ARCH 332 -
STRUCTURAL DESIGN IN ARCHITECTURE II /SPRING 2012

GROUP17

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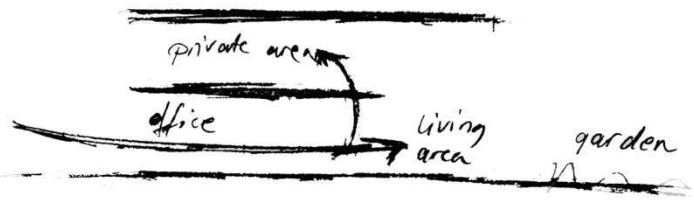
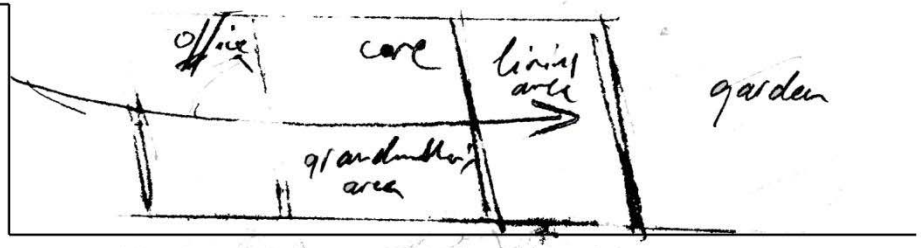
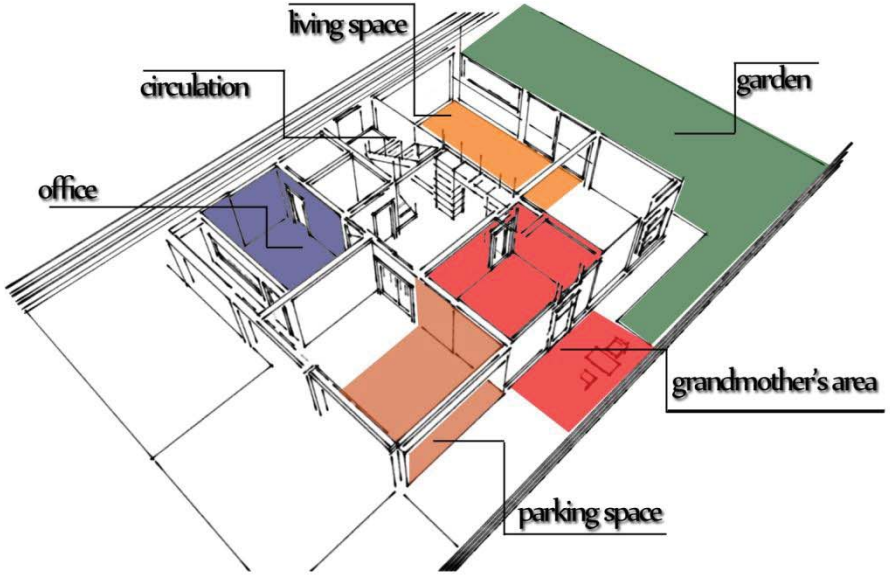
The project consists of a house for five family members ; **including two children ; their parents and a grandmother/grandfather; and an office** used by one family member and quests in Ümitköy; Ankara. The concept of house focuses **the seperation of housing activities and office** and the **connection house in itself with a gallery.** Service core is located on the west of house; including the main circulation and services.



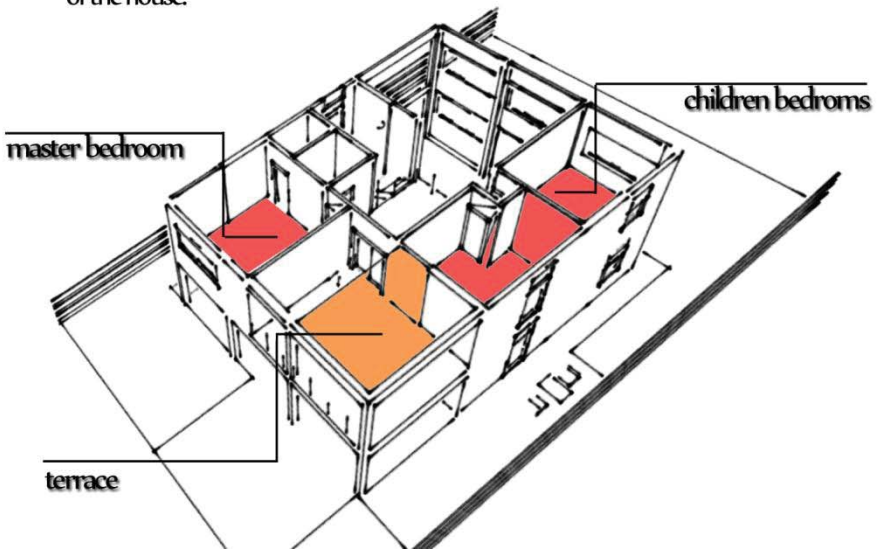
DESIGN CONCEPT

On the **ground floor** ;an office,a living area with a kitchen and a grandmother's room are located. Entrances of office and entrance of house are seperated from each other. The living area faces the south to have efficient light, green areas directly and visually. By the help of gallery ; two floors have connected to the each other. Grandmother's room is located by thinking the least distance to the wet core and living area, and also entrance to the garden is provided for the grandmother's room. The office has own service area which connected to the main core.





On **the first floor;** two bedrooms and master bedroom are isolated from public areas; and they all have connection the hall that faces to the gallery and ends with a terrace. The terrace located in the north has visual contact to the road and main entrance of the house.



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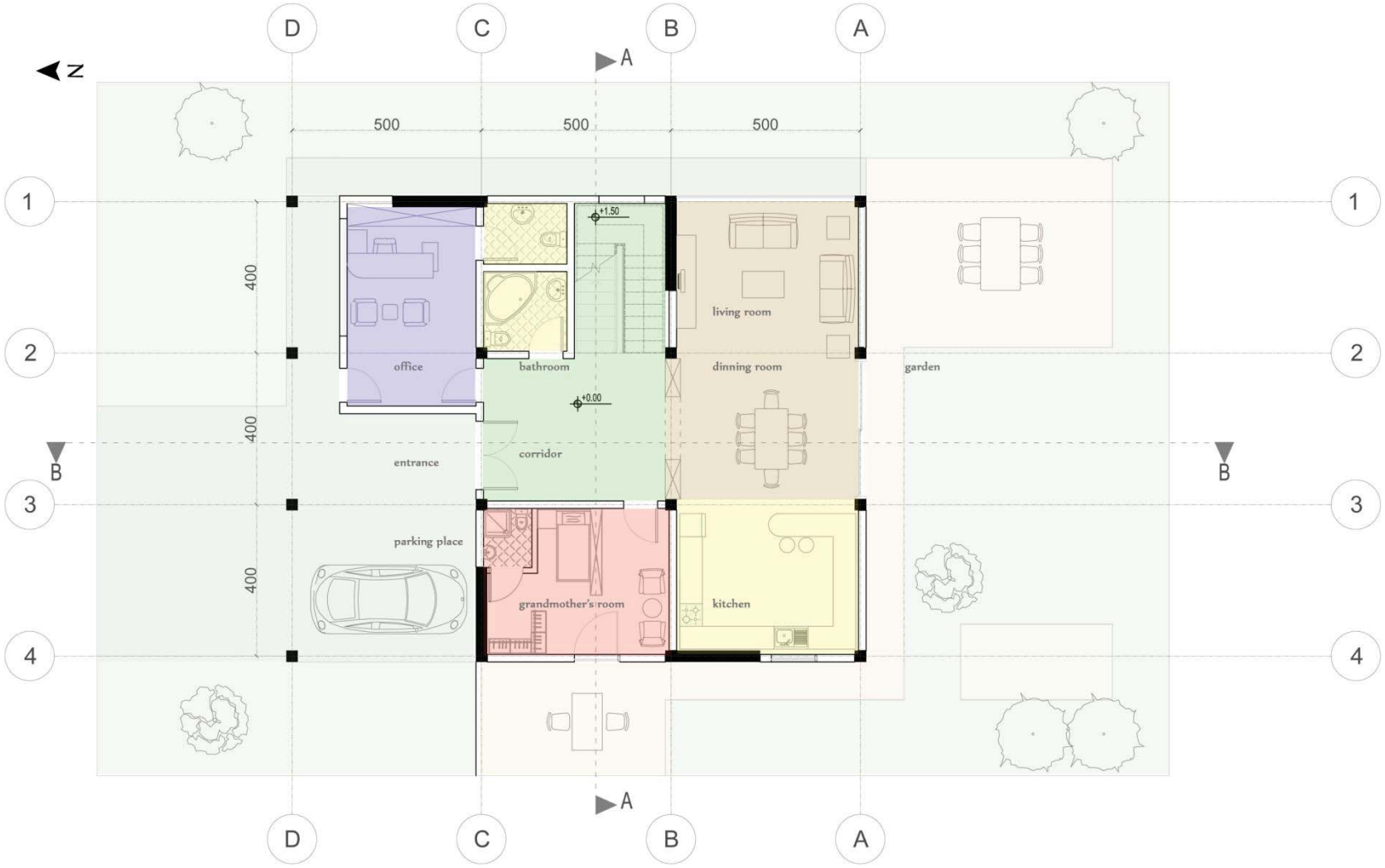
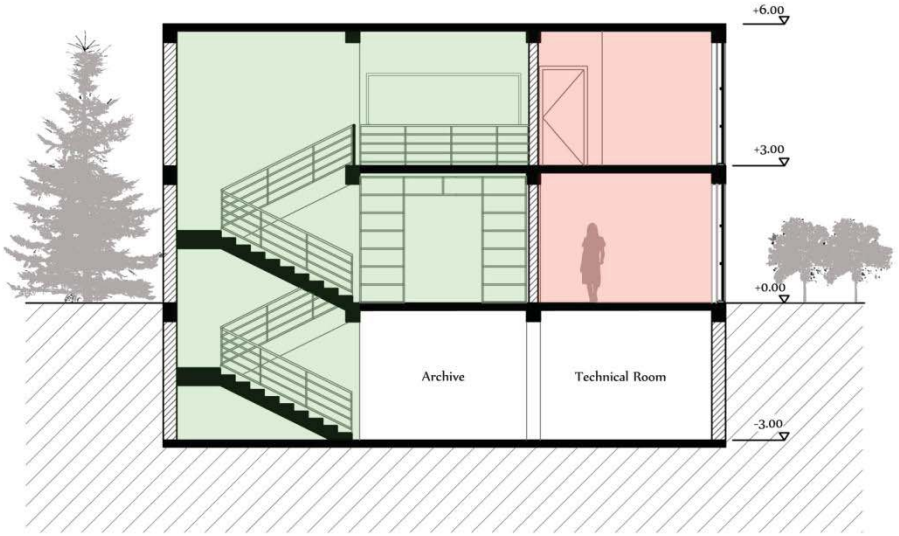
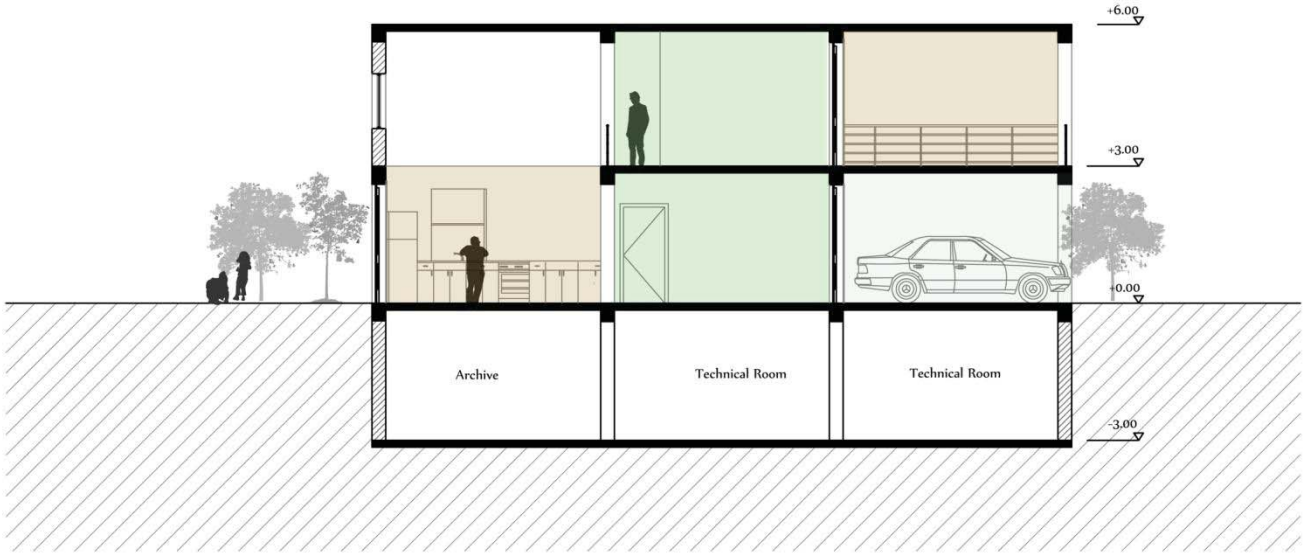


GROUND FLOOR PLAN SCALE 1/100

FIRST FLOOR PLAN SCALE 1/100



SECTION AA SCALE: 1/100



SECTION BB SCALE: 1/100

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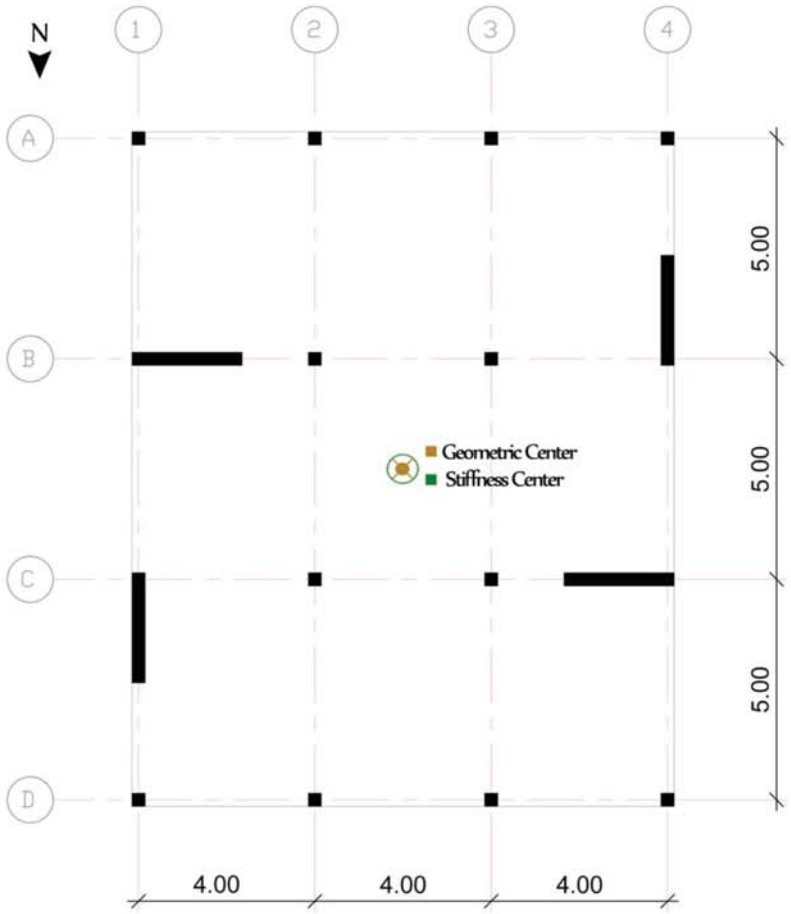
VIEW THROUGH THE LIVING SPACE

VIEW FROM THE KITCHEN

I.SELECTION OF STRUCTURAL SYSTEM



If we take D-1 axis as (0,0) of an x-y coordinate then;

Stiffness Center:

(All the shear walls are identical, their I value is identical)

$$Sy = \frac{(Ix5)+(Ix0)}{I+I} = 7.5\ (X\ direction)$$

$$Sx = \frac{(Ix0)+(Ix12)}{I+I} = 6.0\ (Y\ direction)$$

Geometric Center:

Plan is in 4.00 x 5.00 grid system so geometric center would be in the center of the plan which is on (x=6.0, y=7.5) coordinates.

Gx = 6.0 (X direction)

Gy = 7.5 (Y direction)

-Geometric Center and Stiffness Center coincides.

REINFORCED CONCRETE WALLS

FLOOR AREA (m^2)	DIRECTION	SHEAR WALL AREA (m^2)	PERCENTAGE OF SHEAR WALLS
Ground Floor $180m^2$	North-South	1,5	%0,83
	East - West	1,5	%0,83

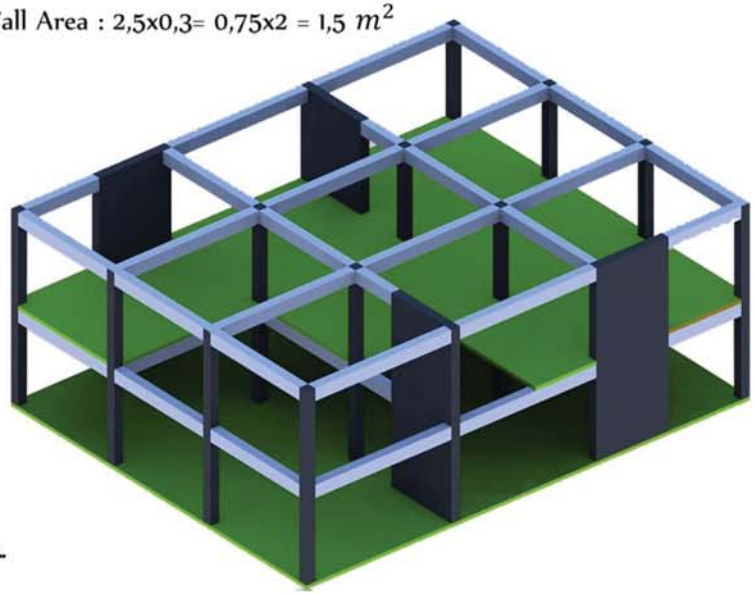
$L \geq 7t$

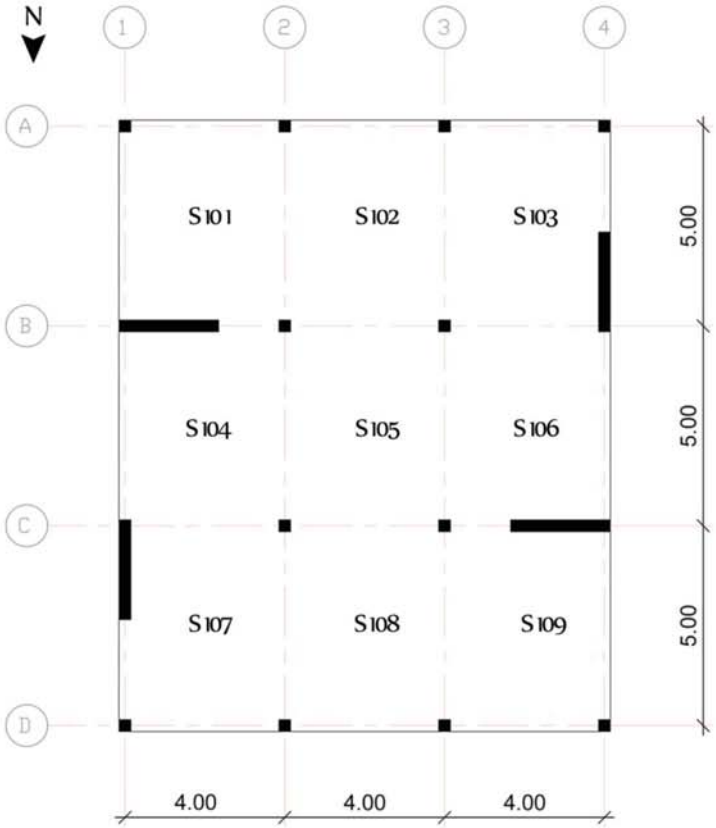
$t \geq \frac{1}{15}$ x Storey Height (Storey Height : 300 cm)

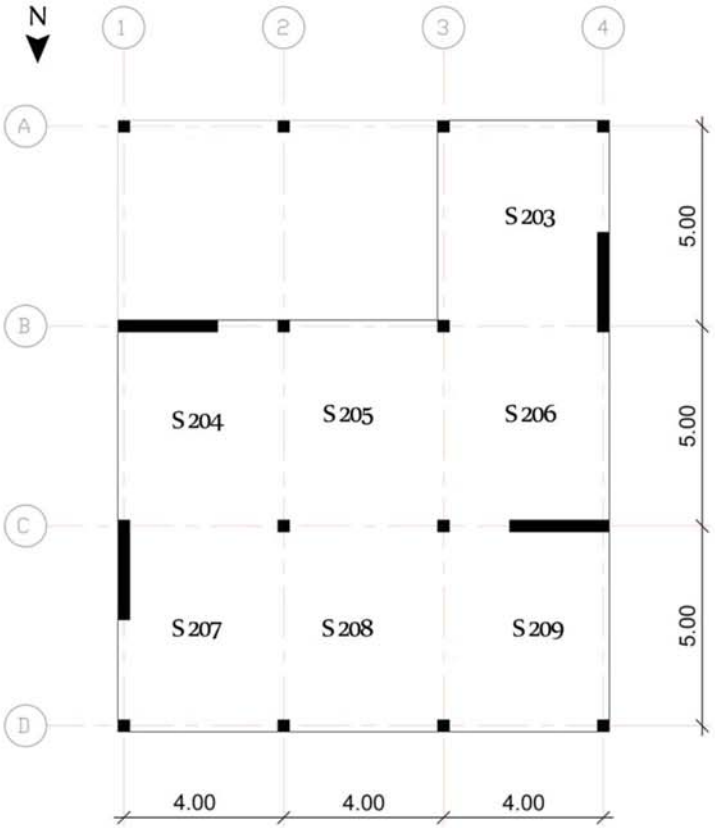
$t \geq 20$ cm

L = 250 cm t = 30cm

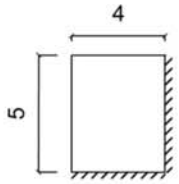
Shear Wall Area : 2,5x0,3= 0,75x2 = 1,5 m^2







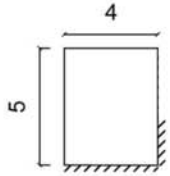
S101, S109 :



$$\alpha = \frac{5+4}{2(5+4)}$$

$\alpha = 0{,}5$

S203 :



$$\alpha = \frac{4+1{,}85}{2(4+5)}$$

$\alpha = 0{,}325$

II.SELECTION OF THE SLAB SYSTEM

SLAB THICKNESS

$$t \geq \frac{l_s}{15+\frac{20}{\frac{l_l}{l_s}}} \times \left(1-\frac{\alpha}{4}\right)$$

$$t_{101,109} \geq \frac{4}{15+\frac{20}{1,25}} \times \left(1-\frac{0,5}{4}\right)$$

$$\geq \frac{3,5}{31}$$

$$\geq 0,113 \text{ m}$$
$$= 11,30 \text{ cm}$$

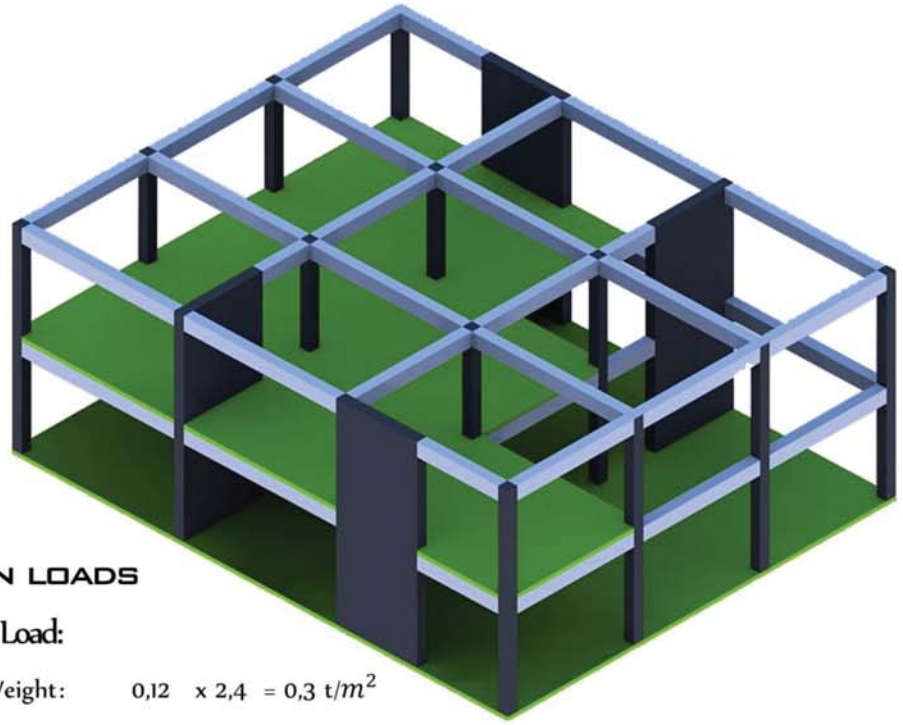
$$t_{203} \geq \frac{4}{15+\frac{20}{1,25}} \times \left(1-\frac{0,325}{4}\right)$$

$$\geq \frac{3,68}{31}$$

$$\geq 0,118 \text{ m}$$
$$= 11,85 \text{ cm}$$

Two Way Solid Slab is chosen.

Slab Thickness is chosen as t=12 cm



DESIGN LOADS

Dead Load:

-Own Weight: 0,12 x 2,4 = 0,3 t/m^2

-Leveling : 0,04 x 2,4 = 0,1 t/m^2

-Covering : 0,025x 0,05= 0,05 t/m^2

-Plastering : 0,02 x 2,4 = 0,04 t/m^2

$\approx$ 0,5 t/m^2

Live Load:

q $\approx$ 0,2 t/m^2

Total Load:

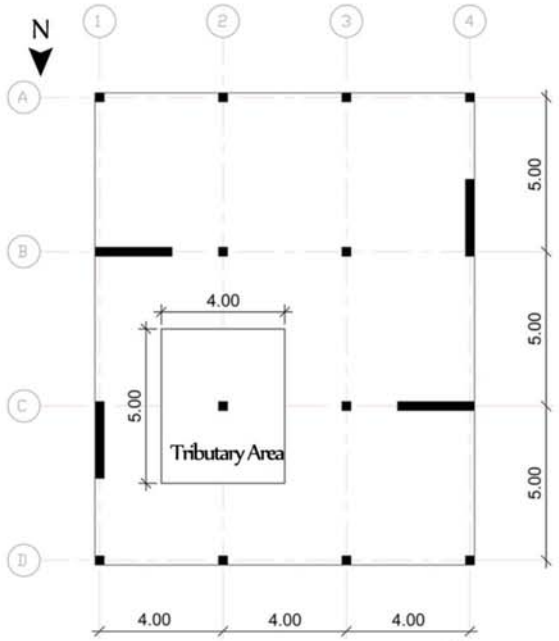
(P_d) = 1,4 x Dead Load + 1,6 x Live Load

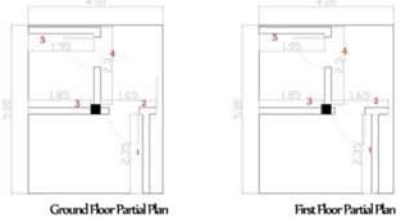
= 1,4 x 0,5 + 1,6 x 0,2

= 1 t/m^2

III. COLUMN DIMENSION

TRIBUTARY AREA





Tributary Area : a x b = 4x5 = 20 m^2

Wall Load : 0,45 t/m^2

First Floor Wall Load = (w_1x h_1 x 0,45 + w_2x h_2 x 0,45 + w_3x h_3 x 0,45 + w_4x h_4 x 0,45+ w_5x h_5 x 0,45+ 2 x (w_6x h_6 x 0,45)) x 1,4

= (2,35x 2,60x 0,45 + 0,75x 2,60 x 0,45 + 1,4x 2,60 x 0,45

+1,85x 2,60 x 0,45 + 1,95x 2,60 x 0,45 + 2 x (0,90x0,50x0,45)) x 1,4

= 14,17 t

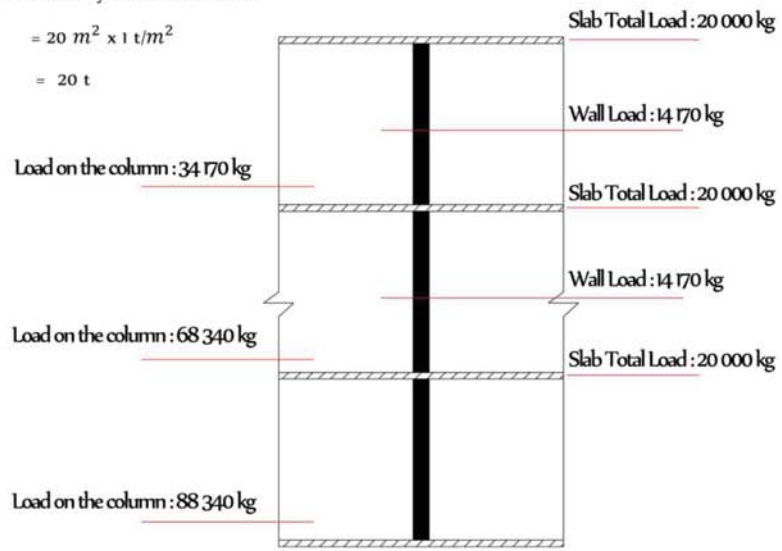
Second Floor Wall Load = First Floor Wall Load

COLUMN DIMENSION

Slab Load Total = Tributary Area x Total Load

= 20 m^2 x 1 t/m^2

= 20 t



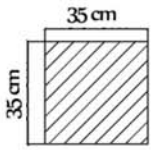
$N_d = \sum Slab\ Load + \sum Wall\ Load$

N_d = 88,34 t

$$\min A_c = \frac{N_d}{0{,}75 x f_{cd}}$$

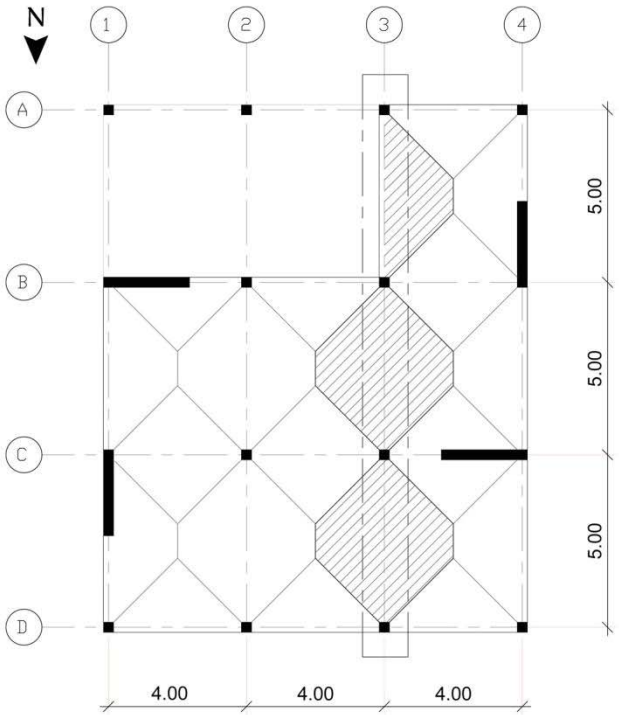
$$\min A_c = \frac{88340}{0{,}75\ x\ 130\ kg/cm^2}$$

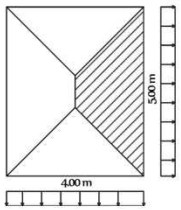
$\min A_c$ = 907 cm^2 → COLUMN DIMENSIONS : 35 X 35 cm



IV. BEAM DEPTH

LOAD DISTRIBUTION





Load : P_d x $\frac{L_{short}}{3}$ x (1.5- $\frac{0.5}{\left(\frac{L_{long}}{L_{short}}\right)^2}$)

A-B Interval

3-4 Interval :

w = 1 x $\frac{4}{3}$ (1.5- $\frac{0.5}{\left(\frac{5}{4}\right)^2}$)

w = 1.57 t/m

wall load = (2.60 x 0.45) x 1.4

= (1.2 x 1.4)

= 1.64 t/m

q= wall load + slab load

q = 1.64 + 1.57 = 3.21 t/m

B-C Interval

2-3 and 3-4 Interval :

w = 1 x $\frac{4}{3}$ (1.5- $\frac{0.5}{\left(\frac{5}{4}\right)^2}$)

w = 1.57 t/m

wall load = (2.60 x 0.45) x 1.4

= (1.2 x 1.4)

= 1.64 t/m

q = 2w + wall load

q = 3.14 + 1,64 = 4.78 t/m

C-D Interval

2-3 and 3-4 Interval :

w = 1 x $\frac{4}{3}$ (1.5- $\frac{0.5}{\left(\frac{5}{4}\right)^2}$)

w = 1.57 t/m

wall load = (2.60 x 0.45) x 1.4

= (1.2 x 1.4)

= 1.64 t/m

q = 2w + wall load

q = 3.14 + 1,64 = 4.78 t/m

FEM CALCULATIONS :

$FEM_{AB} = -FEM_{BA} = \frac{ql^2}{12} = \frac{3{,}21x(5)^2}{12}$ = 6,68 tm

Midspan = $\frac{ql^2}{24} = \frac{3{,}21x(5)^2}{24}$ = 3.34 tm

$FEM_{BC} = -FEM_{CB} = \frac{ql^2}{12} = \frac{4{,}78x(5)^2}{12}$ = 9,96 tm

Midspan = $\frac{ql^2}{24} = \frac{4{,}78x(5)^2}{24}$ = 4,98 tm

$FEM_{CD} = -FEM_{DC} = \frac{ql^2}{12} = \frac{4{,}78x(5)^2}{12}$ = 9,96 tm

Midspan = $\frac{ql^2}{24} = \frac{4{,}78x(5)^2}{24}$ = 4,98 tm

Beam (approximate)

$h = \frac{l}{12} = \frac{5}{12} = 0.42$ m

$I_{beam} = \frac{bh^3}{12}$

$= \frac{0.3x(0.42)^3}{12}$

$= 0.0018\ m^4$

Column

$I_{cd} = \frac{0.35x(0.35)^3}{12}$

$= 0.00125\ m^4$

$r_{AB} = \frac{\left(I_b/L_b\right)_{AB}}{\left(I_b/L_b\right) + 2x\left(I_c/L_c\right)}$

$= \frac{(0.0018/5)_{AB}}{(0.0018/5) + 2x(0.00125/3)} = \frac{3.6x10^{-4}}{3.6x10^{-4} + 8.3x10^{-4}} = 0.30$

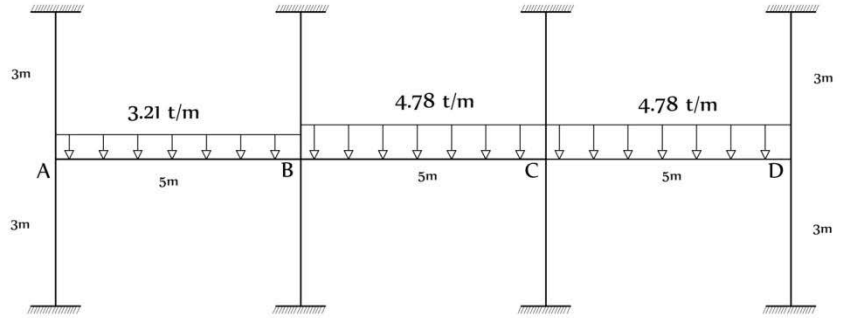
$r_{BA} = \frac{\left(I_b/L_b\right)_{BA}}{\left(I_b/L_b\right)_{BA} + \left(I_b/L_b\right)_{CB} + 2x\left(I_c/L_c\right)} = \frac{3.6x10^{-4}}{7.2x10^{-4} + 8.3x10^{-4}} = 0.23$

$r_{BC} = \frac{\left(I_b/L_b\right)_{CB}}{\left(I_b/L_b\right)_{BA} + \left(I_b/L_b\right)_{CB} + 2x\left(I_c/L_c\right)} = \frac{3.6x10^{-4}}{7.2x10^{-4} + 8.3x10^{-4}} = 0.23$

$r_{CB} = \frac{\left(I_b/L_b\right)_{CB}}{\left(I_b/L_b\right)_{BA} + \left(I_b/L_b\right)_{CB} + 2x\left(I_c/L_c\right)} = \frac{3.6x10^{-4}}{7.2x10^{-4} + 8.3x10^{-4}} = 0.23$

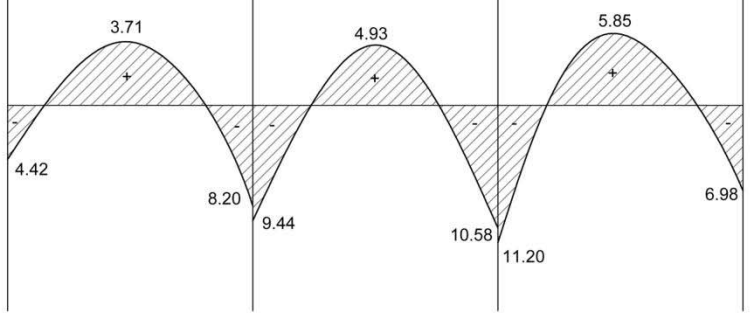
$r_{CD} = \frac{\left(I_b/L_b\right)_{CD}}{\left(I_b/L_b\right)_{CD} + \left(I_b/L_b\right)_{DC} + 2x\left(I_c/L_c\right)} = \frac{3.6x10^{-4}}{7.2x10^{-4} + 8.3x10^{-4}} = 0.23$

$r_{DC} = \frac{\left(I_b/L_b\right)_{DC}}{\left(I_b/L_b\right)_{DC} + 2x\left(I_c/L_c\right)} = \frac{3.6x10^{-4}}{3.6x10^{-4} + 8.3x10^{-4}} = 0.3$



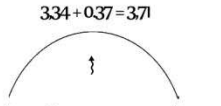
TWO-CYCLE METHOD :

	A	B		C		D
	0.30	0.23	0.23	0.23	0.23	0.30
FEM	+6.68	-6.68	+9.96	-9.96	+9.96	-9.96
Cycle 1	-0.37	-1.00	0.00	-0.37	+1.49	0.00
$\sum_1$	+6.31	-7.68	+9.96	-10.33	+11.45	-9.96
Cycle 2	-1.89	-0.52	-0.52	-0.25	-0.25	+2.98
$\sum_2$	+4.42	-8.20	+9.44	-10.58	+11.20	-6.98



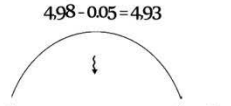
MID-SPAN CALCULATIONS :

AB



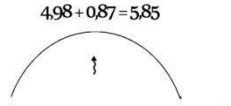
$\frac{2.26 + (-1.52)}{2} = 0.37$

BC



$\frac{0.52 + (-0.62)}{2} = -0.05$

CD



$\frac{(-1.24) + (+2.98)}{2} = 0.87$

BEAM DEPTH:

$K_0 = \frac{b_w d^2}{M}$

$b_w = 30$ cm

M = 11.20 t.m

= 1120 000 kg.cm

$K_o = 0.025\ cm^2/kg$

$0.025 = \frac{30xd^2}{1120000}$

$d^2 = 933.33\ cm^2$

d = 30.55 cm

h = d + 4

= 30.55 + 4 ≈ 34.5 cm

h≥3t

Beam Depth = 36 cm