Structural Design of "Management College at As-Samu University"

Done By:
Faisal Saleh, Shihab Wazwaz, Ahmad Al-Anani, Hamza Ayesh.

Supervisor:
Eng. Fahed Salahat

Submitted to the Architectural and Civil Engineering Department/ College of Engineering in Palestine Polytechnic University, as a part of the Bachelor Degree requirements for the Civil Engineering.

Palestine Polytechnic University, Hebron, Palestine.
Aug 2017

Content index

Chapter One

INTRODUCTION

Chapter Two

ARCHITECTURAL DESCRIPTION

Chapter 3

STRUCTURAL DESCRIPTION

Chapter Four

DESIGN OF STRUCTURAL MEMBERS

Chapter Five

RESULTS AND RECOMMENDATIONS

Index tables

Index of Figure

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

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 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, conference hall, lecture halls, computer halls and concerns literal that fulfilled all the requirements for comfort and safety according to usage requirements.

The theater is a hall and accommodates 208 people with an area of nearly 295 square meters.

The Cafeteria has an area of 313 m^2 and can accommodate 55 people.

The offices section has an area of 1900 m^2.

The administration section has an area of 375 m^2.

The educational section (class rooms) has an area of 5400 m^2.

The computer sections have an area of 1320 m^2.

The corridors, main lobby and other services have an area of 6200 $m^{2.}$

Instruction section: have an area 1780 $m^{2.}$

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 in this building it was necessary to achieve beauty, utility requirements, cost and durability, which are the basic architectural design requirements.

2. Structural Goals:

Structural design of the units will be done in this project with preparing 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. Architectural design (construction drawings, elevations, sections, public location).
2. Study of the units structurally to identify structural elements, loads on the buildings, and the selection of appropriate structural system.
3. Distributing of 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 research was done 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 Flow Chart:

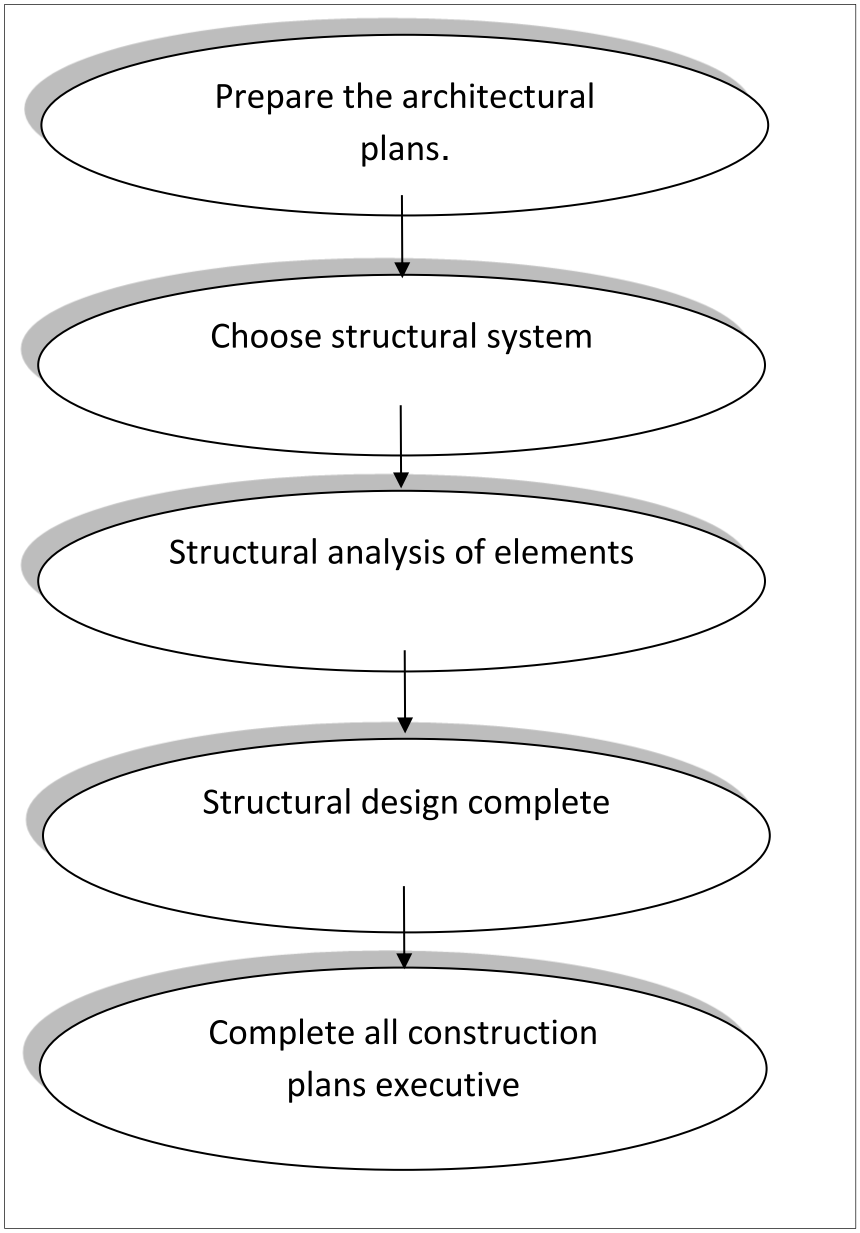


Figure (1-1): Shows the Stages of The Project.

CHAPTER

2

Architectural Description

2.1 INTRODUCTION.

2.2 PROJECT LOCATION.

2.3 THE MAIN ELEMENTS IN THE MANEGEMENT COLLEGE.

- **2.3.1 INTERIOR SPACES.**
- **2.3.2 EXTERIOR SPACES**

2.4 PROJECT PLANS.

2.5 PROJECT ELEVATIONS.

2.6 PROJECT SECTIONS.

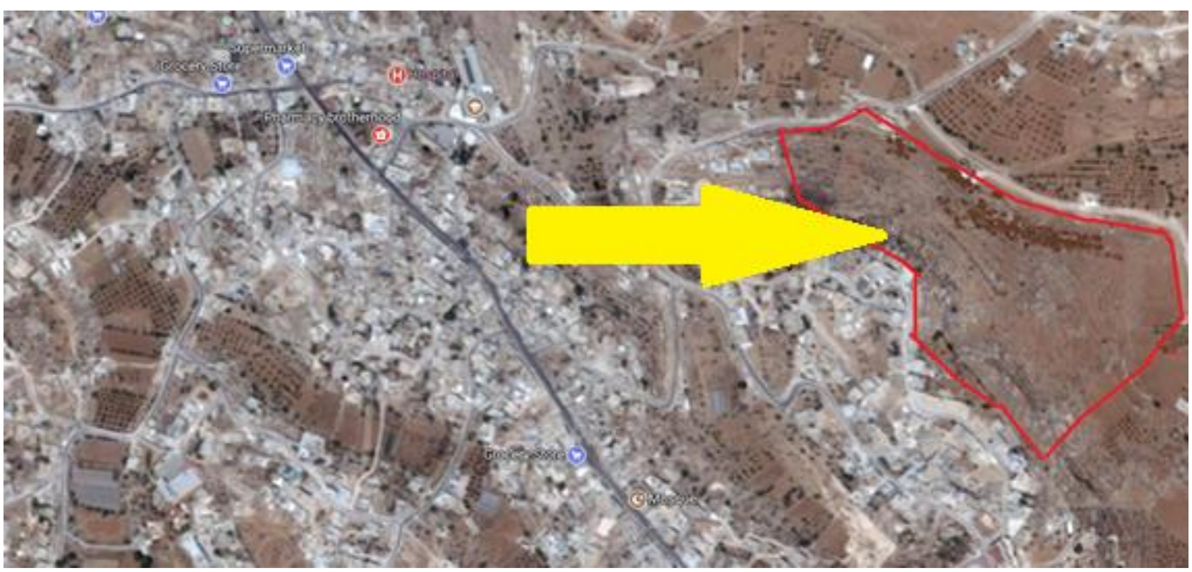
2.1 Introduction: -

Architectural description is the most important thing that should be considered 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 the functional, lasting beauty and economy terms, it is important that these terms can interact between each other in harmony to achieve our vision of optimal design and get an integrated and comprehensive architectural design. 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.

2.2: - Project Location.

The project is located at Al -Samu’ south of Hebron (775m above the sea level) as shown in the picture. The suggested location serves the southern part of the district with a high population including Yutta, Dura, Ithna, Al-Dahryah.



2.3 The Main Elements in the Management college: -

The project areas are divided into interior and exterior spaces tied together to achieve the goals that were found for it.

2.3.1 Interior Spaces:

The interior area of the project is 6600m^2 and 8520m^2 for movement spaces, thus the total interior space is 15120 m^2.

- Interior spaces are divided into:

1- Theater.
2- Computer sections.
3- Administration rooms.
4- Class Rooms.
5- Cafeteria.
6- Instruction Section.

➢ **Theater:**

It resides on one floor " basement floor”, and it accommodates 208 people with an area of nearly 295 m^2 divided into:

- Entrance hall: has an area of 80 m^2.
- Theater Hall: has an area of 295 m^2.
- Lobby: has an area of 44 m^2.
- Sentry-box: has an area of 10 m^2.
- Stage: has an area of 29 m^2.
- Baths: has an area of 30 m^2.
- Theater management room: has an area of 43 m^2.

- **Administration Section:**

It has an area of 375 m^2 divided into:

- Lobbies: has an area of 134 m^2.
- Director General: has an area of 40 m^2.
- Secretariat: has an area of 17 m^2.
- Deputy Director: has an area of 37 m^2.
- Hall Meetings: has an area of 30 m^2.
- Places to wait: has an area of 80 m^2.
- Kitchen: has an area of 11 m^2.
- Baths: has an area of 26 m^2.

- **Cafeteria:**

It resides on the underground floor, and it accommodates 55 people with an area of nearly 313 m^2 divided into:

- Entrance hall: has an area of 15 m^2.
- Dining room: has an area of 157 m^2.
- Accounting: has an area of 28 m^2.
- Services: has an area of 20 m^2.
- Kitchen: has an area of 66 m^2.

- **<u>Educational Section (class rooms):</u>**

It has an area of 5400 m^2 divided into:

- Lecture hall: has an area of 2780 m^2.
- Sitting area: 890 m^2.
- Lobbies: has an area of 1680 m^2.
- Bath rooms: it has an area 50 m^2.

- **<u>Instruction Section:</u>**

It has an area of 1780 m^2 divided into:

- Instructors' offices: has an area of 1010 m^2.
- Share department office: has an area 40 m^2.
- Meetings room: has an area 30.
- Deputy Director office: has an area 35.
- Secretariat: has area 20.
- Kitchen area: has an area 88.
- Bathrooms: has an area 210.
- Sitting places: has an area 225.
- Lobbies: has an area 122.

- **Computer Sections:**

It has an area of 1320 m^2 divided into:

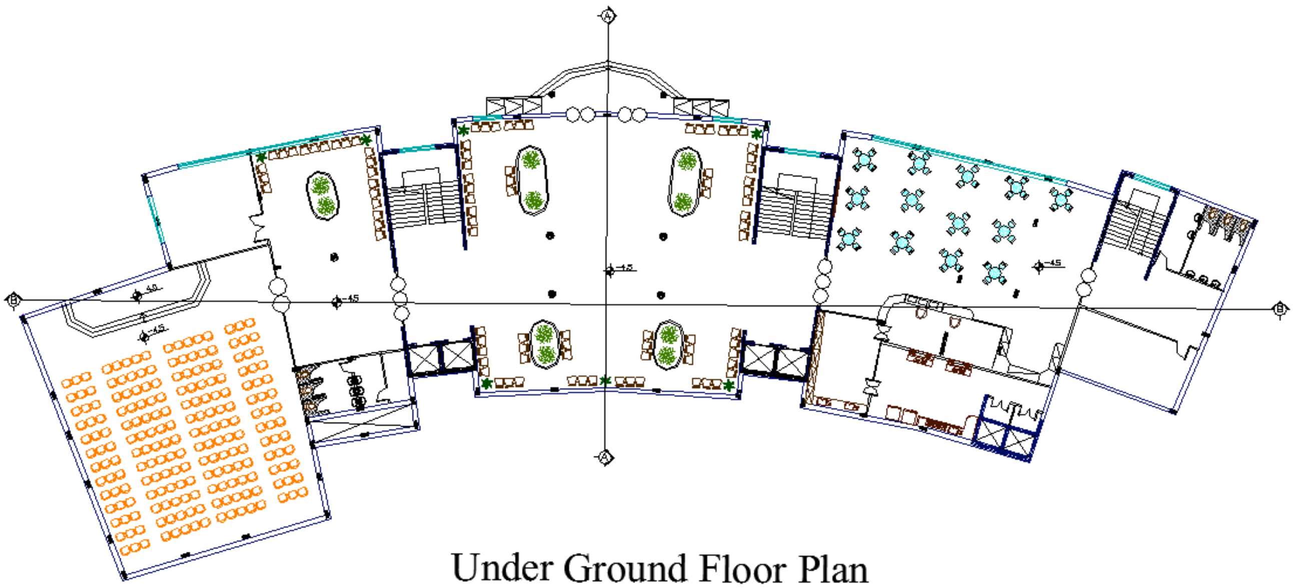
- Computer labs: v an area 1090 m^2.
- Sitting areas: have an area 230 m^2.
- Lobbies: have an area 164 m^2.
- Bath rooms: it has an area 96 m^2.

2.3.2 External Spaces:

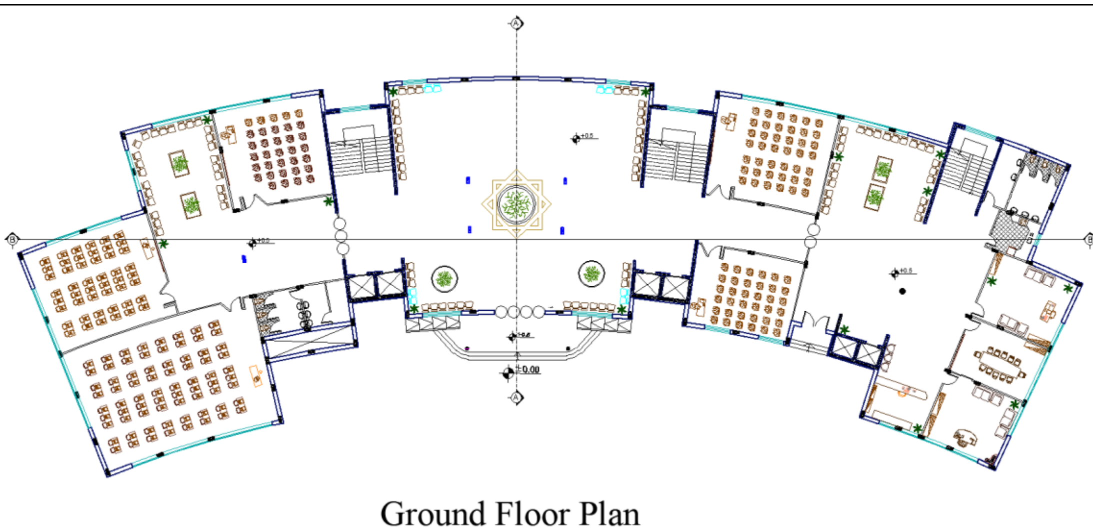
Consisting of:

- Green spaces.
- Cars parking: It consists of 20 car parking with an area 300 m^2.
- Sitting areas

2.4 Project Plans:



.Figure (2-1): Basement floor plan



.Figure (2-2): Ground floor plan

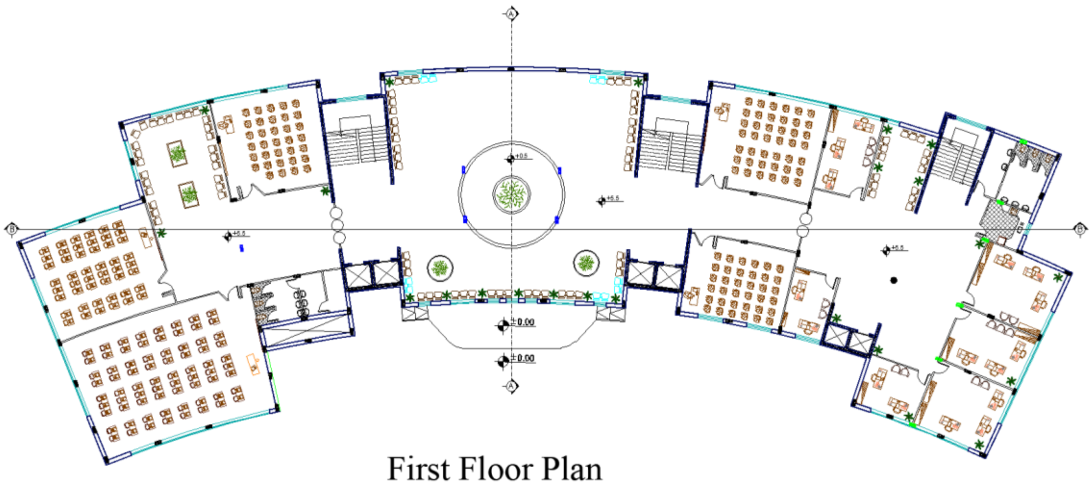


Figure (2-3): First floor plan.

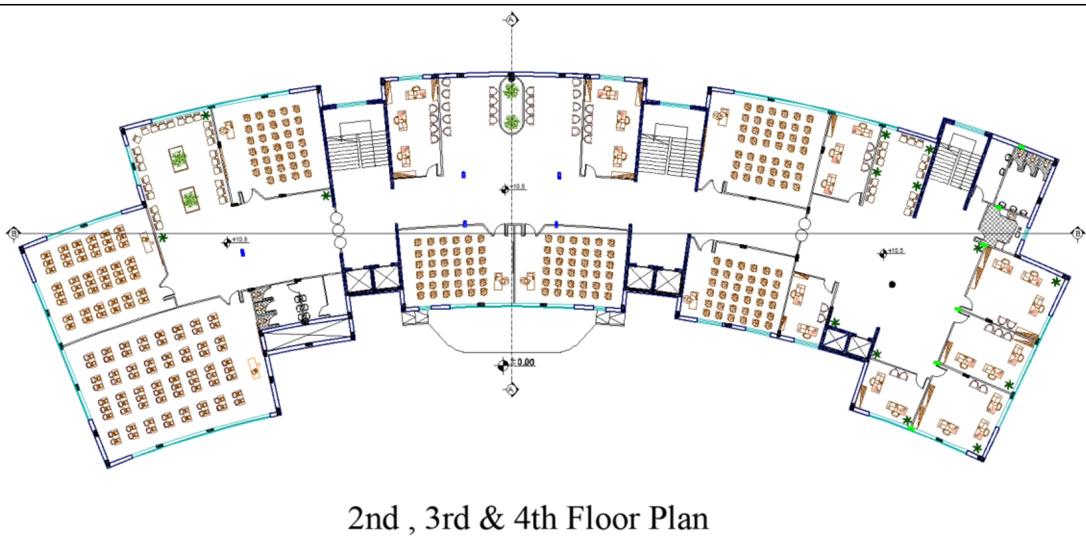


Figure (2-4): 2nd, 3rd, 4th, 5th and 6th floor plan.

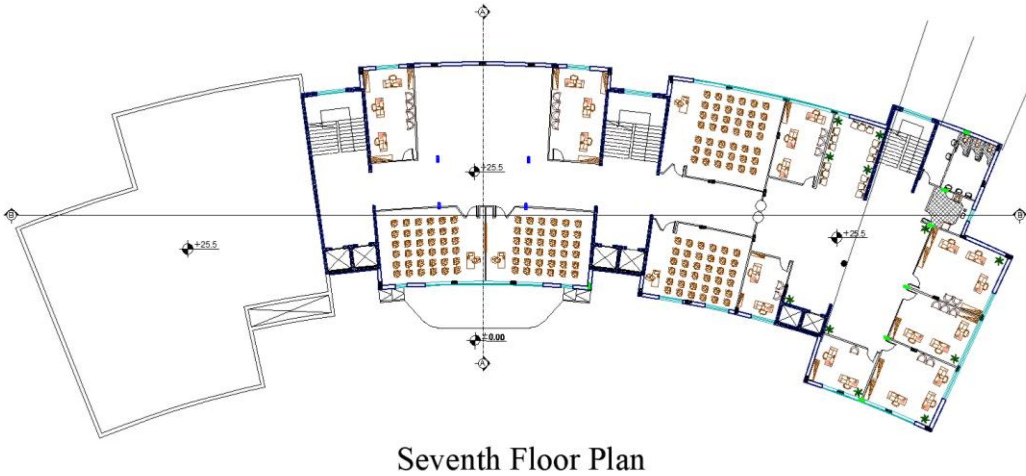


Figure (2-5): Seventh floor plan.

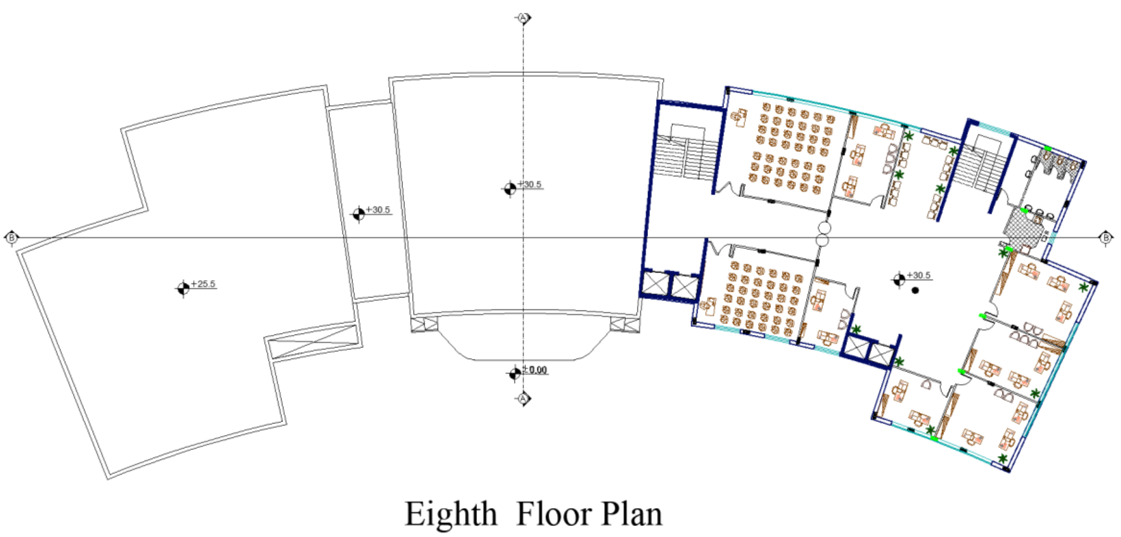


Figure (2-6): Eighth floor plan.

2.5 Project Elevations:

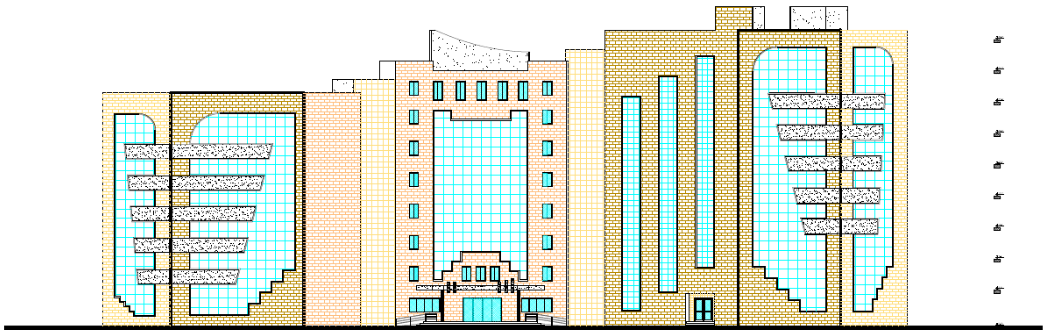
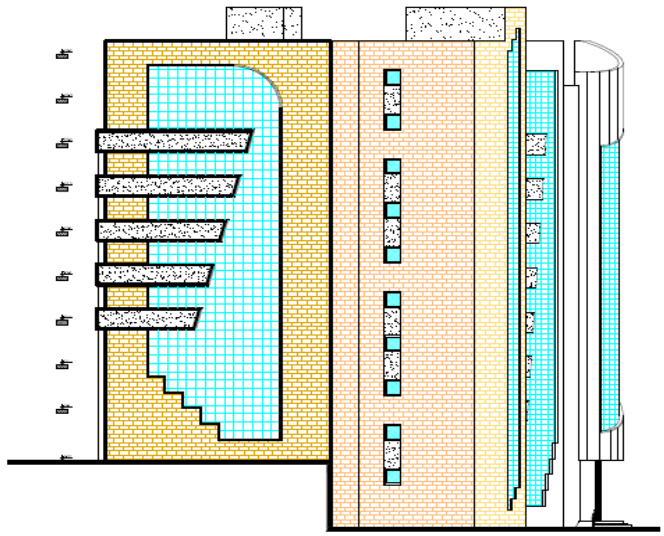


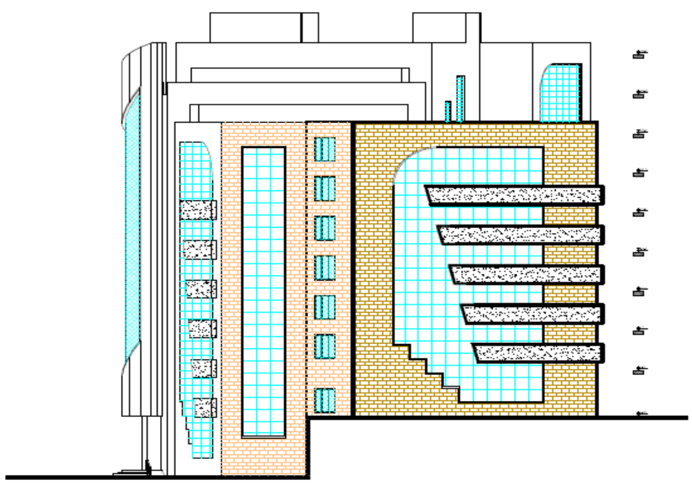
Figure (2-7): South elevation.

Figure (2-8): North elevation.



Eastern Elevation

Figure (2-9): East Elevation.



western Elevation

Figure (2-10): West Elevation.

2.6 Project Sections:

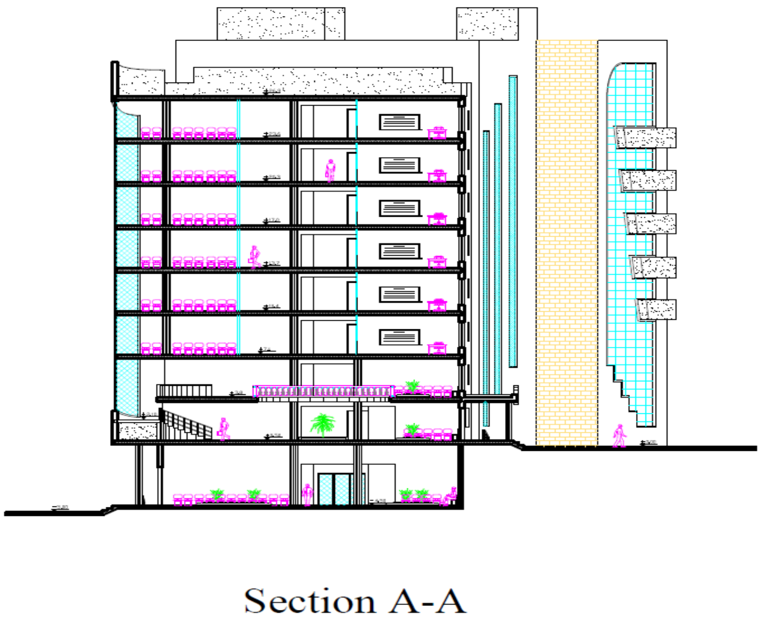


Figure (2-11): section A-A

Figure (2-12): Section B-B.

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 design process 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 which is capable of carrying it and meets 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 some tests must be done, tests of the soil to check the breaking strength, specifications, type, the underground water level and depth of the foundation layer. This is done through specific number of specified depths exploring holes done by the appropriate International Center for Geotechnical Engineering Studies (ICGES) in Bethlehem. Then the extracted samples were tested to measure the previous mentioned properties.

3.4 Stages for Structural Design:

We will divide the structural design of the project into two phases: -

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

3.5 Loads Acting on the Building:

There is a group of forces that the building must be designed to endure, this group consists of several types of loads which must be calculated and selected carefully because any errors in identifying and calculating these loads can reflect negatively on the structural design of various structural elements.

The loads that effect on any structure can be classified as follow:

3.5.1 Main Loads:

a) Dead Loads.
b) Live Loads.
c) Environmental Loads.

3.5.1.1 Dead Loads.

The permanent forces resulting from gravity which are fixed in terms of amount and location and do not change during the age of the building, including the loads of the weight of structural elements and the weights of the permanent nonstructural elements like walls. It also includes the permanent lateral loads like the soil pressure on the basement walls.

The calculation of the loads requires the knowing of the dimensions of the structural elements and specific gravity of the materials used in the manufacturing of the structural elements.

Furthermore, falls within this definition the self-weight of the construction materials, like concrete, reinforcement rebars, insulation materials, plaster, mortar, tiles, and electrical & sanitary installation.

3.5.1.2 Live Loads.

Includes the loads which effect on the building base on the usage of it, they can be classified into the following:

3.5.1.2.1 Dynamic Loads: like the machines that produce vibrations.

3.5.1.2.2 Static Loads: their location can be changed from time to time, like furniture, partitions, machines, and stored materials.

3.5.1.2.3 People Loads: depends on the usage of the building.

3.5.1.2.4 Execution Loads: acts on the building during the execution process, like cranes.

TABLE 1.2 LIVE LOADS ON FLOORS

Loading Class No. (1)	*Types of floors* (2)	*Min. Live Load per m² of floor area* (3)	*Alternative minimum live load* (4)
200	Floors in dwelling houses tenements, hospital wards, bed rooms and private sitting rooms in hostels and dormitories.	200 kg/m² (2 kN/m²)	
250	Office floor other than entrance halls, floors of light workrooms.	250*–400 kg/m² (2.5–4 kN/m²)	
300	Floors of banking halls, office entrance halls and reading rooms	300 kg/m² (3 kN/m²)	Subject to a min. total load of 2.5 times the values in col. 3 for any given slab panel and 6 times the value in col. 3 for any given beam. This total load shall be asuumed uniformly distributed on the entire area of the slab panel and the entire length of the beam.
400	Shop floors used for display and sale of merchandise ; ; floors of classrooms in schools ; floors of places of restaurants ; circulation space in machinery halls ; power stations etc., where not occupied by plant or equipments.	400 kg/m² (4 kN/m²)	
500	Floors of warehouses, workshops, factories and other buildings or parts of buildings of similar categories for light weight loads ; office floors for storage and filling purposes ; floors of places of assembly without fixed seating public rooms hotels, dance halls, waiting halls etc.	500 kg/m² (5 kN/m²)	-

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

3.5.1.3 Environmental Loads: result from environmental factors, including snow loads, earth quick loads, and soil loads. Theses loads vary in both magnitude and location, the wind load even varies in direction, and it depends on the unit of area exposed to the wind.

Snow Loads:

Figure (3-2): snow loads.

Snow loads can be calculated by knowing the altitude using the table below by Jordanian code. (As-Samu / Hebron is 775m above sea level).

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 on surface (page 44).

Based on the scale of previous snow loads and after selecting the high building surface and that equals (775 m) according to item III snow load is calculated as follows:

SL= (h-400)/320

SL= (775-400)/320= 1.17KN/m^2

In case of inclined surfaces, the value of the snow load is multiplied by a slope factor C_s.

The value of C_s depends on: slope of the roof, Temperature of the roof, nature of roofing surface, and the existence of obstructions to sliding.

These values can be found from ASCE 7-05 Figure 7-2.

Earthquake Load:

Earthquakes produce horizontal and vertical vibrations due to the relative motion of the Earth rock layers, resulting in strong cut affects the origin and these loads must be taken into account in the design to ensure the resistance against earthquakes. This will be resisted by shear walls in a building on the construction accounts.

The load is determined based on location. (As-Samu south of Hebron) so (zone is 2A and Z=0.15).

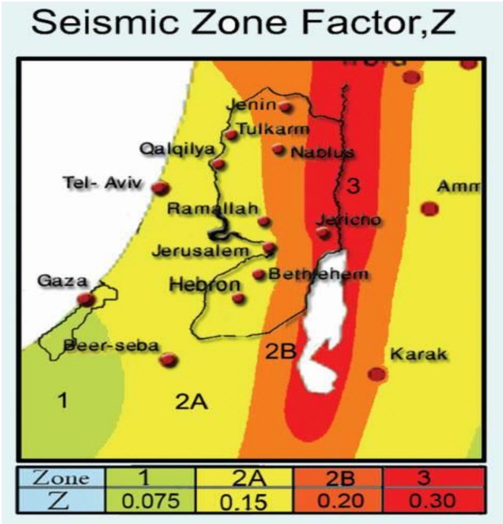


Figure (3-4): Earthquake map for Palestine.

Wind Loads:

Wind loads produce vertical forces on the building, and the wind load determination process depends on wind speed which changes with the height of the structure from the surface of the Earth and the location of the building itself, the surrounding buildings, and many other variables.

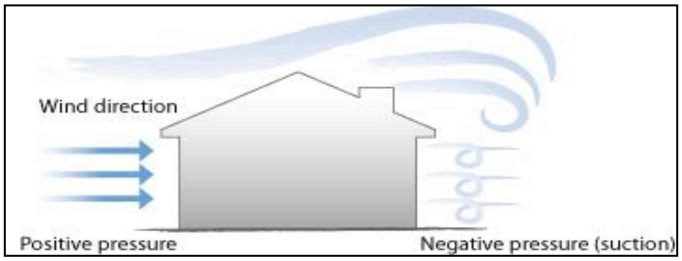


Figure (3-5): Wind Pressure on buildings.

3.5.2 Secondary Loads (Indirect Loads).

This includes the contraction resulting from the drying of the concrete and the expansion caused by the thermal effect and the settlement of the soil.

3.6 Structural Elements of the Building:

All buildings are usually consisting 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 which will clarify the structural design in the subsequent chapter, and below these types:

1- One Way Ribbed Slab.
2- Tow Way Ribbed Slab.

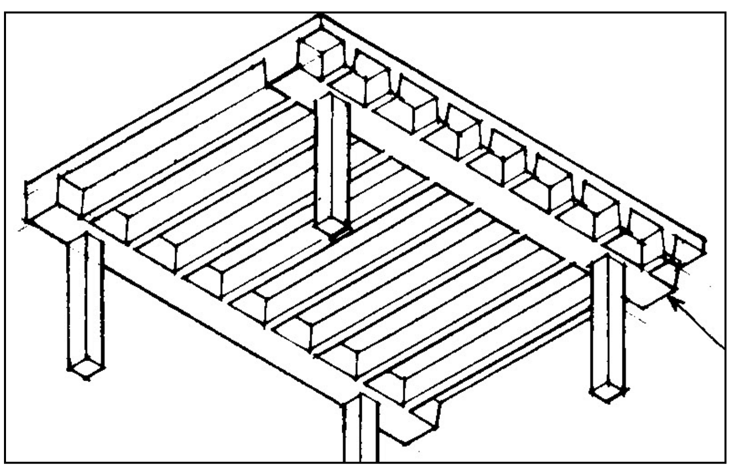


Figure (3-6): One Way Ribbed Slab.

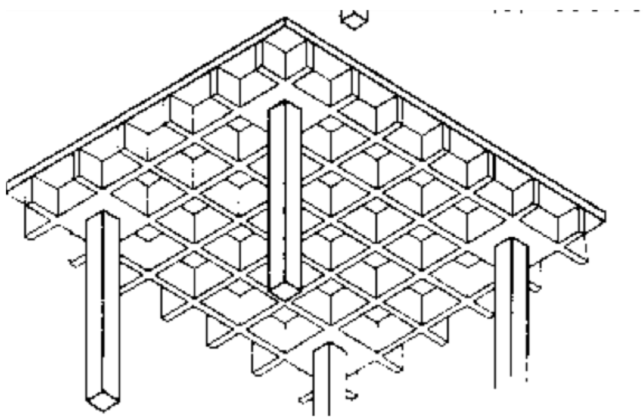


Figure (3-7): Two Way Ribbed Slab.

- **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.

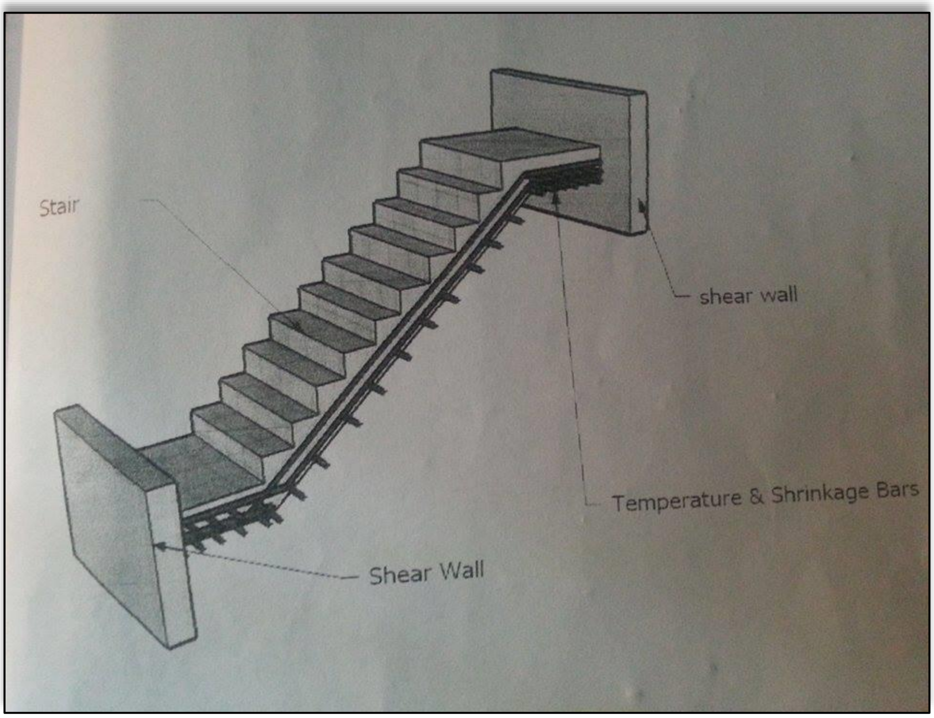


Figure (3-8): The shape of stairs.

- **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).

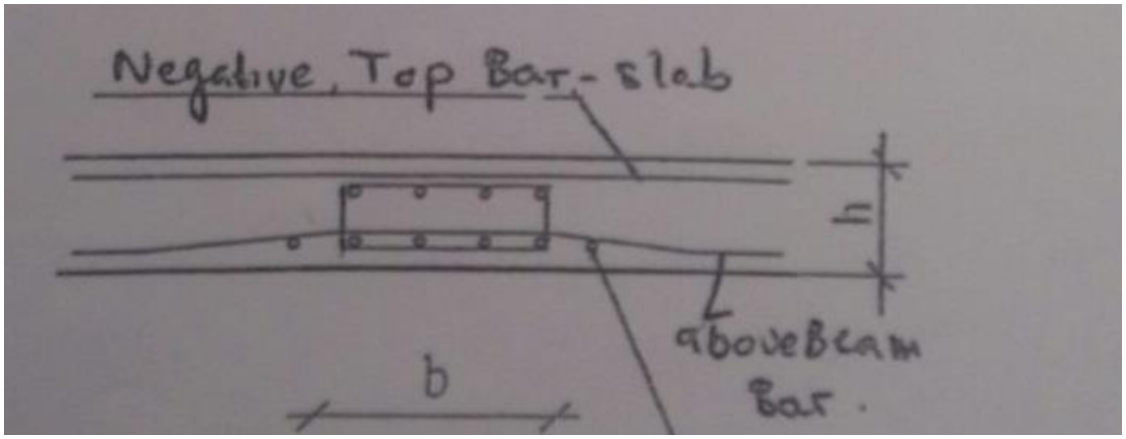


Figure (3-9): Hidden Beam.

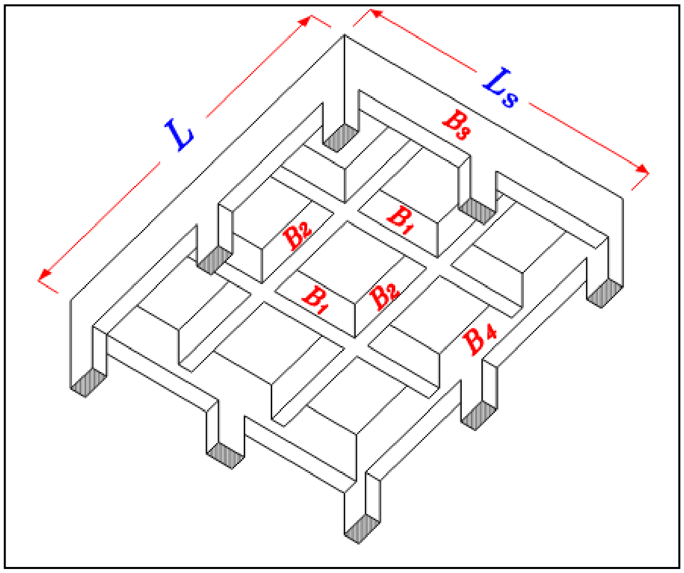


Figure (3-10): Paneled Beam.

- **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.

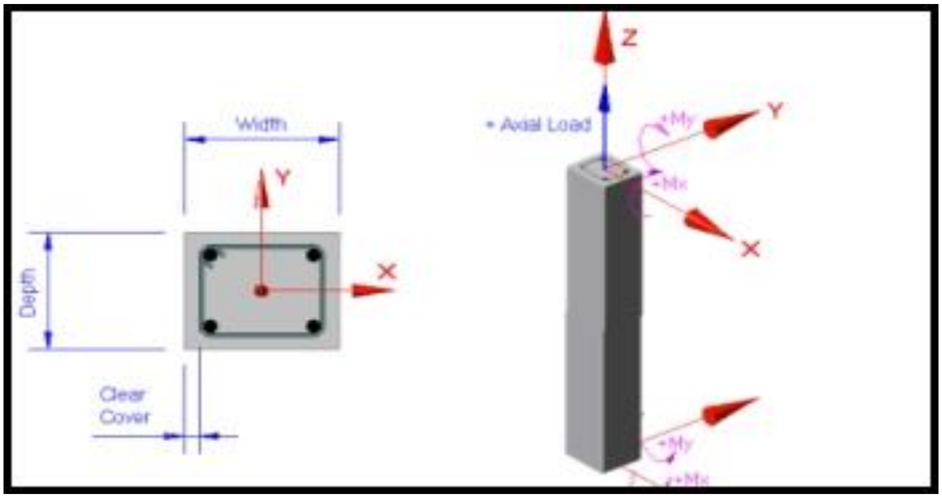


Figure (3-11): Column.

- **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

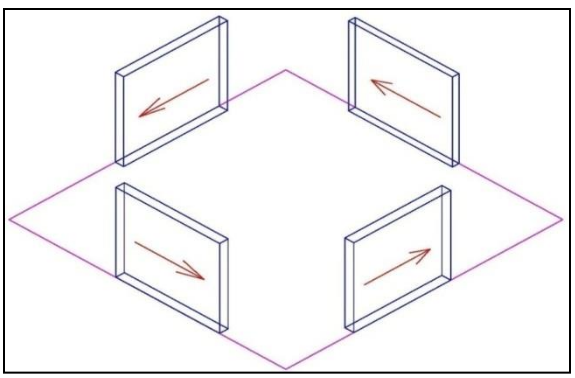


Figure (3-12): Shear Wall.

CHAPTER

4

DESIGN OF STRUCTURAL MEMBERS

4-1 **Introduction**

Many structures are built of reinforced concrete: bridges, buildings, retaining walls, tunnels and others.

Reinforced concrete is logical union of two materials: plain concrete, which possesses high compressive strength but little tensile strength, and steel bars embedded in the concrete, which can provide the needed strength in tension.

Plain concrete is made by mixing cement, fine aggregate, coarse aggregate, water, and frequently admixtures.

Understanding of reinforced concrete behavior is still far from complete, building codes and specifications that give design procedures are continually changing to reflect latest knowledge.

Structural concrete can be classified into: -

- Lightweight concrete with unit weight from about 1350 to 1850 kg/m3.
- Normal weight concrete with unit weight from about 1800 to 2400 kg/m3.
- Heavyweight concrete with unit weight from about 3200 to 5600 kg/m3.

4-2 Design Method and Requirements

The design strength provided by a member is calculated in accordance with the requirements and assumptions of **ACI_code (318_08)**.

- ✓ **Strength design method: -**

In ultimate strength design method, the service loads are increased by factors to obtain the load at which failure is considered to be occurring.

This load called factored load or factored service load. The structure or structural element is then proportioned such that the strength is reached when factored load is acting. The computation of this strength takes into account the nonlinear stress-strain behavior of concrete.

The strength design method is expressed by the following,

Strength provided ≥ strength required to carry factored loads.

NOTE: -

The statically calculation and the key plans dependent on the architectural plans.

- Code: -

  ACI 2008

  UBC

- Material: -

  Concrete: -B300

  $fc' = 30 N/mm^2 (MPa)$ For circular section

  but for rectangular section ($fc' = 30 * 0.8 = 24 MPa$).

  Reinforcement steel: -

  The specified yield strength of the reinforcement {fy = 420 N/mm² (MPa)}.

- ✓ **Factored loads: -**

The factored loads for members in our project are determined by: -

$W_u = 1.2\ D_L + 1.6\ L_L$ **ACI-code-318-08(9.2.1)**

4.3 Check Thickness of Structural Member

Table4-1: - Minimum Thickness of Nonprestressed Beam or One-Way Slabs Unless Deflections Are Calculated. **(ACI 318M-11)**.

Minimum thickness (h)				
Member	Simply supported	One end continuous	Both end continuous	Cantilever
solid one way slabs	L/20	L/24	L/28	L/10
Beams or ribbed one way slabs	L/16	L/18.5	L/21	L/8

Table (4.1): Check of Minimum Thickness of Structural Member.

For Rib: -

$h_{min}$for (one end continuous) =L/18.5=4.12/18.5=22.3cm

$h_{min}$for (both end continuous) =L/21=4.14/21=19.7cm

$h_{min}$for (both end continuous) =L/21=3.39/21=16.1cm

$h_{min}$for (one end continuous) =L/18.5=3.76/18.5=20.3cm

Take h = 35 cm

27 cm block + 8 cm topping = 35cm

For Beam: -

$h_{min}$for (one end continuous) =L/18.5=5.81/18.5=31.4cm

$h_{min}$for (both end continuous) =L/21=3.47/21=16.5cm

$h_{min}$for (both end continuous) =L/21=4.5/21=21.4cm

$h_{min}$for (one end continuous) =L/18.5=2.72/18.5=14.7cm

Take h = 35 cm

4.4 Design of Topping

✓ **Statically System For Topping:-**

Consider the topping as strip of (1m) width, and span of mold length with both end fixed in the ribs.

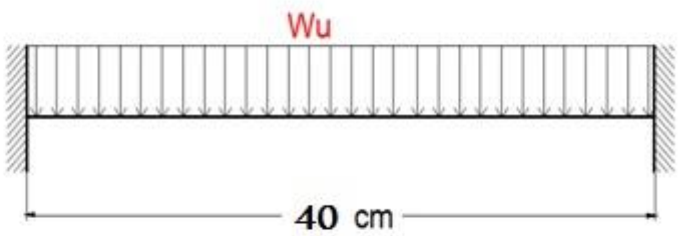


Fig 4.1: Topping Load.

✓ **Load Calculations: -**

Dead Load: -

No.	Parts of Rib	Calculation	
1	Tiles	0.03*23*1 = 0.69 KN/m	
2	Mortar	0.02*22*1 = 0.44 KN/m	
3	Coarse Sand	0.07*17*1 = 1.19 KN/m	
4	Topping	0.08*25*1 = 2.0 KN/m	
5	Partitions	2*1=2 KN/m	
		Sum =	6.32 KN/m

Table (4.2): Dead Load Calculation of Topping.

Live Load: -

L_L =5 KN/m^2

L_L =5 KN/m^2×1m=5KN/m

Factored Load: -

W_U = 1.2 ×6.32 + 1.6×5 =15.6 KN/m

Check the strength condition for plain concrete, $øM_n \geq M_u$, where ø = 0.55

$M_n = 0.42\, \lambda \sqrt{f_c'}\, S_m$ **(ACI 22.5.1, equation 22-2)**

$$S_m = \frac{b.h^2}{6} = \frac{1000.80^2}{6} = 1066666.67\ mm^2$$

$øM_n = 0.55 \times 0.42 \times 1 \times \sqrt{24} \times 1066666.67 \times 10^{-6}$ =1.21 KN.m

$M_u = \frac{W_u L^2}{12} = 0.208$ KN. m (negative moment)

$M_u = \frac{W_u L^2}{24} = 0.104$ KN. m (positive moment)

$øM_n >> M_u = 0.208$ KN. m

No reinforcement is required by analysis. **According to ACI 10.5.4**, provide $A_{s,min}$ for slabs as shrinkage and temperature reinforcement.

$\rho_{shrinkage}$= 0.0018 **ACI 7.12.2.1**

$A_s = \rho \times b \times h_{topping}$ =0.0018 ×1000×80 = 144 mm^2/m

Step (s) is the smallest of:

1. 3h = 3×80 =240 mm ***control*** **ACI 10.5.4**
2. 450mm.
3. $S = 380\left(\frac{280}{f_s}\right) - 2.5C_c = 380\left(\frac{280}{\frac{2}{3}420}\right) - 2.5\,.20 = 330$mm **ACI 10.6.4**

<u>Take ø 8 @ 200 mm in both direction, S = 200 mm < S_{max} = 240 mm … OK</u>

4.5 Design of One Way Rib Slab

Requirements for Ribbed Slab Floor According to ACI- *(318-08)*.

bw ≥ 10cm……………………………………………**ACI (8.13.2)**

Select bw=12 cm

h ≤ 3.5*bw ……………………………….….**ACI (8.13.2)**

Select h=35cm<3.5*12= 49 cm

tf ≥ Ln/12≥50mm …………………………………. **ACI (8.13.6.1)**

Select tf=8cm

❖ **Material: -**

- ⇒ concrete B300 Fc' = 24 N/mm^2
- ⇒ Reinforcement Steel fy = 420 N/mm^2

❖ **Section: -**

- ⇒ B = 550 mm
- ⇒ Bw= 150 mm
- ⇒ h= 350 mm
- ⇒ t= 80 mm
- ⇒ d=350-20-10-12/2= 314 mm

✓ **Static system and Dimensions: -**

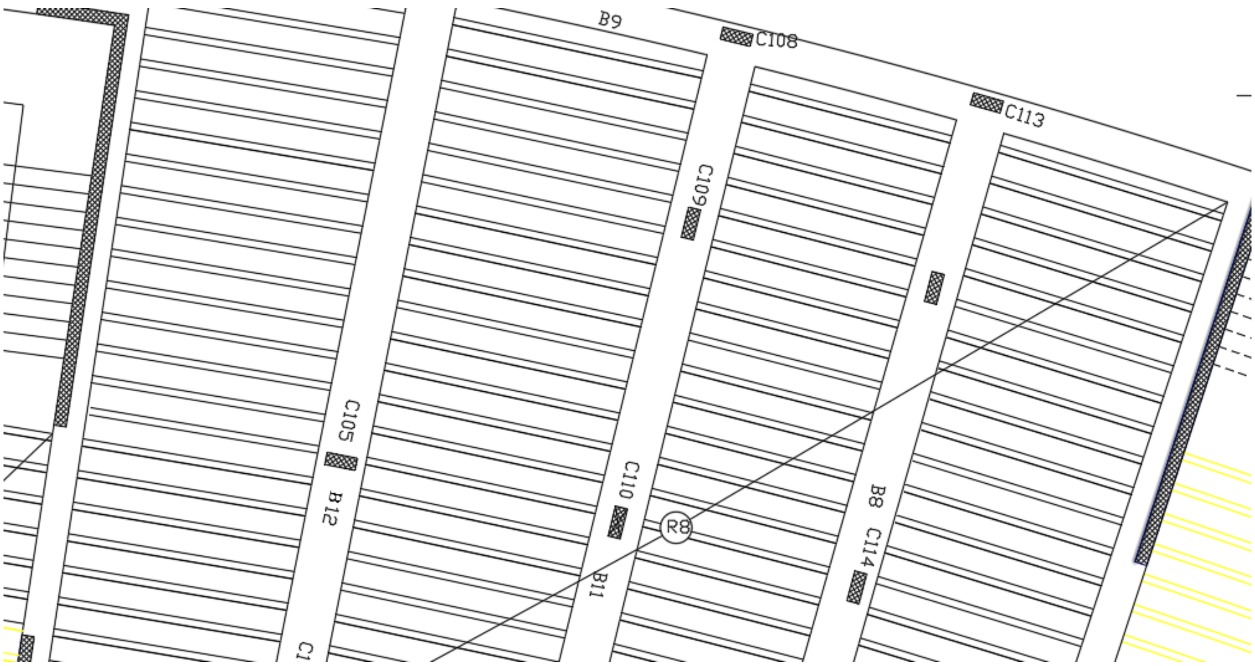


Fig 4.2: One Way Rib Slab (R8).

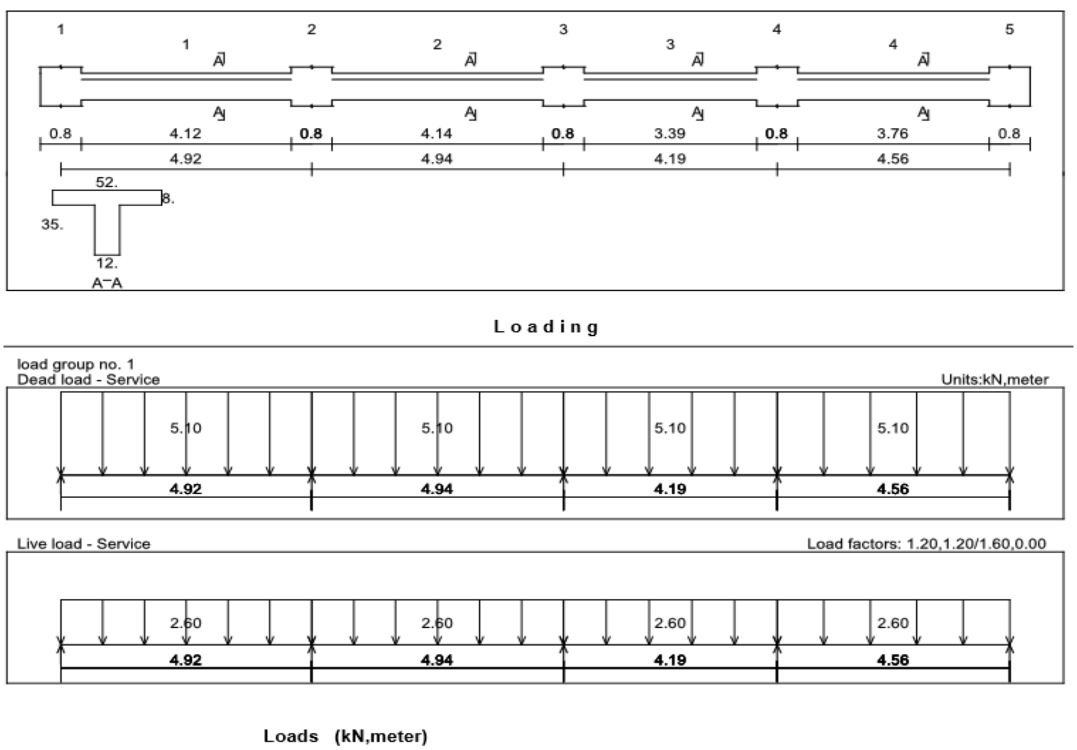


Fig 4.3: Statically System and Loads Distribution of Rib(R8).

✓ Load Calculation: -

Dead Load: -

No.	Parts of Rib	Calculation
1	**Tiles**	0.03*23*0.52 = 0.359 KN/m/rib
2	**Mortar**	0.03*22*0.52 = 0.229 KN/m/rib
3	**Coarse Sand**	0.07*17*0.52 = 0.620 KN/m/rib
4	**Topping**	0.08*25*0.52 = 1.04 KN/m/rib
5	**RC. Rib**	0.27*25*0.12 = 0.81 KN/m/rib
6	**Hollow Block**	0.27*10*0.4 = 1.08 KN/m/rib
7	**plaster**	0.02*22*.52= 0.229 KN/m/rib
8	**partions**	1*0.52= 0.52 KN/m/rib
		Sum = 5.1 KN/m/rib

Table (4.3): Dead Load Calculation of Rib(R8).

Dead Load /rib = 5.1 KN/m

Live Load: -

Live load = 5 KN/M^2

Live load /rib = 5 KN/m^2 × 0.52m = 2.6 KN/m.

❖ Effective Flange Width (b_E): -**ACI-318-11 (8.10.2)**

b_E For T- section is the smallest of the following: -

b_E = L / 4 = 550/ 4 =137.5cm

b_E = 12 + 16 t = 12 + 16 (8) = 140 cm

b_E = $b_e \le$ center to center spacing between adjacent beams = 52 cm.

Control

b_E **For T-section = 52cm.**

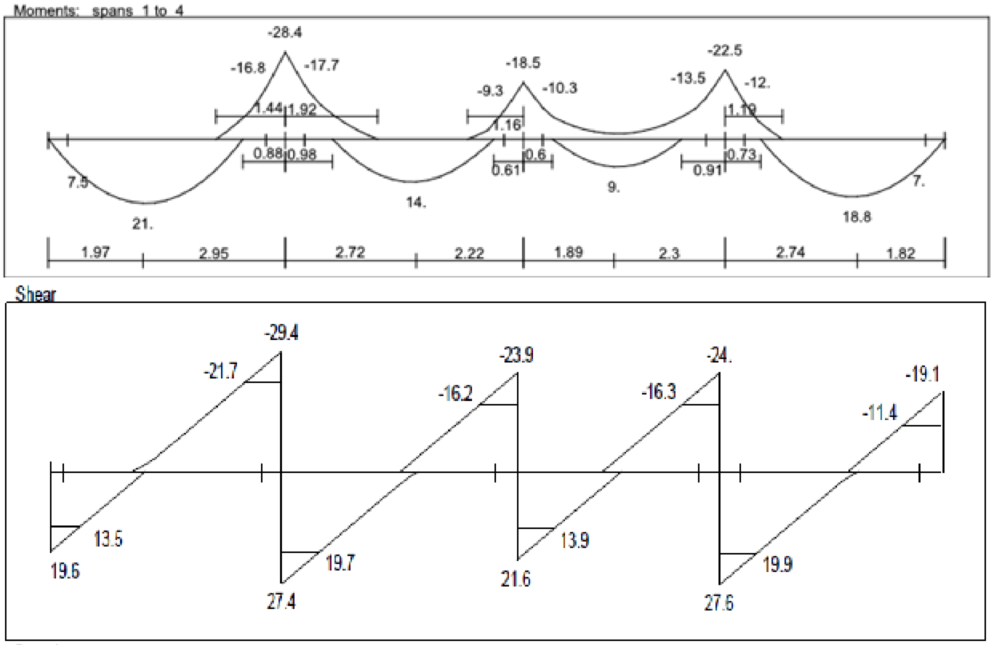


Fig 4.4: Shear and Moment Envelope Diagram of Rib (R8).

✓ <u>Moment Design for (R 3)</u>:-

Design of Positive Moment for (Rib8) :-(Mu=21 KN.m)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$

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

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

$$= 0.85 \times 24 \times 520 \times 80 \times \left(314 - \frac{80}{2}\right) \times 10^{-6} = 232.5\ \text{KN.m}$$

$M_n \gg \frac{M_u}{\varphi} = \frac{21}{0.9} =$ 23. 33KN.m, the section will be designed as rectangular section with b_e =520 mm.

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{21 \times 10^6}{0.9 \times 520 \times 314^2} = 0.455 Mpa$

m= $\frac{f_y}{0.85f_c'} = \frac{420}{0.85\times 24} = 20.6$

ρ= $\frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times 20.6\times 0.455}{420}}\right) = 0.001095$

$A_{s,req}$ = ρ.b.d = 0.001095 ×520×314 = 178.9 mm^2

Check for As min: -

$A s \text{ min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ **ACI-318 (10.5.1)**

$A s \text{ min} = \frac{\sqrt{24}}{4(420)}(120)(314) = 110 mm^2$

$A s \text{ min} = \frac{1.4}{(fy)}(bw)(d)$

$A s \text{ min} = \frac{1.4}{420}(120)(314) = 125.6 mm^2$ **controls**

As_{req}= 178.90mm^2 > As_{min}= 125.6 mm^2 **OK**

Use 2 ø 12, $A_{s,provided}$= 226 mm^2>$A_{s,required}$= 178.90 mm^2 …. Ok

$S = \frac{120-40-20-(2\times 12)}{1} = 36\ mm > d_b = 12 > 25\ mm$ ***OK***

Check for strain: -

a $=\frac{A_{s}.f_y}{0.85b\ f_c'} = \frac{226\times420}{0.85\times520\times24} = 8.94\ mm$

x$= \frac{a}{\mathcal{B}_1} = \frac{8.94}{0.85} = 10.53\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{314\ -10.53}{10.53}\right) = 0.0864 > 0.005 \qquad \mathbf{0k}$$

Design of Positive Moment for (Rib3): - (Mu=14KN.m)

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{14\times10^6}{0.9\times520\times314^2} = 0.303 Mpa$

m$= \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

ρ$= \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times0.303}{420}}\right) = 0.000726$

$A_{s,req}$ = ρ.b.d = 0.000726×520×314 = 118.6 mm^2

Check for As min: -

$A\,s\ \min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ **ACI-318 (10.5.1)**

$A\,s\ \min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110mm^2$

$A\,s\ \min = \frac{1.4}{(fy)}(bw)(d)$

$A\,s\ \min = \frac{1.4}{420}(120)(314) = 125.6mm^2$ **controls**

$A_{s,required}$= 125.6 mm^2.

Use 2 ø 10 ,$A_{s,provided}$= 157.08 mm^2>$A_{s,required}$= 125.6 mm^2 … Ok

S $= \frac{120-40-20-(2\times10)}{1} = 40\ mm > d_b = 10 > 25\ mm \qquad \boldsymbol{OK}$

Check for strain: -

a $=\frac{A_{s}.f_y}{0.85b\ f_c'} = \frac{157\times420}{0.85\times520\times24} = 6.22\ mm$

x$= \frac{a}{\mathcal{B}_1} = \frac{6.22}{0.85} = 7.31mm$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{314-7.31}{7.31}\right) = 0.125 > 0.005 \qquad \mathbf{0k}$$

Design of Positive Moment for (Rib3): - (Mu=9KN.m)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$

$R_n = \frac{M_u}{\emptyset bd^2} = \frac{9\times10^6}{0.9\times520\times314^2} = 0.195\ Mpa$

m$= \frac{f_y}{0.85f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times0.195}{420}}\right) = 0.000467$

$A_{s,req} = \rho.b.d = 0.000467\times520\times314 = 76.2\ mm^2$

Check for As min:-

$A_s \min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ **ACI-318 (10.5.1)**

$A_s \min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110mm^2$

$A_s \min = \frac{1.4}{(fy)}(bw)(d)$

$A_s \min = \frac{1.4}{420}(120)(314) = 125.6mm^2$ **controls**

$A_{s,required}$= 125.6 mm^2.

Use 2 ø 10, $As_{,provided}$= 157.08 mm^2>$A_{s,required}$= 125.6 mm^2 … Ok

Check for strain:-

a $=\frac{A_{s}.f_{y}}{0.85b\ f_c'} = \frac{157\times420}{0.85\times520\times24} = 6.22\ mm$

x$= \frac{a}{\mathcal{B}_1} = \frac{6.22}{0.85} = 7.31mm$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{314-7.31}{7.31}\right) = 0.125 > 0.005 \qquad \mathbf{0k}$$

Design of Positive Moment for (Rib3): - (Mu=18. 8KN.m)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{18.8\times10^6}{0.9\times520\times314^2} = 0.407\ Mpa$

m$= \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

ρ$= \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times0.598}{420}}\right) = 0.000979$

$A_{s,req}$ = ρ.b.d = 0.000979×520×314 = 159.83 mm^2

Check for As min: -

$As\min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ **ACI-318 (10.5.1)**

$As\min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110mm^2$

$As\min = \frac{1.4}{(fy)}(bw)(d)$

$As\min = \frac{1.4}{420}(120)(314) = 125.6mm^2$ **controls**

As_{req} = 159.83mm^{2} > As_{min} = 125.6 mm^{2} **OK**

Use 2 ø 12, $As_{,provided}$= 226 mm^{2}>$A_{s,required}$= 159.83 mm^{2} …. Ok

$$S = \frac{120-40-20-(2\times12)}{1} = 36\ mm > d_b = 12 > 25\ mm \quad \boldsymbol{OK}$$

Check for strain: -

$$a = \frac{A_{s}.f_y}{0.85b\ f_c'} = \frac{226\times420}{0.85\times520\times24} = 8.94\ mm$$

$$x = \frac{a}{\mathcal{B}_1} = \frac{8.94}{0.85} = 10.53\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{314\ -10.53}{10.53}\right) = 0.0864 > 0.005 \quad \boldsymbol{0k}$$

Design of Negative Moment for (Rib3): - (Mu=-17. 7KN.m)

Assume bar diameter ø 12 for main positive reinforcement

$$d = h\text{- cover - }d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$$

$$R_n = \frac{M_u}{\emptyset bd^2} = \frac{17.7\times10^6}{0.9\times120\times314^2} = 1.67\ Mpa$$

$$m = \frac{f_y}{0.85f_c'} = \frac{420}{0.85\times24} = 20.6$$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times1.67}{420}}\right) = 0.00415$$

$A_{s,req}$ = ρ.b.d = 0.00415×120×314 = 156.37 mm^{2}

Check for As min: -

$$As\ \min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$$ **ACI-318 (10.5.1)**

$$A_s \min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110 mm^2$$

$$A_s \min = \frac{1.4}{(fy)}(bw)(d)$$

$$A_s \min = \frac{1.4}{420}(120)(314) = 125.6 mm^2$$ **controls**

$As_{req} = 156.37 mm^2 > As_{min} = 125.6\ mm^2$ **OK**

Use 2 ø 12, $A_{s,provided} = 226\ mm^2 > A_{s,required} = 156.37\ mm^2$ …. Ok

$$S = \frac{120-40-20-(2\times12)}{1} = 36\ mm > d_b = 12 > 25\ mm \qquad \boldsymbol{OK}$$

Check for strain: -

$$a = \frac{A_{s}.f_y}{0.85 b\, f_c'} = \frac{226\times420}{0.85\times120\times24} = 38.77\ mm$$

$$x = \frac{a}{\mathcal{B}_1} = \frac{38.77}{0.85} = 45.62\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{314-45.62}{45.62}\right) = 0.0176 > 0.005 \qquad \mathbf{0}\boldsymbol{k}$$

Design of Negative Moment for (Rib3): - (Mu=-10. 3KN.m)

Assume bar diameter ø 12 for main positive reinforcement

$$d = h - cover - d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$$

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{10.3\times10^6}{0.9\times120\times314^2} = 0.97\ Mpa$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2\times20.6\times0.97}{420}}\right) = 0.00237$$

$A_{s,req} = \rho.b.d = 0.00237 \times 120 \times 314 = 89.2\ mm^2$

Check for As min: -

$$As\ min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$$ **ACI-318 (10.5.1)**

$$As\ min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110m^2$$

$$As\ min = \frac{1.4}{(fy)}(bw)(d)$$

$$As\ min = \frac{1.4}{420}(120)(314) = 125.6mm^2$$ **controls**

$As_{req} = 89.2mm^2 < As_{min} = 125.6\ mm^2$

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

Use 2 ø10, $As_{,provided} = 157.07\ mm^2 > A_{s,required} = 125.6mm^2$… Ok

$$S = \frac{120-40-20-(2\times10)}{1} = 40\ mm > d_b = 12 > 25\ mm \qquad \boldsymbol{OK}$$

Check for strain: -

$$a = \frac{A_{s}.f_y}{0.85b\ f_c'} = \frac{157\times420}{0.85\times120\times24} = 26.94\ mm$$

$$x = \frac{a}{\mathcal{B}_1} = \frac{38.77}{0.85} = 31.69mm$$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{314-31.69}{31.69}\right) = 0.0267 > 0.005 \qquad \boldsymbol{0k}$$

Design of Negative Moment for (Rib3): - (Mu=-13. 5KN.m)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{13.5\times10^6}{0.9\times120\times314^2} = 1.26\ Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times1.26}{420}}\right) = 0.00310$

$A_{s,req} = \rho.b.d = 0.00310 \times120\times314 = 116.76\ mm^2$

Check for As min: -

$As\min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ **ACI-318 (10.5.1)**

$As\min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110m^2$

$As\min = \frac{1.4}{(fy)}(bw)(d)$

$As\min = \frac{1.4}{420}(120)(314) = 125.6mm^2$ **controls**

$As_{req} = 116.76mm^2 < As_{min} = 125.6\ mm^2$

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

Use 2 ø10, $A_{s,provided} = 157.07\ mm^2 > A_{s,required} = 125.6mm^2$… Ok

$S = \frac{120-40-20-(2\times10)}{1} = 40\ mm > d_b = 12 > 25\ mm$ ***OK***

Check for strain: -

a $=\frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{157\times420}{0.85\times120\times24} = 26.94\ mm$

x$= \frac{a}{\mathcal{B}_1} = \frac{38.77}{0.85} = 31.69mm$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{314-31.69}{31.69}\right) = 0.0267 > 0.005 \qquad \boldsymbol{0k}$$

✓ Shear Design for (R 3): -

V_u at distance d from support = 27 KN

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

$V_c = \frac{1.1}{6}\sqrt{f_c'}b_w d = \frac{1.1}{6}\sqrt{24} \times 120 \times 314 \times 10^{-3} = 33.84\ KN$

$øV_c$ =0.75×33.84 =25.38 KN

0.5 ø V_c =0.5×25.38 =12.69 KN

0.5 ø V_c< V_u< ø V_c

V_u> ø V_c

for shear design, shear reinforcement is required $(A_{v,})$,

$Vs_{min} = \frac{1}{16}\sqrt{f_c'}bw\ d \geq \frac{1}{3}\ \ bw\ d$

Vs min$=\frac{1}{16}\sqrt{24} * 120 * 314 = 11.54kn$

$Vs_{min} = \frac{1}{3}\ bw\ d = \frac{1}{3} * 120 * 314 = 12.56kn$

ø(V_c+Vs_{min}) = 0.75(33.84+12.56) =34.8kn

øV_c<Vu <ø (V_c+Vs_{min})

25.38 < 27 <34.8

for shear design, minimum shear reinforcement is required ($A_{v,min}$), Reinforcement.

Use stirrups (2 leg stirrups) ø 8@150 mm, A_v = 2 ×50.24 = 100.5 mm^2

$Av_{min} = \frac{1}{16}\sqrt{f_c'}\frac{b_w s}{fyt} \geq \frac{1}{3}\frac{b_w s}{fyt}$

$Av_{min} = 100.5 = \frac{1}{16}\sqrt{24}\frac{120s}{420} \rightarrow s = 1.145m$

$100.5 = \frac{1}{3}\frac{120s}{420} \rightarrow s = 1.055m$

S max$\rightarrow \frac{d}{2} = 157mm$

S max →≤600mm

Take (2 leg stirrups) ø 8 @ 150 mm

$A_v = \frac{2*50.3}{0.15} = 670.67\ mm^2/m_{strip}$

4.6 Design of Beam 19

❖ **Material: -**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel fy = 420 N/mm^2

❖ **Section: -**

⇒ B = 50 cm
⇒ h= 35 cm
⇒ d=350-40-10-18/2= 291 mm

✓ Statically System and Dimensions: -

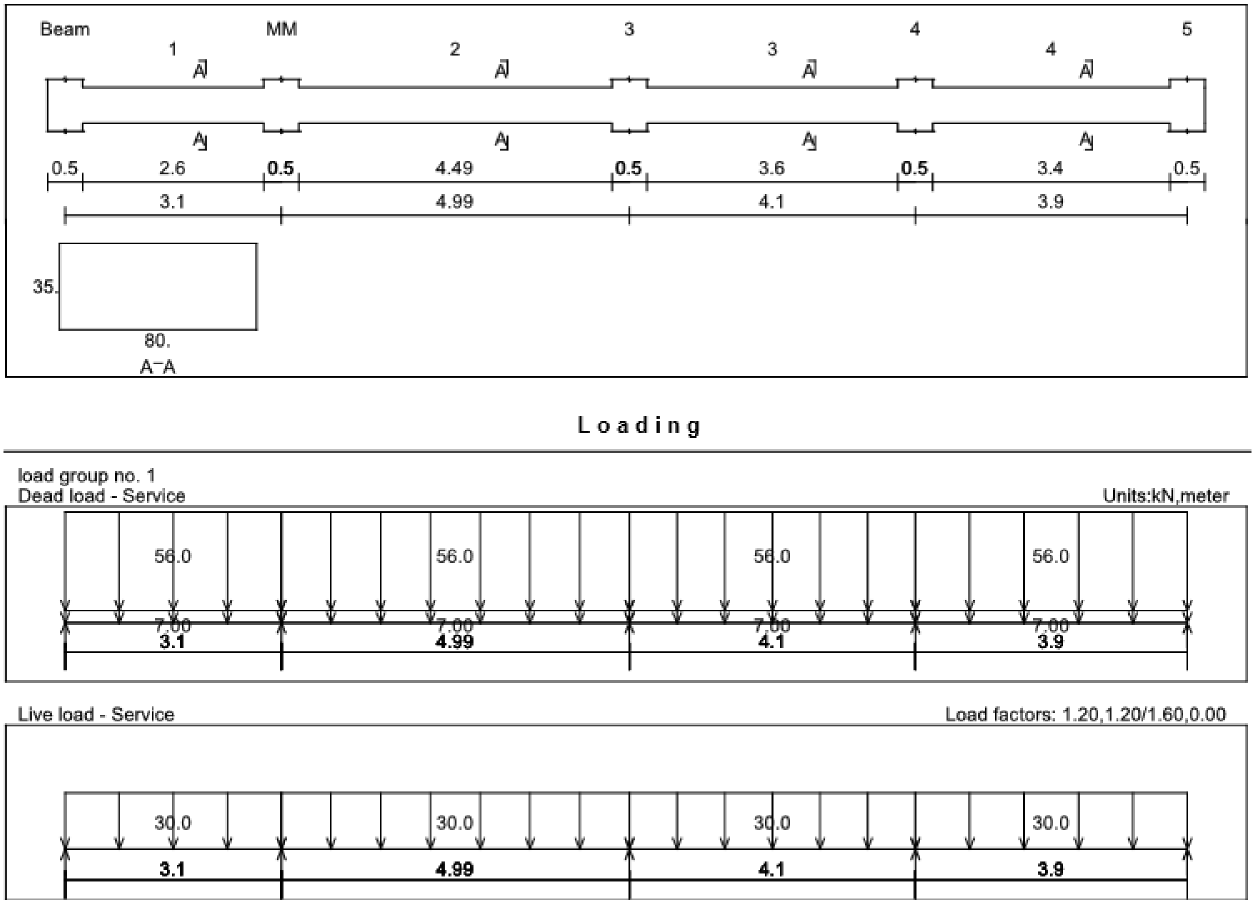


Fig 4.5: Statically System and Loads Distribution of Beam (B 19).

✓ Load Calculations: -

Dead Load Calculations for Beam (B 19): -

The distributed Dead and Live loads acting upon B8 can be defined from the support reactions of the R1.

From Rib8

The maximum support reaction from Dead Loads for R8 upon B8 is 29.16 KN, The distributed Dead Load from the R8on B8.

DL = (29.16/ 0.52) = 56 KN / m

Self-weight of beam = 7 KN / m

DL =56+7 = 63 KN / m

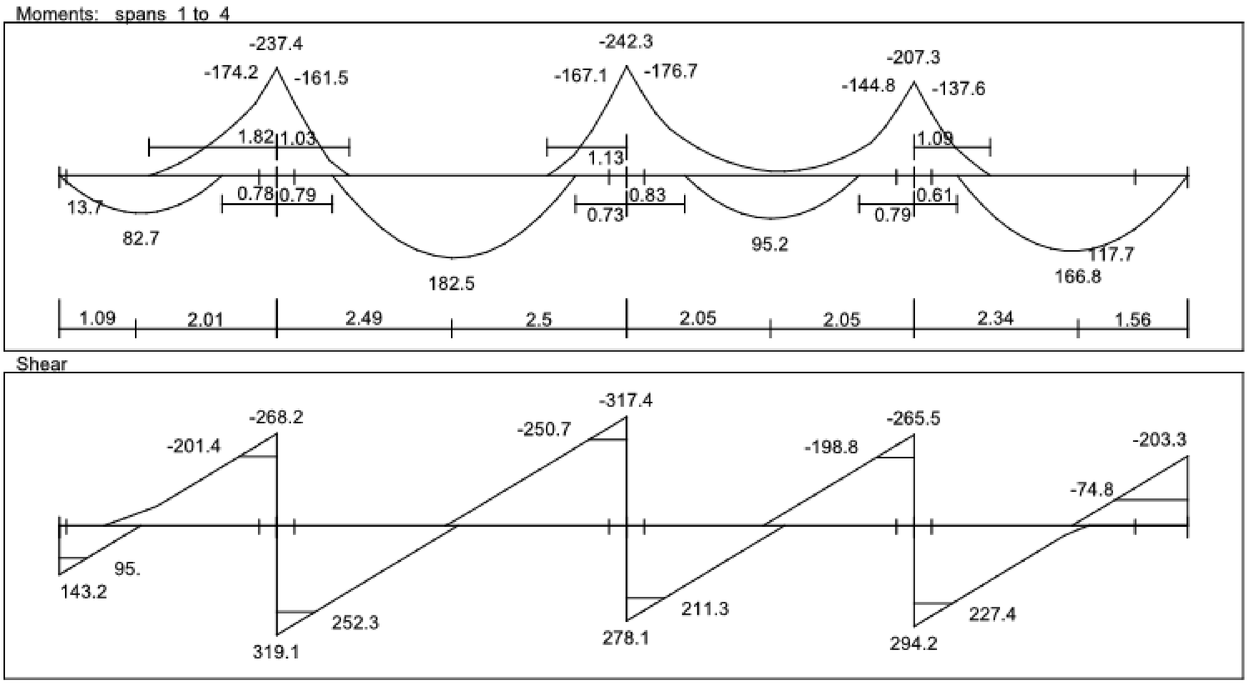


Fig 4.6: Shear and Moment Envelope Diagram of Beam (B 19).

✓ Moment Design for (B19): -

Flexural Design of Positive Moment for(B19) :-(Mu=82.7KN.m)

Determine of $M_{n,max}$

d =350 – 40 -10 – 18\2 = 291 mm

$$x = \frac{3}{7}d = \frac{3}{7}.291 = 124.7\ mm$$

$$a = \mathcal{B}.x = 124.7 * 0.85 = 106\ mm$$

Mn_{max}= 0.85∗ f_c' ∗a *b (d - $\frac{a}{2}$) = 0.85*24*106*800*(291-106/2) *10^{-6}= 411.72 KN.m

Ø Mn_{max} = 0.82* 411.72 = 337.6 KN.m >82.7 KN.m.

Design as singly reinforcement

$$Rn = \frac{M_u}{\emptyset bd^2} = \frac{82.7 \times 10^6}{0.9 \times 800 \times 291^2} = 1.35\ Mpa$$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.6$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 1.35}{420}}\right) = 0.00332$

$A_s = \rho.b.d = 0.00332 \times 800 \times 291 = 773\ mm^2$

Check for $A_{s,min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*291 = 678.9\ mm^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*291 = 776\ mm^2$ **Controls**

$A_{smin} = 776\ mm^2 > A_{sreq} = 773\ mm^2$

Use 4ø 16 Bottom, $A_{s,provided} = 804\ mm^2 > A_{s,required} = 776\ mm^2$… Ok

Check spacing: -

$S = \frac{800-40*2-20-(4\times16)}{3} = 212\ mm > d_b = 16 > 25\ mm$ ***OK***

Check for strain: -

$a = \frac{A_{s.}f_y}{0.85 b\ f_c'} = \frac{804 \times 420}{0.85 \times 800 \times 24} = 20.7\ mm$

$x = \frac{a}{\mathcal{B}_1} = \frac{20.7}{0.85} = 24.34\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{291-24.34}{24.34}\right) = 0.0329 > 0.005 \qquad \mathbf{0k}$$

Flexural Design of Positive Moment for (B19): - (Mu=182. 5KN.m)

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{182.5\times10^6}{0.9\times800\times291^2} = 3Mpa.$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times3}{420}}\right) = 0.00776$

$A_s = \rho.b.d = 0.00776\times800\times291 = 1806\ mm^2.$

Check for $A_{s,min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*291 = 678.9\ mm^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*291 = 776\ mm^2$ **Controls**

$A_s = 1806\ mm^2$

Use 6ø 20, $A_{s,provided}$= 1884 mm^2>$A_{s,required}$= 1806mm^2… Ok

Check spacing: -

$S = \frac{800-40*2-20-(6*20)}{5} = 116mm > d_b = 20 > 25$ ***OK***

Check for strain: -

$a = \frac{A_s.f_y}{0.85b\ f_c'} = \frac{1884\times420}{0.85\times800\times24} = 48.48\ mm$

$x = \frac{a}{\mathcal{B}_1} = \frac{48.48}{0.85} = 57.04\ mm$

$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{291-57.04}{57.04}\right) = 0.0123 > 0.005$ **Ok**

Flexural Design of Positive Moment for (B19) :-(Mu=95. 2KN.m)

$$Rn = \frac{M_u}{\emptyset b d^2} = \frac{95.2 \times 10^6}{0.9 \times 800 \times 291^2} = 1.56\ Mpa$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.6$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 1.56}{420}}\right) = 0.00387$$

$A_s = \rho.b.d = 0.00387 \times 800 \times 291 = 900.5\ mm^2$

Check for $A_{s,min}$:-

$$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4 * 420} * 800 * 291 = 678.9\ mm^2$$

$$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420} * 800 * 291 = 776\ mm^2$$ **Controls**

$A_s = 900.5$

Use 4ø 20, $A_{s,provided}$= 1256 mm^2>$A_{s,required}$= 900.5mm^2… Ok

Check spacing: -

$$S = \frac{800 - 40*2 - 20 - (4*20)}{3} = 206mm > d_b = 20 > 25 \qquad \boldsymbol{OK}$$

Check for strain: -

$$a = \frac{A_s.f_y}{0.85 b\ f_c'} = \frac{1256 \times 420}{0.85 \times 800 \times 24} = 32.32\ mm$$

$$x = \frac{a}{\mathcal{B}_1} = \frac{32.32}{0.85} = 38mm$$

$$\varepsilon_s = 0.003\left(\frac{d - x}{x}\right) = 0.003\left(\frac{291 - 38}{38}\right) = 0.0199 > 0.005 \qquad \boldsymbol{0k}$$

Flexural Design of Positive Moment for (B19) :-(Mu=166. 8KN.m)

$$Rn = \frac{M_u}{\emptyset b d^2} = \frac{166.8 \times 10^6}{0.9 \times 800 \times 291^2} = 2.735\ Mpa$$

$$m= \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.6$$

$$\rho= \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 2.735}{420}}\right) = 0.00702$$

$A_s = \rho.b.d = 0.00702 \times 800 \times 291 = 1634.256\ mm^2$

Check for $A_{s,min}$:-

$$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*291 = 678.9\ mm^2$$

$$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*291 = 776\ mm^2$$ **Controls**

A_s = 1634.256 mm2Controls

<u>Use 6ø 20 Bottom, $A_{s,provided}$= 1884 mm^2>$A_{s,required}$= 1634.256 mm^2… Ok</u>

Check spacing: -

$$S = \frac{800-40*2-20-(6\times20)}{5} = 116\ mm > d_b = 20 > 25\ mm \quad \boldsymbol{OK}$$

Check for strain: -

$$a = \frac{A_{s}.f_y}{0.85 b\ f_c'} = \frac{1886 \times 420}{0.85 \times 800 \times 24} = 48.48\ mm$$

$$x= \frac{a}{\mathcal{B}_1} = \frac{48.48}{0.85} = 57.04\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{291-57.04}{57.04}\right) = 0.0123 > 0.005 \quad \boldsymbol{0k}$$

Flexural Design of Negative Moment for (B19) :-(Mu=174.2 KN.m)

$$Rn = \frac{M_u}{\emptyset b d^2} = \frac{174.2 \times 10^6}{0.9 \times 800 \times 291^2} = 2.85\ Mpa$$

$$m= \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$$

$$\rho= \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times2.85}{420}}\right) = 0.00734$$

$A_s = \rho.b.d = 0.00734\times800\times291 = 1709 mm^2$

Check for $A_{s,min}$:-

$$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*291 = 678.9\ mm^2$$

$$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*291 = 776\ mm^2$$ **Controls**

A_s =**1709** mm^2**Controls**

Use 6ø 20 Bottom, $A_{s,provided}$= 1884 mm^2>$A_{s,required}$= 1709 mm^2… Ok

Check spacing: -

$$S = \frac{800-40*2-20-(6\times20)}{5} = 116\ mm > d_b = 20 > 25\ mm \quad \boldsymbol{OK}$$

Check for strain: -

$$a = \frac{A_{s}.f_y}{0.85 b\ f_c'} = \frac{1886\times420}{0.85\times800\times24} = 48.48\ mm$$

$$x= \frac{a}{\mathcal{B}_1} = \frac{48.48}{0.85} = 57.04\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{291-57.04}{57.04}\right) = 0.0123 > 0.005 \quad \boldsymbol{Ok}$$

Flexural Design of Negative Moment for (B19) :-(Mu=176.7 KN.m)

$$Rn = \frac{M_u}{\emptyset b d^2} = \frac{176.7 \times 10^6}{0.9 \times 800 \times 291^2} = 2.9\ Mpa$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.6$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 2.9}{420}}\right) = 0.00748$$

A_s = ρ.b.d = 0.00748×800×291 = 1741mm^2

Check for $A_{s,min}$:-

$$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*291 = 678.9\ mm^2$$

$$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*291 = 776\ mm^2$$ **Controls**

A_s =**1741** mm^2**Controls**

Use 6ø 20 Bottom, $A_{s,provided}$= 1884 mm^2>$A_{s,required}$= 1741 mm^2… Ok

Check spacing: -

$$S = \frac{800-40*2-20-(6\times20)}{5} = 116\ mm > d_b = 20 > 25\ mm \quad \boldsymbol{OK}$$

Check for strain: -

$$a = \frac{A_s.f_y}{0.85 b\ f_c'} = \frac{1886 \times 420}{0.85 \times 800 \times 24} = 48.48\ mm$$

$$x = \frac{a}{\mathcal{B}_1} = \frac{48.48}{0.85} = 57.04\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{291-57.04}{57.04}\right) = 0.0123 > 0.005 \quad \boldsymbol{0k}$$

Flexural Design of Negative Moment for (B19) :-(Mu=144.8 Kn.m)

$$Rn = \frac{M_u}{\emptyset b d^2} = \frac{144.8 \times 10^6}{0.9 \times 800 \times 291^2} = 2.375\ Mpa$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.6$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 2.375}{420}}\right) = 0.00603$$

$A_s = \rho.b.d = 0.00484 \times 800 \times 291 = 1403\ mm^2$

Check for $A_{s,min}$:-

$$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*291 = 678.9\ mm^2$$

$$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*291 = 776\ mm^2$$ **Controls**

$A_s = 1403\ mm^2$ **Controls**

Use 6ø 20 Bottom, $A_{s,provided}$= 1884 mm^2>$A_{s,required}$= 1403 mm^2… Ok

Check spacing: -

$$S = \frac{800-40*2-20-(6\times20)}{5} = 116\ mm > d_b = 20 > 25\ mm \quad \boldsymbol{OK}$$

Check for strain: -

$a = \frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{1886 \times 420}{0.85 \times 800 \times 24} = 48.48\ mm$

$x = \frac{a}{\mathcal{B}_1} = \frac{48.48}{0.85} = 57.04\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{291-57.04}{57.04}\right) = 0.0123 > 0.005 \qquad \mathbf{0k}$$

✓ **Shear Design for (B19): -**

1. **Case 3: -**

for shear design, minimum shear reinforcement is required ($A_{v,min}$), Reinforcement.

Use stirrups (2 leg stirrups) ø 8/ 150 mm, $A_v = 2 \times 50.24 = 100.5\ mm^2$

1. **V_u = 204.2 KN**

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \frac{1}{6}\sqrt{24} * 800 * 291 = 190.08$ KN

$\Phi\ V_c = 0.75*190.08 = 142.56$ KN

Φ Vsmin$\geq$ 0.75 ($\frac{1}{3}$) * bw * d =0 .75* ($\frac{1}{3}$)*800*291*10^{-3} = 58.2 KN **Controls**

Φ Vsmin $\geq$ 0.75 ($\frac{\sqrt{fc'}}{16}$) * bw * d = 0.75*($\frac{\sqrt{24}}{16}$) * 800 * 291*10^{-3} = 53.46 KN

Φ Vc<Vu $\leq$ Φ Vc + Φ Vsmin

142.5<252.3 ≤ 200.7…… not satisfied

Cases 1&2&3 is not suitable

Case 4: -

$v_{s'} = \frac{1}{3}\sqrt{fc'}b_w\ d = \frac{1}{3}\sqrt{24} * 800 * 291 = 380.16$ KN

$\emptyset(v_c + v_{s,\min)} < v_u \leq \emptyset(v_c + v_{s'})$

0.75(142.5+ 58.2) <204.2< 0.75(142.5 + 380.16)

150.525 <252.3 <392

shear reinforcement is required

Use 2 leg Φ 10

As =158 mm^2

$V_s = V_n - V_c = \frac{252.3}{0.75} - 142.5 = 193.9$KN

$$S = \frac{A_v f_{yt}\, d}{v_s} = \frac{158 * 420 * 291}{193.9 * 1000} = 100\ mm \quad \boldsymbol{control}$$

$$s_{max} \leq \frac{d}{2} = \frac{291}{2} = 145.5\ mm \qquad or \qquad s_{max} \leq 600\ mm$$

Use 2 leg Φ 10 @100mm

4.7 Design of Column (O12):

The total live and dead load

LL=270   DL=1580

P_{uTotal} = 2328 KN(factored)

fc= 24Mpa   fy=420Mpa

(4.7.1) Check the slenderness effect:

(Non-sway system braced, K=1)

$\left(\frac{M_1}{M_2}\right) = 1 \quad breced\ frame\ with$ M min

$$\frac{kL_u}{r} < 34 - 12\left(\frac{M_1}{M_2}\right) \leq 40$$

rx = $\sqrt{\frac{I}{A}} \approx 0.3h = 0.3 \times 0.5 = 0.15$

ry = $\sqrt{\frac{I}{A}} \approx 0.3h = 0.3 \times 0.5 = 0.15$

L_u = 5.0 m

$\frac{\mathrm{kL_u}}{\mathrm{rx}} = \frac{1 * 5.0}{0.15} = 33 > (34 - 12) = 22$ So the column is long at x axis

$\frac{\mathrm{kL_u}}{\mathrm{ry}} = \frac{1 * 5.0}{0.15} = 33 > (34 - 12) = 22$ So the column is long at y axis

e_{min} = (15+0.03h)= 15 + 0.03*500= 30mm

Ec = 4700 √24 = 23025 Mpa

Ig = $bh^3/12$ = 5.2*10^9 mm^2

B_{dns}= 1.2(1580)/((1.2*1580)+(1.6*270)) = 0.814

EI = $\frac{0.4*23025*5.2}{1+0.814}$ = 26395 $KN.m^2s$

P_c= π^2*26395/$(1*5)^2$ =10400 KN

Cm = 0.6+0.4(1) = 1

δns= 1/(1-(2328/(0.75*10400))) = 1.4

M_2 = M_{min} = Pu * emin = 2328*0.03 = 69.84 KN.m

Mc= δns*M_2 = 1.4*69.84 = 97.7 KN.m

e=emin * δns = 42

e/h = 0.084

$\emptyset \frac{pn}{Ag} = \frac{Pu}{Ag}$ = 2328*1000*0.145/(500*500) = 1.35 ksi

$\rho = 0.0123$

Check in Bresler equation:

P_{ux} = $\frac{1.35*500*500}{0.145}$*$10^{-3}$ = 2327.6

P_{uo} = ∅Pno = ∅A_g [$0.85f_c'(1-\rho_g) + \rho_g f_y$]

= 0.65*500*500[0.85*24(1-0.0123) +0.0123*420] *10^{-3} = 2246.7 KN

Substituting P_{ux}, P_{uy}, P_{uo} in Bresler equation:

$$\frac{1}{\phi P_n} = \frac{1}{P_{ux}} + \frac{1}{P_{uy}} - \frac{1}{P_{uo}}$$

$$\frac{1}{\emptyset pn} = \frac{1}{2327.6} + \frac{1}{2327.6} - \frac{1}{2246.7}$$

$\emptyset pn$ = 2416 KN > P_u = 2328 KN ……… OK.

Ast = $\rho * Ag = 0.031 * 500 * 500 = 7750\ mm2$

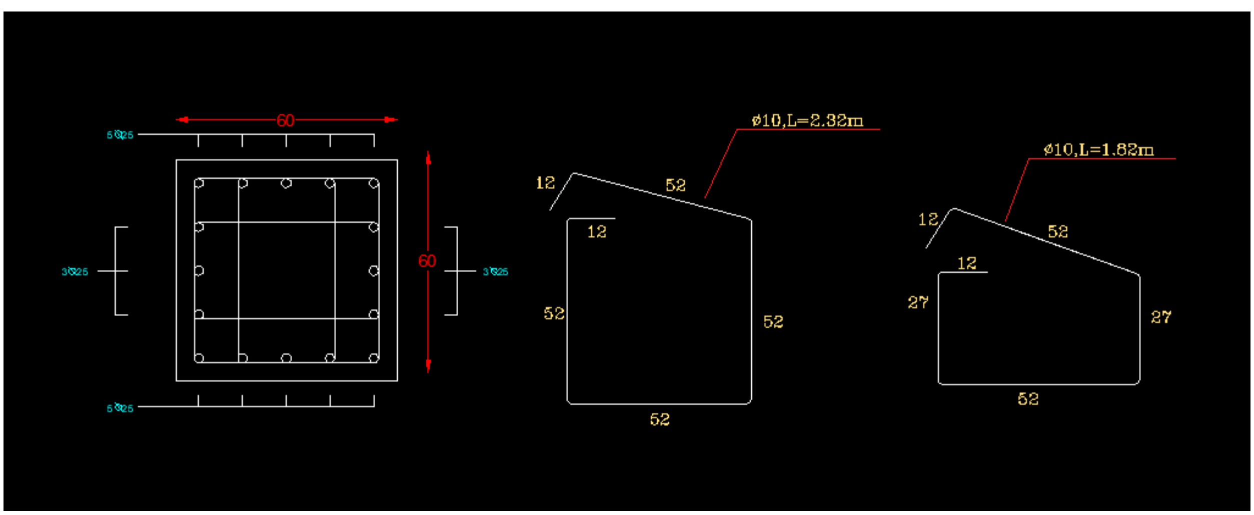
Try 16 Ø 25 = 7840 mm^2 …… OK

(4.7.2) Design the stirrups:

The spacing of ties shall not exceed the smallest of:

- $16\times d_b$ = 16×25 =400 mm control.
- $48\times d_s$ =48 ×10 =480 mm
- Least diminetion of the column = 500 mm

Use ϕ10@200mm.



Fig(4-14) :Column section and reinforcement

(4.7.3) Check for code requirements:

clear spacing between longitudinal bars = $\frac{500-40\times2-10\times2-5*25}{5} = 55mm$

55 mm > 40mm

>1.5 d_b= 37.5 mm

- gross reinforcement ratio = 0.031 $0.01 \leq 0.031 < 0.08$ ok

- NO of bars = 16> 4 bars for square columns.

- min ties diameter: ϕ10 for ϕ32 longitudinal bars and smaller.

4.8 Design of Mat Foundation:

After we tried the isolated footings under all columns the relative area of the footing to the building area was more than 70% so we decided to use strip footing under the theater and mat footing for the rest of the building as detailed in the attached drawings

Procedure to design Mat Footing:

Basically, the design is done based on the following equation:

$$P = \sum_i P_i = P_1 + P_2 + \cdots$$

$$q = \frac{P}{A} + \frac{M_x}{I_x} y + \frac{M_y}{I_y} x \leq q_{allow,net}$$

Where

$A -$ area of the raft $(B \times L)$

$I_x -$ moment of inertia of the raft about x −axis $I_x = \frac{BL^3}{12}$

$I_y -$ moment of inertia of the raft about y −axis $I_y = \frac{LB^3}{12}$

$M_x -$ moment of the applied loads about the x −axis, $M_x = Pe_y + M_{x(lateral\ load)}$

$M_y -$ moment of the applied loads about the y −axis, $M_y = Pe_x + M_{y(lateral\ load)}$

Where e_x and e_y, are the eccentricities of the resultant from the center of gravity of the raft.

The coordinates of the eccentricities are given by:

$$X' = \frac{P_1x_1 + P_2x_2 + P_3x_3 + \cdots}{P}, \qquad Y' = \frac{P_1y_1 + P_2y_2 + P_3y_3 + \cdots}{P}$$

Where $x_1,\ x_2, \ldots$ are the $x-$ coordinates of $P_1,\ P_2, \ldots$

$$e_x = X' - \frac{B}{2}$$

Where $y_1,\ y_2, \ldots$ are the $y-$ coordinates of $P_1,\ P_2, \ldots$

$$e_y = Y' - \frac{L}{2}$$

To draw the shear and moment diagrams we can divide the raft into several strips in the x-direction and in y-direction. The soil pressure at the center-line of the strip is assumed constant along the width of the strip.

Design each strip for shear and flexure as in the continuous footing design.

For the reinforcement details see the attached architectural drawings.

4.9 Design of stair:

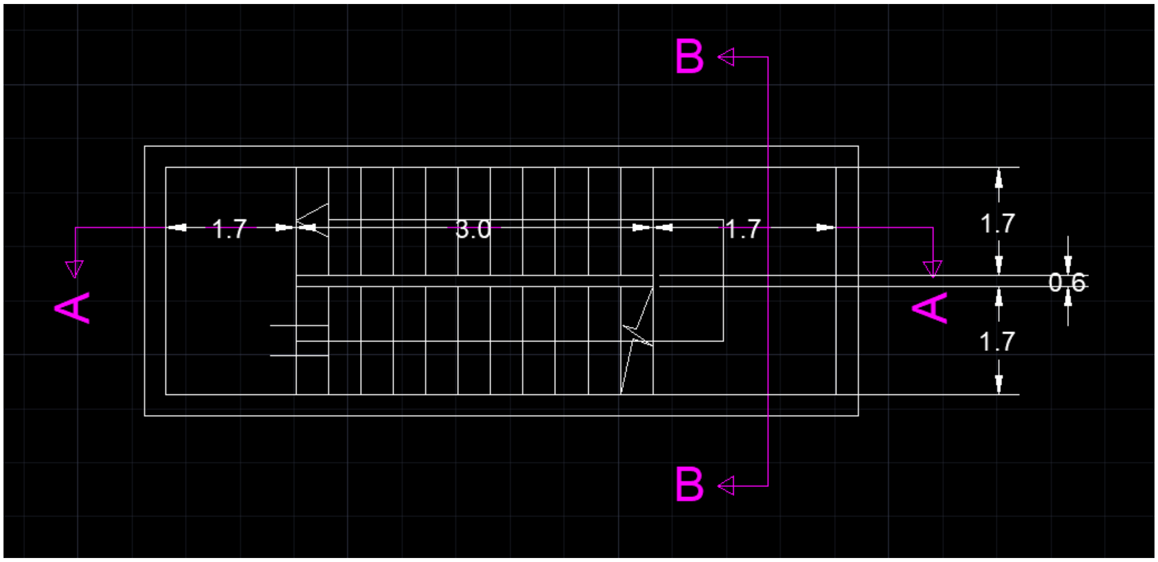


Figure (4-19): Top view of stair

(4.9 .1) Determination of Slab Thickness:

L = 7.16m.

h_{req} = 7.16/ 20 **= 35.8**

⇒ **Use h = 40cm**.

θ = $\tan^{-1}$(175 / 300) = 30.25

Cos θ = 0.864

(4.9.2) Load Calculations at section :

- Load on Flight:

Dead Load:

For 1m strip:

Flight = (25*0.4)/(Cos30.25) = 11.57 KN/m.

Horizontal Mortar = 0.03*22*1 = 0.66 KN/ m.

Plaster =(0.02*22)/ (Cos 30.25) = 0.51 KN/ m.

Horizontal tiles =23*0.03 = 0.7 KN / m.

Vertical tiles =22*0.03*(17.5/30) =0.38 KN/m

Triangle = 25*0.175*1*0.5 = 2.16 KN/m

Total dead load = 15.98 KN/ m.

- Load on landing:

Dead Load:

Tiles = 0.03*23*1 = 0.69 KN/m.

Mortar = 0.02*22*1= 0.44 KN/ m.

Plaster = 0.02*22*1 = 0.44 KN/ m.

Slab = 0.4*25*1 = 10 KN/ m.

Sand = 16*0.07*1= 1.12 KN/m

Total dead load =12.69 KN/ m.

Live load:

Live load for stairs =5 KN/ m^2.

Factor Loads:

W= 1.2*15.98+1.6*5= 27.18 KN/ m^2.

W= 1.2*12.69+1.6*5= 23.23 KN/ m^2.

(4.9.3) Design of Shear:

Assume Ø 12 for main reinforcement: -

So, d = 400-20 -12\2 =374 mm

Vu =60.5-11.615*(0.15+0.374) = 54.42 KN.

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

$$\phi Vc = \frac{0.75 * \sqrt{24} * 1000 * 374}{6} = 229.03KN$$

Vu = 54.42 KN= 229.03 KN. $\phi Vc <$

No shear Reinforcement is required. So the depth of the stair is OK.

(4.9.4) Design of Bending Moment:

Max Mu =60.5*($\frac{6.4}{2}$)-11.62*1.7* ($\frac{1.7+3}{2}$) - 27.18* $\frac{3}{2}$ * $\frac{3}{4}$ = 116.60 KN.m.

Mn= $\frac{Mn}{0.9} = 129.5 KN.m/m$

Assume Ø 12 for main reinforcement: -

So, d = 400-20 -12\2 =374 mm

$$K_n = \frac{Mn}{b \cdot d^2}$$

$$Kn = \frac{129.5 * 10^6}{1000 * 374^2} = 0.95MPa \; .$$

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

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

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mk_n}{f_y}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 0.95}{420}}\right) = 0.00232$$

As_{req} = 0.00232*1000*374 = 868 mm^{2}.

$As_{\min} = 0.0018 * b * h = 0.0018 * 1000 * 40 = 720 mm$

$As_{\min}$ = 720mm$\leq As_{req}$ = 868 mm^2

Use Φ 12@ 12.5 cm

As provided = 904 mm^2>As req.

Check Strain:

T=C

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

420*904 = 0.85*24*1000*a

a=18.61 mm

x=21.89 mm

€s = 0.048 >0.005

So ϕ=0.9

5 -Lateral reinforcement:

As min =7.2 cm^2

Use Φ10 @ 10 cm

As = 7.9 cm^2**/m**

(4.9.5) Design of landing:

Mu max = 38.1 KN.m

(4.9.6) Design of Bending Moment:

Mu = 38.1 KN.m

Mn = Mu / 0.9 =38.1 / 0.9 = 42.28 KN.m.

d = 374mm.

$$K_n = \frac{Mn}{b \cdot d^2}$$

$$k_n = \frac{42.28 * 10^6}{1000 * 374^2} = 3..02 MPa \ .$$

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

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

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mM_n}{f_y}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 3.02}{420}}\right) = 0.0078$$

As_{req} = 0.0096*1000*374 = 2925mm^2

$As_{min} = 0.0018 * b * h = 0.0018 * 100 * 40 = 720$ mm2

As_{min} = 720mm$^2 \leq As_{req}$ = 2925 mm^2

Use Φ 16 \15cm

As = 33 cm^2 /m

Check Strain:

T=C

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

420*33 = 0.85*24*1000*a

a=67.94 mm

x=79.93 mm

€s = = 0.011 ≥ 0.005

So ϕ=0.9

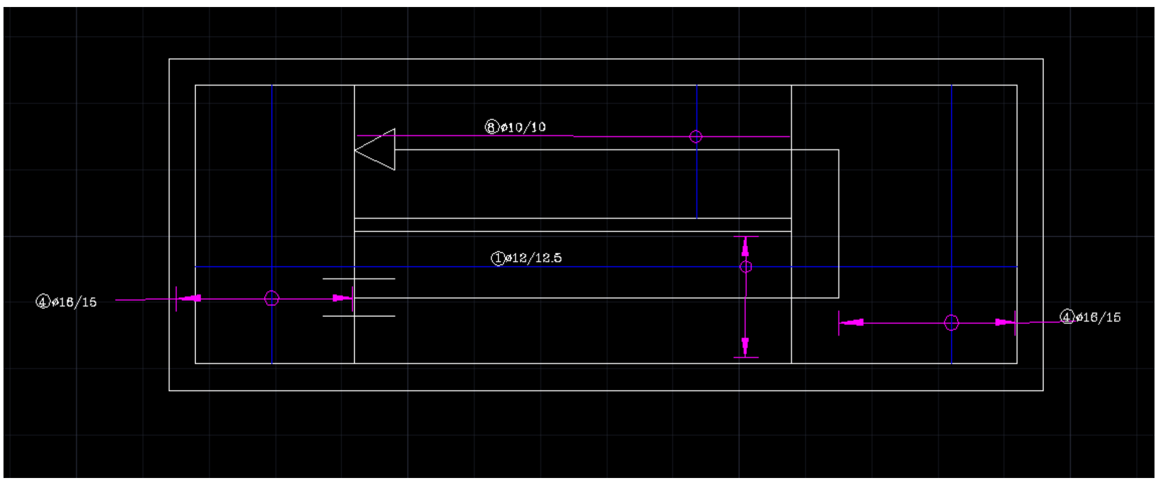


Figure (4-20): Reinforcement for stairs.

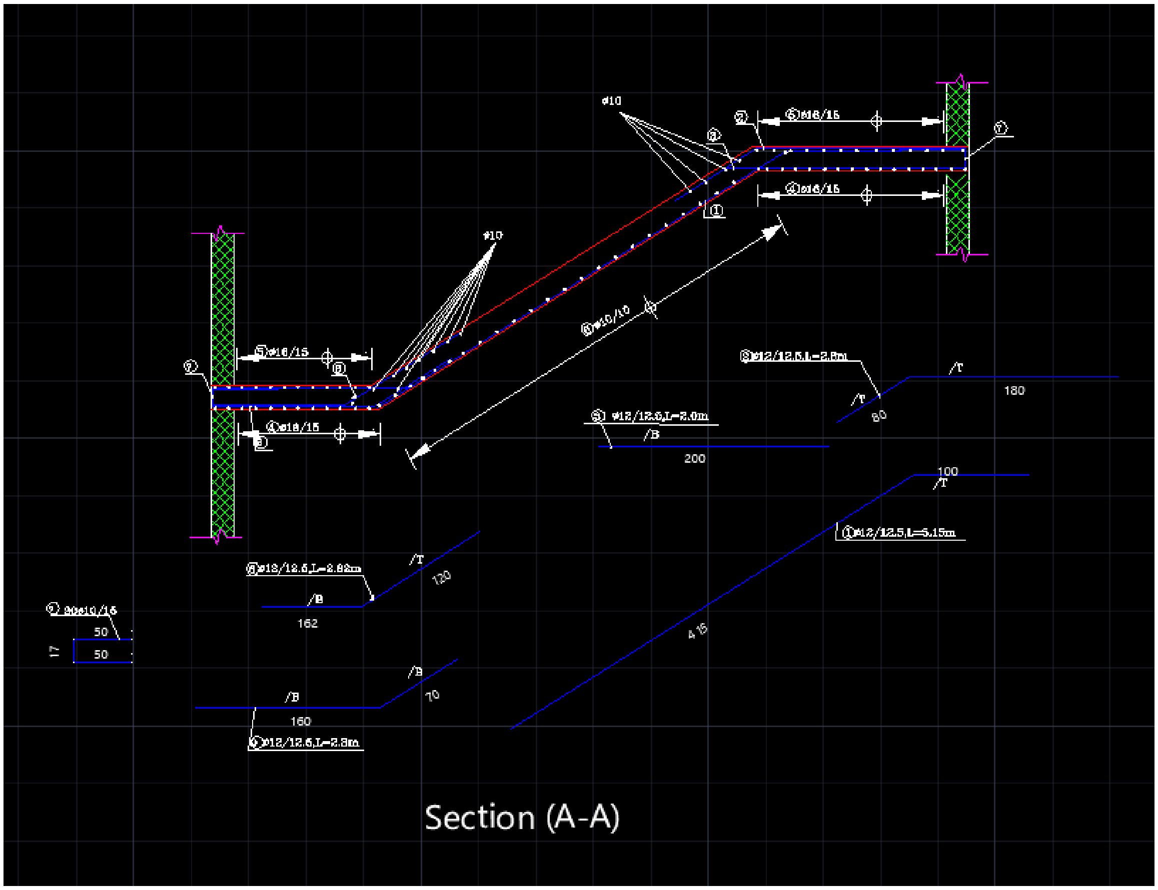


Figure (4-20): Reinforcement for stairs

4.10 Design of Basement Wall:

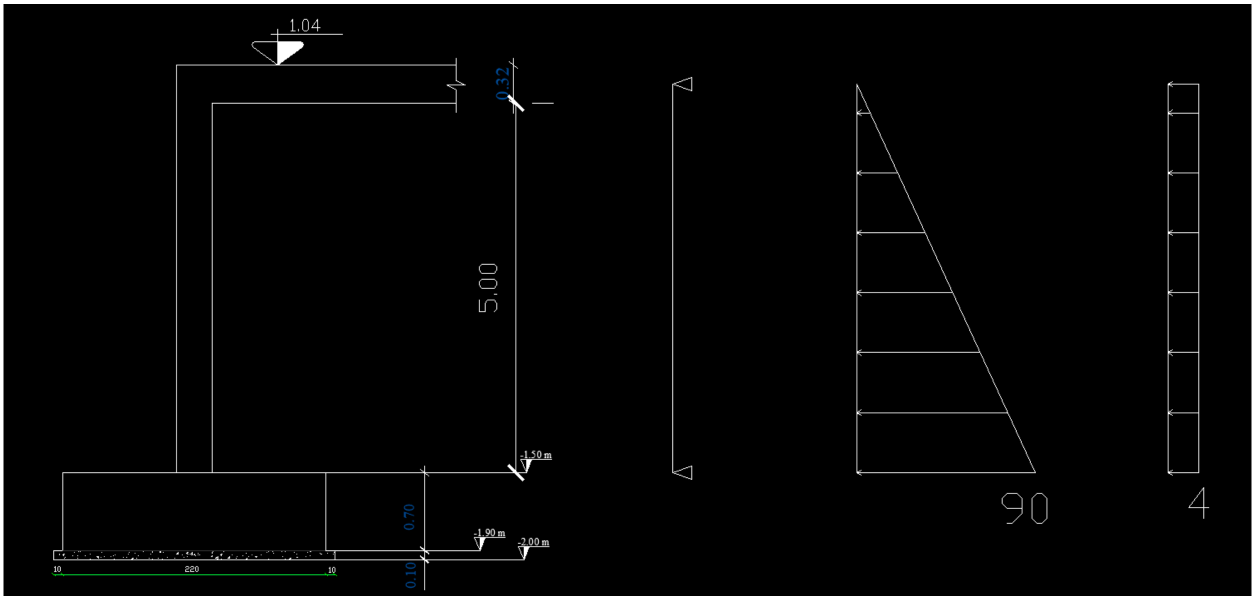


Figure (4-21): Geometry of basement.

Fc' = 24 Mpa Fy = 420 Mpa

$\emptyset = 30° \ \ \gamma = 18.00 KN/m^3$

$Ko = 1 - \sin \emptyset$

$= 1 - \sin 30 = 0.50$

4.10.1 Load on basement wall:

For 1m length of wall:

* **Weight of backfill:**

$q1 = Ko * \gamma * h$

= 0.50*18.0*5 =45 KN/m

$q_{1\ (Factored)}$ = 1.6 *45 = 72 KN/m

$*$ Load from live load:

LL=5 KN/m2

$q2 = Ko * LL$

$= 0.50 * 5 = 2.50$ KN/m

$q_{2\ (Factored)} = 1.6 * 2.50 = 4.0$ KN/m

4.10.2 Design of the shear force:

Assume h = 300 mm,

$d = 300 - 20 - 14 = 266\ mm$

Vmax =96.43 KN

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

$$\phi Vc = \frac{\phi \sqrt{24} * 1000 * 266}{6} = 162.9KN$$

Vu $\phi Vc <$

No shear Reinforcement is required.

4.10.3 Design of bending moment:

Mu max =83.6 KN.m

$$Mn = \frac{Mu}{0.9} = \frac{83.6}{0.9} = 92.9\ KN.m$$

$$Kn = \frac{Mn * 10^6}{b * d^2} = \frac{92.9 * 10^6}{1000 * 266^2} = 1.13\ Mpa$$

$$m = \frac{Fy}{0.85 * fc'} = \frac{420}{0.85 * 24} = 20.58$$

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

$$= \frac{1}{20.58} * \left(1 - \sqrt{1 - \frac{2 * 1.13 * 20.58}{420}}\right)$$

$$= 3.23 * 10^{-3}$$

$Asreq = \rho * b * d = 3.23 * 10^{-3} * 1000 * 266 = \mathbf{8.60\ cm^2/m}$

$Asmin\ = 0.0012 * b * h = 0.0012 * 1000 * 300 = 3.60\ cm^2/m$

$Amin\ \leq Areq$

Select $\mathbf{\emptyset 12@10cm/m}$

Vertical reinforcement at compression face:

As req =As min = 3.60 cm^2/m

$\mathbf{\emptyset 10@15cm/m}$

4.10.4 Design of the horizontal reinforcement:

$Asmin\ = 0.0012 * b * h = 0.002 * 1000 * 300 = 360cm^2/m$

Select$\mathbf{\emptyset 10@20cm/m}$, in two layer.

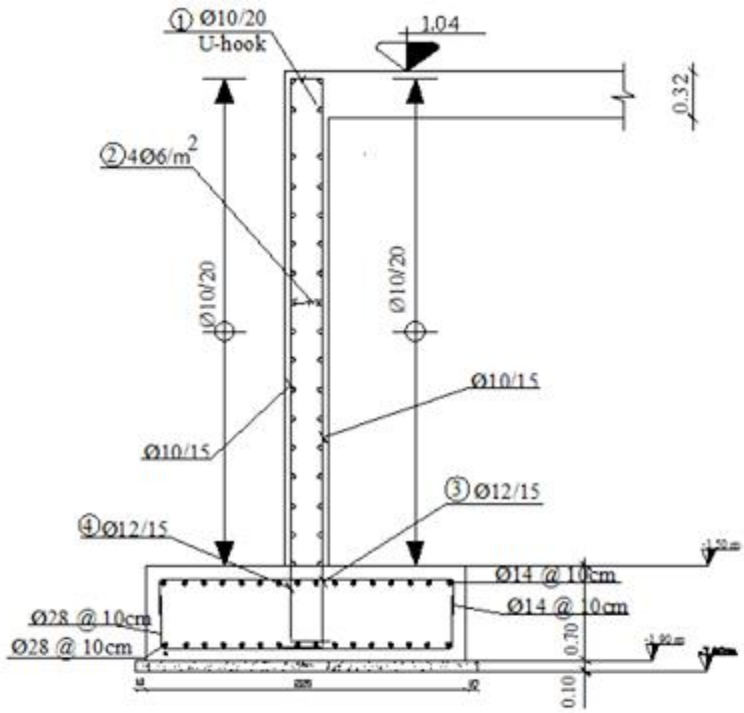


Figure (4-22): Reinforcement for Basement Wall.

4.11 Design of Shear Wall

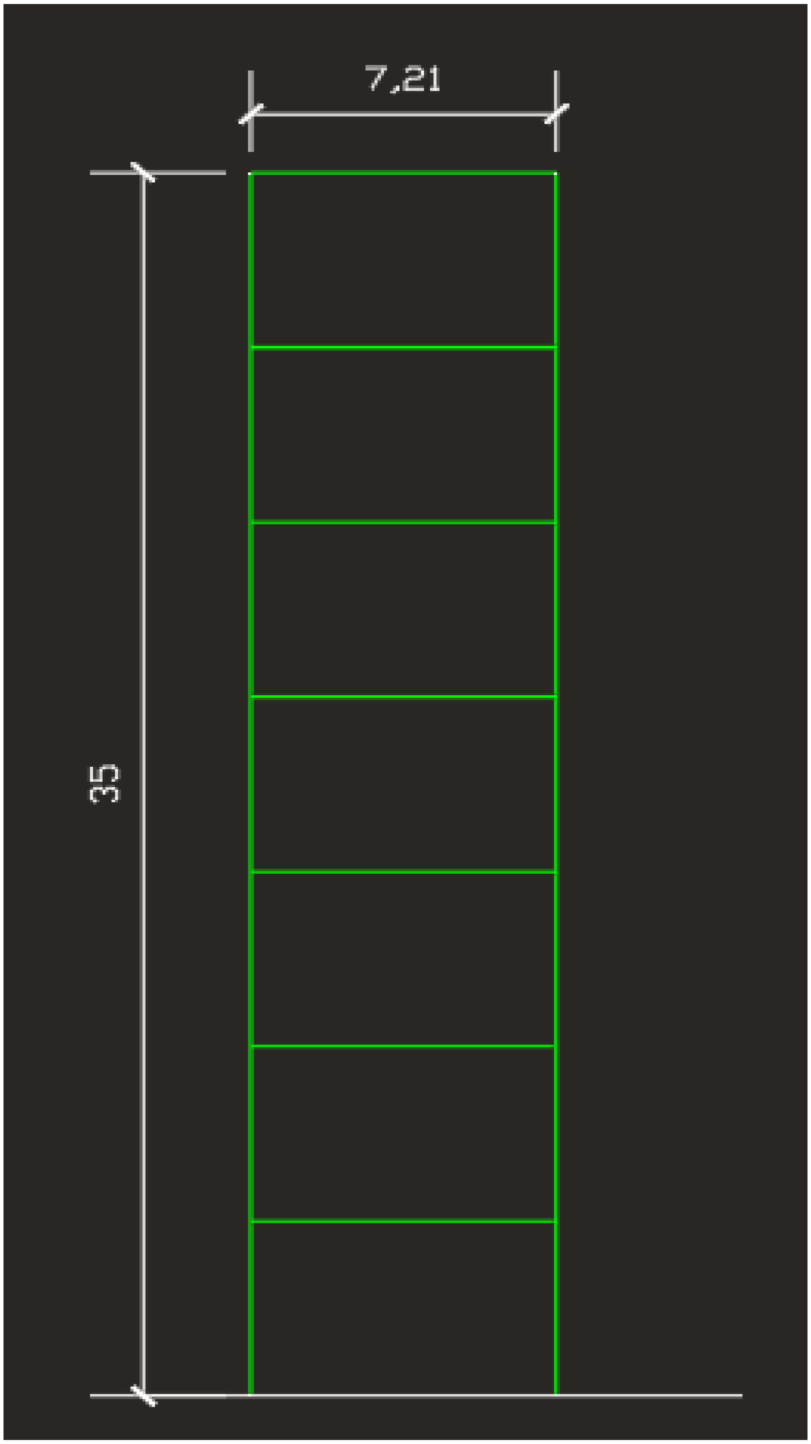


Fig 4.20: Shear Wall.

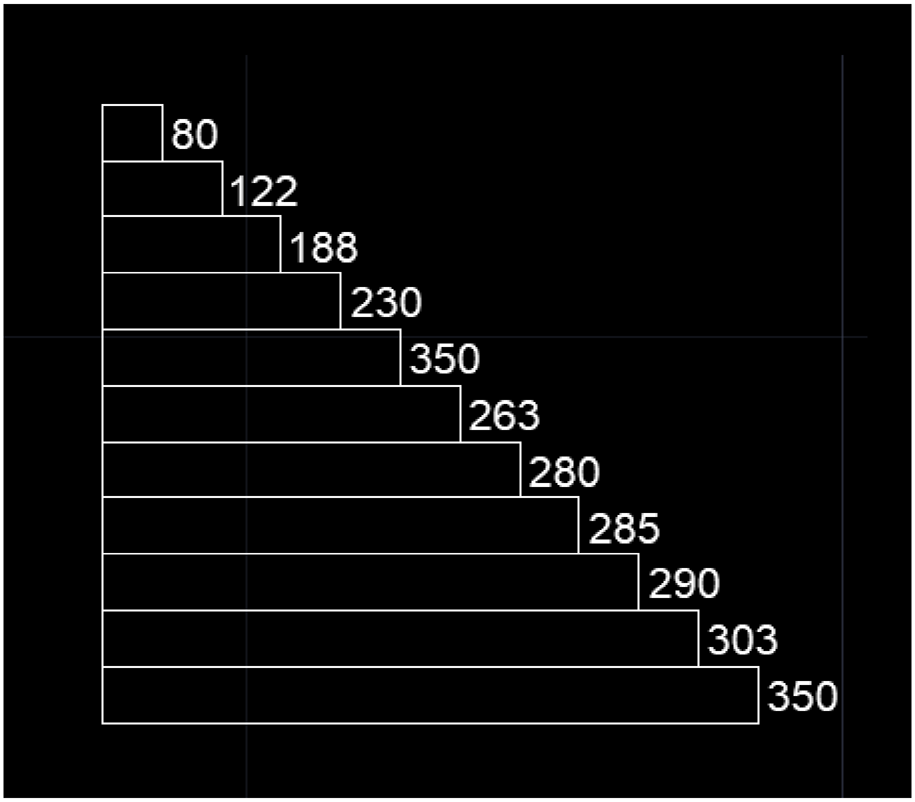


Fig 4.21: Shear Diagram of Shear Wall.

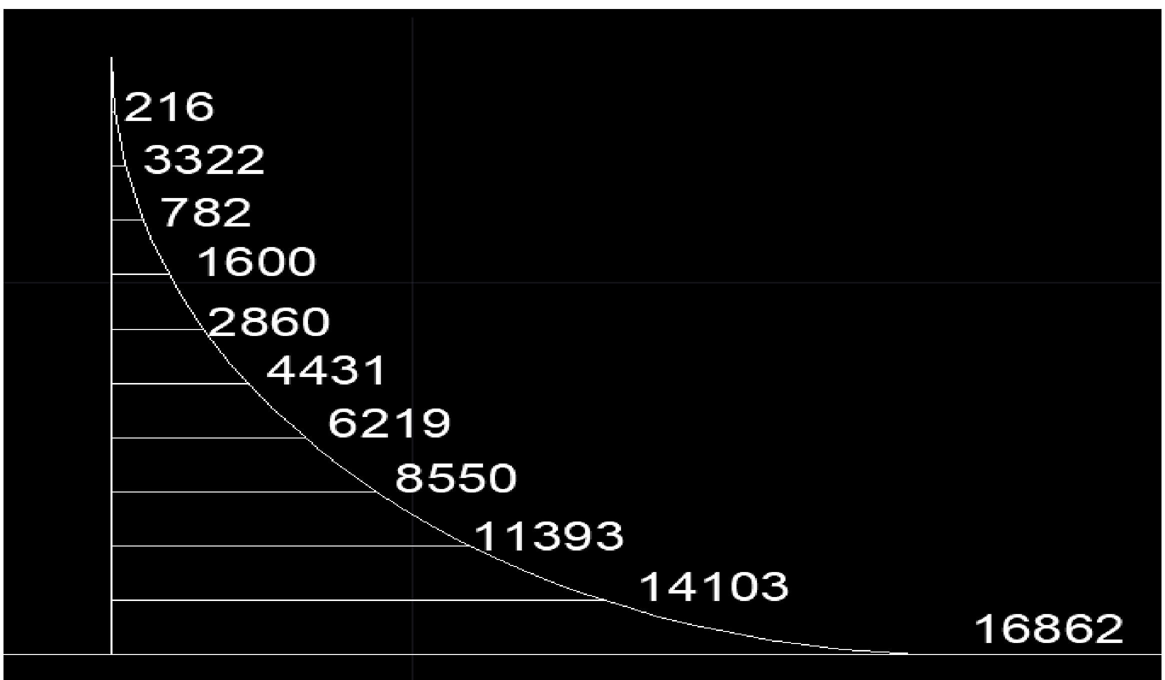


Fig 4.22: Moment Diagram of Shear Wall.

❖ Material and Sections:- (From Shear Wall 2)

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

⇒ Shear Wall Thickness h = 30 cm

⇒ Shear Wall Width Lw = 7.2 m

⇒ Shear Wall Height Hw = 35 m

✓ Design of Horizontal Reinforcement:-

$$\sum Fx = Vu = 350 \ \ KN$$

The critical Section is the smaller of:

$$\frac{lw}{2} = \frac{7.2}{2} = 3.8m$$

$$\frac{hw}{2} = \frac{35}{2} = 17.5m$$

$$storyheigh(Hw) = 4.75m........Control$$

$$d = 0.8 \times Lw = 0.8 \times 7.2 = 5.76m$$

$$\emptyset V_{nmax} = \emptyset \frac{5}{6}\sqrt{f_c{}'}hd$$

$$= 0.75 * 0.83 * \sqrt{24} * 300 * 5760 = 5270\ KN > V_u = 350KN$$

$V_c$is the smallest of:

$1-\ V_c=\frac{1}{6}\sqrt{f_c{}'}hd=\frac{1}{6}\sqrt{24}*300*5760=1410KN$ …….. Control

$2-\ V_c=0.27\sqrt{f_c{}'}hd+\frac{N_u d}{4l_w}=0.27\sqrt{24}*300*5760+0=2285KN$

$$3-\ V_c=\left[0.05\sqrt{f_c}+\frac{l_w\left(0.1\sqrt{f_c{}'}+0.2\frac{N_u}{l_w h}\right)}{\frac{M_u}{V_u}-\frac{l_w}{2}}\right]hd=1729KN$$

$$\frac{14103-11393}{4.75}=\frac{M_u-11393}{4.75-3.8}\Longrightarrow M_u=11935KN.m$$

$$\frac{M_u}{V_u}-\frac{l_w}{2}=\frac{11935}{350}-\frac{7.8}{2}=30.3$$

Vc =$1410KN$

$\emptyset*vc+\emptyset vs=vu$

$\emptyset*vs$=vu-$\emptyset*vc$

Vs=vu/$\emptyset-vc$

Vs=350/0.75-1410= -943.333kn **No need reinforcement**

Minimum shear reinforcementis required:

Min(Avh/Sh)=0.0025*h

=0.0025*300=0.75

Select $\emptyset 10$,two layers

Avh=2*π*10^2/4=157 mm^2

157/Sh=0.75

Sh=157/0.75=209.33

Select Sh=200mm≤Smax=Lw/5=550/5=110 cm.

=3*h =3*30=90 cm.

✓ Design of Vertical Reinforcement:-

$$\frac{A_{vv}}{S_v} = [0.0025 + 0.5\left(2.5 - \frac{h_w}{Lw}\right)\left(\frac{A_{vh}}{S_h * h} - 0.0025\right)]*300$$

$$\frac{A_{vv}}{S_v} = [0.0025 + 0.5\left(2.5 - \frac{35}{7.5}\right)\left(\frac{226}{200*300} - 0.0025\right)]*300$$

$$\frac{A_{vv}}{S_v} = 0.301$$

Select Ø12 in Two Layer

$$A_{vh} = \frac{2*\pi*12^2}{4} = 226\text{mm2}$$

$$\frac{226}{S_v} = 0.301$$

S_v= 750 mm

- Maximum spacing is the least of:

$$\frac{Lw}{3} = \frac{7200}{3} = 2400 \text{ mm}$$

3*h = 3*300 = 900mm

450 mm ……. Control

Use ϕ12/200 mm for two layers

✓ Design of Bending Moment:-

$$A_{st} = \left(\frac{7200}{200}\right) * 2 * 113 = 8143\ mm^2$$

$$w = \left(\frac{A_{st}}{L_w h}\right)\frac{f_y}{f_c'} = \left(\frac{8143}{7200 * 300}\right)\frac{420}{24} = 0.046$$

$$\alpha = \frac{P_u}{l_w h f_c'} = 0$$

$$\frac{C}{l_w} = \frac{w + \alpha}{2w + 0.85\beta_1} = \frac{0.046 + 0}{2 * 0.046 + 0.85 * 0.85} = 0.05647$$

$$\emptyset M_n = \emptyset\left[0.5 A_{st} f_y l_w (1 + \frac{P_u}{A_{st} f_y})(1 - \frac{c}{l_w})\right]$$

$$= 0.9[0.5 * 8143 * 420 * 7200(1 + 0)(1 - 0.05647)] = 12996\ KN \geqq 11935 KN.m$$

Mub=Mu-ØMn=11935-12996= -**1061** KN.m

X≥ $\frac{lw}{600*\frac{\Delta h}{hw}}$=$\frac{7200}{600*.1}$=120 mm

Lb≥ $\frac{X}{2} = 60\ mm$

Since Smallest value of Lb & Mub not require Boundary .

CHAPTER

5

RESULTS AND RECOMMENDATIONS

5.1 RESULTS

5.2 RECOMMENDATIONS

5.3 REFERENCES

5.1 Results

1) إن فهم المخططات المعمارية له دور كبير في إيجاد الحلول الإنشائية الملائمة لنوع الاستخدام في المبنى.

2) إن القدرة على الحل اليدوي ضرورية للمصمم الإنشائي للتأكيد على حل البرامج المحسوبة وفهم طريقة عملها.

3) التعرف على العناصر الإنشائية، وكيفية التعامل معها، ومع آلية عملها، وذلك ليتم تصميمها تصميما جيدا يحقق الأمان والقوة الإنشائية

5.2 Recommendations

1) يجب أن يكون هنالك تنسيق بين المصمم المعماري والإنشائي خلال عملية التصميم حتى ينتج مبنى متكاملاً إنشائياً ومعمارياً.

2) يوصى بتنفيذ المشروع حسب المخططات المرفقة بالمشروع بأقل تغييرات ممكنة.

3) ينصح بوجود مهندس مشرف للإشراف على التنفيذ وأن يلتزم بالمخططات والشروط لضمان التنفيذ الأفضل للمشروع.

4) يجب استكمال التصميم الكهربائي والميكانيكي للمشروع قبل المباشرة في التنفيذ لإدخال أي تعديلات محتملة عليه من الناحية الإنشائية.

5.3 References

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).