GROUP 8

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METU DEPARTMENT OF ARCHITECTURE

2013-2014 ARCH 332
STRUCTURAL DESIGN IN ARCHITECTURE

INSTRUCTORS:
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Integrating Different Functions

-Gallery

-Living & Eating Room

-Hobby Room

-Bedrooms

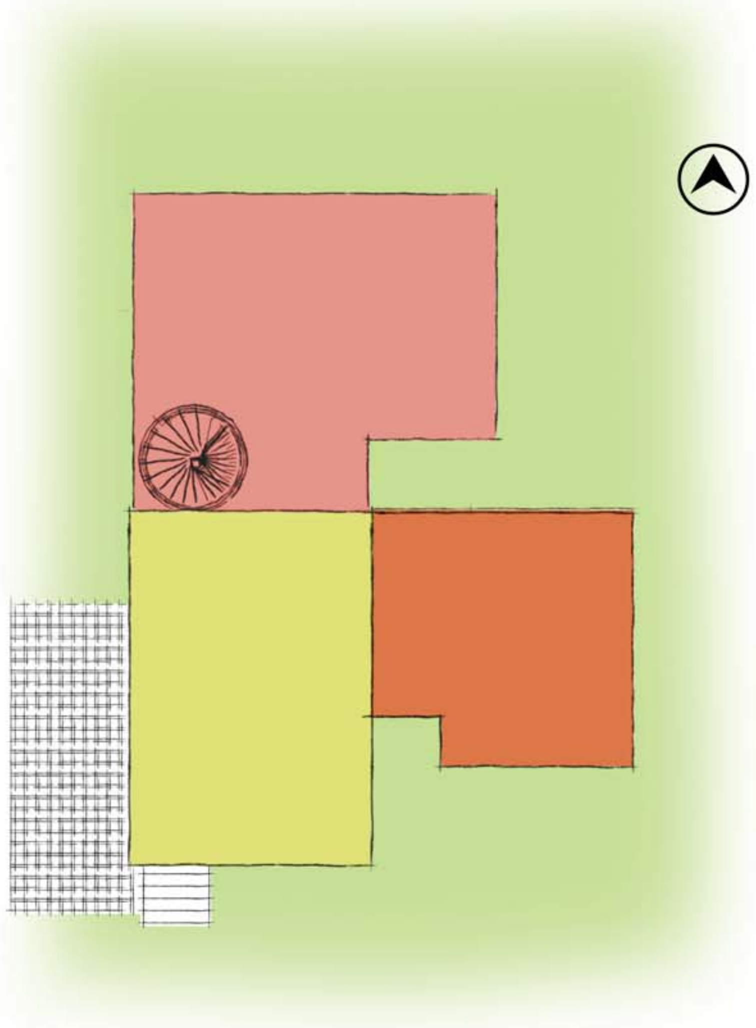
-Hall & Study Room

-Kitchen

-Master Bedroom

-Grandparents' Bedroom

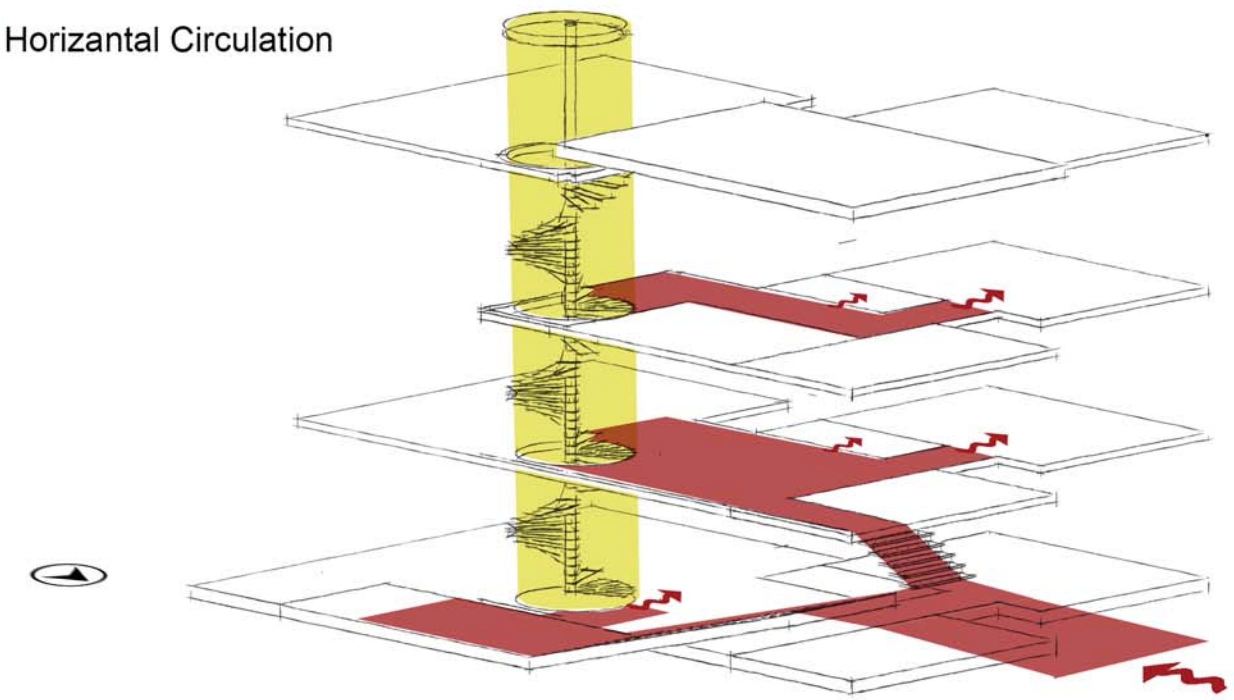
-Housekeeper's Bedroom

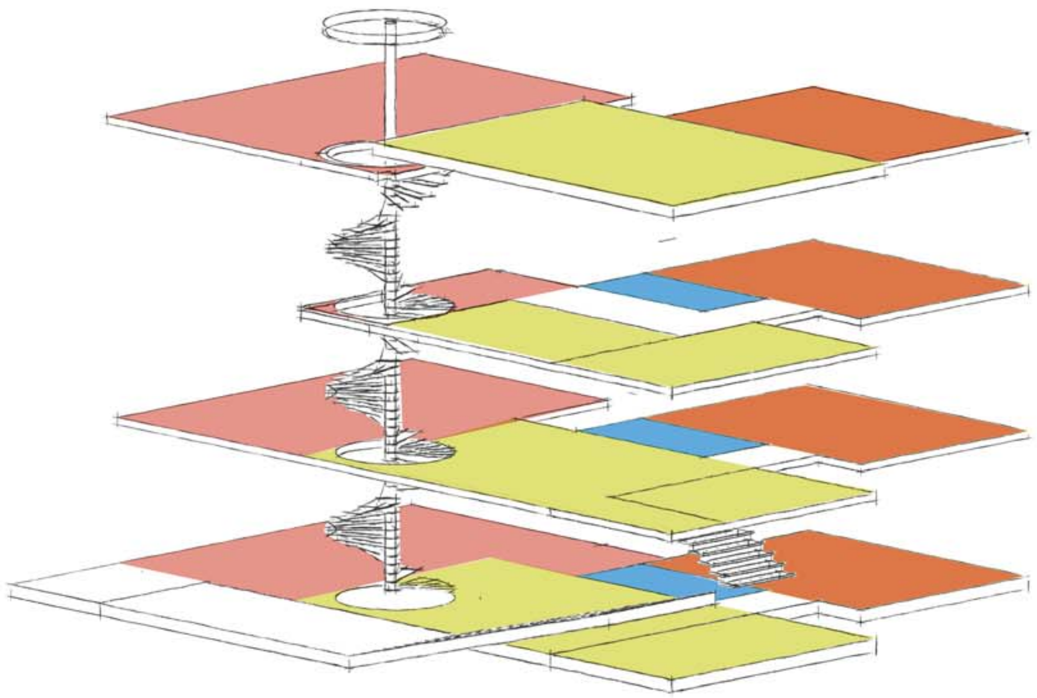


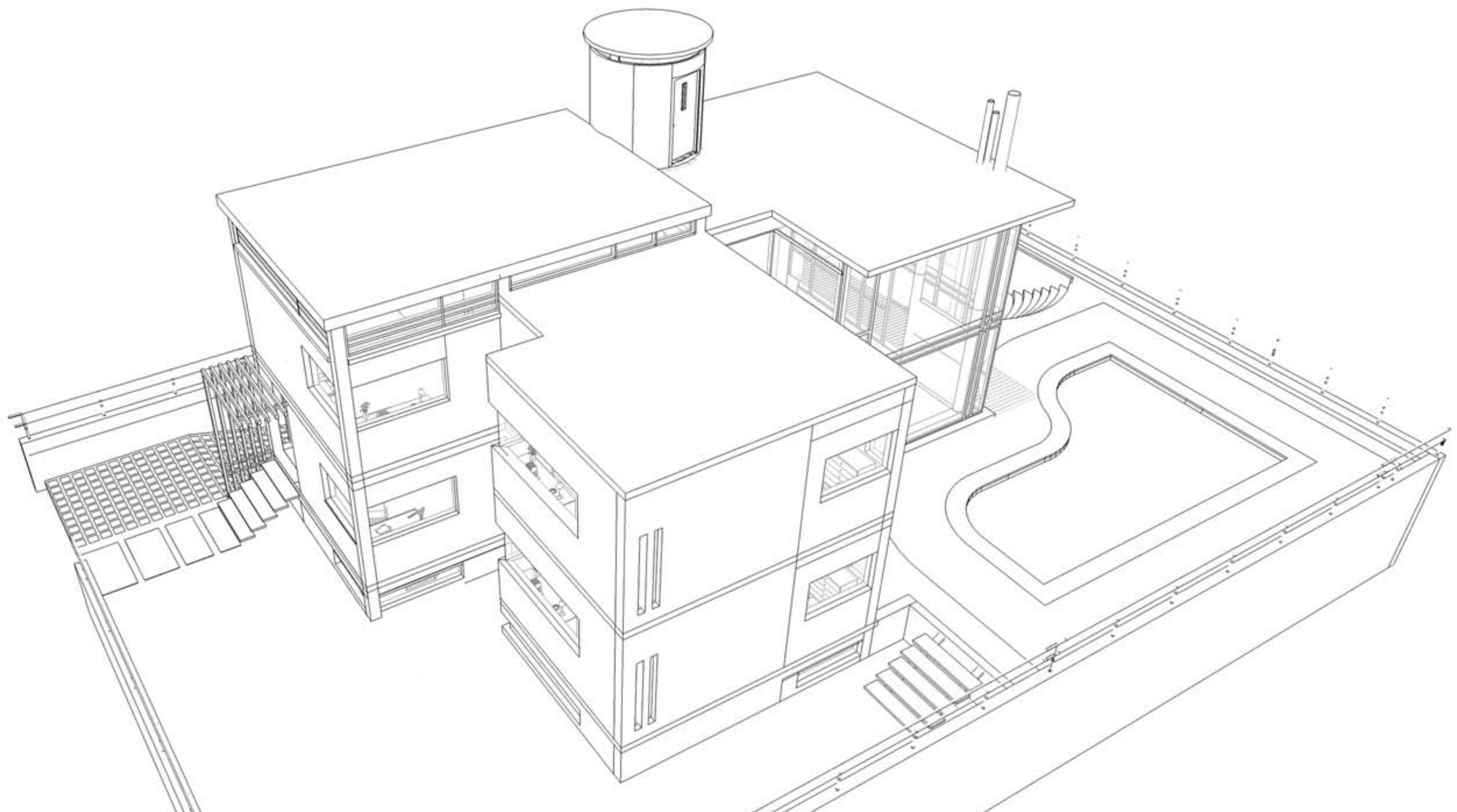
Circulation Diagram

Vertical Circulation

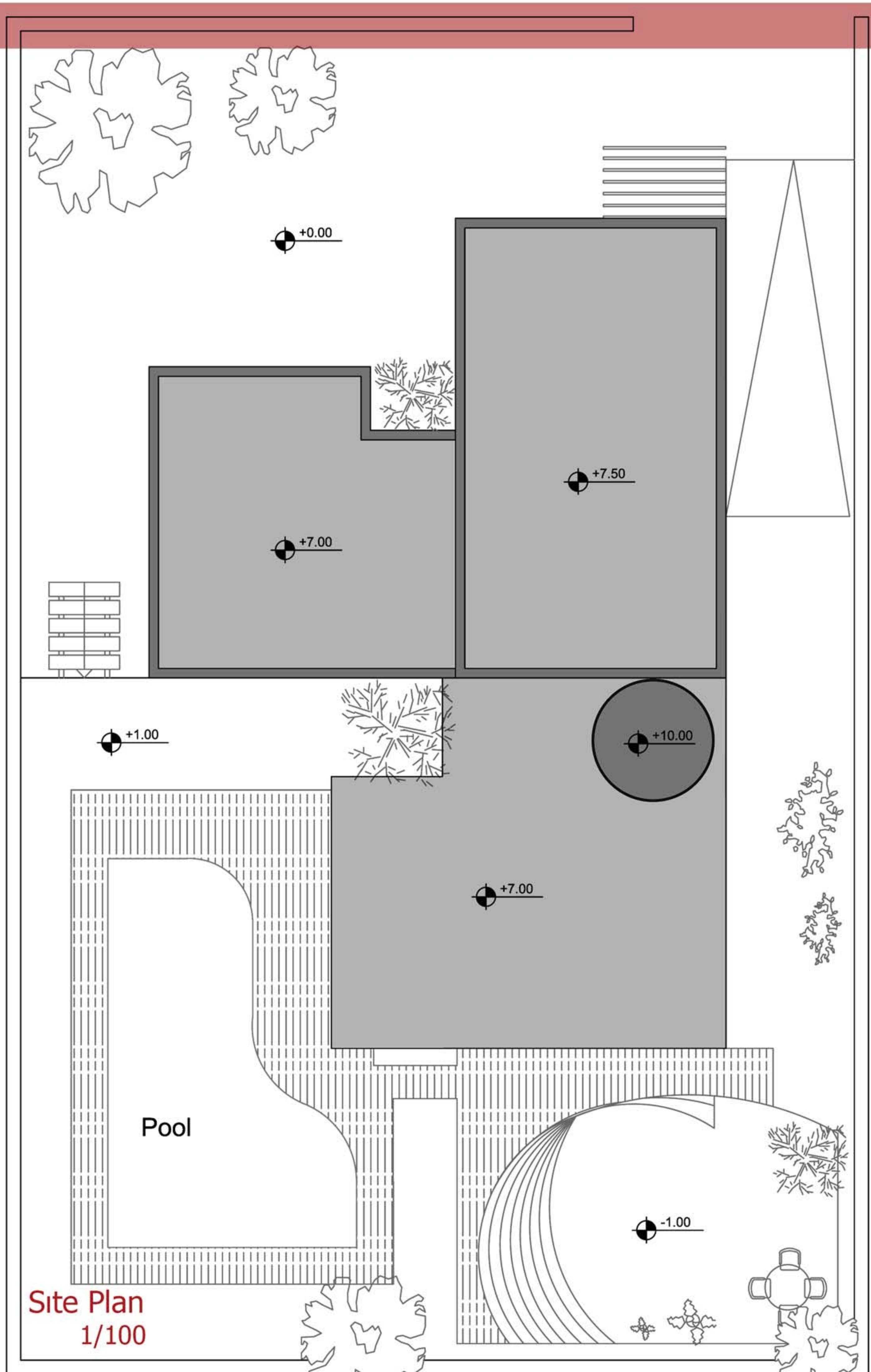
Horizantal Circulation



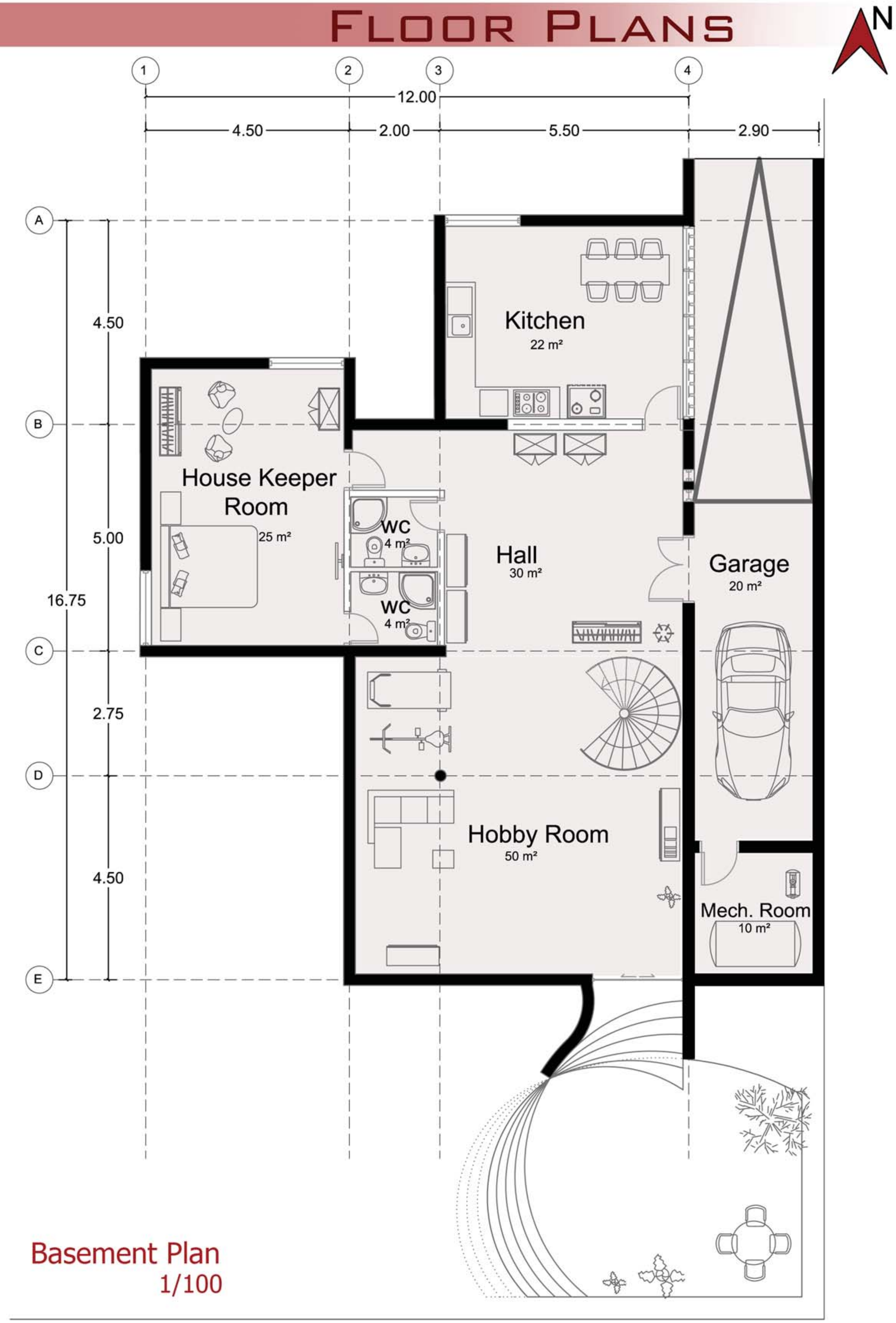




Floor Plans



Site Plan
1/100



Basement Plan
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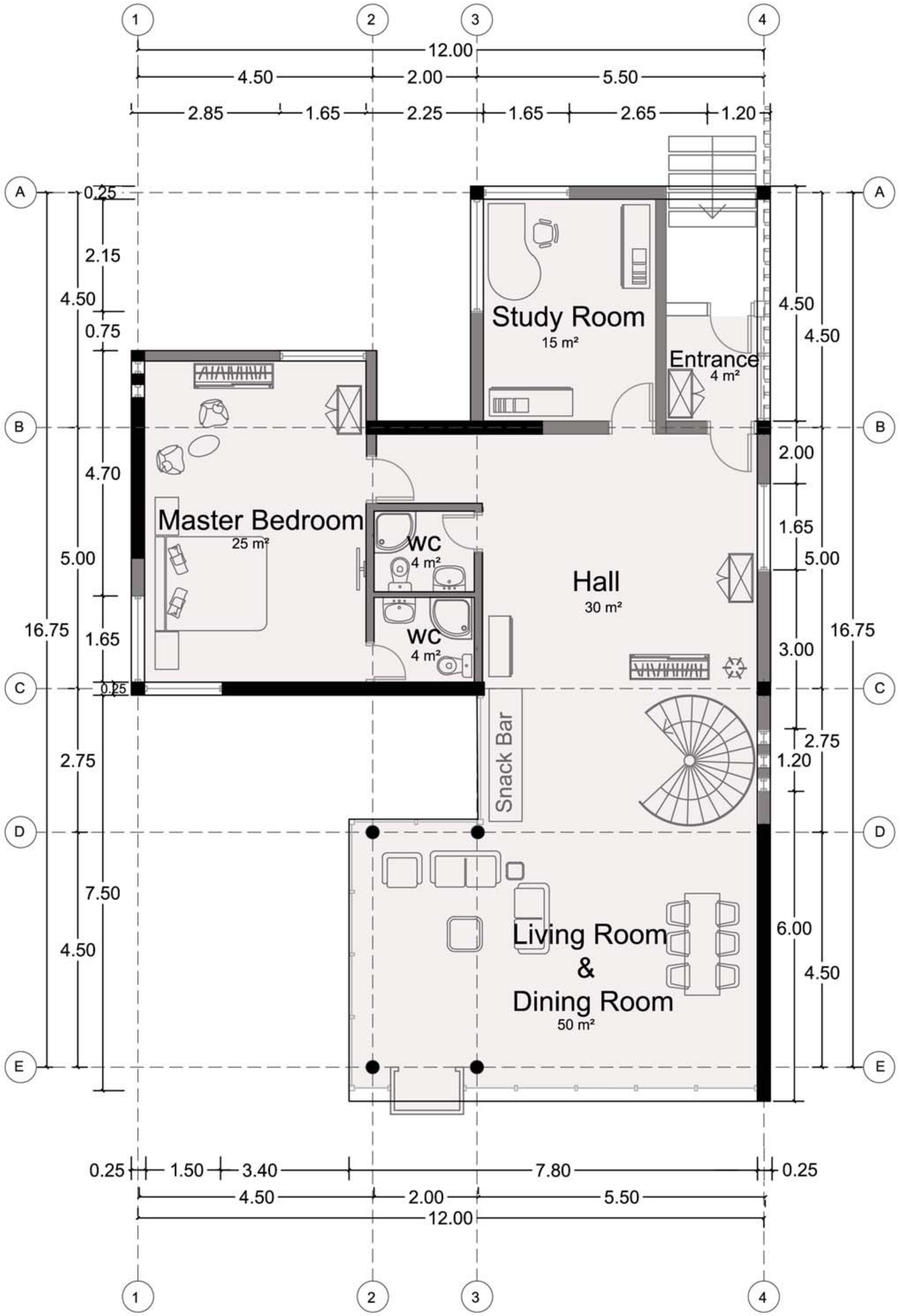
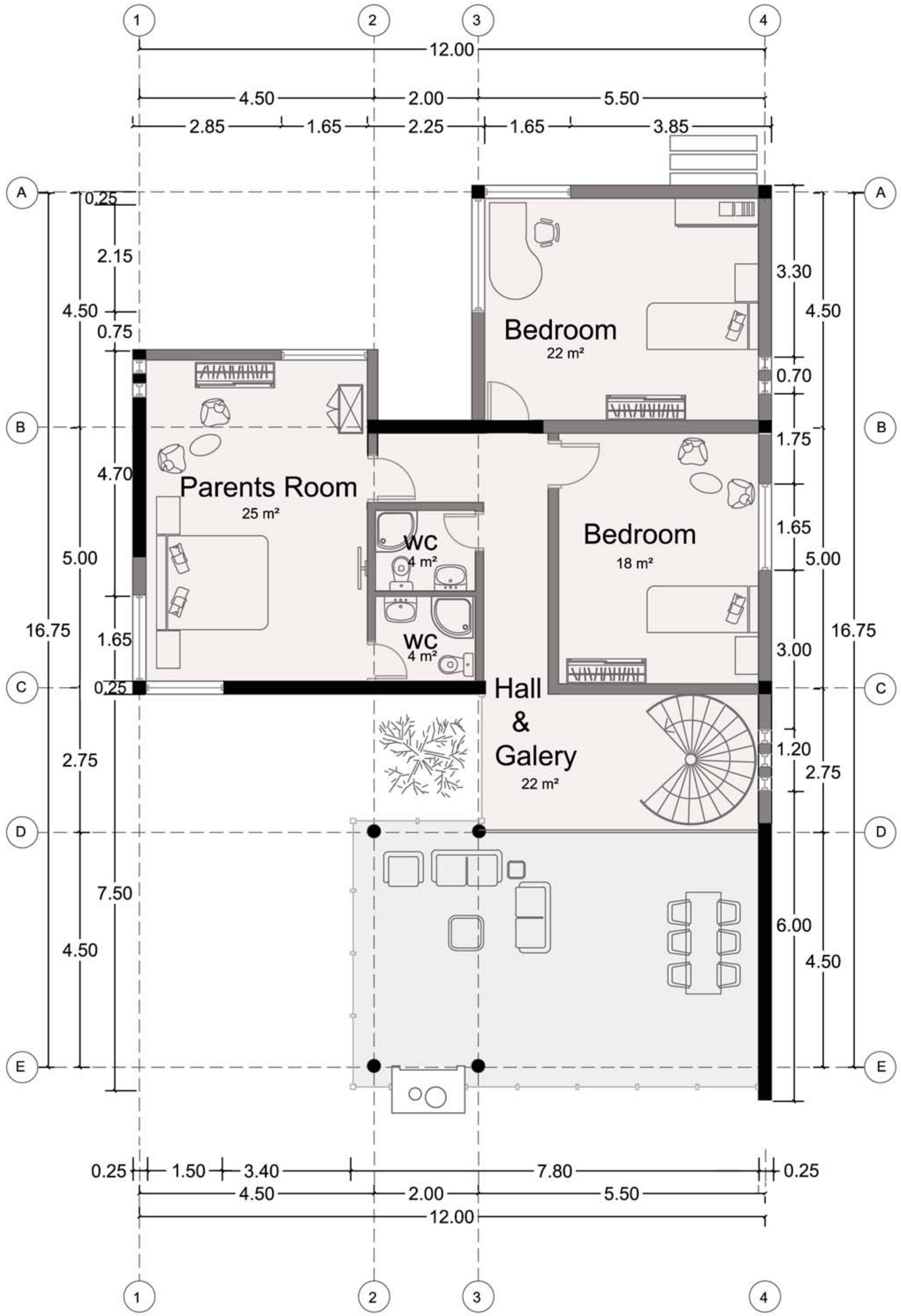
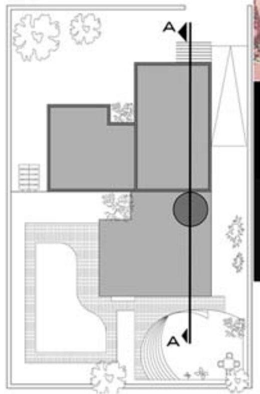
FLOOR PLANS



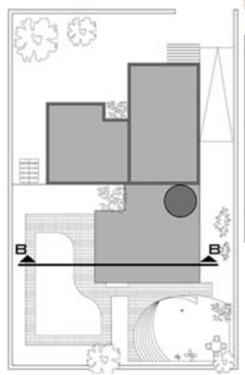
Ground Floor Plan
1/100



First Floor Plan
1/100

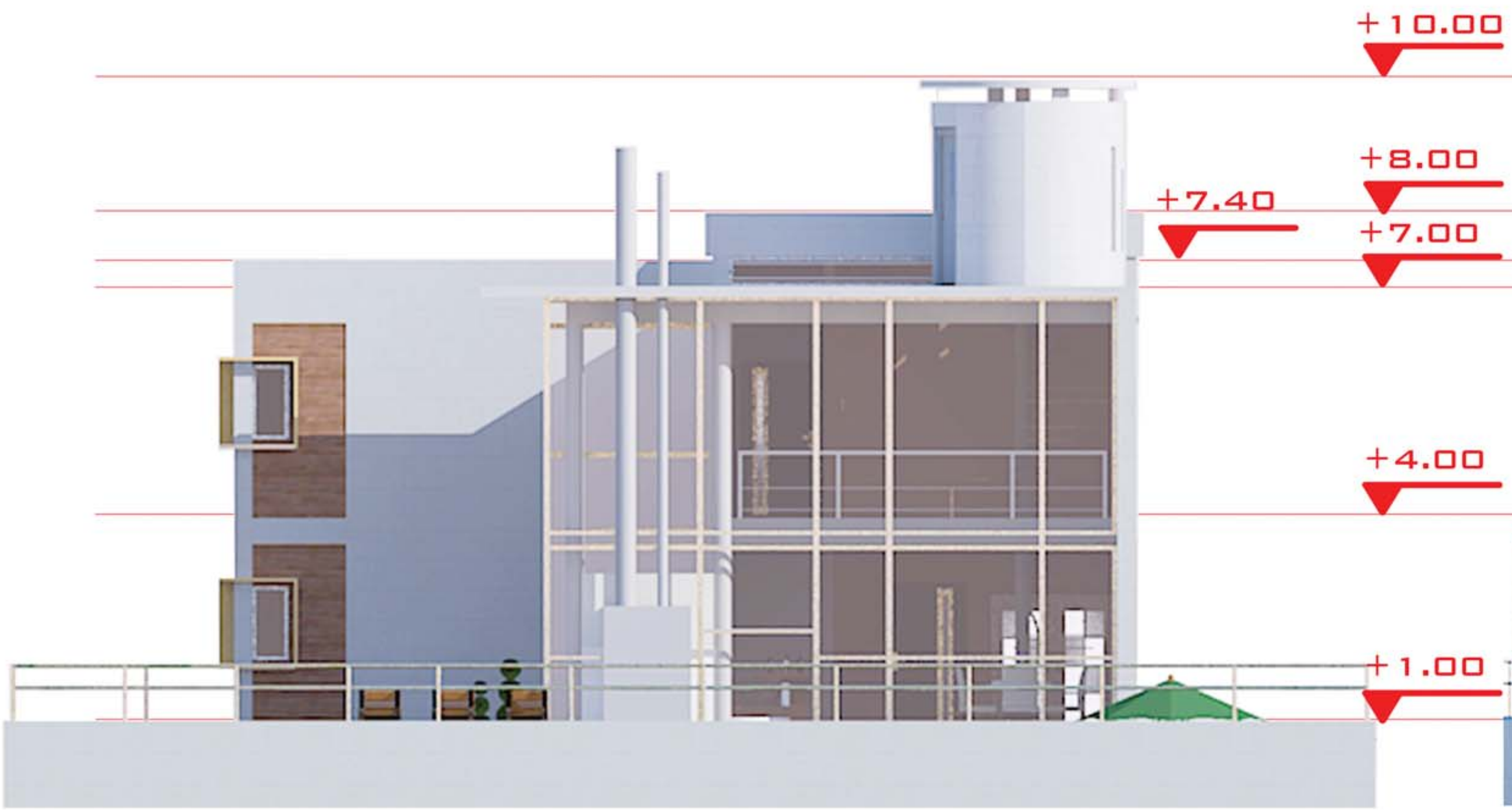


SECTION AA



SECTION BB

Elevations

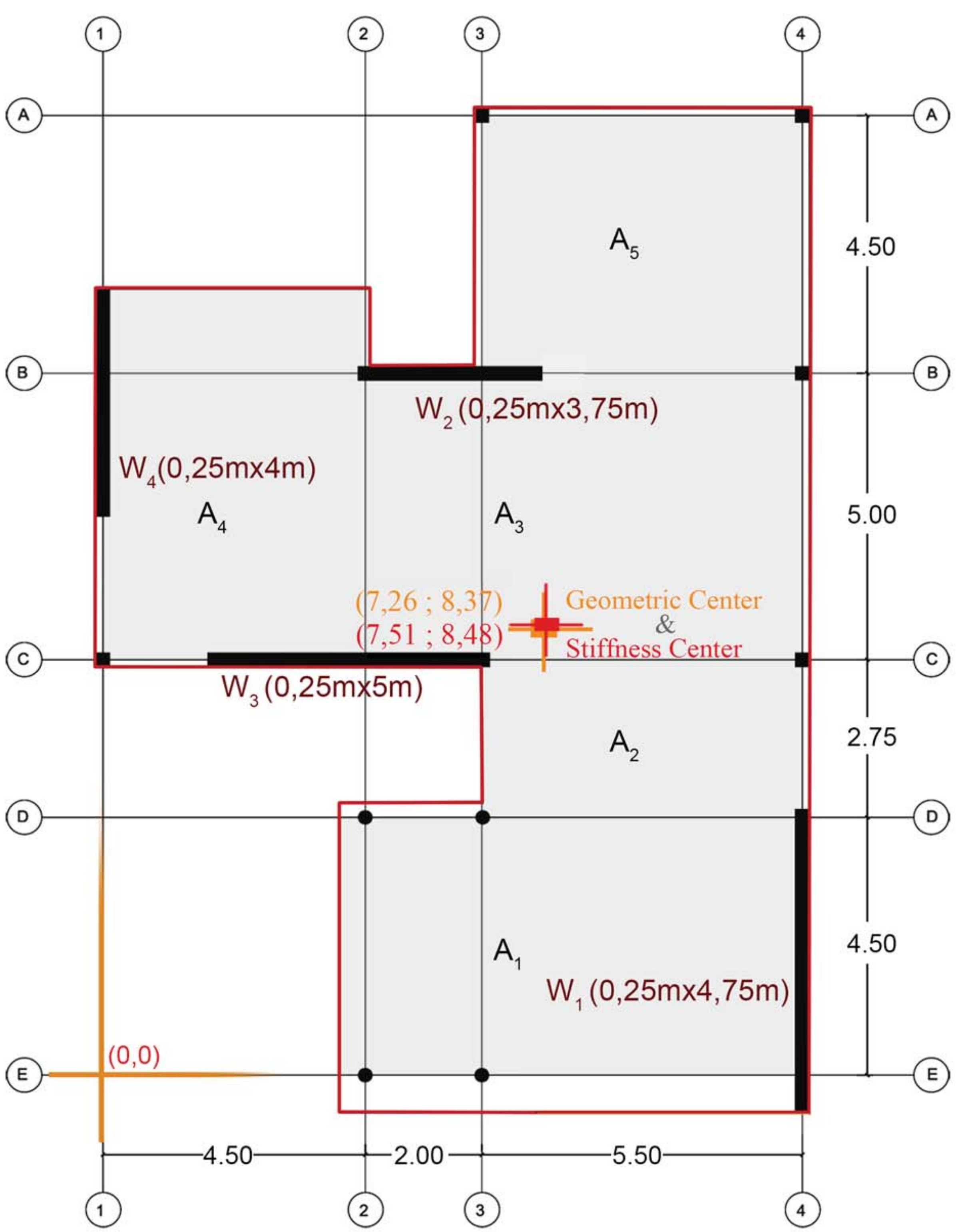


South Elevation

East Elevation

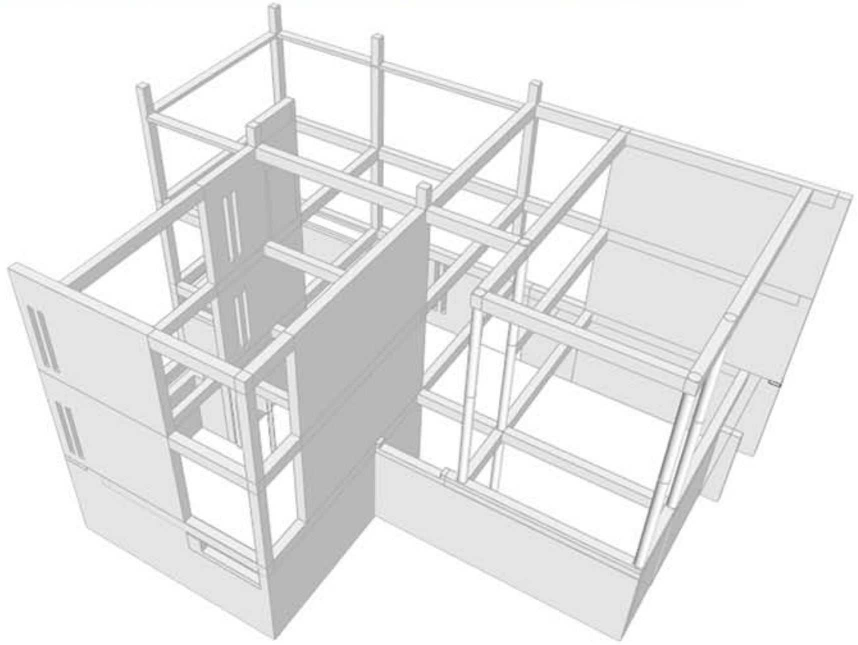
North Elevation

West Elevation



Geometric Center

$$G=\frac{(A_1xd_1+A_2xd_2+......+A_nxd_x)}{A_1+A_2+...+A_n}$$



A_1=7,5x4,5=33,75
A_2=5,5x2,5=13,75
A_3=7,5x5=37,5
A_4=4,5x6,5=29,25
A_5=5,5x4,5=24,75

Geometric Center in X direction

$$G_x=\frac{[(33,75)x(8,25)+(13,75)x(9,25)+(37,5)x(8,25)+(29,25)x(2,25)+(24,75)x(9,75)]}{139}=7,26$$

Geometric Center in Y direction

$$G_y=\frac{[(33,75)x(2,25)+(13,75)x(5,75)+(37,5)x(9,5)+(29,25)x(10,25)+(24,75)x(14,25)]}{139}=8,37$$

Geometric Center

According to these calculations, geometric center is on (7,26;8,37)

Stiffness Center in X direction

$$I_3=\frac{(0,25)x(4,75)^3}{12}=2,23 \qquad I=\frac{b.h^3}{12} \qquad S_x=\frac{I_3.L_3+I_4.L_4}{I_3+I_4}$$

$$I_4=\frac{(0,25)x(4)^3}{12}=1,33 \qquad S_x=\frac{(2,23)x(12)+(1,33)x(0)}{2,23+1,33}=7,51$$

Stiffness Center in Y direction

$$I_2=\frac{(0,25)x(3,75)^3}{12}=1,1 \qquad I=\frac{b.h^3}{12} \qquad S_y=\frac{I_1.L_1+I_2.L_2}{I_1+I_2}$$

$$I_1=\frac{(0,25)x(5)^3}{12}=2,6 \qquad S_y=\frac{(12)x(1,1)+(2,6)x(7)}{1,1+2,6}=8,48$$

Stiffness Center

According these calculations , stifness center is on (7,51;8,48)

Shear Wall Percentage

Total Floor Area: 140 m2

Area of Shear Walls On X Axis:

(0,25 m x 4,75 m) + (0,25 m x 4 m) = 2,187 m²

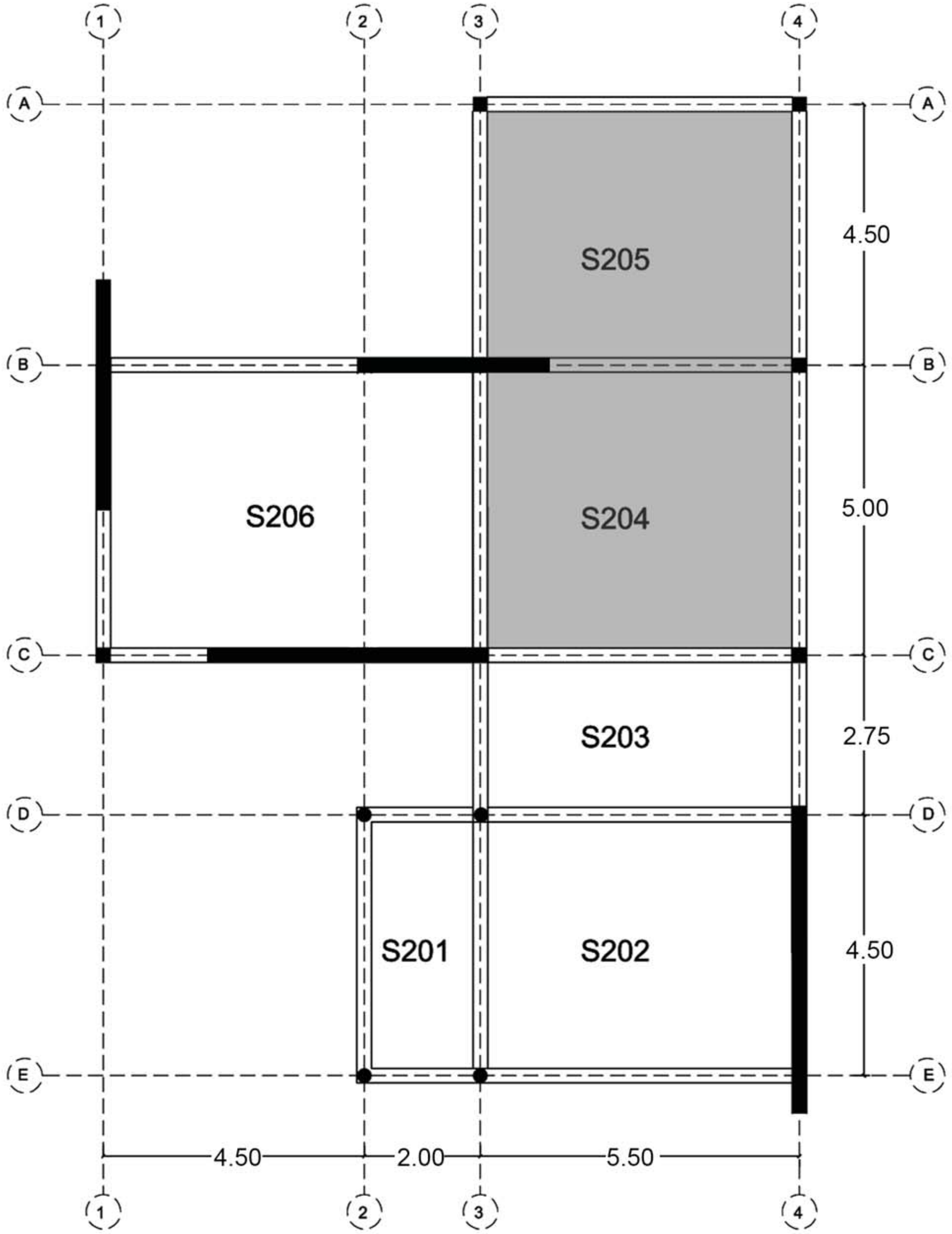
Percentage: 2,187 / 140 = %1,56

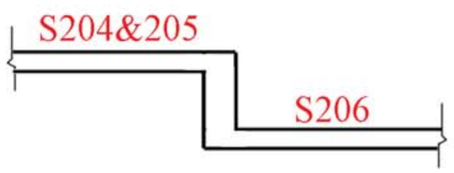
Area of Shear Walls On Y Axis:

(0,25m x 3,75 m) + (0,25m x 5)= 2,19 m²

Percentage: 2,19 / 140 = %1,56

Stiffness Center and Geometric Center is very close and Shear Wall Percantage is above the avarage.





!! S204 & S205 were lifted 50cm and beams were used also as parapet on the roof.

Slab Thickness Calculation

Formula: $t \geq \dfrac{l_{short}}{15+\dfrac{20}{\dfrac{l_l}{l_s}}} \times (1-\dfrac{\alpha}{4})$

$\alpha = \dfrac{\text{length of continous edges}}{\text{total length of all edges}}$

For S204

$\alpha_{204} = \dfrac{5,5}{21} = 0,26$

$t_{204} \geq \dfrac{500}{15+\dfrac{20}{\dfrac{5,5}{5}}} \times (1-\dfrac{0,26}{4})$

$t_{204} \geq 14,16$ cm

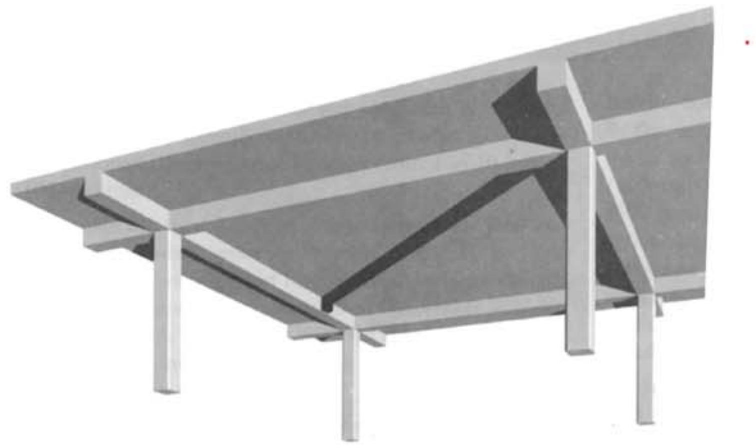
For 205

$\alpha_{205} = \dfrac{5,5}{20} = 0,275$

$t_{205} \geq \dfrac{450}{15+\dfrac{20}{\dfrac{5,5}{4,5}}} \times (1-\dfrac{0,276}{4})$

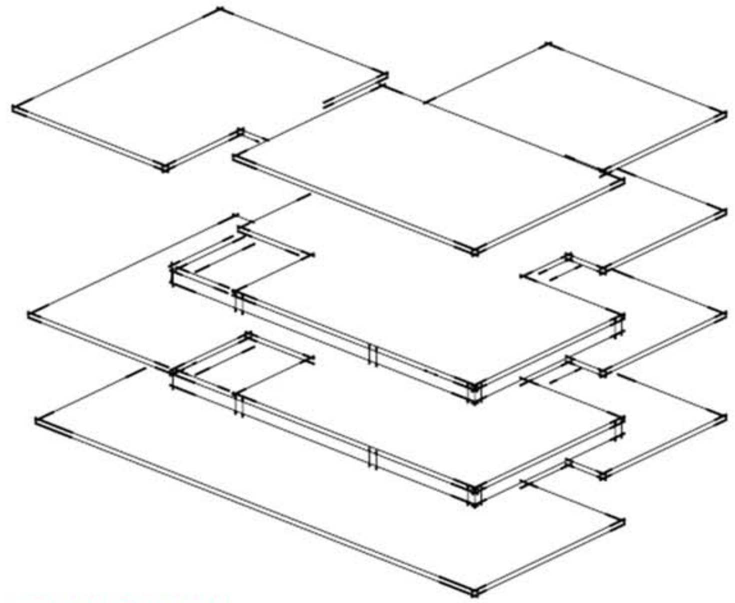
$t_{205} \geq 13,34$ cm

S204 and S205 are most critical slab types so we calculated these two slabs and find two different thicknesses. Thus, we consider the higher one to have a safe system.



Two Way Solid Slab with Beams

According to CODES TS 500 and TURKISH SEISMIC CODE two way solid slab with beams is selected with the calculations.

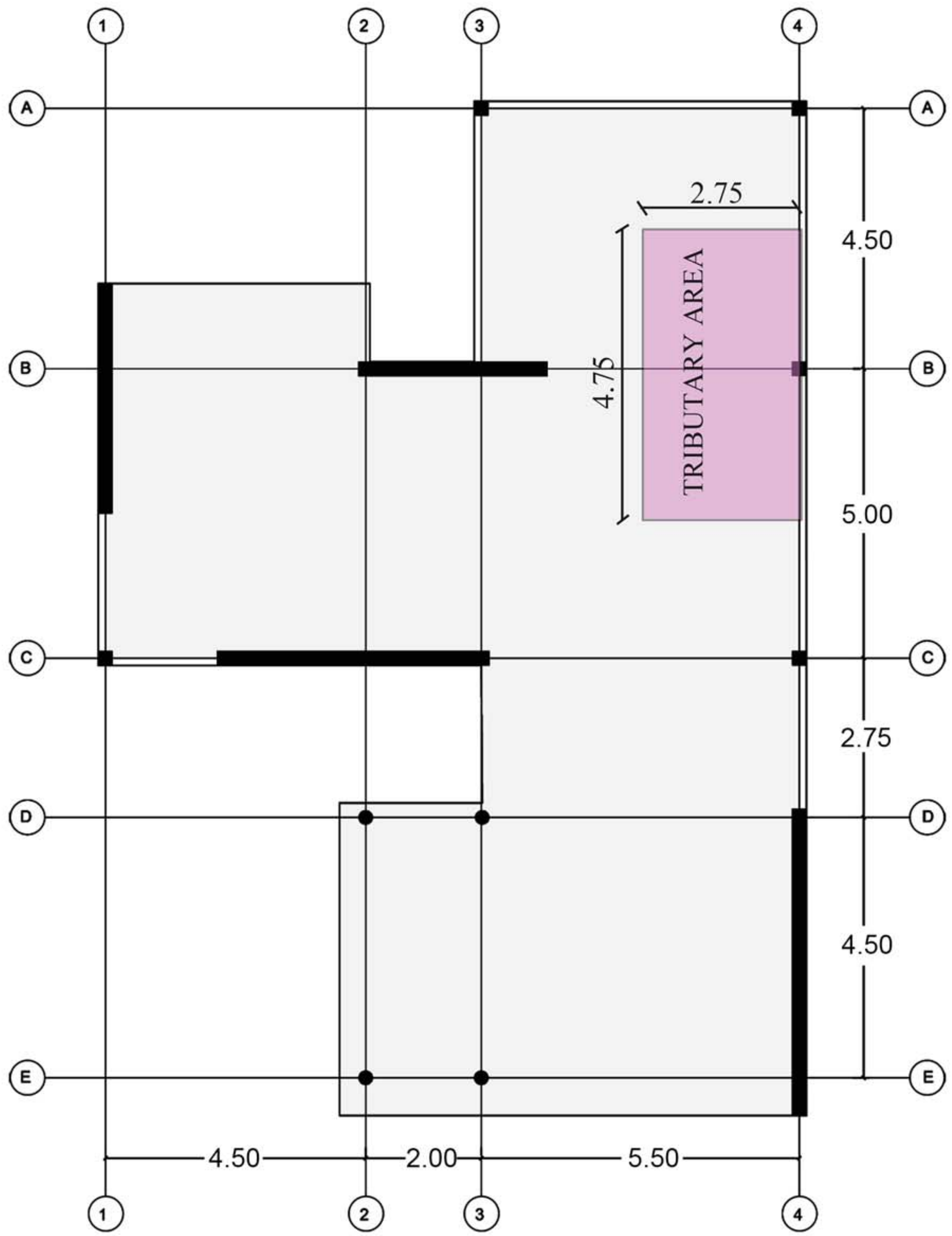


Slab Thickness

There are two critical slab which have maximum spans and we calculated both of them. After find out two different slab thicknesses, we consider the one which has 14.16 cm in height, so we decided to use 15 cm for slab thickness.

Slab thickness is minimum : 15 cm

Tributary Area (Floor Height is 3 meter.)

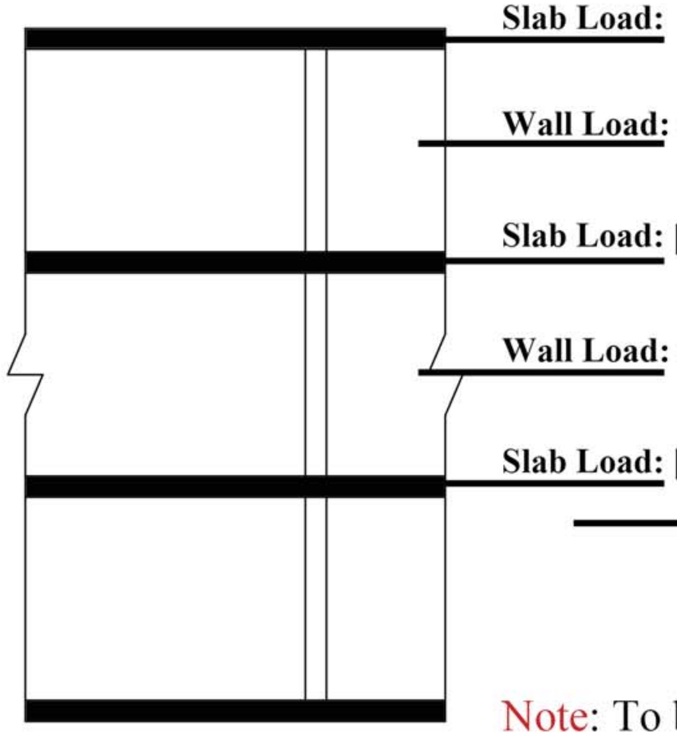


Wall Load=Wall Length xWall Heightx0,45x1,4

Slab Load=Slab Area x 1,02

$Beam_{Average} = \frac{Max\ Span}{12,5}$,so $\frac{550}{12,5} = 44$ cm

Thus, wall height is 2,56cm



Slab Load: [(4,75x2,75)x1,02] = 13,32 t = 13320kg

Wall Load: [(2,45+4,45)x2,56 x0,45x1,4] = 11,12832t =11128 kg

Slab Load: [(4,75+2,75)x1,02] = 13,32 t = 13320kg

Wall Load: [(2,45+4,45+2,25)x2,56 x0,45x1,4] = 14,757t=14757 kg

Slab Load: [(4,75+2,75)x1,02] = 13,32 t = 13320 kg +

Total Load: 65845 kg

Note: To be on the safe side, door openings were ignored

$$\text{Then; } A_c \geq \frac{N_d}{0,75xfcd}$$

$$= \frac{65845}{0,75x130} = 675,56\ cm^2$$

25 cm

30 cm

Column

Since 25 x 30 = 750 > 675 and min A_c must be bigger than 750 cm^2

Column dimensions are **25cm x 30cm** according to TS-500

Design Loads for slab:

Dead Loads

Own Weight: 0,15 x 2,4 = 0,36 t/m²

Levelling: 0,04 x 2,4 = 0,096 t/m²

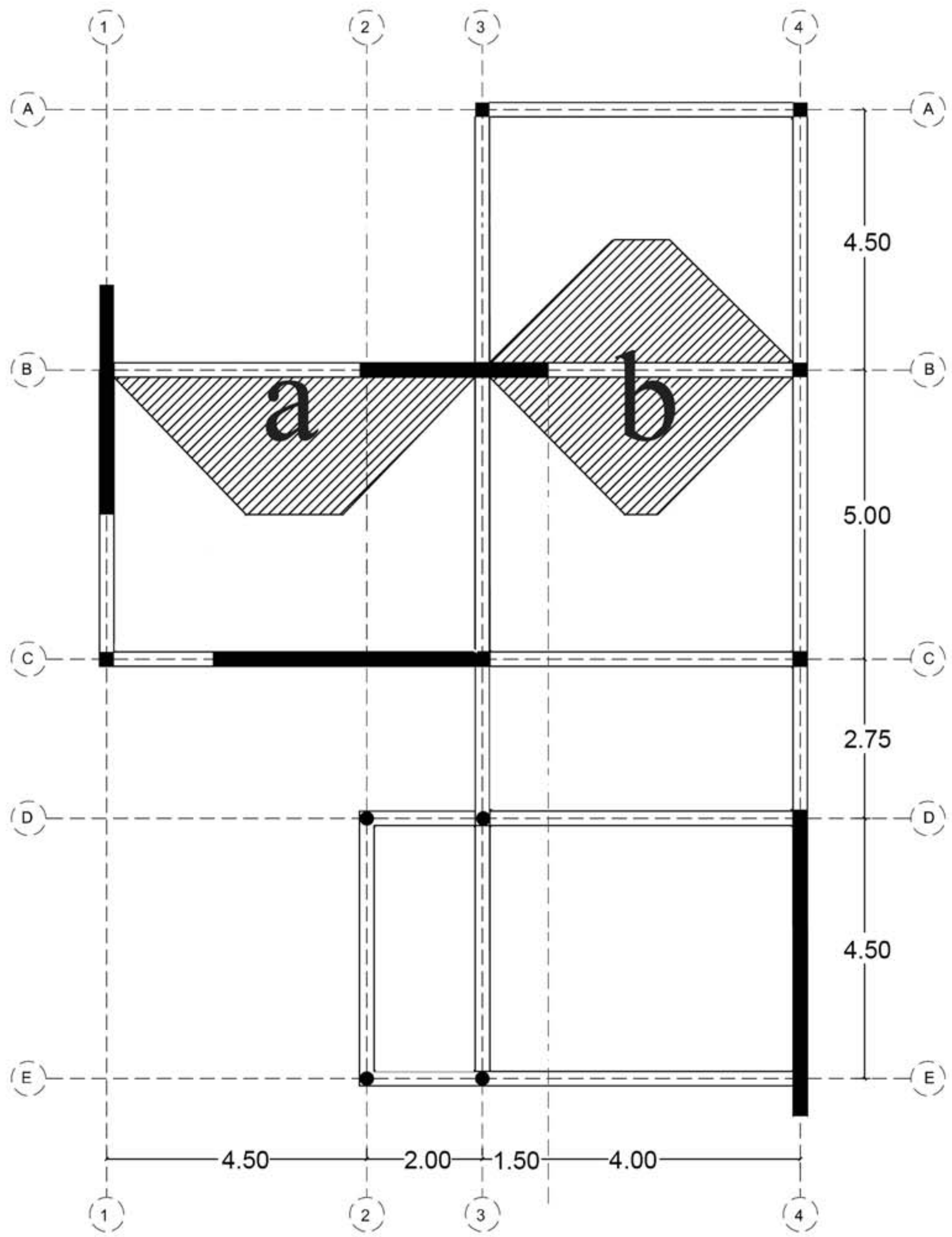
Covering: 0,025 x 2 = 0,05 t/m²

Plastering: 0,02 x 2 = 0,04 t/m² +

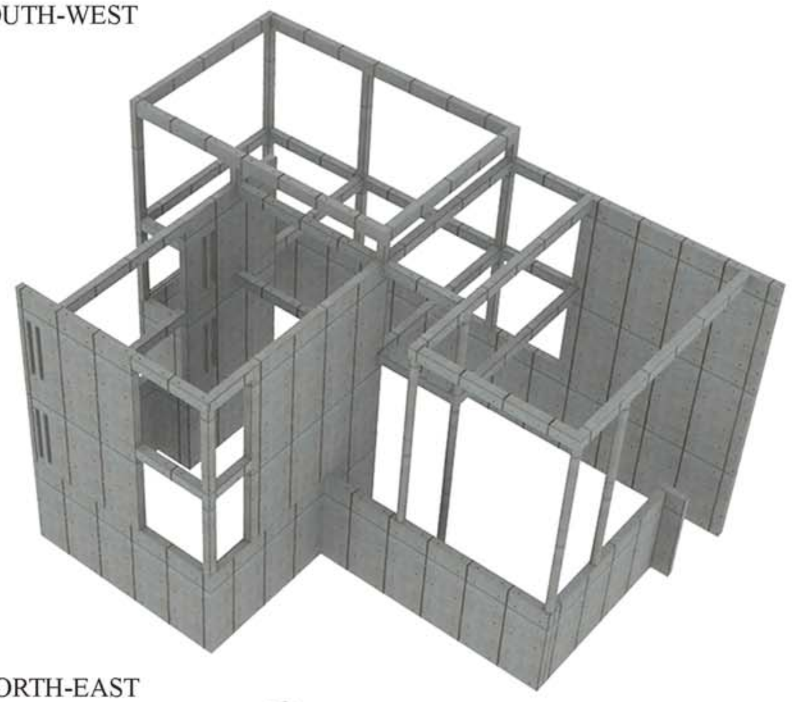
0,36 + 0,096 + 0,05 + 0,04 0,52 t/m²

Live Load : 0,2 t/m²

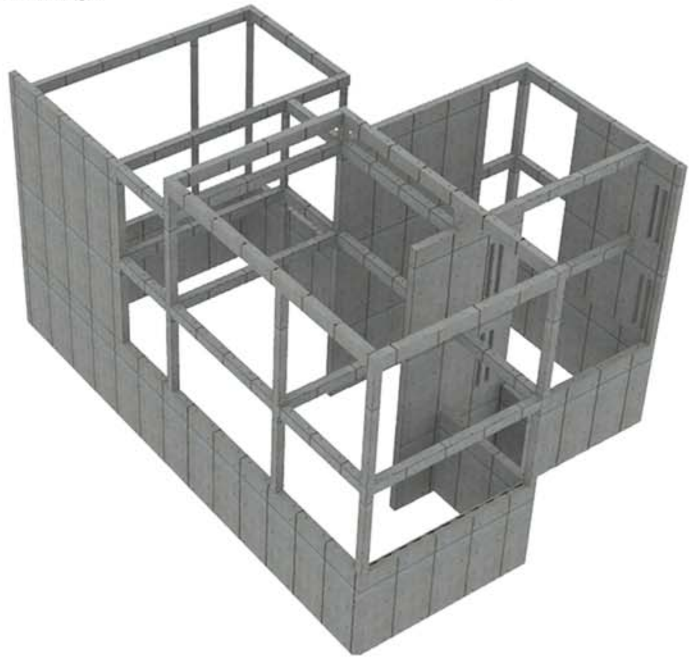
TOTAL LOAD : (1,4)(0,5) + (1,6)(0,2) = **1,02 t/m²**



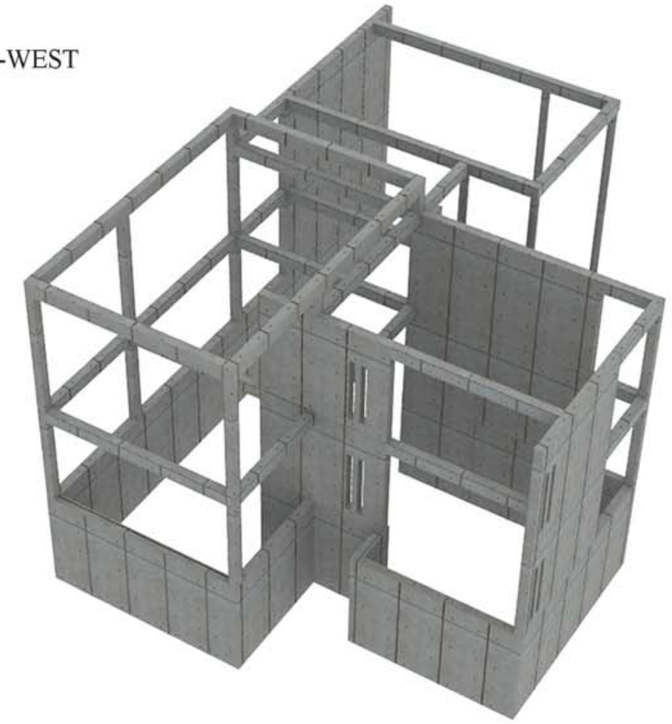
SOUTH-WEST



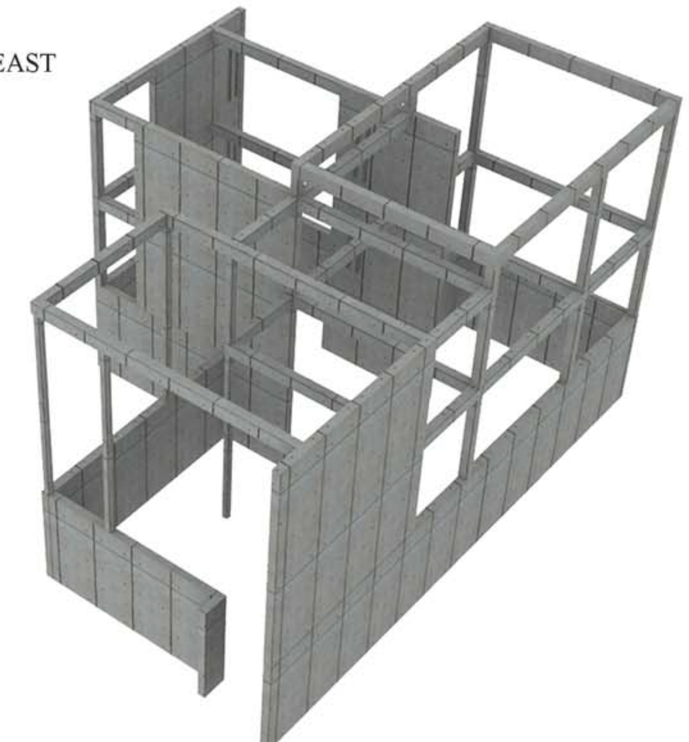
NORTH-EAST



NORTH-WEST



SOUTH-EAST



For Short Span

$$W = Pd \times \frac{Lshort}{3}$$

For Long Span

$$W = Pd \times \frac{Lshort}{3} \times \left(1.5 - \frac{0,5}{\left(\frac{l\,long}{l\,short}\right)^2}\right)$$

$$Pd = (1,4 \times 0,5) + (1,6 \times 0,2) = 1,02\ t/m^2$$

Load on region a;

$$W_{1\text{-}2} = 1,02 \times \frac{5}{3} \times \left(1,5 - \frac{0,5}{\left(\frac{6,5}{5}\right)^2}\right) = 2,04 t/m$$

Load on region b;

$$W_{3\text{-}4} = 1,02 \times \frac{5}{3} \times \left(1,5 - \frac{0,5}{\left(\frac{5,5}{5}\right)^2}\right) + 1,02 \times \frac{4,5}{3} \times \left(1,5 - \frac{0,5}{\left(\frac{5,5}{4,5}\right)^2}\right) = 3.83 t/m$$

$$r_{AB} = \frac{\left(\frac{I}{L}\right)_{AB}}{\sum\left(\frac{I}{L}\right)}$$

$$r_{12} = \frac{\frac{0,003125\ m^4}{4,25\ m}}{\frac{0,003125\ m^4}{4,25\ m} + \frac{0,0052\ m^4}{3\,m} \times 2} = 0,21 \qquad r_{21} = 0$$

$$r_{43} = \frac{\frac{0,003125\ m^4}{4\ m}}{\frac{0,003125\ m^4}{4\ m} + \frac{0,00056 m^4}{3m} \times 2} = 0,66 \qquad r_{34} = 0$$

To calculate beams, we have to know 'r' values and FEM values so that we calculate FEM values at fix end beam system.

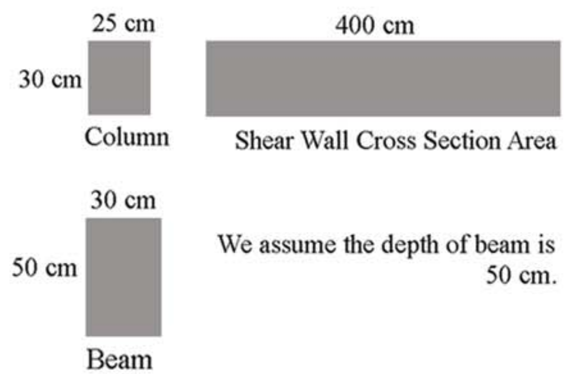
$$FEM = WL^2/12 \qquad FEM_{1\text{-}2} = (2,04) \times (4,25)^2/12 = 3,08tm$$

$$FEM_{3\text{-}4} = (3,83) \times (4)^2/12 = 5,10tm$$

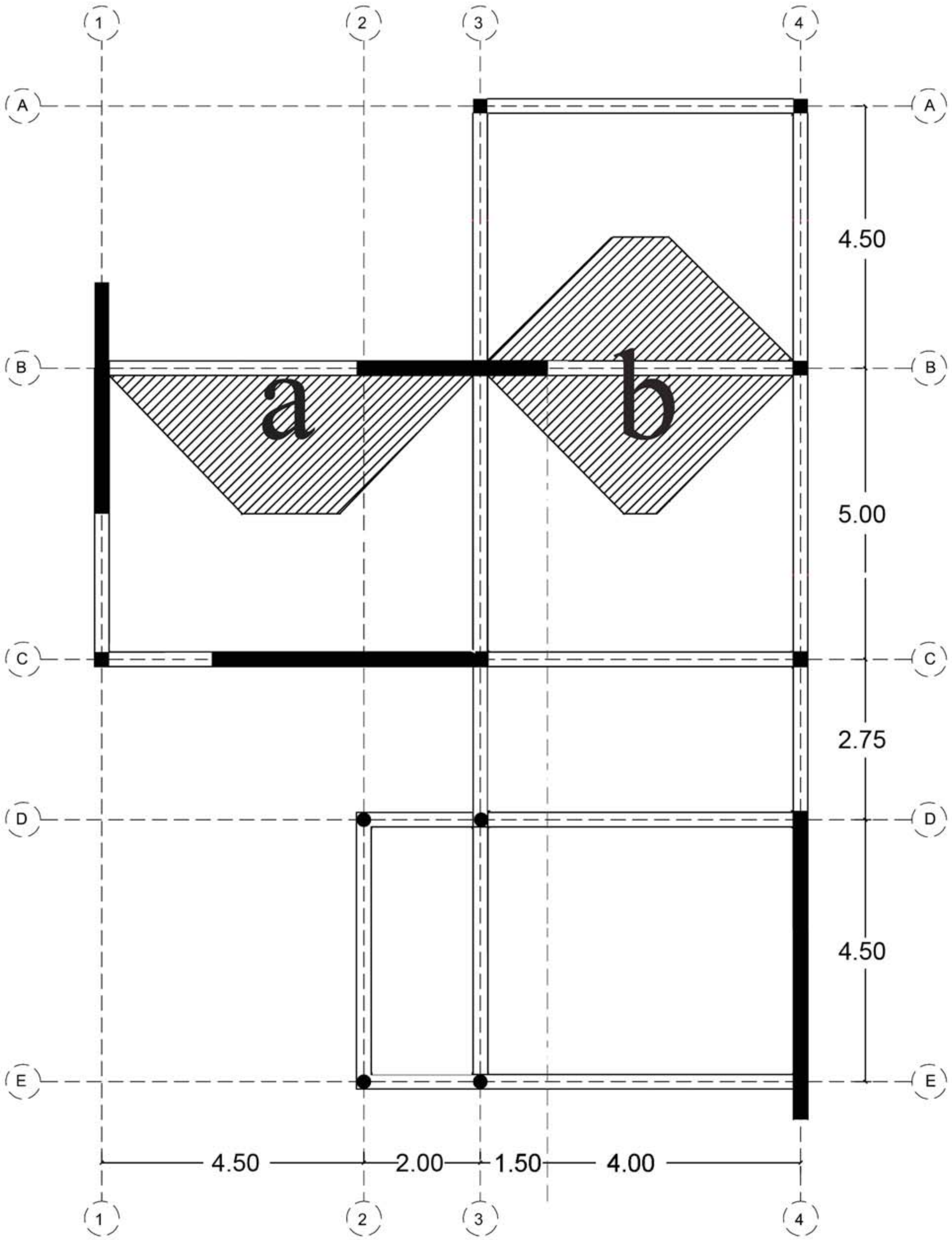
$$I_{column} = \frac{(0,25) \times (0,3)^3}{12} = 0,0005625\ m^4$$

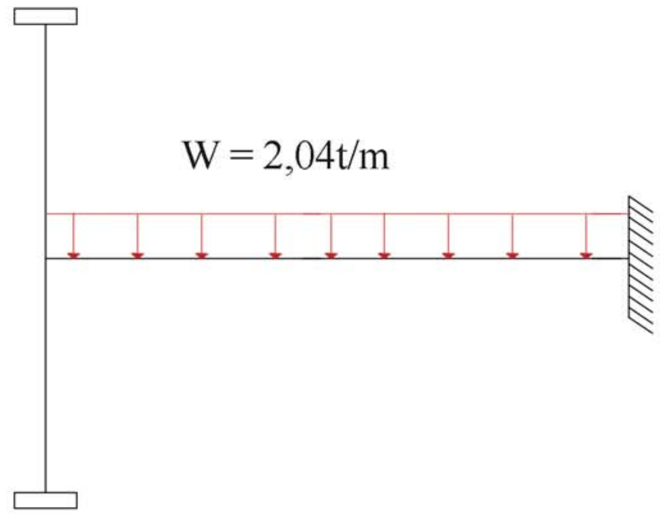
$$I_{shearwall} = \frac{4 \times (0,25)^3}{12} = 0,0052 m^4$$

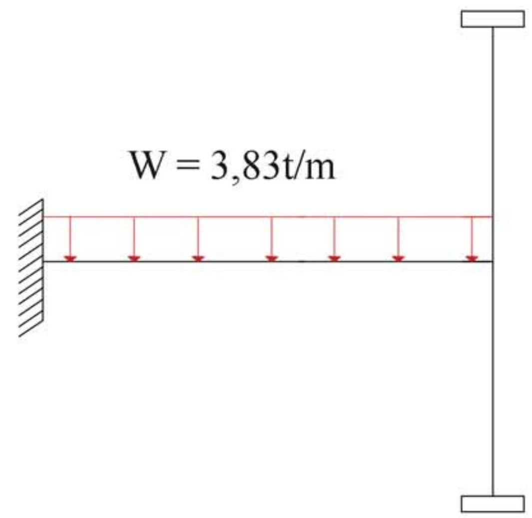
$$I_{beam} = \frac{(0,3) \times (0,5)^3}{12} = 0,003125\ m^4$$



We assume the depth of beam is 50 cm.

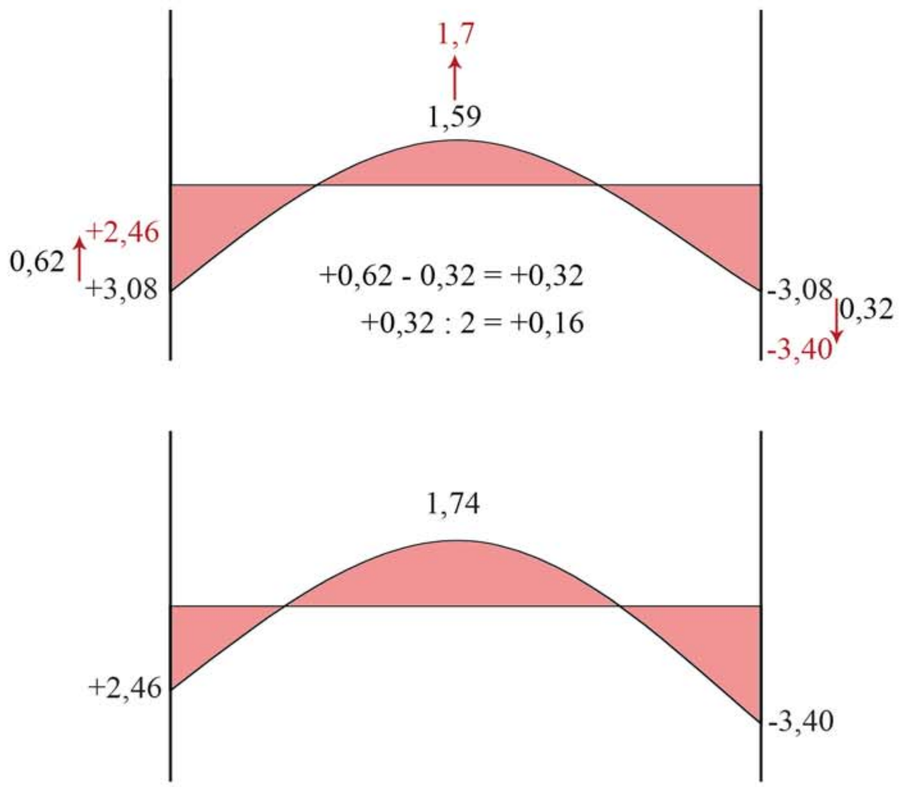


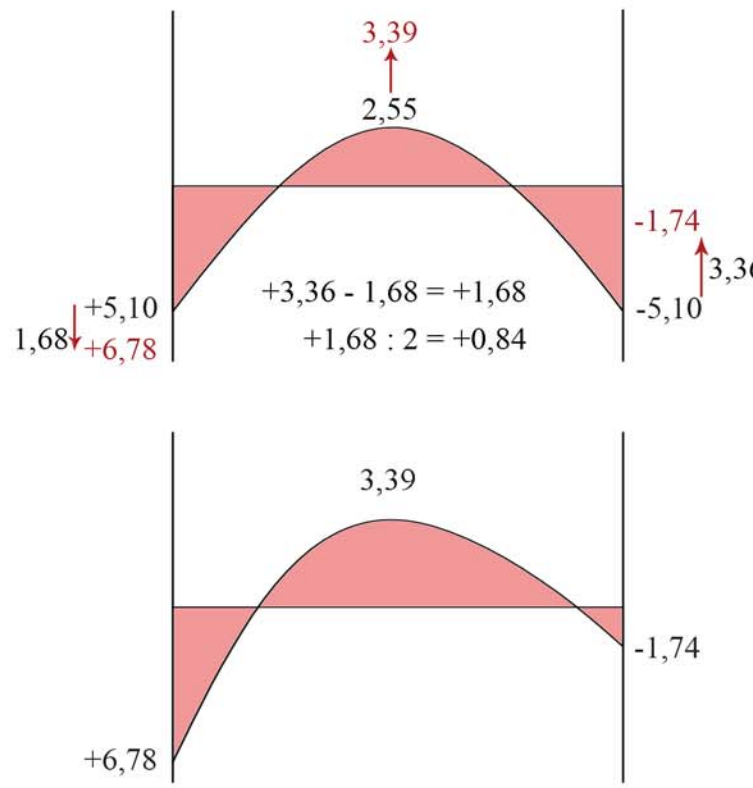




	0,21	0
FEM	+3,08	-3,08
	0	-0,32
	+3,08	-3,40
	-0,65	0
	+2,46	-3,40

	0	0,66
FEM	+5,10	-5,10
	+1,68	0
	+6,78	-5,10
	0	+3,36
	+6,78	-1.74





$FEM = WL^2/12$ $\quad FEM_{1\text{-}2} = (2,04) x (4,25)^2/12 = 3,08 tm$

$FEM_{3\text{-}4} = (3,83) x (4)^2/12 = 5,10 tm$

$$K = \frac{bw \times d^2}{M} \qquad 0,025 = \frac{30 \times d^2}{678000} \rightarrow d = 23,76 \text{ cm}$$

BEAM DEPTH → $h \geq d + 5 = 28,76$ cm $\quad t = 15$ cm and $h \geq 3t = 45$ → Beam Depth =50 cm