بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of Engineering

Civil Engineering Department

Project Graduation

“Eye Specialist Hospital”

Project Team:

Rasha Shakarnah **Bayan Srour**

Supervisor:

Dr. Nafez Nasreideen

Hebron-Palestine

2023 - 2024

Palestine Polytechnic University

College of Engineering

Civil Engineering Department

Project Graduation

"Eye Specialist Hospital"

Project Team:

Rasha Shakarnah **Bayan Srour**

Supervisor:

Dr. Nafez Nasreideen

This project Submitted to the College of Engineering in partial fulfillment of the requirements for the degree of Bachelor's degree in Civil Engineering Branch of Building Engineering.

Hebron-Palestine

2023 - 2024

Palestine Polytechnic University

College of Engineering

Civil Engineering Department

Project Graduation

"Eye Specialist Hospital"

Project Team:

Rasha Shakarnah **Bayan Srour**

In accordance with the recommendation of the project supervisor and acceptance of all examining committee members, this project has been submitted to the Department of Civil Engineering in the College of Engineering in partial fulfillment of the department's requirements for the degree of Bachelor of Building Engineering.

Signature of Project Supervisor

Name……………………………

Signature of Department Chairman

Name ………………………………..

2023 – 2024

الإهداء

إلـهي لا يطيب الليل إلا بشكرك ولا يطيب النهار إلا بطاعتك ولا تطيب اللحظات إلا بذكرك ولا تطيب الآخرة إلا بعفوك ولا تطيب الجنة إلا برؤيتك

الله سبحانه جل في علاه جل جلاله..

إلى من بلغ الرسالة وأدى الأمانة ونصح الأمة إلى نبي الرحمة ونور العالمين، معلم البشرية ومنبع العلم سيدنا محمد صلى الله عليه وسلم..

إلى من حاكت سعادتي بخيوط منسوجة من قلبها يا بسمة الحياة وسر الوجود يا من كان دعائها سر نجاحي وحنانها بلسم جراحي وركع العطاء أمام قدميها..

أمي الغالية..

إلى من أحمل اسمه بكل فخر ومن استلمت منه قيم الإنسانية وعلمتني ارتقي سلم الحياة بحكمة وصبر ستبقى كلماتك نجوم أهتدي بها اليوم وفي الغد وإلى الأبد يا صاحب القلب الكبير

والدي..

إلى رياحين حياتي يا من تطلعتم إلى نجاحي بنظرات الأمل ورافقتهم منذ أن حملت حقائب صغيرة

أخوتي..

إلى من معهم وبرفقتهم سرت وكانوا على طريق النجاح والخير وأمضيت معهم ذكريات الأخوة

الذين تسكن صورهم وأصواتهم أجمل لحظات الأيام التي عشتها

أصدقائي..

إلى من هم أفضل منا جميعا الذين رووا بدمائهم ثرى فلسطين

كل الشهداء..

إلى من عشقوا الحرية وخاضوا بأمعائهم حربا من اجلك

اهدي هذه الثمرة المتواضعة لك

قدسي..

واخيراً وليس اخراً إلى جميع الأساتذة في دائرة الهندسة المدنية والمعمارية الذين لم يبخلوا بنصائحهم وتوجيهاتهم علينا

فريق المشروع

ACKNOWLEDGEMENT

It has been a great opportunity for us to gain a lot of knowledge through working on this project, but the successful completion of any task would be incomplete without mention of the people who made it possible. For that we would like to thank everyone who helped, supported, and encouraged us: starting with Palestine Polytechnic University, Engineering College, and Civil Engineering Department, including all members of the helpful and reverend staff for providing us with everything we need to complete our graduation project.

Special thanks to our supervisor, Dr. Nafez Nasreideen made an effort to encourage us to do a great job, providing our team with valuable information and advice to be better every time. We thank you for the constant support and pleasant communication, which greatly affects our feeling of interest in what we are working on, who was the guiding light every step of the way we worked on this project.

We also extend our thanks to our dear colleagues who, without their presence, would not have felt the pleasure of research, nor the sweetness of positive competition.

In conclusion, we would like to thank our fathers, mothers, and brothers who had the greatest role in reaching what we have reached, and perhaps we will fulfill their right by achieving their satisfaction.

“Eye Specialist Hospital”

Project Team:

Rasha Shakarnah **Bayan Srour**

Supervisor:

Dr. Nafez Nasreideen

ABSTRACT

This project aims to learn the practical application of structural design based on the various structural theory courses studied in the previous semesters.

This project is the structural design of a hospital located in Hebron with a total area of 3241 square meters.

This building consists of 4 floors:

The hospital has clinics, reception, kitchen, cafeteria, WC, stores, administrative rooms, meeting rooms, emergency rooms, doctors, nurses and patients’ rooms, sterilization rooms, operating rooms, and a car park

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

- **A_c =** area of concrete section resisting shear transfer.
- **A_s =** area of non-prestressed tension reinforcement.
- **A_s`=** area of non-prestressed compression reinforcement.
- **A_g =** gross area of section.
- **A_v =** area of shear reinforcement within a distance (S).
- **A_t =** area of one leg of a closed stirrup resisting tension within a (S).
- **b =** width of compression face of member.
- **b_w =** web width, or diameter of circular section.
- **C_c =** compression resultant of concrete section.
- **C_s =** compression resultant of compression steel.
- **DL =** dead loads.
- **d =** distance from extreme compression fiber to centroid of tension reinforcement.
- **E_c =** modulus of elasticity of concrete.
- **f_c` =** compression strength of concrete.
- **f_y =** specified yield strength of non-prestressed reinforcement.
- **h =** overall thickness of member.
- **L_n =** length of clear span in long direction of two- way construction measured face-to- face of supports in slabs without beams and face to face of beam or other supports in other cases.
- **LL =** live loads.
- **L_w =** length of wall.
- **M =** bending moment.
- **M_u =** factored moment at section.

- **M_n** = nominal moment.
- **P_n** = nominal axial load.
- **P_u** = factored axial load
- **S** = Spacing of shear in direction parallel to longitudinal reinforcement.
- **V_c** = nominal shear strength provided by concrete.
- **V_n** = nominal shear stress.
- **V_s** = nominal shear strength provided by shear reinforcement.
- **V_u** = factored shear force at section.
- **W_c** = weight of concrete.
- **W** = width of beam or rib.
- **W_u** = factored load per unit area.
- **Φ** = strength reduction factor.
- **ε_c** = compression strain of concrete = 0.003.
- **ε_s** = strain of tension steel.
- **$\acute{\varepsilon}_s$** = strain of compression steel.
- **ρ** = ratio of steel area.

CHAPTER 1

" INTRODUCTION"

1.1 INTRODUCTION.

1.2 PROJECT OBJECTIVES.

1.3 WORK PROCEDURE.

1.4 PROJECT SCOPE.

1.5 PROGRAMS USED IN THE PROJECT.

Figure 1: Expressive Image

1.1 INTRODUCTION

Engineering is the best way to harness natural resources to serve humanity.

In other words, it is the art of applying scientific principles and life experiences to our lives to improve the things we use or the facilities we live in. In general, it is the body that combines the available technical tools, activities and knowledge. It is the professional activity that uses imagination, wisdom and intelligence in the application of science, technology, mathematics and practical experience in order to be able to design, produce and manage processes that suit the needs of mankind.

Civil engineering affects many of our daily activities: the buildings we live in and work in, the transportation facilities we use, the water we drink, and the drainage and sewage systems that are necessary for our health and well-being, so civil engineering in general is the only way to make the world a more suitable and suitable place to live in.

Building engineering in particular is the engineering that takes care of providing the required housing with the required specifications, the required quality, and the resources available to each individual in the community , and it is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, airports, sewage systems, pipelines, and construction components of buildings and railways.

1.2 PROJECT OBJECTIVES

After completing this project, we hope to achieve the following objectives:

1. Obtaining experience in solving the problems of each project in particular.
2. Improving the ability to choose the appropriate structural system for the project and distributing its structural elements on the plans, taking into account preserving the architectural character.
3. Gaining experience in reaching the best safe and economical design.
4. Using structural design programs and comparing them with theoretical solutions.

1.3 WORK PROCEDURE

To achieve the objectives of the project, the following steps were taken:

1. The architectural study in which the site, building plans and floor heights were studied.
2. Structural planning of the building, in which the type of slab is selected and the location of columns, beams and shear walls is determined, taking into account the architectural design.
3. A structural study in which all structural members are identified and the different loads are indicated
4. Was appreciated.
5. Analysis and design of the elements according to the ACI code using software and theoretical solutions.
6. Preparing construction drawings for all the elements in the building.
7. Writing a project where all these stages are presented in detail.

1.4 PROJECT SCOPE

This Project contains the following chapters:

CHAPTER 1: General introduction.

CHAPTER 2: Architectural description of the project.

CHAPTER 3: General description of the structural elements.

CHAPTER 4: Structural analysis and design of all structural elements.

CHAPTER 5: Results and Recommendations

1.5 PROGRAMS USED IN THE PROJECT

1. Adoption of the American code in the various structural designs (ACI-318-19) and Jordanian code.
2. Using analysis and structural design programs such as (BeamD18, Safe, Etabs, Found and SP column)
3. Other programs such as Microsoft office Word, Excel, Power Point.
4. AutoCAD.

CHAPTER 2

" ARCHITECTURAL DESCRIPTION "

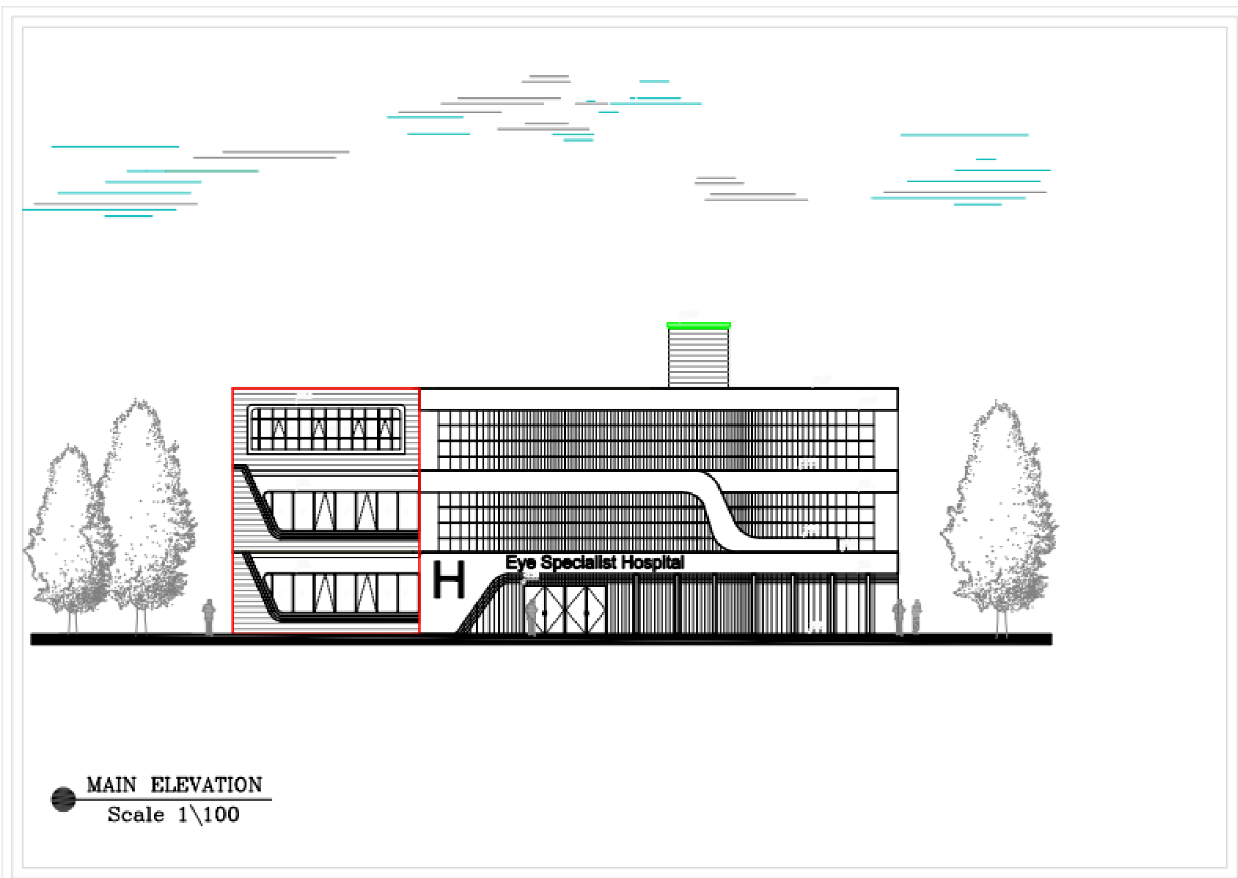


Figure 2: Main Elevation

2.1 INTRODUCTION

Architecture is considered an art, talent, and idea, which derives its fuel from what God has bestowed upon the architect from the talents of beauty. With these talents, he moved from the life of the caves to the best form of luxury, taking advantage of the beauty God gave him of this picturesque nature, and if every art or science has controls and limits, architecture is not subject to any limitation or restriction, as it oscillates between imagination and reality. The result may be buildings of extreme simplicity and beauty.

The design process for any facility or building occurs through several stages until it is completed to the fullest, starting with the architectural design stage. The initial installation of the facilities, achieving the required spaces and dimensions, and in the process lighting, ventilation, movement, mobility, and other functional requirements are also studied.

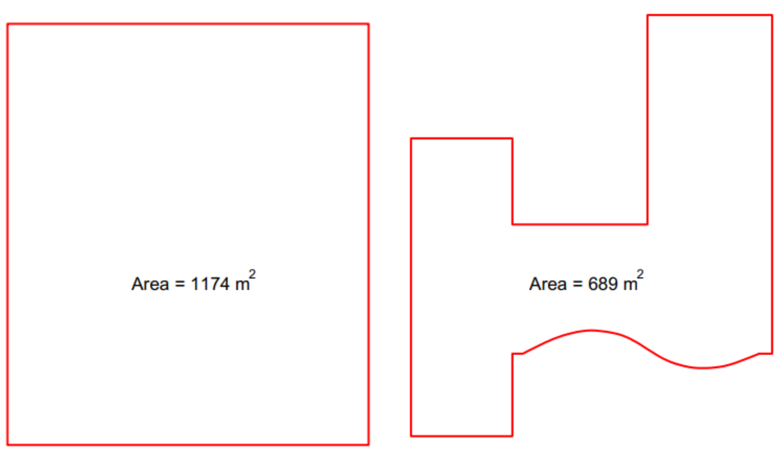
Architectural designs should be easy to deal with and understand the various events and other things of importance that give a clear view of the project thus it will be possible to locate the columns and other structural elements in the structural design process that aims to determine the dimensions of the structural elements and their characteristics depending on the different loads that are placed on them. Transported through these elements to the foundations and then to the soil.

2.2 GENERAL IDENTIFICATION OF THE PROJECT

This hospital is considered unique in that it specializes in everything related to eyes and their treatment.

Because of the nature of this hospital, we considered so many things so we can be able to design it structurally flawless.

The building consists of four floors. The 1st basement floor consists of a parking space, a staircase, an elevator, rooms, a storeroom, a gas room, and a boiler, with an area of 1174 m^2. The ground floor consists of reception, emergency rooms, clinics, pharmacy, laboratory, cafeteria, WC, nurses' rooms, with area of 689 m^2. The first floor, with an area of 689 m^2, consists of administrative rooms, clinics, a lecture hall, an exhibition hall, WC, a meeting room, and rooms for doctors. As for the last floor, with an area of 689 m^2, it consists of patient rooms, a kitchen, medicine stores, WC, operating rooms, sterilization rooms, and rest rooms for patients.



FLOOR	NO	AREA
Firs Basement Floor	1	1174 m^2
Ground Floor	1	689 m^2
First Floor	1	689 m^2
Second Floor	1	689 m^2
Total Proposed Area		3241 m^2

Figure 2: Building Areas

2.3 FLOORS DESCRIPTION

The project consists of four floors with a total area of 3241 m^2.

2.3.1 1st Basement FLOOR:

(Level -3.05 m) with an area of 1174 m^2

The 1st basement floor consists of a parking space, a staircase, an elevator, rooms, a storeroom, a gas room, and a boiler, as shown in the figure (4)

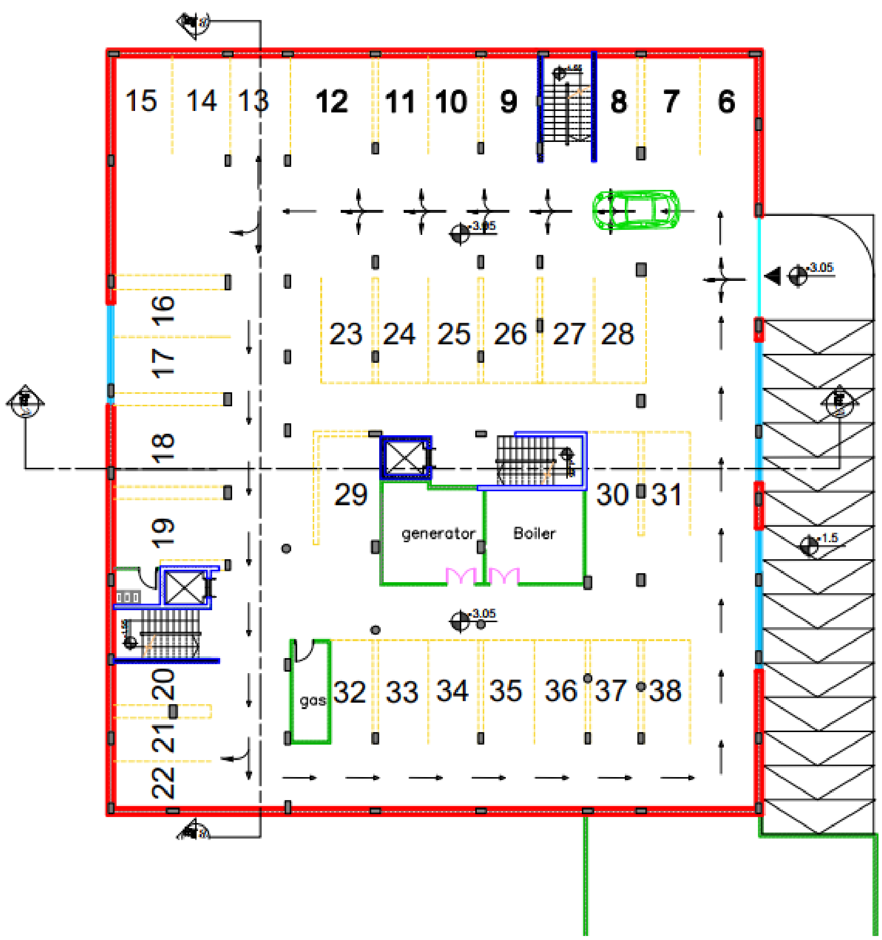


Figure 4: 1st Basement Floor Plan

2.3.2 Ground Floor:

(Level +0.00 m) with an area of 689 m^2

The ground floor consists of reception, emergency rooms, clinics, pharmacy, laboratory, cafeteria, WC, nurses' rooms, as shown in Figure (5).

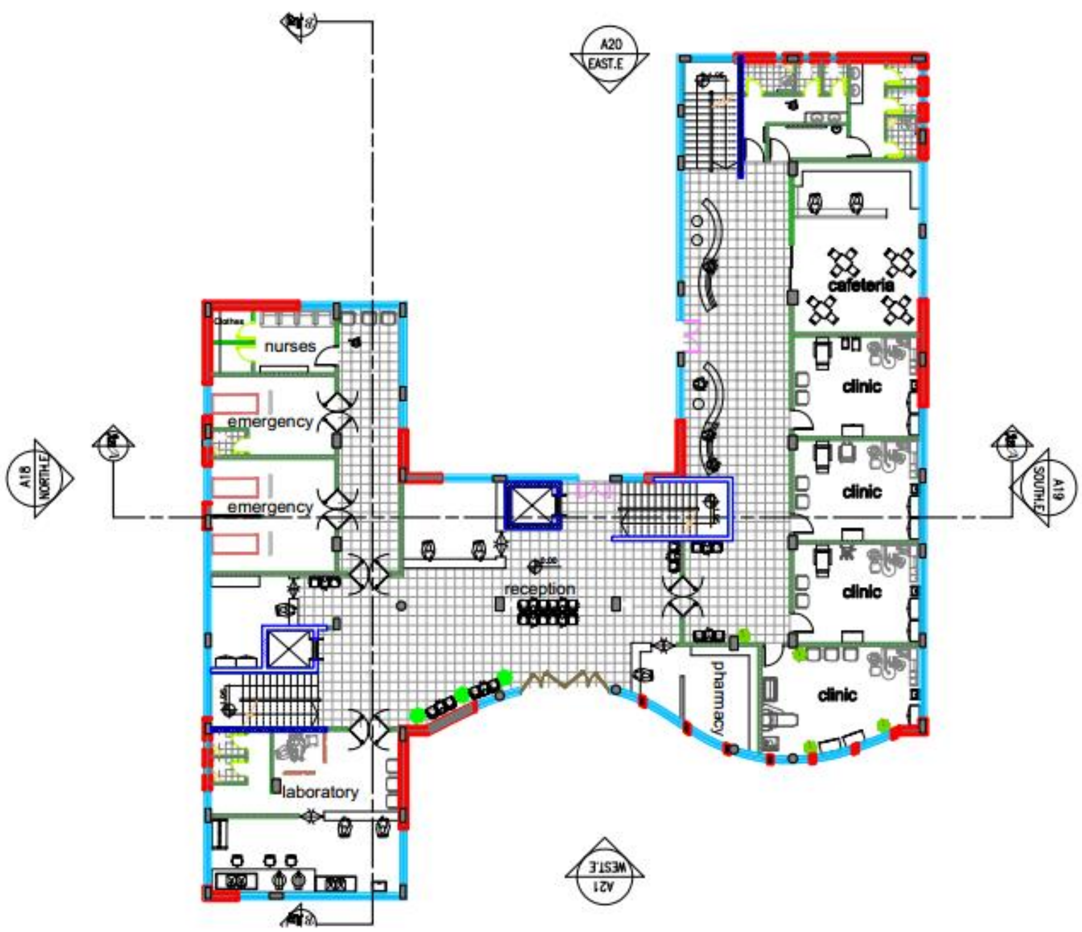


Figure 5: Ground Floor Plan

2.3.3 First Floor:

(Level +3.92 m) with an area of 689 m^2.

The first floor consists of administrative rooms, clinics, a lecture hall, an exhibition hall, WC, a meeting room, and rooms for doctors, as shown in Figure (6).

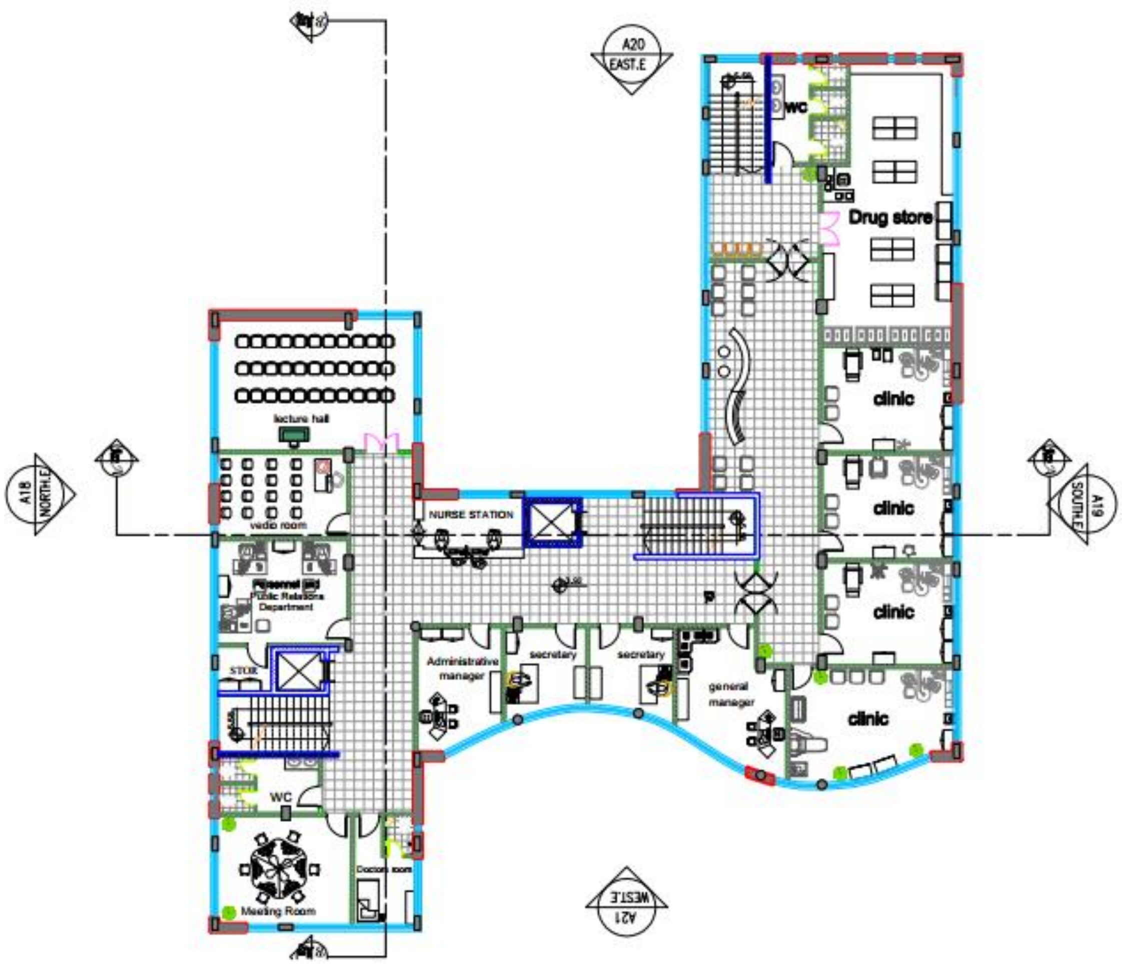


Figure 6: First Floor Plan

2.3.4 Second Floor:

(Level + 7.84 m) with an area of 689 m^2.

The last floor consists of patient rooms, a kitchen, medicine stores, WC, operating rooms, sterilization rooms, and rest rooms for patients as shown in Figure (7).

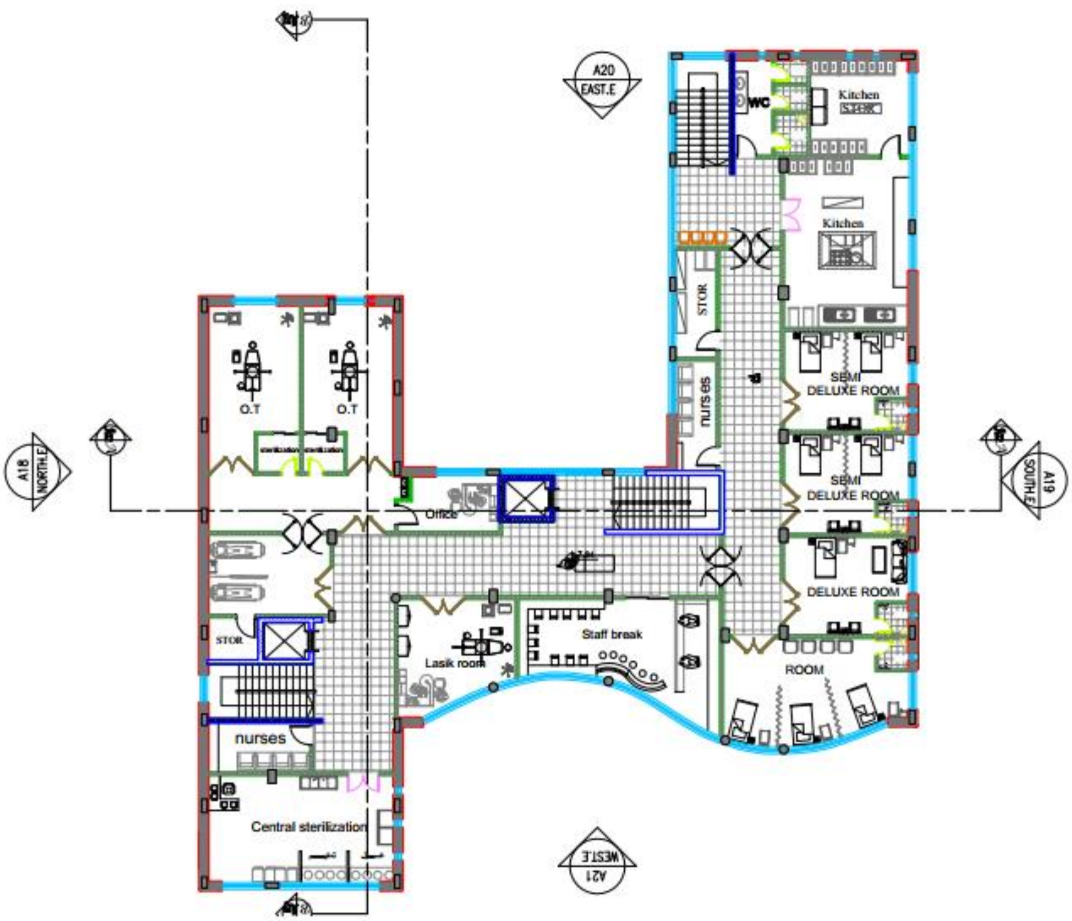


Figure 7: Second Floor Plan

2.4 ELEVATIONS DESCRIPTION

The following is a description of different elements and components of the project elevations:

2.4.1 North Elevation:

The northern elevation shows the entrance to the parking lot, clinic windows, patient rooms, the kitchen, the cafeteria, and the medicine store, as shown in Figure (8).

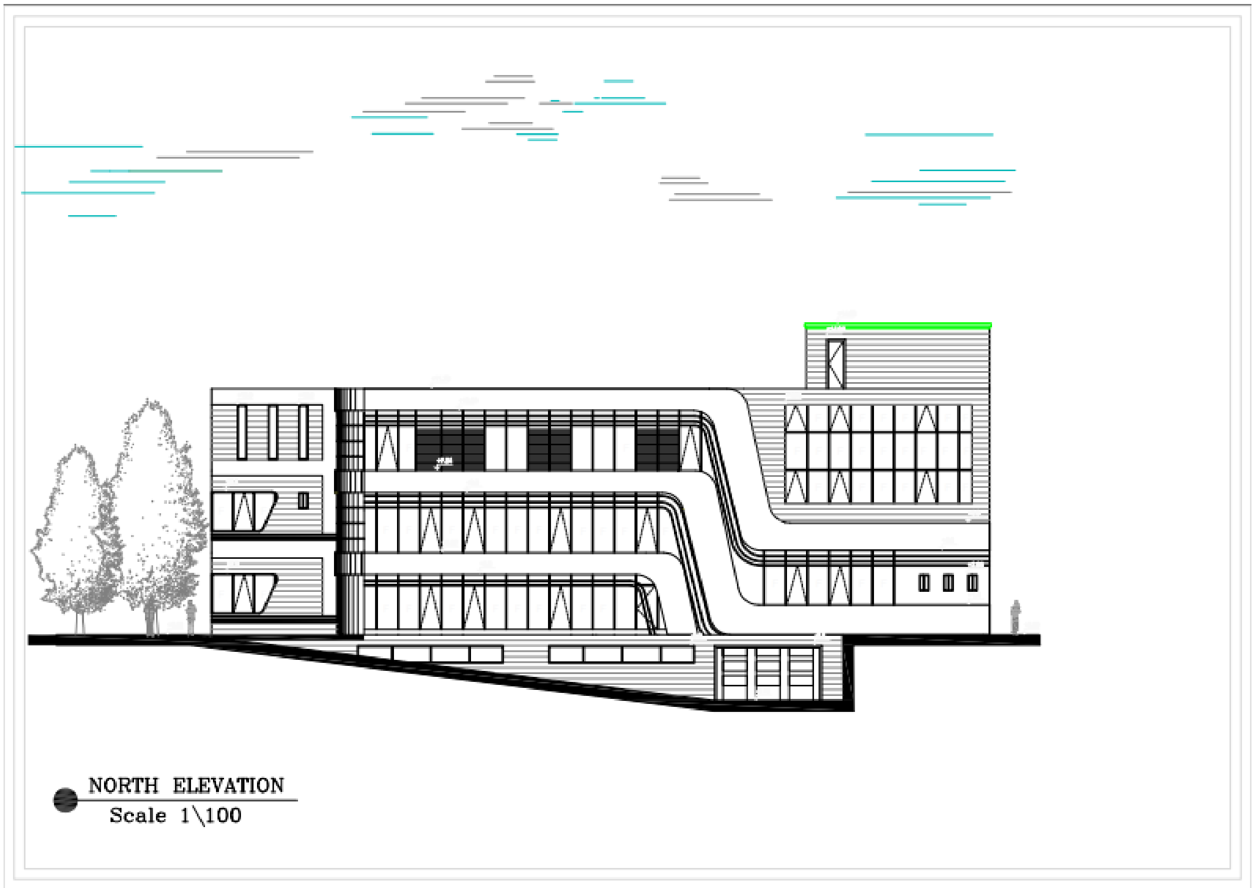


Figure 8: North Elevation

2.4.2 South Elevation:

The southern elevation shows the windows of the emergency, operations, sterilization and nurses rooms, in addition to the meeting rooms, as shown in Figure (9).

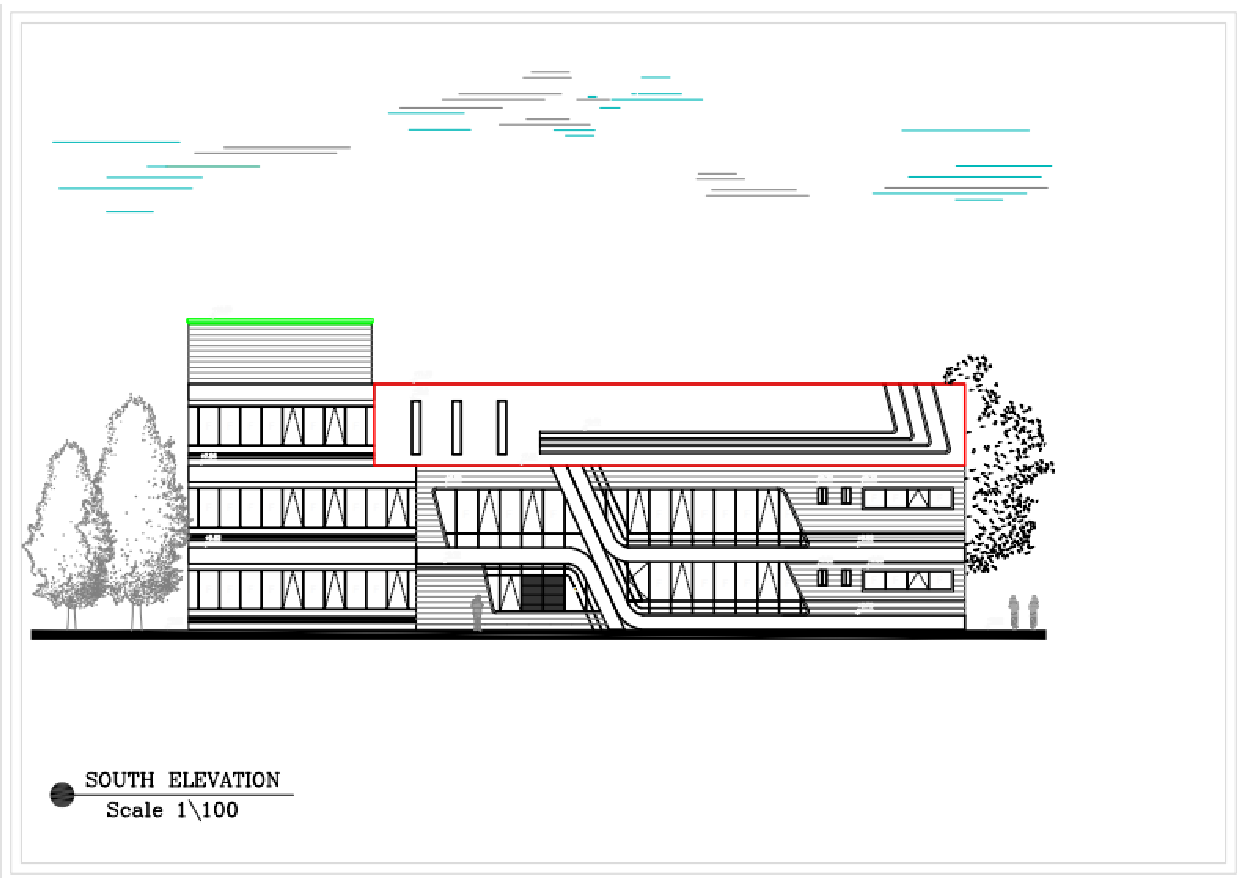


Figure 9: South Elevation

2.4.3 East Elevation:

The eastern elevation shows the main entrance and the windows of the administrative rooms and clinics, as shown in Figure (10).

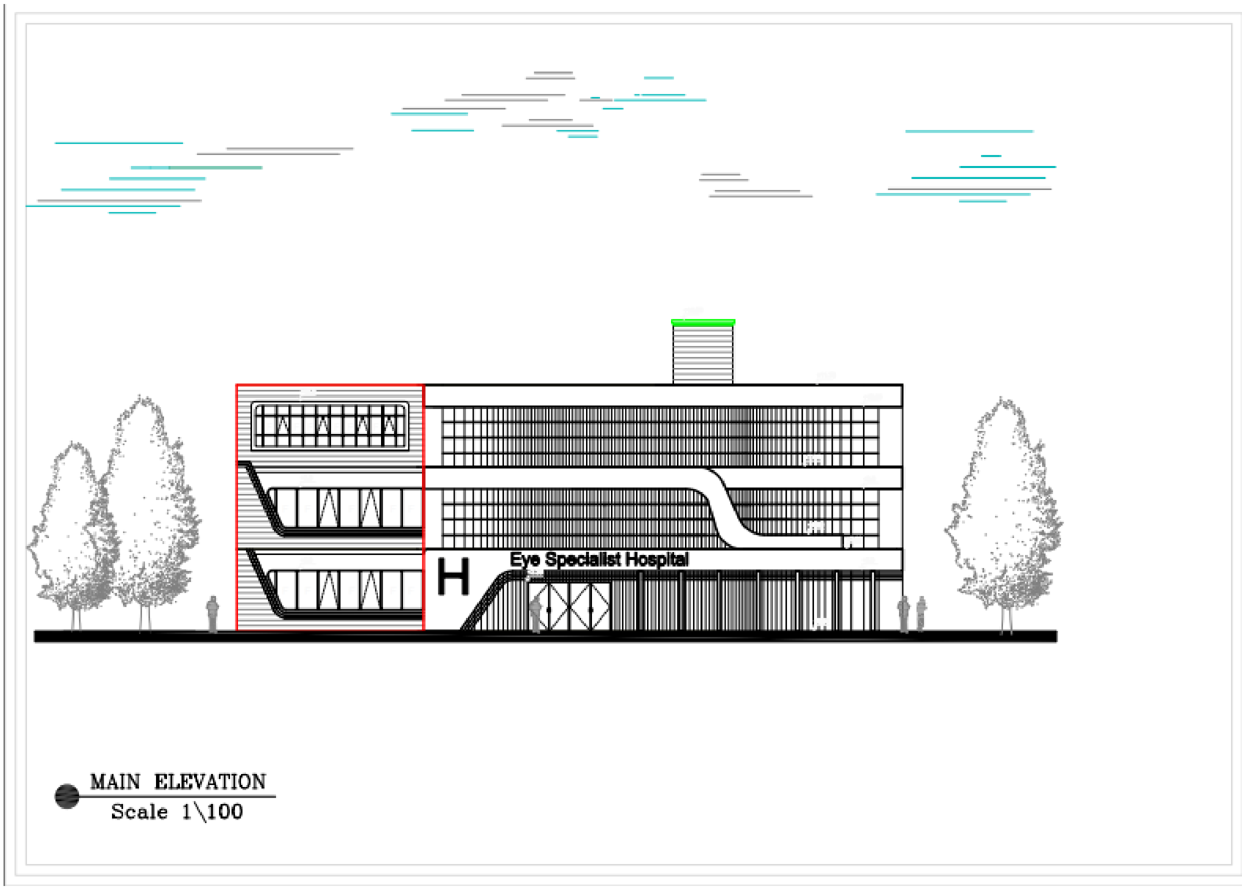


Figure 10 :East Elevation

2.4.4 West Elevation:

The western elevation shows a rear entrance to the hospital, as shown in Figure (11).

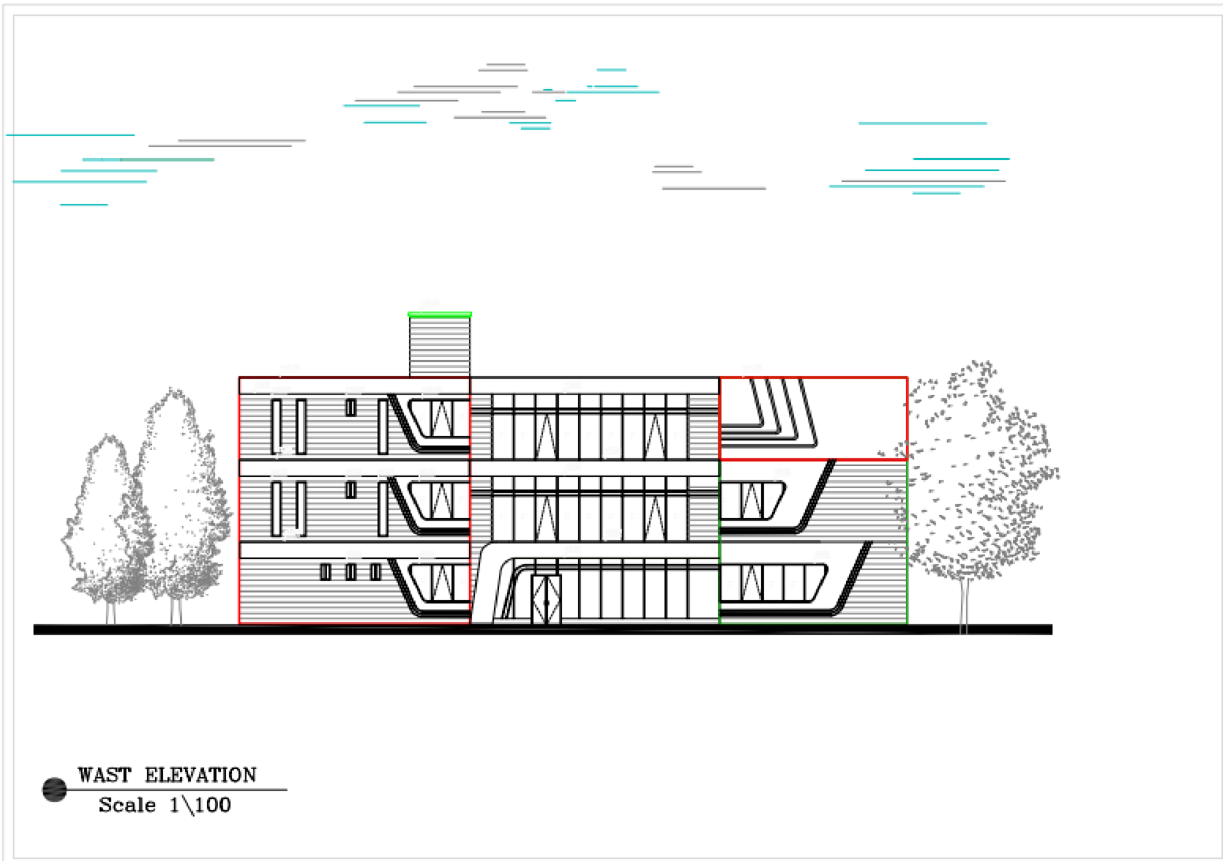


Figure11: West Elevation

CHAPTER 3
"STRUCTURAL DESCRIPTION"

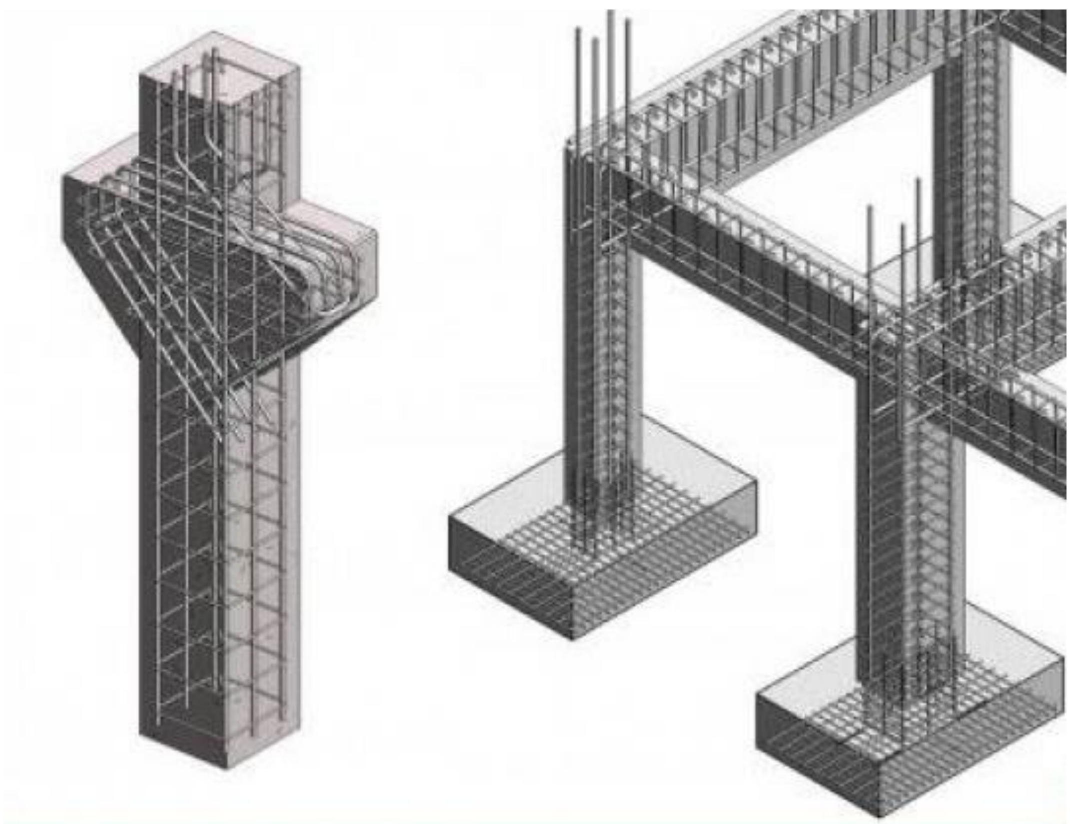


Figure 3: Expressive Image

3.1 INTRODUCTION

Structural design is a methodical investigation to get the economical specification of a structure or a structural element to carry the predicted load safely. With the application of structural design, we can obtain the required size, grade, reinforcement, etc. Of structural members to withstand the internal forces calculated from the structural analysis.

If the structure is not designed properly including proper selection of materials and technology or if the structure that we have designed is subjected to excessive load than the specified limit then it will probably fail to perform its intended function with possible damage both to structure and life, including complete damage.

3.2 THE AIM OF THE STRUCTURAL DESIGN

The following aims must be taken into consideration:

1. Ensure structural safety, which implies providing adequate stiffness and reinforcements to contain deflections and cracks.
2. Durability: The structure should last for a reasonable period.
3. Produce a structure that is capable to resist all applied loads without failure during its service life.
4. Obtain the economical dimensions of structural members. As any engineer can always design a massive structure, which has more than adequate stability, strength, and serviceability, but the ensuing cost of the structure may be exorbitant.
5. Stability to stop overturning, slipping, or buckling of the frame, or sections thereof, under load motion.
6. Investigate the strength and rigidity of structures.

3.3 STAGES OF STRUCTURAL DESIGN

Structural design stages can be divided into two main stages:

3.3.1 The First Stage:

It is the preliminary study of the project in terms of the nature and size of the project, in addition to understanding the project from all its various aspects, determining the building materials that will be approved for the project, then making the basic structural analyzes of this system, and the expected preliminary dimensions of it.

3.3.2 The Second Stage:

It is represented in the structural design of each part of the structure, in a detailed and accurate manner, according to the structural system that was chosen and the necessary structural details for it in terms of drawing horizontal projections, vertical sectors, and details of the reinforcement steel.

3.4 LOADS ACTING ON THE BUILDING

The loads to which the building is exposed are divided into different types, which are as follows:

3.4.1 Dead Load:

They are the loads resulting from the self-weight of the main elements that make up the structure, permanently and steadily, in terms of size and location, in addition to additional parts such as the various internal partitions and any mechanical works or additions that are carried out permanently and steadily in the building, and they can be calculated by determining the dimensions of the structural element, and the densities Its constituent materials, and Table (1) shows the specific densities of the materials used in the project.

Table 1: The Specific Densities of The Materials

MATERIALS USED	SPECIFIC DENSITIES USED (KN/m^3)
Reinforced concrete	**25**
Tiles	**23**
Mortar	**22**
Plaster	**22**
Sand Fill	**17**
Hollow block	**10**

Partition = 2.3 KN/m^2

3.4.2 Live Load:

For this project, live loads include people using the structure, static loads that can affect the building, in addition to unspecified (moving) partitions, and snow loads.

Live load values are chosen according to the Jordanian code tables:

Table 2 : Live Load From Jordanian Code

كما ورد في النوع الثالث من المباني السكنية.	غرف المراجـ ـل والمحركـ ـات والمـ . ـراوح وغـ . . ـرف المشـ ـروبات والحمـ . ـامات والـ . ـشرفات والممـ . . ـرات وغرف الطعـ ـام وردهـ ـات الاستراحة والبلياردو.	الـ . . ـسجون والمستشفيات والـ . . ـمدارس والكليات.	المباني التعليمية وماشابهها
كما ورد في النوع الثاني من المباني السكنية.	الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.		

1.8	2.0	غرف النوم.	**النوع الثاني :** المباني التي لا ينطبـ ـق عليهـ . ـا مـ . ـا ورد في النـ . . . ـوع الأول و البيـ ـسيوتات والمبـ ـاني المخصـ . ـصة لاقامـ . ـة الضيوف.
–	2.0	الحمامات.	
2.7	2.0	الطعام وردهات الاستراحة والبلياردو.	
4.5	3.0	الممرات والمداخل والأدراج و بـ . . . ـسطات الأدراج والممرات المرتفعة الموصـ ـلة بين المباني.	
4.5	3.0	المطابخ وغرف الغسيل.	

الحمل المركز البديل	الحم ل لم وزع	الاستعمال	نوع المبنى	
كن	كن/م٢	الاشغ ال	خاص	ع ام
4.5	7.5	المراجل والمحركات والمراوح وما شابه ذلك بما فيها أوزان الماكينات.	تابع النوع الثاني:	**تابع المباذ ي الخاصة والسكنية.**
1.5لكل مت ر طولي يؤثر عند الحافة الخارجية.	حمل الغرف ة ال تي تؤدي اليها على أن لا يقل عن (3).	الشرفات.		
1.0 على مسافة متر واحد بين الحمل والأخر.	–	الممرات الضيقة.		
1.8	2.0	غرف النوم والمهاجع.	**النوع الثالث:** الفن . . ادق والم . وتيلات ومنازل الطلبة وماشابهه ا.	
–	2.0	الحمامات.		
2.7	2.0	الطعام وردهات الاس تراحة والبليارد و.		
4.5	4.0	الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.		
4.5	3.0	المطاب خ وغرف الغسيل.		

كن	كن/م٢	الاشغ ال	خاص	ع ام
4.5	7.5	المراجل والمحركات والمراوح وماشاب ه ذلك.	تابع النوع الثالث:	**تابع المباذ ي الخاصة والسكنية**
3.6	5.0	قاعات الرقص والم ساحات المشتركة دون مقاعد ثابتة.		
–	4.0	قاعات التجمع بمقاعد ثابتة.		
–	5.0	قاعات المشروبات.		
1.5لكل متر طولي يؤثر عند الحافة الخارجية.	حمل الغرفة التي تؤدي اليها على أن لا يقل عن (4) .	الشرفات.		
كما في النوع الثاني.		الممرات الضيقة.		

Take LL = 5 KN/m^2

3.5 STRUCTURAL ELEMENTS OF THE BUILDING

3.5.1 Slabs:

- After studying the building architecturally and structurally, this type of panels was used in the design:
- **One-way solid slab**

  A one-way slab is a type of concrete slab in which loads are transferred in one direction to the supporting beams and columns. Therefore, the bending occurs in only one direction. It is used in areas that are highly exposed to live loads.

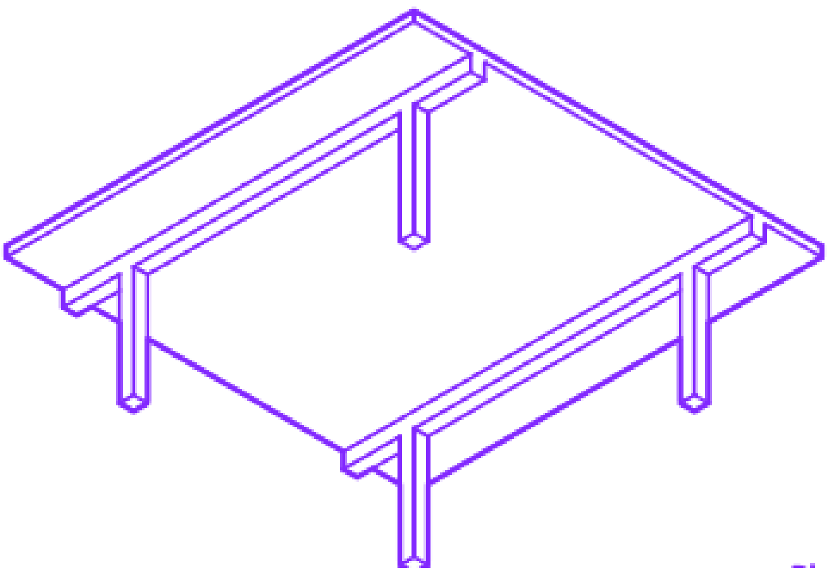


Figure 13: One-Way Solid Slab

- **One-way ribbed slab**

  It's the most common system used in Palestine. It consists of a row of bricks followed by the rib, and the reinforcement is in one direction

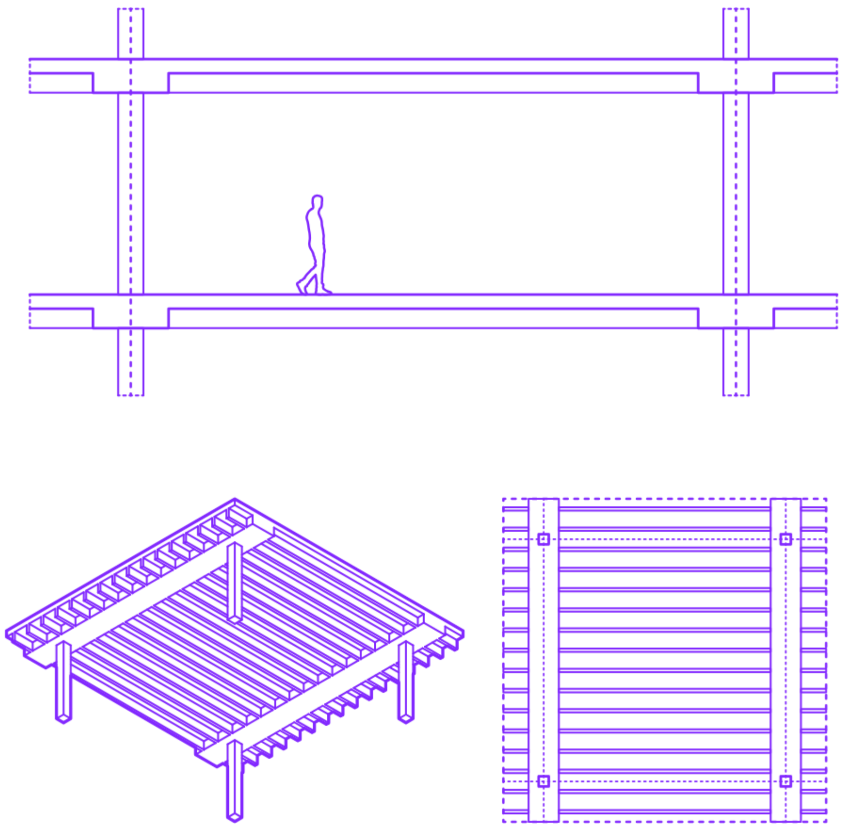


Figure 14: One-Way Ribbed Slab

3.5.2 Beams:

Beams act as structural elements that transfer loads from the slab to the columns. They are usually horizontal members. In our project we used this type:

- Rectangular Beams

  This type of beam is commonly used in construction because it is strong and relatively easy to construct. The strength of a rectangular beam comes from the fact that the concrete and steel work together to resist bending. Concrete is strong in compression while rebar is strong in tension. When load is applied to the beam, the concrete compresses and stretches the rebar.

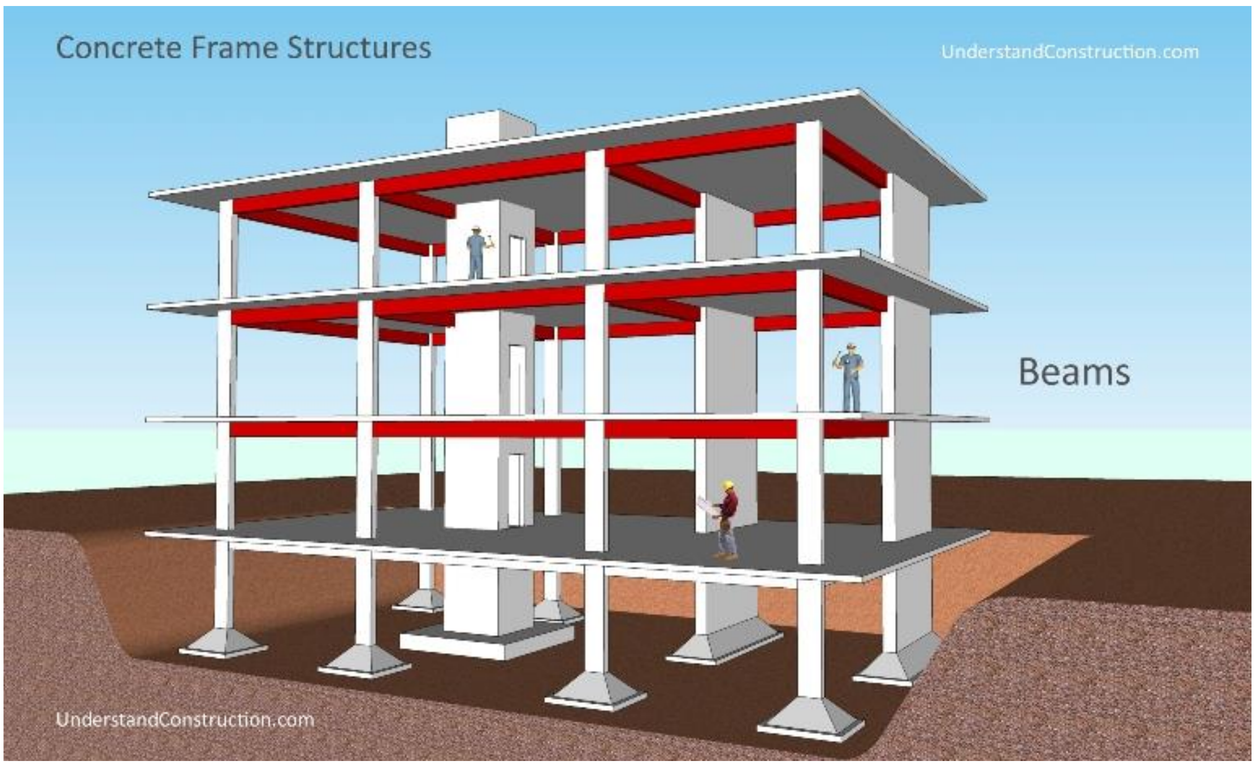


Figure 15: Rectangular Beam

3.5.3 Columns:

Columns act as a structural element that transfers loads from the slab, (i.e., roof, upper floor) to the foundation and finally to the soil under a structure. In our project we use:

- Continues columns
- Basement columns

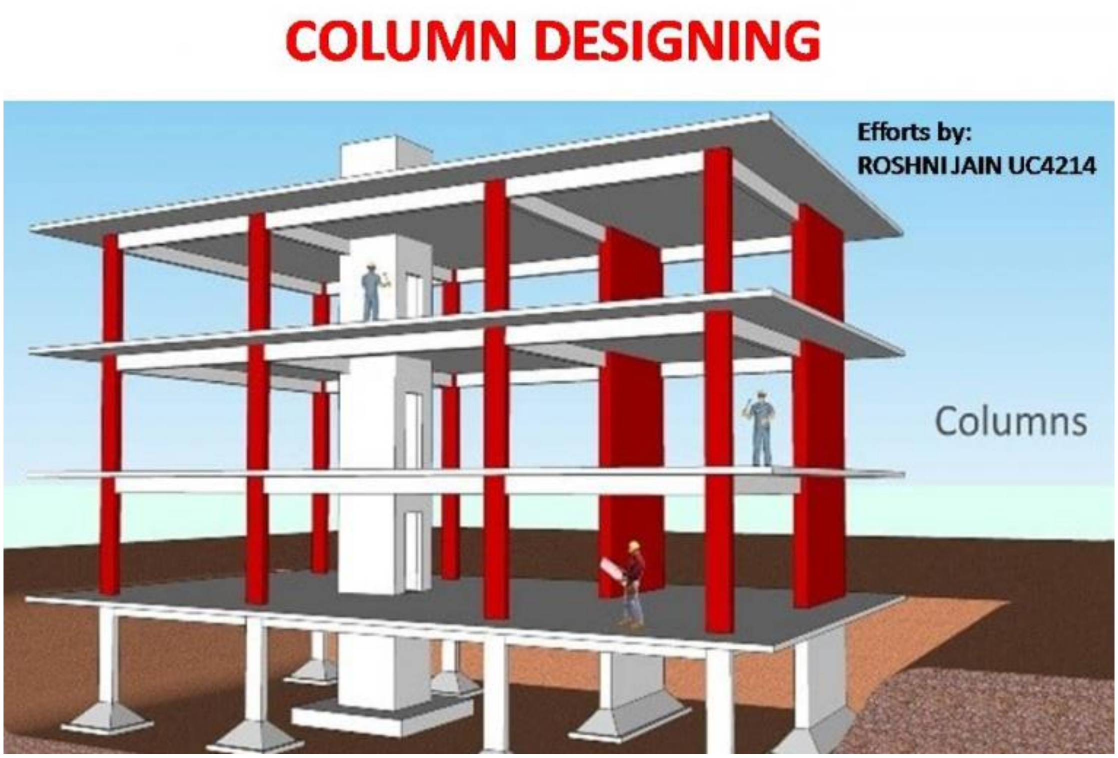


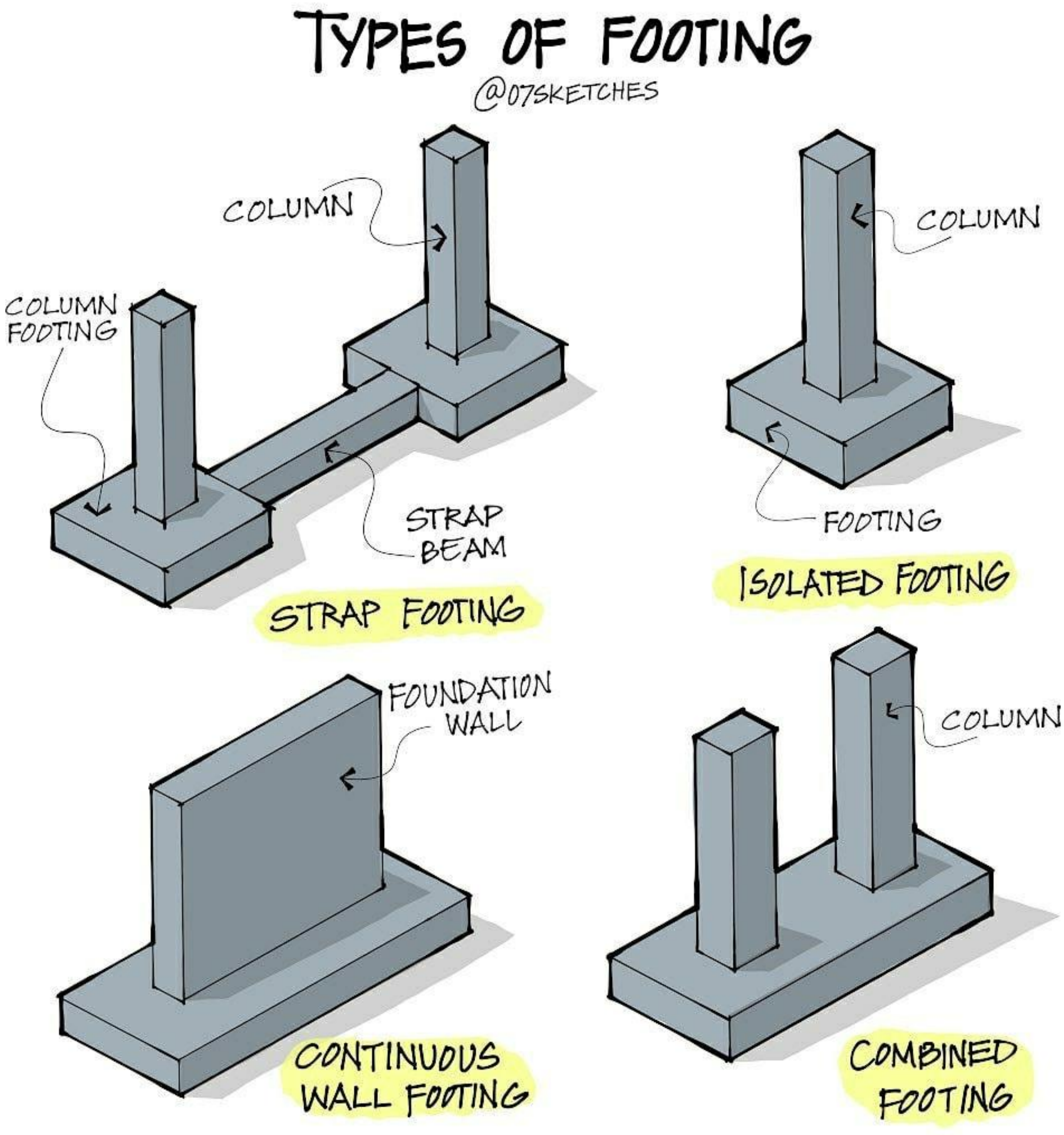
Figure 16: Columns

3.5.4 Foundations:

The foundations are the first thing that begins to be implemented when building, but they are designed after designing all the basic elements in the building, as the foundations transfer loads from columns and load-bearing walls to the soil in the form of strength and pressure.

We have many types of foundation in our building such as

- Isolated footing
- Combined footing
- Strip footing
- Mat footing



. *Figure 17 Foundation*

3.5.5 Shear Walls:

Shear walls are the walls that resist horizontal forces such as wind forces and earthquakes, and be in the walls of the stairwell and the walls of the elevators

In our project we used:

- Continues shear wall (staircase)
- Shear walls along the 1st basement floor

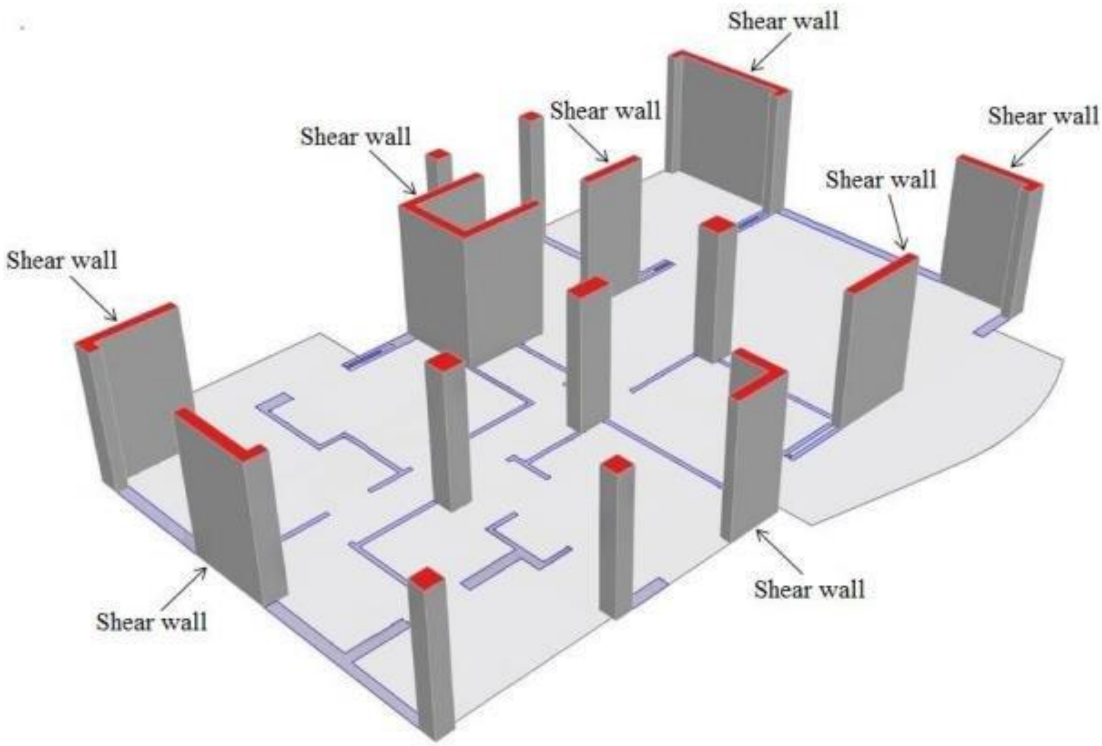


Figure 18: Shear Wall

3.5.6 Basement Walls:

They are reinforced walls that surround the building from all its external borders, and their function is to protect the building from the soil around it and completely isolate it from any factors outside its borders, such as water leakage and others.

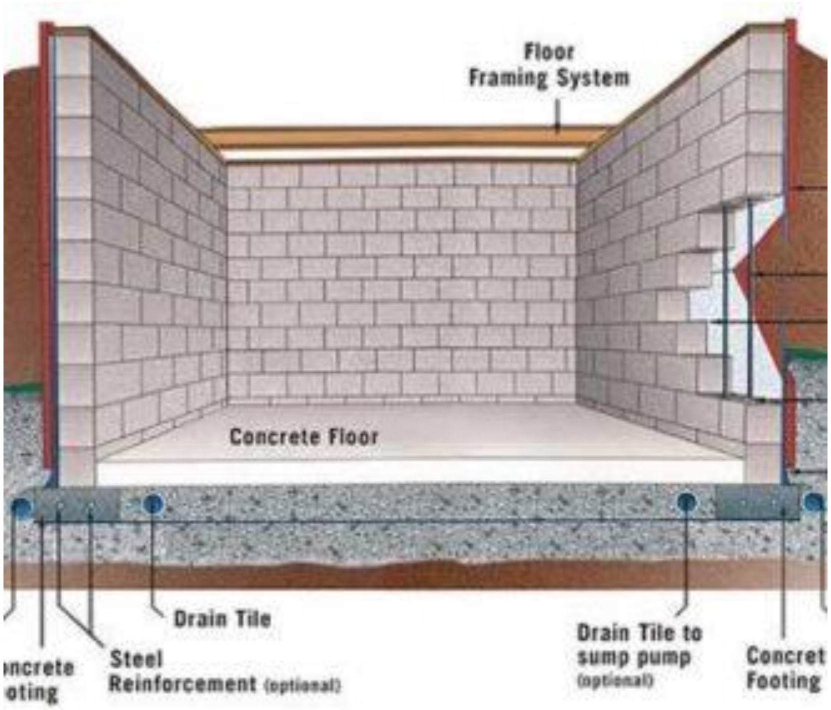


Figure 19: Basement Wall

3.5.7 Stairs:

The staircase is a movement element and a connection between the floors of the building

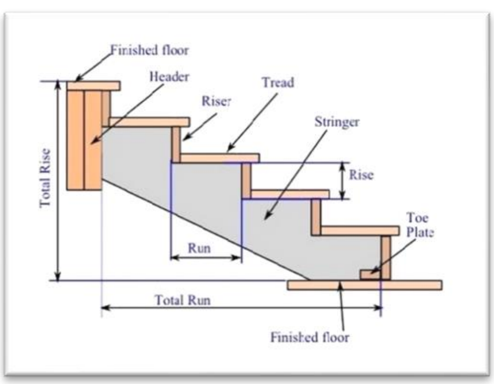


Figure 20: Stairs

CHAPTER 4
"STRUCTURAL ANALYSIS AND DESIGN"

4.1 INTRODUCTION

Normal plain concrete can withstand compressive stress but does not do well with tensile and stresses such as those caused by wind, earthquakes.

Reinforced concrete contains steel embedded in the concrete so the two materials complement each other to resist forces such as tensile, shear and compressive stress in the concrete structure.

This project contains one type of slab, which is “one-way ribbed slab”, which will be analyzed and designed using the finite element design method with the help of a computer program called “Beam D-Software” to find the internal forces, deflections and moments of the ribbed slab, and then calculate Handle to find the steel required for all members.

4.2 DESIGN METHOD AND REQUIREMENTS

The design strength provided by a member is calculated according to the requirements and assumptions of ACI-code (318-19).

4.2.1 Ultimate Strength Design Method:

In this method, the reinforced concrete structure is designed beyond the elastic region. the working dead load and live load are multiplied by a factor of safety. the section designed to fail at factored load. failure at factored load means the section exceeds the elastic region to ultimate strength then failure.

The computation of this strength takes into account the nonlinear stress-strain behavior of concrete. The strength design method is expressed by the following,

Strength provided ≥ strength required to carry factored loads.

4.2.2 Materials:

Reinforced Concrete: B300, $f_ć$ = 24 N/mm^2 (Mpa)

Reinforcement Rebars: f_y = 420 N/mm^2 (Mpa)

4.3 FACTORED LOAD

The structure may be exposed to different loads such as dead and live loads. The value of the load depends on the structure type and the intended use. The factored loads on which the structural analysis and design is based for our project members, is determined as follows:

$$q_u = 1.2DL + 1.6LL \quad \text{……… } ACI - 318 - 14\ (9.2.1.)$$

Where;

q_u: Ultimate Load (KN)

D_L: Dead Load (KN)

L_L: Live Load (KN)

4.4 DETERMINATION OF SLAB THICKNESS

Minimum Thickness of Non prestressed Beam or One-Way Slabs Unless Deflections are Calculated. **(**ACI-Code-318-19**)**

Table 3: Check Of Minimum Thickness of Structural Member.

Minimum Thickness (h)				
Member	**Simply supported**	**One end Continuous**	**Both end continuous**	**Cantilever**
Solid one-way slabs	**L/20**	**L/24**	**L/28**	**L/10**
Beams or ribbed one-way	**L/16**	**L/18.5**	**L/21**	**L/8**

4.4.1 One-Way Solid Slab Thickness:

The final thickness of the slab will be determined based on the deformation that will be calculated through the design programs because the slab is originally one-way ribbed slab.

4.4.2 One-Way Ribbed Slab Thickness:

- **Basement Floor**

  The maximum span length for one end continuous (for ribs):

  h_{min} for one-end continuous = L/24

  = 570/24 = **23.75 cm.**

  The maximum span length for both end continuous (for ribs):

  h_{min} for both-end continuous = L/28

  = 556/28 = **19.86 cm.**

- **Ground Floor, First Floor, Second Floor**

  The maximum span length for one end continuous (for ribs):

  h_{min} for one-end continuous = L/18.5

  = 570/18.5 = **30.8 cm.**

  The maximum span length for both end continuous (for ribs):

  h_{min} for both-end continuous = L/21

  = 556/21 = **26.5 cm.**

Selected a slab thickness of the solid slab thickness = 25 cm.

Selected a slab thickness of the ribbed slabs thickness = 32 cm.

4.5 DESIGN OF TOPPING IN Basement Floor

Consider the Topping as strip of (1m) width.

Dead Load Calculation:

Dead Load from:	δ	γ	b	δ*γ*1=KN/m
Tiles	0.03	23	1	0.69
Mortar	0.03	22	1	0.66
Coarse sand	0.07	17	1	1.19
Topping	0.08	25	1	2
Interior Partitions	2.3		1	2.3
			∑	6.84

Live Load For 1m strip = 5 KN/m^2 × 1 = **5 KN/m**

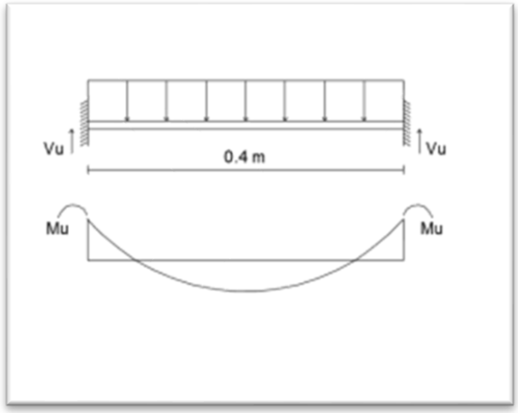


Figure 21: Topping Load

- ✓ Factored load:

W_u= 1.2 ×6.84 + 1.6×5 = 16.208 KN/m

- ✓ Check the strength condition for plain concrete:

$\emptyset M_n \geq M_u$, where $\emptyset$= 0.55

$M_n = 0.42\ \lambda \sqrt{f_c'}\ S_m$ .... **(ACI 22.5.1, equation 22-2)**

$$S_m = \frac{b.h^2}{6} = \frac{1000.80^2}{6} = 1066666.67\ mm^2$$

$\emptyset M_n$ =0.55×0.42×1×$\sqrt{24}$ ×1066666.67 ×10^{-6} =1.2 KN.m

$M_u = \frac{W_u L^2}{12} = 0.216$ KN. m (negative moment)

$M_u = \frac{W_u L^2}{24} = 0.108$ KN. m (positive moment)

$\emptyset M_n >> M_u =$ 0.216 KN. m

No reinforcement is required by analysis. According to ACI 10.5.4, provide As_{min} for slabs as shrinkage and temperature reinforcement.

$\rho_{shrinkage}$**= 0.0018**

$A_s = \rho \times b \times h_{topping}$ =0.0018 ×1000×80 = 144 mm^2/m strip.

Step (s) is the smallest of:

1. 3h = 3×80 =240 mm …… ***control***
2. 450 mm.
3. S =$380\left(\frac{280}{f_s}\right) - 2.5C = 380\ \left(\frac{280}{\frac{2}{3}(420)}\right) - 2.5\ \times 20 = 330$ mm

Take ∅ 8 @ 200 mm in both direction, S = 200 mm <S_{max} = 240 mm … OK

4.6 DETERMINATION OF SLABS LOADS

4.6.1 One-Way Solid Slab.

- **Basement Floor**

Table 4: Dead Load Basement floor with One-Way Solid Slab.

Dead Load Calculation:

Dead Load from:	δ	γ	$\delta*\gamma*1$=KN/m
Tiles	0.03	23	0.69
Mortar	0.03	22	0.66
RC	0.25	25	6.25
Coarse sand	0.07	17	1.19
Plaster	0.03	22	0.66
Interior Partitions	2.3		2.3
		∑	11.75

Nominal Total Dead load = **11.75 KN/m/rib**

Nominal Total Live load = 5 * 1 = **5 KN/m**

4.6.2 One-Way Ribbed Slab.

- **Ground, First and Second Floors**

Table 5: Dead Load Ground, First and Second Floors with One-Way Ribbed Slab.

Dead Load Calculation:

Dead Load from:	δ	γ	b	$\delta*\gamma*1$=KN/m
Tiles	0.03	23	0.52	0.3588
Mortar	0.03	22	0.52	0.3432
Coarse sand	0.07	17	0.52	0.6188
Topping	0.08	25	0.52	1.04
RC Rib	0.24	25	0.12	0.72
Hollow Block	0.24	10	0.4	0.96
Plaster	0.03	22	0.52	0.3432
Interior Partitions	2.3		0.52	1.196
			∑	5.58

Nominal Total Dead load = **5.58KN/m/rib**

Nominal Total Live load = 5* 0.52 = **2.6 KN/m/rib**

4.7 DESIGN OF SECOND FLOOR ONE-WAY RIBBED SLAB(R9)

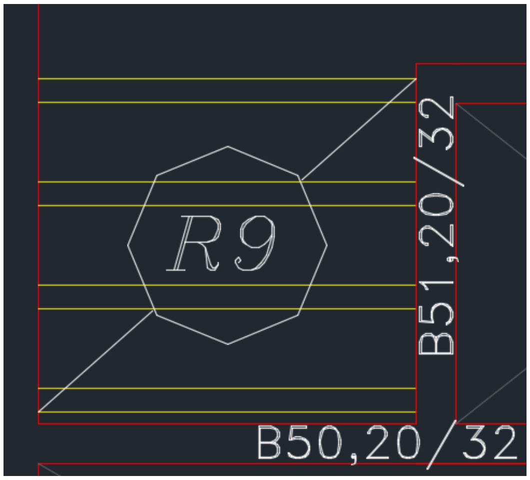


Figure22: Rib Location

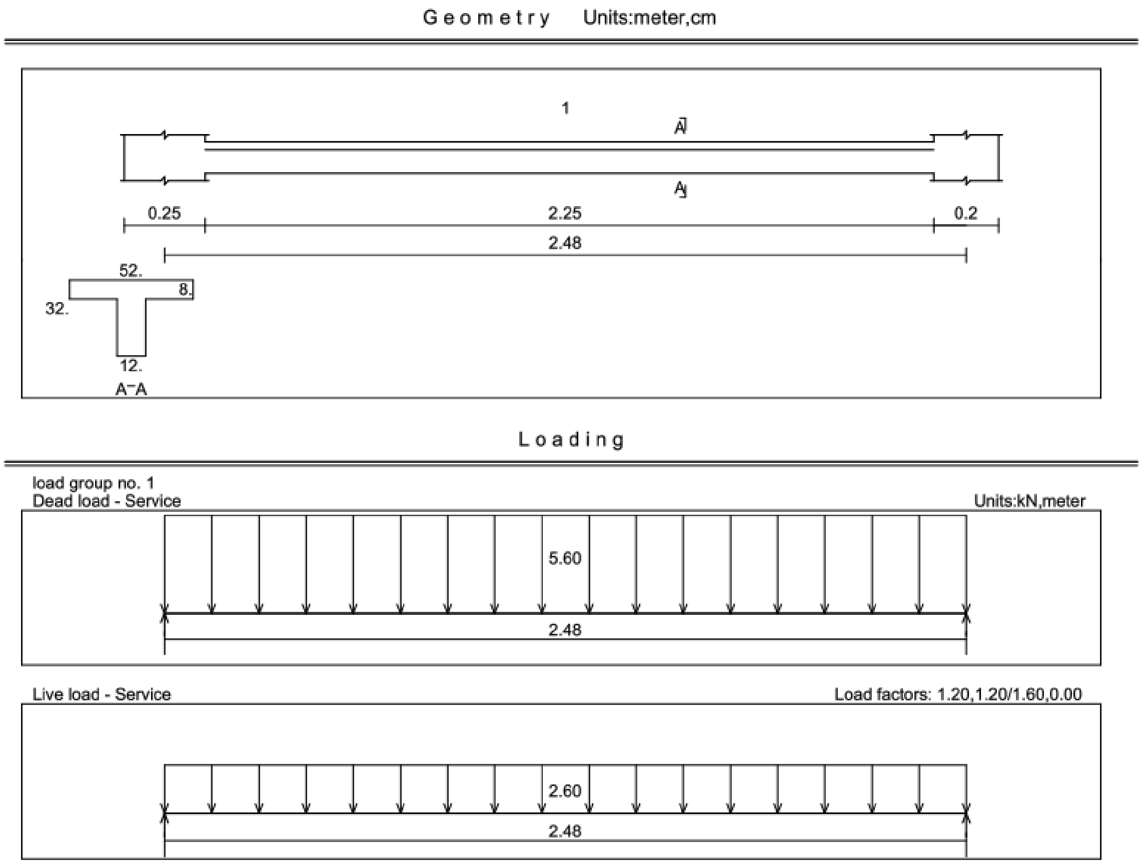


Figure 23: Rib Geometry and loading

- ✓ Material:

concrete B300 $F_c' = 24\ N/mm^2$

Reinforcement Steel $F_y = 420\ N/mm^2$

- ✓ Section:

b =12cm b_f= 52 cm

h =32cm T_f = 8 cm

4.7.1 Design For Flexure:

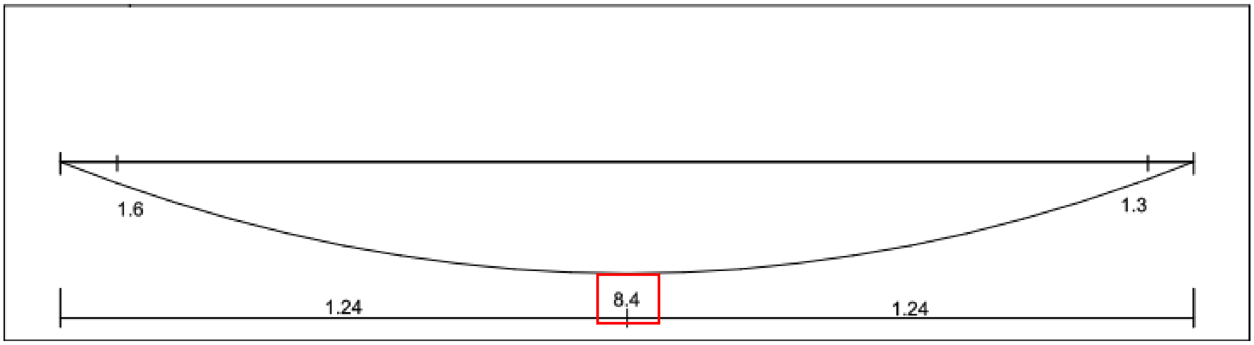


Figure24: Moment Envelope

- ✓ Factored load:

W_u= (1.2 ×5.6) + (1.6×2.6) = **10.88 KN/m**

- ✓ Moment calculation:

$$M_u = \frac{WL^2}{8} = \frac{10.88 \times 2.48^2}{8} = \textbf{8.37 KN.m}$$

- ✓ Design for positive moment (M_u=8.37 KN.m)

Assume bar diameter ∅**10** for main reinforcement.

Assume bar diameter ∅**10** for stirrups.

$D = 320 - 20 - 10 - \frac{10}{2} = 285$ mm

Check if $a > h_f$:

$\overline{Mn_f} = 0.85 f_{\acute{c}}\, b\, h_f (d - \frac{h_f}{2}) = 0.85 \times 24 \times 520 \times 80 \times (285 - \frac{80}{2}) \times 10^{-6}$ = 208 KN.m

$\overline{Mn_f} \gg M_u$ …. $\boldsymbol{a < h_f}$ ➡ **The section is as rectangular section**

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{8.37 \times 10^6}{0.9 \times 520 \times 285^2}$ = 0.22 Mpa

m = $\frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24}$ = 20.58

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.22}{420}})$ = 0.00053

$A_s = \rho \times b \times d$ = 0.00053× 520 × 285 = 78.55 mm^2

$A_{s_{min}} = 0.25 \times \frac{\sqrt{f_{\acute{c}}}}{f_y} \times b_w \times d \geq \frac{1.4}{f_y} \times b_w \times d$

$A_{s_{min}} = 0.25 \times \frac{\sqrt{24}}{420} \times 120 \times 285 \geq \frac{1.4}{420} \times 120 \times 285$

$A_{s_{min}}$ = 99.73 mm^2 ≤ 114 mm^2 **…… Control**

$A_s = 78.55\, mm^2 < A_{s_{min}} = 114\, mm^2$ ➡ **Design for minimum reinforcement.**

<u>Use 2∅12</u> with $\boldsymbol{A_{s_{provid}} = 226\ mm^2 > A_{s_{min}} = 114\, mm^2}$

4.7.2 Design For Shear:

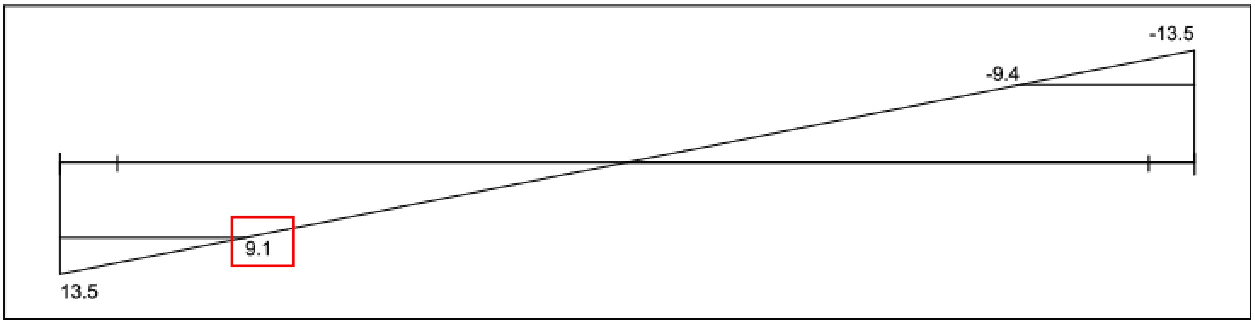


Figure 25: Shear Envelope

✓ $(V_{u,d} = 9.1\ KN)$

d = 320 − 20 − 10 − $\frac{10}{2}$ = 285 mm

$\emptyset V_c = \emptyset\ \frac{1.1}{6} . \lambda . \sqrt{f\acute{c}} . b_w . d$ = 0.75 . $\frac{1.1}{6}$. 1 . $\sqrt{24}$. 120 . 285 . 10^{-3} = 23.037 KN

$\frac{1}{2}\emptyset V_c$ = $\frac{1}{2}$ × 23.037 = 11.518 KN

Check for Cases: -

Case 1: $V_u \leq \frac{\phi V_c}{2}$.

$V_u\ = 9.1\ KN < \frac{1}{2}\emptyset V_c = 11.518\ KN$ → **So, no shear reinforcement is provided.**

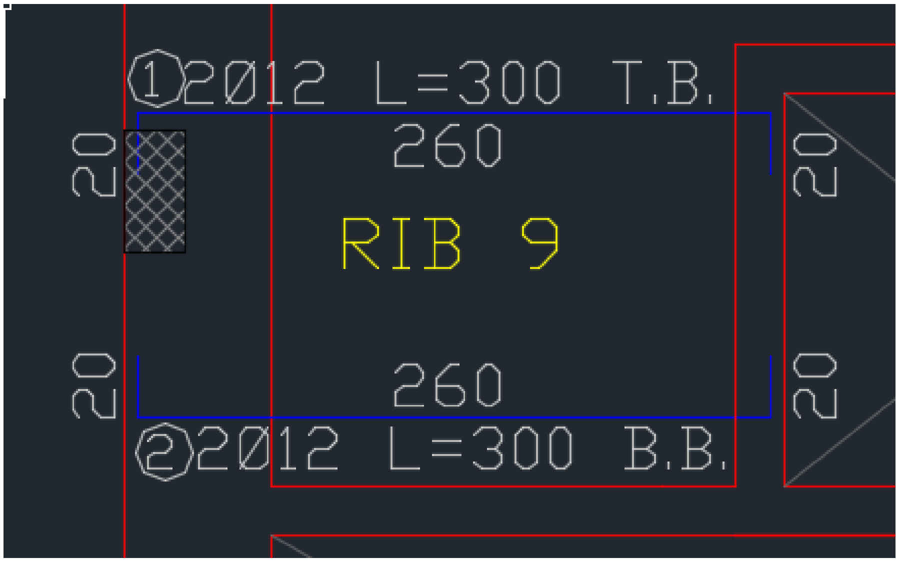


Figure 26: Reinforcement of Rib 9 in Building

4.8 DESIGN OF BEAM(B34)

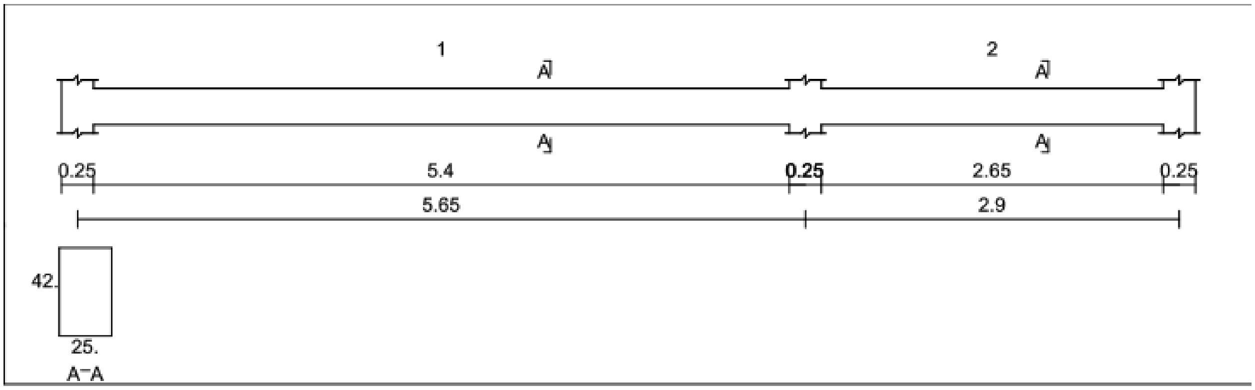


Figure 27: Beam34 Geometry

- ✓ Material:

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel Fy = 420 N/mm^2

- ✓ Section:

B = 25 cm

h =30 cm "choose h= 30 cm, for deflection requirement's L/240"

According to ACI-Code-318, the minimum thickness of no prestressed beams or one-way slabs unless deflections are computed as follow:

h_{min} for one end cont. = L/18.5

=565 /18.5 = 30.54cm.

Select Total depth of beam h= 42cm.

✓ Loads acts on beam B34:

- Own weight of the beam = Sectional Area × γ concrete =0.25*0.42 *25 = 2.625 kN/m
- Reactions from (Wall): 3.6*0.3*25 = 27 → = $\frac{2}{3}$ * 27 = 18 kN/m

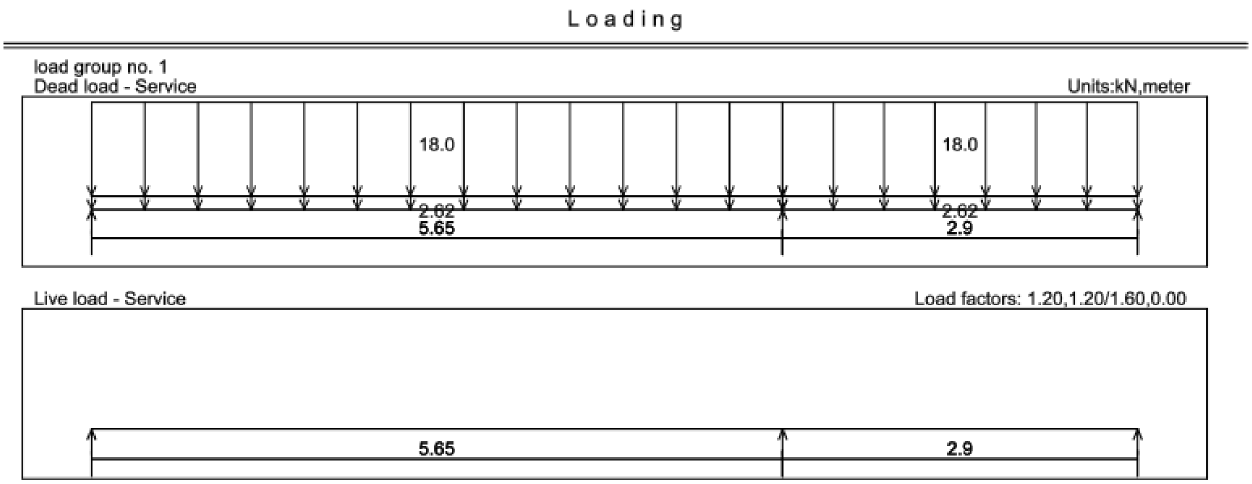


Figure 28: Loads Acts on Beam B34

4.8.1 Design for flexure:

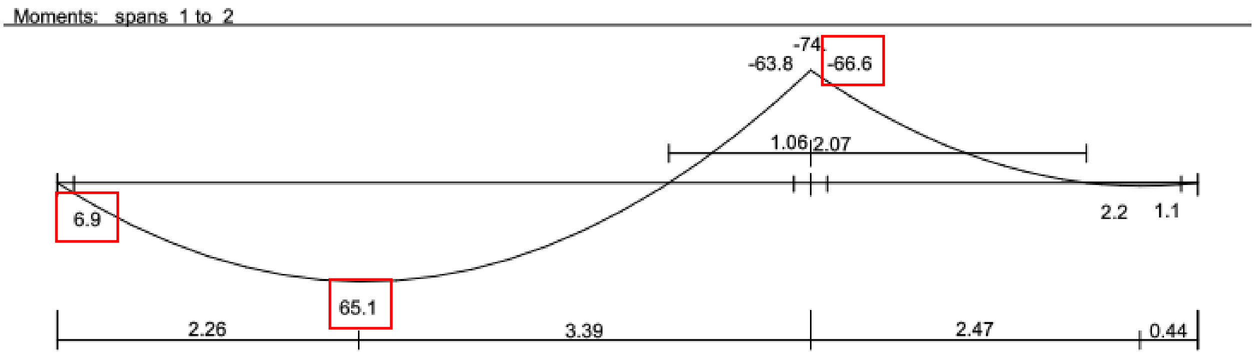


Figure 29: Moment Envelope

✓ ***(Mu_{max} = -66.6 kN.m)***

Assume bar diameter **Ø16** for main reinforcement.

Assume bar diameter **Ø10** for stirrups.

d = depth - cover – diameter of stirrups – (diameter of bar/ 2)

$=420 - 40 - 10 - \frac{16}{2} = 362$ mm

$C_{max} = \frac{3}{7} * d = \frac{3}{7} * 362 = 155.14$ mm.

$a_{max} = \beta_1 * C_{max} = 0.85 * 155.14 = 131.87$ mm.

$M_{n\,max} = 0.85 * f_c' * b * a * (d - \frac{a}{2})$

$= 0.85 * 24 * 0.25 * 0.13187 * (0.362 - 0.13187/2) * 10^3 = 199.12$ KN.m

$\varepsilon_s = 0.003 * \frac{d-c}{c} = 0.003 * \frac{362-155.14}{155.14} = 0.004$

$\Phi = 0.65 + \frac{250}{3} * (0.004 - 0.002) = 0.82$

$\phi\, Mn_{max} = 0.82 * 199.12 = 163.28$ KN.m

→ Mu = 66.6 KN.m < $\phi\, Mn_{max}$ = 163.28 KN.m

∴Singly reinforced concrete section.

✓ Maximum positive moment $Mu^{(+)}$ = 65.1 kN.m

Mn = Mu /ϕ = 65.1 / 0.9 = 72.33 kN.m

m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{72.33*10^6}{250*(362)^2}$ = 2.2 MPa

$\rho = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*2.2*20.58}{420}}\right) = 0.0056$

$A_s = \rho * b * d = 0.0056*250*362 = 502.8\ mm^2$

$$As_{min} = \frac{\sqrt{f_c'}}{4\,(f_y)} * b * d \ \ \geq \frac{1.4}{f_y} * b * d$$

$$= \frac{\sqrt{24}}{4 * 420} * 250 * 362 \ \ \geq \frac{1.4}{420} * 250 * 362$$

= 263.9 mm^2 < 301.7 mm^2 …. As, min = 301.7 mm^2

A_s = *502.8* mm^2 > As, min = 301.7 mm^2 **OK**

<u>Use 2 ϕ20</u> …. As= 628.32 mm^2 for bottom reinforcement

Check for strain:-($\varepsilon_s \geq 0.005$)

Tension = Compression

A_s * Fy = 0.85 * f_c' * b * a

628.32* 420 = 0.85 * 24 * 250* a

a = 51.74 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{51.74}{0.85}$ = 60.88 mm.

d=420 – 40 – 10 – $\frac{20}{2}$ = 360 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{360-51.74}{51.74} * 0.003 = 0.0179 > 0.005$ ∴ **ϕ =0.9 … OK**

✓ Minimum positive moment $Mu^{(+)}$ = 6.9 kN.m

Mn = Mu /ϕ = 6.9 / 0.9 = 7.67 kN.m

m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{7.67*10^6}{250*(362)^2}$ = 0.23 MPa

$\rho = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.23*20.58}{420}}\right)$ = *0.00055*

$A_s = \rho * b * d$ = *0.00055*250*362 = 49.78* mm^2

$$As_{min} = \frac{\sqrt{f_c'}}{4\,(f_y)} * b * d \ \geq \ \frac{1.4}{f_y} * b * d$$

$$= \frac{\sqrt{24}}{4 * 420} * 250 * 362 \ \geq \ \frac{1.4}{420} * 250 * 362$$

= 263.9 mm^2 < 301.7 mm^2 …. As, min = 301.7 mm^2

A_s = *49.78* mm^2 < As, min = 301.7 mm^2 → **Design for minimum reinforcement.**

<u>Use 4 ϕ12</u> …. As= 452.4 mm^2

Check for strain:-($\varepsilon_s \geq 0.005$)

Tension = Compression

A_s * Fy = 0.85 * f_c' * b * a

452.4* 420 = 0.85 * 24 * 250* a

a = 37.26 mm.

f_c' = 24 MPa< 28 MPa→ $\beta_1 = 0.85$

$c = \frac{a}{\beta_1} = \frac{37.26}{0.85}$ = 43.83 mm.

d=420 – 40 – 10 – $\frac{12}{2}$ = 364 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{364-43.83}{43.83} * 0.003 = 0.022 > 0.005$ ∴ **ϕ =0.9 … OK**

✓ Maximum Negative moment $Mu^{(-)}$ = -66.6 KN.m

Mn = Mu /ϕ = 66.6 / 0.9 = 74 kN.m

d=420 – 40 – 10 – $\frac{16}{2}$ = 362 mm

d = 362mm → bar diameter Ø16.

m = 20.58

$R_n = \frac{M_n}{b*d^2} = \frac{74*10^6}{250*(362)^2}$ = 2.26 MPa

$\rho = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*2.26*20.58}{420}}\right)$ = 0.0057

$A_s = \rho$ * b *d =0.0057*250*362 = 515.85 mm^2

As, min = 301.7 mm^2

A_s = 515.85 mm^2 > As, min = 301.7 mm^2

<u>Use 4 Φ16</u> …. As= 804.2 mm^2 for Top reinforcement.

Check for strain:-($\varepsilon_s \geq 0.005$)

Tension = Compression

A_s * Fy = 0.85 * f_c' * b * a

804.2* 420 = 0.85 * 24 * 250* a

a = 66.23 mm.

f_c' = 24 MPa< 28 MPa→ $\beta_1 = 0.85$

$c = \frac{a}{\beta_1} = \frac{66.23}{0.85}$ = 77.92 mm.

d=420 – 40 – 10 – $\frac{16}{2}$ = 362 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{362-77.92}{77.92} * 0.003 = 0.011 > 0.005$ ∴ **ϕ =0.9 … OK**

4.8.2 Design for Shear:

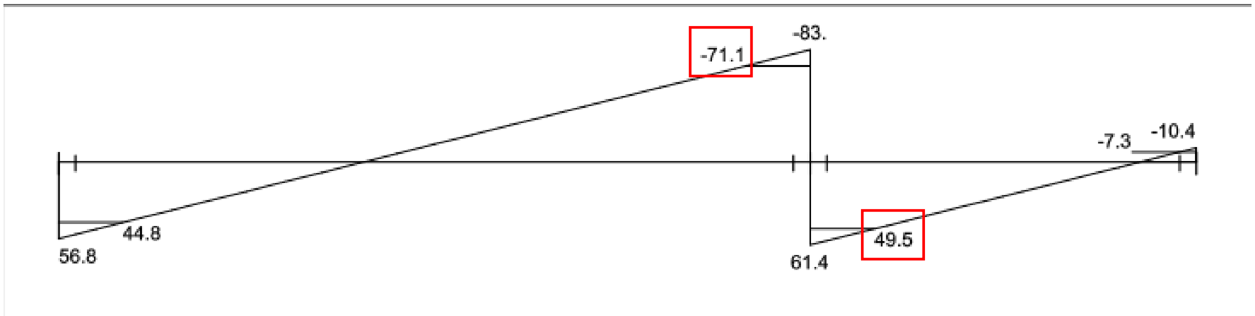


Figure 30: Shear Envelope

✓ $(V_{u,d} = -71.1\ KN)$

$\phi Vc = \phi * \frac{\sqrt{f'_c}}{6} * b * d = 0.75 * \frac{\sqrt{24}}{6} * 250 * 362 * 10^{-3} = 55.42$ KN.

$\frac{\phi V_c}{2} = \frac{55.42}{2} = 27.71$ KN

Check For Cases:-

Case1: $V_u \leq \frac{\phi V_c}{2}$

55.42 > 27.71

∴ Case (1) is NOT satisfied

Case 2: $\frac{\phi V_c}{2} < V_u \leq \phi V_c$

27.71< 71.1 >55.42

∴ Case (2) is NOT satisfied

Case 3: $\phi V_c < V_u \leq (\phi V_c + \phi Vs_{min})$

$\phi\, Vs_{min} \;\geq\; \frac{\phi}{16}\sqrt{f_c'} * b_w * d = \frac{0.75}{16}\sqrt{24} * 0.25 * 0.362 * 10^3 = 20.78$ KN.

$\geq\; \frac{\phi}{3} * b_w * d = \frac{0.75}{3} * 0.25 * 0.362 * 10^3 = 22.625$ KN …. **Control**.

$\therefore \phi Vs_{min} = 22.625$ KN.

$\phi V_c + \phi Vs_{min} = 55.42 + 22.625 = 78.045$ KN.

$\phi V_c < V_u \leq (\phi V_c + \phi Vs_{min})$

$55.42 < 71.1 \leq 78.045$ …. **OK**

∴ **Case (3) is** satisfied

$\left(\frac{Av}{S}\right) = \frac{Vs}{(fy_t * d)}$

$Vs = \left(\frac{Vu}{\phi} - Vc\right)$

$Vs = \left(\frac{71.1}{0.75} - \frac{55.42}{0.75}\right) = 20.91$ KN

Try 2 Φ 10 = 2 * 78.5 = 157 mm^2.

$\frac{2*78.5}{S} = \frac{20.91 * 10^3}{(420 * 362)} \rightarrow s = 1141.57$ mm

$s \leq \frac{d}{2} = \frac{362}{2} = 181$ mm …. CONTROL

≤ 600 mm.

∴ Use Φ10 @ 10 cm 2Lag.

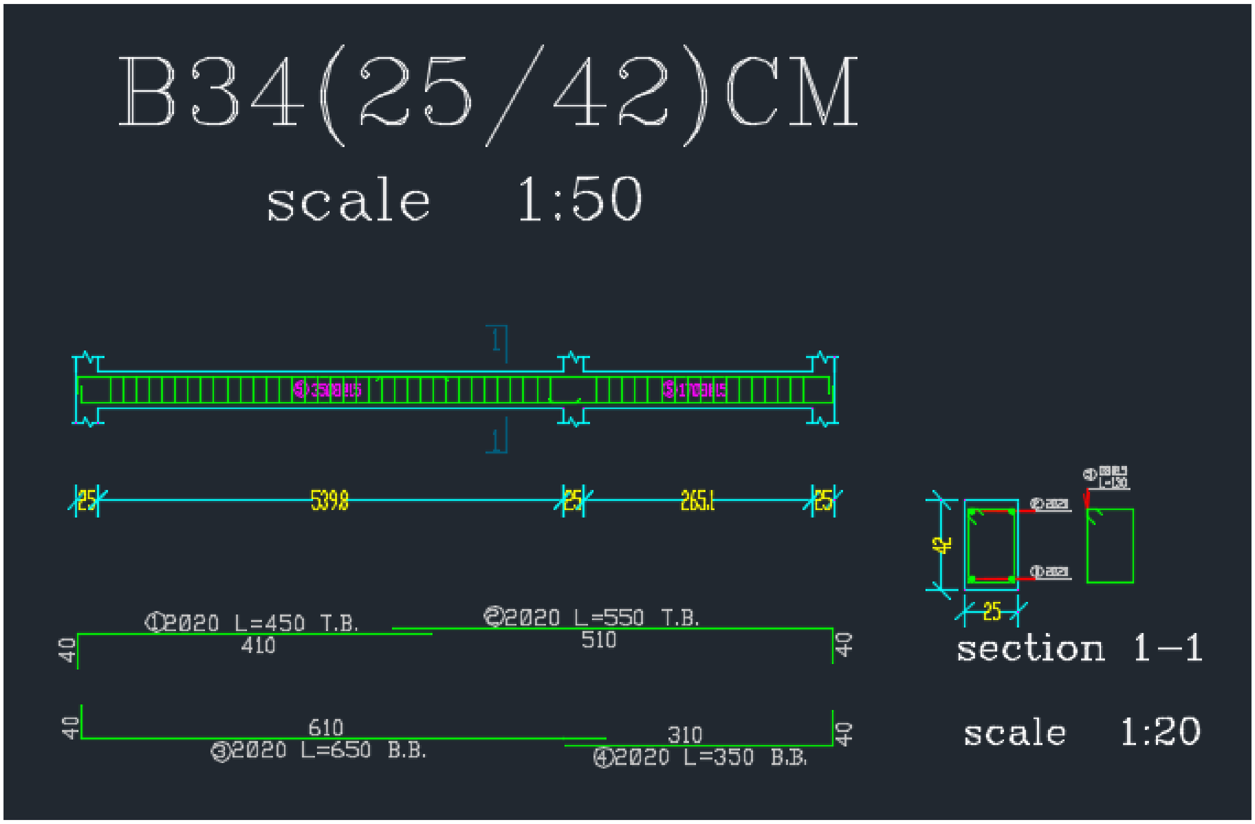


Figure 31: Reinforcement Of Beam34 In Second Floor

4.9 : Design of Column C (14)

✓ **Material: -**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

✓ **Load Calculation: -**

Service Load: -

Dead Load =1461.57 KN
Live Load =372.54 KN

Factored Load: -

P_U = 1.2 ×1461.57+ 1.6×372.54=2349.948 KN

✓ **Dimensions of Column: -**

$Assume\rho g = 0.01$

$\phi * Pn = 0.65 \text{ x } 0.8 \times Ag\{0.85\ fc^{'}(1-\rho g)+\rho g * Fy\}$

$$2349.948 * 1000 = 0.65 \text{ x } 0.8 \times Ag\{0.85 * 24\ (1-0.01) + 0.01 * 420\}$$

Ag= 185240.6447 mm^2
Assume Rectangular Section
h = 350 mm
b = 185240.6447/350 = 529.26 mm
Select b = 600 mm

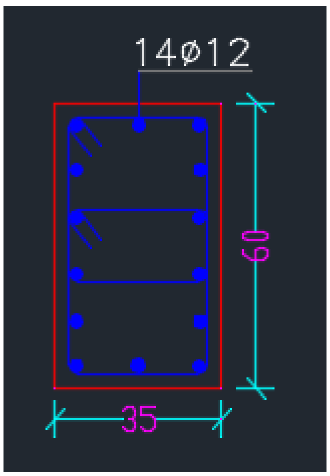


Figure 32: Column section

✓ Check Slenderness Parameter: -

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \leq 40$$

Lu: Actual unsupported (Unbraced) length.

K: effective length factor. According to ACI 318-2002 (10.10.6.3) The effective length factor k, shall be permitted to be taken as 1.0.

R: radius of gyration = $\sqrt{\frac{I}{A}}$ ≈ 0.3 h ………………. For rectangular section

Lu = 3.6 m
M1/M2 =1
K=1 for braced frame.

- **about Y-axis (b= 0.60 m)**

- $\frac{klu}{r} < 34 - 12\frac{M1}{M2} \leq 40$

$$\frac{1 \times 3.6}{0.3 \times 0.60} = 20 < 22 < 40$$

Column Is **Short About** Y-axis

- **about X-axis (h= 0.35m)**

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \quad ....ACI-(10.12.2)$$

$$\frac{1 \times 3.6}{0.3 \times 0.35} = 34.29 > 22$$

Column Is Long About X-axis

✓ Minimum Eccentricity: -

$$ey = \frac{Mux}{Pu} = 0$$
$$min\, e_y = 15 + 0.03 \times h = 15 + 0.03 \times 350 = 25.5mm = 0.0255m$$
$$ey = 0.0255m$$

✓ Magnification Factor: -

$$\delta_{ns} = \frac{Cm}{1 - \frac{Pu}{0.75P_c}} \geq 1.0$$

$$Cm = 0.6 + 0.4\left(\frac{M1}{M2}\right) \geq 0.4$$
$$Cm = 0.6 + 0.4 * 1 = 1 \geq 0.4$$

$$P_{cr} = \frac{\pi^2 EI}{(KLu)^2}$$

$$EI = 0.4\frac{E_c I_g}{1 + \beta_d}$$
$$E_c = 4700\sqrt{fc'} = 4700 \times \sqrt{24} = 23025.2\ Mpa$$
$$\beta_d = \frac{1.2DL}{Pu} = \frac{1.2 * (1461.57)}{2349.948} = 0.75 < 1$$
$$I_g = \frac{b \times h^3}{12} = \frac{0.60 \times 0.35^3}{12} = 0.00214m^4$$
$$EI = \frac{0.4 \times 23025.2 \times 0.00214}{1 + 0.75} = 11.26\ MN.m^2$$

$$P_{cr} = \frac{\pi^2 * 11.26}{(1 * 3.6)^2} = 8.58\ MN = 8580\ KN$$

$$\delta_{ns} = \frac{1}{1 - \frac{2349.948}{(0.75 * 8580)}} = 1.58 \geq 1.0$$

✓ Interaction Diagram: -

$$ey = ens_{min}$$
$$\frac{ey}{h} = \frac{0.0255}{0.6} = 0.0425$$
$$\frac{\gamma}{h} = \frac{554 - 46}{600} = 0.85$$

From the interaction diagram chart

from chart A9-b for $\frac{\gamma}{h} = 0.75 \rightarrow \rho g = 0.01$

from chart A9-c for $\frac{\gamma}{h} = 0.9 \rightarrow \rho g = 0.01$

then for $\frac{\gamma}{h} = 0.85 \rightarrow \rho g = 0.01$

Select reinforcement

Ast $= \rho g \times Ag = 0.01 \times 350 * 600 = 2100 mm^2$

Select 14 $\varphi 14 with$ AS > Ast = 2100 mm^2 .

✓ Design of the Stirrups: -

The spacing of ties shall not exceed the smallest of: -

$$spacing \leq 16 \times d_b = 16 \times 12 = 19.2\ cm$$
$$spacing \leq 48 \times d_s = 48 \times 10 = 48\ cm$$
$$spacing \leq 40\ cm$$

$Use \phi 10 @ 10\ cm$

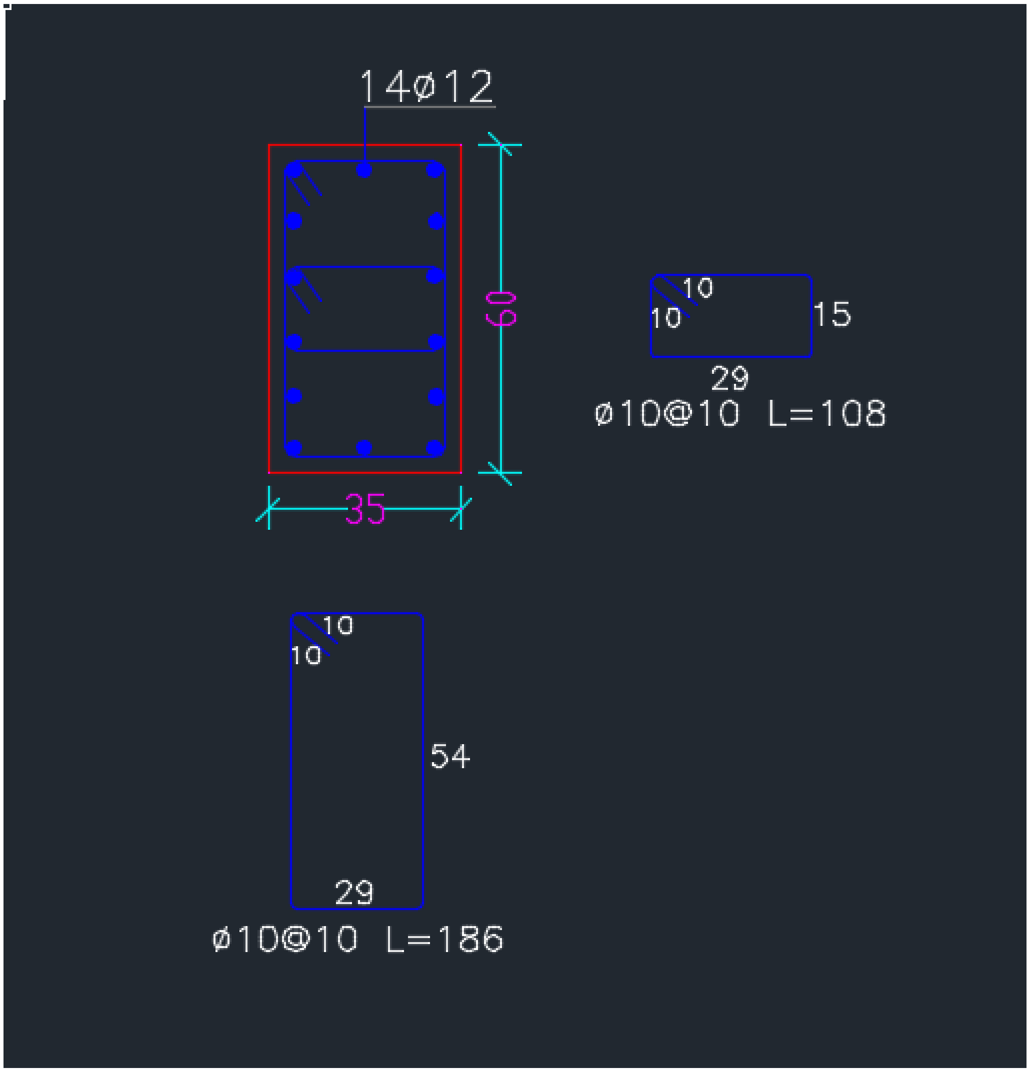


Figure 33: Column Reinforcement Details.

4.10 : Design of Footing (F4)

✓ **Material :-**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

✓ Load Calculations

Dead Load =523.07 Kn , Live Load = 132.15 Kn

Total services load = 523.07 + 132.15 = 655.22 Kn

Total Factored load = 1.2*523.07 + 1.6*132.15 = 839.123 Kn

Column Dimensions (a*b) =25*60 cm

Soil density = 17 Kg/cm3

Allowable Bearing Capacity = 400 Kn/m2

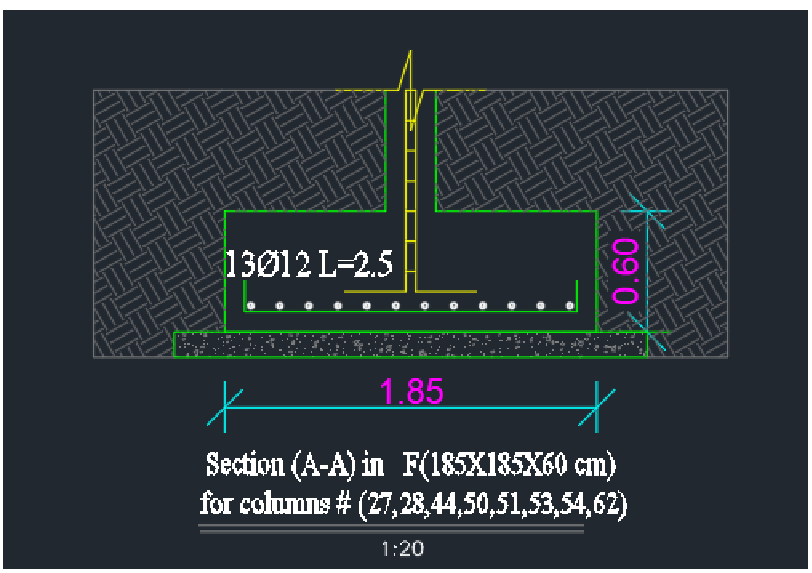


Fig 34: Footing Section.

Assume h = 60cm

$q_{net-allow}$ = 400 –17*0.4 – 25*0.60 = 378.2/m2

✓ Area of Footing :-

$$A = \frac{Pn}{q_{net-allow}} = \frac{839.123}{378.2} = 2.21m^2$$

Assume Square Footing

B required =2 m

Select B = 2m

✓ Bearing Pressure :-

q_u = 882.86/2*2 = 220.71 Kn/m^2

✓ Design of Footing :-

1- Design of One Way Shear Strength :-

Critical Section at Distance (d)From The Face of Column

Assume h = 30cm , bar diameter ø 16 for main reinforcement and 7.5 cm Cover

d = 500– 75 – 16=409 mm

Vu = $q_u * \left(\frac{B-a}{2} - d\right) * L$

Vu = 220.71$* \left(\frac{2-0.3}{2} - 0.409\right) * 2$=194.66kn

$$\varphi.Vc = \varphi.\frac{1}{6} * \sqrt{fc'} * b_w * d$$

$$\varphi.Vc = 0.75 * \frac{1}{6} * \sqrt{24} * 2000 * 409 = 500.9Kn$$

$$\varphi.Vc = 500.9KN > Vu = 194.66Kn$$

$\therefore \quad Safe$

2- Design of Two Way Shear Strength :-

$Vu=Pu-FR_b$

$FR_b= q_u *$area of critical section

Vu=220.71-882.86((0.35+0.409)*(0.6+0.409))=102.3Kn

The punching shear strength is the smallest value of the following equations:-

$$\phi.V_c = \phi.\frac{1}{6}\left(1+\frac{2}{\beta_c}\right)\sqrt{f_c'}\,b_o d$$

$$\phi.V_c = \phi.\frac{1}{12}\left(\frac{\alpha_s}{b_o/d}+2\right)\sqrt{f_c'}\,b_o d$$

$$\phi.V_c = \phi.\frac{1}{3}\sqrt{f_c'}\,b_o d$$

Where:-

$$\beta_C = \frac{Column\ length\ (a)}{Column\ width\ (b)} = \frac{35}{60} = 0.6$$

b_o = Perimeter of critical section taken at (d/2) from the loaded area

$$b_o = 2*(40.9+35)+2*(40.9+60) = 353.6CM$$

α_s = 40 for interior column

$$\varphi.V_C = \varphi.\frac{1}{6}\left(1+\frac{2}{\beta_c}\right)\sqrt{f_c'}\,b_o d = \frac{0.75}{6}*\left(1+\frac{2}{0.6}\right)*\sqrt{24}*353.6*409 = 383.8Kn$$

$$\varphi.V_C = \varphi.\frac{1}{12}\left(\frac{\alpha_s}{b_o/d}+2\right)\sqrt{f_c'}\,b_o d = \frac{0.75}{12}*\left(\frac{40*409}{353.6}+2\right)*\sqrt{24}*353.6*409 = 2137Kn$$

$$\varphi.V_C = \varphi.\frac{1}{3}\sqrt{f_c'}\,b_o d = \frac{0.75}{3}*\sqrt{24}*353.6*409 = 177Kn$$

ΦVc =177 Kn>Vu=102.3Kn

3- Design of Bending Moment :-

Critical Section at the Face of Column

Mu = 220.71*2*0.35*0.35/2 =27Kn.m

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{27\times10^6}{0.9\times2000\times409^2} = 0.089 Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.58$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.58}\left(1-\sqrt{1-\frac{2\times20.58\times0.089}{420}}\right) = 0.000212$

$A_{s,req} = \rho.b.d = 0.0002\times2000\times409 = 163.6\ mm^2$

$A_{s,min} = 0.0018*2000*600 = 2160\ mm^2$

$A_{s,req} < A_{s,min} = 1080\ mm^2$

As,min =2160……… is control

Check for Spacing :-

S = 3h = 3*60 = 180cm

$S = 380*(\frac{280}{\frac{2}{3}*420}) - 2.5*75 = 192.5$ cm

S = 45 cm **……… is control**

<u>Use 10ø14in Both Direction</u>

Check for strain:-

$a = \frac{A_s.f_y}{0.85 b\ f_c'} = \frac{2160*420}{0.85\times2000\times24} = 22\ mm$

$c = \frac{a}{\mathcal{B}_1} = \frac{43}{0.85} = 26\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{409-26}{26}\right) = 0.044 > 0.005\ \ldots\ldots \mathbf{0}\boldsymbol{k}$$

4- Design of Dowels :-

Load Transfer In Footing:-

$$\Phi Pn.b = \Phi(0.85\, fc' A_1 \times \sqrt{\frac{A_2}{A_1}})$$

$A_1 = 60 * 35 = 0.21\ m^2$

$A_2 = 2* 2 = 4\ m^2$

$$\sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{1.44}{0.21}} = 2.6 > 2 \ldots\ldots\ldots\ldots\ldots \sqrt{\frac{A_2}{A_1}} = 2$$

$$\Phi Pn.b = 0.65 \times (0.85 \times 24 \times 210 \times 2) = 5569.2Kn$$

$$\Phi Pn = 5569.2 > Pu = 2206.05 \ldots\ldots\ldots\ldots ok$$

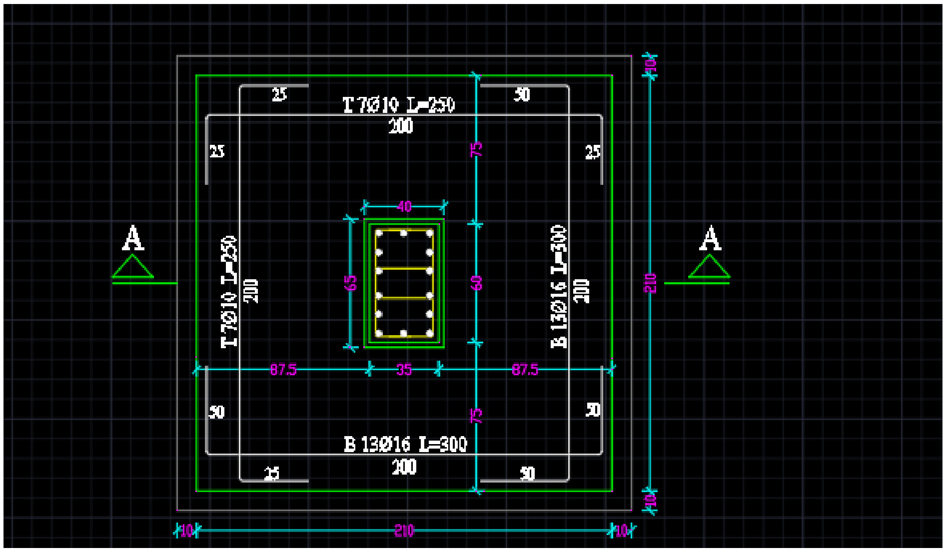


Fig 35 :Foot Reinforcement Details.

4.11 : Design of strip Footing (S4-4)

- ✓ **Material :-**

⇒ concrete B300 $Fc' = 24\ N/mm^2$

⇒ Reinforcement Steel $Fy = 420\ N/mm^2$

⇒ Soil density = 17 Kg/cm3

⇒ Allowable Bearing Capacity = 400 KN/m2

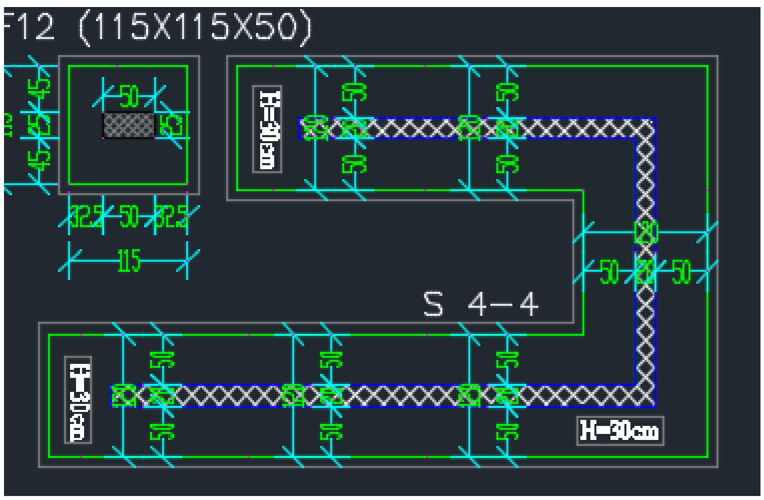


Fig 36: Strip Footing

Dead Load =350 KN, Live Load = 100 KN

Consider a 1- m strip of footing and wall

The thickness of the first try a 300 mm thick footing

$qa_{net} = 400 - (0.3*25) -(1*17) = 375.5\ kN/m^2$

Assume 1.5 m below the final ground surface

$$A = \frac{Pn}{qa\ net}$$

$$A = \frac{(350+100)}{375.5}$$

=1.19 m

A = b * 1m

b = 1.19

b = 1.2 m

Pu = (1.2*350) +(1.6*100) =580 kN/m

$q_u = \frac{Pu}{b}$

$q_u = \frac{580}{1.2}$ = 483.3 kN/m^2

One way shear (beam shear)

Vu=qu *1*($\frac{b}{2} - \frac{h}{2}$ – d)

=483.3*1*($\frac{1.3}{2} - \frac{0.3}{2}$– d)

φVc = φ $\frac{1}{6}$√(fc) b_w d

= 612.3 d

So,

Φ Vc = Vu

d=0.1764

assume cover 75 mm steel bar 20

h = d +75 + 20

=271.4 mm

Take h 300 mm

d=300- 75 – ($\frac{20}{2}$)

d= 215 mm

design fir flexure:

Mu = 483.3 * 1 *0.65 * ($\frac{0.65}{2}$)

= 102.09 kN.m

Rn = $\frac{Mu}{\Phi b d^2}$ = 2.4

m= 20.5

$$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2\times m\times R_n}{f_y}}) = 6.09 * 10^{-6}$$

As = ρ b d

$= 6.09 * 10^{-6} * 1000 * 2015$

$= 1310.4\ mm^2$

As min = 0.0018 *1000 * 300 = 540 mm^2

As > As min ……………. OK

$n = \frac{As}{As\ \Phi 14}$

= 8.5

$S = \frac{1}{n}$

= 0.11

Take 9 Φ14 or Φ14 @ 110 cm

AS = 1383.4 mm^2 > As req = 1310 mm^2…………. Ok

Using bar Φ 14 instead of Φ 20

Check for Spacing: -

S = 3h = 3*250 = 750mm

S = 450 mm ………….. control

S = 110 < Smax ……….. ok

Design for shrinkage reinforcement:

$As_{min} = 0.0018bh$

= 0.0018 * 1200 * 300

= 648

The maximum spacing is 5h or 450 mm

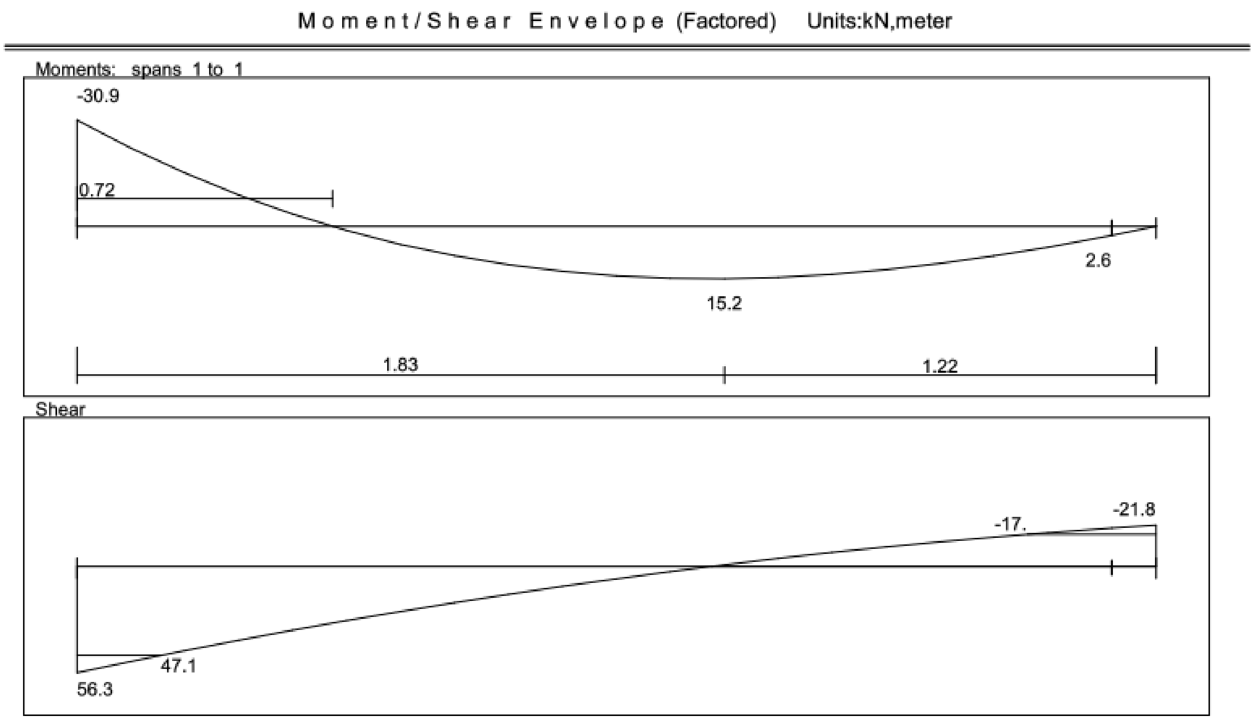
Provide 7 Φ 12 for shrinkage reinforcement As > As req ……..Ok

4.12 : Design of Basement Wall

$f_{c'} = 24\ MPa$, and
$f_y = 420\ MPa$.

$$C_o = 1 - \sin\varphi = 1 - \sin 35 = 0.426,$$
$$h_s\ (due\ to\ surcharge) = \frac{w_s}{W} = \frac{5}{18} = 0.278\ m$$

- Due to soil pressure at rest, $P_o = C_o \omega h = 0.426 \times 18 \times 3.05 = 23.3874\ KN/m2$, and
- Due to surcharge, $P_s = C_o \omega h_s = 0.426 \times 18 \times 0.278 = 2.13\ KN/m2$, and



Take ϕ = 0.9 for flexure

For M_u = 30.9 KN.m

Assuming Ø20

$d = 300 - 75 - \frac{20}{2} = 215$ mm

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{30.9 \times 10^6}{0.9 \times 1000 \times 215^2} = 0.74 \text{ MPa}$$

$$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.58$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.74}{420}}\right) = 0.0018$$

$A_s = \rho \times b \times d$ = 0.0018× 1000 × 215 = 387 mm^2

The minimum vertical A_s according to the ACI Code, Section 14.3, is $Vertical$

$As_{,\,min}$ = 0.0015bh = 0.0015 × 1000 × 300 = 450 mm^2/m

$A_{s_{min}}$ (For Flexure) = $0.25 \times \frac{\sqrt{f\acute{c}}}{f_y} \times b_w \times d \geq \frac{1.4}{f_y} \times b_w \times d$

$A_{s_{min}} = 0.25 \times \frac{\sqrt{24}}{420} \times 1000 \times 215 \geq \frac{1.4}{420} \times 1000 \times 215$

$A_{s_{min}}$ = 626.95 mm^2 ≤ 716.67 mm^2 **…… Control**

$A_s = 387\ mm^2 < A_{s_{min}} = 716.67\ mm^2$ **Design for minimum reinforcement.**

<u>Use 8∅12</u> with $A_{s_{provid}} = 904\ mm^2 > A_{s_{min}} = 716.67\ mm^2$

For M_u = 15.2 KN.m

∅12

d= 300- 75 - $\frac{12}{2}$ = 219 mm

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{15.2 \times 10^6}{0.9 \times 1000 \times 219^2}$ = 0.35 MPa

m = $\frac{f_y}{0.85 f\acute{c}} = \frac{420}{0.85 \times 24}$ = 20.58

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.35}{420}})$ = 0.00085

$A_s = \rho \times b \times d$ = 0.00085× 1000 × 219 = 185.23 mm^2

The minimum vertical A_s according to the ACI Code, Section 14.3, is $Vertical$

$As_{,\,min}$ = 0.0012bh = 0.0012 × 1000 × 300 = 360 mm^2/m

$A_{s_{min}}$ (For Flexure) = $0.25 \times \frac{\sqrt{f\acute{c}}}{f_y} \times b_w \times d \geq \frac{1.4}{f_y} \times b_w \times d$

$A_{s_{min}} = 0.25 \times \frac{\sqrt{24}}{420} \times 1000 \times 219 \geq \frac{1.4}{420} \times 1000 \times 219$

$A_{s_{min}}$ = 638.62 mm^2 ≤ 730 mm^2 **…… Control**

$A_s = 185.23 mm^2 < A_{s_{min}} = 730\ mm^2$ **Design for minimum reinforcement.**

<u>Use 8∅12</u> with $A_{s_{provid}} = 904\ mm^2 > A_{s_{min}} = 730\ mm^2$

Longitudinal reinforcement: Use a minimum steel ratio of 0.0020 (ACI Code, Section 14.3), or $As = 0.0020 \times 1000 \times 300 = 600\ mm^2/m$. Use ∅ 12 bars spaced at 250 mm on each side of the wall.

4.13 : Design of Stair

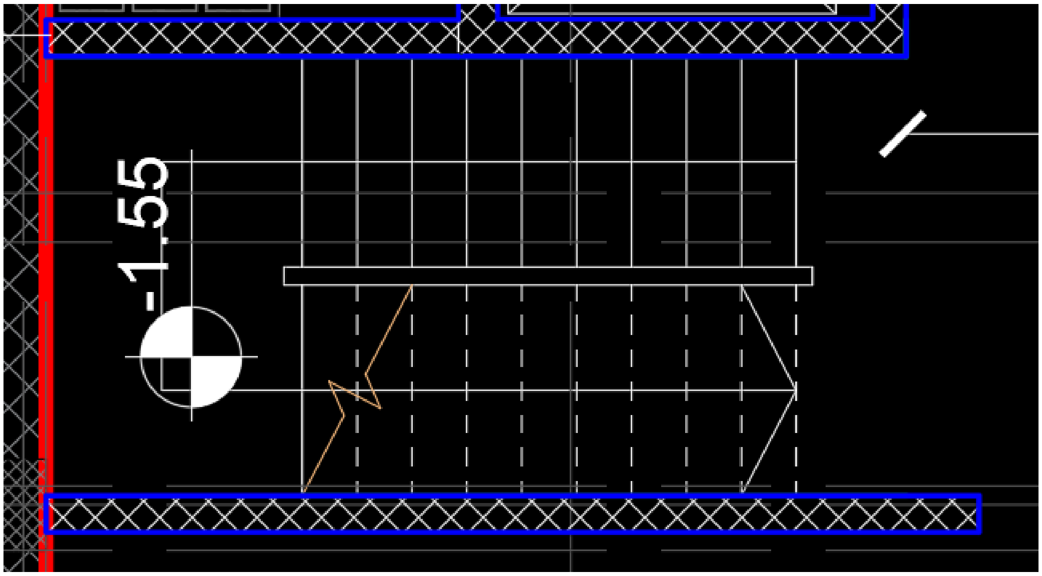


Fig 37: Stair Plan.

✓ **Material :-**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

1- Design of Flight :-

✓ **Determination of Thickness:-**

$h_{min} = L/20$

$h_{min} = 330/20 = 16.5$ cm

Take h = 20cm

The Stair Slope by $\theta = \tan^{-1}(150 / 300) = 26.5$

Dead Load For Flight For 1m Strip:-

Table (4.6): Dead Load Calculation of Flight.

No.	Parts of Flight	Calculation
1	**Tiles**	27*[(0.15+0.35)/0.3]*0.03*1= 1.35 KN/m
2	**Mortar**	22*[(0.15+0.3)/0.3] *0.02*1=0.66 KN/m
3	**Stair**	(25*0.3)*[(0.15/0.3)/2]*1= 1.875 KN/m
4	**R.C**	(25*0.2*1)/(cos26.5)= 5.587 KN/m
5	**Plaster**	(22*0.03*1)/(cos26.5)=0.838KN/m
		Sum = 10.31 KN/m

Dead Load For landing For 1m Strip

No.	Parts of Landing	Calculation
1	**Tiles**	**22*0.03*1= 0.66 KN/m**
2	**Mortar**	**22*0.02*1= 0.44 KN/m**
4	**R.C**	**25*0.2*1= 5 KN/m**
5	**Plaster**	**22*0.03*1= 0.66 KN/m**
		Sum = 6.76 KN/m

Live Load For Flight For 1m Strip = 5*1 =5 KN/m

Factored Load For Flight :-

Qu(F) = 1.2 ×10.31 + 1.6×5=20.372 KN/m
Qu(L)=1.2*6.76+1.6*5=16.112 kn/m

From moment equal zero at a

- ✓ **Design of Shear for Flight :-**

 Take the maximum shear as the support reaction VU=35.13 KN

Assume bar diameter ø 14 for main reinforcement

d =h- cover $-\frac{d_b}{2} = 200 - 20 - \frac{14}{2} = 173\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \ \frac{1}{6}\sqrt{24} * 1000 * 175 = 142.8$ Kn\M

$\Phi\ V_c$ = 0.75* 142.8 = 107.1 KN

0.5 Φ Vc = 0.5*0.75* 142.8 = 53.55 KN > Vu = 35.13 KN **…… No shear reinforcement are required , the thickness of slab is edequate enough.**

- ✓ **Design of Bending Moment for Flight :-**
- ✓ **MU(-35.13*2.5)+(8.05*(0.1+1.65))-(8.05*(0.75+1.65))+(35.13*2.5) +(20.372*(1.65/2)=32.97**

$R_n = \frac{M_u}{\emptyset bd^2} = \frac{32.97\times10^6}{0.9\times1000\times173^2} = 1.1\ Mpa$

$m = \frac{f_y}{0.85f_c'} = \frac{420}{0.85\times24} = 20.5$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.5}\left(1 - \sqrt{1 - \frac{2\times20.5\times1.1}{420}}\right) = 2.693 * 10\text{^} - 3$

$A_{s,req}$ = ρ.b.d = 2.693*10^-3×1000×173= 465.9 mm^2/m

$A_{s,min}$= 0.0018*1000*200 = 311.4 mm^2/m

As_{req} = 465.9 mm^2>$A_{s,min}$=311.4 mm^2/m

Take As req = 465.9 mm2

USE @14 then

N=465.9/153.9=3.02

Take 4ϕ14/m

Φ14@250mm

Check for Spacing :-

S = 3h = 3*250 = 750mm

$S = 380*(\frac{280}{\frac{2}{3}*420}) - 2.5*20 = 330$

S = 450 mm

S = 330 mm **……… is control**

S< S control

Use ø14 @ 250 mm , $A_{s,provided}$=615.6mm^2>$A_{s,required}$ =465.9mm^2… Ok

Check for strain:-

$a = \frac{A_{s}.f_y}{0.85b\, f_c'} = \frac{615.6\times420}{0.85\times1000\times24} = 12.67\ mm$

$c = \frac{a}{\beta_1} = \frac{12.67}{0.85} = 14.9\ mm$

$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{173-14.9}{14.9}\right) = 0.031 > 0.005 \quad \dots\dots \mathbf{0k}$

`

✓ **Lateral or Secondary Reinforcement For Flight :-**

$A_{s,req}$= $A_{s,min}$ =0.0018*1000*200 = 360 mm^2

Use ø12@ 300 mm, As=452.2mm^2>$A_{smin\,,\,required}$= 360mm^2… Ok

2- Design of Landing :-

- ✓ **Determination of Thickness:-**

h_{min} = L/20

h_{min} = 150 /20 = 7.5 cm

Take h = 15 cm

- ✓ **System of Landing:-**

RA=9.91 kn

- ✓ **design of Shear: - (Vu=35.13)**

Assume bar diameter ø 14 for main reinforcement

d =h- cover $- \frac{d_b}{2} = 150 - 20 - \frac{14}{2} = 123mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d = = \ \frac{1}{6}\sqrt{24} * 1000 * 123 = 100.4$ KN

Φ* $V_{c\,=}$ 0.75* 182.1 = 75.3 KN > Vu = 35.13kn **…... No shear reinforcement are required**

- ✓ **Design of Bending Moment:- (Mu=7.819KN.m)**

Assume bar diameter ø 14 for main reinforcement

d =h- cover $- \frac{d_b}{2} = 150 - 20 - \frac{14}{2} = 123\ mm$

$R_n = \frac{M_u}{\emptyset bd^2} = \frac{7.8194 \times 10^6}{0.9 \times 1000 \times 123^2} = 0.57Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.5$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.5}\left(1 - \sqrt{1 - \frac{2 \times 20.5 \times 0.57}{420}}\right) = 1.89\ 9 * 10\text{^} - 3$

$A_{s,req}$ = ρ.b.d = 1.89 9*10^-3×1000×123= 233.5mm^2

$A_{s,min}$ =0.0018*1000*150 = 270mm^2

$A_{s,min}$ =270 mm^2**……… is control**

Check for Spacing:-

S = 3h = 3*150 =450 mm

S = 380*$\left(\frac{280}{\frac{2}{3}*420}\right)$ – 2.5*20 = 330

S = 450 mm

S = 330mm **……… is control**

Use ø14@250 mm

Check for strain:-

a =$\frac{A_{s.fy}}{0.85b\ f_c'} = \frac{765\times420}{0.85\times1000\times24} = 15.75mm$

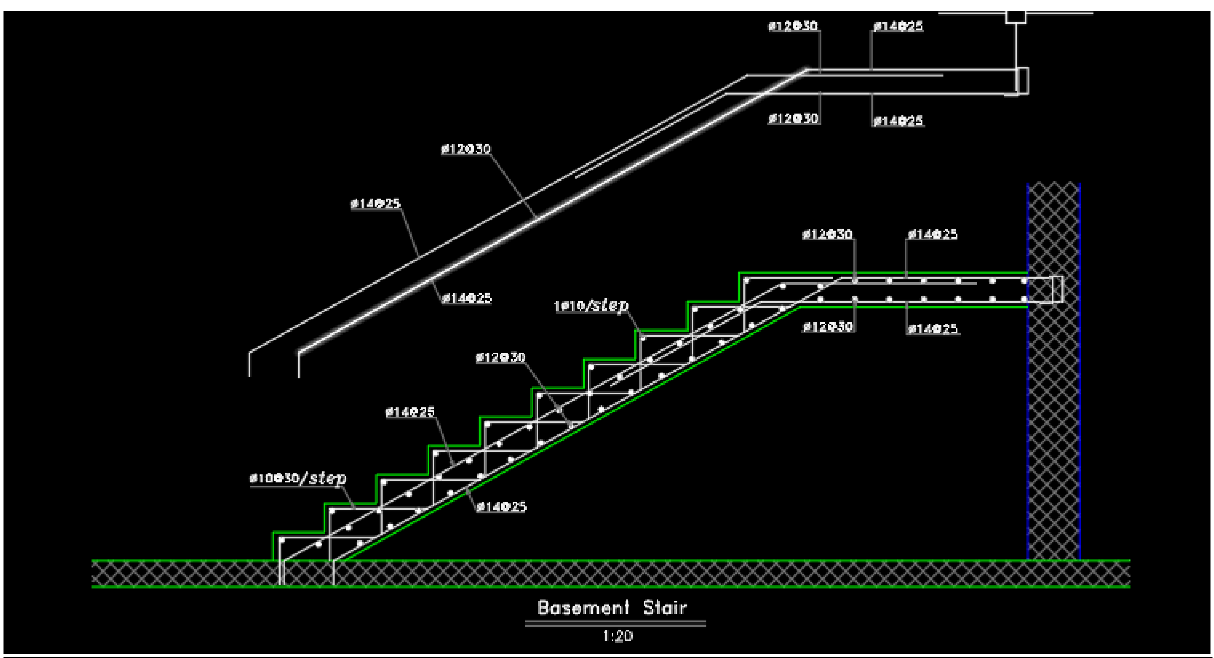
c= $\frac{a}{\mathcal{B}_1} = \frac{15.75}{0.85} = 18.52mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{123-18.52}{18.52}\right) = 0.0169 > 0.005\ \ldots\ldots\boldsymbol{0k}$$

Lateral or Secondary Reinforcement For Landing:-

$A_{s,req}$= $A_{s,min}$ =0.0018*1000*150 = 270 mm^2

Use ø12 @ 300 mm, As, provided= 339.29 mm^2>$A_{s, required}$= 270mm^2… Ok



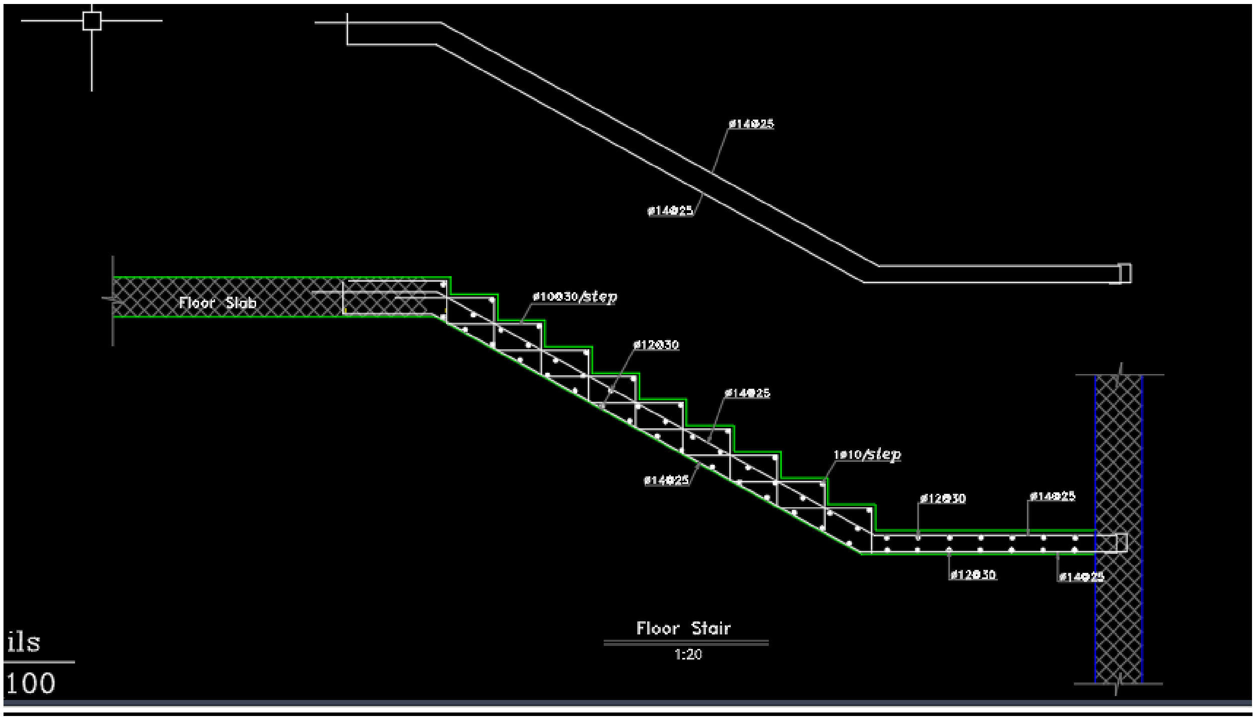


Fig 38: Stair Reinforcement Details

Chapter 5
“REFERENCES”

5.1 REFERENCES

1. كود البناء الأردني , كود الأحمال والقوى , عمان , الأردن: مجلس البناء الوطني الأردني 2006 م
2. Adoption of the American code in the various structural designs (ACI-318-19).

تم بحمد الله