Palestine Polytechnic University

College Of Engineering

Civil Engineering Department

Buildings Engineering

Graduation Project

Structural Design Of "Hebron Hotel" In Hebron City

Project Team

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The undersigned hereby certify that they have read, examined, and recommended to the Department of Civil Engineering in the College of Engineering at Palestine Polytechnic University the approval of a project entitled:

Structural Design Of "Hebron Hotel".

submitted by Mohammad Abu-Zahra, Mohammad Nawajaa and Sadam Abu-Qbeta for partial fulfillment of the requirements for the bachelor's degree.

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التصميم الإنشائي

"لفندق الخليل"

في مدينة الخليل.

فريق العمل:

محمد أبو زهرة **محمد نواجعه** **صدام أبو قبيطة**

إشراف:

د. حمدي ادعيس.

الملخص.

يهدف المشروع لعمل تصميم إنشائي لجميع العناصر الإنشائية المكونة لفندق يتكون من (7) طوابق والذي تبلغ مساحته الإجمالية ب (9211.7) متر مربع، حيث تكمن أهمية مرحلة التصميم الإنشائي عن باقي المراحل التي يمر بها المبنى حيث تم في تلك المرحلة تحديد الأنظمة الإنشائية التي تلائم المبنى وتنوع العناصر الإنشائية في المبنى مثل الجسور والأعمدة والجسور المدلى والبلاطات الخرسانية ذات الأعصاب باتجاه واحد أو اتجاهين والبلاطات المصمتة في اتجاه واحد أو اتجاهين وتحديد نوع الأساس المناسب، وبهذا تم تحويل المخططات المعمارية الأولية إلى مخططات قابلة للتنفيذ.

لتحقيق ما يهدف إليه المشروع تم دراسة المخططات المعمارية واختيار آلية مناسبة لتوزيع العناصر الإنشائية بحيث لا يتعارض مع التصميم المعماري للمخططات، وأيضا تم عمل دراسة إنشائية ودقيقة لتقدير الأحمال المتوقع أن يتعرض لها مختلف العناصر الإنشائية للمبنى بالاعتماد على الكود الأردني، ثم تم تحليل وتصميم العناصر الإنشائية للمبنى حسب الكود الأمريكي ACI318-14 باستخدام بعض برامج التصميم الإنشائي مثل (Atir, Safe, Etabs and Spcolumn)، بعد ذلك تم إعداد المخططات التنفيذية لجميع العناصر الإنشائية التي يتكون منها هيكل المبنى ليصبح جاهز للتنفيذ.

The structural design for

"The Hebron Hotel"

In Hebron City.

The work team:

Mohammad Abu-Zahra Saddam Abu-Qbeta Mohammad Nawajaa

Supervised by: Dr. Hamdi Idais.

Abstract

The project aims to do structural design for all the structural members for hotel consist of 7 floors and has total area of (9211.7 m^2), the importance of structural design stage about other stages of the building that suitable structural systems for the building were determined and diversity of structural members for the building like bridges, columns, one and two way rib and solid slabs and determine the suitable foundation, and thus the initial architectural plans were converted into executable plans.

To achieve what the project aims the architectural plans were studied and the suitable mechanism was selected to distribute the structural elements so that it does not conflict with the architectural design of the plans, also an accurate structural studying was made to estimate the expected loads on the structural members of building according to the Jordanian code, and the structural members of building were analyzed and designed according to the American code ACI318-14 by using structural design programs like (Atir, Safe, Etabs and SP column), then the executable plans were prepared for all structural members of the building to be ready for implementation.

Dedication

To those who have always believed in us

To those who gave us strength

To our families

To our university

To our teachers

To our homeland

We offer you this project

Acknowledgments

We would like to take this opportunity to express our gratitude to the people of whom contributed to the success this project.

We would like to express our appreciation to:

Palestine Polytechnic University, College of Engineering and Department of Civil Engineering including all members of the helpful.

Our supervisor Dr. Hamdi Idais who was a great role model through the course of this project, his advice and guidance allowed us to perform to our fullest potential.

Our instructors who shared us their knowledge and provide us with all useful information.

Finally, our deep gratitude to our parents, our brothers, our sisters and to everyone tried to help us to complete this task.

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List of abbreviations

As	Area Of Non-Prestressed Tension Reinforcement.
As′	Area Of Non-Prestressed Compression Reinforcement.
Ag	Gross Area of Section.
Av	Area Of Shear Reinforcement Within a Distance (S).
At	Area Of One Leg of a Closed Stirrup Resisting Tension Within A (S).
b	Width Of Compression Face of Member.
bw	Web Width, Or Diameter of Circular Section.
d	Distance From Extreme Compression Fiber to Centroid of Tension Reinforcement.
Ec	Modulus Of Elasticity of Concrete.
fy	Specified Yield Strength of Non-Prestressed Reinforcement.
h	Overall Thickness of Member.
I	Moment Of Inertia of Section Resisting Externally Applied Factored Loads.
ln	Length Of Clear Span, Measured Face-To-Face Of Supports In Slabs Without Beams And Face To Face Of Beam Or Other Supports In Other Cases.
M	Bending Moment.
Mu	Factored Moment at Section.
Mn	Nominal Moment.
S	Spacing Of Shear or In Direction Parallel to Longitudinal Reinforcement.
Vc	Nominal Shear Strength Provided by Concrete.
Vn	Nominal Shear Stress.
Vs	Nominal Shear Strength Provided by Shear Reinforcement.
ρ	Ratio Of Steel Area.

εc	Compression Strain of Concrete=0.003mm /Mm
Fsd,r	Total Additional Tension Force Above the Support.
Ved,0	Shear Force at Critical Section.
Vu	Factored Shear Force at Section.
Wu	Factored Load Per Unit Length.
Φ	Strength Reduction Factor.

Chapter 1: Introduction

1.1 :Introduction

1.2 :General Overview

1.3 :Project questions

1.4 :Project aim

1.5 :Project objectives

1.5 :Project methodology

1.6 :Project scope

1.7: Programs used in the project

1.1: Introduction

The civil engineering is term used to describe executing structural work like high buildings, bridges, roads and other structural work from paper to the reality, this word started in 18th century to distinguish this phase of construction about designing phase [1]

The world population [2]was 2.6 billion in 1950, in 2000 the world population was 6.14 billion, in 2022 the world population will be 8 billion at the end of this year, it expected to reach 9.7 billion in 2050 and 10.4 billion in 2080 according to these statistics we see the needs of engineering in our world especially the civil engineering[3] to make the drawings real, the people generally live in the capital cities and the industrial cities, so they need high buildings because the areas of cities do not allow everyone to own house, and the high buildings in structural design have special determinants to be built up .

If we talked about Palestinian citizens who lives in Palestine, the statistics say that at the middle of 2022 the Palestinian population was 5.4 million in the West Bank and Gaza[4], if we add to them the occupying country population estimated at about 10.5 million, we note that Palestine earth population to its area percent is very large, so the civil engineering has founded to solve like these problems by its structural systems, so in our country we need the civil engineering and the civil engineers who can deal with the population growth.

The civil engineers who measure and draw a map of the earth's surface, design and supervise the construction of bridges, tunnels, large buildings, dams, and coastal structures, plan, layout, construct, and maintain railroads, highways, and airports devise systems for the control and efficient flow of traffic[5], plan and build river navigation and flood control projects, and provide plants and systems for water supply, sewage and refuse disposal[6]

The tourism is a global phenomenon and the number of people who visit another country is very huge[7]especially in Palestine because it is a tourist country so we need to build the hotels for the visitors who comes from the other countries[8]

1.2: General Overview

All the Palestinian cities is a tourist city we chose Hebron city[9]to build our hotel in it because there is a lot of historical and religious areas[10]and there is a lot of global organizations that come to help the Palestinian who are expelled from their homes to be demolished, so they need a place to stay in.

1.3: Project questions

1.Why we do this project?

2.Why we do this structural design?

3.Why we chose this building type (hotel)?

4.How that will help the citizens and our country?

1.4: Project aim

This project to design the Hebron hotel full structural design so that we can build it on the ground, and to provide a safe place for the tourists to stay in, and to increase the Palestinian economic.

1.5: Project objectives

1.To apply the acquired skills from my studying in civil engineering in this project.

2.The ability to choose the suitable structural system for the design.

3.The ability to distribute the structural elements.

4.The ability to deal with the different and renewable problems that we face during the design.

5.The ability of using the structural design programs.

1.5: Project methodology

Our work in this project was many phases to achieve the most work in a little time.

1: Architectural study.

1.1: Search for architectural plans.

Searching for a project is confused and it takes many times and effort, so there were many planes for many structural buildings like hospitals, schools, universities, hotels and so on.

1.2: Reading the architectural plans.

Reading the plans is important step to understand how to do the structural design, and because of the many architectural details we need an architectural engineer to help us in reading the plans.

2: Structural study.

2.1: columns placing.

After reading the plans we should start placing the columns, maybe the architectural engineer placed the columns but we should check his work and edit it to suit the structural design requirements, and we should edit any changing in the architectural plans.

2.2: slabs plans.

Now after the columns placing and reading the plans, we choose the suitable structural members, then we could draw the slabs plans and the distribution of the ribs for the slabs for which direction and name every rib, and drawing the beams and specify the carrying beams and name every beam.

3: structural design.

3.1: slabs design.

In structural design we start in calculating of slabs thickness according to ACI318-14, then we design the topping of the slabs, after that we could start designing the ribs on the structural design program (Atir).

3.2: Beams design.

After slab designing, we could take the reactions of the ribs supports to carry the loadings of the ribs on the beams to start the beam designing by the structural design program (Atir).

3.3: columns design.

Now after designing the ribs and the beams, I can design the columns after carrying the loads of the beams by SP column.

3.4: walls design.

In our plans there is a basement wall to resist he soil loads and our hotel should have a shear wall to resist the winds loads, so they should be designed according to the ACI318-14.

3.5: Foundations design

The foundations are designed at the end after designing all the structural members of the building and after calculating the loads on the foundations.

4: Finishing the project.

4.1: preparing the structural drawings.

After designing our project, we should do structural plans to be worked, every structural member we designed should have working drawing until the worker understand how to work.

4.2: Editing the structural drawings.

After preparing the drawings on the structural design programs, we edit the drawings on the AutoCAD 2021 program to make it acceptable for reading and working.

4.3: preparing the book of the project.

The project should have a book to explain the designing steps, and symbols, the elevations, sections of the building and so on.

Table 1. 1: Time duration of designing.

Section	Activity	D.Start	Duration	D.Finish
1	Architectural study.			
1.1	Search for architectural plans.	14/9/2022	11 days	25/9/2022
1.2	Reading the architectural plans.	26/9/2022	15 days	10/10/2022
2	Structural study.			
2.1	columns placing.	11/10/2022	30 days	10/11/2022
2.2	slabs plans.	11/11/2022	10 days	20/11/2022
3	structural design.			
3.1	slabs design.	21/11/2022	20 days	10/12/2022
3.2	Beams design.	11/12/2022	21 days	31/12/2022
3.3	columns design.	1/2/2023	20 days	20/2/2023
3.4	walls design.	21/2/2023	15 days	5/3/2023
3.5	Foundations design.	6/3/2023	26 days	31/3/2023
4	Finishing the project.			
4.1	preparing the structural drawings.	1/4/2023	15 days	15/4/2023
4.2	Editing the structural drawings.	16/4/2023	15 days	30/4/2023
4.3	preparing the book of the project.	1/5/2023	20 days	20/5/2023

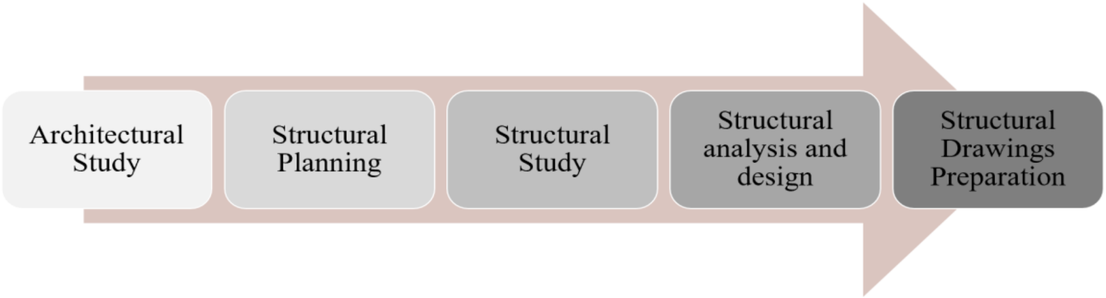


Figure 1. 1: work procedure of designing

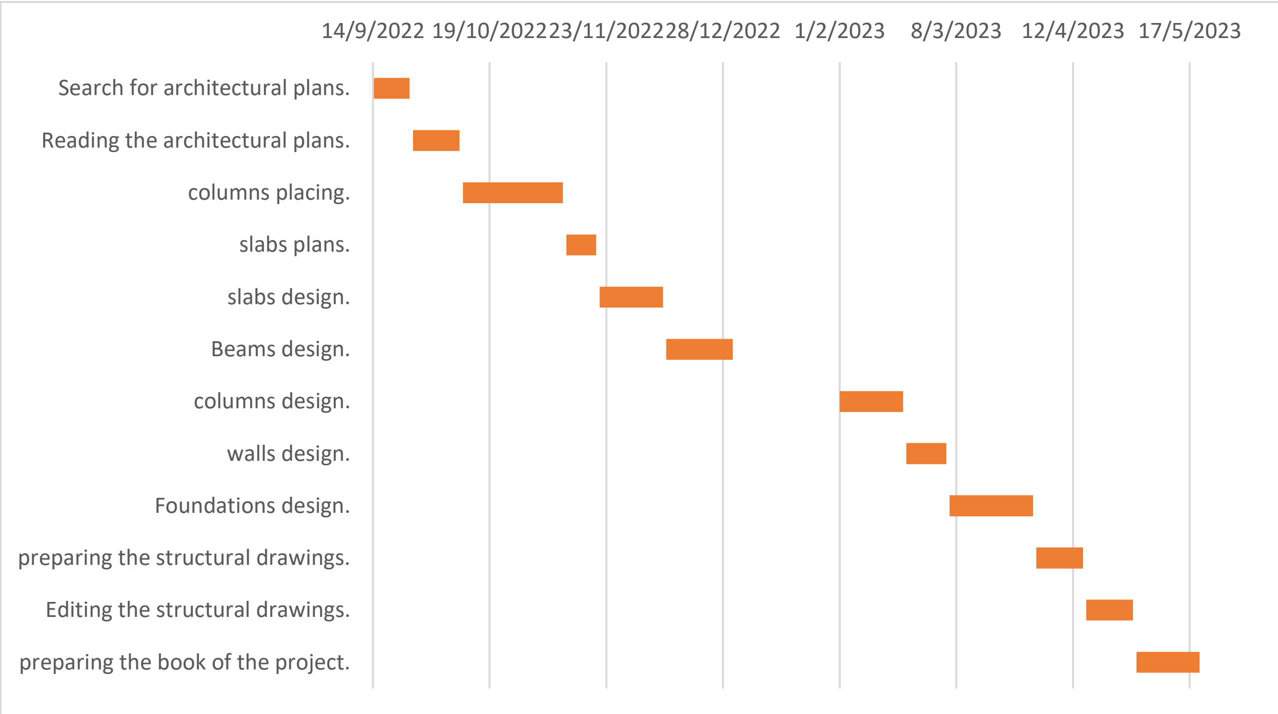


Figure 1. 2: Project timeline

1.6: Project scope

This Project contains the following chapters:

Chapter 1: A general introduction.

Chapter 2: An architectural description of the project.

Chapter 3: A general description of the structural elements .

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

Chapter 5: Results and Recommendations.

1.7: Programs used in the project

There are several computer programs used in this project :

1. AUTOCAD 2020: for detailed drawings of structural elements.
2. ATIR18: Structural design and analysis of structural elements.
3. Safe16: design of Two-way ribbed slabs.
4. Microsoft Office word: for writing the text project.
5. SP column: for columns designing.

Chapter 2: Architectural description

2.1: Introduction

2.2: General identification of the project

2.3: General site description

2.4: Floors description

2.5: Elevations description

2.6: Sections of the building

Figure 2. 1: 3D main entrance side

2.1: Introduction

Building any structure requires the integration of many different engineering specialties, and the design process for any project goes through multiple stages before it is finished.

Starting with the architectural design stage, where the shape of the structure is decided upon while taking into account the investigation of the various functions and requirements for which you will be creating this building, this stage also sees the initial distribution of the facilities made in order to achieve the necessary spaces and dimensions, as well as the study of lighting, ventilation, movement, mobility, and other functional requirements.

An architectural study that must come before the beginning of architectural design must be simple to handle and comprehend in terms of the various events it contains as well as the functional relationships between them, and the nature of the association movement and using these parts, and other things of importance that give a clear view of the project and therefore it will be possible to locate the columns and other structural elements to suit architectural design

2.2: General identification of the project

This Hotel is located in the Hebron area on a plot of (9211.7) m^2, with a total area of approximately 8200 m^2. It consists of 7 floors, 6 floors over the ground and one underground floor. The Hotel has 4 entrances main entrance on the western side, a restaurant entrance on the southern side, emergency entrance on north side and another entrance on southern side. The underground floor that are used as a car park, the area this floor is (1805 $m^{2)}$, and the location area is (5256.2 m^2).

The ground floor consists of two emergency doors lead to the northern entrance, swimming pool, restaurant, store, kitchen and W.C. The total area of this floor is (1080 m^2).

The first floor consists of kitchen, multi-purpose hall, shops, stores, breakfast lounge, offices, and two of terraces, with an area of (1281) m^2.

(2^{nd} – 5^{th}) floor consists of bedrooms with baths and suites, and the area of each one of them it is (1275 m^2).

2.3: General site description

The hotel will be established in Hebron – (Ein sara), where this is land has an area of (5256.2 m^2), the total area of the hotel is (9211.7 m^2).

The hotel is located in an excellent location in this area and is accessible by public transport and several streets connected to it.

Figure 2. 2: The project location

2.4: Floors description

2.4.1 Basement floor

The ground floor consists of two emergency doors lead to the Northern Entrance, swimming pool, Restaurant, Store, Kitchen, dry clean room, storage room and W.C. The total area of this floor is (1805) m2.

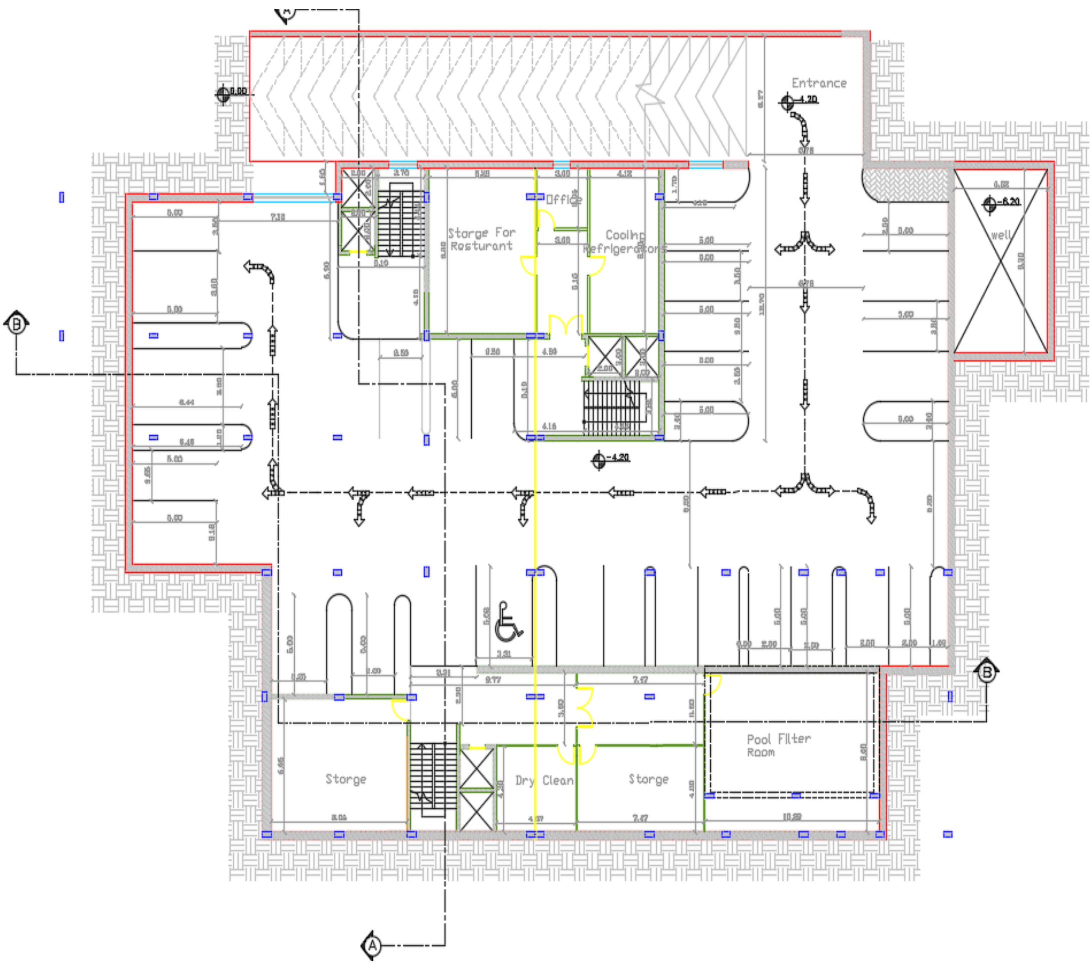


Figure 2. 3: Basement plan

2.4.2: Ground floor

The ground floor consists of two emergency doors lead to the Northern Entrance, swimming pool, Restaurant, Store, Kitchen and W.C. The total area of this floor is (1080) m2.

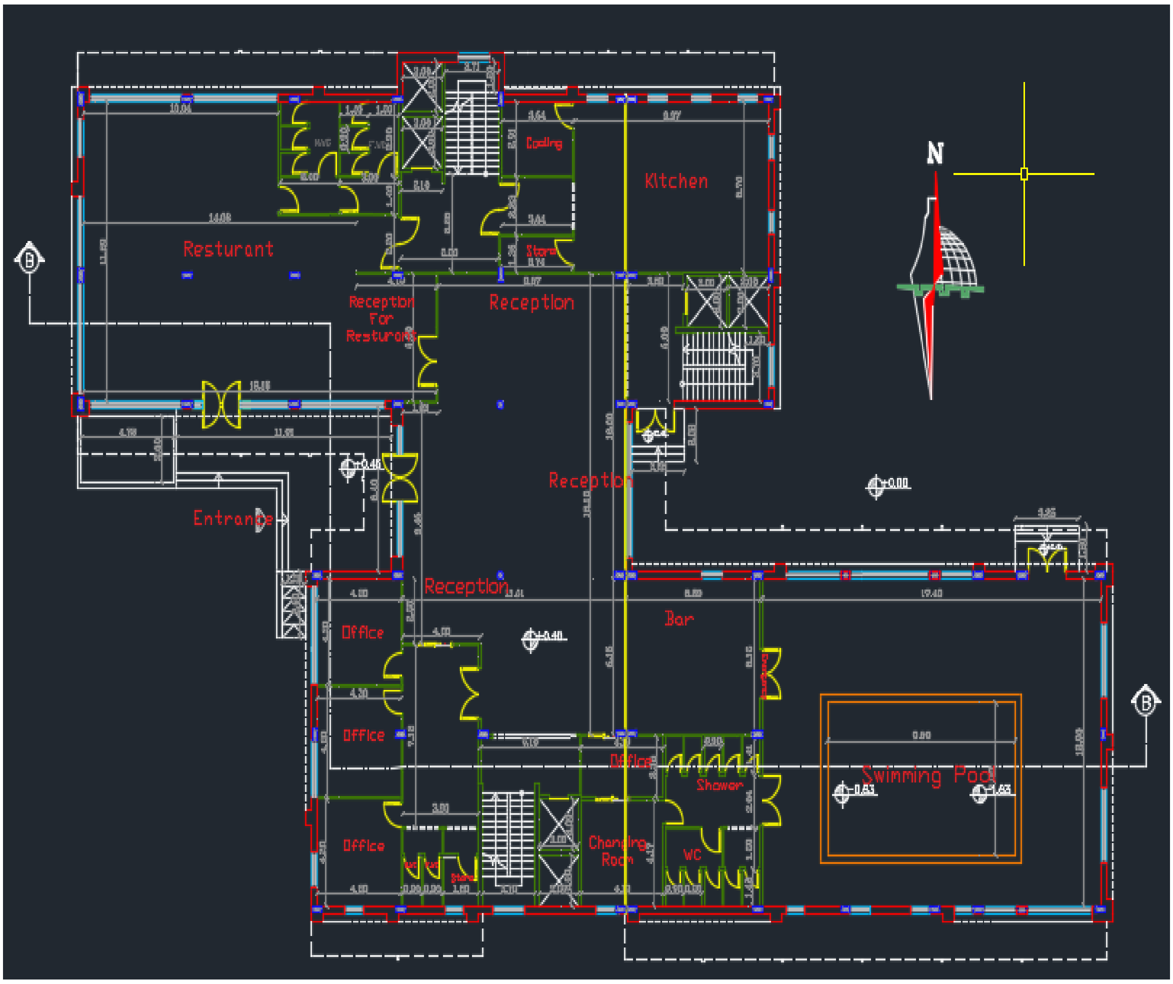


Figure 2. 4: Ground floor plan

2.4.3: First floor

The first floor consists of Kitchen, multi-purpose hall, shops, stores, breakfast lounge, and two of terraces, with an area of (1280) m2.

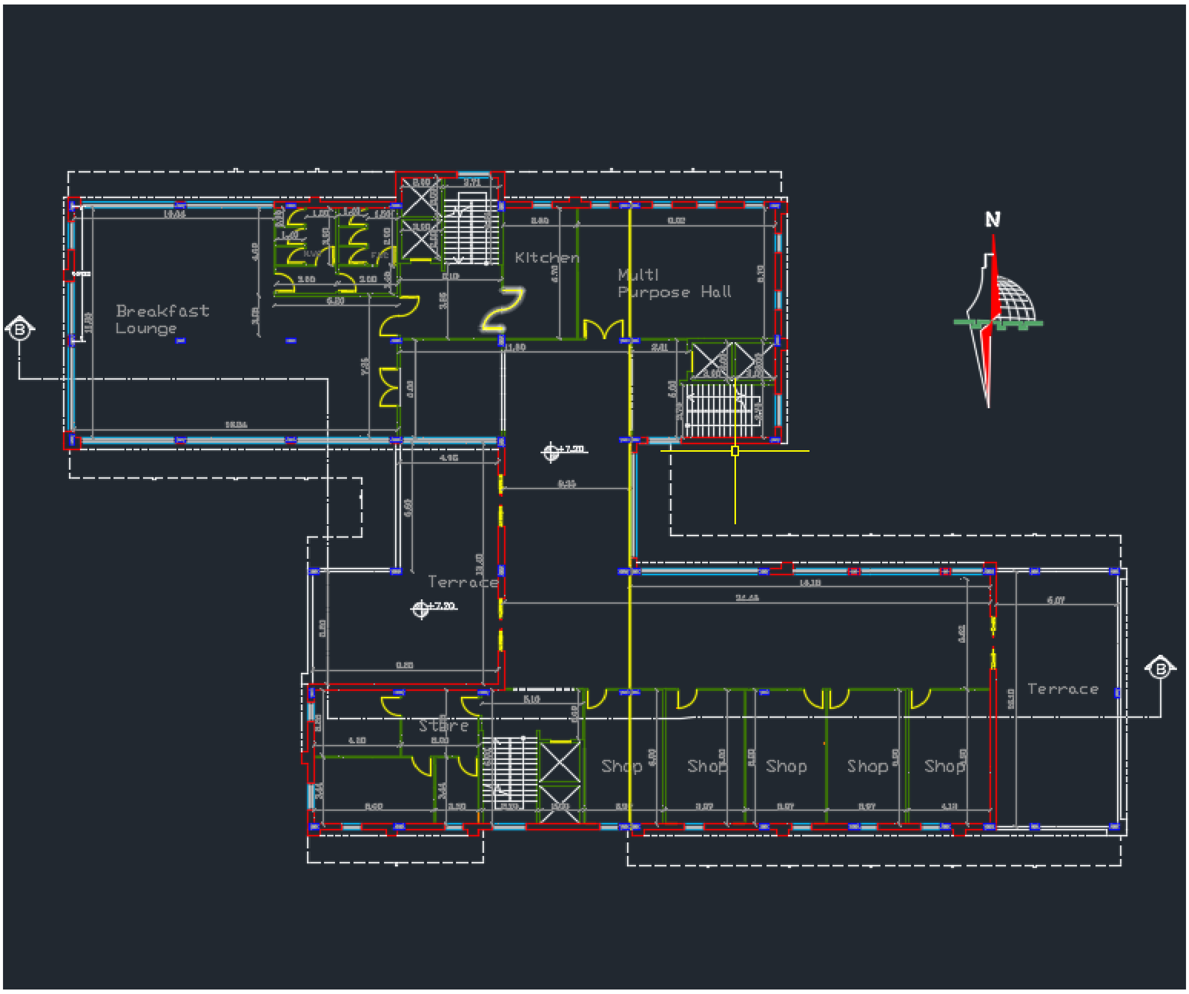


Figure 2. 5: First floor plan

2.4.4: (2^{nd} – 5^{th}) floor

(2^{nd} – 5^{th}) floor consists of bedrooms with baths and suites, and the area of each one of them it is (1275) m2.

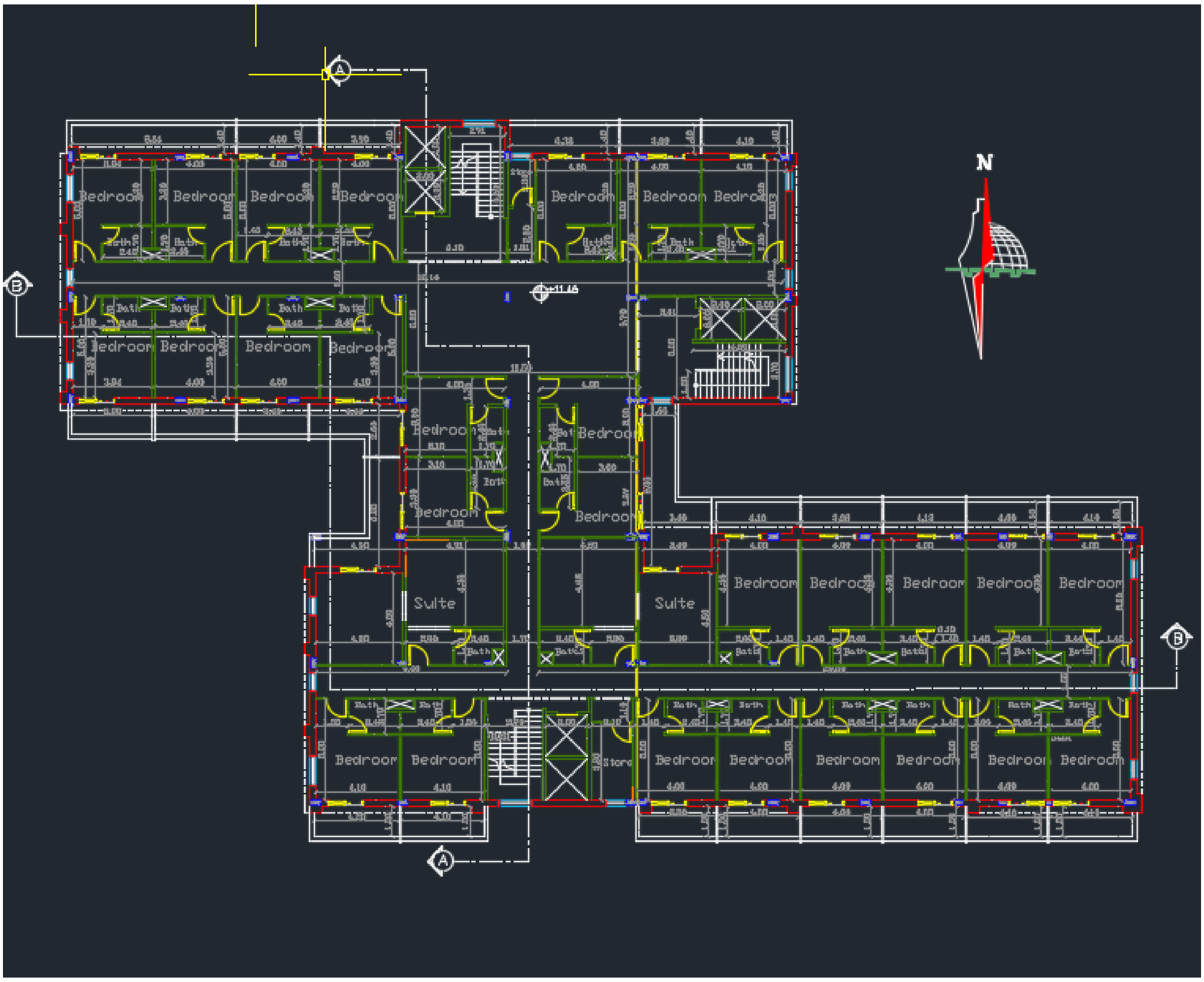


Figure 2. 6: 2^{nd} -5^{th} floor plan

2.5: Elevations description

2.5.1: Northern elevation

Figure 2. 7: Northern elevation

Figure 2. 8: Northern elevation 3D

2.5.2: Southern elevation

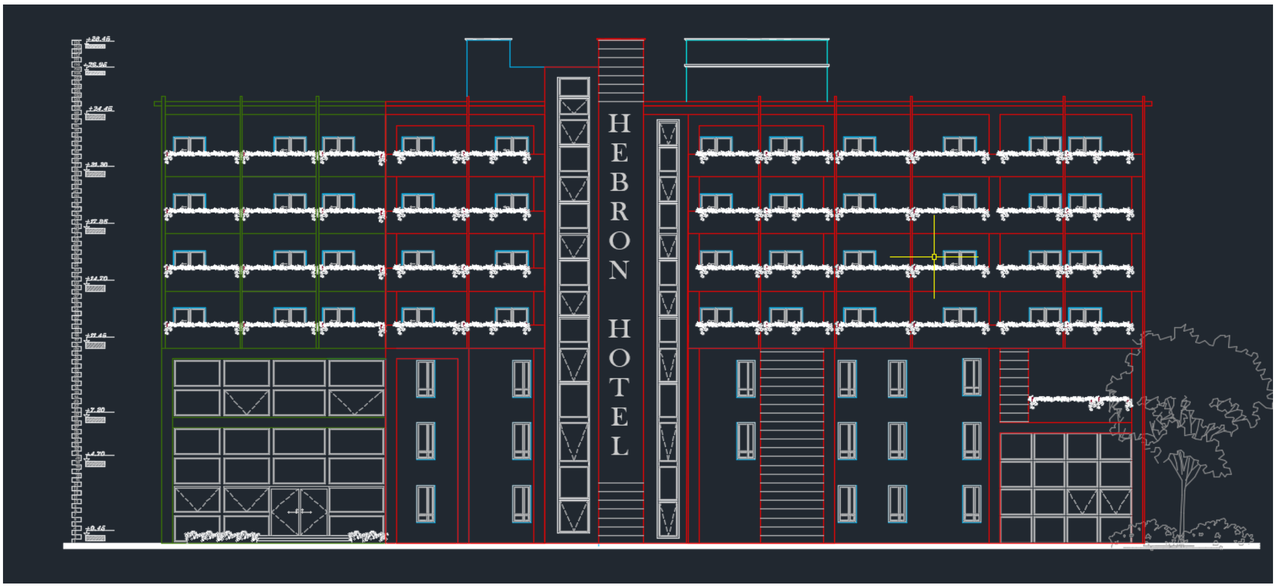


Figure 2. 9: Southern elevation

Figure 2. 10: Southern elevation 3D

2.5.3: Eastern elevation

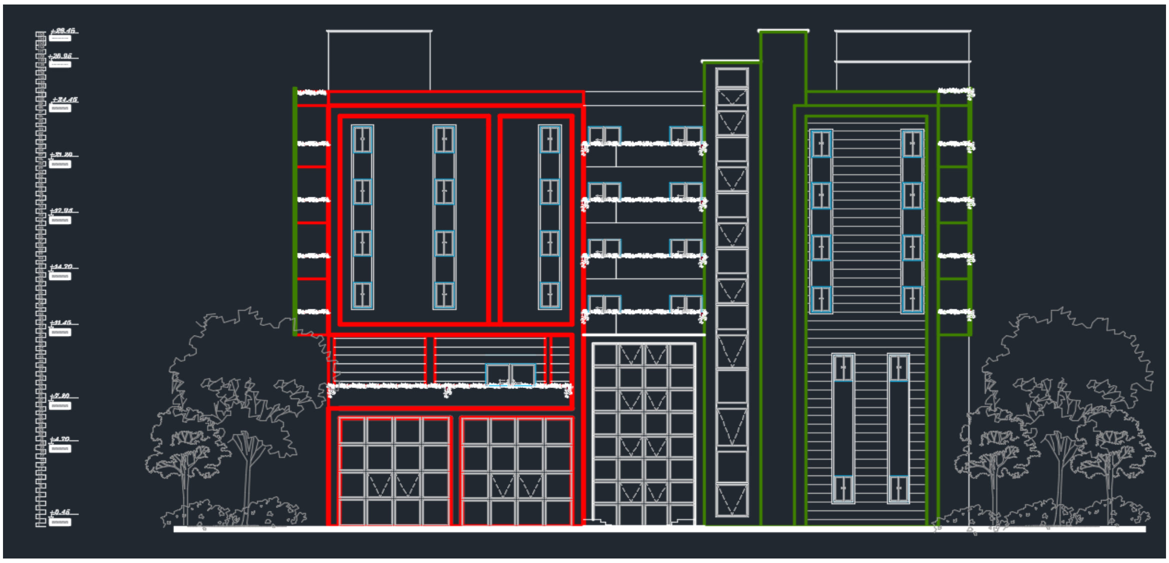


Figure 2. 11: East elevation

Figure 2. 12: East elevation 3D

2.5.4: Western elevation

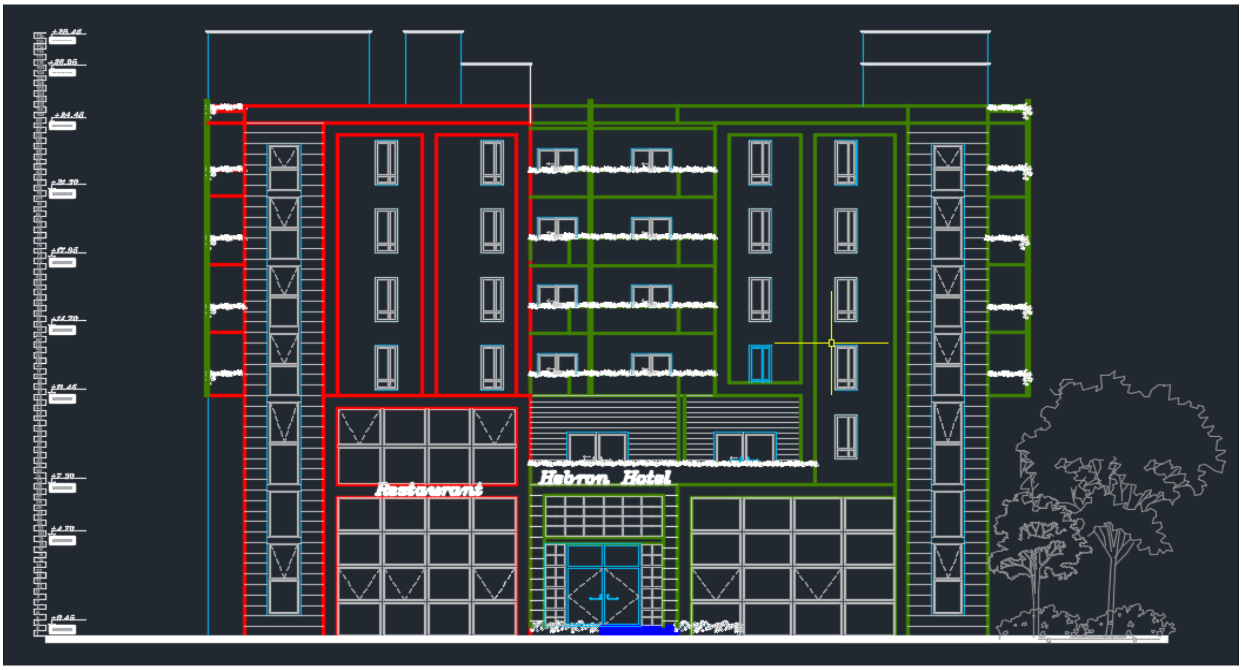


Figure 2. 13: Western elevation

Figure 2. 14: Western elevation 3D

2.6: Sections of the building

2.6.1: section A-A

This section explains the movement inside the building through the stairs and elevator. It also shows more details for the heights and levels for slabs, windows, and doors.

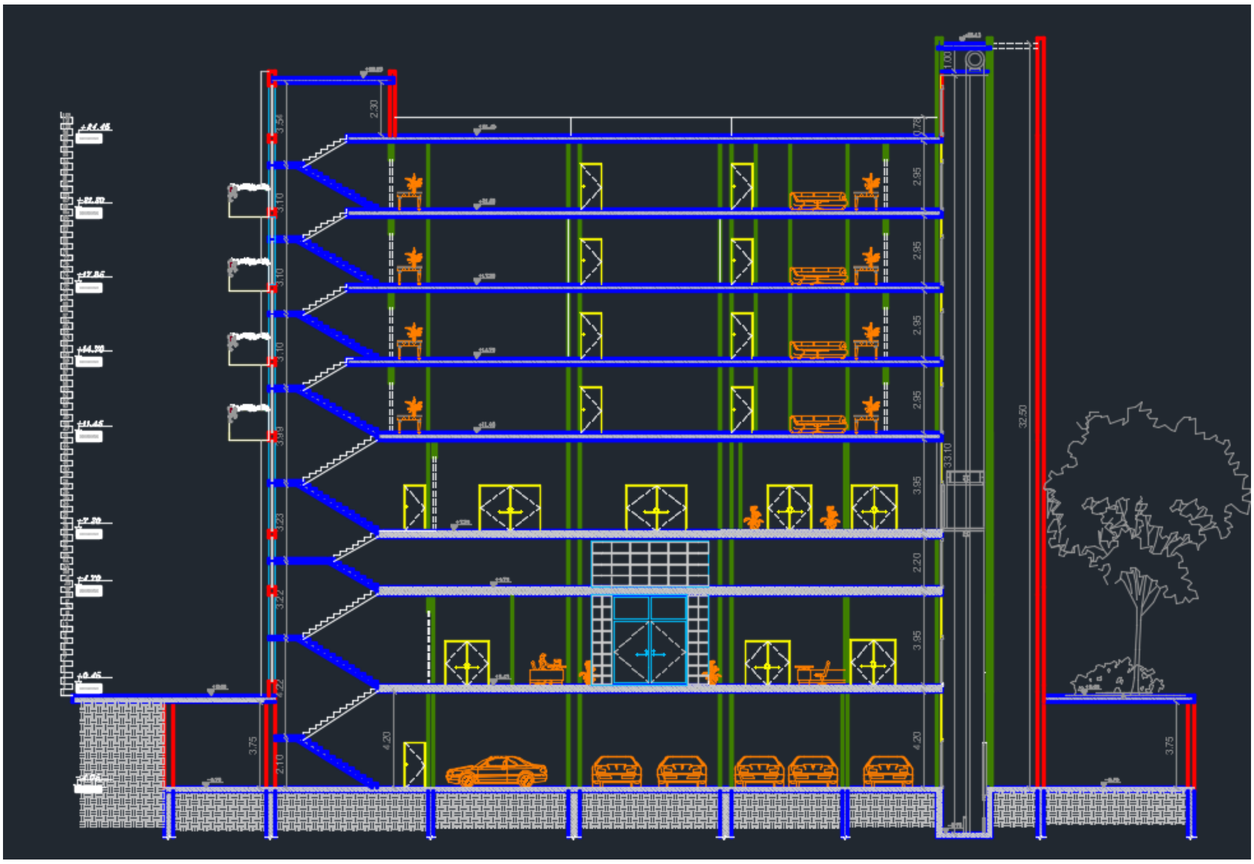


Figure 2. 15: Section A-A

2.6.2: Section B-B

This section explains the movement inside the building through the stairs and elevator. It also shows more details for the heights and levels for slabs, windows, and doors.

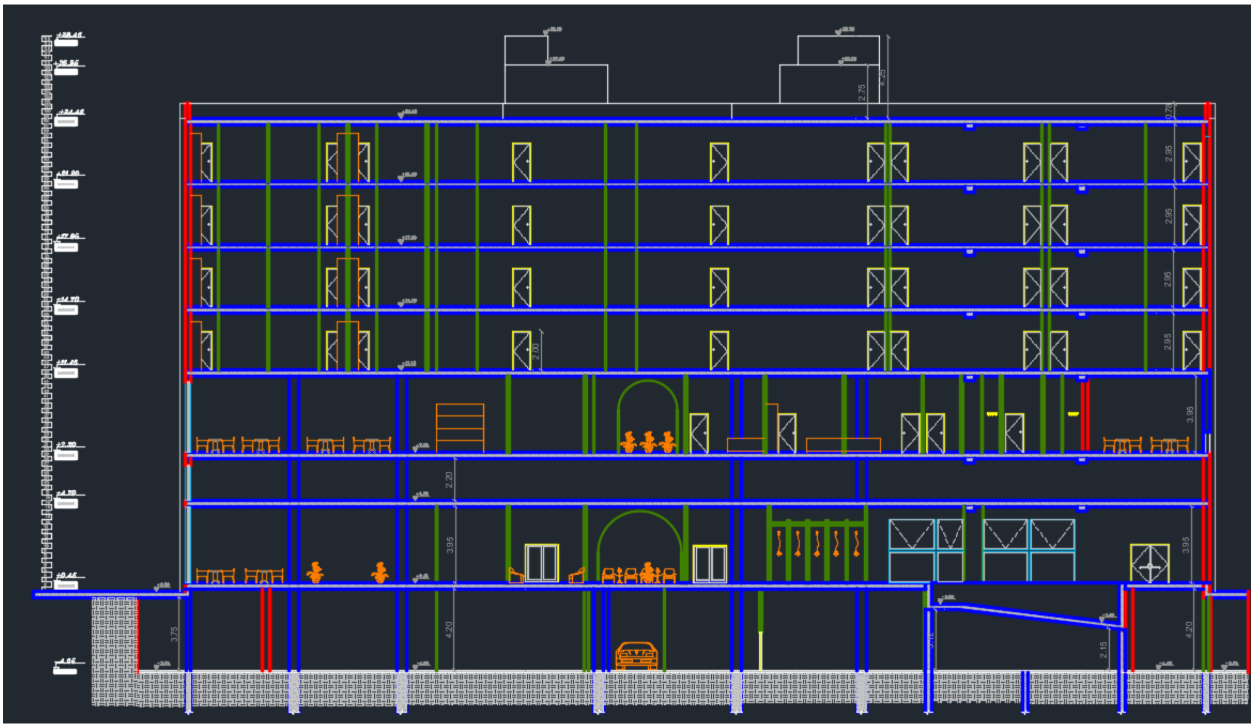


Figure 2. 16: Section B-B

Chapter 3: Structural description.

3.1: Introduction.

3.2: The purpose of structural design.

3.3: Structural design stages.

3.4: loads.

3.5: The structural elements of the building.

3.6: Computer software that was used.

3.1: Introduction

After studying the project from the architectural point of view, it is necessary to move to the structural side to study the structural elements and describe them accurately, where the nature of the loads placed on the building and how to deal with them is studied to come up with a structural design that meets all safety requirements and takes into account the economic aspect of the project.

The structural design also requires choosing the appropriate structural elements for the project to be constructed and taking into account the feasibility of implementing them on the ground so that the building is safe, and we preserve the architectural designs.

3.2: The purpose of structural design

Structural design is an integrated process that depends on each other, as it meets a set of goals and factors that will produce a structure that achieves the desired goal, and these goals are as follows:

Safety: Where the building is safe in all cases and resistant to various natural changes.

The economic cost: It is to achieve the greatest degree of safety for the origin at the lowest economic cost.

Serviceability: Avoid any defect in the structure, such as the presence of some cracks and some types of subsidence that would annoy the building users.

Preserving the architectural design of the facility.

3.3: Structural design stages:

Structural design stages can be divided into four main stages:

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 in all its various aspects, determining the building materials that will be approved for the project, then doing the basic structural analyzes of this system, and the expected preliminary dimensions of it.

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 (ribs) and the work of the necessary structural details for it in terms of drawing horizontal projections, vertical sectors, and details of rebar.

The third 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 (voids) and the work of the necessary structural details for it in terms of drawing horizontal projections, vertical sectors, and details of individualization of reinforcing steel.

The fourth stage:

It depends on the comparison between the two structural systems in terms of weight, loads and quantities of materials used.

3.4: loads

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

3.4.1: Dead loads

-They are the loads resulting from the self-weight of the main elements that make up the structure, on a permanent and fixed basis, 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 permanently in the building, and can be calculated by determining the dimensions of the structural element, and the densities Its constituent materials, and Table (1-3) shows the specific densities of the materials used in the project.

Table 3. 1: The specific densities of the materials used

الكثافة المستخدمة (KN/m³)	المادة المستخدمة	الرقم المتسلسل
23	Tile	**1**
22	Plaster	**2**
25	Reinforcement concrete	**3**
14	Block	**4**
22	Mortar	**5**
16	Sand	**6**

* (Partition loads) = 2.38 kN/m2

3.4.2: Live loads

These are the loads that buildings and constructions are exposed to due to their various uses, or the uses of part of them, including distributed and concentrated loads, and they include:

1 **-** Weights of people using the building.

2- Dynamic loads, such as devices that generate vibrations that affect the building.

3- Static loads, whose locations can be changed from time to time, such as furniture, appliances, stored materials, and equipment.

Referring to the Jordanian code, the live loads for all rooms were taken as 5 kN/m2.

3.4.3: Environmental loads

They include loads that result from natural changes that pass through the source, such as snow, wind, earthquake loads, and loads resulting from soil pressure, which vary in amount and direction and from one region to another. They can be considered as part of the live loads, which are as follows:

Wind Loads:

It is a horizontal force that affects the building and its effect appears in tall buildings, and it is positive if it is a result of pressure and negative if it is a result of tension, and it is measured in kilonewtons per square meter, and wind loads are determined depending on the height of the building above the ground, and the location in terms of surrounding buildings Whether it is high or low, the wind speed is higher the higher we go, due to the decrease in friction between the ground and the wind.

Snow loads:

They are the loads that the facility may be exposed to due to the accumulation of snow. Snow loads can be evaluated based on the following bases:

-The height of the building above sea level.

- The slope of the surface exposed to snowfall.

3.5: Structural elements that make up the building

The building is a group of structural elements linked to each other as a single body to be able to bear the loads that affect it, and the most important of these elements are nodes, bridges, columns and foundations.

3.5.1: Slabs

slaps are the structural elements that transfer the main forces as a result of the loads they are exposed to the load-bearing structural elements in the building such as bridges, walls and columns without subjecting them to distortions.

Type of structural slaps:

One-way ribbed slab

Two-way ribbed slab

One-way solid slab

Two-way solid slab

Flat slab

3.5.1.1: One-way ribbed slab

It is one of the most famous methods used in designing slaps in these countries, and it consists of a row of bricks followed by nerves, and the reinforcement is in one direction.

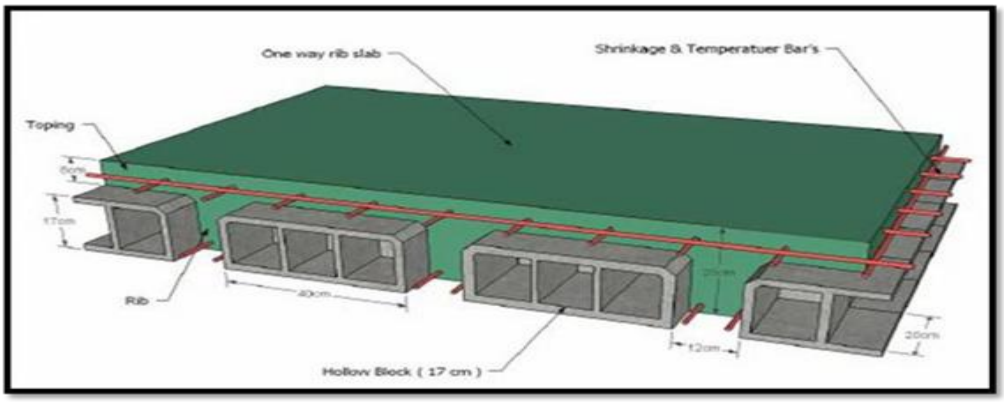


Figure 3. 1 : one-way ribbed slab

3.5.1.2: Two-way ribbed slab

It is similar to the previous one in terms of components, but it differs in terms of the reinforcement being in two directions, and the loads are distributed in all directions, and two bricks and a rib are taken into account when calculating their weight in both directions.

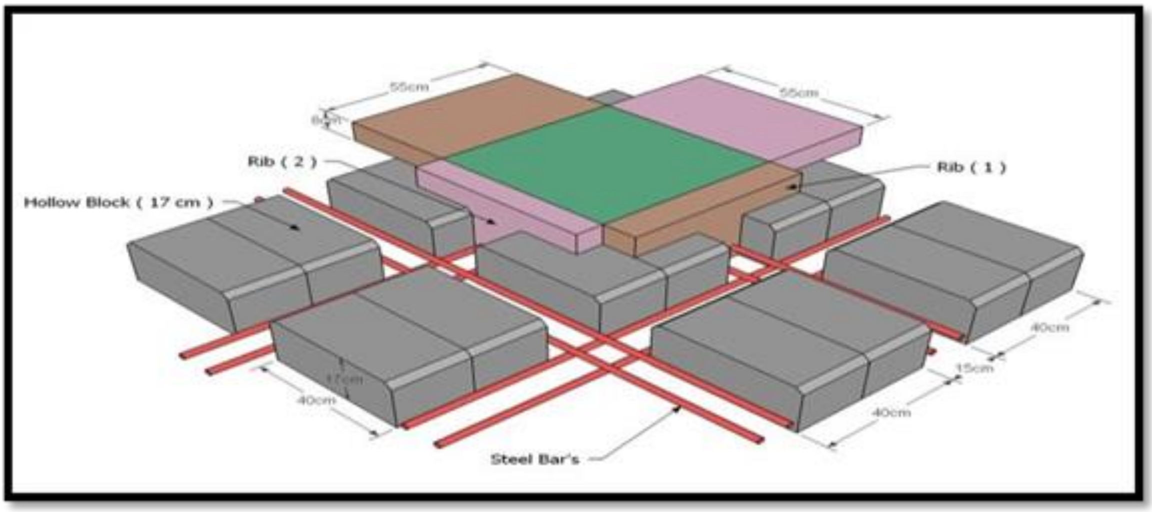


Figure 3. 2: Two-way ribbed slab

3.5.1.3: One-way solid slab

This type of slabs is used in areas that are frequently exposed to live loads, and where the reinforcement is in one direction.

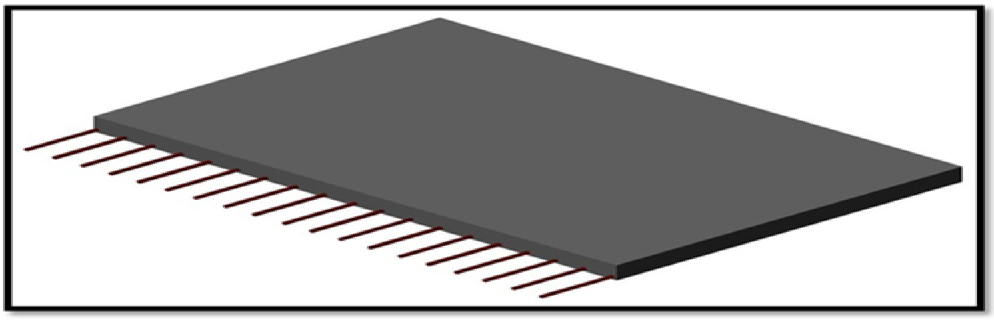


Figure 3. 3: One-way solid slab

3.5.1.4: Two-way solid slab

It is used in the event that the effective loads are greater than the amount that the one way solid can resist it, where the main reinforcement is in two directions.

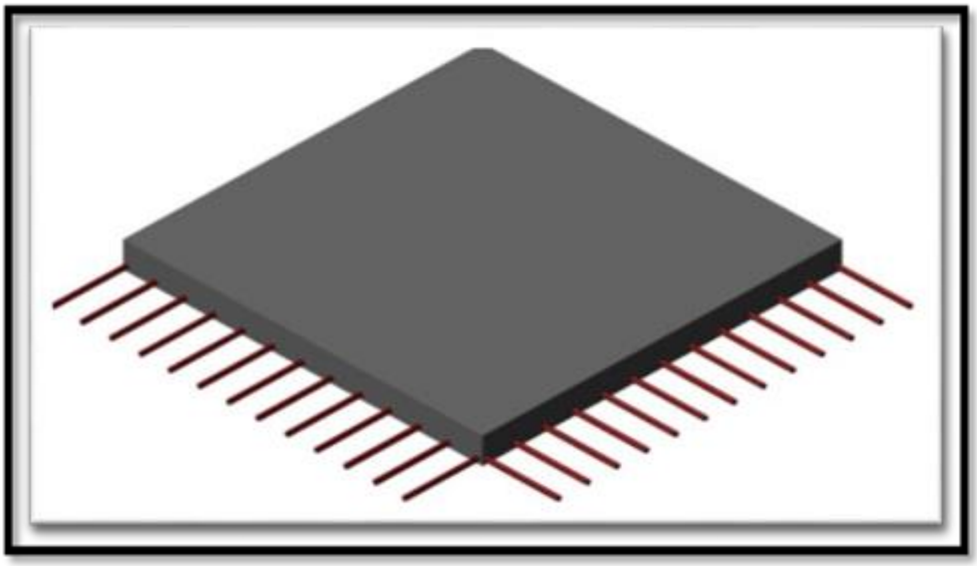


Figure 3. 4: Two-way solid slab

3.5.1.5: Flat slab

This type is used in case of irregular distribution of columns.

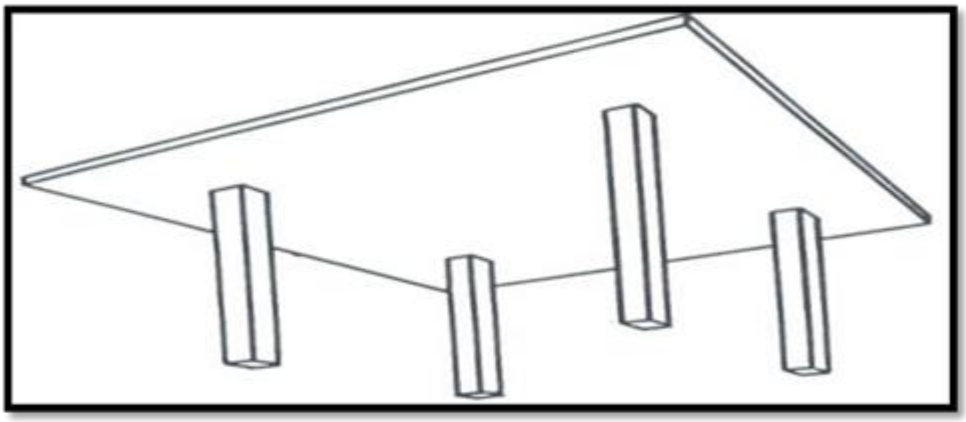


Figure 3. 5: Flat slab

3.5.2: Stairs

Stairs are an architectural element found in buildings to move between two levels on the same floor or between a number of floors of the building.

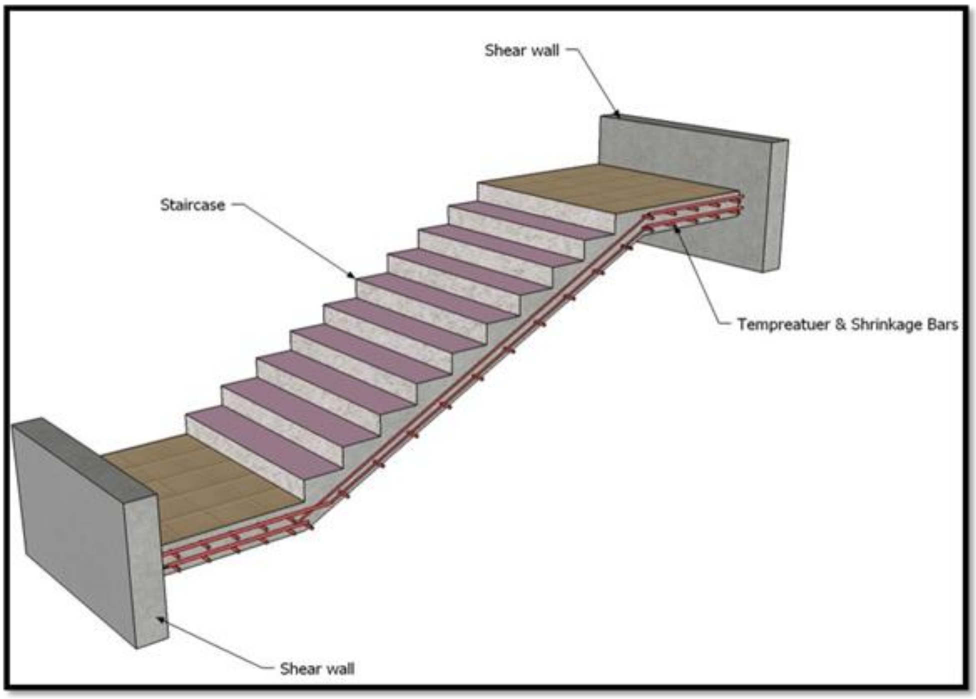


Figure 3. 6: Stairs

3.5.3: Beams

They are basic elements in the building that transfer the loads located on the ribs to the columns, as they are divided into:

Rectangular beams.

T-section beams.

L-section beams.

The reinforcement shall be with horizontal bars to resist the moment on the beam and with stirrup to resist shear force.

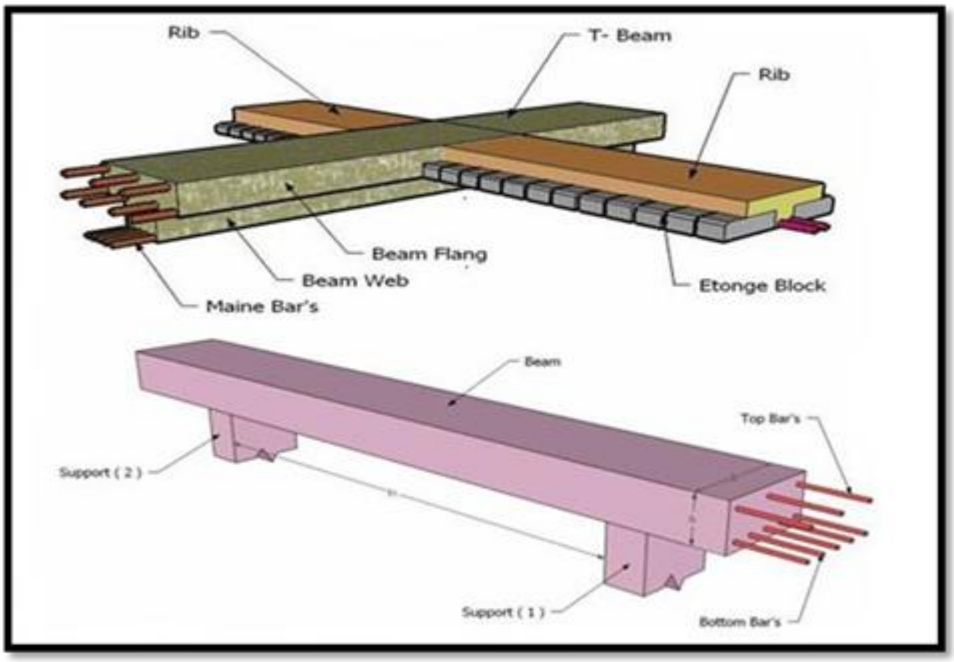


Figure 3. 7: Type of beams

3.5.4: Column

It is a main element in the facility, so it is an essential middle element, so it must be carefully designed to be able to transfer loads and distribute them. Columns are of two types in terms of dealing with them in the structural design:

1. Short column.
2. Long column.

Fig.(3-10): columns

3.5.5: Shear walls

They are the walls that surround the staircase and the walls of the elevators, and sometimes in some areas of the building, and their function is to resist the horizontal shear forces that the building is exposed to as a result of earthquake and wind loads, and they must be available in both directions perpendicular to the stability of the building.

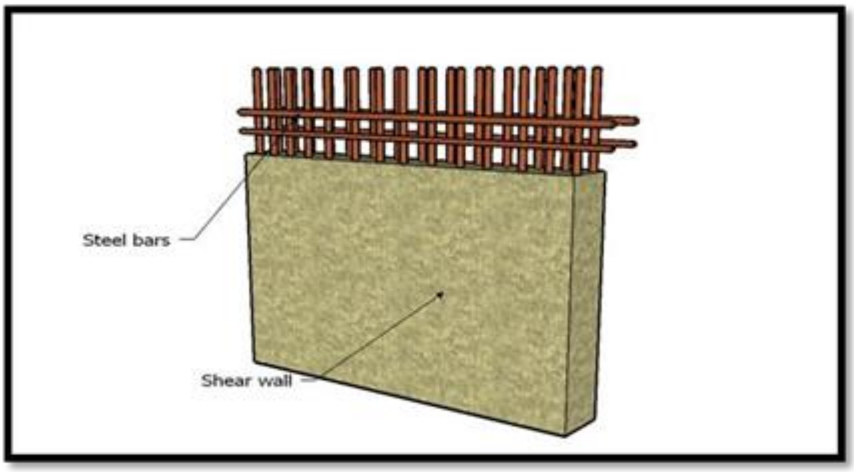


Figure 3. 8: Shear wall reinforcement

3.5.6: Foundations:

The foundations are the first thing that begins to be implemented when building, but their design is done after the completion of the design of all the structural elements in the building, where the foundations transfer the loads from the columns and walls to the soil in the form of pressure force. And its types:

1. Isolated footing.
2. Compound footing.

3. Strip footing.
4. Matt footing.

Foundations of different types will be used, depending on the type of soil, its bearing strength, and the loads placed on it.

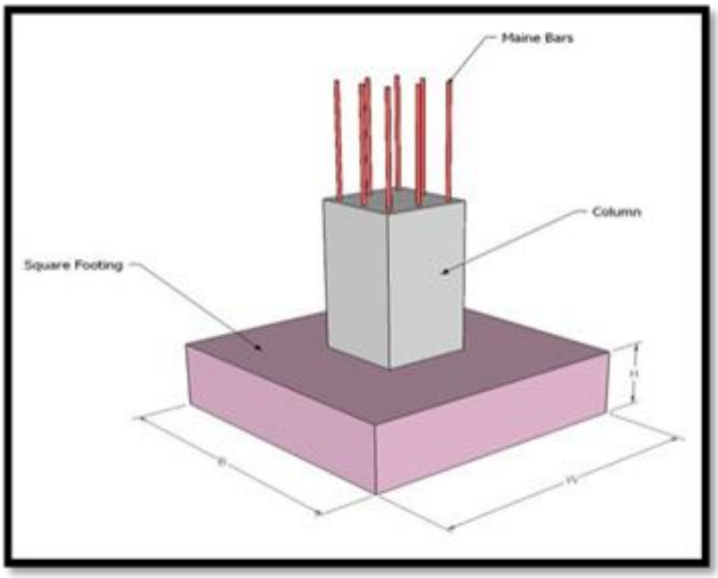


Figure 3. 9: Isolated footing

3.5.7: Expansions and Settlement joints

The maximum distance between expansion joints for normal structures is determined as follows:

1. From 40 to 45m in the temperate regions as in Palestine.
2. From 30 to 35m in hot areas.

Settlement joints are used to separate the entire building, including the foundations, due to the difference in the height of the building blocks.

Chapter 4: Structural Design.

4.1: Introduction

4.2: Factored load

4.3: Determination of slab thickness

4.4: Load calculations

4.5: Design of topping

4.6: Design of rib

4.7: Design of beam

4.1: Introduction

Concrete is the only major building material that can be delivered to the job site in a plastic state. This unique quality makes concrete desirable as a building material because it can be molded to virtually any form or shape.

Concrete used in most construction work is reinforced with steel. When concrete structure members must resist compression stresses, steel supplies the necessary strength. Steel is embedded in the concrete in the form of a mesh, or roughened or twisted bars .

A bond forms between the steel and the concrete, and stresses can be transferred between both components. In This Project, there are three types of slabs: solid slabs, one-way ribbed and two-way ribbed slab. They would be analyzed and designed by using finite element method of design, with aid of a computer Programs called " Atir and Safe - Software" to find the internal forces, deflections and moments for ribbed slabs.

The design strength provided by a member, its connections to other members, and its cross- sections in terms of flexure, and load, and shear is taken as the nominal strength calculated in accordance with the requirements and assumptions of ACI-code.

NOTE:

*Concrete B300, {fc'= 24 MPa for rectangular and L section}.

*The specified yield strength of the reinforcement {fy = 420MPa}.

4.2: 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 + 1.6L   ACI – 318 - 14 (9.2.1)

4.3: Determination of slab thickness

According to ACI-Code-318-14, the minimum thickness of no pre-stressed beams or one-way slabs unless deflections are computed as follow:

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

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

=614/18.5 =33.19 cm

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

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

=556/21 =26.47cm

Select Slab thickness h= 35cm with block 27 cm & Topping 8cm

4.4: Load calculations

4.4.1: One-way ribbed slab:

For the one-way ribbed slabs, the total dead load to be used in the analysis and design is calculated as in the following table:

Table 4. 1: Calculation of the total dead load for one-way rib slab

Materials	Density (KN/m^3)	Thickness (m)	Calculation (Kn/m)
Tiles	23	0.03	23*0.03*0.52=0.36
Mortar	22	0.03	22*0.03*0.52=0.34
Coarse sand	16	0.07	16*0.07*0.52=0.58
R.C	25	0.27	25*0.27*0.52=0.81
Hollow block	14	0.27	14*0.27*0.52=1.96
Topping	25	0.08	25*0.08*0.52=1.04
Plaster	22	0.02	22*0.02*0.52=0.23
partitions	2.38 KN/m^2		2.38*0.52=1.24

Nominal Total Dead load = 6.56 KN/m of rib.

Nominal Total live load =5*0.52 =2.6 KN/m of rib.

4.5: Design of topping

The calculation of the total dead load for the topping is shown below:

Table 4. 2:Calculation of the total dead load topping

Materials	Density (KN/m^3)	Thickness (m)	Calculation (KN/m)
Tiles	23	0.03	23*0.03*1=0.69
Mortar	22	0.03	22*0.03*1=0.66
Coarse sand	16	0.07	16*0.07*1=1.12
Topping	25	0.08	25*0.08*1=2
partitions	2.38 KN/m^2		2.38*1=2.38

Total Dead load for loading = 6.85 KN/m

Wu = 1.2 DL + 1.6 LL

= 1.2*6.85+ 1.6*5 = 16.22 KN/m^2. (Total Factored Load)

$$M_u = \frac{W_u * l^2}{12} = \frac{16.22 * 0.4^2}{12} = 0.216 \text{ KN.m/m}$$

$$\Phi M_n = 0.55 * 0.42\lambda\sqrt{f\acute{c}}\, S_m = 0.55 * 0.42 * 1 * \sqrt{24} * 1000 * \frac{80^2}{6} * 10^{-6}$$
$$= 1.21\ KN.m \gg M_u = 0.216$$

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

$As_{min} = 0.0018 * 1000 * 80 = 144\, mm^2/\text{m strip}$

Try bars Φ8 with As = 50.27 mm^2

$$n = \frac{144}{50.27} = 2.87 \text{ bars}$$

Select 5Φ8 / or Φ8@200 mm in both directions

4.6: Design of one-way Ribbed slab

Material:

Concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel Fy = 420 N/mm^2

Section:

b =12cm b_f=52 cm

h =35cm T_f=8 cm

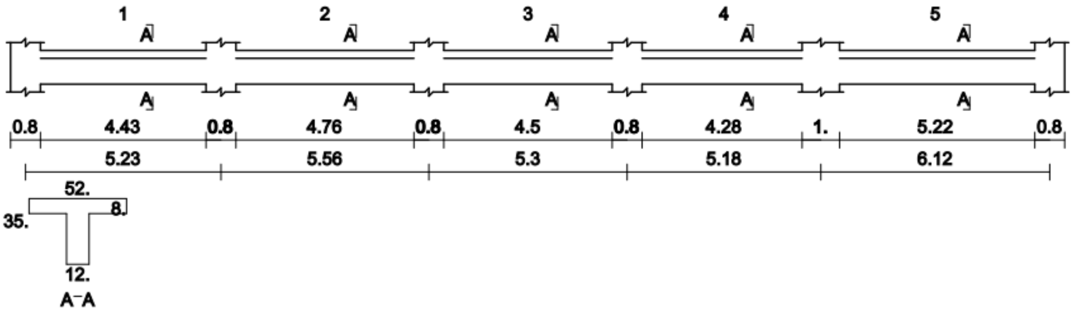


Figure 4. 1: Rib geometry

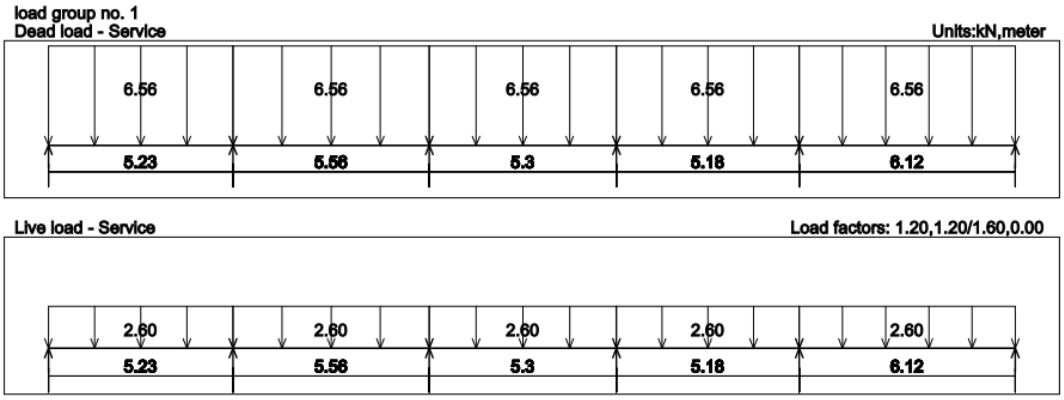


Figure 4. 2: Rib load distribution

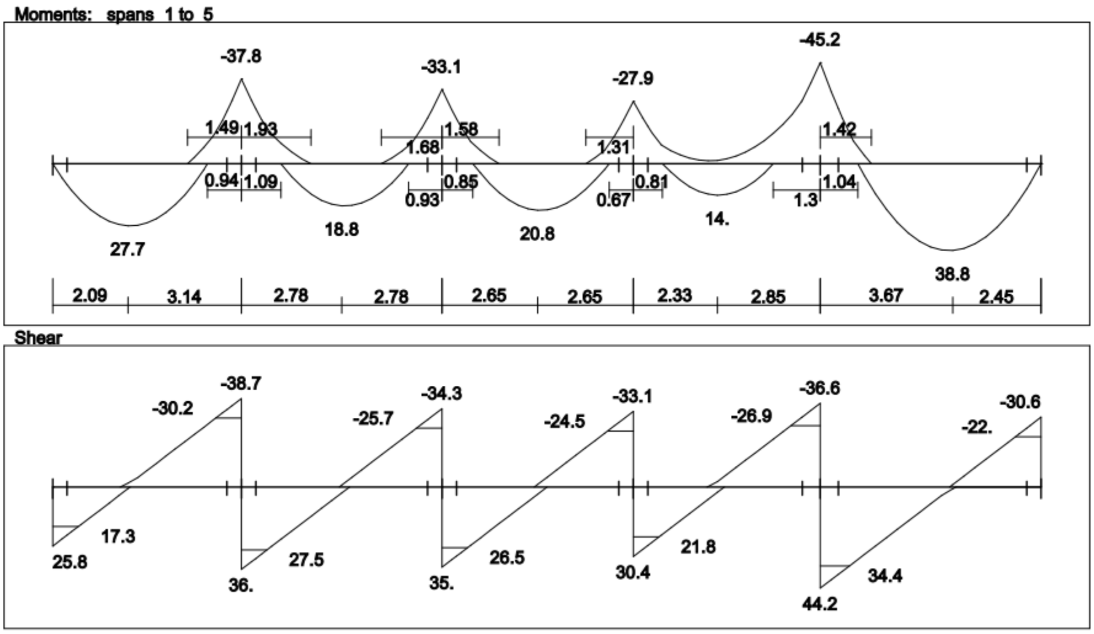


Figure 4. 3:Moment and shear envelope for the rib

4.6.1: Design the rib for flexure (F2, Rib3).

Design of positive moment of rib (F2, Rib3).

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

= 350- 20 – 10 – 12/2 = 314 mm

Mu max = 38.8 KN.m

be ≤ Distance center to center between ribs = 520 mm………… Controlled.

≤ Span/4 = 6120/4 = 1530 mm.

≤ (16* t_f) + b_w = (16* 80) +120 =1400 mm.

b_e= 520 mm.

$$M_{nf} = 0.85\, f_c' * b_E * t_f * \left(d - \frac{t_f}{2}\right)$$

$$=0.85 * 24 * 0.52 * 0.08 * \left(0.314 - \frac{0.08}{2}\right) * 10^3 = 232.53\ KN.m$$

ϕM_{nf} = 0.9 * 232.53 = 209.27 KN.m

ϕM_{nf} =209.27 > Mu max= 38.8 KN.m

Design as rectangular section

M_n = Mu /ϕ =38.8/ 0.9 = 41.11 KN.m

$$m = \frac{f_y}{0.85\, f_c'} = \frac{420}{0.85*24} = 20.58$$

$$R_n = \frac{M_n}{b*d^2} = \frac{43.11*10^6}{520*\,(314)^2} = 0.841 \text{ MPa}$$

$$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.841*20.58}{420}}\right) = 0.00205$$

A_s = ρ * b *d = 0.00205*520 * 314= 334.72 mm^2

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

$$= \frac{\sqrt{24}}{4*420} * 120 * 314 \ \geq \ \frac{1.4}{420} * 120 * 314$$

$=109.87\ mm^2 < 125.6\ mm^2$

$\therefore As = 334.72\ mm^2$.

2 Φ16 $=402.1\ mm^2 > As_{req} = 334.72\ mm^2$ OK.

∴ Use 2 Φ16

Check for strain

Tension = Compression

$As * fy = 0.85 * f'_c * b * a$

$402.1 * 420 = 0.85 * 24 * 120 * a$

a = 68.9 mm.

$f'_c = 24$ MPa< 28 MPa so $\beta_1 = 0.85$

$c = \frac{a}{\beta_1} = \frac{68.9}{0.85} = 81.06$ mm.

d= 350-20-10-16/2= 312 mm

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

$= \frac{312-81.06}{81.06} * 0.003 = 0.00855 > 0.005 \quad \therefore \phi = 0.9$ OK

Maximum negative moment (Mu) = -45.2 KN.m

$M_n = Mu/\phi = 45.2/0.9 = 50.22$ KN.m

$m = \frac{f_y}{0.85\ f'_c} = \frac{420}{0.85*24} = 20.58$

$R_n = \frac{M_n}{b*d^2} = \frac{50.22*10^6}{520*(312)^2} = 0.992$ MPa

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.992*20.58}{420}}\right) = 0.00242$

$A_s = \rho * b * d = 0.00242 * 120 * 312 = 90.6\ mm^2$.

$As_{min} = \frac{\sqrt{f'_c}}{4\,(f_y)} * b_w * d \ \geq \ \frac{1.4}{f_y} * b_w * d$ ………..(ACI-10.5.1)

$= \frac{\sqrt{24}}{4*420} * 120 * 312 \geq \frac{1.4}{420} * 120 * 312$

$= 109.18\ mm^2 < 124.8\ mm^2$

As_{min} = 124.8 mm^2 (control)

∴ As = 124.8 mm^2

2 Φ10 =157 mm^2>As_{req} = 125.2 mm^2 OK

∴ Use 2 Φ10

4.6.2 Design of shear of rib (F2, Rib3).

Vu = 34.4 KN.

$V_c = \frac{\sqrt{f_c'}}{6} * b_w * d$

$= 1.1 * \frac{\sqrt{24}}{6} * 0.12 * 0.312 * 10^3 = 33.63$ KN.

$\phi V_c = 0.75 * 33.63 = 25.22$ KN.

Check for Cases:

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

$34.4 \leq \frac{25.22}{2} = 12.61$ No

Case (1) is not satisfied

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

$12.61 \leq 34.4 \leq 25.22$ No

Case (2) is not satisfied

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

$V_{s, min} = \frac{\sqrt{f_c'}}{16} * b_w * d$

$= \frac{\sqrt{24}}{16} * 0.12 * 0.312 * 10^3 = 11.46$ KN

$V_{s,\,min} = \frac{1}{3} * b_w * d$

$= \frac{1}{3} * 120 * 312 * 10^{-3} = 12.48$ KN (control)

$\phi V_c < V_u \leq \phi\,(V_c + V_{s,\,min})$

25.3 < 34.4 < 34.6

Case (3) is satisfied

Try 2Φ10:

$\frac{157.1*420*313}{S} = 34.7*10^3$

S= 595.17

$S \leq \frac{d}{2} = \frac{313}{2} = 156.5$ mm (control)

$\leq$ 600 mm.

Use 2Φ10 @ 150 mm

4.7: Design of Beam (F2, B18)

Material:

Concrete B300 Fc' = 24 N/mm

Reinforcement Steel Fy = 420 N/mm2

Section:

According to ACI-Code-318-14, the minimum thickness of no prestressed beams or one-way slabs unless deflections are computed as follow:

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

6.95/ 21= 33.1cm

Select Total depth of beam h=45cm. (35cm slab and 10cm drop)

B = 100 cm

H= 45 cm

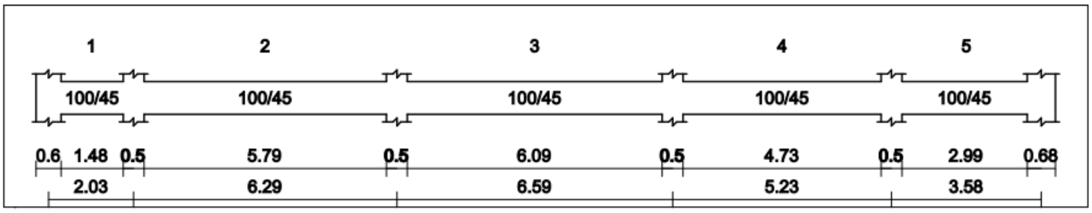


Figure 4. 4: Beam geometry

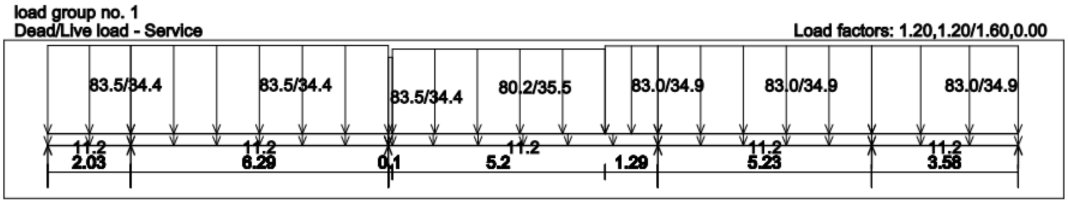


Figure 4. 5: Beam load distribution

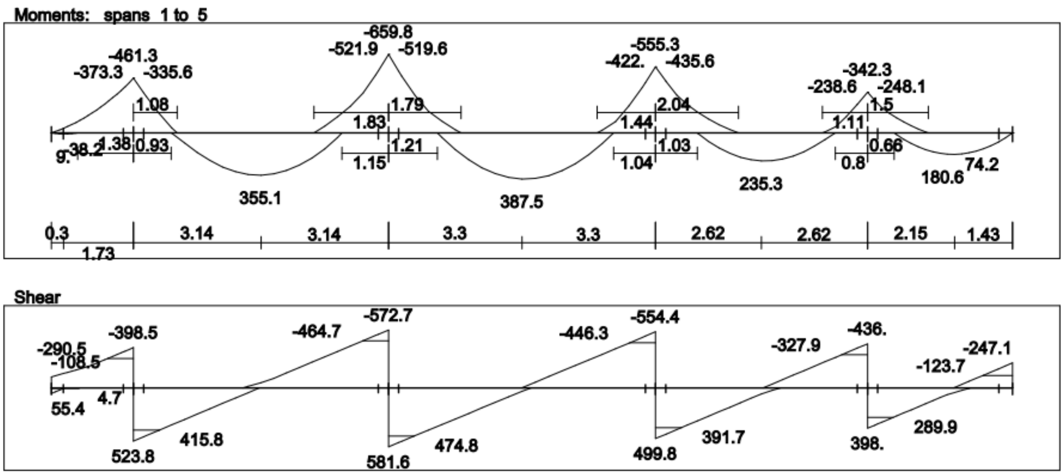


Figure 4. 6: Moment and shear envelope for the beam

4.7.1: Design the beam for flexure

Check if the beam is doubly or not.

The maximum positive moment is 387.5 KN.m

d= 450- 40 -10 -20/2= 390 mm

$C_{max} = \frac{3}{7} * d = \frac{3}{7} * 390 = 167.14$ mm

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

$a_{max} = \beta_1 * C_{max} = 0.85 * 167.14 = 142.07$ mm

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

$= 0.85 * 24 * 1 * 0.142 * (0.39 - 0.142/2) * 10^3$

$= 924.08$ KN.m

$\epsilon_s = 0.004$

ϕ=0.65+250/3*(0.004-0.002) = 0.82

$\phi Mn_{max} = 0.82 * 924.08 = 757.75$ KN.m

Mu = 387.5 KN.m< ϕMn_{max} 757.75 KN.m

∴Singly reinforced concrete section.

The maximum positive moment = 387.5 KN.m

Mn = Mu /ϕ= 387.5/ 0.9 = 430.56 KN.m .

m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{430.56*10^6}{1000*(390)^2} = 2.83$ MPa

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}})$

$= \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*2.83*20.58}{420}}\right) = 0.007284$

$A_s = \rho * b * d = 0.007284*1000*390 = 2840.78$ mm^2

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

$\frac{\sqrt{24}}{4*420} * 1000 * 390 \;\geq\; \frac{1.4}{420} * 1000 * 390$

1137.26 mm^2< 1300mm^2

As_{min} = 1300 mm^2 (control)

∴ As = 2840.78 mm^2

Use 6 Φ25 with As= 2945.2 mm^2 > 2840.78 mm^2

Check for strain:

Tension = Compression

As * fy = 0.85 * f'_c * b * a

2840.78* 420 = 0.85 * 24 * 1000 * a

a = 58.49 mm.

f'_c = 24 MPa< 28 MPa so β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{58.49}{0.85}$ = 68.81 mm.

d= 450- 40- 10- 25/2= 387.5 mm

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

$= \frac{387.5-68.81}{68.81} * 0.003$ = 0.0139 > 0.005 ∴ ϕ =0.9 OK

The maximum negative moment = 521.9 KN.m

d= 450- 40- 10- 25/2= 387.5 mm

Mn = Mu /ϕ= 521.9/ 0.9 = 579.89 KN.m .

m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{579.89*10^6}{1000*(387.5)^2}$ = 3.862 MPa

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}})$

$= \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*3.862*20.58}{420}}\right)$=0.01028

$A_s = \rho$ * b *d =0.01028*1000*387.5= 3984.51 mm^2

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

$$\frac{\sqrt{24}}{4 * 420} * 1000 * 387.5 \;\; \geq \; \frac{1.4}{420} * 1000 * 387.5$$

1129.97 mm^2< 1291.67mm^2

As_{min} = 1291.67 mm^2 (control)

∴ As = 3984.51 mm^2

Use 9 Φ25 with As= 4417.9 mm^2 > 3984.51mm^2

Check for strain:

Tension = Compression

As * fy = 0.85 * f_c' * b * a

3984.51* 420 = 0.85 * 24 * 1000 * a

a = 82.03 mm.

f_c' = 24 MPa< 28 MPa so β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{82.03}{0.85}$ = 96.51 mm.

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

$= \frac{387.5-96.51}{96.51} * 0.003$ = 0.009 > 0.005 ∴ ϕ =0.9 OK

4.7.2: Design beam for shear

V_u= 474.8 KN

$V_c = \frac{\sqrt{f_c'}}{6} * b_w * d$

$= \frac{\sqrt{24}}{6} * 1 * 0.3875 * 10^3$ =316.4 KN.

ϕV_c = 0.75 * 316.4 =237.29 KN.

V_u= 474.8 KN > ϕV_c= 237.29 KN

So, case 1 and case 2 are not satisfied

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

$V_{s, min} = \frac{\sqrt{f_c'}}{16} * b_w * d$

$= \frac{\sqrt{24}}{16} * 1 * 0.3875 * 10^3 = 118.65$ KN

$V_{s, min} = \frac{1}{3} * b_w * d$

$= \frac{1}{3} * 1000 * 387.5 * 10^{-3} = 129.17$ KN (control)

$V_u > \phi (V_c + V_{s, min}) > \phi V_c$

474.8 KN > 334.18 KN > 237.29 KN

case 3 is not satisfied

Case 4: $\phi (V_c + V_{s,min}) < V_u < \phi (V_c + V_s')$

$V_s' = \frac{1}{3}\sqrt{f_c'} * bw * d$

$= \frac{1}{3}\sqrt{24} * 1000 * 387.5 * 10^{-3} = 632.78$ KN

334.18 KN < 474.8 KN < 711.885 KN

Case 4 is satisfied

Try 2Φ10:

$V_s = \frac{Vu}{\Phi} - V_c$

$= \frac{474.8}{0.75} - 316.4 = 316.67$ KN

$\frac{157.1 * 420 * 387.5}{S} = 316.67 * 10^{-3}$, s= 80.74 mm

Try using 4 legs Φ10

S= 161.48 mm

$S \leq \frac{d}{2} = \frac{387.5}{2} = 193.75$ mm ≤ 600 mm

Use Φ10 @ 150 mm, 4 legs.

4.8: Design of two-way ribbed slab.

4.8.1: Design of two-way ribbed slab for flexure.

1- Approximate method:

Approximate value of minimum(h) according to ACI

Minimum (h) ≥ (Maximum clear perimeter/180)

Minimum (h) ≥ (2*6.9+2*6.9)/180=15.33 cm

Select (h=35 cm) > minimum (h); 8cm Topping+27cm Block

2- Accurate method:

All exterior beams have a rectangular section of:

- 80 width and 65cm depth
- 80 width and 55cm depth
- 50 width and 35cm depth

$$\text{I for beam} = \frac{b*h^3}{12}$$

$$\text{I for beam (1\&4)} = \frac{80*65^3}{12}$$

=1830833.33 cm4

$$\text{I for beam (2)} = \frac{80*55^3}{12}$$

=1109166.67 cm4

$$\text{I for beam (3)} = \frac{50*35^3}{12}$$

=178645.83 cm4

The moment of inertia for the ribbed slab:

Be =52 cm was defined in one-way ribbed slab

$$yc = \frac{80*52*31+12*27*13.5}{8*52+12*27}$$

= 23.34 cm

$$\text{I for rib} = \frac{52*11.66^3}{3} - \frac{40*3.66^3}{3} + \frac{12*23.34^3}{3}$$

=77682.21 cm^4

Slab section for exterior beam

Short direction= long direction L=6.90 m

$$Is = \frac{Irib * (\frac{l}{2}L + bw)}{bf}$$

$$Is = \frac{77682.21 * (\frac{610}{2} + 80)}{52}$$

=578881.85 cm^4

$$\alpha = \frac{Ib}{Is}$$

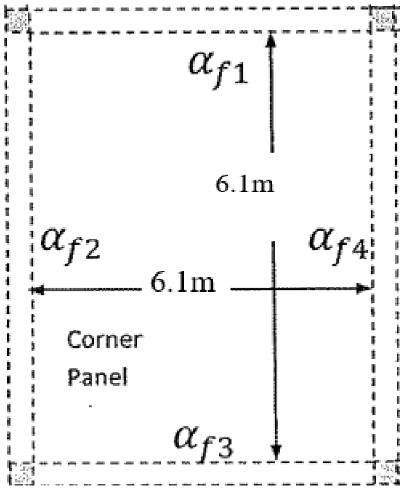


Figure 4. 7: The ratio of flexural stiffness of the beams.

α1= α4=1830833.33/578881.85=3.16

α2=1109166.67/578881.85=1.92

α3=178645.83/578881.85=0.31

αfm= (3.16+3.16+1.92+0.31)/4=2.14

= 2.14 > 2.0 the minimum slab thickness will be:

$$h = \frac{ln\ (0.8 + \frac{fy}{1400})}{36 + 9\beta}$$

$$h = \frac{6900\ (0.8 + \frac{420}{1400})}{36 + 9 * 1}$$

=168.67> 125mm

β= 6.15/6.15= 1.0

First trial thickness h=350mm >168.67 mm ok

Take slab thickness h_{slab} =350mm ,80mm topping ,270mm concrete block.

Load calculation:

Table 4. 3: Calculation of the total dead load for two-war ribbed slab

Material	Quality Density	W = $\gamma \cdot V$
	$KN/ m3$	KN
Tiles	23	23*0.03*0.52*0.52=0.187
mortar	22	22*0.02*0.52*0.52=0.119
Sand	16	16*0.07*0.52*0.52=0.303
Reinforced Concrete Topping	25	25*0.08*0.52*0.52=0.541
Reinforced Concrete Rib	25	25*0.24*0.12*(0.52*0.4) =0.403
Concrete Block	14	14*0.24*0.4*0.4=0.538
Plaster	22	22*0.02*0.52*0.52=0.119
Partitions	2.38	2.38*0.52*0.52=0.644
Total Dead Load, KN		2.85

DL= 2.85 / (0.52*0.52) = 10.54 KN/m2

W_D = 1.2 *10.54 = 12.65 KN/m^2

Live load of slab:

LL= $5KN/m^2$

W_L = 1.6 *5 = $8KN/m^2$

W= 12.65+8=20.65KN/m^2

Moment's calculations:

$$M_a = C_a w l_a^2 \quad \text{and} \quad M_b = C_b w l_b^2$$

L_a/L_b= 6.15/6.15=1

Design of bending moment:

Ma,pos,ll= Mb,pos,ll= Ma,pos,dl= Mb,pos,dl

M=0.036*20.65*6.15^2=28.12 KN.m/m

Design of positive moments:

Mu=28.12 KN.m/m

Mn=28.12/0.9=31.24 KN.m

Assume bar diameter Ø14 for main reinforcement

d=350-20-10-14/2=313mm

Rn=Mn/(b*d2)

= 31.24*10^6/(520*313^2)

= 0.613

$m = f_y / (0.85 fc)$

$= (420/.85*24)$

$= 20.58$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right)$$

$$= \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.613*20.58}{420}}\right)$$

=0.00148

As=0.00148*520*313=241.23 mm2

As,min= 0.25*(√fc'/ fy)*bw*d ≥ 1.4/fy *bw*d

0.25*(√fc'/ fy)*bw*d = 109.53 mm^4

1.4/fy *bw*d= 125.2 mm^4 (control)

As req = 241.23 mm^4 > As min = 125.2 mm^4

2Φ14= 308 mm2 > As req = 241.23 mm^2

∴ Use 2 Φ14

Check for strain :

εs ≥0.005

Tension = Compression

As * fy = 0.85 * fc' * bw * a

308 * 420 = 0.85 * 24 * 520 * a

a = 12.2 mm

fc' = 24 MPa< 28 MPa→ β = 0.85

c=a/β = 12.2/0.85 = 14.36 mm

εs=(d-c)/c * 0.003

= (313-14.36)/14.36*0.003

= 0.0634 >0.005

Design of negative moments:

There is no negative moment so we put 1/3 As,pos

As,neg= 1/3*241.23= 80.41mm^4

As req = 80.41 mm^4 <As min = 125.2 mm^4

2Φ10= 157.1 mm^2 > As req = 125.2 mm^2

∴ Use 2 Φ10

Check for strain :

$\varepsilon s \geq 0.005$

Tension = Compression

As * fy = 0.85 * fc' * bw * a

157.1 * 420 = 0.85 * 24 * 120 * a

a = 26.95 mm

fc' = 24 MPa< 28 MPa→ β = 0.85

c=a/β = 26.95/0.85 = 31.71 mm

εs=(d-c)/c * 0.003

= (313-31.71)/31.71*0.003

= 0.0266 >0.005

4.8.2: Design of two-way ribbed slab for shear.

Wb= 0.5

The total load on the panel being = 6.15*6.15*20.65=781.035 KN

The load per rib at the face of short beam = (0.5*781.035*0.52)/ (2*6.15)

= 16.51KN

Vud =Vu,face-(Wu*bf*d)=16.51-(20.65*0.52*0.313)=13.15 KN

The maximum shear force at the distance d from the face of support:

Vu = 13.15 KN

Vc = 1.1(√fc' /6 * bw * d)

= 1.1(√24/6 * 120 * 313) = 33.73 KN

ϕVc = 0.75 * 39.35= 25.3 KN

Case1: Vu ≤ (ϕVc)/2

13.15 KN > 25.3/2 =12.65KN

Case (1) is not satisfied

Case2: Vu ≤ (ϕVc)

13.15 KN <25.3

Case (2) is satisfied

shear reinforcement is required

$Vs_{min} \geq \frac{1}{16}\sqrt{f_c'} * b_w * d = \frac{1}{16}\sqrt{24} * 120 * 0.313 * 10^3 = 11.50$ KN.

$\geq \frac{1}{3} * b_w * d = \frac{1}{3} * 120 * 0.313 * 10^3 = 12.52$ KN CONTROL.

$\therefore Vs_{min} = 12.52$ KN.

Try 2Φ10

$\frac{157.1*420*313}{S}$ = 12.52*10^3 → S = 1649.55 mm

S ≤$\frac{d}{2}$ = $\frac{313}{2}$ = 156.5 mm. … Control

≤ 600 mm.

∴ Use 2Φ10 @ 15 cm

4.9: Design of column (C52).

Calculation of Loads act on Column (C52)

Loads acting on columns are obtained from support reaction when analyzing the system on Etabs.

Dead Load = 3000 KN (service)

Live Load = 1500 KN (service)

Loads acting on column (C52) are as follows:

Factored loads (Pu) = 1.2*3000+1.6*1500= 6000 KN

Calculation of Required Dimension of Column (C52)

Total load Pu = 6000 KN

Pn = 6000 /(0.65) = 9230.8 KN

$\rho g = 2.0$ %

$\text{Pn} = 0.8 * \text{Ag}\{0.85 * \text{fc}' + \rho\text{g}(\text{fy} - 0.85\text{fc}')\}$

$9230.8 * 10^{-3} = 0.8 * \text{Ag}[0.85 * 24 + 0.02 * (420 - 0.85 * 24)]$

$\text{Ag} = 4064\ c\text{m}^2$

∴Select 65*65 cm with Ag = 4225 cm^2.

Check slenderness effect:

For braced system if $\lambda \leq 34 - 12\frac{M1}{M2} \leq 40$, then column is classified as short column and slenderness effect shall not be considered.

$$\lambda = \frac{Klu}{r}$$

Lu: Actual unsupported (unbraced) length = 3.95 m

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

R: radius of gyration → for rectangular section = $\sqrt{\frac{I}{A}}$ 0.3 h

System about X

$$\rightarrow \lambda = \frac{1 * 3.95}{0.3 * 0.65} = 20.26$$

$\lambda \leq 34 - 12(1) = \mathbf{22} \leq 40$

$\lambda = 20.26 < 22$

System about Y

$$\rightarrow \lambda = \frac{1 * 3.95}{0.3 * 0.65} = 20.26$$

$\lambda \leq 34 - 12(1) = \mathbf{22} \leq 40$

$\lambda = 20.26 < 22$

∴ Short about X and Y.

∴ Column is short, so slenderness effect will not be considered.

Calculation of Required Reinforcement Ratio:

Since Column is short and slenderness effect will not be considered, then Design Strength of column can be calculated using the following equation:

$\phi \text{Pn} = 0.65 * 0.8 * \text{Ag}\{0.85 * \text{fc}' + \rho\text{g}(\text{fy} - 0.85\text{fc}')\}$

Where, Pu = 6000 KN

$6000 * 10^3 = 0.65 * 0.8 * 600 * 800\{0.85 * 24 + \rho(420 - 0.85 * 24)\}$

$\Rightarrow \rho_g = 0.0109 > \rho_{min} = 0.01$ & $< \rho_{max} = 0.08$

As req = 0.0109*600 *800 =5232 mm^2

Use Φ 25 >> $\# of\ bar = \frac{5232}{490.63} = 10.66$

∴ Use 12 Ø 25 with As = 5887.56 mm^2 >As req = 5232 mm^2

Check spacing between the bars:

S = $\frac{600-2*40-2*10-4*25}{3} = 133.33\ mm$

S = 133.33 mm $\geq$ 40mm

$\geq$ 1.5db = 37.5 mm

Determination of Stirrups Spacing

According to ACI:

$\text{Spacing} \leq 16 \times d_b(\text{Longitudinal. bar. diameter}) = 16 \times 2.5 = 40 \text{ cm.}$

$\text{Spacing} \leq 48 \times d_t(\text{tie. bar. diameter}) = 48 \times 1.0 = 48\text{cm.}$

$\text{Spacing} \leq \text{Least. dimension} = 40 \text{ cm}$

Select Ø10/10 cm above the slab and along lap-splice.

Select Ø10/20 cm at the middle.

Column (C52) Section is shown in figure (4-8) where bars arrangement and stirrups detailing appear:

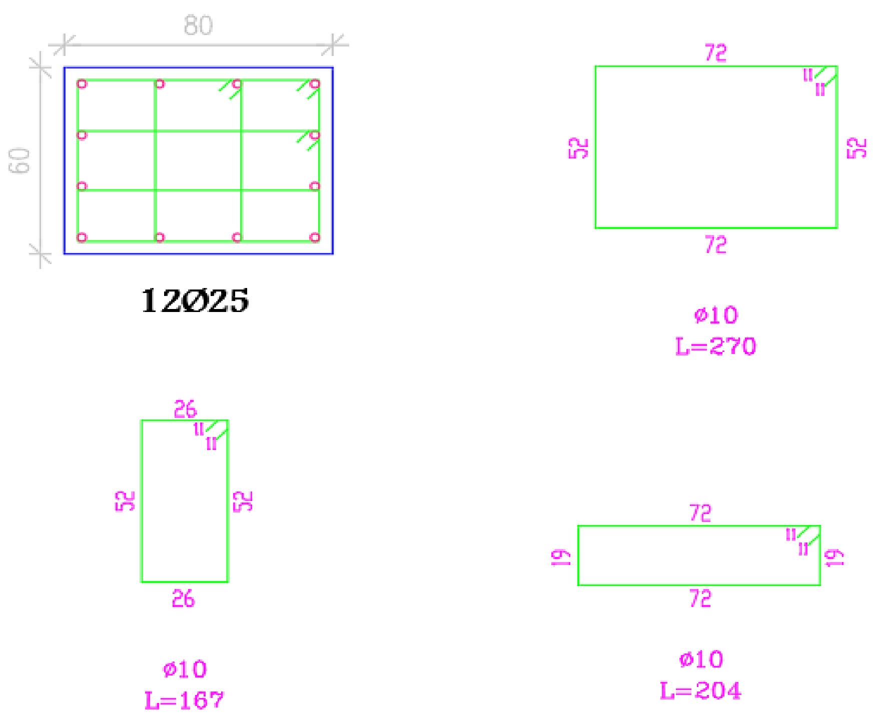


Figure 4. 8: Column C52 detailing.

4.10: Design of Isolated Footing (F4).

Loads that act on footing F4 are :

- PD =3000 KN, PL = 1500 KN
- Pu = 1.2 * 3000 + 1.6*1500= 6000 KN

The following parameters are used in design:

- γ_{concrete} = 25 KN/m^3
- γ_{soil} = 17 KN/m^3
- σ_{allow} = 500 KN/m^2
- clear cover = 5 cm

Determination of footing dimension (a)

Footing dimension can be determined by designing the soil against bearing pressure.

Assume h = 80 cm

$\sigma_{b(allow)\text{net}}$ = 500 – 25*0.8 – 0.3*17 - 5 = 469.9 KN/m^2

$$A = \frac{P_n}{q_{a.net}} = \frac{3000 + 1500}{469.9} = 9.85\ m^2$$

$$l = \sqrt{A} = \sqrt{9.85} = 3.14\ m$$

Select $l = 3.2\ m$

Determination of footing depth (h)

To determine depth of footing both of one and two-way shear must be designed.

$$q_u = \frac{P_u}{A} = \frac{4500}{10.24} = 439.45\ KN/m^2$$

Design of one-way shear:

d = h − $cover$ − ∅ = 800 − 50 − 16 = 734 mm

Vu at distance d from the face of column

$$V_u = q_u b\left(\frac{l}{2} - \frac{a}{2} - d\right)$$

$$= 439.45 * 3.2\left(\frac{3.2}{2} - \frac{0.6}{2} - 0.734\right) = 795.93\ KN$$

$Ø\ Vc = 0.75 * \frac{1}{6} * \sqrt{fc'} * b * d$

$= 0.75 * \frac{1}{6} * \sqrt{24} * 3200 * 0.734 = 1438.34$ KN

Ø Vc =1438.34 KN > Vu= 795.93 KN

∴ h = 80 cm is correct

Design of Punching (Two-way shear).

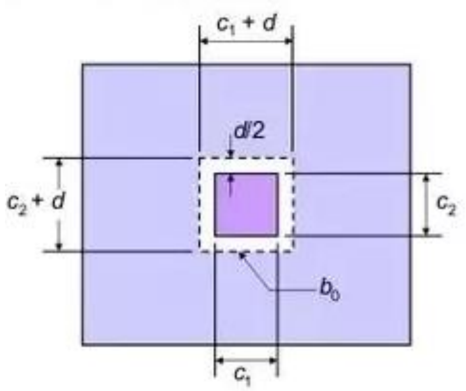


Figure 4. 9: Two way shear (punching)

$d = 734\ mm$

$b_\circ$ = 2(0.6+0.734) +2(0.8+0.734) = 5736 mm

Bc = 1

αs = 40 (interior column)

Vu = 439.45(3.2*3.2 -(0.6+0.734) (0.8+0.734)) = 3600.7 KN

ØVc is the smallest of:

1. $Vc = \frac{1}{6}\left(1+\frac{2}{\beta}\right) \times \sqrt{fc} \times b_o \times d$

   $= \frac{1}{6}\left(1+\frac{2}{1}\right) \times \sqrt{24} \times 5736 \times 734 \times 10^{-3} = 10312.9\ KN$

2. $Vc = \frac{1}{12}\left(\frac{\alpha_s \times d}{b_o}+2\right) \times \sqrt{fc} \times b_o \times d$

   $= \frac{1}{12}\left(\frac{40 \times 734}{5736}+2\right) \times \sqrt{24} \times 5736 \times 734 \times 10^{-3} = 12235.48\ KN$

3. $Vc = \frac{1}{3} \times \sqrt{fc} \times b_o \times d$

   $= \frac{1}{3} \times \sqrt{24} \times 5736 \times 734 \times 10^{-3} = 6875.27$ KN (Control)

ØVc = 0.75 × 6875.27 = 5156.45 KN > Vu = 3600 KN

∴ A= (3.2*3.2)m^2 and h = 75 cm is correct.

Design of Reinforcement

Mu = 439.45 *1.3*3.2*(1.3/2) = 1188.27 KN.m

$m = \frac{Fy}{0.85*Fc'} = \frac{420}{0.85*24} = 20.59$

Mn = 1188.27/0.9 = 1320.3 KN.m

$Rn = \frac{Mn}{b*d^2} = \frac{1320.3*10^6}{3200*734^2}$ = 0.766 MPa

$\rho = \frac{1}{m} * (1- \sqrt{1-\frac{2*Rn*m}{Fy}})$

$= \frac{1}{20.59} * (1- \sqrt{1-\frac{2*0.766*20.59}{420}})$ =0.00186

As,req = $\rho * b * d = 0.00186 * 3200 * 734 = 4367.37\ mm^2$

As (min) = 0.0018*b*h = 0.0018*3200 * 800 = 4608 mm^2

As,min > As, req

Select for this directions: 23Ø16 with As = 4624.42 mm^2 > As,min

Mu = 439.45 *1.2*3.2*(1.2/2) = 1012.5 KN.m

$m = \frac{Fy}{0.85*Fc'} = \frac{420}{0.85*24} = 20.59$

Mn = 1012.5/0.9 = 1125 KN.m

$Rn = \frac{\mathrm{Mn}}{\mathrm{b*d^2}} = \frac{1125*10^6}{3200*734^2}$ = 0.652 MPa

$$\rho = \frac{1}{m} * (1- \sqrt{1 - \frac{2*Rn*m}{Fy}})$$

$$= \frac{1}{20.59} * (1- \sqrt{1 - \frac{2*0.652*20.59}{420}}) = 0.00158$$

As,req = $\rho * b * d = 0.00158 * 3200 * 734 = 3706.45$ mm^2

As (min) = 0.0018*b*h = 0.0018*3200 * 800 = 4608 mm^2

As,min > As, req

Select for this directions: 23Ø16 with As = 4624.42 mm^2 > As,min

Select 23Ø16 in both directions.

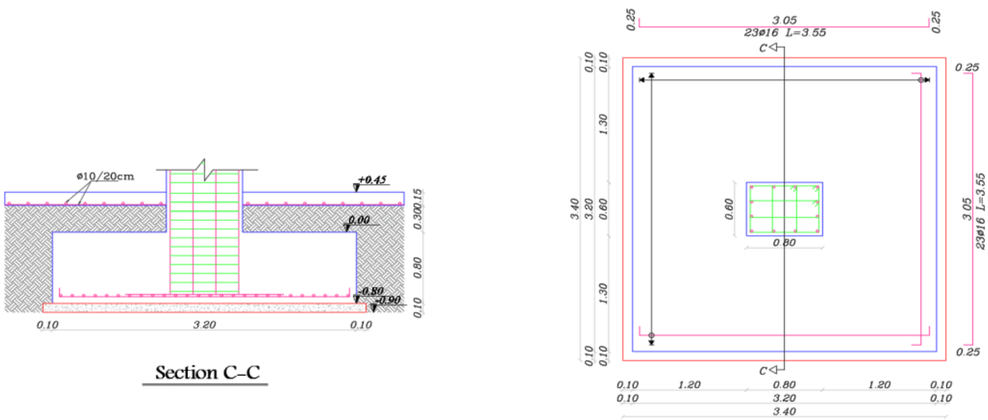
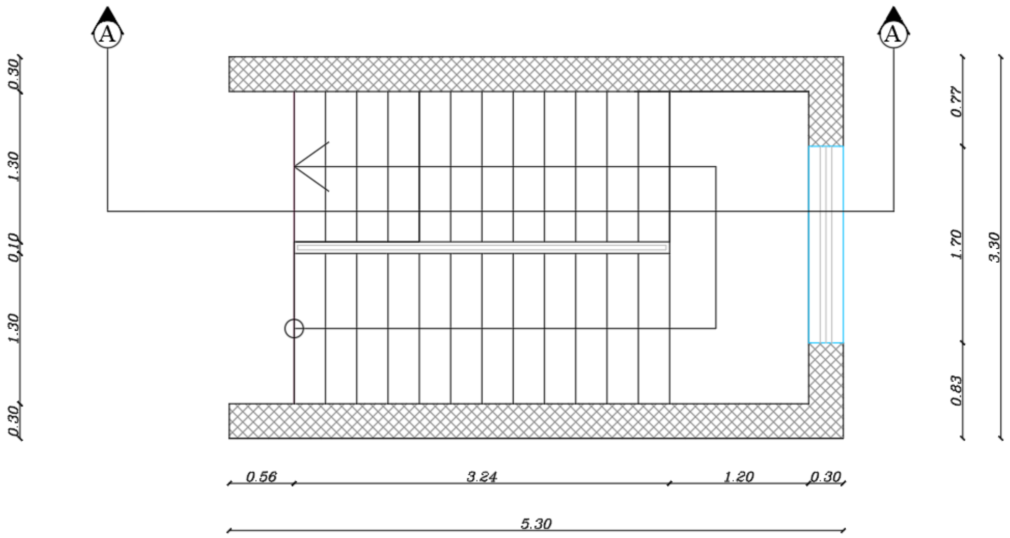


Figure 4. 10: Foundation F4 reinforcement.

4.11: Design of Stairs.

Figure 4. 11: Stair plan.



4.11.1: The flight.

- Determination the thickness:

Limitation of deflection: h ≥ minimum h

h (min) = L/20 = 324/20 = 16.2 cm

∴ Select h = 20 cm, but shear and deflection must be checked

Angle (α): tan(α) = 16.2/27 → α = 31.2

- Load calculation:

Table 4. 4: Load calculation for the flight

Load calculation for the flight		
Concrete Block	Quality Density	W = $\gamma \cdot V$
	$KN/ m3$	KN
Tiles	27	27*((0.1635+0.32)/0.27)*0.03*1=1.451
Mortar	22	22*((0.1635+0.27)/0.27)*0.02*1=0.7064
Stair step	25	(25/0.27)*((0.1635*0.27)/2)*1=2.044
R.C solid slab	25	(25*0.2*1)/(cos 31.2)=5.85
Plaster	22	(22*0.03*1)/(cos 31.2)=0.772
Total Dead Load, KN		10.82 KN/m

Live load= 5 KN/m^2

Wu= 1.2*10.82+ 1.6*5= 20.99 KN/m

- Analysis.

The following figures show shear and moment Diagrams resulted from analysis of the flight:

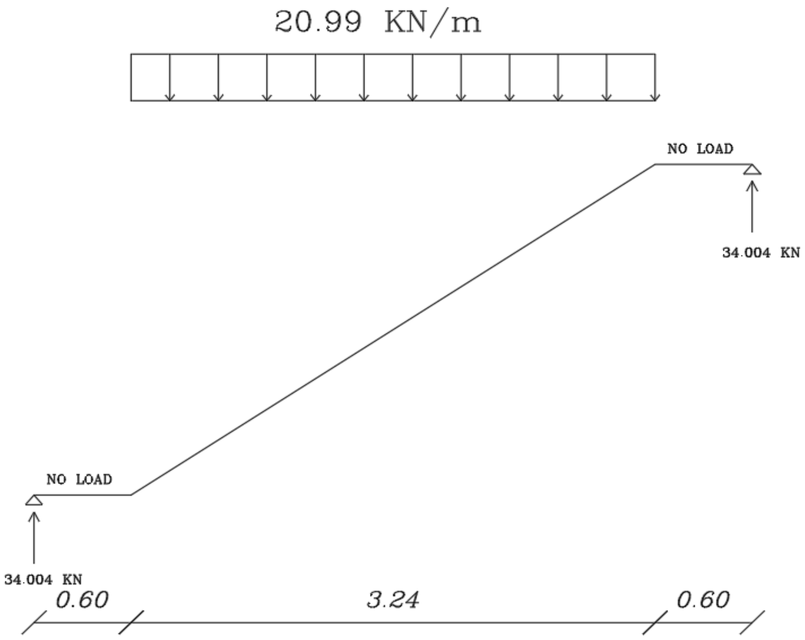


Figure 4. 12: Load distribution for flight.

- Design.

Design for shear:

R=W*L/2= (20.99*3.24)/2= 34.004 KN

d=200-20-(14/2) = 173 mm

$ØVc = 0.75 * \frac{1}{6} * \sqrt{Fc'} * bw * d$

$= 0.75 * \frac{1}{6} * \sqrt{24} * 1000 * 0.173$

= 105.94 KN

0.5* ØVc= 0.5*105.94= 52.97 KN

0.5 ØVc = 52.97 > Vu max = 34.004 kN

∴ No Shear Reinforcement is Required

Design of bending moment:

Mu= 34.004 (0.6+1.62)- 20.99*(1.62^2/2) = 47.95 KN/m

$m = \frac{Fy}{0.85*Fc'} = \frac{420}{0.85*24} = 20.59$

$Rn = \frac{Mu/\emptyset}{b*d^2} = \frac{\mathbf{47.95}*10^6/0.9}{1000*173^2} = 1.78$ MPa

$\rho = \frac{1}{m} * (1- \sqrt{1-\frac{2*Rn*m}{Fy}}) = \frac{1}{20.59} * (1- \sqrt{1-\frac{2*1.78*20.59}{420}}) = 0.0044$

$As, req = \rho * b * d = 0.0044 * 1000 * 173 = 768.4$ mm^2

As min = 0.0018 *1000*200 = 360 mm^2
As, req >As, min

Select 5Ø14 with As= 769.7 mm^2 >As, req

For secondary Reinforcement select Ø10 /20 with as=395 mm2 >As min

Check Strain:

C = T

0.85*fc'*a*b = As*fy

0.85*24*a*1000 = 769.6 *420

a = 15.84 mm

c = a/β = 15.84/0.85 = 18.64 mm

εs =((d-c)/c) * 0.003

= ((173-18.64)/18.64) *0.003

= 0.0248 >0.005

Check spacing:

S= 20cm < 3h = 3*200= 600 mm

= 450 mm

$= 380*(\frac{280}{0.67*420})- 2.5*20= 33.37$ mm

4.11.2: The landing.

- Determination the thickness:

Limitation of deflection: h ≥ minimum h

h (min) = L/20 = 330/20 = 16.5 cm

∴ Select h = 20 cm, but shear and deflection must be checked

d=200-20-(14/2) = 173 mm

- Load calculation:

Table 4. 5: Load calculation for the landing

Load calculation for the landing		
Concrete Block	Quality Density	W = $\gamma \cdot V$
	$KN/\ m3$	KN
Tiles	27	22*0.03*1=0.66
Mortar	22	22*0.02=0.44
R.C solid slab	25	25*0.15*1=3.75
Plaster	22	22*0.02=0.66
Total Dead Load, KN		5.51 KN/m

Live load= 5 KN/m^2

Wu= 1.2*5.51+ 1.6*5= 14.61 KN/m

Wu= 1.2*10.82+ 1.6*5= 20.99 KN/m

- Analysis.

The following figures show shear and moment Diagrams resulted from analysis of the landing:

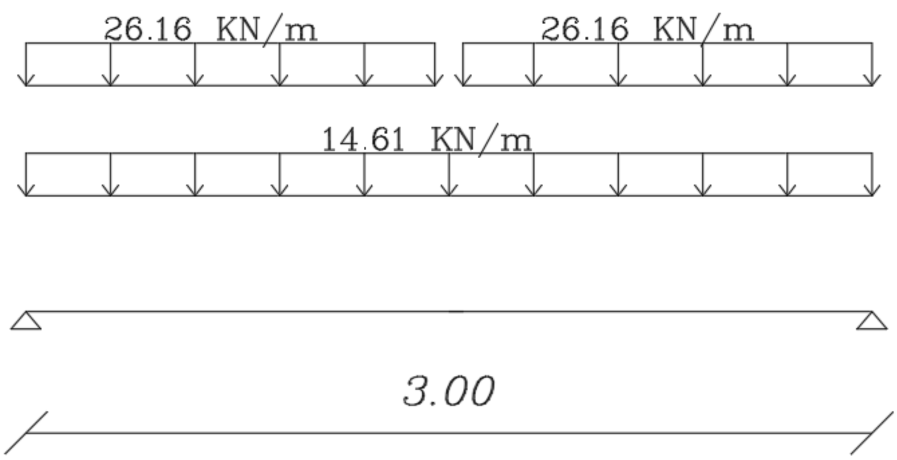


Figure 4. 13: Load distribution for flight.

- Design.

Design for shear:

W_R=34.004/1.3= 26.16 KN

R= (14.61*3)/2+ 26.16*1.3= 52.92

ØVc = 0.75 * $\frac{1}{6}$*$\sqrt{Fc'}$ * bw * d

= 0.75 * $\frac{1}{6}$*$\sqrt{24}$ * 1000 * 0.173

= 105.94 KN

0.5* ØVc= 0.5*105.94= 52.97 KN

0.5 ØVc = 52.97 > Vu max = 52.92 KN

∴ No Shear Reinforcement is Required

Design of bending moment:

Mu= 52.92 *1.5- (14.012*1.35^2)/2- 26.16*1.3*(1.3/2) +0.005) = 42.8 KN/m

m =$\frac{Fy}{0.85*Fc'} = \frac{420}{0.85*24} = 20.59$

Rn = $\frac{Mu/Ø}{b*d^2}$ = $\frac{\mathbf{42.8}*10^6/0.9}{1000*173^2}$ = 1.6 MPa

$\rho = \frac{1}{m}$ * (1- $\sqrt{1-\frac{2*Rn*m}{Fy}}$) = $\frac{1}{20.59}$ * (1- $\sqrt{1-\frac{2*1.6*20.59}{420}}$) = 0.004

As, req = ρ ∗ b ∗ d = 0.004 ∗ 1000 ∗ 173 = 692 mm^2

As min = 0.0018 *1000*200 = 360 mm^2

As, req >As, min

Select 5Ø14 with As= 769.7 mm^2 >As, req

For secondary Reinforcement select Ø10 /20 with as=395 mm2 >As min

Check Strain:

C = T

0.85*fc'*a*b = As*fy

0.85*24*a*1000 = 769.6 *420

a = 15.84 mm

c = a/β = 15.84/0.85 = 18.64 mm

εs =((d-c)/c) * 0.003

= ((173-18.64)/18.64) *0.003

= 0.0248 >0.005

Check spacing:

S= 20cm < 3h = 3*200= 600 mm

= 450 mm

= 380*($\frac{280}{0.67*420}$)- 2.5*20= 33.37 mm

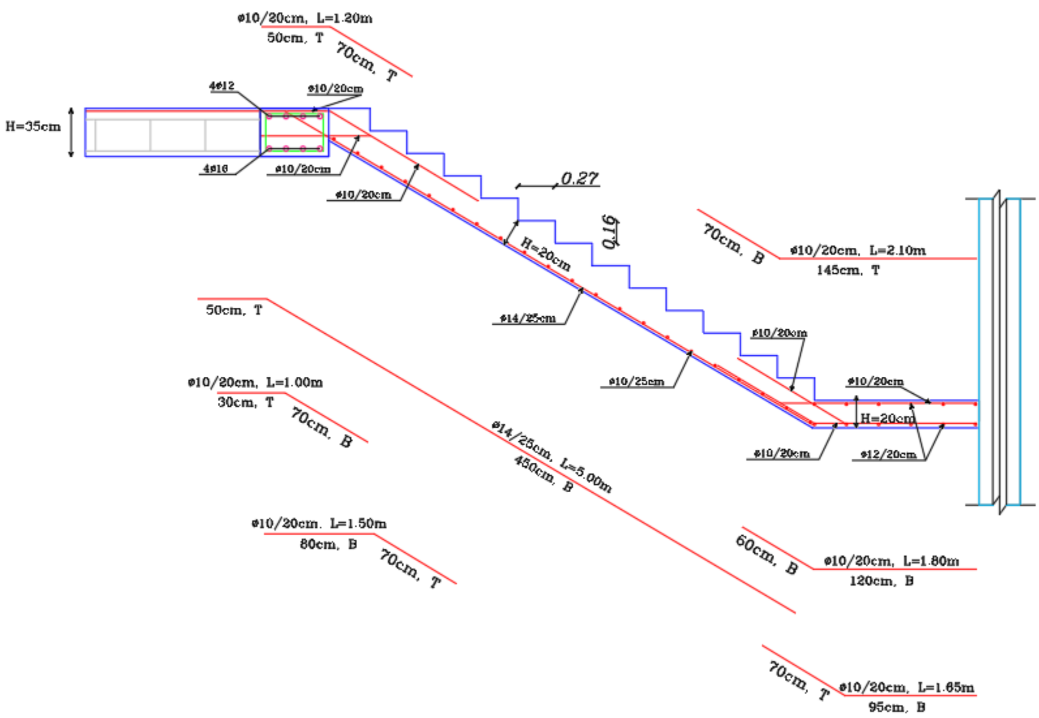


Figure 4. 14: Stair reinforcement.

4.12: Design of shear wall

Analysis and design were done using ETABS program in which the seismic loads were taken into account. The following is a sample calculation for one of the walls, S.W

The following data that used in design:

Shear wall thickness = h = 30 cm

Shear wall length Lw = 5.30 m

Building height Hw= 24.23 m

Critical section shear:

Lw/2=5.3/2=2.65

hw/2=24.23/2=12.12

story height= 3.95

d =0.8*Lw =0.8*5.3 = 4.24 m

Vu= 879.6 KN

Mu= 1366.7 KN.m

Calculation of shear strength provided by concrete Vc:

Shear Strength of Concrete is the smallest of:

- $Vc = \frac{1}{6}\sqrt{fc'} \times b \times d$

  $= \frac{1}{6}\sqrt{24} \times 0.3 \times 4240 = 1038.6$ KN

- $Vc = 0.27\sqrt{fc'} \times h \times d + \frac{Nu \times d}{4Lw}$

  $= 0.27\sqrt{24} \times 0.3 \times 4240 + 0 = 1682.5\ KN$

- $Vc = \left[0.05 * \sqrt{fc'} + \frac{Lw\left(0.1\sqrt{fc'} + 0.2\frac{Nu}{Lw.h}\right)}{\frac{Mu1}{Vu} - \frac{Lw}{2}}\right] \times h \times d$

$\frac{Mu1}{Vu} - \frac{Lw}{2} = \frac{1366.7}{879.6} - \frac{5.3}{2} = -1.096 < 0$ This equation is not applicable.

$\therefore Vc = 1038.6$ KN $\rightarrow$ ØVc $= 778.95 <$ Vumax[1] $= 879.6$ KN

Horizontal Reinforcement is Required.

$$Vs = \frac{Vu}{Ø} - Vc = \frac{879.6}{0.75} - 1038.6 = 134.2\ kN$$

$$\frac{Avh}{s} = \frac{Vs}{fy * d} = \frac{134.2 * 10^3}{420 * 4240} = 0.0754$$

$$\text{but } \left(\frac{Avh}{s}\right) \min = 0.0025 * h = 0.0025 * 300 = \mathbf{0.75}.$$

Avh : For 2 layers of Horizontal Reinforcement Select Ø10 :

Avh = 2 *79 = 158 mm^2

$$\frac{Avh}{s} = 0.75 \rightarrow Sreq = \frac{158}{0.75} = 210.67\ mm$$

Smax= Lw/3 = 5300/3 = 1766.67 mm

= 3h = 3*300 =900mm

$= 45cm \ll$ Controlled.

Select Ø10 @ 200 mm at each side.

4.7.2 Design of Vertical Reinforcement

$$Avv = [0.0025 + 0.5\,(2.5 - \frac{hw}{lw})(\frac{Avh}{Shor * h} - 0.0025)] * h * Sver$$

$$\frac{hw}{lw} = \frac{24.23}{5.3} = 4.57 > 2.50$$

$$\frac{Avv}{Sver} = [0.0025 + 0.5\,(0)(\frac{2 * 79}{250 * 250} - 0.0025)] * 300$$

$\frac{Avv}{Sver} = 0.75$

Smax= Lw/3 = 5300/3 =1766.67 mm

= 3h = 3*300 =900mm

$= 45cm$

Select Ø12 :

Avv = 2 *113.1 = 226.2 mm^2

$$\frac{Avv}{s} = 0.75$$

$$Sreq = \frac{226.2}{0.75} = 301.6 \text{ mm}$$

Select Ø12 @ 200 mm at each side.

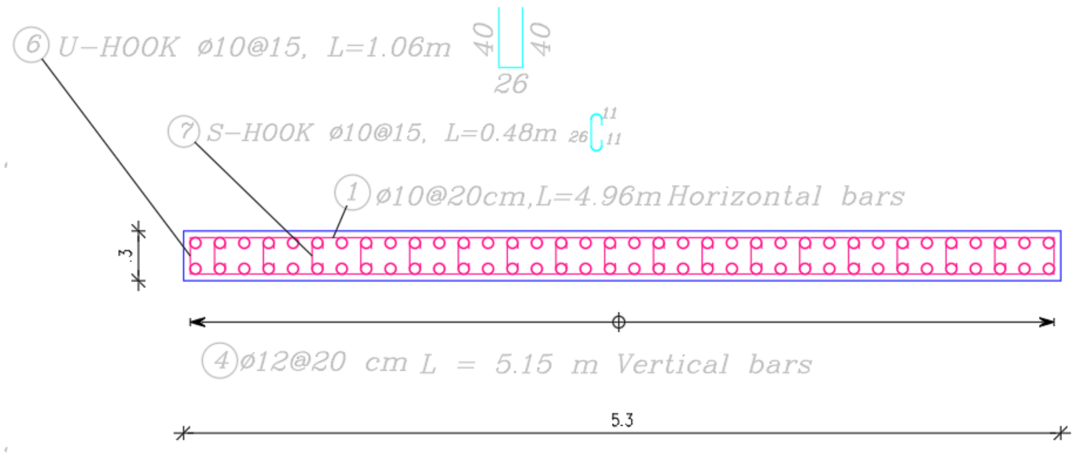


Figure 4. 15: Shear wall 5 reinforcement.

Chapter 5: Results and recommendations.

5.1: Introduction

5.2: Results

5.3: Recommendations

5.1: Introduction.

After starting the project and start dealing with problems that had been faced during the work on it, it is necessary to summarize the results that were reached and to give some recommendations that will be helpful for students who will work on such project.

One of the most prominent problems that we faced in the project was in distribution the columns in the pool region, we solved it by making frames to avoid doing columns in the middle, another problem when we designed the foundation, there was an isolated footing on the basement wall, we solved it by doing the footing of this column with the footing of the basement wall.

5.2: Results.

The following are results that had been reached during the work on this project:

- The most important step before starting a design is to study the architectural plans carefully to distribute the columns correctly.
- Gaining experience in using structural programs cannot be reached without an understanding of basic concepts of the structural design.
- When choosing the structural system, it is better to distribute ribs in the short direction and beams in the long one that will reduce loads that act on beams which leads to reducing of reinforcement which meant reducing costs.
- Gaining experience in frame reinforcement and the additional detail to it.

5.3: Recommendations.

After starting the project and start dealing with problems that had been faced during the work on it, some recommendations should be mentioned that may help students who will work on such projects after us.

First of all, the architectural drawings had to be prepared and studied carefully to choose the most appropriate structural system. Collecting data about the project is an important step as the study of the site and the type of soil are important in choosing the construction materials to be used. Before starting the design of the building, a good structural planning must be done to determine the location of columns, beams, and shear walls to fit with architectural plans.

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