Palestine Polytechnic University

College of Engineering

Graduation Project

Structural Design of Eye Special Hospital

By

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Submitted to the College of Engineering

in partial fulfillment of the requirements for the

Bachelor degree in Civil Engineering

Hebron, May 2021

Project evaluation certificate

Palestine Polytechnic University

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The undersigned hereby certify that they have read, examined and recommended to the Department of Civil and Architectural Engineering in the College of Engineering at Palestine Polytechnic University the approval of a project entitled: Structural Design of Eye Specialist Hospital, submitted by **Amal Al-Tell, Noor Ighneimat**. for partial fulfillment of the requirements for the bachelor's degree circle.

Dr. Haitham Ayyad (Supervisor), Palestine Polytechnic University

Signature:______________________________ Date:__________________

Project Approved

Signature:______________________________ Date:__________________

Dr. Belal Al- Massrie

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DEDICATION

To those who have always believed in me and given me wings to fly and told me that there are no limits in the sky.

To those who have helped me throughout my learning years without every grumbling about my curiosity and appetite to knowledge.

To those who have always showered me with unwavering support and care.

To those who know themselves and know what they mean to me without the need of articulation.

Those are my family, friends and teachers and for them I dedicate this research, hoping that -by doing so- I am repaying them a little amount of what they owe me.

ACKNOWLEDGEMENT

The homeland is built on two things, knowledge and work. thanks to God who has given us the gift from his knowledge.

We would like to take this opportunity to sincerely thank everyone who supported the project team.

In particular:

- *Palestine Polytechnic University, College of Engineering, Department of Civil and Architectural Engineering, including all lecturers and members of the cooperative and distinguished staff.*
- *Special thanks to Dr. Haitham Ayyad, the project supervisor.*
- *To Eng. Anas Abu-fara, for his instructions.*
- *To the student Lisa Makharza, Department of Architecture, who presented us with her project (a specialized eye hospital).*
- *The university library with its entire staff to provide us with the necessary books and resources.*
- *Everyone who helped in the project and had a great help.*

Abstract

The structural design is one of the most important designs necessary for the building that follows the architectural design, as the calculation of the loads and the design of the elements

construction and maintaining the safety and security of the building and people; All are .the responsibility of the civil engineer

The idea of the project is summarized in the structural design of a specialized eye hospital in Hebron. The project was developed to include all the necessary work requirements for a typical eye hospital, where a sufficient number of operating rooms, .clinics, and offices, and all the requirements accompanying the model eye hospital

The design idea is based on taking into account the distribution of architectural blocks in an aesthetic way that reflects the different function contained in the spaces of the building. This hospital consists of four floors, and contains warehouses for the hospital, archive rooms, maintenance rooms, parking, laboratories, operating rooms, lobby, bathrooms for men, women and people with special needs, a kitchen and a cafeteria in addition to Seating lobby, offices and a meeting room, containing 3 stairwells and 2 .elevators, in addition to the availability of a pharmacy

The project consists of four floors, including the basement floor, with an estimated area of approximately 5030 square meters. It contains many activities and services needed by patients, and this building was designed according to the latest architectural styles, and despite its comfort and safety facilities, the elevators were set up to serve all hospital .users

The importance of the project lies in the diversity of the structural elements in the building such as bridges, columns and concrete slabs, the multiplicity of blocks and the presence of regressions in the floor spaces. It is worth noting that the Jordanian code will be used to determine the live loads, as for the structural analysis and design; The American code (ACI_318_14) will be used (it should be noted that some computer .programs will be relied upon, such as

AutoCAD (2017)., Microsoft Office XP, Etabs, Atir, spCoulmn, SAFE

Allah grants success

الملخص

التصميم الإنشائي من أهم التصميمات اللازمة للمبنى التي تلي التصميم المعماري، حيث أن حساب الأحمال وتصميم العناصر الإنشائية والحفاظ على السلامة والأمان للمبنى والناس؛ تقع جميعها على عاتق المهندس المدني.

تتلخص فكرة المشروع في التصميم الإنشائي لمستشفى عيون تخصصي في الخليل، تم تطوير المشروع ليشمل على جميع متطلبات العمل الضرورية لمستشفى العيون النموذجي، حيث العدد الكافي من غرف العمليات، العيادات، المكاتب، وجميع المتطلبات المرافقة للمستشفى النموذجي.

تقوم فكرة التصميم على مراعاة توزيع الكتل المعمارية بشكل جمالي يعكس اختلاف الوظيفة التي تحتويها فراغات المبنى، حيث يتكون هذا المبنى من أربعة طوابق، تحتوي على مخازن للمستشفى ، غرف أرشيف ، غرف الصيانة ، موقف سيارات ،مختبرات ، غرف عمليات ، بهو ، حمامات للرجال والنساء ، مطبخ وكافتيريا بالاضافة إلى صالة جلوس ،مكاتب و غرفة اجتماعات وتحتوي على بئر درج عدد3 ومصعد كهربائي عدد2 إلى جانب توفر صيدلية.

يتكون المشروع من أربعة طوابق بما فيها طابق التسوية، بمساحة اجمالية تقدر ب 5030 متر مربع تقريباً. يحتوي على كثير من الفعاليات والخدمات التي يحتاجها المرضى، وقد صمم هذا المبنى على أحدث الطرز المعمارية، وبالرغم من احتوائها على وسائل الراحة والأمان، وضعت المصاعد الكهربائية لخدمة كافة المستخدمين للمستشفى.

تكمن أهمية المشروع في تنوع العناصر الإنشائية في المبنى مثل الجسور والأعمدة والبلاطات الخرسانية، وتعدد الكتل ووجود تراجعات في المساحات الطابقية. من الجدير بالذكر أنه سيتم استخدام الكود الأردني لتحديد الأحمال الحية، أما بالنسبة للتحليل الإنشائي والتصميم؛ سيتم استخدام الكود الأمريكي (ACI_318_14)ولا بُد من الإشارة إلى أنه سيتم الاعتماد على بعض برامج الحاسوب مثل:

AutoCAD (2017)., Microsoft Office XP, Etabs, Atir, spCoulmn, SAFE

والله ولي التوفيق

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List of Abbreviations

1 .a = depth of compressive stress.

2 .Ac = area of concrete section resisting shear transfer.

3 .As = area of non-prestressed tension reinforcement.

4 .As' = area of non-prestressed compression reinforcement .

5 .Ag = gross area of section.

6 .Av = area of shear reinforcement within a distance (S).

7 .At = area of one leg of a closed stirrup resisting tension within a (S)

8 .b = width of compression face of member .

9 .bo = perimeter .

10 .bw = web width, or diameter of circular section .

11 .C = resultant compression force in concrete .

12 .c = concrete cover.

13 .Cc = compression resultant of concrete section .

14 .Cs = compression resultant of compression steel.

15 .DL = dead loads.

16 .d = distance from extreme compression fiber to centroid of tension reinforcement. XI

17 .Ec = modulus of elasticity of concrete.

18 .Es = modulus of elasticity of steel.

19 .fc ' = compression strength of concrete .

20 .fy = specified yield strength of non-prestressed reinforcement .

21 .h = overall thickness of member .

22 .Ln = 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.

23 .LL = live loads.

24 .Lw = length of wall .

25. M = bending moment.

CHAPTER I

INTRODUCTION

Chapter I : INTRODUCTION

1.1. Introduction

The last century has witnessed a starting of a period of revolution and improvement in all the life aspects, and with the increasing demand of the people in the cities, it was very essential to cope up with this improvement in all of the fields, in such a way that suits and controls the environment.

All of us knows the importance of hospitals, in the treatment of patients and provide them healthservices, especially here in Palestine that are under occupation. Which has recently become the number of hospitals in Palestine currently it is unable to provide health services as should be. So, it was necessary to think of a hospital includes many functions that support eye health care in the city, and that contribute to progress the health services in Palestine.

1.2. General Identification

project is a specialized eye hospital in Al-Salam Street, Hebron, it's provided all requirements needed for suitable work- place like Nurses and Doctors Offices, Bedrooms, Cafeteria, Pharmacy, Outpatient Clinics, Kitchen, Operations Rooms, Central Administration and all services needed.

1.3. Reasons of Choosing Project

After more than a month of searching for a good project, we decided to choose the Eye Specialist Hospital among a lot of other projects due to the suitable size of the project and the beautiful architectural design.

The importance of choosing the project determined by several, including acquiring the skill in designing the various structural elements and increasing knowledge in the construction systems followed in our country, as well as acquiring the scientific and practical knowledge used in the design and implementation of construction projects.

1.4. The Project Objectives

We hope that after completing this research, we will have achieved the following objectives:

- Acquiring the ability to read architectural plans
- Increasing the ability to choose a structural system that suits the objectives of the building.
- To correlate what we have taken in the design courses with the practical thinking.
- The ability to choose the appropriate structural system and distribute the structural elements on the plans based on its architectural design.
- The ability to design various structural elements.
- Linking and applying the theoretical information that was studied in the previous courses with what will be implemented in the research
- Proficiency in the use of various structural analysis and design programs.
- Acquiring the skill of teamwork and teamwork.
- Preparing construction plans with full details
- To get a new skills and experiences while facing problems and obstacles rising while workingin the project, which has not mentioned in the theoretical studying.

1.5. The Problem of Project

The problem of the project is to find the most appropriate structural system that satisfies the strengthand serviceability requirements, and to design and analyze the structural components that consists.

The project which is the eye Hospital, so we will analyse and design these components like slabs, beams, columns, foundation, etc. After determining the loads on each of the structural member so we can select the required dimensions and reinforcement, after that all of the deign outputs will be presented in the structural drawing that used to transfer the project from being a drawing to the practical field.

1.6. The Postulate of the Project

- Studying the architectural plans and ensuring that they are saved and audited so that they are ready for the correct structural design and to achieve the research objectives.

- Studying the most appropriate mechanism for the correct distribution of columns inside the building and with the least possible conflicts with the architectural design

- A structural study of the building, to determine the types of structural elements, as well as to determine the appropriate structures and systems.

- Structural analysis of structural elements

- Structural design of structural elements

- Preparing project implementation plans

- Writing and finalizing the project

1.7. Chapters of Project

Chapter One: General introduction of the project.

Chapter Two: The architectural description of the project.

Chapter Three: The structural studying of the project including: the structural members, the loads,and the function description.

Chapter Four: The structural analysis and the design of some structural members like: beams, andslabs.

Chapter Five: Results and recommendations.

1.8. The Time Table of the Project Stages

The Table below shows the time line table of the project stages.

Table 1.1: The Time Line Table of the Project Stages

Suggested Time	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Project Selection	■	■	■	■	■	■	■																											
Site Study							■	■	■																									
Collect informationabout the project									■	■																								
Architectural study ofthe building										■	■	■																						
Structural study of the building												■	■	■																				
Preparation of graduation project introduction															■																			
Make the presentation																■																		
Structural analysis																	■	■	■	■														
Structural design																				■	■	■	■											
Preparation of construction drawings of the project																							■	■	■	■	■	■						
Writing the document																												■	■	■				
Stand by time																															■	■	■	
Presentation of the project																																		■

CHAPTER II

ARCHITECURAL DESCRIPTION

Chapter II : ARCHITECURAL DESCRIPTION

2.1. Introduction

Architecture is considered the mother of engineering sciences, and it is not a product of this era; Rather, since God Almighty created the human being who unleashed his talents and thoughts, he moved with these talents from the life of caves to the best form of .luxury, taking advantage of the beauty that God gave to this beautiful nature

Thus, architecture has become an art, a talent and an idea that derives its fuel from what God has given the architect and from the talents of beauty. If every art or science has controls and limits, architecture is not subject to a limit or constraint, as it oscillates between fantasy and reality; The result may be very simple and frank buildings that arouse some curiosity in us, although it may hide many surprises for us when we enter .them and interact with its details

The building may appear simple from the outside, as if it has been disassembled into several huge pieces without feeling the connection between these pieces; Although it is in fact connected and interconnected through spaces and bridges. In its engineering composition, the building may depend entirely on a regular geometric shape as a single .unit repeated in all parts of the building

The design process for any facility or building is carried out through several stages until it is completed to the fullest, starting first with the architectural design stage, where at this stage the shape of the facility is determined and the fulfillment of the various functions and requirements for which the building will be established is taken into account, where an initial distribution is made. For its facilities, with the aim of achieving the required spaces and dimensions and determining the locations of columns and axes, and in this process, lighting, ventilation, movement and other functional requirements are .also studied

After the architectural design stage, and its final form, the structural design process begins, which aims to determine the dimensions and characteristics of the structural elements depending on the different loads on them, which are transferred through these elements to the foundations and then unloaded into the soil

2.2. Basic Identification of Project

The idea of the project is summarized in the structural design of the Eye Specialist Hospital in the city of Hebron - Salam Street near Al-Ansar Gas Station, which is considered a vital area in the city.

This building is proposed to meet the needs of patients with regard to problems related to the eyes in particular, to relieve pressure on the city's hospitals.

Eye Specialist Hospital consists of three floors B, with an estimated area of 1,026 square meters for the ground floor, 845 square meters for the first floor, and 924 square meters for the second floor, in addition to 2,145 square meters for the basement floor

2.3. Project Site Analysis

For the design of any project, the site in which the building is to be constructed should be studied very carefully, whether it is related to the geographical location or to the influence of the prevailing climatic forces in the region.

Therefore, a general idea of the elements of the site must be given, starting with clarifying the dimensions of the proposed land for construction, the relationship of the site with the surrounding streets and services, the height of the surrounding buildings, the direction of the prevailing winds, noise and the path of the sun.

The site is selected and determined based on what suits the project and its effectiveness and response to the project problem in an initial manner, where three sites are selected and basic information is collected about them, then a comparison is made between them according to specific criteria, but some points must be taken into account when the initial selection of sites, including:

- Site area
- The relationship of the site with the services surrounding the power stations and the water network
- Ease of access to the site and its connection with the main road network.
- The shape of the site and its external borders are square, rectangular or irregular.
- The economic development of the site, the future economic value

The site is located on a main street called Al-Salam Street and next to Al-Ansar Gas Station, where the street is bounded from the east and from the

south by the gas station.

Figure 2.1. Aerial Photograph

2.3.1. General Climate of the City

This region generally has a Mediterranean climate with dry summers and mild rainy winters Sometimes it snows. The recorded average of precipitation in Hebron for the year 2020 was about 596 mm, approximately 23.5 inches.

While the western and southwestern winds dominate, the northern winds are light and eastern.

2.3.2. Contour Lines of the Project Land

- The project land is semi flat area.
- The project land is 930 m above sea level.

2.4. Description of the floors

The project consists of four floors, and it is a government institution with service facilities, the architectural distribution of these facilities is simple and uncomplicated, which facilitated the process of analysis and structural design, in addition to the asymmetry between the floors, where there is a pharmacy, administration offices, cafeteria, archive rooms And storage, as well as into two operating rooms, it also contains a reception space and an emergency room, and it is also characterized by the presence of a garden for the building.

2.4.1. Parking Floor

A level (3.8) below ground level, with an area of 2145 square meter.

It's consisted of Mechanical and Electrical room, Laundry, X- ray rooms, Kitchen, Physical treatment, Offices, and Cars Park.

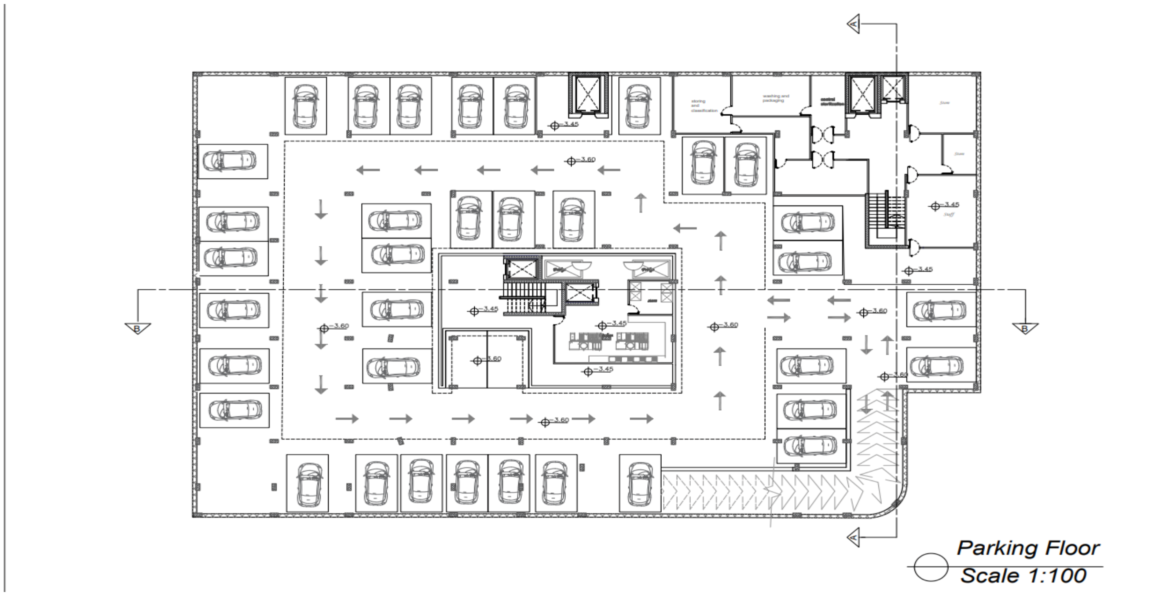


Figure 2.2. Parking Floor

2.4.2. Ground Floor

A level (0.0), ground level, with an area of 1026 square meter.

It's consist of Emergency Area, Additional Emergency Room, nurse stations, Stores, Reception, Accounting and Achieve Room, General Clinic, Examination Rooms, Emergency Foyer, Lobby, Pharmacy , Bathrooms and Cafeteria.

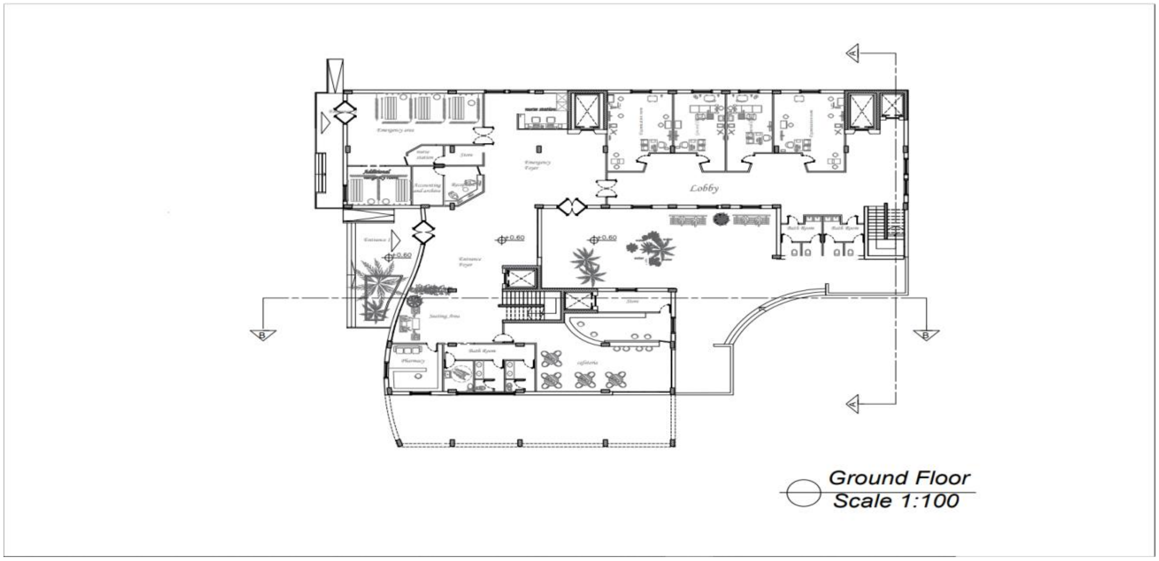


Figure 2.3. Ground Floor

2.4.3. First Floor

A level (3.8) Above ground level, with an area of 845 square meter.

It's consisted of Clinics, Dr's Office, Nurse Station, Waiting Area, Bathrooms, Laboratory, Manager Office, Meeting Room, Store and Archive Rooms.

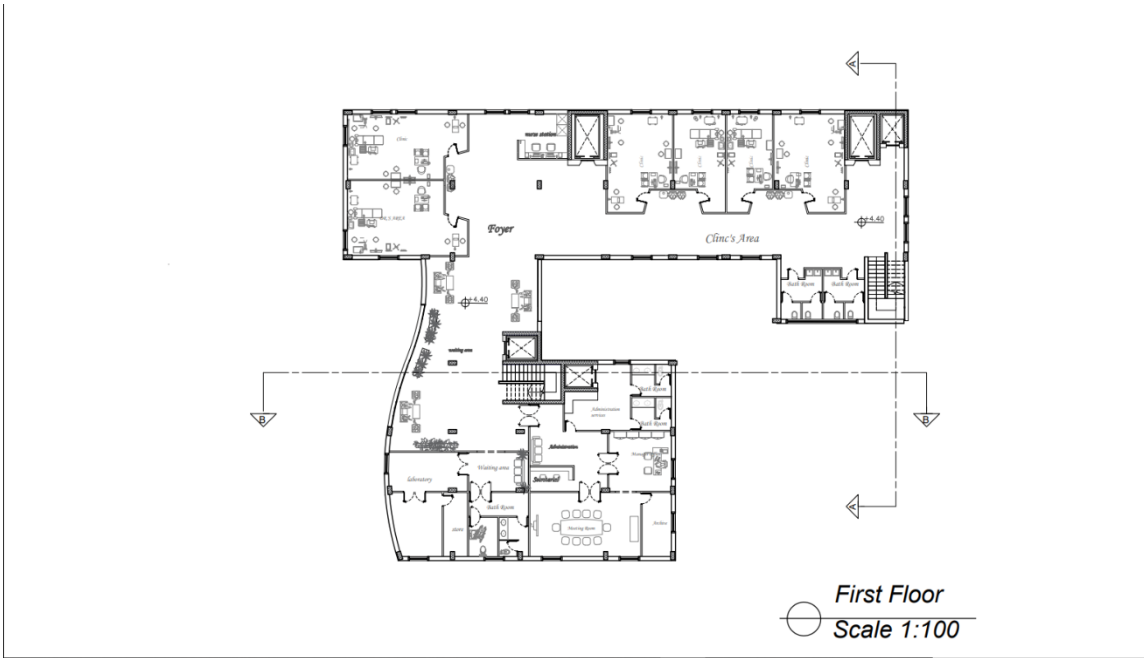


Figure 2.4. First Floor

2.4.4. Second Floor

A level (7.6) Above ground level, with an area of 924 square meter.

It's consisted of Recovery Room, Operations Room, Nursing and equipping Room, Nurse Station, Terrace, Bed Rooms, Bathrooms and Dr's Office.

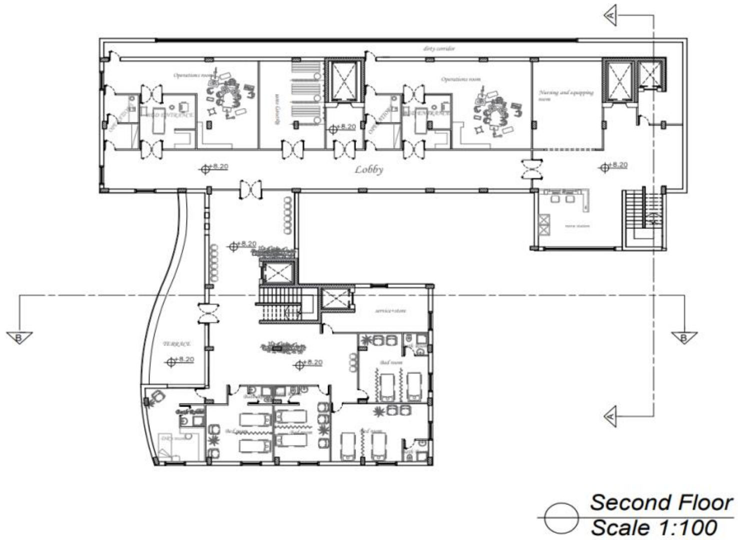


Figure 2.5. Second Floor

2.5. Description of the Elevations

Classical and modern architecture was used at the same time, with glass facades which gives a kind of comfort and a sense of spaciousness, and it is also very bad to design a building where the patient feels confined in space in addition to his illness. At the same time.

2.5.1. Hospital Front Elevation – West

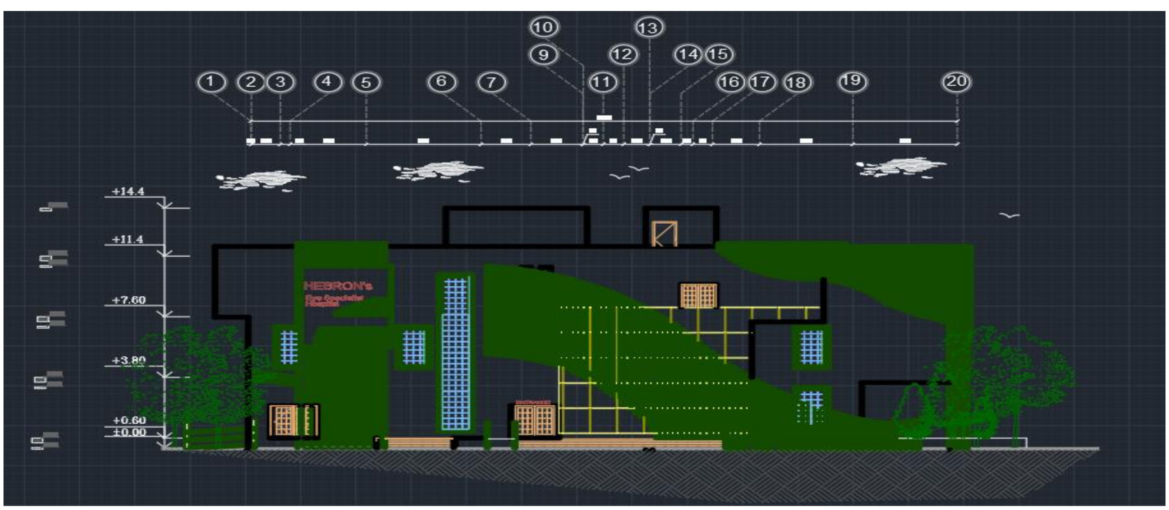
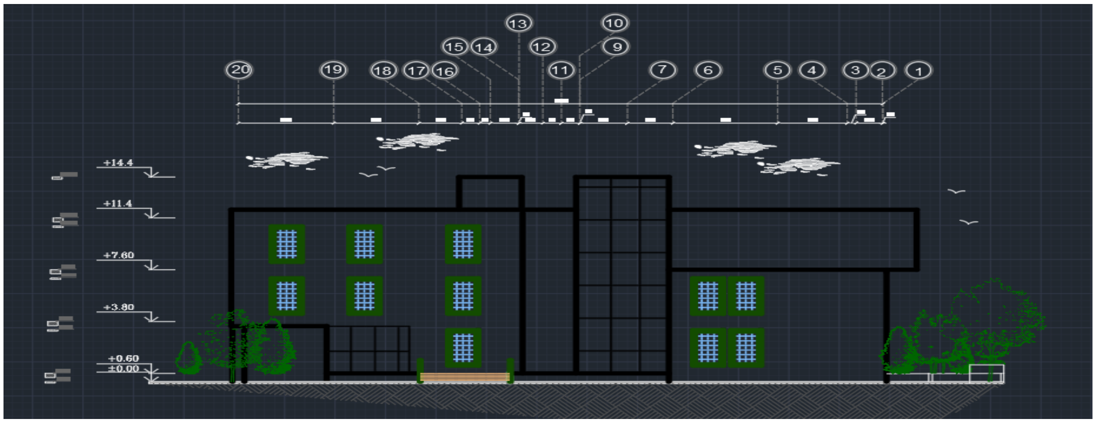


Figure 2.6. West Elevation

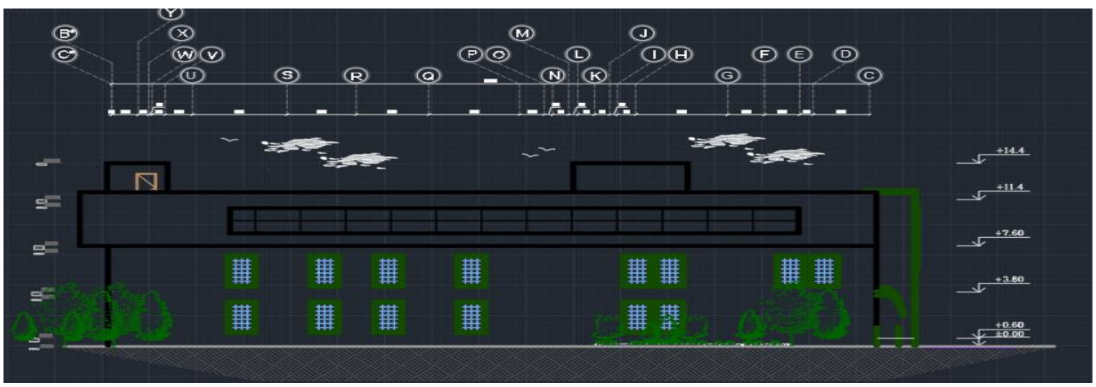
2.5.2. Hospital Back Elevation – East

Figure 2.7. East Elevation



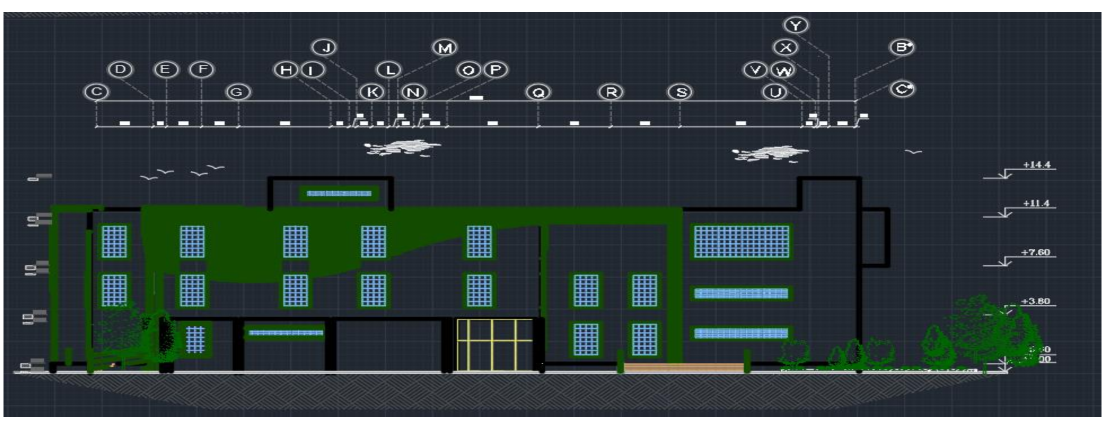
2.5.3. North Elevation

Figure 2.8. North Elevation



2.5.4. South Elevation

Figure 2.9. South Elevation



2.6. Movement description

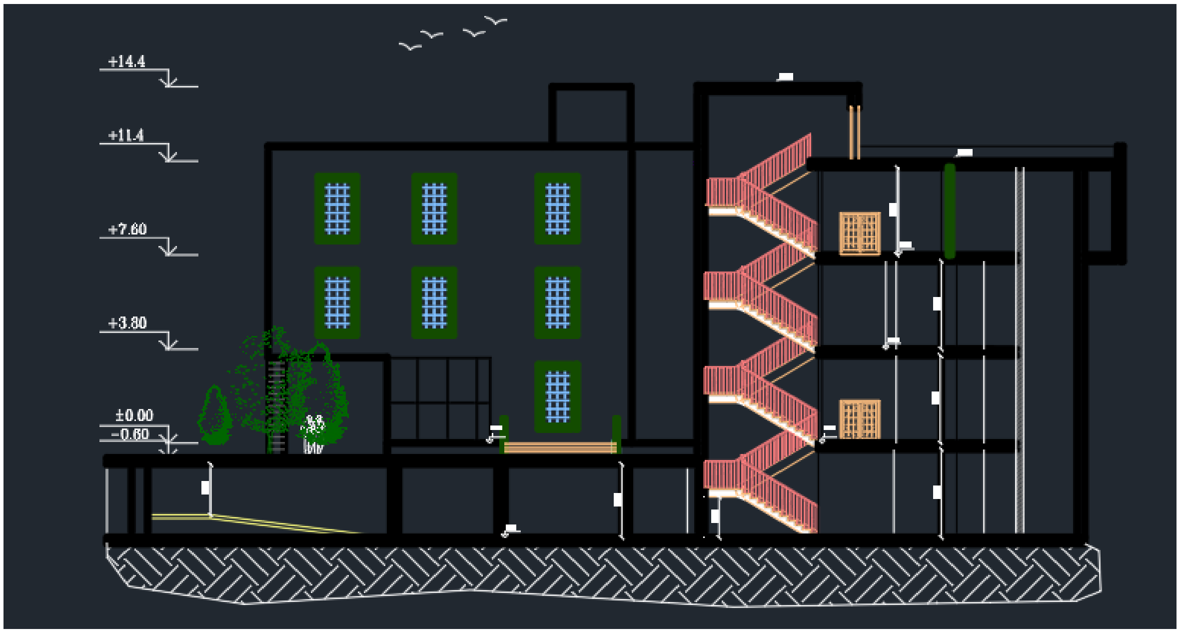
Movement takes many forms, whether from outside the building towards the inside, or movement inside the building itself. The movement from outside the building to the inside takes place smoothly due to the absence of a difference in the level. It is also possible to enter the building from several places, and this in turn allows freedom of entry and exit from the building. As for the movement inside the building, it is divided into horizontal movement within one floor and vertical movement between the different floors.

The movement on all floors takes a linear form in the corridors, due to the stability of the level with regard to the vertical movement between floors, it is done through stairs or elevators, as they take up multiple places in the building, and this in turn facilitates the horizontal movement within the floors and the vertical movement between them.

2.7. Hospital Sections

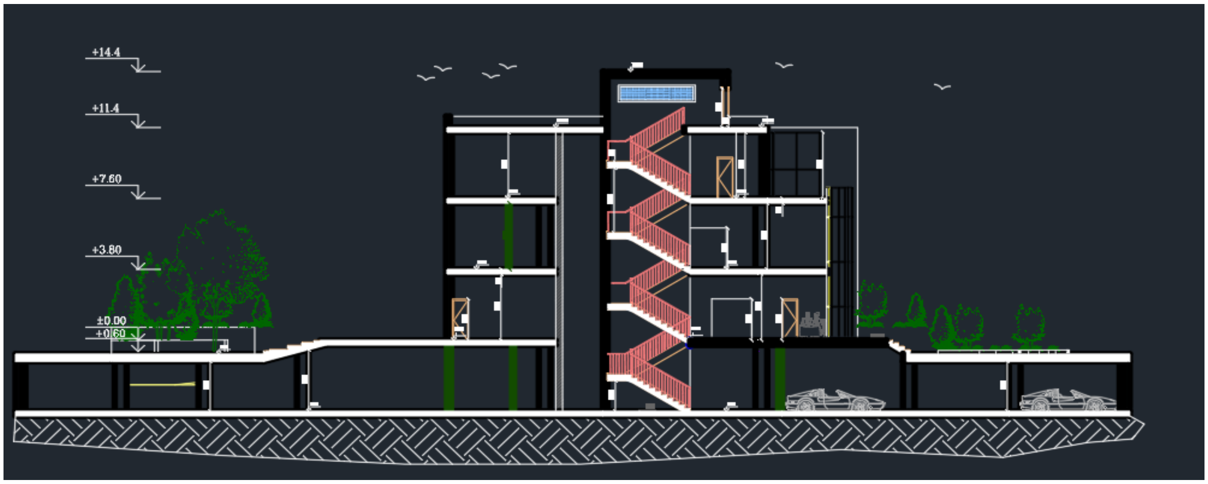
2.7.1. Section A-A

Figure 2.10. Section A-A



2.7.2. Section B-B

Figure 2.11. Section B-B



CHPTER III
STRUCTURAL DESCRIPTION

CHPTER III: STRUTURAL DESCRIPTION

3.1 Introduction

Any description process is not limited to a specific aspect, but rather is by describing and delving into all its details that are an integral part of it. After completing the process of explaining the architectural project with all the details, we must move to the construction phase of the project study, in order to choose the appropriate structural system for each element. In the building, so that it provides all the requirements and work on the design of the elements necessary for the system, taking into account safety and security, as the structural design depends mainly on the study of the ability of the structural elements to bear the loads affecting it, and therefore all the structural elements must be described in an accurate description that meets the requirements of the engineering calculations for this project while maintaining Existing Architectural Design

3.2 The Purpose of Structural Design

The purpose of structural design is the work to find the building is available where all safety requirements, in order to resist all the forces that affect the building in different forms, such as loads of dead and live or external forces such as earthquakes, wind and landing in the soil. When designing any element of these structural elements should be taken in consideration the following standers:

Safety: is the essential element that must be provided in the design, so choosing the appropriate element of each region to resist load that affect them.

Cost: must be supplied when working on the selection of appropriate materials, and sufficient for its desired purpose and appropriate quantity.

Serviceability: work to avoid any external failures, such as the decline in soil or any cracks in the external shape, or anything that works to increase this failure.

Architectural side: work to take into account the architectural elements in the building and try to keep it as much as possible.

3.3 Theoretical Studies of the Structural Elements of the Building

The most important step that should work out of the project before starting the structural design, you must work on a comprehensive study of the project in terms of its size and the nature of its work, and how to work to estimate the loads that effect on the building, and choose items that are exposed to these loads, and identify system construction, which used to resist these loads. The next step is the structural design of each part of the structure, in a detailed and accurate manner according to the chosen structural system and making the necessary structural details for it in terms of drawing horizontal elevations, vertical sectors and details of the individualization of rebar

3.4 Types of Loads

Loads are basically in the design process, so you must give them great importance, so it must work to identify quality.

Accurately, so as to differ from the building to another depends on the architectural design and materials used in construction and other influences, therefore divided loads to:

- Basic loads

It loads which must be taken into account in the structural design of the building in all cases, it includes: Dead load, Live load and Environmental load.

- Secondary loads

The loads that take them into account in the design in some buildings, depending on the nature of the building and other influences, it includes: Shrinkage load, Thermal load, Snows load, Dynamic load, Seismic load.

3.4.1 Dead Load

The dead load includes loads that are relatively constant over time, including the weight of the structure itself, and immovable fixtures such as walls, plasterboard or carpet. Roof is also a dead load.

Dead loads are also known as permanent loads.

The designer can also be relatively sure of the magnitude of dead loads as they are closely linked to density and quantity of the construction materials. These have a low variance, and the designer is normally responsible for specifying these components.

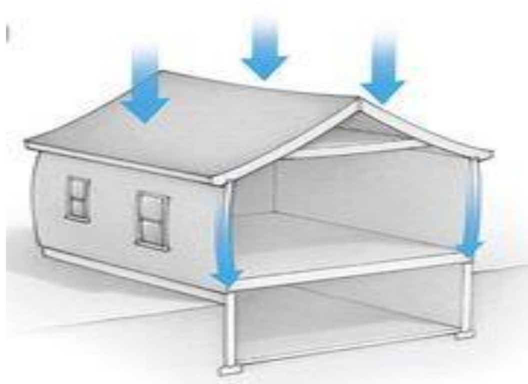


Figure 3.1. Dead Load

Table 3.1. Specific Density of the Materials Used

Number	The type of material	The value of load (KN/m3)
1	Furniture	3.2
2	Reinforcement concrete	25
3	Plain concrete	24
4	Sand	14-17
5	Tiles	24-25
6	Granite stone	28
7	Plaster	22
8	Hollow block	9-12

3.4.2 Live load

Live load is imposed loads, are temporary, of short duration, or moving. These dynamic loads may involve consideration such as impact, momentum, vibration, slosh dynamic of fluids, fatigue, etc. Live loads, sometimes also referred to as probabilistic loads include all the forces that are variable within the object's normal operation cycle not including construction or environmental load.

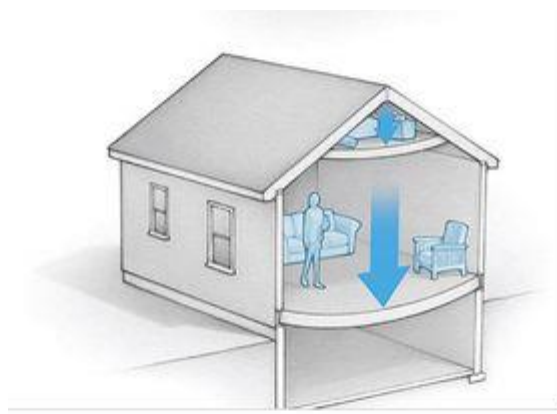


Figure 3.2. Live Load

Table 3.2. Live Loads

Number	The type of material	The value of live load (KN/m3)
1	Kitchens	3
2	Offices	3
3	Corridors and stairs	5
4	Stories	5
5	Roof	1.5

3.4.3 Environmental loads

The loads arising from the changes in the environmental such as seismic, wind and snow.

3.4.3.1 Seismic load:

loads caused by earthquakes. Buildings should be designed to withstand minor earthquakes because they can occur almost anywhere. During an earthquake the ground can move both horizontal and vertically in any direction. This exerts tremendous horizontal loads on members

3.4.3.2 Wind load:

The forces that affect horizontally on the building, appear especially in high-rise buildings, and it's designed on the basis of wind speed and height of the building, and the number of buildings surrounding the building.

3.4.3.3 Snow load

The building must be designed to resist snow loads and to be taken into account the design and it depends on the height of the building and the area of this building.The following table shows the relationship between the height of the building and carry snow that we take him in the case of design.

Note: the building that we will design located in Hebron, so we will take snow in the accounts.

Table 3.3. Loads of Snow by Sea Level

Building height above sea level	The value of load in surface (KN/m2)
250>h	0
500>h>250	(h-250)/800
1500>h>500	(h-400)/320

3.5 Practical Tests

Before we begin the process of design and construction, must be work some of necessary tests at the site, especially on the soil, and work to see the quality of the rocks in the region, and work to deviate place waterfalls groundwater and its impact on the building, and work to resolve the problems if available of these problems.

3.6 Structural Elements

There are many structural elements used in the buildings as the slab, beam, column, stairs, the shear wall and foundations.

3.6.1 The Slabs

Is an element which transfers the loads that are exposed to other structural elements such as column, beam, wall and it based on several factors:

- The distance between the spaces and columns.
- The desired function of the space.
- Cost
- Ease of implementation and duration available for building.

In our project, we will use different types including

3.6.1.1 The ribbed slabs

In general, this type is most commonly used in our project, this contains the pipe steel use to transfer the loads, and block and the concrete between this block and the topping of all, and we have two types of this:

- one way rib.

- two-way rib.

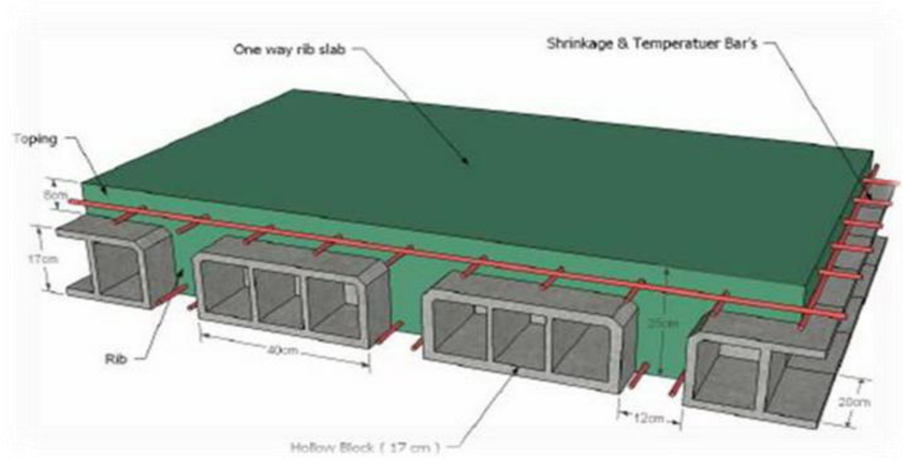


Figure 3.3. One-way ribbed slab

The two-way rib slab is the type use when the length of the two directions in the space approximately is equals, and we used in this type bar of steel in two directions to transfer the load.

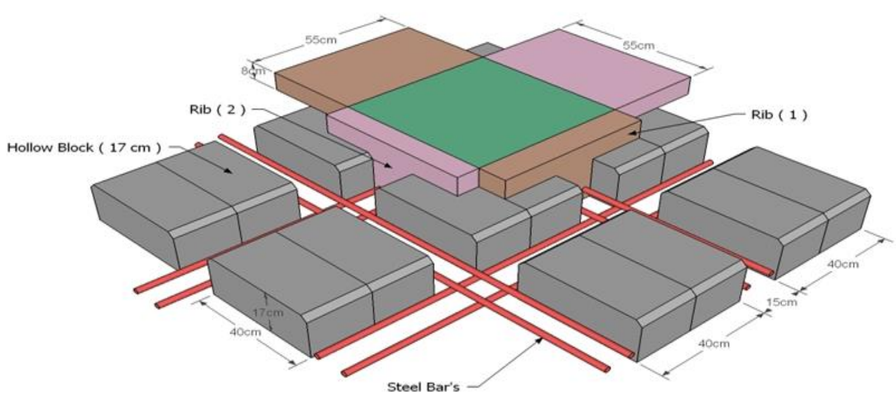


Figure 3.4. Two-way ribbed slabs.

3.6.1.2 Solid slab

We use this method when the height of the spaces is important, and we don't have problem when show the drop beam, and this transfer the load to the beam to the column, and we have two types one way and two-way, and the difference between two types is the direction of transfer load.

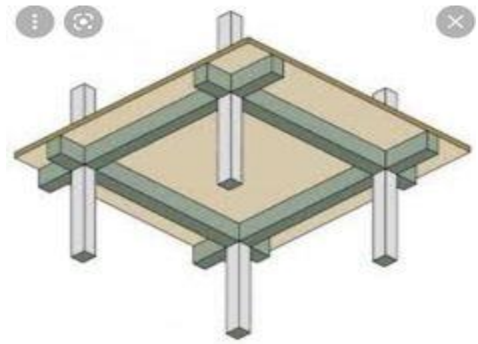


Figure 3.5. Solid Slab

3.6.1.3 Flat plate

Use this type to transfer the load through it to the column directly, don't use the beam, as shown in the figure

:

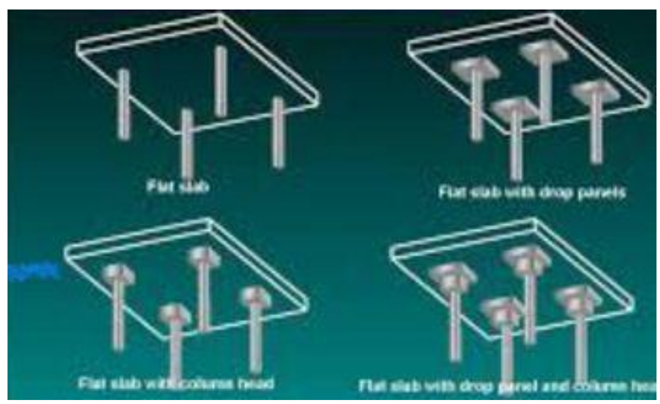
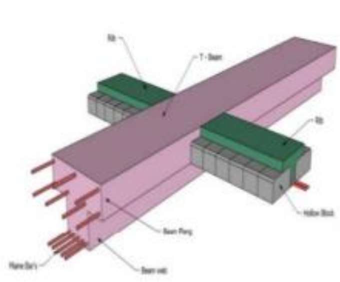


Figure 3.6. Flat Slabs

3.6.2 Beams

Use this element to transfer the load from the slab to the column, and have the type as hidden beam when have the same thickness of slab and drop beam when have different thickness , hidden and drop beams.



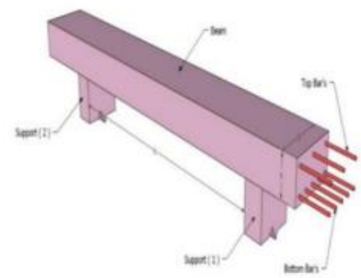


Figure 3.7. Drop Beam **Figure 3.8**. Hidden Beam

3.6.3 Column

The element is use to transfer the load from the slab to the foundation, and it helps in the stability of the building, and when design we will know the type design if short or slender column.

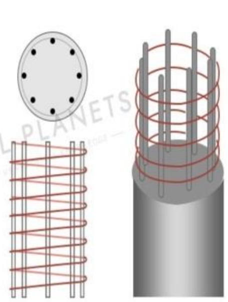
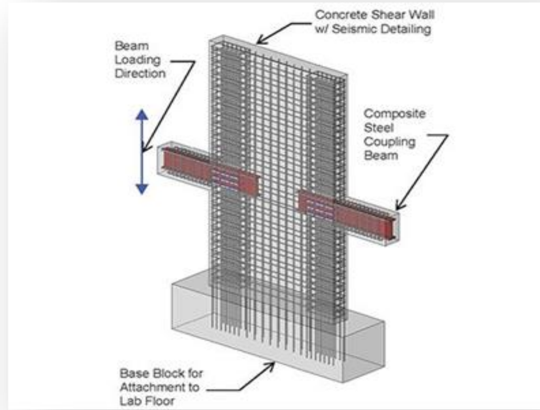


Figure 3.9. Circular Column **Figure 3.10**. Rectangular Column

3.6.4 Shear Wall

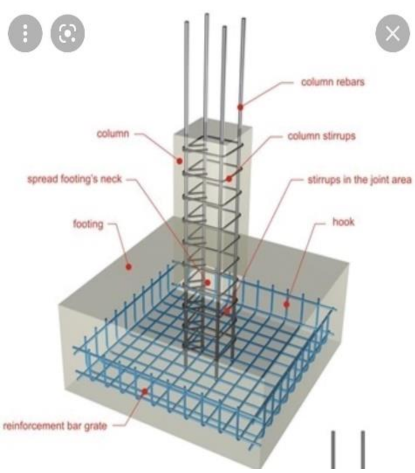
Shear wall is the important element structure because use to resist the vertical and
Shear wall is a type of structural system that provides lateral resistance ;horizontal load to the building or structure. It resist loads as the wind and earthquake. When design this wall, we use two layer steel to give it more strength.

Figure 3.11. Shear Wall



3.6.5 Foundations

The first element we implemented on the ground, but is the last element we design, because all loads are transmitted to it whether the basic load as dead or live load or secondary load. So is the basic element, which receives all the loads and distributed it to the soil.



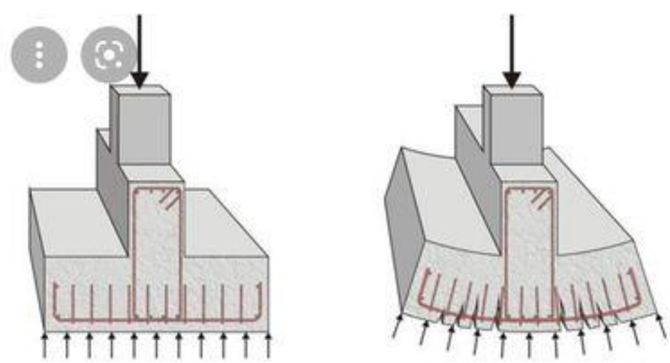


Figure 3.12. Isolated Footing

Figure 3.13. Strip Footing

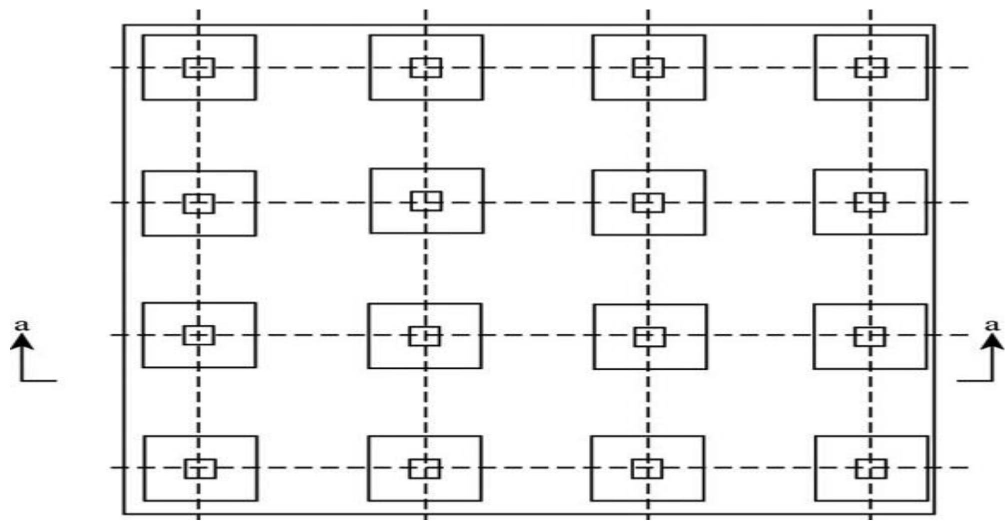


Figure 3.14. Mat Footing

3.6.6 Stairs

The stairs is a vertical transmission elements between the layers, and we used the one way solid slab in the landing.

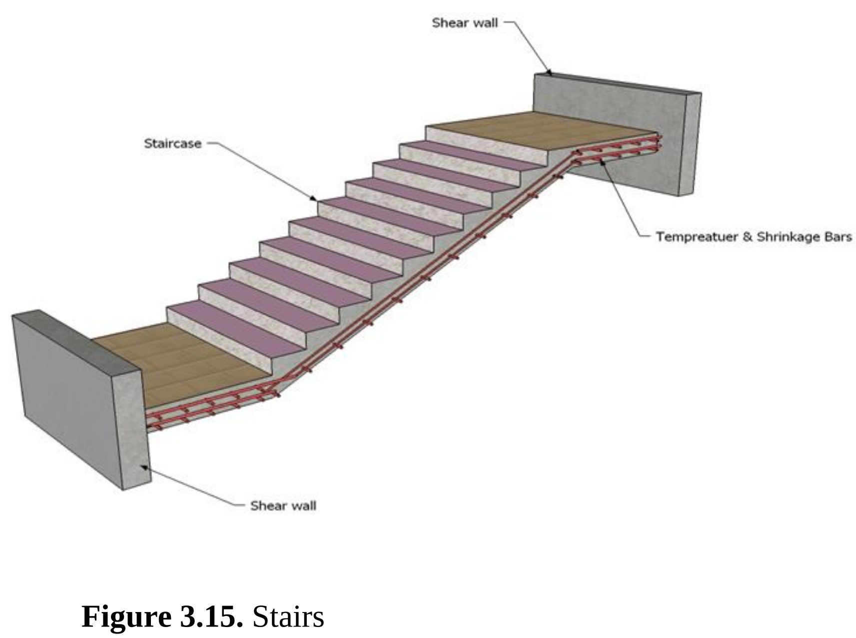


Figure 3.15. Stairs

3.6.7 Expansion joints

Is a spacer which are used in order to avoid getting any expansion or other effects that may impair the building, where the building is separated entirely, and the building is separated after increasing distanced (35-45) m.

when you use joints must take into account the vast spaces of the building:

- 40m areas with high humidity.
- 36m areas with normal humidity.
- 32m areas with medium humidity.
- 28m with dry areas.

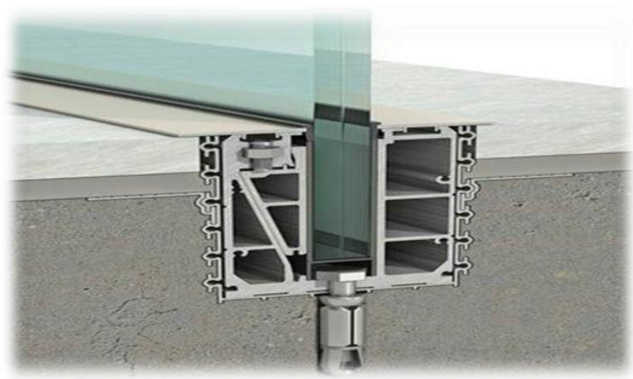


Figure 3.16. Expansion Joints

CHATER IV

SRTUCTURAL ANALYSIS AND DESIGN

CHAPTER IV: STRUCTURAL ANALYSIS AND DESIGN

4.1 Introduction

Many structures are built of reinforced concrete: bridges, buildings, retaining walls, tunnels, and others. Reinforced concrete is logical union of two materials: plain concrete, which possesses high compressive strength but little tensile strength, and steel bars embedded in the concrete, which can provide the needed strength in tension. Plain concrete is made by mixing cement, fine aggregate, coarse aggregate, water, and frequently admixtures. Understanding of reinforced concrete behavior is still far from complete, building codes and specifications that give design procedures are continually changing to reflect latest knowledge. Structural concrete can be classified into:

- Lightweight concrete with unit weight from about 1350 to 1850 kg/m3.
- Normal weight concrete with unit weight from about 1800 to 2400 kg/m3.
- Heavyweight concrete with unit weight from about 3200 to 5600 kg/m3

The structural buildings consists a lot of structural elements that will be designed according to the codes, so at present we can use several computers software such as" ATIR, Safe and Etabs ,…etc." to find the internal forces, deflections, Shear and moments for the all-structural element in order to design them.

4.2 Design method and requirements

The design strength provided by a member is calculated in accordance with the requirements and assumptions of ACI_318_14 code.

- **Strength design method**

In ultimate strength design method, the service loads are increased by factors to obtain the load at which failure is considered to be occurring. This load called factored load or factored service load. The structure or structural element is then proportioned such that the strength is reached when factored load is acting. 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.

The statically calculation and the key plans dependent on the architectural plans that we will to use it from (Code: UBC ACI 2014).

4.3 Determination of Slab Thickness

According to ACI-318M-14 code , the minimum thickness of non-prestressed beams or one-way slabs unless deflections are computed as follow.

Table 4.1. Minimum Thickness of Structural Member.

Minimum thickness , h				
	Simply supported	One end continuous	Both end continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be damaged by large deflection			
Solid one way Slabs	L/20	L/24	L/28	L/10
Beams or ribbed one way slabs	L/16	L/18.5	L/21	L/8

h_{min} for one end continuous (for Rib) =L/18.5 = 510/18.5 =27.57cm

h_{min} for both end continuous (for Rib) =L/21= 510/21 =24.29cm

h_{min} for one end continuous (for Beams) =L/18.5 = 510/18.5 =27.57cm

h_{min} for both end continuous (for Beams) =L/21= 510/21 =24.29cm

The controller slab thickness is 27.57cm

Select slab thickness = 32cm with 24cm *block and 8cm topping

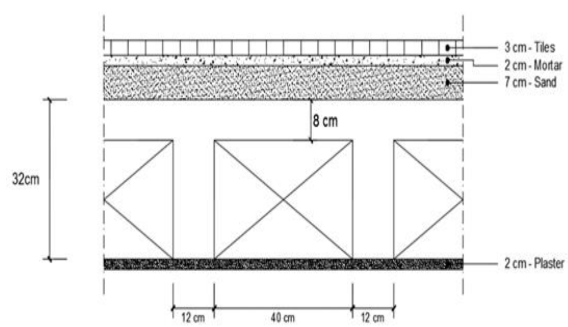


Figure 4.1. Typical Section in Ribbed slab

4.4 Determination of Loads of Ribs

Determination of dead load

Table 4.2. Dead Loads of the One-Way Rib Slab

TYPE	$\delta \times \gamma \times b$	KN/m
Tiles	0.03×23×0.52	0.359
Mortar	0.03×22×0.52	0.343
Coarse Sand	0.07×17×0.52	0.619
Topping	0.08×25×0.52	1.04
Hollow block	0.24×10×0.4	0.96
Plaster	0.03×2×20.52	0.343
R.C rib	0.24×25×0.12	0.72
Partitions	2. ×0.52	1.196
Sum	5.58 KN/m	

Determination of live load

Nominal Total live load for studies = 5× $0.52 = 2.6\ KN/m$

Determination of factored dead and live load

Factored dead load = 1.2× Dead load = 1.2×5.58 =6.696 KN/m

Factored Live load = 1.6× live load = 1.6× 2.6 = 4.16 KN/m

Effective Flange Width (***b***e): ACI-318-14 (8.10.2)

For T- section, be is the smallest of the following:

- ***b***e ≤ L / 4 =5.1/ 4 =127.5cm.

- ***b***e ≤ 12 + 16 t = 12 + 16 (8) = 140 cm.

- ***b***e ≤ center to center spacing between adjacent beams = 52 cm.

Control ***b***e for T-section = 52cm.

4.5 Design of Topping

Statically System for Topping: -

Topping in one-way ribbed slab can be considered as a strip of 1 meter width and

span of hollow block length with both ends fixed in the ribs.

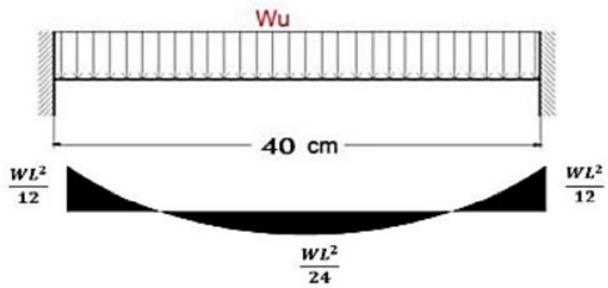


Figure 4.2. Topping Load and Moment Diagram

Determination of dead load of topping

Table 4.3. Dead Loads of the Topping

TYPE	$\boldsymbol{\delta \times \gamma \times 1}$	**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**
Partitions	**2.3×1**	**2.3**
Sum	**6.84 KN/m**	

Live Load = 5× 1m= 5 kN/m

Wu = 1.2DL +1.6LL =1.2×6.84 + 1.6× 5 =16.208 KN/m , (Total Factored Load).

$Mu = \frac{Wu*l^2}{12} = \frac{16.208*0.4^2}{12} = 0.216\ KN.m$

?? $\boldsymbol{(\emptyset M)_n > Mu}$

[Strength Condition, where $\boldsymbol{\emptyset = 0.55}$**] for plane concrete .**

$$Mn = 0.42 \times Sm \times \sqrt{f\acute{c}}$$ ACI 22.5.1, eq'n 22.2

Where Sm for rectangular section of the slab:

$$Sm = \frac{bh^2}{6} = \frac{1000*80^2}{6} = 1066666.67mm^3$$

$$Mn = 0.42 \times \sqrt{24}* \frac{1000*80^2}{6} = 2.19\ KN/m$$

$$\emptyset Mn = 0.55 \times 2.19 = 1.2KN/m$$

$$\emptyset Mn = 1.2 > Mu = 0.216KN/m$$

No Reinforcement is required by analysis According to ACI 10.5.4, provide As_{min}

for slabs as shrinkage and temperature reinforcement.

According to ACI 7.12.2.1, for the temperature and shrinkage reinforcement, ρ = **0:0018**

$$As = \rho \times b \times t = 0.0018 \times 1000 \times 80 = 144mm^2/m\ strip$$

$$Try \quad bars\ \emptyset 8\ with\ As = 50.27mm^2$$

$$n = \frac{As}{100} = \frac{144}{100} = 2.87\ bars$$

$\underline{Take\ 3\emptyset 8\ with\ As = 150.8mm^2/m\ , strip\ or \emptyset 8\ @300mm\ \ in\ both\ directions.}$

Step(s) is the smallest of:

1. $S \leq 3h = 3 \times 80 = 240mm$
2. $S \leq 450mm$
3. $S \leq 380 \times \frac{280}{fs} - 2.5c_c = 380 \times \frac{280}{\left(\frac{2}{3}\times 400\right)} - 2.5 \times 20 = 349mm, but$

$$S \leq 300 \times \frac{280}{fs} = 300 \times \frac{280}{\left(\frac{2}{3} \times 400\right)} = 315mm$$

$$\mathrm{S\ = 200mm < Smax = 240mm}$$

$\underline{TAKE \emptyset 8 @200mm\ in\ both\ direction.}$

4.6 Design of Rib1

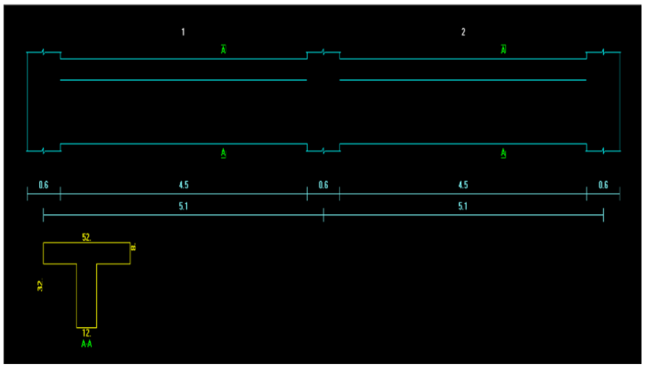


Figure4.3. Statically System and Dimension

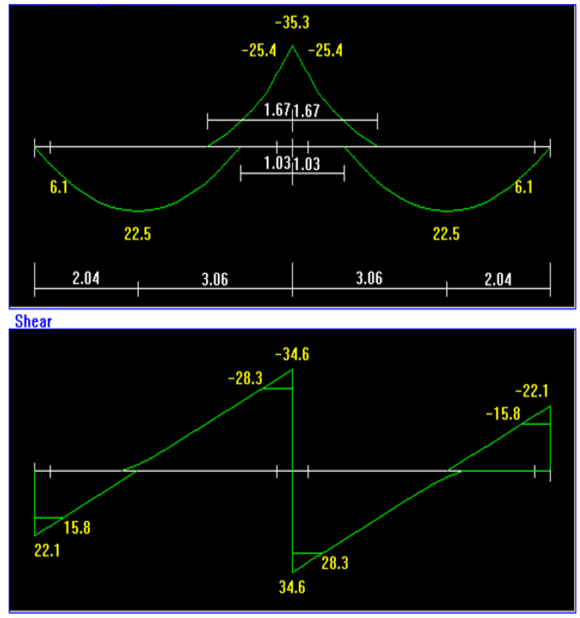


Figure 4.4. Env. Mom. And Shear Forces Diagram

4.6.1 Design for flexure

- Design of positive moment of rib1

Assume$\emptyset 12$ (+ve moment).

$$d = 320 - 20 - 8 - 6 = 286mm$$

The maximum positive moment in all spans of rib 1 $Mu = +22.5KN.m$

Check if a $> h_f$

$$M_{nf} = 0.85 f_{\acute{c}}\, b h_f \left(d - \frac{h_f}{2}\right) = 0.85 \times 24 \times 520 \times 80 \left(286 - \frac{80}{2}\right) \times 10^{-6}$$

$$= 208.76\ KN.m$$

$$M_{nf} = 208.76\ KN.m \gg \frac{Mu}{\emptyset} = \frac{22.5}{0.9} = 25KN.m \quad \rightarrow a < h_f$$

The section will be designed as rectangular section with b = 520mm.

$$R_n = \frac{Mu}{\emptyset b d^2} = \frac{22.5 \times 10^6}{0.9 \times 520 \times 286^2} = 0.588\ MP$$

$$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.59$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 \times 0.588 \times 20.59}{420}}\right) = 0.00142$$

$$A_S = \rho bd = 0.00142 \times 520 \times 286 = 211.18mm^2$$

$$A_{1\emptyset12} = 113.1mm^2$$

Check for $A_{s,min}$.

$$A_{s,min} = \frac{\sqrt{f\acute{c}}}{4(f_y)}(bw)(d) \geq \frac{1.4}{f_y}(bw)(d) \ldots\ldots\ldots\ldots\ldots\ldots..(ACI - 10.5.1)$$

$$A_{s,min} = \frac{\sqrt{24}}{4(420)}(120)(286) \geq \frac{1.4}{420}(120)(286)$$

$$A_{s,min} = 100.08 < 114.4$$

$$A_{s,min} = 114.4mm^2$$

$$211.18mm^2 > A_{s,min} = 114.4mm^2$$

$$Use\ 2\emptyset10\ with\ A_s = 226.2mm^2 > A_{s,req} = 211.18mm^2 \rightarrow\rightarrow OK$$

Tension = Compression

Check for strain:

$$A_s \times f_y = 0.85 \times f\acute{c} \times b \times a$$

$$226.2 \times 420 = 0.85 \times 24 \times 520 \times a$$

$$a = 8.96mm$$

$$c = \frac{a}{\beta 1} = \frac{8.96}{0.85} = 10.54mm \quad , \quad \beta 1 = 0.85$$

$$\varepsilon_s = \frac{(286 - 10.54)}{10.54} \times 0.003 = 0.078 > 0.005 \rightarrow\rightarrow OK$$

Select 2Ø12 At spans 1and2 with As > As req.

- Design of negative moment of rib1

Assume∅12 (-ve moment).

$d = 320 - 20 - 8 - 6 = 286mm$

The maximum negative moment in all spans of rib 1 $Mu = -25.4KN.m$

Check if a > h_f

$$M_{nf} = 0.85f_{\acute{c}}\,bh_f\,\left(d - \frac{h_f}{2}\right) = 0.85 \times 24 \times 520 \times 80\left(286 - \frac{80}{2}\right) \times 10^{-6}$$

$$= 208.76\ KN.m$$

$$M_{nf} = 208.76\ KN.m \gg \frac{\mathrm{Mu}}{\emptyset} = \frac{25.4}{0.9} = 28.22KN.m \quad \rightarrow a < h_f$$

The section will be designed as rectangular section with b = 520mm.

$$R_n = \frac{Mu}{\emptyset bd^2} = \frac{25.4 \times 10^6}{0.9 \times 520 \times 286^2} = 0.663\ MP$$

$$m = \frac{f_y}{0.85f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.59$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 \times 0.663 \times 20.59}{420}}\right) = 0.00161$$

$$A_S = \rho bd = 0.00161 \times 520 \times 286 = 239.44mm^2$$

$$A_{1\emptyset 12} = 113.1mm^2$$

Check for $A_{s,min}$.

$$A_{s,min} = \frac{\sqrt{f\acute{c}}}{4(f_y)}(bw)(d) \geq \frac{1.4}{f_y}(bw)(d) \ldots\ldots\ldots\ldots\ldots\ldots..(ACI - 10.5.1)$$

$$A_{s,min} = \frac{\sqrt{24}}{4(420)}(120)(284) \geq \frac{1.4}{420}(120)(284)$$

$$A_{s,min} = 100.08 < 114.4$$

$$A_{s,min} = 114.4mm^2$$

$$239.44mm^2 > A_{s,min} = 114.4mm^2$$

$Use\ 2\emptyset 14\ with\ A_s = 307.9mm^2 > A_{s,req} = 239.44mm^2 \rightarrow\rightarrow OK$

Tension = Compression

Check for strain:

$A_s \times f_y = 0.85 \times f\acute{c} \times b \times a$

$307.9 \times 420 = 0.85 \times 24 \times 520 \times a$

$a = 12.19mm$

$c = \frac{a}{\beta 1} = \frac{12.19}{0.85} = 14.34mm \quad , \quad \beta 1 = 0.85$

$\varepsilon_s = \frac{(286 - 14.34)}{14.34} \times 0.003 = 0.057 > 0.005 \quad \rightarrow\rightarrow OK$

Select 2Ø14 At spans 1and2 with As > As req.

4.6.2 Design for shear of rib 1

1.$V_{ud} = 28.3KN(at\ support2)$

$\emptyset V_c = \emptyset \times \frac{\sqrt{f\acute{c}}}{6}\ b_w \times d = 0.75 \times \frac{\sqrt{\mathbf{24}}}{6} \times 120 \times 0.286 = 21.02KN$

$1.1 \times \emptyset V_c = 1.1 \times 21.02 = 23.12KN$

$V_{s,min} = \frac{2}{3} \times \sqrt{24} \times 120 \times 286 \times 10^{-3} = 112.09KN$

$V_s = V_n - V_c = \frac{28.3}{0.75} - 28.03 = 9.7KN$

The section thickness is adequate enough.

Check for items:

Case I

$V_u \leq \frac{\emptyset V_c}{2}$

28.3 > 10.51(Not OK)

Case II

$\frac{\emptyset V_c}{2} \leq V_u \leq \ \emptyset V_c$

10.51 < 28.3>21.02(Not OK)

Case III

$\emptyset \boldsymbol{V_c} < \ \boldsymbol{V_u} \leq \emptyset \boldsymbol{V_c} + \emptyset \boldsymbol{V_{s,min}}$

$\rightarrow V_{s,min} = \frac{1}{16} \times \sqrt{\boldsymbol{f}\acute{c}} \times b_w \times d = \frac{1}{16} \times \sqrt{\mathbf{24}} \times 120 \times 0.286 = 10.51KN$

$\rightarrow \emptyset V_{s,min} = 0.75 \times 10.51 = 7.88KN$

OR

$\rightarrow V_{s,min} = \frac{1}{3} \times b_w \times d = \frac{1}{3} \times 120 \times 0.286 = 11.44KN$

$\rightarrow \emptyset V_{s,min} = 0.75 \times 11.44 = 8.58\text{KN} \ \rightarrow\rightarrow controlled$

$\emptyset \boldsymbol{V_c} + \emptyset \boldsymbol{V_{s,min}} = 20.87 + 8.58 = 29.39KN$

$\emptyset \boldsymbol{V_c} = 21.02KN < 28.3KN \leq \emptyset \boldsymbol{V_c} + \emptyset \boldsymbol{V_{s,min}} = 29.6KN$

min reinforcement is required:

S $\leq \frac{d}{2} = 143mm$

$\leq$ *600mm* ……………*Select* ***S*** *=100mm*

Use stirrups (2 leg stirrups) ø 8@100 mm, Av $\frac{2\times\pi\times8^2}{4}$= 100.53 mm^2

4.7. Design of Beam 28

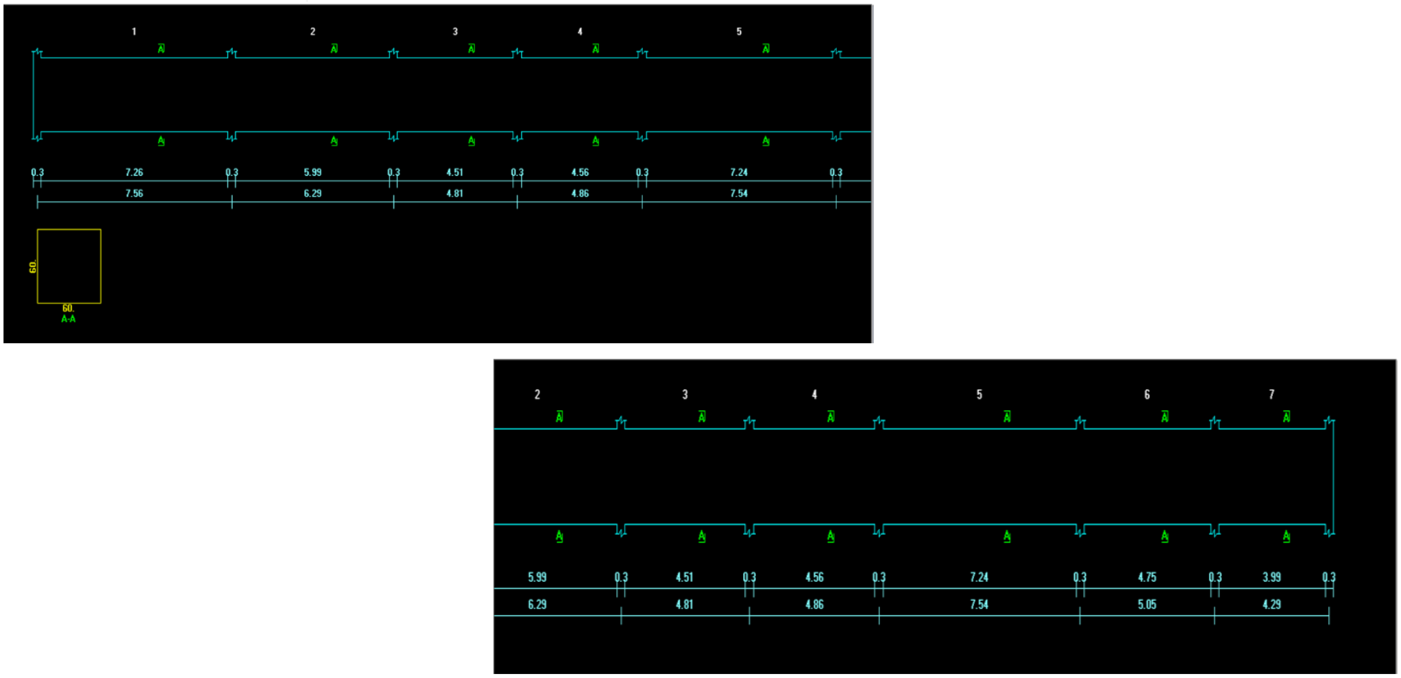


Figure 4.5. Statically System and Dimension

- Determination of dead load of beam

From Rib 1= $\frac{35..57}{0.52} = 68.4KN/m$

From Rib 17= $\frac{30.69}{0.52} = 59.02KN/m$

From Rib 18= $\frac{32.02}{0.52} = 61.58KN/m$

From Rib 19= $\frac{23.28}{0.52} = 44.77KN/m$

From Rib 7= $\frac{31.42}{0.52} = 60.42KN/m$

From Rib 8= $\frac{29.96}{0.52} = 57.62KN/m$

- Determination of live load of beam

From Rib 1= $\frac{16.58}{0.52} = 31.9KN/m$

From Rib 17= $\frac{14.3}{0.52} = 27.5KN/m$

From Rib 18= $\frac{15.96}{0.52} = 30.69KN/m$

From Rib 19= $\frac{12.75}{0.52} = 24.52KN/m$

From Rib 7= $\frac{14.64}{0.52} = 28.15KN/m$

From Rib 8= $\frac{13.96}{0.52} = 26.85KN/m$

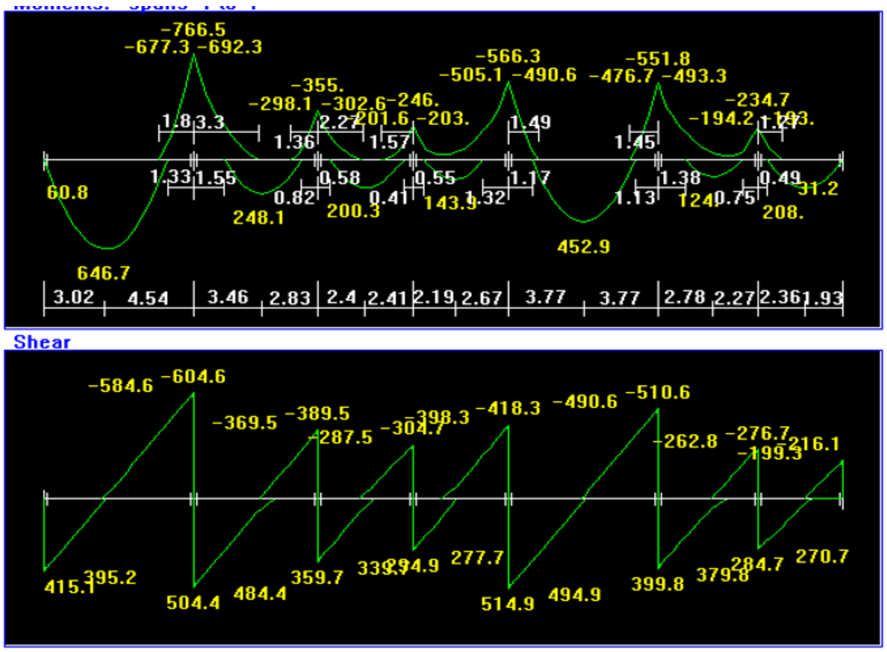


Figure 4.6. Env. Mom. and Shear Diagram

4.7.1 Design for flexure

- Design of maximum positive moment

Assume bars of Ø25 , $b = 60cm$, $h = 60cm$

$Mu,max = 646.7\ KN.m$

$$d = 600 - 40 - \frac{25}{2} - 10 = 537.5mm$$

$$C_{max} = \frac{3}{7} \times d = \frac{3}{7} \times 537.5 = 230.35mm$$

$$a = 0.85 \times C_{max} = 0.85 \times 230.35 = 195.8mm$$

$$\emptyset M_{n,max} = \emptyset \times 0.85f_{\acute{c}} \times a \times b \times \left(d - \frac{a}{2}\right)$$

$$0.82 \times 0.85 \times 24 \times 195.8 \times 600 \times \left(537.5 - \frac{195.8}{2}\right) \times 10^{-6}$$

$$= 863.9KN.m > \ M_u = 646.7\ KN.m$$

<u>Design as Singly</u>

$$M_n = \frac{M_u}{\emptyset} = \frac{646.7}{0.9} = 718.56\ KN.m$$

$$R_n = \frac{M_n}{(b \times d^2)} = \frac{718.56 \times 10^6}{(600 \times 537.5^2)} = 4.15\ MPa$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 \times 4.15 \times 20.59}{420}}\right) = 0.011$$

$$A_S = \ \rho bd = 0.011 \times 600 \times 537.5 = 3547.5mm^2$$

Check for $A_{s,min}$.

$$A_{s,min} = \frac{\sqrt{f\acute{c}}}{4(f_y)}(bw)(d) \geq \frac{1.4}{f_y}(bw)(d) \ldots\ldots\ldots\ldots\ldots\ldots..(ACI - 10.5.1)$$

$$A_{s,min} = \frac{\sqrt{24}}{4(420)}(600)(537.5) \geq \frac{1.4}{420}(600)(537.5)$$

$$A_{s,min} = 1003.4 > 1075$$

$$A_{s,min} = 1003.4mm^2 \rightarrow\rightarrow control$$

$$3547.5mm^2 \ > \ A_{s,min} \ = 1003.4mm^2$$

$$Note A_{\emptyset 25} = 490.9mm^2$$

Number of bars $= \frac{A_S}{A_{s,bar}} = \frac{3547.5}{490.9} = 7.2bars$

<u>$Use\ 8\emptyset 25\ with\ A_s = 3927mm^2 > A_{s,req} = 3547.5mm^2 \rightarrow\rightarrow OK$</u>

Check for strain

Tension = Compression

$A_s \times f_y = 0.85 \times f\acute{c} \times b \times a$

$3927 \times 420 = 0.85 \times 24 \times 600 \times a$

$a = 134.75mm$

$c = \frac{a}{\beta 1} = \frac{134.75}{0.85} = 158.53mm \quad , \quad \beta 1 = 0.85$

$\varepsilon_s = \frac{(537.5 - 158.53)}{158.53} \times 0.003 = 0.00717 > 0.005 \quad \rightarrow\rightarrow OK$

$\emptyset = 0.9$

$M_n = 0.85 \times f_{\acute{c}} \times a \times b \times \left(d - \frac{a}{2}\right)$

$M_n = 0.85 \times 24 \times 134.75 \times 600 \times \left(537.5 - \frac{134.75}{2}\right) = 775.39KN.m$

$\emptyset M_n = 0.9 \times 775.39 = 697.851KN.m > 646.7KN.m$

Check for spacing

$$\mathbf{S} = \frac{(600-40\times2-2\times10-8\times25)}{7} = 42.8\text{mm} > 25\text{mm}$$

- Design of maximum negative moment.

Assume bars of $\emptyset 25$, $b = 60cm$, $h = 60cm$

$Mu,max = 692.3\ KN.m$

$d = 600 - 40 - \frac{25}{2} - 10 = 537.5mm$

$C_{max} = \frac{3}{7} \times d = \frac{3}{7} \times 537.5 = 230.35mm$

$a = 0.85 \times C_{max} = 0.85 \times 230.35 = 195.8mm$

$\emptyset M_{n,max} = \emptyset \times 0.85 f_{\acute{c}} \times a \times b \times \left(d - \frac{a}{2}\right)$

$$0.82 \times 0.85 \times 24 \times 195.8 \times 600 \times \left(537.5 - \frac{195.8}{2}\right) \times 10^{-6}$$

$$= 863.9KN.m > \ M_u = 692.3\ KN.m$$

<u>Design as Singly</u>

$$M_n = \frac{M_u}{\emptyset} = \frac{692.3}{0.9} = 769.2\ KN.m$$

$$R_n = \frac{M_n}{(b \times d^2)} = \frac{769.2 \times 10^6}{(600 \times 537.5^2)} = 4.44\ MPa$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 \times 4.44 \times 20.59}{420}}\right) = 0.012$$

$$A_S = \ \rho bd = 0.012 \times 600 \times 537.5 = 3870mm^2$$

Check for $A_{s,min}$.

$$A_{s,min} = \frac{\sqrt{f\acute{c}}}{4(f_y)}(bw)(d) \geq \frac{1.4}{f_y}(bw)(d) \ldots\ldots\ldots\ldots\ldots\ldots..(ACI - 10.5.1)$$

$$A_{s,min} = \frac{\sqrt{24}}{4(420)}(600)(537.5) \geq \frac{1.4}{420}(600)(537.5)$$

$$A_{s,min} = 1003.4 > 1075$$

$$A_{s,min} = 1003.4mm^2 \to\to control$$

$$3870mm^2\ >\ A_{s,min}\ = 1003.4mm^2$$

$$NoteA_{\emptyset 25} = 490.9mm^2$$

Number of bars $= \frac{A_s}{A_{s,bar}} = \frac{3870}{490.9} = 7.8bars$

<u>$Use\ 8\emptyset 25\ with\ A_s = 3927mm^2 > A_{s,req} = 3870mm^2 \to\to OK$</u>

Check for strain

Tension = Compression

$$A_s \times f_y = 0.85 \times f\acute{c}\ \times b \times a$$

$3927 \times 420 = 0.85 \times 24 \times 600 \times a$

$a = 134.75mm$

$c = \frac{a}{\beta 1} = \frac{134.75}{0.85} = 158.53mm \quad , \quad \beta 1 = 0.85$

$\varepsilon_s = \frac{(537.5 - 158.53)}{158.53} \times 0.003 = 0.00717 > 0.005 \quad \rightarrow\rightarrow OK$

$\emptyset = 0.9$

$M_n = 0.85 \times f_{\acute{c}} \times a \times b \times \left(d - \frac{a}{2}\right)$

$M_n = 0.85 \times 24 \times 134.75 \times 600 \times \left(537.5 - \frac{134.75}{2}\right) = 775.39KN.m$

$\emptyset M_n = 0.9 \times 775.39 = 697.851KN.m > 646.7KN.m$

Check for spacing

S= $\frac{(600-40\times2-2\times10-8\times25)}{7} = 42.8\text{mm} > 25\text{mm}$

4.7.2 Design for shear

$V_{ud} = +494.9KN(at\ support5)$

$\emptyset V_c = \emptyset \times \frac{\sqrt{f\acute{c}}}{6}\ b_w \times d = 0.75 \times \frac{\sqrt{24}}{6} \times 600 \times 0.5375 = 197.49KN$

Check for items:

Case I

$V_u \leq \frac{\emptyset V_c}{2}$

494.9 > 98.75(Not OK)

Case II

$\frac{\emptyset V_c}{2} \leq V_u \leq \emptyset V_c$

98.75 < 494.9>197.49(Not OK)

Case III

$\emptyset V_c < V_u \leq \emptyset V_c + \emptyset V_{s,min}$

$\rightarrow V_{s,min} = \frac{1}{16} \times \sqrt{f\acute{c}} \times b_w \times d = \frac{1}{16} \times \sqrt{24} \times 600 \times 0.5375 = 98.75KN$

$\rightarrow \emptyset V_{s,min} = 0.75 \times 98.75 = 74.06KN$

OR

$\rightarrow V_{s,min} = \frac{1}{3} \times b_w \times d = \frac{1}{3} \times 600 \times 0.5375 = 107.5KN$

$\rightarrow \emptyset V_{s,min} = 0.75 \times 107.5 = 80.63\text{KN} \rightarrow\rightarrow controlled$

$\emptyset V_c + \emptyset V_{s,min} = 197.49 + 80.63 = 278.12KN$

$\emptyset V_c = 197.49KN < 494.9KN \leq \emptyset V_c + \emptyset V_{s,min} = 278.12KN \ \ (Not\ Ok)$

Case IV

$\emptyset(V_c + V_{s,min}) < V_u \leq \emptyset(V_c + V_s')$

Min. reinforcement is required:

$V_s' = \frac{1}{3} \times \sqrt{f\acute{c}} \times b_w \times d$

$V_s' = \frac{1}{3} \times \sqrt{24} \times 600 \times 0.5375 = 526.64KN.$

$\emptyset(V_c + V_s') = 0.75(263.3 + 526.64) = 592.46KN.$

$\emptyset\left(V_c + V_{s,min}\right) = 278.12 < 494.9 \leq \emptyset(V_c + V_s') = 592.46 \ldots\ldots.\ OK$

$\frac{A_v}{s} = \frac{V_s}{(f_{yt} \times d)}$

$\underline{Use\ stirrups\ U -\ shape\ (4\ - leg\ stirrups)\emptyset 10mm\ with A_v = 4 \times 78.54 = 314.159mm^2}$

$$V_S = V_n - V_C = \frac{494.9}{0.75} - 278.12 = 381.75KN$$

$$\frac{A_v}{s} = \frac{V_s}{(f_{yt} \times d)} \rightarrow \frac{314.159 \times 10^{-3}}{S} = \frac{381.75}{420 \times 537.5}$$

$S = 185.78mm$

$S_{max} \leq 600$

$S_{max} \leq \frac{d}{2} = \frac{537.5}{2} = 268.75mm$

$\underline{Take\ S = 15cm}$

- *Design of maximum negative shear*

$.V_{ud} = 584.6KN(at\ support2)$

$$\emptyset V_c = \emptyset \times \frac{\sqrt{f\acute{c}}}{6}\ b_w \times d = 0.75 \times \frac{\sqrt{24}}{6} \times 600 \times 0.5375 = 197.49KN$$

Check for items:

Case I

$$V_u \leq \frac{\emptyset V_c}{2}$$

584.6> 98.75(Not OK)

Case II

$$\frac{\emptyset V_c}{2} \leq V_u \leq \emptyset V_c$$

98.75 <584.6>197.49(Not OK)

Case III

$\emptyset V_c < V_u \leq \emptyset V_c + \emptyset V_{s,min}$

$$\rightarrow V_{s,min} = \frac{1}{16} \times \sqrt{f\acute{c}} \times b_w \times d = \frac{1}{16} \times \sqrt{24} \times 600 \times 0.5375 = 98.75KN$$

$\rightarrow \emptyset V_{s,min} = 0.75 \times 98.75 = 74.06KN$

OR

$$\rightarrow V_{s,min} = \frac{1}{3} \times b_w \times d = \frac{1}{3} \times 600 \times 0.5375 = 107.5KN$$

$$\rightarrow \emptyset V_{s,min} = 0.75 \times 107.5 = 80.63KN \ \rightarrow\rightarrow controlled$$

$$\emptyset V_c + \emptyset V_{s,min} = 197.49 + 80.63 = 278.12KN$$

$$\emptyset V_c = 197.49KN < 584.6KN \leq \emptyset V_c + \emptyset V_{s,min} = 278.12KN \ \ (Not\ Ok)$$

Case IV

$$\emptyset(V_c + V_{s,min}) < \ V_u \leq \emptyset(V_c + V_s')$$

Min. reinforcement is required:

$$V_s' = \frac{1}{3} \times \sqrt{f\acute{c}} \times b_w \times d$$

$$V_s' = \frac{1}{3} \times \sqrt{24} \times 600 \times 0.5375 = 526.64KN.$$

$$\emptyset(V_c + V_s') = 0.75(263.3 + 526.64) = 592.46KN.$$

$$\emptyset\left(V_c + V_{s,min}\right) = 278.12 < 584.6 \leq \emptyset(V_c + V_s') = 592.46 \ldots\ldots.\ OK$$

$$\frac{A_v}{s} = \frac{V_s}{(f_{yt} \times d)}$$

$$\underline{Use\ stirrups\ U-\ shape\ (4\ -leg\ stirrups)\emptyset 10mm\ with A_v = 4 \times 78.54 = 314.159mm^2}$$

$$V_S = V_n - V_C = \frac{584.6}{0.75} - 278.12 = 501.35KN$$

$$\frac{A_v}{s} = \frac{V_s}{\left(f_{yt} \times d\right)} \rightarrow \frac{314.159 \times 10^{-3}}{S} = \frac{501.35}{420 \times 537.5}$$

$$S = 141.46mm$$

$$S_{max} \leq 600$$

$$S_{max} \ \leq \frac{d}{2} = \frac{537.5}{2} = 268.75mm$$

$$TAKE\ S = 15cm$$

4.8. Design of Column (7)

Material: -

Concrete B300 Fc' = 24 N/mm2

Reinforcement Steel fy = 420 N/mm2

DL = 786 kN

LL= 306 kN

Pu = 1433 kN

4.8.1. check for slenderness

$\frac{Lu*K}{r} < 34 - 12\ \frac{M1}{M2}$ …………… (ACI −10.12.2)

Lu: Actual unsupported (unbraced) length.

K: effective length factor (K= 1 for braced frame).

R: radius of gyration = $\sqrt{\frac{1}{A}} \approx 0.3$

Lu =3.2 m

$\frac{M1}{M2}$=1

K=1 , According to ACI 318-02 (10.10.6.3) The effective length factor, k, shall be permitted to be taken as 1.0.

$\frac{Lu*K}{r} < 34 - 12\ \frac{M1}{M2}$

$\frac{3.2*1}{0.3*0.6} < 34 - 12\ (\mathbf{1})$

15.24 > 22 ……. short column in both direction’s

4.8.2. Compute EI

EI = 0.4 $\frac{E\ x\ Ig}{1+\beta d}$ ………… [ACI 318-05(Eq. 10-15)]

Ec = 4700√Fc′ = 4700*24 =23025 Mpa

βd =$\frac{1.2\ DL}{Pu} = \frac{1.2\times786}{1433} = 0.66 < 1$

Ig = $\frac{bh^3}{12}$ = $\frac{600\times350^3}{12} = 2.14$ mm4

EI = $\frac{0.4\ E\ x\ Ig}{1+\beta d}$ = $\frac{0.4(23025\times2.14\times10^9}{(1+0.66)}) = 11873$ kN.m2

Pcr = $\frac{\pi^2\times EI}{(K\times Lu\ )^2}$ …………..(ACI 318-05 (Eq. 10 -13)

Pcr = $\frac{3.14^2\times11873}{(1\times3.2\ )^2}$ = 11443.5 KN

Cm = 0.6 + 0.4 ($\frac{M1}{M2}$) …………..(ACI 318-05 (Eq. 10 -16)

Cm = 1 ……………….(According to ACI 318-05) (10.10.6.4)

δ_{sn}= $\frac{Cm}{1-\frac{Pu}{0.75\ Pcr}}$ ………………..(ACI 318-05 (Eq. 10 -12)

1 < δ_{sn}=$\frac{1}{1-\frac{1433}{0.75\times11443.5}}$ 11− 10220.75x52973 = 1.2 >1

e_{min} =15 + 0.03x h = 15+ (0.03x350) = 25.5 mm

e = $emin\ x\ \delta_{sn}$= 25.5 x 1.2 = 30.6 mm

$\frac{e}{h}$ = 30.6 /350 =0.087

γ= $\frac{350-2(40)-2(10)-20}{350} = 0.66$

$\frac{\emptyset\ Pn}{Ag}$ = $\frac{1433\times10^3}{600\times350}\times 0.145$= 0.99 ksi

From the interaction diagram in chart

Diagram A-9a(for γ = 0.6), ρ_g = 0.013

Diagram A-9b(for γ = 0.6), ρ_g = 0.012

ρ_g = (γ = 0.66) = 0.013 - ($\frac{0.013-0.012}{0.75-0.6}$) (0.66-0.6) = 0.0124 >$\rho_{min} = 0.01$

Select the reinforcement:

$$A_{st} = \rho_g \times A_g = 0.0124 * 600 * 350 = 2604\ mm^2$$

Take 9Ø 20 with A_s = 2827.4 mm^2

4.8.3. Design of the Stirrups

The spacing of ties shall not exceed the smallest of:

Spacing ≤ 16 $\boldsymbol{dB}$ ≤ 16X2=32cm

Spacing ≤ 48 $\boldsymbol{dS}$ ≤ 48X10 = 48 cm

Spacing ≤ 40 cm

Use Ø10@20 cm

4.9. Design of Isolated footing (F3)

From column (7)

* Service dead load (DL) = 786KN

* Service live load (LL) = 306KN

* Column dimensions =60 cm*35 cm

* Allowable soil pressure = 400 KN/ m^2

Calculating the weight of footing: -

Weight of footing (assume h footing = 40cm)

W footing = 0. 5*25 = 12.5 KN/m^2

Weight of Soil:

W soil = 17*1 = 17 KN/m^2

Total surcharge load on foundation:

W = 5 +12.5+ 17 =34.5 KN/m²

q net soil pressure = 400 – 34.5 = 365.5 KN/m²

Required sizes of footing:

A = Pn/q net = (786+306)/365.5 =2.99 m2

√A = √2.99=1.73m

Take L=1.8 m

Depth of footing and shear design:

Pu =1.2DL + 1.6LL = 1.2*786+ 1.6*306= 1432.8 KN

qu = 1432.8/(1.8*1.8)= 442.2 KN/m²

One-way shear (Beam shear):

Vu at distance from the face of support:

Vu = qu *b *$(\frac{l}{2} - \frac{a}{2} - d)$

Let Vu = ø Vc , ø =0.75

Vc = $\frac{1}{6} * \sqrt{fc'} * bw * d = \frac{1}{6} * \sqrt{24} * 1800 * d$

$\frac{1}{6} * \sqrt{24} * 1800 * d = \frac{442.2 * 1.8}{0.75} * (0.9-0.175-d)$

d= 0.304 m

Assume cover 100 mm, and steel bars of (ø10) :

h = 304 +100+10 = 414 mm

Take h = 50 cm

d=500 -100- 10 =390 mm

Two-way shear (Punching shear):

Let Vu = øVc, ø =0.75

Vu =442.2 *(1.8*1.8 – (0.35 +0.39) (0.6+0.39))

Vu = 1108.77 KN

β = $\frac{600}{350}$ =1.7, b_o = 2(0.35+0.39) +2(0.6+0.39) =3.46 m

α s = 30 –edge column

Vc = $\frac{1}{6}(1+\frac{2}{\beta})\sqrt{fc'} * bo * d$ $\quad Where \quad \frac{1}{6}(1+\frac{2}{\beta}) = \frac{1}{6}(1+\frac{2}{1.7})$ =0.36

Vc = $\frac{1}{12}(\frac{d\alpha_s}{b_0}+2)\sqrt{fc'} * bo * d \quad Where \quad \frac{1}{12}(\frac{d\alpha_s}{b_0}+2) = \frac{1}{12}(\frac{30*0.39}{3.46}+2)$=0.45

Vc = $\frac{1}{3}(\sqrt{fc'} * bo * d) \quad Where \quad \frac{1}{3}$ = 0.333

So , Vc =$\frac{1}{3}(\sqrt{fc'} * bo * d) = \frac{1}{3}(\sqrt{24} * 3460 * 390 * 10^{-3})$ =2203.6 kN

ø Vc = 0.75* 2203.6 =1652.7 KN > Vu = 1108.77 KN

Design for flexure in long direction:

Take Steel Bars = ø 10

b =1.8 , h =50 cm

d =0.39 m , fc′=24 , fy =420 Mpa

Mu = 442.2 * 1.8/2* ((1.8-0.35)/2) =288.5 kN

$Rn = \frac{Mu}{ø\, b*d2} = \frac{288.5\times10^6}{0.9\times1800\times390\times390} = 1.17\ Mpa.$

m = $\frac{fy}{0.85xfc\prime} = \frac{420}{0.85\times24}$ = 20.6

ρ = $\frac{1}{m}(1-\sqrt{1-\frac{2\times m\times Rn}{fy}}) = \frac{1}{20.6}(1-\sqrt{1-\frac{2\times20.6\times1.17}{420}})$ = 0.0029

As req = ρ x b xd = 0.0029 *1800*390 = 2035.8 $mm2$.

→ Check for As min:

As min = ρ x b x h = 0.0018 *1800*500 = 1620 $mm2$.

As req = 2035.8 $mm2$ > Asmin= 1620 $mm2$.

Use 7 ø 20 , As, provided = 2199.1 $mm2$ > As req = 2035.8 $mm2$ (OK).

S = $\frac{1800-2*100-7*20}{6}$ = 243.3 $mm.$

Step(S) is the smallest of:

1. 3h = 3*500 = 1500 mm

2. 450 mm -control

S =243.3 mm < S max = 450 mm -OK

4.10. Design of stair

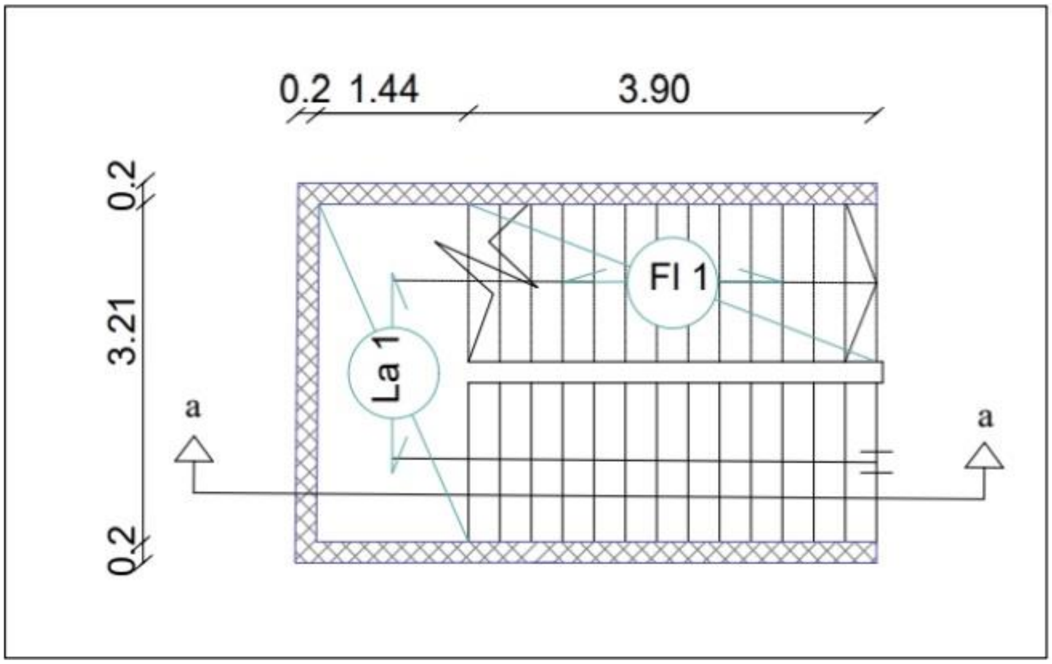


Figure 4.7. Stair plan

Material: -

Concrete B300 ,fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

4.9.1. Determination the Thickness of Slab (flight and landing)

L = 4.36m

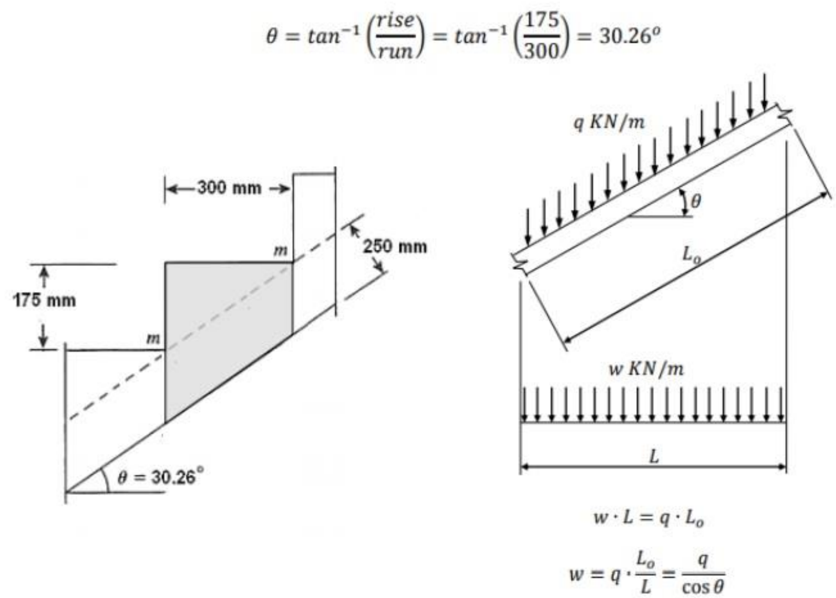
Min. thick = L / 20 = 4.36 / 20 = 21.8 cm or

Min. thick = L / 28 = 4.36 / 28 = 15.6 cm

Take h= 20 cm .

Use h = 20cm. Rise = 17.5cm, run = 30cm

4.9.2. Load Calculations at section:



❖ Landing Dead Load computation:

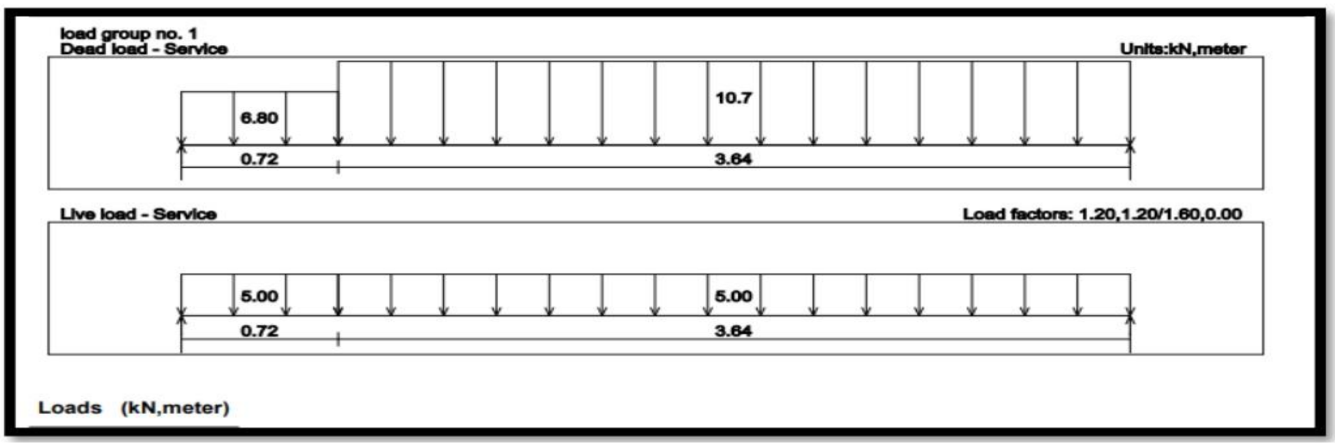
Material	Quality Density KN/m^3	$\gamma \cdot h \cdot 1$ KN/m
Tiles	23	$23 \times 0.03 \times 1 =$ 0.69
mortar	22	$22 \times 0.03 \times 1 =$ 0.66
Reinforced Concrete solid slab	25	$25 \times 0.2 \times 1 =$ 5
Plaster	22	$22 \times 0.02 \times 1 =$ 0.66
Total Dead Load		7.01

Live Load = 5 KN/m^2

Total factored load. landing= 1.2 D. L + 1.6 L. L = 1.2 (7.01) + 1.6 (5)

Total factored load. landing= 16.412 KN/m

Material	Quality Density KN/m^3	$W \quad KN/m$
Tiles	23	$23\times\left(\frac{0.175+0.35}{0.3}\right)\times 0.03\times 1 = 1.2075$
mortar	22	$22\times\left(\frac{0.175+0.3}{0.3}\right)\times 0.03\times 1 = 1.045$
Stair steps	25	$\frac{25}{0.3}\times\left(\frac{0.175\times 0.3}{2}\right)\times 1 = 2.188$
Reinforced Concrete solid slab	25	$\frac{25\times 0.2\times 1}{\cos 30.26^o} = 5.78$
Plaster	22	$\frac{22\times 0.02\times 1}{\cos 30.26^o} = 0.509$
Total Dead Load, KN/m		10.73



Live Load = 5 KN/m^2

Total factored load. Flight = 1.2 D. L + 1.6 L. L = 1.2 (10.73) + 1.6 (5)

Total factored load. Flight = 20.88 KN/m

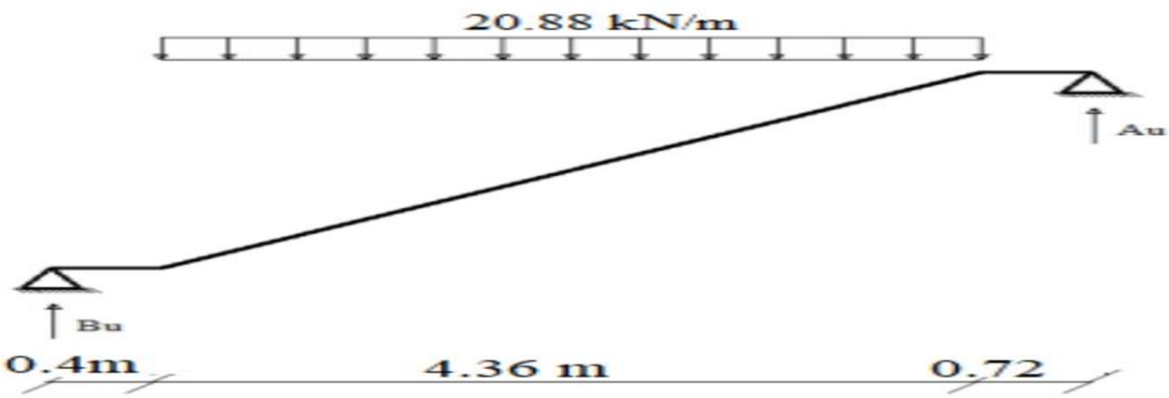


Figure 4.8. Structural system of flight

**Because the load on the landing is carried into one direction ,16.412 /2 =8.206 KN

4.9.3. Check for shear strength

Assume bar diameter for main reinforcement ø16:

d= h – cover - d_B = 200 – 20 – (16/2) = 172mm

Au = (8.206 x 0.4 x $\frac{0.4}{2}$) + (20.88 x 4.63 x ($\frac{4.36}{2}$+ 0.41) + ((8.206 x 0.72 (4.360 + $\frac{0.72}{2}$)

Au = 48.5 KN → Bu =51.27 KN

Vu .max = 51.27- (8.206 x 0.4) - (20.88 x 0.172) = 51.58 kN

Vc = $\frac{1}{6}$ x $\sqrt{fc'}$ x b x d = $\frac{1}{6}$ x $\sqrt{24}$ x 1000 x 172 =*140.44* kN

Ø Vc = 0.75 x 140.44 =105.33 kN

0.5 x Ø Vc = 0.5 x 105.33 =52.66 kN

Vu =51.58 kN $\leq$ 0.5 x Ø Vc =52.66 kN , thickness is educated enough

Mu = (51.58 (0.4 + 2.18)) - (20.88 x $\frac{2.18^2}{2}$) = 83.46 kN

$Rn = \frac{Mn}{b\ d^2} = \frac{83.46 \times 10^6}{1000 \times 172^2}$ = 3.13 MPa

m = $\frac{fy}{0.85 \times fc'} = \frac{420}{0.85 \times 24}$ = 20.6

$\rho = \frac{1}{m}\ (1-\sqrt{1\ -\ \frac{2\ x\ m\ x\ Rn}{fy}}\ ) = \frac{1}{20.6}\ (1-\sqrt{1\ -\ \frac{2\ x\ 20.6\ x\ 3.13}{420}}\ ) = 0.008$

As. req = ρ x b x d = 0.008 x 1000 x 172 = 1399 mm^2 .

⇒ Check for As. min:

As. min = ρ x b x h = 0.018 x 1000 x 200 = 360 mm^2

As. req = 1399 mm^2 > As. min = 360 mm^2 , use ø16

n = $\frac{As}{As\ ø16}$ = $\frac{1399}{201}$ = 6.96, S = $\frac{1}{n}$ = 0.14 m , take ø16 /150 mm /1 m

S is the smallest of :

1- 3 x h = 3 x 200 =600

2- 450 mm

3- S ≤ 380 x ($\frac{280}{fs}$) – 2.5 x Cc = 380 x ($\frac{280}{\frac{2}{3} x\ 420}$) – 2.5 x 20 =330 mm

4- S ≤ 380 x ($\frac{280}{fs}$) = 300 mm → Controlled S =150 mm < 300 mm

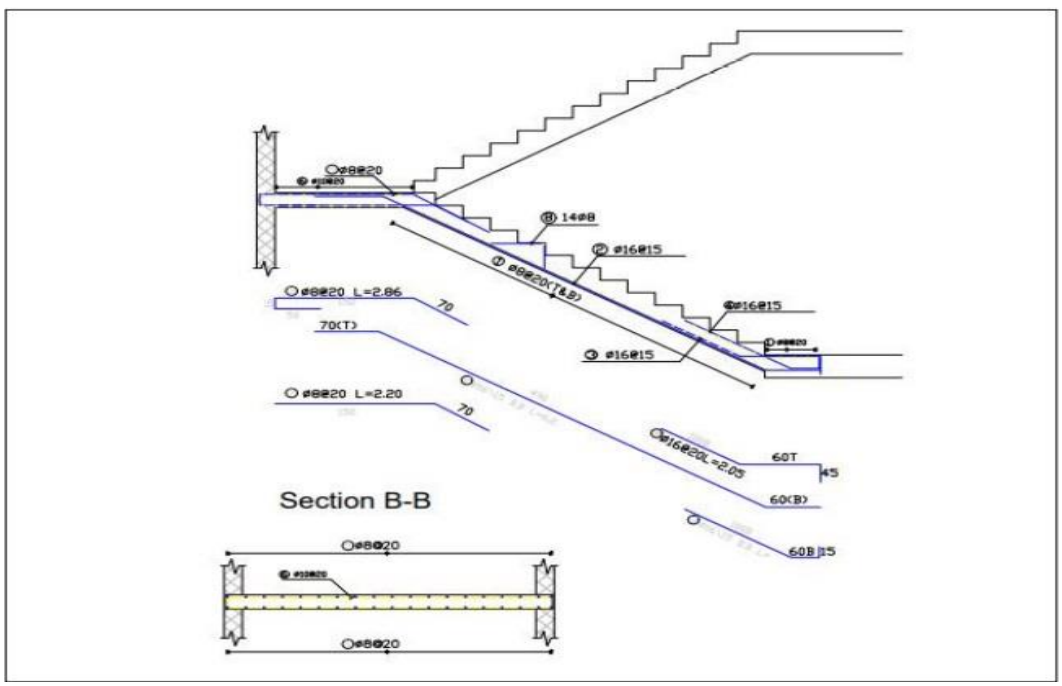


Figure 4.9. Stair Reinforcement Details.

4.10. Design of basement wall

Material: -

Concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

Ø = 30°, γ = 17 kN/m^3

Soil at rest:

Ko =1- sin ø = 1- sin (30) =0.5

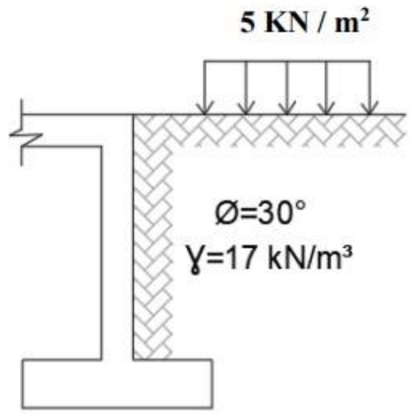


Figure 4.10. Geometry of Basement wall

4.10.1. Load on basement wall

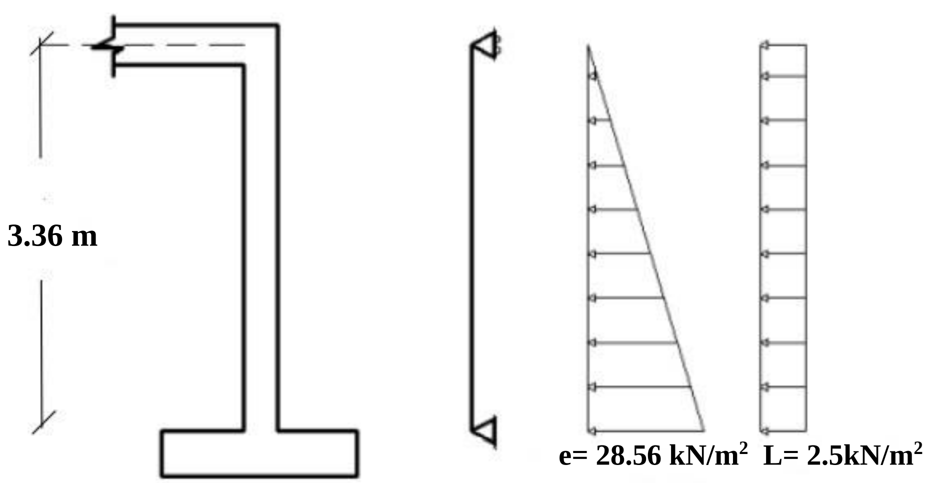


Figure 4.11. System and Loads of Basement wall

For 1m length of wall:

Weight of backfill:

e = Ko x γ x h = 0.5 x 17 x 3.36 =28.56 kN/m^2

qu1. factored = 1.6 x e = 45.7 kN/m^2

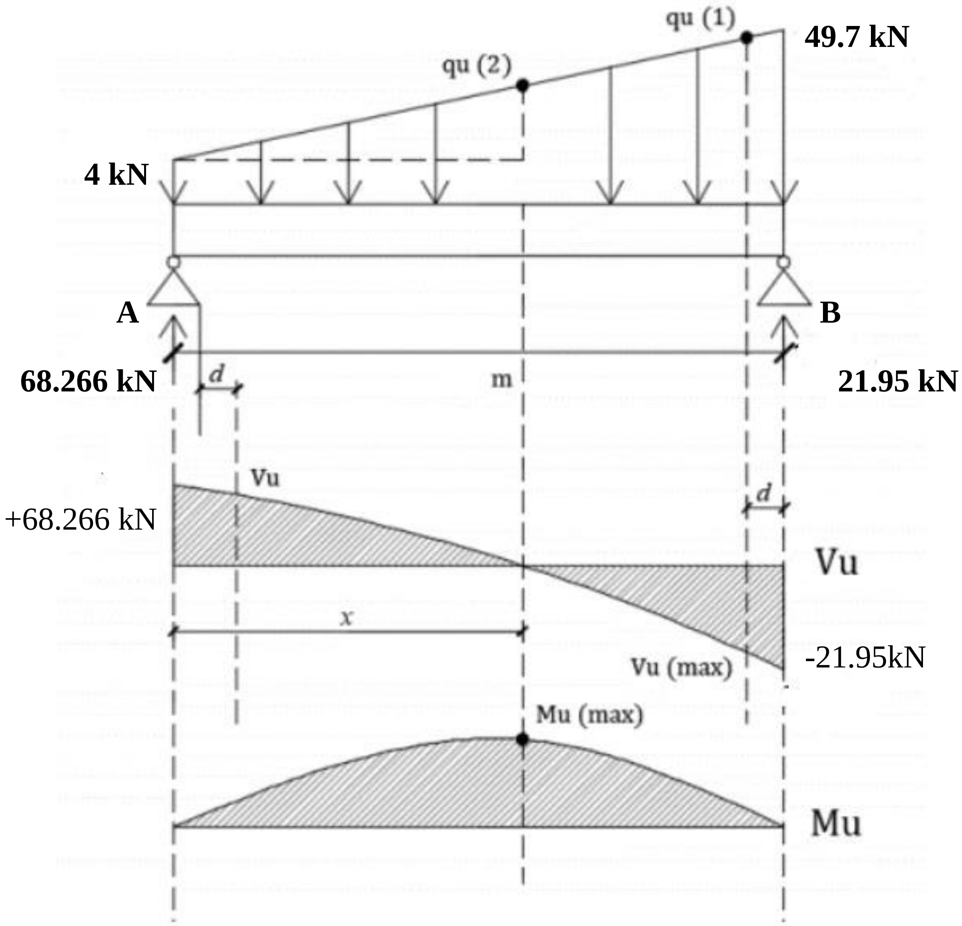


Figure 4.12. Shear and Mom. Diagram for Basement wall

$\sum MR_A =$ $(4 \text{ x } 3.36) \text{ x } \frac{3.36}{2}$ $+ (45.7 \text{ x } 3.36 \text{ x } \frac{1}{2})\text{x } \frac{2}{3} - By \text{ x } 3.36 = 0$

By = 21.95 kN

Ay = 68.266 kN

4.10.2. Design of the shear force

Assume Ø 12 for main reinforcement

Assume h = 250 mm of Wall

d= 250- 20 -12 =218 mm

qu(1) = $\frac{49.7-4}{3.36}$ x (3.36-0.218) + 4 =46.73 kN/m^2

Vu. max = -21.95 + 46.73 x 0.218 +((49.7 -46.73) x ($\frac{0.218}{2}$)) =-11.44 kN

Ø V_c = 1/6 x √fc′ x bw x d = 1/6 * x √24 x 1000 * 218 =178 kN

$\emptyset\ Vc = 178\ kN > Vu = 11.44\ kN$

h = 25 cm is OK

4.10.3. Design of Bending Moment

$Mu.\ max\ at\ Vu = 0$

Vu=0 → 68.266 – 4 X - qu (2) x $\frac{x}{2}$

qu(2) =($\frac{46.73}{3.2}$) x X

68.266 - 4X – $\frac{46.73\ X2}{2\ x3.2}$ =0

X= 2.79 m

qu (2) = ($\frac{46.73}{3.2}$) x 2.79 = 40.74 KN/m

- Section at (x) = 2.79 m

Mu. max = 68.266 x 2.79 – (11.16 x (2.79 x0.5)) –(56.8 x0.93) = 122.06 kN.m

$Rn = \frac{Mn}{\text{b x d}^2} = \frac{122.06 \text{ x } 10^6}{0.9 \text{ x } 1000\text{x } 218\text{x}218} = 2.85\ Mpa.$

m = $\frac{fy}{0.85 \text{ x fc}'}$ = 20.58

ρ = $\frac{1}{m}$ (1-$\sqrt{1-\frac{2 \text{ x m x Rn}}{\text{fy}}}$) = 0.0073

As. req = ρ x b x d = 1591.4 mm^2 x0.5 = 795.7 mm^2 for each face

As. min= ρ x b x h = 300 mm^2 < As. req = 1591.4 mm^2

Select 8 ø 12 with As = 904.77 mm^2 /m

Design for compression face

As = As. Min = 300mm^2 /m

Select 5 ø 12 with As = 565.48 mm^2 /m

Design for horizontal reinforcement

As = As. Min = 300mm^2 /m

According to ACI:

As. Min for the two layer = 0.002 x b x h

For one layer = 0.001 x 1000x 250= 250 mm^2 /m

Select ø 10 /25 cm

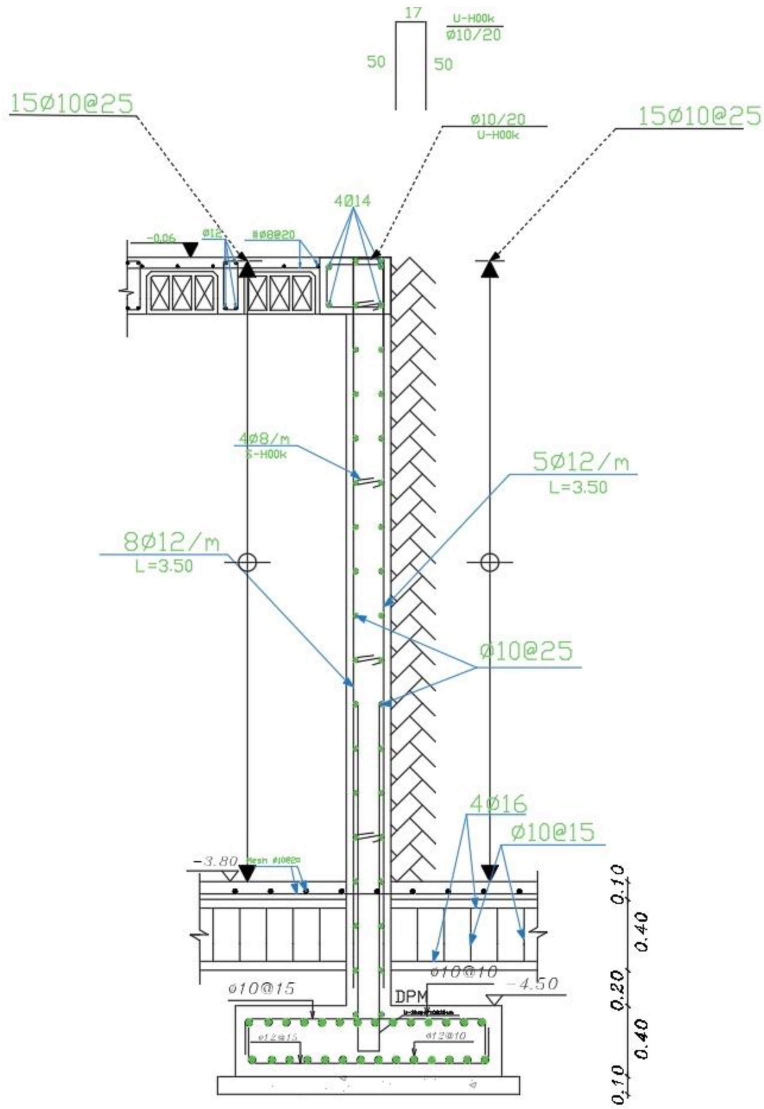


Figure 4.13. Reinforcement of the Basement wall

CHAPTER V
FINDINGS AND RECOMMENDATIONS

CHAPTER V: FINDINGS AND RECOMMENDATIONS

5.1. Introduction

In this project, architectural plans were obtained that lacked many things. After studying all the requirements, all the architectural plans and part of the construction plans were prepared.

This report provides a full explanation of all the steps of architectural and construction design.

5.2. Outcomes

- Every student or structural designer must be able to design manually so that he can understand the mechanism of computerized programs
- Among the factors that must be taken into consideration are the natural factors surrounding the building, the nature of the site, and the effect of natural forces on the site
- One of the most important steps of structural design is how to link the different structural elements through the overall view of the building, and then segment these elements to design them individually and know how to design, taking into account the surrounding conditions of the building.
- The live loads in this project were approved by the Jordanian code
- One of the qualities that the designer must have is his engineering sense, through which he deliberately overcomes any problems that he may encounter in projects.
- Computer software used:

  Several computer programs were used in this project:

  - A - 2020 AUTOCAD in order to make detailed drawings of the structural elements
  - SAFE & ATIR & ETABS: It was used for design and structural analysis
  - Microsoft Office XP: It was used in writing project scripts, formatting, project output, and preparing accompanying tables for the design.

5.3. Recommendations

The aim of this research was the ability to analyze the structure in a complete structural analysis

In the beginning, all the architectural plans were coordinated and prepared so that the building materials were selected and the structural system of the building was determined

At this stage, comprehensive information about the site, its soil and the bearing capacity of the soil must be provided through a geotechnical report for that area. After that, the locations of the load-bearing walls and columns are determined in full agreement and coordination with the architectural engineering team, and the structural engineer is trying at this stage to obtain the largest as much reinforced concrete walls as possible, so that they are distributed regularly or semi-regularly throughout the building to be used later in resisting earthquake loads and other horizontal forces

5.4. Sources and References

Supervising Doctor's Notes

Jordanian load code

ACI Committee 318 (2014), ACI 318-14: Building Code Requirements for Structural Concrete and Commentary, American Concrete Institute, ISBN 0-

2-264-87031