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Design of structure B+G+8 mixed use building Addis Ababa

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Abstract/Summary

This project deals about the structural analysis and design of a B+G+8 building considering all the external and internal effects according to EBCS-3-2015. It includes wind load analysis. The proper design for each structural component is also carried out. Slab analysis and design, staircase analysis and design, wind analysis, beam, column, foundation sign and analysis, design of roof is carried out manually. Frame analysis was handle by using ETABS commercial software. Finally, all the structural members are designed as per the specification of Ethiopian Building code of Standards, EBCS and we used limit state design method. 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

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Back ground

The main aim of this project is, to examine the integrated techniques used in the design of a building. Now a day's it has being practical to choose types of structural members for different criteria especially economy after assuring safety. This project deals about the structural analysis and design of B+G+8 Office building considering all the external effects according to EBCS, 2015. The structural design of this typical building involves design flat roof slab, floor slabs, stairs, beams, columns, foundation and analysis of frames for lateral loads. The building is composed of solid slab for the floors. This structural design is executed based on the Ethiopian Building Code of Standard (EBCS) prepared in 2015 E.C. This code follows the Limit State design approach. Limit state is a state beyond which the structure no longer satisfies the design performance requirements. Its main concern is the safety of structure and people.

The main objective of this design contains determination of the following structural part

1. Design of Flat solid roof slab
2. Wind load analyses
3. Lateral load Analyses
4. Design of floor slab
5. Stair case Analyses
6. Frame Analyses
7. Design of beam
8. Design of column
9. Design of foundation

Objective

Main objective

To change theoretical knowledge of student to practical work and help the students on revision of develop the habit of teamwork. In order to introduce the real world designing and analysis situation. The main purpose of this project is to enable the group members to apply the knowledge gained in class and be able to analyze and design buildings. In addition, the project will enable the group members to have the know-how of analysis and design of the building, soil investigation and selection of the best foundation for a given site and structure

Sub objective

The group members will gain the following benefits after the completion of the project:

We will be able to analyze and design any types of building

Develop self-esteem and self-confidence

Apply the knowledge gained in the class to do the design process

Perform the geotechnical analysis and interpret the results

We haven't taken courses other than soil mechanics which are related to geotechnical investigation, so participating in such a project brings everyone a chance to know more about geotechnical investigation and foundation design.

Most of the time in the real life designers does not perform the actual site investigation before the design and construction of the project which in turn is the cause for different failures of the structure. So, to minimize such things in our country the role of this project is very significant

The building have different features including curved beams, non-rectangular slab, curved slab, inclined column, non-structural shear walls, concrete tanker and other special features

Proposed Methodology

The basic principles of analysis and design of structures will be employed in this project. During our task we will use different software including ETABS 2016, AutoCAD 2007, Safe, spread sheet and others to facilitate our task.

We will follow the following steps under this thesis (Figure 1):

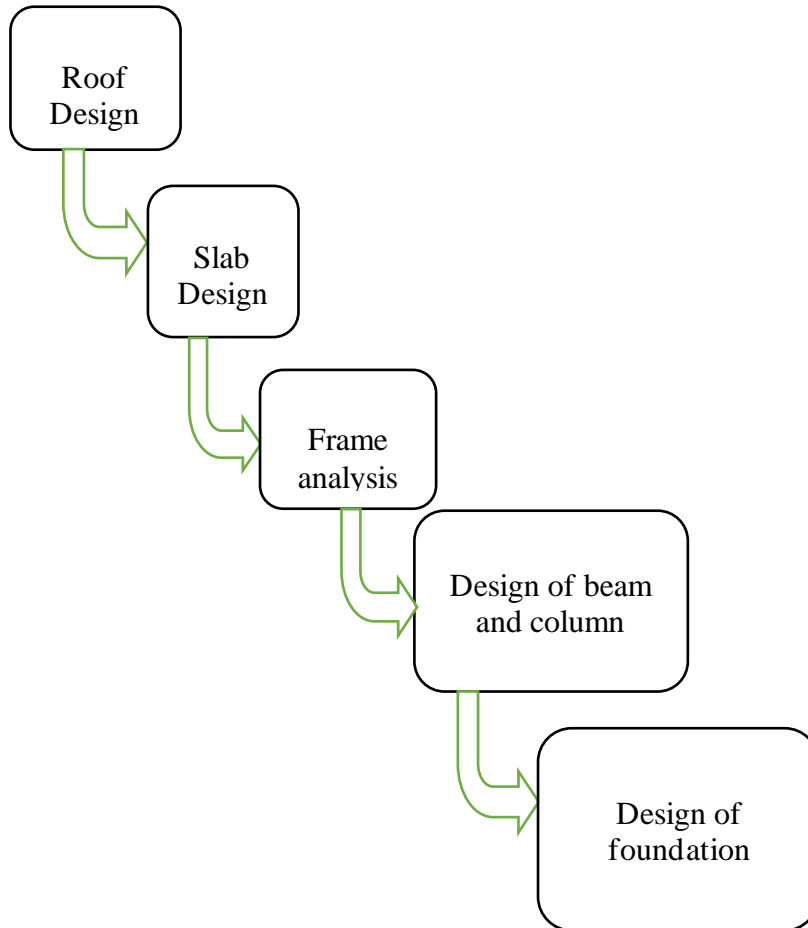


Figure 1: Overall framework of the study

Study Area

Our proposed structural building is to be constructed in Addis Ababa. This project is design for business center having different guest houses, GYM and store. The method used for design is (*ES-EN 2015-1*, 2015).

Effectives of our study Area

Effects Earth quake

Wind action

Data collection

Our data analyses are depending on Arthectural drawing for defining of column beam slab and foundation type are remain found appendixes

- Typical Floor plan
- Descriptive statistics
- Methods to Analyse Roof

Analyses of roof based on the new EBCS code Revised by Euro code

Since our plan roof type is flat we use the procedure the same to slab.

Symbols

For the purposes of this standard, the following symbols apply.

| | |
|---------------|---------------------------------------------------------------------------|
| A | Cross sectional area |
| A_c | Cross sectional area of concrete |
| A_P | Area of a prestressing tendon or tendons |
| A_s | Cross sectional area of reinforcement |
| $A_{s, \min}$ | minimum cross sectional area of reinforcement |
| A_{sw} | Cross sectional area of shear reinforcement |
| b | Overall width of a cross-section, or actual flange width in a T or L beam |
| b_w | Width of the web on T, I or L beams |
| d | Diameter; Depth |
| d | Effective depth of a cross-section |
| d_g | Largest nominal maximum aggregate size |
| e | Eccentricity |
| f_c | Compressive strength of concrete |
| f_{cd} | Design value of concrete compressive strength |
| f_{ck} | Characteristic compressive cylinder strength of concrete at 28 days |
| f_{ck} | Mean value of concrete cylinder compressive strength |
| f_{ck} | Characteristic axial tensile strength of concrete |
| f_{ctm} | Mean value of axial tensile strength of concrete |
| f_{tk} | Characteristic tensile strength of reinforcement |
| f_y | Yield strength of reinforcement |
| f_{yd} | Design yield strength of reinforcement |
| f_{yk} | Characteristic yield strength of reinforcement |
| f_{ywd} | Design yield of shear reinforcement |

1.INTRODUCTION

Building structures are solids, which are composed of architectural and structural parts. The structural part of the building supports the body of the building preventing it from any collapse or failure. Therefore, structural design involves the determination of the different sections of the skeletal part of the building to make it stable and sustainable throughout its design life.

A structural design is executed in such a way that the building will remain fit with appropriate degrees of reliability and in an economic way. It should sustain all the actions and influences during execution and use. Therefore, structural design focuses on structural safety and serviceability with due durability. It must also optimize the cost expended in building the structure and maintenance.

This structural design is executed based on the Ethiopian Building Code of Practice (ES EN 2015)

This code follows the Limit State design approach. Limit state is a state beyond which the structure no longer satisfies the design performance requirements. It consists of two states namely Ultimate Limit and serviceability Limit states. Ultimate Limit states are conditions related with collapse or states prior to structural failure. Its main concern is the safety of structure and people. Serviceability Limit states are those associated to conditions beyond which a structure does not accomplish specified service requirements. It is mainly concerned about the function of construction works, comfort of people, and appearance.

Structural design is a very essential science in many civil engineering works for the safety of the design and the economic aspect of construction. In this building we design structural members for B+G+8 mixed use BLG. The drawing contains many divided slab panels for different uses and roof cover above floors. The design must check that the structure is capable of carrying the loads safely and that it will not deform excessively due to the applied loads. So we design and analyze as well as check deformation due to its weight and other external loads such as wind load and earth quick.

The prime objective of design is structural safety and serviceability. In case the structure fails, it must be in such a way it will minimize risks and casualty. It must extend the time for evacuation of people inside a building. This requirement of structural design is accomplished by the principle called ductility. Ductility allows yielding of steel reinforcement prior to the collapse of the building. Yielding of steel bars warns the start of failure of a structure or its part. Therefore, structures are designed to be under reinforced by certain percent to assure ductility mode of failure if it happens.

1.1 Background

Reinforced concrete is the most widely used construction material in the world in the construction industry. It is a composite structure of construction material concrete and steel reinforcement bars. The universal nature of reinforced concrete construction stems from the

wide availability of reinforcing bars and the constituents of concrete (gravel or crushed rock, sand, water, and cement), from the relatively simple skills required in concrete construction, and from the economy of reinforced concrete compared with other forms of construction. Plain concrete and reinforced concrete are used in buildings of all sorts, underground structures, water tanks, wind turbine foundations and towers, offshore oil exploration and production structures, dams and bridges.

1.2 Design criteria for building

To analyze or design a structure, it is necessary to establish criteria for determining whether a given structure is acceptable for use in a specified circumstance or for use directly as a design objective that must be met. The most important criteria are; Serviceability. Efficiency, Construction, Costs, Other

The structure must be able to carry the design load safely without excessive material distress and with deformations within an acceptable range. The ability of a structure to carry loads safely and without material distress is achieved by using safety factors in the design of the element. By altering the size, shape, and choice of material, stresses in a structure can be maintained at safe levels and such that material distress (e.g. cracking) does not occur. This is basically a strength criterion and is of fundamental importance.

1.3 Building types

There are many types of buildings which can be classified based on their purpose as

- Residential buildings: buildings that provides the facility for private houses, hotels, dormitories, apartments etc.; - Educational buildings: buildings which functions for learning process.
- Institutional buildings: These buildings have built for the purpose of health, recoveries etc.
- Assembly building: these buildings are used for accommodation of many peoples together. e.g. recreation, cinema halls, conference halls etc.
- Business building: which are used for a business purpose like Banks, private libraries dispensaries etc.
- Industrial buildings: are used for fabricating or manufacturing purpose like brick industry, cement factory, steel industry etc.; -Storage buildings: buildings which are used for storage purpose.
- Hazard building: are used for to store materials which are dangerous. Like gases, acids, explosive etc.

1.4 Objectives

The main purpose of this project is to enable the group members to apply the knowledge gained in class and be able to analyze and design buildings.

In addition, the project will enable the group members to have the know-how of analysis and design of the building, soil investigation and selection of the best foundation for a given site and structure.

1.5 Basic structural components

All buildings have two zones a structural above ground level is called Super Structure the underground part is Sub-Structure. The buildings super- structure & sub-structure are defined by geometry, i.e., points, lines, surfaces, spaces, and bodies (solids). In an ordinary building the super structural part is composed of: the nodes or the point elements of joints (connections), the linear members of beams & columns, the surface elements of slabs and walls.

Joints /connections

At the intersections of every building component occurs a joint. Joints range from the large scale of a building joining the ground to the beam column connection and to the small scale of mortar joints bonding brick together in certain patterns in a masonry wall. The joint type is dependent on the location and position of adjacent members the main joint types are

- structural joints (e.g. load bearing & energy dissipating connections)
- movement joints which includes soft joints (e.g. expansion joints, isolation joints)
- control joints (e.g. slip joints, shrinkage strips)

1.5.1 Beams

Beams are linear members and they are distinguished in shape, cross sections material, and Support conditions. The effect of load action (eccentric versus concentric) on beam behavior in response to member shape and profile may be in □ simple bending

- biaxial bending, or
- unsymmetrical bending
- unsymmetrical bending

Beams, in general, must be checked for the primary structural determinant of bending, shear, deflection, possible load effect of bearing, and lateral stability.

Usually, Short beams are governed by shear, - Medium-span beams by flexure, and - Long-span beams by deflection.

1.5.2 Column

Columns support loads in compression. Whereas hangers, ties, and thin brace do so in tension. They carried bending and axial compression where the bending can be more important than the axial load. Columns are the primary components of skeleton structures. They may carry an entire building. It can be

- Short or long
- slender or stocky

The cross section of columns may be varied (Sloped, curved, twisted, stepped, etc) and may have its thinnest part at mid-height or top and /or bottom in X or Y directions.

Columns range from one-story to multistory, from single column to groups (e.g. clustered pipe columns), from exterior to interior, from vertical to inclined columns, and so on. They may be separated from beams so that mainly axial forces are transferred, or they may be continuous with beams to form beam-columns.

Columns normally may not solely serve their function as support, according to engineering requirements, but also may define space and may provide visual order to a wall. They may also help to refine proportion and compositional considerations, or they may be more ornamental, expressing other layers of meaning than just function

1.5.3 Slab

Slabs are plate elements forming floors & roofs in building which normally carry uniformly distributed loads. Slabs may be solid of uniform thickness or ribbed with ribs running in one or two directions.

There are two types of slabs based on the load transferring mechanisms. These are

- One way
- Two way slabs.

One-way slabs transmit their load in one direction. Two way slabs resist applied two directions. These types of slabs are composed of rectangular panels supported at all four edges by walls or beams stiff enough to be treated as unyielding.

1.5.4 Foundation

It is the part of the structure that is usually placed below the surface of the ground and that transmits the load to the underlying soil or rock. All soils compress noticeably when loaded and causes the supported structure to settle. The two essential requirements in the design of foundations are that the total settlement of the structure be limited to a tolerably small amount and the differential settlement of the various parts of the structure be eliminated as nearly as possible.

1.6 Design philosophies

Over the years, various design philosophies have evolved in different parts of the world, with regard to reinforced concrete design. A 'design philosophy, is built up on a few fundamental premises, and is reflective of the way of thinking.

1) Working stress method

This was the traditional method of design not only for reinforced concrete, but also for structural steel and timber design. The conceptual basis of WSM is simple. The method basically assumes that the structure material behaves in a linear elastic manner, and that adequate safety can be ensured by suitably restricting the stress in the material induced by the expected 'working loads' on the structure. As the specified permissible ('allowable') stresses are kept well below the materials strength (i.e., the linear phase of the stress-strain curve), the assumption of linear elastic behavior is considered justifiable

2) Ultimate load method (ULM)

In this method, the stress condition at the state of impending collapse of the structure is analyzed, and the non-linear stress-strain curves of concrete and steel are made use of. The design stresses used are the ultimate strength of materials and for safety the loads are magnified or scaled up by load factors, defined as the ratio of the ultimate load to working load. The ultimate load method makes it possible for different types of loads to be assigned different load factors under loading conditions, thereby overcoming the related shortcoming of WSM.

3) Limit states method (LSM)

Unlike WSM, which based calculations on service load conditions alone, and unlike ULM, which based calculations on ultimate load condition alone, LSM aims for a comprehensive and rational solution to the design problem, by considering safety at ultimate loads and serviceability at working loads. When a structure or structural element becomes unfit for its intended use, it is said to have reached a limit state. The limit states for reinforced concrete structures can be divided into three basic groups.

I. Ultimate limit state. This involves a structural collapse of part or all of the structure. Such limit state should have a very low probability of occurrence, because it may lead to loss of life and major financial losses. The major ultimate limit states are loss of equilibrium of part

or all of the structure as rigid body, rupture of critical parts of the structure, progressive collapse, formation of plastic mechanism, instability due to deformations of the structure, and fatigue.

II. Serviceability limit states. These involve disruption of the functional use of the structure, but no collapse occurs. Because there is less danger of loss of life, a higher probability of occurrence is generally tolerated than in case of an ultimate limit state. The major serviceability limit states include excessive deformations, excessive crack widths, and undesirable vibrations. Special limit states. This class of limit states involve damage or failure due to abnormal conditions or abnormal loadings and includes:

- a) Damage or collapse in extreme earthquakes,
- b) Structural effects of fire, explosions, or vehicular collisions,
- c) Structural effects of corrosion or deterioration, and
- d) Long term physical or chemical instability (normally not a problem with concrete structures).

Among the three method of design, the limit state method of design (LSM) is the most widely used method of design in many countries building code standard. Our structural building is based on this method of design according to the revised Ethiopian building code standard ES EN 1992:2015 adopted from the European building code standard except for typical flat slabs. Flat slab design in ES EN 1992:2015) is based on American concrete institute (ACI).

1.7 Significance of the project

- ✓ Enables the students to have full understanding of the analysis and design of building structures
- ✓ Gaining experience in structural design of structures
- ✓ Enables the students to design special structures on the buildings
- ✓ Develop confidence
- ✓ Helps as a reference for further study and design
- ✓ Develops the software skills
- ✓ Fully understand and differentiate the different types of foundations
- ✓ To know How to use ES EN-2015 Code for the design
- ✓ To introduce the real world designing and situation

To create an important contribution in the civil engineering profession

1.8 Scope of the project

The primary aim of all structural design is to insure that the structure will performs satisfactorily during its design life. Specifically, the design must check that the structure is

capable of carrying the loads safely and that it will not deform excessively due to the applied loads. This requires the designer to make realistic estimates of the strengths of the materials composing the structure and the loading to which it may be subjected during its design life. Furthermore, the designer will need a basic understanding of structural behavior. The designer must make an assessment of the future likely level of loading, including self-weight, to which the structure may be subjected during its design life. Using computer methods or hand calculations the design loads acting on individual elements can be then be evaluated. The design loads are used to calculate the bending moments, shear forces and deflections at critical points along the elements. Finally, suitable dimensions for the element can be determined.

1.9 Material and Methodology

1.9.1 Location of structure

Building is located in central OF Ethiopia Addis Ababa.

1.9.2 Analysis and design process

The overall structural analysis and design process typically consists of several steps

- 1. Load assessment:** - the loads acting on the structure are determined next. Typically, this involves determining loadings associated with the so called live loads on the structure resulting from its occupancy (e.g. loadings do to wind and earth quake forces) and the so called dead loads associated with the self waits of building elements.
- 2. Modeling of the structure and boundary Conditions:** -the structure and its constituent elements are modeled. Typically, such modeling includes characterizing complex real world construction connections consisting of items such as anchor plates, bolts, etc. as one or another an idealized set of support conditions (e.g. pins, rollers, or rigid joints)
- 3. Geometry definition:** - the basic geometry of structure is defined first, with particular attention paid to member hierarchies (which member supports which other members) and spanning directions.

1.10 Design methods and analysis

The basic principles of analysis and design of structures will be employed in this project. During our task we will use different software including ETABS V9, AutoCAD 2007, and Safe, Excel, Zotero and others to facilitate our task.

2.WIND LOAD ANALYSES

Wind produces dynamic loads on a structure at highly variable magnitudes. The variation in pressures at different locations on a building is

Complex to the point that pressures may become too analytically intensive for precise consideration on in design. To simplify the complexity in analysis of wind load different codes provides specifications for wind load by considering basic static pressure zones on a building representative of peak loads that are likely to be experienced. Wind forces act directly or indirectly on the internal and external surface of Structures. Wind loads fluctuate with time. A wind load produces static, dynamic and aerodynamic effects on structures.

Analysis of wind load Wind loads is dynamic loads and there are two methods of analysis of dynamic loads. Quasi- Static method: This is applied to stiff structures in which the movement of the structure with wind is negligible. Dynamic analysis: in which the movement of structures with wind loads in considered. The choice of the two procedures is based on the height of the building and the dynamic coefficient, C_d . Static method or the simplest method of wind load analysis issued for buildings and chimneys less than 200m tall provided that the value of dynamic coefficient. In all other cases the detailed analysis considers the dynamic effect of the load namely dynamic analysis should be applied.

The effect of wind load on the structure depends on many factors such as:

- Analyses of wind load
- Wind loads is dynamic loads and there are two methods of analysis of dynamic loads.
- Quasi Static method: This is applied to stiff structures in which the movement of the structure with wind is negligible.
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Detailed analysis considers the dynamic effect of the load namely dynamic analysis should be applied.

The effect of wind load on the structure depends on many factors such as:

- ✓ wind velocity direction
- ✓ the height of the structure
- ✓ topographic location of the structure
- ✓ shape of the structure
- ✓ terrain category
- ✓ the roughness of the surrounding

Action of the wind loads on structures is represented either as a wind pressure or 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. External wind pressure (W_{ex}) is the wind pressure acting on the external surfaces of a structure and internal wind pressure, is the wind pressure acting on the internal surfaces of a structure.

$$W_{ex} = q_{ref} * C_e(z_e) * C_{pe}$$

$$W_i = q_{ref} * C_e(z_i) * C_{pi}$$

Where: q_{ref} = Reference mean wind pressure

$C_e(z)$ = Exposure coefficient that takes into account the influence of terrain roughness.

C_{pe} = External wind pressure coefficient from Appendix a of EBCS - 1/19

C_{pi} = internal wind pressure coefficient from ES- EN 1991-1-4:2015 section

First let us determine necessary information

Maximum height of building (height of roof) above ground level =30.30m

Roof type; - flat roof

Location of the area –Addis Ababa

Altitude of the area above mean sea level =29.40m

Calculations

2.1 Determination of basic wind velocity (v_b)

$$V_b = C_{dir} * C_{sea} * V_{bo}$$

C_{dir} =direction factor

C_{sea} =seasonal factor

V_{bo} =fundamental basic wind velocity

$C_{dir}=C_{season}=1$ (ES EN 1991-1-4:2015 recommended)

$V_{bo}=22$ m/s for Ethiopia

$$V_b = 1 * 1 * 22 = 22 \text{ m/s}$$

2.2 Determination of mean wind velocity, $v_m(z)$

$$V_m(z) = C_r(z) * C_o(z) * v_b$$

Where; $C_o(z)$ = orographic factor

Orographic factor is calculated by the following formula under different condition

$$C_o(z) = 1 \text{ or } \varphi < 0.05$$

$$C_o(z) = 1 + 2 * S * \varphi \text{ for } 0.05 < \varphi < 0.3$$

$$C_o(z) = 1 + 0.6 * S * \varphi \text{ for } \varphi > 0.3$$

Where, S – is the Orographic location factor

Φ - Is the upwind slope, $\Phi = H/LU$ in the wind direction

LU - is the actual length of the upwind slope

H -is the effective height

2.3 Wind pressure Coefficients

External wind pressure coefficient. External pressure coefficients give the effect of the wind on the external surfaces of buildings.

Internal wind pressure Coefficient; internal pressure coefficients give the effect of the wind on the internal surfaces of buildings.

➤ External Pressure coefficients

The external pressure coefficients are divided into local coefficients and overall coefficients.

- I. Local coefficients, C_{pe1} give the pressure coefficients for loaded areas of 1m^2 . They may be used for the design of small elements and fixings.
- II. Overall coefficients, C_{pe10} give the pressure coefficients for loaded areas of 10m^2 . They may be used for loaded areas larger than 10m^2
- III. The external pressure coefficients C_{pe} for buildings and parts of buildings depend on the size of the loaded area A , which is the area of the structure that produces the wind action in the section to be calculated.

Note: The loaded area is the area of the structure, which produces the wind action in the section to be calculated. For buildings with the loaded area between 1m^2 and 10m^2 , the following procedure is recommended for determining the external pressure coefficient.

From ES-EN 1991, 1-4 Variation of external pressure coefficient for buildings with size of the loaded area A . The figure is based on the following:

$$A \leq 1\text{m}^2, C_{pe} = C_{pe1}$$

$$1\text{m}^2 < A < 10\text{m}^2, C_{pe} = C_{pe1} + (C_{pe10} - C_{pe1}) \log_{10} A$$

$$A \geq 10\text{m}^2, C_{pe} = C_{pe10}$$

The values of C_{pe1} and C_{pe10} are given on Tables from ES-EN 1991, 1-4:2014 SECTION 7.

orthogonal wind directions $0^\circ, 90^\circ, 180^\circ$ but represent highest values obtained in a range of wind direction $0 = \pm 45^\circ$ either side of the relevant

Orthogonal direction. These values are only applicable to buildings.

➤ Internal Pressure coefficients

Internal pressure arises due to openings, such as windows, doors and vents, in the cladding.

In general, if the windward pane has a greater proportion of opening than the leeward panel, then the interior of the structure is subjected to positive (outward) pressure as illustrated in Fig.4.5

(a). Conversely, if the leeward face has more openings, then the interior is subjected to a negative (inward) pressure as illustrated in Fig. Like external pressure internal pressure is considered positive when acting on to the surface of the structure. Thus, internal pressure is positive when the pressure acts outward.

Net Pressure: The net wind pressure across a wall or an element is the difference of the pressures on each surface taking due account of their signs. (Pressure, directed towards the surface is taken as positive, and suction, directed away from the surface as negative.

Wind load analysis

Generally, we should follow the following steps in analyzing wind loads:

- ✓ Determine site design wind speed and basic velocity pressure
- ✓ Identify the roof type
- ✓ Determine wind pressure coefficients namely external wind pressure coefficient and internal wind pressure coefficients
- ✓ Determine net wind pressure coefficient
- ✓ Determine the design or net wind pressure from step above
- ✓ Determine the wind force
- ✓ Load combination

2.4 Design information

The building is located in Addis Ababa city. Therefore, according to ES-EN 1991,1-4:2014 TABLE 4.1 the area is categorized according to the following:

Terrain Category: According to ES-EN 1991, 1-4:2014 TABLE 4.1 the location of the building in Addis Ababa fall under Terrain Category- III

Category I is characterized with

- ✓ Roughness length, $z_0 = 0.03\text{m}$
- ✓ Minimum height, $z_{\min} = 5\text{m}$

Topography coefficient: no escarpment or hills are located around the building site which means the site is topography unaffected zone and therefore,

A. $C_t(z) = 1$ according to terrain condition

Height of the building is 29.40m

B. Width of the roof 19.62m

Dynamic coefficient, C_d : According to Figure 3.7 of EBCS-1, 1995 dynamic coefficient is approximately 0.96 which is less than 1.2. Therefore, we can apply static method of analysis of wind load.

Roughness coefficient: 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:

$$C_r(z) = k_r \ln(z/z_0), \quad \text{for } z_{\min} \leq Z \leq 200\text{m}$$

$$C_r(z) = C_r(z_{\min}), \quad \text{for } z < z_{\min}$$

Where z_0 is the roughness length and z_{\min} is the minimum height. Both z_0 and z_{\min} are dependent on the ground roughness and are given in Table 4.1.

In our case the building height is between z_{\min} and 200m. hence we can use the first formula.

$C_r(z) = k_r \ln(z/z_0)$, but

$$k_r = 0.19 * (Z_0 / Z_{0,II})^{0.07}$$

- ✓ BY calculation of mean wind velocity ($V_m(z_0)$)

$$V_m(z) = C_r(z) * C_o(z) * V_b$$

$$Z = 33.30$$

For terrain category III

$$Z_{\min} = 5$$

$$Z_0 = 0.3$$

$$Z_0, III = 0.05$$

Roughness coefficient $C_r(z)$

$$C_r(z) = K_r \ln(z/z_0) \text{ for } Z_{\min} < Z < Z_{\max}$$

$$K_r = 0.19 \cdot (z_0/z_0, II)^{0.07}$$

$$= 0.19 \cdot (0.3/0.05)^{0.07}$$

$$= 0.215$$

$$C_r(z) = 0.215 \ln(34.94/0.3) = 1.02$$

Orographic factor ($C_o(z)$)

$$C_o(z) = 1, \varnothing < 0.05$$

Basic wind velocity $V_b = 22 \text{ m}$ /recommended value

$$V_m(z) = 0.85 \cdot 1 \cdot 22$$

$$= 18.7 \text{ m/s}$$

Altitude

Temperature and Barometer

But ES EN1991-1-4-2015 recommended as 1.25 kg/m^3

Calculation of peak velocity pressure ($q_p(z)$)

$$P_p(z) = [1 + 7I_v(z)] \cdot 1/2 \cdot \rho_{air} \cdot v_m^2(z)$$

ρ_{air} = density of air, it is depending on: - Altitude Temperature and Barometer but ES EN1991-1-4-2015 recommended as 1.25 kg/m^3

Wind turbulences ($I_v(z_0)$)

$$I_v = k_1 / [C_o(z) \ln(z/z_0)] \text{ for } Z_{\min} < Z < Z_{\max} = 200 \text{ m}$$

Where, K_1 is turbulences factor, recommended value is 1.0

$$I_v = 1 / [1 \cdot \ln(33.30/0.3)] = 0.41$$

$$q(33.30) = [1+7*0.211] * 1/2 * 1.25 * 18.7^2$$

$$= 0.541 \text{ Kpa}$$

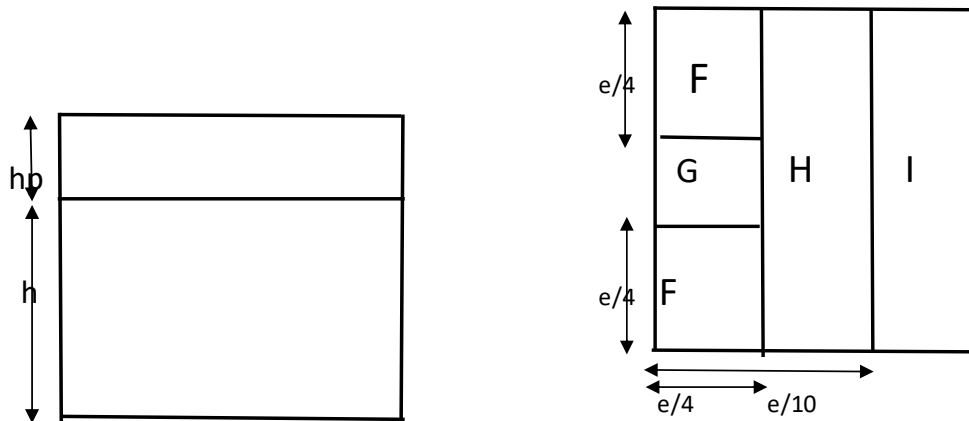


Figure 2.1 key for flat roof

Reference height $z_e = h$

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

b , cross wind dimension

$d = 21.2$

$b = 19.61$

$e = 19.61$ $e/2 = 9.81$ $e/10 = 1.96$

$H_p = 1\text{m}$ $h = 30.30$ $h_p/h = 1/30.30 = 0.03$

Determination of External and Internal Pressure Coefficient

2.4.1 Wind pressure computation

| Region | F | G | H | I |
|--------|---|---|---|---|
|--------|---|---|---|---|

| hp/h | Cpe1 | Cpe10 | Cpe1 | Cpe10 | Cpe1 | Cpe10 | Cpe1 | Cpe10 |
|-------|--------|--------|--------|--------|------|-------|------|-------|
| 0.025 | -2.2 | -1.6 | -1.8 | -1.1 | -1.2 | -0.7 | -0.2 | -0.2 |
| 0.05 | -2 | -1.4 | -1.6 | -0.9 | -1.2 | -0.7 | -0.2 | -0.2 |
| 0.031 | -2.152 | -1.552 | -1.572 | -1.052 | -1.2 | -0.7 | -0.2 | -0.2 |

Table 2.1 Determination of External and Internal Pressure Coefficient

Take the $W_{e(\text{Max})} = 0.271$

Internal Wind pressure

$$q_{ref} = 0.227 \text{KN/m}^2$$

$$C_{pe}(Z_i = 17.16) = 1.611 \text{m or } 19.5\text{m}$$

$$C_{pi} = 0.8 \text{ or } -0.5$$

$$W_i = 0.227 * 1.611 * 0.8 = 0.293$$

$$= 0.227 * 1.611 * -0.5 = -0.183$$

$$\text{Take } W_{i(\text{max})} = 0.293$$

$$W_{(\text{net})\text{max}} = W_e - W_i = 0.271 - 0.293 = -0.022 \text{KN/M}^2 (\text{suction})$$

$$W_i = 0.227 * 1.706 * 0.8 = 0.309 \text{KN/m}^2$$

$$W_{(\text{net})\text{max}} = W_e - W_i = 0.279 - 0.309 \text{KN/m}^2 = -0.03 (\text{suction})$$

2.4.2. Total design load

Dead load calculation

$$\text{RC Slab [135mm]} = 0.17 \times 25 = 4.25 \text{KN/m}^2$$

$$\text{Cement screed [30mm]} = 0.03 \times 23 = 0.69 \text{KN/m}^2$$

$$\text{Marble [20mm]} = 0.02 \times 27 = 0.54 \text{KN/m}^2$$

$$\text{Plastering/mortar [20mm]} = 0.02 \times 23 = 0.46 \text{KN/m}^2$$

$$\text{Total dead load } G_k = 5.94 \text{ KN/m}^2$$

Live load calculation

$$Q_k = 5 \text{KN/m}^2 \text{ for C5 – Category Terrace}$$

2.4.3 Load combination

$$\text{Combination -1, } P_d = 1.35DL + 1.5LL$$

$$= (1.3 \times 5.94) + (1.5 \times 5) = 15.22 \text{KN/m}^2$$

$$\text{Combination-2, } P_d = 1.35DL + 1.5WL$$

$$= (1.35 \times 5.94) + (1.5 \times 0.75) = 9.144 \text{KN/m}^2$$

$$\text{Combination-3, } P_d = 1.35DL + 1.5WL$$

$$= (1.35 \times 5.94) - (1.5 \times 0.65) = 7.044 \text{KN/m}^2$$

$$\text{Combination – 4, } P_d = 1.35DL + 1.5LL + 0.9WL$$

$$= (1.35 \times 5.94) + (1.5 \times 5) + (0.9 \times 0.65) = 16.10 \text{KN/m}^2$$

$$\text{Combination – 5, } P_d = 1.35DL + 1.5LL - 0.9WL$$

$$= (1.35 \times 5.94) + (1.5 \times 5) - (0.9 \times 0.65) = 14.934 \text{KN/m}^2$$

3. FLAT ROOF DESIGN

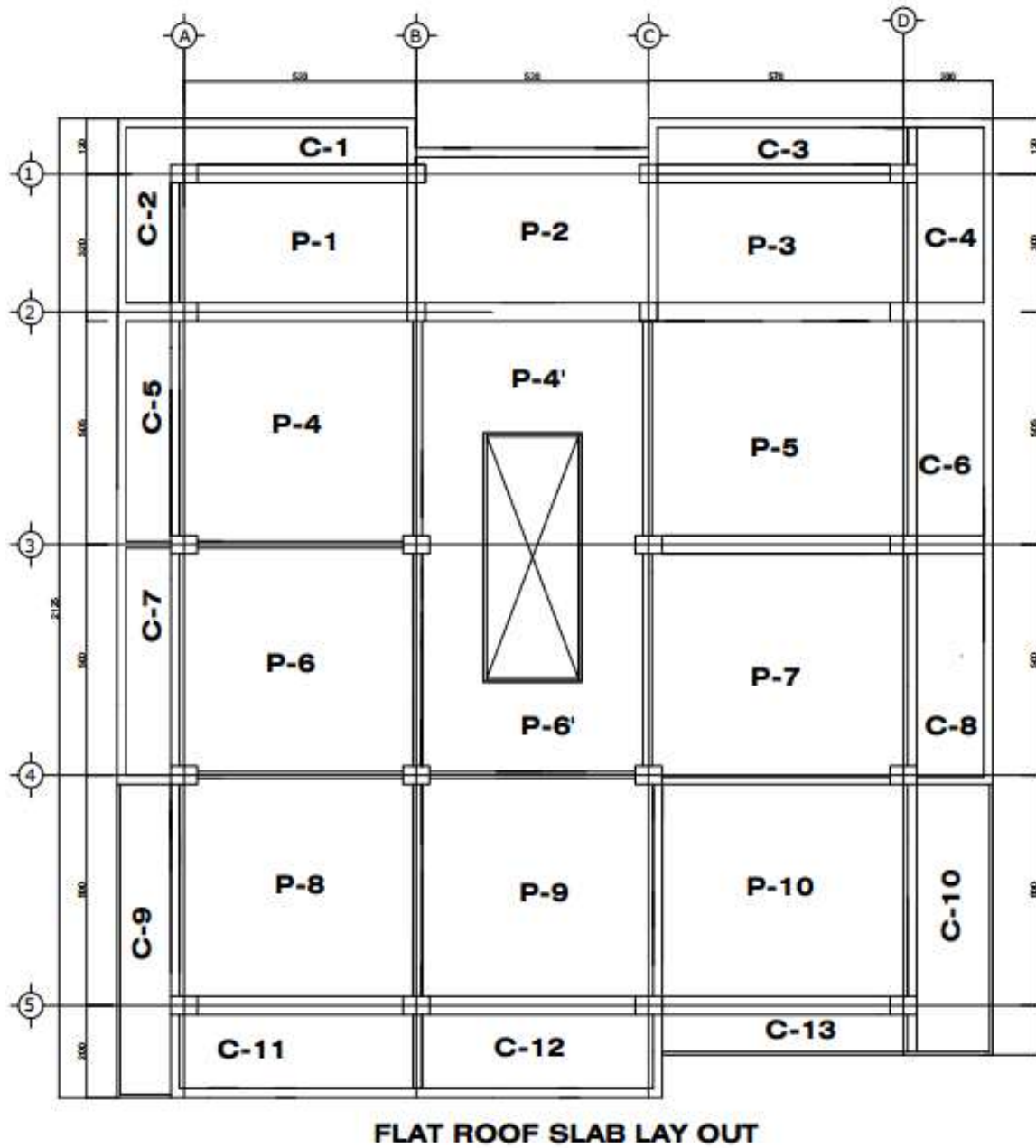


Figure 3.1 flat roof lay out

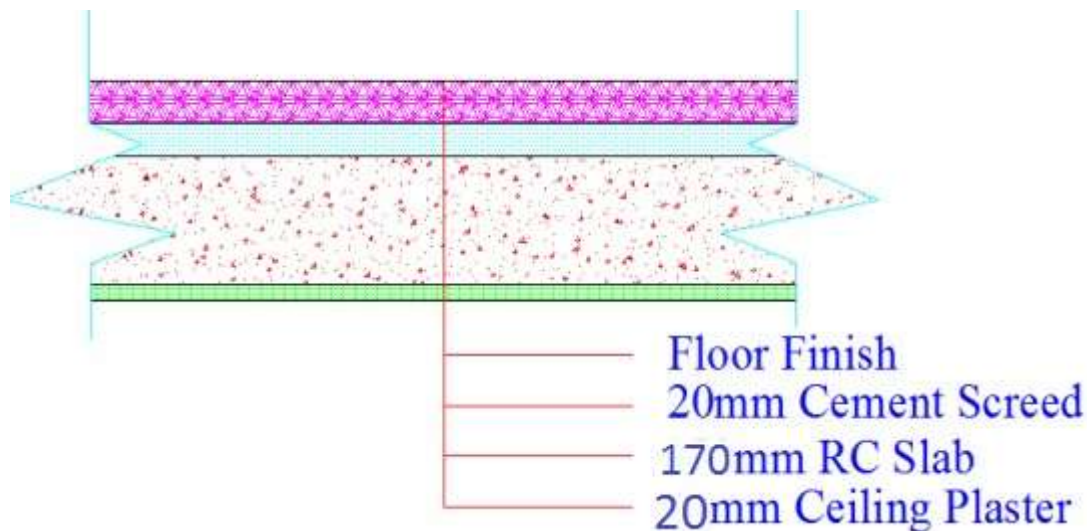


Figure 3.2 section of flat roof

Based on their load transfer mechanism Flat solid slabs are classified as:

- One-way slabs: They are those either supported on the two out of our opposite sides or the longer span to short span ratio is 2.
- Two-way slabs: They are those supported on all four sides and the longer span to short span ratio is less than equal to 2.
- Cantilever slabs: They are those with a fixed support on only one out of four sides

3.1 Panel selection

Before proceeding to the analysis and design of solid slab we should select type of panel. The selection of panels is depending on:

3.2 Boundary condition

Shorter (L_x) and longer(L_y) length of the panel

Function of panel

3.3 Material selected to design the slab structure

Concrete grade of C20/25

Steel grade of S-400

Deformed reinforcement bar of diameter with $\text{Ø}10$ for both span and support

Design strength value

$$\gamma_c = 1.5$$

$$f_{cd} = \alpha_{cc} \cdot f_{ck} / \gamma_c$$

Elastic modulus of concrete E_c

$$\gamma_s = 1.15$$

$$f_{yd} = f_{yk} / \gamma_s$$

Elastic modulus of steel, E_s

3.4 Determine Geometry/Dimension

Consider one-meter strip width, $b = 1000 \text{ mm}$

$$D = \text{effective depth (d)} + \text{cover} + L_{on}/2$$

In order to determine the depth of the slab, first it is needed to find concrete cover and effective depth.

Procedures for design of One-way slab

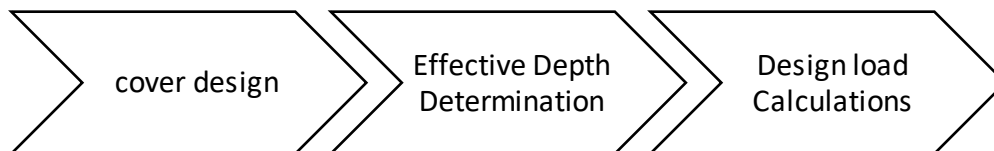


Figure 3.3 Analysis of Slab

3.4.1 Concrete design

- Corrosion

- Bond. /durability
- Fire

Exposure class classification in table 2

Design for corrosion in table 1

Design for bond/durability in table 3 reference

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

Where, C_{min} -minimum cover and

ΔC_{dev} is allowance in design for deviation

Minimum cover is provided in order to ensure

- ✓ Safe transition of bond force
- ✓ Corrosion resistance/durability
- ✓ Fire resistance

$$c_{min} = \max \left\{ \begin{array}{l} c_{min, b} \\ c_{min, dur} + \Delta c_{dur, \gamma} - \Delta c_{dur, add} \\ 10mm \end{array} \right\} \dots\dots\dots (Abdala, 2018) Eq (1)$$

For all panel we use the exposure class XC1

- ✓ Design structural class S3 and for corrosion C20/25
- ✓ Minimum cover required for Bond and Durability is 12 and 10 res.
- ✓ C_{nom} is 20 and slanted fire resistance 20 for panel (40 cantilever) Allowance design for variation is 10

We used Cover design 20 for panel and 40 for Cantilever

3.4.2 Effective depth determination

Effective Depth Determination: For Serviceability requirement

According to ES EN 1992:2015; the limit state of deformation may be checked by either:

By limiting the span/depth ratio, according to 7.4.2 or by comparing a calculated deflection, according to 7.4.3, with a limit value

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

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

Where l/d - is the limit span/depth

K - is the factor to take into account the different structural systems

ρ_0 - is the reference reinforcement ratio = $10 \cdot 3\sqrt{f_{ck}}$

ρ - Is the required tension reinforcement ratio at mid -span to resist the moment due to the design loads (at support for cantilevers)

ρ' - is the required compression reinforcement ratio at mid -span to resist the moment due to design loads (at support for cantilevers) f_{ck} is in MPa units.

- $F_1 = 300 / \sigma_s = 500 / (f_{yk} \cdot a_s, \text{ req} / A_s, \text{ pro})$
- $F_2 = 0.8$, for flanged sections where the ratio of the flange breadth to the rib breadth exceeds 3. Otherwise; $F_2 = 1$ for other cases.
- $F_3 = 7 / l_{eff}$, for beams and slabs, other than flat slabs, with spans exceeding 7 m, which support partitions liable to be damaged by excessive
- Deflections (l_{eff} in meters, see Art. 5.3.2.2 (1)). Or
- $F_3 = 8.5 / l_{eff}$, for flat slabs where the greater span exceeds 8.5 m, and which support partitions liable to be damaged by excessive deflections (l_{eff} in meters). Otherwise; $F_3 = 1$ for both cases. Assumption

Initially we can't know ρ and ρ' . So let's assume $\rho = \rho_0$ and use equation 7.16a.

$A_{s, \text{ req}} = A_s$, provided.

$$N = 11 + 1.5\sqrt{f_{ck}} \cdot \rho_0 / \rho + 3.2 \cdot \sqrt{(\rho_0 / \rho - 1)}^{3/2}$$

$$\rho_0 = 10 \cdot 3\sqrt{f_{ck}}$$

$$N = 11 + 1.5\sqrt{f_{ck}}$$

$$F_1 = 500 / \sigma_s = 500 / (f_{yk} \cdot a_s, \text{ req} / A_s, \text{ pro})$$

Table 7.4N: Basic ratios of span/effective depth for reinforced concrete members without axial compression.

For flat slabs with spans ≤ 8.5 m and slab and beams with spans ≤ 7 m: the depth formulae

$D = d_{min} + C_{nom} + \phi l_2$ where d_{min} is governing effective depth (Eq. 1)

➤ Cover design

- ✓ For all panel the Exposure class XC1
- ✓ For all panel the Design for corrosion C20/25
- ✓ For all panel the structural class S3
- ✓ For all panel the C_{min} , $B C_{min}$, $D C_{min}(mm) = 10$
- ✓ For all panel the Allowance in design for variation ($\Delta C_{dev}(mm)$) = 10 and $C_{nom} = 20$
- ✓ Standard Fire Resistance 20 for rectangular panel and 40 for cantilever

The governing cover design is 20 for slab panel and 40 for cantilever

➤ Depth determination; - For serviceability requirement

| Panel | Lx(m) | Ly(m) | Ly/Lx | Type of slab | Span type | K | N | Lx/d | d |
|-------|-------|-------|-------|--------------|---------------|-----|------|--------|--------|
| P1 | 3 | 5.2 | 1.73 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 62.75 |
| P2 | 3 | 5.7 | 1.90 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 62.75 |
| P3 | 5.05 | 5.2 | 1.03 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 105.62 |
| P4 | 5.05 | 5.7 | 1.13 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 105.62 |
| P5 | 5 | 5.2 | 1.04 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 104.58 |
| P6 | 5.05 | 5.2 | 1.03 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 105.62 |
| P7 | 5 | 5.2 | 1.04 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 104.58 |
| P8 | 5.05 | 5.2 | 1.03 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 105.62 |
| P9 | 5 | 5.7 | 1.14 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 104.58 |
| P10 | 5 | 5.2 | 1.04 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 104.58 |
| P11 | 5 | 5.05 | 1.01 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 104.58 |
| C-1 | 2.1 | 5.2 | 2.48 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 286.30 |
| C-2 | 2.9 | 3 | 1.03 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 395.36 |
| C-3 | 2.1 | 5.23 | 2.49 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 286.30 |
| C-4 | 2.4 | 3 | 1.25 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 327.20 |
| C-5 | 2.9 | 5.2 | 1.79 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 395.36 |
| C-6 | 2.4 | 5.05 | 2.10 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 327.20 |
| C-7 | 2.9 | 5 | 1.72 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 395.36 |
| C-8 | 2.4 | 5 | 2.08 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 327.20 |
| C-9 | 2.9 | 5 | 1.72 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 395.36 |
| C10 | 2.4 | 5 | 2.08 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 327.20 |
| C-11 | 3.05 | 8.33 | 2.73 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 415.81 |
| C-12 | 1.8 | 5.2 | 2.89 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 245.40 |
| C-13 | 1.1 | 8.1 | 7.36 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 149.97 |

Table 3.2 depth calculation for flat roof slab and cantilever

2.1) End panel

$$D = 108.95 + 20 + 5 = 133.95 \text{ mm}$$

2.2) Cantilevers

$$D = 395.36 + 20 + 5 = 420.36 \text{ mm}$$

3.5 Calculate the Design loads for flat roof slab.

Dead load

Dead and live loads are calculated depending on the service of the slabs and self-weight. Ignoring any localized effects caused by concentrated load, the partition loads are distributed over the area of the slab. The design loads are factored according to the following formula.

$$P_d = 1.35DL + 1.5LL + 0.9WL$$

| Material | Density γ [kN / m ³] | Reference |
|----------------------------|-----------------------------------------------|----------------------------------------------------|
| - Concrete | 25 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Cement Screed(mortar) | 23 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Plastering(mortar) | 23 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Partitions walls(HCB) | 14 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| <i>Finishing Materials</i> | | |
| - Porcelain | 25 | <i>Other reference</i> |
| - Marble | 27 | <i>Other reference</i> |
| - Ceramic | 23 | <i>Other reference</i> |
| - Parquet | 9 | <i>Other reference</i> |

Table 3.3 unit weight of flat roof slab

| Panel | T OF SLAB | Y HCB | L _y | L _x | Area of slab | Thickness of plaster | Y plaster | TDL |
|-------|-----------|-------|----------------|----------------|--------------|----------------------|-----------|-------|
| P-1 | 0.14 | 14.00 | 5.20 | 3.20 | 16.64 | 0.04 | 23.00 | 33.53 |
| P-2 | 0.14 | 14.00 | 5.70 | 3.00 | 17.10 | 0.04 | 23.00 | 34.44 |
| P-3 | 0.14 | 14.00 | 5.20 | 5.05 | 26.26 | 0.04 | 23.00 | 52.39 |
| P-4 | 0.14 | 14.00 | 5.70 | 5.05 | 28.79 | 0.04 | 23.00 | 57.34 |
| P-5 | 0.14 | 14.00 | 5.20 | 5.00 | 26.00 | 0.04 | 23.00 | 51.88 |
| P-6 | 0.14 | 14.00 | 5.70 | 5.05 | 28.79 | 0.04 | 23.00 | 57.34 |
| P-7 | 0.14 | 14.00 | 5.20 | 5.00 | 26.00 | 0.04 | 23.00 | 51.88 |

| | | | | | | | | |
|-------------|------|-------|------|------|-------|------|-------|-------|
| P-8 | 0.14 | 14.00 | 5.20 | 5.05 | 26.26 | 0.04 | 23.00 | 52.39 |
| P-9 | 0.14 | 14.00 | 5.70 | 5.00 | 28.50 | 0.04 | 23.00 | 56.78 |
| P-10 | 0.14 | 14.00 | 5.70 | 5.00 | 28.50 | 0.04 | 23.00 | 56.78 |
| P-11 | 0.14 | 14.00 | 5.70 | 5.00 | 28.50 | 0.04 | 23.00 | 56.78 |
| C-1 | 0.42 | 14.00 | 5.20 | 1.20 | 6.24 | 0.04 | 23.00 | 37.61 |
| C-2 | 0.42 | 14.00 | 4.20 | 1.50 | 6.30 | 0.04 | 23.00 | 37.96 |
| C-3 | 0.42 | 14.00 | 5.70 | 1.20 | 6.84 | 0.04 | 23.00 | 41.14 |
| C-4 | 0.42 | 14.00 | 4.20 | 2.00 | 8.40 | 0.04 | 23.00 | 50.31 |
| C-5 | 0.42 | 14.00 | 5.05 | 1.20 | 6.06 | 0.04 | 23.00 | 36.55 |
| C-6 | 0.42 | 14.00 | 5.05 | 2.00 | 10.10 | 0.04 | 23.00 | 60.31 |
| C-7 | 0.42 | 14.00 | 5.00 | 1.50 | 7.50 | 0.04 | 23.00 | 45.02 |
| C-8 | 0.42 | 14.00 | 5.00 | 2.00 | 10.00 | 0.04 | 23.00 | 59.72 |
| C-9 | 0.42 | 14.00 | 5.00 | 1.60 | 8.00 | 0.04 | 23.00 | 47.96 |
| C-10 | 0.42 | 14.00 | 5.00 | 2.00 | 10.00 | 0.04 | 23.00 | 59.72 |
| C-11 | 0.42 | 14.00 | 6.40 | 1.60 | 10.24 | 0.04 | 23.00 | 61.13 |
| C-12 | 0.42 | 14.00 | 5.20 | 2.00 | 10.40 | 0.04 | 23.00 | 62.07 |
| C-13 | 0.42 | 14.00 | 5.70 | 2.00 | 11.40 | 0.04 | 23.00 | 67.95 |

Table 3.4 dead load calculation for roof slab

| PANEL | Slab self-weight | WL | LL | Pd=1.35DL+1.5LL+0.9WL |
|-------|------------------|-------|------|-----------------------|
| P-1 | 5.61 | 16.10 | 0.40 | 22.67 |
| P-2 | 4.97 | 16.10 | 0.40 | 21.80 |
| P-3 | 2.13 | 16.10 | 0.40 | 17.97 |
| P-4 | 2.29 | 16.10 | 0.40 | 18.18 |
| P-5 | 3.08 | 16.10 | 0.40 | 19.25 |
| P-6 | 2.56 | 16.10 | 0.40 | 18.55 |
| P-7 | 3.33 | 16.10 | 0.40 | 19.59 |
| P-8 | 2.07 | 16.10 | 0.40 | 17.89 |
| P-9 | 3.04 | 16.10 | 0.40 | 19.19 |
| P-10 | 2.30 | 16.10 | 0.40 | 18.20 |
| P-11 | 3.09 | 16.10 | 0.40 | 19.27 |

Table 3.5 design load flat roof of slab

Design load for one-way cantilever

| Panel | Ly | Lx | Area of floor | T plaster | T DL | Pd'=TDL/A | LL | Pd''(KN) due self weight | Total design load |
|-------|------|-----|---------------|-----------|------|-----------|-----|--------------------------|-------------------|
| C-1 | 5.20 | 1.2 | 6.24 | 0.04 | 0.92 | 0.15 | 0.4 | 16.33 | 16.48 |
| C-2 | 4.2 | 1.5 | 6.30 | 0.04 | 0.92 | 0.15 | 0.4 | 16.33 | 16.48 |
| C-3 | 5.7 | 1.2 | 6.84 | 0.04 | 0.92 | 0.13 | 0.4 | 16.33 | 16.47 |
| C-4 | 4.2 | 2 | 8.40 | 0.04 | 0.92 | 0.11 | 0.4 | 16.33 | 16.44 |
| C-5 | 5.05 | 1.2 | 6.06 | 0.04 | 0.92 | 0.15 | 0.4 | 16.33 | 16.48 |
| C-6 | 5.05 | 2 | 10.10 | 0.04 | 0.92 | 0.09 | 0.4 | 16.33 | 16.42 |
| C-7 | 5 | 1.5 | 7.50 | 0.04 | 0.92 | 0.12 | 0.4 | 16.33 | 16.45 |
| C-8 | 5 | 2 | 10.00 | 0.04 | 0.92 | 0.09 | 0.4 | 16.33 | 16.42 |
| C-9 | 5 | 1.6 | 8.00 | 0.04 | 0.92 | 0.12 | 0.4 | 16.33 | 16.45 |
| C-10 | 5 | 2 | 10.00 | 0.04 | 0.92 | 0.09 | 0.4 | 16.33 | 16.42 |
| C-11 | 6.4 | 1.6 | 10.24 | 0.04 | 0.92 | 0.09 | 0.4 | 16.33 | 16.42 |
| C-12 | 5.2 | 2 | 10.40 | 0.04 | 0.92 | 0.09 | 0.4 | 16.33 | 16.42 |

Table 3.6 design load for one way cantilever

Similarly, for all other floor found in appendix I

We use unit weight of plastering =23KN/m

3.4.4 Moment Analysis

According to newly revised building code of Ethiopia for two-way slab use coefficient method in order to calculate moment using general formula

$$M_i = \alpha_i q L_x^2$$

Where; $-M_i$ is design moment per unit width at the point of reference

α_i is coefficient

q is design load of each panel

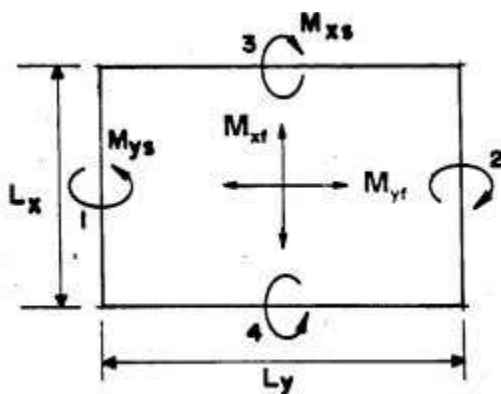
L_x is shorter span

Where; $-M_{XS} = \alpha_{XS} P_d L_x^2$

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

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

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



Checking for Slab Continuity

Before preceding to moment calculation, first the typical slab's continuity has to be checked.

Slab continuity has the following assumptions:

- ❖ Two slabs located side to side considered as continuous if side length of the first slab is greater than or equal to $1/3$ of the length, of the second slab.
- ❖ Continuity determines necessity and location of (top or bottom) reinforcement and it depends on loading type and geometry

Since there no beam that connect all one way slab all edge are discontinuous

| panel | lx | lx ² | Pd | LY | LY/Lx | Moment Coefficient | | Moment location | Mi |
|-------|------|-----------------|--------|-----|-------|--------------------|-------|-----------------|-------|
| | | | | | | location | value | | |
| P1 | 3 | 9.00 | 8.54 | 5.2 | 1.73 | β_{xs} | 0.05 | $M_{xs} =$ | 3.61 |
| | | | | | | β_{xf} | 0.04 | $M_{xf} =$ | 1.68 |
| | | | | | | β_{ys} | 0.05 | $M_{ys} =$ | 3.46 |
| | | | | | | β_{yf} | 0.03 | $M_{yf} =$ | 2.61 |
| P2 | 3 | 9.00 | 12.93 | 5.7 | 1.90 | β_{xs} | 0.03 | $M_{xs} =$ | 3.61 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 1.23 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 3.72 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 2.79 |
| P3 | 5.05 | 25.50 | 11.87 | 5.2 | 1.03 | β_{xs} | 0.03 | $M_{xs} =$ | 9.38 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 3.18 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 9.69 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 7.27 |
| P4 | 5.05 | 25.50 | 13.3 | 5.7 | 1.13 | β_{xs} | 0.03 | $M_{xs} =$ | 10.51 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 3.49 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 10.85 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 8.14 |
| P5 | 5.05 | 25.50 | 13.66 | 5.2 | 1.03 | β_{xs} | 0.03 | $M_{xs} =$ | 10.80 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 3.18 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 11.15 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 8.36 |
| P6 | 5 | 25.00 | 13.3 | 5.2 | 1.04 | β_{xs} | 0.05 | $M_{xs} =$ | 15.63 |
| | | | | | | β_{xf} | 0.04 | $M_{xf} =$ | 4.68 |
| | | | | | | β_{ys} | 0.05 | $M_{ys} =$ | 14.96 |
| | | | | | | β_{yf} | 0.03 | $M_{yf} =$ | 11.31 |
| P7 | 5 | 25.00 | 13.66 | 5.2 | 1.04 | β_{xs} | 0.05 | $M_{xs} =$ | 16.05 |
| | | | | | | β_{xf} | 0.04 | $M_{xf} =$ | 4.68 |
| | | | | | | β_{ys} | 0.05 | $M_{ys} =$ | 15.37 |
| | | | | | | β_{yf} | 0.03 | $M_{yf} =$ | 11.61 |
| P8 | 5 | 25.00 | 13.634 | 5.2 | 1.04 | β_{xs} | 0.04 | $M_{xs} =$ | 13.29 |
| | | | | | | β_{xf} | 0.03 | $M_{xf} =$ | 3.77 |
| | | | | | | β_{ys} | 0.04 | $M_{ys} =$ | 12.61 |
| | | | | | | β_{yf} | 0.03 | $M_{yf} =$ | 9.54 |
| P9 | 5 | 25.00 | 10.24 | 5.7 | 1.14 | β_{xs} | 0.03 | $M_{xs} =$ | 7.94 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 3.42 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 8.19 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 6.14 |

table 3.7 un adjusted moment for roof flat slab

Moment Calculation for one-way cantilever slabs.

Material Data

- ✓ Thickness of HCB=200mm
- ✓ Thickness plastering on two side=20mm
- ✓ Unit weight of HCB=14KN/m³
- ✓ Unit weight of plastering=23 KN/m³
- ✓ Height of wall=3m

Cantiliver-1

$$\text{Load from external wall} = (H_{pl} * t_{pl} * \gamma_{pl}) + (H_{HCB} * t_{HCB} * \gamma_{HCB})$$

Where: H_{pl}, t_{pl} & γ_{pl} =Height, Thickness, Unit Weight of Plastering Respectively.

H_{HCB}, t_{HCB} & γ_{HCB} = Height, Thickness, Unit Weight of HCB Respectively.

$$D.L_{ex} = (0.2m \times 3m \times 14 \text{ KN/m}^3) + (0.02m \times 3m \times 23 \text{ KN/m}^3)$$

$$= 9.78 \text{ KN/m}$$

- Taking 1m strip of the slab in the shorter direction

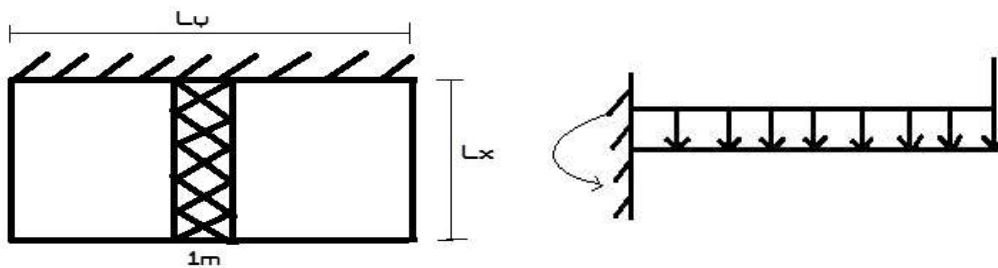


Figure 3.4 cantiliver moment calculation for one way slab

$$D.L_{ex} = 9.78 \text{ KN}$$

$$P_d = 16.73 \text{ KN/m}$$

$$M_x = 9.78 \text{ KN} * 1.2m + 16.73 \text{ KN} * \left(\frac{1.2m}{2}\right)^2$$

Mxs=28. 51KN.m

General formula $M_{xs}=DL*Lx+pd*(Lx^2/2)$

| Panel | Lx | Lx2 | DL | Pd | Mxs |
|-------|------|------|------|-------|-------|
| C1 | 1.20 | 1.44 | 9.78 | 16.48 | 17.67 |
| C2 | 1.50 | 2.25 | 9.78 | 16.48 | 23.94 |
| C3 | 1.20 | 1.44 | 9.78 | 16.47 | 17.66 |
| C4 | 2.00 | 4.00 | 9.78 | 16.44 | 36.00 |
| C5 | 1.20 | 1.44 | 9.78 | 16.48 | 17.67 |
| C6 | 2.00 | 4.00 | 9.78 | 16.42 | 35.98 |
| C7 | 1.50 | 2.25 | 9.78 | 16.45 | 23.93 |
| C8 | 2.00 | 4.00 | 9.78 | 16.42 | 35.98 |
| C9 | 1.60 | 2.56 | 9.78 | 16.45 | 26.17 |
| C10 | 2.00 | 4.00 | 9.78 | 16.42 | 35.98 |
| C11 | 1.60 | 2.56 | 9.78 | 16.42 | 26.16 |
| C12 | 2.00 | 4.00 | 9.78 | 16.42 | 35.98 |

Table3.7 moment of one way slab

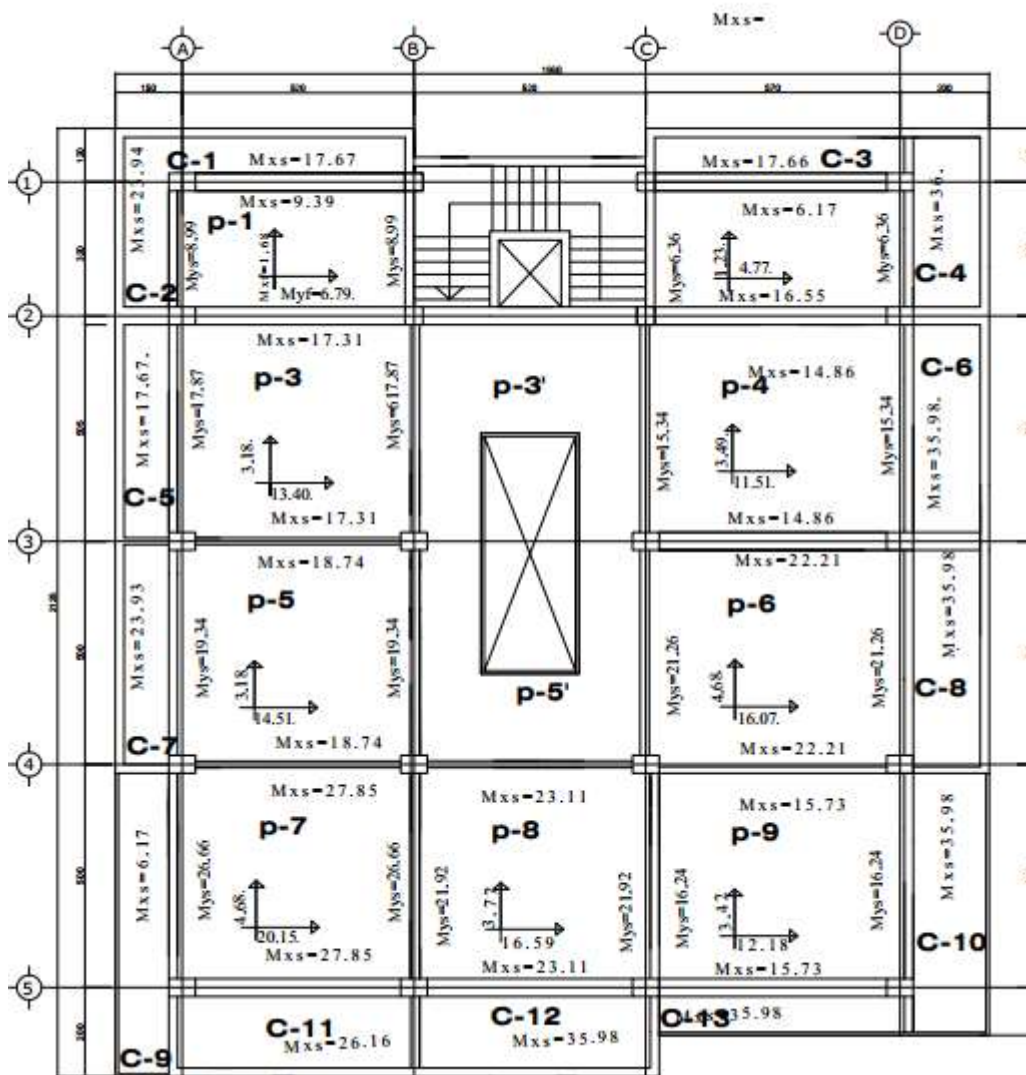


Figure 3.5 moment of unadjusted for slabs

Span Moment Adjustment

3.4.5 Moment Adjustment between Panels ➤ If the support moment is decreased the span moments M_{xf} and M_{yf} are then increased

allow for the changes of support moment.



$$M_{xdf} = M_{xf} + C_x \Delta M'$$

$$M_{ydf} = M_{yf} + C_y \Delta M'$$



Where, $\Delta M' = M_R - M_d$ (on all the supports)

C_x, C_y = Coefficients for adjusting span moments given in table.

- If the support moment is increased, no adjustment shall be made to the span moment

| | | | | | |
|----|-----------------------------------------------------------------------------------|----------------------------------------------------|------|--------------|-------------------------------------------------------------------------------------|
| | | <i>B</i> | | | |
| | | 8.36 | 3.93 | 12.29 | |
| A |  | 5 | | 6 | C  |
| DF | | 0.615 | | 0.385 | |
| | | <u>2.41846</u> | | <u>1.512</u> | |
| | | 10.778 | | 10.778 | |
| | | | | | |
| | | $K_{AB} = \frac{II}{L^3} = \frac{0.2}{I}$ | | | |
| | | $K_{BC} = \frac{3I}{4L^3} = \frac{0.13}{I}$ | | | |
| | | $DF_{AB} = \frac{K_{AB}}{K_{AB} + K_{BC}} = 0.615$ | | | |
| | | $DF_{BC} = \frac{K_{BC}}{K_{BC} + K_{AB}} = 0.385$ | | | |

| | | |
|---------------------------------------------------------------|--|--|
| M _{small} =8.36 | | |
| M _{larg} =12.29 | | |
| ΔM _s =3.93 | | |
| 0.2M _{larg} =2.46 | | |
| ΔM _s >0.2M _{larg} we use stiffness method | | |

| | | | | | |
|----|-------------------------------------------------------------------------------------|----------------------------------------------------|------|--------------|---------------------------------------------------------------------------------------|
| | | <i>B</i> | | | |
| | | 11.97 | 2.09 | 9.88 | |
| A |  | 5 | | 5 | C  |
| DF | | 0.500 | | 0.500 | |
| | | <u>1.045</u> | | <u>1.045</u> | |
| | | 10.93 | | 10.93 | |
| | | $K_{AB} = \frac{3I}{4L} = \frac{3I}{4*5} = 0.15 I$ | | | |
| | | $K_{BC} = \frac{3I}{4L} = \frac{3I}{4*5} = 0.15 I$ | | | |
| | | $DF_{AB} = \frac{K_{AB}}{K_{AB} + K_{BC}} = 0.500$ | | | |
| | | $DF_{BC} = \frac{K_{BC}}{K_{BC} + K_{AB}} = 0.500$ | | | |

| | | | |
|----------------------------------------------------------------|--|--|--|
| M _{small} =8.36 | | | |
| M _{large} =12.29 | | | |
| ΔM _s =3.93 | | | |
| 0.2M _{large} =2.46 | | | |
| ΔM _s >0.2M _{large} we use stiffness method | | | |

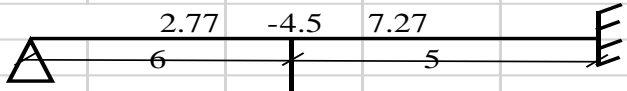
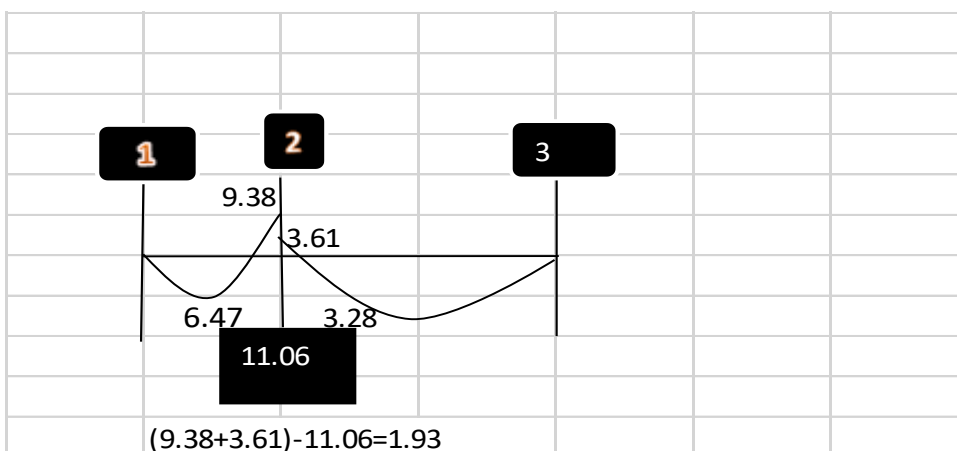
| | | | | | |
|--|------------------------------------------------------------------------------------|-----------------------------------------------------------|------|--------|--|
| | | <i>B</i> | | | |
| | A | 2.77 | -4.5 | 7.27 | |
| |  | 6 | 5 | | |
| | DF | 0.385 | | 0.615 | |
| | | -1.7308 | | -2.769 | |
| | | 1.03923 | | 10.04 | |
| | | | | | |
| | | $K_{AB} = \frac{3I}{4L} = \frac{3I}{4 \cdot 6} = 0.125 I$ | | | |
| | | $K_{BC} = \frac{I}{L} = \frac{I}{5} = 0.20 I$ | | | |
| | | $DF_{AB} = \frac{K_{AB}}{K_{AB} + K_{BC}} = 0.385$ | | | |
| | | $DF_{BC} = \frac{K_{BC}}{K_{BC} + K_{AB}} = 0.615$ | | | |

Table 3.8 adjustment of field moment

✓ Support moment adjustment



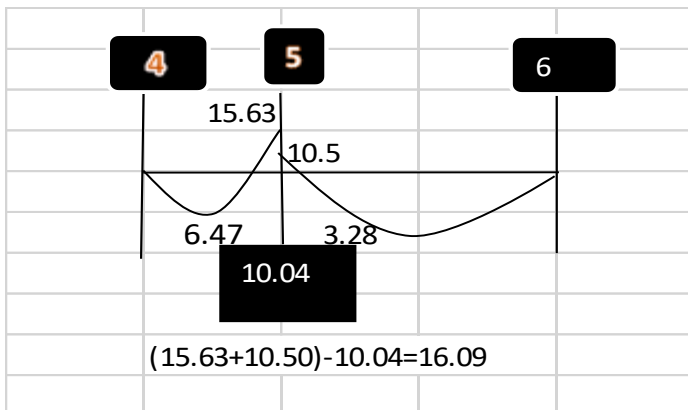
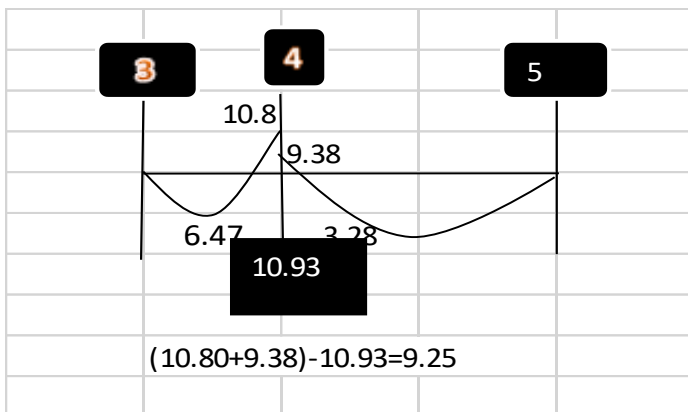
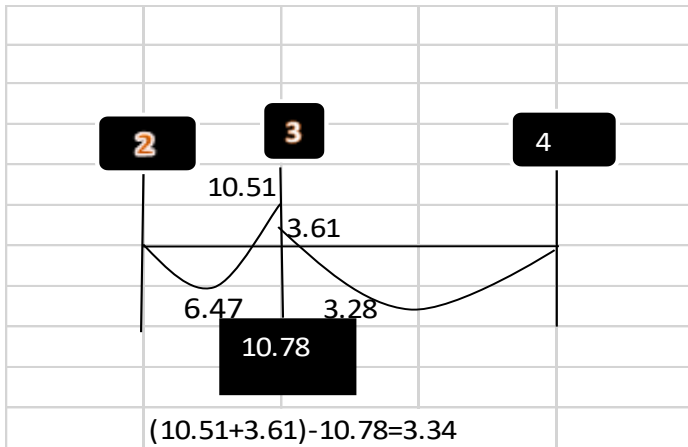


Table 3.9 adjustment of support moment

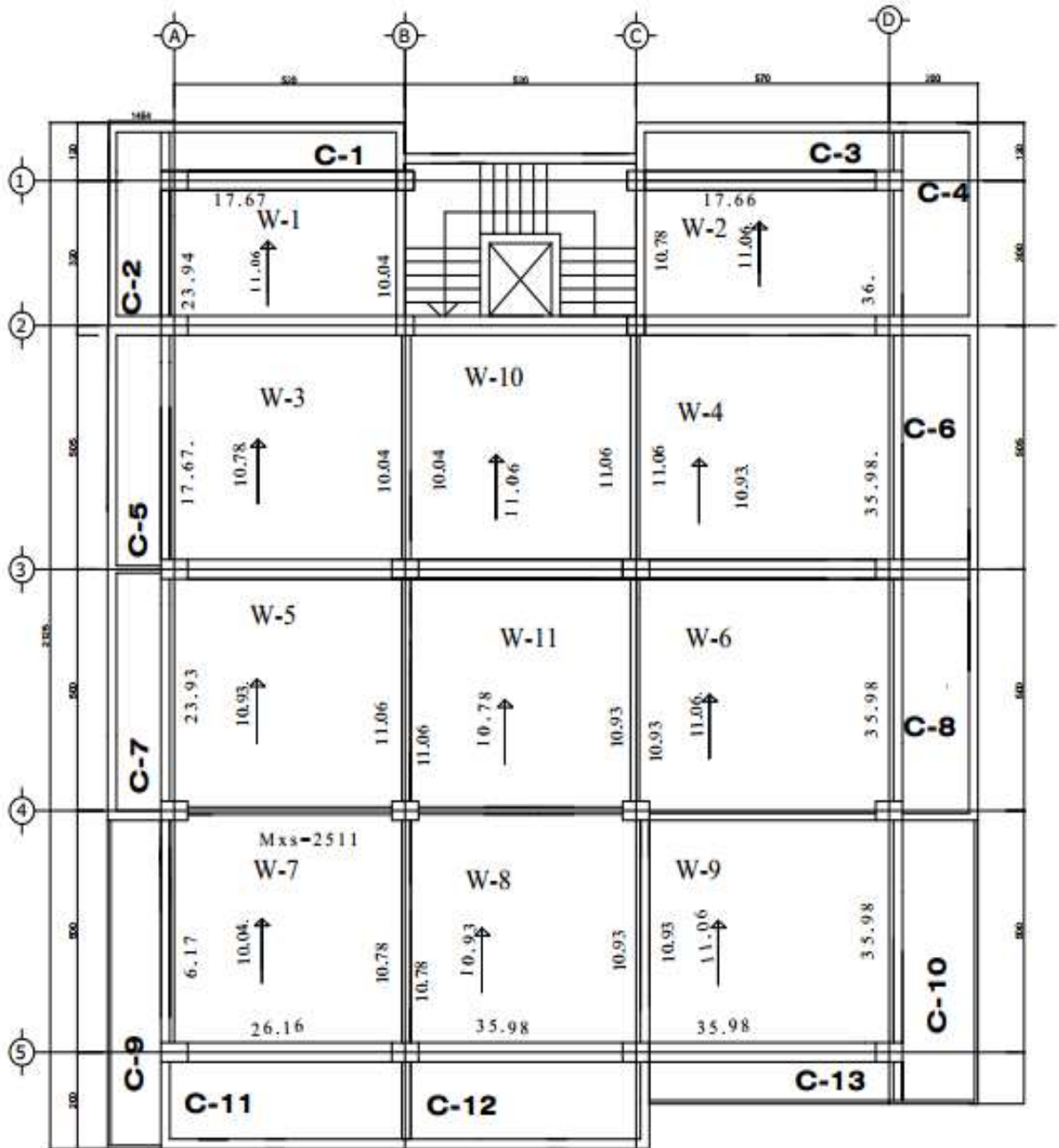


Figure 3.6 Detail drawing of adjusted moment

The design of the slab is done by coefficient method; loads are transferred to beam by load transferring mechanism. Dead load with wall load and live load is present. For the load transfer from the slab to the beams, un-factored slab DL and LL are computed separately. The design loads on beams supporting solid slabs spanning in two directions at right angles and supporting uniformly distributed loads may be assessed from the following equations obtained from Euro code, BS 8110-1:1997 section 3.5.3.7.

Design load on beams supporting solid slab spanning into directions at right angles:

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

when $l = l_y$

=Design end shear on strips of unit width and span L_x and considered to act over the middle three-quarters of the edge

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

when $l = l_x$

=Design end shear on strips of unit width and span L_y and considered to act over the middle three-quarters of the edge

- ❖ For frame analysis using ETABS, the input of loads should be un factored loads; we will compute load transfer from panels to beams separately for dead, live and wind loads.

Un-factored dead load of the slab transferring to beams

$$\beta_{vxc} = 0.34, \quad V_{xc} = \beta_{vxc} * GK * L_x = 0.34 * 8.5 * 3.95 = 10.01 \text{ KN/m}$$

$$\beta_{vxd} = 0.00, \quad V_{xd} = \beta_{vxd} * GK * L_x = 0.00 * 8.5 * 3.95 = 0.00 \text{ KN/m}$$

$$\beta_{vyc} = 0.36, \quad V_{yc} = \beta_{vyc} * GK * L_x = 0.33 * 8.5 * 3.95 = 8.94 \text{ KN/m}$$

$$\beta_{vyd} = 0.24, \quad V_{yd} = \beta_{vyd} * GK * L_x = 0.00 * 8.5 * 3.95 = 0.00 \text{ KN/m}$$

1. Dead load transfer

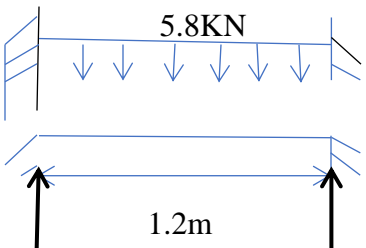
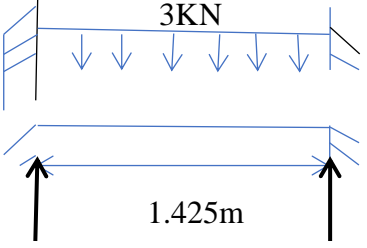
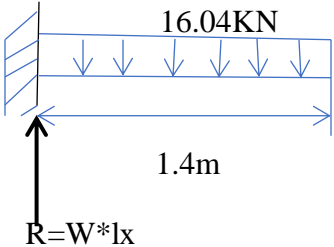
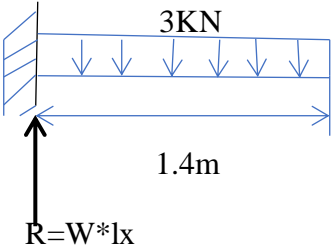
$$VD_x = \beta_{vx} * DL * L_x$$

$$VD_y = \beta_{vy} * DL * L_x$$

2. Live load transfer

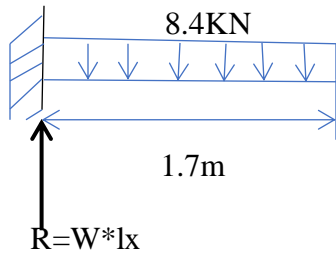
$$VLx = \beta vx * LL * Lx$$

$$VLy = \beta vy * LL * Lx$$

| | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>For C1</p> <ul style="list-style-type: none"> • For dead load <p>for live load</p>  <p>$R = Wl_x/2$</p> <p>$R = Wl_x/2 = 5.8 * 1.425 / 2 = 4.1$</p> | <ul style="list-style-type: none"> • For live load  <p>$R = Wl_x/2$</p> <p>$R = Wl_x/2 = 3 * 1.425 / 2 = 2.13$</p> |
| <p>For C</p> <ul style="list-style-type: none"> • For dead load  <p>$R = W * l_x$</p> <p>$R = W * l_x = 16 * 1.4 = 22.4 \text{ kN}$</p> | <ul style="list-style-type: none"> • For live load  <p>$R = W * l_x$</p> <p>$R = W * l_x = 3 * 1.4 = 4.2 \text{ kN}$</p> |

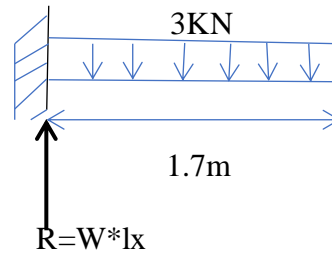
For C2

- **For dead load**



$$R = W * l_x = 8.4 * 1.7 = 14.28 \text{ kN}$$

- **For live load**



$$R = W * l_x = 3 * 1.7 = 5.1 \text{ kN}$$

Table 3.10 UN factored design load calculation

❖ For the given

- 3.4.7 Reinforcement Design
- ✓ Material Data, C-25, S-300
 - ✓ Effective depth, $d=128\text{mm}$
 - ✓ Width, $b=1000\text{mm}$

✓ Moments calculated for each panels

❖ Using design charts

$$K_m = \left(\sqrt{\frac{M}{b}} \right) / d, K_s$$

$$A_s = K_s * M / d$$

❖ To calculate spacing by selecting diameter of bar as

$$S = 1000 a_s / A \quad \text{where } a_s = \text{area of single bar}$$

$$A_s = \text{calculated area of steel}$$

$$S = \text{spacing}$$

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

$$A_{s_{\min}} = \rho_{\min} * b * d = 0.5 / f_{yk} * b * d = 0.5 * 1000 * 128 / 300 = 213.33$$

$$S_{\max} \leq \begin{cases} 2D \\ 350\text{mm} \end{cases} = \begin{cases} 2 * 160\text{mm} \\ 350\text{mm} \end{cases} = 300\text{mm}$$

$$S_{\max} = 300\text{mm}$$

Designing the slab for flexure

Reinforcement design is done using one of the three methods of calculation, those are: -

- I. Using Design Table
- II. Using Design Chart

We use the first method (Design table method) to calculate the area of reinforcement required for the design moment.

The spacing of bars should not exceed S_{\max} , slab from ECBCS EN 1992 - 1 - 1: 2014

Note: For the value of S_{\max} , slab, the recommended value is:

- For the principal reinforcement, $3D \leq 400\text{mm}$, where D is the total depth of the slab;

- For the secondary reinforcement, $3.5D \leq 450\text{mm}$

Provision of principal reinforcement

$$d = D - \text{cover} - \Phi_{\text{bar}}/2 = 180 - 22 - 10/2 = 150 \text{ mm}$$

$$X\text{-direction} = 180 - (22 + 6) = 152\text{mm}$$

$$Y\text{-direction} = 180 - (22 + 12 + 6) = 140\text{mm}$$

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

Material data; - C=25

$$S = 300$$

$$C = 25, f_{ck} = \frac{f_{cu}}{1.25} = \frac{25}{1.25} = 20\text{Mpa}$$

$$\text{Using S-300, } f_{yk} = 300\text{Mpa}$$

$$f_{yd} = \frac{f_{yk}}{1.15} = 300/1.15 = 260.86\text{Mpa}$$

Using general design table no.1 from ES EN1992-1-1:2015

$$K_m = \sqrt{\frac{M_{sd,s}}{bd^2}}$$

$$A_{s=} = \frac{K_s M_{sd,s}}{d}$$

Using corresponding value of K_m take K_s value from the table of moment

Design moment, $M_{sds} = 8.48\text{KNm}$

$$K_m = \sqrt{\frac{M_{sd,s}}{bd^2}} = \sqrt{\frac{8.48}{1 * 0.152^2}} = 19.16$$

$$K_s = 3.96$$

$$A_{s\text{calc}} = \frac{K_s M_{sd,s}}{d} = \frac{3.96 * 8.48\text{kNm}}{0.152} = 220.9\text{mm}^2$$

Secondary transverse reinforcement of not less than 20% of the principal reinforcement should be provided in one-way slabs.

The minimum and maximum value of area of reinforcement is computed in accordance with the provision of the code.

$$f_{ctm} = 0.3(F_{ck}^{2/3}) = 0.3 * 20^{2/3} = 2.2$$

$$A_{s,min} = \text{Max} \left\{ \begin{array}{l} \frac{0.26f_{ctm}btd}{f_{yk}} = \frac{0.26 * 2.2 * 1000 * 152}{300} = 289.8 \text{mm}^2 \\ 0.00013btd = 0.00013 * 1000 * 152 = 19.76 \end{array} \right. \dots\dots\dots[3] \text{ Art.9.2.1.1 (1)}$$

$$A_{sreq} = \text{Max} \left\{ \begin{array}{l} A_{s,calc} = 220.9 \text{mm}^2 \\ A_{s,min} = 289.8 \text{mm}^2 \end{array} \right.$$

$$A_{st \text{ max}} = 0.04 * A_c \dots\dots\dots[3] \text{ Art.9.2.1.1 (3)}$$

$$a_s = \frac{\pi d^2}{4} = \frac{3.14 * 12^2}{4} = 113.09 \text{mm}^2$$

$$\text{Spacing} = \frac{b * a_s}{A_{sreq}} = \frac{1000 * 113.04}{289.8} = 390.1 \text{mm}$$

For slab maximum spacing is defined in section 9.3.1.1(3) of ES EN 1992-1-1

$$S_{provide} = \min \left\{ \begin{array}{l} 3D = 3 * 180 = 540 \\ 400 \text{mm} \\ \text{Spacing} = 390.1 \text{mm} \end{array} \right. \dots\dots\dots[3]$$

$$A_{st \text{ max}} = 0.04 * A_c \dots\dots\dots[3] \text{ Art.9.2.1.1 (3)}$$

$$a_s = \frac{\pi d^2}{4} = \frac{3.14 * 10^2}{4} = 113.09 \text{mm}^2$$

$$\text{Spacing} = \frac{b * a_s}{A_{sreq}} = \frac{1000 * 113.04}{289.8} = 390.1 \text{mm}$$

For slab maximum spacing is defined in section 9.3.1.1(3) of ES EN 1992-1-1

$$S_{provide} = \min \left\{ \begin{array}{l} 3D = 3 * 180 = 540 \\ 400 \text{mm} \\ \text{Spacing} = 390.1 \text{mm} \end{array} \right. \dots\dots\dots[3]$$

Provide, Ø10C/C 390.1mm

| panel | M | values | d(m) | b | ρ | As | As(min) | S(req)mm | S(prov) |
|-------|------------|--------|------|------|----------|----------|---------|----------|---------|
| P1 | Mxs | 0.96 | 0.28 | 1000 | 0.000177 | 49.53784 | 476 | 1584.647 | 300 |
| | Mys | 1.68 | 0.29 | 1000 | 7.68E-05 | 22.28111 | 493 | 3523.164 | 300 |
| | Mxf | 0.92 | 0.28 | 1000 | 0.000169 | 47.42569 | 476 | 1655.221 | 300 |
| | Myf | 0.69 | 0.29 | 1000 | 0.000119 | 34.57688 | 493 | 2270.303 | 300 |
| P2 | Mxs | 3.6075 | 0.28 | 1000 | 0.000177 | 49.46982 | 476 | 1586.826 | 300 |
| | Mys | 1.2312 | 0.29 | 1000 | 5.61E-05 | 16.27823 | 493 | 4822.39 | 300 |
| | Mxf | 3.7238 | 0.28 | 1000 | 0.000182 | 51.06901 | 476 | 1537.136 | 300 |
| | Myf | 2.7929 | 0.29 | 1000 | 0.000127 | 36.95733 | 493 | 2124.071 | 300 |
| P3 | Mxs | 9.3842 | 0.28 | 1000 | 0.000461 | 129.1112 | 476 | 608.0029 | 300 |
| | Mys | 3.1827 | 0.29 | 1000 | 0.000145 | 42.12463 | 493 | 1863.518 | 300 |
| | Mxf | 9.6869 | 0.28 | 1000 | 0.000476 | 133.2992 | 476 | 588.9007 | 300 |
| P4 | Myf | 7.2652 | 0.29 | 1000 | 0.000332 | 96.36644 | 493 | 814.599 | 300 |
| | Mxs | 10.515 | 0.28 | 1000 | 0.000517 | 144.7592 | 476 | 542.2799 | 300 |
| | Mys | 3.4887 | 0.29 | 1000 | 0.000159 | 46.18261 | 493 | 1699.774 | 300 |
| | Mxf | 10.854 | 0.28 | 1000 | 0.000534 | 149.4579 | 476 | 525.2315 | 300 |
| P5 | Myf | 8.1404 | 0.29 | 1000 | 0.000373 | 108.0262 | 493 | 726.6759 | 300 |
| | Mxs | 10.799 | 0.28 | 1000 | 0.000531 | 148.7017 | 476 | 527.9024 | 300 |
| | Mys | 3.1827 | 0.29 | 1000 | 0.000145 | 42.12463 | 493 | 1863.518 | 300 |
| | Mxf | 11.148 | 0.28 | 1000 | 0.000548 | 153.5292 | 476 | 511.3032 | 300 |
| P6 | Myf | 8.3607 | 0.29 | 1000 | 0.000383 | 110.9632 | 493 | 707.4419 | 300 |
| | Mxs | 15.628 | 0.28 | 1000 | 0.000771 | 215.7831 | 476 | 363.7912 | 300 |
| | Mys | 4.68 | 0.29 | 1000 | 0.000214 | 61.99127 | 493 | 1266.307 | 300 |
| | Mxf | 14.963 | 0.28 | 1000 | 0.000738 | 206.5215 | 476 | 380.1056 | 300 |
| P7 | Myf | 11.305 | 0.29 | 1000 | 0.000518 | 150.275 | 493 | 522.3758 | 300 |
| | Mxs | 16.051 | 0.28 | 1000 | 0.000792 | 221.6781 | 476 | 354.1171 | 300 |
| | Mys | 4.68 | 0.29 | 1000 | 0.000214 | 61.99127 | 493 | 1266.307 | 300 |
| | Mxf | 15.368 | 0.28 | 1000 | 0.000758 | 212.1612 | 476 | 370.0017 | 300 |
| P8 | Myf | 11.611 | 0.29 | 1000 | 0.000532 | 154.3678 | 493 | 508.5257 | 300 |
| | Mxs | 13.293 | 0.28 | 1000 | 0.000655 | 183.3036 | 476 | 428.2512 | 300 |
| | Mys | 3.77 | 0.29 | 1000 | 0.000172 | 49.91326 | 493 | 1572.728 | 300 |
| | Mxf | 12.611 | 0.28 | 1000 | 0.000621 | 173.8353 | 476 | 451.577 | 300 |
| P9 | Myf | 9.5438 | 0.29 | 1000 | 0.000437 | 126.7445 | 493 | 619.3562 | 300 |
| | Mxs | 7.936 | 0.28 | 1000 | 0.00039 | 109.0965 | 476 | 719.5461 | 300 |
| | Mys | 3.42 | 0.29 | 1000 | 0.000156 | 45.27097 | 493 | 1734.003 | 300 |
| | Mxf | 8.192 | 0.28 | 1000 | 0.000402 | 112.6323 | 476 | 696.9584 | 300 |
| P10 | Myf | 6.144 | 0.29 | 1000 | 0.000281 | 81.44671 | 493 | 963.8204 | 300 |
| | $M_{xs} =$ | 0.92 | 0.28 | 1000 | 0.000404 | 111.078 | 476 | 428.2512 | 300 |
| | $M_{xf} =$ | 5.6 | 0.29 | 1000 | 0.000165 | 48.1243 | 493 | 1572.728 | 300 |
| | $M_{ys} =$ | 0.82 | 0.28 | 1000 | 0.000524 | 113.245 | 476 | 451.577 | 300 |
| P11 | $M_{yf} =$ | 0.77 | 0.29 | 1000 | 0.000145 | 34.124 | 493 | 619.3562 | 300 |
| | $M_{xs} =$ | 0.74 | 0.28 | 1000 | 0.000314 | 109.0965 | 476 | 719.5461 | 300 |
| | $M_{xf} =$ | 6.79 | 0.29 | 1000 | 0.000149 | 45.27097 | 493 | 1734.003 | 300 |
| | $M_{ys} =$ | 0.64 | 0.28 | 1000 | 0.000165 | 112.6323 | 476 | 696.9584 | 300 |

Table 3.12 maximum spacing calculation for bar re enforcement

To check the depth for deflection weathers it satisfies the serviceability requirement we use the new codes ES EN 1991:2015.

3.4.8 Check deflection

As an example

Initially we assumed $\rho_o = \rho$. But we can calculate them as follows

$$\rho = \frac{A_{st,req}}{bd} = \frac{289.8}{1000 * 152} = 0.19\% \dots\dots\dots N1992: 2017. 7.4.2(7.16a)$$

$$\rho_o = \frac{\sqrt{f_{ck}}}{1000} = \sqrt{20}/1000 = 0.4472\%$$

Now, $\rho = 0.19\% < \rho_o = 0.44721\%$

$$l/d = N * K * F1 * F2 * F3$$

$$\frac{l}{d} = K \left[11 + 1.5 \sqrt{f_{ck}} \frac{\rho_o}{\rho} + 3.2 \sqrt{f_{ck}} \left(\frac{\rho_o}{\rho} - 1 \right)^{3/2} \right] \text{ if } \rho \leq \rho_o \quad (7.16a)$$

$$N = \left[11 + 1.5 \sqrt{20} \frac{0.4472}{0.19} + 3.2 \sqrt{20} \left(\frac{0.4472}{0.19} - 1 \right)^{3/2} \right] = 49.33$$

Where; -K..... from appendix C

$$F1 = 500 / (f_{yk} A_{s,req} / A_{s,prov}) \dots\dots\dots [3] \dots (7.17)$$

F2 & F3 = 1, (because span of slab $\leq 7m$).....[3] ... section 5.3.2.2 (1).

Then we work similarly other slabs by the excel below

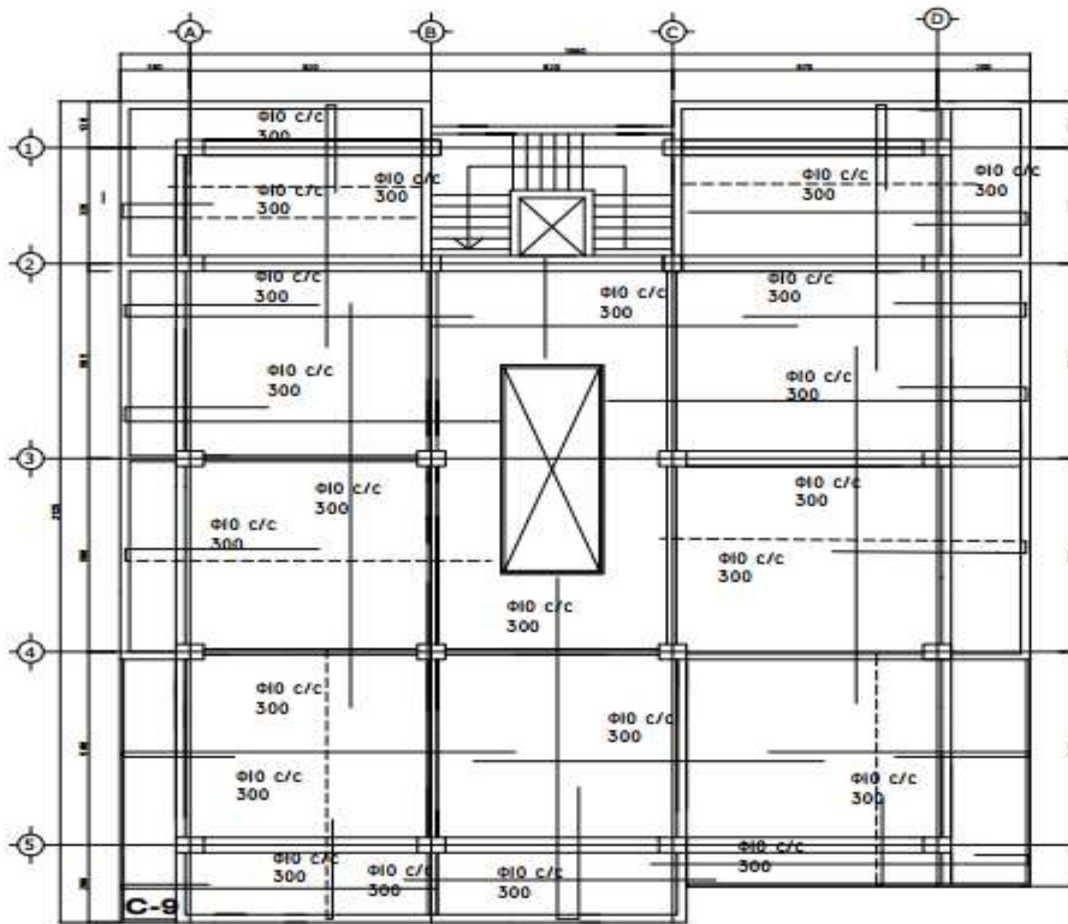


Figure 3.6 detail drawing for Flat roof

4. SOLIDE SLAB DESIGN

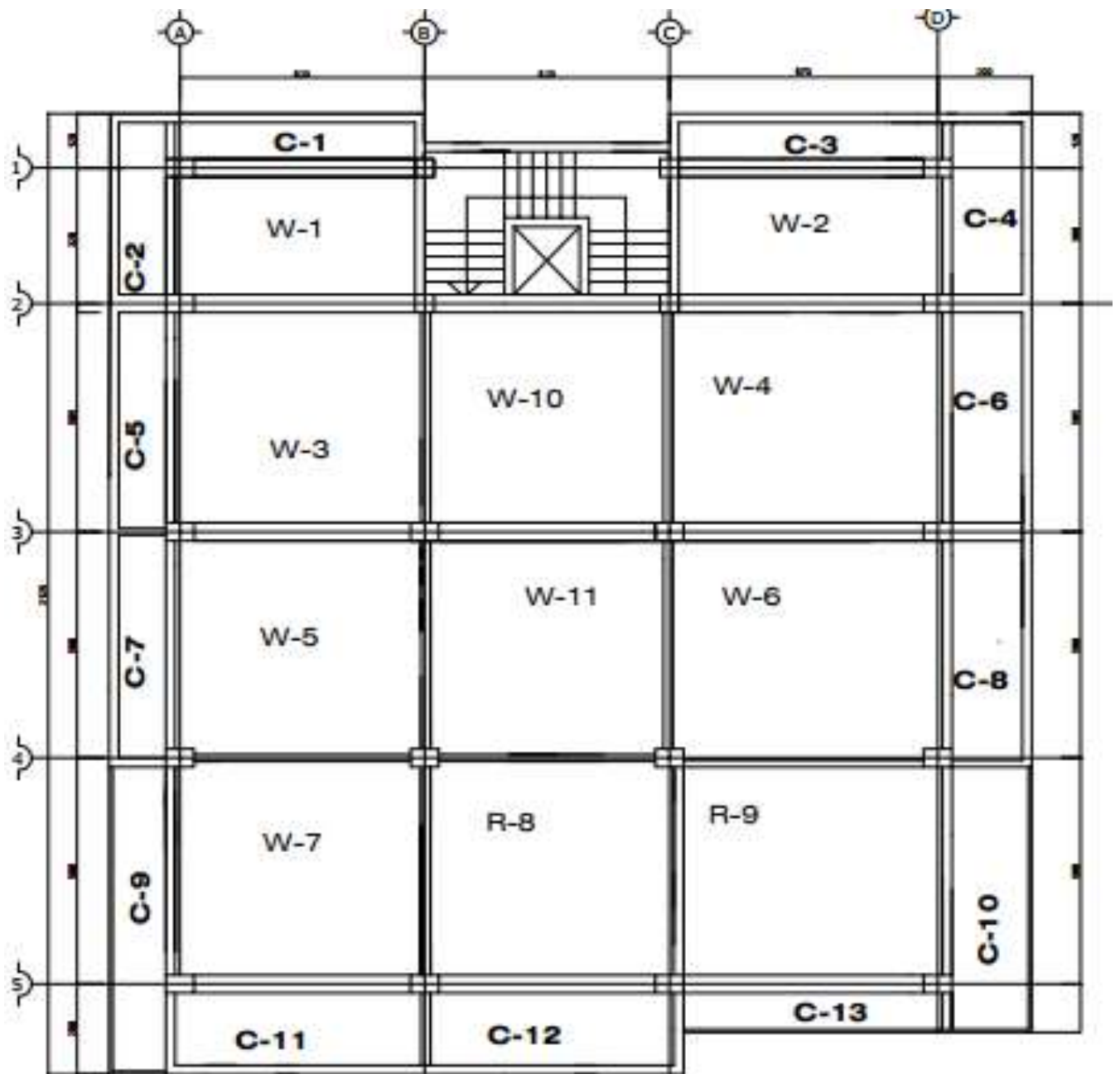
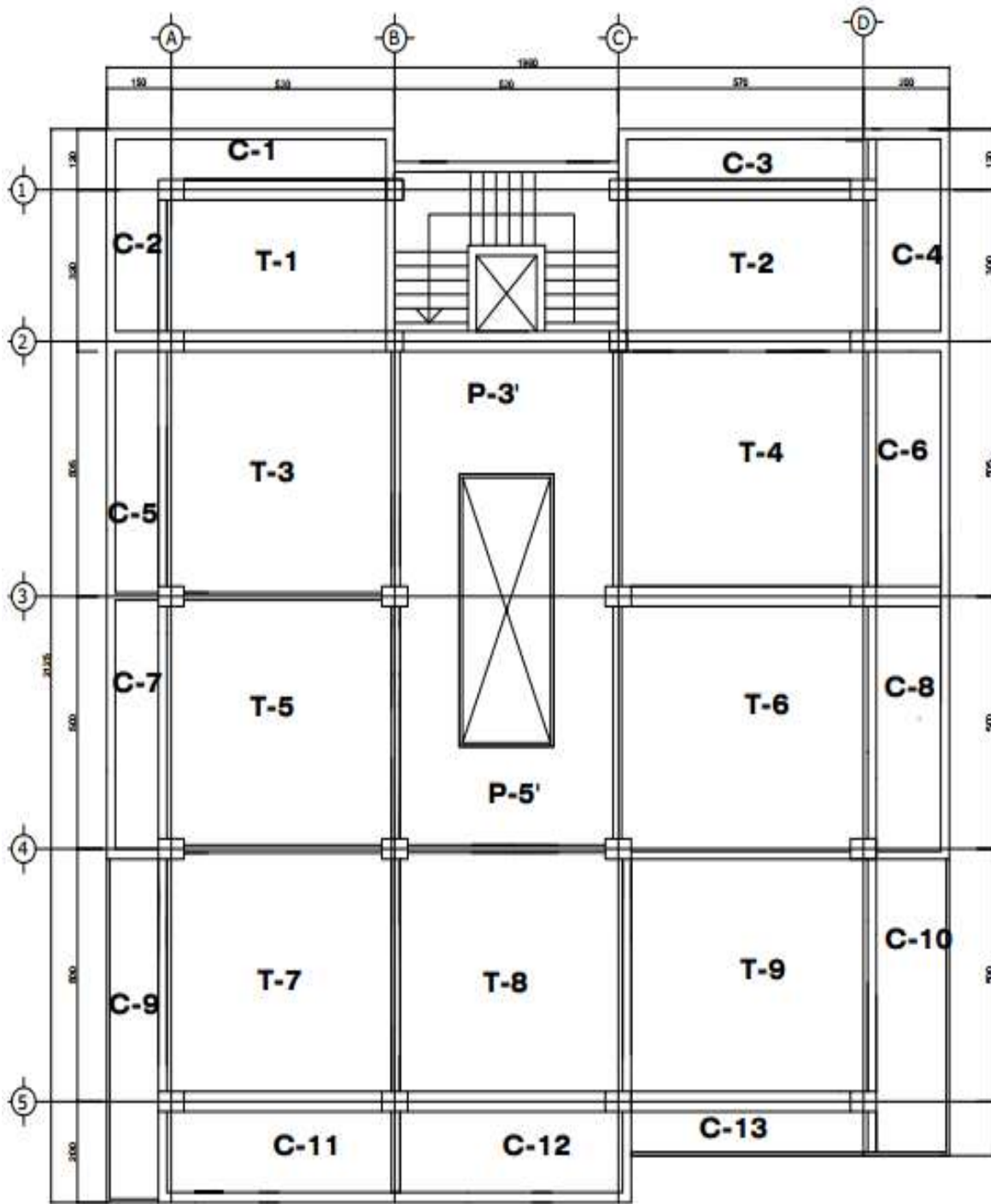
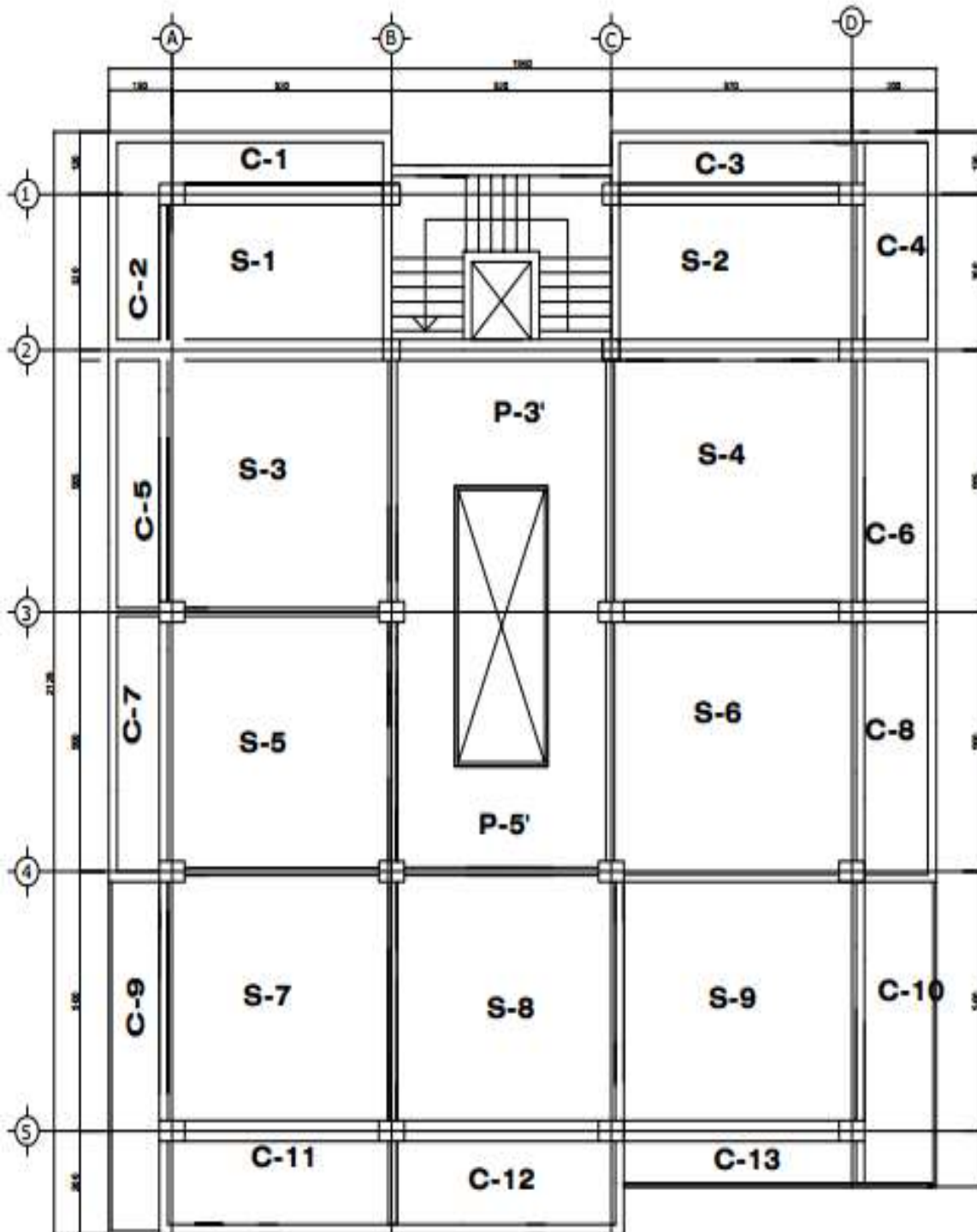


Figure 4.1 Ground floor slab lay out



8th FLOOR SLAB LAY OUT

Figure 4.2 8th floor slab lay out



3rd-7th FLOOR SLAB LAY OUT

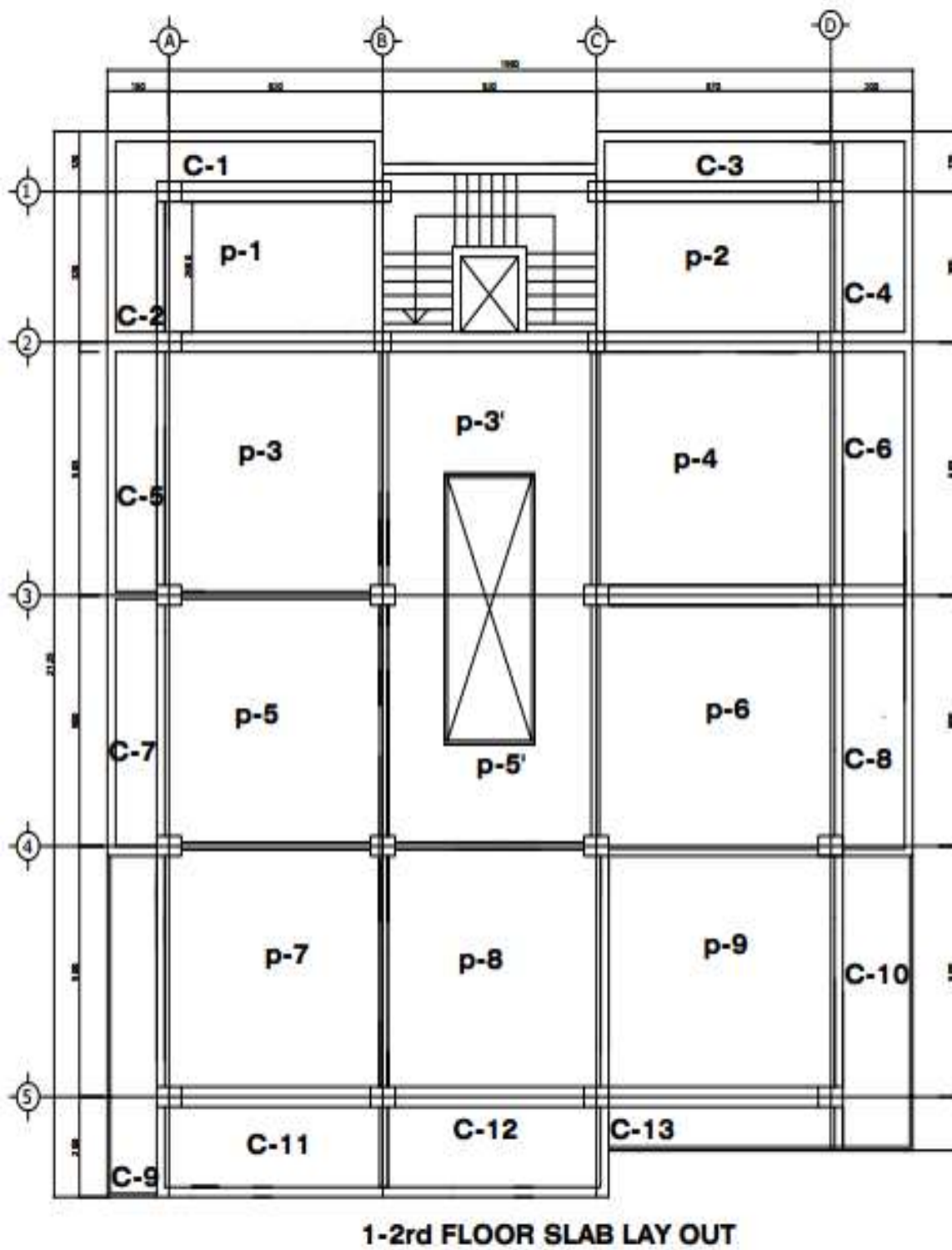


Figure 4.3 1st -2nd floor slab lay out

➤ Floor slab design

A reinforced concrete slab is a broad, flat plate, usually horizontal, with top and bottom surface parallel or nearly so. It is used to provide flat surface mainly for roofs and floors of building parking lots, air fields, road ways, bridges etc. It may be supported by reinforced concrete beam, by masonry or reinforced concrete walls, by structural steel members, directly by columns, or continuously by the ground. But we are intending to design beam supported floor and roofs solid slabs of the building accordingly ES EN-1992:2015

Beam support slab can be classified as one-way slab and two-way slab based on the longer to shorter length ratio

Based on their load transfer mechanism solid slabs are classified as:

One-way slabs: They are those either supported on the two out of our opposite sides or the longer span to short span ratio is 2.

Two-way slabs: They are those supported on all four sides and the longer span to short span ratio is less than equal to 2.

Cantilever slabs: They are those with a fixed support on only one out of four sides

4.1 Panel selection

Before proceeding to the analysis and design of solid slab we should select type of panel. The selection of panels is depending on:

- ✦ Boundary condition
- ✦ Shorter (L_x) and longer(L_y) length of the panel Function of panel

Material selected to design the slab structure

1. Concrete grade of C20/25
2. Steel grade of S-400
3. Deformed reinforcement bar of diameter with $\text{Ø}10$ for both span and support

Design strength value

- ✦ $\gamma_c=1.5$
- ✦ $f_{cd} = \alpha_{cc} * f_{ck} / \gamma_c$
- ✦ $f_{ctd}=1.03\text{mpa}$
- ✦ Elastic modulus of concrete, $E_c=29\text{Gpa}$

Elastic modulus of concrete E_c

Steel $\gamma_s=1.15$

$$f_{yd} = f_{yk} / \gamma_s$$

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

Elastic modulus of steel, $E_s=200\text{Gpa}$

4.2 Determine Geometry/Dimension

Consider one-meter strip width, $b=1000\text{mm}$

$$D = \text{effective depth (d)} + \text{cover} + L_{on}/2$$

In order to determine the depth of the slab, first it is needed to find concrete cover and effective depth.

Procedures for design of Two-way slab

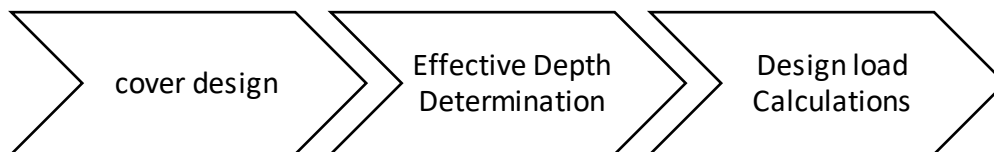


Figure 4.4: Analysis of Slab

4.2.1 Concrete cover design

The concrete cover is the distance from the surface of the reinforcement closest to the nearest concrete surface (including links and stirrups and surface reinforcement where relevant) and the nearest concrete surface. The nominal cover shall be specified on the drawings. It is defined as C_{min}

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

Where, C_{min} – minimum cover and ΔC_{dev} is allowance in design for deviation.

Minimum cover, shall provide in order to ensure

- ❖ Safe transmission of bond force
- ❖ Corrosion resistance/ Durability
- ❖ Fire resistance

4.2.1.1 Cover Design for Bond

In order to transmit bond forces safely and to ensure adequate compaction of the Concrete, the minimum cover should not be less than C_{min} , From table 4

bond requirement, arrangement of bars for separated minimum cover C_{min} , b = diameter of bar

Assume $\Phi 10$ longitudinal bar and $\Phi 25$ nominal maximum aggregate size; Therefore; C_{min} , $b=10$ mm. If nominal maximum aggregate size is greater than 32mm C_{min} , b should be increased by 5mm

4.2.1.2 Cover Design for Corrosion/Durability

The condition of exposure is assumed to be XC1

Exposure Class to determine C_{min} , dur

ForXC1, member with slab geometry (position of reinforcement not affect by construction process the exposure class is reduced class by one

ForXC1 indicative strength class is C-20/25

Note: The recommended Structural Class (design working life of 50 years) is S4 for the Indicative concrete strengths given in Annex E and the recommended modifications to the Structural class is given in Table 4.3N. But based on the above table the exposure class is reducing by 1 and the structural class would be S3.

The value of minimum cover required for durability of reinforcement steel is determined by using ES EN 1992:2015 tables 4.4N.

Using structural class, S3 and XC1:

Cmin, dur=10mm then

Exposure class classification in appendix B table 4

Design for corrosion in Appendix E table 5

Design for bond/durability in Appendix D table 4

4.3 Effective depth determination

Effective Depth Determination: For Serviceability requirement

According to ES EN 1992:2015; the limit state of deformation may be checked by either:

by limiting the span/depth ratio, according to 7.4.2 or by comparing a calculated deflection, according to 7.4.3, with a limit value

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

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

Where l/d - is the limit span/depth

K - is the factor to take into account the different structural systems

ρ_0 - is the reference reinforcement ratio = $10^{-3} \sqrt{f_{ck}}$

ρ - Is the required tension reinforcement ratio at mid-span to resist the moment due to the design loads (at support for cantilevers)

ρ' - is the required compression reinforcement ratio at mid-span to resist the moment due to design loads (at support for cantilevers) f_{ck} is in MPa units.

$$F_1 = 300 / \sigma_s = 500 / (f_{yk} \cdot a_s, req / A_s, pro)$$

$F_2 = 0.8$, for flanged sections where the ratio of the flange breadth to the rib breadth exceeds 3. Otherwise; $F_2 = 1$ for other cases.

$F_3 = 7 / l_{eff}$, for beams and slabs, other than flat slabs, with spans exceeding 7 m, which support partitions liable to be damaged by excessive

Deflections (leff in meters, see Art. 5.3.2.2 (1)). Or

$F_3=8.5/leff$, for flat slabs where the greater span exceeds 8.5 m, and which support partitions liable to be damaged by excessive deflections (leff in meters). Otherwise; $F_3=1$ for both cases.

Assumption

Initially we can't know ρ and ρ' . So let's assume $\rho = \rho_0$ and use equation 7.16a.

$A_{s, req} = A_{s, provided}$.

$$N = 11 + 1.5\sqrt{f_{ck}} \cdot \rho_0 / \rho + 3.2 \cdot \sqrt{(\rho_0 / \rho - 1)}^{(3/2)}$$

$$\rho_0 = 10 - 3\sqrt{f_{ck}}$$

$$N = 11 + 1.5\sqrt{f_{ck}}$$

$$F_1 = 500 / \sigma_s = 500 / (f_{yk} \cdot A_{s, req} / A_{s, pro})$$

Table 7.4N: Basic ratios of span/effective depth for reinforced concrete members without axial compression.

For flat slabs with spans ≤ 8.5 m and slab and beams with spans ≤ 7 m: the depth formulae

$$D = d_{min} + C_{nom} + \phi l_2 \text{ where } d_{min} \text{ is governing effective depth (Eq. 1)}$$

From the above effective depth calculation, the governing depth for design is taken.

4.4 Calculate the design loads on slab.

Dead and live loads are calculated depending on the service of the slabs and self-weight. Ignoring any localized effects caused by concentrated load, the partition loads are distributed over the area of the slab. The design loads are factored according to the following formula.

$$P_d = 1.35DL + 1.5LL$$

Where; - P_d - total factored design load

DL - total dead load on slab

LL - total live load on slab

- Dead load (DL) According to Euro code 1 Part 1, 1 –(2020) PREN 1991-1-1-20015, the nominal density of construction material reference.

Note: Due to the reason the floor comprises different finishing materials, for simplicity we have taken the finishing materials with the larger area coverage.

b) Partition wall load

N.B. partition wall load = HCB load + plastering load

Material data

- Thickness of HCB
- Thickness of plastering on two sides = 20mm
- Unit weight of HCB = 14 kN/m³

The load from the partition wall (DL_p) will be computed by the following equation

$$DL_p = h \cdot l \cdot w \cdot \gamma_c / A$$

Where, DL_p = load of partition wall (kN/m²)

h = height of HCB (m)

l = length of HCB (m)

w = width of HCB (m)

HCB = Unit weight of HCB (m)

A = area of panel (m²)

c) Live load (LL)

The imposed load according to Euro code 1 Part 1, 1 – EN 1991-1-1-2001 Table 6.2 is as follows:

Table 3.2.2 Imposed loads

Design Load Computation for Slab

The design load is composed of the following loads:

- Self-weight

- Partition wall load and Live load

| Panel | Lx(m) | Ly(m) | Ly/Lx | Type of slab | Span type | K | N | Lx/d | d |
|-------|-------|-------|-------|--------------|---------------|-----|------|--------|--------|
| T1 | 3 | 5.2 | 1.73 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 62.75 |
| T2 | 3 | 5.7 | 1.9 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 62.75 |
| T3 | 5.05 | 5.2 | 1.03 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 105.62 |
| T4 | 5.05 | 5.7 | 1.13 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 105.62 |
| T5 | 5 | 5.2 | 1.04 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 104.58 |
| T6 | 5 | 5.2 | 1.04 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 104.58 |
| T7 | 5 | 5.2 | 1.04 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 104.58 |
| T8 | 5.05 | 5.2 | 1.03 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 105.62 |
| T9 | 5.05 | 5.2 | 1.03 | Two way | Interior Span | 1.5 | 25.5 | 47.813 | 105.62 |
| C-1 | 2.1 | 5.2 | 2.48 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 286.30 |
| C-2 | 2.9 | 3 | 1.03 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 395.36 |
| C-3 | 2.1 | 5.23 | 2.49 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 286.30 |
| C-4 | 2.4 | 3 | 1.25 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 327.20 |
| C-5 | 2.9 | 5.2 | 1.79 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 395.36 |
| C-6 | 2.4 | 5.05 | 2.10 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 327.20 |
| C-7 | 2.9 | 5 | 1.72 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 395.36 |
| C-8 | 2.4 | 5 | 2.08 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 327.20 |
| C-9 | 2.9 | 5 | 1.72 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 395.36 |
| C10 | 2.4 | 5 | 2.08 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 327.20 |
| C-11 | 3.1 | 8.33 | 2.73 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 415.81 |
| C-12 | 1.8 | 5.2 | 2.89 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 245.40 |
| C-13 | 1.1 | 8.1 | 7.36 | One way | Cantiliver | 0.4 | 14.7 | 7.34 | 149.97 |
| | | | | | | | | | |

table 4.1 Calculated the design loads on slab.

Effective depth

- ✓ End panel = $D=109.22+20.5=130\text{mm}$
- ✓ Cantilever = $D=395.36+20+5=416\text{mm}$

Solid Floor Slab Cover Design suiting and standard fire resistance respectively

- ✓ 20 for panel
- ✓ 40 for cantilever

Cover design

| Panel | Exposure class | Design for Corrosion | Structural Class | Bond/Durability Minimum cover required | | | $\Delta c_{dev}(m)$ | C_{nom} | Governing Cover Design |
|-------|----------------|----------------------|------------------|----------------------------------------|--------------|---------------|---------------------|-----------|------------------------|
| | | | | $C_{min,B}$ | $C_{min,Du}$ | $C_{min}(mm)$ | | | |
| T1 | XC1 | C20/25 | S3 | 10 | 10 | 10 | 10 | 20 | 20 |
| T2 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 20 |
| T3 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 20 |
| T4 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 20 |
| T5 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 20 |
| T6 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 20 |
| T7 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 20 |
| T8 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 20 |
| T9 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 20 |
| C-1 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-2 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-3 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-4 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-5 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-6 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-7 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-8 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-9 | XC1 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-10 | XC2 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-11 | XC3 | C20/25 | S3 | 12 | 10 | 10 | 10 | 20 | 40 |
| C-12 | XC4 | C20/26 | S4 | 12 | 10 | 10 | 10 | 20 | 40 |

Table 4.2 cover design of slab and cantilever

Slab partition load

| Panel | L HCB | T HCB | H WALL | Y HCB | Ly | Lx | Area of slab | Thicknes s of plaster | Y plaster |
|-------|-------|-------|--------|-------|-----|------|--------------|-----------------------------|-----------|
| T1 | 4 | 0.15 | 3.00 | 14 | 5.2 | 3 | 15.6 | 0.04 | 23 |
| T2 | 4.23 | 0.15 | 3.00 | 14 | 5.7 | 3 | 17.1 | 0.04 | 23 |
| T3 | 4.23 | 0.15 | 3.00 | 14 | 5.2 | 5.05 | 26.26 | 0.04 | 23 |
| T4 | 8 | 0.15 | 3.00 | 14 | 5.7 | 5.05 | 28.79 | 0.04 | 23 |
| T5 | 8 | 0.15 | 3.00 | 14 | 5.2 | 5 | 26 | 0.04 | 23 |
| T6 | 8 | 0.15 | 3.00 | 14 | 5.7 | 5.05 | 28.79 | 0.04 | 23 |
| T7 | 8 | 0.15 | 3.00 | 14 | 5.2 | 5 | 26 | 0.04 | 23 |
| T8 | 8 | 0.15 | 3.00 | 14 | 5.2 | 5.05 | 26.26 | 0.04 | 23 |
| T9 | 8 | 0.150 | 3.000 | 14 | 5.7 | 5 | 28.5 | 0.04 | 23 |

Table 4.3 slab partition load

Calculation of Design load

Sectional (detail) elevation of floor slabs

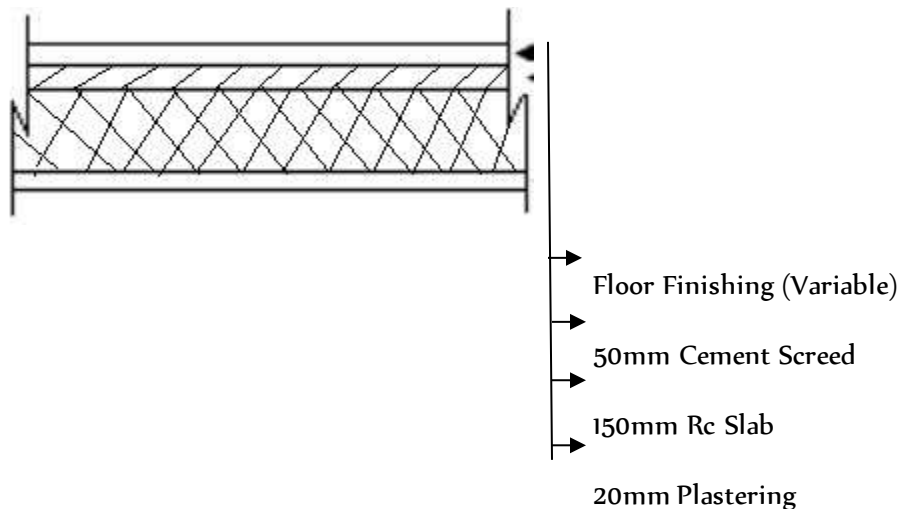


Figure 4.5 Sectional (detail) elevation of floor slabs

Room Functions and their finishing materials

| No | Functions | Finishing | Thickness | Unit wt (kN/m ³) |
|----|---------------|---------------|-----------|------------------------------|
| 1 | Kitchen | Ceramic | 2 cm | 21 |
| 2 | Cafeteria | Terrazzo Tile | 2 cm | 23 |
| 3 | Shop | Terrazzo Tile | 2 cm | 23 |
| 4 | Corridor | Marble | 3 cm | 27 |
| 5 | Retail | Terrazzo Tile | 2 cm | 23 |
| 6 | Balcony | Marble | 3 cm | 27 |
| 7 | Toilet | Ceramic | 2 cm | 21 |
| 8 | Shower | Ceramic | 2 cm | 21 |
| 9 | Landing | Marble | 3 cm | 27 |
| 10 | Internet Cafe | Terrazzo Tile | 2 cm | 23 |
| 11 | Bed Room | PVC Tile | 2 cm | 16 |
| 12 | Janitor Room | Terrazzo Tile | 2 cm | 23 |

Table 4.4 Room Functions and their finishing materials

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

Live Load for different functions based on EBCS-1

| Function | Category | | Live Load |
|-----------|----------|---------|---------------------|
| Kitchen | A | General | 2 KN/m ² |
| Cafeteria | C | C1 | 3 KN/m ² |
| Shop | D | D1 | 5 KN/m ² |

| | | | |
|---------------|---|-----------|---------------------|
| Corridor | C | C3 | 5 KN/m ² |
| Retail | D | D1 | 5 KN/m ² |
| Balcony | A | balconies | 4 KN/m ² |
| Toilet | A | general | 2 KN/m ² |
| Shower | A | general | 2 KN/m ² |
| Landing | A | satires | 3 KN/m ² |
| Internet Cafe | C | C1 | 3 KN/m ² |
| Bed Room | A | general | 2 KN/m ² |
| Janitor Room | D | D1 | 5 KN/m ² |

Table 4.5 Live Load for different functions based on EBCS-1

➤ Dead load

The dead load is composed of the self-weight of the slab itself, weights of the partition walls, weight of the finishing and other considerable permanent loads. Self-weight of the slab is equal to the overall depth times unit weight of concrete. Partition loads are distributed over

Dead load due to partition load

Partition wall dead load computation

Material data

- Thickness of HCB=20cm=0.2m
- Thickness of plastering on two side=20mm=0.02m
- Unit weight of HCB=12 KN/m³
- Unit weight of plastering =23 KN/m³
- Height of wall=3.2m
- Unit weight of Glass =25KN/m³
- Thickness of glass=0.004m`

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 HCB=12 KN/m³

Dead load of partition walls=Dead load of plaster+ Dead load of HCB

$$D.L\ pw = D.L\ pl + D.L\ HCB,$$

$$D.L\ pw\ (kN) = (Hpl * Lpl * tpl * \gamma_{pl}) + (HHCB * LHCB * tHCB * \gamma_{HCB})$$

$$D.L\ pw\ (kN) = (3.2m * Lpl * 0.02m * 23\ KN/m^3) + (3.2m * LHCB * 0.2m * 12\ KN/m^3)$$

$$\text{But } Lpl = LHCB = Lpw$$

$$\text{Therefore, } D.L\ pw\ (kN/m^2) =$$

- Where, D.L pw = Dead load of Partition Wall
- Hpl, Lpl, tpl & pl = Height, Length, Thickness, Unit Weight of Plastering Respectively.
- H(HCB), L(HCB), t(HCB) & HCB = Height, Length, Thickness, Unit Weight of HCB Respectively

Total dead load for floors

Dead Load Computation based on function rooms

| Function | Material | Thickness (m) | Unit Weight, γ (KN/m ²) | γ_t (KN/m ²) | Total Dead Load (KN/m ²) |
|---------------|-----------------------|---------------|--------------------------------------------|---------------------------------|--------------------------------------|
| Kitchen | Ceramic | 0.02 | 21 | 0.42 | 5.63 |
| Toilet | Cement Screed | 0.05 | 23 | 1.15 | |
| Shower | | RC Slab | 0.15 | 24 | |
| | Plastering & Painting | 0.02 | 23 | 0.46 | |
| Cafeteria | Terrazzo Tile | 0.02 | 23 | 0.46 | 5.67 |
| Shop | Cement Screed | 0.05 | 23 | 1.15 | |
| Retail | | RC Slab | 0.15 | 24 | |
| Internet Café | | | | | |

| | | | | | |
|--------------------------------|-----------------------|-------|----|-------|------|
| Janitors Room | Plastering & Painting | 0.02 | 23 | 0.46 | |
| Corridor Balcony Landing | Marble | 0.03 | 27 | 0.81 | 6.02 |
| | Cement Screed | 0.03 | 23 | 1.15 | |
| | RC Slab | 0.15 | 24 | 3.6 | |
| | Plastering & Painting | 0.02 | 23 | 0.46 | |
| Bed Room | PVC | 0.002 | 16 | 0.032 | 5.25 |
| | Cement Screed | 0.05 | 23 | 1.15 | |
| | RC Slab | 0.15 | 24 | 3.6 | |
| | Plastering & Painting | 0.02 | 23 | 0.046 | |

Table 4.6 Dead Load Computation based on function of rooms

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

Live load (LL)

Since the building is multifunction building the live loads are different depending on the function of the building. (see appendix C)

$$P_d = 1.35DL + 1.5LL$$

| PANEL | Slab self-weight | Partition WL | Total SW | Floor finish type | Function | Live load (LL) | Pd=1.35DL+1.5LL |
|-------|------------------|--------------|----------|-------------------|------------|----------------|-----------------|
| T1 | 7.44 | 1.65 | 9.09 | Ceramic tile | Guest room | 2.00 | 8.54 |
| T2 | 7.44 | 1.59 | 9.03 | Ceramic tile | Guest room | 2.00 | 12.93 |
| T3 | 7.44 | 1.46 | 8.90 | Ceramic tile | Guest room | 2.00 | 11.87 |
| T4 | 7.44 | 2.52 | 9.96 | Ceramic tile | Guest room | 2.00 | 13.30 |
| T5 | 7.44 | 2.79 | 10.23 | Ceramic tile | Guest room | 2.00 | 13.66 |
| T6 | 7.44 | 2.52 | 9.96 | Ceramic tile | Guest room | 2.00 | 13.30 |
| T7 | 7.44 | 2.79 | 10.23 | Ceramic tile | Bed room | 2.00 | 13.66 |
| T8 | 7.44 | 2.76 | 10.20 | PVC tile | Suit room | 2.00 | 13.63 |
| T9 | 7.44 | 0.25 | 7.69 | Ceramic tile | Bed room | 2.00 | 10.24 |

| Panel | L HCB | T HCB | H WALL | Y HCB | Ly | Lx | Area of floor | T plaster | Y plaster | T DL | Pd'=TDL/A | Dead load | LL | Pd'(KN) due self weight | Total design load PD(KN/M2) |
|-------|-------|-------|--------|-------|------|-----|---------------|-----------|-----------|-------|-----------|-----------|----|-------------------------|-----------------------------|
| C-1 | 6.4 | 0.15 | 1.5 | 14 | 5.2 | 1.2 | 6.24 | 0.04 | 23 | 28.99 | 4.65 | 7.44 | 4 | 12.09 | 16.73 |
| C-2 | 7.2 | 0.15 | 1.5 | 14 | 4.2 | 1.5 | 6.3 | 0.04 | 23 | 32.62 | 5.18 | 7.44 | 4 | 12.62 | 17.79 |
| C-3 | 8.1 | 0.15 | 1.5 | 14 | 5.7 | 1.2 | 6.84 | 0.04 | 23 | 36.69 | 5.36 | 7.44 | 4 | 12.80 | 18.17 |
| C-4 | 8.2 | 0.15 | 1.5 | 14 | 4.2 | 2 | 8.4 | 0.04 | 23 | 37.15 | 4.42 | 7.44 | 4 | 11.86 | 16.28 |
| C-5 | 5.55 | 0.15 | 1.5 | 14 | 5.05 | 1.2 | 6.06 | 0.04 | 23 | 25.14 | 4.15 | 7.44 | 4 | 11.59 | 15.74 |
| C-6 | 7.05 | 0.15 | 1.5 | 14 | 5.05 | 2 | 10.1 | 0.04 | 23 | 31.94 | 3.16 | 7.44 | 4 | 10.60 | 13.76 |
| C-7 | 6.5 | 0.15 | 1.5 | 14 | 5 | 1.5 | 7.5 | 0.04 | 23 | 29.45 | 3.93 | 7.44 | 4 | 11.37 | 15.29 |
| C-8 | 7 | 0.15 | 1.5 | 14 | 5 | 2 | 10 | 0.04 | 23 | 31.71 | 3.17 | 7.44 | 4 | 10.61 | 13.78 |
| C-9 | 6.5 | 0.15 | 1.5 | 14 | 5 | 1.6 | 8 | 0.04 | 23 | 29.45 | 3.68 | 7.44 | 4 | 11.12 | 14.80 |
| C-10 | 7 | 0.15 | 1.5 | 14 | 5 | 2 | 10 | 0.04 | 23 | 31.71 | 3.17 | 7.44 | 4 | 10.61 | 13.78 |
| C-11 | 8.4 | 0.15 | 1.5 | 14 | 6.4 | 1.6 | 10.24 | 0.04 | 23 | 38.05 | 3.72 | 7.44 | 4 | 11.16 | 14.87 |
| C-12 | 7.2 | 0.15 | 1.5 | 14 | 5.2 | 2 | 10.4 | 0.04 | 23 | 32.62 | 3.14 | 7.44 | 4 | 10.58 | 13.71 |
| C-13 | 7.7 | 0.15 | 1.5 | 14 | 5.7 | 2 | 11.4 | 0.04 | 23 | 24.26 | 2.13 | 7.44 | 4 | 9.57 | 11.70 |

Table 4.7 design load

*****Similarly, for all floor worked in appendix I

4.5 Moment Analyses

According to newly revised building core of Ethiopia for two-way slab use coefficient method in order to calculate moment using general formula

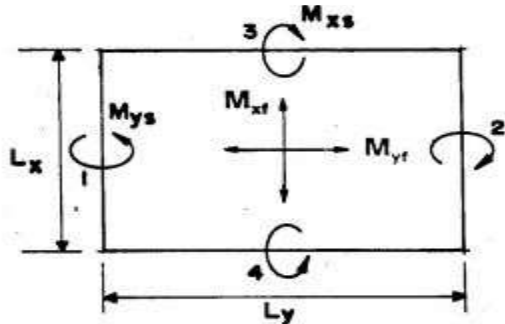
$$M_i = \alpha_i q L_x^2$$

Where; $-M_i$ is design moment per unit width at the point of reference

α_i is coefficient

q is design load of each panel

L_x is shorter span



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

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

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

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

Check for slab Continuity

Before proceeding to moment calculation first the typical slabs continuity has to be checked slab continuity has the following assumption.

- ✓ Two slab located side to side considered as continues if side length of side slab is greater than or equal to $1/3$ of length of second slab
- ✓ Continuity determines necessity and location of top or bottom reinforcement and it Depend on loading type and geometry

Material Data

- ✓ Thickness of HCB=200mm
- ✓ Thickness plastering on two side=20mm
- ✓ Unit weight of HCB=14KN/m³
- ✓ Unit weight of plastering=23 KN/m³
- ✓ Height of wall=3m

Individual panel moment calculation

Below the procedure for moment panel calculation is included.

A sample panel (s-1) taken to show step for calculation panel moment. Same procedure taken to others. Subscripts for moments and moment coefficients, α_i have the following meanings:

S, support f, field (span) x -direction of shorter span y direction of longer span

. For rectangular slab

Let us do panel one for sample and others are done by excel.

$$L_y=5.2\text{m}, L_x=3.2\text{m}$$

$$M_{xs} = \alpha_{xs} * pd * L_x^2, \quad M_{xf} = \alpha_{xf} * pd * L_x^2$$

$$M_{ys} = \alpha_{ys} * pd * L_x^2, \quad M_{yf} = \alpha_{yf} * pd * L_x^2$$

$$\alpha_{xs} = 0.05, \alpha_{xf} = 0.04$$

$$\alpha_{ys} = 0.05, \alpha_{yf} = 0.03$$

$$M_{xs} = 0.05 * 8.54 * 3.2^2 = 4.37 \text{KNm}$$

$$M_{xf} = 0.04 * 8.51 * 3.2^2 = 3.49 \text{KNm}$$

$$M_{ys} = 0.05 * 8.51 * 3.2^2 = 4.37 \text{KNm}$$

$$M_{yf} = 0.03 * 8.51 * 3.2^2 = 2.61 \text{KN}$$

| panel | lx | lx ² | Pd | LY | LY/Lx | Moment Coefficient | | Moment location | Mi= $\beta_i P_d L^2 x$ |
|-------|----|-----------------|-------|-----|-------|--------------------|-------|-----------------|----------------------------|
| | | | | | | location | value | | |
| T1 | 3 | 9.00 | 8.54 | 5.2 | 1.73 | β_{xs} | 0.05 | $M_{xs} =$ | 3.61 |
| | | | | | | β_{xf} | 0.04 | $M_{xf} =$ | 1.68 |
| | | | | | | β_{ys} | 0.05 | $M_{ys} =$ | 3.46 |
| | | | | | | β_{yf} | 0.03 | $M_{yf} =$ | 2.61 |
| T2 | 3 | 9.00 | 12.93 | 5.7 | 1.90 | β_{xs} | 0.03 | $M_{xs} =$ | 3.61 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 1.23 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 3.72 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 2.79 |
| T3 | 5 | 25.50 | 11.87 | 5.2 | 1.03 | β_{xs} | 0.03 | $M_{xs} =$ | 9.38 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 3.18 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 9.69 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 7.27 |
| T4 | 5 | 25.50 | 13.3 | 5.7 | 1.13 | β_{xs} | 0.03 | $M_{xs} =$ | 10.51 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 3.49 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 10.85 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 8.14 |
| T5 | 5 | 25.50 | 13.66 | 5.2 | 1.03 | β_{xs} | 0.03 | $M_{xs} =$ | 10.80 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 3.18 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 11.15 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 8.36 |
| T6 | 5 | 25.00 | 13.3 | 5.2 | 1.04 | β_{xs} | 0.05 | $M_{xs} =$ | 15.63 |
| | | | | | | β_{xf} | 0.04 | $M_{xf} =$ | 4.68 |
| | | | | | | β_{ys} | 0.05 | $M_{ys} =$ | 14.96 |
| | | | | | | β_{yf} | 0.03 | $M_{yf} =$ | 11.31 |
| T7 | 5 | 25.00 | 13.66 | 5.2 | 1.04 | β_{xs} | 0.05 | $M_{xs} =$ | 16.05 |
| | | | | | | β_{xf} | 0.04 | $M_{xf} =$ | 4.68 |
| | | | | | | β_{ys} | 0.05 | $M_{ys} =$ | 15.37 |
| | | | | | | β_{yf} | 0.03 | $M_{yf} =$ | 11.61 |
| T8 | 5 | 25.00 | 13.63 | 5.2 | 1.04 | β_{xs} | 0.04 | $M_{xs} =$ | 13.29 |
| | | | | | | β_{xf} | 0.03 | $M_{xf} =$ | 3.77 |
| | | | | | | β_{ys} | 0.04 | $M_{ys} =$ | 12.61 |
| | | | | | | β_{yf} | 0.03 | $M_{yf} =$ | 9.54 |
| T9 | 5 | 25.00 | 10.24 | 5.7 | 1.14 | β_{xs} | 0.03 | $M_{xs} =$ | 7.94 |
| | | | | | | β_{xf} | 0.02 | $M_{xf} =$ | 3.42 |
| | | | | | | β_{ys} | 0.03 | $M_{ys} =$ | 8.19 |
| | | | | | | β_{yf} | 0.02 | $M_{yf} =$ | 6.14 |

Table 4.8 Moment Calculation for one-way cantilever slabs.

Moment for one-way slab

Cantiliver-1

$$\text{Load from external wall} = (H_{pl} * t_{pl} * \gamma_{pl}) + (H_{HCB} * t_{HCB} * \gamma_{HCB})$$

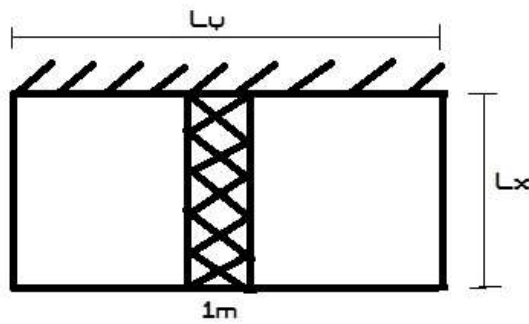
Where: H_{pl}, t_{pl} & γ_{pl} = Height, Thickness, Unit Weight of Plastering Respectively.

H_{HCB}, t_{HCB} & γ_{HCB} = Height, Thickness, Unit Weight of HCB Respectively.

$$D.L_{ex} = (0.2m \times 3m \times 14 \text{ KN/m}^3) + (0.02m \times 3m \times 23 \text{ KN/m}^3)$$

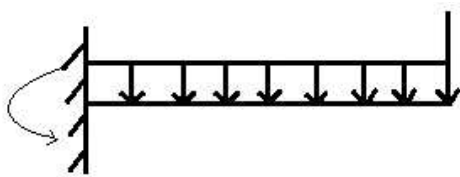
$$= 9.78 \text{ KN/m}$$

➤ Taking 1m strip of the slab in the shorter direction



$$D.L_{ex} = 9.78 \text{ kN}$$

$$P_d = 16.73 \text{ KN/m}$$



$$M_{xs} = 9.78 \text{ KN} * 1.2m + 16.73 \text{ KN} * \left(\frac{1.2m}{2}\right)^2$$

$$M_{xs} = 28.51 \text{ KN.m}$$

$$\text{General formula } M_{xs} = DL * L_x + p_d * \left(\frac{L_x^2}{2}\right)$$

| Panel | Lx | Lx2 | DL | Pd | Mxs |
|-------|------|------|------|-------|-------|
| C1 | 1.20 | 1.44 | 9.78 | 16.48 | 17.67 |
| C2 | 1.50 | 2.25 | 9.78 | 16.48 | 23.94 |
| C3 | 1.20 | 1.44 | 9.78 | 16.47 | 17.66 |
| C4 | 2.00 | 4.00 | 9.78 | 16.44 | 36.00 |
| C5 | 1.20 | 1.44 | 9.78 | 16.48 | 17.67 |
| C6 | 2.00 | 4.00 | 9.78 | 16.42 | 35.98 |
| C7 | 1.50 | 2.25 | 9.78 | 16.45 | 23.93 |
| C8 | 2.00 | 4.00 | 9.78 | 16.42 | 35.98 |
| C9 | 1.60 | 2.56 | 9.78 | 16.45 | 26.17 |
| C10 | 2.00 | 4.00 | 9.78 | 16.42 | 35.98 |
| C11 | 1.60 | 2.56 | 9.78 | 16.42 | 26.16 |
| C12 | 2.00 | 4.00 | 9.78 | 16.42 | 35.98 |

Table 4.9 unadjusted moment for cantilever

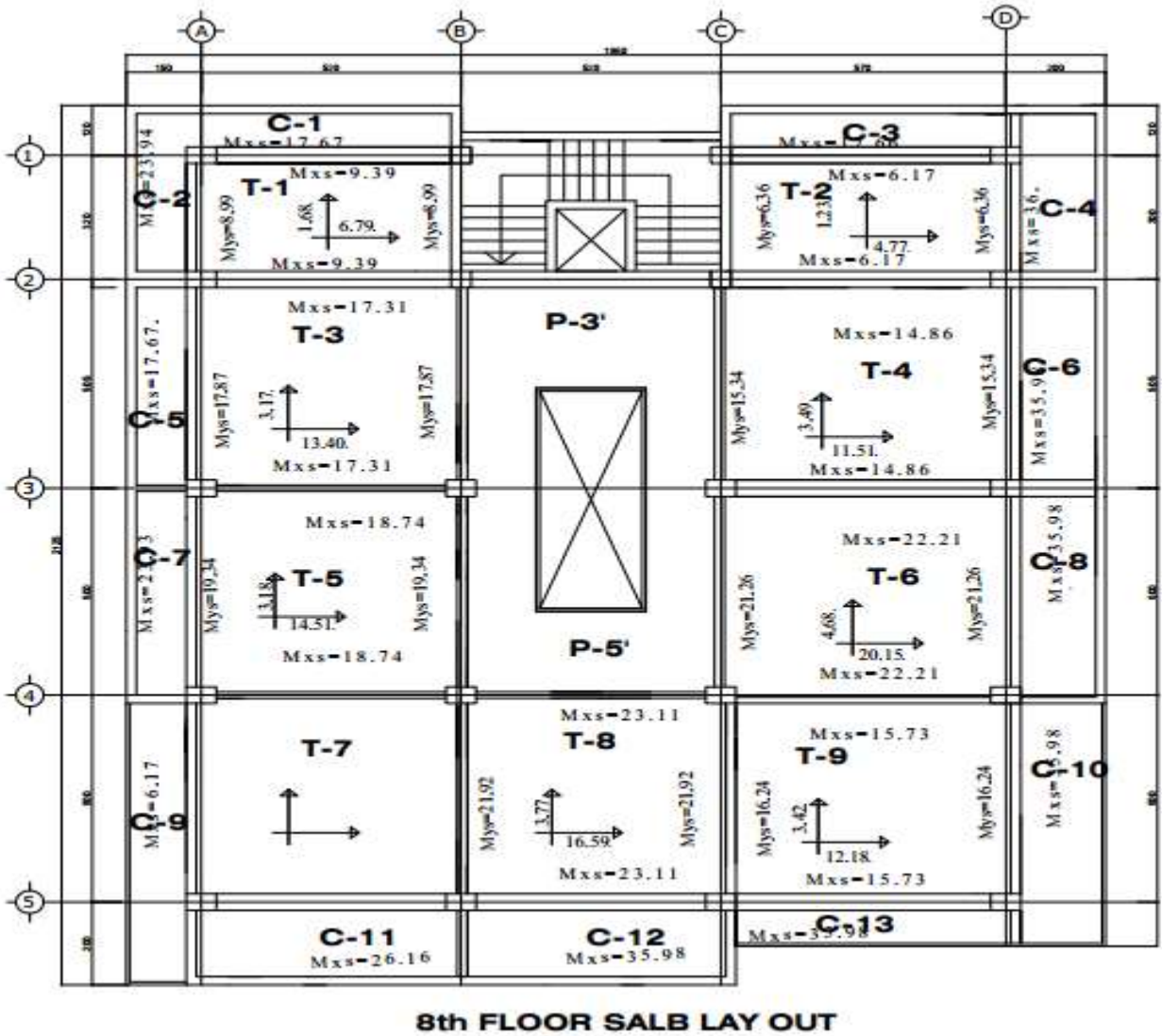


Figure 4.6 unadjusted moment for 8th floor


***** Similarly, for other floor worked in appendix I

4.6 Moment adjustment


Field moment adjustment

Note: If M_s is decreased, then field moments are increased to allow equilibrium compatibility. If M_s is increased, no field moment adjustment is required.

Adjustments are required between (S1 & S3), (P1 & P3), (T1 & T3), (W1 & W5), (S2 & S4), (P1 & P4) (T2 & T4) (W2 & W4) (S3 & S5) (P3&P5) T3&T5) (W3&W5) (S5&S7) (P5&P7) (T5&T7) (W5&W7) (S6&S6) (P6&P9) (T6&T9) (W6&W9))

| | | | | | |
|----|-----------------------------------------------------------------------------------|----------------------------------------------|------|---------------|---|
| | | <i>B</i> | | | |
| | | 8.36 | 3.93 | 12.29 | |
| A |  | 5 | | 6 | C |
| DF | | 0.615 | | 0.385 | |
| | | 2.41846 | | 1.512 | |
| | | 10.778 | | 10.778 | |
| | | $K_{AB} = \frac{II}{L^3} =$ | | <u>0.2 I</u> | |
| | | $K_{BC} = \frac{3I}{4L^3} =$ | | <u>0.13 I</u> | |
| | | $DF_{AB} = \frac{K_{AB}}{K_{AB} + K_{BC}} =$ | | 0.615 | |
| | | $DF_{BC} = \frac{K_{BC}}{K_{BC} + K_{AB}} =$ | | 0.385 | |

M_{small}=8.36
M_{larg}=12.29
ΔM_s=3.93
0.2M_{larg}=2.46
ΔM_s>0.2M_{larg} we use stiffness methode

| | | | | | |
|----|-------------------------------------------------------------------------------------|----------------------------------------------|------|---------------|---|
| | | <i>B</i> | | | |
| | | 11.97 | 2.09 | 9.88 | |
| A |  | 5 | | 5 | C |
| DF | | 0.500 | | 0.500 | |
| | | 1.045 | | 1.045 | |
| | | 10.93 | | 10.93 | |
| | | $K_{AB} = \frac{3I}{4L} = \frac{3I}{4*5}$ | | <u>0.15 I</u> | |
| | | $K_{BC} = \frac{3I}{4L} = \frac{3I}{4*5}$ | | <u>0.15 I</u> | |
| | | $DF_{AB} = \frac{K_{AB}}{K_{AB} + K_{BC}} =$ | | 0.500 | |
| | | $DF_{BC} = \frac{K_{BC}}{K_{BC} + K_{AB}} =$ | | 0.500 | |

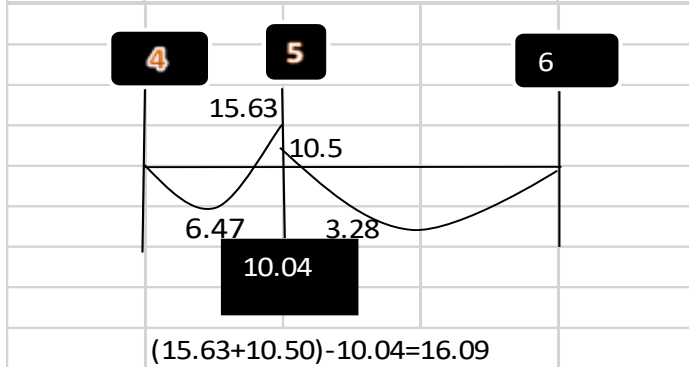
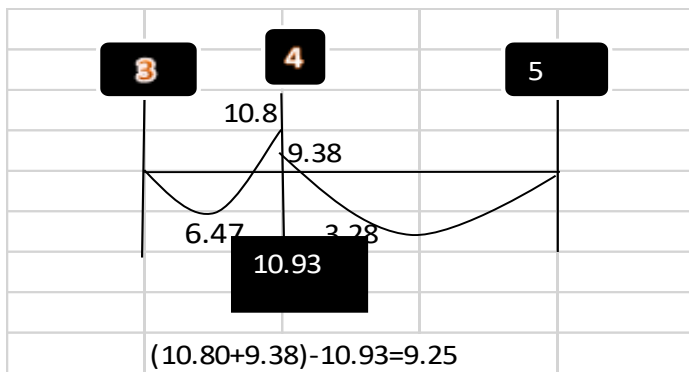
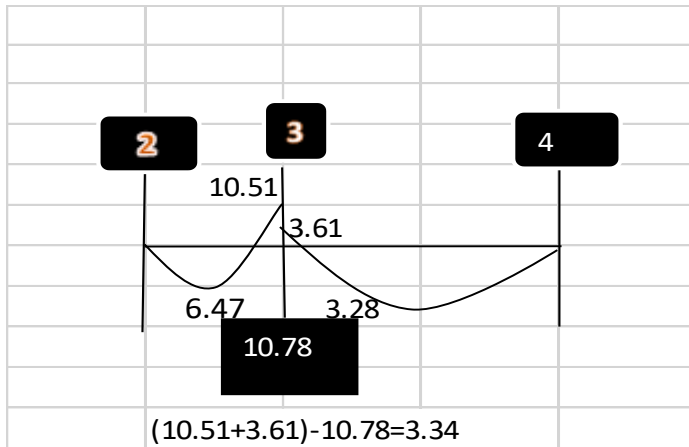


Table 4.1 support moment adjustment

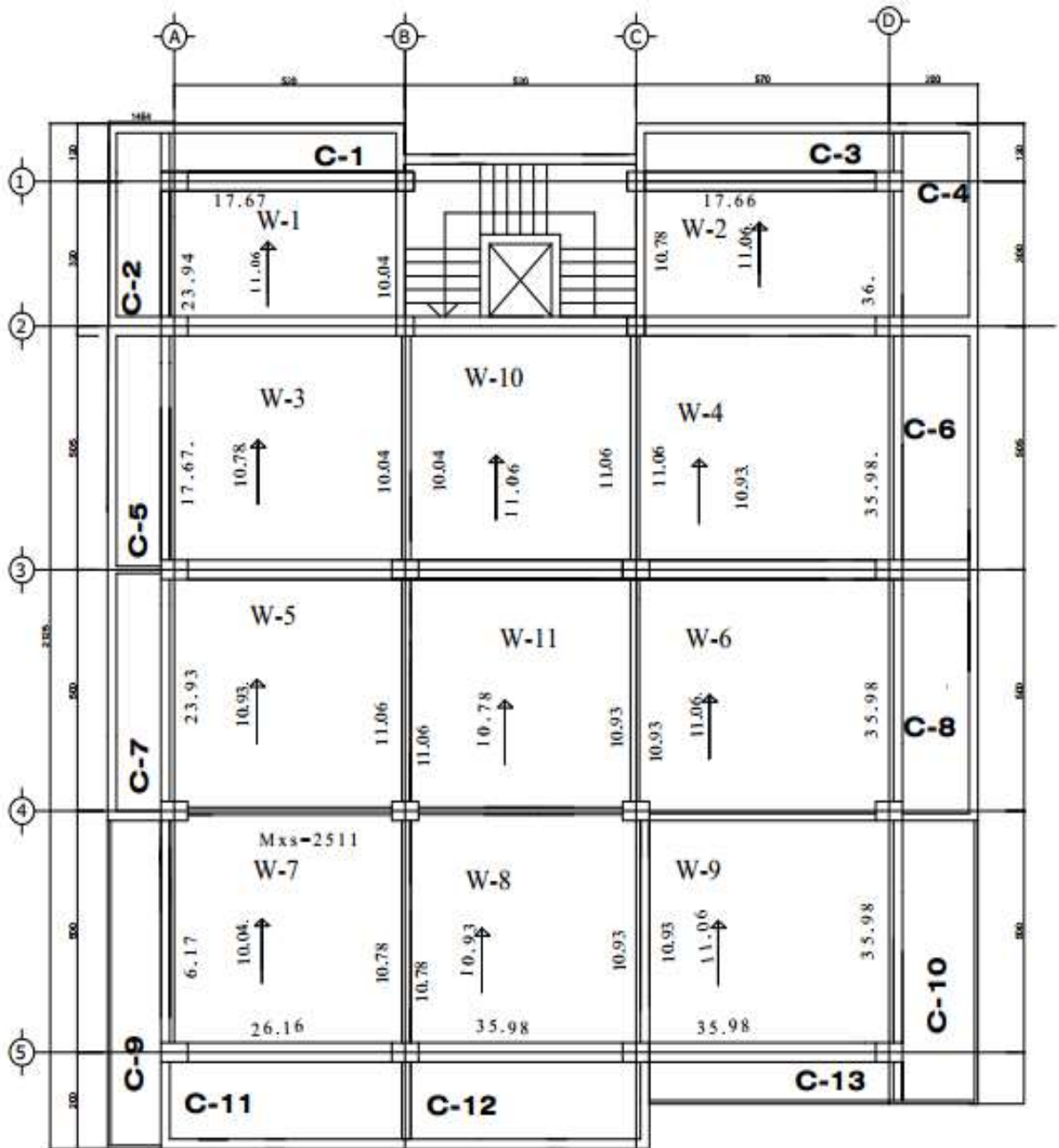


Figure 4.7 moment adjustment

4.7 Load transfer mechanism

The design of the slab is done by coefficient method; loads are transferred to beam by load transferring mechanism. Dead load with wall load and live load is present. For the load transfer from the slab to the beams, un-factored slab DL and LL are computed separately. The design loads on beams supporting solid slabs spanning in two directions at right angles and supporting uniformly distributed loads may be assessed from the following equations obtained from Euro code, BS 8110-1:1997 section 3.5.3.7. Design load on beams supporting solid slab spanning into directions at right angles:

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

- when $l = l_y$
- =Design end shear on strips of unit width and span L_x and considered to act over the middle three-quarters of the edge.

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

- when $l = l_x$
- Design end shear on strips of unit width and span L_y and considered to act over the middle three-quarters of the edge.

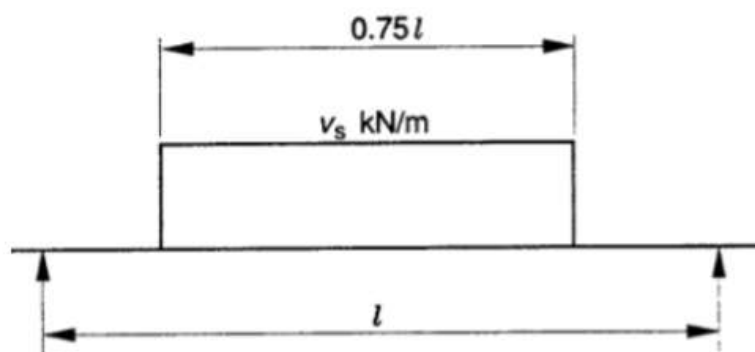


Figure 4.8 Distribution of load on a beam supporting a two-way spanning slab

- ❖ For frame analysis using ETABS, the input of loads should be un factored loads; we will compute load transfer from panels to beams separately for dead, live and wind loads.

1. Dead load transfer

$$VDx = \beta vx * DL * Lx$$

$$VDy = \beta vy * DL * Lx$$

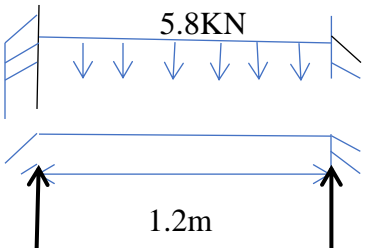
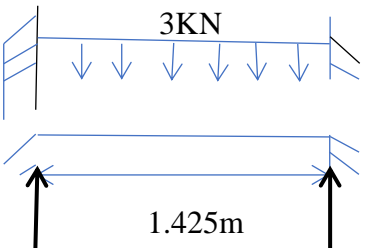
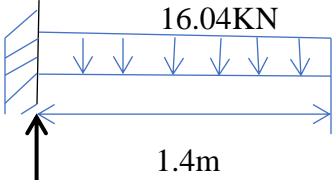
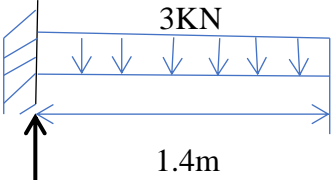
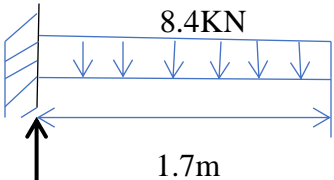
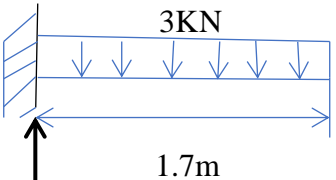
2. Live load transfer

$$VLx = \beta vx * LL * Lx$$

$$VLy = \beta vy * LL * Lx$$

| panel | support conditio | Ly | Lx | Ly/Lx | DL | LL | coefficient | shear forces | | | |
|-----------|------------------|-----|------|-------|------|----|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------|-----------|--|
| | | | | | | | | due to DL | | due to LL | |
| R/W/ST/1 | | 5.2 | 3 | 1.73 | 6.80 | 3 | $\beta_{vxc} = 0.34$ $\beta_{vxd} = 0$ $\beta_{vyc} = 0.33$ $\beta_{vyd} = 0$ | $V_{xc} = 6.94$ $V_{xd} = -$ $V_{yc} = 6.73$ $V_{yd} = -$ | $V_{xc} = 3.06$ $V_{xd} = -$ $V_{yc} = 2.97$ $V_{yd} = -$ | | |
| R/W/S/T-2 | | 5.7 | 3 | 1.9 | 5.8 | 3 | $\beta_{vxc} = 0.49$ $\beta_{vxd} = 0$ $\beta_{vyc} = 0.33$ $\beta_{vyd} = 0$ | $V_{xc} = 8.53$ $V_{xd} = -$ $V_{yc} = 5.74$ $V_{yd} = -$ | $V_{xc} = 4.41$ $V_{xd} = -$ $V_{yc} = 2.97$ $V_{yd} = -$ | | |
| R/W/S/T-3 | | 5.2 | 5.05 | 1.03 | 5.80 | 3 | $\beta_{vxc} = 0.51$ $\beta_{vxd} = 0$ $\beta_{vyc} = 0.36$ $\beta_{vyd} = 0.24$ | $V_{xc} = 14.94$ $V_{xd} = -$ $V_{yc} = 10.54$ $V_{yd} = 7.03$ | $V_{xc} = 7.73$ $V_{xd} = -$ $V_{yc} = 5.45$ $V_{yd} = 3.64$ | | |
| R/W/S/T-4 | | 5.2 | 5.7 | 0.91 | 5.80 | 3 | $\beta_{vxc} = 0.39$ $\beta_{vxd} = 0$ $\beta_{vyc} = 0.33$ $\beta_{vyd} = 0$ | $V_{xc} = 12.89$ $V_{xd} = -$ $V_{yc} = 10.91$ $V_{yd} = -$ | $V_{xc} = 6.67$ $V_{xd} = -$ $V_{yc} = 5.64$ $V_{yd} = -$ | | |
| R/W/S/T-5 | | 5.2 | 5 | 1.04 | 10.0 | 3 | $\beta_{vxc} = 0.4$ $\beta_{vxd} = 0$ $\beta_{vyc} = 0.33$ $\beta_{vyd} = 0$ | $V_{xc} = 20.00$ $V_{xd} = -$ $V_{yc} = 16.50$ $V_{yd} = -$ | $V_{xc} = 6.00$ $V_{xd} = -$ $V_{yc} = 4.95$ $V_{yd} = -$ | | |
| R/W/S/T-6 | | 5.2 | 5 | 1.04 | 7.80 | 3 | $\beta_{vxc} = 0$ $\beta_{vxd} = 0.34$ $\beta_{vyc} = 0.45$ $\beta_{vyd} = 0.3$ | $V_{xc} = -$ $V_{xd} = 13.26$ $V_{yc} = 17.55$ $V_{yd} = 11.70$ | $V_{xc} = -$ $V_{xd} = 5.10$ $V_{yc} = 6.75$ $V_{yd} = 4.50$ | | |
| R/W/S/T-7 | | 5.2 | 5 | 1.04 | 6.90 | 3 | $\beta_{vxc} = 0.49$ $\beta_{vxd} = 0.32$ $\beta_{vyc} = 0.36$ $\beta_{vyd} = 0$ | $V_{xc} = 16.91$ $V_{xd} = 11.04$ $V_{yc} = 12.42$ $V_{yd} = -$ | $V_{xc} = 7.35$ $V_{xd} = 4.80$ $V_{yc} = 5.40$ $V_{yd} = -$ | | |
| R/W/S/T-8 | | 5.2 | 5 | 1.04 | 6.90 | 3 | $\beta_{vxc} = 0.49$ $\beta_{vxd} = 0.32$ $\beta_{vyc} = 0.36$ $\beta_{vyd} = 0$ | $V_{xc} = 16.91$ $V_{xd} = 11.04$ $V_{yc} = 12.42$ $V_{yd} = -$ | $V_{xc} = 7.35$ $V_{xd} = 4.80$ $V_{yc} = 5.40$ $V_{yd} = -$ | | |
| R/W/S/T-9 | | 5.2 | 5 | 1.04 | 6.90 | 3 | $\beta_{vxc} = 0.49$ $\beta_{vxd} = 0.32$ $\beta_{vyc} = 0.36$ $\beta_{vyd} = 0$ | $V_{xc} = 16.91$ $V_{xd} = 11.04$ $V_{yc} = 12.42$ $V_{yd} = -$ | $V_{xc} = 7.35$ $V_{xd} = 4.80$ $V_{yc} = 5.40$ $V_{yd} = -$ | | |

Table 4.12 shear transfer mechanism

| | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>For C1</p> <ul style="list-style-type: none"> • For dead load <p>for live load</p>  <p>$R = Wl_x/2$</p> <p>$R = Wl_x/2 = 5.8 * 1.425 / 2 = 4.1$</p> | <ul style="list-style-type: none"> • For live load  <p>$R = Wl_x/2$</p> <p>$R = Wl_x/2 = 3 * 1.425 / 2 = 2.13$</p> |
| <p>For C</p> <ul style="list-style-type: none"> • For dead load  <p>$R = W * l_x$</p> <p>$R = W * l_x = 16 * 1.4 = 22.4 \text{ kN}$</p> | <ul style="list-style-type: none"> • For live load  <p>$R = W * l_x$</p> <p>$R = W * l_x = 3 * 1.4 = 4.2 \text{ kN}$</p> |
| <p>For C2</p> <ul style="list-style-type: none"> • For dead load  <p>$R = W * l_x$</p> <p>$R = W * l_x = 8.4 * 1.7 = 14.28 \text{ kN}$</p> | <ul style="list-style-type: none"> • For live load  <p>$R = W * l_x$</p> <p>$R = W * l_x = 3 * 1.7 = 5.1 \text{ kN}$</p> |

4.8 Design the reinforcement and check Shear resistance of the section

Design the slab for flexure

Reinforcement design is done using one of the three methods of calculation, those are: -

- III. Using Design Table
- IV. Using Design Chart

We use the first method (Design table method) to calculate the area of reinforcement required for the design moment.

The spacing of bars should not exceed S_{max} , slab from ECBCS EN 1992 - 1 - 1: 2014

Note: For the value of S_{max} , slab, the recommended value is:

- For the principal reinforcement, **$3D \leq 400\text{mm}$** , where D is the total depth of the slab;
- For the secondary reinforcement, **$3.5D \leq 450\text{mm}$**

Provision of principal reinforcement

$$d = D - \text{cover} - \Phi_{\text{bar}}/2 = 180 - 22 - 12/2 = 152 \text{ mm}$$

$$\text{X-direction} = 180 - (22 + 6) = 152 \text{ mm}$$

$$\text{Y-direction} = 180 - (22 + 12 + 6) = 140 \text{ mm}$$

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

Material data $C = 25$

$$S = 300$$

$$C = 25, f_{ck} = \frac{f_{cu}}{1.25} = \frac{25}{1.25} = 20 \text{ Mpa}$$

$$\text{Using S-300, } f_{yk} = 300 \text{ Mpa}$$

$$f_{yd} = \frac{f_{yk}}{1.15} = 300/1.15 = 260.86 \text{ Mpa}$$

Using general design table no.1 from ES EN1992-1-1:2015

$$K_m = \sqrt{\frac{M_{sd,s}}{bd^2}}$$

$$A_s = \frac{K_s M_{sd,s}}{d}$$

Using corresponding value of K_m take K_s value from the table 1a

Design moment, $M_{sd}=8.48\text{KNm}$

$$K_m = \sqrt{\frac{M_{sd,s}}{bd^2}} = \sqrt{\frac{8.48}{1 \cdot 0.152^2}} = 19.16$$

$$K_s = 3.96$$

$$A_{s,calc} = \frac{K_s M_{sd,s}}{d} = \frac{3.96 \cdot 8.48 \text{ kNm}}{0.152} = 220.9 \text{ mm}^2$$

Secondary transverse reinforcement of not less than 20% of the principal reinforcement should be provided in one-way slabs.

The minimum and maximum value of area of reinforcement is computed in accordance with the provision of the code.

$$f_{ctm} = 0.3(F_{ck})^{2/3} = 0.3 \cdot 20^{2/3} = 2.2$$

$$A_{s,min} = \text{Max} \left\{ \begin{array}{l} \frac{0.26 f_{ctm} b t d}{f_{yk}} = \frac{0.26 \cdot 2.2 \cdot 1000 \cdot 152}{300} = 289.8 \text{ mm}^2 \\ 0.00013 b t d = 0.00013 \cdot 1000 \cdot 152 = 19.76 \end{array} \right. \dots\dots\dots [3] \text{ Art.9.2.1.1 (1)}$$

$$A_{s,req} = \text{Max} \left\{ \begin{array}{l} A_{s,calc} = 220.9 \text{ mm}^2 \\ A_{s,min} = 289.8 \text{ mm}^2 \end{array} \right.$$

$$A_{st,max} = 0.04 \cdot A_c \dots\dots\dots [3] \text{ Art.9.2.1.1 (3)}$$

$$a_s = \frac{\pi d^2}{4} = \frac{3.14 \cdot 10^2}{4} = 113.09 \text{ mm}^2$$

$$\text{Spacing} = \frac{b \cdot a_s}{A_{s,req}} = \frac{1000 \cdot 113.04}{289.8} = 390.1 \text{ mm}$$

For slab maximum spacing is defined in section 9.3.1.1(3) of ES EN 1992-1-1

$$S_{provide} = \min \left\{ \begin{array}{l} 3D = 3 \cdot 180 = 540 \\ 400 \text{ mm} \\ \text{Spacing} = 390.1 \text{ mm} \end{array} \right. \dots\dots\dots [3]$$

Provide, $\emptyset 10\text{C/C } 390.1\text{mm}$

| panel | M | values | d(m) | b | ρ | As | As(min) | S(req)mm | S(prov) |
|-------|-----|----------|------|------|----------|----------|---------|----------|---------|
| T1 | Mxs | 3.61242 | 0.28 | 1000 | 0.000177 | 49.53784 | 476 | 1584.647 | 300 |
| | Mys | 1.6848 | 0.29 | 1000 | 7.68E-05 | 22.28111 | 493 | 3523.164 | 300 |
| | Mxf | 3.4587 | 0.28 | 1000 | 0.000169 | 47.42569 | 476 | 1655.221 | 300 |
| | Myf | 2.61324 | 0.29 | 1000 | 0.000119 | 34.57688 | 493 | 2270.303 | 300 |
| T2 | Mxs | 3.60747 | 0.28 | 1000 | 0.000177 | 49.46982 | 476 | 1586.826 | 300 |
| | Mys | 1.2312 | 0.29 | 1000 | 5.61E-05 | 16.27823 | 493 | 4822.39 | 300 |
| | Mxf | 3.72384 | 0.28 | 1000 | 0.000182 | 51.06901 | 476 | 1537.136 | 300 |
| | Myf | 2.79288 | 0.29 | 1000 | 0.000127 | 36.95733 | 493 | 2124.071 | 300 |
| T3 | Mxs | 9.384155 | 0.28 | 1000 | 0.000461 | 129.1112 | 476 | 608.0029 | 300 |
| | Mys | 3.182712 | 0.29 | 1000 | 0.000145 | 42.12463 | 493 | 1863.518 | 300 |
| | Mxf | 9.68687 | 0.28 | 1000 | 0.000476 | 133.2992 | 476 | 588.9007 | 300 |
| | Myf | 7.265152 | 0.29 | 1000 | 0.000332 | 96.36644 | 493 | 814.599 | 300 |
| T4 | Mxs | 10.51468 | 0.28 | 1000 | 0.000517 | 144.7592 | 476 | 542.2799 | 300 |
| | Mys | 3.488742 | 0.29 | 1000 | 0.000159 | 46.18261 | 493 | 1699.774 | 300 |
| | Mxf | 10.85386 | 0.28 | 1000 | 0.000534 | 149.4579 | 476 | 525.2315 | 300 |
| | Myf | 8.140398 | 0.29 | 1000 | 0.000373 | 108.0262 | 493 | 726.6759 | 300 |
| T5 | Mxs | 10.79929 | 0.28 | 1000 | 0.000531 | 148.7017 | 476 | 527.9024 | 300 |
| | Mys | 3.182712 | 0.29 | 1000 | 0.000145 | 42.12463 | 493 | 1863.518 | 300 |
| | Mxf | 11.14765 | 0.28 | 1000 | 0.000548 | 153.5292 | 476 | 511.3032 | 300 |
| | Myf | 8.36074 | 0.29 | 1000 | 0.000383 | 110.9632 | 493 | 707.4419 | 300 |
| T6 | Mxs | 15.6275 | 0.28 | 1000 | 0.000771 | 215.7831 | 476 | 363.7912 | 300 |
| | Mys | 4.68 | 0.29 | 1000 | 0.000214 | 61.99127 | 493 | 1266.307 | 300 |
| | Mxf | 14.9625 | 0.28 | 1000 | 0.000738 | 206.5215 | 476 | 380.1056 | 300 |
| | Myf | 11.305 | 0.29 | 1000 | 0.000518 | 150.275 | 493 | 522.3758 | 300 |
| T7 | Mxs | 16.0505 | 0.28 | 1000 | 0.000792 | 221.6781 | 476 | 354.1171 | 300 |
| | Mys | 4.68 | 0.29 | 1000 | 0.000214 | 61.99127 | 493 | 1266.307 | 300 |
| | Mxf | 15.3675 | 0.28 | 1000 | 0.000758 | 212.1612 | 476 | 370.0017 | 300 |
| | Myf | 11.611 | 0.29 | 1000 | 0.000532 | 154.3678 | 493 | 508.5257 | 300 |
| T8 | Mxs | 13.29315 | 0.28 | 1000 | 0.000655 | 183.3036 | 476 | 428.2512 | 300 |
| | Mys | 3.77 | 0.29 | 1000 | 0.000172 | 49.91326 | 493 | 1572.728 | 300 |
| | Mxf | 12.61145 | 0.28 | 1000 | 0.000621 | 173.8353 | 476 | 451.577 | 300 |
| | Myf | 9.5438 | 0.29 | 1000 | 0.000437 | 126.7445 | 493 | 619.3562 | 300 |
| T9 | Mxs | 7.936 | 0.28 | 1000 | 0.00039 | 109.0965 | 476 | 719.5461 | 300 |
| | Mys | 3.42 | 0.29 | 1000 | 0.000156 | 45.27097 | 493 | 1734.003 | 300 |
| | Mxf | 8.192 | 0.28 | 1000 | 0.000402 | 112.6323 | 476 | 696.9584 | 300 |
| | Myf | 6.144 | 0.29 | 1000 | 0.000281 | 81.44671 | 493 | 963.8204 | 300 |

Table 4.13 spacing provide for slabs re bar

4.9 Check deflection and cracking.

To check the depth for deflection weathers it satisfies the serviceability requirement we use the new codes ES EN 1991:2015.

As an example

Initially we assumed $\rho_o = \rho$. But we can calculate them as follows

$$\rho = \frac{A_{st,req}}{bd} = \frac{289.8}{1000 * 152} = 0.19\% \dots\dots\dots N1992: 2017. 7.4.2(7.16a)$$

$$\rho_o = \frac{\sqrt{f_{ck}}}{1000} = \sqrt{20}/1000 = 0.4472\%$$

Now, $\rho = 0.19\% < \rho_o = 0.44721\%$

$$l/d = N * K * F1 * F2 * F3$$

$$\frac{l}{d} = K \left[11 + 1.5 \sqrt{f_{ck}} \frac{\rho_o}{\rho} + 3.2 \sqrt{f_{ck}} \left(\frac{\rho_o}{\rho} - 1 \right)^{3/2} \right] \text{if } \rho \leq \rho_o \quad (7.16a)$$

$$N = \left[11 + 1.5 \sqrt{20} \frac{0.4472}{0.19} + 3.2 \sqrt{20} \left(\frac{0.4472}{0.19} - 1 \right)^{3/2} \right] = 49.33$$

Where; -K..... from appendix F

$$F1 = 500 / (f_{yk} A_{s,req} / A_{s,prov}) \dots\dots\dots [3] \dots (7.17)$$

F2 & F3 = 1, (because span of slab $\leq 7m$).....[3] ... section 5.3.2.2 (1).

*****Then we work similarly other slabs by the excel in appendix F

| panel | M | values | Lx | d(m) | Ks | As(calc) | As(min) | AS(req)mm | ρ | po | F1 | K | Lx/d | d | check |
|-------|-----|--------|------|------|------|----------|---------|-----------|--------|---------|------|-----|-------|--------|-------|
| S1 | Mxs | 3.6124 | 3 | 0.28 | 3.96 | 51.09 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 23.69 | OK |
| | Mys | 1.6848 | | 0.29 | 3.96 | 23.01 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 23.69 | OK |
| | Mxf | 3.4587 | | 0.28 | 3.96 | 48.92 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 23.69 | OK |
| | Myf | 2.6132 | | 0.29 | 3.96 | 35.68 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 23.69 | OK |
| S2 | Mxs | 3.6075 | 3 | 0.28 | 3.96 | 51.02 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 23.69 | OK |
| | Mys | 1.2312 | | 0.29 | 3.96 | 16.81 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 23.69 | OK |
| | Mxf | 3.7238 | | 0.28 | 3.96 | 52.67 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 23.69 | OK |
| | Myf | 2.7929 | | 0.29 | 3.96 | 38.14 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 23.69 | OK |
| S3 | Mxs | 9.3842 | 5.05 | 0.28 | 3.96 | 132.72 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.878 | OK |
| | Mys | 3.1827 | | 0.29 | 3.96 | 43.46 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.878 | OK |
| | Mxf | 9.6869 | | 0.28 | 3.96 | 137.00 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.878 | OK |
| | Myf | 7.2652 | | 0.29 | 3.96 | 99.21 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.878 | OK |
| S4 | Mxs | 10.515 | 5.2 | 0.28 | 3.96 | 148.71 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 41.063 | OK |
| | Mys | 3.4887 | | 0.29 | 3.96 | 47.64 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 41.063 | OK |
| | Mxf | 10.854 | | 0.28 | 3.96 | 153.50 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 41.063 | OK |
| | Myf | 3.1827 | | 0.29 | 3.96 | 43.46 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 41.063 | OK |
| S5 | Mxs | 11.148 | 5 | 0.28 | 3.96 | 157.66 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.484 | OK |
| | Mys | 8.3607 | | 0.29 | 3.96 | 114.2 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.484 | OK |
| | Mxf | 15.628 | | 0.28 | 3.96 | 221.0 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.484 | OK |
| | Myf | 4.68 | | 0.29 | 3.96 | 63.9 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.484 | OK |
| S6 | Mxs | 11.611 | 5 | 0.28 | 3.96 | 164.2 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.484 | OK |
| | Mys | 13.293 | | 0.29 | 3.96 | 181.5 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.484 | OK |
| | Mxf | 3.77 | | 0.28 | 3.96 | 53.3 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.484 | OK |
| | Myf | 12.611 | | 0.29 | 3.96 | 172.2 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.484 | OK |
| S7 | Mxs | 9.5438 | 5 | 0.28 | 3.96 | 135.0 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 4.4634 | OK |
| | Mys | 7.936 | | 0.29 | 3.96 | 108.4 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 4.4634 | OK |
| | Mxf | 3.42 | | 0.28 | 3.96 | 48.4 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 4.4634 | OK |
| | Myf | 8.192 | | 0.29 | 3.96 | 111.9 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 4.4634 | OK |
| S8 | Mxs | 6.144 | 5.05 | 0.28 | 3.96 | 86.9 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.878 | OK |
| | Mys | 11.335 | | 0.29 | 3.96 | 154.8 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.878 | OK |
| | Mxf | 11.53 | | 0.28 | 3.96 | 163.1 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.878 | OK |
| | Myf | 11.726 | | 0.29 | 3.96 | 160.1 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 39.878 | OK |
| S9 | Mxs | 11.921 | 5 | 0.28 | 3.96 | 168.6 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 4.4634 | OK |
| | Mys | 12.117 | | 0.29 | 3.96 | 165.5 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 4.4634 | OK |
| | Mxf | 12.312 | | 0.28 | 3.96 | 174.1 | 476 | 476.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 4.4634 | OK |
| | Myf | 12.507 | | 0.29 | 3.96 | 170.8 | 493 | 493.00 | 0.17 | 0.44721 | 1.67 | 1.3 | 126.6 | 4.4634 | OK |

Table 4.14 checking of deflection and cracking

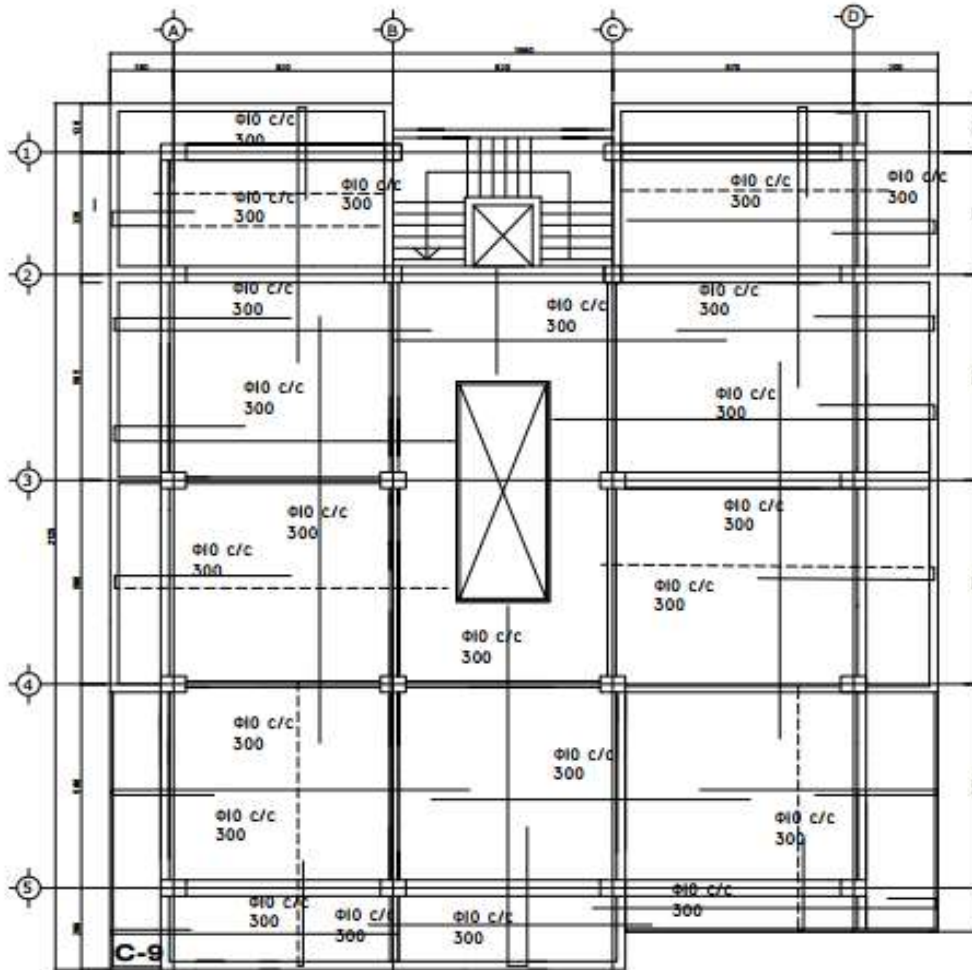


Figure 4.9 detail drawing

5. STAIR CASE DESIGN

Stair, - are structures which provide access passage to different floor levels one of the structural elements constructed with steps rising without a break from floor to floor or with steps rising to landing between floors with a series of steps rising further from the landing to floor above. Design procedures

5.1. Concrete cover design

Determination of depth for deflection: which is a function of design tensile strength of steel, effective span length of the shortest span in which more load is expected to transfer and support condition

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

The concrete cover is the distance from the surface of the reinforcement closest to the nearest concrete surface (including links and stirrups and surface reinforcement where relevant) and the nearest concrete surface. The nominal cover shall be specified on the drawings. it is defined as C_{min}

$C_{nom} = C_{min} + \Delta C_{dev}$[3] Art. 4.4.1.2

Where, C_{min} – minimum cover and

ΔC_{dev} is allowance in design for deviation

Minimum cover, shall provide in order to ensure

- ✓ Safe transmission of bond force

- ✓ Corrosion resistance/ Durability
- ✓ Fire resistance $C_{min} = \max$

Where;

$C_{min, b}$ - minimum cover due to bond requirement, see ES EN1992:2015 Art. 4.4.1.2 (3).

$C_{min, dur}$ - minimum cover due to environmental conditions, see [3] Art 4.4.1.2 (5)

$\Delta C_{dur, \gamma}$ - additive safety element, see ES EN1992:2015 Art 4.4.1.2 (6)

$\Delta \Delta c_{dur, st}$ -reduction of minimum cover for use of stainless steel, see [3] Art 4.4.1.2 (7)

$\Delta C_{dur, add}$ -reduction of minimum cover for use of additional protection, [3] Art 4.4.1.2 (8)

But; the recommended value of $\Delta C_{dur, \gamma}$, $\Delta C_{dur, st}$, and $\Delta C_{dur, add}$ is zero [3] Art. 4.4.1.2 (6, 7, and 8).

Assume $\Phi 10$ longitudinal bar and $\Phi 25$ nominal maximum aggregate size;

5.1.1 Cover Design for Bond Therefore; $C_{min, b} = 10\text{mm}$

Note: - The stair case slab is designed as one-way reinforced slab.

5.2 Effective depth calculation

The depth of the section for design purpose of longitudinally spanning slab is taken as the minimum thickness perpendicular to soffit of stair case. I.e. the waist (w). For transverse stair case, there is no universal method to determine effective depth.

The live loads for design of stair case are to be taken from table 2.10 ES EN 1-1 on loading standards. The value used is category A (see Appendix C)

According to ES EN 1992:2015; the limit state of deformation may be checked by either: by limiting the span/depth ratio, according to 7.4.2 or by comparing a calculated deflection, according to section 7.4.3, with a limit value

$$l/d = K * N * F1 * F2 * F3$$

Where K; -from appendix C

$$N = \left[11 + 1.5\sqrt{f_{ck}} \frac{\rho_o}{\rho - \rho'} + \frac{1}{12}\sqrt{f_{ck}} \sqrt{\frac{\rho'}{\rho_o}} \right] \text{ if } \rho > \rho_o \quad \dots(7.16a) \text{ refer Appendix F}$$

$$F1 = 500 / (f_{yk} A_{s,req} / A_{s,prov}) \dots\dots\dots [3] \dots (7.17)$$

F2 & F3 = 1, (because span of slab ≤ 7m).....[3] ... section 5.3.2.2 (1).

F3 = 8.5/leff, for flat slabs where the greater span exceeds 8.5 m, and which support partitions liable to be damaged by excessive deflections (leff in meters). Otherwise; F3 = 1 for both cases.

5.3 Moment and shear forces analyzed

5.4 Reinforcement calculation

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. $A_{s2} \geq 20\% A_{s1}$

5.5 Shear Reinforcement:

The design value for the shear resistance $V_{Rd,c}$ is given by:

$$V_{Rd,c} = [k(100 \cdot f_{ck})^{1/3} + k_1 \cdot \rho_1] b_w d \leq (v_{min} + k_1 \cdot \rho_1) b_w d$$

Where: f_{ck} is in MPa

$$k = 1 + \sqrt{\frac{200}{d}} \leq 2.0, \text{ with } d \text{ in mm}$$

Take, $k_1 = 2$

$$\rho_1 = \frac{A_{s1}}{b_w d} \leq 0.02$$

Date required

$$\text{➤ Height of Riser} = \frac{\text{Height of Stair}}{\text{No of Stair}} = \frac{2\text{m}-0\text{m}}{13} = 15.38\text{m}$$

Therefore, we use riser height 16 cm for the design.

Material

C-25

S-300

Cover Design for Bond

Assume $\Phi 10$ longitudinal bar and $\Phi 25$ nominal maximum aggregate size;

Therefore; C_{min} , $b=10mm$

Note: - The stair case slab is designed as one-way reinforced slab. The depth of the section for design purpose of longitudinally spanning slab is taken as the minimum thickness perpendicular to soffit of stair case. I.e. the waist (w). For transverse stair case, there is no universal method to determine effective depth.

The live loads for design of stair case are to be taken from table 2.10 ES EN 1-1 on loading standards. The value used is category A (see Appendix C)

According to ES EN 1992:2015; the limit state of deformation may be checked by either: by limiting the span/depth ratio, according to 7.4.2 or by comparing a calculated deflection, according to section 7.4.3, with a limit value

$$l/d = K * N * F1 * F2 * F3$$

where K from appendix c

$$N = \left[1 + 1.5 \sqrt{f_{ck}} \frac{\rho_o}{\rho - \rho'} + \frac{1}{12} \sqrt{f_{ck}} \sqrt{\frac{\rho'}{\rho_o}} \right] \text{ if } \rho > \rho_o \quad \dots (7.16a) \text{ refer Appendix C}$$

$$F1 = 500 / (f_{yk} A_{s,req} / A_{s,prov}) \dots [3] \dots (7.17)$$

$F2 \& F3 = 1$, (because span of slab $\leq 7m$).....[3] ... section 5.3.2.2 (1).

$F_3=8.5/l_{eff}$, for flat slabs where the greater span exceeds 8.5 m, and which support partitions liable to be damaged by excessive deflections (l_{eff} in meters). Otherwise; $F_3=1$ for both cases.
Use $K = 1.5$ & $N=25.5$

$$d=L/1.5*1*1*1*25.5$$

$$d=L/38.25=5.2/25.5$$

$$d=105.6$$

➤ Overall depth

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

$$D=105.5+20+7=132.5\text{mm}$$

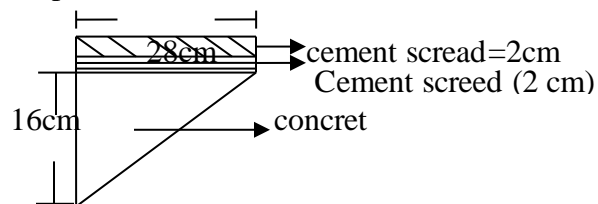
$$D_{\text{used}}=150\text{mm}$$

Load combination

Material Data

- Unit weight of marble=27 KN/m³
- Unit weight of cement screed=23 KN/m³
- Unit weight of concrete=24 KN/m³
- Unit weight of plastering=23 KN/m³
- Thickness of cement screed=2cm
- Thickness of plastering=2cm
- Thickness of marble=3cm
- Take 1m width strip

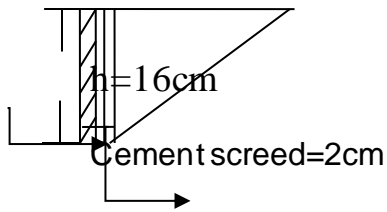
Step dead load



- 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= $1/2 * h * \gamma_{conc} = 1/2 * 0.16\text{m} * 24 \text{ KN/m}^3 = 1.92 \text{ KN/m}$

➤ Therefore, DL of step = 0.46 KN/m + 0.81 KN/m + 1.92 KN/m = 3.226 KN/m

Riser Dead Load



- D.L of cement screed = $\frac{\text{No of riser (hcs*tcs*\gamma_{sc})}}{\text{Projected length (12*28 cm)}}$

$$= \frac{13(0.16\text{m}*0.02\text{m}*23\text{KN/m}^3)}{3.36}$$

$$= 0.285 \text{ KN/m}$$

- D.L of Finishing = $\frac{\text{No of riser (hcs*tcs*\gamma_{sc})}}{\text{Projected length (12*28 cm)}}$

$$= \frac{13(0.16\text{m}*0.03\text{m}*27\text{KN/m}^3)}{3.36}$$

$$= 0.501 \text{ KN/m}$$

Therefore, D.L of riser (16cm) = 0.285 KN/m + 0.501 KN/m

$$= 0.786 \text{ KN/m}$$

Waist Dead Load

Tan $\theta = 2/3.36$

$\theta = \tan^{-1}\left(\frac{2}{3.36}\right)$

= 30.76°

Sin $\theta = 2/L_{inc}$

$L_{inc} = 2/\sin \theta = 2\text{m}/\sin 30.76^\circ$

= 3.91 m

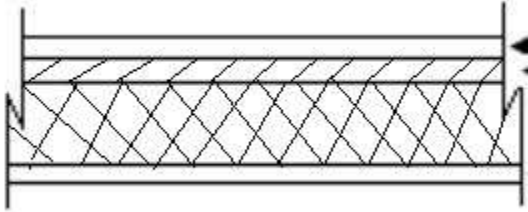
- D.L of concrete = $\frac{D*L_{inc}*\gamma_{conc}}{\text{Projected}} = \frac{0.15\text{m}*3.91\text{m}*24 \text{ KN/m}^3}{3.36 \text{ m}}$
- = 4.19 KN/m
- D.L of Plastering = $\frac{t_{pl}*L_{inc}*\gamma_{pl}}{\text{Projected}} = \frac{0.02\text{m}*3.91\text{m}*23 \text{ KN/m}^3}{3.36 \text{ m}}$

$$= 0.535 \text{ KN/m}$$

Therefore, D.L of waist = 4.19KN/m + 0.535 KN.m

$$=4.725 \text{ KN/m}$$

Landing Dead Load



Floor Finishing (3cm)

Cement Screed (2cm)

Concrete (160mm)

Plastering (2cm)

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

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

$$=0.03\text{m}*27 \text{ KN/m}^3+0.02*23 \text{ KN/m}^3 + 0.15\text{m}*24 \text{ KN/m}^3 +0.02\text{m}*23 \text{ KN/m}^3$$

$$=5.33 \text{ KN/m}$$

Therefore, D.L of Landing=5.33 KN/m

- Total Dead Load and design load

- For the inclined slab

- Total D. L=D.L of Step+D.L of riser+D.L of waist

$$=3.226 \text{ KN/m}+0.501 \text{ KN/m}+4.725 \text{ KN/m}$$

$$=8.452 \text{ KN/m}$$

- Live load=5 KN/m²*1m=5 KN/m

- Design Load, Pd=1.3 D.L + 1.6 L.L

$$=1.3*8.45 \text{ KN/m} + 1.6*5 \text{ KN/m}$$

$$=18.98 \text{ KN/m}$$

- For the landing

- D.L=5.33 KN/m

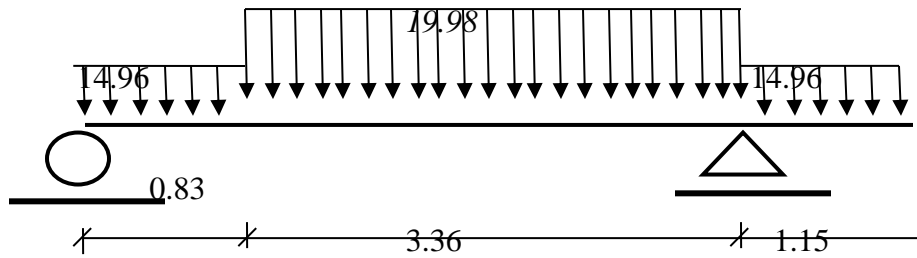
- L.L=5 KN/m² * 1m=5KN/m

- Design load, pd=1.3 D.L + 1.6 L.L

$$=1.3*5.33 \text{ KN/m} + 1.6*5 \text{ KN/m}$$

$$=14.93 \text{ KN/m}$$

- Loading



Moment Analysis



$$+\Sigma M \text{ at } 1=0$$

$$14.93*(0.83) *0.83/2+18.98*3.36m*(0.83+3.36/2) +14.93*1.15*(4.19+1.15/2)-R_2*4.19m=0$$

$$R_2*4.19m=247.025 \text{ KN.m}$$

$$R_2=58.95 \text{ KN}$$

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

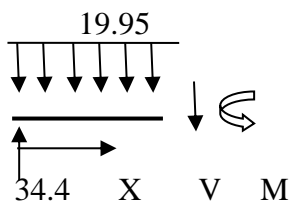
$$R_1+R_2=14.93 \text{ KN/m}*0.83 \text{ m}+18.98 \text{ KN/m}*3.36 \text{ m}+14.93 \text{ KN/m}*1.15 \text{ m}$$

$$R_1=58.95 \text{ KN}=93.33 \text{ KN}$$

$$R_1=34.38 \text{ KN}$$

Analyzing using the method of section,

For $Z=0$, to $Z=0.83\text{m}$ (Z in measured from support 1)



$$M(x)+14.93 \text{ KN/m} * x + x^2/2=34.38x$$

$$M(x)=34.38x-7.465 x^2$$

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

$$M(0) =0$$

- At $Z=0.83$, $x=0.83$

$$M(0.83) =23.39 \text{ KN.m}$$

- For $Z=0.83$ to $Z=4.19\text{m}$

$$M(x)+18.98 \text{ KN/m} \cdot x^2/2+14.93 \text{ KN/m} \cdot 0.83 \text{ m} \cdot (x+0.83/2) =34.38 \text{ KN} (x+0.83)$$

$$M(x)=-9.39x^2+21.98x+23.289$$

- At $Z=0.83\text{m}$, $x=0$

$$M(0) =23.389 \text{ KN.m}$$

- At $Z=4.19\text{m}$, $X=3.36\text{m}$

$$M(3,36) =-9.896 \text{ KN.m}$$

- For $Z=4.19$ to $Z=5.34\text{m}$

- $M(x)=-14.93 x^2/2$

$$=-7.465 x^2$$

- At $Z=5.34\text{m}$, $x=0$

$$M(0) =0$$

- At $Z=4.93\text{m}$, $x=1.15\text{m}$

$$M(1.15) =-9.896 \text{ KN.m}$$

- M_{max} (+ve) is b/n $Z=0.83$ to $Z=4.19\text{m}$

$$M(x)=-9.49 x^2+21.98x+23.389$$

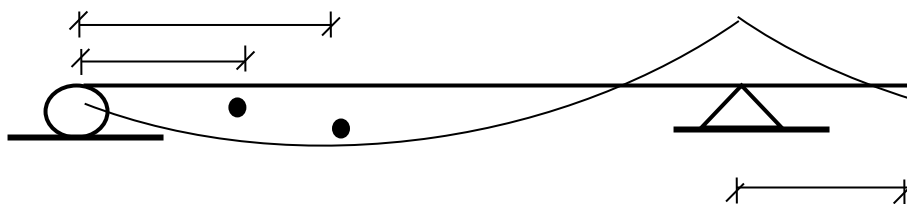
M is max at $V=0$, $dm(x)/dx=0$

$$dM(x)/dx=d/dx (9.49 x^2+21.98x+23.389)=0$$

$$=-18.98x+21.98=0, x=1.178\text{m}, Z=1.988\text{m}$$

$$M(1.158\text{m}) =36.116 \text{ KN.m}$$

Bending Moment Diagram

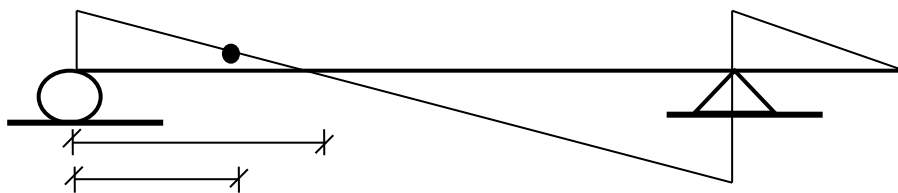


Shear Force computation

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

- For $Z=0$ to $Z=0.83\text{m}$
 $M(x)=34.38x-7.465x^2$
 $dM(x)/dx=V(x)=-14.93x+34.8$
at $Z=0, x=)$
 $V(0)=34.8\text{ KN}$
At $Z=0.88\text{m}, x=0.83\text{m}$
 $V(0.83)=21.98\text{ KN}$
- For $Z=0.83\text{m}$ to $Z=4.19\text{m}$
 $M(x)=-9.49x^2+21.98x+23.389$
 $dM(x)/dx=V(x)=18.98x+21.98$
at $Z=0.83\text{m}, x=0$
 $V(0)=21.98\text{ KN}$
At $Z=4.19\text{m}, x=3.36\text{m}$
 $\downarrow V(3.36)=-41.79\text{ KN}$
- For $Z=4.19\text{m}$ to $Z=5.34\text{m}$
 $M(x)=-7.465x^2$
 $dM(x)/dx=-14.93x$
at $Z=4.19\text{m}, x=1.15\text{m}$
 $\downarrow V(1.15)=-17.169\text{ KN}$

Shear Force Diagram

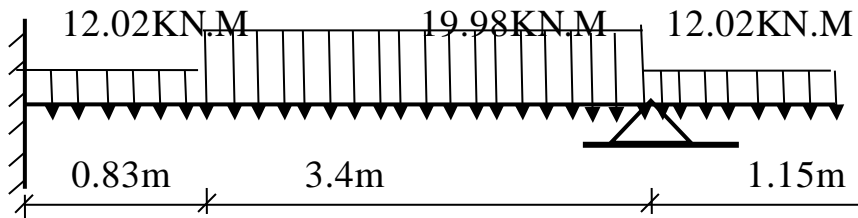


- Height of riser (for Ground floor) = Height of Stair/No of riser = $200\text{cm}/12=15.38\text{ cm}$
- Height of riser (for 1st, 2nd & 3rd floor) = Height of stair/No of riser
Therefore, use height of riser = 16cm for the design of stair type '2'
- Depth for deflection & load computation are the same as stair case 1.

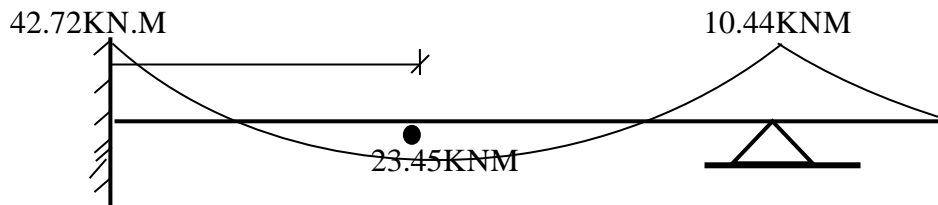
Therefore, $P_d=18.98 \text{ KN/m}$, for the inclined slab.

$P_d=12.04 \text{ KN/m}$, for the landing.

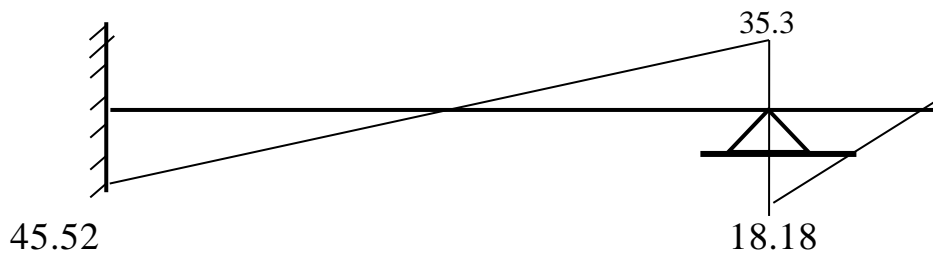
Loading



Analyzing using S.A.P V.14.000



B.M.D



S.F.D

Check depth for flexure

- $d \geq \frac{\sqrt{M/b}}{K_m}$
- ❖ M is M_{\max} of all the stair moment
- ❖ $M_{\max}=42.72 \text{ KN.m}$
- ❖ $b=1\text{m}$,
- ❖ $K_m=57.83$ (without moment distribution)
- ❖ $d=150\text{mm}-\text{cover}-\phi/2$, assuming $\phi=14\text{mm}$
 $=150\text{mm}-15\text{mm}-14\text{mm}/2$
 $=128\text{mm}$

$$d \geq \frac{\sqrt{42.72 \text{KN.m/1m}}}{57.83}$$

$$d \geq 113.02 \text{ mm}$$

128mm \geq 113.02 mm OK!

5.3 Reinforcement calculation

❖ For the given

- Material Data, C-25, S-300
- Effective depth, $d=128\text{mm}$
- Width, $b=1000\text{mm}$
- Moments calculated for each panels

❖ Using design charts

$$K_m = \left(\sqrt{\frac{M}{b}} \right) / d, K_s$$

$$A_s = K_s * M / d$$

❖ To calculate spacing by selecting diameter of bar as

$$S = 1000 a_s / A \quad \text{where } a_s = \text{area of single bar}$$

$$A_s = \text{calculated area of steel}$$

$$S = \text{spacing}$$

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. $A_s \geq 20\% A_{s, cal}$

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

$$A_{s_{min}} = \rho_{min} * b * d = 0.5 / f_{yk} * b * d = 0.5 * 1000 * 128 / 300 = 213.33$$

$$S_{max} \leq \begin{cases} 2D \\ 350mm \end{cases} = \begin{cases} 2 * 160mm \\ 350mm \end{cases} = 300mm$$

$$S_{max} = 300mm$$

Development Length

$$l_{bnet} = a_b A_{s_{cal}} / A_{s, prov}$$

$$a = 0.7 \text{ for hook, } a = 1 \text{ for straight}$$

$$l_b = \emptyset / 4 * f_{yd} / f_{bd}$$

$f_{bd}=2f_{ctd}$, for deformed bar.

$$l_b = \phi / 8 * f_{yd} / f_{bd}$$

$$f_{yd} = f_{yk} / \gamma_s = 300 \text{ Mpa} / 1.15 = 260.8 \text{ MPa}$$

$$f_{ctd} = 0.21(f_{ck})^{2/3} / \gamma_c = 0.21(30/1.25)^{2/3} / 1.5$$

$$= 1.165 \text{ Mpa}$$

$$l_b = \phi / 8 * 260.87 \text{ Mpa} / 1.165 \text{ MPa} = \phi * 223.86$$

STAIR CASE REINFORCEMENT DESIGN

| Panel | moment | Km | Ks | As | Asmin | Calculated | Provided | Remark |
|--------------|--------|-------|------|---------|--------|------------|----------|----------|
| Stair case-1 | 36.12 | 46.23 | 4.31 | 1197.38 | 216.60 | 94.46 | 70 | φ14C/C70 |
| | 9.92 | 24.20 | 3.98 | 302.97 | 216.60 | 373.30 | 70 | φ14C/C70 |
| Stair case-2 | 42.72 | 50.28 | 4.41 | 1449.19 | 216.60 | 78.04 | 70 | φ14C/C70 |
| | 23.45 | 37.25 | 4.12 | 743.18 | 216.60 | 152.18 | 70 | φ14C/C70 |
| | 10.44 | 24.85 | 3.98 | 319.62 | 216.60 | 353.85 | 70 | φ14C/C70 |

Table 5.1 Staircase reinforcement and spacing

Development Length

| Moment | Ascalc | As prov | φ | lb | lbnet(mm) | |
|--------|---------|---------|----|--------|-----------|----------|
| | | | | | for a=0.7 | for a=1 |
| 36.116 | 1197.38 | 1256.6 | 12 | 2686.3 | 1791.875 | 2559.821 |
| 9.896 | 302.97 | 376.97 | 12 | 2686.3 | 1511.305 | 2159.008 |
| 42.72 | 1449.19 | 1615.6 | 12 | 2686.3 | 1686.771 | 2409.673 |

| | | | | | | |
|-------|--------|--------|----|--------|----------|----------|
| 23.45 | 743.18 | 753.93 | 12 | 2686.3 | 1853.615 | 2648.022 |
| 10.44 | 319.62 | 376.97 | 12 | 2686.3 | 1594.384 | 2277.692 |

Table 5.2 developmental length of stair

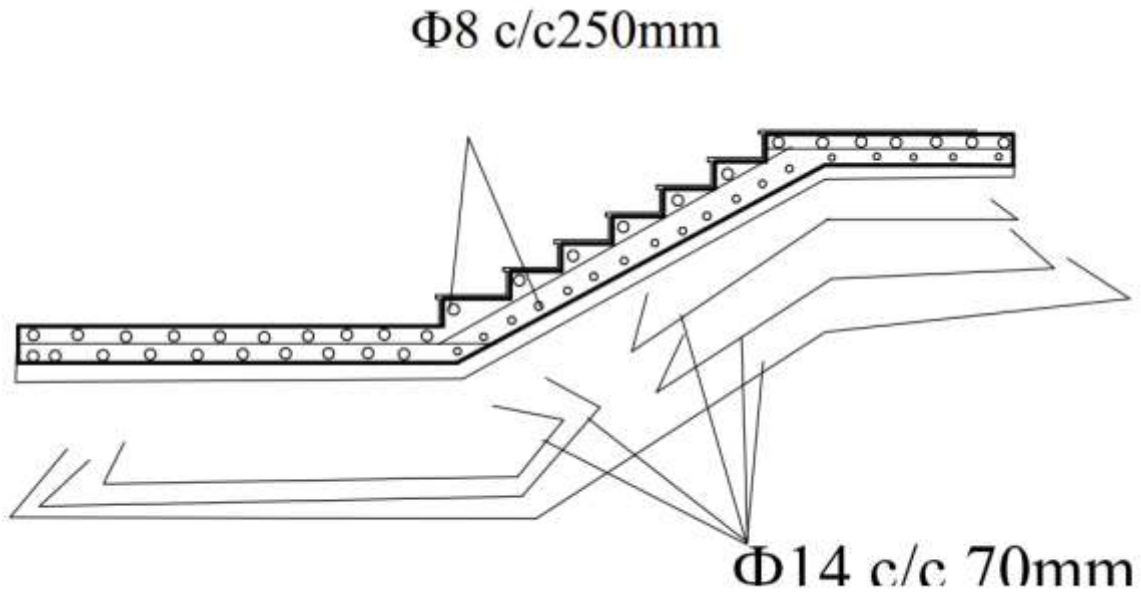


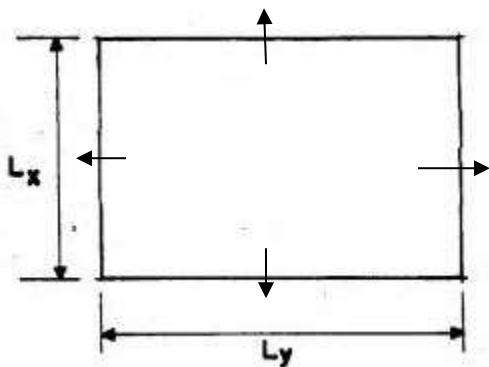
Figure 5.1 detail drawing of stair case

Load Transfer

Load Transfer from one-way cantilever slab to beam

For analysis to use SAP the dead load and live load should transfer separately:

Load Transfer from Two-way slab



N.B for analysis we transfer factored dead load and live load because of we factor load in SAP analysis.

i) Dead Load Transfer

$$V_{DX} = \beta V_X * D.L * L_x$$

$$V_{DY} = \beta V_y * D.L * L_x$$

ii) Live Load Transfer

$$V_{LX} = \beta V_X * L.L * L_x$$

$$V_{LY} = \beta V_y * L.L * L_x$$

Dead Load Transfer

| Panel | Support Condition | Shear | Span Ratio | D.L | Lx | βV_x | βV_y | Vx | Vy | 0.92Vx | 0.92Vy |
|-------|-------------------|-------|------------|------|------|-------------|-------------|-------|----|--------|--------|
| F5 | Type 1 | Vx1 | 1.18 | 5.25 | 2.81 | 0.38 | | 5.66 | | 5.21 | |
| S5 | | Vx2 | | | | 0.38 | 5.66 | 5.21 | | | |
| T5 | | Vy1 | | | | 0.33 | 4.87 | 4.48 | | | |
| | | Vy2 | | | | 0.33 | 4.87 | 4.48 | | | |
| T6 | Type 1 | Vx1 | 1.02 | 5.67 | 3.26 | 0.34 | | 6.21 | | 5.71 | |
| T6 | | Vx2 | | | | 0.34 | 6.21 | 5.71 | | | |
| | | Vy1 | | | | 0.33 | 6.10 | 5.61 | | | |
| | | Vy2 | | | | 0.33 | 6.10 | 5.61 | | | |
| F8 | Type 1 | Vx1 | 1.13 | 5.67 | 2.81 | 0.466 | | 7.42 | | 6.83 | |
| S8 | | Vx2 | | | | 0.466 | 7.42 | 6.83 | | | |
| T8 | | Vy1 | | | | 0.33 | 5.26 | 4.84 | | | |
| | | Vy2 | | | | 0.33 | 5.26 | 4.84 | | | |
| F9 | Type 3 | Vx1 | 1.41 | 6.02 | 3.26 | 0.522 | | 10.24 | | 9.42 | |
| S9 | | Vx2 | | | | 0.322 | 6.32 | 5.81 | | | |

| | | | | | | | | | | | | |
|-----|--------|-----|------|------|------|-------|------|------|------|------|------|------|
| T9 | | Vy1 | | | | | 0.36 | | 7.07 | | 6.50 | |
| | | Vy2 | | | | | 0.36 | | 7.07 | | 6.50 | |
| F10 | Type 1 | Vx1 | | | | 0.434 | | 6.91 | | 6.36 | | |
| S10 | | Vx2 | 1.42 | 5.67 | 2.81 | 0.434 | | 6.91 | | 6.36 | | |
| T10 | | Vy1 | | | | | | 0.33 | | 5.26 | | 4.84 |
| | | Vy2 | | | | | | 0.33 | | 5.31 | | 4.88 |
| F11 | | Vx1 | | | | 0.394 | | 7.7 | | 7.1 | | |
| S11 | Type 1 | Vx2 | 1.22 | 6.02 | 3.26 | 0.394 | | 3 | | 1 | | |
| T11 | | Vy1 | | | | | | 0.33 | | 6.48 | | 5.96 |
| | | Vy2 | | | | | | 0.33 | | 6.48 | | 5.96 |
| F13 | Type 2 | Vx1 | | | | 0.448 | | 7.32 | | 6.73 | | |
| S13 | | Vx2 | 1.38 | 5.67 | 2.88 | 0.448 | | 7.32 | | 6.73 | | |
| T13 | | Vy1 | | | | | | 0.36 | | 5.88 | | 5.41 |
| | | Vy2 | | | | | | 0.24 | | 3.92 | | 3.61 |
| F15 | Type 1 | Vx1 | | | | 0.492 | | 8.32 | | 7.66 | | |
| S15 | | Vx2 | 1.9 | 6.02 | 2.81 | 0.492 | | 8.32 | | 7.66 | | |
| T15 | | Vy1 | | | | | | 0.33 | | 5.58 | | 5.14 |
| | | Vy2 | | | | | | 0.33 | | 5.58 | | 5.14 |
| F16 | Type 1 | Vx1 | | | | 0.465 | | 9.13 | | 8.40 | | |
| S16 | | Vx2 | 1.63 | 6.02 | 3.26 | 0.465 | | 9.13 | | 8.40 | | |
| T16 | | Vy1 | | | | | | 0.33 | | 6.48 | | 5.96 |
| | | Vy2 | | | | | | 0.33 | | 6.48 | | 5.96 |
| F17 | Type 1 | Vx1 | | | | 0.473 | | 9.00 | | 8.28 | | |
| S17 | | Vx2 | 1.69 | 6.02 | 3.16 | 0.473 | | 9.00 | | 8.28 | | |
| T17 | | Vy1 | | | | | | 0.33 | | 6.28 | | 5.78 |

| | | | | | | | | | | | |
|-----|--------|-----|------|------|------|-------|------|------|------|------|------|
| | | Vy2 | | | | | 0.33 | | 6.28 | | 5.78 |
| F18 | Type 1 | Vx1 | | | | 0.487 | | 8.44 | | 7.77 | |
| T18 | | Vx2 | 1.84 | 6.02 | 2.88 | 0.487 | | 8.44 | | 7.77 | |
| S18 | | Vy1 | | | | | 0.33 | | 5.72 | | 5.26 |

Live Load Transfer

| Panel | Support Condition | Shear | Span Ratio | L.L | Lx | βV_x | βV_y | Vx | Vy | 0.92Vx | 0.92Vy | |
|-------|-------------------|-------|------------|------|------|-------------|-------------|------|------|--------|--------|------|
| F5 | Type 1 | Vx1 | | | | 0.38 | | 2.16 | | 1.99 | | |
| S5 | | Vx2 | 1.18 | 2 | 2.81 | 0.38 | | 2.16 | | 1.99 | | |
| T5 | | Vy1 | | | | | 0.33 | | 1.85 | | 1.71 | |
| | | Vy2 | | | | | 0.33 | | 1.85 | | 1.71 | |
| T6 | Type 1 | Vx1 | | | | 0.34 | | 5.48 | | 5.04 | | |
| | | Vx2 | 1.02 | 5 | 3.26 | 0.34 | | 5.48 | | 5.04 | | |
| | | Vy1 | | | | | 0.33 | | 5.38 | | 4.95 | |
| | | Vy2 | | | | | 0.33 | | 5.38 | | 4.95 | |
| F8 | Type 1 | Vx1 | | | | 0.466 | | 3.93 | | 3.61 | | |
| | | S8 | Vx2 | 1.13 | 3 | 2.81 | 0.466 | | 3.93 | | 3.61 | |
| | | T8 | Vy1 | | | | | 0.33 | | 2.78 | | 2.56 |
| | | | Vy2 | | | | | 0.33 | | 2.78 | | 2.56 |
| F9 | Type 3 | Vx1 | | | | 0.522 | | 8.51 | | 7.83 | | |
| | | S9 | Vx2 | 1.41 | 5 | 3.26 | 0.322 | | 5.25 | | 4.83 | |
| | | T9 | Vy1 | | | | | 0.36 | | 5.87 | | 5.40 |
| | | | Vy2 | | | | | 0.36 | | 5.87 | | 5.40 |
| F10 | | Vx1 | | | | 0.434 | | 6.10 | | 5.61 | | |

| | | | | | | | | | | | |
|-----|--------|-----|------|---|------|-------|------|------|------|------|------|
| S10 | Type 1 | Vx2 | 1.42 | 5 | 2.81 | 0.434 | | 6.10 | | 5.61 | |
| T10 | | Vy1 | | | | | 0.33 | | 4.64 | | 4.27 |
| | | Vy2 | | | | | 0.33 | | 4.68 | | 4.30 |
| F11 | | Vx1 | | | | 0.394 | | 6.42 | | 5.91 | |
| S11 | Type 1 | Vx2 | 1.22 | 5 | 3.2 | 0.39 | | 6.42 | | 5.9 | |

6. LATERAL LOAD ANALYSES

Buildings are designed to satisfy the basic structural and functional requirements. Thus, the design of a structure should be strong enough to withstand all lateral loads without excessive deformation or deflection. Normally in the design of building the lateral load due to earth quake and wind load shall be calculated and compared so that the maximum of the two is taken for design

- We analyze lateral load using ETABS V 9.6

Steps to analyze

Step 1

- Plot grid Coordinates that represent the given structural design

Step 2 Define Material

- We define two types of material those are C-25 Concrete and S-300 Rebar with their material

Properties.

I.e. C-25 Material type: concrete

- ✓ Symmetry type: Isotropic
- ✓ Modulus of Elasticity: 29Gpa
- ✓ Poisson 's ratio: 0.2
- ✓ Shear Modulus (G):10356491
- ✓ Coefficient of Thermal Expansion: 10E-06
- ✓ Unit Weight: 25 KN/m³

S300: Material type: Rebar

- ✓ Unit Weight: 7.849 KN/m³.
- ✓ Modulus of Elasticity: 2.1E+08
- ✓ Poisson 's ratio: 0.3

- ✓ Shear Modulus (G):76903069
- ✓ Coefficient Thermal Expansion: 1.17E-05
- ✓ Minimum Yield Stress, F_y : 260.870 Mpa
- ✓ Minimum Tensile Stress, F_u : 300.000 Mpa

Step 3 Define Frame Section

The analysis of frame having beam and column to be designed using Etabs and sap software. The other analyses using this software application are Wind AND EQ Loads

We define three types of Frame Section those are

- ✓ Rectangular column (40x25 cm),
- ✓ Rectangular column (30x25 cm),
- ✓ Square column(25x25cm)
- ✓ Beam (50x25 cm)

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 Assignment of Loads

First, Introduce Live Load on Definition of load Pattern then

We use Load Combination:

First, Introduce Live Load and load transferred from slab to the beam as dead load on Definition of load Pattern then,

We use Load Combination: refer [5]

| | | |
|-------------|-------------|---------|
| Combination | Factored | Loading |
| | Combination | |

| | | |
|---------|------------------------------|-------|
| Comb 1 | $1.35*DL+1.5*LL$ | - |
| Comb 2 | $0.75(1.35*DL+1.5*LL)$ | +EQX1 |
| Comb 3 | $0.75(1.35*DL+1.5*LL)$ | -EQX1 |
| Comb 4 | $0.75(1.35*DL+1.5*LL)$ | +EQx2 |
| Comb 5 | $0.75(1.35*DL+1.5*LL)$ | -EQx2 |
| Comb 6 | $0.75(1.35*DL+1.5*LL)$ | +EQY1 |
| Comb 7 | $0.75(1.35*DL+1.5*LL)$ | -EQY1 |
| Comb 8 | $0.75(1.35*DL+1.5*LL)$ | +EQY2 |
| Comb 9 | $0.75(1.35*DL + 1.5*LL)$ | -EQY2 |
| Comb 10 | $DL + LL$ | +EQY1 |
| Comb 11 | Factored Loading Combination | -EQY1 |
| Comb 12 | $1.35*DL+1.5*LL$ | +EQY2 |

Table 6.1 load combination

7. FRAME ANALYSIS

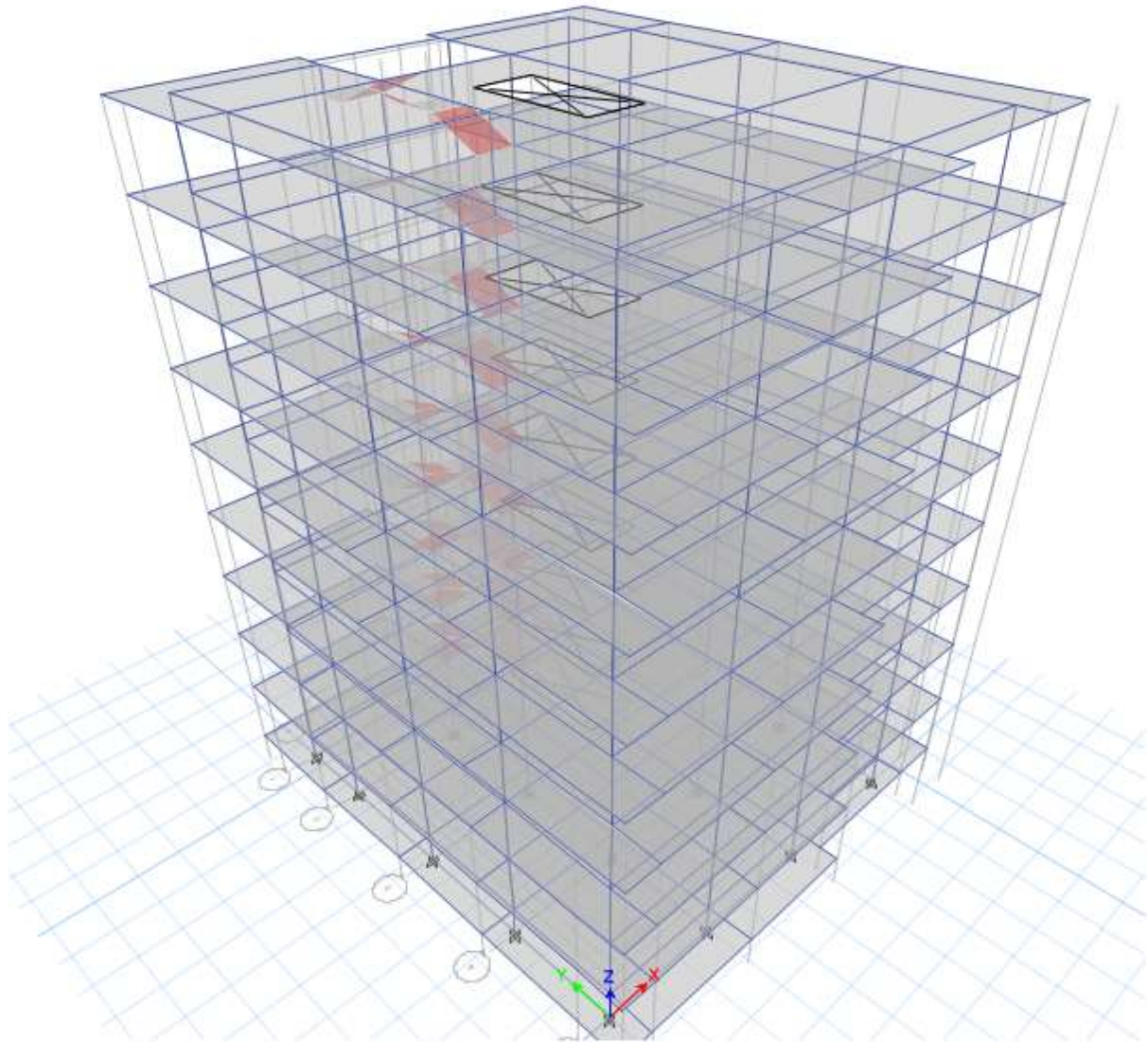
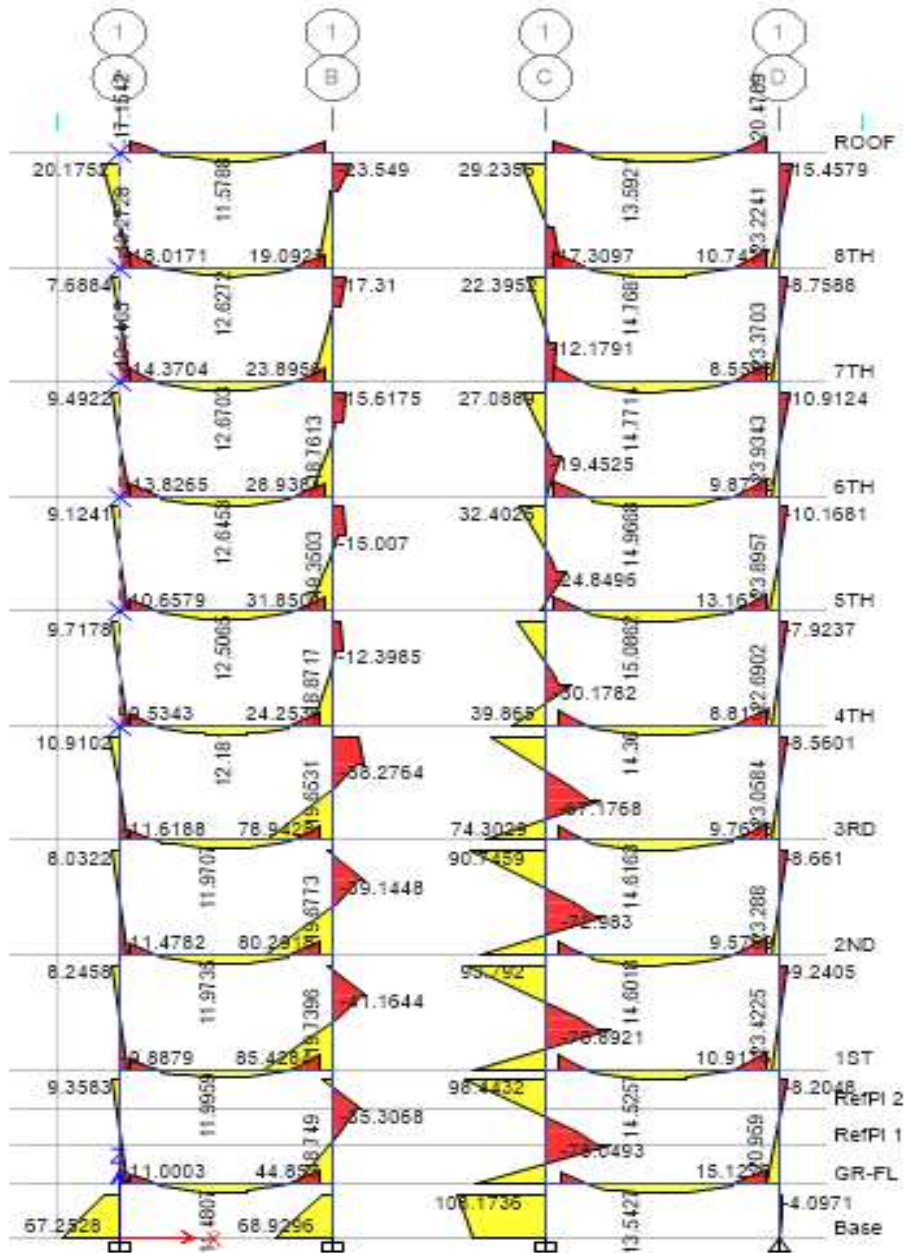


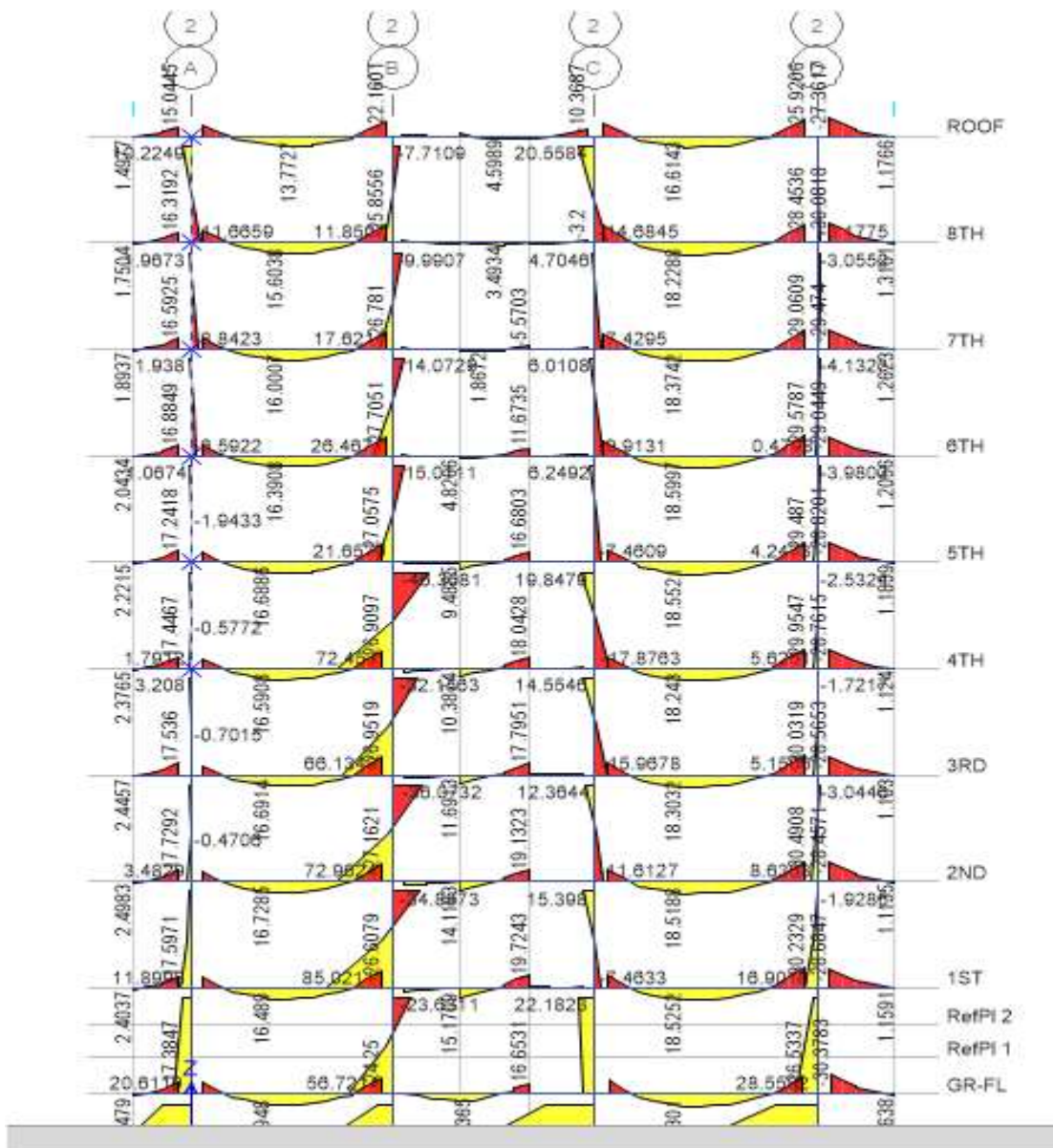
Figure 7.1 3-D model of mixed used building

Moment 3-3 diagram

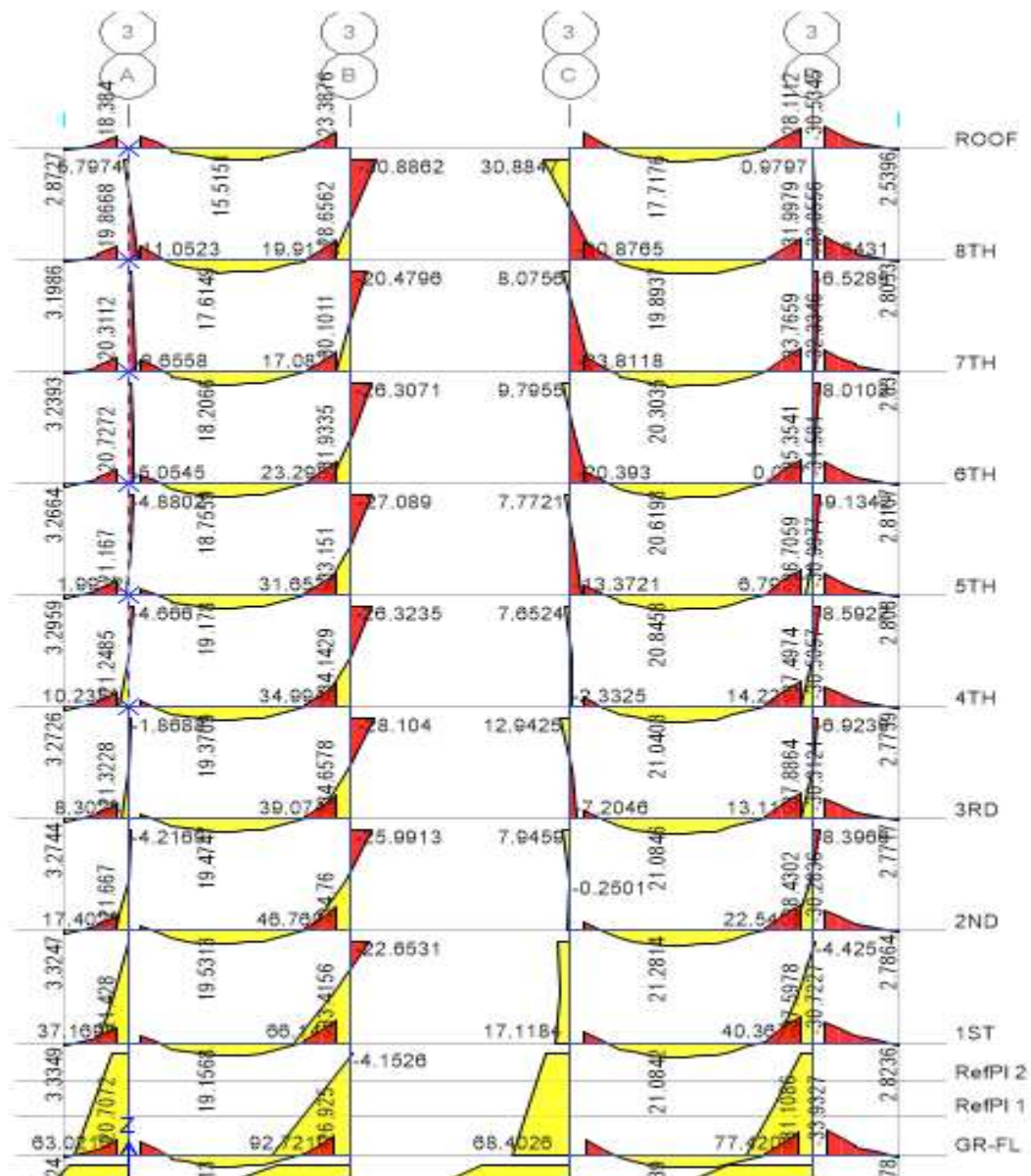
Elevation view 1 moment 3-3 diagram



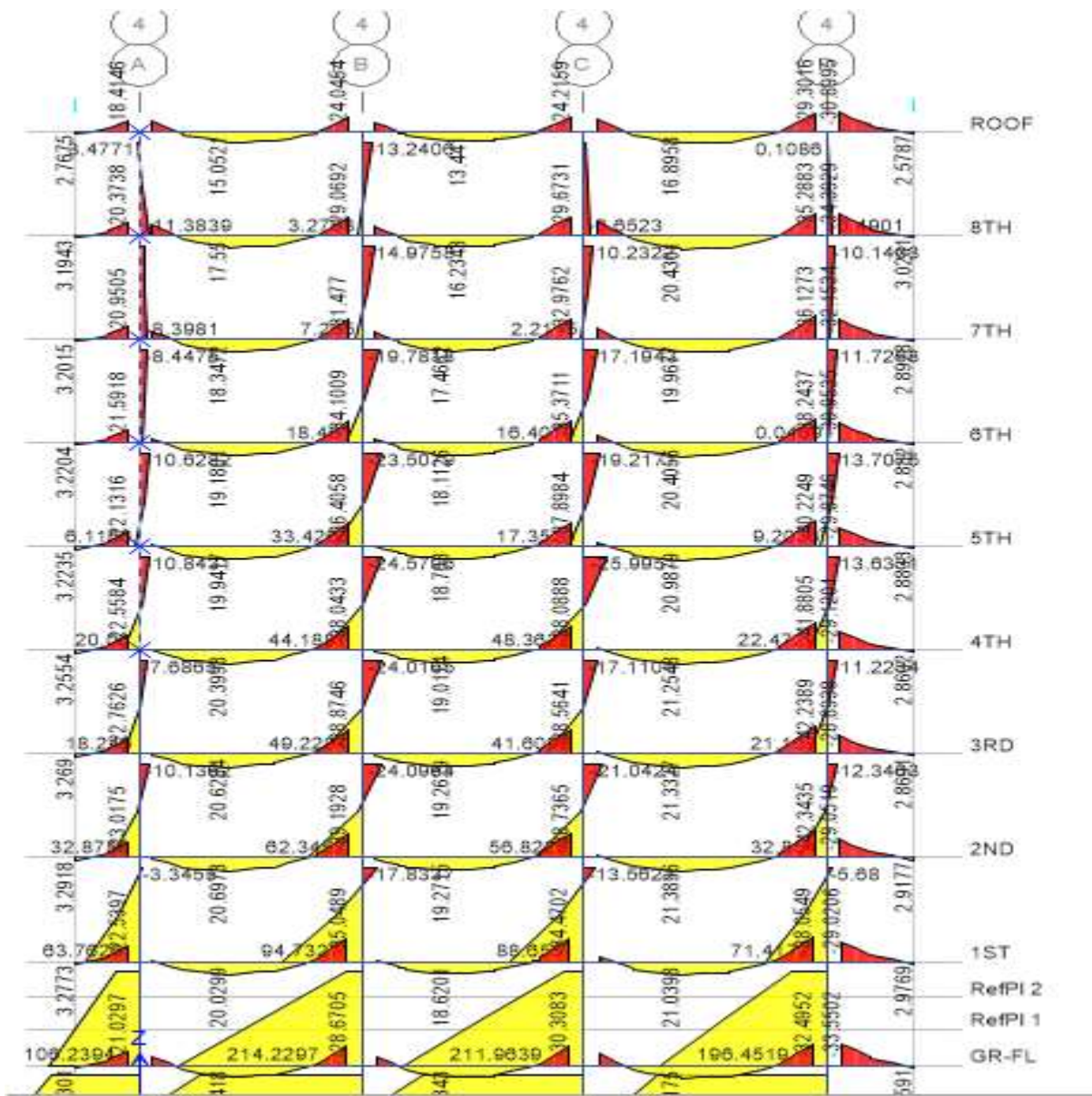
Elevation view 2 moment diagram



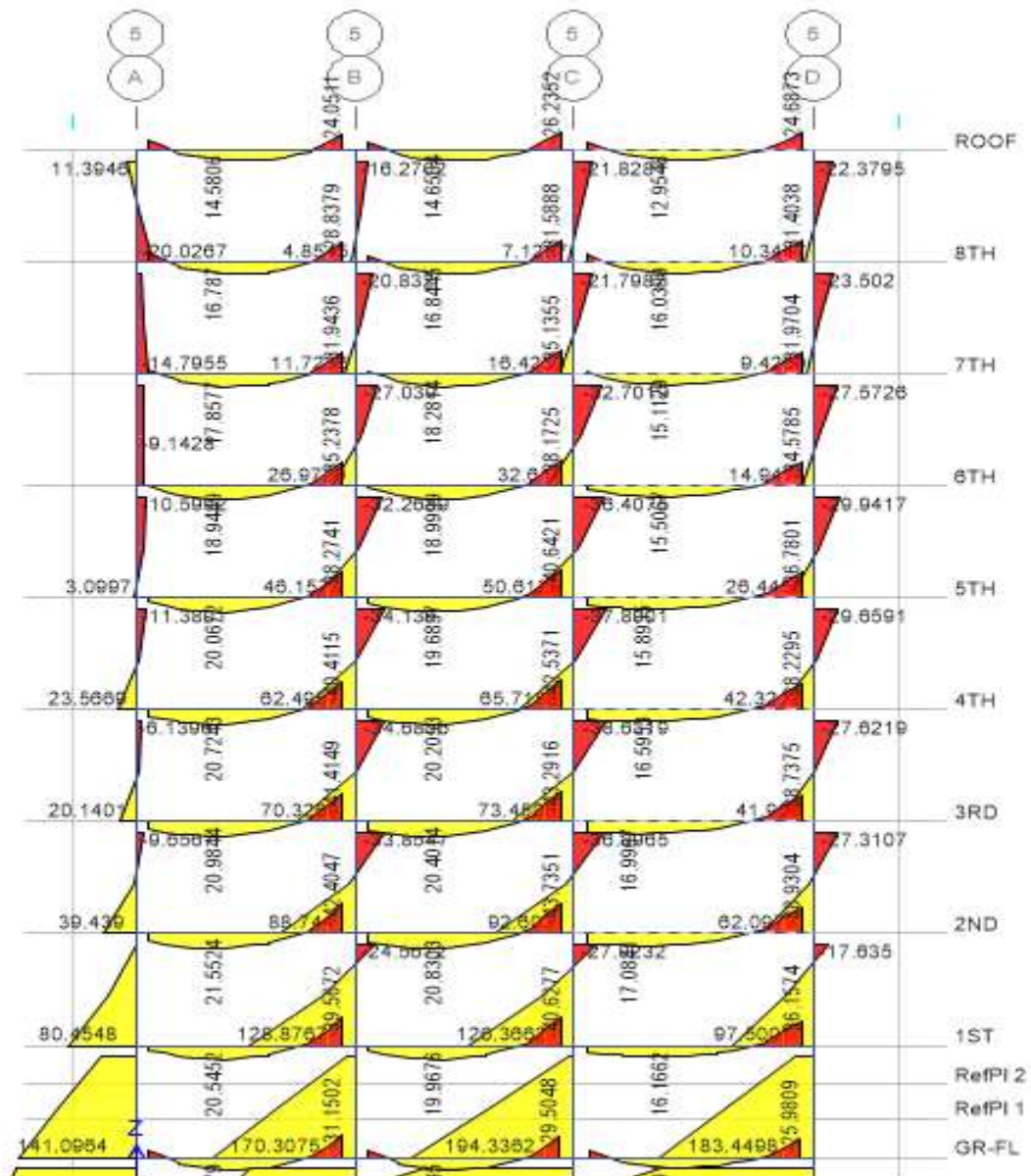
Elevation view 3 moment diagram



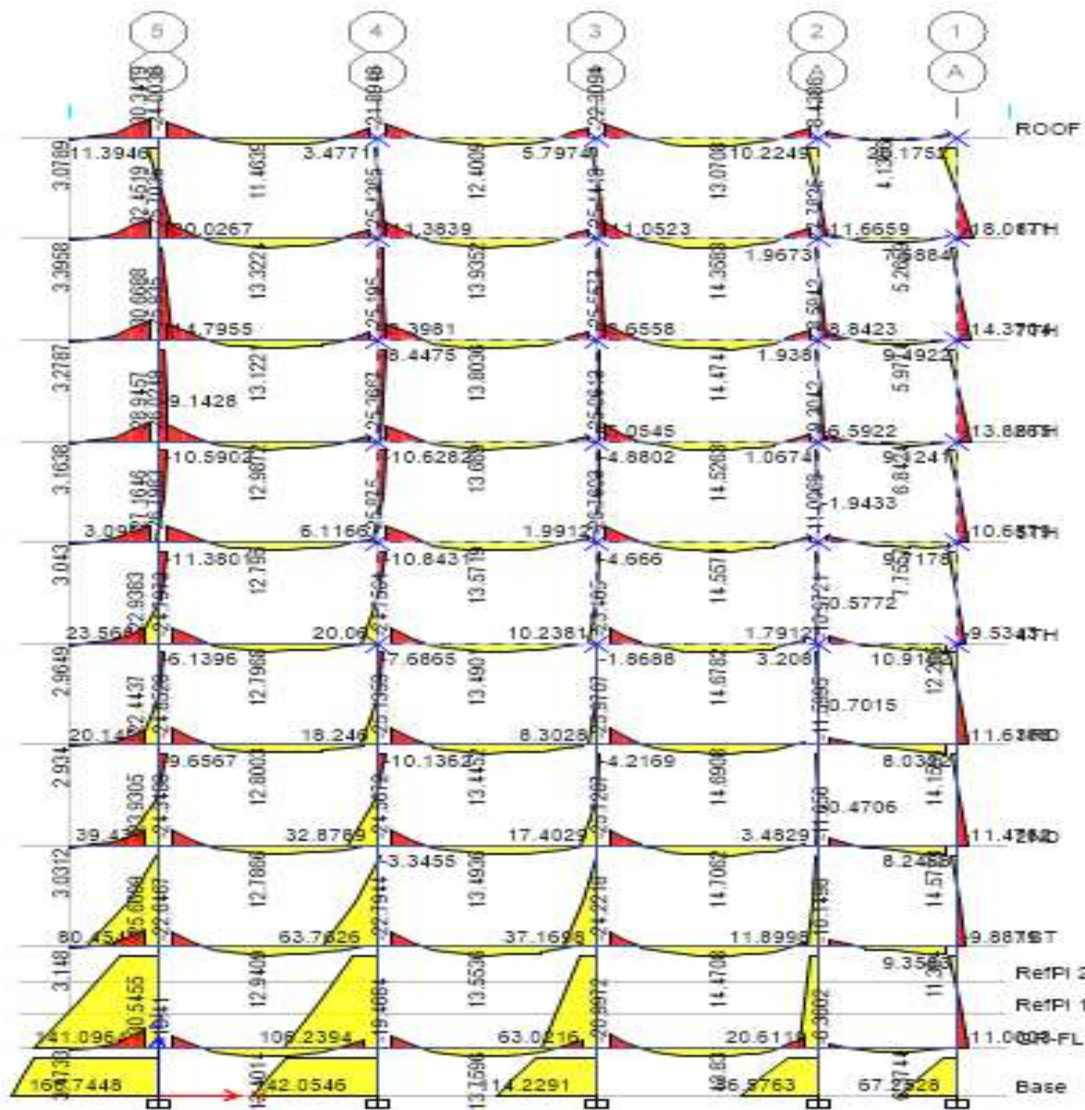
Elevation view 4 moment diagram



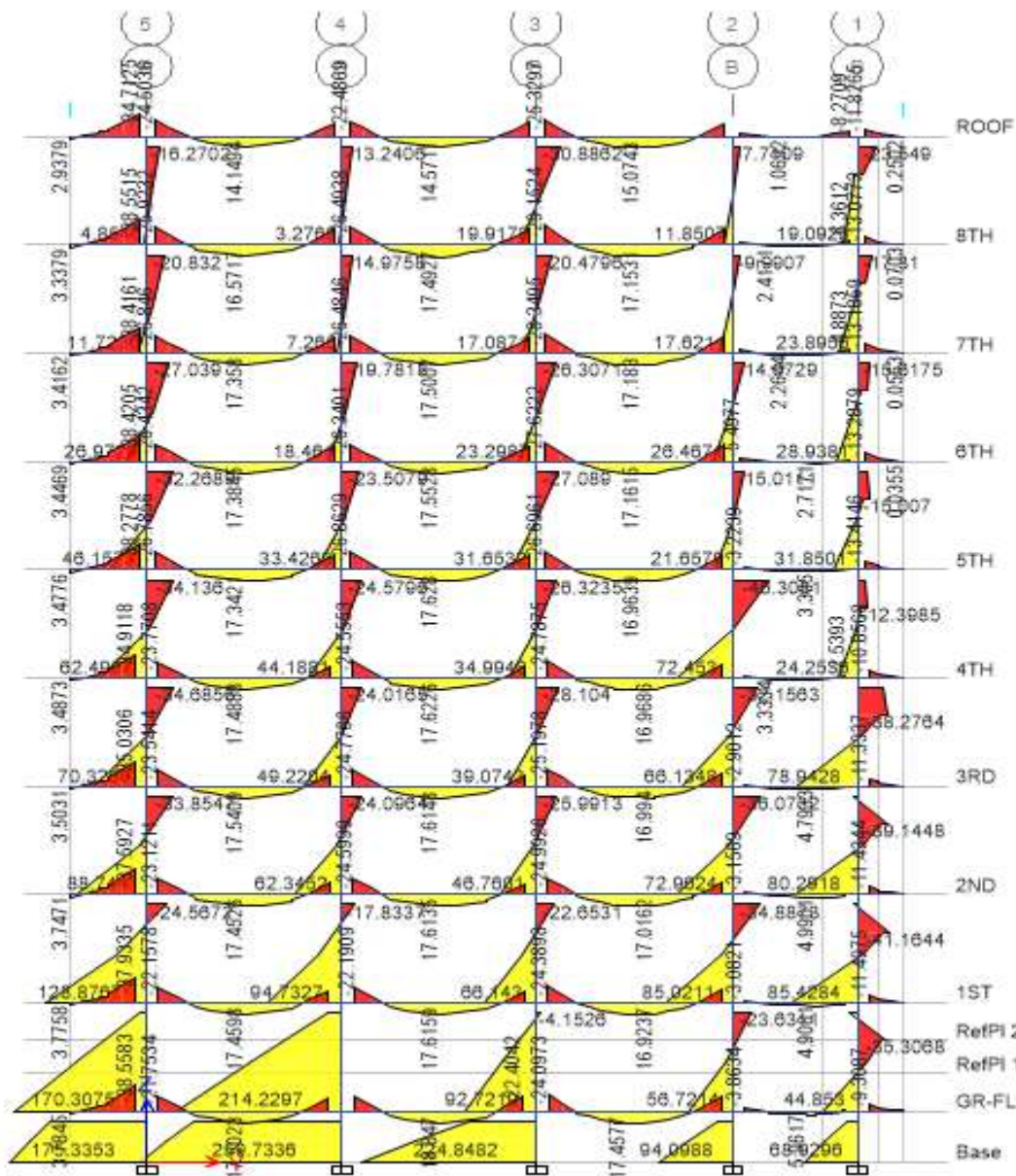
Elevation view 5 moment diagram



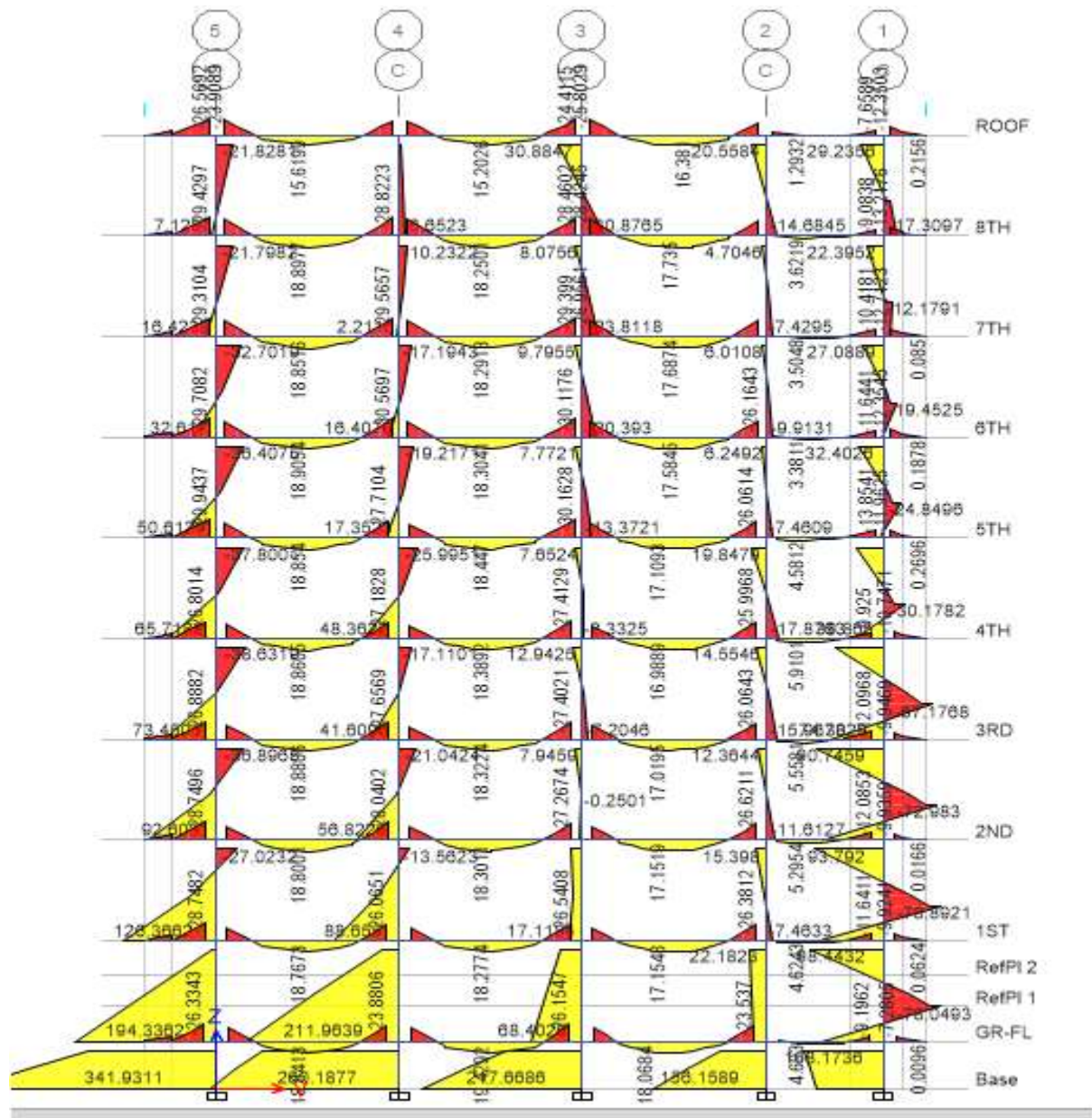
Elevation view of moment diagram A



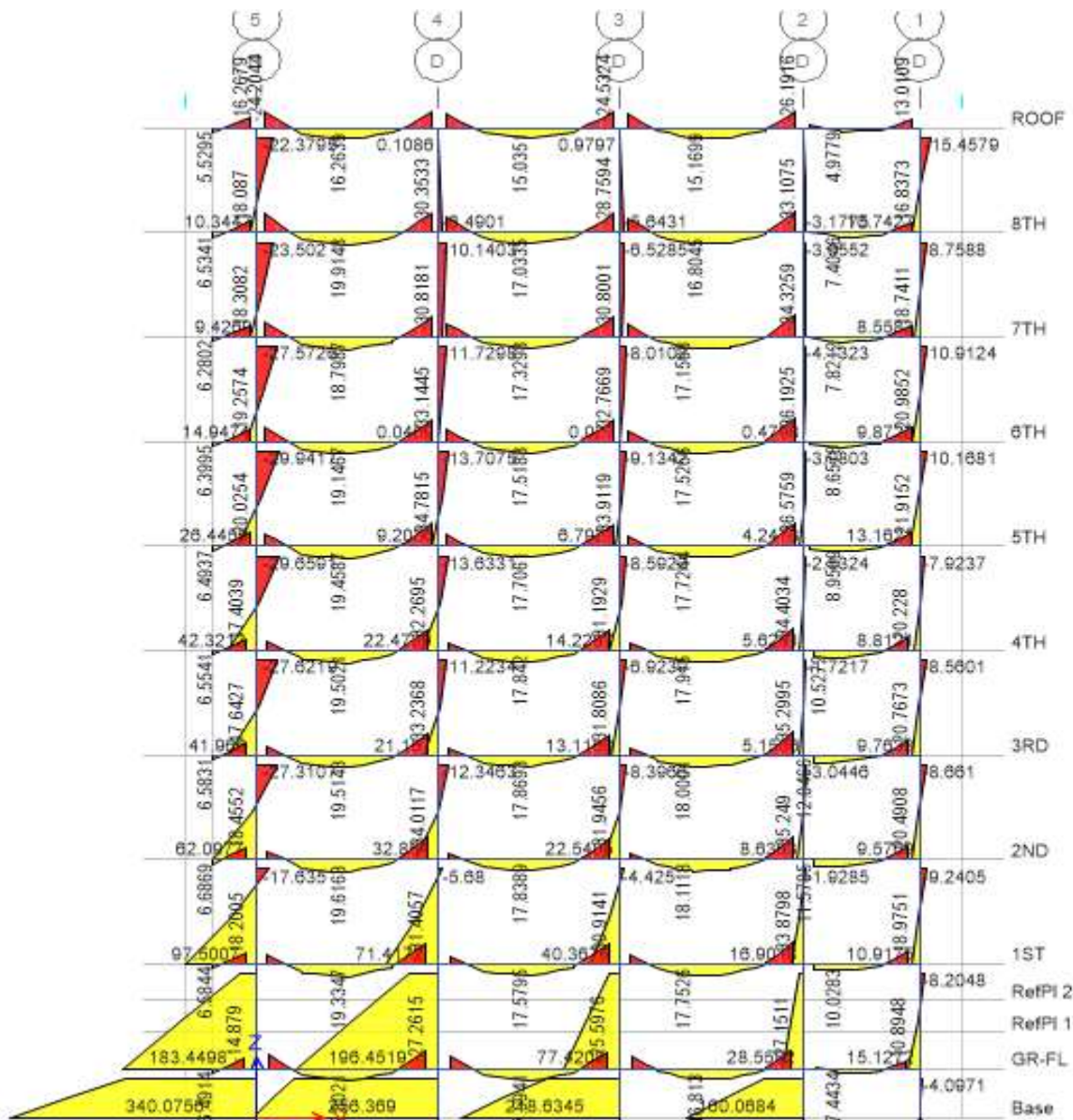
Elevation view of moment diagram B



Elevation view of moment diagram C

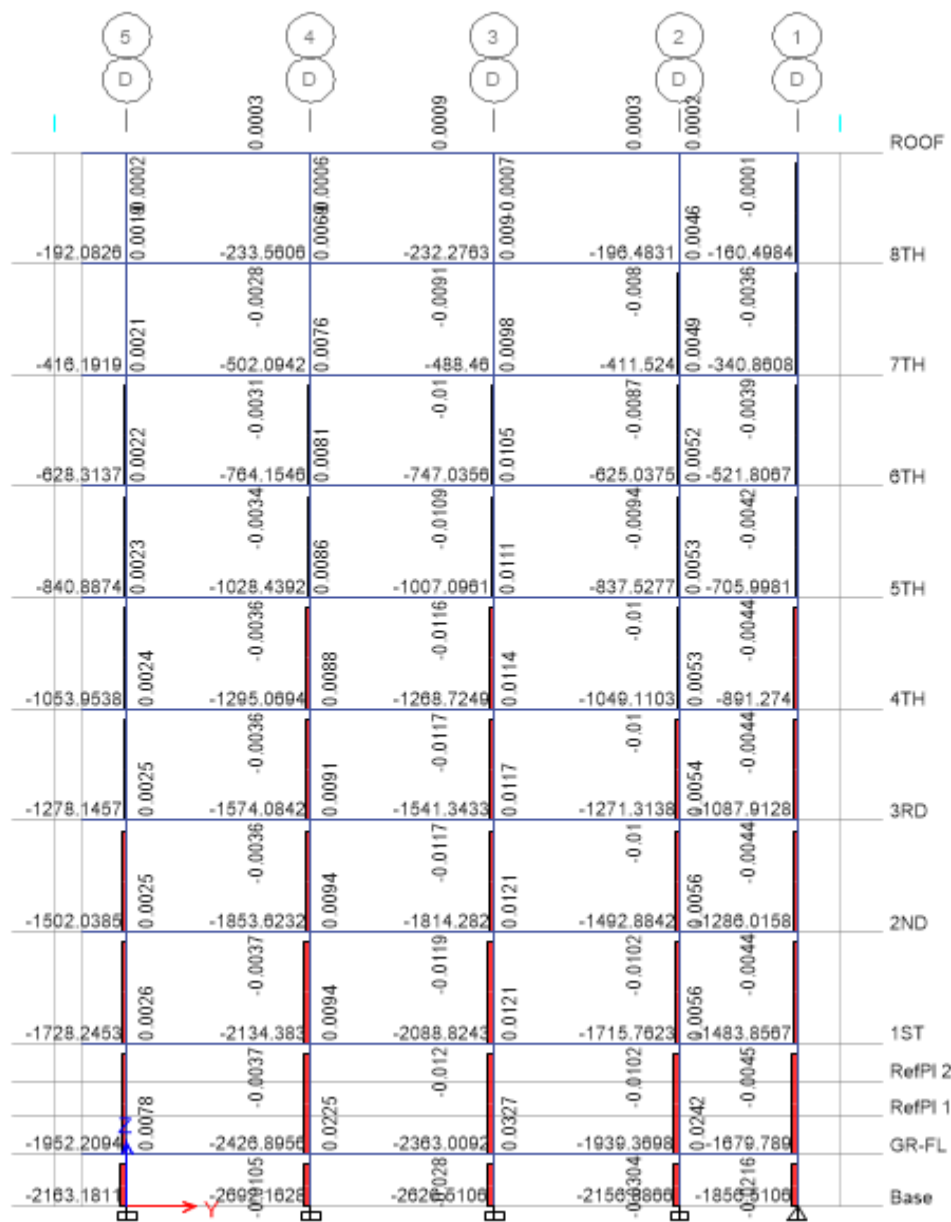


Elevation view of moment diagram D

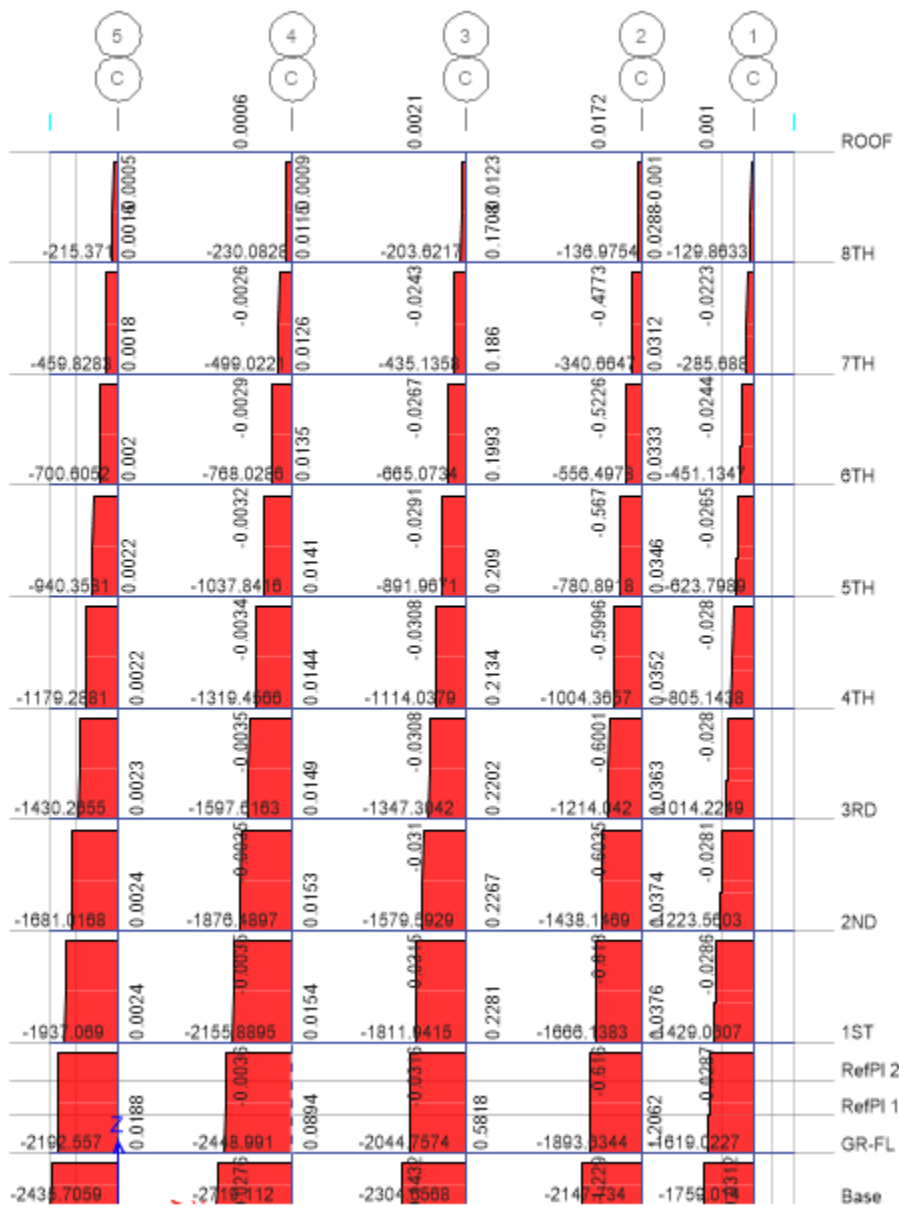


Elevation view D axial force diagram

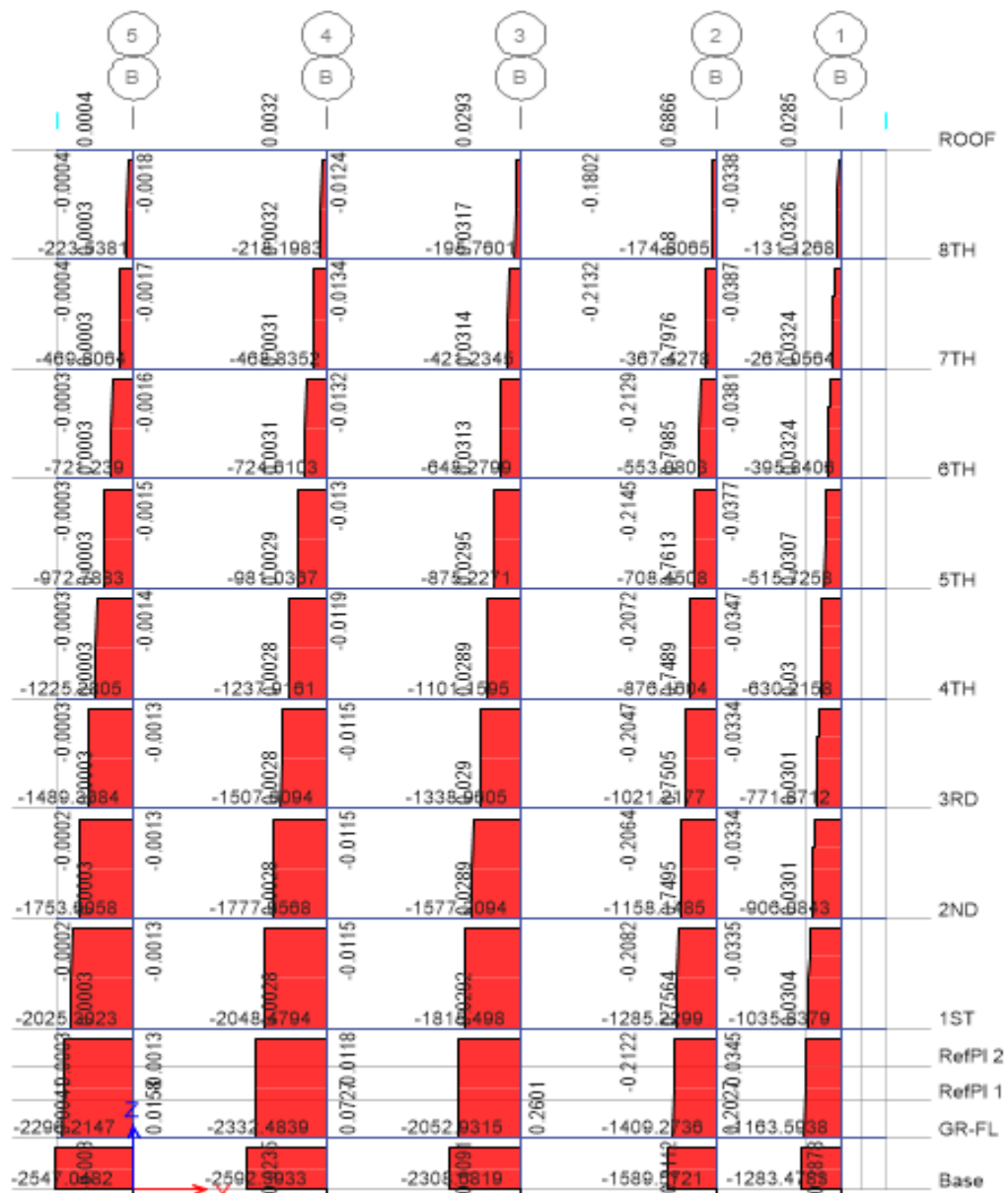
View D axial load diagram



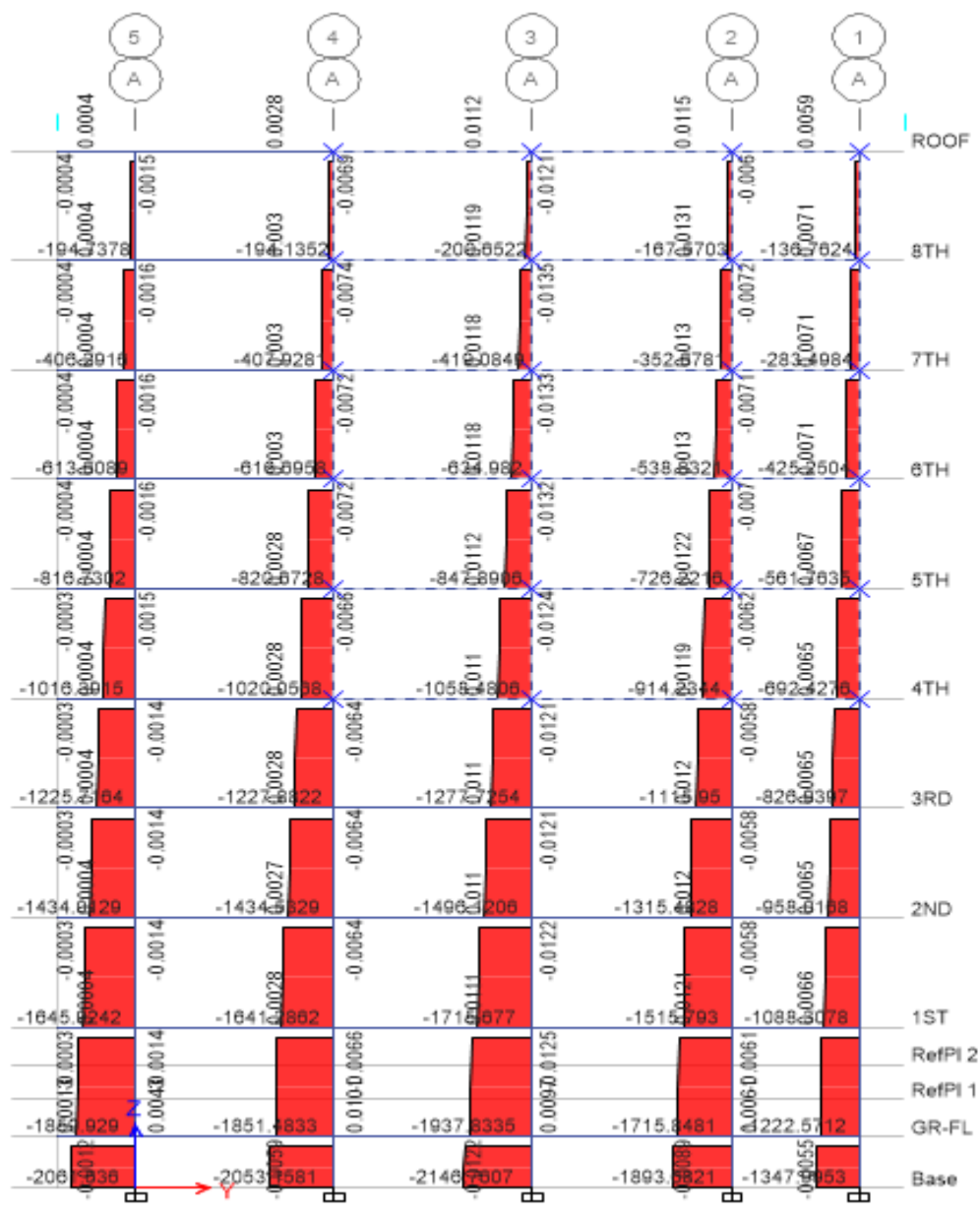
Elevation view C axial force diagram



Elevation view B axial force diagram

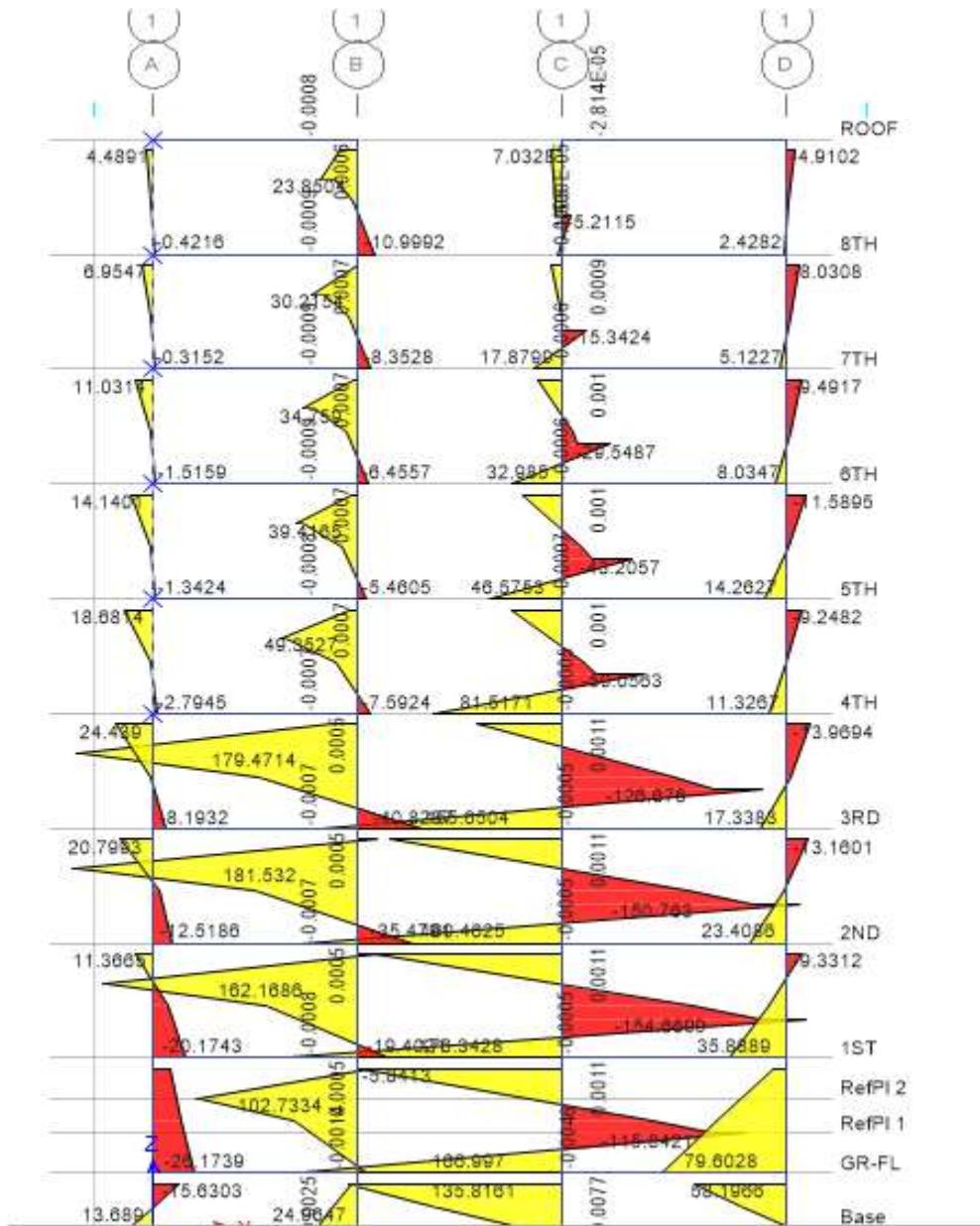


Elevation view A axial force diagram

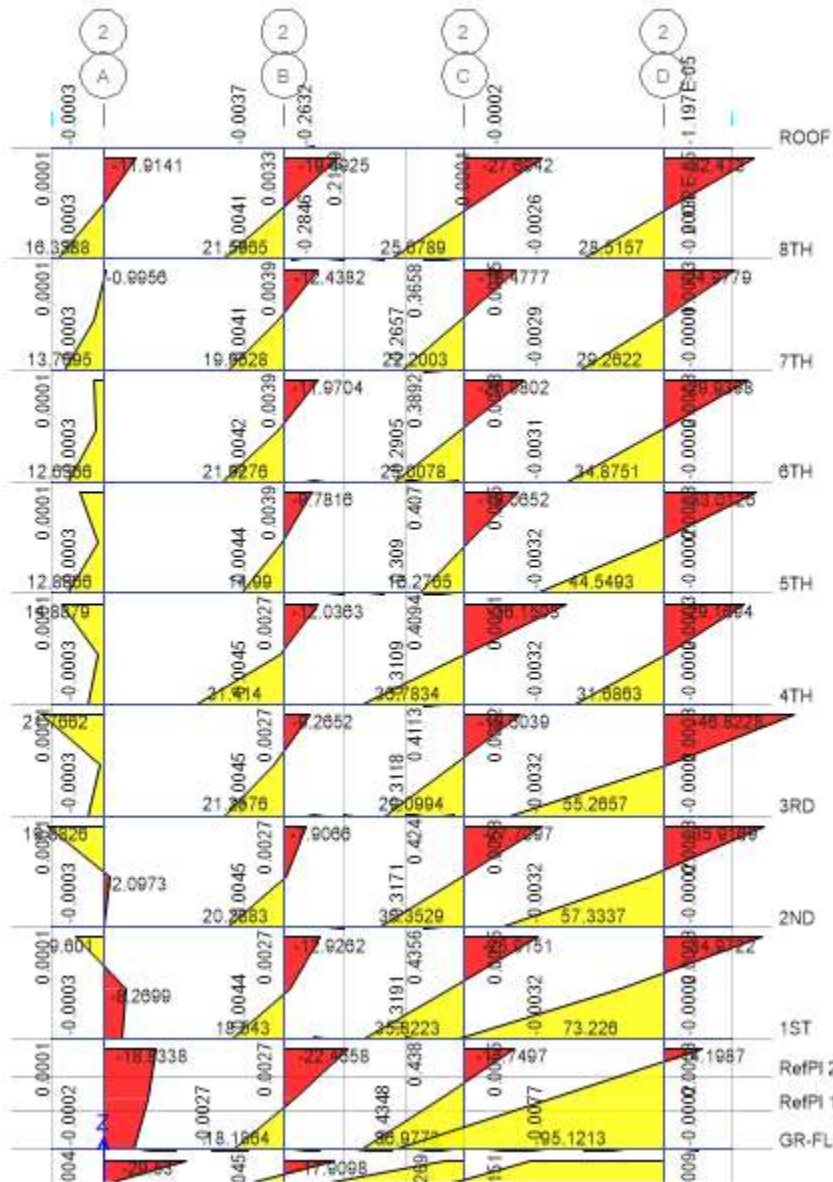


Elevation view of moment 2-2 diagram

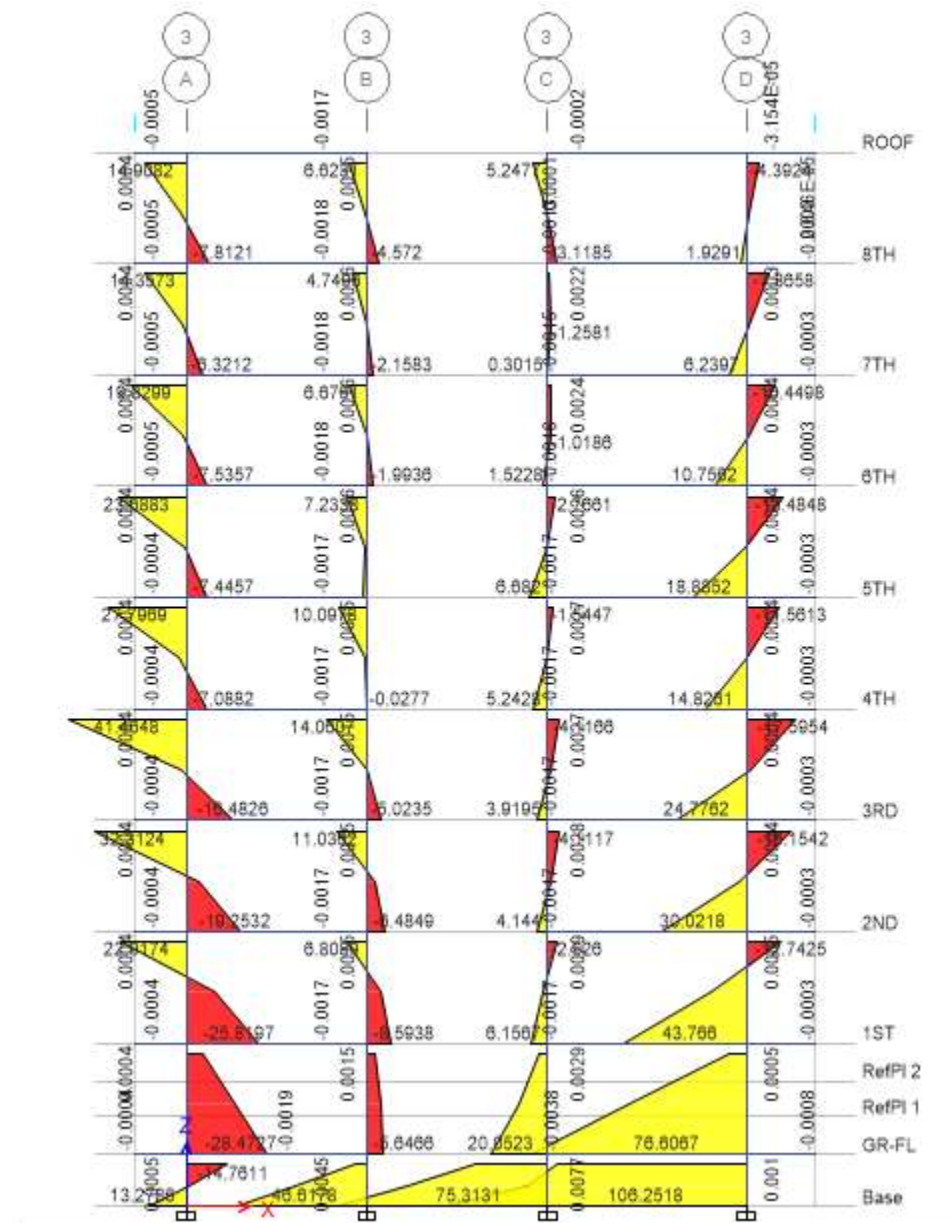
Elevation view 1 moment 2-2 diagram



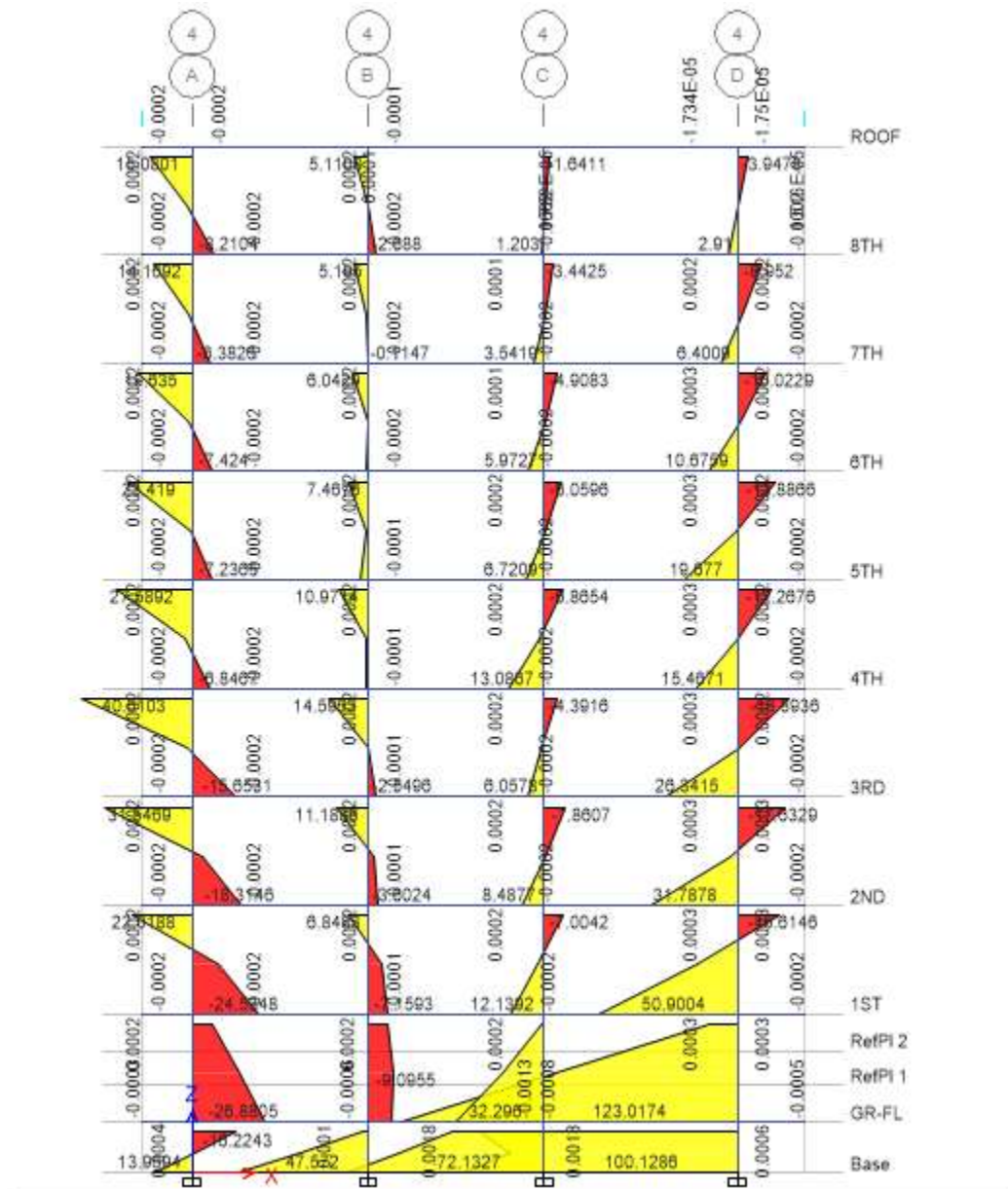
Elevation view 2 moment diagram



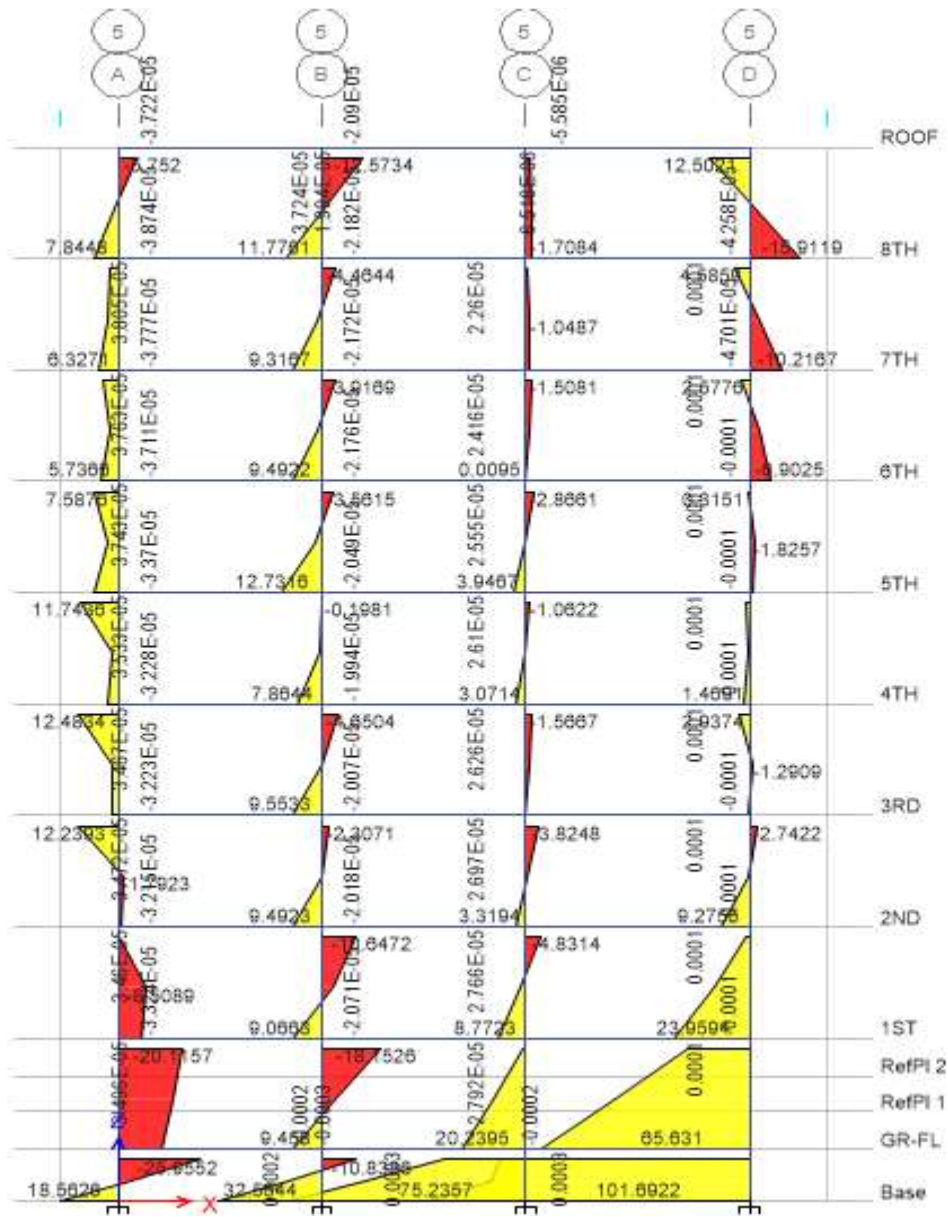
Elevation view 3 moment diagram



Elevation view 4 moment diagram



Elevation view 5 moment diagram



8. BEAM DESIGN

Beams should be design in such a way that they can carry their own weight in addition to transferring the load from slabs or roofs (in top tie beams) to the column without excessive deflection due to moment or cracks from shear force.

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.

Doubly reinforced cross section Incase when the dimension of the section is limited The concrete may be subjected to higher compression stress.

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

Thus additional steel bars are placed in the compression zone of the section

We have the following given dimensions

- ☞ Top tie beam=25cm*40cm
- ☞ Intermediate beam=30cm*40cm
- ☞ Grade beam=40cm*50cm

Material Data

- C-25
- S-300
- Class-I work

Design of Constant

- Concrete Partial safety factor for concrete $\gamma_c = 1.5$
- $f_{cu} = 25 \text{ Mpa}$
- $f_{ck} = 0.8 \cdot f_{cu} = 0.8 \cdot 25 = 20 \text{ Mpa}$
- $f_{cd} = 0.85 \cdot f_{ck} / 1.5 = 0.85 \cdot 20 / 1.5 = 11.33 \text{ Mpa}$
- $f_{ctd} = 1.03 \text{ Mpa}$
- Steel Partial safety factor for steel $\gamma_s = 1.15$
- $f_{yk} = 400 \text{ Mpa}$
- $f_{yd} = f_{yk} / 1.15 = 400 / 1.15 = 347.82 \text{ Mpa}$
- $c = 0.0035$
- $s = F_{yd} / E = 347.82 / 200000 = 0.00174$
- $f_{cd} = 0.85 f_{ck} / \gamma_c = 0.85 \cdot (25 / 1.25) \text{ Mpa} / 1.5 = 11.33 \text{ Mpa}$
- $f_{yd} = f_{yk} / \gamma_s = 400 \text{ Mpa} / 1.15 = 347.82 \text{ Mpa}$

8.1 Design of beam for Flexure

Inductive strength class for durability

The choice of adequately durable concrete for corrosion protection of reinforcement and protection of concrete attack requires consideration of the composition of concrete. This may result in a higher compressive strength of the concrete than is required for structural design. The relationship between concrete strength classes and environmental classes (Table 1-1) may be described by indicative strength classes.

Steps to analyses beam

It is necessary to have cover (concrete between the surface of the slab or beam and the reinforcing bar) for four primary reason

8.1.1 Concrete cover determination

To bond the reinforcement to the concrete so that the two elements act together. The efficiency of the bond increases as the cover increases.

The nominal concrete cover is the distance b/n the surface of reinforcement closest to the nearest concrete surface including links and stirrups.

$$C_{nom} = C_{min} + \Delta C_{dev} \quad \text{ES EN 1992: 2015 Art 4.4.12(1)}$$

$$C_{min, b}$$

$$C_{min} = \text{Max} \{ C_{min,dur} + \Delta C_{dur,\gamma} - \Delta C_{dur,st} - \Delta C_{dur,add}$$

$$10\text{mm}$$

Where;

- $C_{min, b}$ - minimum cover due to bond requirement, see ES EN Art. 4.4.1.2 (3).
- $C_{min, dur}$ - minimum cover due to environmental conditions, see ES EN Art 4.4.1.2 (5)
- $\Delta C_{dur,\gamma}$ - additive safety element, see ES EN Art 4.4.1.2 (6)
- $\Delta C_{dur,st}$ - reduction of minimum cover for use of stainless steel, see ES EN Art 4.4.1.2 (7)
- $\Delta C_{dur,add}$ - reduction of minimum cover for use of additional protection, see ES EN Art 4.4.1.2 (8)

But; the recommended value of $\Delta C_{dur,\gamma}$, $\Delta C_{dur,st}$, and $\Delta C_{dur,add}$ is zero see Art. 4.4.1.2 (6, 7, and 8).

To protect the reinforcement against corrosion.

To protect the reinforcement from strength loss, due to overheating in the case of fire.

Additional cover sometimes is provided on the top of slabs, particularly in garages and factories, so that abrasion and wear due to traffic will not reduce the cover below that required for structural and other purposes. The concrete cover is the distance between the surface of the reinforcement closest to the nearest concrete surface (including links and stirrups and surface reinforcement where relevant) and the nearest concrete surface.

Concrete cover according to EN 1992-1-1 and EN 1992-1-2

$$C_{nom} = C_{min} + \Delta C_{dev} \dots\dots\dots ES EN 1992:2015 \quad 4.4.12(1)$$

Minimum concrete cover, c_{min} shall be provided in order to ensure:

The nominal cover is defined as a minimum cover, c_{min} , plus an allowance in design for deviation, ΔC_{dev} : and ΔC_{dev} is an allowance which should be made in the design for deviations from the minimum cover. It should be taken as 10 mm, unless fabrication (i.e. construction) is subjected to a quality assurance system, in which case it is permitted to reduce ΔC_{dev} to 5 mm.

where c_{min} should be set to satisfy the requirements below:

- ✓ Safe transmission of bond forces
- ✓ Durability / Fire resistance

$$c_{min} = \max\{c_{min,b}; c_{min,dur}; 10 \text{ mm}\}$$

- ✓ Minimum cover for bond

The minimum cover to ensure adequate bond should not be less than the bar diameter, unless the aggregate size is over 32 mm. If the aggregate size is over 32 mm, $c_{min,b}$ should be increased by 5 mm. In order to transmit bond forces safely and to ensure adequate compaction of the

Concrete, the minimum cover should not be less than $C_{min,b}$ given in Table 4.2. (ES EN 2) (Refer Appendix B)

Slab reinforcement= Φ 16

Width; $C_{min,b}$ =16

8.1.2 Minimum cover for durability

EC-2 leaves the choice of $C_{min,D}$ to countries, but gives the following recommendation:

The value of $C_{min,D}$ depends on the “structural class”, which has to be determined first. If the specified service life is 50 years, the structural class is defined as 4. The “structural class” can be modified in case of the following conditions:

- ❖ The service life is 100 years instead of 50 years
- ❖ The concrete strength is higher than necessary
- ❖ Slabs (position of reinforcement not affected by construction process)

❖ Special quality control measures apply

The finally applying service class can be calculated with Table 4.3 N but the recommended minimum structural class is 1. (Refer appendix B)

$$C_{min} = \max (c_{min}, b; c_{min}, dur + \Delta c_{dur} - \Delta c_{dur}, st - \Delta c_{dur}), add; 10 \text{ mm.}$$

| Environmental requirement | | | | |
|-----------------------------------|----|-----|---------|-----|
| Exposure class according to table | | | | |
| Structural class | X0 | Xc1 | Xc2/xc3 | Xc4 |
| S1 | 10 | 10 | 10 | 15 |
| S2 | 10 | 10 | 15 | 20 |
| S3 | 10 | 10 | 20 | 25 |
| S4 | 10 | 15 | 25 | 30 |
| S5 | 15 | 20 | 30 | 35 |
| S6 | 20 | 25 | 35 | 40 |

Table 8.1 exposure class to find depth of the slab

Moreover,

- ✓ $C_{min}, dur = 10 \text{ mm}$
- ✓ $\Delta c_{dur} = 0;$
- ✓ $\Delta c_{dur}, St = 0;$
- ✓ $\Delta c_{dur}, add = 0.$ But from the relation

$$c_{min} = \max (c_{min}, b; c_{min}, dur + \Delta c_{dur}, \gamma - \Delta c_{dur}, st - \Delta c_{dur}, add; 10 \text{ mm})$$

$$= \max (16; 10 + 0 - 0 - 0; 10 \text{ mm}) = 16 \text{ mm}$$

$\Delta c_{dev}=10\text{mm}$ (recommended)

$C_{nom}=C_{min}+\Delta C_{dev}=16\text{mm}+10\text{mm}=26\text{mm}$

8.1.3 Effective Depth Determination: Serviceability requirement

According to ES EN 1992:2015; the limit state of deformation may be checked by either:

- By limiting the span/depth ratio, according to 7.4.2 or
- By comparing a calculated deflection, according to 7.4.3, with a limit value

$$l/d = N * K * F1 * F2 * F3$$

$$N = \left[11 + 1.5 \sqrt{f_{ck}} \frac{\rho_o}{\rho - \rho'} + \frac{1}{12} \sqrt{f_{ck}} \sqrt{\frac{\rho'}{\rho_o}} \right] \text{ if } \rho > \rho_o$$

Initially we can't know ρ and ρ' . So let's assume $\rho = \rho_o$ and use equation 7.16a. $A_s, req = A_s$, provided (Refer appendix F)

Assumptions

Initially we can't know ρ and ρ' . So let's assume $\rho = \rho_o$ and equation 7.16a. $A_s, req = A_s$, provided

Where; $N = 11 + 1.5 \sqrt{f_{ck}} \frac{\rho_o}{\rho} + 3.2 \sqrt{f_{ck}} \left(\frac{\rho_o}{\rho} - 1 \right)^{\frac{3}{2}}$ but $\rho_o = \rho$ (assumption)

$$\rho_o = \sqrt{f_{ck}} * 10^{-3} = * = 0.00447 = 0.0045\%$$

$$N = 11 + 1.5 * 20^{0.5} = 17.708$$

- $F1 = 1.67$
- $F2 = 1$
- $F3 = 1$

$$l/d = N * K * F1 * F2 * F3$$

$$l/d=17.708*1.3*1.67*1*1=38.444$$

$$L=5200\text{mm}$$

$$d=5000/38.444=130.05\text{mm}=130\text{mm}$$

After determining the value of effective depth

$$D = d + d',$$

$$d' = C_c + \varnothing_{\text{stirrup}} + \varnothing/2 \quad \text{using } \Phi 8 \text{ stirrup}$$

$$d' = 26 + 16/2 + 8 = 26 + 8 + 8 = 42\text{mm}$$

$$D = 130\text{mm} + 42\text{mm} = 172\text{mm} = 200\text{mm}$$

- Design constants

8.1.4 Design for flexure (using design chart)

$$\checkmark f_{cd} = 0.85f_{ck}/\gamma_c = 0.85*(25/1.25) \text{ Mpa}/1.5 = 11.33 \text{ Mpa}$$

$$\checkmark F_{yd} = f_{yk}/\gamma_s = 300 \text{ Mpa}/1.15 = 260.87 \text{ Mpa}$$

$$\checkmark m = f_{yd}/0.8*f_{cd} = 260.87 \text{ Mpa}/0.8*11.33\text{Mpa} = 28.78$$

$$\checkmark C_1 = 2.5/m = 2.5/28.78 = 0.0869$$

$$\checkmark C_2 = 0.32m^2f_{cd} = 0.32*(28.78)^2*11.33 \text{ Mpa} = 3003.04 \text{ Mpa}$$

$$\checkmark \varepsilon_c = 0.0035$$

$$\checkmark \varepsilon_s = f_{yd}/E = 260.87 \text{ Mpa}/200*10^3\text{Mpa} = 0.0013$$

$$\checkmark \rho_b = 0.8 * \varepsilon_c * f_{cd} / (\varepsilon_c + \varepsilon_s) \quad f_{yd} = (0.8 * 0.0035 * (11.33\text{Mpa})) / (260.87 \text{ Mpa} * 0.0035 + 0.0013) = 0.02997$$

$$\rho_{\max} = 0.75 * \rho_b = 0.025$$

$$\checkmark \rho_{\min} = 0.5/f_{yk} = 0.5/300 = 0.00167$$

Since the depth is fixed architecturally for beams with $\rho > \rho_{\max}$, i.e the section doesn't satisfy depth for flexure, the section will be provided with double reinforcement.

The area of longitudinal tension reinforcement should not be taken as less than $A_{s, \min}$

The beams are treated as rectangular beam with $b=b_w$

$$f_t b d_t \quad \text{but not less than } 0.0013 b d_t \text{ (1-3) } A_{s, \min} * 0.2$$

$$f_{yk} b = d_t \quad \text{but not less than } 0.0013 b d_t \text{ (1-3) } A_{s, \min} * 0.26$$

The cross-sectional area of tension or compression reinforcement should not exceed $A_{s, \max}$ outside lap locations.

The value of $A_{s, \max}$ for beams for use in a country may be found in its National Annex. The recommended value is $0.04A_c$.

$$\rho = 0.5 [C_1 \pm \sqrt{C_1^2 - 4M/bd^2 c_2}]$$

- ✓ if $\rho_{\text{calculated}} > \rho_{\text{max}}$, double reinforcement.
- ✓ If $\rho_{\text{min}} < \rho_{\text{calculated}} < \rho_{\text{max}}$, single reinforcement.
- ✓ If $\rho_{\text{calculated}} < \rho_{\text{min}}$, use ρ_{min}
- ✓ $M_{\text{max}} = 20.69 \text{ kNm}$
- ✓ $D = 300 \text{ mm}$
- ✓ $d = 300 \text{ mm} - 26 \text{ mm} - 8 - 8 = 258 \text{ mm}$
- ✓ $\mu_{sd,s} = \frac{M_{sd,s}}{f_{cd} * b * d^2} = \frac{20.69 * 10^6}{11.33 * 250 * 258^2} = 0.184$
- ✓ $d \geq \sqrt{\frac{M_{sd,s}}{\mu_{sd,s} f_{cd} * b}} = \sqrt{\frac{20.69 * 10^6}{0.184 * 11.33 * 250}} = 265 \text{ mm}$ Not ok!!
- ✓ Use $D = 400 \text{ mm}$
- ✓ $d = 400 \text{ mm} - 42 \text{ mm} = 358 \text{ mm}$
- ✓ $\mu_{sd,s} = \frac{M_{sd,s}}{f_{cd} * b * d^2} = \frac{20.69 * 10^6}{11.33 * 250 * 358^2} = 0.1$
- ✓ $d \geq \sqrt{\frac{M_{sd,s}}{\mu_{sd,s} f_{cd} * b}} = \sqrt{\frac{20.69 * 10^6}{1 * 11.33 * 250}} = 70.2 \text{ mm} < 358 \text{ mm}$ ok!!

$$D = 70.5 + 26 + 8 + 8 = 112.5 < 400 \text{ mm}$$

kz from the general design chart No 1A

$$Z_k = k * d \dots\dots\dots \text{EN ES-2 2015}$$

kz from the general design chart No 1A

$$Z_k = k * d \dots\dots\dots \text{EN ES-2 2015}$$

Then $\mu_{sd,s} = 0.1$

$K=0.94$

$Z=0.94*358\text{mm}=331.82\text{mm}^2$

$f_{yd}=300 \text{ Mpa}/1.15=260.87 \text{ Mpa}$

$$A_s = \frac{M_{sd,s}}{Z * f_{yd}} = \frac{20.69 * 10^6}{331.82 * 260.87} = 239.02\text{mm}^2$$

8.1.5 Check the minimum and maximum limit for area of reinforcement

$$A_{s,min} = \text{Max} \left\{ \begin{array}{l} \frac{0.26f_{ct}mbtd}{f_{yk}} = \frac{0.26*2.2*250*358}{300} = 170.6\text{mm}^2 < 239.02 \\ 0.00013btd = 0.00013 * 250 * 358 = 11.63\text{mm} \end{array} \right.$$

$170.6\text{mm}^2 < 239.02 \dots \dots \dots \text{ok!!!}$

$A_{st, \max}=0.04*Ac=0.04*250*400=4000\text{mm}^2 > A_s \dots \text{OK}$

Use $\emptyset 16$ bars and $\emptyset 8$ stirrups

8.1.6 Calculate the number of reinforcement

$$a_s = \frac{\pi d^2}{4} = \frac{3.14 * 16^2}{4} = 200.96\text{mm}^2$$

$$N = \frac{A_s}{a_s} = \frac{200.9}{200.96\text{mm}^2} = 2$$

8.1.7 Spacing of bars according to EN 1992-1-1-2004

The clear distance (horizontal and vertical) between individual parallel bars or horizontal layers of parallel bars should be not less than

$$S_{\min} = \text{max} \left\{ \begin{array}{l} K1 = \text{Bar diameter} \\ dg + k2\text{mm} \\ 20\text{mm} \end{array} \right.$$

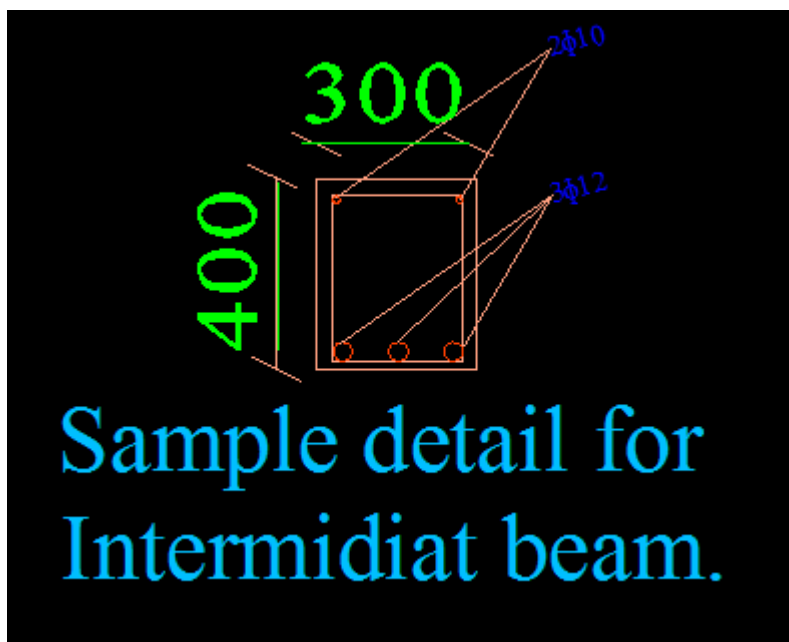
The recommended values of k1 and k2 are 1 and 5 mm respectively

$$d = 2C_c + 2\phi_{st} + N_o \phi + \text{no of spacing} * S$$

$$S = \frac{2C_c + 2\phi_{st} + N_o \phi}{\text{no of spacing}} = \frac{2*26 + 2*8 + 2}{2} = 35\text{mm}$$

$$S_{min} = \max \begin{cases} 2 * 16 = 32\text{mm} \\ 20 + 5 = 25\text{mm} \\ 20\text{mm} \end{cases}$$

$$S_{min} = 32\text{mm} < 35\text{mm} \quad \text{ok}$$



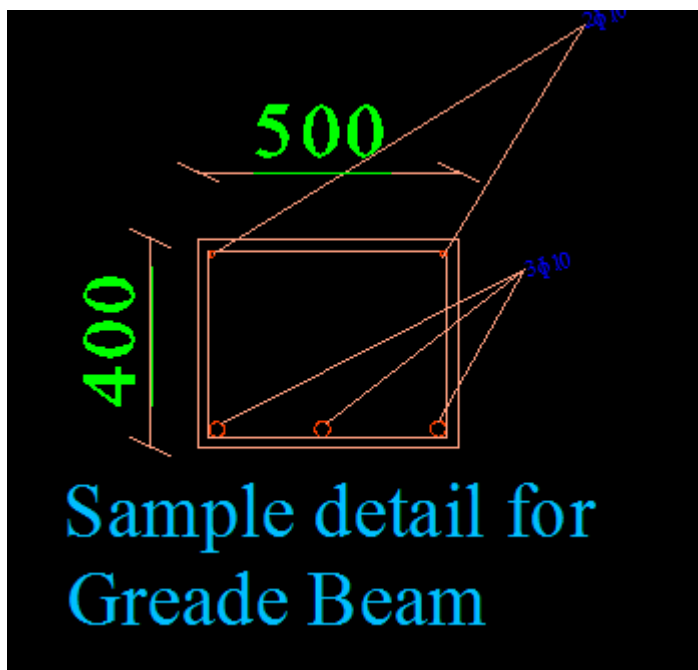
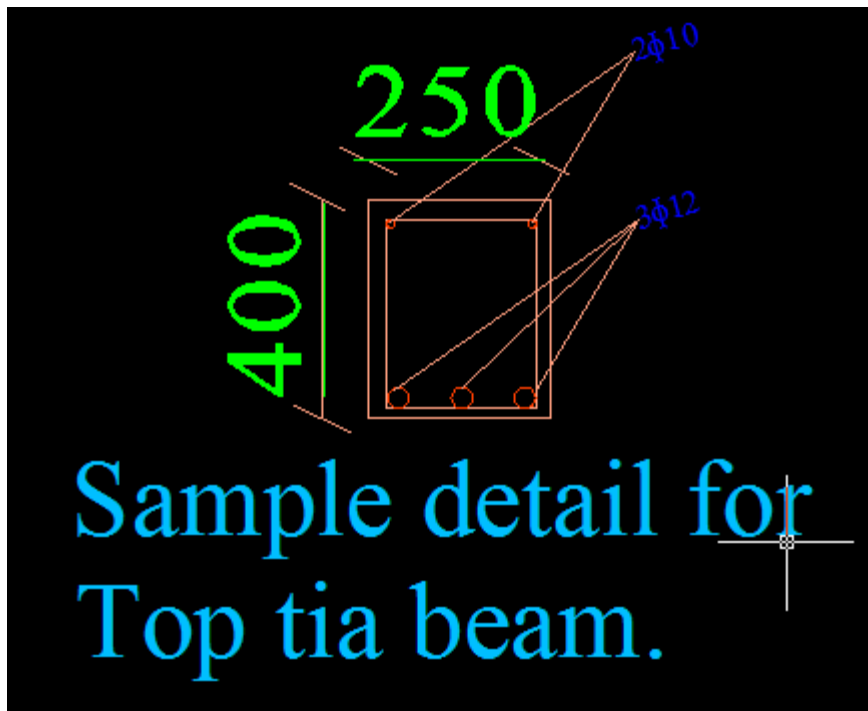


Figure 8.1 detail of beam cross section

Using the above criteria, we design our beam for shear as tabulated below

Flat roof beam shear design

| Axes 4 roof slab | | | | | | | | | | | | |
|------------------|-----|-------|-----|-------|-------|-------|-----|-------|--------|-------|------|--------|
| Type | L/n | Msd | be | ρcal | d(mm) | ρmin | K | Z(mm) | As | S | N | REMARK |
| Support | A | 18.42 | 250 | 0.001 | 350 | 0.002 | 0.6 | 210.5 | 274.20 | 560.9 | 1.78 | 2Ø16 |
| Span | AB | 15.05 | 250 | 0.001 | 350 | 0.002 | 0.5 | 172.0 | 274.20 | 560.9 | 1.78 | 2Ø16 |
| Support | B | 24.05 | 250 | 0.002 | 350 | 0.002 | 0.8 | 274.9 | 274.20 | 560.9 | 1.78 | 2Ø18 |
| Span | BC | 13.44 | 250 | 0.001 | 350 | 0.002 | 0.4 | 153.6 | 274.20 | 560.9 | 1.78 | 2Ø20 |
| Support | C | 24.21 | 250 | 0.002 | 350 | 0.002 | 0.8 | 276.7 | 274.20 | 560.9 | 1.78 | 2Ø16 |
| Span | CD | 16.89 | 250 | 0.001 | 350 | 0.002 | 0.6 | 193.0 | 274.20 | 560.9 | 1.78 | 2Ø16 |
| Support | D | 30.89 | 250 | 0.002 | 350 | 0.002 | 1.0 | 353.0 | 274.20 | 560.9 | 1.78 | 2Ø16 |

| Axes 4 for 8th | | | | | | | | | | | | |
|----------------|-----|--------|-----|---------|-------|-------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρcal | d(mm) | ρmin | K | Z(mm) | As | S | N | Remark |
| Support | A | 20.37 | 300 | 0.00126 | 258 | 0.002 | 1.0 | 263.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 17.55 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 29.06 | 300 | 0.00182 | 258 | 0.002 | 1.5 | 375.5 | 274.20 | 560.90 | 1.78 | 2Ø18 |
| Span | BC | 16.23 | 300 | 0.00100 | 258 | 0.002 | 0.8 | 209.7 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | C | 29.67 | 300 | 0.00185 | 258 | 0.002 | 1.5 | 383.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 20.43 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 264.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 35.29 | 300 | 0.00222 | 258 | 0.002 | 1.8 | 455.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4-4 for 7th | | | | | | | | | | | | |
|------------------|----------|--------|-----|---------|-------|-------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρcal | d(mm) | ρmin | K | Z(mm) | As | S | N | REMARK |
| Support | A | 20.95 | 300 | 0.00130 | 258 | 0.002 | 1 | 270.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 18.35 | 300 | 0.00114 | 258 | 0.002 | 0.9 | 237.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 17.47 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 225.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 17.74 | 300 | 0.00110 | 258 | 0.002 | 0.9 | 229.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 32.97 | 300 | 0.00207 | 258 | 0.002 | 1.7 | 426.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 19.97 | 300 | 0.00124 | 258 | 0.002 | 1.0 | 258.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 36.13 | 300 | 0.00227 | 258 | 0.002 | 1.8 | 466.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4-4 6th floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 21.19 | 300 | 0.00132 | 258 | 0.002 | 1.1 | 273.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 19.18 | 300 | 0.00119 | 258 | 0.002 | 1.0 | 247.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 34.1 | 300 | 0.00214 | 258 | 0.002 | 1.7 | 440.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.13 | 300 | 0.00112 | 258 | 0.002 | 0.9 | 234.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 35.37 | 300 | 0.00222 | 258 | 0.002 | 1.8 | 457.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 20.41 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 263.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 38.24 | 300 | 0.00241 | 258 | 0.002 | 1.9 | 494.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4-4 for 5th floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | A | 21.17 | 300 | 0.00132 | 258 | 0.002 | 1.1 | 273.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 19.18 | 300 | 0.00119 | 258 | 0.002 | 1.0 | 247.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 33.15 | 300 | 0.00208 | 258 | 0.002 | 1.7 | 428.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | C | 15.75 | 300 | 0.00097 | 258 | 0.002 | 0.8 | 203.5 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Span | CD | 20.85 | 300 | 0.00130 | 258 | 0.002 | 1.0 | 269.4 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | D | 36.71 | 300 | 0.00231 | 258 | 0.002 | 1.8 | 474.3 | 274.20 | 560.90 | 1.78 | 2Ø20 |

| Axes 4-4 4th floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 22.56 | 300 | 0.00140 | 258 | 0.002 | 1.1 | 291.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.39 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 263.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 38.04 | 300 | 0.00239 | 258 | 0.002 | 1.9 | 491.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.01 | 300 | 0.00118 | 258 | 0.002 | 1.0 | 245.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.08 | 300 | 0.00240 | 258 | 0.002 | 1.9 | 492.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.25 | 300 | 0.00132 | 258 | 0.002 | 1.1 | 274.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 41.88 | 300 | 0.00264 | 258 | 0.002 | 2.1 | 541.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4-4 3rd floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | A_s | S | N | REMARK |
| Support | A | 22.76 | 300 | 0.00142 | 258 | 0.002 | 1.1 | 294.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.53 | 300 | 0.00128 | 258 | 0.002 | 1.0 | 265.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 38.87 | 300 | 0.00245 | 258 | 0.002 | 1.9 | 502.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.26 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 248.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.56 | 300 | 0.00243 | 258 | 0.002 | 1.9 | 498.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.33 | 300 | 0.00133 | 258 | 0.002 | 1.1 | 275.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 42.24 | 300 | 0.00267 | 258 | 0.002 | 2.1 | 545.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4-4 2nd floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | A_s | S | N | REMARK |
| Support | A | 23.02 | 300 | 0.00143 | 258 | 0.002 | 1.2 | 297.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.7 | 300 | 0.00129 | 258 | 0.002 | 1.0 | 267.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 39.2 | 300 | 0.00247 | 258 | 0.002 | 2.0 | 506.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.27 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 249.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.74 | 300 | 0.00244 | 258 | 0.002 | 1.9 | 500.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.38 | 300 | 0.00133 | 258 | 0.002 | 1.1 | 276.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 42.24 | 300 | 0.00267 | 258 | 0.002 | 2.1 | 545.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4-4 1st floor | | | | | | | | | | | | |
|--------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | A_s | S | N | Remark |
| Support | A | 22.54 | 300 | 0.00140 | 258 | 0.002 | 1.1 | 291.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.03 | 300 | 0.00124 | 258 | 0.002 | 1.0 | 258.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 35.05 | 300 | 0.00220 | 258 | 0.002 | 1.8 | 452.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.62 | 300 | 0.00115 | 258 | 0.002 | 0.9 | 240.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 34.47 | 300 | 0.00216 | 258 | 0.002 | 1.7 | 445.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.04 | 300 | 0.00131 | 258 | 0.002 | 1.1 | 271.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 38.05 | 300 | 0.00239 | 258 | 0.002 | 1.9 | 491.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |

Table 8.1 reinforcement for moment

*****Refer detail of other floor in appendix G

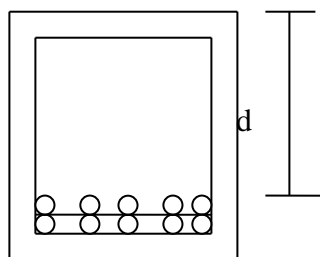
8.2 Shear Design for beam

Beams are designed for critical shear force at the left or right of the beam. critical sheer force of beam is shear at a distance “d” from the center of column.

$$d' = d + \text{column width} * 0.5$$

where d=effective depth of beam

and in our case we take minimum d from all beam.



using $\varnothing 24$, $d = 400\text{mm} - 25\text{mm} - 24\text{mm} = 343\text{mm}$ for grade - 8th floor beam

$d = 300\text{mm} - 25 - 24\text{mm} = 243\text{mm}$ for top tie beam

NB; All the beam shall be provided with at least the minimum web reinforcement

8.2.1 Determination of shear force to be resisted by shear reinforcement

$V_s = V_{sd} - v_c$ where v_s =shear force above concrete resistance capacity

v_{sd} = design shear force from sap out put

v_c =shear resistance of concrete

$$v_c = 0.25 f_{ctd} * k_1 * k_2 * b_w * d \dots \dots \dots \text{EBCS} - 2, 1995 \text{ arts } 4.5.3$$

where $f_{ctd} = 0.21 (f_{cd})^{2/3} = 0.21(11.33)^{2/3} = 1.06$

$$k_1 = 1 + 50 * r_{min},$$

$$r_{min} = 0.4 / f_{yk} \dots \dots \dots \text{EBCS} - \text{art } 7.2.12$$

$$= 0.4 / 300 = 0.00133$$

$$K_1=1+50*0.00133=1.067$$

$$K_2=1.6-d=1.6-0.343=1.26$$

8.2.2 Determination of stirrup spacing

$$\text{Spacing} = A_v * f_{yd} / v_s$$

Where, A_v = area of shear reinforcement for s distance

NB; spacing must be less than maximum spacing

Maximum spacing

Case 1; for shear less than v_c we provide maximum spacing

$$S_{\max} = A_v * f_{yk} / 0.4b_w \quad b_w = \text{width of beam}$$

Case 2 when $v_{sd} < 2/3 * v_{rd}$ then

$$S_{\max} = \min (0.5d \text{ and } 300\text{mm})$$

For top tie beam, $S_{\max} = \min (0.5*243 \text{ and } 300)$

For other beams, $S_{\max} = \min (0.5*343 \text{ and } 200)$

$$=170.5\text{mm}$$

Case 3; when $v_{sd} > 2/3 * v_{rd}$

$$S_{\max} = \min (0.3d \text{ and } 200\text{mm})$$

For top tie beam, $S_{\max} = \min (0.3*243 \text{ and } 200)$

$$=70.1\text{mm}$$

For other beams, $S_{\max} = \min (0.3*340 \text{ and } 200)$

$$=100$$

Effective width of flanges (all limit states)

- (1) P in T beams the effective flange width, over which uniform conditions be assumed, depends on the web and flange dimensions, the type of loading the support conditions and the transverse reinforcement.
- (2) The effective width of flange should be based on the distance l_0 between points of zero moment, which may be obtained from.

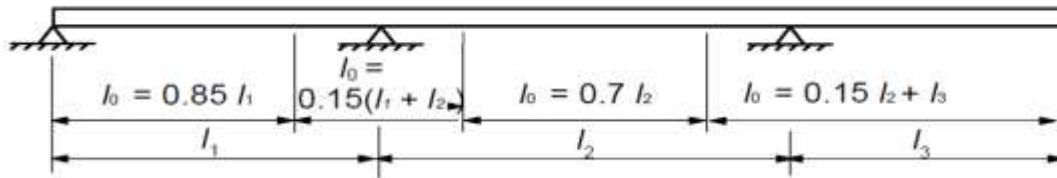


Figure 8 Definition of l_0 , for calculation of effective flange width

Note: The length of the cantilever, l_3 , should be less than half the adjacent span and the ratio of adjacent spans should lie between 2/3 and 1.5.

- (3) The effective flange width b_{eff} for a T beam of L beam maybe derived as:

$$b_{\text{eff}} = \sum b_{\text{eff},i} + b_w \leq b \dots \dots \dots (5.7)$$

where

$$b_{\text{eff},i} = 0.2b_i + 0.1l_0 \leq 0.2l_0 \dots \dots \dots (5.7a) \quad \text{and}$$

$$b_{\text{eff},i} \leq b_i$$

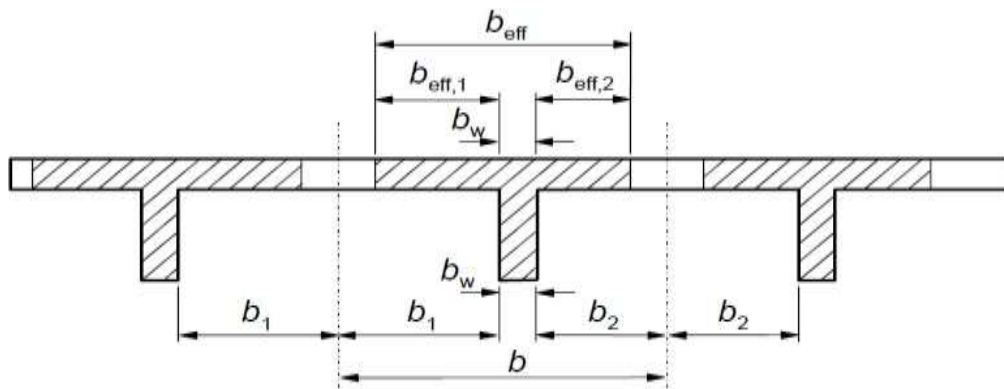
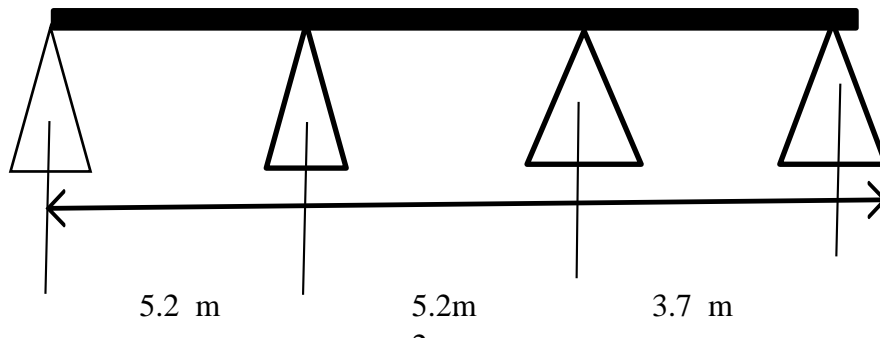


Figure 8.2: Effective flange width parameters



Effective span of beams and slabs in buildings

Note: The following provisions are provided mainly for member analysis. For frame analysis some of these simplifications may be used where appropriate.

The effective span, l_{eff} of a member should be calculated as follows

$$l_{\text{eff}} = l_n + a_1 + a_2$$

where:

l_n is the clear distance between the faces of the supports;

values for a_1 and a_2 , at each end of the span, may be determined from the appropriate a_i values in Figure 5.4 [3]

Using ETABS output for moments and shear, we can analyse.

$$\mu_s d_s = M_{sd} / f_{cd} * b * d^2$$

$$Z = k_z * d$$

$$\text{Thus } A_{st, \text{calculated}} = M_{ED} / f_{yd} * z$$

Minimum and maximum reinforcement areas

A. The area of longitudinal tension reinforcement should not be taken as less than $A_{s, \text{min}}$

Note 1: See also 7.3 for area of longitudinal tension reinforcement to control cracking.

Note 2: For the value of A_s , min for beams, refer to the National Annex. The recommended value is given in the following:

$$A_{s,min} = 0.26 \frac{f_{ctm}}{f_{yk}} b_t d \quad \text{but not less than } 0.0013b_t d \dots (9.1N)$$

where:

b_t = denotes the mean width of the tension zone; for a T-beam with the flange in, only the width of the web is taken into account in calculating the value of b_t .

f_{ctm} = should be determined with respect to the relevant strength class according to Table 3.1.

Alternatively, for secondary elements, where some risk of brittle failure may be accepted, $A_{s, min}$ may be taken as 1.2 times the area required in ULS verification.

8.2.3 Check failure type

$$\rho_{pro} = \frac{A_{stprovided}}{bd}$$

$$\epsilon_{yd} = f_{yd}/E_s$$

$$\rho_b = 0.8 \left(E \frac{\rho_{cu}}{E_{cu} + E_{yd}} \right) \frac{f_{cd}}{f_{yd}}$$

Reinforcement calculation

For member with vertical shear reinforcement the shear resistance, V_{RD} is the smaller value of]

$$V_{rd} = \text{Max} \left\{ \begin{array}{l} V_{rds} = \frac{A_{sw}}{s} * z f_{yd} \cot \theta \\ V_{rds} = \alpha_c * b_w * z * v * \frac{f_{cd}}{\cot \theta + \tan \theta} \end{array} \right.$$

Where,

α = is the angle between shear reinforcement and the main tension chord (Recommended value of 1 for non pre stressed structures) θ = is the angle between concrete compression struts and the main tension chord

F_{td} = is the design value of the tensile force in the longitudinal reinforcement

F_{cd} = is the design value of the concrete compression force in the direction of the longitudinal member axis. b_w = is the minimum width between tension and compression chords z = is the inner lever arm, for a member with constant depth, corresponding to the maximum bending moment in the element under consideration. In the shear analysis, the approximate value $z = 0.9d$ may normally be used. A_{sw} = is the cross-sectional area of the shear reinforcement s = is the spacing of the stirrups

f_{ywd} = is the design yield strength of the shear reinforcement

$V = 0.6$ for $f_{ck} \leq 60$ MPa

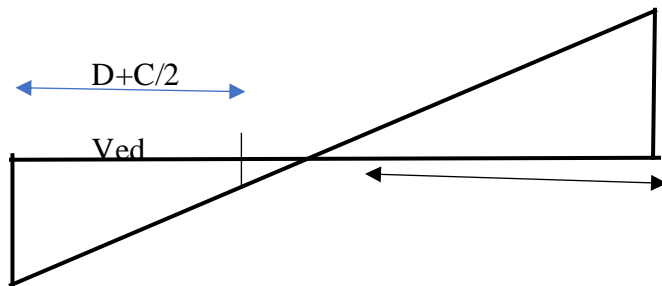
Now let's determine the angle θ between the concrete compression strut and the main tension chord by considering V_{rd} , $s = V_{Ed}$

$$V_{Ed} = \alpha c * b_w * z * v * \frac{f_{cd}}{\cot\theta + \tan\theta} = \alpha c * b_w * z * v * \frac{f_{cd}}{\left(\frac{\sin 2\theta}{2}\right)}$$

$$\theta = 0.5 * \text{SIN}^{-1}(2 * V_{ED} / (\alpha * b_w * z * v * f_{cd}))$$

8.2.4. Check the section for shear resistance

The design shear is located d distance from the face of the column. By similarity of triangle, V_{ed} can obtain from shear force diagram from etabs output:



$$V_c = 0.25 f_{ctd} k_1 k_2 b w d \dots \text{EBCS - 2, 1995 arts 4.5.3}$$

Where $f_{ctd} = 0.21 (f_{cd})^{2/3} = 0.21 (11.33)^{2/3} = 1.06$

$$k_1 = 1 + 50 r_{min} = 0.4 / f_{yk} \dots \text{EBCS - art 7.2.12}$$

(1) In monolithic construction, even when simple supports have been assumed in design, the section at supports should be designed for a bending moment arising from partial fixity of at least β_1 of the maximum bending moment in the span.

Note 1: For the value of β_1 for beams, refer to the National Annex. The recommended value is 0.15.

Note 2: The minimum area of longitudinal reinforcement section defined in 9.2.1.1 (1) applies.

(2) At intermediate supports of continuous beams, the total area of tension reinforcement A_s of a flanged cross-section should be spread over the effective width of flange (see 5.3.2). Part of it may be concentrated over the web width

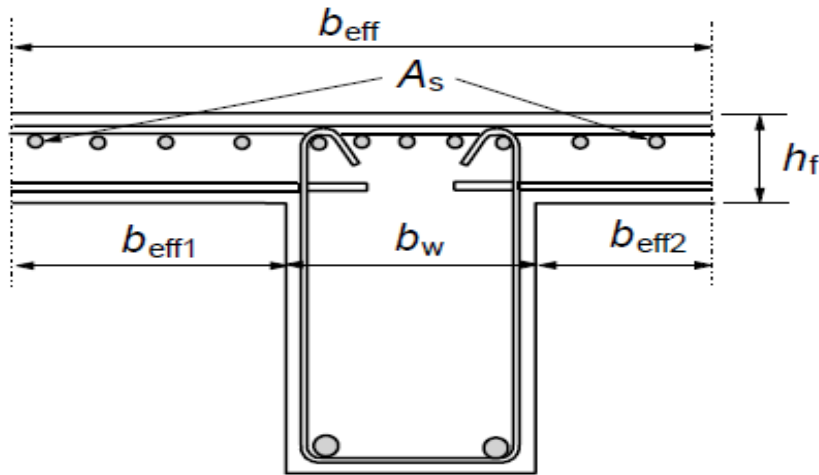


Figure 8.1 Placing of tension reinforcement in flanged cross-section

Determination of stirrup spacing

$$\text{Spacing} = A_v * f_{yd} / v_s$$

Where, A_v = area of shear reinforcement for s distance

NB; spacing must be less than maximum spacing

Maximum spacing

The ratio of shear reinforcement is given by the expression

$\rho_w =$: Where, ρ_w = is the shear reinforcement ratio

b_w = is the breadth of the web of the member

take $\rho_w = 0.000894$

A_{sw} = is area of shear reinforcement with length s

α = is the angle between shear reinforcement and the longitudinal axis

s = is the spacing of the shear reinforcement measured along the longitudinal axis of the member

$$S_{1, \max} = 0.75d(1 + \cot \alpha), \text{ considering } \alpha = 90^\circ \quad S_{1, \max} = 0.75d = 0.75 * 400 = 300 \text{ mm}$$

$$S_{max}=562.25\text{mm}$$

Case 1; for shear less than v_c we provide maximum spacing

$$S_{max} = A_v * f_{yk} / 0.4b_w \quad b_w = \text{width of beam}$$

Case 2 when $v_s < 2/3 * V_{rd}$ then

$$S_{max} = \min(0.5d \text{ and } 300\text{mm})$$

For top tie beam, $S_{max} = \min(0.5 * 247 \text{ and } 300)$

For other beams, $S_{max} = \min(0.5 * 347 \text{ and } 200)$

$$= 173.5\text{mm}$$

Case 3; when $v_s > 2/3 * V_{rd}$

$$S_{max} = \min(0.3d \text{ and } 200\text{mm})$$

For top tie beam, $S_{max} = \min(0.3 * 247 \text{ and } 200)$

$$= 74.1\text{mm}$$

For other beams, $S_{max} = \min(0.3 * 347 \text{ and } 200) = 104.1\text{mm}$

8.2.5 Check depth for flexure

$$M_{rd} = 0.8kx(1-0.4kx) f_{cd} b d^2$$

$$M_{rd} = 0.8 * 0.448(10.4 * 0.448) * 11.33 * 300 * 350 = 1$$

$$22.48\text{knm}$$

$$M_{rd} = 122.48\text{KNm} > M_{ED} = 49.9\text{KNm} \dots \text{ok!}$$

$$\rho_o = \frac{\overline{f_{ck}}}{f_{ck}} * 10^{-3} = \sqrt{20} * 10^{-3} = 0.447\% \checkmark$$

8.2.6 Check depth for Deflection/Serviceability requirement

$$\rho = \left(\frac{A_{st\text{provided}}}{bd} \right) - \frac{628}{300 \times 350} = 0.00598 = 0.598\%$$

Since $\rho = 0.598\% > \rho_o = 0.447\%$ using ES-EN 1992 Art.7.4.2 (7.16b)

$$\frac{l}{d} = K * N * F1 * F2 * F3 \quad \text{Where } N = \left(11 + 1.5 \sqrt{f_{ck}} * \frac{\rho}{\rho - \rho_o} + \left(\frac{1}{12} \right) * \sqrt{f_{ck}} * \sqrt{\frac{\rho'}{\rho_o}} \right)$$

$$\rho' = 0$$

$$N = \frac{11 + 1.5 * \sqrt{20} * \frac{0.447}{0.598}}{1} = 16$$

$$K = 1$$

$$F1 = 0.87$$

$$F2 = 1 \text{ since } b_{eff}/b_w \text{ is } < 3$$

$$F3 = 1 \text{ Since the span is less than } 7$$

$$\frac{l}{d} = 1 * 16 * 0.87 * 1 * 1 = 13.92$$

$$d = 4720 / 13.92 = 339.08 \text{ mm} < 350 \text{ mm} \dots\dots\dots \text{ok}$$

Similarly worked by Excel

Flat roof beam shear design

For Roof shear design

| Axes 4 for roof slab | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 18.42 | 250 | 0.00137 | 350 | 0.002 | 0.6 | 210.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 15.05 | 250 | 0.00112 | 350 | 0.002 | 0.5 | 172.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 24.05 | 250 | 0.00180 | 350 | 0.002 | 0.8 | 274.9 | 274.20 | 560.90 | 1.78 | 2Ø18 |
| Span | BC | 13.44 | 250 | 0.00100 | 350 | 0.002 | 0.4 | 153.6 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | C | 24.21 | 250 | 0.00182 | 350 | 0.002 | 0.8 | 276.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 16.89 | 250 | 0.00126 | 350 | 0.002 | 0.6 | 193.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 30.89 | 250 | 0.00233 | 350 | 0.002 | 1.0 | 353.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for 8th | | | | | | | | | | | | |
|----------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | A | 20.37 | 300 | 0.00126 | 258 | 0.002 | 1.0 | 263.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 17.55 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 29.06 | 300 | 0.00182 | 258 | 0.002 | 1.5 | 375.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 16.23 | 300 | 0.00100 | 258 | 0.002 | 0.8 | 209.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 29.67 | 300 | 0.00185 | 258 | 0.002 | 1.5 | 383.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 20.43 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 264.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 35.29 | 300 | 0.00222 | 258 | 0.002 | 1.8 | 455.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for 7th floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 20.95 | 300 | 0.00130 | 258 | 0.002 | 1.0 | 270.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 18.35 | 300 | 0.00114 | 258 | 0.002 | 0.9 | 237.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 17.47 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 225.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 17.74 | 300 | 0.00110 | 258 | 0.002 | 0.9 | 229.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 32.97 | 300 | 0.00207 | 258 | 0.002 | 1.7 | 426.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 19.97 | 300 | 0.00124 | 258 | 0.002 | 1.0 | 258.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 36.13 | 300 | 0.00227 | 258 | 0.002 | 1.8 | 466.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for 6th | | | | | | | | | | | | |
|----------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 21.19 | 300 | 0.00132 | 258 | 0.002 | 1.1 | 273.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 19.18 | 300 | 0.00119 | 258 | 0.002 | 1.0 | 247.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 34.1 | 300 | 0.00214 | 258 | 0.002 | 1.7 | 440.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.13 | 300 | 0.00112 | 258 | 0.002 | 0.9 | 234.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 35.37 | 300 | 0.00222 | 258 | 0.002 | 1.8 | 457.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 20.41 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 263.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 38.24 | 300 | 0.00241 | 258 | 0.002 | 1.9 | 494.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for 5th | | | | | | | | | | | | |
|----------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 22.13 | 300 | 0.00138 | 258 | 0.002 | 1.1 | 285.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 19.94 | 300 | 0.00124 | 258 | 0.002 | 1.0 | 257.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 36.41 | 300 | 0.00229 | 258 | 0.002 | 1.8 | 470.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.71 | 300 | 0.00116 | 258 | 0.002 | 0.9 | 241.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.89 | 300 | 0.00245 | 258 | 0.002 | 1.9 | 502.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 20.98 | 300 | 0.00130 | 258 | 0.002 | 1.1 | 271.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 40.22 | 300 | 0.00253 | 258 | 0.002 | 2.0 | 519.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for 4th floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 22.56 | 300 | 0.00140 | 258 | 0.002 | 1.1 | 291.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.39 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 263.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 38.04 | 300 | 0.00239 | 258 | 0.002 | 1.9 | 491.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.01 | 300 | 0.00118 | 258 | 0.002 | 1.0 | 245.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.08 | 300 | 0.00240 | 258 | 0.002 | 1.9 | 492.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.25 | 300 | 0.00132 | 258 | 0.002 | 1.1 | 274.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 41.88 | 300 | 0.00264 | 258 | 0.002 | 2.1 | 541.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for 3rd floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 22.76 | 300 | 0.00142 | 258 | 0.002 | 1.1 | 294.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.53 | 300 | 0.00128 | 258 | 0.002 | 1.0 | 265.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 38.87 | 300 | 0.00245 | 258 | 0.002 | 1.9 | 502.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.26 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 248.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.56 | 300 | 0.00243 | 258 | 0.002 | 1.9 | 498.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.33 | 300 | 0.00133 | 258 | 0.002 | 1.1 | 275.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 42.24 | 300 | 0.00267 | 258 | 0.002 | 2.1 | 545.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for 2nd floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 23.02 | 300 | 0.00143 | 258 | 0.002 | 1.2 | 297.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.7 | 300 | 0.00129 | 258 | 0.002 | 1.0 | 267.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 39.2 | 300 | 0.00247 | 258 | 0.002 | 2.0 | 506.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.27 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 249.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.74 | 300 | 0.00244 | 258 | 0.002 | 1.9 | 500.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.38 | 300 | 0.00133 | 258 | 0.002 | 1.1 | 276.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 42.24 | 300 | 0.00267 | 258 | 0.002 | 2.1 | 545.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for 1st floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 22.54 | 300 | 0.00140 | 258 | 0.002 | 1.1 | 291.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.03 | 300 | 0.00124 | 258 | 0.002 | 1.0 | 258.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 35.05 | 300 | 0.00220 | 258 | 0.002 | 1.8 | 452.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.62 | 300 | 0.00115 | 258 | 0.002 | 0.9 | 240.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 34.47 | 300 | 0.00216 | 258 | 0.002 | 1.7 | 445.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.04 | 300 | 0.00131 | 258 | 0.002 | 1.1 | 271.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 38.05 | 300 | 0.00239 | 258 | 0.002 | 1.9 | 491.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 4 for on ground floor | | | | | | | | | | | | |
|----------------------------|----------|--------|----------------|------------------|-------|------------------|-----|-------|----------------|--------|------|--------|
| Type | Location | Moment | b _e | ρ _{cal} | d(mm) | ρ _{min} | K | Z(mm) | A _s | S | N | REMARK |
| Support | A | 21.03 | 400 | 0.00098 | 258 | 0.002 | 0.8 | 203.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 17.84 | 400 | 0.00083 | 258 | 0.002 | 0.7 | 172.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 26.67 | 400 | 0.00124 | 258 | 0.002 | 1.0 | 258.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.84 | 400 | 0.00087 | 258 | 0.002 | 0.7 | 182.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 30.03 | 400 | 0.00140 | 258 | 0.002 | 1.1 | 291.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 19.61 | 400 | 0.00091 | 258 | 0.002 | 0.7 | 190.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 32.49 | 400 | 0.00152 | 258 | 0.002 | 1.2 | 314.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |

Table 8.3 re enforcement for shear

***** For other all floor worked in appendix H

9 ANALYSES AND DESIGN OF COLUMN

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.

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

Three types of Frame Section in our building, those are:

- ✓ Rectangular column (30x25 cm),
- ✓ Square column(25x25cm)

Columns are designed so as to transfer the load from beams and slabs (in flat slab) down to the foundation without buckling or crashing.

Before designing an isolated column, the column should be checked whether it is

- ❖ Sway or non-Sway
- ❖ Short or long (slenderness)

Because the column should resist the moment due to its slenderness and its sway mode, in addition to its 1st order moments.

To determine the nature of the frame we substitute the beams and columns by one substitute frames.

Substitute column

The value of the axial force on each substitute frame column is obtained by adding the axial load of each column for the story including self-weight.

The value of the stiffness coefficients of the substitute frame is given by

- ❖ For beams= $2\sum K_{bi}$

❖ For Column= $\sum K_{ci}$

The effective length of substitute frame is computed for each story assuming as sway frame and given as follows

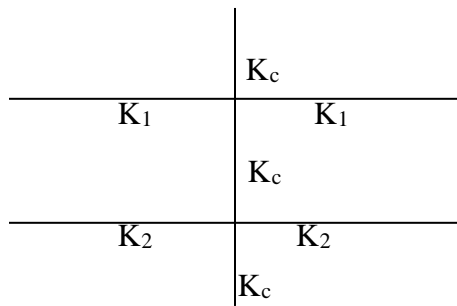
✓ For Non Sway

$$L_e/L = \alpha_n + 0.4 / (\alpha_m + 0.8) \geq 0.7L$$

✓ For Sway mode

$$L_e/L = \sqrt{\frac{7.5 + 4(\alpha_1 + \alpha_2) + 1.6\alpha_1 \alpha_2}{7.4 + \alpha_1 + \alpha_2}} \geq 1.15$$

For the theoretical model shown in fig. below, the stiffness coefficient α_1 , α_2 and α_m are obtained as follows.



$$\alpha_1 = K_{c1} + K_c / (\alpha_f K_{11} + K_{12} \alpha_f)$$

$$\alpha_2 = K_{c2} + K_c / (\alpha_f K_{21} + K_{c22} \alpha_f)$$

$$\alpha_m = (\alpha_1 + \alpha_2) / 2$$

where

K_{c1} and K_{c2} are the column stiffness coefficients (EI/L)

K_c is the stiffness coefficients of the column being designed.

α_f is the effective beam stiffness coefficients (EI/L)

=1.0 for opposite end elastically or rigidly restrained.

=0.5 for opposite end free to rotate.

=0 for a cantilever beam.

The above approximate equation for effective length calculation is applicable for values of α_1 and α_2 not exceeding 10.

1. If a base is designed to resist the column moment, may be taken as 1.0.

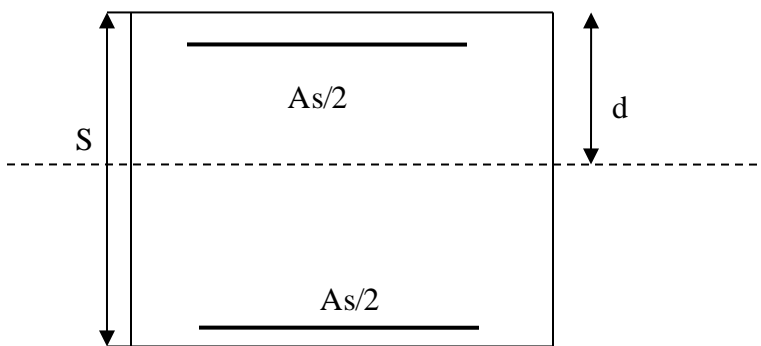
2. The dimension of the substitute column is computed to find the moment of inertia of the section (I_c).
3. The amount of reinforcement required by the substitute column is computed and the moment of inertia of the reinforcements with respect to centroid of concrete section is determined, in lieu of more accurate determination the 1st order moment M_{d1} , at critical section of the substitute may be determined

Using $M_{d1} = (\alpha_2 + 3) * HL / (\alpha_1 + \alpha_2 + 6)$

Where; H=the total horizontal reaction at the bottom of the story

L=the length of the column.

- M_o Moment of inertial of the cross section is determined as follows.



$$I_s = [n(\pi r^4 / 4) + \pi r^2 d^2]$$

Where, n= number of bars

Reinforcing the substitute column using the biaxial chart using the following formulas

- $V = N_{sd} * 10^3 / (A_c * f_{cd})$
- $N = M_{d1} * 10^6 / (A_c * f_{cd} * S)$
- $W = A_{Stot} * f_{yd} / (A_c * f_{cd})$
- $A_{Stot} = W * A_c * f_{cd} / f_{yd}$

Determination of whether the frame is sway or non-sway

A frame (equivalent column) may be classified as non-sway for a given load

If $N_{sd} / N_{cr} \leq 0.1$ **EBCS-2,1995 Page 40**

Where N_{sd} =Pd total design axial load.

N_{cr} is critical load for buckling.

Determination of N_{cr}

The buckling load of a story may be assumed to be equal to that of the substitute beam-column.

$$N_{cr} = \pi^2 E I_e / L_e^2.$$

Where,

$E I_e$ is effective stiffness of the substitute column design using the equivalent reinforcement area.

- L_e effective length.

$$E I_e = 0.2 E_c I_c + E_s I_s \geq 0.4 E_c I_c$$

For this purpose, $E_c = 1100 f_{cd}$

I_c, I_s moment of inertia of concrete and steel sections respectively of substitute column, with respect to centroid of concrete section.

- As calculation

Square column of the same x-sectional area concrete cover and bar arrangement shall be taken to be the same as those of actual columns, in case of rectangular column.

The equivalent column dimension calculated by summing all column area of story. And $A_{S_{tot}}$ in the substitute column to be used for calculating I_s and M_{bd} in above may be obtained by designing the substitute column at each floor level to carry the story design axial load and amplified sway mode.

Methods to analyses column

9.1 determination of Effective length

Concert cover

In order to transmit bond forces safely and to ensure adequate compaction of the concrete, the minimum cover should not be less than C_{min} , b given in Table 4.2.

Assume $\Phi 24$ longitudinal bar and $\Phi 20$ nominal maximum aggregate size;

Therefore; C_{min} ,

The nominal concrete cover is the distance b/n the surface of reinforcement closest to the nearest concrete surface (including g links and stirrups). *from* (Betelhem, 2020) *ESEN 1992:2015 ART 4.4.12(1)*

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

Note;-The value of ΔC_{dev} for use in a country may be found in its national annex. The recommended value is 10mm.

$$C_{min} = \text{Max} = \begin{cases} C_{min,B} \\ C_{min,Dur} \\ 10\text{mm} \end{cases}$$

| Bond Requirement | |
|----------------------------------------------------------------------------------------------------------|----------------------------------------------|
| Arrangement of bars | Minimum cover $C_{min,b}^*$ |
| Separated | Diameter of bar |
| Bundled | Equivalent diameter (ϕ_n) (see 8.9.1) |
| *: If the nominal maximum aggregate size is greater than 32 mm, $C_{min,b}$ should be increased by 5 mm. | |

- Arrangement of Bars we selected separated

Assume $\Phi 24$ longitudinal bar and $\Phi 20$ nominal maximum aggregate size; Therefore; $C_{min,b} = 24\text{mm}$.

Cover Design for Corrosion/Durability

- The condition of exposure is given to be XC2

| Class Designation | Description of the Environment | Informative examples where exposure classes may occur |
|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| 1. No risk of corrosion or attack | | |
| X0 | For concrete without reinforcement or embedded metal: all exposures except where there is freeze/thaw, abrasion or chemical attack For concrete with reinforcement or embedded metal: very dry | Concrete inside buildings with very low air humidity |
| 2. Corrosion induced by carbonation | | |
| XC1 | Dry or permanently wet | Concrete inside buildings with low air humidity Concrete permanently submerged in water |
| XC2 | Wet, rarely dry | Concrete surfaces subject to long-term water contact Many foundations |
| XC3 | Moderate humidity | Concrete inside buildings with moderate or high air humidity External concrete sheltered from rain |
| XC4 | Cyclic wet and dry | Concrete surfaces subject to water contact, not within exposure class XC2 |

- Exposure Class to determine C_{min} , d_{ur}

| Structural Class | | | | | | | |
|--------------------------------------------------------------------------------------------|---------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| Criterion | Exposure Class according to Table 4.1 | | | | | | |
| | X0 | XC1 | XC2 / XC3 | XC4 | XD1 | XD2/ XS1 | XD3/ XS2/ XS3 |
| Design working life of 100 years | Increase class by 2 | Increase class by 2 | Increase class by 2 | Increase class by 2 | Increase class by 2 | Increase class by 2 | Increase class by 2 |
| Strength Class ⁽¹⁾⁽²⁾ | $\geq C30/37$ reduce class by 1 | $\geq C30/37$ reduce class by 1 | $\geq C35/45$ reduce class by 1 | $\geq C40/50$ reduce class by 1 | $\geq C40/50$ reduce class by 1 | $\geq C40/50$ reduce class by 1 | $\geq C45/55$ reduce class by 1 |
| Member with slab geometry (Position of reinforcement not affected by construction process) | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 |
| Special Quality Control of the concrete production ensured | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 |

Note: For use of strength classes, refer to National Annex. The recommended values are given in Table E.1N.

Table E.1N: Indicative minimum strength class

| Exposure Classes according to Table 4.1 | | | | | | | | | | |
|-----------------------------------------|-------------------------------|--------------------|--------|--------|----------------------------|-----------------|--------|-------------------------------------------|--------|-----|
| Corrosion | | | | | | | | | | |
| | Carbonation-induced corrosion | | | | Chloride-induced corrosion | | | Chloride-induced corrosion from sea-water | | |
| | XC1 | XC2 | XC3 | XC4 | XD1 | XD2 | XD3 | XS1 | XS2 | XS3 |
| Indicative Strength Class | C20/25 | C25/30 | C30/37 | | C30/37 | | C35/45 | C30/37 | C35/45 | |
| Damage to Concrete | | | | | | | | | | |
| | No risk | Freeze/Thaw Attack | | | | Chemical Attack | | | | |
| | X0 | XF1 | XF2 | XF3 | XA1 | XA2 | XA3 | | | |
| Indicative Strength Class | C12/15 | C30/37 | C25/30 | C30/37 | C30/37 | | C35/45 | | | |

Table 9.1 Indicative minimum strength class

Note: The recommended Structural Class (design working life of 50 years) is S4 for the indicative concrete strengths given in Annex E and the recommended modifications to the structural class is given in Table 4.3N. But based on the above table the exposure class is reducing by 1 and the structural class would be S3.

Therefore, the value of minimum cover required for durability of reinforcement steel is determined using ES EN 1992:2015 table 4.4N.

| Environmental Requirement for $c_{min,dur}$ (mm) | | | | | | | |
|--------------------------------------------------|---------------------------------------|-----|-----------|-----|-----------|-----------|-----------|
| Structural Class | Exposure Class according to Table 4.1 | | | | | | |
| | X0 | XC1 | XC2 / XC3 | XC4 | XD1 / XS1 | XD2 / XS2 | XD3 / XS3 |
| S1 | 10 | 10 | 10 | 15 | 20 | 25 | 30 |
| S2 | 10 | 10 | 15 | 20 | 25 | 30 | 35 |
| S3 | 10 | 10 | 20 | 25 | 30 | 35 | 40 |
| S4 | 10 | 15 | 25 | 30 | 35 | 40 | 45 |
| S5 | 15 | 20 | 30 | 35 | 40 | 45 | 50 |
| S6 | 20 | 25 | 35 | 40 | 45 | 50 | 55 |

Table 9.2 Values of minimum cover $C_{min, dur}$ requirement with regard to durability of reinforcement

Step 1 Determination of effective length of the column

Rectangular column sample calculation for C15 story 8th floor column

Given data

$$C_{min, dur}=10mm.$$

$$\text{Then; } C_{min} = \{ C_{min, b}=24mm$$

$$C_{min, } =10mm$$

$$\text{Therefore; } C_{min}=10mm$$

Δc_{dev} (allowance in Design for Variation)

Note: The value of Δc_{dev} for use in a Country may be found in its National Annex. The recommended value is 10 mm. *Then;*

$$C_{nom}=C_{min,b}+\Delta C_{dev}=24mm+10mm=34mm$$

- Cover Design for Fire

For the slab to sustain fire incident for 60 minutes the required cover and minimum height of the section can be determined form Table 5.8 Of EN 1992-1-2.

$$C_{fire} = 10mm, h_s = 80mm$$

| Bottom beam | depth(m) | width(m) | length(m) | Bottom beam | depth(m) | width(m) | length(m) |
|-------------|----------|----------|-----------|-------------|----------|----------|-----------|
| b3(x,x) | 0.4 | 0.3 | 5.2 | b3(x,x) | 0.4 | 0.3 | 5.2 |
| b4(x,x) | 0.4 | 0.3 | 5.2 | b4(x,x) | 0.4 | 0.3 | 5.2 |
| b3(y,y) | 0.4 | 0.3 | 5.2 | b3(y,y) | 0.4 | 0.3 | 5.2 |
| b4(y,y) | 0.4 | 0.3 | 5.2 | b4(y,y) | 0.4 | 0.3 | 5.2 |

Table 9.3 Dimensions of top and bottom beams for foundation

$$M_{top-x}=44.31KNm \quad M_{top-y}=3.63 KNm$$

$$M_{botx-x}=82.74KNm \quad M_{boty-y}=15.96KNm$$

$$NED=2633KN$$

9.2 Governing Cover for Design

Governing cover accounting for

- Corrosion

- Bond/Durability
- Fire

Cover=34mmfcd

$$\alpha_{cc} * \frac{f_{ck}}{\gamma_{mc} f_{cd}} = 0.85 * \frac{20}{1.5} = 11.33 \text{ Mpa}$$

$$f_{yd} = \frac{f_{yk}}{\gamma_{ms}}$$

$$f_{yd} = \frac{400}{1.15} = 347.8 \text{ Mpa}$$

9.3 Check slenderness limit and effective length column

Effective length (l_0) for load braced member

From EBCSEN1992-1-1:2014(5:15)

$$l_0 = 0.5 * \sqrt{\left(1 + \frac{k_1}{0.45 + k_1}\right) \left(1 + \frac{k_2}{0.45 + k_2}\right)}$$

Where k_1 and k_2 - relative flexibilities of rotational restraint at both ends 1.2

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.

$$l_0 = 0.5 * \sqrt{\left(1 + \frac{K_1}{0.45 + k_1}\right) \left(1 + \frac{K_2}{0.45 + k_2}\right)}$$

Where

K_1 - stiffness at end 1

K_2 - stiffness at end 2

Stiffness at each end (K) = column stiffness / Σ beam stiffness

$$K_{1x} = \frac{\left(\frac{EI}{l}\right)_C}{\left(\frac{2 \cdot EI}{l}\right)_B} \geq 0.1$$

Axis X-X

$$K1_{\text{topX-X}} = \frac{666666.67}{533333.33} = 1.25$$

$$K2_{\text{botX-X}} = \frac{666666.67}{640000.00} = 1.04$$

$$K1_{\text{topY-Y}} = \frac{666666.67}{533333.33} = 1.25$$

$$K2_{\text{botY-Y}} = \frac{666666.67}{640000.00} = 1.04$$

$$L_{\text{ox-x}} = 0.5 * \sqrt{\left(1 + \frac{K1_{\text{x-x}}}{0.45 + k1_{\text{x-x}}}\right) \left(1 + \frac{K2_{\text{x-x}}}{0.45 + k2_{\text{x-x}}}\right)}$$

$$L_{\text{ox-x}} = 0.5 * 3.2 \sqrt{\left(1 + \frac{1.25}{0.45 + 1.25}\right) \left(1 + \frac{1.04}{0.45 + 1.04}\right)}$$

$$L_{\text{ox-x}} = 2.75\text{m}$$

$$L_{\text{oy-y}} = 0.5 * \sqrt{\left(1 + \frac{K1_{\text{y-y}}}{0.45 + k1_{\text{y-y}}}\right) \left(1 + \frac{K2_{\text{y-y}}}{0.45 + k2_{\text{y-y}}}\right)}$$

$$L_{\text{oy-y}} = 0.5 * 3.2 \sqrt{\left(1 + \frac{1.25}{0.45 + 1.25}\right) \left(1 + \frac{1.04}{0.45 + 1.04}\right)}$$

$$L_{\text{oy-y}} = 2.75\text{m}$$

9.4 Maximum and minimum moment calculation

$$A_s, \text{ min} = \max \begin{cases} 0.1 * \frac{NED}{f_{yd}} = 0.1 * \frac{2633}{347.8} = 1604.25\text{mm}^2 \\ 0.002 * A_c = 0.002 * 600 * 600 = 720\text{mm}^2 \end{cases}$$

$$A_s, \text{ min} = 1604.25\text{mm}^2$$

$$A_s, \text{ max} = 0.04 * A_c = 0.04 * 400 * 400 = 6400\text{mm}^2$$

9.5 Design action

The effect of imperfection taken from ES1992:Art5.2.7

$$e_{ix-x}=\max \left\{ \begin{array}{l} \frac{l_0}{400} \\ \frac{h}{30} = 20\text{mm} \end{array} \right. \dots\dots\dots(1995)(\text{EBCS 2, 1995})$$

$$e_{iy-y}=\max \left\{ \begin{array}{l} \frac{l_0}{400} \\ \frac{h}{30} = 20\text{m} \end{array} \right.$$

$$e_{ix-x}=\max \left\{ \begin{array}{l} \frac{2750}{400} = 6.8\text{mm} \\ \frac{h}{30} = \frac{306}{30} = 10.2\text{mm} \\ 20\text{mm} \end{array} \right.$$

$$e_{ix-x}=20\text{mm}$$

$$e_{iy-y}=\max \left\{ \begin{array}{l} \frac{2660}{400} = 6.8\text{mm} \\ \frac{h}{30} = \frac{306}{30} = 10.2\text{mm} \\ 20\text{mm} \end{array} \right.$$

$$e_{iy-y}=20\text{mm}$$

Note: The first order effect includes the geometric imperfection, but not consideration of slenderness.

The second order effect is considered the slenderness of structural members or deformation of the structure.

9.6 First order iteration

$$M_{ED}=\max \{ M_{O2}, M_{oe}+M_2, M_{o1}+0.5M_2 \}$$

$$M_{O1}=m \quad M_{O2}=\max \{ |M_{\text{top}}|, |M_{\text{bottom}}| + e_i * N_{ED} \}$$

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

For first order moment $M_2 = 0$

In the X-dirn

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

$$M_{01x-x} = \min \{ |20.76|, |3.06| + 0.02 * 2633 \}$$

$$M_{01x-x} = 44.31 \text{ KNm}$$

$$M_{02x-x} = \max \{ |M_{topx-x}|, |M_{bottomx-x}| + e_i * NED \}$$

$$M_{02x-x} = \max \{ |20.76|, |3.06| + 0.02 * 2633 \}$$

$$M_{02x-x} = 135.4 \text{ KNm}$$

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

$$M_{oex-x} = 0.4 * 44.3 + 0.6 * 135.4 \geq 0.4 * 135.4$$

$$M_{oex-x} = 96.96 \text{ KNm}$$

$$M_{EDx-x} = 135.4 \text{ KNm}$$

In the Y-dirn

$$M_{01y-y} = \min \{ |M_{topy-y}|, |M_{bottomy-y}| + e_i * NED \}$$

$$M_{01y-y} = \min \{ |3.63|, |15.96| + 0.02 * 2633 \}$$

$$M_{01y-y} = 3.63 \text{ KNm}$$

$$M_{02y-y} = \max \{ |M_{topy-y}|, |M_{bottomy-y}| + e_i * NED \}$$

$$M_{02y-y} = \max \{ |3.63|, |15.96| + 0.02 * 2633 \}$$

$$M_{02y-y} = 68.62 \text{ kNm}$$

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

$$M_{oe y-y} = 0.4 * 3.63 + 0.6 * 15.96 \geq 0.4 * 15.96$$

$$M_{oe y-y} = 42.624 \text{ kNm}$$

$$M_{EDy-y} = 68.62 \text{ kNm}$$

Check slenderness

Slenderness ratio $\lambda = \frac{l_0}{i}$ where l_0 -effective length of column i -is radius of gyration of the uncracked concrete

$$\lambda_{x-x} = \frac{l_{0x-x}}{i} = 21.98$$

$$\lambda_{y-y} = \frac{l_{0y-y}}{i} = 21.42$$

The minimum limiting value of slenderness is

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

Where, $A = 1 / (1 + 0.2\varphi ef)$, φef -effective creep ratio

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

$C = 1.7 - r_m$, $r_m = N_{Ed} / A_c f_{cd}$, relative normal force r_m ,

moment ratio = $M_{01_{x-x}} / M_{02_{x-x}}$

M_{01} , M_{02} are the first order end moments, $|M_{02}| \geq |M_{01}|$

If φef is not known, $A = 0.7$

$$B = 1.1$$

$$C = 1.7 - r_m = 2.3$$

$A_c = b * h = 400 * 400 = 160000 \text{ mm}^2$ for rectangular

$$\text{column} = n = NEd / A_c f_{cd} = (2253.26 * 1000) / (160000 * 11.3)$$

$$n = 1.2$$

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

$$= 13.93 \text{ mm}$$

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

$$C = 1.7 - r_m = 1.1$$

$$A_c = b * h = 400 * 400 = 160000 \text{ mm}^2 \text{ for rectangular column}$$

$$n = NEd / A_c f_{cd} = (5580 * 1000) / (160000 * 11.33) = 3.07$$

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

$$= 8.84 \text{ mm}$$

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

$$A = 0.7 \quad B = 1.1 \quad C = 1.7 - r_m = 0.32 \quad n = NEd / A_c f_{cd} = (5580 * 1000) / (160000 * 11.33) = 3.07$$

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

$$= 8.84 \text{ mm}$$

slenderness

$$\lambda_{x-x} > \lambda_{\text{lim}_{x-x}}, \text{ slender column otherwise short column}$$

$$\lambda_{y-y} > \lambda_{\text{lim}_{y-y}}, \text{ slender column otherwise short column } \lambda_{x-x} < \lambda_{\text{lim}_{x-x}} = 16.84 < 23.87, \text{ short column}$$

$$\lambda_{y-y} < \lambda_{\text{lim}_{y-y}} = 16.7 < 34.86, \text{ short column } \nu_{sd} = N_{sd} / (A_c * f_{cd}) = 5580 * 1000 / (400 * 400 * 11.33) = 1.35$$

$$\mu_{sd_{x-x}} = M_{ED_{x-x}} / (f_{cd} * A_c * h) = 135.4 * 1000000 / (11.33 * 160000 * 400) = 0.055$$

$$\mu_{sd_{y-y}} = M_{ED_{y-y}} / (f_{cd} * A_c * h) = 54.09 * 1000000 / (11.33 * 160000 * 400) = 0.081$$

rectangular chart number

$$\omega=0.08$$

9.6 reinforcement calculation

✓ Longitudinal reinforcement

$$A_s, \text{ tot} = \omega * A_c * f_{cd} / f_{yd}$$

$$A_s, \text{ tot} = 0.08 * 160000 * 11.33 / 347.8$$

$$A_s, \text{ tot} = 938.4 \text{ mm}^2$$

$$A_s \text{ min} = 720 \text{ mm}^2 \text{ and } A_s \text{ max} = 14400 \text{ mm}^2$$

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

$$\text{Take } \phi 24 \text{ mm, } a_s = 3.14 * (24)^2 / 4 = 452 \text{ mm}^2$$

$$\text{Number of bar} = A_s / a_s = 938.4 \text{ mm}^2 / 452 \text{ mm}^2 = 2.07 \approx 3 \text{ bars}$$

Provide 4 $\phi 24$ mm

9.7 For shear reinforcement

$$\text{Diameter of bar} = \max \left\{ \begin{array}{l} \frac{1}{4} * \text{longitudinal bar diameter} = \frac{24}{4} = 6 \\ 6 \text{ mm} \\ \text{Diameter of stirrup} = 8 \text{ mm} \end{array} \right.$$

From above take $\phi 8$ mm

$$\text{Spacing of shear reinforcement} = \min \left\{ \begin{array}{l} 20 * \phi_{\text{long}}, = 20 * 24 \text{ mm} = 480 \text{ mm} \\ \text{lesser dimension of column} = 306 \text{ mm} \\ 400 \text{ mm} \end{array} \right.$$

Finally, provide $\phi 8$ C/C 306 mm

All the steps in the above calculation and values are summarized in the table below by using excel template.

| location | column | bc | hc | bb | hb | Lc | Lbx left | lhx right | lby left | lby right | k1x | k2x | k1y | k2y | Lox | Loy |
|----------|--------|-----|-----|-----|-----|------|----------|-----------|----------|-----------|------|------|------|------|---------|---------|
| ROOF | C1 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 0 | 5200 | 3.16 | 3.16 | 5.14 | 5.14 | 3000.58 | 3071.10 |
| ROOF | C2 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5200 | 5200 | 3.16 | 3.16 | 2.57 | 2.57 | 3000.58 | 2961.42 |
| ROOF | C3 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5200 | 5700 | 3.16 | 3.16 | 2.69 | 2.69 | 3000.58 | 2970.39 |
| ROOF | C4 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5700 | 0 | 3.16 | 3.16 | 5.63 | 5.63 | 3000.58 | 3081.57 |
| ROOF | C5 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 0 | 5200 | 1.93 | 1.93 | 5.14 | 5.14 | 2898.06 | 3071.10 |
| ROOF | C6 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5200 | 5200 | 1.93 | 1.93 | 2.57 | 2.57 | 2898.06 | 2961.42 |
| ROOF | C7 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5200 | 5700 | 1.93 | 1.93 | 2.69 | 2.69 | 2898.06 | 2970.39 |
| ROOF | C8 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5700 | 0 | 1.93 | 1.93 | 5.63 | 5.63 | 2898.06 | 3081.57 |
| ROOF | C9 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 0 | 5200 | 2.48 | 2.48 | 5.14 | 5.14 | 2954.39 | 3071.10 |
| ROOF | C10 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 5200 | 0 | 2.48 | 2.48 | 5.14 | 5.14 | 2954.39 | 3071.10 |
| ROOF | C11 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 0 | 5700 | 2.48 | 2.48 | 5.63 | 5.63 | 2954.39 | 3081.57 |
| ROOF | C12 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 5700 | 0 | 2.48 | 2.48 | 5.63 | 5.63 | 2954.39 | 3081.57 |
| ROOF | C13 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 0 | 5200 | 2.47 | 2.47 | 5.14 | 5.14 | 2953.35 | 3071.10 |
| ROOF | C14 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 5200 | 5200 | 2.47 | 2.47 | 2.57 | 2.57 | 2953.35 | 2961.42 |
| ROOF | C15 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 5200 | 5700 | 2.47 | 2.47 | 2.69 | 2.69 | 2953.35 | 2970.39 |
| ROOF | C16 | 400 | 400 | 300 | 300 | 3200 | 5000 | 500 | 5700 | 0 | 0.45 | 0.45 | 5.63 | 5.63 | 2399.05 | 3081.57 |
| ROOF | C17 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 0 | 5200 | 4.94 | 4.94 | 5.14 | 5.14 | 3066.38 | 3071.10 |
| ROOF | C18 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5200 | 5200 | 4.94 | 4.94 | 2.57 | 2.57 | 3066.38 | 2961.42 |
| ROOF | C19 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5200 | 5700 | 4.94 | 4.94 | 2.69 | 2.69 | 3066.38 | 2970.39 |
| ROOF | C20 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5700 | 0 | 4.94 | 4.94 | 5.63 | 5.63 | 3066.38 | 3081.57 |

| colmn | location | MEDx | MEDy | Vsd | μ sd _y | μ sd _x | ω | As | As, min | As, max | As, prov |
|-------|----------|---------|---------|----------|-----------------------|-----------------------|----------|----------|---------|---------|----------|
| ROOF | C1 | 22.9152 | 9.6852 | 0.075441 | 0.013357 | 0.031602 | 1.3 | 7971.34 | 320 | 6400 | |
| ROOF | C2 | 26.1726 | 32.8426 | 0.072336 | 0.045293 | 0.036094 | 2.3 | 14103.14 | 320 | 6400 | 14103.14 |
| ROOF | C3 | 31.8372 | 20.4772 | 0.071635 | 0.02824 | 0.043906 | 0.1 | 613.18 | 320 | 6400 | 613.18 |
| ROOF | C4 | 18.67 | 8.12 | 0.088537 | 0.011198 | 0.025747 | 0.3 | 1839.54 | 320 | 6400 | 1839.54 |
| ROOF | C5 | 15.0214 | 19.6914 | 0.092437 | 0.027156 | 0.020716 | 0.15 | 919.77 | 320 | 6400 | 919.77 |
| ROOF | C6 | 15.3462 | 25.0962 | 0.096431 | 0.03461 | 0.021164 | 6.3 | 38630.34 | 320 | 6400 | 38630.34 |
| ROOF | C7 | 23.2996 | 30.4296 | 0.075563 | 0.041965 | 0.032132 | 7.3 | 44762.14 | 320 | 6400 | 44762.14 |
| ROOF | C8 | 7.1096 | 36.3996 | 0.108385 | 0.050198 | 0.009805 | 8.3 | 50893.94 | 320 | 6400 | 50893.94 |
| ROOF | C9 | 15.069 | 18.923 | 0.110685 | 0.026096 | 0.020781 | 9.3 | 57025.74 | 320 | 6400 | 57025.74 |
| ROOF | C10 | 34.7952 | 10.5352 | 0.107988 | 0.014529 | 0.047985 | 10.3 | 63157.54 | 320 | 6400 | 63157.54 |
| ROOF | C11 | 34.9524 | 8.4624 | 0.112323 | 0.01167 | 0.048202 | 11.3 | 69289.34 | 320 | 6400 | 69289.34 |
| ROOF | C12 | 10.2856 | 12.8556 | 0.128133 | 0.017729 | 0.014185 | 12.3 | 75421.14 | 320 | 6400 | 75421.14 |
| ROOF | C13 | 15.2828 | 18.9628 | 0.107094 | 0.026151 | 0.021076 | 13.3 | 81552.94 | 320 | 6400 | 81552.94 |
| ROOF | C14 | 17.604 | 9.474 | 0.120366 | 0.013065 | 0.024277 | 14.3 | 87684.74 | 320 | 6400 | 87684.74 |
| ROOF | C15 | 11.2516 | 6.2416 | 0.12692 | 0.008608 | 0.015517 | 15.3 | 93816.54 | 320 | 6400 | 93816.54 |
| ROOF | C16 | 11.1612 | 8.6212 | 0.128839 | 0.011889 | 0.015392 | 16.3 | 99948.34 | 320 | 6400 | 99948.34 |
| ROOF | C17 | 23.9248 | 11.7448 | 0.107425 | 0.016197 | 0.032994 | 17.3 | 106080.1 | 320 | 6400 | 106080.1 |
| ROOF | C18 | 20.7408 | 17.0408 | 0.123312 | 0.023501 | 0.028603 | 18.3 | 112211.9 | 320 | 6400 | 112211.9 |
| ROOF | C19 | 26.1374 | 6.0174 | 0.118805 | 0.008298 | 0.036046 | 19.3 | 118343.7 | 320 | 6400 | 118343.7 |
| ROOF | C20 | 26.2216 | 19.7616 | 0.105958 | 0.027253 | 0.036162 | 20.3 | 124475.5 | 320 | 6400 | 124475.5 |

| location | column | Mx top | Mx botm | My top | My bot | NED | M01x | M01y | M02x | M02y | λ_x | λ_y | λ_{lim} | λ_{ylim} | slenderness(x) | slenderness(y) |
|----------|--------|--------|---------|--------|--------|--------|-------|-------|-------|-------|-------------|-------------|-----------------|------------------|----------------|----------------|
| ROOF | C1 | 18.02 | 20.18 | 0.32 | 6.95 | 136.76 | 20.76 | 3.06 | 22.92 | 9.69 | 25.99 | 26.60 | 44.53 | 77.63 | short | short |
| ROOF | C2 | 19.09 | 23.55 | 8.36 | 30.22 | 131.13 | 21.71 | 10.98 | 26.17 | 32.84 | 25.99 | 25.65 | 49.84 | 78.19 | short | short |
| ROOF | C3 | 17.31 | 29.24 | 15.34 | 17.88 | 129.86 | 19.91 | 17.94 | 31.84 | 20.48 | 25.99 | 25.72 | 61.84 | 47.41 | short | short |
| ROOF | C4 | 10.47 | 15.46 | 4.91 | 2.43 | 160.50 | 13.68 | 5.64 | 18.67 | 8.12 | 25.99 | 26.69 | 50.06 | 52.04 | short | short |
| ROOF | C5 | 11.67 | 10.23 | 11.91 | 16.34 | 167.57 | 13.58 | 15.27 | 15.02 | 19.69 | 25.10 | 26.60 | 40.31 | 46.84 | short | short |
| ROOF | C6 | 7.71 | 11.85 | 19.49 | 21.60 | 174.81 | 11.21 | 22.99 | 15.35 | 25.10 | 25.10 | 25.65 | 48.09 | 38.88 | short | short |
| ROOF | C7 | 14.68 | 20.56 | 27.69 | 25.68 | 136.98 | 17.42 | 28.42 | 23.30 | 30.43 | 25.10 | 25.72 | 53.35 | 42.92 | short | short |
| ROOF | C8 | 3.18 | 0.30 | 32.47 | 28.52 | 196.48 | 4.23 | 32.45 | 7.11 | 36.40 | 25.10 | 26.69 | 51.69 | 37.82 | short | short |
| ROOF | C9 | 11.06 | 5.79 | 7.81 | 14.91 | 200.65 | 9.80 | 11.82 | 15.07 | 18.92 | 25.59 | 26.60 | 48.58 | 49.77 | short | short |
| ROOF | C10 | 30.88 | 19.92 | 4.57 | 6.62 | 195.76 | 23.84 | 8.49 | 34.80 | 10.54 | 25.59 | 26.60 | 47.57 | 41.92 | short | short |
| ROOF | C11 | 30.88 | 30.88 | 3.21 | 4.39 | 203.62 | 34.95 | 7.28 | 34.95 | 8.46 | 25.59 | 26.69 | 32.16 | 38.57 | short | short |
| ROOF | C12 | 5.64 | 1.00 | 1.93 | 8.21 | 232.28 | 5.65 | 6.58 | 10.29 | 12.86 | 25.59 | 26.69 | 49.52 | 51.13 | short | short |
| ROOF | C13 | 11.40 | 3.48 | 8.21 | 15.08 | 194.14 | 7.36 | 12.09 | 15.28 | 18.96 | 25.58 | 26.60 | 57.33 | 49.99 | short | short |
| ROOF | C14 | 13.24 | 3.28 | 2.68 | 5.11 | 218.20 | 7.64 | 7.04 | 17.60 | 9.47 | 25.58 | 25.65 | 56.19 | 42.46 | short | short |
| ROOF | C15 | 6.65 | 0.00 | 1.64 | 1.21 | 230.08 | 4.60 | 5.81 | 11.25 | 6.24 | 25.58 | 25.72 | 55.81 | 33.24 | short | short |
| ROOF | C16 | 6.49 | 0.11 | 3.95 | 2.91 | 233.56 | 4.78 | 7.58 | 11.16 | 8.62 | 20.78 | 26.69 | 54.56 | 35.21 | short | short |
| ROOF | C17 | 20.03 | 11.40 | 5.75 | 7.85 | 194.74 | 15.29 | 9.64 | 23.92 | 11.74 | 26.56 | 26.60 | 49.84 | 41.29 | short | short |
| ROOF | C18 | 16.27 | 4.85 | 12.57 | 11.78 | 223.54 | 9.32 | 16.25 | 20.74 | 17.04 | 26.56 | 25.65 | 54.85 | 32.73 | short | short |
| ROOF | C19 | 21.83 | 7.13 | 1.71 | 0.00 | 215.37 | 11.44 | 4.31 | 26.14 | 6.02 | 26.56 | 25.72 | 56.40 | 43.97 | short | short |
| ROOF | C20 | 22.38 | 10.35 | 15.92 | 12.50 | 192.08 | 14.19 | 16.34 | 26.22 | 19.76 | 26.56 | 26.69 | 54.82 | 41.30 | short | short |

FOUNDATION DESIGN

The foundation is the part of an engineered system that transmits to, and into, the underlying soil or rock the loads supported by the foundation and its self-weight.

Purposes of foundations to distribute the load of the structure over a large bearing area so as to bring intensity of loading within the safe bearing capacity of the soil lying underneath. To load the bearing surface at a uniform rate so as to prevent unequal settlement.

- ✓ To prevent the lateral movement of the supporting material.
- ✓ To secure a level and firm bed for building operations.
- ✓ To increase the stability of the structure as a whole.
- ✓ The soil below doesn't fail in shear
- ✓ The settlement is within the safe limit

| Column | POINT | LOAD | FZ | MX | MY |
|--------|-------|--------|----------|-------|------|
| A1 | 1 | COMB10 | 1410.55 | 4.06 | 4.57 |
| A2 | 2 | COMB10 | 2143.97 | 2.33 | 0.75 |
| A3 | 3 | COMB10 | 2230.44 | 0.01 | 3.78 |
| A4 | 4 | COMB10 | 2555.19 | 0.53 | 7.76 |
| A5 | 5 | COMB10 | 1947.96 | 4.99 | 1.81 |
| B1 | 6 | COMB10 | 1531.744 | 5.54 | 2.17 |
| B2 | 7 | COMB10 | 2550.04 | 0.53 | 5.71 |
| B3 | 8 | COMB10 | 2555.91 | 0.73 | 3.33 |
| B4 | 9 | COMB10 | 2972.99 | 4.31 | 3.63 |
| B5 | 10 | COMB10 | 2758.44 | 6.88 | 0.79 |
| C1 | 11 | COMB10 | 1607.59 | 2.23 | 1.6 |
| C2 | 12 | COMB10 | 2018.05 | 2.03 | 3.56 |
| C3 | 13 | COMB10 | 2062.78 | 5.56 | 4.11 |
| C4 | 14 | COMB10 | 2358.35 | 14.66 | 6.65 |
| C5 | 15 | COMB10 | 2905.91 | 6.07 | 0.73 |
| D3 | 16 | COMB10 | 955.86 | 14.66 | 5.54 |
| D4 | 17 | COMB10 | 2953.87 | 16.27 | 5.02 |
| D5 | 18 | COMB10 | 2817.65 | 1.83 | 1.85 |
| E3 | 19 | COMB10 | 1153.17 | 8.01 | 1.59 |
| E4 | 20 | COMB10 | 2918.95 | 6.46 | 1.73 |
| E5 | 21 | COMB10 | 2046.67 | 1.66 | 0.87 |

Table 10.1 The values of axial load, Mx, My are obtained from ETABS 2016 analysis result from base reaction.

We have the footing of two type such as, F1\$ F2

Footing 1 include the load from 500-1500 and

Footing 2 include the loads from 1500-3000

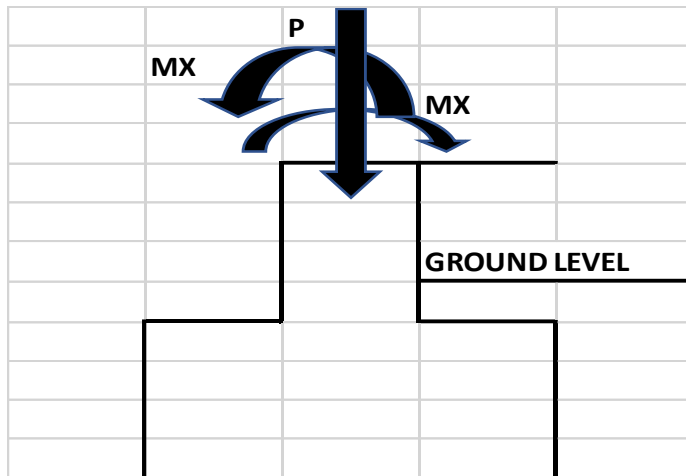
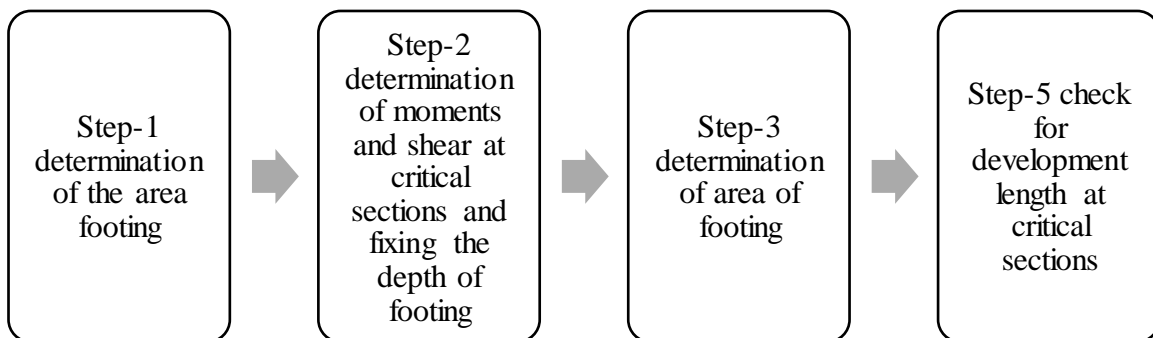


Figure 10.1 model of rectangular isolated footing



❖ BEARING CAPACITY

The soil must be capable of carrying the loads from the structure placed up on it without a shear failure and with the resulting settlements being tolerable for the structure. The design bearing resistance can be taken from the presumed design bearing pressure for different soils according to EBCS-7, 1995 ART 6.10.2 Table 6.3 or can be calculated analytically according to EBCS-7, 1995 ART 6.5.22 for drained as well as un-drained conditions. We have assumed type of soil to be cohesive clay stiff soil. And thus we take the corresponding bearing capacity from the presumed design bearing pressure from EBCS-7, 1995 ART 6.10.2 Table 6.3 page 805 which is **350kPa**

Sample footing design of footing 1 at the axis A1

$$\sigma_{Max} \leq Q_{max}$$

$$\sigma_{Max/min} = \frac{P}{A} * \left(1 \pm \frac{6e_y}{B} \pm \frac{6e_x}{L} \right) \dots \dots \dots 1$$

Now finding the eccentricity of each loadings

Eccentricity for service load

$$e_x = \frac{M_y}{F_z}, e_y = \frac{M_x}{F_z}$$

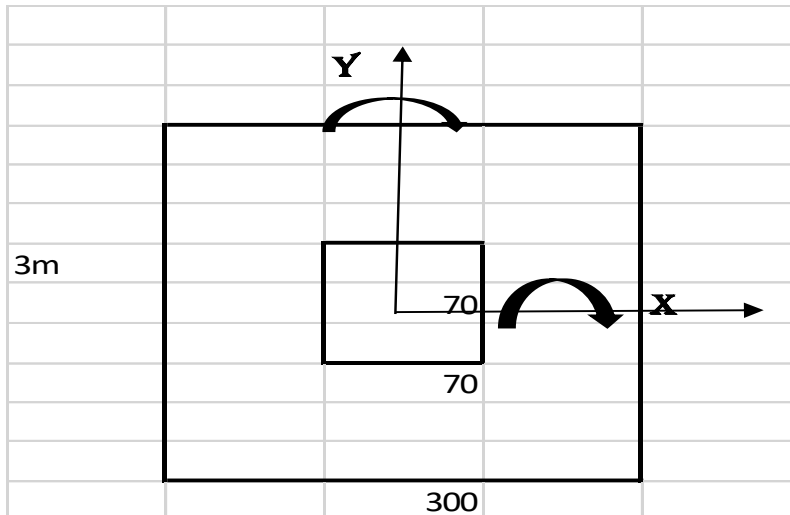
Dimension of column is 300x300mm

From bearing capacity of the soil using the theoretical method

Cover design

Area proportioning

First let us assume that the footing pad is square



Dimension of column is 600x600mm

From bearing capacity of the soil using the theoretical method

Service axial= $p=2600\text{KN}/1.4=1857.15\text{kN}$

$P=2600\text{KN}/M$

$M_X=11.5\text{Knm}$

$M_Y=6.4\text{knm}$

Service moment= $50\text{KN}/m$

Assumed the self-weight= 10% of the service load or axial= $260\text{Kn}/1.4=185.72\text{KN}$

Area of footing required = $\left(\frac{N+W}{\gamma_{soil}}\right)$, $\gamma_{soil} = 150\text{N}/\text{mm}^2$

$$A = \left(\frac{1857.15 + 185.72}{150}\right) = 13.36\text{m}^2$$

❖ Try square footing size, $B \cdot H \cdot h = 3 \cdot 3 \cdot 0.65$

$$A = 3 \cdot 3 = 9\text{m}^2$$

Self-weight, $W = A \cdot h \cdot \text{unit weight of concrete}$

$$W = 9 \cdot 0.65 \cdot 25 = 146.25\text{Kn}$$

$$\sigma = \frac{P}{A} \left(1 \pm \frac{6ey}{B} \pm \frac{6ey}{B}\right)$$

$$e_x = \frac{MY}{P} = \frac{6.4}{2600} = 0.00246 \quad e_y = \frac{MX}{P} = \frac{11.5}{2600} = 0.00442$$

$$\sigma_{\max} = \frac{1857.15}{9} \left(1 + \frac{6 \cdot 0.00442}{3} + \frac{6 \cdot 0.00246}{3} \right) = 209.19 \text{ kN/mm}^2$$

$$\sigma_{\min} = \frac{1857.15}{9} \left(1 - \frac{6 \cdot 0.00442}{3} - \frac{6 \cdot 0.00246}{3} \right) = 201.48 \text{ kN/mm}^2$$

$$\sigma_{\text{avg}} = (\sigma_{\min} + \sigma_1 + \sigma_2 + \sigma_{\max}) / 4$$

$$= 200.25 \text{ Kpa}$$

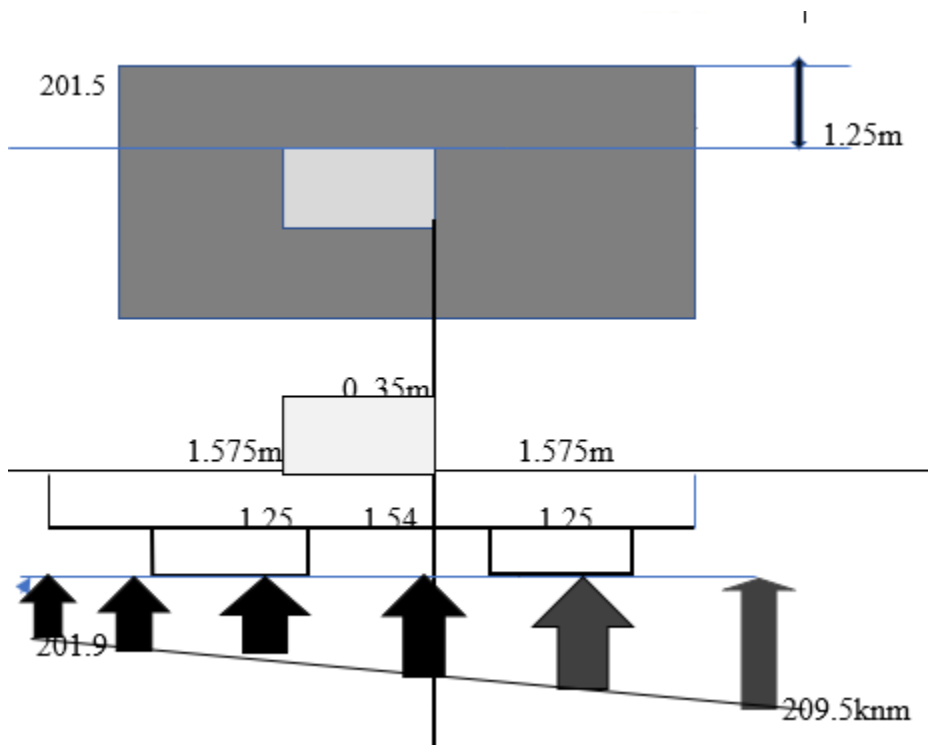


Figure 10.2 effect of loads on footing

$$M_{xx} = \left(201.02 \cdot \frac{1.25^2}{2} \right) + (209.19 - 201.48) \cdot \left(\frac{1.25}{2} \right) \cdot \left(1.25 \cdot \frac{2}{3} \right)$$

$$= 161.2 \text{ kN.m}$$

$$M_{yy} = \frac{209.19 + 201.48}{2} \cdot \left(\frac{1.25^2}{2} \right) = 160.42 \text{ kN.m}$$

Depth determination

The critical section used for footing depth determination is similar to flat slab section.

These sections are

- Wide beam shear section
- Punching shear section
- Bending moment section

Wide beam shear section

Critical section for shear is at distance d from the face of supports.

First assume the depth of footing pad to be

$$dx = h - c - 0.5\phi_{\text{bar}} \quad \text{use C-40 and } \phi 32$$

$$= 650 - 40 - 0.5 * 32$$

$$594 \text{ mm}$$

$$dy = h - c - 1.5\phi_{\text{bar}} = 650 - 40 - 1.5 * 32$$

$$= 562 \text{ mm}$$

Main reinforcement -longitudinal bar

$$K = \frac{M_{xx}}{f_c d b d^2} = < K_{bal} = 0.167$$

$$K = \frac{161.2 * 10^6}{32 * 3000 * 594^2} = 0.008 < K_{bal} = 0.167 \dots \dots \dots \text{ok}$$

$$\rho_{min} = \min \left\{ \begin{array}{l} 0.26 \frac{f_{tcm}}{400} \\ 0.02 \end{array} \right. = 0.26 \frac{2.6}{400} = 0.0014$$

$$V_{yy} = \sigma_{avge} * B * \left(\frac{B}{2} - \frac{col(H)}{2} - \frac{d_{vrmin}}{1000} \right)$$

Compression reinforcement is not required

Obtain lever arm Z

$$Z = \frac{d}{2} [1 + \sqrt{1 - 3.53K}] \leq 0.95d$$

$$Z = \frac{d}{2} [1 + \sqrt{1 - 3.53 * 0.0058}]$$

$$= 0.495d \leq 0.95d \dots \dots \dots \text{ok}$$

$$= 0.995 * 0.594 \leq 0.95 * 0.594$$

$$= 0.564$$

$$A_{s, req} = \frac{M_{xx}}{0.87 f_{yk} Z} = \frac{161.2 * 10^6}{0.87 * 400 * 0.564} = 821.41 \text{ mm}^2$$

$$A_{s, min} = \frac{0.26 * f_{ctm} * b d}{f_{yk}} \text{ where } f_{ck} \geq 25$$

$$A_{s, min} = \frac{0.26 * 3.2 * 3000 * 594}{400} = 3706.56 \text{ mm}^2$$

$$A_{s, max} = 0.04 A_c = 0.04 * b h$$

$$A_{s, max} = 0.04 A_c = 0.04 * 3000 * 594 = 71280 \text{ mm}^2$$

Since $A_s < A_{s, min}$ use $A_{s, min} = 3706.56 \text{ mm}^2$

Main reinforcement- transverse bar-transverse bar

$$K = \frac{M_{yy}}{f_{cd} b * d^2} = < K_{bal} = 0.167$$

$$K = \frac{160.42 * 10^6}{32 * 3000 * 562^2} = 0.0053 < K_{bal} = 0.167$$

Compression reinforcement is not required

$$Z = \frac{d}{2} [1 + \sqrt{1 - 3.53K}] \leq 0.95d$$

$$Z = \frac{d}{2} [1 + \sqrt{1 - 3.53 * 0.00419}] = 0.996d \leq 0.95d = 0.5339 \text{ mm}$$

$$A_{s, req} = \frac{M_{yy}}{0.87 f_{yk} Z}$$

$$A_{s, req} = \frac{160.42 * 10^6}{0.87 * 400 * 0.5339} = 863.4 \text{ mm}^2$$

$$A_{s, min} = \frac{0.26 * f_{ctm} * b d}{f_{yk}} \text{ where } f_{ck} \geq 25$$

$$A_{s, min} = \frac{0.26 * 3.2 * 3000 * 562}{400} = 3506.88 \text{ mm}^2$$

$$A_{s, max} = 0.04 A_c = 0.04 * b h$$

$$A_{s, max} = 0.04 A_c = 0.04 * 3000 * 563 = 67440 \text{ mm}^2$$

Since $A_s < A_{s, min}$ use $A_{s, min} = 3506.88 \text{ mm}^2$

i. Vertical shear (wide beam shear)

Critical shear at $1.0d$ from face of column

$$\text{Average pressure at critical section} = 201.48 + \frac{2.344}{3} * 4.43 = 205 \text{ kN/m}^2$$

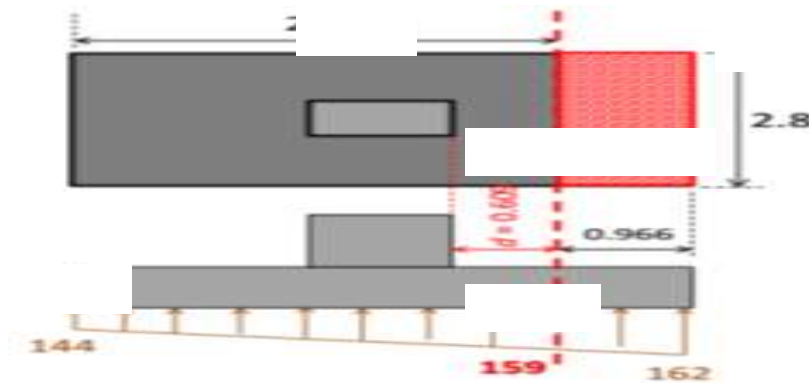


Figure 10.3 pressure at critical section

$$\text{Design shear force, } V_{Ed} = 205.0 * 0.656 * 3 = 403.44 \text{ kN}$$

Note bar extend beyond critical section at $= 656 - 35 = 606 > (l_{bd} + d) = 36\phi + d$ use $\phi 32$

$$= 36 * 32 + 594 = 1746 \text{ mm}, A_{sl} = 0 \text{ mm}^2$$

$$\rho_l = \frac{A_{sl}}{b d} = 0.001$$

$$K_3 = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{594}} = 1.58 < 2$$

$$V_{rdc}=0$$

$$V_{min}=[0.035 * K3/2\sqrt{f_{ck}}]bd$$

$$V_{min}=[0.035 * 1.58^{3/2}\sqrt{32}] * 300 * 594=700.707kN$$

$$V_{Ed}(322.65kN) < V_{min}(700.707kN) \dots\dots\dots ok$$

ii. Punching shear

Critical shear at 2d from face of column

$$\text{Average } d = \frac{D+dy}{2} = \frac{594+562}{2} =578mm$$

$$2d=2*578=1156mm$$

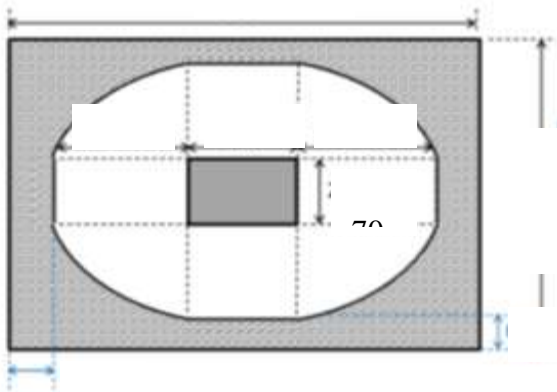


Figure 10.4 punching shear

Control perimeter

$$U_1=2(700+700) +(2\Pi*1156) =10063.4mm$$

Area with in perimeter

$$A=0.7*0.7+2(0.7*1.156) +2*0.7*1.156+ \Pi*1.156^2$$

$$7.16 m^2$$

Average punching shear force at control perimeter

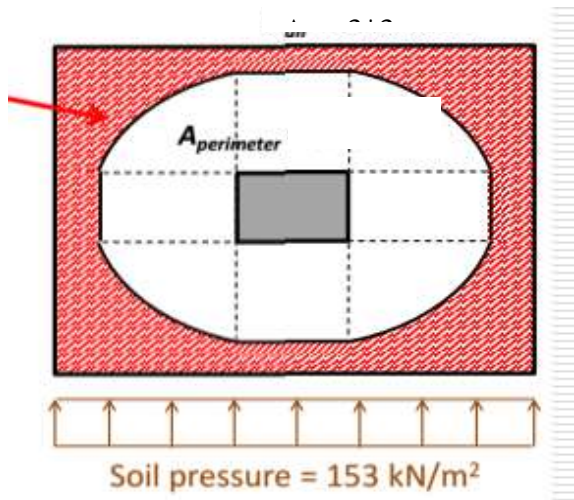


Figure 10.5 effect of punching shear on soil

$$V_{Ed} = 153(3 \times 3 - 7.16) = 281.52 \text{ kN}$$

Punching shear stress

$$v_{Ed} = \frac{\beta V_{Ed}}{u d}$$

Where

$$\beta = 1 + k \left(\frac{M_{Ed}}{V_{Ed}} \right) \left(\frac{u_1}{w_1} \right)$$

$$K = 0.65 \quad \frac{c_1}{c_2} = \frac{700}{700} = 1$$

$$W_1 = 0.5 C_1^2 + C_1 C_2 + 4 C_2 d = 16 d^2 + 2 \Pi d C_1$$

$$= 0.5 \times 700^2 + 700 \times 700 + 4 \times 700 d = 16 d^2 + 2 \Pi d C_1$$

$$= 0.5 \times 700^2 + 700 \times 700 + 4 \times 700 \times 578 + 16 \times 578^2 + 2 \Pi \times 578 \times 700$$

$$= 10.23 \times 10^6 \text{ mm}^2$$

$$V_{rd, max} = c_w * U_0 * 1000 * z * \Theta * f_{cd} / (\cot \Theta + \tan \Theta) / 1000$$

$$= (1 * 12.11 * 1000 * 757.8 * 22 * 11.33 / (2.475 + 0.404))$$

$$= 1610.74$$

$V_{ed, red} < V_{rd, max} \text{ --- } 1610.74 > 1124.3$ -----punching shear at the face of the column is **safe**

check punching shear at critical perimeter (1.5d distance from the column face)

$$V_{ed, red} = Fz - \sigma_{avg} * \left[3 * \frac{d}{1000} + H \right] * \left[3 * \frac{d}{1000} + B \right]$$

$$V_{ed, red} = 680.26$$

U_0 =perimeter of column

$$U_0 = 2 * [L_{punching} + W_{punching}]$$

$$d = 842$$

$$L_{Punching} = \left[3 * \frac{d}{1000} + H \right] \text{ ---- } [3 * 0.842 + 0.5] = 3.026$$

$$W_{Punching} = \left[3 * \frac{d}{100} + H \right] \text{ --- } [3 * 0.832 + 0.5] = 3.026$$

$$U_0 = 2 * [3.026 + 3.026] = 12.11$$

$$V_{rdc} = c_{rdc} * k * \frac{[100 * \rho_{min} * f_{ck}]^{1/3}}{3} * U_0 * d$$

$$V_{rdc} = 0.12 * 1 * \frac{[100 * 0.0014 * 25]^{1/3}}{3} * 12.11 * 842$$

$$V_{rdc} = 1850.04$$

$$V_{min} = 0.035 * k^{1.5} * F_{ck}^{0.5} * U_0 * d$$

$$V_{min} = 0.035 * 1^{1.5} * 25^{0.5} * 12.11 * 642$$

$$V_{min} = 1360.56$$

Min of V_{min} , $V_{rdc} \gg V_{ed, red} = 1850.04 > 680.26$ ---- punching shear at the face of the column is safe check punching shear at critical perimeter (2d distance from the column face)

$$V_{ed, red} = Fz - \sigma_{avg} * \left[4 * \frac{d}{1000} + H \right] * \left[4 * \frac{d}{1000} + B \right]$$

$$V_{ed, red} = -2872.16$$

U_0 = perimeter of column

$$U_0 = 2 * [L_{punching} + W_{punch}]$$

$$L_{Punching} = [4 * d / 100 + H] = [4 * 0.842 + 0.5] = 3.868$$

$$W_{Punching} = [4 * d / 100 + H] = [4 * 0.842 + 0.5] = 3.868$$

$$U_0 = 2 * [3.868 + 3.868] = 15.472$$

$$V_{rdc} = c_{rdc} * k * \frac{[100 * \rho_{min} * f_{ck}]^{1/3}}{3} * U_0 * d$$

$$V_{rdc} = 0.12 * 1 * [100 * 0.0014 * 25]^{(1/3)} * 12.11 * 842$$

$$V_{rdc} = 1660.67$$

$$V_{min} = 0.035 * k^{1.5} * F_{ck}^{0.5} * U_0 * d$$

$$V_{min} = 0.035 * 1^{1.5} * 25^{0.5} * 12.11 * 842$$

$$V_{min} = 1784.40$$

Min of V_{min} , $V_{rdc} \gg V_{ed, red} = 1660.67 > 2872.16$ ---- punching shear at the face of the column is safe

The depth of footing required for both wide beam and punching shear

$$D = d + \text{cover} / 2 = 842 + 50 + 8 = 900$$

Reinforcement Calculation

parallel to longer direction

$$M_{sdx} = \sigma_{avg} * B * \left[\left(\frac{L}{2} - \frac{col(H)}{2} \right)^2 \right] / B$$

$$M_{sdx} = 286.25 * 2.2 * \left[\left(\frac{2.2}{2} - \frac{col(0.5)2}{2} \right)^2 \right] / 2.45 = 122.09$$

$$s_d = m_{sd} * 10^6 / [F_{cd} * 1000 * d^2]$$

$$122.09 * 10^6 / [11.33 * 1000 * 842^2]$$

$$S_d = 0.02$$

$$K_z = 0.986$$

$$M_{sdx} = 122.09 \text{ kNm}$$

$$A_{s \text{ calculated}} = m_{sdx} * 10^6 / (k_z * d * F_{yd})$$

$$A_{s \text{ calculated}} = 185.55 * 10^6 / (0.986 * 842 * 347.83)$$

$$A_{s \text{ calculated}} = 642.40 \text{ mm}^2$$

$$A_{s \text{ min}} = 0.26 * f_{ctm} / f_{yk} * 1000 * d$$

$$A_{s \text{ min}} = (0.26 * 2.565 / 400) * 1000 * 842$$

$$A_{s \text{ min}} = 1403.82 \text{ mm}^2$$

$$A_{s \text{ max}} = 0.04 * 1000 * d$$

$$A_{s \text{ max}} = 0.04 * 1000 * 842$$

$$A_{s, \text{ max}} = 33680 \text{ mm}^2$$

$$A_{s, \text{ provided}} = A_{s \text{ calculated}} \leq A_{s \text{ min}} \leq A_{s, \text{ max}}$$

$$A_{s, \text{ provided}} = 1403.82$$

Spacing

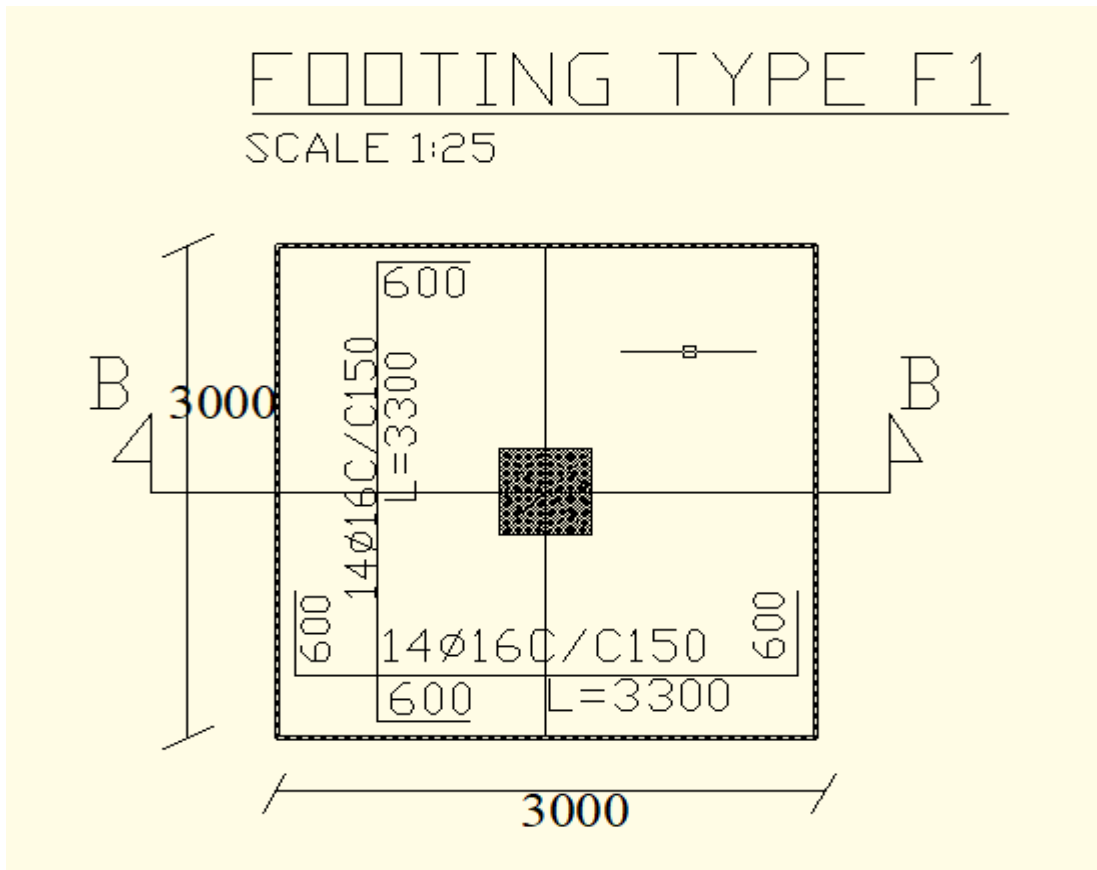
$$\text{Spacing} = \text{Min} \left\{ \frac{b * a_s}{A_s} = \frac{1000 * 3.14 * 8^2}{1403.82} = 143.15 \text{ mm} \right.$$

$$3 * d = 3 * 842 = 2526\text{mm}$$

400

So we take the minimum spacing =150mm

Provide $\phi 16$ C/C 150mm



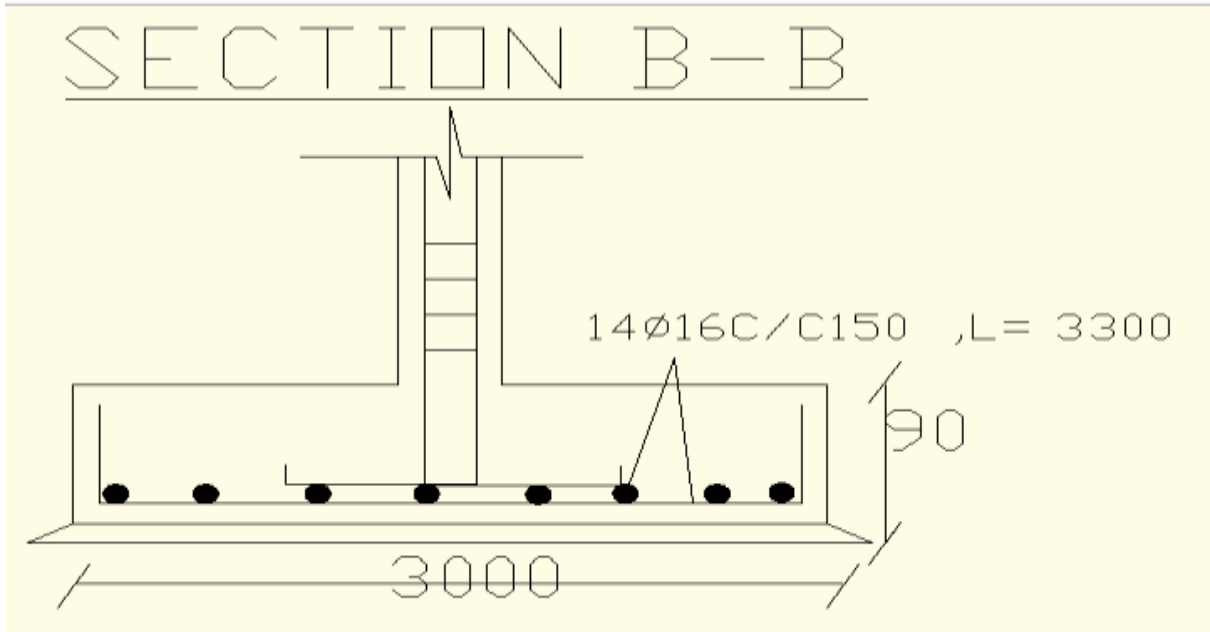


Figure 10.6 detail drawing of footing and foundation column

Proposed Time Plan

| Nº | Activity | Date |
|----|--------------------------------------------------------|------------------|
| | Day One class one | 27/05/2012 EC |
| | Choice of Title | 27-30/05/2012 EC |
| | Submit agreement paper | 16//04/2013 EC |
| | Rifer Literature, consult advisors and write proposals | 27/04/2013 EC |
| | Submit Proposal | 16/04/2013 EC |
| | Class end` | 23/04/2013 EC |

REFERENCE

Construction Minister. (1995). *EBCS-2-1995*.

EBCS 2, 1995. (1995). *Design of Column*.

ES-EN 2015-1. (2015).

Appendix A

| | moderate humidity | concrete more exchange than very low air humidity |
|-------------------------------------------|------------------------|-------------------------------------------------------------------------------------------------------|
| 2 Corrosion induced by carbonation | | |
| XC1 | Dry or permanently wet | Concrete inside buildings with low air humidity Concrete permanently submerged in water |
| XC2 | Wet, rarely dry | Concrete surfaces subject to long-term water contact Many foundations |
| XC3 | Moderate humidity | Concrete inside buildings with moderate or high air humidity External concrete sheltered from rain |
| XC4 | Cyclic wet and dry | Concrete surfaces subject to water contact, not within exposure class XC2 |

Appendix B

| Exposure Classes according to Table 4.1 | | | | | | | | | | |
|-----------------------------------------|-------------------------------|--------------------|--------|--------|----------------------------|-----|--------|-------------------------------------------|--------|-----|
| Corrosion | | | | | | | | | | |
| | Carbonation-induced corrosion | | | | Chloride-induced corrosion | | | Chloride-induced corrosion from sea-water | | |
| | XC1 | XC2 | XC3 | XC4 | XD1 | XD2 | XD3 | XS1 | XS2 | XS3 |
| Indicative Strength Class | C20/25 | C25/30 | C30/37 | | C30/37 | | C35/45 | C30/37 | C35/45 | |
| Damage to Concrete | | | | | | | | | | |
| | No risk | Freeze/Thaw Attack | | | Chemical Attack | | | | | |
| | X0 | XF1 | XF2 | XF3 | XA1 | XA2 | XA3 | | | |
| Indicative Strength Class | C12/15 | C30/37 | C25/30 | C30/37 | C30/37 | | | C35/45 | | |

Appendix C

| Structural System | K | Concrete highly stressed $\rho = 1,5\%$ | Concrete lightly stressed $\rho = 0,5\%$ |
|---------------------------------------------------------------------------------------------------------------|-----|--------------------------------------------|---------------------------------------------|
| Simply supported beam, one- or two-way spanning simply supported slab | 1,0 | 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 |

APPENDIX D

Table 4.2: Minimum cover, $C_{min,b}$, requirements with regard to bond

| Bond Requirement | |
|----------------------------------------------------------------------------------------------------------|----------------------------------------------|
| Arrangement of bars | Minimum cover $C_{min,b}$ * |
| Separated | Diameter of bar |
| Bundled | Equivalent diameter (ϕ_n) (see 8.9.1) |
| *: If the nominal maximum aggregate size is greater than 32 mm, $C_{min,b}$ should be increased by 5 mm. | |

Recommended structural classification

| Structural Class | | | | | | | |
|--------------------------------------------------------------------------------------------|---------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Criterion | Exposure Class according to Table 4.1 | | | | | | |
| | X0 | XC1 | XC2 / XC3 | XC4 | XD1 | XD2/ XS1 | XD3/ XS2/ XS3 |
| Design working life of 100 years | Increase class by 2 | Increase class by 2 | Increase class by 2 | Increase class by 2 | Increase class by 2 | Increase class by 2 | Increase class by 2 |
| Strength Class ¹⁾²⁾ | C30/37 reduce class by 1 | C30/37 reduce class by 1 | C35/45 reduce class by 1 | C40/50 reduce class by 1 | C40/50 reduce class by 1 | C40/50 reduce class by 1 | C45/55 reduce class by 1 |
| Member with slab geometry (Position of reinforcement not affected by construction process) | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 |
| Special Quality Control of the concrete production ensured | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 | reduce class by 1 |

APENDIX E

Table 4.4N: Values of minimum cover, $c_{min,dur}$, requirements with regard to durability for reinforcement steel in accordance with EN 10080.

| Environmental Requirement for $c_{min,dur}$ (mm) | | | | | | | |
|--------------------------------------------------|---------------------------------------|-----|-----------|-----|-----------|-----------|-----------|
| Structural Class | Exposure Class according to Table 4.1 | | | | | | |
| | X0 | XC1 | XC2 / XC3 | XC4 | XD1 / XS1 | XD2 / XS2 | XD3 / XS3 |
| S1 | 10 | 10 | 10 | 15 | 20 | 25 | 30 |
| S2 | 10 | 10 | 15 | 20 | 25 | 30 | 35 |
| S3 | 10 | 10 | 20 | 25 | 30 | 35 | 40 |
| S4 | 10 | 15 | 25 | 30 | 35 | 40 | 45 |
| S5 | 15 | 20 | 30 | 35 | 40 | 45 | 50 |
| S6 | 20 | 25 | 35 | 40 | 45 | 50 | 55 |

Table 4.5N: Values of minimum cover, $c_{min,dur}$ requirements with regard to durability for prestressing steel

| Environmental Requirement for $c_{min,dur}$ (mm) | | | | | | | |
|--------------------------------------------------|---------------------------------------|-----|-----------|-----|-----------|-----------|-----------|
| Structural Class | Exposure Class according to Table 4.1 | | | | | | |
| | X0 | XC1 | XC2 / XC3 | XC4 | XD1 / XS1 | XD2 / XS2 | SD3 / XS3 |
| S1 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
| S2 | 10 | 15 | 25 | 30 | 35 | 40 | 45 |
| S3 | 10 | 20 | 30 | 35 | 40 | 45 | 50 |
| S4 | 10 | 25 | 35 | 40 | 45 | 50 | 55 |
| S5 | 15 | 30 | 40 | 45 | 50 | 55 | 60 |
| S6 | 20 | 35 | 45 | 50 | 55 | 60 | 65 |

Appendix F

| Material | Density γ [kN/m ³] | Reference |
|----------------------------|---------------------------------------------|----------------------------------------------------|
| - Concrete | 25 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Cement Screed(mortar) | 23 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Plastering(mortar) | 23 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Partitions walls(HCB) | 14 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| <i>Finishing Materials</i> | | |
| - Porcelain | 25 | <i>Other reference</i> |
| - Marble | 27 | <i>Other reference</i> |
| - Ceramic | 23 | <i>Other reference</i> |
| - Parquet | 9 | <i>Other reference</i> |

Appendix G

| Material | Density γ [kN / m ³] | Reference |
|----------------------------|-----------------------------------------------|----------------------------------------------------|
| - Concrete | 25 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Cement Screed(mortar) | 23 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Plastering(mortar) | 23 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| - Partitions walls(HCB) | 14 | Eurocode 1 Part 1,1 – prEN 1991-1-1-2001 Table A.1 |
| <i>Finishing Materials</i> | | |
| - Porcelain | 25 | <i>Other reference</i> |
| - Marble | 27 | <i>Other reference</i> |
| - Ceramic | 23 | <i>Other reference</i> |
| - Parquet | 9 | <i>Other reference</i> |

Appendix H

| Function | Category | Live load | | | |
|------------------|-------------|-----------|--|--|--|
| suit room | General | 2 | | | |
| bath room/toilet | General | 2 | | | |
| Guest room | General | 2 | | | |
| Balcony | Balcony | 4 | | | |
| Corridor | Category C3 | 5 | | | |
| Shop | Category D1 | 5 | | | |
| Terrace | Category C5 | 5 | | | |
| | | | | | |
| | | | | | |

Appendix I

1 Design load for Ground floor

| Panel | Slab self-weight | Partition wall load | Total self-weight | Floor finish type | Function | Live load (LL) | Pd=1.35DL+1.5LL |
|-------|------------------|---------------------|-------------------|-------------------|----------|----------------|-----------------|
| W-1 | 7.44 | 1.65 | 9.09 | Ceramic tile | Shope | 5.00 | 19.77 |
| W-2 | 7.44 | 1.59 | 9.03 | Ceramic tile | Shope | 5.00 | 19.69 |
| W-3 | 7.44 | 1.46 | 8.90 | Ceramic tile | Shope | 5.00 | 19.51 |
| W-4 | 7.44 | 2.52 | 9.96 | Ceramic tile | lobby | 5.00 | 20.94 |
| W-5 | 7.44 | 2.79 | 10.23 | Ceramic tile | shope | 2.00 | 16.81 |
| W-6 | 7.44 | 2.52 | 9.96 | Ceramic tile | shope | 5.00 | 20.94 |
| W-7 | 7.44 | 2.79 | 10.23 | Ceramic tile | lobby | 5.00 | 21.31 |
| W-8 | 7.44 | 2.76 | 10.20 | PVC tile | shope | 5.00 | 21.27 |
| W-9 | 7.44 | 0.25 | 7.69 | Ceramic tile | shope | 5.00 | 17.89 |
| W-10 | 7.44 | 0.25 | 10.23 | PVC tile | lobby | 5 | 21.31 |
| W-11 | 7.44 | 0.25 | 9.96 | PVC tile | Shope | 5 | 20.95 |

2.1st and 2nd floor

| Panel | Slab self-weight | Partition wall load | Total self-weight | Floor finish type | Function | Live load (LL) | Pd=1.35DL+1.5LL |
|-------|------------------|---------------------|-------------------|-------------------|----------|----------------|-----------------|
| P-1 | 7.44 | 1.65 | 9.09 | Ceramic tile | Shope | 5.00 | 19.77 |
| P-2 | 7.44 | 1.59 | 9.03 | Ceramic tile | Shope | 5.00 | 19.69 |
| P-3 | 7.44 | 1.46 | 8.90 | Ceramic tile | Shope | 5.00 | 19.51 |
| P-4 | 7.44 | 2.52 | 9.96 | Ceramic tile | corridor | 5.00 | 20.94 |
| P-5 | 7.44 | 2.79 | 10.23 | Ceramic tile | shope | 2.00 | 16.81 |
| P-6 | 7.44 | 2.52 | 9.96 | Ceramic tile | shope | 5.00 | 20.94 |
| P-7 | 7.44 | 2.79 | 10.23 | Ceramic tile | lobby | 5.00 | 21.31 |
| P-8 | 7.44 | 2.76 | 10.20 | PVC tile | shope | 5.00 | 21.27 |
| P-9 | 7.44 | 0.25 | 7.69 | Ceramic tile | shope | 5.00 | 17.89 |

3.3rd to 7th floor design load

| Panel | Slab self-weight | Partition wall load | Total self-weight | Floor finish type | Function | (LL) | Pd=1.35DL+1.5LL |
|-------|------------------|---------------------|-------------------|-------------------|------------|------|-----------------|
| S-1 | 9.23 | 1.65 | 10.88 | PVC tile | Guest room | 5.00 | 22.19 |
| S-2 | 9.23 | 1.59 | 10.82 | PVC tile | Guest room | 5.00 | 22.11 |
| S-3 | 9.23 | 1.46 | 10.69 | PVC tile | Guest room | 5.00 | 21.93 |
| S-4 | 9.23 | 2.52 | 11.75 | Marble | lobby | 5.00 | 23.36 |
| S-5 | 9.23 | 2.79 | 12.02 | PVC tile | Guest room | 5.00 | 23.72 |
| S-6 | 9.23 | 2.52 | 11.75 | Marble | lobby | 5.00 | 23.36 |
| S-7 | 9.23 | 2.79 | 12.02 | PVC tile | Guest room | 5.00 | 23.72 |
| S-8 | 9.23 | 2.76 | 11.99 | Marble | lobby | 5.00 | 23.69 |
| S-9 | 9.23 | 0.25 | 9.48 | PVC tile | Guest room | 5.00 | 20.30 |

4.8th floor design load

| Panel | Slab self-weight | Partition wall load | Total self-weight | Floor finish type | Function | Live load (LL) | Pd=1.35DL+1.5LL |
|-------|------------------|---------------------|-------------------|-------------------|-----------|----------------|-----------------|
| T-1 | 9.23 | 1.65 | 10.88 | PVC tile | GYM | 5.00 | 22.19 |
| T-2 | 9.23 | 1.59 | 10.82 | Ceramic tile | WC ladies | 5.00 | 22.11 |
| T-3 | 9.23 | 1.46 | 10.69 | PVC tile | GYM | 5.00 | 21.93 |
| T-4 | 9.23 | 2.52 | 11.75 | PVC tile | Bath room | 2.00 | 18.86 |
| T-5 | 9.23 | 2.79 | 12.02 | PVC tile | Story | 5.00 | 23.72 |
| T-6 | 9.23 | 2.52 | 11.75 | PVC tile | Bath room | 2.00 | 18.86 |
| T-7 | 9.23 | 2.79 | 12.02 | PVC tile | Office | 5.00 | 23.72 |
| T-8 | 9.23 | 2.76 | 11.99 | PVC tile | Office | 5.00 | 23.69 |
| T-9 | 9.23 | 0.25 | 9.48 | Marble | Terrace | 5.00 | 20.30 |

Appendix J

Unadjusted moment for ground floor

| panel | support condition | lx | lx ² | Pd | LY | LY/Lx | Moment | | Moment location | moment Mi= |
|-------|------------------------|------|-----------------|-------|-----|-------|--------------|-------|-----------------|------------|
| | | | | | | | location | value | | |
| W-1 | All Edge discontinuous | 3 | 9.00 | 19.77 | 5.2 | 1.73 | β_{xs} | 0.047 | $M_{xs} =$ | 8.36 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 1.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 8.01 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 6.05 |
| W-2 | All Edge discontinuous | 3 | 9.00 | 19.69 | 5.7 | 1.90 | β_{xs} | 0.031 | $M_{xs} =$ | 5.49 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 1.23 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 5.67 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 4.25 |
| W-3 | All Edge discontinuous | 5.05 | 25.50 | 19.51 | 5.2 | 1.03 | β_{xs} | 0.031 | $M_{xs} =$ | 15.42 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.18 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 15.92 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 11.94 |
| W-4 | All Edge discontinuous | 5.05 | 25.50 | 20.94 | 5.7 | 1.13 | β_{xs} | 0.031 | $M_{xs} =$ | 16.55 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.49 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 17.09 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 12.82 |
| W-5 | All Edge discontinuous | 5.05 | 25.50 | 16.81 | 5.2 | 1.03 | β_{xs} | 0.031 | $M_{xs} =$ | 13.29 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.18 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 13.72 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 10.29 |
| W-6 | All Edge discontinuous | 5 | 25.00 | 20.94 | 5.2 | 1.04 | β_{xs} | 0.047 | $M_{xs} =$ | 24.60 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 4.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 23.56 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 17.80 |
| W-7 | All Edge discontinuous | 5 | 25.00 | 21.37 | 5.2 | 1.04 | β_{xs} | 0.047 | $M_{xs} =$ | 25.11 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 4.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 24.04 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 18.16 |
| W-8 | All Edge discontinuous | 5 | 25.00 | 21.27 | 5.2 | 1.04 | β_{xs} | 0.039 | $M_{xs} =$ | 20.74 |
| | | | | | | | β_{xf} | 0.029 | $M_{xf} =$ | 3.77 |
| | | | | | | | β_{ys} | 0.037 | $M_{ys} =$ | 19.67 |
| | | | | | | | β_{yf} | 0.028 | $M_{yf} =$ | 14.89 |
| W-9 | All Edge discontinuous | 5 | 25.00 | 17.89 | 5.7 | 1.14 | β_{xs} | 0.031 | $M_{xs} =$ | 13.86 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.42 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 14.31 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 10.73 |

2.1st and 2nd floor design moment

| panel | support condition | lx | lx ² | Pd | LY | LY/Lx | Moment | | Moment location | moment Mi= |
|-------|------------------------|------|-----------------|------|-----|-------|--------------|-------|-----------------|------------|
| | | | | | | | location | value | | |
| T-1 | All Edge discontinuous | 3 | 9.00 | 22.2 | 5.2 | 1.73 | β_{xs} | 0.047 | $M_{xs} =$ | 9.39 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 1.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 8.99 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 6.79 |
| T-2 | All Edge discontinuous | 3 | 9.00 | 22.1 | 5.7 | 1.90 | β_{xs} | 0.031 | $M_{xs} =$ | 6.17 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 1.23 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 6.36 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 4.77 |
| T-3 | All Edge discontinuous | 5.05 | 25.50 | 21.9 | 5.2 | 1.03 | β_{xs} | 0.031 | $M_{xs} =$ | 17.31 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.18 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 17.87 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 13.40 |
| T-4 | All Edge discontinuous | 5.05 | 25.50 | 18.8 | 5.7 | 1.13 | β_{xs} | 0.031 | $M_{xs} =$ | 14.86 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.49 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 15.34 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 11.51 |
| T-5 | All Edge discontinuous | 5.05 | 25.50 | 23.7 | 5.2 | 1.03 | β_{xs} | 0.031 | $M_{xs} =$ | 18.74 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.18 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 19.34 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 14.51 |
| T-6 | All Edge discontinuous | 5 | 25.00 | 18.9 | 5.2 | 1.04 | β_{xs} | 0.047 | $M_{xs} =$ | 22.21 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 4.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 21.26 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 16.07 |
| T-7 | All Edge discontinuous | 5 | 25.00 | 23.7 | 5.2 | 1.04 | β_{xs} | 0.047 | $M_{xs} =$ | 27.85 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 4.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 26.66 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 20.15 |
| T-8 | All Edge discontinuous | 5 | 25.00 | 23.7 | 5.2 | 1.04 | β_{xs} | 0.039 | $M_{xs} =$ | 23.11 |
| | | | | | | | β_{xf} | 0.029 | $M_{xf} =$ | 3.77 |
| | | | | | | | β_{ys} | 0.037 | $M_{ys} =$ | 21.92 |
| | | | | | | | β_{yf} | 0.028 | $M_{yf} =$ | 16.59 |
| T-9 | All Edge discontinuous | 5 | 25.00 | 20.3 | 5.7 | 1.14 | β_{xs} | 0.031 | $M_{xs} =$ | 15.73 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.42 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 16.24 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 12.18 |

4. 3rd to 7th design moment

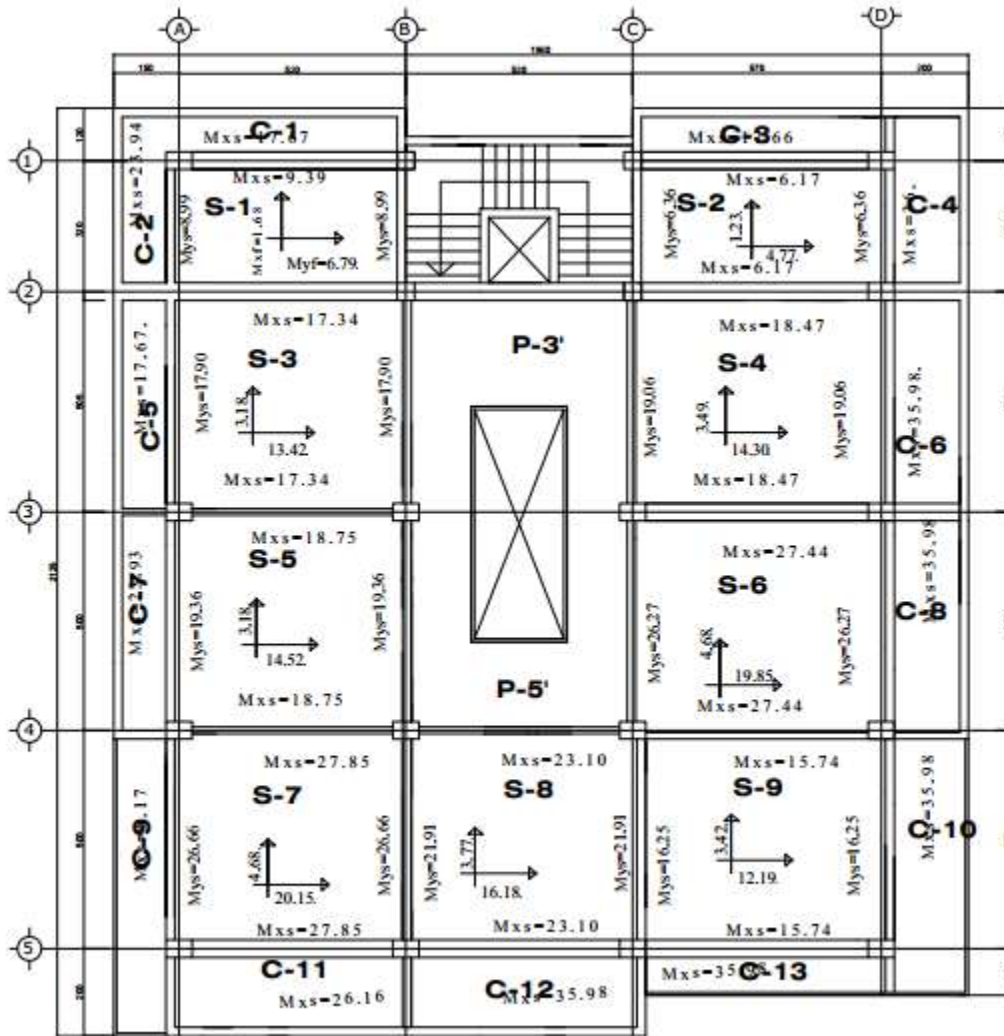
| panel | support condition | lx | lx ² | Pd | LY | LY/Lx | Moment | | Moment location | moment Mi= |
|-------|------------------------|------|-----------------|-------|-----|-------|--------------|-------|-----------------|------------|
| | | | | | | | location | value | | |
| S-1 | All Edge discontinuous | 3 | 9.00 | 22.19 | 5.2 | 1.73 | β_{xs} | 0.047 | $M_{xs} =$ | 9.39 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 1.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 8.99 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 6.79 |
| S-2 | All Edge discontinuous | 3 | 9.00 | 22.11 | 5.7 | 1.90 | β_{xs} | 0.031 | $M_{xs} =$ | 6.17 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 1.23 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 6.37 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 4.78 |
| S-3 | All Edge discontinuous | 5.05 | 25.50 | 21.93 | 5.2 | 1.03 | β_{xs} | 0.031 | $M_{xs} =$ | 17.34 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.18 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 17.90 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 13.42 |
| S-4 | All Edge discontinuous | 5.05 | 25.50 | 23.36 | 5.7 | 1.13 | β_{xs} | 0.031 | $M_{xs} =$ | 18.47 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.49 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 19.06 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 14.30 |
| S-5 | All Edge discontinuous | 5.05 | 25.50 | 23.72 | 5.2 | 1.03 | β_{xs} | 0.031 | $M_{xs} =$ | 18.75 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.18 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 19.36 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 14.52 |
| S-6 | All Edge discontinuous | 5 | 25.00 | 23.35 | 5.2 | 1.04 | β_{xs} | 0.047 | $M_{xs} =$ | 27.44 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 4.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 26.27 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 19.85 |
| S-7 | All Edge discontinuous | 5 | 25.00 | 23.72 | 5.2 | 1.04 | β_{xs} | 0.047 | $M_{xs} =$ | 27.87 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 4.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 26.69 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 20.16 |
| S-8 | All Edge discontinuous | 5 | 25.00 | 23.69 | 5.2 | 1.04 | β_{xs} | 0.039 | $M_{xs} =$ | 23.10 |
| | | | | | | | β_{xf} | 0.029 | $M_{xf} =$ | 3.77 |
| | | | | | | | β_{ys} | 0.037 | $M_{ys} =$ | 21.91 |
| | | | | | | | β_{yf} | 0.028 | $M_{yf} =$ | 16.58 |
| S-9 | All Edge discontinuous | 5 | 25.00 | 20.31 | 5.7 | 1.14 | β_{xs} | 0.031 | $M_{xs} =$ | 15.74 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.42 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 16.25 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 12.19 |

4 8th floor un adjusted moment

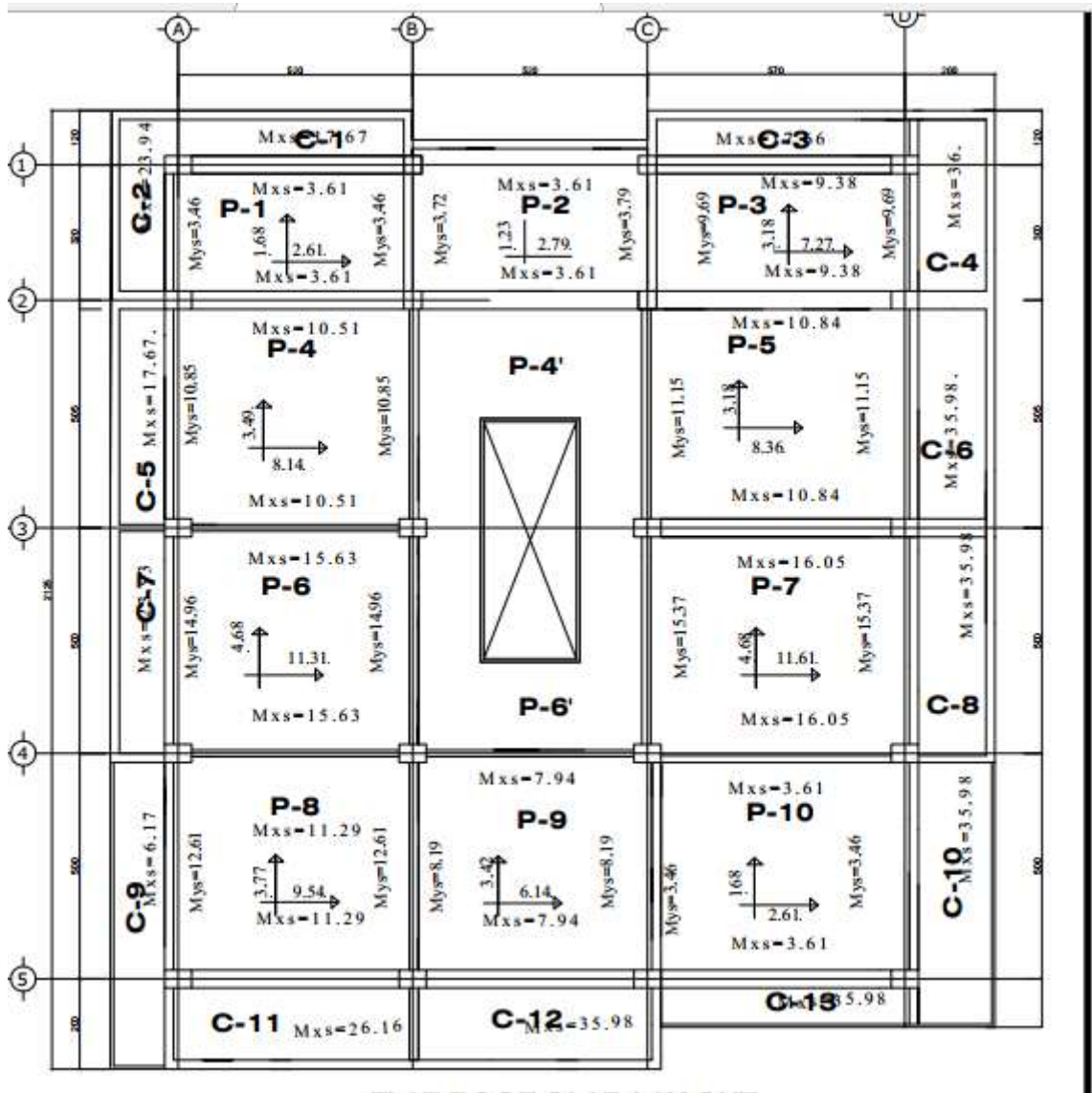
| panel | support condition | lx | lx ² | Pd | LY | LY/Lx | Moment | | Moment location | moment Mi= |
|-------|------------------------|------|-----------------|------|-----|-------|--------------|-------|-----------------|------------|
| | | | | | | | location | value | | |
| T-1 | All Edge discontinuous | 3 | 9.00 | 22.2 | 5.2 | 1.73 | β_{xs} | 0.047 | $M_{xs} =$ | 9.39 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 1.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 8.99 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 6.79 |
| T-2 | All Edge discontinuous | 3 | 9.00 | 22.1 | 5.7 | 1.90 | β_{xs} | 0.031 | $M_{xs} =$ | 6.17 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 1.23 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 6.36 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 4.77 |
| T-3 | All Edge discontinuous | 5.05 | 25.50 | 21.9 | 5.2 | 1.03 | β_{xs} | 0.031 | $M_{xs} =$ | 17.31 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.18 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 17.87 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 13.40 |
| T-4 | All Edge discontinuous | 5.05 | 25.50 | 18.8 | 5.7 | 1.13 | β_{xs} | 0.031 | $M_{xs} =$ | 14.86 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.49 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 15.34 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 11.51 |
| T-5 | All Edge discontinuous | 5.05 | 25.50 | 23.7 | 5.2 | 1.03 | β_{xs} | 0.031 | $M_{xs} =$ | 18.74 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.18 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 19.34 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 14.51 |
| T-6 | All Edge discontinuous | 5 | 25.00 | 18.9 | 5.2 | 1.04 | β_{xs} | 0.047 | $M_{xs} =$ | 22.21 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 4.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 21.26 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 16.07 |
| T-7 | All Edge discontinuous | 5 | 25.00 | 23.7 | 5.2 | 1.04 | β_{xs} | 0.047 | $M_{xs} =$ | 27.85 |
| | | | | | | | β_{xf} | 0.036 | $M_{xf} =$ | 4.68 |
| | | | | | | | β_{ys} | 0.045 | $M_{ys} =$ | 26.66 |
| | | | | | | | β_{yf} | 0.034 | $M_{yf} =$ | 20.15 |
| T-8 | All Edge discontinuous | 5 | 25.00 | 23.7 | 5.2 | 1.04 | β_{xs} | 0.039 | $M_{xs} =$ | 23.11 |
| | | | | | | | β_{xf} | 0.029 | $M_{xf} =$ | 3.77 |
| | | | | | | | β_{ys} | 0.037 | $M_{ys} =$ | 21.92 |
| | | | | | | | β_{yf} | 0.028 | $M_{yf} =$ | 16.59 |
| T-9 | All Edge discontinuous | 5 | 25.00 | 20.3 | 5.7 | 1.14 | β_{xs} | 0.031 | $M_{xs} =$ | 15.73 |
| | | | | | | | β_{xf} | 0.024 | $M_{xf} =$ | 3.42 |
| | | | | | | | β_{ys} | 0.032 | $M_{ys} =$ | 16.24 |
| | | | | | | | β_{yf} | 0.024 | $M_{yf} =$ | 12.18 |

Appendix K

1. Adjusted moment for 3rd-7th floor



3rd-7th FLOOR SLAB LAY OUT



Appendix j
1.coificiant of load transfer moment

| Type of Panel and location | β_{vx} for values of l_y/l_x | | | | | | | | β_{vy} |
|-----------------------------------------------------------------|--------------------------------------|------|------|------|------|------|------|------|--------------|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.75 | 2.0 | |
| Four edges continuous | | | | | | | | | |
| Continuous edge | 0.33 | 0.36 | 0.39 | 0.41 | 0.43 | 0.45 | 0.48 | 0.50 | 0.33 |
| One short edge discontinuous | | | | | | | | | |
| Continuous edge | 0.36 | 0.39 | 0.42 | 0.44 | 0.45 | 0.47 | 0.50 | 0.52 | 0.36 |
| Discontinuous edge | - | - | - | - | - | - | - | - | 0.24 |
| One long edge discontinuous | | | | | | | | | |
| Continuous edge | 0.36 | 0.40 | 0.44 | 0.47 | 0.49 | 0.51 | 0.55 | 0.59 | 0.36 |
| Discontinuous edge | 0.24 | 0.27 | 0.29 | 0.31 | 0.32 | 0.34 | 0.36 | 0.38 | - |
| Two adjacent edges discontinuous | | | | | | | | | |
| Continuous edge | 0.40 | 0.44 | 0.47 | 0.50 | 0.52 | 0.54 | 0.57 | 0.60 | 0.40 |
| Discontinuous edge | 0.26 | 0.29 | 0.31 | 0.33 | 0.34 | 0.35 | 0.38 | 0.40 | 0.26 |
| Two short edges discontinuous | | | | | | | | | |
| Continuous edge | 0.40 | 0.43 | 0.45 | 0.47 | 0.48 | 0.49 | 0.52 | 0.54 | - |
| Discontinuous edge | - | - | - | - | - | - | - | - | 0.26 |
| Two long edges discontinuous | | | | | | | | | |
| Continuous edge | - | - | - | - | - | - | - | - | 0.40 |
| Discontinuous edge | 0.26 | 0.30 | 0.33 | 0.36 | 0.38 | 0.40 | 0.44 | 0.47 | - |
| Three edges discontinuous (one long edge discontinuous) | | | | | | | | | |
| Continuous edge | 0.45 | 0.48 | 0.51 | 0.53 | 0.55 | 0.57 | 0.60 | 0.63 | - |
| Discontinuous edge | 0.30 | 0.32 | 0.34 | 0.35 | 0.36 | 0.37 | 0.39 | 0.41 | 0.29 |
| Three edges discontinuous (one short edge discontinuous) | | | | | | | | | |
| Continuous edge | - | - | - | - | - | - | - | - | 0.45 |
| Discontinuous edge | 0.29 | 0.33 | 0.36 | 0.38 | 0.40 | 0.42 | 0.45 | 0.48 | 0.30 |
| Four edges discontinuous | | | | | | | | | |
| Discontinuous edge | 0.33 | 0.36 | 0.39 | 0.41 | 0.43 | 0.45 | 0.48 | 0.50 | 0.33 |

Table 6

Appendix K

1.beam reinforcement for filatures

Axis 5-5

| Axes 5 -5 roof slab | | | | | | | | | | | | |
|---------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 14.38 | 400 | 0.00067 | 358 | 0.002 | 0.3 | 100.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 14.58 | 400 | 0.00067 | 358 | 0.002 | 0.3 | 101.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 24.05 | 400 | 0.00112 | 358 | 0.002 | 0.5 | 167.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 14.65 | 400 | 0.00068 | 358 | 0.002 | 0.3 | 102.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 26.24 | 400 | 0.00122 | 358 | 0.002 | 0.5 | 183.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 12.95 | 400 | 0.00060 | 358 | 0.002 | 0.3 | 90.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 24.69 | 400 | 0.00115 | 358 | 0.002 | 0.5 | 172.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Axes 5-5 8th floor | | | | | | | | | | | | |
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 13.69 | 300 | 0.00085 | 258 | 0.002 | 0.7 | 176.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 16.79 | 300 | 0.00104 | 258 | 0.002 | 0.8 | 216.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 28.84 | 300 | 0.00180 | 258 | 0.002 | 1.4 | 372.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 16.85 | 300 | 0.00104 | 258 | 0.002 | 0.8 | 217.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 31.59 | 300 | 0.00198 | 258 | 0.002 | 1.6 | 408.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 16.04 | 300 | 0.00099 | 258 | 0.002 | 0.8 | 207.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 31.4 | 300 | 0.00197 | 258 | 0.002 | 1.6 | 405.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 5 -5 7th floor | | | | | | | | | | | | |
|---------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 7.11 | 300 | 0.00044 | 258 | 0.002 | 0.4 | 91.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 17.86 | 300 | 0.00111 | 258 | 0.002 | 0.9 | 230.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 31.94 | 300 | 0.00200 | 258 | 0.002 | 1.6 | 412.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.28 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 236.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 35.14 | 300 | 0.00221 | 258 | 0.002 | 1.8 | 454.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 15.11 | 300 | 0.00093 | 258 | 0.002 | 0.8 | 195.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 31.97 | 300 | 0.00200 | 258 | 0.002 | 1.6 | 413.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axis 5-5 5th floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 5.65 | 300 | 0.00035 | 258 | 0.002 | 0.3 | 73.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.07 | 300 | 0.00125 | 258 | 0.002 | 1.0 | 259.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 38.24 | 300 | 0.00241 | 258 | 0.002 | 1.9 | 494.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.68 | 300 | 0.00122 | 258 | 0.002 | 1.0 | 254.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 40.64 | 300 | 0.00256 | 258 | 0.002 | 2.0 | 525.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 15.89 | 300 | 0.00098 | 258 | 0.002 | 0.8 | 205.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 36.78 | 300 | 0.00231 | 258 | 0.002 | 1.8 | 475.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 5 -5 4rd floor | | | | | | | | | | | | |
|---------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 9.44 | 300 | 0.00058 | 258 | 0.002 | 0.5 | 122.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.72 | 300 | 0.00129 | 258 | 0.002 | 1.0 | 267.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 40.41 | 300 | 0.00255 | 258 | 0.002 | 2.0 | 522.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 20.21 | 300 | 0.00125 | 258 | 0.002 | 1.0 | 261.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 42.53 | 300 | 0.00268 | 258 | 0.002 | 2.1 | 549.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 56.59 | 300 | 0.00361 | 258 | 0.002 | 2.8 | 731.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 38.23 | 300 | 0.00241 | 258 | 0.002 | 1.9 | 493.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 5 -5 3rd floor | | | | | | | | | | | | |
|---------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 11.18 | 300 | 0.00069 | 258 | 0.002 | 0.6 | 144.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.98 | 300 | 0.00130 | 258 | 0.002 | 1.1 | 271.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 41.42 | 300 | 0.00261 | 258 | 0.002 | 2.1 | 535.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 20.4 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 263.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 43.29 | 300 | 0.00273 | 258 | 0.002 | 2.2 | 559.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 16.99 | 300 | 0.00105 | 258 | 0.002 | 0.9 | 219.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 38.74 | 300 | 0.00244 | 258 | 0.002 | 1.9 | 500.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 5-5 2nd floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 10.99 | 300 | 0.00068 | 258 | 0.002 | 0.6 | 142.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 21.55 | 300 | 0.00134 | 258 | 0.002 | 1.1 | 278.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 42.41 | 300 | 0.00268 | 258 | 0.002 | 2.1 | 547.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 20.86 | 300 | 0.00130 | 258 | 0.002 | 1.0 | 269.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 43.74 | 300 | 0.00276 | 258 | 0.002 | 2.2 | 565.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 17.08 | 300 | 0.00106 | 258 | 0.002 | 0.9 | 220.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 38.5 | 300 | 0.00242 | 258 | 0.002 | 1.9 | 497.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 5-5 1st floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 5.79 | 300 | 0.00036 | 258 | 0.002 | 0.3 | 74.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.55 | 300 | 0.00128 | 258 | 0.002 | 1.0 | 265.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 39.57 | 300 | 0.00249 | 258 | 0.002 | 2.0 | 511.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.97 | 300 | 0.00124 | 258 | 0.002 | 1.0 | 258.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 40.63 | 300 | 0.00256 | 258 | 0.002 | 2.0 | 524.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 16.17 | 300 | 0.00100 | 258 | 0.002 | 0.8 | 208.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 36.16 | 300 | 0.00227 | 258 | 0.002 | 1.8 | 467.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 5-5 ground floor | | | | | | | | | | | | |
|-----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 10.44 | 400 | 0.00048 | 358 | 0.002 | 0.2 | 72.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 17.58 | 300 | 0.00109 | 358 | 0.002 | 0.5 | 163.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 31.15 | 300 | 0.00195 | 358 | 0.002 | 0.8 | 290.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 17.96 | 300 | 0.00111 | 358 | 0.002 | 0.5 | 167.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 29.51 | 300 | 0.00184 | 358 | 0.002 | 0.8 | 274.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 14.97 | 300 | 0.00093 | 358 | 0.002 | 0.4 | 139.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 25.98 | 300 | 0.00162 | 358 | 0.002 | 0.7 | 241.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

Table1.10

| Axes 3-3for roof slab | | | | | | | | | | | | |
|-----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 15.52 | 250 | 0.00116 | 258 | 0.002 | 0.9 | 240.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 15.52 | 250 | 0.00116 | 258 | 0.002 | 0.9 | 240.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 23.38 | 250 | 0.00175 | 258 | 0.002 | 1.4 | 362.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 250 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 23.08 | 250 | 0.00173 | 258 | 0.002 | 1.4 | 357.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 17.72 | 250 | 0.00132 | 258 | 0.002 | 1.1 | 274.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 30.54 | 250 | 0.00230 | 258 | 0.002 | 1.8 | 473.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| 8th floor | | | | | | | | | | | | |
|-----------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 19.87 | 300 | 0.00123 | 258 | 0.002 | 1.0 | 256.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 17.62 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 227.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 28.66 | 300 | 0.00179 | 258 | 0.002 | 1.4 | 370.3 | 274.20 | 560.90 | 1.78 | 2Ø18 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | C | 26.17 | 300 | 0.00163 | 258 | 0.002 | 1.3 | 338.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 19.89 | 300 | 0.00123 | 258 | 0.002 | 1.0 | 257.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 33.06 | 300 | 0.00207 | 258 | 0.002 | 1.7 | 427.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| 7th floor | | | | | | | | | | | | |
|-----------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 20.31 | 300 | 0.00126 | 258 | 0.002 | 1.0 | 262.4 | 274.20 | 560.90 | 1.78 | 2Ø18 |
| Span | AB | 18.21 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 235.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 30.1 | 300 | 0.00188 | 258 | 0.002 | 1.5 | 388.9 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 22.42 | 300 | 0.00139 | 258 | 0.002 | 1.1 | 289.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 20.31 | 300 | 0.00126 | 258 | 0.002 | 1.0 | 262.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 33.76 | 300 | 0.00212 | 258 | 0.002 | 1.7 | 436.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| 6th floor | | | | | | | | | | | | |
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | A | 20.73 | 300 | 0.00129 | 258 | 0.002 | 1.0 | 267.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 18.76 | 300 | 0.00116 | 258 | 0.002 | 0.9 | 242.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 31.93 | 300 | 0.00200 | 258 | 0.002 | 1.6 | 412.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 18.96 | 300 | 0.00118 | 258 | 0.002 | 0.9 | 245.0 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Span | CD | 20.61 | 300 | 0.00128 | 258 | 0.002 | 1.0 | 266.3 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | D | 35.32 | 300 | 0.00222 | 258 | 0.002 | 1.8 | 456.3 | 274.20 | 560.90 | 1.78 | 2Ø20 |

| 5th floor | | | | | | | | | | | | |
|-----------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | A | 21.17 | 300 | 0.00132 | 258 | 0.002 | 1.1 | 273.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 19.18 | 300 | 0.00119 | 258 | 0.002 | 1.0 | 247.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 33.15 | 300 | 0.00208 | 258 | 0.002 | 1.7 | 428.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | C | 15.75 | 300 | 0.00097 | 258 | 0.002 | 0.8 | 203.5 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Span | CD | 20.85 | 300 | 0.00130 | 258 | 0.002 | 1.0 | 269.4 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | D | 36.71 | 300 | 0.00231 | 258 | 0.002 | 1.8 | 474.3 | 274.20 | 560.90 | 1.78 | 2Ø20 |

| 4th floor | | | | | | | | | | | | |
|-----------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | A | 21.25 | 300 | 0.00132 | 258 | 0.002 | 1.1 | 274.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 19.37 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 250.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 34.14 | 300 | 0.00214 | 258 | 0.002 | 1.7 | 441.1 | 274.20 | 560.90 | 1.78 | 2Ø18 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø18 |
| Support | C | 12.66 | 300 | 0.00078 | 258 | 0.002 | 0.6 | 163.6 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Span | CD | 21.04 | 300 | 0.00131 | 258 | 0.002 | 1.1 | 271.8 | 274.20 | 560.90 | 1.78 | 2Ø20 |
| Support | D | 37.49 | 300 | 0.00236 | 258 | 0.002 | 1.9 | 484.4 | 274.20 | 560.90 | 1.78 | 2Ø20 |

| 3rd floor | | | | | | | | | | | | |
|-----------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 22.76 | 300 | 0.00142 | 258 | 0.002 | 1.1 | 294.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.53 | 300 | 0.00128 | 258 | 0.002 | 1.0 | 265.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 38.87 | 300 | 0.00245 | 258 | 0.002 | 1.9 | 502.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.26 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 248.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.56 | 300 | 0.00243 | 258 | 0.002 | 1.9 | 498.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.33 | 300 | 0.00133 | 258 | 0.002 | 1.1 | 275.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 42.24 | 300 | 0.00267 | 258 | 0.002 | 2.1 | 545.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| 2nd floor | | | | | | | | | | | | |
|-----------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 23.02 | 300 | 0.00143 | 258 | 0.002 | 1.2 | 297.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 20.7 | 300 | 0.00129 | 258 | 0.002 | 1.0 | 267.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 39.2 | 300 | 0.00247 | 258 | 0.002 | 2.0 | 506.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.27 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 249.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 38.74 | 300 | 0.00244 | 258 | 0.002 | 1.9 | 500.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 21.38 | 300 | 0.00133 | 258 | 0.002 | 1.1 | 276.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 42.24 | 300 | 0.00267 | 258 | 0.002 | 2.1 | 545.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| ground floor | | | | | | | | | | | | |
|--------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 21.03 | 400 | 0.00098 | 258 | 0.002 | 0.8 | 203.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 17.84 | 400 | 0.00083 | 258 | 0.002 | 0.7 | 172.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 26.67 | 400 | 0.00124 | 258 | 0.002 | 1.0 | 258.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.84 | 400 | 0.00087 | 258 | 0.002 | 0.7 | 182.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 30.03 | 400 | 0.00140 | 258 | 0.002 | 1.1 | 291.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 19.61 | 400 | 0.00091 | 258 | 0.002 | 0.7 | 190.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 32.49 | 400 | 0.00152 | 258 | 0.002 | 1.2 | 314.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |

Axis 2-2

| Axes 2-2 roof slab | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.76 | 400 | 0.00082 | 358 | 0.002 | 0.3 | 124.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 13.77 | 400 | 0.00064 | 358 | 0.002 | 0.3 | 96.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 22.16 | 400 | 0.00103 | 358 | 0.002 | 0.4 | 154.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 4.59 | 400 | 0.00021 | 358 | 0.002 | 0.1 | 32.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 19.49 | 400 | 0.00090 | 358 | 0.002 | 0.4 | 136.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 16.61 | 400 | 0.00077 | 358 | 0.002 | 0.3 | 116.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 27.36 | 400 | 0.00127 | 358 | 0.002 | 0.5 | 191.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axis 2-2 8th floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 19.7 | 300 | 0.00122 | 258 | 0.002 | 1.0 | 254.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 15.6 | 300 | 0.00097 | 258 | 0.002 | 0.8 | 201.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 25.86 | 300 | 0.00161 | 258 | 0.002 | 1.3 | 334.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 3.49 | 300 | 0.00021 | 258 | 0.002 | 0.2 | 45.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 26.43 | 300 | 0.00165 | 258 | 0.002 | 1.3 | 341.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 18.22 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 235.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 30.08 | 300 | 0.00188 | 258 | 0.002 | 1.5 | 388.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 2 for 7th floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.59 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 227.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 16.5 | 300 | 0.00102 | 258 | 0.002 | 0.8 | 213.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 26.61 | 300 | 0.00166 | 258 | 0.002 | 1.3 | 343.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.72 | 300 | 0.00122 | 258 | 0.002 | 1.0 | 254.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 19.32 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 249.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 18.52 | 300 | 0.00115 | 258 | 0.002 | 0.9 | 239.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 30.23 | 300 | 0.00189 | 258 | 0.002 | 1.5 | 390.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 2 for 6th floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 18.08 | 300 | 0.00112 | 258 | 0.002 | 0.9 | 233.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 16 | 300 | 0.00099 | 258 | 0.002 | 0.8 | 206.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 26.78 | 300 | 0.00167 | 258 | 0.002 | 1.3 | 346.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 1.86 | 300 | 0.00011 | 258 | 0.002 | 0.1 | 24.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 24.15 | 300 | 0.00150 | 258 | 0.002 | 1.2 | 312.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 18.37 | 300 | 0.00114 | 258 | 0.002 | 0.9 | 237.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 29.47 | 300 | 0.00184 | 258 | 0.002 | 1.5 | 380.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 2 for 5th floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 16.47 | 300 | 0.00102 | 258 | 0.002 | 0.8 | 212.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 16.39 | 300 | 0.00102 | 258 | 0.002 | 0.8 | 211.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 27.71 | 300 | 0.00173 | 258 | 0.002 | 1.4 | 358.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 11.67 | 300 | 0.00072 | 258 | 0.002 | 0.6 | 150.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 22.37 | 300 | 0.00139 | 258 | 0.002 | 1.1 | 289.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 18.59 | 300 | 0.00115 | 258 | 0.002 | 0.9 | 240.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 29.57 | 300 | 0.00185 | 258 | 0.002 | 1.5 | 382.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 2 for 4th floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.24 | 300 | 0.00107 | 258 | 0.002 | 0.9 | 222.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 16.69 | 300 | 0.00103 | 258 | 0.002 | 0.8 | 215.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 27.05 | 300 | 0.00169 | 258 | 0.002 | 1.4 | 349.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 16.68 | 300 | 0.00103 | 258 | 0.002 | 0.8 | 215.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 19.35 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 250.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 18.55 | 300 | 0.00115 | 258 | 0.002 | 0.9 | 239.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 29.29 | 300 | 0.00183 | 258 | 0.002 | 1.5 | 378.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 2 for 3rd floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.45 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 225.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 16.59 | 300 | 0.00103 | 258 | 0.002 | 0.8 | 214.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 26.91 | 300 | 0.00168 | 258 | 0.002 | 1.3 | 347.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 18.04 | 300 | 0.00112 | 258 | 0.002 | 0.9 | 233.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 18.07 | 300 | 0.00112 | 258 | 0.002 | 0.9 | 233.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 18.24 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 235.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 29.95 | 300 | 0.00187 | 258 | 0.002 | 1.5 | 387.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 2 for 2nd floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.54 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 16.69 | 300 | 0.00103 | 258 | 0.002 | 0.8 | 215.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 26.95 | 300 | 0.00168 | 258 | 0.002 | 1.3 | 348.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 17.79 | 300 | 0.00110 | 258 | 0.002 | 0.9 | 229.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 17.54 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 18.3 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 236.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 30.03 | 300 | 0.00188 | 258 | 0.002 | 1.5 | 388.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 2 for 1st floor | | | | | | | | | | | | |
|----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.72 | 300 | 0.00110 | 258 | 0.002 | 0.9 | 228.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 16.72 | 300 | 0.00104 | 258 | 0.002 | 0.8 | 216.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 27.16 | 300 | 0.00169 | 258 | 0.002 | 1.4 | 350.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 19.13 | 300 | 0.00119 | 258 | 0.002 | 1.0 | 247.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 17.91 | 300 | 0.00111 | 258 | 0.002 | 0.9 | 231.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 18.52 | 300 | 0.00115 | 258 | 0.002 | 0.9 | 239.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 30.49 | 300 | 0.00191 | 258 | 0.002 | 1.5 | 393.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 2 forground floor | | | | | | | | | | | | |
|------------------------|----------|--------|-----|---------|-------|-------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρcal | d(mm) | ρmin | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.38 | 400 | 0.00081 | 358 | 0.002 | 0.3 | 121.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 15.39 | 300 | 0.00095 | 358 | 0.002 | 0.4 | 143.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 24.25 | 300 | 0.00151 | 358 | 0.002 | 0.6 | 225.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 16.65 | 300 | 0.00103 | 358 | 0.002 | 0.4 | 155.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 20.48 | 300 | 0.00127 | 358 | 0.002 | 0.5 | 190.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 17.53 | 300 | 0.00109 | 358 | 0.002 | 0.5 | 163.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 30.38 | 300 | 0.00190 | 358 | 0.002 | 0.8 | 282.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

Axis 1-1

| Axes 1 for roof slab | | | | | | | | | | | | |
|----------------------|----------|--------|-----|---------|-------|-------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρcal | d(mm) | ρmin | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.15 | 400 | 0.00079 | 358 | 0.002 | 0.3 | 119.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 11.58 | 400 | 0.00054 | 358 | 0.002 | 0.2 | 80.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 14.47 | 400 | 0.00067 | 358 | 0.002 | 0.3 | 101.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 400 | 0.00000 | 358 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 16.59 | 400 | 0.00077 | 358 | 0.002 | 0.3 | 115.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 13.59 | 400 | 0.00063 | 358 | 0.002 | 0.3 | 94.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 20.47 | 400 | 0.00095 | 358 | 0.002 | 0.4 | 142.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| 8th floor | | | | | | | | | | | | |
|-----------|----------|--------|-----|---------|-------|-------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρcal | d(mm) | ρmin | K | Z(mm) | As | S | N | REMARK |
| Support | A | 19.27 | 300 | 0.00120 | 258 | 0.002 | 1.0 | 249.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 12.62 | 300 | 0.00078 | 258 | 0.002 | 0.6 | 163.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 17.11 | 300 | 0.00106 | 258 | 0.002 | 0.9 | 221.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 14.78 | 300 | 0.00091 | 258 | 0.002 | 0.7 | 191.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 23.22 | 300 | 0.00144 | 258 | 0.002 | 1.2 | 300.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 18.15 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 234.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 1-1 7th floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 18.15 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 234.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 12.67 | 300 | 0.00078 | 258 | 0.002 | 0.6 | 163.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 18.08 | 300 | 0.00112 | 258 | 0.002 | 0.9 | 233.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 20.93 | 300 | 0.00130 | 258 | 0.002 | 1.0 | 270.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 14.77 | 300 | 0.00091 | 258 | 0.002 | 0.7 | 190.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 23.37 | 300 | 0.00145 | 258 | 0.002 | 1.2 | 301.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 1-1 6th floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 19.87 | 300 | 0.00123 | 258 | 0.002 | 1.0 | 256.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 15.08 | 300 | 0.00093 | 258 | 0.002 | 0.8 | 194.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 23.89 | 300 | 0.00149 | 258 | 0.002 | 1.2 | 308.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 19.75 | 300 | 0.00123 | 258 | 0.002 | 1.0 | 255.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 15.08 | 300 | 0.00093 | 258 | 0.002 | 0.8 | 194.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 23.89 | 300 | 0.00149 | 258 | 0.002 | 1.2 | 308.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 1-1 5th floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 17.19 | 300 | 0.00107 | 258 | 0.002 | 0.9 | 222.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 12.65 | 300 | 0.00078 | 258 | 0.002 | 0.6 | 163.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 18.36 | 300 | 0.00114 | 258 | 0.002 | 0.9 | 237.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 20.25 | 300 | 0.00126 | 258 | 0.002 | 1.0 | 261.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 14.97 | 300 | 0.00093 | 258 | 0.002 | 0.7 | 193.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 23.95 | 300 | 0.00149 | 258 | 0.002 | 1.2 | 309.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 1-1 4th floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 15.08 | 300 | 0.00093 | 258 | 0.002 | 0.8 | 194.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 11.97 | 300 | 0.00074 | 258 | 0.002 | 0.6 | 154.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 19.65 | 300 | 0.00122 | 258 | 0.002 | 1.0 | 253.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 20.51 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 265.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 14.62 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 23.06 | 300 | 0.00143 | 258 | 0.002 | 1.2 | 297.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 1-1 3rd floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 15.61 | 300 | 0.00097 | 258 | 0.002 | 0.8 | 201.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 12.18 | 300 | 0.00075 | 258 | 0.002 | 0.6 | 157.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 18.87 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 243.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 21.66 | 300 | 0.00135 | 258 | 0.002 | 1.1 | 279.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 14.36 | 300 | 0.00089 | 258 | 0.002 | 0.7 | 185.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 22.69 | 300 | 0.00141 | 258 | 0.002 | 1.1 | 293.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axis 1-1 2nd floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 14.93 | 300 | 0.00092 | 258 | 0.002 | 0.7 | 192.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 11.97 | 300 | 0.00074 | 258 | 0.002 | 0.6 | 154.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 19.68 | 300 | 0.00122 | 258 | 0.002 | 1.0 | 254.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 20.01 | 300 | 0.00124 | 258 | 0.002 | 1.0 | 258.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 14.61 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 23.28 | 300 | 0.00145 | 258 | 0.002 | 1.2 | 300.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 1-1 1st floor | | | | | | | | | | | | |
|--------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 15.02 | 300 | 0.00093 | 258 | 0.002 | 0.8 | 194.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 11.99 | 300 | 0.00074 | 258 | 0.002 | 0.6 | 154.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 19.74 | 300 | 0.00123 | 258 | 0.002 | 1.0 | 255.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 258 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 19.53 | 300 | 0.00121 | 258 | 0.002 | 1.0 | 252.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 14.53 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 187.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 23.43 | 300 | 0.00146 | 258 | 0.002 | 1.2 | 302.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes 1-1 ground floor | | | | | | | | | | | | |
|-----------------------|----------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | Location | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | REMARK |
| Support | A | 13.94 | 400 | 0.00064 | 358 | 0.002 | 0.3 | 97.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | AB | 11.48 | 300 | 0.00071 | 358 | 0.002 | 0.3 | 106.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | B | 18.75 | 300 | 0.00116 | 358 | 0.002 | 0.5 | 174.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | BC | 0 | 300 | 0.00000 | 358 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | C | 13.54 | 300 | 0.00084 | 358 | 0.002 | 0.4 | 126.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | CD | 20.96 | 300 | 0.00130 | 358 | 0.002 | 0.5 | 195.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | D | 30.38 | 300 | 0.00190 | 358 | 0.002 | 0.8 | 282.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |

Axis A-A

| Axes A-A for roof slab | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 30.34 | 400 | 0.00142 | 358 | 0.002 | 0.6 | 211.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 11.46 | 400 | 0.00053 | 358 | 0.002 | 0.2 | 80.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 14.47 | 400 | 0.00067 | 358 | 0.002 | 0.3 | 101.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 12.4 | 400 | 0.00057 | 358 | 0.002 | 0.2 | 86.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 22.31 | 400 | 0.00104 | 358 | 0.002 | 0.4 | 155.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 13.07 | 400 | 0.00060 | 358 | 0.002 | 0.3 | 91.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 16.4 | 400 | 0.00076 | 358 | 0.002 | 0.3 | 114.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 4.14 | 400 | 0.00019 | 358 | 0.002 | 0.1 | 28.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 1 | 5.95 | 400 | 0.00027 | 358 | 0.002 | 0.1 | 41.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes A-A for 8th slab | | | | | | | | | | | | |
|-----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 32.45 | 300 | 0.00203 | 258 | 0.002 | 1.6 | 419.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 13.32 | 300 | 0.00082 | 258 | 0.002 | 0.7 | 172.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 25.44 | 300 | 0.00159 | 258 | 0.002 | 1.3 | 328.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.93 | 300 | 0.00086 | 258 | 0.002 | 0.7 | 180.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.44 | 300 | 0.00159 | 258 | 0.002 | 1.3 | 328.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.35 | 300 | 0.00089 | 258 | 0.002 | 0.7 | 185.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 17.46 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 225.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 5.26 | 300 | 0.00032 | 258 | 0.002 | 0.3 | 68.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 1 | 4.75 | 300 | 0.00029 | 258 | 0.002 | 0.2 | 61.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes A-A for 7 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 30.67 | 300 | 0.00192 | 258 | 0.002 | 1.5 | 396.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 13.32 | 300 | 0.00082 | 258 | 0.002 | 0.7 | 172.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 25.14 | 300 | 0.00157 | 258 | 0.002 | 1.3 | 324.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.31 | 300 | 0.00082 | 258 | 0.002 | 0.7 | 172.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.55 | 300 | 0.00159 | 258 | 0.002 | 1.3 | 330.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.47 | 300 | 0.00089 | 258 | 0.002 | 0.7 | 187.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 15.63 | 300 | 0.00097 | 258 | 0.002 | 0.8 | 201.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 14.47 | 300 | 0.00089 | 258 | 0.002 | 0.7 | 187.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 1 | 5.98 | 300 | 0.00037 | 258 | 0.002 | 0.3 | 77.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes A-A for 6 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 28.95 | 300 | 0.00181 | 258 | 0.002 | 1.4 | 374.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.98 | 300 | 0.00080 | 258 | 0.002 | 0.7 | 167.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 25.44 | 300 | 0.00159 | 258 | 0.002 | 1.3 | 328.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.94 | 300 | 0.00086 | 258 | 0.002 | 0.7 | 180.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.96 | 300 | 0.00162 | 258 | 0.002 | 1.3 | 335.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.54 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 187.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 12.75 | 300 | 0.00079 | 258 | 0.002 | 0.6 | 164.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 6.84 | 300 | 0.00042 | 258 | 0.002 | 0.3 | 88.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 1 | 2.77 | 300 | 0.00017 | 258 | 0.002 | 0.1 | 35.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes A-A for 5 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 27.16 | 300 | 0.00169 | 258 | 0.002 | 1.4 | 350.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.79 | 300 | 0.00079 | 258 | 0.002 | 0.6 | 165.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 25.85 | 300 | 0.00161 | 258 | 0.002 | 1.3 | 334.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.57 | 300 | 0.00084 | 258 | 0.002 | 0.7 | 175.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 26.76 | 300 | 0.00167 | 258 | 0.002 | 1.3 | 345.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.56 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 11 | 300 | 0.00068 | 258 | 0.002 | 0.6 | 142.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 7.76 | 300 | 0.00048 | 258 | 0.002 | 0.4 | 100.3 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 7.19 | 300 | 0.00044 | 258 | 0.002 | 0.4 | 92.9 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for 4th floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 24.78 | 300 | 0.00154 | 258 | 0.002 | 1.2 | 320.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.8 | 300 | 0.00079 | 258 | 0.002 | 0.6 | 165.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 24.76 | 300 | 0.00154 | 258 | 0.002 | 1.2 | 319.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.49 | 300 | 0.00083 | 258 | 0.002 | 0.7 | 174.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.41 | 300 | 0.00158 | 258 | 0.002 | 1.3 | 328.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.67 | 300 | 0.00091 | 258 | 0.002 | 0.7 | 189.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 12.28 | 300 | 0.00076 | 258 | 0.002 | 0.6 | 158.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 12.28 | 300 | 0.00076 | 258 | 0.002 | 0.6 | 158.7 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 12.28 | 300 | 0.00076 | 258 | 0.002 | 0.6 | 158.7 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for 3rdslab | | | | | | | | | | | | |
|----------------------|------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/on | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 24.85 | 300 | 0.00155 | 258 | 0.002 | 1.2 | 321.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.8 | 300 | 0.00079 | 258 | 0.002 | 0.6 | 165.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 25.14 | 300 | 0.00157 | 258 | 0.002 | 1.3 | 324.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.45 | 300 | 0.00083 | 258 | 0.002 | 0.7 | 173.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.97 | 300 | 0.00162 | 258 | 0.002 | 1.3 | 335.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.69 | 300 | 0.00091 | 258 | 0.002 | 0.7 | 189.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 11 | 300 | 0.00068 | 258 | 0.002 | 0.6 | 142.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 56 | 300 | 0.00357 | 258 | 0.002 | 2.8 | 723.5 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 14.16 | 300 | 0.00088 | 258 | 0.002 | 0.7 | 182.9 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for 2ndslab | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 24.35 | 300 | 0.00152 | 258 | 0.002 | 1.2 | 314.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.78 | 300 | 0.00079 | 258 | 0.002 | 0.6 | 165.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 24.57 | 300 | 0.00153 | 258 | 0.002 | 1.2 | 317.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.49 | 300 | 0.00083 | 258 | 0.002 | 0.7 | 174.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.72 | 300 | 0.00160 | 258 | 0.002 | 1.3 | 332.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.71 | 300 | 0.00091 | 258 | 0.002 | 0.7 | 190.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 11.66 | 300 | 0.00072 | 258 | 0.002 | 0.6 | 150.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 14.57 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.2 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 14.57 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.2 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for 2ndslab | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 24.35 | 300 | 0.00152 | 258 | 0.002 | 1.2 | 314.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.78 | 300 | 0.00079 | 258 | 0.002 | 0.6 | 165.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 24.57 | 300 | 0.00153 | 258 | 0.002 | 1.2 | 317.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.49 | 300 | 0.00083 | 258 | 0.002 | 0.7 | 174.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.72 | 300 | 0.00160 | 258 | 0.002 | 1.3 | 332.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.71 | 300 | 0.00091 | 258 | 0.002 | 0.7 | 190.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 11.66 | 300 | 0.00072 | 258 | 0.002 | 0.6 | 150.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 14.57 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.2 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 14.57 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.2 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for 1st floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 25.66 | 300 | 0.00160 | 358 | 0.002 | 0.7 | 238.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.94 | 300 | 0.00080 | 358 | 0.002 | 0.3 | 120.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 22.79 | 300 | 0.00142 | 358 | 0.002 | 0.6 | 212.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.55 | 300 | 0.00084 | 358 | 0.002 | 0.4 | 126.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 24.22 | 300 | 0.00151 | 358 | 0.002 | 0.6 | 225.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.47 | 300 | 0.00089 | 358 | 0.002 | 0.4 | 134.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 10.15 | 300 | 0.00063 | 358 | 0.002 | 0.3 | 94.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 11.38 | 300 | 0.00070 | 358 | 0.002 | 0.3 | 106.0 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 11.38 | 300 | 0.00070 | 358 | 0.002 | 0.3 | 106.0 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for Ground floor | | | | | | | | | | | | |
|---------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 30.55 | 400 | 0.00143 | 358 | 0.002 | 0.6 | 213.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 13.4 | 400 | 0.00062 | 358 | 0.002 | 0.3 | 93.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 19.47 | 400 | 0.00090 | 358 | 0.002 | 0.4 | 136.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.76 | 400 | 0.00064 | 358 | 0.002 | 0.3 | 96.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 20.99 | 400 | 0.00097 | 358 | 0.002 | 0.4 | 146.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 13.83 | 400 | 0.00064 | 358 | 0.002 | 0.3 | 96.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 14.62 | 400 | 0.00068 | 358 | 0.002 | 0.3 | 102.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 6.37 | 400 | 0.00029 | 358 | 0.002 | 0.1 | 44.5 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 1.16 | 400 | 0.00005 | 358 | 0.002 | 0.0 | 8.1 | 274.20 | 560.90 | 1.78 | 2Ø18 |

Axis B-B

| Axes B-B for roof slab | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 34.71 | 400 | 0.00162 | 358 | 0.002 | 0.7 | 242.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 14.15 | 400 | 0.00065 | 358 | 0.002 | 0.3 | 98.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 22.49 | 400 | 0.00104 | 358 | 0.002 | 0.4 | 157.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 14.57 | 400 | 0.00118 | 358 | 0.002 | 0.5 | 176.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.33 | 400 | 0.00070 | 358 | 0.002 | 0.3 | 105.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 15.07 | 400 | 0.00087 | 358 | 0.002 | 0.4 | 131.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 18.82 | 400 | 0.00005 | 358 | 0.002 | 0.0 | 7.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 1.06 | 400 | 0.00055 | 358 | 0.002 | 0.2 | 82.6 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 11.83 | 400 | 0.00000 | 358 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes B-B for 8th slab | | | | | | | | | | | | |
|-----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 38.55 | 300 | 0.00243 | 258 | 0.002 | 1.9 | 498.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 16.57 | 300 | 0.00103 | 258 | 0.002 | 0.8 | 214.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 26.49 | 300 | 0.00165 | 258 | 0.002 | 1.3 | 342.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.49 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 226.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 29.15 | 300 | 0.00182 | 258 | 0.002 | 1.5 | 376.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.15 | 300 | 0.00106 | 258 | 0.002 | 0.9 | 221.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 24.79 | 300 | 0.00154 | 258 | 0.002 | 1.2 | 320.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 2.42 | 300 | 0.00015 | 258 | 0.002 | 0.1 | 31.3 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 13.07 | 300 | 0.00081 | 258 | 0.002 | 0.7 | 168.9 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes B-B for 7 floor | | | | | | | | | | | | |
|----------------------|------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/on | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 38.42 | 300 | 0.00242 | 258 | 0.002 | 1.9 | 496.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 17.36 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 224.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 26.48 | 300 | 0.00165 | 258 | 0.002 | 1.3 | 342.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.5 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 226.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 28.35 | 300 | 0.00177 | 258 | 0.002 | 1.4 | 366.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.18 | 300 | 0.00106 | 258 | 0.002 | 0.9 | 222.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 23.91 | 300 | 0.00149 | 258 | 0.002 | 1.2 | 308.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 2.26 | 300 | 0.00014 | 258 | 0.002 | 0.1 | 29.2 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 13.19 | 300 | 0.00082 | 258 | 0.002 | 0.7 | 170.4 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes B-B for 6 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 3.42 | 300 | 0.00021 | 258 | 0.002 | 0.2 | 44.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 17.38 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 224.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 26.34 | 300 | 0.00164 | 258 | 0.002 | 1.3 | 340.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.55 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 27.62 | 300 | 0.00172 | 258 | 0.002 | 1.4 | 356.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.16 | 300 | 0.00106 | 258 | 0.002 | 0.9 | 221.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 23.81 | 300 | 0.00148 | 258 | 0.002 | 1.2 | 307.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 2.72 | 300 | 0.00017 | 258 | 0.002 | 0.1 | 35.1 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 13.29 | 300 | 0.00082 | 258 | 0.002 | 0.7 | 171.7 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes B-B for 5 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 38.28 | 300 | 0.00241 | 258 | 0.002 | 1.9 | 494.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 17.34 | 300 | 0.00107 | 258 | 0.002 | 0.9 | 224.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 26.86 | 300 | 0.00168 | 258 | 0.002 | 1.3 | 347.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.63 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 227.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 26.69 | 300 | 0.00167 | 258 | 0.002 | 1.3 | 344.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 16.96 | 300 | 0.00105 | 258 | 0.002 | 0.8 | 219.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 20.67 | 300 | 0.00128 | 258 | 0.002 | 1.0 | 267.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 3.3 | 300 | 0.00020 | 258 | 0.002 | 0.2 | 42.6 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 13.42 | 300 | 0.00083 | 258 | 0.002 | 0.7 | 173.4 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes B-B for 4th floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 34.91 | 300 | 0.00219 | 258 | 0.002 | 1.7 | 451.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 17.5 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 226.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 24.56 | 300 | 0.00153 | 258 | 0.002 | 1.2 | 317.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.62 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 227.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 24.79 | 300 | 0.00154 | 258 | 0.002 | 1.2 | 320.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 16.96 | 300 | 0.00105 | 258 | 0.002 | 0.8 | 219.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 19.25 | 300 | 0.00119 | 258 | 0.002 | 1.0 | 248.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 3.33 | 300 | 0.00020 | 258 | 0.002 | 0.2 | 43.0 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 10.86 | 300 | 0.00067 | 258 | 0.002 | 0.5 | 140.3 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes B-B for 3rdslab | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 35.03 | 300 | 0.00220 | 258 | 0.002 | 1.8 | 452.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 17.54 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 24.78 | 300 | 0.00154 | 258 | 0.002 | 1.2 | 320.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.62 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 227.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.19 | 300 | 0.00157 | 258 | 0.002 | 1.3 | 325.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 16.99 | 300 | 0.00105 | 258 | 0.002 | 0.9 | 219.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 17.56 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 4.79 | 300 | 0.00029 | 258 | 0.002 | 0.2 | 61.9 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 11.33 | 300 | 0.00070 | 258 | 0.002 | 0.6 | 146.4 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for 2ndslab | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 24.35 | 300 | 0.00152 | 258 | 0.002 | 1.2 | 314.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.78 | 300 | 0.00079 | 258 | 0.002 | 0.6 | 165.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 24.57 | 300 | 0.00153 | 258 | 0.002 | 1.2 | 317.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.49 | 300 | 0.00083 | 258 | 0.002 | 0.7 | 174.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.72 | 300 | 0.00160 | 258 | 0.002 | 1.3 | 332.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.71 | 300 | 0.00091 | 258 | 0.002 | 0.7 | 190.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 11.66 | 300 | 0.00072 | 258 | 0.002 | 0.6 | 150.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 14.57 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.2 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 14.57 | 300 | 0.00090 | 258 | 0.002 | 0.7 | 188.2 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for 1st floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 25.66 | 300 | 0.00160 | 358 | 0.002 | 0.7 | 238.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 12.94 | 300 | 0.00080 | 358 | 0.002 | 0.3 | 120.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 22.79 | 300 | 0.00142 | 358 | 0.002 | 0.6 | 212.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.55 | 300 | 0.00084 | 358 | 0.002 | 0.4 | 126.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 24.22 | 300 | 0.00151 | 358 | 0.002 | 0.6 | 225.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 14.47 | 300 | 0.00089 | 358 | 0.002 | 0.4 | 134.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 10.15 | 300 | 0.00063 | 358 | 0.002 | 0.3 | 94.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 11.38 | 300 | 0.00070 | 358 | 0.002 | 0.3 | 106.0 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 11.38 | 300 | 0.00070 | 358 | 0.002 | 0.3 | 106.0 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes A-A for Ground floor | | | | | | | | | | | | |
|---------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 30.55 | 400 | 0.00143 | 358 | 0.002 | 0.6 | 213.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 13.4 | 400 | 0.00062 | 358 | 0.002 | 0.3 | 93.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 19.47 | 400 | 0.00090 | 358 | 0.002 | 0.4 | 136.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 13.76 | 400 | 0.00064 | 358 | 0.002 | 0.3 | 96.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 20.99 | 400 | 0.00097 | 358 | 0.002 | 0.4 | 146.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 13.83 | 400 | 0.00064 | 358 | 0.002 | 0.3 | 96.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 14.62 | 400 | 0.00068 | 358 | 0.002 | 0.3 | 102.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 6.37 | 400 | 0.00029 | 358 | 0.002 | 0.1 | 44.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 1 | 1.16 | 400 | 0.00005 | 358 | 0.002 | 0.0 | 8.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |

Axis C-C

| Axes C-C for roof slab | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 26.56 | 400 | 0.00124 | 358 | 0.002 | 0.5 | 185.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 15.62 | 400 | 0.00072 | 358 | 0.002 | 0.3 | 109.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 23.31 | 400 | 0.00108 | 358 | 0.002 | 0.5 | 162.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 15.2 | 400 | 0.00120 | 358 | 0.002 | 0.5 | 180.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 25.8 | 400 | 0.00076 | 358 | 0.002 | 0.3 | 114.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 16.38 | 400 | 0.00085 | 358 | 0.002 | 0.4 | 128.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 18.36 | 400 | 0.00006 | 358 | 0.002 | 0.0 | 9.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 1.29 | 400 | 0.00057 | 358 | 0.002 | 0.2 | 86.2 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 12.35 | 400 | 0.00000 | 358 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes C-C for 8th slab | | | | | | | | | | | | |
|-----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 29.43 | 300 | 0.00184 | 258 | 0.002 | 1.5 | 380.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.89 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 244.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 28.82 | 300 | 0.00180 | 258 | 0.002 | 1.4 | 372.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18.25 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 235.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 28.46 | 300 | 0.00178 | 258 | 0.002 | 1.4 | 367.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.74 | 300 | 0.00110 | 258 | 0.002 | 0.9 | 229.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 25.11 | 300 | 0.00156 | 258 | 0.002 | 1.3 | 324.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 3.62 | 300 | 0.00022 | 258 | 0.002 | 0.2 | 46.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 1 | 13.22 | 300 | 0.00082 | 258 | 0.002 | 0.7 | 170.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes C-C for 7 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 29.31 | 300 | 0.00183 | 258 | 0.002 | 1.5 | 378.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.85 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 243.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 29.56 | 300 | 0.00185 | 258 | 0.002 | 1.5 | 381.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18.29 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 236.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 29.39 | 300 | 0.00184 | 258 | 0.002 | 1.5 | 379.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.69 | 300 | 0.00110 | 258 | 0.002 | 0.9 | 228.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 24.79 | 300 | 0.00154 | 258 | 0.002 | 1.2 | 320.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 3.51 | 300 | 0.00022 | 258 | 0.002 | 0.2 | 45.3 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 12.72 | 300 | 0.00079 | 258 | 0.002 | 0.6 | 164.3 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes C-C for 6 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 29.71 | 300 | 0.00186 | 258 | 0.002 | 1.5 | 383.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.91 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 244.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 30.57 | 300 | 0.00191 | 258 | 0.002 | 1.5 | 395.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18.3 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 236.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 30.12 | 300 | 0.00188 | 258 | 0.002 | 1.5 | 389.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.58 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 227.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 26.16 | 300 | 0.00163 | 258 | 0.002 | 1.3 | 338.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 6.38 | 300 | 0.00039 | 258 | 0.002 | 0.3 | 82.4 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 12.35 | 300 | 0.00076 | 258 | 0.002 | 0.6 | 159.6 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes C-C for 5 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 29.94 | 300 | 0.00187 | 258 | 0.002 | 1.5 | 386.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.85 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 243.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 27.71 | 300 | 0.00173 | 258 | 0.002 | 1.4 | 358.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18.45 | 300 | 0.00114 | 258 | 0.002 | 0.9 | 238.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 30.16 | 300 | 0.00189 | 258 | 0.002 | 1.5 | 389.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.11 | 300 | 0.00106 | 258 | 0.002 | 0.9 | 221.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 26.06 | 300 | 0.00162 | 258 | 0.002 | 1.3 | 336.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 4.58 | 300 | 0.00028 | 258 | 0.002 | 0.2 | 59.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |

| Axes C-C for 4th floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 26.8 | 300 | 0.00167 | 258 | 0.002 | 1.3 | 346.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.86 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 243.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 27.18 | 300 | 0.00170 | 258 | 0.002 | 1.4 | 351.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18.39 | 300 | 0.00114 | 258 | 0.002 | 0.9 | 237.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 27.41 | 300 | 0.00171 | 258 | 0.002 | 1.4 | 354.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 16.99 | 300 | 0.00105 | 258 | 0.002 | 0.9 | 219.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 25.99 | 300 | 0.00162 | 258 | 0.002 | 1.3 | 335.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 5.91 | 300 | 0.00036 | 258 | 0.002 | 0.3 | 76.4 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 10.75 | 300 | 0.00066 | 258 | 0.002 | 0.5 | 138.9 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes C-C for 3rd slab | | | | | | | | | | | | |
|-----------------------|-----|--------|-----|--------------|-------|--------------|-----|--------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 26.89 | 300 | 0.00168 | 258 | 0.002 | 1.3 | 347.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.88 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 243.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 27.66 | 300 | 0.00173 | 258 | 0.002 | 1.4 | 357.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 168.32 | 300 | 0.01193 | 258 | 0.002 | 8.4 | 2174.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 27.4 | 300 | 0.00171 | 258 | 0.002 | 1.4 | 354.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.02 | 300 | 0.00105 | 258 | 0.002 | 0.9 | 219.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 26.06 | 300 | 0.00162 | 258 | 0.002 | 1.3 | 336.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 5.56 | 300 | 0.00034 | 258 | 0.002 | 0.3 | 71.8 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 12.09 | 300 | 0.00075 | 258 | 0.002 | 0.6 | 156.2 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes C-C for 2nd slab | | | | | | | | | | | | |
|-----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 28.75 | 300 | 0.00180 | 258 | 0.002 | 1.4 | 371.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.8 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 242.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 28.04 | 300 | 0.00175 | 258 | 0.002 | 1.4 | 362.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18.3 | 300 | 0.00113 | 258 | 0.002 | 0.9 | 236.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 27.27 | 300 | 0.00170 | 258 | 0.002 | 1.4 | 352.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.15 | 300 | 0.00106 | 258 | 0.002 | 0.9 | 221.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 26.62 | 300 | 0.00166 | 258 | 0.002 | 1.3 | 343.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 5.29 | 300 | 0.00033 | 258 | 0.002 | 0.3 | 68.3 | 274.20 | 560.90 | 1.78 | 2Ø18 |
| Support | 1 | 12.08 | 300 | 0.00075 | 258 | 0.002 | 0.6 | 156.1 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes C-C for 1st floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 28.75 | 300 | 0.00180 | 358 | 0.002 | 0.7 | 267.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.78 | 300 | 0.00116 | 358 | 0.002 | 0.5 | 174.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 26.06 | 300 | 0.00162 | 358 | 0.002 | 0.7 | 242.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18.28 | 300 | 0.00113 | 358 | 0.002 | 0.5 | 170.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 26.55 | 300 | 0.00166 | 358 | 0.002 | 0.7 | 247.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.15 | 300 | 0.00106 | 358 | 0.002 | 0.4 | 159.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 26.38 | 300 | 0.00165 | 358 | 0.002 | 0.7 | 245.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 4.62 | 300 | 0.00028 | 358 | 0.002 | 0.1 | 43.0 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 11.64 | 300 | 0.00072 | 358 | 0.002 | 0.3 | 108.4 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes C-C for Ground floor | | | | | | | | | | | | |
|---------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 26.34 | 400 | 0.00123 | 358 | 0.002 | 0.5 | 183.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.64 | 400 | 0.00086 | 358 | 0.002 | 0.4 | 130.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 23.8 | 400 | 0.00111 | 358 | 0.002 | 0.5 | 166.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18.43 | 400 | 0.00085 | 358 | 0.002 | 0.4 | 128.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 26.15 | 400 | 0.00122 | 358 | 0.002 | 0.5 | 182.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 8.07 | 400 | 0.00037 | 358 | 0.002 | 0.2 | 56.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 23.54 | 400 | 0.00109 | 358 | 0.002 | 0.5 | 164.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 4.69 | 400 | 0.00022 | 358 | 0.002 | 0.1 | 32.8 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 9.2 | 400 | 0.00042 | 358 | 0.002 | 0.2 | 64.2 | 274.20 | 560.90 | 1.78 | 2Ø18 |

Axis D-D

| Axes D-D for roof slab | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| . | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 24.2 | 400 | 0.00113 | 358 | 0.002 | 0.5 | 169.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 16.26 | 400 | 0.00075 | 358 | 0.002 | 0.3 | 113.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 23.31 | 400 | 0.00108 | 358 | 0.002 | 0.5 | 162.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 15.03 | 400 | 0.00070 | 358 | 0.002 | 0.3 | 105.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 24.52 | 400 | 0.00114 | 358 | 0.002 | 0.5 | 171.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 15.17 | 400 | 0.00070 | 358 | 0.002 | 0.3 | 105.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 26.19 | 400 | 0.00122 | 358 | 0.002 | 0.5 | 182.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 4.98 | 400 | 0.00023 | 358 | 0.002 | 0.1 | 34.8 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 13.01 | 400 | 0.00000 | 358 | 0.002 | 0.0 | 0.0 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| D for 8th slab | | | | | | | | | | | | |
|----------------|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|--|
| L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark | |
| 5 | 29.04 | 300 | 0.00181 | 258 | 0.002 | 1.5 | 375.2 | 274.20 | 560.90 | 1.78 | 2Ø16 | |
| 5-4 | 19.91 | 300 | 0.00124 | 358 | 0.002 | 0.5 | 185.4 | 274.20 | 560.90 | 1.78 | 2Ø16 | |
| 4 | 30.35 | 300 | 0.00190 | 358 | 0.002 | 0.8 | 282.6 | 274.20 | 560.90 | 1.78 | 2Ø16 | |
| 4-3 | 17.03 | 300 | 0.00106 | 358 | 0.002 | 0.4 | 158.6 | 274.20 | 560.90 | 1.78 | 2Ø16 | |
| 3 | 28.76 | 300 | 0.00180 | 358 | 0.002 | 0.7 | 267.8 | 274.20 | 560.90 | 1.78 | 2Ø16 | |
| 3-2 | 16.8 | 300 | 0.00104 | 358 | 0.002 | 0.4 | 156.4 | 274.20 | 560.90 | 1.78 | 2Ø16 | |
| 2 | 33.11 | 300 | 0.00208 | 358 | 0.002 | 0.9 | 308.3 | 274.20 | 560.90 | 1.78 | 2Ø16 | |
| 2-1 | 7.41 | 300 | 0.00046 | 358 | 0.002 | 0.2 | 69.0 | 274.20 | 560.90 | 1.78 | 2Ø17 | |
| 1 | 16.8 | 300 | 0.00104 | 358 | 0.002 | 0.4 | 156.4 | 274.20 | 560.90 | 1.78 | 2Ø18 | |

| Axes D-D for 7 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 24.25 | 300 | 0.00151 | 258 | 0.002 | 1.2 | 313.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.79 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 242.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 30.82 | 300 | 0.00193 | 258 | 0.002 | 1.5 | 398.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.33 | 300 | 0.00107 | 258 | 0.002 | 0.9 | 223.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 30.8 | 300 | 0.00193 | 258 | 0.002 | 1.5 | 397.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.16 | 300 | 0.00106 | 258 | 0.002 | 0.9 | 221.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 34.33 | 300 | 0.00215 | 258 | 0.002 | 1.7 | 443.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 7.82 | 300 | 0.00048 | 258 | 0.002 | 0.4 | 101.0 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 18.74 | 300 | 0.00116 | 258 | 0.002 | 0.9 | 242.1 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes D-D for 6 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 21.42 | 300 | 0.00133 | 258 | 0.002 | 1.1 | 276.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 19.15 | 300 | 0.00119 | 258 | 0.002 | 1.0 | 247.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 33.14 | 300 | 0.00208 | 258 | 0.002 | 1.7 | 428.2 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.52 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 32.76 | 300 | 0.00205 | 258 | 0.002 | 1.6 | 423.3 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.53 | 300 | 0.00109 | 258 | 0.002 | 0.9 | 226.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 36.18 | 300 | 0.00227 | 258 | 0.002 | 1.8 | 467.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 8.66 | 300 | 0.00053 | 258 | 0.002 | 0.4 | 111.9 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 20.98 | 300 | 0.00130 | 258 | 0.002 | 1.1 | 271.1 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes D-D for 5 floor | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 20.05 | 300 | 0.00124 | 258 | 0.002 | 1.0 | 259.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 19.46 | 300 | 0.00121 | 258 | 0.002 | 1.0 | 251.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 34.78 | 300 | 0.00218 | 258 | 0.002 | 1.7 | 449.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.7 | 300 | 0.00110 | 258 | 0.002 | 0.9 | 228.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 33.95 | 300 | 0.00213 | 258 | 0.002 | 1.7 | 438.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.73 | 300 | 0.00110 | 258 | 0.002 | 0.9 | 229.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 36.56 | 300 | 0.00230 | 258 | 0.002 | 1.8 | 472.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 8.96 | 300 | 0.00055 | 258 | 0.002 | 0.4 | 115.8 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 21.92 | 300 | 0.00136 | 258 | 0.002 | 1.1 | 283.2 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes D-D for 4th floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 17.4 | 300 | 0.00108 | 258 | 0.002 | 0.9 | 224.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 19.51 | 300 | 0.00121 | 258 | 0.002 | 1.0 | 252.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 32.26 | 300 | 0.00202 | 258 | 0.002 | 1.6 | 416.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.84 | 300 | 0.00111 | 258 | 0.002 | 0.9 | 230.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 31.19 | 300 | 0.00195 | 258 | 0.002 | 1.6 | 403.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.23 | 300 | 0.00107 | 258 | 0.002 | 0.9 | 222.6 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 34.4 | 300 | 0.00216 | 258 | 0.002 | 1.7 | 444.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 10.53 | 300 | 0.00065 | 258 | 0.002 | 0.5 | 136.0 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 20.23 | 300 | 0.00126 | 258 | 0.002 | 1.0 | 261.4 | 274.20 | 560.90 | 1.78 | 2Ø18 |

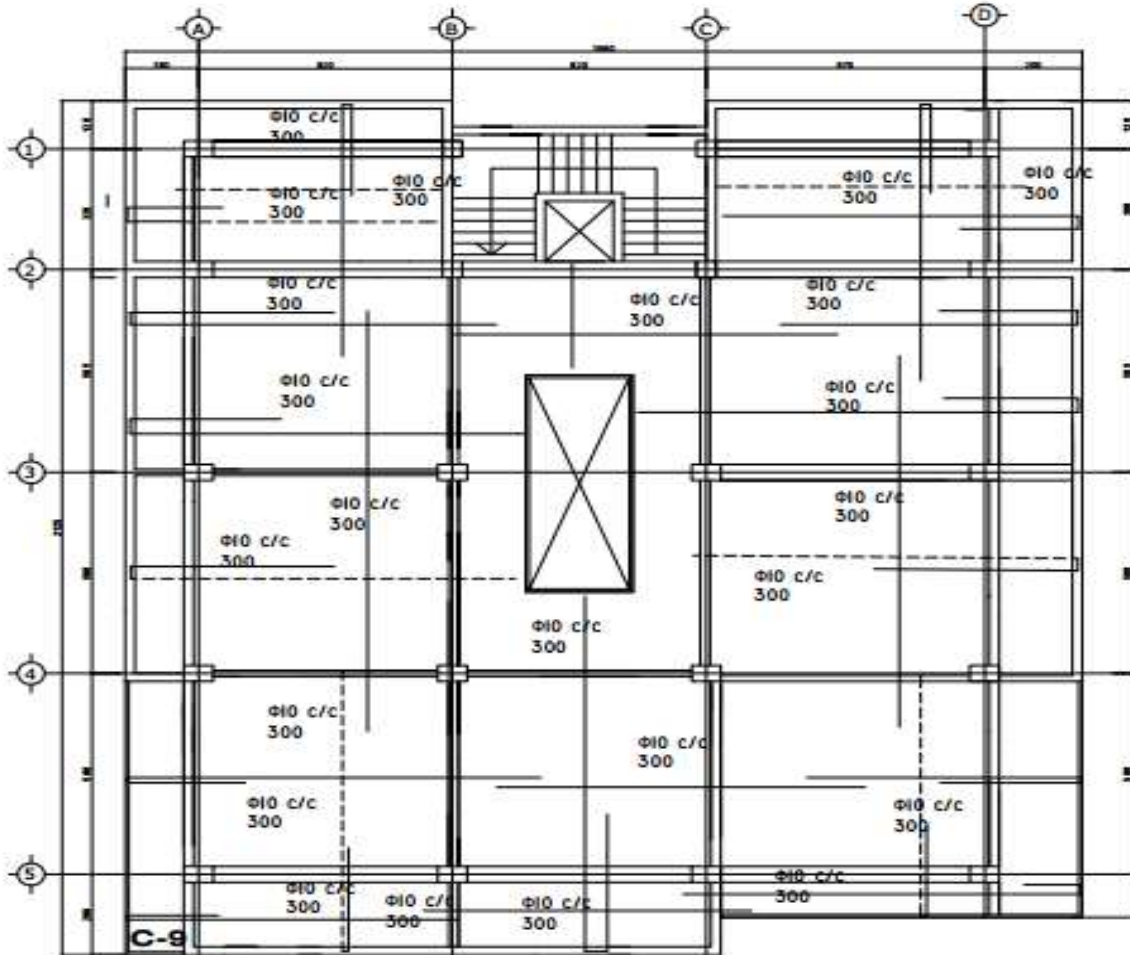
| Axes D-D for 3rdslab | | | | | | | | | | | | |
|----------------------|-----|--------|-----|--------------|-------|--------------|-----|--------|--------|--------|------|--------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 26.89 | 300 | 0.00168 | 258 | 0.002 | 1.3 | 347.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 18.88 | 300 | 0.00117 | 258 | 0.002 | 0.9 | 243.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 27.66 | 300 | 0.00173 | 258 | 0.002 | 1.4 | 357.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 168.32 | 300 | 0.01193 | 258 | 0.002 | 8.4 | 2174.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 27.4 | 300 | 0.00171 | 258 | 0.002 | 1.4 | 354.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.02 | 300 | 0.00105 | 258 | 0.002 | 0.9 | 219.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 26.06 | 300 | 0.00162 | 258 | 0.002 | 1.3 | 336.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 5.56 | 300 | 0.00034 | 258 | 0.002 | 0.3 | 71.8 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 12.09 | 300 | 0.00075 | 258 | 0.002 | 0.6 | 156.2 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes D-D for 2ndslab | | | | | | | | | | | | |
|----------------------|-----|----|-----|--------------|-------|--------------|-----|-------|--------|--------|------|--------|
| Type | L/n | Mo | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Remark |
| Support | 5 | 18 | 300 | 0.00114 | 258 | 0.002 | 0.9 | 238.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 20 | 300 | 0.00122 | 258 | 0.002 | 1.0 | 253.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 34 | 300 | 0.00213 | 258 | 0.002 | 1.7 | 439.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 18 | 300 | 0.00111 | 258 | 0.002 | 0.9 | 230.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 32 | 300 | 0.00200 | 258 | 0.002 | 1.6 | 412.8 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 18 | 300 | 0.00112 | 258 | 0.002 | 0.9 | 234.0 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 35 | 300 | 0.00221 | 258 | 0.002 | 1.8 | 455.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 12 | 300 | 0.00071 | 258 | 0.002 | 0.6 | 149.6 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 20 | 300 | 0.00127 | 258 | 0.002 | 1.0 | 264.7 | 274.20 | 560.90 | 1.78 | 2Ø18 |

| Axes D-D for 1st floor | | | | | | | | | | | | |
|------------------------|-----|--------|-----|--------------|-------|--------------|-----|-------|--------|--------|------|-------|
| Type | L/n | Moment | be | ρ_{cal} | d(mm) | ρ_{min} | K | Z(mm) | As | S | N | Reark |
| Support | 5 | 18.2 | 300 | 0.00113 | 358 | 0.002 | 0.5 | 169.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 5-4 | 19.34 | 300 | 0.00120 | 358 | 0.002 | 0.5 | 180.1 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 4 | 31.41 | 300 | 0.00197 | 358 | 0.002 | 0.8 | 292.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 4-3 | 17.58 | 300 | 0.00109 | 358 | 0.002 | 0.5 | 163.7 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 3 | 30.92 | 300 | 0.00193 | 358 | 0.002 | 0.8 | 287.9 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 3-2 | 17.76 | 300 | 0.00110 | 358 | 0.002 | 0.5 | 165.4 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Support | 2 | 33.88 | 300 | 0.00212 | 358 | 0.002 | 0.9 | 315.5 | 274.20 | 560.90 | 1.78 | 2Ø16 |
| Span | 2-1 | 10.03 | 300 | 0.00062 | 358 | 0.002 | 0.3 | 93.4 | 274.20 | 560.90 | 1.78 | 2Ø17 |
| Support | 1 | 18.98 | 300 | 0.00118 | 358 | 0.002 | 0.5 | 176.7 | 274.20 | 560.90 | 1.78 | 2Ø18 |

Appendix L

Re enforcement of detail drawing for all slab



Appendix M

Column design

Roof column

| location | column | bc | hc | bb | hb | Lc | Lbx left | lbx right | lby left | lby right | k1x | k2x | k1y | k2y | Lox | Loy |
|----------|--------|-----|-----|-----|-----|------|----------|-----------|----------|-----------|------|------|------|------|---------|---------|
| ROOF | C1 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 0 | 5200 | 3.16 | 3.16 | 5.14 | 5.14 | 3000.58 | 3071.10 |
| ROOF | C2 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5200 | 5200 | 3.16 | 3.16 | 2.57 | 2.57 | 3000.58 | 2961.42 |
| ROOF | C3 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5200 | 5700 | 3.16 | 3.16 | 2.69 | 2.69 | 3000.58 | 2970.39 |
| ROOF | C4 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5700 | 0 | 3.16 | 3.16 | 5.63 | 5.63 | 3000.58 | 3081.57 |
| ROOF | C5 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 0 | 5200 | 1.93 | 1.93 | 5.14 | 5.14 | 2898.06 | 3071.10 |
| ROOF | C6 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5200 | 5200 | 1.93 | 1.93 | 2.57 | 2.57 | 2898.06 | 2961.42 |
| ROOF | C7 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5200 | 5700 | 1.93 | 1.93 | 2.69 | 2.69 | 2898.06 | 2970.39 |
| ROOF | C8 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5700 | 0 | 1.93 | 1.93 | 5.63 | 5.63 | 2898.06 | 3081.57 |
| ROOF | C9 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 0 | 5200 | 2.48 | 2.48 | 5.14 | 5.14 | 2954.39 | 3071.10 |
| ROOF | C10 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 5200 | 0 | 2.48 | 2.48 | 5.14 | 5.14 | 2954.39 | 3071.10 |
| ROOF | C11 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 0 | 5700 | 2.48 | 2.48 | 5.63 | 5.63 | 2954.39 | 3081.57 |
| ROOF | C12 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 5700 | 0 | 2.48 | 2.48 | 5.63 | 5.63 | 2954.39 | 3081.57 |
| ROOF | C13 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 0 | 5200 | 2.47 | 2.47 | 5.14 | 5.14 | 2953.35 | 3071.10 |
| ROOF | C14 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 5200 | 5200 | 2.47 | 2.47 | 2.57 | 2.57 | 2953.35 | 2961.42 |
| ROOF | C15 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 5200 | 5700 | 2.47 | 2.47 | 2.69 | 2.69 | 2953.35 | 2970.39 |
| ROOF | C16 | 400 | 400 | 300 | 300 | 3200 | 5000 | 500 | 5700 | 0 | 0.45 | 0.45 | 5.63 | 5.63 | 2399.05 | 3081.57 |
| ROOF | C17 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 0 | 5200 | 4.94 | 4.94 | 5.14 | 5.14 | 3066.38 | 3071.10 |
| ROOF | C18 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5200 | 5200 | 4.94 | 4.94 | 2.57 | 2.57 | 3066.38 | 2961.42 |
| ROOF | C19 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5200 | 5700 | 4.94 | 4.94 | 2.69 | 2.69 | 3066.38 | 2970.39 |
| ROOF | C20 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5700 | 0 | 4.94 | 4.94 | 5.63 | 5.63 | 3066.38 | 3081.57 |

| colmn | location | MEDx | MEDy | Vsd | μ sd _y | μ sd _x | ω | As | As, mi | As, max | As, prov |
|-------|----------|---------|---------|----------|-----------------------|-----------------------|----------|----------|--------|---------|----------|
| ROOF | C1 | 22.9152 | 9.6852 | 0.075441 | 0.013357 | 0.031602 | 1.3 | 7971.34 | 320 | 6400 | |
| ROOF | C2 | 26.1726 | 32.8426 | 0.072336 | 0.045293 | 0.036094 | 2.3 | 14103.14 | 320 | 6400 | 14103.14 |
| ROOF | C3 | 31.8372 | 20.4772 | 0.071635 | 0.02824 | 0.043906 | 0.1 | 613.18 | 320 | 6400 | 613.18 |
| ROOF | C4 | 18.67 | 8.12 | 0.088537 | 0.011198 | 0.025747 | 0.3 | 1839.54 | 320 | 6400 | 1839.54 |
| ROOF | C5 | 15.0214 | 19.6914 | 0.092437 | 0.027156 | 0.020716 | 0.15 | 919.77 | 320 | 6400 | 919.77 |
| ROOF | C6 | 15.3462 | 25.0962 | 0.096431 | 0.03461 | 0.021164 | 6.3 | 38630.34 | 320 | 6400 | 38630.34 |
| ROOF | C7 | 23.2996 | 30.4296 | 0.075563 | 0.041965 | 0.032132 | 7.3 | 44762.14 | 320 | 6400 | 44762.14 |
| ROOF | C8 | 7.1096 | 36.3996 | 0.108385 | 0.050198 | 0.009805 | 8.3 | 50893.94 | 320 | 6400 | 50893.94 |
| ROOF | C9 | 15.069 | 18.923 | 0.110685 | 0.026096 | 0.020781 | 9.3 | 57025.74 | 320 | 6400 | 57025.74 |
| ROOF | C10 | 34.7952 | 10.5352 | 0.107988 | 0.014529 | 0.047985 | 10.3 | 63157.54 | 320 | 6400 | 63157.54 |
| ROOF | C11 | 34.9524 | 8.4624 | 0.112323 | 0.01167 | 0.048202 | 11.3 | 69289.34 | 320 | 6400 | 69289.34 |
| ROOF | C12 | 10.2856 | 12.8556 | 0.128133 | 0.017729 | 0.014185 | 12.3 | 75421.14 | 320 | 6400 | 75421.14 |
| ROOF | C13 | 15.2828 | 18.9628 | 0.107094 | 0.026151 | 0.021076 | 13.3 | 81552.94 | 320 | 6400 | 81552.94 |
| ROOF | C14 | 17.604 | 9.474 | 0.120366 | 0.013065 | 0.024277 | 14.3 | 87684.74 | 320 | 6400 | 87684.74 |
| ROOF | C15 | 11.2516 | 6.2416 | 0.12692 | 0.008608 | 0.015517 | 15.3 | 93816.54 | 320 | 6400 | 93816.54 |
| ROOF | C16 | 11.1612 | 8.6212 | 0.128839 | 0.011889 | 0.015392 | 16.3 | 99948.34 | 320 | 6400 | 99948.34 |
| ROOF | C17 | 23.9248 | 11.7448 | 0.107425 | 0.016197 | 0.032994 | 17.3 | 106080.1 | 320 | 6400 | 106080.1 |
| ROOF | C18 | 20.7408 | 17.0408 | 0.123312 | 0.023501 | 0.028603 | 18.3 | 112211.9 | 320 | 6400 | 112211.9 |
| ROOF | C19 | 26.1374 | 6.0174 | 0.118805 | 0.008298 | 0.036046 | 19.3 | 118343.7 | 320 | 6400 | 118343.7 |
| ROOF | C20 | 26.2216 | 19.7616 | 0.105958 | 0.027253 | 0.036162 | 20.3 | 124475.5 | 320 | 6400 | 124475.5 |

8th slab column

| location | column | bc | hc | bb | hb | Lc | Lbx left | lbx right | lby left | lby rig | k1x | k2x | k1y | k2y | Lox | Loy |
|----------|--------|-----|-----|-----|-----|------|----------|-----------|----------|---------|----------|----------|----------|----------|----------|----------|
| 8th | C1 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 0 | 5200 | 3.160494 | 3.160494 | 5.135802 | 5.135802 | 3000.581 | 3071.102 |
| 8th | C2 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5200 | 5200 | 3.160494 | 3.160494 | 2.567901 | 2.567901 | 3000.581 | 2961.424 |
| 8th | C3 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5200 | 5700 | 3.160494 | 3.160494 | 2.685695 | 2.685695 | 3000.581 | 2970.386 |
| 8th | C4 | 400 | 400 | 300 | 300 | 3200 | 0 | 3200 | 5700 | 0 | 3.160494 | 3.160494 | 5.62963 | 5.62963 | 3000.581 | 3081.572 |
| 8th | C5 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 0 | 5200 | 1.934605 | 1.934605 | 5.135802 | 5.135802 | 2898.063 | 3071.102 |
| 8th | C6 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5200 | 5200 | 1.934605 | 1.934605 | 2.567901 | 2.567901 | 2898.063 | 2961.424 |
| 8th | C7 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5200 | 5700 | 1.934605 | 1.934605 | 2.685695 | 2.685695 | 2898.063 | 2970.386 |
| 8th | C8 | 400 | 400 | 300 | 300 | 3200 | 3200 | 5050 | 5700 | 0 | 1.934605 | 1.934605 | 5.62963 | 5.62963 | 2898.063 | 3081.572 |
| 8th | C9 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 0 | 5200 | 2.48142 | 2.48142 | 5.135802 | 5.135802 | 2954.385 | 3071.102 |
| 8th | C10 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 5200 | 0 | 2.48142 | 2.48142 | 5.135802 | 5.135802 | 2954.385 | 3071.102 |
| 8th | C11 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 0 | 5700 | 2.48142 | 2.48142 | 5.62963 | 5.62963 | 2954.385 | 3081.572 |
| 8th | C12 | 400 | 400 | 300 | 300 | 3200 | 5050 | 5000 | 5700 | 0 | 2.48142 | 2.48142 | 5.62963 | 5.62963 | 2954.385 | 3081.572 |
| 8th | C13 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 0 | 5200 | 2.469136 | 2.469136 | 5.135802 | 5.135802 | 2953.352 | 3071.102 |
| 8th | C14 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 5200 | 5200 | 2.469136 | 2.469136 | 2.567901 | 2.567901 | 2953.352 | 2961.424 |
| 8th | C15 | 400 | 400 | 300 | 300 | 3200 | 5000 | 5000 | 5200 | 5700 | 2.469136 | 2.469136 | 2.685695 | 2.685695 | 2953.352 | 2970.386 |
| 8th | C16 | 400 | 400 | 300 | 300 | 3200 | 5000 | 500 | 5700 | 0 | 0.448934 | 0.448934 | 5.62963 | 5.62963 | 2399.051 | 3081.572 |
| 8th | C17 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 0 | 5200 | 4.938272 | 4.938272 | 5.135802 | 5.135802 | 3066.376 | 3071.102 |
| 8th | C18 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5200 | 5200 | 4.938272 | 4.938272 | 2.567901 | 2.567901 | 3066.376 | 2961.424 |
| 8th | C19 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5200 | 5700 | 4.938272 | 4.938272 | 2.685695 | 2.685695 | 3066.376 | 2970.386 |
| 8th | C20 | 400 | 400 | 300 | 300 | 3200 | 5000 | 0 | 5700 | 0 | 4.938272 | 4.938272 | 5.62963 | 5.62963 | 3066.376 | 3081.572 |

| location | column | Mx top | Mx bot | My top | My bot | NED | M01x | M01y | M02x | M02y | λ_x | λ_y | λ_{lim} | λ_{ylim} | slenderne | slenderne |
|----------|----------|---------|---------|----------|-------------|-------------|----------|----------|---------|---------|-------------|-------------|-----------------|------------------|-----------|-----------|
| 8th | C1 | 14.37 | 7.69 | 0.32 | 6.95 | 283.49 | 13.3598 | 5.9898 | 20.0398 | 12.6198 | 25.9858 | 26.59652 | 40.24099 | 47.7191 | short | short |
| 8th | C2 | 17.31 | 23.89 | 8.36 | 30.22 | 267.06 | 22.6512 | 13.7012 | 29.2312 | 35.5612 | 25.9858 | 25.64668 | 37.11768 | 52.75004 | short | short |
| 8th | C3 | 12.18 | 22.39 | 15.34 | 17.88 | 285.69 | 17.8938 | 21.0538 | 28.1038 | 23.5938 | 25.9858 | 25.7243 | 41.24795 | 31.331 | short | short |
| 8th | C4 | 8.76 | 8.56 | 8.03 | 5.12 | 340.86 | 15.3772 | 11.9372 | 15.5772 | 14.8472 | 25.9858 | 26.68719 | 25.31624 | 31.82101 | slender | short |
| 8th | C5 | 8.84 | 1.96 | 1 | 13.77 | 352.68 | 9.0136 | 8.0536 | 15.8936 | 20.8236 | 25.09796 | 26.59652 | 39.55384 | 45.85128 | short | short |
| 8th | C6 | 9.99 | 17.62 | 12.44 | 19.95 | 367.43 | 17.3386 | 19.7886 | 24.9686 | 27.2986 | 25.09796 | 25.64668 | 34.39748 | 33.35493 | short | short |
| 8th | C7 | 7.43 | 4.71 | 18.48 | 22.2 | 340.66 | 11.5232 | 25.2932 | 14.2432 | 29.0132 | 25.09796 | 25.7243 | 31.65172 | 29.4225 | short | short |
| 8th | C8 | 3.06 | 1.96 | 24.78 | 34.88 | 411.52 | 10.1904 | 33.0104 | 11.2904 | 43.1104 | 25.09796 | 26.68719 | 25.77458 | 30.19801 | short | short |
| 8th | C9 | 11.05 | 5.8 | 6.32 | 14.36 | 419.08 | 14.1816 | 14.7016 | 19.4316 | 22.7416 | 25.58573 | 26.59652 | 31.07412 | 33.74404 | short | short |
| 8th | C10 | 30.89 | 19.92 | 2.16 | 4.75 | 421.23 | 28.3446 | 10.5846 | 39.3146 | 13.1746 | 25.58573 | 26.59652 | 31.27754 | 28.64377 | short | short |
| 8th | C11 | 23.82 | 8.07 | 1.26 | 0 | 435.14 | 16.7728 | 8.7028 | 32.5228 | 9.9628 | 25.58573 | 26.68719 | 37.22494 | 25.97817 | short | slender |
| 8th | C12 | 6.53 | 0 | 7.87 | 6.24 | 488.46 | 9.7692 | 16.0092 | 16.2992 | 17.6392 | 25.58573 | 26.68719 | 32.65305 | 23.50877 | short | slender |
| 8th | C13 | 8.39 | 0 | 6.38 | 14.17 | 407.93 | 8.1586 | 14.5386 | 16.5486 | 22.3286 | 25.57678 | 26.59652 | 39.18385 | 34.0509 | short | short |
| 8th | C14 | 10.14 | 0 | 0.15 | 5.19 | 468.84 | 9.3768 | 9.5268 | 19.5168 | 14.5668 | 25.57678 | 25.64668 | 36.93038 | 31.67465 | short | short |
| 8th | C15 | 14.99 | 7.27 | 3.44 | 3.54 | 499.02 | 17.2504 | 13.4204 | 24.9704 | 13.5204 | 25.57678 | 25.7243 | 29.62097 | 20.76345 | short | slender |
| 8th | C16 | 10.23 | 2.21 | 8.95 | 6.4 | 502.09 | 12.2518 | 16.4418 | 20.2718 | 18.9918 | 20.77639 | 26.68719 | 32.0602 | 24.41241 | short | slender |
| 8th | C17 | 14.79 | 0 | 0 | 6.33 | 406.29 | 8.1258 | 8.1258 | 22.9158 | 14.4558 | 26.5556 | 26.59652 | 43.76541 | 37.0149 | short | short |
| 8th | C18 | 20.83 | 11.73 | 4.46 | 9.32 | 469.81 | 21.1262 | 13.8562 | 30.2262 | 18.7162 | 26.5556 | 25.64668 | 30.2828 | 29.03057 | short | short |
| 8th | C19 | 21.8 | 16.43 | 1.05 | 0 | 459.83 | 25.6266 | 9.1966 | 30.9966 | 10.2466 | 26.5556 | 25.7243 | 26.70134 | 24.53734 | short | slender |
| 8th | C20 | 23.5 | 9.43 | 10.26 | 4.59 | 416.19 | 17.7538 | 12.9138 | 31.8238 | 18.5838 | 26.5556 | 26.68719 | 36.70813 | 32.30435 | short | short |
| colmn | location | MEDx | MEDy | Vsd | μ_{sdy} | μ_{sdx} | ω | As | As, min | As, max | As, prov | | | | | |
| 8th | C1 | 20.0398 | 12.6198 | 0.156382 | 0.017404 | 0.027637 | 24.3 | 149002.7 | 320 | 6400 | 149002.7 | | | | | |
| 8th | C2 | 29.2312 | 35.5612 | 0.147319 | 0.049042 | 0.040312 | 25.3 | 155134.5 | 320 | 6400 | 155134.5 | | | | | |
| 8th | C3 | 28.1038 | 23.5938 | 0.157596 | 0.032538 | 0.038757 | 26.3 | 161266.3 | 320 | 6400 | 161266.3 | | | | | |
| 8th | C4 | 15.5772 | 14.8472 | 0.18803 | 0.020476 | 0.021482 | 27.3 | 167398.1 | 320 | 6400 | 167398.1 | | | | | |
| 8th | C5 | 15.8936 | 20.8236 | 0.19455 | 0.028717 | 0.021919 | 28.3 | 173529.9 | 320 | 6400 | 173529.9 | | | | | |
| 8th | C6 | 24.9686 | 27.2986 | 0.202686 | 0.037647 | 0.034434 | 29.3 | 179661.7 | 320 | 6400 | 179661.7 | | | | | |
| 8th | C7 | 14.2432 | 29.0132 | 0.187919 | 0.040012 | 0.019643 | 30.3 | 185793.5 | 320 | 6400 | 185793.5 | | | | | |
| 8th | C8 | 11.2904 | 43.1104 | 0.227008 | 0.059453 | 0.01557 | 31.3 | 191925.3 | 320 | 6400 | 191925.3 | | | | | |
| 8th | C9 | 19.4316 | 22.7416 | 0.231178 | 0.031363 | 0.026798 | 32.3 | 198057.1 | 320 | 6400 | 198057.1 | | | | | |
| 8th | C10 | 39.3146 | 13.1746 | 0.232364 | 0.018169 | 0.054218 | 33.3 | 204188.9 | 320 | 6400 | 204188.9 | | | | | |
| 8th | C11 | 32.5228 | 9.9628 | 0.240038 | 0.01374 | 0.044852 | 34.3 | 210320.7 | 320 | 6400 | 210320.7 | | | | | |
| 8th | C12 | 16.2992 | 17.6392 | 0.269451 | 0.024326 | 0.022478 | 35.3 | 216452.5 | 320 | 6400 | 216452.5 | | | | | |
| 8th | C13 | 16.5486 | 22.3286 | 0.225028 | 0.030793 | 0.022822 | 36.3 | 222584.3 | 320 | 6400 | 222584.3 | | | | | |
| 8th | C14 | 19.5168 | 14.5668 | 0.258628 | 0.020089 | 0.026915 | 37.3 | 228716.1 | 320 | 6400 | 228716.1 | | | | | |
| 8th | C15 | 24.9704 | 13.5204 | 0.275276 | 0.018646 | 0.034436 | 38.3 | 234847.9 | 320 | 6400 | 234847.9 | | | | | |
| 8th | C16 | 20.2718 | 18.9918 | 0.276969 | 0.026191 | 0.027956 | 39.3 | 240979.7 | 320 | 6400 | 240979.7 | | | | | |
| 8th | C17 | 22.9158 | 14.4558 | 0.224123 | 0.019936 | 0.031603 | 40.3 | 247111.5 | 320 | 6400 | 247111.5 | | | | | |
| 8th | C18 | 30.2262 | 18.7162 | 0.259163 | 0.025811 | 0.041684 | 41.3 | 253243.3 | 320 | 6400 | 253243.3 | | | | | |
| 8th | C19 | 30.9966 | 10.2466 | 0.253657 | 0.014131 | 0.042747 | 42.3 | 259375.1 | 320 | 6400 | 259375.1 | | | | | |
| 8th | C20 | 31.8238 | 18.5838 | 0.229584 | 0.025629 | 0.043888 | 43.3 | 265506.9 | 320 | 6400 | 265506.9 | | | | | |

