Structural Design for Dora Hospital

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DIDICATION

To Palestine…

To our Parents….

To The Soul of Martyrs….

To our Teachers ….

To our Friend's …

To whom we Love ….

To Everyone who gave us Help …

To DR. Belal Almassri …

Team Work

ACKNOWLEDGMENT

We would like to thank and gratitude to Allah, who gives us the most Merciful who granted us the ability and willing to start project.

We thank "Palestine Polytechnic University", "Department of Civil and Architectural Engineering" and wish to it more progress and successes. We express our thanks to Eng. Belal Almassri, who gave us the knowledge, valuable help, encouragement, supervision and guidance.

Thanks for all teachers that gave us a little of theirs time and answers our questions.

Finally, our deep sense and sincere thanks to our parents, brothers and sisters for their patience, and for their endless support and encouragement also for everybody who tried to help us during our work and gave us strength to complete this task.

Team Work

ABSTARCT

Government and private hospitals are one of the most important institutions that serve our country and serve our people. They provide services and health care to them and provide them with the necessary treatment requirement It is necessary from all diseases, especially because we are suffering today from an increase in the population and the services and treatment that it requires all sides.

The project is a hospital in the city of Dura, it is a city with a large population so that it needs a hospital to serve this number of residents, as health centers in the city have become unable to meet the needs of this population and there has been a trend from the government several years ago this construction the hospital.

The project consists of 5 floors

*Two level floors, each with an area of 726 m 2.

*The ground floor area is 3667 m 2.

*The first floor has an area of 1893 m 2.

*The second floor has an area of 1881 m 2.

*The total project area is 8893 m 2.

*The land area required for the hospital must not be less than 11,000 square meters.

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DESIGNOF STRUCTURAL MEMBERS

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List of Abbreviations:

- **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.
- **Vn8** = 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

INTRODUCTION

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 SCHEDULE

1.1 Introduction

Human nature needs to have places of worship 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 Theater, Library,Management rooms, Galleries, Mosque, Restaurant, Conference Hall Lecture halls, Stores, Computer halls and Concerns literal. 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 summary of the idea of this project, is to prepare a structural design of a general hospital , consisting of all facilities that should be available in any optima medical center . This building is consisting of 5 floors with a nice elevation, which reflecting the medical face of the building, on the other hand , no doubt that the structural design at a same level of importance of archeries one ,by supporting the building with a structural element ,which will be designed according to ACI code. The project contains the structural analysis for vertical and horizontal loads and the structural design and details for each member in the building.

1.3 An Overview of the Project:

The project is a hospital in the city of Dura, it is a city with a large population so that it needs a hospital to serve this number of residents, as health centers in the city have become unable to meet the needs of this population and there has been a trend from the government several years ago this construction the hospital.

The project consists of 5 floors

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The ground floor area is 3667 m 2.*

The first floor has an area of 1893 m 2.*

The second floor has an area of 1881 m 2.*

The total project area is 8893 m 2.*

The land area required for the hospital must not be less than 11,000 square meters.*

1.4 The Objective of the Project

The objectives of the project are divided into two parts:

1. 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.

2. 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 increasing knowledge of machine 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.

This search is to submit it to the department of civil engineering and architecture at the College of engineering and technology at Palestine Polytechnic University to meet graduation requirements and a Bachelor's degree in civil engineering for building engineering.

1.7 The scope of the Project

This 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 Schedule:

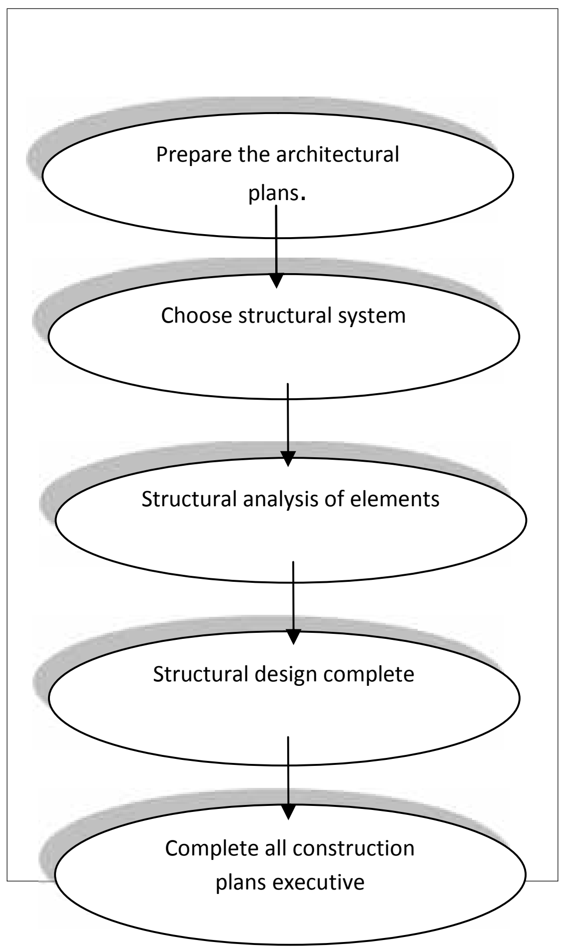


Figure (1-1): Shows The Stages of The Project.

e.

O. Week N Task	١	٢	3	٤	٥	٦	٧	٨	٩	١٠	١١	١٢	١٣	١٤	١٥	١٦
Select project	■															
Inception report		■														
Collect information			■													
Architectural study				■	■											
Structural study					■	■										
Prepare the introduction							■									
Display the introduction								■								
Structural analysis								■	■	■						
Structural design											■	■				
Prepare the project plans												■	■			
Write the project													■	■	■	
Project presentation																■

CHAPTER

2

Architectural Description

2.1 INTRODUCTION.

2.2 THE MAIN ELEMENTS IN THE ISLAMIC CULTURAL CENTER.

2.2.1 INTERIOR SPACES.

2.2.2 EXTERNAL SPACES

2.3 PROJECT PLANS.

2.4 PROJECT ELEVATIONS.

2.5 PROJECT SECTIONS.

2.6 SOME PERSPECTIVE SHOTS FOR THE ISLAMIC CULTURAL CENTRE.

2.1 Introduction:-

Architectural description is the most important things that should be consider when preparing for any project because of its importance in defining and understanding the nature of the project and its sections.

Architectural design requirements task must meet the desired job and human needs in the present time, these terms are in the functional, lasting beauty and economy, it is important in these conditions can interact between each other and in harmony to achieve our vision of optimal design and get an integrated and comprehensive architectural design, and this is achieved by understanding the functional demands of the building and space as well as taking into account nature 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 picture of the project and therefore it will be possible to locate the columns and other structural elements to suit architectural design.

2.2 Project overview:

Through wandering on our Palestinian street, and the cover revealed its concerns, we find the need for our society With model hospitals, you keep in mind the modern requirements

of public health and safety systems. The urgent need for hospitals in our area, the current medical deficit in the country, will be the solution .
The idea of the project is summarized by designing a general hospital that achieves the goals mentioned above and meetsAll the needs that the Palestinian family demands, as the project consists of three floors in addition to two settlement levels, ranging in area from about 726 square meters to 3667 square meters, and the total area is 8,893, in which the career services vary appropriately with the required design need.

2.3 Study the project components :

2.3.1 Plans :

The project includes five floors, with a variety of services, on each floor distributed according to the following:

- Second Basement:It contains the morgue.

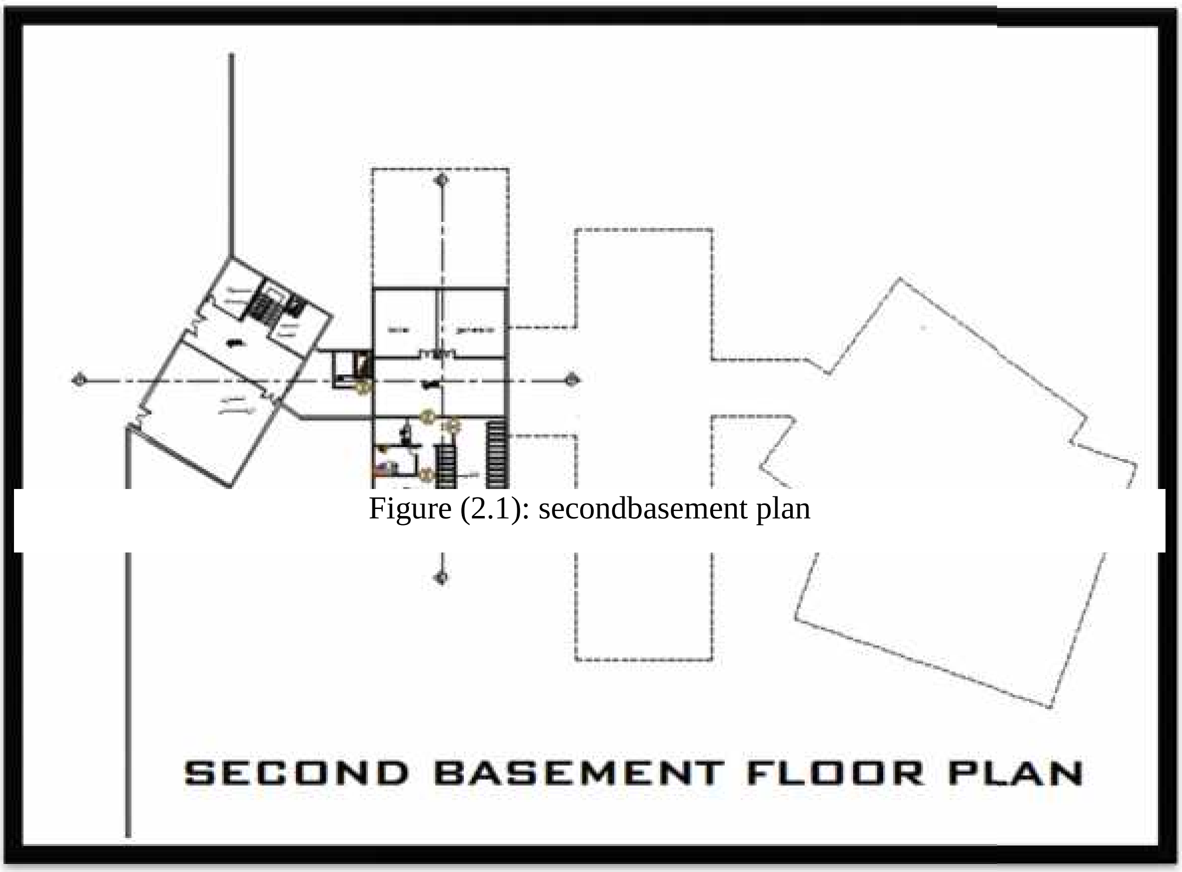
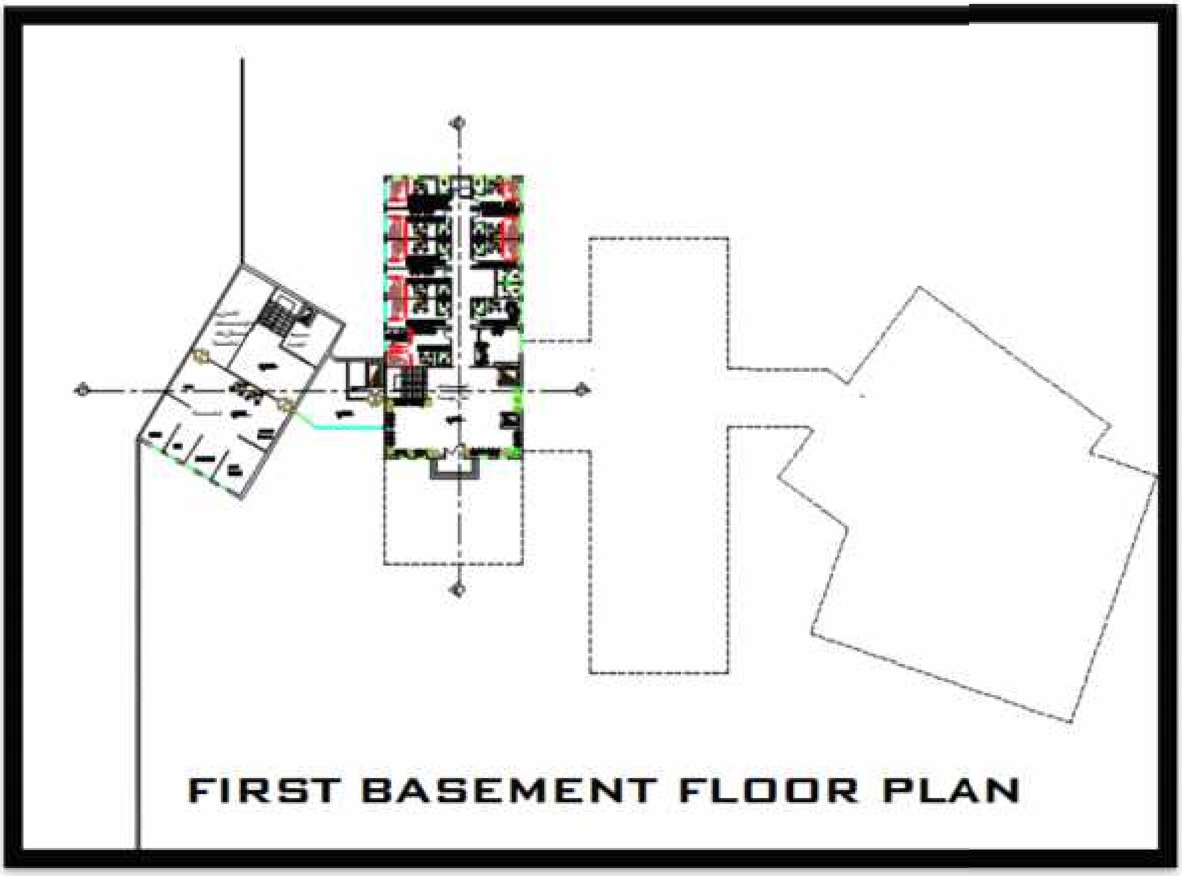


Figure (2.1): secondbasement plan

- First Basement Floor : It contains
  1. Washing machine
  2. Outpatient clinics



(2.2) : Figure first basement plan

- Ground Floor : It has an area 3667 m 2

  It Contain :

  1. Kitchen.
  2. x_ray place.
  3. Orthopedic department.

4. children section.
5. Emergency department.

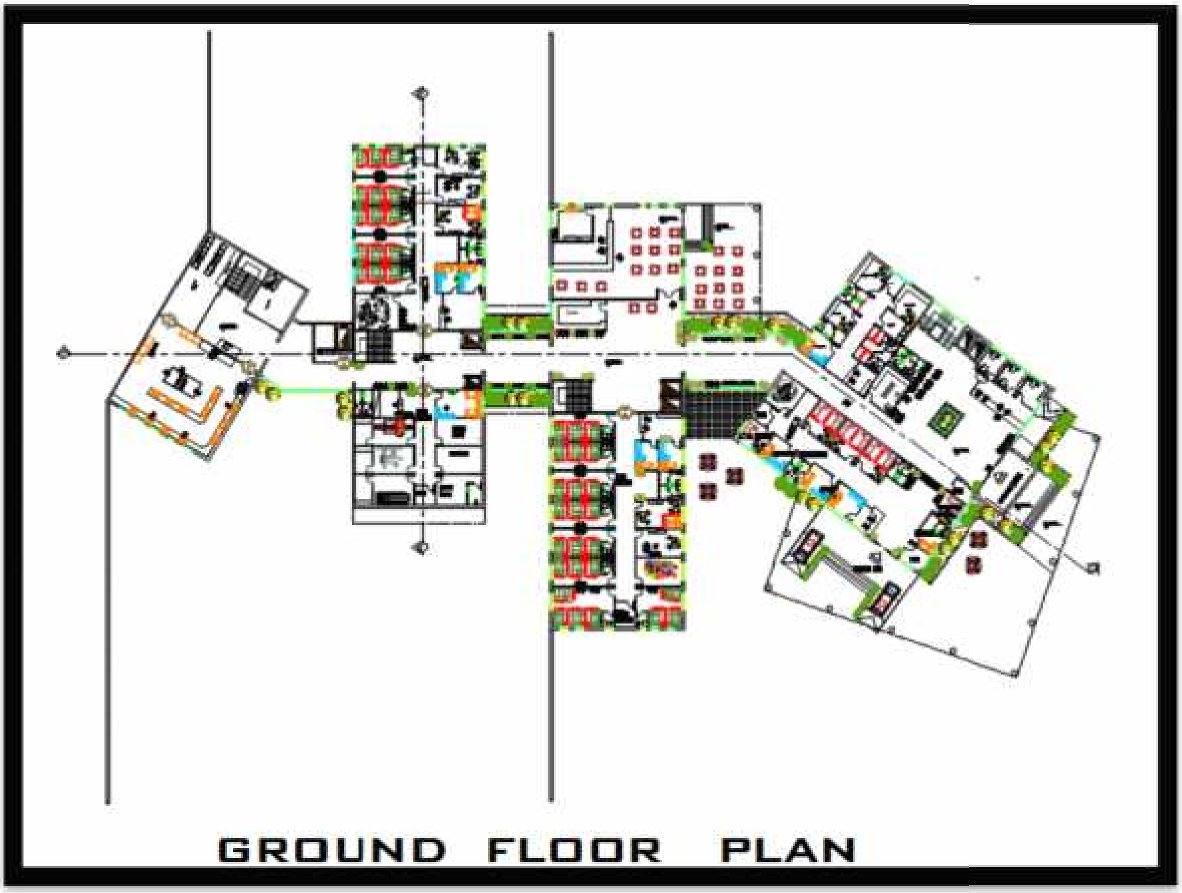


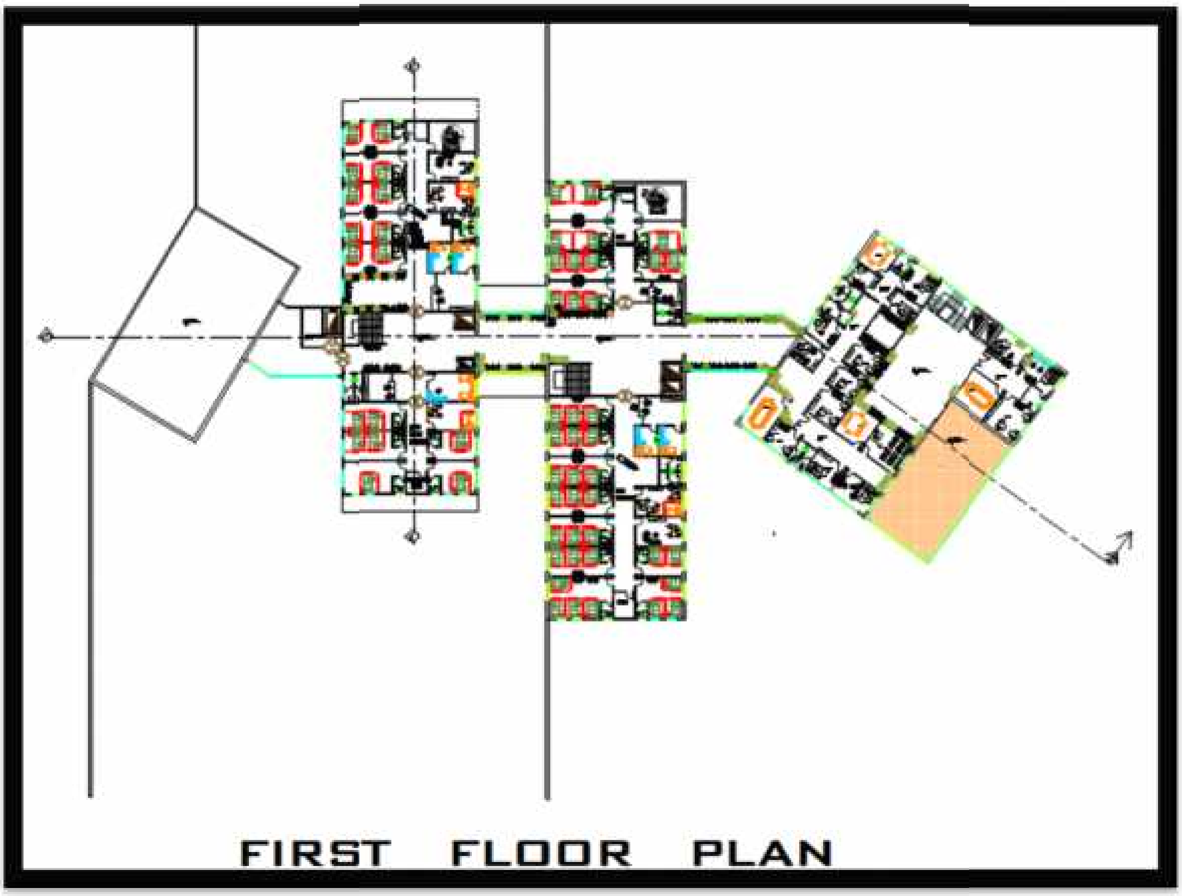
Figure (2.3) :Ground floor plan

- First Floor: It has an area1893 m 2.

  It Contain:

  1. Department of ENT.

2. Quarantine department.



Figure(2.4) : First Floor Plan

- Second Floor **:** It has an area1881 m 2.

  It Contain:

  1. Department of Medical Director.

  2. The esoteric section**.**

.

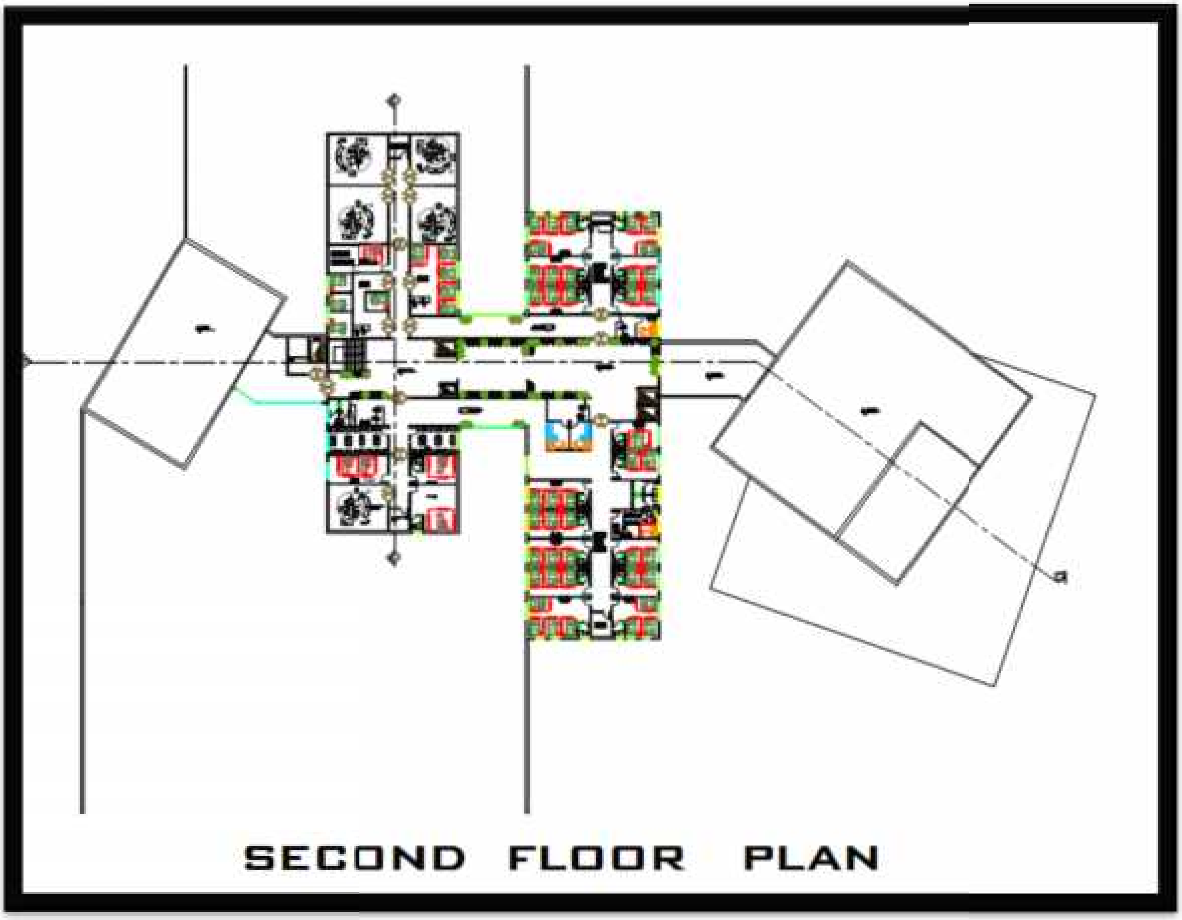


Figure (2.5) :Second floor plan

2.3.2 Description ofElevation

The main materials used in the construction process are reinforced concrete, and ordinary concrete .And two types of stone are stained stone and Al-Matabba stone (sesame stone), provided that they are suitable for conditions.Resist weather conditions and provide beauty, where stained stone is used inThe facades, and the stone bricks above the windows, doors and plaques.

- **North east Elevation**

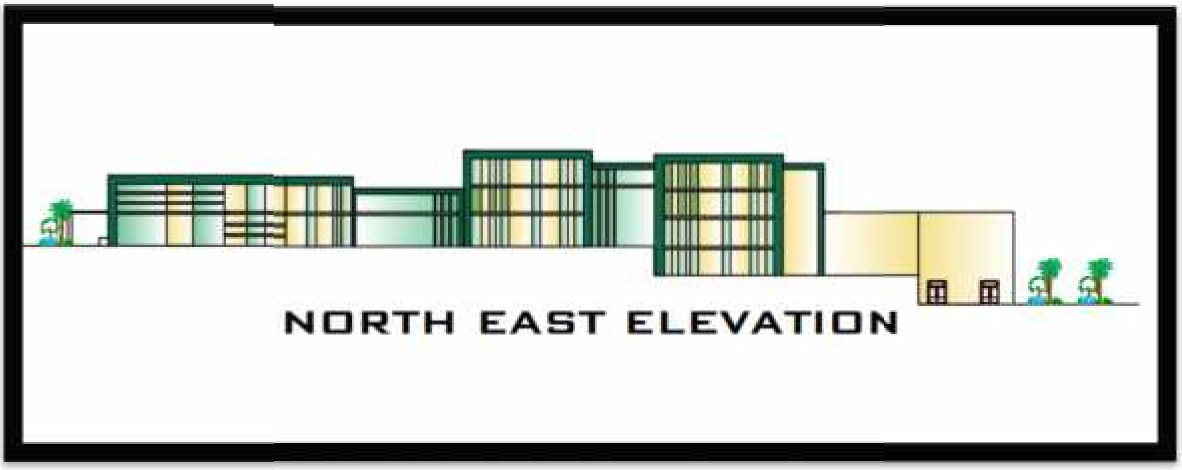


Figure (2.6): North East Elevation

- **South westElevation**

Figure (2.7) :South West Elevation

- **North Wes**

t Elevation

Figure (2.8) :North West Elevation

- **South east Elevation**

Figure (2.9) :south east elevation

2.3.3 The Movement in the Building

There are many forms of movement in the building, as comfort, safety and ease of movement were taken into consideration.Which externally is to reach the hospital and internally by horizontal and vertical movement.

- **Section A-A**

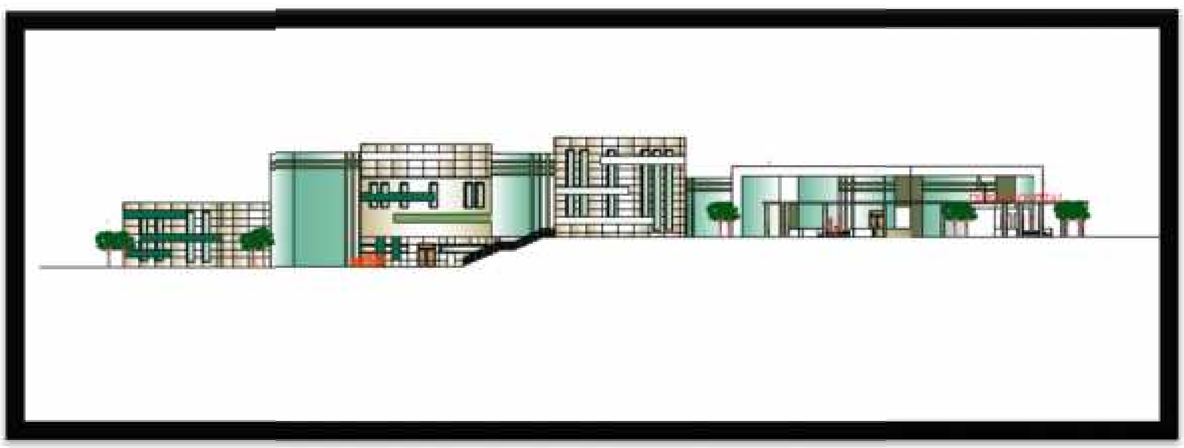


Figure (2.10): Section A-A

- **SECTION B-B**

- **SITE PLAN**

Figure (2.11) :Section B-B

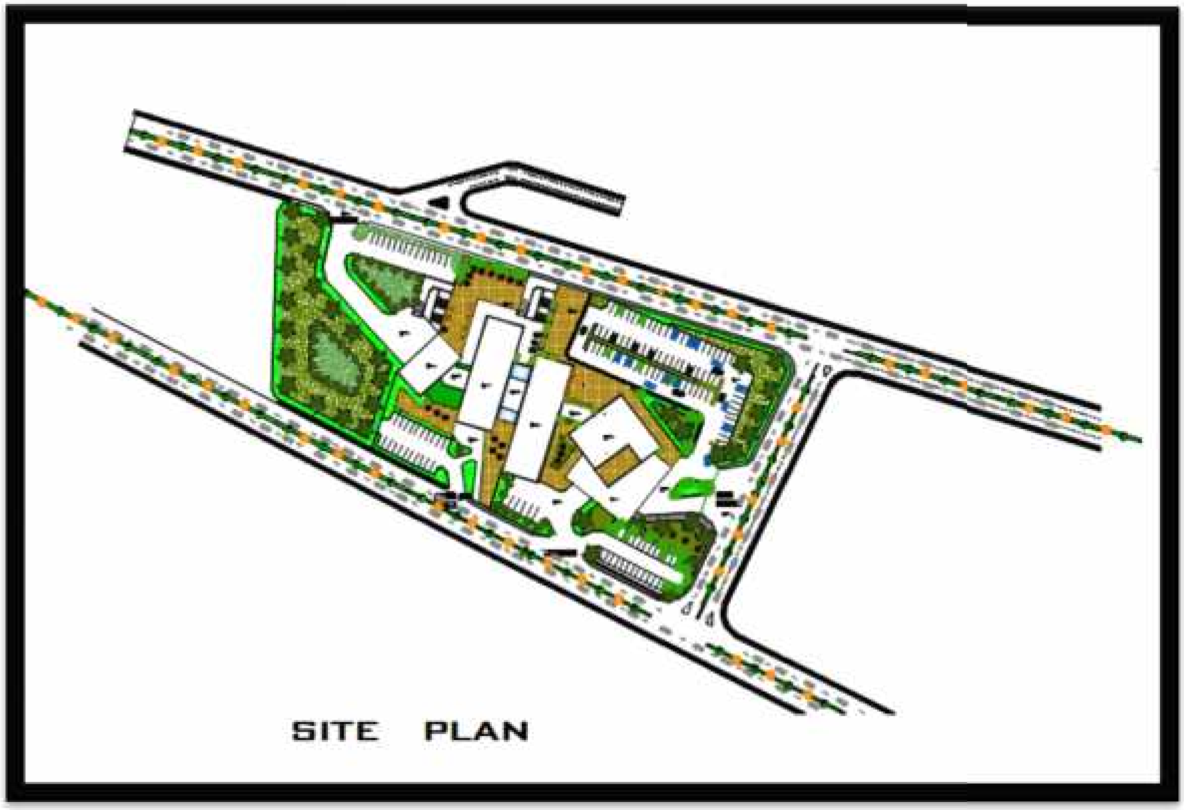


Figure (2.12) :Site Plan

CHAPTER

3

Structural Description

3.1 INTRODUCTION.

3.2 THE GOAL 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 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, and through holes up and depths measured by the appropriate International Center for Geotechnical Engineering Studies (ICGES) in Bethlehem, and took samples of the soil, has been getting the value soil durability of Earth-based project.

3.4 Stages for Structural Design:

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

1. The first stage:-
   In this stage, the appropriate structural system of project construction and analysis for this system will be determined.
2. The second stage:- 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.

تابع الأحمال الحية للأرضيات والعقدات

الحمل المركز البديل	الحمل الموزع	الاستعمال	نوع المبنى	
كن	كن/م²	الاستعمال	خاص	عام
7.0	4.8 لكل متر من ارتفاع التخزين على أن لا يقل عن (15)	أماكن التخزين الكثيف للكتب [illegible]	تابع [illegible] والمستشفيات [illegible] والكليات	تابع المباني التعليمية وما شابهها
7.0	2.4 لكل متر من ارتفاع التخزين على أن لا يقل عن (6.5)	غرف تخزين الكتب		
9.0	4 لكل متر من ارتفاع التخزين	مستودعات القرطاسية		
4.5	5.0	الممرات والمداخل المعرضة لحركة [illegible] والعربات [illegible]		
9.0	5.0	غرف والقاعات [illegible]		
3.6	5.0	قاعات التجمع والمسارح والمستودعات دون مقاعد ثابتة		
4.5	3.0	المختبرات بما فيها من أجهزة والمطابخ وغرف الغسيل		
2.7	3.0	[illegible] والأدراج [illegible]		

Snow Loads:

Figure (3-2): 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 (3.3): Determination of snow loads code (page 44).

Based on the scale of previous snow loads and after selecting the high building surface and that equals (700 m) according to item III snow load is calculated as follows:

SL= (h-400)/320

SL= (775-400)/320= 1.17KN/m²

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 be taken into account in the design to ensure resistance to earthquakes. This will be resisted by shear walls in a building on the construction accounts.

Figure (3-4): Earthquake map for Palestine.

Wind 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.

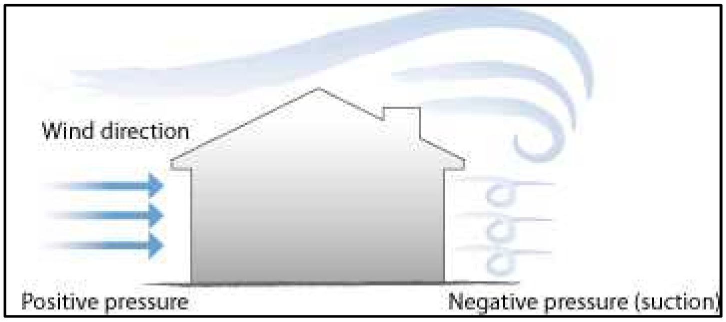


Figure (3-5): Wind Pressure on buildings.

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.

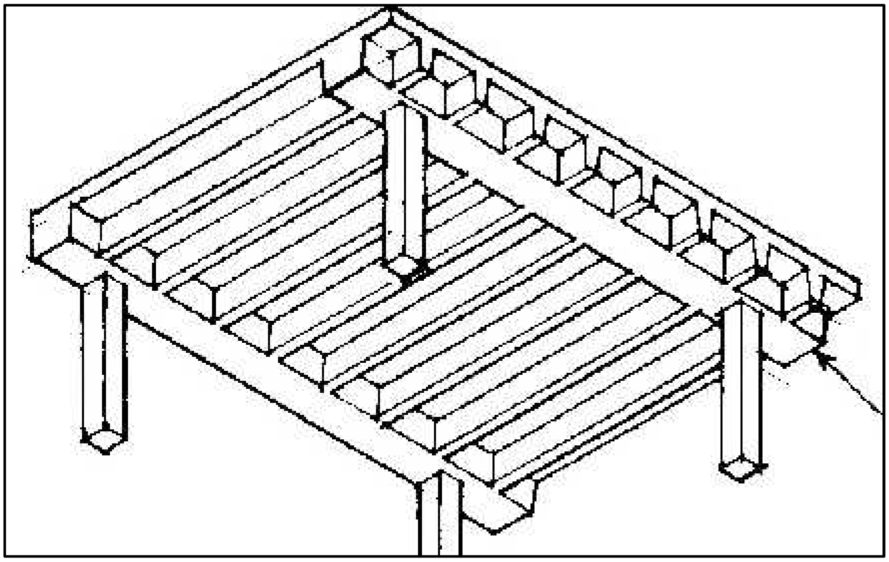
- **Slabs:**

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, without distortions.

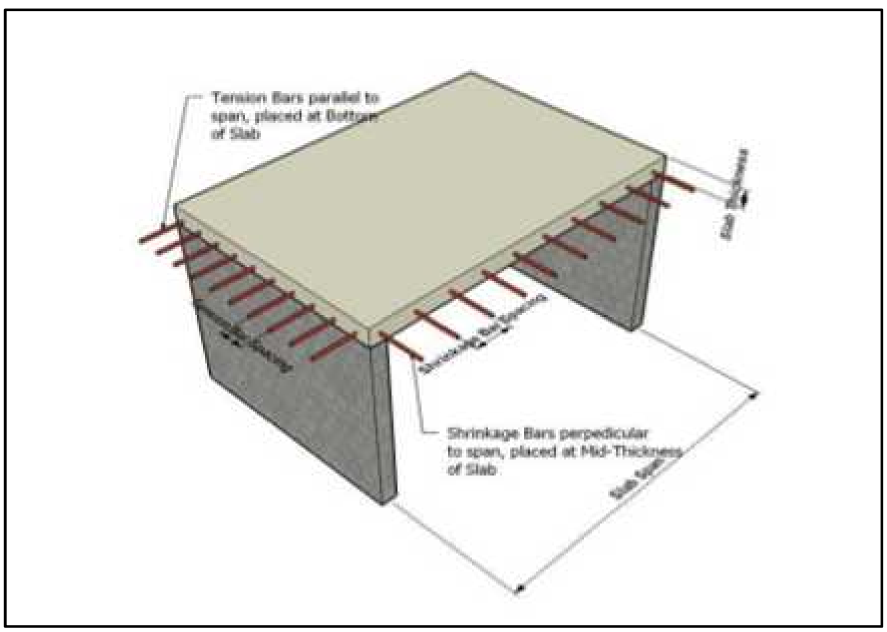
In this project, two types of components both in its appropriate place, and in, which will clarify the structural design in the subsequent chapter, and below these types:

1- One Way Ribbed Slab.

2- Tow Way Solid Slab.



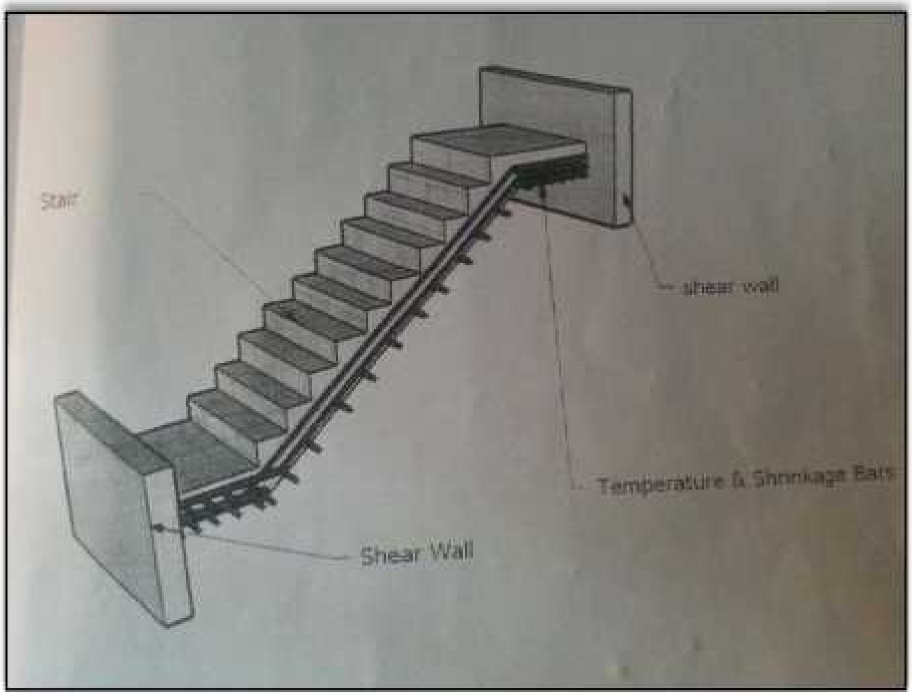
.Figure (3-6): Solid Slab.



.Figure (3-7): One Way Ribbed Slab.

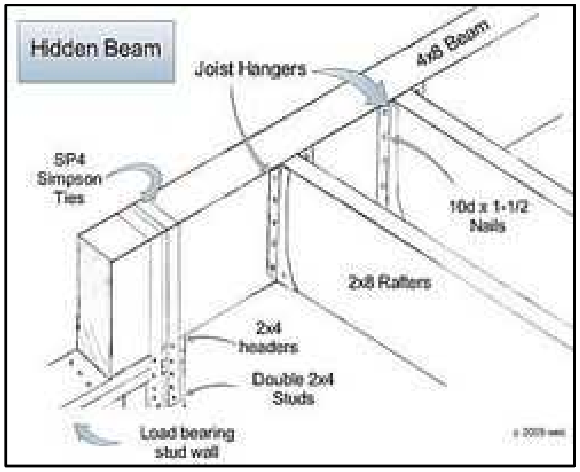
- **Stairs:**

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.

- **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 (3-9): Hidden Beam.

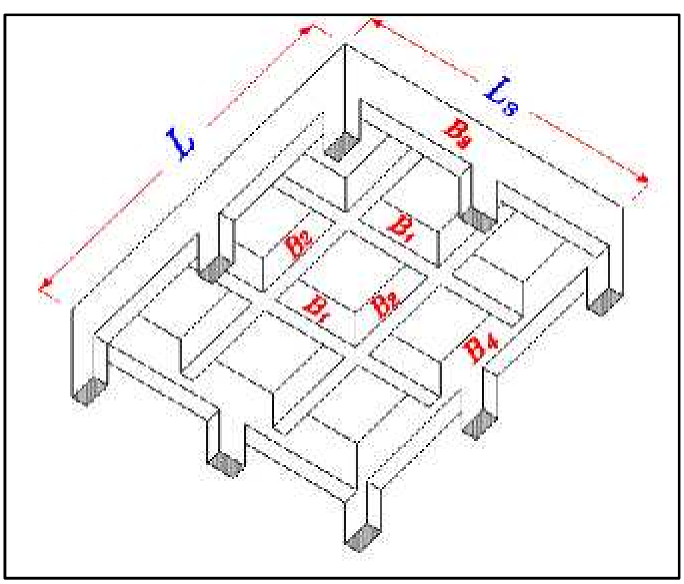
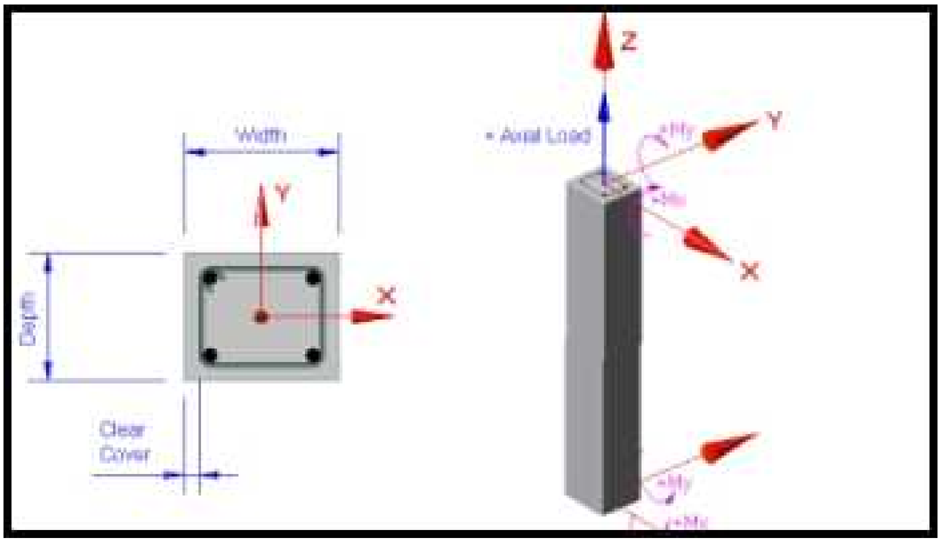


Figure (3-10): Paneled Beam.



- **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 (3-11): Column.

- **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 (3-12): Shear Wall.

- **Frames:**

The frame construction is a method of building and designing structures, primarily using steel or steel-reinforced precast concrete. The connections between the columns and the rafters are designed to be moment-resistant.

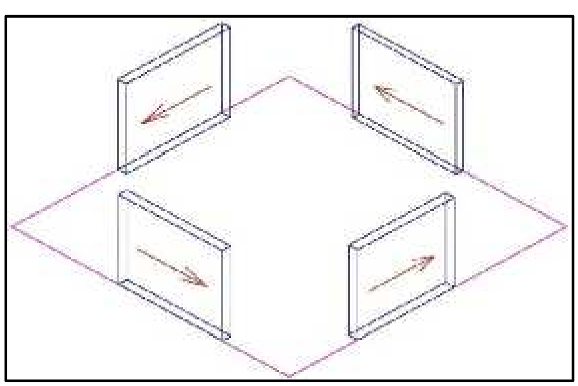


Figure (3-13): Frame Structure.

CHAPTER

4

DESIGN OF STRUCTURAL MEMBERS

4.1 Introduction:

This chapter contains the structural analysis and design of some elements of the Islamic Cultural Center.

The structural design of the project is the most important thing to be done, through design we determine the amount of reinforcement in each part of the project to be realized all the conditions of construction and safety.

As we mentioned before, ACI 318m-08, and some engineering programs were used in the design of the structures like: Atir, to find the internal forces, deflection and moments, and then hand calculation were done to find the required reinforcement for the structures.

4.2 Factored Loads:

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

qu = 1.2DL + 1.6L   ACI – 318 - 02 (9.2.1)

4.3 Determination of Thickness:

4.3.1 Determination of Thickness for One Way Ribbed Slab:

According to ACI-Code-318-05, the minimum thickness of nonprestressed beams or one way slabs unless deflections are computed as follow:

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

=5240 /18.5 = 28.3cm.

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

= 4660/21 = 22.4 cm

The controller slab thickness is 28 cm.

Select Slab thickness h= 28cm with block 20 cm & Topping 8cm.

4.4 Design of One Way Ribbed Slab:

4.4.1 Design of Topping:

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

No.	Parts	Density	Calculation
1	Tiles	23	**23×0.03=0.69 KN/m**
2	Mortar	22	**22×0.02=0.44 KN/m**
3	Coarse Sand	17	**16×0.07=1.12KN/m**
4	Topping	25	**25×0.08=2 KN/m**
5	Partition		**2.5×1=2.5 KN/m**
			6.75 KN/m

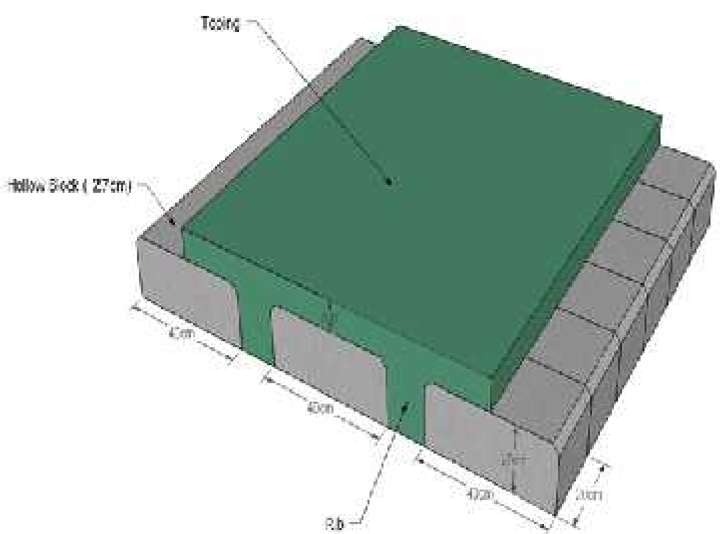


Figure (4-1): Toping of slab

Wu = (1.2 * 6.75) + (1.6 * 5)=16.1 KN/m

→ For a one meter strip Wu = 16.1 KN/m

Assume slab fixed at supported points (ribs):

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

$$Mu = \frac{16.1 * 0.4^2}{12} = 0.21 \text{ KN.m/m of strip width}$$

$$S = \frac{bh^2}{6} = \frac{1.00 \times (0.08^2)}{6} = 1.06 \times 10^{-3} m^3$$

Mn = **0**.42*√24* 1.06×10^{-3} = 2.19 KN.m

Φ Mn = 0.55 * 2.19= 1.21 KN.m

Φ Mn = 1.21KN.m > Mu = 0.22 KN.m

No structural reinforcement is needed. Therefore, shrinkage and temperature reinforcement must be provided.

For the shrinkage and temperature reinforcement:

ρ =0.0018 *ACI-318-02 (7.12.2)*

As = ρ * b * h = 0.0018 * 100 * 8 = 144 mm^2

Use Φ8 @ 20 cm c\c in both directions.

4.4.2 Design of Ribs:

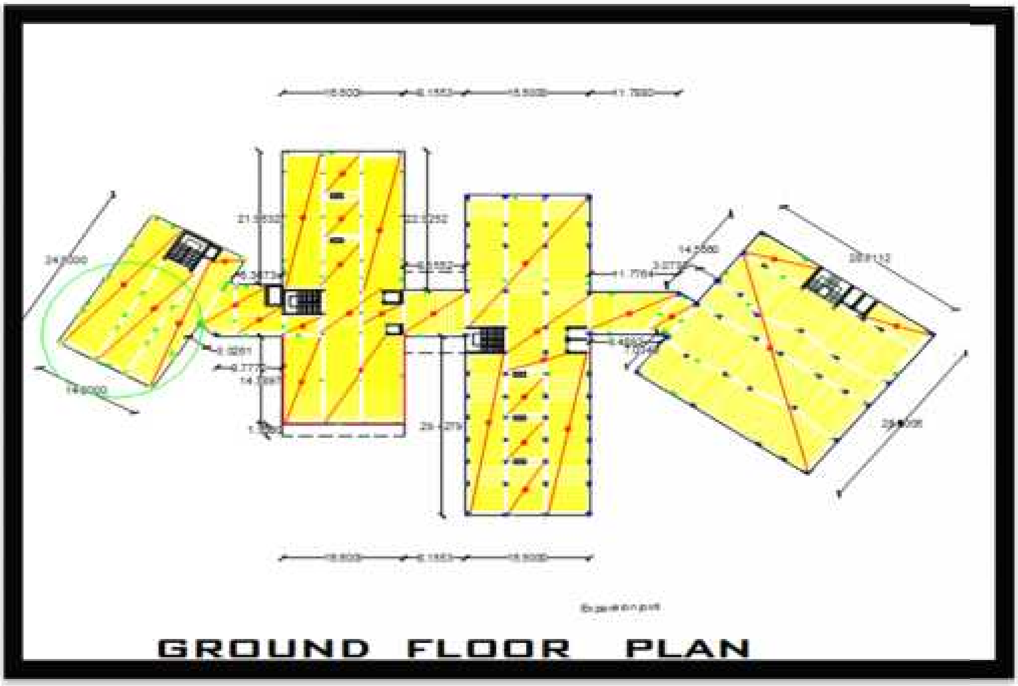


Figure (4-2): Rib location

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

No.	Parts of Rib	Density	Calculation
1	Tiles	23	0.03*23*0.52 = 0.359 KN/m
2	Mortar	22	0.02*22*0.52 = 0.228 KN/m
3	Sand	17	0.07*16*0.52 = 0.582 KN/m
4	Topping	25	0.08*25*0.25 = 1.04 KN/m
5	Rib	25	0.20*25*0.12 = 0.6 KN/m
6	Block	10	0.2*9*0.4 = 0.864 KN/m
7	Plaster	22	0.02*22*0.052 = 0.228 KN/m
8	partition		2.5*.52 = 1.3 KN/m
			5.201 KN/m

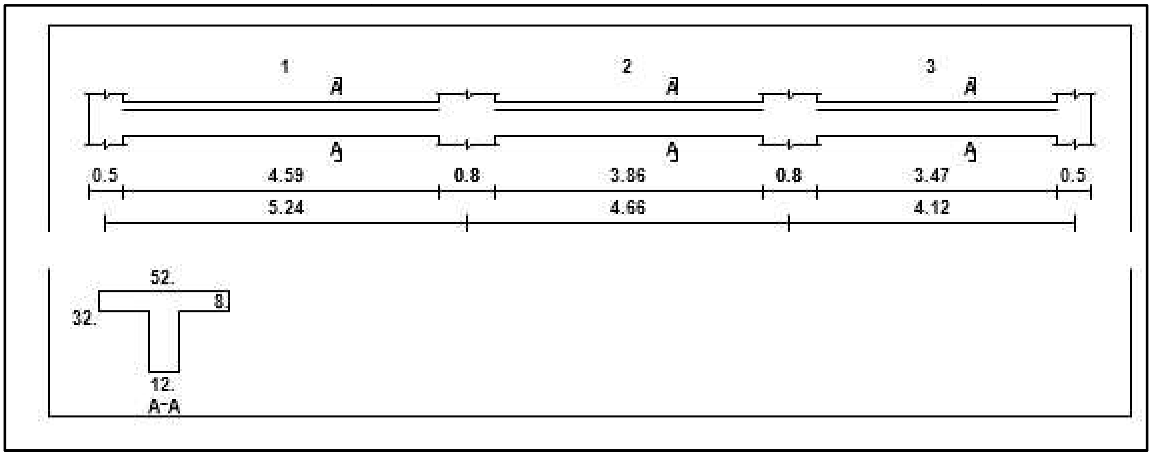


Figure (4-3): Rib geometry.

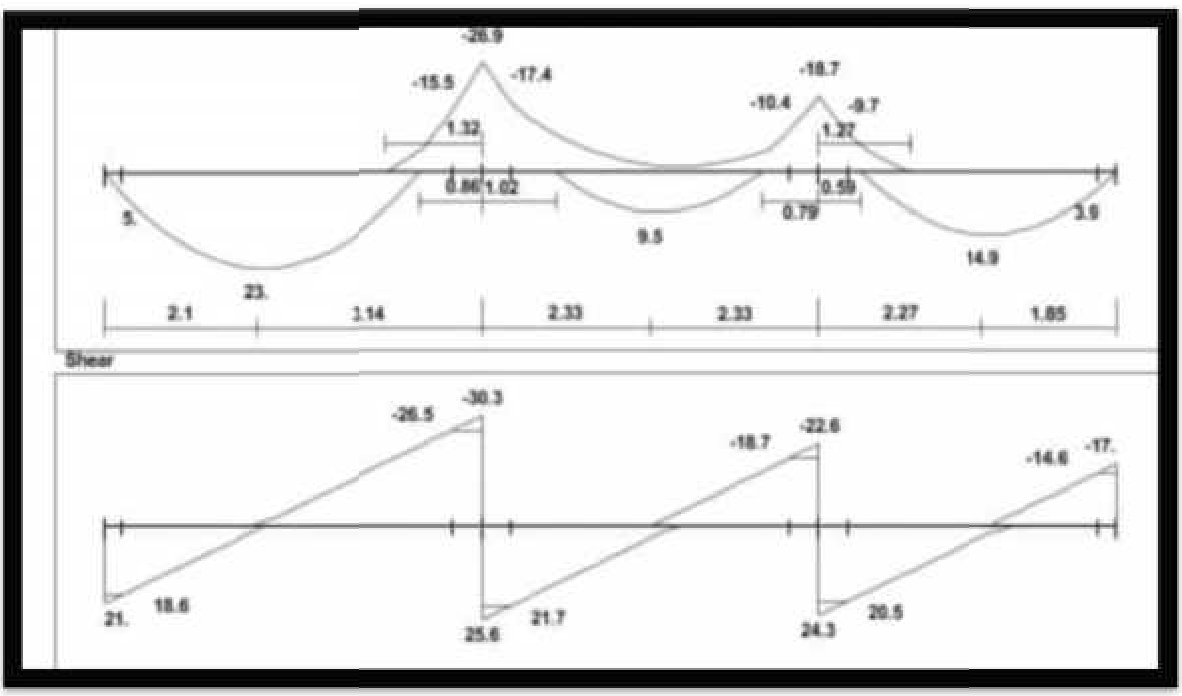


Figure (4-4) : Moment and Shear Envelop of rib.

Design Negative Moment of Rib:

Maximum negative moment Mu = 17.4 KN.m

Mn = 17.4/ 0.9 =19.3kN.m

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

$Rn = \frac{Mn}{b * d^2} = \frac{19.3 * 10^{-3}}{0.12 * (0.244)^2} = 2.701 Mpa$

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

$\rho = \frac{1}{20.6} (1 - \sqrt{1 - \frac{2(20.6)(2.701)}{420}}) = 0.00692$

As = 0.00692 (120) (244) = 202.7 mm^2

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

$$As_{min} = \frac{\sqrt{24}}{4(412)}(120)(315) \geq \frac{1.4}{412}(120)(315))$$

$As_{min} = 86.1 < 98.4$ …………the larger is control

$As_{min} = 98.4 mm^2$

202.7 $mm^2 > As_{min} = 98.4 mm^2$

# of bars = As/ As $_{bar}$ = 202.7/113.1 =2bars * Note $A_{\Phi 12}$ = 113.1 mm²

As provided=226.2 mm^2

Select 2 Φ 12mm .

- Check for Yielding

Tension = compression

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

$226.2*420 = 0.85*120*24*a$

$a = 38.81mm$

$c = \frac{a}{_1} = \frac{38.81}{0.85} = 45.66mm$ **OK**

$£_s = \frac{244-45.66}{45.66} X0.003$

$£_s = 0.01303 > 0.005$

Design of Positive Moment of Rib

Maximum positive moment is Mu = 21kN.m

Mn = 23 / 0.9 = 25.5kN.m

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

Rn = $\frac{Mn}{b*d^2} = \frac{25.5*10^{-3}}{0.52*(0.244)^2}$ = 0.825Mpa

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

ρ = $\frac{1}{20.6}$ (1 - $\sqrt{1-\frac{2(0.825)(20.6)}{420}}$) = 0.002

As = 0.002 (520) (244) = 254.4 mm^2

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

$$As_{\min} = \frac{\sqrt{24}}{4(420)}(120)(246) \geq \frac{1.4}{420}(120)(246))$$

$$As_{\min} = 86.1 < 98.4$$

$$As_{\min} = 98.4 mm^2$$

$$226\, mm^2 > As_{\min} = 98.4 mm^2$$

# of bars = As/ As $_{bar}$ = 254.4/113.1 = 2 bars * Note $A_{\Phi 12}$ = 113.1 mm²

As providing =226.2 mm^2

Select 2 Φ 12mm .

- Chick for yielding

Tension = Compression

As * fy = 0.85* b * a

$$226.2 * 420 = 0.85 * 520 * 24 * a$$
$$a = 8.96 mm$$
$$c = \frac{a}{_1} = \frac{8.78}{0.85} = 10.53 mm$$
$$£_s = \frac{244 - 10.53}{10.53} X0.003$$
$$£_s = 0.066 > 0.005 OK$$

4.4.3 Design for shear

V_u=25.1

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

= 0.75 * $\frac{\sqrt{24}}{6}$ 0.12 * 0.244*1000

= 17.9 KN

1.1 * Φ Vc = 1.1*17.9 = 19.7 KN.

Check for items:-

1/ Vu ≤ Φ Vc/2

26.5 ≤ 8.95 (X)

2/ Φ Vc/2 ≤ Vu ≤ Φ Vc

8.95 ≤ 26.5 ≤ 17.9 (X)

3/ Φ Vc ≤ Vu ≤ Φ Vc + Φ Vsmin

17.9 ≤25.22 ≤ 26.5 (**(√)**)

Φ Vsmin ≥ 0.75 ($\frac{1}{3}$) * bw * d = 0 .75*($\frac{1}{3}$)*0.12 *0.244 *1000= 7.32 KN.

≥ 0.75 ($\frac{\sqrt{24}}{16}$ * bw * d = 0.75 * $\frac{\sqrt{24}}{16}$ * 0.12 * 0.244 * 1000 = 6.72 kn.

Φ Vsmin = 7.32 KN.

So Case (3) satisfy

Take Av = 2 Φ 8 = 2 * 50

Av/ s = Vs/fy * d

2*50/ s = 15.5 /420*244→ s = 666.6 mm

S ≤ d/2 =123 mm

≤ 600 m.

Use Φ 8 @ 12.5 cm c/c

4.5 Design Of Beam

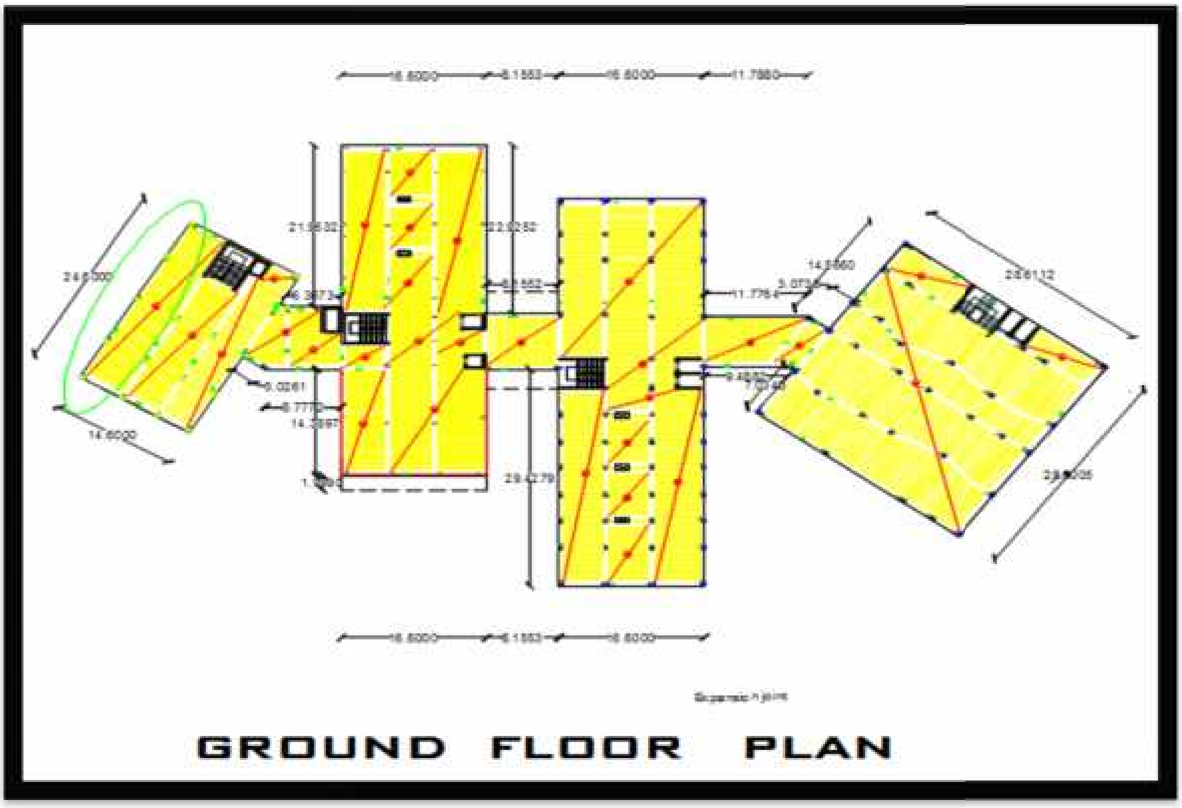


Figure (4-5) : Beam location.

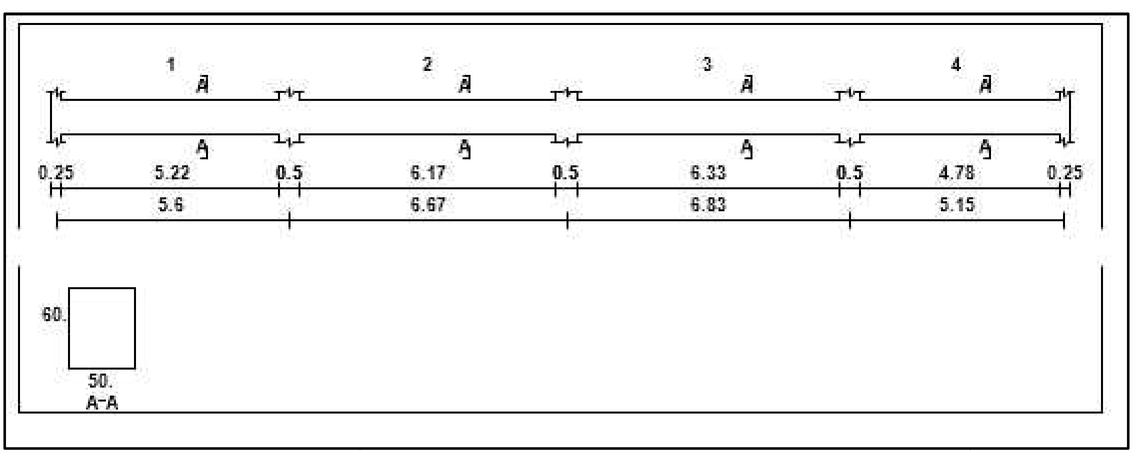


Figure (4-6) : Beam geometry.

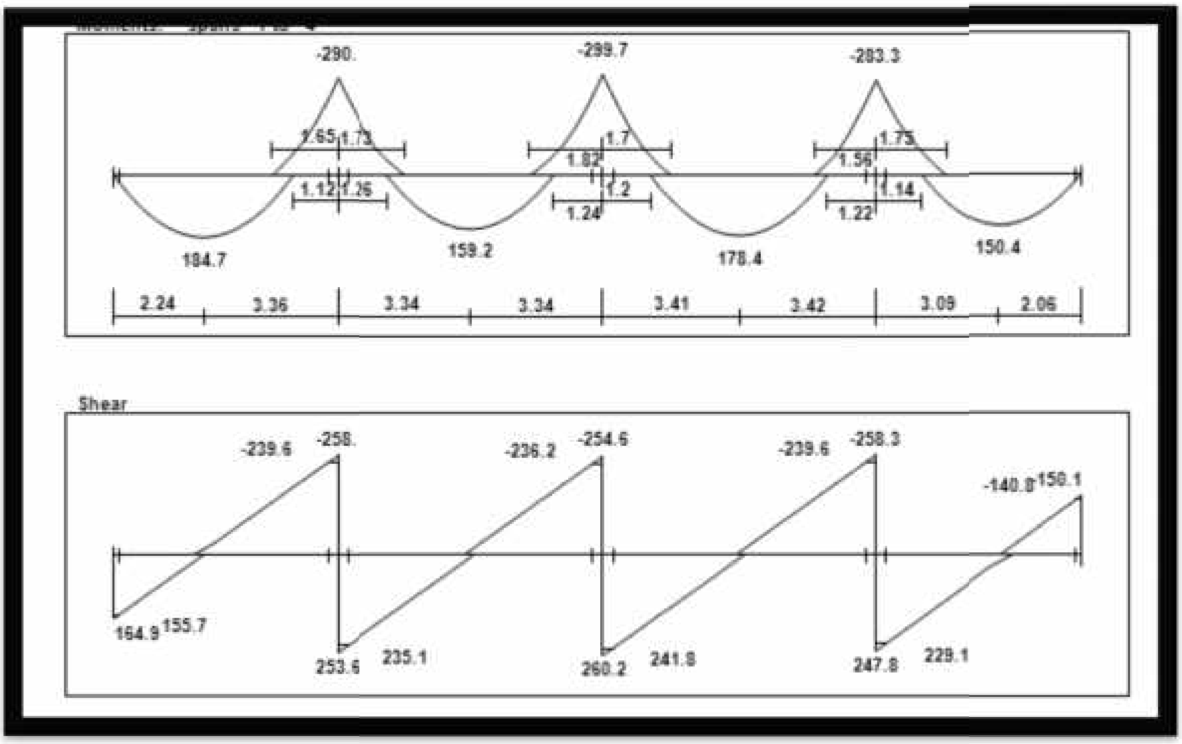


Figure (4-7) : Moment and shear envelop of beam.

Table (4 – 3): Calculation of the dead load from beam weight and the floor.

No.	Parts of Beam	Density	Calculation
1	Tiles	23	**0.03*23 = 0.69 KN/m**
2	Mortar	22	**0.03*22 = 0.66 KN/m**
3	Sand	17	**0.07*17 = 1.19 KN/m**
4	Beam	25	**0.4*25 = 10 KN/m**
5	Plaster	22	**0.03*22 = 0.66 KN/m**
6	partition		**1 KN/m**
			14.2 KN/m

Dead load from rib: 11.49 KN/m

Live load from rib: 9.56 KN/m

$W_{D\ from\ rib}$ = 11.49/0.52 = 22.09 KN/m.

$W_{L\ from\ rib}$ = 9.56/0.52 =18.3 KN/m.

Total dead load = 22.09 + (1.2*14.2) = 39.13 KN/m.

Total live load = 18.3 + (1.6*5) = 26.3 KN/m.

4.5.1 Design of Positive Moment

h=500mm

$d = 500 - 40 - 10 - (16/2) = 442mm$

Mu =185 KN .m

C = $\frac{3}{7}$ d = $\frac{3}{7}$ * 442 = 189.4 mm.

a = B *c = 0.85 * 189.4= 161.01 mm.

Mn max = 0.85* fc * a * b * (d- a/2)

= 0.85 * 24 * 0.161 * 0.5 * (0.442 – 0.161/2) * 10^{-6} = 593.655 KN.m

Φ Mn = 0.85 *593.655 = 504.6 KN .m

Φ Mn ≥ Mu= 185 KN.m

The section is singly

Mn = 185 / 0.9 = 205.55kN.m

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

Rn = $\frac{Mn}{b*d^2} = \frac{205.55*10^{-3}}{0.5*(0.442)^2}$ = 2.104 MPa

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

$$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2(2.104)(20.6)}{420}}\right) = 0.00529$$

As = .00529 (500) (442) = 1169.09 mm^2

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

$$As_{\min} = \frac{\sqrt{24}}{4(420)}(500)(442) \geq \frac{1.4}{420}(500)(442)$$

$$As_{\min} = 644.44 < 736.66$$

$$As_{\min} = 736.66mm^2$$

1169.09 $mm^2 > As_{\min} = 736.66mm^2$

# of bars = As/ As $_{bar}$ = 1169/201.06 = 6 bars * Note $A_{\Phi16}$ = 201.06 mm²

As providing =1206.36 mm²

Select 6Φ 16 mm .

- Check for Yielding

Tension = Compression

As * fy = 0.85 * b * a

$$1206.36 * 420 = 0.85 * 500 * 24 * a$$

$$a = 49.69mm$$

$$c = \frac{a}{_1} = \frac{49.69}{0.85} = 58.44mm$$

$$£_s = \frac{442 - 58.44}{58.44} X0.003$$

$$£_s = 0.0196 > 0.005$$

4.5.2 Design of Negative Moment

$d = 500 - 40 - 10 - (16/2) = 442mm$

Mu = 299.7KN .m

Mn = 299.7 / 0.9 =333 KN.m

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

Rn = $\frac{Mn}{b * d^2} = \frac{333 * 10^{-3}}{0.5 * (0.442)^2}$ = 3.41 MPa

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

ρ = $\frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2(3.41)(20.6)}{420}}\right)$ = 0.00893

As = 0.00893 (500) (442) = 1973.53 mm^2

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

$$As_{\min} = \frac{\sqrt{24}}{4(420)}(500)(442) \geq \frac{1.4}{420}(500)(442)$$

$$As_{\min} = 644.44 < 736.66$$

$As_{\min} = 736.66 mm^2$

$1973.53\, mm^2 > As_{\min} = 736.66 mm^2$

#of bars = As/ As $_{bar}$ = 1973.53/201.06 = 10 bars * Note $A_{\Phi 16}$ = 201.06 mm²

As providing =2010.6 mm^2

Select 10 Φ 16mm .

• Check for Yielding

Tension = Compression

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

$$2010.6 * 420 = 0.85 * 500 * 24 * a$$
$$a = 82.7 mm$$
$$c = \frac{a}{_1} = \frac{82.7}{0.85} = 79.399 mm$$
$$£_s = \frac{442 - 79.399}{79.399} X0.003$$
$$£_s = 0.01.06 > 0.005$$

Ok

4.5.3 Design of shear

Vu = 239.6KN

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

$$Vc = \frac{\sqrt{24}}{6}\ 1 * 500 * 442$$

Vc = 180.4 KN

Vs = (Vu/Φ) – Vc = 239.6/.75 – 180.4 = 139.06 Kn

$V_{s,max} = 2/3 * \sqrt{fc'} * b_w * d * 10^{-3} = 2/3 * \sqrt{24} * 500 * 442 * 10^{-3} = 721.728$ Kn

721.728> Vu= 239.6 KN. → The dimension is big enough.

Check for Items:-

1/ Vu ≤ Φ Vc/2 (X)

2/ Φ Vc/2 ≤ Vu ≤ Φ Vc (X)

3/ Φ (Vc+Vs,min) ≤ Vu ≤ Φ (Vc + Φ Vs') (√)

$Vs' = \frac{1}{3} * \sqrt{fc'} * b_w * d = \frac{1}{3} * \sqrt{24} * 500 * 442 * 10^{-3} = 360.89$ Kn …. Vs ≤ Vs'

$V_{s,min} = \frac{1}{16} * \sqrt{fc'} * b_w * d = \frac{1}{16} * \sqrt{24} * 500 * 442 * 10^{-3} = 67.66$ Kn

$Vsmin \geq (\frac{1}{3}) * bw * d = (\frac{1}{3}) * 500 * 442 * 10^{-3} = 73.66$ KN. (control)

Φ (Vc+Vs,min) ≤ Vu ≤ Φ (Vc + Vs')

186.04 ≤ 239.6 ≤ 405.96

$S = \frac{100.5 * 420 * 442}{139.06} * 10\text{-}3 = 134.2$ mm

Take Φ8 – 4leg – 18cm.

REFERANCE

- كود البناء الأردني، كود الأحمال والقوى، مجلس البناء الوطني الأردني، عمان،الأردن، ٢٠٠٦م.
- Building code requirements for structural concrete (ACI-318-14), USA, 2014.
- Uniform Building Code (UBC).