An-Najah National University

Faculty of Engineering

Civil Engineering Department

Graduation Project II

Structural Design of The Faculty of Optical and Nursing in An-Najah National University-Nablus

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- Seismic design
- Three Dimensional Structural Analysis and Design
- Column Design
- Foundation Design
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Introduction

The Faculty of Optical and Nursing is located in An-Najah National University – Nablus, which is established before 11 years.

This structure consists of a three basement floors, ground floor and two upper floors. The area of each floor is around 1242 m^2.

Uses of each floor

Floor	Area (m^2)	Height (m)	Use of floor
3rd Basement	1242	4	Instruments rooms and laboratory
2nd Basement	1242	4	Laboratory and stores
1ST Basement	1242	4	Class room and laboratory
Ground	1242	4	Class room
1st Floor	1242	4	Gests , class room and offices
2nd Floor	1242	4	Offices

Codes and Standards

- ACI 318-08: American concrete institute provisions for reinforced concrete structure design.
- UBC 97: Uniform Building Code.

Structural Materials :

* Concrete properties

Property	Value	Value
Compressive strength (f'c)	28 Mpa	35 Mpa
Modulus of elasticity (Ec)	24.87 * 10^3 Mpa	27.87* 10^3 Mpa
Unit weight of reinforced concrete	25 KN/m^3	25 KN/m^3
Uses	For all elements in structure except columns ,shear wall, and footing	For columns ,shear wall, and footing

* Reinforcement steel

Property	Value
Yielding strength (fy)	420 Mpa
Modulus of elasticity (Es)	2.04 * 10^5 Mpa

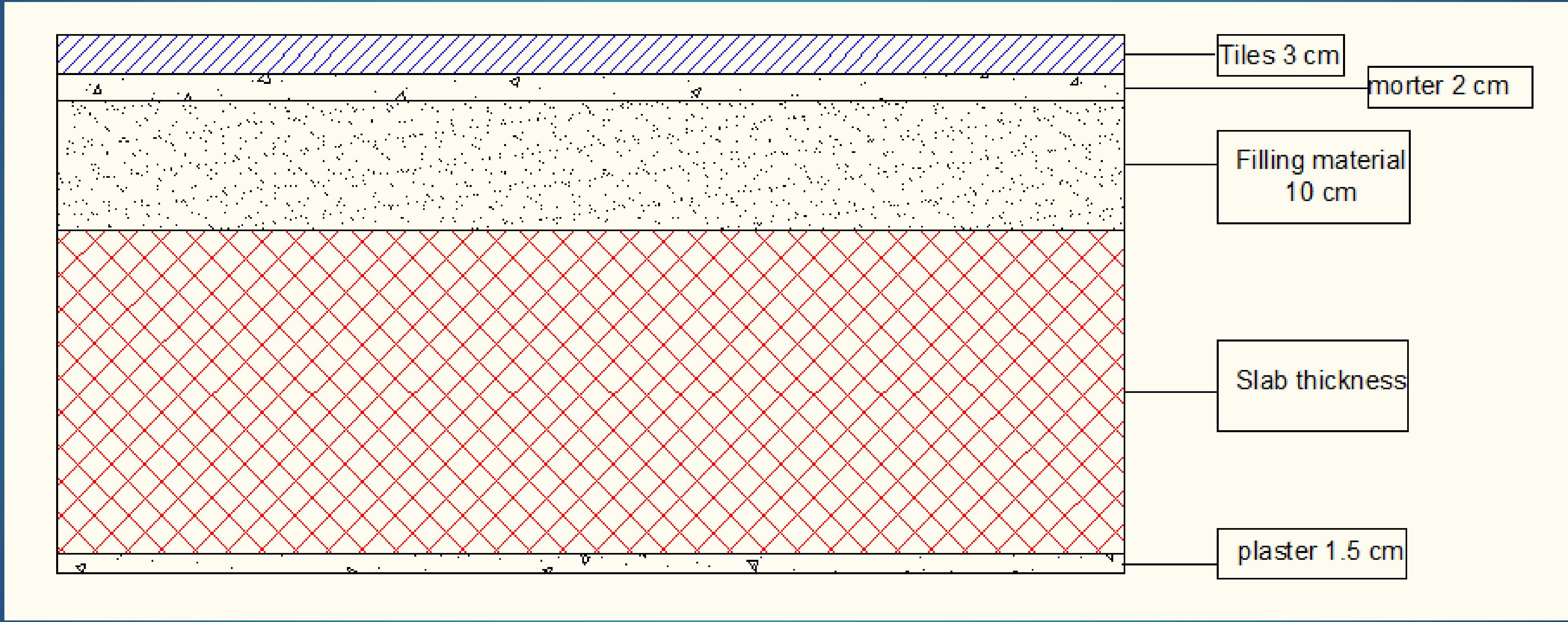
Non-Structural Materials

Material	γ in KN/m^3
Masonry	27
Mortar	23
Block	12
Plaster	23
Tile	26
Filling material	18
Plain Concrete	23
Reinforcement Concrete	25

Soil properties :

- this structure is constructed on a hard rock
- Bearing capacity of this soil is 350 KN/m2.

Section in Slab



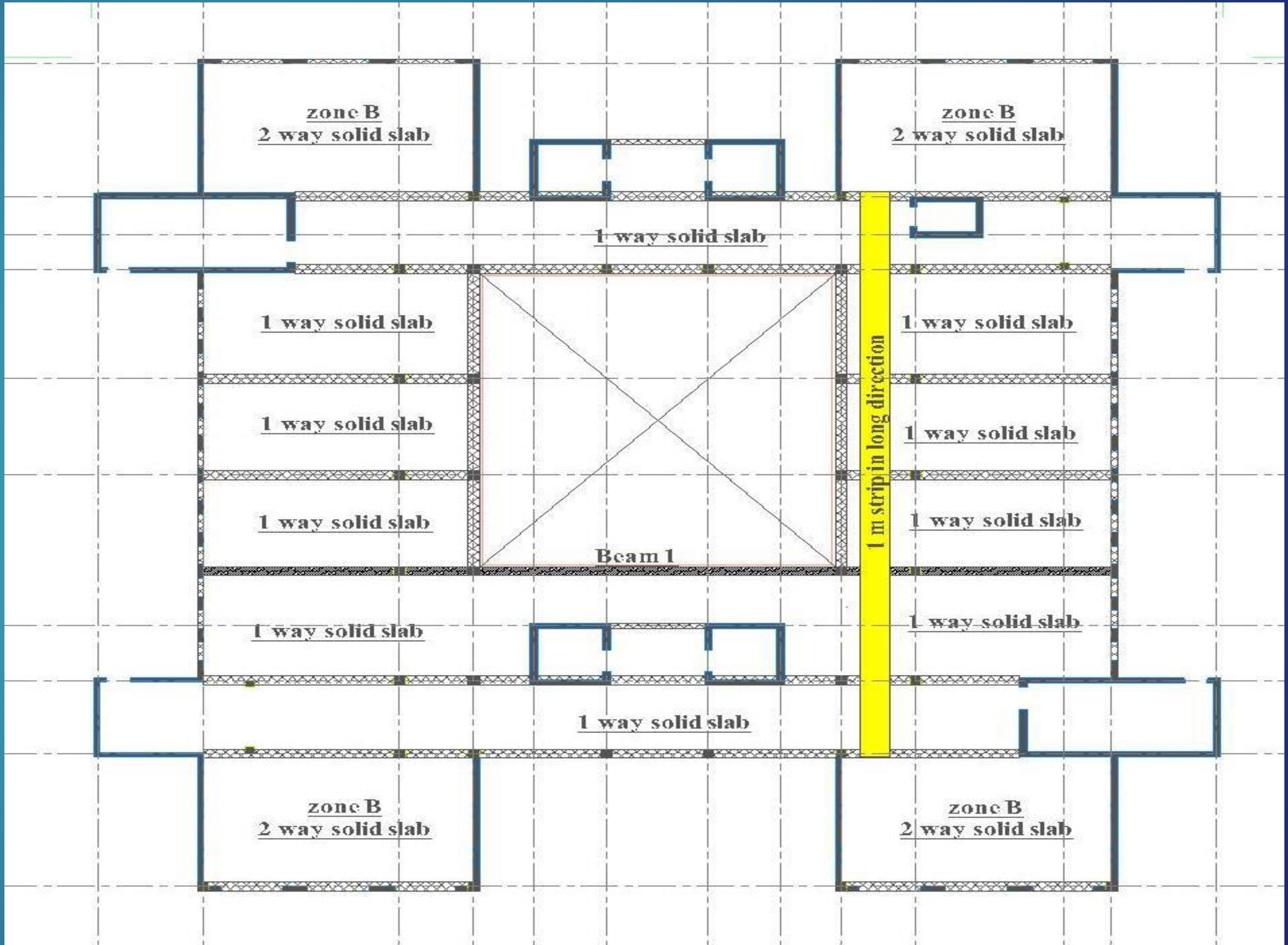
Superimposed Dead Load & Live Load

Floor	Dead Load (KN/m^2)	Live load (KN/m^2)
3rd Basement	4	5
2nd Basement	4	5
1ST Basement	4	5
Ground	4	5
1st Floor	4	2.5
2nd Floor	1	10

Preliminary Design

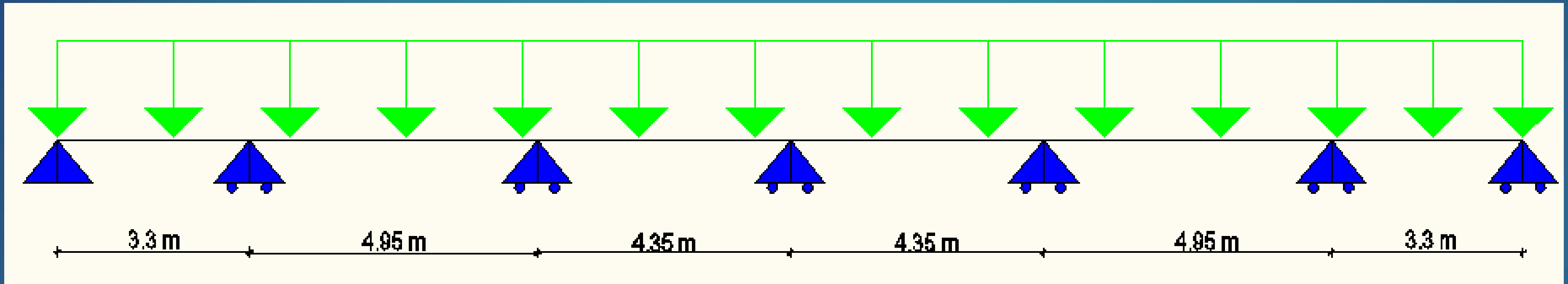
Slab

- The slab will be designed as 1-way and 2-way solid slab
- The figure shows a plan for one slab (second floor slab)



Slab Preliminary dimensions

- The figure below shows a 1-D model for second floor slab



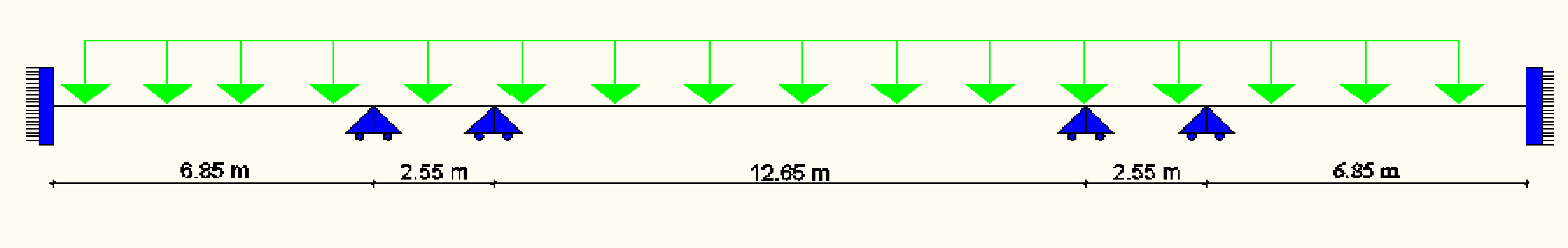
- According to ACI table:
- h1 (min) = Ln/24 (for one end continuous) = 3.3/24 = 137.5 mm.
- h2 (min) = Ln/28 (for two end continuous) = 4.95/28 = 176.7 mm.
- So, h min = 176.7 mm
- We take h=200 mm

The table shows the selected thickness for each slab

Slab	Thickness
Slab 1 (second floor)	200 mm
Slab 2 (first floor)	200 mm
Slab 3 (Ground floor)	200 mm
Slab 4 (first basement floor)	250 mm
Slab 5 (second basement floor)	250 mm
Slab 6 (third basement floor)	250 mm

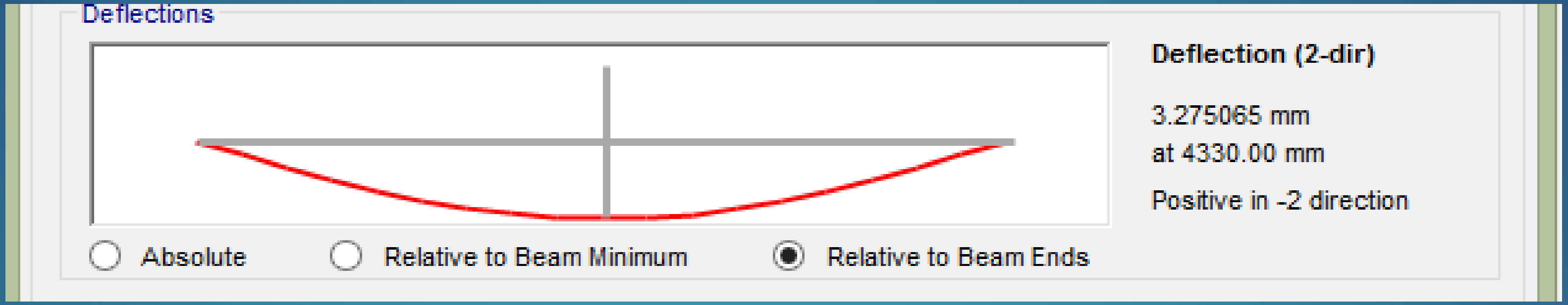
Beam Preliminary dimensions

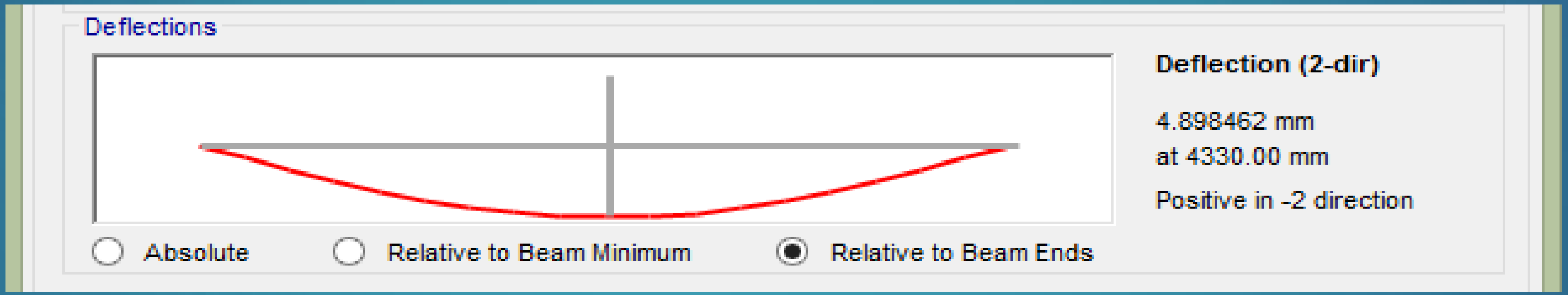
The figure bellow shows a 1-D model for second floor slab



- According to ACI table:
- $H_{\text{min 1}} = \frac{6.55}{18.5} = 0.354$ m
- $H_{\text{min 2}} = \frac{12.650}{21} = 0.602$
- We will take H= 800 mm

Check for serviceability:





The maximum deflection on the beam:

$\Delta allowable = \frac{\mathrm{L}}{240}$ ACI 318-08 Table 9.5 (b) maximum deflections

$\Delta allowable = \frac{12.625}{240} = 52.6$ mm

Total long-term deflection:

$\Delta = 1.5\ \Delta live + 2\ \Delta dead = 13.875$ mm

The preliminary dimension for beams

Beam	Thickness
Beam 1 (for second floor)	800 mm
Beam 2 (for first floor)	400 mm
Beam 3 (for Ground floor)	400 mm
Beam 4 (for first basement floor)	850 mm
Beam 5 (for second basement floor)	850 mm
Beam 6 (for third basement floor)	850 mm

Seismic Load

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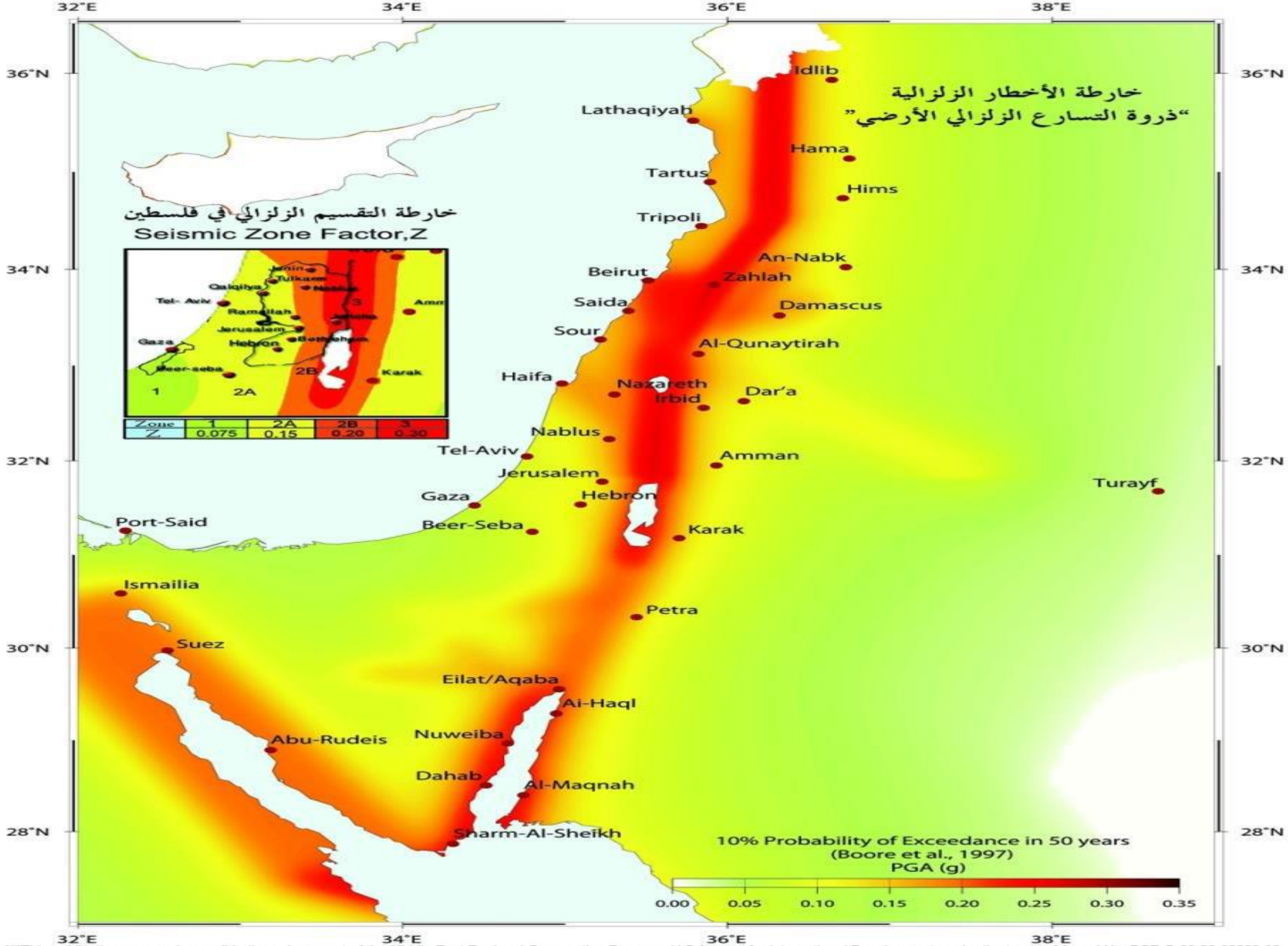
SEISMIC HAZARD MAP FOR BUILDING CODES IN THE LEVANT



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- Seismic load will be calculated depending on UBC-97.
- the location of the structure is (Nablus) .
- Soil type (rock) , with bearing capacity = 350 KN/m^2
- According to Palestinian seismic map,
- seismic zone is **2B** thus the value of zone factor is **(Z=0.2)**. From UBC-97 table 16-I
- Soil classification is **SB**, From UBC-97 table 16-J

structure period:

- $T = Ct * (hn)^{3/4}$ → UBC-97 Eq(30-8)

  where: hn = height of the building = 24 m
  Ct = 0.048

- T= 0.52 sec

Base shear

- We use static lateral force method

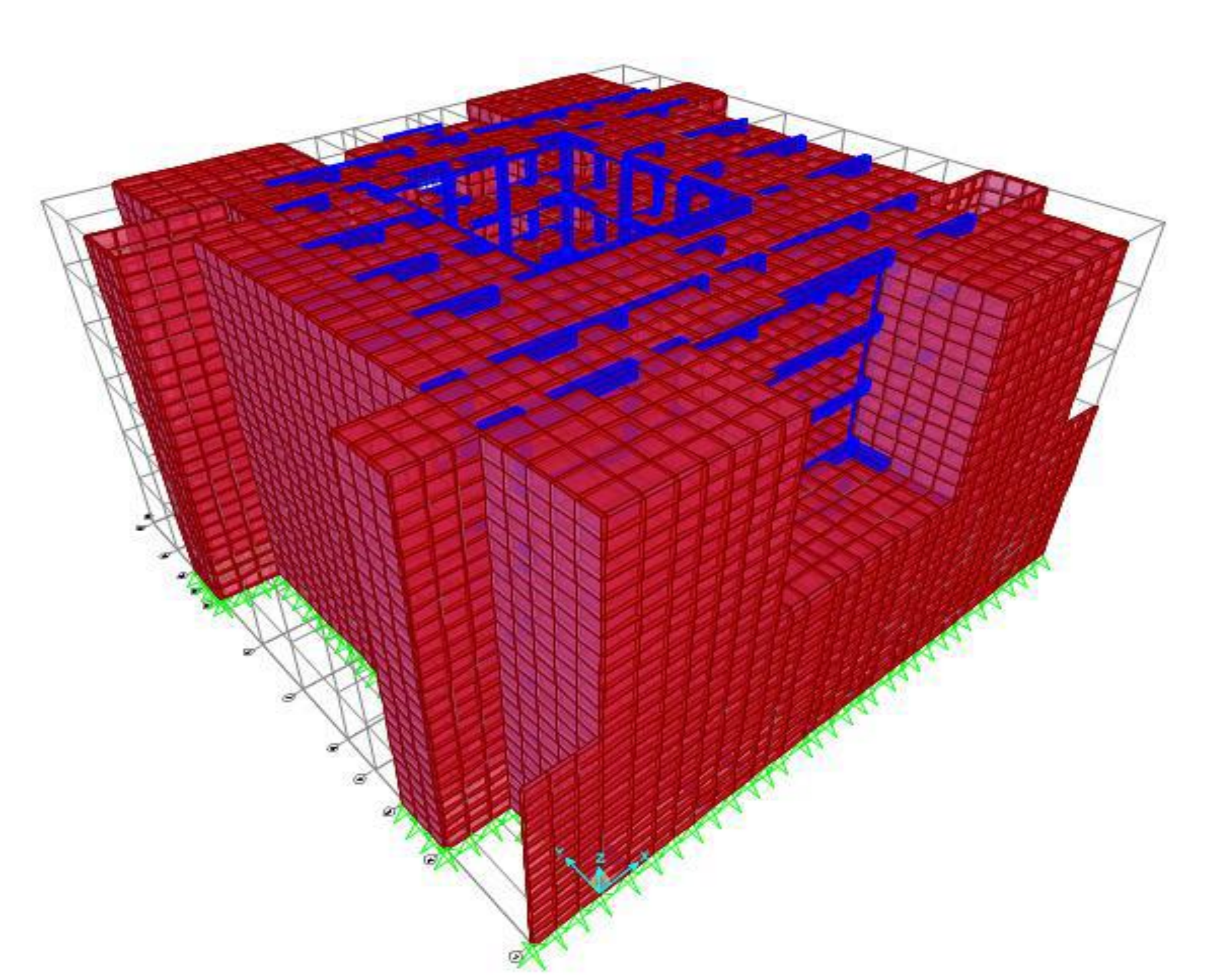
where $V = \frac{Cv * I}{R * T} W$ → UBC 97 – Eq (30-4)

- W = the total seismic dead load
- R = the response modifier = 5.5 → UBC 97 – table 16-N
- I = the importance factor = 1 → UBC 97 – table 16-K
- CV =seismic coefficient = 0.2 → UBC 97 – table 16-R
- → base shear : V = 0.0687 * W
- According to UBC → Vmax = (2.5*Ca*I/R)W = 0.09 W
  Vmin = 0.11*Ca*W = 0.022 W

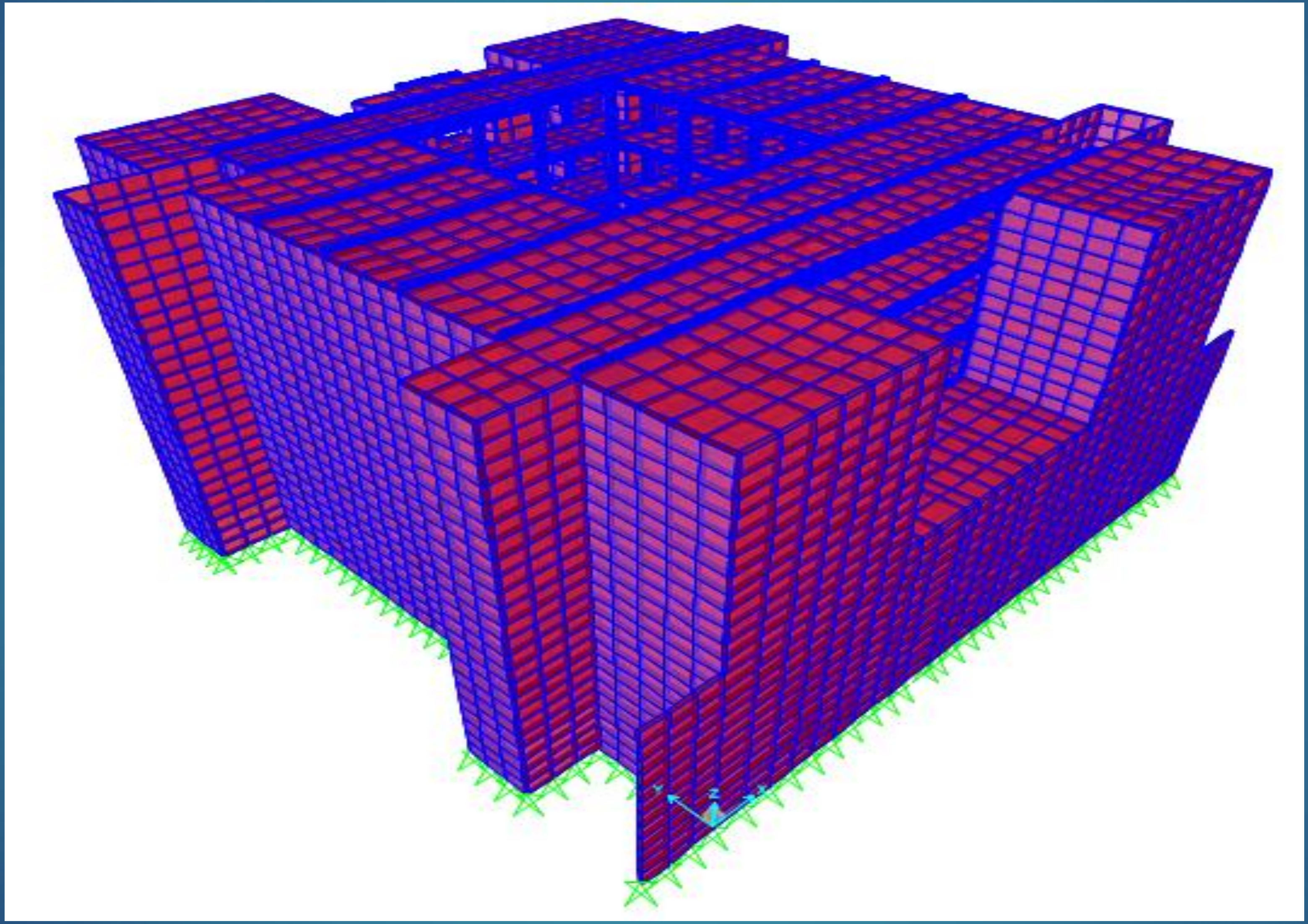
  Where: Ca = Seismic coefficient = 0.2 → UBC-97 table 16-Q
- V min < (V =0.0687 W) < V max → OK.

3D Model

- The structure was built using sap 18 program
- We define all section for columns, beam, shear wall, slab
- We put pin supports under the structure



Compatibility Check



Period and modal participation ratio

OutputCase	StepType Text	StepNum Unitless	Period Sec	UX Unitless	UY Unitless	UZ Unitless	SumUX Unitless	SumUY Unitless
MODAL	Mode	1	0.306983	7.329E-09	1.074E-06	0.01711	7.329E-09	1.074E-06
MODAL	Mode	2	0.271783	1.082E-05	9.089E-06	0.01447	1.083E-05	1.016E-05
MODAL	Mode	3	0.264159	1.907E-06	3.749E-06	0.00222	1.274E-05	1.391E-05
MODAL	Mode	4	0.245102	0.62186	0.00086	4.188E-06	0.62187	0.00087
MODAL	Mode	5	0.230083	9.033E-07	4.288E-05	5.369E-05	0.62187	0.00092
MODAL	Mode	6	0.217519	8.802E-05	8.821E-06	0.00264	0.62196	0.00093
MODAL	Mode	7	0.2042	0.00014	6.991E-05	0.00113	0.6221	0.001
MODAL	Mode	8	0.192311	7.522E-06	0.00119	4.036E-05	0.62211	0.00219
MODAL	Mode	9	0.176576	0.00095	0.73964	0.00027	0.62306	0.74183
MODAL	Mode	10	0.162044	0.00111	5.687E-05	2.909E-05	0.62417	0.74188
MODAL	Mode	11	0.152251	0.00031	0.00858	0.02113	0.62447	0.75046
MODAL	Mode	12	0.133029	0.00213	0.0001	0.00028	0.62661	0.75056
MODAL	Mode	13	0.09624	0.00076	0.01828	0.00622	0.62736	0.76885
MODAL	Mode	14	0.091042	0.22346	6.535E-05	0.00017	0.85082	0.76891
MODAL	Mode	15	0.072289	0.00059	0.13211	0.00073	0.85141	0.90103
MODAL	Mode	16	0.061426	0.06335	0.00091	0.00054	0.91476	0.90193

Equilibrium Check

Base Reactions

File View Format-Filter-Sort Select Options

Units: As Noted

Filter:

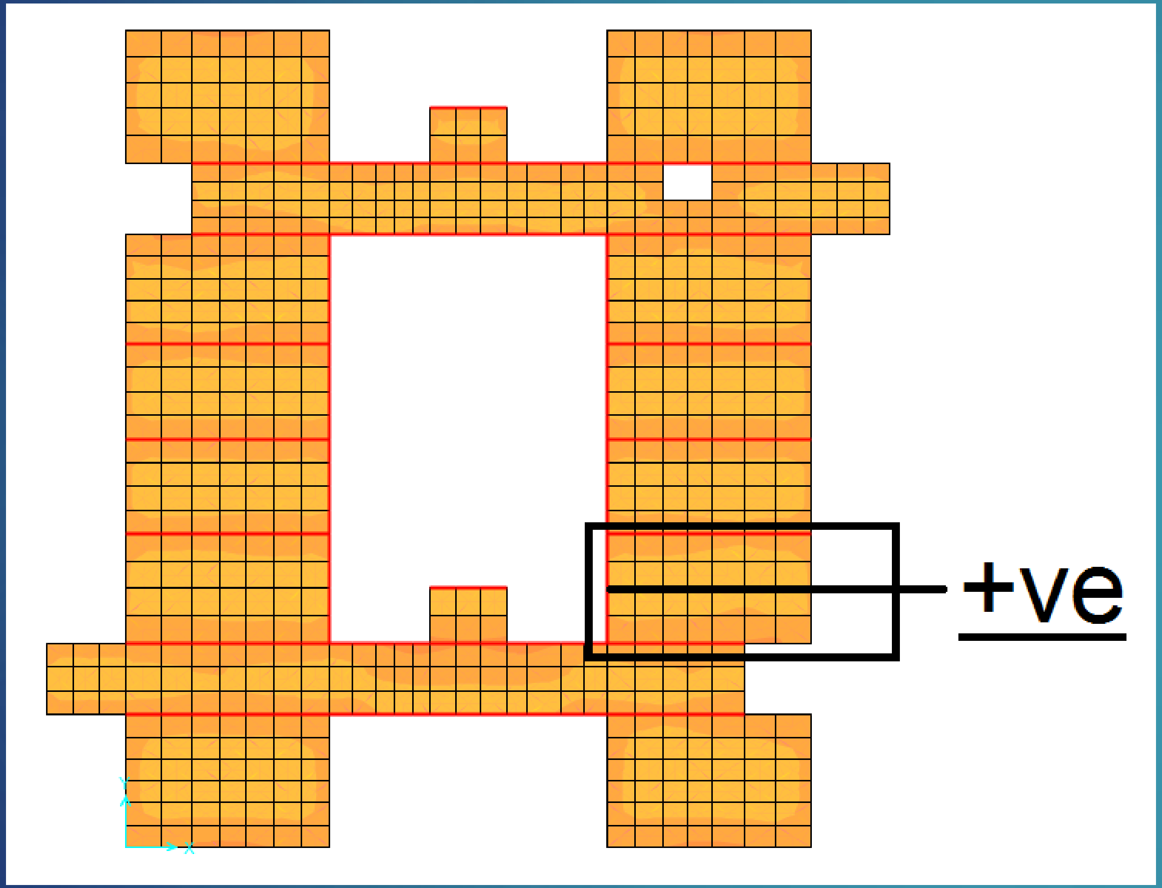
Base Reactions

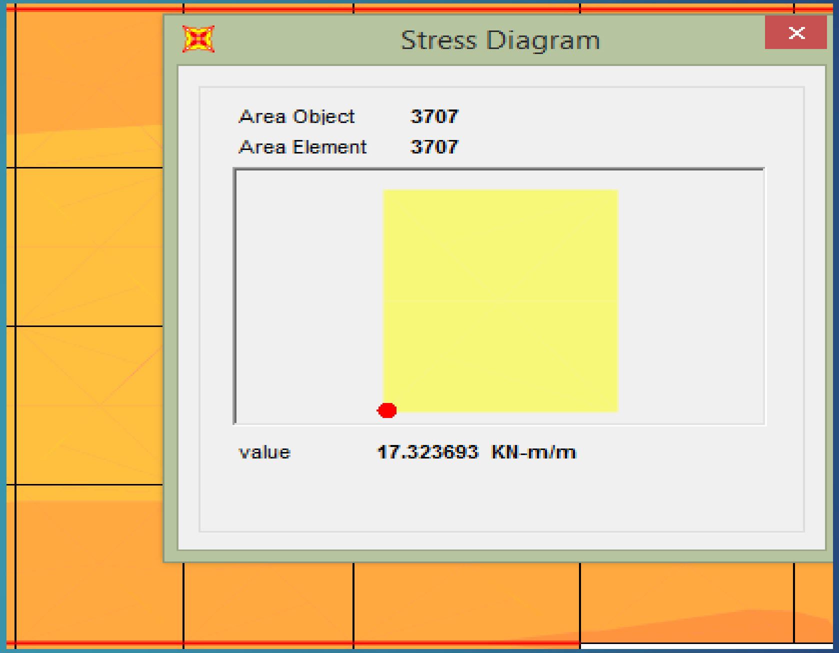
OutputCase	CaseType Text	GlobalFX KN	GlobalFY KN	GlobalFZ KN	GlobalMX KN-m	GlobalMY KN-m	GlobalMZ KN-m	GlobalX m	GlobalY m	GlobalZ m	XCe
DEAD	LinStatic	5.767E-11	2.307E-11	71019.514	1313442.289	-1116771.01	-3.603E-10	0	0	0	
Suoerimpoo...	LinStatic	1.155E-11	5.915E-12	18314.317	329251.648	-284930.48	3.536E-11	0	0	0	
Live	LinStatic	2.806E-11	1.389E-11	33856.13	613424.38	-527559.45	3.86E-11	0	0	0	

Load type	Hand results KN	SAP results KN	Difference %
Dead	68571	71019	3.4
Live	33753	33856	0.3
Superimposed	18207	18314	0.6

Stress Strain relationship

slab moment

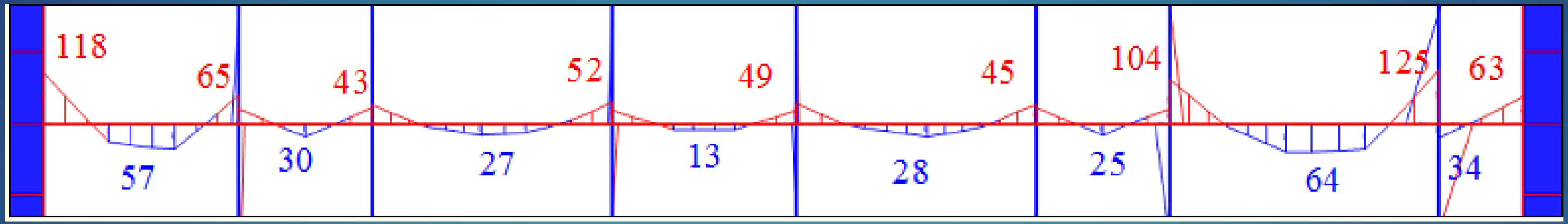


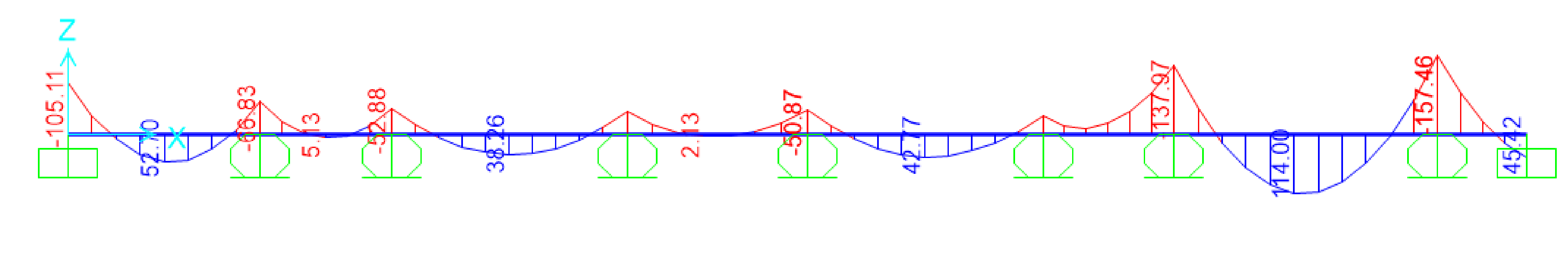


Difference between 1-D and 3-D model

- $\% \text{ error} = \frac{17.32 - 17.72}{17.72} * 100\% = 2.3\% < 10\%$, OK

Beam moments

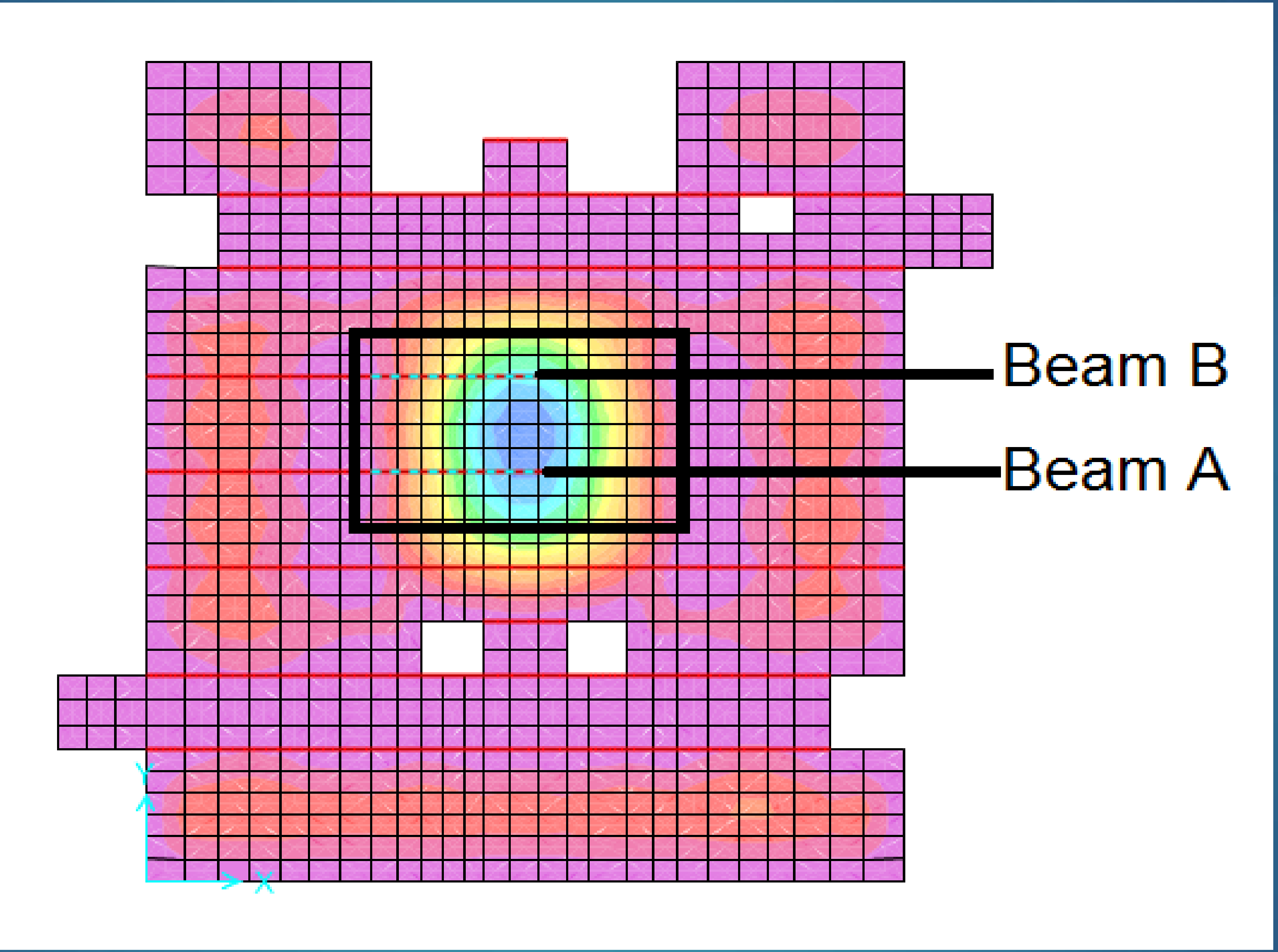




% error = $\left(\frac{942-954.93}{942}\right)$*100% = 1.4% which is less than 10%, OK

3.3.5 Check slab for deflection (Serviceably check):

- *Actual beams deflection = total beam deflection - average axial deformation of columns that support the beam.
- * Actual floor deflection = total deflection - the average axial deformation of the four surrounding columns.
- * Actual slab deflection = Actual floor deflection - the average actual beams deflection

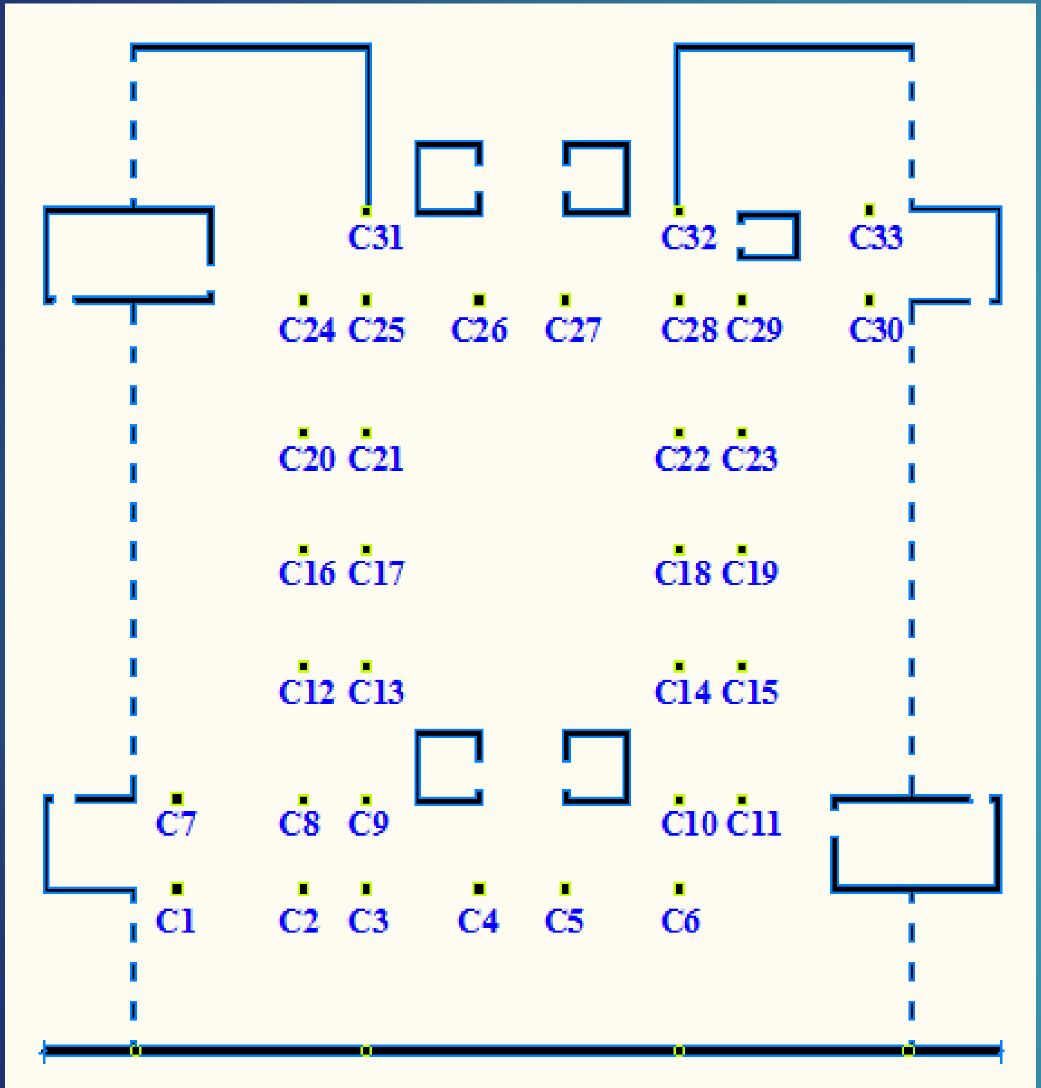


Beam B
Beam A
Y
X

- Δ (Total dead) = 5 mm.
- Δ (Live) = 1.9525 mm.
- The long-term deflection = 13.928 mm.
- The allowable deflection = L/240 = 4.35/240 = 0.018125 m=18.125 mm
- 12.928 < 18.125, OK

Columns Design

- In this project, columns will be classified as group according to the range of axial load. All columns of the building are assumed as squares (40 *40) cm



Group number	Column number	Axial force range KN	Critical columns
1	C31,C32,C33	400-1000	C33=659 KN
2	C1,C3,C4,C5,C6,C7, C9,C10,C11 C22,C24,C25,C26,C 27,C28,C29,C30	1000-2000	C22=1752 KN
3	C2,C8,C12,C13,C14, C15,C16,C17 C18,C19,C20,C21,C 23	2000-3000	C18=2939 KN

- Columns are classified into short and long columns according to the effect of buckling on each type

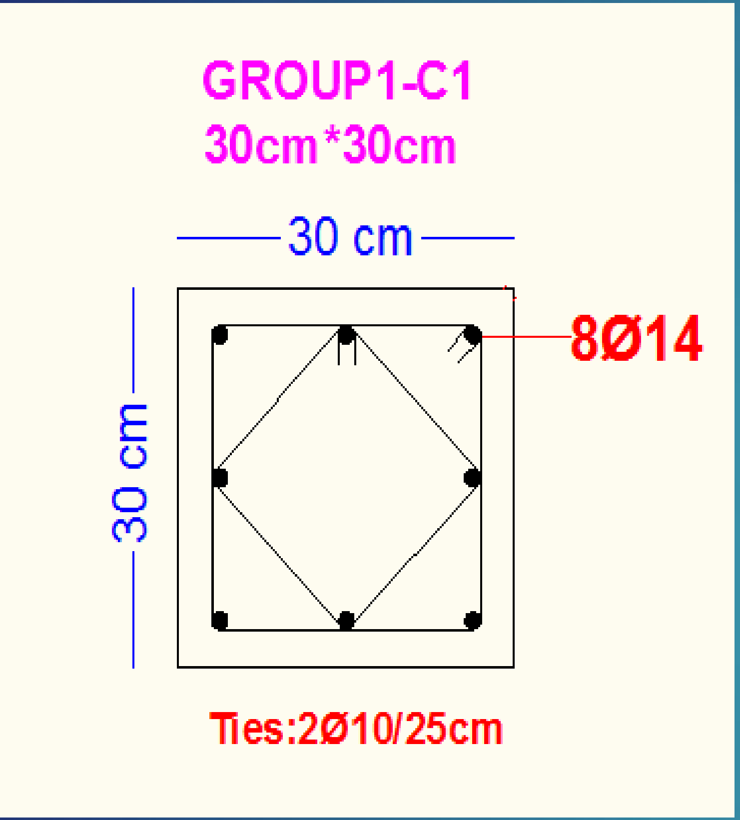
- All columns are short columns , and we used the below equation according to ACI 318 to check the columns for buckling
- $\frac{K\ Lu}{r} \leq 34 - 12(M1/M2)$

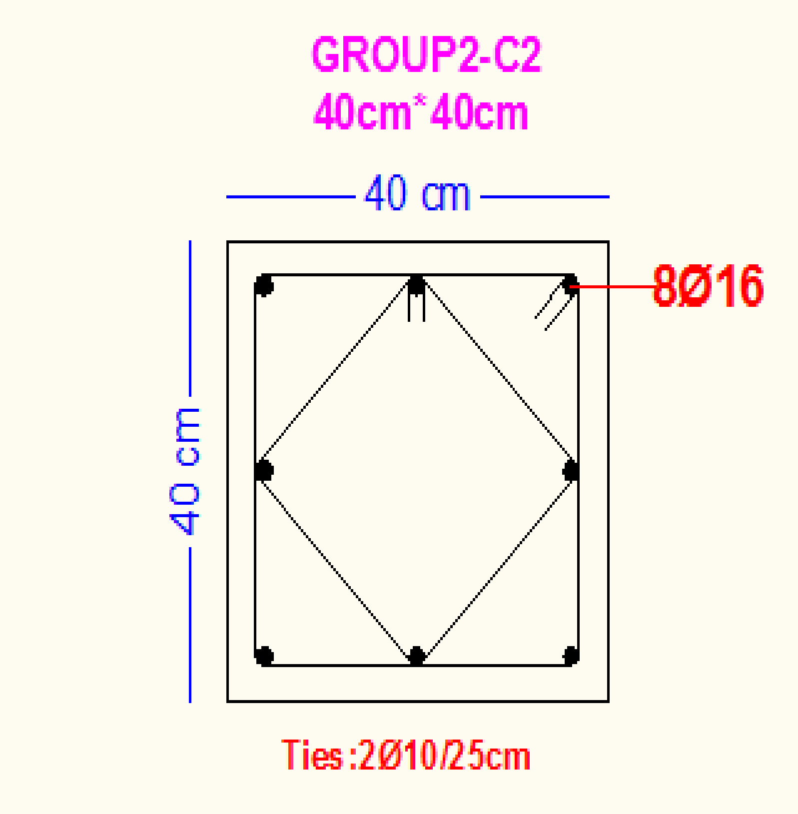
- For design the columns we take a critical column for each group and design it

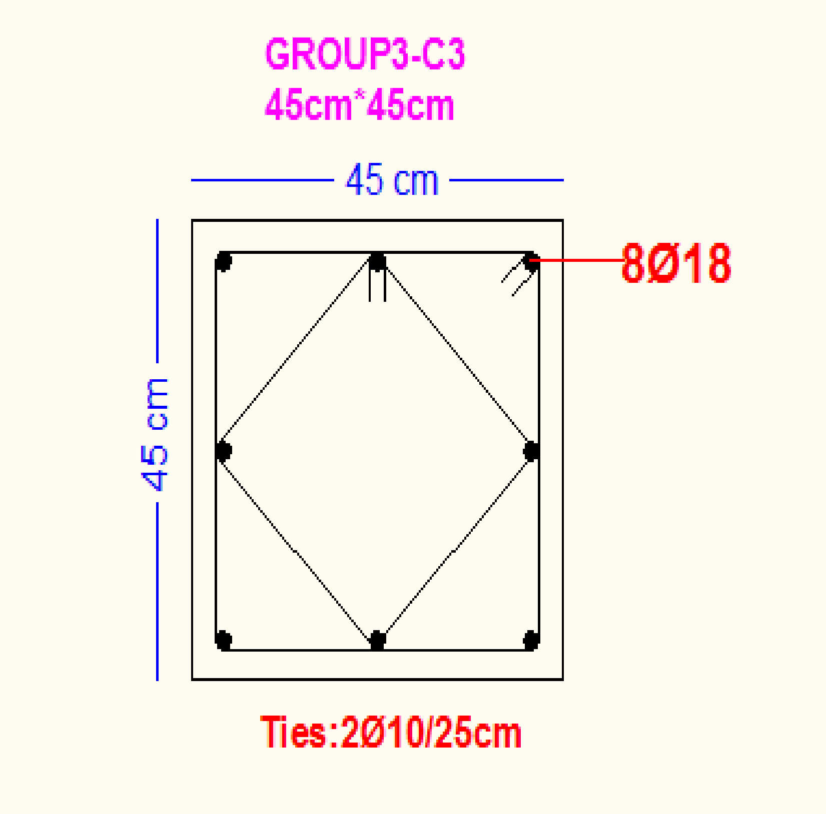
- For computing gross area of the columns, we assume Pu= Ø Pn
- **Ø Pn = Ø λ (0.85*f'c(Ag-As) + As (Fy))**
- Ø Pn: Capacity of column in compression axial force.
- Ø: 0.65 for tied columns and 0.75 for spiral columns.
- λ: 0.8 for tied columns and 0.85 for spiral columns.
- Ag: Gross sectional-area of the column.
- As: Area of longitudinal steel → As = ρ Ag → assuming ρ=0.01 then As=0.01Ag
- fc': Concrete compression capacity in MPa.
- fy: Steel yielding strength in MPa

columns design values

Group #	Critical Column #	Pu KN	Ag mm^2	Dimension mm	As mm^2	Reinforcement	Ties mm
1	C33	659	40285	300*300	900	8 Ø 14	2Ø10/250
2	C22	1752	107600	400*400	1600	8 Ø 16	2Ø10/250
3	C18	2939	167942	450*450	2500	8 Ø 18	2Ø10/250


GROUP1-C1
30cm*30cm
30 cm
30 cm
8Ø14
Ties:2Ø10/25cm


GROUP2-C2
40cm*40cm
40 cm
40 cm
8Ø16
Ties:2Ø10/25cm


GROUP3-C3
45cm*45cm
45 cm
45 cm
8Ø18
Ties:2Ø10/25cm

Foundation design

- Bearing capacity of the soil is 350 KN/m2.

- we design all footing as single, combined and wall footing.

- We have three group of single footing according to the axial load on columns, the group of foundation are the same of columns groups.

- footing are designed as single footing, and if the areas of two footing interact to each other or the stress under two footing is more than 350 KN/m^2 they are designed as combined footing.

Single footing design

Footing dimension → A = Pservice / q all

Footing thickness:

 # wide beam shear

$$Vu = qu\left(\frac{l-c}{2} - d\right)$$

$$\text{øVc} = ø * (1/6) * \sqrt{f'c} * bw * d$$

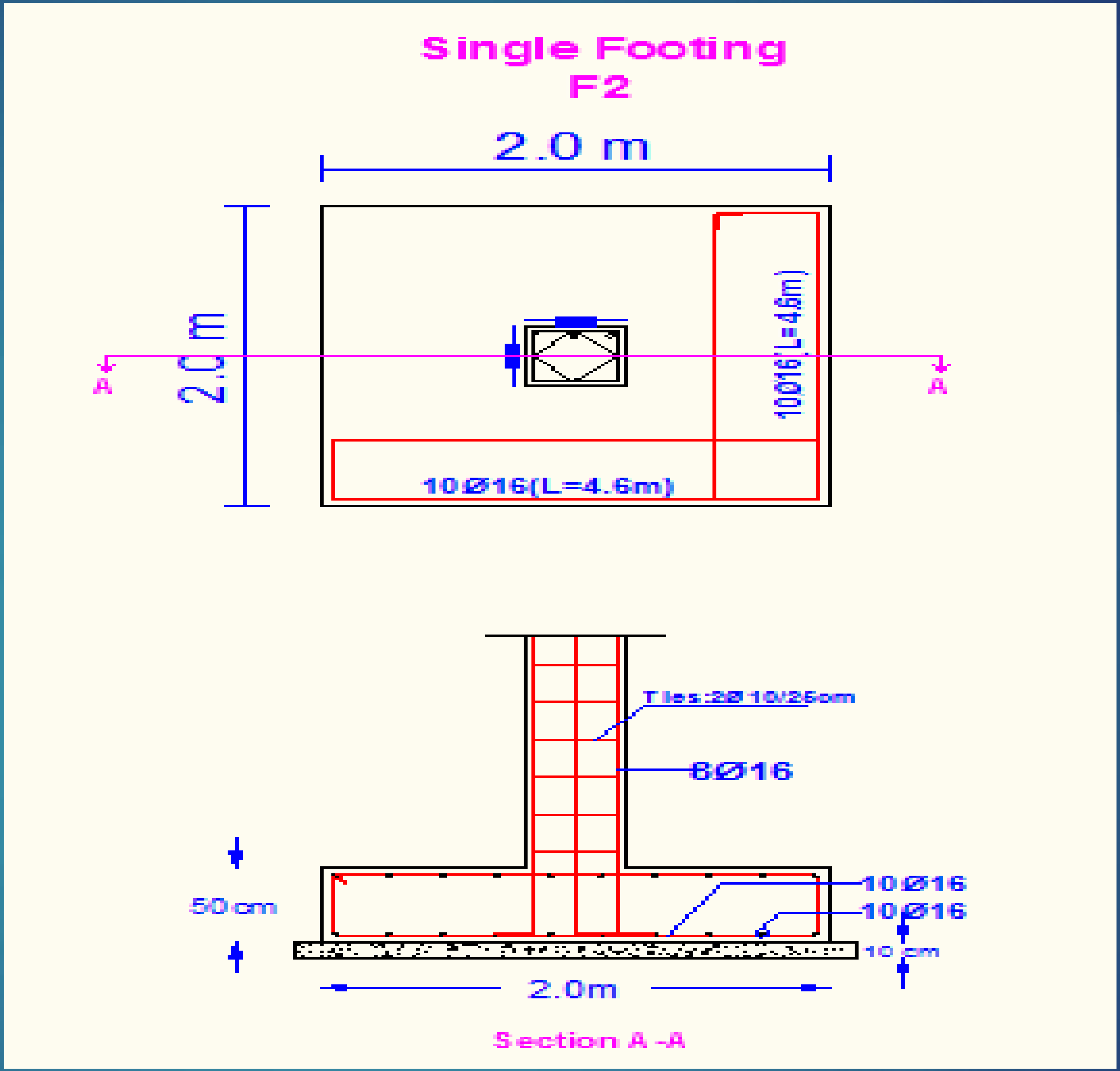
 # punching shear:

Vu punching = Pu – qu (c+d)^2

$$\text{øVcp} = ø * 0.33 * \sqrt{f'c} * bo * d$$

Footing number	Columns number	Length *width (m)	Depth (m)	Bottom steel (in each direction)	Top steel (in each direction)
F1	C31,C32,C33	1.5*1.5	0.4	1Ø14 /200 mm	1Ø14 /200 mm
F2	C1,C3,C4,C5,C6,C7,C9,C10, C11,C22,C24,C25,C26,C27, C28,C29,C30	2*2	0.5	1Ø16 /200 mm	1Ø14 /160 mm
F3	C2,C8, C23	2.6*2.6	0.7	1Ø22 /140 mm	1Ø12/150 mm

F2 design

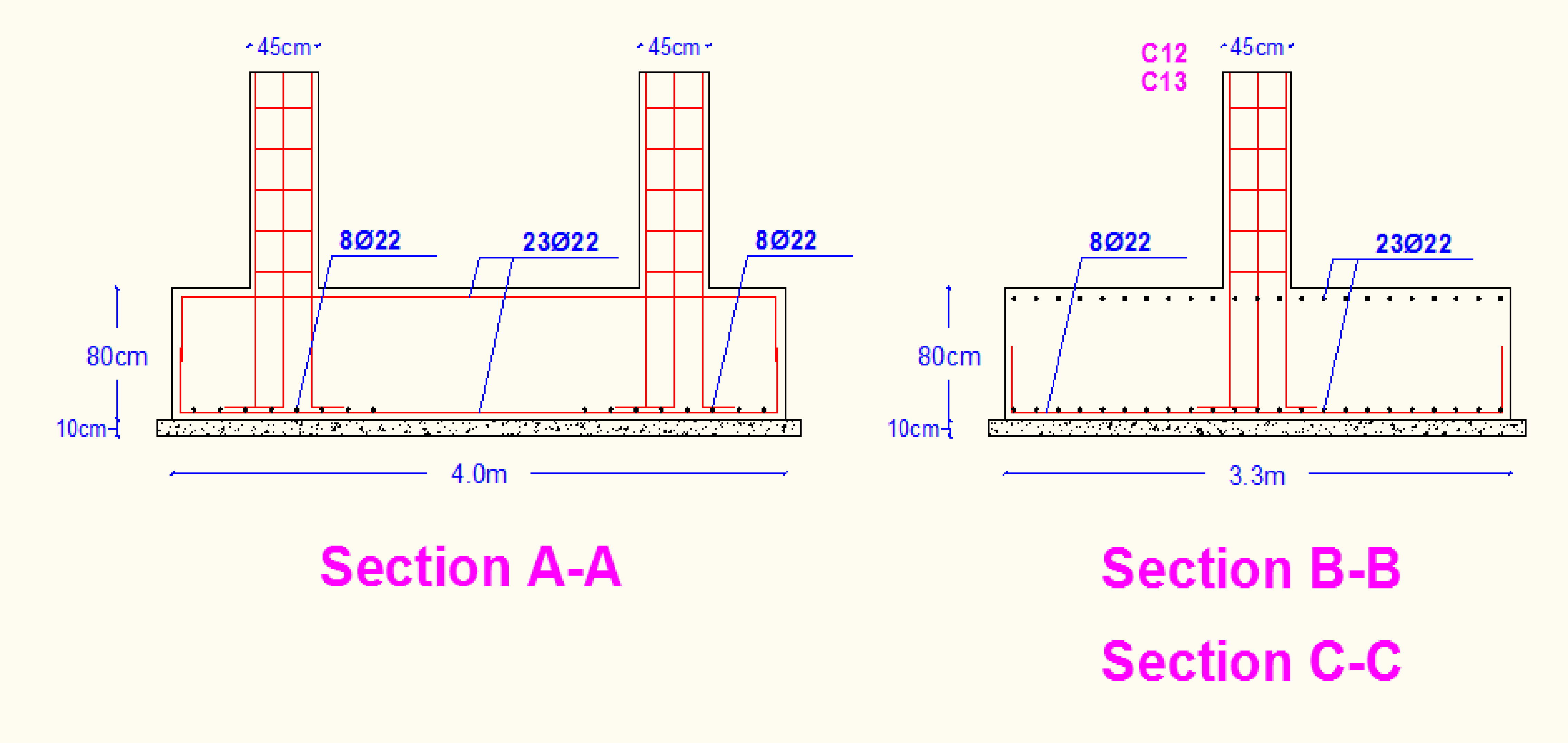

Single Footing
F2
2.0 m
2.0 m
A
A
10Ø16(L=4.6m)
10Ø16(L=4.6m)
Tiles:2Ø10/25cm
8Ø16
50 cm
10Ø16
10Ø16
10 cm
2.0m
Section A-A

Combined Footing Design

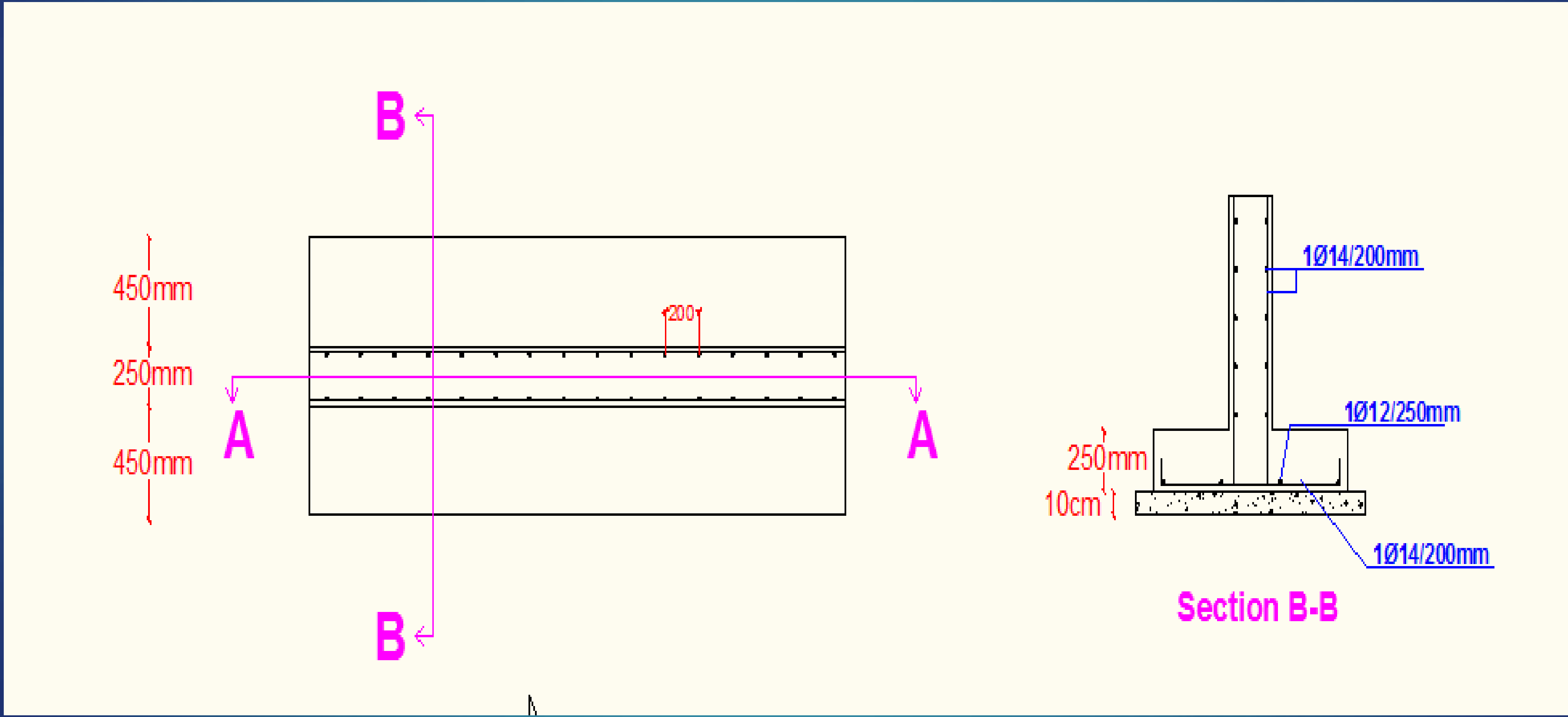
- We design 2 footing as combined footing

Footing number	Columns number	Length (m)	Width (m)	Depth (m)
F4	C12-C13	4	3.3	0.8
F5	C14-C15	4.3	3	0.7

F4 Design


45cm
45cm
45cm
C12
C13
8Ø22
23Ø22
8Ø22
8Ø22
23Ø22
80cm
10cm
80cm
10cm
4.0m
3.3m
Section A-A
Section B-B
Section C-C

Shear wall and wall footing



Thank You For Listening