ARCH 332 STRUCTURAL DESIGN IN ARCHITECTURE II

SPRING 2018

GROUP 6

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INSTRUCTORS

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SITE PLAN

SCALE: 1/100

N

-0.10 M

B

A B C D

1415

1

2

3

4

POOL

1000

+6.00 M

A

A

SPORT COURT

+0.00 M

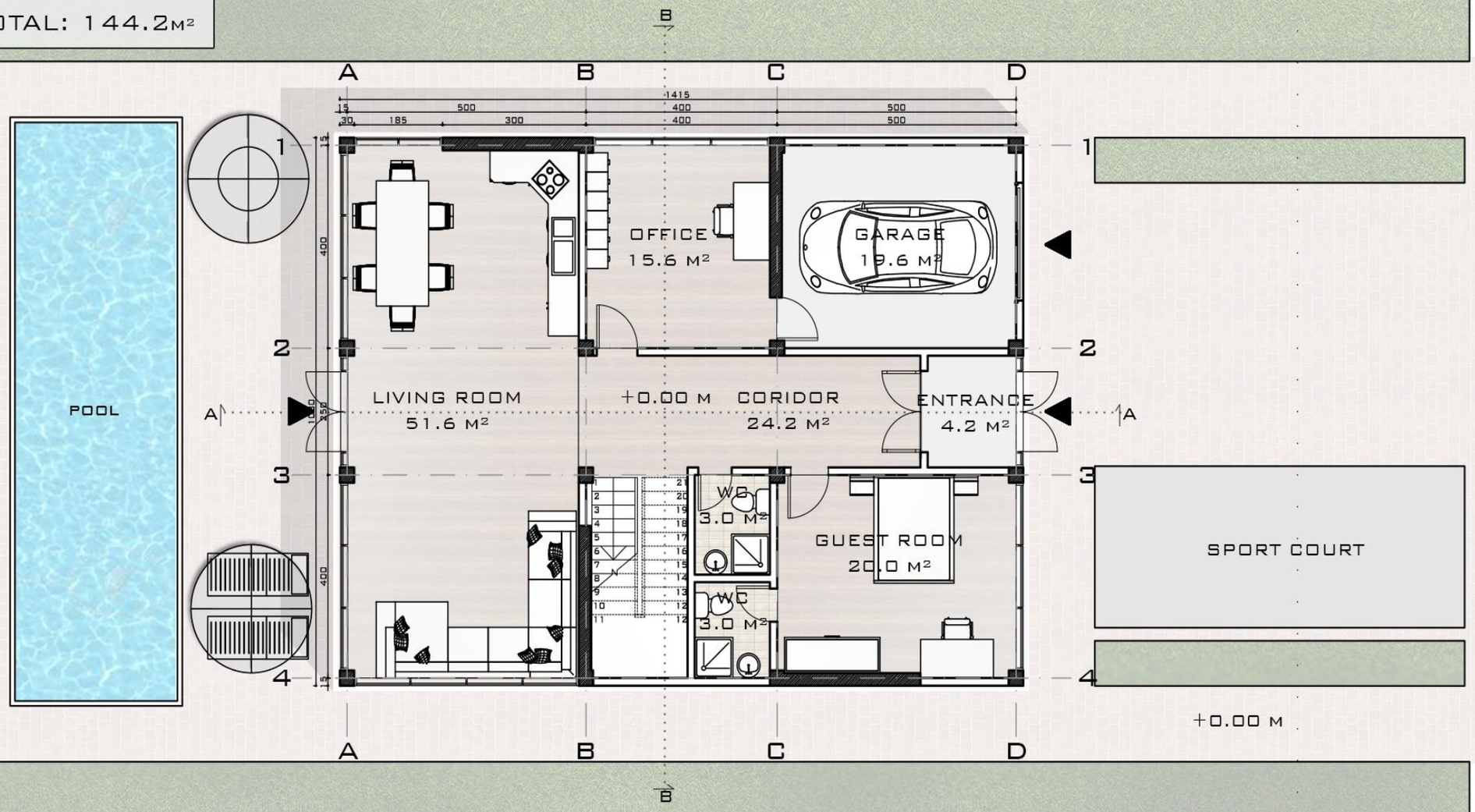
ROAD

GROUND FLOOR PLAN

SCALE: 1/100

ENTRANCE 4.2M²
GARAGE 19.6M²
CORIDOR 24.2M²
OFFICE 15.6M²
GUEST ROOM 20.0M²
WC 3.0M²
WC 3.0M²
LIVING ROOM 51.6M²
TOTAL: 144.2M²

-0.10 M

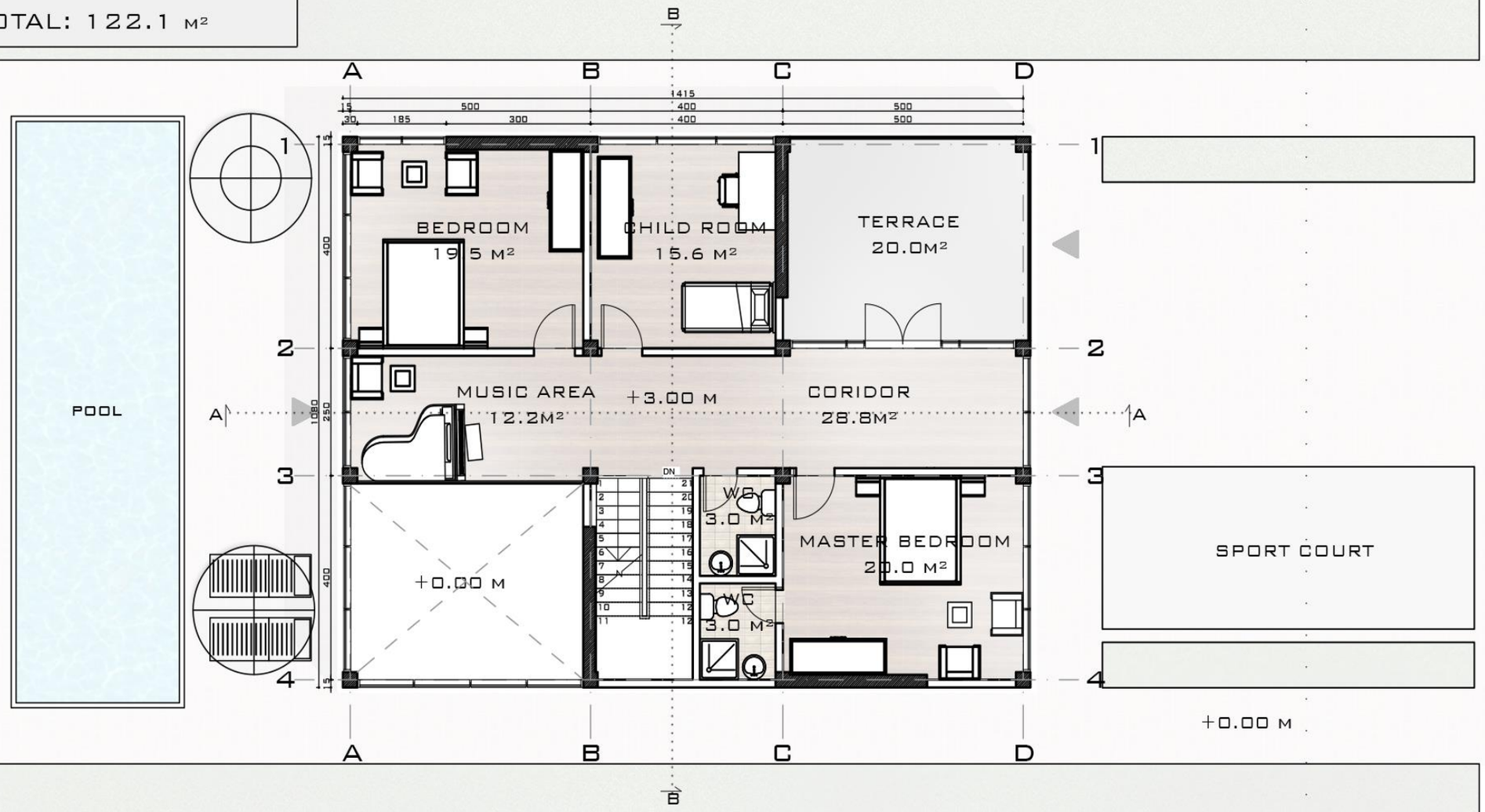


FIRST FLOOR PLAN

SCALE: 1/100

CORIDOR 28.8 M²
MUSIC AREA 12.2 M²
MASTER BEDROOM 20.0 M²
BEDROOM 19.5 M²
CHILD ROOM 15.6 M²
TERRACE 20.0 M²
WC 3.0 M²
WC 3.0 M²
TOTAL: 122.1 M²

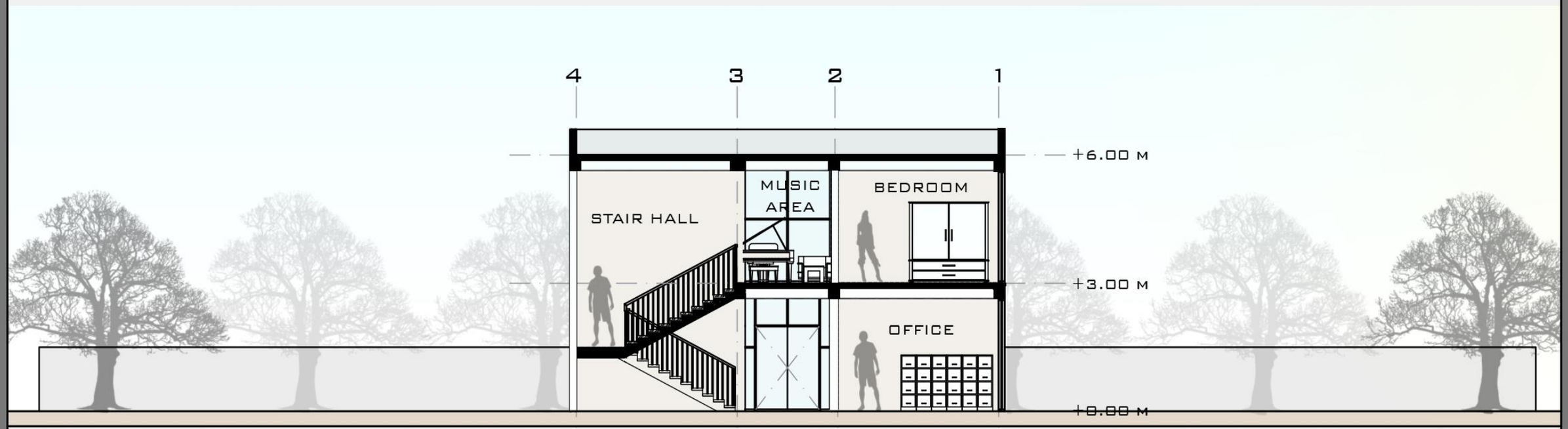
-0.10 M



SECTIONS

SCALE: 1/100

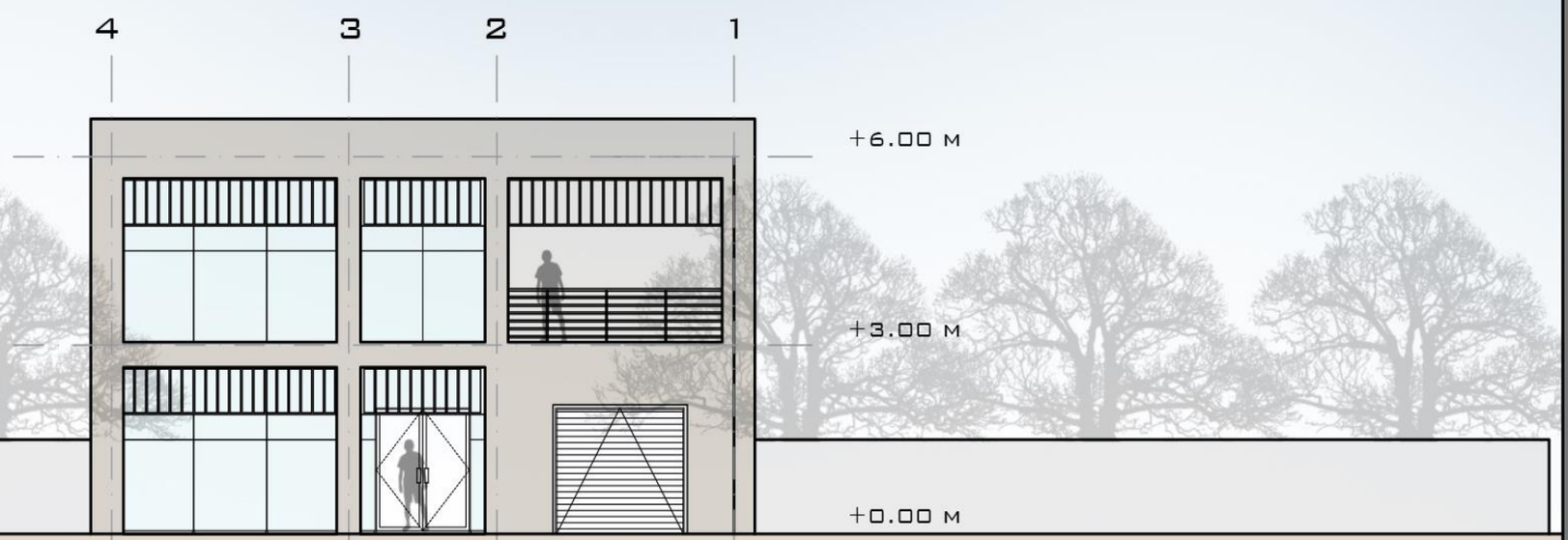
SECTION A-A



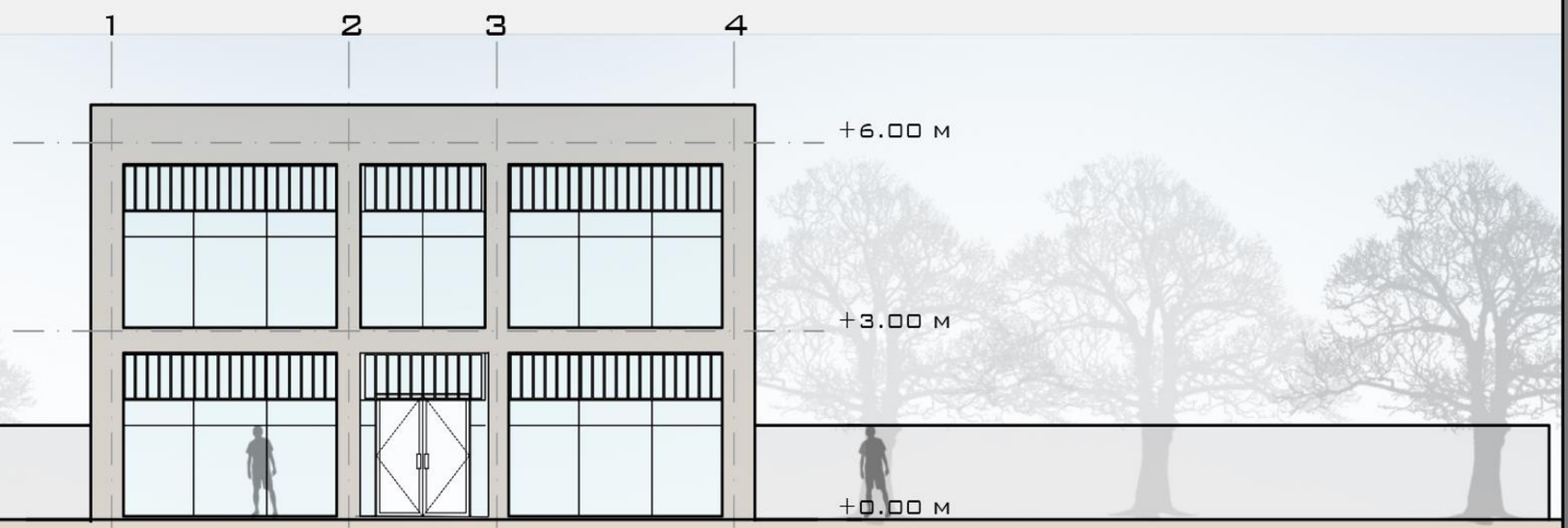
SECTION B-B

ELEVATIONS

SCALE: 1/100



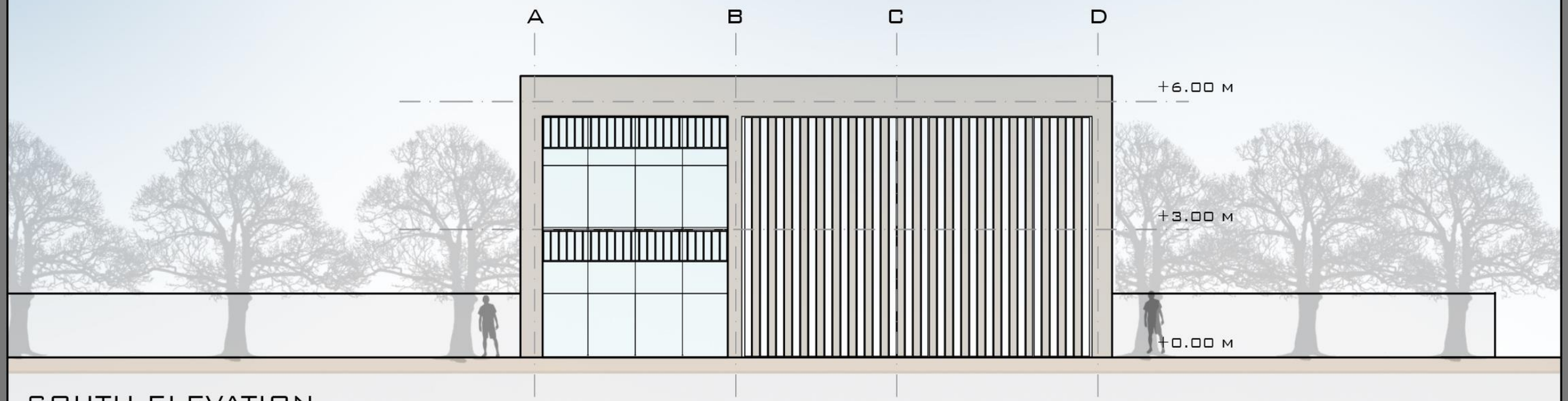
EAST ELEVATION



WEST ELEVATION

ELEVATIONS

SCALE: 1/100

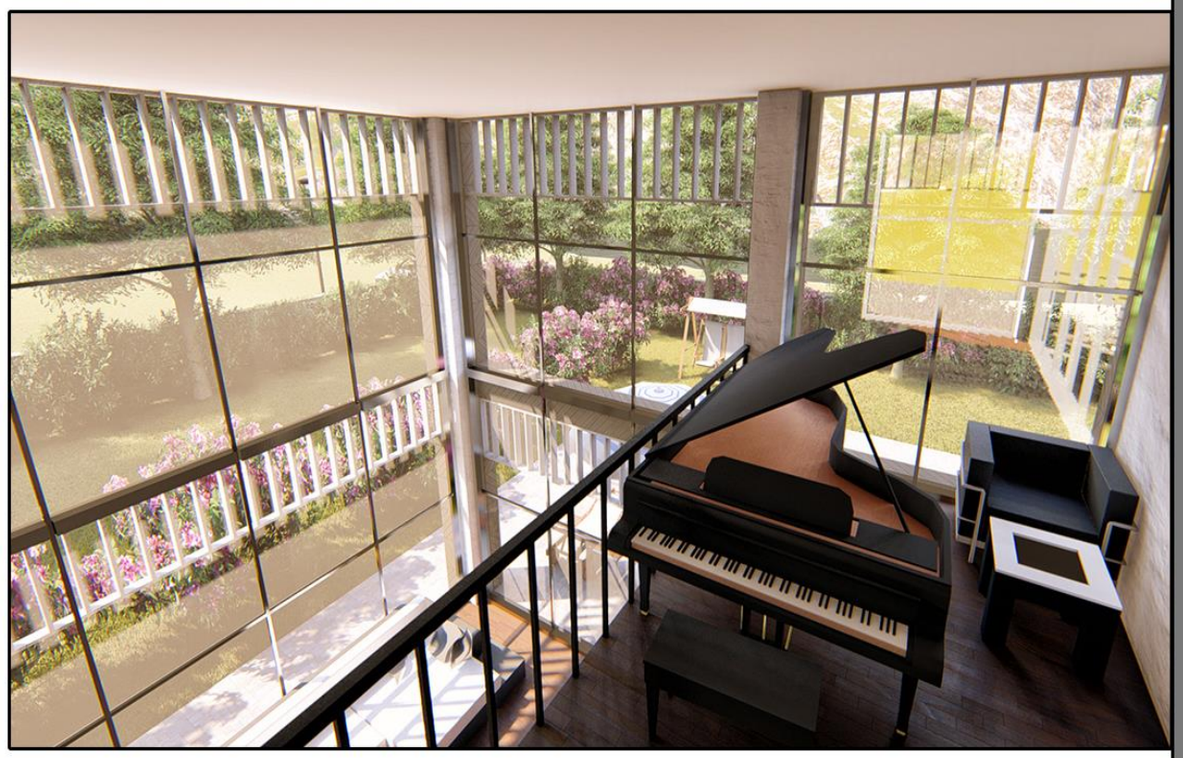


SOUTH ELEVATION

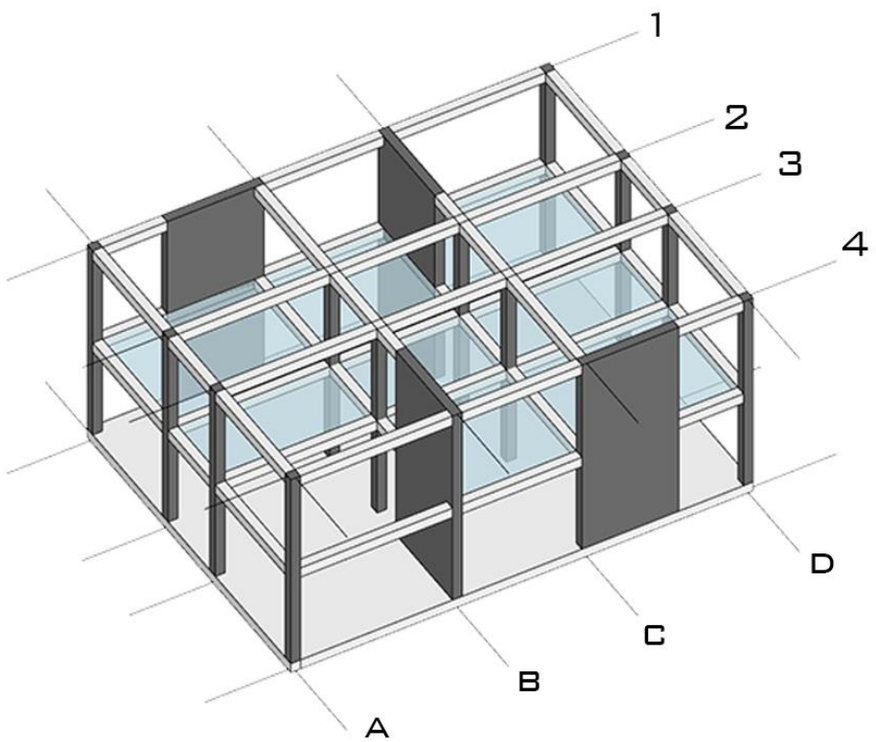
NORTH ELEVATION

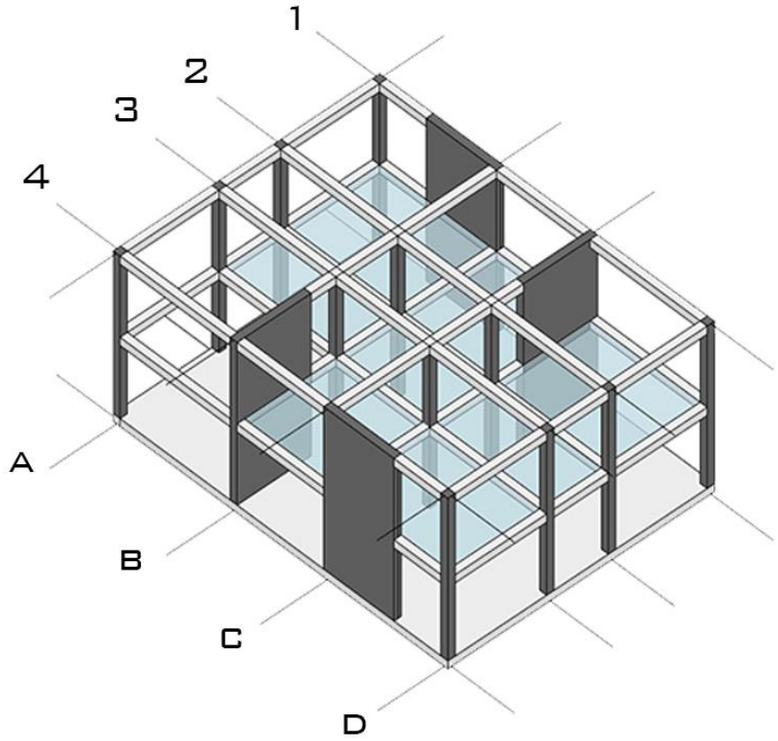
RENDERS

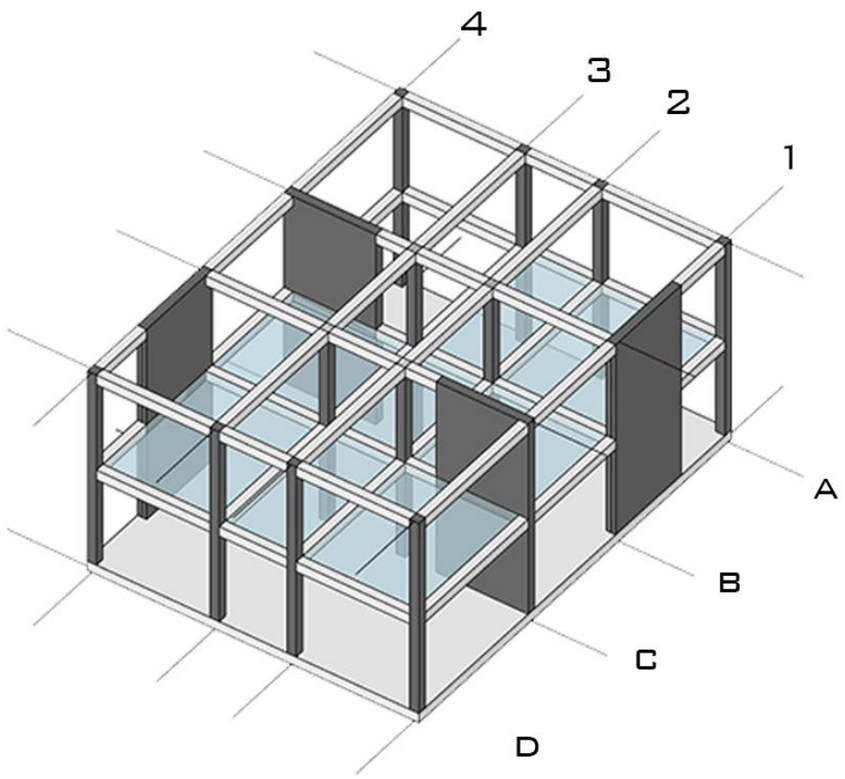
RENDERS

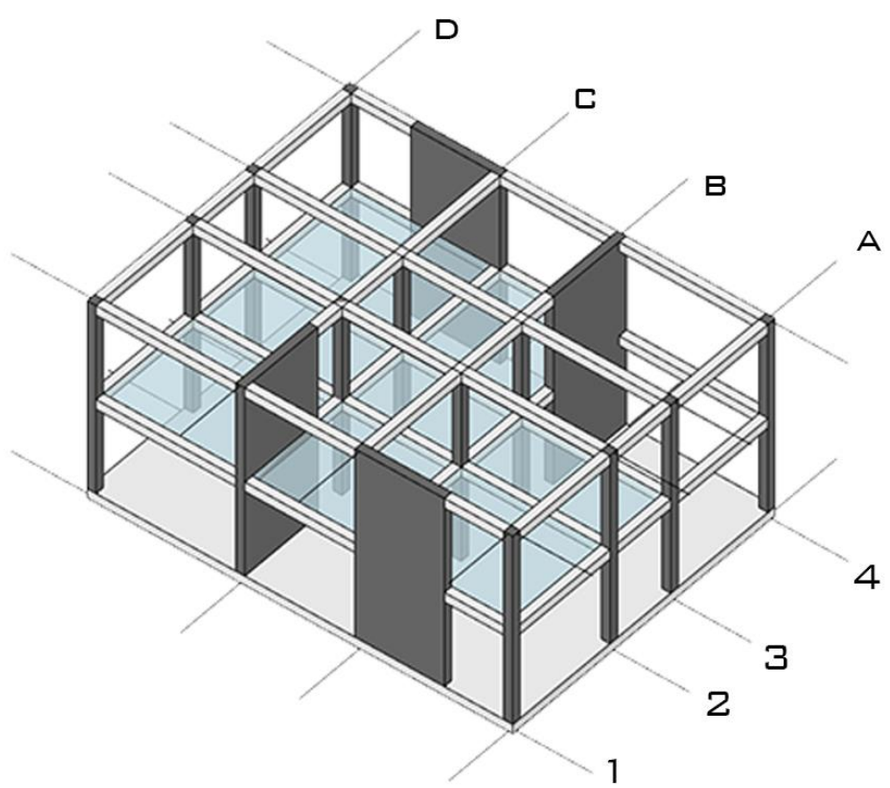


AXONOMETRIC DRAWING

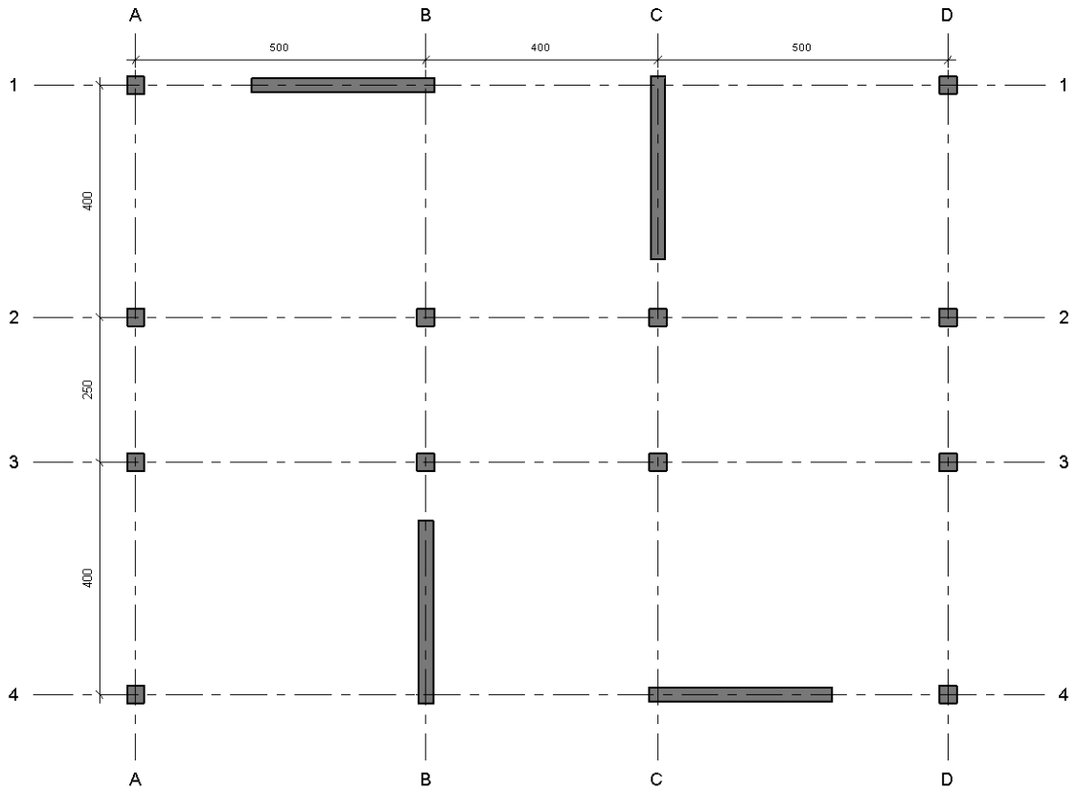








SHEER WALL PERCENTAGE



- **Floor Area**= 147 m²

- **X DIRECTION**
- **Area of shear walls in x direction:**

SW_3 = 0,25 x 3 = 0,75 m²

SW_4 = 0,25 x 3 = 0,75 m²

- **Ratio of Shear Wall Area to Floor Area on X Direction**

1,5 m² ~%1 $^{1,5}/_{147} \cong 0.01$

- **Y DIRECTION**
- **Area of shear walls in y direction:**

SW_1 = 0,25 x 3 = 0,75 m²

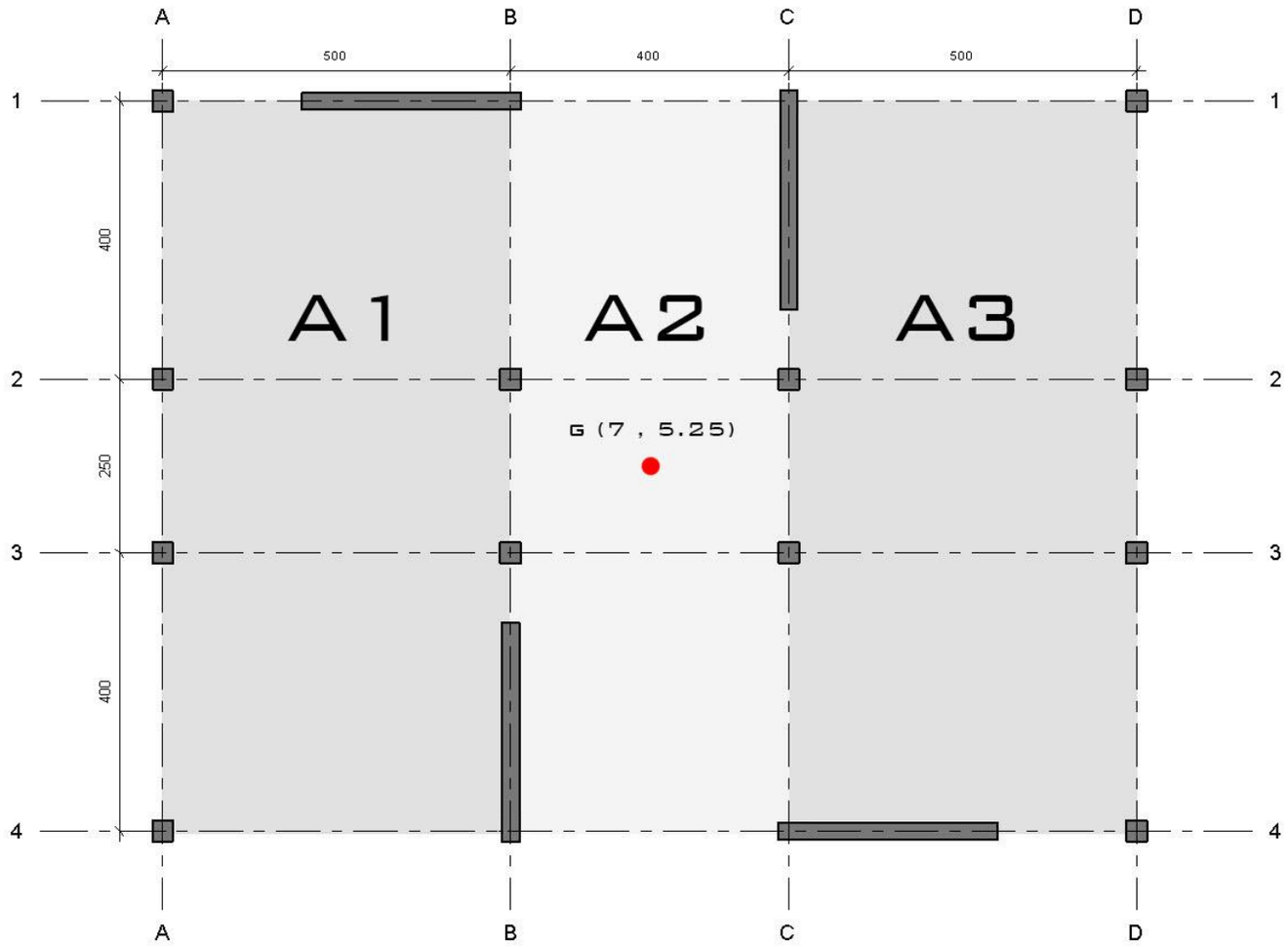
SW_2= 0,25 x 3 = 0,75 m²

- **Ratio of Shear Wall Area to Floor Area on Y Direction**

1,5 m² ~%1 $^{1,5}/_{147} \cong 0.01$

- The minimum shear wall cross sectional area should be 1 % of the plan area in both direction.

MASS CENTER CALCULATIONS



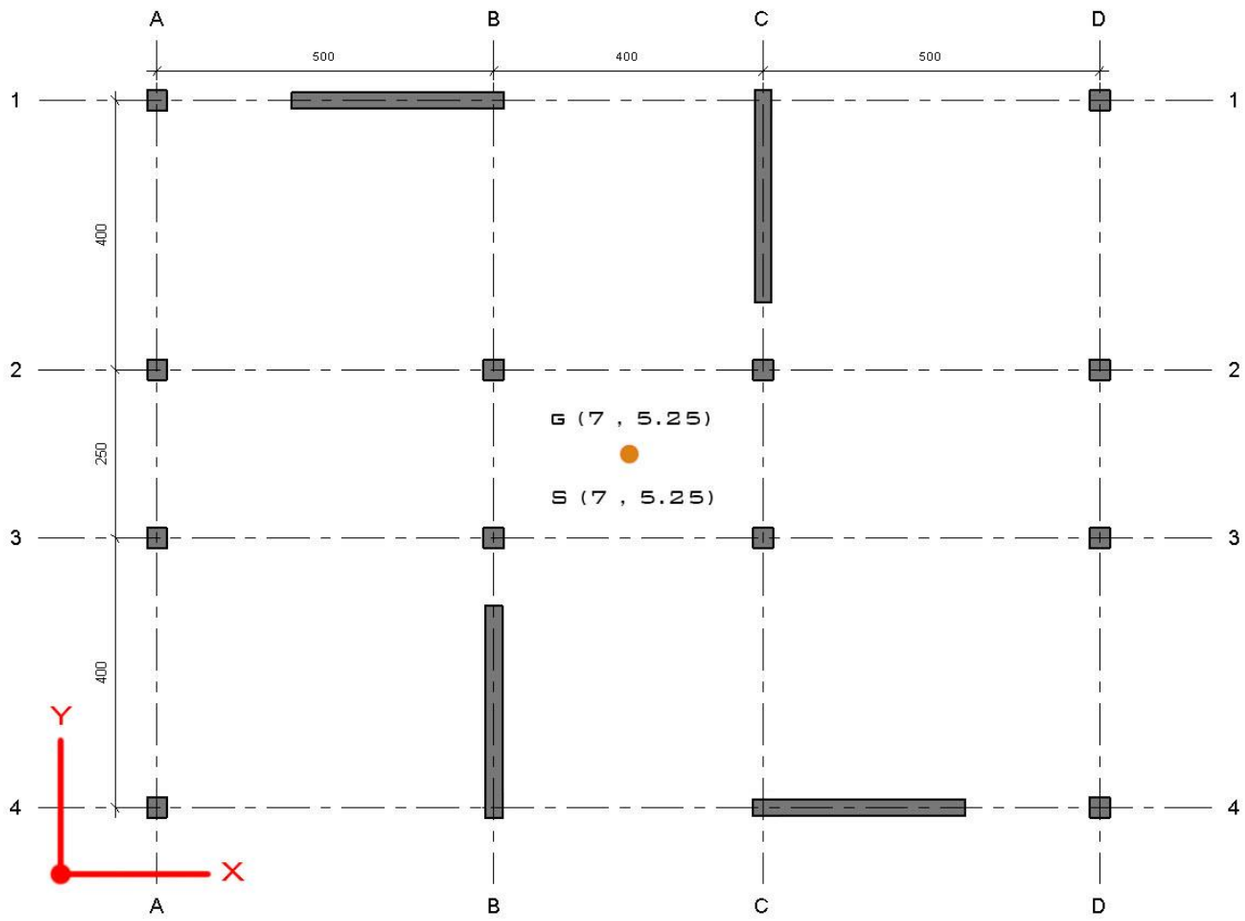
- $A_1 = 52.5\ m^2$
- $A_2 = 42\ m^2$
- $A_3 = 52.5\ m^2$

- **X Direction**
- $\frac{A_1 x_1 + A_2 x_2 + A_3 x_3}{A_1 + A_2 + A_3} = G_x$
- $\frac{(52{,}5 \text{ x } 2{,}5) + (42 \text{ x } 7) + (52{,}5 \text{ x } 11{,}5)}{52{,}5 + 42 + 52{,}5} = 7$

- **Y Direction**
- $\frac{A_1 y_1 + A_2 y_2 + A_3 y_3}{A_1 + A_2 + A_3} = G_y$
- $\frac{(52{,}5\ x\ 5{,}25) + (42\ x\ 5{,}25) + (52{,}5\ x\ 5{,}25)}{52{,}5 + 42 + 5{,}25} = 5.25$

- **G(7, 5.25)**

STIFFNESS CENTER CALCULATIONS



- $I = 1/12 \times B \times h^3$
- $I_1 = I_2 = I_3 = I_4 = \frac{1}{12} \times (0.25) \cdot 3^3 = 0.5625\, m^4$
- **X Direction**

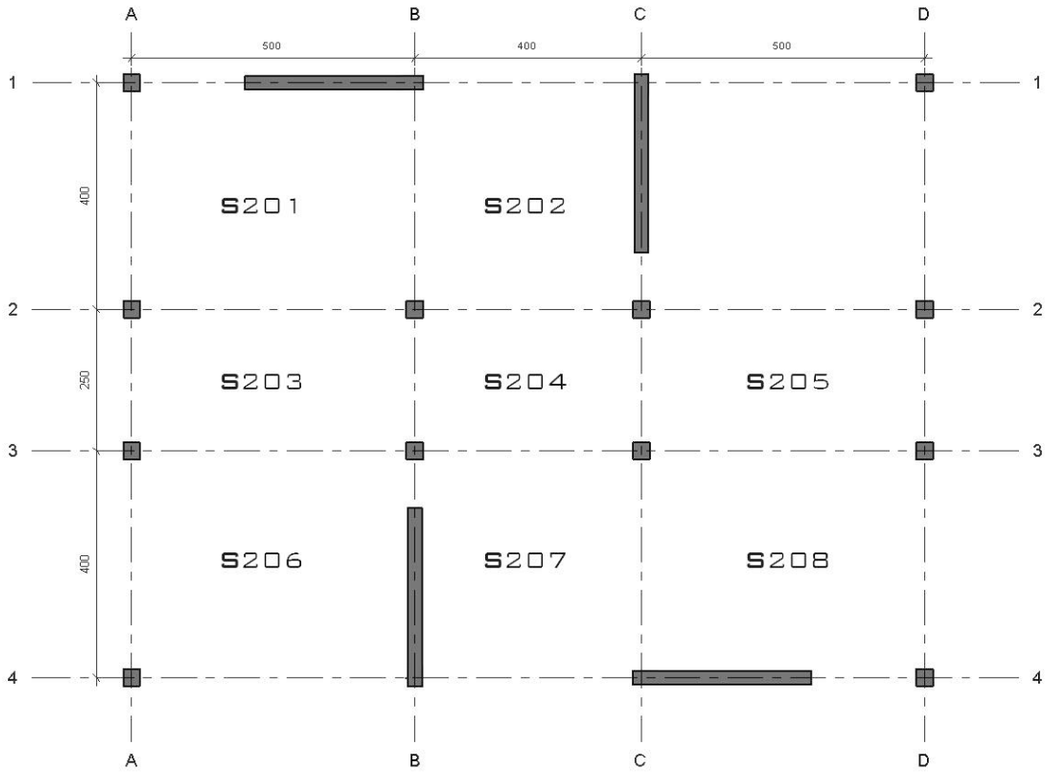
$$S_X = \frac{Ix5 + Ix9}{I + I} = \frac{14I}{2I} = 7$$

- **Y Direction**

$$S_y = \frac{0xI + 10{,}5I}{2I} = 5.25$$

- **S(7 , 5.25)**
- **G(7 , 5.25)**
- **NO ECCENTRICITY;** Stiffness Center and Mass center coincided.

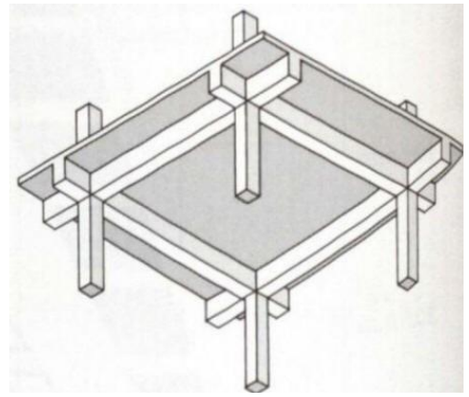
SLAB SYSTEM



As a slab system, SOLID SLAB WITH BEAMS is selected with the following calculations. Two way solid slab should be utilized since $L_L/L_s \leq 2$ for these slabs.

- The most critical three slabs were selected and calculated as shown below;

- $\alpha = \frac{\text{Σ length of continuous edges}}{\text{Σ length of all edges}}$
- $s_{201} = s_{206} = s_{208}$
- $s_{201} = \frac{5+4}{5+5+4+4} = 0,5$
- $s_{202} = \frac{4+4}{4+4+4+4} = 0,5$



- $T \geq \frac{L_s}{15+\frac{20}{L_L/L_s}} \times (1-\frac{\alpha}{4}) = 11.3$ cm

- $t_{S201} = t_{S206} = t_{S208}$
- $t_{S201} \geq \frac{4}{15+\frac{20}{\frac{5}{4}}} \times (1-\frac{0.5}{4}) = 11.3$ cm
- $t_{S202} \geq \frac{4}{15+\frac{20}{\frac{4}{4}}} \times (1-\frac{0.5}{4}) = 10$ cm

- To be on the safe side slab thickness is **12 cm.**

COLUMN DIMENSIONS

- **Tributary Area & Minimum Column Area Calculations**
- Column 2B is selected since it has the largest tributary area which carries 4 slabs around itself.
- **Tributary Area**= 4.5 x 3.25 = 14.625 m²
- **LOADS**

Dead Loads of Solid Slabs

- **- own weight:** 0.120 x2.4 = 0.30 t/m²
- **- leveling:** 0.04 x 2.4 = 0.10 t/m²
- **- covering:** 0.025 x 2.0 = 0.05 t/m²
- **- plastering:** 0.020 x 2.0 = 0.04 t/m²

≈ 0.50 t/m

= 5 kN/m²

Live Loads of Solid Slabs;

0.2 t/m² ≈ 2 kN/m² for residential buildings.

Total Load = 1.4 Dead Load + 1.6 Live Load= P_d

P_d = 1.4 x 0.50 + 1.6 x 0.20 =1.0 t/m²= 10 kN/m²

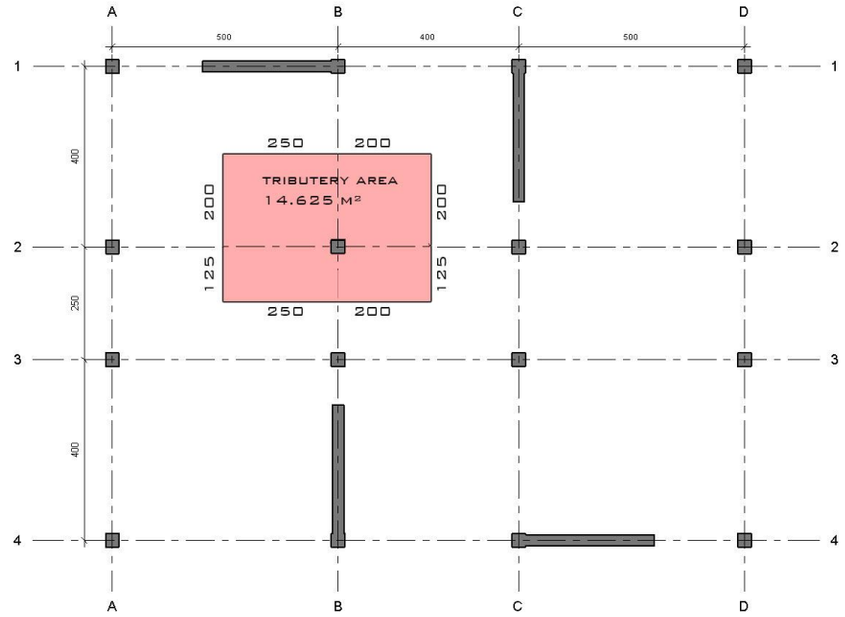
Dead Loads of Walls;

Wall Load = 0.15 t/m²= 150 kg/m²

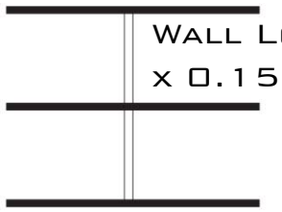
Total Wall Load = 1.4 x 0.15 x Tributary Area

=(1.4)x0.15x14.625=3.07 t

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



Slab Load=Tributary Area x P_d= 1000 kg /m² x 14.625 m² = 14625 kg



Wall Load=Tributary Area x 0.15 x 1.4= 14.625 x 0.15 x 1.3 = 3070 kg

Slab Load=Tributary Area x P_d= 1000 kg /m² x 14.625 m² = 14625 kg

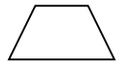
Total Loads on Critical Column is; 2xSlab Load + 1xWall Load = 2x14625 + 3070 = 32320 kg

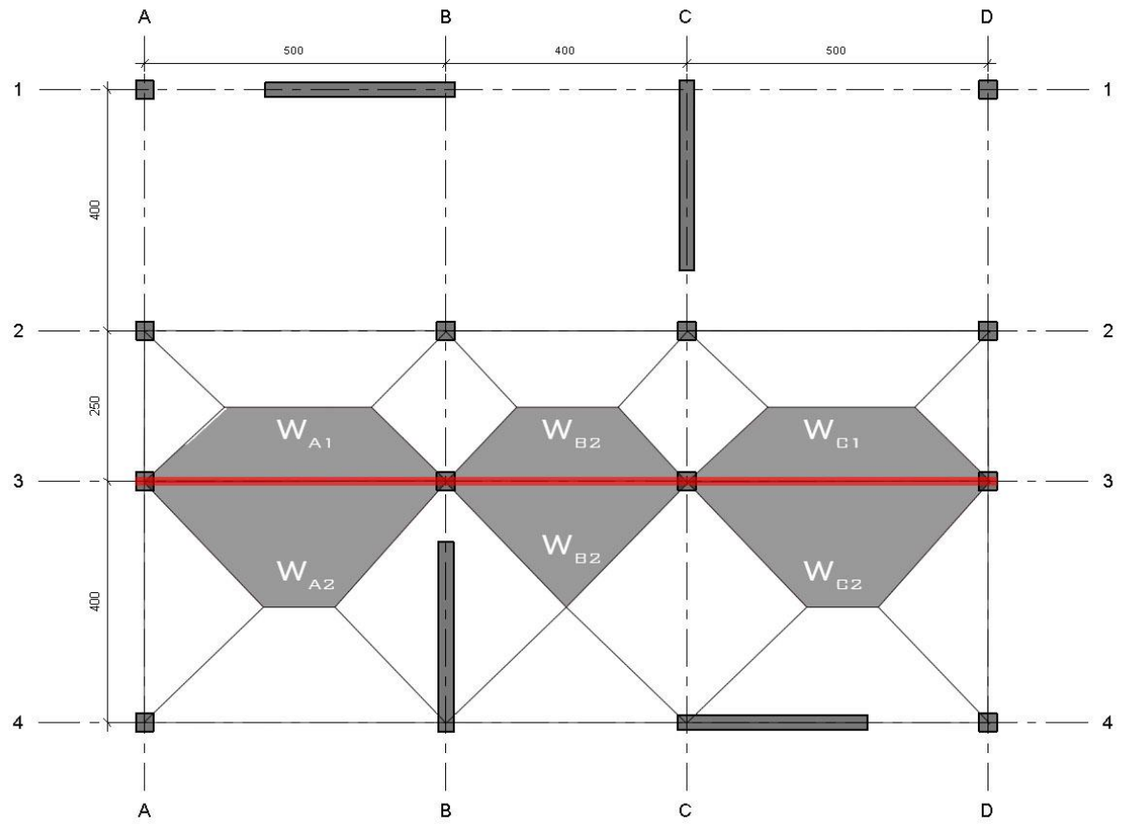
N_d=32320 kg

$$A_c \geq \frac{N_d}{(0.40 \times f_{ck})} = \frac{32320}{0.40 \times 200} \qquad A_c \geq 404\ cm^2$$ (it should be minimum 900 cm^2)

According to TS500 column dimensions are 30x30 cm

LOAD TRANSFERS

- The Beam on Axis 3 is selected to be analyzed because it has the least amount of shear walls and the largest amount of spans.
- Since all slabs provide $L_L/L_S \leq 2$ condition, two way solid slab is used.
- $P_{uni} = P_d \times \frac{l_s}{3}\left[1.5 - \frac{0.5}{(\frac{l_l}{l_s})^2}\right]$ 
- $P_{uni} = P_d \times \frac{l_s}{3}$ 



$W_{A1} = 1 \times \frac{2.5}{3} \times [1.5 - \frac{0.5}{(\frac{5}{2.5})^2}] = 0.83 \times 1.25 \approx \underline{1.146\ t/m}$

$W_{A2} = 1 \times \frac{4}{3} \times [1.5 - \frac{0.5}{(\frac{5}{4})^2}] = 1.34 \times 1.18 \approx \underline{1.573\ t/m}$

$W_{B1} = 1 \times \frac{2.5}{3} \times [1.5 - \frac{0.5}{(\frac{4}{2.5})^2}] = 1.087\ t/m$

$W_{B2} = 1 \times \frac{4}{3} = 1.33\ t/m$

$W_{C1} = W_{A1} = 1.146\ t/m$

$W_{C2} = W_{A2} = 1.573\ t/m$

Floor to Floor Height=3m & Assumed Beam Depth=500/12=42cm

Wall Height=3.00-0.42=2.58 m

Distributed Wall Load on Beam= Wall Height x Wall Load x Dead Load Factor

=2.58x0.15x1.4=<u>0.54 t/m</u>

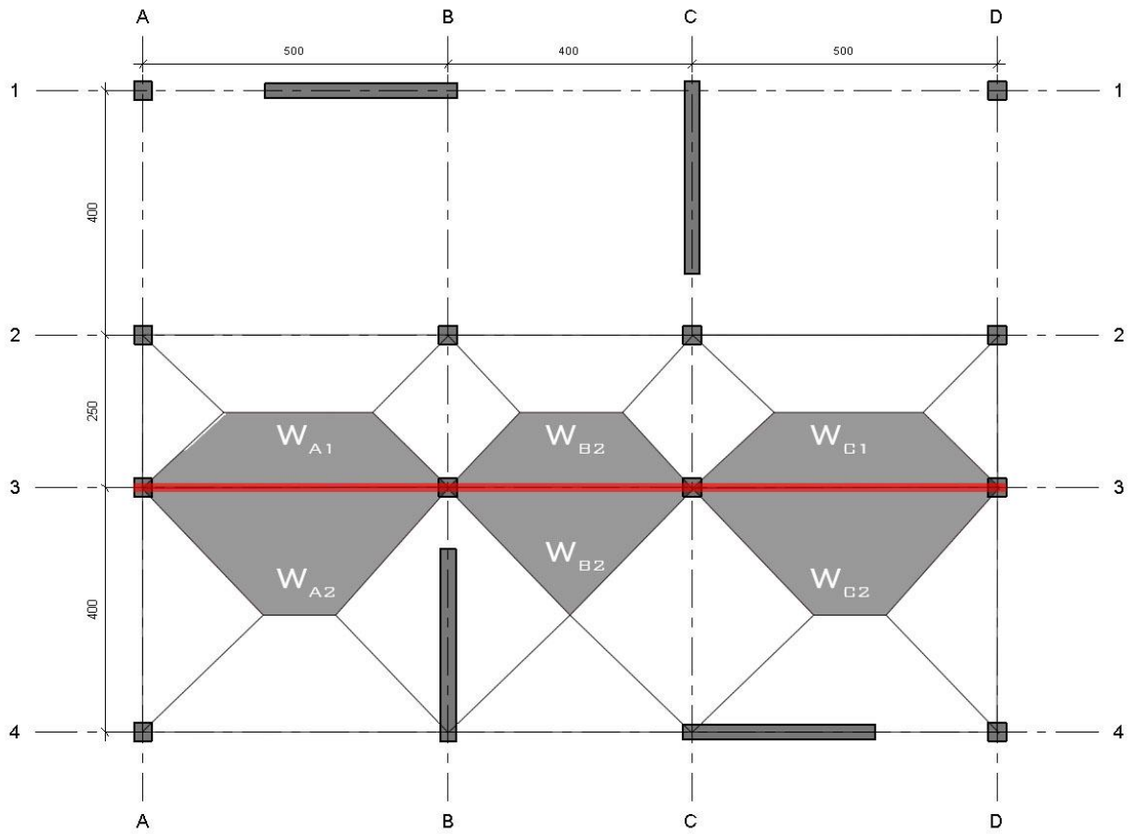
Beam's Own Weight=Volume of Beam x Unit Weight of RC x Dead Load Factor $W_{BeamA} = W_{BeamC}$ = (0.42x0.30x5)x2.4x1.4=2.12 t 2.12 t / 5m = 0.42 t/m
W_{BeamB}=(0.42x0.30x4)x2.4x1.4=1.69 t 1.69t / 4m = 0.42 t/m

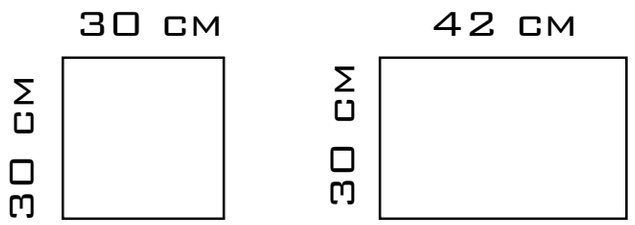
$W_{A-total}$= 2.72+0.54+0.42= <u>3.68 t/m</u>

$W_{B-total}$=2.42+0.54+0.42= <u>3.38 t/m</u>

$W_{C-total}$=2.72+0.54+0.42= <u>3.68 t/m</u>

MOMENT OF INERTIA AND LOAD DISTRUBITION FACTORS





COLUMN BEAM

- BEAM APPROXIMATION: $h=\frac{l}{12}=\frac{5}{12}=0.42$ CM
- $I=\frac{1}{12}$ X A X H^3

$$I_{column} = \frac{1}{12} \times (0.3)^3 \times (0.3) = 0.000675 \text{ м}^4$$

$$I_{beam} = \frac{1}{12} \times (0.42)^3 \times 0.3 = 0.00185 \text{ м}^4$$

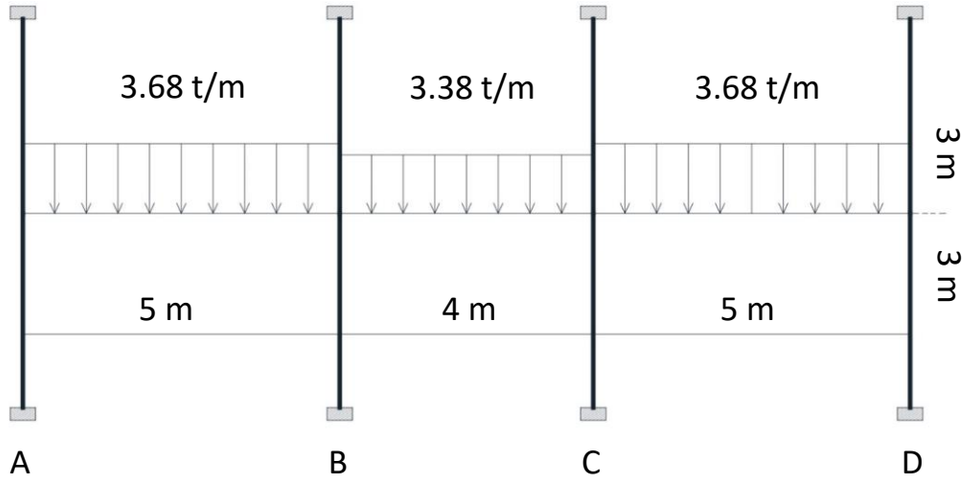
- $r = \frac{I/L}{\Sigma I/L}$

$$r_{AB} = r_{DC} = \frac{\frac{0.00185}{5}}{\frac{0.00185}{5}+\frac{0.000675}{3}x2} = \frac{0.00037}{0.00037+0.00045} = 0.45$$

$$r_{BA} = r_{CD} = \frac{\frac{0.00185}{5}}{\frac{0.00185}{5}+\frac{0.00185}{4}+\frac{0.000675}{3}x2} = \frac{0.00037}{0.00037+0.00045+0.00046} = 0.29$$

$$r_{BC} = r_{CB} = \frac{\frac{0.00185}{4}}{\frac{0.00185}{5}+\frac{0.00185}{4}+\frac{0.000675}{3}x2} = 0.36$$

TWO CYCLE METHOD AND BEAM DEPTH



r	0.45	0.29	0.36	0.36	0.29	0.45
FEM	7.67	-7.67	4.51	-4.51	7.67	-7.67
1st cycle	0.46	-1.73	-0.57	0.57	1.73	-0.46
Σ	8.13	-9.40	3.94	-3.94	9.40	-8.13
2nd cycle	-3.66	1.58	1.97	-1.97	-1.58	3.66
Σ	4.47	-7.82	5.91	-5.91	7.82	-4.47

$$\text{FEM}_{AB-CD} = \frac{3.68\ x\ (5)^2}{12} = 7.67 \text{ tm} \qquad \text{FEM}_{BC} = \frac{3.38\ x\ (4)^2}{12} = 4.51 \text{ tm}$$

$$\text{Midspan Moment}_{AB-CD} = \frac{3.68\ x\ (5)^2}{24} = 3.83 \text{ tm}$$

$$\text{Midspan Moment}_{BC} = \frac{3.38\ x\ (4)^2}{24} = 2.25 \text{ tm}$$

MIDSPAN MOMENT CALCULATIONS;

- 7.67-4.47=3.2, 7.82-7.67=0.15

  3.2-0.15=3.05, 3.05:2=1.525 ; 3.83+1.525= 5.36 тм
- 5.91-4.51=1.4, 5.91-4.51=1.4

  1.4+1.4=2.8, 2.8:2=1.4 ; 2.25-1.4=0.85 тм

BEAM DEPTH

- $K_o = \frac{bw\ x\ d^2}{M_d}$ $\qquad K_o = 25\ cm^2/t$ bw =30 см

  M_{max}= 7.82 тм= 782 тс
- $25 = \frac{30\ x\ d^2}{782}$ d= 25.53=26 см, h > d+5, h > 31 см
- Since the beam depth should be three times larger than the slab thickness, minimum depth is 12x3=36 cm. 36 >30 cm. Then **minimum beam depth is 36 cm.**