STRUCTURAL DESIGN IN ARCHITECTURE II

TERM PROJECT : DREAM HOUSE

INSTRUCTORS:

B.OZER AY ,M. HALIS GUNEL ,MELTEM ERDIL , GOKCE NIHAN TASKIN

2017-2018 , SPRING

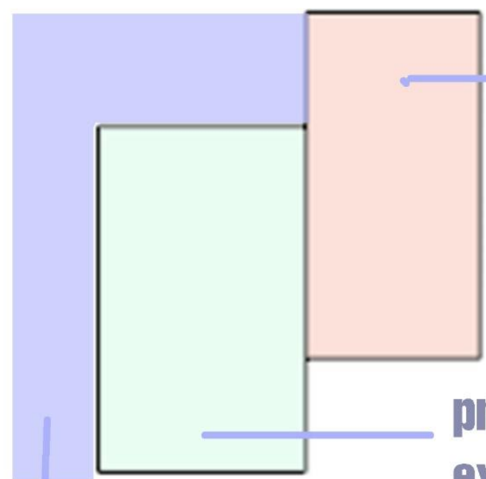
GROUP 20:

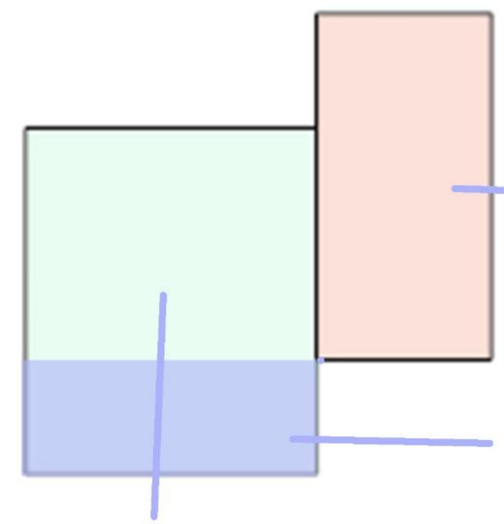
ABDULLAH EREN DEMIREL

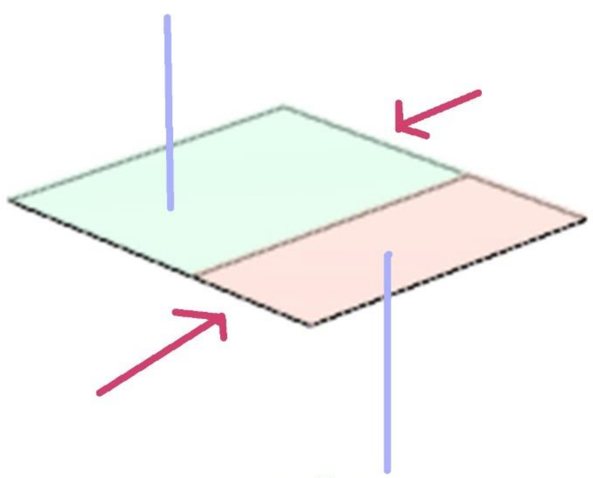
CIGDEM CALIK

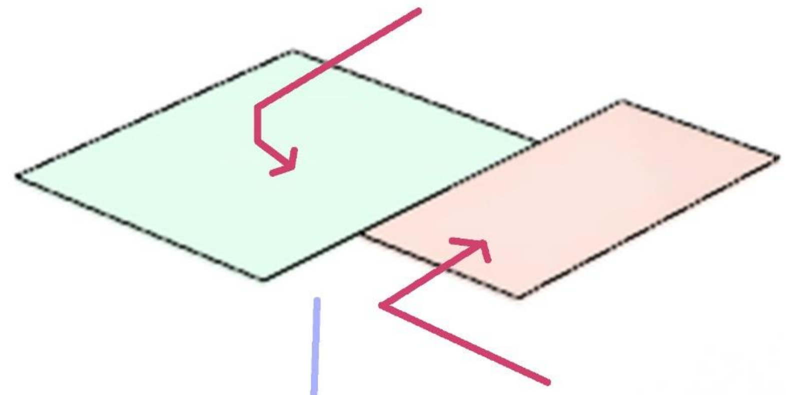
HASAN BERKCAN AYDIN

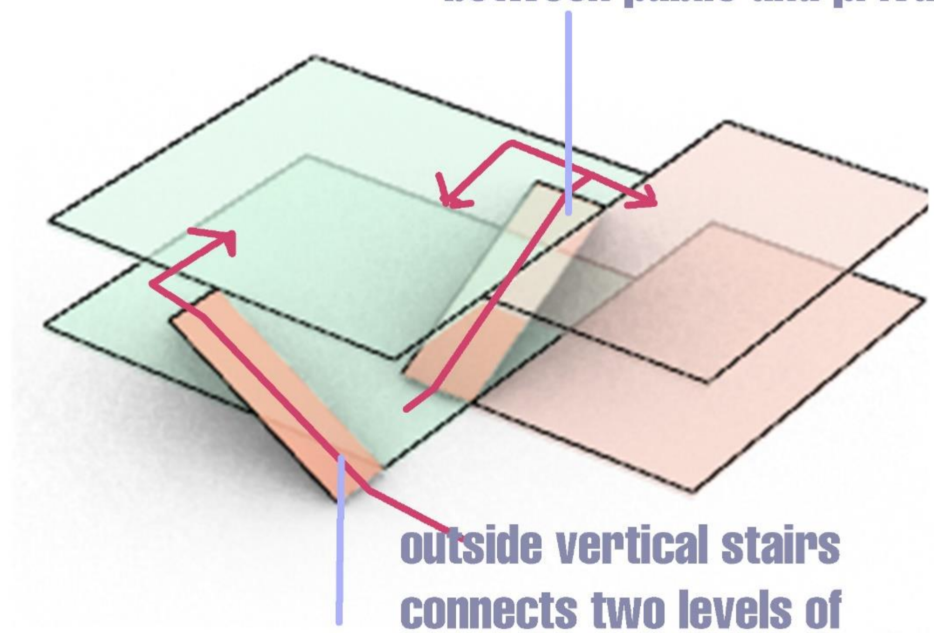
house for a painter :



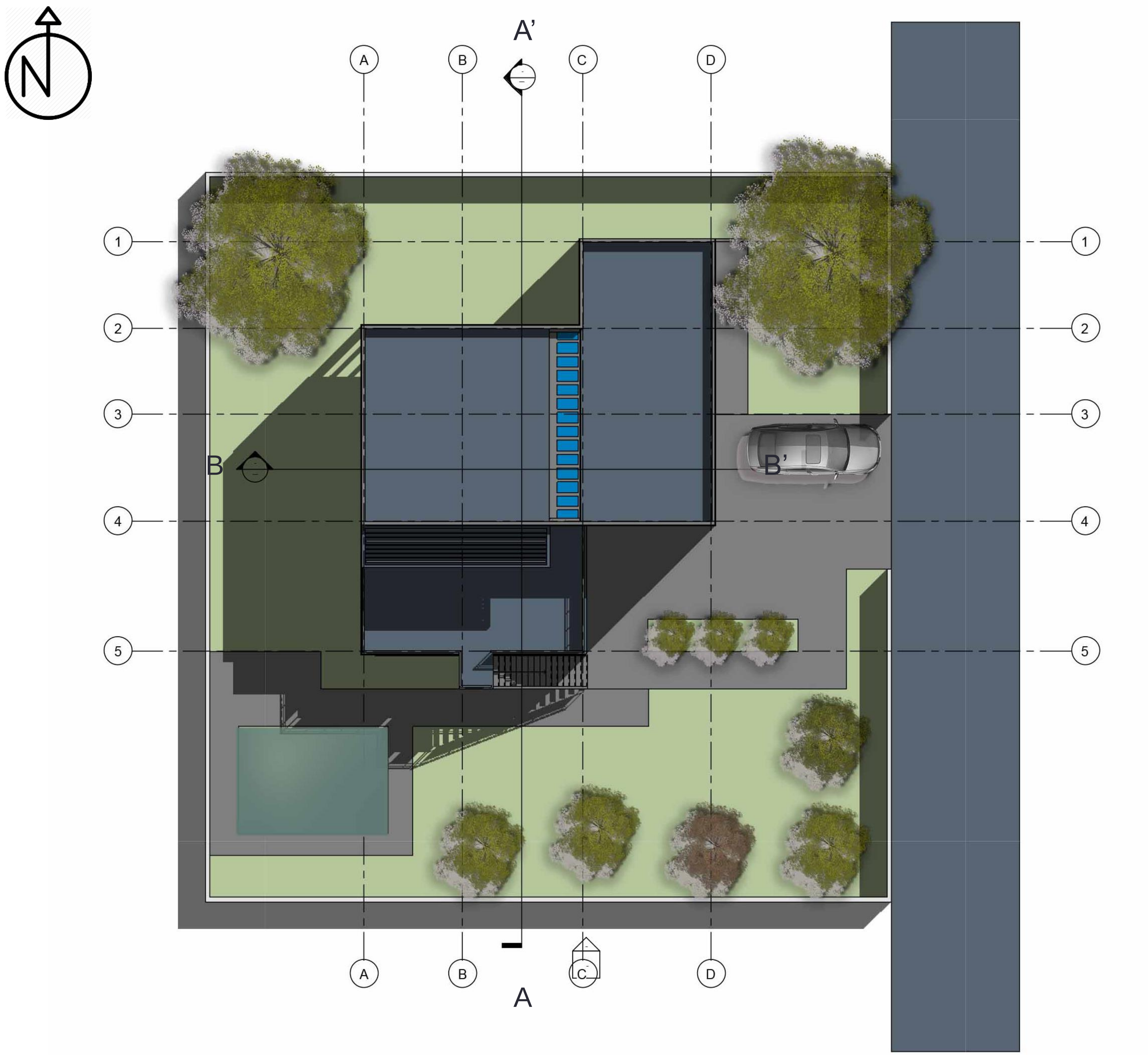


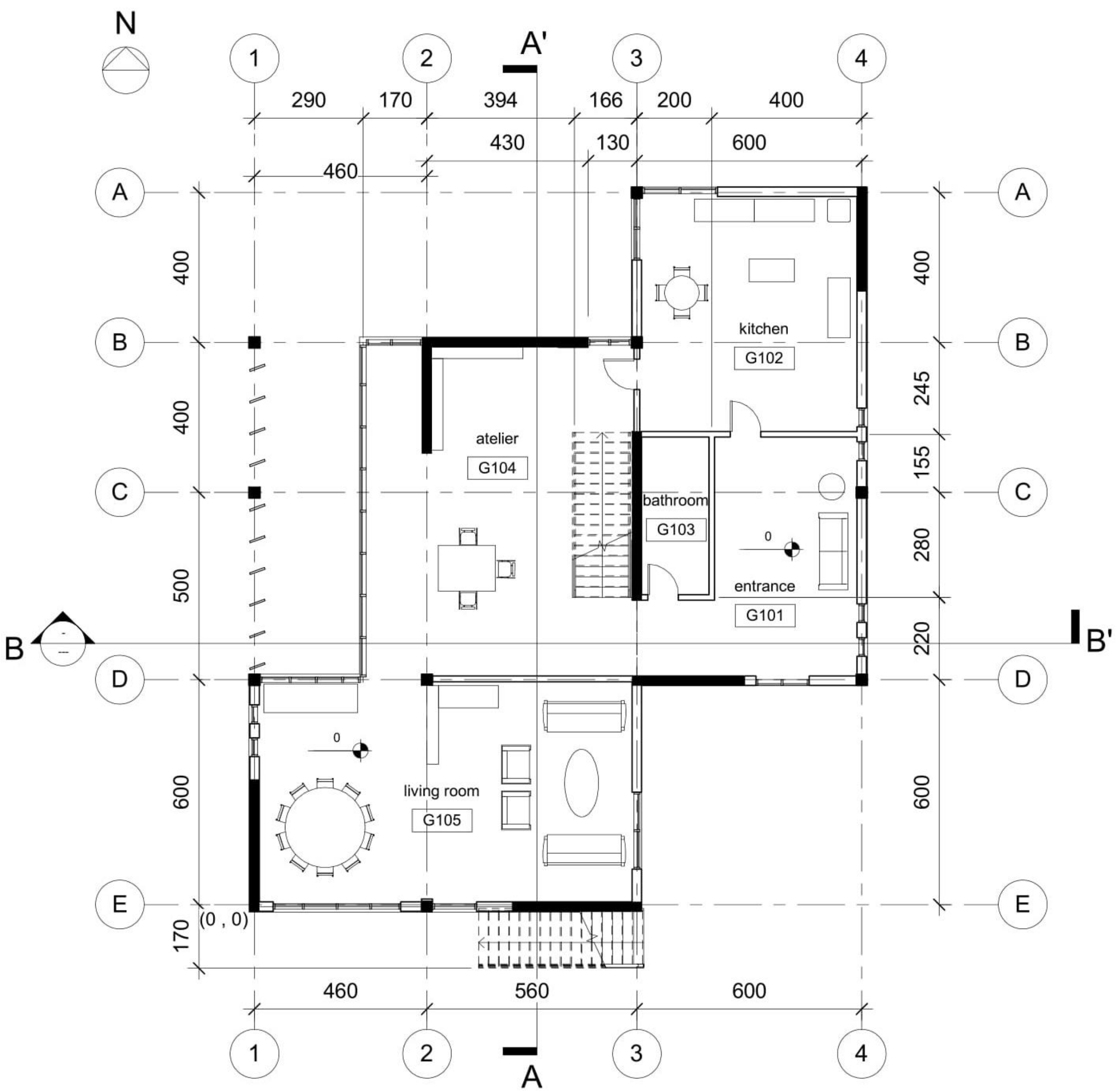




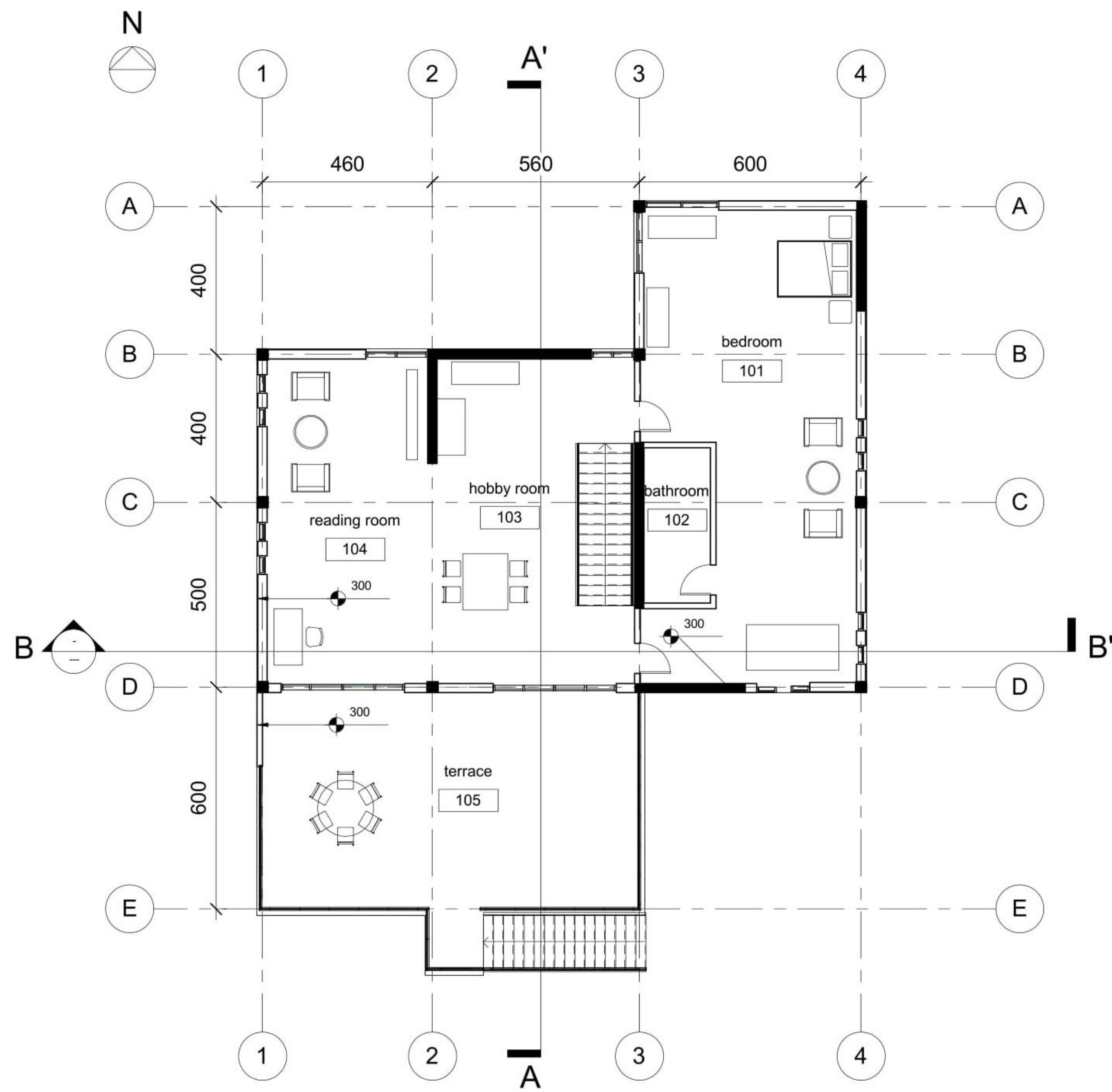


SITE PLAN

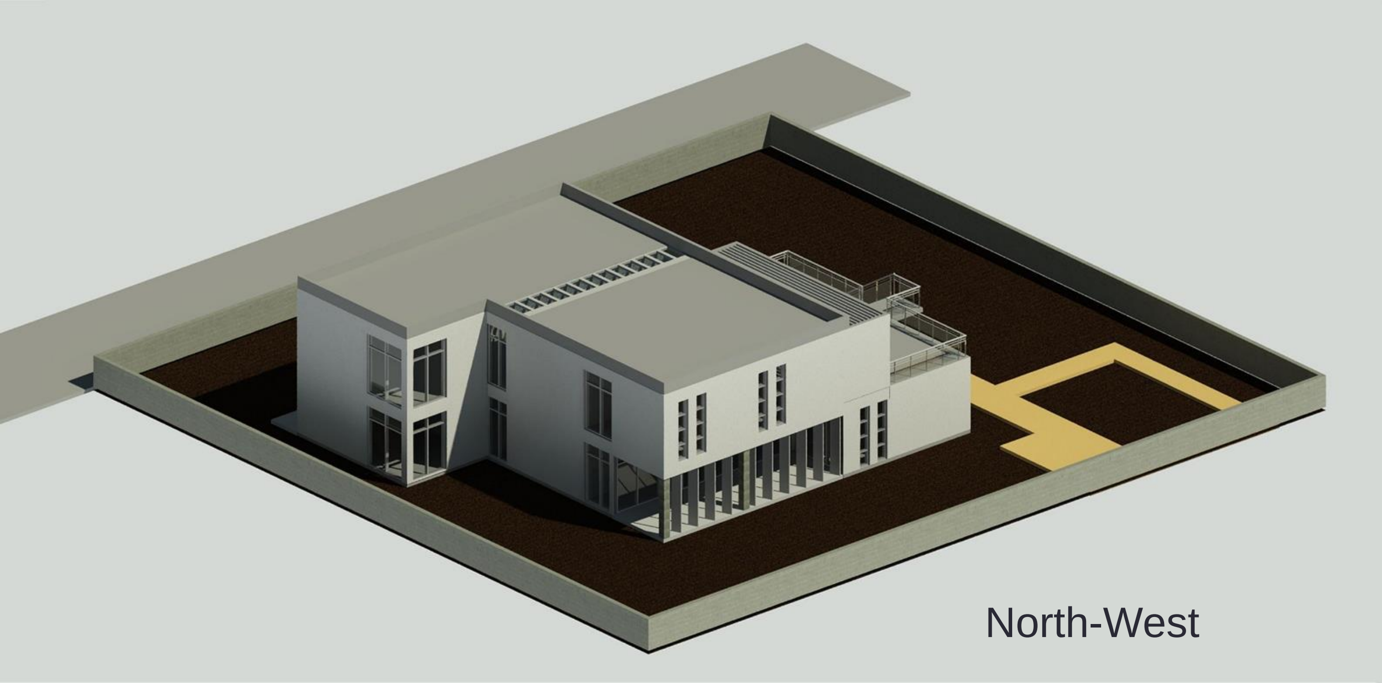




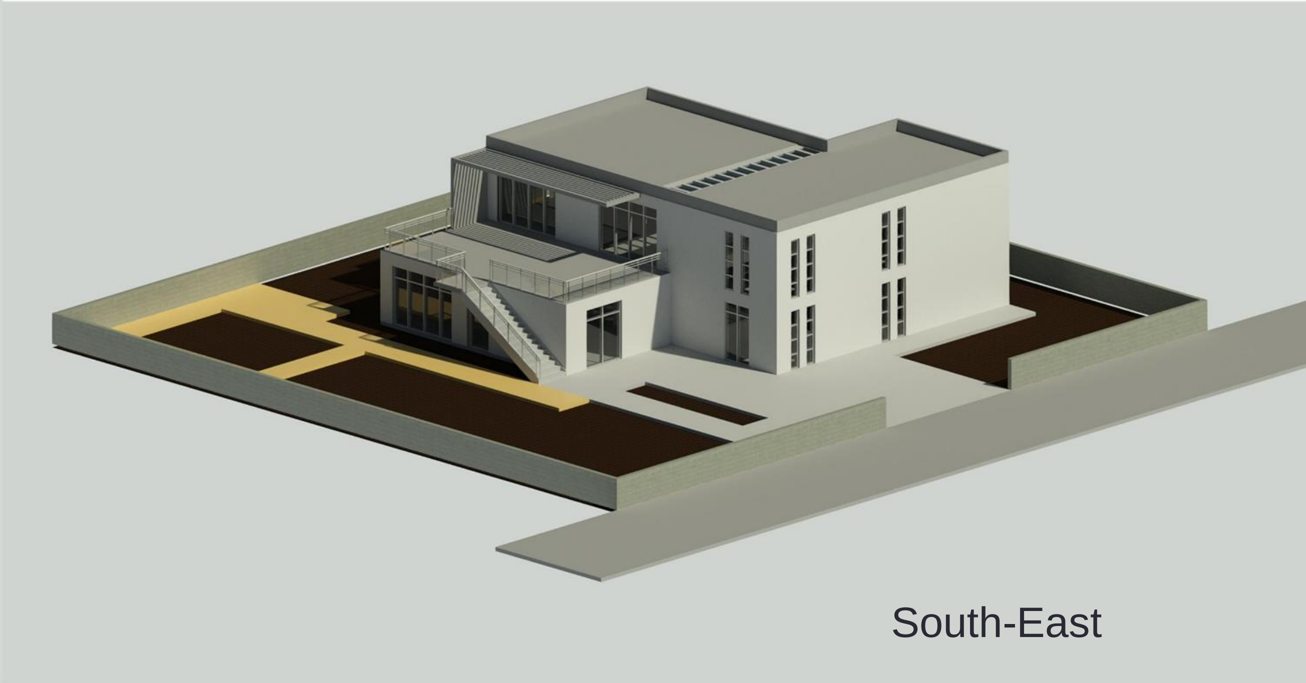
Ground Floor Plan



First Floor Plan



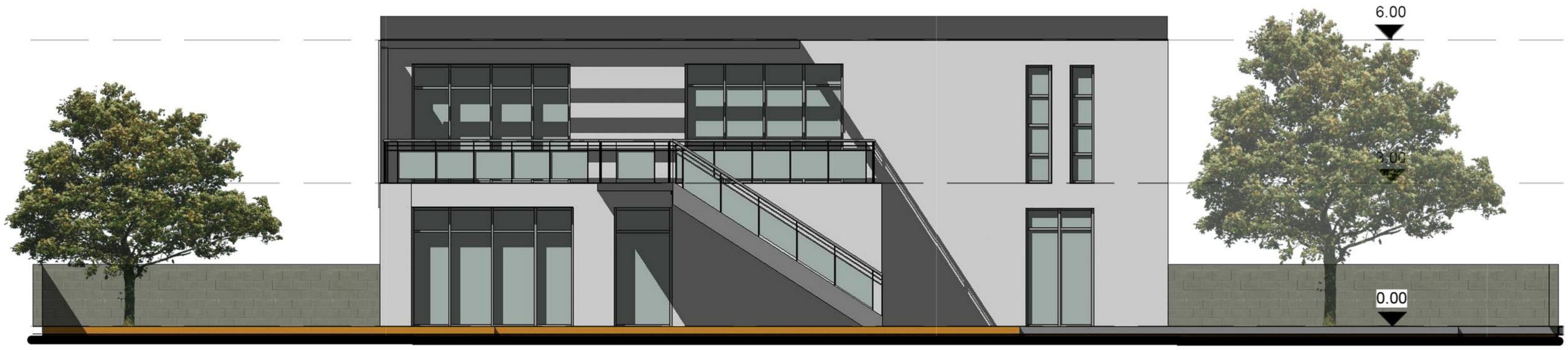
North-West



South-East

Section AA’

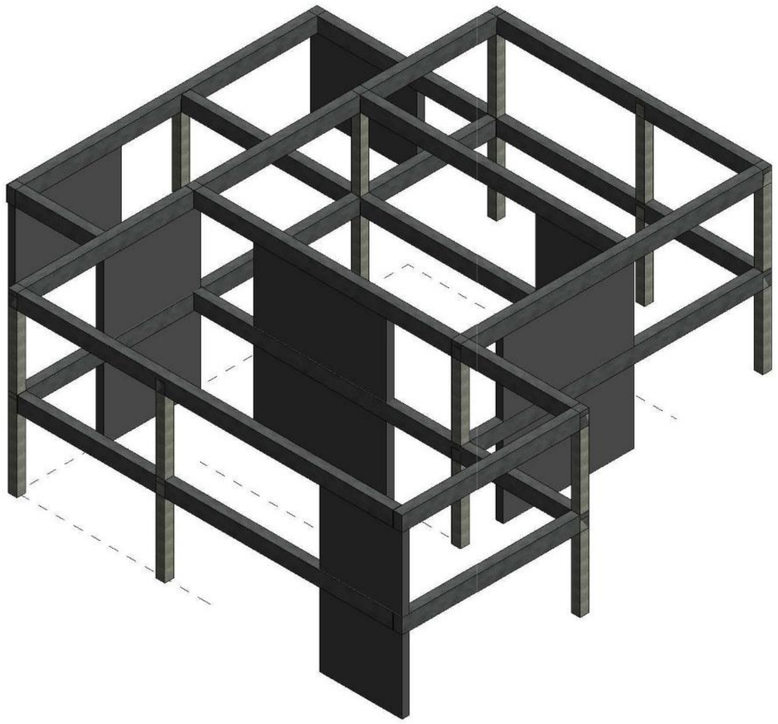
Section BB’



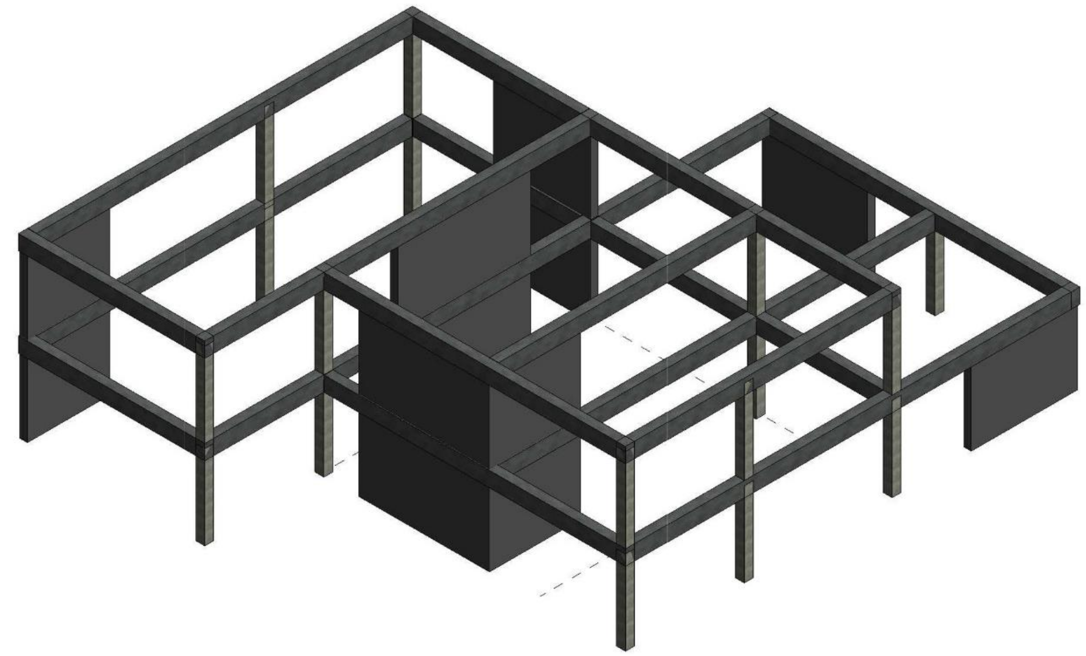
South Elevation

West Elevation

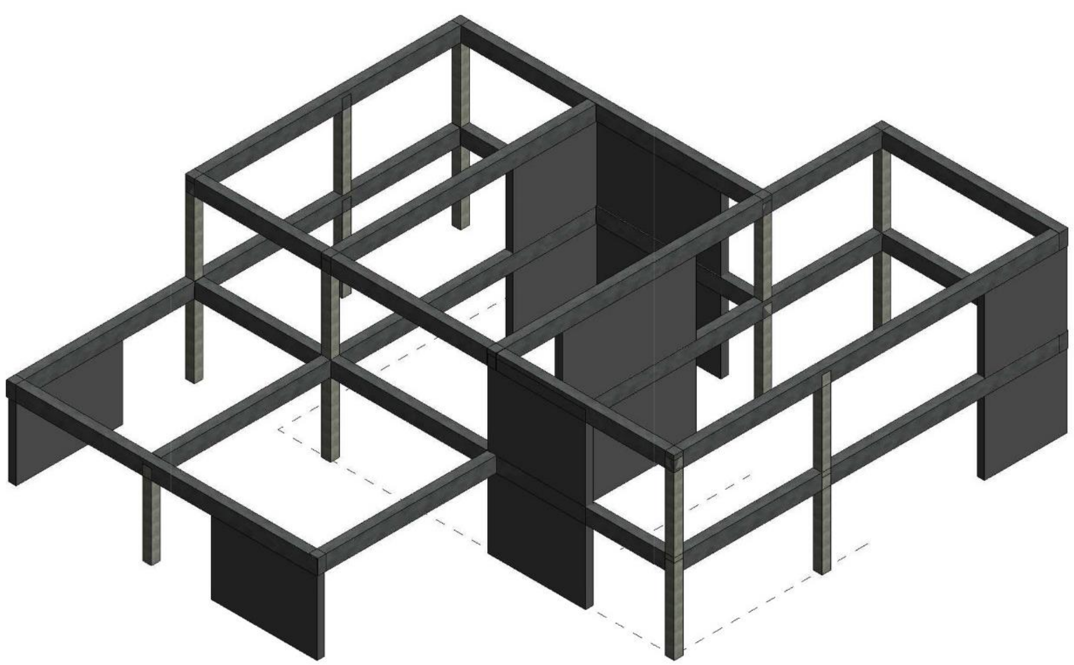
STRUCTURAL SYSTEM



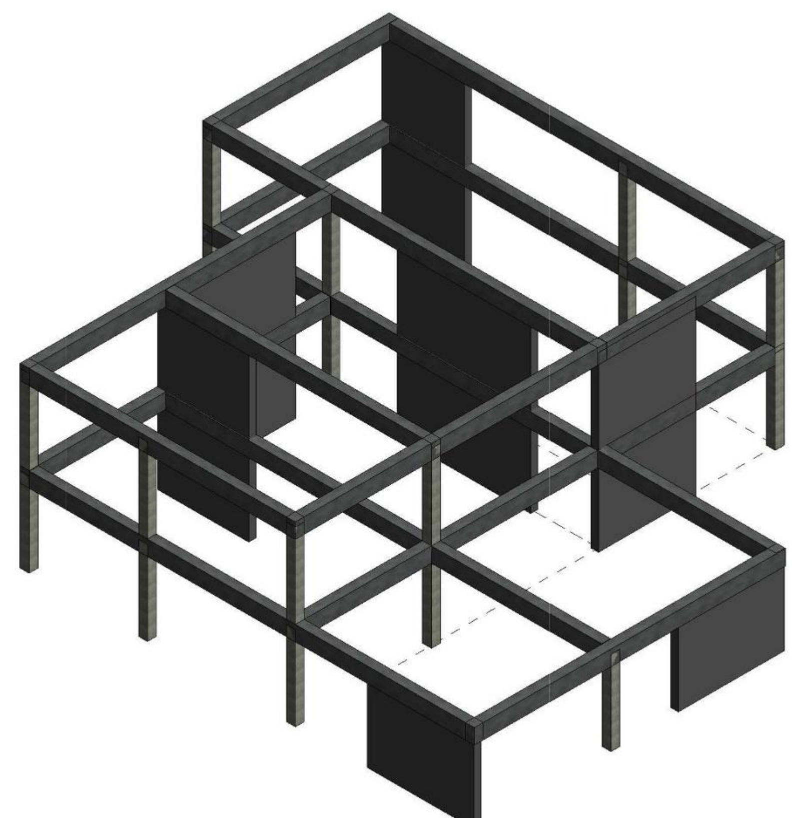
North-East



North-West

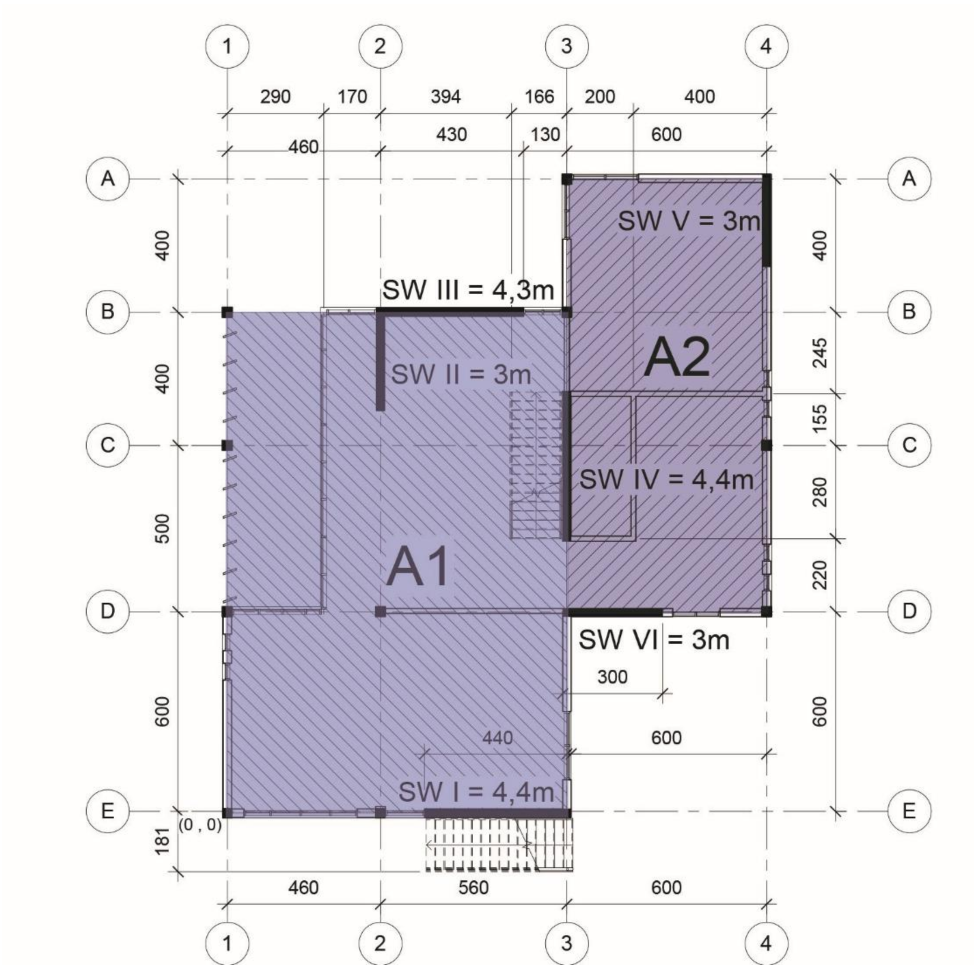


South-East



South-West

Mass / Geometric Center



$A_1 = 15 \times 10.2 = 153\ m^2$

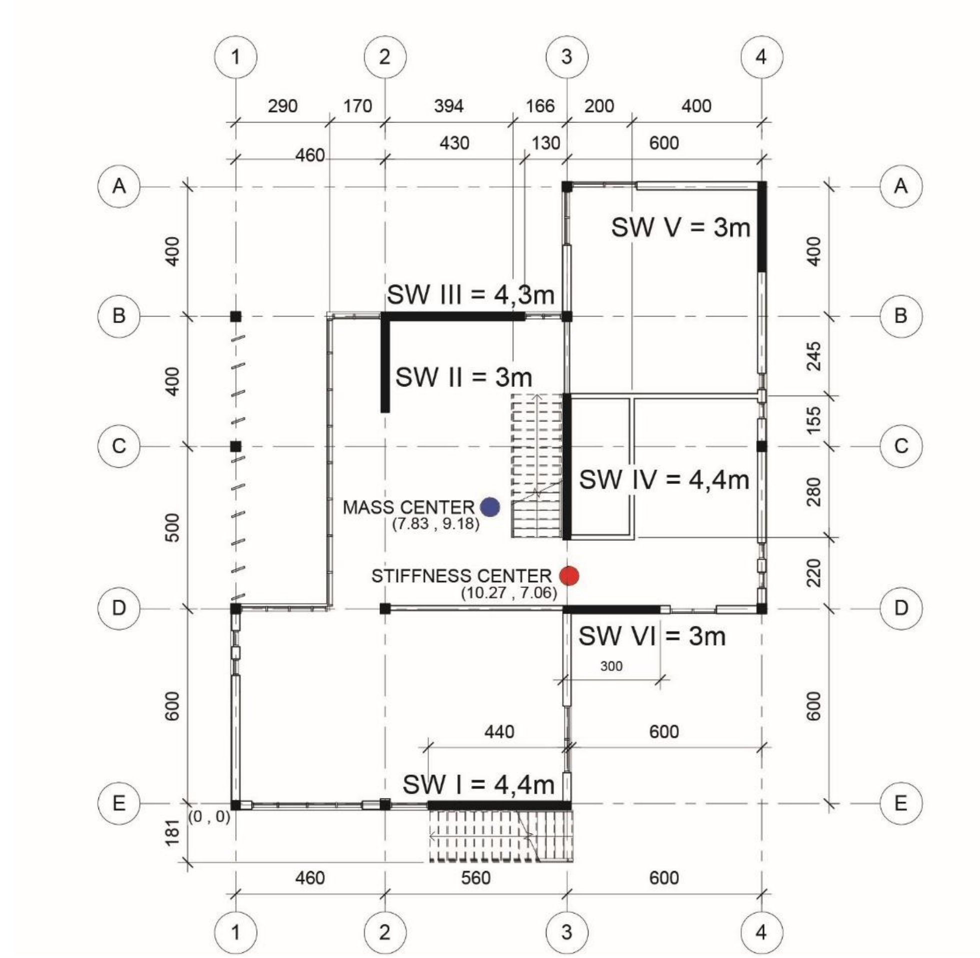
$A_2 = 6 \times 13 = 78\ m^2$

$A = A_1 + A_2 = 153 + 78 = 231\ m^2$

$$C_{GX} = \frac{153 \times 5.2 + 78 \times 13.2}{231} = 7.83\ cm$$

$$C_{GY} = \frac{153 \times 7.5 + 78 \times 12.5}{231} = 9.18\ cm$$

Rigidity / Stiffness Center



$$I_{SW1} = \frac{1}{12} \times 0.25 \times (4.4)^3 = 1.77\ m^4$$

$$I_{SW2} = \frac{1}{12} \times 0.25 \times (3)^3 = 0.56\ m^4$$

$$I_{SW3} = \frac{1}{12} \times 0.25 \times (4.3)^3 = 1.65\ m^4$$

$$I_{SW4} = \frac{1}{12} \times 0.25 \times (4.4)^3 = 1.77\ m^4$$

$$I_{SW5} = \frac{1}{12} \times 0.25 \times (3)^3 = 0.56\ m^4$$

$$I_{SW6} = \frac{1}{12} \times 0.25 \times (3)^3 = 0.56\ m^4$$

$$X_S = \frac{\Sigma x I_x}{\Sigma I_x} \qquad Y_S = \frac{\Sigma y I_y}{\Sigma I_y}$$

$$X_S = \frac{4.6 \times 0.56 + 10.2 \times 1.77 + 16.2 \times 0.56}{0.56 + 1.77 + 0.56}$$

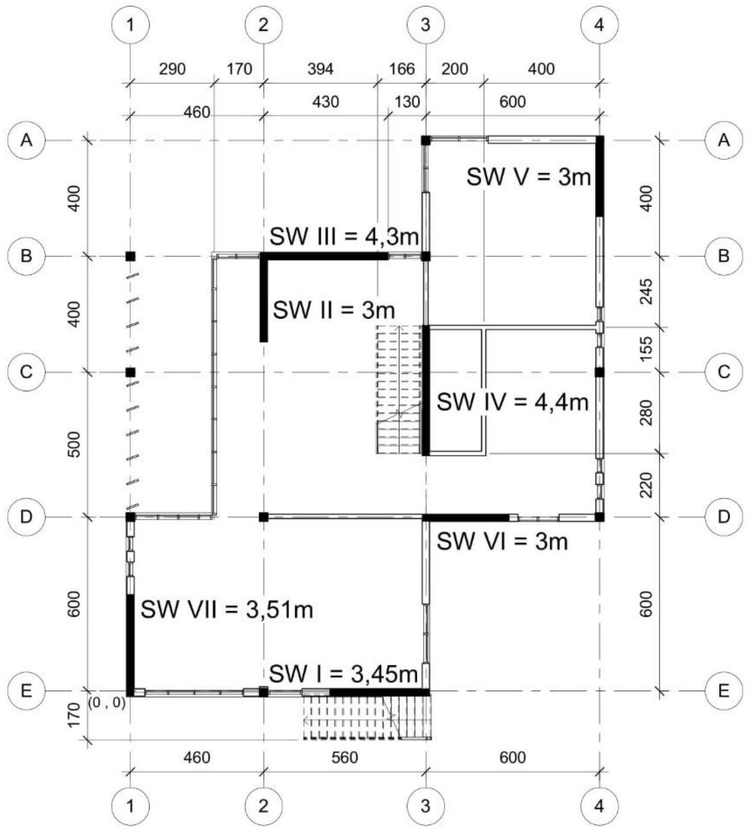
$$= 10.27\ cm$$

$$Y_S = \frac{0 \times 1.77 + 15 \times 1.65 + 6 \times 0.56}{1.77 + 1.65 + 0.56}$$

$$= 7.06\ cm$$

$(X_S , Y_S) = (10.27 , 7.06)$

Shear Wall Percentage



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

Total Floor Area : 231 m^2

Area of Shear Walls in X direction:

0.25 × 3 + 0.25 × 3 + 0.25 × 4.4 = 1.13 > 1 ✓

Area of Shear Walls in Y direction:

0.25 × 4.4 + 0.25 × 3 + 0.25 × 4.3 = 1.27 > 1 ✓

Eccentricity

$$e_X = \frac{|XM - XS|}{L_X} \times 100 = \frac{|7.83 - 10.27|}{16.2} \times 100 = \%15.1 > \%5$$

$$e_Y = \frac{|YM - YS|}{L_Y} \times 100 = \frac{|9.18 - 7.06|}{19} \times 100 = \%11.1 > \%5$$

We shoud make additions and/or alterations on shear walls to superpose mass center and rigidity center

Shear Wall Operations

- Adding shear wall on Axis 1

$$X_S = \frac{4.6 \times 0.56 + 10.2 \times 1.77 + 16.2 \times 0.56 + 0 \times \mathrm{I_{SWVII}}}{0.56 + 1.77 + 0.56 + \mathrm{I_{SWVII}}} = 7.83$$

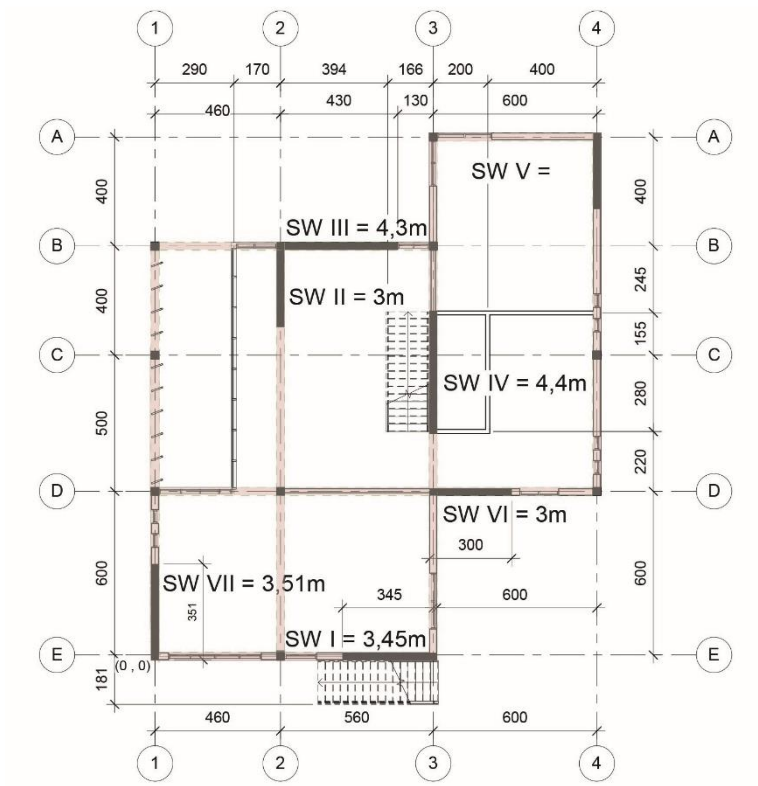
$$\mathrm{I_{SWVII}} = 0.9 = \frac{1}{12} \times 0.25 \times h^3 \qquad h = 3.51\ m$$

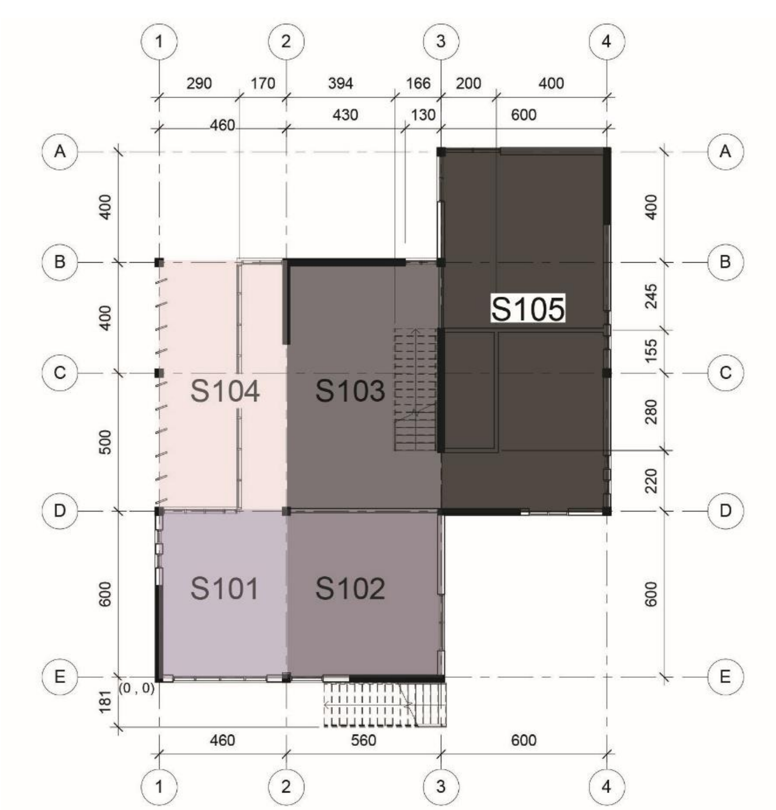
- Shortening SWI

$$Y_S = \frac{0 \times \mathrm{ISWI} + 6 \times 0.56 + 15 \times 1.65}{\mathrm{I_{SWI}} + 0.56 + 1.65} = 9.18$$

$$\mathrm{I_{SWI}} = 0.86 = \frac{1}{12} \times 0.25 \times h^3 \qquad h = 3.45\ m$$

Slab Thickness

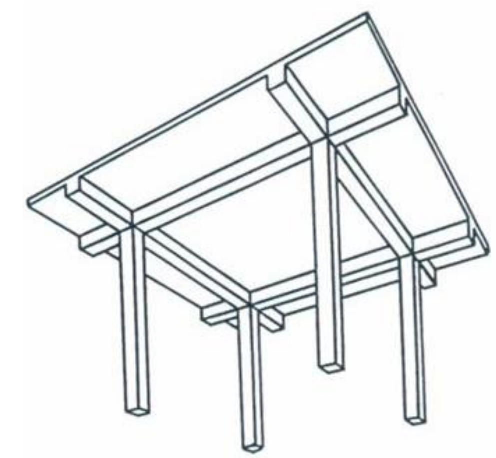




Two Way Solid Slab (S101, S102, S103, S104)

$$t \geq 8\ cm \qquad t \geq \frac{l_{sn}}{15 + \left(\frac{20}{m}\right)}\left[1 - \frac{\alpha_s}{4}\right]$$

$$\alpha_s = \frac{\Sigma\ length\ of\ cont.edges}{\Sigma\ lenth\ of\ all\ edges}$$



For S103 $\rightarrow$ $$\alpha_{s203} = \frac{5.6+9+9}{5.6+9+9+5.6} = 0.81$$

$$t \geq \frac{560}{15 + \left(\frac{20}{\left(\frac{9}{5.6}\right)}\right)}\left[1 - \frac{0.81}{4}\right]$$

$t \geq 16.32\ cm$

For S104 $\rightarrow$ $$\alpha_{s204} = \frac{4.6+9}{4.6+9+9+4.6} = 0.5$$

$$t \geq \frac{460}{15 + \left(\frac{20}{\left(\frac{9}{4.6}\right)}\right)}\left[1 - \frac{0.5}{4}\right]$$

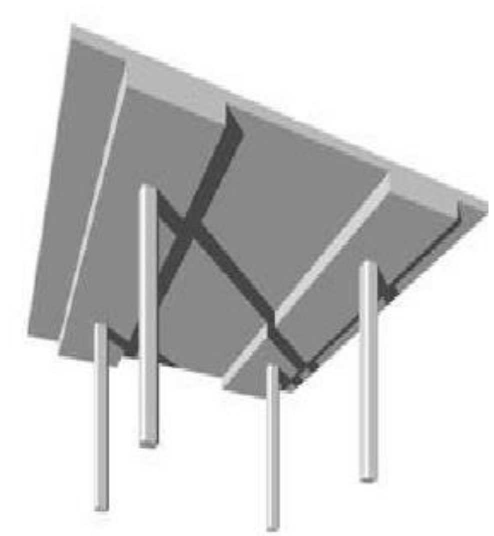
$t \geq 15.96\ cm$

S103 and S104 are the critical slab types, so we calculated them and we decided to take minimum slab thickness as 17 cm according to TSC(2018) and TS - 500 regulations.

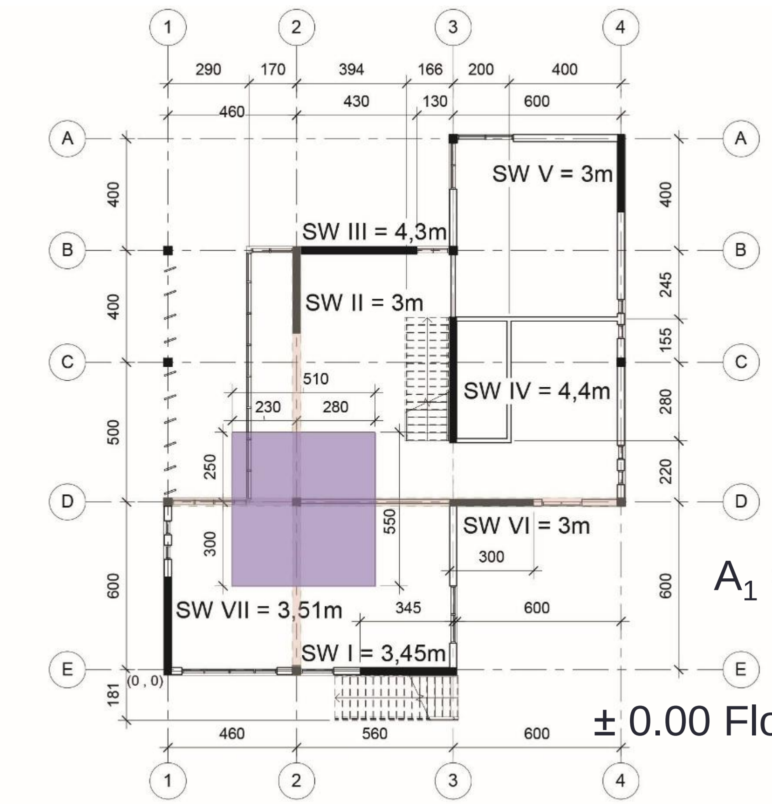
One Way Solid Slab (S105)

$$t \geq 8\ cm \qquad t \geq \frac{l_s}{25} \qquad \text{since } \frac{l_l}{l_s} = \frac{13}{6} > 2$$

For S105 $\rightarrow$ $$t \geq \frac{600}{25} = 24\ cm$$

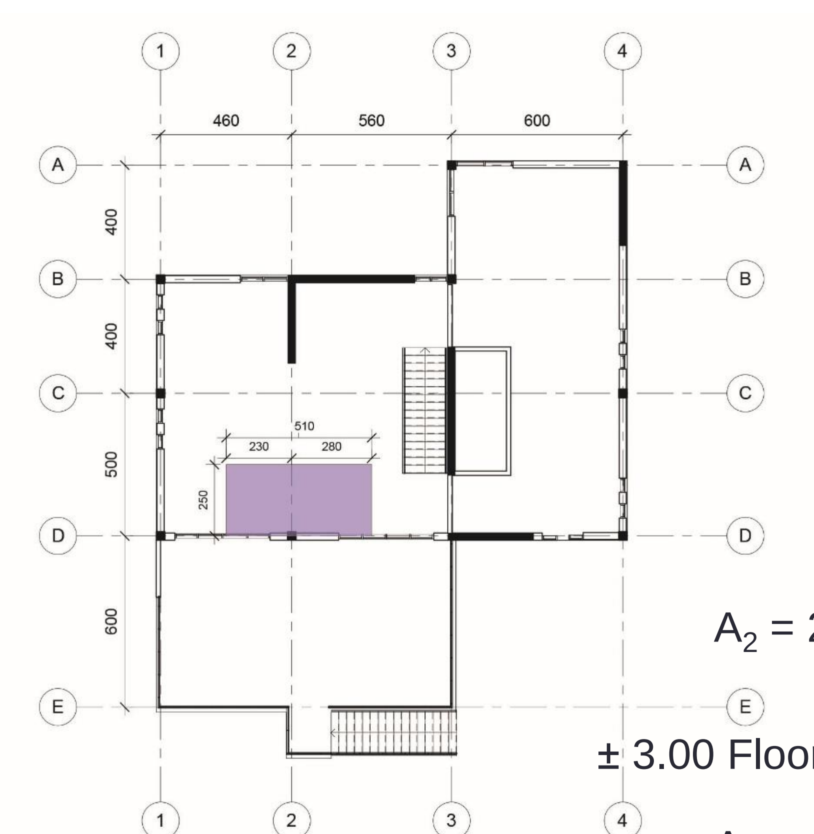


Tributary Area



$A_1 = 4.5 \times 5.1 = 28\ m^2$

± 0.00 Floor



$A_2 = 2.5 \times 5.1 = 12.75\ m^2$

± 3.00 Floor

$A_{total} = A_1 + A_2 = 40.75\ m^2$

Design Loads

<u>Dead Load on Solid Slab</u>

Own weight : $0.17 \times 2.4 = 0.408\ t/m^2$
Leveling : $0.04 \times 2.4 = 0.09\ t/m^2$
Covering : $0.025 \times 2.0 = 0.05\ t/m^2$
Plastering : $0.020 \times 2.0 = 0.04\ t/m^2$

Total Dead Load $= 0.588\ t/m^2$

<u>Live Load on Solid Slab</u> $0.2\ t/m^2$ for residential buildings

Total Load = 1.4 × Dead Load + 1.6 × Live Load
$= 1.4 \times 0.588 + 1.6 \times 0.2$
$= 1.14\ t/m^2$

<u>Slab Load on Column</u>
$1.14 \times 40.75 = 46.45\ t$

<u>Wall Loads</u>

Wall Load $= 0.15\ t/m^2$
Tributary Area $= 5.5 \times 5.1 = 28.05\ m^2$
<u>Wall Load on Column</u> $= 28.05 \times 0.15 \times 1.4$
$= 5.89\ t$ (Beam own weight is not included)

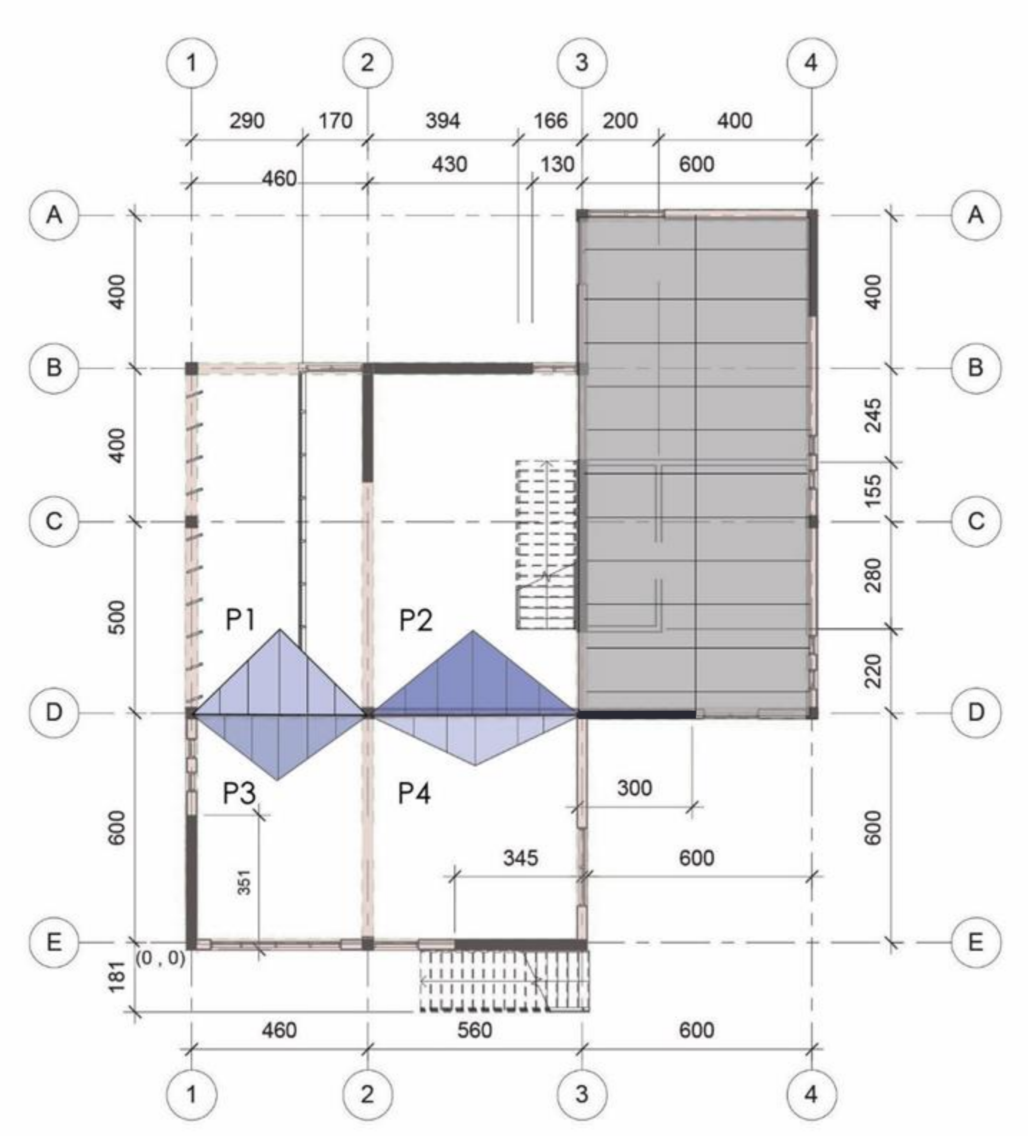
<u>Total Load on Column</u>
$N_d = 46.45\ t + 5.89\ t = 52.64\ t$

$$A_C \geq \frac{N_d}{0.40 fck} \quad A_C \geq \frac{52640}{0.40 \times 200} \quad A_C \geq 658\ cm^2$$

However, according to TC-500 minimum column dimension can be 30×30 cm, so we take column dimensions as 30×30 cm

Beam on Axis D

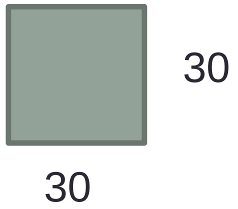
$P_d = 1.14\ t$ $\quad P = P_d \times \frac{l_s}{3}$ $\quad P = Pd \times \frac{l_s}{3} \times \left[1.5 - \frac{0.5}{\left(\frac{l_l}{l_s}\right)^2}\right]$



$P_1 = P_3 = 1.14 \times \frac{4.6}{3} = 1.75\ t/m$ $\quad P_1 + P_3 = 3.5\ t/m$

$P_2 = P_4 = 1.14 \times \frac{5.6}{3} = 2.13\ t/m$ $\quad P_2 + P_4 = 4.26\ t/m$

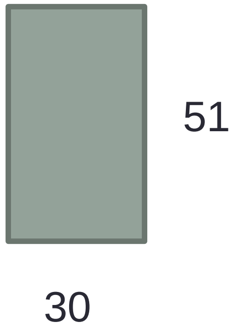
I_{column}



$$\frac{1}{12} \times 0.3 \times (0.3)^2 = 0.00068\ m^4$$

→ Since the beam depth should be at least 3 times the slab thickness, assumed beam depth is taken as 51 cm

I_{beam}



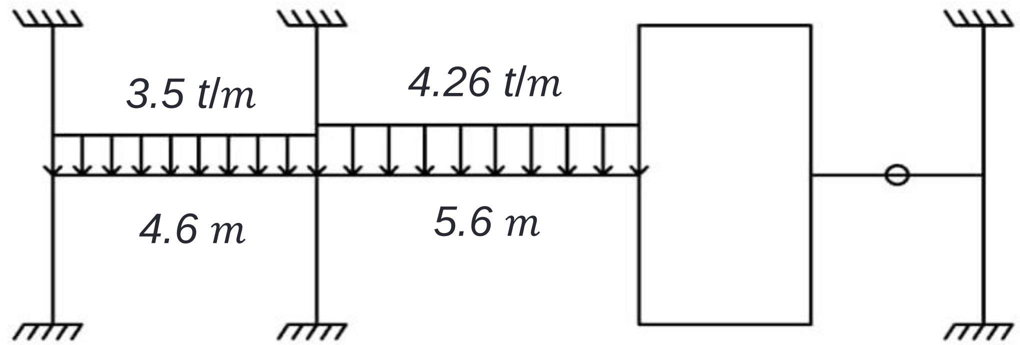
$$\frac{1}{12} \times 0.3 \times (0.51)^2 = 0.0033\ m^4$$

$$r_{12} = \frac{\frac{0.0033}{4.6}}{\frac{0.0033}{4.6} + 2 \times \frac{0.00068}{3}} = 0.61$$

$$r_{21} = \frac{\frac{0.0033}{4.6}}{\frac{0.0033}{4.6} + 2 \times \frac{0.00068}{3} \times \frac{0.0033}{5.6}} = 0.41$$

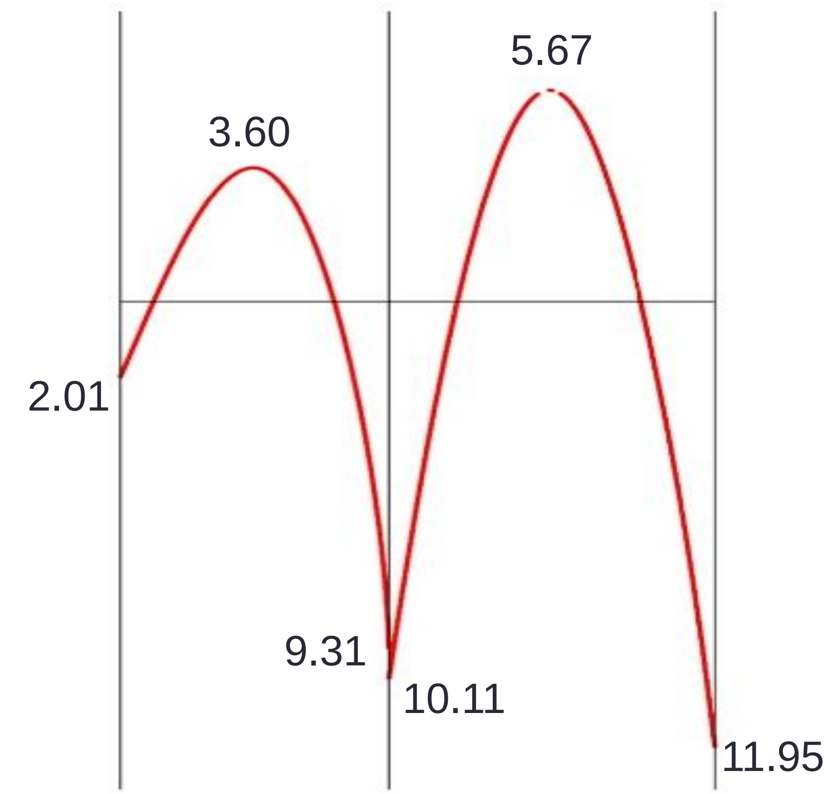
$$r_{23} = \frac{\frac{0.0033}{5.6}}{\frac{0.0033}{4.6} + 2 \times \frac{0.00068}{3} \times \frac{0.0033}{5.6}} = 0.33$$

$$r_{32} = 0$$



$$FEM_{12} = FEM_{21} = \frac{qL^2}{12} = \frac{3.5\times(4.6)^2}{12} = 6.17\ tm$$

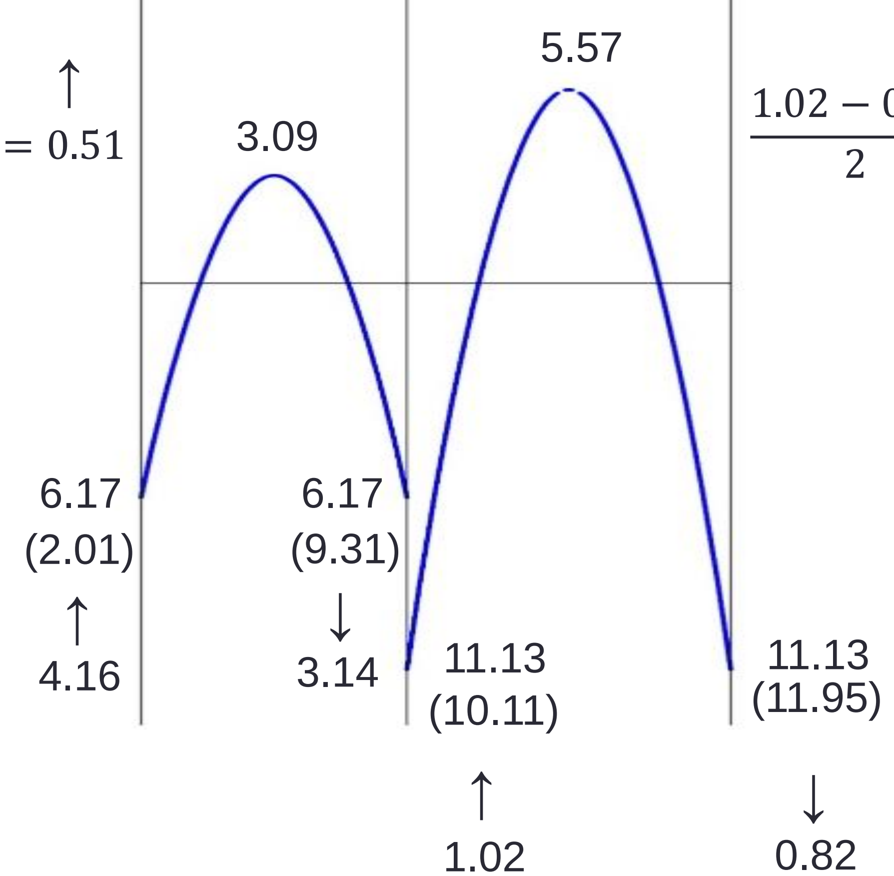
$$FEM_{23} = FEM_{32} = \frac{qL^2}{12} = \frac{4.26\times(5.6)^2}{12} = 11.13\ tm$$



r	0.61	0.41	0.33	0
FEM	6.17	-6.17	11.13	-11.13
1st cycle	-1.02	-1.88	0	-0.82
Σ	5.15	-8.05	11.13	-11.95
2nd cycle	-3.14	-1.26	-1.02	0
Σ	2.01	-9.31	10.11	-11.95

$$\frac{4.16-3.14}{2} = 0.51 \uparrow$$

$$\frac{1.02-0.82}{2} = 0.1 \uparrow$$



$$K_0 = \frac{bwd^2}{M} \qquad K_0 = 25\ m^2/t \qquad 25 = \frac{30\times d^2}{1195}$$

$$d = 31.56\ cm$$

$$h = d + 5\ (clear\ cover) = 36.56\ cm$$

According to TC-500, beam depth should be at least 3 times of slab thickness, so beam depth is selected as 51 cm.

Beam on Axis 2

$P_d = 1.14\ t \qquad P = Pd \times \frac{l_s}{3} \times \left[1.5 - \frac{0.5}{\left(\frac{l_l}{l_s}\right)^2}\right]$

$$P_1 = 1.14 \times \frac{4.6}{3} \times \left[1.5 - \frac{0.5}{\left(\frac{9}{4.6}\right)^2}\right] = 2.39\ t$$

$$P_2 = 1.14 \times \frac{5.6}{3} \times \left[1.5 - \frac{0.5}{\left(\frac{9}{5.6}\right)^2}\right] = 2.78\ t$$

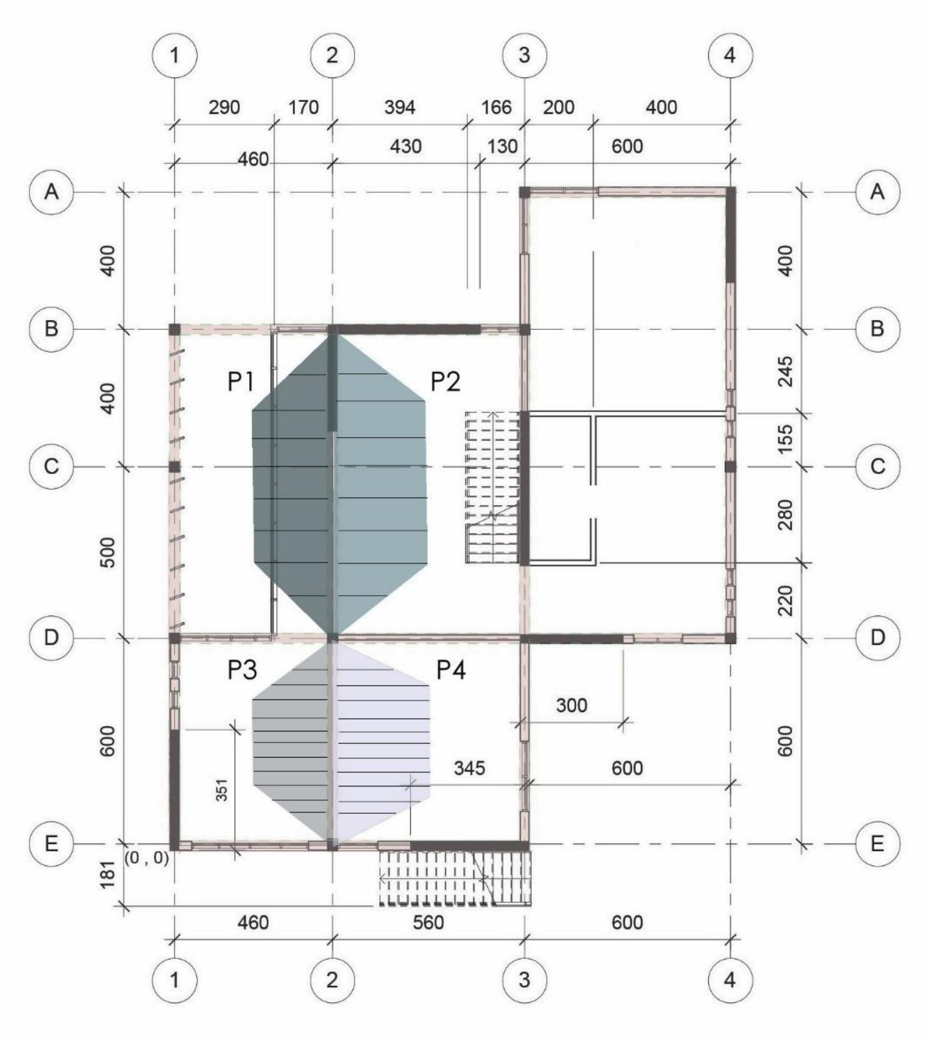
$$P_3 = 1.14 \times \frac{4.6}{3} \times \left[1.5 - \frac{0.5}{\left(\frac{6}{4.6}\right)^2}\right] = 2.11\ t$$

$$P_4 = 1.14 \times \frac{5.6}{3} \times \left[1.5 - \frac{0.5}{\left(\frac{6}{5.6}\right)^2}\right] = 2.27\ t$$

$P_1 + P_2 = 5.17\ t/m$

$P_3 + P_4 = 4.38\ t/m$

$I_{column} = 0.00068 \qquad I_{beam} = 0.0033$

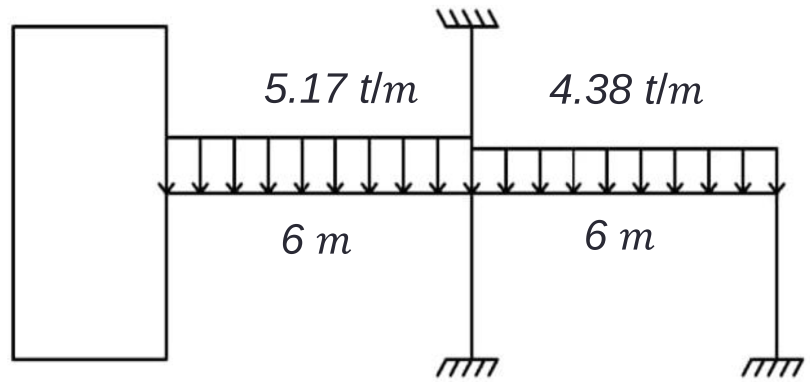


$$r_{12} = 0$$

$$r_{21} = \frac{\frac{0.0033}{6}}{\frac{0.0033}{6} + 2 \times \frac{0.00068}{3} \times \frac{0.0033}{6}} = 0.35$$

$$r_{23} = \frac{\frac{0.0033}{6}}{\frac{0.0033}{6} + 2 \times \frac{0.00068}{3} \times \frac{0.0033}{6}} = 0.35$$

$$r_{32} = \frac{\frac{0.0033}{6}}{\frac{0.0033}{6} + \frac{0.00068}{3}} = 0.71$$



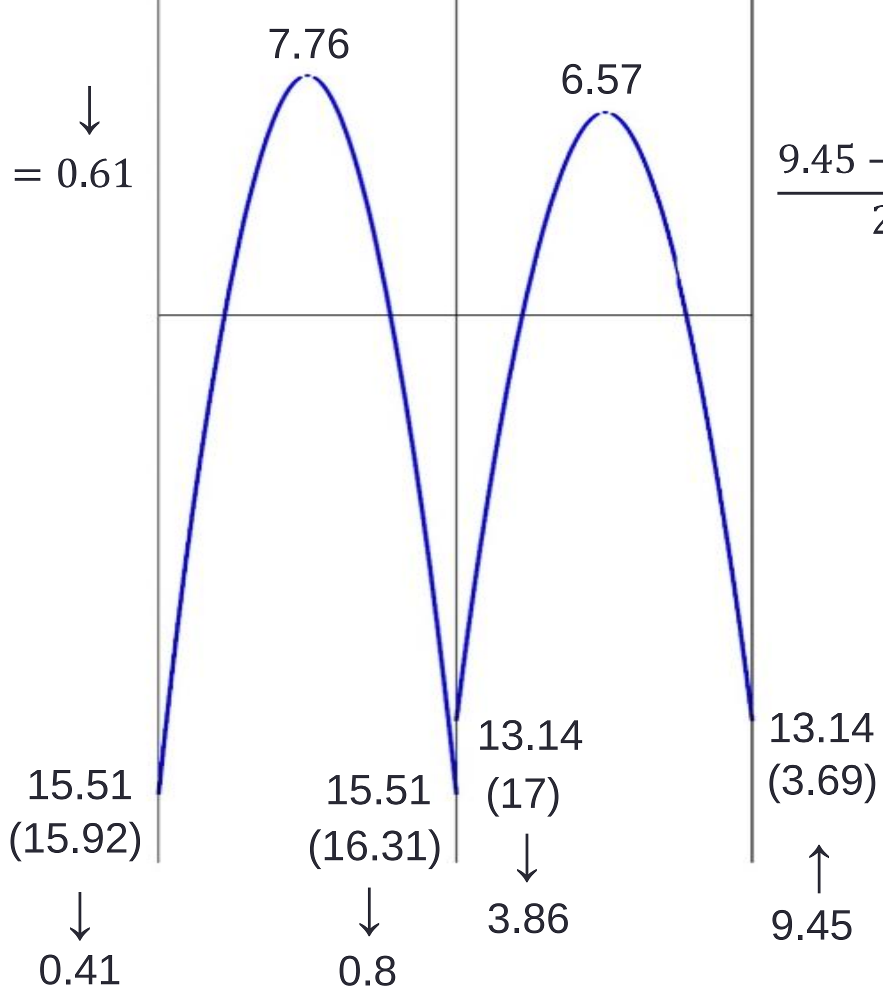
$$FEM_{12} = FEM_{21} = \frac{qL^2}{12} = \frac{5.17 \times 6^2}{12} = 15.51\ tm$$

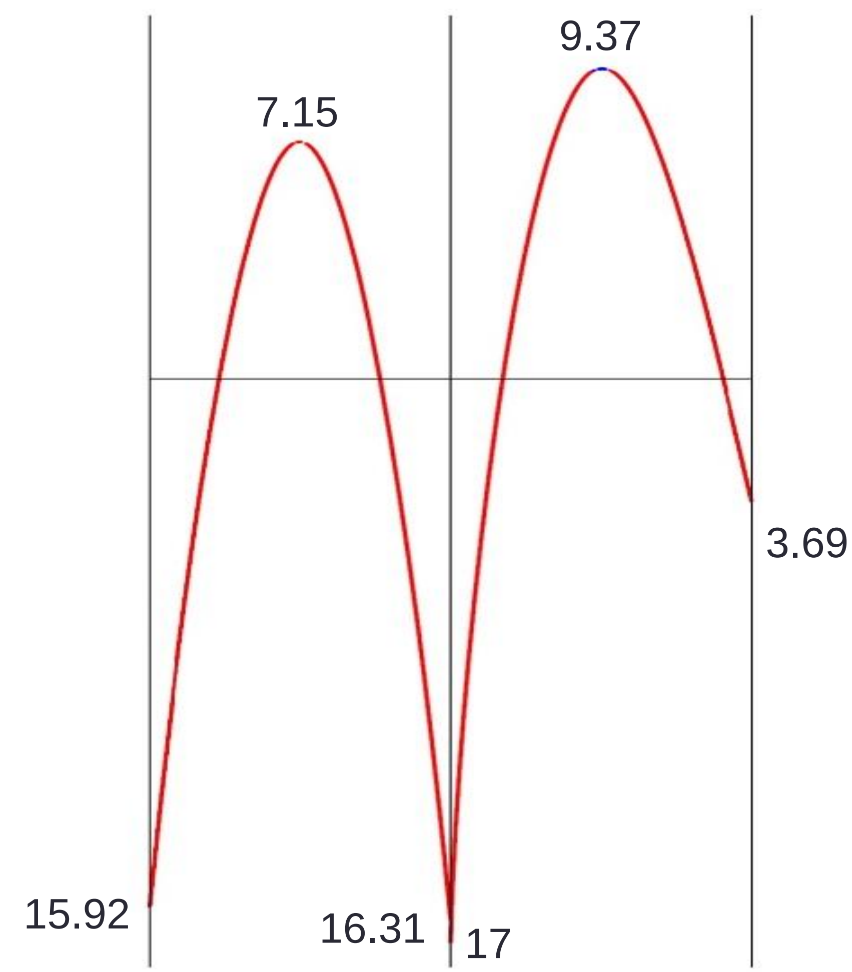
$$FEM_{23} = FEM_{32} = \frac{qL^2}{12} = \frac{4.38 \times 6^2}{12} = 13.14\ tm$$

r	0	0.35	0.35	0.71
FEM	15.51	-15.51	13.14	-13.14
1st cycle	0.41	0	4.66	0.41
Σ	15.92	-15.51	17.8	-12.73
2nd cycle	0	-0.80	-0.80	9.04
Σ	15.92	-16.31	17	-3.69

$$\frac{0.41 + 0.8}{2} = 0.61 \downarrow$$

$$\frac{9.45 - 3.86}{2} = 2.8 \uparrow$$





$$K_0 = \frac{bwd^2}{M} \qquad K_0 = 25\ m^2/t \qquad 25 = \frac{30 \times d^2}{1700}$$

$$d = 37.64\ cm$$

$$h = d + 5\ (clear\ cover) = 42.64\ cm$$

According to TC-500, beam depth should be at least 3 times of slab thickness, so beam depth is selected as 51 cm.