ARCH 332 STRUCTURAL DESIGN IN ARCHITECTURE

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WALL HOUSE

HOUSE PROJECT IN UMITKOY

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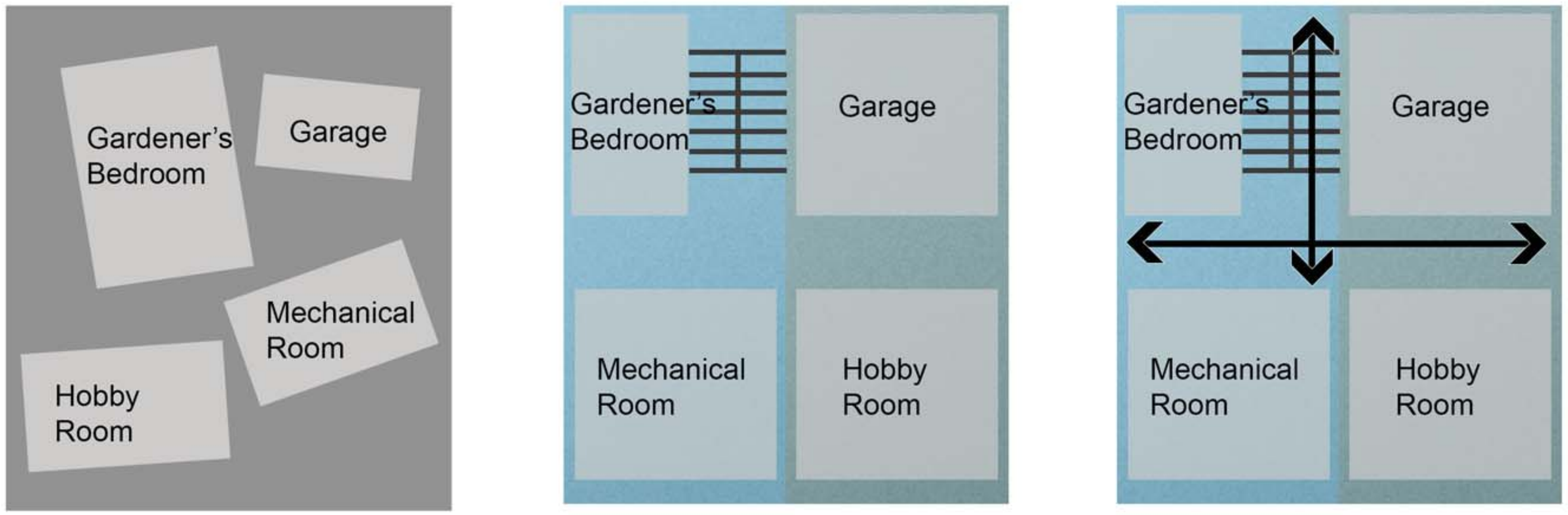
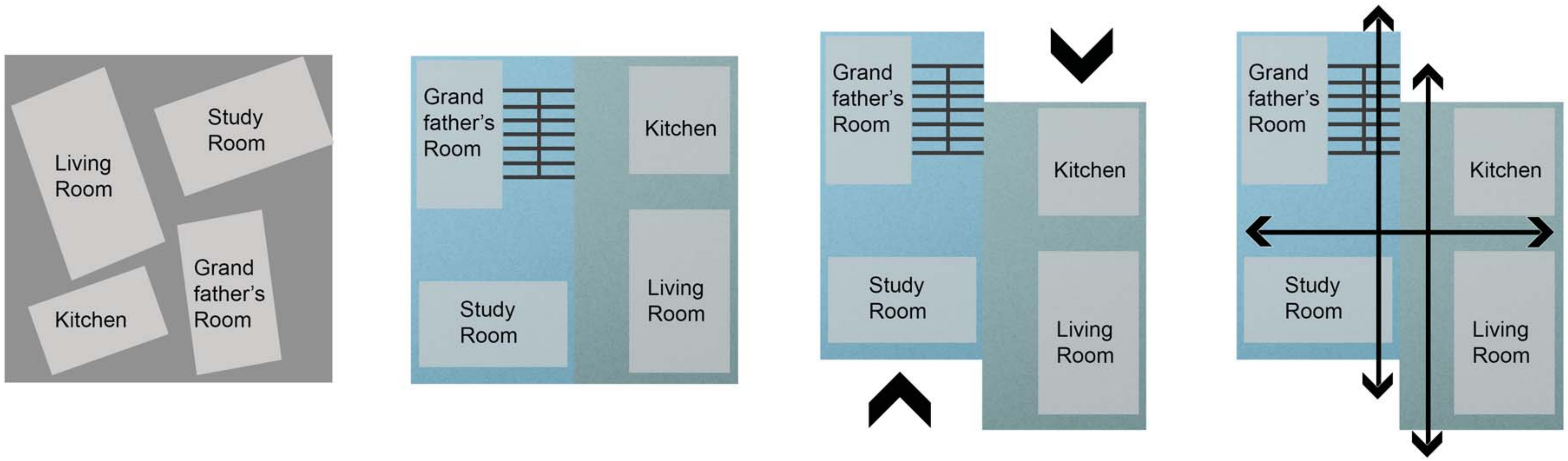
2013-14, SPRING

DESIGN DIAGRAMS

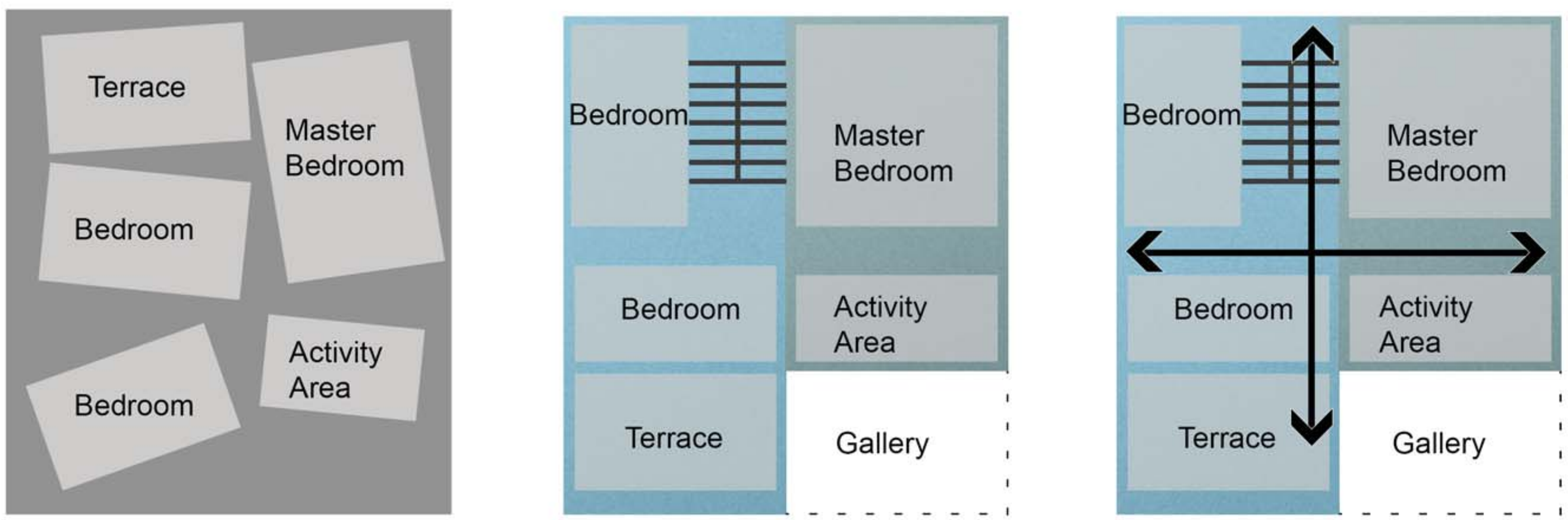
BASEMENT FLOOR



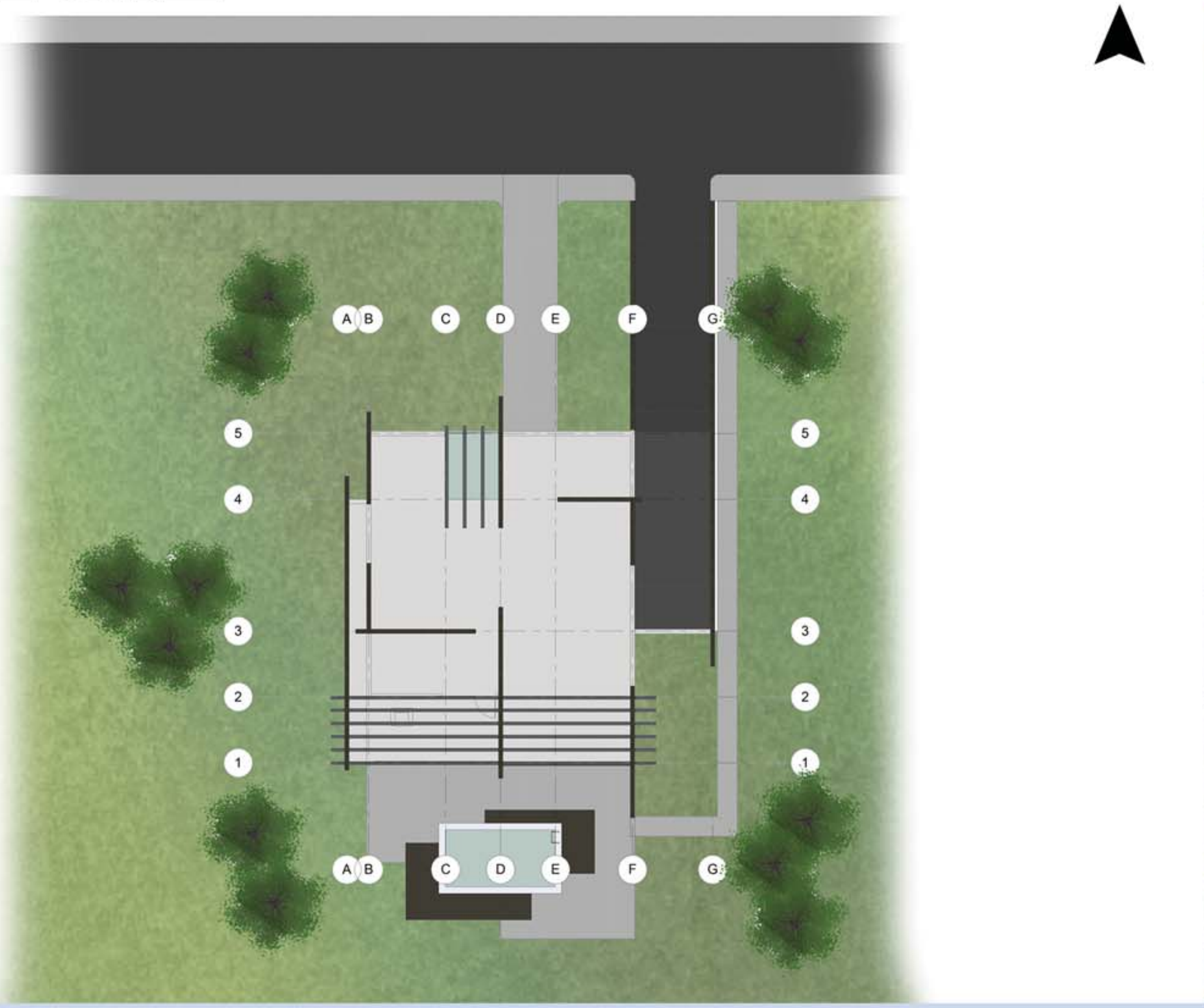
GROUND FLOOR



FIRST FLOOR

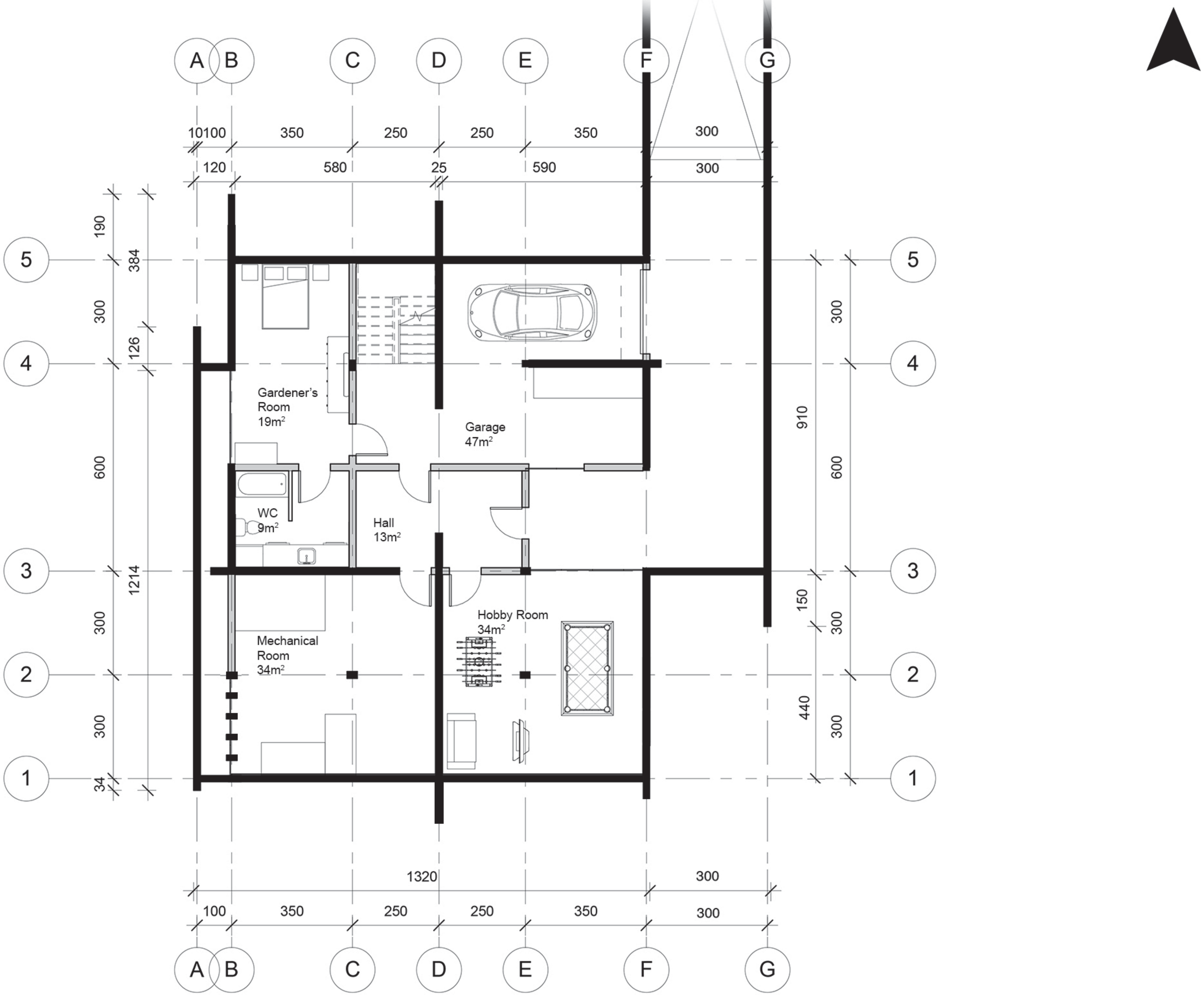


SITE PLAN

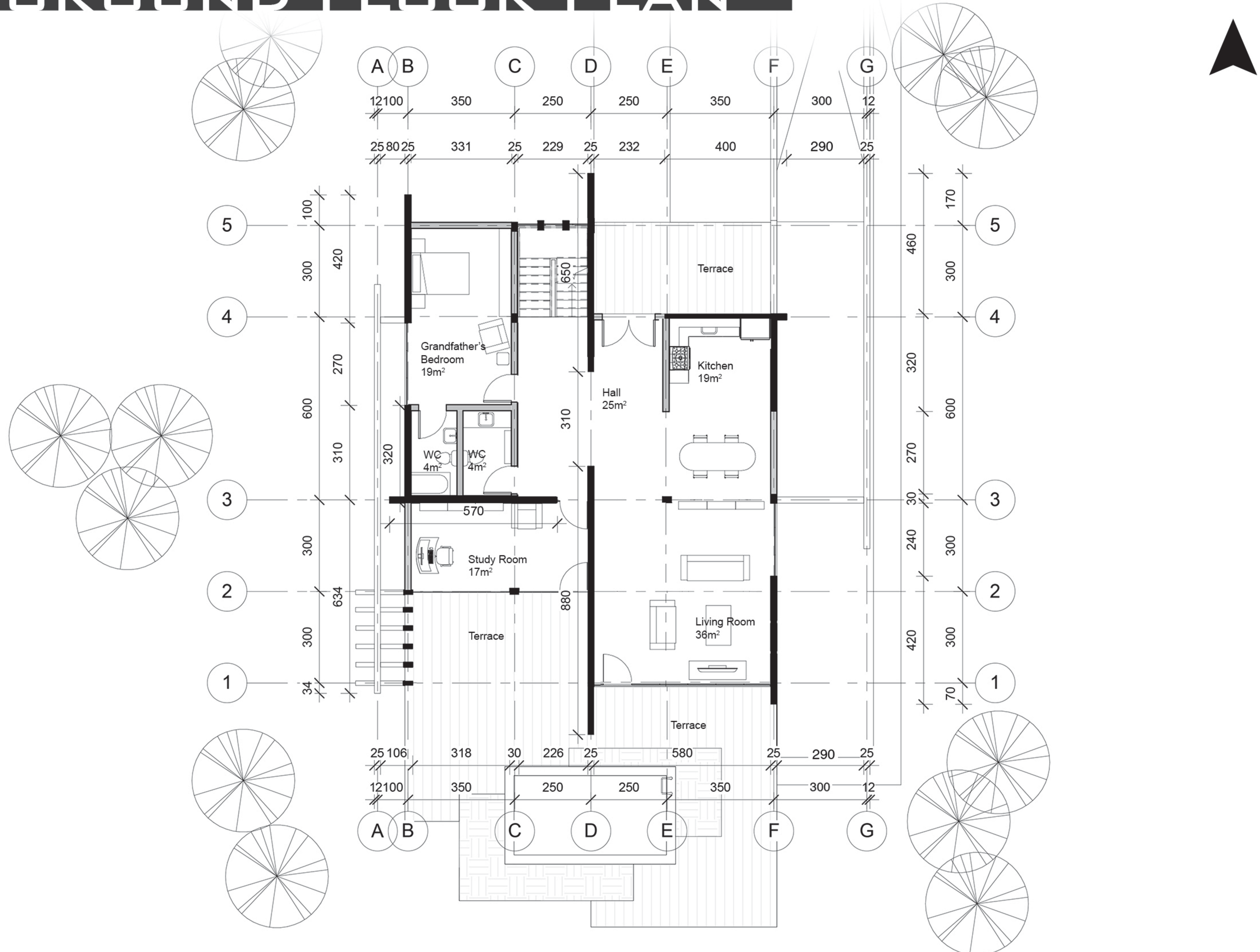


RENDER

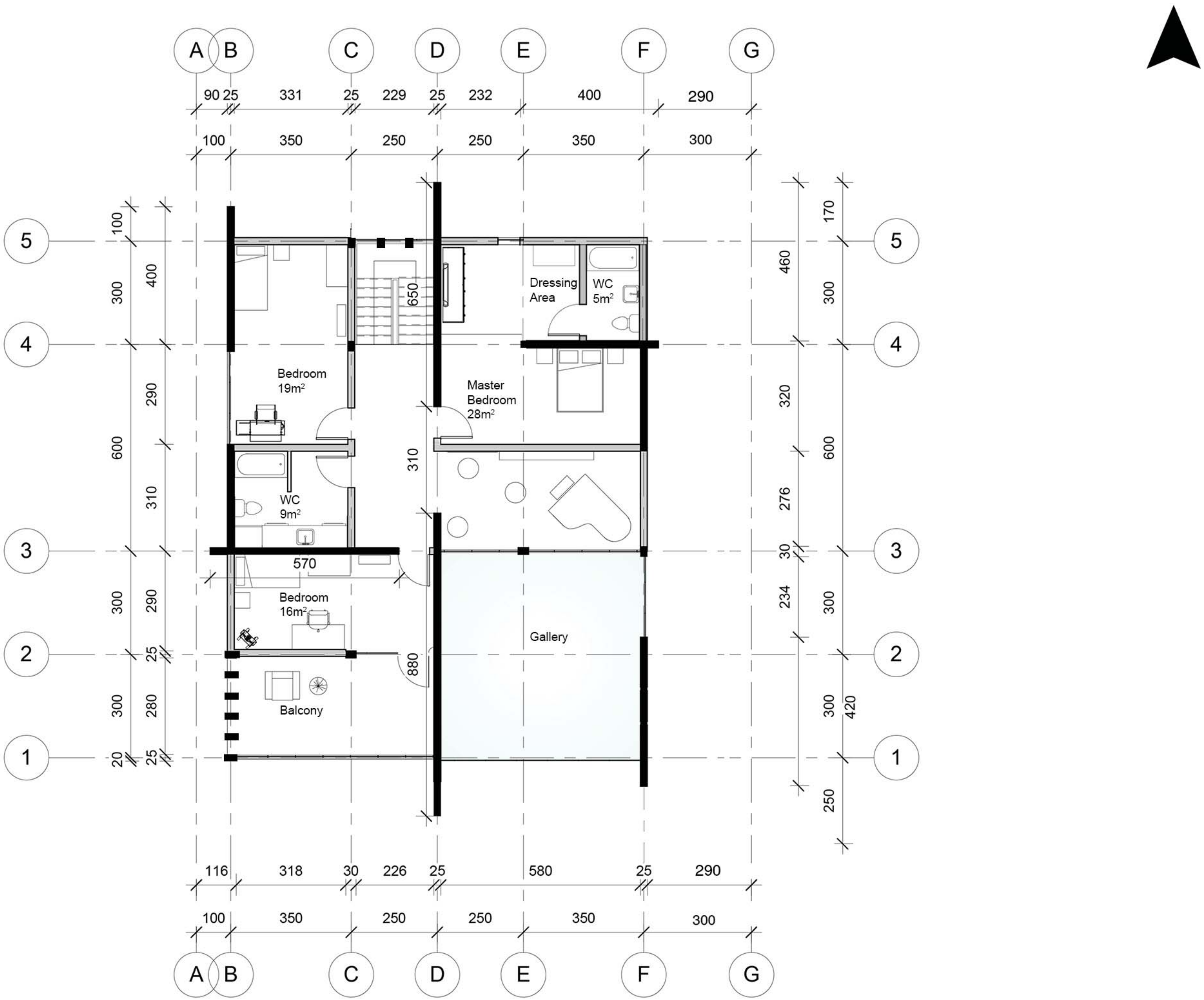
BASEMENT FLOOR PLAN



GROUND FLOOR PLAN



FIRST FLOOR PLAN



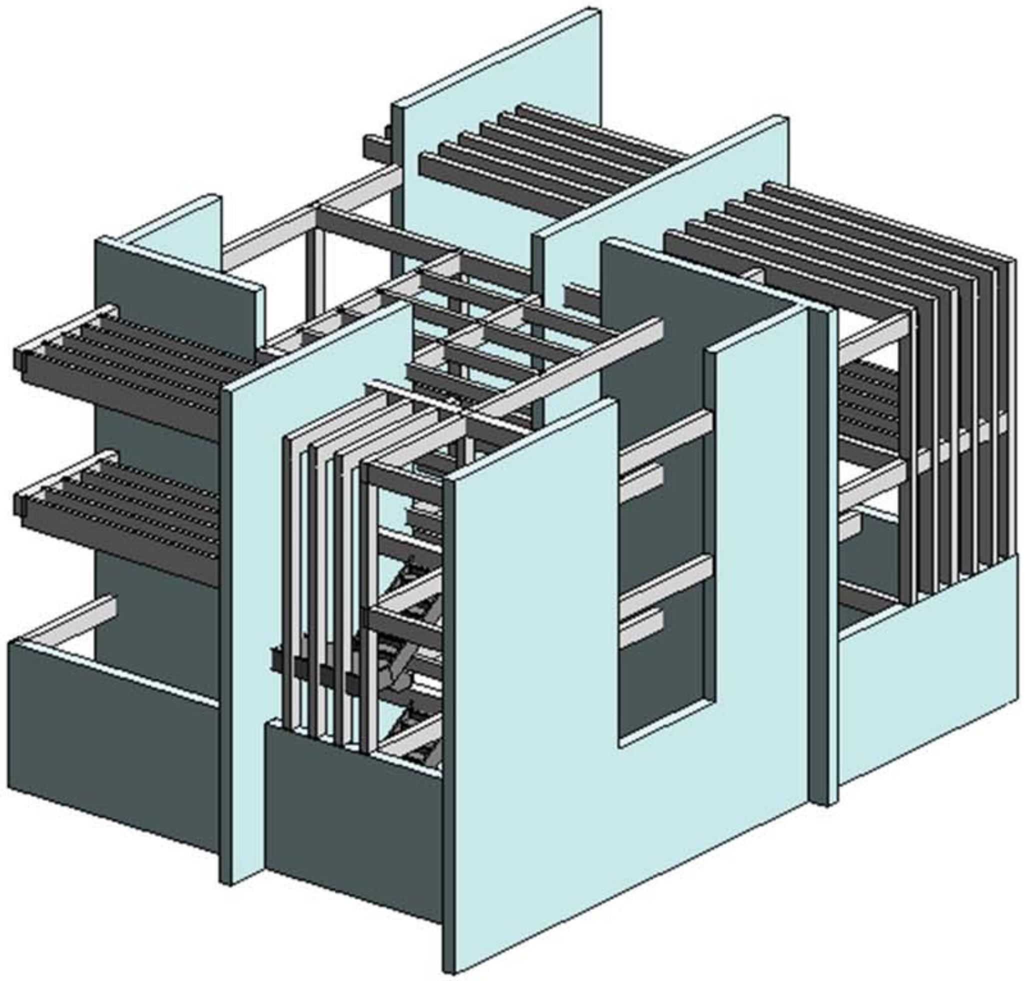
SECTION AA

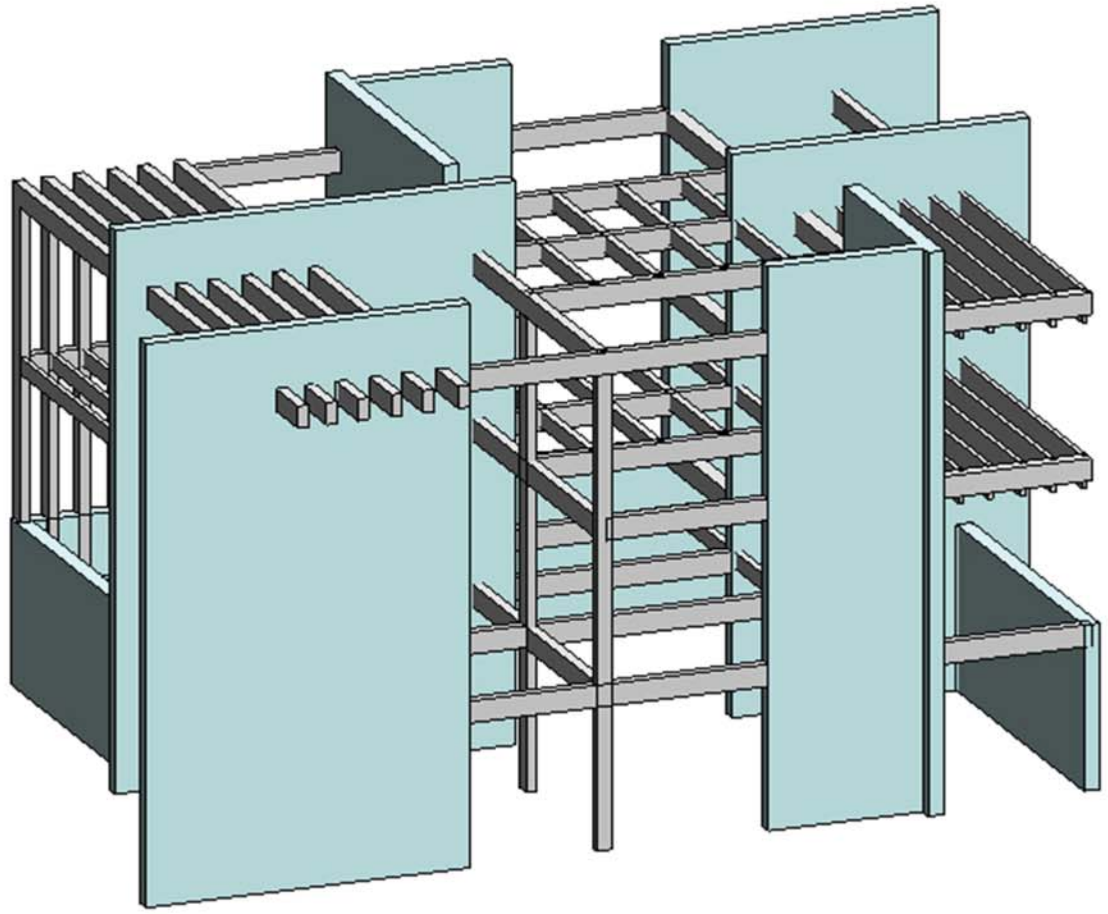
SECTION BB

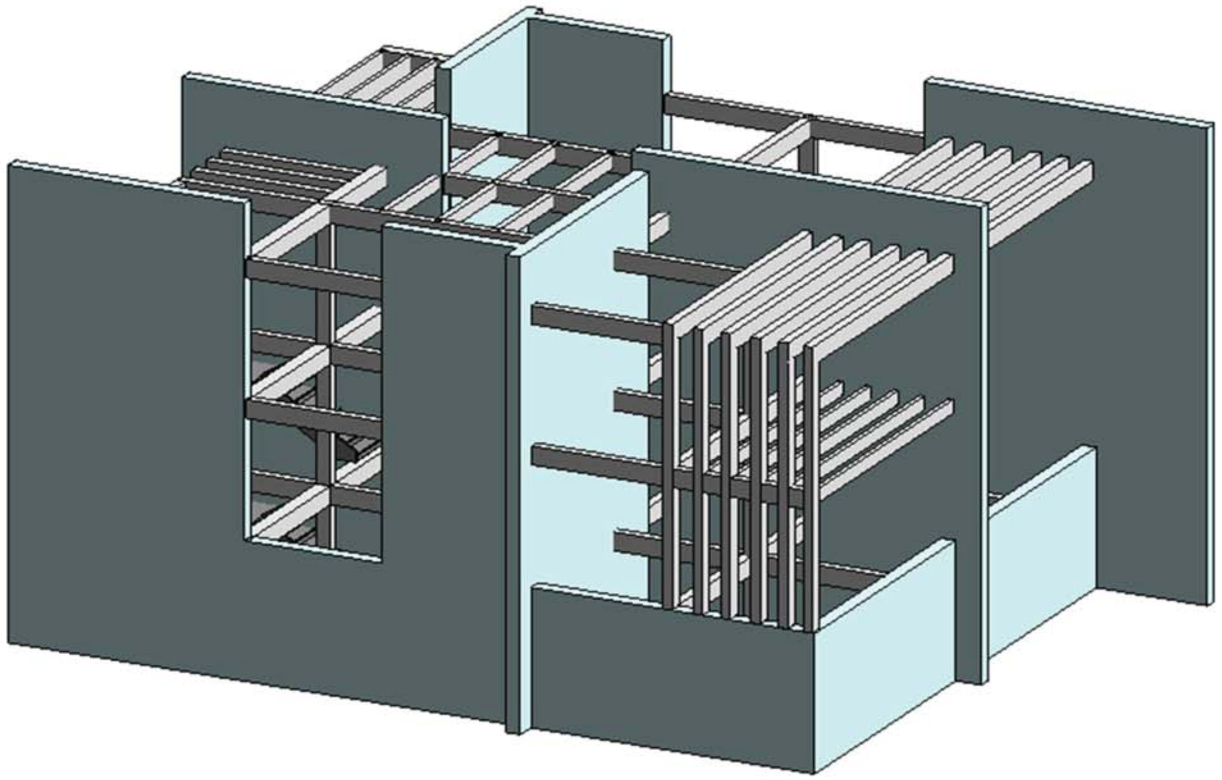

NORTH ELEVATION

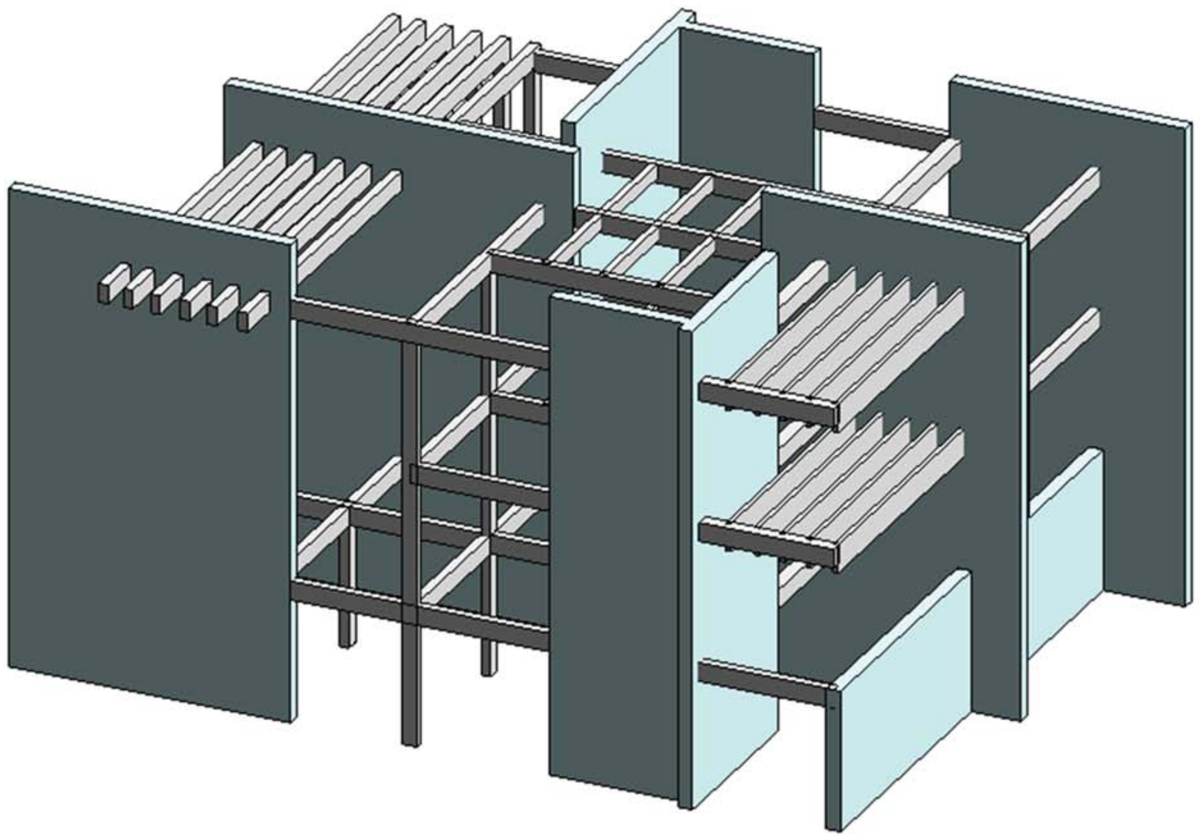

SOUTH ELEVATION

STRUCTURAL SYSTEM MODEL

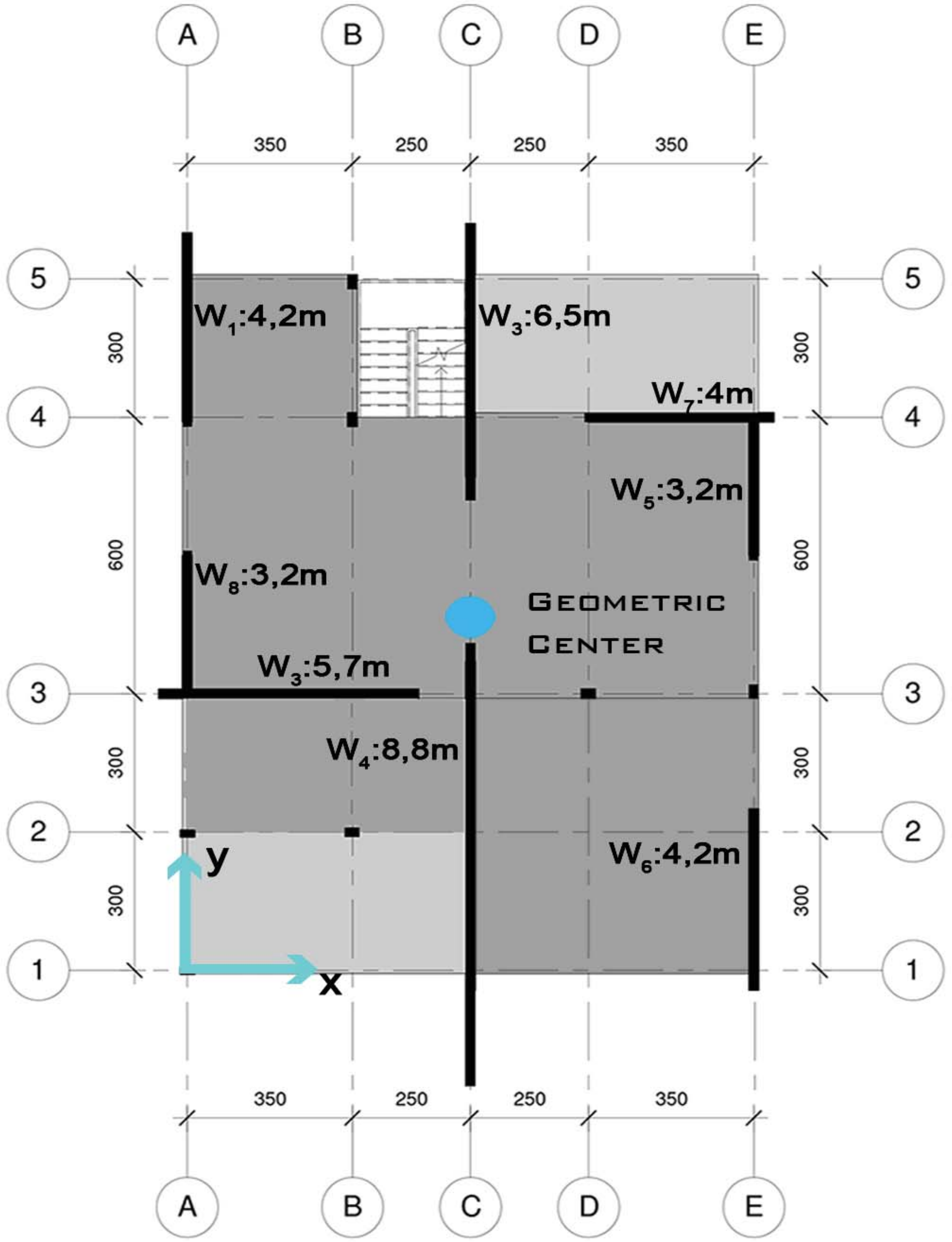








STRUCTURAL SYSTEM



Ground Floor

Geometric Center

G_x x 180 = [(52.5) x (1.75)] + [(37.5) x (4.75)] + [(37.5) x (7.25)] + [(52.5) x (10.25)] ; G_x = 6
G_y x 180 = [36 x (1.5)] + [36 x (4.5)] + [36 x (7.5)] + [36 x (10.5)] + [36 x (13.5)] ; G_y = 7.5
So ; Geometric Center ; (6, 7.5)

Stiffness Center

According to y-axis:

$$\frac{\left[\left(\frac{1}{12}\right)\times(0.25)\times(5.7)^3\times 6\right]+\left[\left(\frac{1}{12}\right)\times(0.25)\times(4)^3\times 12\right]}{\left[\left(\frac{1}{12}\right)\times(0.25)\times(5.7)^3\right]+\left[\left(\frac{1}{12}\right)\times(0.25)\times(4)^3\right]}=7{,}5$$

According to x-axis:

$$\frac{\left[\left(\frac{1}{12}\right)\times(0.25)\times(3.2)^3\times 0\right]+\left[\left(\frac{1}{12}\right)\times(0.25)\times(4.2)^3\times 0\right]+\left[\left(\frac{1}{12}\right)\times(0.25)\times(8.8)^3\times 6\right]+\left[\left(\frac{1}{12}\right)\times(0.25)\times(6.5)^3\times 6\right]+\left[\left(\frac{1}{12}\right)\times(0.25)\times(4.2)^3\times 12\right]+\left[\left(\frac{1}{12}\right)\times(0.25)\times(3.2)^3\times 12\right]}{\left[\left(\frac{1}{12}\right)\times(0.25)\times(3.2)^3\right]\times 2+\left[\left(\frac{1}{12}\right)\times(0.25)\times(4.2)^3\right]\times 2+\left[\left(\frac{1}{12}\right)\times(0.25)\times(8.8)^3\right]+\left[\left(\frac{1}{12}\right)\times(0.25)\times(6.5)^3\right]}=6$$

Stiffness center; (6, 7.5). In x and y direction geometric and stiffness centers coincide.

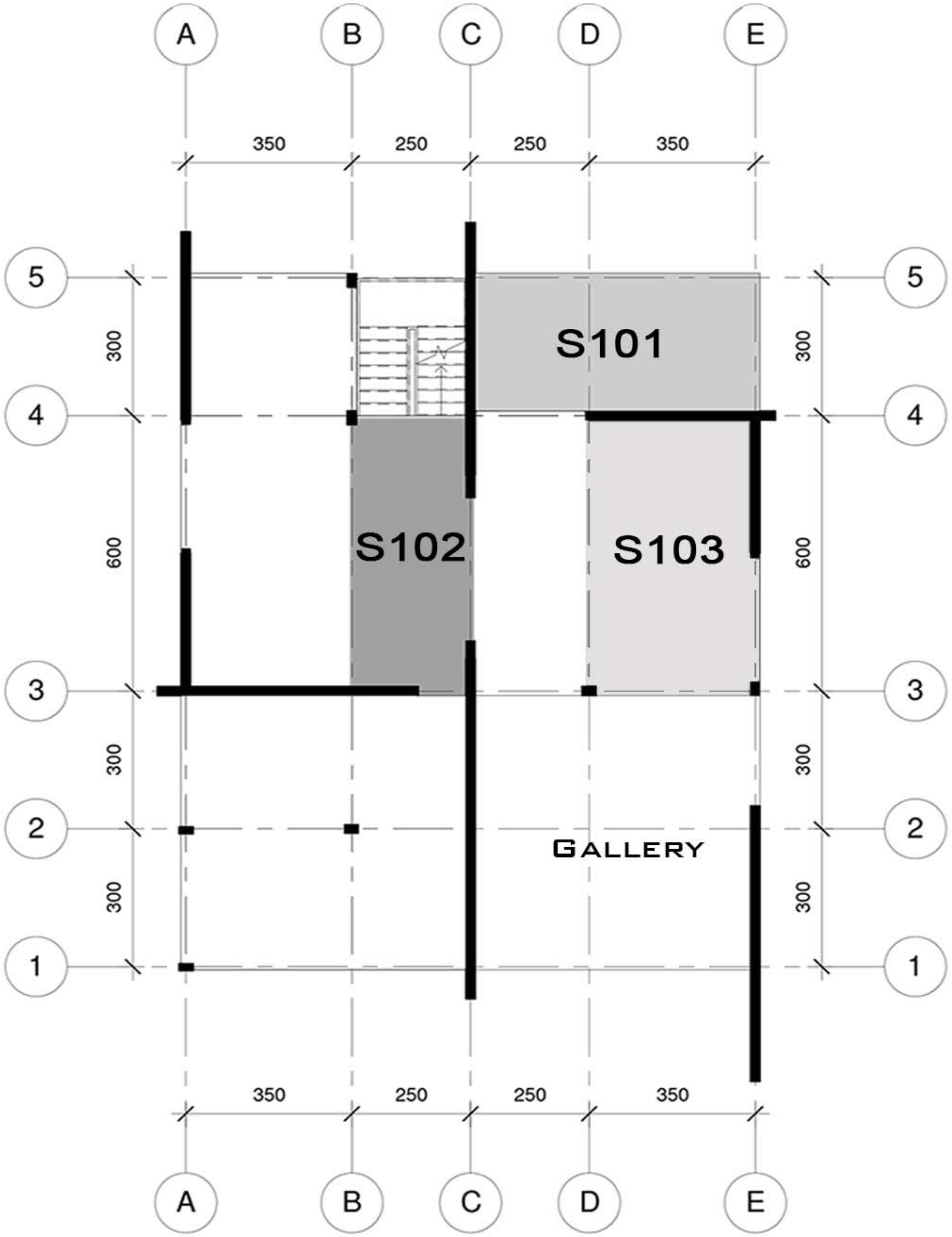
Shear Wall Percentage

Floor area: 180 m^2

Area of shear walls on x-direction: $\{[(3{,}2)\times 2]+[(4{,}2)\times 2]+(8{,}8)+(6{,}5)\}\times 0{,}25=7{,}52$
The ration of shear wall area in x-direction to floor area: $\frac{7{,}52}{180}$ = 0,0418 4 %

Area of shear walls on y-direction: $[(5{,}7)+4]\times 0{,}25=2{,}42$
The ration of shear wall area in y-direction to floor area: $\frac{2{,}42}{180}$ = 0,0134 1 %

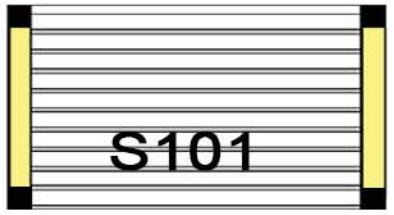
SLAB THICKNESS



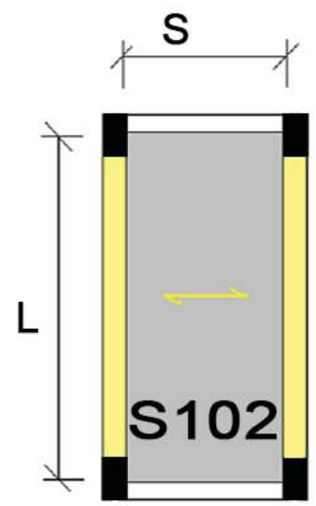
First Floor

Selected Slab

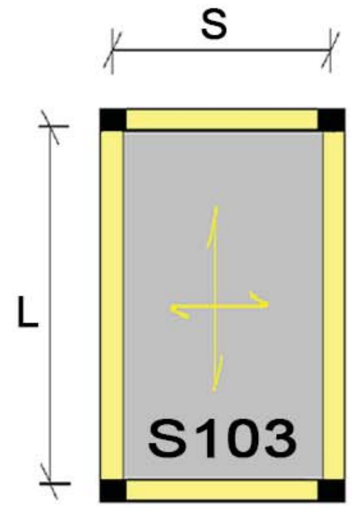
According to the Codes- TS500 and Turkish Seismic Code, solid slab with beams (one way and two way) and one way joist slab is selected.



One Way Joist Slab



Solid Slab with Beams (One Way)



Solid Slab with Beams (Two Way)

One Way Joist Slab Thickness

For S101:

$d \geq$ length of clear span/20

$d_{101} = 600/20 = 30$ cm

One Way Solid Slab Thickness

For S102:

Since; $\frac{l_l}{l_s} > 2 \qquad \frac{600}{250} = 2,4$

one way solid slab is selected.

$$t_{S102} \geq \frac{l_s}{25}$$

$$\frac{250}{25} = 10 \text{ cm}$$

The smallest permissible thickness is 8 cm.

$10 \geq 8$, $\quad d_{102} = 10$ cm

Two Way Solid Slab Thickness

$$\propto = \frac{\text{length of the slab continous edges}}{\text{lengths of all edges}}$$

For S103:

$$\propto_3 = \frac{3,5 + 6 + 6}{3,5 + 6 + 3,5 + 6} = 0,8$$

$$t \geq \frac{l_{short}}{15 + \frac{20}{\frac{l_{long}}{l_{short}}}} \left(1 - \frac{\propto}{4}\right)$$

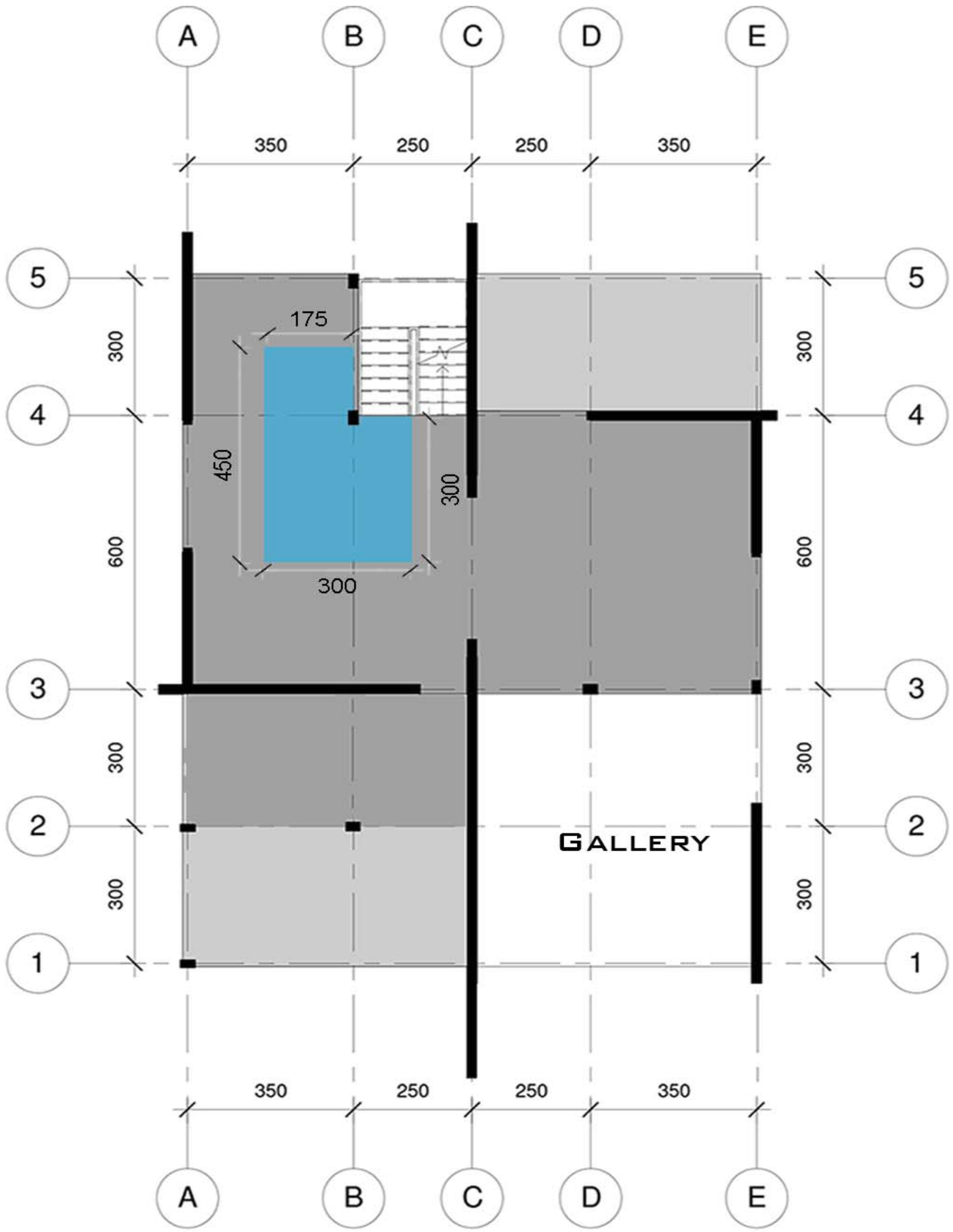
$$t_{S103} \geq \frac{350}{15 + \frac{20}{\frac{600}{350}}} \left(1 - \frac{0,8}{4}\right)$$

$t_{S103} \geq 10,52$ cm

Then t = 11 cm

COLUMN DIMENSION

Tributary area



First Floor

Loads

Column 4B is chosen since it has the largest tributary area.

Solid Slabs

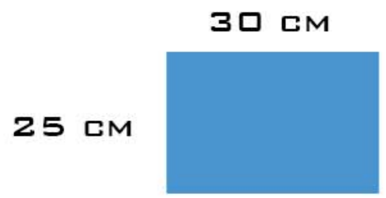
Own weight: 0,12 x 2,4 = 0,288 t/m²
Leveling: 0,04 x 2,4= 0,1 t/m²
Covering: 0,025 x 2,0 = 0,05 t/m²

Dead Load: 0,288 + 0,1 + 0,05 + 0,04 = 0,47 t/m²
Live Load: 0,2 t/m²
Total Load: 1,4 x 0,47 + 1,6 x 0,2 = 0,98 t/m²
Total Tributary Area: (3 x 3) + (1,5 x 1,75) = 11,62

SL_1: 11,62 x 0,98 = 11,39 t
SL_2: 11,62 x 0,98 = 11,39 t
SL_3: 11,62 x 0,98 = 11,39 t
Total Slab Load= 34,17t

Walls

Floor Height: 3 m
Net Wall Height: 2,6 m
Wall Length: (4,5 + 1,75) = 6,25 m
Wall load on the tributary area
WL_1: 2,6 x 6,25 x 0,45 x 1,4 = 10,24 t
WL_2: 2,6 x 6,25 x 0,45 x 1,4 = 10,24 t
Total Wall Load= 20,48 t



Column Cross Section

The column cross sectional area (A_c) should satisfy the following requirements:

$$A_c \geq \frac{N_d}{0,75 \; x \; f_{cd}}$$

$$N_d = (\,34,17\,) + (\,20,48\,) = 54,65 \; t$$

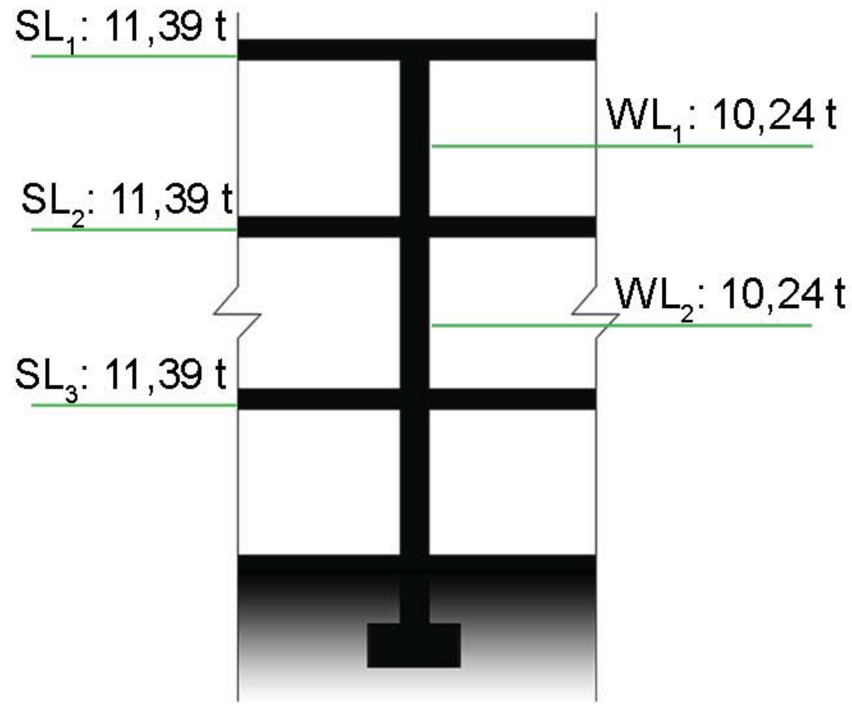
$$= 54650kg$$

$$f_{cd} = 130 \;\; kgf/cm^2$$

$$A_c \geq \frac{54650}{0,75 \; x \; 130}$$

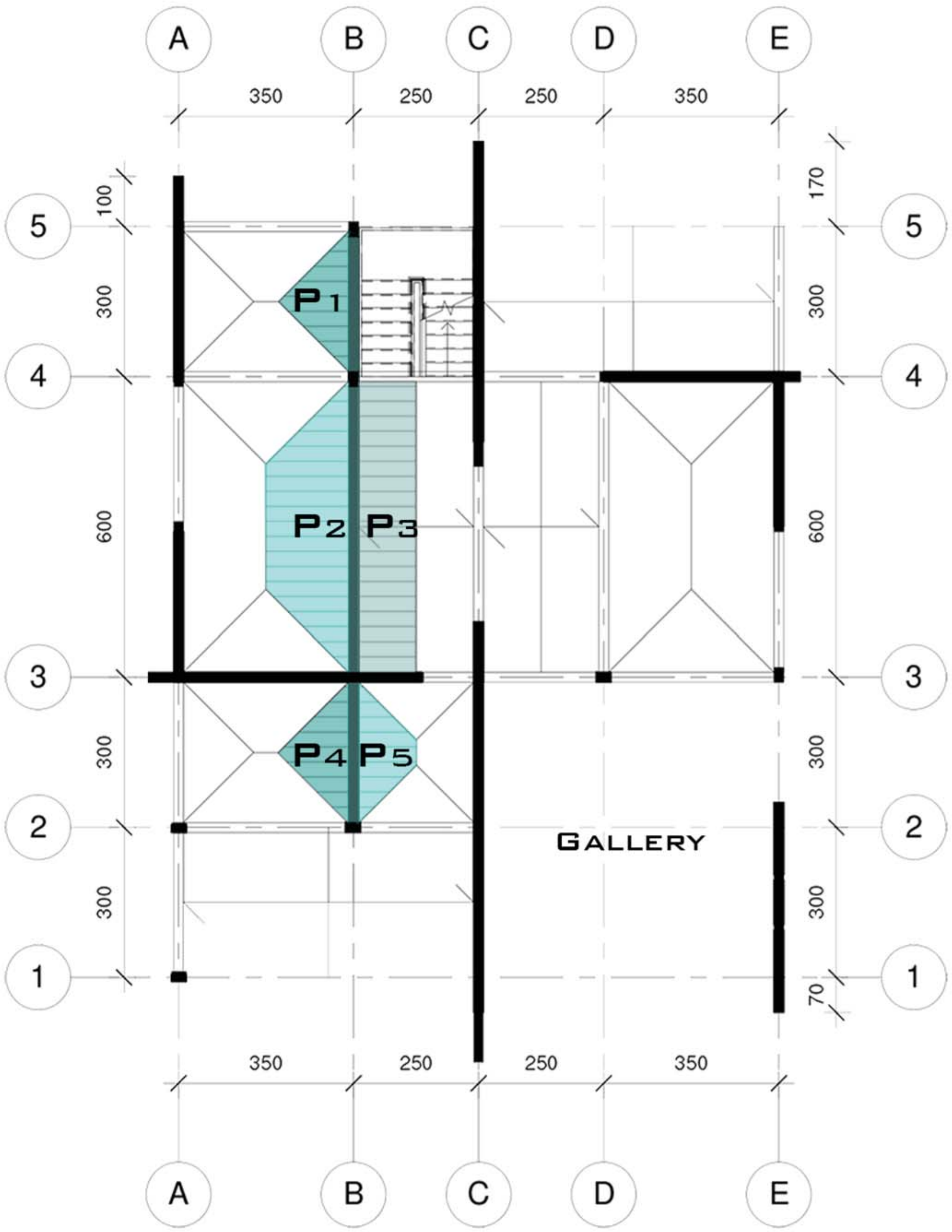
$$A_c \geq 560,5 \; cm^2$$

The cross section area shall not be less than 750 cm². Thus, in order to satisfy the requirements, column dimensions are chosen as 30 x 25 cm with a cross section area of 750 cm².



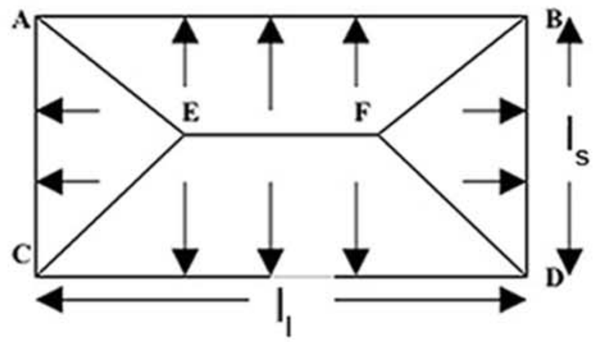
BEAM ANALYSIS

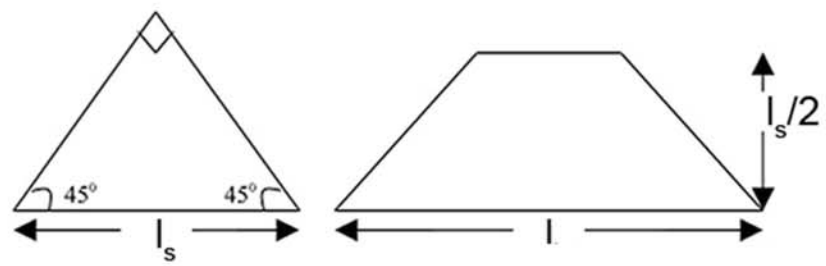
Load Transfer



First Floor

Two-way Solid Slab





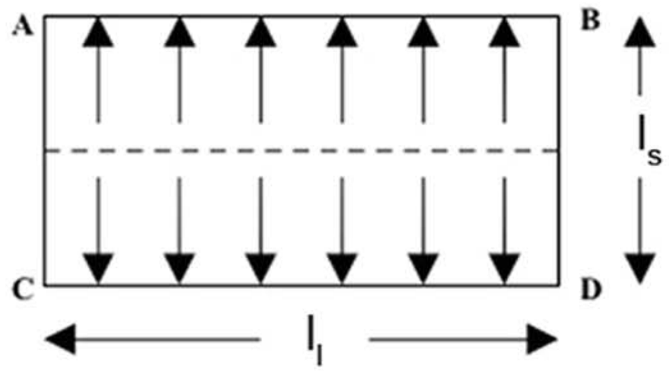
For short span:

$W = P_d \times \frac{l_s}{3}$

For long span:

$W = P_d \times \frac{l_s}{3} \times (1,5 - \frac{0,5}{(\frac{l_l}{l_s})^2})$

One-way Solid Slab



$W = P_d \times \frac{l_s}{2}$

Loads on Beam

Loads on B_{45} Beam:

$P_1 = 0,98 \times \frac{3}{3} = 0,98$ t/m

Loads on B_{43} Beam:

$P_2 = 0,98 \times \frac{3,5}{3} \times (1,5 - \frac{0,5}{(\frac{6}{3,5})^2}) = 1,5$ t/m

$P_3 = 0,98 \times \frac{2,5}{2} = 1,225$ t/m

Loads on B_{32} Beam:

$P_4 = 0,98 \times \frac{3}{3} = 0,98$ t/m

$P_5 = 0,98 \times \frac{2,5}{3} \times (1,5 - \frac{0,5}{(\frac{3}{2,5})^2}) = 0,93$ t/m

Uniform Distrubuted Wall Load on Beam

WL= Wall Height x 0,45 x 1,4

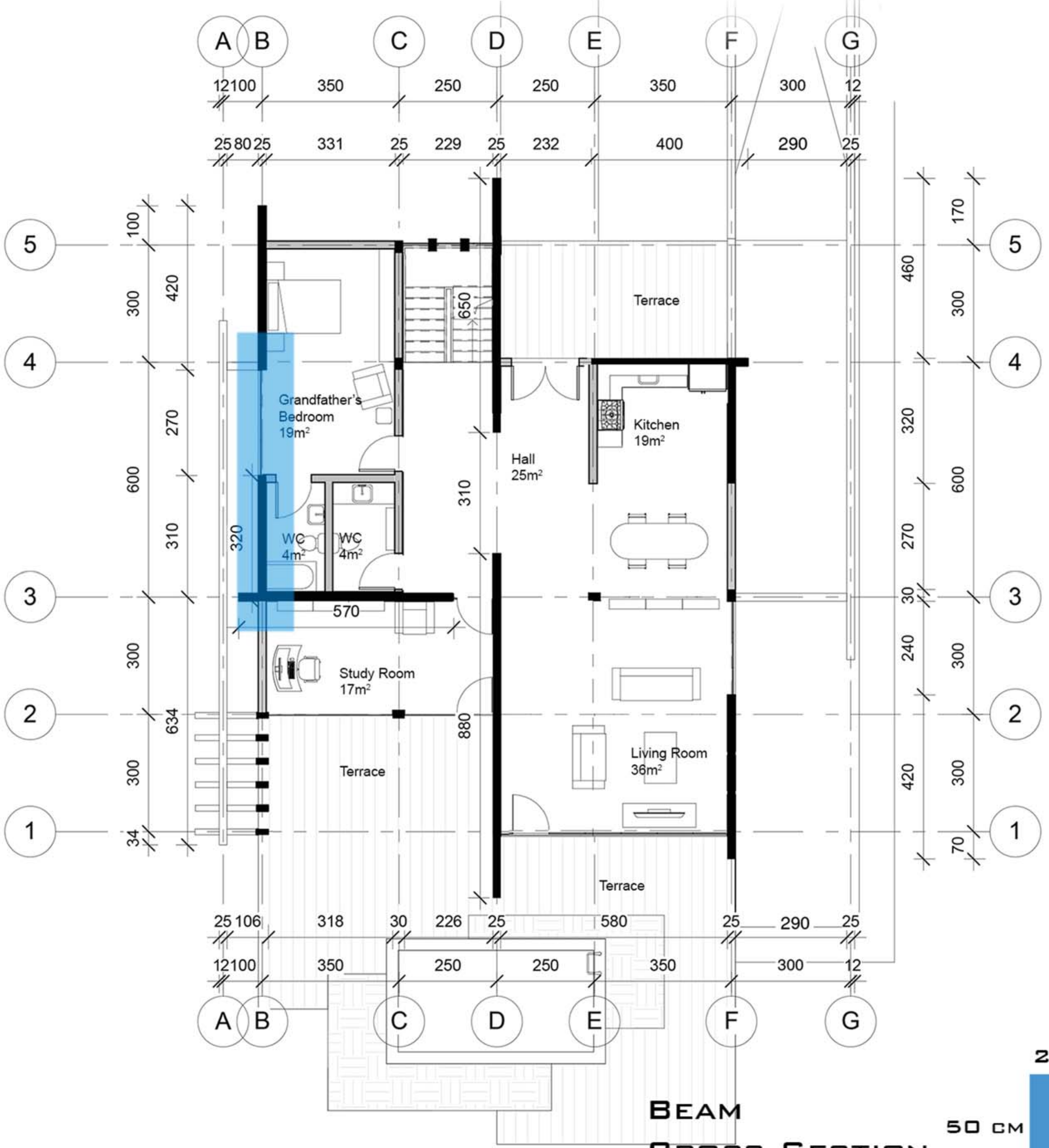
WL= 2,6 x 0,45 x 1,4 = 1,6 t/m

P_{B54} = 0,98 + 1,6 = 2,58 t/m

P_{B43} = 1,5 + 1,225 + 1,6 = 4,32 t/m

P_{B32} = 0,98 + 0,93 = 1,91 t/m

BEAM ANALYSIS



BEAM
CROSS SECTION

25 CM

50 CM

B_{34} has the longest span = 6 m

Beam depth = span length/12,5 = $\frac{600}{12,5}$ = 48 cm

$P_d = (1,4 \times DL) + (1,6 \times LL)$

$$I_{beam} = \frac{b \times h^3}{12}$$

$$I_{beam} = \frac{(0,25)\times(0,5)^3}{12} = 0,0026\ m^4$$

$$I_{column} = \frac{(0,25)\times(0,3)^3}{12} = 0,00056\ m^4$$

$$I_{shearwall} = \frac{(5,7)\times(0,25)^3}{12} = 0,0074\ m^4$$

$$r = \frac{\frac{I}{l}}{\Sigma\frac{I}{l}}$$

$$r_{54} = \frac{0,0026/3}{\frac{0,0026}{3}+\left(\frac{0,00056}{3}\right)\times 2} = 0,699$$

$$r_{45} = \frac{0,0026/3}{\frac{0,0026}{3}+\frac{0,0026}{6}+\left(\frac{0,00056}{3}\right)\times 2} = 0,518$$

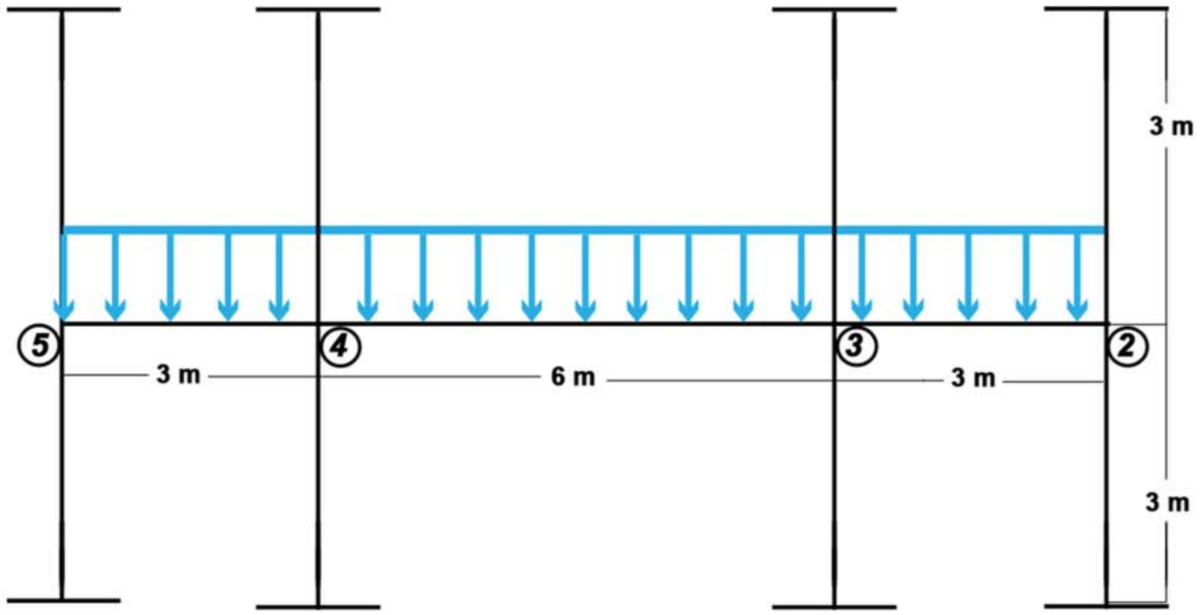
$$r_{43} = \frac{0,0026/6}{\frac{0,0026}{3}+\frac{0,0026}{6}+\left(\frac{0,00056}{3}\right)\times 2} = 0,259$$

$$r_{34} = \frac{0,0026/6}{\frac{0,0026}{6}+\frac{0,0026}{3}+\left(\frac{0,0074}{3}\right)\times 2} = 0,065$$

$$r_{32} = \frac{0,0026/3}{\frac{0,0026}{3}+\frac{0,0026}{6}+\left(\frac{0,0074}{3}\right)\times 2} = 0,131$$

$$r_{23} = \frac{0,0026/3}{\frac{0,0026}{3}+\left(\frac{0,00056}{3}\right)\times 2} = 0,699$$

BEAM ANALYSIS



SIGN CONVENTION OF FEM

	0,699	0,518	0,259	0,065	0,131	0,699
FEM	1,93	-1,93	12,96	-12,96	1,43	-1,43
1st Cycle	-2,85	-0,67	0,37	-1,42	0,49	0,75
∑	-0,92	-2,6	13,36	-14,38	1,92	-0,68
2nd Cycle	0,64	-5,77	-2,78	0,8	1,63	0,47
∑	-0,28	-8,17	10,58	-13,58	3,55	-0,21

$r_{54} = 0,699$ $r_{34} = 0,065$

$r_{45} = 0,518$ $r_{32} = 0,131$

$r_{43} = 0,259$ $r_{23} = 0,699$

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

$$FEM_{54} = \frac{2,58 \times (3)^2}{12} = 1,93 \text{ tm}$$

$$FEM_{43} = \frac{4,32 \times (6)^2}{12} = 12,96 \text{ tm}$$

$$FEM_{32} = \frac{1,91 \times (3)^2}{12} = 1,43 \text{ tm}$$

BEAM DEPTH

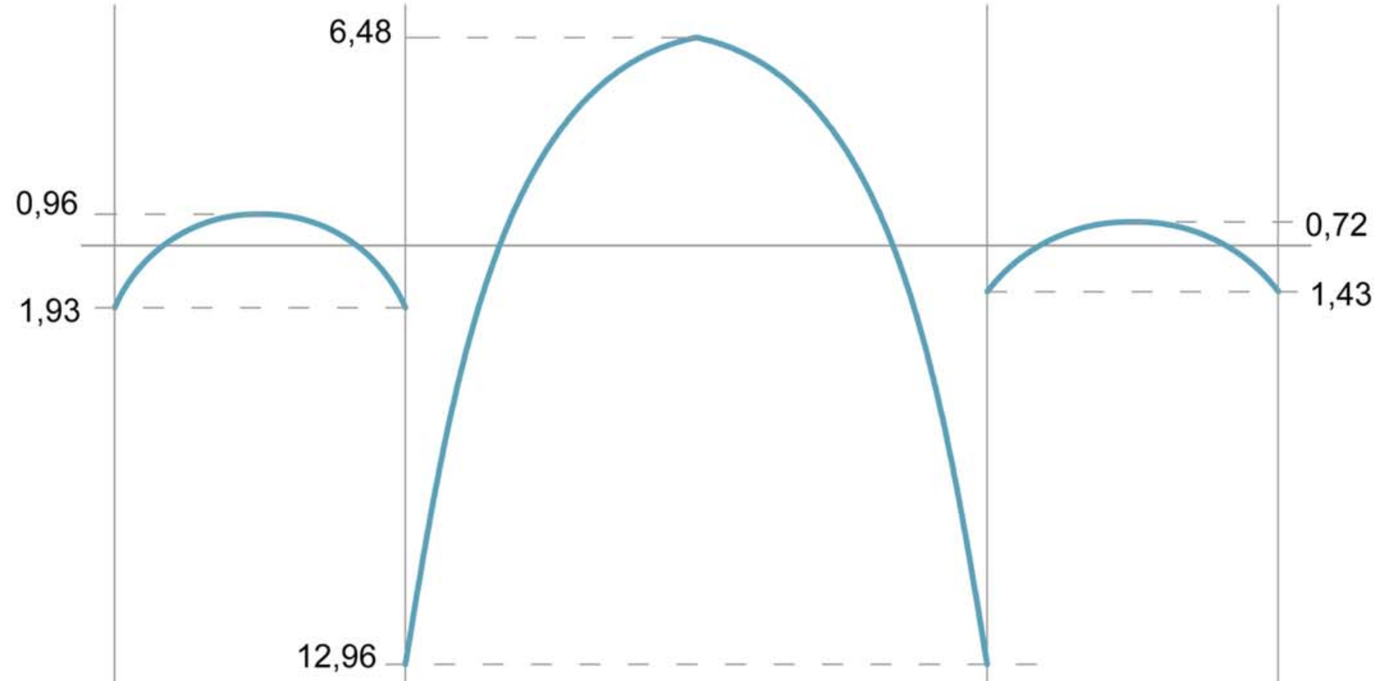
$$K_0 = \frac{b_w \times d^2}{M_{max}}$$

K_0=250 mm²/KN
K_0=25 cm²/t

$$25 = \frac{25 \times d^2}{1358}$$

d=36,8 cm
clear cover=5 cm
h=42 cm

According to the building regulations, beam depth can not be smaller than the three times of slab thickness. Thus, the beam depth>33 cm. The beam depth is chosen as **50 cm**.



changes of the moments

+0,28 (2,21) -1,93 | -1.93 (6,24) -8,17

-10,58 (2,38) -12,96 | -12,96 (0,62) -13,58

-1,43 (2,12) -3,55 | -0,21 (1,22) -1,43

change on the mid-span moment

$\frac{(6,24 - 2,21)}{2} = 2,02$ $\frac{(2,38 - 0,62)}{2} = 0,88$ $\frac{(2,12 - 1,22)}{2} = 0,45$

end value of the mid-span moment

0,96 - 2,02 = -1,06 6,48 + 0,88 = +7,36 0,72 - 0,45 = 0,27