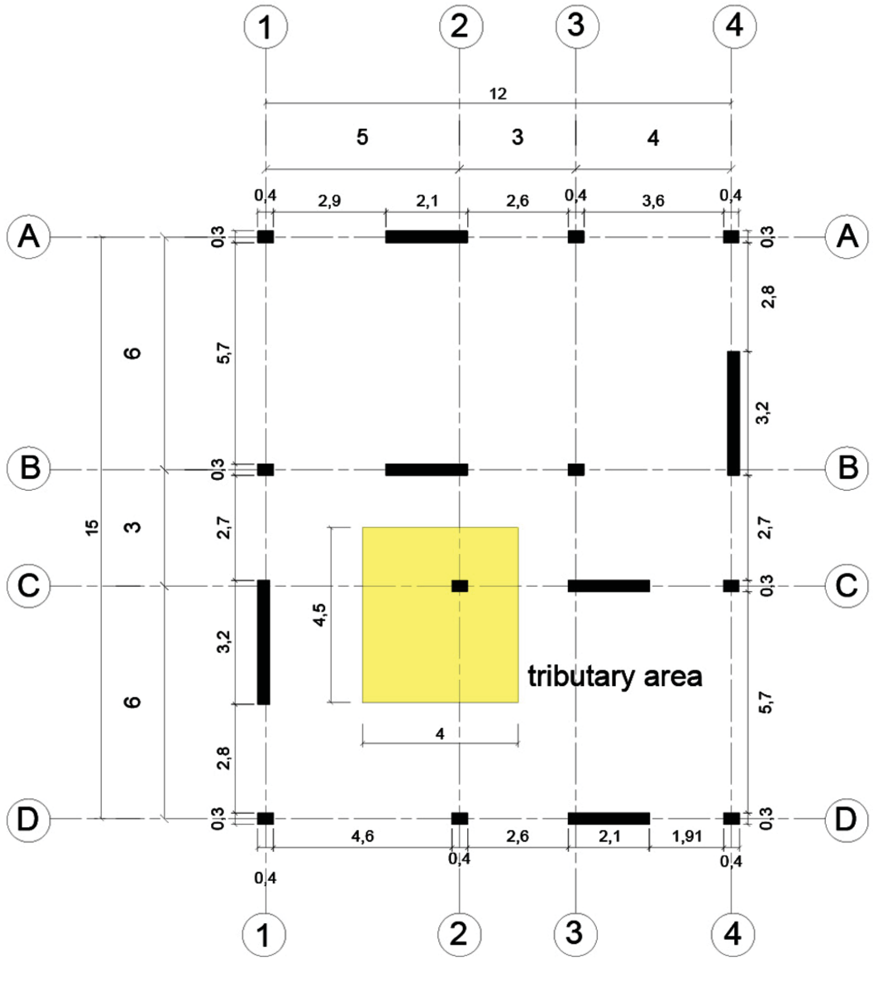
Column Dimensions



Design Loads (Live Load and Dead Load)

Dead Load for Flat Slab is:

Own Weight : 0.2 x 2.4 = 0.48 t/m²
Leveling : 0.04 x 2.4 = 0.096 t/m²
Covering : 0.025 x 2 = 0.05 t/m²
Plastering : 0.02 x 2 = 0.04 t/m²
+
0.666 t/m2 ~ 0.7 t/m²

Live Load

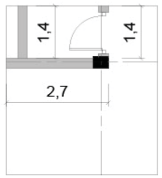
We can consider 200 kg/m2 (0.2 t/m2) which is for residential buildings according to the standards.

Total Load = (1.4x DL) + (1.6 x LL)
= (1.4x 0.7) + (1.6 x 0.2)
$\boxed{=1.3 \text{ t/m}^2}$

Wall Load

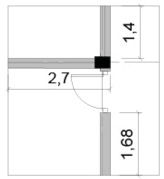
Tributary Area : 4.5 x 4 = $\boxed{18 \text{ m}^2}$

+0.00 Floor Tributary Area



Total Wall Length : 5.5 m

+3.00 Floor Tributary Area

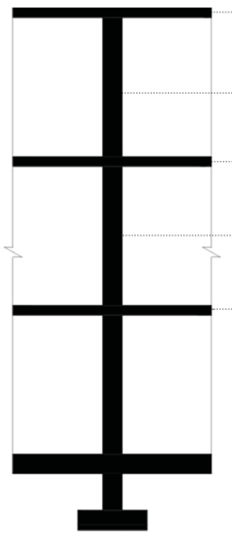


Total Wall Length : 5.78 m

**In order to be on the safe side, door loads are taken as wall loads.*

Wall Load = Wall Length x Wall Height x Distributed Wall Load(0.45 t/m2) x Dead Load Factor
Slab Load =Total Design Load x Tributary Area

Assume Slab depth is 20 cm and wall height is 280 cm



Slab Load : 1.3 t/m² x 18 m² = 23.4 t = **23400 kg**

Wall Load : 5.78 m x 2.8m x 0.45 t/m² x 1.4 = 10.196 t =**10196 kg**

Slab Load : 1.3 t/m² x 18 m² = 23.4 t = **23400 kg**

Wall Load : 5.5m x 2.8m x 0.45t/m² x 1.4 =9.702 t = **9702 kg**

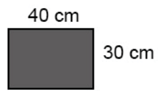
Slab Load : 1.3 t/m² x 18 m² = 23.4 t = **23400 kg**

Total Load : 23400 + 10196+ 23400 + 9702 + 23400 = **90098 kg**

Acording to Standards;

$$A_c \geq \frac{N_d}{0.75 \times f_{cd}} = \frac{90098}{0.75 \times 130} = 924 \text{ cm}^2$$

$A_c \geq 750 \text{mm}^2$



Ac:1200 cm²

According to TS-500 column dimensions :

Then; **1200cm² > 924 cm²**

☑

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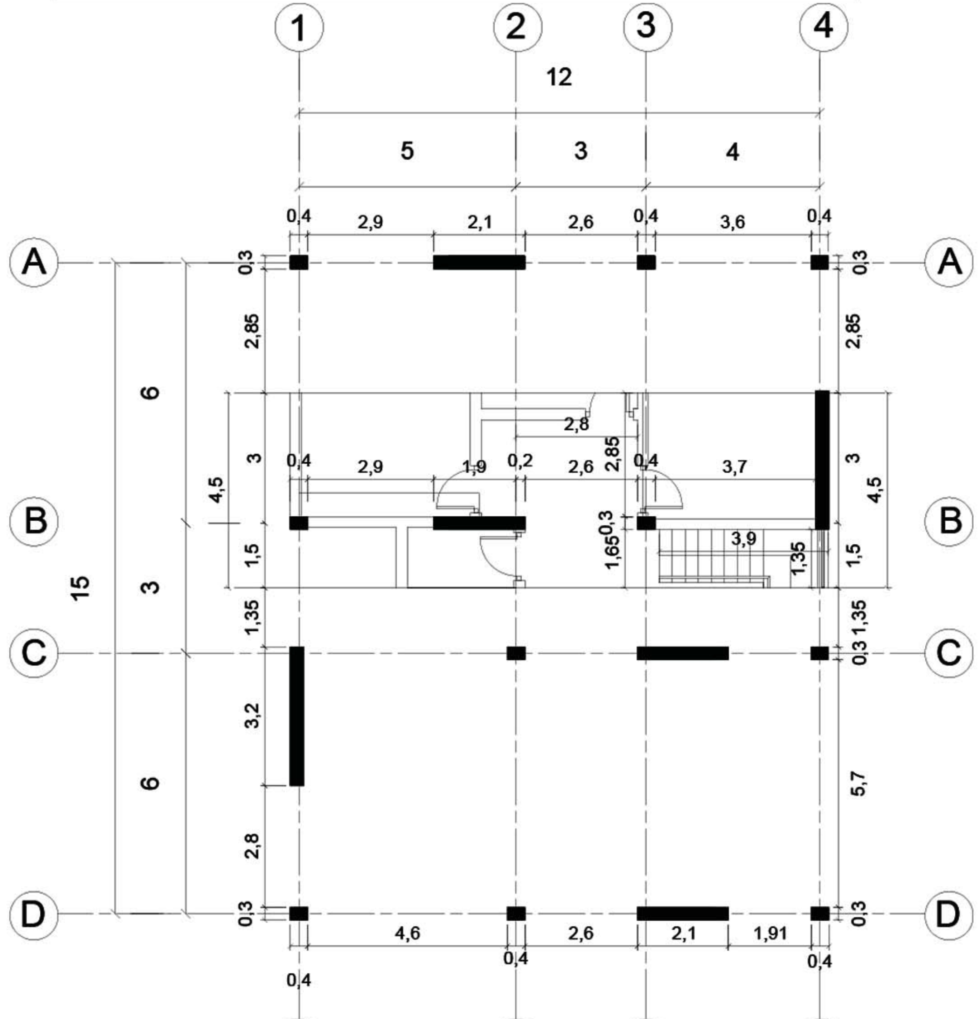
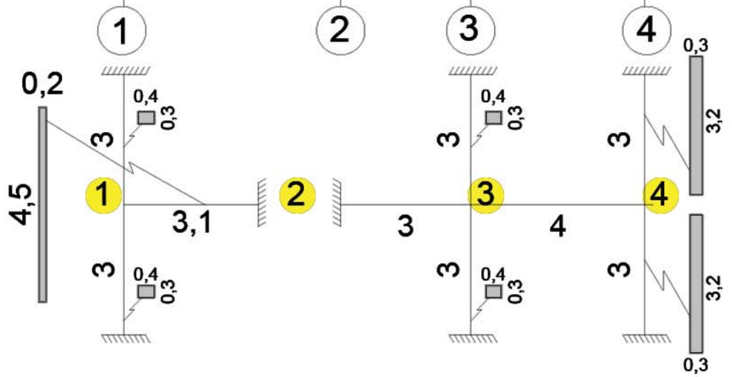
Column dimensions Approximate Method





The area depicted in the figure choosen for the two cycle method since the columns and the shear walls in that axis have the greatest distance to the other walls and shear walls. We will make the calculation according to the first floor in that area because wall load on the first floor is greater than ground floor. (Live load and the slab load is the same.)

Calculation of Wall Loads (First Floor)

For two cycle graphics, axis 1-2 will be taken as 2.9 m instead of 4.15m but, to be on the safe side, whole wall load on the 1-2 axis was taken (in 4.15 distance).

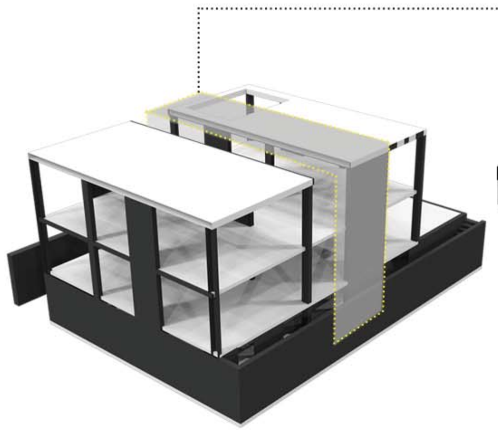
Between the axis		Load	Total Load	
1-2______	13.125 x 2.8 x 0.45 x 1.4	=23.153 t	23.153+29.25	= **52.403 t**
2-3______	6.15 x2.8x0.45x1.4	= 10.849 t	10.849+17.55	= **28.399 t**
3-4______	7.25 x2.8x0.45x1.4	= 12.789 t	12.789+16.56	= **29.349 t**

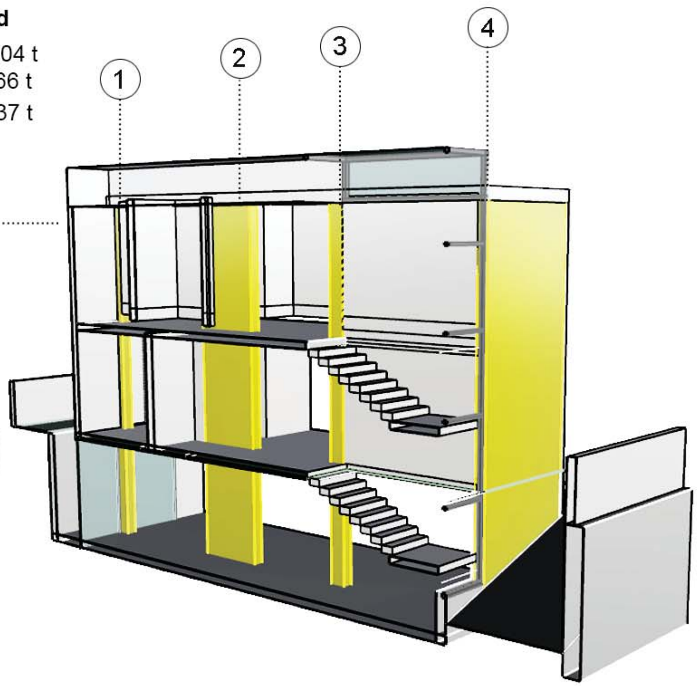
Calculation of Slab Loads (First Floor)

Between the axis		Load
1-2______	1.3x4.5x5	= 29.25 t
2-3______	1.3x4.5x3	= 17.55 t
3-4______	1.3x[(4.5x4)-(3.9x1.35)] Stair	=16.56 t

Calculation of the Distributed Loads (First Floor)

Between the axis		Load
1-2______	52.403 / 3.1	=16.904 t
2-3______	28.399/3	= 9.466 t
3-4______	29.349 / 4	= 7.337 t





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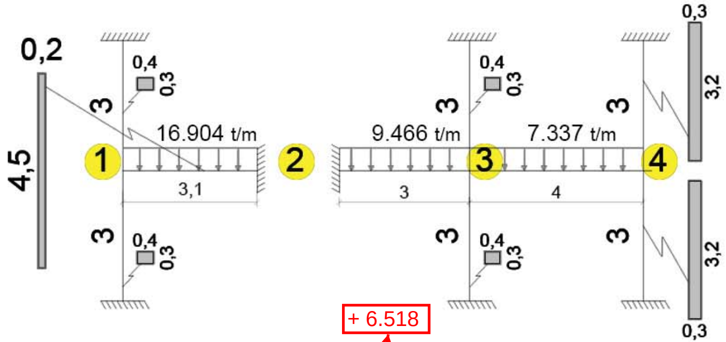
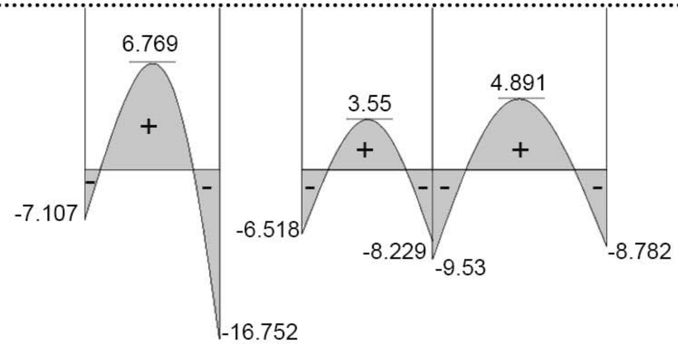
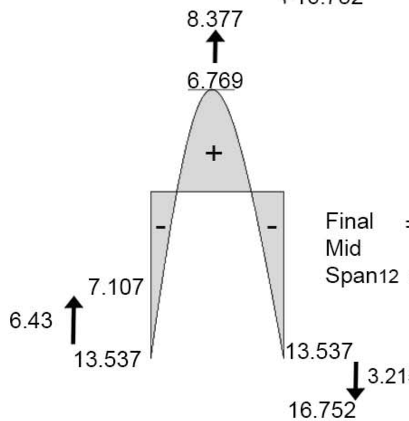
Design of Beams
Two Cycle Method



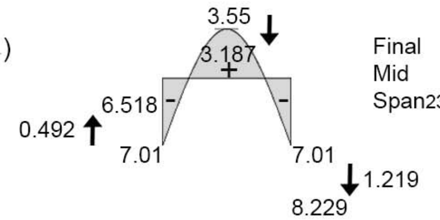
r	0.475	0	0	0.355	0.266	0.135
FEM	13.537	-13.537	7.01	-7.01	9.783	-9.783
1st cycle	0	-3.215	-0.492	0	0.660	-0.369
Σ	13.537	-16.752	-6.518	-7.01	10.443	-10.152
2nd cycle	-6.430	0	0	-1.219	-0.913	1.370
Σ	**7.107**	**-16.752**	**-6.518**	**-8.229**	**9.53**	**-8.782**

$M.S._{12} = \frac{16.904 \times 3.1^2}{24} = 6.769$ $\quad M.S._{23} = \frac{9.466 \times 3^2}{24} = 3.55$ $\quad M.S._{34} = \frac{7.337 \times 4^2}{24} = 4.891$

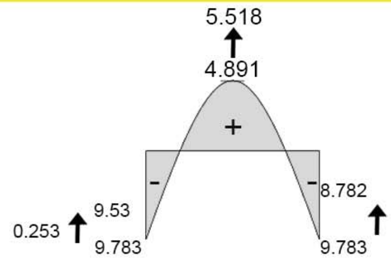




Final Mid Span12 $= 6.769 + \left(\frac{6.43 - 3.215}{2}\right) = 8.377$



Final Mid Span23 $= 3.55 + \left(\frac{0.492 - 1.219}{2}\right) = 3.187$



Final Mid Span23 $= 4.891 + \left(\frac{0.253 + 1.001}{2}\right) = 5.518$

Span43

Calculation of I Values

$$I = \frac{1}{12} \times A \times B^3$$

(flat slab) $I_{12} = I_{23} = I_{34} = \frac{1}{12} \times 4.5 \times (0.2)^3 = 0.003\ m^4$

(Columns) $I_1 = I_3 = \frac{1}{12} \times 0.3 \times (0.4)^3 = 0.0016\ m^4$

(Shear Wall) $I_4 = \frac{1}{12} \times 3.2 \times (0.3)^3 = 0.0072\ m^4$

Calculation of r Values

$$r_{12} = \frac{\frac{I_{12}}{L_{12}}}{\frac{I_{12}}{L_{12}} + 2 \times \left(\frac{I_1}{L_1}\right)} = \frac{\frac{0.003}{3.1}}{\frac{0.003}{3.1} + \left[2 \times \left(\frac{0.0016}{3}\right)\right]} = \mathbf{0.475}$$

$r_{21} = \mathbf{0}$

$$r_{32} = \frac{\frac{I_{32}}{L_{32}}}{\frac{I_{32}}{L_{32}} + \frac{I_{34}}{L_{34}} + \left[2 \times \left(\frac{I_3}{L_3}\right)\right]} = \frac{\frac{0.003}{3}}{\frac{0.003}{3} + \frac{0.003}{4} + \left[2 \times \left(\frac{0.0016}{3}\right)\right]} = \mathbf{0.355}$$

$r_{23} = \mathbf{0}$

r_{34}

$$r_{32} = \frac{\frac{I_{34}}{L_{34}}}{\frac{I_{34}}{L_{34}} + \frac{I_{32}}{L_{32}} + \left[2 \times \left(\frac{I_3}{L_3}\right)\right]} = \frac{\frac{0.003}{4}}{\frac{0.003}{4} + \frac{0.003}{3} + \left[2 \times \left(\frac{0.0016}{3}\right)\right]} = \mathbf{0.266}$$

r_{43}

$$r_{12} = \frac{\frac{I_{43}}{L_{43}}}{\frac{I_{43}}{L_{43}} + 2 \times \left(\frac{I_4}{L_4}\right)} = \frac{\frac{0.003}{4}}{\frac{0.003}{4} + \left[2 \times \left(\frac{0.0072}{3}\right)\right]} = \mathbf{0.135}$$

FEM

$$FEM = \frac{q \times l^2}{12}$$

$$FEM_{12} = \frac{16.904 \times (3.1)^2}{12} = 13.537\ tm$$

$$FEM_{23} = \frac{9.466 \times (3)^2}{12} = 7.01\ tm$$

$$FEM_{34} = \frac{7.337 \times (4)^2}{12} = 9.783\ tm$$

Slab Depth

$$K_0 = \frac{bw \times d^2}{M_{max}}$$

$$0.025 = \frac{450 \times d^2}{1675200} = 9.647$$

Since **20 cm** ≥ 9.647cm , our flat is **SAFE**