An- Najah National university
Faculty of Engineering
Department of civil engineering

Graduation project II

"Design of foundation system for Residential building under effect different loads"

Supervised by:Dr. Isam Jaradanh

Prepared by : Ahmad Hamad

Obada Daragmah

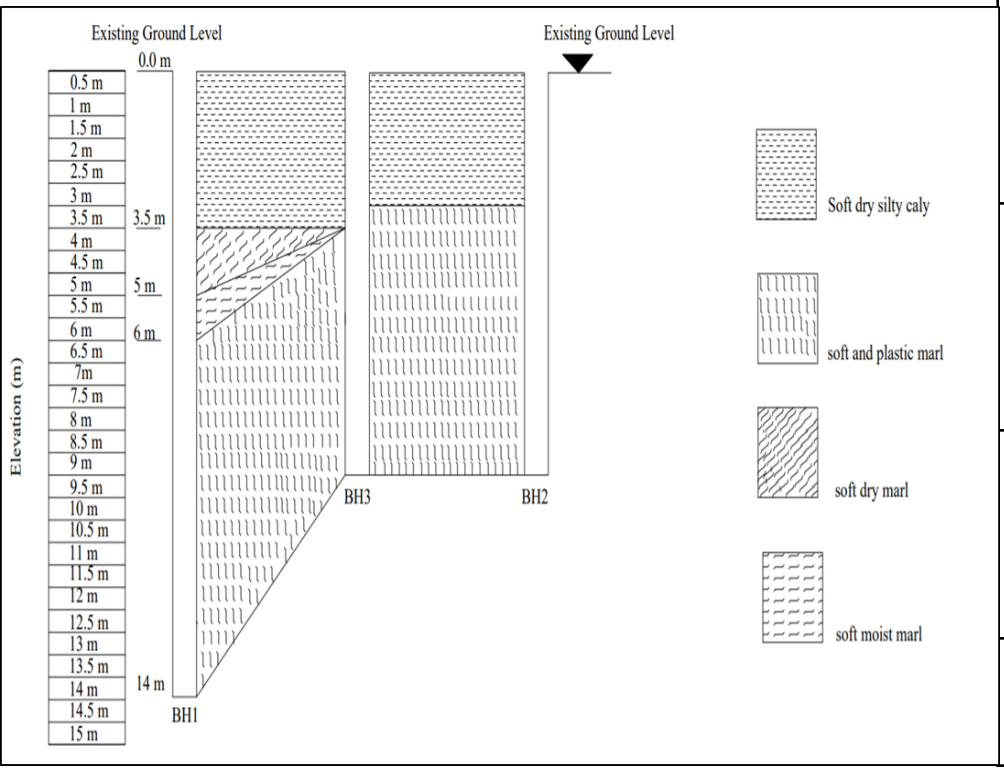
Taha Msallam

Safe AlDin Odah

Project Description

- The main aim of the graduation project is to select and design the most suitable foundation system or systems for a Residential Building. The building has 8 floor and the average area of each floor is 350 m2 .
- After make analysis in project1 for the building by using ETABS depending on loads the most suitable foundation system is mat foundation .
- The aim of this project is design the mat foundation in case the building under effect live and dead loads .On the other hand, design of the same mat in case under effect live , dead and seismic loads .
- Find the dimensions and steel reinforcement of mat for each case and make comparison between them .

Soil Parameters and geological section



BH No.	Sample No	Depth (m)	Passing 200	Plasticity Index	Cohesion (kN/m^2)	Angle of Internal Friction (φ°)
1	1	0.0-3.5	88	12.6		
	2	3.5-5.0	64	6.9	10	20
	3	5.0-6.0	68	7.4		
	4	6.0-14.0	81	10.9		
2	1	0.0-3.0	85	11.8		
	2	3.0-9.0	83	12.3	14	18
3	1	0.0-3.5	89	13.5		
	2	3.5-9.0	80	12.7	13	18

- **Bearing Capacity of soil**

By using special computer program to calculate the bearing capacity of the soil, it comes out that is equal 2.5 kg/cm2 for depth 3.5m from the ground level.

BEARING CAPACITY OF SHALLOW FOUNDATIONS
Terzaghi and Vesic Methods

Date	November 14, 2020	
Identification	imad braik	

Input

Units of Measurement		
	si	SI or E
Foundation Information		
Shape	sq	SQ, CI, CO, or RE
B =	2	m
L =	2	m
D =	3.5	m
Soil Information		
c =	12	kPa
phi =	18	deg
gamma =	17	kN/m^3
Dw =	17	m
Factor of Safety		
F =	3	

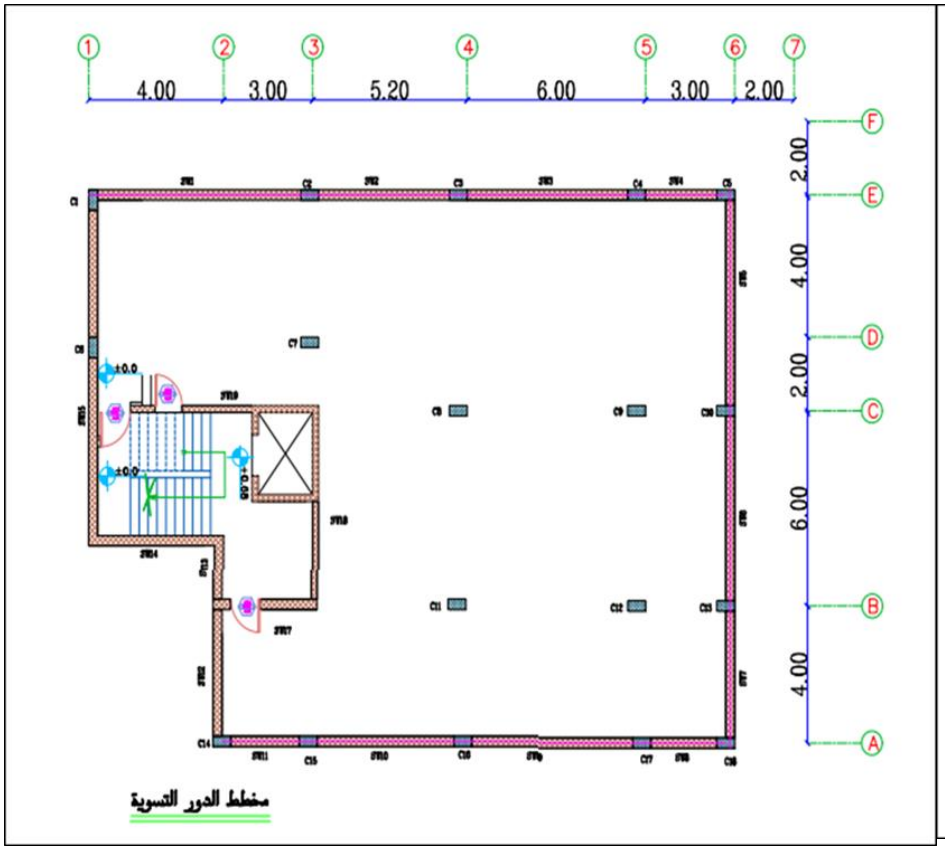
Results

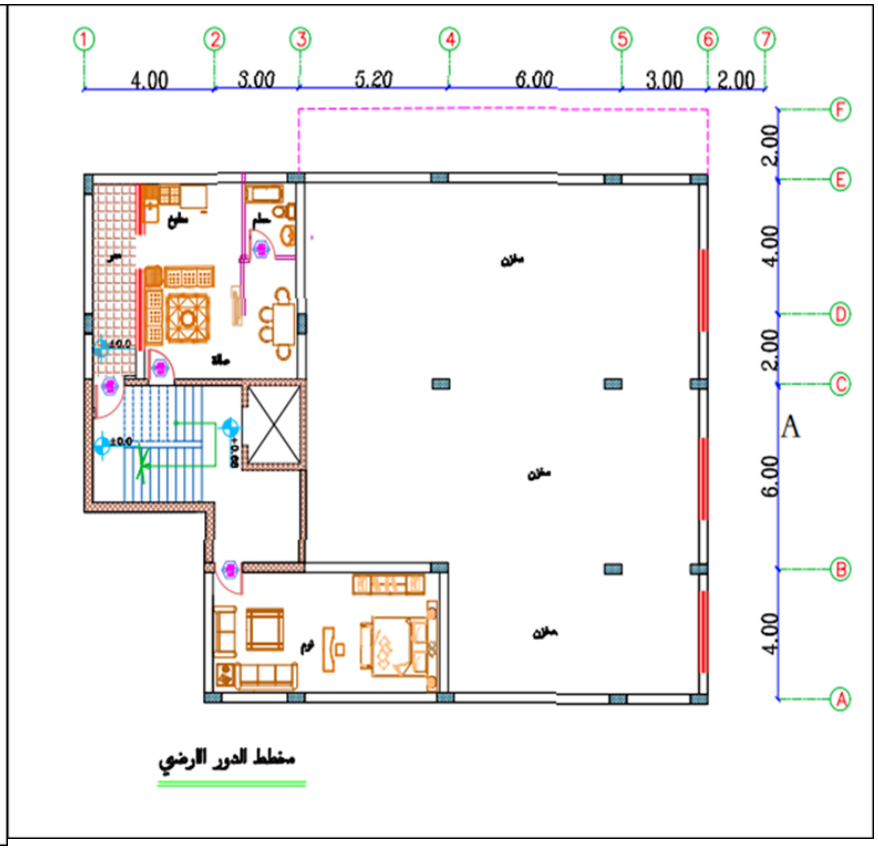
	Terzaghi	Vesic
Bearing Capacity		
q ult =	647 kPa	904 kPa
q a =	216 kPa	301 kPa
Allowable Column Load		
P =	862 kN	1,206 kN

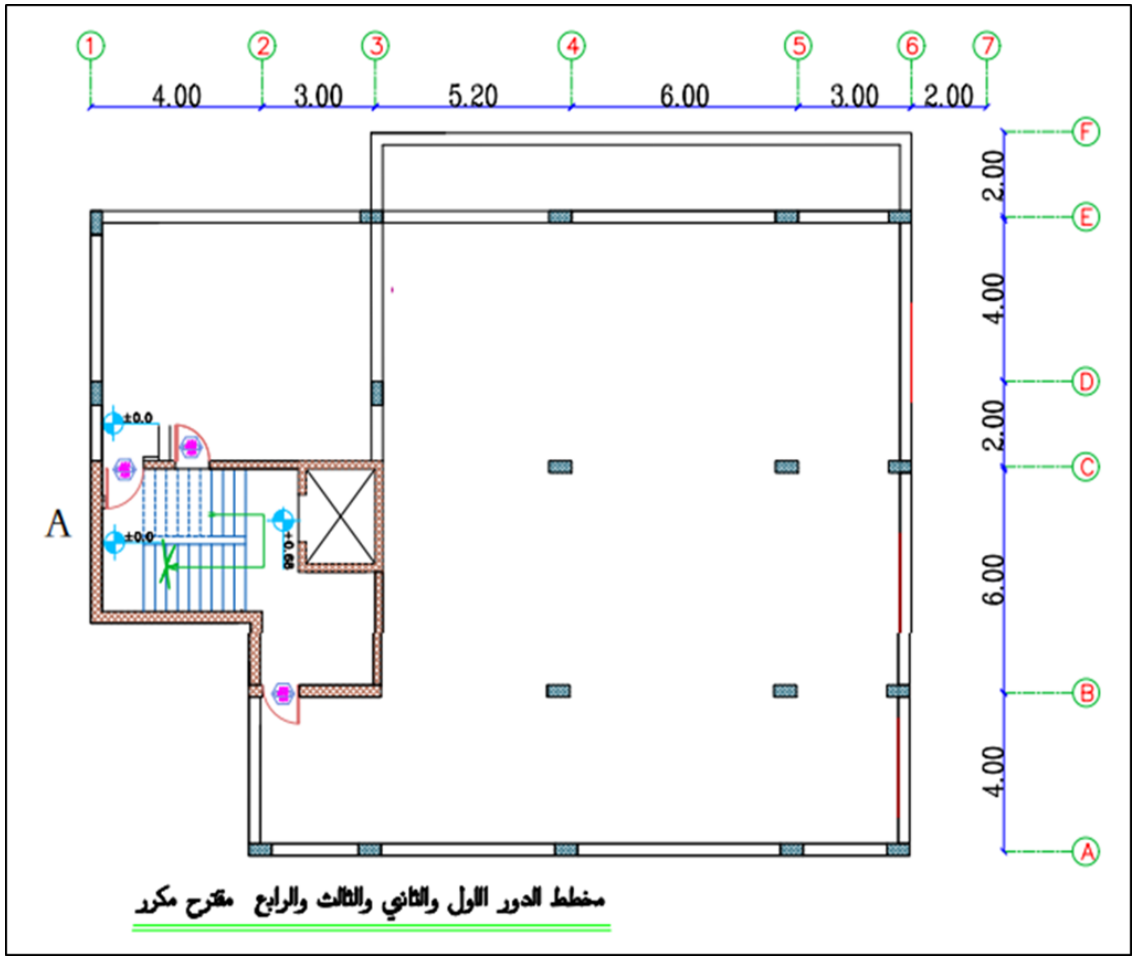
- **Architectural and structural description**

NO. floors = 8 height of floor 3.5 m and besamat 3.5m under the ground level

Tow way solid slab system , beams and columns and shear walls .






1
2
3
4
5
6
7
4.00
3.00
5.20
6.00
3.00
2.00
F
E
D
C
B
A
2.00
4.00
2.00
6.00
4.00
±0.0
±0.0
+0.60
A
مخطط الدور الاول والثاني والثالث والرابع مقترح مكرر

- **Loads**
- Gravity loads

Load type	Value (kN/m^2)
Dead load	Will be calculated automatically from ETABS software as the weight of the structural elements
Live load	2
SID Load	4

- seismic loads

Seismic factors From ASCE 7-10 found the following :

- Risk category (II)
- Importance factor= 1
- Mapped acceleration parameters (Ss =0.4 and S1= 0.12)
- Site classification= C

- Site coefficients (Fa, Fv):
- Fa: short-period site coefficient at 0.2 sec = 1.2 sec
- Fv: long-period site coefficient at 1sec= 1.7 sec.
- Spectral response acceleration parameters (SM1,SMS):

  $SMS = Fa * Ss$ Eq (11.4-1), from ASCE 7-10

  =1.2*0.4=0.48

  $SM1 = Fv * S1$ Eq (11.4-2), from ASCE 7-10

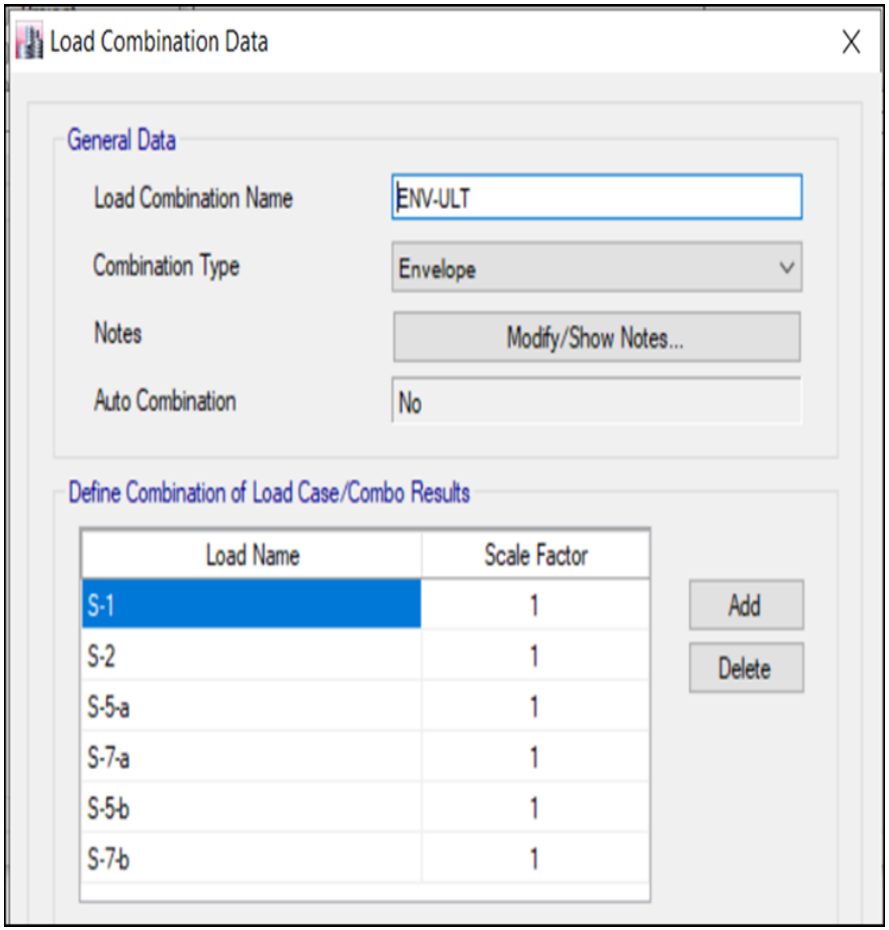
  =1.68*0.12=0.2016
- Design Spectral Acceleration Parameters (SDS,SD1):

  SDs=2/3 Sms Eq. (11.4-3), from ASCE 7-10

  =2/3*0.48=0.32
- SD1=2/3 Sm1 =2/3*0.2016=0.1344 Eq. (11.4-4), from ASCE 7-10
- Seismic Design Category = C

- **Load combinations**
  - Ultimate combinations

Eq. No. from ASCE 7-10	Eq. from ASCE 7-10	Load combinations
1	1.4D	1.4D
2	1.2D + 1.6L + 0.5(Lr or S or R)	1.2D + 1.6L
5	1.2D + 1.0E + L + 0.2S	1.264D+EQx+0.3 EQy+L
		1.264D-EQx-0.3EQy+L
		1.264D+EQy+0.3 EQx+L
		1.264D-EQy-0.3EQx+L
7	0.9D + 1.0E 0.836D+EQy+0.3EQx	0.836D+EQy+0.3 EQx
		0.836D-EQy-0.3EQx
		0.836D+EQx+0.3 EQy
		0.836D-EQx-0.3EQy

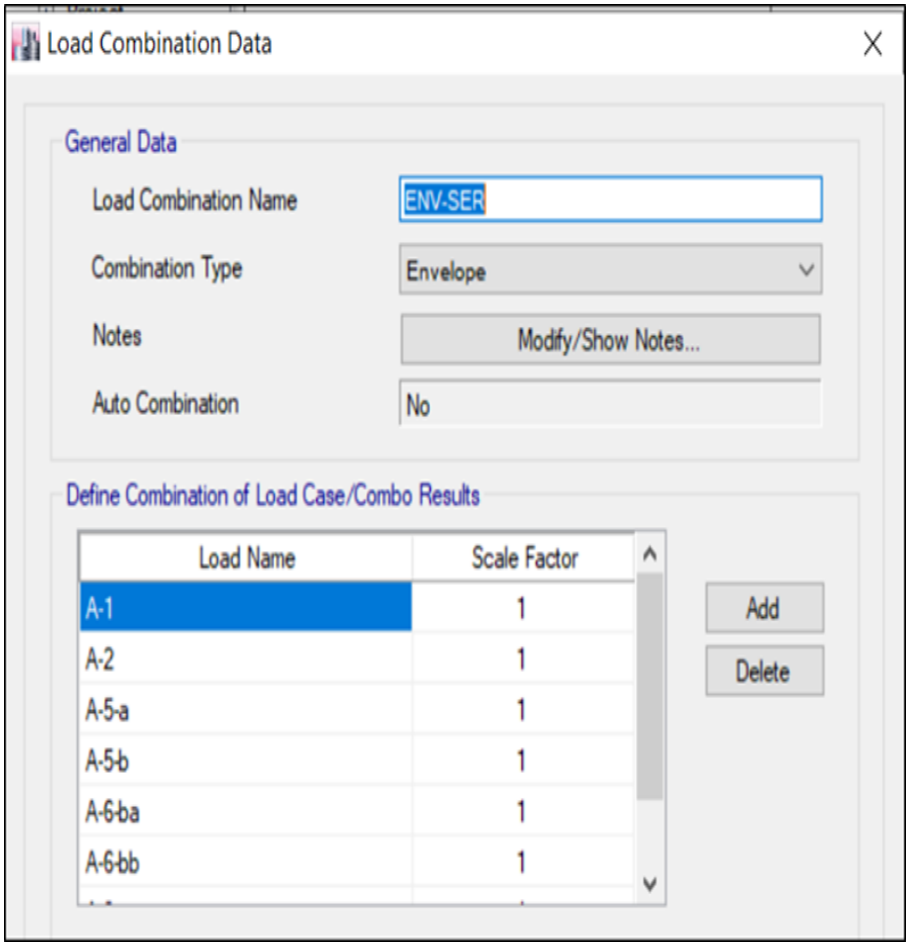


D: Dead load / L:Live load / EQX : Earthquake load in X – direction

EQY: Earthquake load in y – direction

- **Load combinations**
  - Service combinations

Eq. No. from ASCE 7-10	Eq. from ASCE 7-10	Load combinations
1	D	D
2	D + L	D + L
5	D + (0.6W or 0.7E)	1.0448D+0.7EQx+0.21EQy
		1.0448D+0.7EQy+0.21EQx
6b	D + 0.75L + 0.75(0.7E) + 0.75S	1.0336D+0.525EQx+0.1575EQy+0.75L
		1.0336D+0.525EQy+0.1575EQx+0.75L
8	0.6D + 0.7E	0.5552D+0.7EQx+0.21EQy

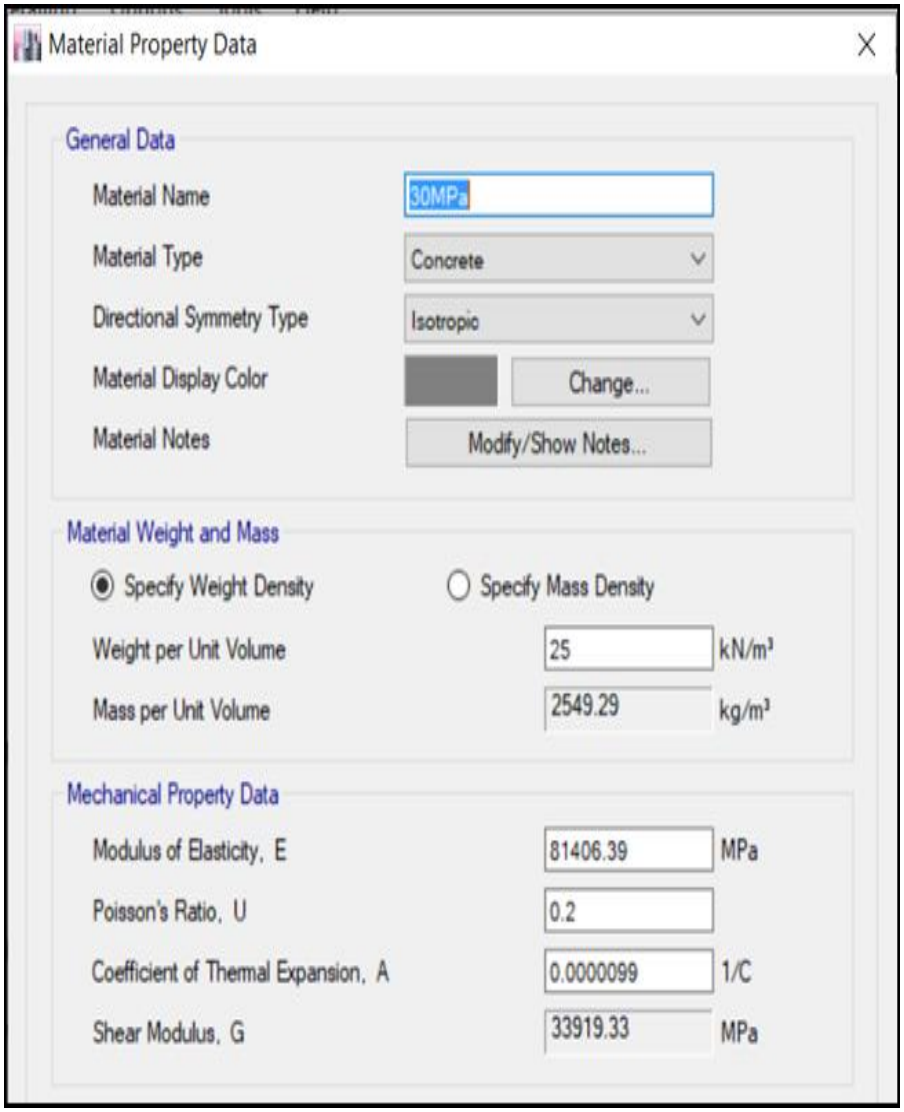


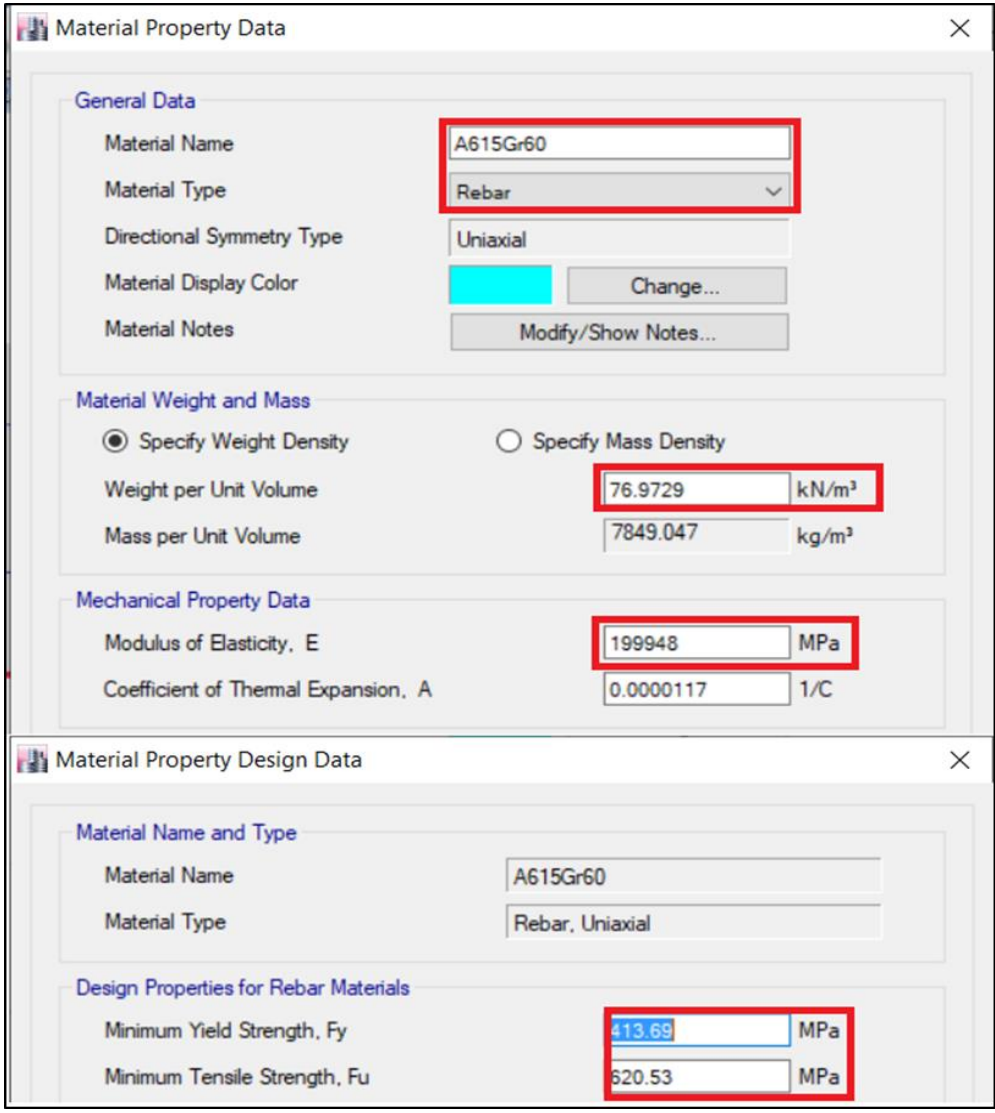
D: Dead load / L:Live load / EQX : Earthquake load in X – direction

EQY: Earthquake load in X – direction

- **Define material**

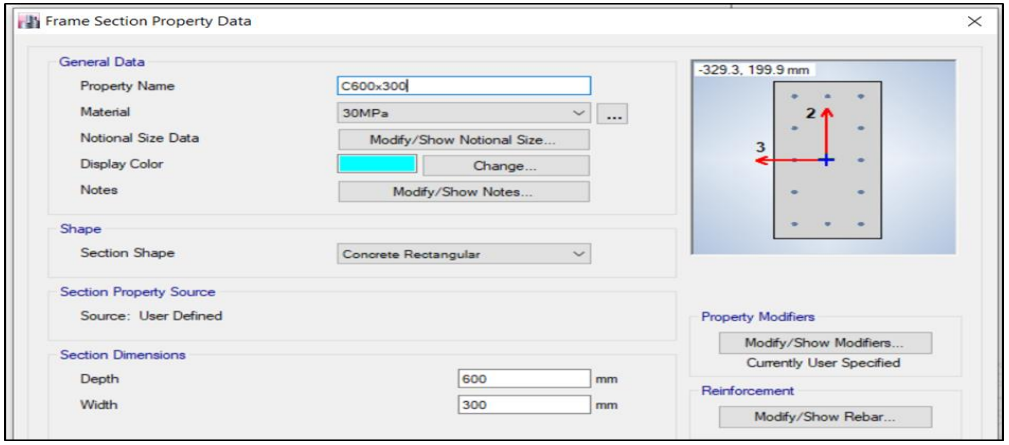
Concrete (f'c = 30 Mpa , γ= 25 Kn/ m2) /steel reinforcement Fy= 413 Mpa



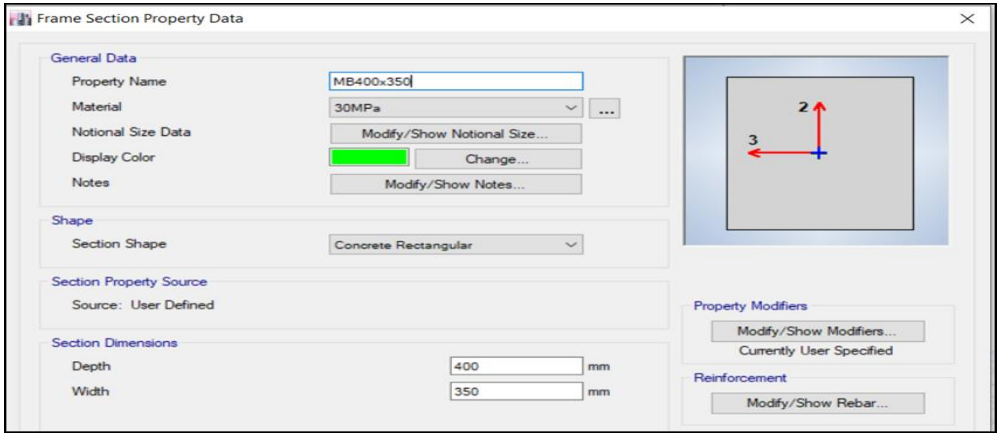


- **Define sections**

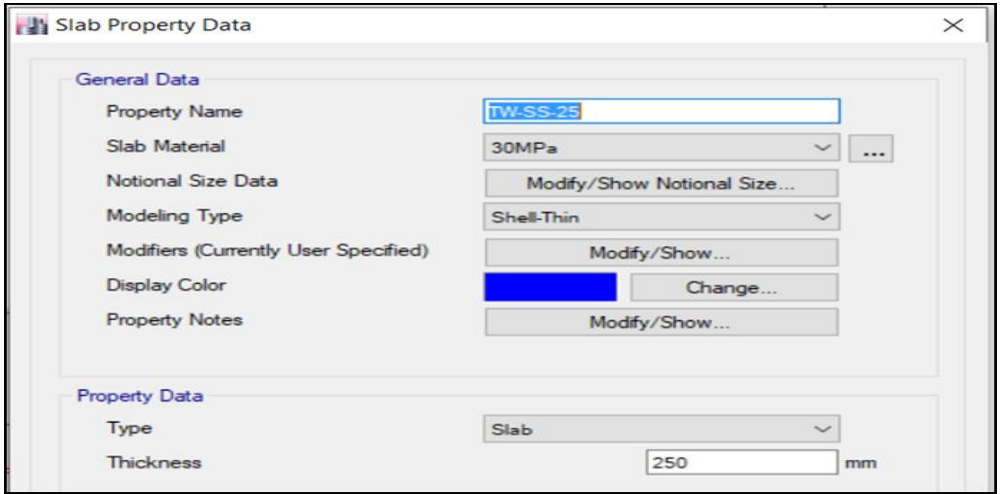
- Columns (300mm x600mm)



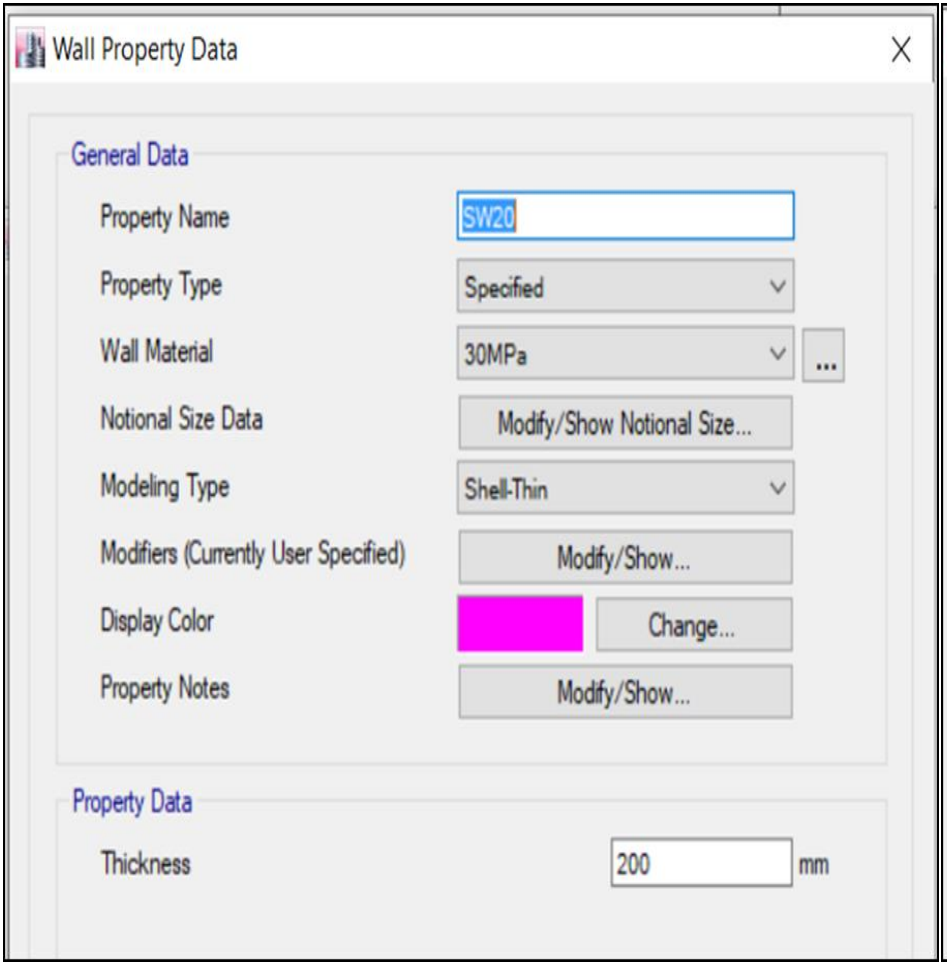
- Beams(400mmx350mm)

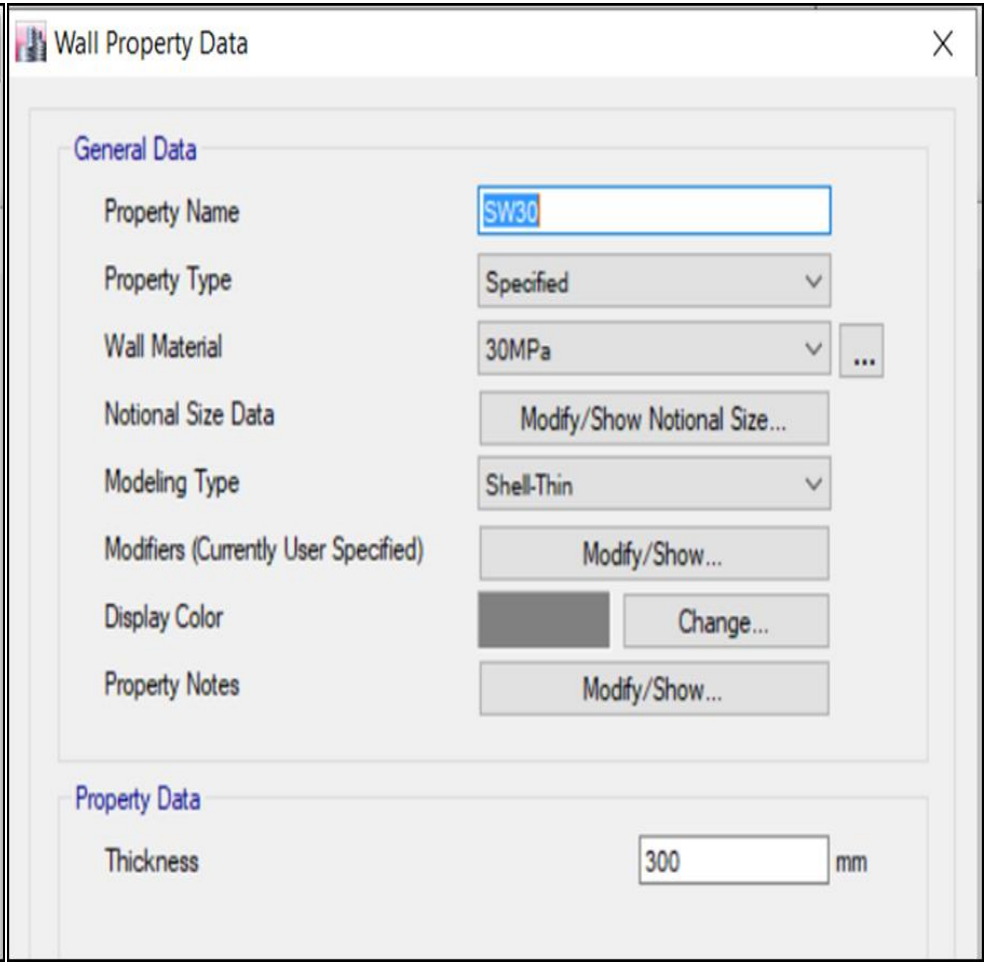


- Slab (250mm thickens)

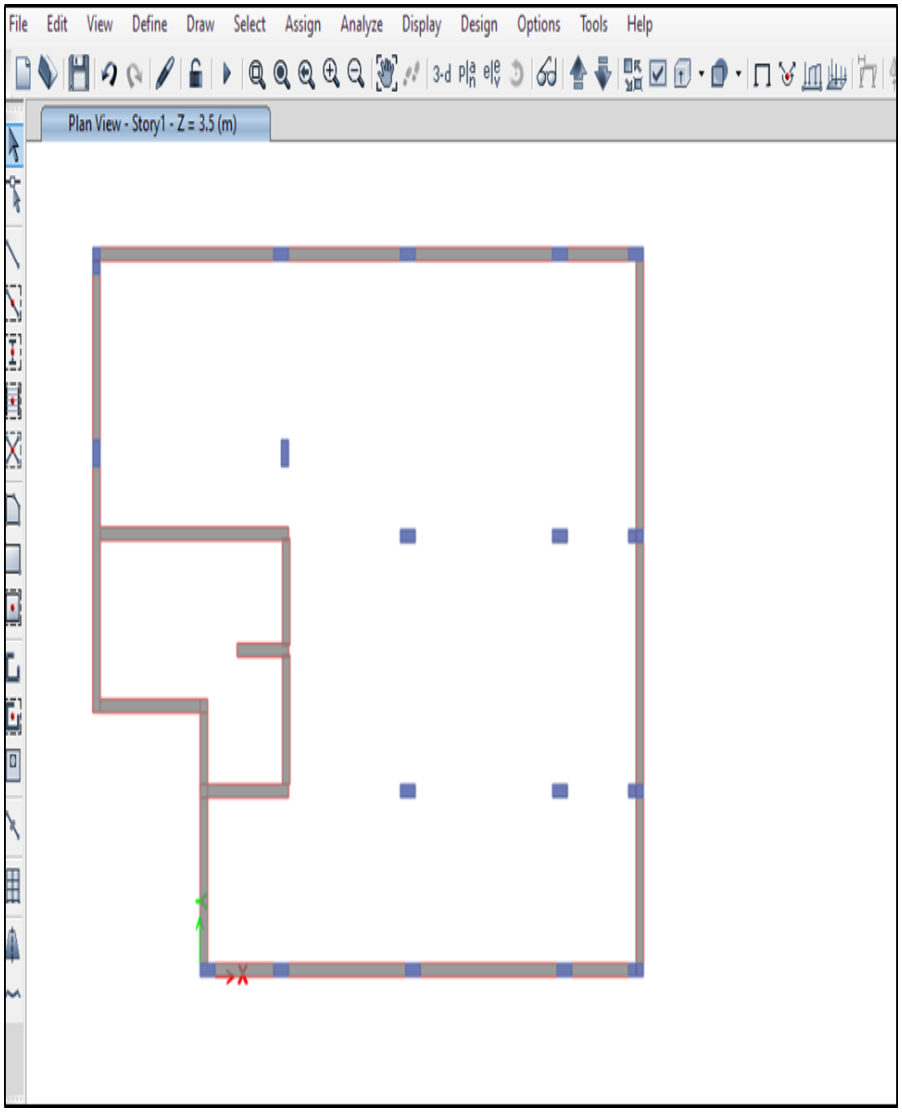


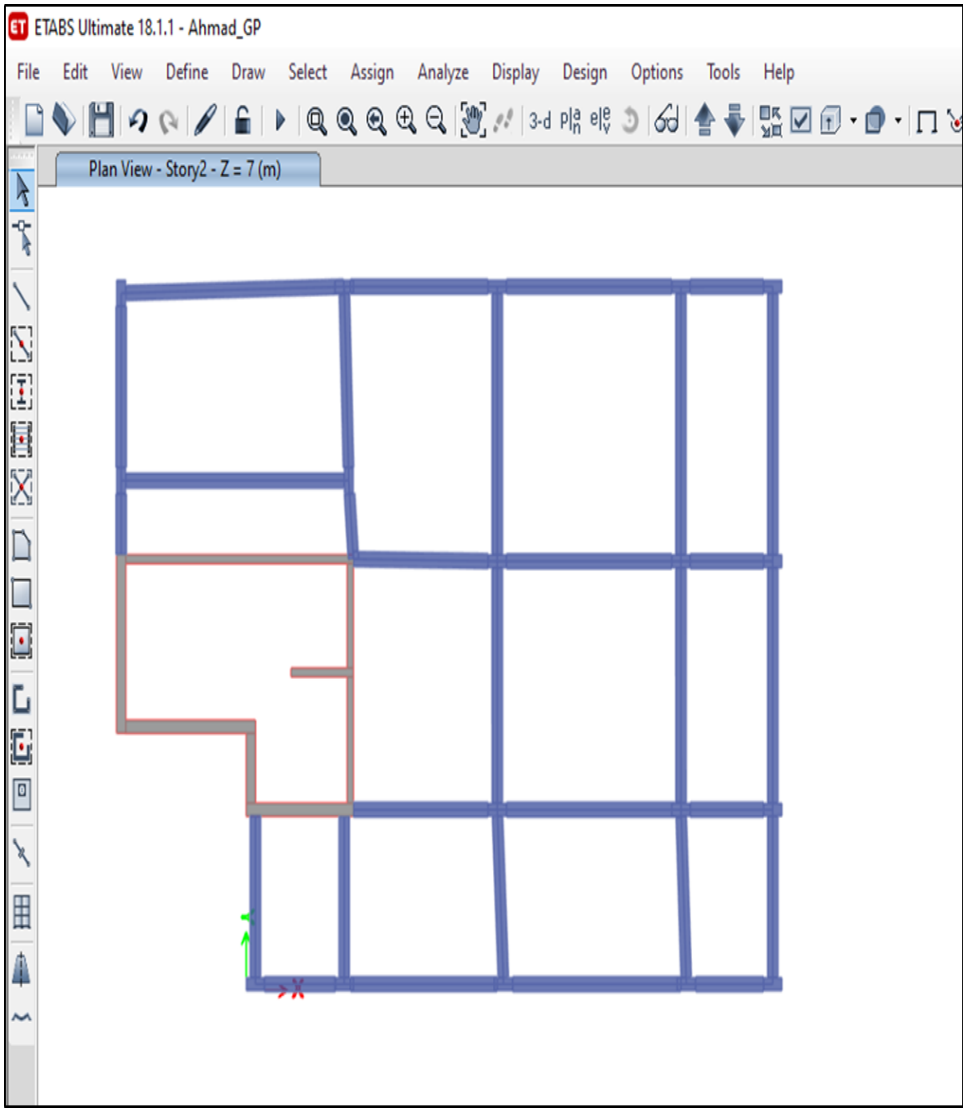
Walls


Wall Property Data
General Data
Property Name
SW20
Property Type
Specified
Wall Material
30MPa
Notional Size Data
Modify/Show Notional Size...
Modeling Type
Shell-Thin
Modifiers (Currently User Specified)
Modify/Show...
Display Color
Change...
Property Notes
Modify/Show...
Property Data
Thickness
200
mm

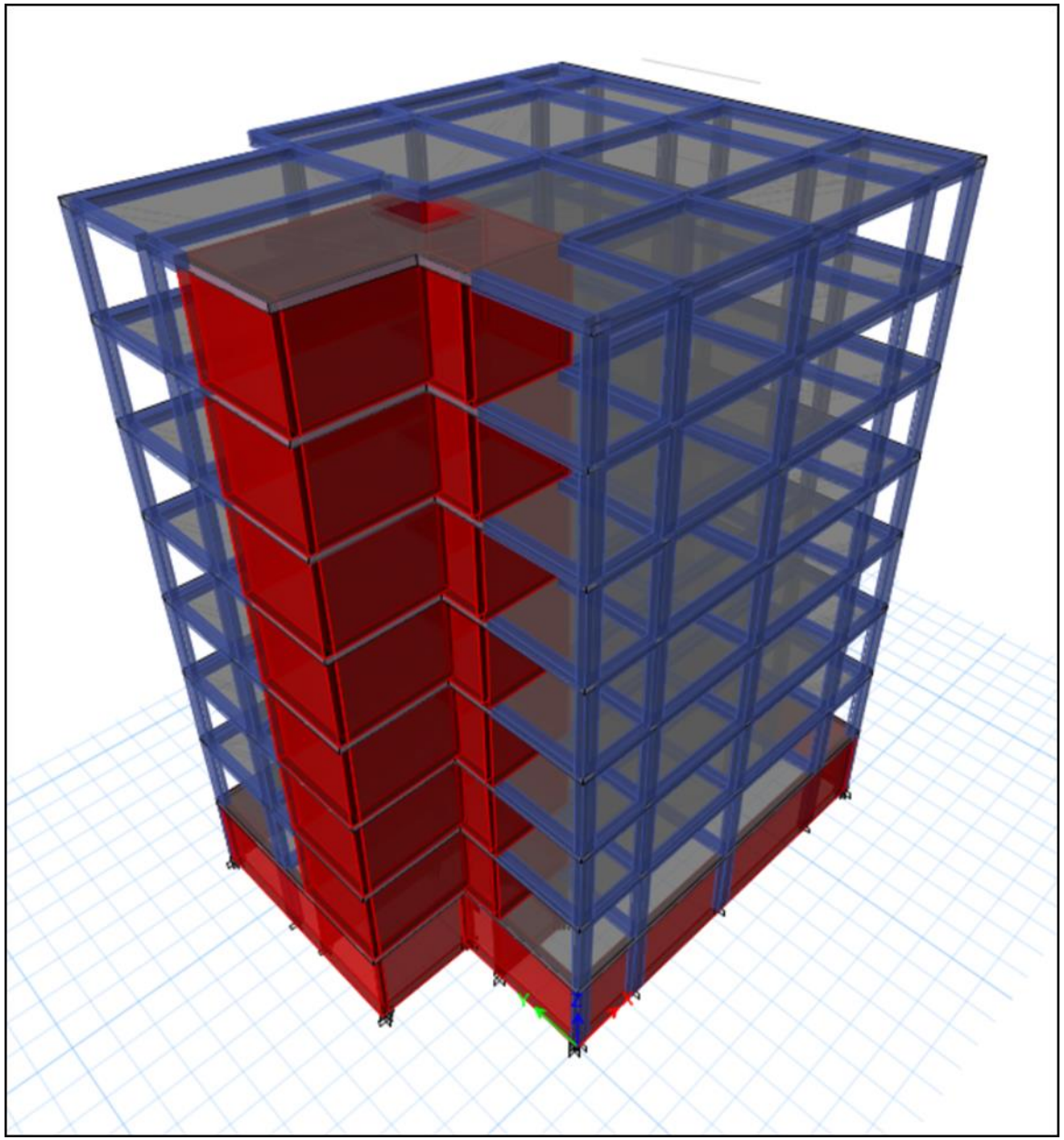

Wall Property Data
General Data
Property Name
SW30
Property Type
Specified
Wall Material
30MPa
Notional Size Data
Modify/Show Notional Size...
Modeling Type
Shell-Thin
Modifiers (Currently User Specified)
Modify/Show...
Display Color
Change...
Property Notes
Modify/Show...
Property Data
Thickness
300
mm

- drowning and layout





- 3-D modeling



- **Loads from analysis**
  - Ultimate and service Loads from effect live and Dead loads

Ultimate combination			
Columns		Walls	
Name	load kN	Name	Load kN
21	1955.449	SW1	3713.83
30	4094.92	SW2	2410.92
39	4750.35	SW3	2487.84
75	2069.52	SW4	1703.52
48	3781.08	SW5	1647.09
66	578.31	SW6	1519.44
57	391.83	SW7	2784.72
84	2311.26	SW8	5311.41
93	3834.11	SW9	1899.01
129	1893.44	SW10	1344.8
120	3230.89	SW11	1878.47
147	1422.64	SW12	1986.91
138	2096		
156	2575.55		
111	3557.84		
165	1852.66		
174	633.97		
102	4136.244		

Service combination			
Columns		Walls	
Name	Load kN	Name	Load kN
21	1519.24	SW1	2846.299
30	3201.36	SW2	1829.19
39	3783.12	SW3	1921.8
75	1651.27	SW4	1279.94
48	3001.07	SW5	1249.97
66	451.23	SW6	1173.41
57	306.84	SW7	2084.97
84	1812.76	SW8	3842.65
93	3053.95	SW9	1357.06
129	1479.812	SW10	967.09
120	2580.65	SW11	1349.25
147	1112.01	SW12	1448.95
138	1592.48		
156	2005.43		
111	2834.38		
165	1433.82		
174	477.92		
102	3283.28		

Ultimate and service Loads from effect live and Dead and seismic

Ultimate combination				Service combination			
Columns		Walls		Columns		Walls	
Name	load kN	Name	Load kN	Name	Load kN	Name	Load kN
21	2293.24	P1	2309.94	21	1748.31	P1	1401.08
30	4094.92	P2	1525.62	30	3281	P2	918.6
39	4750.35	P3	1345.17	39	3823.91	P3	804.48
75	2485.3	P4	221.43	75	1883.86	P4	43
48	3828.85	P5	1133.74	48	3077.002	P5	892.14
66	810	P6	1845.08	66	606.66	P6	1372
57	392.96	P7	934.54	57	315.93	P7	467.9
84	2311.26	P8	934.54	84	1852.064	P8	543.38
93	3834.11	P9	387.27	93	3061.65	P9	428.27
129	1934.32	P10	378.6	129	1544.58	P10	155.38
120	3230.89	P11	94.87	120	2595.88	P11	218.08
147	1452.72	P12	1162.5	147	1160.23	P12	963.03
138	2130.95			138	1694.17		
156	2575			156	2068.5		
111	3557.84			111	2853.88		
165	1858.66			165	1481.85		
174	764.53			174	590.07		
102	4136.24			102	3310.27		

Load on column	unique name	Qall	Area Required
2293.24	1	250	9.17296
4094.92	2	250	16.37968
4750.35	3	250	19.0014
2485.3	4	250	9.9412
3828.85	5	250	15.3154
810	6	250	3.24
392.96	7	250	1.57184
2311.26	8	250	9.24504
3834.11	9	250	15.33644
1934.32	10	250	7.73728
3230.89	11	250	12.92356
1452.72	12	250	5.81088
2130.95	13	250	8.5238
2575	14	250	10.3
3557.84	15	250	14.23136
1858.66	16	250	7.43464

Load on pier in kN	Length of pier	load in pier kN/m	Qall	Width of footing/m	length of footing	Area required
2309.94	21.73	106.3018868	250	0.425207547	21.98	9.346061887
1525.62	16.3	93.59631902	250	0.374385276	16.55	6.196076319
1345.17	17.5	76.86685714	250	0.307467429	17.75	5.457546857
221.43	6.2	35.71451613	250	0.142858065	6.45	0.921434516
1133.74	4.54	249.722467	250	0.998889868	4.79	4.784682467
1845.08	4.09	451.1198044	250	1.804479218	4.34	7.831439804
934.54	6.55	142.6778626	250	0.57071145	6.8	3.880837863
934.54	7.78	120.1208226	250	0.48048329	8.03	3.858280823
387.27	2.88	134.46875	250	0.537875	3.13	1.68354875

Total Area for columns	Total area for pier
185.76856	51.04384522

- Floor aera =315 m^2 , 50% Floor aera = 157.5 m^2 , Total aera required for footing = 236.8 so ,
- Total area required for footing > 50 % area of building
- The best alternative is mat foundation

- calculation of Settlement

The settlement of 3.5 clay , NCC clay

The consolidation settlement as

$$\Delta H = H \frac{C_c}{(1+e_0)} \log \frac{(p_0{}'+\Delta p)}{p_0{}'}$$

Max. area of single footing = 16.24 m2

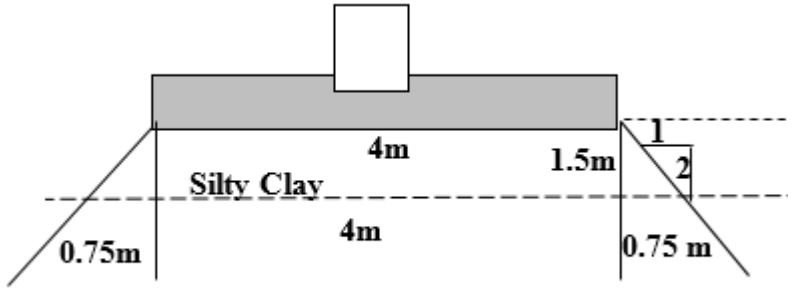
The length of fitting = 4 m and Total load on column =4136.24KN

L.L= 35

Cc = 0.009(L.L-100) = 0.225

γclay = 18 KN/m

p0'=18×3.5=63 kN/m2.



Area of the mid section of the clay layer =

(0.75 + 4+ 0.75) × (0.75 + 4 + 0.75) = 30.25m2.

Δp=4136.24/30.25 =136.73 kN/m2.

ΔH=HC[Cc/ (1+e0)] log[(p0'+Δp)/p0]'

ΔH=3.50*[0.225/(1+0.67)] log[(63+136.73)/136.73]=0.276 m =276mm > 50 mm [not within Allowable settlement]

Chapter 5: SAFE design of mat foundation(primarily dimensions)

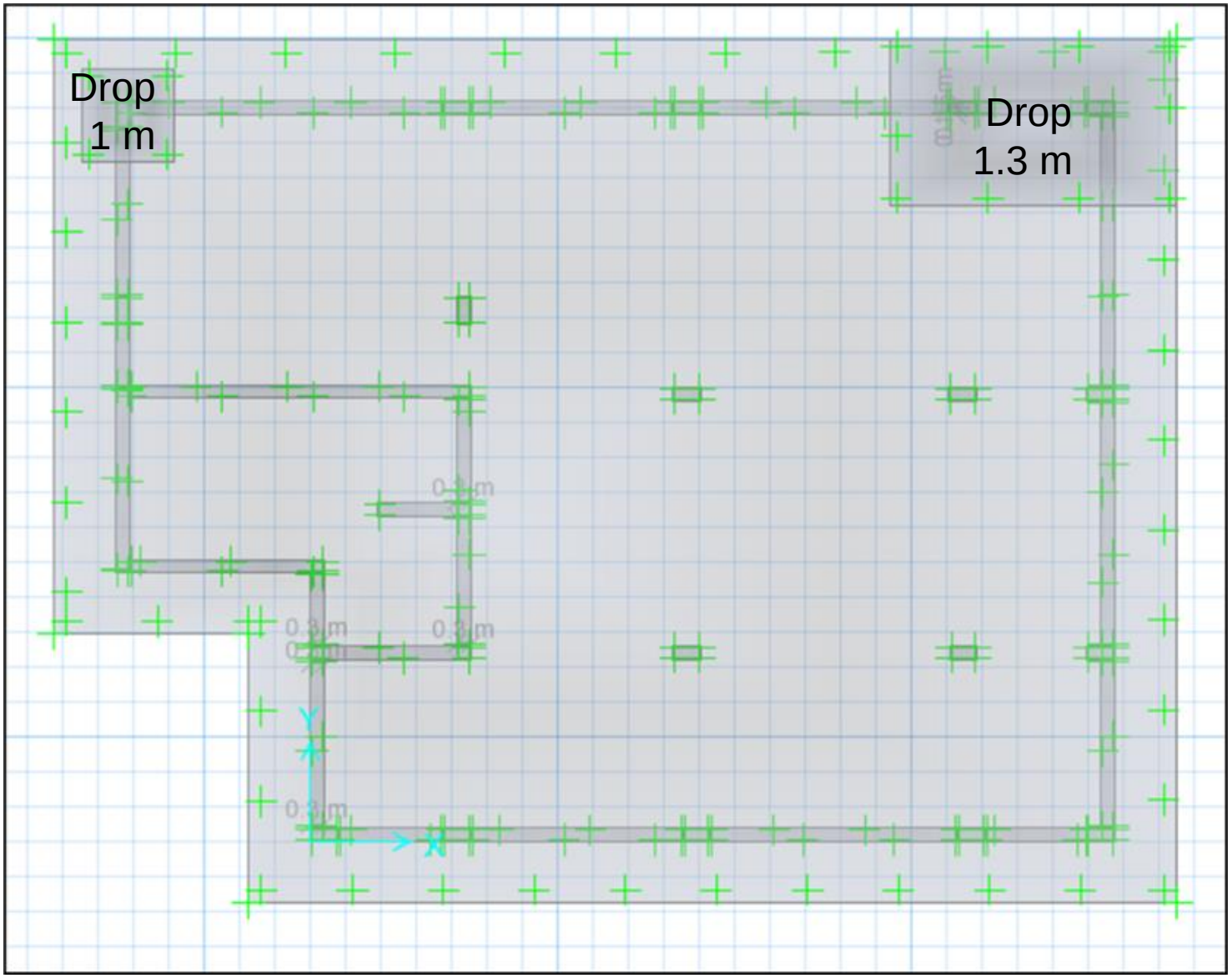
- His foundation will be done for a storage 8 story building. The raft will be used for economical consideration.

- In this project, the raft will be designed as flat plate.

- Preliminary mat thickness will be determined according to this conceptual design equation:

- $Preliminary\ mat\ thickness = number\ of\ floors * 10\ cm$ = 8 * 10= 80 cm

Final thickness of mat = 90 cm with drop panels 1.3m and 1m as shown



Chapter(6+7): SAFE Design for tow models of mat foundation (dimension &steel reinforcement)

- Design Model 1(Chapter 6):

mat foundation under effect live and dead load

- Design Model 2(Chapter 7):

mat foundation under effect live and dead in addition seismic loads

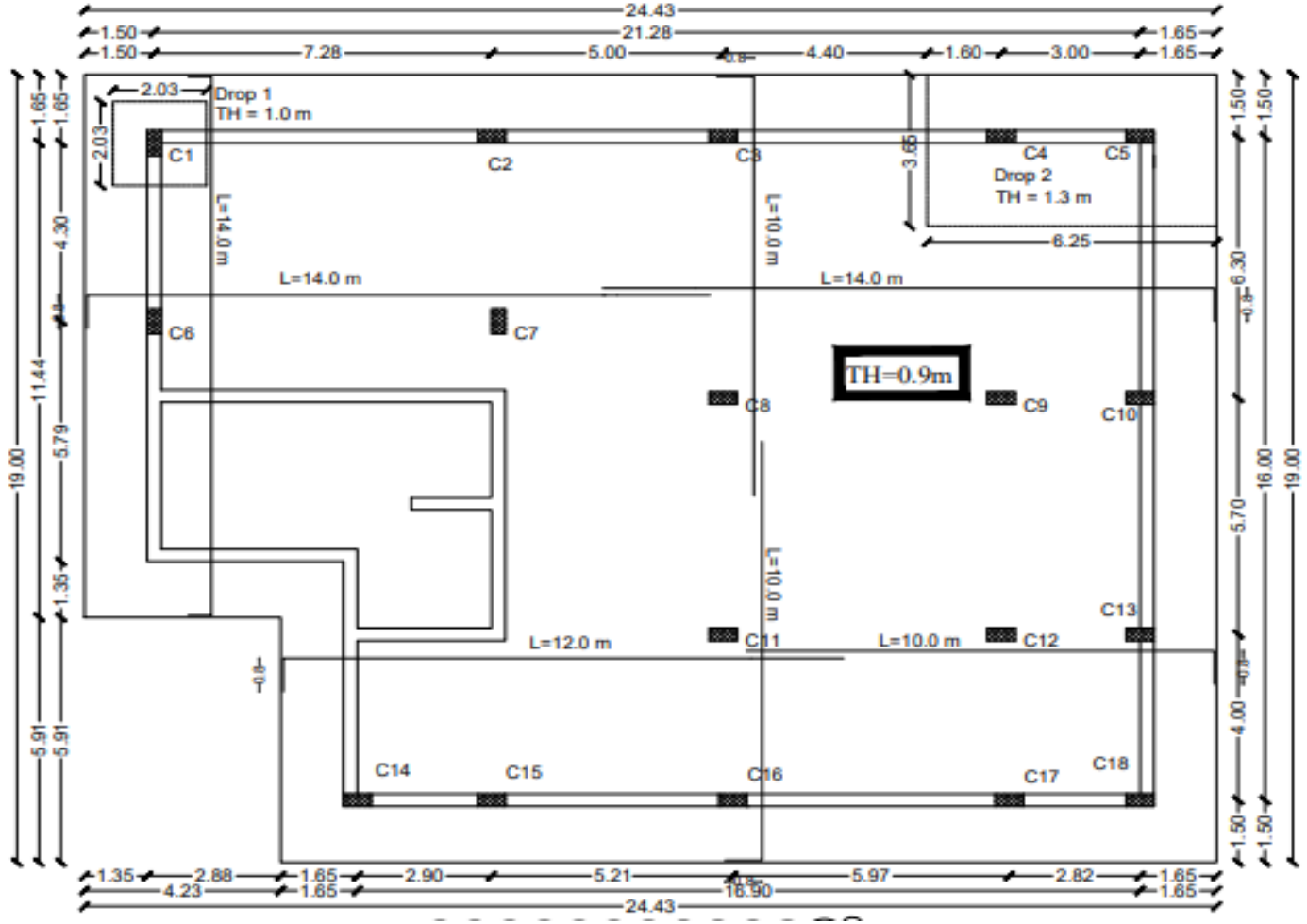
After Design the Cheeks from SAFE :

Check	Mat under effect Dead and live loads	Mat under effect live and dead and seismic loads
punching shear check	All the values less than 1	All the values less than 1
Soil pressure check (Bearing capacity)	all the values are negative and less than the bearing capacity(2.5)	all the values are negative and less than the bearing capacity(2.5)
Safe settlement analysis(Max. settlement) on depth 3.5	3.87 mm < 50 mm	8.40mm < 50 mm

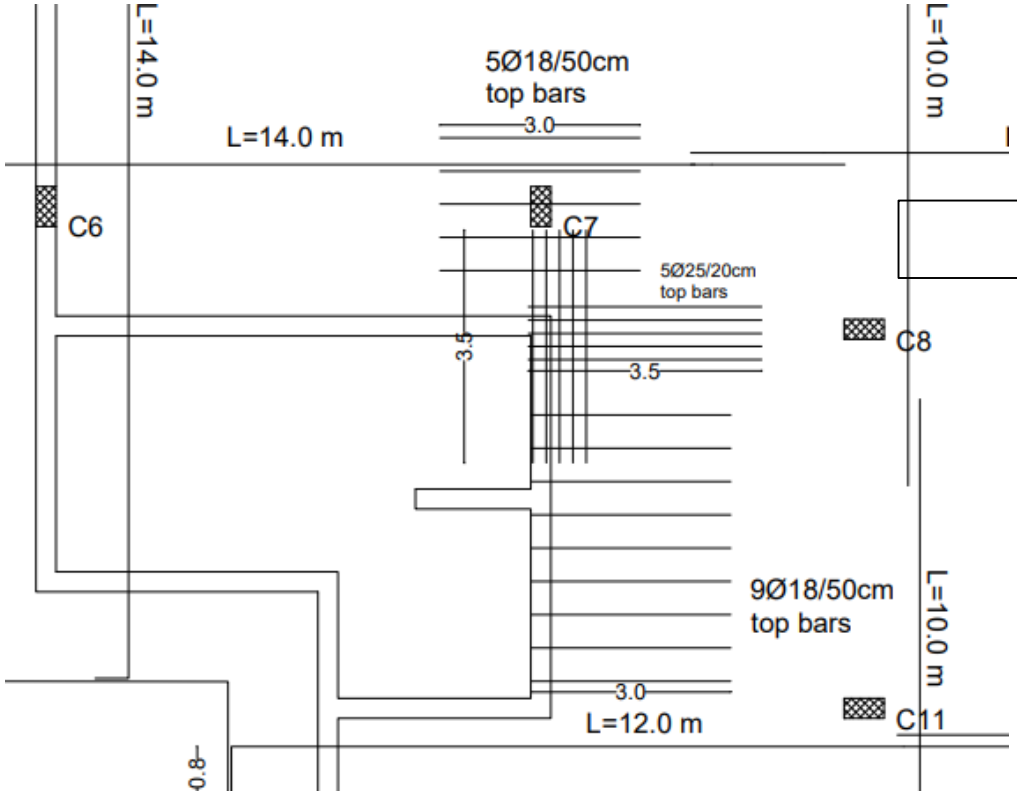
Steel reinforcement(Tow models)

- Flexural reinforcement

As,min = 0.0018xbxh = 0.0018*1000*900 = 1620 mm2/m → use 1ø20/160 mm **top and bottom bars.**



- Mat foundation longitudinal reinforcement in seismic modle



صورعن ءbottom

Shear reinforcement

	X-Direction	Distance (m)	Y-Direction	Distance (m)
C1	no need for shear reinforcement		no need for shear reinforcement	
C2	no need for shear reinforcement		1Ø10/200mm	1
C3	1Ø10/300mm	1	1Ø10/325mm	1
C4	no need for shear reinforcement		no need for shear reinforcement	
C5	no need for shear reinforcement		no need for shear reinforcement	
C6	1Ø10/225mm	1.25	no need for shear reinforcement	
C7	no need for shear reinforcement		no need for shear reinforcement	
C8	1Ø10/375mm	1	1Ø10/200mm	1
C9	no need for shear reinforcement		1Ø10/200mm	1
C10	no need for shear reinforcement		no need for shear reinforcement	
C11	no need for shear reinforcement		1Ø10/250mm	1
C12	no need for shear reinforcement		1Ø10/250mm	1
C13	no need for shear reinforcement		1Ø10/375mm	1
C14	no need for shear reinforcement		no need for shear reinforcement	
C15	no need for shear reinforcement		no need for shear reinforcement	
C16	no need for shear reinforcement		no need for shear reinforcement	
C17	no need for shear reinforcement		no need for shear reinforcement	
C18	no need for shear reinforcement		1Ø10/250mm	1

	X-Direction	Distance (m)	Y-Direction	Distance (m)
C1	no need for shear reinforcement		no need for shear reinforcement	
C2	no need for shear reinforcement		1Ø10/200mm	1
C3	1Ø10/200mm	1.5	1Ø10/200mm	1
C4	no need for shear reinforcement		no need for shear reinforcement	
C5	no need for shear reinforcement		Drop	
C6	1Ø10/100mm	1.5	no need for shear reinforcement	
C7	1Ø10/75mm	2	1Ø10/375mm	1
C8	1Ø10/225mm	1.5	1Ø10/200mm	1.2
C9	no need for shear reinforcement		1Ø10/200mm	1
C10	no need for shear reinforcement		no need for shear reinforcement	
C11	1Ø10/375mm	1.5	1Ø10/200mm	1.5
C12	no need for shear reinforcement		1Ø10/175mm	1.5
C13	no need for shear reinforcement		1Ø10/300mm	1
C14	no need for shear reinforcement		1Ø10/175mm	1
C15	no need for shear reinforcement		no need for shear reinforcement	
C16	no need for shear reinforcement		no need for shear reinforcement	
C17	no need for shear reinforcement		no need for shear reinforcement	
C18	no need for shear reinforcement		1Ø10/225mm	1