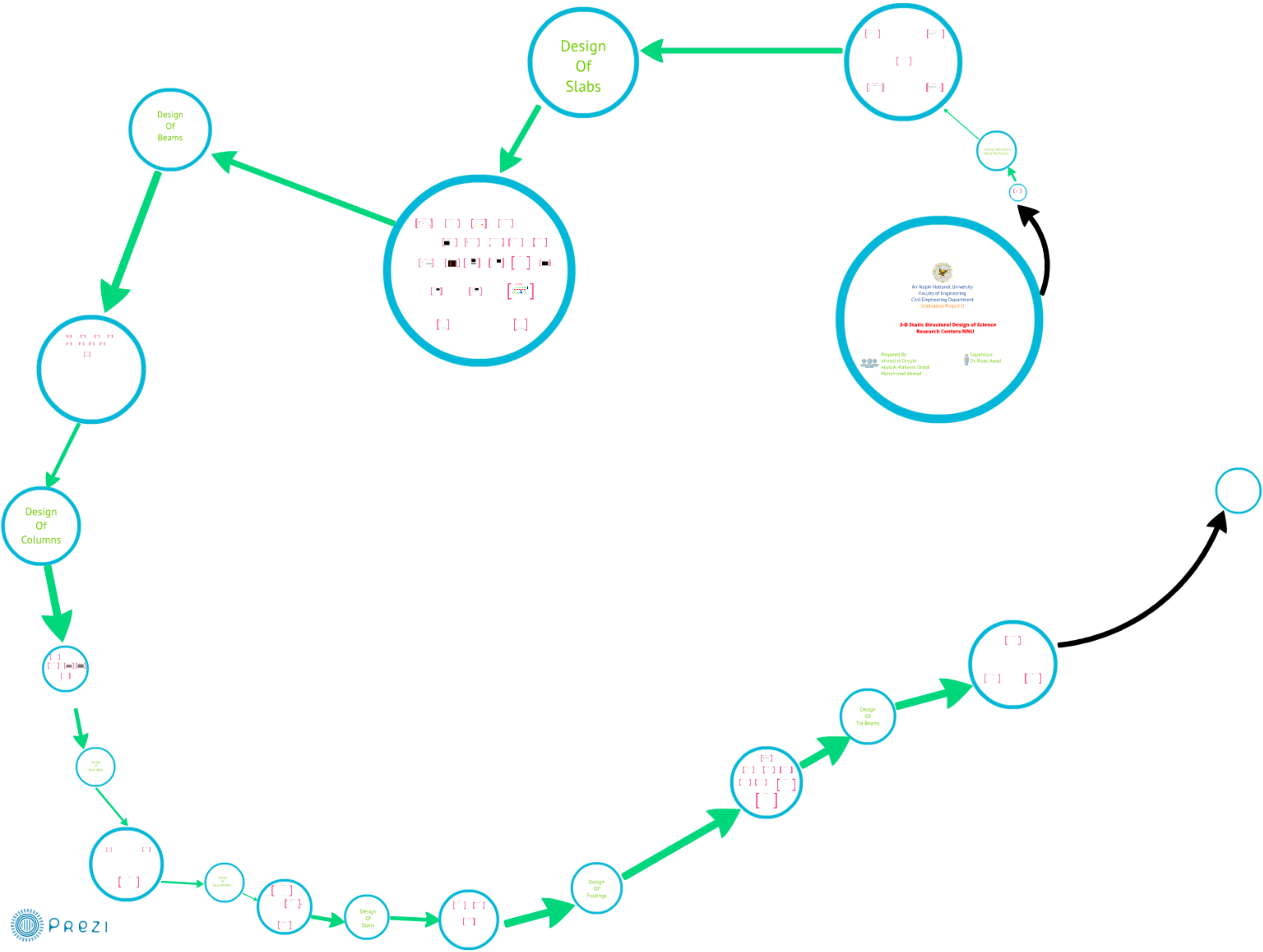

An-Najah National University
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Graduation Project II
3-D Static Structural Design of Science Research Centers-NNU
Prepared By:
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Mohammad Ahmad
Supervisor:
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Design Of Slabs
Design Of Beams
Design Of Columns
Design Of Stairs
Design Of Footings
Design Of Tie Beams

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Presentation Outline

- Project Description.
- Design Determinants.
- Preliminary Design.
- 3D- Modeling & Checks.
- Static Design.
  - Slabs.
  - Beams.
  - Columns.
  - Shear walls.
  - Basement Walls.
  - Stairs.
  - Footings.
  - Tie Beams.

General Information About The Project

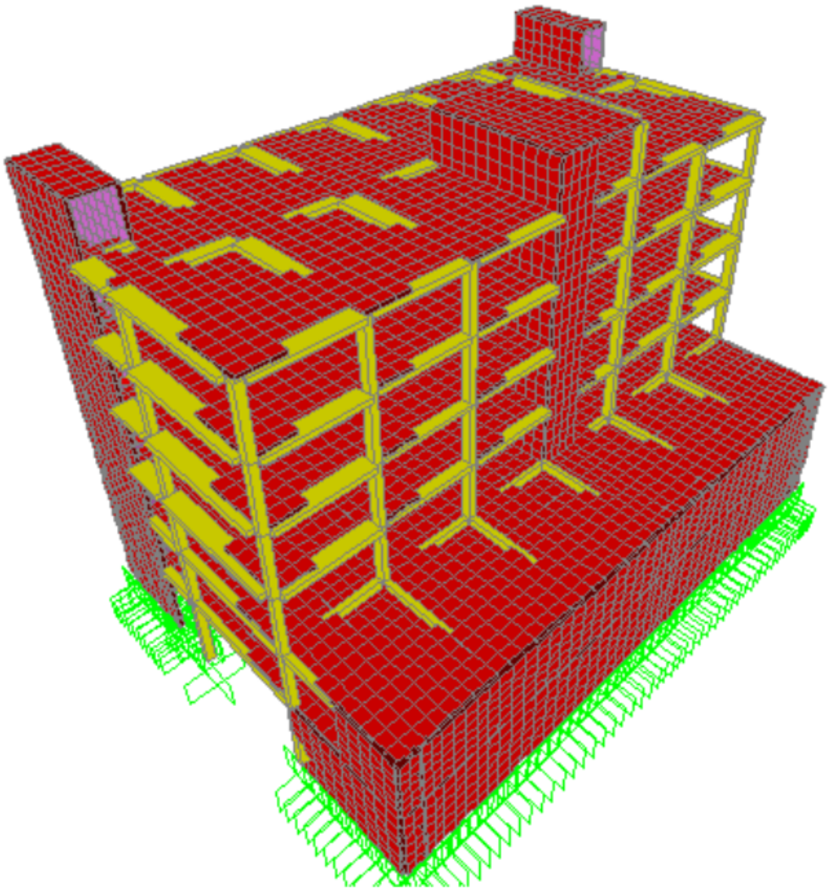
Prezi

Project Description

This project is a static structure Analysis & design for an Educational Building "Science Research Centers".

- The building consist of six floors, two of them are basement floors.
- The area of the building it's about 6000m2.
- The Basement floor elevation is 5.5m and all other floors are 4.5m elevated .

SAP 3D Model



Design Determinants

★**Materials**

★Concrete:

- For slabs, beams & stairs the compressive strength f'c = 28 MPa.
- For columns, shear walls, basement walls, footings & tie beams the compressive strength f'c = 32 Mpa.
- The unit weight of the concrete is 25KN/m3.

★Steel:

- Steel yielding strength fy = 420 MPa.

★Soil:

- Soil bearing capacity is 400KN/m2 .

★Concrete blocks:

- The unit weight of the concrete blocks used is 12KN/m3.

Design Determinants

★ **Loads**

★Dead loads:

Static & constant loads, including the weight of structural elements & super imposed dead loads which including partitions (SDL).

★Live Loads:

Non permanent loads on the structure like weight of people, furniture, water tank & the building content.

★Soil loads:

come from the soil behind the walls that cause inclined pressure along the wall.

★Perimeter Wall:

- The weight of the perimeter wall 25KN/m.

Floor number	Usage	SD load (kN/m²)	Live load (kN/m²)
1-2	Stores- Offices	4.5	5
3-6	Offices-Labs	4.5	3

Design Determinants

★ Codes:

- The most commonly used code in the modern world that used mainly in Palestine is ACI 318-08 which is used in this project.

★ Load combinations:

- U1 = 1.4(D.L)
- U2 = 1.2(D.L)+ 1.6(L.L)
- U3= 1.6(S.L)

★ Programmes Used :

- Sap2000 -14.2.4 will be used in analysis of the structure.
-
- SP-Column program design.
-

American Concrete Institute®
Advancing concrete knowledge

Design Of Slabs

Preliminary Design of Slabs & Beams

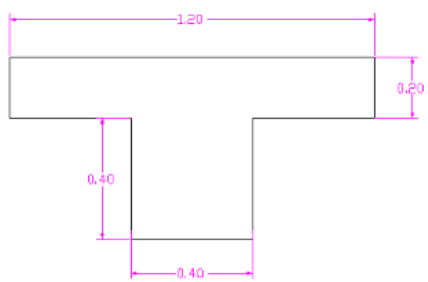
★ **In this Project Two Slab Systems are used which are:**

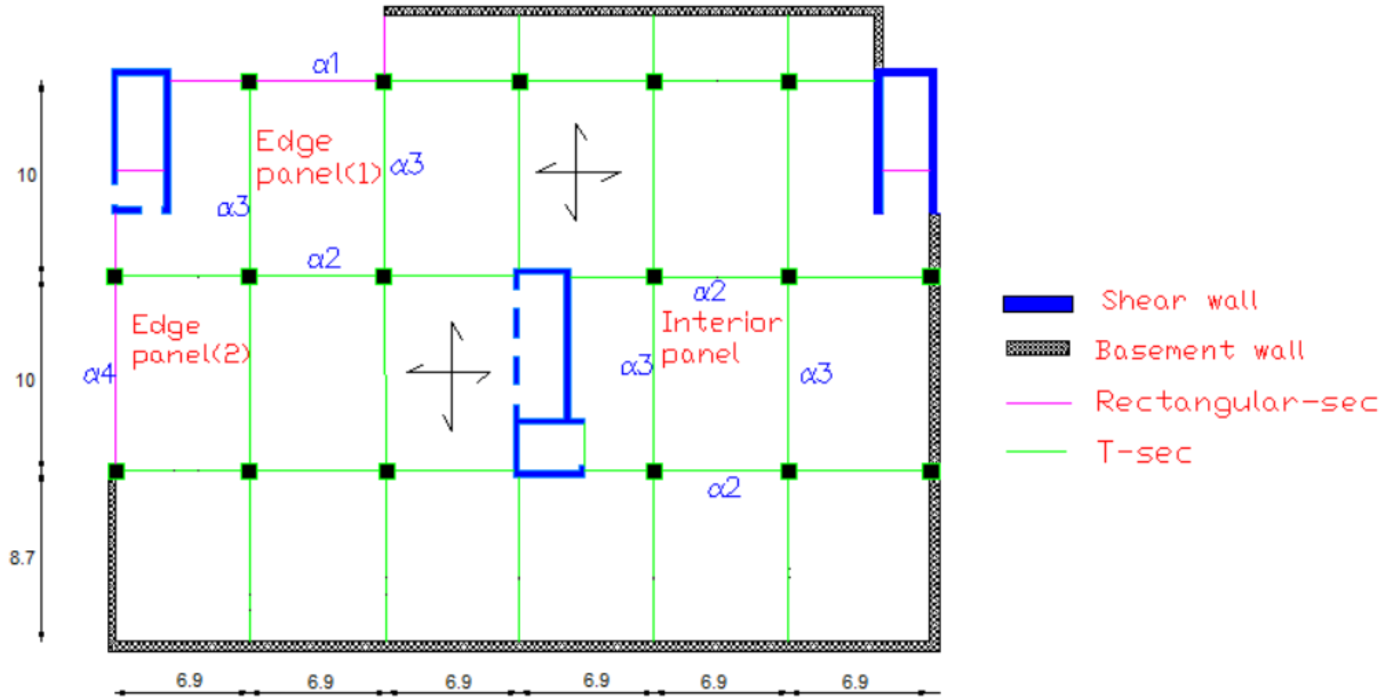
★ Two Way Solid Slab for the first two floors.
★ Two Way Ribbed Slab for the other floors (3-6).

★ **Two Way Solid Slab Plan:**

★Rectangular Beams (50*60)cm.

★T-section Beams.





Preliminary Design of Slabs

★ Direct Design Method used to get thicknesses & for checks later :

- ★ Three or more spans in each direction….. Ok
- ★ Variation in successive spans 33% (10 - 8.7/10) = 13% <33% …. Ok
- ★ LL /DL < 2…….. (5/4.5) = 1.11< 2…… Ok
- ★ L/B < 2……. (10/6.9) =1. 45<2 … …Ok

★ Assuming $\alpha_m \geq 2$,then

$$h_{min} = \frac{Ln(\,0.8 + \frac{fy}{1400}\,)}{36 + 9(\beta)}$$

- ★ β= Ln " long span"/ Ln "short span"= 9.2/6.1=1.51
- ★ h_{min}= 0.2m

Check $\alpha_{fm} = \frac{I_{beam}}{I_{slab}}$ for different panels.

$\alpha_1 = 2.7$, $\alpha_2 = 1.74$, $\alpha_3 = 2.52$, $\alpha_4 = 3.9$

For all panels ($\alpha_{fm} \geq$ 2) So,

$$h_{min} = Ln\frac{(0.8+\frac{Fy}{1400})}{36+9\beta} = 9.2\ \frac{(08+\frac{420}{1400})}{36+9*\frac{9.2}{6.1}}$$ = **0.20m which is used.**

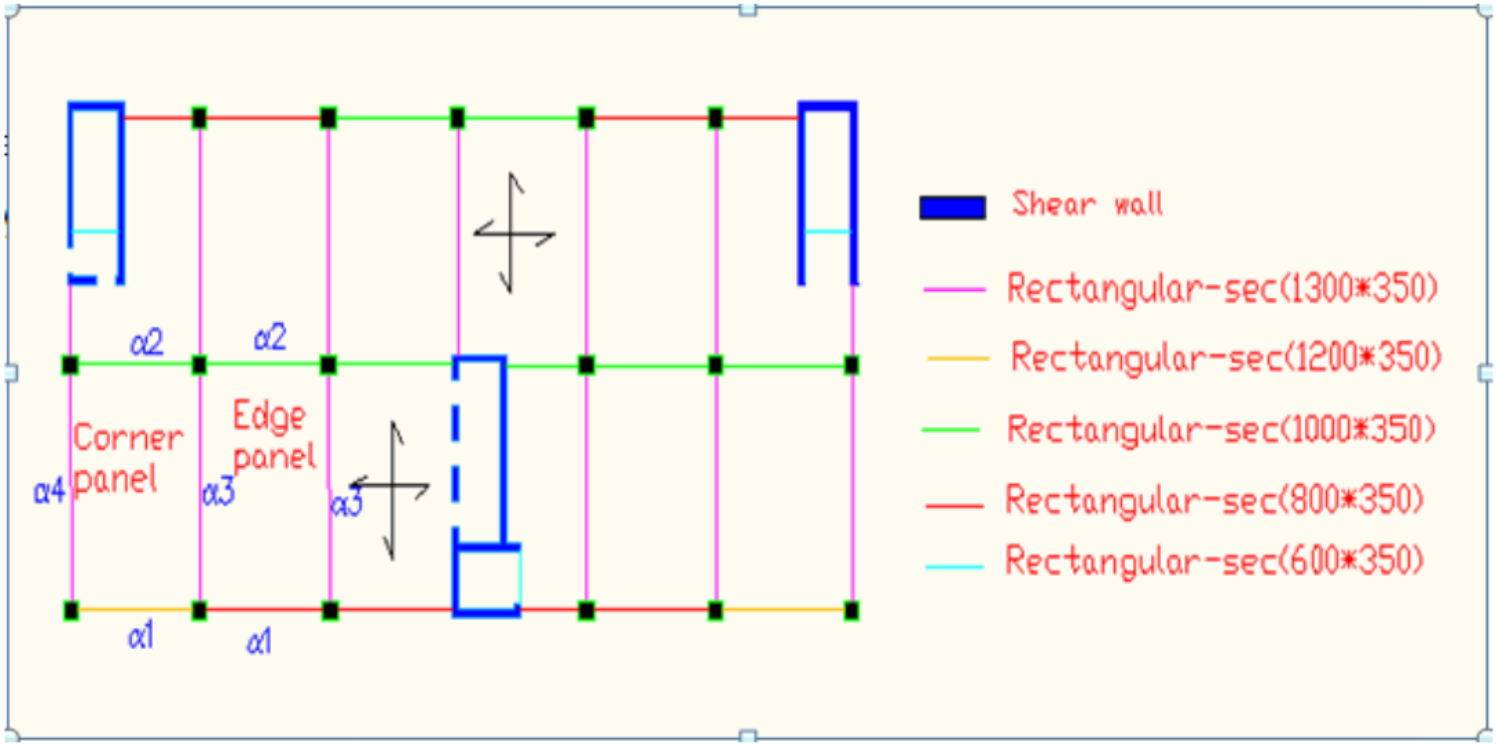
Preliminary Design of Slabs & Beams

★ **Two way Ribbed slab plan:**

★ For Edge panel: $\alpha_{fm} = \frac{I_{beam}}{I_{slab}} = 0.853 < 2$

★ Two way solid slab with thickness as equivalent = 25cm.

✔ **So use Two Way Ribbed Slab with thickness = 35cm**



Preliminary Design of Slabs

Check Shear In Two way Ribbed Slab (3-6):

- Own weight = $\{(0.55^2 \times 0.35) - (0.4^2 \times 0.28)\} \times 25 + (0.4^2 \times 0.28) \times 12$
  $= 2.06 kN/0.55m^2$ (rib).
  $= 6.83 KN/m^2$.

- Live load = $3.0\ KN/m^2$.

- SDL = $4.5\ KN/m^2$.

Ultimate load = $W_u = 1.2\ (6.83+4.5) + 1.6\ (3) = 18.4 kN/m^2$.

$V_u = 1.15\ W_u \times L_n /2 - W_u \times d$

$= 1.15 \times 18.4 \times 9.2 /2 - 18.4 \times 0.31$

$= 91.63 kN/m = 50.4 kN/rib.$

$\Phi Vc = \frac{0.75 \times 1.1}{6} \times \frac{\sqrt{28} \times 150 \times (310)}{1000} = 33.83 kN < Vu = 50.4 kN.$

$Av/s = 0.17\ mm^2/mm$ >>>>> $S=157/0.17= 924mm > S_{max} =150mm$

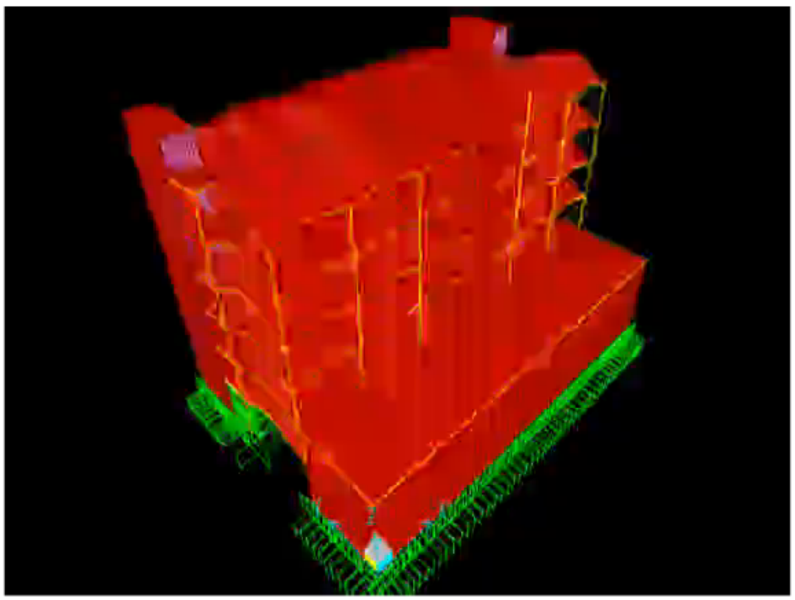
So >>>Use $1\Phi10/150\ mm$ Stirrups.

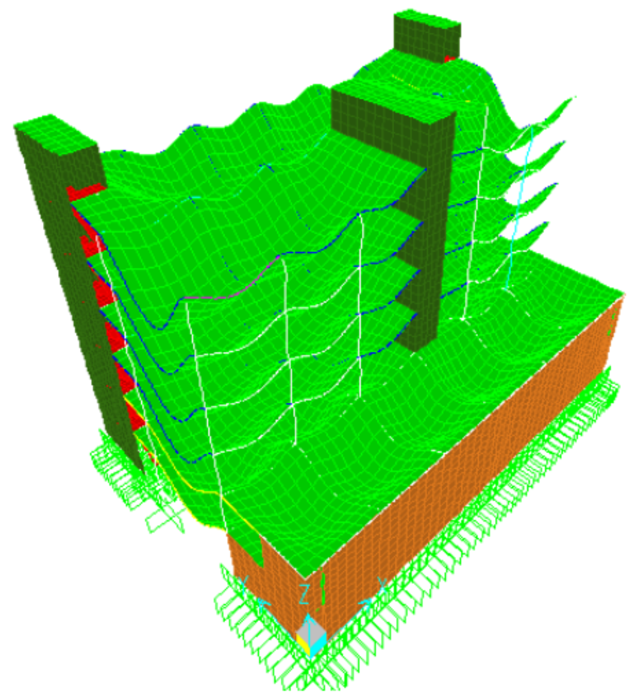
- Minimum Reinforcement in two way ribbed slab (3-6 floors):
  $As_{min} = 0.0033 \times 150 \times 310 = 154\ mm^2$ ($2\Phi\ 10mm$).

3D-Modeling & Checks

★ **Compatibility:**

★ **The structure works as one unit is verified.** ✓



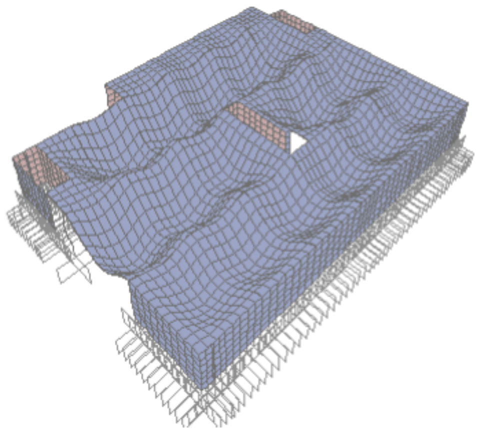


Prezi

3D-Modeling & Checks

★Equilibrium: (5% acceptable)

- For the basement floor, the own weight of the structural element are:
- Slab weight = 1228.9 *0.20*25 = 6144.5KN
- Columns weight = 1003.75KN
- Beams weight = 1694.41KN
- Basement wall weight = 5880KN
- Shear wall weight =2200.25KN



- Total dead load = 16922.9KN
- Total live load = 1228.9*5 =6144.5KN

%error for dead load = (16899.4 – 16922.9) / 16899.4 = 0.14 % < 5 % ..... OK.

	OutputCase Text	CaseType Text	GlobalFX KN	GlobalFY KN	GlobalFZ KN
▶	DEAD	LinStatic	50.325	-203.475	16899.394
	LIVE	LinStatic	43.672	-170.694	6144.5

3D-Modeling & Checks

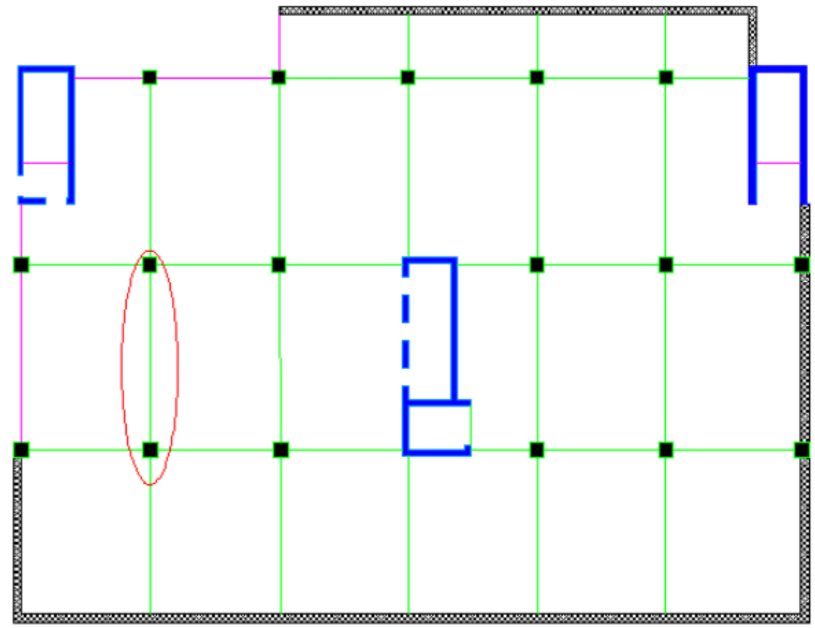
★ **Stress-Strain relationship:** (10% acceptable)

Mo= Wu *l2 *Ln^2/8 +(o.w(Beam)* Ln^2/8)
= 19.4*6.9*9.4^2/8 + (0.40*0.4*25)(1.2)(9.4^2/8)
= 1531KN.m

L2/L1 = 6.9/10 = 0.69
α_3 *L2/L1 = 2.52*0.69 =1.74

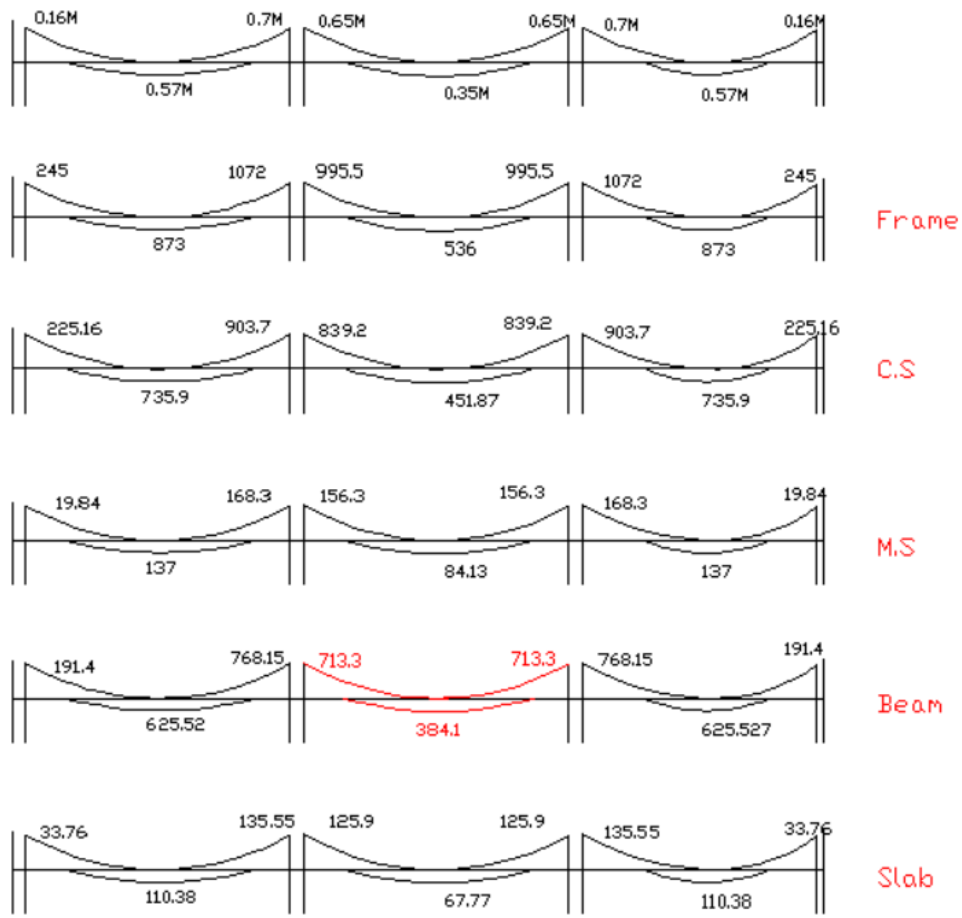
Moment Distribution ratios For Column Strip:

★ Interior positive moment =84.3%
★ Interior negative moment =84.3%
★ Exterior negative moment =91.9%



3D-Modeling & Checks

★ Moment distribution Results On Frame (Y2) :



3D-Modeling & Checks

★ Taking the moment at the beam to be checked:

★ The moment at the left edge of the beam from sap = 714.46kN.m

★ The moment at the left edge of the beam (hand calculation) = 713.3kN.m

So the %Error at the left edge = (Msap – Mcal) / Msap

= (714.46 – 713.3) / 714.46

= 0.17% < 10% …… OK.

Prezi

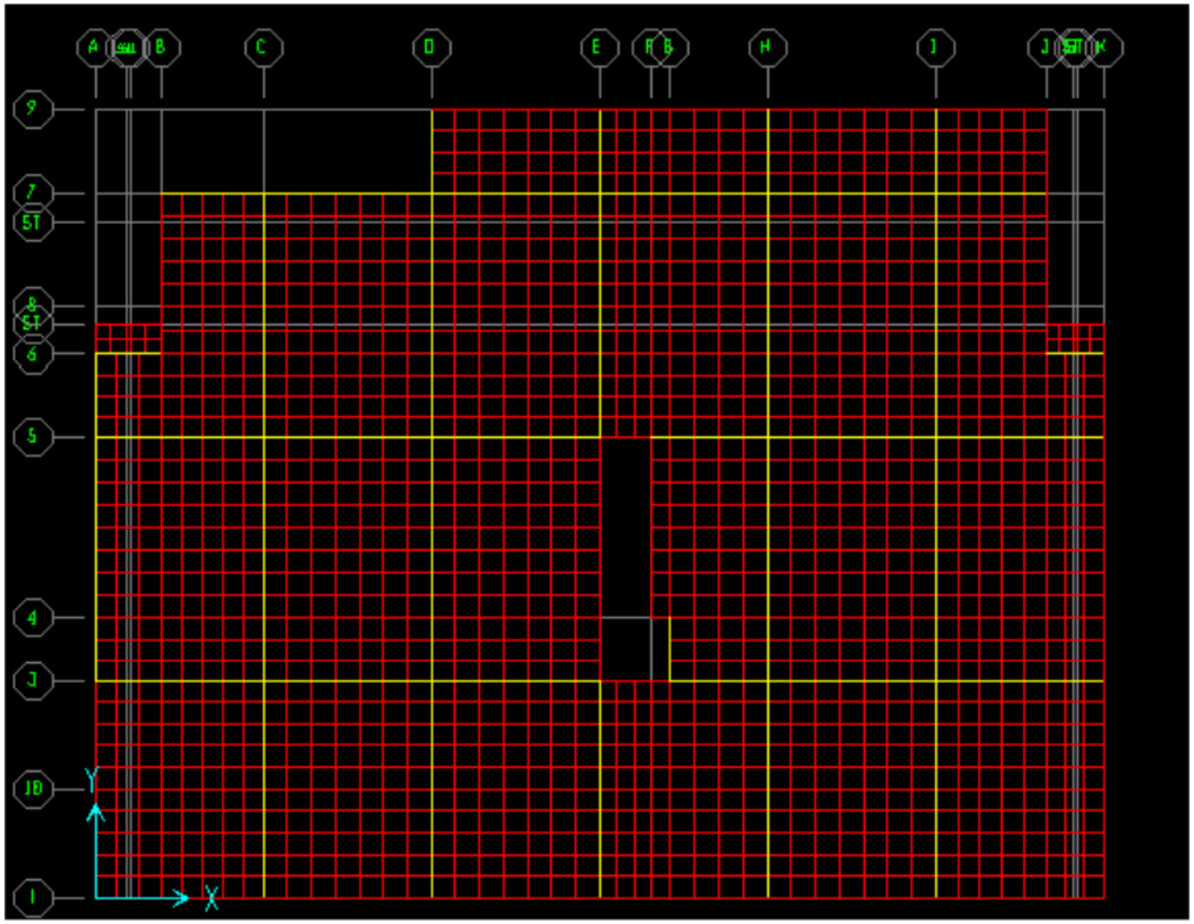
3D-Modeling & Checks

★The moment at the right edge of the beam from sap = 701.2kN.m
★The moment from (hand calculation) = 713.3kN.m
%error at the right edge = 1.7% < 10% …… OK. ✔

★ The moment at the mid of the beam from sap = 371.72kN.m
★ The moment at the mid of the beam (hand calculation) = 384.1kN.m
%Error at the middle =3.4% < 10%…..OK.✔

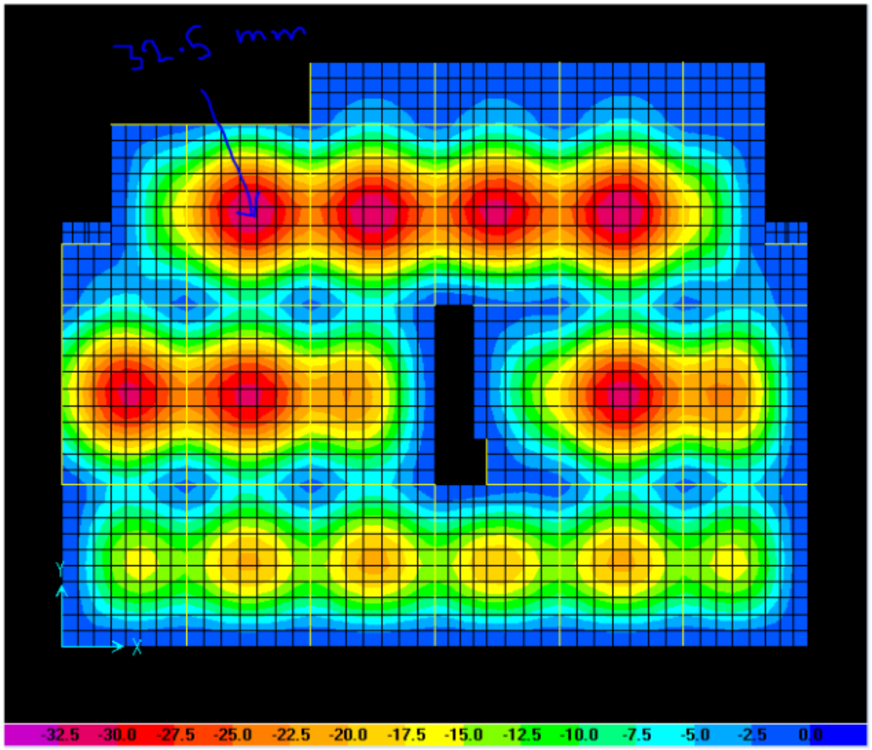
Static Design/Slabs

★ Two way Solid Slab: taking **column strip** & **middle strip** to be Reinforced.



Static Design/Slabs

★Deflection Of Solid Slab:



★ Max. Slab Deflection=32.5mm.

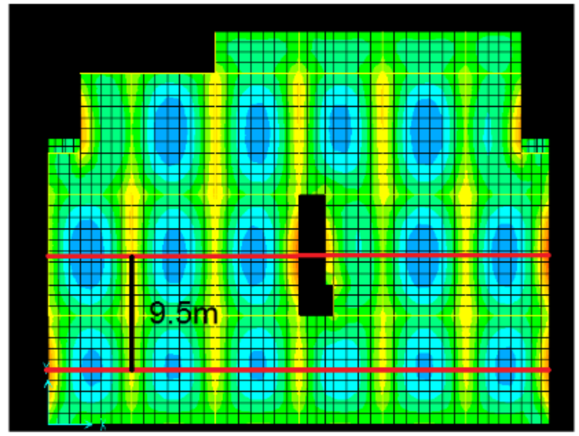
★ Allowable Deflection= L/240=10000/240=42mm.

SAFE ✓

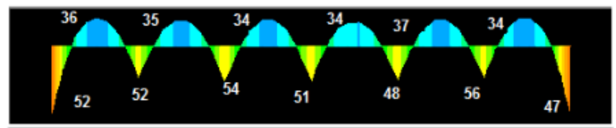
Prezi

Static Design/Slabs

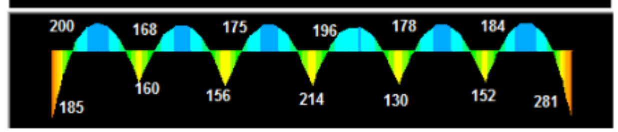
X-Direction (M11)

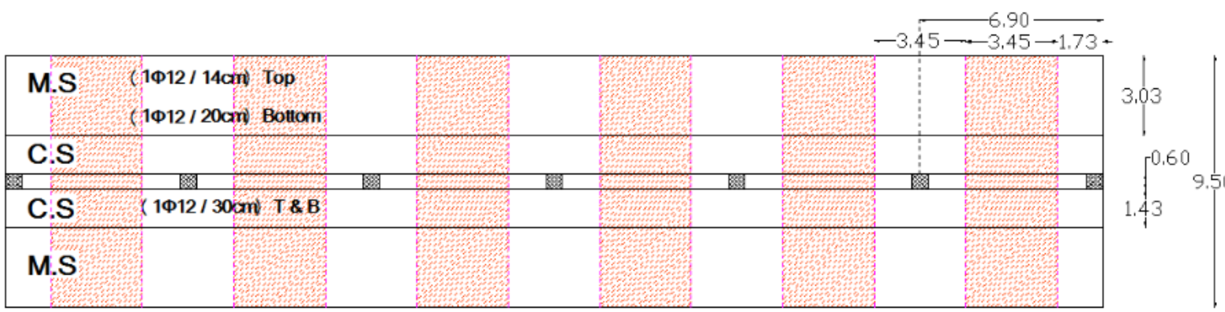


Moment C.S



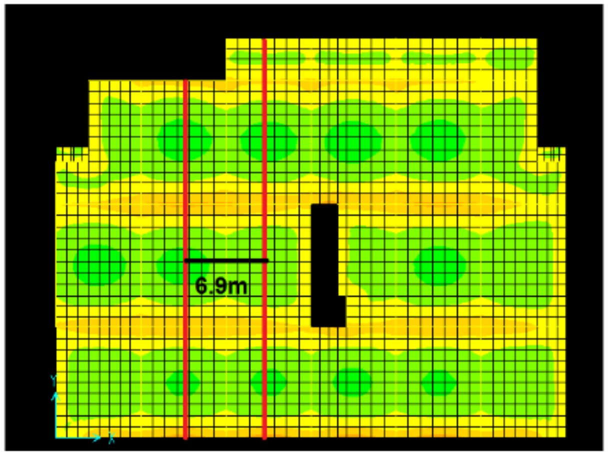
Moment M.S



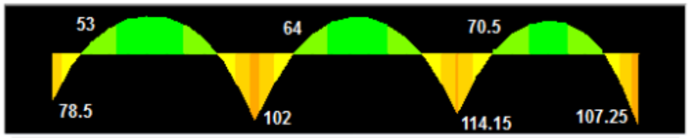


Static Design/Slabs

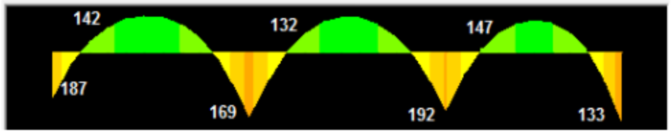
★ Y-Direction (M11)

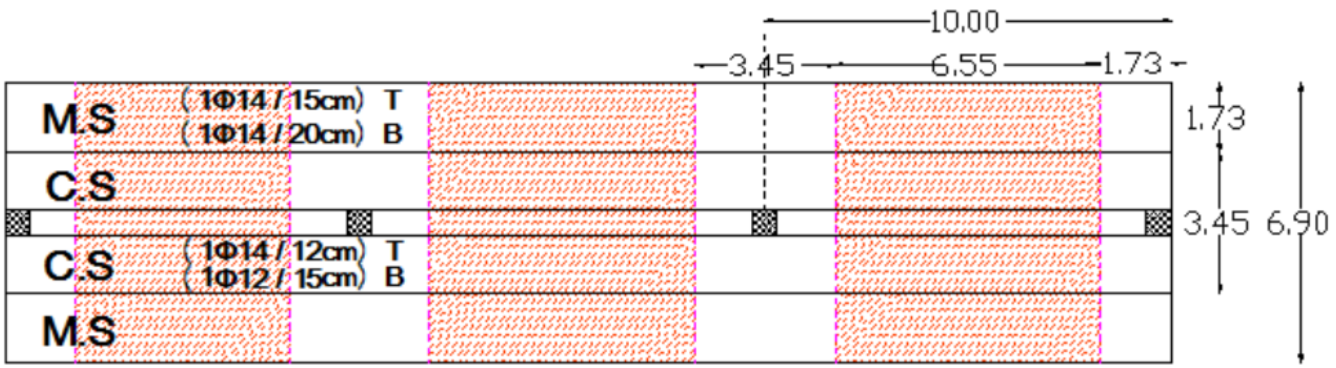


★ Moment C.S



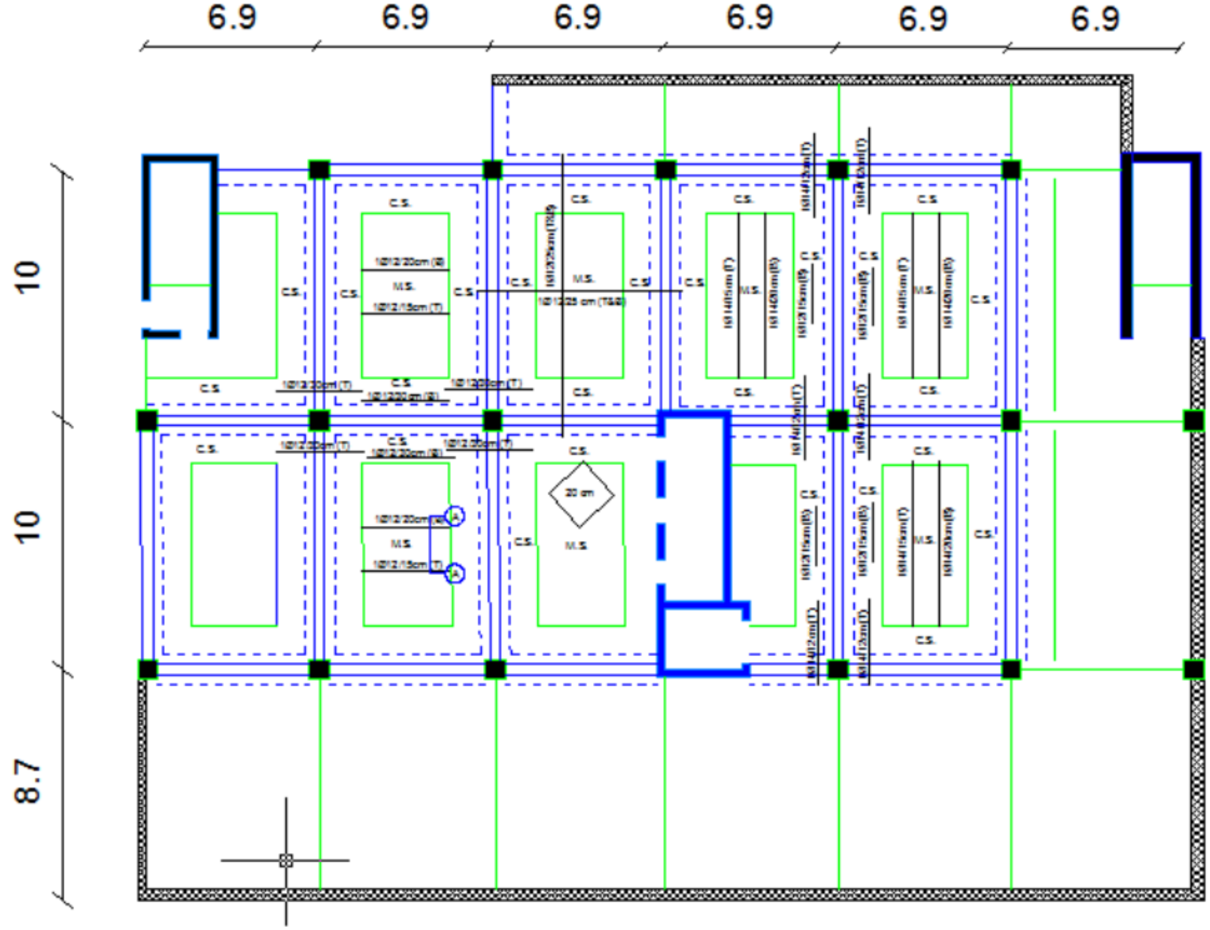
★ Moment M.S

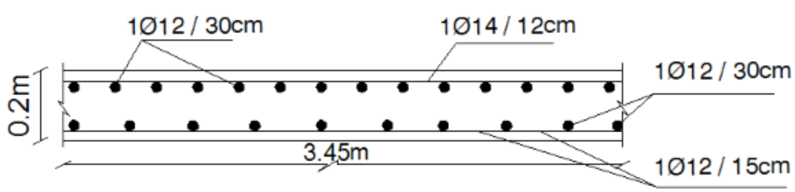




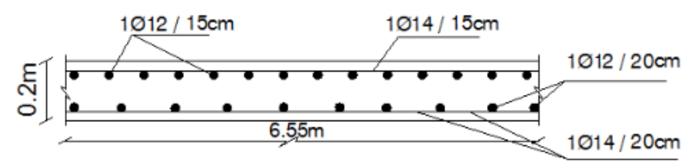
Prezi

Static Design/Slabs





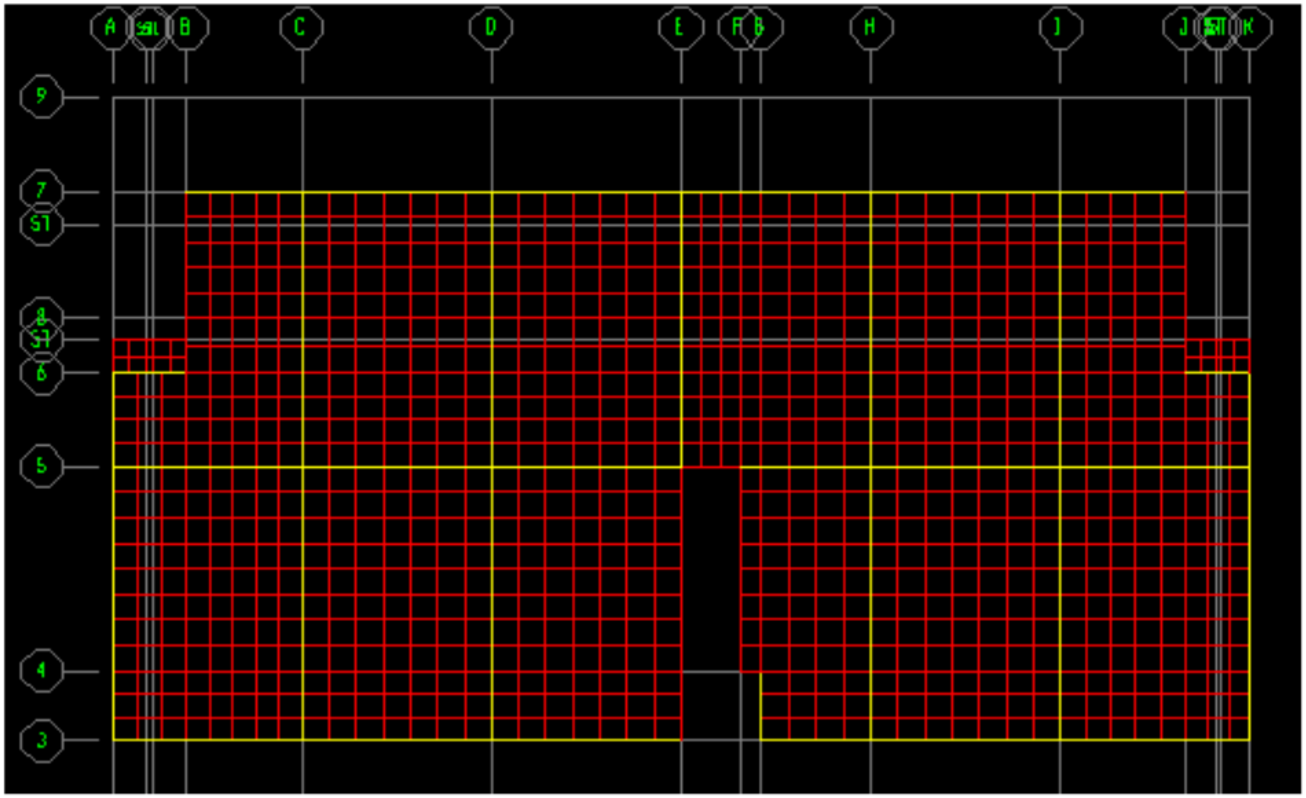
Section B-B: Solid Slab Column Strip Reinforcement



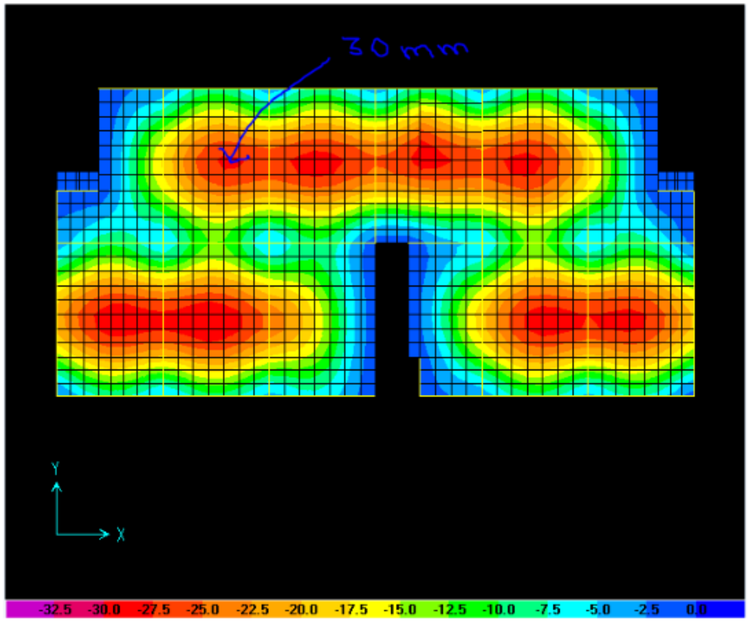
Section A-A: Solid Slab Middle Strip Reinforcement

Static Design/Slabs

★ Two Way Ribbed Slab: taking **column strip & middle strip** to be Reinforced.



★ Deflection Of Ribbed Slab:



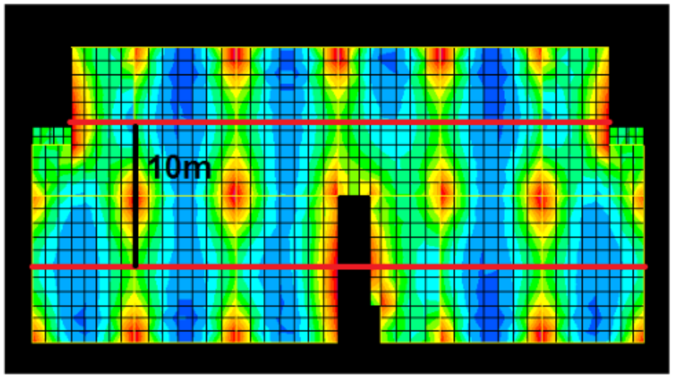
★ Max. Deflection Of Slab=30mm.

★ Allowable Deflection=L/240=10000/240=42mm.

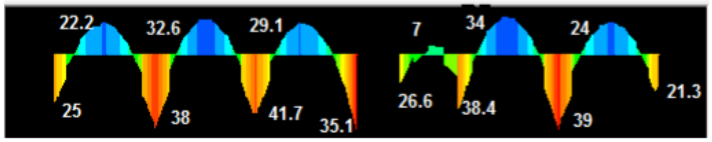
SAFE ✔

Static Design/Slabs

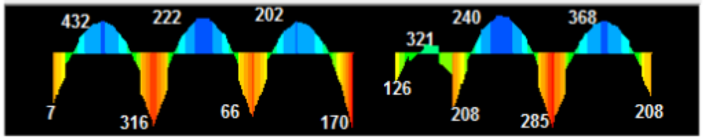
★ X-Direction (M11)

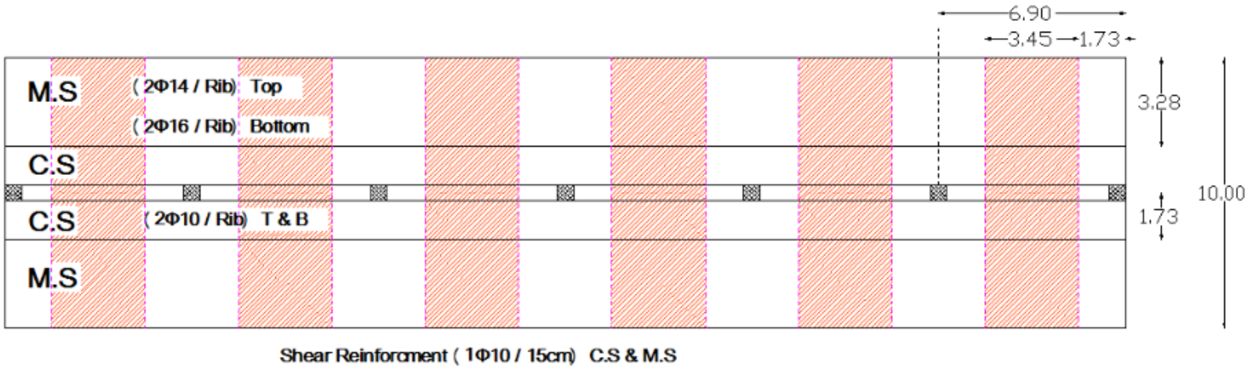


★ Moment C.S



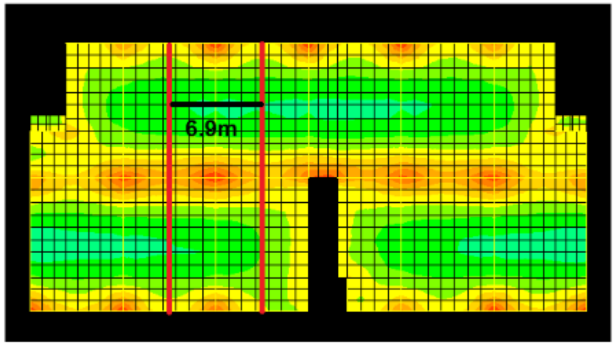
★ Moment M.S



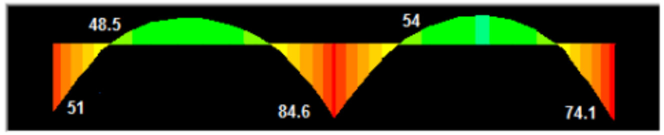


Static Design/Slabs

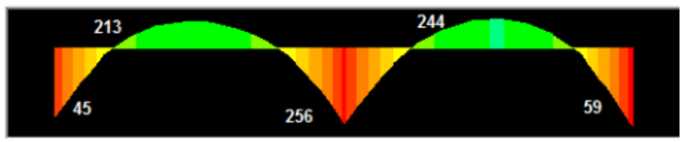
★ Y-direction (M22)

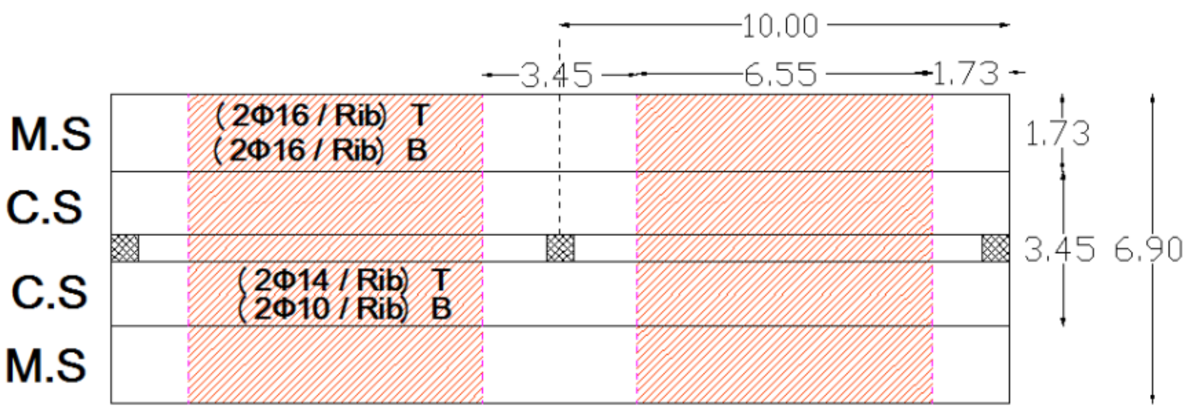


★ Moment C.S



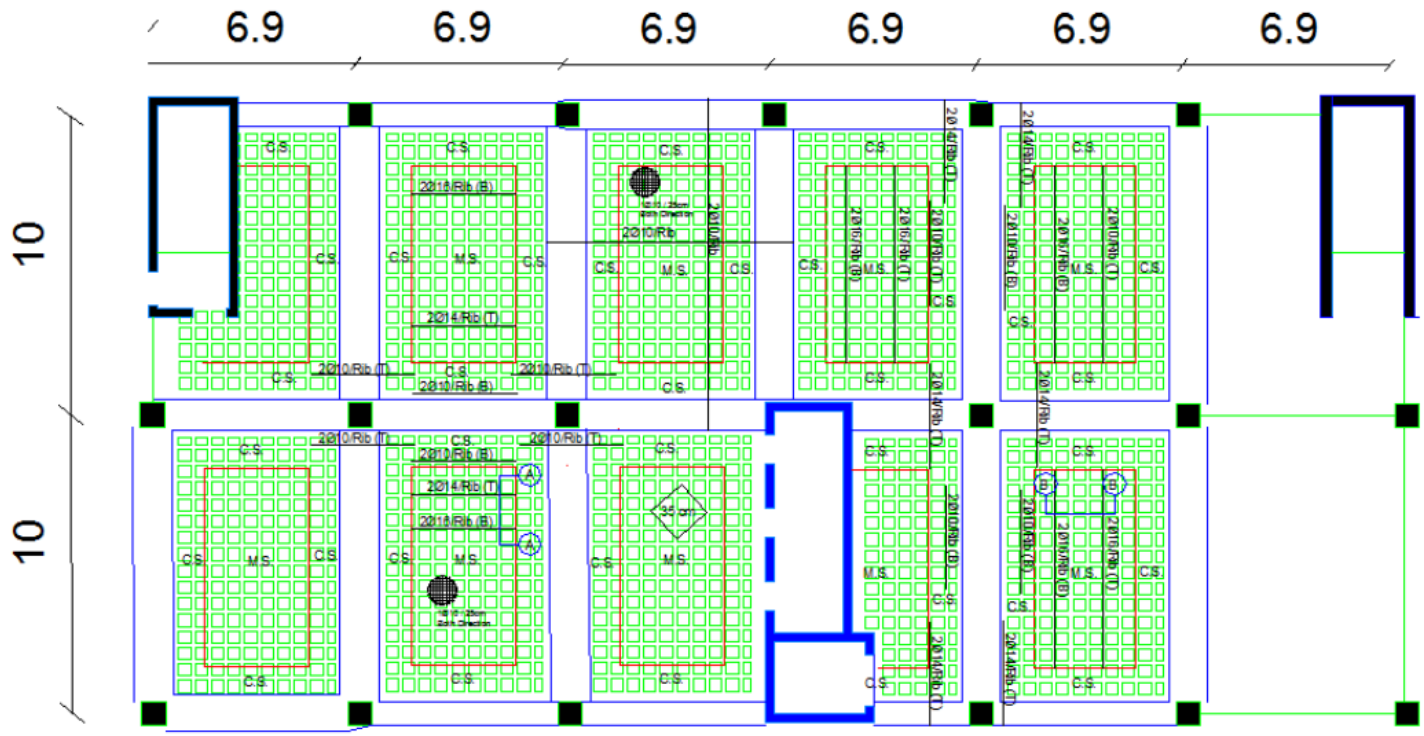
★ Moment M.S

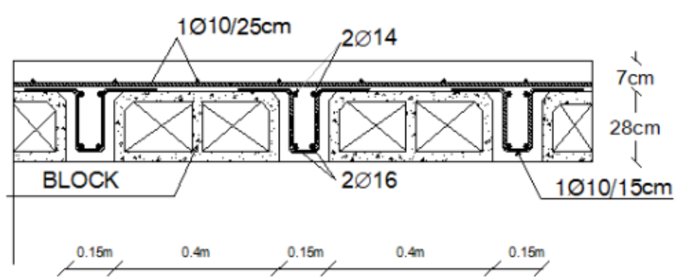




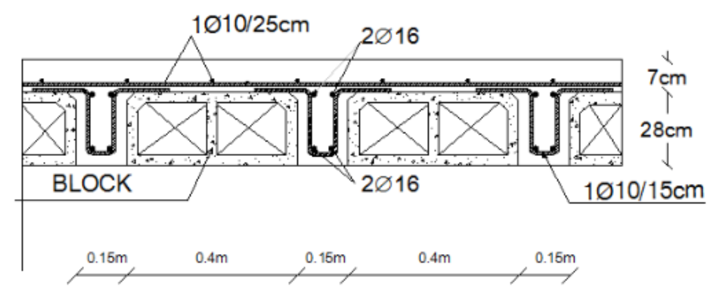
Shear Reinforcment (1Φ10 / 15cm) C.S & M.S

Static Design/Slabs





Section A-A: Ribbed slab reinforcement X-Direction



SectionB-B: Ribbed slab reinforcement Y-Direction

Design Of Beams

Static Design/Beams

★ Minimum steel Reinforcement for Beams of the whole structure:

Type of Beam	Depth(mm)	$As_{min}(mm^2)$	As #of bars
500*600	540	891	5Φ16
300*200	160	159	3Φ10
T-sec	540	712.8	5Φ14
1300*350	290	1244.1	9Φ14
1200*350	290	1148.4	8Φ14
1000*350	290	957	7Φ14
800*350	290	765.6	5Φ14
600*350	290	574.2	4Φ14

Static Design/Beams

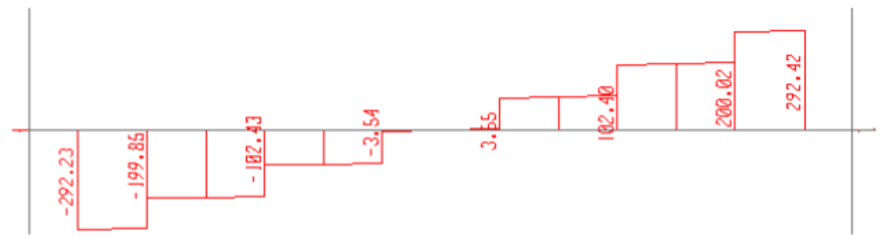
★ Minimum Shear Reinforcement For Beams Of The whole Structure.

★ $\left(\frac{Av}{S}\right)_{min.} = \frac{0.35\ bw}{Fy}$

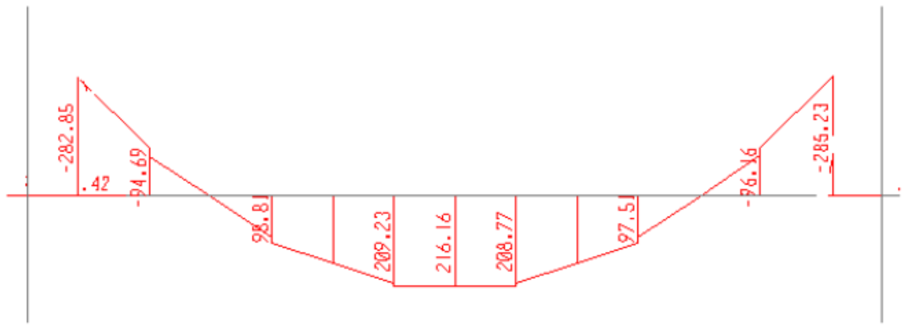
Beam Width (mm)	$\left(\frac{Av}{S}\right)_{min.}$	Av min. Φ10 /spacing(mm)	Max. spacing(d/2)(mm)
400	0.333	1Φ10/470	270
500	0.417	1Φ10/370	270
600	0.5	1Φ10/310	150
800	0.67	2Φ10/470	150
1000	0.83	2Φ10/380	150
1200	1.00	2Φ10/310	150
1300	1.083	2Φ10/290	150

Static Design/Beams

- Taking Beam X11 in the Basement floor :
- Shear Force Diagram (KN)

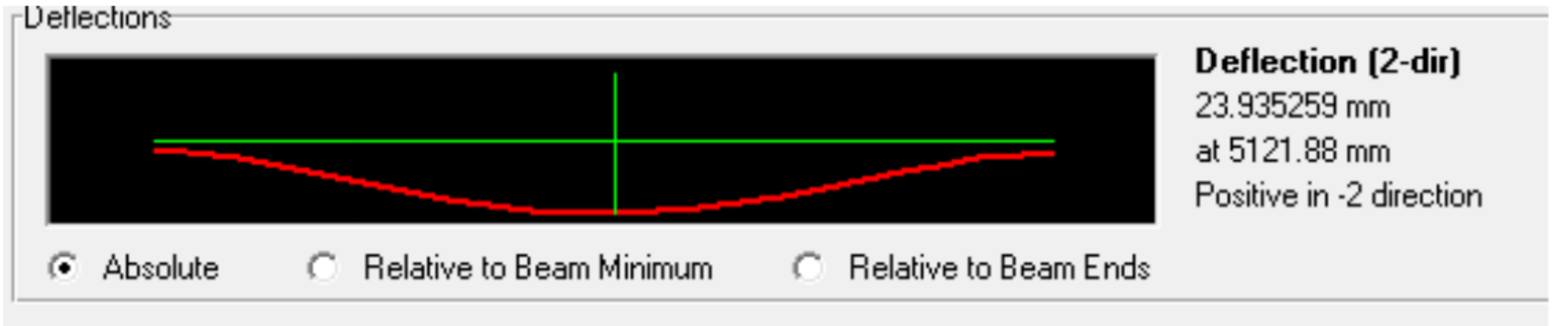


- Bending Moment Diagram (KN.m)



Static Design/Beams

★ Beams Deflection:



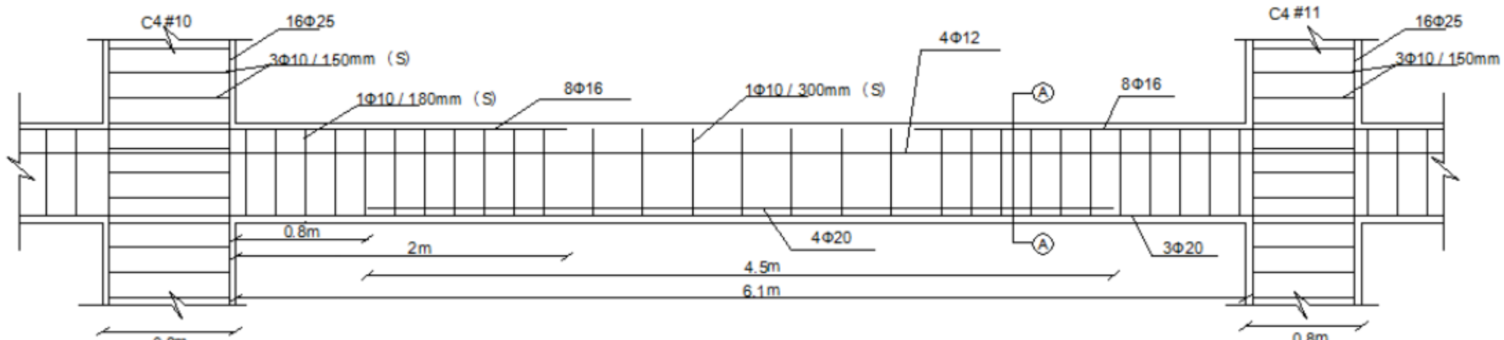
★ Max. Beam Deflection= 24mm.

★ Allowable deflection = L/240=6900/240=28mm.

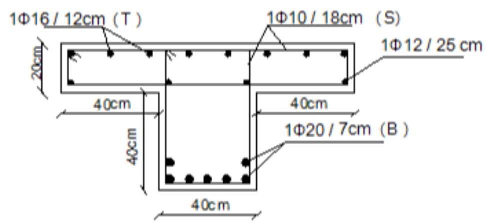
Safe

Static Design/Beams

★ Reinforcement Detailing of Beam X11:



Longitudinal Section BEAM X11 - BASEMENT FLOOR

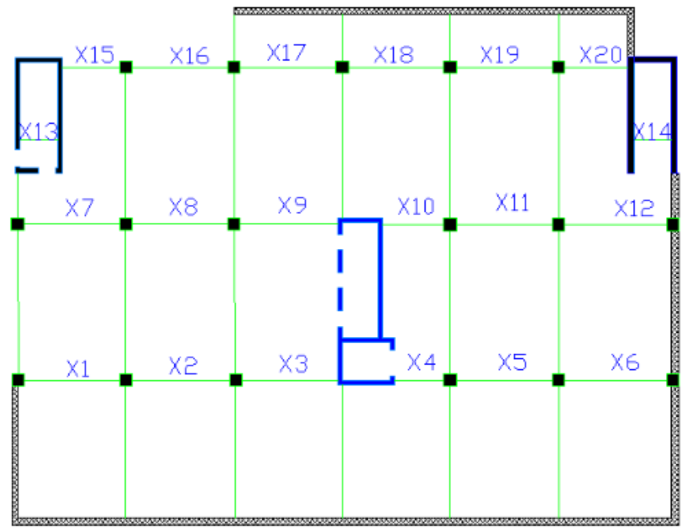


Section A-A :BEAM X11 - BASEMENT FLOOR

Static Design/Beams

★ Steel Reinforcement for Beams in Solid slab(Basement floor) X-Direction:

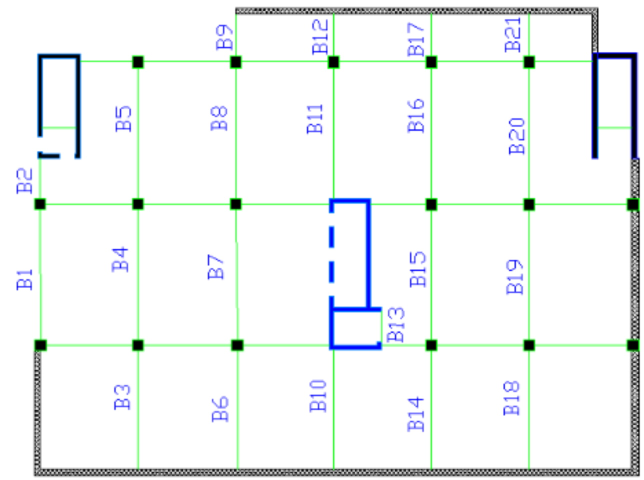
Beam	Depth(mm)	Width(mm)	Negative Left Reinforcement at support	Positive (mid) Reinforcement	Negative Right Reinforcement at support	Spacing (mm)
X1	540	400	8Φ16	7Φ20	8Φ16	1Φ10/190
X2	540	400	8Φ16	7Φ20	8Φ16	1Φ10/190
X3	540	400	8Φ16	7Φ20	9Φ16	1Φ10/200
X4	540	400	5Φ14	7Φ20	5Φ14	1Φ10/270
X5	540	400	8Φ16	7Φ20	8Φ16	1Φ10/200
X6	540	400	7Φ16	7Φ20	7Φ16	1Φ10/200
X7	540	400	5Φ16	7Φ20	7Φ16	1Φ10/210
X8	540	400	8Φ16	7Φ20	8Φ16	1Φ10/170
X9	540	400	7Φ16	7Φ20	10Φ16	1Φ10/170
X10	540	400	6Φ14	7Φ20	5Φ14	1Φ10/270
X11	540	400	8Φ16	7Φ20	8Φ16	1Φ10/180
X12	540	400	5Φ16	7Φ20	6Φ16	1Φ10/230
X13	160	300	3Φ10	3Φ10	3Φ10	1Φ10/270
X14	160	300	3Φ10	3Φ10	3Φ10	1Φ10/270
X15	540	500	5Φ16	5Φ16	5Φ16	1Φ10/270
X16	540	500	6Φ16	5Φ16	7Φ16	1Φ10/250
X17	540	400	6Φ16	7Φ20	6Φ16	1Φ10/270
X18	540	400	6Φ16	7Φ20	6Φ16	1Φ10/270
X19	540	400	7Φ16	7Φ20	6Φ16	1Φ10/270
X20	540	400	5Φ14	7Φ20	5Φ14	1Φ10/270



Static Design/Beams

★ Steel Reinforcement for Beams in Solid Slab(Basement floor) Y-Direction.

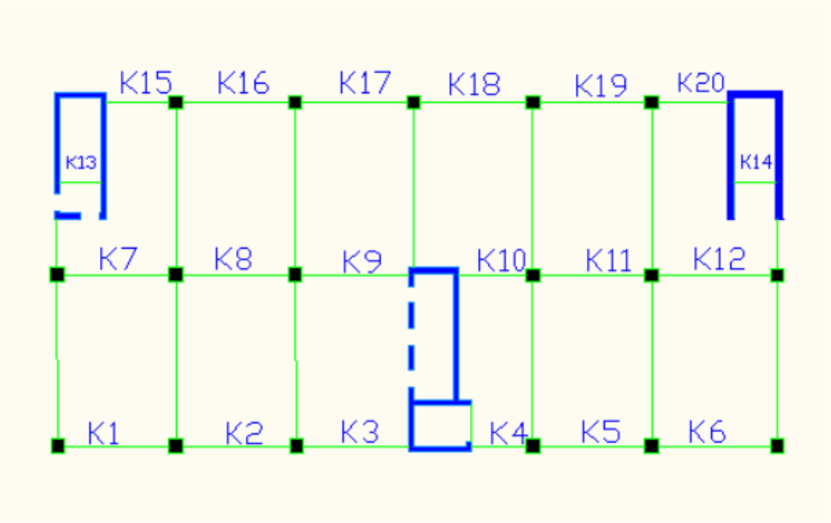
Beam	Depth(mm)	Width(mm)	Negative Left Reinforcement at support	Positive (mid) Reinforcement	Negative Right Reinforcement at support	Spacing (mm)
B1	540	500	7Φ25	5Φ25	9Φ20	1Φ10/140
B2	540	500	5Φ16	5Φ16	5Φ16	1Φ10/270
B3	540	400	10Φ20	7Φ20	10Φ18	1Φ10/150
B4	540	400	12Φ20	7Φ20	12Φ20	1Φ10/110
B5	540	400	11Φ18	7Φ20	10Φ18	1Φ10/150
B6	540	400	10Φ20	7Φ20	10Φ18	1Φ10/140
B7	540	400	11Φ20	7Φ20	11Φ20	1Φ10/120
B8	540	400	12Φ20	7Φ20	12Φ20	1Φ10/110
B9	540	500	5Φ16	5Φ16	5Φ16	1Φ10/270
B10	540	400	10Φ20	7Φ20	10Φ20	1Φ10/160
B11	540	400	9Φ25	7Φ20	11Φ20	1Φ10/120
B12	540	400	5Φ14	7Φ20	4Φ16	1Φ10/270
B13	160	300	3Φ10	3Φ10	3Φ10	1Φ10/270
B14	540	400	10Φ20	7Φ20	10Φ18	1Φ10/160
B15	540	400	9Φ20	7Φ20	11Φ18	1Φ10/150
B16	540	400	12Φ20	7Φ20	11Φ20	1Φ10/120
B17	540	400	5Φ14	7Φ20	4Φ16	1Φ10/270
B18	540	400	10Φ20	7Φ20	10Φ18	1Φ10/150
B19	540	400	11Φ20	7Φ20	11Φ20	1Φ10/120
B20	540	400	9Φ20	7Φ20	10Φ18	1Φ10/140
B21	540	400	5Φ14	7Φ20	4Φ16	1Φ10/270



Static Design/Beams

★ Steel Reinforcement for Beams in Ribbed Slab X-Direction.

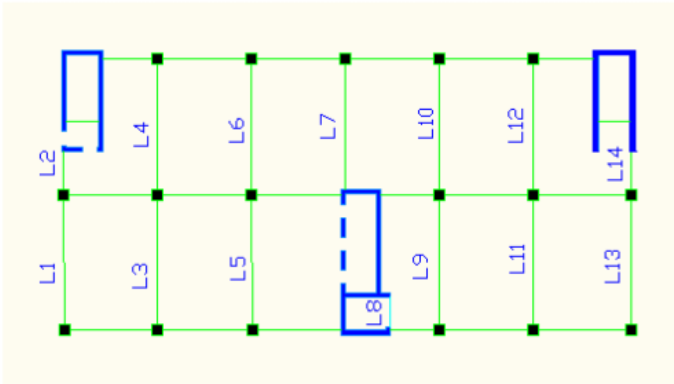
Beam	Depth(mm)	Width(mm)	Negative Left Reinforcement at support	Positive (mid) Reinforcement	Negative Right Reinforcement at support	Spacing (mm)
K1	290	1200	10Φ16	7Φ16	10Φ16	2Φ10/ 150
K2	290	800	8Φ16	5Φ16	8Φ16	2Φ10/ 150
K3	290	800	7Φ16	5Φ16	8Φ16	2Φ10/ 150
K4	290	800	5Φ14	5Φ14	5Φ14	2Φ10/ 150
K5	290	800	8Φ16	5Φ16	8Φ16	2Φ10/ 150
K6	290	1200	9Φ16	6Φ16	10Φ16	2Φ10/ 150
K7	290	1000	7Φ16	7Φ14	9Φ16	2Φ10/ 150
K8	290	1000	10Φ16	6Φ16	10Φ16	2Φ10/ 150
K9	290	1000	8Φ16	9Φ16	12Φ16	2Φ10/ 150
K10	290	1000	7Φ16	7Φ14	7Φ14	2Φ10/ 150
K11	290	1000	10Φ16	7Φ16	11Φ16	2Φ10/ 150
K12	290	1000	8Φ16	7Φ14	8Φ16	2Φ10/ 150
K13	290	600	4Φ14	4Φ14	4Φ14	1Φ10/ 150
K14	290	600	4Φ14	4Φ14	4Φ14	1Φ10/ 150
K15	290	800	5Φ14	5Φ14	5Φ14	2Φ10/ 150
K16	290	800	8Φ16	5Φ16	8Φ16	2Φ10/ 150
K17	290	1000	8Φ16	7Φ14	8Φ16	2Φ10/ 150
K18	290	1000	7Φ16	7Φ14	8Φ16	2Φ10/ 150
K19	290	800	8Φ16	5Φ16	8Φ16	2Φ10/ 150
K20	290	800	5Φ14	5Φ14	5Φ16	2Φ10/ 150



Static Design/Beams

★ Steel Reinforcement for Beams in Ribbed Slab Y-Direction.

Beam	Depth(mm)	Width(mm)	Negative Left Reinforcement at support	Positive (mid) Reinforcement	Negative Right Reinforcement at support	Spacing (mm)
L1	290	1300	15Φ20	13Φ16	14Φ20	2Φ10/ 150
L2	290	1300	9Φ14	9Φ14	9Φ14	2Φ10/ 150
L3	290	1300	15Φ20	13Φ16	15Φ20	2Φ10/ 150
L4	290	1300	14Φ16	10Φ14	11Φ18	2Φ10/ 150
L5	290	1300	13Φ20	10Φ16	13Φ20	2Φ10/ 150
L6	290	1300	14Φ20	12Φ16	15Φ20	2Φ10/ 150
L7	290	1300	11Φ25	12Φ16	14Φ20	2Φ10/ 150
L8	290	600	4Φ14	4Φ14	4Φ14	1Φ10/ 150
L9	290	1300	10Φ16	10Φ14	15Φ20	2Φ10/ 150
L10	290	1300	13Φ20	12Φ16	15Φ20	2Φ10/ 150
L11	290	1300	15Φ20	12Φ16	15Φ20	2Φ10/ 150
L12	290	1300	10Φ16	10Φ14	10Φ20	2Φ10/ 150
L13	290	1300	14Φ20	13Φ16	14Φ20	2Φ10/ 150
L14	290	1300	9Φ14	9Φ14	9Φ14	2Φ10/ 150



Design Of Columns

Static Design/Columns

Non-sway (braced) structure because there is no lateral loads.

Finding dimension of the column:

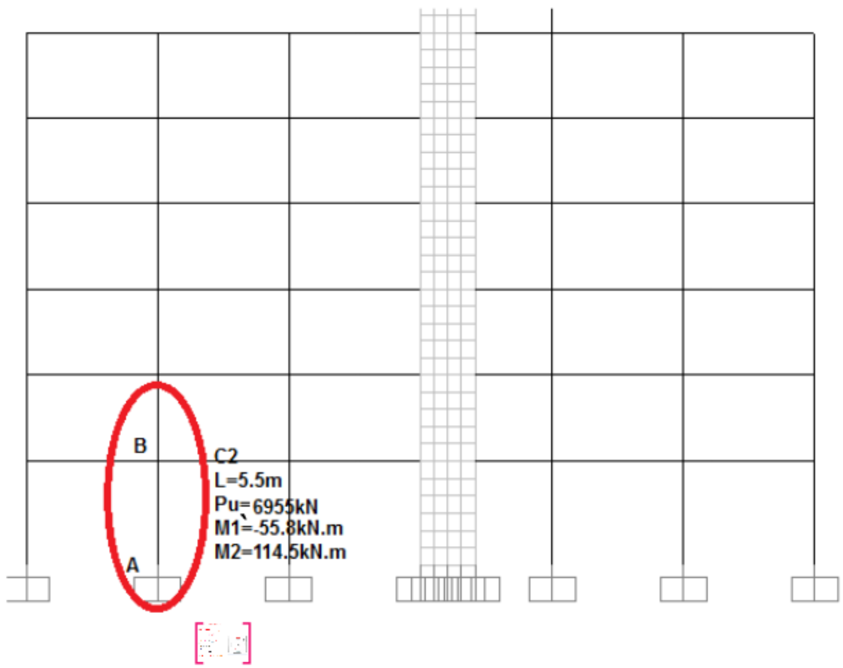
Assume ρ=1% >>> As =0.01Ag & ignoring moments .

ØPn= 0.65*0.8(0.85*F'c(Ag-As)+Fy*As)

>>Ag= 429677.5mm^2 … Use column 60*70cm

For column 60*70cm Ag= 420000mm^2 .

So the Dimensions or the Steel Ratio must be increased.



Slenderness Check:

Slenderness effects can be ignored if $\frac{K\times Lu}{r} \leq 34\text{-}12\frac{M1}{M2} \leq 40$

To find K >>>> $\Psi = \frac{\sum\left(\frac{E*I}{L}\right)column}{\sum\left(\frac{E*I}{L}\right)beam}$

I_{column}= 0.0126mm^2.

I_{beam}= 0.0116mm^2.

Ψ_A= 0.0 .... $\Psi_B = \frac{2\left(\frac{0.0126}{5.5}\right)}{2\left(\frac{0.0116}{6.9}\right)+2\left(\frac{0.0116}{8.7}\right)} = 0.76$

✓ So the value of K = 0.62

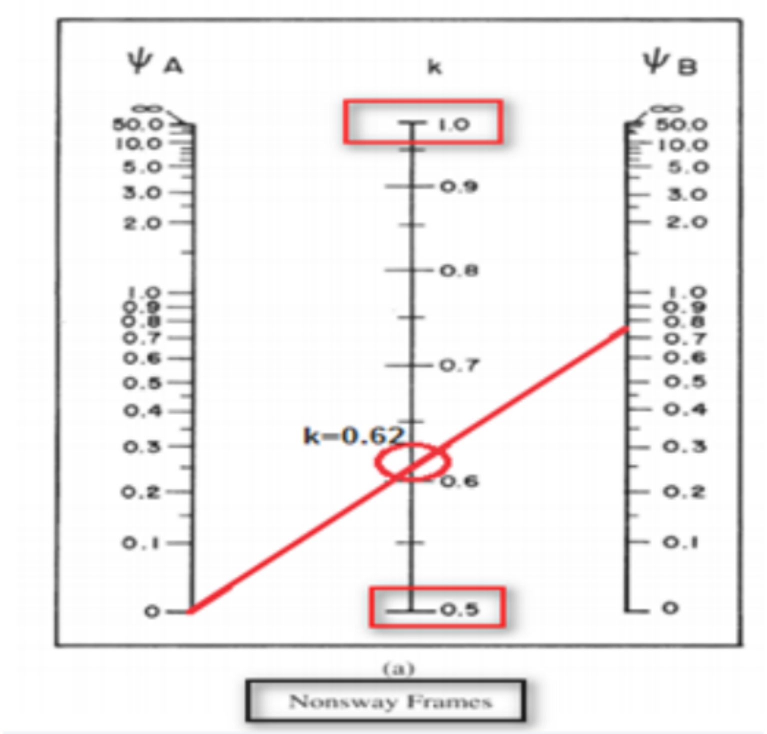
r= 0.3h =0.3*700 = 210

$\frac{K\times Lu}{r} = \frac{0.62\times5500}{210} = 16.24$

$\frac{K\times Lu}{r}$ =16.24 ≤ 34-12* $\frac{-55.8}{114.5}$ =39.85.....Ok

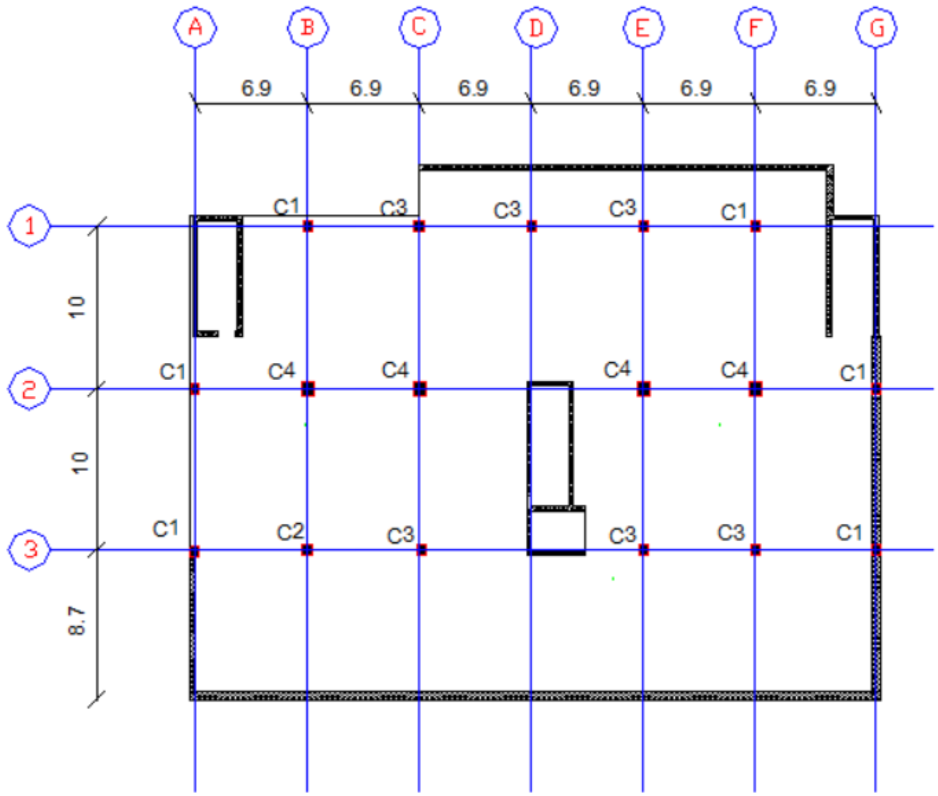
≤ 40

✓ **So the Column is a Non-Slender Short Column.**



Static Design/Columns

★ By taking moment in consideration & using PC-column program design the Dimensions & Reinforcement were as follows:



Static Design/Columns

★ Columns Dimension & Reinforcement for floors (1-2):

column		Dimension	Ultimate Load	Mx	My	Reinforcement	Confinement
#		(cm)	(KN)	(KN.m)	(KN.m)	#Ød	At Supports/ /At mid column
1	C1	50*60	2100	222	238	16 Ø 16	2 Ø 10/150 //2 Ø 10/300
2	C2	60*70	6955	10	114.4	20 Ø 20	2 Ø 10/150 //2 Ø 10/300
3	C3	60*70	6530	13	73.6	16 Ø 20	2 Ø 10/150 //2 Ø 10/300
4	C3	60*70	5366	119.15	25	16 Ø 20	2 Ø 10/150 //2 Ø 10/300
5	C3	60*70	6889	25	92	16 Ø 20	2 Ø 10/150 //2 Ø 10/300
6	C1	50*60	4490	86	85	16 Ø 16	2 Ø 10/150 //2 Ø 10/250
7	C1	50*60	4404	135	209.6	16 Ø 16	2 Ø 10/150 //2 Ø 10/250
8	C4	80*80	8607	38.5	90	16 Ø 25	3 Ø 10/150 //3 Ø 10/400
9	C4	80*80	9332	16.5	37.2	16 Ø 25	3 Ø 10/150 //3 Ø 10/400
10	C4	80*80	7942	120	77	16 Ø 25	3 Ø 10/150 //3 Ø 10/400
11	C4	80*80	8658	70	60	16 Ø 25	3 Ø 10/150 //3 Ø 10/400
12	C1	50*60	4500	25	10	16 Ø 16	2 Ø 10/150 //2 Ø 10/250
13	C1	50*60	4270	87	262.6	16 Ø 16	2 Ø 10/150 //2 Ø 10/250
14	C3	60*70	6167	7.5	335	16 Ø 20	2 Ø 10/150 //2 Ø 10/300
15	C3	60*70	5889	1	315	16 Ø 20	2 Ø 10/150 //2 Ø 10/300
16	C3	60*70	5990	9.5	317	16 Ø 20	2 Ø 10/150 //2 Ø 10/300
17	C1	50*60	4484	82	211	16 Ø 16	2 Ø 10/150 //2 Ø 10/250

Static Design/Columns

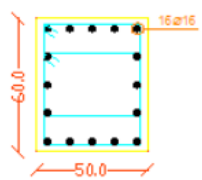
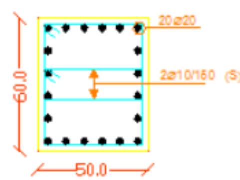
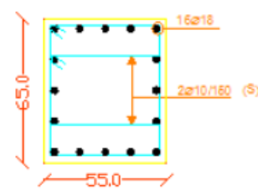
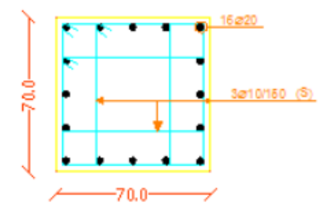
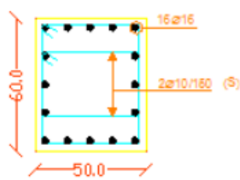
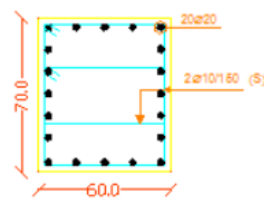
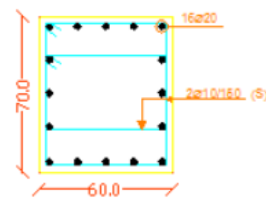
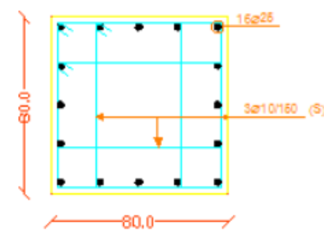
★ Columns Dimension & Reinforcement for floors (3-6):

column #		Dimension (cm)	Ultimate Load (KN)	Mx (KN.m)	My (KN.m)	Reinforcement #Ød	Confinement At Supports / /At mid column
1	C1	50*60	2803	270	365	16 ∅ 16	2 Ø 10/150 //2 Ø 10/300
2	C2	50*60	4050	15	407	20 ∅ 20	2 Ø 10/150 //2 Ø 10/300
3	C1	50*60	3677	34	335	16 ∅ 16	2 Ø 10/150 //2 Ø 10/250
4	C1	50*60	2976	147	244	16 ∅ 16	2 Ø 10/150 //2 Ø 10/250
5	C3	55*65	4651	20	400	16 ∅ 18	2 Ø 10/150 //2 Ø 10/250
6	C1	50*60	2810	177	312	16 ∅ 16	2 Ø 10/150 //2 Ø 10/250
7	C1	50*60	2885	178	330	16 ∅ 16	2 Ø 10/150 //2 Ø 10/250
8	C3	55*65	5642	70	161	16 ∅ 18	2 Ø 10/150 //2 Ø 10/250
9	C4	70*70	6205	49	48	16 ∅ 20	3 Ø 10/150 //3 Ø 10/300
10	C3	55*65	5216	164	97	16 ∅ 18	2 Ø 10/150 //2 Ø 10/250
11	C3	55*65	5756	83	137	16 ∅ 18	2 Ø 10/150 //2 Ø 10/250
12	C1	50*60	3063	156	241	16 ∅ 16	2 Ø 10/150 //2 Ø 10/250
13	C1	50*60	2746	153	298.4	16 ∅ 16	2 Ø 10/150 //2 Ø 10/250
14	C3	55*65	3400	10	478	16 ∅ 18	2 Ø 10/150 //2 Ø 10/250
15	C3	55*65	3806	3	471	16 ∅ 18	2 Ø 10/150 //2 Ø 10/250
16	C3	55*65	3881	10	470	16 ∅ 18	2 Ø 10/150 //2 Ø 10/250
17	C1	50*60	2876	142	320	16 ∅ 16	2 Ø 10/150 //2 Ø 10/250

Static Design/Columns

★ **Columns Reinforcement**:

COLUMNS SCHEDULE

COLUMN No. / FLOOR	C1	C2	C3	C4
(3-6) FLOORS				
BASEMENT & GROUND				

Design
Of
Shear Walls

Static Design/Shear walls

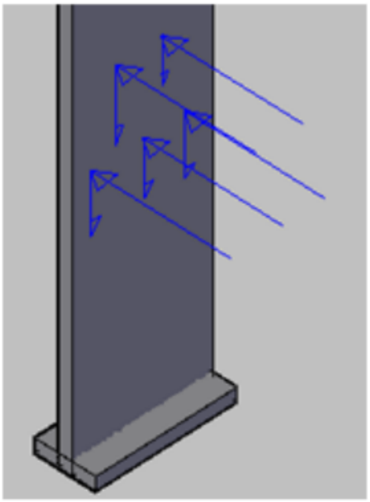
- Getting maximum load on shear wall from sap 3D model = 900 kN.
- Taking a strip of 1m & assume the width of the shear wall =25cm , to ensure the width is appropriate.. check will be made as follows:
- $\rho_{min(vertical)} = 0.0015$, then check capacity $\emptyset Pn$:

$$\emptyset Pn = \emptyset(0.85 * f'c(Ag - As) + fy * As)$$

$$= 0.65(0.85*32(250*1000 - 250*1000*0.0015) + 420*250*1000*0.0015)$$

$= 4516kN >> 900\ KN$ ..... **The width 25cm is appropriate.**

Because of $\emptyset Pn > Pu$ .....



- Use $\rho_{min(vertical)} = 0.0015$, $\rho_{min(horizontal)} = 0.0025$
- $As_{,vertical} = 375\ mm^2$ **(1 Φ12/25cm)**
- $As_{,\ horizontal} = 625\ mm^2$ **(1 Φ12/15cm)**
- Check spacing:

$S \leq 3h(thickness)$

$S \leq 3(25) \leq 75cm$ & the max. spacing used is $25cm < 75cm$ .... Ok.

Prezi

Static Design/Shear walls

★ **Shear Wall Footing Design:**

★ Footing width=(P,service)/(q,all)= (390+90)/400= 1.2m >>>> use **B= 1.25m**

★ Footing thickness H:

Vu=qu*L2

qu= Pu/B =(1.2*390 +1.6*90) / 1.25 = 490kN/m2.

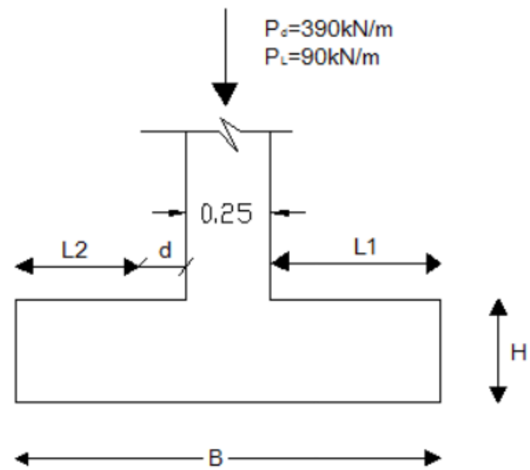
L2= L1 – d , L1= (B-0.25)/2 , B=1.25m

Vu=490*((B-0.25)/2 – d) = 245 – 490*d

ΦVc = 707.12*d = 245 – 490*d = Vu

d= 205mm >150mm ..... OK.

H= d+cover =205+ 60 = 265mm ....but H ≥ 300mm ...so use **H=300mm.**



Static Design/Shear walls

★ **Design for flexure:**

Mu= (qu * L12)/2

= (400* 0.52)/2 = 50kN.m

ρ= 0.00233 , d=240mm.

As=560.3mm2 .... **(1Φ12/20cm).**

As(shrinkage)= 0.0018*1250*300

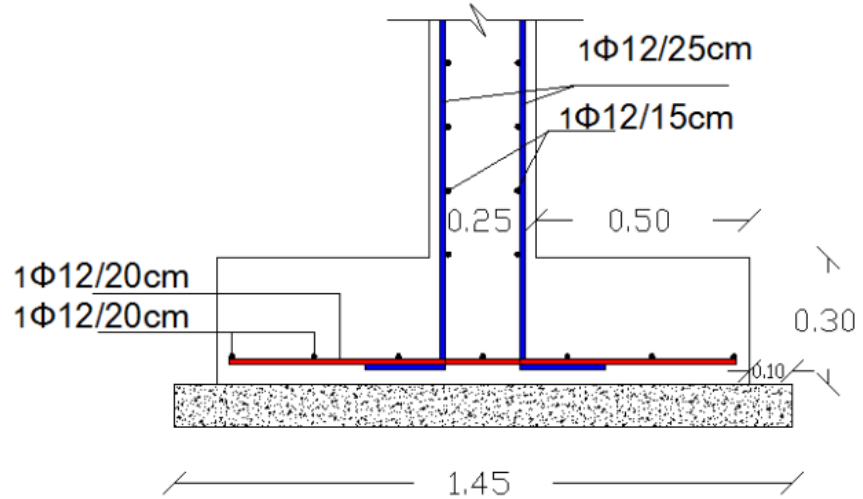
= 675mm2 .... **(1Φ12/20cm).**

★ **Check Bars Anchorage:**

db< 20mm so, Ldt= (0.48×Fy)/(√F'c) * db

if Ldt > 650 mm...there is need for hook

Ldt= (0.48×420)/(√32) * 12 = 427.6mm < 650mm ... So, No Need For Hook.



Design
Of
Basement Walls

Static Design/Basement walls

q_{all}=400kN/m^2.

H=5.5m.

Ø=30°....K_o=1-sin30° = 0.5

Using sap14 to analysis the model the result was as follows:

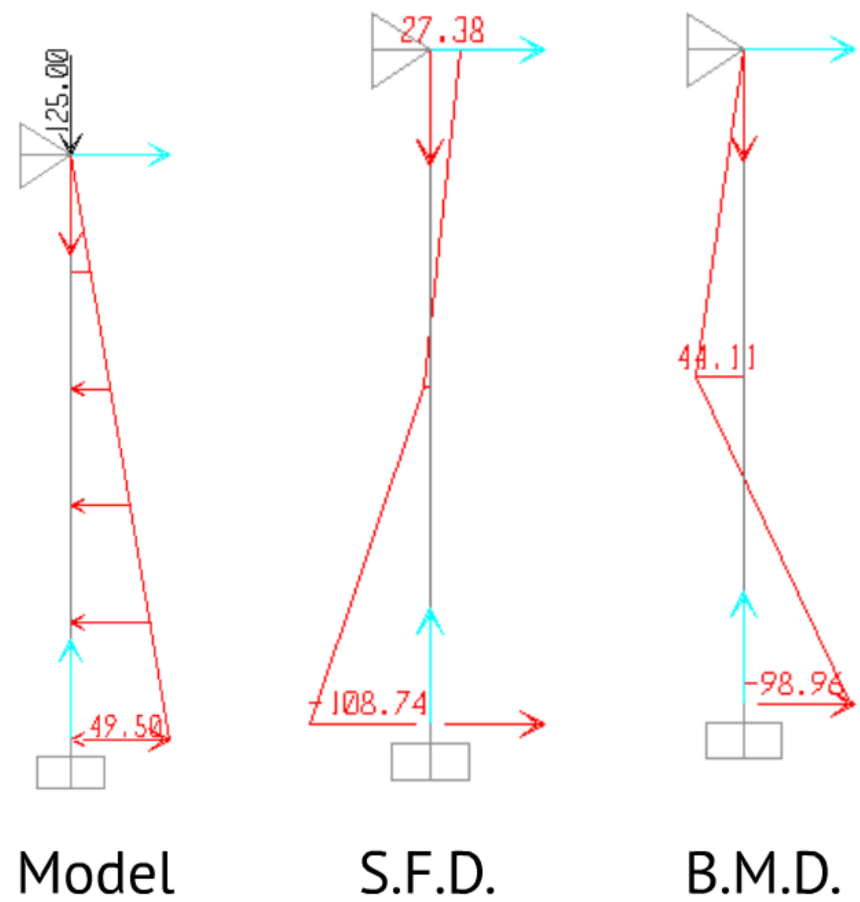
ɣs*H*Ko=49.5kN/m2.

To get thickness of wall:

Vu= ΦVc

1.6*108.7 = 0.75/6×(√32 ×1000×(d))/1000

>>> d= 250mm .... **Use h=300mm.**



Static Design/Basement walls

★ **Basement wall Reinforcement:**

★ **Main steel (from soil side):**

$Mu=1.6*98.96=158.34kN.m$
$\rho= 0.00732$
$As = \rho \times b \times d = 1801.8mm2$ ...... **(1 Φ20/15cm).**

★ **Main steel (for inner side):**

$Mu=1.6*44.2=70.72kN.m$
$\rho= 0.00316$
$As = \rho \times b \times d = 777.4mm2$ .... **(1 Φ14/15cm).**

★ **Horizontal steel:**

$As(horizontal)=0.002 \times b \times h$
$= 600mm2$ ...... **(1 Φ12/15cm).**

Static Design/Basement walls

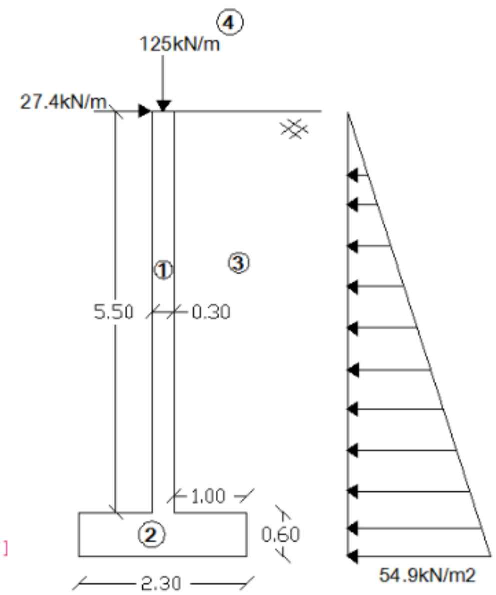
Basement wall Footing design:

Assume the following dimensions for the footing of wall (W1)

Mo= (q*H)/2*(H/3)

= (54.9*6.1*6.1)/6

= 340.47kN.m/m.



M(Resisting)=27.4*6.1+409.07

= 576.21KN.m.

Part	Wright (kN)	Arm(m)	Moment (kN.m)
1	41.25	1.15	47.44
2	34.5	1.15	39.675
3	99	1.8	178.2
4	125	1.15	143.75
sum	299.75		409.07

Static Design/Basement walls

Basement wall Footing design:

$a = (M_R - M_o) / P$

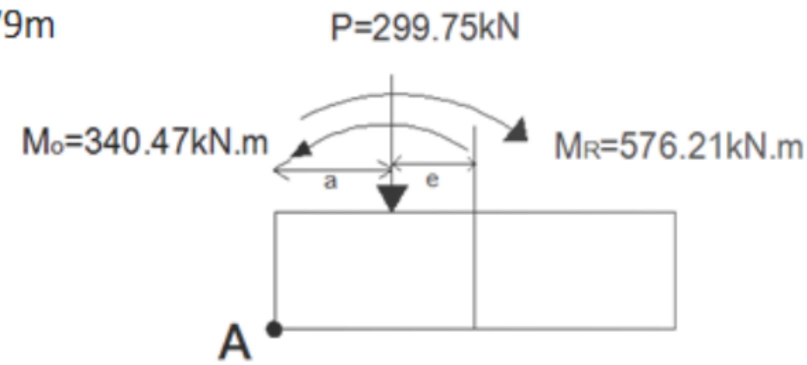
$= (576.21 - 340.47)/299.75 = 0.79m$

$e = (B/2) - a$

$= 2.3/2 - 0.79 = 0.36m$

$M = P * e$

$= 299.75 * 0.36 = 107.91kN.m$



$$\sigma = \frac{-P}{A} \pm \frac{M \times C}{I}$$

$= (-299.75/2.3) \pm \{107.91*(2.3/2) / (2.3^3/12)\}$

$\sigma_{max} = -252.71kN/m^2 < 400kN/m^2$...... Ok.

$\sigma_{min} = -7.93kN/m^2 > 0$ ... no tension ..... Ok.

Static Design/Basement walls

★ **Basement wall Footing design:**

★ **Heel Design:**

Vu= (1.6*99*1)+(0.6*1*25*1.2)-(1.6*1*(114.36+7.93)/2 = 78.57kN.

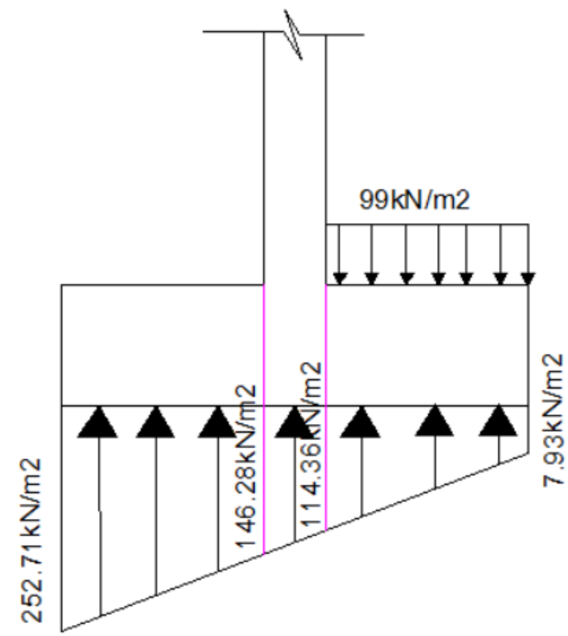
$$\Phi Vc = \frac{0.75}{6} \times \frac{\sqrt{32} \times 1000 \times (540)}{1000}$$

= 381.84kN > Vu= 78.57kN....Ok

$Mu=(1.6*99*1^2/2)+1.2*(0.6*25*1^2/2)$

$-1.6*\{(1^2*(114.36+7.93)/2)/6\}$ = 71.89kN.m/m

$\rho=0.00065 < \rho_{min}=0.002$ ... use As_{min} =1080mm^2 ... **(1Φ14/12cm) for both directions.**



★ **Toe Design:**

Vu= 1.6*1*(252.71+146.28)/2 = 319.192kN.

ΦVc = 381.84kN > Vu= 78.57kN....Ok

$Mu= 1.6*\{(146.28*1^2/2) +((252.71-146.28)/2)*1*2/3)\}$ = 173.7kN.m/m

$\rho=0.0016 < \rho_{min}=0.002$ ... use As_{min} =1080mm^2 ... **(1Φ14/12cm) for both direction.**

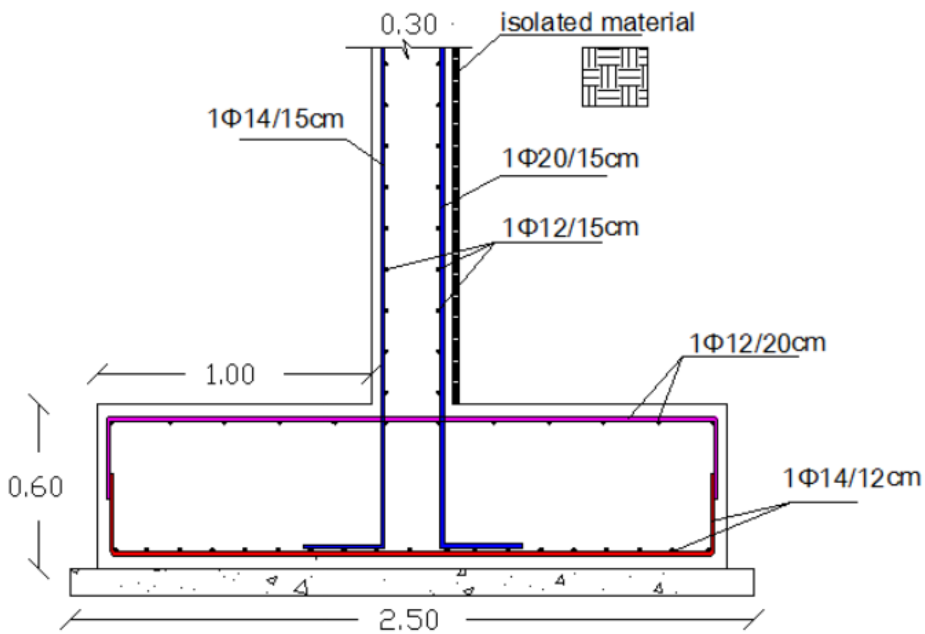
Static Design/Basement walls

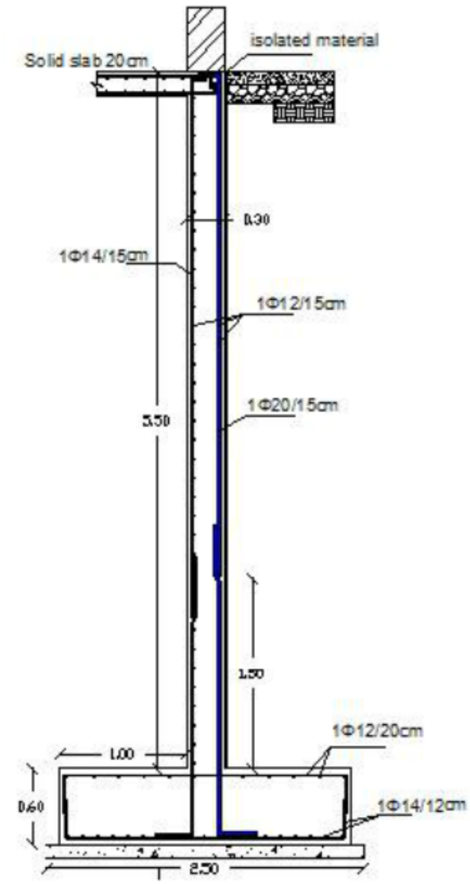
Basement wall Footing design:

As shrinkage:

$As_{shrinkage} = 0.0018*1000*540 = 972mm^2$.

For both direction in upper side use 972/2 =486mm² **(1 Φ12/20cm).**





Design Of Stairs

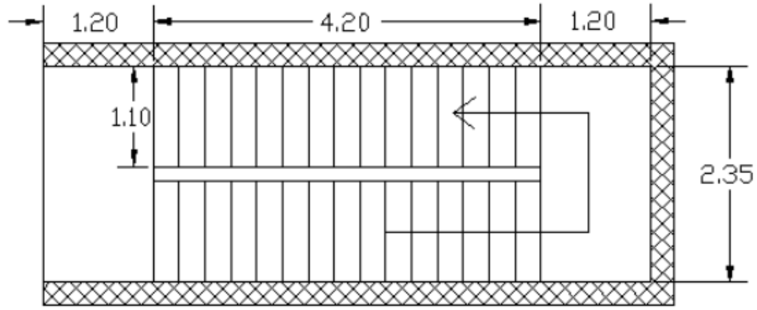
Static Design/ Stairs

SED Load = $3kN/m^2$...... Live load = $4kN/m^2$.

# of running = 4.2/ 0.28 = 15

# of rising =2.75/0.18 = 15

# of steps for one flight = 15 Steps.



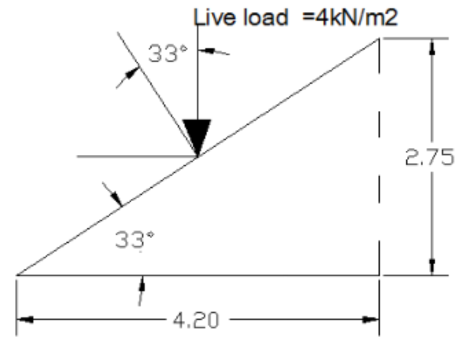
Thickness of the stairs:

Assume simply supported slab:

hmin = 0.85*(L/20) = 0.85*(4.2/20)

= **0.18 m** ...... Take **h=20cm** with cover 3cm.

Flight Load:



O.W(flight) = 0.18*0.28*25*0.5*3 +1*0.2*25 = 6.89 kN/m.

Live load = 4*cos α = 4*cos33= 3.35 kN/m2.

$W_{ultimate}$ = 1.2D.L +1.6L.L

= 1.2(6.89+3) + 1.6(3.35) = 17.23kN/m2.

Vu= Wu*L/2 = 17.23*4.2/2 = 36kN.

ΦVc =112.44kN >> Vu = 36kN. ..... Ok.

Static Design/Stairs

★ Reinforcement:

$M_u = W_{ult} * L^2 / 8$

$= 17.23 * 4.2^2 / 8 = 40$ kN.m

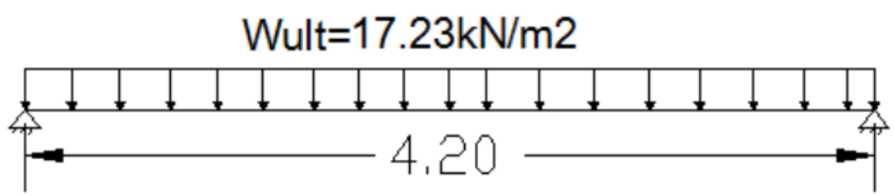
$\rho = 0.0038$

★ Main steel:

$As = \rho \times b \times d$

$= 0.0038 * 1000 * 170$

$= 646 mm^2$ ....**(1 Φ12/15cm).**



★ Secondary Steel:

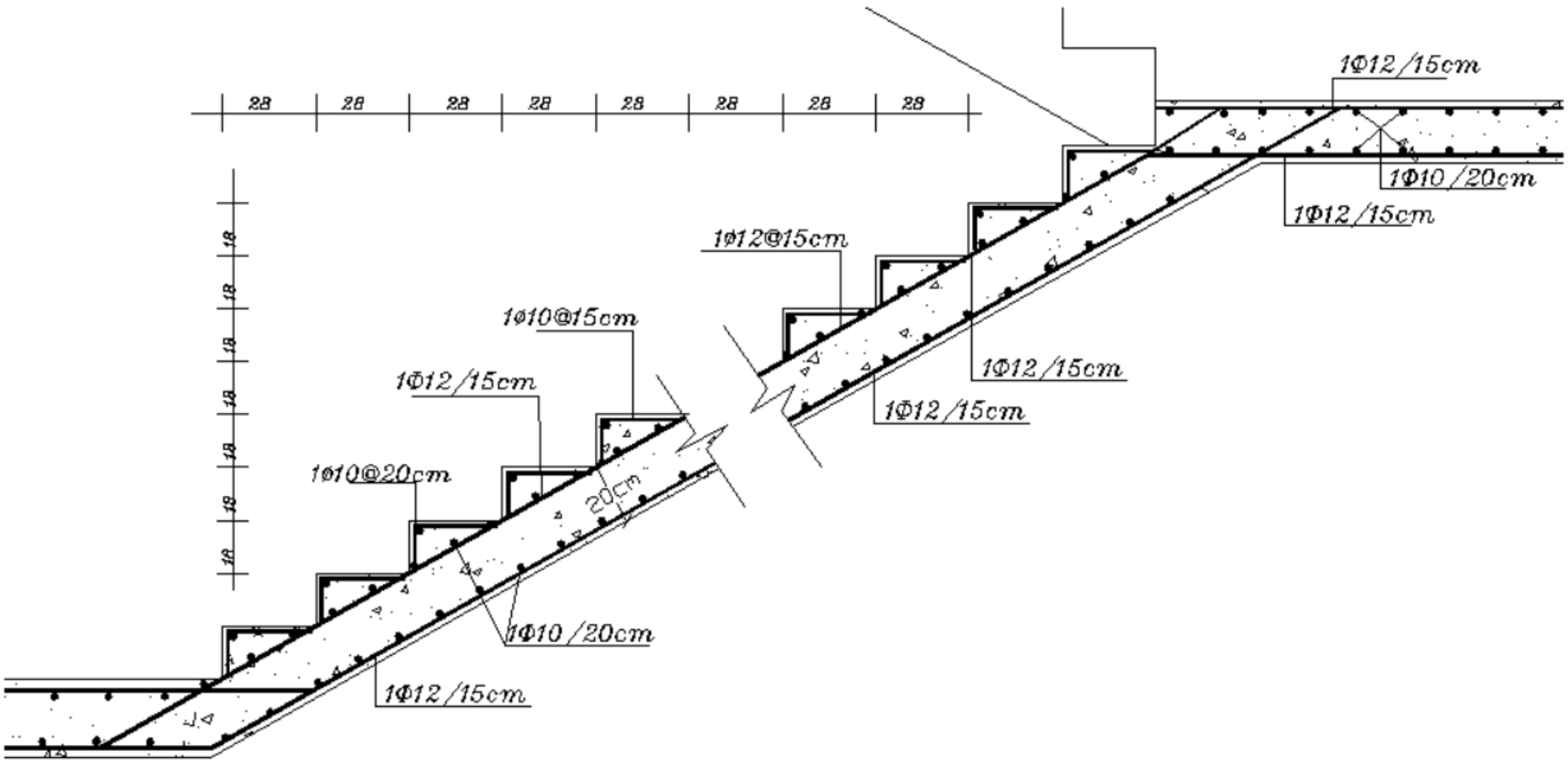
$As_{(shrinkage)} = 0.0018 \times b \times h$

$= 0.0018 * 1000 * 200$

$= 360 mm^2$ ....**(1 Φ10/20cm).**

Static Design/Stairs

★ Stairs Detailing Reinforcement:



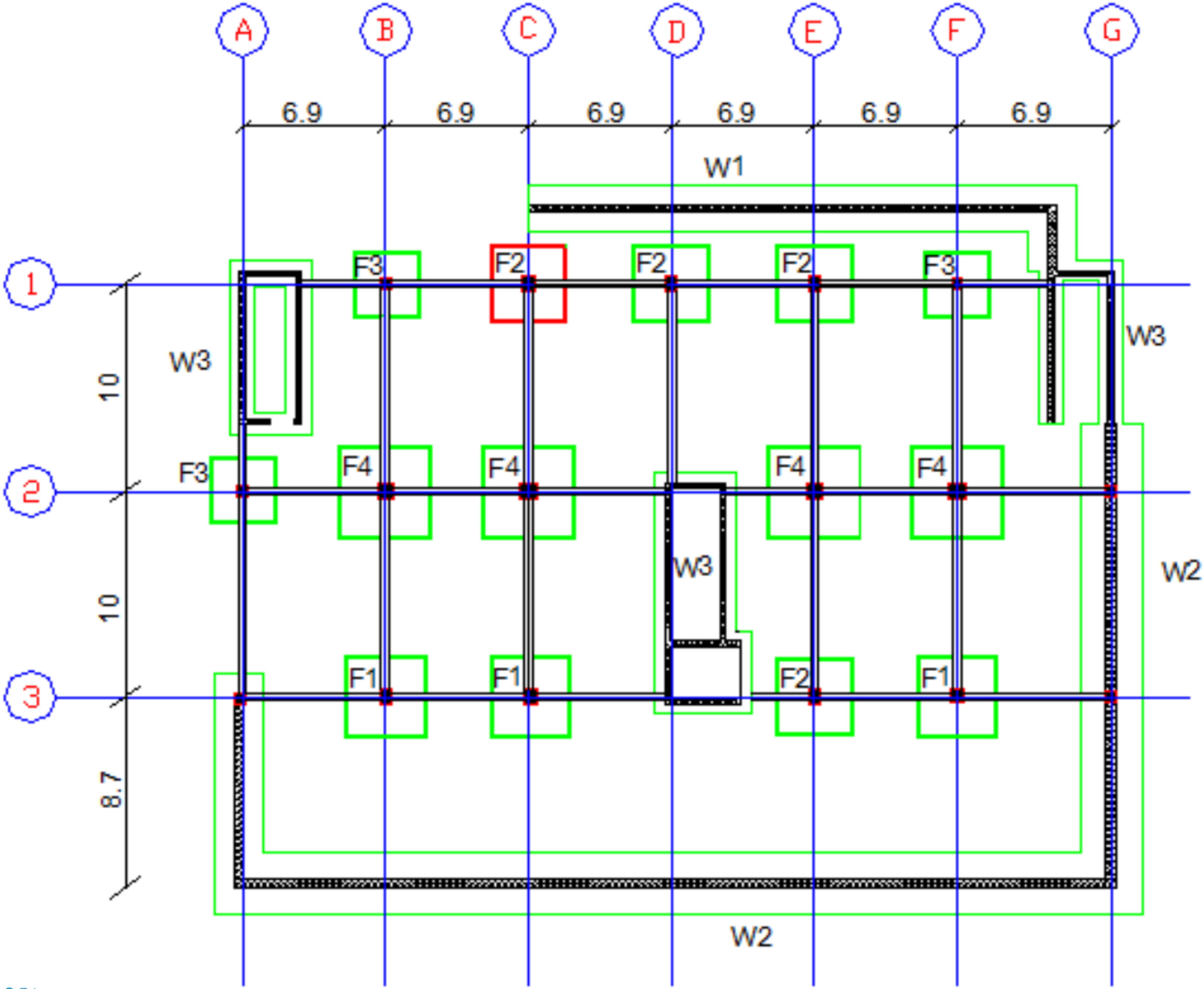
Design
Of
Footings

Static Design/Footing

- The main function for footing is to carry the whole loads from columns and distribute it over a larger area on the ground.

In this Project we decided to use a Single footing Type due to main reasons:

- Firstly, The Bearing Capacity (qall) of the soil is 400KN/m2. Which is good (Rock Soil Type).
- Secondly, The Total Area of Whole Footing is (560) m2 and it is less Than 50% of the Area of basement floor(1200) m2.
- And Finally, The Ultimate Moments on the footing is negligible as we compare it with the axial loads.


A
B
C
D
E
F
G
6.9
6.9
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6.9
6.9
6.9
W1
1
2
3
10
10
8.7
F3
F2
F2
F2
F3
W3
W3
F3
F4
F4
F4
F4
W3
W2
F1
F1
F2
F1
W2

Static Design/Footings

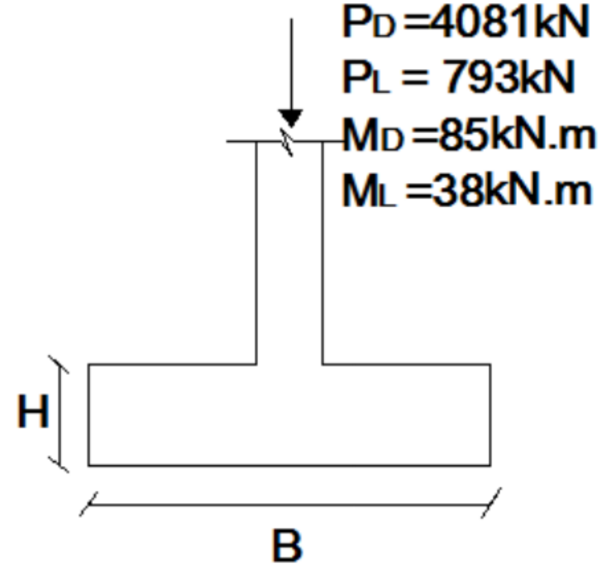
★ **Taking Footing F2 Column #14 to be calculated:**

Column Dimensions (60*70)cm.
To get the area of the footing, assume (M=0).

AF=Pservice/qall = (4081+793)/400 = 12.185m2.
Preliminary Footing Dimensions (3.5*3.5)m.

$$\sigma = \frac{Pservice}{A} \pm \frac{Mservice \times C}{I}$$ ..... (check q ≤ qall).

= (4874/12.185) ± {(123*(3.5/2)} / (3.53*3.5/12)
= 400 ± 18
= 418 & 382
400 ≠ 418 ....So, 382 = Pservice/Af = 4872/Af = 382
AF = 12.75m2 >>> **B=L=3.6m.**



Static Design/Footings

★ **Footing Thickness:**

P_u = 6166KN , M_u = 163KN.m

Finding the ultimate pressure under the footing:

$$\sigma = \frac{Pu}{Af} \pm \frac{Mu \times C}{I}$$

σ_{max} = 497 kN/m^2.

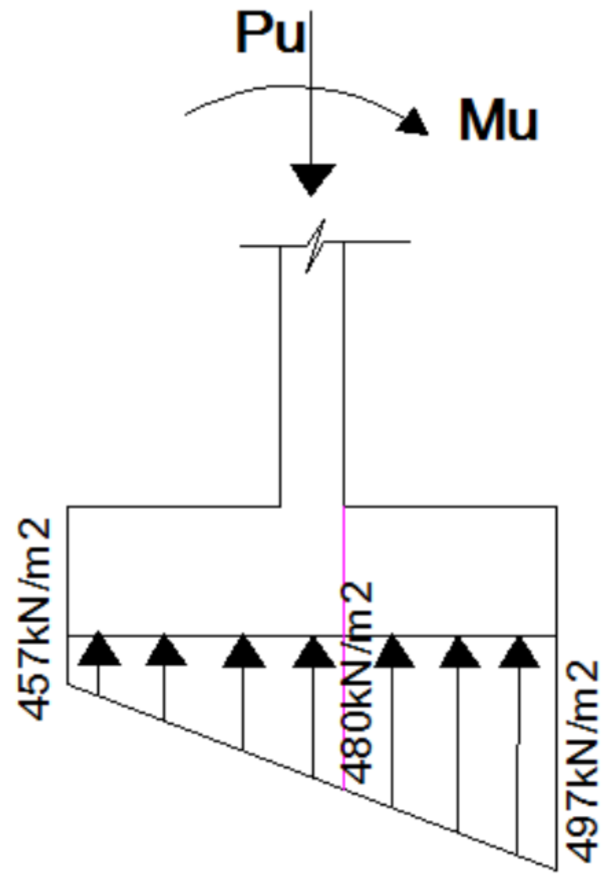
σ_{min} = 457 kN/m^2.

★ **Wide beam shear:**

$Vu \leq \Phi Vc$

$$0.5(480+497)(1.5-d) = \frac{0.75}{6} \times \frac{\sqrt{32} \times 1000 \times (d) \times 1000}{1000}$$

d= 0.62m >>>>> Try H = 0.7m.



Static Design/Footings

Check Punching Shear:

Using simplified method:

$V_{u,p} = q_u * A_F$

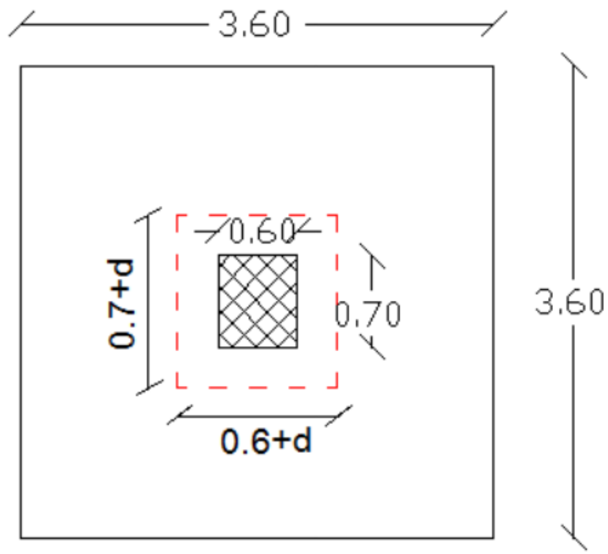
$= 497*(3.6*3.6 = 6441.12kN.$

$$\Phi V_{c,p} = \frac{0.75}{6} \times \frac{\sqrt{f'c} \times bo \times (d) \times 1000}{1000}$$

$$= \frac{0.75}{6} \times \frac{\sqrt{32} \times \{(700+620+600+620)\times 2\} \times (620) \times 1000}{1000} = 4454.2kN.$$

$V_{u,p} > \Phi V_{c,p}$ .... Not good so after some trials, use **H=0.9m** with d=0.82m

$\Phi V_{c,p} = 6818.77 > 6441.1 = V_{u,p}$ ...... Ok ✔



Static Design/Footings

★ **Footing Reinforcement:**

x-direction: L1= (3.6-0.6)/2 = 1.5m.

y-direction: L2=(3.6-0.7)/2 = 1.45m.

As the two lengths are approximately same we use the larger one to get moment L=1.5m.

Mu = (qu*L^2)/2 =(497*1.5^2)/2 = 559.2kN.m

ρ= 0.00223 , ρmin=0.0018

As = 1828.6mm2 , Asmin=1620mm2.

Use for bottom As = 1828.6mm2 >>>>**(1 Φ18/120mm) for both directions.**

Use for top Asmin= 1620mm2 /2

= 810mm2 >>>>>> **(1 Φ14/170mm) for both directions.**

Static Design/Footings

★ **Check bar anchorage:**

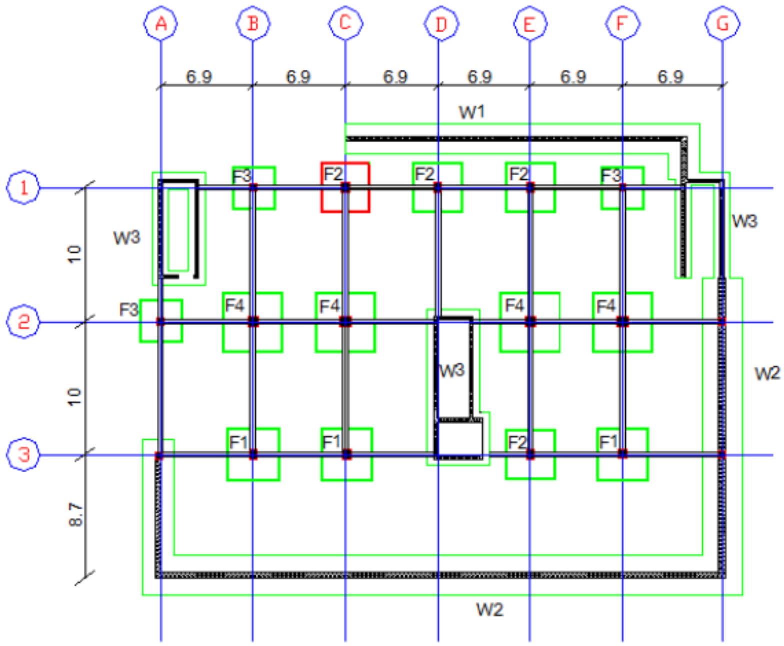
$d_b < 20mm$ so $L_{dt} = \frac{0.48 \times Fy}{\sqrt{F'c}} * d_b$ .... if $L_{dt} > 650$ mm ... there is need for hook.

$$L_{dt} = \frac{0.48 \times 420}{\sqrt{32}} * 18 = 645mm < 650mm$$ ... no need for hook but as depth of footing 90cm, hook will be used so

$$L_{dh} \geq \frac{0.24 \times Fy}{\sqrt{F'c}} * d_b = 320mm$$
$$\geq 8 * d_b = 144mm$$
$$\geq 150mm$$

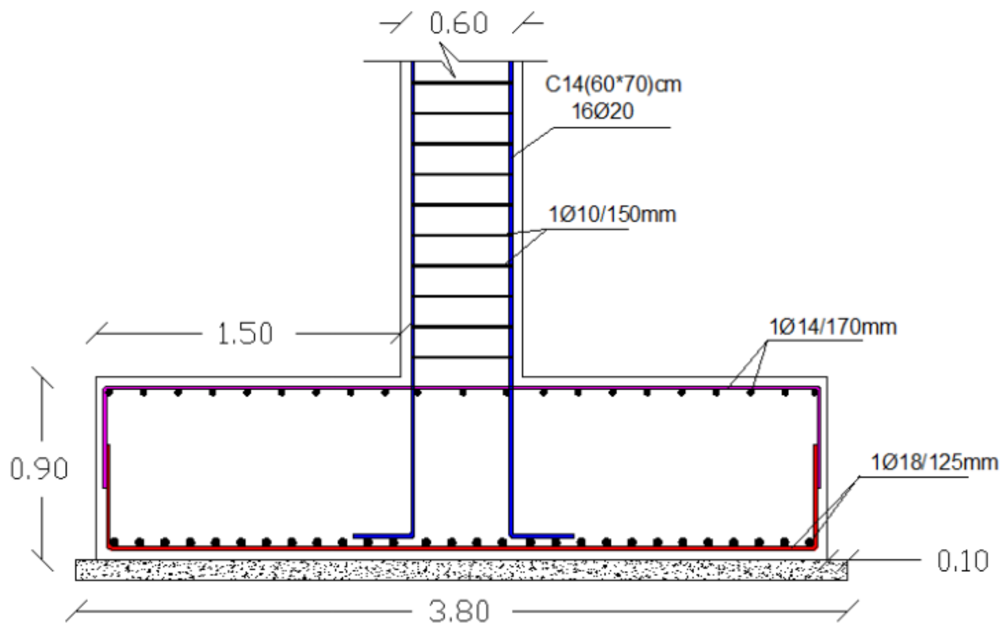
Use hook with 1.3* 320=420mm.

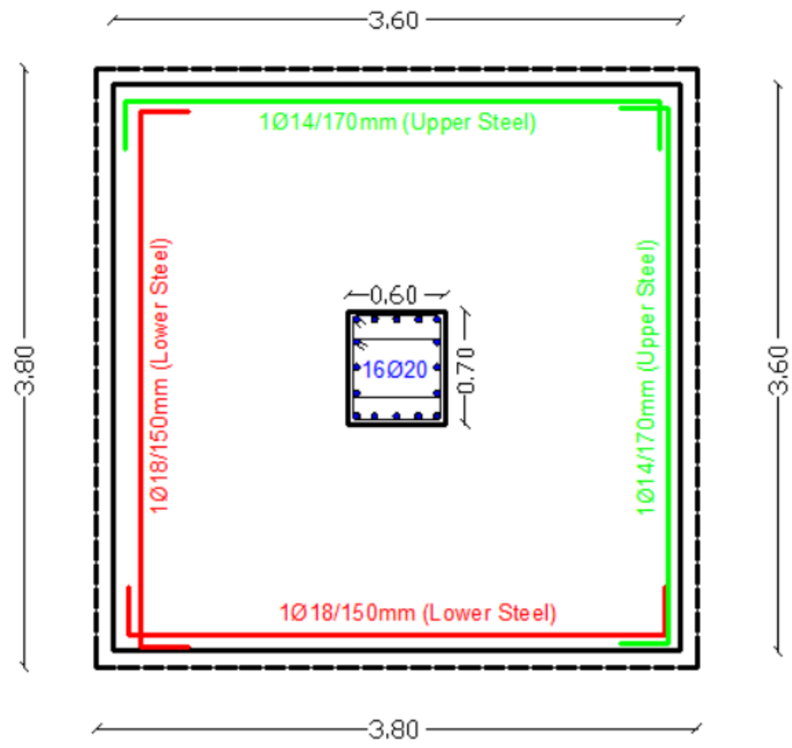
Static Design/Footings



Footing Number		Ultimate Axial Load	Footing Dimensions	Main Reinforcement	Secondary Reinforcement
Column#	F#	Pu (kN	(width×Length×Depth) (m)	Longitudinal And Transverse	Longitudinal And Transverse
2,3,5	F1	6957-6530-6956	3.70×3.70×1.00	8Φ18 1Φ18/125	6Φ14 1Φ14/170
4,14,15,16	F2	5362-6168-5890-5990	3.60×3.60×0.90	8Φ18 1Φ18/125	6Φ14 1Φ14/170
7,13,17	F3	4405-4266-4486	3.00×3.00×0.75	6Φ18 1Φ18/170	5Φ14 1Φ14/200
8,9,10,11	F4	8608-9332-7940-8642	4.30×4.30×1.10	9Φ18 1Φ18/110	7Φ14 1Φ14/150

Static Design/Footings





Design
Of
Tie Beams

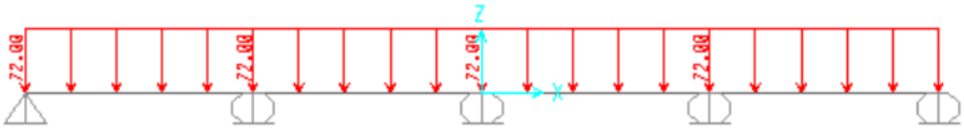
Static Design/Tie Beams

F'c=32Mpa, Fy=420Mpa.

Wall load=25kN/m.

Ultimate load from ground slab=10kN/m².

Tie Beam Dimensions: **(40*60)cm.**

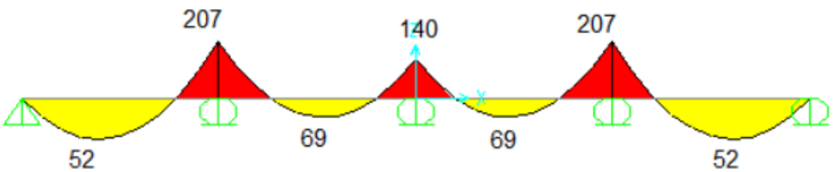


★ Tie Beam at Y-direction:

O.W. = (0.4*0.60*25) =6.0kN/m.

Wu=1.2(6+25) + (6.9*10*0.5)= 72kN/m.

★ Flexure Design:



For Mu=207KN.m
ρ=0.0047<0.0033
As=0.0047*400*550
= 1031mm2. **Use (6Φ16).**

For Mu=69KN.m
ρ=0.0015>0.0033
As=0.0033*400*550
=726mm2. **Use (5Φ14).**

Static Design/Tie Beams

Wide Beam Shear:

Vu=237kN.

ΦV_c= ((0.75/6)*√32*400*550)/1000 =156kN.

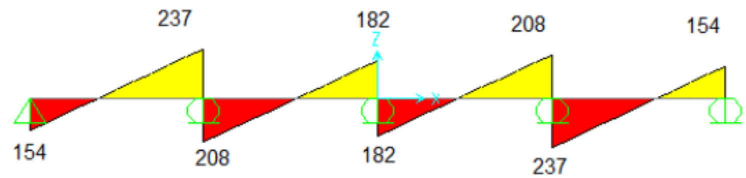
$\Phi V_c < V_u$------So we need Shear Reinforcement.

$V_s = (V_u/\Phi)-V_c$
= (237/0.75)-208 =108KN.

(A_v/S)= (108*1000)/(420*550)

=0.47mm/mm > (A_v/S)min = 0.33mm/mm.

Assume Φ10 stirrup--------Av=2*78.5=157mm^2.
S=157/0.47=334mm



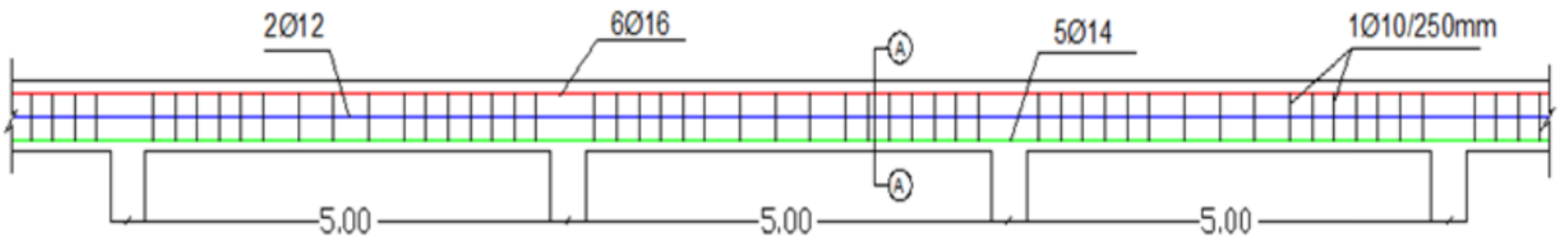
Check Spacing:

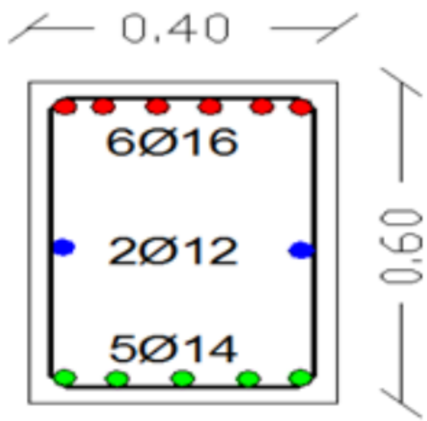
Vs=108kN<2*208 ---------So, S=min(550/2,600)---------S=250mm.

Use 1Φ10/250mm.

Static Design/Tie Beams

★Detailing Of Tie Beam:





A-A


الحمدُ لله
الذي بنعمته تتم الصالحات


Thank You
For Your
Attention
Any
Questions?