Palestine Polytechnic University
College of Engineering
Civil Engineering Department

Graduation project

Structural Design for the
" Al-Samu Hospital"

Project Team

Maisa Al-Atrash & Sojoud Rjoob

Supervisor:

Eng. Inas Shweki

Submitted to the College of Engineering in partial fulfillment
of the requirements for the Bachelor degree
in Civil Engineering

Hebron - Palestine
January 2024

The undersigned hereby certify that they have read, examined, and recommended to the Department of Civil Engineering in the College of Engineering at Palestine Polytechnic University the approval of a project entitled: **Structural Design for the**

" Al-Samu Hospital " in Al-Samu City

Submitted **By Maisa Alatrash & Sojoud Rjoob** For partial fulfillment of the requirements for the Bachelor degree in Civil Engineering.

Eng. Inas Shweki (Supervisor) :

Signature:……………...………………… Date:…..……………...…………………

Project Approved by :

Dr. Ghadi Zakarneh

Head of Civil Engineering Department

Palestine Polytechnic University

Signature:……………...………………… Date:…..……………...…………………

Dr. Iyad Hashlamon

Dean of College of Engineering

Palestine Polytechnic University

Signature:……………...………………… Date:…..……………...…………………

Structural Design for the

" Al-Samu Hospital "

in Al-Samu City

Supervisor : Eng. Inas Shweki

Project Team:

Maisa Alatrash & Sojoud Rjoob .

ABSTRACT

The structural design is the most important design of the building after the architectural design necessary for the distribution of columns, walls, loads, the best prices and the highest levels of safety are the responsibility of the structural designer. In this project, a structural design will be made for Al-Samu Hospital with a total area of 9000 square meters.

The idea of this project is in the structural design of Al-Samu Hospital, the project includes the design of all the details and the necessary structural elements used in this building. This building consists of 3 floors in addition of basement floor and ground floor. Which contains the main sections of the nursing units, detection and treatment sections, outpatient clinics, general services, emergency department, radiology department, laboratories, operations and surgery department, ...etc

The project was designed using ACI-318-11 will be used in the design and we were use some of programs of structural design such as Autocad, Office, safe, Etabs, Atir...etc. We were refer to several references and graduation projects for data and design calculations. So the project was include detailed structural study, analysis of the structural elements, expected and calculated loads, the structural design of the elements required and the preparation of construction plans.

التصميم الإنشائي لِ

"مستشفى السموع"

في بلدة السموع

فريق العمل :

ميساء الاطرش و سجود رجوب

إشراف : م. إيناس شويكي

الملخص

يعتبر التصميم الإنشائي أهم تصميم للمبنى بعد التصميم المعماري اللازم لتوزيع الأعمدة والجدران والأحمال وأفضل الأسعار وأعلى مستويات الأمان تقع على عاتق المصمم الإنشائي.تدور فكرة هذا المشروع حول التصميم الانشائي لمستشفى مقترح إنشاؤه في بلدة السموع والذي تم اختياره بعد دراسة مجموعة من المشاريع المعمارية المتنوعة، وتم للشعور بالحاجة الماسة الانشاء مستشفى ، و يتألف المبنى من التمريض وأقسام الكشف والعالج والعيادات الخارجية والخدمات العامة وقسم الطوارئ وقسم االشعة والمختبرات وقسم العمليات والجراحة وغيرها.

يتكون المبنى من ثالثة طوابق إضافة إلى طابق التبوية والطابق الارضي، ويتميز التصميم المعماري المشروع بأنه تم بأسلوب يقوم على تعدد الكتل الفراغية وتوزيعها بشكل متناسق من الناحية الجمالية والوظيفية، إضافة إلى كثرة التراجعات المعمارية التي تضيف الرونق الجمالي والمعماري المبنى، إضافة أنه تم الاهتمام من قبل المصمم المعماري بعد توزيع الكتل بتوفير الراحة وسهولة وسرعة الوصول المستخدمين ، وتكمن أهمية المشروع في تنوع العناصر الانشائية في المبنى مثل الاعمدة والجسور والبالطات الخرسانية وغيرها.

تم تصميم المشروع باستخدام ACI-318-11 وتم استخدام بعض برامج التصميم الإنشائي مثل Autocad، Office، Etabs، Atir...إلخ. وتم الرجوع إلى العديد من المراجع ومشاريع التخرج للبيانات والحسابات التصميمية. لذلك تضمن المشروع الدراسة الإنشائية التفصيلية وتحليل العناصر الإنشائية والأحمال المتوقعة والمحسوبة والتصميم الإنشائي للعناصر المطلوبة وإعداد المخططات الإنشائية.

DEDICATION

To those who have always believed in us ...

To those who have been our source of inspiration ...

To those who gave us strength ...

To those who provide us their endless support and encouragement ... To our families ...

Maisa Alatrash

Sojoud Rjoob

ACKNOWLEDGEMENT

It has been a great opportunity for us to gain a lot of knowledge through working on this project, but the successful completion of any task would be incomplete without mention of the people who made it possible.

For that we would like to thank everyone who helped, supported and encouraged us:

Palestine Polytechnic University, Engineering Collage, Civil and Architectural Engineering Department, including all members of the helpful and reverend staff.

Special thanks to our supervisor **Eng. Inas Shweki**, who was the guiding light every step of the way as we worked for this project.

Thanks for all instructors for all efforts they did to provide us with all useful information and sharing their knowledge and experience to make from us successful engineers.

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

Maisa Alatrash

Sojoud Rjoob

Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

As	Area Of Non-Prestressed Tension Reinforcement.
As′	Area Of Non-Prestressed Compression 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.
d	Distance From Extreme Compression Fiber To Centroid Of Tension Reinforcement.
Ec	Modulus Of Elasticity Of Concrete.
fy	Specified Yield Strength Of Non-Prestressed Reinforcement.
h	Overall Thickness Of Member.
I	Moment Of Inertia Of Section Resisting Externally Applied Factored Loads.
ln	Length Of Clear Span , Measured Face-To-Face Of Supports In Slabs Without Beams And Face To Face Of Beam Or Other Supports In Other Cases.
M	Bending Moment.
Mu	Factored Moment At Section.
Mn	Nominal Moment.
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.
ρ	Ratio Of Steel Area.
εc	Compression Strain Of Concrete=0.003mm /Mm
Fsd,r	Total Additional Tension Force Above The Support.
Ved,0	Shear Force At Critical Section.
Vu	Factored Shear Force At Section.
Wu	Factored Load Per Unit Length.

CHAPTER 1

INTRODUCTION

1.1. Introduction
1.2. Research Problem
1.3. General Overview
1.4. Project Problem
1.5. Project Objectives
1.6. Reasons to Choose the Project
1.7. Work Procedure
1.8. Project Scope
1.9. Project Timeline
1.10. Programs Used In The Project

1.1 Introduction

Civil engineering affects many of our daily activities: the buildings we live in and work in, the transportation facilities we use, the water we drink, and the drainage and sewage systems that are necessary to our health and well-being.Civil engineering is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, airports, sewage systems, pipelines, structural components of buildings, and railways ... .

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

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 General Overview

The idea of this project is in the structural design of Al-Samu Hospital, this idea arose from the suffering experienced by the population in the Hebron Governorate and in its south in particular; Because of the lack of health services in the governorate, the idea behind the project was motivated. The importance of providing a local hospital in the study area stems from that it gives part of this shortage and provides the population with high-level health support.

This project includes the design of all the details and the necessary structural elements used in this building, which is consists of 3 floors in addition of basement floor and ground floor. Also it contains the main sections of the nursing units, detection and treatment sections, outpatient clinics, general services, emergency department, radiology department, laboratories, operations and surgery department, ...etc.

1.4 Project Problem

The problem of this project in the work of the structural design of the building that was chosen to be the field of this research, where the study was done in the work of a study of the work of equilibrium of the entire building on implementation to avoid any risk to users of this building, and in this project will be analyzed each of the elements of construction such as : beams, columns, foundations, and other structural elements, and determine the loads located on the structural elements of the loads of live or dead loads resulting from the node and the entire elements built in the structure.

As well as taking into account the safety factor of the building and that the economic aspect and enable the achievement of the highest resistance to safety, and then the work plans of the structural elements that have been designed, to move this project from the proposal to the implementation.

1.5 Project Objectives

The objectives of the project are divided into two parts:

- Architectural Goals:

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

- ❖ Structural Goals:
- ✓ Structural design of the units will be done in this project with prepare all structural drawings for beams, slabs, columns, footings and shear walls to be ready for fulfillment on the location of the project.
- ✓ Correlate the theory that has been gained in the design courses with practical life.
- ✓ Increase the ability to choose a suitable structural system of elements that meets design requirements.
- ✓ Practice the structural analysis and design programs as well as theoretical knowledge.

1.6 Reasons to Choose the Project

The reason of selecting the project back to several things, including The need to increase the experience and skill of structural design, which we studied and applied in practice by linking the relationship between the theoretical aspects that have been gained from the courses studied in this specialization, and the application of this in this project and its structural elements, and design of structural elements to suit the loads On the structural elements, taking into account the provision of durability, strength, durability and economy.

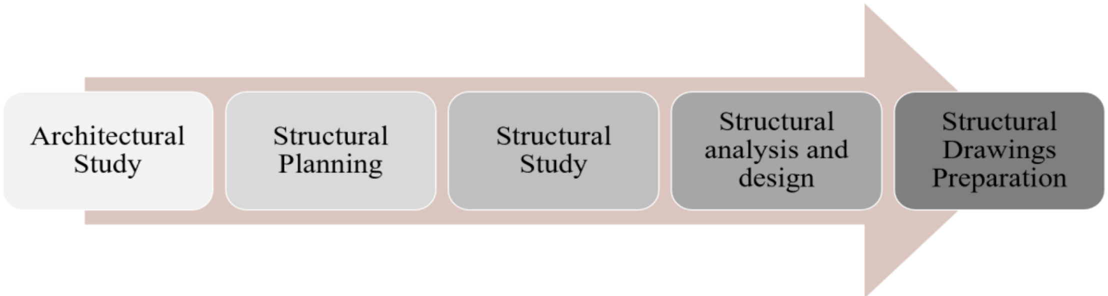
Also because this project is widely implemented in our society and the need toimplement buildings in an engineering manner.

1.7 Work Procedure

To achieve the objectives of the project following steps were followed :

1. Architectural study in which the site, building plans, and elevations were been studied.
2. Structural planning of the building, in which the location of columns, beams, and shear walls was determined to fit with architectural design.
3. Structural study in which all structural members were identified and different loads were been estimated.
4. Starting analysis and design for elements according to the ACI Code.
5. Preparation of Structural drawings of all existing elements in the building.

6. Project Writing in which all these stages were presented in detail.



Figure(1- 1) :Work Procedure

1.8 Project Scope

This Project will be contain the following Chapters :

CHAPTER 1: A general introduction.

CHAPTER 2: An architectural description of the project.

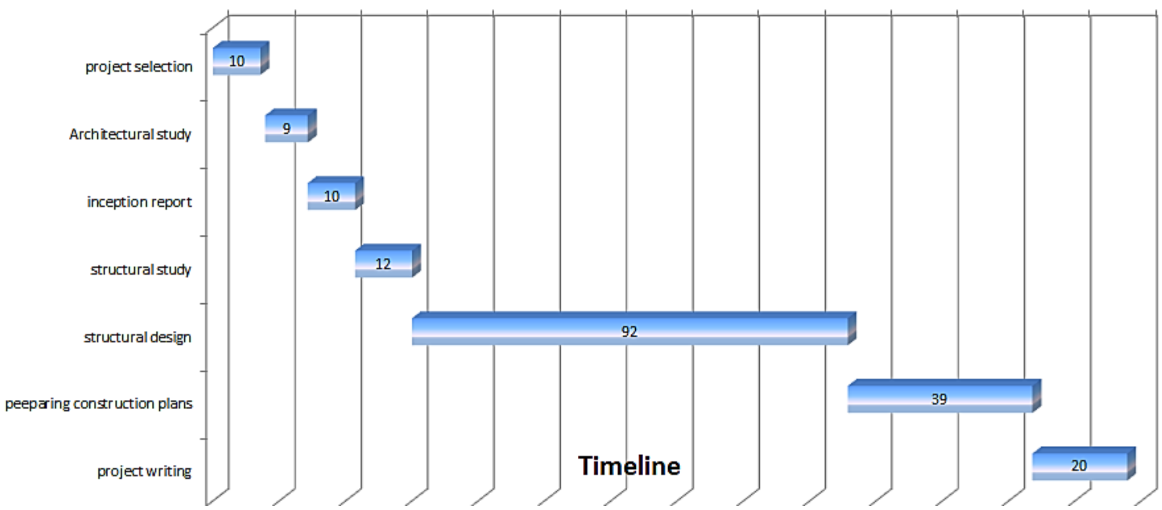
CHAPTER 3: A general description of the structural elements.

CHAPTER 4: Structural analysis and design of all structural elements.

CHAPTER 5: Results and Recommendations.

1.9 Project Timeline

The following chart shows the project plan and timeline :



Figure(1- 2):Project Timeline

1.10 Programs used in the project

There are several computer programs used in this project:

1. Microsoft Office: It was used in various parts of the project such as text writing and project output.
2. AUTOCAD 2021: for detailed drawings of structural elements.
3. ATIR18: Structural design and analysis of structural elements.
4. ETABS: Structural design and analysis of shear wall.
5. Spcolumn: Structural design and analysis of column.
6. Found: Structural design and analysis of isolated footing.

CHAPTER 2

ARCHITECTURAL DESCRIPTION

2.1. Introduction
2.2. General Identification of the project
2.3. General site description
2.4. Floors Description
2.5. Elevations Description
2.6. Sections of the building

2.1 Introduction

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

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

An Architectural study that must precede the start of architectural design must be easy to handle and understand different events that it contains building and functional relations among them, and the nature of the association movement and using these parts, and other things of importance that give a clear picture of the project and therefore it will be possible to locate the columns and other structural elements to suit architectural design.

2.2. General Identification of the project

This Hospital is located in the Al-Samu area on a plot of 12910 m 2 , with an area of approximately 9000 square meters. It consists of three floors in addition of basement floor and ground floor .

Which it contains the main sections of the nursing units, detection and treatment sections, outpatient clinics, general services, emergency department, radiology department, laboratories, operations and surgery department, meetings hall , managing ,director ,technical Director, secretarial, male sleep rooms ,doctors food hall ,children sleep room ,nursing break ,store, nursing rooms, doctor rooms ,female sleep rooms and waiting rooms ...etc.

2.3 General site description

2.4 Floors Description

1. Basement FLOOR

The basement floor consists of parking ,dead refrigerator ,administrator ,washing the dead, mechanical, kitchen store ,medicine refrigerator, kitchen refrigerator, medicine store, kitchen ,wells and electricity with an area of 2100 square metres.

2. GROUND FLOOR

The ground floor consists of waiting, tooth clinic ,outpatient clinic, reception, break, waiting, doctor rooms ,ray unit, emergency ,pharmacy, food hall ,terrace, entrance, laboratory ,sampling and store with an area of 1737 square metres.

3. FIRST FLOOR:

The firs floor consists of after birth rooms , doctor rooms ,nursing break , nursing, store, food hall, sleep rooms , birth rooms, terrace and prematurity rooms with an area of 1737 square metres.

4. Second FLOOR:

The second floor consists of male sleep rooms ,waiting ,store ,doctor rooms , break, intensive care ,operating room ,female sleep rooms ,nursing rooms and Patient anesthesia room with an area of 1737 square metres.

5. Third FLOOR:

The third floor consists of meetings hall , managing ,director ,technical Director, secretarial, male sleep rooms ,doctors food hall ,children sleep room ,nursing break ,store, nursing rooms, doctor rooms ,female sleep rooms and waiting with an area of 1737 square metres.

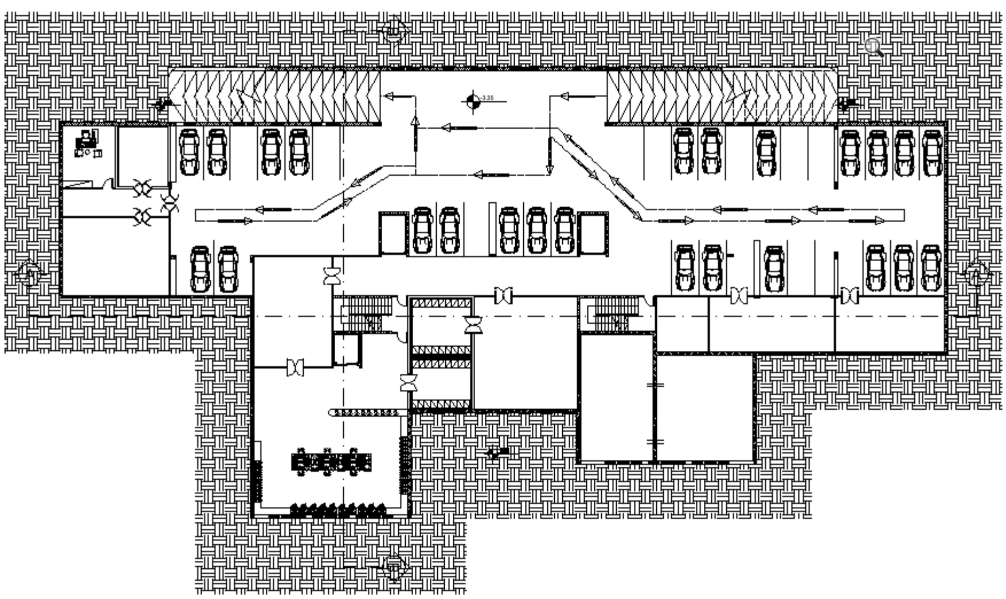


Figure (2- 2): Basement floor Plan

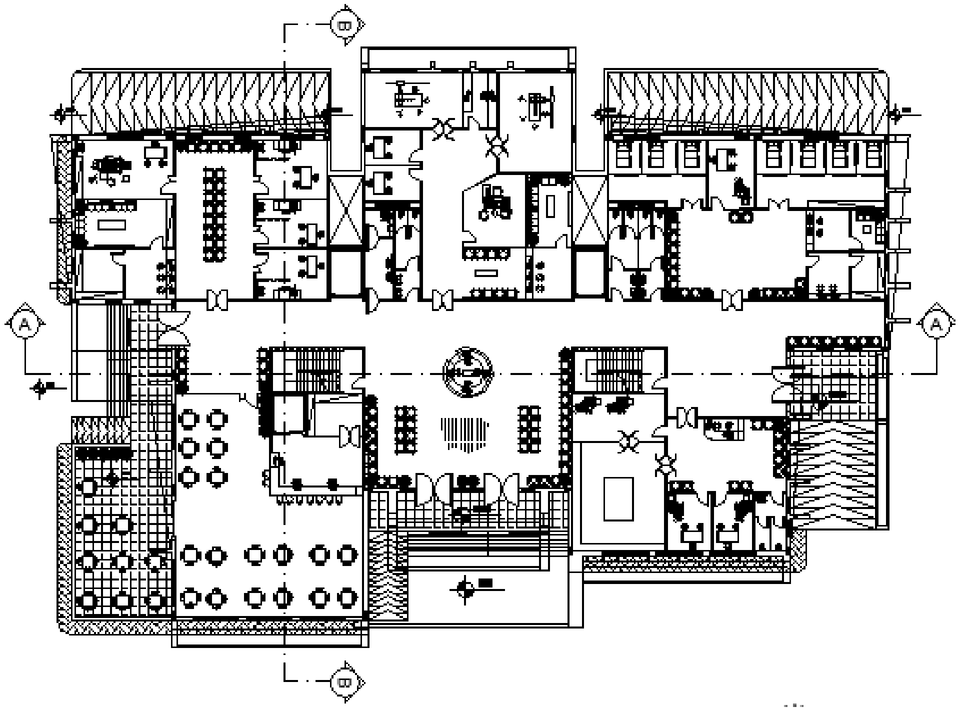


Figure (2- 3):Ground floor Plan

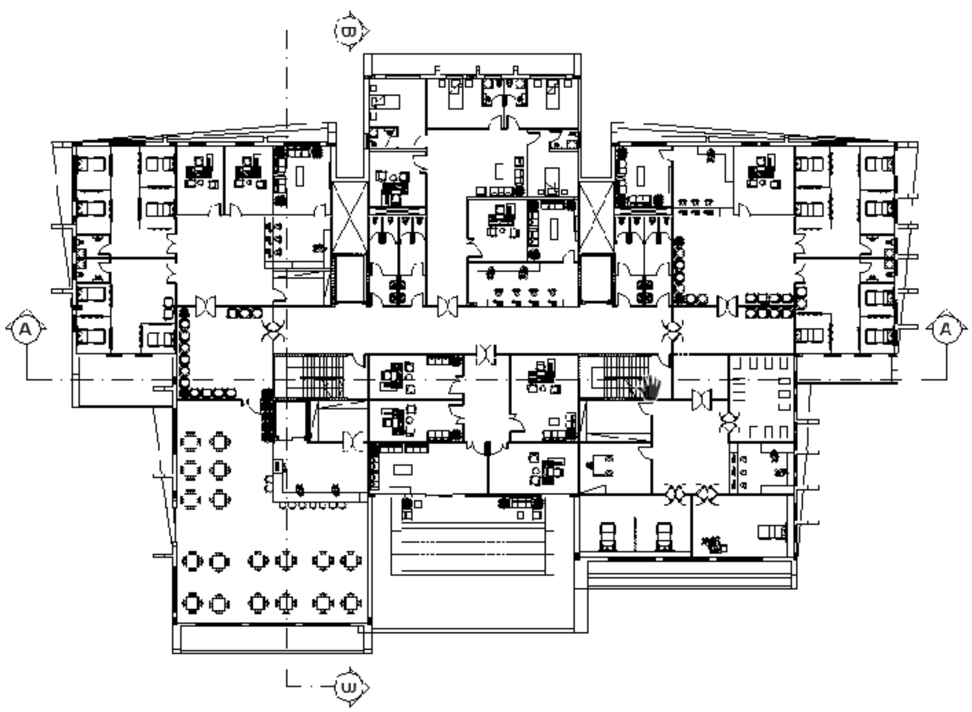


Figure (2- 4):First floor Plan

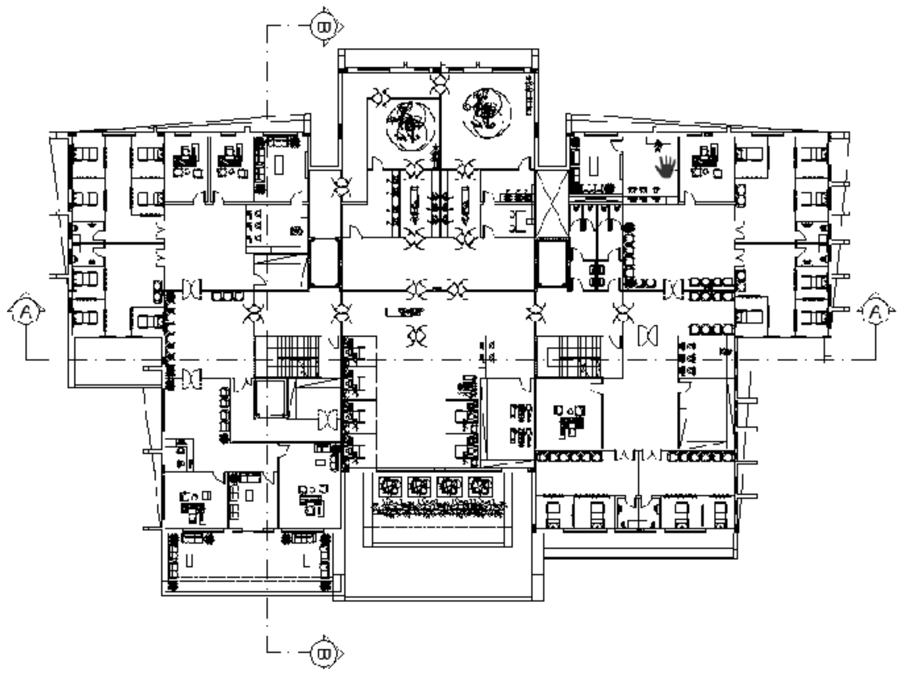


Figure (2- 5):Second floor Plan

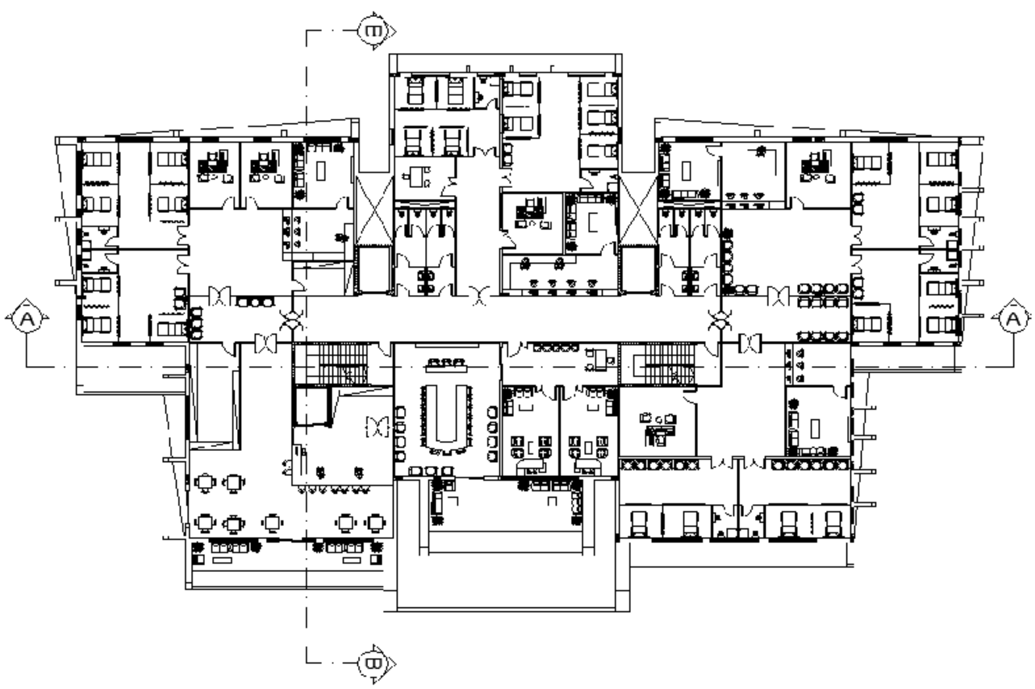


Figure (2- 6):Third floor Plan

2.5 Elevations Description

The following is a description of different elements and components of the project elevations :

- North elevation :

The northern elevation shows the main entrance to the project .

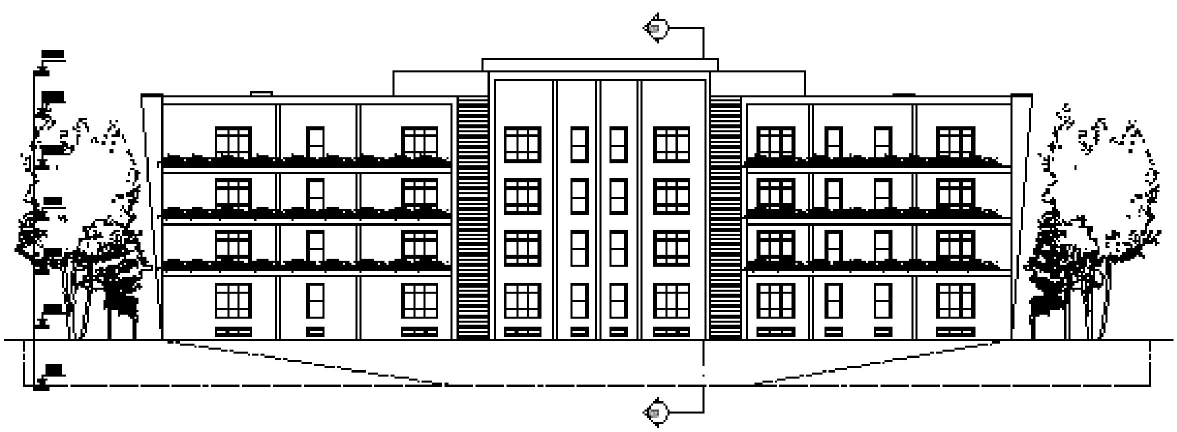


Figure (2- 7):North elevation

- South elevation:

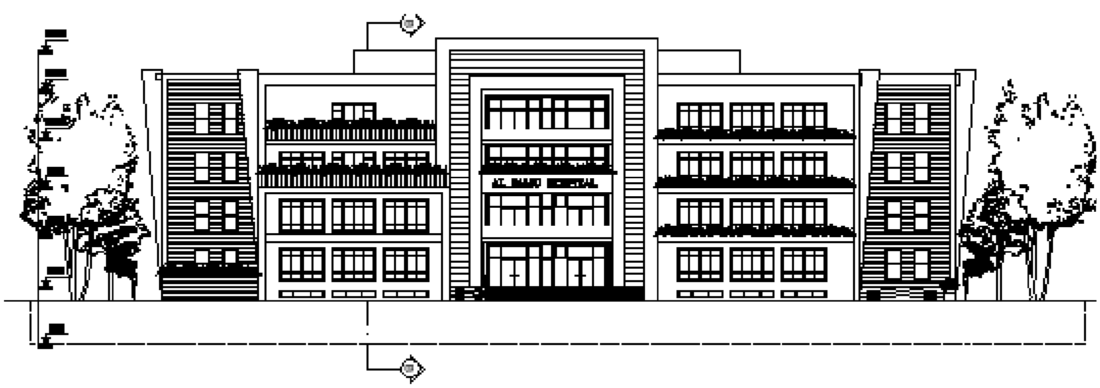


Figure (2- 8):South elevation

- East elevation:

Figure (2- 9): East elevation

- West elevation:

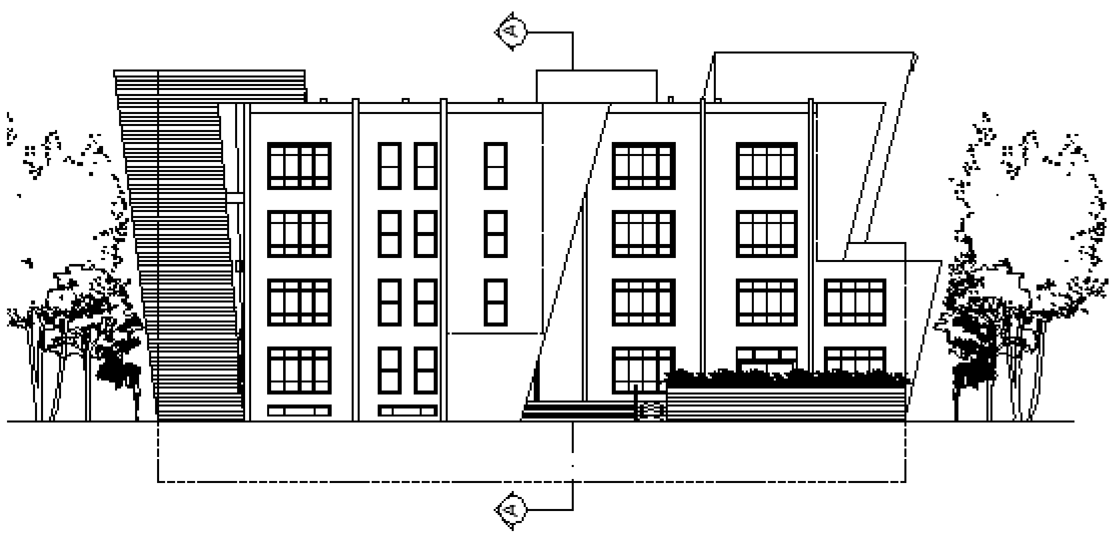


Figure (2- 10): West elevation

2.5 Sections of the building

These sections explain the movement inside the building through the stairs and elevator. It also shows more details for the heights and levels for slabs, windows, and doors.

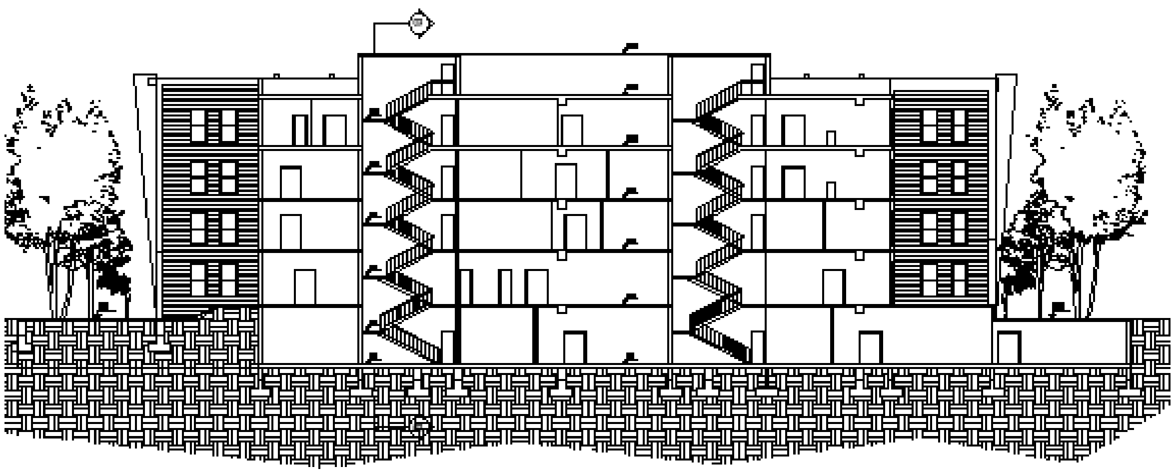


Figure (2- 11):Section A-A

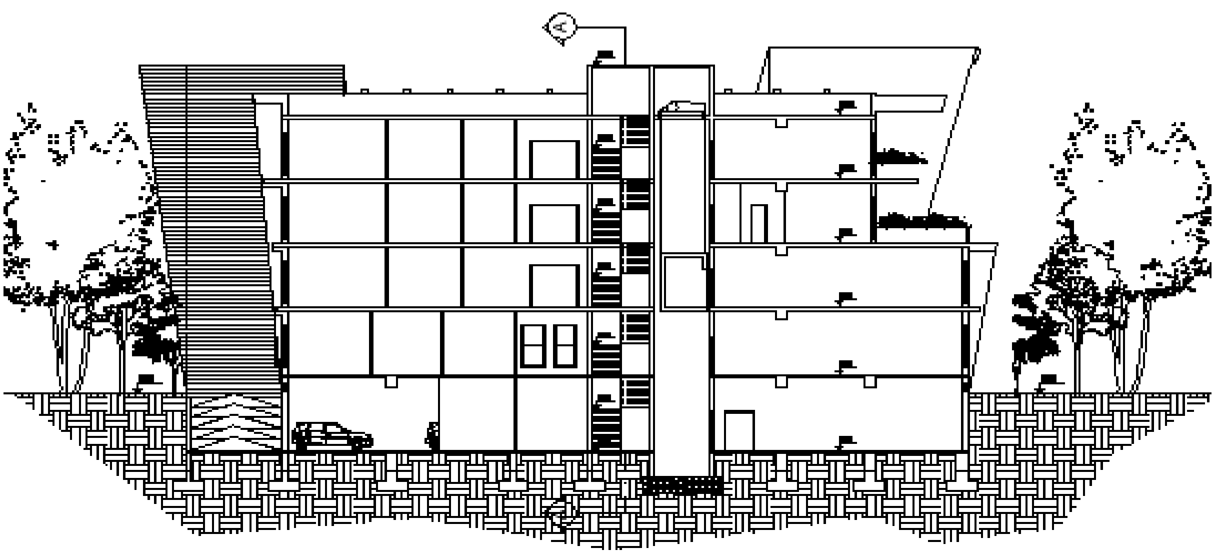


Figure (2- 12):Section B-B

CHAPTER 3

STRUCTURAL DESCRIPTION

3.1 Introduction
3.2 The Aim of the Structural Design
3.3 Scientific Tests
3.4 Loads Acting on the Building
3.5 Structural Elements of the Building

3.1 Introduction

After completion of the architectural study of the building, A study of the structural elements was done to determine the optimal structural system for the building to make the best design of all structural elements.

After the human known the structural design, it was necessary to evolve its structural

design to provide two basic factors, namely safety and economy.

Therefore, it is necessary to identify the structural structures that make up the project

in order to choose the best and optimal elements so as to achieve safety and economy,

in addition to not to conflict with the architectural plans laid down, and the purpose

of the process of structural design is to ensure that the necessary operating

advantages, while preserving as much as possible On the economic factor.

So In this chapter, the structural elements of the project will be identified and explained.

3.2 The Aim of the Structural Design

The main purpose of structural design is to make a safe, economic, and serviceable design, so In designing a structure the following objectives must be taken into consideration :

1- **Safety**: The structure should be able to carry all expected loads safely, without failure, that is, without breaking or collapsing under the loads.

2- **Durability:** The structure should last for a reasonable period of time.

3- **Stability:** to prevent overturning, sliding, or buckling of the structure, or parts of it, under the the action of loads.

4- **Strength:** to resist safely the stresses induced by the loads in the various structural members.

5- **Serviceability**: To ensure satisfactory performance under service load conditions - which implies providing adequate stiffness and reinforcements to contain deflections, crack widths,and vibrations within acceptable limits, and also providing impermeability and durability (including corrosion-resistance), etc.

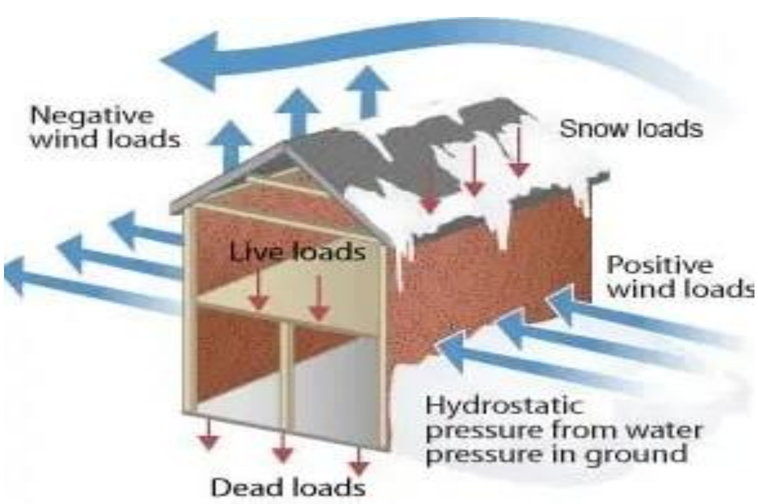
There are two other considerations that a sensible designer must bear in mind, economy and aesthetics. As any engineer can always design a massive structure, which has more than adequate stability, strength, and serviceability, but the ensuing cost of the structure may be exorbitant, and the end product, far from aesthetic.

3.3 Scientific Tests

Before the structural study of any building, there is the work of geotechnical studies of the site, which means all work related to exploring the site and studying soil, rocks, and groundwater, then analyzing information and translating it to predict the way the soil behaves when building on it, and the most important thing is to obtaining soil durability (Bearing Capacity) required to design the building's foundations.

3.4 Loads Acting on the Building

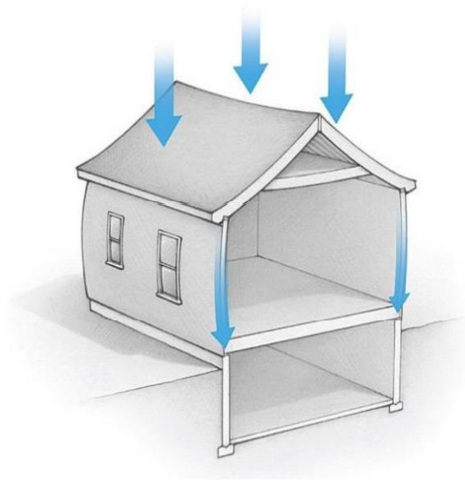
Loads that acting on the building must be calculated and selected carefully because any error in identifying and calculating loads reflects negatively on the structural design of various structural elements. The building is exposed to loads of live and dead loads, wind loads, snow loads, and loads of earthquakes.



Figure(3- 1): Types of loads

3.4.1 dead loads

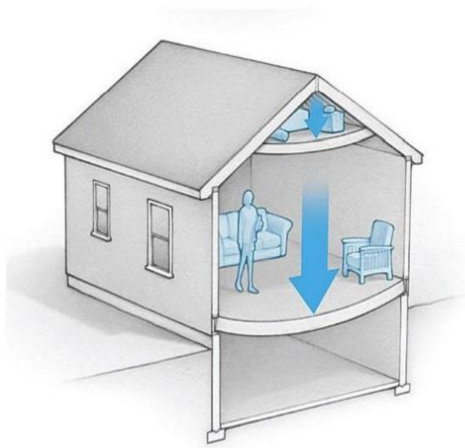
Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self weight of structural members, permanent partition walls, fixed permanent equipments and weight of different materials. It majorly consists of the weight of roofs, beams, walls and column etc. which are otherwise the permanent parts of the building. The calculation of dead loads ofeach structure are calculated by the volume of each section and multiplied with the unit weight.



Figure(3- 2): Dead Load

3.4.2 live load

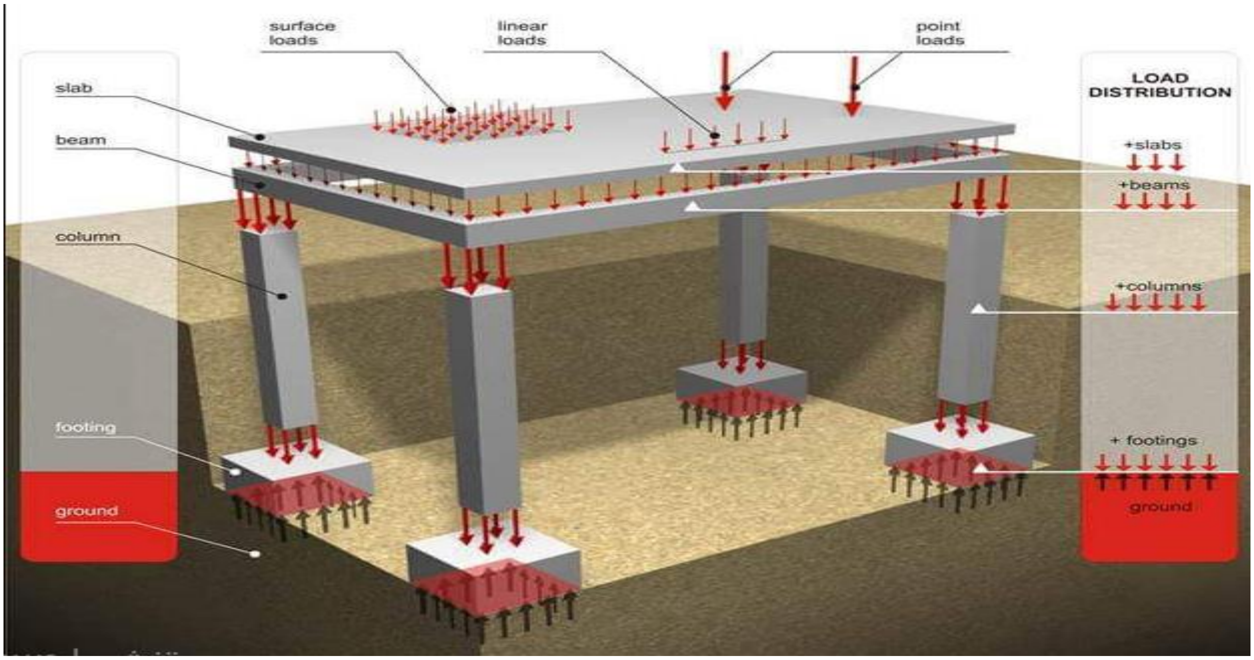
Live loads are either movable or moving loads with out any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc.. Live loads keeps on changing from time to time. These loads are to be suitably assumed by the designer.



Figure(3- 3): Live Load

3.4.3 sesimic load

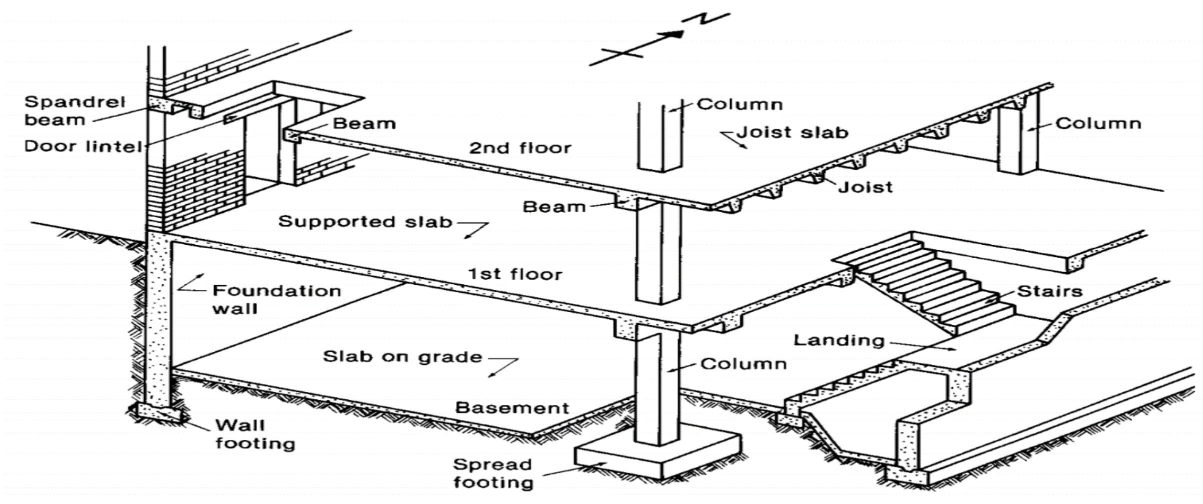
horizontal and vertical forces that generate torque, and can be resisted by using shear walls designed with thicknesses and sufficient reinforcement to ensure the safety of the building.



Figure(3- 4): Load Path

3.5 Structural Elements of the Building

All buildings usually consist 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.

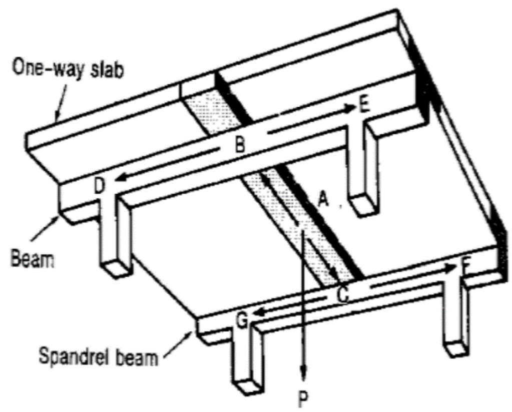


3.5.1 Slabs

Structural elements are capable of delivering vertical forces due to the loads affecting the building's load-bearing structural elements such as beams, columns, and walls, without distortions.
There are many different Structural systems of reinforced concrete slabs, including the following:

3.5.1.1 Solid slab (one or two way)

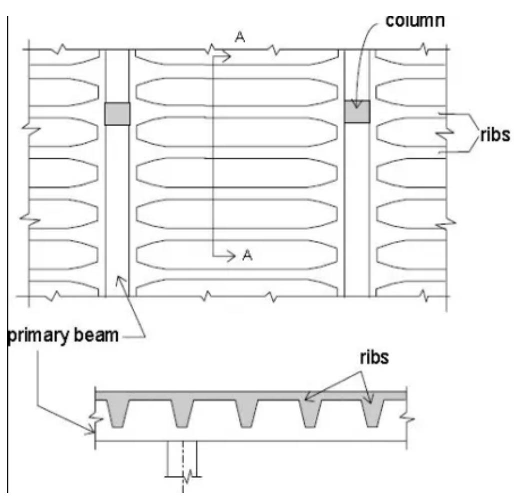
Solid Slabs are fully customizable concrete slabs of varying width, length, and thickness. They can be used in a variety of applications such as bridges, piers, and building floors. It is known that solid slabs should be supported by drop beams.



Figure(3- 6): Solid slab

3.5.1.2 Ribbed slab (one or two way)

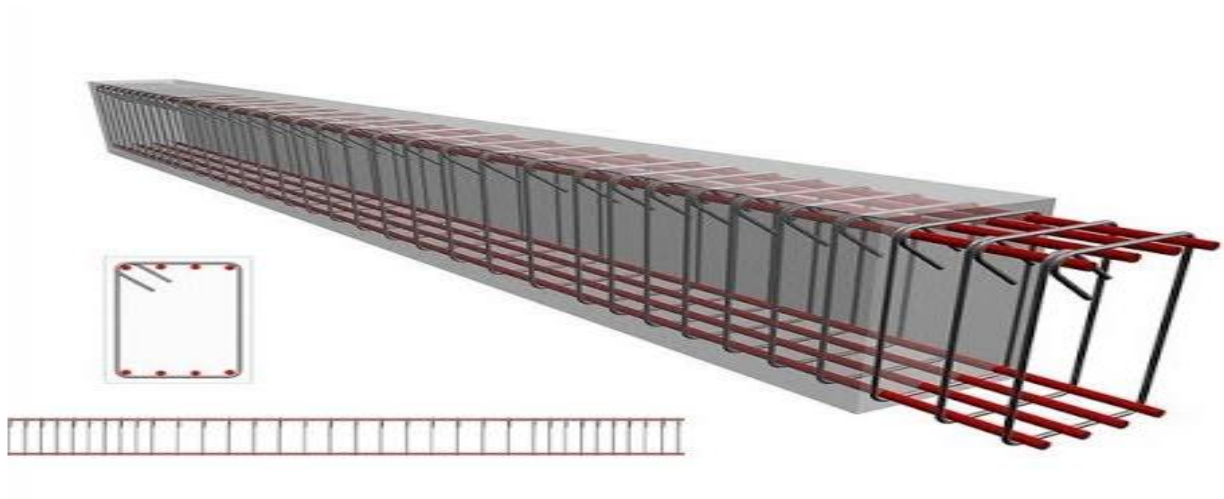
It’s the most common system used in Palestine. They are made up of wide band beams running between columns with narrow ribs spanning the orthogonal direction. Normally the ribs and the beams are the same depth. A thin topping slab completes the system. It can be designed to carry loads either in one direction only, or in two directions.



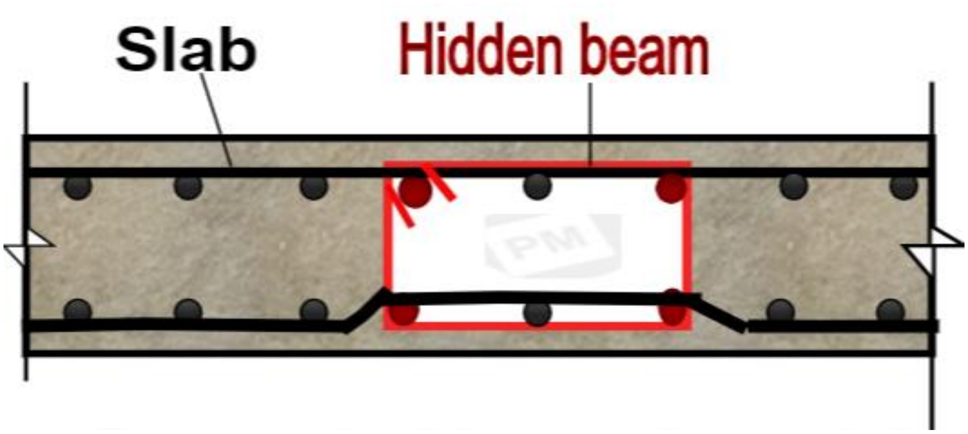
Figure(3- 7):One way ribbed slab.

3.5.2 Beams

They are basic structural elements in transferring loads from slabs to the columns, and they are of two types, hidden inside the slab and Dropped Beams that emerge from the slab from the bottom.



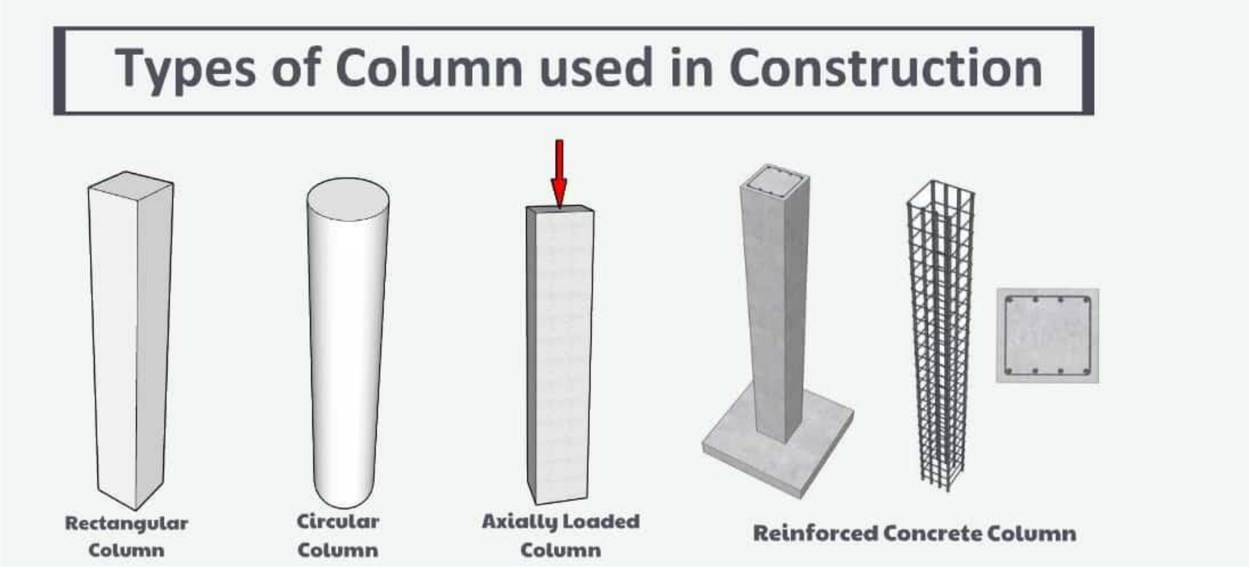
Figure(3- 8):Rectangular Beam.



Figure(3- 10):Hidden Beam.

3.5.3 Columns

Columns are the main member in transporting loads from slabs and beams to foundations, and as such, they are a necessary structural component for conveying loads and building stability. Therefore, they must be designed to be able to carry and distribute the loads on them.

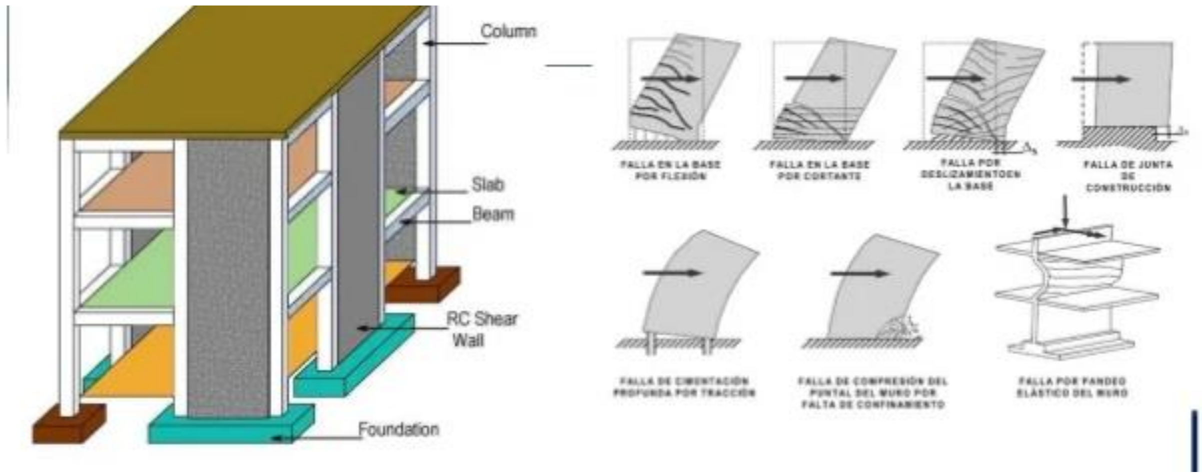


Figure(3- 12):Different types of Columns

3.5.4 Shear walls

They are structural load-bearing elements that resist vertical and horizontal forces located on them and are mainly used to resist horizontal loads such as wind and earthquake forces.

These walls are armed with two layers of steel to increase their efficiency to resist the horizontal forces. The two directions taking into consideration that the distance between the center of resistance formed by the shear walls in each direction and the center of gravity of the building is minimal. And that these walls are sufficient to prevent or reduce the generation of torque waves and their effects on the walls of the building resisting horizontal forces.

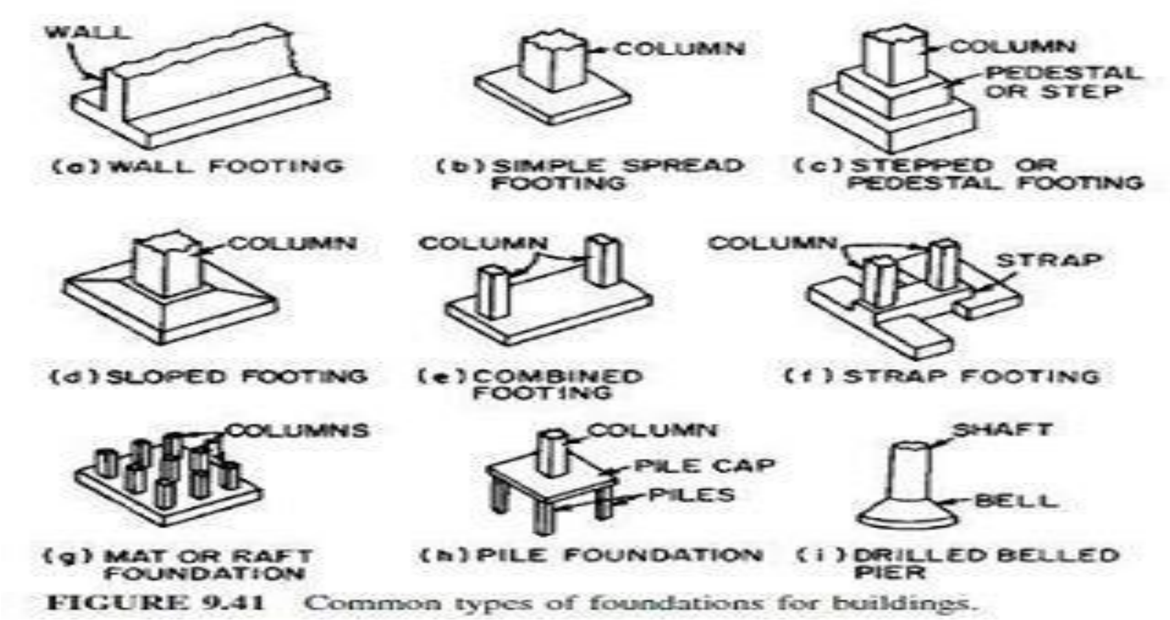


Figure(3- 13):shear wall

3.5.5 Foundations

Loads act on foundations came from the loads on the slabs which transferred to the beams, then to columns, and finally to foundations. and these loads are the design loads for the foundations.

There a many types of foundations that can be used in each project it depends on the type of loads and the nature of the soi in the site.

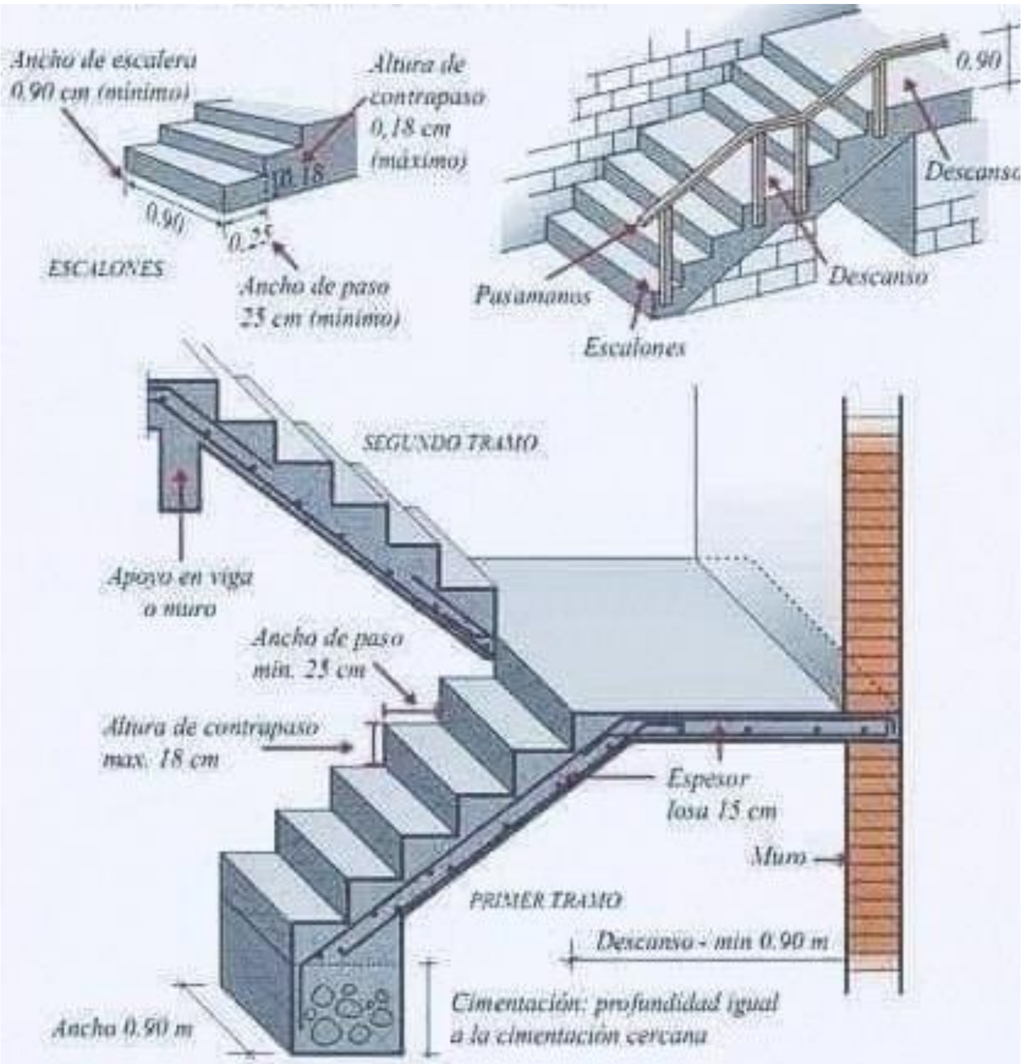


Figure(3- 14):types of footing

3.5.6 Stairs

Stairs must be provided in almost all buildings. It consists of rises, runs, and landings. The total steps and landings are called a staircase.

There are different types of stairs, which depend mainly on the type and function of the building and the architectural requirements.



Figure(3- 15):stair detail

CHAPTER 4

STRUCTURAL ANALYSIS AND DESIGN

4.1 Introduction

4.2 Factored load

4.3 Determination of slab thickness

4.4 Design of one-way ribbed slab

4.5 Design of solid slab

4.6 Design of Beam

4.7 Design of Column

4.8 Design of Isolated Footing

4.9 Design of Stairs

4.10 Design of Shear wall

4.11 Design of Basement wall

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 virtually any form or shape.

Concrete used in most construction work is reinforced with steel. When concrete structure members must resist extreme tensile stresses, steel 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, and stresses can be transferred between both components. In This Project, there are two types of slabs: solid slabs, one-way ribbed and . They would be analyzed and designed by using finite element method of design, with aid of a computer Programs called " ATTIR " to find the internal forces, deflections and moments for ribbed slabs.

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

NOTE:

*****Concrete B300, {fc' = 24 MPa for rectangular and L section}.

*The specified yield strength of the reinforcement {fy = 420MPa}.

4.2 Determination of slab thickness

Determination of Thickness for One Way Ribbed Slab:

According to ACI-Code-318-08, the minimum thickness of non prestressed beams or one-way slabs unless deflections are computed as follow:

The maximum span length for one end continuous (for ribs):

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

=625 /18.5 = **33.78cm**

The maximum span length for both end continuous (for ribs):

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

= 671/21 = **31.95cm**

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

4.3 Determination of Loads of ribs :-

4.3.1 Determination of Dead load:-

Table (4 – 1) Calculation of the total dead load for one way rib slab

Type	**γb h**	**KN/m**
Tiles	0.03*0.52*23	0.359
Mortar	0.02*0.52*22	0.229
Sand	0.07*0.52*16	0.5824
Topping	0.08*0.52*25	1.04
Hollow block	0.4*0.24*9	0.864
Plaster	0.02*0.52*22	0.229
R.C rib	0.12*0.24*25	0.72
Partitions	2.3*0.52	1.2
Sum		**5.22**

4.3.2 Determination of live load:-

Nominal Total live load = 5 * 0.52 = 2.6kN/m of rib

4.3.3 Determination of factored dead & live load

Factored dead load = 1.2*Dead load = 1.2*5.22 = 6.27 KN/m.

Factored Live load = 1.6*live load = 1.6*2.6 = 4.16 KN/m

4.3.4 Design of topping

The calculation of the total dead load for the topping is shown below:

Table (4 – 2) Calculation of the total dead load on topping

Type	**γb h**	**KN/m**
Tiles	0.03*1*23	0.69
Mortar	0.02*1*22	0.44
Sand	0.07*16*1	1.12
Topping	0.08*1*25	2
Partitions	2.3*1	2.3
Sum		**6.55**

W_u = 1.2 DL + 1.6 LL

= 1.2 * 6.55+ 1.6 * 5 = 15.86 KN/m^2. (Total Factored Load)

$\boldsymbol{M_u} = \frac{\boldsymbol{W_u * l^2}}{\boldsymbol{12}}$ = 15.86 *0.4*0.4/12 = 0.211 KN. m/m of strip width .

$\boldsymbol{\emptyset Mn = \emptyset 0.42 \sqrt[2]{fc}\, Sm}$ = 0.55 *0.42*1*$\sqrt[2]{24} * \frac{1*0.8^3}{6}$ = 1.21 KN .m >> 0.211KN.m

NO reinforcement is required by analysis. According to ACI 10.5, provided $A_{s,min}$for slabs as shrinkage and temperature reinforcement. According to ACI 7.12.2.1, $\rho_{shrinkage} = 0.0018.$

$A_s = \rho * b * h = 0.0018 * 1000 * 80 = 144\ mm^2/\ strip.$

Minimum (As) = 0.0018 * Ag = 0.0018 * 100 * 8 = 1.44 cm^2/m

As = 144 $\boldsymbol{mm^2/m}$

Try bars $\emptyset 8\ with\ A_s = 50.27mm^2$

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

Try $3\emptyset 8/m\ with\ A_s = 150.8mm^2/m\ strip\quad or\quad \emptyset 8@300mm$ in both directions.

Step (S) is smallest of:

$$3h = 3 * 80 = 240mm - control$$

$$450mm$$

$$s = 380\left(\frac{280}{f_s}\right) - 2.5C_c = 380\left(\frac{280}{\frac{2}{3}420}\right) - 2.5 * 20 = 330mm$$

$$s \leq 300\left(\frac{280}{f_s}\right) = 300\left(\frac{280}{\frac{2}{3}420}\right) = 300mm$$

Take $\emptyset 8@200mm$ in both directions. $s = 200mm < s_{max} = 240mm - ok$

Take $\boldsymbol{\emptyset 8\ at\ 200\ mm\ in\ both\ directions}$

4.4 Design of one way Ribbed slab

(Rib No#G.R1)

Material: -

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

Section: -

b =12cm b_f=52 cm

h =32cm T_f=8 cm

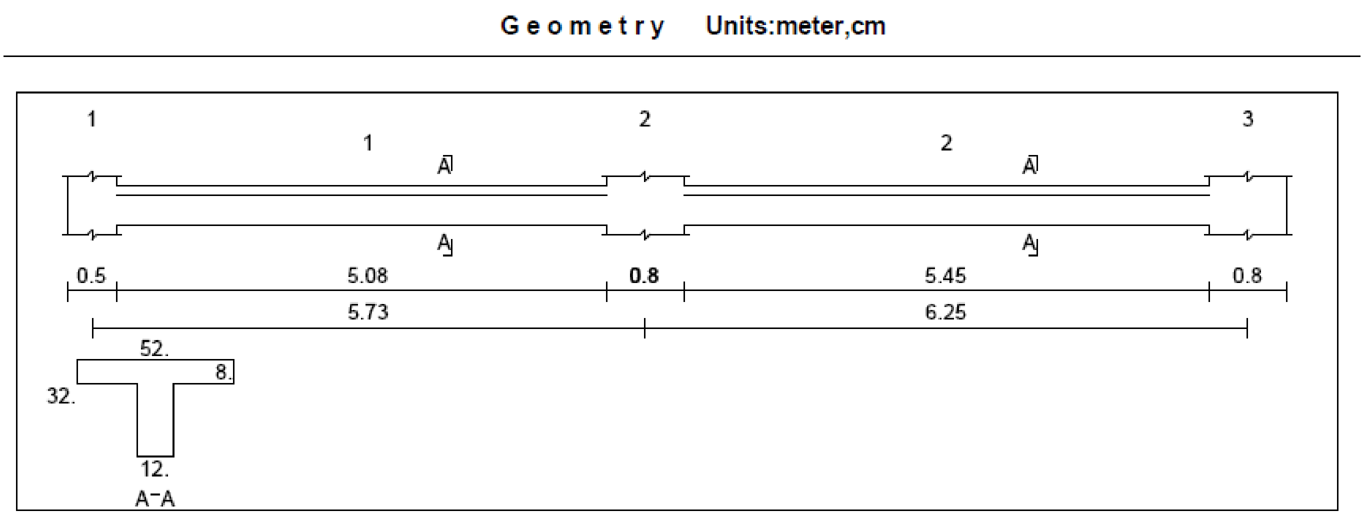


Figure (4-1): Rib geometry.

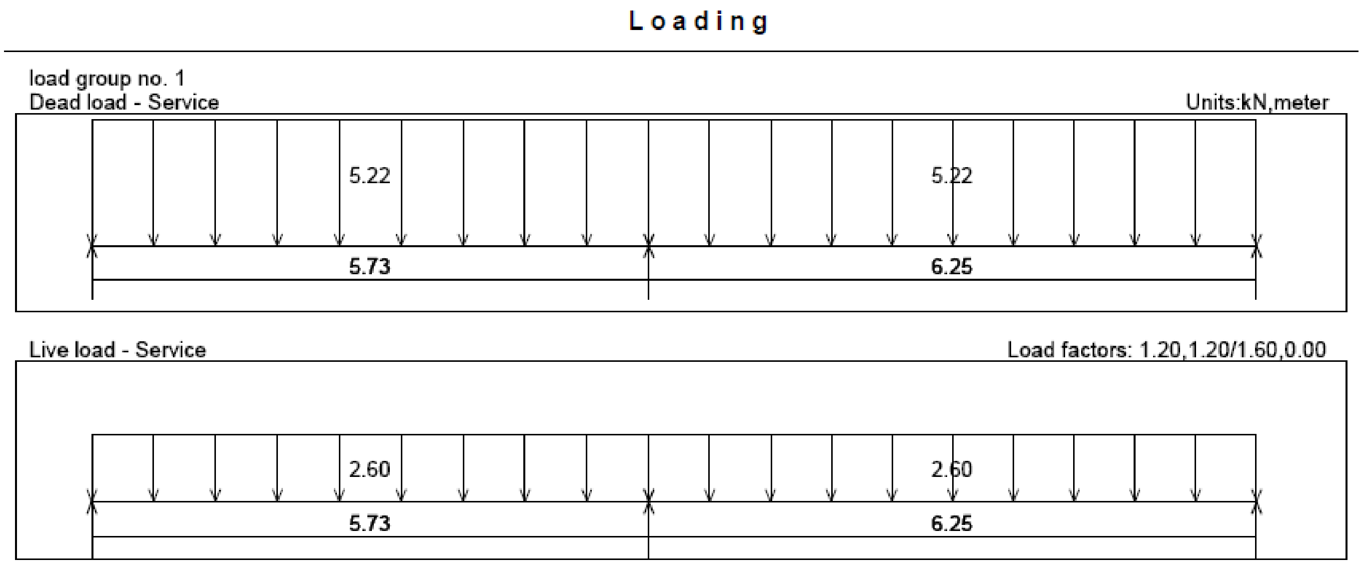


Figure (4-2): loading of rib (18)

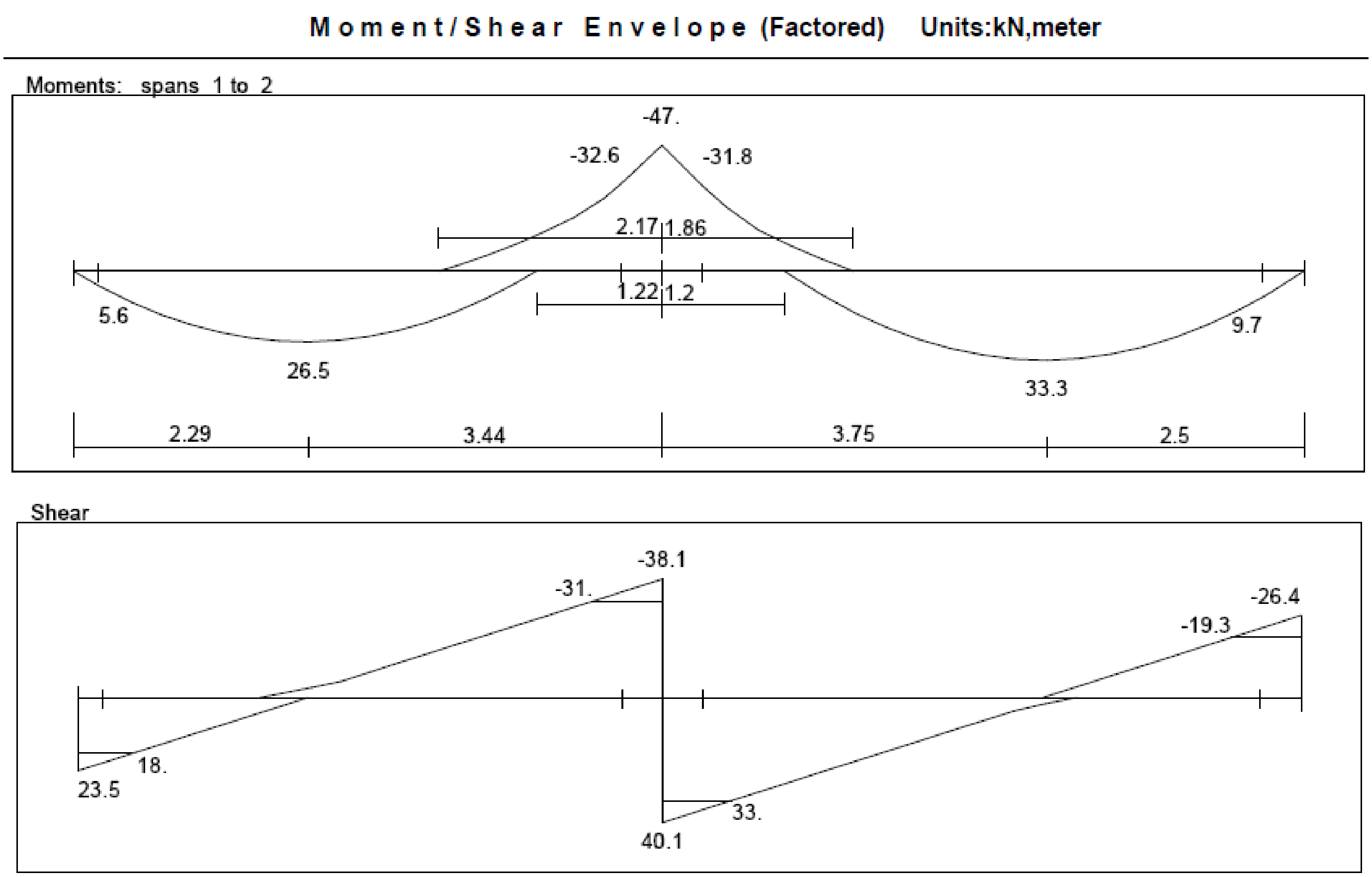


Figure (4-3): Moment Envelop And Shear Envelop of rib (18)

4.6.1 Design of flexure: -

4.6.1.2 Design of Positive moment of rib (RIB 1):

d = depth - cover – diameter of stirrups – (diameter of bar/ 2)

= 320 – 20 – 8 – $\frac{16}{2}$= 284 mm.

→$M_{u\ max}$ = 33.3 KN.m

be ≤ Distance center to center between ribs = 540 mm………… Controlled.

≤ L/4+ b_w = 5080/4 +120 = 1390 mm.

(Where L is taken as the smallest clear span of the rib.)

≤ (16* t_f) + b_w =(16* 80) +120 =1400 mm.

→b_E= 520 mm.

$$\rightarrow M_{nf} = 0.85\, f_c' * b_E * t_f * \left(d - \frac{t_f}{2}\right)$$

$$= 0.85 * 24 * 0.52 * 0.08 * \left(0.284 - \frac{0.08}{2}\right) * 10^3 = 207.1\ KN.m$$

ϕM_{nf} = 0.9 * 207.1 = 186.4 KN.m

→ϕM_{nf} =186.4 > $M_{u\ max}$= 33.3 KN.m.

∴ **DESIGN AS RECTANGULAR SECTION**.

Maximum positive moment $Mu^{(+)}$ = 33.3 KN.m

M_n = Mu /ϕ =33.3/ 0.9 = 36.9 KN.m

$$m = \frac{f_y}{0.85\, f_c'} = \frac{420}{0.85*24} = 20.58$$

$$R_n = \frac{M_n}{b*d^2} = \frac{36.9*10^6}{520*\,(284)^2} = 0.88 \text{ MPa}$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.88*20.58}{420}}\right) = 0.00214$$

→A_s = ρ * b *d = 0.00*214** 520 * 284= 316.4 mm^2.

$As_{min} = \frac{\sqrt{f_c'}}{4\,(f_y)} * b_w * d \geq \frac{1.4}{f_y} * b_w * d$ …………(ACI-10.5.1)

$= \frac{\sqrt{24}}{4*420} * 120 * 284 \geq \frac{1.4}{420} * 120 * 284$

$= 99.4mm^2 < 113.6\ mm^2$ …………. Larger value is control.

→$As_{min} = 113.6\ mm^2 < As_{req} = 316.4\ mm^2$.

∴ As = 316.4 mm^2.

2 Φ16 =402.12 $mm^2 > As_{req} = 316.4\ mm^2$. OK.

∴ Use 2 Φ16

→ Check for strain:-($\varepsilon_s \geq 0.005$)

Tension = Compression

$A_s * fy = 0.85 * f_c' * b * a$

402.12 * 420 = 0.85 * 24 * 120 * a

a =68.99mm.

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

$c = \frac{a}{\beta_1} = \frac{59.1468.99}{0.85} = 81.17$ mm.

$\varepsilon_s = \frac{d-c}{c} * 0.003$

$= \frac{284-81.17}{81.17} * 0.003 = 0.0075 > 0.005$ ∴ ϕ =0.9 … Ok

4.4.1.1 Maximum negative moment

$Mu^{(-)}$ = 32.6 KN.m

M_n = Mu /ϕ =32.6/ 0.9 = 36.22 KN.m

$m = \frac{f_y}{0.85\, f_c'} = \frac{420}{0.85*24} = 20.58$

$R_n = \frac{M_n}{b*d^2} = \frac{36.22*10^6}{120*(284)^2}$ = 3.74 MPa

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*3.74*20.58}{420}}\right)$= 0.0099

→$A_s = \rho$ * b *d = 0.*0099** 120 * 284= 337.96 mm^2.

$As_{min} = \frac{\sqrt{f_c'}}{4\,(f_y)} * b_w * d \;\; \geq \; \frac{1.4}{f_y} * b_w * d$ ....(ACI-10.5.1)

$= \frac{\sqrt{24}}{4*420} * 120 * 284 \;\; \geq \; \frac{1.4}{420} * 120 * 284$

= 99.4mm^2<113.6 mm^2 .... Larger value is control.

→As_{min} = 113.6 mm^2 <As_{req} = 337.96 mm^2.

∴ As = 337.96 mm^2.

2 Φ16 =402.12 mm^2>As_{req} = 337.96 mm^2 . OK.

∴ Use 2 Φ16

→ Check for strain:-($\varepsilon_s \geq 0.005$)

Tension = Compression

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

402.12 * 420 = 0.85 * 24 * 120 * a

a =68.99mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{59.1468.99}{0.85}$ = 81.17 mm.

$\varepsilon_s = \frac{d-c}{c}$ * 0.003

$= \frac{284-81.17}{81.17}$ * 0.003 = 0.0075 > 0.005 ∴ ϕ =0.9 … OK!

4.6.2 Design of shear of rib (RIB 18):

→Vu = 33 KN.

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

$= 1.1 * \frac{\sqrt{24}}{6} * 0.12 * 0.284 * 10^3 = 30.61$ KN.

$\phi V_c = 0.75 * 30.61 = 22.96$ KN.

→Check for Cases: -

1- Case 1: $V_u \le \frac{\phi V_c}{2}$.

$33 \le \frac{22.96}{2} = 11.48$ KN.

∴ Case (1) is NOT satisfied

2- Case 2: $\frac{\phi V_c}{2} < V_u \le \phi V_c$

$11.48 \le 33 \le 22.96$ KN.

∴ Case (2) is NOT satisfied → shear reinforcement is required.

Vs $= \frac{V_u}{\phi} - Vc = 13.39$ KN.

Vs min$= \frac{1}{16} * \sqrt{f_c'} * bw * d = 10.43$ KN.

Vs min$= \frac{1}{3} * b_w * \mathbf{d} = 11.36$ KN. ....**Control.**

$VS = 10.43 \le VSmin = 11.36$ KN. ......$OK!$

∴ **Case (3) is NOT satisfied → shear reinforcement is required.**

Vs\` $=\frac{1}{3}*\sqrt{f_c'}$ * bw* d =55.65 KN.

Vs = $\frac{V_u}{\phi} - Vc = 13.39$ KN.

$Vs = 13.39 \leq Vs\` = 55.65$ KN. ……OK!

$CASE\ 4: stirrups\ are\ required$

<u>Try 2Φ8: -</u>

$\frac{(2*\frac{8^2\pi}{4})*420*284}{S}$ = 13.39*10^3 → S = 895.3 mm.

S $\leq\frac{d}{2}$ = $\frac{284}{2}$ = 142 mm. … **Control**

≤ 600 mm.

∴ **Use 2Φ8 @ 15**

4.5 Design of solid slab

(SLAB NO#S5)

Material: concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

Section: -

B = 100 cm

According to ACI-Code-318-08, the minimum thickness of no prestressed one way solid slabs unless deflections are computed as follow:

h_{min} for one end cont. = L/24 =573/24 =23.9 cm.

h_{min} for both ends cont. = L/28 =628/28 = 22.4 cm.

→Select Total depth of slab h=25cm. Assume bar diameter Ǿ 16 for main reinforcement. **d = 250 -20 -14/2 = 222 mm**

Determination of Dead load:-

Table (4 – 1) Calculation of the total dead load for one way solid slab

Type	γb h	KN/m^2
Tiles	0.03*23	0.69
Mortar	0.02*22	0.44
Sand	0.07*16	1.12
Plaster	0.02*22	0.44
R.C solid slab	0.25*25	6.25
Partitions	2.3	2.3
Sum		**11.24**

Determination of live load:-

Nominal Total live load = 5 = 5 kN/m^2

Dead Load for 1 m strip of slab= 11.24 *1 = 11.24 KN/m

Live Load for 1 m strip of slab = 5.0 * 1= 5.0KN/m

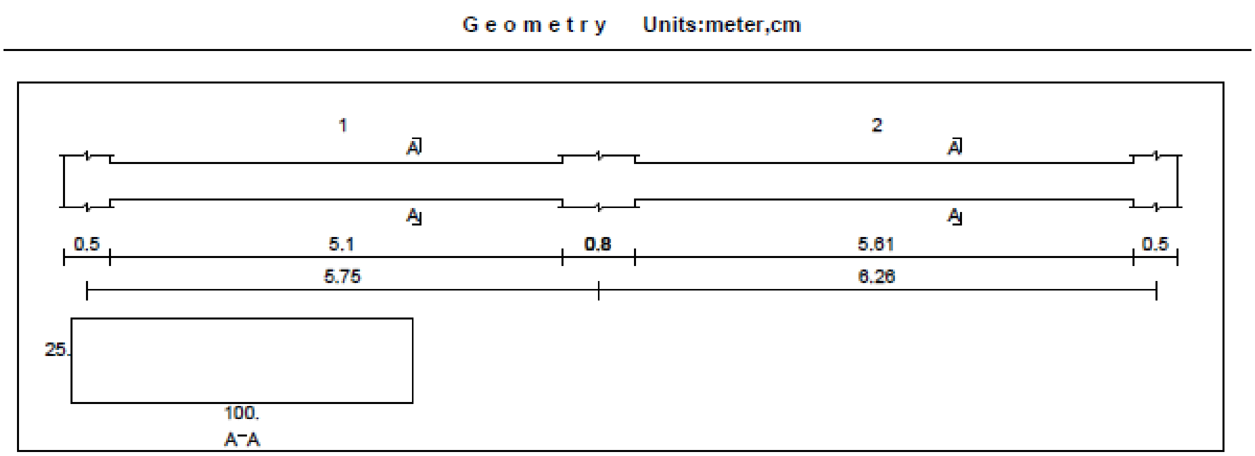


Figure (4-4): solid slab Geometry.

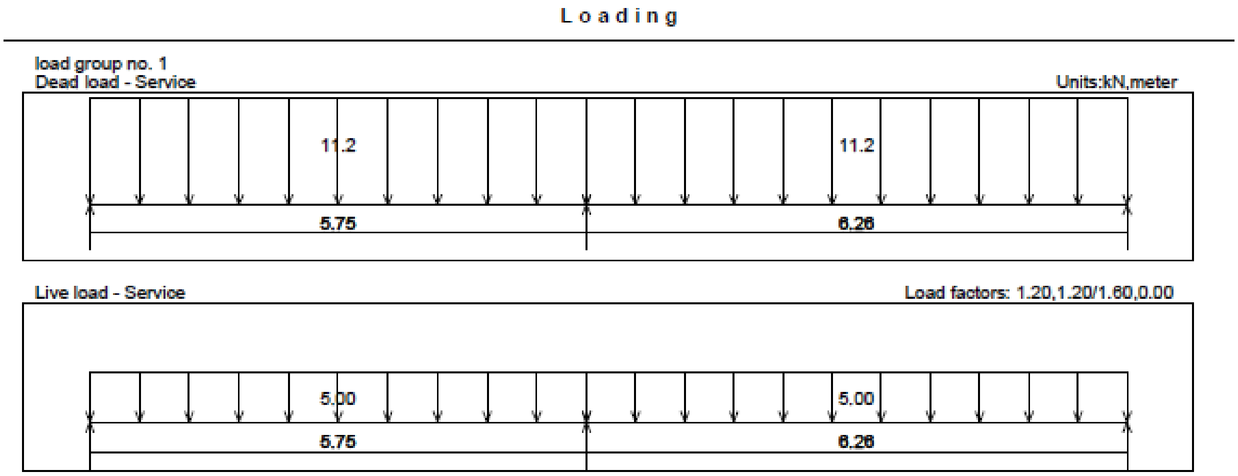


Figure (4-5): Load of solid slab

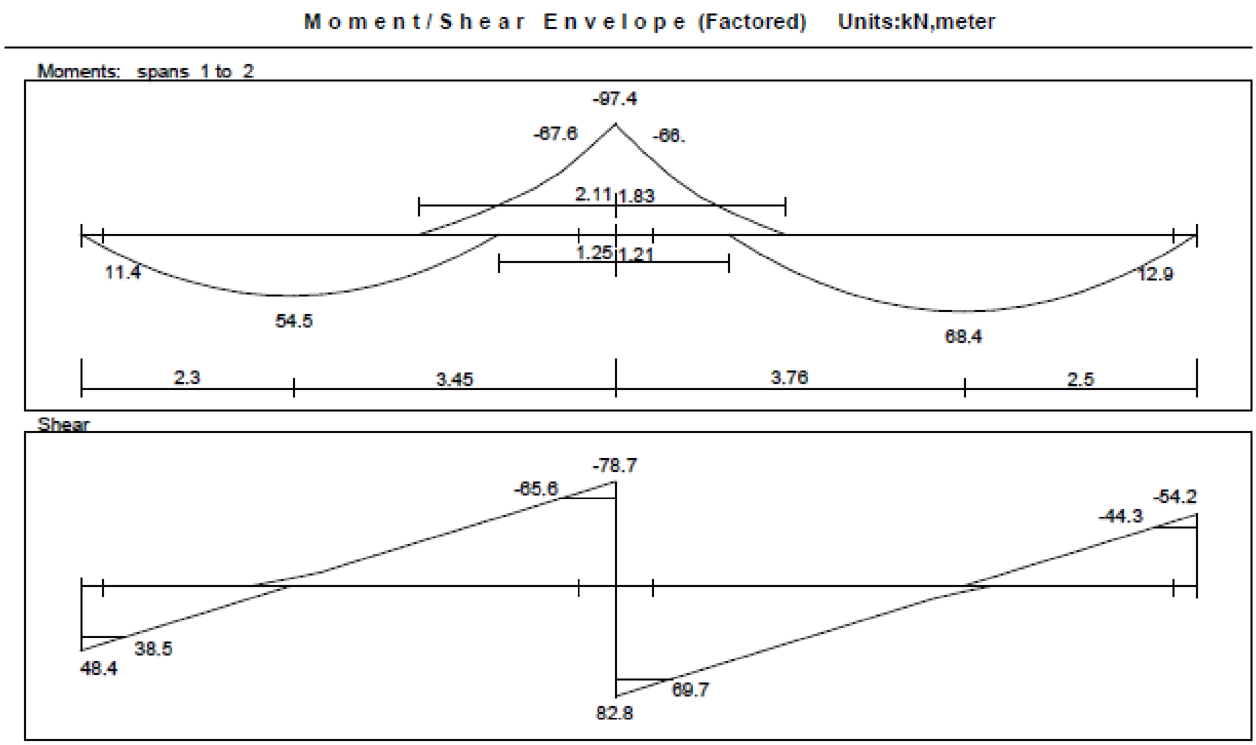


Figure (4-6): Moment And Shear Envelop for slab

According to ACI 8.9.2 — In analysis of frames or continuous construction for determination of moments, span length shall be taken as the distance center-to-center of supports.
According to ACI 8.9.3 — For beams built integrally with supports, design on the basis of moments at faces of support shall be permitted.

- Check whether thickness is adequate for shear:

$$V_{u,max} = 69.7 KN/1\ m\ strip$$

$$V_c = \frac{1}{6}\lambda\sqrt{f_c'}b_w d = \frac{1}{6}\cdot 1\cdot\sqrt{24}\cdot 1000\cdot 0.222 = 181.2\ KN/\ 1\ m\ strip$$

$\phi = 0.75$ - for shear.

$$\phi V_c = 0.75 * 0.223 = 135.9\ KN/\ 1\ m\ strip$$

$$V_{u,max} = 69.7KN/1\ m\ strip < 135.9\ KN/1\ m\ strip$$

The thickness of the slab is adequate enough.

Design of flexure: -

- ### Design of negative moment: -

→Mu_{max} = - 67.6 KN.m

d = depth - cover – diameter of stirrups – (diameter of bar/ 2)

d = 250 -20 -14/2 = 222 mm

$$M_n = \frac{M_u}{\phi} = \frac{67.6}{0.9} = 75.1\ KN * m/m$$

$$R_n = \frac{M_n}{bd^2} = \frac{75.1}{1000 * 222^2} = 1.52\ MPa \qquad m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\cdot 24} = 20.6$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = \qquad = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 1.52}{420}}\right) = 0.0038$$

$A_s = \rho bd =$ 0.0038 * 1000 * 222 = 835.8 mm^2

$\rho =$ .0038 $> \rho_{min} = 0.0018$ $- \ OK$

Use Ø16 then

$n = \frac{A_s}{A_s} = \frac{835.8}{201.06} = 4.2$

Take 5Ø16 *with* $A_s =$ 1005.3mm2/1 m *or* Ø16 @ 200mm

Step (s) is the smallest of:

1. $3h =$ 3* 250 = 750 mm
2. 450 $mm.$
3. $s = 380\left(\frac{280}{f_s}\right) - 2.5C_c = 380\left(\frac{280}{\frac{2}{3}\ 420}\right) - 2.5 \cdot 20 =$ 330 mm *but*

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

$s = 200\ mm < s_{max}$ = 300mm $- OK$

➢ Check for strain (tension-controlled section - $\varepsilon_s \geq 0.005$):

$a = \frac{A_s f_y}{0.85\ f_c' b} = \frac{1005.3 * 420}{0.85 \cdot 24 \cdot 1000} = 1$ 20.7 mm

$c = \frac{a}{\beta_1},$ $\beta_1 = 0.85$ $\Rightarrow$ $c = \frac{20.7}{0.85}$ = 24.3 mm

$\varepsilon_t = 0.003\left(\frac{d-c}{c}\right) =$ 0.024 > 0.005 OK

- Design of positive moment: -

→Mu_{max} =68.4 KN.m

d = depth - cover – diameter of stirrups – (diameter of bar/ 2)

d = 250 -20 -14/2 = 222 mm

$$M_n = \frac{M_u}{\phi} = \frac{68.4}{0.9} = 76.0\ KN * m/m$$

$$R_n = \frac{M_n}{bd^2} = \frac{76.0}{1000 * 222^2} = 1.54\ MPa \qquad m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \cdot 24} = 20.6$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = \qquad = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 1.54}{420}}\right) = 0.0039$$

$A_s = \rho bd = 0.0039 * 1000 * 222 = 865.8\ mm^2$

$\rho = .0039 > \rho_{min} = 0.0018 \quad - OK$

Use Ø16 then

$$n = \frac{A_s}{A_s} = \frac{865.8}{201.06} = 4.3$$

Take 5Ø16 *with* $A_s =$ 1005.3mm2/1 m *or* Ø16 @ 200mm

Step (s) is the smallest of:

1. $3h =$ 3* 250 = 750 mm
2. $450\ mm.$
3. $s = 380\left(\frac{280}{f_s}\right) - 2.5C_c = 380\left(\frac{280}{\frac{2}{3}\ 420}\right) - 2.5 \cdot 20 =$ 330 mm *but*

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

$s = 200\ mm < s_{max}$ = 300mm $- OK$

- ## Temperature and shrinkage reinforcement

$A_s(Temperature\ and\ shrinkage) = 0.0018bh = 0.0018 \cdot 1000 \cdot$ 250 = 450 mm2

$$n = \frac{A_s}{A_{s\varnothing 12}} = \frac{450}{113.1} = 3.9$$

Take $4 \varnothing 12/m$ *or* $\varnothing 12$ @ $250\ mm.$

Step ($s - for\ shrinkage\ and\ temperature\ reinforcement$) is the smallest of:

1. $5h =$ 5* 250 = 1250 mm
2. $450\ mm - control.$

$s = 250\ mm < s_{max} = 450\ mm - OK$

4.6 Design of Beam

(Beam No. #20)

Material: - concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

Section: -

B = 80 cm

h =42 cm "choose h=42, for deflection requirement's L/240"

According to ACI-Code-318-08, the minimum thickness of no prestressed beams or one way slabs unless deflections are computed as follow:

h_{min} for one end cont. = L/18.5

=518/18.5 = 28 cm.

→Select Total depth of beam **h=42cm. (32cm slab and10cm drop)**

.

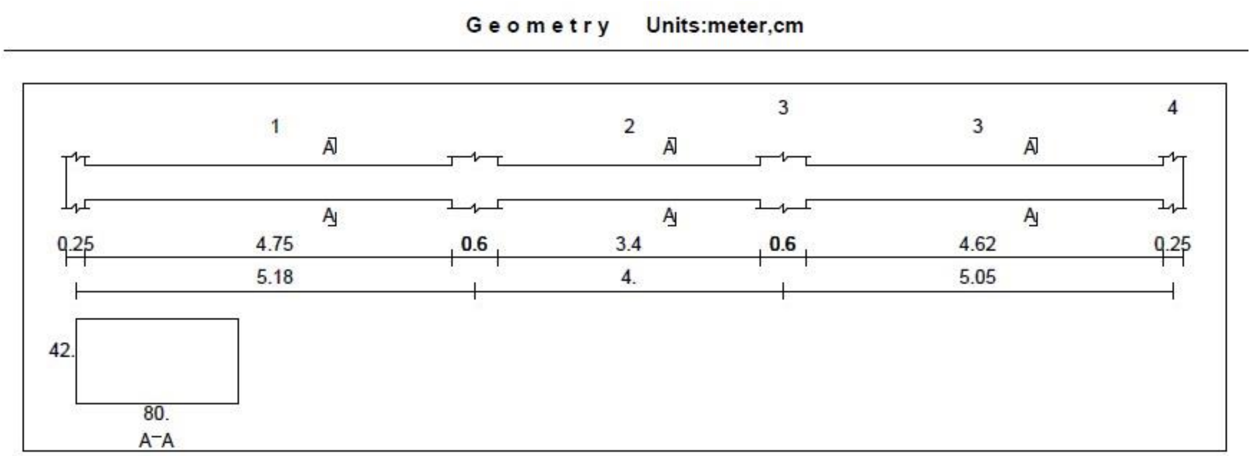


Figure (4-4): Beam Geometry

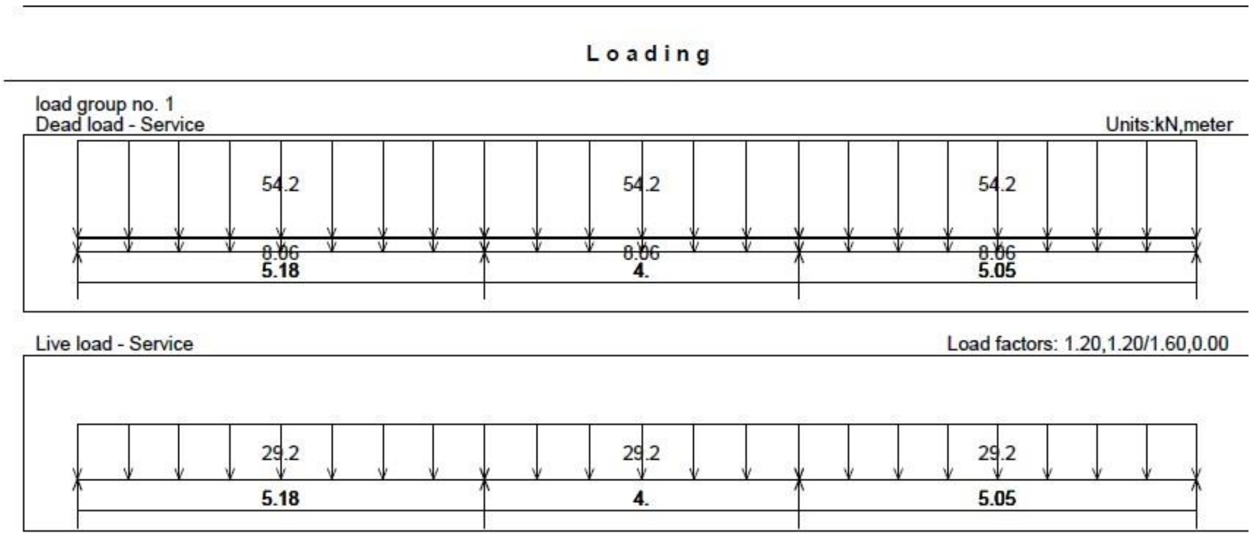


Figure (4-5): Load of Beam

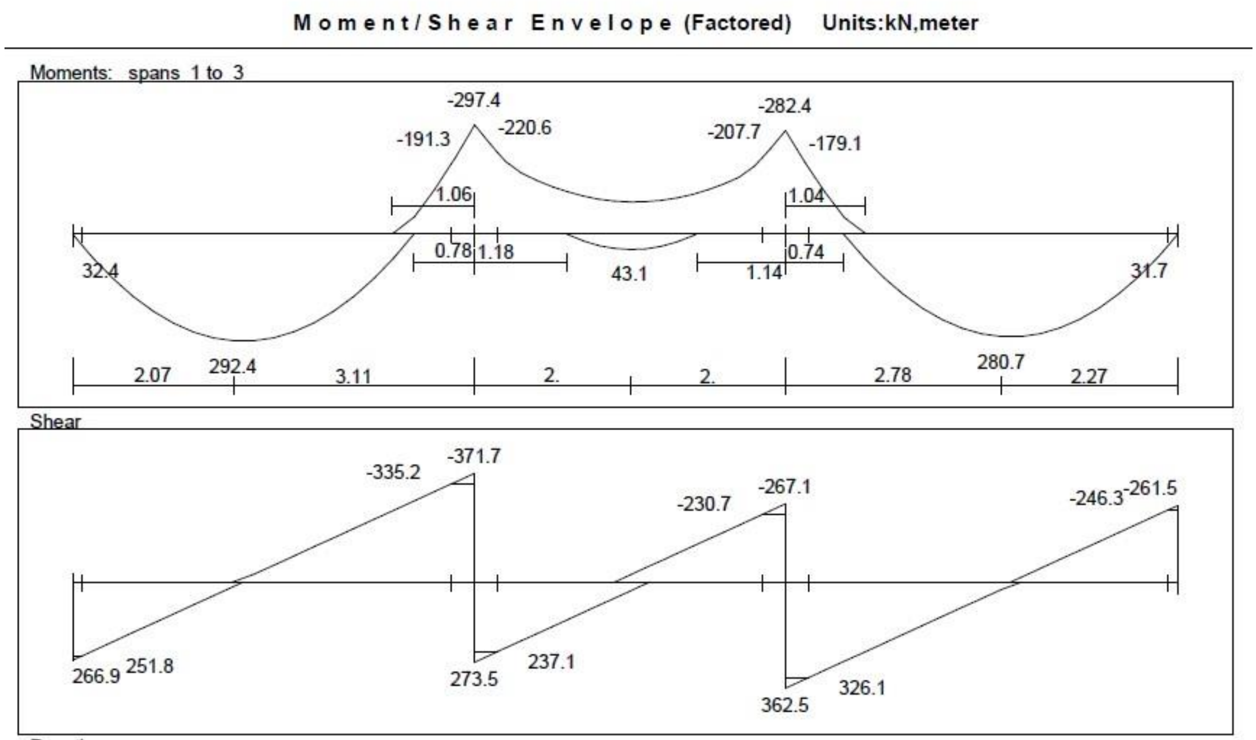


Figure (4-6): Moment and Shear Envelop for Beam

Design of flexure: -

- ### Design of Positive moment: -

→Mu_{max} =292.4 KN.m

b_w = 80 Cm.   h =42 Cm.

d = depth - cover – diameter of stirrups – (diameter of bar/ 2)

$=420 - 40 - 10 - \frac{18}{2} = 361mm$

$C_{max} = \frac{3}{7} * d = \frac{3}{7} * 361 = 154.7mm.$

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

$a_{max} = \beta_1 * C_{max} = 0.85 * 154.7 = 131.5$ mm.

*Note:

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

$= 0.85 * 24 * 0.8 * 0.132 * (.361 - 0.132/2) * 10^3$

=635.5 KN.m

$\epsilon_s = 0.004$

$\phi = 0.65 + \frac{250}{3} * (0.004-0.002) = 0.82$

→$\phi Mn_{max} = 0.82 * 635.5 = 521.1$ KN.m

→ Mu = 292.4KN.m< $\phi Mn_{max} =$ 521.1 KN.m

∴Singly reinforced concrete section.

- ### Maximum positive moment

$Mu^{(+)} = 292.4$ KN.m

Mn = Mu /ϕ= 292.4/ 0.9 =324.9 KN.m .

→m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{324.9*10^6}{800*(361)^2} = 3.12$ MPa

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

$\frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*3.12*20.58}{420}}\right) = 0.0081$

$A_s = \rho * b * d = 0.0081*800*361 = 2339.3\ mm^2$

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

$$\frac{\sqrt{24}}{4 * 420} * 800 * 361 \geq \frac{1.4}{420} * 800 * 361$$

$= 842.2mm^2 < 962.67mm^2$ …. Larger value is CONTROL

As, min = $962.67\ mm^2$

Use5 Φ25…. As= 1963.5 mm^2

→ Check for strain:-($\varepsilon_s \geq 0.005$)

Tension = Compression

$A_s * fy = 0.85 * f_c' * b * a$

1963.5* 420 = 0.85 * 24 * 800 * a

a = 50.53 mm.

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

$$c = \frac{a}{\beta_1} = \frac{50.53}{0.85} = 59.45\ mm.$$

$$\varepsilon_s = \frac{d-c}{c} * 0.003$$

$= \frac{361-59.45}{59.45} * 0.003 = 0.0152 > 0.005$ ∴ ϕ =0.9 … OK!

- ## Design of shear: -

→Vu = 335.2KN .

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

$$= 0.75 * \frac{\sqrt{24}}{6} * 800 * 361 * 10^{-3} = 176.85KN.$$

→ Check For Cases:-

<u>Case1 :</u>

$$V_u \leq \frac{\phi V_c}{2}.$$

$$335.2 \leq \frac{176.85}{2} = 88.43$$

∴ **Case (1) is NOT satisfied**

Case 2 :

$\frac{\phi V_c}{2} < V_u \leq \phi V_c$

88.43<335.2≤ 176.85

∴ **Case (2) is NOT satisfied**

3- Case 3 : $\phi V_c < V_u \leq \phi V_c + \phi Vs_{min}$

$\phi\ Vs_{min} \geq \frac{\phi}{16}\sqrt{f_c'} * b_w * d = \frac{0.75}{16}\sqrt{24} * 0.8 * 0.361 * 10^3 = 66.32KN.$

$\geq \frac{\phi}{3} * b_w * d = \frac{0.75}{3} * 0.8 * 0.361 * 10^3 = 72.2KN$ …. CONTROL.

$\therefore \phi Vs_{min} = 72.2KN.$

$\phi V_c + \phi Vs_{min} = 176.85 + 72.2 = 249.05KN.$

$\phi V_c < V_u \leq \phi V_c + \phi Vs_{min}$

176.85 < 335.2 ≤ 249.05

∴ **Case (3) is NOT satisfied**

4-Case (4):- $\phi(V_c+V_{s,min}) < V_u \leq \phi(V_c+V_s')$

$V_S' = \frac{1}{3}\sqrt{fc'}bwd = \frac{1}{3}\sqrt{24} * 0.8 * 0.361 * 10^3 = 471.6\ KN$

$\phi(V_c+V_{s,min}) = 0.75(235.8+96.3) = 249.1$ KN

$\phi(V_c+V_s') = 0.75(235.8+471.6) = 530.55$KN

$\phi(V_c+V_{s,min}) < V_u \leq \phi(V_c+V_s')$

249.1<335.2 ≤ 530.55

∴ **Case (4) is satisfied**

Try 2Φ10 =2 * 78.5 = 157 mm^2.

$V_S = \frac{335.2}{0.75} - 235.8 = 211.1$ KN

$\frac{2*78.5}{S} = \frac{211.1*10^3}{(420*361)}$ → s =112.75 mm …. CONTROL

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

s ≤ 600 mm.

∴ Use Φ10 @ 12 Cm 4L.

4.7 Design of Column

Calculation of Loads act on Column (C22)

Loads acting on columns are obtained from support reaction when analyzing the system on (BEAMD) .

Dead Load = (Service Dead reaction from BEAMD15)

=1300 KN

Live Load = (Service Live reaction from BEAMD26)

=180 KN

PU factored =(1.2*1300) + (1.6*180) = 1848 KN

- Calculation of Required Dimension of Column (C1)

Total load Pu =1848 KN

Pn = 1848 /(0.65) = 2843.1KN ø =0.65 – for tied column

$\rho g = 2.0$ %

$Pn = 0.8 * Ag\{0.85 * fc' + \rho g(fy - 0.85fc')\}$
$2843 * 10^3 = 0.8 * Ag[0.85 * 24 + 0.02 * (420 - 0.85 * 24)]$
$Ag = 125167.3mm^2$=$1251.67cm^2$

∴Select 70*55cm

Check Slenderness Effect :

For braced system if $\lambda \le 34 - 12\frac{M1}{M2} \le 40$, then column is classified as short column and slenderness effect shall not be considered.

$$\lambda = \frac{Klu}{r}$$

Where :

Lu: Actual unsupported length = 3.75 m

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

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

System about X

$\rightarrow \lambda = \frac{1 * 3.75}{0.3 * 0.7} = 19.23$

$\lambda \le 34 - 12(1) = \mathbf{22} \le 40$

$\lambda = 19.23 < 22$ ∴ short column about X.

System about Y

$\rightarrow \lambda = \frac{1 * 3.75}{0.3 * 0.55} = 31.25$

$\lambda \le 34 - 12(1) = \mathbf{22} \le 40$

$\lambda = 31.25 > 22$ ∴ long column about Y

Minimum eccentricity e_{min} and Minimum moment M_{min}:

E min = (15+0.03*550) = 27mm

M min = 1848*0.027 = 49.9 KN.m

Compute EI :

Ec = 4700*$\sqrt{24}$ = 23025.2 Mpa

$Ig = 3.47 * 10^9 mm^4$

$$\beta dns = \frac{1.2D}{1.2D + 1.6L} = \frac{1560}{1848} = 0.84$$

$$EI = \frac{0.4EcIg}{1+\beta dns} = \frac{0.4*23025.2*3.47}{1+0.84} = 17369.01 KN.m^2$$

Buckling load :

$$pc = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 * 17369.01}{3.75^2} = 12190.24KN$$

Moment magnifier factor δns:

Cm = 0.6 + 0.4 $\frac{M1}{M2}$ = 0.6 + 0.4*1 = 1 $\quad 0.4 \le Cm \le 1$

$$\delta ns = \frac{cm}{1 - \frac{pu}{0.75pc}} = \frac{1}{1 - \frac{1848}{0.75 * 12190.24}} = 1.253 \qquad 1 < \delta ns \le 1.4$$

emin = 1.253*27 = 33.84 mm

Mmin = 1.253*49.9 = 62.52 KN.m

e/h = 33.84/550 =0.085< 0.1 *the limit for concentrically loaded short column*

- Calculation of Required Reinforcement Ratio

∅Pn=0.65*0.8*Ag(0.85*fc′+ ρg(Fy-0.85Fc′))

$1848*10^3$ =0.65*0.8*550*700*(0.85*24+ (420-0.85*24))

→ ρg=0.017> ρ_{min}=0.01 & < ρ_{max} =0.08

As req=0.017*550*700=4420mm²

use∅18→ # of bars =$\frac{4420}{201.06}$ = 17.4

∴ **Use** 18**Ø** 18**with As =4580.4mm² >As $_{req}$ = 4420 mm²**

Check spacing between the bars :

S = $\frac{650-2*40-2*10-6*16}{5} = 90.8\ mm$

S = 90.8 mm $\ge 40mm$

$\ge$ 1.5db = 24 mm

Determination of Stirrups Spacing :

According to ACI :

$\text{Spacing} \leq 16 \times d_b(\text{Longitudinal. bar. diameter}) = 16 \times 1.6 = 25.6\ \text{cm}.$
$\text{Spacing} \leq 48 \times d_t(\text{tie. bar. diameter}) = 48 \times 1.0 = 48\text{cm}.$
$\text{Spacing} \leq \text{Least. dim e nsion} = 55\ \text{cm}$
∴ **Select Ø 10/20cm**

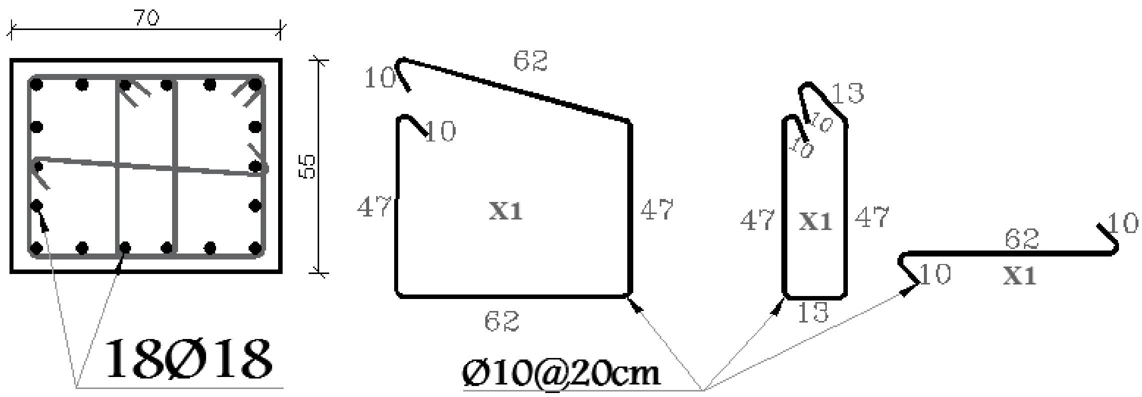


Figure (4-7): section of column

4.8 Design of Isolated Footing

Footing (F2)

$Pu_{survice}$= 1440KN

$Pu_{factored}$=1900KN

Load factor $=\frac{1900}{1440} = 1.32$

- Loads that act on footing F2 are :

The following parameters are used in design :

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

$\gamma_{soil} = 16\ kN/m^3$

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

clear cover = 7.5 cm

service surcharge=5 kN/m^2

- Determination of footing dimension (L)

Footing dimension can be determined by designing the soil against bearing pressure .

Assume h =60 cm

$W_{footing}$= 25*0.6=15 kN/m^2

W_{soil} = 16*0.7=11.2 kN/m^2

Total surcharge(W)= $W_{footing}$ +W_{soil} + service surcharge = 31.2 kN/m^2

$q_{(allow)net} = \sigma_{allow}$ – Total surcharge(W)= 400 –31.2= 368.8kN/m^2

A= pn/qa,net= 1440/368.8 = 3.9m^2 L=1.97m

$Bearing\ Pressure\ \sigma bu = {}^{Pu}/_{A} = \frac{1900}{1.97*1.97} = \mathbf{489.6}\ \boldsymbol{kN/m^2}$

- Determination of footing depth (h)

To determine depth of footing both of one and two way shear must be designed.

Design of one way shear

Assume h=55 cm and ∅16 for main reinforcement and 7.5cm cover

d= 550-75-$\frac{16}{2}$ = 467 mm

Vu= q_u*b*($\frac{l}{2}$ -$\frac{a}{2}$-d

=499.67*1.97*($\frac{1.97}{2}$ - $\frac{0.65}{2}$ -0.467) = 189.98 KN

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

=$\frac{1}{6}$ *$\sqrt{24}$ * 1970*467*10^{-3}=751.2 KN

∅Vc=0.75*751.2=563.4 KN

∴safe

- **Design of Punching (two way shear)**

$d = 467mm$

$b_\circ$ =2*(0.65+0.467)+2*(0.4+0.467)=3.97

β= 650/400=1.625

αs = 40 (interior column)

Vu = 499.67(1.97*1.97-(0.4+0.467)*(0.65+0.467))= 1455.32kN

ØVc is the smallest of :

$$\mathrm{Vc} = \left(1+\frac{2}{\beta}\right) \times \frac{\sqrt{fc'}}{6} \times b_o \times d = \left(1+\frac{2}{1.625}\right) * \frac{\sqrt{24}}{6} * 3970 * 467 * 10^{-3} = 3376.9\ KN$$

$$\mathrm{Vc} = \left(\frac{\alpha_s \times d}{b_o}+2\right) \times \frac{\sqrt{fc'}}{12} \times b_o \times d = \left(\frac{40*0.467}{3.97}+2\right) \frac{\sqrt{24}}{12} * 3970 * 467 * 10^{-3} = 5075.2KN$$

$\mathrm{Vc} = 0.333 \times \sqrt{fc} \times b_o \times d = 0.3333 * \sqrt{24} * 3970 * 467 * 10^{-3} = 3024.53KN \prec$ **cont.**

ØVc = 0.75*3024.53 = **2268.4** kN > Vu = **1455.32** kN

∴ **h = 55 cm is correct**

- **Design of Reinforcement**

Take steel bars with ∅16

d= 550-75-$\frac{16}{2}$ = 467mm

Mu = 499.67 *1.97*0.65*(0.65/2) = 207.94 kN.m

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

Mn = $207.94/0.9$= 231.05kN.m

Rn = $\frac{\text{Mn}}{\text{b}*\text{d}^2}$ = $\frac{231.05*10^6}{1970*467^2}$ =0.54 MPa

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

$$= \frac{1}{20.6} * (1- \sqrt{1-\frac{2*0.54*20.6}{420}}) = 0.0013$$

Asreq = $\rho * b * d = 0.0013 * 1970 * 467$ =1193.94mm^2

As (min) = 0.0018*b*h = 0.0018*1970 * 550 = 1950.3mm^2

Asreq < As (min)

∴ **Select for both directions: 8Ø16@15cm with As = 1608.5mm^2 > Asreq … (ok)**

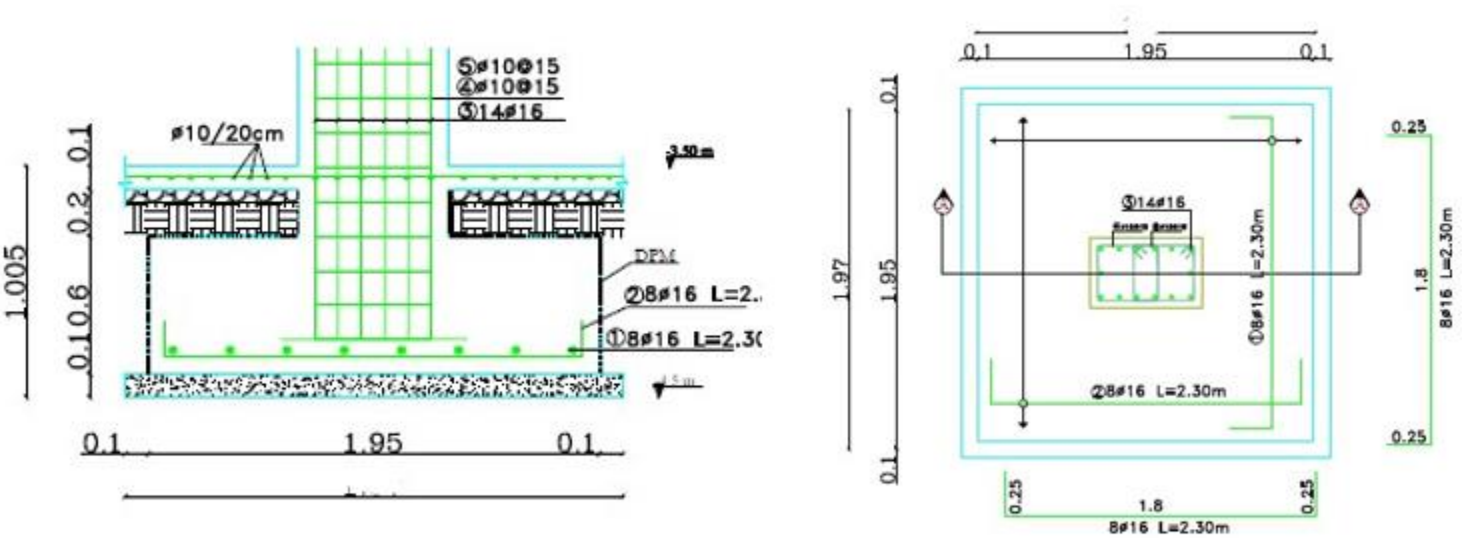


Figure (4-8): section of footing

4.9 Design of Stairs

Material: concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

-

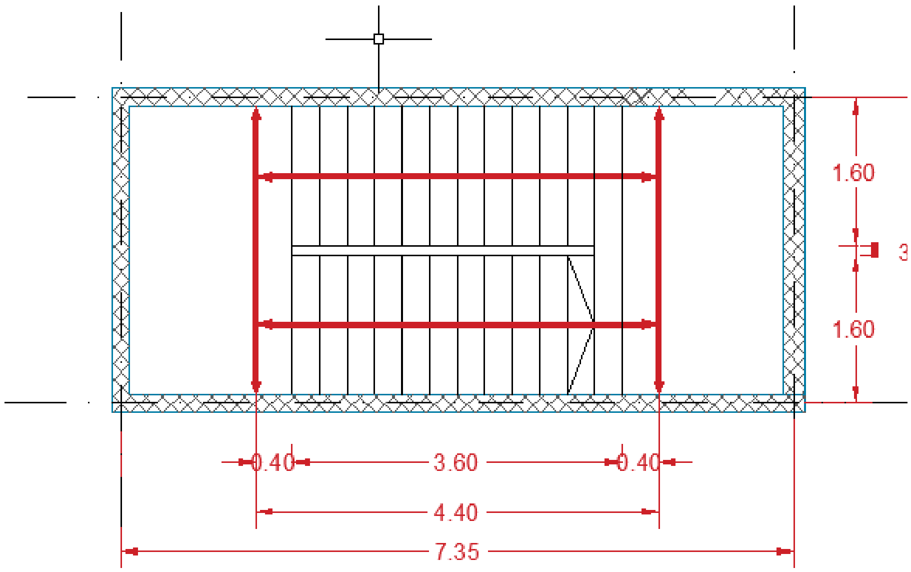


Figure (4-8): section of stair

Determination of flight thickness

h_{min} for one end cont. = L/20 =4.4/20 =22.0 cm.

→Select Total depth of slab **h=22cm.**

: **Determination of Dead load:-**

Flight Dead Load computation

$$\theta = tan^{-1}\left(\frac{rise}{run}\right) = \quad 28.07$$

Table (4 – 1) Calculation of the total dead load for Flight Dead Load computation

Type	$\gamma\ (KN/m^3)$	W (KN/m)
Tiles	23	$23*(\frac{.16+.35}{.3})*.03*1=1.17$
Mortar	22	$22*(\frac{.16+.3}{.3})*.02*1=0.67$
Stair steps	25	$\frac{25}{0.3}*(\frac{.16*.3}{2})*1=2.0$
Plaster	22	$\frac{(22*.03*1)}{\cos 28.07}=.75$
Reinforced Concrete solid slab	25	$\frac{(25*.22*1)}{\cos 28.07}=6.23$
Sum		**10.82**

- **Landing Dead Load computation:**

Table (4 – 1) Calculation of the total dead load for Landing Dead Load computation

Type	$\gamma\ (KN/m^3)$	W (KN/m)
Tiles	23	23*.03*1=0.69
Mortar	22	22* .02*1=0.44
Plaster	22	22*.03*1=0.66
Reinforced Concrete solid slab	25	25*.22*1=5.5
Sum		7.29

Determination of live load:-

Nominal Total live load = 5 = 5 kN/m^2

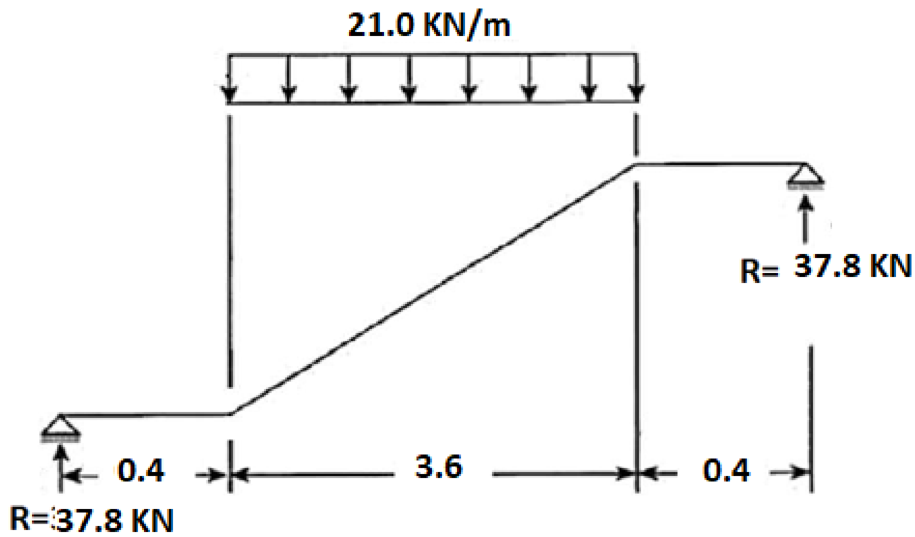
- **Total factored Load:** For Flight = 1.2 *10.82 + 1.6*5*1 = 21.0 KN/m

For Landing= 1.2 *7.29 + 1.6*5*1 = 16.75 KN/m

- ## Design of slab S1 FLIGHT:

Slab S1 is supported at the centerline of slabs (S2) landing

Assume bar diameter Ø 14 for main reinforcement. **d = 220 -20 -14/2 = 193 mm**



The reaction at each end

$$R = \frac{wl}{2} = \frac{21.0*3.6}{2} = 37.8 \text{ KN}$$

✓ Check for shear strenght:

Assume bar diameter ∅ 14 for main reinforcement.

$$d = h - 20 - \frac{d_b}{2} = 193 \text{ mm}$$

Take the maximum shear as the support reaction $V_u = 37.8\text{KN}$

$$V_c = \frac{1}{6}\sqrt{f_c'}b_w d = \frac{1}{6} \cdot \sqrt{24} \cdot 1000 \cdot 0.193 = 157.6 \text{ KN}$$

$\phi = 0.75$ - for shear.

$$\phi V_c = 0.75 *157.6 = 118.2 \text{ KN}$$

$$V_{u,max} = 37.8 \text{ KN} < \frac{1}{2}\phi V_c = 59.1 \text{ KN}$$

The thickness of the slab is adequate enough.

- ✓ Calculate the maximum bending moment and steel reinforcement:

$$M_u = -21*1.8*1.8/2 + 37.8*(.4+1.8) = 49.14 \text{ KN.m}$$

$$M_n = \frac{M_u}{\phi} = \frac{49.14}{0.9} = 54.6 \text{ KN}$$

Assume bar diameter ∅ 14 for main reinforcement.

$$R_n = \frac{M_n}{bd^2} = 1.47 \text{ MPa} \qquad m = \frac{f_y}{0.85 f_c'} = 20.59$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = 0.0036$$

$$A_s = \rho bd = 701.77 \quad mm^2$$

$$A_{s,min} = 0.0018bh = 396 \quad mm^2$$

$$A_s = 701.77 \quad > A_{s,min} = 396 \quad mm^2 \qquad - OK$$

Use ∅ 14 then

$$n = \frac{A_s}{A_{s\varnothing}} = 4.55$$

Take 5 ∅ 14/m $\quad with \quad A_s = 769.7 \ mm^2/m \ strip \quad or \quad$ ∅ 14@ 200 mm.

Step (s) is the smallest of:

1. $3h = 660$ mm
2. 450 mm.
3. $s = 380\left(\frac{280}{f_s}\right) - 2.5C_c = 330$ mm $\qquad but$

$$s \le 300\left(\frac{280}{f_s}\right) = 300 \text{ mm} \qquad - control$$

$s = 200$ mm $< s_{max} = 300$ mm $- OK$

- Temperature and shrinkage reinforcement

$A_s(Temperature\ and\ shrinkage) = 0.0018bh =$ 486 mm

$n = \frac{A_s}{A_{s\varnothing 12}} =$ 4.28

Take $5\varnothing 12/m$ or $\varnothing 12 @ 200\ mm.$

Step $(s - for\ shrinkage\ and\ temperature\ reinforcement)$ is the smallest of:

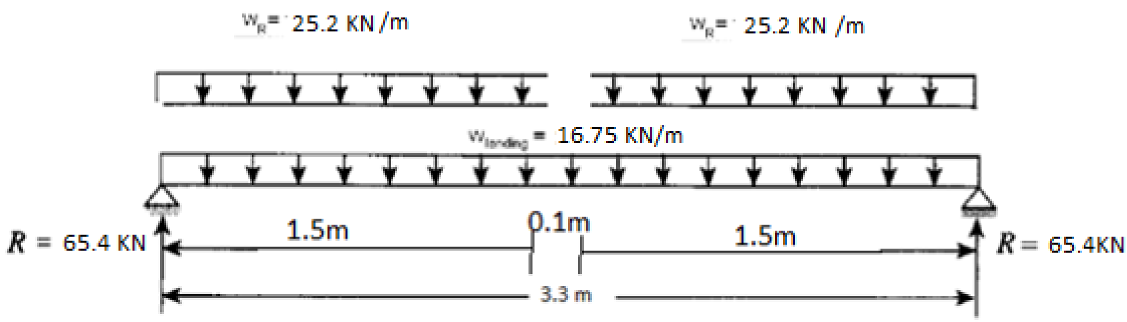
1. $5h = 1350$ mm
2. 450 $mm - control.$

s = 200 $< s_{max}$ = 450mm - OK

- **Design of slab S1 landing :**

Slab S2 is supported on the beams located on axis 1,2 at the floor level. The reaction of the slab S1 is applied at the centerline of the slab S2. Since the width of S2 is m, the reaction R will be distributed along this width. Thus the load per meter w_R equals

$$w_R = \frac{R_{S1(per\ meter)}}{B} = \frac{37.8}{1.5} = 25.2 \text{ KN}$$



The reaction at each end

$$R = 25.2 \text{ KN}$$

✓ Check for shear strenght:

Assume bar diameter $\varnothing$ 14 for main reinforcement.

$$d = h - 20 - \frac{d_b}{2} = 193 \text{ mm}$$

Take the maximum shear as the support reaction V_u = 25.2 KN

$$V_c = \frac{1}{6}\sqrt{f_c'}b_w d = \frac{1}{6}\cdot\sqrt{24}\cdot 1000 * 0.193 = 157.58$$

$\phi = 0.75$ - for shear.

$$\phi V_c = 118.2 \text{ KN}$$

$$V_{u,max} = 25.2 \text{ KN} \quad < \frac{1}{2}\phi V_c = 59.1 \text{ KN}$$

The thickness of the slab is adequate enough.

- ✓ Calculate the maximum bending moment at midspan and the steel reinforcement:

$$M_u = 65.4 * 1.65 - 16.75 * 1.65 * 1.65 /2 - 25.2 * 1.5 * (1.5/2 + .05) = 54.87 \text{ KN.m}$$

$$M_n = \frac{M_u}{\phi} = 60.1 \text{ KN.m}$$

Assume bar diameter ∅ 14 for main reinforcement.

$$R_n = \frac{M_n}{bd^2} = 1.6\text{MPa}$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = .0039$$

$A_s = \rho bd = 766.6 \quad mm^2$

$A_{s,min} = 0.0018bh = 396 \ mm^2$

$A_s = 766.6 \quad > A_{s,min} = 396 \quad mm^2 \qquad - OK$

Use ∅ 14 then

$$n = \frac{A_s}{A_{s\varnothing}} = 4.014$$

Take 5 ∅ 14 /m *with* $A_s = 769.7\text{mm} \ /m \ strip$ *or* ∅ 14@ 200 mm.

Step (s) is the smallest of:

1. $3h = 660$ mm
2. $450 \ mm.$
3. $s = 380\left(\frac{280}{f_s}\right) - 2.5C_c = 330$ mm

$$s \leq 300\left(\frac{280}{f_s}\right) = 300 \text{ mm} \qquad - control$$

$$s = 200 \text{ mm} < s_{max} = 300 \text{ mm} \quad - OK$$

Temperature and shrinkage reinforcement

$A_s(Temperature\ and\ shrinkage) = 0.0018bh =$ 396 mm

$$n = \frac{A_s}{A_s} = 3.5$$

Take $4 \varnothing 12/m$ or $\varnothing 12$ @ $250mm.$

Step $(s - for\ shrinkage\ and\ temperature\ reinforcement)$ is the smallest of:

1. $5h =$ 1100 mm
2. $450\ mm - control.$

s = 250mm< s_{max} = 450mm - OK

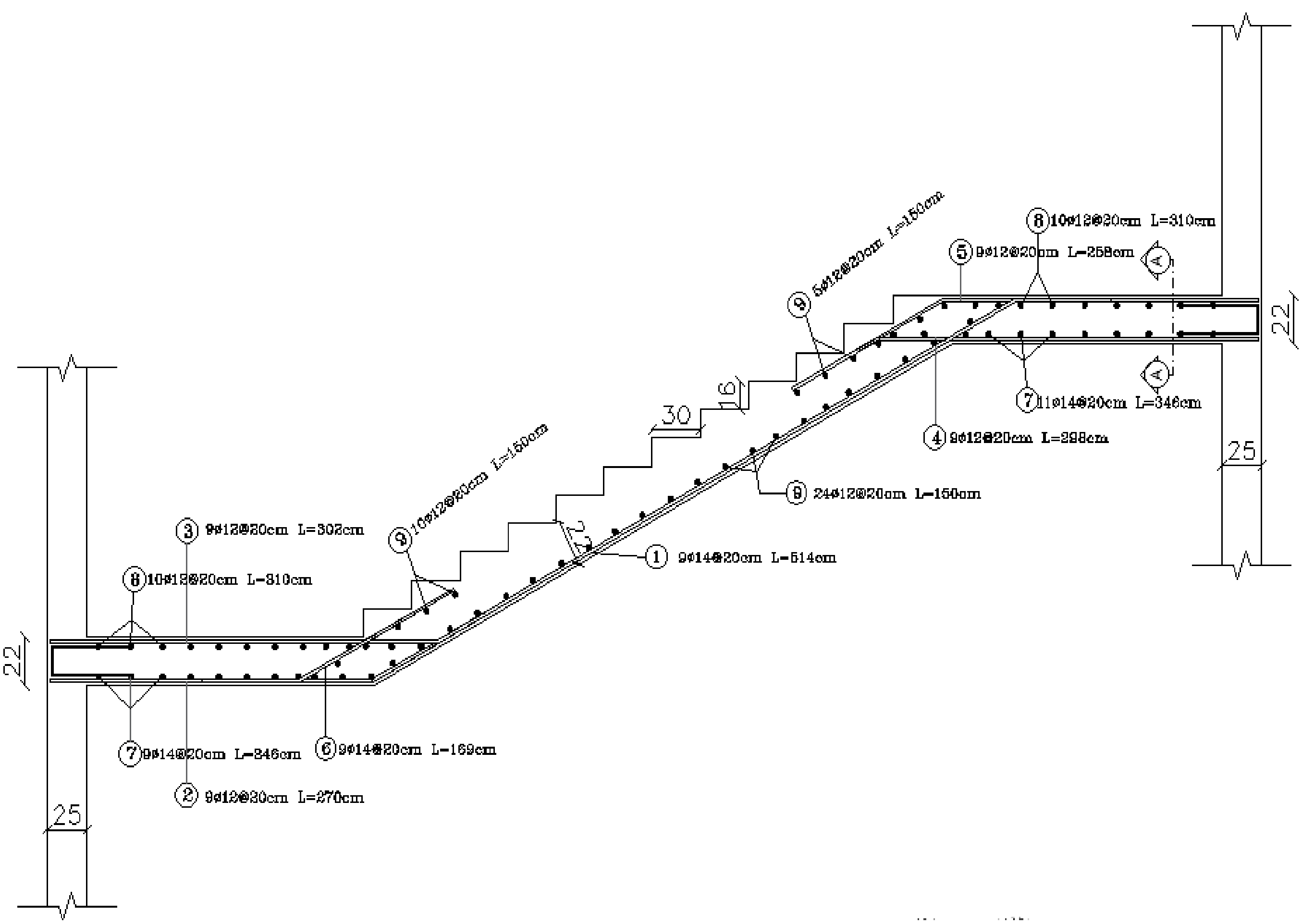


Figure (4-8): section of stair

4.10 Design of Shear wall

Analysis and design were done using ETABS program in which the seismic loads were taken into account. The following is a sample calculation for one of the walls

The following data that used in design**:**

Shear Wall thickness = h = 25 cm

Shear Wall length Lw = 4.4m

Building height Hw=16.3 m

Critical section shear :

Lw/2=4.4/2=2.2 ….. **control**

hw/2=16.3/2=8.1

→ d =0.8*Lw =0.8*4.4 = 3.5 m

Design of Horizontal Reinforcement

Calculation of Shear Strength Provided by concrete Vc:

Shear Strength of Concrete is the smallest of :

Vc = $\frac{1}{6}\sqrt{fc'} \times b \times d$

= $\frac{1}{6}\sqrt{24} \times 250 \times 3500 = \mathbf{710.35kN} \ll$ Controlled

Vc = $0.27\sqrt{fc'} \times h \times d + \frac{Nu \times d}{4Lw}$

= $0.27\sqrt{24} \times 250 \times 3500 + 0 = 3068.7\ KN$

$$Vc = \left[0.05 * \sqrt{fc'} + \frac{Lw\left(0.1\sqrt{fc'} + 0.2\frac{Nu}{Lw.h}\right)}{\frac{Mu1}{Vu} - \frac{Lw}{2}}\right] \times h \times d$$

Where:

Mu1=762.8kN.m

- $\frac{Mu1}{Vu} - \frac{Lw}{2} = \frac{762.7}{324.4} - \frac{4.35}{2} = 0.177 > 0$

$$Vc = \left[0.05 * \sqrt{24} + \frac{4350\left(0.1\sqrt{24} + 0.2\right)}{0.177}\right] \times 250 \times 3480 = 14751.2kN$$

$\therefore Vc = 710.35\text{kN} \rightarrow \emptyset\text{Vc} = 532.8 < \text{Vumax}$[1] $= 324.4$ kN →Horizontal Reinforcement is Required.

$$\text{Vs} = \frac{\text{Vu}}{\emptyset} - \text{Vc} = \frac{324.4}{0.75} - 710.35 = 277.8\ \text{kN}$$

$$\frac{\text{Avh}}{\text{s}} = \frac{\text{Vs}}{\text{fy} * \text{d}} = \frac{277.8 * 10^3}{420 * 3480} = 0.19$$

but $\left(\frac{\text{Avh}}{\text{s}}\right)\text{min} = 0.0025 * \text{h} = 0.0025 * 250 = \mathbf{0.625} \ll \text{Controlled.}$

Avh : For 2 layers of Horizontal Reinforcement

Select Ø8 :

Avh = 2 *79 = 158mm^2

$$\frac{Avh}{s} = 0.625 \rightarrow Sreq = \frac{158}{0.625} = 252.8\ mm$$

Smax= Lw/3 =440/3 = 1450 mm

= 3h = 3*250 =750mm

$= 45cm \ll$ Controlled.

∴Select Ø10 @ 200 mm at each side.

Design of Vertical Reinforcement

$Avv = [0.0025 + 0.5\ (2.5 - \frac{hw}{lw})(\frac{Avh}{Shor*h} - 0.0025)] * h * Sver$

$\frac{hw}{lw} = \frac{16}{6} = 1.5 < 2.50$

$\frac{Avv}{Sver} = [0.0025 + 0.5\ (1.5)(\frac{2*79}{250*250} - 0.0025)] * 250$

$\therefore \frac{Avv}{Sver} = 0.63$

Smax= Lw/3 =4400/3 = 1450 mm

= 3h = 3*250 =750mm

$= 45cm \ll$ Controlled.

∴Select Ø16 @ 150 mm at each side.

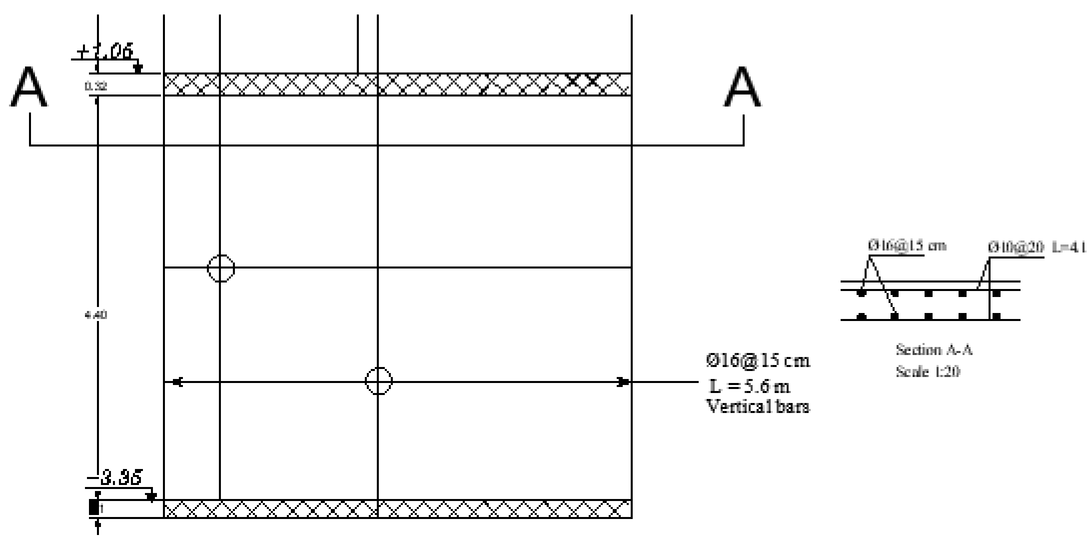


Figure (4- 13):section of shear wall

4.11 Design of Basement wall :

Weight of dry backfill= 16 KN/m^3

Weight of surcharge = 5KN/m^3

Angle of internal friction = -35°

Fc′=24 Mpa

Fy=420Mpa

C_{o} = 1- sin ∅= 1-sin (35) =0.426

h_s (due to surcharge)=$\frac{\omega s}{\omega} = \frac{5}{16} = 0.3125$m

Due to soil pressure at rest , $P_o = C_o * \omega * h$ = 0.426*0.3125*3.75 = 25.56KN/m^3

$H_o = \frac{\text{po h}}{2} = \frac{25.56*3.75}{2}$ = 47.93KN

Due to surcharge, $P_s = C_o * \omega * h_s$= 0.426*16*0.3125= 2.13KN/m^3

$H_s = P_s h$ = 2.13*3.75=7.99 KN

$Mu=1.6* H_o*\frac{L}{7.5}+1.6* H_s *\frac{L}{8}$

$1.6*47.93*\frac{3.75}{7.5} + 1.6*7.99*\frac{3.75}{8}$ = 44.33 KN.m

$R_B = 1.6\ (\frac{Ho}{3}+\frac{Hs}{3}) - \frac{Mu}{L} = 1.6(\frac{47.93}{3} + \frac{7.99}{3}) - \frac{44.33}{3.75}$ = 20.13KN

$R_A = 1.6(H_o+ H_s)- R_B$=1.6(47.93+7.99)-20.13=69.33KN

Maximum positive bending moment within the span occurs at the section of zero shear

$Vu = R_B - 1.6*\frac{1}{2}(\frac{Po}{L})\ X^2- 1.6* P_s\ X$ =0.0

$= 20.13-1.6*\frac{1}{2}(\frac{25.56}{3.75})\ X^2- 1.6*2.13*X=0.0$

X=1.63m

For the positive moment

$Mc = R_B*X-1.6*[\frac{1}{2} *\frac{Po}{L} *X^2 *\frac{X}{L} +P_S*\frac{X2}{2}\ ]$

$=20.13*1.63-1.6[\frac{1}{2} * \frac{25.56}{3.75} * 1.63^2 *\frac{1.63}{3.75} + 2.13 *\frac{1.63^2}{3.75}]$=24.1KN.m

Assume h= 600mm and ∅20 for bar diameter

d= h-cover-$\frac{dbar}{2}$

600-75-10=515mm

For Mu = 44.33KN.m

$R_n = \frac{M_n}{b*d^2} = \frac{44.33*10^6}{0.9*1000*515^2}$=0.185 Mpa

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

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

$= \frac{1}{20.6}(1 - \sqrt{1 - \frac{2*0.185*20.6}{420}})$=0.00044

As = ρ *b*d=0.00044*1000*515=226.6mm^2/m

$As_{min} = \frac{\sqrt{f_c'}}{4\,(f_y)} * b * d$ =1501.8 mm^2/m

$\frac{1.4}{f_y} * b * d$=1716.7 mm^2/m………..control

Use 9∅16 ….. As =1809.6mm^2>As $_{req}$=1716.7mm^2

spacing = $\frac{100}{9}$ = 11.11 …… take ∅16@10cm (vertical outside)

For Mu = 24.1KN.m

Assume h= 600mm and ∅16 for bar diameter

d= h-cover-$\frac{dbar}{2}$ = 600-75-8=517mm

$R_n = \frac{M_n}{b*d^2} = \frac{24.1*10^6}{0.9*1000*517^2}$=0.1 Mpa

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

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}) = \frac{1}{20.6}(1 - \sqrt{1 - \frac{2*0.1*20.6}{420}})$=0.00024

As = ρ *b*d=0.00024*1000*517=123.4mm^2/m

$As_{min} = \frac{\sqrt{f_c'}}{4\,(f_y)} * b * d$ =1507.6 mm^2/m

$\frac{1.4}{f_y} * b * d$=1723.3 mm^2/m………..control

Use 9Ø16 ….. As =1809.6mm^2>As $_{req}$=1723.3mm^2

take Ø16@10cm (vertical inside)

Minimum horizontal reinforcement

for $\emptyset \leq \emptyset 16$

As_{min}= ρ*b*h=0.002*100*30=6cm^2/m both sides

Use Ø10 @ 20cm (horizontal reinforcement each side)

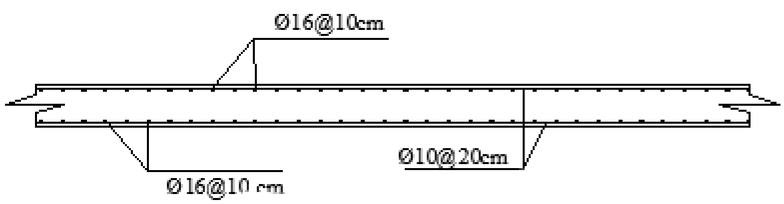


Figure (4-9): section of BASMENT WALL

CHAPTER 6

RESULTS AND RECOMMENDATIONS

6.1 Introduction

6.2 Results

6.3 Recommendations

6.1 INTRODUCTION

After starting the project and start dealing with problems that had been faced during the work on it, it is necessary to summarize the results that were reached and to give some recommendations that will be helpful for students who will work on such projects.

The most prominent of these problems was deflection in beams and long term deflection in slabs that could have been solved by using drop beams . So that another solution had been found, and that was through changing the structural system by changing the bearing direction of ribs and beams. After dealing with that problem a complete design for all slabs and beams were done and the results of the design is presented in a form of drawings.

6.2 RESULTS

The following are results that had been reached during the work on this project:

The most important step before starting a design is to study the architectural plans carefully to distribute the columns correctly.

Gaining experience in using structural programs cannot be reached without an understanding of basic concepts of the structural design.

When choosing the structural system it is better to distribute ribs in the long direction and beams in the short one that will reduce loads that act on beams which leads to reducing of reinforcement which meant reducing costs.

6.3 RECOMMENDATIONS

After starting the project and start dealing with problems that had been faced during the work on it, some recommendations should be mentioned that may help students who will work on such projects after us.

First of all, the architectural drawings had to be prepared and studied carefully to choose the most appropriate structural system. Collecting data about the project is an important step as the study of the site and the type of soil are important in choosing the construction materials to be used. Before starting the design of the building a good structural planning must be done to determine the location of columns, beams, and shear walls to fit with architectural plans.

References

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

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

[3] Uniform Building Code : UBC -97 code .

[4] كود البناء الأردني, كود الأحمال والقوى, عمان,الأردن: مجلس البناء الوطني الأردني, 2006م.