Palestine Polytechnic University

Faculty of Engineering and Technology

Department of Civil Engineering and Architecture

Specialization in Civil Engineering-Building Engineering Branch

Project Name

Structural Design of Land of Civilizations Museum

Supervisor:

Eng. Inas Jamal Al-Shweiki

Team:

Rand Ra'ed Sharabati

Salsabeel Imad Abu Rayyyan

Aya Hani Arman

Palestine – Hebron

2019

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Submitted to the College of Engineering in Partial Fulfillment of Requirements of the Bachelor Degree of Civil engineering/ Building Engineering Branch.

Faculty of Engineering and Technology

Department of Civil Engineering and Architecture

Palestine Polytechnic University

Evaluation certificate graduation project page
Certification of Evaluate Graduation Project

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Based on the instructions of Eng. Inas Jamal Al-Shweiki and the approval of all members of the committee, this project was introduced to the department of Civil Engineering and Architecture in the Collage of Engineering and Technology for partial fulfillment of the requirements for The Bachelor Degree.

Supervisor signature	**Head of the department signature**
Eng. Inas Jamal l-Shweiki	**Eng.Faydi Shabana**

2019

Palestine Polytechnic University

Dedication

To Mom and Dad, family and friends.

To our competitors and supporters.

To caffeine and sugar, our companions through long nights.

To everyone that has made us the persons who we are.

Also, we dedicate this simple work for our Teachers who tries to simplify the engineer science for us.

RSharabati, S.Abu Rayyan, A.Arman.

Thanks

To our God,

for blessing us to finish this project.

To our Parents,

Words do little to express how thankful we are to you as a role models. Teachers and guides. You have shown us how to live life to the fullest, how to be strong, how to love and how to treat other. All that we are, all that we do, and all that we become, is a result of your unconditional love and unwavering support.

THANK YOU FOR MAKING TODAY POSSIBLE.

To our Supervisor,

We are so fortunate to have such a creative supervisor, you have supported us through good times and bad, We would like to express our deepest gratitude to you Mrs. Inas.

We would like to extend our thanks to those who collegial guidance and support over this project.

RSharabati, S.Abu Rayyan, A.Arman.

الملخص

التصميم الإنشائي لمتحف ارض الحضارات

المشرف:
م. ايناس جمال الشويكي

فريق العمل :

رند الشرباتي　　اية عرمان　　سلسبيل أبو ريان

يمكن تلخيص هدف المشروع على عمل التصميم الانشائي لجميع العناصر التي يحتويها هذا الصرح - متحف ارض الحضارات- من عقدات و جسور و اعمدة و اساسات و جدران و غيرها من العناصر الإنشائية الأخرى. و قد أصبحت الاتجاهات الحديثة في العمارة و المهتمة بالاثار و التاريخ تتجه الى اعادة احياء الابنية و المواقع التاريخية و ترميمها لاعادة تشغيلها من جديد كمتاحف اثرية تهدف الى تخليد الحضارات و تجذب السياح و المهتمين من جميع اقطار العالم .

يتكون المبنى من ثلاثة طوابق اثنان منهم تحت الارض، يحتوي المتحف على سبعة اقسام: قسم الزوار، معارض الاثار، القسم الاداري، قسم الابحاث، قسم التخزين، قسم خدمات المبنى، قسم الحدائق و تبلغ المساحة الكلية للمبنى 30445 متر مربع، يركز المتحف على الموقع الاثري لجبل هيروديون-فريديس- الموجود في الطريق بين الخليل و بيت لحم، بحيث يحتضن مبنى المتحف الاثار الموجودة في الموقع كما هي بدون تغيير مكانها، بالاضافة الى صالات عرض للاثار التي تم العثور عليها في مناطق مختلفة في فلسطين.

يكمن تميز المشروع في تنوع طرق الانشاء له، فاحد اقسامه يمكن عمله بنظام الاطارات و الاخر بالخرسانة المسلحة و ايضا يمكن استخدام الستيل فيه، كما تتنوع فيه العناصر الانشائية كالجسور و الاعمدة و البلاطات و غيرها مع تعدد الكتل الموجودة، اضافة الى الاهتمام بتوفير الراحة و السهولة و الهدوء بسبب بعده عن صخب المدينة و سرعة وصول المستخدمين من المدن المختلفة.

من المهم الإشارة انه سيتم استخدام كود الأحمال الأردني و الأمريكي (ACI 318-14) ولا بد من الإشارة إلى انه سيتم الاعتماد على العديد من البرامج منها : Microsoft Office, AutoCAD 2016, Safe, Etabs, Air, Sp Column.

Abstract

Structural Design for Land of Cultures Museum

Supervisor:

Eng. Inas Jamal Shweiki

Team:

Rand R. Sharabati **Aya H. Arman** **Salsabeel I. Abu Rayyan**

We can summarize the aim of the project, is to work on the structural design for all elements in this edifice -Land of Cultures Museum- like slabs, beams, columns, foundations, walls and other structural elements. Modern trends in architecture and its interests In Archaeology have moved to rebuild the historical places, buildings, and restore to reuse it as archaeological museums aimed to immortalize civilizations and attract tourists from all over the world.

Museum contains three stories; two of it is underground floors. This museum contains seven sections: visitors', archaeology exhibitions, administrative, research, storage structure service and gardens part. The total building area is 30455-meter square. This museum is located in Herodian mountain (Hebron-Bethlehem high way). The museum embraces the archaeology without change its place and there are showrooms for the archaeology from different places in Palestine.

This project can distinguish in variety of construction methods. One of these is Frame system, another one is reinforcement concrete, and we can use steel elements. There are different elements in this structure, such as columns, beams, slabs, etc. It contains different architecture blocks. Furthermore, this structure is comfortable and quiet, because it's far from the city noise and it's easy to arrive.

American concrete institute (ACI 318-14) is the reference code during project analysis and design, we will use software applications such as: AutoCAD 2016, Microsoft Office, ETABS, SAFE, Atir, SpColumn.

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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
b	width of compression face of member
Cc	compression resultant of concrete section.
Dl	dead loads.
d	distance from extreme compression fiber to centroid of tension reinforcement.
Fc	compression strength of concrete.
Fy	specified yield strength of non-prestressed reinforcement.
h	overall thickness member.
LL	live loads.
M	bending moment.
Mu	factored moment at section.
Mn	nominal moment.
Pn	nominal axial load.
Pu	factored axial load.
S	spacing of shear 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)
W	width of beam or rib.
Wu	factored load per unit area.
φ	strength reduction factor.
S_c	compression strain of concrete.
S_s	strain of compression steel.
ρ	ratio of steel area.
ε_c	compression strain of concrete=0.003mm /mm
Fsd, r	total additional tension force above the support.
Ved,0	shear force at critical section.
Ned,0	normal tension force at support.
α	angel of stirrup.

Chapter 1

1.1 Introduction

The last century has witnessed a starting of a period of revolution and improvement in whole life aspects, and with the increasing of population in the cities it was very essential to cope up with these improvements in all fields in a way that suits and controls the environment.

Today museums have progressed from being more spaces where art and science products are displayed and all treasures of the past are conserved to being informal educational Ares and tools for communicating the mass culture. Museums, consisting wide base libraries, project development facilities, art ateliers and display rooms, museums are turning into educational areas which enrich social life.

1.2 General Identification

The project is a cultural museum in Bethlehem -Herodion mountain-, it provides all requirements needed for a suitable place such as show rooms, library, reception, storages, Cafeteria, Bedrooms for visitors, Manager and administration rooms, and all services needed.

1.3 Reasons for choosing the project

After more than a month of searching on a special project, we decided to challenge ourselves by choosing the “land of civilizations’’ museum in Bethlehem from a lot of other projects because of the large size of the project and including many various structural members that it’s the most important thing we are looking for.

1.4 The Project Objectives

The objectives of this project are divided into architectural and structural objectives.

Architectural Objectives

The main architectural aim is to create a design that is unique in views, representative and improve the architectural that Palestine lacks. So, the museum is designed upon the latest architectural styles

and technologies.

Structural objectives

The Structural objectives of this project are:

- To correlate what we have taken in the design courses with practical thinking.
- Take advantage of a strong technical education at the undergraduate level to embark on successful professional careers in life or to continue with a graduate education in this area of specialization.
- Increasing the ability of choosing a structural system that suit the objective of the building.

1.5 The Problem of the Project

The problem of the project is to find the most appropriate structural system that satisfies the strength and serviceability requirements m and to design and analyze the structural components that consists in the “Land od civilizations” museum. So, we will analyze and design these components such slabs, beams, columns, foundations, etc. After determining the loads on each of structural member so we can select the required dimensions and reinforcement, after that all of the design outputs will be presented in the structural drawing that used to transfer the project from being a drawing to the practical field.

1.6 The Postulate of the Project

Our study aims to prepare the required structural drawings of the various structural members existing in the building in a way that takes the architectural design as the main outlet. The design will be based on the requirements of the American Code (ACI -318-14), and the Jordanian Code of Lodes.

1.7 Chapters of Project

Chapter One:
General introduction of the project.

Chapter Two:
The architectural description of the project.

Chapter Three:
The structural studying of the project including structural members, loads, and the function description.

Chapter Four:
The structural analysis and the design of some structural members like: beams, and slabs.

Chapter Five:
Results, Recommendations & References.

1.8 Time Table For the Project

The Table below shows the time line table of the project stages.

Table 1.1: The Time Line Table of the Project Stages

Week NO. **Task**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Select project	■	■	■	■																												
Inception report					■	■	■																									
Collect information about the project							■	■																								
Architectural study of the building									■	■	■																					
Structural study of the building											■	■	■																			
Prepare the introduction														■	■																	
Display the introduction																■																
Structural analysis																	■	■	■	■	■	■										
Structural design																					■	■	■	■								
Prepare the project plans																									■	■	■	■				
Write the project																												■	■	■	■	
Project presentation																																■

Chapter 2

Architectual Description

2.1 Basic Identification of project
2.2 Project Site
2.2.1 Project Land Location
2.2.2 General Climate of the City
2.3 Project Components Description
2.3.1 Project Plans Description
2.3.2 Project Elevations Description
2.3.3 Project Sections Description

Architectural Description

The soul of architecture is suitable for humans to live in, work in, play in, etc. it is also to give comfort to its residents in order to make them feel comforted, uplifted, and feel that the structure is designed to appeal their requirements of leisure and enjoyment. A good architect does more than just designing buildings, yet the designer understands how people's environment affects their feelings in order to create an atmosphere that meets their needs and desires.

Architecture, the art and technique of designing and building, as distinguished from the skills associated with construction. It requires a strong technical knowledge in the fields of engineering, logistics, geometry. Building techniques, functional design and ergonomics. It also requires a certain sensibility to arts and aesthetics. Finally, it also requires talking in consideration human questions and societies problems. Architecture is a very broad humanistic field that, at the same time, is technical artistic and social.

2.1 Basic Identification of Project

The Idea of the project is the structural design of museum in Bethlehem. The museum consists of three floors, and seven sections, First one is Visitors section with area of 9880 m^2, Second one is Exhibitions of remains with area of 12165 m^2, third one is Administrative section with area of 425 m^2, forth one is research section with area of 445 m^2, fifth one is Storage section with area of 1450 m^2, sixth one is Building services with area of 80 m^2, and the last section is for Gardens with area of 6000 m^2, the total area of the museum is 30445 m^2. The project is featured by many declines which adds special architecture beauty to the structure, also by its integration with nature in general.

Figure 2.1: General Picture of Project.

2.2 Project Site

Its recommended that we can’t build on this site, because it taken by Israeli occupation.

Herodian mountain is located 6 km from Bethlehem and 12 km from East Jerusalem, its Within the boundaries of the municipality of Zaatara. In the north-east there is Za’tara town and to the east there is Jibba al-Deeb town, and on the western side there are Khirbat al-Deir and Khirbet al-'Uqban.

Figure 2.2: The location of the Project.

2.2.1 General climate of the City

This area generally enjoys a Mediterranean climate of a dry summer and mild, rainy winter with occasional snowfall. The recorded average of Bethlehem's rainfall is about 750 mm (26 in). While the western winds dominate, the northern winds are light and the eastern winds still blow on occasion.

2.2.2 Contour Lines of the Project Land

The project land isn't a flat area ,it has a varying level. Its slopes range from 650 to 655 meters above sea level. Herodian Mountain, which will connect with the project, rises to 750 meters above sea level, the difference between the project land and the mountain is from 100 to 105 meters.

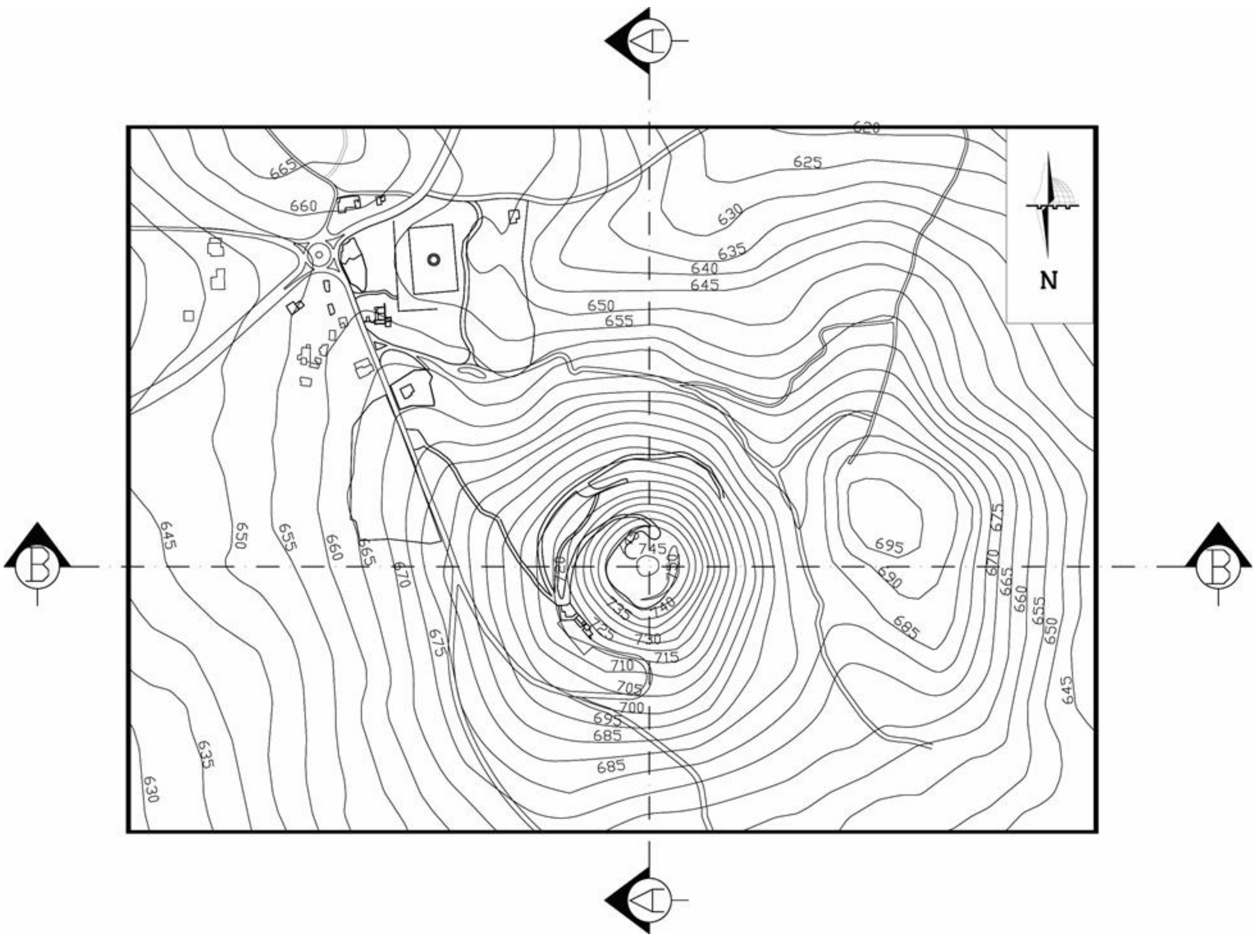


Figure 2.3: Contour lines of the Project.

2.3 Project Components Description

The designer used many declines which add special architecture beauty to the structure.

2.3.1 Project Plans Description

The museum has three floors (two basements, ground) with total area of 9097 m².

1. Second Basement floor Plan

The area of this floor is 1825 m², its level is -3.85, and it consists show rooms, Storages, Archives and mosque.

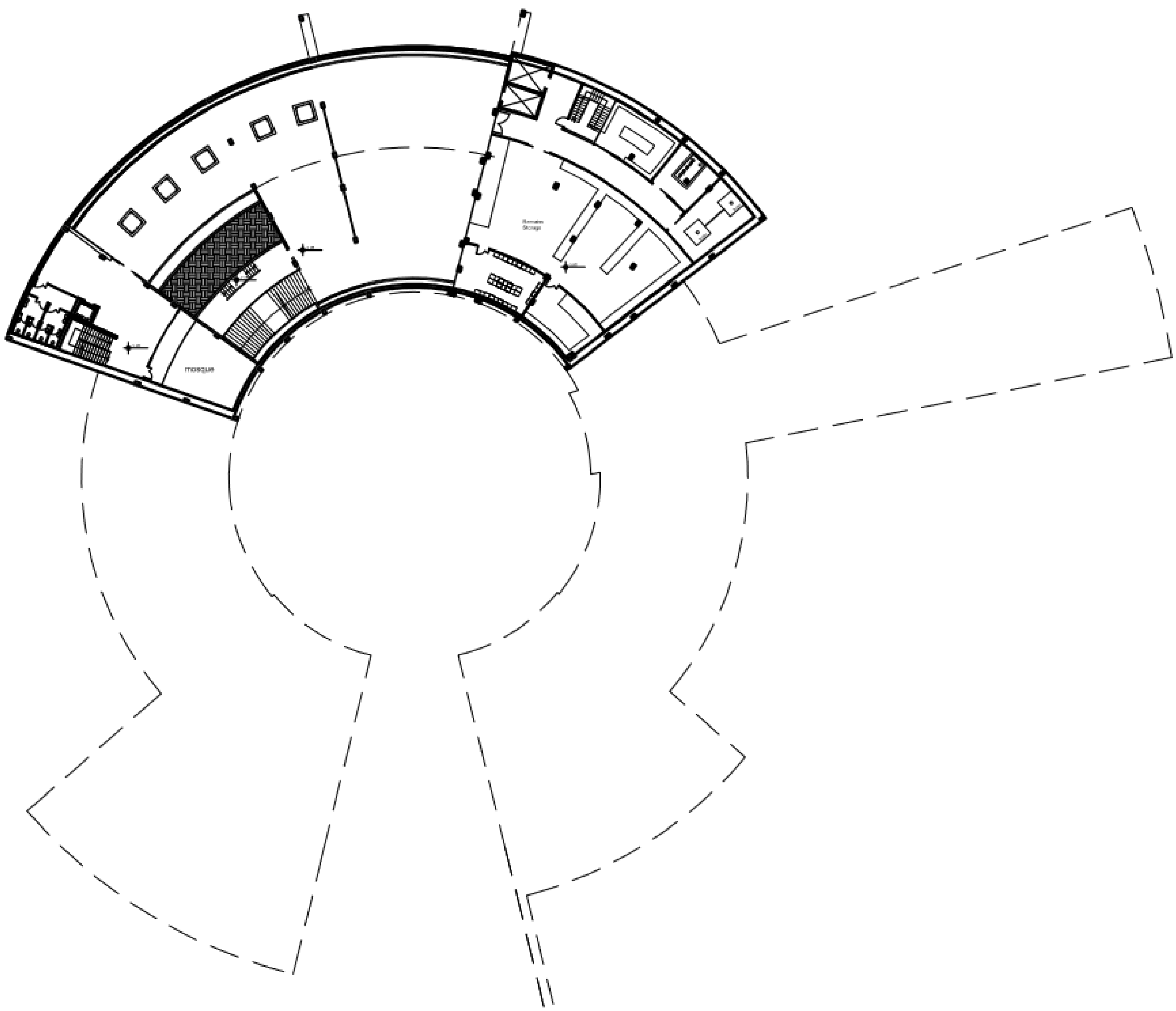


Figure 2.4: Second Basement Floor

2. First Basement Floor Plan

The area of this floor is 4036 m², its level is +0.15, and it consists of Offices, Showrooms, Halls, Cinema, Library, Bathrooms, Medical unit and lectures.

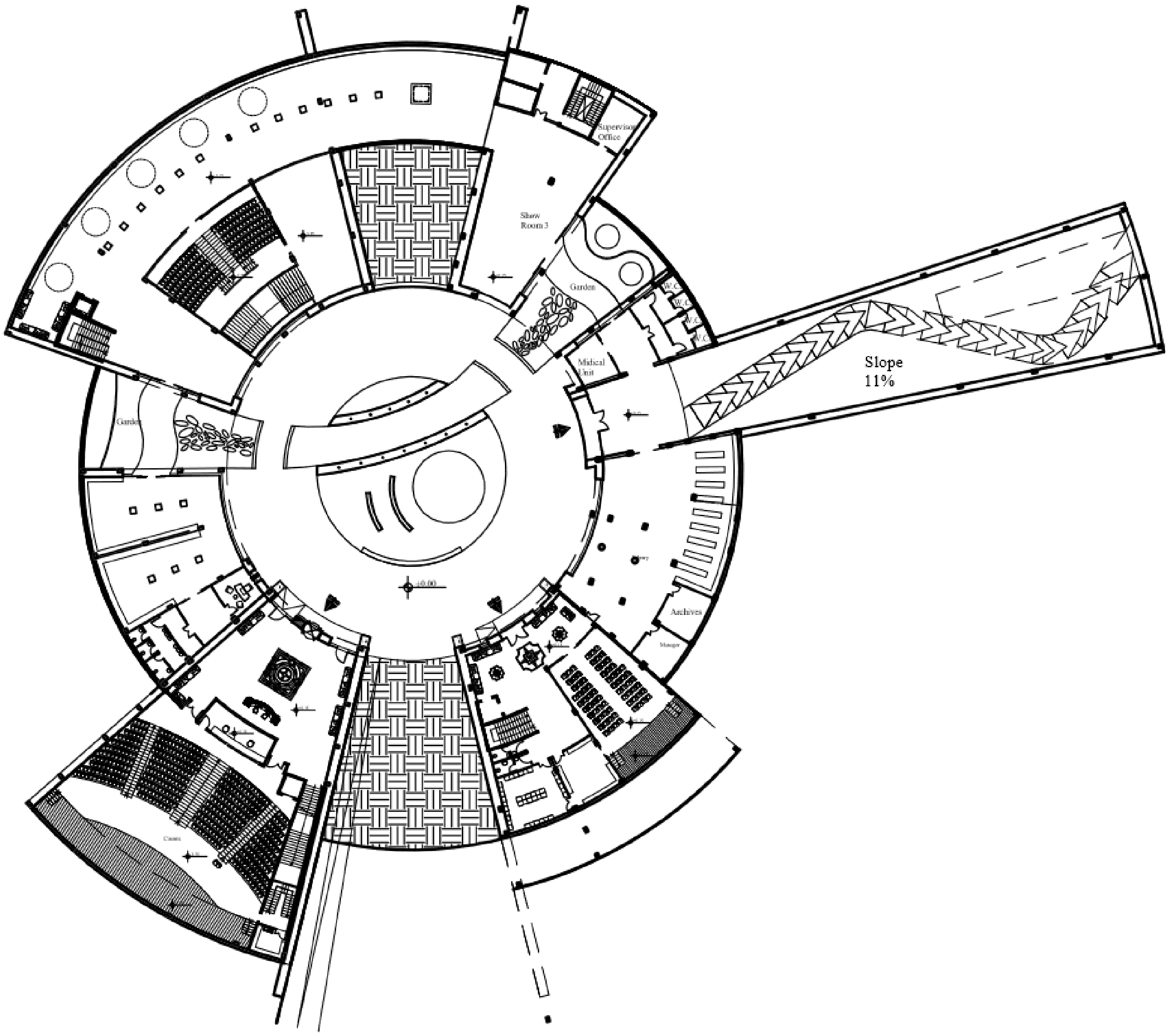


Figure 2.5: First Basement Floor

3. Ground Floor Plan

The area of this floor is 3236 m², its level is +4.00, and it consists of Cafeteria, Client Services, Cooking areas, Bedrooms, living rooms, Offices, Storages, and reception.

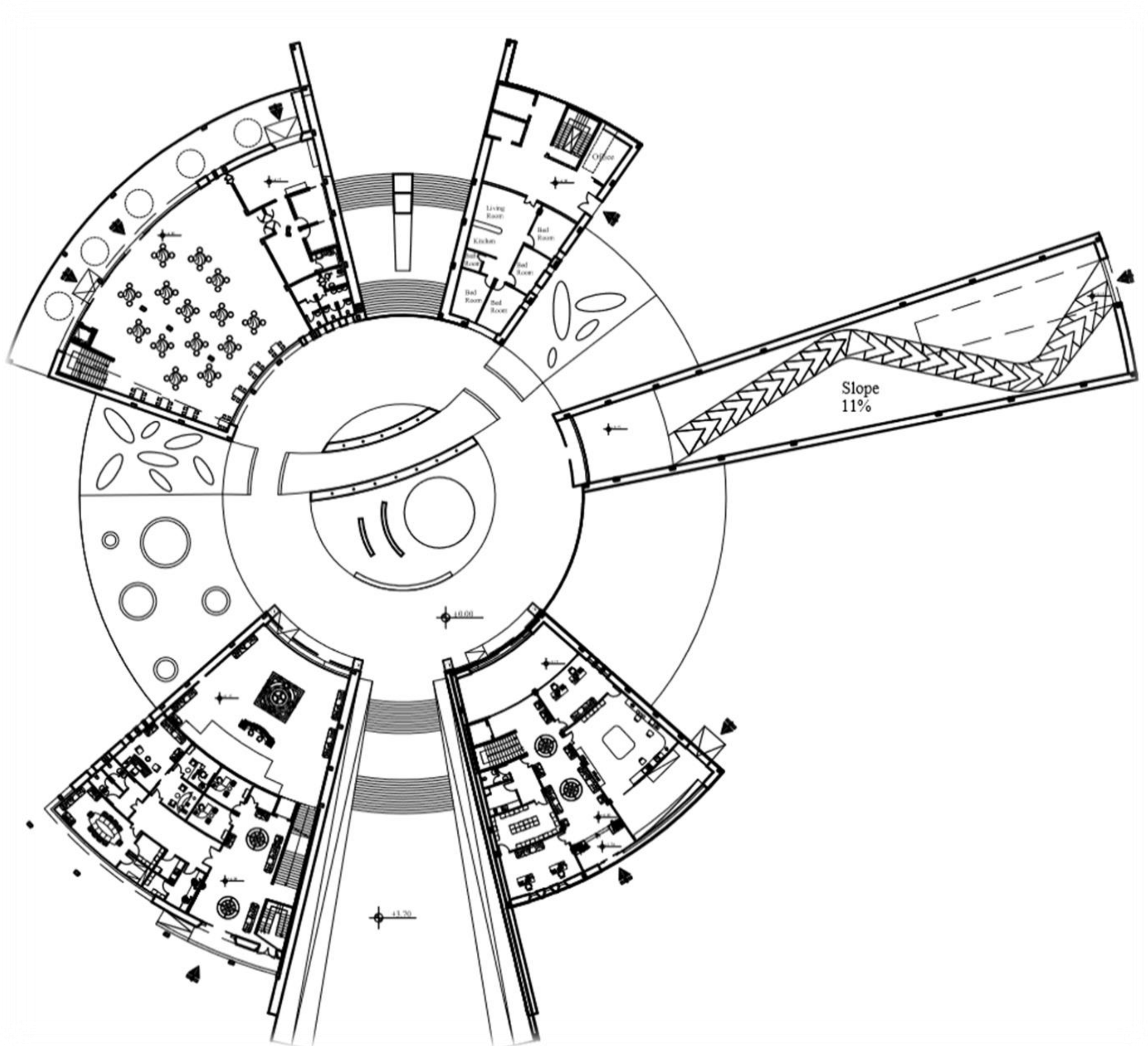


Figure 2.6: Ground Floor

2.3.2 Project Elevations Description

The interest of elevation for any architect is great as the elevation appearance should be suitable with the kind of the building and its uses, so its duty of the engineer to consider every detail of the elevations in terms of materials used, the distribution of the openings, and other factors that highlight the beauty of elevations design.

South Elevation

This elevation shows the tunnel which is connects between the mountain and the museum, and we can observe the differences between materials such as stone and steel, also the museum here looks like two buildings because of its circular shape, and the space in the middle is cort.

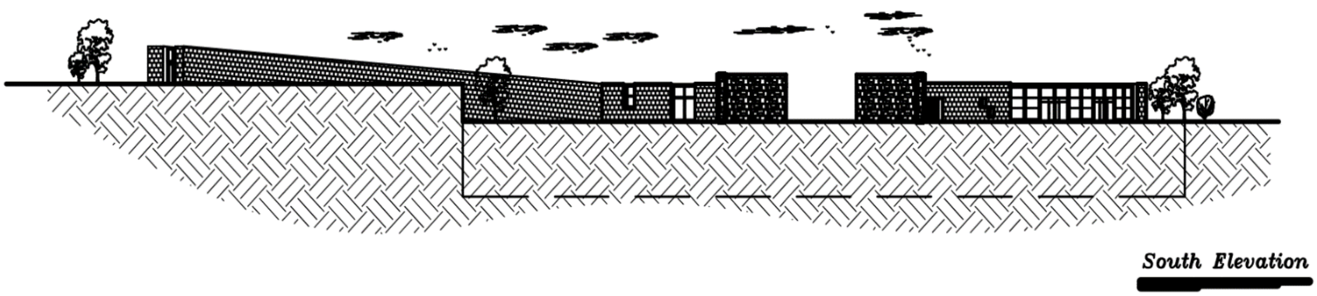


Figure 2.7: South Elevation

East Elevation

In this elevation we can observe the glass entrance and the integration between glass and stone also we can see some parts of the garden.

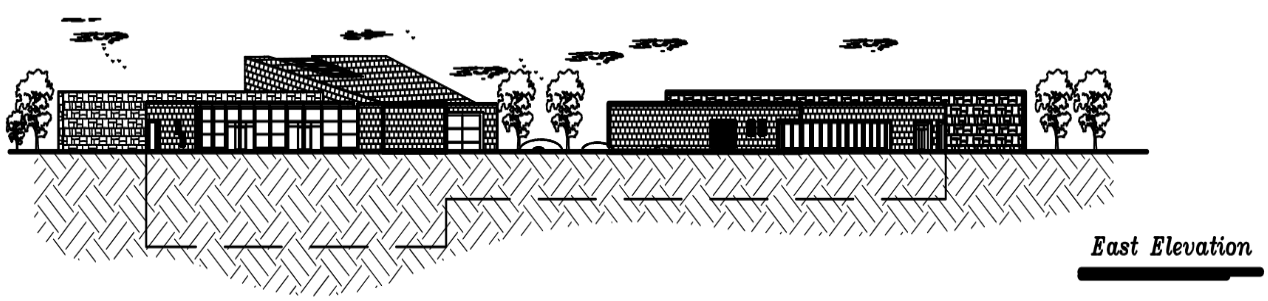


Figure 2.8: East Elevation

West Elevation

Here we can see the deference in elevations, and materials, and we can observe the setbacks between floors.

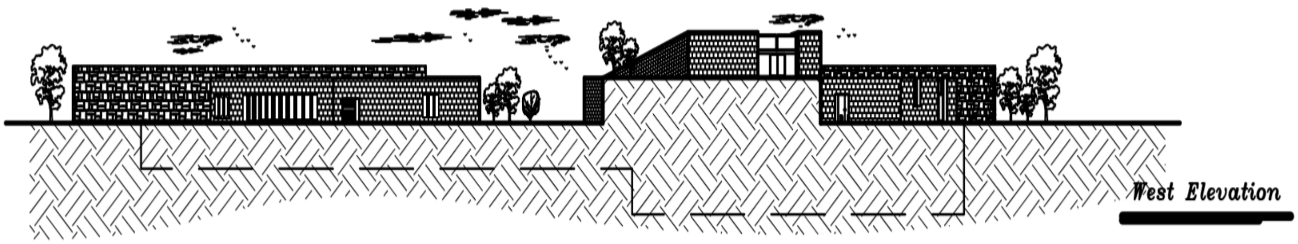


Figure 2.9: West Elevation

North Elevation

In this elevation we can see the tunnel which connects between the mountain and the museum again, the cort appears clearly in the middle.

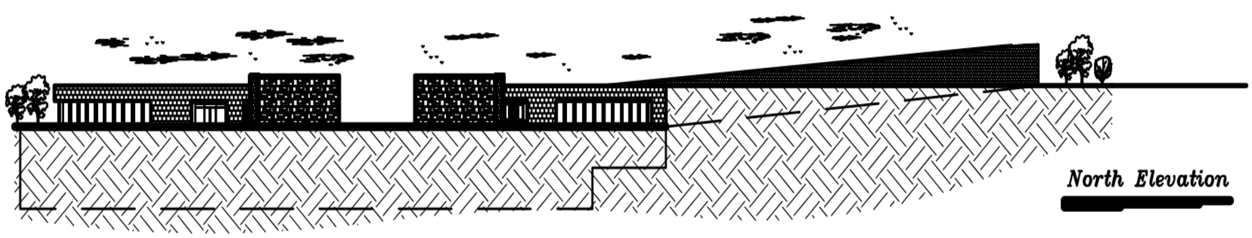


Figure 2.10: North Elevation

2.3.3 Description of Sections

The designer distributed the movement through the horizontal and vertical axes through stairs and corridors, according to the number of users and the allowable distance between each vertical axis for easy movements between the floors and to facilitate exiting in case of emergency.

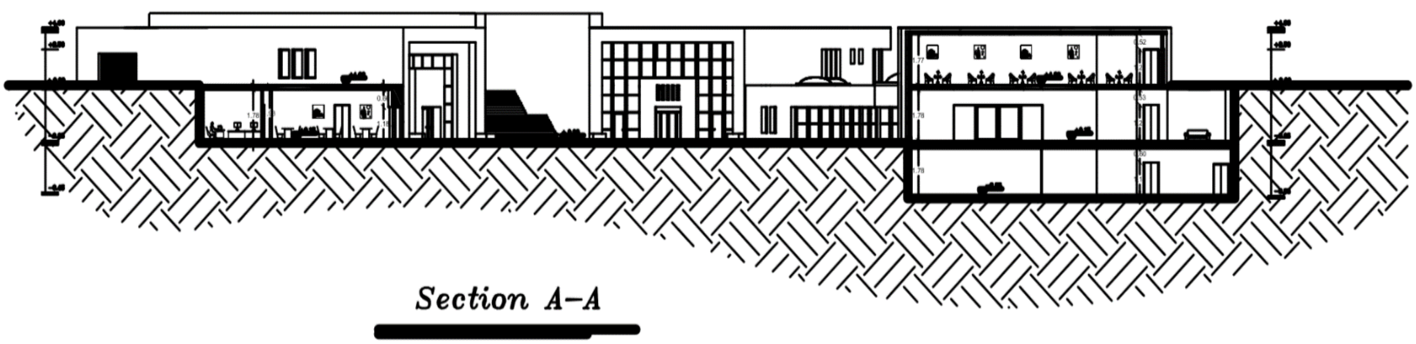


Figure 2.11: Section A-A

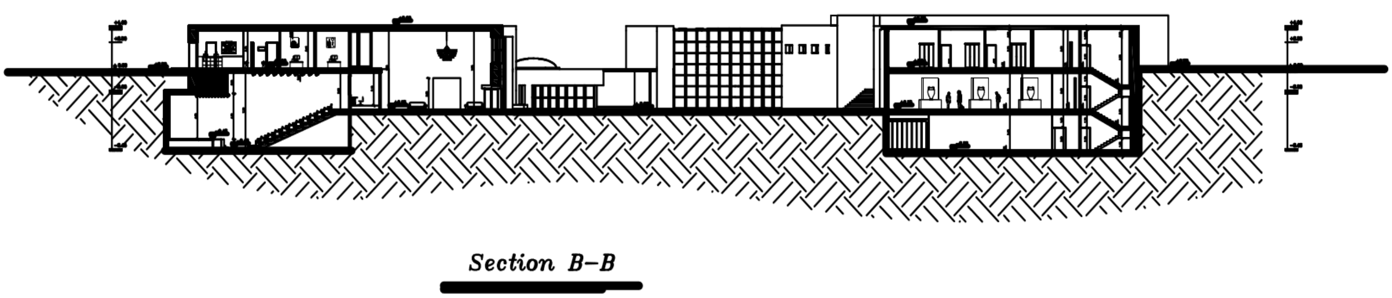


Figure 2.12: Section B-B

B-B

Chapter 3

3.1 The purpose of structural design

3.2 Studies of the structural elements of the building

3.3 Types of Loads

3.4 Practical Tests

3.5 Structural Elements

Structural Description

After completing the process of the architectural project explanation of all the details, we must move to the construction phase of the study for the project, in order to choose the appropriate structural system for each element in the building, in order to provide all requirement and design all elements necessary for the system. So, this taking into account the loads affecting the types of elements, showing how to deal with them and work to resist them, so we must know these structural elements in detail, in order to be customized and analyzed accurately.

3.1 The purpose of structural design

The purpose of structural design is to find the building is available where all safety requirements, in order to resist all the forces that affect the building in different forms, such as loads of dead and live or external forces such as earthquakes, wind and landing in the soil. When designing any element of these it should be taken in consideration the following standers:

1. **Safety**: is the essential element that must be provided in the design, so choosing the appropriate element of each region to resist loads that affecting them.

2. **Economy**: must be supplied when working on the selection of appropriate materials, and sufficient for its desired purpose and appropriate quantity, with lowest cost and highest quantity.

3. **Serviceability**: work to avoid any external failures, such as the decline in soil or any cracks in the external shape, or anything that works to increase this failure.

4. **Architectural side**: work to take into account the architectural elements in the building and try to keep it as much as possible.

3.2 Studies of the structural elements of the building

The most important step that should work out of the project before starting the structural design, working on a comprehensive study of the project in terms of its size the nature of its work, how to estimate the loads that effect on the building, choose items that are exposed to these loads, and identify system construction, which used to resist these loads.

3.3 Types of Loads

Loads are the base of design process, so they must have great consideration is specialty, identifying and study. Accurately, so differing building from another depends on the architectural design, project site, materials used in construction and other influences, therefore loads can be classified as follow:

1. **Basic loads**:
   The loads which must be taken into account in the structural design of the building in all cases, it includes: Dead load, Live load and Environmental loads.

2. **Secondary loads**:
   The loads that should be take into account in the design in some buildings, depending on the nature of the building and other influences, it includes: Shrinkage load, Thermal load, Snows load, Dynamic load, Seismic load.

3.3.1 Dead Load

These loads are permanent loads which are carried to the structure throughout their lifespan. Dead loads are also called as stationary loads. These loads occur mainly due to the self-weight of the structural members, fittings, fixed partitions, fixed equipment, etc.
Dead loads are calculated by estimating the quantity of each material and then multiplying it with the unit weight of that specific material.

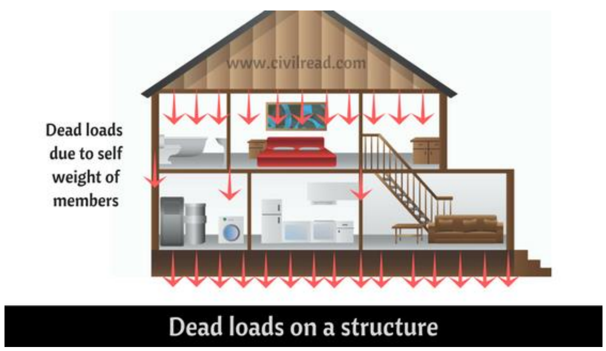


Figure 3.1 Dead Load

Table 3.1: Specific Density of the Materials Used

Number	Material	Density (KN/m³)
1.	Tiles	23
2.	Mortar	22
3.	Sand	16
4.	Plaster	22
5.	Block	15
6.	Reinforcement Concrete	25

3.3.2 Live load

As the name itself resembling that these types of loads are real-time loads. Live loads are also called as imposed or sudden loads. Live loads changes with respect to time. This type of loading may come and go. For example, At one moment the room may be empty hence the live load is zero. If the same room is packed with the people, then the live load intensity will vary considerably. The live load includes the weight of furniture, people occupying the floor, etc.

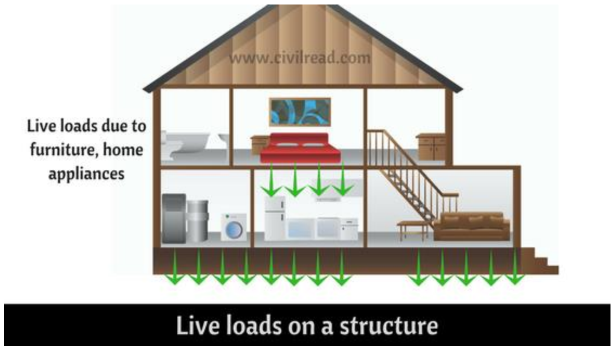


Figure 3.2 Live Load

Table 3.2: Live Loads (Ref: Jordanian Code)

Number	Use	Live Load (KN/m²)
1.	Apartments	2.0
2.	Stairs	4.0
3.	Museums Floors	4.0
4.	Banking Halls	3.0
5.	Parking	5.0

3.3.3 Environmental loads

The loads arising from the changes in the environmental such as seismic, wind and snow.

3.3.3.1 Seismic load (Earthquake load):

These type of loads causes movement of the foundation of structures. Earthquake forces are internal forces that developed on the structure because of ground movements.

Three mutually perpendicular forces act on the structure during an earthquake, two horizontal forces which acts in opposite direction and one vertical force due to the weight of the structure. As vertical force doesn't affect much during earthquake whereas two opposite horizontal forces results in movement of the building during an earthquake. These two horizontal direction forces are considered in the design.

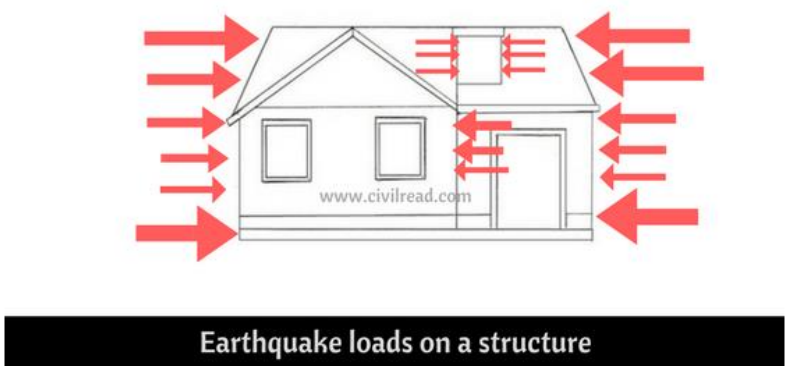


Figure 3.3 Seismic Load

3.3.3.2 Wind load:

This type of loads is considered in design for high-rise buildings. Wind loads are occurred due to the horizontal load caused by the wind. As an increase in using lighter materials in the construction, wind load for a building should be considered. The structure should be strong enough with the heavy dead weights and anchored to the ground to resist this wind load. If not, the building may blow away. Wind load acts horizontally towards roofs and walls.

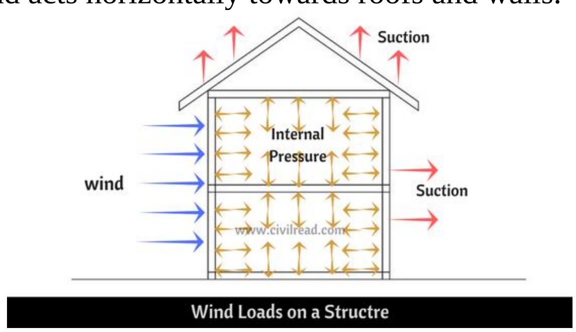


Figure 3.4 Wind Loads

3.3.3.3 Snow load:

The building must be designed to resist snow loads and to be taken into account the design and it depends on the height of the building and the area of this building.

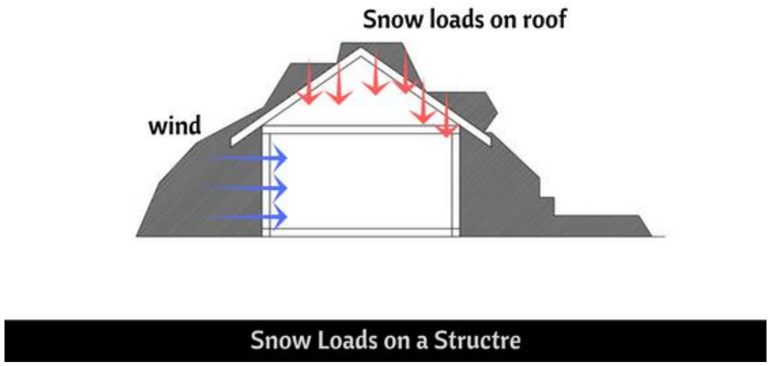


Figure 3.5 Snow Load

Table 3.3: Loads of Snow (Ref. Jordanian Code)

Building height above sea level	The value of load in surface (KN/m^2)
250 > h	0
500 > h > 250	(h-250)/800
1500 > h > 500	(h-400)/320

3.4 Practical Tests

Before you begin the process of design and construction, should work some of necessary tests at the site, especially on the soil, and work to see the quality of the rocks in the region, and work to deviate place waterfalls groundwater and its impact on the building, and work to resolve the problems if available of these problems, as soil test.

3.5 Structural Elements

There are many structural elements used in the buildings as the slab, beam, column, stairs, the shear wall and foundations.

3.5.1 The Slabs

Is an element which transfers the loads that are exposed to other structural elements such as column, beam, wall. There are many factors to select type of slabs:

1. The distance between the spaces and columns.
2. The desired function of the space.
3. Cost.
4. Ease of implementation and duration available for building.

And in Projects, we can use different types including:

3.5.1.1 Ribbed Slab:

In general, this type is most commonly used in our project, this contains the steel bars use to transfer the loads, and block and the concrete between this block and the topping of all, and we have two types of this:

• One-way ribbed slab.
• Two-way ribbed slab. -we didn't used it in our project-

In **one-way ribbed slab** system the joists or ribs run, usually, in the shorter direction. Since the joists act as T beams, the floor system would transfer load in one direction, hence it is deemed one way ribbed slab system.

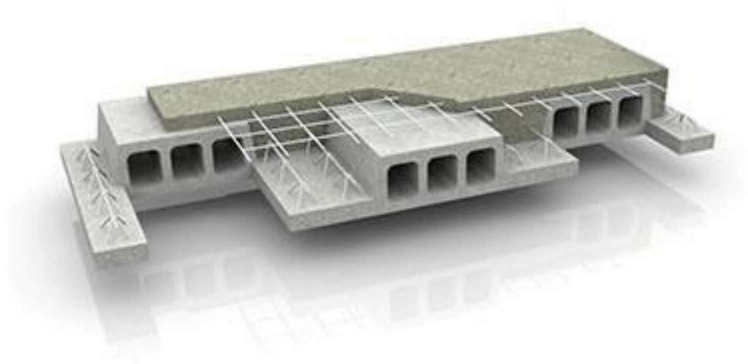


Figure 3.6 One Way Rib Slab.

Two-way ribbed slab is the type that used when the length of the two directions in the space approximately equal, and we used in this type a bar of steel in two direction to transfer the load.

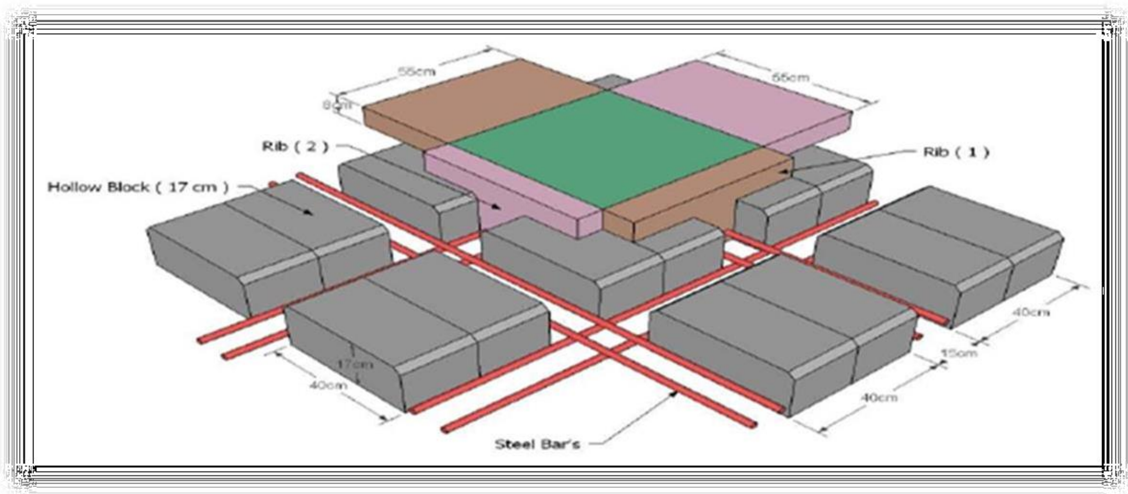


Figure 3.7 Two Way Rib Slab.

3.5.1.2 Solid Slab:

We use this method when the height of the spaces is important, and we don't have problem when show the drop beam and this transfer the load to the beam to the column, and we have two types:

one way and two way, and the difference between two types is the direction of transfer load.

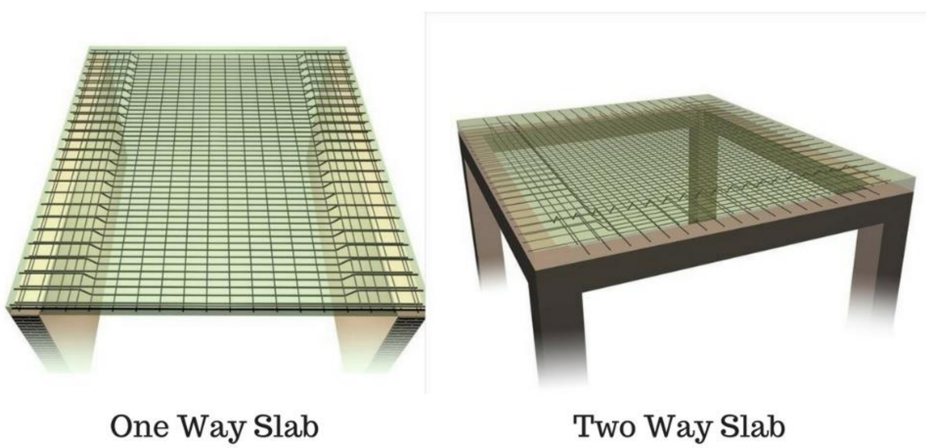


Figure 3.8 Solid Slabs

3.5.2 Beams

Use this element to transfer the load from the slab to the column, and have the type as hidden beam when have the same thickness of slab and drop beam when have different thickness.

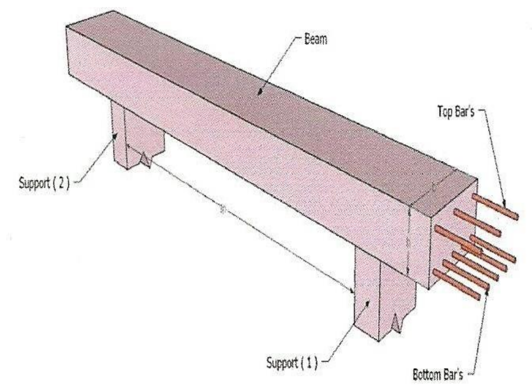
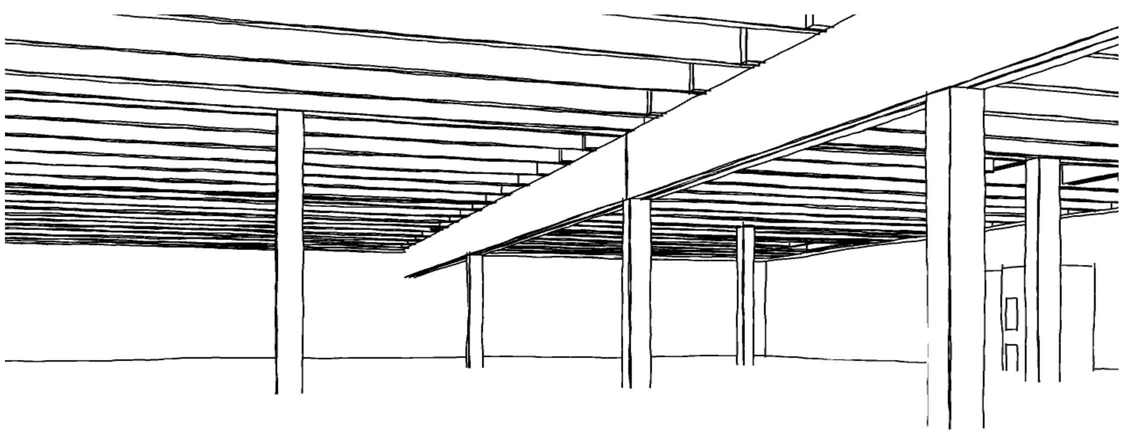


Figure 3.9 Hidden Beam.



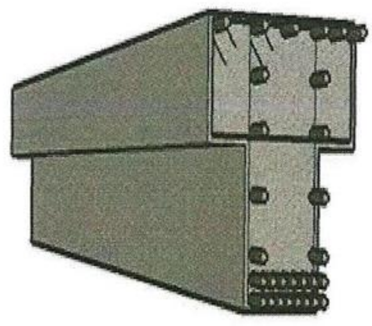


Figure 3.10 Drop Beam.

3.5.3 Columns

This element is uses to transfer the load from the slab to the foundation, and it helps in the stability of the building, and when design we will know the type design if short or slender column.

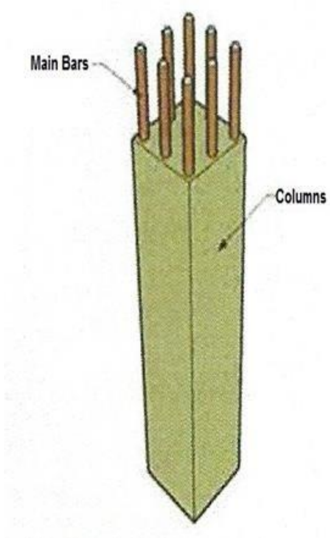


Figure 3.11 Square Column.

Figure 3.12 Circular Column.

3.5.4 Shear Wall

Shear wall is the important element structure because it is uses to resist the vertical and horizontal load; Shear wall is a type of structural system that provides lateral resistance to the building or structure. It resists loads as the wind and earthquake. When design this wall, we use two layer steel to give it more strength.

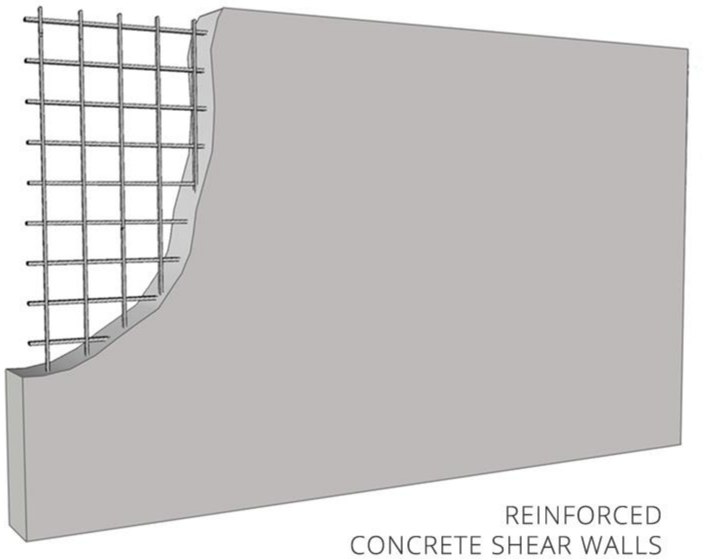


Figure 3.13 Shear wall.

3.5.5 Foundations

The first element we implemented on the ground, but is the last element we design, because all loads are transmitted to it whether the basic load as dead or live load or secondary load. So is the basic element, which receives all the loads and distributed it to the soil.

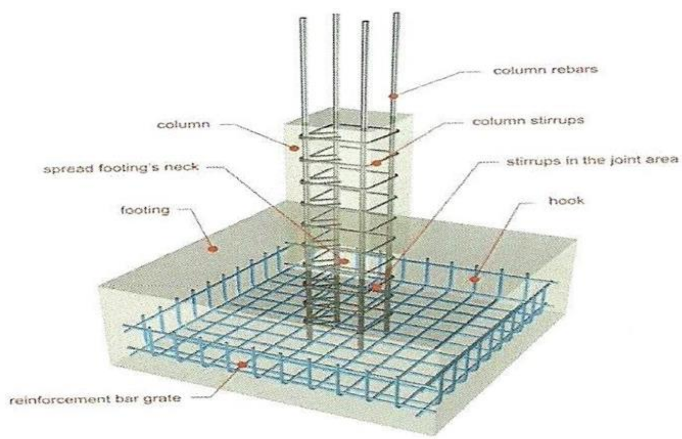


Figure 3. 14 Isolated Footing.

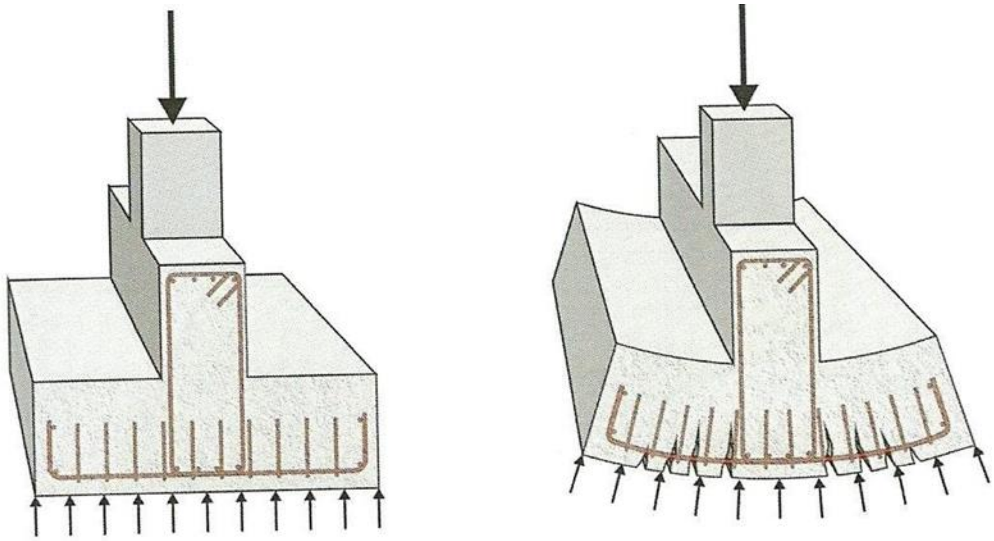


Figure 3.15 Strip Footing

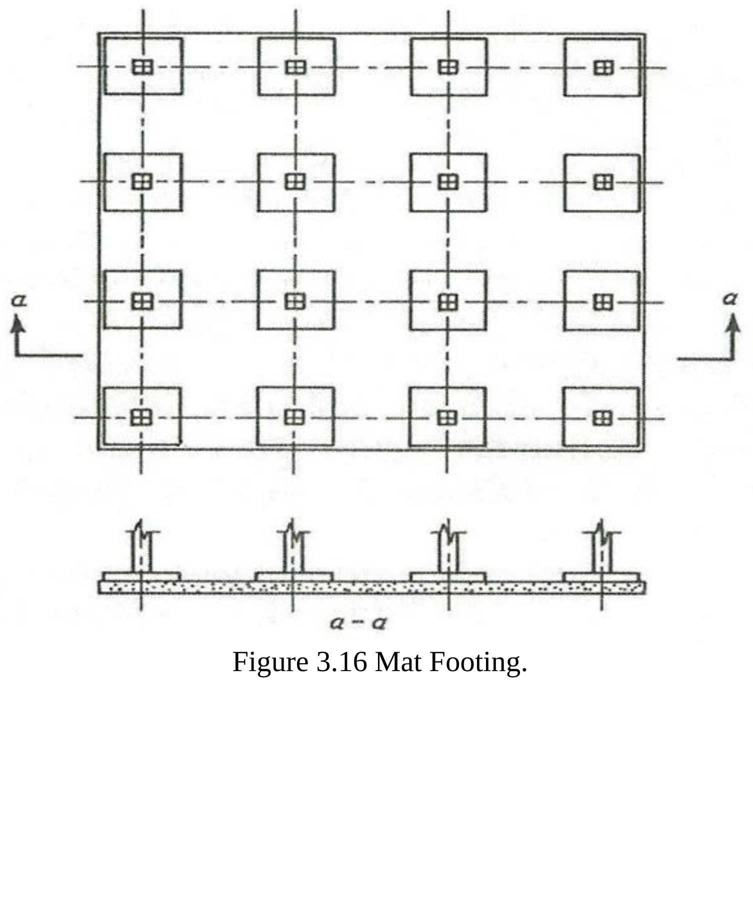


Figure 3.16 Mat Footing.

3.5.6 Stairs

The stairs are a vertical transmission element between the levels, and we used the one-way solid slab in the landing structural design.

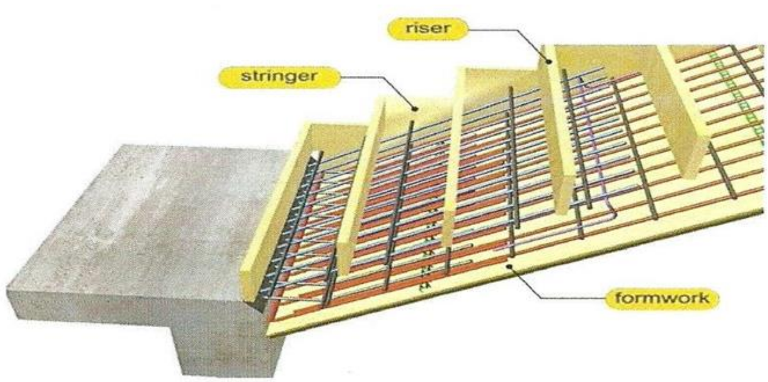


Figure 3.17 Stairs.

3.5.7 Expansion joints

Is a spacer which are used in order to avoid getting any expansion or other effects that may impair the building, where the building is separated entirely, and the building is separated after increasing distanced (35-45) m.

When you use joints must take into account the vast spaces of the building:

1. 40m areas with high humidity.
2. 36m areas with normal humidity.
3. 32m areas with medium humidity.
4. 28m with dry areas.

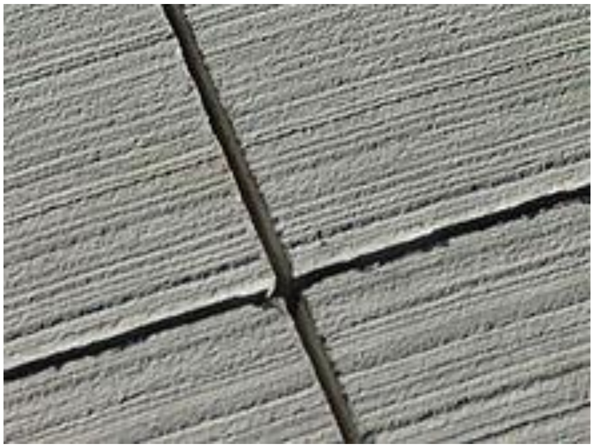


Figure 3.18 Expansion Joint.

Chapter 4

Structural Analysis and Design

4.1 Introduction.

4.2 Materials Properties were used.

4.3 Design of Rib 62.

4.4 Design of Beam (B, 58).

4.5 Design of Solid Slab.

4.6 Design of Staircase.

4.7Design of Column 06.

4.8 Design of Shear Wall.

4.9 Design of Basement Wall and its Footing.

4.10 Design of Isolated Footing.

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 and one-way ribbed. They would be analyzed and designed by using finite element method of design, with aid of a computer Program called " ATIR- Software" 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.

4.2 Materials Properties were used

For concrete, it was used a B300 ($fc' = 30 * 0.8 = 24MPa$) concrete compressive strength for slabs, beams and columns and B350 ($fc' = 35 * 0.8 = 28MPa$) for foundations.

For reinforcement steel, it is used a 420Mpa steel yielding strength.

4.3 Design of Rib (B1R62)

The structure may be exposed to different loads such as dead and live loads. The value of the load depends on the structure type and the intended use. The factored loads on which the structural analysis and design is based for our project members, is determined as follows:

$$q_u = 1.2DL + 1.6L \qquad \textit{ACI – 318 - 14 (9.2.1)}$$

Slabs thickness calculation:

Determination of Thickness for One Way Ribbed Slab:

According to ACI-Code-318-08, the minimum thickness of no 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
=522.3 /18.5 = **28.232 cm**
The maximum span length for both end continuous (for ribs):
h_{min} for both-end continuous = L/21
= 530/21 = **25.238 cm**
Select Slab thickness **h= 30cm** with **block 22 cm** & **Topping 8cm.**

Load calculations:

One-way ribbed slab:

For the one-way ribbed slabs, the total dead load to be used in the analysis and design is calculated as in the following table:

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

Parts of Rib	Density	Calculation
RC. Rib	25	0.12*0.22*25= 0.66 KN/m
Top Slab	25	0.08*0.52*25 = 1.04 KN/m.
Plaster	22	0.03*0.52*22 = 0.343 KN/m.
Block	10	0.4*0.22*10= 0.88 KN/m
Sand Fill	16	0.07*0.52*16= 0.5824 KN/m
Tile	23	0.03*0.52*23 = 0.359KN/m
Mortar	22	0.03*0.52*22 =0.343 KN/m.
partition	2.3	2.3*0.52 =1.196 KN/m

Nominal Total Dead load = **5.4034 KN/m** of rib
Nominal Total live load =4*0.52=**2.08 KN/m** of rib

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

No.	Material	Calculation
1	Tile	0.03*23*1= 0.69 KN/m
2	mortar	0.03*22*1= 0.66 KN/m
3	Coarse sand	0.07*16*1= 1.12 KN/m
4	topping	0.08*25*1 = 2 .0 KN/m
5	Interior partitions	2.3 *1 =2.3 KN/m
Sum		6.77 KN/m

W_u = 1.2 DL + 1.6 LL

= 1.2 * 6.77+ 1.6 * 4 = 14.524 KN/m^2. (Total Factored Load)

$$M_u = \frac{W_u * l^2}{12} = \frac{14.524 * 0.4^2}{12} = 0.194\ KN.m$$

$M_n = f_r * S$

$= 0.42\sqrt{f_c'} * \frac{bh^2}{6} = 0.42\sqrt{24} * \frac{1*0.08^2}{6} * 10^3 = 2.194\ \ KN.m$

$\phi M_n = 0.55 * 2.19 = 1.207\ KN.m$

$\phi M_n = 1.207\ KN.m > M_u = 0.194\ KN.m$

∴No structural reinforcement is needed

Shrinkage and temperature reinforcement must be provided.

For the shrinkage and temperature reinforcement: -

$\rho = 0.0018$

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

0f Φ8 = $\frac{As_{req}}{A_{bar}} = \frac{144}{50.27}$ = 2.86 → Spacing(S) = $\frac{1}{2.86}$ = 0.349m = 349 mm.

$\leq 380\,(\frac{280}{fs}) - 2.5 * C_c \leq 380\,(\frac{280}{fs})$

$= 380 * (\frac{280}{\frac{2}{3}fy}) - 2.5 * 20 \leq 380 * (\frac{280}{\frac{2}{3}fy})$

$= 380 * (\frac{280}{\frac{2}{3} * 420}) - 2.5 * 20 \leq 380 * (\frac{280}{\frac{2}{3} * 420})$

$= 330$ mm. ≤ 380mm.

$\leq 3 * h = 3 * 80 = 240$ mm, CONTROL!

≤ 450 mm.

∴Use Φ8 @ 20 Cm C/C in both directions.

Design of Rib (62):

Section: -

b =12cm b_f=52 cm
h =30cm T_f=8 cm

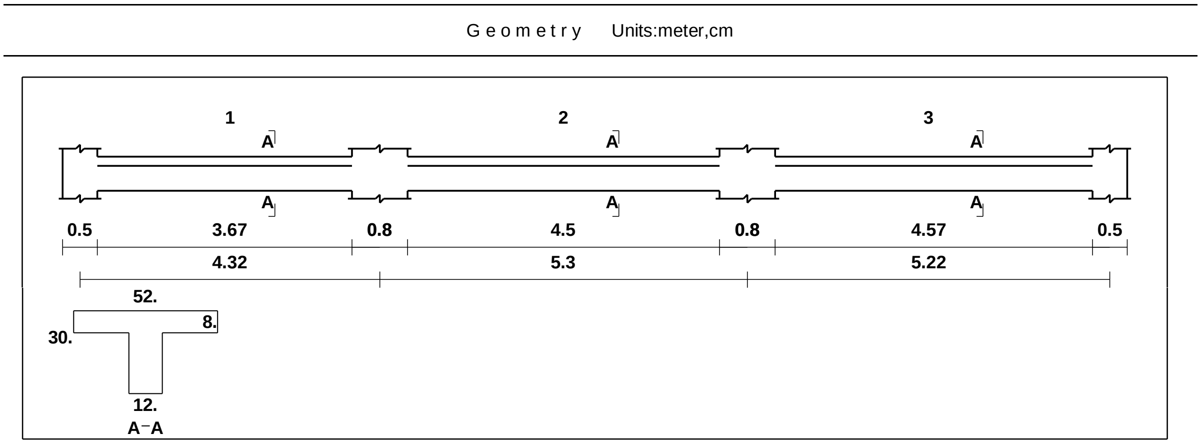


Figure (4-1): Rib geometry.

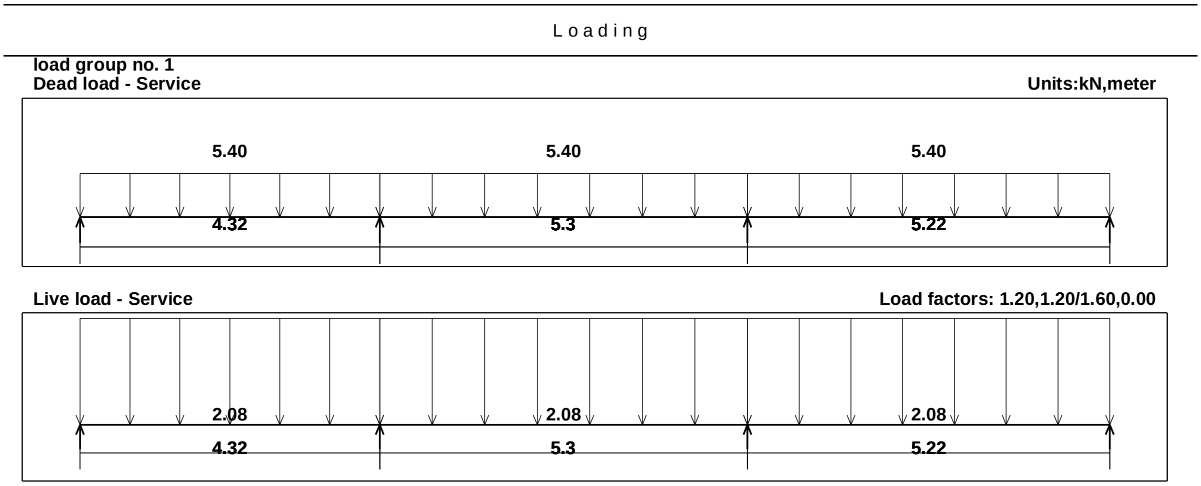


Figure (4-2): loading of rib (18)

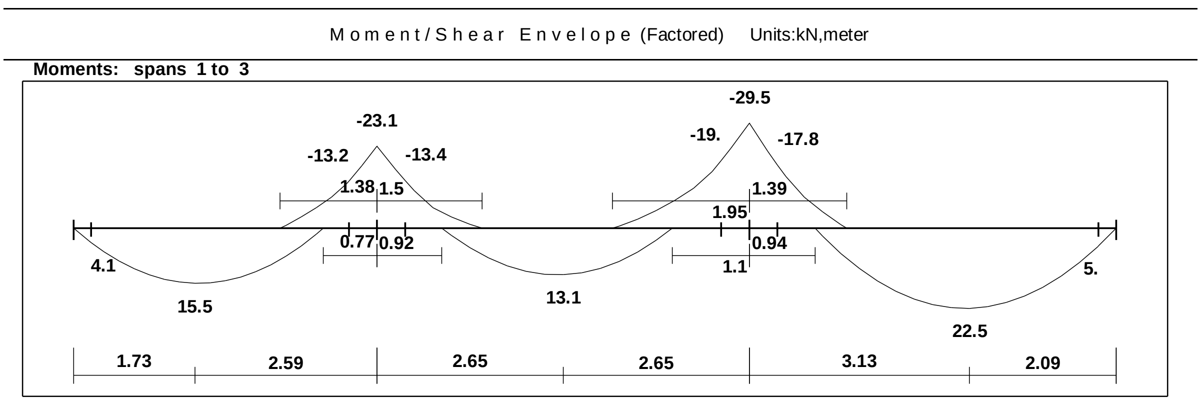


Figure (4-3): Moment Envelop of rib (62)

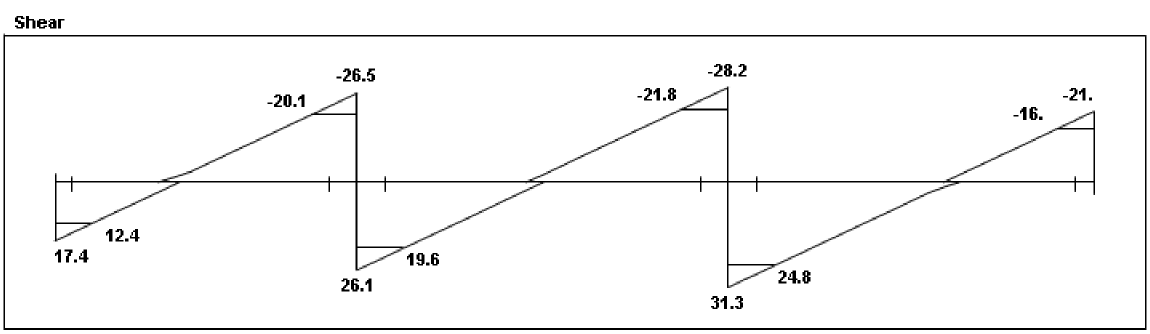


Figure (4-4): Shear Envelop of rib (62)

Design of flexure:

Design of Positive moment of rib (RIB 62):

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

= 300 – 20 – 8 – $\frac{12}{2}$= 266 mm.

→$M_{u\ max}$ = 22.5 KN.m

be ≤ Distance center to center between ribs = 520 mm……….. Controlled.

≤ Span/4 = 5300/4 = 1325 mm.

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

→b_E= 520 mm.

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

$$= 0.85 * 24 * 0.52 * 0.08 * \left(0.266 - \frac{0.08}{2}\right) * 10^3 = 191.79\ KN.m$$

→M_{nf} =191.79 KN.m> $\frac{Mu\ max}{\emptyset}$= $\frac{22.5}{0.9}$ = 25 KN.m.

∴ **DESIGN AS RECTANGULAR SECTION WITH b=520mm**

1) Maximum positive moment $Mu^{(+)}$ = 22.5 KN.m

M_n = Mu /ϕ =22.5/ 0.9 = 25 KN.m

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

$$R_n = \frac{M_n}{b*d^2} = \frac{25*10^6}{520*(266)^2} = 0.679 \text{ MPa}$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.679*20.58}{420}}\right) = 0.0016$$

→A_s = ρ * b *d = 0.0016* 520 * 266 = 221.31 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)

$$= \frac{\sqrt{24}}{4*420} * 120 * 266 \ \geq \ \frac{1.4}{420} * 120 * 266$$

= 93.08 mm^2<106.4 mm^2 ………… Larger value is control.

→As_{min} = 106.4mm^2<As_{req} = 221.31 mm^2.

∴ As = 221.31 mm^2.

2 Φ12 =226 mm^2>As_{req} = 221.31 mm^2 . OK.

∴ Use 2 Φ12

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

Tension = Compression

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

226* 420 = 0.85 * 24 * 120 * a

a = 38.77 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{38.77}{0.85}$ = 45.62 mm.

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

$= \frac{266-45.62}{45.62} * 0.003$ = 0.0145 > 0.005 ∴ ϕ =0.9 … OK!

2) Maximum negative moment $Mu^{(-)}$ = 19 KN.m

M_n = Mu /ϕ =19/ 0.9 = 21.11 KN.m

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

$R_n = \frac{M_n}{b*d^2} = \frac{21.11*10^6}{120*(266)^2}$ = 2.48MPa

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*2.48*20.58}{420}}\right)$ = 0. 0063.

→A_s = ρ * b *d = 0.*0063** 120 * 266 = 201.09 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)

$= \frac{\sqrt{24}}{4*420} * 120 * 266 \;\geq\; \frac{1.4}{420} * 120 * 266$

= 93.08 mm^2<106.4 mm^2 ………… Larger value is control.

→As_{req} = 201.096mm^2 ≥ As_{min} = 106.4mm^2.

∴ As = 201.096mm^2.

2 Φ12 =226 mm^2>As_{req} = 201.096 mm^2 . OK.

∴ **Use 2 Φ12**

Design of shear of rib (RIB 62):

1) Vu = 24.8 KN.

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

$= 1.1 * \frac{\sqrt{24}}{6} * 0.12 * 0.266 * 10^3 = 28.66$ KN.

$\phi V_c = 0.75 * 28.66 = 21.49$KN.

→**Check for Cases: -**

1- <u>Case 1:</u> $V_u \le \frac{\phi V_c}{2}$.

$24.8 > \frac{21.49}{2} = 10.75$

∴ **Case (1) is NOT satisfied**

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

$10.67 \le 24.8 \le 21.49$

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

Case (3):

Vs $= \frac{V_u}{\phi} - Vc = \frac{24.8}{0.75} - 28.66 = 4.41$

Vs max $= \frac{2}{3} * \sqrt{f_c'} * d * b_w = \frac{2}{3} * \sqrt{24} * 120 * 266 * 10^{-3} = 104.25$

Vs´ $= \frac{Vs\ max}{2} = 52.125$

$Vs < Vs_{max}$ … The section is large enough

Vs min$= \frac{1}{16} * \sqrt{f_c'} * b_w * d = 9.77$

Vs min$= \frac{1}{3} * b_w * d = 10.64$ ....**Control.**

<u>Try 2Φ8: -</u>

$\frac{100.5*420*264}{S} = 6.48*10^3 \rightarrow S = 2546$ mm.

$S \le \frac{d}{2} = \frac{264}{2} = 133$mm.

≤ 600 mm.

∴ **Use 2 Φ8 @ 10 Cm**

4.4 Design of Beam (B.F- 58):

Section: -

B = 80 cm

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 simply supported = L/16

=550/16 = 34.37 cm.

→Select Total depth of beam **h=35cm. (35cm slab and 5 cm drop)**

"for deflection requirements L/240"

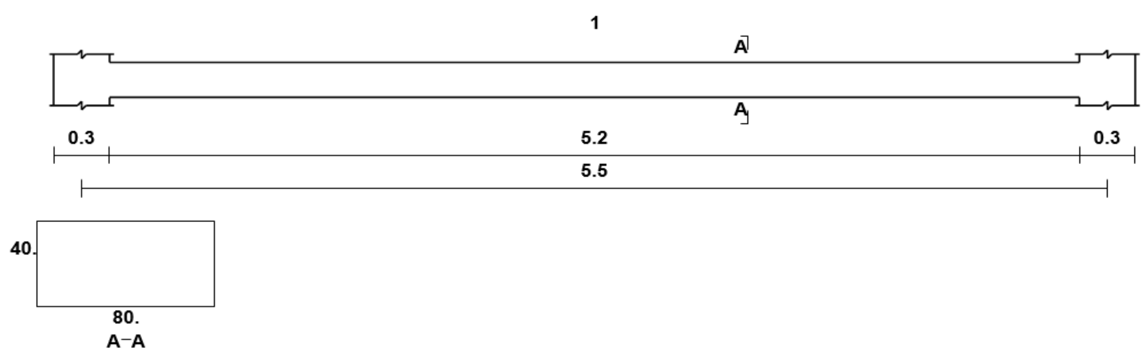


Figure (4-5): Beam Geometry.

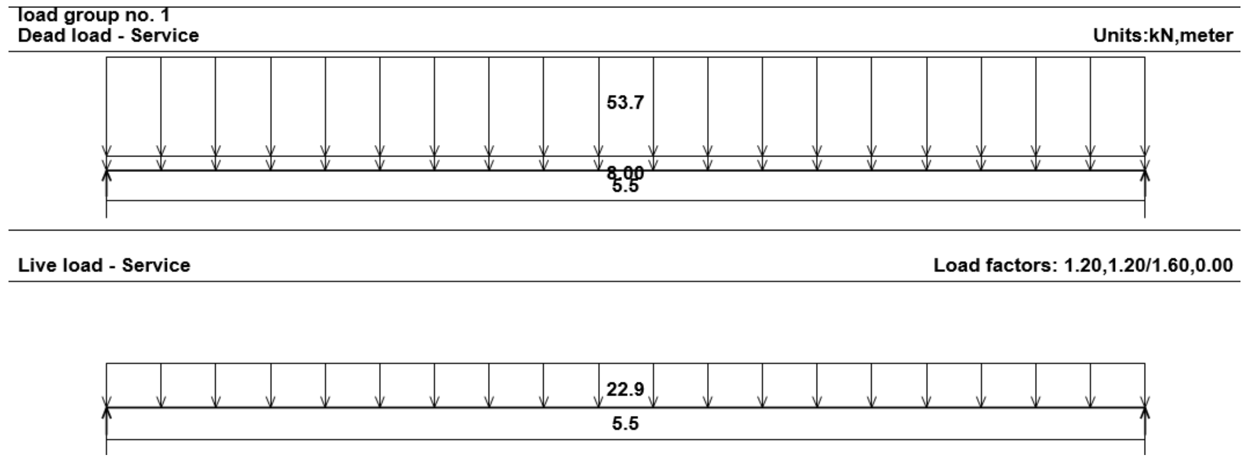


Figure (4-6): Load of Beam (B.F-58)

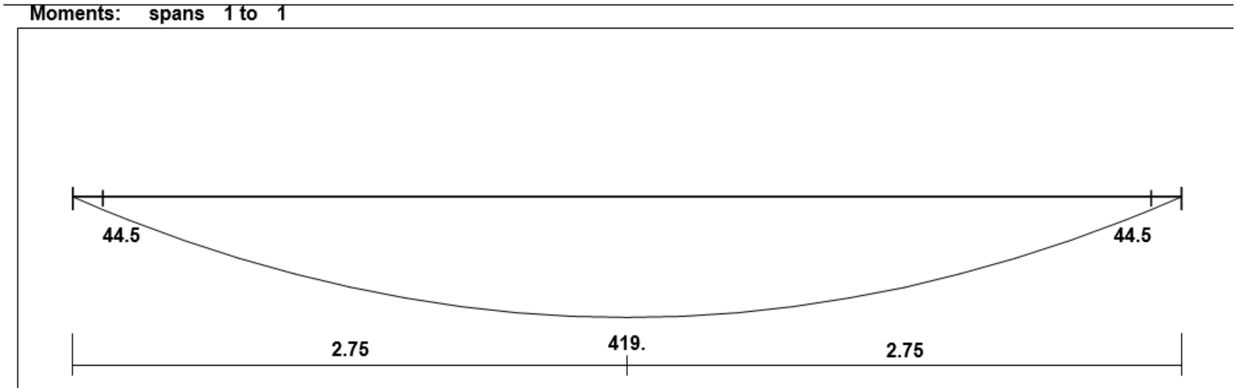


Figure (4-7): Moment Envelop for Beam (B.F-58)

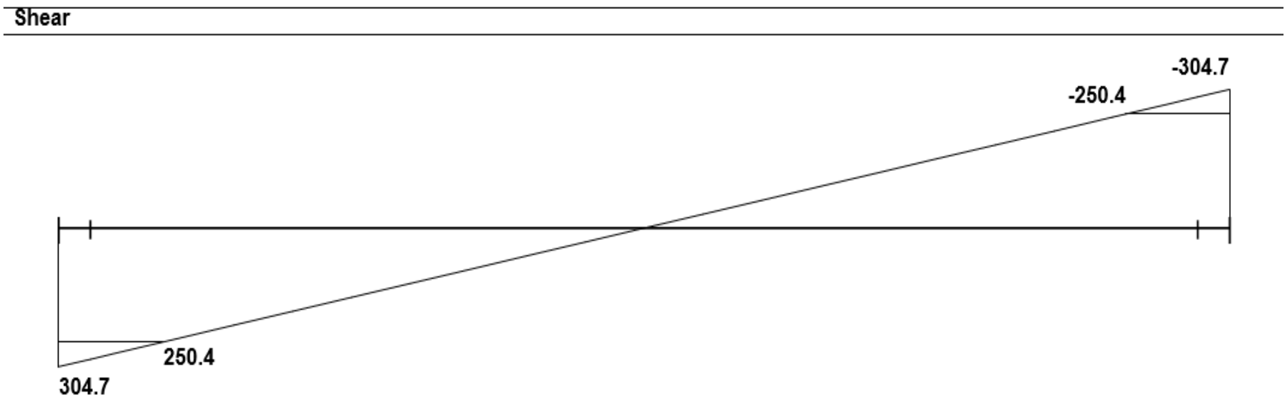


Figure (4-8): Shear Envelop for Beam (B.F-58)

Design of flexure:

Design of Positive moment:

$\rightarrow Mu_{max}$ =419 KN.m

b= 80 Cm. h =40 Cm.

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

$=400 - 40 - 10 - \frac{18}{2} = 341mm$

$C_{max} = \frac{3}{7} * d = \frac{3}{7} * 341 = 146.14mm.$

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

$a_{max} = \beta_1 * C_{max} = 0.85 * 146.14 = 124.22mm.$

*Note:

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

= 0.85 * 24 * 800* 124.22 * (341 – 124.22/2) * 10^{-6}

=565.39 KN.m

ϵ_s = 0.004

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

→ϕMn_{max} = 0.82 * 565.39=463.62 KN.m

→ Mu = 419 KN.m< ϕMn_{max} 463.62 KN.m

∴Singly reinforced concrete section.

1) Maximum positive moment $Mu^{(+)}$ = 419 KN.m

Mn = Mu /ϕ= 419/ 0.9 =465.55 KN.m .

→m=20.6

$R_n = \frac{M_n}{b*d^2} = \frac{465.55*10^6}{800*(341)^2}$ =5.004MPa

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

$\frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*5.004*20.6}{420}}\right)$=0.014

A_s = ρ * b *d =0.014*800*341=3819.2mm^2

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

$$\frac{\sqrt{24}}{4*420} * 800 * 341 \;\; \geq \; \frac{1.4}{420} * 800 * 341$$

=795.55mm^2<909.33mm^2 …. Larger value is CONTROL

As= 3819.2mm^2

Use Φ25…. As=490.87mm^2

#of bars= (3819.2/490.87) +1=8

∴ **Use 8 Φ25…As=3926.9** > 3819.2mm^2

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

Tension = Compression

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

3926.9* 420 = 0.85 * 24 * 800 * a

a = 101.062 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{101.062}{0.85}$ = 118.89 mm.

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

$= \frac{341-118.89}{118.89} * 0.003 = 0.0056 > 0.005$ ∴ ϕ =0.9 … OK!

Design of shear: -

1) Vu = 250.4 KN .

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

$= 0.75 * \frac{\sqrt{24}}{6} * 800 * 341 * 10^{-3} = 167.055$KN.

→ Check For dimensions: -

$\phi Vc + (\frac{2}{3} * \phi * \sqrt{f_c'} * b_w * d) = 167.055 + (\frac{2}{3} * 0.75 * \sqrt{24} * 0.8 * 0.341 * 10^3)$

$= 835.27$KN > Vu = 250.4KN.

∴ Dimension is adequate.

→ Check For Cases: -

1- <u>Case1 :</u> $V_u \le \frac{\phi V_c}{2}$.

$250.4 \le \frac{167.055}{2} = 83.53$ .... Not SATISFIED!

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

83.53 <250.4≤167.055 …. Not SATISFIED!

3- <u>Case 3 :</u>

$Vs = (\frac{Vu}{\phi} - Vc) = \frac{250.4}{0.75} - 222.74 = 111.13$KN

Vs max $= \frac{2}{3} * \sqrt{f_c'} * d * b_w = \frac{2}{3} * \sqrt{24} * 800 * 341 * 10^{-3} = 890.96$ KN

$\phi\ Vs_{min}\ \geq\ \frac{\phi}{16}\sqrt{f_c'} * b_w * d = \frac{0.75}{16}\sqrt{24} * 0.8 * 0.341 * 10^3 = 62.64KN.$

$\geq\ \frac{\phi}{3} * b_w * d = \frac{0.75}{3} * 0.8 * 0.341 * 10^3 = 68.2KN$ …. CONTROL.

$\therefore \phi Vs_{min} = 68.2KN.$

$V_c + \phi Vs_{min} = 167.055 + 68.2 = 235.255KN.$

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

216.04<250.4≤ 235.255 …. NOT SATISFIED!

4. Case4:

$\phi\ Vs' = \geq\ \frac{\phi}{3} * \sqrt{f_c'} * b_w * d = \frac{0.75}{3} * 0.8 * \sqrt{24} * 0.341 * 10^3 = 334.11KN$

$\Phi Vc + \Phi Vs = 167.055 + 3341 = 501.16$ KN.

$\Phi(V_c + V_{S,min}) < V_u \leq \phi(V_c + Vs^{\backslash})$

235.255<250.4<501.65

$\frac{Av}{s} = \frac{Vs}{fy*d} = \frac{314.16}{s} = \frac{\mathbf{111.13*10^3}}{\mathbf{420*341}}$ ….. s=404.87mm

$S \leq \frac{d}{2} = \frac{341}{2} = 170.5$.mm………. CONTROL.

≤ 600 mm.

∴ Use 4 Φ10 @ 15 Cm

$Vc = \frac{216.04}{0.75} = 288.05KN$

$= (\frac{233.2}{0.75} - 288.05) = 22.88$ KN.

Try 2Φ10 =2 * 78.5 = 157 mm^2.

$\frac{2*78.5*}{S} = \frac{11.68\ *\ 10^{-3}}{(420*441)} \longrightarrow s = 1270.96mm$

$s \leq\ \frac{d}{2} = \frac{441}{2} = 220.5$ mm …. CONTROL

≤ 600 mm.

\∴ Use Φ10 @ 20Cm 2L.

4.5 Design of Solid slab

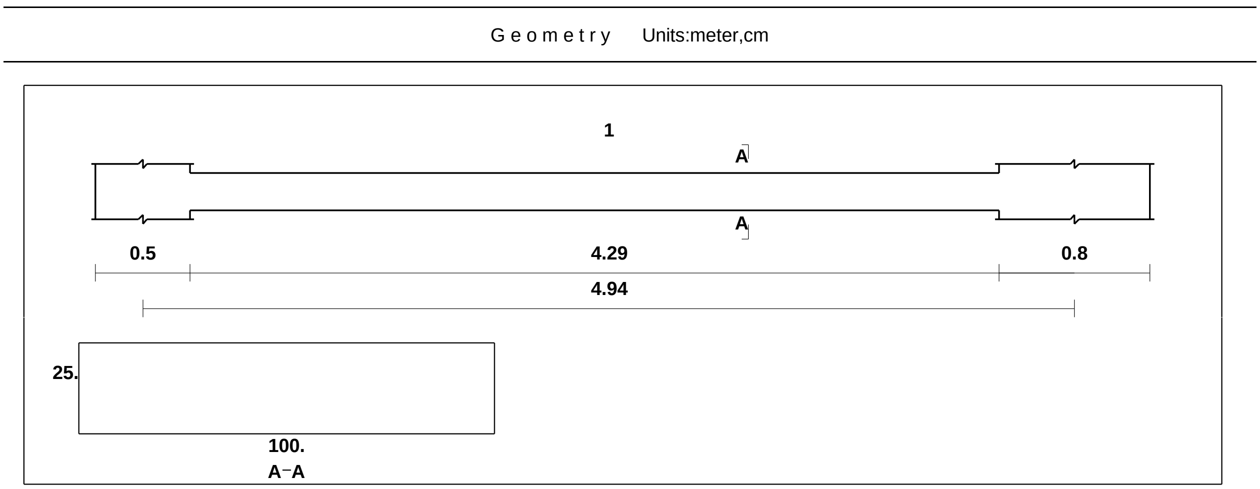


Figure (4-9): Solid Geometry

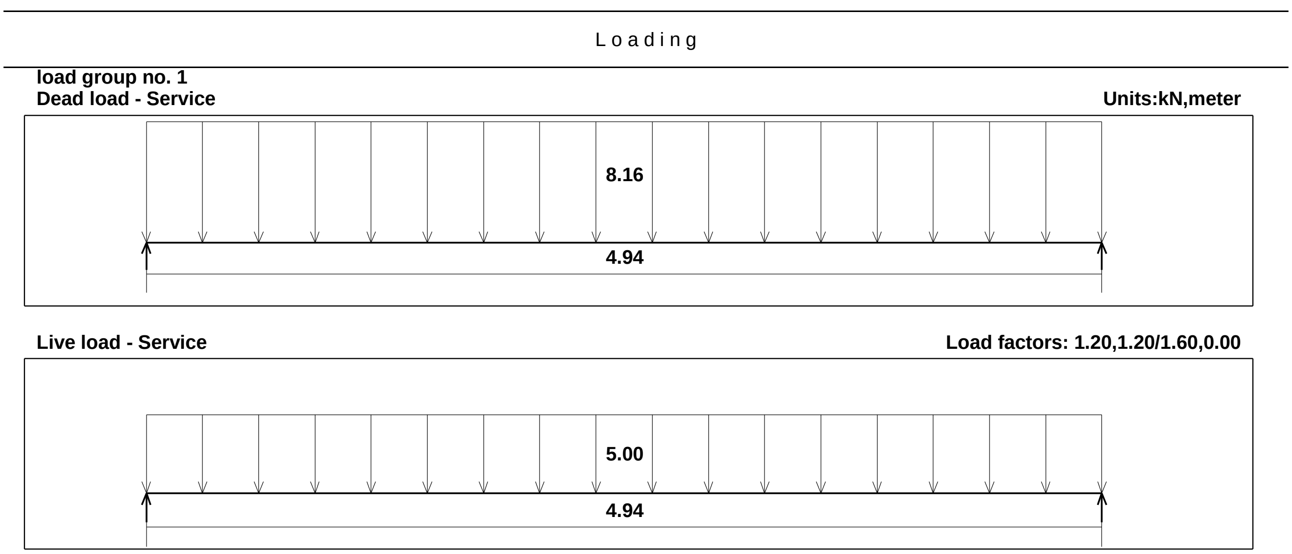


Figure (4-10): loading of Solid

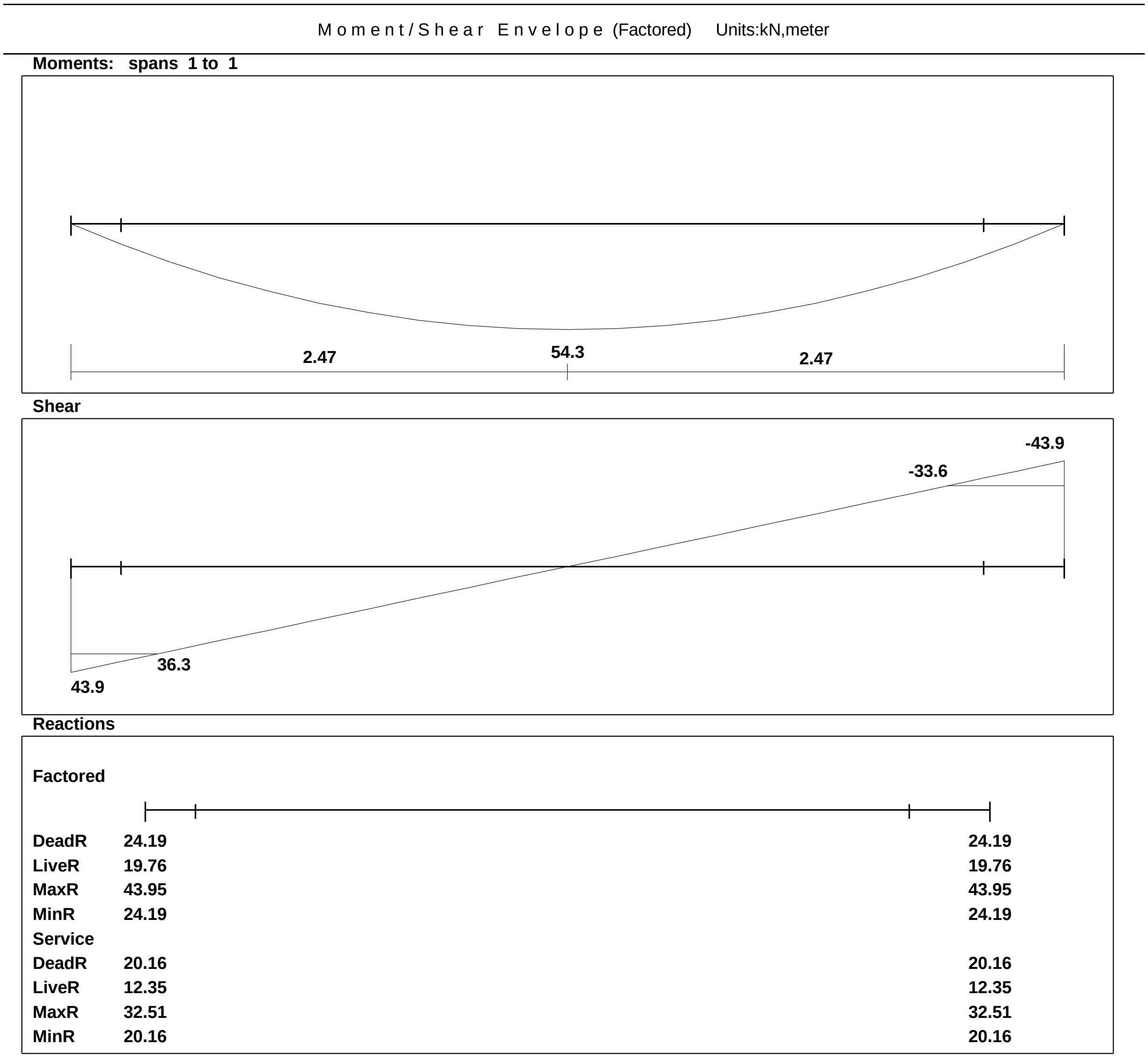


Figure (4-11): Moment & Shear Envelope of Solid

Slab Thickness Calculation:

The overall depth must satisfy ACI Table (9.5.a), Min h (deflection requirement):-

-For simply supported:

$$\frac{L}{20} = \frac{4.94}{20} = 0.247$$

For One-way solid slab, will use thickness of slab 25 cm.

$$d = h - cover - \frac{db}{2} = 250 - 20 - \frac{12}{2} = 224mm$$

Load Calculation ((For one Meter Strip)

For the one-way solid slabs, the total dead load to be used in the analysis and design is calculated as follows: -

Table (4 – 3) Calculation of the total dead load for one-way solid slab.

Dead load from	$\delta * \gamma$	KN/m
Tiles	$0.03 * 22$	0.66
Mortar	$0.02 * 22$	0.44
Coarse Sand	$0.07 * 16$	1.12
RC solid	$0.25 * 25$	6.25
Plaster	$0.02 * 22$	0.44
$\sum$		8.16

Live load =5 KN/m

Design of Positive Moment (Mu = 54.3 KN.m):

Assume bar diameter Φ12 for main reinforcement

d=250-20-6= 224

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

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

$$Rn = \frac{54.3 * 10\overline{6}/0.9}{1000 * (224)^2} = 1.20 \text{ (Mpa)}$$

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

$$\rho = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2(20.59)(1.39)}{420}}\right) = 0.00295$$

$A_s = \rho * b * d = 0.00295 * 1000 * 224 = 661.41$

Check for As min:

$A_{s\,min} = \rho_{min} * b * h = 0.0018 * 1000 * 250 = 450 mm^2$

$As_{req} = 661.41\ mm^2 > As_{min} = 450\ mm^2$ **OK**

Use ø 14/20cm , $A_{s,\ provided} = 15.4\ cm^2 > A_{s,\ required} = 6.61 cm^2$ …. Ok

Design of Top Reinforcement:

Assume bar diameter Φ12 for main reinforcement

As min: -

$A_{s\,min} = \rho_{min} * b * h = 0.0018 * 1000 * 250 = 450 mm^2$

Use ø 12/20cm , $A_{s,\ provided} = 11.3\ cm^2 > A_{s,\ required} = 4.50\ cm^2$ …. Ok

Shear Design:

Check Whether Thickness Is Adequate For Shear: -

$V_{u,max}$ = 36.3 KN/ 1m strip

d = h – 20 – db = 250 – 20 – (12 /2) = 224 mm

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

$= \frac{1}{6} * 0.75 * \sqrt{24} * 1000 * 224 = 137.17$ KN / 1 m strip

$\Phi Vc = 137.17 KN > V_{u,max} = 36.3$ KN/ 1m strip

The thickness of the slab is adequate enough.

4.6 Design of Staircase:

Minimum slab thickness:

Minimum slab thickness for deflection is (for simply supported one-way solid slab):
$h_{min} = L/20$

$h_{min} = 5.97/20 = 29.84$ cm

Take h = 30 cm

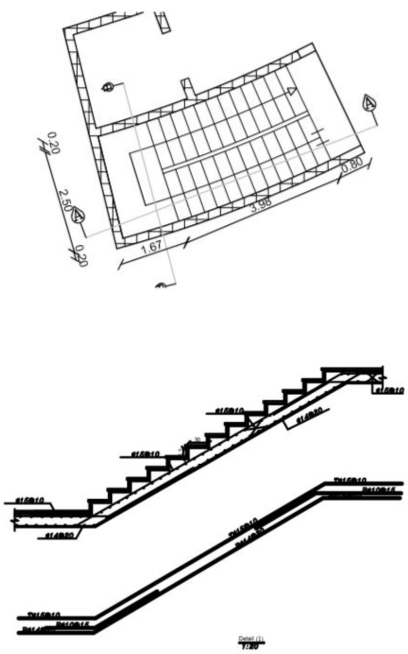


Figure 4. 1: Staircase Dimensions.

4.6.2 Load Calculation:

Load: the applied live loads are based on the plan area (horizontal) projection, while the dead load is based on the sloped length to transfer the dead load into horizontal projection.
The Stair Sloped by $\theta = \tan^{-1}(\text{riser / run})$

$= \tan^{-1}(15.5 / 30) = 29.85^{o}$

- Flight dead load computation:

Table 4. 4: Flight Dead Load Computation

Parts of Flight	Quality Density kN/m^3	Calculation of(W) kN/m
Tiles	**27**	27 * 0.03 * 1 * ((0.35+0.155)/0.3) = 1.36
Mortar	**22**	22 * 0.03 * 1 * ((0.35+0.155)/0.3) 1.001
Stair Steps	**25**	(25/0.3) * ((0.155 * 0.3)/2)) *1 = 1.39
R.C Solid Slab	**25**	25 * 0.3 * 1 / (cos27.32^o) = 8.44
Plaster	**22**	22 * 0.03 * 1 /(cos27.32^o) = 0.75
Total Dead Load		**13.48 kN/m**

Landing dead load computation:

Table 4.5: Landing Dead Load Computation.

Parts of Flight	Quality Density kN/m^3	Calculation of(W) kN/m
Tiles	**23**	23 * 0.03 * 1 * = 0.69
Mortar	**22**	22 * 0.03 * 1 * = 0.66
R.C Solid Slab	**25**	25 * 0.3 * 1 = 7.5
Plaster	**22**	22 * 0.03 * 1= 0.66
Total Dead Load		**9.51 kN/m**

- Live Load: LL = 4 kN/m^2.
- Total factored load: w = 1.2 DL + 1.6 LL

For flight w = 1.2 * 13.48 + 1.6 * 4 * 1 = 22.576 kN/m^2.
For landing w = 1.2 * 9.51 + 1.6 * 4 * 1 = 17.812 kN/m^2.

Because the load on landing, where the shear wall surrounding it, is carried into two directions, only half the load will be considered in each direction (17.812 / 2 = 8.906 kN/m).

4.6.3 Design of slab S1:

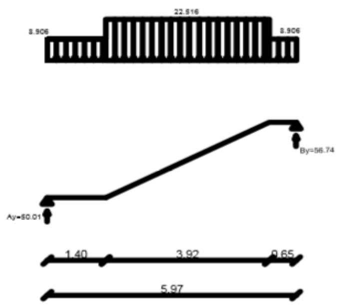


Figure 4. 2: Stair Loading.

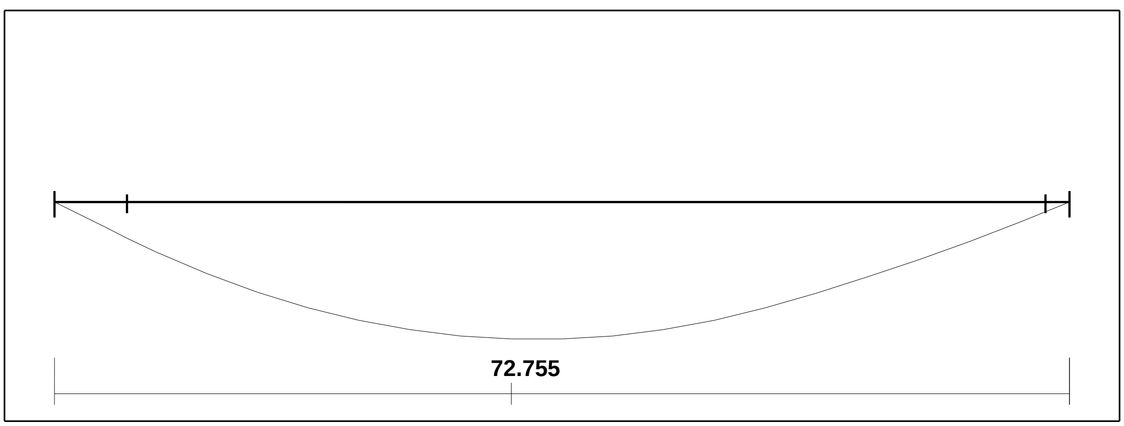


Figure 4. 3: Stair Bending Moment Diagram.

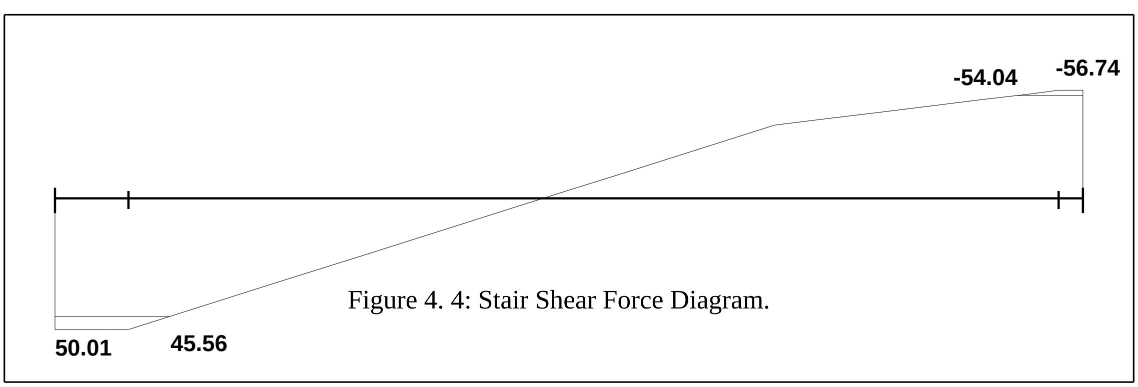


Figure 4. 4: Stair Shear Force Diagram.

4.6.3.1 Check for shear strength:

Assume initial bar diameter Ø14 $for\ main\ reinforccment$, Φ = 0.75 $for\ shear$

Assume bar diameter Ø14 for main reinforcement

d =h- cover $- \frac{d_b}{2} = 300 - 20 - \frac{14}{2} = 273\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d = = \ \frac{1}{6}\sqrt{24} * 1000 * 273 = 222.9$ kN.

Φ V_{c} = 0.75* 222.9 = 167.17 kN

167.17kN > Vu = 54.04 kN, the slab thickness is adequate enough.

4.6.3.2 Design the flight for bending moment:

Mu=72.775 kN.m

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{72.775\times10^6}{0.9\times1000\times273^2} = 1.3\ Mpa$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2\times20.6\times1.3}{420}}\right) = 0.0032$

$A_{s,\ req}$ = ρ.b.d = 0.0032 ×1000×273 = 873.8 mm^2/m

$A_{s,\ min}$= 0.0018*1000*300 = 540mm^2/m

$A_{s,\ req}$ = 873.8 mm^2>$A_{s,\ min}$=540mm^2/m

Check for which maximum spacing is control:

1. S = 3h = 3*300 =900 mm

2. S = 380*$\left(\frac{280}{\frac{2}{3} * 420}\right)$ – 2.5*20 = 330 mm **OR** 300 * $\left(\frac{280}{\frac{2}{3} * 420}\right)$ =300 mm control

3. S = 450 mm

- S = 300 mm is control
- Use Ø14 @200 mm, $A_{s,\ provided}$= 923.4 mm^2 > $A_{s,\ required}$= 873.8 mm^2……………… Ok
-

Check for strain:-

$a = \frac{A_s . f_y}{0.85 b\ f_c'} = \frac{923.4 \times 420}{0.85 \times 1000 \times 24} = 19.011\ mm$

$c = \frac{a}{\mathcal{B}_1} = \frac{19.011}{0.85} = 22.37\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{273-22.73}{22.73}\right) = 0.033 > 0.005 \ldots\ldots\ldots\ldots\ldots \mathbf{0k}$$

Temperature and shrinkage reinforcement:

$A_{s,\ req} = A_{s,\ min} = 0.0018*1000*300 = 540mm^2$

4.6.4 Design of slab S2 (landing):

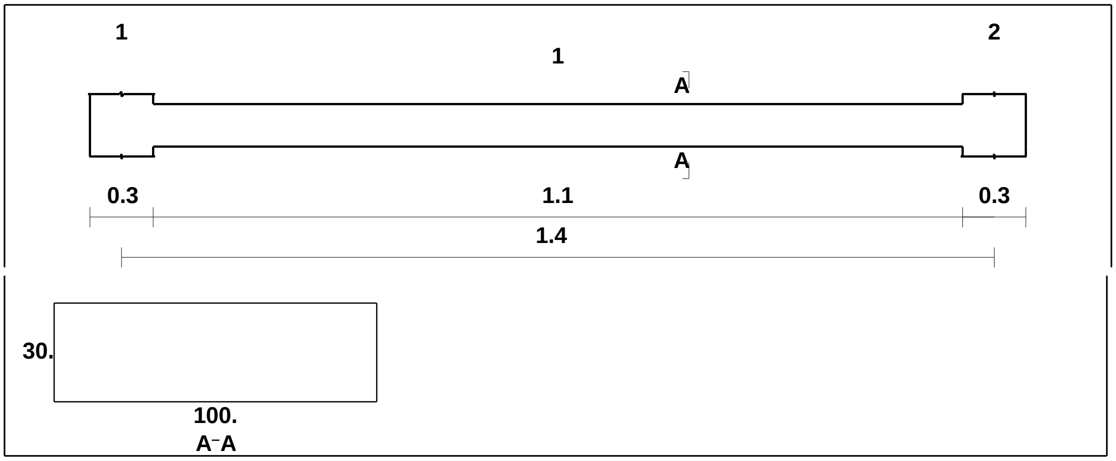


Figure 4. 5: Landing Bending Moment Diagram.

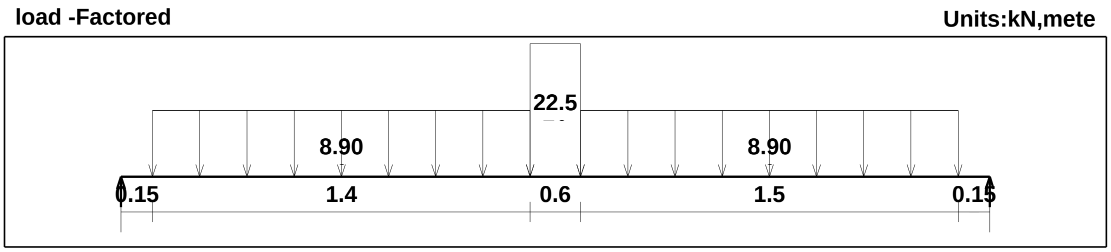


Figure 4. 6: Landing Loading System.

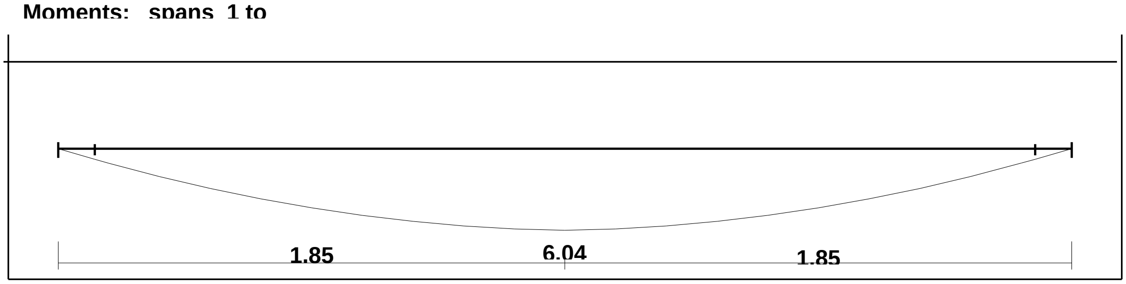


Figure 4. 7: Landing Bending Moment Diagram.

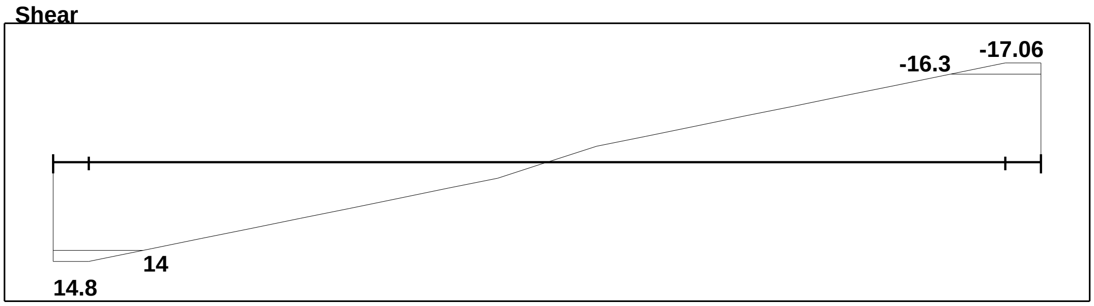


Figure 4. 8: Landing Shear Force Diagram

4.6.4.1 Check for shear strength:

Assume bar diameter ø 14 for main reinforcement

d =h- cover $-\frac{d_b}{2}=300-20-\frac{14}{2}=273\ mm$

$V_c=\frac{1}{6}\sqrt{fc'}b_w\ d==\ \frac{1}{6}\sqrt{24}*1000*273=222.9$ kN

$\Phi * V_c =$ 0.75* 222.9 = 167.17 kN

167.17KN > Vu = 16.3 kN**,** the slab thickness is adequate enough.

4.6.4.2 Design the landing for bending moment:

Mu=13.3 kN.m

$R_n=\frac{M_u}{\emptyset bd^2}=\frac{6.04\times10^6}{0.9\times1000\times273^2}=0.114\ Mpa$

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

$\rho=\frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right)=\frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times0.114}{420}}\right)=0.00027$

$A_{s,req} = \rho.b.d = 0.00027 \times 1000 \times 273 = 72.13\ mm^2/m$

$A_{s,min} = 0.0018*1000*300 = 540 mm^2/m$

$A_{s,req} = 72.13\ mm^2 < A_{s,min} = 540 mm^2/m$, use $A_{s,min} = 540 mm^2/m$.

Check for which maximum spacing is control:

1. S = 3h = 3*300 =900 mm

2. S = $380*(\frac{280}{\frac{2}{3}*420}) - 2.5*20 = 330$ mm **OR** $300 * (\frac{280}{\frac{2}{3}*420})$ =300 mm control

3. S = 450 mm

- S = 300 mm is control, use Ø10 @ 150 mm, $A_{s,\ provided} = 520\ mm^2 > A_{s,\ required} = 450\ mm^2$…… Ok

Temperature and shrinkage reinforcement:

$A_{s,req} = A_{s,min} = 0.0018*1000*300 = 540 mm^2$

Use Ø10 @ 150mm, $A_{s,\ provided} = 520\ mm^2 > A_{s,\ required} = 540 mm^2$ …………. Ok

4.7 Design of Column 10 (Group 3):

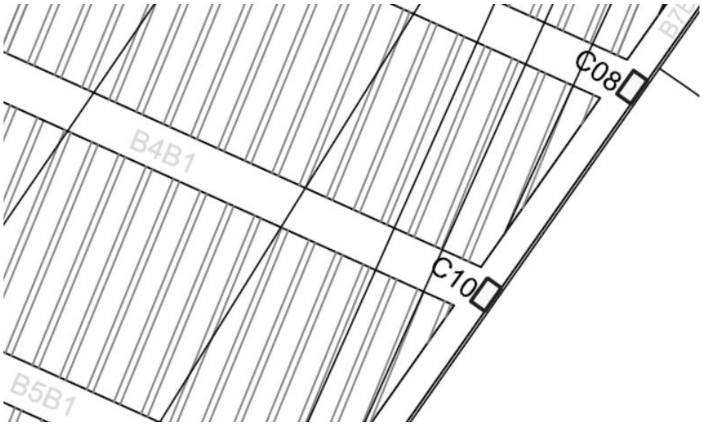


Figure (4-12): Location of Column

4.7.1 Load Calculation

Service Load: -

Dead Load = 2293.77 KN
Live Load = 484.68 KN

Factored Load: -

P_U = 1.2 × 2293.77 + 1.6 ×484.68 = 3528.012 KN

4.7.2 Column Dimensions

$Assume\ \rho g = 0.01$

$\phi * Pn = 0.65 \times 0.8 \times Ag\{0.85\ fc'(1-\rho g) + \rho g * Fy\}$

$3528.012*1000 = 0.65 \times 0.8 \times Ag\ \{0.85 * 24\ (1 - 0.01) + 0.01 * 420\}$

Ag= 238960 mm2

Assume Rectangular Section

Try h = 500 mm

b = 500 mm

Ag=250000 mm^2

Selecting Longitudinal Bars:

$3528.012*1000 = 0.65 \times 0.8 \times 250000\{0.85 * 24\ (250000 - Ast) + Ast * 420\}$

Ast=2352 mm^2

Use 12 ø 16, Ast(prov) =2412mm^2 > Ast=2352mm^2

ρg = Ast/Ag = 0.01

4.7.3 Design of Tie reinforcement

S ≤16 db. (longitudinal bar diameter)

S≤ 48dt (tie bar diameter).

S ≤ Least dimension.

spacing ≤16×d_b=16×1.6 =25.6 cm Control

spacing ≤48×dt=48×1.0 = 48 cm

spacing ≤ least. Dim = 30 cm

Use ø 10@20 cm

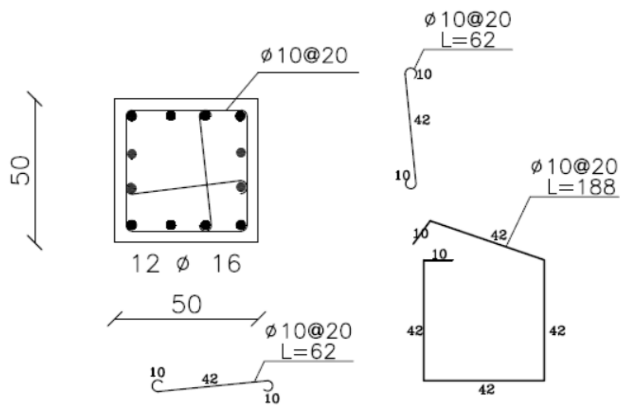


Figure (4-13): Detailing of Column

4.8 Design of Shear Wall:

4.8.1 <u>Shear wall general information:</u>

⇒ Shear Wall Thickness h = 25 cm

⇒ Shear Wall Width Lw = 6.00 m

⇒ Shear Wall Height Hw =3.55 m

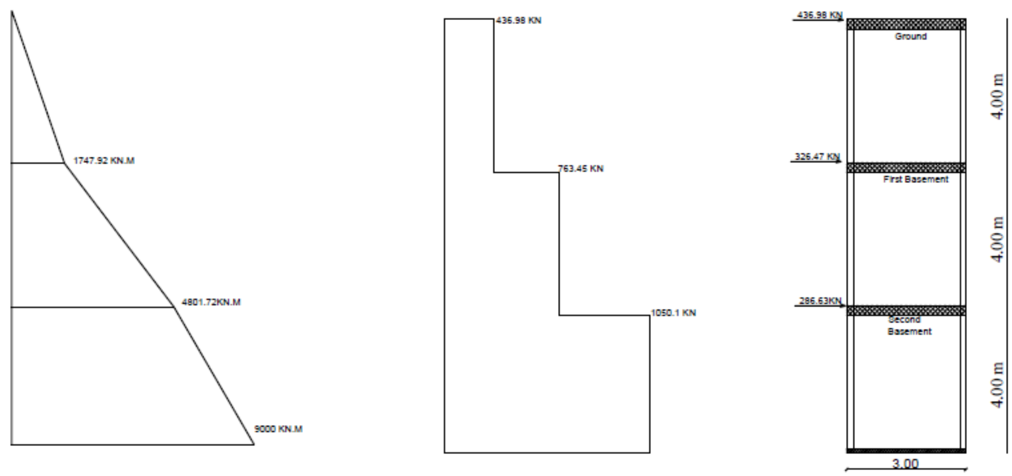


Figure 4. 9: Shear Wall Dimensions and Loads From ETABS.

4.8.2 <u>Check for shear strength:</u>

4.8.2.1 Maximum shear strength permitted:

$\emptyset V_{nmax} = \emptyset \frac{5}{6}\sqrt{f_c{}'}hd$, d = 0.8$L_w$ = 0.8*6 = 4.8m.

$= 0.75 * 0.83 * \sqrt{24} * 250 * 4.8 \;= 3659.53\; kN$ > $V_{u,\,max}$ = 612 kN.

4.8.2.2 Shear strength provided by concrete Vc:

Critical Section for shear is the smaller of:

$$\frac{lw}{2} = \frac{6}{2} = 3m - control$$
$$\frac{hw}{2} = \frac{10.65}{2} = 5.3m$$

Story height = 3.55m.

V_c is the smallest of :

$1 - V_c = \frac{1}{6}\sqrt{f_c'}hd = \frac{1}{6}\sqrt{24} * 250 * 4.8 = 979.79KN$ …….. Control

$$2 - V_c = 0.27\sqrt{f_c'}hd + \frac{N_u d}{4l_w} = 0.27\sqrt{24} * 250 * 4.8 + 0 = 1587.269KN$$

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

$$\Longrightarrow M_u = 1747.92 + 326 * (3 - 2.65) = 1862.02kN.m$$

$\frac{M_u}{V_u} - \frac{l_w}{2} = \frac{1862.02}{612} - \frac{6}{2} = 0.4 <1$, so the previous equation does not available to apply for shear calculations.

- Determine required horizontal shear reinforcement:

$Vu = 612 > \frac{1}{2}Vc = \frac{1}{2} * 0.75 * 979.79 = 367.42kN$ …. reinforcement is required.

Shear reinforcement must be provided in accordance with 11.9.9.

Assume Ø10 for shear reinforcement.

$Vu \leq ØVn = Ø(Vc + Vs)$

$Vs = \frac{Vu}{Ø} - Vc = \frac{612}{0.75} - 979.79 = -163.79, use\ minimum\ ratio\ of$ $\rho_t = 0.0025$

Minimum shear reinforcement is required,

Maximum spacing is the least of:

$$\frac{Lw}{5} = \frac{6000}{5} = 1200\ mm.$$

$3h = 3 * 250 = 750\ mm.$

$450\ mm - control.$

Select Ø10, two layers:

$$\rho_t = \frac{Avh}{hS_2} = \frac{2 * 78.5}{250 * S_2} = 0.0025$$

So that S_2 =251.2 mm < 450, Take Ø10@200mm in both sides.

- Determine vertical shear reinforcement:

$$\frac{h_w}{L_w} = \frac{10.65}{6} = 1.775$$

$$\rho_l = [0.0025 + 0.5\left(2.5 - \frac{h_w}{L_w}\right)(\rho_t - 0.0025)] \geq 0.0025$$

$$= [0.0025 + 0.5(2.5 - 1.775)(0.0025 - 0.0025)] \geq 0.0025$$

So, ρ_l = 0.0025.

Maximum spacing is the least of:

$$\frac{Lw}{5} = \frac{6000}{5} = 1200\ mm.$$

$$3h = 3 * 250 = 750\ mm.$$

$$450\ mm - control.$$

Select Ø10 @ 200 mm.

4.8.3 <u>Design of shear wall for flexure:</u>

Uniformly distributed flexure reinforcement method was followed.

The uniformly distributed vertical reinforcement Ø10 @ 200 mm

$$A_{st} = \left(\frac{6000}{200}\right) * 2 * 78.5 = 4710\ mm^2$$

$$w = \left(\frac{A_{st}}{L_w h}\right)\frac{f_y}{f_c'} = \left(\frac{4710}{6000 * 250}\right)\frac{420}{24} = 0.055$$

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

$$\frac{C}{l_w} = \frac{w + \alpha}{2w + 0.85\beta_1} = \frac{0.055 + 0}{2 * 0.055 + 0.85 * 0.85} = 0.066$$

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

$$= 0.9[0.5 * 4.710 * 420 * 6.000(1 + 0)(1 - 0.066)] = 4988.62\ kN.\text{m} > 2460\ kN.m$$

Vertical reinforcement provided is enough.

4.9 Design of Basement wall and its Footing:

4.9.1 Basement wall design:

4.9.1.1 General information:

Height of the basement wall = 7.8 m.

Thickness of the basement wall is 30 cm.

Soil internal friction angle Φ = 35, density = 17 kN/m^3, and 5 kN/m^2 surcharge.

Loads acting on basement wall:

$q_1 \; = \; Earth\; pressure\; soil$

$q_1 \; = \gamma_H \; * \; h \; * \; k_0$

$k_0 = \; 1 - \; sin\;\Phi \; = 1 - \; sin\; 35 = \; 0.426$

$q_1 = \; 17 \; * \; 7.8 * \; 0.426 \; = \; 56.5 \text{N/m}^2$

$q_2 \; = Surcharge\; pressure = q_{\text{surcharge vertical}} * k_0$

$q_2 = 5 * 0.426 = 2.13\ \text{kN/m}^2$.

- ❖ Designed the basement wall as continuous beam(pin-pin-pin)

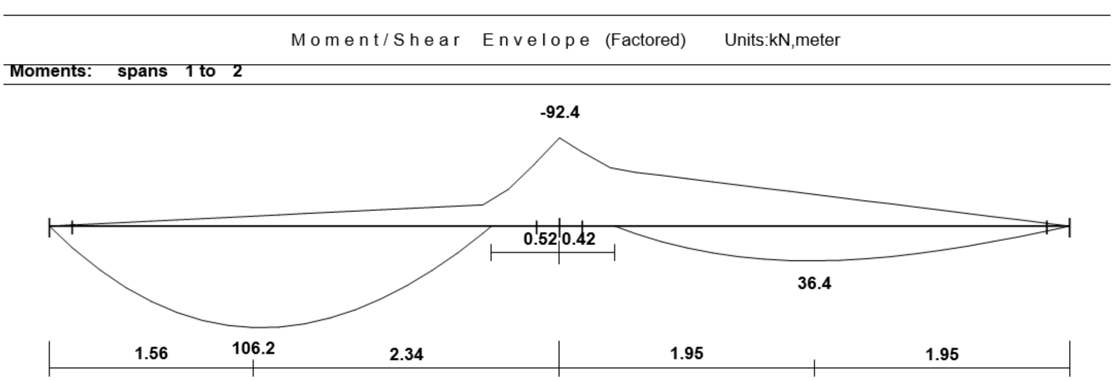


Figure 4. 10: Bending Moment Diagram of Basement Wall.

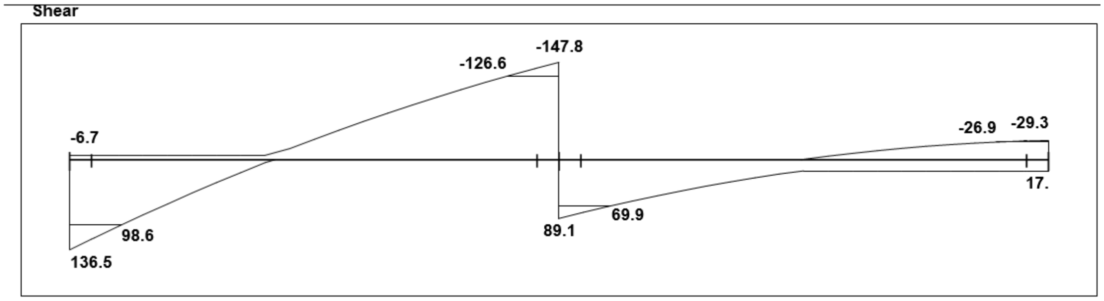


Figure 4. 11: Shear Force Diagram of Basement Wall.

4.9.1.2 Check basement wall for shear design:

From atir program $V_u = 126.6\ kN$, assume Ø20 for main reinforcement,

$$d = 300 - 75 - \frac{20}{2} = 215\ mm$$

$$\emptyset V_c = 0.75 * 0.17 * \sqrt{24} * 1000 * 215 * 10^{-3} = 134.3\ Kn > V_u = 126.6KN \quad \ggg\ okay$$

4.9.1.3 Design for vertical reinforcement:

$$M_u = 106.2\ kN.m$$

$$R_n = \frac{M_u}{0.9bd^2} = \frac{106.2 * 10^6}{0.9 * 1000 * 215^2} = 2.55$$

$$m = \frac{f_y}{0.85f'_c} = 20.6\ MPa$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = 0.0065 \quad \ggg\gg\ A_s = \rho bd = 13.97\ cm^2/m$$

$$A_{s,min} = \frac{0.25 * \sqrt{f'_c}}{f_y} bd = 6.27\ \frac{cm^2}{m} \quad OR \quad \frac{1.4}{f_y} bd = 7.16\ cm^2/m$$

$A_s = 13.97\ cm^2/m$ - is control

So, use Ø 18/15

FOR Mu=92.4

Rn=2.22Mpa

ρ=0.0056

As=12.13 cm^2/m.

Use Ø18/15.

For Mu=36.4Mpa.

Rn=0.84 Mpa

ρ=0.0021

As=4.41 cm^2/m.

So, use $\emptyset 12/15cm$

4.9.1.4 Design for horizontal reinforcement:

Use $A_{sh,min} = 0.002bh = 0.002 * 100 * 30 = 6\ cm^2/m$

For one side is $\frac{6}{2} = 3cm^2/m$

So, use $\emptyset 12/20cm$ for each side.

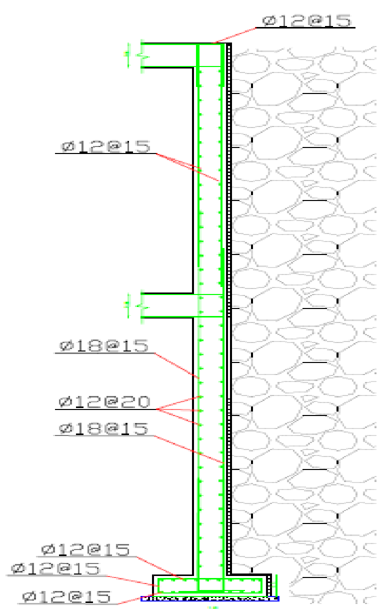


Figure 4. 12: Basement Wall Detail

4.9.2 Design of basement wall footing (strip footing):

The service loads form ETABS program:

- Dead load "including self-weight"= 120 kN/m.
- Live load = 50 kN/m.

Soil density = 17 KN/m3
Allowable soil Pressure = 400 KN/m2

4.9.2.1 Determination of q_{net}:

Assume footing thickness is 30 cm,

$q_{net} = 400 - (25 \times 0.3) - (17 \times 1.2) = 372.1\ KN/m^2$

$A = \frac{total\ service\ loads}{q_{net}} = \frac{170}{372.1} = 0.45\ m^2$

$q_{net} = \frac{1.2 \times 300 + 1.6 \times 90}{1 \times 1} = 224\ KN/\ m^2$

4.9.2.2 Check for one way shear:

$d = 300 - 75 - 9 = 216\ mm.$

$\emptyset\ V_c = 0.75\ \times 0.17\ \times \sqrt{24} \times 1000\ \times 216\ \times 10^{-3}\ = 134.9kN$

$V_u\ = 224\ \times \left(\frac{1 - 0.2}{2} - 0.216\right) = 41.216\ < 134.9\ kN\quad \ggg \gg\ okay$

4.9.2.3 Design for main reinforcement:

$M_u\ = 224\ \times 1 \times (0.4^2) * 0.5 = 17.92\ KN.m$

$R_n\ = 0.426\ MPa$

$m = 20.6$

$\rho = 0.001\ \rightarrow\ A_s\ = 2.16\ cm^2\ /m$

$A_{S\,min}\ = 0.0018\ bh = 5.4\ cm^2\ /m$

$A_{S\,min}\ = 5.7\ cm^2\ /m$ −control

So, use Ø 12/15 cm.

For shrinkage and temperature reinforcement, use $A_{S\,min}\ = 5.7\ cm^2\ /m$

So, use Ø 12/15 cm.

4.10 Design of Isolated Footing: (Footing Group 1)

Material:
Concrete B300 Fc' = 24 kN/m^2
Reinforcement Steel Fy = 420 kN/m^2

4.10.1 Load Calculations:

Dead Load = 933.7kN "included own weight"

Live Load = 54 kN

Total services load = 933.7 + 54 = 987.7 kN

Total Factored load = 1.2*933.7 + 1.6*54 = 1206.84 kN

Column Dimensions (a*b) = 30*50 cm

Soil density = 17 Kg/cm3

Allowable Bearing Capacity = 400 KN/m2

Assume h = 40cm

$$q_{net-allow} = 400 - 25 * 0.4 - 17 * 0.6 = 379.8\ KN/m^2$$

4.10.2 Area of Footing:

$$A = \frac{P_{total\ service}}{q_{net-allow}} = \frac{987.7}{379.8} = 2.6\ m^2$$

Assume Square Footing

b required = 1.61m

Select b = 1.65 m

Bearing Pressure:

$$q_{u,net} = \frac{P_{total\ factored}}{A} = \frac{1206.84}{1.65 * 1.65} = 443.28\ KN/m^2$$

4.10.3 Design of Footing:

4.10.3.1 Design footing for one way shear:

Critical Section at distance (d) from face of column.

Assume h = 460cm, bar diameter Ø 12 for main reinforcement and 7.5 cm Cover.

d = 400 – 75 – 12 = 313 mm

$$Vu = q_u * \left(\frac{B-a}{2} - d\right) * L$$

$$Vu = 443.28 * \left(\frac{1.65-0.3}{2} - 0.313\right) * 1.65$$

$$= 154.52\ KN$$

$$\emptyset V_c = 0.75 * 0.17 * \sqrt{f'_c} * b_w * d$$

$$\emptyset V_c = 0.75 * 0.17 * \sqrt{24} * 1650 * 313 * 10^{-3}$$
$$= 322.6\ KN$$

$$\emptyset V_c > V_u \qquad \gg\gg\gg\gg\gg\ okay$$

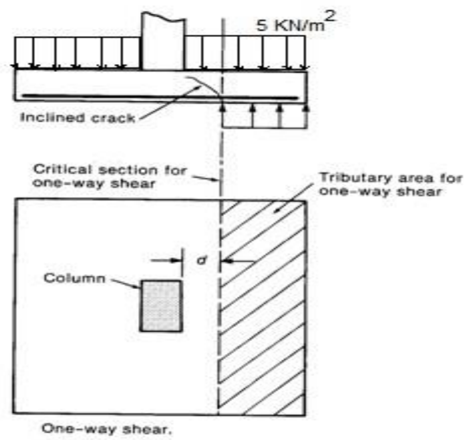


Figure 4. 13: One Way Shear of Footing.

4.10.3.2 Design Footing for two way shear:

$$V_u = P_u - FR_b$$

$$FR_b = q_{u,net} * area\ of\ critical\ section$$

$$V_u = 1206.84 - 443.28 * \left((0.3 + 0.313) * (0.5 + 0.313)\right) = 985.92\ KN$$

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

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

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

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

Where:-

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

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

$$b_o = 2 * (31.3 + 50) + 2 * (31.3 + 30) = 285.2\ cm$$

α_s = 40 for interior column

$$\phi.V_C = \phi.\frac{1}{6}\left(1+\frac{2}{\beta_c}\right)\sqrt{f_c'}\,b_o d = 2135.7\ kN$$

$$\phi.V_C = \phi.\frac{1}{12}\left(\frac{\alpha_s}{b_o/d}+2\right)\sqrt{f_c'}\,b_o d = 1746.52\ \text{kN}$$

$$\phi.V_C = \phi.\frac{1}{3}\sqrt{f_c'}\,b_o d = 1093.3\ kN$$

$\emptyset V_c = 1093.3\ KN > V_u = 985.92kN \ \ggg\gg okay$

4.10.3.3 Design of Bending Moment:

Critical section at the face of column.

$M_u = 443.28 * \left(\frac{1.65}{2}\right) * \left(\frac{1.65-0.3}{2}\right)^2 = 166.62\ KN.m$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{166.62\times10^6}{0.9\times1650\times313^2} = 1.145\ MPa$

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

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times1.145}{420}}\right) = 0.0028$

$A_{s,req} = \rho.b.d = 0.0028\times1650\times313 = 14.46\ cm^2$

$A_{s,min} = 0.0018*1650*400 = 11.88\ cm^2$

$A_{s,req}$ **is control**

Check for Spacing:

S = 3h = 3*40 = 120cm

S = 380*($\frac{280}{\frac{2}{3}*420}$) – 2.5*75 = 192.5 cm

S = 45 cm **……… is control**

Use 12ø12 in Both Direction

4.10.3.4 Development length of steel reinforcement in footing:

- Tension development length in footing:

$Ld_{T\ req} = \frac{9}{10} * \frac{F_y}{\lambda\sqrt{fc}} * \frac{\psi_e\psi_s\psi_t}{\frac{ktr+cb}{db}} * db \ \geq 300\text{mm}$

$Ktr = 0\ (Nostripes)$

$cb = 75 + \frac{12}{2} = 81\ mm$

$Or\ cb = \frac{150}{2} = 75mm\ is\ control$

$\frac{ktr + cb}{db} = \frac{0 + 75}{12} = 6.25 > 2.5$

$\frac{ktr + cb}{db} = 2.5$

$D = \frac{9}{10} * \frac{420}{1*\sqrt{24}} * \frac{1*1*0.8}{2.5} * 12 = 296.3\ mm\ < 300\text{mm}$

So, $Ld_{T\ req} = 300\ mm$

$Ld_{T\ available} \frac{1650-500}{2} - 75 = 500\ mm$

$Ld_{T\ available} = 500\ mm\ > ld_{req} = 300\ mm\ \ \ggg\gg \boldsymbol{okay}$

- Compression development length in footing:(For Dowels)

$Ld_{c\ req} = \frac{0.24 * Fy * dB}{\sqrt{f'_c}} \geq 0.043 * \text{f}_y * \text{d}_B\ \geq 200\text{mm}$

$Ld_{c\ req} = \frac{0.24*420*14}{\sqrt{24}} = 288.05\ mm \geq 0.043 * 420 * 14 = 252.84\text{mm}\ \geq 200\text{mm}$

$Ld_{c\ req} = 288.05mm$

$Ld_{c\ ava} = 400 - 75 - 12 - 12 = 301mm\ >\ Ld_{c\ req}\ \ \ggg\gg okay$

- Lap splice of dowels in column:

$L_{sc} = 0.071 * f_y * d_B = 417.48\ mm > 300mm$

Select $L_{sc} = 45\ cm$

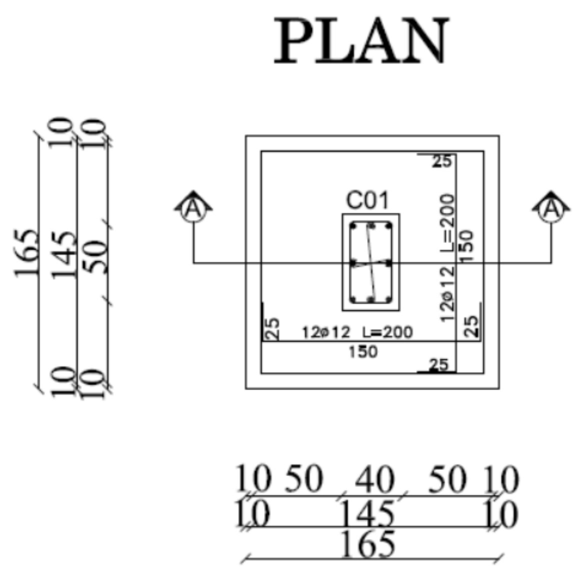


Figure 4. 14: Plan with Reinforcement of the Footing.

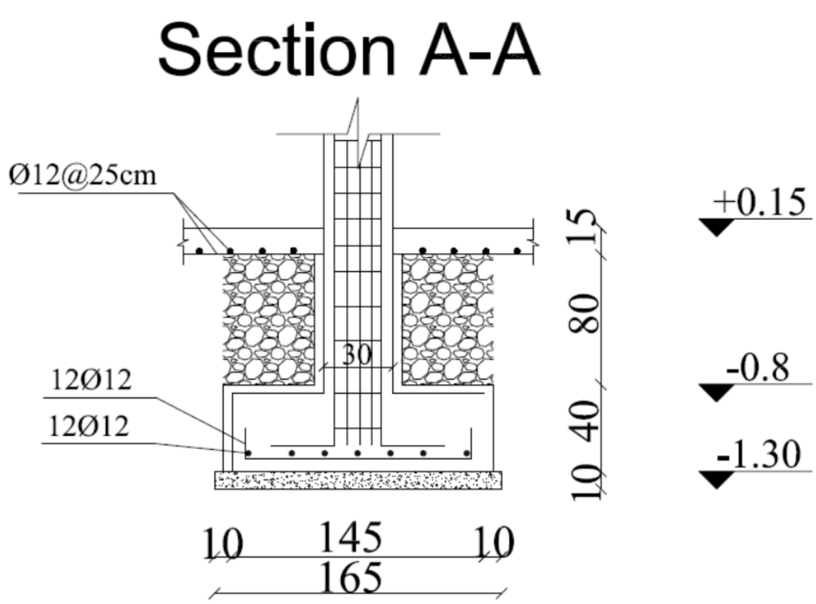


Figure 4. 15: Section in the Footing.

Chapter Five

Results, Recommendations and References

5.1 Results.

5.2 Recommendations.

5.3 References.

5.4 Appendix.

5.1 Results:

1. Each student or structural designer should be able to design manually, so he can get the experience and knowledge in using the computer software.
2. One of the factors that must be taken in consideration is the environment factors surrounding the building, the site terrains, and the forces effects on the site.
3. One of the important steps of the structural design is how to connect the structural members to work together, then to divide these members and design them individually, and should take the surrounding condition in the consideration.
4. Various types of slabs have been used: two way and one-way ribbed slabs, in some slabs that have a regular or nearly regular distribution of columns and beams. One-way solid slabs mainly in the stairs, because it has high resistance to the concentrated forces.
5. The useful software programs were used:
   - AutoCAD 2016, to draw the detail of drawings for structural drawings.
   - ATIR, Etabs, Safe, Sp column, adapt to analysis and design the structural members.

a. Recommendations:

This project has an important role in widening and enhancing the understanding to the nature of the structural project including all the details, analysis, and designs. It is very helpful-through this experience-to introduce a group of recommendations. At the beginning, the architectural drawings have to be prepared and ordered and the construction material and the structural system have to be choose alongside. And it is essential at this stage to have information about the project site, the soil, the soil strength capacity at the site from the geotechnical report, after that the bearing walls and the columns is going to be set up alongside the architectural team in a compatible manner. The civil engineer tries at this stage to plant as much as possible the reinforced concrete walls, which should be use after that in resisting the earthquake loads and other lateral loads.

5.3 References:

1. American concrete institute, Building code requirements for structural concrete ACI 318M, 2011.
2. American concrete institute, Details and Detailing of Concrete Reinforcement ACI315, 1999.
3. Abboushi, Nasr, Reinforced concrete, Palestine polytechnic university, 2013.
4. National Jordanian Construction Council, Jordanian Building Code.

Appendix

TABLE 9.5(a)—MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE CALCULATED

	Minimum thickness, ***h***			
	Simply supported	One end continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be damaged by large deflections.			
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**

Notes:
Values given shall be used directly for members with normalweight concrete (density w_c = 2320 kg/m^3) and Grade 420 reinforcement. For other conditions, the values shall be modified as follows:
a) For structural lightweight concrete having unit density, w_c, in the range 1440-1920 kg/m^3, the values shall be multiplied by ($1.65 - 0.003w_c$) but not less than 1.09.
b) For f_y other than 420 MPa, the values shall be multiplied by ($0.4 + f_y/700$).

[1] MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE CALCULATED. -ACI Code-

الجدول (٣-١-ب)

تابع الأحمال الحية للأرضيات والعقدات

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الاشغال	كن/م٢	كن
تابع مباني التجمعات العامة.	تابع القاعات، قاعات الاجتماعات، المطاعم، المتاحف، المكتبات،	الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.	4.0	4.5
	النوادي، المسارح، ستوديوهات الاذاعة.	المنصات.	7.5	4.5
		أرضيات المتاحف وصالات عرض الفنون.	4.0	4.5
		أماكن العبادة (المساجد والكنائس).	3.0	2.7
مباني المكاتب.	المكاتب والبنوك.	مستودعات القرطاسية.	4 لكل متر من ارتفاع التخزين.	9.0
		غرف حفظ الملفات.	5.0	4.5
		قاعات البنوك.	3.0	–
		مكاتب للاستعمالات الخفيفة.	2.5	2.7
		الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.	4.0	4.5

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[2] LIVE LOAD