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StructuralG+4 Residential Building in Addis Ababa

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SUMMARY

This project deals about the structural analysis and design of G+4 building considering all the external and internal effects according to EBCS 2015. The project is located in Addis Ababa. It includes wind load analysis The proper design for each structural component is also carried out. Slab analysis and design, staircase analysis and design is carried out manually. Frame analysis was carried out by using ETABS commercial software and lateral load analysis. Finally, the foundation for the structure was designed.

From the analysis, we observed that the structure is designed safely and economically under the exposed load. Based on the output from ETABS software it is selected that, isolated footing is the most compatible for the bearing capacity of the soil. In a view of these analysis and design producer, it is essential to use soft wares like ETABS in order to save time and accuracy. Finally, it is recommended that, it is appreciated to incorporate such kind of project for further experience of the student and it is better to come up with the design data which have the necessary information.

ACKNOWLEDGMENT

Our greatest thanks from the depth of our heart is to GOD for endowing us with the courage, Strength as well as health throughout our school time.

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1. INTRODUCTION

1.1 Background of the project

There are so many type of structure design based on its function such as Residential, Hotel, and Mixed use.....etc. structure design. In this case Residential building structure is design.

This project is G+4 Residential building allocated on Addis Ababa,. It is under terrain category IV and zone 2 it is not hazard to earth quake but analysis earth quake effect in the building. The total area of the site is about 469.6m².

The height of the building is +18.36 m. The geometry of the roof is flat roof type and the geometry of slab is solid slab. On the ground floor it includes office, study room, dining room, store, bathroom are presented. First& second floor 3.06m room, it includes dressing room, living room bathroom, bed room, store, kitchen is presented. Thired floor 3.06m height long, it include dressing room, bathroom, are presented. Fourth floor includes, Master Bed room, terrace, Fourth and fifth floor are typical 3.06m long, it includes study room, family room, Bed room and toilet.

The limit state design method is used for the entire structure. The Ethiopian Building code of standards (EBCS_2015) is used in the design with some books and lecture note as a reference.

1.2 Objectives

The main objective of this project is to design G+4 residential building using EBCS 2015

Sub-objective

- In order to revise what have learnt in the time of study.
- To get more knowledge about engineering software like, Etabs, Sap.
- It develops the habit of working together or team.
- To understand more information about EBCS 2015
- To identify natural hazards and make the building strong enough to sustain those hazards.

1.3 Material Selection & Design Data

The first step in design is to select construction materials which are capable of resisting the applied load. Considering the availability in market we select concrete and steel reinforcement as follows.

❖ Concrete

Class I workmanship and ordinary loading condition is used.

Concrete grade C-25 is used because it can be used for construction in all areas including foundations. Domestic and commercial buildings are the type of buildings in which the C-25 concrete mix is applicable for.

- ✓ Partial safety factor for concrete $\gamma_c = 1.5$
- ✓ Characteristic strength, $f_{ck} = \frac{f_{cu}}{1.25} = \frac{25}{1.25} = 20$ Mpa where $f_{cu} = 25$ Mpa
- ✓ Design strength, $f_{cd} = \frac{\alpha_{cc} f_{ck}}{\gamma_c} = \frac{0.85 \times 20}{1.5} = 11.33$ Mpa

❖ Reinforcement

Steel S-400

- ✓ Partial safety factor for concrete $\gamma_s = 1.15$
- ✓ Characteristic strength, $f_{yk} = 400$ Mpa
- ✓ Design strength, $f_{yd} = \frac{f_{yk}}{\gamma_c} = \frac{400}{1.15} = 347.83$ Mpa

❖ Concrete cover

- ✓ $C_{nom} = C_{min} + \Delta C_{dev}$

$C_{min} = \max$ of (Cmin, b, Cmin, dur + ΔC_{dur} – ΔC_{dur} , st - ΔC_{dur} , add, 10mm)

$C_{min} = \max$ of (10, 10 + 0 – 0 - 0, 10mm)

$C_{min} = 10$ mm

$C_{nom} = 10 + 10 = 20$ mm

We take $\emptyset = 10$ mm for slab reinforcement and concrete cover of 20 mm

❖ Partial safety factors for load

- ✓ 1.35 for dead load
- ✓ 1.50 for live load

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Table 1 Basic ratios of span/effective depth for reinforced concrete members without axial compression

Structural System	K	Concrete highly stressed $\rho= 1.5\%$	Concrete lightly stressed $\rho= 1.5\%$
Simply supported beam, one – or two- way spanning simply supported slab	1	14	20
End span of continuous beam or one- way continuous slab or two-way spanning slab continuous over one long side	1.3	18	26
Interior span of beam or one-way or two-way spanning slab	1.5	20	30
Slab supported on columns without beams (flat slab) (based on longer span)	1.2	17	24
Cantilever	0.4	6	8

Note 1: The values given have been chosen to be generally conservative and calculation may frequently show that thinner members are possible.

Note 2: For 2-way spanning slabs, the check should be carried out on the basis of the shorter span. For flat slabs the longer span should be taken.

Note 3: The limits given for flat slabs correspond to a less severe limitation than a mid-span deflection of span/250 relative to the columns. Experience has shown this to be satisfactory

Taking $L/d=26$ for end span $L/d = 30$ for interior span from ES EN 1992:2015 9table 7.4N)

Where L =effective length of two-way slab (the shorter length L_x)

d = effective depth but those value is for steel grade 500,

We must have to modify it in our case modification factor $=500/400=1.25$ there for end span $26*1.25=32.5$

- Interior span $30 \times 1.25 = 37.5$
- Cantilever $8 \times 1.25 = 10$

2. ROOF DESIGN ANALYSIS

Roof is the upper part of a building that protects from any kind of weather. It is subjected to different kinds of loads such as wind load, its own self-weight, and the loads of the persons who go on the roof for maintenance and snow loads too. Most type of roof consists of network of frames of wood or steel and covering materials.

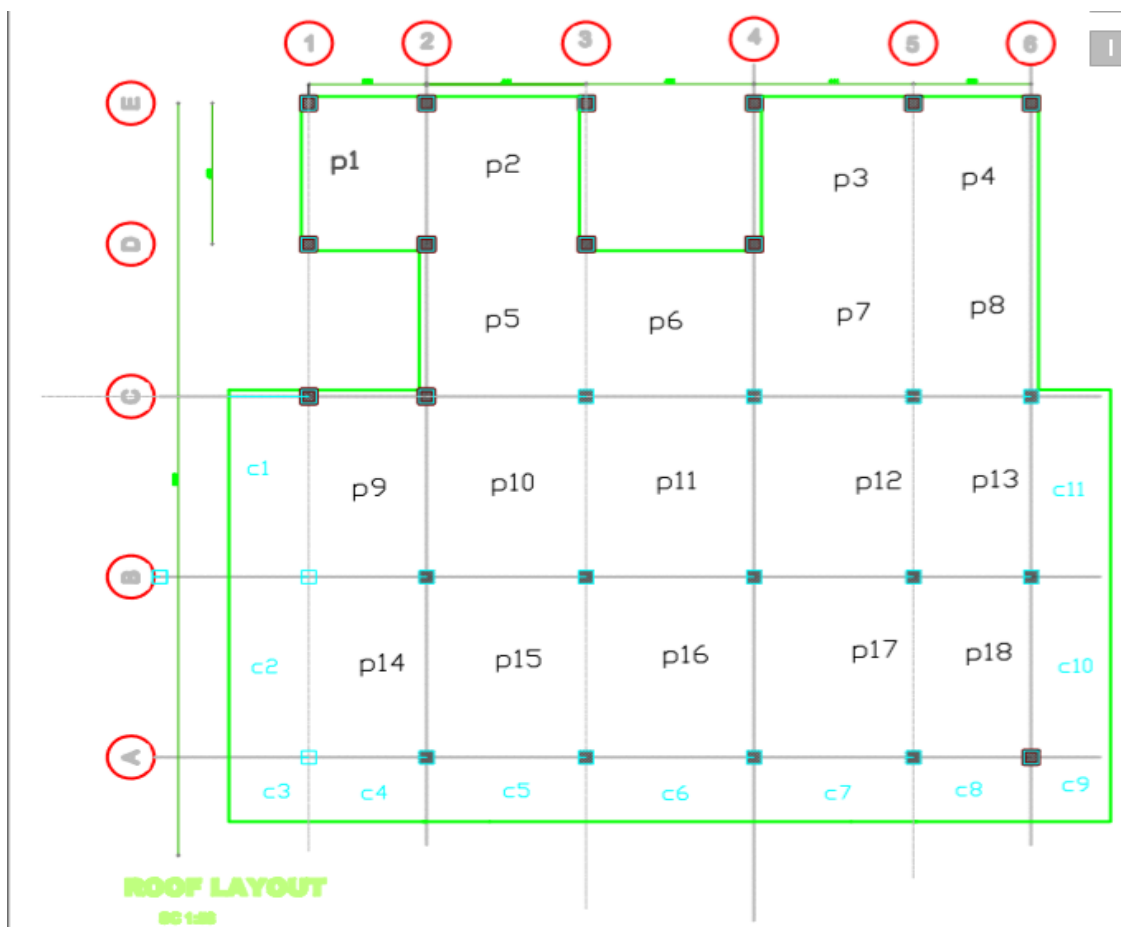


Figure 1 Roof plan

2.1 Wind load analysis of roof

The action of wind can be applied by the type of suction or pressure to our structures both externally or Internally.

Design Data and Material Property specification

The Building is residential building and it has the following material property.

✓ **Concrete:** Class I work

- Unit weight of concrete, $\gamma_c = 25 \text{KN/m}^3$
- Safety factor for concrete $\gamma_s = 1.5$

For C-25 $f_{ck} = 0.8 * 25 \text{Mpa} = 20 \text{Mpa}$

$$f_{ctk} = 0.21 * (f_{ck})^{2/3} = 0.21(20)^{2/3} = 1.547 \text{Mpa}$$

$$f_{cd} = 0.85 * \frac{20}{1.5} = 11.33 \text{Mpa}$$

$$f_{ctd} = \frac{1.547}{1.5} \text{Mpa} = 1.03 \text{Mpa}$$

For C-30 $f_{ck} = 0.8 * 30 \text{Mpa} = 24 \text{Mpa}$

$$f_{cd} = 0.85 * \frac{24}{1.5} = 13.6 \text{Mpa}$$

Reinforcement: Steel S-400

Partial safety factor for concrete $\gamma_s = 1.15$

Characteristic strength, $f_{yk} = 400 \text{Mpa}$

$$\text{Design strength, } f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{400}{1.15} = 347.83 \text{Mpa}$$

Partial safety factors for load

1.35 for dead load

1.50 for live load

Analysis Information

The building under consideration has the following properties: -

- The height of building above the ground level is 16.5m including slab thickness.
- The building roof is Flat roof from the given.
- Building is located in adissababa, which is seismic region 3.
- Adiss Ababa is Category IV based on terrain category as set in ES EN.
- Adissababa altitude is 2355m above sea level.
- Width and length of the buildings is 23.81m and 22.79m respectively taken from floor plan.
- Height of parapet of the roof=1m
- Thickness of RC solid slab=170mm
- Thickness of cement screed=30mm

2.1.1 Wind pressure

A. External wind pressure (We)

It is the wind pressure acting on the external surfaces of a structure.

B. Internal wind pressure(Wi)

It is the wind pressure acting on the internal surfaces of a structure.

- Wind load = $q_p(Z)C_p$
 - ✓ $W_{net} = W_e - W_i = q_p(Z)C_{pe} - q_p(Z)C_{pi}$
 - ✓ $W_{net} = q_p(Z)(C_{pe} - C_{pi})$

Where W_{net} : - Net wind pressure load

W_e : - External wind Pressure

W_i : - Internal wind Pressure

$q_p(Z)$: - is the Peck velocity Pressure

C_{pe} : - is the external pressure coefficient

C_{pi} : - is the internal pressure coefficient

External wind Pressure on the roof floor

The wind pressure acting on the external surface of a structure is function of the peck velocity Pressure In order to determine the contact pressure on the outside of a structure or part of a structure, the peck velocity Pressure, q_p of the wind must be multiplied by an external pressure coefficient. The external pressure coefficient is accounts for the variation in dynamic pressure on different zones of the structure due to its geometry, area and proximity to other structures. Since our roof is flat roof.

➤ $W_{ex} = q_p(Z) C_{pe}$EBCS-1, 2015

C_{pe} - is the external pressure coefficient

Determination of $q_p(Z)$ =Peck velocity Pressure

➤ $q_p(Z) = [1 + 7I_v(z)] * 0.5 * \rho_{air} * V_m^2(z)$

Where: $I_v(z)$ - Turbulence intensity

ρ_{air} - Air density

$V_m(z)$ -Mean wind velocity

A. Turbulence intensity($I_v(z)$)

➤ $I_v(z) = \frac{\sigma_v}{V_m(z)}$ for $Z_{min} < Z < Z_{max}$

➤ $I_v(z) = I_v(Z_{min})$ for $Z < Z_{max}$

Where:- $V_m(z)$ -Mean wind velocity

σ_v – Standard deviation of Turbulence

from table 2.1 below we take $Z_0=1, Z_{min}=10$

Table 2 Terrain Categories and Related Parameters

Category	Terrain classification	Zo(m)	Zmin
0	Sea or coastal area exposed to the open sea	0.003	1
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles	0.01	2
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle height	0.05	4
III	Area with regular cover of vegetation or buildings or with Isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0.3	5

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IV	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1	10
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We use this formula $I_v(z) = \frac{\sigma v}{V_m(z)}$, b/c $Z_{min} < Z < Z_{max}$ $10 < 20 < 200$ for roof 1 and $10 < 18 < 200$

B. Mean wind velocity $V_m(z)$

$$\triangleright V_m(z) = C_r(Z) C_o(Z) V_b$$

Where: $C_r(Z)$ -Roughness factor

$C_o(Z)$ - Terrain Topography

V_b -basic wind velocity

$$V_b = C_{dir} C_{season} V_{b,o}, \text{Where, } C_{dir} = \text{Directional factor} = 1.0$$

$$C_{season} = \text{Seasonal factor} = 1.0$$

$$V_{b,o} = \text{Fundamental value of basic wind velocity} = 22 \text{ m/s}$$

$$\text{Therefore, } V_b = C_{dir} C_{season} V_{b,o} = 1 * 1 * 22 \text{ m/s} = \mathbf{22 \text{ m/s}}$$

C. Roughness factor ($C_r(Z)$)

The roughness coefficient $C_r(z)$, accounts for the variability of mean wind velocity due to the height of the structure above ground level and the roughness of the terrain. It is defined by the logarithmic relationship:

$$\triangleright C_r(Z) = K_r \ln \left(\frac{Z}{Z_0} \right), \text{ for } Z_{min} \leq Z \leq Z_{max}$$

Where, K_r -Terrain factor depending on the roughness length Z_0 calculated using

$$K_r = 0.19 \left(\frac{Z_0}{Z_{0,II}} \right)^{0.07},$$

$Z_{0,II}$ -Roughness length for category III=0.05m

$$K_r = 0.19 \left(\frac{Z_0}{Z_{0,II}} \right)^{0.07} = 0.19 (1/0.05)^{0.07} = \mathbf{0.2343}$$

$$h = 16.5 \text{ m}$$

$$C_r(Z) = 0.2343 \ln(16.5/1) = \mathbf{0.657}$$

D. Terrain orography ($C_o(Z)$): Based on EBCS-1, 2015 Art 3.8.4 (Page 58) defined by

$$C_t(z) = 1 + 2s\Phi \text{ for } 0.05 < \Phi < 0.3$$

$$C_t(z) = 1 + 0.6s \text{ for } \Phi > 0.3$$

Where: Φ - is the up wind slope H/L_u in the wind direction.

S -is the factor to be obtained by interpolation from the values of $s = 1$ at crest of hills, ridge or escarpment and the values of $S = 0$ at boundary of topography affected zone.

$$C_t(z) = 1 \text{ for } \Phi < 0.05$$

After finding terrain orography we can calculate V_m

$$\triangleright V_m(z) = C_r(Z)C_o(Z) V_b = 0.657 * 1 * 22 \text{m/s} = \mathbf{14.45 \text{m/s}}$$

E. Standard deviation of Turbulence (σ_v)

$$\triangleright \sigma_v = K_r V_b K_1$$

Where, K_r -Terrian factor=0.2343 from above

K_1 -Turbulence Factor=1 recommended value

V_b -basic wind velocity=22m/s

$$\sigma_v = 0.2343 * \frac{22 \text{m}}{s} * 1 = \mathbf{5.06 \text{m/s}}$$

$$I_v(z) = \frac{\sigma_v}{V_m(z)} = \frac{5.06}{14.45} = \mathbf{0.35}$$

F. Air density

Is affected by altitude and depends on the temperature and pressure to be expected in the region during windstorms. This is donated by pair in kg/m^3 . A temperature of 20°C has been selected as appropriate for Ethiopia and the variation of mean atmospheric pressure with altitude is given in table 3.1 of EBCS 1,2015 as below.

Table 3: Air density and its altitude (m) above sea level.

Site altitude above sea level (m)	Air density (kg/m^3)
0	1.20
500	1.12
1000	1.06
1500	1.00

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2000	0.94
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Therefore the altitude of adissababa is 2355m which is greater than 2000m. so we take the maximum value of air density 0.94 from the above table.

Now we can calculate the **peak velocity**

$$\begin{aligned}q_p(Z) &= [1 + 7I_v(z)] * 0.5 * \rho_{\text{air}} * V_m^2(z) = (1 + 7 * 0.35)(0.5 * 0.94 * (14.45)^2) \\ &= 338.58 \text{ N/m}^2 \\ q_p(Z) &= \mathbf{0.34 \text{ KN/m}^2}\end{aligned}$$

Where, $\rho = 0.94$ for altitude greater than 2000m.

Calculation for external wind pressure coefficient (Cpe)

Geometric data of the building

- The height of building above the ground level is 20m including slab thickness.
- The building roof is Flat roof from the given.
- Width and length of the buildings is 20m and 18.85m respectively taken from floor plan.
- Height of parapet of the roof = 1m
- Our building is G+4 which have 4 story.

20m < 18.85m (h < b), and from EBCS-1 Section A.2.2 it is stated that “for building whose height, h is less than b, shall be considered to be one part

Roof 1 at h= 18m

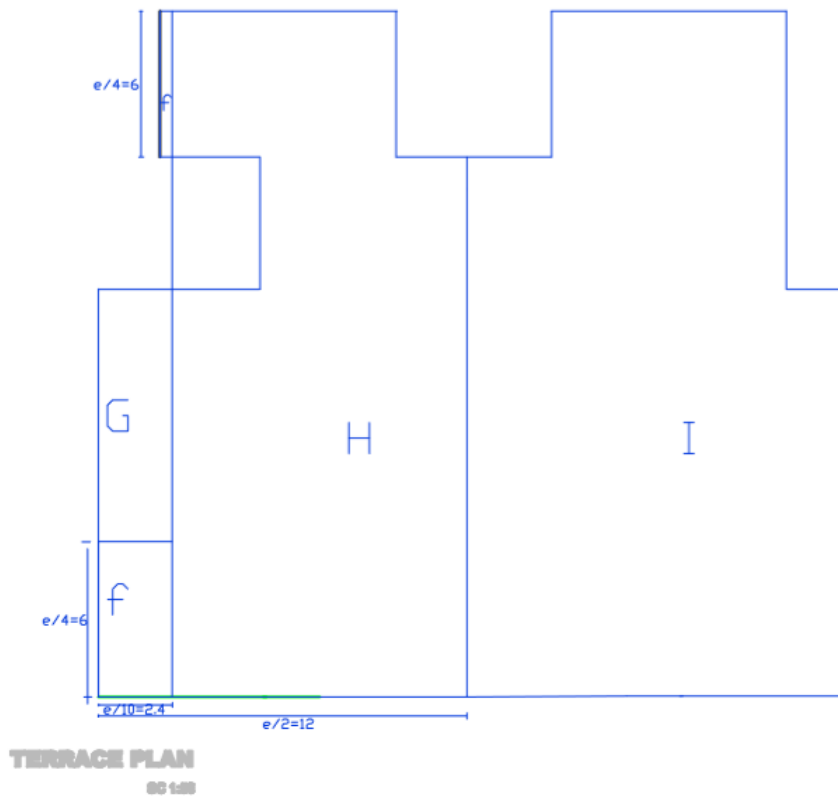


Figure 2 Area of roof

- $e = b$ or $2h$ whichever is the smaller

$$\text{Then, } e \leq \min \begin{cases} b = 23.81\text{m} \\ 2h = 2 * 22.79 = 45.58\text{m} \end{cases} \Rightarrow e = \mathbf{23.81\text{m}}$$

Areas of each roof zone

- $e/4 = 23.81/4 = \mathbf{6\text{m}}$
- $e/10 = 23.81/10 = \mathbf{2.38\text{m}}$
- $e/2 = 23.81/2 = \mathbf{12\text{m}}$
- $b = \mathbf{23.81\text{m}}$
- $d = \mathbf{22.79\text{m}}$

Area F = $\mathbf{17.41\text{m}^2}$

Area G = $\mathbf{18.4\text{m}^2}$

Area H = $\mathbf{180.28\text{m}^2}$

Area I = $\mathbf{245.2\text{m}^2}$

Determine external wind pressure coefficient

h=18

- ❖ Height of parapet wall $h_p=1\text{m}$
- ❖ Height of the building $h = 16.5\text{m}$

For $\frac{h_p}{h} = \frac{1}{16.5} = 0.061,$

Then using EBCS-1, 2015 Table 7.2 (Page 33) to determine external pressure coefficient as in a table, but for roofs with parapets, linear interpolation may be used for intermediate values of h_p/h . Values of C_{pe} are given in Table 7.2 on EBCS-1 (Page 33), for different values of h_p/h and for zone area above 10 m^2 and zone area below 1 m^2 . For Zone F, G, H, I we use $C_{pe,10}$ because they have area more than 10 m^2 . The corresponding values are taken from the Table 7.2 using interpolation to determine the value of the intermediate values.

Table 4 External wind pressure coefficients

Zone	F		G		H		I	
Area	17.41m ²		18.4m ²		180.3m ²		245.2m ²	
d/h	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$
	-1.36	-1.96	-0.88	-1.56	-0.7	-1.2	+0.2	-0.2
Cpe	-1.36		-0.88		-0.7		0.2	

Table 04: shows the external pressure coefficient (C_{pe}) values.

Internal wind pressure coefficients

- For closed building with internal partitions and opening windows the extreme values are

✓ $c_{pi} = 0.8$ for pressure

✓ $c_{pi} = -0.5$ for suction

Table 5 Internal wind pressure

Region	F		G		H		I	
Area	17.41m ²		18.41m ²		180.3m ²		245.2m ²	
$q_p(Z_i)$	0.34		0.34		0.34		0.34	
Cpi(+ve) for pressure	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Cpi(-ve) for suction	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5

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C _{pe}	-1.36	0	-0.88	0	-0.7	0	0.2	0
$W_{net(+ve)} = q_p(Z_i) * (C_{pe} - C_{pi(+ve)})$	-0.292	-0.17	-0.13	0.17	-0.07	-0.17	0.24	-0.102
$W_{net(-ve)} = q_p(Z_i) * (C_{pe} - C_{pi(-ve)})$	-0.73	-0.272	-0.57	-0.272	-0.51	-0.272	-0.48	-0.34

Therefore $W_{net(+ve)} = +0.238$

$W_{net(-ve)} = -0.73$

2.2. Structural design of roof slab

2.2.1 Load calculation

Dead load, live load and wind loads on panels were converted to equivalent uniformly distributed loads. All loads are calculated depending on the service of the roof slabs and self weight. The design loads are factored according to the following formula.

$$\text{Pd} = 1.35LL + 1.5LL + 0.9WL$$

Where: Pd - design load

DL - total dead load on slab

LL - total live load on slab

WL - total wind load on slab

i. Live load

The live load of the roof is determined by assuming the roof is not accessible except for normal maintenance, repair, painting & minor repairs. So it is categorized in Category of H according to ES EN1991-1-1. Therefore, the recommended value as it is set by the National Annex is Live load from code $q_k = 0.5 \text{KN/m}^2$ uniformly distributed load or $Q_k = 1 \text{KN}$ concentrated load (as our roof is flat).

ii. Dead load(DL)

Usually the major part of the dead load is the weight of the structure itself. It will comprise the forces due to the static weights of the structure as well as attachment to the structures.

iii. Wind load (W.L)

Action of the wind loads on structures is represented either as a wind pressure or as a wind force. The action of wind pressure on a structure is assumed to act normal to the surface except otherwise specified; e.g. for tangential friction forces. Wind pressure on the structure may be

external wind pressure or internal wind pressure. The magnitude of the wind load depends on the roof shape, wind direction and location of the building. Appropriate fasteners and holding down bolts or anchors must be used.

STEP 1: Load determination

A. Dead Load calculation

- Concrete = $0.17 \times 25 = 4.25 \text{ kN/m}^2$
- 30mm thick cement screed = $0.03 \times 23 = 0.69 \text{ kN/m}^2$
- Ceramic tiles = $0.02 \times 21 = 0.42 \text{ kN/m}^2$

$$DL = 4.25 + 0.69 + 0.42 = 5.36 \text{ kN/m}^2$$

B. Live Load

The roof is not accessible except for normal maintenance, repair, painting and minor repairs. The characteristic values, q_k , and Q_k are given in ES EN1991-1-1.

- It is category H roof, hence
 - ✓ The distributed live load, $q_k = 0.5 \text{ kN/m}^2$
 - ✓ The concentrated live load, $Q_k = 1 \text{ kN}$

C. Wind Load

- ✓ Wind Load (Suction) = -0.73 kN/m^2
- ✓ Wind Load (Pressure) = 0.238 kN/m^2

STEP 2: Load combination

1. Combination -1 , Dead load + Live load

$$P_d = 1.35DL + 1.50LL = 1.35(5.36) + 1.5(0.5) = 7.98 \text{ kN/m}^2$$

2. Combination -2 , Dead load + Wind load

$$P_d = 1.35DL + 1.50WL = 1.35(5.36) + 1.5(-0.73) = 6.14 \text{ kN/m}^2$$

3. Combination -3 , Dead load - Wind load

$$P_d = 1.35DL - 1.50WL = 1.35(5.36) - 1.5(-0.73) = 8.33 \text{ kN/m}^2$$

4. Combination -4 , Dead load + live load + Wind load

$$P_d = 1.35DL + 1.50LL + 0.9WL = 1.35(5.36) + 1.5(0.5) + 0.9(-0.73) = 7.33 \text{ kN/m}^2$$

5. Combination -5 , Dead load + live load - Wind load

$$P_d = 1.35DL + 1.5LL + 0.9WL = 1.35(5.36) + 1.5(0.5) - 0.9(-0.73) = 8.6 \text{ kN/m}^2$$

The maximum design load combinations is 8.6 kN/m^2

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2.2.2 Depth of slab for roof

Table 6 Depth of slab for roof

Panel	Ly	Lx	Ly/Lx	Support type	Slab type	L/d*1.25	D	D Calculated
P1	4.29	3.25	1.32	Two way	end	28.76	113	138
P2	4.41	4.29	1.03	Two way	end	28.76	149.2	169.2
P3	4.41	4.29	1.03	Two way	end	28.76	149.2	169.2
P4	4.29	2.35	1.32	Two way	end	28.76	113	138
P5	4.65	4.41	1.05	Two way	end	28.76	153.4	138.4
P6	4.65	4.65	1	Two way	interior	33.2	140	165
P7	4.65	4.41	1.05	Two way	interior	33.2	132.8	157.8
P8	4.65	3.25	1.43	Two way	end	28.76	113	138
P9	5.5	3.25	1.7	Two way	interior	33.2	97.9	122.9
P10	5.5	4.41	1.25	Two way	interior	33.2	132.8	157.8
P11	5.5	4.65	1.19	Two way	interior	33.2	140	165
P12	5.5	4.41	1.25	Two way	interior	33.2	132.8	157.8
P13	5.5	3.25	1.7	Two way	interior	33.2	97.9	122.9
P14	5.5	3.25	1.7	Two way	interior	33.2	97.9	122.9
P15	5.5	4.41	1.25	Two way	interior	33.2	132.8	157.8
P16	5.5	4.65	1.19	Two way	interior	33.2	140	165
P17	5.5	4.41	1.25	Two way	interior	33.2	132.8	157.8
P18	5.5	3.25	1.7	Two way	interior	33.2	97.9	122.9
C1	550	190	2.9	One way	cantilever	8.85	21.5	46.5
C2	550	190	2.9	One way	cantilever	8.85	21.5	46.5
C3	190	170	1.12	Two way	cantilever	8.85	19.2	44.2
C4	325	170	1.91	Two way	cantilever	8.85	19.2	44.2
C5	441	170	2.6	One way	cantilever	8.85	19.2	44.2
C6	465	170	2.74	One way	cantilever	8.85	19.2	44.2
C7	441	170	2.6	One way	cantilever	8.85	19.2	44.2
C8	325	170	1.91	Two way	cantilever	8.85	19.2	44.2
C9	170	170	1	Two way	cantilever	8.85	19.2	44.2
C10	550	170	3.24	One way	cantilever	8.85	19.2	44.2
C11	550	170	3.24	One way	cantilever	8.85	19.2	44.2

2.3 Moment Analysis

Moment Calculation for two way slab using coefficient method

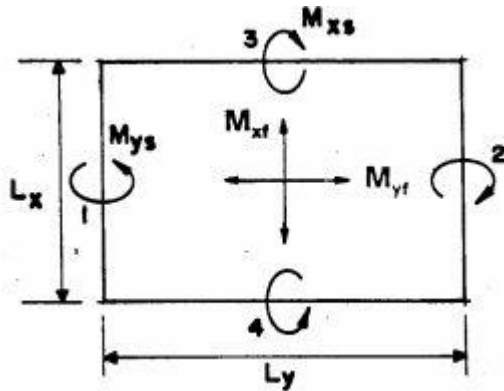
- The first stage of design is to determine support and span moments for all panels.
- The support and span moments are calculated as

$$M_i = \beta_{si} P_d L_x^2 \text{ ES-EN 1992}$$

Where M_i = Design moment per unit width of reference

P_d = Uniformly Distributed Design Load

β_{si} = Coefficient given in ES-EN



$$M_{XS} = \beta_{si} P_d L_x^2$$

$$M_{XF} = \beta_{si} P_d L_x^2$$

$$M_{YS} = \beta_{si} P_d L_x^2$$

$$M_{YF} = \beta_{si} P_d L_x^2$$

Moment analysis for first & second floor

For panel 1

$$\triangleright M_{XS} = \beta_{si} P_d L_x^2$$

$$M_{XS} = 0.077 * 8.6 * 3.25^2$$

$$M_{XS} = 6.99$$

$$\triangleright M_{XF} = \beta_{si} P_d L_x^2$$

$$M_{XF} = 0.058 * 8.6 * 3.25^2$$

$$M_{XF}=5.27$$

$$\triangleright M_{YS}=\beta si P_d L_x^2$$

$$M_{YS}=0*8.6*3.25^2$$

$$M_{YS}=0$$

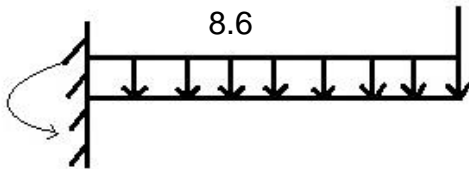
$$\triangleright M_{YF}=\beta si P_d L_x^2$$

$$M_{YF}=0.044*8.6*3.25^2$$

$$M_{YF}= 4$$

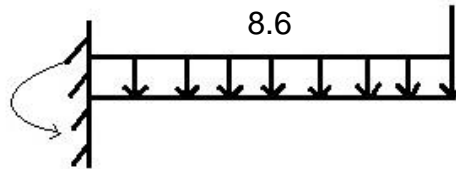
For cantilever slab

FOR C1=C2



$$\begin{aligned} &= pd * L_x * L_x / 2 \\ &= L_x^2 / 2 * 8.6 \\ &= 1.7^2 / 2 * 8.6 \\ &= \underline{12.43} \end{aligned}$$

FOR C5=C6=C7=C10=C11



$$\begin{aligned} &= pd * L_x * L_x / 2 \\ &= L_x^2 / 2 * 8.6 \\ &= 1.9^2 / 2 * 8.6 \\ &= \underline{15.52} \end{aligned}$$

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Table 7 Moment analysis for roof

PANEL	TYPE	Lx	Ly	Ly/Lx	n(pd)	β_{sx-}	β_{sx+}	β_{sy-}	β_{sy+}	Mxs	Mxf	Mys	Myf
P1	End	3.25	4.29	1.32	8.6	0.077	0.058		0.044	6.99	5.27	0.00	4.00
P2	End	4.29	4.41	1.03	8.6	0.052	0.039	0.045	0.034	8.23	6.17	7.12	5.38
P3	End	4.29	4.41	1.03	8.6	0.052	0.039	0.045	0.034	8.23	6.17	7.12	5.38
P4	End	3.25	4.29	1.32	8.6	0.07	0.052	0.045	0.034	6.36	4.72	4.09	3.09
P5	End	4.41	4.65	1.05	8.6	0.046	0.033	0.037	0.028	7.69	5.52	6.19	4.68
P6	Interior	4.65	4.65	1.00	8.6	0.039	0.03	0.032	0.028	7.25	5.58	5.95	5.21
P7	Interior	4.41	4.65	1.05	8.6	0.034	0.026	0.037	0.024	5.69	4.35	6.19	4.01
P8	End	3.25	4.65	1.43	8.6	0.07	0.052	0.037	0.028	6.36	4.72	3.36	2.54
P9	Interior	3.25	5.5	1.69	8.6	0.062	0.0462	0.032	0.028	5.63	4.20	2.91	2.54
P10	Interior	4.41	5.5	1.25	8.6	0.044	0.034	0.032	0.024	7.36	5.69	5.35	4.01
P11	Interior	3.25	5.5	1.69	8.6	0.042	0.032	0.032	0.024	3.82	2.91	2.91	2.18
P12	Interior	4.41	5.5	1.25	8.6	0.044	0.034	0.032	0.024	7.36	5.69	5.35	4.01
P13	Interior	3.25	5.5	1.69	8.6	0.058	0.043	0.032	0.024	5.27	3.91	2.91	2.18
P14	Interior	3.25	5.5	1.69	8.6	0.058	0.043	0.032	0.024	5.27	3.91	2.91	2.18
P15	Interior	4.41	5.5	1.25	8.6	0.044	0.034	0.032	0.024	7.36	5.69	5.35	4.01
P16	Interior	4.65	5.5	1.18	8.6	0.042	0.032	0.032	0.024	7.81	5.95	5.95	4.46
P17	Interior	4.41	5.5	1.25	8.6	0.044	0.034	0.032	0.024	7.36	5.69	5.35	4.01
P18	Interior	3.25	5.5	1.69	8.6	0.058	0.043	0.032	0.024	5.27	3.91	2.91	2.18
C3	Cantilive	1.7	1.9	1.12	8.6	0.057	0.043	0.045	0.034	1.42	1.07	1.12	0.85
C4	Cantilive	1.7	3.25	1.91	8.6	0.086	0.065	0.037	0.028	2.14	1.62	0.92	0.70
C8	Cantilive	1.7	3.25	1.91	8.6	0.086	0.065	0.037	0.037	2.14	1.62	0.92	0.92
C9	Cantilive	1.7	1.7	1.00	8.6	0.031	0.024	0.032	0.032	0.77	0.60	0.80	0.80

PANEL		Lx	Ly	Ly/Lx	n(pd)	Mxs(KN)
C 1	cantilever	1.9	5.5	2.89	8.6	15.52
C 2	cantilever	1.9	5.5	2.89	8.6	15.52
C5	cantilever	1.7	4.41	2.59	8.6	12.43
C6	cantilever	1.7	4.465	2.63	8.6	12.43
C7	cantilever	1.7	4.41	2.59	8.6	12.43
C10	cantilever	1.7	5.5	3.24	8.6	12.43
C11	cantilever	1.7	5.5	3.24	8.6	12.43

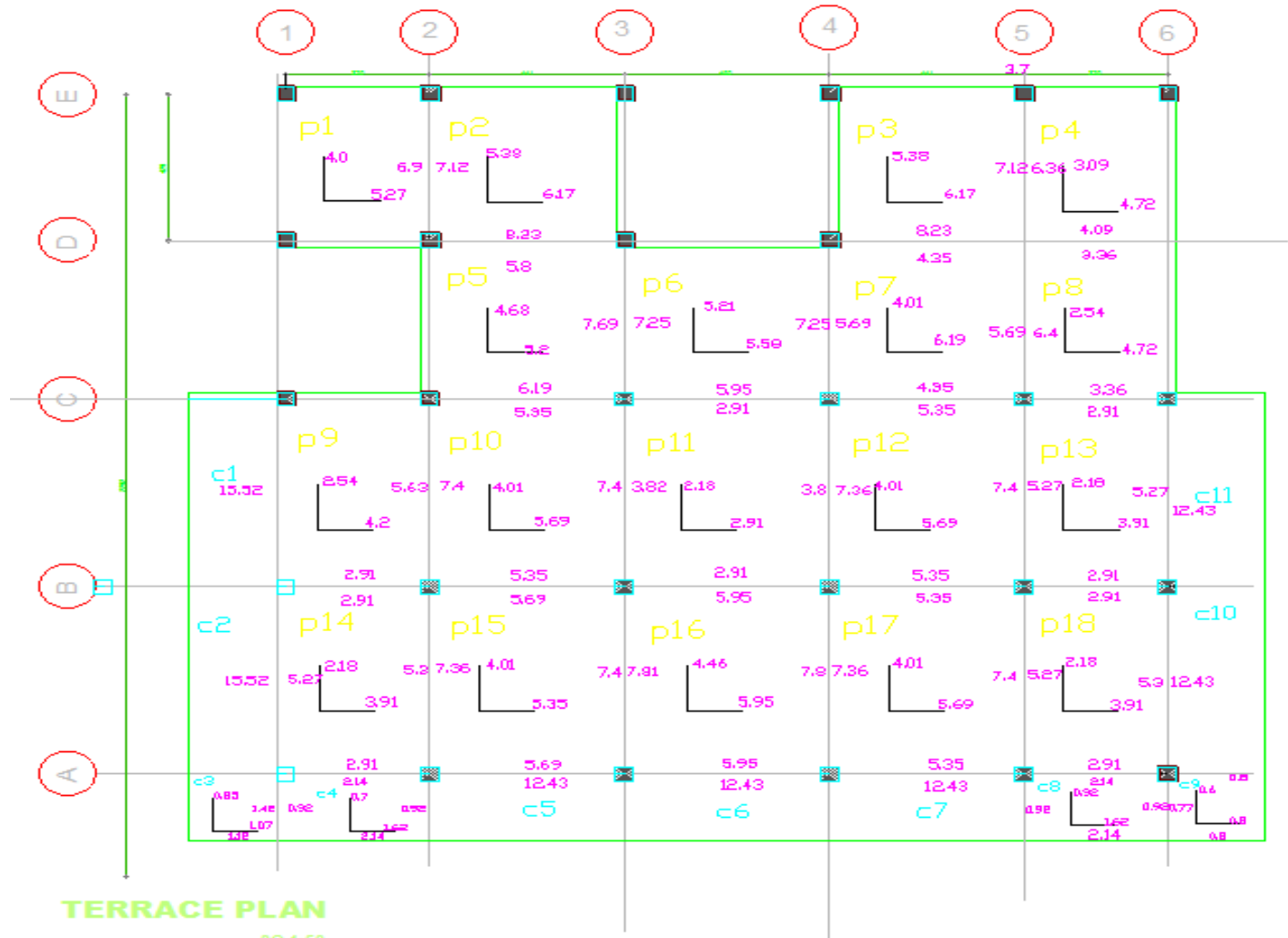


Figure 3 Moment analysis for roof

Moment adjustment between panels

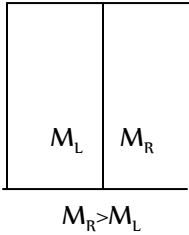
Support moment adjustment

There are two cases.

Case (1) If $\frac{M_R - M_L}{M_R} * 100 < 20\%$ then $M_d = \frac{M_R + M_L}{2}, M_R > M_L$

Case (2) If $\frac{M_R - M_L}{M_R} * 100 > 20\%$ then Distribute unbalanced moment $M_D = M_R - M_L$ based on relative stiffness.... $M_R > M_L$

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$$M_d = M_R - \frac{K_R}{K_R + K_L} * \Delta M \dots \dots \dots \text{Considering right}$$

$$M_d = M_R + \frac{K_R}{K_R + K_L} * \Delta M \dots \dots \dots \text{Considering Left}$$

Note that If adjustment is between two-way and cantilever, then $M_d = M_{\max}$

Support moment adjustment for 1st & 2nd floor

For panel 1 & panel 2

$$\frac{M_R - M_L}{M_R} * 100 < 20\% = \frac{7.12 - 6.99}{7.12} * 100 = 1.8\% < 20\%$$

Use method 1 $\frac{7.12 + 6.99}{2} = 7.05$

For panel 2 & panel 5

$$\frac{M_R - M_L}{M_R} * 100 < 20\% = \frac{8.23 - 5.8}{8.23} * 100 = 29.5\% > 20\%$$

Use method 2

$$K_{AB} = \frac{3}{4L_X} = \frac{3}{4 * 4.29} = 0.17$$

$$K_{BC} = \frac{1}{L_X} = \frac{1}{4.41} = 0.225$$

$$DF_{AB} = \frac{K_{AB}}{K_{AB} + K_{BC}} = \frac{0.17}{0.17 + 0.225} = 0.43$$

$$DF_{BC} = \frac{K_{BC}}{K_{AB} + K_{BC}} = \frac{0.225}{0.17 + 0.225} = 0.57$$

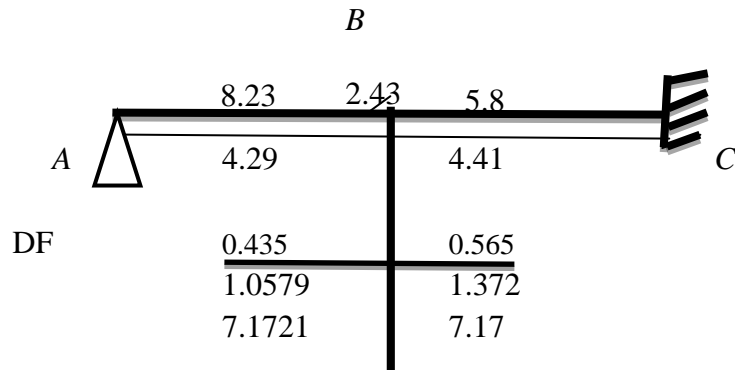


Table 8 Support moment adjustment

pannel	Mtd 1	Mtd2	Max
P1&P2	7.06		
P2&P5		7.2	
P3&P4	6.74		
P3&P7		6.54	
P4&P8	3.73		
P5&P6	7.47		
P5&P10	5.77		
P6&P7		6.49	
P6&P11		4.43	
P7&P8	6.03		
P7&P12	4.85		
P8&P13	3.14		
P9&P10		6.63	
P9&P14	2.91		
P9&C1			15.52
P10&P11		5.54	
P10&P15	5.52		
P11&P12		5.54	
P11&P16		4.43	
P12&P13		6.47	
P12&P17	5.35		
P13&P18	2.91		
P13&C11			12.45
P14&P15		6.47	
P14&C2			15.52
P14&C4			2.91

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P15&P16	7.59		
P15&C5			12.43
P16&P17	7.59		
P16&C6			12.43
P17&P18		6.47	
P17&C7			12.43
P18&C8			2.91
P18&C10			12.43
C1&C2			15.52
C2&C3			15.52
C3&C4			1.42
C4&C5			12.43
C5&C6			12.43
C6&C7			12.43
C7&C8			12.43
C8&C9			0.92
C9&C10			12.43
C10&C11			12.43

2.3.2 Span Moment adjustment

If the support moment is decreased while carrying on moment distribution of a balanced support moment, the span moment M_{xf} and M_{yf} are increased to allow for the change of support moment. This increase is calculated being equal to the change of the support moment multiplied by the factor given in EBCS. If the support moment increased, no adjustment shall be made to the span moment.

Table 9 Span moment adjustment

				$M_{xs}+M_{xf}-M_{adj}$
PANEL	M_{xs}	M_{xf}	M_{adjust}	$M_{xf\ adj}$
P1		5.27	7.06	5.27
P2	8.23	6.17	7.06	7.34
P3	8.23	6.17	6.54	7.86
P4	4.09	4.09	3.73	4.45
P5	6.19	5.52	5.77	5.94
P6	5.95	5.58	4.43	7.10
P7	4.35	6.19	4.85	5.69
P8	3.36	4.72	3.14	4.94

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P9	2.91	4.2	2.91	4.2
P10	5.35	5.69	5.52	5.52
P11	2.91	2.91	4.43	1.39
P12	5.35	5.69	5.35	5.69
P13	2.91	3.91	2.91	3.91
P14	2.91	3.91	6.47	0.35
P15	5.69	5.35	7.59	3.45
P16	5.95	5.95	7.59	4.31
P17	5.35	5.69	6.47	4.57
P18	2.91	3.91	2.91	3.91
C3	1.42	1.07	1.42	1.07
C4	2.14	1.62	1.42	2.34
C8	2.14	1.62	2.91	0.85
C9	0.77	0.8	0.92	0.65

				Mys+Myf- Madj
PANEL	Mys	Myf	Madjust	Myf adj
P1	6.99	4	7.06	3.93
P2	7.12	5.38	7.2	5.30
P3	7.12	5.38	6.74	5.76
P4	6.36	3.09	3.73	5.72
P5	7.69	4.68	7.47	4.90
P6	7.25	5.21	6.49	5.97
P7	5.69	4.01	6.03	3.67
P8	6.36	2.54	3.14	5.76
P9	5.63	2.54	6.63	1.54
P10	7.36	4.01	5.54	5.83
P11	3.82	2.18	5.54	0.46
P12	7.36	4.01	6.47	4.9
P13	5.27	2.18	2.91	4.54
P14	5.27	2.18	7.05	0.4
P15	7.36	5.69	12.43	0.62
P16	7.81	4.46	7.59	4.68
P17	7.36	4.01	6.47	4.9
P18	5.27	2.18	2.91	4.54
C3	1.42	0.85	1.42	0.85
C4	2.14	0.7	1.42	1.42
C8	2.14	0.92	0.92	2.14
C9	0.77	0.6	0.92	0.45

2.3.3 Load on Support Beams

$$V_{sx} = \beta_{vx} n L_x$$

$$V_{sy} = \beta_{vy} n L_x$$

Table 10 Load on Support Beams

PANEL	TYPE	L _x	L _y	L _y /L _x	n(pd)	β _{vx} c	β _{vx} dc	β _{vy} c	β _{vy} dc	V _{sx} c	V _{sx} dc	V _{sy} c	V _{sy} dc
P1	end	3.25	4.29	1.32	8.6	0.534	0.352	0.4	0.26	14.93	9.84	11.18	7.27
P2	end	4.29	4.41	1.03	8.6	0.452	0.269		0.29	16.68	9.92	0.00	10.70
P3	end	4.29	4.41	1.03	8.6	0.452	0.269		0.29	16.68	9.92	0.00	10.70
P4	end	3.25	4.29	1.32	8.6	0.504	0.332	0.4	0.26	14.09	9.28	11.18	7.27
P5	end	4.41	4.65	1.05	8.6	0.38	0.255	0.36		14.41	9.67	13.65	0.00
P6	interior	4.65	4.65	1.00	8.6	0.36	0.4	0.36	0.27	14.40	16.00	14.40	10.80
P7	interior	4.41	4.65	1.05	8.6	0.345		0.24		13.08	0.00	9.10	0.00
P8	end	3.25	4.65	1.43	8.6	0.496	0.326	0.33		13.86	9.11	9.22	0.00
P9	interior	3.25	5.5	1.69	8.6	0.494		0.36	0.24	13.81	0.00	10.06	6.71
P10	interior	4.41	5.5	1.25	8.6	0.41		0.36		15.55	0.00	13.65	0.00
P11	interior	4.65	5.5	1.18	8.6	0.382		0.33		15.28	0.00	13.20	0.00
P12	interior	4.41	5.5	1.25	8.6	0.4		0.33		15.17	0.00	12.52	0.00
P13	interior	3.25	5.5	1.69	8.6	0.474		0.33		13.25	0.00	9.22	0.00
P14	interior	3.25	5.5	1.69	8.6	0.474		0.33		13.25	0.00	9.22	0.00
P15	interior	4.41	5.5	1.25	8.6	0.4		0.33		15.17	0.00	12.52	0.00
P16	interior	4.65	5.5	1.18	8.6	0.387		0.33		15.48	0.00	13.20	0.00
P17	interior	4.41	5.5	1.25	8.6	0.4		0.33		15.17	0.00	12.52	0.00

PANEL	TYPE	L _x	L _y	L _y /L _x	n (Pd)	WL
C 1	cantiliver	1.9	5.5	2.89	8.6	16.34
C2	cantiliver	1.9	5.5	2.89	8.6	16.34
C3	cantiliver	1.7	1.9	1.12	8.6	14.62
C4	cantiliver	1.7	3.25	1.91	8.6	14.62
C5	cantiliver	1.7	4.41	2.59	8.6	14.62
C6	cantiliver	1.7	4.65	2.74	8.6	14.62
C7	cantiliver	1.7	4.41	2.59	8.6	14.62
C8	cantiliver	1.7	3.25	1.91	8.6	14.62
C9	cantiliver	1.7	1.7	1.00	8.6	14.62
C10	cantiliver	1.7	5.5	3.24	8.6	14.62
C11	cantiliver	1.7	5.5	3.24	8.6	14.62

Check depth for flexure

$$\begin{aligned} \text{Cubic strength (fcu)} &= 25 & \gamma_s &= 1.15 \\ \gamma_c &= 1.5 & \epsilon_{cu} &= 3.5 \\ \text{S-400} & & b &= 1000 \end{aligned}$$

$$F_{ck} = 0.85 * F_{ck} / 1.25 = 25 / 1.25 = 20 \text{Mpa}$$

$$F_{cd} = 0.85 * F_{ck} / \gamma_c = 0.85 * 20 \text{Mpa} / 1.5 = 11.33 \text{Mpa}$$

$$F_{yd} = s / \gamma_s = 400 / 1.15 = 347.83 \text{Mpa}$$

$$m = \frac{f_{yd}}{0.8 * f_{cd}} = \frac{347.83 \text{Mpa}}{0.8 * 11.33} = 38.36$$

$$C1 = \frac{2.5}{m} = \frac{2.5}{38.36} = 0.0652$$

$$C2 = 0.32 * m^2 * f_{cd} = 0.32 * 38.36^2 * 11.33 = 5337$$

$$\begin{aligned} \rho_b &= (((0.8 * \epsilon_{cu}) / (\epsilon_{cu} + f_{yd}(200)))) * (F_{cd} * F_{yd}) \\ &= (((0.8 * 3.5) / (3.5 + 347.83))) * (11.33 * 347.83) \\ &= 0.01741 \text{Mpa} \end{aligned}$$

$$\begin{aligned} \rho_{max} &= 0.75 * \rho_b = 0.75 * 0.01741 \\ &= 0.01306 \end{aligned}$$

$$M_{max} = 15.52$$

$$d = \sqrt{(M_{max} / (0.8 * b * f_{cd} * \rho_{max} * m * (1 - (0.4 * m * \rho_{max}))))}$$

$$d = 65.36 \text{mm}$$

2.4 Reinforcement Calculation

- For the given
 - o Material Data, C-25, S-400
 - o Effective depth, d=170mm
 - o Width, b=1000mm
 - o Moments calculated for each panels

$$A_{st,min} = \max \left\{ \begin{array}{l} 0.26 \frac{f_{ctm}}{f_{yk}} bd \\ 0.0013bd \end{array} \right.$$

$$A_{st,min} = \max \left\{ \begin{array}{l} 0.26 \frac{2.2}{400} * 1000 * 170 = 243.1 \\ 0.0013 * 1000 * 170 = 221 \end{array} \right.$$

$$A_{st,min} = \mathbf{240}$$

➤ Spacing

$$S_{max} = \max \left\{ \begin{array}{l} 3D = 3 * 170 = 510mm \\ 400mm \end{array} \right.$$

$$S_{max} = \mathbf{510 \text{ mm}}$$

$$A_{st} = \frac{m_{sd}}{Z * f_{yd}}$$

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{400Mpa}{1.15} = 347.83 \text{ Mpa}$$

$$Z = 0.9d = 0.9 * 145mm = 130.5 \text{ mm}$$

Example for panel 1 support moment = 11.66 KN-m

$$A_{st} = \frac{m_{sd}}{Z * f_{yd}} = \frac{11.66 * 1000 * 1000N-mm}{130.5mm * 347.83N/mm^2} = \mathbf{254.5 \text{ mm}^2} > 240mm^2 \text{ OK!!}$$

Let the ϕ of reinforcement be 10mm

$$a_{st} = \frac{\pi d^2}{4} = \frac{3.14 * 10^2}{4} = \mathbf{78.5 \text{ mm}^2}$$

$$\text{Spacing of bars} = S = \frac{ba_s}{A_s} = \frac{1000 * 78.5}{254.5} = \mathbf{308.5mm}$$

308.5 mm \approx 300 mm used < 510mm OK!!

Table 11 Reinforcement Calculation

Panel	moment		$A_{st}=M_{sd}/Z*f_{yd}$	ϕ	spacing	spacing used	Reinforcement			
P-1	$M_{xs} =$	0	240.00	10	327.08	300	ϕ	10	c/c	300
	$M_{xf} =$	5.27	240.00	10	327.08	300	ϕ	10	c/c	300
	$M_{ys} =$	7.06	240.00	10	327.08	300	ϕ	10	c/c	300

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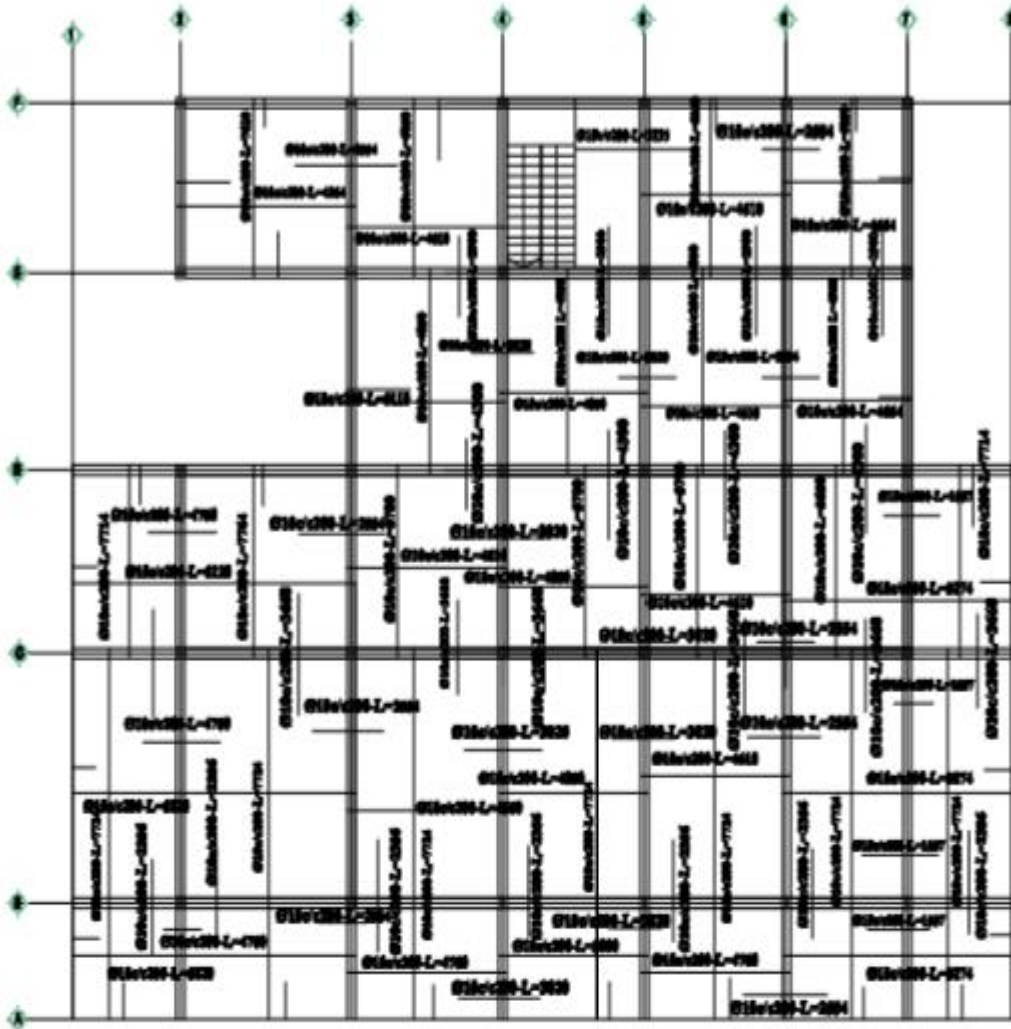
P-2	$M_{yf} =$	3.93	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	7.20	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	7.34	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	7.06	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	5.3	240.00	10	327.08	300	\emptyset	10	c/c	300
P-3	$M_{xs} =$	6.54	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	7.86	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.74	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	5.76	240.00	10	327.08	300	\emptyset	10	c/c	300
P-4	$M_{xs} =$	3.73	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	4.45	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.74	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	5.72	240.00	10	327.08	300	\emptyset	10	c/c	300
P-5	$M_{xs} =$	5.77	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	5.94	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	7.47	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.9	240.00	10	327.08	300	\emptyset	10	c/c	300
P-6	$M_{xs} =$	4.43	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	7.1	240.00	10	327.08	250	\emptyset	10	c/c	250
	$M_{ys} =$	6.49	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	5.97	240.00	10	327.08	300	\emptyset	10	c/c	300
P-7	$M_{xs} =$	4.85	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	5.69	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.03	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	3.67	240.00	10	327.08	300	\emptyset	10	c/c	300
P-8	$M_{xs} =$	3.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	4.94	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.03	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	5.76	240.00	10	327.08	300	\emptyset	10	c/c	300
P-9	$M_{xs} =$	2.91	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	4.2	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.63	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.54	240.00	10	327.08	300	\emptyset	10	c/c	300

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P-10	$M_{xs} =$	5.52	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	5.52	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	5.54	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	5.83	240.00	10	327.08	300	\emptyset	10	c/c	300
P-11	$M_{xs} =$	4.43	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	1.39	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	5.54	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.46	240.00	10	327.08	300	\emptyset	10	c/c	300
P-12	$M_{xs} =$	5.35	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	5.69	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.47	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.9	240.00	10	327.08	300	\emptyset	10	c/c	300
P-13	$M_{xs} =$	2.91	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	3.91	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.47	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.54	240.00	10	327.08	300	\emptyset	10	c/c	300
P-14	$M_{xs} =$	2.91	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	0.35	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.47	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.4	240.00	10	327.08	300	\emptyset	10	c/c	300
P-15	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	3.45	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	7.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.62	240.00	10	327.08	300	\emptyset	10	c/c	300
P-16	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	4.31	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	7.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.68	240.00	10	327.08	300	\emptyset	10	c/c	300
P-17	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	4.57	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.47	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.9	240.00	10	327.08	300	\emptyset	10	c/c	300
P-18	$M_{xs} =$	2.91	240.00	10	327.08	300	\emptyset	10	c/c	300

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	$M_{xf} =$	3.91	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	6.47	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.54	240.00	10	327.08	300	\emptyset	10	c/c	300
C3	$M_{xs} =$	15.52	284.93	10	275.51	250	\emptyset	10	c/c	250
	$M_{xf} =$	1.07	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	1.42	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.85	240.00	10	327.08	300	\emptyset	10	c/c	300
C4	$M_{xs} =$	2.91	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	2.34	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	2.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.42	240.00	10	327.08	300	\emptyset	10	c/c	300
C8	$M_{xs} =$	2.91	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	2.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	2.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.92	240.00	10	327.08	300	\emptyset	10	c/c	300
C9	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	0.65	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	2.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.45	240.00	10	327.08	300	\emptyset	10	c/c	300
C1	$M_{xs} =$	15.52	284.93	10	275.51	250	\emptyset	10	c/c	250
C2	$M_{xs} =$	15.52	284.93	10	275.51	250	\emptyset	10	c/c	250
C5	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300
C6	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300
C7	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300
C10	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300
C11	$M_{xs} =$	12.43	240.00	10	327.08	300	\emptyset	10	c/c	300



Roof Floor Slab detailing

Scale 1:50

Figure 4 Roof detail drawing

3. SLAB DESIGN

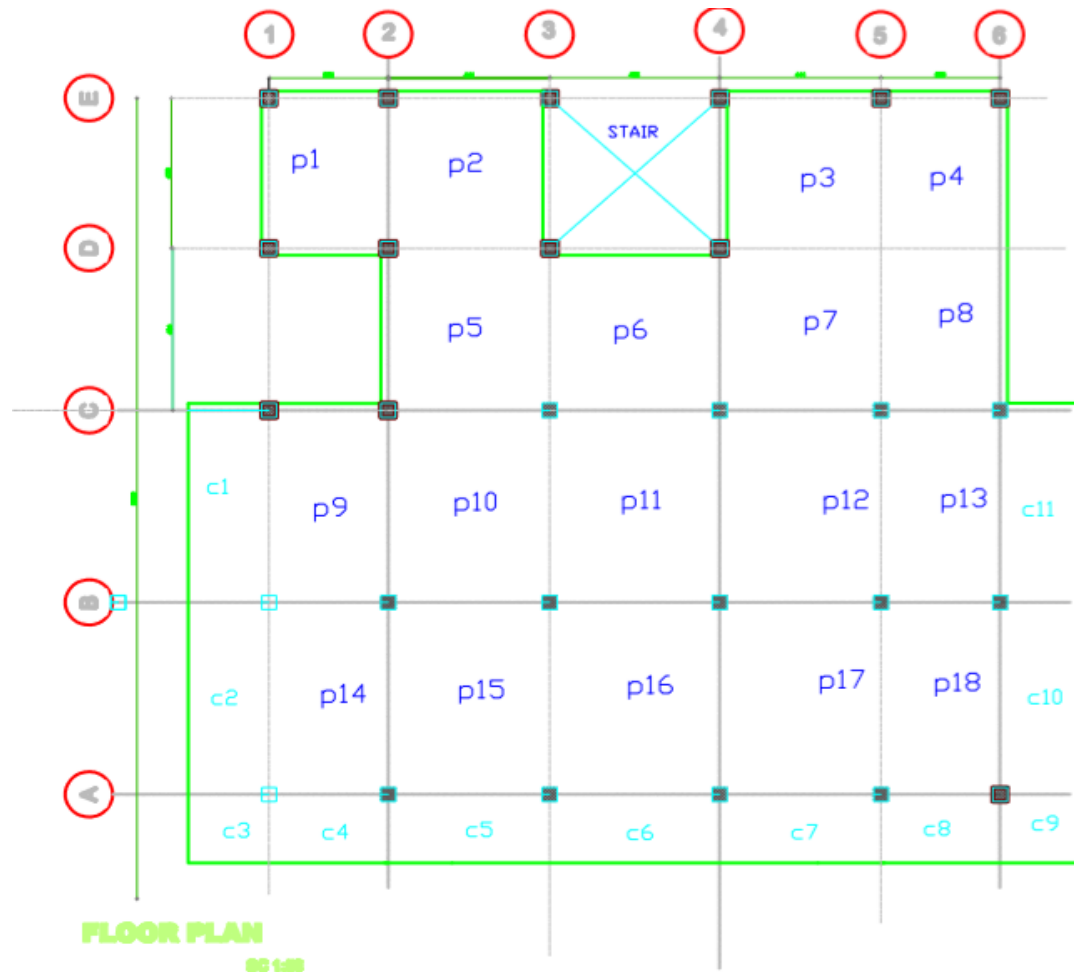


Figure 5 Slab layout

3.1 Overall process in design of slabs

A durable structure should satisfy strength and serviceability requirements throughout its design working life. One of the main causes for poor durability is the corrosion of steel reinforcement. Good quality dense concrete and adequate cover are prime requirements in order to produce durable structures. Water/cement ratio, minimum cement content for producing good quality concrete to satisfy various exposure classes and C_{min} , dur which is the minimum cover to steel from durability considerations.

The minimum cover C_{min} to steel should satisfy the code equation:

$$C_{min} = \text{Maximum} \{C_{min, b}; C_{min, dur}; 10 \text{ mm}\}$$

i. For safe transmission of bond forces, the required cover is $C_{min, b}$ as given in Table 4.2 of ES-EN1992.

ii. For separated bars, $C_{min, b} \geq \text{bar diameter}, \phi$.

iii. For bundled bars, $C_{min, b} \geq \text{equivalent bar diameter}, \phi_n$.

$\phi_n = \phi \sqrt[n_b]{n_b} \leq 55 \text{ mm}$. n_b = Number of bars in the bundle. $n_b \leq 4$ for vertical bars in compression and for bars in a lapped joint, $n_b \leq 3$ for all other cases.

If the nominal maximum size of the aggregate is greater than 32 mm, $C_{min, b}$ should be increased by 5 mm. The cover can be reduced if stainless steel bars are used.

For a design life of 50 years, minimum values of $C_{min, dur}$ for various classes of exposure are given as follows in Table 4.4 N of ES-EN1992

X0=10mm, XC1=15mm, XC2/XC3=25mm, XC4=30mm, XD1/XS1=35mm, XD2/XS2=40mm, XD3/XS3=45mm

Exposure condition (according to ES EN 1992-1-1:2013 Table 4.1)

Structural class 2—XC1 – moderate humidity (concrete inside building with moderate or high air humidity)

Step 1: cover determination

✓ Cover for stirrup

$$C_{nom} = C_{min} + C_{dev}$$

$$C_{min} \rightarrow \max(C_{min}; \text{bond or } C_{min, dur} \text{ or } 10)$$

Concrete grade (according to Pr EN 1992-1-1:2013 ANNEX E (informative) Table E.1N)

Recommended limiting values for composition and properties of concrete and minimum cover to steel for durability.

Class designation	Maximum w/c ratio	Minimum strength class	Minimum cement content (kg/m ³)	Minimum air content (%)	C_{dur} (mm)
X0	-	C12/15	-	-	10
XC1	0.65	C20/25	260	-	15(25)
XC2	0.60	C25/30	280	-	25(35)

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XC3	0.55	C30/37	280	-	25(35)
XC4	0.50	C30/37	300	-	30(40)
XD1	0.55	C30/37	300	-	35(45)
XD2	0.55	C30/37	320	-	40(50)
XD3	0.45	C35/45	320	-	45(55)
XS1	0.50	C30/37	300	-	35(45)
XS2	0.45	C35/45	320	-	40(50)
XS3	0.45	C35/45	340	-	45(55)
XF1	0.55	C30/37	300	-	
XF2	0.55	C25/30	300	4.0	
XF3	0.50	C30/37	320	4.0	
XF4	0.45	C30/37	340	4.0	
XA1	0.55	C30/37	300	-	
XA2	0.50	C30/37	320	-	
XA3	0.45	C35/45	360	-	

For C-20/25 the exposure class is XC1 which implies dry or permanently wet.

For XC1 min C-20/25 C_{min} ; b requirements (according to PrEN 1992-1-1:2013 Table 4.2)

Arrangement of bar for separated use

Assume the diameter of the bar is **Ø10mm**

C_{min} ;dur requirements (according to EN 1992-1-1:2013 Table 4.4)

For structural
class-1 (S2)

• use 10mm

For exposure
condition -Xc1

$$C_{min} = \begin{cases} C_{min}; \text{ bond} = 10 \\ C_{min}; \text{ dur} = 10 \\ 10 \end{cases}$$

- C min=10
- C nom=C min + C fire resistance
- C nom =10+10=**20mm**

✓ Concrete cover for longitudinal bar

$C_{nom} = C_{min} + C_{dev}$

$C_{min} \rightarrow \max(C_{min}; \text{ bond or } C_{min}; \text{ dur or } 10)$

$C_{min} \rightarrow (C_{min}; \text{ bond} = 10 \text{ or } C_{min}; \text{ dur} = 10 \text{ or } 10)$

- $C_{min}=10$
- $C_{nom}=C_{min} + C_{fire\ resistance}$

C_{dur} (according to EBCS EN 1992-1-1:2013; 4.4.1.3)

The recommended value is 10mm because of cast in suite.

$C_{nom}=C_{min} + C_{fire\ resistance} = 10+10=\underline{\underline{20mm}}$

- The governing C nominal is **20mm**

Step 2: Material property

Concrete

C-20/25

Characteristic strength $f_{cu}=0.8*25MPa,=20MPa$

Design compressive strength concrete $f_{cd}=0.85*f_{ck}/\gamma_c=0.85*25*0.8/1.5, f_{cd}=11.33MPa$

Design tensile strength of concrete $f_{ctk}=0.21*(0.8*37)^{2/3}$

$f_{ctk} = f_{ctk}/\gamma_c=2.01/1.5$

$f_{ctd}=1.34MPa$ $f_{ctm}=2.9Gpa$

Modulus of elasticity of concrete *where: E_{cm} is in Gpa and F_{ck} is in Mpa* $E_{cm}=31Gpa$

Steel

We use S-400 grade of deformed bar with the modules of elasticity of $E=200GPa$

Steel reinforcement was deformed bar

Characteristic strength

$f_{yk} = 400Mpa$

Design strength

$f_{yd} = f_{yk}/\gamma_s=400/1.15=347.8Mpa$

3.2 Depth determination

For panel 1

From EN 1992-1-1-2004 section 7.4.2 depth of the slab is determined

$$\frac{l}{d} = k(11 + 1.5\sqrt{fck} * \frac{\rho_0}{\rho} + 3.2\sqrt{fck} * (\frac{\rho_0}{\rho} - 1)^{\frac{3}{2}}) \text{ if } \rho \leq \rho_0$$

$$\frac{l}{d} = k \left(11 + 1.5\sqrt{fck} * \frac{\rho^0}{\rho - \rho'} + \frac{1}{12}\sqrt{fck} * \sqrt{\frac{\rho'}{\rho}} \right) \text{ if } \rho > \rho_0$$

$$fck = 25\text{Mpa}$$

Assume the concrete is lightly stressed $\rho = 0.5\%$

$$\rho_0 = \sqrt{fck} * 10^{-3} = \sqrt{20} * 10^{-3} = 0.4472\%$$

$\rho^0 < \rho$ So use

$$\frac{l}{d} = k(11 + 1.5\sqrt{fck} * \frac{\rho_0}{\rho - \rho'} + \frac{1}{12}\sqrt{fck} * \left(\sqrt{\frac{\rho'}{\rho_0}} \right))$$

$$\frac{l}{d} = k(11 + 1.5\sqrt{20} * \frac{0.4472}{0.5 - \rho'} + \frac{1}{12}\sqrt{fck} * \left(\sqrt{\frac{\rho'}{0.4472}} \right))$$

For exterior slab $K=1.3$ as EN 1992-1-1 table 7.4

$$\frac{l}{d} = k(11 + 1.5\sqrt{20} * \frac{0.4472}{0.5})$$

$$\frac{l}{d} = 17.7 * k * 1.25$$

$$\frac{3250}{d} = 17.7 * 1.3 * 1.25 = 28.76$$

$$d = \frac{3250}{28.76} = 113 \text{ mm}$$

$$D = d + \frac{\emptyset}{2} + \text{cover}$$

$$D = 113 + 10/2 + 20 = 138\text{mm}$$

$$D = \underline{\underline{140 \text{ mm}}}$$

From Pr EN 1992-1-1-2004 section 7.4.2 depth of the slab is determined

For cantilever $K=0.4$ as EN 1992-1-1 table 7.4

$$\frac{l}{d} = k(11 + 1.5\sqrt{20} * \frac{0.4472}{0.5} + 3.2\sqrt{20} * \left(\frac{0}{0.5} \right)^{\frac{1}{2}})$$

$$\frac{l}{d} = 17.7 * k * 1.25$$

$$\frac{190}{d} = 17.7 * 0.4 * 1.25 = 8.55$$

$$d = \frac{190}{8.55} = 22.22 \text{ mm}$$

$$D = d + \frac{\emptyset}{2} + \text{cover}$$

$$D = 22.22 + 5 + 20 = 47.22 \text{ mm}$$

$$D = \underline{47.22 \text{ mm}}$$

From EN 1992-1-1-2004 section 7.4.2 depth of the slab is determined

For interior span slab $K = 1.5$ as EN 1992-1-1 table 7.4

$$\frac{l}{d} = k \left(11 + 1.5 \sqrt{f_{ck}} * \frac{\rho_0}{\rho} + 3.2 \sqrt{f_{ck}} * \left(\frac{\rho_0}{\rho} - 1 \right)^{\frac{3}{2}} \right) \text{ if } \rho \leq \rho_0$$

$$\frac{l}{d} = k \left(11 + 1.5 \sqrt{f_{ck}} * \frac{\rho_0}{\rho - \rho'} + \frac{1}{12} \sqrt{f_{ck}} * \sqrt{\frac{\rho'}{\rho}} \right) \text{ if } \rho > \rho_0$$

$$f_{ck} = 30 \text{ Mpa}$$

Assume the concrete is lightly stressed $\rho = 0.5\%$

$$\rho_0 = \sqrt{f_{ck}} * 10^{-3} = \sqrt{20} * 10^{-3} = 0.448\%$$

$\rho_0 > \rho$ So use

$$\frac{l}{d} = k \left(11 + 1.5 \sqrt{f_{ck}} * \frac{\rho_0}{\rho - \rho'} + \frac{1}{12} \sqrt{f_{ck}} * \sqrt{\frac{\rho'}{\rho}} \right) \text{ if } \rho > \rho_0$$

$$\frac{l}{d} = k \left(11 + 1.5 \sqrt{20} * \frac{0.448}{0.5} + 0 \right)$$

$$\frac{l}{d} = 17.7 * k * 1.25$$

$$\frac{4650}{d} = 17.7 * 1.5 * 1.25 = 33.19$$

$$d = \frac{4650}{33.19} = 140.1 \text{ mm}$$

$$D = d + \frac{\emptyset}{2} + \text{cover}$$

$$D = 140.1 + 10/2 + 20 = 165.1 \text{ mm}$$

$$D = \underline{170 \text{ mm}}$$

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Take maximum depth for panels = **170mm**

Table 12 Depth of slab

Panel	Ly	Lx	Ly/Lx	Support type	Slab type	L/d*1.25	D	D=d+25
P1	4.29	3.25	1.32	Two way	end	28.76	113	138
P2	4.41	4.29	1.03	Two way	end	28.76	149.2	169.13
P3	4.41	4.29	1.03	Two way	end	28.76	149.2	169.13
P4	4.29	2.35	1.32	Two way	end	28.76	113	138
P5	4.65	4.41	1.05	Two way	end	28.76	153.4	138.4
P6	4.65	4.65	1	Two way	interior	33.2	140	165
P7	4.65	4.41	1.05	Two way	interior	33.2	132.8	157.8
P8	4.65	3.25	1.43	Two way	end	28.76	113	138
P9	5.5	3.25	1.7	Two way	interior	33.2	97.9	122.9
P10	5.5	4.41	1.25	Two way	interior	33.2	132.8	157.8
P11	5.5	4.65	1.19	Two way	interior	33.2	140	165
P12	5.5	4.41	1.25	Two way	interior	33.2	132.8	157.8
P13	5.5	3.25	1.7	Two way	interior	33.2	97.9	122.9
P14	5.5	3.25	1.7	Two way	interior	33.2	97.9	122.9
P15	5.5	4.41	1.25	Two way	interior	33.2	132.8	157.8
P16	5.5	4.65	1.19	Two way	interior	33.2	140	165
P17	5.5	4.41	1.25	Two way	interior	33.2	132.8	157.8
P18	5.5	3.25	1.7	Two way	interior	33.2	97.9	122.9
C1	550	190	2.9	One way	cantilever	8.85	21.5	46.5
C2	550	190	2.9	One way	cantilever	8.85	21.5	46.5
C3	190	170	1.12	Two way	cantilever	8.85	19.2	44.2
C4	325	170	1.91	Two way	cantilever	8.85	19.2	44.2
C5	441	170	2.6	One way	cantilever	8.85	19.2	44.2
C6	465	170	2.74	One way	cantilever	8.85	19.2	44.2
C7	441	170	2.6	One way	cantilever	8.85	19.2	44.2
C8	325	170	1.91	Two way	cantilever	8.85	19.2	44.2
C9	170	170	1	Two way	cantilever	8.85	19.2	44.2
C10	550	170	3.24	One way	cantilever	8.85	19.2	44.2
C11	550	170	3.24	One way	cantilever	8.85	19.2	44.2

3.2.1 Analysis & Load Calculation

Sectional (detail) elevation of floor slabs

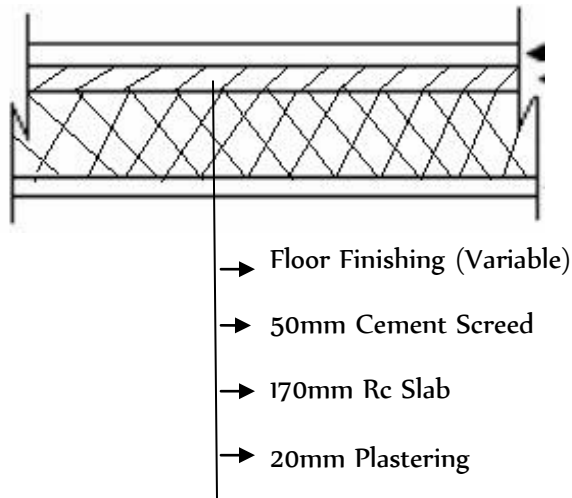


Table 13 Room Functions and their finishing materials

No	Functions	Finishing	Thickness	Unit wt (kN/m ³)
1	Kitchen	Ceramic	2 cm	21
2	Shower	Ceramic	2 cm	21
3	Store	Ceramic	2 cm	21
4	Bathroom	Ceramic	2 cm	21
5	Balcony	Ceramic	2 cm	21
6	Praying room	Parquet	5 cm	29
7	Studyroom	Parquet	5 cm	29
8	Living room	Parquet	5 cm	29
9	Dyning roo m	PVC tile	2 cm	16
10	Family room	Parquet	5cm	29
11	Bar	PVC tile	2 cm	16
12	Lobby	Terazzo	3 cm	23
13	Jacuzzi	Ceramic	2 cm	21
14	Dressing room	Ceramic	2 cm	21

Note: Unit weight for RC slabs ranges from 20-28 KN/m³, we use the average; $\gamma=24$ KN/m³ for C-25 Concrete.

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Table 14 Live Load for different functions based on ES-EN 1990

Function	Category	Live Load
Kitchen	General	2 KN/m ²
Shower	General	2 KN/m ²
Store	General	2 KN/m ²
Bathroom	General	2 KN/m ²
Balcony	Balconies	3 KN/m ²
Praying room	General	2 KN/m ²
Study room	General	2 KN/m ²
Living room	General	2 KN/m ²
Dining room	General	2 KN/m ²
Family room	General	2 KN/m ²
Bar	General	2 KN/m ²
Lobby	Lobbies	3 KN/m ²
Jacuzzi	General	2 KN/m ²
Dressing room	General	2 KN/m ²

Table 15 Dead Load Computation based on function rooms

Function	Material	Thickness (m)	Unit Weight, γ (KN/m ³)	γ_t (KN/m ²)	Total Dead Load (KN/m ²)
Kitchen Shower Bathroom Balcony Dressing room Store Jacuzzi	Ceramic	0.02	21	0.42	6.11
	Cement Screed	0.05	23	1.15	
	RC Slab	0.17	24	4.08	
	Plastering & Painting	0.02	23	0.46	
	PVC tile	0.02	16	0.32	
	Cement screed	0.05	23	1.15	
Dining room	RC slab	0.17	24	4.08	6.01

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Bar	Plastering & painting	0.02	23	0.46	
Lobby	Terazzo	0.02	23	0.46	6.15
	Cement screed	0.05	23	1.15	
	RC slab	0.17	24	4.08	
	Plastering & painting	0.02	23	0.46	
Bed room Study room Living room Family room Praying room	Parquet	0.05	27	0.81	6.5
	Cement Screed	0.02	23	1.15	
	RC Slab	0.17	24	4.08	
	Plastering & Painting	0.02	23	0.46	

Design Dead Load and Live Loads for each Panel

- Since an individual panel might have different purpose (function) and finishing material, we might encounter different live load and dead load in a single panel. In such cases we used the maximum value as a governing dead load or live load for that panel.
- $Pd' = 1.35D.L + 1.5L.L$

Table 16 First & Second Floor Panels

Panel	Function	Calculated dead load (KN/m ²)	Governing dead load (KN/m ²)	Live load (KN/m ²)	Governing live load (KN/m ²)	Pd' = 1.35D.L + 1.5L.L (KN/m ²)
P1	Bathroom	6.5	6.5	2	2	11.78
	Dressing room	6.11		2		
P2	Balcony	6.11	6.5	3	3	13.28
	Bed room	6.5		2		

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P3	Balcony	6.11	6.5	3	3	13.28
	Bed room	6.5		2		
P4	Bathroom	6.5	6.5	2	2	11.78
	Dressing room	6.11		2		
P5	Bed room	6.5	6.5	2	2	11.78
P6	Lobby	6.15	6.15	3	3	15.8
P7	Bed room	6.5	6.5	2	2	11.78
	Store	6.11		2		
	Kitchen	6.11		2		
P8	Kitchen	6.11	6.11	2	2	11.25
P9	Shower	6.11	6.11	2	2	11.25
	Dressin room	6.11		2		
	Jacuzzi	6.11		2		
P10	Bed room	6.5	6.5	2	2	11.78
P11	Lobby	6.15	6.15	3	3	15.8
P12	Dyning room	6.01	6.01	2	2	11.11
P13	Bar	6.01	6.01	2	2	11.11
P14	Study room	6.5	6.5	2	2	11.78
P15	Familyroom	6.5	6.5	2	2	11.78
P16	Lobby	6.15	6.15	3	3	15.8
P17	Living room	6.5	6.5	2	2	11.78
P18	Living room	6.5	6.5	2	2	11.78
C1-	Balcony	6.11	6.11	3	3	12.75
C11	Shower	6.11		2		

Table 17 Design dead load & liveload for 1st & 2nd floor panels

Panel	Function	Calculated dead load(KN/m ²)	Governing dead load (KN/m ²)	Live load (KN/m ²)	Governin g live load (KN/m ²)	Pd'=1.35D.L+1.5L.L (KN/m ²)
P1	Bathroom	6.5	6.5	2	2	11.78

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	Dressing room	6.11		2		
P2	Balcony	6.11	6.5	3	3	13.28
	Bed room	6.5		2		
P3	Balcony	6.11	6.5	3	3	13.28
	Bed room	6.5		2		
P4	Bathroom	6.5	6.5	2	2	11.78
	Dressing room	6.11		2		
P5	Bed room	6.5	6.5	2	2	11.78
P6	Lobby	6.15	6.15	3	3	15.8
P7	Bed room	6.5	6.5	2	2	11.78
	Store	6.11		2		
	Kitchen	6.11		2		
P8	Kitchen	6.11	6.11	2	2	11.25
P9	Shower	6.11	6.11	2	2	11.25
	Dressin room	6.11		2		
	Jacuzzi	6.11		2		
P10	Bed room	6.5	6.5	2	2	11.78
P11	Lobby	6.15	6.15	3	3	15.8
P12	Dyning room	6.01	6.01	2	2	11.11
P13	Bar	6.01	6.01	2	2	11.11
P14	Study room	6.5	6.5	2	2	11.78
P15	Familyroom	6.5	6.5	2	2	11.78
P16	Lobby	6.15	6.15	3	3	15.8
P17	Living room	6.5	6.5	2	2	11.78
P18	Living room	6.5	6.5	2	2	11.78
C1-	Balcony	6.11	6.11	3	3	12.75
C11	Shower	6.11		2		

Partition wall dead load computation

Material data

- Thickness of HCB=0.2m
- Thickness of plastering on two side=0.02m
- Unit weight of HCB=14 KN/m³
- Unit weight of plastering =23 KN/m³
- Height of wall=2.9m
 - Unit weight of HCB for light weight aggregate range from 10-14 KN/m³ & lower values are used for smaller size thickness (100mm to 200mm) ,so we use $\gamma_{HCB}=11 \text{ KN/m}^3$
- Dead load of partition wall=Dead load of plaster+ Dead load of HCB

$$D.L_{pw} = D.L_{pl} + D.L_{HCB}$$

$$D.L_{pw}(\text{kN}) = (H_{pl} * L_{pl} * t_{pl} * \gamma_{pl}) + (H_{HCB} * L_{HCB} * t_{HCB} * \gamma_{HCB})$$

$$D.L_{pw}(\text{kN}) = (2.9\text{m} * L_{pl} * 0.02\text{m} * 23 \text{ KN/m}^3) + (2.9\text{m} * L_{HCB} * 0.2\text{m} * 14 \text{ KN/m}^3)$$

$$D.L_{pw}(\text{kN}) = 1.334 \text{ KN/m}^2 * L_{pl} + 8.2 \text{ KN/m}^2 * L_{HCB}$$

$$\text{Therefore } D.L_{pw}(\text{kN/m}^2) = \frac{D.L_{pw}(\text{kN})}{\text{Area of Panel}}$$

Where, $D.L_{pw}$ = Dead load of Partition Wall

$H_{pl}, L_{pl}, t_{pl} \& \gamma_{pl}$ = Height, Length, Thickness, Unit Weight of Plastering Respectively.

$H_{HCB}, L_{HCB}, t_{HCB} \& \gamma_{HCB}$ = Height, Length, Thickness, Unit Weight of HCB Respectively.

Then calculating in a tabular form.

Table 18 Dead Load of partition wall on 1st & 2nd floor panels

panel	Length (m)	D.L (kN) = (1.334*L + 8.12*L) KN/m ²	Area (m ²)	D.L (kN/m ²) = D.L pw (kN)/Area
P1	2.3	21.74	13.94	1.56

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P2	1.8	17	18.92	0.89
P3	1.8	17	18.92	0.89
P4	2.3	21.74	13.94	1.56
P5	4.55	43	20.5	2.09
P6	N0 partition wall			
P7	4.9	46.32	20.5	2.26
P8	No partition wall			
P9	4.15	39.2	17.87	2.09
P10	4.27	40.37	24.25	1.66
P11-P18	No partition wall			

Summary of Imposed load

- Case-i : for panels where $\frac{\text{partition load} \times 100\%}{P_d' = (1.35 \text{ D.L} + 1.5 \text{ L.L})}$ is less than 20%

$$P_d = P_d' + 1.35 \text{ D.L}_{pw}$$

$$\text{Where, } P_d' = 1.35 \text{ D.L} + 1.5 \text{ L.L}$$

D.L_{pw} = Dead load of Partition wall

- Case-ii : for panels where $\frac{\text{partition load} \times 100\%}{P_d' = (1.35 \text{ D.L} + 1.5 \text{ L.L})}$ is greater than 20% , they are designed by strip method

$$\text{For panel 1} = \frac{0.35 \times 100\%}{10.6}$$

$$= 3.3 < 20\%$$

$$P_d = P_d' + 1.35 \text{ D.L}_{pw}$$

$$= 10.6 + 1.35 \times 1.56$$

$$= \underline{\underline{12.7}}$$

For every floor panel which have partition wall we have compute imposed load.

3.2.2 Design Moment Analysis

Moment Calculation for two way slab using coefficient method

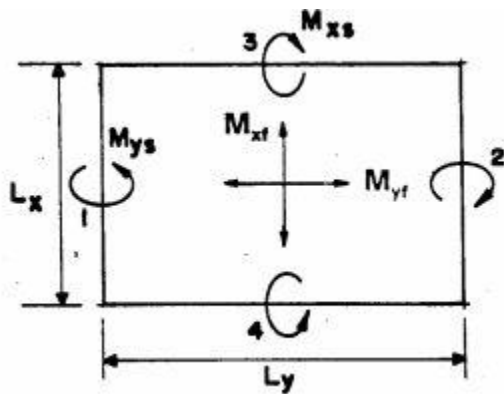
- The first stage of design is to determine support and span moments for all panels.
- The support and span moments are calculated as

$$M_i = \beta_i P_d L_x^2 \text{ ES-EN 1992}$$

Where M_i = Design moment per unit width of reference

P_d = Uniformly Distributed Design Load

β_i = Coefficient given in ES-EN



$$M_{XS} = \beta_i P_d L_x^2$$

$$M_{XF} = \beta_i P_d L_x^2$$

$$M_{YS} = \beta_i P_d L_x^2$$

$$M_{YF} = \beta_i P_d L_x^2$$

Moment analysis for first & second floor

For panel 1

$$\triangleright M_{XS} = \beta_i P_d L_x^2$$

$$M_{XS} = 0.077 * 13.89 * 3.25^2$$

$$M_{XS}=11.3$$

$$\triangleright M_{XF}=\beta si P_d L_x^2$$

$$M_{XF}=0.058*13.89*3.25^2$$

$$M_{XF}=8.51$$

$$\triangleright M_{YS}=\beta si P_d L_x^2$$

$$M_{YS}=0*13.89*3.25^2$$

$$M_{YS}=0$$

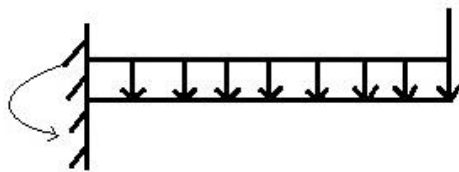
$$\triangleright M_{YF}=\beta si P_d L_x^2$$

$$M_{YF}=0.044*13.89*3.25^2$$

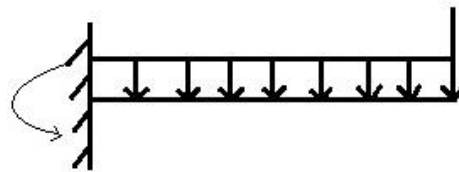
$$M_{YF}= 6.46$$

For cantilever

h=1.53m



$$\begin{aligned} &= pd*Lx*Lx/2 \\ &= Lx^2/2*12.75 \\ &= 1.7^2/2*12.75 \\ &= \mathbf{18.42} \end{aligned}$$



$$\begin{aligned} &= pd*Lx*Lx/2 \\ &= Lx^2/2*12.75 \\ &= 1.9^2/2*12.75 \\ &= \mathbf{\underline{23.01}} \end{aligned}$$

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Table 19 For 1st & 2nd floor

PANEL	TYPE	Lx	Ly	Ly/Lx	n(pd)	β_{sx-}	β_{sx+}	β_{sy-}	β_{sy+}	Mxs	Mxf	Mys	Myf
P1	End	3.25	4.29	1.32	13.9	0.077	0.058		0.044	11.30	8.51	0.00	6.46
P2	End	4.29	4.41	1.03	14.5	0.052	0.039	0.045	0.034	13.88	10.41	12.01	9.07
P3	End	4.29	4.41	1.03	14.5	0.052	0.039	0.045	0.034	13.88	10.41	12.01	9.07
P4	End	3.25	4.29	1.32	13.9	0.07	0.052	0.045	0.034	10.27	7.63	6.60	4.99
P5	End	4.41	4.65	1.05	14.6	0.046	0.033	0.037	0.028	13.06	9.37	10.51	7.95
P6	Interior	4.65	4.65	1.00	15.8	0.039	0.03	0.032	0.028	13.32	10.25	10.93	9.57
P7	Interior	4.41	4.65	1.05	14.8	0.034	0.026	0.037	0.024	9.81	7.50	10.67	6.92
P8	End	3.25	4.65	1.43	11.3	0.07	0.052	0.037	0.028	8.32	6.18	4.40	3.33
P9	Interior	3.25	5.5	1.69	14.1	0.062	0.0462	0.032	0.028	9.21	6.87	4.76	4.16
P10	Interior	4.41	5.5	1.25	14	0.044	0.034	0.032	0.024	12.00	9.27	8.73	6.54
P11	Interior	3.25	5.5	1.69	15.8	0.042	0.032	0.032	0.024	7.01	5.34	5.34	4.01
P12	Interior	4.41	5.5	1.25	11.1	0.044	0.034	0.032	0.024	9.51	7.35	6.91	5.19
P13	Interior	3.25	5.5	1.69	11.1	0.058	0.043	0.032	0.024	6.81	5.05	3.76	2.82
P14	Interior	3.25	5.5	1.69	11.8	0.058	0.043	0.032	0.024	7.22	5.35	3.98	2.99
P15	Interior	4.41	5.5	1.25	11.8	0.044	0.034	0.032	0.024	10.08	7.79	7.33	5.50
P16	Interior	4.65	5.5	1.18	15.8	0.042	0.032	0.032	0.024	14.35	10.93	10.93	8.20
P17	Interior	4.41	5.5	1.25	11.8	0.044	0.034	0.032	0.024	10.08	7.79	7.33	5.50
P18	Interior	3.25	5.5	1.69	11.8	0.058	0.043	0.032	0.024	7.22	5.35	3.98	2.99
C3	cantilever	1.7	1.9	1.12	12.8	0.057	0.043	0.045	0.034	2.10	1.58	1.66	1.25
C4	cantilever	1.7	3.25	1.91	12.8	0.086	0.065	0.037	0.028	3.17	2.40	1.36	1.03
C8	cantilever	1.7	3.25	1.91	12.8	0.086	0.065	0.037	0.037	3.17	2.40	1.36	1.36
C9	cantilever	1.7	1.7	1.00	12.8	0.031	0.024	0.032	0.032	1.14	0.88	1.18	1.18

PANEL		Lx	Ly	Ly/Lx	n(pd)	Mxs(KN)
C 1	cantilever	1.9	5.5	2.89	12.75	23.01
C 2	cantilever	1.9	5.5	2.89	12.75	23.01
C5	cantilever	1.7	4.41	2.59	12.75	18.42
C6	cantilever	1.7	4.465	2.63	12.75	18.42
C7	cantilever	1.7	4.41	2.59	12.75	18.42
C10	cantilever	1.7	5.5	3.24	12.75	18.42
C11	cantilever	1.7	5.5	3.24	12.75	18.42

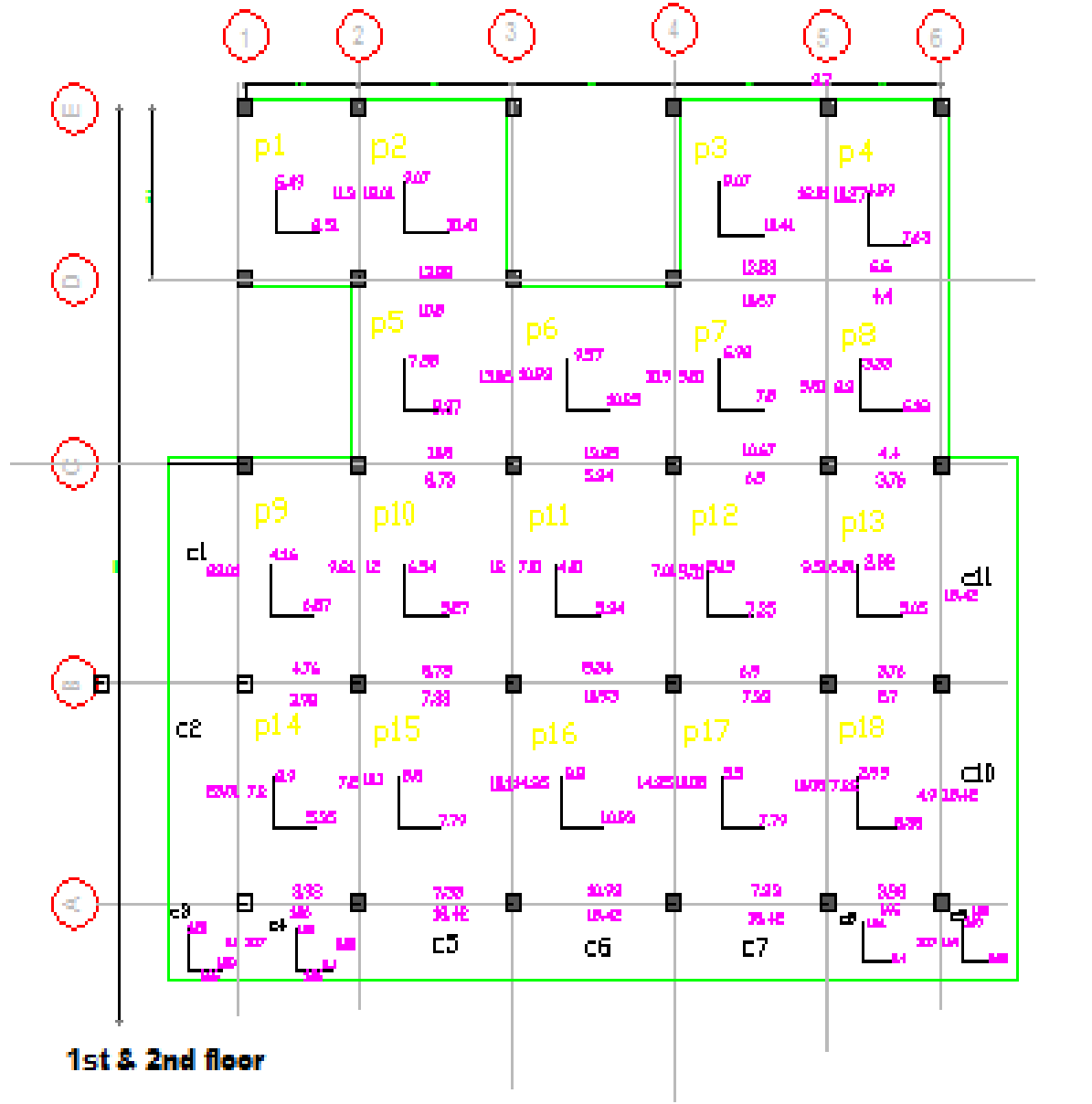


Figure 6 Moment analysis diagram for 1st & 2nd floor slab

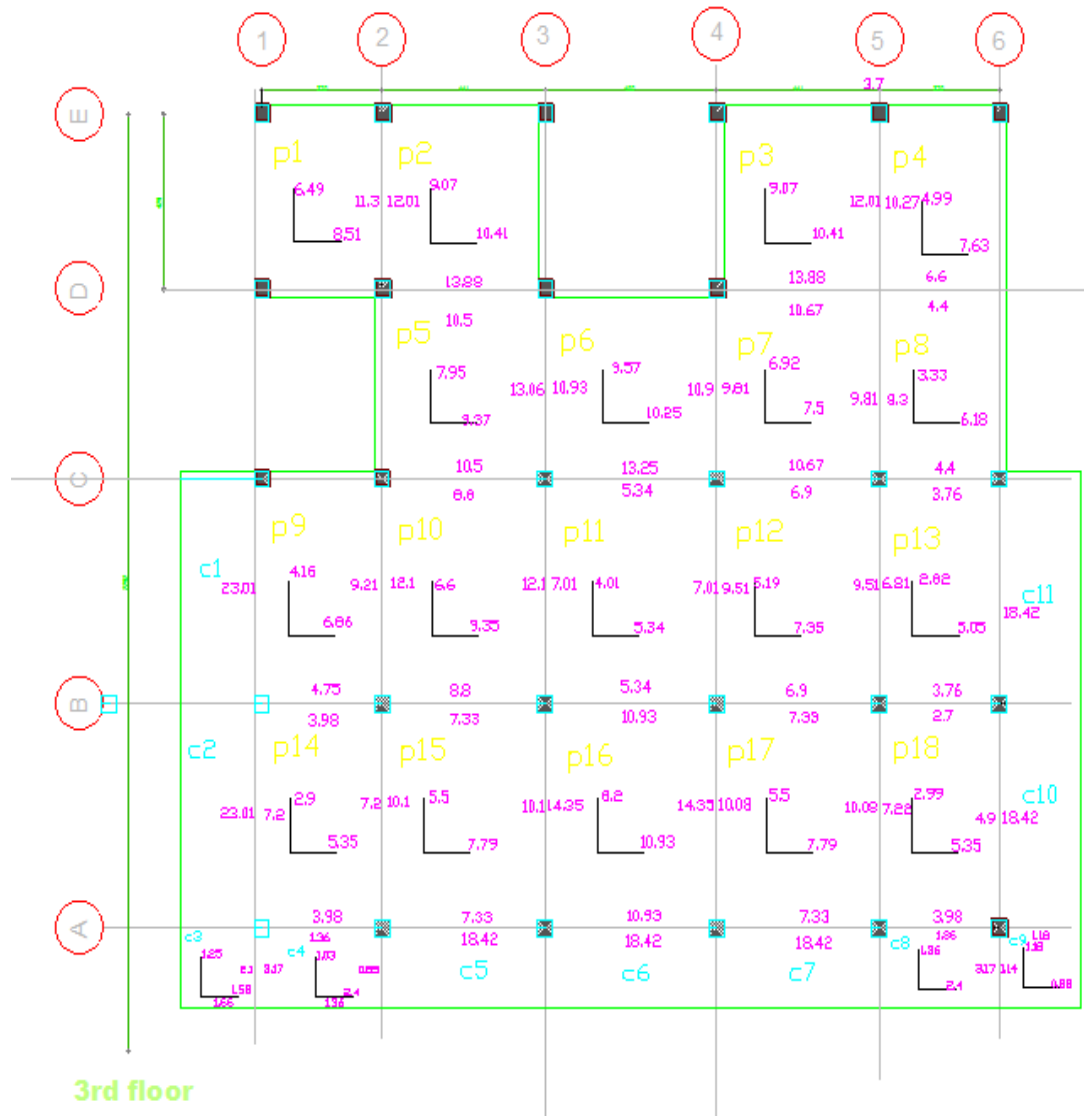


Figure 7 Moment analysis diagram for 4th floor slab

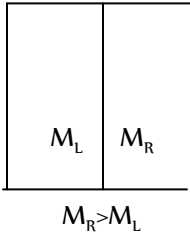
3.2.3 Moment adjustment between panels

3.2.3.1 Support moment adjustment

There are two cases.

Case (1) If $\frac{M_R - M_L}{M_R} * 100 < 20\%$ then $M_d = \frac{M_R + M_L}{2}$, $M_R > M_L$

Case (2) If $\frac{M_R - M_L}{M_R} * 100 > 20\%$ then Distribute unbalanced moment $M_D = M_R - M_L$ based on relative stiffness.... $M_R > M_L$



$$M_d = M_R - \frac{K_R}{K_R + K_L} * \Delta M \dots \dots \dots \text{Considering right}$$

$$M_d = M_R + \frac{K_R}{K_R + K_L} * \Delta M \dots \dots \dots \text{Considering Left}$$

Note that If adjustment is between two-way and cantilever, then $M_d = M_{\max}$

Support moment adjustment for 1st & 2nd floor

For panel 1 & panel 2

$$\frac{M_R - M_L}{M_R} * 100 < 20\% = \frac{12.01 - 11.3}{12.01} * 100 = 5.9\% < 20\%$$

Use method 1 $\frac{12.01 + 11.3}{2} = 11.66$

For panel 2 & panel 5

$$\frac{M_R - M_L}{M_R} * 100 < 20\% = \frac{13.88 - 10.51}{13.88} * 100 = 24.6\% > 20\%$$

Use method 2

$$K_{AB} = \frac{3}{4L_X} = \frac{3}{4 * 4.49} = 0.17$$

$$K_{BC} = \frac{1}{L_X} = \frac{1}{4.41} = 0.225$$

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$$DF_{AB} = \frac{K_{AB}}{K_{AB} + K_{BC}} = \frac{0.17}{0.17 + 0.225} = 0.43$$

$$DF_{BC} = \frac{K_{BC}}{K_{AB} + K_{BC}} = \frac{0.225}{0.17 + 0.225} = 0.57$$

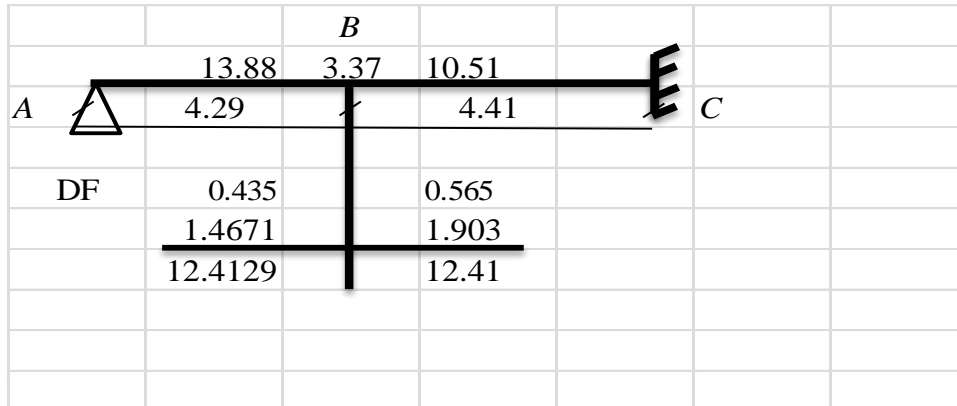


Table 20 Support moment adjustment for 1st & 2nd floor

Panel	Mtd 1	Mtd2	Max
P1&P2	11.66		
P2&P5		12.17	
P3&P4	11.14		
P3&P7		12.48	
P4&P8		5.5	
P5&P6	12		
P5&P10	9.62		
P6&P7	10.37		
P6&P11		9.3	
P7&P8	9.07		
P7&P12		8.79	
P8&P13	4.08		
P9&P10		10.39	
P9&P14	4.37		
P9&C1			23.01
P10&P11		9.44	
P10&P15	8.03		
P11&P12		8.29	
P11&P16		8.14	
P12&P13		8.36	
P12&P17	7.12		

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P13&P18	3.87		
P13&C11			18.42
P14&P15		8.43	
P14&C2			23.01
P14&C4			3.98
P15&P16		12.16	
P15&C5			18.42
P16&P17		12.27	
P16&C6			18.42
P17&P18		8.87	
P17&C7			18.42
P18&C8			3.98
P18&C10			18.42
C1&C2			23.01
C2&C3			23.01
C3&C4			2.1
C4&C5			18.42
C5&C6			18.42
C6&C7			18.42
C7&C8			18.42
C8&C9			3.17
C9&C10			18.42
C10&C11			18.42

3.2.3.2 Span moment adjustment

If the support moment is decreased while carrying on moment distribution of a balanced support moment the span moment M_{xf} and M_{yf} are the increased to allow for the change of support moment. This increase is calculated being equal to the change of the support moment multiplied by the factor given in EBCS. If the support moment increased, no adjustment shall be made to the span moment.

Table 21 span moment adjustment for 1st & 2nd

				$M_{xs}+M_{xf}-M_{adj}$
PANEL	M_{xs}	M_{xf}	M_{adjust}	M_{xfadj}
P1	0	11.87	11.66	0.21
P2	13.88	10.41	11.66	12.63
P3	13.88	10.41	11.14	13.15

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P4	6.6	7.63	5.5	8.73
P5	10.51	9.37	9.62	10.26
P6	13.25	10.25	9.3	14.20
P7	10.67	7.5	8.79	9.38
P8	4.4	6.18	4.08	6.50
P9	4.76	6.87	4.37	7.26
P10	8.37	9.27	8.03	9.61
P11	5.34	5.34	8.14	2.54
P12	6.91	7.35	7.12	7.14
P13	3.76	5.05	3.87	4.94
P14	3.98	5.35	8.43	0.90
P15	7.33	7.79	12.16	2.96
P16	10.93	10.93	12.27	9.59
P17	7.33	7.79	8.87	6.25
P18	3.98	5.35	3.98	5.35
C3	1.66	1.58	2.1	1.14
C4	1.36	2.4	2.1	1.66
C8	1.36	2.4	3.17	0.59
C9	1.36	2.4	3.17	0.59

				Mys+Myf- Madj
PANEL	Mys	Myf	Madjust	Myfadj
P1	11.3	6.46	11.66	6.10
P2	12.01	9.07	12.17	8.91
P3	12.01	9.07	12.48	8.60
P4	10.27	4.99	5.5	9.76
P5	13.06	7.95	12	9.01
P6	10.93	9.57	10.37	10.13
P7	9.81	6.92	9.07	7.66
P8	8.32	3.33	4.08	7.57
P9	9.21	4.16	10.39	2.98
P10	12	6.54	9.44	9.10
P11	7.01	4.01	8.29	2.73
P12	9.51	5.19	8.36	6.34
P13	6.81	2.82	3.87	5.76
P14	7.22	2.99	8.43	1.78
P15	10.08	5.5	12.16	3.42
P16	14.35	8.2	18.42	4.13
P17	10.08	5.5	8.87	6.71

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P18	7.22	2.99	3.98	6.23
C3	2.1	1.25	2.1	1.25
C4	3.17	1.03	2.1	2.10
C8	3.17	1.36	3.17	1.36
C9	1.14	1.18	2.1	0.22

3.2.3.3 Load on Support Beams

$$V_{sx} = \beta v_{xn} L_x$$

$$V_{sy} = \beta v_{yn} L_x$$

G+4 Residential building project

Table 22 For 1st & 2nd floor

PANEL	TYPE	Lx	Ly	Ly/Lx	n(pd)	$\beta_{vx\ c}$	$\beta_{vx\ dc}$	$\beta_{vy\ c}$	$\beta_{vy\ dc}$	Vsx c	Vsx dc	Vsy c	Vsy dc
P1	end	3.25	4.29	1.32	13.89	0.534	0.352	0.4	0.26	24.11	15.89	18.06	11.74
P2	end	4.29	4.41	1.03	14.5	0.452	0.269		0.29	28.12	16.73	0.00	18.04
P3	end	4.29	4.41	1.03	14.5	0.452	0.269		0.29	28.12	16.73	0.00	18.04
P4	end	3.25	4.29	1.32	13.89	0.504	0.332	0.4	0.26	22.75	14.99	18.06	11.74
P5	end	4.41	4.65	1.05	14.6	0.38	0.255	0.36		24.47	16.42	23.18	0.00
P6	interior	4.65	4.65	1.00	15.8	0.36	0.4	0.36	0.27	26.45	29.39	26.45	19.84
P7	interior	4.41	4.65	1.05	14.83	0.345		0.24		22.56	0.00	15.70	0.00
P8	end	3.25	4.65	1.43	11.25	0.496	0.326	0.33		18.14	11.92	12.07	0.00
P9	interior	3.25	5.5	1.69	14.07	0.494		0.36	0.24	22.59	0.00	16.46	10.97
P10	interior	4.41	5.5	1.25	14.02	0.41		0.36		25.35	0.00	22.26	0.00
P11	interior	4.65	5.5	1.18	15.8	0.382		0.33		28.07	0.00	24.25	0.00
P12	interior	4.41	5.5	1.25	11.11	0.4		0.33		19.60	0.00	16.17	0.00
P13	interior	3.25	5.5	1.69	11.11	0.474		0.33		17.11	0.00	11.92	0.00
P14	interior	3.25	5.5	1.69	11.78	0.474		0.33		18.15	0.00	12.63	0.00
P15	interior	4.41	5.5	1.25	11.78	0.4		0.33		20.78	0.00	17.14	0.00
P16	interior	4.65	5.5	1.18	15.8	0.387		0.33		28.43	0.00	24.25	0.00
P17	interior	4.41	5.5	1.25	11.78	0.4		0.33		20.78	0.00	17.14	0.00
P18	interior	3.25	5.5	1.69	11.78	0.474		0.33		18.15	0.00	12.63	0.00

PANEL	TYPE	Lx	Ly	Ly/Lx	n (Pd)	WL
C 1	cantiliver	1.9	5.5	2.89	12.75	24.23
C2	cantiliver	1.9	5.5	2.89	12.75	24.23
C3	cantiliver	1.7	1.9	1.12	12.75	21.68
C4	cantiliver	1.7	3.25	1.91	12.75	21.68
C5	cantiliver	1.7	4.41	2.59	12.75	21.68
C6	cantiliver	1.7	4.65	2.74	12.75	21.68
C7	cantiliver	1.7	4.41	2.59	12.75	21.68
C8	cantiliver	1.7	3.25	1.91	12.75	21.68
C9	cantiliver	1.7	1.7	1.00	12.75	21.68
C10	cantiliver	1.7	5.5	3.24	12.75	21.68
C11	cantiliver	1.7	5.5	3.24	12.75	21.68

Check depth for flexure

$$\text{Cubic strength (fcu)} = 25 \quad \gamma_s = 1.15$$

$$\gamma_c = 1.5 \quad \epsilon_{cu} = 3.5$$

$$\text{S-400} \quad b = 1000$$

$$F_{ck} = 0.85 \cdot F_{ck} / 1.25 = 25 / 1.25 = 20 \text{Mpa}$$

$$F_{cd} = 0.85 \cdot F_{ck} / \gamma_c = 0.85 \cdot 20 \text{Mpa} / 1.5 = 11.33 \text{Mpa}$$

$$F_{yd} = s / \gamma_s = 400 / 1.15 = 347.83 \text{Mpa}$$

$$m = \frac{f_{yd}}{0.8 \cdot f_{cd}} = \frac{347.83 \text{Mpa}}{0.8 \cdot 11.33} = 38.36$$

$$C1 = \frac{2.5}{m} = \frac{2.5}{38.36} = 0.0652$$

$$C2 = 0.32 \cdot m^2 \cdot f_{cd} = 0.32 \cdot 38.36^2 \cdot 11.33 = 5337$$

$$\begin{aligned} \rho_b &= (((0.8 \cdot \epsilon_{cu}) / (\epsilon_{cu} + f_{yd}(200)))) \cdot (F_{cd} \cdot F_{yd}) \\ &= (((0.8 \cdot 3.5) / (3.5 + 347.83))) \cdot (11.33 \cdot 347.83) \\ &= 0.01741 \text{Mpa} \end{aligned}$$

$$\rho_{\max} = 0.75 \cdot \rho_b = 0.75 \cdot 0.01741$$

$$= 0.01306$$

$$M_{\max} = 23.01$$

$$d = \sqrt{(M_{\max} / (0.8 b f_{cd} \rho_{\max} m (1 - (0.4 m \rho_{\max}))))}$$

$$d = 80.6$$

3.2.4 Reinforcement Design

- For the given

- Material Data, C-25, S-400
- Effective depth, $d=170\text{mm}$
- Width, $b=1000\text{mm}$
- Moments calculated for each panels

➤ Area of steel

$$A_{st,min} = \max \left\{ \begin{array}{l} 0.26 \frac{f_{ctm}}{f_{yk}} bd \\ 0.0013bd \end{array} \right.$$

$$A_{st,min} = \max \left\{ \begin{array}{l} 0.26 \frac{2.2}{400} * 1000 * 145 = 243.1 \\ 0.0013 * 1000 * 145 = 221 \end{array} \right.$$

$$A_{st,min} = \mathbf{240}$$

➤ Spacing

$$S_{max} = \max \left\{ \begin{array}{l} 3D = 3 * 170 = 510\text{mm} \\ 400\text{mm} \end{array} \right.$$

$$S_{max} = \mathbf{510 \text{ mm}}$$

$$A_{st} = \frac{m_{sd}}{Z * f_{yd}}$$

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{400\text{Mpa}}{1.15} = 347.83 \text{ Mpa}$$

$$Z = 0.9d = 0.9 * 145\text{mm} = 130.5 \text{ mm}$$

Example for panel 1 support moment = 11.66 KN-m

$$A_{st} = \frac{m_{sd}}{Z * f_{yd}} = \frac{11.66 * 1000 * 1000 \text{ N-mm}}{130.5\text{mm} * 347.83 \text{ N/mm}^2} = \mathbf{254.5 \text{ mm}^2} > 240\text{mm}^2 \text{ OK!!}$$

Let the \varnothing of reinforcement be 10mm

$$a_{st} = \frac{\pi d^2}{4} = \frac{3.14 * 10^2}{4} = \mathbf{78.5 \text{ mm}^2}$$

$$\text{Spacing of bars} = S = \frac{ba_s}{A_s} = \frac{1000 * 78.5}{254.5} = \mathbf{308.5 \text{ mm}}$$

308.5 mm \approx 300 mm used < 510mm OK!!

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Table 23 Reinforcement for 1st & 2nd floor

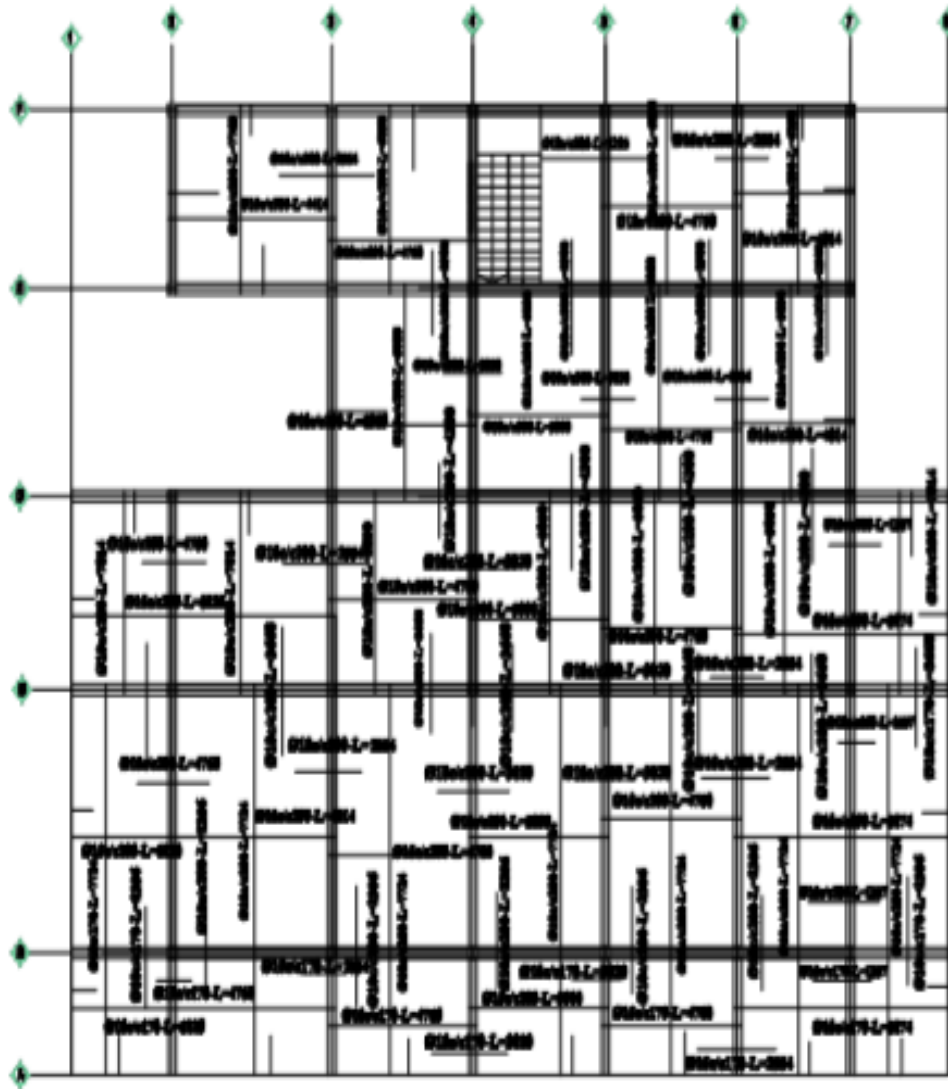
panel	moment		Ast=Msd/Z*fyd	∅	spacing	spacing used	Reinforcement			
P-1	M _{xs} =	0.21	240.00	10	327.08	300	∅	10	c/c	300
	M _{xf} =	0.21	240.00	10	327.08	300	∅	10	c/c	300
	M _{ys} =	11.66	240.00	10	327.08	300	∅	10	c/c	300
	M _{yf} =	6.1	240.00	10	327.08	300	∅	10	c/c	300
P-2	M _{xs} =	12.17	240.00	10	327.08	300	∅	10	c/c	300
	M _{xf} =	12.63	240.00	10	327.08	300	∅	10	c/c	300
	M _{ys} =	11.66	240.00	10	327.08	300	∅	10	c/c	300
	M _{yf} =	8.91	240.00	10	327.08	300	∅	10	c/c	300
P-3	M _{xs} =	12.48	240.00	10	327.08	300	∅	10	c/c	300
	M _{xf} =	13.15	241.42	10	325.16	300	∅	10	c/c	300
	M _{ys} =	11.14	240.00	10	327.08	300	∅	10	c/c	300
	M _{yf} =	8.6	240.00	10	327.08	300	∅	10	c/c	300
P-4	M _{xs} =	5.5	240.00	10	327.08	300	∅	10	c/c	300
	M _{xf} =	8.73	240.00	10	327.08	300	∅	10	c/c	300
	M _{ys} =	11.14	240.00	10	327.08	300	∅	10	c/c	300
	M _{yf} =	9.76	240.00	10	327.08	300	∅	10	c/c	300
P-5	M _{xs} =	9.62	240.00	10	327.08	300	∅	10	c/c	300
	M _{xf} =	10.26	240.00	10	327.08	300	∅	10	c/c	300
	M _{ys} =	12	240.00	10	327.08	300	∅	10	c/c	300
	M _{yf} =	9.01	240.00	10	327.08	300	∅	10	c/c	300
P-6	M _{xs} =	9.3	240.00	10	327.08	300	∅	10	c/c	300
	M _{xf} =	15.46	283.83	10	276.58	250	∅	10	c/c	250
	M _{ys} =	10.37	240.00	10	327.08	300	∅	10	c/c	300
	M _{yf} =	10.13	240.00	10	327.08	300	∅	10	c/c	300
P-7	M _{xs} =	8.79	240.00	10	327.08	300	∅	10	c/c	300
	M _{xf} =	9.38	240.00	10	327.08	300	∅	10	c/c	300
	M _{ys} =	9.07	240.00	10	327.08	300	∅	10	c/c	300
	M _{yf} =	7.66	240.00	10	327.08	300	∅	10	c/c	300
P-8	M _{xs} =	4.08	240.00	10	327.08	300	∅	10	c/c	300

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	$M_{xf} =$	6.5	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	9.07	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	7.57	240.00	10	327.08	300	\emptyset	10	c/c	300
P-9	$M_{xs} =$	4.37	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	1.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	10.39	240.00	10	327.08	300	\emptyset	10	c/c	300
P-10	$M_{yf} =$	2.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	8.03	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	8.53	240.00	10	327.08	300	\emptyset	10	c/c	300
P-11	$M_{ys} =$	9.44	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	9.26	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	8.14	240.00	10	327.08	300	\emptyset	10	c/c	300
P-12	$M_{xf} =$	2.54	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.29	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	2.73	240.00	10	327.08	300	\emptyset	10	c/c	300
P-13	$M_{xs} =$	7.12	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	7.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.36	240.00	10	327.08	300	\emptyset	10	c/c	300
P-14	$M_{yf} =$	6.34	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	3.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	4.94	240.00	10	327.08	300	\emptyset	10	c/c	300
P-15	$M_{ys} =$	8.36	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	5.76	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
P-16	$M_{xf} =$	0.9	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.43	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.78	240.00	10	327.08	300	\emptyset	10	c/c	300
P-15	$M_{xs} =$	18.42	338.17	10	232.13	300	\emptyset	10	c/c	300
	$M_{xf} =$	2.96	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	12.16	240.00	10	327.08	300	\emptyset	10	c/c	300
P-16	$M_{yf} =$	3.42	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	9.59	240.00	10	327.08	300	\emptyset	10	c/c	300

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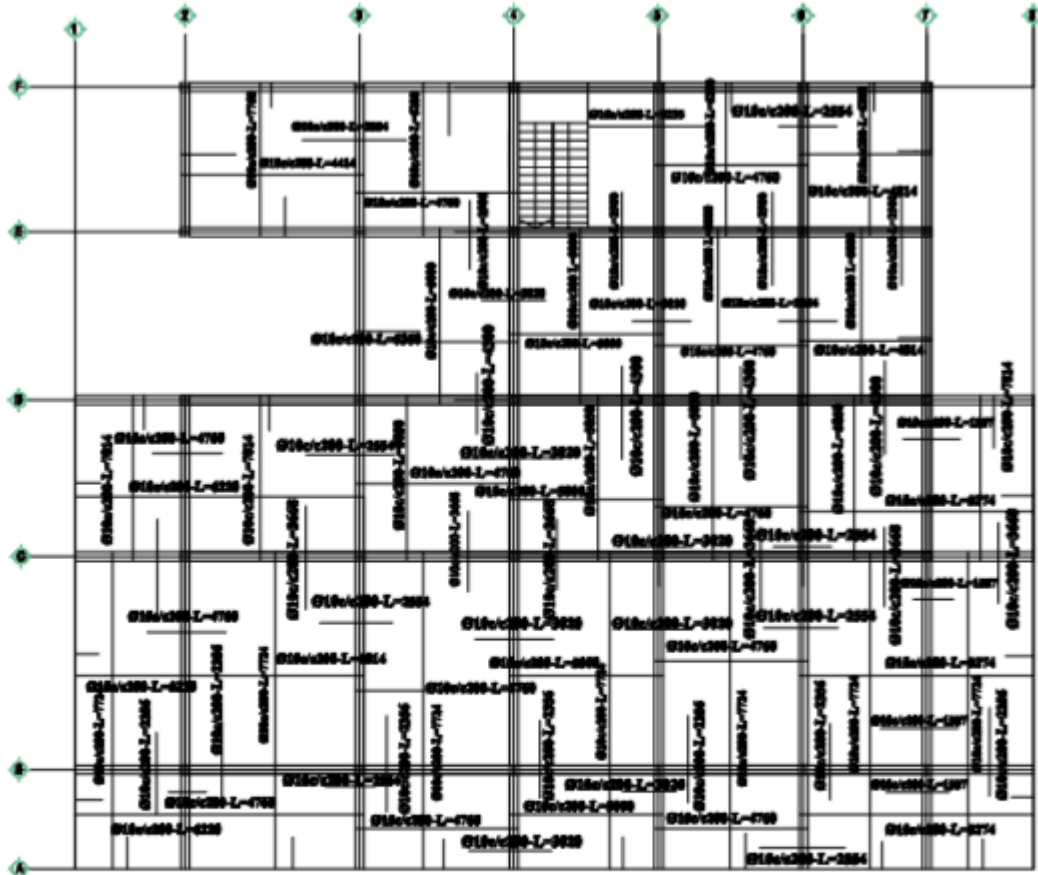
	$M_{ys} =$	12.27	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.13	240.00	10	327.08	300	\emptyset	10	c/c	300
P-17	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	6.25	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	6.71	240.00	10	327.08	300	\emptyset	10	c/c	300
P-18	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	5.35	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	6.23	240.00	10	327.08	300	\emptyset	10	c/c	300
C3	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
	$M_{xf} =$	1.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	2.1	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.25	240.00	10	327.08	300	\emptyset	10	c/c	300
C4	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	1.66	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{yf} =$	2.1	240.00	10	327.08	300	\emptyset	10	c/c	300
C8	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	0.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	3.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.36	240.00	10	327.08	300	\emptyset	10	c/c	300
C9	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	0.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	3.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.22	240.00	10	327.08	300	\emptyset	10	c/c	300
C1	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
C2	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
C5	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C6	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C7	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C10	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C11	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210



First & Second Floor Slab detailing

Scale 1:50

Figure 8 1st & 2nd floor slab detail drawing



Third Floor Slab detailing
Scale 1:50

Figure 9 3rd floor slab detail drawing

4. STAIR CASE DESIGN

Stairs are one of the structural element constructed with steps which provide access to different floor levels. are sloping one-way spanning slab Stairs are different in their mode of planning.

DESIGN PROCEDURE

- Determination of depth for deflection.
- Loading: which determines the total load in the stair and landing Analysis: determines moment and shear forces based on the analyzed moment
- Check depth for flexure: this step helps to cross check the design depth as it is safe for flexure or not, if not revise the depth determined in step 1 and also the loads.
- Reinforcement provision: using the computed moments, number and area of reinforcement bars determined.
- Detailing: the arrangement of reinforcement

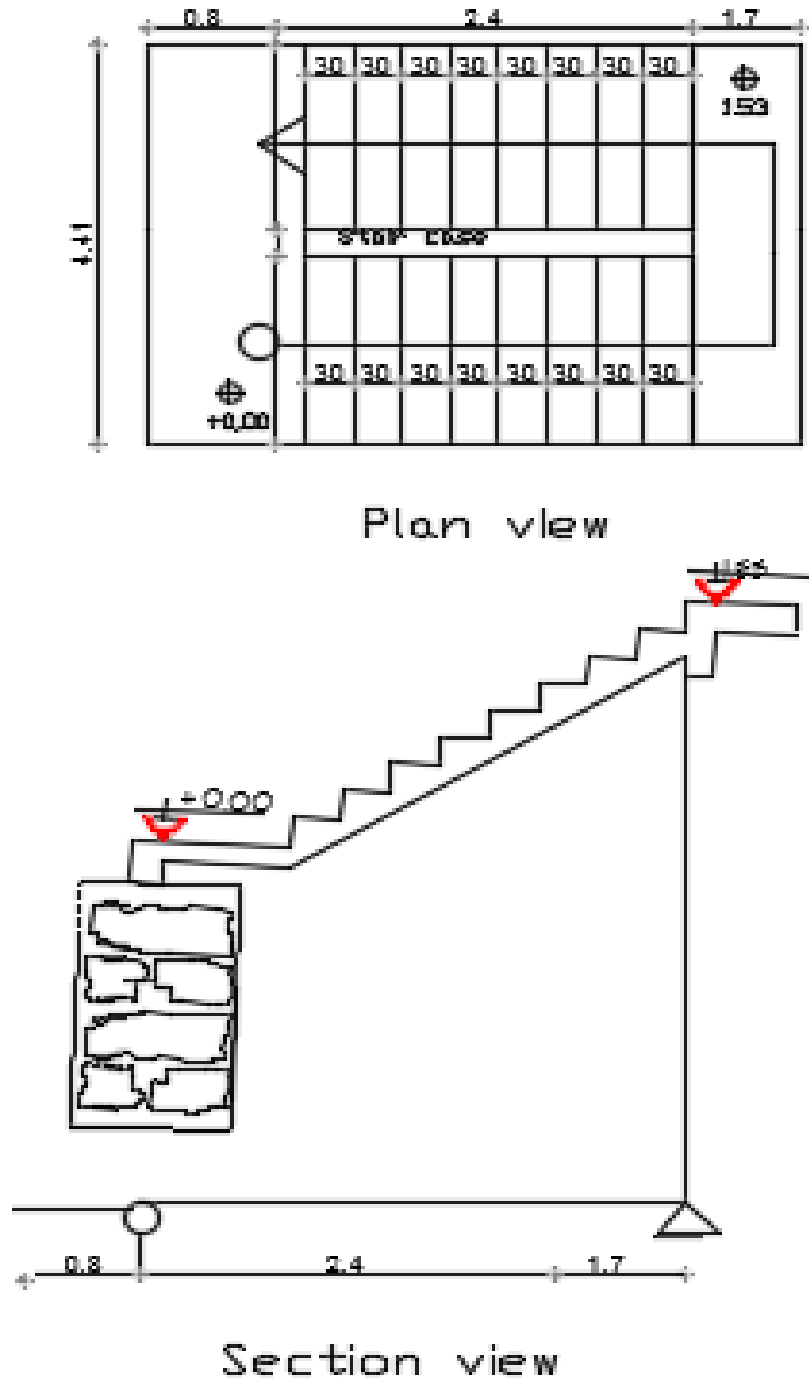


Figure 11 Stair section view

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$$\text{Height of Riser} = \frac{\text{Height of Stair}}{\text{No of Stair}} = \frac{1.53\text{m}-0\text{m}}{9} = 0.17\text{m}$$

Therefore we use riser height 17 cm for the design.

Material

C-25

S-400

➤ Depth for deflection for the inclined slab

From EN 1992-1-1-2004 section 7.4.2 depth of the slab is determined

$$\frac{l}{d} = k(11 + 1.5\sqrt{fck} * \frac{\rho_0}{\rho} + 3.2\sqrt{fck} * (\frac{\rho_0}{\rho} - 1)^{\frac{3}{2}}) \text{ if } \rho \leq \rho_0$$

$$\frac{l}{d} = k \left(11 + 1.5\sqrt{fck} * \frac{\rho_0}{\rho - \rho'} + \frac{1}{12}\sqrt{fck} * \sqrt{\frac{\rho'}{\rho}} \right) \text{ if } \rho > \rho_0$$

$fck = 20\text{Mpa}$

Assume the concrete is lightly stressed $\rho = 0.5\%$

$$\rho_0 = \sqrt{fck} * 10^{-3} = \sqrt{20} * 10^{-3} = 0.4472\%$$

$\rho_0 < \rho$ So use

$$\frac{l}{d} = k \left(11 + 1.5\sqrt{fck} * \frac{\rho_0}{\rho - \rho'} + \frac{1}{12}\sqrt{fck} * \sqrt{\frac{\rho'}{\rho}} \right)$$

For interior slab $K=1.3$ as EN 1992-1-1 table 7.4

$$\frac{l}{d} = k(11 + 1.5\sqrt{20} * \frac{0.4472}{0.5} + 3.2\sqrt{20} * (\frac{0}{0.5})^{\frac{1}{2}})$$

$$\frac{l}{d} = 18.5 * k$$

G+4 Residential building project

$$\frac{2400}{d} = 18.5 * 1.3$$

$$d = \frac{2400}{27.75} = 86.49 \text{ mm}$$

➤ Depth for deflection for the Landing

From EN 1992-1-1-2004 section 7.4.2 depth of the slab is determined

$$\frac{l}{d} = k(11 + 1.5\sqrt{fck} * \frac{\rho_0}{\rho} + 3.2\sqrt{fck} * (\frac{\rho_0}{\rho} - 1)^{\frac{3}{2}}) \text{ if } \rho \leq \rho_0$$

$$\frac{l}{d} = k \left(11 + 1.5\sqrt{fck} * \frac{\rho_0}{\rho - \rho'} + \frac{1}{12}\sqrt{fck} * \sqrt{\frac{\rho'}{\rho}} \right) \text{ if } \rho > \rho_0$$

$$fck = 20 \text{ Mpa}$$

Assume the concrete is lightly stressed $\rho = 0.5\%$

$$\rho_0 = \sqrt{fck} * 10^{-3} = \sqrt{20} * 10^{-3} = 0.4472\%$$

$\rho^0 > \rho$ So use

$$\frac{l}{d} = k \left(11 + 1.5\sqrt{fck} * \frac{\rho_0}{\rho - \rho'} + \frac{1}{12}\sqrt{fck} * \sqrt{\frac{\rho'}{\rho}} \right)$$

For interior slab $K=1.3$ as EN 1992-1-1 table 7.4

$$\frac{l}{d} = k(11 + 1.5\sqrt{20} * \frac{0.4472}{0.5-0} + 1/12 \sqrt{20} * (\frac{0}{0.5})^{\frac{1}{2}})$$

$$\frac{l}{d} = 18.5 * k$$

$$\frac{1700}{d} = 18.5 * 1.3$$

$$d = \frac{1700}{27.75} = 61.26 \text{ mm}$$

$$d_{\max} = \max(86.49 \text{ mm}, 61.26 \text{ mm})$$

G+4 Residential building project

$$d_{\max}=86.49\text{mm}$$

➤ Overall depth

$$D=d+\text{cover}+\phi/2, \text{ assume } \phi 14$$

$$=86.49\text{ mm}+15\text{ mm}+14\text{mm}/2$$

$$=108.49\text{ mm}$$

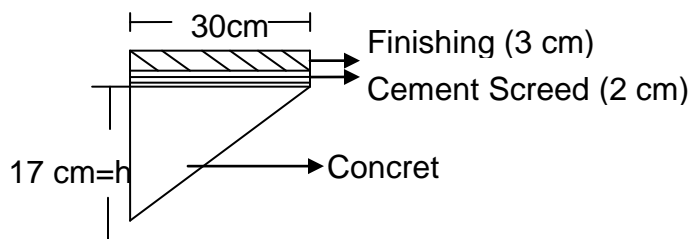
Use $D=120\text{ mm}$

4.1 Load computation

Material Data

- Unit weight of marble= 27 KN/m^3
- Unit weight of cement screed= 23 KN/m^3
- Unit weight of concrete= 24 KN/m^3
- Unit weight of plastering= 23 KN/m^3
- Thickness of cement screed= 2cm
- Thickness of plastering= 2cm
- Thickness of marble= 3cm
- Take 1m width strip

Step dead load

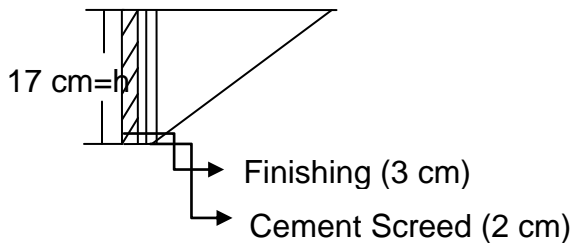


- D.L of cement screed= $t_{sc}*\gamma_{sc}=0.02*23\text{ KN/m}^3=0.46\text{ KN/m}$
- D.L of finishing= $t_{fin}*\gamma_{fin}=0.03*27\text{ KN/m}^3=0.81\text{ KN/m}$
- D.L of Concrete= $1/2*h*\gamma_{conc}=1/2*0.17\text{m}*24\text{ KN/m}^3=2.04\text{ KN/m}$

Therefore DL of step= $0.46\text{ KN/m} + 0.81\text{ KN/m} + 2.04\text{ KN/m}=3.31\text{ KN/m}$

G+4 Residential building project

Riser Dead Load



- D.L of cement screed = $\frac{\text{No of riser (hcs*tcs*\gamma_{sc})}}{\text{Projected length (8*30cm)}}$

$$= \frac{9(0.17\text{m} * 0.02\text{m} * 23\text{KN/m}^3)}{2.4}$$

$$= 0.293 \text{ KN/m}$$

- D.L of Finishing = $\frac{\text{No of riser (hcs*tcs*\gamma_{sc})}}{\text{Projected length (8*30 cm)}}$

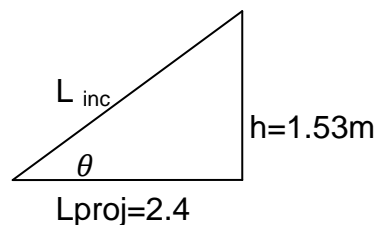
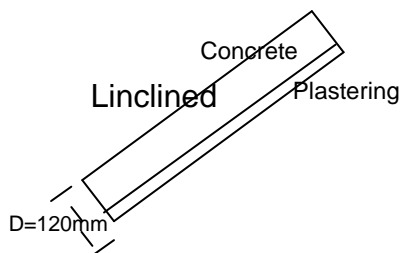
$$= \frac{9(0.17\text{m} * 0.03\text{m} * 27\text{KN/m}^3)}{2.4}$$

$$= 0.52 \text{ KN/m}$$

Therefore D.L of riser (17cm) = 0.293 KN/m + 0.52 KN/m

$$= 0.813 \text{ KN/m}$$

- Waist Dead Load



$$\tan \theta = 1.53/2.4$$

$$\theta = \tan^{-1}\left(\frac{1.53}{2.4}\right)$$

$$= 32.52^\circ$$

$$\sin \theta = 1.53/L_{inc}$$

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$$L_{inc} = 1.53 / \sin \theta = 1.53 \text{ m} / \sin 32.52^\circ$$

$$= 2.85 \text{ m}$$

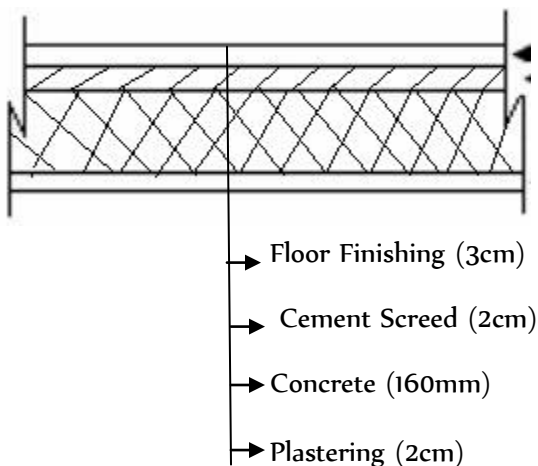
- D.L of concrete = $\frac{D * L_{inc} * \gamma_{conc}}{L_{projected}} = \frac{0.12 \text{ m} * 2.85 \text{ m} * 24 \text{ KN/m}^3}{2.4 \text{ m}}$
 $= 3.42 \text{ KN/m}$

- D.L of Plastering = $\frac{t_{pl} * L_{inc} * \gamma_{pl}}{L_{projected}} = \frac{0.02 \text{ m} * 2.85 \text{ m} * 23 \text{ KN/m}^3}{2.4 \text{ m}}$
 $= 0.55 \text{ KN/m}$

Therefore D.L of waist = $3.42 \text{ KN/m} + 0.55 \text{ KN/m}$

$$= 3.97 \text{ KN/m}$$

Landing Dead Load



- D.L of landing = D.L of finishing + D.L of cement screed + D.L of concrete + D.L of plastering

$$= t_{fin} * \gamma_{fin} + t_{cs} * \gamma_{cs} + t_c * \gamma_c + t_{pl} * \gamma_{pl}$$

$$= 0.03 \text{ m} * 27 \text{ KN/m}^3 + 0.02 * 23 \text{ KN/m}^3 + 0.12 \text{ m} * 24 \text{ KN/m}^3 + 0.02 \text{ m} * 23 \text{ KN/m}^3$$

$$g = 4.61 \text{ KN/m}$$

Therefore D.L of Landing = 4.61 KN/m

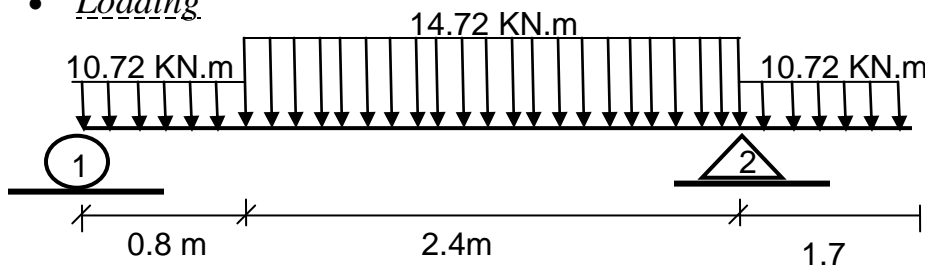
- Total Dead Load and design load

G+4 Residential building project

- *For the inclined slab*
 - Total D.L=D.L of Step+D.L of riser+D.L of waist
 $=3.31 \text{ KN/m}+0.293 \text{ KN/m}+3.97 \text{ KN/m}$
 $=7.573 \text{ KN/m}$
 - Live load= $5 \text{ KN/m}^2*1\text{m}=3\text{KN/m}$
 - Design Load, $p_d=1.35 \text{ D.L} + 1.5\text{L.L}$
 $=1.35*7.573 \text{ KN/m} + 1.5*3\text{KN/m}$
 $=14.72\text{KN/m}$

- *For the landing*
 - D.L= 4.61 KN/m
 - L.L= $5 \text{ KN/m}^2 * 1\text{m}=3\text{KN/m}$
 - Design load, $p_d=1.35 \text{ D.L} + 1.5 \text{ L.L}$
 $=1.35*4.61\text{KN/m} + 1.5*3 \text{ KN/m}$
 $=10.72 \text{ KN/m}$

- Loading.



4.2 Moment Analysis

$$\sum M \text{ at } 1=0$$

$$14.72*2.4\text{m}*(0.8+2.4/2)+10.72*1.7*(3.2+1.7/2)-R_2*3.2\text{m}+10.72*(0.8)*0.8/2=0$$

$$3.43+73.81+70.66=R_2*3.2$$

$$3.2R_2=147.9 \text{ KN.m}$$

$$R_2=46.22 \text{ KN}$$

$$\sum F_y=0 (\downarrow)$$

$$R_1+R_2=10.72 \text{ KN/m}*0.8 \text{ m}+14.72 \text{ KN/m}*2.4 \text{ m}+10.72 \text{ KN/m}*1.7\text{m}$$

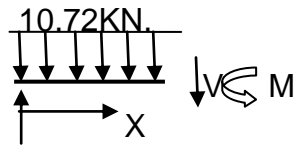
$$R_1=62.13 \text{ KN}-46.22 \text{ KN}$$

$$R_1=15.91\text{KN}$$

G+4 Residential building project

Analyzing using the method of section,

- For $Z=0$, to $Z=0.4\text{m}$ (Z in measured from support 1)



$$15.91\text{K}$$

$$M(x) + 10.72 \text{ KN/m} \cdot x + \frac{x^2}{2} = 15.91x$$

$$M(x) = 15.91x - 5.36x^2$$

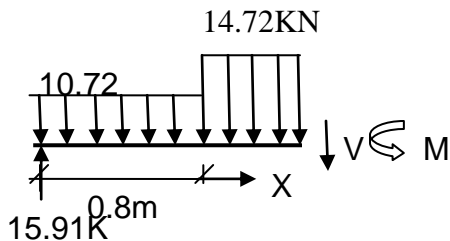
- At $Z=0$, $X=0$

$$M(0) = 0$$

- At $Z=0.8$, $x=0.8$

$$M(0.8) = 9.3 \text{ KN.m}$$

- For $Z=0.8$ to $Z=3.2\text{m}$



$$M(x) + 14.72 \text{ KN/m} \cdot \frac{x^2}{2} + 10.72 \text{ KN/m} \cdot 0.8 \text{ m} \cdot \left(\frac{x+0.8}{2}\right) = 15.91 \text{ KN} (x+0.8)$$

$$M(x) = -7.36x^2 + 7.33x + 9.3$$

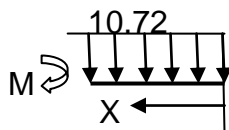
$$\text{At } Z=0.8\text{m}, x=0$$

$$M(0) = 9.3 \text{ KN.m}$$

$$\text{At } Z=3.2\text{m}, X=2.4\text{m}$$

$$M(2.4) = -15.5 \text{ KN.m}$$

- For $Z=3.2$ to $Z=4.9\text{m}$



$$M(x) = -10.72 \frac{x^2}{2}$$

$$= -5.36x^2$$

$$\text{At } Z=4.9\text{m}, x=0$$

$$M(0)=0$$

$$\text{At } Z=3.2\text{m, } x=1.7\text{m}$$

$$M(1.7)= -15.5\text{KN.m}$$

- M_{\max} (+ve) is b/n $Z=0.8$ to $Z=3.2$
 $M(x) = -7.36x^2 + 7.33x + 9.3$
 M is max at $V=0$, $dM(x)/dx=0$
 $dM(x)/dx = d/dx(-7.36x^2 + 7.33x + 9.3) = 0$
 $= -10.72x + 7.33 = 0$, $x = 0.69\text{m}$, $Z = 0.69\text{m}$
 $M(0.69\text{m}) = 10.85\text{KN.m}$

Shear Force computation

$$V(x) = dM(x)/dx$$

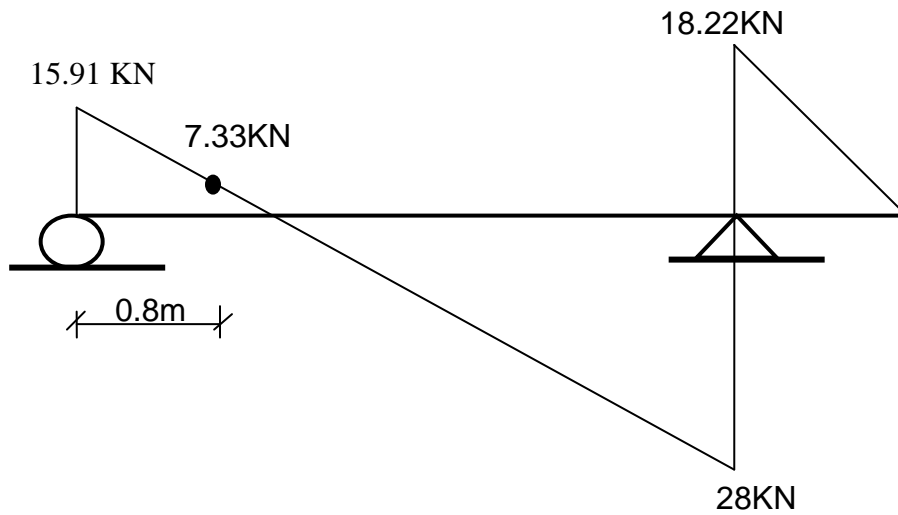
- For $Z=0$ to $Z=0.8\text{m}$
 $M(x) = 15.91x - 5.36x^2$
 $dM(x)/dx = V(x) = -10.72x + 15.91$
at $Z=0$, $x=0$
 $V(0) = 15.91 \text{ KN}$
At $Z=0.8\text{m}$, $x=0.8\text{m}$
 $V(0.8) = 7.33 \text{ KN}$
- For $Z=0.8\text{m}$ to $Z=3.2\text{m}$
 $M(x) = -7.36x^2 + 7.33x + 9.3$
 $dM(x)/dx = V(x) = -14.72x + 7.33$
at $Z=0.8\text{m}$, $x=0$
 $V(0) = 7.33 \text{ KN}$
At $Z=3.2\text{m}$, $x=2.4\text{m}$
▼ $V(3.36) = -28\text{KN}$
- For $Z=3.2\text{m}$ to $Z=4.9\text{m}$
 $M(x) = -5.36x^2$
 $dM(x)/dx = -10.72x$

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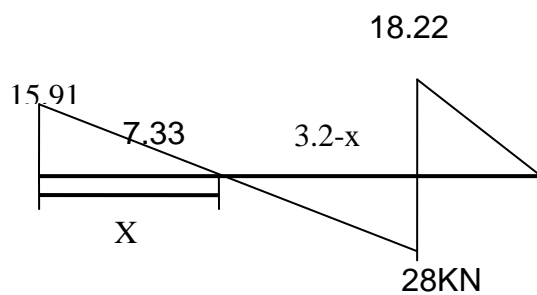
at $Z=3.2\text{m}$, $x=1.7\text{m}$

$$\downarrow V(1.7) = -18.22 \text{ KN}$$

Shear Force Diagram



Bending Moment Diagram



$$\frac{15.91}{x} = \frac{28}{3.2-x}$$

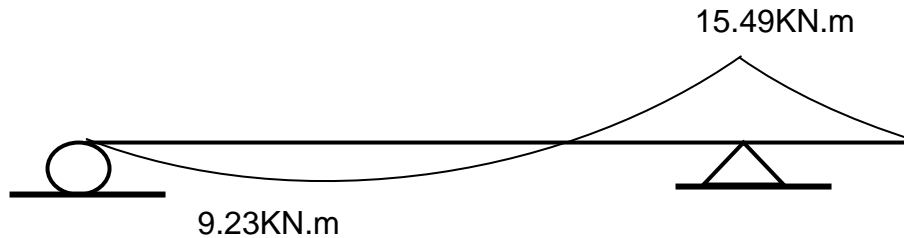
$$15.91(3.2-x) = 28x$$

$$50.91 - 15.91x = 28x$$

$$X = \underline{1.16}$$

$$\frac{1}{2} * 15.91 * 1.16 = 9.23$$

Bending Moment Diagram



Check depth for flexure

$$\text{Cubic strength (f}_{cu}\text{)} = 25 \quad \gamma_s = 1.15$$

$$\epsilon_{cu} = 3.5 \quad \gamma_c = 1.5$$

$$b = 1000 \quad \text{S-400}$$

$$F_{ck} = 0.85 * F_{ck} / 1.25 = 25 / 1.25 = 20 \text{ Mpa}$$

$$F_{cd} = 0.85 * F_{ck} / \gamma_c = 0.85 * 20 \text{ Mpa} / 1.5 = 11.33 \text{ Mpa}$$

$$F_{yd} = s / \gamma_s = 400 / 1.15 = 347.83 \text{ Mpa}$$

$$m = \frac{f_{yd}}{0.8 * f_{cd}} = \frac{347.83 \text{ Mpa}}{0.8 * 11.33} = 38.36$$

$$C1 = \frac{2.5}{m} = \frac{2.5}{38.36} = 0.0652$$

$$C2 = 0.32 * m^2 * f_{cd} = 0.32 * 38.36^2 * 11.33 = 5337$$

$$\rho_b = (((0.8 * \epsilon_{cu}) / (\epsilon_{cu} + f_{yd}(200)))) * (F_{cd} * F_{yd})$$

$$= (((0.8 * 3.5) / (3.5 + 347.83))) * (11.33 * 347.83)$$

$$= 0.01741 \text{ Mpa}$$

$$\rho_{max} = 0.75 * \rho_b = 0.75 * 0.01741$$

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$$= 0.01306$$

$$M_{\max} = 15.49$$

$$d = \sqrt{\frac{M_{\max}}{(0.8bfcd\rho_{\max}m(1 - (0.4m\rho_{\max})))}}$$

$$d = 65.3$$

4.3 Reinforcement

Material Data, C-25,

S-400

Effective depth, $d=98\text{mm}$

Width, $b_s=1000\text{mm}$

Using $M = 15.49\text{KN/m}$, calculate reinforcement,

$$\mu_{sd} = \frac{M}{fcd * b * d^2} = \frac{15.49 * 10^6}{11.33 * 1000 * 98^2} = 0.142$$

using $\mu_{sd} = 0.142$

$$K_z = 0.91$$

$$Z = K_z * d = 0.91 * 98 = 89.2\text{mm}$$

$$A_s = \frac{M}{(f_y d * z)}$$

$$A_s = \frac{15.49 * 10^6}{(89.2 * 347.82)}$$

$$= 499.3\text{mm}^2$$

To calculate spacing by selecting diameter of bar as

$$S = \frac{1000a_s}{A_s} \text{ where: } a_s = \text{area of single bar} = \frac{3.14 * 14^2}{4} = 153.9\text{mm}^2$$

A_s = calculated area of steel

S = spacing

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$$S = 1000 * 153.9 / 499.3 = 308.23 \approx 300 \text{mm}$$

Compare the above result with minimum provision given by our code.

$$A_{smin} = 0.26 * 2.2 \text{Mpa} / 400 \text{Mpa} * 1000 \text{mm} * 98 \text{mm}$$

$$= 140.14 \text{mm}^2$$

With $d = 120 - 15 - 7 = 98 \text{mm}$, for $\phi 14$ main rebar

$$A_{smin} = 140.14 \text{mm}^2 < A_{scal} = 499.3 \text{mm}^2 \text{ ok}$$

$$s_{max} \leq \begin{cases} 2D & 400 \text{mm} \\ 400 \text{mm} \\ S_{calc} & = 300 \text{mm} \end{cases}$$

$$S_{max} = 240 \text{mm}$$

Provide $\phi 14$ c/c 240mm

$$A_{sprovided} = 1000 * 153.9 / 240 = 641.3 \text{mm}^2$$

B) Transverse reinforcement

According to Eurocode 2 Part 1,1 - prEN 1992-1-1-2002 Section 9.3.1.1 the ratio of secondary to the main reinforcement shall be at least equal to 20% of the main reinforcement

$$A_s \geq 20\% A_s,$$

$$A_s \geq 0.2 * 499.3 = 99.86 \text{mm}^2 < A_{smin}$$

Therefore take the minimum reinforcement

Using $\phi 8$ main transverse rebar

$$S = b a_s / A_s = 1000 * 50.26 / 99.86 = 503.3 \text{mm}$$

$$S_{max} = \begin{cases} 2D & = 2 * 120 = 240 \\ 400 \\ S_{calc} & = 503.3 \end{cases}$$

$$S_{max} = 240$$

G+4 Residential building project

5.1 WIND LOAD ANALYSIS

This calculation presents the automatically generated lateral wind loads for load pattern WLX according to EUROCODE1 2005, as calculated by ETABS.

Exposure Parameters

Exposure From = Diaphragms

Terrain Category = IV

Wind Direction = 0;90 degrees

Basic Wind Velocity, V_b [EC 4.2(2)] $V_b = 22 \frac{\text{meter}}{\text{sec}}$

Windward Coefficient, $C_{p,\text{wind}}$ $C_{p,\text{wind}} = 0.8$

Leeward Coefficient, $C_{p,\text{lee}}$ $C_{p,\text{lee}} = 0.5$

Air Density, ρ $\rho = 1.25$

Top Story = ROOF

Bottom Story = Base

Include Parapet = No

Factors and Coefficients

Structural Factor, $c_s c_d$ $c_s c_d = 0.85$

Elevation, z_0 $z_0 = 1$

Minimum Elevation, z_{min} $z_{\text{min}} = 10$

Maximum Elevation, z_{max} $z_{\text{max}} = 200$

Turbulence Factor, k_1 [EC 4.4(1)] $k_1 = 1$

Orography Factor, c_o [EC 4.3.3] $c_o = 1$

Turbulence Intensity, I_v [EC 4.4(1)] $I_v = \frac{k_1}{c_o(z) \ln\left(\frac{z}{z_0}\right)}$ for $z_{\text{min}} \leq z \leq z_{\text{max}}$
 $= I_v(z_{\text{min}})$ for $z < z_{\text{min}}$

Terrain Factor, k_r [EC 4.3.2(1) Eq. 4.5] $k_r = 0.19 \left(\frac{z_0}{0.05}\right)^{0.2}$ $k_r = 0.234329$

Roughness Factor, $c_r(z)$ [EC 4.3.2(1) Eq. 4.4] $c_r(z) = k_r \ln\left(\frac{z}{z_0}\right)$ for $z_{\text{min}} \leq z \leq z_{\text{max}}$

G+4 Residential building project

$$= c_r(z_{\min}) \text{ for } z_{\min}$$

Lateral Loading

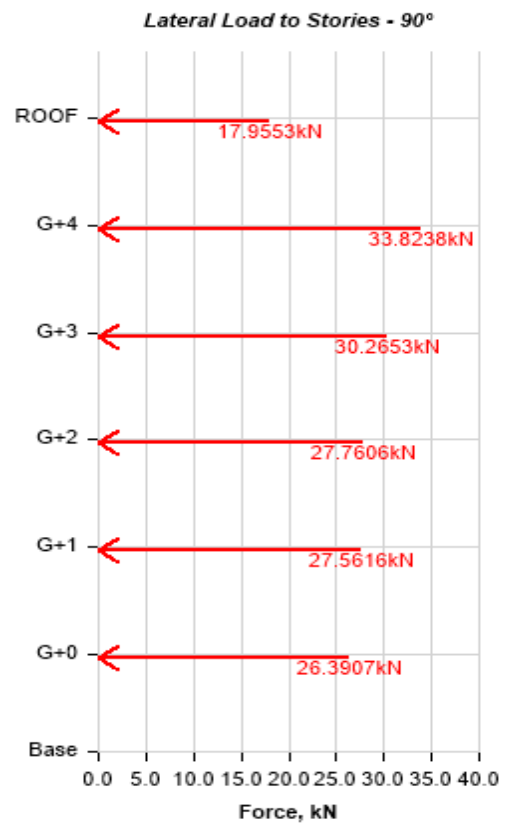
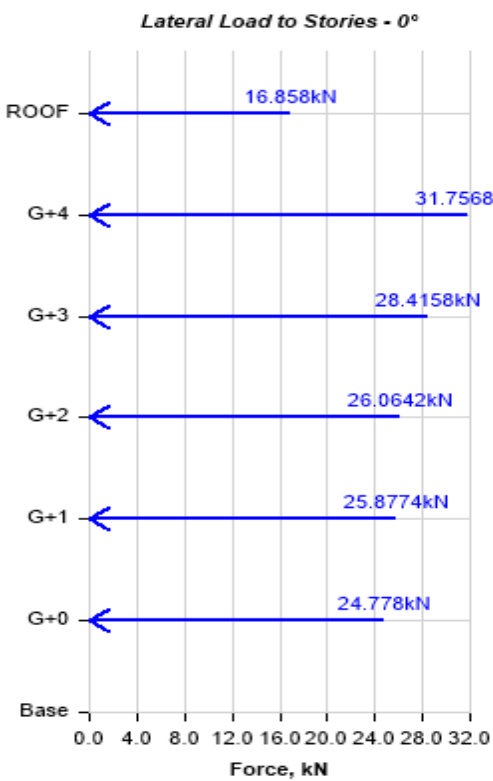
Peak Velocity Pressure, $\langle q_{p>(z)} \rangle$ [EC 4.5(1) Eq. 4.8]

$$q_p(z) = [1 + 7I_v(z)] \frac{1}{2} \rho [c_r(z)c_o(z)v_b]^2$$

Wind Pressure, w [EC 5.2(1) Eq. 5.1]

$$w = q_p(z)c_s c_d (c_{p,\text{wind}} + c_{p,\text{lee}})$$

Applied Story Forces



G+4 Residential building project

Story	Elevation	X-Dir	Y-Dir
	M	kN	kN
ROOF	18.1	16.858	0
G+4	15.04	31.7568	0
G+3	11.98	28.4158	0
G+2	8.92	26.0642	0
G+1	5.86	25.8774	0
G+0	2.8	24.778	0
Base	0	0	0

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
ROOF	18.1	0	17.9553
G+4	15.04	0	33.8238
G+3	11.98	0	30.2653
G+2	8.92	0	27.7606
G+1	5.86	0	27.5616
G+0	2.8	0	26.3907
Base	0	0	0

EUROCODE1 2005 Auto Wind Load Calculation

This calculation presents the automatically generated lateral wind loads for load pattern WLY according to EUROCODE1 2005, as calculated by ETABS.

Exposure Parameters

Exposure From = Diaphragms

Terrain Category = IV

Wind Direction = 0 degrees

Basic Wind Velocity, V_b [EC 4.2(2)]

$$V_b = 22 \frac{\text{meter}}{\text{sec}}$$

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Windward Coefficient, $C_{p,wind}$

$$C_{p,wind} = 0.8$$

Leeward Coefficient, $C_{p,lee}$

$$C_{p,lee} = 0.5$$

Air Density, ρ

$$\rho = 1.25$$

Top Story = ROOF

Bottom Story = Base

Include Parapet = No

Factors and Coefficients

Structural Factor, $c_s < c_d$ [EC 6.2(1)]

$$c_s c_d = 0.85$$

Elevation, z_0

$$z_0 = 0.3$$

Minimum Elevation, z_{min}

$$z_{min} = 5$$

Maximum Elevation, z_{max}

$$z_{max} = 200$$

Turbulence Factor, k_1 [EC 4.4(1)]

$$k_1 = 1$$

Orography Factor, c_o [EC 4.3.3]

$$c_o = 1$$

Turbulence Intensity, I_v [EC 4.4(1)]
$$I_v = \frac{k_1}{c_o(z) \ln\left(\frac{z}{z_0}\right)} \text{ for } z_{min} \leq z \leq z_{max}$$

$$= I_v(z_{min}) \text{ for } z \leq z_{min}$$

Terrain Factor, k_r [EC 4.3.2(1) Eq. 4.5] $k_r = 0.19 \left(\frac{z_0}{0.05}\right)^{0.05}$ $k_r = 0.215389$

Roughness Factor, $c_r(z)$ [EC 4.3.2(1) Eq. 4.4]
$$c_r(z) = k_r \ln\left(\frac{z}{z_0}\right) \text{ for } z_{min} \leq z \leq z_{max}$$

$$= c_r(z_{min}) \text{ for } z \leq z_{min}$$

Lateral Loading

G+4 Residential building project

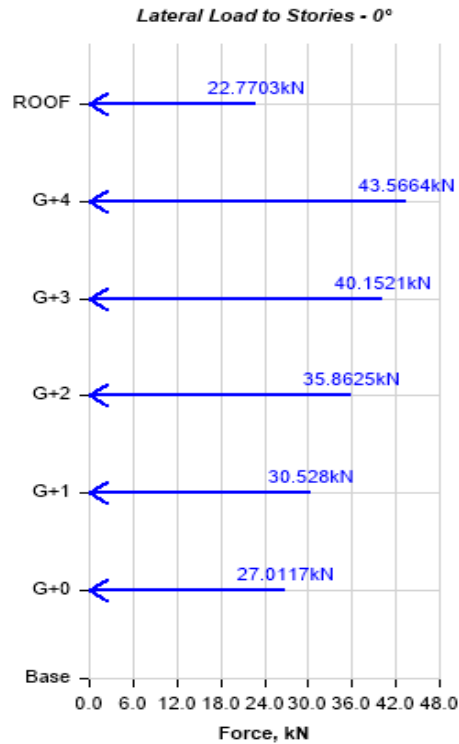
Peak Velocity Pressure, $\langle q_{p(z)} \rangle$ [EC 4.5(1) Eq. 4.8]

$$q_p(z) = [1 + 7I_v(z)] \frac{1}{2} \rho [c_r(z)c_o(z)v_b]^2$$

Wind Pressure, w [EC 5.2(1) Eq. 5.1]

$$w = q_p(z)c_s c_d (c_{p,wind} + c_{p,lee})$$

Applied Story Forces



Story	Elevation	X-Dir	Y Dir
	m	Kn	kN
ROOF	18.1	22.7703	0
G+4	15.04	43.5664	0
G+3	11.98	40.1521	0

G+4 Residential building project

G 2	8.9	35.8625	0
G+1	5.86	30.528	0
G+0	2.8	27.0117	0
Base	0	0	0

G+4 Residential building project

5.2 EARTHQUAKE ANALYSIS

This calculation presents the automatically generated lateral seismic loads for load pattern EQXL according to EUROCODE8 2004, as calculated by ETABS.

Direction and Eccentricity

Direction = X - Eccentricity Y

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Program Calculated

Coefficient, C_t [EC 4.3.3.2.2] $C_t = 0.075m$

Structure Height Above Base, H $H = 18.1 m$

Factors and Coefficients

Country = Other

Design Ground Acceleration, a_g $a_g = 0.07g$

Ground Type [EC Table 3.1] = D

Soil Factor, S [EC Table 3.3] $S = 0$

Constant Acceleration Period Limit, T_B [EC Table 3.3] $T_B = 0.15 \text{ sec}$

Constant Acceleration Period Limit, T_C [EC Table 3.3] $T_C = 0.5 \text{ sec}$

Constant Displacement Period Limit, T_D [EC Table 3.3] $T_D = 2 \text{ sec}$

Lower Bound Factor, β [EC 3.2.2.5(4)] $\beta_0 = 0$

Behavior Factor, q [EC 3.2.2.5(3)] $q = 4.9$

G+4 Residential building project

Seismic Response

Spectral Response Acceleration, $S_d(T_1)$ [EC 3.2.2.5(4) $S_d(T_1) = a_g S \left[\frac{2}{3} + \frac{T}{T_B} \left(\frac{2.5}{q} - \frac{2}{3} \right) \right]$ for $T \leq T_B$
Eq. 3.13]

$$= a_g S \frac{2.5}{q} \text{ for } T_B \leq T \leq T_C$$

$$= a_g S \frac{2.5}{q} \left[\frac{T_C}{T} \right] \geq \beta a_g \text{ for } T_C \leq T \leq T_D$$

$$= a_g S \frac{2.5}{q} \left[\frac{T_C T_D}{T^2} \right] \geq \beta a_g \text{ for } T_D \leq T$$

Equivalent Lateral Forces

Seismic Base Shear Coefficient

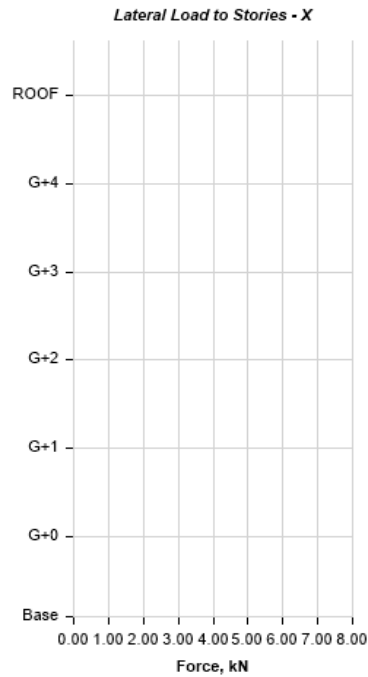
$$V_{coeff} = S_d(T_1) \lambda$$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	F_b (kN)
X - Ecc.	0.898	21049.52	0
Y		3	

G+4 Residential building project

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	M	kN	kN
ROOF	18.1	0	0
G+4	15.04	0	0
G+3	11.98	0	0
G+2	8.92	0	0
G+1	5.86	0	0
G+0	2.8	0	0

G+4 Residential building project

Base	0	0	0
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This calculation presents the automatically generated lateral seismic loads for load pattern EQXR according to EUROCODE8 2004, as calculated by ETABS.

Direction and Eccentricity

Direction = X + Eccentricity Y

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Program Calculated

Coefficient, C_t [EC 4.3.3.2.2] $C_t = 0.075m$

Structure Height Above Base, H $H = 18.1 m$

Factors and Coefficients

Country = Other

Design Ground Acceleration, a_g $a_g = 0.07g$

Ground Type [EC Table 3.1] = D

Soil Factor, S [EC Table 3.3] $S = 1.35$

Constant Acceleration Period Limit, T_B [EC Table 3.3] $T_B = 0.15 sec$

Constant Acceleration Period Limit, T_C [EC Table 3.3] $T_C = 0.5 sec$

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Constant Displacement Period Limit, T_D [EC Table 3.3] $T_D = 2 \text{ sec}$

Lower Bound Factor, β [EC 3.2.2.5(4)] $\beta_0 = 0.2$

Behavior Factor, q [EC 3.2.2.5(3)] $q = 4.9$

Seismic Response

Spectral Response Acceleration, $S_d(T_1)$ [EC 3.2.2.5(4)] $S_d(T_1) = a_g S \left[\frac{2}{3} + \frac{T}{T_B} \left(\frac{2.5}{q} - \frac{2}{3} \right) \right]$ for $T \leq T_B$

$$= a_g S \frac{2.5}{q} \text{ for } T_B \leq T \leq T_C$$

$$= a_g S \frac{2.5}{q} \left[\frac{T_C}{T} \right] \geq \beta a_g \text{ for } T_C \leq T \leq T_D$$

$$= a_g S \frac{2.5}{q} \left[\frac{T_C T_D}{T^2} \right] \geq \beta a_g \text{ for } T_D \leq T$$

Equivalent Lateral Forces

Seismic Base Shear Coefficient

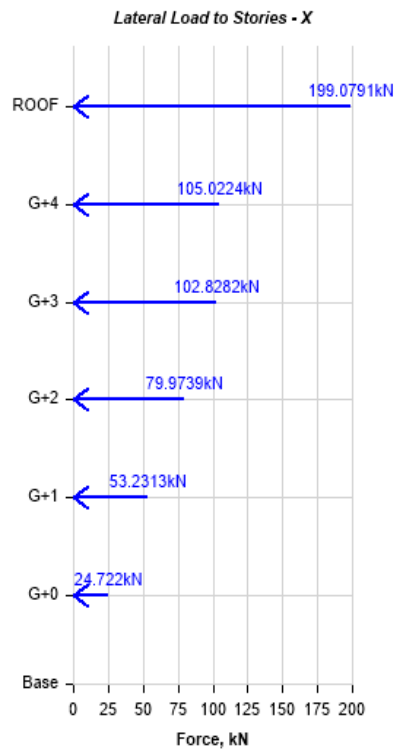
$$V_{\text{coeff}} = S_d(T_1) \lambda$$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	F_b (kN)
X + Ecc.	0.898	21049.52	564.856
Y		3	8

G+4 Residential building project

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	M	kN	kN
ROOF	18.1	199.07 91	0
G+4	15.04	105.02 24	0
G+3	11.98	102.82 82	0
G+2	8.92	79.973	0

G+4 Residential building project

		9	
G+1	5.86	53.231 3	0
G+0	2.8	24.722	0
Base	0	0	0

This calculation presents the automatically generated lateral seismic loads for load pattern EQYR according to EUROCODE8 2004, as calculated by ETABS.

Direction and Eccentricity

Direction = Y + Eccentricity X

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Program Calculated

Coefficient, C_t [EC 4.3.3.2.2] $C_t = 0.075m$

Structure Height Above Base, H $H = 18.1 m$

Factors and Coefficients

Country = Other

Design Ground Acceleration, a_g $a_g = 0.07g$

Ground Type [EC Table 3.1] = B

Soil Factor, S [EC Table 3.3] $S = 0$

Constant Acceleration Period Limit, T_B [EC Table 3.3] $T_B = 0.15 sec$

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Constant Acceleration Period Limit, T_C [EC Table 3.3] $T_C = 0.5 \text{ sec}$

Constant Displacement Period Limit, T_D [EC Table 3.3] $T_D = 2 \text{ sec}$

Lower Bound Factor, β [EC 3.2.2.5(4)] $\beta_0 = 0$

Behavior Factor, q [EC 3.2.2.5(3)] $q = 4.9$

Seismic Response

Spectral Response Acceleration, $S_d(T_1)$ [EC 3.2.2.5(4)] $S_d(T_1) = a_g S \left[\frac{2}{3} + \frac{T}{T_B} \left(\frac{2.5}{q} - \frac{2}{3} \right) \right]$ for $T \leq T_B$
Eq. 3.13]

$$= a_g S \frac{2.5}{q} \text{ for } T_B \leq T \leq T_C$$

$$= a_g S \frac{2.5}{q} \left[\frac{T_C}{T} \right] \geq \beta a_g \text{ for } T_C \leq T \leq T_D$$

$$= a_g S \frac{2.5}{q} \left[\frac{T_C T_D}{T^2} \right] \geq \beta a_g \text{ for } T_D \leq T$$

Equivalent Lateral Forces

Seismic Base Shear Coefficient

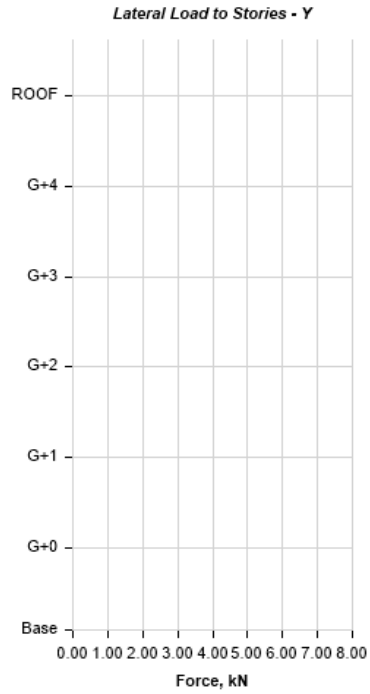
$$V_{\text{coeff}} = S_d(T_1) \lambda$$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	F_b (kN)
Y + Ecc. X	0.837	21049.52 3	0

G+4 Residential building project

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
ROOF	18.1	0	0
G+4	15.04	0	0
G+3	11.98	0	0
G+2	8.92	0	0
G+1	5.86	0	0
G+0	2.8	0	0

G+4 Residential building project

Base	0	0	0
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This calculation presents the automatically generated lateral seismic loads for load pattern EQYL according to EUROCODE8 2004, as calculated by ETABS.

Direction and Eccentricity

Direction = Y - Eccentricity X

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Program Calculated

Coefficient, C_t [EC 4.3.3.2.2] $C_t = 0.075m$

Structure Height Above Base, H $H = 18.1 m$

Factors and Coefficients

Country = Other

Design Ground Acceleration, a_g $a_g = 0.07g$

Ground Type [EC Table 3.1] = D

Soil Factor, S [EC Table 3.3] $S = 1.35$

Constant Acceleration Period Limit, T_B [EC Table 3.3] $T_B = 0.15 \text{ sec}$

Constant Acceleration Period Limit, T_C [EC Table 3.3] $T_C = 0.5 \text{ sec}$

Constant Displacement Period Limit, T_D [EC Table 3.3] $T_D = 2 \text{ sec}$

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Lower Bound Factor, β [EC 3.2.2.5(4)] $\beta_0 = 0.2$

Behavior Factor, q [EC 3.2.2.5(3)] $q = 4.9$

Seismic Response

Spectral Response Acceleration, $S_d(T_1)$ [EC 3.2.2.5(4) Eq. 3.13] $S_d(T_1) = a_g S \left[\frac{2}{3} + \frac{T}{T_B} \left(\frac{2.5}{q} - \frac{2}{3} \right) \right]$ for $T \leq T_B$

$$= a_g S \frac{2.5}{q} \text{ for } T_B \leq T \leq T_C$$

$$= a_g S \frac{2.5}{q} \left[\frac{T_C}{T} \right] \geq \beta a_g \text{ for } T_C \leq T \leq T_D$$

$$= a_g S \frac{2.5}{q} \left[\frac{T_C T_D}{T^2} \right] \geq \beta a_g \text{ for } T_D \leq T$$

Equivalent Lateral Forces

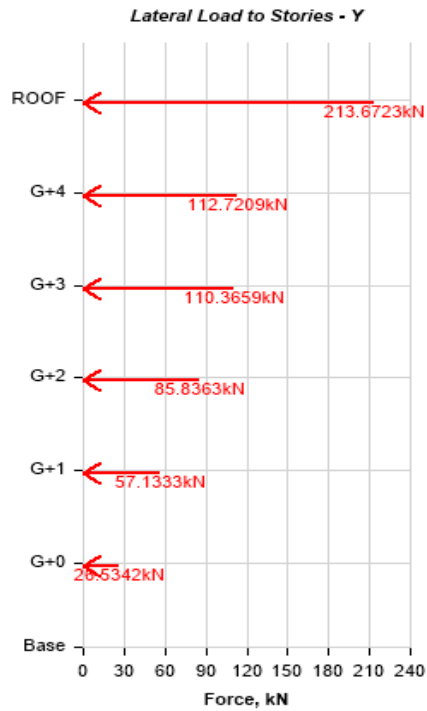
Seismic Base Shear Coefficient $V_{coeff} = S_d(T_1) \lambda$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	F _b (kN)
Y - Ecc.	0.837	21049.52	606.263
X		3	

G+4 Residential building project

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
ROOF	18.1	0	213.67 23
G+4	15.04	0	112.72 09
G+3	11.98	0	110.36 59
G+2	8.92	0	85.836

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			3
G+1	5.86	0	57.133 3
G+0	2.8	0	26.534 2
Base	0	0	0

5.2.1 Center of mass

The horizontal forces at each floor level, F_i , are distributed to lateral load resistive structural elements in proportion to their rigidities assuming rigid floor diaphragms.

Center of mass (X_m, Y_m): it is a point on a floor level where the whole floor mass.

Table 24 Centers of Mass and Rigidity

Story	Diaphragm	Mass X kg	Mass Y kg	XCM m	YCM m	Cumulative X Kg	Cumulative Y kg	XCCM m	YCCM m	XCR m	YCR m
ROOF	D1	441744.42	441744	11.7422	10.3611	441744.4	441744.42	11.7422	10.3611		
G+4	D1	280451.72	280452	11.7154	10.5326	722196.1	722196.13	11.7318	10.4277		
G+3	D1	344730.38	344730	11.6979	10.7784	1066927	1066926.5	11.7208	10.541		
G+2	D1	360087.01	360087	11.69	10.8093	1427014	1427013.5	11.713	10.6087		
G+1	D1	362040.28	362040	11.6855	10.8369	1789054	1789053.8	11.7075	10.6549		

6.FRAME ANALYSIS

6.1. MODELING FOR 3D FRAME ANALYSIS USING ETABS V.2016.

Step 1: Plot Grid Coordinates - Plot Grid Coordinates that represent the given structural design.

Step 2: Define Material - We define material those are C-25 Concrete and S-400 Rebar with their material Properties.

Therefore, we used ETABS software V.2016.

6.1.1. Material specification to input Etabs

C-25: -Material type: concrete:

Symmetry type: Isotropic

Modulus of Elasticity: 29E3 Mpa

Poisson's ratio: 0.2

Modulus (G):10356491

Coeff. Thermal Expansion: 9.9E-06

Unit Weight:25 KN/m³

S-400: - Material type: Rebar:

Unit Weight: 77 KN/m³.

Modulus of Elasticity: 200E+09

Poisson's ratio: 0.3

Shear Modulus (G):76903069

Coeff. Thermal Expansion: 1.17E-05

Minimum Yield Stress, Fy: 440 Mpa

Minimum Tensile Stress, Fu: 400.000 Mpa

Directional Symmetry type: uniaxial

Step 3: Define Frame Section - We define three types of Frame Section those are

Square Column (40x40 cm), Beam (40*30cm) and top tie beam (30*25cm)

These frame section has the C-25 material and S-400 rebar defined in step 1.

Step 4: Draw the different Structural Members

Using the grid System Draw the structural Members with their Defined Frame Section Properties.

It includes assignment of Restraints (fixed Joint)

Step 5: Assign Loads

First, Introduce Live Load on Definition of load Pattern then: -

We use Load Combination: Serviceability = D. L+L.L

Combo 1 = 1.35D. L+1.5L.L

Combo 2 = 0.75 (combo 1) + EQx1

Combo 3 = 0.75 (combo 1) + (-EQx1)

Combo 4 = 0.75 (combo 1) + EQx2

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$$\text{Combo 5} = 0.75 (\text{combo 1}) + (-\text{EQx2})$$

$$\text{Combo 6} = 0.75(\text{combo 1}) + \text{EQY1}$$

$$\text{Combo 7} = 0.75(\text{combo 1}) + (-\text{EQY1})$$

$$\text{Combo 8} = 0.75(\text{combo 1}) + \text{EQY2}$$

$$\text{Combo 9} = 0.75(\text{combo 1}) + (-\text{EQY2})$$

$$\text{Combo 10} = \text{DL} + \text{LL}$$

$$\text{Combo 11} = \text{Envelope (Combo 2 up to Combo 5)}$$

$$\text{Combo 12} = \text{Envelope (Combo 6 up to Combo 9)}$$

Where: -

DL and LL is dead load and live load of the building.

EQX is earth quick along X- axis

EQY is earth quick along Y- axis

Next we assigned F_i (Story shear) as a joint load on each frame Joint. Note that We analyzed the 3D frame separately for each earthquake coming from X and Y Direction. Finally, we imposed the un-factored distributed load transferred from slab and wall on the beam members.

Step 6: Analysis

After checking for errors we run the analysis.

Finally, as shown below we determined the moments for major and minor Axis and shear Force

6.1.2. ETABS Software Output

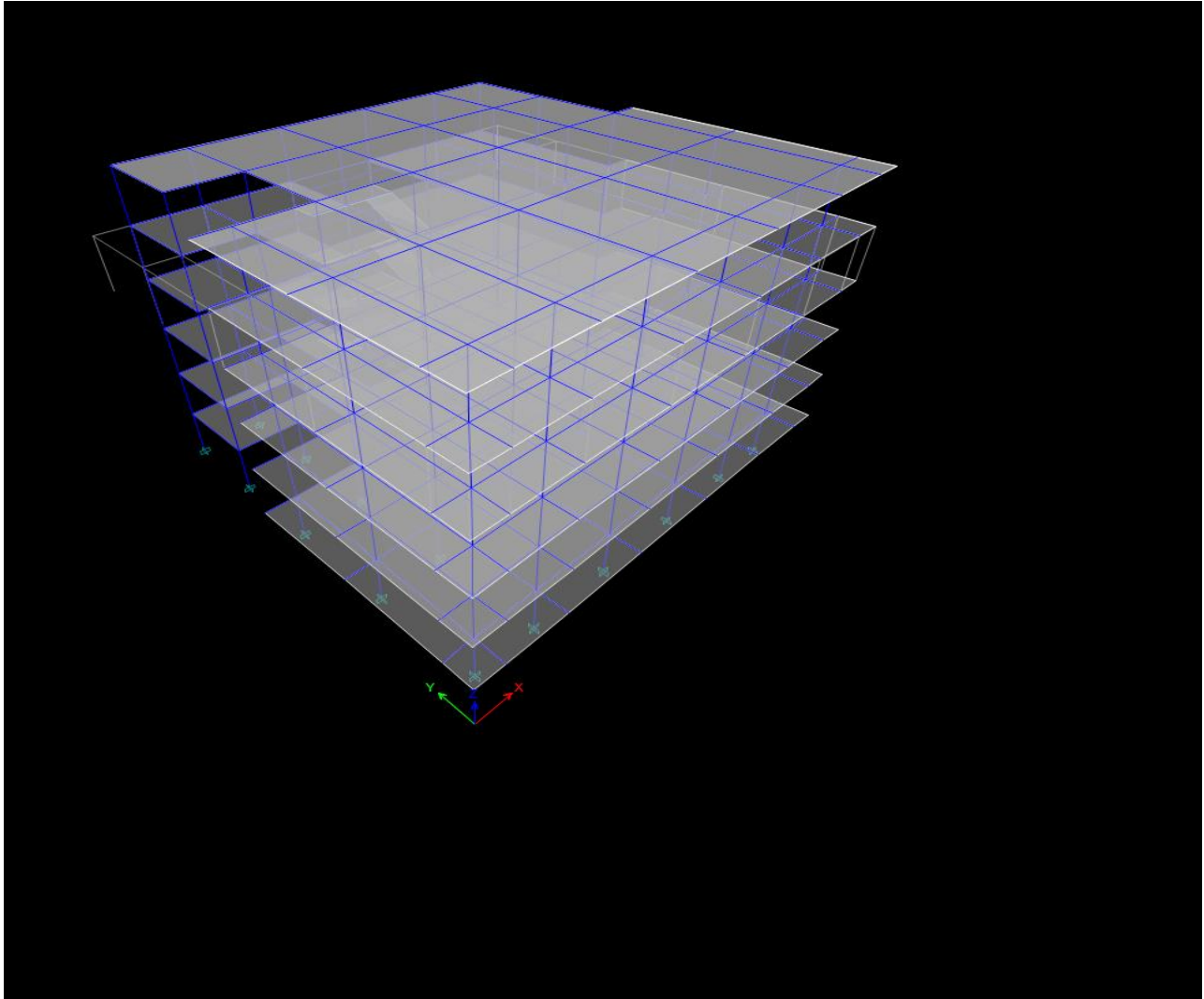


Figure 13 ETABS Software Output

- We took axis B as a sample from ETABS Analysis of frame

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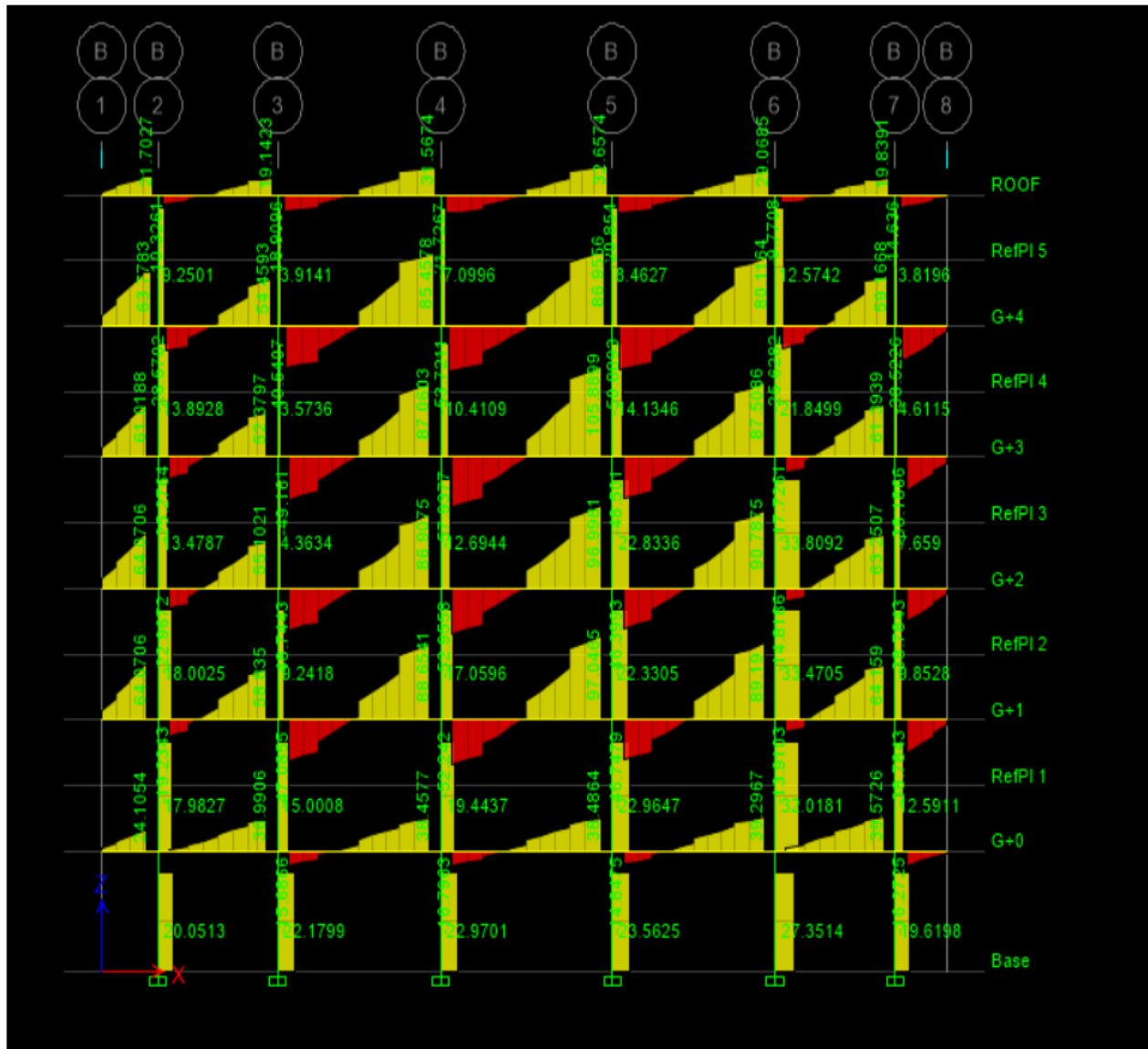


Figure 14 shear load diagram

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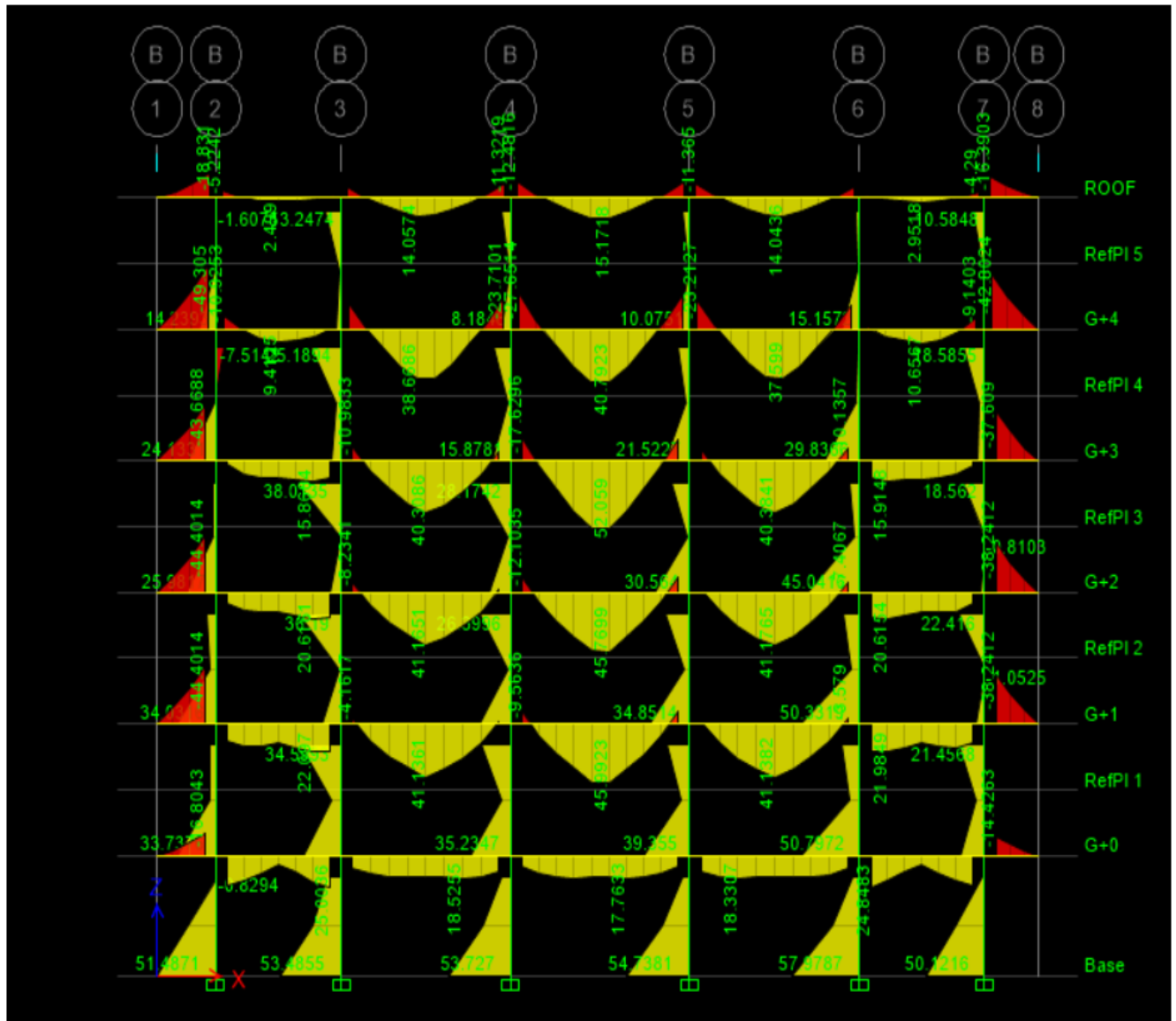


Figure 15 Bending moment diagram

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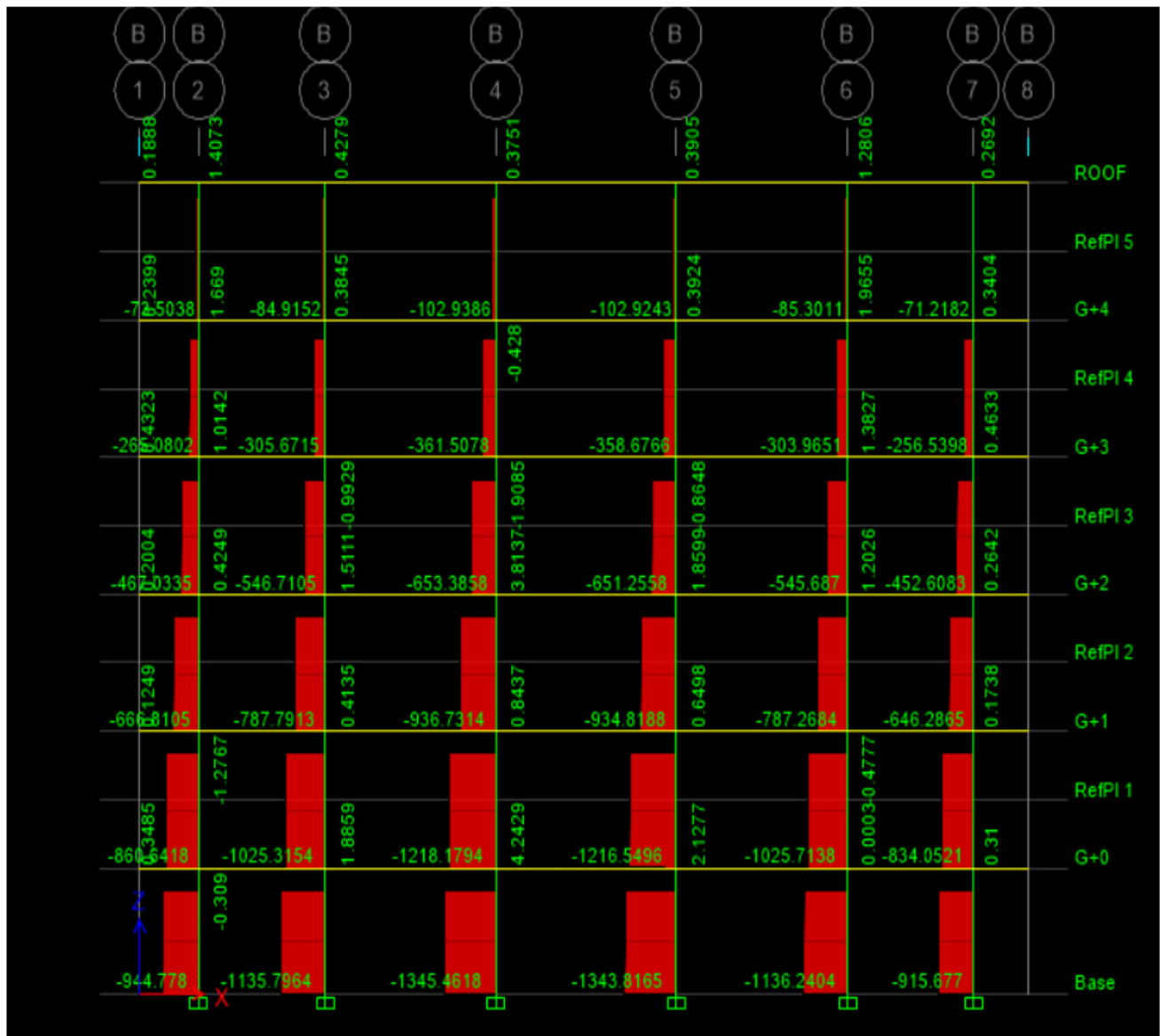


Figure 16 Axial force diagram

7. BEAM DESIGN

Beams are flexural members which are used to transfer the loads from slab to columns. Basically beams should be designed for flexure (moment). Furthermore, it is essential to check and design the beam sections for torsion and shear. Beams may be designed for flexural moment depending on the magnitude of the moment and the X- sectional dimensions. on the other hand, the beam can be singly reinforced, doubly reinforced section.

Types of beam

There are many types of beams that are classified according to different bases. Some of the bases for classification are:

- Based on support condition
- Based on geometry
- Based on equilibrium condition

Material data:

- Grade of concrete C-25
- Steel grade S-400
- Ø 16 bar
- Use concrete cover $C = 20\text{mm}$

Cross sections of beams are

- Top tie beam = $250\text{mm} \times 300\text{mm}$
- 1st floor beams ,2nd floor beams,3rd floor ,4th floor,5th-9th floor beams = $300 \times 400\text{mm}$
- Grade beam, = $500 \times 400\text{mm}$

Design constants

- Concrete Partial safety factor for concrete $\gamma_c = 1.5$
- $f_{cu} = 25 \text{ Mpa}$
- $f_{ck} = 0.8 \cdot f_{cu} = 0.8 \cdot 25 = 20 \text{ Mpa}$
- $f_{cd} = 0.85 \cdot f_{ck} / 1.5 = 0.85 \cdot 20 / 1.5 = 11.33 \text{ Mpa}$
- $f_{ctd} = 1.03 \text{ Mpa}$

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- Steel Partial safety factor for steel $\gamma_s = 1.15$
- $f_{yk} = 400 \text{ Mpa}$
- $f_{yd} = f_{yk}/1.15 = 400/1.15 = 347.82 \text{ Mpa}$

Therefore, we have taken $\Delta C_{dev} = 10 \text{ mm}$

$$C_{nom} = C_{min} + \Delta C_{dev} = 20 \text{ mm} + 10 \text{ mm} = 30 \text{ mm}$$

STEP 2: Check depth for deflection

$$l/d = K(11 + 1.5\sqrt{f_{ck}} * \rho_0/\rho + 3.2 * \sqrt{f_{ck}}(\rho_0/\rho - 1)^{3/2}) * F_1 * F_2 * F_3 \dots \text{if } \rho < \rho_0 \text{ art.7.4.2.(7.16a)}$$

$$l/d = K(11 + 1.5\sqrt{f_{ck}} * \rho_0/(\rho - \rho') + 1/12 * \sqrt{f_{ck}}\sqrt{(\rho_0/\rho)}) * F_1 * F_2 * F_3 \dots \text{if } \rho > \rho_0 \text{ art.7.4.2.(7.16b)}$$

Table 25 Basic ratios of span/effective depth for reinforced concrete members without

Structural System	K	Concrete highly stressed $\rho = 1.5\%$	Concrete lightly stressed $\rho = 0.5\%$
Simply supported beam, one – or twoway spanning simply supported slab	11	14	20
End span of continuous beam or oneway continuous slab or two-way spanning slab continuous over one long side	11.3	18	26
Interior span of beam or one-way or two-way spanning slab	11.5	20	30
Slab supported on columns without beams (flat slab) (based on longer span)	11.2	17	24
Cantilever	0.4	6	8

Note 1: The values given have been chosen to be generally conservative and calculation may frequently show that thinner members are possible.

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Note 2: For 2-way spanning slabs, the check should be carried out on the basis of the shorter span. For flat slabs the longer span should be taken.

Note 3: The limits given for flat slabs correspond to a less severe limitation than a mid-span deflection of span/250 relative to the columns. Experience has shown this to be satisfactory axial compression

Taking $L/d=26$ for end span $L/d = 30$ for interior span from ES EN 1992:2015 9table 7.4N

Where L = effective length of the beam

d = effective depth but those value is for steel grade 400,

We must have to modify it. In our case, Modification factor $=500/400=1.25$

Therefore,

- End span, $26*1.25=32.5$
- Interior span, $30*1.25=37.5$
- Cantilever, $8*1.25=10$

End span, $d=L/26=4290/32.5=132$

Interior span, $d=L/30= 4290/37.5=114.4$

$$D_{required} = d_{required} + stirrup + \frac{\phi_{bar}}{2} = 132 + 8 + \frac{14}{2} = 147mm$$

Therefore, $D_{provided} > D_{required}$...ok

Step-3 check the whether the beam single or double reinforced

A beam should be treated as singly reinforced if $K < 0.167$

A beam should be treated as doubly reinforced if $K > 0.167$

$$\text{Where } K = \frac{Msd}{bd^2fck} = \frac{64.3*10^6}{300*400^2*20} = 0.067$$

Step-4 provide reinforcement

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$$Z = \frac{d}{2} (1 + \sqrt{1 - 3.53K}) = \frac{400}{2} (1 + \sqrt{1 - 3.53 * 0.067}) = 421.6$$

$$A_{st, cal} = \frac{Msd}{Zfyd} = \frac{64.3 * 10^6}{421.6 * 347.83} = 238.5$$

Step-5 check the minimum and maximum reinforcement

$$A_{st, min} = \max \begin{cases} 0.26 \frac{f_{ctm}}{f_{yk}} bd = 0.26 \frac{2.2}{400} * 300 * 400 = 171.6 \text{ mm}^2 \\ 0.0013bd = 0.0013 * 300 * 400 = 156 \text{ mm}^2 \end{cases}$$

$$A_{st, min} = 171.6 \text{ mm}^2$$

$$A_{st, max} = 0.04bd = 0.04 * 300 * 400 = 4800 \text{ mm}^2$$

Therefore $A_{st, min} \leq A_{st, cal} \leq A_{st, max}$

$$\text{no of bar} = \frac{A_{s,pro}}{A_{st}} = \frac{438.5}{153.86} = 2.85$$

Use 3 Ø 14

Table 26 Beam reinforcement

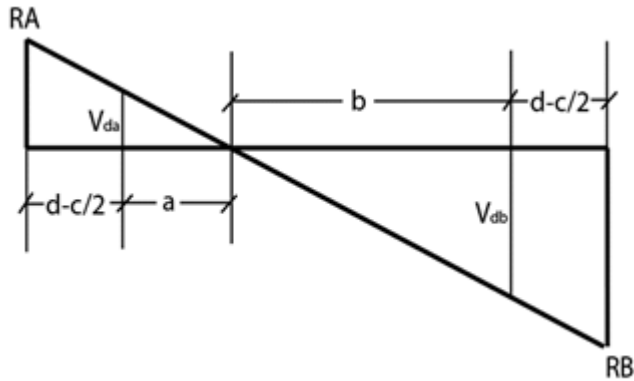
Type	Loc	Moment	b(mm)	D(mm)	d(mm)	K	Z(mm)	Beam type	As,min	As,max	As,cal	As,prov	No of bar	Remark
support	B	16.23	250	300	250	0.0519	237.962	single	89.375	2500	196.087	196.1	1.27445	2Ø14
span	B-C	20.61	250	300	250	0.0660	234.487	single	89.375	2500	252.696	252.7	1.64237	2Ø14
support	C	23.92	250	300	250	0.0765	231.785	single	89.375	2500	296.697	296.7	1.92836	2Ø14
span	C-D	24.53	250	300	250	0.0785	231.28	single	89.375	2500	304.928	304.9	1.98185	2Ø14
support	D	7.91	250	300	250	0.0253	244.285	single	89.375	2500	93.0932	93.09	0.60505	2Ø14
support	E	1.94	250	300	250	0.0062	248.623	single	89.375	2500	22.4336	89.38	0.58089	2Ø14
span	E-F	12.61	250	300	250	0.0404	240.755	single	89.375	2500	150.583	150.6	0.9787	2Ø14

Stirrup calculation for beam

F_{ck}=20

F_{yk}=400 b_w=250 d=225

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$$\rho_w = 0.08 * \frac{f_{yk}^{0.5}}{400}$$

$$\rho_w = 0.08 * \frac{20^{0.5}}{400} = 0.000894$$

$$ASW = \frac{\pi d^2}{4} = \frac{3.14 * 8^2}{4} = 50.24$$

$$\cos \alpha = 2.5$$

$$F_{yd} = \frac{400}{1.15} = 347.8$$

$$Z = 0.9 * d = 0.9 * 225 = 229.5$$

$$a = \frac{RA * L}{RA + RB} - \left(d + C \frac{C}{2} \right)$$

$$a = \frac{12.5 * 4.29}{12.5 + 14.94} = 0.38$$

$$= 1.574$$

$$b = L - \left(2 * D + C \frac{C}{2} + a \right)$$

$$= 4.29 - (2 * 0.38 + 1.574) = 1.956$$

$$V_{E_{da}} = (RA * a) \frac{RA * a}{D + \frac{C}{2} + a} = \frac{12.5 * 1.574}{0.38 + 1.574} = 10.07$$

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$$VE_{db} = \frac{RB*b}{D + \frac{C}{2} + b} = \frac{14.94 * 1.957}{0.38 + 1.956} = 12.51$$

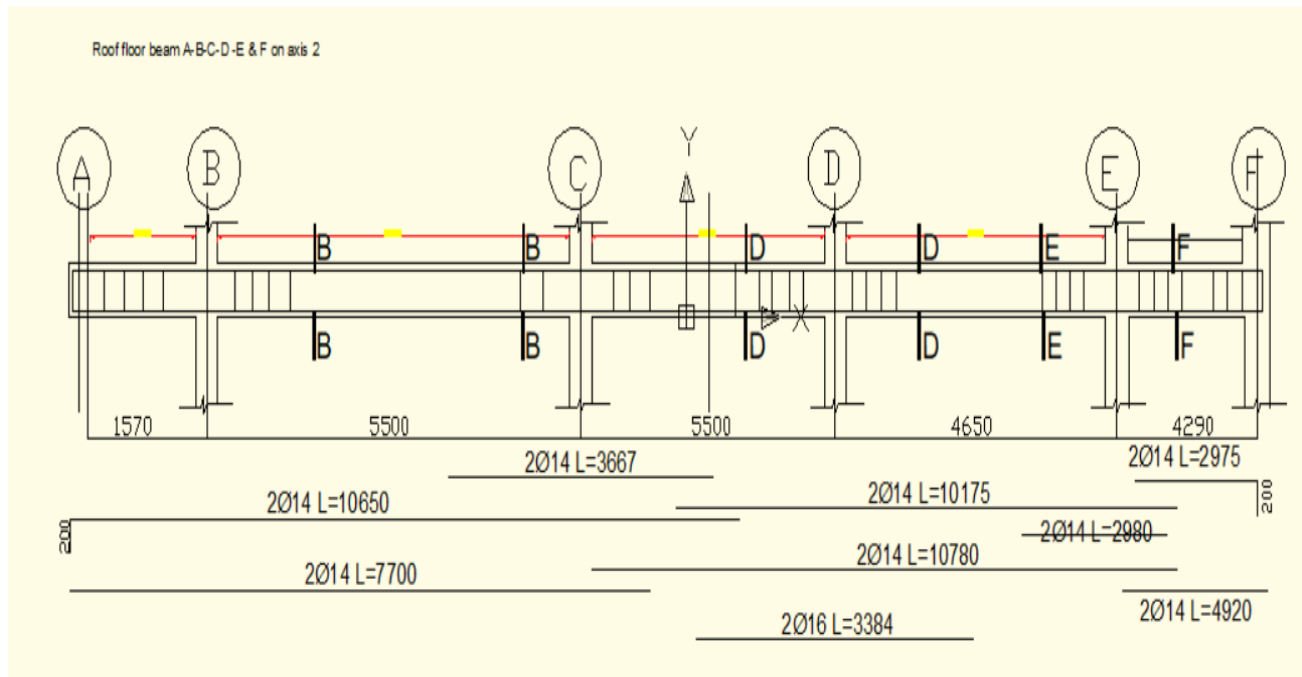
$$VE_d = \text{Max}(VE_{da}, VE_{db})$$

$$= \text{Max}(10.07, 12.51)$$

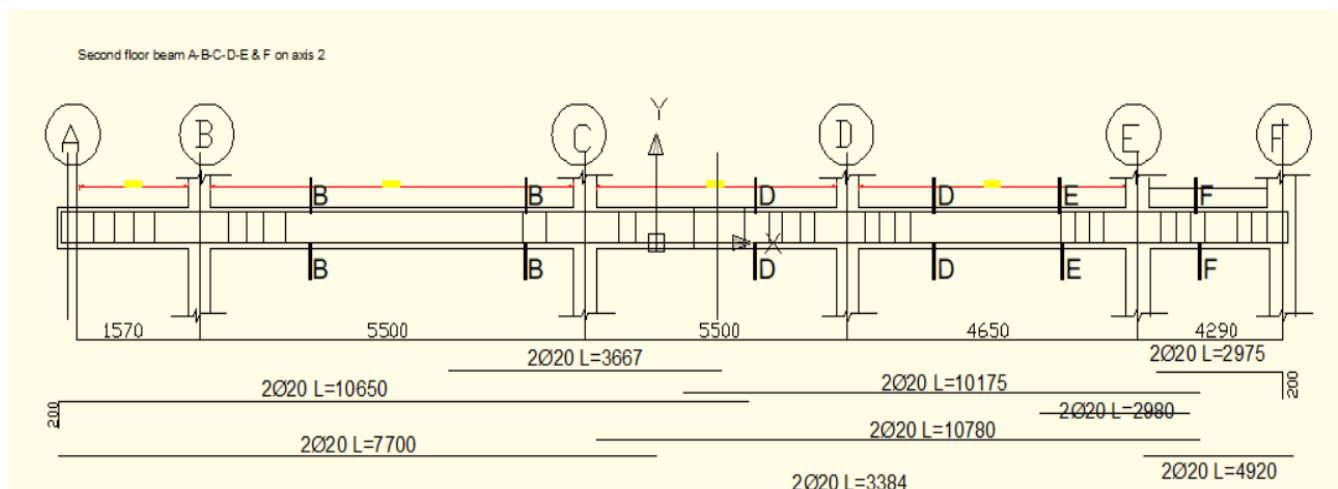
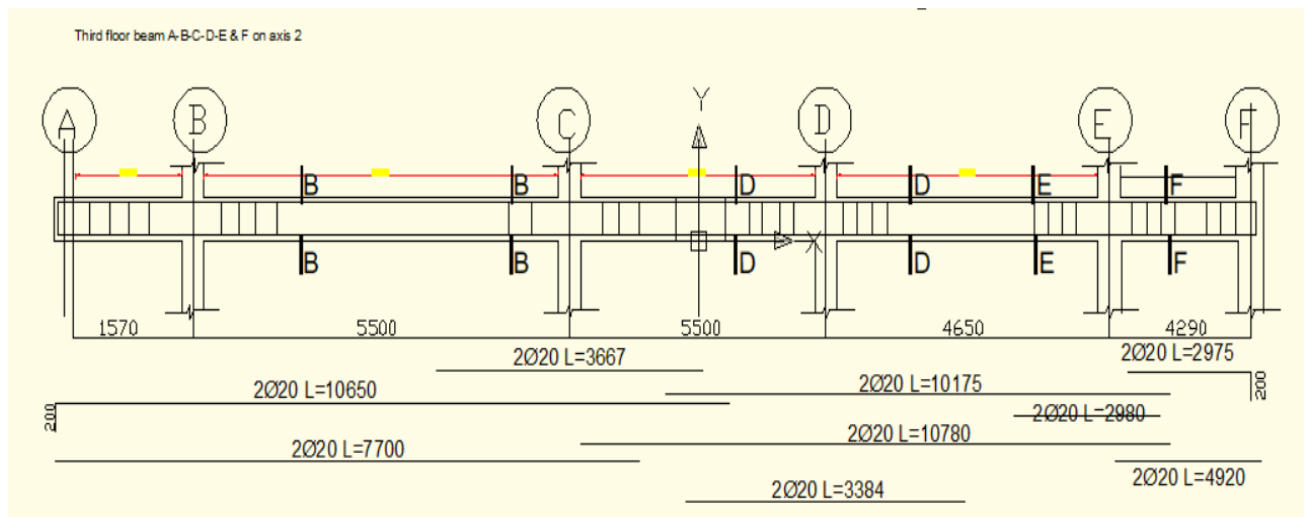
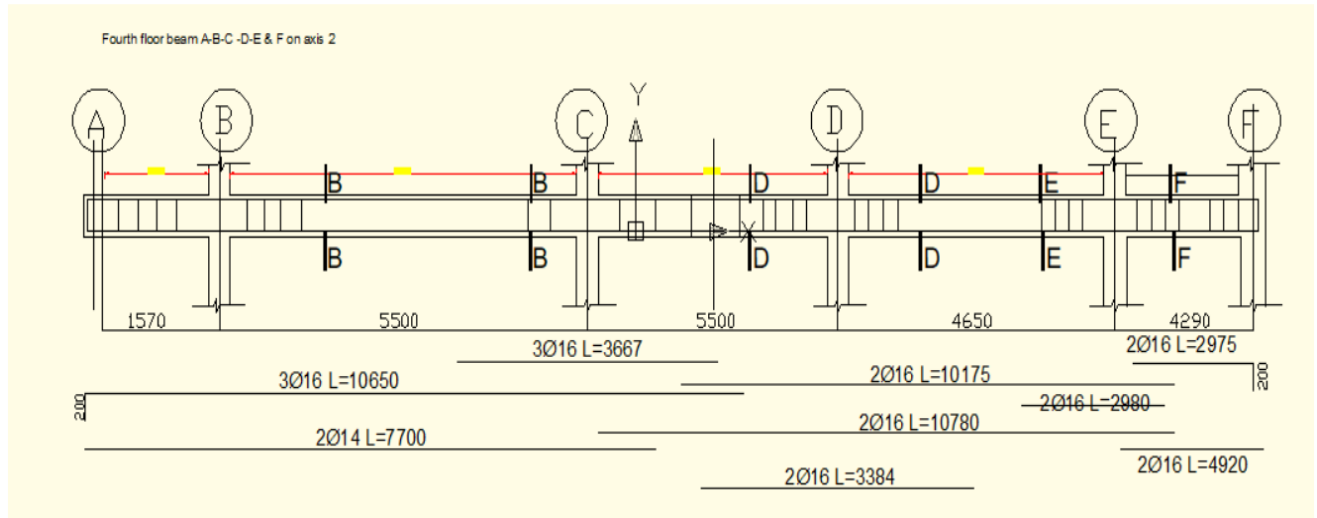
$$VE_d = 12.51$$

Table 27 Design shear calculation for beam

AXIS2						
span	Vmax	Ved	Sbmax	Scal	Smin	Spro
B-C	35.65	31.55	191.25	317.8	224.7	191.3
C-D	31.49	27.46	191.25	365.1	224.7	191.3
E-F	16.48	14.06	191.25	713.1	224.7	191.3



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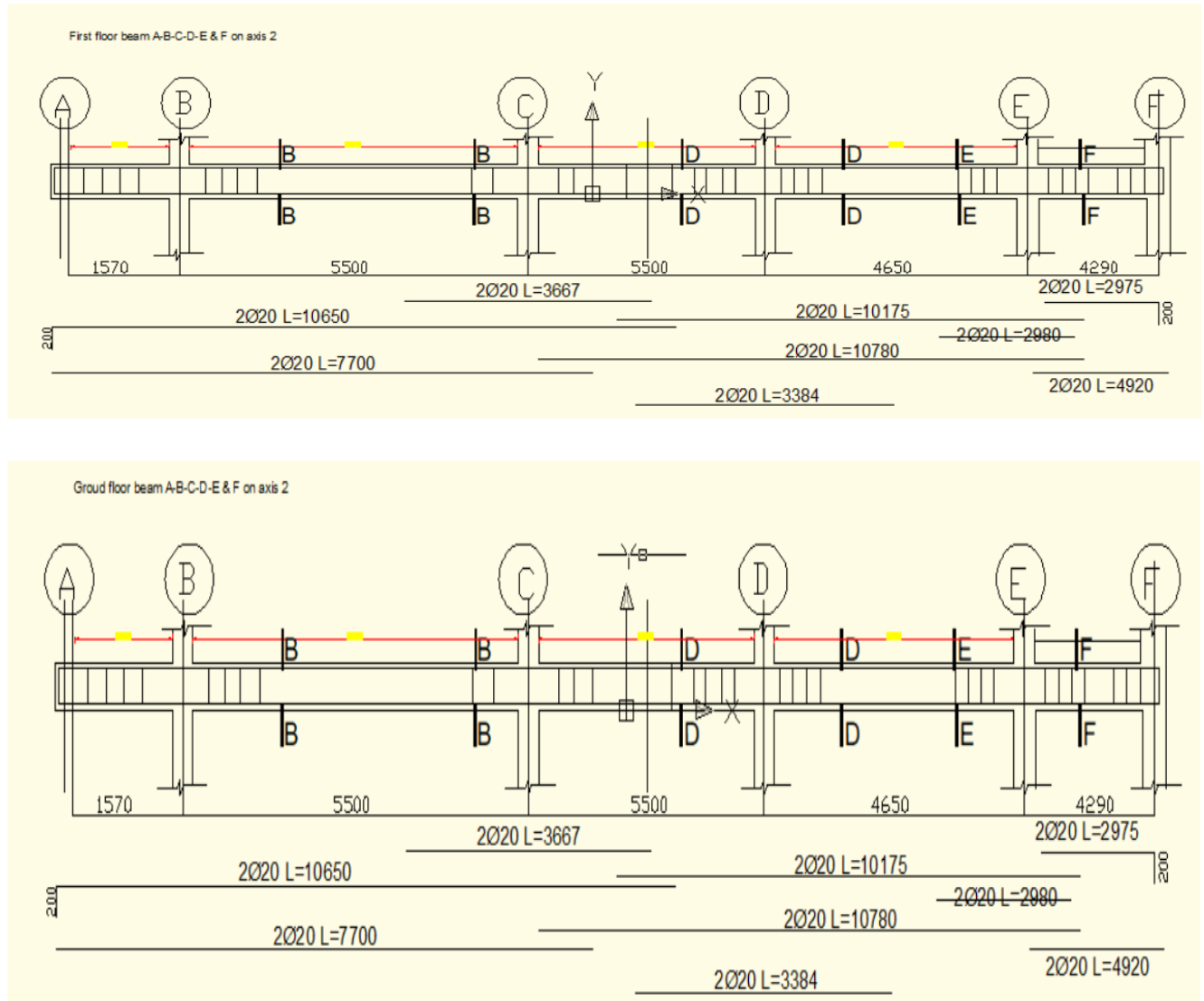


Figure 17 Beam detail drawing

G+0- Roof Floor Beam Section

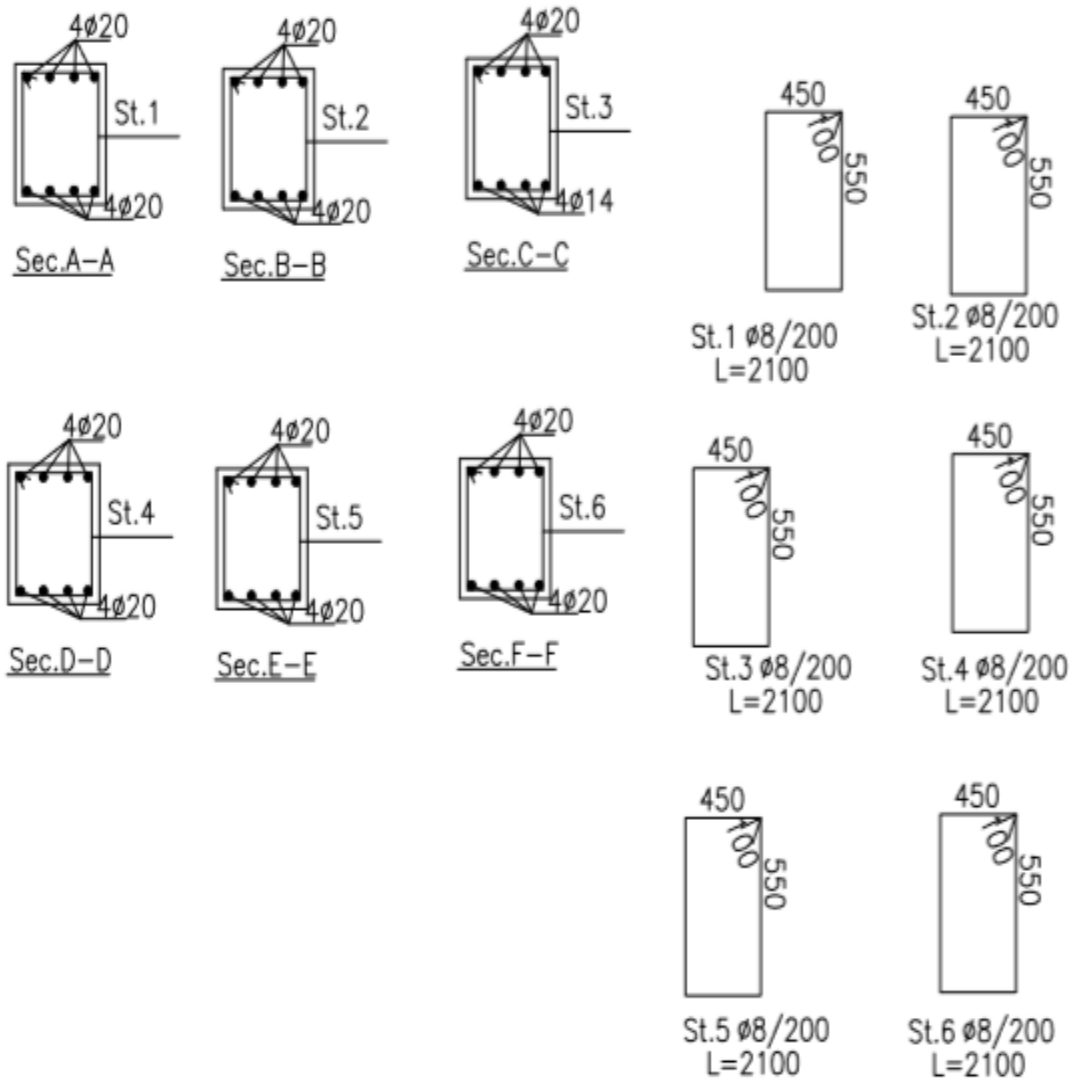


Figure 18 Beam section

8. COLUMN DESIGN

8.1. INTRODUCTION

A column is a vertical structural member transmitting axial compression loads with or without moments. The cross sectional dimensions of a column are generally considerably less than its height. Column support mainly vertical loads from the floors and roof and transmit these loads to the foundation.

The strength of a column depends on many factors including the following:

- ✓ The strength of the material
- ✓ Shape and size of the cross section
- ✓ Length
- ✓ The degree of positional and directional restraints at its end

Classification of columns

- ✓ Classification on the basis of geometry; rectangular, square, circular, L-shaped, T-shaped, etc. depending on the structural or architectural requirements.
- ✓ Classification on the basis of degree of slenderness; short column, slender column.
- ✓ Classification on the basis of loading: axially loaded column, columns under uni-axial bending or columns under biaxial bending.
- ✓ Classification on the basis of lateral reinforcement; tied columns, spiral columns.
- ✓ Classification on the basis of lateral stability is provided to the structure as a whole; braced or un braced column

Table 28. Rectangular column sample calculation for 4th floor column

Given data

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Top beam	depth(m)	width(m)	Length(m)
b1(x,x)	0.3	0.25	4.41
b2(x,x)	0.3	0.25	4.65
b1(y,y)	0.3	0.25	4.29
b2(y,y)	0.3	0.25	4.65

bottom beam	depth(m)	width(m)	length(m)
b3(x,x)	0.4	0.3	4.41
b4(x,x)	0.4	0.3	4.65
b3(y,y)	0.4	0.3	4.29
b4(y,y)	0.4	0.3	4.65
Column	0.4	0.3	3.06

$M_{top-x}=14.76\text{KNm}$

$M_{bot-y}=2.68\text{KNm}$

$M_{top-x}=14.76\text{KNm}$

$M_{bot-y}=2.68\text{KNm}$

$NED=75.18\text{KN}$

Determination of effective length of the column

Effective length is used to account for the shape of the deflection curve: it can also be defined as buckling length i.e. the length of pin-ended column with constant normal force, having the same cross section and buckling load.

Effective length (l_0) for braced member

From EBCS EN 1992-1-1:2014 (5:15)

$$L_0 = \sqrt{\left(l + \frac{k_1}{0.45+k_2}\right)\left(l + \frac{k_2}{0.45+k_2}\right)}$$

where, K_1, K_2 -relative flexibilities of rotational restraint at both ends 1,2

l - length of column

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K1-stiffness at end 1

K2-stiffness at end 2

Stiffness at each end (K) = column stiffness/Σbeam stiffness

$$K_{1x-x} = \frac{I_c/L_c}{2 \left(\frac{I_{b-1T}}{L_{b-1T}} + \frac{I_{b-2T}}{L_{b-2T}} \right)}$$

$$I_c = \frac{bh^3}{12} = \frac{400 \cdot 400^3}{12} = 21.3 \cdot 10^8 \text{ mm}^4$$

$$I_{b-1T} = \frac{300 \cdot 250^3}{12} = 3.906 \cdot 10^8 \text{ mm}^4$$

$$K_{1y-y} = \frac{21.3 \cdot 10^8 / 3.06}{2 \left(\frac{3.906 \cdot 10^8}{4.29} + \frac{3.906 \cdot 10^8}{4.65} \right)}$$

$$K_{1y-y} = 1.98$$

$$K_{1x-x} = \frac{21.3 \cdot 10^8 / 3.06}{2 \left(\frac{3.906 \cdot 10^8}{4.41} + \frac{3.906 \cdot 10^8}{4.65} \right)}$$

$$= 2.02$$

$$K_{2y-y} = \frac{21.3 \cdot 10^8 / 3.06}{2 \left(\frac{1.6 \cdot 10^9}{4.29} + \frac{1.6 \cdot 10^9}{4.65} \right)}$$

$$= 0.49$$

$$K_{2x-x} = \frac{21.3 \cdot 10^8 / 3.06}{2 \left(\frac{1.6 \cdot 10^9}{4.41} + \frac{1.6 \cdot 10^9}{4.65} \right)}$$

$$= 0.492$$

$$L_{ox-x} = 0.5 \cdot 3.06 \cdot \sqrt{\left(1 + \frac{2.02}{0.45+0.492}\right) \left(1 + \frac{0.492}{0.45+0.492}\right)}$$

$$L_{ox-x} = 3.33 \text{ m}$$

$$L_{oy-y} = 0.5 \cdot 3.06 \cdot \sqrt{\left(1 + \frac{1.98}{0.45+0.49}\right) \left(1 + \frac{0.49}{0.45+0.49}\right)}$$

$$L_{oy-y} = 3.29 \text{ m}$$

Maximum and minimum reinforcement calculation

$$A_{s,\min} = \max \left\{ \begin{array}{l} 0.1 \cdot NED/f_{yd} = 0.1 \cdot 75.18 / 347.8 = 21.62 \text{ mm}^2 \\ 0.002 \cdot A_c = 0.002 \cdot 400 \cdot 400 = 320 \text{ mm}^2 \end{array} \right.$$

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$$A_{s,min}=320\text{mm}^2$$

$$A_{s,max}=0.04 \cdot A_c = 0.04 \cdot 300 \cdot 400^2 = \underline{6400\text{mm}^2}$$

Step 4 design action

The effect of imperfection taken from According to ES EN 1992: Art 5.2.7

$$e_{ix_xmax} \begin{cases} \frac{L_o}{400} = \frac{3300}{400} = 8.25\text{mm}, e_{ix-x} = 20\text{mm} \\ \frac{h}{30} = \frac{400}{30} = 13.3\text{mm} \\ 20\text{mm} \end{cases}$$
$$e_{iy_ymax} \begin{cases} \frac{L_o}{400} = \frac{3290}{400} = 6.23\text{mm}, e_{iy-y} = 20\text{mm} \\ \frac{h}{30} = \frac{400}{30} = 13.3\text{mm} \\ 20\text{mm} \end{cases}$$

$$M_{01} = \text{Min} \{ |M_{\text{top}}|, |M_{\text{bottom}}| + e_i \cdot N_{ED} \}$$

$$M_{02} = \text{Max} \{ |M_{\text{top}}|, |M_{\text{bottom}}| + e_i \cdot N_{ED} \}$$

$$M_{oe} = 0.4 \cdot M_{01} + 0.6 \cdot M_{02} \geq 0.4 \cdot M_{02}$$

For first order moment $M_2=0$

In the X-direction

$$M_{01x-x} = \text{min} \{ |M_{\text{top}x-x}|, |M_{\text{bottom}x-x}| + e_i \cdot N_{ED} \}$$

$$M_{01x-x} = \text{min} \{ |14.76|, |2.68| + 0.02 \cdot 75.18 \}$$

$$\text{min} \{ 16.26, 4.18 \}$$

$$M_{01x-x} = 4.18 \text{KNm}$$

$$M_{02x-x} = \text{max} \{ |M_{\text{top}x-x}|, |M_{\text{bottom}x-x}| + e_i \cdot N_{ED} \}$$

$$M_{02x-x} = \text{max} \{ 16.26, 4.18 \}$$

$$M_{02x-x} = 16.26 \text{KNm}$$

$$M_{oex-x} = 0.4 \cdot M_{01x-x} + 0.6 \cdot M_{02x-x} \geq 0.4 \cdot M_{02x-x}$$

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$$M_{oex-x} = 0.4 * 4.18 + 0.6 * 16.26 \geq 0.4 * 16.26$$

$$= 11.43 \geq 6.5$$

$$M_{oex-x} = 11.43 \text{KNm}$$

$$M_{EDx-x} = 16.26 \text{KNm}$$

In the Y-direction

$$M_{01y-y} = \min \{ |M_{topx-x}|, |M_{bottomx-x}| + e_i * N_{ED} \}$$

$$M_{01y-y} = \min \{ |14.76|, |2.68| + 0.02 * 75.18 \}$$

$$\min \{ 16.26, 4.18 \}$$

$$M_{01y-y} = 4.18 \text{KNm}$$

$$M_{02y-y} = 16.26 \text{KNm}$$

$$M_{oey-y} = 0.4 * M_{01y-y} + 0.6 * M_{02y-y} \geq 0.4 * M_{02y-y}$$

$$M_{oey-y} = 0.4 * 4.18 + 0.6 * 16.26 \geq 0.4 * 16.26$$

$$= 11.43 \geq 6.5$$

$$M_{oey-y} = 11.43 \text{KNm}$$

$$M_{EDy-y} = 16.26 \text{KNm}$$

Check slenderness

Slenderness ratio $\lambda = \frac{l_o}{i}$ where l_o - effective length of column

i - is radius of gyration of the uncracked concrete

$$\lambda_{x-x} = \frac{l_{ox-x}}{i} = 28.7$$

$$\lambda_{y-y} = \frac{l_{oy-y}}{i} = 28.61$$

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The minimum limiting value of slenderness is

$$\lambda_{lim} = 20 * A * B * C / \sqrt{n}$$

$$\lambda_{lim\ x-x} = 20 * A * B * C / \sqrt{n}$$

Where, $A = 1 / (1 + 0.2\varphi_{ef})$, φ_{ef} -effective creep ratio

$B = \sqrt{1 + 2\omega}$, $\omega = A_s f_{yd} / A_c f_{cd}$, mechanical reinforcement ratio

$$C = 1.7 - r_m$$

$n = N_{Ed} / A_c f_{cd}$, relative normal force

$$r_m, \text{moment ratio} = M_{o1\ x-x} / M_{o2\ x-x} = 4.18 / 16.26 = 0.26$$

M_{o1} , M_{o2} are the first order end moments, $|M_{o2}| \geq |M_{o1}|$

If φ_{ef} is not known, $A = 0.7$

If ω is not known, $B = 1.1$

$$C = 1.7 - r_m$$

X- dxn

$$r_m = \frac{M_{o1\ x-x}}{M_{o2\ x-x}} = \frac{242.68}{246.18} = 0.98$$

$$C = 1.7 - 0.26 = 1.44$$

$A_c = b * h = 300 * 300 = 90000 \text{mm}^2$ for rectangular column

$$n = \frac{N_{Ed}}{A_c f_{cd}} = \frac{75.18 * 1000}{160000 * 11.33} = 0.04$$

Therefore, slenderness limit ($\lambda_{lim\ x-x}$) = $20 * A * B * C / \sqrt{n}$

$$\lambda_{lim\ x-x} = \frac{20 * 0.7 * 1.1 * 1.44}{\sqrt{0.04}} = 110.8$$

Y- dxn

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$$A=0.7$$

$$B=1.1$$

$$C=1.7-(0.68)=0.72$$

$$n = \frac{NEd}{Acfcd} = \frac{485.2 \cdot 1000}{90000 \cdot 11.33} = 0.476$$

$$\lambda_{limy-y} = 20 \cdot A \cdot B \cdot C / \sqrt{n}$$

$$\lambda_{limy-y} = \frac{20 \cdot 0.7 \cdot 1.1 \cdot 1.44}{\sqrt{0.04}} = 110.8$$

Check slenderness

$\lambda_{x-x} > \lambda_{limx-x}$, slender column otherwise short column

$\lambda_{y-y} > \lambda_{limy-y}$, slender column otherwise short column

$\lambda_{x-x} < \lambda_{limx-x} = 19.39 > 16.07$, slender column

$\lambda_{y-y} < \lambda_{limy-y} = 17.9 > 16.07$, slender column

$$v_{sd} = \frac{NEd}{Acfcd} = \frac{75.18 \cdot 1000}{160000 \cdot 11.33} = 0.04$$

$$\mu_{sdx-x} = \frac{MED_{x-x}}{fcd \cdot Ac \cdot h} = \frac{16.26 \cdot 10^6}{11.33 \cdot 400 \cdot 400 \cdot 306} = 0.03$$

$$\mu_{sdy-y} = \frac{MED_{y-y}}{fcd \cdot Ac \cdot h} = \frac{73.18 \cdot 10^6}{11.33 \cdot 400 \cdot 400 \cdot 306} = 0.03$$

Using biaxial rectangular chart number

$$\omega = 0.25$$

Step 5 reinforcement calculation

✓ Longitudinal reinforcement

$$A_{s,tot} = \frac{\omega \cdot A_c \cdot f_{cd}}{f_{yd}}$$

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$$A_{s,tot} = \frac{0.25 * 160000 * 11.33}{347.8}$$

$$A_{s,tot} = 1303.05 \text{ mm}^2$$

$$A_{s \text{ min}} = 320 \text{ mm}^2 \text{ and } A_{s \text{ max}} = 6400 \text{ mm}^2$$

$$A_{s \text{ min}} < A_s < A_{s \text{ max}} \dots \dots \dots \text{OK}$$

$$\text{Take } \varnothing 20 \text{ mm, } a_s = \frac{3.14 * (16)^2}{4} = 200.96 \text{ mm}^2$$

$$\text{Number of bar} = A_s / a_s = 1303.05 \text{ mm}^2 / 200.96 \text{ mm}^2 = 4 \text{ bar}$$

Provide 6 $\varnothing 16 \text{ mm}$

✓ For shear reinforcement

$$\text{Diameter of bar} = \text{Max} \left\{ \begin{array}{l} \frac{1}{4} * \text{longitudinal bar diameter} = \frac{16}{4} = 5 \\ 5 \text{ mm} \\ \text{Diameter of stirrup} = 8 \text{ mm} \end{array} \right.$$

From above take $\varnothing 8 \text{ mm}$

$$\text{Spacing of shear reinforcement} = \text{Min} \left\{ \begin{array}{l} 20 * \varnothing_{\text{long}} = 20 * 16 \text{ mm} = 320 \text{ mm} \\ \text{Lesser dimension of column} = 400 \text{ mm} \\ 400 \text{ mm} \end{array} \right.$$

Finally, provide $\varnothing 8 \text{ c/c } 320 \text{ mm}$

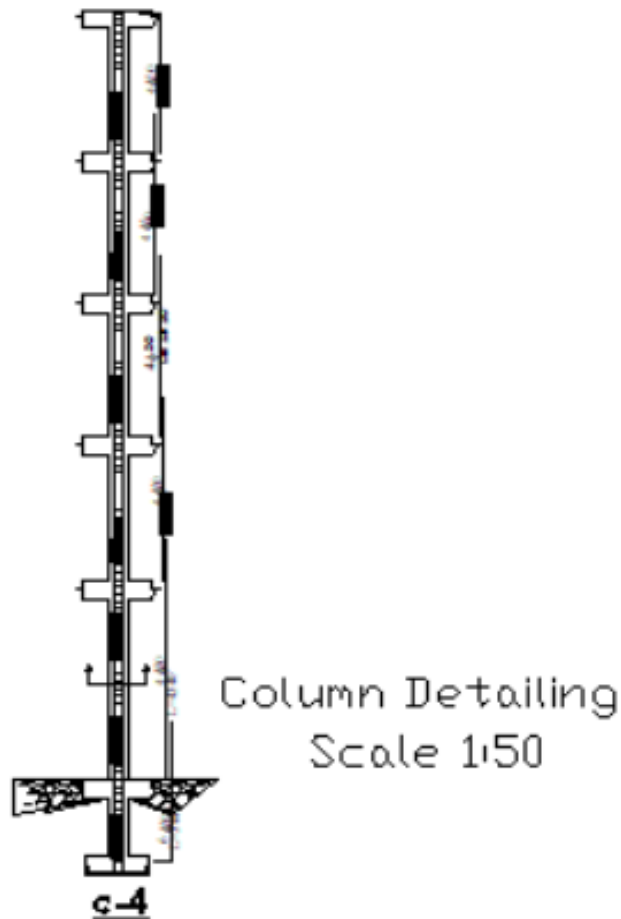


Figure 18 Column detail drawing

10. FOUNDATION

10.1. Introduction To Foundation

The main purpose of footings and other foundation systems is to transfer column loads safely to the soil. Since, the soil bearing capacity is much lower than the concrete columns; the loads need to be transferred safely to the soil by using larger areas usually called shallow foundations. If the soil has low bearing capacity, or the applied loads are very large, it may be necessary to transfer the load to a deeper soil through the use of piles or caissons usually called deep foundation.

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For the satisfactory design of foundations, it is important to have an understanding of the local geology and the type, thickness, parameters, properties and design bearing pressures of the soil or rock layers to which the foundation transfers the loads.

The main objectives of a foundation are the following

- To distribute the weight of the structure over larger area so as to avoid over loading of the soil beneath.
- To load the sub structure evenly so as to avoid unequal settlement.
- To provide a level surface for building operations
- To take the sub structure deep into the ground and thus increase its stability and avoid over turning.

Axially loaded footing at intersection of axis C-4 on structure two which has a compression force of **1877.6KN** is selected as a representative sample for isolated footing design. From ETABS analysis output results the following loading data are obtained.

$$P=1877.6$$

$$M_Y=26.5$$

$$M_X=6.05$$

Area of footing req

$$A = \frac{(N+W)}{\gamma_{soil}} = \frac{1877.6+187.76}{150} = \underline{\underline{13.77}} \text{ where } W=10\%N$$

$$B*H*h = 2.5*2.5*0.7$$

$$\text{Area} = 2.5*2.5$$

$$= \underline{\underline{6.25m^2}}$$

$$\text{Weight} = 6.25*0.7*25$$

$$= 109.4\text{KN}$$

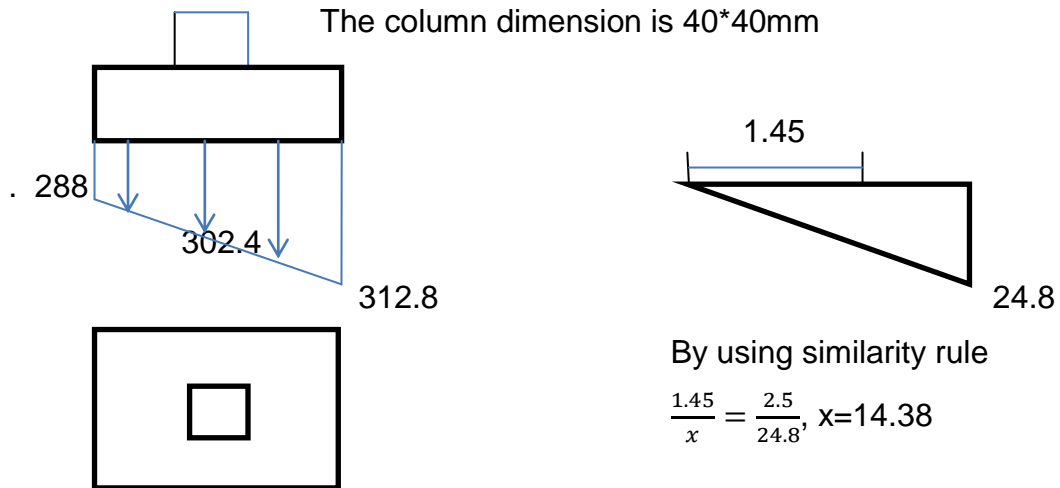
$$\delta = \frac{P}{A} * \left(1 \pm \frac{6ey}{B} \pm \frac{6eX}{B}\right) \text{ where } ex = \frac{My}{P} = \frac{26.5}{1877.6} = 0.014$$

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$$e_x = \frac{Mx}{P} = \frac{6.05}{1877.6} = 0.0032$$

$$\delta_{\max} = \frac{1877.6}{6.25} * \left(1 + \frac{6(0.0032)}{2.5} + \frac{6(0.014)}{2.5}\right) = \underline{312.8}$$

$$\delta_{\min} = \frac{1877.6}{6.25} * \left(1 - \frac{6(0.0032)}{2.5} - \frac{6(0.014)}{2.5}\right) = \underline{288}$$



Punching shear resistance

$$M_{xx} = 302.4 * \frac{1.05^2}{2} + (312.8 - 288) * \left(\frac{1.05}{2}\right) * \left(1.05 * \frac{2}{3}\right)$$

$$= 166.7 + 9.12$$

$$= \underline{\underline{175.82}}$$

$$M_{yy} = \left(\frac{312.8 + 288}{3}\right) * \frac{1.05^2}{2}$$

$$= \underline{\underline{165.6}}$$

Effective depth

Before calculating the effective depth we need to find concrete cover

Cover design

$$c_{nom} = c_{min} + \Delta c_{dev}$$

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- ✓ exposure class-xc₃, EBCS-2 Table 0.1 exposure classes
 - ✓ min cover regard to bond, c_{min}, b=12mm
 - ✓ min cover regard to durability, c_{min}, dur=25mm
 - ✓ allowance is design for deviation, Δc_{dev}=10mm
- } c_{min}=25mm

$$c_{nom} = c_{min} + \Delta c_{dev} = 25 + 10 = \mathbf{35mm}$$

$$dx = h - ccov - 0.5\phi_{bar} = 700 - 35 - (0.5 * 24) = 653mm$$

$$dy = h - ccov - 1.5\phi_{bar} = 700 - 35 - (1.5 * 24) = 629mm$$

Main reinforcement longitudinal bar

$$K = \frac{M_{xx}}{fck * b * d^2} = \frac{175.82}{24 * 2.5 * 70^2} = 0.0059 < \underline{0.167} \quad \text{Where } fck = 0.8 * 30 = 24$$

$$Z = d(0.25 - (\frac{K}{1.134})) \leq 0.95d, 0.55 * 0.7 \leq 0.665$$

$$Z = 0.7(0.25 - (\frac{0.0059}{1.134}))$$

$$Z = \underline{\mathbf{0.175}}$$

$$Z = \frac{d}{2}(1 + \sqrt{1 - 3.53k}) \leq 0.665$$

$$Z = \frac{0.7}{2}(1 + \sqrt{1 - 3.53(0.0059)}) \leq 0.665$$

$$Z = 0.696 \leq 0.665$$

$$Z = \underline{\mathbf{0.665}}$$

$$A_s = \frac{M}{f_y d z} = \frac{175.82}{347.82 * 0.665} = 760 \text{ mm}^2$$

Min & max area of reinforcement

$$A_{s_{min}} = \frac{0.26 * f_{ctm} * b * d}{f_{yk}} \quad \text{where } f_{ctm} = 0.3 * f_{ck}^{2/3}, f_{ck} = \frac{400}{1.15} = 347.82$$

$$= 0.3 * 24^{2/3} = \mathbf{2.5}$$

$$= \frac{0.26 * 2.5 * 2.5 * 0.7}{400}$$

$$A_{s_{min}} = \mathbf{2843mm^2}$$

$$A_{s_{max}} = 0.04 * A_c$$

$$= 0.04 * 2.5 * 0.7$$

$$A_{s_{max}} = \mathbf{70000mm^2}$$

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Use $A_{s_{min}}=2843\text{mm}^2$

$$n=\frac{A_s}{a_s}, \text{ where } a_s=\frac{\pi d^2}{4}=\frac{3.14*24^2}{4}=452.16$$

$$n=\frac{2843}{452.16}=6.26$$

provide 7Ø24

Main reinforcement-transvers bar

$$k=\frac{M_{yy}}{f_{ck} * b * d^2}=\frac{165.6}{24 * 2500 * 629^2}=0.0069 < K$$

There for compression reinforcement is not required.

$$z=d\left(0.25-\frac{k}{1.134}\right)=0.244d < 0.95d$$

$$A_{sreq}=\frac{M_{yy}}{0.87f_{yk} * z}=\frac{165.6 * 10^6}{0.87 * 400 * 0.244 * 629}=3100\text{mm}^2$$

Minimum and maximum area of reinforcement

$$A_{smin}=0.26 * \left(\frac{f_{ctm}}{f_{yk}}\right) * bd=0.26 * \left(\frac{2.5}{500}\right) * 2500 * 629=2555.3\text{mm}^2$$

$$A_{smax}=0.04 * A_c=0.04 * 2.5 * 0.629=62900\text{mm}^2$$

Since $A_s < A_{min}$ use $A_{smin}=2555.3\text{mm}^2$

$$n=\frac{A_s}{a_s}, \text{ where } a_s=\frac{\pi d^2}{4}=\frac{3.14*24^2}{4}=452.16$$

$$n=\frac{2555.3}{452.16}=5.65$$

provide 6Ø24

$$k=\frac{M_{xx}}{f_{ck} * b * d^2}=\frac{175.82}{24 * 2500 * 629^2}=0.0074$$

There for compression reinforcement is not required.

$$z=d\left(0.25-\frac{k}{1.134}\right)=0.243d < 0.95d$$

$$A_{sreq}=\frac{M_{xx}}{0.87f_{yk} * z}=\frac{175.82 * 10^6}{0.87 * 400 * 0.243 * 629}=3305.46\text{mm}^2$$

$$A_{smin}=0.26 * \left(\frac{f_{ctm}}{f_{yk}}\right) * bd=0.26 * \left(\frac{2.5}{400}\right) * 2500 * 629=2555.3\text{mm}^2$$

G+4 Residential building project

$$A_{smax} = 0.04 * A_c = 0.04 * 2500 * 0.629 = 62900mm^2$$

Since $A_s < A_{min}$ use $A_{smin} = 2555.3mm^2$

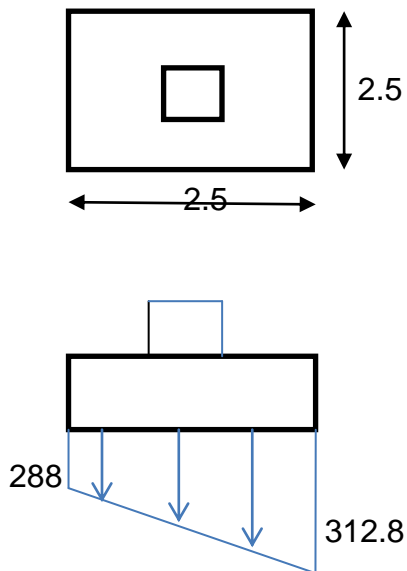
$$n = \frac{A_s}{a_s}, \text{ where } a_s = \frac{\pi d^2}{4} = \frac{3.14 * 24^2}{4} = 452.16$$

$$n = \frac{2555.3}{452.16} = 5.65$$

provide 6 ϕ 24

1. Vertical shear

Critical shear at load from face of column



Average pressure critical section

$$= 288 + \left(\frac{2.15}{2.5}\right) * 24.8$$

$$= 309.33$$

↳ Design shear force

$$V_{\epsilon d} = 309.33 * 0.35 * 2.5 = 270.6 \text{KN}$$

$$K = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{700}} = 1.535 < 2.0$$

G+4 Residential building project

Note bar extend beyond critical section at $350-35 = 315 > (bdf) = 36\phi + d$

$$36 * 24 + 700 = 1564$$

$$A_{sl} = Dmm^2$$

$$\delta_1 = \frac{A_{sl}}{bd} = 0$$

$$V_{RdC} = 0$$

$$V_{min} = [0.035K^{3/2} \sqrt{fck}]bd$$

$$V_{min} = [0.035 * 1.532^{3/2} \sqrt{24}]2500 * 700$$

$$V_{min} = 570.655 \text{ KN}$$

$$V_{ed} < V_{min} \text{ OK!}$$

2. Punching shear

Critical shear at 2.0d from face of column

$$\text{Average } d = \frac{700 * 629}{2} = 664.5$$

$$2d = 1329$$

Control perimeter

$$U = 2(400 + 400) + (2\pi * 1329) = 9950 \text{ mm}$$

Area within perimeter

$$A = [0.4 * 0.4] + [2 * 0.4 * 1.329] + [2 * 0.4 * 1.329] + [\pi * 1.329^2]$$

$$= 7.835 \text{ m}^2$$

Average punching shear stress

$$V_{ed} = \left(\frac{312.8 + 288}{2} \right) [(2.5 * 2.5) - 7.835] = 477 \text{ KN}$$

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Punching shear stress

$$V_{\epsilon d} = \frac{BV_{\epsilon d}}{Ud}, \quad B = 1 + K \left(\frac{M_{\epsilon d}}{V_{\epsilon d}} \right) \left(\frac{U_1}{W_1} \right)$$

$$W_1 = 0.5c_1^2 + c_1c_2 + 4c_2d + 16d^2 + 2\pi dc_1$$

$$= 0.5(400)^2 + 400 \cdot 400 + 4 \cdot 400 \cdot 664.5 + 16 \cdot 664.5^2 + 2 \cdot \pi \cdot 664.5 \cdot 400$$

$$W_1 = \underline{10038234.65 \text{ mm}^2}$$

$$B = 1 + 0.659 \left(\frac{6.05 \cdot 10^6}{477 \cdot 10^3} \right) \left(\frac{9950}{10038234.65} \right) = 1.01$$

$$V_{\epsilon d} = \frac{1.01 \cdot 477 \cdot 10^3}{9950 \cdot 700} = 0.069 \text{ N/mm}^2$$

Punching shear resistance

$$K = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{700}} = 1.535 < 2$$

$$V_{Rdc} = V_{\min} = 0.035 K^{3/2} f_{ck}^{1/2}$$

$$= 0.035 (1.535)^{3/2} (24)^{1/2} = 0.326$$

$$0.326 > V_{\epsilon d} (0.069) \quad \mathbf{OK}$$

3. Maximum punching shear at column perimeter

Max punching shear force

$$V_{\epsilon d} = \left(\frac{BV_{\epsilon d}}{U_{od}} \right) \quad B = 1 + K \left(\frac{M_{\epsilon d}}{V_{\epsilon d}} \right) \left(\frac{U_o}{W_1} \right)$$

$$W_1 = 0.5 \cdot 400^2 + 400 \cdot 400$$

$$W_1 = 240000 \text{ mm}^2$$

$$B = 1 + 0.65 \left(\frac{6.05 \cdot 10^6}{1877.6 \cdot 10^3} \right) \left(\frac{1600}{240000} \right)$$

$$B = 1.014$$

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$$V_{ed} = \left(\frac{1014 * 1887.6 * 10^3}{1600 * 664.5} \right) = 1.8 \text{ N/mm}^2$$

Maximum shear resistance

$$\begin{aligned} V_{ed, \max} &= 0.5 \left[0.6 \left(1 - \frac{f_{ck}}{250} \right) \right] \frac{f_{ck}}{1.5} \\ &= 0.5 \left[0.6 \left(1 - \frac{24}{250} \right) \right] \left(\frac{24}{1.5} \right) \\ &= 4.34 > V_{ed} \quad \mathbf{OK} \end{aligned}$$

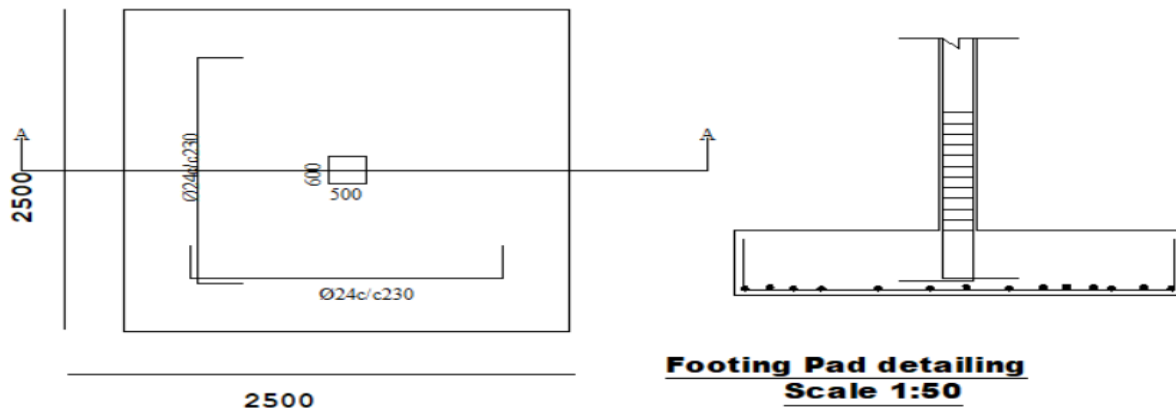


Figure 19 Foundation detail drawing

REFERENCE

- Ethiopian standard on european norm (ES EN 199p:2015)
- Sample document from Mr Debissa(slab)
- Sample document from Mr Mustefa(foundation)

APPENDIX

Appendix A. Design Dead Load and Live Loads for 3rd Floor Panels

panel	function	Calculated dead load(KN/m ²)	Governing dead load (KN/m ²)	Live load (KN/m ²)	Governin g live load (KN/m ²)	Pd'=1.35D.L +1.5L.L (KN/m ²)
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P1	Bathroom	6.5	6.5	2	2	11.78
	Dressing room	6.11		2		
P2	Balcony	6.11	6.5	3	3	13.28
	Bed room	6.5		2		
P3	Balcony	6.11	6.5	3	3	13.28
	Bed room	6.5		2		
P4	Bathroom	6.5	6.5	2	2	11.78
	Dressing room	6.11		2		
P5	Bed room	6.5	6.5	2	2	11.78
P6	Lobby	6.15	6.15	3	3	15.8
P7	Bed room	6.5	6.5	2	2	11.78
	Store	6.11		2		
	kitchen	6.11		2		
P8	Kitchen	6.11	6.11	2	2	11.25
P9	Shower	6.11	6.11	2	2	11.25
	Dressin room	6.11		2		
	jacuzzi	6.11		2		
P10	Bed room	6.5	6.5	2	2	11.78
	Praying room	6.5				
P11	Lobby	6.15	6.15	3	3	15.8
P12	Dyning room	6.01	6.01	2	2	11.11
P13	Bar	6.01	6.01	2	2	11.11
P14	Family room	6.5	6.5	2	2	11.78
P15	Family room	6.5	6.5	2	2	11.78
P16	Lobby	6.15	6.15	3	3	15.8
P17	Living room	6.5	6.5	2	2	11.78
P18	Living room	6.5	6.5	2	2	11.78
C1-	Family room	6.5	6.5	2	2	11.78
C5						
C6	<u>Balcony</u>	<u>6.11</u>	6.11	<u>3</u>	3	13.28
C7-	<u>Living room</u>	<u>6.5</u>	6.5	<u>2</u>	2	11.78

G+4 Residential building project

C11						
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Appendix B Design Dead Load and Live Loads for 4th floor Panels

Panel	Function	Calculated dead load(KN/m ²)	Governing dead load (KN/m ²)	Live load (KN/m ²)	Governing live load (KN/m ²)	Pd'=1.35D.L+1.5L.L (KN/m ²)
P1	Bathroom	6.5	6.5	2	2	11.78
	Dressing room	6.11		2		
P2	Balcony	6.11	6.5	3	3	13.28
	Bed room	6.5		2		
P3	Balcony	6.11	6.5	3	3	13.28
	Bed room	6.5		2		
P4	Bathroom	6.5	6.5	2	2	11.78
	Dressing room	6.11		2		
P5	Bed room	6.5	6.5	2	2	11.78
P6	Lobby	6.15	6.15	3	3	15.8
P7	Bed room	6.5	6.5	2	2	11.78
	Kitchen	6.11		2		
P8	Kitchen	6.11	6.11	2	2	11.25
P9	Balcony	6.11	6.11	3	3	13.28
P10	Jacuzzi	6.11	6.11	2	2	11.25
	Dressing room	6.11		2		
	Shower					
	Store	6.11		2		
		6.11		2		
P11	Lobby	6.15	6.15	3	3	15.8
P12	Dyning room	6.01	6.01	2	2	11.11
P13	Balcony	6.11	6.11	3	3	13.28
P14	Balcony	6.11	6.11	3	3	13.28
P15	Living room	6.5	6.5	2	2	11.78
P16	Living room	6.5	6.5	2	2	11.78

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P17	Bar	6.01	6.01	2	2	11.11
P18	Balcony	6.11	6.11	3	3	13.28
C1- C4	Balcony	6.11	6.11	3	3	13.28
C5- C7	Bar	6.01	6.01	2	2	11.11
C8- C11	Balcony	6.11	6.11	3	3	13.28

Appendix C Dead Load of Partition Wall on Third Floor Panels

panel	Length (m)	D.L (kN)=(1.334*L+8.12*L)KN/m ² <small>pw</small>	Area (m ²)	D.L (kN/m ²)=D.L pw (kN)/Area <small>pw</small>
P1	2.3	21.74	13.94	1.56
P2	1.8	17	18.92	0.89
P3	1.8	17	18.92	0.89
P4	2.3	21.74	13.94	1.56
P5	4.55	43	20.5	2.09
P6	NO partition wall			
P7	4.9	46.32	20.5	2.26
P8	No partition wall			
P9	3.94	37.24	17.87	2.08
P10	4,5	42.54	24.25	1.75
P11- P18	No partition wall			

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Appendix D Dead Load of Partition Wall on fourth Floor Panels

panel	Length (m)	D.L (kN)=(1.334*L+8.12*L)KN/m ² _{pw}	Area (m ²)	D.L (kN/m ²)=D.L pw (kN)/Area _{pw}
P1	2.3	21.74	13.94	1.56
P2	1.8	17	18.92	0.89
P3	1.8	17	18.92	0.89
P4	2.3	21.74	13.94	1.56
P5	4.55	43	20.5	2.09
P6	NO partition wall			
P7	4.9	46.32	20.5	2.26
P8	No partition wall			
P9	No partition wall			
P10	3.51	33.18	24.25	1.37
P11- P18	No partition wall			

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Appendix E Moment analysis for For 3rd floor

PANEL	TYPE	Lx	Ly	Ly/Lx	n(pd)	β_{sx-}	β_{sx+}	β_{sy-}	β_{sy+}	Mxs	Mxf	Mys	Myf
P1	End	3.25	4.29	1.32	13.89	0.077	0.058		0.044	11.30	8.51	0.00	6.46
P2	End	4.29	4.41	1.03	14.5	0.052	0.039	0.045	0.034	13.88	10.41	12.01	9.07
P3	End	4.29	4.41	1.03	14.5	0.052	0.039	0.045	0.034	13.88	10.41	12.01	9.07
P4	End	3.25	4.29	1.32	13.89	0.07	0.052	0.045	0.034	10.27	7.63	6.60	4.99
P5	End	4.41	4.65	1.05	14.6	0.046	0.033	0.037	0.028	13.06	9.37	10.51	7.95
P6	Interior	4.65	4.65	1.00	15.8	0.039	0.03	0.032	0.028	13.32	10.25	10.93	9.57
P7	Interior	4.41	4.65	1.05	11.83	0.034	0.026	0.037	0.024	7.82	5.98	8.51	5.52
P8	End	3.25	4.65	1.43	11.25	0.07	0.052	0.037	0.028	8.32	6.18	4.40	3.33
P9	Interior	3.25	5.5	1.69	14.06	0.062	0.046	0.032	0.028	9.21	6.86	4.75	4.16
P10	Interior	4.41	5.5	1.25	14.14	0.044	0.034	0.032	0.024	12.10	9.35	8.80	6.60
P11	Interior	3.25	5.5	1.69	15.8	0.042	0.032	0.032	0.024	7.01	5.34	5.34	4.01
P12	Interior	4.41	5.5	1.25	11.11	0.044	0.034	0.032	0.024	9.51	7.35	6.91	5.19
P13	Interior	3.25	5.5	1.69	11.11	0.058	0.043	0.032	0.024	6.81	5.05	3.76	2.82
P14	Interior	3.25	5.5	1.69	11.78	0.058	0.043	0.032	0.024	7.22	5.35	3.98	2.99
P15	Interior	4.41	5.5	1.25	11.78	0.044	0.034	0.032	0.024	10.08	7.79	7.33	5.50
P16	Interior	4.65	5.5	1.18	15.8	0.042	0.032	0.032	0.024	14.35	10.93	10.93	8.20
P17	Interior	4.41	5.5	1.25	11.78	0.044	0.034	0.032	0.024	10.08	7.79	7.33	5.50
P18	Interior	3.25	5.5	1.69	11.78	0.058	0.043	0.032	0.024	7.22	5.35	3.98	2.99
C3	Cantilever	1.7	1.9	1.12	12.75	0.057	0.043	0.045	0.034	2.10	1.58	1.66	1.25
C4	Cantilever	1.7	3.25	1.91	12.75	0.086	0.065	0.037	0.028	3.17	2.40	1.36	1.03
C8	Cantilever	1.7	3.25	1.91	12.75	0.086	0.065	0.037	0.037	3.17	2.40	1.36	1.36
C9	Cantilever	1.7	1.7	1.00	12.75	0.031	0.024	0.032	0.032	1.14	0.88	1.18	1.18

PANEL		Lx	Ly	Ly/Lx	n(pd)	Mxs(KN)
C 1	cantilever	1.9	5.5	2.89	12.75	23.01
C 2	cantilever	1.9	5.5	2.89	12.75	23.01
C5	cantilever	1.7	4.41	2.59	12.75	18.42
C6	cantilever	1.7	4.465	2.63	12.75	18.42
C7	cantilever	1.7	4.41	2.59	12.75	18.42
C10	cantilever	1.7	5.5	3.24	12.75	18.42
C11	cantilever	1.7	5.5	3.24	12.75	18.42

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Appendix F Moment analysis for For 4th floor

PANEL	TYPE	Lx	Ly	Ly/Lx	n(pd)	β_{sx-}	β_{sx+}	β_{sy-}	β_{sy+}	Mxs	Mxf	Mys	Myf
P1	End	3.25	4.29	1.32	13.89	0.077	0.058		0.044	11.30	8.51	0.00	6.46
P2	End	4.29	4.41	1.03	14.5	0.052	0.039	0.045	0.034	13.88	10.41	12.01	9.07
P3	End	4.29	4.41	1.03	15.5	0.052	0.039	0.045	0.034	14.83	11.13	12.84	9.70
P4	End	3.25	4.29	1.32	13.89	0.07	0.052	0.045	0.034	10.27	7.63	6.60	4.99
P5	End	4.41	4.65	1.05	14.6	0.046	0.033	0.037	0.028	13.06	9.37	10.51	7.95
P6	Interior	4.65	4.65	1.00	15.8	0.039	0.03	0.032	0.028	13.32	10.25	10.93	9.57
P7	Interior	4.41	4.65	1.05	14.83	0.034	0.026	0.037	0.024	9.81	7.50	10.67	6.92
P8	End	3.25	4.65	1.43	11.25	0.07	0.052	0.037	0.028	8.32	6.18	4.40	3.33
P9	Interior	3.25	5.5	1.69	14.06	0.062	0.046	0.032	0.028	9.21	6.86	4.75	4.16
P10	Interior	4.41	5.5	1.25	13.1	0.044	0.034	0.032	0.024	11.21	8.66	8.15	6.11
P11	Interior	3.25	5.5	1.69	15.8	0.042	0.032	0.032	0.024	7.01	5.34	5.34	4.01
P12	Interior	4.41	5.5	1.25	11.11	0.044	0.034	0.032	0.024	9.51	7.35	6.91	5.19
P13	Interior	3.25	5.5	1.69	11.11	0.058	0.043	0.032	0.024	6.81	5.05	3.76	2.82
P14	Interior	3.25	5.5	1.69	11.78	0.058	0.043	0.032	0.024	7.22	5.35	3.98	2.99
P15	Interior	4.41	5.5	1.25	11.78	0.044	0.034	0.032	0.024	10.08	7.79	7.33	5.50
P16	Interior	4.65	5.5	1.18	15.8	0.042	0.032	0.032	0.024	14.35	10.93	10.93	8.20
P17	Interior	4.41	5.5	1.25	11.78	0.044	0.034	0.032	0.024	10.08	7.79	7.33	5.50
P18	Interior	3.25	5.5	1.69	11.78	0.058	0.043	0.032	0.024	7.22	5.35	3.98	2.99
C3	Cantiliver	1.7	1.9	1.12	12.75	0.057	0.043	0.045	0.034	2.10	1.58	1.66	1.25
C4	Cantiliver	1.7	3.25	1.91	12.75	0.086	0.065	0.037	0.028	3.17	2.40	1.36	1.03
C8	Cantiliver	1.7	3.25	1.91	12.75	0.086	0.065	0.037	0.037	3.17	2.40	1.36	1.36
C9	Cantiliver	1.7	1.7	1.00	12.75	0.031	0.024	0.032	0.032	1.14	0.88	1.18	1.18

PANEL		Lx	Ly	Ly/Lx	n(pd)	Mxs(KN)
C 1	cantilever	1.9	5.5	2.89	12.75	23.01
C 2	cantilever	1.9	5.5	2.89	12.75	23.01
C5	cantilever	1.7	4.41	2.59	12.75	18.42
C6	cantilever	1.7	4.465	2.63	12.75	18.42
C7	cantilever	1.7	4.41	2.59	12.75	18.42
C10	cantilever	1.7	5.5	3.24	12.75	18.42
C11	cantilever	1.7	5.5	3.24	12.75	18.42

Appendix G Support moment adjustment for 3rd floor

Panel	Mtd 1	Mtd2	Max
P1&P2	11.66		
P2&P5		12.17	
P3&P4	11.14		

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P3&P7		12.48	
P4&P8		5.5	
P5&P6	12		
P5&P10	9.62		
P6&P7	10.37		
P6&P11		9.3	
P7&P8	9.07		
P7&P12		8.79	
P8&P13	4.08		
P9&P10		10.44	
P9&P14	4.37		
P9&C1			23.01
P10&P11		9.62	
P10&P15	8.07		
P11&P12		8.29	
P11&P16		8.14	
P12&P13		8.36	
P12&P17	7.12		
P13&P18	3.87		
P13&C11			18.42
P14&P15		8.43	
P14&C2			23.01
P14&C4			3.98
P15&P16		12.16	
P15&C5			18.42
P16&P17		12.27	
P16&C6			18.42
P17&P18		8.87	
P17&C7			18.42
P18&C8			3.98
P18&C10			18.42
C1&C2			23.01
C2&C3			23.01
C3&C4			2.1
C4&C5			18.42
C5&C6			18.42
C6&C7			18.42
C7&C8			18.42
C8&C9			3.17
C9&C10			18.42
C10&C11			18.42

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Appendix H Support moment adjustment for 4th floor

Panel	Mtd 1	Mtd2	Max
P1&P2	11.66		
P2&P5		12.17	
P3&P4	11.14		
P3&P7		12.48	
P4&P8		5.5	
P5&P6	12		
P5&P10	9.62		
P6&P7	10.37		
P6&P11		9.3	
P7&P8	9.07		
P7&P12		8.79	
P8&P13	4.08		
P9&P10		10.44	
P9&P14	4.37		
P9&C1			23.01
P10&P11		9.05	
P10&P15	7.74		
P11&P12		8.29	
P11&P16		8.14	
P12&P13		8.36	
P12&P17	7.12		
P13&P18	3.87		
P13&C11			18.42
P14&P15		8.43	
P14&C2			23.01
P14&C4			3.98
P15&P16		12.16	
P15&C5			18.42
P16&P17		12.27	
P16&C6			18.42
P17&P18		8.87	
P17&C7			18.42
P18&C8			3.98
P18&C10			18.42
C1&C2			23.01
C2&C3			23.01

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C3&C4			2.1
C4&C5			18.42
C5&C6			18.42
C6&C7			18.42
C7&C8			18.42
C8&C9			3.17
C9&C10			18.42
C10&C11			18.42

Appendix I span moment adjustment for 3rd floor

				Mxs+Mxf- Madj
PANEL	Mxs	Mxf	Madjust	Mxfadj
P1	0	11.87	11.66	0.21
P2	13.88	10.41	11.66	12.63
P3	13.88	10.41	11.14	13.15
P4	6.6	7.63	5.5	8.73
P5	10.51	9.37	9.62	10.26
P6	13.25	10.25	9.3	14.20
P7	10.67	7.5	8.79	9.38
P8	4.4	6.18	4.08	6.50
P9	4.75	6.86	10.44	1.17
P10	8.8	9.35	9.62	8.53
P11	5.34	5.34	8.14	2.54
P12	6.91	7.35	7.12	7.14
P13	3.76	5.05	3.87	4.94
P14	3.98	5.35	8.43	0.90
P15	7.33	7.79	12.16	2.96
P16	10.93	10.93	12.27	9.59
P17	7.33	7.79	8.87	6.25
P18	3.98	5.35	3.98	5.35
C3	1.66	1.58	2.1	1.14
C4	1.36	2.4	2.1	1.66
C8	1.36	2.4	3.17	0.59
C9	1.36	2.4	3.17	0.59

				Mys+Myf- Madj
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PANEL	Mys	Myf	Madjust	Myfadj
P1	11.3	6.46	11.66	6.10
P2	12.01	9.07	12.17	8.91
P3	12.01	9.07	12.48	8.60
P4	10.27	4.99	5.5	9.76
P5	13.06	7.95	12	9.01
P6	10.93	9.57	10.37	10.13
P7	9.81	6.92	9.07	7.66
P8	8.32	3.33	4.08	7.57
P9	9.21	4.16	10.39	2.98
P10	12.1	6.6	9.44	9.26
P11	7.01	4.01	8.29	2.73
P12	9.51	5.19	8.36	6.34
P13	6.81	2.82	3.87	5.76
P14	7.22	2.99	8.43	1.78
P15	10.08	5.5	12.16	3.42
P16	14.35	8.2	18.42	4.13
P17	10.08	5.5	8.87	6.71
P18	7.22	2.99	3.98	6.23
C3	2.1	1.25	2.1	1.25
C4	3.17	1.03	2.1	2.10
C8	3.17	1.36	3.17	1.36
C9	1.14	1.18	2.1	0.22

Appendix J span moment adjustment for 4th floor

				Mxs+Mxf- Madj
PANEL	Mxs	Mxf	Madjust	Mxfadj
P1	0	11.87	11.66	0.21
P2	13.88	10.41	11.66	12.63
P3	13.88	10.41	11.14	13.15
P4	6.6	7.63	5.5	8.73
P5	10.51	9.37	9.62	10.26
P6	13.25	10.25	9.3	14.20
P7	10.67	7.5	8.79	9.38
P8	4.4	6.18	4.08	6.50
P9	4.75	6.86	10.44	1.17
P10	11.27	6.11	9.05	8.33
P11	5.34	5.34	8.14	2.54
P12	6.91	7.35	7.12	7.14

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P13	3.76	5.05	3.87	4.94
P14	3.98	5.35	8.43	0.90
P15	7.33	7.79	12.16	2.96
P16	10.93	10.93	12.27	9.59
P17	7.33	7.79	8.87	6.25
P18	3.98	5.35	3.98	5.35
C3	1.66	1.58	2.1	1.14
C4	1.36	2.4	2.1	1.66
C8	1.36	2.4	3.17	0.59
C9	1.36	2.4	3.17	0.59

				Mys+Myf- Madj
PANEL	Mys	Myf	Madjust	Myfadj
P1	11.3	6.46	11.66	6.10
P2	12.01	9.07	12.17	8.91
P3	12.01	9.07	12.48	8.60
P4	10.27	4.99	5.5	9.76
P5	13.06	7.95	12	9.01
P6	10.93	9.57	10.37	10.13
P7	9.81	6.92	9.07	7.66
P8	8.32	3.33	4.08	7.57
P9	9.21	4.16	10.39	2.98
P10	12	6.54	9.44	9.10
P11	7.01	4.01	8.29	2.73
P12	9.51	5.19	8.36	6.34
P13	6.81	2.82	3.87	5.76
P14	7.22	2.99	8.43	1.78
P15	10.08	5.5	12.16	3.42
P16	14.35	8.2	18.42	4.13
P17	10.08	5.5	8.87	6.71
P18	7.22	2.99	3.98	6.23
C3	2.1	1.25	2.1	1.25
C4	3.17	1.03	2.1	2.10
C8	3.17	1.36	3.17	1.36
C9	1.14	1.18	2.1	0.22

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Appendix K Load on support beam for 3rd floor

PANEL	TYPE	Lx	Ly	Ly/Lx	n(pd)	$\beta_{vx\ c}$	$\beta_{vx\ dc}$	$\beta_{vy\ c}$	$\beta_{vy\ dc}$	$V_{sx\ c}$	$V_{sx\ dc}$	$V_{sy\ c}$	$V_{sy\ dc}$
P1	end	3.25	4.29	1.32	13.89	0.534	0.352	0.4	0.26	24.11	15.89	18.06	11.74
P2	end	4.29	4.41	1.03	14.5	0.452	0.269		0.29	28.12	16.73	0.00	18.04
P3	end	4.29	4.41	1.03	14.5	0.452	0.269		0.29	28.12	16.73	0.00	18.04
P4	end	3.25	4.29	1.32	13.89	0.504	0.332	0.4	0.26	22.75	14.99	18.06	11.74
P5	end	4.41	4.65	1.05	14.6	0.38	0.255	0.36		24.47	16.42	23.18	0.00
P6	interior	4.65	4.65	1.00	15.8	0.36	0.4	0.36	0.27	26.45	29.39	26.45	19.84
P7	interior	4.41	4.65	1.05	11.83	0.345		0.24		18.00	0.00	12.52	0.00
P8	end	3.25	4.65	1.43	11.25	0.496	0.326	0.33		18.14	11.92	12.07	0.00
P9	interior	3.25	5.5	1.69	14.06	0.494		0.36	0.24	22.57	0.00	16.45	10.97
P10	interior	4.41	5.5	1.25	14.14	0.41		0.36		25.57	0.00	22.45	0.00
P11	interior	4.65	5.5	1.18	15.8	0.382		0.33		28.07	0.00	24.25	0.00
P12	interior	4.41	5.5	1.25	11.11	0.4		0.33		19.60	0.00	16.17	0.00
P13	interior	3.25	5.5	1.69	11.11	0.474		0.33		17.11	0.00	11.92	0.00
P14	interior	3.25	5.5	1.69	11.78	0.474		0.33		18.15	0.00	12.63	0.00
P15	interior	4.41	5.5	1.25	11.78	0.4		0.33		20.78	0.00	17.14	0.00
P16	interior	4.65	5.5	1.18	15.8	0.387		0.33		28.43	0.00	24.25	0.00
P17	interior	4.41	5.5	1.25	11.78	0.4		0.33		20.78	0.00	17.14	0.00
P18	interior	3.25	5.5	1.69	11.78	0.474		0.33		18.15	0.00	12.63	0.00

PANEL	TYPE	Lx	Ly	Ly/Lx	n (Pd)	WL
C 1	cantiliver	1.9	5.5	2.89	12.75	24.23
C2	cantiliver	1.9	5.5	2.89	12.75	24.23
C3	cantiliver	1.7	1.9	1.12	12.75	21.68
C4	cantiliver	1.7	3.25	1.91	12.75	21.68
C5	cantiliver	1.7	4.41	2.59	12.75	21.68
C6	cantiliver	1.7	4.65	2.74	12.75	21.68
C7	cantiliver	1.7	4.41	2.59	12.75	21.68
C8	cantiliver	1.7	3.25	1.91	12.75	21.68
C9	cantiliver	1.7	1.7	1.00	12.75	21.68
C10	cantiliver	1.7	5.5	3.24	12.75	21.68
C11	cantiliver	1.7	5.5	3.24	12.75	21.68

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Appendix L Load on support beam for 4th floor

PANEL	TYPE	Lx	Ly	Ly/Lx	n(pd)	$\beta_{vx\ c}$	$\beta_{vx\ dc}$	$\beta_{vy\ c}$	$\beta_{vy\ dc}$	Vsx c	Vsx dc	Vsy c	Vsy dc
P1	end	3.25	4.29	1.32	13.89	0.534	0.352	0.4	0.26	24.11	15.89	18.06	11.74
P2	end	4.29	4.41	1.03	14.5	0.452	0.269		0.29	28.12	16.73	0.00	18.04
P3	end	4.29	4.41	1.03	15.5	0.452	0.269		0.29	30.06	17.89	0.00	19.28
P4	end	3.25	4.29	1.32	13.89	0.504	0.332	0.4	0.26	22.75	14.99	18.06	11.74
P5	end	4.41	4.65	1.05	14.6	0.38	0.255	0.36		24.47	16.42	23.18	0.00
P6	interior	4.65	4.65	1.00	15.8	0.36	0.4	0.36	0.27	26.45	29.39	26.45	19.84
P7	interior	4.41	4.65	1.05	14.83	0.345		0.24		22.56	0.00	15.70	0.00
P8	end	3.25	4.65	1.43	11.25	0.496	0.326	0.33		18.14	11.92	12.07	0.00
P9	interior	3.25	5.5	1.69	14.06	0.494		0.36	0.24	22.57	0.00	16.45	10.97
P10	interior	4.41	5.5	1.25	13.1	0.41		0.36		23.69	0.00	20.80	0.00
P11	interior	4.65	5.5	1.18	15.8	0.382		0.33		28.07	0.00	24.25	0.00
P12	interior	4.41	5.5	1.25	11.11	0.4		0.33		19.60	0.00	16.17	0.00
P13	interior	3.25	5.5	1.69	11.11	0.474		0.33		17.11	0.00	11.92	0.00
P14	interior	3.25	5.5	1.69	11.78	0.474		0.33		18.15	0.00	12.63	0.00
P15	interior	4.41	5.5	1.25	11.78	0.4		0.33		20.78	0.00	17.14	0.00
P16	interior	4.65	5.5	1.18	15.8	0.387		0.33		28.43	0.00	24.25	0.00
P17	interior	4.41	5.5	1.25	11.78	0.4		0.33		20.78	0.00	17.14	0.00
P18	interior	3.25	5.5	1.69	11.78	0.474		0.33		18.15	0.00	12.63	0.00

PANEL	TYPE	Lx	Ly	Ly/Lx	n (Pd)	WL
C 1	cantiliver	1.9	5.5	2.89	12.75	24.23
C2	cantiliver	1.9	5.5	2.89	12.75	24.23
C3	cantiliver	1.7	1.9	1.12	12.75	21.68
C4	cantiliver	1.7	3.25	1.91	12.75	21.68
C5	cantiliver	1.7	4.41	2.59	12.75	21.68
C6	cantiliver	1.7	4.65	2.74	12.75	21.68
C7	cantiliver	1.7	4.41	2.59	12.75	21.68
C8	cantiliver	1.7	3.25	1.91	12.75	21.68
C9	cantiliver	1.7	1.7	1.00	12.75	21.68
C10	cantiliver	1.7	5.5	3.24	12.75	21.68
C11	cantiliver	1.7	5.5	3.24	12.75	21.68

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Appendix M Reinforcement for 3rd floor

panel	Momen t		Ast=Msd/Z*fy d	ø	Spacin g	spacin g used	Reinforcment			
P-1	M _{xs} =	0.21	240.00	10	327.08	300	ø	10	c/c	300
	M _{xf} =	0.21	240.00	10	327.08	300	ø	10	c/c	300
	M _{ys} =	11.66	240.00	10	327.08	300	ø	10	c/c	300
	M _{yf} =	6.1	240.00	10	327.08	300	ø	10	c/c	300
P-2	M _{xs} =	12.17	240.00	10	327.08	300	ø	10	c/c	300
	M _{xf} =	12.63	240.00	10	327.08	300	ø	10	c/c	300
	M _{ys} =	11.66	240.00	10	327.08	300	ø	10	c/c	300
	M _{yf} =	8.91	240.00	10	327.08	300	ø	10	c/c	300
P-3	M _{xs} =	12.48	240.00	10	327.08	300	ø	10	c/c	300
	M _{xf} =	13.15	241.42	10	325.16	300	ø	10	c/c	300
	M _{ys} =	11.14	240.00	10	327.08	300	ø	10	c/c	300
	M _{yf} =	8.6	240.00	10	327.08	300	ø	10	c/c	300
P-4	M _{xs} =	5.5	240.00	10	327.08	300	ø	10	c/c	300
	M _{xf} =	8.73	240.00	10	327.08	300	ø	10	c/c	300
	M _{ys} =	11.14	240.00	10	327.08	300	ø	10	c/c	300
	M _{yf} =	9.76	240.00	10	327.08	300	ø	10	c/c	300
P-5	M _{xs} =	9.62	240.00	10	327.08	300	ø	10	c/c	300
	M _{xf} =	10.26	240.00	10	327.08	300	ø	10	c/c	300
	M _{ys} =	12	240.00	10	327.08	300	ø	10	c/c	300
	M _{yf} =	9.01	240.00	10	327.08	300	ø	10	c/c	300
P-6	M _{xs} =	9.3	240.00	10	327.08	300	ø	10	c/c	300
	M _{xf} =	15.46	283.83	10	276.58	250	ø	10	c/c	250
	M _{ys} =	10.37	240.00	10	327.08	300	ø	10	c/c	300
	M _{yf} =	10.13	240.00	10	327.08	300	ø	10	c/c	300
P-7	M _{xs} =	8.79	240.00	10	327.08	300	ø	10	c/c	300
	M _{xf} =	9.38	240.00	10	327.08	300	ø	10	c/c	300
	M _{ys} =	9.07	240.00	10	327.08	300	ø	10	c/c	300

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	$M_{yf} =$	7.66	240.00	10	327.08	300	\emptyset	10	c/c	300
P-8	$M_{xs} =$	4.08	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	6.5	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	9.07	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	7.57	240.00	10	327.08	300	\emptyset	10	c/c	300
P-9	$M_{xs} =$	4.37	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	1.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	10.44	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	2.98	240.00	10	327.08	300	\emptyset	10	c/c	300
P-10	$M_{xs} =$	8.07	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	8.53	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	9.62	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	9.26	240.00	10	327.08	300	\emptyset	10	c/c	300
P-11	$M_{xs} =$	8.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	2.54	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.29	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	2.73	240.00	10	327.08	300	\emptyset	10	c/c	300
P-12	$M_{xs} =$	7.12	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	7.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.36	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	6.34	240.00	10	327.08	300	\emptyset	10	c/c	300
P-13	$M_{xs} =$	3.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	4.94	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.36	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	5.76	240.00	10	327.08	300	\emptyset	10	c/c	300
P-14	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	0.9	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.43	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.78	240.00	10	327.08	300	\emptyset	10	c/c	300
P-15	$M_{xs} =$	18.42	338.17	10	232.13	300	\emptyset	10	c/c	300
	$M_{xf} =$	2.96	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	12.16	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	3.42	240.00	10	327.08	300	\emptyset	10	c/c	300

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P-16	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	9.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	12.27	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.13	240.00	10	327.08	300	\emptyset	10	c/c	300
P-17	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	6.25	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	6.71	240.00	10	327.08	300	\emptyset	10	c/c	300
P-18	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	5.35	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	6.23	240.00	10	327.08	300	\emptyset	10	c/c	300
C3	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
	$M_{xf} =$	1.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	2.1	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.25	240.00	10	327.08	300	\emptyset	10	c/c	300
C4	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	1.66	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{yf} =$	2.1	240.00	10	327.08	300	\emptyset	10	c/c	300
C8	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	0.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	3.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.36	240.00	10	327.08	300	\emptyset	10	c/c	300
C9	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	0.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	3.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.22	240.00	10	327.08	300	\emptyset	10	c/c	300
C1	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
C2	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
C5	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C6	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C7	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210

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C10	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C11	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210

Appendix N Reinforcement for 4th floor

panel	Moment		$A_{st} = M_{sd} / Z * f_{yd}$	\emptyset	spacing	spacing used	Reinforcement			
P-1	$M_{xs} =$	0.21	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	0.21	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	11.66	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	6.1	240.00	10	327.08	300	\emptyset	10	c/c	300
P-2	$M_{xs} =$	12.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	12.63	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	11.66	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	8.91	240.00	10	327.08	300	\emptyset	10	c/c	300
P-3	$M_{xs} =$	12.48	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	13.15	241.42	10	325.16	300	\emptyset	10	c/c	300
	$M_{ys} =$	11.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	8.6	240.00	10	327.08	300	\emptyset	10	c/c	300
P-4	$M_{xs} =$	5.5	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	8.73	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	11.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	9.76	240.00	10	327.08	300	\emptyset	10	c/c	300
P-5	$M_{xs} =$	9.62	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	10.26	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	12	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	9.01	240.00	10	327.08	300	\emptyset	10	c/c	300
P-6	$M_{xs} =$	9.3	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	15.46	283.83	10	276.58	250	\emptyset	10	c/c	250
	$M_{ys} =$	10.37	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	10.13	240.00	10	327.08	300	\emptyset	10	c/c	300
P-7	$M_{xs} =$	8.79	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	9.38	240.00	10	327.08	300	\emptyset	10	c/c	300

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	$M_{ys} =$	9.07	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	7.66	240.00	10	327.08	300	\emptyset	10	c/c	300
P-8	$M_{xs} =$	4.08	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	6.5	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	9.07	240.00	10	327.08	300	\emptyset	10	c/c	300
P-9	$M_{yf} =$	7.57	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	4.37	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	1.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	10.44	240.00	10	327.08	300	\emptyset	10	c/c	300
P-10	$M_{yf} =$	2.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	7.74	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	8.33	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	9.05	240.00	10	327.08	300	\emptyset	10	c/c	300
P-11	$M_{yf} =$	9.1	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	8.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	2.54	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.29	240.00	10	327.08	300	\emptyset	10	c/c	300
P-12	$M_{yf} =$	2.73	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	7.12	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	7.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.36	240.00	10	327.08	300	\emptyset	10	c/c	300
P-13	$M_{yf} =$	6.34	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	3.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	4.94	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.36	240.00	10	327.08	300	\emptyset	10	c/c	300
P-14	$M_{yf} =$	5.76	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	0.9	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.43	240.00	10	327.08	300	\emptyset	10	c/c	300
P-15	$M_{yf} =$	1.78	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xs} =$	18.42	338.17	10	232.13	300	\emptyset	10	c/c	300
	$M_{xf} =$	2.96	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	12.16	240.00	10	327.08	300	\emptyset	10	c/c	300

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	$M_{yf} =$	3.42	240.00	10	327.08	300	\emptyset	10	c/c	300
P-16	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	9.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	12.27	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	4.13	240.00	10	327.08	300	\emptyset	10	c/c	300
P-17	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	6.25	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	6.71	240.00	10	327.08	300	\emptyset	10	c/c	300
P-18	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	5.35	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	8.87	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	6.23	240.00	10	327.08	300	\emptyset	10	c/c	300
C3	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
	$M_{xf} =$	1.14	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	2.1	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.25	240.00	10	327.08	300	\emptyset	10	c/c	300
C4	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	1.66	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{yf} =$	2.1	240.00	10	327.08	300	\emptyset	10	c/c	300
C8	$M_{xs} =$	3.98	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{xf} =$	0.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	3.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	1.36	240.00	10	327.08	300	\emptyset	10	c/c	300
C9	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
	$M_{xf} =$	0.59	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{ys} =$	3.17	240.00	10	327.08	300	\emptyset	10	c/c	300
	$M_{yf} =$	0.22	240.00	10	327.08	300	\emptyset	10	c/c	300
C1	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
C2	$M_{xs} =$	23.01	422.43	10	185.83	160	\emptyset	10	c/c	160
C5	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C6	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210

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C7	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C10	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210
C11	$M_{xs} =$	18.42	338.17	10	232.13	210	\emptyset	10	c/c	210

Appendix O For beam

G+4 Residential building project

Roof Beam Reinforcement

AXis2														
Type	Loc	Moment (KNm)	b(mm)	D(mm)	d(mm)	K	Z(mm)	Beam type	As,min	As,max	As,cal	As,prov	No of bar	Remark
support	B	16.23	250	300	250	0.0519	237.962	single	89.375	2500	196.087	196.087	1.27445	2Ø14
span	B-C	20.61	250	300	250	0.0660	234.487	single	89.375	2500	252.696	252.696	1.64237	2Ø14
support	C	23.92	250	300	250	0.0765	231.785	single	89.375	2500	296.697	296.697	1.92836	2Ø14
span	C-D	24.53	250	300	250	0.0785	231.28	single	89.375	2500	304.928	304.928	1.98185	2Ø14
support	D	7.91	250	300	250	0.0253	244.285	single	89.375	2500	93.0932	93.0932	0.60505	2Ø14
support	E	1.94	250	300	250	0.0062	248.623	single	89.375	2500	22.4336	89.375	0.58089	2Ø14
span	E-F	12.61	250	300	250	0.0404	240.755	single	89.375	2500	150.583	150.583	0.9787	2Ø14
support	F	2.376	250	300	250	0.0076	248.311	single	89.375	2500	27.5098	27.5098	0.1788	2Ø14
AXis3														
Type														
support	B	24.53	250	300	250	0.078496	231.28	single	89.375	2500	304.928	304.9279	1.98185	2Ø14
span	B-C	29.67	250	300	250	0.094944	226.923	single	89.375	2500	375.904	375.9044	2.44316	3Ø14
support	C	32.46	250	300	250	0.103872	224.478	single	89.375	2500	415.732	415.7317	2.70201	3Ø14
span	C-D	30.56	250	300	250	0.097792	226.149	single	89.375	2500	388.505	388.5046	2.52505	3Ø14
support	D	21.88	250	300	250	0.070016	233.458	single	89.375	2500	269.449	269.4487	1.75126	2Ø14
span	D-E	7.37	250	300	250	0.023584	244.684	single	89.375	2500	86.5965	89.375	0.58089	2Ø14
support	E	12.93	250	300	250	0.041376	240.511	single	89.375	2500	154.561	154.5614	1.00456	2Ø14
span	E-F	20.387	250	300	250	0.0652384	234.666	single	89.375	2500	249.77	249.7701	1.62336	2Ø14
support	F	2.456	250	300	250	0.0078592	248.254	single	89.375	2500	28.4427	28.44266	0.18486	2Ø14
AXis4														
Type														
support	B	27.684	250	300	250	0.0885888	228.628	single	89.375	2500	348.127	348.1266	2.26262	3Ø14
span	B-C	32.67	250	300	250	0.104544	224.291	single	89.375	2500	418.769	418.7692	2.72175	3Ø16
support	C	35.4	250	300	250	0.11328	221.834	single	89.375	2500	458.788	458.7882	2.98185	3Ø16
span	C-D	32.56	250	300	250	0.104192	224.389	single	89.375	2500	417.177	417.1774	2.71141	3Ø16
support	D	25.4	250	300	250	0.08128	230.555	single	89.375	2500	316.735	316.7354	2.0586	3Ø16
span	D-E	18.35	250	300	250	0.05872	236.293	single	89.375	2500	223.266	223.2658	1.4511	2Ø16
support	E	15.99	250	300	250	0.051168	238.149	single	89.375	2500	193.035	193.0354	1.25462	2Ø16
span	E-F	20.28	250	300	250	0.064896	234.752	single	89.375	2500	248.368	248.3681	1.61425	2Ø16
support	F	2.023	250	300	250	0.0064736	248.564	single	89.375	2500	23.3989	23.39895	0.15208	2Ø14

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AXis5														
Type														
support	B	27.59	250	300	250	0.088288	228.708	single	89.375	2500	346.823	346.8231	2.25415	3Ø14
span	B-C	32.74	250	300	250	0.104768	224.229	single	89.375	2500	419.783	419.7829	2.72834	3Ø14
support	C	35.012	250	300	250	0.1120384	222.187	single	89.375	2500	453.039	453.0388	2.94449	3Ø14
span	C-D	32.42	250	300	250	0.103744	224.513	single	89.375	2500	415.154	415.1538	2.69826	3Ø14
support	D	26.4	250	300	250	0.08448	229.716	single	89.375	2500	330.408	330.4083	2.14746	3Ø14
span	D-E	18.384	250	300	250	0.0588288	236.266	single	89.375	2500	223.705	223.7051	1.45395	2Ø14
support	E	15.77	250	300	250	0.050464	238.321	single	89.375	2500	190.243	190.2426	1.23647	2Ø14
span	E-F	20.13	250	300	250	0.064416	234.873	single	89.375	2500	246.405	246.4045	1.60149	2Ø14
support	F	2.35	250	300	250	0.00752	248.33	single	89.375	2500	27.2068	27.20677	0.17683	2Ø14
AXis6														
Type														
support	B	24.42	250	300	250	0.078144	231.371	single	89.375	2500	303.441	303.4407	1.97219	2Ø14
span	B-C	29.76	250	300	250	0.095232	226.845	single	89.375	2500	377.174	377.1742	2.45141	3Ø14
support	C	31.94	250	300	250	0.102208	224.938	single	89.375	2500	408.235	408.2348	2.65329	3Ø14
span	C-D	29.09	250	300	250	0.093088	227.424	single	89.375	2500	367.744	367.7442	2.39012	3Ø14
support	D	24.28	250	300	250	0.077696	231.487	single	89.375	2500	301.55	301.5498	1.9599	2Ø14
span	D-E	17.48	250	300	250	0.055936	236.981	single	89.375	2500	212.063	212.0633	1.37829	2Ø14
support	E	15.44	250	300	250	0.049408	238.577	single	89.375	2500	186.061	186.0612	1.20929	2Ø14
span	E-F	19.1	250	300	250	0.06112	235.697	single	89.375	2500	232.979	232.9791	1.51423	2Ø14
support	F	2.15	250	300	250	0.00688	248.473	single	89.375	2500	24.877	24.87697	0.16169	2Ø14
AXis7														
Type														
support	B	16.59	250	300	250	0.053088	237.68	single	89.375	2500	200.674	200.6739	1.30426	2Ø14
span	B-C	20.56	250	300	250	0.065792	234.527	single	89.375	2500	252.039	252.0392	1.63811	2Ø14
support	C	22.21	250	300	250	0.071072	233.189	single	89.375	2500	273.828	273.8279	1.77972	2Ø14
span	C-D	20.77	250	300	250	0.066464	234.358	single	89.375	2500	254.798	254.7975	1.65603	2Ø14
support	D	15.29	250	300	250	0.048928	238.694	single	89.375	2500	184.164	184.1637	1.19696	2Ø14
span	D-E	8.37	250	300	250	0.026784	243.944	single	89.375	2500	98.6445	98.64453	0.64113	2Ø14
support	E	7.33	250	300	250	0.023456	244.713	single	89.375	2500	86.1161	89.375	0.58089	2Ø14
span	E-F	10.69	250	300	250	0.034208	242.21	single	89.375	2500	126.889	126.8888	0.8247	2Ø14
support	F	2.73	250	300	250	0.008736	248.058	single	89.375	2500	31.6408	31.64085	0.20565	2Ø14

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AXisB														
Type														
support	2	18.38	250	300	250	0.058816	236.27	single	89.375	2500	223.653	223.6534	1.45362	2Ø14
span	2-3	2.5	250	300	250	0.008	248.222	single	89.375	2500	28.9559	89.375	0.58089	2Ø14
support	3	8.1	250	300	250	0.02592	244.144	single	89.375	2500	95.3842	95.38419	0.61994	2Ø14
span	3-4	14.06	250	300	250	0.044992	239.645	single	89.375	2500	168.677	168.6768	1.0963	2Ø14
support	4	12.48	250	300	250	0.039936	240.855	single	89.375	2500	148.97	148.9696	0.96822	2Ø14
span	4-5	15.17	250	300	250	0.048544	238.787	single	89.375	2500	182.647	182.647	1.1871	2Ø14
support	5	12.48	250	300	250	0.039936	240.855	single	89.375	2500	148.97	148.9696	0.96822	2Ø14
span	5-6	14.04	250	300	250	0.044928	239.66	single	89.375	2500	168.426	168.426	1.09467	2Ø14
support	6	8.09	250	300	250	0.025888	244.152	single	89.375	2500	95.2635	95.26354	0.61916	2Ø14
	6-7	2.95	250	300	250	0.00944	247.9	single	89.375	2500	34.2124	34.21243	0.22236	2Ø14
	7	16.39	250	300	250	0.052448	237.837	single	89.375	2500	198.124	198.1242	1.28769	2Ø14
AXisC														
Type														
support	2	25.73	250	300	250	0.082336	230.279	single	89.375	2500	321.235	321.2354	2.08784	3Ø14
span	2-3	2.17	250	300	250	0.006944	248.458	single	89.375	2500	25.1098	89.375	0.58089	2Ø14
support	3	11.27	250	300	250	0.036064	241.773	single	89.375	2500	134.015	134.0154	0.87102	2Ø14
span	3-4	18.42	250	300	250	0.058944	236.238	single	89.375	2500	224.17	224.1702	1.45698	2Ø14
support	4	17.25	250	300	250	0.0552	237.162	single	89.375	2500	209.113	209.1132	1.35911	2Ø14
span	4-5	20.03	250	300	250	0.064096	234.953	single	89.375	2500	245.097	245.0967	1.59299	2Ø14
support	5	17.58	250	300	250	0.056256	236.902	single	89.375	2500	213.347	213.3474	1.38663	2Ø14
span	5-6	18.34	250	300	250	0.058688	236.301	single	89.375	2500	223.137	223.1367	1.45026	2Ø14
support	6	11.38	250	300	250	0.036416	241.689	single	89.375	2500	135.37	135.37	0.87983	2Ø14
	6-7	2.8	250	300	250	0.00896	248.007	single	89.375	2500	32.4587	32.45872	0.21096	2Ø14
	7	22.3	250	300	250	0.07136	233.116	single	89.375	2500	275.024	275.0241	1.7875	2Ø14
AXisD														
Type														
support	2	13.75	250	300	250	0.044	239.883	single	89.375	2500	164.794	164.7938	1.07106	2Ø14
span	2-3	0.64	250	300	250	0.002048	249.547	single	89.375	2500	7.37335	89.375	0.58089	2Ø14
support	3	12.08	250	300	250	0.038656	241.159	single	89.375	2500	144.013	144.013	0.936	2Ø14
span	3-4	18.72	250	300	250	0.059904	236	single	89.375	2500	228.051	228.0512	1.4822	2Ø14
support	4	16.79	250	300	250	0.053728	237.524	single	89.375	2500	203.227	203.2272	1.32086	2Ø14
span	4-5	20.34	250	300	250	0.065088	234.704	single	89.375	2500	249.154	249.1541	1.61936	2Ø14
support	5	18.44	250	300	250	0.059008	236.222	single	89.375	2500	224.429	224.4287	1.45866	2Ø14
span	5-6	18.15	250	300	250	0.05808	236.452	single	89.375	2500	220.684	220.6844	1.43432	2Ø14
support	6	11.82	250	300	250	0.037824	241.356	single	89.375	2500	140.798	140.7981	0.91511	2Ø14
	6-7	4.87	250	300	250	0.015584	246.513	single	89.375	2500	56.7972	56.79717	0.36915	2Ø14
	7	11.89	250	300	250	0.038048	241.303	single	89.375	2500	141.663	141.6631	0.92073	2Ø14

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AXisE														
Type														
support	2	0.401	250	300	250	0.0012832	249.717	single	89.375	2500	4.61673	89.375	0.58089	2Ø14
span	2-3	3.38	250	300	250	0.010816	247.59	single	89.375	2500	39.2483	89.375	0.58089	2Ø14
support	3	11.46	250	300	250	0.036672	241.629	single	89.375	2500	136.356	136.3558	0.88623	2Ø14
span	3-4	18.53	250	300	250	0.059296	236.151	single	89.375	2500	225.592	225.5923	1.46622	2Ø14
support	4	18.09	250	300	250	0.057888	236.499	single	89.375	2500	219.911	219.9107	1.42929	2Ø14
span	4-5	20.3	250	300	250	0.06496	234.736	single	89.375	2500	248.63	248.6301	1.61595	2Ø14
support	5	17.91	250	300	250	0.057312	236.642	single	89.375	2500	217.592	217.5916	1.41422	2Ø14
span	5-6	17.91	250	300	250	0.057312	236.642	single	89.375	2500	217.592	217.5916	1.41422	2Ø14
support	6	11.39	250	300	250	0.036448	241.682	single	89.375	2500	135.493	135.4932	0.88063	2Ø14
span	6-7	7.53	250	300	250	0.0241	244.5657	single	89.375	2500	88.51916	89.375	0.580885	2Ø14
support	7	1.51	250	300	250	0.0048	248.9294	single	89.375	2500	17.43969	17.43969	0.113348	2Ø14
AXisF														
Type														
support	2	0.903	250	300	250	0.0028896	249.361	single	89.375	2500	10.4111	89.375	0.58089	2Ø14
span	2-3	4.47	250	300	250	0.014304	246.803	single	89.375	2500	52.0708	89.375	0.58089	2Ø14
support	3	5.09	250	300	250	0.016288	246.353	single	89.375	2500	59.4015	89.375	0.58089	2Ø14
span	3-4	10.05	250	300	250	0.03216	242.691	single	89.375	2500	119.056	119.0557	0.77379	2Ø14
support	4	9.45	250	300	250	0.03024	243.14	single	89.375	2500	111.741	111.7411	0.72625	2Ø14
span	4-5	11.35	250	300	250	0.03632	241.712	single	89.375	2500	135	135.0005	0.87742	2Ø14
support	5	9.46	250	300	250	0.030272	243.133	single	89.375	2500	111.863	111.8628	0.72704	2Ø14
span	5-6	9.98	250	300	250	0.031936	242.743	single	89.375	2500	118.201	118.2009	0.76824	2Ø14
support	6	5.15	250	300	250	0.01648	246.31	single	89.375	2500	60.1123	89.375	0.58089	2Ø14
span	6-7	4.5	250	300	250	0.0144	246.7816	single	89.375	2500	52.4249	89.375	0.580885	2Ø14
support	7	0.8	250	300	250	0.0026	249.4339	single	89.375	2500	9.220879	9.220879	0.05993	2Ø14
G+4 floor Beam reinforcement calculation														
AXisB														
Type														
support	2	4.931	300	400	354	0.006558088	351.939	single	151.866	4248	40.2815	151.866	0.7557	2Ø16
span	2-3	9.42	300	400	354	0.012528328	350.042	single	151.866	4248	77.3693	151.866	0.7557	2Ø16
support	3	19.75	300	400	354	0.026266931	345.594	single	151.866	4248	164.3	164.3002	0.81758	2Ø16
span	3-4	38.67	300	400	354	0.051429985	337.129	single	151.866	4248	329.774	329.7736	1.64099	2Ø16
support	4	27.65	300	400	354	0.036773703	342.113	single	151.866	4248	232.361	232.3614	1.15626	2Ø16
span	4-5	40.79	300	400	354	0.054249524	336.152	single	151.866	4248	348.863	348.8634	1.73598	2Ø16
support	5	27.16	300	400	354	0.036122017	342.331	single	151.866	4248	228.098	228.0982	1.13504	2Ø16
span	5-6	37.6	300	400	354	0.050006916	337.62	single	151.866	4248	320.183	320.1828	1.59327	2Ø16
support	6	18.9	300	400	354	0.025136455	345.965	single	151.866	4248	157.061	157.0607	0.78155	2Ø16
span	6-7	10.66	300	400	354	0.0142	349.514	single	151.866	4248	87.68604	151.866	0.755703	2Ø16
support	7	42.8	300	400	354	0.0569	335.2208	single	151.866	4248	367.0715	367.0715	1.82659	2Ø16

G+4 Residential building project

AXisC														
Type														
support	2	68.34	300	400	354	0.090890229	322.867	single	151.866	4248	608.539	608.5391	3.02816	4Ø16
span	2-3	9.14	300	400	354	0.012155936	350.161	single	151.866	4248	75.0441	151.866	0.7557	2Ø16
support	3	30.34	300	400	354	0.040351325	340.91	single	151.866	4248	255.867	255.8666	1.27322	2Ø16
span	3-4	53.44	300	400	354	0.071073659	330.196	single	151.866	4248	465.3	465.3001	2.31539	3Ø16
support	4	43.43	300	400	354	0.057760648	334.928	single	151.866	4248	372.801	372.8006	1.8551	2Ø16
span	4-5	62.82	300	400	354	0.083548789	325.624	single	151.866	4248	554.65	554.6497	2.76	3Ø16
support	5	43.15	300	400	354	0.057388256	335.058	single	151.866	4248	370.253	370.253	1.84242	2Ø16
span	5-6	49.04	300	400	354	0.065221786	332.293	single	151.866	4248	424.294	424.2937	2.11133	3Ø16
support	6	27.85	300	400	354	0.037039697	342.023	single	151.866	4248	234.103	234.1031	1.16492	2Ø16
span	6-7	11.23	300	400	354	0.0149	349.2709	single	151.866	4248	92.439	151.866	0.755703	2Ø16
support	7	58.97	300	400	354	#REF!	#REF!	single	151.866	4248	#REF!	#REF!	#REF!	3Ø16
AXisD														
Type														
support	2	35.47	300	400	354	0.047174077	338.592	single	151.866	4248	301.177	301.1774	1.49869	2Ø16
span	2-3	2.7	300	400	354	0.003590922	352.875	single	151.866	4248	21.9979	151.866	0.7557	2Ø16
support	3	36.46	300	400	354	0.048490749	338.141	single	151.866	4248	309.997	309.9966	1.54258	2Ø16
span	3-4	58.57	300	400	354	0.077896411	327.713	single	151.866	4248	513.83	513.8303	2.55688	3Ø16
support	4	42.69	300	400	354	0.056776469	335.272	single	151.866	4248	366.072	366.0722	1.82162	2Ø16
span	4-5	64.35	300	400	354	0.085583645	324.865	single	151.866	4248	569.486	569.4858	2.83383	3Ø16

G+4 Residential building project

support	5	47.66	300	400	354	0.063386426	332.946	single	151.866	4248	411.546	411.5463	2.0479	3Ø16
span	5-6	54.68	300	400	354	0.072722823	329.599	single	151.866	4248	476.958	476.9582	2.3734	3Ø16
support	6	32.92	300	400	354	0.043782651	339.748	single	151.866	4248	278.574	278.5739	1.38622	2Ø16
span	6-7	14.43	300	400	354	0.0192	347.8993	single	151.866	4248	119.2479	151.866	0.755703	2Ø16
support	7	30.6	300	400	354	0.0407	340.7933	single	151.866	4248	258.1477	258.1477	1.284572	2Ø16
AXisE														
Type														
support	2	2.45	300	400	354	0.003258429	352.979	single	151.866	4248	19.9551	151.866	0.7557	2Ø16
span	2-3	7.95	300	400	354	0.010573271	350.665	single	151.866	4248	65.1796	151.866	0.7557	2Ø16
support	3	35.41	300	400	354	0.047094279	338.619	single	151.866	4248	300.644	300.6437	1.49604	2Ø16
span	3-4	61.83	300	400	354	0.082232117	326.114	single	151.866	4248	545.09	545.0901	2.71243	3Ø16
support	4	41.7	300	400	354	0.055459798	335.731	single	151.866	4248	357.094	357.0936	1.77694	2Ø16
span	4-5	19.64	300	400	354	0.026120634	345.642	single	151.866	4248	163.362	163.3624	0.81291	2Ø16
support	5	38.5	300	400	354	0.05120389	337.207	single	151.866	4248	328.248	328.2479	1.6334	2Ø16
span	5-6	63.71	300	400	354	0.084732463	325.183	single	151.866	4248	563.271	563.2706	2.8029	3Ø16
support	6	38.05	300	400	354	0.050605403	337.413	single	151.866	4248	324.213	324.2128	1.61332	2Ø16
span	6-7	19.46	300	400	354	0.0259	345.7209	single	151.866	4248	161.8285	161.8285	0.805277	2Ø16
support	7	7.88	300	400	354	0.0105	350.6951	single	151.866	4248	64.60028	64.60028	0.321458	2Ø16

G+4 Residential building project

AXisF														
Type														
support	2	0.241	300	400	354	0.000320523	353.9	single	151.866	4248	1.95783	151.866	0.7557	2Ø16
span	2-3	11.77	300	400	354	0.015653761	349.04	single	151.866	4248	96.948	151.866	0.7557	2Ø16
support	3	15.8	300	400	354	0.021013544	347.309	single	151.866	4248	130.791	151.866	0.7557	2Ø16
span	3-4	34.07	300	400	354	0.045312118	339.228	single	151.866	4248	288.748	288.7477	1.43684	2Ø16
support	4	16.45	300	400	354	0.021878026	347.028	single	151.866	4248	136.282	151.866	0.7557	2Ø16
span	4-5	1.97	300	400	354	0.002620043	353.18	single	151.866	4248	16.0365	151.866	0.7557	2Ø16
support	5	13.98	300	400	354	0.018592997	348.093	single	151.866	4248	115.465	151.866	0.7557	2Ø16
span	5-6	35.13	300	400	354	0.046721887	338.747	single	151.866	4248	298.154	298.1543	1.48365	2Ø16
support	6	17.1	300	400	354	0.022742507	346.747	single	151.866	4248	141.782	151.866	0.7557	2Ø16
span	6-7	11.54	300	400	354	0.0153	349.1385	single	151.866	4248	95.02676	151.866	0.755703	2Ø16
support	7	1.44	300	400	354	0.0019	353.4007	single	151.866	4248	11.71475	11.71475	0.058294	2Ø16
AXis2														
Type														
support	B	45.61	300	400	354	0.060659985	333.909	single	151.866	4248	392.708	392.7077	1.95416	2Ø16
span	B-C	59.52	300	400	354	0.079159884	327.248	single	151.866	4248	522.905	522.9054	2.60204	3Ø16
support	C	51.94	300	400	354	0.069078702	330.914	single	151.866	4248	451.258	451.2579	2.24551	3Ø16
span	C-D	65.69	300	400	354	0.087365806	324.197	single	151.866	4248	582.542	582.5423	2.8988	3Ø16
support	D	30.56	300	400	354	0.040643919	340.811	single	151.866	4248	257.797	257.7966	1.28283	2Ø16
span	E	7.34	300	400	354	0.009761988	350.924	single	151.866	4248	60.1342	151.866	0.7557	2Ø16
support	E-F	31.92	300	400	354	0.04245268	340.2	single	151.866	4248	269.753	269.7534	1.34232	2Ø16
span	F	2.07	300	400	354	0.00275304	353.138	single	151.866	4248	16.8525	16.85248	0.08386	2Ø16
AXis3														
Type														
support	B	66.16	300	400	354	0.087990892	323.962	single	151.866	4248	587.136	587.1359	2.92166	3Ø16
span	B-C	84.66	300	400	354	0.112595359	314.393	single	151.866	4248	774.182	774.1815	3.85242	4Ø16
support	C	78.56	300	400	354	0.104482535	317.621	single	151.866	4248	711.1	711.1001	3.53852	4Ø16
span	C-D	90.74	300	400	354	0.120681584	311.099	single	151.866	4248	838.566	838.5663	4.1728	5Ø16
support	D	61.3	300	400	354	0.081527232	326.375	single	151.866	4248	539.985	539.9852	2.68703	3Ø16
span	D-E	27.65	300	400	354	0.036773703	342.113	single	151.866	4248	232.361	232.3614	1.15626	2Ø16
support	E	32.83	300	400	354	0.043662953	339.789	single	151.866	4248	277.779	277.779	1.38226	2Ø16
span	E-F	59.01	300	400	354	0.078481599	327.498	single	151.866	4248	518.03	518.0301	2.57778	3Ø16
support	F	15.95	300	400	354	0.02121304	347.244	single	151.866	4248	132.058	132.0577	0.65713	2Ø16

G+4 Residential building project

AXis4														
Type														
support	B	71.85	300	400	354	0.095558428	321.087	single	151.866	4248	643.342	643.342	3.20134	4Ø16
span	B-C	88.87	300	400	354	0.118194538	312.121	single	151.866	4248	818.597	818.5966	4.07343	5Ø16
support	C	88.75	300	400	354	0.118034941	312.186	single	151.866	4248	817.32	817.3203	4.06708	5Ø16
span	C-D	105.91	300	400	354	0.140857246	302.505	single	151.866	4248	1006.57	1006.567	5.00879	6Ø16
support	D	72.17	300	400	354	0.095984019	320.924	single	151.866	4248	646.536	646.5363	3.21724	4Ø16
span	D-E	62.59	300	400	354	0.083242895	325.738	single	151.866	4248	552.426	552.426	2.74894	3Ø16
support	E	33.75	300	400	354	0.044886527	339.373	single	151.866	4248	285.913	285.9134	1.42274	2Ø16
span	E-F	28.29	300	400	354	0.037624884	341.827	single	151.866	4248	237.938	237.9382	1.18401	2Ø16
support	F	6.78	300	400	354	0.009017205	351.16	single	151.866	4248	55.5089	55.50885	0.27622	2Ø16
AXis5														
Type														
support	B	70.79	300	400	354	0.094148659	321.627	single	151.866	4248	632.787	632.7866	3.14882	4Ø16
span	B-C	87.42	300	400	354	0.116266079	312.908	single	151.866	4248	803.215	803.2154	3.99689	4Ø16
support	C	82.88	300	400	354	0.11022801	315.343	single	151.866	4248	755.622	755.6221	3.76006	4Ø16
span	C-D	100.23	300	400	354	0.13330301	305.79	single	151.866	4248	942.35	942.3505	4.68924	5Ø16
support	D	69.84	300	400	354	0.092885186	322.109	single	151.866	4248	623.36	623.3599	3.10191	4Ø16
span	D-E	63.14	300	400	354	0.083974379	325.466	single	151.866	4248	557.746	557.7464	2.77541	3Ø16
support	E	33.44	300	400	354	0.044474236	339.513	single	151.866	4248	283.17	283.1702	1.40909	2Ø16
span	E-F	31.3	300	400	354	0.041628098	340.479	single	151.866	4248	264.297	264.297	1.31517	2Ø16
support	F	1.68	300	400	354	0.002234352	353.301	single	151.866	4248	13.6711	13.67108	0.06803	2Ø16
AXis6														
Type														
support	B	65.14	300	400	354	0.086634322	324.472	single	151.866	4248	577.176	577.1761	2.87209	3Ø16
span	B-C	83.13	300	400	354	0.110560503	315.21	single	151.866	4248	758.221	758.2211	3.77299	4Ø16
support	C	73.68	300	400	354	0.097992276	320.15	single	151.866	4248	661.659	661.6588	3.29249	4Ø16
span	C-D	82.79	300	400	354	0.110108313	315.391	single	151.866	4248	754.687	754.6871	3.75541	4Ø16
support	D	60.46	300	400	354	0.080410057	326.788	single	151.866	4248	531.913	531.9127	2.64686	3Ø16
span	D-E	55.73	300	400	354	0.074119293	329.092	single	151.866	4248	486.866	486.8658	2.4227	3Ø16
support	E	36.61	300	400	354	0.048690244	338.072	single	151.866	4248	311.335	311.3351	1.54924	2Ø16
span	E-F	56.23	300	400	354	0.074784279	328.85	single	151.866	4248	491.595	491.5953	2.44623	3Ø16
support	F	16.1	300	400	354	0.021412536	347.179	single	151.866	4248	133.325	151.866	0.7557	2Ø16

G+4 Residential building project

AXis7														
Type														
support	B	44.78	300	400	354	0.059556109	334.298	single	151.866	4248	385.113	385.1132	1.91637	2Ø16
span	B-C	58.58	300	400	354	0.077909711	327.708	single	151.866	4248	513.926	513.9257	2.55735	3Ø16
support	C	50.71	300	400	354	0.067442838	331.5	single	151.866	4248	439.792	439.7919	2.18846	3Ø16
span	C-D	60.28	300	400	354	0.080170662	326.876	single	151.866	4248	530.186	530.1858	2.63827	3Ø16
support	D	37.63	300	400	354	0.050046815	337.606	single	151.866	4248	320.451	320.4513	1.5946	2Ø16
span	D-E	22.61	300	400	354	0.030070648	344.342	single	151.866	4248	188.777	188.7765	0.93937	2Ø16
support	E	14.41	300	400	354	0.019164885	347.908	single	151.866	4248	119.08	151.866	0.7557	2Ø16
span	E-F	26.67	300	400	354	0.035470331	342.548	single	151.866	4248	223.841	223.8406	1.11386	2Ø16
support	F	1.57	300	400	354	0.002088055	353.346	single	151.866	4248	12.7743	12.77429	0.06357	2Ø16

G+4 Residential building project

G+3 floor Beam reinforcement calculation														
AXis2														
Type														
support	B	40.28	400	500	452	0.024644647	441.946	single	258.544	7232	262.034	262.0344	0.8345	2Ø20
span	B-C	60.06	400	500	452	0.036746711	436.833	single	258.544	7232	395.282	395.2825	1.25886	2Ø20
support	C	39.37	400	500	452	0.024087879	442.178	single	258.544	7232	255.98	258.544	0.82339	2Ø20
span	C-D	69.31	400	500	452	0.042406169	434.399	single	258.544	7232	458.717	458.7169	1.46088	2Ø20
support	D	29.19	400	500	452	0.017859415	444.76	single	258.544	7232	188.689	258.544	0.82339	2Ø20
support	E	0.192	400	500	452	0.000117472	451.953	single	258.544	7232	1.22137	258.544	0.82339	2Ø20
span	E-F	31.52	400	500	452	0.019284987	444.172	single	258.544	7232	204.02	258.544	0.82339	2Ø20
support	F	16.35	400	500	452	0.010003475	447.974	single	258.544	7232	104.931	258.544	0.82339	2Ø20
AXis3														
Type														
support	B	62.44	400	500	452	0.038202874	436.21	single	258.544	7232	411.534	411.5338	1.31062	2Ø20
span	B-C	86.55	400	500	452	0.052954176	429.785	single	258.544	7232	578.966	578.9664	1.84384	2Ø20
support	C	70.78	400	500	452	0.043305564	434.01	single	258.544	7232	468.866	468.8661	1.4932	2Ø20
span	C-D	99.55	400	500	452	0.06090801	426.236	single	258.544	7232	671.474	671.4739	2.13845	3Ø20
support	D	58.19	400	500	452	0.035602582	437.322	single	258.544	7232	382.547	382.5472	1.2183	2Ø20
span	D-E	32.47	400	500	452	0.019866229	443.932	single	258.544	7232	210.283	258.544	0.82339	2Ø20
support	E	18.67	400	500	452	0.011422929	447.397	single	258.544	7232	119.975	258.544	0.82339	2Ø20
span	E-F	57.54	400	500	452	0.035204891	437.491	single	258.544	7232	378.127	378.1274	1.20423	2Ø20
support	F	7.51	400	500	452	0.004594868	450.16	single	258.544	7232	47.9635	258.544	0.82339	2Ø20

G+4 Residential building project

AXis4															
Type															
support	B	73.62	400	500	452	0.045043171	433.255	single	258.544	7232	488.528	488.5283	1.55582	2Ø20	
span	B-C	105.91	400	500	452	0.06479927	424.476	single	258.544	7232	717.334	717.3341	2.2845	3Ø20	
support	C	82.99	400	500	452	0.050776049	430.747	single	258.544	7232	553.913	553.9133	1.76405	2Ø20	
span	C-D	103.02	400	500	452	0.063031071	425.278	single	258.544	7232	696.445	696.4449	2.21798	3Ø20	
support	D	62	400	500	452	0.037933667	436.325	single	258.544	7232	408.526	408.5257	1.30104	2Ø20	
span	D-E	65.37	400	500	452	0.039995546	435.439	single	258.544	7232	431.607	431.6071	1.37454	2Ø20	
support	E	27.49	400	500	452	0.016819299	445.188	single	258.544	7232	177.529	258.544	0.82339	2Ø20	
span	E-F	31	400	500	452	0.018966834	444.303	single	258.544	7232	200.595	258.544	0.82339	2Ø20	
support	F	0.035	400	500	452	2.14142E-05	451.991	single	258.544	7232	0.22263	258.544	0.82339	2Ø20	
AXis5															
Type															
support	B	73.96	400	500	452	0.045251194	433.165	single	258.544	7232	490.887	490.887	1.56333	2Ø20	
span	B-C	108.91	400	500	452	0.06663477	423.641	single	258.544	7232	739.108	739.108	2.35385	3Ø20	
support	C	71.45	400	500	452	0.043715493	433.832	single	258.544	7232	473.498	473.4983	1.50796	2Ø20	
span	C-D	94.57	400	500	452	0.05786108	427.603	single	258.544	7232	635.844	635.844	2.02498	3Ø20	
support	D	52.68	400	500	452	0.032231381	438.755	single	258.544	7232	345.193	345.1926	1.09934	2Ø20	
span	D-E	66.84	400	500	452	0.040894941	435.052	single	258.544	7232	441.706	441.7059	1.40671	2Ø20	
support	E	21.85	400	500	452	0.013368559	446.603	single	258.544	7232	140.659	258.544	0.82339	2Ø20	
span	E-F	31.09	400	500	452	0.019021899	444.281	single	258.544	7232	201.188	258.544	0.82339	2Ø20	
support	F	0.68	400	500	452	0.000416047	451.834	single	258.544	7232	4.32681	258.544	0.82339	2Ø20	
AXis6															
Type															
support	B	62.92	400	500	452	0.038496554	436.084	single	258.544	7232	414.817	414.8172	1.32107	2Ø20	
span	B-C	87.41	400	500	452	0.053480353	429.552	single	258.544	7232	585.036	585.0363	1.86317	2Ø20	
support	C	67.7	400	500	452	0.041421118	434.825	single	258.544	7232	447.623	447.6227	1.42555	2Ø20	
span	C-D	83.99	400	500	452	0.051387883	430.477	single	258.544	7232	560.939	560.9388	1.78643	2Ø20	
support	D	46.51	400	500	452	0.028456369	440.349	single	258.544	7232	303.66	303.6599	0.96707	2Ø20	
span	D-E	60.22	400	500	452	0.036844604	436.791	single	258.544	7232	396.373	396.3735	1.26234	2Ø20	
support	E	19.32	400	500	452	0.01182062	447.235	single	258.544	7232	124.197	258.544	0.82339	2Ø20	
span	E-F	55.99	400	500	452	0.034256549	437.895	single	258.544	7232	367.602	367.6022	1.17071	2Ø20	
support	F	11.51	400	500	452	0.007042202	449.173	single	258.544	7232	73.6715	258.544	0.82339	2Ø20	

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Axis7															
Type															
support	B	40.46	400	500	452	0.024754777	441.9	single	258.544	7232	263.233	263.2327	0.83832	2020	
span	B-C	59.24	400	500	452	0.036245007	437.048	single	258.544	7232	389.694	389.6944	1.24106	2020	
support	C	37.96	400	500	452	0.023225194	442.538	single	258.544	7232	246.612	258.544	0.82339	2020	
span	C-D	59.13	400	500	452	0.036177706	437.076	single	258.544	7232	388.945	388.9452	1.23868	2020	
support	D	27.14	400	500	452	0.016605157	445.276	single	258.544	7232	175.234	258.544	0.82339	2020	
span	D-E	26.61	400	500	452	0.016280885	445.41	single	258.544	7232	171.76	258.544	0.82339	2020	
support	E	1.2	400	500	452	0.0007342	451.707	single	258.544	7232	7.6377	258.544	0.82339	2020	
span	E-F	29.17	400	500	452	0.017847179	444.765	single	258.544	7232	188.557	258.544	0.82339	2020	
support	F	11.6	400	500	452	0.007097267	449.151	single	258.544	7232	74.2512	258.544	0.82339	2020	
AXisB															
Type															
support	2	43.67	400	500	452	0.026718762	441.078	single	258.544	7232	284.646	284.6462	0.90652	2020	
span	2-3	15.86	400	500	452	0.009703677	448.096	single	258.544	7232	101.758	258.544	0.82339	2020	
support	3	10.98	400	500	452	0.00671793	449.304	single	258.544	7232	70.2586	258.544	0.82339	2020	
span	3-4	40.39	400	500	452	0.024711949	441.918	single	258.544	7232	262.767	262.7667	0.83684	2020	
support	4	17.63	400	500	452	0.010786622	447.656	single	258.544	7232	113.226	258.544	0.82339	2020	
span	4-5	52.06	400	500	452	0.031852044	438.916	single	258.544	7232	341.005	341.0051	1.086	2020	
support	5	17.2	400	500	452	0.010523534	447.763	single	258.544	7232	110.438	258.544	0.82339	2020	
span	5-6	40.38	400	500	452	0.024705831	441.92	single	258.544	7232	262.7	262.7001	0.83662	2020	
support	6	10.14	400	500	452	0.00620399	449.512	single	258.544	7232	64.8537	258.544	0.82339	2020	
span	6-7	15.91	400	500	452	0.009734269	448.083	single	258.544	7232	102.082	258.544	0.82339	2020	
support	7	37.61	400	500	452	0.023011052	442.627	single	258.544	7232	244.289	258.544	0.82339	2020	
AXisC															
Type															
support	2	61.46	400	500	452	0.037603277	436.467	single	258.544	7232	404.836	404.8362	1.28929	2020	
span	2-3	16.44	400	500	452	0.01005854	447.951	single	258.544	7232	105.514	258.544	0.82339	2020	
support	3	24.25	400	500	452	0.014836959	446.002	single	258.544	7232	156.319	258.544	0.82339	2020	
span	3-4	57.27	400	500	452	0.035039696	437.562	single	258.544	7232	376.293	376.2925	1.19838	2020	
support	4	29.58	400	500	452	0.01809803	444.662	single	258.544	7232	191.252	258.544	0.82339	2020	
span	4-5	67.13	400	500	452	0.041072373	434.975	single	258.544	7232	443.7	443.7004	1.41306	2020	
support	5	31.14	400	500	452	0.01905249	444.268	single	258.544	7232	201.517	258.544	0.82339	2020	
span	5-6	52.83	400	500	452	0.032323156	438.716	single	258.544	7232	346.206	346.2061	1.10257	2020	
support	6	21.32	400	500	452	0.013044287	446.735	single	258.544	7232	137.206	137.2065	0.43696	2020	
span	6-7	15.5	400	500	452	0.009483417	448.185	single	258.544	7232	99.42882	99.42882	0.31665	2020	
support	7	52.64	400	500	452	0.032206907	438.765	single	258.544	7232	344.9223	344.9223	1.09848	2020	

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AXisC														
Type														
support	2	61.46	400	500	452	0.037603277	436.467	single	258.544	7232	404.836	404.8362	1.28929	2020
span	2-3	16.44	400	500	452	0.01005854	447.951	single	258.544	7232	105.514	258.544	0.82339	2020
support	3	24.25	400	500	452	0.014836959	446.002	single	258.544	7232	156.319	258.544	0.82339	2020
span	3-4	57.27	400	500	452	0.035039696	437.562	single	258.544	7232	376.293	376.2925	1.19838	2020
support	4	29.58	400	500	452	0.01809803	444.662	single	258.544	7232	191.252	258.544	0.82339	2020
span	4-5	67.13	400	500	452	0.041072373	434.975	single	258.544	7232	443.7	443.7004	1.41306	2020
support	5	31.14	400	500	452	0.01905249	444.268	single	258.544	7232	201.517	258.544	0.82339	2020
span	5-6	52.83	400	500	452	0.032323156	438.716	single	258.544	7232	346.206	346.2061	1.10257	2020
support	6	21.32	400	500	452	0.013044287	446.735	single	258.544	7232	137.206	137.2065	0.43696	2020
span	6-7	15.5	400	500	452	0.009483417	448.185	single	258.544	7232	99.42882	99.42882	0.31665	2020
support	7	52.64	400	500	452	0.032206907	438.765	single	258.544	7232	344.9223	344.9223	1.09848	2020
AXisD														
Type														
support	2	33.21	400	500	452	0.020318985	443.744	single	258.544	7232	215.166	258.544	0.82339	2020
span	2-3	7.64	400	500	452	0.004674407	450.128	single	258.544	7232	48.7973	258.544	0.82339	2020
support	3	37.45	400	500	452	0.022913159	442.667	single	258.544	7232	243.227	258.544	0.82339	2020
span	3-4	64	400	500	452	0.039157334	435.8	single	258.544	7232	422.212	422.2121	1.34462	2020
support	4	33.84	400	500	452	0.02070444	443.585	single	258.544	7232	219.327	258.544	0.82339	2020
span	4-5	63.13	400	500	452	0.038625039	436.029	single	258.544	7232	416.254	416.2543	1.32565	2020
support	5	39.27	400	500	452	0.024026696	442.204	single	258.544	7232	255.315	258.544	0.82339	2020
span	5-6	54.9	400	500	452	0.033589651	438.179	single	258.544	7232	360.213	360.2125	1.14717	2020
support	6	25.05	400	500	452	0.015326425	445.801	single	258.544	7232	161.549	161.5489	0.51449	2020
span	6-7	17.82	400	500	452	0.01090287	447.608	single	258.544	7232	114.4583	114.4583	0.36452	2020
support	7	28.42	400	500	452	0.017388304	444.954	single	258.544	7232	183.6313	258.544	0.82339	2020
AXisE														
Type														
support	2	10.17	400	500	452	0.006222345	449.504	single	258.544	7232	65.0467	258.544	0.82339	2020
span	2-3	22.76	400	500	452	0.013925327	446.375	single	258.544	7232	146.592	258.544	0.82339	2020
support	3	28.8	400	500	452	0.0176208	444.858	single	258.544	7232	186.127	258.544	0.82339	2020
span	3-4	65.17	400	500	452	0.039873179	435.492	single	258.544	7232	430.235	430.2346	1.37017	2020
support	4	25.36	400	500	452	0.015516094	445.724	single	258.544	7232	163.577	258.544	0.82339	2020
span	4-5	29.06	400	500	452	0.017779877	444.793	single	258.544	7232	187.835	258.544	0.82339	2020
support	5	31.23	400	500	452	0.019107555	444.245	single	258.544	7232	202.11	258.544	0.82339	2020
span	5-6	64.11	400	500	452	0.039224636	435.771	single	258.544	7232	422.966	422.9659	1.34703	2020
support	6	24.06	400	500	452	0.01472071	446.05	single	258.544	7232	155.078	155.078	0.49388	2020
span	6-7	24.54	400	500	452	0.01501439	445.929	single	258.544	7232	158.2145	158.2145	0.50387	2020
support	7	15.28	400	500	452	0.009348814	448.24	single	258.544	7232	98.00563	258.544	0.82339	2020
AXisF														
Type														
support	2	1.53	400	500	452	0.000936105	451.626	single	258.544	7232	9.7398	258.544	0.82339	2020
span	2-3	14.46	400	500	452	0.00884711	448.443	single	258.544	7232	92.7041	258.544	0.82339	2020

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span	4-5	61.32	400	500	452	0.037517621	436.503	single	258.544	7232	403.88	403.8801	1.28624	2020
support	5	29.34	400	500	452	0.01795119	444.722	single	258.544	7232	189.675	258.544	0.82339	2020
span	5-6	57.44	400	500	452	0.035143707	437.517	single	258.544	7232	377.448	377.4478	1.20206	2020
support	6	24.19	400	500	452	0.014800249	446.017	single	258.544	7232	155.927	258.544	0.82339	2020
span	6-7	21.88	400	500	452	0.013386914	446.595	single	258.544	7232	140.8545	258.544	0.82339	2020
support	7	28.86	400	500	452	0.01765751	444.843	single	258.544	7232	186.5207	186.5207	0.59402	2020
AXisE														
Type														
support	2	7.5	400	500	452	0.00458875	450.162	single	258.544	7232	47.8994	258.544	0.82339	2020
span	2-3	28.93	400	500	452	0.017700339	444.826	single	258.544	7232	186.981	258.544	0.82339	2020
support	3	28.93	400	500	452	0.017700339	444.826	single	258.544	7232	186.981	258.544	0.82339	2020
span	3-4	63.15	400	500	452	0.038637276	436.023	single	258.544	7232	416.391	416.3912	1.32609	2020
support	4	21.4	400	500	452	0.013093234	446.715	single	258.544	7232	137.727	258.544	0.82339	2020
span	4-5	30.94	400	500	452	0.018930124	444.318	single	258.544	7232	200.2	258.544	0.82339	2020
support	5	26.92	400	500	452	0.016470554	445.332	single	258.544	7232	173.792	258.544	0.82339	2020
span	5-6	63	400	500	452	0.038545501	436.063	single	258.544	7232	415.365	415.3646	1.32282	2020
support	6	24.39	400	500	452	0.014922615	445.967	single	258.544	7232	157.234	258.544	0.82339	2020
span	6-7	25.06	400	500	452	0.015332544	445.799	single	258.544	7232	161.6143	161.6143	0.5147	2020
support	7	12.3	400	500	452	0.00752555	448.978	single	258.544	7232	78.76222	78.76222	0.25084	2020
AXisF														
Type														
support	2	1.03	400	500	452	0.000630188	451.748	single	258.544	7232	6.55509	258.544	0.82339	2020
span	2-3	17.83	400	500	452	0.010908989	447.606	single	258.544	7232	114.523	258.544	0.82339	2020
support	3	17.83	400	500	452	0.010908989	447.606	single	258.544	7232	114.523	258.544	0.82339	2020
span	3-4	35.36	400	500	452	0.021634427	443.199	single	258.544	7232	229.378	258.544	0.82339	2020
support	4	6.78	400	500	452	0.00414823	450.339	single	258.544	7232	43.284	258.544	0.82339	2020
span	4-5	4.47	400	500	452	0.002734895	450.906	single	258.544	7232	28.5009	258.544	0.82339	2020
support	5	6.9	400	500	452	0.00422165	450.31	single	258.544	7232	44.053	258.544	0.82339	2020
span	5-6	35.45	400	500	452	0.021689492	443.176	single	258.544	7232	229.974	258.544	0.82339	2020
support	6	18.07	400	500	452	0.011055829	447.546	single	258.544	7232	116.08	116.0802	0.36968	2020
span	6-7	18.26	400	500	452	0.011172077	447.499	single	258.544	7232	117.3132	117.3132	0.37361	2020
support	7	0.28	400	500	452	0.000171313	451.932	single	258.544	7232	1.781243	258.544	0.82339	2020
AXis2														
Type														
support	B	37.51	400	500	452	0.022949869	442.652	single	258.544	7232	243.625	258.544	0.82339	2020
span	B-C	60.54	400	500	452	0.037040391	436.708	single	258.544	7232	398.556	398.5562	1.26929	2020
support	C	36.17	400	500	452	0.022130012	442.993	single	258.544	7232	234.741	258.544	0.82339	2020
span	C-D	68.66	400	500	452	0.042008478	434.571	single	258.544	7232	454.235	454.2351	1.44661	2020
support	D	26.64	400	500	452	0.01629924	445.402	single	258.544	7232	171.957	258.544	0.82339	2020
support	E	4.17	400	500	452	0.002551345	450.98	single	258.544	7232	26.5838	258.544	0.82339	2020
span	E-F	30.66	400	500	452	0.01875881	444.389	single	258.544	7232	198.357	258.544	0.82339	2020
support	F	21.35	400	500	452	0.013062642	446.728	single	258.544	7232	137.402	258.544	0.82339	2020

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AXis3														
Type														
support	B	59.97	400	500	452	0.036691646	436.857	single	258.544	7232	394.669	394.6689	1.25691	2Ø20
span	B-C	86.01	400	500	452	0.052623786	429.931	single	258.544	7232	575.159	575.1586	1.83172	2Ø20
support	C	67.35	400	500	452	0.041206976	434.917	single	258.544	7232	445.214	445.2139	1.41788	2Ø20
span	C-D	98.21	400	500	452	0.060088153	426.605	single	258.544	7232	661.863	661.8629	2.10784	3Ø20
support	D	54.07	400	500	452	0.033081829	438.394	single	258.544	7232	354.592	354.5922	1.12927	2Ø20
span	D-E	33.63	400	500	452	0.020575955	443.638	single	258.544	7232	217.94	258.544	0.82339	2Ø20
support	E	14	400	500	452	0.008565667	448.557	single	258.544	7232	89.7322	258.544	0.82339	2Ø20
span	E-F	56.22	400	500	452	0.034397271	437.835	single	258.544	7232	369.163	369.1627	1.17568	2Ø20
support	F	2.96	400	500	452	0.001811027	451.276	single	258.544	7232	18.8576	258.544	0.82339	2Ø20
AXis4														
Type														
support	B	68.21	400	500	452	0.041733153	434.69	single	258.544	7232	451.135	451.1345	1.43673	2Ø20
span	B-C	96.19	400	500	452	0.05885225	427.159	single	258.544	7232	647.408	647.4079	2.06181	3Ø20
support	C	73.06	400	500	452	0.044700544	433.404	single	258.544	7232	484.646	484.6456	1.54346	2Ø20
span	C-D	103.67	400	500	452	0.063428763	425.098	single	258.544	7232	701.136	701.1358	2.23292	3Ø20
support	D	57	400	500	452	0.034874501	437.632	single	258.544	7232	374.458	374.4583	1.19254	2Ø20
span	D-E	64.93	400	500	452	0.039726339	435.555	single	258.544	7232	428.588	428.588	1.36493	2Ø21
support	E	17.3	400	500	452	0.010584717	447.738	single	258.544	7232	111.086	258.544	0.82339	2Ø20
span	E-F	31.26	400	500	452	0.01912591	444.238	single	258.544	7232	202.307	258.544	0.82339	2Ø20
support	F	3.99	400	500	452	0.002441215	451.024	single	258.544	7232	25.4338	258.544	0.82339	2Ø20
AXis5														
Type														
support	B	68.15	400	500	452	0.041696443	434.706	single	258.544	7232	450.721	450.7213	1.43542	2Ø20
span	B-C	96.4	400	500	452	0.058980735	427.102	single	258.544	7232	648.909	648.9087	2.06659	3Ø20
support	C	66.04	400	500	452	0.040405474	435.263	single	258.544	7232	436.208	436.2076	1.3892	2Ø20
span	C-D	95.59	400	500	452	0.05848515	427.324	single	258.544	7232	643.122	643.122	2.04816	3Ø20
support	D	48.93	400	500	452	0.029937006	439.725	single	258.544	7232	319.913	319.913	1.01883	2Ø20
span	D-E	65.77	400	500	452	0.040240279	435.334	single	258.544	7232	434.353	434.3532	1.38329	2Ø20
support	E	17.11	400	500	452	0.010468469	447.785	single	258.544	7232	109.855	258.544	0.82339	2Ø20
span	E-F	30.4	400	500	452	0.018599734	444.455	single	258.544	7232	196.645	196.6454	0.62626	2Ø20
AXis6														
Type														
support	B	60.37	400	500	452	0.036936379	436.752	single	258.544	7232	397.397	397.3965	1.26559	2Ø20
span	B-C	86.43	400	500	452	0.052880756	429.818	single	258.544	7232	578.12	578.12	1.84115	2Ø20
support	C	58.45	400	500	452	0.035761659	437.254	single	258.544	7232	384.316	384.3161	1.22394	2Ø20
span	C-D	83.14	400	500	452	0.050867824	430.706	single	258.544	7232	554.967	554.9665	1.76741	2Ø20
support	D	41.07	400	500	452	0.025127996	441.744	single	258.544	7232	267.296	267.2957	0.85126	2Ø20
span	D-E	59.71	400	500	452	0.036532569	436.925	single	258.544	7232	392.897	392.8966	1.25126	2Ø20
support	E	14.54	400	500	452	0.008896057	448.423	single	258.544	7232	93.2211	258.544	0.82339	2Ø20
span	E-F	54.94	400	500	452	0.033614124	438.168	single	258.544	7232	360.484	360.4835	1.14804	2Ø20
support	F	7.1	400	500	452	0.004344017	450.261	single	258.544	7232	45.3349	258.544	0.82339	2Ø20

G+4 Residential building project

AXis7															
Type															
support	B	37.56	400	500	452	0.02298046	442.639	single	258.544	7232	243.957	258.544	0.82339	2Ø20	
span	B-C	59.52	400	500	452	0.036416321	436.974	single	258.544	7232	391.602	391.6019	1.24714	2Ø20	
support	C	34.35	400	500	452	0.021016475	443.455	single	258.544	7232	222.697	258.544	0.82339	2Ø20	
span	C-D	59.54	400	500	452	0.036428557	436.969	single	258.544	7232	391.738	391.7382	1.24757	2Ø20	
support	D	22.76	400	500	452	0.013925327	446.375	single	258.544	7232	146.592	258.544	0.82339	2Ø20	
span	D-E	26.74	400	500	452	0.016360424	445.377	single	258.544	7232	172.612	258.544	0.82339	2Ø20	
support	E	7.7	400	500	452	0.004711117	450.113	single	258.544	7232	49.1821	258.544	0.82339	2Ø20	
span	E-F	28.68	400	500	452	0.01754738	444.889	single	258.544	7232	185.339	258.544	0.82339	2Ø20	
support	F	16.15	400	500	452	0.009881109	448.024	single	258.544	7232	103.636	103.6357	0.33005	2Ø20	
						G+1 Floor Beam Reinforcement									
AXisB															
Type															
support	2	44.4	400	500	452	0.027165401	440.891	single	258.544	7232	289.527	289.5274	0.92206	2Ø20	
span	2-3	22.1	400	500	452	0.013521517	446.54	single	258.544	7232	142.288	258.544	0.82339	2Ø20	
support	3	21.87	400	500	452	0.013380795	446.598	single	258.544	7232	140.789	258.544	0.82339	2Ø20	
span	3-4	41.14	400	500	452	0.025170824	441.726	single	258.544	7232	267.762	267.7621	0.85275	2Ø20	
support	4	9.56	400	500	452	0.005849127	449.655	single	258.544	7232	61.1247	258.544	0.82339	2Ø20	
span	4-5	45.99	400	500	452	0.028138216	440.482	single	258.544	7232	300.174	300.1737	0.95597	2Ø20	
support	5	9.08	400	500	452	0.005555447	449.773	single	258.544	7232	58.0404	258.544	0.82339	2Ø20	
span	5-6	41.14	400	500	452	0.025170824	441.726	single	258.544	7232	267.762	267.7621	0.85275	2Ø20	
support	6	21.98	400	500	452	0.013448097	446.57	single	258.544	7232	141.506	258.544	0.82339	2Ø20	
span	6-7	38.24	400	500	452	0.023396507	442.466	single	258.544	7232	248.4709	248.4709	0.79131	2Ø20	
support	7	38.24	400	500	452	0.023396507	442.466	single	258.544	7232	248.4709	248.4709	0.79131	2Ø20	
AXisC															
Type															
support	2	62.5	400	500	452	0.038239584	436.194	single	258.544	7232	411.944	411.9441	1.31192	2Ø20	
span	2-3	20.21	400	500	452	0.012365152	447.013	single	258.544	7232	129.982	258.544	0.82339	2Ø20	
support	3	17.56	400	500	452	0.010743794	447.673	single	258.544	7232	112.772	258.544	0.82339	2Ø20	
span	3-4	57.04	400	500	452	0.034898974	437.622	single	258.544	7232	374.73	374.73	1.19341	2Ø20	
support	4	21.94	400	500	452	0.013423624	446.58	single	258.544	7232	141.246	258.544	0.82339	2Ø20	
span	4-5	61.16	400	500	452	0.037419727	436.545	single	258.544	7232	402.788	402.7876	1.28276	2Ø20	
support	5	22.57	400	500	452	0.013809079	446.423	single	258.544	7232	145.353	258.544	0.82339	2Ø20	
span	5-6	52.72	400	500	452	0.032255854	438.745	single	258.544	7232	345.463	345.4628	1.1002	2Ø20	
support	6	17.21	400	500	452	0.010529652	447.76	single	258.544	7232	110.503	258.544	0.82339	2Ø20	
span	6-7	19.87	400	500	452	0.012157129	447.097	single	258.544	7232	127.7714	127.7714	0.40692	2Ø20	
support	7	53.53	400	500	452	0.032751439	438.535	single	258.544	7232	350.9386	350.9386	1.11764	2Ø20	
AXisD															
Type															
support	2	33.73	400	500	452	0.020637139	443.612	single	258.544	7232	218.6	258.544	0.82339	2Ø20	

G+4 Residential building project

span	2-3	22.19	400	500	452	0.013576582	446.518	single	258.544	7232	142.875	258.544	0.82339	2Ø20
support	3	22.19	400	500	452	0.013576582	446.518	single	258.544	7232	142.875	258.544	0.82339	2Ø20
span	3-4	63.59	400	500	452	0.038906482	435.908	single	258.544	7232	419.404	419.4036	1.33568	2Ø20
support	4	26.61	400	500	452	0.016280885	445.41	single	258.544	7232	171.76	258.544	0.82339	2Ø20
span	4-5	60.7	400	500	452	0.037138284	436.666	single	258.544	7232	399.648	399.6478	1.27276	2Ø20
support	5	25.77	400	500	452	0.015766945	445.621	single	258.544	7232	166.26	258.544	0.82339	2Ø20
span	5-6	57.44	400	500	452	0.035143707	437.517	single	258.544	7232	377.448	377.4478	1.20206	2Ø20
support	6	20.79	400	500	452	0.012720015	446.868	single	258.544	7232	133.756	258.544	0.82339	2Ø20
span	6-7	20.79	400	500	452	0.012720015	446.868	single	258.544	7232	133.756	258.544	0.82339	2Ø20
support	7	28.86	400	500	452	0.01765751	444.843	single	258.544	7232	186.5207	186.5207	0.59402	2Ø20
AXisE														
Type														
support	2	3.72	400	500	452	0.00227602	451.09	single	258.544	7232	23.7092	258.544	0.82339	2Ø20
span	2-3	24.44	400	500	452	0.014953207	445.954	single	258.544	7232	157.561	258.544	0.82339	2Ø20
support	3	24.45	400	500	452	0.014959325	445.952	single	258.544	7232	157.626	258.544	0.82339	2Ø20
span	3-4	62.99	400	500	452	0.038539382	436.065	single	258.544	7232	415.296	415.2962	1.3226	2Ø20
support	4	23.43	400	500	452	0.014335255	446.208	single	258.544	7232	150.964	258.544	0.82339	2Ø20
span	4-5	35.17	400	500	452	0.021518179	443.247	single	258.544	7232	228.12	258.544	0.82339	2Ø20
support	5	26.79	400	500	452	0.016391015	445.364	single	258.544	7232	172.94	258.544	0.82339	2Ø20
span	5-6	62.86	400	500	452	0.038459844	436.099	single	258.544	7232	414.407	414.4067	1.31977	2Ø20
support	6	22.22	400	500	452	0.013594937	446.51	single	258.544	7232	143.071	258.544	0.82339	2Ø20
span	6-7	22.22	400	500	452	0.013594937	446.51	single	258.544	7232	143.0706	143.0706	0.45564	2Ø20
support	7	0.68	400	500	452	0.000416047	451.834	single	258.544	7232	4.32681	4.32681	0.01378	2Ø20
AXisF														
Type														
support	2	8.24	400	500	452	0.005041507	449.98	single	258.544	7232	52.6468	258.544	0.82339	2Ø20
span	2-3	17.64	400	500	452	0.01079274	447.653	single	258.544	7232	113.291	258.544	0.82339	2Ø20
support	3	17.64	400	500	452	0.01079274	447.653	single	258.544	7232	113.291	258.544	0.82339	2Ø20
span	3-4	35.4	400	500	452	0.0216589	443.189	single	258.544	7232	229.643	258.544	0.82339	2Ø20
support	4	5.28	400	500	452	0.00323048	450.708	single	258.544	7232	33.6804	258.544	0.82339	2Ø20
span	4-5	5.28	400	500	452	0.00323048	450.708	single	258.544	7232	33.6804	258.544	0.82339	2Ø20
support	5	5.17	400	500	452	0.003163178	450.735	single	258.544	7232	32.9767	258.544	0.82339	2Ø20
span	5-6	35.49	400	500	452	0.021713965	443.166	single	258.544	7232	230.238	258.544	0.82339	2Ø20
support	6	17.56	400	500	452	0.010743794	447.673	single	258.544	7232	112.772	112.772	0.35915	2Ø20
span	6-7	17.56	400	500	452	0.010743794	447.673	single	258.544	7232	112.772	112.772	0.35915	2Ø20
support	7	8.33	400	500	452	0.005096572	449.958	single	258.544	7232	53.22444	258.544	0.82339	2Ø20
AXis2														
Type														
support	B	35.88	400	500	452	0.02195258	443.067	single	258.544	7232	232.82	258.544	0.82339	2Ø20
span	B-C	60.59	400	500	452	0.037070982	436.694	single	258.544	7232	398.897	398.8973	1.27037	2Ø20
support	C	35.42	400	500	452	0.021671137	443.184	single	258.544	7232	229.775	258.544	0.82339	2Ø20

G+4 Residential building project

span	C-D	69.55	400	500	452	0.042553009	434.336	single	258.544	7232	460.373	460.3726	1.46615	2020
support	D	19.48	400	500	452	0.011918514	447.195	single	258.544	7232	125.236	258.544	0.82339	2020
support	E	10.32	400	500	452	0.00631412	449.467	single	258.544	7232	66.0115	258.544	0.82339	2020
span	E-F	33.43	400	500	452	0.020453589	443.688	single	258.544	7232	216.619	258.544	0.82339	2020
support	F	26.32	400	500	452	0.016103454	445.483	single	258.544	7232	169.861	258.544	0.82339	2020
AXis3														
Type														
support	B	52.76	400	500	452	0.032280327	438.734	single	258.544	7232	345.733	345.7331	1.10106	2020
span	B-C	86.19	400	500	452	0.052733916	429.883	single	258.544	7232	576.428	576.4276	1.83576	2020
support	C	65.26	400	500	452	0.039928244	435.468	single	258.544	7232	430.852	430.8522	1.37214	2020
span	C-D	98.81	400	500	452	0.060455253	426.44	single	258.544	7232	666.164	666.1641	2.12154	3020
support	D	49.99	400	500	452	0.030585549	439.451	single	258.544	7232	327.047	327.047	1.04155	2020
span	D-E	32.56	400	500	452	0.019921294	443.909	single	258.544	7232	210.877	258.544	0.82339	2020
support	E	11.48	400	500	452	0.007023847	449.181	single	258.544	7232	73.4782	258.544	0.82339	2020
span	E-F	57.34	400	500	452	0.035082524	437.544	single	258.544	7232	376.768	376.7682	1.1999	2020
support	F	4.26	400	500	452	0.00260641	450.958	single	258.544	7232	27.1589	258.544	0.82339	2020
AXis4														
Type														
support	B	60.67	400	500	452	0.037119929	436.674	single	258.544	7232	399.443	399.4431	1.27211	2020
span	B-C	96.95	400	500	452	0.059317243	426.951	single	258.544	7232	652.842	652.8417	2.07911	3020
support	C	68.17	400	500	452	0.041708679	434.701	single	258.544	7232	450.859	450.859	1.43586	2020
span	C-D	103.03	400	500	452	0.06303719	425.275	single	258.544	7232	696.517	696.5171	2.21821	3020
support	D	52.43	400	500	452	0.032078422	438.82	single	258.544	7232	343.504	343.5037	1.09396	2020
span	D-E	65.27	400	500	452	0.039934363	435.466	single	258.544	7232	430.921	430.9208	1.37236	2021
support	E	13.54	400	500	452	0.008284224	448.671	single	258.544	7232	86.7618	258.544	0.82339	2020
span	E-F	33.75	400	500	452	0.020649375	443.607	single	258.544	7232	218.732	258.544	0.82339	2020
support	F	11.29	400	500	452	0.006907598	449.228	single	258.544	7232	72.2546	258.544	0.82339	2020
AXis5														
Type														
support	B	60.78	400	500	452	0.037187231	436.645	single	258.544	7232	400.194	400.1938	1.2745	2020
span	B-C	97.38	400	500	452	0.059580331	426.833	single	258.544	7232	655.919	655.9186	2.08891	3020
support	C	62.85	400	500	452	0.038453726	436.102	single	258.544	7232	414.338	414.3383	1.31955	2020
span	C-D	95.24	400	500	452	0.058271008	427.42	single	258.544	7232	640.623	640.6235	2.0402	3020
support	D	46.01	400	500	452	0.028150452	440.477	single	258.544	7232	300.308	300.3077	0.95639	2020
span	D-E	65.66	400	500	452	0.040172978	435.363	single	258.544	7232	433.598	433.5979	1.38089	2020
support	E	14.02	400	500	452	0.008577904	448.552	single	258.544	7232	89.8614	258.544	0.82339	2020
span	E-F	34.07	400	500	452	0.020845162	443.526	single	258.544	7232	220.847	220.8466	0.70333	2020
AXis6		12.17												
Type														
support	B	53.43	400	500	452	0.032690256	438.561	single	258.544	7232	350.262	350.2623	1.11549	2020
span	B-C	86.98	400	500	452	0.053217264	429.669	single	258.544	7232	582	582.0005	1.8535	2020
support	C	55.41	400	500	452	0.033901686	438.046	single	258.544	7232	363.669	363.6688	1.15818	2020

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span	6-7	22.05	400	500	452	0.013490925	446.553	single	258.544	7232	141.9624	141.9624	0.45211	2Ø20
support	7	20.06	400	500	452	0.012273377	447.05	single	258.544	7232	129.0068	129.0068	0.41085	2Ø20
AXisD														
Type														
support	2	15.31	400	500	452	0.009367169	448.232	single	258.544	7232	98.1997	258.544	0.82339	2Ø20
span	2-3	28.29	400	500	452	0.017308765	444.987	single	258.544	7232	182.778	258.544	0.82339	2Ø20
support	3	25.29	400	500	452	0.015473265	445.741	single	258.544	7232	163.119	258.544	0.82339	2Ø20
span	3-4	16.81	400	500	452	0.010284919	447.86	single	258.544	7232	107.911	258.544	0.82339	2Ø20
support	4	3.61	400	500	452	0.002208718	451.117	single	258.544	7232	23.0068	258.544	0.82339	2Ø20
span	4-5	21.76	400	500	452	0.013313494	446.625	single	258.544	7232	140.073	258.544	0.82339	2Ø20
support	5	4.53	400	500	452	0.002771605	450.892	single	258.544	7232	28.8844	258.544	0.82339	2Ø20
span	5-6	21.41	400	500	452	0.013099352	446.713	single	258.544	7232	137.793	258.544	0.82339	2Ø20
support	6	22.08	400	500	452	0.01350928	446.545	single	258.544	7232	142.158	258.544	0.82339	2Ø20
span	6-7	22.08	400	500	452	0.01350928	446.545	single	258.544	7232	142.158	258.544	0.82339	2Ø20
support	7	14.36	400	500	452	0.008785927	448.468	single	258.544	7232	92.0579	92.0579	0.29318	2Ø20
AXisE														
Type														
support	2	12.26	400	500	452	0.007501077	448.988	single	258.544	7232	78.5044	258.544	0.82339	2Ø20
span	2-3	24.93	400	500	452	0.015253005	445.832	single	258.544	7232	160.764	258.544	0.82339	2Ø20
support	3	24.93	400	500	452	0.015253005	445.832	single	258.544	7232	160.764	258.544	0.82339	2Ø20
span	3-4	21.52	400	500	452	0.013166654	446.685	single	258.544	7232	138.509	258.544	0.82339	2Ø20
support	4	5.49	400	500	452	0.003358965	450.656	single	258.544	7232	35.0239	258.544	0.82339	2Ø20
span	4-5	30.64	400	500	452	0.018746574	444.394	single	258.544	7232	198.225	258.544	0.82339	2Ø20
support	5	3.67	400	500	452	0.002245428	451.103	single	258.544	7232	23.3899	258.544	0.82339	2Ø20
span	5-6	20.73	400	500	452	0.012683305	446.883	single	258.544	7232	133.365	258.544	0.82339	2Ø20
support	6	22.24	400	500	452	0.013607174	446.505	single	258.544	7232	143.201	258.544	0.82339	2Ø20
span	6-7	22.24	400	500	452	0.013607174	446.505	single	258.544	7232	143.2009	143.2009	0.45605	2Ø20
support	7	10.94	400	500	452	0.006693457	449.314	single	258.544	7232	70.00114	70.00114	0.22293	2Ø20
AXisF														
Type														
support	2	13.42	400	500	452	0.008210804	448.701	single	258.544	7232	85.9872	258.544	0.82339	2Ø20
span	2-3	19.41	400	500	452	0.011875685	447.212	single	258.544	7232	124.781	258.544	0.82339	2Ø20
support	3	19.41	400	500	452	0.011875685	447.212	single	258.544	7232	124.781	258.544	0.82339	2Ø20
span	3-4	14.64	400	500	452	0.00895724	448.398	single	258.544	7232	93.8674	258.544	0.82339	2Ø20
support	4	6.4	400	500	452	0.003915733	450.433	single	258.544	7232	40.8496	258.544	0.82339	2Ø20
span	4-5	5.67	400	500	452	0.003469095	450.612	single	258.544	7232	36.1758	258.544	0.82339	2Ø20
support	5	6.68	400	500	452	0.004087047	450.364	single	258.544	7232	42.6433	258.544	0.82339	2Ø20
span	5-6	13.82	400	500	452	0.008455537	448.602	single	258.544	7232	88.5697	258.544	0.82339	2Ø20
support	6	18.65	400	500	452	0.011410692	447.402	single	258.544	7232	119.845	119.8448	0.38167	2Ø20
span	6-7	18.65	400	500	452	0.011410692	447.402	single	258.544	7232	119.8448	119.8448	0.38167	2Ø20
support	7	14.51	400	500	452	0.008877702	448.431	single	258.544	7232	93.02722	258.544	0.82339	2Ø20

G+4 Residential building project

AXis2														
Type														
support	B	14.5	400	500	452	0.008871584	448.433	single	258.544	7232	92.9626	258.544	0.82339	2020
span	B-C	25.11	400	500	452	0.015363135	445.786	single	258.544	7232	161.941	258.544	0.82339	2020
support	C	7.55	400	500	452	0.004619342	450.15	single	258.544	7232	48.2201	258.544	0.82339	2020
span	C-D	29.34	400	500	452	0.01795119	444.722	single	258.544	7232	189.675	258.544	0.82339	2020
support	D	7.97	400	500	452	0.004876312	450.046	single	258.544	7232	50.9142	258.544	0.82339	2020
support	E	19.43	400	500	452	0.011887922	447.207	single	258.544	7232	124.911	258.544	0.82339	2020
span	E-F	31.54	400	500	452	0.019297224	444.167	single	258.544	7232	204.152	258.544	0.82339	2020
support	F	31.54	400	500	452	0.019297224	444.167	single	258.544	7232	204.152	258.544	0.82339	2020
AXis3														
Type														
support	B	18.68	400	500	452	0.011429047	447.394	single	258.544	7232	120.04	258.544	0.82339	2020
span	B-C	34.42	400	500	452	0.021059304	443.437	single	258.544	7232	223.16	258.544	0.82339	2020
support	C	12.2	400	500	452	0.007464367	449.003	single	258.544	7232	78.1176	258.544	0.82339	2020
span	C-D	34.17	400	500	452	0.020906345	443.501	single	258.544	7232	221.507	258.544	0.82339	2020
support	D	8.86	400	500	452	0.005420843	449.827	single	258.544	7232	56.6273	258.544	0.82339	2020
span	D-E	20.62	400	500	452	0.012616004	446.91	single	258.544	7232	132.65	258.544	0.82339	2020
support	E	18.99	400	500	452	0.011618715	447.317	single	258.544	7232	122.053	258.544	0.82339	2020
span	E-F	25.98	400	500	452	0.01589543	445.568	single	258.544	7232	167.634	258.544	0.82339	2020
support	F	22.16	400	500	452	0.013558227	446.525	single	258.544	7232	142.679	258.544	0.82339	2020
AXis4														
Type														
support	B	21.4	400	500	452	0.013093234	446.715	single	258.544	7232	137.727	258.544	0.82339	2020
span	B-C	35.56	400	500	452	0.021756794	443.148	single	258.544	7232	230.702	258.544	0.82339	2020
support	C	16.83	400	500	452	0.010297155	447.855	single	258.544	7232	108.04	258.544	0.82339	2020
span	C-D	35.6	400	500	452	0.021781267	443.138	single	258.544	7232	230.966	258.544	0.82339	2020
support	D	1.89	400	500	452	0.001156365	451.538	single	258.544	7232	12.0339	258.544	0.82339	2020
span	D-E	22.54	400	500	452	0.013790724	446.43	single	258.544	7232	145.157	258.544	0.82339	2021
support	E	15.91	400	500	452	0.009734269	448.083	single	258.544	7232	102.082	258.544	0.82339	2020
span	E-F	26.08	400	500	452	0.015956614	445.543	single	258.544	7232	168.289	258.544	0.82339	2020
support	F	22.51	400	500	452	0.013772369	446.438	single	258.544	7232	144.961	258.544	0.82339	2020
AXis5														
Type														
support	B	21.4	400	500	452	0.013093234	446.715	single	258.544	7232	137.727	258.544	0.82339	2020
span	B-C	35.45	400	500	452	0.021689492	443.176	single	258.544	7232	229.974	258.544	0.82339	2020
support	C	17.14	400	500	452	0.010486824	447.777	single	258.544	7232	110.049	258.544	0.82339	2020
span	C-D	35.76	400	500	452	0.02187916	443.097	single	258.544	7232	232.026	258.544	0.82339	2020
support	D	4.96	400	500	452	0.003034693	450.786	single	258.544	7232	31.6336	258.544	0.82339	2020
span	D-E	22.86	400	500	452	0.01398651	446.35	single	258.544	7232	147.244	258.544	0.82339	2020
support	E	16.41	400	500	452	0.010040185	447.959	single	258.544	7232	105.319	258.544	0.82339	2020
span	E-F	24.19	400	500	452	0.014800249	446.017	single	258.544	7232	155.927	155.9273	0.49658	2020
	F	19.92	400	500	452	0.01218772	447.085	single	258.544	7232	128.096	128.0964	0.40795	2020

G+4 Residential building project

AXis6														
Type														
support	B	18.68	400	500	452	0.011429047	447.394	single	258.544	7232	120.04	258.544	0.82339	2020
span	B-C	34.2	400	500	452	0.0209247	443.493	single	258.544	7232	221.706	258.544	0.82339	2020
support	C	13.36	400	500	452	0.008174094	448.716	single	258.544	7232	85.5999	258.544	0.82339	2020
span	C-D	34.13	400	500	452	0.020881872	443.511	single	258.544	7232	221.243	258.544	0.82339	2020
support	D	2.85	400	500	452	0.001743725	451.303	single	258.544	7232	18.1557	258.544	0.82339	2020
span	D-E	23.05	400	500	452	0.014102759	446.303	single	258.544	7232	148.484	258.544	0.82339	2020
support	E	12.74	400	500	452	0.007794757	448.869	single	258.544	7232	81.5995	258.544	0.82339	2020
span	E-F	21.1	400	500	452	0.012909684	446.79	single	258.544	7232	135.774	258.544	0.82339	2020
support	F	20.62	400	500	452	0.012616004	446.91	single	258.544	7232	132.65	258.544	0.82339	2020
AXis7														
Type														
support	B	14.12	400	500	452	0.008639087	448.527	single	258.544	7232	90.5073	258.544	0.82339	2020
span	B-C	24.65	400	500	452	0.015081692	445.902	single	258.544	7232	158.934	258.544	0.82339	2020
support	C	7.44	400	500	452	0.00455204	450.177	single	258.544	7232	47.5147	258.544	0.82339	2020
span	C-D	25.38	400	500	452	0.01552833	445.719	single	258.544	7232	163.708	258.544	0.82339	2020
support	D	10.68	400	500	452	0.00653438	449.378	single	258.544	7232	68.3277	258.544	0.82339	2020
span	D-E	20.43	400	500	452	0.012499755	446.958	single	258.544	7232	131.413	258.544	0.82339	2020
support	E	20.43	400	500	452	0.012499755	446.958	single	258.544	7232	131.413	258.544	0.82339	2020
span	E-F	28.41	400	500	452	0.017382185	444.957	single	258.544	7232	183.566	258.544	0.82339	2020
support	F	28.41	400	500	452	0.017382185	444.957	single	258.544	7232	183.566	183.5656	0.5846	2020
Landing Beam Reinforcement														
G+0														
AxisF	4	4.56	300	400	354	0.006064669	352.095	single	151.866	4248	37.23426	151.866	0.7557	2016
Type	4-5	13.36	300	400	354	0.017768415	348.359	single	151.866	4248	110.2598	151.866	0.7557	2016
	5	4.28	300	400	354	0.005692277	352.213	single	151.866	4248	34.93628	34.93628	0.17385	2016
G+1														
AxisF	4	4.95	300	400	354	0.006583357	351.931	single	151.866	4248	40.43759	151.866	0.7557	2016
Type	4-5	13.48	300	400	354	0.017928011	348.308	single	151.866	4248	111.2666	151.866	0.7557	2016
	5	5.18	300	400	354	0.006889251	351.835	single	151.866	4248	42.32814	42.32814	0.21063	2016
G+2														
AxisF	4	6.32	300	400	354	0.008405418	351.354	single	151.866	4248	51.71418	151.866	0.7557	2016
Type	4-5	13.61	300	400	354	0.018100908	348.252	single	151.866	4248	112.3576	151.866	0.7557	2016
	5	6.8	300	400	354	0.009043804	351.152	single	151.866	4248	55.67394	55.67394	0.27704	2016
G+3														
AxisF	4	2.01	300	400	354	0.002673242	353.163	single	151.866	4248	16.36285	151.866	0.7557	2016
Type	4-5	15.81	300	400	354	0.021026844	347.304	single	151.866	4248	130.8758	151.866	0.7557	2016
	5	2.93	300	400	354	0.003896816	352.778	single	151.866	4248	23.8783	23.8783	0.11882	2016

G+4 Residential building project

Appendix P Design Shear Calculation ForRoof Beam

AXIS2						
span	Vmax	Ved	Sbmax	Scal	Smin	Spro
B-C	35.65	31.55	191.25	317.8	224.7	191.3
C-D	31.49	27.46	191.25	365.1	224.7	191.3
E-F	16.48	14.06	191.25	713.1	224.7	191.3
AXIS3						
B-C	46.44	41.08	191.25	244.1	224.7	191.3
C-D	43.03	37.69	191.25	266.0	224.7	191.3
D-E	18.75	15.95	191.25	628.6	224.7	191.3
E-F	28.1	23.63	191.25	424.3	224.7	191.3
AXIS4						
B-C	49.38	43.64	191.25	229.7	224.7	191.3
C-D	46.37	40.66	191.25	246.6	224.7	191.3
D-E	34.78	29.76	191.25	336.9	224.7	191.3
E-F	27.67	23.11	191.25	433.8	224.7	191.3
AXIS5						
B-C	49.41	43.67	191.25	229.6	224.7	191.3
C-D	46.62	40.9	191.25	245.1	224.7	191.3
D-E	34.39	29.38	191.25	341.3	224.7	191.3
E-F	27.87	23.31	191.25	430.1	224.7	191.3
AXIS6						
B-C	45.46	40.16	191.25	249.7	224.7	191.3
C-D	48.8	43.1	191.25	232.6	224.7	191.3
D-E	32.7	27.9	191.25	359.4	224.7	191.3
E-F	27.11	22.67	191.25	442.3	224.7	191.3
AXIS7						
B-C	34.9	30.88	191.25	324.7	224.7	191.3
C-D	32.9	28.88	191.25	347.2	224.7	191.3
D-E	17.8	15.18	191.25	660.5	224.7	191.3
E-F	14.94	12.51	191.25	801.5	224.7	191.3
AXISB						
2-3	14.8	11.87	191.25	844.7	224.7	191.3
3-4	18.2	15.14	191.25	662.2	224.7	191.3
4-5	29.6	25.54	191.25	392.6	224.7	191.3

G+4 Residential building project

5-6	26.1	22.22	191.25	451.2	224.7	191.3
6-7	18.2	15.17	191.25	660.9	224.7	191.3
AXISC						
2-3	15.7	12.36	191.25	811.2	224.7	191.3
3-4	34.4	29.59	191.25	338.8	224.7	191.3
4-5	36.5	31.46	191.25	318.7	224.7	191.3
5-6	31.6	26.83	191.25	373.7	224.7	191.3
6-7	20.9	17.42	191.25	575.6	224.7	191.3
AXISD						
2-3	6.5	8.16	191.25	1228.7	224.7	191.3
3-4	33.8	28.99	191.25	345.8	224.7	191.3
4-5	36.9	31.84	191.25	314.9	224.7	191.3
5-6	31.5	26.72	191.25	375.2	224.7	191.3
6-7	19.6	16.1	191.25	622.7	224.7	191.3
AXISE						
2-3	11.8	9.85	191.25	1017.9	224.7	191.3
3-4	34.6	29.77	191.25	336.8	224.7	191.3
4-5	36.3	31.24	191.25	320.9	224.7	191.3
5-6	30.9	26.14	191.25	383.6	224.7	191.3
6-7	18.1	14.6	191.25	686.7	224.7	191.3
AXISF						
2-3	11.8	9.8	191.25	1023.1	224.7	191.3
3-4	20.6	17.82	191.25	562.6	224.7	191.3
4-5	20.8	17.89	191.25	560.4	224.7	191.3
5-6	17.8	14.89	191.25	673.3	224.7	191.3
6-7	10.9	8.89	191.25	1127.8	224.7	191.3

Design Shear Calculation For G+4 Beam

AXISB						
2-3	41.1	29.68	191.25	337.8	224.7	191.3
3-4	75.6	60.56	191.25	165.6	224.7	165.6
4-5	75.1	60.97	191.25	164.4	224.7	164.4
5-6	71.1	56.5	191.25	177.5	224.7	177.5
6-7	52.5	40.41	191.25	248.1	224.7	191.3
AXISC						
2-3	41.7	28.95	191.25	346.3	224.7	191.3
3-4	98.8	79.01	191.25	126.9	224.7	126.9
4-5	109.6	88.57	191.25	113.2	224.7	113.2
5-6	86.4	68.27	191.25	146.9	224.7	146.9
6-7	61.5	47.25	191.25	212.2	224.7	191.3
AXISD						

G+4 Residential building project

2-3	24.2	17.34	191.25	578.2	224.7	191.3
3-4	103.8	82.52	191.25	121.5	224.7	121.5
4-5	114.1	92.54	191.25	108.3	224.7	108.3
5-6	94.9	74.76	191.25	134.1	224.7	134.1
6-7	55.9	42.16	191.25	237.8	224.7	191.3
AXISE						
2-3	31.2	23.34	191.25	429.6	224.7	191.3
3-4	108.3	86.39	191.25	116.1	224.7	116.1
4-5	52.5	44.15	191.25	227.1	224.7	191.3
5-6	106.3	84.33	191.25	118.9	224.7	118.9
6-7	52.9	38.24	191.25	262.2	224.7	191.3
AXISF						
2-3	32.2	24.14	191.25	415.3	224.7	191.3
3-4	57.2	45.72	191.25	219.3	224.7	191.3
4-5	7.5	6.46	191.25	1552.0	224.7	191.3
5-6	57.8	46.28	191.25	216.6	224.7	191.3
6-7	31.1	23.11	191.25	433.8	224.7	191.3
AXIS2						
B-C	100.87	84.36	191.25	118.8	224.7	118.8
C-D	95.78	79.46	191.25	126.2	224.7	126.2
E-F	47.66	37.75	191.25	265.6	224.7	191.3
AXIS3						
B-C	132.19	110.42	191.25	90.8	224.7	90.8
C-D	131.8	109.33	191.25	91.7	224.7	91.7
D-E	58.11	46.19	191.25	217.1	224.7	191.3
E-F	91.66	71.82	191.25	139.6	224.7	139.6
AXIS4						
B-C	136.61	113.99	191.25	88.0	224.7	88.0
C-D	151.21	125.87	191.25	79.7	224.7	79.7
D-E	100.86	79.94	191.25	125.4	224.7	125.4
E-F	54.44	43.16	191.25	232.3	224.7	191.3
AXIS5						
B-C	133.84	111.65	191.25	89.8	224.7	89.8
C-D	144.95	120.82	191.25	83.0	224.7	83.0
D-E	103.94	82.54	191.25	121.5	224.7	121.5
E-F	51.86	40.67	191.25	246.5	224.7	191.3
AXIS6						
B-C	129.4	108.06	191.25	92.8	224.7	92.8
C-D	125.8	104.54	191.25	95.9	224.7	95.9
D-E	100.01	79.66	191.25	125.9	224.7	125.9

G+4 Residential building project

E-F	90.23	70.45	191.25	142.3	224.7	142.3
AXIS7						
B-C	98.9	82.7	191.25	121.2	224.7	121.2
C-D	85.9	70.78	191.25	141.7	224.7	141.7
D-E	45.9	36.63	191.25	273.7	224.7	191.3
E-F	45.8	35.87	191.25	279.5	224.7	191.3

Design Shear Calculation For G+3 Beam

AXISB						
2-3	44.9	31.9	191.25	314.3	224.7	191.3
3-4	76.5	58.8	191.25	170.5	224.7	170.5
4-5	95.1	74.56	191.25	134.5	224.7	134.5
5-6	78.5	60.73	191.25	165.1	224.7	165.1
6-7	54.4	41.38	191.25	242.3	224.7	191.3
AXISC						
2-3	47.7	31.97	191.25	313.6	224.7	191.3
3-4	100.1	76.27	191.25	131.5	224.7	131.5
4-5	117	91.35	191.25	109.8	224.7	109.8
5-6	96.5	74.23	191.25	135.1	224.7	135.1
6-7	61	45.79	191.25	219.0	224.7	191.3
AXISD						
2-3	26.9	17.27	191.25	580.6	224.7	191.3
3-4	105.5	78.75	191.25	127.3	224.7	127.3
4-5	114.2	89.33	191.25	112.2	224.7	112.2
5-6	102.9	78.65	191.25	127.5	224.7	127.5
6-7	65.9	50.21	191.25	199.7	224.7	191.3
AXISE						
2-3	24.2	15.53	191.25	645.6	224.7	191.3
3-4	107.7	81.72	191.25	122.7	224.7	122.7
4-5	43.4	34.05	191.25	294.5	224.7	191.3
5-6	107.5	81.45	191.25	123.1	224.7	123.1
6-7	74.7	57.09	191.25	175.6	224.7	175.6
AXISF						
2-3	28.7	19.11	191.25	524.7	224.7	191.3
3-4	62.1	48.07	191.25	208.6	224.7	191.3
4-5	6.9	5.92	191.25	1693.6	224.7	191.3
5-6	60.3	46.33	191.25	216.4	224.7	191.3
6-7	44	33.95	191.25	295.3	224.7	191.3
AXIS2						
B-C	97.35	78.24	191.25	128.1	224.7	128.1
C-D	108.92	87.95	191.25	114.0	224.7	114.0

G+4 Residential building project

E-F	50.69	38.82	191.25	258.3	224.7	191.3
AXIS3						
B-C	131.2	105.39	191.25	95.1	224.7	95.1
C-D	147.51	118.44	191.25	84.7	224.7	84.7
D-E	62.99	48.44	191.25	207.0	224.7	191.3
E-F	99.6	75.81	191.25	132.3	224.7	132.3
AXIS4						
B-C	152.32	122.76	191.25	81.7	224.7	81.7
C-D	146.86	117.31	191.25	85.5	224.7	85.5
D-E	113.94	87.67	191.25	114.4	224.7	114.4
E-F	65.56	51.64	191.25	194.2	224.7	191.3
AXIS5						
B-C	151.92	122.35	191.25	81.9	224.7	81.9
C-D	138.67	111.36	191.25	90.0	224.7	90.0
D-E	111.9	85.99	191.25	116.6	224.7	116.6
E-F	65.74	51.77	191.25	193.7	224.7	191.3
AXIS6						
B-C	130.9	105.08	191.25	95.4	224.7	95.4
C-D	126.8	101.8	191.25	98.5	224.7	98.5
D-E	104.3	79.86	191.25	125.5	224.7	125.5
E-F	101.3	77.38	191.25	129.6	224.7	129.6
AXIS7						
B-C	95.4	76.59	191.25	130.9	224.7	130.9
C-D	96.8	78.02	191.25	128.5	224.7	128.5
D-E	52.9	41.32	191.25	242.6	224.7	191.3
E-F	51.9	39.79	191.25	252.0	224.7	191.3

Design Shear Calculation For G+2 Beam

AXISB						
2-3	49.1	36	191.25	278.5	224.7	191.3
3-4	76.6	59.08	191.25	169.7	224.7	169.7
4-5	87.1	68	191.25	147.4	224.7	147.4
5-6	81.1	63.77	191.25	157.2	224.7	157.2
6-7	58.5	45.4	191.25	220.8	224.7	191.3
AXISC						
2-3	51.4	35.65	191.25	281.2	224.7	191.3
3-4	98.8	75.37	191.25	133.0	224.7	133.0
4-5	109.1	85.28	191.25	117.6	224.7	117.6
5-6	97.8	75.76	191.25	132.3	224.7	132.3
6-7	61.7	47.06	191.25	213.1	224.7	191.3

G+4 Residential building project

AXISD						
2-3	28.5	18.85	191.25	531.9	224.7	191.3
3-4	109.4	82.98	191.25	120.8	224.7	120.8
4-5	109.3	85.17	191.25	117.7	224.7	117.7
5-6	104.6	80.53	191.25	124.5	224.7	124.5
6-7	66.5	51.39	191.25	195.1	224.7	191.3
AXISE						
2-3	25.4	15.83	191.25	633.4	224.7	191.3
3-4	106.6	80.95	191.25	123.9	224.7	123.9
4-5	47.3	37.56	191.25	266.9	224.7	191.3
5-6	109.5	83.57	191.25	120.0	224.7	120.0
6-7	75.4	58.37	191.25	171.8	224.7	171.8
AXISF						
2-3	30.9	21.33	191.25	470.0	224.7	191.3
3-4	62.22	48.4	191.25	207.2	224.7	191.3
4-5	6.5	5.53	191.25	1813.0	224.7	191.3
5-6	60.22	46.47	191.25	215.8	224.7	191.3
6-7	44.85	35.28	191.25	284.2	224.7	191.3
AXIS2						
B-C	98.88	78.24	191.25	128.1	224.7	128.1
C-D	110.81	88.17	191.25	113.7	224.7	113.7
E-F	51.74	39.2	191.25	255.8	224.7	191.3
AXIS3						
B-C	130.54	102.98	191.25	97.4	224.7	97.4
C-D	147.6	116.51	191.25	86.1	224.7	86.1
D-E	63.94	48.59	191.25	206.3	224.7	191.3
E-F	99.92	74.71	191.25	134.2	224.7	134.2
AXIS4						
B-C	140.51	110.87	191.25	90.4	224.7	90.4
C-D	150.04	118.39	191.25	84.7	224.7	84.7
D-E	113.94	85.65	191.25	117.1	224.7	117.1
E-F	66.89	52.24	191.25	191.9	224.7	191.3
AXIS5						
B-C	140.64	110.98	191.25	90.3	224.7	90.3
C-D	139.75	110.48	191.25	90.8	224.7	90.8
D-E	112.32	84.77	191.25	118.3	224.7	118.3
E-F	65.28	50.79	191.25	197.4	224.7	191.3
AXIS6						
B-C	130.5	104.88	191.25	95.6	224.7	95.6
C-D	126.8	101.8	191.25	98.5	224.7	98.5

G+4 Residential building project

D-E	104.3	79.86	191.25	125.5	224.7	125.5
E-F	101.8	78.26	191.25	128.1	224.7	128.1
AXIS7						
B-C	97.1	78.23	191.25	128.2	224.7	128.2
C-D	88.4	70.77	191.25	141.7	224.7	141.7
D-E	53.2	41.93	191.25	239.1	224.7	191.3
E-F	52.6	40.84	191.25	245.5	224.7	191.3

Design Shear Calculation For G+1 Beam

AXISB						
2-3	53.4	40.3	191.25	248.8	224.7	191.3
3-4	78.2	60.77	191.25	165.0	224.7	165.0
4-5	87.1	68.59	191.25	146.2	224.7	146.2
5-6	79.6	62.08	191.25	161.5	224.7	161.5
6-7	80.8	47.7	191.25	210.2	224.7	191.3
AXISC						
2-3	55.7	40.05	191.25	250.3	224.7	191.3
3-4	100.9	77.51	191.25	129.4	224.7	129.4
4-5	108.3	84.76	191.25	118.3	224.7	118.3
5-6	95.5	73.78	191.25	135.9	224.7	135.9
6-7	63.5	48.88	191.25	205.1	224.7	191.3
AXISD						
2-3	35.4	25.77	191.25	389.1	224.7	191.3
3-4	112	85.77	191.25	116.9	224.7	116.9
4-5	108.5	84.66	191.25	118.4	224.7	118.4
5-6	102.8	78.98	191.25	126.9	224.7	126.9
6-7	62.6	48.16	191.25	208.2	224.7	191.3
AXISE						
2-3	33.9	24.33	191.25	412.1	224.7	191.3
3-4	108.8	83.12	191.25	120.6	224.7	120.6
4-5	49.7	39.31	191.25	255.1	224.7	191.3
5-6	108.7	82.92	191.25	120.9	224.7	120.9
6-7	66.9	50.97	191.25	196.7	224.7	191.3
AXISF						
2-3	36.3	26.73	191.25	375.1	224.7	191.3
3-4	61.59	47.95	191.25	209.1	224.7	191.3
4-5	6.9	5.82	191.25	1722.7	224.7	191.3
5-6	60.44	46.7	191.25	214.7	224.7	191.3
6-7	44.33	34.76	191.25	288.4	224.7	191.3
AXIS2						

G+4 Residential building project

B-C	100.89	81.78	191.25	122.6	224.7	122.6
C-D	109.3	88.47	191.25	113.3	224.7	113.3
E-F	54.68	43.04	191.25	232.9	224.7	191.3
AXIS3						
B-C	132.87	107.33	191.25	93.4	224.7	93.4
C-D	147.19	118.44	191.25	84.7	224.7	84.7
D-E	63.97	49.87	191.25	201.0	224.7	191.3
E-F	98.73	75.65	191.25	132.5	224.7	132.5
AXIS4						
B-C	142.99	115.51	191.25	86.8	224.7	86.8
C-D	150.83	121.35	191.25	82.6	224.7	82.6
D-E	111.3	85.99	191.25	116.6	224.7	116.6
E-F	69.7	55.44	191.25	180.8	224.7	180.8
AXIS5						
B-C	142.87	115.38	191.25	86.9	224.7	86.9
C-D	139.97	112.91	191.25	88.8	224.7	88.8
D-E	112	86.59	191.25	115.8	224.7	115.8
E-F	68.99	54.76	191.25	183.1	224.7	183.1
AXIS6						
B-C	132.4	106.86	191.25	93.8	224.7	93.8
C-D	127.3	102.6	191.25	97.7	224.7	97.7
D-E	105.3	81.65	191.25	122.8	224.7	122.8
E-F	99.2	76.08	191.25	131.8	224.7	131.8
AXIS7						
B-C	98.8	80.02	191.25	125.3	224.7	125.3
C-D	88.2	70.7	191.25	141.8	224.7	141.8
D-E	52.9	42.82	191.25	234.1	224.7	191.3
E-F	53.6	41.94	191.25	239.1	224.7	191.3

Design Shear Calculation For G+0 Beam

AXISB						
2-3	35.9	27.47	191.25	365.0	224.7	191.3
3-4	37.4	30.07	191.25	333.4	224.7	191.3
4-5	37.6	30.42	191.25	329.6	224.7	191.3
5-6	33.4	26.79	191.25	374.2	224.7	191.3
6-7	39.9	30.07	191.25	333.4	224.7	191.3
AXISC						
2-3	36.3	28.74	191.25	348.9	224.7	191.3
3-4	40.3	31.49	191.25	318.4	224.7	191.3
4-5	40.8	32.19	191.25	311.5	224.7	191.3
5-6	41.5	32.69	191.25	306.7	224.7	191.3

G+4 Residential building project

6-7	40.4	31.19	191.25	321.5	224.7	191.3
AXISD						
2-3	27.4	21.3	191.25	470.7	224.7	191.3
3-4	21.3	15.36	191.25	652.7	224.7	191.3
4-5	40.9	32.47	191.25	308.8	224.7	191.3
5-6	41.3	32.47	191.25	308.8	224.7	191.3
6-7	40.2	31.07	191.25	322.7	224.7	191.3
AXISE						
2-3	24.2	19.34	191.25	518.4	224.7	191.3
3-4	30.2	22.7	191.25	441.7	224.7	191.3
4-5	27.6	22.01	191.25	455.5	224.7	191.3
5-6	39.3	30.46	191.25	329.2	224.7	191.3
6-7	30.8	23.64	191.25	424.1	224.7	191.3
AXISF						
2-3	24.8	19.68	191.25	509.5	224.7	191.3
3-4	28.8	22.99	191.25	436.1	224.7	191.3
4-5	6.36	5.43	191.25	1846.4	224.7	191.3
5-6	28.58	22.77	191.25	440.3	224.7	191.3
6-7	30	22.79	191.25	439.9	224.7	191.3
AXIS2						
B-C	42.3	34.55	191.25	290.2	224.7	191.3
C-D	44.74	36.68	191.25	273.3	224.7	191.3
E-F	34.04	28.4	191.25	353.0	224.7	191.3
AXIS3						
B-C	53.94	43.76	191.25	229.1	224.7	191.3
C-D	54.73	44.41	191.25	225.8	224.7	191.3
D-E	33.14	27.06	191.25	370.5	224.7	191.3
E-F	43.22	34.65	191.25	289.4	224.7	191.3
AXIS4						
B-C	54.4	43.98	191.25	228.0	224.7	191.3
C-D	55.1	44.54	191.25	225.1	224.7	191.3
D-E	43.21	34.28	191.25	292.5	224.7	191.3
E-F	42.52	35.21	191.25	284.8	224.7	191.3
AXIS5						
B-C	54.58	44.15	191.25	227.1	224.7	191.3
C-D	54.88	44.33	191.25	226.2	224.7	191.3
D-E	42.55	33.66	191.25	297.9	224.7	191.3
E-F	43.22	35.93	191.25	279.0	224.7	191.3
AXIS6						
B-C	54.2	43.99	191.25	227.9	224.7	191.3

G+4 Residential building project

C-D	54.2	43.89	191.25	228.4	224.7	191.3
D-E	42.8	33.82	191.25	296.5	224.7	191.3
E-F	43.7	35.13	191.25	285.4	224.7	191.3
AXIS7						
B-C	41.8	34.14	191.25	293.7	224.7	191.3
C-D	43.7	35.66	191.25	281.2	224.7	191.3
D-E	32.4	26.61	191.25	376.8	224.7	191.3
E-F	33.2	27.56	191.25	363.8	224.7	191.3

Design Shear Calculation For Landing Beam

AXISF						
L4	28.4	22.96	191.25	436.7	224.7	191.3
L3	28.28	22.7	191.25	441.7	224.7	191.3
L2	28.2	22.71	191.25	441.5	224.7	191.3
L1	28.1	22.65	191.25	442.7	224.7	191.3

Appendix Q Column calculation

locati on	colu mn	bc	hc	bb	hb	Lc	Lbx left	lbr right	lby left	lbr right	k1x	k2x	k1y	k2y	Lox
roof	c1	400	400	250	300	2700	0	3250	0	4290	4.57	4.57	6.03	6.03	2578.87
roof	c2	400	400	250	300	2700	3250	4410	0	4290	2.63	2.63	6.03	6.03	2502.65
4th	C1	400	400	300	400	2600	0	3250	0	4290	1.67	1.67	2.20	2.20	2323.62
4th	C2	400	400	300	400	2600	3250	4410	0	4290	0.96	0.96	2.20	2.20	2184.97
3rd	C1	400	400	300	400	2600	0	3250	0	4290	1.67	1.67	2.20	2.20	2323.62
3rd	C2	400	400	300	400	2600	3250	4410	0	4290	0.96	0.96	2.20	2.20	2184.97
2nd	C1	400	400	300	400	2600	0	3250	0	4290	1.67	1.67	2.20	2.20	2323.62
2nd	C2	400	400	300	400	2600	3250	4410	0	4290	0.96	0.96	2.20	2.20	2184.97
1st	C1	400	400	300	400	2600	0	3250	0	4290	1.67	1.67	2.20	2.20	2323.62
1st	C2	400	400	300	400	2600	3250	4410	0	4290	0.96	0.96	2.20	2.20	2184.97
Grd	C1	400	400	300	400	2600	0	3250	0	4290	1.67	1.67	2.20	2.20	2323.62
Grd	C2	400	400	300	400	2600	3250	4410	0	4290	0.96	0.96	2.20	2.20	2184.97

G+4 Residential building project

location	column	Mx top	Mx botm	My top	My bot	NED	M01x	M01y	M02x	M02y	λ_x	λ_y	λ_{lim}	$\lambda_{y_{lim}}$	slen dern	slende rnes(y)
roof	c1	8.30	2.67	8.33	2.67	24.00	3.15	3.15	8.78	8.81	22.33	22.57	179.51	179.68	short	short
roof	c2	14.76	2.68	14.76	2.68	75.18	4.18	4.18	16.26	16.26	21.67	22.57	109.10	109.10	short	short
4th	C1	14.84	1.59	14.84	1.59	87.12	3.33	3.33	16.58	16.58	20.12	20.60	105.31	105.31	short	short
4th	C2	35.15	3.39	35.15	3.30	288.31	9.16	9.07	40.92	40.92	18.92	20.60	57.09	57.01	short	short
3rd	C1	29.40	12.45	29.40	12.45	174.37	15.94	15.94	32.89	32.89	20.12	20.60	60.35	60.35	short	short
3rd	C2	51.83	20.60	51.84	20.60	508.42	30.77	30.77	62.00	62.01	18.92	20.60	35.01	35.01	short	short
2nd	C1	24.53	4.09	24.54	4.09	259.35	9.28	9.28	29.72	29.73	20.12	20.60	56.50	56.51	short	short
2nd	C2	42.10	11.46	42.74	11.45	728.51	26.03	26.02	56.67	57.31	18.92	20.60	30.14	30.27	short	short
1st	C1	21.39	6.38	21.30	6.38	334.57	13.07	13.07	28.08	27.99	20.12	20.60	44.25	44.20	short	short
1st	C2	39.48	4.38	39.49	4.38	951.39	23.41	23.41	58.51	58.52	18.92	20.60	27.63	27.63	short	short
Grd	C1	34.56	0.29	34.56	0.29	373.10	7.75	7.75	42.02	42.02	20.12	20.60	51.45	51.45	short	short
Grd	C2	37.57	0.78	37.57	0.78	1050.85	21.80	21.80	58.59	58.59	18.92	20.60	26.86	26.86	short	short

colmn	location	MEDx	MEDy	Vsd	μ_{sdy}	μ_{sdx}	ω	As	As, min	As, max	As, prov	ϕ	no of bar	longitud inal reinforcement	shear reinforcement
roof	C1	8.78	8.18	0.0	0.01	0.01	0.3	1839.54	320	6400	1839.54	16	9.15	4 ϕ 20	ϕ 8 c/c 320
roof	C2	16.26	16.26	0.0	0.02	0.02	1.3	1226.36	320	6400	1226.36	16	6.10	4 ϕ 20	ϕ 8 c/c 320
4th	C1	16.58	16.58	0.0	0.02	0.02	2.3	3065.9	320	6400	3065.9	16	15.26	4 ϕ 20	ϕ 8 c/c 320
4th	C2	40.92	40.92	0.2	0.06	0.06	0.1	1226.36	320	6400	1226.36	16	6.10	4 ϕ 20	ϕ 8 c/c 320
3rd	C1	32.89	32.89	0.1	0.05	0.05	0.3	1839.54	320	6400	1839.54	16	9.15	4 ϕ 20	ϕ 8 c/c 320
3rd	C2	62.00	62.00	0.3	0.09	0.09	0.15	919.77	320	6400	919.77	16	4.58	4 ϕ 20	ϕ 8 c/c 320
2nd	C1	29.72	29.72	0.1	0.04	0.04	6.3	2452.72	320	6400	2452.72	16	12.21	4 ϕ 20	ϕ 8 c/c 320
2nd	C2	56.67	57.31	0.4	0.08	0.08	7.3	2146.13	320	6400	2146.13	16	10.68	4 ϕ 20	ϕ 8 c/c 320
1st	C1	28.08	27.99	0.2	0.04	0.04	8.3	1532.95	320	6400	1532.95	16	7.63	4 ϕ 20	ϕ 8 c/c 320
1st	C2	58.51	58.52	0.5	0.08	0.08	9.3	3065.9	320	6400	3065.9	24	6.78	4 ϕ 20	ϕ 8 c/c 320
Grd	C1	42.02	42.02	0.2	0.06	0.06	10.3	1226.36	320	6400	1226.36	16	6.10	4 ϕ 20	ϕ 8 c/c 320