Palestine Polytechnic University

Faculty of Engineering

Department of Civil Engineering and Architecture

Project Name

AL Wihdat Hospital

Team:

Baha Alawneh | Ibraheem Barqawi

Naeema Tubakhi | Usaid Muslet

Supervision:

ENG. Fahed Salahat

Hebron – Palestine

2017-2018

Project Abstract

Structural design is the most important design of the building after the necessary of architectural design, the distribution of columns, loads, offer durability, the best prices and the highest degree of safety are the responsibility of the structural designer. In this project we will do the structural design of hospital building. The building consists ten floors with a total area of 33707 m^2.

This project was selected because of the importance to know how to design these buildings, which have a design requirements higher than other tiles with long spans and diversity in the form of the building by the architectural design, also it has been chosen for the importance of increasing this structure in this area ”Nemra”.

It is important mentioning that we will use the Jordanian code to determine the live loads, and to determine the loads of earthquakes, for the analysis of the structural and design sections we will use the US Code (ACI_318_11), it must be noted that we will be relying on some computer programs such as: Autocad2007, Safe , Office2007, Atir, and others.

Expected after completion of the project to be able to provide structural design of all the structural elements of the project accordance to the requirements of the code.

Allah grants success

الإهـــــــــــــــــــــــــداء

إلى....المعلم الأول ....رسولنا الكريم سيد البشرية محمد بن عبد الله

إلى ... من هم أحق منا بالحياة إلى .... الشهداء

إلى ... الأسود الرابضة خلف القضبان ..... إلى من كسروا قيد السجان .... الأسرى

إلى .... أنشودة الصغر وقدوة الكبر إلى .... أبي العزيز

إلى ....نبع العطاء وسيل الحنان إلى ....أمي العزيزة

إلى ....عنوان سعادتي إلى .... إخوتي الأعزاء

إلى .... هبة السماء ..... أصدقائي الأوفياء

إلى .... الشموع التي احترقت لتنير الدرب إلى ... أساتذتي

إلى .... مَن عرفتهم في هذا الصرح العلمي ... زملائي و زميلاتي

إلى مَنهل العلم ..... جامعتي

إليكُم جَميعاً نُهدي فاتِحَة العَطاء

على أملِ البَقاء بإذن الله تَعالى.

فريق العمل

شكر و تقدير

(وقل اعملوا فسيرى الله عملكم ورسوله والمؤمنون)

صدق الله العظيم

الهي لا يطيب الليل إلا بشكرك ولا يطيب النهار إلا بطاعتك .. ولا تطيب اللحظات إلا بذكرك

ولا تطيب الآخرة إلا بعفوك .. ولا تطيب الجنة إلا برؤيتك

لابد لنا ونحن نخطو خطواتنا الأخيرة في الحياة الجامعية من وقفة نعود إلى أعوام قضيناها في رحاب الجامعة مع أساتذتنا الكرام الذين قدموا لنا الكثير باذلين بذلك جهودا كبيرة في بناء جيل الغد لتبعث الأمة من جديد...

وقبل أن نمضي نقدم أسمى آيات الشكر والامتنان والتقدير والمحبة إلى الذين حملوا أقدس رسالة في الحياة ...

إلى الذين مهدوا لنا طريق العلم والمعرفة ...

إلى جميع أساتذتنا الأفاضل......

" كن عالما ... فإن لم تستطع فكن متعلما ، فإن لم تستطع فأحب العلماء ، فإن لم تستطع فلا تبغضهم"

ونخص بالتقدير والشكر إلى من قدم لنا يد العون والمساعدة وكان لنا سندا والذي علمنا التفاؤل والمضي إلى الأمام ، إلى من رعانا وحافظعلينا ، إلى من وقف إلى جانبنا عندما ضللنا الطريق ..... المهندس فهد صلاحات ....

الذي نقول له بشراك قول رسول الله صلى الله عليه وسلم :

" إن الحوت في البحر ، والطير في السماء ، ليصلون على معلم الناس الخير "

فريق العمل

Table of Contents

Chapter 4

Chapter 5

List of Figures

Figure Name **Page Number**

List of Tables

List of Abbreviation

- **Ac** = area of concrete section resisting shear transfer.
- **As** = area of non- prestressed tension 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.
- **DL** = dead load.
- **d** = distance from extreme compression fiber to cancroids of tension reinforcement.
- **Ec** = modulus of elasticity of concrete.
- **Fy** = specified yield strength of non- prestressed reinforcement.
- **I** = moment of inertia of section resisting externally applied factored loads.
- **Ln** = length of clear span in long direction of tow-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 load.
- **Ld** = development length.
- **M** = bending moment.
- **Mu** = factored moment at section.
- **Mn** = nominal moment.
- **Pn** = nominal axial load.
- **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.
- **Vu** = factored shear force at section.
- **Wc** = weight of concrete. (Kg/m^3).

CHAPTER

1

Proposal

1.1 INTRODUCTION.

1.2 RESEARCH PROBLEM

1.3 AN OVERVIEW OF THE PROJECT

1.4 THE OBJECTIVE OF THE PROJECT

1.5 PROJECT STEPS

1.6 REASONS TO CHOOSE PROJECT

1.7 THE SCOPE OF THE PROJECT

1.8 ACTION PLAN

1.1 Introduction

Human nature needs to have places of curing in place of residence, and these places must have all the means to ensure comfort and safety. General design process requires the introduction of all aspects of the building to be created both in the architectural appearance of the building and how to distribute the spaces and areas within various service sections linked to each other, or structural terms dealing with structural system capable of carrying the loads affecting the building taking into account the minimum possible economical system construction as is compatible with the architectural design choice.

The project includes the architectural and structural design of Barking, Stores, Oxygen Store, Generator room, Pharmaceutical Store, Mortuary ,reception hall, Dissection Room, Archive room, gases room, Changing room, kitchen, Refrigerators Rooms, food stores, Emergency Rooms, Doctors and nurses office ,Laboratories, Food supplies warehouse ,blood bank Sterilization room ,X-ray room ,Bedrooms doctors and nurses, Kidney dialysis rooms, water pool ,Intensive care rooms. Distributing columns and bridges in line with architectural and design elements from components to bases and foundations and structural schemes and processing in order to produce an integrated project and implementation.

1.2 Research Problem

The problem centralized in the project is design of structural elements in the hospital building , Structural design includes various structural elements of slabs , beams, columns and foundations, according to the distribution of elements and does not contradict with architectural design.

1.3 An Overview of the Project

This project includes the structural design of Emergency department, Pharmacy, Department of Radiology, operation department, ICU, Obstetrics and Gynecology department, laboratory and blood bank, Internal Medicine Department, gases room, boilers room, laundry, maintenance, stores and shops fulfilled all the requirements for comfort and safety according to usage requirements.

Basement Floor-3 :

parking, awell , have an area 3286 m^2.

Basement Floor-2:

parking , a well ,Oxygen Store , Stores ,Generator Room ,Maintenance room , have an area 4182.7 m^2

Basement Floor-1 :

parking, a well , Stores , Food supplies warehouse , Refrigerators ,a kitchen, Mortuary, dissecting rooms , a reception, Staff Exchange Room and Archive Room , have an area 4321 m^2

Ground Floor:

Emergency Room, Security Room, Nursery Room, Patient Examination Room, Doctor's Room, Blood Bank, Laboratories, Cafeteria, pharmacy, Waiting Room, Massage Room, Water Pool, Sauna, , Archive Room, Store , Bathrooms, Kitchen , cleaning tools Room, radiology room, development of pictures room, Staff Room, CT Room , which have an area of 4191.3m^2.

First Floor:

ICU , operation ward, Nursery Room, Dressing Room , Doctor's office, Nursery office, central sterile supply department , Store , bedroom, Nursing Room, , Employees break room, Bathrooms, Staff room , Recovery-Room, break room, which have an area of 4152.2m^2.

Second Floor:

Lecture hall, Staff room ,Secretary room, Management Room ,Meeting Room, Store, Archive Room ,Video conference room, ICU ,Bathrooms, which have an area of 3903.6 m^2.

Third Floor:

Patients bedrooms , Store , Nursing office, Doctor's office, ICU, Kitchen ,Control room, Bathrooms, Which have an area of 3737.2 m^2.

Fourth Floor:

Patients bedrooms , Store , Nursing office ,Doctor's office, ICU for child, Kitchen , Bathrooms, Which have an area of 3412.9m^2.

Fifth Floor:

Store , Nursing office, Doctor's office, kidney department, Bathrooms, Which have an area of 1622.9m^2

Sixth Floor:

Nursing Bedrooms ,Doctor's Bedrooms ,Which have an area of 560.2m^2

1.4 The Objective of the Project

The objectives of the project are divided into two parts:

- Architectural Goals:

In this project architectural design is not the main goal as civil and building engineers, however this buildings where necessary to achieve beauty and utility requirements, cost and durability in these facilities, which are the basic architectural design requirement.

- Structural Goals:

Structural design of the units will be done in this project with prepare all structural drawings for beams, slabs, columns, footings and shear walls to be ready for fulfillment on the location of the project.

1.5 Project Steps

1. Architecture design (construction drawings, elevations, sections, public location).
2. Study the units structurally to identify structural elements, loads on the buildings, and the selection of appropriate structural system.
3. Distribute columns to the chosen structural system.
4. Structural analysis of all structural elements of the units.
5. Structural design of all structural elements.

6. Preparation of construction drawings of the building to remove the executable image.
7. Writing project in accordance with the requirements of the construction engineering.

1.6 Reasons to Choose the Project

The reason of selecting the project back to several things, including the conquest of skill in design for structural elements in buildings, in addition to increase the knowledge of construction systems in our country and other countries, as well as the conquest of scientific knowledge and the process followed in the design and implementation of construction projects and the structural engineer after graduation in the work market in the future.

.

1.7 The scope of the Project

Project contains several chapters are detailed as follows:

- Chapter One: A general introduction to the project.
- Chapter Two: Includes description of architectural project.
- Chapter Three: Contains a description of the structural elements of the project.
- Chapter Four: Analysis and structural design of all structural elements.
- Chapter Five: The results that have been reached and recommendations.

1.8 Action Plan

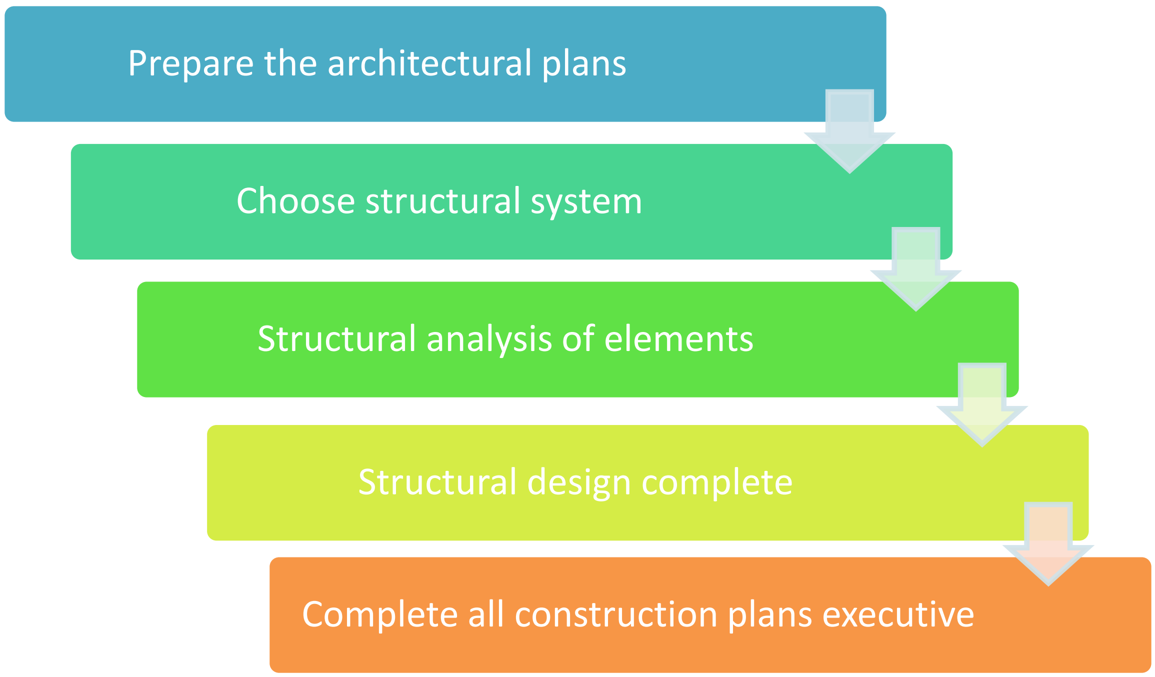


Figure (1.1): The Stages of The Project.

Table (1.1):Time Table

Task / Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Select project	■															
Inception report		■														
Collect information			■													
Architectural study				■	■											
Structural study					■	■										
Prepare the introduction							■									
Display the introduction								■								
Structural analysis								■	■	■						
Structural design											■	■				
Prepare the project plan												■	■			
Write the project													■	■	■	
Project presentation																■

CHAPTER

2

Architectural Description

2.1Introduction

Architectural description is the most important thing. That defining and understanding the nature of the project and its sections.

Architectural design requirements must meet the required job and human needs in this time. These terms are in the functional beauty and economy, it is important in these conditions that they can connect between each other and in conformity to achieve our vision of optimal design and get an integrated and overall architectural design, and this is achieved by understanding the functional demands of the building and space as well as taking into account the natural movement of each part of the project.

Architectural study that must precede the start of architectural design must be easy to handle and understand different events that it contains building and functional relations among 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 The Main Elements in Al-Wihdat Hospital

The project areas is divided into internal and external spaces tied together to achieve the goals that were found for it.

2.2.1Interior Spaces:

The interior area of the project is 25118.32.2m^2 and 8588.68 m^2 for movement spaces, thus the total interior spaces is 33707 m^2.

- Interior spaces are divided into:

Basement Floor -3:

This floor has an area of 3286m^2
Water well : 314.2 m^2
Parking:2971.8 m^2

Basement Floor -2:

This floor has an area of 4182.7 m^2

Water well : 314.2 m^2

Oxygen Store : 424.35m^2

pharmacy; 133.56 m^2

Generator Room: 160.02 m^2

Stores:375.89 m^2

Parking:2908.24 m^2

Basement Floor -1:

This floor has an area of 4321 m^2

Water well : 314.2 m^2

Stores:450.34 m^2

Food Store : 80.6m^2

Medicine Store: 60.44m^2

Washing room : 163.08m^2

Anatomy department (waiting room , Mortuary, Archive Room , Morgue, Room for Washing the dead) :152.5 m^2

Bathroom : 2.3m^2

Dressing Room : 23.2m^2

Refrigerator room : 49m^2

Parking:3025.04 m^2

Ground Floor:

This floor has an area of4191.3 m^2

Pharmacy:42.6m^2

Bathrooms:106.8m^2

Gift Shop: 57.7 m^2

Radiology department: has an area of 422.8m^2

X-ray rooms: 170.2m^2

Medical imaging room :36.5m^2

Information and archive rooms: 36 m^2

Break room:51.6m^2

Development of pictures room :37.7 m^2

Doctor room : 7.2m^2

Employee room : 7.2m^2

CT Room : 76.4 m^2

Cafeteria Department: has an area of 264 m^2

Cafeteria:227m^2

Bathrooms: 40.2m^2

Kitchen: 37.9 m^2

Dining room: 48.9m^2

Blood bank and laboratory: have an area of 234 m^2

Lab rooms: 168.3 m^2

Information and archive rooms :22.9m^2

Break room: 12.3 m^2

Blood sampling room:30.5m^2

Physiotherapy department: has an area of 415.7 m^2

Multi-purpose hall: 99.6 m^2

Physiotherapy room: 63.4 m^2

Sauna room: 23.5 m^2

Waiting room: 58.8 m^2

Bathrooms and Closet room : 61.5 m^2

Doctors room: 28.3 m^2

store: 10.5 m^2

Massage room: 51.1 m^2

Reception and archive room : 19 m^2

Outpatient department: has an area of 335.1 m^2

Clinics :182.3 m^2

Waiting room : 121.4 m^2

Cleaning Tools Room :31.4 m^2

Emergency Department : has an area of 554.2 m^2

Examination room: 88.9m^2

Emergency rooms : 143 m^2

Sterile tool room : 29.5 m^2

Doctor room :43.5 m^2

Nurses Room : 35.6 m2

security room : 14.6 m^2

Reception : 66.1m^2

waiting room : 133 m^2

Other spaces : 1910.8 m^2

<u>First Floor</u>:

This floor has an area of4152.2 m^2

Surgery department: has an area of 1223.9 m^2

Operation rooms:376.86m^2

Sterile rooms: 60.22 m^2

ICU:149.7 m^2

Examination rooms: 262 m^2

Bathrooms: 25 m^2

Recovery-Room : 149.7 m^2

Brake rooms : 128.8 m^2

Dressing rooms : 34.4 m^2

Files rooms: 14.37 m^2

Reception rooms:22.8 m^2

Sterile department: has an area of 527.8 m^2

Sterile rooms: 178.7 m^2

Staff room: 24 m^2

Staff Break Room:34.5 m^2

Sterile tool preparation room:38.3 m^2

Sterile corridor: 252.3 m^2

Department of sleeping patients: has an area of 845.62m^2

Patient bedrooms: 623.92 m^2

Store: 52.2 m^2

Nurses rooms :144.8 m^2

Doctor's Room : 24.7 m^2

Other spaces : 1554.88 m^2

Second Floor:

This floor has an area of 3903.6 m^2

Administration department: has an area of 697.5 m^2

Meeting room :49.82m^2

Management room :35.3 m^2

Secretary room : 45.8m^2

Employee rooms:156 m^2

Store : 73.1 m^2

Lecture hall:124.4 m^2

Archive room : 51 m^2

Bathrooms : 29.6 m^2

Video conferencing room : 132.43 m^2

Department of sleeping patients: has an area of 1611.3 m^2

Patient bedrooms: 1181.7 m^2

Doctor rooms :24.3m^2

stores :106.6 m^2

Nurse room: 193.1 m^2

Cafeteria:76.2 m^2

Dining room: 29.4m^2

Surgery department: has an area of 175 m^2

ICU for men's :76.7 m^2

ICU for women's :57.4 m^2

Nurse room: 30.6 m^2

Control room : 10.3m^2

Other spaces : 1419.8 m^2

<u>Third Floor:</u>

This floor has an area of3737.2 m^2

Department of sleeping patients: has an area of 2128.6m^2

Patients bedrooms:1700 m^2

Stores: 106.6 m^2

Doctors offices:24.3 m^2

Nurse room: 193.2 m^2

Patients rest rooms :66.5m^2

Cafeteria:38 m^2

Surgery department: has an area of 175 m^2

ICU for men's :76.7 m^2

ICU for women's :57.4 m^2

Nurse room: 30.6 m^2

Control room : 10.3m^2

Other spaces : 1433.6 m^2

<u>Fourth Floor:</u>

This floor has an area of 3412.9 m^2

Department of sleeping patients: has an area of 2004.1m^2

Patients bedrooms:1575.5 m^2

Stores: 106.6 m^2

Doctors offices:24.3 m^2

Nurse room: 193.2 m^2

Patients rest rooms :66.5m^2

Surgery department: has an area of 99.7 m^2

ICU for kids :58.8 m^2

Nurse room: 30.6 m^2

Control room : 10.3m^2

Other spaces : 1039.2 m^2

Fifth Floor:

This floor has an area of 1622.9 m^2

kidney department: has an area of 712m^2

kidney rooms:615 m^2

Store: 6 m^2

Nurse room: 53 m^2

Cafeteria:38 m^2

Other spaces : 910.9 m^2

Sixth Floor:

This floor has an area of 560.2 m^2

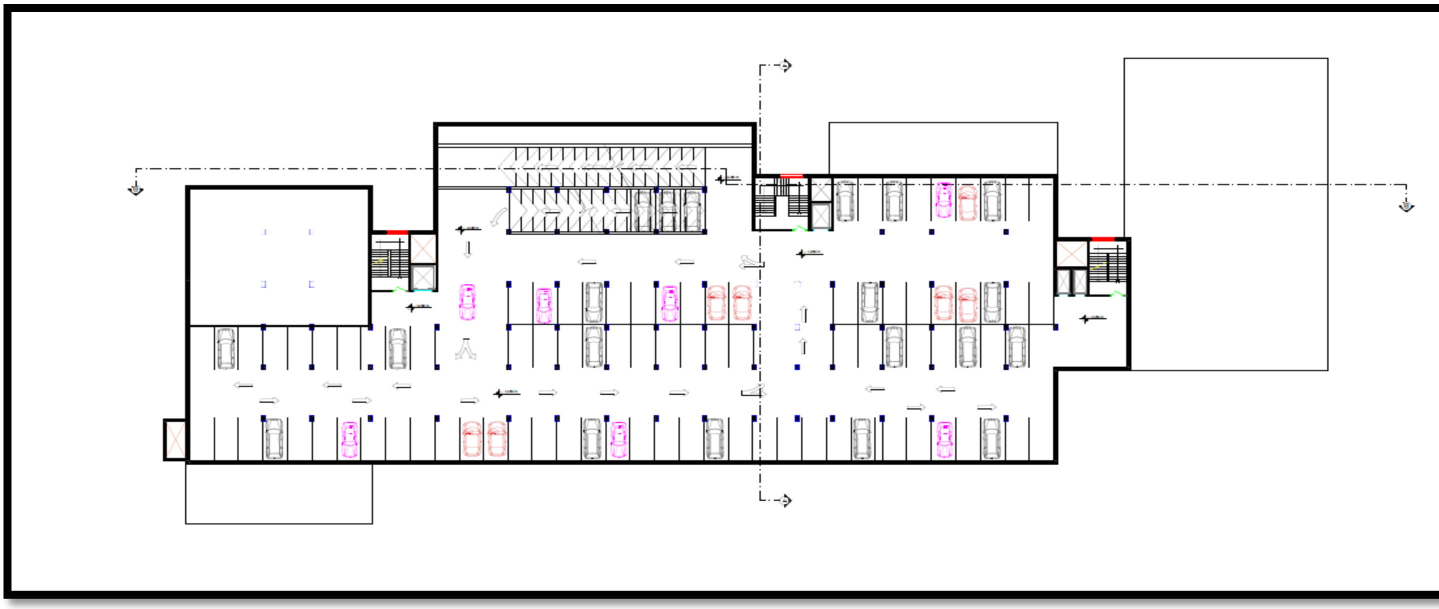
Department of sleeping Doctors and Nurses: has an area of 560.2m^2

2.2.2External Spaces

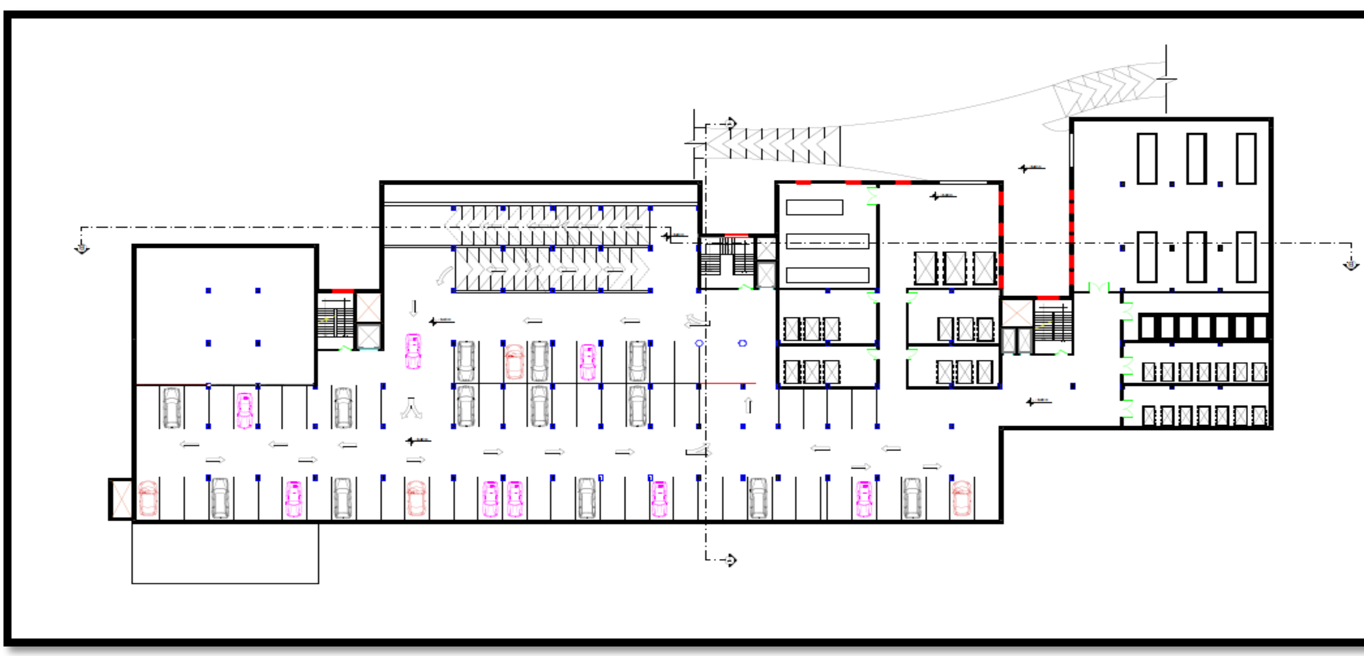
Consist of:

- Green spaces: 3715.5m^2
- Parking: enough for32 cars and 5Ambulancewith an area 673 m2.

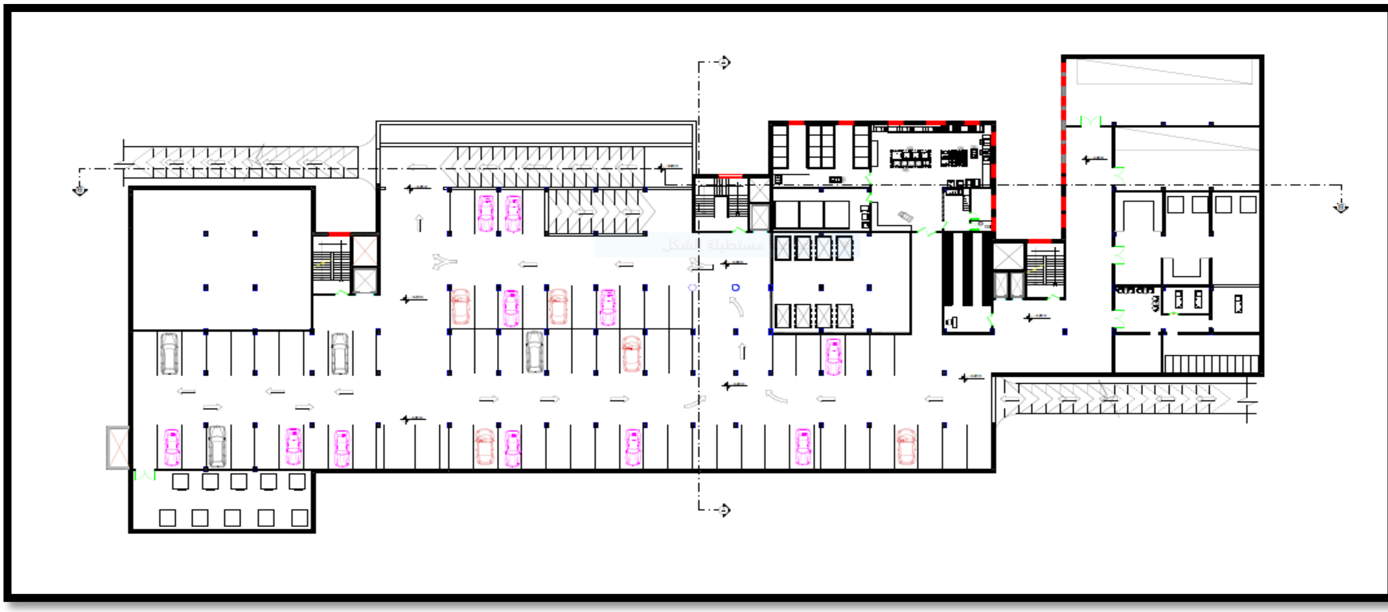
2.3 Project Plans



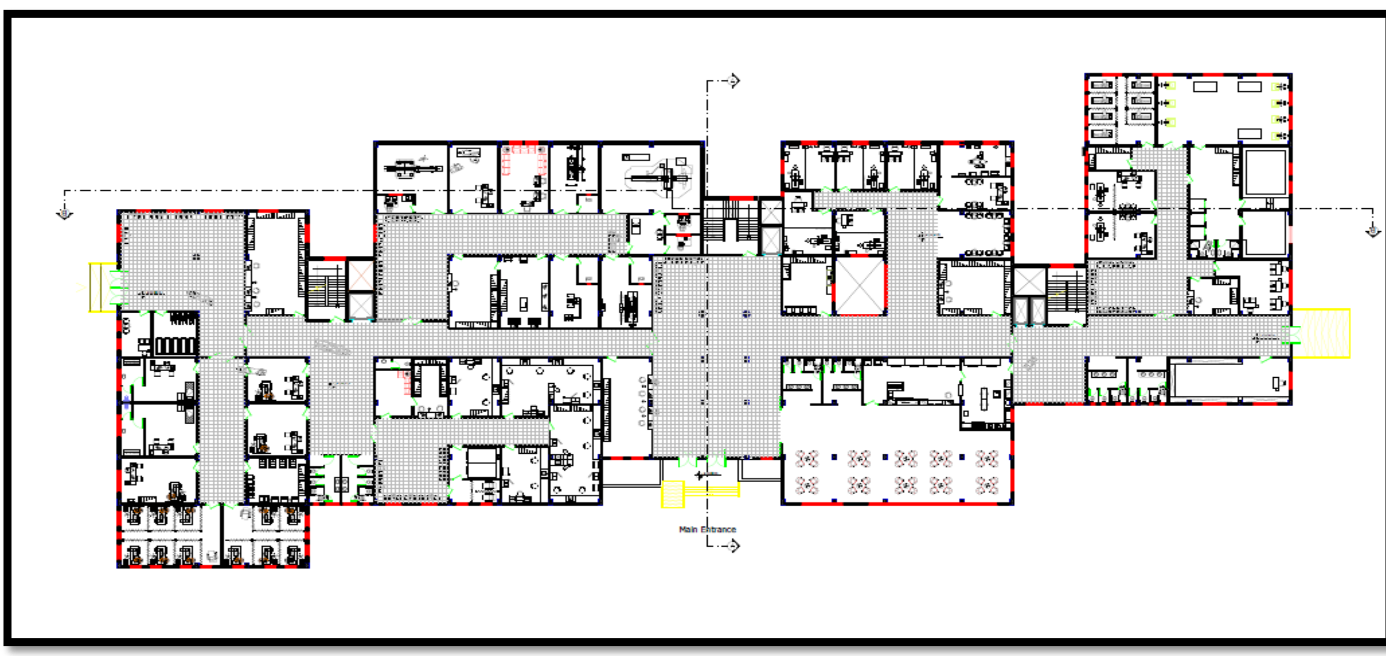
Figure(2.1): Basement Floor -3 Plan.



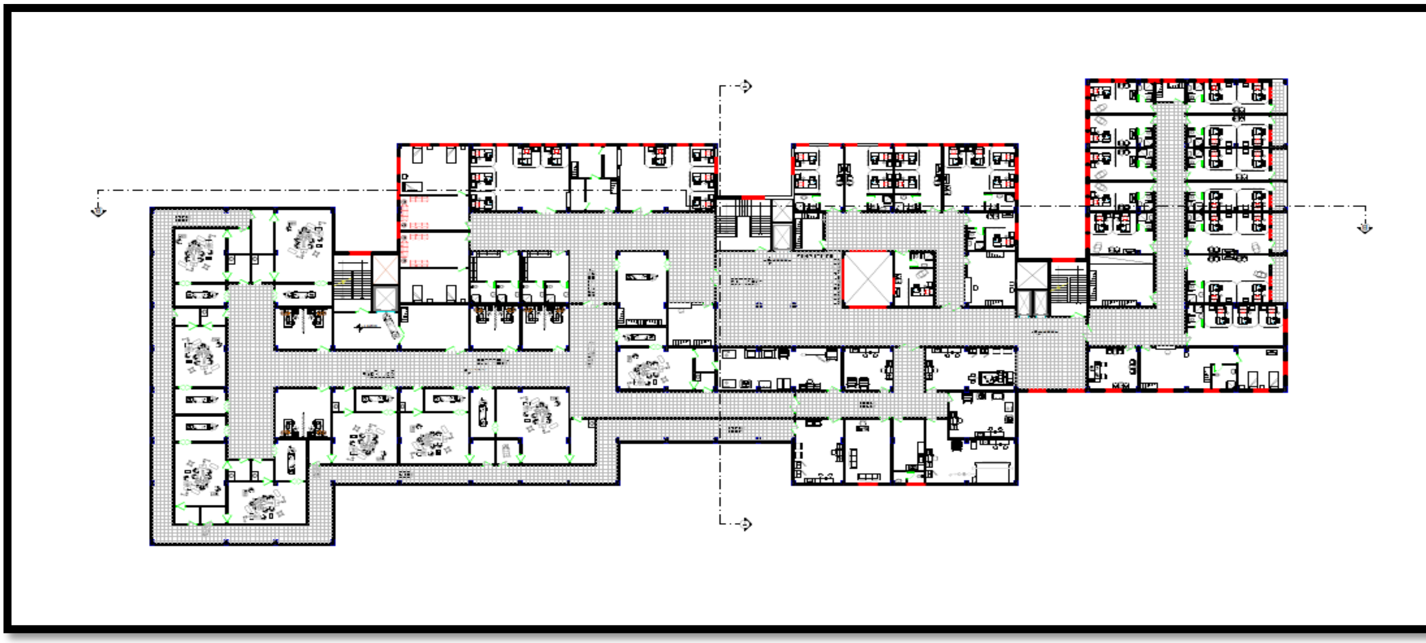
Figure(2.2): Basement Floor -2 Plan.



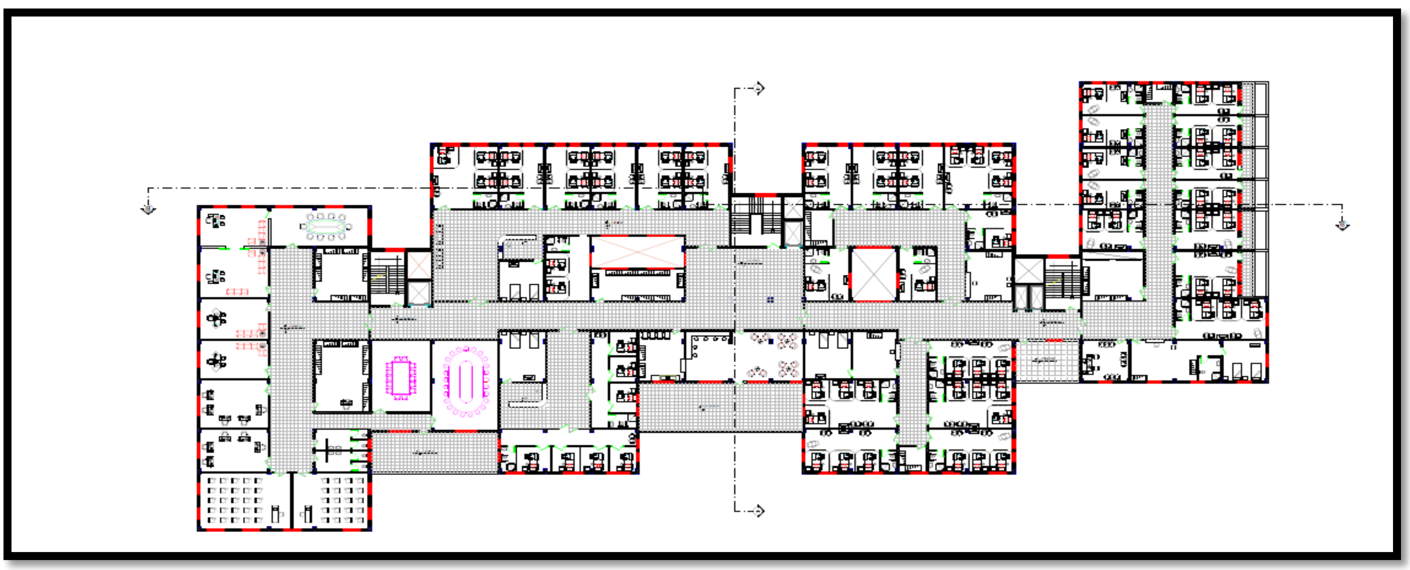
Figure(2.3): Basement Floor -1 Plan.



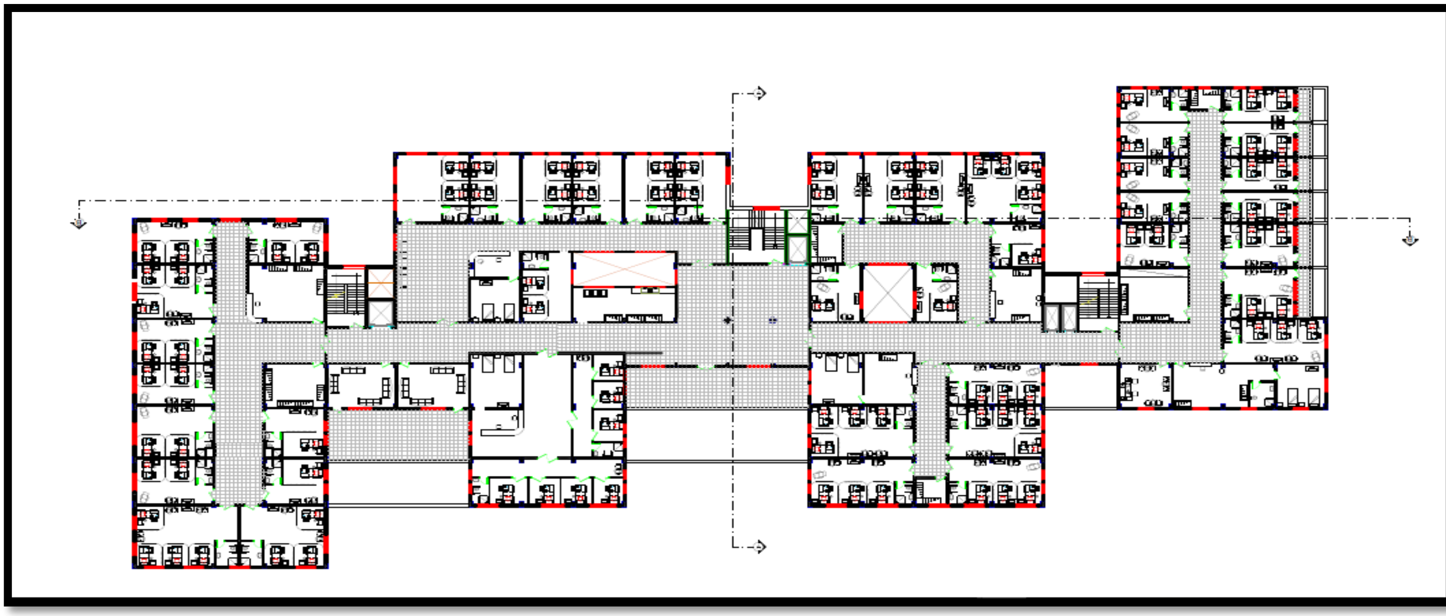
Figure(2.4): Ground Floor Plan



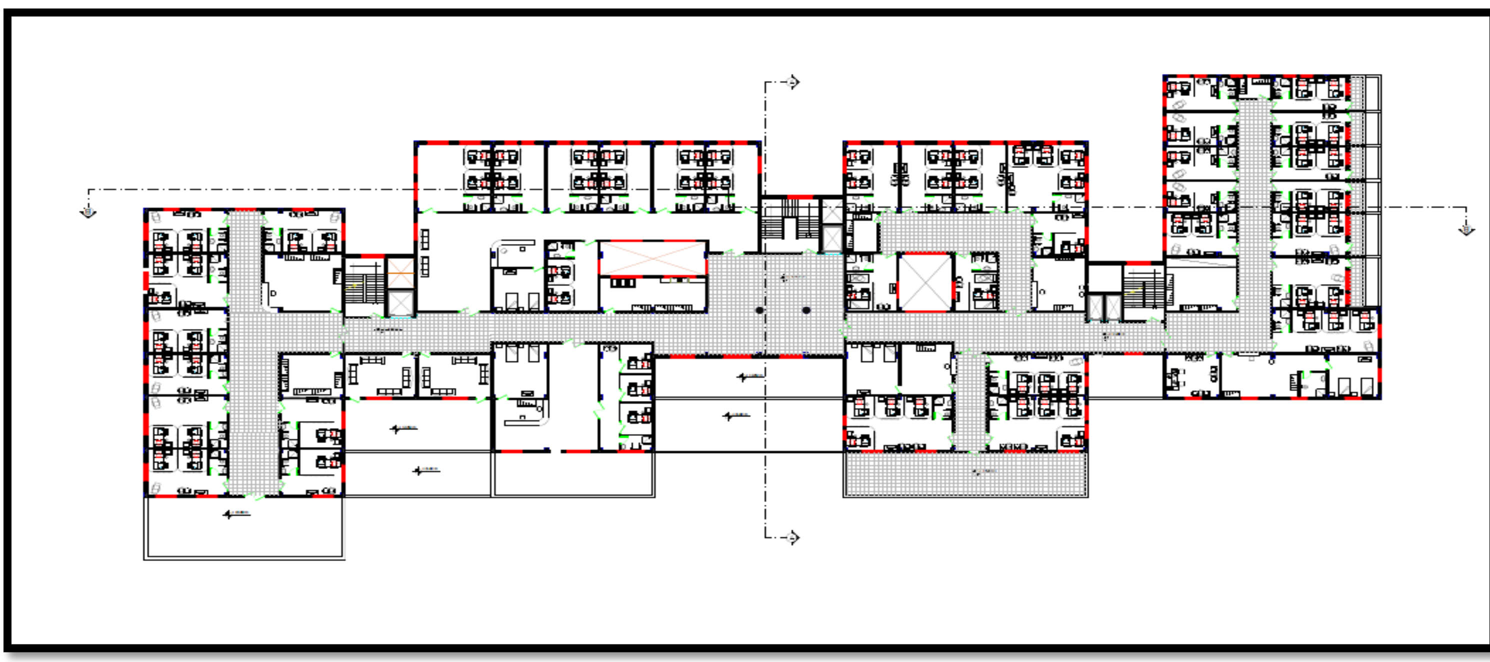
Figure(2.5): First Floor Plan.



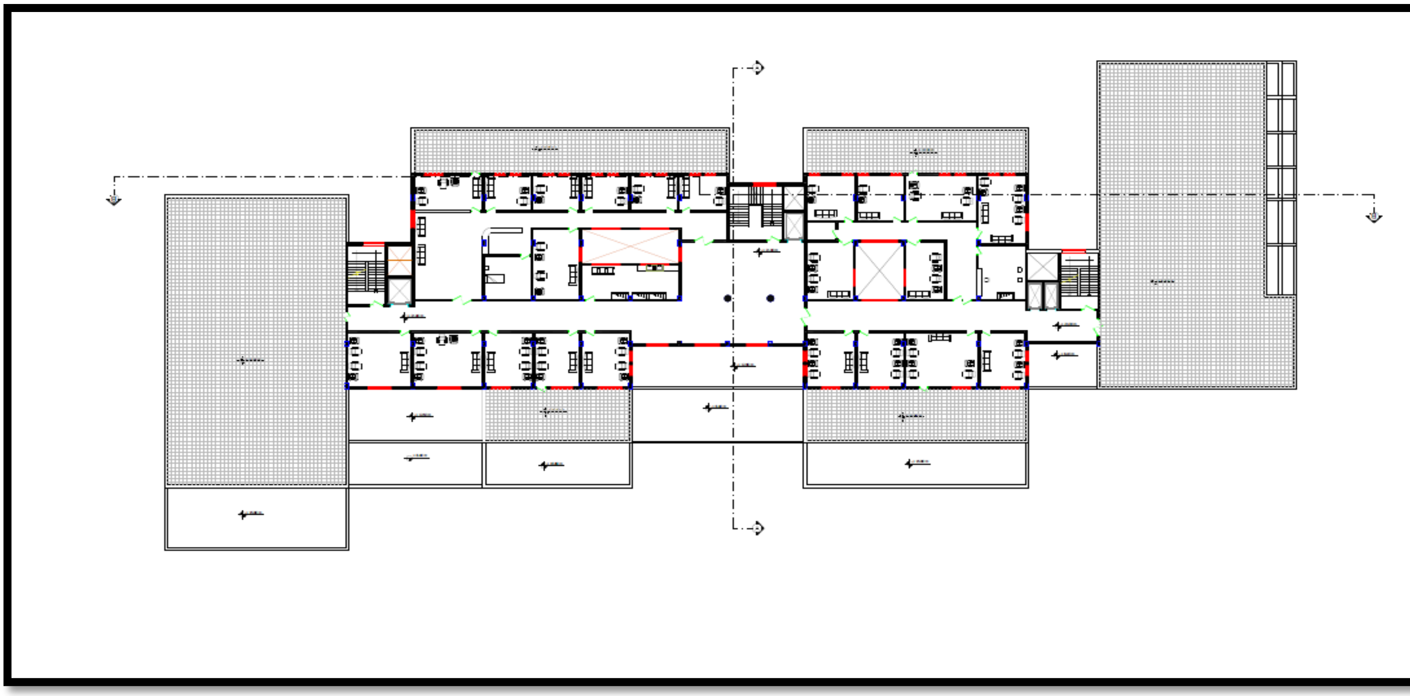
Figure(2.6): Second Floor Plan.



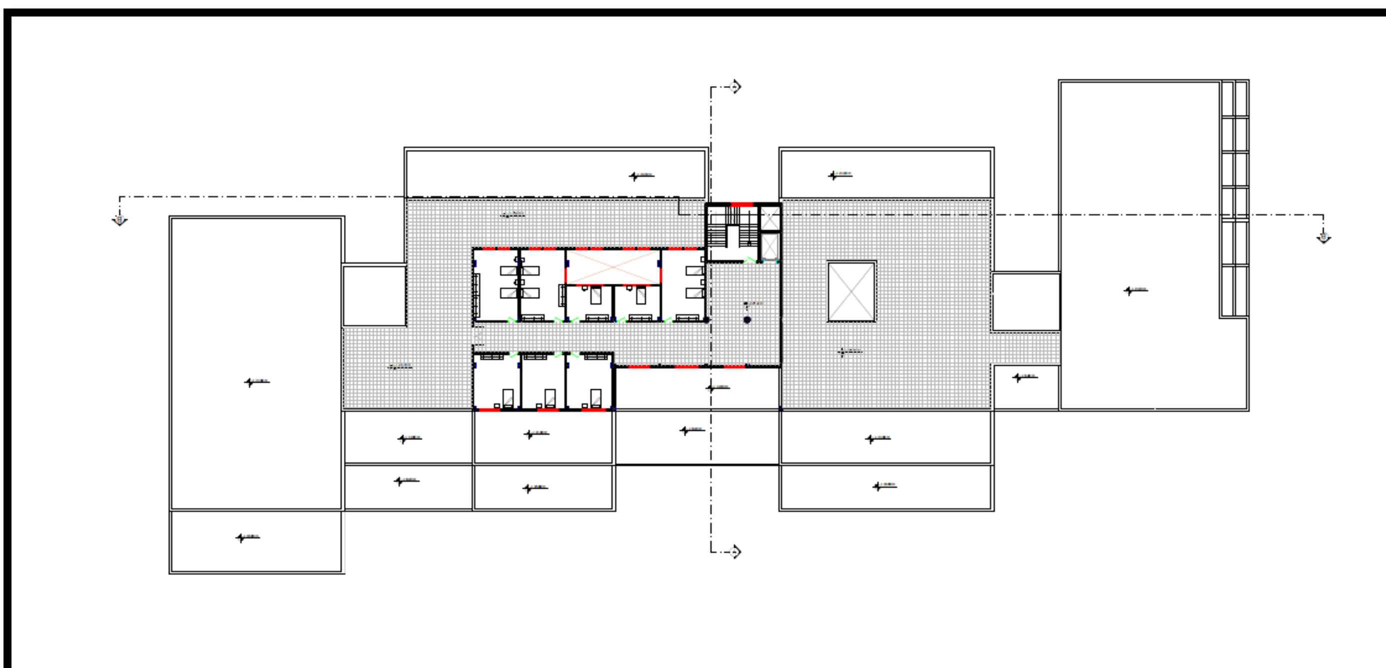
Figure(2.7): Third Floor Plan.



Figure(2.8):Forth Floor Plan.

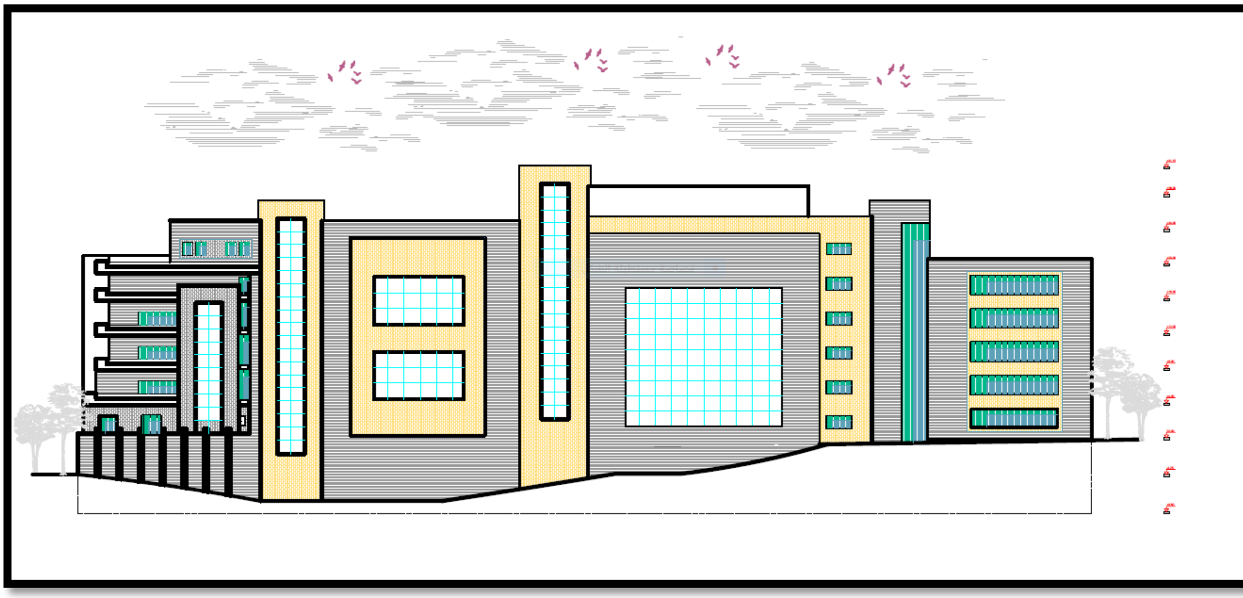


Figure(2.9):Fifth Floor Plan.

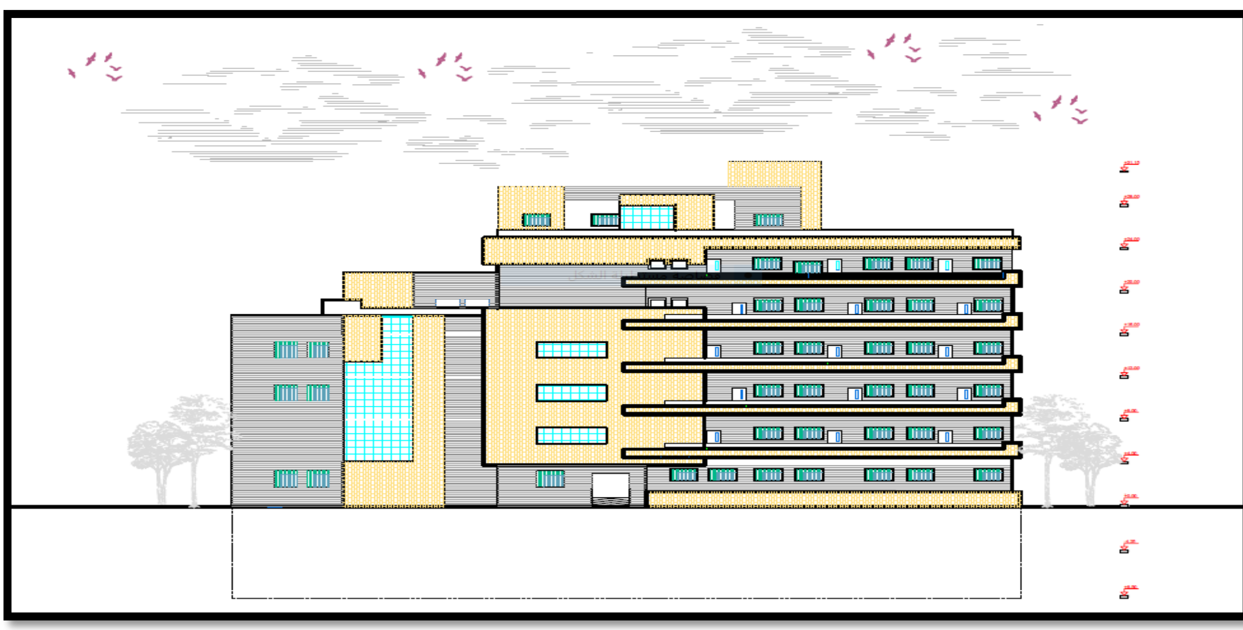


Figure(2.10):Sixth Floor Plan.

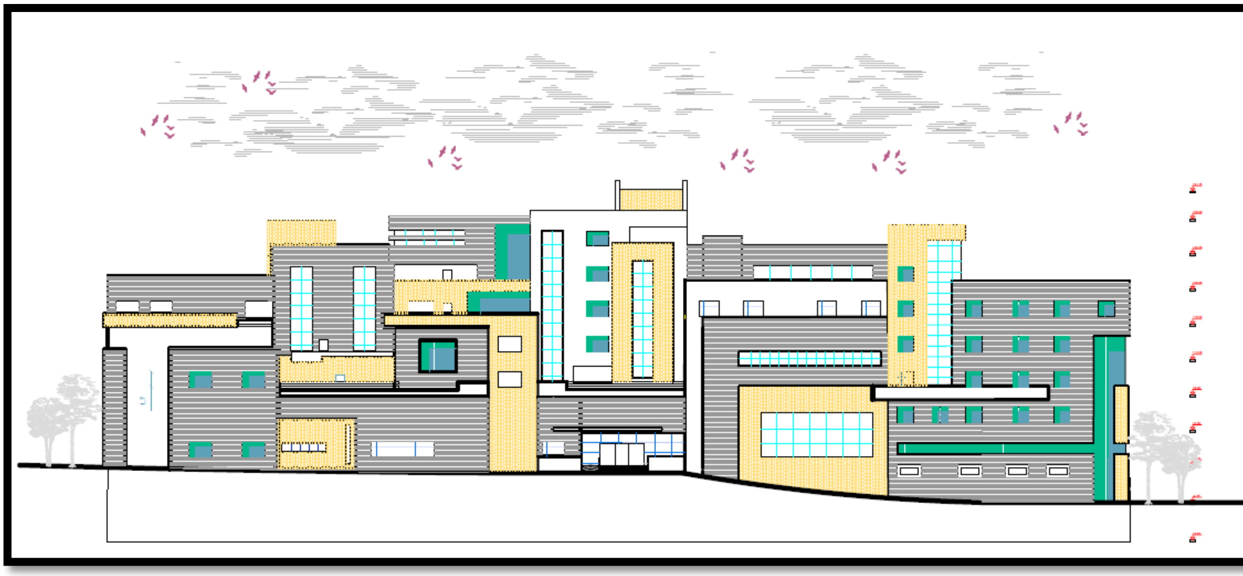
2.4 Project Elevations



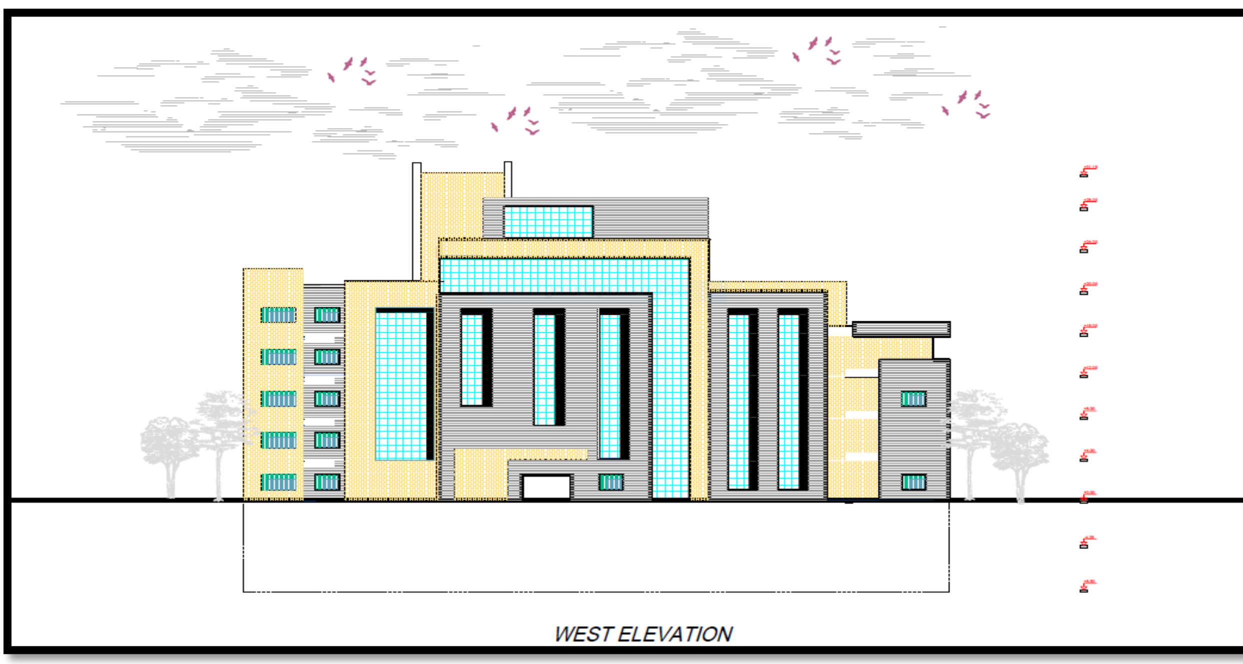
Figure(2.11): North Elevation.



Figure(2.12): East Elevation.

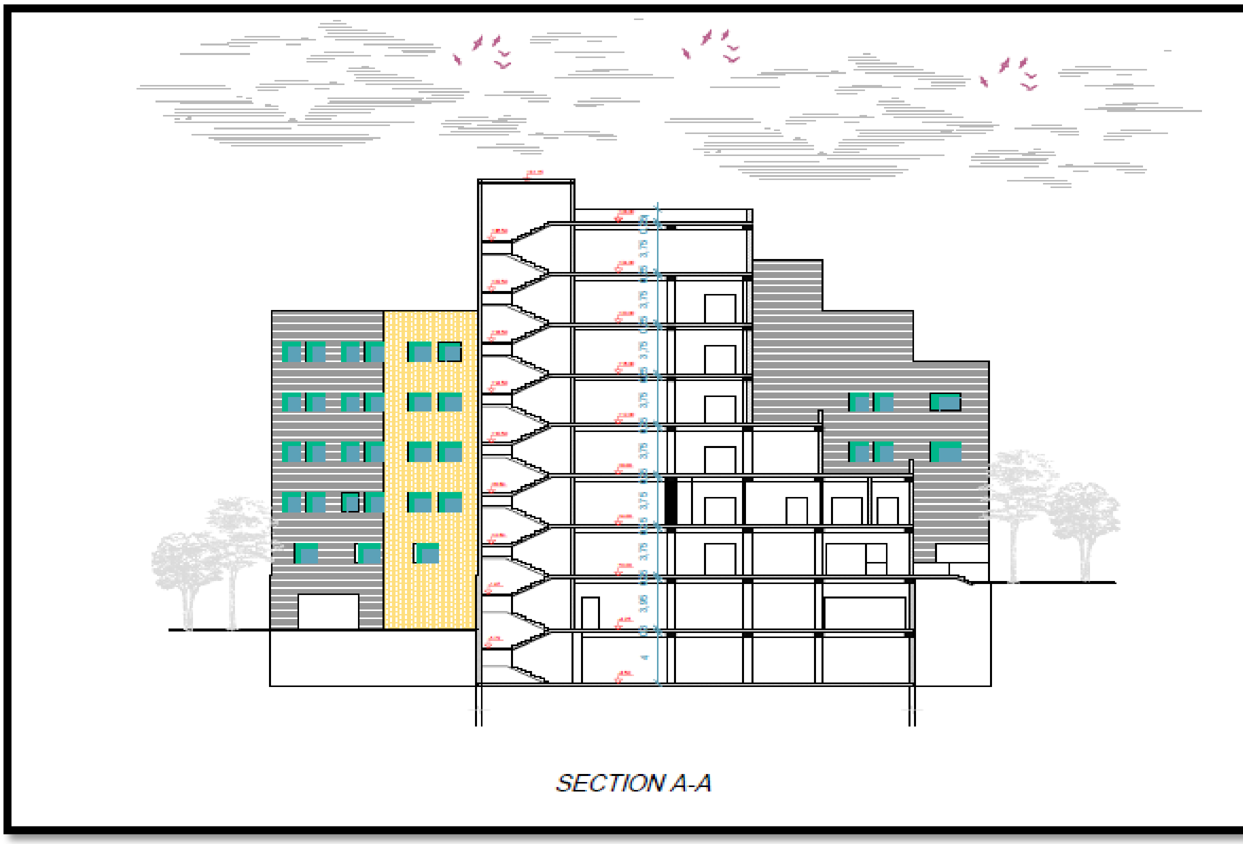


Figure(2.13): South Elevation.

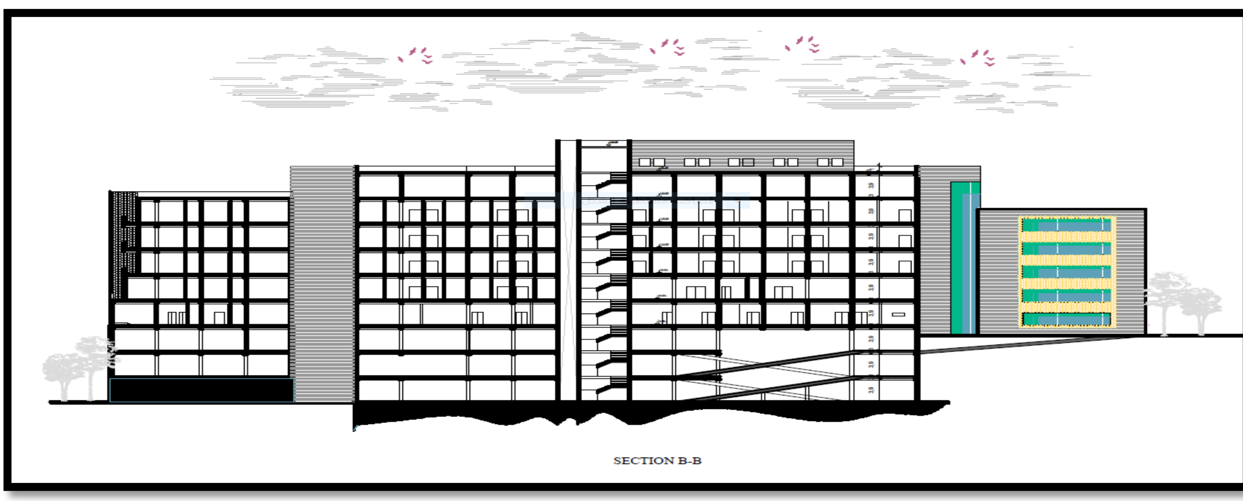


Figure(2.14): West Elevation.

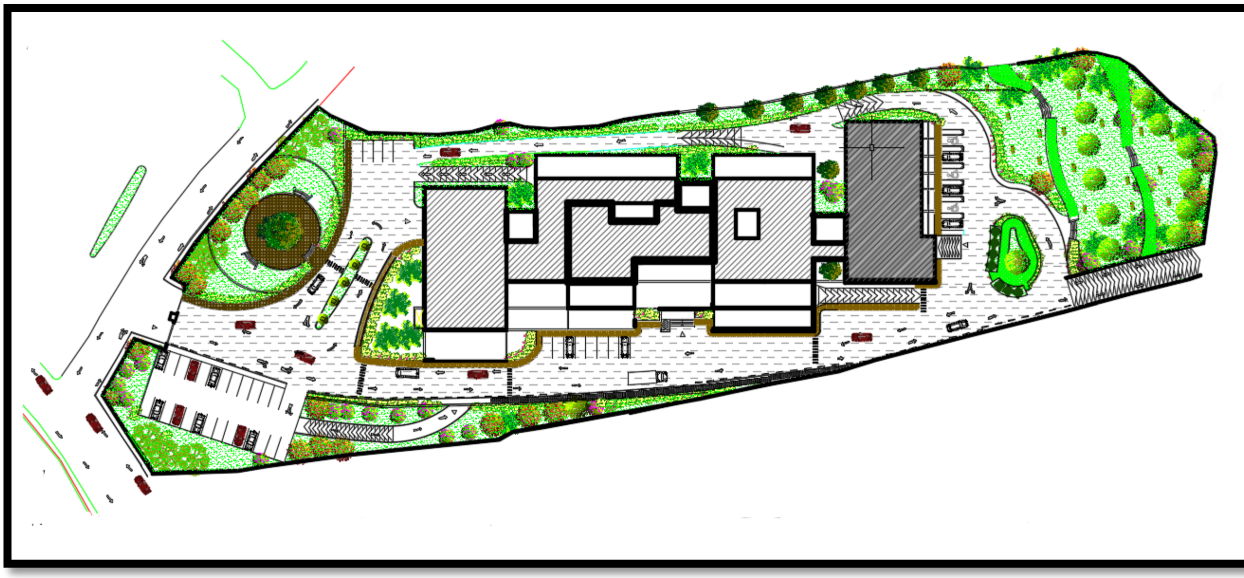
2.5 Project Sections



Figure(2.15): Section A-A.



Figure(2.16): Section B-B.



Figure(2.17): Site plane.

CHAPTER

3

Structural Description

3.1Introduction

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

3.3 Scientific Tests:

Before the design of any construction project must be doing some tests, tests of the soil to see breaking strength, specifications, type, the underground water level and depth of the foundation layer.

3.4 Steps for Structural Design:

We will distribute the structural design of the project in two phases:-

1. The first step :-
   In this step , the appropriate structural system of project construction and analysis for this system will be determined.
2. The second step: - The structural design of each element of the set is detailed and accurate according to the chosen construction system and structural blueprints for executable.

3.5 Loads Acting on the Building:

Is a group of forces that is designed to endure, and that any building is subjected to several types of loads must be calculated and selected carefully because any error in identifying and calculating loads reflect negatively on structural design of various structural elements. The building is exposed to loads of live and dead loads, wind loads, snow loads, loads of earthquakes.

The permanent forces and resulting from strong gravity which are fixed in terms of amount and location and does not change during the age of the building, and the loads on the weight of structural elements and the weights of the items based upon sustainably as cutters and walls, as well as the weight of the body adjacent to the building permanently, and the calculation and estimate the loads by knowing the dimensions of the structural elements and specific gravity of the material used in the manufacture of structural elements, And are most often include: concrete, and Rebar, and plaster, and bricks, tiles and finishes, and the stone used in building

coverage abroad, there is also a tube extensions, as well as suspended ceilings and decorations for the building

.3.5.1 Dead Loads

Material	Density(KN/m^3)	Thickness(m)
Tiles	23	**0.03**
Mortar	22	**0.02**
Sand	16	**0.07**
Concrete	25	**0.08**
Plaster	22	**0.02**
Partition=1.5 KN/m^2		

Table (3-1) Dead load

3.5.2Live Loads

Which are the loads that are subjected to buildings and constructions depending on various uses, including distributed and concentrated loads, which include the following:

1. The weights of the hospital's users.
2. Dynamic loads, such as devices that produce vibration.
3. Static loads, which can be changed from time to time, such as furniture, machines, static unstable machines, stored materials, furniture, equipment unstable machines, stored materials, furniture, equipment.

NO.	Building Type	Live Load
1	**School**	**5**
2	**Hospital**	**5**
3	**Hotel**	**2.5**
4	**Restaurant**	**5**
5	**Residential building**	**2.5**
6	**Barking**	**5**
7	**Sport Center**	**5**

Table 3-2 shows the value of live loads depending on type of building according to the Jordanian code.

We take live load for hospital =5KN/m^2 .

3.5.3 Snow Loads

Figure (3.1): snow loads.

Snow loads can be calculated by knowing the altitude using the table below by Jordanian code.

حمل الثلج (S_o) (كن/م٢)	ارتفاع المنشأ عن سطح البحر (h) (بالمتر)
0	250 > h
(h-250)/800	500 > h > 250
(h-400)/320	1500 > h > 500

Figure (3.2): Determination of snow load, Jordanian loads code

Based on the scale of previous snow loads and after selecting the high building surface and that equals (965 m) according to item III snow load is calculated as follows:

S_o= (h-400)/320

SL= (965-400)/320= 1.77KN/m²

3.5.4 Earthquake Load:

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 resisted by shear walls in the building

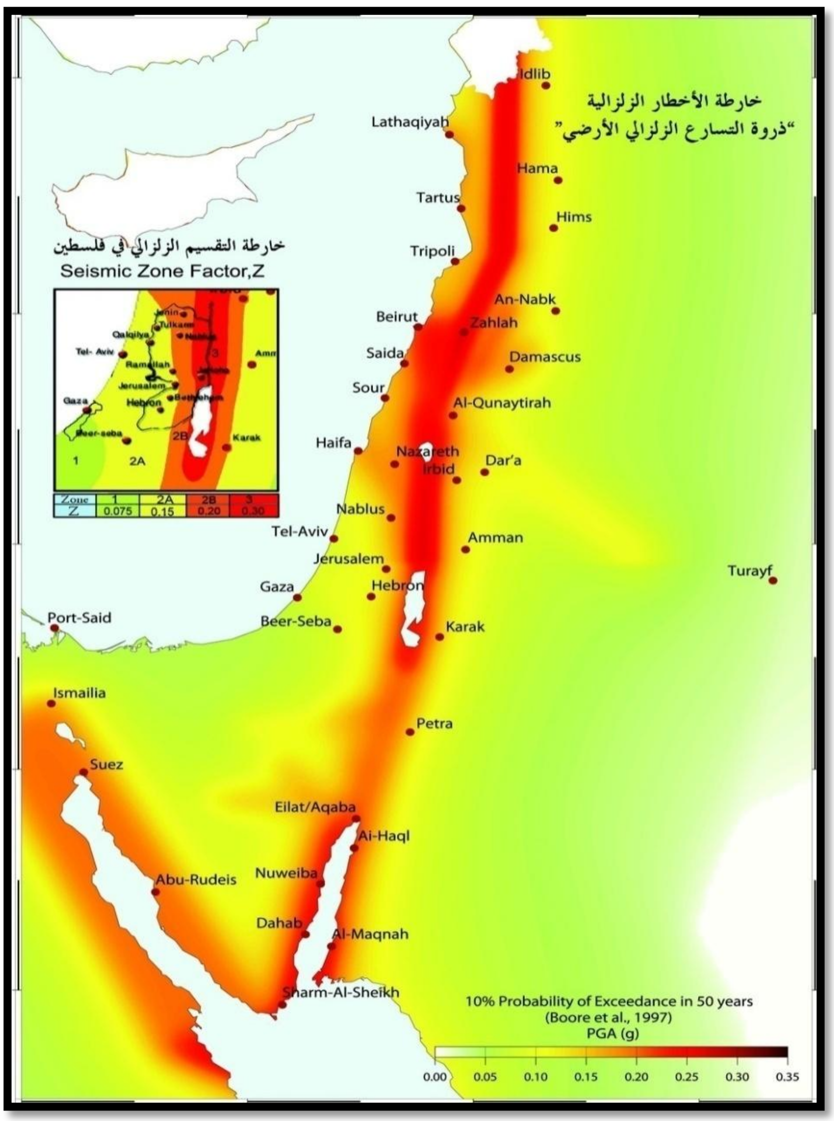


Figure (3.3): Earthquake map for Palestine

3.5.5Wind Loads:

Wind loads affect the horizontal forces on the building, and the wind load determination process is depending on wind speed and change height from the surface of the Earth and the location of where his high buildings or having established himself in the high or low position and many other variables.

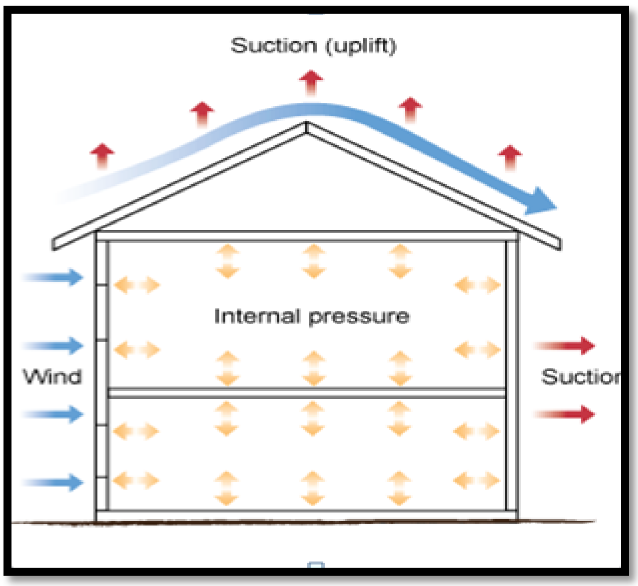


Figure (3.4): Wind Pressure on buildings.

3.6 Structural Elements of the Building:

All buildings are usually consists of a set of structural elements that work together to maintain the continuity of a building and its suitability for human use, and the most important of these slabs and beams and columns and load-bearing walls, etc.

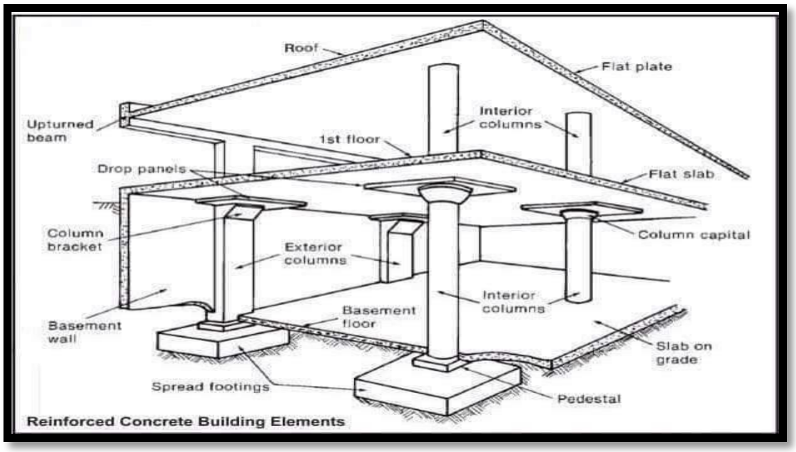


Figure (3.5): Structural Elements of the Building.

3.6.1 Slabs:

Structural elements are capable of delivering vertical forces due to the loads affecting the building's load-bearing structural elements such as beams, columns and walls ,In this project, two types of components both in its appropriate place, and which will clarify the structural design in the subsequent chapter, and below these types:

1- One Way Ribbed Slab.
2- One Way Solid Slab.
3- Two Way solid Slab

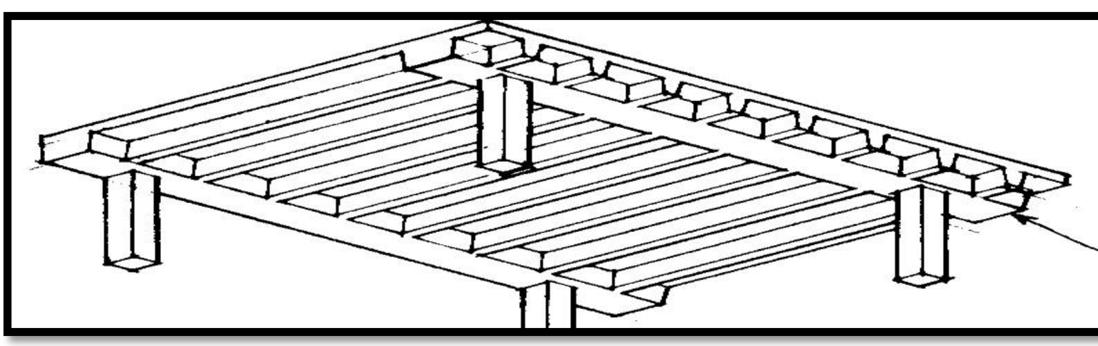


Figure (3.6) One Way Ribbed Slab

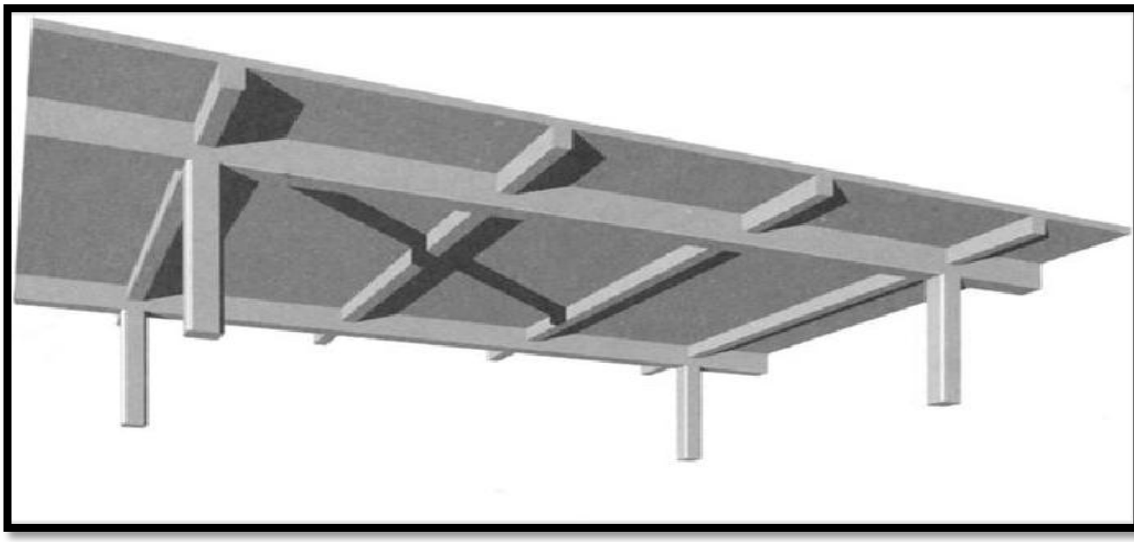


Figure (3.7)One Way Solid Slab.

.

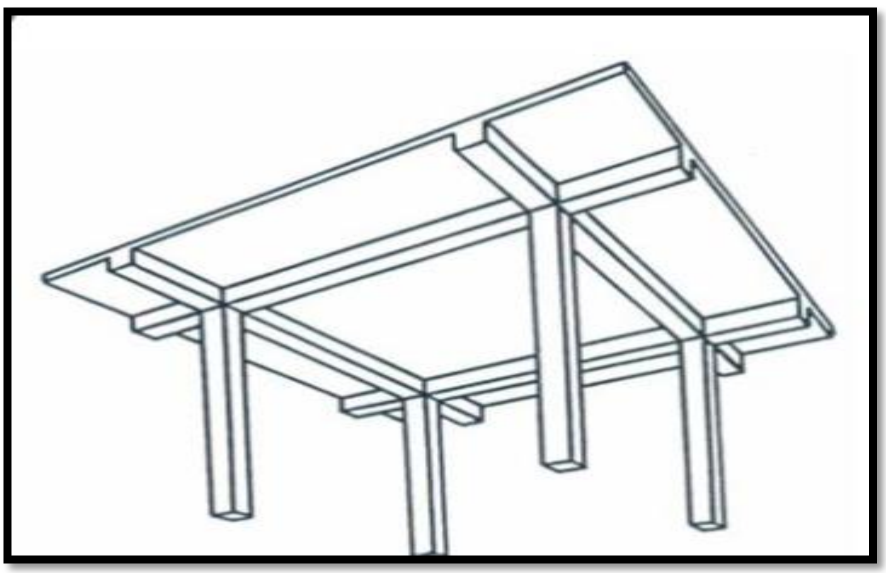


Figure (3.8) Two Way Solid Slab.

3.6.2 Stairs:

The architectural elements used for vertical transmission between the different levels of the lever through the building, and will be one of inclusion type design development.

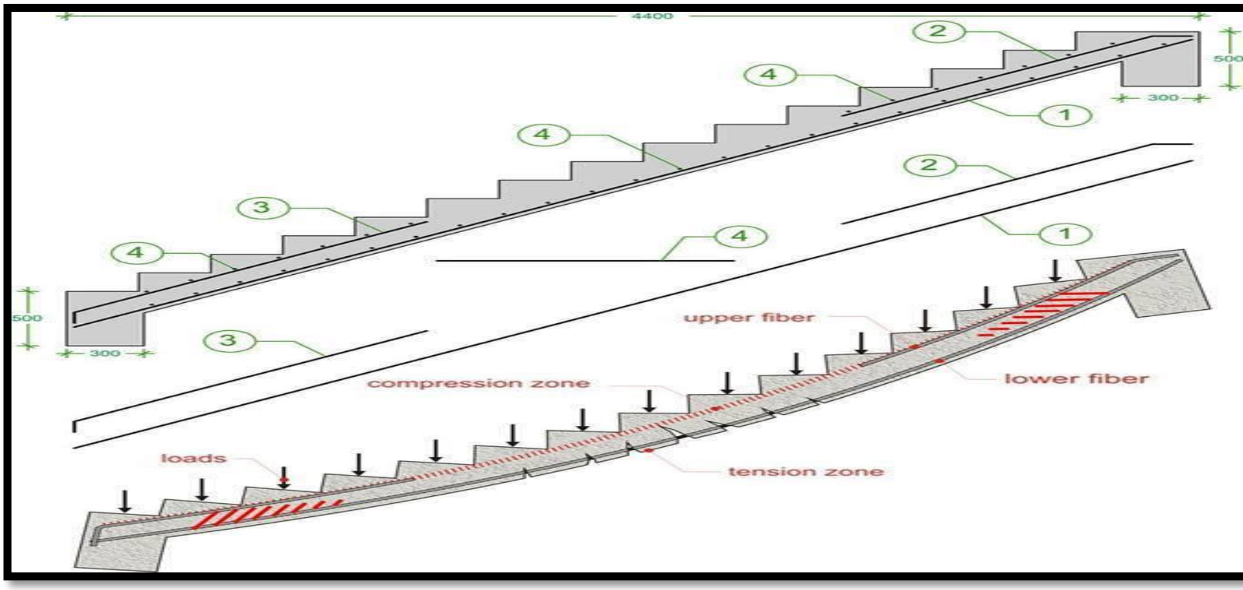


Figure (3.9) The shape of stairs.

3.6.3 Beams :

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

1- Hidden Beam: Hidden inside Slabs.
2- Dropped Beam: (Paneled Beam).

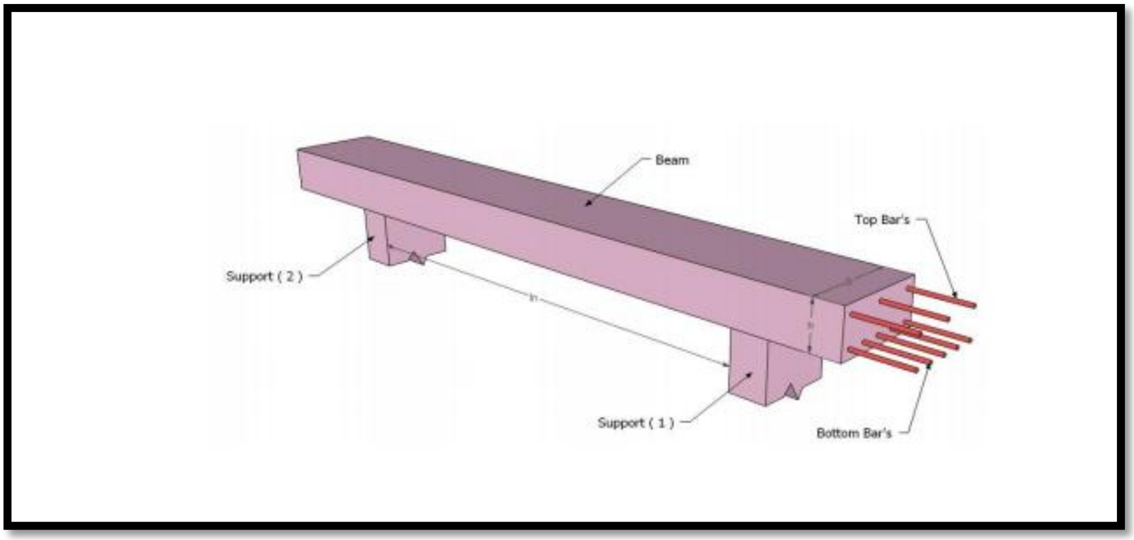


Figure (3.10) Hidden Beam.

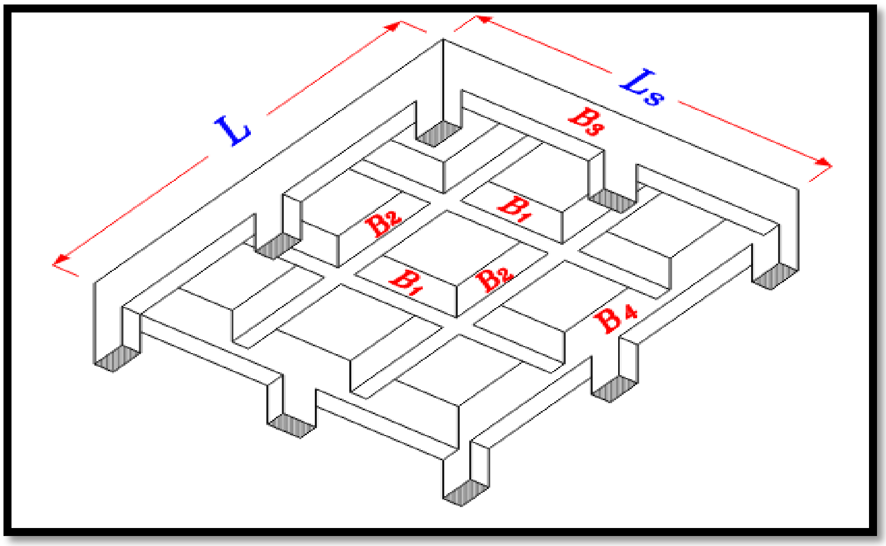


Figure (3.11) Paneled Beam.

3.6.4 Column :

The column is an important element in moving loads of bridges to the foundations, it is essential to transfer the loads and the building, and therefore must be designed so as to be able to download and load them, and two rectangular and square concrete columns.

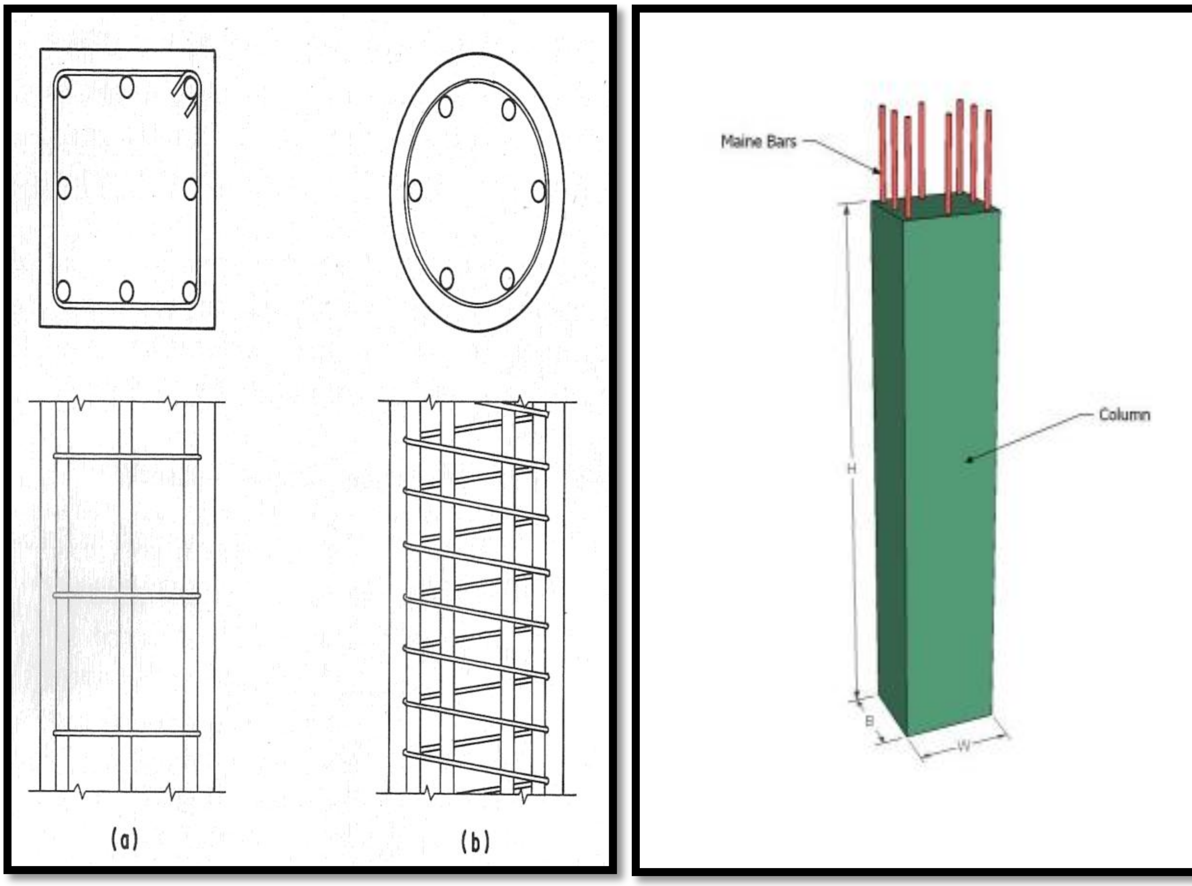


Figure (3.12) Column

.

3.6.5 Shear wall:

Is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on the building, the building contains a number of shear wall continued from Foundation to the end minaret.

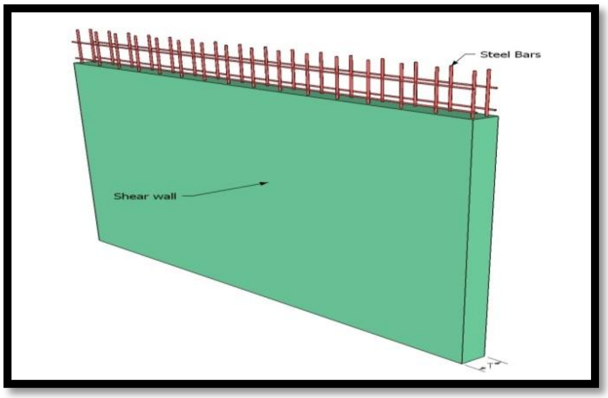


Figure (3.13) Shear Wall.

3.6.6 Expansion joint :

We can determine the maximum distance between the expansion joints for buildings as follow:

- From 40 to 45 m in normal regions like Palestine.
- From 30 to 35 m in warm regions like Palestine.
- We can increase these distances by consider the effect of creep and shrinkage.
    - In retaining walls we must decrease distances between expansion joints, and

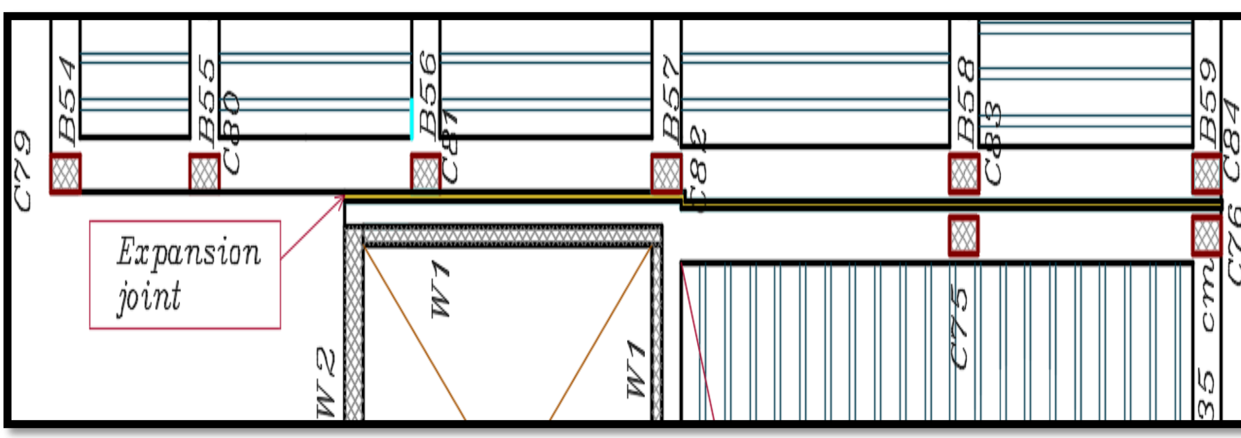


Figure (3.14): Expansion joint

3.6.7 Foundation :

Although the foundations are the first element constructs, but we did the design after the completion design all the structural elements in the building.

The foundations are the link between the structural elements in the building and the earth. The loads on the slab move to the beams and then to the columns and finally to the foundations to the soil. The foundation is responsible for carrying the dead loads of the building and also the dynamic loads resulting from wind, snow and earthquakes. Also Live loads inside the building.

We determined the type of foundations depending on the strength of the soil and the loads on each footing.

3.6.7.1 Mat

When the bearing capacity of the soil is low, isolated footings are replaced by a raft foundation. In such a case, a solid reinforced concrete rigid slab is constructed under the entire building as shown below. Structurally, raft foundations resting directly on soil act as a flat slab or a flat plate, upside down

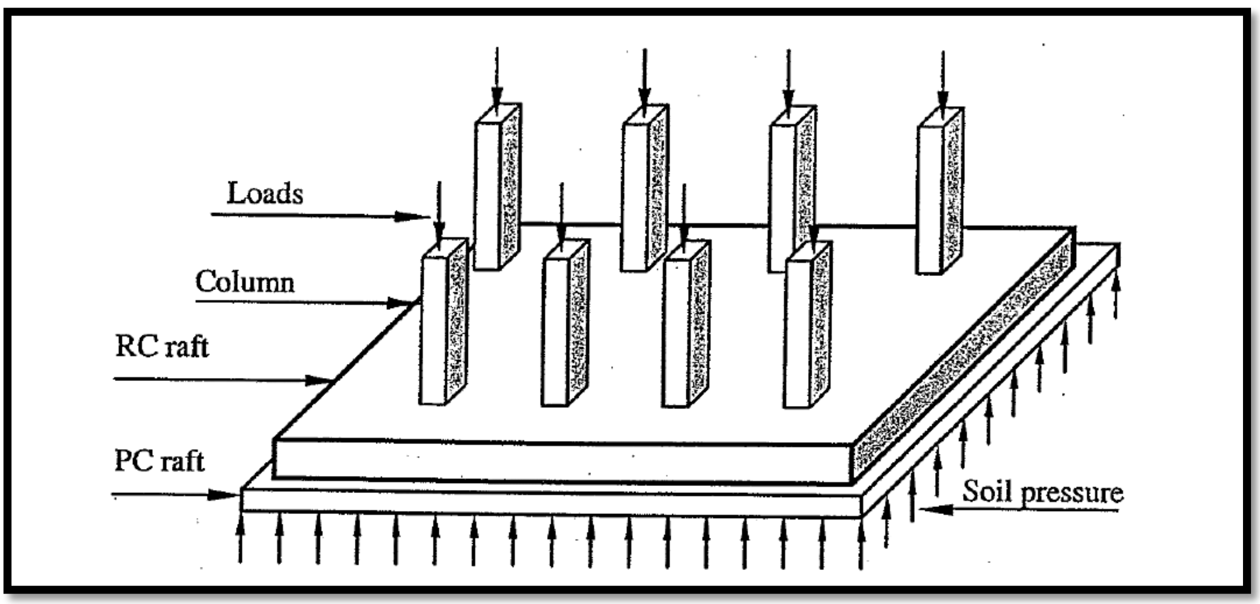


Figure (3.15): Mat Foundation

3.7 Structural programs

1. AutoCAD (2007/2014) for Structural and Architectural Drawings.
2. Microsoft Office word (2010)For Text Edition.
3. Microsoft Office Excel (2010).
4. Atir 11.5 (BEAMD/FOUND).
5. Sp Column.
6. ETABS 2016.
7. SAFE 2016.

CHAPTER

4

DESIGN OF STRUCTURAL MEMBERS

4.1 INTRODUCTION

4.2 FACTORED LOAD

4.3 DETERMINATION OF THICKNESS

4.3.1 DETERMINATION OF THICKNESS FOR ONE-WAY RIBBED SLAB

4.4 DESIGN OF ONE-WAY RIBBED SLAB

4.4.1 DESIGN OF TOPPING

4.4.2 DESIGNOF RIBS

4.4.2.1 Design Negative Moment of Rib 8:

4.4.2.2 Design of Positive Moment of Rib 8 :

4.4.2.3Design for shear:

4.5 DESIGN OF BEAM

4.5.1 DESIGN FOR POSITIVE MOMENT

4.5.2 DESIGN FOR NEGATIVE MOMENT

4.5.3 DESIGN FOR SHEAR

4.6 DESIGN OF ONE-WAY SOLID SLAB

4.6.1 CALCULATION MINIMUMM THICKNESS SLAB

4.6.2 DEAD LOAD CALCULATION

4.6.3 SHEAR DESIGN

4.6.4 FLEXTURE DESIGN

4.6.5 POSITIVE MOMENT

4.7 DESIGN OF LONG COLUMN

4.7.1 DIMENTION OF COLUMN

4.7.2 CHECK SLENDERNESS EFFECT

4.7.3 DESIGN OF THE TIE REINFORCEMENT

4.8 DESIGN OF STAIR

4.8.1 LIMITATION OF DEFLICTION

4.8.2 CALCULATION OF LOAD

4.8.3 DESIGN OF SLAB S1

4.8.3.1 Design of shear forces:

4.8.3.2 Design of bending moment:

4.8.3.3 Check of strain:

4.8.4 DESIGN OF SLAB S2

4.8.4.1 Design of shear forces:

4.8.4.2 Design of bending moment:

4.8.4.3 Check of strain:

4.9DESIGN OF BASEMENT WALL

4.9.1 Loads on basement wall:

4.9.2 Design of shear force:

4.9.3 Design of the reinforcement concrete

4.9.3.1 Design of the Vertical reinforcement in tension side:

4.9.3.2 Design of the horizontal reinforcement in tension side:

4.10 MAT FOUNDATION

4.1 Introduction:

Concrete is the only major building material that can 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 info any form or shape.

Concrete used in most construction work. It can reinforced with steel ,when concrete structure members must resist extreme tensile stresses; steel will supplies the necessary strength. Steel embedded in the concrete in the form of a mesh, or roughened or twisted bars. A bond forms between the steel and the concrete, are exist stresses can be transferred between both components.

In this project, all of the design calculation for all structural members will done upon the structural system chosen in the previous chapter.

Therefore, in this project there are many type of slabs such as “one way ribbed slab”, they will analyzed and designed by using finite element method of design, with aid of a computer program called "Beamed- Software” to find the internal forces, deflections and moments for ribbed slabs. Then handle calculation will made to find the required steel for all members.

The design strength provided by a member is connections to other members, and its cross – sections in terms of flexure, load, shear, and torsion taken as the nominal strength calculated in accordance with the requirements and assumptions of ACI-318-11 code.

Materials properties:-

- **Compressive strength of concrete = 24 MPa.**
- **Yield strength of steel fy = 420 MPa.**

4.2 Factored Loads:

The factored loads on which the structural analysis and design based for our project members, is determined as follows:

Q u =1.2Dl +1.6LL ACI-318-11 (9.2)

DL: Dead Load.

LL: Live Load.

4.3 Determination of Thickness:

4.3.1 Determination of Thickness for One-Way Ribbed Slab:

According to ACI-Code-318-11, Table (7.3.1.1), the minimum thickness computed as follow of non-re-stressed beams or one-way slabs (unless deflections are calculated):-

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

= 500/18.5 = 27cm.

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

=760/21 = 36 cm.

The controller slab thickness is 35 cm.

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

4.4 Design Of One Way Ribbed Slab:

4.4.1 Design of Topping:

No.	Parts	Density	Calculation
1	Tiles	23	**23×0.03=0.69 KN/m**
2	Mortar	22	**22×0.03=0.66 KN/m**
3	Coarse Sand	17	**17×0.07=1.19 KN/m**
4	Topping	25	**25×0.08=2 KN/m**
5	Partition	1.5 KN/m^2	**1.5×1=1.5 KN/m**
			6.04 KN/m

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

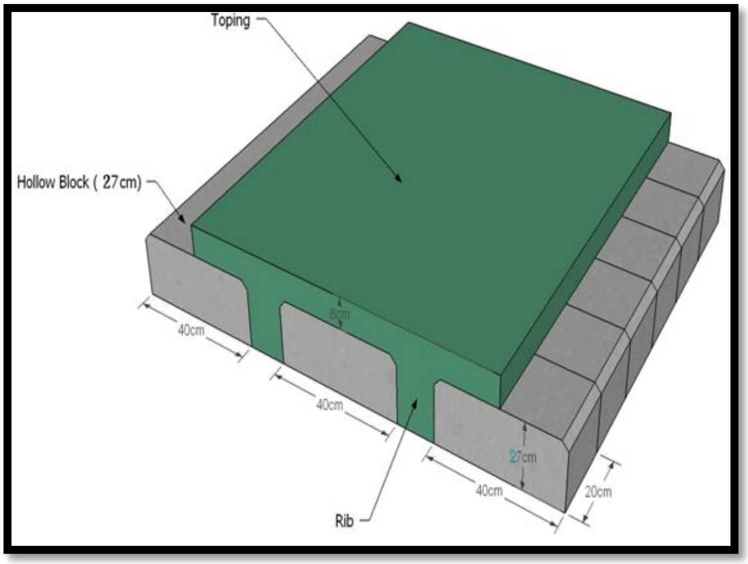


Figure (4-1): Toping of slab

(Assume a stripe 1 m long with 0.4 m width).

From Jordanian code LL = 5 KN/m^2.

Q u = 1.2×DL+1.6×LL

= 1.2×6.04+1.6×5 = 15.248 KN/m.

(Total Factored Load) .Assume slab fixed at supported points (ribs):

$$Mu = \frac{Wu * l^2}{12}$$

$$Mu = \frac{15.248 * 0.4^2}{12} = 0.2KN.m$$

Ø*Mn=0.55*0.42*√24*1000*80^2/6=1.207 KN.m

Ø*Mn (plane concrete) =1.207 KN.m> Mu max=0.2KN.m.

No structural reinforcement needed. Therefore, shrinkage and temperature reinforcement must provide.

For the shrinkage and temperature reinforcement:-

ρ min=0.0018

As= ρ*b*h=0.0018*1000*80=144 mm^2.

Number 0f Ø8 = As_{req}/A_{bar} = 144/50.3 = 2.87 → Spacing(S) = 1/2.87 = 35cm = 350 mm.

$S \leq 380\ (280/f_s) - 2.5 \times C_c \leq 300\ (280/fs)$

$= 380 \times (\ 280/(2/3\ f_y\ )\ ) - 2.5 \times 20 \leq 300 \times (\ 280/(2/3\ f_y\ )\ )$

$= 380 \times (280/\ (2/3 * 420)) - 2.5 \times 20 = 330\ mm \leq 300 \times (280/\ (2/3 * 420))$

$= S \leq 300$ mm.

$\leq 3 \times h = 3 \times 80 = 240$ mm…...controlled.

≤ 450 mm.

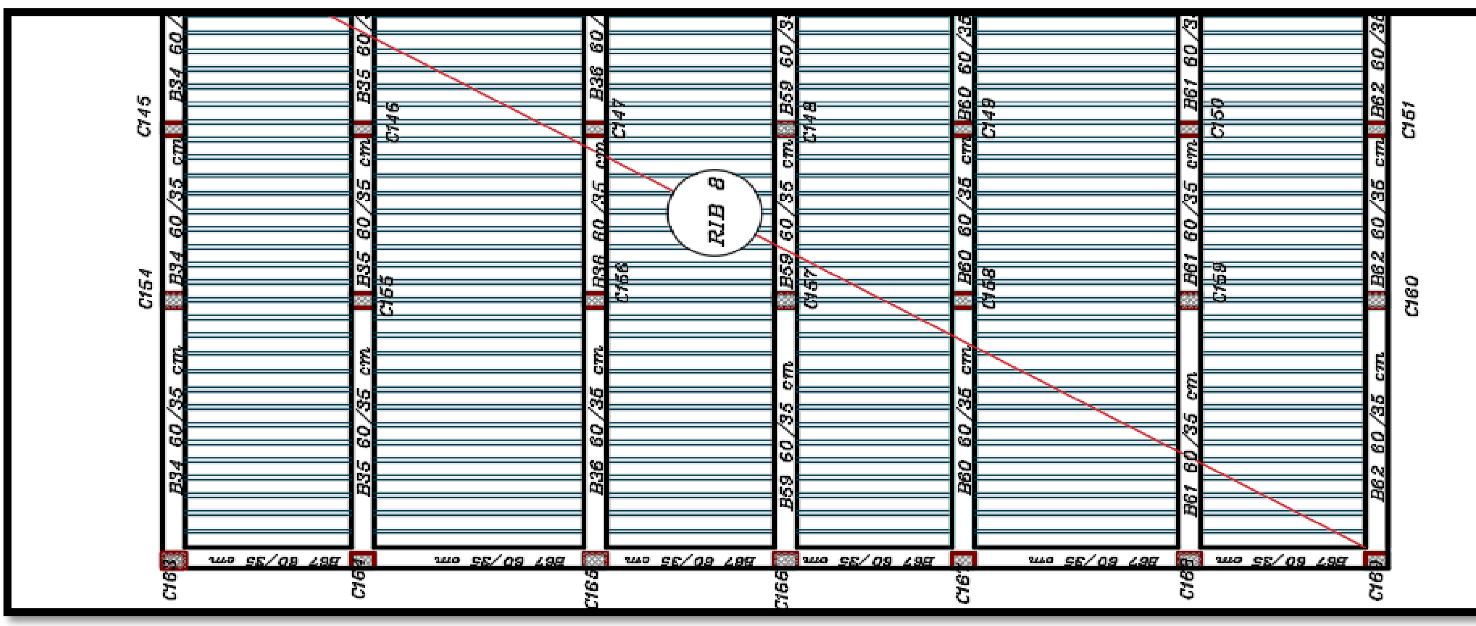


Figure (4-2): Rib location

4.4.2 Design of Ribs (Rib 8):

Table (4 – 2): Calculation of the total dead load for rib 8.

No.	Parts of Rib	Density KN/m^3	Calculation
1	**Tiles**	**23**	**0.03*23*0.52 = 0.359 KN/m**
2	**Mortar**	**22**	**0.03*22*0.52 = 0.343 KN/m**
3	**Sand**	**17**	**0.07*17*0.52 = 0.619 KN/m**
4	**Topping**	**25**	**0.08*25*0.25 = 1.04 KN/m**
5	**Rib**	**25**	**0.27*25*0.12 = 0.81 KN/m**
6	**Block**	**10**	**0.27*10*0.4 = 1.08 KN/m**
7	**Plaster**	**22**	**0.03*22*0. 52 = 0.343 KN/m**
8	**partition**		**1.5*.52 = 0.78 KN/m**
			5.374 KN/m

Concrete B300 Fc' = 24 Mpa

Reinforcement Steel FY = 420 Mpa

.

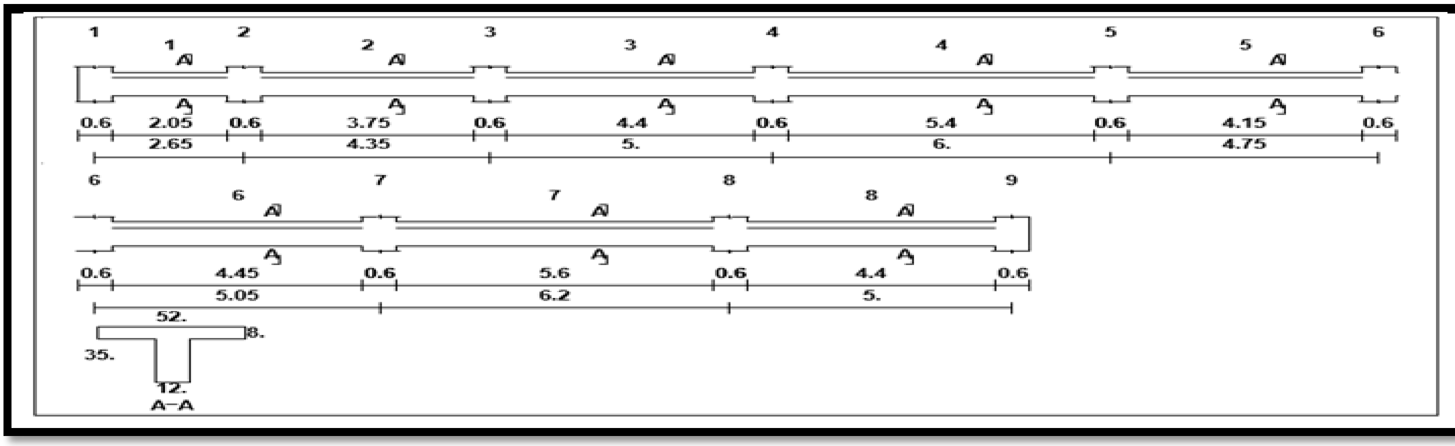


Figure (4-3): Rib 8 Geometry

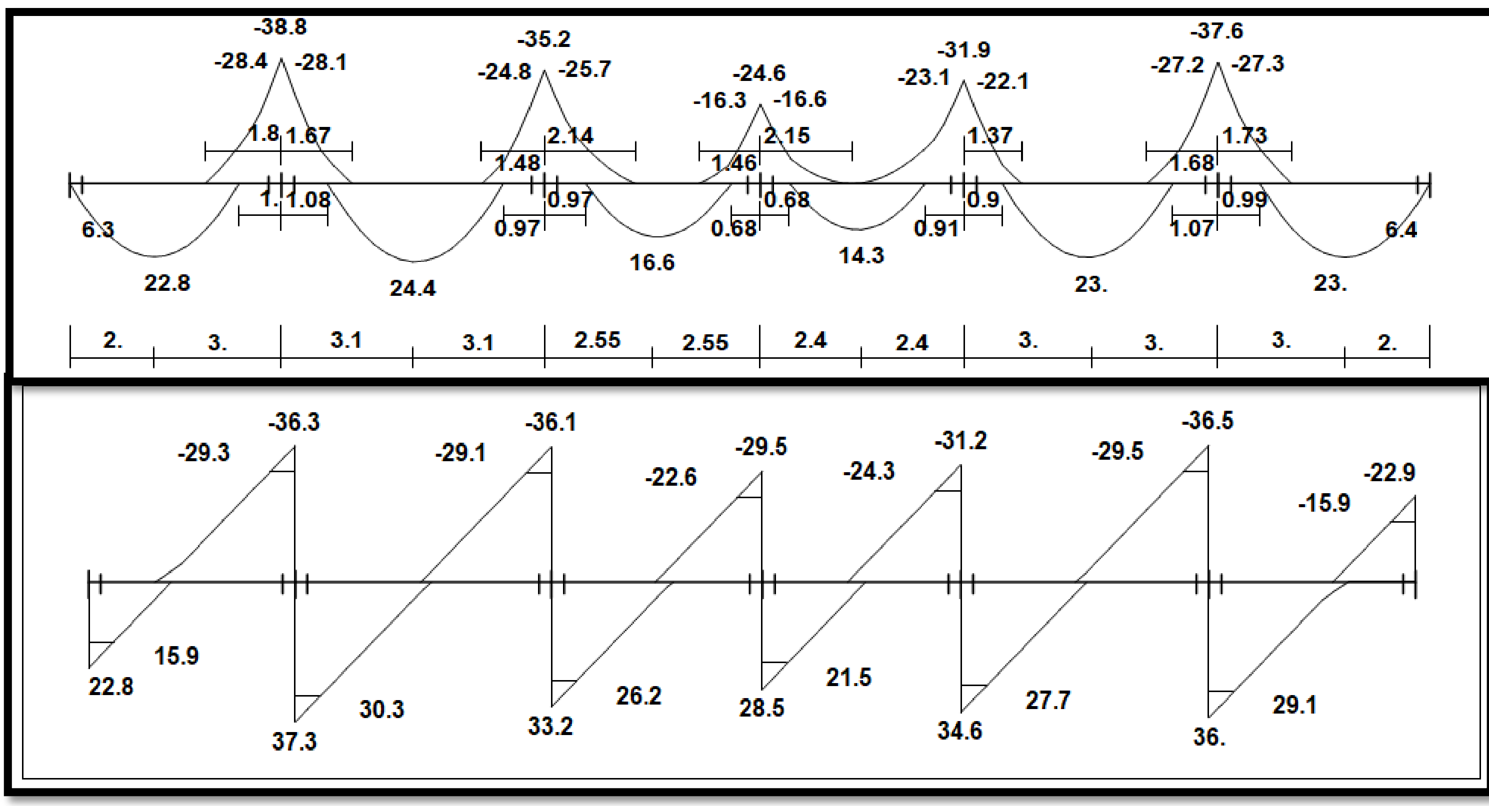


Figure (4-4): Moment and shear Envelop of rib 8.

4.4.2.1 Design Negative Moment of Rib 8:

d= h- cover – d $_{stirrups}$ –d_b/2 = 350 – 20 – 10 – 7 = 313mm

Maximum negative moment M_u= -28.4 KN.m

M_n = 28.4/ 0.9 = 31.56 kN.m

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

$$Rn = \frac{31.56 * 10^6}{120 * 313^2} = 2.77 \text{ MPa.}$$

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

$$\rho = \frac{1}{20.59}(1 - \sqrt{1 - \frac{2(20.59)(2.77)}{420}}) = 0.00711$$

As = 0.00711 (120) (313) = 267.3 mm^2

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

$$= \frac{\sqrt{24}}{4*420} * 120 * \; 313 \;\geq\; \frac{1.4}{420} * 120 * 313$$

$As_{min} = 109.5 < 125.5$…………the larger is control

$A_{s\,min}$ = 125.5 mm^2

A_s= 267.3 mm^2 >As $_{min}$ = 125.2 mm^2

Of bars = As/ As $_{bar}$ = 267.3 /113.097 =2bars * Note $A_{\Phi 12}$ = 113.097 mm^2

Select 3 Φ 12mm.

As provided= 339.3 mm^2

- **Check for strain:-($\varepsilon_s \geq 0.005$)** **ACI-318-11 (10.3.5)**

$As \times f_y = 0.85 \times f_c' \times b \times a$

$339.3 \times 420 = 0.85 \times 24 \times 120 \times a$

a=58.2 mm.

$$c = \frac{a}{\beta_1}$$

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

c= 58.2/0.85 = 68.47

d = 350 – 20 – 10 – 7 = 313 mm

ε_s = 0.003*((d-c)/c) = 0.003*((313 - 68.47)/68.47) = 0.0107> 0.005

∴∅ = 0.9.... OK.

4.4.2.2 Design of Positive Moment of Rib 8 :

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

d= h- cover – $d_{stirrups}$ –d_b/2 = 350 – 20 – 10 – 6 = 314 mm

∴ Assume rectangular & tension control section.

Maximum positive moment is M_u= 24.4 kN.m.

Mn = 24.4 / 0.9 = 27.1kN.m

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

$$Rn = \frac{27.1*10^6}{520*314^2} = 0.53 \text{ MPa}$$

$\rho = \frac{1}{20.59}(1 - \sqrt{1 - \frac{2(0.53)(20.59)}{420}}) = 0.0013$

As = 0.00161 (520) (314) = 208.8 mm^2

$$As_{\min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) \geq \frac{1.4}{fy}(bw)(d) \ldots\ldots\ldots\ldots\ldots\ldots(ACI - 10.5.1)$$

$$As_{\min} = \frac{\sqrt{24}}{4(420)}(120)(314) \geq \frac{1.4}{420}(120)(314))$$

$$As_{\min} = 109.9 < 125.6$$

$$As_{\min} = 125.6 mm^2$$

208.8 mm^2> $As_{\min} = 125.6 mm^2$

# of bars = As/ As $_{bar}$ = 208.8/153.93 = 2 bars * Note $A_{\Phi 14}$ = 153.93 mm²

As providing = 307.87 mm^2

Select 2 Φ 14mm.

- **Check for strain:-($\varepsilon_s \geq 0.005$) ACI-318-11 (10.3.5)**

As × f_y = 0.85 × f_c' × b × a

307.87 × 420 = 0.85 × 24 × 120 × a

a=52.82 mm

$$c = \frac{a}{\beta_1} = \frac{52.82}{0.85} = 44.897mm$$

$$\varepsilon_s = \frac{283 - 44.897}{44.897} X0.003$$

$$\varepsilon_s = 0.0159 > 0.005 OK$$

4.4.2.3Design for shear:

V_u= 30.3 KN

$$\Phi\ Vc = \Phi * \frac{\sqrt{fc'}}{6} * bw * d$$

$$= 0.75 * \frac{\sqrt{24}}{6} * 0.12 * 0.313*1000$$

= 23 KN

1.1 * Φ Vc = 1.1*23 = 25.3 KN.

Check for Vu:-

1) Vu ≤ Φ Vc/2

30.3 ≤ 12.65 (X)

2) Φ Vc/2 ≤ Vu ≤ Φ Vc

12.65 ≤30.3 ≤ 25.3 (X)

3) Φ Vc ≤ Vu ≤ Φ Vc + Φ Vsmin

$$Vsmin = \frac{\sqrt{fc'}}{16} * bw * d \qquad \text{OR} \qquad Vsmin = 1/3 * bw * d$$

Vsmin = 11.5 KN OR Vsmin = 12.52 KN

Φ Vsmin = 0.75*12.52 = 9.39 KN

23 ≤ 30.3 ≤ 23+9.39

23 ≤ 30.3 ≤ 32.39…. (OK)

So Case (3) satisfy

Vs = (Vu-(ΦVc))/Φ = 23KN.

Take Av = 2 Φ 8 = 2 * 50.265=100.53 mm^2.

Av/ s = 1/3 (b_w/f_y)

100.53/ s = 1/3 (313/420)→ s = 404.7 mm

S ≤ d/2 =141.5 mm

S ≤ 600 m

Use Φ 8 @ 14 cm c/c.

4.5 Design of Beam 6:

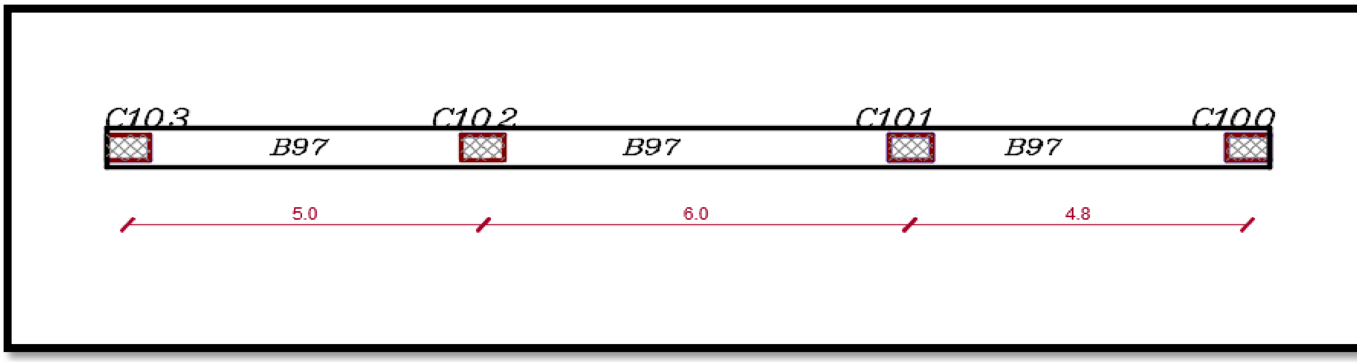


Figure (4-5): Beam location

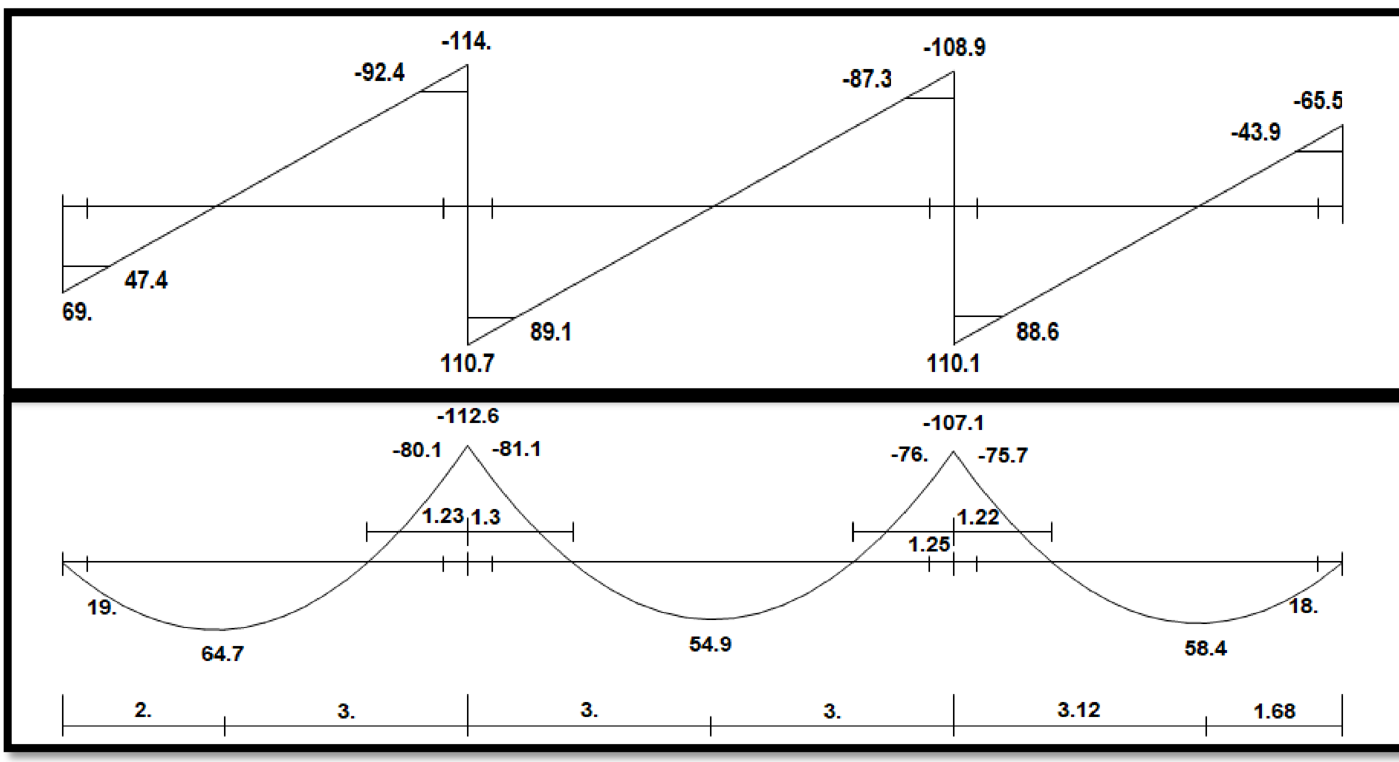


Figure (4-6): Moment and shear Envelop of Beam 97

L/18.5 = 6/18.5 = 0.32 m for span 1 and span 3

L/18.5 = 5/18.5 = 0.27 m for span 1

Take h = 35 cm

Self-Wight of beam 97 = 0.8*0.35*25 = 7 KN/m

4.5.1 Design of Positive Moment:

For main positive reinforcement Φ16 Assume bar diameter, stirrups Φ10

$b_w = 80cm, h = 35cm$

$d = 350 - 40 - 10 - (16/2) = 292mm$

$Mu^{(+)}_1$ = 64.7 KN.m

∴ Assume rectangular & tension control section.

C_{max} = 3/7 * d = 3/7 * 292= 125.14

$a_{max} = \beta 1 * C_{max}$= 0.85 * 125.14 = 106.37 mm *Note: fc' = 24 MPa < 28 MPa→$\beta 1$ = 0.85

Mn_{max}= 0.85 * fc' * b * a * (d – a/2)

Mn_{max}= 0.85 * 24 * 800 * 20.7 * (292-(20.7/2)) * 10^{-6}= 96 KN.m

* Note: ϵs = 0.004 → ϕ = 0.82

ΦMn_{max} = 0.82 * 96 = 78.77 KN.m

Mu<ΦMn max

∴ Design section as singly reinforced concrete section.

Design of positive moment Mu $^{(+)}$ =64.7 KN.m

Mn= Mu/ϕ = 64.7/0.9 = 71.88 KN.m

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

$$Rn = \frac{71.88*10^6}{800*292^2} = 1.05 \text{ MPa}$$

$$\rho = \frac{1}{20.59}\left(1 - \sqrt{1-\frac{2*(1.05)(20.59)}{420}}\right) = 0.0026$$

As_{req} = ρ × b ×d = 0.0026× 800 × 292 = 607.36 mm2.

$$As_{\min} \geq \frac{\sqrt{fc'}}{4(fy)}(bw)(d) \geq \frac{1.4}{fy}(bw)(d)$$

$$As_{\min} \geq \frac{\sqrt{24}}{4(420)}(800)(292) \geq \frac{1.4}{420}(800)(292)$$

=681.2 mm^2< 778.67 mm^2 ………… Larger value is control.

As_{min}=778.67 mm^2>As_{req} = 607.36 mm^2.

∴As = 778.67 mm^2.

4∅16 = 804.2 mm^2>As = 778.67 mm^2 … OK.

∴ Use 4 ∅16

- **Check for strain ($\varepsilon_s \geq 0.005$)** **ACI-318-11 (10.3.5)**

As × fy = 0.85 × fc' × b × a

804.2 × 420 = 0.85 × 24 × 800 × a

a =20.7 mm

$$c = \frac{a}{\beta_1} = \frac{20.7}{0.85} = 24.35mm$$

$$\varepsilon_s = \frac{292-24.35}{24.35}\times 0.003$$ **=0.033 > 0.005 (tension control section).**

∴∅ = 0.9 …. OK.

4.5.2 Design of Negative Moment:

For main negative reinforcement Assume bar diameterΦ14, stirrups Φ10

$b_w = 80cm, h = 32cm$

$d = 350-40-10-(14/2) = 293mm$

$Mu^{(-)} = 81.1$ KN.m

Mn = 81.1 / 0.9 = 90.1 KN.m

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

$$Rn = \frac{90.1*10^6}{800*(293)^2} = 1.31 \text{ MPa}$$

$$\rho = \frac{1}{20.59}\left(1 - \sqrt{1-\frac{2(1.93)(20.59)}{420}}\right) = 0.0048$$

As = 0.0048 (800) (293) = 1125.12 mm^2.

$$As_{\min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) \geq \frac{1.4}{fy}(bw)(d) \ldots\ldots\ldots\ldots\ldots\ldots(ACI-10.5.1)$$

$$As_{\min} = \frac{\sqrt{24}}{4(420)}(800)(293) \geq \frac{1.4}{420}(800)(293)$$

$$As_{\min} = 683.5 < 781.33$$

$$As_{\min} = 781.33mm^2$$

1125.12 mm^2>As_{min} = 781.33 mm^2

#Of bars = As/ As $_{bar}$ = 1125.12/201.1 = 6 bars * Note AΦ16 = 201.1 mm²

As providing = 1206.4 mm^2

Select 6 Φ 16 mm.

- **Check for strain (εs ≥0.005) ACI-318-11 (10.3.5)**

Tension = Compression

As * fy = 0.85 * b * a

$$1206.4 * 420 = 0.85 * 800 * 24 * a$$
$$a = 31.05.mm$$
$$c = \frac{a}{\beta_1} = \frac{31.05}{0.85} = 35.53mm$$
$$\varepsilon_s = \frac{293 - 35.53}{35.35} X0.003$$
$$\varepsilon_s = 0.022 > 0.005$$

∴∅ = 0.9 …. OK.

4.5.3 Design of shear:

Vu = 92.4 KN

$$Vc = \frac{\sqrt{fc'}}{6} bw * d = \frac{\sqrt{24}}{6} *800 *293*10^{-3} = 191.38 \text{ KN}$$

ΦVc= 0.75 * 191.38 = 143.54 KN

Check For dimensions:-

$\phi Vc + (2/3 \times \phi \times \sqrt{fc'} \times bw \times d) = 143.54 + (2/3 * 0.75 * \sqrt{24} * 800 * 293)*10^{-3} = 717.7$ KN

717.7 > Vu max = 92.4 KN

∴ Dimension is adequate enough.

ΦVs min = (0.75*√24*800*293)/16 = 53.83 KN

ΦVs min = (0.75 * 800 * 293)/3 = 58.6 KN ….. (Control)

$$\emptyset\, V`s = \frac{0.75}{3} * \sqrt{24} * 800 * 293 * 10^{-3} = 287.08\, KN.$$

$$\emptyset\, Vs\, max = 0.75 * \frac{2}{3} * \sqrt{24} * 800 * 293 = 574.16\, KN$$

1- $\emptyset(Vc + Vs\, min) = 202.14\, KN.$
2- $\emptyset(Vc + Vs`) = 430.62\, KN.$
3- $\emptyset(Vc + Vs\, max) = 717.7\, KN.$

1.

0.5 * Φ Vc≤ Vu ≤ Φ Vc

71.77 ≤ 92.4 ≤ 143.54
Minimum shear reinforcement is required (Av,min)

Use 2 leg Φ 10 @10cm for stirrups

4.6 Design of Two Way Solid Slab:

4.6.1 Calculate the minimum thickness slab :

$$\boldsymbol{hmin = 16\, cm}$$

$$\boldsymbol{y(CB6) = \frac{16 * (30 + 44) * (44 + 8) + 30 * 44 * 22}{16 * (30 + 44) + 30 * 44} = 36.2cm}$$

$$\boldsymbol{Ib(CB6) = \frac{(30 + 44)(16 * 7.8^3)}{3} - \frac{44 * 7.8^3}{3} + \frac{(30 * 36.2^3)}{3} = 799957cm}$$

$$y(CB6) = \frac{16 * (30 + 44 * 2) * (44 + 8) + 30 * 44 * 22}{16 * (30 + 44 * 2) + 30 * 44} = 39.7cm$$

$$Ib(CB6) = \frac{(30 + 44 * 2)(16 * 4.3^3)}{3} - \frac{2 * 44 * 4.3^3}{3} + \frac{(30 * 39.7^3)}{3} = 952416cm$$

$$Is1 = \frac{(620/2 + 30) * 16\text{^}3}{12} = 116053cm^4$$

$$Is2 = \frac{(780/2 + 30) * 16\text{^}3}{12} = 141653cm^4$$

$$Is3 = \frac{(620 + 30) * 16\text{^}3}{12} = 221867cm^4$$

$$Is4 = \frac{(770 + 30) * 16\text{^}3}{12} = 273067cm^4$$

$$\propto f1 = \frac{Ib}{Is} = \frac{799957}{141653} = 5.6$$

$$\propto f2 = \frac{Ib}{Is} = \frac{799957}{116053} = 6.9$$

$$\propto f3 = \frac{Ib}{Is} = \frac{952416}{273067} = 3.5$$

$$\propto f4 = \frac{Ib}{Is} = \frac{952416}{221867} = 4.3$$

$$\propto fm = \frac{\in\propto}{4} = \frac{5.6 + 6.9 + 3.5 + 4.3}{4} = 5.1$$

$for \propto fm \leq 0.2 \beta = \frac{lnlong}{lnshort} = 7.7/6.2$=1.24

$$hmin = \frac{ln * (0.8 + Fy/1400)}{36 + 9B} = \frac{780 * (0.8 + 420/1400)}{36 + 9 * 1.24} = 17.7\ cm$$

but we will select 20cm slab thickness.

4.6.2 Dead load calculations:

Table(4.3) calculation of the two way solid Dead load

Dead load from:	δ×γ	KN/m
Tiles	0.03×22×1	0.66
Mortar	0.02×22×1	0.44
Coarse sand	0.07×16×1	1.12
Slab	0.20×25×1	5
Plaster	0.02×22×1	0.44
Partitions	2*1	2
		9.66

Dead load =9.66 KN/m^2.

Live load = 5 KN/m^2.

WuD = 1.2*Dead load = 1.2*9.66= 11.6 KN/m^2.

WuL = 1.6*live load = 1.6*5 = 8 KN/m^2.

Wu = 11.6+8 = 19.6 KN/m^2

4.6.3 Shear Design :

l_a/l_b=0.81

W_b=0.79

Wa=0.21

- **The total load on the panel being (7.6*6.5*19.6) = 968.487 KN**
- **The load at face of the long beam is (0.79×1614/(2*6.5))=58.86 KN**

Assume the Φ 14

d=200-20-12\2=174mm

- **V_c =(√20 *1000*174*10^-3)\6 =129KN**

ø$V_{c\ =\ 0.75}$ x 129= 96.75 KN

V_u<øV_c.

The thickness of the slab is adequate enough

4.6.4 Flexural Design:

(l_a/l_b=0.92)

Positive moments :

CaD=0.029

Cla=0.042

CbD=0.01

Clb=0.017

$M_{a+ve,Dl}=C_a*W*L_a^2$ =0.029*11.6*6.3 ^{2}= 13.35KN.m\m

$M_{a+ve,Ll}=C_a*W*L_a^2$ =0.042*8*6.3 ^{2}= 13.3KN.m\m

$M_{a+ve} = M_{a+ve,L} + M_{a+ve,D}$ = 26.65KN.m\m

$M_{b+ve,D}=C_b*W*L_b^2$ =0.01*11.6*7.8^2= 8.78KN.m\m

$M_{b+ve,L}=C_b*W*L_b^2*b$ =0.017*8*7.8 ^{2}= 10.29KN.m\m

$M_{b+ve} = M_{b+ve,L} + M_{b+ve,D}$ = 19.07KN.m/m

4.6.5 Positive Moment:

***Mub= 19.07KN.m/m**

Assume the d_{Bar} =12 mm

d =h- cover - (d_{Bar}\2) =200-20-6=174mm

Rn = $\frac{Mu/\phi}{b*d^2}$

$$= \frac{19.07*10^6/0.9}{1000*176^2} = 0.60 MPa \quad .$$

$$m = \frac{fy}{0.85\times fc'} = \frac{420}{0.85\times 24} = 22.5$$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2mK_n}{f_y}}\right) = \frac{1}{20.5}\left(1-\sqrt{1-\frac{2*20.5*0.61}{420}}\right) = 0.003$$

As_{req} = 0.003*1000*176 =534mm2/m

$$As_{\min} = 0.0018*b*h = 0.0018*1000*200 = 360mm2/m$$

As = 534mm2≥ $As_{\min}$ = 360mm2/m

<u>Use Φ 14 \ 20cm with As=770mm^2/m</u>

<u>*Mua= 26.65KN.m/m</u>

Assume the d_{Bar} =12 mm

d =h- cover - (d_{Bar}\2) =200-20-6=174mm

$$K_n = \frac{Mu}{b\cdot d^2} = \frac{24.28*10^6/0.9}{1000*176^2} = 0.85 MPa \quad .$$

$$m = \frac{fy}{0.85\times fc'} = \frac{420}{0.85\times 24} = 20.59$$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2mK_n}{f_y}}\right) = \frac{1}{20.59}\left(1-\sqrt{1-\frac{2*20.59*0.85}{420}}\right) = 0.002$$

$As_{req} =$ 0.002*1000*174 =385mm2/m

$As_{\min} = 0.0018 * b * h = 0.0018 * 1000 * 200 = 360 mm2/m$

$As =$ 385mm2≥ $As_{\min} =$ 360mm2/m

Use Φ 14 \ 20cm with As=770 mm^2/m

- ✓ Negative Moment:

Mua= 42.5N.m/m

Assume the d_{Bar} =12 mm

d =h- cover - (d_{Bar}\2) =200-20-6=174mm

$$K_n = \frac{Mu}{b \cdot d^2} = \frac{49.7 * 10^6 / 0.9}{1000 * 176^2} = 1.768\, MPa \quad .$$

$$m = \frac{fy}{0.85 \times fc'} = \frac{420}{0.85 \times 28} = 17.64$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mK_n}{f_y}}\right) = \frac{1}{17.64}\left(1 - \sqrt{1 - \frac{2 * 17.64 * 1.768}{420}}\right) = 0.00438$$

$As_{req} =$ 0.00438***1000*174 =770mm^2/m**

$As_{\min} = 0.0018 * b * h = 0.0018 * 1000 * 200 = 360 mm2/m$

$As =$ **770mm2/≥** $As_{\min}$ **= 360mm2/m**

Use Φ 16 \ 20cm with As=1004.8mm^2/m

Note: other moments requires areinforcement less than minimum, Use Φ 12 \ 15cm with As=678 mm^2/m

4.7 DESIGN OF LONG COLUMN:

4.7.1 Dimension of column:

Pu = 2435.6 KN

Pn = 2435.6/ (0.65) = 3747 KN

Assume $\rho g = 1.35$ %

$$Pn = 0.8 * Ag\{0.85 * fc' + \rho g(fy - 0.85 fc')\}$$
$$3747 = 0.8 * Ag[0.85 * 24 + 0.01 * (420 - 0.85 * 24)]$$
$$Ag = 1919.8 cm^2$$

Assume rectangular column

Use 50*45cm with Ag = 2250cm² >Agreq = 1919 cm².

4.7.2 Check Slenderness Effect:

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

Lu: Actual unsupported (unbraced) length.

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

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

Lu = 3.6 m

M1&M2 =1

K=1, According to ACI 318-2002 (**10.10.6.3)** the effective length factor, ***k***, shall be permitted to be taken as 1.0.

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

$$\frac{1*3.6}{0.3*0.6} = 24 > 22$$

$$\therefore long \;\; Coloumn$$

Slenderness is consider

$$EI = 0.4\frac{E_c I_g}{1+\beta_d} \quad \ldots\ldots\ldots\ldots [ACI318-2002 \;\; (Eq.\ 10-15)]$$

$$E_c = 4750\sqrt{fc'} = 4750*\sqrt{24} = 23270.15Mpa$$

$$\beta_d = \frac{1.2DL}{Pu} = \frac{1717.2}{2435.6} = 0.70$$

$$I_g = \frac{b*h^3}{12} = \frac{0.5*0.45^3}{12} = 0.00379m^4$$

$$EI = \frac{0.4*23270.15*10^6*0.00379}{1+0.70} = 20.75MN.m^2$$

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

$$P_c = \frac{3.14^2*20.75}{(1.0*3.6)^2} = 15.78MN.$$

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

$$Cm = 1 \ldots\ldots According\ to\ \ ACI318-2002(10.10.6.4)$$

$$\delta_{ns} = \frac{Cm}{1-(Pu/0.75P_{c)}} \geq 1.0 \quad \ldots\ldots\ldots\ldots ACI318-2002(Eq.\ 10-12)$$

$$\delta_{ns} = \frac{1}{1-(2435.6/0.75*15.78*10^3)} = 1.26 > 1$$

$$e_{\min} = 15 + 0.03*h = 15 + 0.03*450 = 28.5mm = 0.0285m$$

$$e = e_{\min} \times \delta_{ns} = 0.0285*1.21 = 0.034$$

$$\frac{e}{h} = \frac{0.034}{0.45} = 0.075$$

From Interaction Diagram

$$\frac{\phi P_n}{A_g} = \frac{2435.6}{0.45*0.5}*\frac{145}{1000} = 1569.6 Psi$$

$\rho_g = 0.01$

$A_s = \rho * Ag = 0.01*600*400 = 2400\ mm^2$

Use 12 Φ 16 with As = 2412mm² >Asreq = 3038mm².

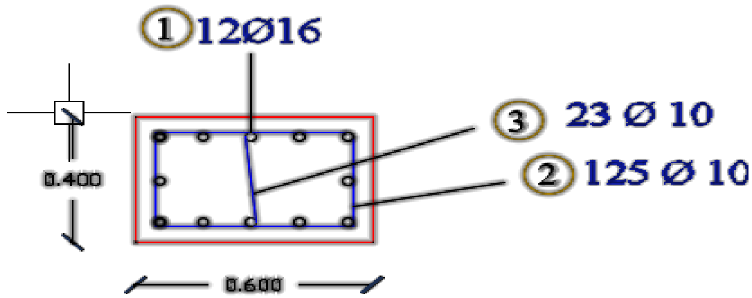


Figure (4–7): Column Section

4.7.3 Design of the Tie Reinforcement:

For Φ 10 mm ties:

$S \leq 16$ db (longitudonal bar diameter)......................ACI - 7.10.5.2

$S \leq 48$ dt (tie bar diameter).

$S \leq$ Least dimension.

$S \leq 16 \times 1.6 = 25.6$ cm

$S \leq 48 \times 1 = 48$ cm

$S \leq 40$ Use Φ10 @20

And use Φ10 @10 for end

.

4.8 Design of Stair:

4.8.1 Limitation of deflection:

hmin= 3.91 / 20 = 19.5 cm

Select h = 20 cm

Tanϕ = 17 /30

ϕ = 29.5

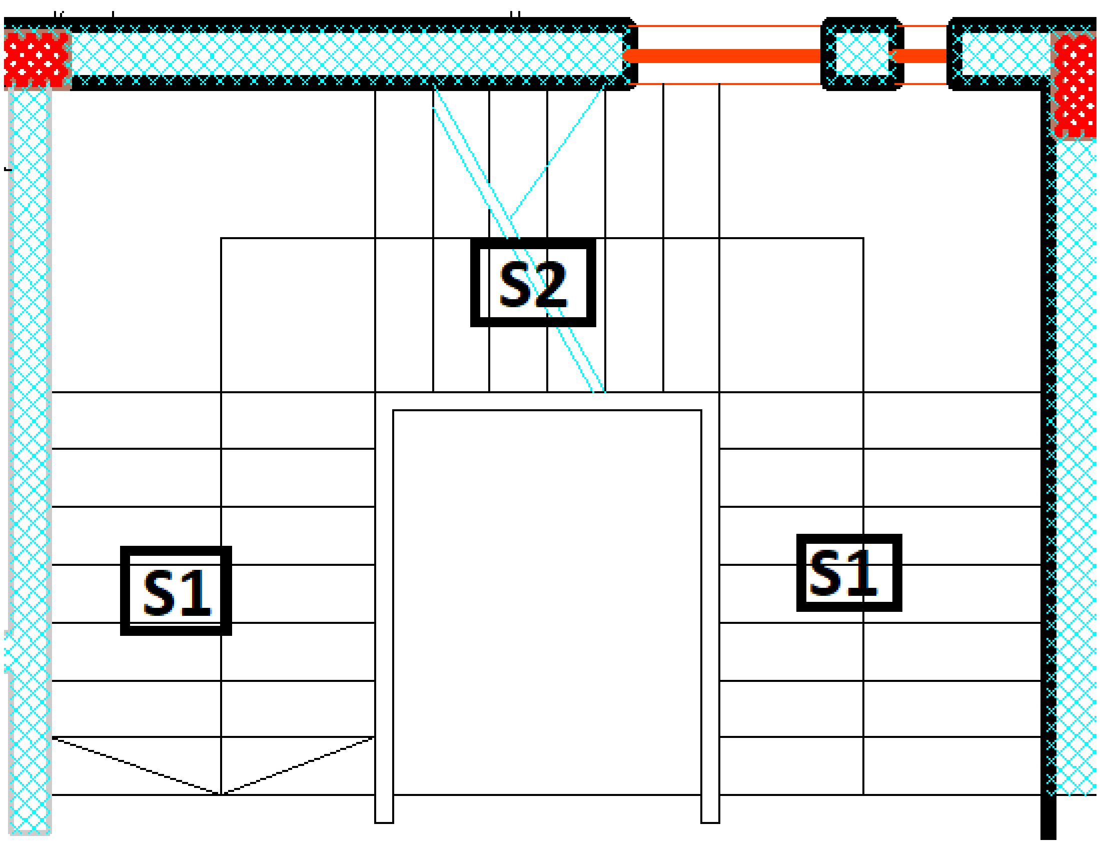


Figure (4-8): The shape of Stair

4.8.2 Calculation of load:

(Note: calculation for 1 meter strip)

Table (4 – 4): Calculation flight dead load.

No.	Parts of Beam	Density	Calculation
1	Tiles	23	**23*((0.17+0.35)/0.3)*0.03*1=1.196 KN/m**
2	Mortar	22	**22*((0.15+0.3)/0.3)*0.02*1=0.69 KN/m**
3	Stair steps	25	**(25/0.3)*(0.17*0.3/2)*1= 2.125 KN/m**
4	R.C solid slab	25	**(25*0.20*1)/cos29.5=5.75 KN/m**
5	Plaster	22	**(22*0.03*1)/cos29.5 = 0.76 KN/m**
			10.521 KN/m

Table (4 – 5): Calculation landing dead load.

No.	Parts of Beam	Density	Calculation
1	Tiles	23	**23*0.03*1=0.69 KN/m**
2	Mortar	22	**22*0.02*1=0.44 KN/m**
3	R.C solid slab	25	**25*0.2*1=5 KN/m**
4	Plaster	22	**(22*0.03*1)/cos29.5 = 0.76 KN/m**
			6.89 KN/m

L.L= 5 KN/m^2.

Total factored load:

For flight w = 1.2D +1.6L = 1.2*10.521+1.6*5= 20.625 KN/m.

For landing w = 1.2*6.89+1.6*5=16.268 KN/m.

4.8.3 Design of slab (1):

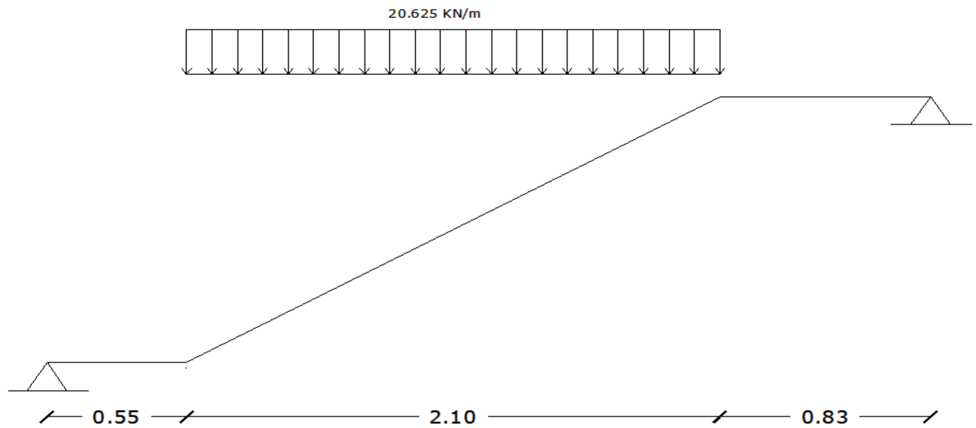


Figure (4-9): System of stair slab 1.

4.8.3.1 Design of shear forces:

The reaction at each end:

R= W*L/2 = (20.625*2.1)/2 = 21.656 KN.

Assume bar diameter 12 mm.

Max Vu = 22 KN/m.

d=200 -20 - 6 = 174 mm

$$\Phi * V_c = 0.75 * \frac{\sqrt{fc'}}{6} bw * d = 0.75 * \frac{\sqrt{24}}{6} * 174 * 1000 = 106.5 \text{ KN} >> V_u.$$

h is correct.

4.8.3.2 Design of bending moment:

Max Mu = (22 *1.9) – (20.96 *1.05^2*0.5) = 30.43KN.m

Rn = $\frac{Mn}{b*d^2}$

Rn = $\frac{30.43*10^6/0.9}{1000*(174)^2}$ = 1.11MPa

ρ = $\frac{1}{m}$ (1 - $\sqrt{1-\frac{2mRn}{fy}}$)

ρ = $\frac{1}{20.59}$ (1 - $\sqrt{1-\frac{2(20.59)(1.11)}{420}}$) = 0.00271

As req = ρ * b * d = 0.00271* 100 *17.4 = 4.71 cm²/m.

As min = 0.0018 * b * h = 0.0018*100 * 20 = 3.6 cm^2/m

As req>As min

Select Φ12@ 10 cmwithA$_s$= 11.3 cm^2/m.

4.8.3.3 Check of strain:

Tension = compression

As * fy = 0.85 * f_c * b * a

113*420=0.85*24*1000*a

a=2.326 mm.

$$x=\frac{a}{\beta_1}=\frac{2.326}{0.85}=2.737mm.$$

$$\varepsilon_s=\frac{174-2.737}{2.737}\times 0.003$$

$$\varepsilon_s=0.1877>0.005$$

∴∅ = 0.9 …. OK.

4.8.4 Design of slab (2):

$W_R = R_{s1}/B = 22/1.65 = 13.3$ KN/m.

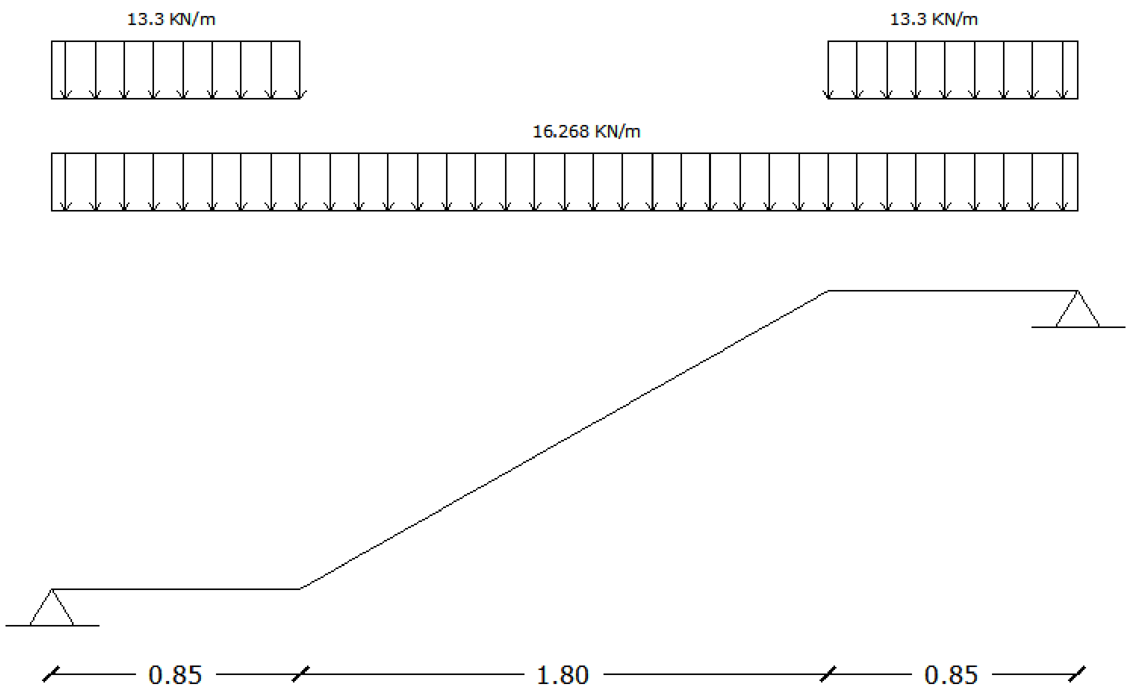


Figure (4-10): System of stair slab 2.

4.8.4.1 Design of shear forces:

R= ((16.268*3.5)/2) + (13.3*0.85) = 39.77 KN.

d=200 -20 - 6 = 174 mm

$\Phi * V_c = 0.75 * \frac{\sqrt{fc'}}{6} bw * d = 0.75 * \frac{\sqrt{24}}{6} * 174 * 1000 = 106.5 \text{ KN} >> Vu$

h is correct.

4.8.4.2 Design of bending moment:

Max Mu = (39.77*1.75) – (16.268*1.75^2*0.5) – 13.3*0.85*((0.85/2) +0.9) =29.7KN.m

Rn = $\frac{Mn}{b*d^2}$

Rn = $\frac{29.7*10^6/0.9}{1000*(174)^2}$ = 1.08MPa

ρ = $\frac{1}{m}$ (1 - $\sqrt{1-\frac{2mRn}{fy}}$)

ρ = $\frac{1}{20.59}$ (1 - $\sqrt{1-\frac{2(20.59)(1.08)}{420}}$) = 0.00264

As req = ρ * b * d = 0.00264* 100 *17.4 = 4.6 cm²/m.

As min = 0.0018 * b * h = 0.0018*100 * 20 = 3.6 cm^2/m

As req>As min

Select Φ12@ 10 cmwithA_s= 11.3 cm^2/m.

4.8.4.3 Check of strain:

Tension = compression

As * fy = 0.85 * f_c * b * a

113*420=0.85*24*1000*a

a=2.326 mm.

$$x=\frac{a}{\beta_1}=\frac{2.326}{0.85}=2.737mm.$$

$$\varepsilon_s=\frac{174-2.737}{2.737}\times 0.003$$

$$\varepsilon_s = 0.1877 > 0.005$$

∴Ø = 0.9 …. OK.

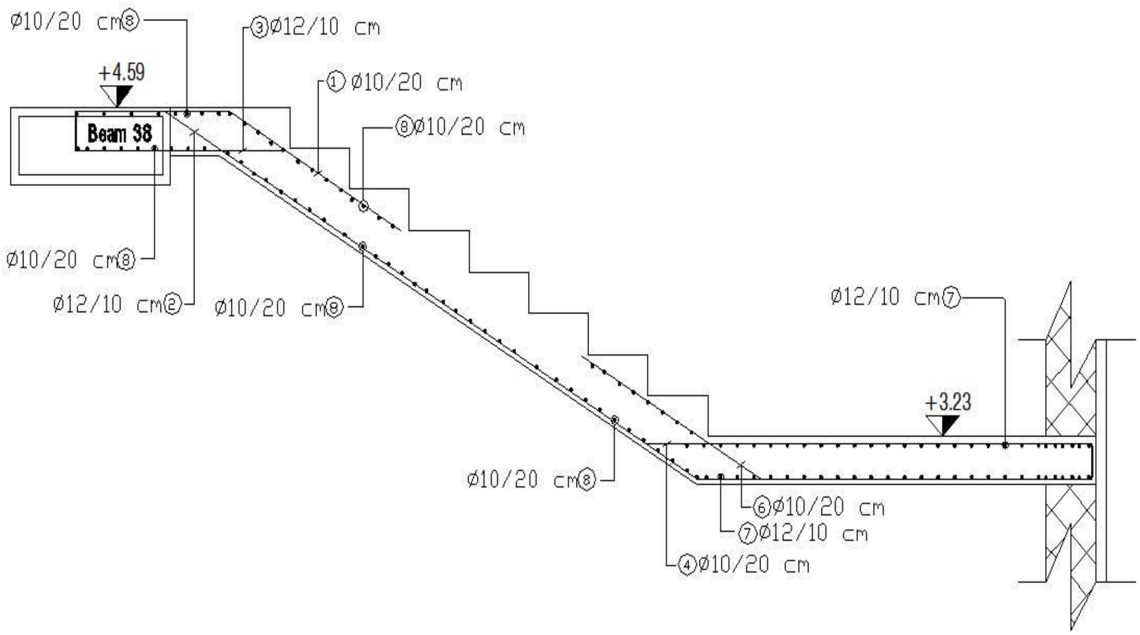


Figure (4-11): Detailing of stair slab 1.

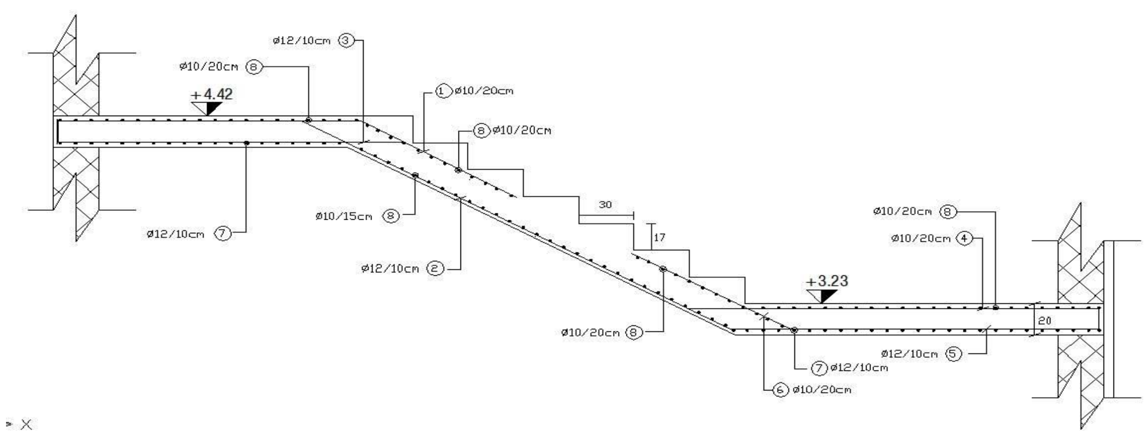


Figure (4-12): Detailing of stair slab 2.

4.9 DESIGN OF BASEMENT WALL:

4.9.1 Loads on basement wall:

q1 = Earth pressure soil

q1= γ * h * k0

K0 = 1 – sin 30 = 0.5

q1= 18 * 3.85* 0.5 = 34.65 KN/m^2

Factored load (qu) =1.6 * q1 = 1.6 * 34.6 = 55.44 KN/m^2

h wall = 40 cm.

4.9.2 Design of shear force:

From atir Vu = 560 KN

d= 1200-75-20= 1105 mm.

Φ* Vc = 0.75* $\frac{\sqrt{fc'}}{6}$ bw * d = 0.75 *$\frac{\sqrt{24}}{6}$ * 1105 * 1000 =676.7 KN > Vu

(h =40 is correct).

4.9.3 Design of the reinforcement concrete:

4.9.3.1 Design of the Vertical reinforcement in tension side:

Max Mu from Atir = 415KN.m.

Rn = $\frac{Mn}{b*d^2}$

Rn = $\frac{415*10^6/0.9}{1000*(1105)^2}$ = 0.37MPa

ρ = $\frac{1}{m}$ (1 - $\sqrt{1-\frac{2mRn}{fy}}$)

ρ = $\frac{1}{20.59}$ (1 - $\sqrt{1-\frac{2(20.59)(0.37)}{420}}$) =8.8 *10^{-4}

As req = ρ * b * d = 8.8*10^{-4}*** 100*110.5=9.8cm²/m.**

As min = 0.0012 * b * h = 0.0012*100 * 120= 14.4 cm^2/m

As min >Asreq

Select Φ20@ 20 cm .As provided =15.7 cm^2/m

4.9.3.2 Design of the horizontal reinforcement in tension side:

For One layer:

As min = 0.0012 * b * h = 0.0012*100 * 120 = 14.4 cm^2/m

Select Φ20 @ 20 cm. As provided =15.7cm^2/m

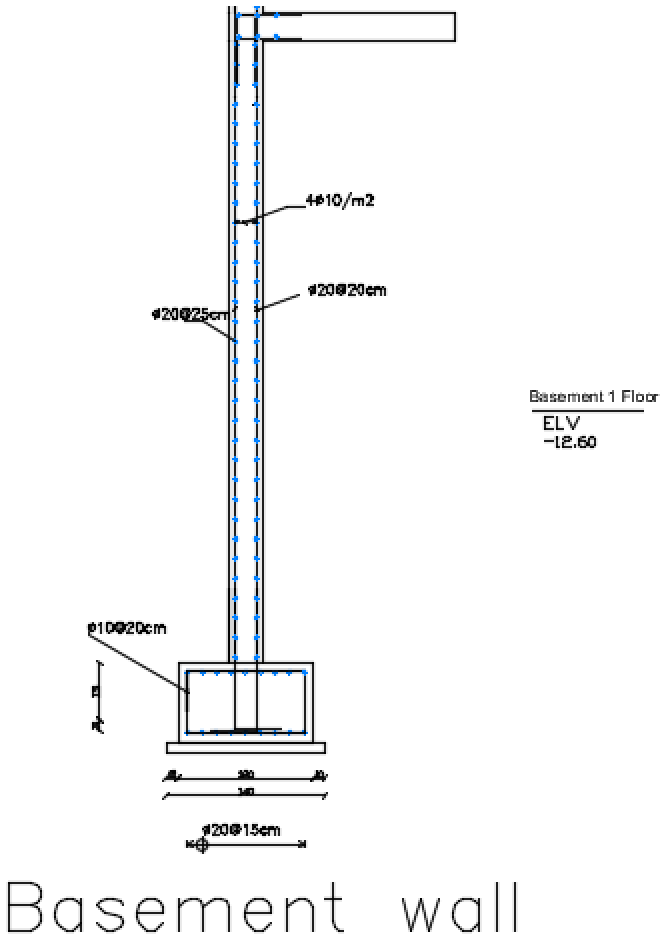


Figure (4-13): Detailing of Basement Wall.

4.10 MAT FOUNDATION:

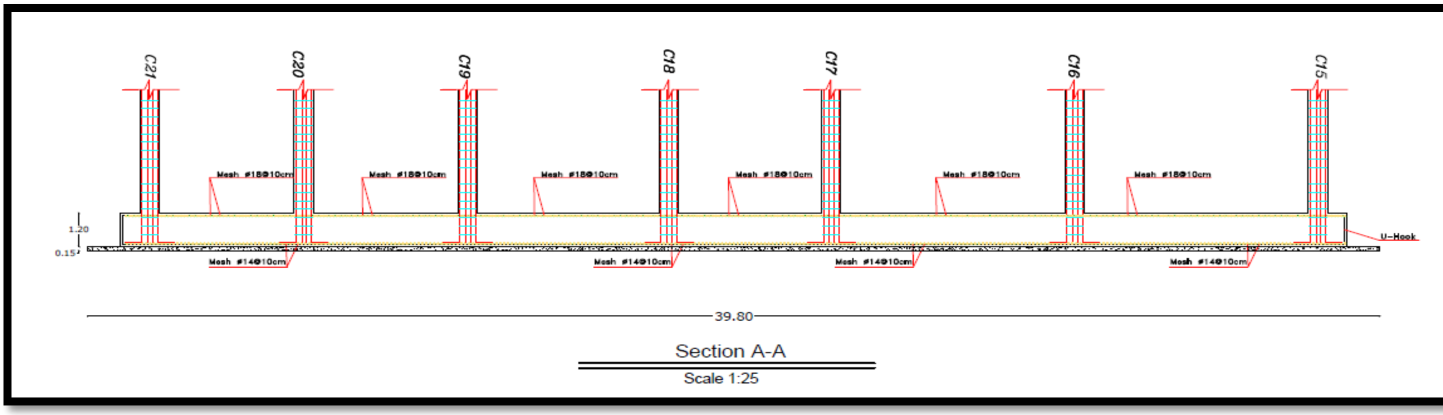


Figure (4-14): MAT foundation.

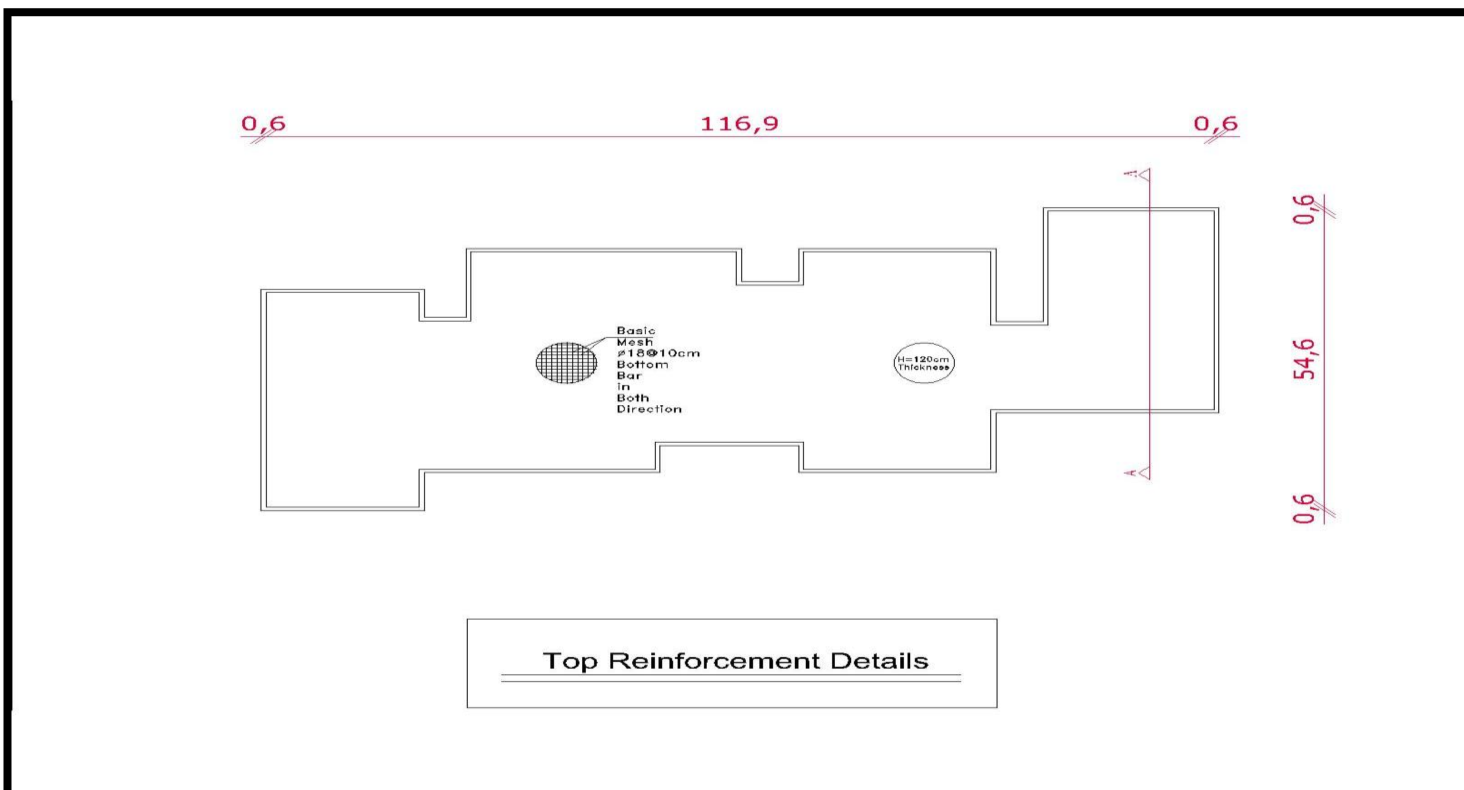


Figure (4-15): Top Reinforcement details .

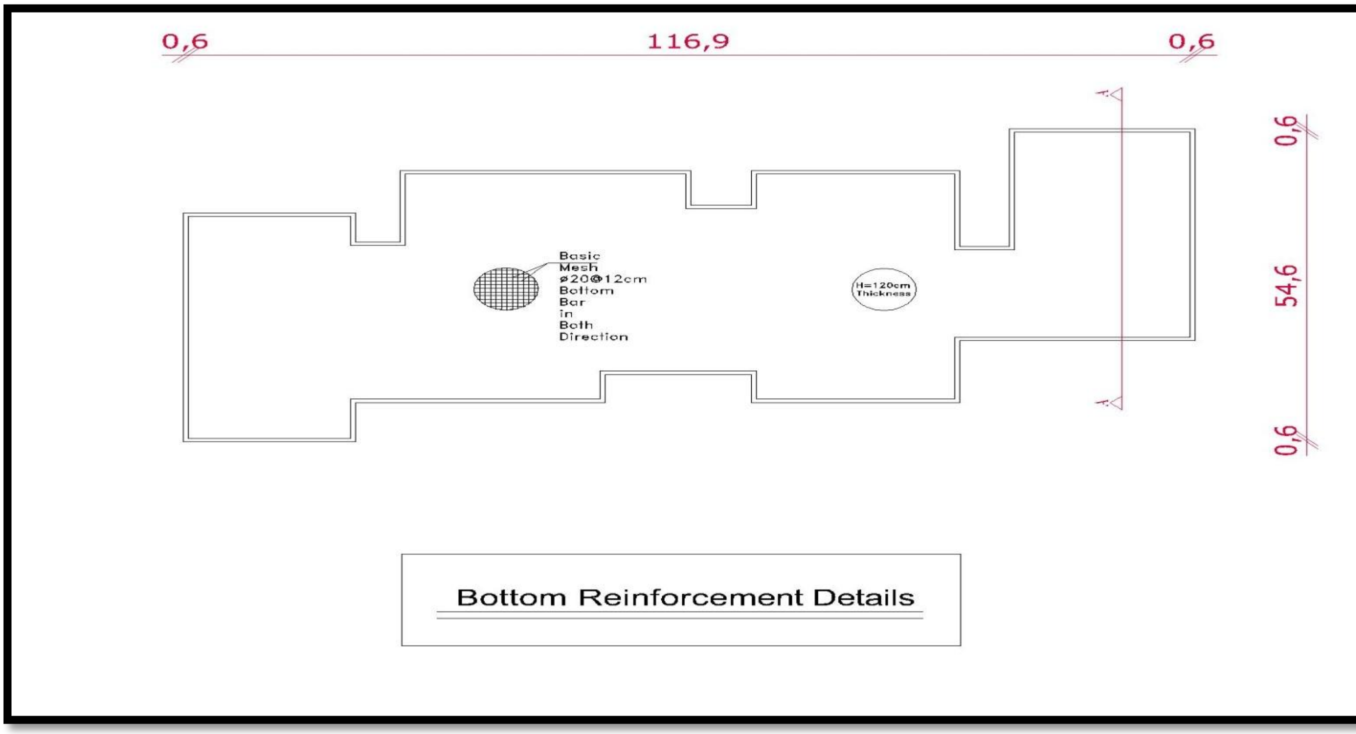


Figure (4-16): Bottom Reinforcement Details .

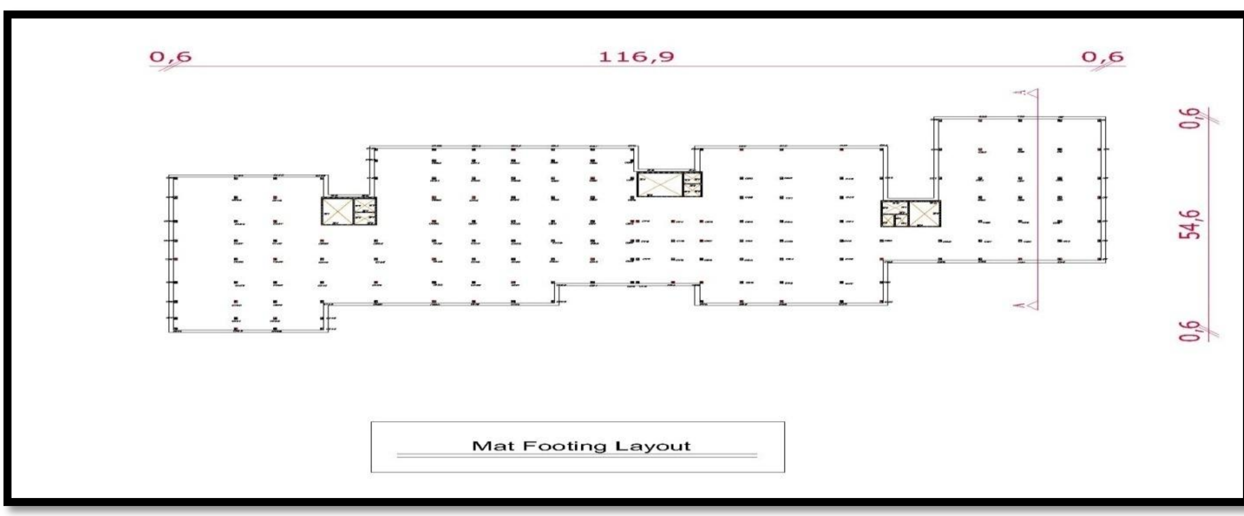


Figure (4-17): MAT Footing layout .

CHAPTER

5

Results and Recommendations

5.1 The Results

1. Each student or structural designer should be able to design manually so he can get the experience and knowledge in using the computer software
2. Oneofthefactorsthatmustbetakeninconsiderationistheenvironmentfactorssurroundingthebuilding,thesiteterrains,andtheforceseffectsonthesite.
3. 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, and should take the surrounding condition in the consideration.
4. Various types of slabs have been used: One way solid and one way ribbed slabs, in some slabs that have a regular or nearly regular distribution of columns and beams. One way solid slabs mainly in the stairs and parking floors , because it has high resistance to the concentrated forces.
5. The used software programs:
   - AutoCAD2016,todrawthedetailofdrawingsforstructuraldrawings.
   - ATIR, Etabs, Safe, Sp column, Straap1, Staad pro and Autodesk Robot structure and analysis 2017 to analysis and design the structural members.

6. 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.

Wewantherethroughthisexperience-tointroduceagroupofrecommendations,wehopeitto 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 choose 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.