Palestine Polytechnic University

College of Engineering

Department of Civil Engineering

Building Engineering

Hebron – Palestine

The Graduation Project

Structural Design of the AZ Hotel in Al-Hijri / Dora

Team of Work

Shrouq Ihmedat Mohammed Fanoun

Supervisor

Eng. Inas Shweiki

December, 2022

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"Graduation Project Submitted to the Civil Engineering Department in Partial Fulfillment of the Requirements for the Degree of B.Sc. in Civil Engineering depends on the instructions of the project supervisor and with the consent of all members."

Project Supervisor Signature | **Signature of the Head of Department**

Eng. Inas Shweiki | Dr. Bilal Al-Masri

Dedication

To those who have taken credit for us from our birth to this day, to those who taught us to read and write, to those who motivated us every time we felt we were going to fail.

To those who made great efforts to convey all the information to us, our dear doctors.

To those who gave us everything they could, and their prayers protected us from all harm, and always remained by our side, our dear mothers.

To those whose names we proudly bear, from whom we learned human values, and who accompanied us with their great hearts, our dear fathers.

To those who looked upon us with pride after every success, our brothers, sisters and friends.

Acknowledgement

Praise be to God in the beginning and in the end, it did not come with our hard work, not even with our efforts, but rather with the blessings of God upon us.

First of all, thanks to our esteemed university, Palestine Polytechnic University, which was the best choice for us.

Moreover, the greatest thanks go to our supervisor Eng. Inas Shweiki, who did not spare us any guidance and any information, may God reward her with all the best.

The final and all thanks are given to all the college Doctors, without whom we would not have been able to reach this final stage in our university life, and to all those who provided us with any great advice or assistance.

List of abbreviation:

• A_c = area of concrete section resisting shear transfer.
• A_s = area of non-prestressed tension reinforcement.
• A'_s = area of non-prestressed compression reinforcement.
• A_g= gross area of section.
• A_v = area of shear reinforcement within a distance (S).
• A_t = area of one leg of a closed stirrup resisting tension within a (S).
• b = width of compression face of member.
• b_w = web width, or diameter of circular section.
• C_c = compression resultant of concrete section.
• C_s = compression resultant of compression steel.
• DL = dead loads.
• d = distance from extreme compression fiber to centroid of tension reinforcement.
• E_c = modulus of elasticity of concrete.
• f'_c = compression strength of concrete .
• f_y = specified yield strength of non-prestressed reinforcement.
• h = overall thickness of member.
• L_n = length of clear span in long direction of two- way construction, measured face-to-face of supports in slabs without beams and face to face of beam or other supports in other cases.
• LL = live loads.
• L_w = length of wall.
• M = bending moment.
• M_u = factored moment at section.
• M_n = nominal moment.
• P_n = nominal axial load.
• P_u = factored axial load.
• S = Spacing of shear in direction parallel to longitudinal reinforcement.
• V_c = nominal shear strength provided by concrete.
• V_n = nominal shear stress.
• V_s = nominal shear strength provided by shear reinforcement.

- V_u = factored shear force at section.
- W_c = weight of concrete.
- W = width of beam or rib.
- W_u = factored load per unit area.
- $\emptyset$ = strength reduction factor.
- ε_c = compression strain of concrete = 0.003.
- ε_s = strain of tension steel.
- $\acute{\varepsilon}_s$ = strain of compression steel.
- ρ = ratio of steel area.

Abstract

The main idea of the project revolves around the structural design of AZ Hotel, the structural design is one of the most important designs subsequent to the architectural design process, as the process of distributing columns and studying the behavior of the building under the influence of vertical and horizontal loads and choosing The best type of knots, walls and foundations and following the best methods and solutions from an economic point of view is the main objective of this project.

AZ Hotel is a proposed hotel to be built in the mountainous village of Al-Hijri in the town of Dura. Architecturally, this project is characterized by the presence of setbacks that led to a difference in floor space, in addition to differences in levels. The project consists of 6 floors in addition to two basement floors, the second basement floor is a Parking and the first basement floor is for various services, and the total area is about 11128m^2.

After completion of the project, we expect to be able to provide structural design of all the structural elements of the project accordance to the requirements of the code (ACI-318-11, ACI-318-08, Jordanian code).

الملخص

إن الفكرة الرئيسية للمشروع تدور حول التصميم الإنشائي لفندق (AZ)، ويعتبر التصميم الإنشائي هو من أهم التصاميم اللاحقة لعملية التصميم المعماري، إذ أن عملية توزيع الأعمدة ودراسة سلوك المبنى تحت تأثير الأحمال الرأسية والأفقية واختيار أفضل نوع للعقدات والجدران والأساسات واتباع أفضل الطرق والحلول من الناحية الاقتصادية هو الهدف الأساسي لهذا المشروع.

فندق AZ هو فندق مُقترح البناء في قرية الهجري الجبلية في بلدة دورا، ويتميز هذا المشروع معمارياً بوجود التراجعات التي أدت إلى اختلاف في المساحة الطابقية، بالإضافة إلى وجود فروقات في المناسيب، يتكون المشروع من 6 طوابق بالإضافة إلى طابقين تسوية، وطابق التسوية الثاني هو كراج للسيارات وطابق التسوية الأول هو للخدمات المختلفة، وتبلغ المساحة الطابقية حوالي 11252 م^2.

وبعد إنجاز المشروع، نتوقع أن نكون قادرين على توفير تصميم إنشائي لجميع العناصر الإنشائية للمشروع وفقا لمتطلبات الكود الأمريكي والأردني

CHAPTER

1

Introduction

1.1 Introduction

1.2 Project problem

1.3 Project over view

1.4 Project objectives

1.5 Project methodology

1.6 Reasons for choosing the project

1.7 Project scope

1.8 Project schedule

1.1 Introduction

Man, since his birth, has been in a constant quest to search for food, and food is not available in one area, so he was forced to travel and move in order to obtain it, and based on the developments that occurred in all lifestyles, a new need emerged, which is the human need for housing during his travel and movement, and here appeared The idea of hotels, which in turn plays an important role in the economy, culture and tourism.

As part of the Bachelor's degree in Civil Engineering at Palestine Polytechnic University, and since we are required to apply the knowledge that we have obtained throughout our educational years, we will use it to form one complete and integrated picture in our project to eventually obtain a complete structural design for the proposed AZ Hotel in Dura city (Al-Hijri village), Which is located southeast of Dura it's a mountainous area and does not contain many religious places, Dura was chosen to establish this hotel because it has become a tourist area, and this would play an important role in the development of the economy, so the presence of such a hotel in Al-Hijri village will lead To revive it and thus improve all its services.

The AZ Hotel consists of a Parking, kitchens, restaurants, gym, pantry, bathrooms and bedrooms for staff، standard rooms, a music hall as well as an amphitheater, a cafe and a set of offices.

The hotel consists of: two basement floors, a ground floor and a mezzanine floor, in addition to four other floors. The project includes the structural design work and its careful selection due to the presence of architectural design in addition to the distribution of columns and beams in line with the architectural elements and then the design starting with the slabs and ending with the foundations and exiting all plans constructional.

1.2 Project problem

- The problem is centered in analyzing the hotel from the structural side, and then making the architectural and structural design of all the hotel's elements.
- An analysis and design of ribs, beams, columns, foundations, stairs, and shear, basement walls will be done.

- Dimensions for the different sections and Reinforcement for all selected structural elements will be specified.

1.3 Project overview

Given that hotels must provide all the services needed by the individuals who will stay in them, we find that AZ Hotel provides almost all the required services such as restaurants, gyms, terraces, etc...

The project consists of 6 floors in addition to two basement floors, the second basement floor is a Parking and the first basement floor is for various services, and the total area is about 11252 square meters.

1.4 Project objectives

1. Calculation of the different loads to which the structural subjected.

2. Selection of the structural system for the design based on quality and cost.

3. Distribute the columns on the basis of architectural plans.

4. Analysis and design of structural elements based on vertical and horizontal loads.

5. Using manual methods in designing, analyzing and using the experiences and knowledge gained in previous courses.

6. Use of structural design software such as (ATIR, SPcolumn, Found, SAFE, ETAPS).

1.5 Project Methodology

1. Studying the architectural plans and making the necessary modifications.

2. Distribution of columns and then making beams and ribs in a way that achieves the economic aspect.

3. Analysis of the loads affecting the structural elements.

4. Design of all structural elements.

5. Writing the project text depending on scientific research methods.

1.6 Reasons for choosing a project

This project was chosen for several reasons:

- Practical application of what has been learned regarding the structural design of the various elements in a series of reinforced concrete courses.
- The use of various programs in the design of columns, slabs, beams and foundations.
- Identify the mechanism through which projects are designed in the market.
- Choosing the best structural solutions.

This project is submitted to the Department of Civil Engineering in order to fulfill the conditions for graduation and obtaining a Bachelor's degree in Building Engineering.

1.7 project Scope

This project contains five chapters:

1. Chapter One: It includes the general introduction to the project.

2. Chapter Two: It includes the architectural description of the project.

3. Chapter Three: It includes the structural study of the project, including its structural elements and loads, and the functional description of these elements.

4. Chapter Four: Analysis and Structural Design of Structural Elements.

5. Chapter Five: Findings and Recommendations.

1.8 Project Schedule

Table 1-1: The Stages of the project (Introduction of graduation project @ second semester 2021-2022)

(Graduation Project @ First semester 2022-2023)

Week NO. / Task	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
Select project	■	■	■	■																												
Inception report					■	■	■																									
Collect information about the project							■	■																								
Architectural study of the building									■	■	■																					
Structural study of the building												■	■	■																		
Prepare the introduction															■	■																
Display the introduction																	■															
Structural analysis																		■	■	■	■	■	■									
Structural design																						■	■	■	■							
Prepare the project plans																									■	■	■	■				
Write the project																												■	■	■	■	
Project presentation																																■

CHAPTER

2

Architecture Description

2.1 INTRODUCTION

2.2 BASIC ELEMENT OF AZ HOTEL

1.2.2 Interior spaces
2.2.2 External spaces

2.3 AZ HOTEL PLANS

2.3.1 Second basement floor plan
2.3.2 First basement floor plan
2.3.3 Ground floor plan
2.3.4 Mezzanine floor plan
2.3.5 First floor plan
2.3.6 Second floor plan
2.3.7 Third floor plan
2.3.8 Fourth floor plan

2.4 AZ HOTEL ELEVATIONS

2.4.1 Northwest
2.4.2 Southwest
2.4.3 Southeast
2.4.4 Northwest

2.5 AZ HOTEL SECTIONS

2.5.1 Section A-A
2.5.2 Section B-B

2.6 3D SHOTS FOR AZ HOTEL

2.1 Introduction

The site analysis process is the initial step before the architectural design; In order to identify the exact mechanism of the building orientation process and then design it architecturally, taking into account the basic functions, the best view and many other things.

The architectural design process begins with the idea of the project and then the final form of the project, taking into account all the details such as ventilation, lighting, circulation, car parking and all other services and details such as spaces and openings, determine columns locations and other things...

Then comes the structural design of building, through which all the structural elements from beams, columns, slabs and foundations determine with certain dimensions and characteristics based on the nature of the load on each of them.

Since hotel projects require the provision of all social services, unlike other buildings, the project was chosen to be a structural design project for a hotel called AZ in Dura city specifically in the AL-Hijri which located at southeast of Dura, and the presence of such a hotel in such an area would work to improve the economy of the region by attracting tourists.

2.2 Basic Elements of AZ Hotel

The project areas are divided into internal and external spaces tied together to reach the goals that we need it:

2.2.1 Interior spaces

The interior area of the project is 10691 m^2.

Interior spaces divided to:

1. **Parking**

   It is located at the second basement floor with an area equal to 1913 $m^{2.}$

2. **2 Restaurants**

   They are located at the first basement floor and ground floor with an area equal to 265 m^2.

3. **Gym**

   It is located at the first basement floor with an area equal to 55.7 m^2.

4. **Kitchen**

   It is located at the First basement floor and it has a kitchen panty, the area of the whole Kitchen equal to 209.4 m^2.

5. **Generator room**

   It is located at the second basement floor with an area equal to 24.1 m^2.

6. **Central air conditioning room**

   It is located at the second basement floor with an area equal to 24.1 m^2.

7. **Laundry room**

   It is located at the second basement floor with an area equal to 26 m^2.

8. **Show Hall**

   It is located at the Ground floor with an area equal to 51 m^2.

9. **Cafeteria**

   It is located at the Ground floor with an area equal to 105 m^2.

10. **Music teaching hall**

    It is located at the First floor with an area equal to 153 m^2.

11. **Bed Rooms**

    They are Located at First, Second, Third and fourth Floors and they are vary between masters to Individual rooms with area of 32 m^2.

2.2.2 External spaces

Consisting of:

1. Green spaces.
2. Yards.

3. Swimming pools.
4. Parking.

2.3 AZ Hotel Plans

AZ Hotel consists of 8 floors as follows:

2.3.1 Second basement floor plan

It is a Parking with an area of 1983 m^2 at level -6.00.

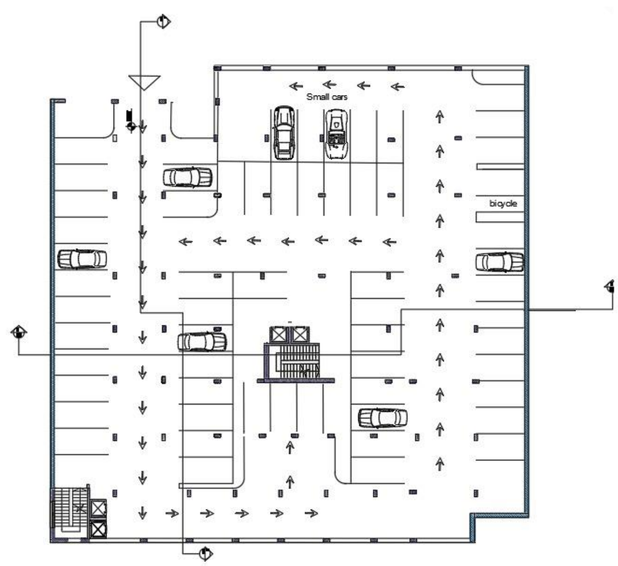

Figure 2-1: Basement two Floor

2.3.2 First basement Floor Plan:

It is consists of a Restaurant, Gym, Kitchen, bedrooms and bathrooms for stuff, the area of it equal to 1574m^2 and it located at level -3.12.

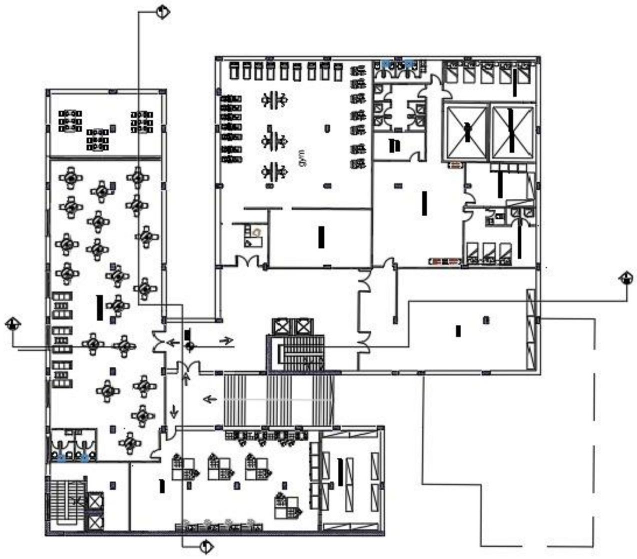

Figure 2-2: Basement One Floor

2.3.3 Ground Floor Plan:

It is consists of a Restaurant, cafeteria, Management rooms, Show hall, Reception and bathrooms, the area of it equal to 1886 m^2 and it located at level 0.00.

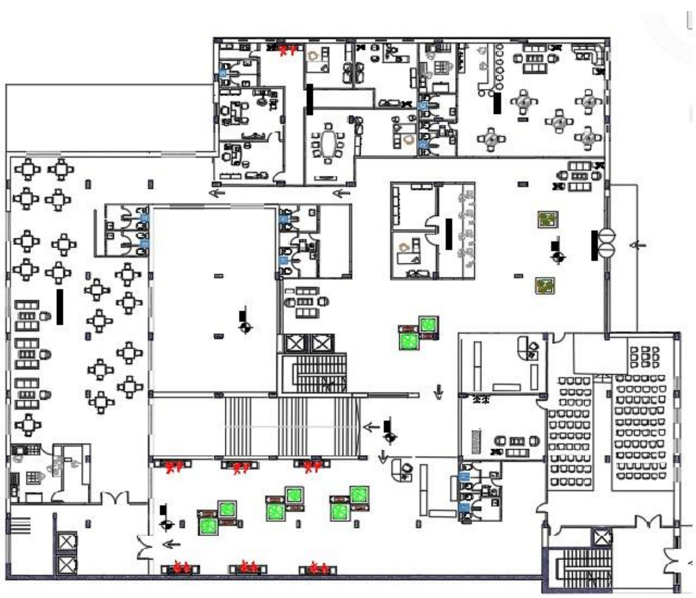

Figure 2-3: Ground Floor

2.3.4 Mezzanine Floor Plan:

With area of 1265 m^2 and it located at level +4.

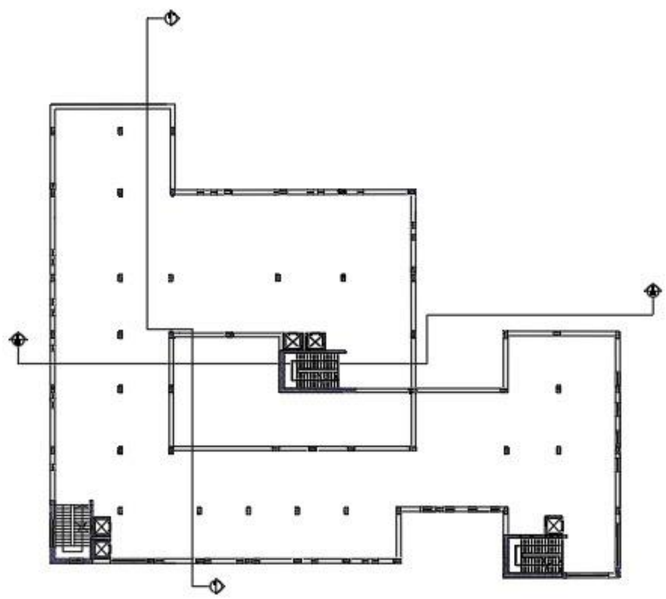

Figure 2-4: Mezzanine Floor

2.3.5 First Floor Plan:

It is consist of hall of leaning music and different types of bedrooms, with area of 1600m^2, and it located at level +6.00.

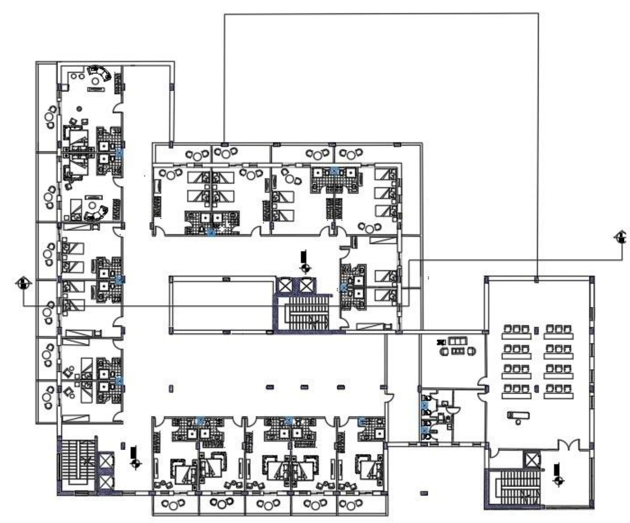

Figure 2-5: First Floor

2.3.6 Second Floor Plan:

It is consist of Bedrooms, with area of 1264m^2 and it located at level +9.12.

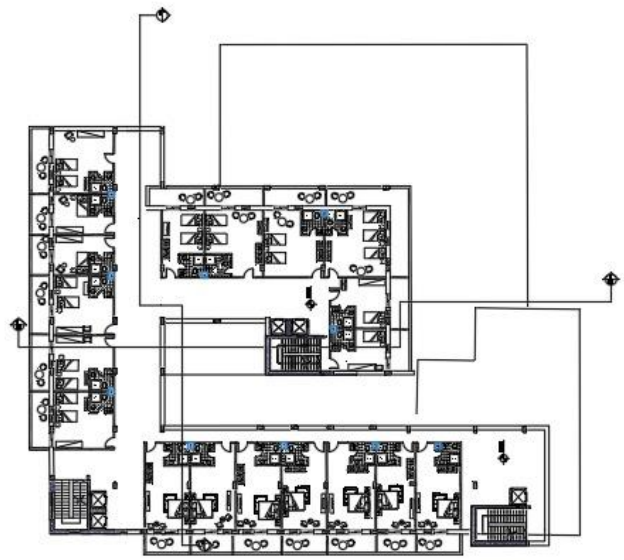

Figure 2-6: Second Floor

2.3.7 Third Floor Plan:

It is consist of Bedrooms, with area of 843m^2 and it located at level +12.12.

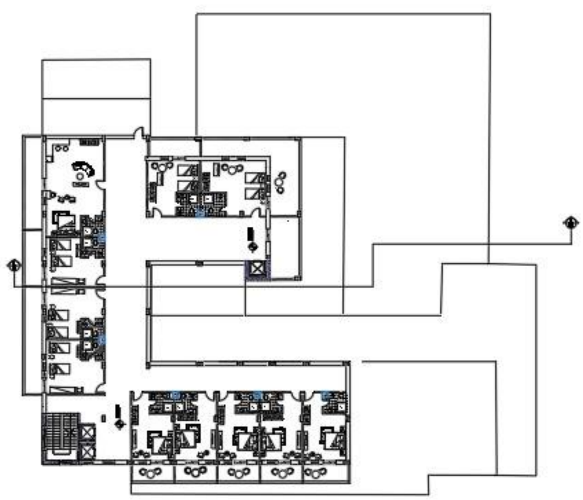

Figure 2-7: Third Floor

2.3.8 Fourth Floor Plan:

It is consist of Bedrooms, with area of 632m^2 and it located at level +15.12.

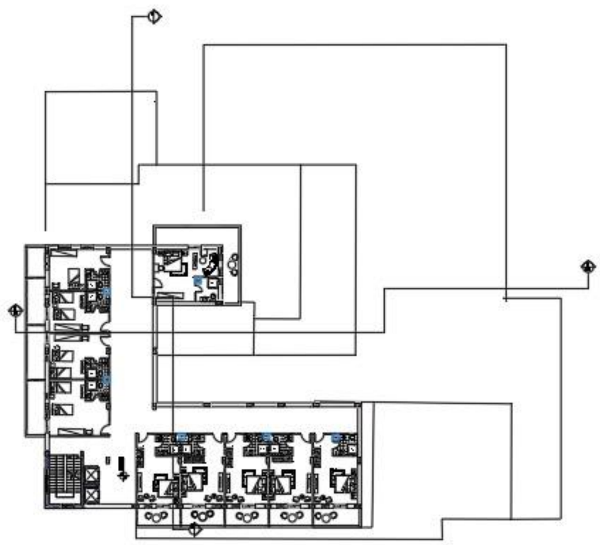

Figure 2-8: Forth Floor

2.4 AZ Hotel Elevations

The Elevations give an initial view of the building, so taking care of them is one of the most important things.

2.4.1 Northwest:

It is considered the main elevation in which the entrance appears, and it located at the main street, and it is noticeable that it is made from glass, which adds to the building the character of modernity.

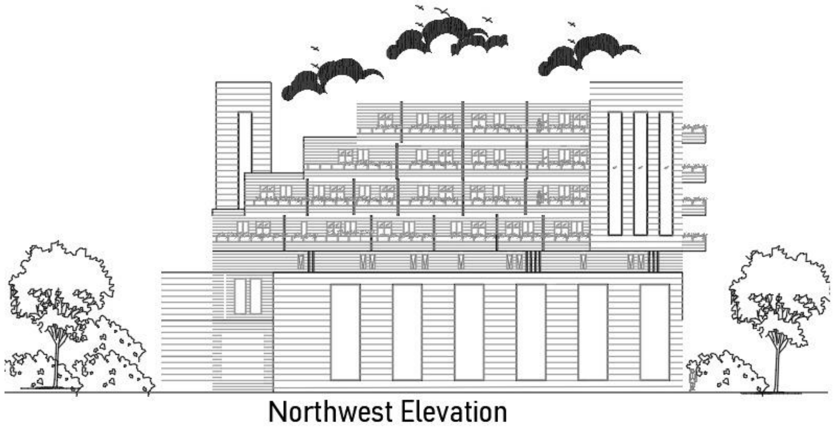

Figure 2-9: Northwest Elevation

2.4.2 Southwest:

This elevation shows the different levels on which the hotel was built, in addition shows the clear setbacks.

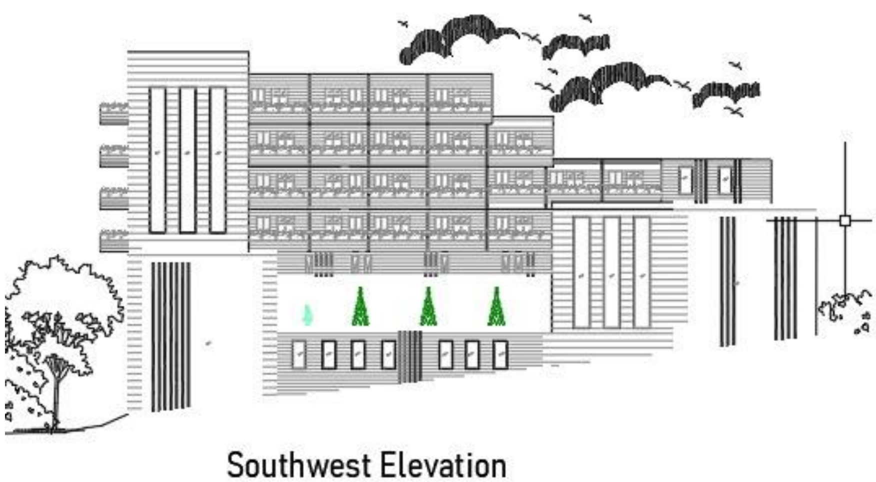

Figure 2-10: Southwest Elevation

2.4.3 Southeast:

This elevation appears on flat ground.

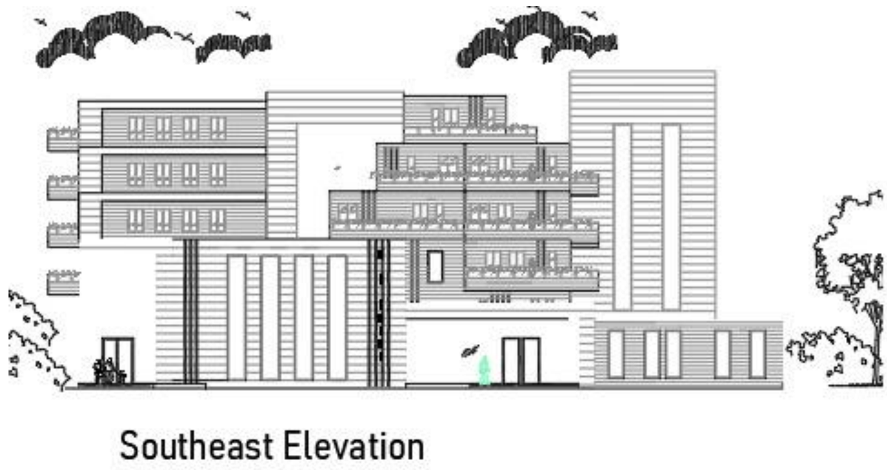

Figure 2-11: Southeast Elevation

2.4.4 Northwest:

It shows the setbacks on the different floors, and the different function on each floor.

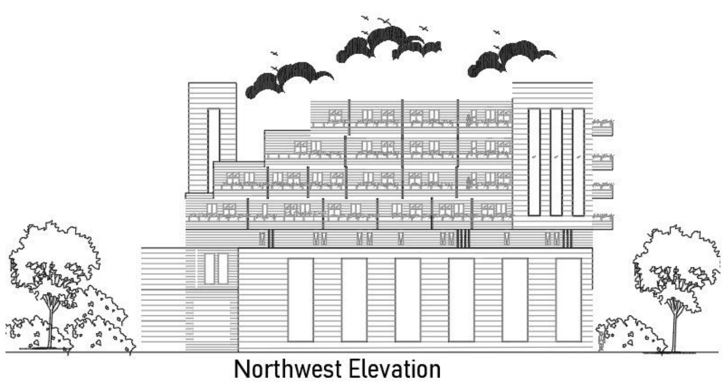

Figure 2-12: Northwest Elevation

2.5 AZ Hotel Sections

The sections are important to clarify some of the details inside the building.

Section A-A

This section was taken in the staircase, and shows some interior details such as doors, seats, etc.

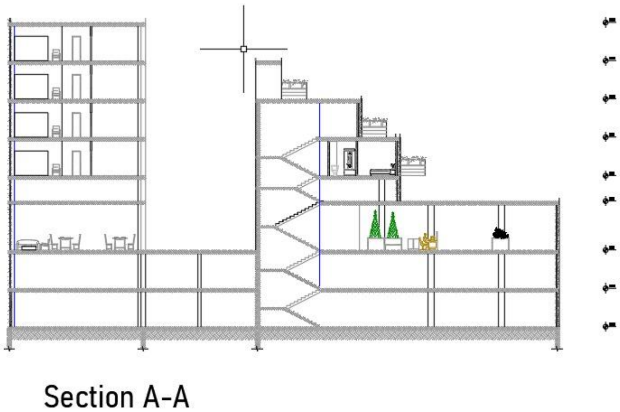

Figure 2-13: Section A-A

Section B-B

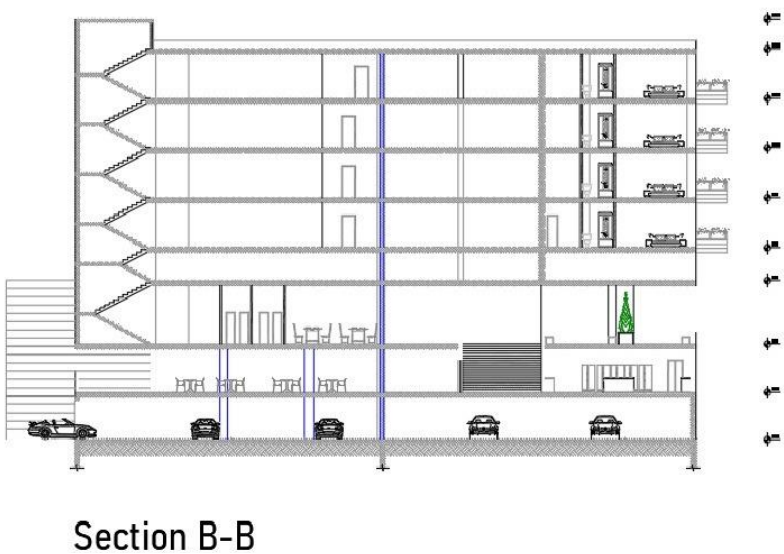

Figure 2-14: Section B-B

2.6 3-D Shots for AZ Hotel

Figure 2-16: Shot for AZ Hotel

Figure 2-17: Shot for AZ Hotel

CHAPTER

3

Structural Description

3.1 Introduction

3.2 The goals of the structural design

3.3 Scientific tests

3.4 Stages of structural design

3.5 Loads acting on the building

3.6 Structural elements of the building

3.1 Introduction:

The main objective of the process design is to ensure the existence of necessary operating advantages with structural elements on the most suitable dimensions in terms of security and economic terms.

The knowledge of structural elements of any project is essential in the design of reinforced concrete structures to make comparisons between different types of these elements for the construction of safer system. So, the structural elements that go into the design of this project will described.

3.2 The Goal of the Structural Design:

The structural design is an integrated and balanced structural system capable of carrying it meet the established requirements and desires of users, and thus determines the structural elements from the following:

1. Factor of Safety: Is achieving by selecting sections for structural elements capable of withstanding the forces and resulting stresses.
2. Economy: Checked by choosing the appropriate building materials and by selecting the perfect low-cost section.
3. Serviceability: To avoid excessive landing (deflection), cracks.
4. Preservation of architectural design.
5. Preserving the environment.

3.3 Scientific Tests:

Before the design of any construction project some test must done. For example, tests of the soil to know the bearing capacity of the soil, specifications, type, the underground water level and depth of the foundation layer.

3.4 Steps for Structural Design:

We will divide the structural design of the project into two steps:

The first step:

In this step, the appropriate structural system of project construction and analysis for this system will be determined.

The second step:

The structural design of each element according to the chosen construction system and executive structural plans.

3.5 Loads Acting on the Building:

Is a group of forces that is designed to bear, any building is subjected to several types of loads they must be calculated and selected carefully because any error in identifying and calculating loads reflect negatively on structural design of various structural elements.

The permanent forces and resulting from gravity and location do not change during the age of the building, such as loads from structural elements self-weight and the weights of the items based upon permanently as cutters and walls, as well as the weight of the body adjacent to the building. Beside the calculation and estimate of the loads by knowing the dimensions of the structural elements and specific gravity of the material used in the manufacture of structural elements. These elements include concrete, steel reinforcement, plaster, bricks, tiles, finishes, and the stone used in building coverage abroad.

3.5.1 Vertical Loads:

It's dividing to:

3.5.1.1 Dead Loads:

These loads result from the self-weights of the structural elements, the self-weight of the building, in addition to the weight of the soil in the retaining walls. These loads are considered to have a permanent effect on the building.

The following table **(Table 3-1)** shows the Specific weights of the materials for which the self-weights are calculated according to the ACI code for loads.

Table 3-1: Specific weights for materials which use at the structural elements

Material	Specific weight (KN/m^3)
1. Tile	23
2. Mortar	22
3. Sand	17
4. Hollow Block	10
5. Reinforced concrete	25
6. Plaster	22
7. Partitions	1

3.5.1.2 Live Loads:

Buildings of all kinds are exposed to several uses, and for these uses loads may be concentrated or distributed. Live loads are classified into:

1. Static loads: such as furniture and electrical appliances.

2. People Loads: varies according to the use of the building

3. Executing Loads: Like Cranes

Table (3-2) shows the values of live loads according to the Jordanian code of loads and forces.

Table 3-2: Live loads in different buildings

Type of area	Live load (KN/m^2)
1. Restaurants	4
2. Platform	7.5
3. Stairs	4
4. Corridors	4

Live load selected to be 4 KN/m^2 for our project.

3.5.2 Horizontal Loads:

They include snow, earthquake, and wind loads, they vary by amount, location, and direction also it's depend primarily on the unit area they faced.

There are several factors to determine these loads which are:

1. The speed.
2. Building height.
3. The importance of the building.

3.5.2.1 Earthquake Loads:

Produce earthquakes of horizontal and vertical vibrations due to the relative motion of the earth rock layers, resulting in strong cut affect the origin, and these loads must take into account during the design to ensure resistance of earthquakes. This will be resisted by shear walls in the building.

3.5.2.2 Wind Loads:

It is determined based on the maximum wind speed that varies with the height of building above sea level.

Figure 3-1 shows positive and negative pressures that are formed from wind load.

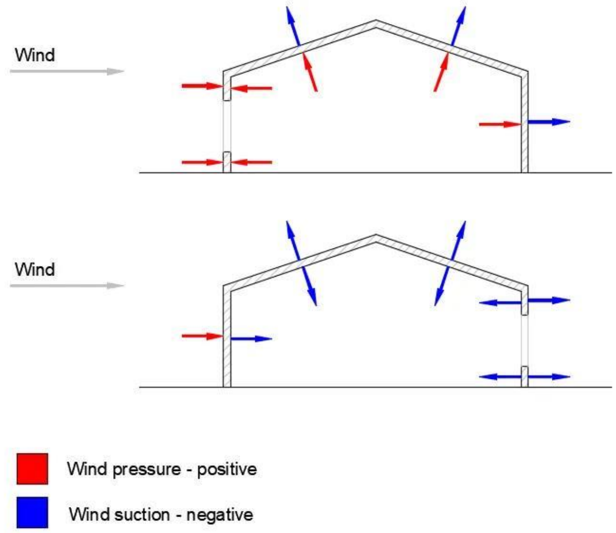

Figure 3-1: wind pressures

3.5.2.3 Snow Loads:

It is determined based on the height from the sea level.

Table (3.3) Shown the snow loads based on the height from the sea level according to the Jordanian code of loads and forces 2006.

Table 3-3: snow loads based on the height from the sea level

Height of the building above sea level (h) m	S_0 (KN/m^2)
h>250	0
500>h>250	(h – 250) / 800
1500>h>500	(h – 400) / 320

$$S_d = \mu_i * S_0$$

$S_0: Snow\ load\ (KN/m^2)$

$\mu_i = Shape\ Factor\ (0.8)$

Dura is located at 800 m above sea level.

$$S_0 = \frac{800 - 400}{320} = 1.25\ KN/m^2$$

$$S_d = 0.8 * 1.25 = 1\ KN/m^2$$

3.5.3 Secondary Loads:

Such as shrinkage and Temperature loads resulting from the drying of concrete and Settlement of the foundation soil. This problem is solved by placing expansion joints inside the building. We don't need expansion joint at our project.

3.6 Structural Elements of the Building:

All buildings are usually consisting of a set of structural elements that work together to satisfy the continuity of the building and its suitability for human use. The most important of these slabs, beams, columns and load-bearing walls, it must define.

Figure 3-2 shows all structural elements.

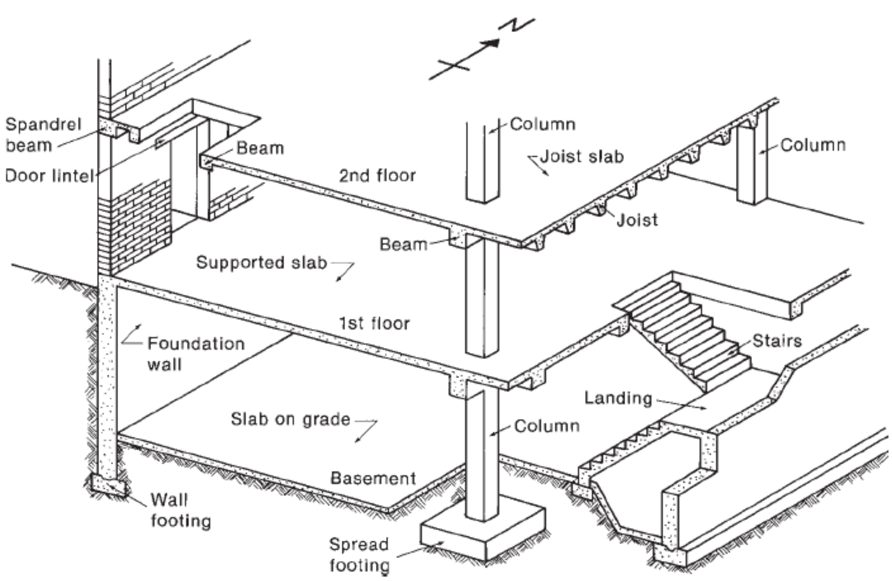

Figure 3-2: Structural elements

3.6.1 Slabs:

Structural elements such as beams, columns and walls are capable of delivering vertical forces due to the loads affecting on the building.

Slabs divided into two types:

1. Solid slabs.
2. Ribbed slabs.

In this project, two types of Slabs will use, and will clarify the structural design in the subsequent chapter, and these types are:

- One Way Ribbed Slab.
- One Way Solid Slab.

The following is a description of the different types of slabs:

3.6.1.1 Solid Slabs:

It's divided into:

3.6.1.1.1 One way Solid Slab:

The solid slab called one way if it has those categories:

- L/b is equal or more than 2.
- Beams located at two directions.
- The concrete slab is cast in one uniform thickness without any voids.
- The loads transferring in the short direction and the slab may be treated as a beam.
- The design done by using strip of 1m.
- The live load is very large.

  Figure 3-3 shows One Way Solid Slab.

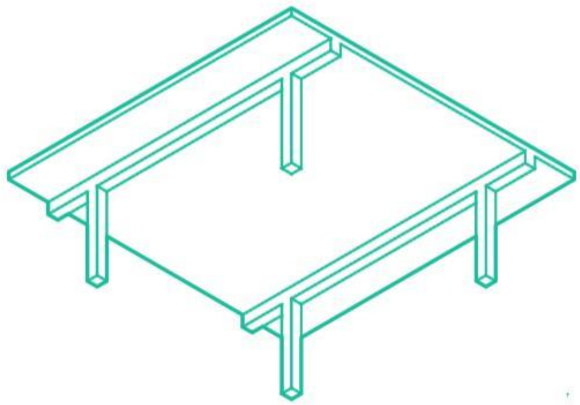

Figure 3-3: One way Solid Slab

3.6.1.1.2 Two way Solid Slab:

The solid slab called one way if it has those categories:

- ➢ If L/b is less than 2.
- ➢ Beams are located at four directions to support them.
- ➢ The loads transferring to all four supporting beams

  Figure 3-4 Shows two way Solid Slab.

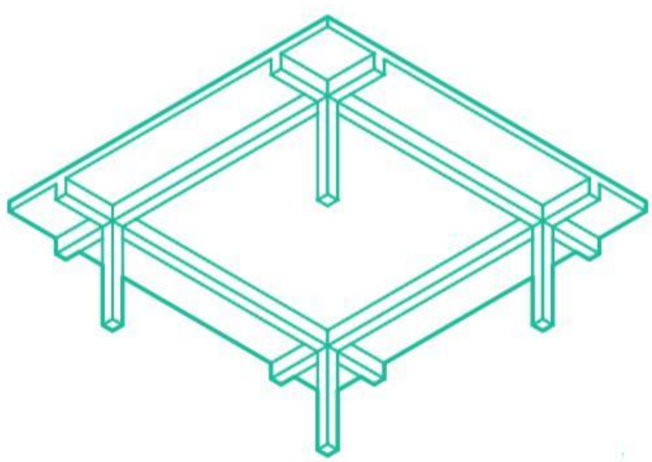

Figure 3-4two way Solid Slab

3.6.1.2Ribbed Slabs:

It's divided into:

3.6.1.2.1 One way Ribbed Slab:

- Reinforcement from one direction.
- This system more economical for buildings when the loads are small and the spans large such as schools, hotels…
- The concrete in the tension zone is ineffective so the area is left open between ribs or filled with lightweight material to reduce the self-weight of the slab.

  Figure 3-5 Shows One way Ribbed slab.

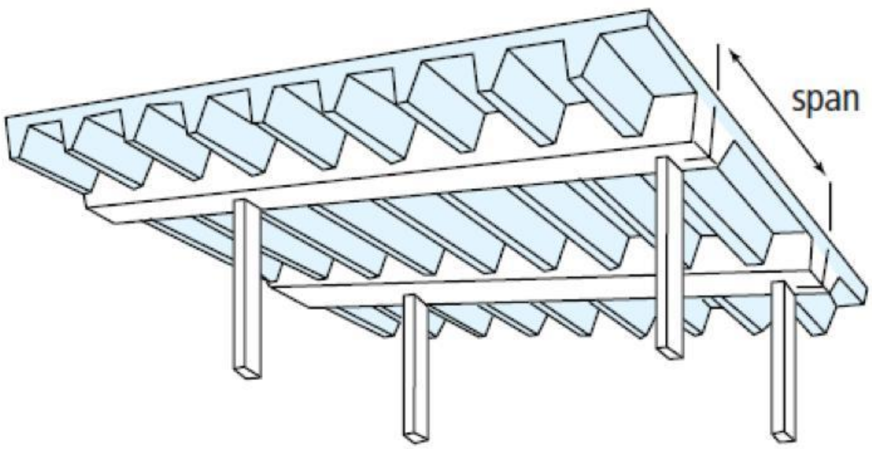

Figure 3-5 One way Ribbed Slab

3.6.1.2.2 Two way Ribbed Slab:

- In Two way Ribbed Slab Both ends of the slab become supported by walls or columns at different levels with one of the edges having a waffle design pattern. The Ribs are vertical to one edge, and inclined to the other edge.
- It is used to cover large areas, especially when the distances between spans are close and the distances are greater than 6 m.
- Reinforcement from two directions.

Figure 3-6 Shows two way Ribbed slab.

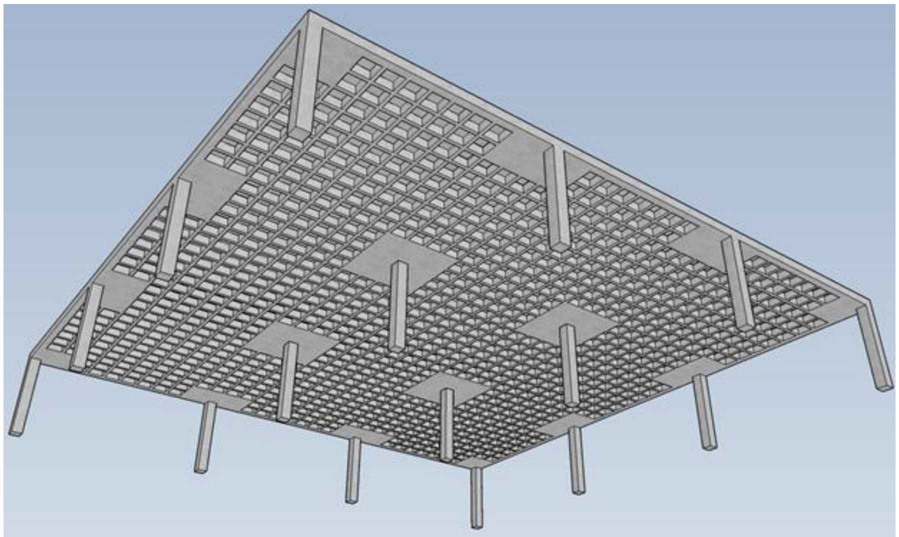

Figure 3-6 two way Ribbed Slab

3.6.2 Beams:

The basic structural elements in moving load of tiles into columns, and are of two types:

- **Hidden Beam**: Hidden inside Slabs, its height equally to the height of slab.
- **Dropped Beam**: its height is larger than the height of slab, also called T-section or L-section.

Figure 3-7 shows hidden and drop beams.

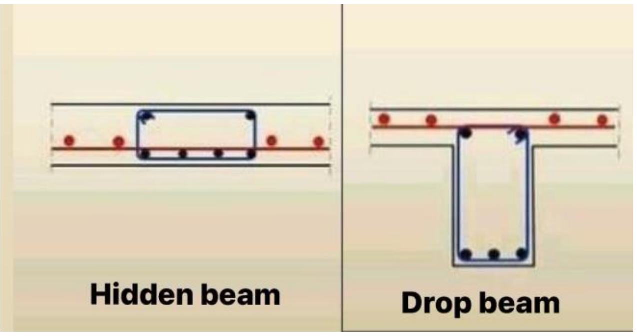

Figure 3-7 Hidden and Drop beams

Beams are used for:

- Make frames by attaching columns to each other.
- They are placed under the walls to load the walls on them.
- Reduce the buckling for columns.

3.6.3 Columns:

- Columns carry loads from slabs and beams to the foundations, and there are two types of columns: long columns and short columns.
- There are several types of columns sections, including circular, square, rectangular and composite.

The columns used in this hotel vary between short and long concrete columns. The whole columns are rectangular.

Figure 3-7 shows the types of columns.

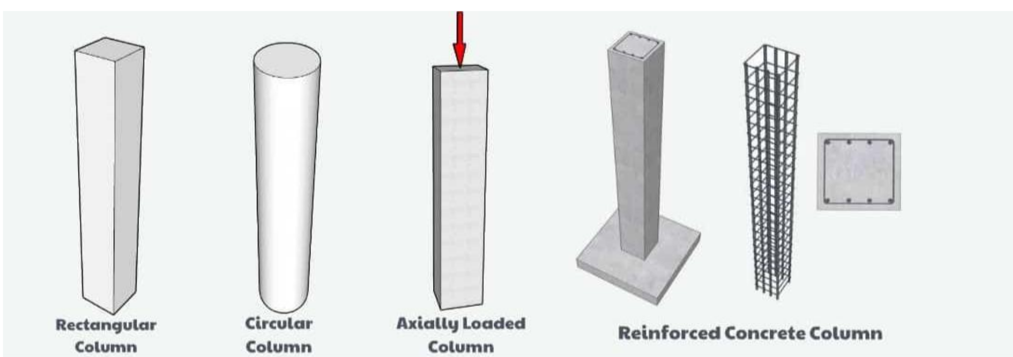

Figure 3-8 Types of columns

3.6.4 Shear Walls:

- They are the elements that resist lateral loads such as wind and earthquakes.
- It must be taken into account that these walls are available in both directions, and their number is at least 3, two in the same direction and the third at the other direction.
- Shear walls shall be sufficient to minimize torque.

Shear walls in this project in stair walls and elevator walls as well as others starting from the foundations.

Figure 3-9 shows shear walls.

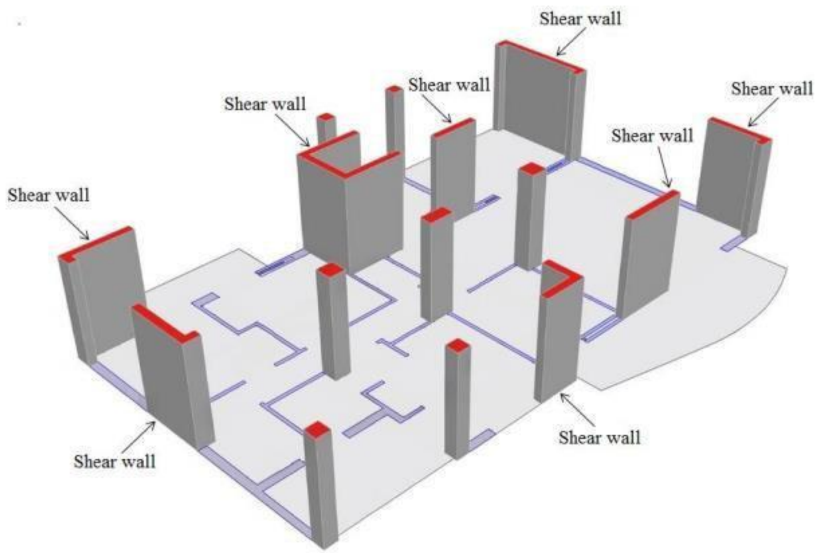

Figure 3-9 Shear walls

3.6.5 Footing:

- It is a structural member used to support columns and walls and to transmit and distribute their loads to the soil.
- The last element to be designed and the first to be executed.
- Responsible for bearing loads of various kinds: dead loads, dynamic loads and live loads.
- The foundation that is close to the surface of the earth is called the **Surface foundation**.
- The deep foundation that transfers the loads of the structure to the deep soil layers is called the **Deep foundation**.
- There are several types of foundations, including Isolates, wall footing, Mat footing, Strap footing, Pile footing and combined footing.

Several types of foundation are expected to be used in this project.

Figure 3-10 shows Reinforcing details for isolated footing.

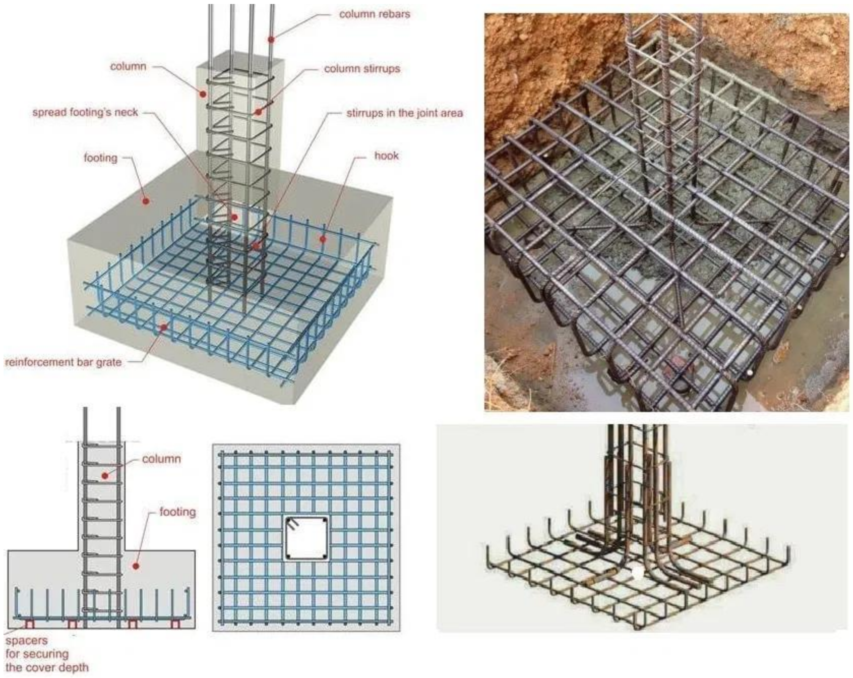

Figure 3-10 Reinforcement detailing of isolated footing

3.6.6 Stairs:

- Consist of rises (vertical distance between two steps), runs (The depth of the step) and landings (the horizontal part of the staircase without rises).
- There are different types of stairs: Single flight stairs, double flight stairs, three or more flights of stairs and cantilever stairs…

Figure 3-11 shows single flight stair.

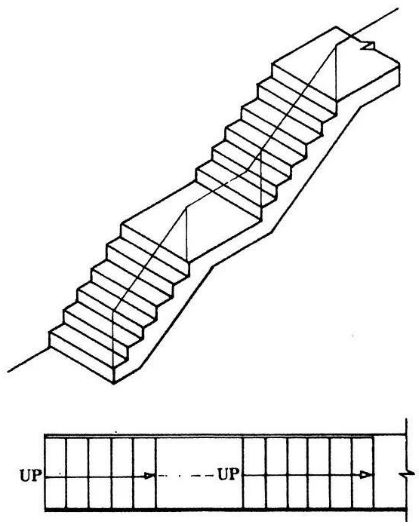

Figure 3-11 Single flight stairs

3.6.7 Basement walls:

- The basement walls are either load bearing to bear the load of super structure or as non load bearing walls.
- The basement outer walls are act as retaining wall and it is some time called as cantilever retaining wall because it is free standing structure without lateral supports at top.
- The lateral pressure at the top of basement wall is minimum and increased with the depth and maximum at the bottom.
- The forces created by the earth may push the basement wall forward or over turn when it is not designed well properly.
- Designing the basement wall, all the forces should be taken in to consideration such as earth pressure, rain water effect and vibratory pressure due to side traffic.
- The width of foundation is increase from top level of earth up to the bottom of the foundation and the width should be maximum at bottom.
- The basement wall should be safe against excessive foundation pressure, sliding and over turning.

  Figure 3-12 shows Basement wall.

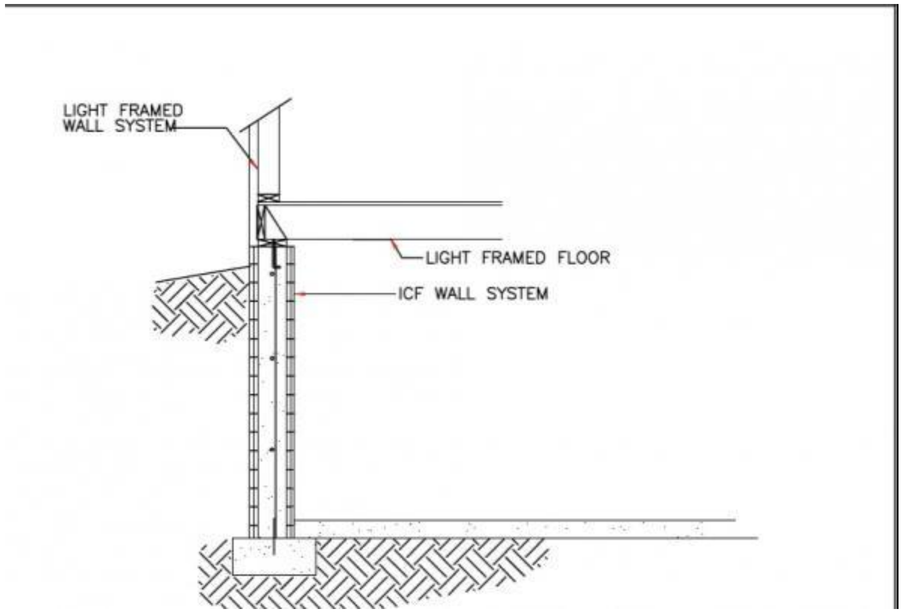

Figure 3-12 Basement wall

CHAPTER

4

Design Of Structural Members

4.1 Introduction

4.2 Factored Load

4.3 Determination of thickness for one way ribbed slab

4.4 One way ribbed slab design

4.5 Beam design

4.6 Long column (C1) from group A Design

4.7 Stair Design

4.8 Isolated footing (F1) Design

4.9 Shear wall Design

4.10 Basement wall Design

4.1 Introduction

Concrete is a one of construction materials which is composed of cement, aggregate, water and chemical admixtures.

After mixing the previous components, the concrete will take a shape and it will reach to its hardens, the water will reacts with the cement which bonds the other components together.
Concrete is used to make pavements, structures, roads…
In this project there are three types of slabs: one way solid slab, one way ribbed slab and two way ribbed slab.

“ATER-software” will use to find the shear and moment, then hand calculations will make.

$f_c' = 24\ MPa$

$Fy = 420\ MPa$

4.2 Factored Load

The factored loads for the structural analysis and design for our project determined as follows:
$U = 1.2D + 1.6\ L \ldots\ldots\ldots\ldots.\boldsymbol{ACI - 318 - 08(9.2.1)}$

D: Dead Load (KN)

L: Live Load (KN)

4.3 Determination of thickness for one way ribbed slab

Any structure may expose to different types of loads such as dead and live loads (its value depends on the type of structure).

The minimum thickness must satisfy by **ACI table (9.5.a) shown below:**

Minimum thickness for one way ribbed slab:

$$h_{min} = \frac{L}{18.5} = \frac{6.0}{18.5} = 0.324\ m \qquad (one\ \ End\ continuous)$$

$$h_{min} = \frac{L}{21} = \frac{6.60}{21} = 0.31\ m \qquad (Both\ End\ continuous)$$

For Rib 8 in the first basement floor the thickness is 32 cm including (24cm block and 8 cm topping).

4.4 One way ribbed slab design

For Rib 8 in the first basement floor as shown in figure 4-1:

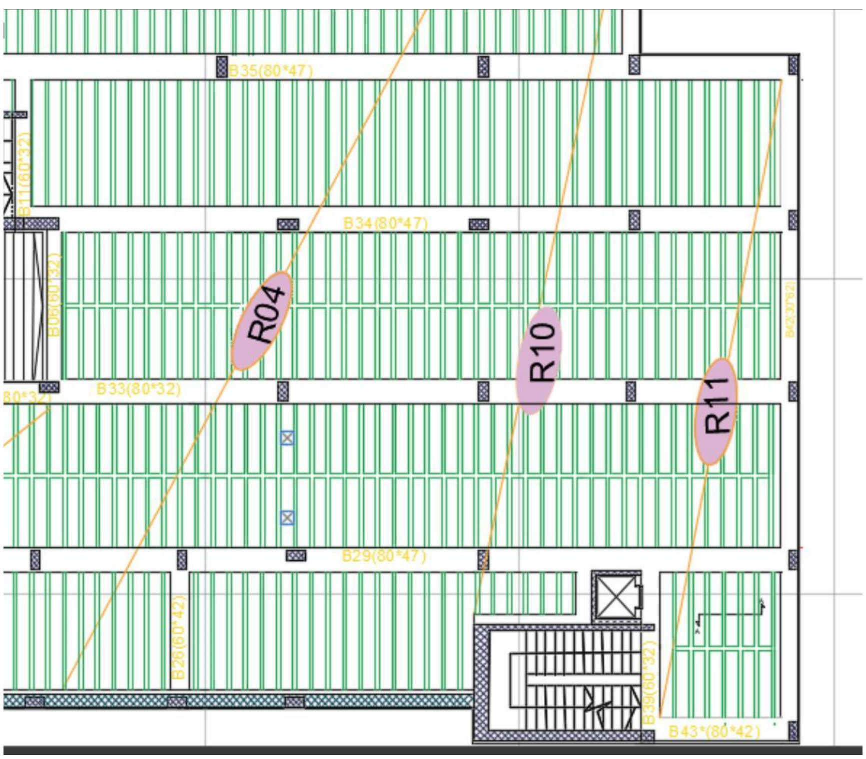

Figure 4-1 Rib 8

4.4.1 Topping design

Table (4 – 1) Calculation of the total dead load for topping

Dead load from	Specific density	calculations	KN/m
Tiles	23	0.03 * 23 * 1	**0.69**
Mortar	22	0.03 * 22 * 1	**0.66**
Coarse Sand	17	0.07 * 17 * 1	**1.19**
Topping	25	0.08 * 25 * 1	**2**
Interior Partition	1	1	**1**
ε			**5.54**

Live Load calculations: 4 * 1 = 4 KN/m

Total Factored Load: $w_u = 1.2D + 1.6\ L$

$$= 1.2 * 5.54 + 1.6 * 4 = 13.048\ \ KN/m$$

$$M_u = \frac{w_u l^2}{12}$$

$$= \frac{13.048 *\ 0.4^2}{12} = 0.174\ KN.\frac{m}{m}\ of\ strip\ width.$$

$\emptyset M_n \geq M_u$ – *Strength condition, where* $\emptyset = 0.55 - for\ plain\ concrete.$

$$M_n = 0.42\ \lambda \sqrt{f_c'}\ \ S_m$$

Where S_m for rectangular section of the slab:

$$S_m = \frac{bh^2}{6}$$

$$= \frac{1000 * 80^2}{6}$$

$$= 1066666.67\ mm^2$$

$$M_n = 0.42 * 1 * \sqrt{24} * 1066666.67 * 10^{-6} = 2.19\ KN.m$$

$$\emptyset M_n = 0.55 * 2.19 = 1.2045\ KN.m \gg M_u = 0.195\ KN.m$$

No reinforcement is required by analysis, so minimum reinforcement will use (Shrinkage and temperature reinforcement):

$$\rho_{shrinkage} = 0.0018 \qquad (ACI\ 7.12.2.1)$$

$$A_s = \rho b h_f$$

$$= 0.0018 * 1000 * 80$$

$$= 144 \frac{mm^2}{m} strip$$

Try bar Ø8 with $A_s = 50.27\ mm^2$

Bar numbers $n = \frac{A_s}{A_{s\emptyset 8}} = \frac{144}{50.27} = 2.87$

$Take\ 3\emptyset 8\ /m\ with A_s 150.8 \frac{mm^2}{m}\ strip\ or\ \emptyset 8/30cm$

$Step\ (s) is\ the\ smallest\ of:$

$1.\ 3h = 3 * 80 = 240\ mm - control$

$2.\ 450\ mm$

$3.\ s = 380(\frac{280}{f_s}) - 2.5C_c$

$$f_s = \frac{2}{3} f_y$$

$$f_s = \frac{2}{3} * 420 = 280\ MPa$$

$$s = 380\left(\frac{280}{280}\right) - 2.5 * 20 = 330\ mm$$

$\boldsymbol{Take\ \emptyset 8\ /\ 20\ cm\ in\ both\ directions}$ $s = 200\ mm < s_{max} = 240mm - ok$

4.4.2 Load Calculations

For one way ribbed slab, the total dead load to be used in the analysis and design as follows:

Table (4 – 2) Calculation of the total dead load for Rib8

#	Dead Load From	Density (KN/m^3)	Calculations	KN/m/Rib
1	Rib	25	0.27 * 25 * 0.12	**0.81**
2	Topping	25	0.08 * 25 * 0.52	**1.04**
3	Plaster	22	0.03 * 22 * 0.52	**0.3432**
4	Block	10	0.27 * 10 * 0.4	**1.08**
5	Sand	17	0.07 * 17 * 0.52	**0.6188**
6	Tile	23	0.03 * 23 * 0.52	**0.3588**
7	Mortar	22	0.03 * 22 * 0.52	**0.3432**
8	Partition	1	1 * 0.52	**0.52**
$\boldsymbol{\varepsilon}$				**5.11**

Total Dead Load = $5.11/0.52 = 9.83\ KN/m^2$

Live Load = 4 * 0.52 = 2.08 KN/m/Rib

Factored dead load = 1.2 * 5.11 = 6.13 KN/m/Rib

Factored live load = 1.6 * 2.08 = 3.33 KN/m/Rib

$w_u = 6.13 + 3.33 = 9.46\ KN/m/Rib$

4.4.3 Determination of b_e

Effective Flange width b_e

b_e For T-section is the smallest of: **(ACI 8.12.2)**

1. $b_e \leq \frac{L}{4} = \frac{6.6}{4} = 1.65m$
2. $b_e \leq b_w + 16\ h_f = 12 + 16 * 8 = 140\ cm$
3. . $be \leq$ Center to Center spacing between adjacent beam =

   $\frac{40}{2} + \frac{40}{2} + 12 = 52\text{cm} \ldots \ldots \ldots \ldots \ldots \ldots \ldots Control$

4.4.4 Rib11 Design

By using ATIR program we get the envelope shear and moment diagrams as the follows:

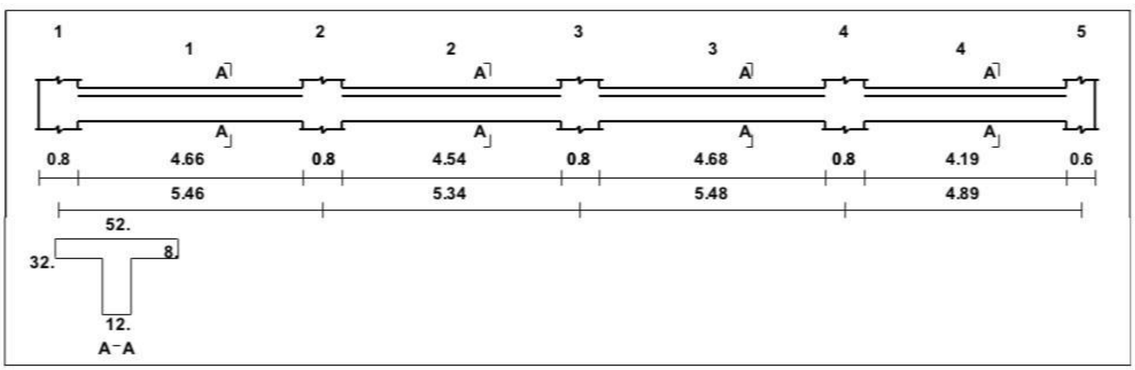

Figure 4-2 Rib 11 Geometry

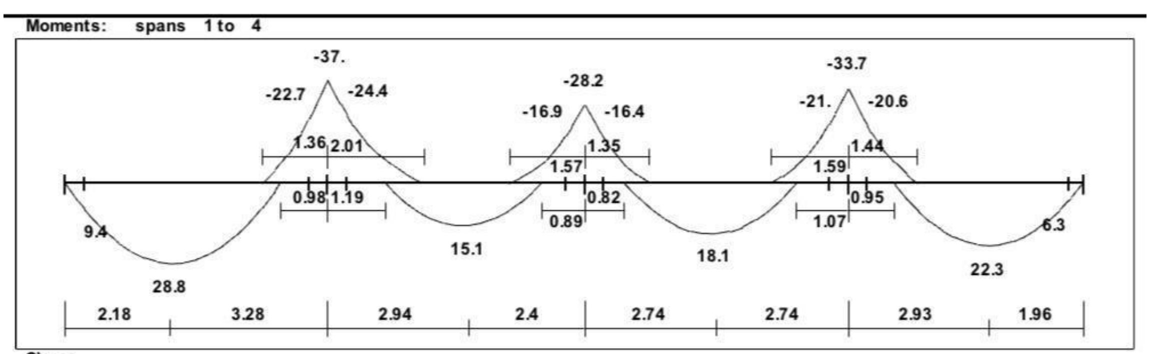

Figure 4-3 Moment Envelop for Rib11 (KN.m)

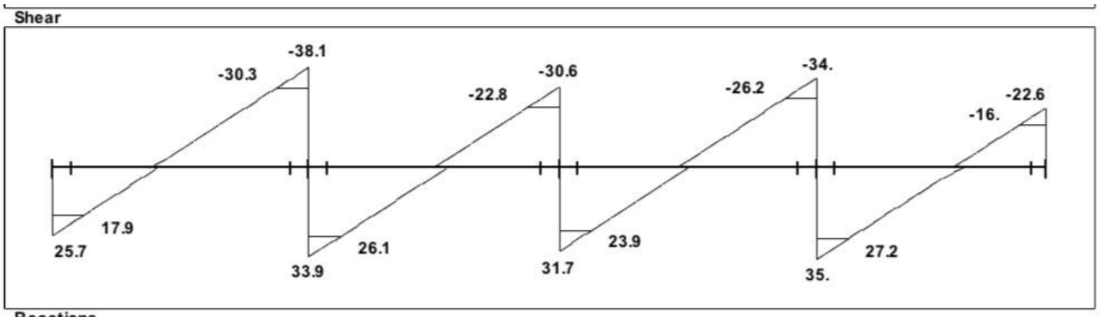

Figure 4-4 Shear Envelop for Rib11 (KN)

4.4.4.1 Design of Negative Moment of Rib11:

Assume bar diameter Ø 12 for main negative reinforcement.

$d = h - cover - d_{stirrup} - \frac{db}{2} = 320 - 20 - 10 - \frac{12}{2} = 284\text{mm}$

The Maximum negative moment at the face of support Mu $= -24.4KN.\text{m}$

$R_n = \frac{Mu}{\emptyset b w d^2}$

$= \frac{24.4*10^6}{0.9*120*284^2} = 2.84\text{MPa}$

$\text{m} = \frac{f_y}{0.85 f_c'}$

$= \frac{420}{0.85*24} = 20.59$

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

$= \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2*2.84*20.59}{420}}\right) = 7.3*10^{-3}$

$A_{s,req} = \rho b_w d$

$= 7.3*10^{-3}\ (120)\ (314) = 275.07\ \text{mm}^2$

Check for $A_{s,min}$

$A_{s,\,min}$ is the maximum of: -

$$A_{s,min} = 0.25\frac{\sqrt{f'_c}}{f_y}b_w d \geq \frac{1.4}{f_y}b_w d$$

1. $A_{s,\,min} = 0.25\frac{\sqrt{24}}{420}\ 120 * 284 = 99.38 mm^2$
2. $A_{s,\,min} = \frac{1.4}{420} * 120 * 284 = 113.6\ mm^2.\ Control$

$A_{s,req}$ = 275.07 mm² > $A_{s,min}$ 113.6 mm^2

Of bars $\frac{As}{As_{bar}} = \frac{275.07}{153.9} = 2$bars   * Note $A_{\Phi 14}$ = 153.9 mm²

Select 2 Ø 14

As provided= 307.88 mm² > $A_{s,req} = 275.07 mm^2 \ldots .OK$

Check for strain:

According to AC -318-11 (10.3.5)، ($\varepsilon_s \geq 0.005$)

$$a = \frac{A_s f_y}{0.85 b\ f'_c}$$

$$= \frac{307.88*420}{0.85*120*24} = 52.82 mm$$

$$c = \frac{a}{\mathcal{B}_1}$$

$$= \frac{52.82}{0.85} = 62.14\ mm$$

* Note $f'_c = 24\ MPa < 28$ Mpa → $\mathcal{B}_1 = 0.85$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right)$$

$$= 0.003\left(\frac{284-62.14}{62.14}\right) = 0.0107 > 0.005 \qquad \boldsymbol{0k}$$

$\therefore \emptyset = 0.9$.... OK.

$\emptyset M_n = \emptyset A_{sf_y}(\text{d} - \frac{c}{2})$

$= 0.9*307.88*420*(284 - (\frac{62.14}{2}))*10^{-6}$

$= 29.44$ KN.m $>$ Mu max $= 24.4$KN.m

4.4.4.1 Design of Positive Moment of Rib11:

For main positive reinforcement Assume Φ 12 bar diameter, stirrups Φ 10

$d = h - cover - d_{stirrups} - d_b/2 = 320 - 20 - 10 - 6 = 284$ mm.

The Maximum positive moment is $M_u = 28.8$ KN.m

Check if $a > h_f$ to determine whether the section will act as rectangular or T- section,

$M_{nf} = 0.85\, f_c' b_e h_f (d - \frac{h_f}{2})$

$$= 0.85 * 24 * 520 * 80 * \left(284 - \frac{80}{2}\right) * 10^{-6} = 207.068\, KN.m$$

$M_{nf} \gg \frac{\boldsymbol{M_u}}{\boldsymbol{\varphi}} = \frac{\mathbf{28.8}}{\mathbf{0.9}} = 32$ KN.m, the section will be designed as rectangular section with

$be = 520\ mm.$

$Rn = \frac{Mu}{\emptyset bwd^2}$

$= \frac{\mathbf{28.8*10^6}}{\mathbf{0.9*520*284^2}} = 0.763$ Mpa

$\mathrm{m} = \frac{f_y}{0.85 f_c'}$

$= \frac{420}{0.85*24} = 20.59$

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

$= \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2*0.763*20.59}{420}}\right) = 1.85*10^{-3}$

$A_{s,req} = \rho b_w d$

$= 1.85*10^{-3}$ (520) (284) = 273.208 mm^2

Check for $A_{s,min}$

$A_{s,\ min}$ is the maximum of: -

$A_{s,\ min} = 0.25\frac{\sqrt{f'_c}}{f_y} b_w d \geq \frac{1.4}{f_y} b_w d$

1. $A_{s,\ min} = 0.25\frac{\sqrt{24}}{420}\ 120 * 284 = 99.38 mm^2$
2. $A_{s,\ min} = \frac{1.4}{420} 120 * 284 = 113.6\ mm^2.\ Control$

$A_{s,\ req} = 273.208\ mm^2 > A_{s,\ min} = 113.6 mm^2$

Of bars $\frac{As}{Asbar} = \frac{273.208}{153.93} = 2$bars * Note $A_{\Phi 14} = 153.93\ mm^2$

Select 2 Ø 14 mm.

As provided= 307.87 mm^2

Check for strain:

According to AC -318-11 (10.3.5)، ($\varepsilon_s \geq 0.005$)

$$a = \frac{A_s f_y}{0.85 b\, f_c'}$$

$$= \frac{307.87 * 420}{0.85 * 520 * 24} = 12.19 mm$$

$$c = \frac{a}{\mathcal{B}_1}$$

$$= \frac{12.19}{0.85} = 14.34\ mm$$

* Note $f_c' = 24\ MPa < 28$ Mpa $\rightarrow \mathcal{B}_1 = 0.85$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right)$$

$$= 0.003\left(\frac{284 - 14.34}{14.34}\right) = 0.0564 > 0.005 \qquad \mathbf{0k}$$

4.4.5 Shear design for Rib11:

The maximum shear force at the distance d from the face of support **V_u= 30.3 KN**

Shear strength V_c, provided by concrete for the rib may be taken 10% greater than for beams. This is mainly due to the interaction between the slab and closely spaced ribs. (ACI, 8.13.8).

$$d = h - cover - d_{stirrup} - \frac{db}{2} = 320 - 20 - 10 - \frac{14}{2} = 283\text{mm}$$

$V_c = \frac{1.1}{6} \lambda \sqrt{f_c'} b_w d$

$= \frac{1.1}{6} \sqrt{24} * 120 * 283 * 10^{-3} = 30.50KN$

$\emptyset V_c$ = 0.75*30.50 =22.88 KN

0.5 $\emptyset V_c$ = 0.5*22.88 =11.44 KN

0.5 $\emptyset V_c < V_u < \emptyset V_c$ **OK.**

Minimum shear reinforcement is required except for concrete joist construction. so

، No shear reinforcement is provided.

4.5 Beam 43 design:

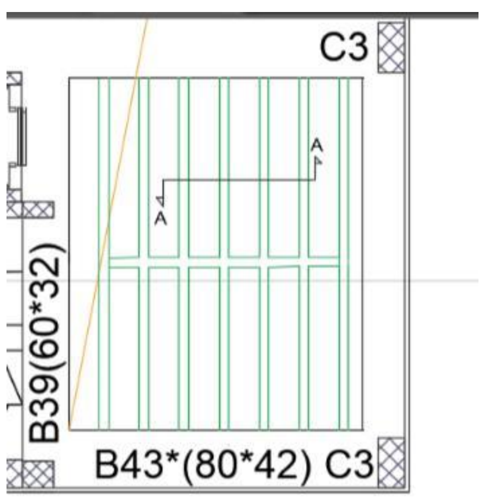

Figure 4-5 beam43

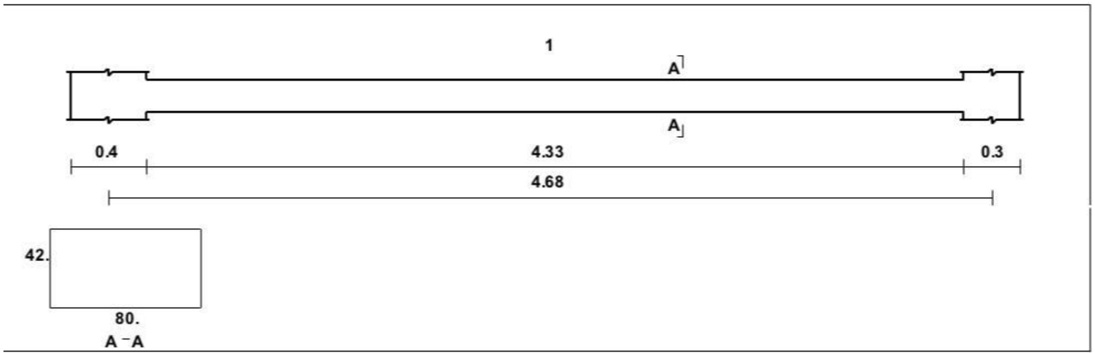

Figure 4-6 The Geometry for beam43

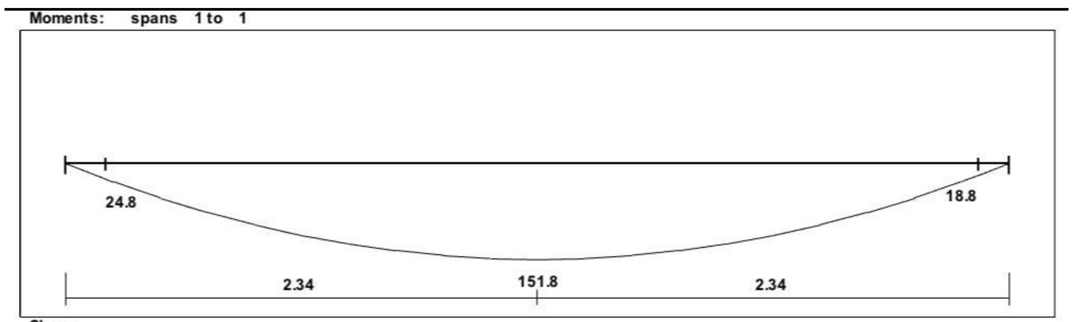

Figure 4-7 Moment Envelop for Beam 43 (KN.m)

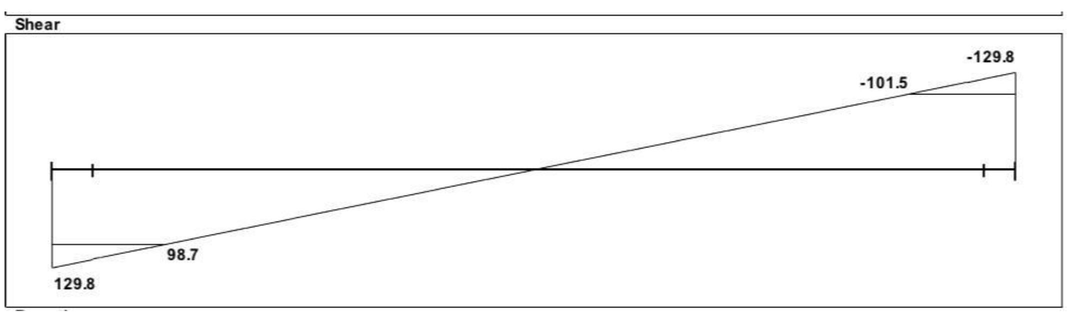

Figure 4-8 Shear Envelop for Beam43 (KN)

4.5.1 Determination of thickness:

$$h = \frac{l}{16} = \frac{4.68}{16} = 0.293m \ldots\ldots\ldots\ldots (Simply\ supported\ beam)$$

Take h=32cm

4.5.2 Load calculations:

$$DL\ from\ rib11 = \frac{1.16}{0.52} = 2.23\ KN/m$$
$$LL\ from\ rib11 = \frac{5.1}{0.52} = 9.81\ KN/m$$
$$DL\ from\ wall = 24 * 0.3 * 3 = 21.6\ KN/m$$

4.5.3 Design beam 43 for flexure:

Assume bar diameter Φ20 for main positive reinforcement, stirrups Φ10

$b = 80cm \qquad h = 32cm$

$$d = 320 - 40 - 10 - \frac{20}{2} = 260mm$$

4.5.3.1 Design for positive moment: $M_u = 151.8\ KN.m$

$$c = \frac{3}{7}d$$
$$= \frac{3}{7} * 260 = 111.43\ mm$$

$$a = \mathcal{B}_1 c$$

$= 0.85 * 111.43 = 94.72\ mm$ * Note: $fc' = 24$ MPa < 28 Mpa → $\beta1 = 0.85$

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

$$= 0.85 * 24 * 94.72 * 800 * (260 - \frac{94.72}{2}) * 10 - 6 = 328.71\ KN.m$$

$\emptyset M_{n,max} = 0.82 * 328.71 = 269.54\ KN.m$ * Note: $\epsilon s = 0.004 \rightarrow \emptyset = 0.82$

$$Mu(151.8\ KN.m) < \emptyset\ M_{n,max}(269.54\ KN.m)$$

∴ **Design section as singly reinforced concrete section.**

$$Rn = \frac{M_u}{\emptyset b d^2}$$

$$= \frac{151.8 * 10^6}{0.9 * 800 * 260^2} = 3.1\ Mpa.$$

$$m = \frac{f_y}{0.85 f_c'}$$

$$= \frac{420}{0.85*24} = 20.59$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mR_n}{420}}\right)$$

$$= \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2*20.59*3.1}{420}}\right) = 8.05 * 10^{-3}$$

$$A_{s,req} = \rho b d$$

$$= 8.05 * 10^{-3} * 800 * 260 = 1674.4\ mm^2$$

Check for $A_{s,min}$

$A_{s,min}$ *Is* the maximum of:

$$A_{s,min} = 0.25 \frac{\sqrt{f'_c}}{f_y} b_w d \geq \frac{1.4}{f_y} b_w d$$

1. $A_{s,min} = 0.25 \frac{\sqrt{24}}{420}\ 800 * 260 = 606.54\ mm^2$
2. $A_{s,min} = \frac{1.4}{420} 800 * 260 = 693.33\ mm^2.\ Control$

$$A_{s,req} == 1674.4\ mm^2 > A_{s,min} = 693.33\ mm^2$$

Of bars = $\frac{As}{Asbar} = \frac{1674.4}{314.16}$ = 6bars * Note $A_{\emptyset 20} = 314.16\ mm^2$

Select 4Ø20

$A_{s,prov} = 1885\ mm^2 > A_{s,req} = 1674.4 mm^2$

Check for strain:

According to AC -318-11 (10.3.5)، ($\varepsilon_s \geq 0.005$)

a $= \frac{A_s f_y}{0.85 b\ f_c'}$

$= \frac{1885*420}{0.85*800*24} = 48.51\ mm$

c $= \frac{a}{\mathcal{B}_1}$

$= \frac{48.51}{0.85} = 57.07\ mm$ * Note $f_c' = 24\ MPa < 28$ Mpa → $\mathcal{B}_1$ = 0.85

$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right)$

$= 0.003\left(\frac{260-57.07}{57.07}\right) = 0.011 > 0.005$ **$0k$**

$\therefore \emptyset = 0.9$

4.5.3.2 Design negative Moment:

Assume bar diameter Φ12 for main negative reinforcement, stirrups Φ10

$d = 320 - 20 - 10 - \frac{12}{2} = 284 mm$

$A_{s,neg} = \frac{1}{3} A_{s,pos}$

$= \frac{1}{3} * 1885 = 628.33 mm^2$

$\#of\ bars = \frac{A_s}{A_{s,bar}} = \frac{628.33}{113.1} = 6bars$ * Note $A_{\emptyset 12} = 113.1\ mm^2$

Select 6 Ø12

$A_{s,prov} = 678.6 mm^2 > A_{s,req} = 628.33 mm^2$ OK

Check for strain:

According to AC -318-11 (10.3.5)، ($\varepsilon_s \geq 0.005$)

$a = \frac{A_s f_y}{0.85 b\ f_c'}$

$= \frac{678.6 * 420}{0.85 * 800 * 24} = 17.46 mm$

$c = \frac{a}{\mathcal{B}_1}$

$= \frac{17.46}{0.85} = 20.54\ mm$ * Note $f_c' = 24\ MPa < 28$ Mpa → $\mathcal{B}_1 = 0.85$

$\varepsilon_s = 0.003 \left(\frac{d - c}{c}\right)$

$= 0.003 \left(\frac{284 - 20.54}{20.54}\right) = 0.038 > 0.005$ $\mathbf{0k}$

∴ Ø = **0.9**

4.5.4 Design beam 43 for shear:

Critical section at distance d = 260 mm from the face support:

$V_{u,max} = 101.5 KN$

$V_c = \frac{1}{6}\sqrt{fc'} b_w \, d$

$= \frac{1}{6}\sqrt{24} * 800 * 260 * 10^{-3} = 169.83\text{KN}$

$\emptyset \, V_c \; = \; 0.75 * 169.83 \; = \; 127.37 \; KN$ * Note for shear → Ø= 0.75

$$\frac{1}{2} \emptyset \, V_c = \frac{1}{2} * 127.37 = 63.69 KN$$

$$\frac{1}{2} \emptyset \, V_c (\, 63.69 \; KN) < \; V_{u,max} \; (101.5 KN) < \; \emptyset \, V_c \; (169.83 KN)$$

Minimum shear reinforcement is required ($A_{v,min}$)

$\boldsymbol{S_{max}}$ *is the smallest of*:

1. $\frac{d}{2} = \frac{260}{2} = 130 \; mm$………. Control

2. $600 mm$

$$A_{v,min} = \frac{1}{16}\sqrt{24}\frac{b_w S}{f_{yt}} \; \geq \frac{1}{3}\frac{b_w S}{f_{yt}}$$

$$A_{v,min} = \frac{1}{16}\sqrt{24}\frac{b_w S}{f_{yt}} = \frac{1}{16}\sqrt{24}\frac{800 * 130}{420} = 75.82 mm^2$$

$$A_{v,min} = \frac{1}{3}\frac{b_w S}{f_{yt}} = \frac{1}{3}\frac{800 * 130}{420} = 82.54 mm^2 \qquad \ldots . Control$$

Select Ø10 (4legs) with $A_v = 4 * \frac{\pi^2 * 10^2}{4} = 314.16 \; mm^2 > A_{v,min} = 82.54 \; mm^2$

$$S = \frac{A_v f_{yt} \; d}{v_s}$$

$$v_s = \frac{v_u}{\emptyset} - v_c$$

$$S = \frac{314.16 * 420 * 260}{112.78 * 1000} = 304.19 mm$$

Select S = 100 mm.

Check For dimensions:

$\emptyset v_c + (\frac{2}{3} \times \emptyset \times \sqrt{fc'} \times b_w \times d) > V_{u,max}$

$= 127.37 \quad + (\frac{2}{3} * 0.75 * \sqrt{24} * 800 * 260) * 10^{-3} = 636.86\, KN$

$$636.86\, KN > V_{u,max} = 101.5\, KN$$

∴ Dimension is adequate enough.

4.6 Design of long column (C1) Group A:

$Concrete\ B300 \qquad f_c' = 24MPa \qquad f_y = 420MPa$

4.6.1 Load Calculation:

Service Load:

$Dead\ Load = 545.67KN$

$Live\ Load = 206.62\, KN$

$P_u = 1.2 * DL + 1.6 * LL$

$= 1.2 * 545.67 + 1.6 * 206.62 = 985.476KN$

$P_n = \frac{P_u}{\emptyset} = \frac{985.476}{0.65} = 1516.117KN$

* Note for Tide Column → Ø= 0.65

4.6.2 Dimension of column:

$Assume\ \rho_g = 0.01 \quad \rightarrow \quad Ast = 0.01A_g$

$\emptyset Pn = \emptyset 0.8 * \{0.85 * f_c'(A_g - A_{st}) + A_{st} * f_y\}$

$985.476 * 10^3 = 0.65 * 0.8 * \{0.85 * 24(Ag - 0.01A_g) + 0.01A_g * 420\}$

$\rightarrow \quad A_g = 776.822\, cm^2$

$A_g = b * h$

$77682.169 = b * 300$

$b = 258.94\ mm$

Assume rectangular column.

Select b=600mm

$A_g = b * h = 600 * 300 = 180\ 000 mm^2 (0.18m^2) > A_{s,req} = 0.077m^2$

4.6.3 Check Slenderness Effect:

$\frac{Klu}{r} \leq 34 - 12 \left(\frac{M1}{M2}\right) \leq 40 \rightarrow ACI - 10.12.2$

Where:

L_u: Actual unbraced length.

K: effective length factor k. According to ACI 318-2002 (10.10.6.3) the effective length factor k, shall be permitted to taken as 1.

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

L_u= 3.68 m

$\frac{M1}{M2} = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .Braced\ fram$

About x axis ($\boldsymbol{h = 300mm}$)

$\frac{Klu}{r} \leq 34 - 12 \left(\frac{M1}{M2}\right) \leq 40 \rightarrow ACI - 10.12.2$

$\frac{Klu}{rx} = \frac{1*3.68}{0.3*0.3} = 40 > 22$ *∴ Long column about x-axis direction.*

About y axis ($\boldsymbol{b = 600mm}$)

$\frac{Klu}{ry} = \frac{1*3.68}{0.3*0.6} = 20 < 22$ *∴ short column about y-axis direction.*

$$EI = \frac{0.4E_c I_g}{1 + \beta dns} \ldots\ldots\ldots\ldots\ldots\ldots .[\ ACI\ 318 - \ 2002(Eq. 10 - 15)]$$

$$Ec = 4700\sqrt{fc'} = 4700\sqrt{24} = 23025.20\ Mpa$$

$$\beta_{dns} = \frac{1.2DL}{1.2DL + 1.6\,LL} = \frac{1.2 * 545.67}{985.476} = 0.664$$

$$Ig = \frac{bh^3}{12} = \frac{0.6 * 0.3^3}{12} = 1.35 * 10^9\ mm^4$$

$$EI = \frac{0.4 * 23025.20 * 1.35}{1 + 0.664} = 7472.12\ KN.m^2$$

Determine the Euler buckling load P_c:

$$P_c = \frac{\pi^2 EI}{(KLu)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots. ACI318 - 2002(Eq.10 - 13)$$

$$P_{cr} = \frac{3.14^2 * 7472.12}{(1.0 * 3.68)^2} = 5445.628\ KN$$

Calculate the moment magnifier factor $\boldsymbol{\delta_{ns}}$:

$$Cm = 0.6 + 0.4\left(\frac{M1}{M2}\right) \ldots\ldots\ldots\ldots\ldots\ldots ACI318 - 2002(Eq.10 - 16)$$

$$Cm = 0.6 + 0.4 * 1 = 1$$

$$\delta_{ns} = \frac{Cm}{1 - \left(\frac{Pu}{0.75Pc}\right)} \geq 1.0 \ \rightarrow ACI318 - 2002(Eq.10 - 12)$$

$$\delta_{ns} = \frac{1}{1 - \left(\frac{985.476}{0.75 * 5445.628}\right)} = 1.32 > 1$$

The magnified eccentricity and moment:

$$e_{min} = 15 + 0.03 * h$$
$$= 15 + 0.03 * 300 = 24mm = 0.024m$$

$$e = e_{min} * \delta_{ns}$$

$$= 24 * 1.32 = 31.68mm$$

$$\frac{e}{h} = \frac{31.68 * 10^{-3}}{0.3} = 0.11$$

Assume Ø14

$$\gamma = \frac{h - 2 * cover - 2 * d_s - d_b}{h}$$

$$= \frac{300 - 2*40 - 2*10 - 14}{300} = 0.62$$

γ: *the ratio of the distance between the centers of the outside layers of bars to the over all depthes of the column*

$$\frac{\emptyset P_n}{A_g} = \frac{985.476*10^3}{300*600}*0.145 = 0.794$$

From Interaction diagram:

$\gamma(0.6) < \gamma(0.62) < \gamma(0.75)$
$\rho g = 0.01$

Use linear interpolation to compute the value of $\gamma = 0.62$

Diagram A-9a for ($\gamma = \mathbf{0.6}$):

$$\frac{\emptyset P_n}{A_g} == 1.9$$

Diagram A-9b for ($\gamma = \mathbf{0.75}$):

$$\frac{\emptyset P_n}{A_g} = 2.1$$

$\frac{\emptyset P_n}{A_g}$ for $(\gamma = 0.62) = 1.9 + \frac{2.1-1.9}{0.75-0.6}*(0.62-0.6) = 1.93$

Diagram A-9a for ($\gamma = \mathbf{0.6}$): $\rho_g = 0.011$

Diagram A-9b for ($\gamma = \mathbf{0.75}$): $\rho_g = 0.012$

$$\rho_g for\ (\gamma = 0.62) = 0.012 - \frac{0.012 - 0.011}{0.75 - 0.6}*(0.62 - 0.6) = 0.0119$$

$\rho_g(0.0119) > \rho_{g,min}(0.01)$

$A_{st} = \rho_g * A_g = 0.0119*300*600 = 2142mm^2$

Select 14Ø14 with $A_s = 2155.13mm^2 > A_{st} = 2142mm^2$

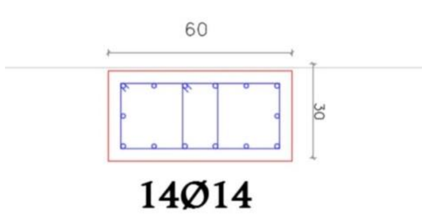

Figure (4-9): Column Section

4.6.4 Design of the Tie Reinforcement:

Use ties Ø10 with spacing of ties shall not exceed the smallest of:

1. $48\ times\ the\ tie\ \ diemeter, 48\ d_s = 48 * 10 = 480mm$
2. $16\ times\ the\ longitudinal\ bar\ diemeter, 16\ d_b = 16 * 14 = 224mm \ldots\ldots\ldots\ldots\ldots Control$
3. $The\ least\ dimension\ of\ the\ column = 300mm$

Use ties Ø10 /20

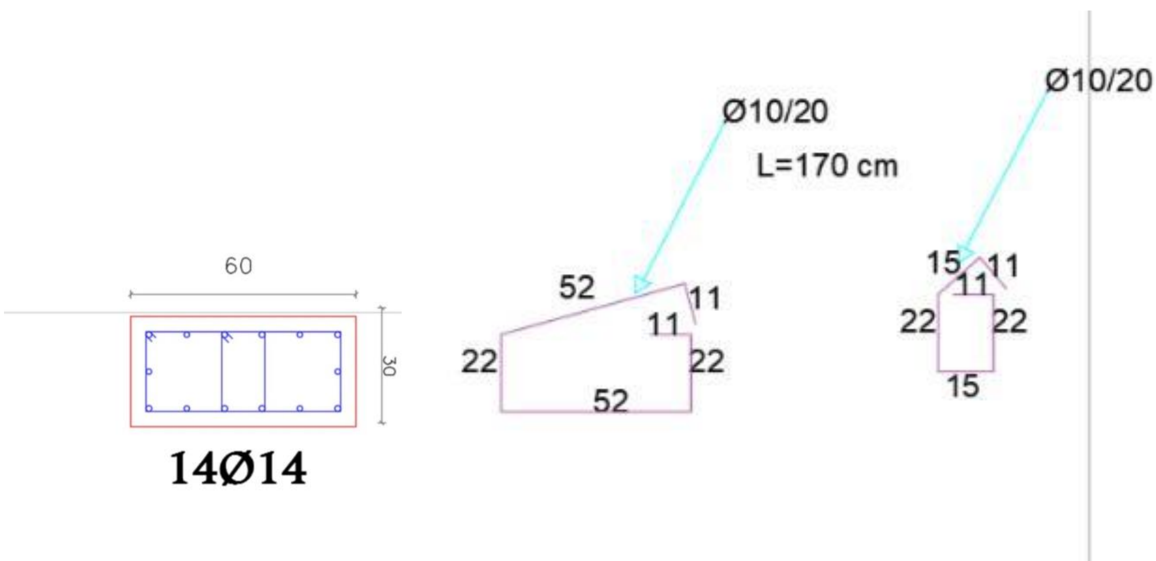

Figure (4 - 10): C1 Reinforcement Details

4.6.5 Check for code Requirements:

$$1. Clear\ space = \frac{600 - 40 * 2 - 10 * 2 - 6 * 14}{5} = 83.4mm > 40mm \ldots\ldots..OK$$

$2. Gross\ Reinforcement\ ratio:$

$\rho_{g,min}(0.01) < \rho_g(0.0119) < 0.08 \quad \ldots\ldots..OK$

$3. Number\ of\ bars: 14 > 4 - For\ rectangular\ section \ldots\ldots\ldots\ldots OK$

4. $Minumum\ tie\ diameter: \emptyset 10\ for\ \emptyset 14\ \ldots\ldots\ldots\ldots OK$

5. $Spacing\ for\ ties: s = 20cm \ldots\ldots\ldots\ldots OK$

4.7 Stair design:

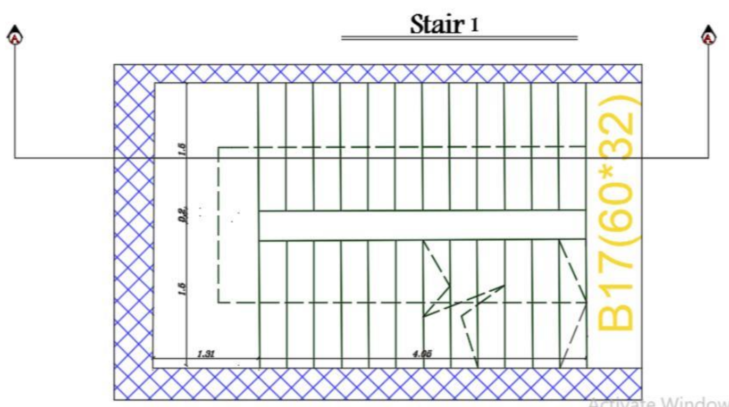

Figure 4-11 The shape of Stair

4.7.1 Determination of thickness:

Minimum slab thickness for deflection is:

$h_{min} = \frac{L}{20} = \frac{410}{20} = 20.5\ cm$ ………. (For a simply supported one-way solid slab)

$h_{min} = \frac{L}{28} = \frac{410}{28} = 14.6\ cm$………. (For a both End continuous)

∴ Select h = 20 cm

$$\theta = tan^{-1}\left(\frac{Rise}{Run}\right) = tan^{-1}\left(\frac{17.29}{33.71}\right) = 27.15°$$

4.7.2 Load Calculations:

4.7.2.1 Flight Dead Load Computation:

Table (4 – 3) Calculation of the total dead load for Flight

Material	Quality Density KN/m^3	calculations	KN/m
Tiles	23	$0.03 * 23 *(\frac{0.1729+0.36}{0.337})$	**1.1**
Mortar	22	$0.03 * 22 \; *(\frac{0.1729+0.337}{0.337})$	**0.67**
Stair Steps	25	$(\frac{0.1729+0.337}{2})* \frac{25}{0.34} * 1$	**2.14**
Reinforced Concrete Solid Slab	25	$(\frac{25*0.2*1}{cos27.15})$	**5.62**
Plaster	22	$(\frac{22*0.03*1}{cos27.15})$	**0.74**
Total Dead Load (KN/m)			**10.4**

4.7.2.2 Landing Dead Load Computation:

Table (4 – 4) Calculation of the total dead load for Landing

Material	Quality Density KN/m^3	calculations	KN/m
Tiles	23	0.03 * 23 *1	**0.69**
Mortar	22	0.03 * 22 *1	**0.66**
Reinforced Concrete Solid Slab	25	25*0.2	**5**
Plaster	22	22*0.03*1	**0.66**
Total Dead Load (KN/m)			**7.01**

$LL = 4KN/m^2$

Total Factored Load for flight: $w = 1.2D_L + 1.6L_L$

$1.2 * 10.4 + 1.6 * 4 = 18.88KN/m$

Total Factored Load for Landing=

$1.2 * (33.176 + 7.01) + 1.6 * 4 = 54.62KN/m$

4.7.3 Flight Design:

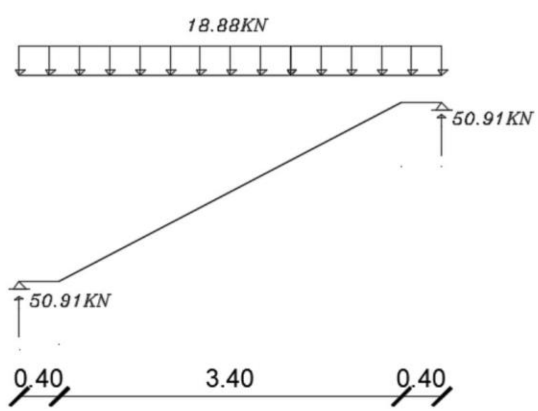

Figure 4-12 System of stair

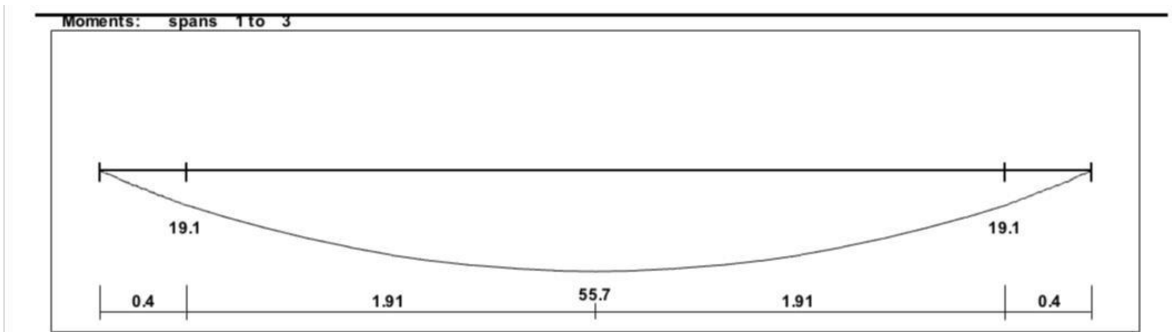

Figure 4-13 Bending Moment for stair

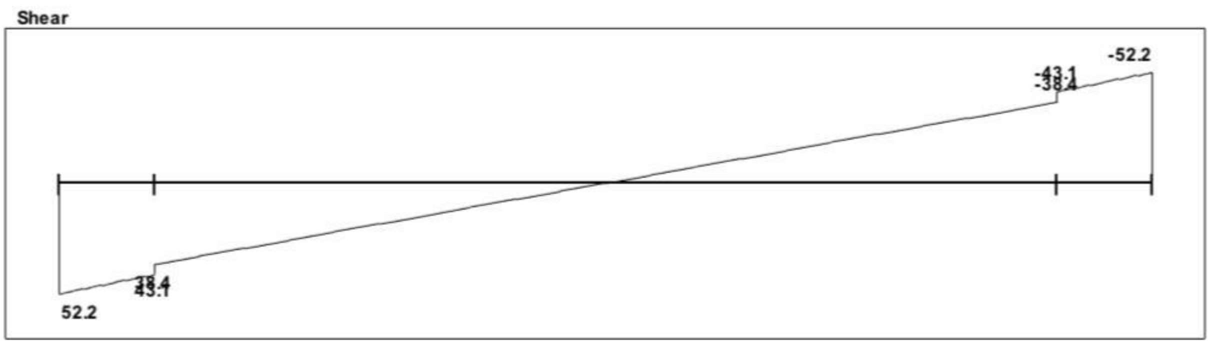

Figure 4-14 Shear for stair

4.7.3.1 Shear Design for flight:

Take the maximum shear as the support reaction $\boldsymbol{V_u = 43.1\ KN}$

Assume bar diameter Ø 14 for main reinforcement.

$d = \boldsymbol{h - 20 - \frac{db}{2}}$

$= 200 - 20 - \frac{14}{2} = 173\ mm$

$Vc = \frac{1}{6}\sqrt{fc'}b_w d = \frac{1}{6} * \sqrt{24} * 1000 * 173 * 10^{-3} = 141.254\ KN/1\ m\ strip$.

$\emptyset = 0.75 - for\ shear$

$\emptyset Vc = 0.75 * 141.254 = 105.94KN\ /\ 1m\ strip$

$\frac{1}{2}\emptyset Vc = \frac{1}{2} * 105.94 = 52.97KN\ /\ 1m\ strip$

$Vu = 43.1\ KN < \frac{1}{2}\ \emptyset\ Vc = 52.97\ KN$

No shear Reinforcement required. The thickness is adequate enough.

4.7.3.2 Bending Moment Design:

Take the maximum Moment $\boldsymbol{M_u = 55.7\ KN}$

$$Mn = \frac{Mu}{\emptyset} = \frac{55.7}{0.9} = 61.89\ KN.m$$

$$Rn = \frac{M_n}{bd^2} = \frac{61.89 * 10^6}{1000 * 173^2} = 2.07\ Mpa.$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 * 24} = 20.59$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2 * m * R_n}{420}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 * 20.59 * 2.07}{420}}\right) = 5.2 * 10^{-3}$$

$$A_s = \rho bd = 5.2 * 10^{-3} * 1000 * 173 = 900.95\ mm^2$$

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

$$A_{s,req} = 900.95\ mm^2 > A_{s,min} = 360\ mm^2$$

Use Ø14then

$n = \frac{A_{s,req}}{A_{s\emptyset14}} = \frac{900.95}{153.86}$ = 5.86 = 6 bars

$$s = \frac{1}{n} = \frac{1}{5.86} = 0.17\ m$$

Take 6Ø14 with $A_s = 923.63mm^2 / \ m\ strip, or\ \emptyset 14\ @\ 15cm$

Step (s) is the smallest of:

1. $3h = 3 * 200 = 600mm$

2. $450mm$

3. $s = 380\left(\frac{280}{fs}\right) - 2.5Cc = 380\left(\frac{280}{\frac{2}{3} * 420}\right) - 2.5 * 20 = 330mm, but$

$s \le 300\left(\frac{280}{\frac{2}{3} * 420}\right) = 300mm. \quad - \boldsymbol{control}$

$s = 150mm < Smax = 300mm \quad - OK$

Check for strain:

According to AC -318-11 (10.3.5)، ($\varepsilon_s \geq 0.005$)

$a = \frac{A_s f_y}{0.85 b\, f_c'}$

$= \frac{923.63*420}{0.85*1000*24} = 19.02mm$

$c = \frac{a}{\mathcal{B}_1}$

$= \frac{19.02}{0.85} = 22.38mm$ * Note $f_c' = 24\ MPa < 28$ Mpa $\rightarrow \mathcal{B}_1 = 0.85$

$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right)$

$= 0.003\left(\frac{173-22.38}{22.38}\right) = 0.021 > 0.005$ ……… . $\mathbf{0k}$

$\therefore \emptyset =$ **0.9**

4.7.5 Landing design:

$w_u = 54.62KN$

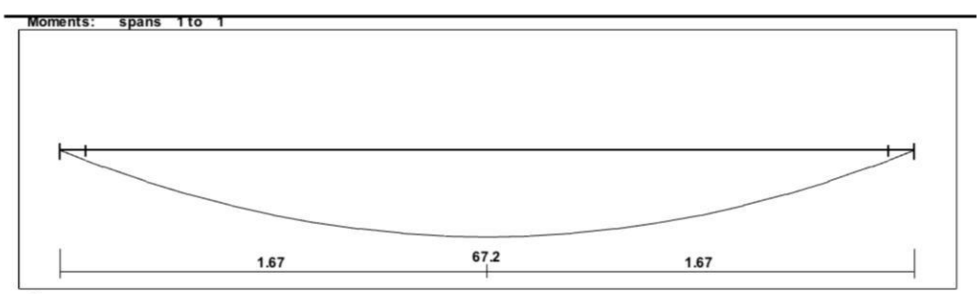

Figure 4-15 Bending Moment for Landing

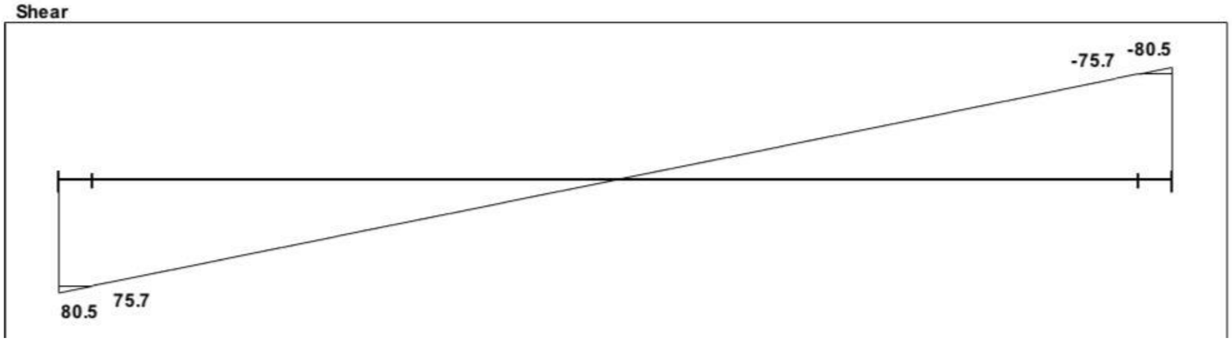

Figure 4-16 Bending Moment for Landing

4.7.3.1 Shear Design for Landing:

Take the maximum shear as the support reaction $\boldsymbol{V_u = 75.7KN}$

Assume bar diameter Ø 14 for main reinforcement.

$d = \boldsymbol{h - 20 - \frac{db}{2}}$

$= 300 - 20 - \frac{14}{2} = 273\ mm$

$Vc = \frac{1}{6}\sqrt{fc'}b_w d = \frac{1}{6} * \sqrt{24} * 1000 * 273 * 10^{-3} = 222.904\ KN/1\ m\ strip$.

$\emptyset = 0.75 - for\ shear$

$\emptyset Vc = 0.75 * 222.904 = 167.178KN\ /\ 1m\ strip$

$\frac{1}{2}\emptyset Vc = \frac{1}{2} * 167.178 = 83.589KN\ /\ 1m\ strip$

$Vu = 75.5\ KN < \frac{1}{2}\ \emptyset\ Vc = 83.589\ KN$

No shear Reinforcement required. The thickness is adequate enough.

4.7.3.2 Bending Moment Design:

Take the maximum Moment $\boldsymbol{M_u = 67.2\ KN}$

$Mn = \frac{Mu}{\emptyset} = \frac{67.2}{0.9} = 74.667\ KN.m$

$Rn = \frac{M_n}{bd^2} = \frac{74.667 * 10^6}{1000 * 273^2} = 1\ Mpa.$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 * 24} = 20.59$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2 * m * R_n}{420}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 * 20.59 * 1}{420}}\right) = 2.44 * 10^{-3}$

$A_s = \rho bd = 2.44 * 10^{-3} * 1000 * 273 = 666.77\ mm^2$

$A_{s,min} = 0.0018bh = 0.0018 * 1000 * 300 = 540\ mm^2$

$A_{s,req} = 666.77\ mm^2 > A_{s,min} = 540 mm^2$

Use Ø14then

$n = \frac{A_{s,req}}{A_{sØ14}} = \frac{666.77}{153.86}$ = 4.33 = 5 bars

$s = \frac{1}{n} = \frac{1}{4.33} = 0.23\ m$

Take 5Ø14 with $A_s = 769.69 mm^2 /\ m\ strip, or\ Ø14\ @\ 20cm$

Step (s) is the smallest of:

1. $3h = 3 * 300 = 900mm$

2. $450mm$

3. $s = 380\left(\frac{280}{fs}\right) - 2.5Cc = 380\left(\frac{280}{\frac{2}{3} * 420}\right) - 2.5 * 20 = 330mm, but$

$s \leq 300\left(\frac{280}{\frac{2}{3} * 420}\right) = 300mm. \quad - \boldsymbol{control}$

$s = 200mm < Smax = 300mm \quad - OK$

Check for strain:

According to AC -318-11 (10.3.5)، ($\varepsilon_s \geq 0.005$)

a = $\frac{A_s f_y}{0.85b\ f_c'}$

$= \frac{769.69 * 420}{0.85 * 1000 * 24} = 15.85mm$

$c = \frac{a}{\mathcal{B}_1}$

$= \frac{15.85}{0.85} = 18.64mm$ * Note $f_c' = 24\ MPa < 28$ Mpa $\rightarrow \mathcal{B}_1 = 0.85$

$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right)$

$= 0.003\left(\frac{273-18.64}{18.64}\right) = 0.041 > 0.005$ ……… . $\mathbf{0k}$

$\therefore \emptyset = \mathbf{0.9}$

4.7.3.3 Temperature and shrinkage reinforcement:

$\boldsymbol{As, Temperature}\ \&\ \boldsymbol{shrinkage} = \mathbf{0.0018bh} = 0.0018 * 1000 * 300 = 540mm^2$

Use Ø12 then, $n = \frac{A_{s,req}}{A_{s\emptyset 12}} = \frac{540}{113.1} = 4.77$

$s = \frac{1}{n} = \frac{1}{4.77} = 0.209\ m$

Take 5Ø12 with $As = 565.49mm^2 /\ m\ strip, or\ \emptyset 12\ @\ 200mm$

Step (s for $temperature\ \&\ shrinkage$) is the smallest of:

1. $5h = 5 * 300 = 1500mm$
2. $450mm\ - contorl$

$s = 200\ mm < Smax = 450\ mm\ \ - OK$

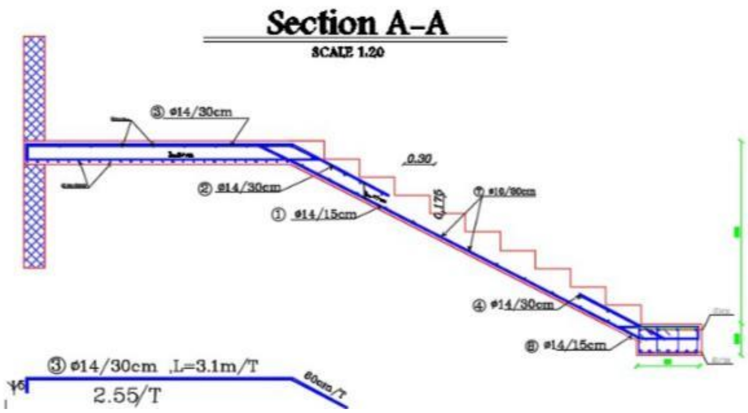

Figure 4-17 Stair details

4.8 Isolated Footing Design (F1):

4.8.1 Determination of footing dimensions:

The following parameters are used in design:

$\gamma_{\ concrete} \ = \ 25\ KN/m^3$

$D_L = 548.4\ KN$

$L_L = 204.42\ KN$

$\gamma_{\ soil} \ = \ 18\ KN/m^3$

$\sigma_{allow} \ = \ 400\ KN/m^2$

$column\ dimention = 30 * 60$

4.8.2Design of footing Area:

$Allowable\ soil\ pressure = 400KN/m^2$

Calculating the weight of footing and soil loads:

$assume\ h = 50cm$

$W_{footing} = 0.5 * 25 = 12.5KN/m^2$

$W_{soil} = 0.95 * 18 = 17.1KN/m^2$

$q_{a,net} = \sigma_{allow} - W_{footing} - W_{soil}$

$= 400 - 12.5 - 17.1 = 370.4\ KN/m^2$

$$Area(A) = \frac{Total\ Weight(P_n)}{Soil\ pressure(q_{a,net})}$$

$$= \frac{548.4 + 204.42}{370.4} = 2.032m^2$$

Assume square footing:

$A = L^2$

$L = \sqrt{A} = \sqrt{2.032} = 1.4m$

$Take\ L = 1.5m$

$A = L^2$

$= 1.5 * 1.5 = 2.25m \dots\dots OK$

$P_u = 1.2D_L + 1.6\ L_L$

$= 1.2 * 548.4 + 1.6 * 204.42 = 985.152KN$

$$q_u = \frac{P_u}{A}$$

$$= \frac{985.152}{1.5 * 1.5} = 437.84\ KN/m^2$$

4.8.3Design of footing:

4.8.3.1 Design for One way shear strength:

Assume $h = 50cm$ and Ø10 for main reinforcement &7.5 cm cover.

$d = 500 - 75 - 10 = 415mm$

V_u At distance d from the face of support:

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

$= 437.84 * 1.5 \left(\frac{1.5}{2} - \frac{0.3}{2} - 0.415\right) = 121.5KN$

$Vc = \frac{1}{6}\sqrt{fc'}\,b_w\,d$

$= \frac{1}{6} * \sqrt{24} * 1500 * 415 = 508.27KN$

$\emptyset Vc = 0.75 * 508.27 = 381.2KN$

$\emptyset Vc = 381.2KN > V_u = 121.5KN$

- **Safe**

4.8.3.2 Design for Two way shear strength:

$let\ V_u = \emptyset Vc, \emptyset = 0.75$

$V_u = 437.84\,(1.5 * 1.5 - (0.3 + 0.415) * (0.6 + 0.415)) = 667.389$ KN

$\beta = \frac{600}{300} = 2,$ $b_o = 2(0.6 + 0.415) + 2(0.3 + 0.415) = 3.46\ m$

$\alpha_s = 40\ For\ interior\ column$

$Vc = \frac{1}{6}\left(1 + \frac{2}{\beta}\right)\sqrt{fc'}b_o d$ $where$ $\frac{1}{6}\left(1 + \frac{2}{2}\right) = 0.333$

$Vc = \frac{1}{12}\left(\frac{\alpha_s d}{b_o} + 2\right)\sqrt{fc'}b_o d$ $where$ $\frac{1}{12}\left(\frac{40 * 0.415}{3.6} + 2\right) = 0.566$

$Vc = \frac{1}{3}\sqrt{fc'}b_o d$ $where$ $\frac{1}{3} = 0.333 - Control$

$Take\ Vc = 0.333\sqrt{fc'}b_o d = 0.333\sqrt{24} * 3460 * 415 * 10^{-3} = 2110.33\ KN$

$\emptyset Vc = 0.75 * 2110.33 = 1582.75\ KN < Vu = 667.38$ KN $- OK$

4.8.3.3 Design of flexure in short direction:

Take steel bars of Ø 12

$d = 600 - 75 - \frac{12}{2} = 419\ mm$

$$Mu = 437.84 * 1.5 * 0.6 * \frac{0.6}{2} = 118.217\ KN.m$$

$$Rn = \frac{M_u}{\emptyset bd^2} = \frac{118.217 * 10^6}{0.9 * 1500 * 419^2} = 0.499\ Mpa.$$

$$\text{m} = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 * 24} = 20.59$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 * 20.59 * 0.499}{420}}\right) = 1.202 * 10^{-3}$$

$$As = \rho bd = 1.202 * 10^{-3} * 1500 * 419 = 755.457\ mm^2$$

$$A_{smin} = 0.0018bh = 0.0018 * 1500 * 500 = 1350\ mm^2$$

$$\boldsymbol{A_{s,min}} = 1350\ mm^2 > \boldsymbol{A_{s,req}} = 755.457\ mm^2$$

Take $\boldsymbol{A_{s,min}} = 1350\ mm^2$

Use Ø12 , $n = \frac{\boldsymbol{A_{s,req}}}{\boldsymbol{A_{s,\emptyset 16}}} = \frac{1350}{113.1} = 11.94$

Take 12Ø12 $with\ \boldsymbol{A_{prov}} = 1357.17\ mm^2 > \boldsymbol{A_{s,min}} = 1350\ mm^2$

$$\boldsymbol{S} = \frac{1500 - 75 * 2 - 12 * 12}{11} = 109.63\ mm$$

Step (s) is the smallest of:

1. $3h = 3 * 500 = 1500\ mm$
2. $450\ mm\ \ - Control$

$S = 109.63\ mm < Smax = 450\ mm \ldots \ldots \ldots OK$

Check for strain:

According to AC -318-11 (10.3.5)، ($\varepsilon_s \geq 0.005$)

$$\text{a} = \frac{A_s f_y}{0.85 b\ f_c'}$$

$$= \frac{1357.17 * 420}{0.85 * 1500 * 24} = 18.63 mm$$

$c = \frac{a}{\mathcal{B}_1}$

$= \frac{18.63}{0.85} = 21.9mm$ * Note $f_c' = 24\ MPa < 28$ Mpa → $\mathcal{B}_1$ = 0.85

$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right)$

$= 0.003\left(\frac{419-21.9}{21.9}\right) = 0.05 > 0.005$ ……… . $\boldsymbol{0k}$

∴ Ø = **0.9**

4.8.3.3 Design of flexure in long direction:

Take steel bars of Ø 12

$d = 600 - 75 - 20 - \frac{12}{2} = 399\ mm$

$Mu = 437.84 * 1.5 * 0.45 * \frac{0.45}{2} = 66.49\ KN.m$

$Rn = \frac{M_u}{\emptyset bd^2} = \frac{66.496 * 10^6}{0.9 * 1500 * 399^2} = 0.31\ Mpa.$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 * 24} = 20.59$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 * 20.59 * 0.31}{420}}\right) = 0.744 * 10^{-3}$

$As = \rho bd = 0.744 * 10^{-3} * 1500 * 399 = 444.29\ mm^2$

$A_{smin} = 0.0018bh = 0.0018 * 1500 * 500 = 1350\ mm^2$

$\boldsymbol{A_{s,min}} = 1350\ mm^2 > \boldsymbol{A_{s,req}} = 444.29\ mm^2$

Take $\boldsymbol{A_{s,min}} = 1350\ mm^2$

Use Ø12 , $n = \frac{\boldsymbol{A_{s,req}}}{\boldsymbol{A_{s,\emptyset 16}}} = \frac{1350}{113.1} = 11.94$

Take 12Ø12 $with\ \boldsymbol{A_{prov}} = 1357.17\ mm^2 > \boldsymbol{A_{s,min}} = 1350\ mm^2$

$$\boldsymbol{S} = \frac{1500 - 75 * 2 - 12 * 12}{11} = 109.63\ mm$$

Step (s) is the smallest of:

1. $3h = 3 * 500 = 1500\ mm$
2. $450\ mm\ \ - Control$

$S = 109.63\ mm < Smax = 450\ mm \ldots \ldots \ldots OK$

Check for strain:

According to AC -318-11 (10.3.5)، ($\varepsilon_s \geq 0.005$)

$a = \frac{A_s f_y}{0.85 b\, f'_c}$

$= \frac{1357.17*420}{0.85*1500*24} = 18.63mm$

$c = \frac{a}{\mathcal{B}_1}$

$= \frac{18.63}{0.85} = 21.9mm$ * Note $f'_c = 24\ MPa < 28$ Mpa → $\mathcal{B}_1 = 0.85$

$$\varepsilon_s = 0.003\left(\frac{d - c}{c}\right)$$

$$= 0.003\left(\frac{419 - 21.9}{21.9}\right) = 0.05 > 0.005\ \ \ldots \ldots \ldots.\ \ \boldsymbol{0k}$$

∴ Ø = **0.9**

4.8.4Design of Dowels:

Load transfer in footing:

$$\emptyset P_{n,b} = \emptyset(0.85 f_c' \, A_1 \sqrt{\frac{A_2}{A_1}}$$

$A_1 = 30 * 60 = 0.18m^2$

$A_2 = 1.5 * 1.5 = 2.25m^2$

$A_1 = 30 * 60 = 0.18m^2$

$$\sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{2.25}{0.18}} = 3.54 > 2 \qquad \ldots\ldots\ldots\ldots\ldots. \sqrt{\frac{A_2}{A_1}} = 2$$

$\emptyset P_{n,b} = 0.65(0.85 * 24 * 180 * 2) = 4773.6KN > P_u = 1985.152KN$

No need for dowels

Load transfer in column:

$\emptyset P_{n,b} = 0.65(0.85 * 24 * 180) = 2386.8KN > P_u = 1985.152KN$

No need for dowels

$A_{s,min} = 0.005 * A_c = 0.005 * 300 * 600 = 900mm^2$

Take $12\emptyset 12 \; with \; \boldsymbol{A_{prov}} = 1357.17 \; mm^2 > \boldsymbol{A_{s,min}} = 900 \; mm^2$

4.8.5 Development Length:

4.8.5.1 Tension development length:

$$Ld_{t,req} = \frac{9}{10} * \frac{f_y}{\square\sqrt{f_c'}} * \frac{\Psi_e \Psi_s \Psi_t}{\frac{k_{tr} + c_b}{d_b}} * d_b > 300mm$$

$$= \frac{9}{10} * \frac{420}{1\sqrt{24}} * \frac{1 * 1 * 0.8}{\frac{0 + 56}{12}} * 12 = 13.23cm = 132.3 \; mm < 300mm$$

$Take \; Ld_{t,req} = 30cm$

$$Ld_{t,available} = \frac{1500-300}{2} - 75 = 525mm$$

$$Ld_{t,available}(525mm) > Ld_{t,req}(300\ mm)$$

4.8.5.2 Compression development length:

$$Ld_{c,req} = \frac{0.24 * f_y}{\sqrt{f_c'}} * d_b > 0.0043 * f_y * d_b > 200\ mm$$

$$\frac{0.24*420}{\sqrt{24}} * 12 = 246.91mm > 0.0043 * 420 * 12\ (216.72mm) > 200\ mm \ldots\ldots\ldots OK$$

$$Ld_{c,available} = 600 - 75 - 20 - 12 = 493mm > Ld_{c,req}(246.91mm)$$

4.8.5.3 Lab splice of dowels in column:

$$L_{sc} = 0.071 * f_y * d_b$$

$$= 0.071 * 420 * 12 = 357.84mm > 300mm$$

$$L_{sc} = 400mm$$

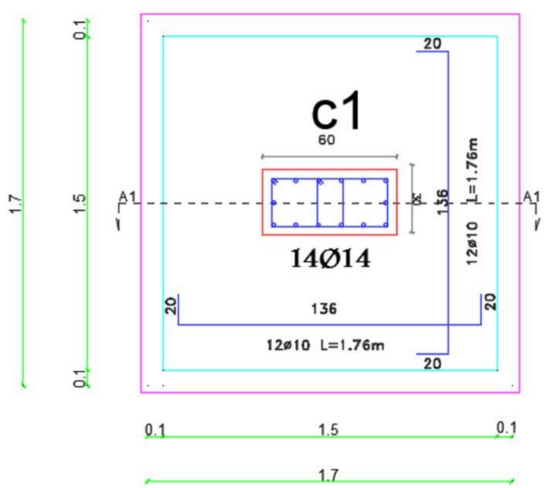

Figure 4-18 F1 Reinforcement

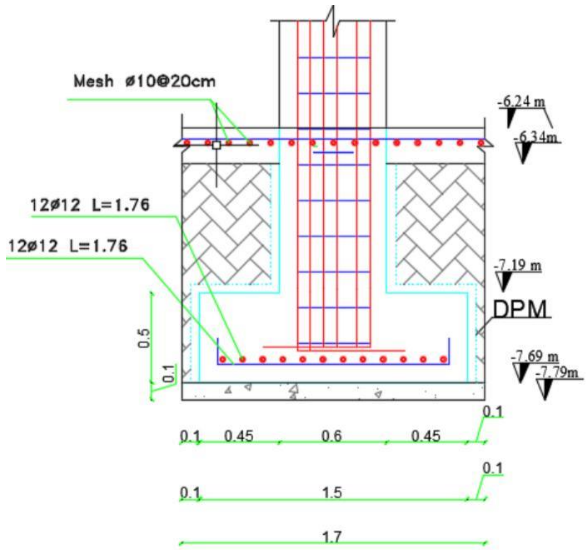

Figure 4-19 F1 Reinforcement details

4.9 Shear Wall (S.W8) design:

From ETSAPS:

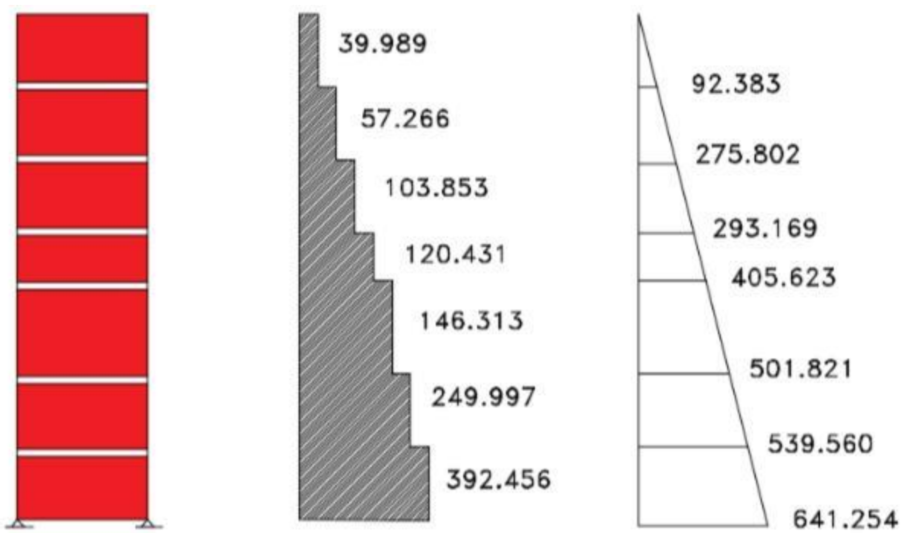

Figure 4-20 Shear and Moment diagrams for shear bwall

Materials and sections:

- $f_c' = 24MPa$
- $f_y = 240MPa$
- $h = 30cm$
- $shear\ wall\ width\ (L_w = 5.55m)$

- $shear\ wall\ height\ (h_w = 3.12m)$

4.9.1 Horizontal reinforcement Design:

$\boldsymbol{\varepsilon f_x = V_u = 392.456KN}$

The critical section is the smallest of:

1. $\frac{h_w}{2} = \frac{(5*3.12)+4+2}{2} = 10.8m$
2. $\frac{L_w}{2} = \frac{5.55}{2} = 2.775m \dots\dots\dots\dots\dots\dots Control$

$d = 0.8 * L_w = 0.8 * 5.55 = 4.44m$

$$\emptyset V_{n,max} = \emptyset * \frac{5}{6} * \sqrt{fc'} * h * d$$

$$= 0.75 * \frac{5}{6} * \sqrt{24} * 300 * 4440 * 10^{-3} = 5437.87KN$$

$\emptyset V_{n,max}\ (5437.87KN) > V_u\ (392.456KN) \dots\dots OK$

v_c is the smallest of:

1. $V_c = \frac{1}{6}\sqrt{fc'}hd$

$$V_c = \frac{\sqrt{24}}{6} * 300 * 4440 * 10^{-3} = 1087.571KN \dots\dots\dots control$$

2. $V_c = 0.27\sqrt{fc'} * h * d + \frac{Nu*d}{4Lw}$

$$= 0.27 * \sqrt{24} * 300 * 4440 * 10^{-3} + 0 = 1761.87KN$$

3. $V_c = \left\{0.05\sqrt{fc'} + \frac{l_w\left(0.1\sqrt{fc'}+0.2\frac{N_u}{l_{wh}}\right)}{\frac{M_u}{V_u}-\frac{l_w}{2}}\right\}hd$

$$\frac{641.254 - 539.560}{3.12} = \frac{M_u - 539.560}{3.12 - 2.775}$$

$$M_u = 550.805KN.m$$

$$\frac{M_u}{V_u} - \frac{l_w}{2} = 3.25 > 0$$

$$V_c = \left\{0.05\sqrt{24} + \frac{5.55\left(0.1\sqrt{24} + 0\right)}{3.25}\right\} 300 * 4440 * 10^{-3} = 1440.62KN$$

$$V_c = 1087.571KN$$
$$\emptyset V_c = 0.75 * 1087.571 = 815.678KN$$
$$\frac{1}{2}\emptyset V_c = 407.839KN$$

$$\boldsymbol{V_u = 392.456KN} < \frac{1}{2}\emptyset V_c = 407.839KN$$

- ❖ Thickness is adequate enough.

$A_{vh}\ min = 0.002 * s * h$

$\frac{A_{vh}\ min}{s} = 0.002 * h$

$\frac{A_{vh}\ min}{s} = 0.002 * 300$

Try 2 Ø10 with $A_{vh}\ min = 157.1mm^2$

$\frac{157.1}{s} = 0.002 * 300$

$s = 261.833mm$

$\boldsymbol{S_{max}}$ **is the smallest of:**

1. $\frac{l_w}{5} = \frac{5550}{5} = 1110mm$
2. $450\ mm$
3. $3 * h = 3 * 300 = 900\ mm$

$Take\ s = 200\ mm < Smax = 450\ mm$

Select Ø10/20 *cm*

4.9.2 Vertical reinforcement Design:

$A_{vh}\ min = 0.0012 * s * h$

$\frac{A_{vh}\ min}{s} = 0.0012 * h$

$\frac{A_{vh}\ min}{s} = 0.0012 * 300$

Try 2 Ø10 with $A_{vh}\ min = 157.1 mm^2$

$\frac{157.1}{s} = 0.0012 * 300$

$s = 436.389 mm$

S_{max} is the smallest of:

1. $\frac{l_w}{5} = \frac{5550}{5} = 1110 mm$
2. $450\ mm$
3. $3 * h = 3 * 300 = 900 mm$

$Take\ s = 250\ mm < Smax = 450\ mm$

$Select$ Ø14/25 cm

4.9.3 Bending Moment Design:

$Mu = 539.560 + 392.456 * (3.12 - 2.775) = 674.957\ KN.m$

$C > \frac{l_w}{(0.007 * 600)} = \frac{5550}{4.2} = 1321.43\ mm$

$Length\ of\ boundary\ element = C - 0.1 * l_w$
$= 1321.43 - 0.1 * 5550 = 766.43\ mm$

$C_w = \frac{C}{2} = \frac{1321.43}{2} = 660.715\ mm$

$Select\ the\ boundary\ element = 800\ mm$

$A_{vs} = \frac{l_w}{s} * A_{sv} = \frac{5550}{200} * 2 * 79 = 4384.5mm^2$

$$\frac{Z}{l_w} = \frac{1}{2 + \frac{0.85 * \beta * fc' * l_w * h}{As * Fy}}$$

$$\frac{Z}{l_w} = \frac{1}{2 + \frac{0.85 * 0.85 * 24 * 5550 * 300}{4384.5 * 420}} = 0.0566$$

$$M_{uv} = 0.9 * F_y * 0.5 * A_s * l_w * \left(1 - \frac{Z}{l_w}\right)$$

$$= 0.9 * 420 * 0.5 * 4384.5 * 5550 * (1 - 0.0566) * 10^{-6} = 4338.962\ KN.m$$

$\boldsymbol{M_{uv}} = 4338.962\ \boldsymbol{KN.m} > \boldsymbol{Mu} = \boldsymbol{674.957\ KN.m}$

So, Boundary Element isn't required.

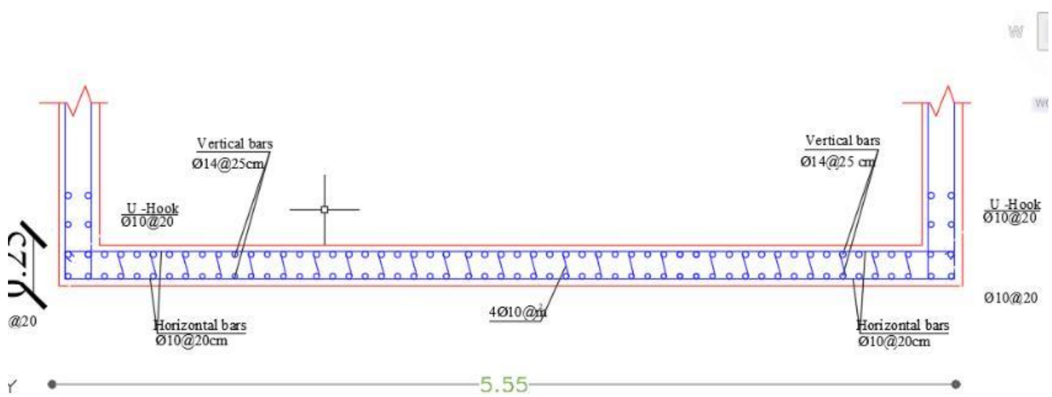

Figure 4-21 Detailing of shear wall

4.10 Basement Wall design:

Materials:

- ❖ $f_c' = 24MPa$
- ❖ $f_y = 240MPa$
- ❖ $h_{wall} = 30cm$
- ❖ $\emptyset = 30$
- ❖ $\Upsilon = 18KN/m^2$

4.10.1 Loads on basement wall:

Self-weight of earth (DL):

$k_0 = 1 - \sin 30 = 0.5$

$q_1 = \gamma * h * k_0$

$q_1 = 18 * 3.12 * 0.5 = 28.08\ KN/m^2$

Load from live load ($LL = 4\ KN/m^2$):

$q_2 = LL * k_0 = 2 * 0.5 = 2\ KN/m^2$

4.10.2 Shear design:

From Atir $V_u = 25.8\ KN$

$$d = 300 - 20 - \frac{14}{2} = 274\ mm$$

$$\emptyset\ Vc = 0.75 \frac{\sqrt{fc'}}{6} bw * d = 0.75 * \frac{\sqrt{24}}{6} * 1000 * 274 = 167.8\ KN$$

$$\frac{1}{2} \emptyset\ Vc = 83.9\ KN$$

$$V_u = 25.8\ KN \frac{1}{2} \emptyset\ Vc = 83.9\ KN$$

- ❖ Thickness is adequate enough.

4.9.3 Design of the Vertical reinforcement in tension side:

from Atir $M_{u\,Max} = 30.9\ KN.m.$

$$Rn = \frac{M_n}{\emptyset bd^2}$$

$$= \frac{30.9 * 10^6}{0.9 * 1000 * 274^2} = 0.457\ Mpa.$$

$$\text{m} = \frac{f_y}{0.85 f_c'}$$

$$= \frac{420}{0.85 * 24} = 20.59$$

$$\rho\ = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right)$$

$$= \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 * 20.59 * 0.457}{420}}\right) = .001101$$

$$A_s = \rho bd$$

$$= 0.001101 * 1000 * 274 = 301.76\ mm^2/m$$

$$A_{s,min} = 0.0012bh$$

$$= 0.0012 * 1000 * 30 = 360\ mm^2/m$$

$$A_{s,min} = 360\ mm^2/m > A_{s,req} = 2.74\ cm^2/m$$

Select Ø10 */ 20 cm, with As provided =* $392.6\ mm^2/m$ > $A_{s,min} = 360\ mm^2/m$

4.9.4 Design of the horizontal reinforcement in tension side:

For One layer:

$As, min = 0.0012bh$
$= 0.0012 * 1000 * 30 = 360\ mm^2/m$
Select Ø10 / 20 cm, with As provided = 392.6 mm^2/m > $A_{s,min} = 360\ mm^2/m$

CHAPTER

5

Results and Recommendations

5.1 The Results

1. The most important step before you start designing is to carefully study architectural plans for making column distribution.
2. Each student or structural designer should be able to design manually so he can get the experience and knowledge in using the computer software.
3. Experience in the use of construction programs cannot be reached without understanding the basic concepts of structural design.
4. One of the important steps of the structural design is how to connect the structural members to work together, then to divide these members and design them individually .
5. When choosing the construction system, it is best to distribute nerves in the long dir ection and bridges in the short direction to reduce the loads on bridges resulting in le ss armament which means fewer costs.

1 We have used the live loads using the Jordanian code of loads.

5.2 The Recommendations

This project has an important role in widening and enhancing our understanding to the nature of the structural project including all the details, analysis, and designs.

We want here through this experience- to introduce a group of recommendations; we hope it to be useful for planning to select a structural project.

At the beginning, the architectural drawings have to be prepared and ordered and the construction material and the structural system have to be chosen alongside. And it's essential at this stage to have information about the project site, the soil, the soil strength capacity at the site from the geotechnical report, after that the bearing walls and the columns is going to be set up alongside the architectural team in a compatible manner. The civil engineer tries at this stage to plant as much as possible the reinforced concrete walls, which should be use after that in resisting the earthquake loads and other lateral loads.

5.3 Reference

[1] Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE7-16).

[2] Building code requirements for structural concrete (ACI-318-14), USA: American Concrete Institute, 2014.

[3] كود البناء الأردني، كود الأحمال والقوى، عمان، الأردن: مجلس البناء الوطني الأردني، 2006م