Palestine Polytechnic University

College of Engineering

Structural Design of Plant Biodiversity Research Center

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DEDICATION

To Palestine…

To our Parents….

To The Soul of Martyrs….

To our Teachers ….

To our Friends …

To whom we Love ….

To Everyone who gave us Help …

To ENG. Fahed Salahat …

Team Work

ACKNOWLEDGMENT

We would like to thank and send our gratitude to Allah, who gave us the strength who granted us the ability and willing to start this project.

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

Thanks for all teachers who gave us a little of their time and answered our questions.

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

Team Work

ABSTARCT

The idea of this project revolves around the architectural and Structural design of " Plant Biodiversity Research Center " in Al-arroub, which was selected after a study set of different architectural projects.

The center consists of four floors including basement floor and stores .The basement floor consists of a store ,generator room and air conditioning room. The ground floor consists of cafeteria , kitchen, store ,gallery, video conference , theater , chapel, toilets and offices room. The first floor consists of plant storing, plant desiccation, plant Packaging, plant receipt, seeds store, herbarium, seeds Packaging, seeds desiccation, seeds sorting and sifting, seeds receipt, toilets, offices room, plant microbiology lab, plant physiology lab, Molecular biology lab and extra rooms, the second floor consists of library, office, printing hall, publication store, raw material store, toilets and lecture rooms, the third floor consists of finance manager, secretary rooms, manager room, manager assistant, archive room, personnel officer, stores and toilets, in addition warehouses third-party tools , a water cistern and a parking.

The main aim of this project is to prepare all the structural design and construction details of the:

1. Theater.
2. Library.
3. Management rooms.
4. Gallery.
5. Chapel.
6. Cafeteria.
7. Conference Hall Lecture halls.
8. Stores.
9. Computer halls and Concerns literal.

All of these elements are located in the Plant Biodiversity Research Center in Al-arroub.

The project contains the structural analysis for vertical and horizontal loads, the structural design, and details for each element. ACI 318m-14, Jordanian loads code 2006, and some engineering programs were used in the design of the structures.

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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.
- **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

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

Palestine is an agricultural country that needs facilities such as biological research center so we adopted this project as a graduation project where we take into account the importance of the project and its requirements that have been designed to meet these considerations. 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 deal with structural system capable of carrying the loads affecting the building taking into account the most possible economical construction system as is compatible with the architectural design choice.

The project includes the architectural and structural design of Theater, Library, Management rooms, Galleries, Chapel, 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 problem centralized in the project analysis, architectural design and structural system of all sections of the buildings. Forces and loads of structural components, such as beams and columns, ribs, etc. will be analyzed in the project. Then the dimensions and the arming of various structural elements will be determined.

1.3 An Overview of the Project:

This project includes the structural design of theater, library, management rooms, gallery, capable, cafeteria, conference hall, lecture halls, stores, computer halls and concerns literal that fulfilled all the requirements of comfort and safety according to usage requirements.

The theater is located in the ground floor and it can accommodate about 212 persons with an area of nearly 339 square meters.

The library has an area of 220 m^2 and it can accommodate up to 60 persons .

The management rooms has an area of 134 m^2 .

The gallery has an area of 235 $m^{2.}$

The capable has an area of 35 m^2 and it can almost accommodate 27 persons.

The cafeteria has an area of 171 m^2 and it can accommodate nearly 100 persons.

The educational section and other services has an area of 544 m^2 .

The stores contain water well underneath an area equivalent to 57 m^2.

The external stores have an area of 487 m^2.

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 building 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 preparation of 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 Methodology

Architecture design (construction drawings, elevations, sections, public location).

1. Study the units structurally to identify structural elements, loads on the buildings, and the selection of appropriate structural system.
2. Distribute columns to the chosen structural system.
3. Structural analysis of all structural elements of the units.
4. Structural design of all structural elements.
5. Preparation of construction drawings of the building to remove the executable images.
6. Writing project in accordance with the requirements of the construction engineering.

1.6 Reasons to Choose the Project:

The reason of selecting the project refer to causes things, including the improving our 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 to acquire 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 research submitted to the department of civil engineering and architecture at the College of engineering and technology at Palestine Polytechnic University to meet graduation requirements for a Bachelor's degree in civil engineering and 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:

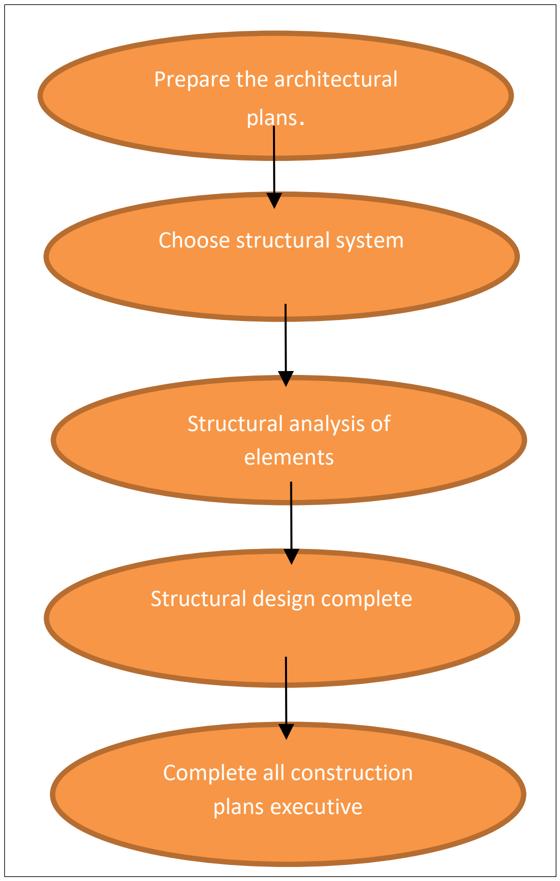

Figure (1-1): The Stages of The Project.

Table (1.1): Project Schedule.

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 plans																
Write the project																
Project presentation																

CHAPTER

2

Architectural Description

2.1 Introduction:-

Architectural description is the most important thing 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 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 the Plant Biodiversity Research Center:-

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

2.2.1 Interior Spaces:

The interior area of the project is 4000 m^2 and 1271.76 m^2 for movement spaces, Thus the total interior spaces is 51271.76 m^2.

- Interior spaces are divided into:

1- Basement.
2- Theater.
3- Cafeteria.
4- Gallery.
5- Video conference.
6- Labs.
7- Library.
8- Office rooms.
9- Internal stores.
10- Educational section.
11- The external stores.

➢ **1-Basement:**

It is less than the level in the building, an area equivalent to 132 m^2 divided into quarters services as follows: -

- Laundry: has an area of 33 m^2.
- Heating and air conditioning room: has an area of 33 m^2.
- Generator room : has an area of 26 m^2.
- Elevator Room: has an area of 8 m^2.
- Stores: has an area of 32 m^2.

- **2-Theater :**

It is located on ground floor and it accommodates 212 persons with an area of nearly 339 m2 divided into**:**

- Backstage1: has an area of 19 m^2.
- Control room: has an area of 10 m^2.
- Backstage2: has an area of 13 m^2.
- Platform: has an area of 30 m^2.
-

- **3-Cafeteria:**

It has an area of 171 m2 and can accommodate about 100 persons.

- **4-Gallery:**

It resides on ground floor with an area of nearly 290 m^2.

- **5-Video conference:**

It is located on ground floor and it accommodates 32 persons with an area of nearly 42 m^2 .

- **6-Labs:**

They are located on first floor and it accommodates about 32 persons with an area of nearly 131 m^2 divided into :

- Plant physiology lab has an area of 60 m^2.
- Molecular physiology lab: has an area of 71 m^2.

- **7-Library:**

It is located on first floor and it accommodates about 60 persons with an area of nearly 240 m2 divided into:-

- Office : has an area of 40 m^2.
- Entrance : has an area of 36 m^2.
- Reading hall : has an area of 105 m^2.
- Book shelves : has an area of 59 m^2.

- **8-Office rooms:-**

They have an area of 90 m^2 .

- **<u>9- Foreign stores:</u>**

  They have an area of 71 m2 .

- **<u>10-Educational section:</u>**

  It has an area of 120 m^2.

- **<u>11- The external stores:</u>**

  They have an area of 587 m^2 and this contain water well underneath an area equivalent to 96 m^2 and the depth of well is 4 m and it contains of 384 m^3 water.

2.2.2 External Spaces:

Consisting of:

- Green spaces.
- Cars parking: It consists of 41 car parking with an area 915 m^2.
- External Theater.
- External display spaces.

2.3 Project Plans:

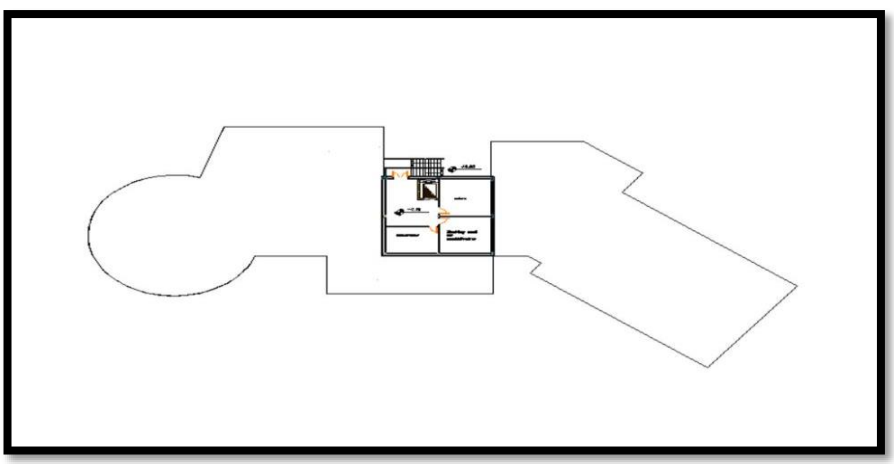

Figure (2-1): Basement floor plan.

Figure (2-2): Ground floor plan.

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Figure (2-3): First floor plan.

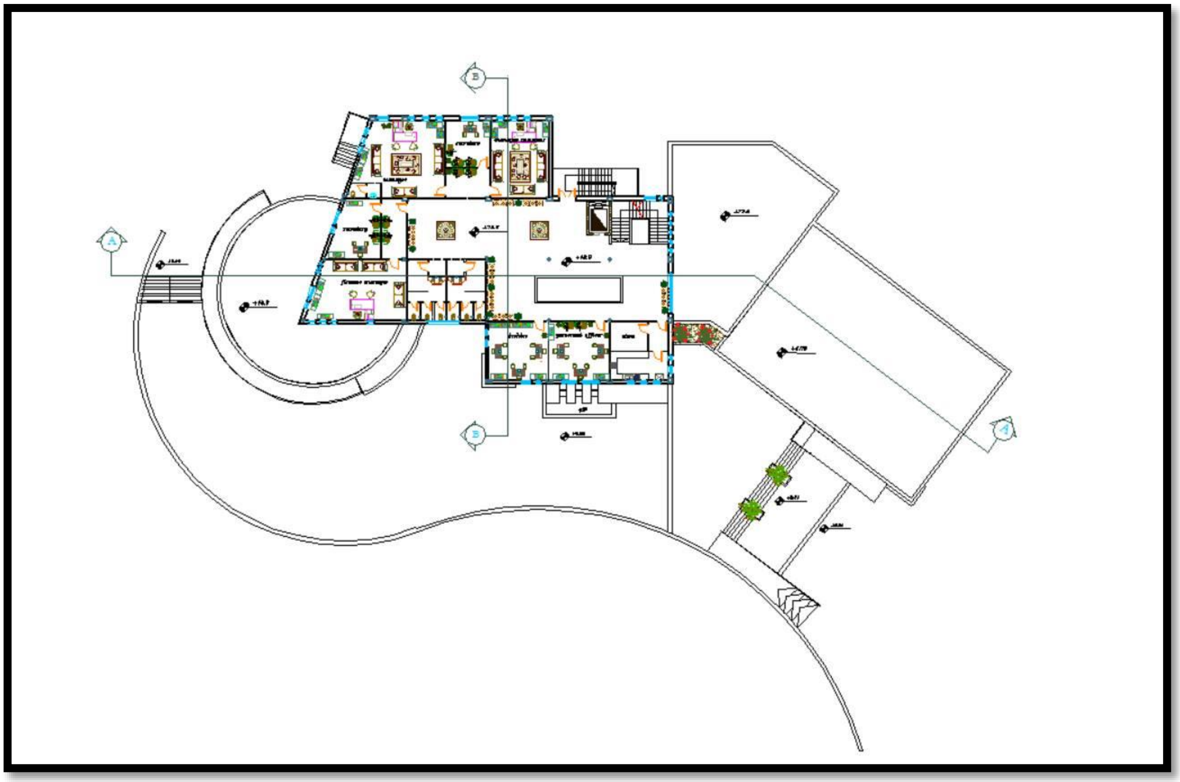


Figure (2-4): Second floor plan.

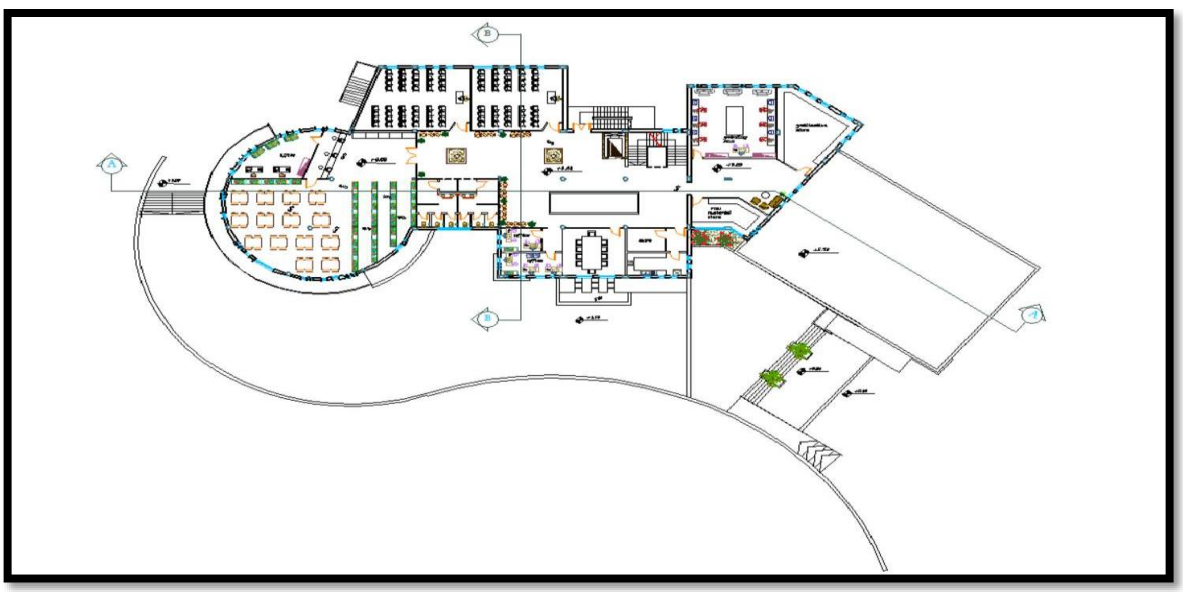


Figure (2-5): Third floor plan.

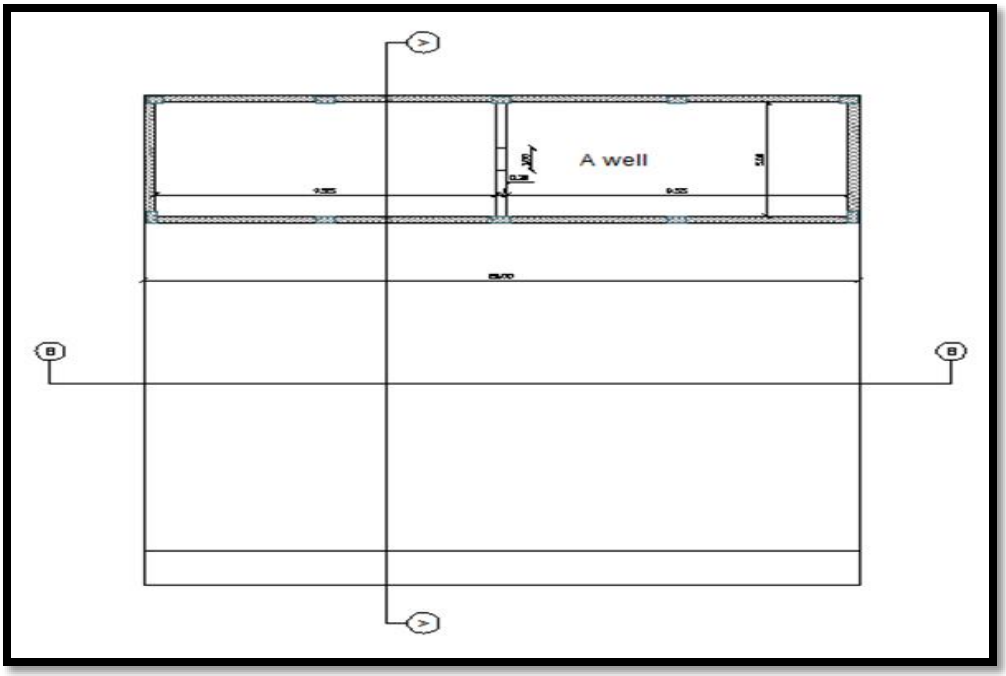


Figure (2-6): Foreign stores water well plan.

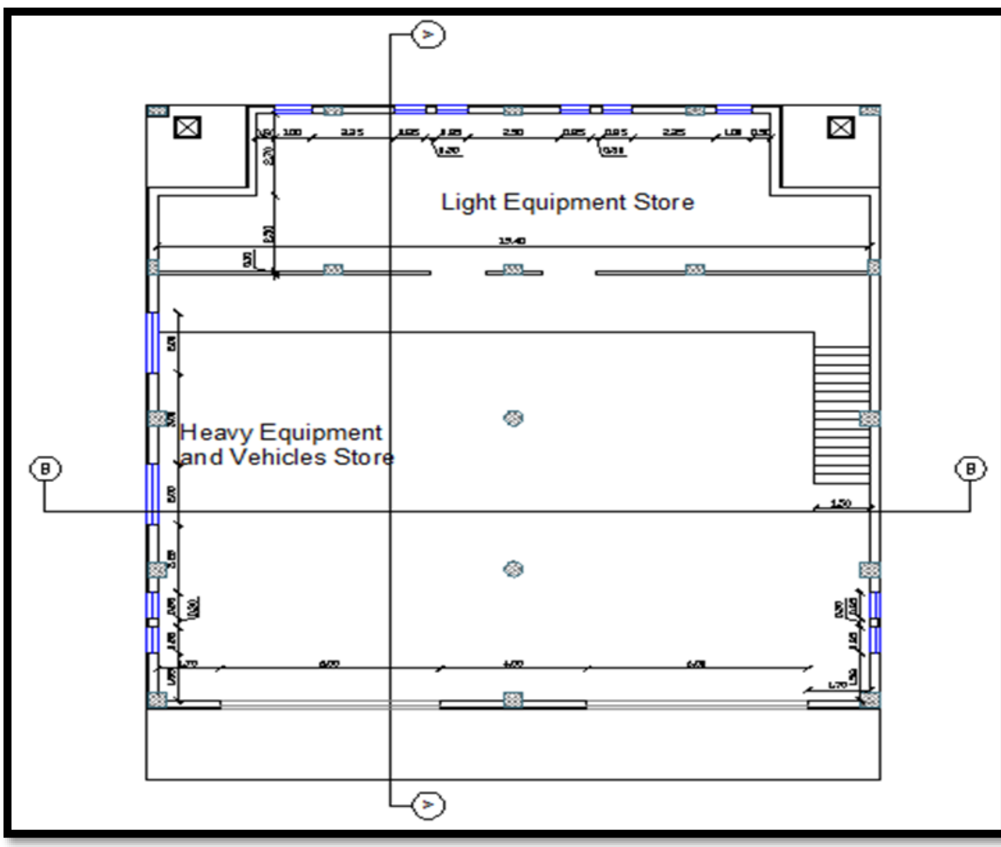


Figure (2-7): Foreign stores 1st level plan.

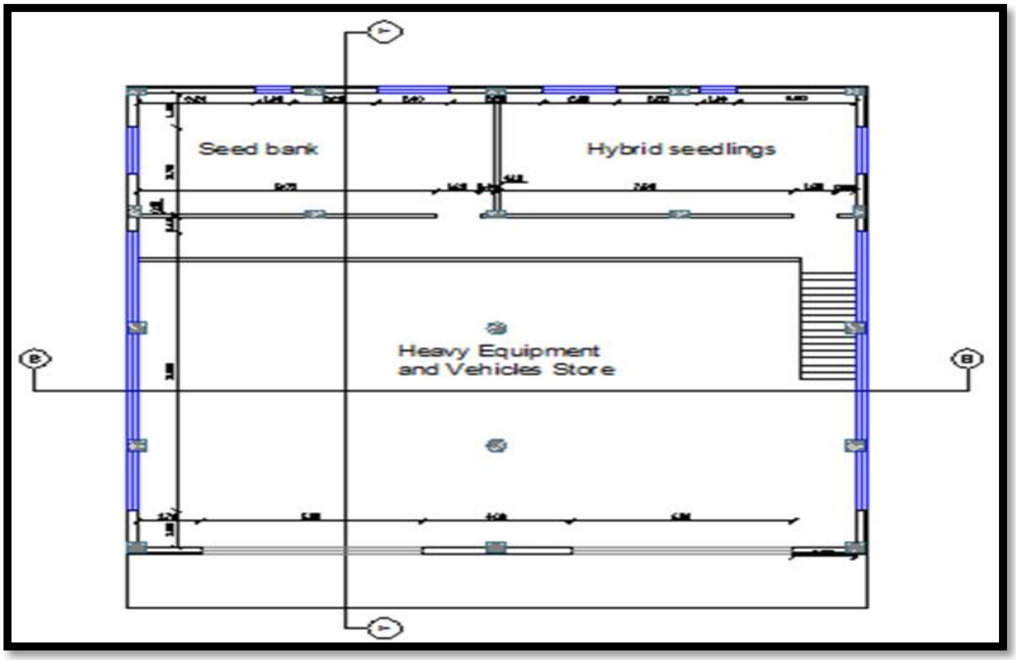


Figure (2-8): Foreign stores Ground Floor 2nd level plan.

2.4 Project Elevations:

Figure (2-9): South East Elevation.

(Main elevation)

Figure (2-10): South West Elevation.

Figure (2-11) : North West Elevation .

Figure (2-12) :North East Elevation .

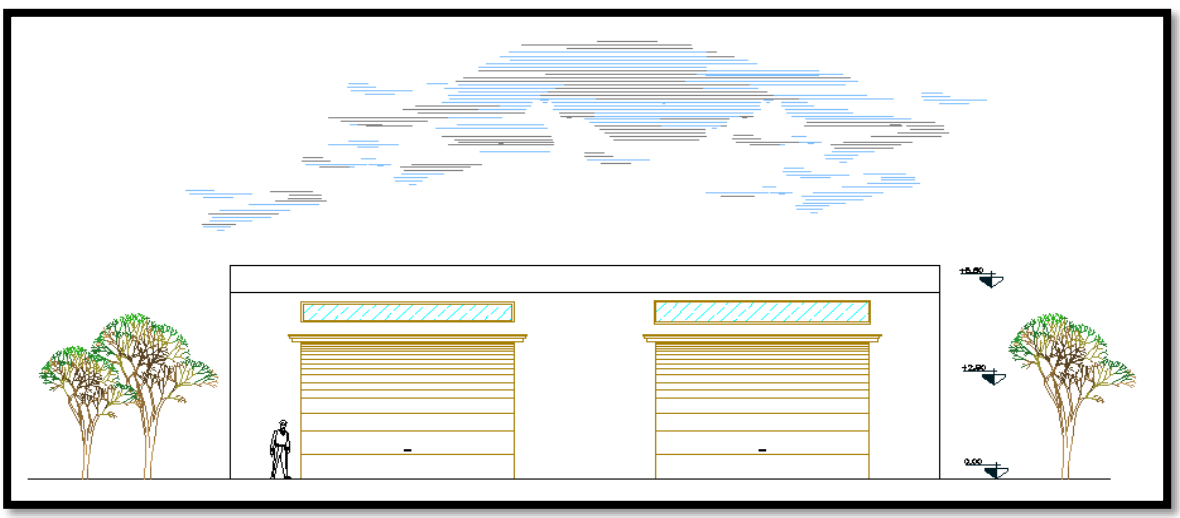


Figure (2-13) : Foreign Stores North East Elevation .

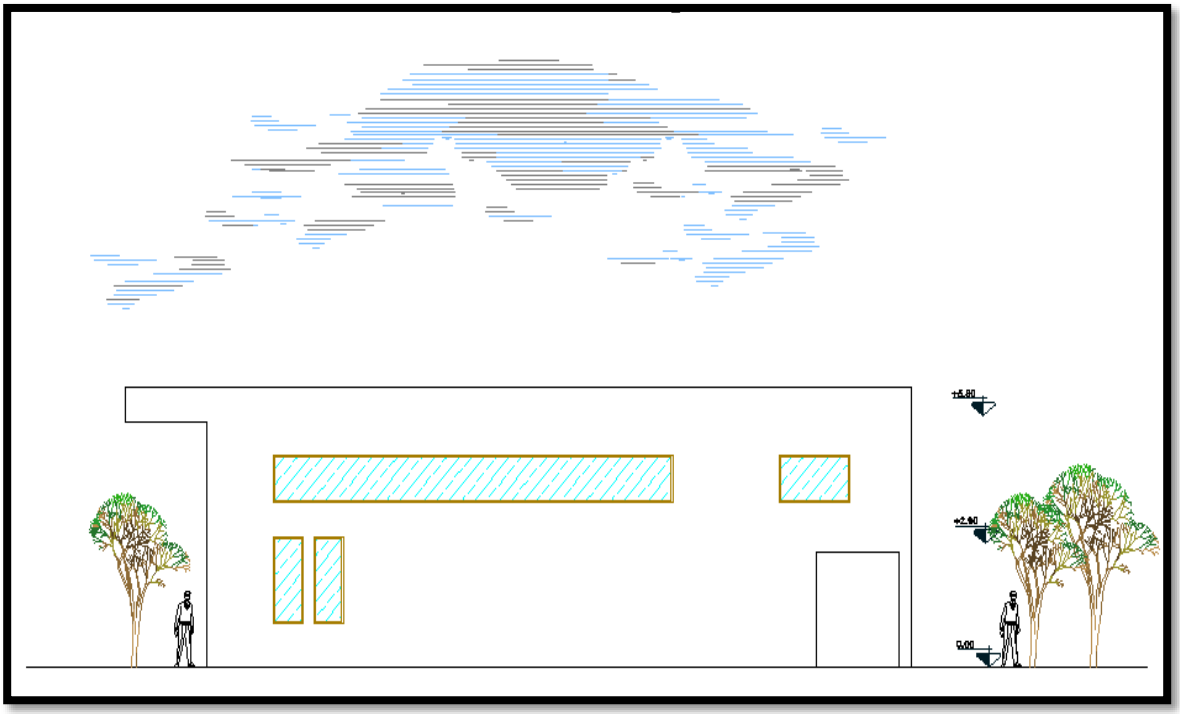


Figure (2-14) : Foreign Stores North West Elevation .

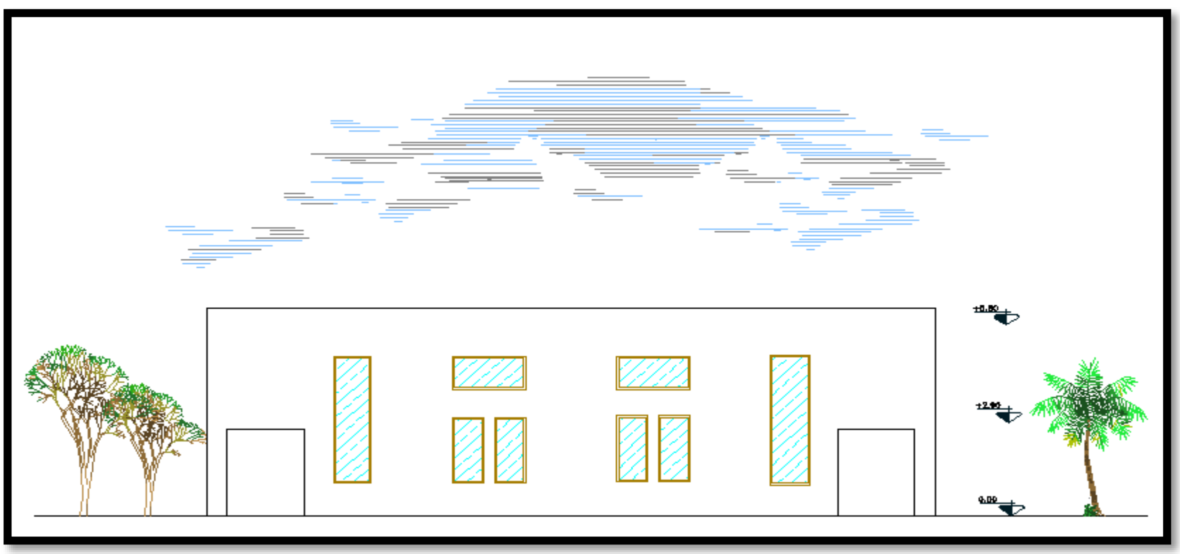


Figure (2-15) : Foreign Stores South East Elevation .

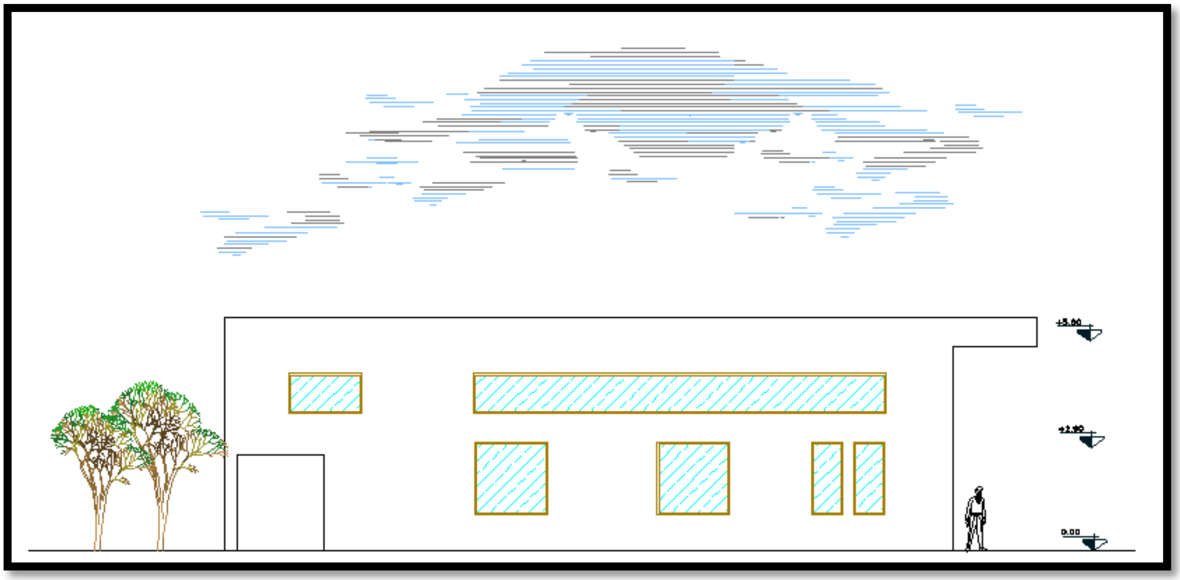


Figure (2-16) : Foreign Stores South West Elevation .

2.5 Project Sections:

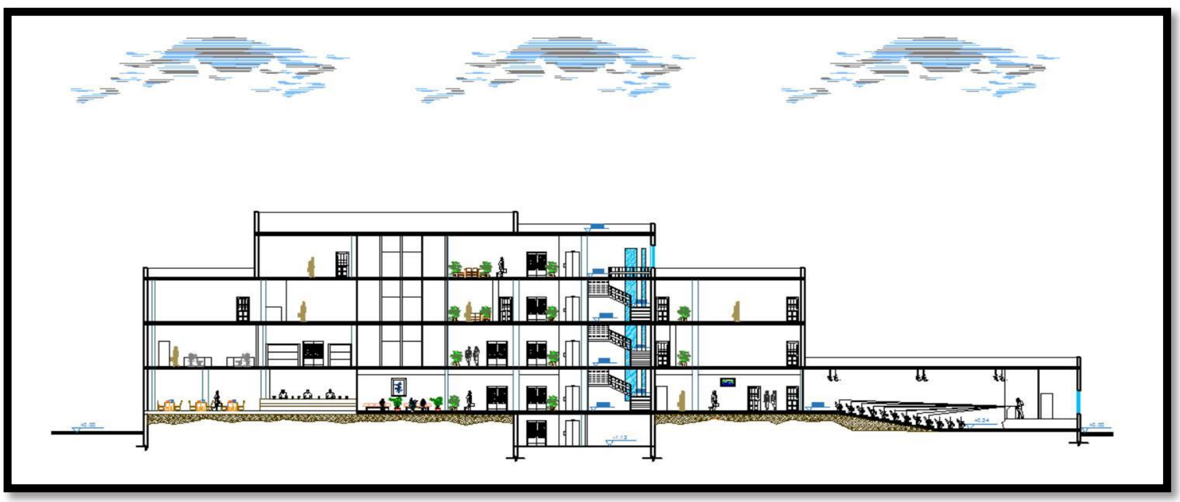


Figure (2-17):section A-A

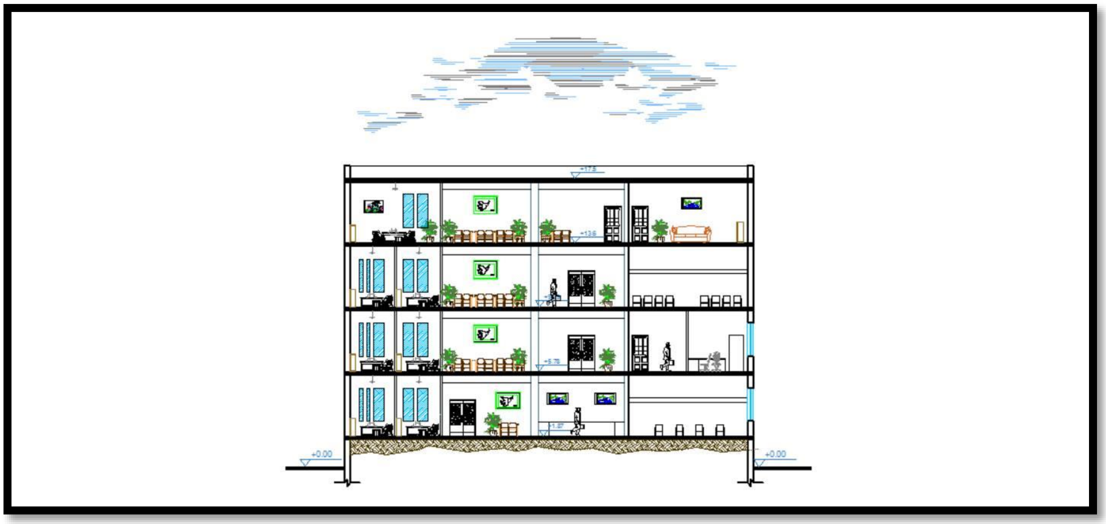


Figure (2-18):Section B-B .

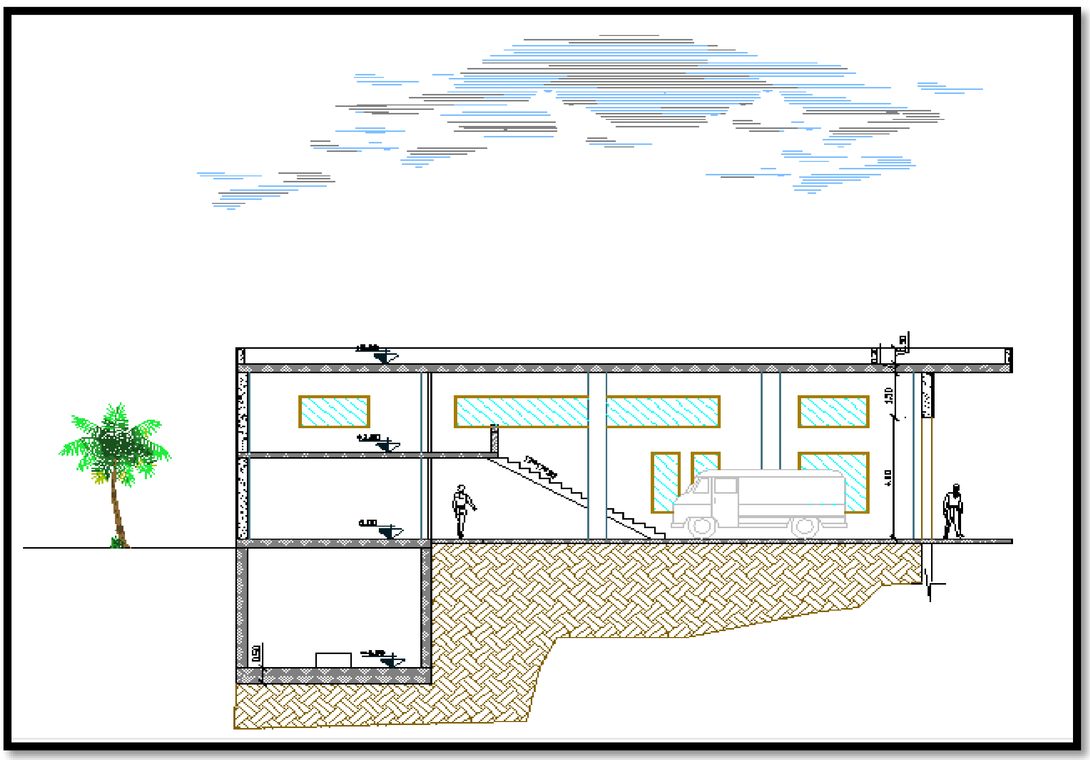


Figure (2-19): Foreign Stores Section A-A .

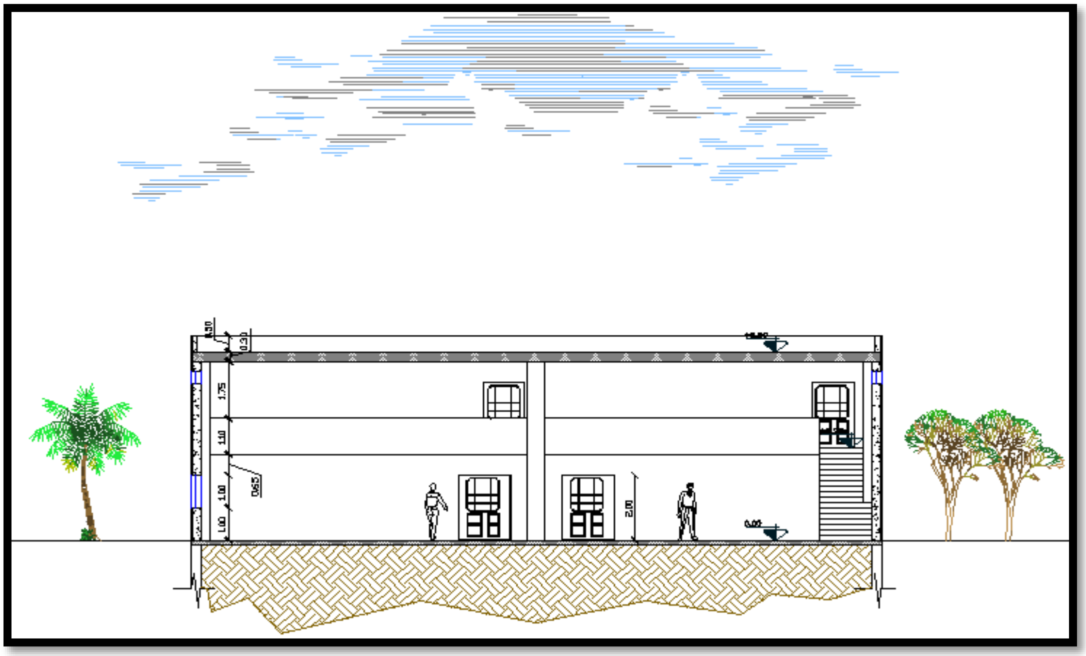


Figure (2-20): Foreign Stores Section B-B .

2.6 Some Perspective Shots for the Biological Research Centre:

Figure (2-21):snapshots for biodiversity & store buildings.

Figure (2-22): snapshot for biodiversity building.

Figure (2-23): snapshot for 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: Checked by choosing the appropriate building materials and by selecting 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 some test must be done , for example, 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 samples of the soil, 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 examined 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 and 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, beside the calculation and estimate on of the loads by knowing the dimensions of the structural elements and specific gravity of the material used in the manufacture of structural elements. These elements include: concrete, Rebar, plaster, bricks, tiles ,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.

الحمل المركز البديل	الحم ل الم وزع	الاستعمال	نوع المبنى	
كن	كن/م²	الاشغ ال	خاص	ع ام
4.5	4.0	المم رات والم داخل والأدراج وب سطحات الأدراج والممرات المرتفعة الموصلة بين المباني.	تابع القاعات، قاع ات الاجتماعات، المطاعم، المتاحف، المكتبات، النوادي، المسارح، ستوديوهات الاذاعة.	تابع مباني التجمعات العامة.
4.5	7.5	المنص ات.		
4.5	4.0	أرضي ات المتاح ف وصالات عرض الفنون.		
2.7	3.0	أماكن العبادة (المساجد والكنائس).		

Figure (3-1) Determination of live load code (page 25)

Snow Loads:

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

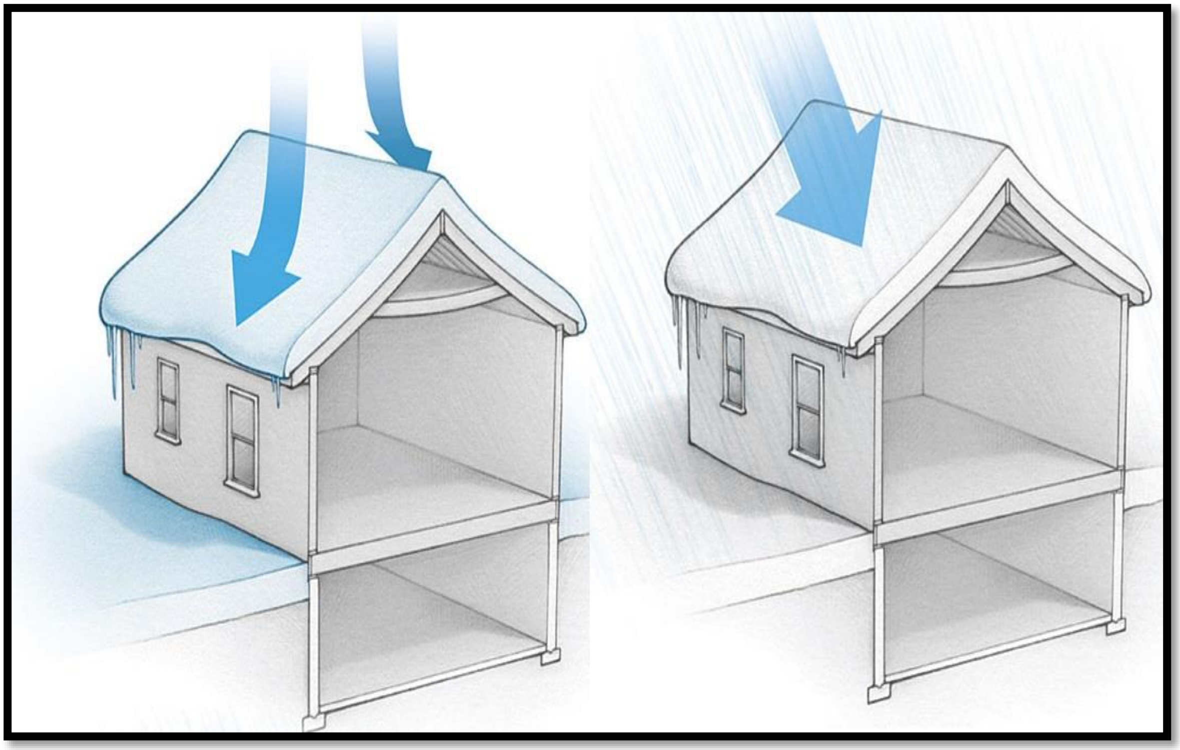


Figure (3-2): snow loads.

Based on the scale of previous snow loads and after selecting the high building surface and that equals (860 m) according to item III snow load is calculated as follows:

S_o= (h-400)/320 = (860-400)/320 = 1.44 KN/m^2 .

S_d= M_i * S_o= 0.8 * 1.44 = 1.152 KN/m^2 .

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

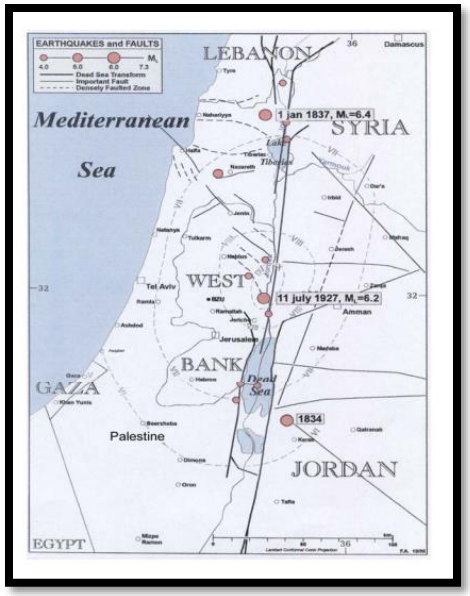


Figure (3-3): Earthquake map for Palestine.

Wind Loads:

Wind loads affect the horizontal forces on the building. The wind load determination process depends on the wind speed and the change height from the surface of the Earth and the building location ,whether it is built in a high or a low place taking into consideration many other variables .

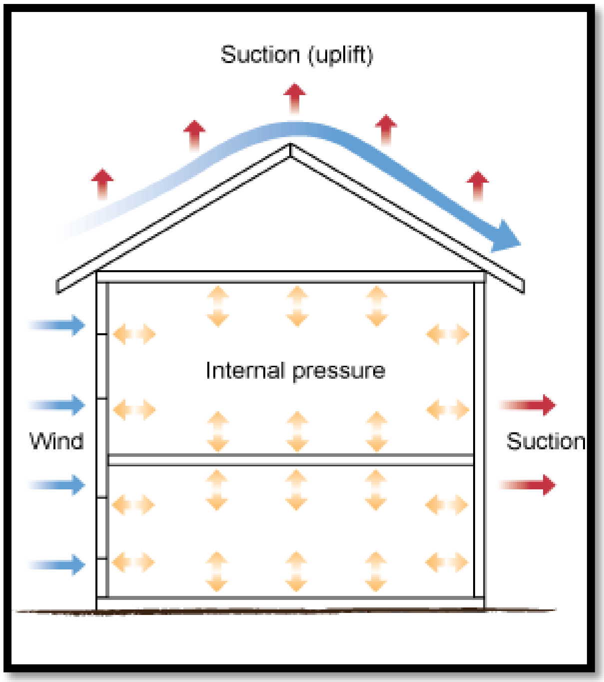


Figure (3-4): Wind Pressure on buildings.

3.6 Structural Elements of the Building:

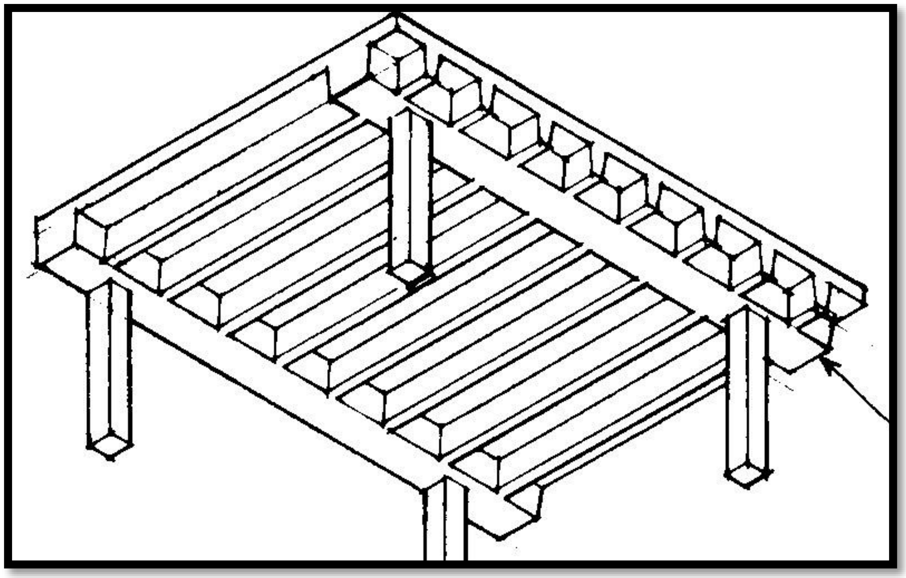
All buildings are usually consists of a set of structural elements that work together to maintain the continuity of the building and its suitability for human use. The most important of these slabs, beams, columns and load-bearing walls, etc are being defined.

- **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 each 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- Tow Way Solid Slab.
3- Tow Way Ribbed Slab.



.Figure (3-5): One Way Ribbed Slab.

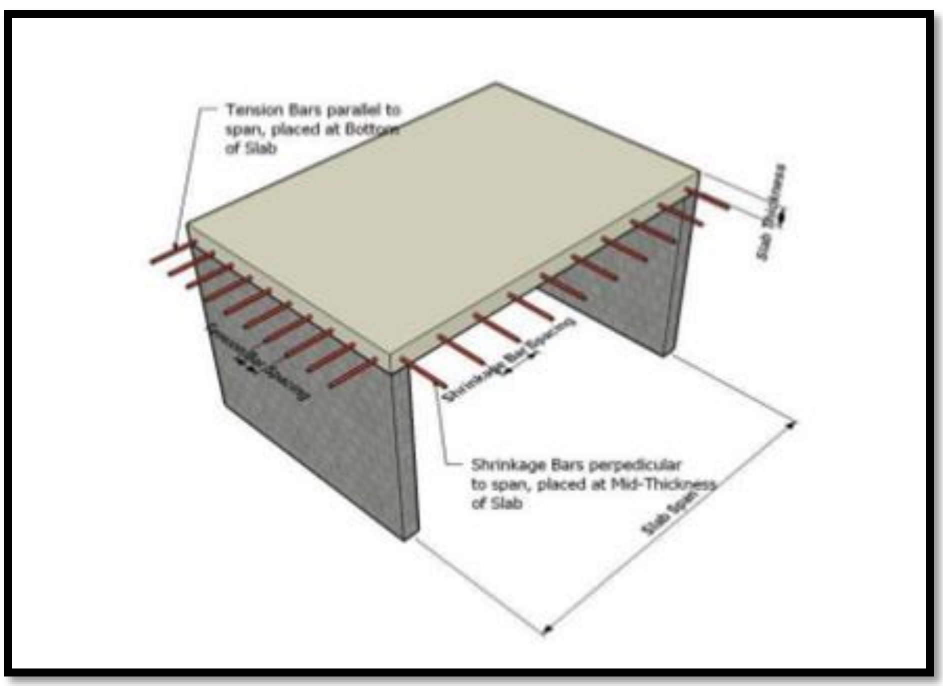


Figure (3-6): Solid Slab.

- **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.

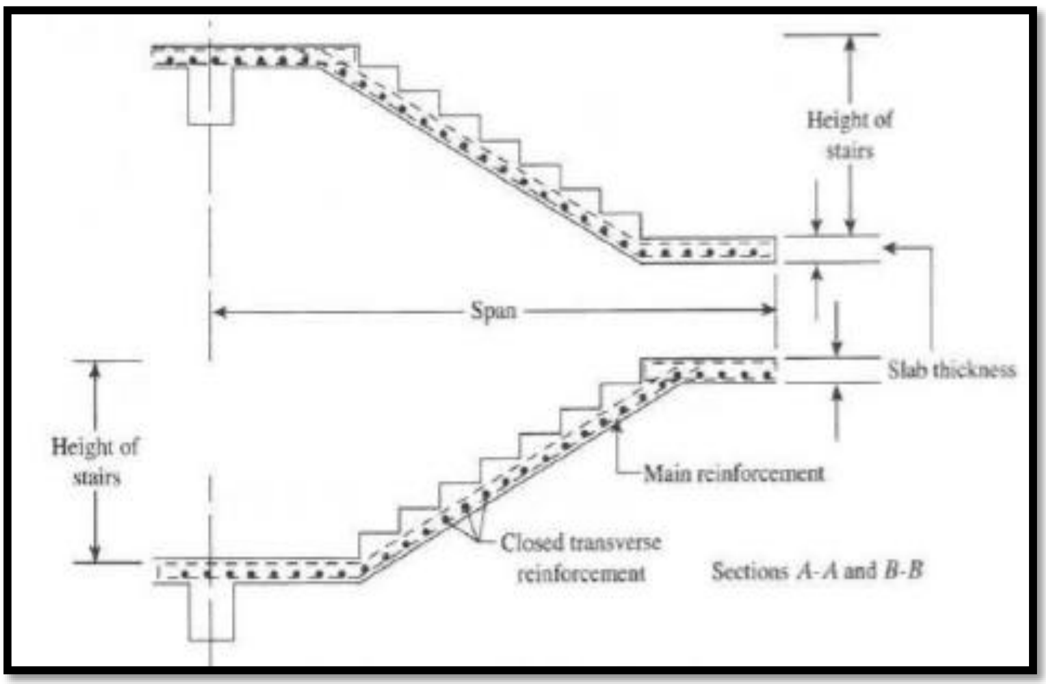


Figure (3-7): The shape of stairs.

- **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).

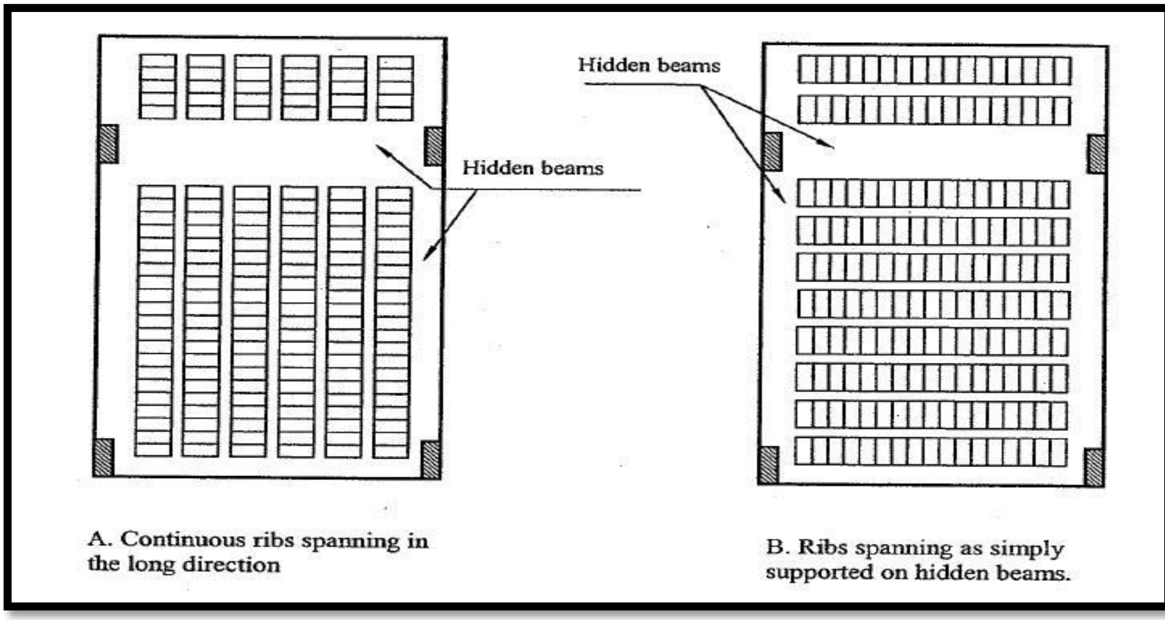


Figure (3-8): Hidden Beam.

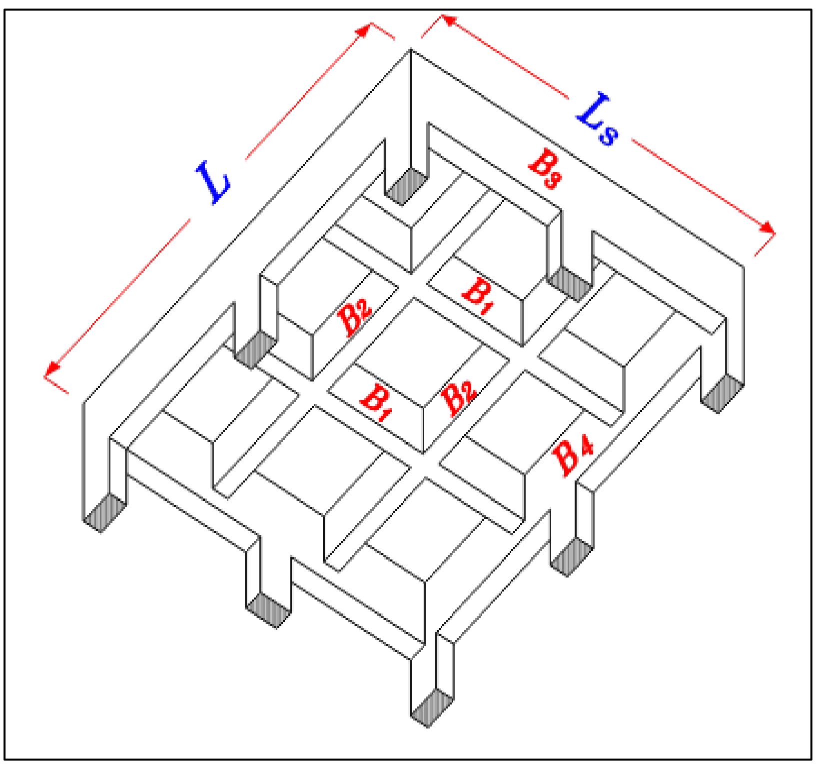


Figure (3-9): Paneled Beam.

- **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.

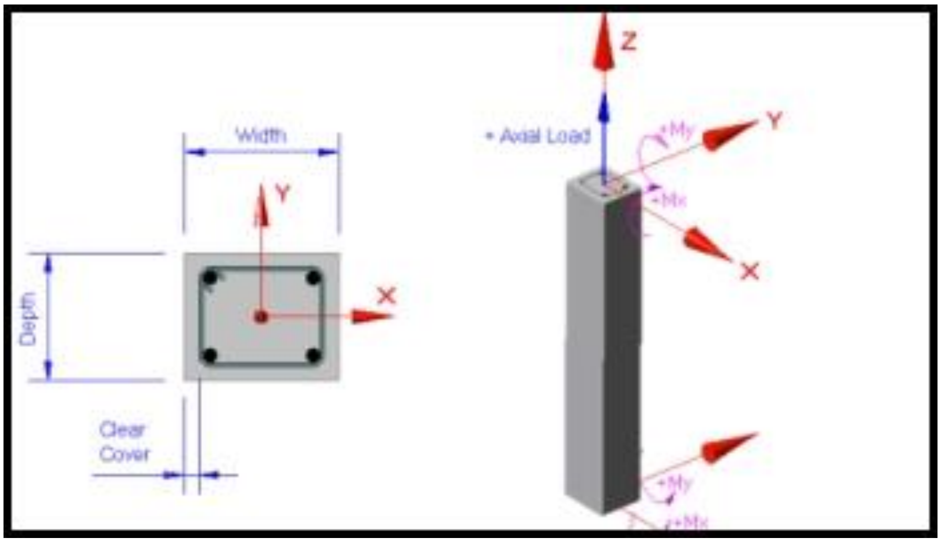


Figure (3-10): Column.

- **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.

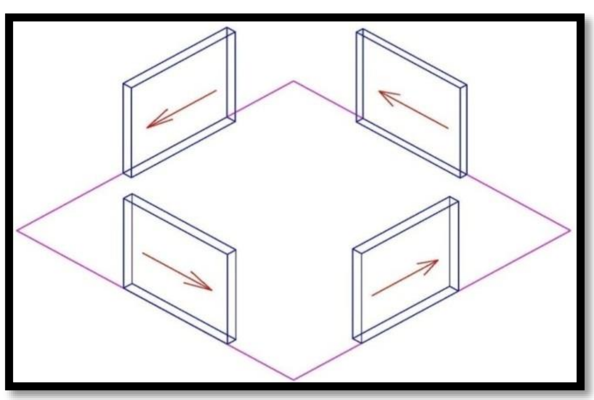


Figure (3-11): Shear Wall.

- **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.

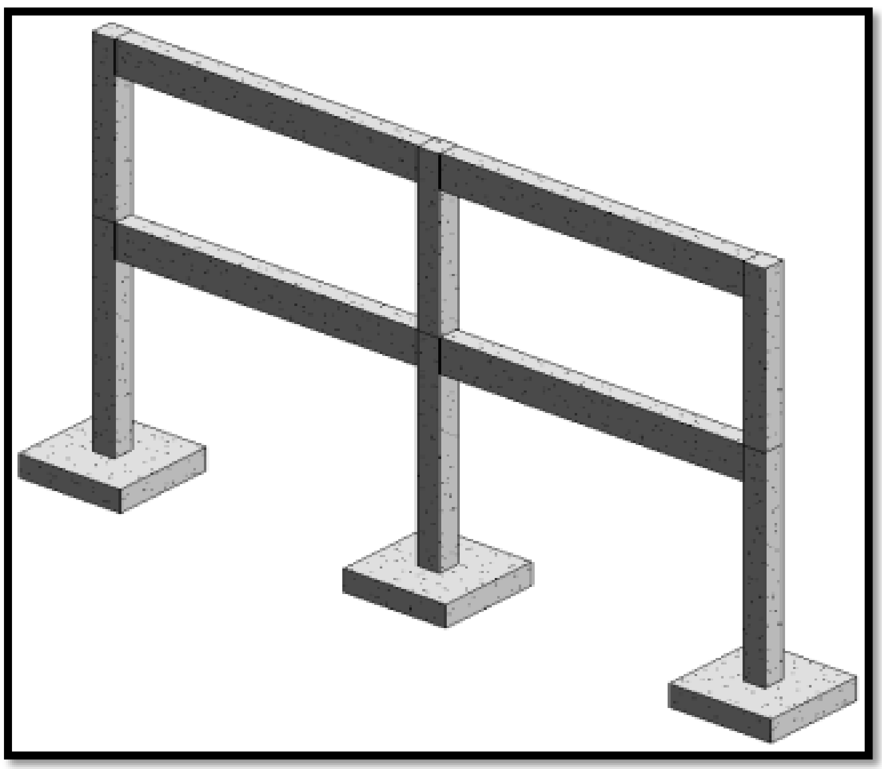


Figure (3-12): Frame Structure.

CHAPTER

4

DESIGN OF STRUCTURAL MEMBERS

4.1 Introduction:

Concrete is the only major building material that can be delivered to the job site in a plastic state. This unique quality makes concrete desirable as a building material because it can be molded to 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 is embedded in the concrete in the form of a mesh, or roughened or twisted bars. A bond forms between the steel and the concrete, are exist stresses can be transferred between both components.

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

So, in this project, there are many type of slabs such as “one way ribbed slab”,. They will be 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 be 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 is 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 is 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 prestressed beams or one way slabs (unless deflections are calculated) :-

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

= 5500 /18.5 = 30 cm.

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

= 5500/21 = 26 cm.

The controller slab thickness is 30 cm.

Select Slab thickness h= 32cm with block 24 cm & Topping 8cm.

4.4 Load Calculations & Design:

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	**22×0.03=0.66 KN/m**
3	Coarse Sand	17	**17×0.07=1.19 KN/m**
4	Topping	25	**25×0.08=2 KN/m**
			4.54 KN/m

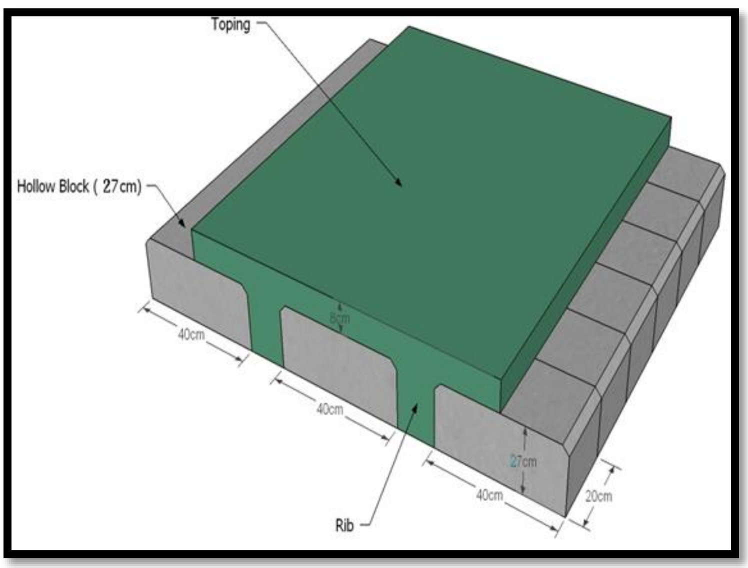


Figure (4-1): Toping of slab

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

From Jordanian code LL = 5 KN/m2 .

Q u = 1.2×D+1.6×L

= 1.2×4.54+1.6×5 = 13.448 KN/m.

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

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

$$Mu = \frac{13.448 * 0.4^2}{12} = 0.18 \text{ KN.m}$$

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

$\emptyset$*Mn (plane concrete)=1.207 KN.m > Mu max=0.18 KN.m.

No structural reinforcement is needed. Therefore, shrinkage and temperature reinforcement must be provided .For the shrinkage and temperature reinforcement :-

ρ min=0.0018

As= ρ*b*h=0.0018*1000*80=144 mm^2.

Number 0f $\emptyset$8 = As_{req}/A_{bar} = 144/50.3 = 2.87 → Spacing(S) = 1/2.87 = 35cm = 350 mm.

S ≤ 380 (280/f_s) – 2.5 × C_c ≤ 300 (280/fs)

= 380 × (280/(2/3 f_y)) – 2.5× 20 ≤ 300 × (280/(2/3 f_y))

= 380 × (280/(2/3* 420)) – 2.5 × 20 = 330 mm ≤ 300 × (280/(2/3* 420))

= S ≤ 300 mm.

≤ 3 × h = 3× 80 = 240 mm………..controlled.

≤ 450 mm.

4.4.2 Design of Ribs Rib 3- GF :

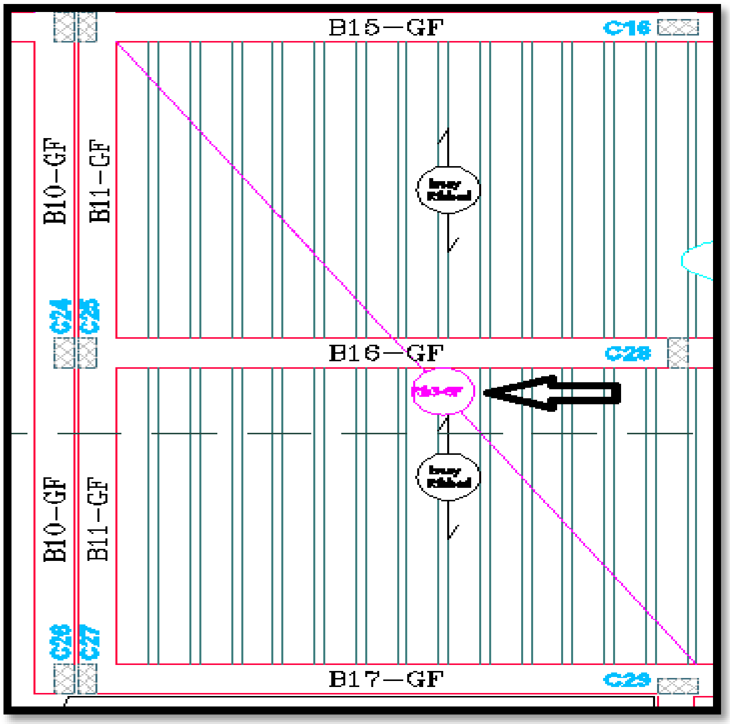


Figure (4-2): Rib location

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	0.03*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*0.52 = 1.04 KN/m
5	Rib	25	0.24*25*0.12 = 0.72 KN/m
6	Block	10	0.24*10*0.4 = 0.96 KN/m
7	Plaster	22	0.03*22*0.52 = 0.3432 KN/m
			4.4 KN/m

concrete B300 Fc' = 24 Mpa

Reinforcement Steel Fy = 420 Mpa

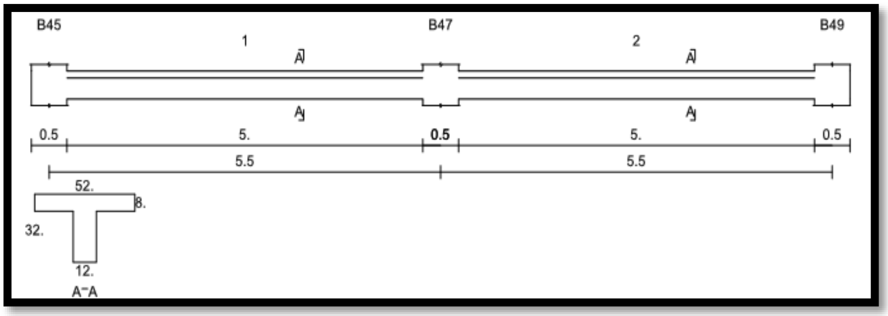


Figure (4-3): Rib geometry.

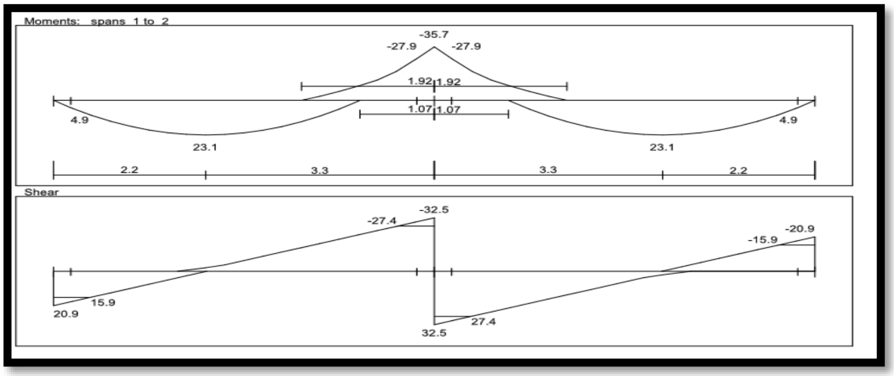


Figure (4-4) : Moment and Shear Envelop of rib.

Design Negative Moment of Rib 3- GF:

Maximum negative moment M_u= 27.9 KN.m

M_n = 27.9/ 0.9 = 31 kN.m

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

Kn = $\frac{31*10^6}{120*282^2}$ = 3.25 MPa.

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

$\rho = \frac{1}{20.6}(1 - \sqrt{1 - \frac{2(20.6)(3.25)}{420}}) = 0.0085$

As = 0.0085 (120) (282) = 287.64 mm^2

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

$$= \frac{\sqrt{24}}{4*420} * 120 * 282 \;\; \geq \;\; \frac{1.4}{420} * 120 * 282$$

$As_{min} = 98.68 < 112.8$ …………the larger is control

$As_{min} = 112.8 mm^2$

287.64 mm^2 > $As_{min} = 112.8 mm^2$

# of bars = As/ As_{bar} = 287.64/153.86 =2bars * Note $A_{\Phi 14}$ = 153.86 mm^2

As provided=307.72 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

307.72 × 420 = 0.85 × 24 × 120 × a

a=52.8mm.

$c = \frac{a}{\beta_1} = \frac{52.8}{0.85} = 62.117$ mm * Note: $f_c' = 24$ MPa< 28 MPa→ $\beta_1 = 0.85$

d = 320 – 10 – 20 – 16/2 = 282 mm.

$$\varepsilon_s = \frac{282-62.117}{62.117} * 0.003$$

= 0.0106 > 0.005

∴Ø = 0.9 .... OK.

ØMn =0.9*307.72*420*(282 – 52.8 /2)*10^{-6} = 29.73 KN.m >Mu max = 27.3 KN.m.

Design of Positive Moment of Rib 3- GF:

for main positive reinforcement Φ 12 Assume bar diameter , stirrups Φ 10 d = depth - cover – diameter of stirrups – (diameter of bar/ 2)

= 320 – 20– 10 –12/2= 284 mm.

∴ Assume rectangular & tension control section.

Maximum positive moment is M_u= 23.1 kN.m.

Mn = 23.1 / 0.9 = 25.7 kN.m

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

Kn = $\frac{25.7*10^6}{520*284^2}$ = 0.613 MPa

ρ = $\frac{1}{20.6}$ (1 - $\sqrt{1-\frac{2(0.613)(20.6)}{420}}$) = 0.0015

As = 0.0015 (520) (284) = 221.52 mm^2

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

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

$$As_{\min} = 99.38 < 113.6$$

$$As_{\min} = 113.6 mm^2$$

221.52mm^2> $As_{\min} = 113.6 mm^2$

# of bars = As/ As $_{bar}$ = 221.52/153.86 = 2 bars * Note $A_{\Phi 14}$ = 153.86 mm²

As providing =307.72 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

$307.72 \times 420 = 0.85 \times 24 \times 120 \times a$

a=52.8

$$c = \frac{a}{\beta_1} = \frac{52.8}{0.85} = 62.12mm$$

$$\varepsilon_s = \frac{284 - 62.12}{62.12} X0.003$$

$$\varepsilon_s = 0.0107 > 0.005 OK$$

4.4.3 Design for shear

V_u=27.4

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

$$= 0.75 * \frac{\sqrt{24}}{6}\ 0.12 * 0.282*1000$$

= 20.7 KN

1.1 * Φ Vc = 1.1*20.7 = 22.8 KN.

Check for items:-

1/ Vu ≤ Φ Vc/2

27.4 ≤ 10.35 (X)

2/ Φ Vc/2 ≤ Vu ≤ Φ Vc

10.35 ≤ 27.4 ≤ 20.7 (X)

3/ Φ Vc ≤ Vu ≤ Φ Vc + Φ Vsmin

20.7 ≤ 27.4 ≤ 31.5 (OK)

So Case (3) satisfy

Vs = (Vu-(Φ Vc))/ Φ = 16.8 KN.

Take Av = 2 Φ 8 = 2 * 50.24=157 mm^2.

Av/ s = Vs/fy * d

157/ s = 16.8 /(420*282) → s = 708.525 mm

S ≤ d/2 =141 mm

≤ 600 m.

Use Φ 8 @ 14 cm c/c.

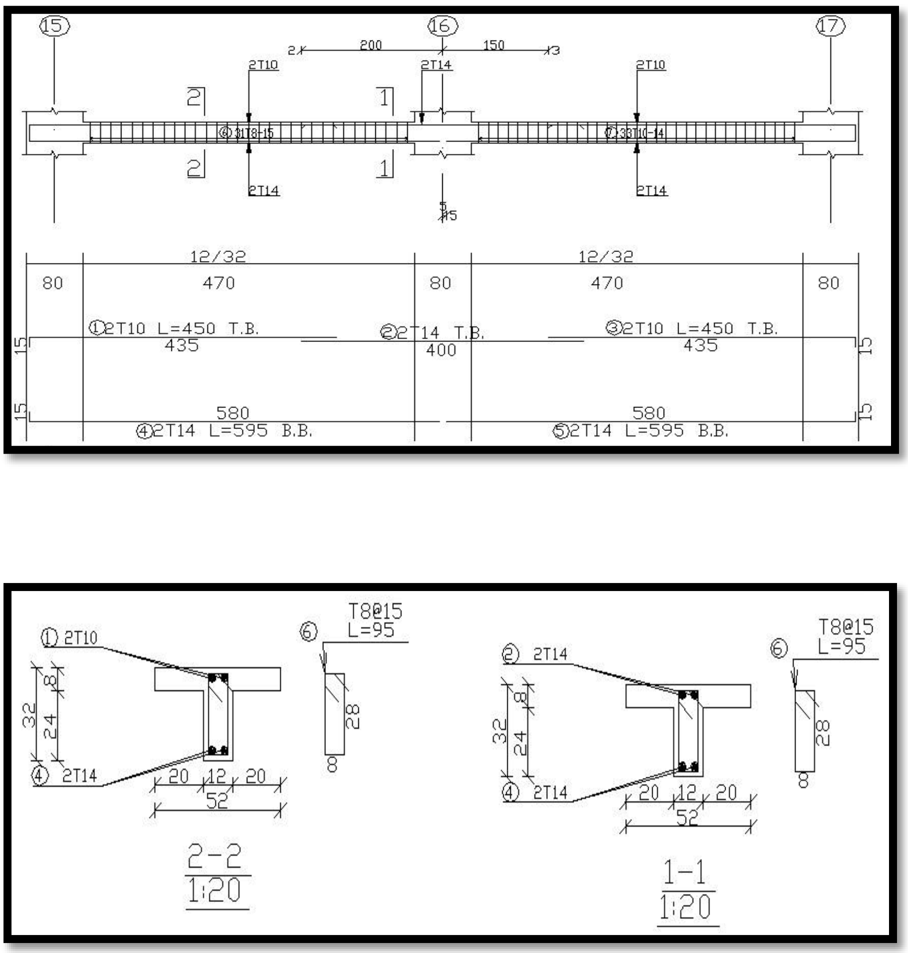


Figure (4-5) :The shape of distribution of bars on rib 3-GF.

4.5 Design Of Beam 23 – GF:-

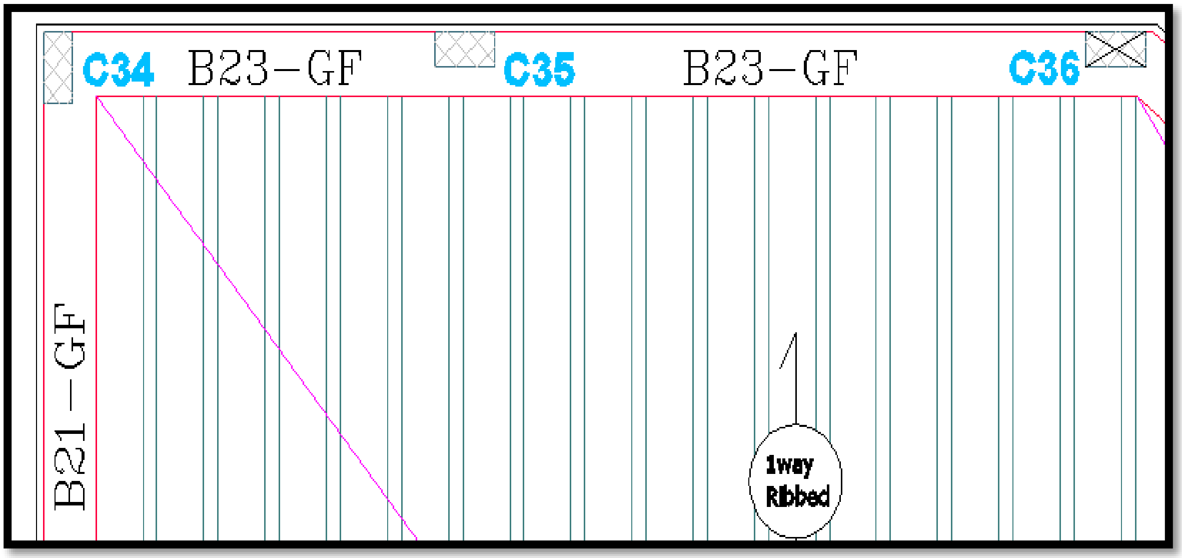


Figure (4-6) : Beam location.

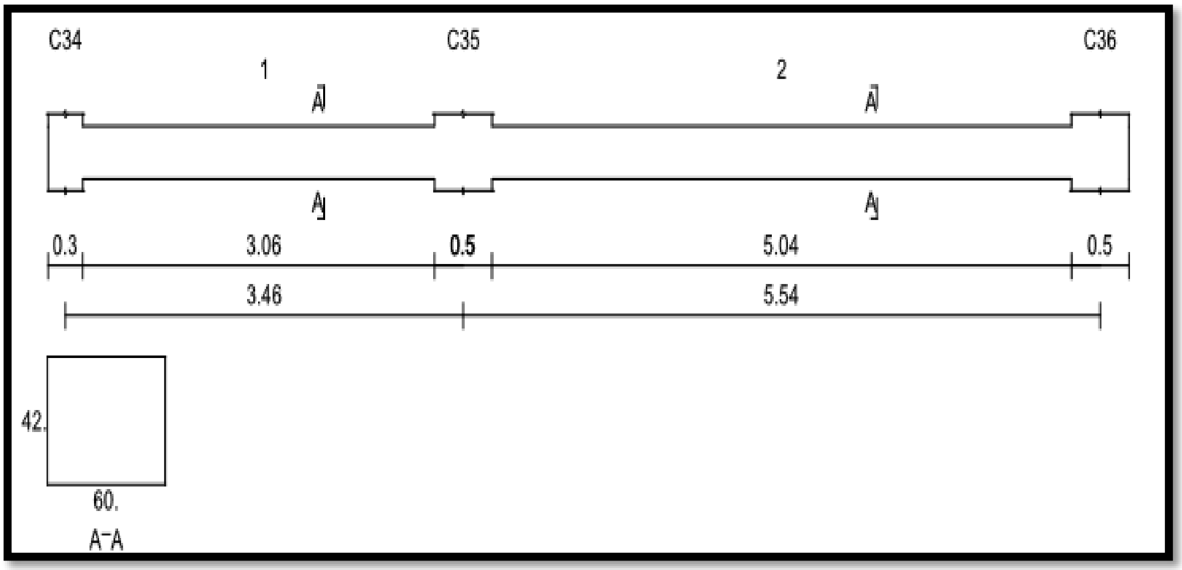


Figure (4-7) : Beam geometry.

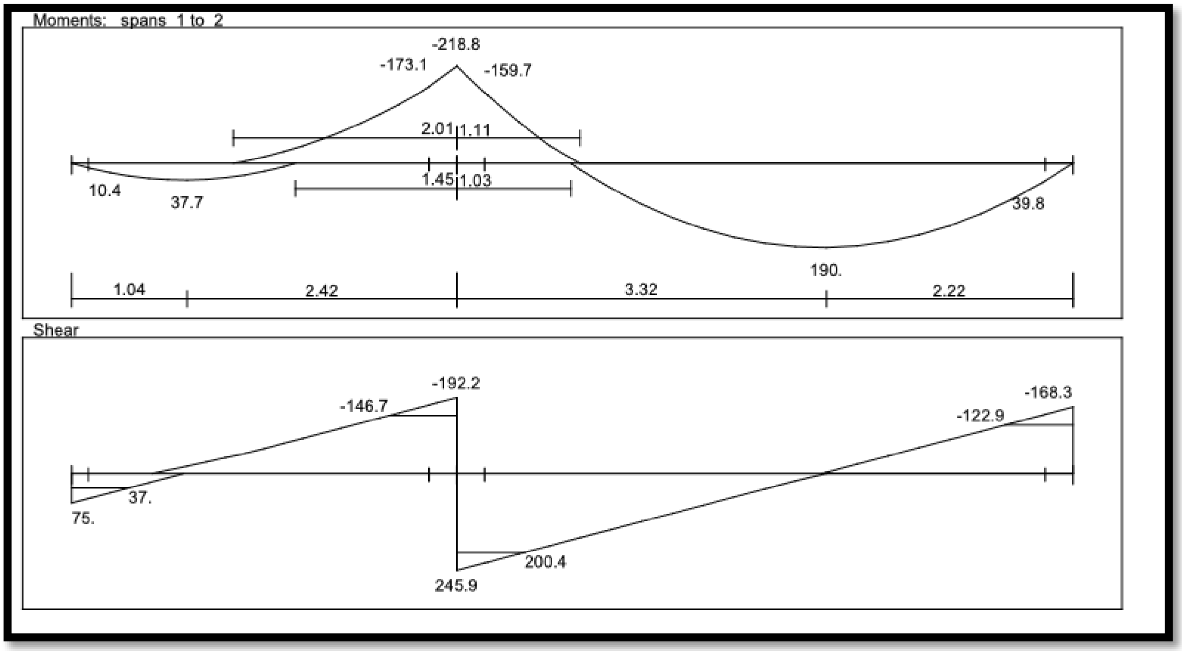


Figure (4-8) : Moment and shear envelop of beam.

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*0.4 = 0.276 KN/m**
2	Mortar	22	**0.03*22*0.4 = 0.264 KN/m**
3	Sand	17	**0.07*17*0.4 = 0.476 KN/m**
4	Beam	25	**0.4*25*0.32 = 3.2 KN/m**
5	Plaster	22	**0.02*22*0.4 = 0.176 KN/m**
6	Reac.Rib 8	----	**17.216**
7	D.L from Ex.P	----	**23*0.05*3.66+25*0.25*3.66=27.09KN/m**
			48.7KN/m

L.L= 5 + L.L from Rin 8 = 5+ 8.56 = 13.56 KN/m.

4.5.1 Design of Positive Moment

4.5.1.1 Design of Span I :-

for main positive reinforcement Φ16 Assume bar diameter , stirrups Φ10

$b_w = 60cm, h = 42cm$

$d = 420 - 40 - 10 - (16/2) = 362mm$

Design of positive moment $Mu^{(+)}_1$ = 37.7 KN.m:

∴ Assume rectangular & tension control section.

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

Kn = $\frac{41.9 * 10^6}{600 * 362^2}$ = 0.533 MPa

ρ = $\frac{1}{20.6}$ (1 - $\sqrt{1 - \frac{2(0.533)(20.6)}{420}}$) = 0.0013

As_{req} = ρ × b ×d = 0.0013 × 600 × 362 = 282.36 mm2.

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

$$As_{min} \geq \frac{\sqrt{24}}{4(420)}(600)(362) \geq \frac{1.4}{420}(600)(362)$$

=633.4 mm^2 < 724 mm^2 ………… Larger value is control.

As_{min} = 724mm^2 > As_{req} = 282.36mm^2.

∴ As = 724 mm^2.

4 Ø16 = 803.84mm^2>As_{req} = 724 mm^2 … OK.

∴ Use 4 Ø16

S = $\frac{420 - 2*40 - 2*10 - 4*16}{3}$

∴ S=85.33 mm.

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

As × fy = 0.85 × fc' × b × a

803.84 × 420 = 0.85 × 24 × 600 × a

a = 27.6mm<420 mm

∴ rectangular section .

$$x = \frac{a}{\beta_1} = \frac{27.6}{0.85} = 32.5mm$$

$$\varepsilon_s = \frac{362 - 32.5}{32.5} \times 0.003$$

=0.0304 > 0.005 (tension control section).

∴∅ = 0.9 …. OK.

4.5.1.2 Design of Span III :-

for main positive reinforcement Φ18 Assume bar diameter , stirrups Φ10

$$b_w = 60cm, h = 42cm$$
$$d = 420 - 40 - 10 - (18/2) = 361mm$$

Design of positive moment $Mu^{(+)}_2$ = 190 KN.m:

∴ Assume rectangular & tension control section.

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

$$Kn = \frac{211.11 * 10^6}{600 * 361^2} = 2.7 \text{ MPa}$$

$$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2(2.7)(20.6)}{420}}\right) = 0.0069$$

As_{req} = ρ × b ×d = 0.0069 ×600 × 361 = 1494.5 mm2.

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

$$As_{\min} \geq \frac{\sqrt{24}}{4(420)}(600)(361) \geq \frac{1.4}{420}(600)(361)$$

=631.62 mm^2 < 722 mm^2 …………. Larger value is control.

As_{min} = 722mm^2 < As_{req} = 1494.5 mm^2.

∴ As = 1494.5 mm^2.

6Ø18 = 1526.04mm^2>As_{req} = 1494.5 mm^2 … OK.

∴ Use 6 Ø18

$$S = \frac{420-2*40-2*10-6*18}{5}$$

∴ S= 42.4 mm.

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

As × fy = 0.85 × fc' × b × a

1526.04 × 420 = 0.85 × 24 × 600 × a

a = 52.4 mm<420 mm

∴ rectangular section .

$$x = \frac{a}{\beta_1} = \frac{52.4}{0.85} = 61.6mm$$

$$\varepsilon_s = \frac{361-61.6}{61.6} \times 0.003$$

=0.0145 > 0.005 (tension control section).

∴Ø = 0.9 …. OK.

4.5.2 Design of Negative Moment

$b_w = 60cm, h = 42cm$
$d = 42-40-10-(14/2) = 363mm$

$Mu^{(-)}$ = 173.1 KN.m

Mn = 49.1 / 0.9 =54.6 KN.m

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

Rn = $\frac{192.34*10^6}{600*(363)^2}$ = 2.433 MPa

ρ = $\frac{1}{20.6}$ (1 - $\sqrt{1-\frac{2(2.433)(20.6)}{420}}$) = 0.0062

As = 0.0062 (600) (363) =1350.4 mm^2.

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

$$As_{\min} = \frac{\sqrt{24}}{4(420)}(600)(363) \geq \frac{1.4}{420}(600)(363)$$

$$As_{\min} = 635.12 < 726$$

$$As_{\min} = 726 mm^2$$

1350.4 mm^2> $As_{\min} = 726 mm^2$

#of bars = As/ As $_{bar}$ = 1350.4/200.96 = 7 bars * Note $A_{\Phi 16}$ = 200.96 mm²

As providing =1406.72 mm^2

Select 7 Φ 16 mm .

S = 34.67 mm.

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

Tension = Compression

As * fy = 0.85 * b * a

$1406.72 * 420 = 0.85 * 600 * 24 * a$

$a = 48.3.mm$

$c = \frac{a}{\beta_1} = \frac{48.3}{0.85} = 56.83mm$

$\varepsilon_s = \frac{362 - 56.83}{56.83} \text{X} 0.003$

$\varepsilon_s = 0.0162 > 0.005$

∴∅ = 0.9 …. OK.

4.5.3 Design of shear

Vu = 200.4KN

Vc = $\frac{\sqrt{fc'}}{6}$ bw * d = $\frac{\sqrt{24}}{6}$ *600 *361*10^{-3} = 176.86 KN

0.5 * Φ Vc= 0.5*0.75 * 176.86 = 66.33 KN

Vs = $\frac{Vu}{\emptyset} - vc$ = = $\frac{200.4}{0.75} - 176.86 = 90.34\ KN$

1. Item 1:

0.5 * Φ Vc ≤ Vu ≤ Φ Vc (not control)

2. Item 2 :

Vs min ≥ $\frac{1}{3}$ bw $*$ d $= \frac{1}{3}$ 600 $*$ 361 = 72.2KN $CONTROL$

Vs min ≥ $\frac{1}{16}$ $\sqrt{fc'}$ bw $*$ d $= \frac{1}{16}$ $\sqrt{24}$ $* 600 * 361 = 66.32$ KN

Φ Vc ≤ Vu ≤ Φ Vc + Φ* Vs min

132.645 ≤ 200.4 ≤ 204.845 (control).

use 4 leg Φ 10 for stirrups …… Av = 314.16 mm^2

S= $\frac{Av*fy*d}{vs} = \frac{314.16*420*287.5}{126.23*1000}$ = 300 mm

Select s = 15cm ≤ $\frac{d}{2} = \frac{361}{2} = 180.5\ mm$

≤ 300 mm ok .

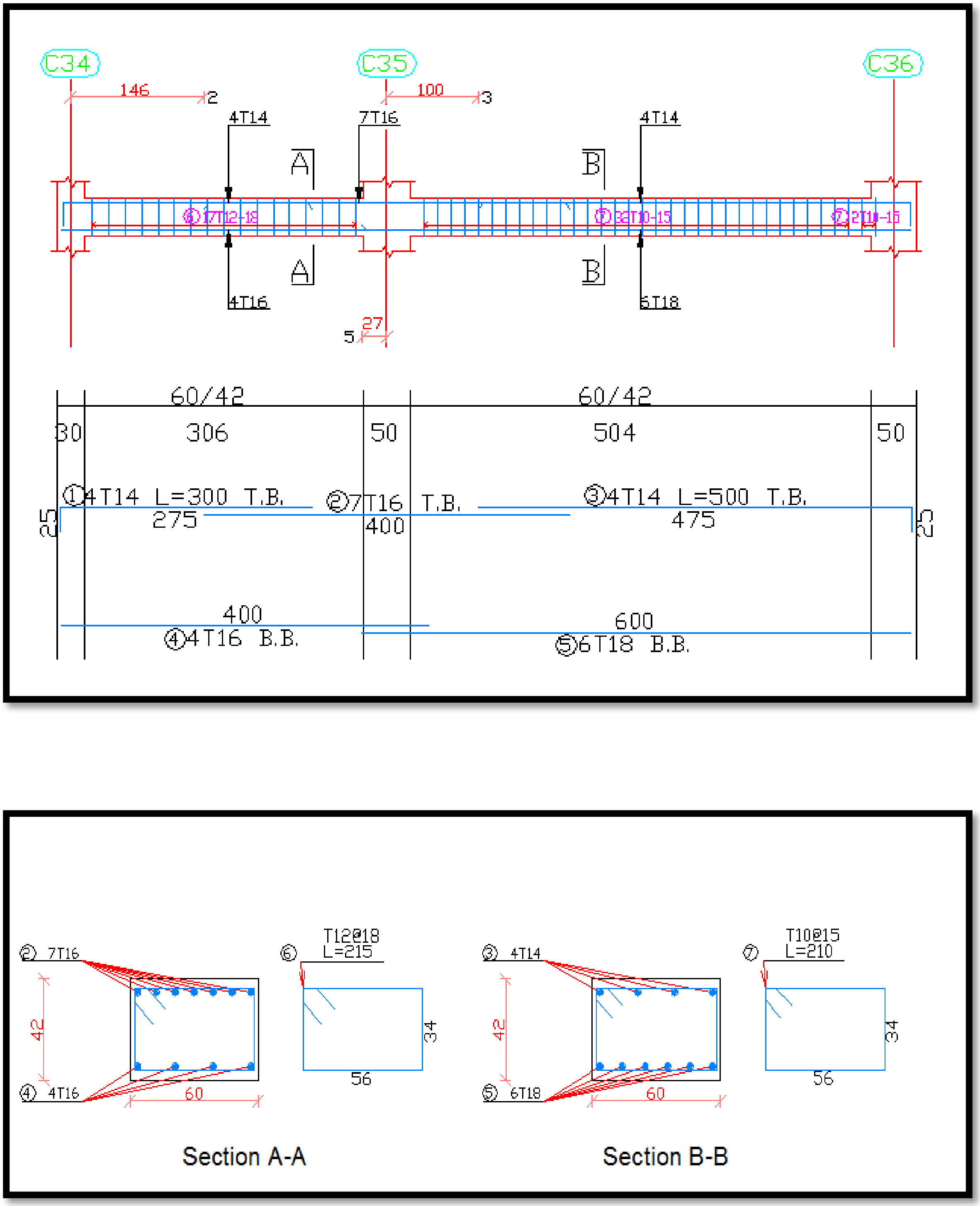


Figure (4-9) :The shape of distribution of bars on beam 23 GF.

4.6 Design of Stair:-

4.6.1 Limitation of deflection :-

hmin= 3.53 / 20 = 17.6 cm

select h = 20 cm

tan ϕ = 17 /30

ϕ = 29.5

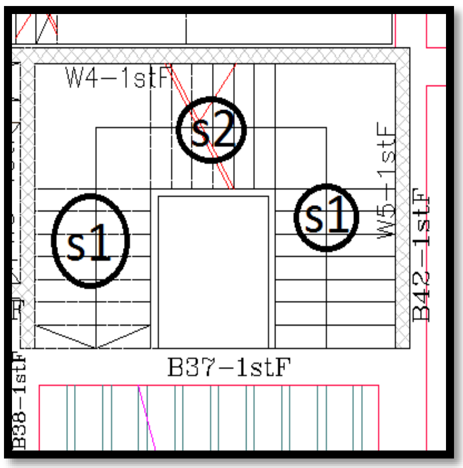


Figure (4-10) :The shape of Stairs.

4.6.2 Calculation of load :-

(Note : calculation for 1 meter strip)

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

No.	Parts of Beam	Density	Calculation
1	Tiles	27	**27*((0.17+0.35)/0.3)*0.03*1=1.404 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**
			10.8 KN/m

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

No.	Parts of Beam	Density	Calculation
1	Tiles	27	**22*0.03*1=0.66 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**
			6.86 KN/m

L.L= 5 KN/m^2.

Total factored load :

For flight w = 1.2D +1.6L = 1.2*10.8+1.6*5= 20.96 KN/m.

For landing w = 1.2*6.86+1.6*5=16.232 KN/m.

4.6.3 Design of slab (1) :-

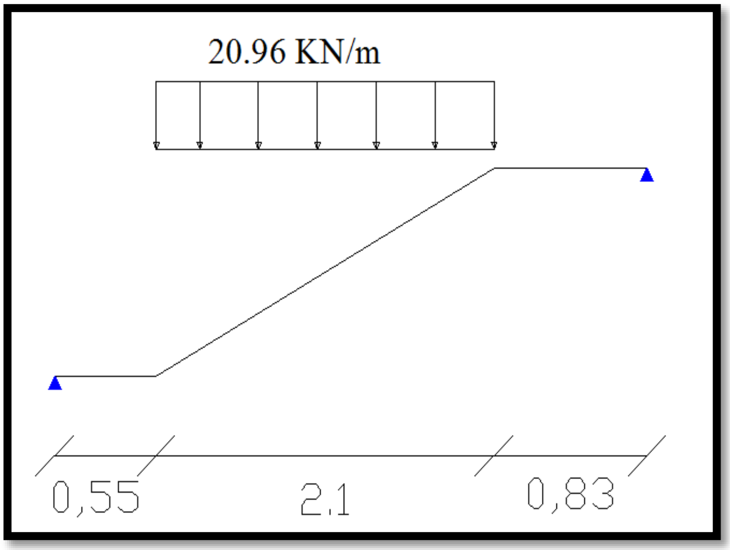


Figure (4-11) :System of stair slab 1.

4.6.3.1 Design of shear forces :-

The reaction at each end :-

R= W*L/2 = (20.96*2.1)/2 = 22.008 KN.

Assume bar diameter 12 mm.

Max Vu = 22.1 KN/m.

- d=200 -20 - 6 = 174 mm

Φ* Vc = 0.75* $\frac{\sqrt{fc'}}{6}$ bw * d = 0.75 *$\frac{\sqrt{24}}{6}$ * 174 * 1000 = 106.5 KN >> Vu.

h is correct.

4.6.3.2 Design of bending moment :-

Max Mu = (22.1*1.9) –(20.96 *1.05^2*0.5) = 30.44 KN.m

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

Kn = $\frac{30.44*10^6/0.9}{1000*(174)^2}$ = 1.12 MPa

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

ρ = $\frac{1}{20.6}$ (1 - $\sqrt{1-\frac{2(20.6)(1.12)}{420}}$) = 0.00275

As req = ρ * b * d = 0.00275* 100 *17.4 = 4.8 cm²/m.

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

As req > As min

Select Φ12@ 20 cm $A_{s(prov)}$ = 5.652 cm^2/m.

4.6.3.3 Check of strain :-

Tension = compression

As * fy = 0.85 * f_c * b * a

565.2*420=0.85*24*1000*a

a=11.64 mm.

$$x = \frac{a}{\beta_1} = \frac{11.64}{0.85} = 13.7mm$$

$$\varepsilon_s = \frac{174 - 13.7}{13.7} \times 0.003$$

$$\varepsilon_s = 0.0351 > 0.005$$

∴∅ = 0.9 …. OK.

4.6.4 Design of slab (2) :-

$W_R = R_{s1}/B$ = 22.1/1.65 = 13.4 KN/m.

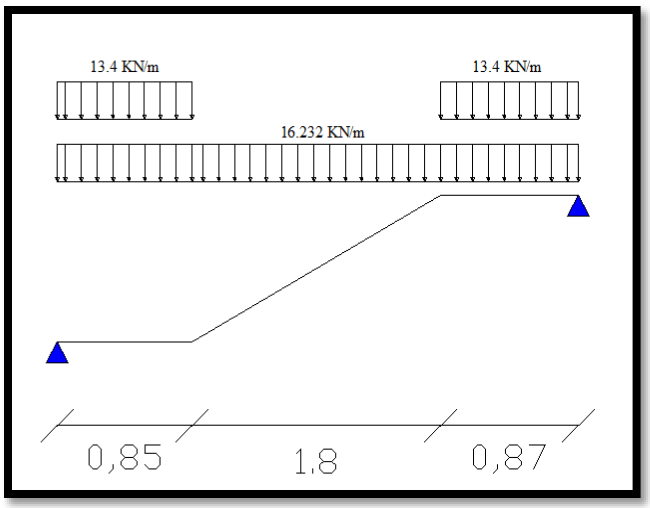


Figure (4-12) :System of stair slab 2.

4.6.4.1 Design of shear forces :-

R= ((16.232*3.52)/2) + (13.4*0.87) = 40.23 KN.

d=200 -20 - 6 = 174 mm

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

h is correct.

4.6.4.2 Design of bending moment :-

Max Mu = (40.23*1.77) – (16.232*1.77^2*0.5) – 13.4*0.87*((0.87/2)+0.9) = 30.22 KN.m

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

Kn = $\frac{30.22*10^6/0.9}{1000*(174)^2}$ = 1.11 MPa

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

ρ = $\frac{1}{20.6}$ (1 - $\sqrt{1-\frac{2(20.6)(1.11)}{420}}$) = 0.00270

As req = ρ * b * d = 0.0027* 100 *17.4 = 4.7 cm²/m.

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

As req > As min

Select Φ12@ 20 cm $A_{s(prov)}$ = 5.652 cm^2/m.

4.6.4.3 Check of strain :-

Tension = compression

As * fy = 0.85 * f_c * b * a

565.2*420=0.85*24*1000*a

a=11.64 mm.

$$x = \frac{a}{\beta_1} = \frac{11.64}{0.85} = 13.7 mm$$

$$\varepsilon_s = \frac{174 – 13.7}{13.7} \times 0.003$$

$$\varepsilon_s = 0.0351 > 0.005$$

∴∅ = 0.9 …. OK.

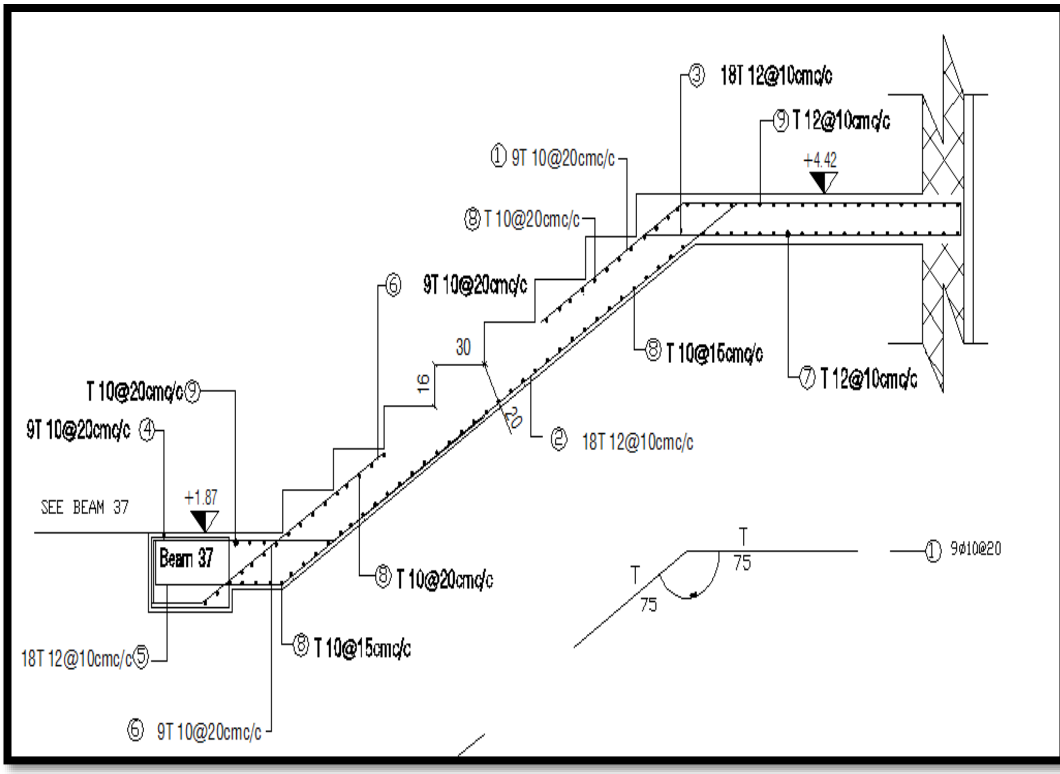


Figure (4-13) :Detailing of stair slab 1.

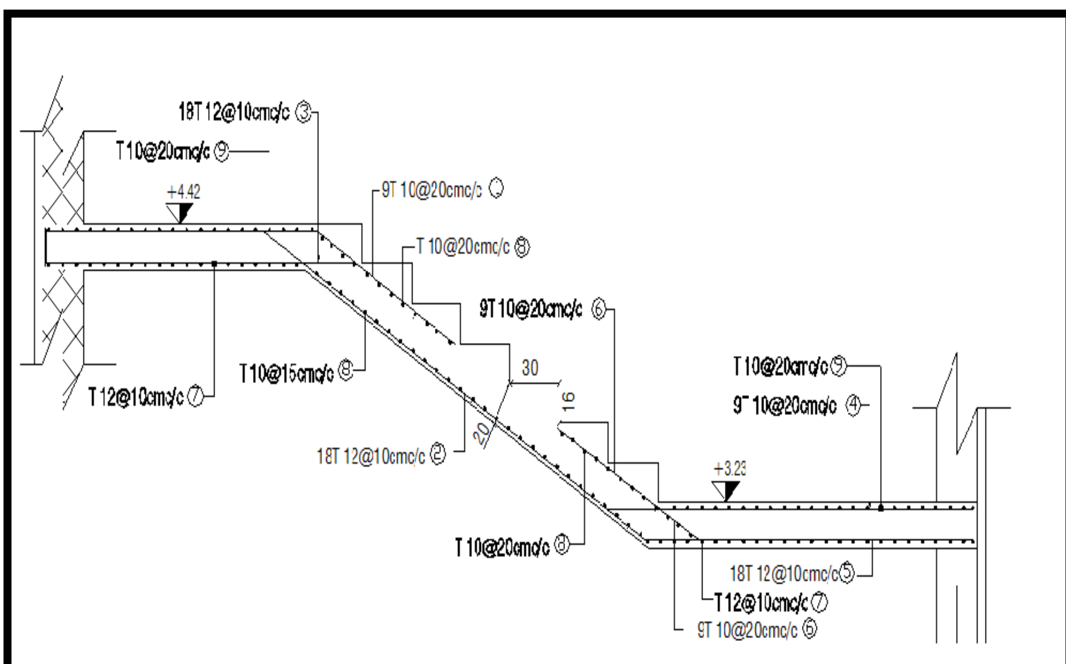


Figure (4-14) :Detailing of stair slab 2.

4.7 Design of column :-

4.7.1 Dimension of column :-

Pu = 2000 KN

Pn = 2000/(0.65) = 3077 KN

Assume $\rho g = 1\ \%$

$$Pn = 0.8 * Ag\{0.85 * fc' + \rho g(fy - 0.85 fc')\}$$
$$3077 = 0.8 * Ag[0.85 * 24 + 0.01 * (420 - 0.85 * 24)]$$
$$Ag = 1577 cm^2$$

Assume square column

Use 40*40cm with Ag = 1600cm² > Agreq = 1577 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 = 3.66 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.

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \quad ....ACI - (10.12.2)$$
$$\frac{1*3.66}{0.3*0.4} = 30.5 > 22$$
$$\therefore long\ Coloumn$$

Slenderness is consider

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

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

$$\beta_d = \frac{1.2DL}{Pu} = \frac{1400}{2000} = 0.70$$

$$I_g = \frac{b*h^3}{12} = \frac{0.4*0.4^3}{12} = 0.00214m^4$$

$$EI = \frac{0.4*23270.15*10^6*0.00214}{1+0.70} = 117.2MN.m^2$$

$$P_{cr} = \frac{\pi^2 EI}{(KLu)^2} \quad ....ACI\,318-2002(Eq.\ 10-13)$$

$$P_c = \frac{3.14^2*11.72}{(1.0*3.66)^2} = 8.64MN.$$

$$Cm = 0.6+0.4\left(\frac{M1}{M2}\right) \quad ....ACI\,318-2002(Eq.10-16)$$

$$Cm = 1 \ ....According\ to\ ACI\,318-2002(10.10.6.4)$$

$$\delta_{ns} = \frac{Cm}{1-(Pu/0.75P_{c)}} \geq 1.0 \quad ....ACI\,318-2002(Eq.\ 10-12)$$

$$\delta_{ns} = \frac{1}{1-(2000/0.75*8.64*10^3)} = 1.44 > 1$$

$$e_{\min} = 15+0.03*h = 15+0.03*400 = 27mm = 0.027m$$

$$e = e_{\min}\times\delta_{ns} = 0.027*1.44 = 0.039$$

$$\frac{e}{h} = \frac{0.039}{0.4} = 0.098$$

From Interaction Diagram

$$\frac{\phi P_n}{A_g} = \frac{3077}{0.4*0.6}*\frac{145}{1000} = 1859.02Psi$$

$$\rho_g = 0.01$$

A_s= ρ * Ag = 0.01*400*400 = 1600mm^2

Use 8 Φ 16 wit h As = 1608mm² >Asreq = 1600mm².

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 @25.

4.8 Design of Basement wall :-

4.8.1 Loads on basement wall :-

q1 = Earth pressure soil

q1= γ * h * k0

K0 = 1 – sin 30 = 0.5

q1= 18 * 2.985* 0.5 = 26.865 KN/m^2

factored load (qu) =1.6 * q1 = 1.6 * 26.865 = 42.984 KN/m^2

h wall = 30 cm.

4.8.2 Design of shear force :-

From atir Vu = 45.2 KN

d=300 -20 – 14/2 = 274 mm.

$\Phi * V_c = 0.75 * \frac{\sqrt{fc'}}{6} bw * d = 0.75 * \frac{\sqrt{24}}{6} * 274 * 1000 = 167.8 \text{ KN} > V_u$

(h =30 is correct) .

4.8.2 Design of the reinforcement concrete :-

4.8.2.1 Design of the Vertical reinforcement in tension side :-

Max Mu from Atir = 28.2 KN.m.

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

Kn = $\frac{28.2*10^6/0.9}{1000*(274)^2}$ = 0.42 MPa

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

ρ = $\frac{1}{20.6}$ (1 - $\sqrt{1-\frac{2(20.6)(0.42)}{420}}$) = 0.00101

As req = ρ * b * d = 0.00101* 100 *27.4 = 2.7674 cm²/m.

As min = 0.0012 * b * h = 0.0012*100 * 30 = 3.6 cm²/m

As min > As req

select Φ10@ 20 cm $A_s\,provided = 3.95 cm^2/m$.

4.8.2.2 Design of the horizontal reinforcement in tension side :-

For One layer :

As min = 0.001 * b * h = 0.001*100 * 30 = 3 cm²/m

select Φ10@ 20 cm $A_s\,provided = 3.95 cm^2/m$.

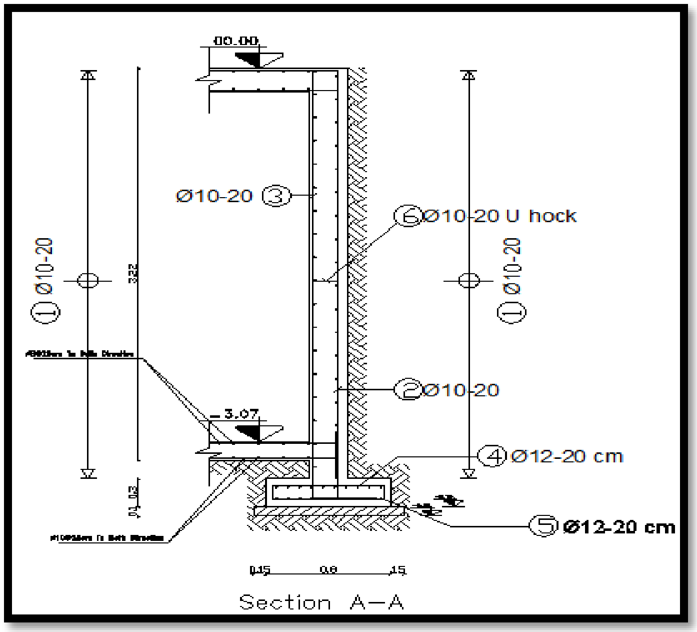


Figure (4-15) :Detailing of Basement Wall.

4.9 Design of Basement footing:-

Total factored load in basement = 1.2* 10.52*25*0.3 = 94.68 KN/m

Soil density = 18 KN/m3

Allowable soil Pressure = 350 KN/m2

Assume footing to be about (30 cm) thick.

Footing weight =1.2 *25 *0.4 =12 KN/m^2

Soil weight above the footing = 1.6 *3* 18 = 86.4 KN/m^2

qallow,net = 350 – 86.4- 12=251.6KN/m2

assume b = 0.8 m , h =0.3 m

d= 300 – 75 – 12 = 213 mm .

4.9.1 Design of One Way Shear:-

qult = 94.68 / (1* 0.8)= 118.35 KN/m^2

Vu = 1* (0.4-0.15-0.213) *118.35 = 4.38 KN

$\Phi * Vc = 0.75 * \frac{\sqrt{fc'}}{6}$ bw * d = $0.75 * \frac{\sqrt{24}}{6}$ * 213 * 1000 = 130.44 KN

Φ* Vc >> Vu….. (No Shear Reinforcement is Required.)

4.9.2 Design of Bending Moment:-

Mu = 118.35 * (0.25) ^{2} *0.5 = 3.7 KN.m

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

$Kn = \frac{3.7 * 10^6 / 0.9}{1000 * (213)^2}$ = 0.0906 MPa

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

$\rho = \frac{1}{20.6} (1 - \sqrt{1 - \frac{2(20.6)(0.0906)}{420}})$ = 0.0002162

As req = ρ * b * d = 0.0002162* 100 *21.3 = 0.4606cm²/m.

As min = 0.0018 * b * h = 0.0018*100 * 30 = 5.4 cm²/m

As min > As req

select Φ12@ 20 $A_s\,provided = 5.652 cm^2 / m$

<u>in lateral direction :</u> As min = 0.0018 * b * h = 0.0018*100 * 30 = 5.4 cm²/m

select Φ12@ 20 $A_s\,provided = 5.652 cm^2 / m$.

4.10 Design of Isolated Foundation (F2) :-

factored load = 1500 KN

Soil density = 18 KN/m3

Allowable soil Pressure = 350 KN/m2

assume h =0.45 m

Footing weight =(25*0.45) =11.25 KN/m^2

Allowable soil Pressure net = 350 – 11.25 = 338.75 KN/m^2

$\sigma \leq \sigma_{allow.\ net}$

$\leq$ 1.4 * σnet = 1.4 * 338.75 = 474.25 KN/m^2

- assume square footing

$474.25 = \frac{1500}{a^2}$

a= 1.8 with As = 3.24 m^2

$\frac{1500}{1.8^2}$ =462.96

462.96 $\leq$ 474.25 …. (ok)

4.10.1 Design against sliding :-

Hori. Force = 0.0 (not required to check)

4.10.2 Design of reinforcement concrete :-

❖ Check for one way shear :-

Cover = 75 mm , Φ =12 mm , thickness = 450 mm

d= 450 – 75 – 12 = 363 mm

Vu = 0.287 * 462.96 * 1.8 = 239.17 KN

$\Phi * V_c = 0.75 * \frac{\sqrt{f_c'}}{6}\ b_w * d = \mathbf{0.75} * \frac{\sqrt{24}}{6} * 1800 * 363 = 400.124 > V_u$

So h is correct.

❖ Check for two way shear action (punching) :-

d= 363 mm

Vu = 1500 –(462.96* 0.863^2) = 1155.2 KN

The punching shear strength is the smallest value of the following equations:

$$\phi.V_c = \phi.\frac{1}{6}\left(1+\frac{2}{\beta_c}\right)\sqrt{f_c'}\,b_o d$$

$$\phi.V_c = \phi.\frac{1}{12}\left(\frac{\alpha_s}{b_o/d}+2\right)\sqrt{f_c'}\,b_o d$$

$$\phi.V_c = \phi.\frac{1}{3}\sqrt{f_c'}\,b_o d$$

Where: $\beta_C = \frac{Column\ Length\ (a)}{Column\ Width\ (b)} = \frac{50}{30} = 1.67$

b_o = Perimeter of critical section taken at (d/2) from the loaded area

$$b_o = 2(d+a1)+2(d+a2) = (2*863)+(2*663) = 3052mm$$

α_s = 40 for interior column

$$\phi.V_C = \phi.\frac{1}{6}\left(1+\frac{2}{\beta_c}\right)\sqrt{f_c'}\,b_o d = \frac{0.75}{6}*\left(1+\frac{2}{1.67}\right)*\sqrt{24}*3052*363 = 1490.93KN$$

$$\phi.V_C = \phi.\frac{1}{12}\left(\frac{\alpha_s*d}{b_o}+2\right)\sqrt{f_c'}\,b_o d = \frac{0.75}{12}*\left(\frac{40*363}{3052}+2\right)*\sqrt{24}*3052*363 = 2292.27KN$$

$$\phi.V_C = \phi.\frac{1}{3}\sqrt{f_c'}\,b_o d = \frac{0.75}{3}*\sqrt{24}*3052*363 = 1356.9KN$$

$\phi.V_C = 1356.9KN$ .... *Control*

$Vu = 1155.2KN$

$\phi.Vc = 1356.9KN > Vu = 1155.2KN$........ *satisfied*

❖ Design of Bending Moment:-

$$Mu = 462.92*1.8*0.65^2/2 = 176.03kN.m$$

Mu = 176.03 KN.m

$$d = 450 - 75 - 12 = 363\,mm$$

$$Kn = \frac{Mn}{b*d^2} = \frac{(176.03/0.9)\times 10^6}{1800\times 363^2} = 0.83Mpa$$

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

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

$$\rho = \frac{1}{20.6}(1-\sqrt{1-\frac{2\times 20.6\times 0.83}{420}}) = 2.02\times 10^{-3}$$

$$As_{req} = 2.02\times 10^{-3}\times 1800\times 363 = 1319.87mm^2$$

$$As_{\min} = 0.0018*1800*450 = 1458mm^2$$

$$As_{req} = 1319.87mm^2 < As_{\min} = 1458mm^2$$

$$\#of\,bar = \frac{1458}{113.04} = 13bars$$

Select 13 Φ12 $A_{s,prov}$ = 1469.52 mm^2

❖ Check for strain :-

As * fy = 0.85 * f_c * b * a

1469.52*420=0.85*24*1800*a

a=16.81 mm.

$$x = \frac{a}{\beta_1} = \frac{16.81}{0.85} = 19.78mm$$

$$\varepsilon_s = \frac{363 - 19.78}{19.78} \times 0.003$$

$$\varepsilon_s = 0.052 > 0.005$$

∴Ø = 0.9 …. OK.

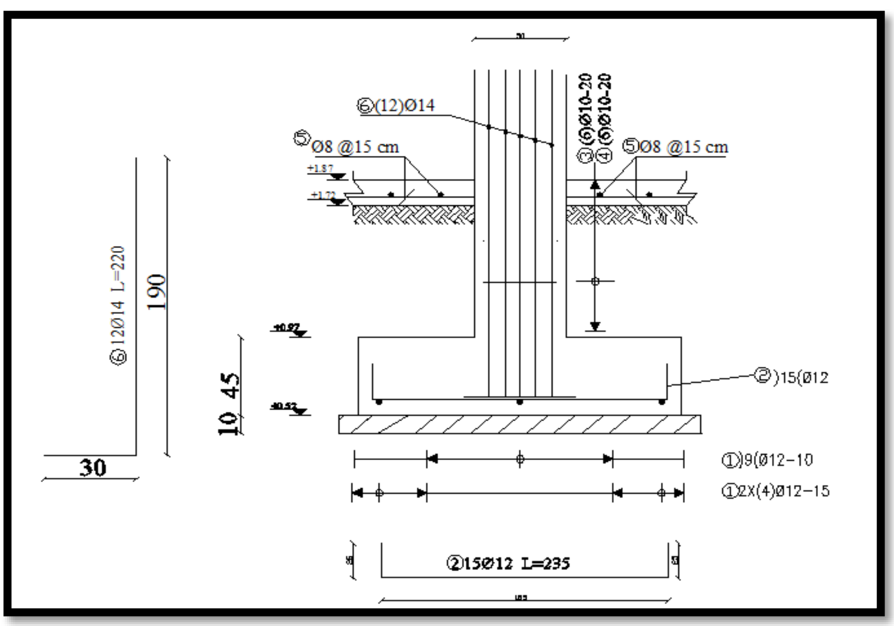


Figure (4-16) :Detailing of isolated foundation.

4.11 Design of two-way ribbed slab :-

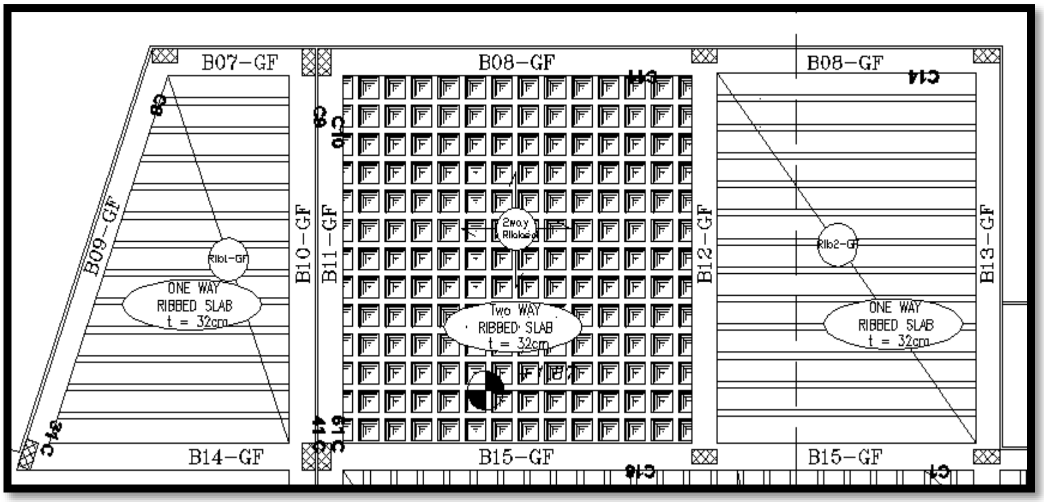


Figure (4-17) :Location of tow-wat ribbed slab.

4.11.1 Minimum thickness of slab :-

By using safe program (CSI programs) : H=32 cm with 8cm topping and 24cm block.

4.11.2 Load calculation :-

Table (4 – 6): Load calculation of 2-way ribbed slab.

No.	Parts of Beam	Density	Calculation
1	Tiles	22	**22*0.03*0.52*0.52=0.178 KN**
2	Mortar	22	**22*0.02*0.52*0.52=0.199 KN**
3	sand	16	**16*0.07*0.52*0.52=0.303 KN**
4	R.C Topping	25	**25*0.08*0.52*0.52=0.541 KN**
5	R.C Rib	25	**25*0.24*0.12*(0.52+0.4)=0.662 KN**
6	Concrete Block	9	**9*0.24*0.4*0.4=0.346 KN**
7	Plaster	22	**22*0.02*0.52*0.52=0.119 KN**
			2.348 KN

Dead Load of slab = 2.348/(0.52*0.52) = 8.7 KN/m^2.

W_D = 1.2*8.7 = 10.44 KN/m^2.

Live Load of slab = 5 KN/m^2.

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

W= 8 + 10.44 = 18.44 KN/m^2.

4.11.3 Moments calculations :-

$M_a = C_a*W_{La}^2$ and $M_b = C_b*W_{Lb}^2$

All negative and positive coefficients from tables.

L_a/L_b = 7.5/7.5 = 1.0

$C_{b,neg}$ = 0.05 , $C_{a,D}$ = 0.027 , $C_{b,D}$ = 0.027 , $C_{a,L}$ = 0.032 ,$C_{b,L}$ = 0.032

$M_{u,a}^+ = \{(C_{a,D} * W_D * L_a^2) + (C_{a,L} * W_L * L_a^2) \} * 0.52$

$= \{(0.027 * 10.44 * 7.5^2) + (0.032*8*7.5^2)\} *0.52$ = 15.733 KN.m/rib.

$M_{u,b}^+ = \{(C_{b,D} * W_D * L_b^2) + (C_{b,L} * W_L * L_b^2) \} * 0.52$

$= \{(0.027 * 10.44 * 7.5^2) + (0.032*8*7.5^2)\} *0.52$ = 15.733 KN.m/rib.

$M_{u,a}^- = (C_{a,neg} * W * L_a^2) *0.52 = 0.05 * 18.44* 7.5^2 *0.52$ = 26.97 KN.m/rib.

$M_{u.b}^- = M_{u,a}^-$.

4.11.4 Design of slab reinforcement :-

❖ **Design of negative moment = M_u^-= 29.97 KN.m.**

M_n = 29.97/0.9 = 33.3 KN.m

Assume bar diameter D=14 mm for main reinforcement.

$$d = 320 - 20 - 8 - 7 = 285\, mm$$

$$Kn = \frac{Mn}{b*d^2} = \frac{33.3\times10^6}{120\times285^2} = 3.42 Mpa$$

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

$$\rho = \frac{1}{20.6}(1-\sqrt{1-\frac{2\times20.6\times3.42}{420}}) = 8.98\times10^{-3}$$

$$As_{req} = 8.98 \times 10^{-3} \times 120 \times 285 = 307.116 mm^2$$

$$As_{\min} = \frac{\sqrt{24}}{4(420)}(120)(285) \geq \frac{1.4}{420}(120)(285)$$

$A_{s,min}$ = 114 mm^2 > $A_{s,req}$ = 307.116 mm^2.

Use 2 Ø 14 in both durection with A_s= 307.9 mm^2 > 307.116 mm^2.

❖ Check for strain :-

As * fy = 0.85 * f_c * b * a

307.9*420=0.85*24*120*a

a=52.83 mm.

$$x = \frac{a}{\beta_1} = \frac{52.83}{0.85} = 62.15 mm.$$

$$\varepsilon_s = \frac{285 - 62.15}{62.15} \times 0.003$$

$$\varepsilon_s = 0.0108 > 0.005$$

∴Ø = 0.9 …. OK.

❖ Design of positive moment = M_u^-= 15.733 KN.m.

M_n = 15.733/0.9 = 17.5 KN.m

Assume bar diameter D=10 mm for main reinforcement.

$$d = 320 - 20 - 8 - 5 = 287 mm$$

$$Kn = \frac{Mn}{b * d^2} = \frac{17.5 \times 10^6}{120 \times 287^2} = 1.77 Mpa$$

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

$$\rho = \frac{1}{20.6}(1 - \sqrt{1 - \frac{2 \times 20.6 \times 1.77}{420}}) = 4.42 \times 10^{-3}$$

$$As_{req} = 4.42 \times 10^{-3} \times 120 \times 287 = 152.055 mm^2$$

$$As_{min} = \frac{\sqrt{24}}{4(420)}(120)(285) \geq \frac{1.4}{420}(120)(285)$$

$A_{s,min}$ = 114 mm^2 > $A_{s,req}$ = 152.055 mm^2.

Use 2 Ø 10 in both direction with A_s= 157 mm^2 > 152.055 mm^2.

❖ Check for strain :-

As * fy = 0.85 * f_c * b * a

157*420=0.85*24*120*a

a=26.94 mm.

$$x = \frac{a}{\beta_1} = \frac{26.94}{0.85} = 31.7 mm.$$

$$\varepsilon_s = \frac{287 - 31.7}{31.7} \times 0.003$$

$$\varepsilon_s = 0.0241 > 0.005$$

∴Ø = 0.9 …. OK.

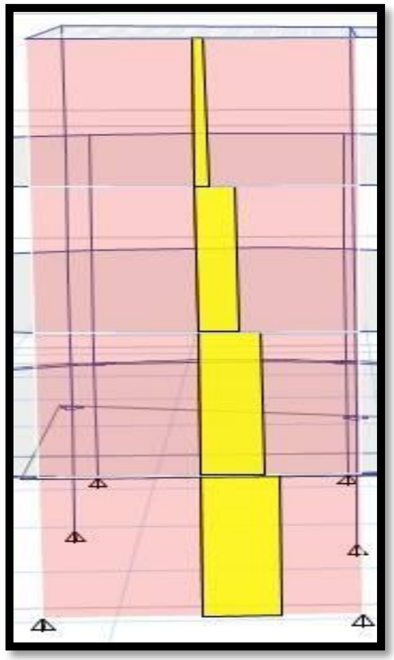
By using safe program for shear reinforcement is 2Ø 8 @ 12.5 cm c/c .

4.12 Design of the shear wall :-

h_w = 14.64 m , L_w = 5.6 m

d ≤ 0.8* L_w = 0.8 *5.6 = 4.48 m … control

d ≤ 0.8*h_w = 0.8 * 14.64 = 11.712 m



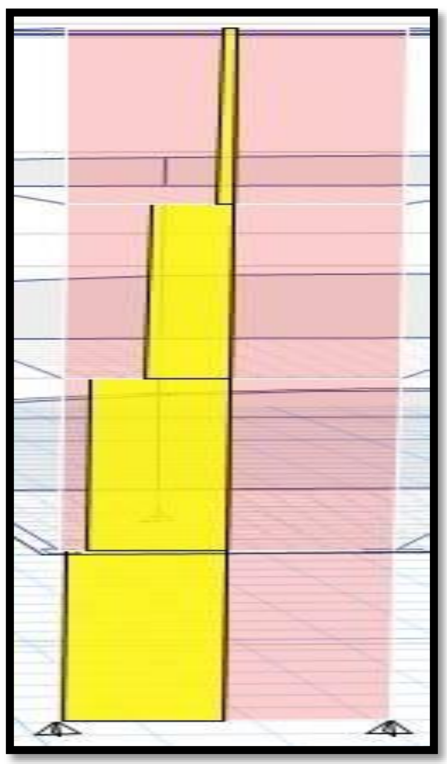


Figure (4-18) : Shear force and moment on the wall from ETABS .

$L_w / 2 = 2.8$ m …… control

$h_w / 2 = 7.32$ m

- **Design horizontal reinforcement** :

$$V_{C1} = \frac{\sqrt{fc'}}{6} \times b \times d$$

$$V_{c1} = \frac{\sqrt{24}}{6} \times 200 \times 4480 = 731.6KN\,(control)$$

$$V_{c2} = \frac{\sqrt{fc'} \times b \times d}{4} + \frac{N_u \times d}{4 \times L_w}$$

$$N_u = 0.0KN$$

$$V_{c2} = \frac{\sqrt{24} \times 200 \times 4480}{4} + 0.0 = 1097.4KN$$

$$Mu(1) = 1438.87 + 294 * (3.66 - 2.65) = 1735.81kN.m$$

$$V_{c3} = \left[\frac{\sqrt{fc'}}{2} + \frac{l_w \left(\sqrt{fc'} + \frac{2 \times N_u}{l_w \times h} \right)}{\left\langle \frac{M_u(1)}{V_u} - \frac{l_w}{2} \right\rangle} \right] \times \frac{h \times d}{10}$$

$$V_{c3} = \left[\frac{\sqrt{24}}{2} + \frac{2.65\left(\sqrt{24} + 0.0\right)}{\left\langle 294 - \frac{5.6}{2} \right\rangle} \right] \times \frac{200 \times 4480}{10} = 1770.03KN$$

So thickness of wall is safe.

- **Design for horizontal reinforcement :**

A_{vh} min. $= 0.0025 * s * h$

A_{vh} = 2 Φ 10 = 158 mm^2

$$\left(\frac{2 * 79}{s} \right) = 0.5$$

S = 316 mm

Smax ≤ L_w/5 =6900 /5 = 1380mm

≤ 450 mm

≤ 3 * h = 3*200= 600 mm

Take s = 300 mm < s max

Select Φ10/20 cm

- **Design for Vertical reinforcement:-**

$$Avv=\left\{0.0025+0.5\left(2.5-\frac{h_w}{l_w}\right)*\left(\frac{A_{vh}}{S_2*h}-0.0025\right)\right\}*s*h$$

Avh = 2 Φ 10 = 158 mm^2

$$Avv\ =\left\{0.0025+0.5\left(2.5-\frac{13}{6.9}\right)*\left(\frac{2*79}{300*200}-0.0025\right)\right\}*s*200$$

$$Avv=0.0025*s*h$$

$$\left(\frac{Avv}{s}\right)=0.53$$

Avv = 2 Φ 10 = 158 mm^2

S=298mm

Smax ≤ L_w/3 =6900 /3 = 2300 mm

≤ 450mm

≤ 3 * h = 3*200= 600 mm

Take s = 250 mm < s max

Select Φ10/20cm

❖ Design of bending moment:

$$C>\left(\frac{Lw}{0.007*600}\right)=\frac{6900}{4.2}=1642.36mm$$

$$length\ \ of\ \ boundary\ \ element=C-0.1\times L_w$$
$$length\ \ of\ \ boundary\ \ element=1642.36-0.1\times 6900=952.86mm$$

$$C_w=\frac{C}{2.0}=\frac{1642.86}{2.0}=821.43mm$$

$$SelectThe\,boundary element = 960mm$$

$$\text{Avs}=\frac{Lw}{s1}\times As_v \longrightarrow =\frac{2*79}{250}\times 6900 = 4360mm^2$$

$$\frac{Z}{Lw}=\frac{1}{2+0.85*\beta*fc*Lw*h/(As*Fy)}$$

$$\frac{Z}{Lw}=\frac{1}{2+0.85\times 0.85\times 24\times 6900\times 200/(4360.8\times 420)}=0.0664$$

$$Muv = 0.9\times Fy\times 0.5\times As\times Lw\times\left(1-\left(\frac{Z}{Lw}\right)\right)$$

$$Muv = 0.9*420*0.5*4360.8\times 6900*(1-(0.0664/2)) = 5498.2\,KN.m$$

$$Muv \quad > Mu$$

So Boundary is not required .

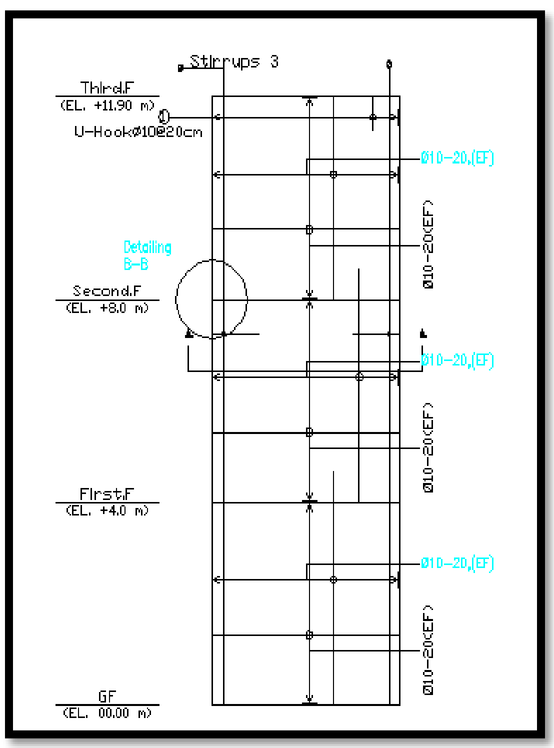


Figure (4-19) : Shear wall detailing .

REFERANCES

- كود البناء الأردني, كود الأحمال والقوى, مجلس البناء الوطني الأردني, عمان,الأردن, 2006م.
- Building code requirements for structural concrete (ACI-318-14), USA, 2014.
- Uniform Building Code (UBC).